국토교통부

ARAIB/AIR1301

Aircraft Serious Incident Report

Runway Excursion During Landing Roll

Jeju Air

B737-800, HL7780

Gimpo International Airport, Runway 14R

3 February 2013

28 July 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 Serious Incident Report

Aviation and Railway Accident Investigation Board. ***Runway Excursion During Landing Roll, Jeju Air, HL7780, B737-800, Gimpo International Airport, Runway 14R, 3 February 2013.*** **Aircraft Serious Incident Report ARAIB/AIR1301, 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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Runway Excursion During Landing Roll at Gimpo International Airport

- ○ Operator: Jeju Air
- ○ Manufacturer: The Boeing Company
- ○ Type: B737-800
- ○ Registration Mark: HL7780
- ○ Location: Gimpo International Airport, Runway 14R
- ○ Date & Time: 3 February 2013, Approximately 22:20 (KST[1])

Synopsis

On 3 February 2013, Jeju Air flight 120, a B737-800 airplane, HL7780, a scheduled domestic passenger flight, which took off from Jeju International Airport about 21:09, attempted to vacate runway 14R via taxiway B1 at the end of the runway during its landing roll at Gimpo International Airport about 22:18, but as the airplane failed to decelerate to a taxiing speed and went straight, it veered to the green zone beside the paved area, about 40 meters from the end of runway 14R, and finally came to a halt about 22:20. As a result of this serious incident, there was no damage to the aircraft or personal injuries.

The Aviation and Railway Accident Investigation Board (ARAIB) determines that the causes of this serious incident were ① Since the flight crew failed to carefully consider the runway condition before landing, they failed to neither predict and select the braking action of the runway under adverse conditions during landing nor share information on landing distance and deceleration plan between the Pilot Flying (PF) and the Pilot Monitoring (PM); ② The PF not only disengaged the deceleration system altogether before the aircraft decelerated enough to vacate the runway during landing roll, but also failed to respond to the slippery condition in the last 1/3 section of the runway since he mistakenly

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

believed that the remaining distance to the end of the runway was enough. Contributing to this serious incident were (1) the PF's failure to conduct the landing briefing; and (2) non-provision of the runway surface information after snow removal operations on runway 14R for the flight crew.

Regarding this serious incident, the ARAIB addresses four safety recommendations to Jeju Air and one safety recommendation to Korea Airport Corporation (KAC).

1. Factual Information

1.1 History of Flight

On 3 February 2013, Jeju Air flight 120, a B737-800 airplane, HL7780 (hereafter referred to as "HL7780"), a scheduled domestic passenger flight, took off from Jeju International Airport (hereafter referred to as "Jeju Airport") for Gimpo International Airport (hereafter referred to as "Gimpo Airport") approximately 21:09. HL7780's flight crew were the captain and the first officer (FO) who took the left seat as the PF and the right seat as the PM, respectively. They were given the meteorological information (moderate snow, braking action: medium to good) at the ramp by Jeju Air's operation personnel before takeoff from Jeju Airport.

At 21:14:46, the flight crew made a request for Gimpo Airport's meteorological information while reporting[2] the completion of takeoff to Jeju Air. The weather conditions they were notified of by Jeju Air were as follows: wind 120 at 6 kt, visibility 1,200 m with light snow and mist, scattered at 1,000 ft, overcast at 8,000 ft, temperature -2°C, and QNH 1021.

After the in-flight announcement by the captain during en-route flight, the flight crew listened to the Automated Terminal Information Service (ATIS) "S (Sierra)" broadcast to check for the weather conditions at Gimpo Airport at 21:26:46. According to ATIS, runway 14R was in use at Gimpo Airport as of 21:17, and the weather conditions were as follows: wind 130 at 5 kt, visibility 600 m, temperature -2°C, runway 14R visual range (touchdown RVR: 1,400 m, mid RVR: 1,300 m, end RVR: 1,300 m), runway condition damp, and braking action[3] "medium to good." Runway 14L was closed due to snow removal.

2) Reported at 129.075 MHz, radio frequency for master control used by Jeju Air.
3) Classification of Braking Action: "Good", "Medium", and "Poor", which can be combined and expressed as "Medium to Good", "Medium to Poor", etc.

The flight crew ran the descent checklist at 21:39:08, and the captain selected "Auto Brake 3."

When HL7780 was flying at 13,000 ft, the Seoul Approach Control (SEL APP) made a blind broadcast to all airplanes entering Gimpo Airport on the control frequency of 119.75 MHz to announce “Two aircraft has made a go-around due to poor breaking action" at 21:46:17. The PF and the PM listened to the broadcast, and the PF gave a skeptical response, without any particular action.

When HL7780 was flying at 10,000 ft, SEL ACC broadcast, to all airplanes approaching Gimpo Airport, runway 14R's visual range and braking action "Medium to Poor" at 22:00:14. The PM who listened to this broadcast told the PF that he would listen to ATIS and check more, but the PF said it would be unnecessary because they knew the weather conditions were repeatedly changing, and thus, no particular action was taken.

When HL7780 was approaching Anyang VORTAC at 10,000 ft at 22:02:17, SEL ACC cleared the flight for an ILS approach to runway 14R, and the flight crew ran the approach checklist at 22:08:11, received runway 14R's ILS signal at 22:13:09, and started on the glidepath at 22:15:29.

At 22:15:43, HL7780 communicated with the Gimpo Control Tower, about 6.5 NM of the final approach path for runway 14R, lowered the landing gear a little later, checked flap 30 and airspeed, ran the before-landing checklist at 22:16:35, and completed the checklist at 22:16:47.

When HL7780 was flying at 1,000 ft at 22:17:03, the flight crew was informed of "Approach light insight 400 ft and braking action medium reported by B737" by the Gimpo Control Tower, and they were cleared to land at

runway 14R along with the weather information indicating wind 080 at 4 kt.

At 22:17:24, HL7780 disengaged the autopilot about 2.3 NM from the threshold of runway 14R and approached manually. At 22:15:45, the aircraft achieved a stable landing attitude at 500 ft, visually confirmed the approach lights, and did not use windshield wipers.[4)]

At 22:18:24, HL7780 passed through 50 ft, and the precision approach path indicator (PAPI) displayed "three red lights."[5)] During landing roll after touchdown on runway 14R, the PM called out, "Speed brakes up," "Two reverser green," "Auto brake disarm," "80 kt," and "50 kt," followed by the PF's callout, "End of runway."

At 22:19:34, HL7780 was instructed by the tower to "taxi via taxiways B1 and B2" and the flight crew acknowledged. About five seconds later, HL7780 started to veer off the runway, and about 22:20, came to a halt at the green zone on the left of the paved area (stopway)[6)] at the end of runway 14R.

1.2 Injuries to Persons

Aboard the aircraft were two pilots, four flight attendants, and 187 passengers, and there was no personal injuries as a result of this serious incident.

1.3 Damage to Aircraft

As HL7780 veered off the runway as shown in [Figure 1], its nose and main landing gears entered the green zone, and about half the diameter of the wheels were buried under ground, but there was no damage to the aircraft and both

4) CVR Transcript: "Wipers?" "No need, no need."
5) Stated by the captain, and the aircraft touched down below 3-degree glidepath.
6) The term "paved area" was used since the "stopway" was not established at Gimpo Airport.

engines that were on borescope inspection (BSI).

After HL7780 was towed to the ramp, its landing gear and brake assembly were placed under special inspection, which failed to discover any particular defect, but Jeju Air replaced all tires of nose and main landing gears, and the brake assembly of the main landing gear to eliminate the possibility of a potential defect.

The test flight was conducted in accordance with the maintenance manual[7] to check for the aircraft's conditions due to runway overrun, and the result showed that the aircraft functioned normally.

[Figure 1] Aircraft after Runway Excursion

1.4 Other Damage

There was no other damage.

7) AMM 05-51-01.

1.5 Personnel Information

1.5.1 The Captain

The captain (male, age 57) was hired by Jeju Air on 12 March 2012, and held a valid air transport pilot license,[8] B737 type rating,[9] a first-class airman medical certificate,[10] an aeronautical radio operator license,[11] and level 4 ICAO English Proficiency Certificate.[12] He had accumulated 16,367 total flight hours, including 11,370 hours as pilot-in-command and 370 hours in B737 airplanes as pilot-in-command. The captain had flown 226 and 68 hours in the 90 and 30 days, respectively.

To obtain B737 type rating, the captain completed his simulator training from 17 June to 15 July 2012, and passed his proficiency check and line check on 16 July 2012 and 5 September 2012, respectively.

