

AA2011-3

**AIRCRAFT ACCIDENT
INVESTIGATION REPORT**

ASIANA AIRLINES INC.

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March 25, 2011

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

ASIANA AIRLINES INC. (REPUBLIC OF KOREA)
AIRBUS A321-200, HL7763
ON RUNWAY 06L OF KANSAI INTERNATIONAL AIRPORT
AT ABOUT 10:08 JST, OCTOBER 28, 2009

March 11, 2011

Adopted by the Japan Transport Safety Board

Chairman	Norihiro Goto
Member	Shinsuke Endoh
Member	Toshiyuki Ishikawa
Member	Sadao Tamura
Member	Yuki Shuto
Member	Toshiaki Shinagawa

1. PROCESS AND PROGRESS OF THE INVESTIGATION

1.1 Summary of the Accident

On October 28 (Wednesday), 2009, an Airbus A321-200, registered HL7763, operated by Asiana Airlines Inc., took off from Gimpo International Airport, the Republic of Korea, as a non-scheduled Flight 1125 of the company at about 08:51 Japan Standard Time (JST: UTC+9hr, unless otherwise stated all times are indicated in JST on a 24-hour clock). When the aircraft landed on runway 06L of Kansai International Airport, the aircraft's aft fuselage struck the runway and sustained damage.

There were 147 persons on board, consisting of the Captain, 8 other crewmembers, and 138 passengers. No one was injured.

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 October 28, 2009, the Japan Transport Safety Board designated an investigator-in-charge and two other investigators to investigate this accident.

1.2.2 Representatives from Foreign Authorities

An accredited representative of the Republic of Korea, as the State of Registry and the Operator of the aircraft involved in the accident, and an accredited representative of France, as the State of Design and Manufacture of the aircraft involved in the accident, participated in the investigation.

1.2.3 Implementation of the Investigation

October 28 to 30, 2009	Aircraft examination, On-site investigation and Interviews
December 9, 2009	Interviews

1.2.4 Comments from 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 Participating States

Comments were invited from the participating States.

2. FACTUAL INFORMATION

2.1 History of the Flight

On October 28, 2009, an Airbus A321-200, registered HL7763 (hereinafter referred to as "the Aircraft"), operated by Asiana Airlines Inc. (hereinafter referred to as "the Company"), took off from Gimpo International Airport, as a non-scheduled Flight 1125 bound for Kansai International Airport (hereinafter referred to as "the Airport") at about 08:51.

The outline of the flight plan was as follows:

Flight rules : Instrument flight rules (IFR)

Departure aerodrome : Gimpo International Airport

Estimated off-block time : 08:40

Cruising speed : 454 knots(TAS)

Cruising altitude : FL370

Route : (Omitted) – JEC (Miho VORTAC) – TRE (Tottori VOR/DME) – KIJYY (reporting point) – SAEKI (reporting point) — HAKBI (reporting point) – OKC (Okayama VORTAC) – ALISA (reporting point) – EDDIE (reporting point)
Destination aerodrome : Kansai International Airport
Estimated flight time : 1 h and 18 min,
Fuel load expressed in endurance : 2 h and 10 min,
Alternate aerodrome : Chubu International Airport

There were a total of 147 persons on board the Aircraft, consisting of the Captain, 8 other crewmembers, and 138 passengers. In the cockpit of the Aircraft, the Captain seated on the left seat as the PNF (the pilot mainly in charge of duties other than flying) and the First Officer on the right seat as the PF (the pilot mainly in charge of flying).

When the Aircraft took off from Gimpo International Airport, the weather conditions did not satisfy the requirements to entrust flight control to First Officer. As a result, the Captain initially performed as the PF and later, he let the First Officer take over the role of the PF.

The history of the flight up to the time of the accident is outlined below based on the records of the digital flight data recorder (hereinafter referred to as “the DFDR”), air traffic control (ATC) communication records and the statements from the flight crewmembers:

2.1.1 History of Flight Based on DFDR and ATC Communication Records

After taking off from Gimpo International Airport, the Aircraft continued to fly in accordance with its flight plan and began its final approach for runway 06L of the Airport following the instructions from the Kansai Radar Approach Control .

- 10:00:28 The Aircraft received a landing clearance for runway 06L.
- 10:02:51 The Aircraft began to descend at an altitude of 4,000 feet.
- 10:05:57 The Captain reconfirmed the landing clearance.
- 10:06:35 At an altitude of 1,000 feet, the autopilot was turned off and the auto thrust control unit was set for the speed maintaining mode with a target speed of 137 knots.
- 10:07:48 At an altitude of 100 feet, the descent rate was 736 ft/min and the pitch angle of the Aircraft was 2.1 degrees, but the pitch angle continued to decrease further, and it became 1.8 degrees about 2 seconds later.
- 10:07:53 At a radio altitude of 33 feet, the side-stick on the First Officer’s side began to be operated toward the nose up side. Later, the pitch angle began to gradually increase from 1.8 degrees.
- 10:07:56 The spoilers began to be extended the moment the AIR/GROUND sensors with the main landing gears on both sides detected GROUND. The input from the side-stick on the First Officer’s side (Stick Right Position Pitch) at that time had an angle of 15.9 degrees to the nose up side (the maximum input angle: 16 degrees) and the pitch angle was 4.6 degrees, and the pitch angle began to increase again. The thrust levers for both engines were in the idle position. At that time, the Aircraft had a vertical acceleration of 1.91G, but the value decreased to 0.67G just after that.
- 10:07:57 The AIR/GROUND sensor on the left main landing gear momentarily detected AIR. The pitch angle of the Aircraft continued to increase after that. After the touchdown of the main landing gears, Stick Right Position Pitch had continuously varied from

a minimum of 1.1 degrees to a maximum of 14.1 degrees to the nose up side. The input from the side-stick on the Captain's side (Stick Left Position Pitch) had varied between 2.2 degrees to the nose up side and 1.6 degrees to the nose down side.

10:07:58 The pitch angle became 10.2 degrees and the radio altitude became -4 feet.

10:07:59 A vertical acceleration of 1.20G was recorded, almost simultaneously, the pitch angle decreased to 9.8 degrees. This angle was maintained for about two seconds. The spoilers were fully extended.

10:08:01 The thrust lever was moved to the TOGA *¹ position. Stick Right Position Pitch was 15.1 degrees to the nose up side.

10:08:02 The CAS (Computed Air Speed) was 124 knots, while the pitch angle began to decrease after reaching 10.5 degrees.
The AIR/GROUND sensors with the main landing gears detected AIR.

10:08:03 The pitch angle became 6.7 degrees.
Stick Right Position Pitch was 15.0 degrees to the nose up side.

10:08:04 The pitch angle became 7.0 degrees.

10:08:05 Stick Right Position Pitch was 1.4 degrees to the nose down side.
The radio altimeter began to increase gradually.

10:08:07 An operation to retract the landing gears was carried out.
The CAS was 140 knots and the radio altitude was 15 feet.

10:08:10 The Captain reported go-around to the airport traffic control tower.

10:08:14 The autopilot was engaged.
The radio altitude was 43 feet.

10:13:33 The Aircraft received an approach clearance for runway 06L again.

10:15:51 The Aircraft received a landing clearance for runway 06L.

10:18 The Aircraft normally landed on runway 06L.

10:26 The Aircraft entered spot 14.

(See Figure 3 DFDR Records)

2.1.2 Statements from Flight Crewmembers on History of Flight

(1) Captain

When we took off from Gimpo International Airport, visibility was poor at less than 800 meters. Because the weather conditions did not satisfy the requirements to entrust flight control to First Officer, I initially performed as the PF. I let the First Officer take over the role of the PF at 14,000 feet during the climb and he continued to perform as the PF after that.

