Aircraft Serious Incident Report

Runway Excursion during Landing Roll
Jade Cargo International Company Ltd., People's Republic of China
B747-400F
B2440
Incheon International Airport, Republic of Korea
16 April 2009

8 June 2010

Aviation and Railway Accident Investigation Board
Ministry of Land, Transport and Maritime Affairs
Republic of Korea

According to the provisions of the Article 30 of the Aviation and Railway Accident Investigation Act of the Republic of Korea, 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 and recommended as follows;

The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents, and it is not the purpose of the activity to apportion blame or liability. Any judicial or administrative proceedings to apportion blame or liability should be separate from any investigation conducted under the provisions of this Annex.

Thus, this incident investigation report issued as the result of the investigation on the basis of the Aviation and Railway Accident Investigation Act of the Republic of Korea and the Annex 13 to the Convention on International Civil Aviation, 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, Jade Cargo International Company Ltd., People's Republic of China B747-400F, B2440, Incheon International Airport, 16 April 2009. Aircraft Serious Incident Report ARAIB/AIR-F0901. Seoul, Republic of Korea

Korea Aviation and Railway Accident Investigation Board (ARAIB) is a government organization for independent investigation of aviation and railway accident, and the accident investigation shall be carried out based on the Aviation and Railway Accident Investigation Law of the Republic of Korea and Annex 13 of the Convention on International Civil Aviation.

The objective of accident or incident investigation of the Korea Aviation and Railway Accident Investigation Board is not to apportion blame or liability but to prevent accidents and incidents.

The main office is located near Gimpo International Airport.

Address: 100 Haneulgil, Gangseo-gu, Seoul, 157 - 815, Republic of Korea
Tel.: 02 - 6096 - 1032
Fax: 02 - 6096 - 1031
e-mail: araib@korea.kr
URL: http://www.araib.go.kr

Contents

Jade Cargo International Company Ltd., People's Republic of China
Boeing B747-400F
B2440
Incheon International Airport, Republic of Korea
16 April 2009 (11:50 UTC)[1)]

Synopsis

On 16 April 2009 about 11:50, a B747-400F cargo (registration B2440, hereinafter referred to as "B2440"), operated by the Jade Cargo International Company Ltd., which departed the Frankfurt Main International Airport of Germany, landed normally on runway 33R at the Incheon International Airport (hereinafter referred to as "Incheon Airport") of the Republic of Korea, and then veered off the runway at the process of the landing roll.

When the PIC (hereinafter referred to as "captain") activated the reverse thrust systems after touchdown on the runway, the reverse thrust systems of the No. 1, 2 and 3 engines operated normally but the No. 4 did not operate. Then the No. 4 forward thrust lever increased to the intermediate thrust position[2)] while the No. 1, 2 and 3 reverse thrust systems were operating, and then the forward thrust lever of the No. 4 engine suddenly came up to the maximum thrust position[3)] for unknown reason.

B2440 veered off the runway abruptly to the left in an asymmetric thrust condition, eventually stopping in the grass about 2,170 m from the runway threshold. A captain, a 2nd captain, a first officer and a maintenance personnel were on board the aircraft. There were no injuries due to this incident, and there were only minor damage to all four engines and minor cuts to tires.

The Aviation and Railway Accident Investigation Board (hereinafter referred to as "ARAIB") notified ICAO, the NTSB of the Unites States of America and the CAAC of the Peoples Republic of China of the serious incident, and the CAAC and the NTSB assigned their Accredited Representatives.

The ARAIB reviewed general information, aircraft system and flight crew's performance in the analysis of this serious incident investigation, and developed findings derived from the factual information and analysis of this incident in three categories: findings related to probable causes, findings related to risk, and other findings, and issued two (2) safety recommendations to the Jade Cargo International Company Ltd., on the basis of the results of the serious incident investigation.

1) Unless otherwise indicated, all times in this report are UTC (Universal time coordinated).
2) N1 72 - 74 % RPM
3) N1 108 - 109 % RPM

1. Factual Information

1.1 History of Flight

B2440 with three flight crew and one maintenance personnel on board[4] took off from the Frankfurt Main Airport of Germany as a ferry flight on 16 April 2009 at 09:59:13 and landed on the runway 33R of the Incheon Airport at 20:50:00 through the ILS DME Rwy 33R approach.

[Photo 1] General view of the Incheon Airport runways

B2440 made a normal touchdown at a speed of 129 knots on the runway centerline about 1,700 ft from the runway 33R threshold, and then the captain operated the reverse thrust system in accordance with the normal procedures. The reverse thrust system of the No. 1, 2 and 3 engines operated[5] normally but the reverse thrust system of the No. 4 engine did not operate.

At 20:50:18, the forward thrust lever of the No. 4 engine increased to the intermediate thrust position[6], and at 20:50:24, the forward thrust lever of the No. 4 engine suddenly came up to the maximum thrust position[7] by unknown reason.