In the 72 hours before the serious incident, the captain took a rest at home during a day off on 1 February 2013. On 2 February, he had a turnaround flight between Incheon and Nagoya in the afternoon, went home about 20:00, and went to bed about 24:00. On the day of the serious incident, 3 February, he got up about 08:00, went to work about 13:00, and started a turnaround flight (Gimpo-Jeju-Gimhae-Jeju-Gimpo) about 16:05.

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

8) License No.: 11-001255 (acquired on 27 Jul. 1996).
9) Acquisition Date: 6 Aug. 2012.
10) Issue No.: 122-2593 (valid until 31 Mar. 2013).
11) License No.: 90-34-0-0136 (issued on 4 Apr. 1990).
12) Expiration Date: 27 Jan. 2015.

1.5.2 The First Officer

The FO (age 36, male) was hired by Jeju Air on 8 October 2012, and held a valid air transport pilot license[13], B737 type rating,[14] a first-class airman medical certificate,[15] an aeronautical radio operator license,[16] and level 4 ICAO English Proficiency Certificate.[17] He had accumulated 7,036 total flight hours, including 238 hours in B737 airplanes. The FO had flown 153 and 48 hours in the 90 and 30 days, respectively.

As part of the B737 transition process, the FO completed his simulator training from 2 November to 14 November 2012, and passed his proficiency check and line check on 15 November 2012 and 10 December 2012, respectively.

In the 72 hours before the serious incident, the FO had a family trip from 30 January to 1 February 2013, and on 2 February, took a rest at home and went to bed about 23:00. On the day of the serious incident, 3 February, he got up about 08:00, did light exercise, went to work about 13:00, and started his turnaround flight (Gimpo-Jeju-Gimhae-Jeju-Gimpo) about 16:05.

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

13) License No.: 11-002926 (acquired on 12 Oct. 2006).
14) Acquisition Date: 6 Feb. 2012.
15) Issue Date: 111-1451 (valid until 31 Jul. 2013).
16) License No.: 98-34-8-0038 (issued on 3 May 2012).
17) Expiration Date: 31 Oct. 2013.

1.6 Aircraft Information

1.6.1 Aircraft General

The aircraft was a B737-800 airplane manufactured[18] by the Boeing Company on 29 January 2000, leased[19] by Jeju Air on 20 July 2008, and registered in Korea. It held a valid airworthiness certificate.[20]

The airplane had accumulated 39,033 total flight hours and 24,148 total cycles at the time of the serious incident.

The aircraft was equipped with two CFM56-7B26 engines manufactured by CFMI[21], a joint venture between the US and France, and the engine information is shown in [Table 1].

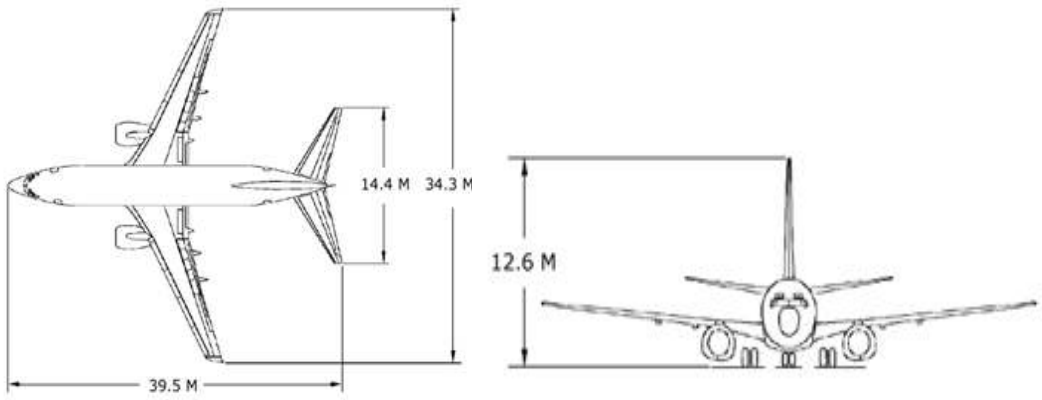
Location	Serial No.	Time Since New	Cycles	Installation Date
Left (No. 1)	875520	40,387	24,033	20 Dec. 2011
Right (No. 2)	876201	37,929	23,159	20 Sep. 2011

[Table 1] HL7780 Engine Information

1.6.2 Aircraft Dimensions

The dimensions of the aircraft are shown in [Figure 2].

18) Manufacturing Serial No.: 28827, Manual Application No.: 007.
19) Lessor: Macquarie Group, Australia.
20) Certificate No.: AB08008.
21) CFM International.



[Figure 2] Aircraft Dimensions

HL7780's standard landing roll distance set by the manufacturer is 1,633 meters, and in accordance with「Flight Safety Regulations」, paragraph 8.3.4.8 (Landing Limitations), the landing roll on runway 14R in Gimpo Airport should be done within 1,920 meters, 60% of the runway length 3,200 meters. When the runway is slippery, the landing roll should be fully completed within 1,878 meters, 115% of 1,633 meters.

1.6.4 History of Aircraft Maintenance

On the day of the serious incident, the aircraft had a total of 8 domestic flights, and for the last flight between "Jeju Airport and Gimpo Airport," the aircraft mechanic stationed in Jeju Airport carried out preflight inspection of the aircraft in accordance with preflight inspection procedures[22] and released it.

For seven days before the serious incident, there was no major repair due to an abnormal defect, and one day before the event,[23] No. 4 wheel and tire together was replaced in accordance with the maintenance manual[24] due to wear in the main landing gear's tire.

22) B737-800 Transit Check Sheet (JJA-MA-006).
23) 2 Feb. 2013.
24) AMM 32-45-11-000.

As No. 2 engine's thrust reverser cowl opening actuator rod was bent, the actuator was replaced on 7 January 2013.

1.6.4 Weight and Balance

The weight and balance data of HL7780 is shown in [Table 2].

(Unit: kg)

Takeoff Weight	64,732	Max. Takeoff Weight	79,015
Zero Fuel Weight	56,912	Max. Zero Fuel Weight	61,688
Landing Weight	61,840	Max. Landing Weight	65,317
Takeoff Fuel	7,820	Trip Fuel	2,892
Passenger Weight	14,049	Cargo Weight	1,084

[Table 2] HL7780's Weight

As shown in [Table 3], HL7780's center of gravity (C.G.) during takeoff and landing was within the permissible range of the C.G. specified by the flight manual.

(Unit: C.G. % MAC)

Category	Takeoff Weight C.G.		Landing Weight C.G.	
	Forward	Aft	Forward	Aft
Permissible Range	11.3	30.3	9.5	29.5
Actual C.G.	22.63		19.2	

[Table 3] HL7780's C.G. During Takeoff and Landing

1.7 Meteorological Information

A METAR report filed when HL7780 landed at Gimpo Airport about 22:20 is as follows:

METAR 1300Z 11004 kt 0800 R14R/1300V1600U R14L/1300V1600U SN BR BKN004 OVC020 M02/M04 Q1020hPa NOSIG = (wind 110 at 4 kt, prevailing visibility 800 m and runway 14R visibility variable from 1,300 meters to 1,600 meters with moderate snow and mist, broken at 400 ft and overcast at 2,000 ft, temperature -2°C, pressure 1020 hPa)

Gimpo Airport's weather information at 21:17 was broadcast via ATIS Sierra, and HL7780 listened to this information three times[25] by 21:57 after takeoff from Jeju Airport. The weather conditions at Gimpo Airport are as follows:

"Gimpo International Airport information SIERRA, time 1217 Zulu. Expect ILS/DME RWY14R approach. Runway condition damp. Braking action Medium to Good reported by B737. Runway 14R runway condition reading 19 30 40 by SFT at 1205 Zulu. Runway 14R touchdown wind 130 at 5 knots, visibility six hundred meters with MOD SN BR. Runway 14R touchdown RVR one thousand four hundred meters mid RVR one thousand three hundred meters end RVR one thousand three hundred meters. Cloud BKN five hundred feet, OVC three thousand feet. Temperature minus 02 centigrade, dew point minus 04. QNH 1021 hectopascal, 3015 inches. Trend weather NOSIG. Runway 14L closed due to snow removal."

When HL7780 approached and landed at Gimpo Airport after cruising at 27,000 ft, it was under the control of SEL APP and the Gimpo Control Tower and given the information on Gimpo Airport's braking action by the controller as

25) Confirmed by the CVR transcript.

shown below.

Time	Control	Weather Information
21:46:06	Approach Control	Be advised all aircraft inbound Gimpo, 2 aircraft has made a go-around due to poor braking action.
22:00:29	Arrival Control	Gimpo runway 14R braking action medium to poor.
22:10:08	Arrival Control	Attention all aircraft, now braking action 14R is medium to good reported by B737.
22:17:01	Local Control	JJA120, advise approach light insight 400 ft, braking action medium reported B737.