The approach to the Airport was normal until 30 feet to the ground. But because the timing of flare*² was delayed and also because the amount of flare was insufficient, the descent rate did not reduce. As a result, the Aircraft made a hard landing and bounced. The bounce was only once. In this case, there are two choices: going around to try to land once again and completing the landing as it is. The First Officer selected

*¹ TOGA stands for take-off and go-around. When thrust levers are shifted to this position in go-around, the maximum thrust can be provided

*² Flare means a maneuver to raise aircraft's nose just before landing on runway in order to reduce forward speed and descending speed.

go-around. After that, I took over flight control at an altitude of about 3,000 feet.

The normal landing procedures call for starting flare operations at a radio altitude of 30 feet to reduce descent rate and reducing auto thrust power at 20 feet. The First Officer continued pitch-up input even after touchdown, and it remained after the thrust was increased.

In order to maintain pilots' control skill, autopilot is usually disengaged at 1,000 feet to shift to a manual control. The auto thrust is used until 20 feet in the speed maintaining mode. On that day, the target speed was set at 137 knots, while the flaps were extended full down (30 degrees). The approach had been stable until 30 feet. The Aircraft's tailstrike angle is 9 degrees when the main landing gear struts have compressed or 11 degrees when the struts have extended. I thought the first touchdown was made at a point 1,000 to 1,500 feet from the runway threshold, but I suppose the actual touchdown point had been closer to the threshold, in light of the position where the tailstrike marks were found. I do not think that the pitch angle had reached the tailstrike angle at the time of the first touchdown.

According to the Company's manuals, I am authorized to entrust flight control to First Officer during landing. So far, I entrusted flight control to the First Officer twice in the past, but there were no problem with his control skill. I had been comfortable with his operation because the weather was good and the approach was stable. When I found the delay in First Officer's flare, I failed to call his attention to it. That was my only mistake.

(2) First Officer

We made an ILS approach to the Airport. The autopilot was disengaged at around the time when we slightly descended from an altitude of 1,000 feet and the auto thrust was set in the speed maintaining mode. I pulled the side-stick at a radio altitude of 30 feet and started to flare, but I felt sink rate just before touchdown was faster than usual. I think that the start of flare was late and also the input was insufficient. In the first touchdown, the Aircraft contacted the runway hard and bounced. So, I was afraid that a greater impact would occur on the second touchdown. I also observed the Aircraft got out of alignment with the runway. So, I decided to make a go-around and began to make it with the thrust levers in the TOGA position. I think it was at the top of the first bounce when I increased the thrust. I retracted the flaps by one notch from the full down position and I retracted the landing gears after checking the climb of the Aircraft. At that time, I didn't aware of a tailstrike. I understand that the tailstrike angle provided in the aircraft specifications is 9 to 10 degrees. Although I did not check the instruments for confirmation, I do not think the actual angle was so large. I think the pitch angle in normal touchdown is 5 to 6 degrees, but I think the angle was 4.5 to 5 degrees in that time. Because the attitude at the start of go-around was almost the same as the attitude at touchdown, I did not think the Aircraft's pitch angle exceeded the tailstrike angle. I have no idea about why this accident occurred despite the good weather condition. I think I had a lapse of concentration just before the flare, because I was too much relaxed.

I became a First Officer for the aircraft type in November two years ago. I have had about 400 times of landing experience. It is up to each Captain's judgment, but I have had many opportunities to perform as the PF when the situation is favorable. I have been entrusted flight control for more than half of the flights. I think this flight was the third or fourth experience of landing to me by the Captain involved. That was the worst

Total flight time on the type of aircraft	2,079 h 01 min
Flight time in the last 30 days	62 h 51 min
(2) First Officer	Male, Age 35
Commercial pilot certificate (Airplane) (Issued by the Republic of Korea)	October 9, 2007
Type rating for Airbus A320	October 9, 2007
Instrument flight certificate	January 8, 2007
Class 1 aviation medical certificate (Issued by the Republic of Korea)	
Validity	July 31, 2010
Total flight time	1,789 h 56 min
Flight time in the last 30 days	33 h 12 min
Total flight time on the type of aircraft	1,498 h 02 min
Flight time in the last 30 days	33 h 12 min
(3) Company Qualifications for Captain	
The Captain had satisfied the Company's requirements for allowing first officers to make landing on the right seat.	
(4) Company Qualifications for First Officer	
The First Officer was qualified as a first officer for Airbus A320 family aircraft (hereinafter including A319 and A321 models, unless otherwise indicated) on November 14, 2007.	
The reported weather conditions were within the range of conditions that allow him to make landing operations on the right seat.	
(5) First Officer's Experience with A320 Family Aircraft	
The First Officer had experienced landing operations on the right seat 7 times aboard Airbus A320 family aircraft in the 30 days before the accident. He had also received periodic training for the second half of 2009 on September 24, 2009 and October 10 and 11, 2009.	

2.5 Aircraft Information

2.5.1 Aircraft

Type	Airbus A321-200
Serial number	3297
Date of manufacture	October 30, 2007
Certificate of airworthiness (Issued by the Republic of Korea)	IB07004
Validity	November 12, 2009
Category of airworthiness	Airplane, Transport T
Total flight time	79,398 h 28 min
Flight time since last periodical check (C maintenance on May 14, 2009)	978 h 11 min

(See Figure 4 Three Angle View of Airbus A321-200)

2.5.2 Weight and Balance

When the accident occurred, the Aircraft's weight is estimated to have been 146,700 pounds and the center of gravity is estimated to have been 24.1% mean aerodynamic chord (MAC), both of which are estimated to have been within the allowable ranges (maximum landing weight of 166,448 pounds, and 11.0% to 42.0% of MAC corresponding to the weight at the time of the accident).

2.6 Meteorological Information

2.6.1 The regular weather observations at the Airport around the time of the Aircraft's landing are as follows:

- 10:00 Wind direction 040°, Wind velocity 7 knots, CAVOK*4, Temperature 18 °C, Dew point 10°C, Altimeter setting (QNH) 30.25 in.Hg
- 10:30 Wind direction 020°, Wind velocity 8 knots, CAVOK, Temperature 19 °C, Dew point 10°C, Altimeter setting (QNH) 30.24 in.Hg

2.6.2 Surface Winds at the Time of the Accident

An aerodrome weather observation system set up near the touchdown point marking on runway 06L had recorded data about the instantaneous wind direction and wind velocity every three seconds. The wind direction for the 10 minutes around the time of the accident was 016 to 053 degrees and the wind velocity was 5 to 10 knots.

2.7 Information on Air Navigation Facilities

An inspection conducted after the accident showed no abnormalities for aerodrome lights and ILS installed on the runway 06L side at the Airport.

2.8 Information on the Accident Site and the Accident Aircraft

2.8.1 Situation of the Accident Site

- (1) The Airport is an offshore airport located about 5 kilometers off the Senshu coast facing Osaka Bay in the southern part of Osaka Prefecture. It has two runways that run parallel to each other along the coastline—runway A with a length of 3,500 meters and a width of 60 meters (06R/24L) and runway B with a length of 4,000 meters and a width of 60 meters (06L/24R) which connects to runway A via taxiways and lies about 2 kilometers further off the runway A.
- (2) Parallel tire marks at a distance of about 7.6 meters were left intermittently from a point about 167 meters from the threshold of runway 06L. The distance between the marks corresponded to the center-to-center distance between the two main landing gears of the Aircraft.
- (3) Contact marks of orange paints had been left in an area about 10.5 meters long and a maximum about 0.3 meter wide on the runway center line from a point about 380 meters from the threshold of runway 06L. The contact marks left on the runway and the skin abrasion seen in the lower aft part of the Aircraft's fuselage almost corresponded with each other.