Due to this, B2440 became asymmetric thrust condition and started to veer abruptly to the left. The No. 1, 2 and 3 reverse thrust levers working at this time were down at 20:50:25, and then they were raised up again at 20:50:30.

An attempt was made to regain directional control by using the brakes and the right rudder, but B2440 made excursion to the left of the runway hitting a runway distance marker sign, and at 20:50:40, stopped[8] near about 2,170 m from the runway 33R threshold.

---

4) When the aircraft landed, all of the captain, first officer, 2nd captain (observer seat), maintenance person (observer seat) were in the cockpit, and the captain performed landing.
5) Increases up to maximum 67% N1
6) Increased from the thrust lever angle 43.4° to 54.7°
7) Increased from the thrust lever angle 54.7° to 84.9°
8) Landing runway direction 334°, stopped nose direction 210°

1.2 Injuries to Persons

Injuries	Crew	Passenger	Total in the aircraft	Other
Fatal	0	0	0	0
Serious	0	0	0	0
Minor	0	0	0	0
No injury	4	0	4[9)]	-
Total	**4**	**0**	**4**	**0**

1.3 Damage to Aircraft

When the aircraft ran off the runway, all four engines were suffered minor damage caused by foreign objects sucked into the engines, and the No. 2 engine cowl had a damage of 100 x 40 cm by hitting the runway distance marker sign, and two nose tires suffered minor cuts. So the repair of the No. 2 engine cowl, replacement of the two nose tires, repair and special cleaning of all four engines incurred damages of about 3.5 billion won (3 million USD).

1.4 Other Damage

As B2440 ran off the runway, it hit one runway distance marker sign and one runway edge light to break, and one stop sign was broken due to the engine blast.

1.5 Personnel Information

1.5.1 The Captain

The captain (age 47, male) was employed[10)] by the Jade Cargo in October 2007 and was qualified as B747-400 captain in June 2008. He held a valid Airline Transport Pilot Licence[11)], B747-400 type rating[12)] and Class 1 Airman Medical Certificate[13)].

The captain's total flying time was 16,000 hours[14)], including 640 hours on the B747-400 aircraft, 432 hours as captain on the same type of aircraft, 83:58 hours for the latest three months[15)], and 34:08 hours for the latest one month. He completed regular line check on 5 November 2008 and regular flight simulator check on 8 November 2008.

The captain stated that after arriving at Frankfurt on 13 April 2009, he took a rest in the hotel until he had this flight on 16 April.

---

9) Maintenance personnel onboard
10) C560 captain until Sept. 1990, B757 captain until Sept. 2006, B767 captain until Oct. 2007.
11) Qualification number 000248196105173001(issued on 23 April 2008 by CAAC)
12) B747-400, B757/767, Multi-engine Land
13) Certificate number: N0026813, inspection date: 16 October 2008
14) B747-400: 640 hours, B767: 9,440 hours, B757: 1,455 hours, C560: 546 hours, Others: 4,495 hours
15) Flying time limitation: by the CAAR: 100 hours/1 month, 270 hours/3 months, 1,000 hours/1 year

1.5.2 The First Officer

The first officer (age 34, male) was employed[16] by the Jade Cargo in August 2008 and was qualified as first officer of B747-400 in March 2009. He held a valid Airline Transport Pilot Licence[17], multi-engine type rating[18] and Class 1 Airman Medical Certificate[19].

The first officer's total flying time was 6,800 hours[20] including 2,728 hours on the B747-400 aircraft, 59:11 hours for the latest three months and 25:46 hours for the latest one month. He completed flight simulator check on 9 November 2008 and line check on 19 March 2009.

The first officer had no flights between 22 March and 13 April 2009. After he arrived at the Frankfurt on 14 April as a deadheading crew, he took a rest[21] at the hotel until he had the event flight on 16 April.

1.6 Aircraft Information

1.6.1 Aircraft History

B2440 was a B747-400F built[22] in November 2006 by the Boeing Company, and introduced by the Jade Cargo international Company and registered[23] with the CAAC on 26 December 2006, and had a valid airworthiness certificate[24].

Its total service time was 8,129:04 hours and the number of take-offs and landings were 1,172 cycles. It had its No. 2 engine changed in December 2007 and the first C Check[25] was made in October 2008.

