국토교통부

ARAIB/AAR1303

Aircraft Accident Report

Tail Strike During Landing

Asiana Airlines Flight 340

A321-200, HL7730

Incheon International Airport, Runway 16

16 April 2013

September 2014

AVIATION AND RAILWAY ACCIDENT INVESTIGATION BOARD

This aircraft serious incident report has been prepared in accordance with the Article 25 of the Aviation and Railway Accident Investigation Act of the Republic of Korea.

According to the provisions of the Article 30 of the Aviation and Railway Accident Investigation Act, it is stipulated;

The accident investigation shall be conducted separately from any judicial, administrative disposition or administrative lawsuit proceedings associated with civil or criminal liability.

And in the Annex 13 to the Convention on International Civil Aviation, Paragraphs 3.1 and 5.4.1, it is stipulated as follows:

The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of the activity to apportion blame or liability. Any investigation conducted in accordance with the provision of this Annex shall be separate from any judicial or administrative proceedings to apportion blame or liability.

Thus, this investigation report shall not be used for any other purpose than to improve aviation safety.

In case of divergent interpretation of this report between the Korean and English languages, the Korean text shall prevail.

Aircraft Accident Report

Aviation and Railway Accident Investigation Board. ***Tail Strike During Landing, Asiana Airlines, HL7730, A321-200, Incheon International Airport, Runway 16, 16 April 2013.*** **Aircraft Accident Report ARAIB/AAR1303, Sejong Special Self-Governing City, Republic of Korea.**

The Aviation and Railway Accident Investigation Board (ARAIB), Republic of Korea, is a government organization established for independent investigation of aviation and railway accident, and the ARAIB conducts accident investigation in accordance with the provisions of the Aviation and Railway Accident Investigation Act of the Republic of Korea and Annex 13 to the Convention on International Civil Aviation.

The objective of the investigation by the ARAIB is not to apportion blame or liability but to prevent accidents and incidents.

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Tail Strike During Landing at Incheon International Airport

- Operator: Asiana Airlines
- Manufacturer: Airbus
- Type: A321-200
- Registration Mark: HL7730
- Location: Incheon International Airport, Runway 16
- Date & Time: 16 April 2013, Approximately 17:37 (KST[1])

Synopsis

On 16 April 2013, about 17:37, an A321-200 airplane, HL7730, operated by Asiana Airlines as a scheduled international passenger flight, which took off from Harbin Taiping International Airport, China for Incheon International Airport, the Republic of Korea, experienced a tail strike while touching down on runway 16 at Incheon International Airport. As a result of this accident, three flight attendants were injured, and the airplane sustained substantial damage to the pressure bulkhead and stringers, and scratches at the exterior skin of the rear fuselage.

The Aviation and Railway Accident Investigation Board (ARAIB) determines that the causes of this accident were ① The pilot flying (PF) failed to maintain the proper approach speed until the flare just before touchdown, and the airplane bounced on touchdown since higher-than-normal vertical gravity was applied due to a high sink rate and increased thrust and speed just before touchdown; and ② The airplane made a second touchdown at the pitch attitude exceeding an A321 airplane's limitation and sustained a tail strike since the PF failed to keep thrust at idle and establish the proper pitch attitude during the bounce.

1) Unless otherwise indicated, all times stated in the report are Korean Standard Time (KST), based on 24-hour clock.

Contributing to this accident were ① the inadequate training program dealing with the recovery form the bounce; ② lack of pre-landing preparation due to a failure to conduct an approach briefing on pitch attitude; ③ the PF's failure to properly allocate his attention due to his delegation of flight control to the pilot monitoring (PM) who failed to meet flight control requirements; ④ the PM's inadequate advice and monitoring due to the PF's failure to make standard callouts; ⑤ the disconnection of the autothrottle and a failure to manually control thrust and speed; and ⑥ a failure to execute a go-around when stabilized approach criteria are not met.

Regarding this accident, the ARAIB addresses four safety recommendations to Asiana Airlines and two safety recommendations to the Ministry of Land, Infrastructure and Transport (MOLIT).

1. Factual Information

1.1 History of Flight

On 16 April 2013, about 15:46, Asiana Airlines flight 340 (hereafter referred to as "HL7730"), took off from Harbin Taiping International Airport, China for Incheon International Airport (hereafter referred to as "Incheon Airport"), passed an altitude of 4,200 meters (14,000 ft)[2] after takeoff, checked weather conditions at Incheon Airport, made an in-flight announcement, continued to climb, and entered the en-route flight phase at a cruising altitude of 9,200 meters.

About 16:52:07, HL7730 was given an instruction to descend to 8,900 meters and then, to fly 6 miles to the right of its flight route by Dalian Area Control Center (ACC), China.

About 17:08:31, the captain started to explain to the first officer (FO) how to use the primary flight display (PFD) and said, "Try to manage the descent profile although you will not make a landing." At this time, the FO asked, "Can I do that although I have yet to accumulate 100 flight hours?" The captain replied, "Do not land the airplane."

About 17:10:49, HL7730 communicated with Incheon ACC and was given its instruction to fly direct to "AGAVO[3]" and operate on the airway according to its flight plan.

About 17:12:56, HL7730 requested Incheon ACC to allow its descent while approaching waypoint AGAVO. After given an instruction to "descend to 15,000 ft via waypoint REBIT[4]" about 17:14:40, HL7730 made a descent.

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2) In the Chinese airspace, a meter is used as a metric unit of an altitude.
3) A major point on airway G597, in an encounter with Incheon flight information region (FIR).
4) A point on airway Y644 in parallel with airway G697.

About 17:20:04, the captain said to the FO, "Manually fly the airplane," and the FO gave an affirmative response. About 17:20:30, the FO switched to manual flight, calling out "manual flight" From this moment on, the FO was the PF, and the captain was the PM.

While making first contact with Seoul ACC about 17:21:42, HL7730 listened to the Automated Terminal Information Service (ATIS) "Yankee" broadcast and stated that it was maintaining 15,000 ft. Then, given radar vector to the final approach course to runway 16, the airplane intercepted the final approach course, using the ILS approach.

When HL7730 intercepted the final approach course about 17:33:33, the PM called out "manage speed," followed by the PF's callout, "check." About 17:33:57, "gear down" was performed on the final approach course, about 7 NM from the runway.

When HL7730 was on course (LOC star) about 17:34:08, the PM reported "on course" to Seoul ACC's arrival control, which then transferred HL7730 to the Incheon Control Tower.

About 17:34:21, the PF selected flap "3" as advised by the PM, and about 17:34:32, the Incheon Control Tower cleared HL7730 for landing, giving information on wind 10 kt at 220. About 17:34:37, flap "full (25°)" was selected, followed by no callout by the PM.

About 17:34:43, the captain was informed by the tower that base ceiling was 200 ft, and about 17:34:48, took over control of the flight and became the PF, stating "I have control, base ceiling is too low, two hundred."

About 17:35:02, the PF called out "set go-around altitude," and the PM set it

as 3,000 ft.

About 17:35:13, the PF stated, "add 1 kt to final speed," and the PM replied, "VAPP 138 set." About 18:35:20, the PF called out "landing checklist," and the PM completed the checklist about 17:35:29.

According to the FDR data, about 17:35:36, the autothrottle was disconnected when the airplane was at about 137.6 kt at an altitude of 1,209 ft AGL, 6,465 meters (3.49 NM) from the runway threshold, but the PF made no callout.

About 17:35:50, the PM called out "one thousand" when the airplane was at 138.5 kt at an altitude of 1,000 ft AGL, and the PF replied "stabilized," adding "right cross wind at 10 kt," followed by the PM's reply, "check."

About 17:36:30, the PM called out "five hundred" when the airplane was at 143.1 kt at an altitude of 500 ft AGL, and the PF replied, "stabilized." Subsequently, when an electronic voice announced "400 ft AGL" and later "300 ft AGL," the PF and the PM replied.

About 17:36:47, the PM called out "one hundred above" and "minimum" when the airplane was approaching 300 ft and 200 ft, respectively. When an electronic voice announced "two hundred" about 17:36:56, the airplane was at 135 kt, and the PF stated, "continue, in sight." About 2 seconds later, the PM stated, "runway in sight."

When an electronic voice announced "one hundred" about 17:37:04, the airplane was at 137.6 kt, and the PF stated, "Mmm, this is CAT-Ⅲ." About 17:37:07, the airplane was at 131.4 kt at an altitude of 59 ft AGL (near the runway threshold), and about 17:37:09, at 129 kt at an altitude of 29 ft AGL (flare point) at a pitch angle of 3.2°.

About 17:37:11, HL7730 bounced when it touched down at a lower angle (2.276°[5]) than standard 3°, about 155.3 meters from runway 16 threshold, and at this time, the airplane was at 135.9 kt at a pitch angle of 6.7° at an attack angle of 15.5°, with vertical gravity of 1.965 g and an increase of thrust.

About 5 seconds after touchdown and bouncing, HL7730 touched down again about 491.3 meters from runway 16 threshold, making a sound of crash against the ground. At this time, the airplane was at 136.9 kt at a pitch angle of 10.9° at an attack angle of 23.2° with vertical gravity of 1.715 g and a higher thrust than that at initial touchdown. Then, HL7730 completed the landing roll and taxied to ramp 129 for itself.