(See Figure 2 Accident Site Layout, Photo 3 Contact Marks on Runway, Photo 4 Estimated Touchdown Marks with Main Landing Gears)

2.8.2 Details of Aircraft Damage

The summary of the detailed damage found on the aircraft examination is as follows:

*4 CAVOK stands for Cloud and Visibility Okay. The term means that there is no cloud either below an altitude of 5,000 feet or the maximum height of the minimum sector altitude, whichever is higher, and there are no cumulonimbus and tower-like cumulus, either, at all altitudes. The term also means a situation where there is none of the phenomena mentioned in the meteorological code table.

(1) Fuselage

- ① Skin abrasion was found in an area about 2.4 meters long and a maximum about 0.3 meter wide on the lower aft part of the fuselage.
- ② The following damages were found on three pieces of frame in the aft part of the fuselage where skin abrasion was found:

FR64	20 centimeters long, 1.8 millimeters deep
FR65	28 centimeters long, 3.8 millimeters deep
FR66	16 centimeters long, 1.0 millimeter deep

(2) Others

Skin abrasion was found with the water drain mast.

(See Photo 2 Damaged Fuselage)

2.9 Information on DFDR and Cockpit Voice Recorder

The Aircraft was equipped with a DFDR (part number: 980-4700-042) and a cockpit voice recorder (hereinafter referred to as “the CVR”) (part number: 980-6022-001) made by Honeywell of the United States of America.

The DFDR had retained records at the time of the accident. The time was determined by collating VHF transmission keying signals during the ATC communication recorded on the DFDR with speaking clock recorded on the ATC communication records

The CVR of the Aircraft was capable of recording voices for about two hours. But the voices at the time of the accident had been erased by overwriting because the recording had not been stopped.

2.10 Situation for Flights to and from the Airport before the Time of the Accident

There were no aircraft which landed on or took off from runway B in the 30 minutes before the accident. On the day of the accident, there were no reports of irregular weather conditions like turbulence, either, from aircraft which used not only runway B but also runway A.

2.11 Additional Information

2.11.1 Information from ITV Images

Footages recorded with several ITV cameras installed at the Airport mainly by the Ministry of Land, Infrastructure, Transport and Tourism retained a scene of the go-around of the Aircraft. The distance from the cameras to the Aircraft was a maximum 1.5 kilometers. Because the resolution of the images was not so fine, a precise measurement could not be made. An overall analysis of the information obtained from the images indicated the following observations:

The Aircraft approached the runway with its nose slightly raised and touched down at a point about 150 meters from the threshold of the runway 06L. While raising its nose further after touchdown, the Aircraft was flying (making landing roll) almost horizontally on the runway. But white smoke was seen puffing out of the aft part of the Aircraft near the touchdown zone marking about 360 meters from the runway threshold. Later, the Aircraft continued to fly while gradually moving up. From a point about 1,500 meters from the threshold, the Aircraft was moving up quickly while raising its nose sharply.

2.11.2 Changes in the Aircraft’s Descent Rate and Others Recorded on DFDR

The descent rate, the pitch angle and the CAS of the Aircraft recorded on the DFDR before

touchdown are as follows:

Radio Altitude	(125 ft)	(85 ft)	(46 ft)	Start of Flare (33 ft)	Touchdown (-1 ft)
CAS (kt)	137	135	137	134	136
Pitch angle (degree)	2.5	2.1	1.8	1.8	4.6
Descent Rate (ft/min)	736	736	768	768	544

(See Figure 3 DFDR Records)

2.11.3 Manual on Entrusting Control to First Officer

The following provisions are prescribed in the Company's Flight Operations Manual (Excerpt):

These provisions show the qualifications, the items to be observed and the limitations, in cases for entrusting control to first officers in the right seat in order to improve their flying skills while ensuring the safety of flight.

2.2.3.2 Entrusting Control to First Officer

A. Qualification for Entrusting Control

<i>Captain's Qualification</i>	<i>Phase of Flight</i>	<i>First Officer's Qualification</i>	<i>Approach</i>
<i>Type Command Time of 300 hours or more</i>	<i>All phase</i>	<i>Type Command Time 100 hours or more (after 0.E)</i>	<i>ILS (CAT-II/III not permitted)</i>

B. Items to be observed during Entrusting control to First Officer Bear in mind that even while Captain entrust flight control to First Officer, final responsibility for flight safety still lies on Captain.

- When flight control is to be entrusted to First Officer, Captain must adequately consider various conditions such as qualification, airplane status, weather, airport and ATC.*
- During briefing, adequate discussion with First Officer is necessary, especially on procedures during T/O & L/D.*

Whenever Captain finds First Officer's control inappropriate, undertaking of flight control is required. Especially during T/O & L/D, Captain must keep Soft Touch on rudder Pedal, Control Wheel (Sidestick) and Trust Lever.

- During Rejected Takeoff or Missed Approach (Go-Around), Captain must take control of airplane.*
- Captain must put best effort on coaching to improve First Officer's flying skill.*
- When flight control is to be entrusted to first officer, captain must adequately consider weather and duty ability etc.*

C. Limitation during entrusting flight control to First Officer

Takeoff (RVR/VIS)	Landing (Ceiling/PVR or VIS)		
	ILS, PAR	Non-Precision	Circling
800/800M	400FT – 1,600/1,600M	500FT – 2,000M	1,000FT – 4,800M

2.11.4 Procedures for Landing Operations

The following provisions are prescribed in the Company’s Flight Crew Operating Manual (Excerpt):

These provisions show standard operating procedures in the case of landing and at the same time, precautions to prevent tailstrike.

STANDARD OPERATING PROCEDURES

LANDING

The cockpit cut-off angle is 20 degrees.

• In stabilized approach conditions, the flare height is approximately 30 feet:

–FLARE.....PERFORM

–ATTITUDE.....MONITOR

The PNF should monitor the attitude, and call out:

–“PITCH, PITCH”, if the pitch angle reaches 7.5 degrees.

–“BANK, BANK”, if the bank angle reaches 7 degrees.

–THRUST Levers.....IDLE

If autothrust is engaged, it automatically disconnects when the pilot sets both thrust levers to the IDLE detent.

In manual landing conditions, the “RETARD” callout is triggered at 20 feet Radio Altitude (RA), in order to remind the pilot to retard the thrust levers.

Note : If one or both thrust levers remain above the IDLE detent, ground spoilers extension is inhibited.

Ground Clearance

• Avoid flaring high.

• A tailstrike occurs, if the pitch attitude exceeds 11 degrees (9.5 degrees with the landing gear compressed).

• A wingtip or engine scrape occurs, if the roll angle exceeds 18 degrees (16 degrees with the landing gear compressed).

• Be aware of the pitch-up tendency, with ground spoiler extension

2.11.5. Flight Control Devices

A321 aircraft are equipped with lever-type flight control devices called the side-stick, in the left side console for the left seat pilot and in the right side console for the right seat pilot. When a pilot operates the side-stick, input signals are sent to actuator to control the rolling and pitching of aircraft.

The side-sticks on the left and right sides independently send their respective signals to a computer. Because they are not interlocked to each other, the movements of one side-stick provide no information about the amount of operation added to the other. If two pilots simultaneously send signals in the opposite direction or signals in the same direction, the value of the signals comes to their algebraic sum. Each side-stick is equipped with a take-over switch. If the switch is pressed,

the signal input with the side-stick on the last operated side will be valid to perform the required operation.

2.11.6 Maximum Allowable Pitch Attitude

A321 is the type of aircraft derived from A320. The body lengths of the two types of aircraft are different, but the shape and flight method of A321 is basically the same as that of A320. The overall length of A321 (44.51 meters) is longer than that of A320 (37.57 meters). Therefore, the maximum allowable pitch attitude for A321 to prevent a tailstrike during take-off and landing is smaller than that for A320. According to the Company's Flight Crew Operating Manual, the pitch attitude for A321 aircraft with which the aft part of the fuselage contacts the ground with an angle of zero degree in the direction of rolling is given as 11.2 degrees with the main landing gear struts not compressed and 9.7 degrees with the main landing gear struts fully compressed.