1.6.2 Weight and Balance

The weight and balance data of B2440 were as follows;

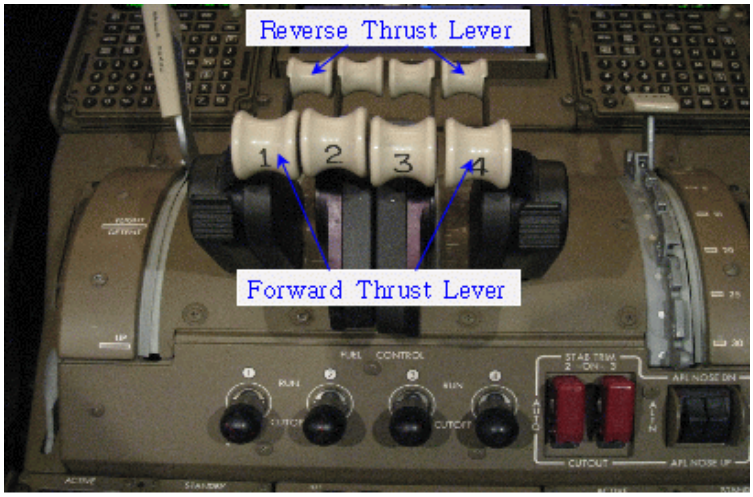
· Zero fuel weight (ZFW)..... 166,857 kg (maximum 277,144 kg)
· Take-off fuel (TOF)..... 95,000 kg
· Takeoff weight (TOW)..... 261,857 kg (maximum 412,769 kg)
· Trip Fuel (TIF)..... 82,030 kg
· Landing weight (LDW)..... 179,827 kg (maximum 302,092 kg)
· Landing weight center of gravity (LDW C.G % MAC): 27.21 % MAC
※ (Limit range): 13.5% MAC ~ 31.5 % MAC

16) B1900D captain until Dec. 2004, B747-400 first officer until March 2007, E190 first officer until Jan. 2008, B767 first officer until July 2008.
17) Qualification number: 000001197410213001(issued on 23 December 2008 by CAAC)
18) Multi-engine Land
19) Certificate number: 08111982, inspection date: 1 August 2008
20) B747-400: 2728 hours, B767: 296 hours, B1900D: 4,450 hours, Others: 674 hours
21) Arrived on 14th at 05:58, departed on 16th at 00:45, Minimum rest time : 10 hours (by CCAR 121.483)
22) Manufacturing number: 35171
23) No. : NR2409(26 December 2006)
24) Number: AC2381(21 November 2006)
25) Carried out every 6,000 hours

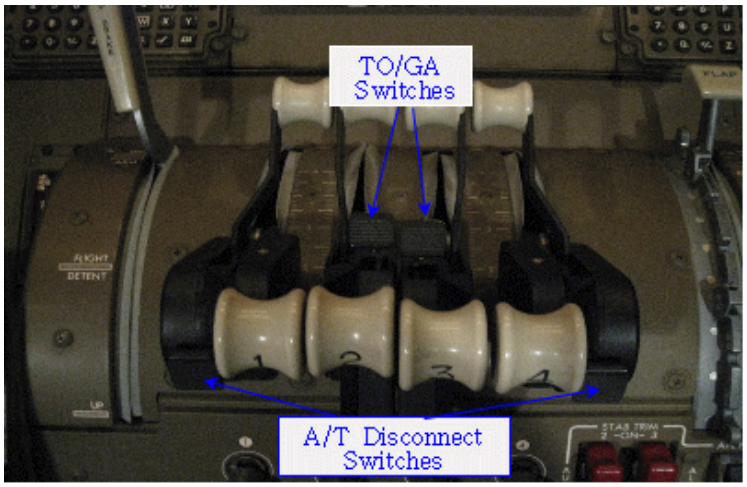
1.6.3 Aircraft Systems

1.6.3.1 Thrust Levers

As shown in [Photo 2] and [Photo 3], the thrust levers were composed of the forward thrust control levers and the reverse thrust control levers, respectively, for four engines, two Takeoff/Go-around switches (TO/GA switch)[26] and two autothrottle disconnect switches[27].