Gimpo Airport's heavy snow warning announced[26] via Aeronautical Fixed Telecommunication Network (AFTN) at 15:40 on 3 February 2013 is as follows:

RKSS AD WRNG 1 VALID 030840/032100 HVY SN MORE THAN 05CM = (heavy snowfall more than 5 cm between 17:40 on 3 and 06:00 on 4)

Gimpo Airport's low visibility warning announced via AFTN at 20:00 on 3 February 2013 is as follows:

RKSS AD WRNG 2 VALID 031200/031500 SFC VIS LESS THAN 600M = (visibility less than 600 meters between 21:00 and 24:00 on 3)

1.8 Aids to Navigation

HL7780 landed at runway 14R of Gimpo Airport, using the ILS/DME approach, which was in normal operation.

According to the records of the "airfield lighting on-off device" installed in

26) Announced to all domestic operators including Jeju Air.

Gimpo Airport's airfield lighting control office, approach lighting system, PAPI, runway edge lights[27], and taxiway lights were illuminated when HL7780 landed at runway 14R.

The lighting, which guides the aircraft landing on runway 14R to taxiway B1 connected to the end of the runway, is shown in [Figure 3].

[Figure 3] Runway and Taxiway Centerline Lights

The illumination of runway 14R's end lights and the paved area beyond the end of the runway are shown in [Figure 4].

[Figure 4] Runway 14R's End Lights

27) Runway edge lights are turned on/off in connection with runway threshold lights and runway end lights.

1.9 Communications

When HL7780 communicated with SEL APP and the Gimpo Control Tower to approach and land at Gimpo Airport, no communication problems were reported, and the major content of the ATC/pilot communications is shown in [Table 4].

Time	Transmitter	Content
21:37:51	JJA120	Approach, good evening, JJA120 approaching OLMEN, descending flight level 160, Sierra.
21:39:56	SAPP	JJA120 descend to 13,000, Gimpo QNH 1021.
21:40:00	JJA120	13,000, JJA120.
21:46:06	SAPP	Be advised all aircraft inbound Gimpo, 2 aircraft has made a go-around due to poor braking action.
21:50:40	SAPP	JAL95 how long would you like to hold?
21:50:46	JAL95	Well...ah...until runway 14 left open. We cannot land in the braking action very poor. (B767-300)
21:55:59	SAPP	JJA120 contact Gimpo arrival 119.9.
22:00:13	GARV	Attention all aircraft, Gimpo runway 14R touch down RVR 1,700 m, mid 1,800, roll out 1,800.
22:00:29	GARV	Gimpo runway 14R braking action medium to poor.
22:08:41	GARV	KAL1248 current RVR runway 14R 1,700 1,700 1,500 and braking action medium to poor.
22:08:50	KAL1248	Roger, KAL1248.
22:10:02	TWR	KAL1252, how about approach light insight and braking action?
22:10:06	KAL1252	Approach light insight at 550 ft and braking action medium. Not up to poor. (B737-900)
22:10:08	GARV	Attention all aircraft, now braking action 14R is medium to good reported by B737.
22:13:36	ABL883	Runway insight at 450 ft and braking action medium.
22:15:28	JJA120	Seoul arrival, JJA120 established.

Time	Transmitter	Content
22:15:32	GARV	JJA120 roger, contact Tower 118.1.
22:15:35	JJA120	118.1, JJA120 good night.
22:15:42	JJA120	Gimpo Tower, JJA120 established 14R.
22:15:47	TWR	JJA120 Tower, continue approach runway 14R.
22:15:50	JJA120	Continue 14R, JJA120.
22:17:01	TWR	JJA120, advice approach light insight 400 ft and braking action medium reported by B737.
22:17:11	JJA120	Roger, thank you.
22:17:13	GARV	JJA120 now cleared to land runway 14R, wind 080 at 4.
22:17:16	JJA120	JJA120 cleared to land 14R.
22:19:03	JJA120	Tower, JJA120 vacate via end of runway.
22:19:07	TWR	Roger.
22:19:32	TWR	JJA120 cross runway 14L, B1 then B2.
22:19:57	JJA120	JJA120 overrun.

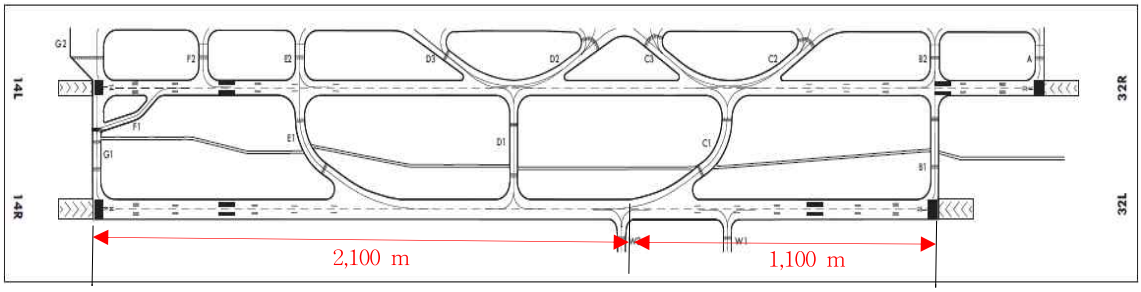
※ JJA: JEJU AIR; JAL: JAPAN AIR; ABL: AIR BUSAN; SAPP: Seoul Approach Control Approach Sector; GARV: Seoul Arrival Control Arrival Sector; and TWR: Gimpo Control Tower.

[Table 4] Major Content of ATC/Pilot Communications

1.10. Aerodrome Information

1.10.1 Aerodrome General

Gimpo Airport's runway layout is shown in [Figure 5], and runway 14R is 3,200 meters long and 60 meters wide, paved with asphalt. The distance between runway threshold and rapid exit taxiway, C1, and between C1 and right angle exit taxiway, B1, is about 2,100 meters and about 1,100 meters, respectively.



[Figure 5] Gimpo Airport's Runway Layout

1.10.2 Snow Removal Operations in Gimpo Airport

1.10.2.1 Snow Removal Criteria

When Gimpo Airport has snowfalls, Korea Airport Corporation (KAC) examines its runways in accordance with「Aviation Act」, Article 111-2,「Airport Operation Standards」, Chapter 4, Section 14, Snow Removal Plan,「Airport Operation Regulations」, Paragraph 4.15, and Appendix 2 of the same Regulations, "Gimpo International Airport Snow Plan," and if the examination results require[28] snow removal operations, it carries out the operations in cooperation with the Gimpo Control Tower.

Snow removal is categorized as the following three levels according to the accumulation rate of a snowfall and then prioritized: 1st level (at a rate of 2.5 cm/0.5 hr); 2nd level (at a rate of 3.5 cm/0.5 hr); and 3rd level (at a rate of 5 cm/0.5 hr).

1.10.2.2 Snow Removal Equipment and De-icer

As shown in [Figure 6], 8 multipurpose snow removal trucks equipped with plough, sweeper, and blower were simultaneously deployed for snow removal operations in Gimpo Airport on the day of the serious incident, and their specifications are shown in [Table 5].

28) If a snowfall accumulates and covers runway surface markings.

Category	Specifications	Unit	Standard
GENERAL	Blade Width	m	More Than 5.6 m
	Working Speed (Max, Normal)	Km/h	More Than 40 km/h
	Main Engine Power (Gross, Net)	HP/rpm	More Than 320 HP
	Working Weight	Kg	Less Than 30,000 kg
	Full Length	mm	Less Than 13,000 mm
	Full Width	mm	Less Than 2,900 mm
	Full Height	mm	Less Than 3,800 mm
	Wheel Base	mm	Less Than 6,760 mm
	Min. Ground Clearance	mm	More Than 330 mm
	Min. Turning Radius (Inner, Outer)	mm	Inner - Less Than 17 m Outer- Less Than 20 m
	Wheel Drive Type	-	More Than 4 X 4

[Table 5] Standard for Snow Removal Truck

[Figure 6] Multipurpose (Plough, Sweeper, Blower) Snow Removal Truck

After the removal of snow, the spreader vehicle shown in [Figure 7] was used to spray about 5 tons of de-icer, "GREEN SR-100[29]," onto runway 14R, which melts the remaining snow and ice on the runway by using chemical reaction that lowers their freezing point.

According to the criteria of Eco-labelling Certification, this product's quality criteria is as follows: the amount of the melted ice for 10, 30 and 60 minutes shall be more than 90% of sodium chloride at temperatures of -5°C and -12°C.