1.2 Injuries to Persons

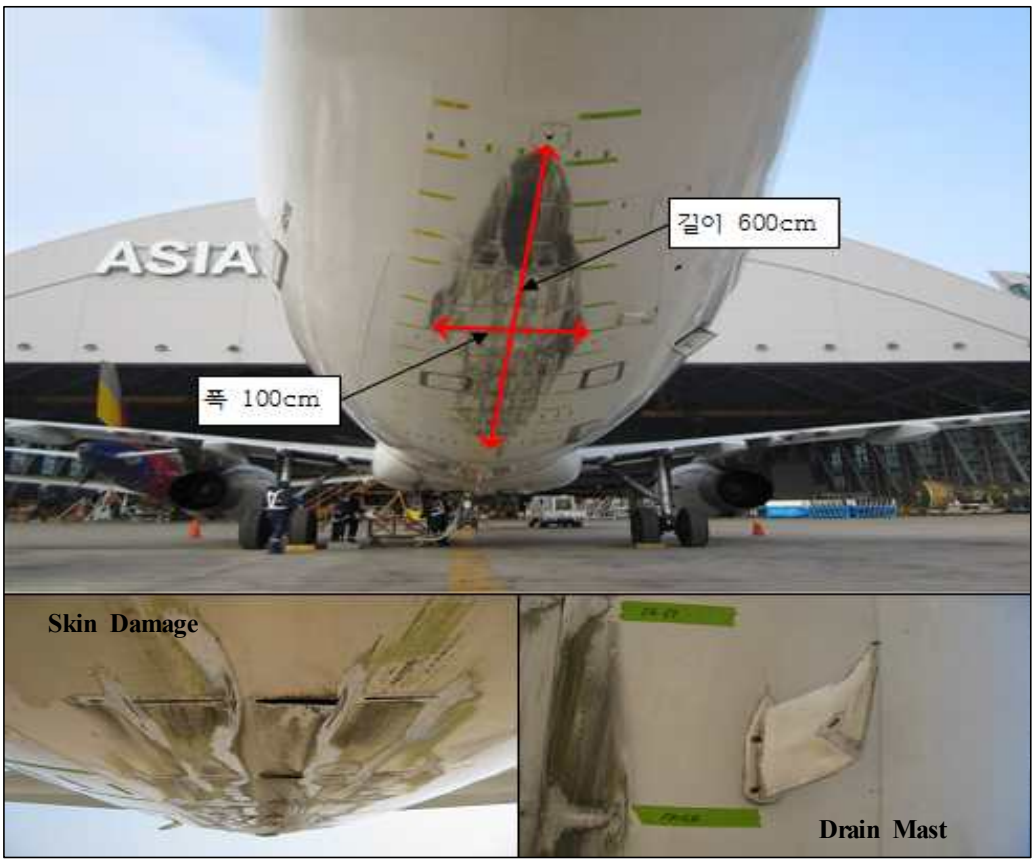
Aboard the aircraft were two pilots, nine flight attendants, and 128 passengers, and three flight attendants sustained minor injuries[6].

1.3 Damage to Aircraft

1.3.1 Damage to the Exterior Fuselage

As shown in [Figure 1], as the belly of the rear fuselage contacted the ground during landing, it sustained abrasion damage 100 cm wide and 600 cm long, including wear-through. The drain mast was bent to the side.

5) The angle is recorded as -0.181 DDM (Difference in Depth of Modulation) by the FDR. Since 0.001 DDM is 0.004, -0.181 DDM is converted into 2.276°.
6) Refer to Section 1.15 Survival Aspects.



[Figure 1] Damage on the Exterior Surface of the Rear Fuselage

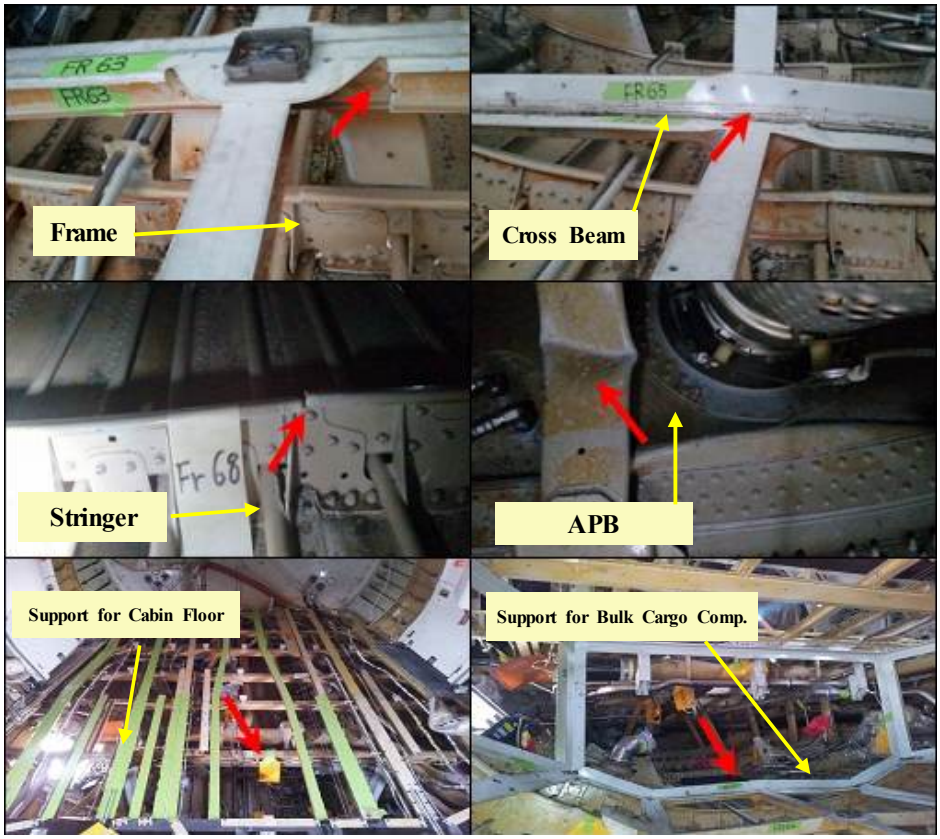
1.3.2 Damage to the Interior Fuselage

[Figure 2] shows damage to the interior fuselage. Out of frames, major structure of the fuselage, 11 of them from No. 62 to 72 were cracked or deformed. Also, nine stringers[7] in the same location, from STGR39LH to STGR41RH, were damaged.

CGO floor cross beam at FR62, FR63, and FR64 was damaged, and PAX floor cross beam at FR65 and FR70 was fractured.

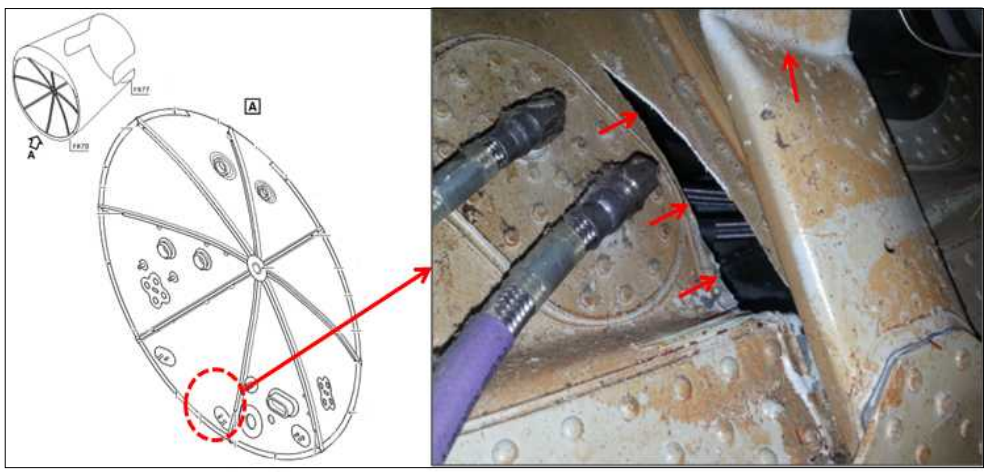
The supports for the water tank and the waste water tank were damaged.

7) STGR39LH - STGR43LH, STGR44, STGR42RH - STGR43RH.



[Figure 2] Damage to the Interior of the Airplane

As shown in [Figure 3], part of the dished segment was deformed or torn at the 6 o'clock position of the aft pressure bulkhead (APB).



[Figure 3] Damage to the Dished Segment

1.3.3 Repair and Restoration of the Aircraft Damage

As shown in [Figure 4], major repair or replacement of the affected components were performed with technical support of the manufacturer's AOG team for about three months and completed on 12 August 2013. The cost of repairs was about 3.7 billion won ($ 3.37 million) including personnel expenses.

[Figure 4] Aircraft Repair

1.4 Other Damage

There was no other damage.

1.5 Personnel Information

1.5.1 The Captain

The captain (age 46, male) held a valid air transport pilot license,[8] A321 type rating,[9] a first-class airman medical certificate,[10] an aeronautical radio

8) License No.: 11-003982 (acquired on 26 Jan. 2011).
9) Acquisition Date: 21 Aug. 2003.

operator license,[11] and level 4 ICAO English Proficiency Certificate.

He had accumulated 7,530 total flight hours, including 1,914 hours during military service and 2,892 hours in A321 airplanes, 722 hours of which he had accumulated as pilot-in-command. The captain had flown 116 and 74 hours in the 90 and 30 days, respectively.

The captain was hired by Asiana Airlines in September 2002 and promoted to captain on A321 in March 2012 after having served as the first officer on A321 and B747-400. He completed his simulator training and passed his proficiency check from 16 to 17 January 2013 to be qualified for stage 3 - low visibility IFR flight. He also passed his line check on 10 March 2013.

In the 72 hours before the accident, on 13 April, the captain had a flight to Busan in the morning and took a rest for the rest of the day. On 14 April, He was on a roundtrip from Jeju to Fukuoka back, returning to Gimpo Airport as a deadhead crew.[12] On 15 April, he was off duty and engaged in routine activities at home. He went to sleep about 22:30.

He did not drink any alcohol or take any illegal medication in the 24 hours before the accident flight and was in good health.

1.5.2 The First Officer

The FO (age 32, male) held a valid air transport pilot license,[13] A321 type rating,[14] a first-class airman medical certificate,[15] an aeronautical radio operator license,[16] and level 4 ICAO English Proficiency Certificate.

10) Certificate No.: 062-11021 (valid until 31 Aug. 2013).
11) License No.: 03-34-1-0109 (issued on 3 Sep. 2003).
12) Seated in the cabin.
13) License No.: 12-008273 (acquired on 15 May 2012).
14) Acquisition Date: 5 Feb. 2013.
15) Certificate No.: 062-11686 (valid until 31 Jan. 2014).

He had accumulated 383 total flight hours, including 128 hours in A321 airplanes. He had flown 128 hours in the 90 days and completed his A321 FO training two weeks ago, since when he had accumulated 33 hours and 31 minutes as second-in-command.

He was hired as the FO by Asiana Airlines on 18 June 2012 since his civilian flight experience was recognized. He received his ground and flight training on A321, passed his checkride, and was appointed the A321 FO on 2 April 2013.

