AA2014-8

AIRCRAFT ACCIDENT INVESTIGATION REPORT

JAPAN AIRLINES CO., LTD.

J A 7 0 1 J

December 18, 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 determine the causes of an accident and damage incidental to such an accident, thereby preventing future accidents and reducing damage. It is not the purpose of the investigation to apportion blame or liability.

Norihiro Goto
Chairman,
Japan Transport Safety Board

Note:

This report is a translation of the Japanese original investigation report. The text in Japanese shall prevail in the interpretation of the report.

AIRCRAFT ACCIDENT INVESTIGATION REPORT

DAMAGE DUE TO TAILSTRIKE DURING GO-AROUND
JAPAN AIRLINES CO., LTD.
BOEING 777-200, JA701J
ON RUNWAY 34L OF TOKYO INTERNATIONAL AIRPORT, JAPAN
AT ABOUT 16:08 JST, MARCH 31, 2012

December 5, 2014
Adopted by the Japan Transport Safety Board
Chairman Norihiro Goto
Member Shinsuke Endoh
Member Toshiyuki Ishikawa
Member Sadao Tamura
Member Yuki Shuto
Member Keiji Tanaka

SYNOPSIS

<Summary of the Accident>

On Saturday, March 31, 2012, a Boeing 777-200, registered JA701J, operated by Japan Airlines Co., Ltd., took off from Shanghai Hongqiao International Airport and approached Runway 34L of Tokyo International Airport. At around 16:08 Japan Standard Time (JST: UTC+9hr; unless otherwise stated all times are indicated in 24-hour clock JST), when the aircraft made go-around after touching down on the runway, the lower part of its aft fuselage made contact with the runway, and then damaged the airframe. Afterwards, the aircraft landed at Tokyo International Airport at around 16: 35.

There were 308 people on board, consisting of a captain, 11 crew members, and 296 passengers, but nobody sustained injuries.

The Aircraft sustained substantial damage, but there was no outbreak of fire.

<Probable Causes>

In this accident, it is highly probable that the Aircraft continued rolling with the pitch-up attitude after touchdown, causing the aft fuselage to come into contact with the runway and be damaged.

It is highly probable that the Aircraft continued rolling with the pitch-up attitude due to the following reasons: after touchdown, the PIC had felt that the Aircraft had bounced to the extent necessary for go-around, and judged to make go-around to avoid a hard landing, even after he became aware that the reverse thrust levers had been raised, he continued go-around; hence, it took time for the engine thrust to increase and he continued to pull his control column. Moreover, it is somewhat likely that, in a situation in which the PIC had been assisting the control of the FO, and without the PIC's declaring a takeover, the intention of the PIC was not properly conveyed to the FO, the sharing of duties between PF (Pilot mainly in charge of flying) and PM (Pilot mainly in charge of duties other than flying). became momentarily unclear, and the monitoring of flight information such as pitch angle and speed, which was the duty of PM, was not performed adequately.

Abbreviations used in this report are as follows:

AOM:	Aircraft Operating Manual
ATIS:	Automatic Terminal Information Service
CIG:	Ceiling
CMV:	Converted Meteorological Visibility
CVR:	Cockpit Voice Recorder
DFDR:	Digital Flight Data Recorder
EICAS:	Engine Indication and Crew Alerting System
F/D:	Flight Director
FL:	Flight Level
ILS:	Instrument Landing System
INTRNS:	In Transit
MAC:	Mean Aerodynamic Chord
PAPI:	Precision Approach Path Indicator
PAR:	Precision Approach Radar
PF:	Pilot Flying
PIC:	Pilot-In-Command
PIREP:	Pilot Report
PM:	Pilot Monitoring
RA:	Radio Altitude
RNAV:	Area Navigation
RVR:	Runway Visual Range
TEM:	Threat and Error Management
TO/GA:	Take Off / Go Around
VHF:	Very High Frequency
VIS:	Visibility
WOW:	Weight On Wheel

Unit Conversion Table

1ft:	0.3048m
1kt:	1.852km/h (0.5144m/s)
1lb:	0.4536kg
1psi:	0.06895bar: 0.07031kgf/cm^2

1 PROCESS AND PROGRESS OF THE AIRCRAFT ACCIDENT INVESTIGATION

1.1 Summary of the Accident

On Saturday, March 31, 2012, a Boeing 777-200, registered JA701J, operated by Japan Airlines Co., Ltd., took off from Shanghai Hongqiao International Airport and approached Runway 34L of Tokyo International Airport. At around 16:08 Japan Standard Time (JST: UTC+9hr, unless otherwise stated all times are indicated in JST on a 24-hour clock), when the aircraft made go-around after touching down on the runway, the lower part of its aft fuselage made contact with the runway, and then damaged the airframe. Afterwards, the aircraft landed at Tokyo International Airport at around 16: 35.

There were 308 people on board, consisting of a Pilot-In-Command (PIC), 11 crew members, and 296 passengers, but nobody sustained injuries.

The aircraft sustained substantial damage, but there was no outbreak of fire.

1.2 Outline of the Accident Investigation

1.2.1 Investigation Organization

On March 31, 2012, the Japan Transport Safety Board (JTSB), received an accident notification, designated an investigator-in-charge and two investigators to investigate this accident.

1.2.2 Representatives of the Relevant State

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

1.2.3 Implementation of the Investigation

April 1, 2012	Interviews and aircraft examination
April 2, 2012	On-site investigation and aircraft examination
April 17, 2012	Interviews

1.2.4 Comments from the Parties Relevant to the Cause of the Accident

Comments were invited from parties relevant to the cause of the accident.

1.2.5 Comments from the Relevant State

Comments were invited from the relevant State.

2 FACTUAL INFORMATION

2.1 History of the Flight

On March 31, 2012, a Boeing 777-200, registered JA701J (hereinafter referred to as “the Aircraft”), operated by Japan Airlines Co., Ltd. (hereinafter referred to as “the Company”), took off from Shanghai Hongqiao International Airport at 14:00 and approached Runway 34L of Tokyo International Airport as a scheduled flight 82 of the Company.

The outline of the flight plan for the Aircraft was as follows:

Flight rules: Instrument Flight rules (IFR)

Departure aerodrome: Shanghai Hongqiao International Airport
Estimated off-block time: 13:50
Cruising speed: 445 kt
Cruising altitude: Flight Level (FL) 290
Route: (Omitted)-Y21 (RNAV Route)-ADDUM (position reporting point)
Destination aerodrome: Tokyo International Airport
Total estimated elapsed time: 1 hr and 58 min
Fuel load expressed in endurance: 4 hr and 53 min
Alternate aerodrome: Kansai International Airport

When the accident occurred, the PIC sat in the left seat in the cockpit of the Aircraft as the Pilot Monitoring (PM: pilot mainly in charge of duties other than flying) and the First Officer (FO) sat in the right seat as the Pilot Flying (PF: pilot mainly in charge of flying).

Based on the records from the digital flight data recorder (hereinafter referred to as "DFDR"), the cockpit voice recorder (hereinafter referred to as "CVR"), the multilateration system[1] and the airport surface detection equipment of Tokyo International Airport, records of communication with air traffic controllers, and the statements of crew members, the flight history for the Aircraft up to the time of the accident is summarized as follows.

2.1.1 History of the Flight based on the DFDR, CVR, the multilateration system, the airport surface detection equipment and ATC Communications Records

16:01:34	Airport Traffic Control Tower (hereinafter referred to as the "Tower") issued a landing clearance to the Aircraft for Runway 34L and informed the Aircraft that the wind was 020 degrees and at 17 kt.
16:01:42	The Aircraft read back the landing clearance for 34L to the Tower.
16:01:45	The Tower informed the Aircraft that a wind shear was reported at an altitude of 800 ft and that the wind speed was fluctuating at an amplitude of 25 kt.
16:05:40	The flap lever was set at 25 degrees.
16:06:36–16:07:10	During the radio altitude decreased through 1,150 to 650 ft, the wind direction changed from 210 degrees to 070 degrees in a clockwise direction, and afterwards changed to 240 degrees in a counter-clockwise direction, then changed to 010 degrees in a clockwise direction. In addition, the wind speed changed from 5 kt to 10 kt, and after reverting back to 5 kt, it increased to 13 kt.
16:06:43	The radio altitude was at approximately 1,000 ft.
16:07:35	Auto pilot was disengaged at a radio altitude of 334 ft.
16:07:56	The Aircraft passed over the runway threshold almost above the centerline of the runway at an airspeed of 152 kt and a radio altitude of 41 ft. Auto callout "Fifty" was announced.
16: 07:58	The FO's control column was pulled in the pitch-up direction. Auto callout "Thirty" was announced.
16:07:59	Auto callout "Twenty" was announced.