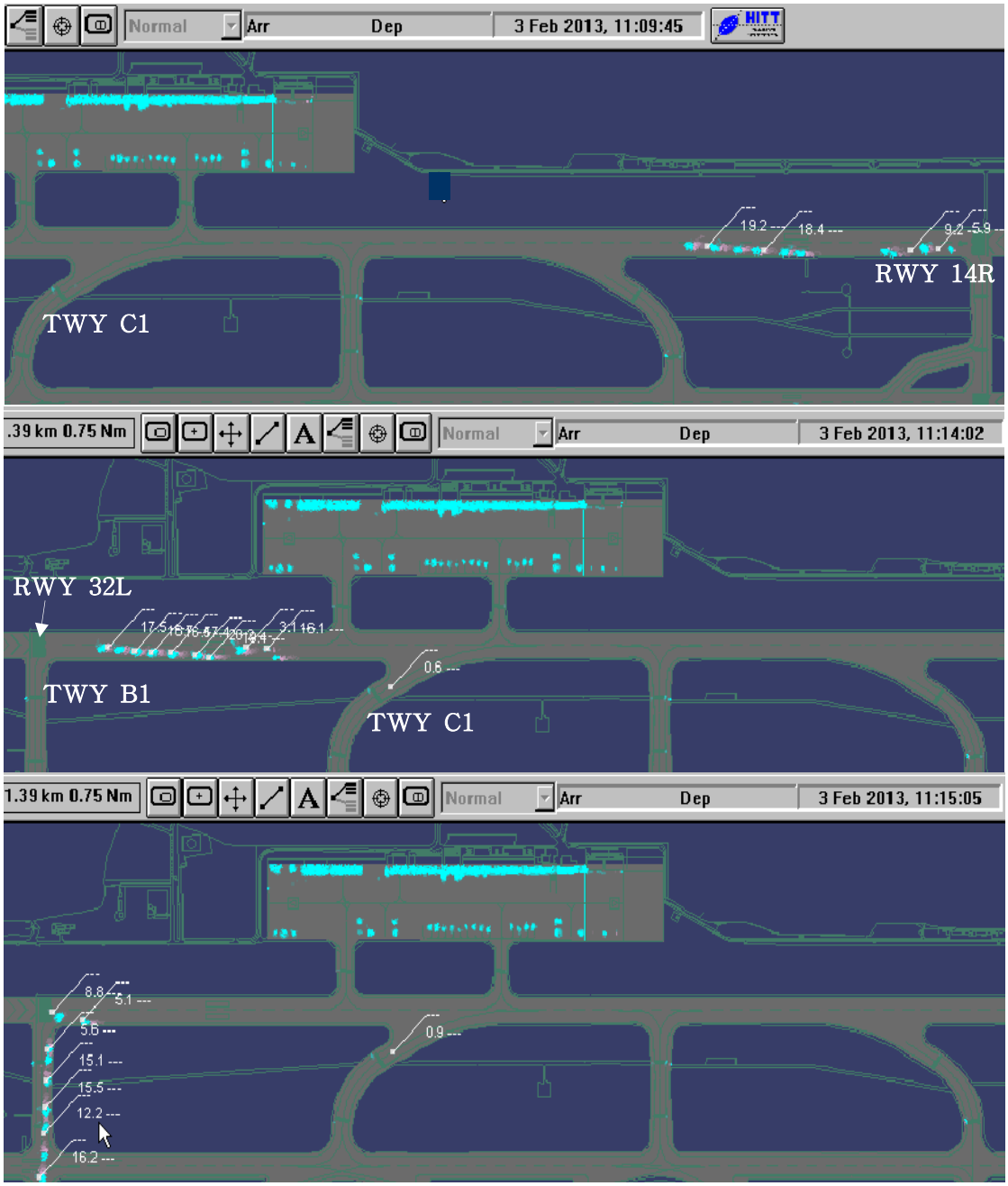
29) Product certified as "environment impact suitable" by Korea Conformity Laboratories.

[Figure 7] De-icer Spreader Vehicle

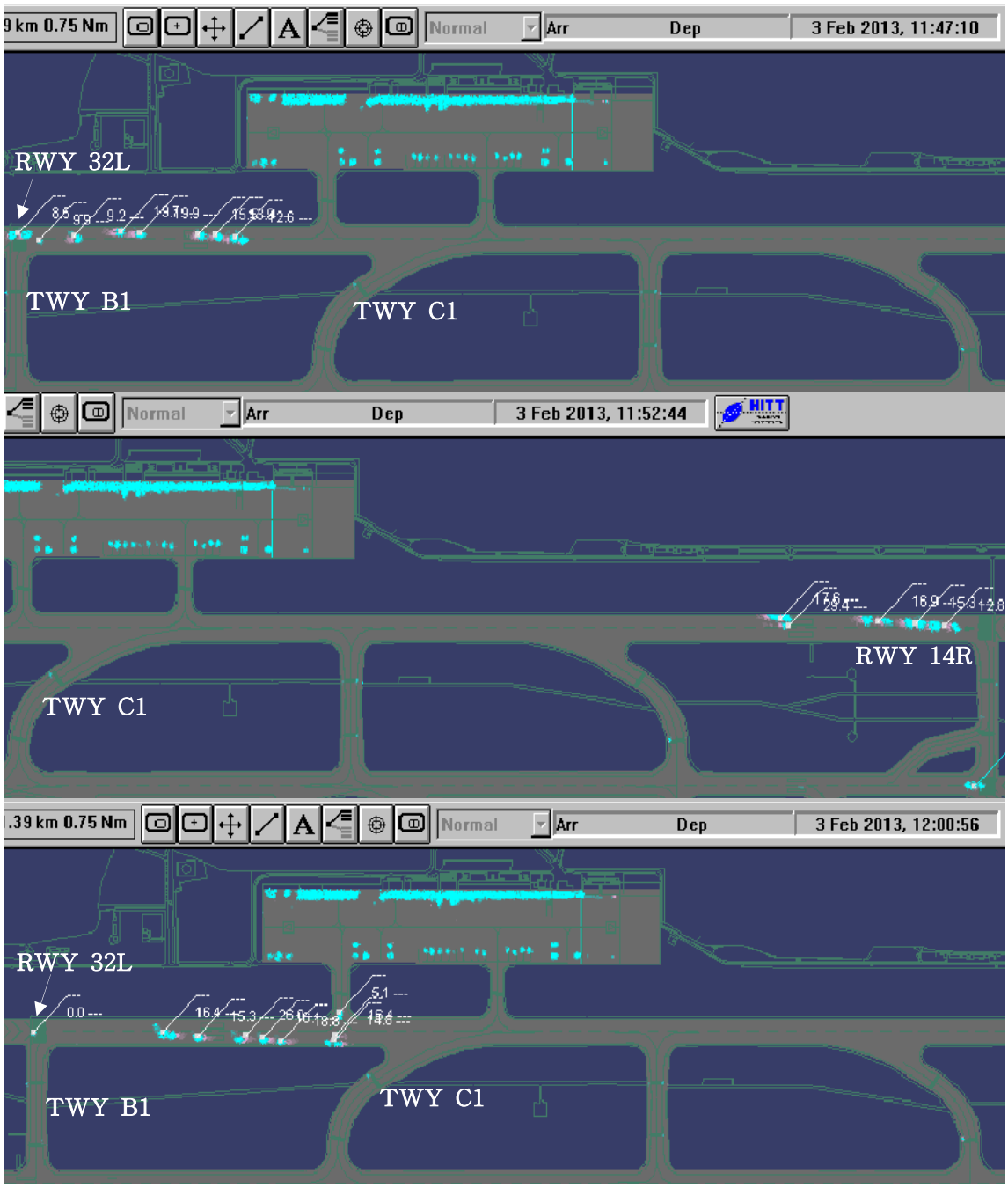
1.10.2.3 Snow Removal Operations

According to the Gimpo Control Tower's "ATC Duty Log" and KAC's "Snow Removal Log," before HL7780 landed at runway 14R about 22:20, a snow removal operation was carried out twice on both runway 14R and taxiways C and B at between 20:08 and 20:25 and between 20:46 and 21:02, respectively.

The snow removal operations conducted by 8 snow removal trucks on runway 14R were recorded by the Airport Surface Detection Equipment (ASDE)'s video recorder, as shown in [Figure 8] and [Figure 9].



[Figure 8] Initial Snow Removal Operation on Runway 14R



[Figure 9] Secondary Snow Removal Operation on Runway 14R

1.10.2.4 Actions after Snow Removal Operations

After two snow removal operations conducted before HL7780's landing at runway 14R, KAC carried out a surface friction test on runway 14R twice at 20:36 and 21:06. The test results, which were disseminated[30] to the Gimpo

Control Tower and Aeronautical Information Office, are shown in [Table 6].

The Gimpo Control Tower broadcast[31] the results of runway surface friction tests given by KAC via ATIS.