2.11.7 Inspection Conducted after the Aircraft's Landing

After the Aircraft's landing, the Company's mechanics received a report from the Captain that the Aircraft had made a hard landing and they examined the Aircraft based on their maintenance manual. Because the vertical acceleration recorded on the data management unit (DMU) aboard the Aircraft was about 2.1G, they concluded that there would be no need for a hard landing inspection. But because marks of tailstrike were found in the aft section of the fuselage on a post-flight inspection, the mechanics notified the passenger service division that the return flight would be behind schedule due to maintenance. But they failed to provide detailed information, such as the existence of the marks of tailstrike, to the passenger service division. Later, the mechanics made an arrangement for temporary repair based on the manufacturer's manual.

2.11.8 Reports from the Company to the Relevant Authorities

It was 14:41, more than four hours after the occurrence of the accident, when a report to the effect that the Aircraft sustained damage in the aft part of the fuselage was made to the Kansai Airport Office of the Osaka Regional Civil Aviation Bureau of the Ministry of Land, Infrastructure, Transport and Tourism (hereinafter referred to as "the Airport Office"). As a result, the runway had not been inspected just after the accident. By the time when an inspection begins, 17 aircraft had landed on the runway.

According to the Company's procedure for communication in emergency situations, it is stipulated that communication to the Airport Office is made by staff in charge of passenger service, but the staff had been temporarily out at the time of the accident because they had to deal with passengers.

3. ANALYSIS

3.1 Qualifications of Personnel

The Captain and the First Officer held both valid airman competence certificates and valid aviation medical certificates.

3.2 Airworthiness Certificate of the Aircraft

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

The width and the paint color of the skin abrasion corresponded with those of the contact

marks left on the runway as described in 2.3. And as described in 2.11.1, the scene that white smoke was seen puffing out of the aft part of the Aircraft's fuselage was recorded in the ITV images. Therefore, it is considered highly probable that the damage to the Aircraft as described in 2.2 had been caused when the Aircraft contacted the runway during its landing on Kansai International Airport.

3.3 Relations to Meteorological Condition

It is considered highly probable that the meteorological condition at the time of the accident was not related to the occurrence of this accident.

3.4 Flight Operations at the Time of the Accident

3.4.1 Landing Operation

The Aircraft continued its approach while using ILS from an altitude of 4,000 feet. From 500 feet to 50 feet, its average speed was about 137 knots and its average descent rate was about 730 ft/min. These values are within the range of STABILIZED APPROACH*⁵ criteria established by the Company. Therefore, it is considered highly probable that the Aircraft was on a normal approach.

Judging from the DFDR records in Figure 3, it is considered highly probable that a flare operation was started by the First Officer from an radio altitude of 33 feet by moving the side-stick on the right side. It is considered probable that, this made the pitch angle of the Aircraft begin to increase gradually from 1.8 degrees, but just after this, since the side-stick was returned to 0.9 degree, the elevator angle became zero degree, and caused temporarily leveling off of the increase of the pitch angle.

Later, a nose-up signal for a maximum of 15.9 degrees was inputted from the side-stick. It is considered highly probable that this operation caused the pitch angle to begin to increase again and the pitch angle became 4.6 degrees at the time of touchdown. The altitude where the flare operation was initiated was in line with the provisions described in 2.11.4, but the Aircraft's descent rate decreased from 768 ft/min at the time of initiating the flare to only 544 ft/min at the time of touchdown as described in 2.11.2. There was no major change in the CAS, either. Therefore, it is considered highly probable that the effect of this flare operation was not sufficiently effective. With regard to the insufficient effect of the flare operation, it is considered highly probable that, since the return of the side-stick caused the temporarily leveling off of the increase of the pitch angle as described above, there was not enough time to increase the pitch angle to a level where a necessary lift can be obtained to reduce the Aircraft's sinking.

It is considered highly probable that the First Officer failed to perform a flare operation properly due to following reasons: As the First Officer stated, "I had a lapse of concentration just before the flare, because I was too much relaxed" in 2.1.2(2), the weather condition was favorable on the day with no problem seen for flight at all and there was no need to pay attention to the movement of other planes in the absence of preceding traffic. In addition, he had enough landing experience with the A320 family aircraft as described in 2.4. Therefore, he didn't exercise enough caution thinking that there would be no problem with the landing and lost his concentration.

3.4.2 Touchdown

It is considered highly probable that the descent rate of 544 ft/min at the time of touchdown

*⁵ The term means a situation in which the aircraft maintains the approach speed, the descent rate and the vertical/horizontal flight path in a stable manner in its landing phase.

as described in 2.11.2 was high and the Aircraft contacted the runway hard. As described in 2.1.1, the AIR/GROUND sensors with the main landing gears on both sides simultaneously detected GROUND at 10:07:56 and at the same time, the Aircraft had a vertical acceleration of 1.91G. Therefore, it is considered highly probable that, at this point of time, the Aircraft landed the runway with its wings held horizontal and began to extend all spoilers simultaneously. Stick Right Position Pitch at this time was 15.9 degrees to the nose-up side. The input to the nose-up side was continued after that, while the extension of the spoilers further produced a nose-up effect. As a result, it is considered highly probable that the Aircraft's pitch angle of 4.6 degrees at the time of touchdown increased to 10.2 degrees.

3.4.3 Situation after Touchdown

As described in 2.1.1, the vertical acceleration decreased to 0.67G from 1.91G just after touchdown, but the right main landing gear sensor had detected GROUND for six seconds after touchdown. As described in 2.8.1 (2), the tire marks left on the runway were seen intermittently on the runway, while a conspicuous bouncing was not confirmed from information obtained by the ITV images as described in 2.11.1. And the AIR/GROUND sensor on the left main landing gear sensor alone momentarily detected AIR one second after the first touchdown. Therefore, it is considered highly probable that the height of the Aircraft's bouncing after touchdown was very slight rise and that the Aircraft was in a situation of landing roll, leaning itself slightly to the right, with its main landing gears slightly touching the runway.

In these circumstances, the First Officer continued inputting from the side-stick even after touchdown. As a result, it is considered highly probable that the pitch angle was further increasing. Regarding the First Officer's continued nose-up operation after the touchdown, it is considered somewhat likely that the nose-up signal input had been kept as it is for about two seconds as he became upset by the strong impact at the time of touchdown, as indicated by his statement in 2.1.2 (2) that the landing was the worst one since he became a first officer two years before.

As described in 2.1.2 (1) and (2), both the Captain and the First Officer stated that the Aircraft greatly bounced after the first touchdown. In this regard, the vertical acceleration quickly decreased to 0.67G from 1.91G just after the first touchdown, while the Aircraft's pitch angle increased to 10.2 degrees from 4.6 degrees in about two seconds. These indicate that the height of the cockpit floor had risen to 23.6 feet from 16.1 feet above the runway even when the main landing gears were contacted on the ground. As a result, it is considered highly probable that such an upward movement of the nose made the crew feel a big bouncing.

3.4.4 Tailstrike on the Runway

The Aircraft had a pitch angle of 10.2 degrees while experiencing a vertical acceleration of 1.20G at 10:07:58, about two and a half seconds after touchdown. This angle was in excess of the maximum allowable pitch attitude of 9.7 degrees, as described in 2.11.6, for the aft part of the aircraft with a rolling angle of zero degree and with the main landing gear struts fully compressed. In addition, the radio altitude at that time was a minimum value of -4 feet. Therefore, it is considered highly probable that the Aircraft had suffered tailstrike at this point of time.