[1] "Multilateration system" is a system to measure the location of an aircraft in which signals sent from transponder for air traffic control that are equipped on an aircraft are received by multiple receiving stations at the airport

16:08:00	Auto callout "Ten" was announced.
16:08:04	A load was applied on the right main landing gear (touchdown), the speedbrake lever extended toward the extend direction, and the spoilers started to deploy. The thrust levers were retarded toward the IDLE position. The FO's control column was being pulled toward the pitch-up direction, and the PIC's control column was being pushed toward the pitch-down direction. At this time, the airspeed was 145 kt, pitch angle was 3.3 degrees, roll angle was 2.1 degrees to the right, vertical acceleration was 1.27 G and the Aircraft was at about 610 m from the runway threshold.
16:08:05	After the left main landing gear touchdown, the load on the left main landing gear was momentarily reduced to zero. Reverse thrust levers were raised to the interlock position. The PIC's control column was pulled toward the pitch-up direction. The airspeed was 144 kt, pitch angle was 1.8 degrees, and roll angle was 0.7 degrees to the right.
16:08:05–16:08:08	Vertical acceleration fluctuated twice significantly between 0.52 and 1.62 G.
16:08:06	The PIC's control column was pushed toward the pitch-down direction. The PIC called "Go around, Go around." A load was applied on the left main landing gear, and the brake pressure of the main landing gears began to increase. At this time, the airspeed was 142 kt, pitch angle was 2.5 degrees, and the Aircraft was at about 760 m from the runway threshold.
16:08:07	The PIC called "Go around." The PIC's control column was pulled toward pitch-up direction, and The FO side column force began to decrease. The position of the control column rapidly rose toward the pitch-up direction.
16:08:09	Pitch angle was 10.4 degrees, and airspeed was 130 kt.
16:08:10	The FO called "Flaps 20." All spoilers extended completely.
16:08:14–16:08:15	The reverse thrust levers were returned to the full down position, and the thrust levers were advanced forward. The brake pressure of the main landing gears began to decrease. In addition, the speedbrake lever moved toward the down direction, and the spoilers started to be retracted. At this time, the airspeed was 108 kt, and the Aircraft was at about 1,370 m from the runway threshold.
16:08:21	Tail Strike Caution[2] was issued. At this time, the airspeed was 105 kt, pitch angle was 11.0 degrees,

[2] "Tail Strike Caution" is issued when the tail strike sensors in the lower part of the aft fuselage come into contact with the ground surface and are destroyed.

	and the Aircraft was at about 1,710 m from the runway threshold.
	Engine thrust began to increase.
	The FO called “I will set Flaps 20.”
16:08:23	The PIC called “I have control.”
	The flap lever was set at 20 degrees.
16:08:24	The FO called “You have control.”
16:08:24	The ground speed was a minimal value of 100 kt.
16:08:28	Pitch angle reached a maximum angle of 13.5 degrees.
16:08:29	No load on the main landing gears.
	At this time, the airspeed was 116 kt, and the Aircraft was at about 2,130 m from the runway threshold.
16:08:32	The FO reported to the Tower that they had made go-around.
16:08:33	The FO called “Positive rate.”
16:08:42	The FO called “I will retract the landing gear.”
16:08:43	The PIC called “Gear up.”
16:08:45	The gear lever was set at the UP position.
16:09:03	The FO reported to the Tower that a tail strike had occurred.

Moreover, during this period, the nose landing gear did not touch the ground.

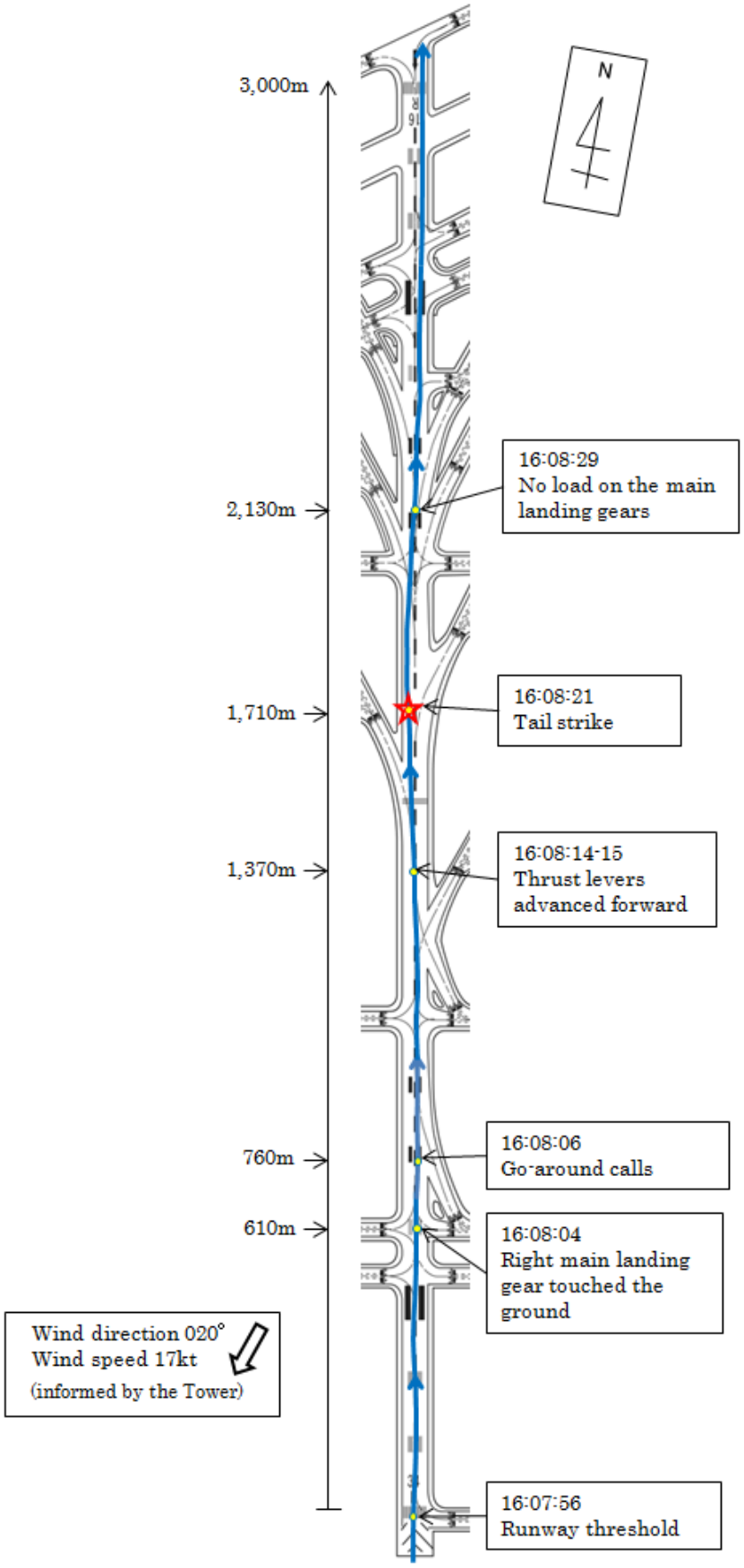


Figure A: Estimated Flight Route

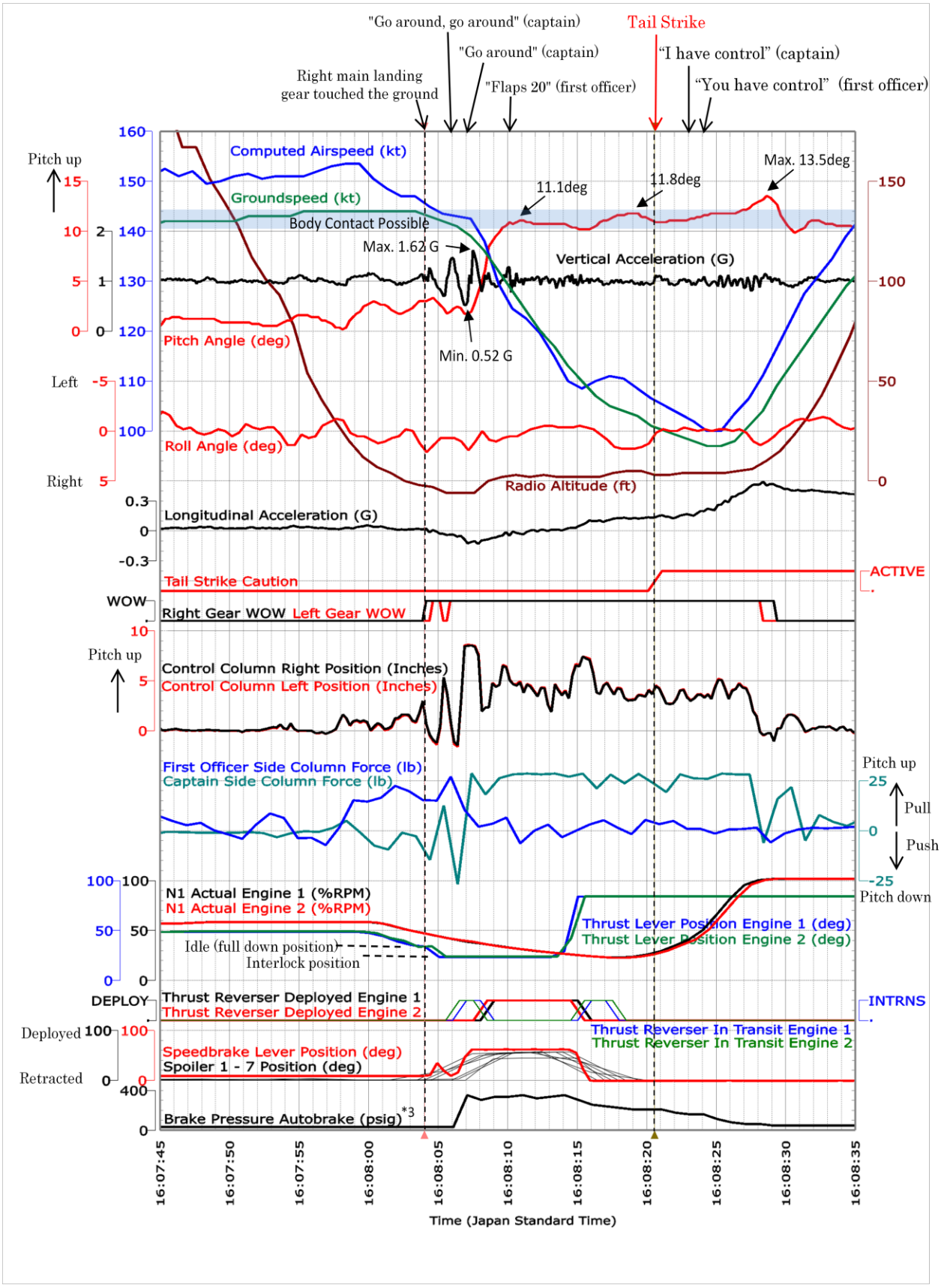


Figure B: DFDR Records

[3] "psig" is a pressure measurement unit relative to atmospheric pressure (which is considered as 0).