Category	Time	A Area[32]	B Area	C Area	Average
14R	20:32	0.06	0.11	0.24	0.14
32L	20:36	0.12	0.17	0.34	0.21
Average		0.09	0.14	0.29	0.18
14R	21:02	0.18	0.19	0.39	0.25
32L	21:06	0.20	0.41	0.40	0.34
Average		0.19[33]	0.30	0.40	0.30

[Table 6] Runway Friction Test Results

1.11 Flight Recorders

1.11.1 Flight Data Recorder

HL7780 was equipped with the solid-state flight data recorder (FDR, Part No.: 980-4700-042, Serial No.: 5400) manufactured by Honeywell. The FDR was retrieved from the site on 3 February and sent to the ARAIB's analysis lab for readout and evaluation.

The FDR recorded data for the 25 hours before the engine shutdown. The

30) In accordance with「Airport Operation Regulations」, Paragraph 4.5, "runway friction test results" were disseminated.
31) Code "S (sierra)."
32) The length of runway 14R is divided into three equal parts: the first 1/3 from the runway threshold is A area; the second 1/3 is B area; and the last 1/3 is C area.
33) Measured Value 0.18: Braking Action Poor, 0.30: Medium, and 0.40: Good.

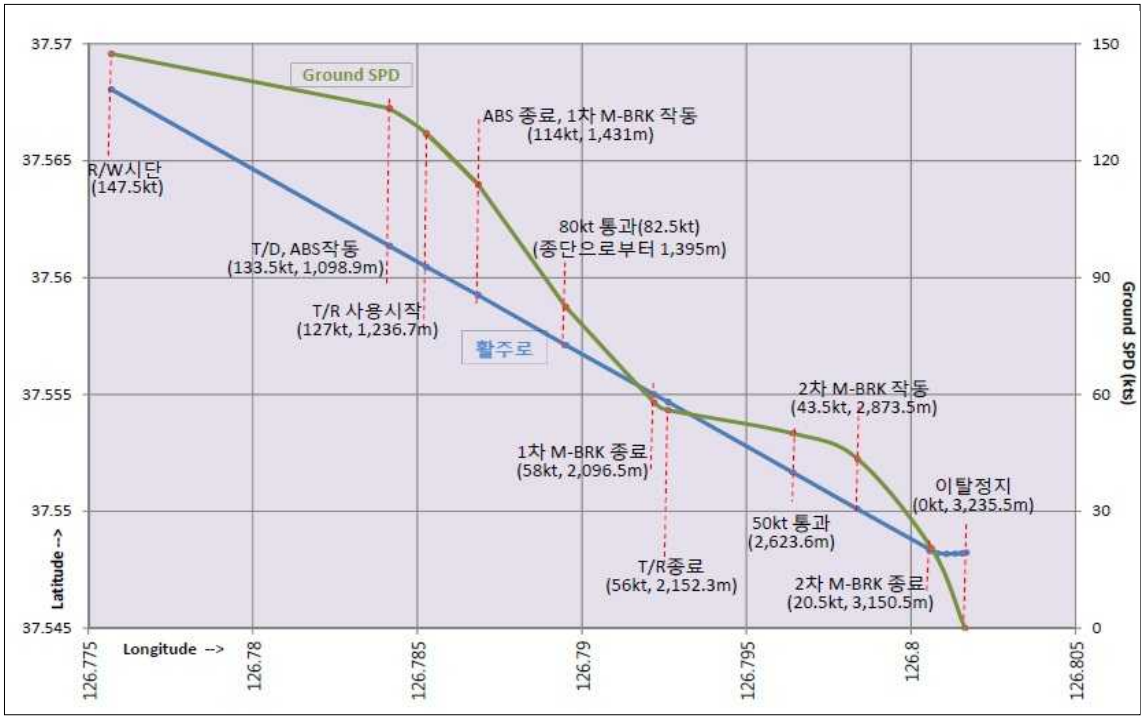
ARAIB retrieved this 25 hours worth of raw data, from which it collected about 1,100 parameters, and major parameters[34] in relation to landing maneuvers are shown in [Table 7]. Major landing maneuvers and ground speed marked from the runway threshold based on the parameters are shown graphically in [Figure 10].

Major Landing Maneuvers	Time	Location (Latitude)	Location (Longitude)	Speed (GS)	Distance from Threshold (m)
Auto Pilot Off	22:17:24	37.59592844	126.7396531	150.8	4,397.6
R/W 14R Threshold (AIP Coordinate)	22:18:24	37.56838611	126.7754444	147.5	0
Touchdown Point	22:18:39	37.56090949	126.7835984	133.5	1,098.9
Auto Brake Activation	22:18:39	37.56090949	126.7835984	133.5	1,098.9
Thrust Reverser Activation	22:18:41	37.56022285	126.7849717	127	1,236.7
Auto Brake Deactivation	22:18:44	37.55884955	126.7863450	114	1,431.0
1st Manual Brake Activation	22:18:44	37.55884955	126.7863450	114	1,431.0
Passage Through 80 kt	22:18:52	37.55678962	126.7890916	82.5	1,763.6
1st Manual Brake Deactivation	22:19:01	37.55472968	126.7918382	58	2,096.5
Thrust Reverser Deactivation	22:19:02	37.55404303	126.7918382	56	2,152.3
Passage Through 50 kt	22:19:22	37.55129645	126.7959580	50	2,623.6
2nd Manual brake Activation	22:19:31	37.54923651	126.7973313	43.5	2,873.5
2nd Manual Brake Deactivation	22:19:51	37.54786322	126.8000779	20.5	3,150.5
Halt after Overrun	22:19:59	37.54786322	126.8014512	0	3,235.5

* Vref (Landing Reference Speed: IAS): 145 kt

[Table 7] Major FDR Parameters in Relation to Landing Maneuvers

34) The distance from the runway threshold is calculated by using "dtcc.4.1" program developed by the US Department of Defence.



[Figure 10] Major Landing Maneuvers Marked from Runway Threshold

1.11.2 Cockpit Voice Recorder

HL7780 was equipped with the solid-state cockpit voice recorder (CVR, Part No.: 980-6022-001, Serial No.: CVR120-05956) manufactured by Honeywell. The CVR was retrieved from the site 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. HL7780 overran the end of the runway after about 01:59:55 elapsed time of the 120-minute stream file.

The ARAIB listened to the whole 120-minute audio information recorded by

the CVR, and the recording between departure from Jeju Airport and landing at Gimpo Airport was transcribed.

1.12 Wreckage and Impact Information

Wreckage and impact aspects are not related to this serious incident.

1.13 Medical and Pathological Information

Medical and pathological aspects are not related to this serious incident.

1.14 Fire

No fire occurred as a result of this serious incident.

1.15 Survival Aspects

At 22:20, the Gimpo Control Tower notified of the runway overrun by HL7780 disseminated the emergency situation to primary agencies,[35] including Gimpo Airport's 119 rescue team, over a telephone hot line, and at 22:23, fire trucks arrived on scene to prepare for fire.

At 22:57:52, a step car for passenger disembarkment and buses arrived on scene, and at 23:17:18, all passengers deplaned through R2 door and were transported to the passenger terminal.

1.16 Tests and Research

No tests and research were conducted in relation to this serious incident.

35) ATC Communications Division/Night-duty Room, Aeronautical Information Office, Airside Operations Control Room, 119 Rescue Team, All-source Situation Room, and Airport Weather Office.

1.17 Organizational and Management Information

The "Snow Removal Control Office" consisting of related agencies and companies established the "Gimpo International Airport Snow Plan", according to which duties of each agency stationed in Gimpo Airport in case of snow are as follows:

○ Gimpo Aviation Management Office of Seoul Regional Aviation Administration
- Place limits on aircraft operations, close runways, and issue SNOWTAM
- Control snow removal vehicles when snow removal operations in aircraft movement areas are performed

○ Gimpo Airport Weather Office of Korea Aviation Meteorological Agency
- Disseminate the latest meteorological data

○ Gimpo International Airport Office of KAC
- Perform snow removal operations in aircraft movement areas

○ Airlines and ground handling companies
- Perform snow removal operations around the aircraft parking in a ramp

The "Snow Removal Control Office" has been established under Gimpo International Airport Office of KAC in charge of snow removal, with the head of Gimpo International Airport Office as a person in charge. On the day of the serious incident, the Snow Removal Control Office was operated to perform the operations.

1.18 Additional Information

1.18.1 Statements of the Flight Crew

After the event, the ARAIB conducted an interview with the captain and the FO at its Seoul Office, and the main content stated by them is as follows:

On the day of the serious incident, the PF and the PM flew together as a pair on the same flight (Gimpo-Jeju-Busan-Jeju-Gimpo) that had begun at Gimpo Airport at 16:10.

Before departure from Jeju Airport, they were given by Jeju Air's office on the radio (frequency 129.075 Mhz), the meteorological information on Gimpo Airport, which specified "moderate snow" and braking action "medium to good."