This corresponds to that the Aircraft's position at that time as calculated with its speed is consistent with the position in a scene recorded in the ITV images as described in 2.11.1, where white smoke was puffing up from the Aircraft, and the position where the contact marks were found on the runway as described in 2.8.1, as well as corresponds to that the cabin attendant heard an

abnormal noise that indicated the Aircraft's body was rubbing the ground as described in 2.1.2 (3).

3.4.5 Go-Around

As described in 2.1.2 (2), the First Officer decided to make a go-around and moved the Aircraft's thrust lever in the TOGA position about four seconds after touchdown. It is considered highly probable that, about two seconds later, the main landing gear sensors on both sides detected AIR and the Aircraft began to lift off from the runway, then the Aircraft started climbing slowly above the runway to a point about 1,500 meters from the runway threshold with its landing gears retracted, and the Aircraft continued to climb in line with the missed approach procedures stipulated for a situation with the autopilot on.

3.5 PF Duties by First Officer

(1) Entrusting of PF duties

According to the Company's manual as described in 2.11.3, the entrusting flight control from the Captain to the first officer must be made in consideration of weather, the first officer's duty ability and other factors. Therefore, it is considered highly probable that, in accordance with the manual, the Captain took control of the Aircraft by himself when it took off from Gimpo International Airport and after he entrusted flight control to the First Officer at an altitude of about 14,000 feet while the Aircraft was climbing, the First Officer made an operation for landing on the Airport.

(2) Take-over

According to the Company's manual as described in 2.11.3, whenever Captain finds first officer's control inappropriate, undertaking of flight control is required. Especially during take-off and landing, the Captain must keep soft touch on rudder pedal, control wheel (side-stick) and thrust lever. During go-around, Captain must take control of airplane.

However, as described in the statements in 2.1.2 (1) and (2), any undertaking of flight control did not occur during the phases from the flare to the subsequent operation for go-around. With regard to this, it is considered highly probable that the Captain did not undertake control of the Aircraft due to following reasons: the Captain was feeling relieved about the First Officer's operation in view of his enough experience, the Captain's intention to entrust flight control to the First Officer as long as possible to help improve his flying skill, the Captain didn't exercise enough caution toward tailstrike and the Captain was momentarily puzzled over what to do following the strong impact after touchdown.

According to the DFDR records as described in 2.1.1, there was input for about six seconds in the directions of rolling and pitching from the side-stick on the Captain's side just after touchdown. Therefore, it is considered probable that the Captain had been engaged in fine adjustment with his hand touching on the side-stick softly so that he can undertake control at any time. As described in 2.11.5, the signals input on the Captain's side come to an algebraic sum with the signals from the side-stick on the First Officer's side. It is considered probable that because the amount of the algebraic sum was small, influence on the Aircraft's attitude was limited.

(3) Prevention of tailstrike

As described in 2.4, the First Officer received periodic training for A320 family aircraft in September and October 2009. It is considered highly probable that he had received

general education for tailstrike prevention as part of the training. But, as described in 2.1.2 (2), the First Officer was not aware of tailstrike until the Aircraft entered the spot. Therefore, it is desired that education and training will be provided for crewmembers while assuming various situations, such as the case in which tailstrike occurred due to the First Officer's continued input signals from the side-stick after touchdown.

(4) Captain's Duties

As described in the Company's manual in 2.11.3, when the Captain entrusts flight control to first officer, the timing of undertaking of flight control has to be considered after fully grasping the first officer's qualification. Judging from the First Officer's experience as described in 2.1.2 (2) and 2.4 (5), it is considered probable that he had enough landing in the right seat. Even in that case, it is considered probable that Captain needs to pay full attention to first officer's performance and if he finds first officer's control inappropriate or delayed, he has to undertake flight control without delay before a dangerous situation occurs. In this accident, the Captain did not undertake flight control from the First Officer even when the inappropriate flare operation was made by the First Officer and when making the go-around after the strong impact at the time of touchdown on the runway. If the Captain had undertaken flight control of the Aircraft at the time when he found the flare of the Aircraft was inappropriate, it is considered somewhat likely that the strong impact at the time of touchdown on the runway and the subsequent tailstrike would have been prevented.

(5) Flight Operations Manual

The Flight Operations Manual provides a policies, procedures, practices, instructions and others for the Company to conduct commercial air transportation operations and to assist flight personnel to perform duties. The manual has a top priority for application of aircraft operation standards in the Company. According to the provisions in the manual regarding the Captain's duty during entrusting flight control to first officer, the Captain must consider airplane status, and when necessary, the Captain must immediately undertake flight control of the aircraft. Because final duty for flight safety still lies on the Captain even when flight control is to be entrusted to first officer, the provision prescribes the need for the Captain to make a general judgment about the first officer's inappropriate operations, but there is no clear provision that a judgment must be made depending on flight phases, such as final approach. However, at a low altitude, even if the Captain gives advice or instructions to the first officer when finding an inappropriate operation, a certain period of time is necessary for the first officer to make necessary corrective actions and recover the aircraft's attitude in line with the Captain's advice. Therefore, when there is no enough time in cases like this accident which occurred on operations just before landing, it might be an option for Captain to consider immediately undertaking control of the aircraft rather than giving advice or instructions to first officer.

3.6 Communication after the Accident Occurred

As described in 2.11.8, it was more than four hours after the occurrence of the accident when the report to the effect that the Aircraft sustained damage in the aft part of the fuselage was made to the Airport Office. Until the report was made, 17 aircraft had landed on the runway. As described in 2.11.8, the Company's procedure for communication in emergency situation stipulates that the staff in charge of passenger service must make communication to the Airport Office, but it is not

clearly provided that who covers such duties in the absence of the staff in charge. As described in 2.11.7, the mechanics only notified the passenger service division that the return flight would be behind schedule due to maintenance, but it was not detailed information for the division. Therefore, it is considered probable that these results contributed to the delay in the communication to the Airport Office. If aircraft parts are dropped from an aircraft, the following aircraft are threatened with drawing these parts into their engines or bursting their tires, bringing about additional accidents. Therefore, the Company is required to improve its communication procedures so that necessary reports will be made to the Airport Office without delay.

According to the statements in 2.1.2 (3), the cabin attendant heard an abnormal noise that indicated the Aircraft's body was rubbing the ground, after the impact was felt and before the Aircraft was moving up. If this was reported from the cabin attendant to the Captain, the Captain might have been aware of the possibility of tailstrike, have checked the Aircraft's condition using the checklist, and have taken appropriate measures such as making a tentative report to the Airport Office. Therefore, the Company is required to reaffirm and keep its employee informed about the significance of communication among crewmembers in order to ensure a steady implementation of it.

3.7 Retainment of CVR Data

As described in 2.9, communication records on the CVR around the time of the accident had been erased by overwriting. CVR is vital system which must be made available to investigate the causes of aircraft accidents and incidents from the point of view of preventing a recurrence of accidents. Therefore, when the mechanics confirmed the condition of the Aircraft upon receiving the report from the Captain, the Company should have judged that it might be a potential accident and have taken measures to stop the CVR.

4. PROBABLE CAUSES

In this accident, it is considered highly probable that, during the landing on Kansai International Airport, the Aircraft sustained damage in the aft part of the fuselage which contacted the runway, since the pitch angle became excessively large after the touchdown on the runway.

It is considered highly probable that the Aircraft's pitch angle became excessive because the First Officer continued inputting pitch-up signals even after touchdown.

The flare by the First Officer was inappropriate and as a result, the sink rate of the Aircraft did not fully decrease, causing the Aircraft to land with a strong impact on the ground. It is considered probable that, that the First Officer became upset by the impact contributed to his continuous input for pitch-up after touchdown.