2.1.2 Statements of Crew Members

(1) PIC

While approaching Runway 34L under flight control of the FO, the PIC received as the information on the arrival flight that there was a wind shear at around 1,200 ft, and confirmed linear clouds that seemed to cross over the final approach course. As there was a possibility that a significant change in the wind would occur when passing through that position, the PIC ordered the FO not to disengage the auto pilot until any changes had passed, and to fly with a little more speed than normal. In actuality, there were changes in the wind at around 1,200 ft, but it was mostly stable after that.

During approach, the PIC put his right hand on the lower part of the thrust levers, and his left hand on the control column.

Before touchdown, he judged that it was time to retard the thrust levers, and gradually retarded it. At that time, he thought that the FO might have been retarding on the thrust levers as well.

The timing at which the FO had initiated the flare and its amount were such that the PIC had felt nothing abnormal about it. The landing attitude was as it usually was, and the PIC felt that the pitch angle was somewhere about 3 to 4 degrees.

The landing itself was basically a smooth, soft landing; however, the PIC felt a floating-like sensation, and thought that he had involuntarily pushed the control column. The PIC felt a sinking sensation, and the Aircraft floating again after touchdown again, and realized that it was continuing to float in mid-air. He judged that the next touchdown was going to become hard; accordingly, he called for go-around. At this time, he was not aware of the actuation of the speedbrake lever.

After calling for go-around, the FO had not advanced the thrust levers forward. Therefore, the PIC called "I have control" and judged to take over. Since the thrust levers could not be advanced forward, he turned his sight to the thrust levers, and then noticed that the reverse thrust levers had been raised to the interlock position. After returning the reverse thrust levers to its full down position, the PIC advanced the thrust levers forward, and confirmed the increase in engine thrust on the instrument.

As the pitch tends to increase with the increase in engine thrust, the PIC waited for the Aircraft to climb while holding the control column. During that time, the PIC ordered the FO to set the flaps at 20 as in a normal go-around procedure, and the FO set the flap lever position change.

Just at that time, the Aircraft began to climb, and the FO advised on whether to "I will retract the landing gear." Therefore, the PIC ordered to gear up.

When the FO reached out his hand to the gear lever, a master caution issued and the FO called out "We have a tail strike (message)." After the Aircraft climbed and stabilized, the PIC ordered the FO to report the Tower of a possibility of a tail strike.

After reporting to the Tower, having received advice from the FO that the gears are still down, the PIC ordered to gear up again.

Flying level at 4,000 ft, a tail strike checklist was accomplished.

After making preparations for landing, the PIC received a report from the aft cabin crew member that a metallic noise like the Aircraft had dragged its rear end was heard during go-around.

After that, the Aircraft landed at Runway 34L under flight control of the PIC.

The PIC did not hear any unusual noises or feel any impact during go-around. Moreover, he was not aware of any abnormalities in the systems of the Aircraft.

(2) FO

The FO was in charge of PF operations in the right seat. He set the flaps at 25, and the autobrakes to 3. The approach speed was set to 150 kt, including an additional 10 kt intended for wind speed correction. Unfavorable air current persisted during approach; however, the conditions remained steady at an altitude of 500 ft and below. The runway was clearly visible, and no rain was present. The PIC advised that there was a possibility of turbulence in the vicinity of the touchdown point due to the effect of the wind crossing over the hangars.

After the air current stabilized, the FO disengaged the auto pilot and auto throttle, and shifted to manual control. After this, he did not feel the effect of wind crossing over the hangers as much as he had anticipated.

The FO controlled aircraft up to touchdown according to his own plans, and felt that the touchdown went smoothly. As he felt touchdown and heard the sound of touchdown, he raised the reverse thrust levers to the interlock position. He was unable to remember the movement of the speedbrake lever or whether the PIC called out “Speedbrake up.”

The FO judged that the main landing gears had touched the ground since he had felt the sensation of landing and that he was able to raise the reverse thrust levers to the interlock position. Therefore, he decided to prevent the nose from falling by pulling on the control column. However, at that moment he felt the sensation of touchdown again. Since he had assumed that the Aircraft was not floating, he felt something strange.

When he tried to make the nose landing gear touch the ground, he heard the PIC’s go-around call. He tried to push the TO/GA switch, but was unable to do so. At this time, he did not report to the PIC that the reverse thrust levers had not been returned to the full down position, but was positioned at the interlock position. When the PIC was trying to advance the thrust levers forward, he assumed that the pitch angle was around 10 degrees; he did not see the PIC returning the reverse thrust levers to the full down position.

He was unable to remember precisely when the PIC called out “I have,” whether he called out “You have,” or when they had exchanged controls.

The master caution issued during go-around; accordingly, he looked at EICAS and saw the tail strike message being displayed there, but did not hear any sound or feel any vibrations of the rear end being dragged.

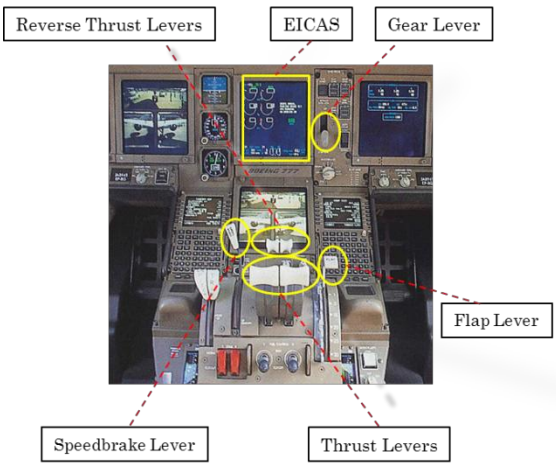


Photo A: Cockpit

(3) Chief Purser

The chief purser was seated near the door to the left side at the fore passenger cabin.

During landing, there was a vertical shaking that was larger than usual, and the impact upon touchdown felt unusually large. After touchdown, she could not quite feel the sense of speed decreasing, but there was a gradual increase in speed and the nose rose upwards.

During the climb, a cabin crew member at the aft left side notified the chief purser that a sound like metal being dragged was heard from the rear end when landing.

The chief purser ordered the cabin crew member to report the situation to the flight crew.

The accident occurred at about 1,710 m from the Runway 34L threshold of Tokyo International Airport (35°33'01"' N, 139°46'34" E) at around 16:08 JST on March 31, 2012.

2.2 Damage to the Aircraft

2.2.1 Extent of Damage

The Aircraft sustained substantial damage.

2.2.2 Damage to the Aircraft Components

On the external skin for the lower part of the aft fuselage, there was an abrasion of about 11 m in length and about 40 cm in width, with holes and cracks. The frame within this area was exposed and damaged. Tail strike sensors had been stripped off. And the lower part of the aft pressure bulkhead was slightly deformed.

(See Photo: Damage to the Fuselage)

2.3 Personnel Information

(1) PIC Male, Age 42

Airline Transport Pilot Certificate (Airplane)	May 31, 2007
Type rating for Boeing 777	February 22, 2005
Class 1 Aviation Medical Certificate	
Validity	April 29, 2012
Total flight time	6,848 hr and 49 min.
Flight time in the last 30 days	45 hr and 56 min.
Total flight time on the type of aircraft	3,754 hr and 27 min.
Flight time in the last 30 days	45 hr and 56 min.

Company-Qualification

The PIC held company qualification of the Left Approved captain that allowed the FO seated in the right seat to conduct flight operations as PF.

(2) FO Male, Age 29

Commercial Pilot Certificate (Airplane)	August 2, 2006
Type rating for Boeing 777	November 12, 2008
Instrument Flight Certificate	August 4, 2006
Class 1 Aviation Medical Certificate	
Validity	March 23, 2013
Total flight time	1,810 hr and 59 min.
Flight time in the last 30 days	61 hr and 01 min.

Total flight time on the type of aircraft	1,506 hr and 38 min.
Flight time in the last 30 days	61 hr and 01 min.

2.4 Aircraft Information

2.4.1 Aircraft

Type	Boeing 777-200
Serial number	32889
Date of manufacture	June 18, 2002
Certificate of airworthiness	No. 2009-160

Validity: For the period in which the maintenance management manual (JAL Engineering Co., Ltd.) approved under Article 113-2 of the Civil Aeronautics Act applies, starting on October 1, 2009.