In the 72 hours before the accident, on 13 April, the FO was on two roundtrips from Gimpo to Jeju and back. On 14 April, he was off duty, went to church, met his friends, returned home, and took a rest. On 15 April, he was on a roundtrip from Incheon and Gimpo and back in the morning and took a rest in the afternoon. He went to sleep about 23:00. In the morning on the day of the accident, he was on the first leg of a roundtrip from Incheon to Harbin with the captain, and on the way back to Incheon, had the accident during landing.

He did not drink any alcohol or take any illegal medication in the 24 hours before the accident flight and was in good health.

1.6 Aircraft Information

1.6.1 Aircraft History

The aircraft was an A321-200 airplane manufactured[17] by Airbus on 20 April 2004 and delivered new to Asiana Airlines on 14 May 2004. It was registered[18] with the Ministry of Land, Infrastructure and Transport in Korea and held a

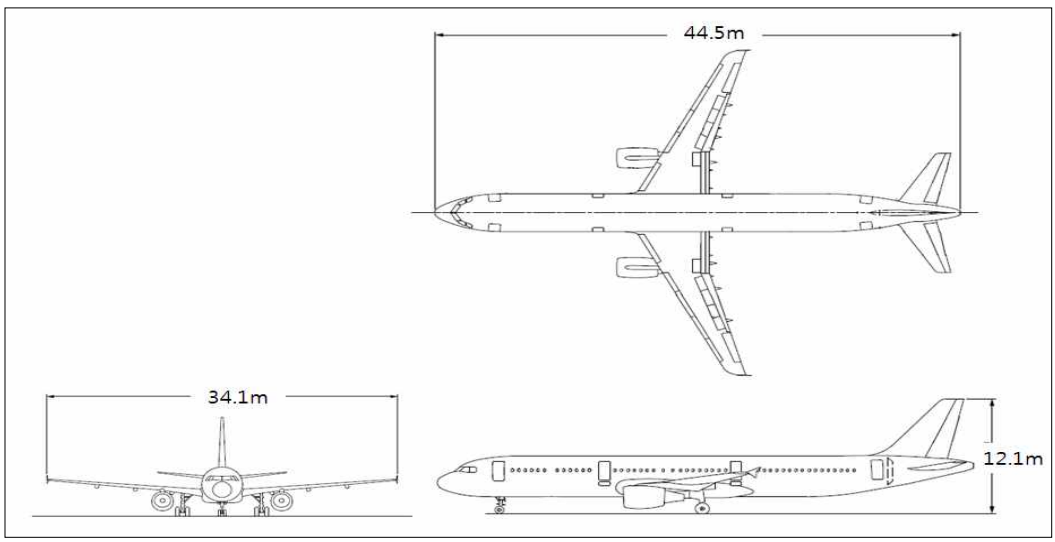
16) License No.: 09-34-1-0617 (issued on 15 Mar. 2012).
17) Manufacturing No.: 2224.
18) Registration No.: 2008-321.

valid airworthiness certificate.[19)]

Until 16 April 2013, the airplane had accumulated 30,268 total hours and 13,619 total cycles.

The airplane was powered by two V2533-A5 turbofan engines manufactured by the US International Aero Engines (IAE). The left No. 1 engine and the right No. 2 engine had accumulated 19,891 service hours/10,534 cycles and 4,351 service hours/2,040 cycles, respectively.

The dimensions of HL7730 are shown in [Figure 5].



[Figure 5] Aircraft Dimensions

1.6.2 History of Aircraft Maintenance

On the day of the accident, Asiana Airlines' aircraft mechanic stationed in Harbin Taiping International Airport carried out preflight inspection of HL7730 before takeoff, but no fault was not only found but also reported until its arrival at Incheon Airport.

19) Certificate No.: AB12042 (issued on 29 Aug. 2012).

Asiana Airlines has performed scheduled maintenance of HL7730 in accordance with its maintenance program: "A" check[20] on 21 February 2013; "C" check[21] on 18 May 2012; and "D" check[22] on 27 March 2013.

1.6.3 Weight and Balance

The weight and balance data of HL7730 is as follows:

Zero Fuel Weight (ZFW)	63,351 kg (Max. Permitted Limit 71,499 kg)
Takeoff Weight (TOW)	72,286 kg (Max. Permitted Limit 88,999 kg)
Landing Weight (LDW)	66,798 kg (Max. Permitted Limit 75,499 kg)
Takeoff Weight C.G. % MAC	32.7% MAC (Range: 14 - 34% MAC)

1.7 Meteorological Information

A METAR report filed when HL7730 landed at Incheon Airport about 17:37 is as follows:

METAR 0800Z 230/09 8000 BR SCT 500 OVC 2,500 11/8 QNH 1003 hPa (17:00, wind 230 at 9 kt, visibility 8 km, scattered at 500 ft, overcast at 2,500 ft, temperature 11°C, pressure 1003 hPa)

According to ATIS "Yankee" HL7730 tuned into, weather conditions at Incheon Airport were surface wind 220 at 10 kt, and other meteorological factors were the same as those in the METAR report above, issued at 17:00.

When HL7730 on the runway 16 final approach course was cleared for

20) Check interval: every 750 hours/750 cycles or 4 months, whichever comes first.
21) Check interval: every 7,500 hours/5,000 cycles or 24 months, whichever comes first.
22) Check interval: 6 years.

landing, surface wind was 220 at 10 kt, and visibility and base ceiling on the course were at such a level that the approach lighting system started to be in insight when HL7730 crossed 200 ft AGL.

According to the FDR data, when HL7730 was at 100 ft on the final approach course, at the runway threshold, and at touchdown, wind was 217.3 at 19 kt, 218 at 16 kt, and 234.8 at 12 kt, respectively.

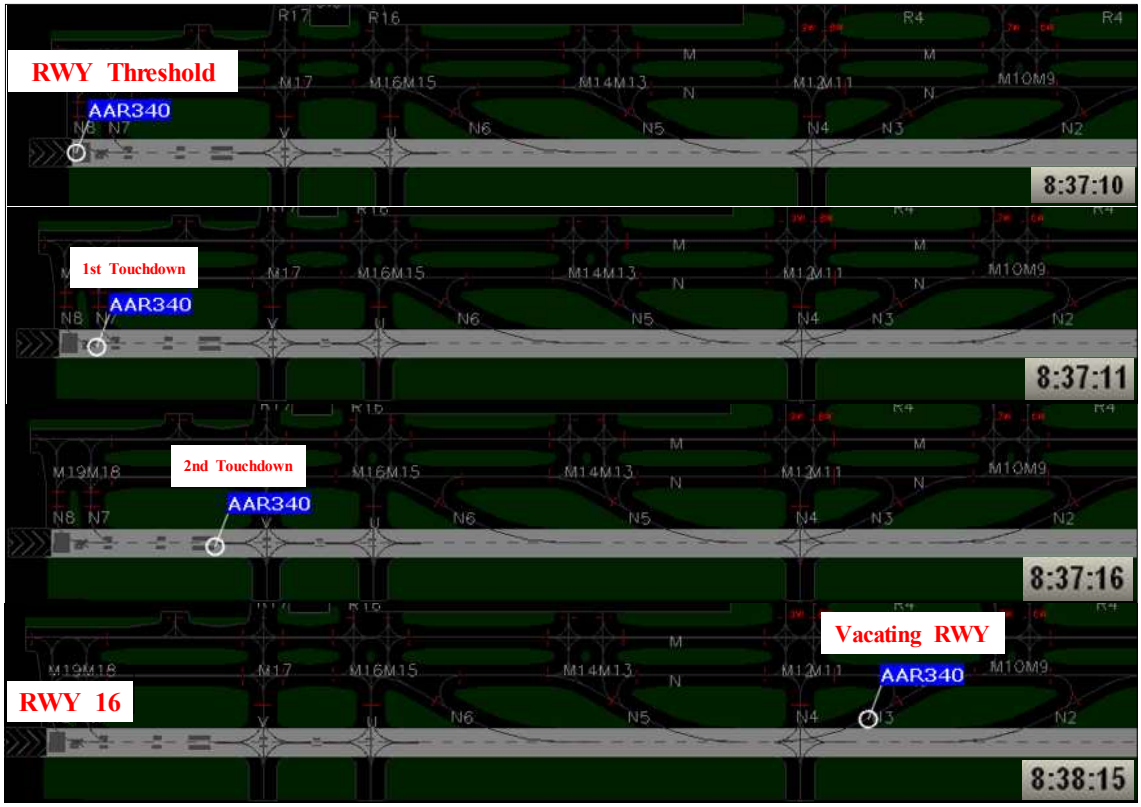
According to Incheon Airport's LLWAS and TDWR data, there was no wind shear when HL7730 approached and landed at runway 16.

1.8 Aids to Navigation

When HL7730 on an ILS runway 16 approach landed, the ILS was in normal operation, and the approch lighting system, runway edge lights, and PAPI were illuminated.[23)]

Images recorded by Incheon Airport's Airport Surface Detection Equipment (ASDE) when HL7730 landed are shown in [Figure 6], which show when and where HL7730 passed the runway threshold, performed the initial and second touchdowns, sustained a tail strike, and vacated the runway.

23) Confirmed by the records of the "airfield lighting on-off device."



[Figure 6] Major Images Recorded by the ASDE During Landing

1.9 Communications

The major content of the ATC/pilot communications is shown in [Table 1], and no communication problems were reported.