Figure 1 Estimated Flight Route

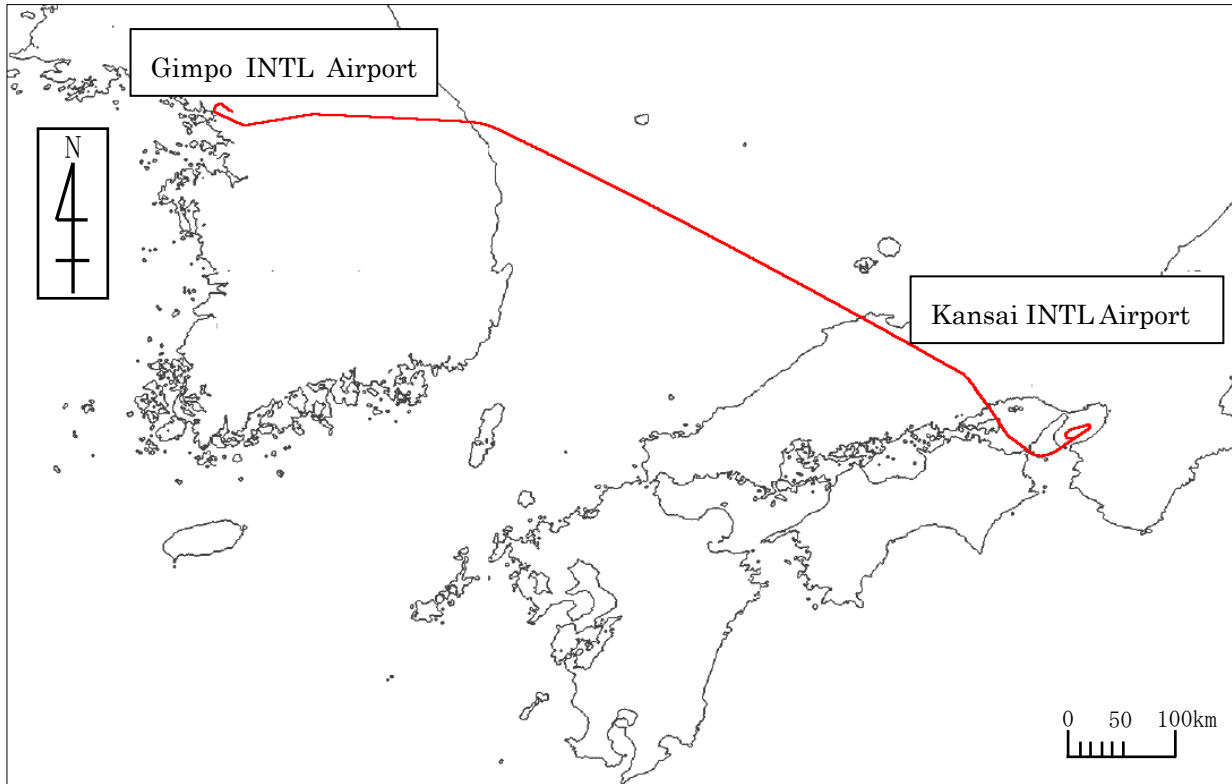


Figure 2 Accident Site Layout

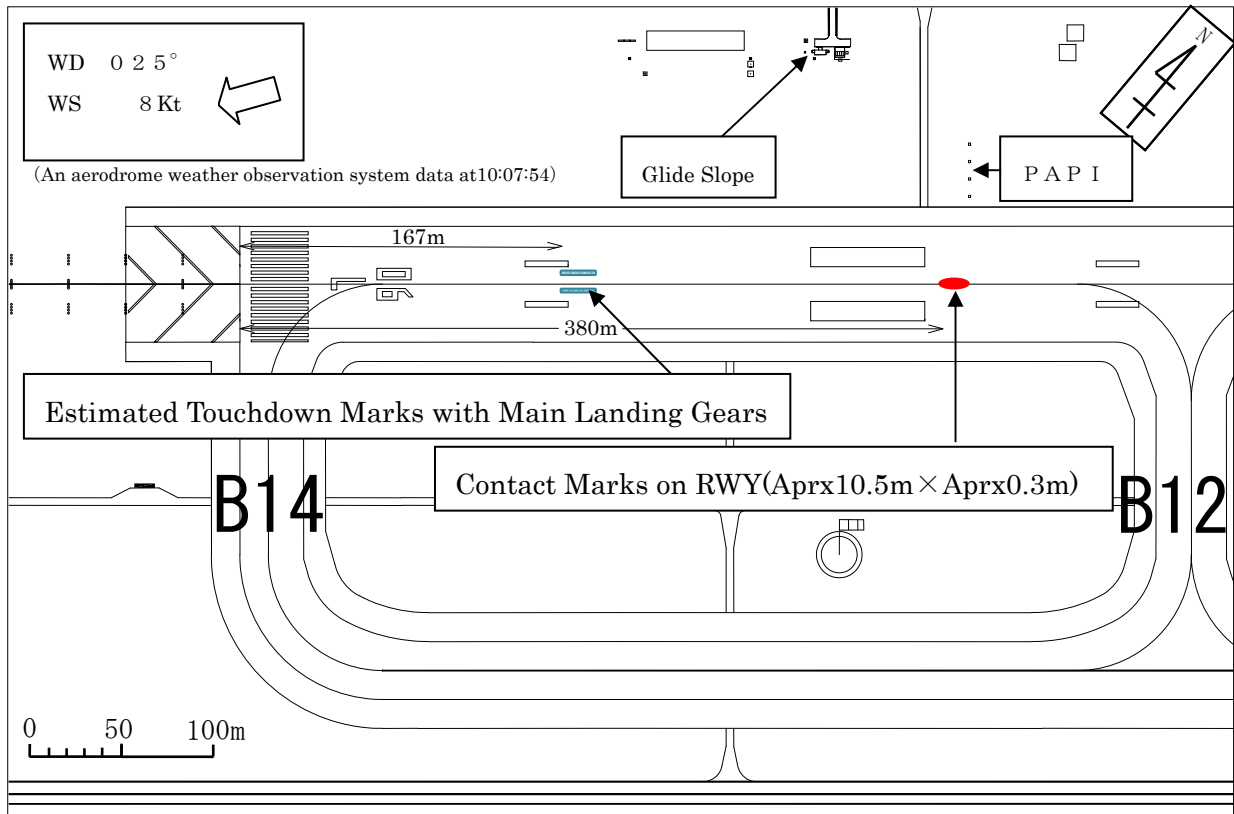