Category of airworthiness	Airplane Transport T
Total flight time	30,856 hr and 06 min.

Flight time since the last periodic inspection (07A inspection conducted on February 1, 2012) 670 hr and 02 min.

(See Figure 1: Three angle View of Boeing 777-200)

2.4.2 Weight and Balance

When the accident occurred, the weight of the Aircraft was estimated to have been 423,532 lb, and the position of the center of gravity was estimated to have been 27.8 % MAC, respectively, within the allowable range (maximum landing weight of 470,000 lb. and CG range of 14.0–44.0 % MAC that corresponded to the weight at the time of the accident).

2.4.3 Landing Field Length

According to the Vref Speed & Landing Field Length of 777 Aircraft Operating Manual (hereinafter referred to as the "AOM"), the landing field length was around 1,800 m for aircraft weight (420,000 lb); flap position (25); condition of runway (WET, on sea level, no slope); no wind; outside temperature (15˚C).

2.4.4 Tail Strike Pitch Angle

The aft fuselage of the Aircraft touches the ground at a pitch angle of 10.2 degrees when the shock absorbers of the main landing gears are compressed completely and at a pitch angle of 12.1 degrees when they are extended completely.

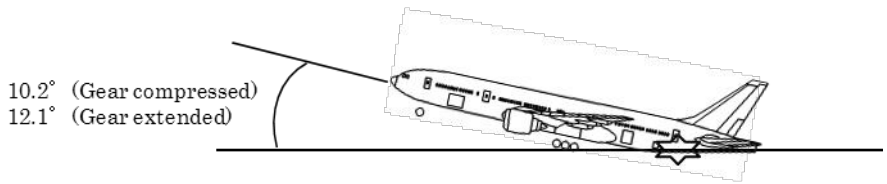


Figure C: Tail Strike Pitch Angle

2.5 Meteorological Information

2.5.1 Aerodrome Routine Meteorological Report

Aerodrome routine meteorological report for Tokyo International Airport announced at 16:00 was as follows:

Wind direction 360°; Wind velocity 17 kt; Visibility 7 km; Light shower
Cloud: Amount FEW, Type Stratus, Cloud base 1,000 ft
Amount BKN, Type Cumulus, Cloud base 1,200 ft
Amount BKN, Type Stratocumulus, Cloud base 1,500 ft
Temperature 10°C; Dew point 7°C
Altimeter setting (QNH) 29.48 in Hg

2.5.2 Ground Winds

Regarding the instantaneous wind direction and wind velocity at Runway 34L of Tokyo International Airport, the averages at 5-minute intervals were as follows:

Time	15:50–15:55	15:55–16:00	16:00–16:05	16:05–16:10
Wind direction	010°	006°	010°	007°
Wind velocity	14 kt	14 kt	14 kt	12 kt

2.6 Information on DFDR and CVR

The Aircraft was equipped with a DFDR (part number: 980-4700-042) and a CVR (part number: 980-6022-001) manufactured by Honeywell of the United States of America, and records of the accident when it occurred were retained in both recorders.

The time calibration for DFDR and CVR was conducted by comparing the time signals recorded in the air traffic control communication records with the VHF radio signals recorded in DFDR and air traffic control communications recorded in CVR.

2.7 Accident Site Information

Tokyo International Airport has four runways. Runway 34L has a length of 3,000 m (9,840 ft), width of 60 m (200 ft), with grooving (grooves dug on runway surface) and touchdown point elevation of 18.4 ft. It is installed with ILS and PAPI, and the approach angle for both is set at 3 degrees. The ILS Glide Path Antenna is located at 338 m from the threshold on the right side of the runway, and PAPI is located at 449 m from the threshold on the left side of the runway.

As there were multiple marks on Runway 34L caused by takeoff and landing by other aircraft, it was impossible to locate the abrasion marks made when the lower part of the aft fuselage of the Aircraft made contact. No damage was caused to the runway, lighting, or marking.

2.8 Additional Information

2.8.1 Speedbrakes

The AOM Supplement stated as follows (excerpts):

Spoiler Speedbrake Operation

(Omitted)

The speedbrake spoilers are controlled by the speedbrake lever located on the control stand. The speedbrake lever has three marked positions:

- *DOWN*
- *ARMED*
- *UP*

The speedbrake lever can be placed in intermediate positions between ARMED and UP.

In the ARMED position, the speedbrake lever is driven aft to the UP position when the landing gear is fully on the ground (not tilted) and the thrust levers are at idle.

On the ground when either reverse thrust lever is moved to the reverse idle detent, the speedbrakes automatically extend. The speedbrake lever does not need to be in the ARMED position. A mechanical link between the speedbrake lever and the reverse thrust levers raises the speedbrake lever out of the DOWN detent. The speedbrake lever is then driven aft and the speedbrakes extend. If either thrust lever is advanced to a takeoff position, the speedbrake lever is driven to the down position.

2.8.2 Thrust Reversers

The AOM Supplement stated as follows (excerpts):

Thrust Reverser System

(Omitted)

The reverse thrust levers can be raised only when the forward thrust levers are in the idle position.

(Omitted)

Pushing the reverse thrust levers to the full down position retracts the reversers to the stowed and locked position. The thrust levers cannot be moved forward until the reverse thrust levers are fully down.

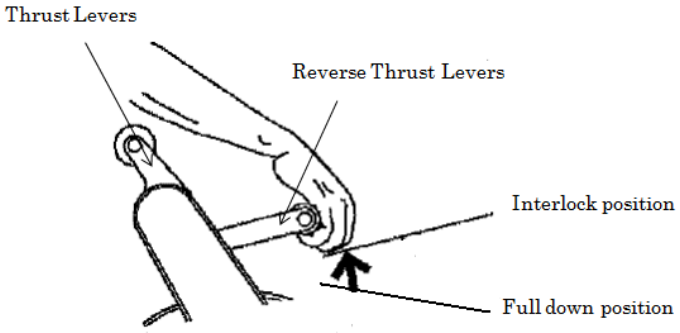


Figure D: Reverse Thrust Levers

2.8.3 Autobrakes

The AOM Supplement stated as follows (excerpts):

Autobrake system

The autobrake system provides automatic braking at preselected deceleration rates for Landing.

(Omitted)

Landing

Five levels of deceleration can be selected for landing. However, on dry runways, the maximum autobrake deceleration rate in the landing mode is less than that produced by full pedal braking.

After landing, autobrake application begins when:

・both thrust levers are retarded to idle, and

・the wheels have spun up.

Autobrake application occurs slightly after main gear touchdown. If MAX AUTO is selected, deceleration is limited to the AUTOBRAKE 4 level until pitch angle is less than one degree,

then deceleration is increased to the MAX AUTO level. The deceleration level can be changed (without disarming the system) by rotating the selector.

To maintain the selected airplane deceleration rate, autobrake pressure is reduced as other controls, such as thrust reversers and spoilers, contribute to total deceleration. The system provides braking to a complete stop or until it is disarmed.

2.8.4 Manuals on Landing procedure

(1) The Operations Manual on the standards for a FO controlling in the right seat stated as follows:

5-5-4 Standards for a first officer controlling in the right seat (excerpts):

(3) Prior to flight, the PIC shall brief the Flight Crew Member qualified as First Officer thoroughly. Especially, in takeoff and landing, the PIC shall confirm specified procedures beforehand.

(4) The PIC shall call out "You have (Controls)" when handing over the controls to the Flight Crew Member qualified as First Officer. To resume the controls, the PIC shall call out "I have (Controls)" to order the Flight Crew Member qualified as First Officer to reassume his/her normal duties.

(5) The PIC shall be always in a position ready to take over the controls from the Flight Crew Member qualified as First Officer, keeping a close check on his/her performance and the condition of the aircraft. The PIC shall takeover the controls from the Flight Crew Member qualified as First Officer, when it is judged to be necessary.

(6) Except when the Flight Crew Member qualified as First Officer at the left seat is performing the PF duty, the PIC shall assume full control of the aircraft by himself/herself when making an aborted takeoff, missed approach or go-around. However, in case of missed approach or go-around, the PIC can let the First Officer commence the initial manipulation.

5-5-4 Attached Table: Limitations of operations for a first officer controlling in the right seat or left seat

Requirements:

1. To meet the following requirements during takeoff and landing.

(1) Takeoff and Landing performance according to runway condition specified in Aircraft Operating Manual shall be applied, Dry, Dump, Wet Grooved or Qualified Dry.

(2) To have a runway allowance of 15 per cent of the required field length or 1,000 ft, whichever is longer.

(3) MAX Crosswind Component according to runway condition specified in Aircraft Operating Manual shall be applied, within 15 knots.

(4) No aircraft system deficiencies that would affect takeoff or landing performance will be involved.

(5) Weather condition is not less than the table1 in Note5 at initiating Takeoff or final approach. Only ground Visibility (VIS) or RVR shall be used to judge Visibility's condition.

(Note5) *Table1*

Category	(Omitted)	*Landing*	
		PRECISION (ILS, PAR)	(Omitted)
(Omitted)			
D	(Omitted)	*CIG.400 -R1600/1600*[4]	(Omitted)

(2) The AOM on landing operations stated as follows:

Landing Roll Procedure

WARNING: Once reverse thrust is initiated, a full stop landing must be made.