[Photo 2] Thrust levers



[Photo 3] TO/GA and A/T disconnect switches

1.6.3.1.1 Forward Thrust Levers

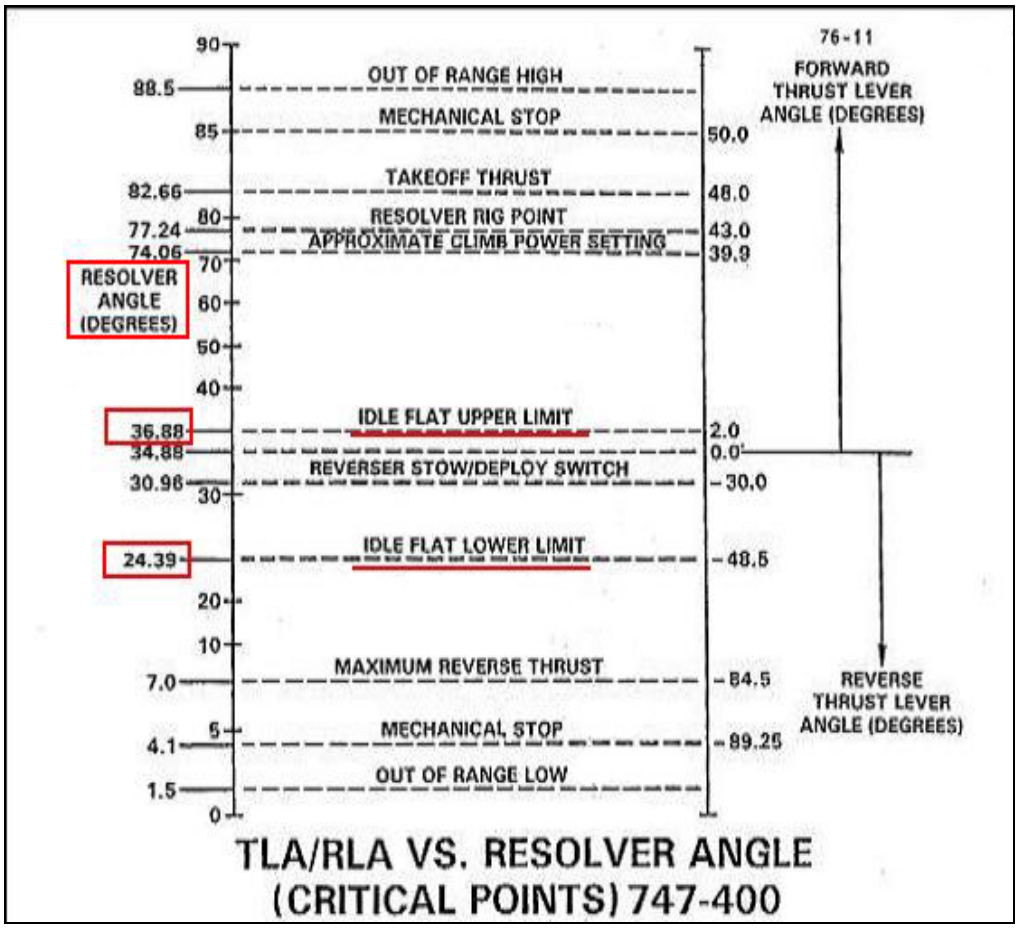
Moving these levers forward and backward[28] controls the forward thrust of the aircraft to move forward. Each forward thrust lever can only be advanced when the respective reverse thrust lever is in the down position.

---

[26] Mounted on No. 2 and No. 3 forward thrust levers
[27] Mounted on No. 1 and No. 4 forward thrust levers
[28] Pushing forward increases the forward thrust

1.6.3.1.2 Reverse Thrust Levers

Controlling these levers up/down[29] controls reverse thrust. Each reverse thrust lever can only be moved when the respective forward thrust lever is in the closed position. For this aircraft, as shown in [Fig. 1], in order for any reverse thrust lever to move, the forward thrust lever angle shall not be in the position exceeding 36.88°.



[Fig. 1] Thrust lever angle

1.6.3.1.3 Takeoff/Go-around (TO/GO) Switch

Pushing the TO/GA switch, below 50 knots and flaps out of the up position on the ground, activates the autothrottle in the THR REF mode at reference thrust limit selected on the THRUST LIMIT page. If not pushed below 50 knots, the A/T operation is inhibited until reaching 400 feet of altitude.

Pushing the TO/GA switch, after lift-off[30], removes the takeoff derates, and if the autothrottle is in the HOLD mode, it operates autothrottle in the THR REF mode. Pushing it at altitude between 50 feet and 400 feet selects the TO/GA roll mode, and pushing it above 400 feet selects the TO/GA roll mode and pitch mode.

---

[29] Raising them to the interlock position operates reverse thrust and raising them up increases thrust.
[30] If lift off with takeoff reference thrust limit appearing

Pushing the TO/GA switch during approach[31] with flaps out of the up position, activates the autothrottle in the THR mode, and selects the TO/GA roll mode and pitch mode. The second push activates the autothrottle in the THR REF mode.

But the TO/GA switches are inhibited two seconds[32] after the radio altitude decreases through five feet on landing. The TO/GA is enabled again three seconds after the radio altitude increases through five feet for a rejected landing or touch and go.

Ten seconds after all four reverse thrust levers are down, the autothrottle is armed until the flaps are retracted. Pushing a TO/GA switch while the autothrottle is armed, activates the autothrottle in THR REF mode.

1.6.3.1.4 Autothrottle Disconnect Switch

Pushing this switch disconnects the autothrottle, illuminates the master caution lights, and displays the EICAS[33] message of "> AUTOTHROT DISC".

The second pushing resets the master caution lights and the EICAS message. But the autothrottle remains armed.

1.6.3.2 Autothrottle System

The autothrottle system provides thrust control from takeoff through landing. The autothrottle operation is controlled from the MCP (Main Control Panel) and the CDUs (Control Display Units).

The MCP allows the mode and speed selection. The CDU allows the FMC[34] reference thrust limit selection. The autothrottle can be operated without using the flight director or the autopilot.