The PF skipped the landing briefing since he did not fully recognize the seriousness of the meteorological information. Also, he planned to use "Auto Brake 3" and selected it as planned.

The flight crew were given information on braking action twice by SEL ACC: "Medium to Good," then "Medium to Poor". They should have set the brake to "Max" when given "Medium to Poor," but left it intact. Usually, the auto brake should be set to "3" and "Max" when the runway condition is "wet," and the braking condition is "poor," respectively.

During departure from Jeju Airport, the PF expected that the runway would be covered with some snow, thereby being slippery since weather conditions at Gimpo Airport were "moderate snow," but snow accumulated more than he expected.

During landing at Gimpo Airport, PAPI displayed "three red lights (slightly lower approach angle)," and the PF thought that the aircraft did not touch down beyond the touchdown zone but landed slightly lower and longer.

The runway after touchdown was partially covered with snow (more than 50%), and the PF deployed the "reverser" as usual and stowed it at 60 kt. Yet it was an inappropriate decision. If the runway had been so slippery, he should have used the reverser longer to achieve enough deceleration.

Normally, the aircraft vacates runway 14R via taxiway C1 after landing, but passing C1, the aircraft was at 80 kt, and the reverser was stowed at 60 kt. If the PF had considered, before landing, the fact that the runway after taxiway C1 was slippery, he should have made the reverser[36] ready for re-use.

Not long ago, the PF made the transition from B747-400 that uses a long runway, in the case of which, the aircraft can still have much longer runway left even after passing the first rapid exit taxiway. This time, however, he had only 1/4 of the runway left. Without considering this aspect, he passed the first rapid exit taxiway C1 and relaxed his attention to the use of the brake since he thought there was still a good margin until the end of the runway.

The PF used the wheel brake at about 100 kt, and released it after passing C1 since he thought there would be a good margin because the aircraft passed C1. As the end of the runway approached faster than he expected, he applied the "max" wheel brake, but the aircraft hardly slowed down. He thought the reason for this was that the runway was fully covered with snow that had been packed by passing vehicles or something, which he failed to consider in advance, and that he should have used a brake or a reverser to brake the aircraft harder.

36) Put the reverser in "idle" instead of stowing it and, when deemed necessary, increase the opening angle.

Rapid exit taxiways are normally used at 50 kt, whereas the speed at which right angle exit taxiways are used has yet to be determined, but it is possible to use them normally at a speed not higher than 10 kt,

When the PF tried to vacate the runway via right angle exit taxiway B1, the aircraft was at about 23 - 25 kt, which did not warrant the use of the taxiway. Then, as the aircraft could not decelerate, it went straight and veered off the runway. At this time, there was no impact, and the PF thought that the aircraft was at less than 10 kt.

The aircraft failed to reach a taxiing speed until taxiway B1 due to deceleration maneuvers that could not prepare against a slippery runway, so the PF tried to vacate the runway via B1 while turning left but it was impossible. Then, as he determined it would be better to stop at least on the paved area, he tried to turn right and go straight, but the aircraft veered to the green zone (beside the paved area).

1.18.2 Preparation for Landing

Jeju Air's flight manual specifies that the pilots should try to have a landing briefing before descent if possible, and that the landing briefing is completed after the PF and the PM discuss and cross-check general matters of approach.

Referring to the on-board checklist, the landing briefing deals with weather conditions (ATIS weather information, significant weather procedures), landing performance (remaining amount and weight of fuel, landing flaps, landing reference speed, landing distance specified in the QRH), landing runway and considerations during taxiing (runway length and condition, location for vacating the runway, taxiing path to the ramp), standard callouts, and flight crew's actions.

HL7780's CVR transcript and the flight crew's statements showed that, before landing at Gimpo Airport, the landing briefing for the preparation for landing was not conducted, and that the flight crew failed to discuss or cross-check the aircraft's landing performance in consideration of weather and runway conditions.

1.18.2.1 Landing Distance Calculation

When the aircraft lands using flaps 30, with the runway braking action "medium" or "poor", HL7780's (no winglet, B737-800) calculation criteria for landing distances specified by the aircraft manufacturer are shown in [Table 8].

According to the calculation criteria for landing distances, adjustments to HL7780's landing distances are as follows: wind 130 at 5 kt, temperature -2°C, approach speed 150 kt (V_{ref} 145 kt + 5 kt), and landing weight 61,840 kg.

ADVISORY INFORMATION

Normal Configuration Landing Distances

Flaps 30

	LANDING DISTANCE AND ADJUSTMENT (M)											
	REF DIST	WT ADJ	ALT ADJ	WIND ADJ PER 10 KTS		SLOPE ADJ PER 1%		TEMP ADJ PER 10°C		APP SPD ADJ	REVERSE THRUST ADJ	
BRAKING CONFIGURATION	65000 KG LANDING WEIGHT	PER 5000 KG ABOVE/ BELOW 65000 KG	PER 1000 FT STD/ HIGH*	HEAD WIND	TAIL WIND	DOWN HILL	UP HILL	ABV ISA	BLW ISA	PER 5 KTS ABOVE VREF30	ONE REV	NO REV
Medium Reported Braking Action												
MAX MANUAL	2085	130/-140	65/85	-110	385	100	-75	60	-60	75	220	520
MAX AUTO	2130	140/-145	65/85	-110	390	90	-70	60	-60	85	220	525
AUTOBRAKE 3	2215	140/-145	65/85	-110	395	75	-50	65	-65	110	160	470
AUTOBRAKE 2	2580	160/-180	80/105	-125	450	75	-70	75	-75	110	120	260
AUTOBRAKE 1	2795	190/-205	90/120	-140	485	100	-90	80	-85	100	240	400
Poor Reported Braking Action												
MAX MANUAL	2720	190/-195	90/125	-160	610	235	-155	75	-80	85	460	1200
MAX AUTO	2725	190/-195	90/125	-160	610	235	-155	75	-80	90	460	1210
AUTOBRAKE 3	2745	195/-195	90/125	-160	615	230	-145	75	-80	100	460	1215
AUTOBRAKE 2	2905	200/-205	100/130	-165	635	220	-145	80	-85	105	385	1065
AUTOBRAKE 1	3025	215/-220	100/140	-175	650	225	-155	85	-90	100	435	1070

Reference distance is for sea level, standard day, no wind or slope, VREF30 approach speed and two engine detent reverse thrust.
For max manual braking and manual speed brakes, increase reference landing distance by 60 m.
For autobrake and manual speed brakes, increase reference landing distance by 50 m.
Distances and adjustments for GOOD, MEDIUM, and POOR are increased by 15%.
Includes distance from 50 ft above threshold (305 m of air distance).
***For landing distance at or below 8000 ft pressure altitude, apply the STD adjustment. For altitudes higher than 8000 ft, first apply the STD adjustment to derive a new reference landing distance for 8000 ft then apply the HIGH adjustment to this new reference distance.**

[Table 8] Calculation Criteria for Landing Distances at Flaps 30

2. Analysis

2.1 General

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

HL7780 was registered in accordance with「Aviation Act」of the Republic of Korea, and held a valid airworthiness certificate. There were no defects in the deceleration system (flaps, reverser, wheel brake, etc.), and the aircraft was operated within the allowable range of weight and balance.

The ARAIB concentrated its analysis on the airport operator's snow removal operations on runways due to snowfalls during HL7780's landing at Gimpo Airport, the flight crew's recognition of the information on runway conditions, and the flight crew's pre-landing preparation and deceleration maneuvers during landing.

2.2 Snow Removal Operations on the Airport

According to the video of the Airport Surface Detection Equipment (ASDE) and the Gimpo Control Tower's ATC Duty Log, snow removal and de-icer spread operations were conducted twice on runway 14R, and taxiways C and B that would be used by airplanes to vacate the runway after landing between 20:08 and 21:06.

At 21:12, runway 14R and taxiways C and B were used for takeoff/landing and runway vacation, respectively, whereas runway 14L was closed as snow removal operations started.

The ARAIB concludes that KAC conducted snow removal operations in accordance with the snow plan and procedures specified in「Airport Operation Regulations」by making the most of its pre-organized manpower, snow removal trucks, and de-icer spread trucks.

2.3 Information on Runway Condition

2.3.1 Runway Surface Condition

According to Gimpo Airport's weather observation data, runway 14 started to be used at 21:12 when the snow removal operations were completed, and for about 1 hour 6 minutes until HL7780 landed at 22:18 and after, snow continued to fall.

During this period of time, 15 aircraft including a B747-400 airplane landed and 5 aircraft including a B777-200 airplane took off at Gimpo Airport, and two of them vacated the runway via B1 at the end of runway 14R, instead of C1.