PF	*PM*
Verify that the thrust levers are closed. *Verify that the SPEED BRAKE lever is up.* *Without delay, move the reverse thrust levers to the interlocks.* *If SPEED BRAKE lever failed to extend automatically, extend speedbrake manually.*	*Verify that the SPEED BRAKE lever is UP and call "SPEEDBRAKE UP."* *If the SPEED BRAKE lever is not UP, call "NO SPEEDBRAKE."*
Monitor the rollout.	
Verify correct autobrake operation.	
Apply reverse thrust as needed.	*Verify that REV on EICAS is Green.*

(3) The AOM on go-around procedure stated as follows:

Go-Around and Missed Approach Procedure

PF	*PM*
Call "GO AROUND." *Push the TO/GA switch and call FLAPS 20."*	
	Position the FLAP Lever to 20.
Verify: *- the rotation to go-around attitude* *- that the thrust increases*	
	Verify that the thrust is sufficient for the go-around or adjust as needed.
Verify a positive rate of climb on the altimeter and call "GEAR UP."	*Verify a positive rate of climb on the altimeter and call "POSITIVE RATE."* *Set the landing gear lever to UP.*

[4] "R1600/1600" indicates that a runway visual range (RVR) is 1,600 m or visibility is 1,600 m.

(4) The 777 Flight Technical Guide of the Company on go-around stated as follows (excerpts):

(i) Precautions during Go-Around

When landing, the system is designed so that the ENG idle Thrust will shift from Approach idle to Minimum (Ground) idle under the condition that RA 5 ft or below is maintained for 5 seconds or longer. When making go-around after touchdown, keep in mind that after shifting to Minimum idle, it takes around 10 seconds to obtain go-around thrust even when the thrust levers are advanced.

(ii) Bounced Landing Recovery

If the airplane should bounce, hold or re-establish a normal landing attitude and add thrust as necessary to control the rate of descent. Thrust need not be added for a shallow bounce or skip. When a high, hard bounce occurs, initiate go-around. Apply go-around thrust and use normal go-around procedures. Do not retract the landing gear until a positive rate of climb is established because a second touchdown may occur during go-around.

If higher than idle thrust is maintained through initial touchdown, the automatic speedbrake deployment may be disabled even when the speedbrakes are armed. This can result in a bounced landing.

(iii) Over-Rotation during Go-Around

Go-arounds initiated very late in the approach, such as during the landing flare or after touching down, are a common cause of tail strikes. When the go-around mode is initiated, the flight director immediately commands a go-around pitch attitude. If the pilot flying abruptly rotates up to the pitch command bar, a tail strike can occur before the airplane responds and begins climbing. During go-around, an increase in thrust as well as a positive pitch attitude is needed. If the thrust increase is not adequate for the increased pitch attitude, the resulting speed decay will likely result in a tail strike. Another contributing factor in tail strikes may be a strong desire by the flight crew to avoid landing gear contact after initiating a late go-around when the airplane is still over the runway. In general, this concern is not warranted because a brief landing gear touchdown during a late go-around is acceptable. This had been demonstrated during autoland and go-around certification programs.

(iv) Go-Around after Touchdown

If a go-around is initiated before touchdown and touchdown occurs, continue with normal go-around procedures. The F/D go-around mode will continue to provide go-around guidance commands throughout the maneuver.

If a go-around is initiated after touchdown but before thrust reverser selection, auto speedbrakes retract and autobrakes disarm as thrust levers are advanced. The F/D go-around mode will not be available until go-around is selected after becoming airborne.

Once reverse thrust is initiated following touchdown, a full stop landing must be made. If an engine stays in reverse, safe flight is not possible.

(v) Automatic Brakes

Immediate initiation of reverse thrust at main gear touchdown and full reverse thrust allow the autobrake system to reduce brake pressure to the minimum level.

(Omitted)

The importance of establishing the desired reverse thrust level as soon as possible after touchdown cannot be overemphasized. This minimizes brake temperatures and tire and

brake wear and reduces stopping distance on very slippery runways.

(5) The Operations Guide of the Company on takeover operation of the PIC when the FO controlling flight in the right seat stated as follows (excerpts):

1. Takeover

(Omitted)

(iii) At takeover, the Captain should first make sure the aircraft is under his control so as to secure continuity of operation, and then call, "I Have (Control)."

(iv) The Captain should be aware that after takeover, the First Officer may not be able to reassume PM duty smoothly.

After takeover, it is important that the Captain provides necessary orders to the First Officer depending on the circumstances involved.

2.8.5 Duties of Flight Crew Members

The AOM stated as follows (excerpts):

Crew Duties

(Omitted)

PF

- Taxiing

- Flight Path and Airspeed Control

- Airplane Configuration

- Navigation

PM

- Monitoring Taxiing, Flight Path, Airspeed, Airplane Configuration and Navigation

- Checklist Reading

- Communications

- Tasks asked for by the PF

2.8.6 Go-around after Reverse Operation

The Boeing Company, which designed and manufactured the Aircraft, issued a "Multi Operator Message" to the operators of 777 after this accident on July 24, 2012, in consideration of the fact that there were four rejected landings in the 777 fleet over the last three years which have occurred after reverse thrust had been selected following normal touchdown.

[MESSAGE NUMBER: MOM-MOM-12-0503-01B] Multi Operator Message

MESSAGE DATE: 24 Jul 2012 0857 US PACIFIC TIME / 24 Jul 2012 1557 GMT (excerpts)

There are several risk items that are incurred by rejecting a landing after reverse thrust has been selected, these include:

1. A reverser could fail to re-stow properly. Becoming airborne with a reverser deployed could be catastrophic.

2. A significant amount of time and runway distance will be used to accelerate to rotation speed, increasing the risk of runway overrun.

3. Lack of visibility to the side of runway could exist if the airplane is rotated prematurely. This increases the risk of a high speed runway excursion.

4. An increased risk of tail strike is present as the tendency is to rotate prematurely.

3 ANALYSIS

3.1 Qualifications of Personnel

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

3.2 Aircraft Airworthiness Certificates

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

3.3 Meteorological Condition

As described in 2.5.1, the weather at Tokyo International Airport during the time period related to the accident was cloudy with occasional showers. It is highly probable that visibility was fairly good under visual meteorological conditions.

As described in 2.5.2, it is highly probable that the wind at Runway 34L during the time period related to the accident was coming from at around 010 degrees (true bearing) at around 14 kt. This indicates that the wind was a headwind from around 40 degrees to the right side of Runway 34L, and the crosswind component and headwind component would be 9 kt and 11 kt respectively.

The meteorological conditions at the time of the accident were within the limitations for a FO controlling in the right seat as described in 2.8.4 (1), and it is unlikely that the condition had a bearing on the accident.

3.4 Situations leading up to Go-around

3.4.1 Approach

(1) During approach

As described in 2.1.1, during the approach the radio altitude decreased through 1,150 to 650 ft, the wind direction and wind speed had some changes. Later on, the auto pilot was disengaged at a radio altitude of 334 ft and as indicated in Figure B, only the FO operated the control column until around seven seconds prior to the right main landing gear touchdown. The speed and pitch angle were fairly stable, and the descending rate of the radio altimeter was normal. In addition, as described in 2.1.2, the PIC stated that he ordered the FO not to disengage the auto pilot until any changes in the wind had passed. The FO stated that he disengaged the auto pilot and auto throttle, and shifted to manual control after the air current stabilized.

From this, it is highly probable that the FO had shifted to manual control after passing through the anticipated wind shear airspace, and had approached under steady conditions.

(2) Control by the FO

As described in 2.3, the PIC held the company qualification of the Left Approved captain. As described in 2.5.1, the condition of the landing runway (34L) was "Wet Grooved," which is approved for a FO controlling in the right seat as described in 2.8.4 (1). The landing field length was calculated to around 2,100 m, which was more than adequate for the length of Runway 34L (3,000 m). Moreover, there were no abnormalities in the Aircraft at landing, and as described in 3.3, the meteorological conditions were within the limitations for a FO controlling in the right seat.

From these points, it is highly probable that the FO controlled in the right seat in accordance with the company requirements.

3.4.2 Touchdown

(1) Situation of touchdown

As described in 2.1.1, at 16:08:04, the right main landing gear touched down at about 610 m from the runway threshold with a pitch angle of 3.3 degrees, roll angle of 2.1 degrees to the right, and vertical acceleration of 1.27 G. Following that, as indicated in Figure B, after the left main landing gear touched the ground, the load on the left gear was momentarily reduced to zero. However, there were no changes in the pitch angle, roll angle or radio altitude.

From this, it is probable that the Aircraft had touched down on its right main landing gear at around the area a little past the aiming point marking with rolling to the right slightly, and then when the left main landing gear touched down, the shock absorber of the left main landing gear became compressed and extended momentarily.

(2) Operation for touchdown

As indicated in Figure B, when the FO pulled on the control column and initiated flare six seconds before the right main landing gear touched down at 16:07:58, the PIC had already started control. After touchdown, in correspondence to the PIC's large operation of his control column, the FO side column force had decreased.

Moreover, as described in 2.1.2, the FO stated that he controlled aircraft up to touchdown according to his own plans, and felt that the touchdown went smoothly. The PIC stated that, during approach, he put his right hand on the lower part of the thrust levers, and his left hand on the control column, and before touchdown, he judged that it was time to retard the thrust levers, and gradually retarded it.