Figure 3 DFDR Records

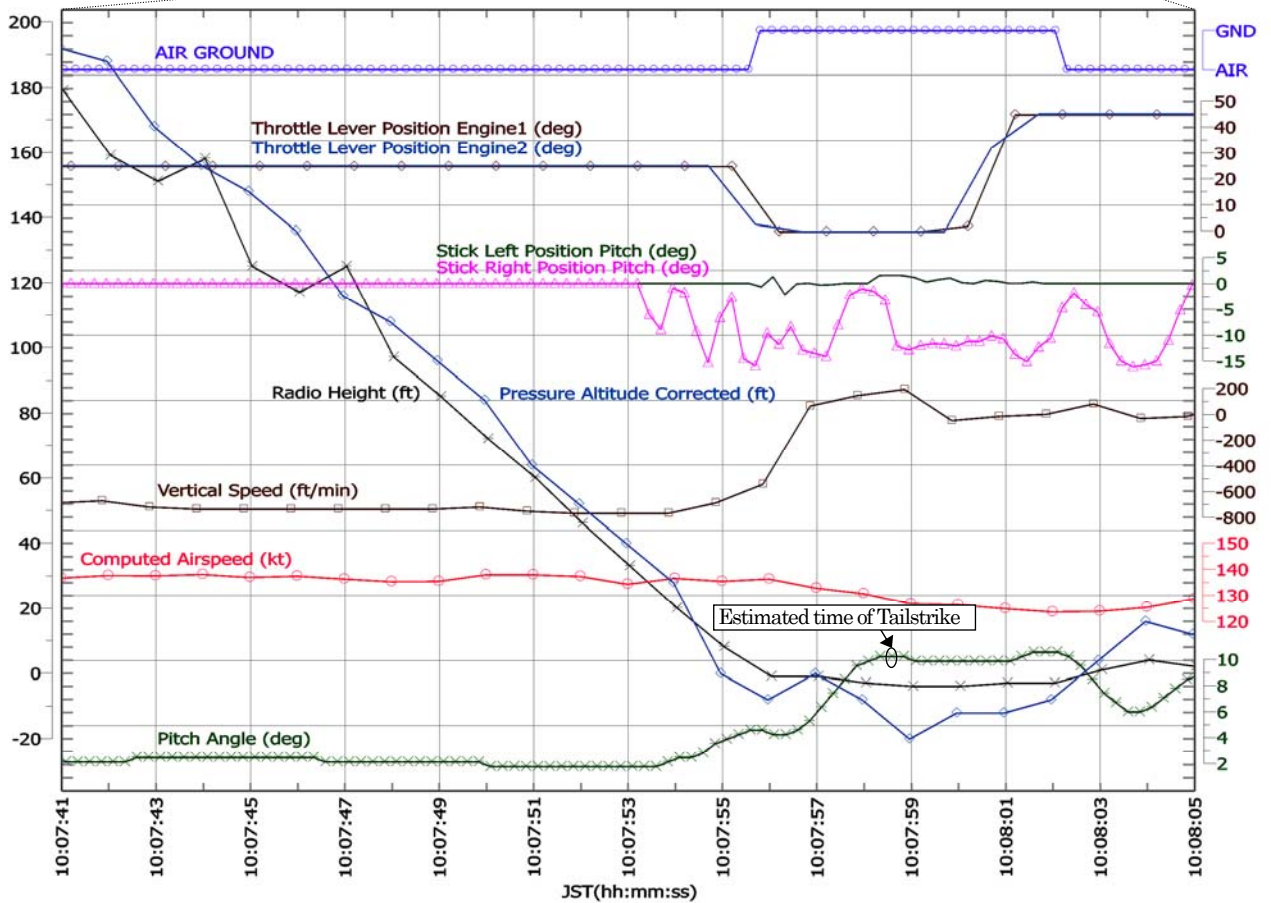
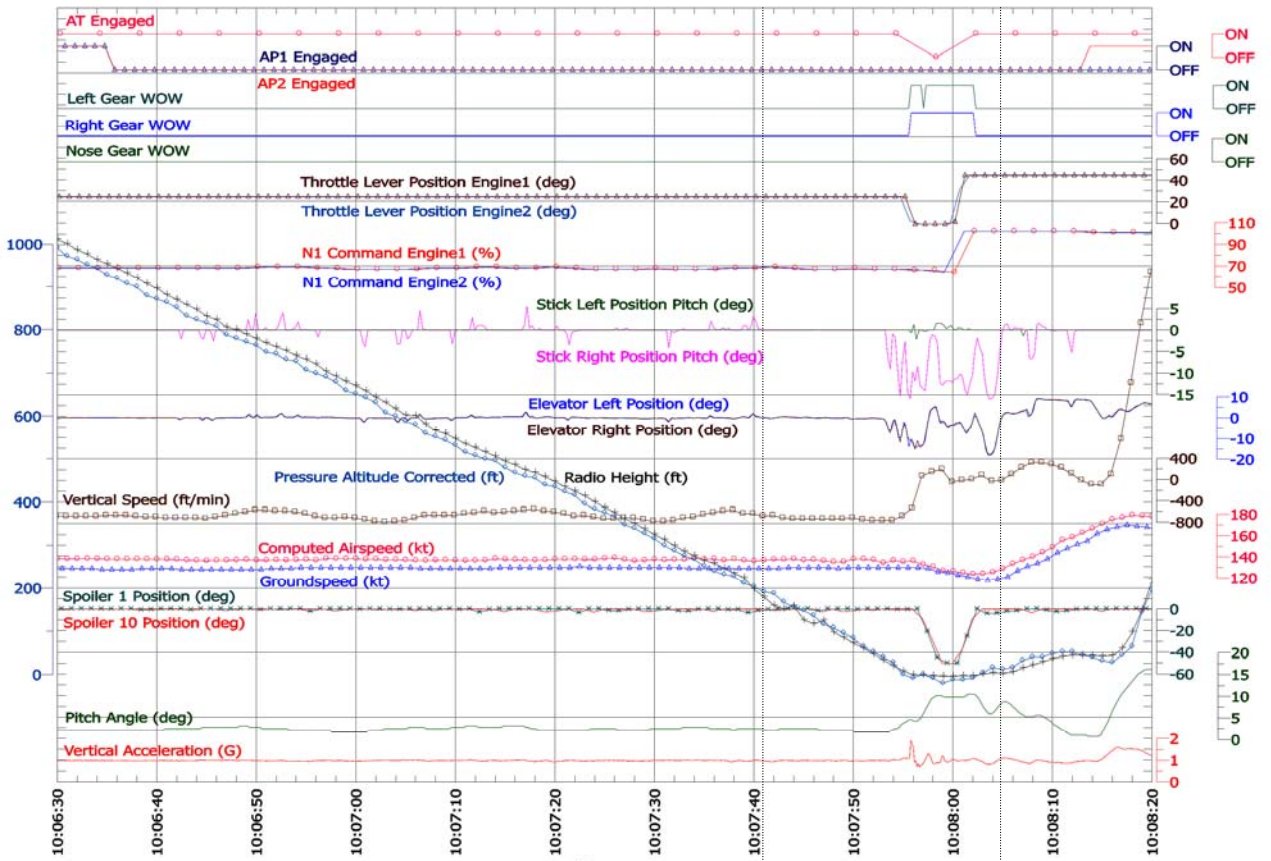