Time	Transmitter	Content
16:43:55	F/O	Darlian control Asiana 340, 3 mile right of track, maintain 9,200 m.
16:44:04	DAECON	Asiana 340 Darlian control radar contact.
16:52:07	DAECON	Asiana 340 descend and maintain 8,900 m.
16:52:14	F/O	Descending to 8,900 m, Asiana 340.
17:10:49	F/O	Incheon control Asiana 340 good afternoon, maintaining 8,900 m, 6 mile right of track.
17:11:50	ICNCON	Asiana 340 radar contact direct AGAVO, then flight plan route.
17:12:56	CAPT	Incheon control Asiana 340 approaching AGAVO, request for descend.
17:14:40	ICNCON	Asiana 340 descend to flight level 150 via RAVIT.
17:21:42	CAPT	Seoul approach good afternoon, Asiana 340, information **Yankee**, maintaining flight level 150.
17:22:07	SAPP	Asiana 340 Seoul approach radar contact, fly heading 080, descend and maintain 13,000.
17:33:08	SARR	Asiana 340, turn right, heading 120, cleared ILS runway 16 approach.
17:33:14	CAPT	Right turn heading 120, cleared ILS runway 16 Approach, Asiana 340.
17:34:08	CAPT	Asiana 340 established localizer.
17:34:12	SARR	Asiana 340 contact tower 118.8.
17:34:25	CAPT	Tower, AAR340 established localizer, runway 16, good afternoon.
17:34:31	TWR	Good afternoon, AAR340 Incheon tower, **wind 220 degrees 10 knots**, runway 16, cleared to land.
17:34:39	CAPT	Cleared to land runway 16, AAR340.
17:34:42	TWR	AAR340, advice, base **ceiling is 200 feet**.
17:34:47	CAPT	AAR340.
17:37:04	CSN369	Tower CSN369, good afternoon, now runway 16.
17:37:26	TWR	CSN369, now surface **wind 220 degrees 12 knots maximum 16 knots, base ceiling is 200 feet**.
17:38:06	TWR	AAR340, taxi via November then Mike 7.
17:38:10	F/O	Taxi via November then Mike 7, AAR340

※ F/O: First Officer, CAPT: Captain, DAECON: Darlian Area Control Center, ICNCON: Incheon Area Control Center, SAPP: Seoul Approach Control Approach Sector, SARR: Seoul Approach Control Arrival Sector, TWR: Incheon Control Tower.

[Table 1] Major Content of ATC/Pilot Communications

1.10. Aerodrome Information

Incheon Airport's runway 16 is 4,000 meters long and 60 meters wide, paved with asphalt. Its touchdown zone is at an elevation of 22.9 ft MSL.

Runway 16's tail skid mark left by HL7730 during landing is shown in [Figure 7]. The mark began about 491 meters from the runway threshold, about 2.2 meters[24] to the right of the runway centerline, as shown in [Table 2].

[Figure 7] Tail Skid Mark on Runway

1.11 Flight Recorders

1.11.1 Flight Data Recorder

24) Measured during the on-scene investigation.

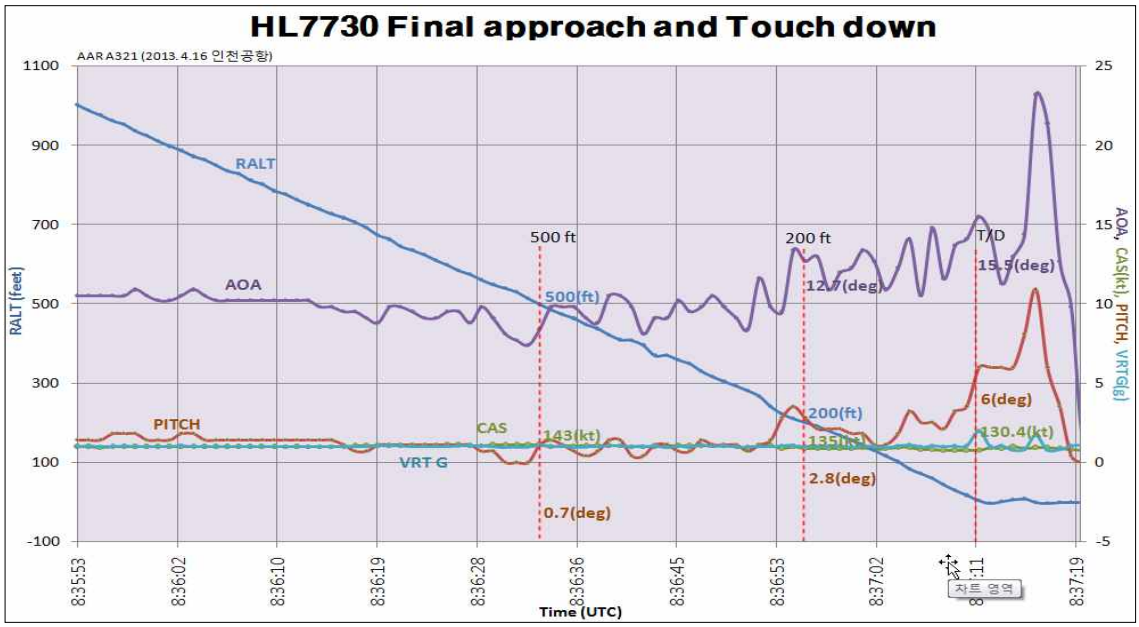
HL7730 was equipped with the solid-state flight data recorder (FDR, Part No.: 980-4700-042, Serial No.: 5400) manufactured by Honeywell. On the day of the accident, the FDR was retrieved from the scene and sent to the ARAIB's analysis lab for readout and evaluation. Visual inspection revealed that the FDR was free from damage.

The FDR recorded data for the 25 hours before the engine shutdown. The ARAIB retrieved this 25 hours worth of raw data, from which it collected about 1,100 parameters. Major parameters are not only shown in [Table 2] but also displayed graphically in [Figure 8].

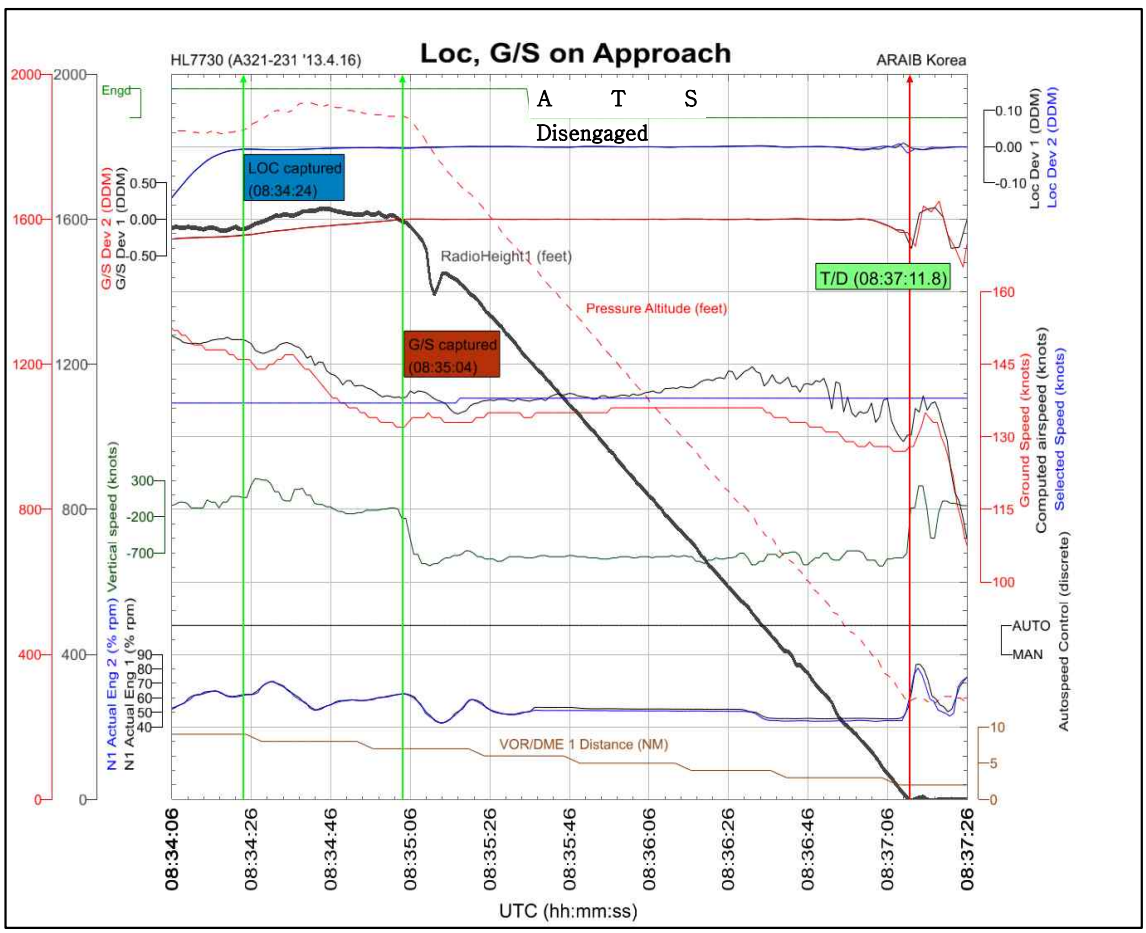
Time	Aircraft Location	RALT (ft)	CAS (kt)	GS (kt)	PITCH (deg)	N1/N2 (%)	AOA (deg)	GVRT (g)	Distance from RWY Threshold (m)
17:35:36	37.52054216N 126.3736725E	1,209	137.6	134	1.8	Auto THR off	10.9	1.004	6,465
17:35:53	37.51161576N 126.3815689E	1,003	138.5	135	1.4	52.5/79.19	10.5	1.004	5,253
17:36:33	37.49084474N 126.3999367E	500	143.1	136	0.7	49.72/77.75	8.4	1.090	2,433
17:36:56	37.47917176N 126.4100647E	201	135.0	129	2.8	45.91/76.06	12.7	1.035	858.2
17:37:04	37.47522355N 126.4136696E	101	137.6	128	1.4	45.72/75.94	12.3	1.121	316.7
17:37:07	37.47376443N 126.4149571E	59	131.4	127	2.5	45.56/75.75	14.8	1.035	119.4
17:37:09	37.47273446N 126.4157296E	29	129	127	3.2	45.94/76.13	13.7	1.063	16.1
17:37:11	37.47161866N 126.4165020E	3	135.9	128	**6.7**	53.19/80.69	**15.5**	**1.965**	155.3
17:37:16	37.46921540N 126.4188195E	-1	136.9	134	**10.9**	72.34/84.00	**23.2**	**1.715**	491.3

[Table 2] FDR Data in Relation to Final Approach and Touchdown

Major flight parameters recorded between HL7730's approach to runway 16 using the ILS approach and touchdown are shown in [Figure 9].