1.6.3.2.1 Autothrottle Operation

The autothrottle system moves the thrust levers to control speed or thrust, depending on the active mode. The thrust levers can be manually positioned without disconnecting the autothrottle.

After a manual positioning and release, the autothrottle repositions the thrust levers to comply with the active mode selected. The autothrottle system does not reposition the thrust levers while in the HOLD mode.

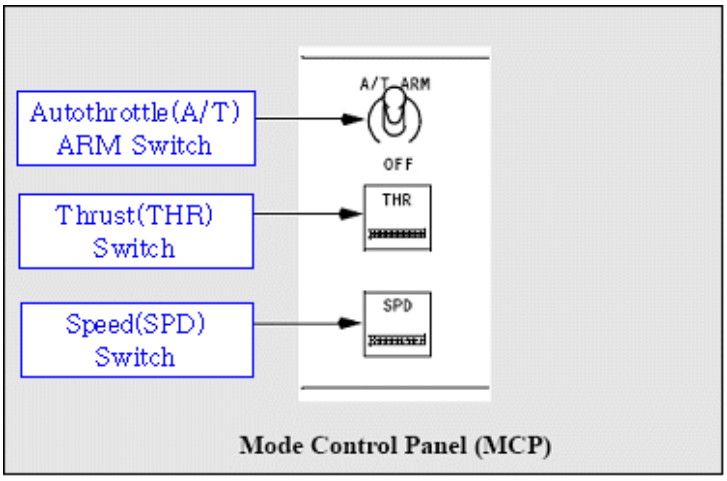
1.6.3.2.2 Autothrottle Disconnection

The autothrottle system can be disconnected manually by positioning the autothrottle arm switch to the OFF position [Fig. 2] or by pushing any one of two autothrottle disconnect switches [Photo 3].

Autothrottle disconnection occurs if a fault in the active autothrottle mode is detected, or when a reverse thrust lever is raised to the reverse idle.

---

31) If flaps are not fully up or glide slope is captured
32) Touchdown condition
33) Engine Instrument and Crew Alerting System
34) FMC : Flight Management Computer

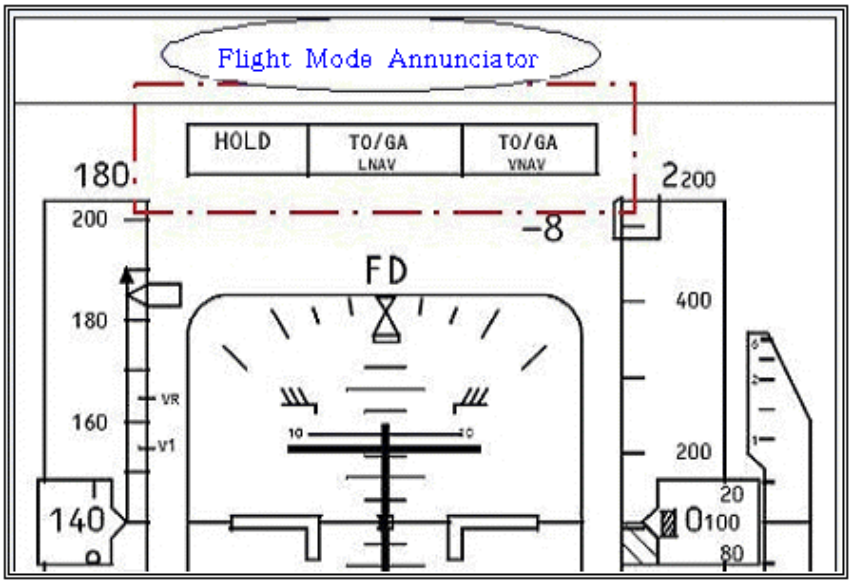


[Fig. 2] Automatic thrust control system switches

The autothrottle also disconnects and cannot be reactivated if both the FMCs (Flight Management Computers) fail or two or more engines are shut down. The autothrottle disconnects when the FMC Master switch is switched, but can be reactivated. Electrical faults or interruptions may also cause the autothrottle to disconnect.

1.6.3.3 Flight Mode Annunciation

Flight mode annunciations are displayed in 3 boxes located above the primary flight display as shown in [Fig. 3]. Mode annunciations, from left to right, are the autothrottle mode[35], roll mode[36] and pitch mode[37]. The active modes displayed at the top of the flight mode annunciation boxes are in large green letters. The armed modes are displayed in smaller white letters at the bottom portion of the flight mode annunciation boxes.



[Fig. 3] Flight mode annunciation system

[35] Autothrottle mode : THR, IDLE, THR REF, SPD, HOLD
[36] Roll mode : HDG HOLD, LOC, HDG SEL, ROLLOUT, LNAV, TO/GA, ATT
[37] Pitch mode : TO/GA, VNAV ALT, ALT, G/S, V/S, FLARE, VNAV PTH, FLCH SPD, VNAV SPD

1.6.3.4 Thrust Reverser

Each engine has a pneumatically actuated fan air thrust reverser. Each thrust reverser is powered by bleed air from the related engine. The reverse thrust is available only on the ground.