Figure 4 Three Angle View of Airbus A321-200

Unit : m

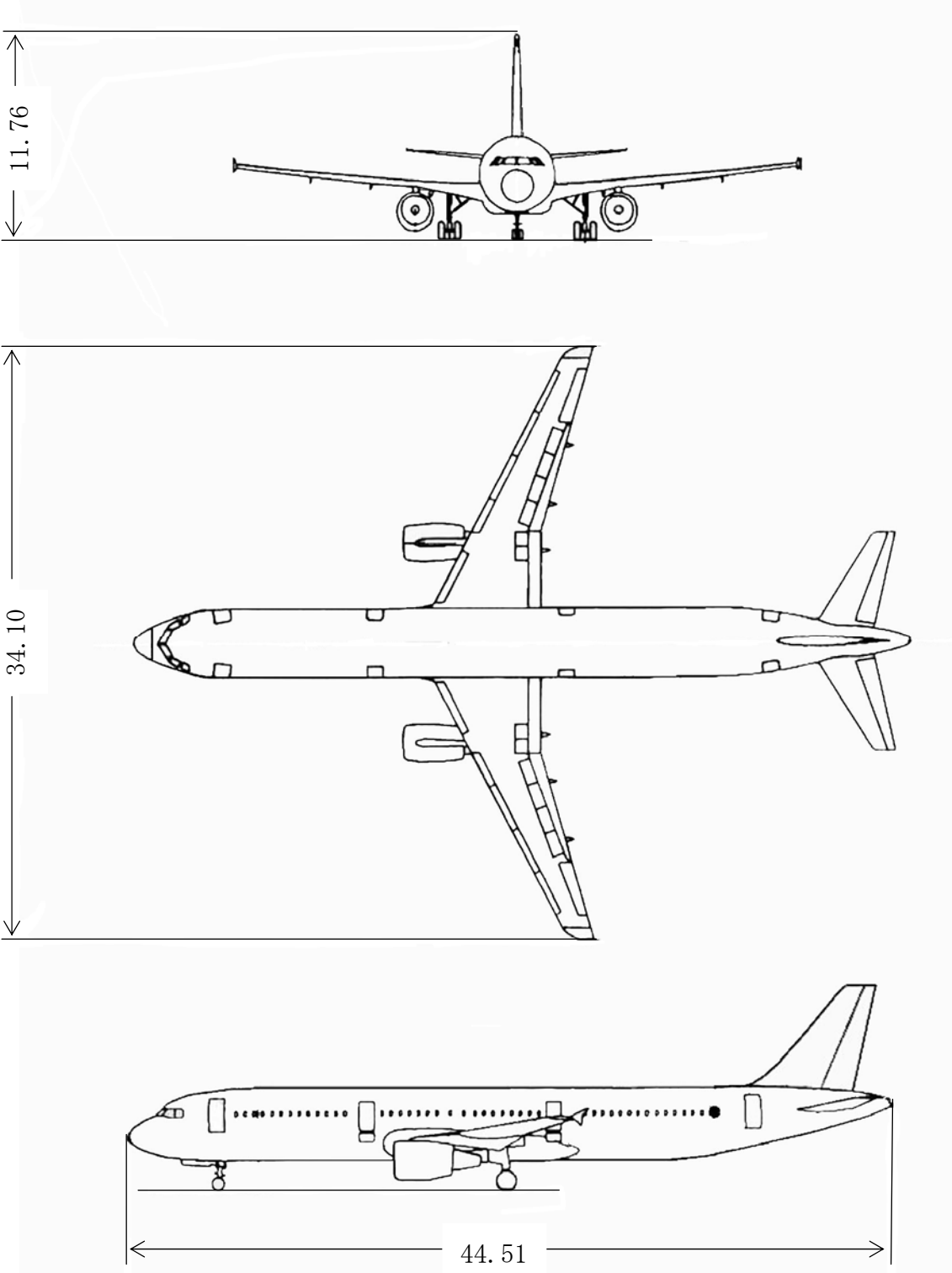


Photo 1 Accident Aircraft



Photo 2 Damaged Fuselage

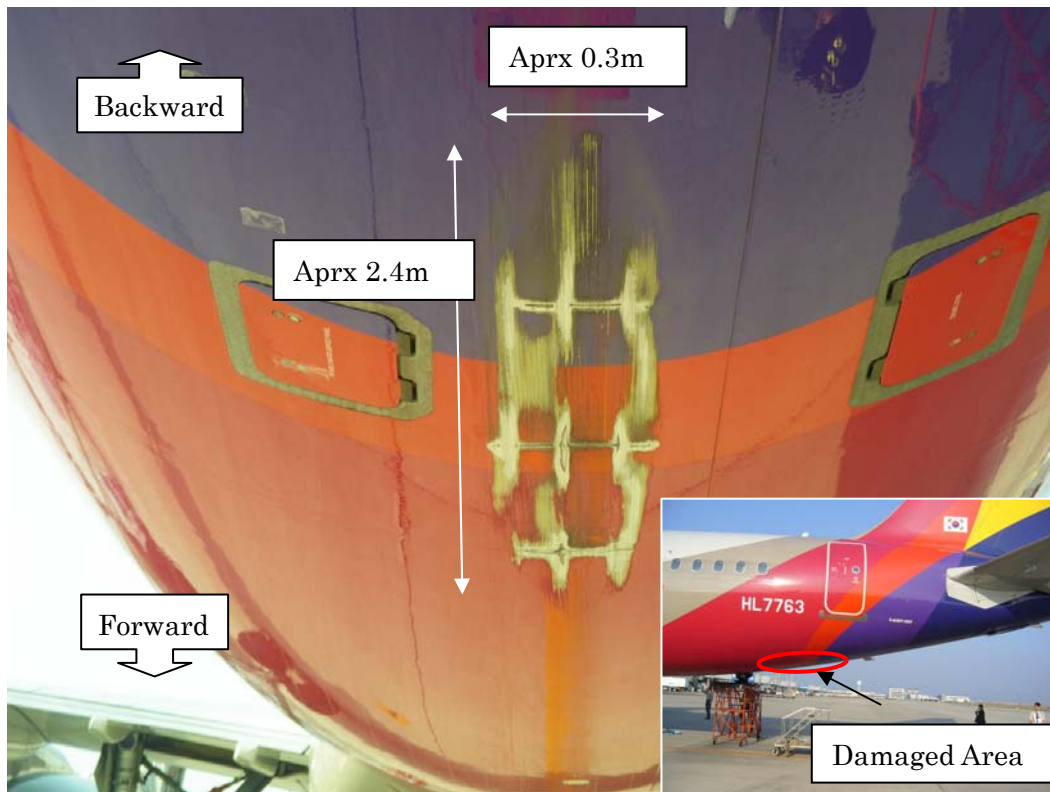


Photo 3 Contact Marks on Runway

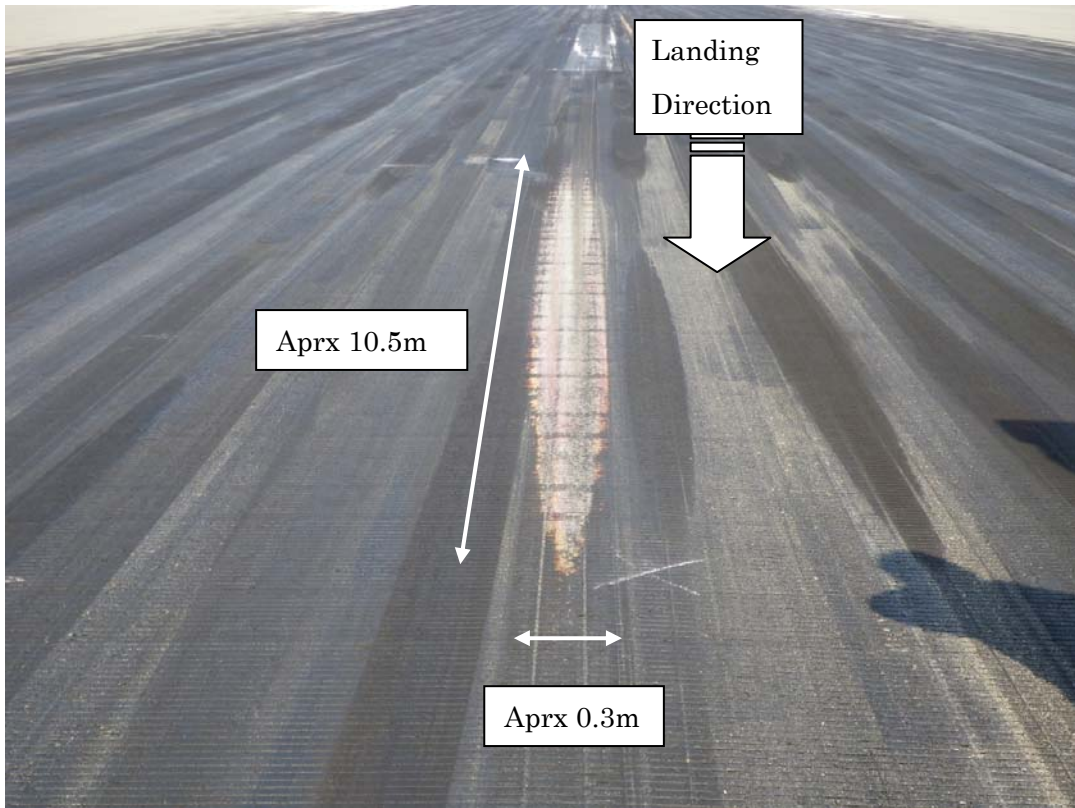


Photo 4 Estimated Touchdown Marks with Main Gears