[Figure 8] Major Parameters During Final Approach and Touchdown



[Figure 9] Major Parameters During ILS Approach and Touchdown

Major FDR parameters used for readout are shown in [Table 3].

Abbreviation	FDR Parameters	Unit
N1A.1	N1 Actual Eng 1	% rpm
N1A.2	N1 Actual Eng 2	% rpm
Pitch	Pitch Attitude	deg
Roll	Roll Attitude	deg
RUDP	Rudder Pedal Position	deg
GS	Ground Speed	kt
WDT	Wind Direction True	deg
WS	Wind Speed	kt
GVRT	Normal Acceleration	g
VS	Vertical Speed	ft/min
G/S Dev 1	Glide Slope Deviation 1	dot
G/S Dev 2	Glide Slope Deviation 2	dot
Loc Dev 1	Localizer Deviation 1	dot
Loc Dev 2	Localizer Deviation 2	dot
RALT.1	Radio Height 1	ft

[Table 3] FDR Parameters

1.11.2 Cockpit Voice Recorder

HL7730 was equipped with the solid-state cockpit voice recorder (CVR, Part No. 980-6022-001, Serial No.: CVR120-2264) manufactured by Honeywell.

The CVR was retrieved from the site on the day of the accident and sent to the ARAIB's analysis lab for readout and evaluation.

The CVR records, to its IC memory card, the audio information, which is recorded by four channels (captain and FO seats, cockpit area, and backup microphone) and stored as six stream files.

These files consist of four 30-minute high quality stream files and two 120-minute standard quality stream files. HL7730's landing at the time of the accident was recorded after about 01:39:08 elapsed time of the 120-minute stream file. The ARAIB transcribed a segment of the CVR data necessary for accident investigation and used it in the course of the investigation.

1.12 Wreckage and Impact Information

The airplane sustained damage to the interior·exterior of the fuselage when the rear fuselage impacted the ground during landing, but no wreckage was found.

1.13 Medical and Pathological Information

Medical and pathological aspects are not related to this accident.

1.14 Fire

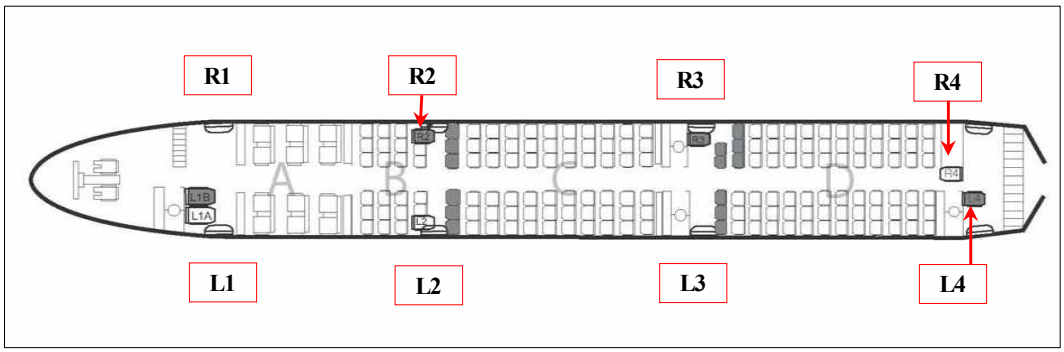
No fire occurred as a result of this accident.

1.15 Survival Aspects

HL7730's cabin manager stated, "During landing, the airplane unusually bounced once after the impact at touchdown, and at that time, passengers and flight attendants were seated in passenger seats and jumpseats, respectively. No passengers complained of external injury or expressed dissatisfaction, but flight

attendants in jumpseats R2, R4, and L4 sustained injuries[25] as shown in [Figure 10]."

Flight attendant R4 stated, "I felt like the airplane smashed into the ground with a sudden bang. At the time, two oxygen masks dropped from the ceiling, and the handset for the interphone system fell out of the stowage cradle."



[Figure 10] Locations of Injured Flight Attendants

1.16 Tests and Research

The ARAIB conducted a simulation test at Asiana Airlines and reviewed measures to develop the pilots' proficiency in recovering safely from bouncing at touchdown by using Asiana Airlines' flight procedures.

During the test, Asiana Airlines' safety captain (A321) operated the simulator as the pilot flying (PF), whereas the ARAIB's investigator was the pilot monitoring (PM) as the observer. Also, Asiana Airlines' A321 instructor captain took an instructor seat.

The simulation was conducted in such a way that the PF maneuvered the aircraft into bouncing in the six simulation sessions in the two attempts, by

25) Flight Attendant R2: cervical and lumbar sprain, and chest contusion; Flight Attendants L4: cervical and lumbar sprain; and Flight Attendant R4: cervical and lumbar sprain, spondylolysis of fifth lumbar vertebrae (suspect), herniation of lumbar disk (suspect).

using manual throttle on the final approach course, 3 miles from the runway (1,000 ft), at the lowest altitude at which a flight simulator can simulate a given flight.

In the first two sessions out of three in the first simulation attempt, the simulator stopped since it regarded as ground impact when the airplane's rear fuselage severely contacted the ground after a high bounce, but in the final third session, the airplane experienced a high bounce and attempted a go-around.

In all three sessions in the second simulation attempt, the simulator's ground impact recognition function was disengaged, and go-around procedures and techniques after a high bounce as well as recovery procedures and techniques after a light bounce were simulated and tested.

When the recovery from the bounce was tested in the simulator, the rear end of the fuselage sharply contacted the ground during a severe bounce, and at this time, the simulator regarded this as ground impact and stopped. Thus, with the simulator's ground impact recognition function engaged, training in the bounce recovery procedures could not be continued.

As a result, it is better to have simulator training in the bounce recovery procedures, with the simulator's ground impact recognition function disengaged, after other training programs requiring the ground impact recognition function are completed.

1.17 Organizational and Management Information

1.17.1 Training in the Recovery from the Bounce at Touchdown

Asiana Airlines has trained its pilots in the bounce recovery procedures in the

ground school course of their type training, and training contents are specified in the flight crew training manual (FCTM) as shown in [Table 4].

BOUNCING AT TOUCHDOWN
In case of a light bounce, maintain the pitch attitude and complete the landing, while keeping thrust at idle. Do not allow the pitch attitude to increase, particularly following a firm touchdown with a high pitch rate. In case of a high bounce, maintain the pitch attitude and initiate a go-around. Do not try to avoid a second touchdown during the go-around. Should it happen, it would be soft enough to prevent damage to the aircraft, if pitch attitude is maintained.

[Table 4] Bounce Recovery Techniques

After hired by Asiana Airlines, HL7730's captain learned to maneuver the airplane out of bouncing and to prevent a tail strike when he learned the FCTM for 8 hours in his initial training for A321 first officers and for 4 hours in his A321 captain training.

Besides, he was also informed of four tail strike events involving Asiana Airlines and other operators.

1) Jun. 2008. B737, PUS, tail strike due to an excessive sink rate (Asiana Airlines)
2) Dec. 2009. A321, KIX, tail strike during go-around (Asiana Airlines)
3) Feb. 2012. A320, SDJ, tail strike during go-around (ANA)
4) Apr. 2013. B767, tail strike during takeoff (Aero Mexico)

As shown in 2) above, in December 2009, when an A321 airplane bounced during approach and landing at Kansai International Airport, the captain immediately took over flight control from the FO playing the PF's role at the time and attempted a go-around, resulting in a tail strike. In this case, the

primary cause of a tail strike was bouncing, and the secondary cause was a sharp increase in the aircraft's pitch attitude during go-around.

1.17.2 Flight Control for the Prevention of a Tail Strike

According to Asiana Airlines' A321 FCTM and the pilot's operating manual (POM), causes of a tail strike during landing and safety requirements for the prevention of a tail strike are as follows:

I. Causes of a Tail Strike During Landing

1) When the airplane's speed substantially decreases to a lower-than-proper approach speed before the pilot's landing maneuvers.
2) When the airplane's pitch attitude continues to increase for smooth landing.
3) In case of the pilot's landing maneuvers at a higher-than-normal altitude.
4) When the airplane excessively sinks before the pilot's landing maneuvers.
5) When the airplane bounces after landing.
6) In case of the pilot's inadequate landing maneuvers during cross wind landing.
7) When the airplane's pitch attitude excessively increases during go-around.

Ⅱ. Safety Requirements for the Prevention of a Tail Strike (POM, Chapter 2)

1) The autothrottle should be used until the thrust decreases to a minimum during landing.
2) If the pilot is going to perform the landing, using the autothrottle, the aircraft's nose should not be sharply lifted.
3) If the pilot is going to land manually, the autopilot, if possible, should be disconnected at over 500 ft after the airplane achieved landing

configuration and a landing clearance. Also, when to disconnect the autothrottle should be considered based on the conditions such as runway in sight and weather.

4) During approach briefing, the pilot should make a distinction between A320 and A321 and deal with the airplane's characteristics per type and a tail strike.
5) The pilot should follow stable approach procedures and if the approach is unstable, stop approach and attempt a go-around.

1.18 Additional Information

1.18.1 Asiana's Stabilized Approach Criteria

According to Asiana Airlines' flight operations manual (FOM), paragraph 7.8.5, ① stabilized approach criteria should be followed to ensure safety during approach and landing and to prevent "controlled flight into terrain (CFIT)" accidents, and the flight crew should conduct monitoring and maneuvers to ensure a stabilized approach; ② all approaches should be stabilized by 1,000 ft above field elevation (AFE) regardless of meteorological conditions (IMC/VMC); and ③ if a stabilized approach is not established above 1,000 ft AFE or maintained below 1,000 ft AFE, an immediate go-around should be executed.

According to stabilized approach criteria, the aircraft should maintain maximum target speed of +10 kt and minimum target speed of - 5 kt, which should be maintained[26] even when the aircraft passes above the runway landing threshold.

1.18.2 Use of the Autothrottle for Speed Control

26) Airbus' policy specifies that stabilized approach criteria should be met until the landing flare altitude.

After the airplane intercepted the runway 16 final approach course, it was cleared for landing by the Incheon Control Tower and about 9 seconds later, the captain was informed that the base ceiling was 200 ft and took over flight control from the FO. About 17:35:36, when the airplane was at about 138 kt at 1,209 ft AGL,[27] the autothrottle was disconnected, followed by no relevant callout by the captain.