Under these circumstances, when HL7780 landed, the runway surface between runway 14R's threshold and taxiway C1, approximately 2,100 meters in length, was covered with very little snow due to jet blast from the aircraft taking off/landing continuously. On the other hand, the runway surface between taxiway C1 and runway 14R's end, approximately 1,100 meters in length, and the paved area beyond the end of the runway, 60 meters in length, were covered with snow that has accumulated as time went on after the snow removal operations.

Yet it seems that the airport operator and the tower's controllers could not predict or verify such change in the runway surface condition since many airplanes including large aircraft continued to take off/land after the snow removal operations. As a result, airplanes taking off/landing were not given the

information about differences in the runway surface condition by section.

Meanwhile, at that time, Gimpo Airport's night operations restrictions (at 23:00) were imminent, and there were many airplanes waiting for takeoff/landing. Under these circumstances, runway 14R could not be closed to examine the part of it and conduct snow removal operations since runway 14L was closed due to snow removal operations.

Against this backdrop, it is determined that, if the Gimpo Control Tower and the airport operator had paid more attention to continuous snowfalls and considered the length of the runway used by most of the airplanes for takeoff/landing after snow removal, and taxiways the airplanes used to vacate after landing, they could have expected that the accumulated snow on the runway between C1 and B1, about 1/3 of runway 14R, might have affected the landing roll of the aircraft, and that there was the necessity to inform the aircraft taking off/landing of the runway surface condition.

In addition, when landing on a long runway like that of Gimpo Airport during continuous snowfalls, the PF and the PM should have cross-checked the fact that the unused runway sections would be covered with snow, and the expectation that there would be differences between the information on the runway condition provided by ATCs and the actual runway condition during landing. Also, they should have planned ahead and prepared for a situation where the aircraft's actual landing distance would be longer than the expected one.

2.3.2 Runway Braking Action

After snow removal operations on runway 14R had completed, the airport operator carried out a surface friction test using the Surface Friction Tester

(SFT) at 21:06, and disseminated the test results (19, 30, 40) to the Gimpo Control Tower, which broadcast them via ATIS in accordance with「ATC procedures」from 21:17. HL7780 listened twice to the meteorological information, including friction changes, which was broadcast via ATIS.

According to Jeju Air's "FCOM," Chapter 4, the flight crew shall check and apply the "estimated braking action," which corresponds to friction coefficients they listened to, and if the braking action is "Medium," the flight crew shall apply the criteria for adverse conditions. Accordingly, it is analyzed that the braking action, which HL7780's flight crew should have applied during landing, was "Poor."

In addition, before landing, HL7780 listened four times to the braking action reported by the aircraft (B737) that had landed on runway 14R when it communicated with the controller. At that time, the worst braking action received by HL7780 was "Poor."

The braking action measured and reported by the aircraft that had landed was the measurement value for the entire runway, and that it could be different from the braking action for about 1/3 of the runway unused during landing.

Therefore, the ARAIB concludes that, if the aircraft that lands without using the entire length of the runway reports braking action, the tower should announce that the braking action for the unused runway (last 1/3 section) was "not measured" or "unknown" when informing other airplanes of the braking action, so that it can prevent the pilots from misunderstanding.

Also, when the flight crew are informed of the braking action measured by other aircraft by the tower, they should not regard it as the braking action for the entire runway, and that, during or before the landing briefing, the PF and

the PM, through a cross-check, should comprehensively analyze the length of the runway, landing distance of the applicable type, and whether or not snow continues to fall, and expect and prepare for the braking action under adverse conditions.

2.4 Flight Crew's Response to Snowfalls

2.4.1 Pre-landing Preparation

Before HL7780 descended out of cruise flight, the PF and the PM listened to the information on Gimpo Airport's weather and runway conditions and failed to do the landing briefing specified in the "operation procedures of the flight manual," but they were able to find V_{ref} from the cockpit panel without it.

According to the CVR transcript, the flight crew were aware of the fact that weather conditions at Gimpo Airport continued to change, but the PF and the PM did not discuss specific actions on landing distance, range of using a deceleration system, and coordination of their tasks, which are related to variables such as varying weather conditions during approach or landing and slipperiness of the runway.

As a result, the PM was not given the opportunity to express his opinions about or cross-check whether or not the PF's unilateral landing plan was appropriate, and failed to appropriately monitor and advise during approach or landing phases.

A landing briefing or standard callouts are a means of avoiding wrong decision-making and communicating between the PF and the PM in order to execute flight maneuvers suitable for the flight environment during landing, so they are required to be conducted, but it is determined that the PF's skipping

them due to his bad habit or inattention caused by landing at a familiar airport can lead to dangerous consequences.

Such a wrong habit of the flight crew within the cockpit should be certainly corrected, and, to this end, in case of landing at the airport under unusually adverse weather conditions, related flight procedures need to be more materially improved or established so that the PF and the PM can share accurate and appropriate information.

2.4.2 Maneuvers During Landing

According to the FDR data, the sequence and positions of touchdown and the operation of the braking system while HL7780 was landing at runway 14R are shown in [Figure 11].

2.4.2.1 Touchdown

When HL7780 landed at 14R using the ILS precision approach, the aircraft approached slightly below 3-degree glidepath during final approach, and its speed was maintained within the landing reference speed range when passing the threshold of the runway.

Hl7780 touched down on the runway at 133.5 kt, lower and longer than normal, and its touchdown point[37] was 1,098.9 meters from the runway threshold, which was 698.9 meters from the aiming point marking or 198.9 meters from the touchdown zone. This resulted in longer landing distance because HL7780 used the braking system about 700 meters later than normal touchdown.

37) Jeju Air's FOM, paragraph 11.1.9.1 specifies that the "touchdown zone is chosen between the first 3,000 ft of the runway length or 1/3 of the runway length, whichever is shorter," and that "attention should be paid not to touch down before 1,000 ft for safe landing."

[Figure 11] Positions of the Braking System Operation During Landing

2.4.2.2 Use of Auto and Manual Brakes

When HL7780 approached Gimpo Airport, the PF selected "Auto Brake 3" considering the runway surface condition. At the time of the touchdown, the auto brake started to be activated, and in about 5 seconds when the manual brake started to be used, was deactivated (at ground speed of 114 kt).

It is determined that the PF's transfer to the manual brake after the use of the auto brake for 5 seconds (distance of about 333 meters) at a higher speed than when the runway condition was normal[38] resulted from his inattention to the fact that the runway braking action was "Poor" with snowfalls.

As stated by the flight crew, if they had set the auto brake[39] to "Max" when notified of the braking action as "Medium to Poor," it would have been easier for them to decelerate the aircraft, but the PF's choice to select "auto brake 3" resulted from his failure to seriously consider weather and runway surface conditions.

When HL7780 passed the rapid exit taxiway C1 at about 58 kt while decelerating during landing roll, the PF decided not to vacate the runway via C1, kept rolling to the end of the runway, then deactivated the manual brake.

As a result, the aircraft approached the end of the runway faster than the PF expected, and when it reached at about 44 kt, about 330 meters from the runway threshold, the PF realized that the aircraft ran too fast to vacate the runway via right angle exit taxiway B1 connected to the runway threshold, and used the manual brake for about 20 seconds. Yet the aircraft failed to slow down to the taxiing speed since the runway was covered with snow, with the distance to the runway threshold remaining short.

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38) The manual brake is normally used at 60 - 80 kt when the runway condition is normal.
39) The auto brake can deliver a stabler braking performance, including anti-skid, than the manual brake.

2.4.2.3 Use of the Reverser

According to the FDR data, the reverser was deployed at about 127 kt, about 2 seconds after the touchdown and used as "Max" for about 21 seconds, then it was fully stowed when the aircraft passed C1 at about 56 kt.

At this time, as the PF determined that the aircraft was moving too fast to vacate via C1, he continued the landing roll up to the end of the runway and mistakenly believed that there remained a good distance from C1 to the end of the runway, so he fully deactivated the braking system, thereby resulting in slow deceleration.

As the PF realized that the end of the runway was approaching faster than he expected, he used the manual brake, but the aircraft did not slow down as much as he wanted. At this time, if he had set the reverser at "Idle" instead of stowing it, this would have helped him reuse it to prevent the aircraft's overrun.

Yet the PF failed to use the reverser as an emergency means under the circumstances because he neither carefully considered nor prepared for the runway conditions when he had received the information on the runway braking action of "Medium to Poor" with snowfalls, and because he executed the same deceleration maneuvers as ones under normal runway conditions.

2.5 Runway Braking Action and Landing Distances

Jeju Air's POM specifies that, when applying the runway braking action to predict landing distances, if the braking action is at a medium level like "Medium to Poor," the criteria for adverse conditions shall be applied, so in this case, the braking action in consideration of landing distances or deceleration was "Poor."