From these points, it is highly probable that the FO had been assisted with controls by the PIC from around the time when he initiated flare.

(3) Awareness of bounce

As indicated in Figure B, after the right main landing gear touched the ground, the PIC operated his control column in a large way toward the pitch-up and pitch-down directions to assist the control of the FO, and the vertical acceleration of the Aircraft fluctuated significantly twice. Moreover, as described in 2.1.2 (1), the PIC felt a sinking sensation, and the Aircraft floating again after touchdown again, and realized that it was continuing to float in mid-air.

It is probable that due to the changes in vertical acceleration that occurred after touchdown, the PIC had felt that the Aircraft had bounced and was floating. However, as described in (1), it is probable that although the shock absorber of the left main landing gear became compressed and extended momentarily, a bounce that would lead to the main landing gears moving away from the runway did not occur.

Moreover, it is probable that the significant changes in the vertical acceleration had occurred due to the PIC having operated the control column in a large way.

(4) Verification of speedbrake lever actuation

As described in 2.8.1, the speedbrake lever is driven aft to the up position when the landing gear is fully on the ground and the thrust levers are at idle. In addition, as described in 2.8.4 (2), PM is supposed to verify the actuation of the speedbrake lever and to call out the

position of the lever.

As indicated in Figure B, the speedbrake lever extended toward the upside direction after the main landing gears had touched the ground. However, as described in 2.1.2 (1), the PIC stated that he was not aware of the actuation of the speedbrake lever, and there were no calls related to the lever in CVR records.

As described in (3), the PIC felt the Aircraft had bounced and was floating; accordingly, he had diverted his attention to look outside of the Aircraft to confirm its attitude, and then judged to make go-around. Therefore, it is probable that the PIC had not been verifying the actuation of the speedbrake lever as PM.

(5) Reverse operations

As described in 2.8.4 (2), PF is supposed to verify that the thrust levers are closed and the speedbrake lever is up, and without delay, move the reverse thrust levers to the interlock position.

As described in 2.1.1, when both main landing gears touched the ground at 16:08:05, the thrust levers were in the interlock position, and as described in 2.1.2 (2), the FO stated that as he felt touchdown and heard the sound of touchdown, he raised the reverse thrust levers to the interlock position.

Based on this, it is highly probable that the FO was aware of touchdown, and had raised the reverse thrust levers.

On the other hand, as described in 2.1.2 (1), the PIC stated that since the thrust levers could not be advanced forward, he turned his sight to the thrust levers and noticed that the reverse thrust levers had been raised to the interlock position.

Based on this, it is probable that, as with (4), the PIC had diverted his attention to look outside of the Aircraft to confirm its attitude; therefore, he was not aware of the reverse thrust levers raised by the FO.

3.4.3 Go-around

(1) Judgment for Go-around

As described in 3.4.2 (3), the PIC had felt the Aircraft had bounced and was floating, and as described in 2.1.2 (1), he stated that he judged that the next touchdown was going to become hard; accordingly, he called for go-around.

Based on this, it is highly probable that from what was described in 2.8.4 (4) *(ii),* the PIC had felt that the Aircraft had bounced to the extent necessary for go-around, and then judged to make go-around to avoid a hard landing.

As described in 2.8.4 (2), it is stated in the AOM that once reverse thrust is initiated, a full stop landing must be made. However, as described in 3.4.2 (5), the PIC was not aware of the reverse thrust levers raised by the FO. Assuming that the PIC (as PM) had monitored the levers raised by the FO (as PF), or had been informed of raising of the levers by the FO, it is somewhat likely that the PIC would not have made go-around.

However, the PIC had continued with the go-around even after he had noticed that the reverse thrust levers had been initiated. Since go-around after reverse operation incurs several risk items as described in 2.8.6, the flight crew should be well aware of the fact that the AOM states that once reverse thrust levers are initiated, a full stop landing must be made.

(2) Orders for Go-around

As described in 2.1.1, the PIC called out for go-around three times at 16:08:06 and 16:08:07, and as described in 2.1.2 (1), he stated that the FO had not advanced the thrust levers forward after calling for go-around.

As described in (1), the PIC judged to make go-around to avoid a hard landing and ordered the FO to do it. However, at this time, the PIC had diverted his attention to look outside of the Aircraft to confirm its attitude, and as he was calling out for go-around several times during a short time period, it is probable that the PIC ordered under heavily stressed conditions.

(3) Controls by the FO

As described in 2.1.2 (2), the FO controlled aircraft up to touchdown according to his own plans, and felt that the touchdown went smoothly. As he felt touchdown and heard the sound of touchdown, he raised the reverse thrust levers to the interlock position. He decided to prevent the nose from falling by pulling on the control column. When he tried to make the nose landing gear touch the ground, he heard the PIC's go-around call. He tried to push the TO/GA switch, but was unable to do so.

Based on this, it is somewhat likely that the FO had controlled for touchdown as normal, but having received unexpected orders from the PIC to make go-around, he then tried to push the TO/GA switch even though the reverse thrust levers were in the interlock position and the thrust levers could not be advanced forward.

3.4.4 Takeover

(1) As described in 2.1.1, the PIC called out for go-around at 16:08:06 and 16:08:07, and sixteen seconds later, at two seconds after the tail strike, he called "I have control."

As described in 2.1.2 (1), the PIC stated that after calling for go-around, the FO had not advanced the thrust levers forward. Therefore, the PIC called "I have control" and judged to take over.

Based on this, it is highly probable that the PIC had ordered the FO to make go-around, but the FO had not advanced the thrust levers forward; consequently, he initiated a takeover. Moreover, as described in 3.4.3 (2), the PIC had diverted his attention to confirm the attitude of the Aircraft, and ordered to make go-around under heavily stressed conditions. However, as described in the above, it was sixteen seconds after the go-around call, at two seconds after the tail strike when the PIC called "I have control" and took over controls.

As described in 2.8.4 (5), the PIC should be aware that after takeover, the FO may not be able to reassume PM duty smoothly; therefore, it is important that the PIC provides necessary orders to the FO depending on the circumstances involved. However, there were no records in CVR to order it.

(2) As described in 2.1.1, at 16:08:10 after the PIC had called for go-around and started operating the control column, the FO had called "Flaps 20" as with the go-around procedure for PF. In addition, as described in 3.4.2 (2), the FO had been assisted with controls by the PIC from around the time when he initiated flare, and the FO side column force had been decreasing.

Based on this, it is probable that the FO had judged that he had continued to be assisted with control by the PIC after the call for go-around, and while entrusting controls to the PIC, he had continued his duty as PF until the PIC called out for takeover.

(3) Based on the above, it is somewhat likely that, in a situation in which the PIC had been

assisting the control of the FO, and without the PIC's declaring a takeover, the intention of the PIC was not properly conveyed to the FO, the sharing of duties between PF and PM became momentarily unclear, and the monitoring of flight information such as pitch angle and speed, which was the duty of PM as described in 2.8.5, was not performed adequately.

3.4.5 Tailstrike

(1) After touchdown

As indicated in Figure B, after the main landing gears touched the ground, the spoilers started to deploy, and the brake pressure of the main landing gears began to increase. After that, the speed began to decrease as the pitch angle increased, and the Aircraft maintained a pitch angle of 10.2 degrees and above, that is the angle which tail strike occurs when the shock absorbers of the main landing gears are compressed, as described in 2.4.4.

Based on this, it is highly probable that after touchdown, the Aircraft rose its nose rapidly while decelerating due to the functions of the spoilers and the autobrakes, and had been rolling with a pitch angle in which a tail strike occurs.

(2) Control after touchdown

As indicated in Figure B, the thrust levers had been advanced forward eight seconds after the PIC called for go-around at around 16:08:14, and the engine thrust began to increase six seconds later. In addition, as described in 2.1.2 (1), the PIC stated that he could not advance the thrust levers forward after he called for go-around and then noticed that the reverse thrust levers had been raised to the interlock position. After that, he first returned the reverse thrust levers to its full down position and advanced the thrust levers forward.

Based on this, it is probable that as described in 3.4.2 (5), the PIC was not aware of the reverse thrust levers raised by the FO; consequently, he was unable to immediately advance the thrust levers. As in AOM described in 2.8.4 (2), the PIC would have to reject the go-around and continue the landing when he became aware that the reverse thrust levers had been raised. Instead, it is highly probable that he decided to first return the reverse thrust levers to full down position and advance the thrust levers, which took time for the engine thrust to increase as it had already shifted to Ground idle.

As indicated in Figure B, the PIC had been pulling his control column toward the pitch-up direction from around 16:08:07 after he had called out for go-around. The pitch angle had increased rapidly, and had been maintaining an angle of 10.2 degrees and above.

It is highly probable that as described in 3.4.3 (1), the PIC had felt that the Aircraft had bounced to the extent necessary for go-around, and judged to make go-around to avoid a hard landing; hence, he had pulled his control column to maintain a pitch-up attitude.

(3) Occurrence of tail strike

It is highly probable that, as described in (1), the Aircraft had been rolling with the pitch-up attitude, and as described in (2), it took time for the engine thrust to increase. Therefore, it continued rolling until the aft fuselage came into contact with the runway and the Tail Strike Caution was issued. In addition, it is somewhat likely that as described in 3.4.4 (3), the sharing of duties between PF and PM became momentarily unclear and the monitoring of flight information, which was the duty of PM, was not performed adequately, leading the Aircraft to continue rolling with the pitch-up attitude.