According to the statement of the captain, he determined that it would be better to control the thrust manually rather than automatically since a strong and irregular cross wind was blowing on the runway.

According to Asiana Airlines' A321 FCTM, as shown in [Table 5], "the pilot should use the autothrottle as it provides accurate speed control. If the authothrottle is unsatisfactory, the pilot should disconnect it and control the thrust manually. In this case, the authothrottle should be disconnected by 1,000 ft on the final approach."

USE OF A/THR

The pilot should use the A/THR for approaches as it provides accurate speed control. The pilot will keep the hand on the thrust levers so as to be prepared to react if needed.
During final approach, the managed target speed moves along the speed scale as a function of wind variation. The pilot should ideally check the reasonableness of the target speed by referring to GS on the top left on ND. If the A/THR performance is unsatisfactory, the pilot should disconnect it and control the thrust manually.
If the pilot is going to perform the landing using manual thrust, the A/THR should be disconnected by 1 000 ft on the final approach.

[Table 5] Use of the Autothrottle

1.18.3 Delegation of Flight Control to the FO

The captain started to train the FO in the use of the primary flight director

27) FDR data.

(PFD) about 17:08:37 when HL7730 was flying at a cruising altitude of 8,900 meters (29,000 ft). About 17:10:41, he delegated flight control to the FO so that he could manage the descent profile until a landing phase of flight, using the PFD.

About 17:20:04, when HL7730 descended to 15,000 ft, the captain asked the FO to fly the airplane manually,[28] and right after HL7730 intercepted the runway 16 final approach course and was informed by the tower that the base ceiling was 200 ft, the captain took over flight control from the FO.

According to Asiana Airlines' FOM, the conditions for the captain's delegation of flight control to the FO are as shown in [Table 6].

FOM 아시아나항공 제 2 장 운항정책

2.2.3.2 부기장에 대한 조종위임

가. 조종위임의 자격

기장자격	위임단계	부기장 경험충족	접근종류
교관/검열운항승무원	전 비행단계	제한 없음	제한 없음
당해 기종 기장시간 300시간 이상 (단, 신규도입 대형기종의 경우 기장시간 1,500시간 이상 및 당해 기종 기장시간 200시간 이상 Note4))	전 비행단계	당해 기종 부기장 비행시간 100시간 이상 또는 부기장으로서 비행시간 300시간 이상	ILS
		당해 기종 부기장 비행시간 100시간과 부기장으로서 비행시간 300시간 이상	NON-ILS (PAR/ASR, VOR, Circling, Visual etc)
당해 기종 기장시간 100시간~300시간 미만	T/O 및 L/D을 제외한 비행단계	당해 기종 부기장 비행시간 100시간 이상	
당해 기종 기장시간 100시간 미만	조종위임 불가		

[Table 6] Conditions for the Captain's Delegation of Flight Control to the FO

28) According to the FDR data, the autopilot was disconnected at 17:20:32.

1.18.4 Approach Briefing by the Flight Crew

According to the CVR transcript, the captain failed to give an approach briefing to the FO before the commencement of descent for landing at Incheon Airport.

Asiana Airlines has specified approach briefing in A320's POM,[29] Chapter 2 as shown in [Table 7], which has been kept in the cockpit so that the pilots can refer to it during flight.

As shown in [Table 8], A321 FCOM specifies that, if pitch attitude is more than 9.7°, with HL7730's main gear oleo position fully compressed (wheels are compressed by the weight of the fuselage), a tail strike will occur.

A320 POM 아시아나항공 제 2 장 Supplementary SOP

2.9.1.3 Approach Briefing

가. Approach Briefing 준비, 시기 및 방법

1) Approach briefing은 강하, 접근 및 착륙에 요구되는 준비 (FMGC 자료입력, 각종 Bug Set 등)을 완료 후 실시한다.
2) 브리핑은 TOD 이전에 수행함을 원칙으로 하며 늦어도 Approach checklist 수행 전 완료한다.
3) 브리핑은 PF가 실시하며 조종사 상호간 FMGS와 Approach chart를 확인하고 접근절차를 재확인한다.
4) A320 과 A321를 구분하여 기종에 따른 항공기 특성과 Tailstrike를 방지하도록 브리핑한다.

나. 브리핑에 포함될 내용

PF briefing	Associated cross check
Aircraft type and technical status	
NOTAM	
Weather – Accessibility – Runway in use	
Fuel – Extra fuel	FUEL PRED Page
Descent – TOD (time, position) – MORA, STAR, MSA – Altitude and Speed constraints	 FPLN Page FPLN Page
Holding (if expected) – Entry in holding pattern – MHA and MAX Speed	

[Table 7] Contents of Approach Briefing

29) A321 uses the same POM as that of A320.

SUBJECT : AVOIDING TAILSTRIKES

Note : This FCOM Bulletin has been revised to include information relative to the A318.

Inadvertent tailstrikes may occasionally occur, and may result in expensive structural damage.

Several tailstrikes have been reported throughout service life.

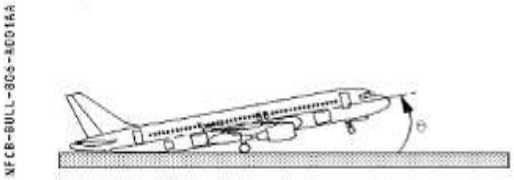
They are very often associated with such adverse conditions as crosswind, turbulence, windshear, etc.

A/C GEOMETRY LIMITS

Two limits need to be considered :

- The geometry limit corresponding to the main gear oleo fully extended (Θ_1)
- The geometry limit corresponding to the main gear oleo fully compressed (Θ_2).

Example :



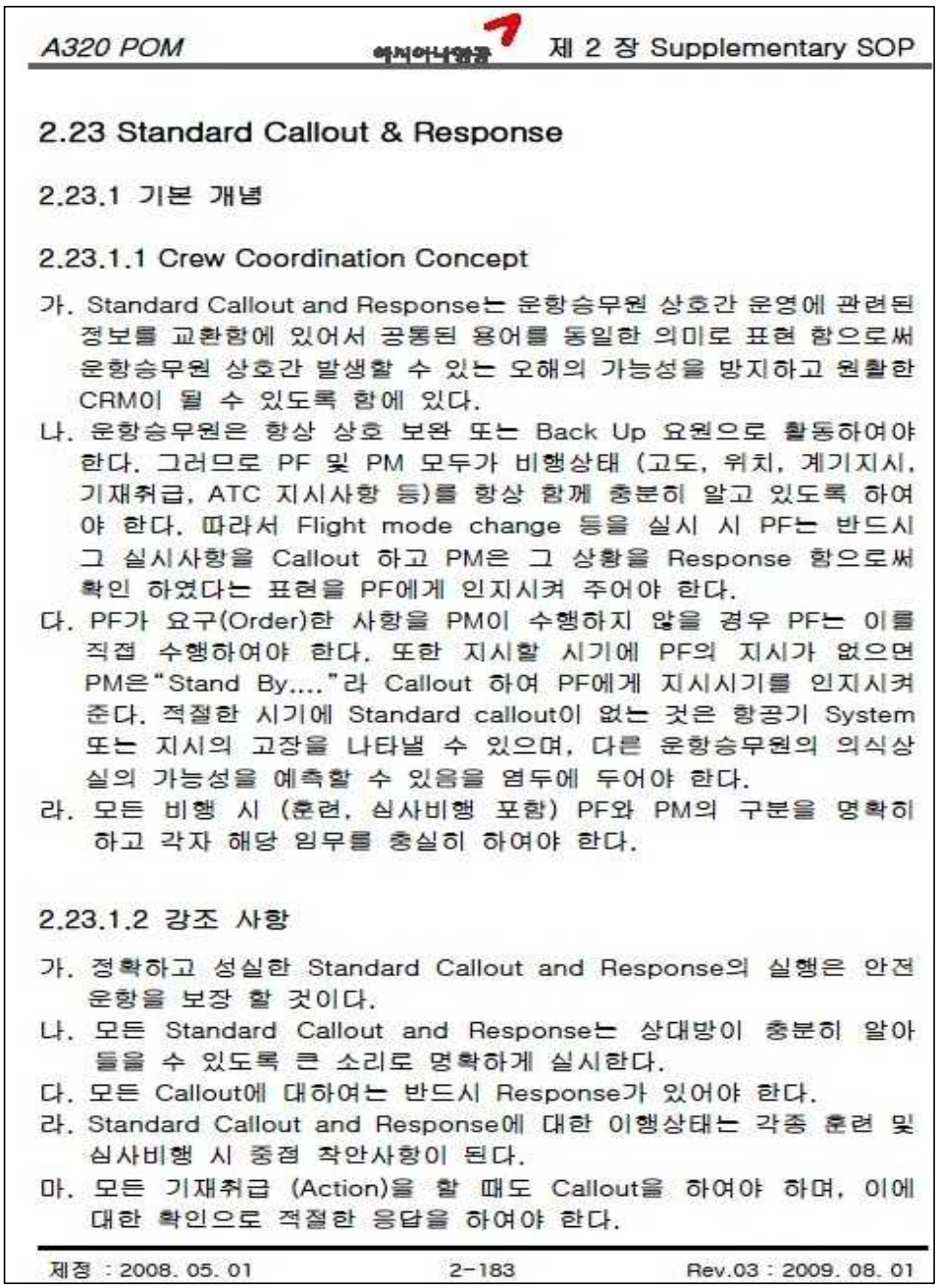
	Pitch attitude Θ			
Main Gear Oleo Position	A318	A319	A320	A321
Fully extended	17.3°	15.5°	13.5°	11.2°
Fully compressed	15.7°	13.9°	11.7°	9.7°

Note : On the A321, the installation of a TFTS antenna decreases these values.

[Table 8] Pitch Attitude Limits for the Prevention of Tail Strikes

1.18.5 Standard Callout and Response Procedures

Standard callout and response procedures, essential to flight control, are specified in A320's POM, Chapter 2, as shown in [Table 9]. They are procedures for ensuring that the pilots follow established flight procedures, cross-checking a change in flight control.