An interlock mechanism in the thrust lever assembly prevents simultaneous movement of the forward and reverse thrust levers. The reverse thrust levers can be raised[38] only when the forward thrust levers are in the closed position. When the reverse levers are down, the reversers are locked in the stowed position.

Raising the reverse thrust levers to the idle detent locks the forward thrust levers in position. Bleed air unlocks and extends the reversers aft to the deployed position. A thrust reverser status annunciator displays above the digital indicator of each NI indication. The annunciator is displayed in amber when the related reverser is unlocked or moving. The annunciation changes color to green when the reverser is fully deployed. The interlock then releases and the reverse thrust levers can be moved to full reverse.

Pushing the reverse thrust levers to the full down position retracts the reversers to the stowed (forward) and locked position. The REV indication changes color back to amber while the reverser is moving. When the reverser is stowed and locked, the REV indication is removed. The forward thrust levers cannot be moved forward until the reverse thrust levers are fully down.

The thrust reversers are protected against deploying inadvertently. If a reverser unlocks and deploys inadvertently, the reverser system applies bleed air to stow and lock the reverser.

1.7 Meteorological Information

According to the Incheon Airport special weather report[39] observed at 20:55, which is the most approximate to the time of B2440 runway excursion, the wind at the touchdown zone of runway 33R was 310° at 5 knots, visibility and sky condition were very good.

> SPECIAL RKSI 161155Z WIND RWY 33L TDZ 300/05KT END 280/05KT RWY 33R TDZ 310/05 END 290/05KT CAVOK T09 DP04 QNH 1012HPA QFE 1012HPA TREND NOSIG=

1.8 Aids to Navigation

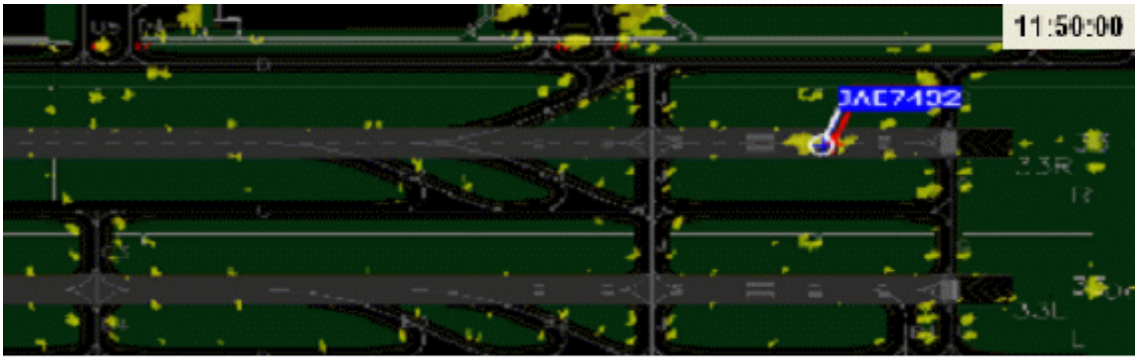
The instrument approach procedures used by B2440 to land at the Incheon Airport was “ILS/DME RWY 33R.” According to the record of the ILS alarm history monitor which the Incheon International Airport Corporation offered, the instrument landing system installed at the runway 33R was operating normally. And according to the airport lighting system ON/OFF record, the lights installed on the runway 33R were on at the time when B2440 landed.

According to the video record of ASDE, B2440's touchdown and landing roll on the runway 33R are as shown in [Fig. 4] and [Fig. 5], and deviating to left from the runway centerline, excursion and stopping on grass are shown in [Fig. 6] to [Fig. 8].

---

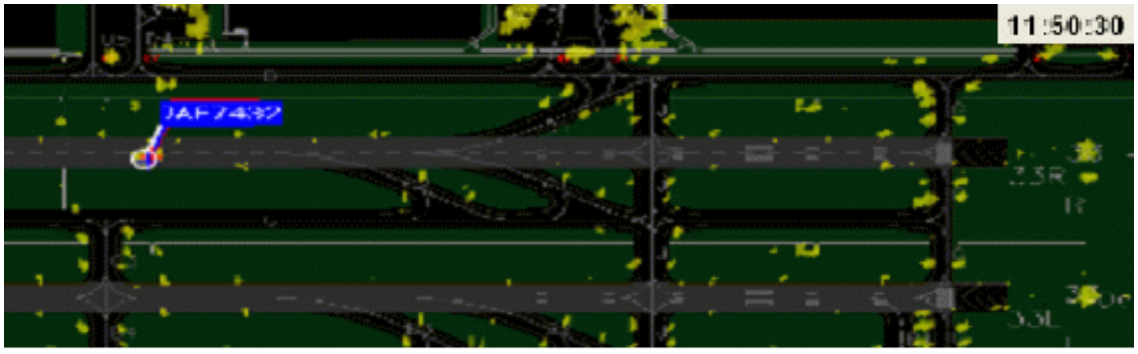
[38] Lever is raised up when using reverse thrust