The flight crew skipped the landing briefing, and the PF planned to select "Auto Brake 3" at flaps 30 and landed as planned. Based on these two conditions, however, the PF and the PM should have considered the braking action that they had received before landing, weather information (wind, temperature), and landing weight, and confirmed landing distances according to the criteria specified in the QRH, as shown in [Table 8].

If "Auto Brake 3" and "Auto Brake Max" are used when the braking action is "Poor," landing distances will be 2,512 meters and 2,482 meters, respectively, as shown in [Table 9], which means the use of "Auto Brake Max" can reduce landing distance by 30 meters than "Auto Brake 3."

Braking Configuration	Landing Distance (m) & Adjustment					
	Ref. Dist. (65,000 kg)	Weight (62,000 kg)	Wind	Temp.	App. Speed	Landing Dist.
Auto "Max"	2,725 m	-117 m (-195×0.6)	-80 m (160×0.5)	-136 m (-80×1.7)	+90	2,482 m
Auto "3"	2,745 m	-117 m (-195×0.6)	-80 m (160×0.5)	-136 m (-80×1.7)	+100	2,512 m

[Table 9] Landing Distance for "Poor" Braking Action

According to the statements of the flight crew, when they were informed by the ATC after selecting "Auto Brake 3" that the braking action was "Medium to Poor," they left the brake setting intact, but they should have changed it into "Auto Brake Max." This indicates that they prepared for landing under the impression that the braking action was "Medium."

If "Auto Brake 3" and "Auto Brake Max" are used when the braking action is "Medium," landing distances will be 2,072 meters and 1,971 meters, respectively, as shown in [Table 10], which means the use of "Auto Brake Max" can reduce landing distance by 100 meters than "Auto Brake 3."

Braking Configuration	Landing Distance (m) & Adjustment					
	Ref. Dist. (65,000 kg)	Weight (62,000 kg)	Wind	Temp.	App. Speed	Landing Dist.
Auto "Max"	2,130 m	-87 m (-145×0.6)	-55 m (110×0.5)	-102 m (-60×1.7)	+85	1,971
Auto "3"	2,215 m	-87 m (-145×0.6)	-55 m (110×0.5)	-111 m (-65×1.7)	+110	2,072

[Table 10] Landing Distance for "Medium" Braking Action

[Table 9] and [Table 10] show that selecting the braking action as "Poor" rather than "Medium" has a stronger influence on landing distances than selecting the braking configuration as "Auto Brake 3" or "Auto Brake Max."

In addition, if the landing distance had been calculated based on the "Poor" braking action, HL7780 could have reduced enough speed to fully stop at the position, 380 - 410 meters from taxiway C1 as shown in [Figure 5], regardless of the selection of "Auto Brake 3" or "Auto Brake Max." At this position, HL7780 could have safely vacated the runway via taxiway B1 at the end of the runway since the distance from HL7780 to the end of the runway was still 688~718 meters, but the airplane failed to reduce enough speed to vacate via B1 and veered off the runway.

The ARAIB concludes that HL7780 rolled off the runway because the flight crew deactivated the deceleration system altogether before the aircraft decelerated enough to vacate the runway during landing roll since they neither conducted the landing briefing nor considered the runway condition carefully before landing, and because the flight crew failed to respond to the slippery condition in the last 1/3 section of the runway that was covered with snow and almost unused by airplanes taking off/landing since they mistakenly believed that the remaining distance to the end of the runway was enough.

3. Conclusions

3.1 Findings

1. The flight crew held an airman certificate required for operation and nothing significant before flight or no health problems that could have affected the flight were found.

2. HL7780's maintenance records shows that there were no defects in the deceleration system (flaps, reverser, wheel brake, etc.) before this serious incident.

3. The aircraft was loaded with suitable fuel for flight and operated within the allowable range of weight and balance.

4. When HL7780 landed at Gimpo Airport, a heavy snow warning and a low visibility warning were issued at Gimpo Airport, and the airport was in low visibility conditions due to moderate snow and mist.

5. Snow removal and de-icer spread operations were conducted twice on runway 14R, and taxiways C and B about 1 hour and 18 minutes before HL7780 landed.

6. After snow removal operations on runway 14R, the airport operator carried out a surface friction test using the Surface Friction Tester (SFT) and disseminated the test results (19, 30, 40) to the Gimpo Control Tower, which broadcast them via ATIS.

7. For about 1 hour and 12 minutes after snow removal operations on runway 14R, 15 and 5 airplanes landed and took off, respectively, and two of the

airplanes that had landed vacated runway 14R via taxiway B1 at the end of the runway.

8. For about 1 hour and 12 minutes before HL7780's landing after snow removal operations on runway 14R, the last 1/3 section of the runway was covered with more snow than the rest 2/3 section of the runway, but the information about this was not given to airplanes.

9. Despite continuous snowfall, the flight crew failed to separately consider runway 14R's surface condition and braking action in the last section of the runway before landing, except the braking action informed by the Gimpo Control Tower.

10. Before landing, ATCs provided HL7780 four times with the braking action reported by the aircraft that had landed on runway 14R.

11. When HL7780 landed, lights on runway 14R and all the related lights were illuminated, and no problems caused by snowfalls and snow removal operations were reported.

12. HL7780 touched down 198.9 meters from the touchdown zone, and at the time of the touchdown, the auto brake started to be activated and in 5 seconds when the manual brake started to be used, was deactivated. The manual brake was deactivated when the aircraft was passing taxiway C1 at 58 kt and 30 seconds later, reactivated when the aircraft was about 330 meters from the end of the runway at about 44 kt, and used for 20 seconds until the runway overrun.

13. HL7780's reverser was deployed at 127 kt, about 2 seconds after the touchdown and fully stowed when the aircraft passed C1 at 56 kt.

14. The PM failed to adequately monitor or give advice on the PF's landing maneuvers because the PF's failure to do the landing briefing led to their failure to discuss not only the selection of the type of flight (auto or manual), landing configuration, and range of using a deceleration system, but also coordination of their tasks, which are related to variables such as weather conditions during landing and slipperiness of the runway.

15. The PF's transfer to the manual brake after the use of the auto brake for 5 seconds at a higher speed than when the runway condition was normal resulted from his inattention to the fact that the runway braking action was "Poor."

16. The PF fully stowed the reverser when the aircraft passed taxiway C1 at 56 kt because he failed to neither predict the runway condition after C1 nor consider the possibility of reusing the reverser due to his incorrect interpretation of the remaining distance.

17. Selecting the braking action as "Poor" rather than "Medium" has a stronger influence on landing distances than selecting the braking configuration as "Auto Brake 3" or "Auto Brake Max."

3.2 Causes

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

1. Since the flight crew failed to carefully consider the runway condition before landing, they failed to neither predict and select the braking action of the runway under adverse conditions during landing nor share information on landing distance and deceleration plan between the PF and

the PM.

2. The PF not only disengaged the deceleration system altogether before the aircraft decelerated enough to vacate the runway during landing roll but also failed to respond to the slippery condition in the last 1/3 section of the runway since he mistakenly believed that the remaining distance to the end of the runway was enough.

Contributing to this serious incident were (1) the PF's failure to conduct the landing briefing; and (2) non-provision of the runway surface information after snow removal operations on runway 14R for the flight crew.

4. Safety Recommendations

As a result of the investigation of the serious incident that occurred to HL7780 at Gimpo Airport on 3 February 2013, the ARAIB makes the following safety recommendations:

To Jeju Air

1. Seek measures to get rid of your PFs' bad habit of skipping the landing briefing and not sharing the landing plan with PMs, which undermines the purpose of the landing briefing and standard callouts. (AIR1301-1)

2. Modify flight procedures to be more specific, and incorporate them in training and evaluation programs for pilots so that PFs and PMs can surely share information about the selection of the type of flight (auto or manual) and landing configuration as well as the use of the deceleration system when landing on the runway under adverse conditions including snowfall. (AIR1301-2)

3. With emphasis, give the flight crew training in the following so that they can predict and prepare: understanding of the results of the runway surface friction test; the fact that the braking action reported by other airplanes (PIREP) is not a real-time representative quality of the landing runway; the fact that, with continuous snowfall, the surface condition of the last section of the runway that is barely used by airplanes taking off/landing can be worse than expected. (AIR1301-3)

4. Seek measures to add a callout (e.g. 40 kt) to Standard Callouts & Response Procedures to ensure safe deceleration during landing roll on the slippery runway. (AIR1301-4)

To Korea Airport Corporation

1. Modify「Airport Operation Regulations」to incorporate a procedure under which the surface condition of the last 1/3 section of the runway barely used by most airplanes is assessed at regular and short intervals (e.g. every 30 minute) in consultation with the control tower and these assessment results are notified to the control tower. (AIR1301-5)