As described in 2.2.2, there was abrasion on the aft fuselage indicating that it had been dragged for a prolonged period. In addition, the Aircraft had maintained its excessive pitch

angle after the Tail Strike Caution had been issued at 16:08:21, as indicated in Figure B. Therefore, it is highly probable that the aft fuselage had been continued dragging for around seven seconds until the Aircraft became airborne again.
(See Figure 2 "Chain of Probable Causes of the Accident")

3.5 Prevention of Tail Strike at Control in the Right Seat

When landing with the FO as PF and the PIC as PM, the following factors should be taken into account in order to prevent the occurrence of tail strike:

(1) Before approach

The PIC and the FO shall mutually confirm any points of concern regarding approach and landing, and make sure there are no discrepancies in their perceptions.

The PIC shall explain to the FO the procedures for takeover.

(2) During approach

The FO shall accurately communicate his or her intention to the PIC.

The PIC shall always monitor the controls on the FO while performing PM duty, and provide necessary advice regarding safety action as needed. However, in case of situations that cannot be handled by providing advice alone, the PIC shall immediately initiate a takeover. In such cases, the PIC shall make sure to call out that he or she will take over, and that the FO is able to immediately reassume PM duty.

(3) After touchdown

The FO shall be well aware that once reverse thrust is initiated, a full stop landing must be made, and to operate the reverse thrust levers carefully.

The PIC shall always monitor the controls on the FO while performing PM duty certainly, and immediately initiate a takeover as needed.

The flight crew shall carefully monitor the attitude of the Aircraft while rolling to make sure that it does not go into any abnormal attitude that risks causing a tail strike.

4 CONCLUSION

4.1 Findings

(1) It is unlikely that the meteorological conditions at the time of the accident had a bearing on the accident. (3.3)

(2) It is highly probable that the FO had shifted to manual control after passing through the anticipated wind shear airspace, and had approached under steady conditions.

It is highly probable that the FO controlled in the right seat in accordance with the company requirements. (3.4.1)

(3) It is probable that the Aircraft had touched down on its right main landing gear at around the area a little past the aiming point marking with rolling to the right slightly, and then when the left main landing gear touched down, the shock absorber of the left main landing gear became compressed and extended momentarily.

It is highly probable that the FO had been assisted with controls by the PIC from around the time when he initiated flare.

It is probable that due to the changes in vertical acceleration that occurred after touchdown, the PIC had felt that the Aircraft had bounced and was floating.

The PIC felt the Aircraft had bounced and was floating; accordingly, he had diverted his attention to look outside of the Aircraft to confirm its attitude, and then judged to make go-around. Therefore, it is probable that the PIC had not been verifying the actuation of the speedbrake lever as PM.

It is highly probable that the FO was aware of touchdown, and had raised the reverse thrust levers. It is probable that the PIC had diverted his attention to look outside of the Aircraft to confirm its attitude; therefore, he was not aware of the reverse thrust levers raised by the FO. (3.4.2)

(4) It is highly probable that the PIC had felt that the Aircraft had bounced to the extent necessary for go-around, and then judged to make go-around to avoid a hard landing.

The PIC judged to make go-around and ordered the FO to do it. However, at this time, the PIC had diverted his attention to look outside of the Aircraft to confirm its attitude, and as he was calling out for go-around several times during a short time period, it is probable that the PIC ordered under heavily stressed conditions.

It is somewhat likely that the FO had controlled for touchdown as normal, but having received unexpected orders from the PIC to make go-around, he then tried to push the TO/GA switch even though the reverse thrust levers were in the interlock position and the thrust levers could not be advanced forward. (3.4.3)

(5) It is highly probable that the PIC had ordered the FO to make go-around, but the FO had not advanced the thrust levers forward; consequently, he initiated a takeover.

It is somewhat likely that, in a situation in which the PIC had been assisting the control of the FO, and without the PIC's declaring a takeover, the intention of the PIC was not properly conveyed to the FO, the sharing of duties between PF and PM became momentarily unclear, and the monitoring of flight information such as pitch angle and speed, which was the duty of PM, was not performed adequately. (3.4.4)

(6) It is highly probable that after touchdown, the Aircraft rose its nose rapidly while decelerating due to the functions of the spoilers and the autobrakes, and had been rolling with a pitch angle in which a tail strike occurs.

It is probable that the PIC was not aware of the reverse thrust levers raised by the FO; consequently, he was unable to immediately advance the thrust levers. The PIC would have to reject the go-around and continue the landing when he became aware that the reverse thrust levers had been raised. Instead, it is highly probable that he decided to first return the reverse thrust levers to full down position and advance the thrust levers, which took time for the engine thrust to increase as it had already shifted to Ground idle.

It is highly probable that the PIC had felt that the Aircraft had bounced to the extent necessary for go-around, and judged to make go-around to avoid a hard landing; hence, he had pulled his control column to maintain a pitch-up attitude.

It is highly probable that the Aircraft had been rolling with the pitch-up attitude, and it took time for the engine thrust to increase. Therefore, it continued rolling until the aft fuselage came into contact with the runway and the Tail Strike Caution was issued. In addition, it is somewhat likely that the sharing of duties between PF and PM became momentarily unclear and the monitoring of flight information, which was the duty of PM, was not performed adequately, leading the Aircraft to continue rolling with the pitch-up attitude. (3.4.5)

4.2 Probable Causes

In this accident, it is highly probable that the Aircraft continued rolling with the pitch-up attitude after touchdown, causing the aft fuselage to come into contact with the runway and be damaged.

It is highly probable that the Aircraft continued rolling with the pitch-up attitude due to the following reasons: after touchdown, the PIC had felt that the Aircraft had bounced to the extent necessary for go-around, and judged to make go-around to avoid a hard landing; even after he became aware that the reverse thrust levers had been raised, he continued go-around; hence, it took time for the engine thrust to increase and he continued to pull his control column. Moreover, it is somewhat likely that, in a situation in which the PIC had been assisting the control of the FO, and without the PIC's declaring a takeover, the intention of the PIC was not properly conveyed to the FO, the sharing of duties between PF and PM became momentarily unclear, and the monitoring of flight information such as pitch angle and speed, which was the duty of PM, was not performed adequately.

5 SAFETY ACTIONS

5.1 Safety Action Taken by the Company

5.1.1 Directions Given After the Occurrence of the Accident

In light of the occurrence of this accident, the Company implemented the following directions to the flight crew members under the order from the Manager of Flight Training and Check, Planning and Development Department.

(1) Appropriate takeover

The Company explained the fact that it does not allow "assist", in which the PIC operates the aircraft flight control to correct the operation of the FO while the FO is controlling in the right seat, as well as the unsafe factors associated with that, such as the duties between PF and PM becoming unclear, and it directed the PIC to take over in such cases.

In addition, the Company explained that when taking over, the FO may not be able to reassume PM duty smoothly, and the importance of both PF and PM to ensure coordination between crew members by briefing appropriately with a correct common perceptions and a sense of risk.

(2) Meteorological conditions for the FO to takeoff and landing in the right seat

This accident and the case of tail skid contact that occurred in the previous year both occurred on a day with strong winds relatively after a typhoon or low pressure system passed, and in both cases the requirements for controls in the right seat were cleared. Bearing this in mind, the Company added the following requirements related to meteorological conditions in the Operations Manual and directed to refrain from takeoff and landing with the controls in the right seat:

- When head wind component exceed 25 kt
- When tail wind component exceed 10 kt
- When gust component exceed 10 kt
- When a wind shear reported on ATIS and PIREP exceed 10 kt
- When strong turbulence is forecasted
- When bad weather is forecasted before or after a typhoon or front passed

5.1.2 Revision to the Operation Guide

The Company has revised the Operation Guide, which is used as the guide for aircraft operation. Mainly, the following points have been made explicit.

(1) The FO controlling in the right seat

(i) Advice by the PIC is an oral order.

(ii) At altitudes of 300 ft and below, takeover shall be made instead of correction through advice.

(iii) Takeover shall be made when the aircraft bounces or skips.

(iv) Takeover shall be made when the speedbrake lever failed to extend at landing.

(2) Appropriate takeover

(i) After takeover, do not persist in landing and do not hesitate to make go-around.

(ii) The PIC shall not operate the aircraft flight controls, and so on for assistance while performing PM duty, but shall take over.

(iii) Advice by the PIC is an oral order.

(iv) At altitudes of 300 ft and below, takeover shall be made instead of correction through advice.

(v) Takeover shall be made when the aircraft bounces or skips.

5.1.3 Classroom Lectures

During the period from June 1 to June 30, 2014, classroom lectures, and so on were provided to the flight crew members on the following subjects.

(1) Questionnaire survey

Questionnaire survey on experience of takeover and/or problems encountered during PM duty and hesitating to control in the right seat

(2) Introduction of cases in which a tail strike and tail contact occurred during right seat flight operation in the Company

(3) Case studies of accident based on aircraft accident investigation reports focusing on takeover

(4) Explanation, discussion, and so on about the revision made to the Operation Guide and the order from the Manager of Flight Training and Check, Planning and Development Department

(5) The importance, and so on of Threat and Error Management (TEM) during controls in the right seat

(i) TEM during approach

Consideration of ways to identify and deal with risk elements and share between crew members

Questions and assertions in ensuring safety

(ii) Detailed briefing on sharing the controls envisioned by PF and PM

(iii) Timing for an appropriate takeover

At altitudes of 300 ft and below, take over if any advice is required.