[39] Observed by Incheon Aviation Meteorological Agency



[Fig. 4] Touchdown on the runway 33R

[Fig. 5] Landing roll



[Fig. 6] Position deviating from the runway centerline

[Fig. 7] Position away from the runway

[Fig. 8] Position at which it stopped after excursion

1.9 Communications

According to the records of the cockpit voice recorder of B2440 and air traffic control recorder, there were no records of communication problems between the flight crew and approach control, and between the flight crew and control tower.

1.10 Aerodrome Information

The runway 33R on which B2440 landed is 3,750 m long and 60 m wide and is paved with asphalt. The place at which B2440 stopped after runway excursion is grass between taxiway C and runway 33R and is located about 2,170 m from the threshold of runway 33R.

1.11 Flight Recorders

1.11.1 Cockpit Voice Recorder

B2440 was equipped with a solid-state cockpit voice recorder which was manufactured[40] by the L-3 Communications and can record for 2 hours.

The ARAIB prepared a transcript from the time when B2440 passed altitude 1,000 feet for landing to the time when it made a full stop after its landing and runway excursion.

1.11.2 Flight Data Recorder

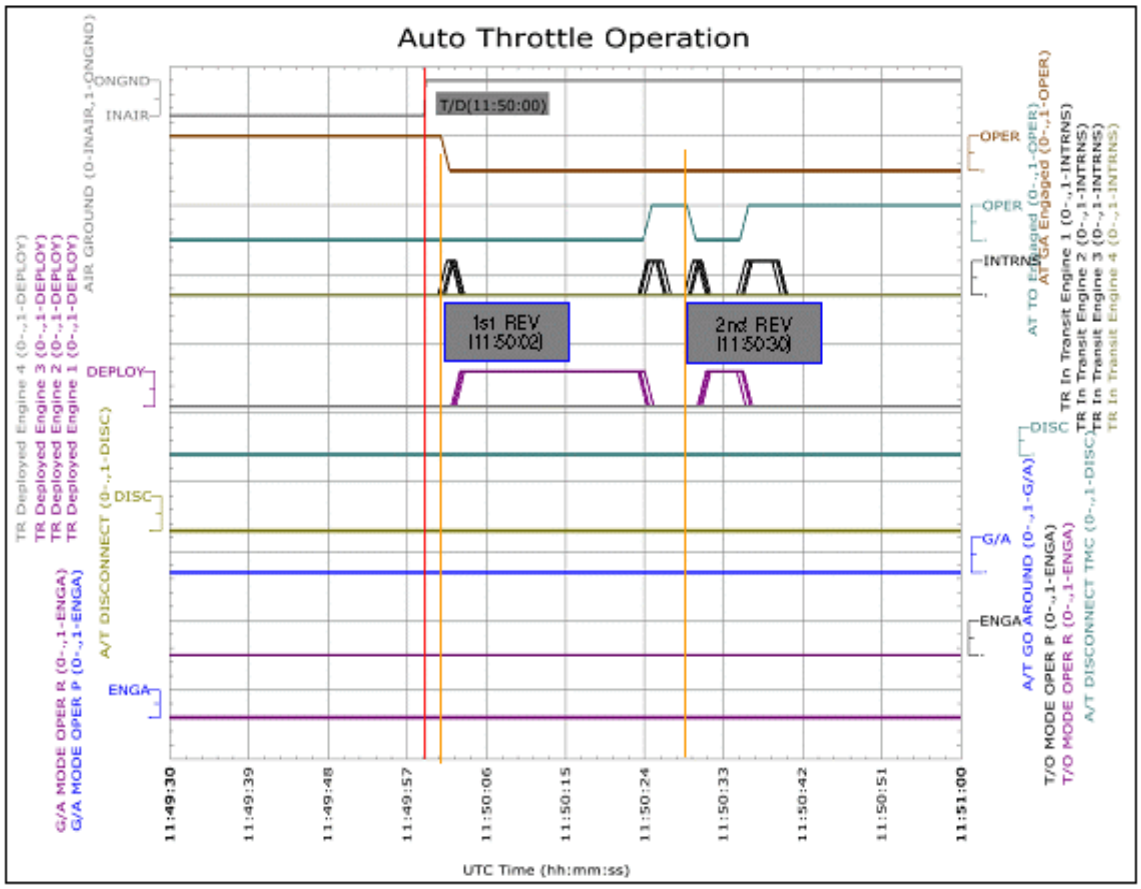
B2440 was equipped with a solid-state flight data recorder which was manufactured[41] by the L-3 Communications and can record for at least 25 hours. The ARAIB excerpted and analyzed major data at the time of landing and made an animation so as to be helpful for analyzing the data.