A320 POM 아시아나항공 제 2 장 Supplementary SOP

2.23 Standard Callout & Response

2.23.1 기본 개념

2.23.1.1 Crew Coordination Concept

가. Standard Callout and Response는 운항승무원 상호간 운영에 관련된 정보를 교환함에 있어서 공통된 용어를 동일한 의미로 표현 함으로써 운항승무원 상호간 발생할 수 있는 오해의 가능성을 방지하고 원활한 CRM이 될 수 있도록 함에 있다.

나. 운항승무원은 항상 상호 보완 또는 Back Up 요원으로 활동하여야 한다. 그러므로 PF 및 PM 모두가 비행상태 (고도, 위치, 계기지시, 기재취급, ATC 지시사항 등)를 항상 함께 충분히 알고 있도록 하여야 한다. 따라서 Flight mode change 등을 실시 시 PF는 반드시 그 실시사항을 Callout 하고 PM은 그 상황을 Response 함으로써 확인 하였다는 표현을 PF에게 인지시켜 주어야 한다.

다. PF가 요구(Order)한 사항을 PM이 수행하지 않을 경우 PF는 이를 직접 수행하여야 한다. 또한 지시할 시기에 PF의 지시가 없으면 PM은"Stand By...."라 Callout 하여 PF에게 지시시기를 인지시켜 준다. 적절한 시기에 Standard callout이 없는 것은 항공기 System 또는 지시의 고장을 나타낼 수 있으며, 다른 운항승무원의 의식상실의 가능성을 예측할 수 있음을 염두에 두어야 한다.

라. 모든 비행 시 (훈련, 심사비행 포함) PF와 PM의 구분을 명확히 하고 각자 해당 임무를 충실히 하여야 한다.

2.23.1.2 강조 사항

가. 정확하고 성실한 Standard Callout and Response의 실행은 안전 운항을 보장 할 것이다.

나. 모든 Standard Callout and Response는 상대방이 충분히 알아 들을 수 있도록 큰 소리로 명확하게 실시한다.

다. 모든 Callout에 대하여는 반드시 Response가 있어야 한다.

라. Standard Callout and Response에 대한 이행상태는 각종 훈련 및 심사비행 시 중점 착안사항이 된다.

마. 모든 기재취급 (Action)을 할 때도 Callout을 하여야 하며, 이에 대한 확인으로 적절한 응답을 하여야 한다.

제정 : 2008. 05. 01 2-183 Rev.03 : 2009. 08. 01

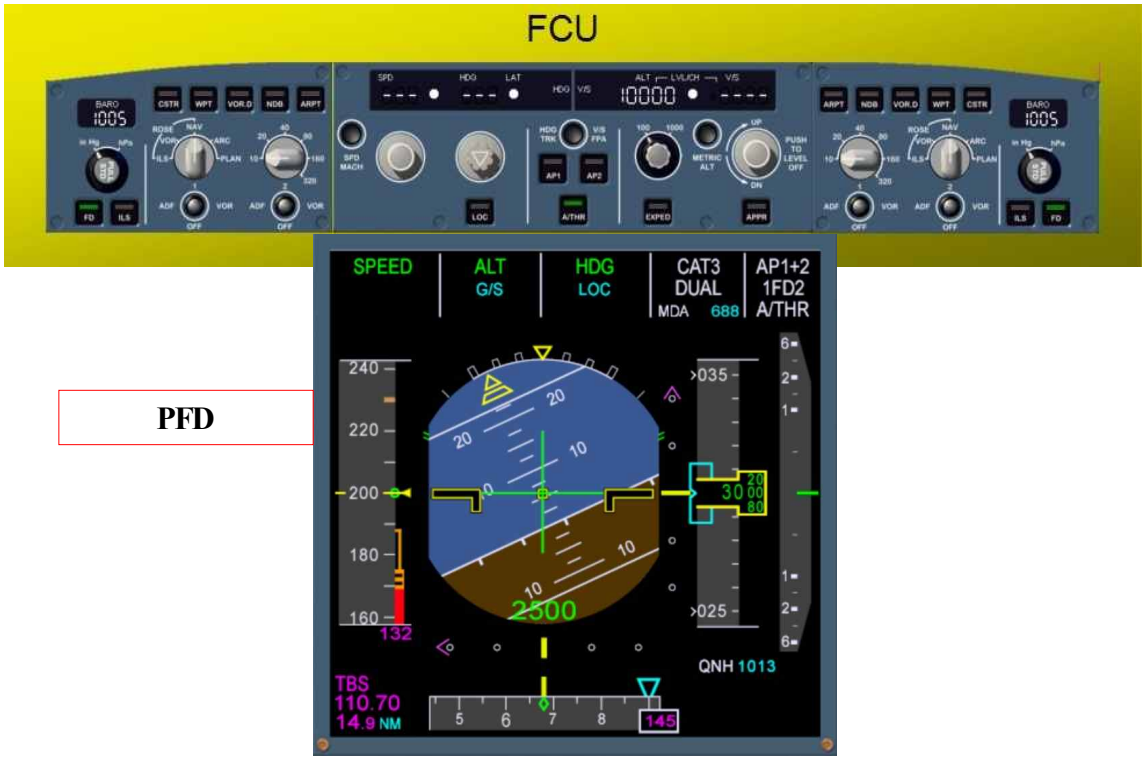
[Table 9] Standard Callout and Response Procedures

Standard callout and response procedures are applied differently depending on auto and manual flights.

In case of auto flight, if the PF selects a mode on the flight control unit (FCU) shown in [Figure 11] and makes a callout, the PM will check the

changes at the top of the primary flight display (PFD) and respond.

In case of manual flight, if the PF controls the airplane with the control column and makes a callout about the mode he wants to select on the FCU, the PM will select the mode accordingly and check the changes to the mode at the top of his PFD, making a related callout. Then, the PF will also check the changes at the top of his PFD.



[Figure 11] FCU and PFD

According to the CVR transcript, the captain and the FO failed to make standard callouts and responses in relation to the changes to flight control between descent at an early stage of approach and approach to runway 16 on the final approach course, as shown in the following cases:

When HL7730 was instructed to descend to 15,000 ft by Incheon ACC during cruise flight; when it was instructed to fly at 13,000 ft on a heading of

080° after transferred to Seoul ACC; when it was instructed to descend to 10,000 ft; and when it was instructed to fly respectively on a heading of 340°, 060°, then 090°.

Before intercepting the final approach course, using the ILS approach, the PF and the PM failed to make a callout about the selection of "APPR mode" on the FCU and the confirmation of "LOC and G/S ARM" displayed at the top of the PFD, respectively.

In addition, after intercepting the final approach course, the PM did not make a callout about neither "G/S Star" while approaching on glidepath nor the crossing of the FAF.

The PF also failed to call out "autothrottle off" when he switched to manual flight on the final approach course, followed by no response by the PM.

2. Analysis

2.1 General

The flight crew held an airman certificate required for operation and a valid airman medical certificate.

HL7730 was registered in accordance with 「Aviation Act」 of the Republic of Korea, and held a valid airworthiness certificate. There were no defects in the airframe, engines, and flight control system, and the aircraft was operated within the allowable range of weight and balance.

The ARAIB concentrated its analysis on the causes of and related factors in both bouncing on touchdown at Incheon Airport and a tail strike on second touchdown, as well as on related regulations and non-compliance with them.

2.2 Stabilized Approach

According to the FDR and CVR records, an approach became stabilized when HL7730 was at 1,000 ft on the final approach course, but its speed dropped to less than that of the stabilized approach criteria crossing at about 60 ft, then reached 129 kt, maximum 9 kt less than the proper approach speed, at 29 ft. At this time, the PM failed to advise the PF or make relevant callouts.

In this regard, the PF and the PM failed to pay attention to or ignore Asiana Airlines' policy that "if a stabilized approach is not established, go-around is the safest choice," and that "deciding to make go-around does not mean that the procedure has been done wrong, but it means that crews follow the company safety policy and executed safety procedure normally.

2.3 Bouncing on Touchdown

2.3.1 Failure to Maintain the Proper Approach Speed and Bouncing

Before descending out of a cruising altitude, the captain entered Incheon Airport's QNH (1002), temperature (12℃), and wind direction and speed (220°/15 kt) into the flight management guidance system (FMGS), and selected flaps 25. As a result, as the VLS (lowest selected speed) of 132 kt calculated on the basis of the aircraft landing weight at the time and the VAPP of 137 kt calculated by adding 5 kt to the VLS were displayed on the FMGS, the captain and the FO together were able to share this data.

After HL7730 on the runway 16 final approach course was cleared for landing, the captain took over flight control and set the proper approach speed to 138 kt by instructing the PM to add 1 kt, in consideration of an error of the speed, which, the ARAIB concludes, was an adequate decision.

It is concluded that, when HL7730 was on the final approach course, about 3.5 NM from the runway threshold, the PF disconnected the autothrottle and controlled the approach speed manually without making relevant callouts, thereby causing the PM's failure to pay attention to the changes to speed.

As the airplane decelerated to a lower-than-proper approach speed (131 kt), crossing at 100 ft AGL, its sink rate increased, and it thus approached below the standard 3° glidepath (2.286 - 2.276°).

After the airplane decelerated to 129 kt at 29 ft AGL, 9 kt less than the proper approach speed, its thrust and speed increased, then it made an initial touchdown about 155 meters from the runway threshold at a higher-than-normal pitch angle of 6.7° at a speed of 136 kt, about 7 kt higher than 129 kt. At this

time, as its attack angle increased due to the rear fuselage under the downward force of gravity, higher than normal vertical gravity of 1.965 g was created.

The ARAIB concludes that, as the PF failed to maintain the proper approach speed while controlling thrust manually, he approached below the standard glidepath, and aware of this situation, increased thrust (speed) but the airplane sharply contacted the ground due to a high sink rate and the resulting inertia, and that the airplane bounced on the initial touchdown because an increase in thrust and speed after the flare before touchdown generated the impact force when the main gear touched down and because the airplane's attack angle increased due to the rear fuselage's inertia.