(iv) Sharing of duties between PF and PM after takeover

Note that PM duty tends to be neglected after takeover

Reaffirm the importance of PM duty in mutual check with PF

5.1.4 Simulator Training

The following simulator training was provided to those holding company qualification of Left Approved captain.

(1) Reaffirming the importance of PM duty

Having set for visibility, cloud base, winds, and so on which will become loads when performing PM duty in the left seat, occurrence for system malfunctions, and so on after landing were set, and it was confirmed whether the crew had shared the situation through appropriate calls and respond appropriately.

(2) Conducting and confirming an appropriate takeover

Confirmed whether the crew had correctly recognized the change in conditions at an altitude of around 300 ft and in the vicinity of the touchdown point, and had taken over safely and promptly.

(3) Making a safe go-around after takeover near touchdown

The crew had practiced go-around multiple times while appropriately controlling the energy and attitude (especially the pitch) of the aircraft in order that go-around could be safely made when go-around was judged to be necessary near touchdown.

Figure 1: Three-angle View of Boeing 777-200

Unit: m

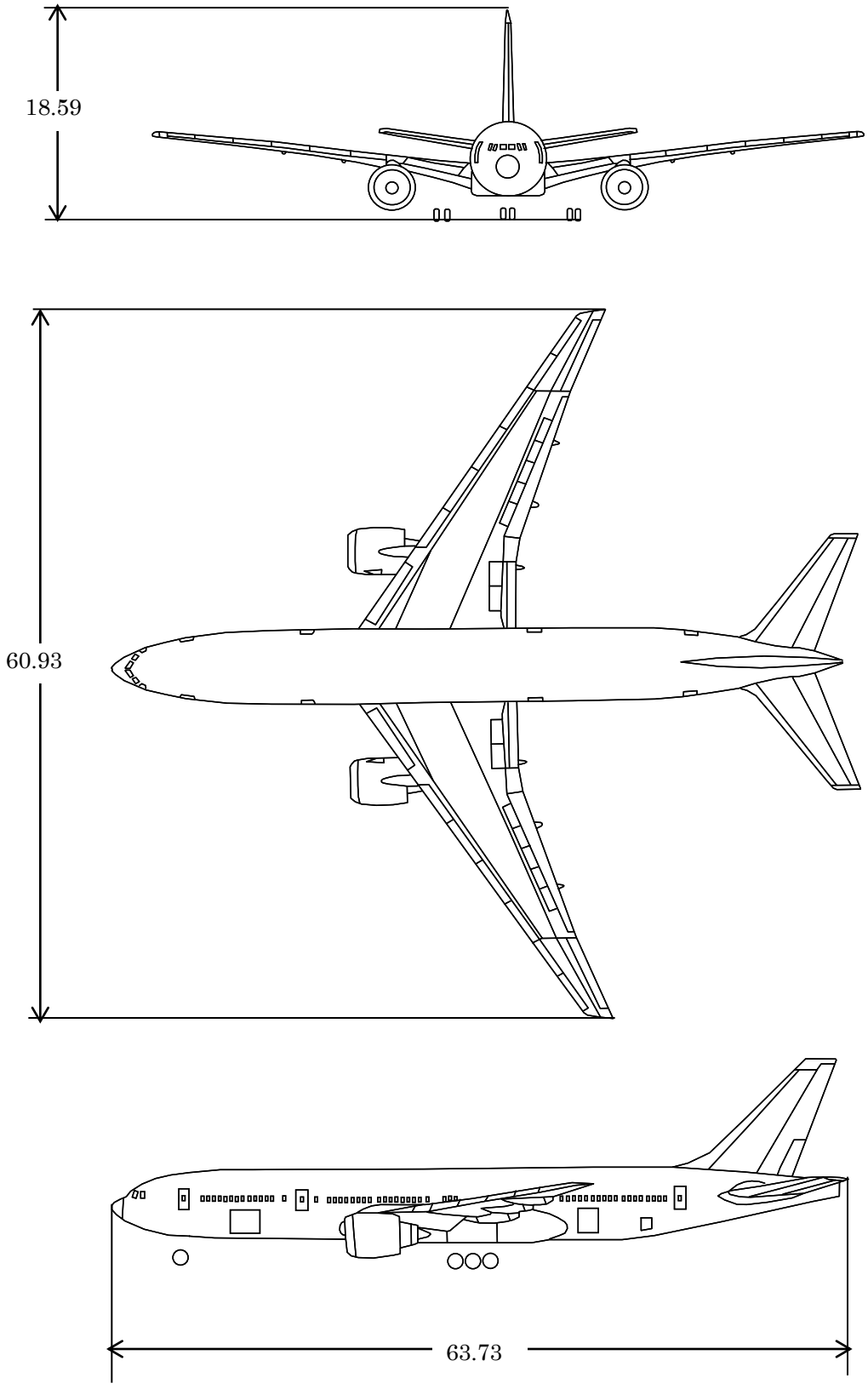
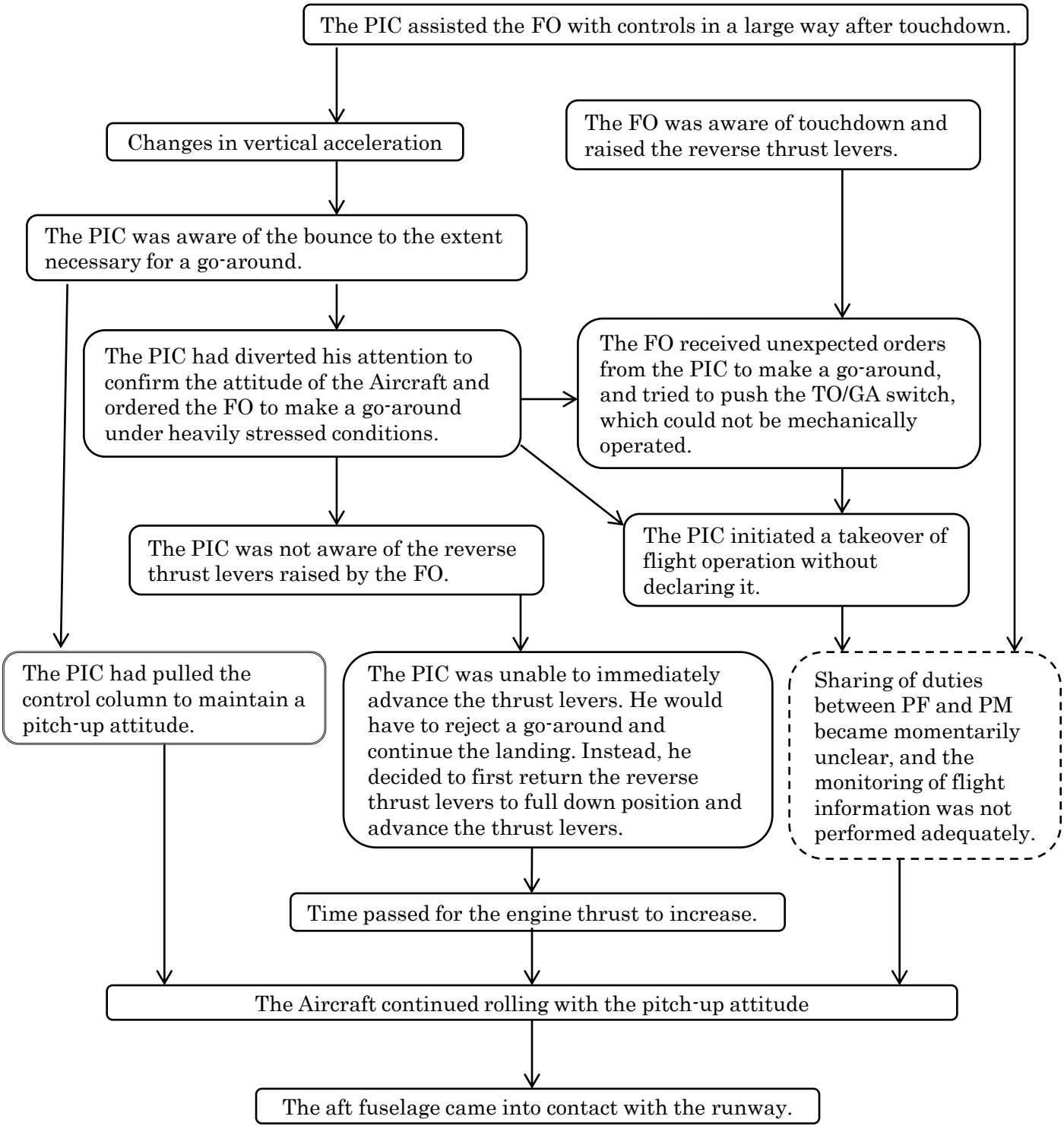


Figure 2: Chain of Probable Causes of the Accident



Events that could be highly probable from records (DFDR, and so on), and statements of involved parties

Events that could be somewhat likely from related status, and so on.

Photo: Damage to the Fuselage