2.3.2 Final Approach and Speed Monitoring During Landing

When the PF disconnected the autothrottle and switched to manual flight during approach on the final approach course, about 3.5 NM from the runway, he did not call out, thereby leaving the PM unaware of the change. As a result, the PM failed not only to monitor the PF's failure to maintain the approach speed during his manual control of thrust, but also to make a callout about a decrease to less than the proper approach speed.

According to the CVR transcript, the PF failed to make a callout in the following cases: ATC's instruction to descend or to change heading for radar vector; selection of the approach mode; interception of the final approach course; and disconnection of autothrottle. This indicates that crew resource management (CRM) was not adequately practiced, and that the PM's role could not be adequately performed.

The ARAIB concludes that it is necessary to seek measures to respect the PM's role regardless of his/her flight experience and hours and to ensure full

compliance with standard callout procedures since the procedures aim to secure safe flight by ensuring that the pilots cross-check the changes to flight control, including monitoring of the proper speed.

2.3.3 Attention Allocation During Landing

The captain delegated flight control to the FO, instructing him to manage the descent profile until a landing phase of flight, and started to train him in the use of the PFD. About 12 minutes later, the Captain instructed the FO to fly manually, and the FO thus disconnected the autopilot and switched to manual flight.

According to the CVR transcript, the captain focused his attention on the monitoring of the FO who changed heading and managed the descent profile when given radar vector from Seoul ACC. He continued to train the FO and allocated much attention to this until he took over the PF role and disconnected the autothrottle after HL7730's interception of the runway 16 final approach course.

At that time, the FO's flight hours were not enough to meet the conditions for taking over flight control from the captain, so the FO reminded him of this, but the captain delegated flight control to the FO in order to train him in the use of the PFD. As a result, it is concluded that the captain's attention was placed on training the FO, and that the FO failed to adequately play the PM's role during approach and landing.

The captain as the PF controlled the approach speed for about 1 minute 36 seconds between the commencement of manual thrust control and touchdown, but recognizing late, at flare right before touchdown, that it was about 9 kt less than the proper approach speed, he increased thrust. It is concluded that this resulted

from the fact that the captain allocated his attention to training the FO, and that this had a negative effect on preparation for approach and landing maneuvers during final approach as well as concentration of attention.

2.4 Tail Strike on Touchdown

2.4.1 Touchdown Maneuvers after Bouncing

According to the FCTM, in case of a bounce, the pilots should maintain pitch attitude and complete the landing, while keeping thrust at idle. On the other hand, HL7730 bounced up to about 7 ft high as it made an initial touchdown with thust increasing after flare right before touchdown, then, the airplane made a second touchdown with its thrust, speed, attack angle and pitch attitude increasing more.

According to the FDR data, HL7730's pitch attitude was 6.7°, 9.8°, and 10.9° on initial touchdown, in the air after bouncing, and on second touchdown, respectively, which indicates that its pitch attitude on second touchdown exceeded 9.7°, an A321 airplane's pitch attitude limitation with the main gear oleo position fully compressed, and that the PF failed to establish the proper pitch attitude at second touchdown after bouncing.

Accordingly, the ARAIB concludes that the causes of the tail strike were ① Thrust was not kept at idle after bouncing at initial touchdown, and ② HL7730 made a second touchdown with its pitch attitude exceeding an A321 airplane's limitation.

2.4.2 Human Factors Relating to Bouncing Landing Recovery Maneuvers

2.4.2.1 Noncompliance with Regulations and Procedures

The POM specifies that the PF, before the commencement of descent, should conduct an approach briefing, which deals with the characteristics of A321, the prevention of a tail strike, and pitch attitude limitations for avoiding a tail strike, but according to the CVR transcript, the PF skipped the briefing.

The ARAIB concludes that the PF failed to think of pitch attitude limitations required for avoiding a tail strike when the airplane's pitch attitude was increasing during the bounce on the initial touchdown, and that, as a result, he failed to maintain the proper pitch attitude so that the airplane could not touch down at pitch attitude below its limitations.

2.4.2.2 Flight Training Program and Proficiency Attainment

It took about 5 seconds for HL7730 to fly about 340 meters until the second touchdown from the bounce during the initial touchdown. It is determined that practical training is needed in order for the PF to make instinctive judgements and decisions, which allow him to make a safe touchdown or go-around by properly controlling pitch attitude and thrust in such a very short period of time.

The PF, like the other pilots in Asiana Airlines, theoretically learned about bounce recovery techniques in the ground school course of type training, by using the FCTM, POM, and a case study, but has never been trained in the simulator to attain proficiency in the recovery from the bounce.

After this accident, the ARAIB conducted a simulation test to see how the pilot responded to a bounce. Although a seasoned captain operated the simulator, the airplane sustained a tail strike, bouncing severely, which indicates that theoretical learning in the ground school course alone cannot allow the flight crew to make a safe touchdown after actual bouncing.

Accordingly, the ARAIB concludes that bouncing recovery training should be added to the existing simulator training program of Asiana Airlines, more specifically, to captain and instructor training syllabuses, and that it can be likely implemented, with the ground impact recognition function disengaged, after other training subjects are taught.

3. Conclusions

3.1 Findings

1. HL7730 held a valid airworthiness certificate. There were no defects in the airframe, engines, and flight control system, and the aircraft was operated within the allowable range of weight and balance.

2. The flight crew held an airman certificate required for operation and a valid airman medical certificate.

3. HL7730 sustained damage to the main structure of the fuselage and the APB due to a tail strike at touchdown, and major repair or replacement of the affected components were performed.

4. Three flight attendants in jumpseats R2, R4, and L4 sustained injuries, and two oxygen masks dropped from the ceiling in front of the lavatory.

5. When HL7730 was landing, there was right cross wind at 10 kt with no wind shear, and base ceiling was 200 ft.

6. When HL7730 landed, the ILS was in normal operation, and the approach lighting system, runway edge lights, and PAPI were illuminated.

7. The autopilot and the autothrottle were disconnected during approach/descent and at a point on the final approach course, 3.49 NM from the runway threshold, respectively.

8. The ARAIB concludes that the PF made an adequate decision when he set the proper approach speed to 138 kt by instructing the PM to add 1 kt to

137 kt calculated by the FMGS, in consideration of an error of the speed, before descent out of a cruising altitude.

9. Crossing at 100 ft AGL on the final approach course, HL7730 decelerated to a lower-than-proper approach speed and accelerated, with thrust increasing, from flare right before touchdown, and finally touched down.

10. HL7730 approached below the standard 3° glidepath while decelerating to a lower-than-proper approach speed. The airplane bounced up to about 7 ft AGL when it initially touched down with a high sink rate and higher-than-normal vertical gravity.

11. When HL7730 made an initial touchdown and bounced, its thrust was not kept at idle, then when it made a second touchdown with its pitch attitude exceeding an A321 airplanes' limitation, it sustained a tail strike.

12. Since the PF failed to call out when he disconnected the autothrottle, the PM failed not only to monitor the PF as the airplane decelerated to a less-than-proper approach speed but also to make a callout about maintaining speed.

13. As the PF and PM failed to make several callouts during approach/descent and about disconnection of the autothrottle, the CRM was not adequately practiced, which contributed to the failure of the PM to fulfill his role during final approach and landing.

14. The captain delegated flight control to the FO for the purpose of training him although the FO's flight hours were not qualified for flight control during all phases of flight. As a result, his attention was placed on training, and this had a negative effect on preparation for approach and

landing maneuvers.

15. The captain failed to conduct an approach briefing about an A321 airplane's pitch attitude limitations required for avoiding a tail strike, which contributed partly to his failure to maintain the proper pitch attitude while performing touchdown maneuvers after bouncing.

16. Asiana Airlines' pilots theoretically learned about bounce recovery techniques in the ground school course of type training, but this type of training was inadequate to make them ready to recover from bouncing that occurs in an instant. Thus, bouncing recovery training should be added to the existing simulator program to improve the pilots' proficiency in the recovery from the bounce.

3.2 Causes

The Aviation and Railway Accident Investigation Board determines the causes of this accident as follows:

1. The PF failed to maintain the proper approach speed until the flare just before touchdown, and the airplane bounced on touchdown since higher-than-normal vertical gravity was applied due to a high sink rate and increased thrust and speed just before touchdown, and

2. The airplane made a second touchdown at the pitch attitude exceeding an A321 airplane's limitation and sustained a tail strike since the PF failed to keep thrust at idle and establish the proper pitch attitude during the bounce.

Contributing to this accident were ① the inadequate training program dealing

with the recovery form the bounce; ② lack of pre-landing preparation due to a failure to conduct an approach briefing on pitch attitude; ③ the PF's failure to properly allocate his attention due to his delegation of flight control to the pilot monitoring (PM) who failed to meet flight control requirements; ④ the PM's inadequate advice and monitoring due to the PF's failure to make standard callouts; ⑤ the disconnection of the autothrottle and a failure to manually control thrust and speed; and ⑥ a failure to execute a go-around when stabilized approach criteria are not met.

4. Safety Recommendations

As a result of the investigation of the accident that occurred to HL7730 at Incheon Airport on 16 April 2013, the ARAIB makes the following safety recommendations:

To Asiana Airlines

1. Reemphasize, through your pilot training programs, you policy that if a stabilized approach is not established, executing go-around is the safest choice for safe operation so that flight crew can be fully aware of it. (AAR1303-1)

2. Train your pilots in a simulator to ensure that they can operate the airplane in a stable manner after bouncing on touchdown, and add this training to your ground training program. (AAR1303-2)

3. Train your pilots to comply with POM's conditions for flight control delegation to the FO and to put top priority on performing roles as the PF and the PM during flight, and incorporate their training outcomes into evaluation. (AAR1303-3)

4. Reinforce, through your training programs, flight crew adherence to POM's approach briefing and standard callout procedures on every flight. (AAR1303-4)

To the Ministry of Land, Infrastructure and Transport (Office of Civil Aviation)

1. During your line qualification check and aviation safety inspection, strictly check whether the pilots of all air carriers conduct an approach/landing

briefing and comply fully with standard callout procedures, and take complementary institutional measures (AAR1303-5)

2. Review measures to ensure that all pilots of Korean airlines can be given simulator training as part of ground training programs to attain proficiency that enables them to operate the airplane in a stable manner after bouncing during landing. (AAR1303-6)