As shown in [Fig. 9], B2440 touched down at 11:50:00 and the autothrottle, which was standing by in the GA mode during approach, stood by[42] in the TO mode after touchdown. After landing, the No. 1, 2 and 3 reversers operated two times, and the No. 4 reverser did not function at all.

It touched down with the autothrottle disconnected, and there was no record of the go-around made by the autothrottle. And the G/A mode and the T/O mode were not operated.

---

[40] Part Number: 2100-1020-00, Serial Number: 000142629
[41] Part Number: 2100-4043-00, Serial Number: 000439824
[42] It does not stand by while the thrust reverser (TR) is deployed.



[Fig. 9] Major mode parameters

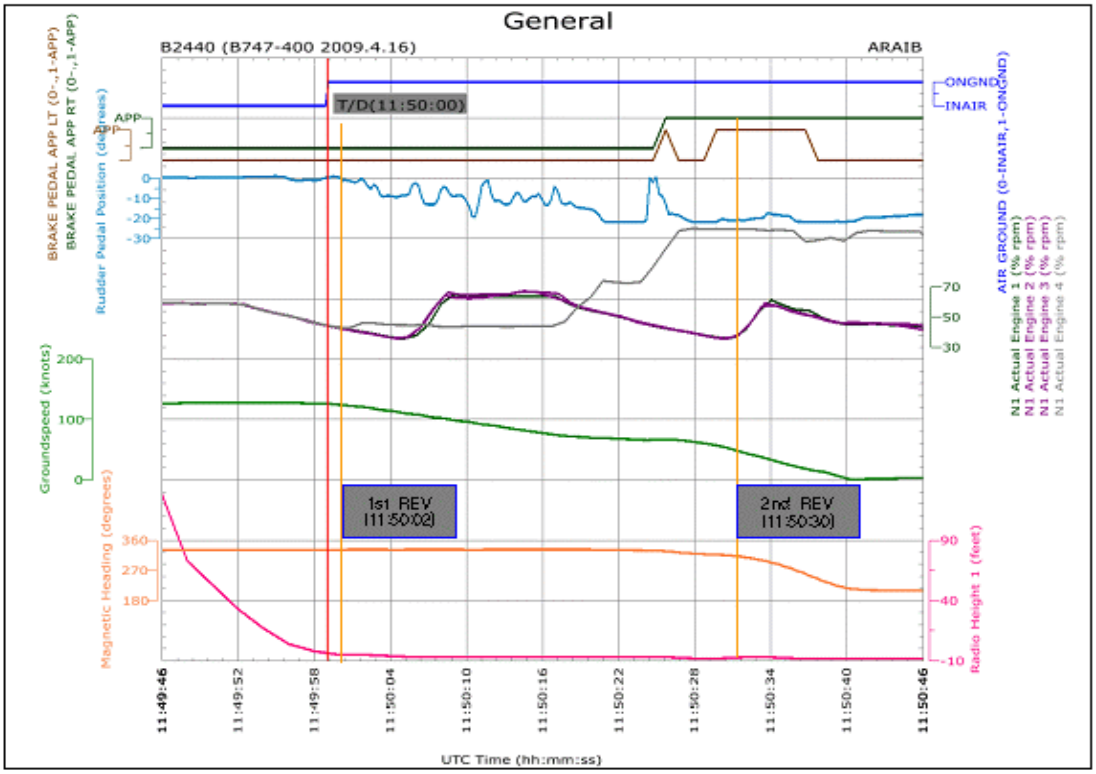
Looking at the engine N1 in [Fig. 10], it shows the reverse thrusts of the No. 1, 2 and 3 engines were used 2 times, but the reverse thrust of the No. 4 engine was not used. And while the No. 4 forward thrust lever raised to the maximum thrust position, the reverse thrusts of the No. 1, 2 and 3 engines were used for the second time. Even when the aircraft stopped completely, the N1 of the No. 4 engine was indicating maximum thrust.

The rudder pedal was used to the right while the No. 1, 2 and 3 reversers were operating, and at the moment when the No. 4 engine thrust increased suddenly and both brake pedals were applied it came to neutral, and after that, it was used continuously to the right even after the aircraft stopped.

The left brake pedal was applied two times momentarily as the No. 4 engine thrust increased suddenly, but the right brake pedal was applied continuously even after the aircraft had stopped.

As shown in [Fig. 11], the No. 4 forward thrust lever position increased from 35° to 43.8° at the stage where the reverser started to deploy after touchdown. After that, it rose to 62.9° with the reverser deployed, and when the reverse started to close, it increased to 84.9° position.

As shown in [Fig. 12], the FMA Thrust Mode was not annunciated and there was no record of the A/T GO AROUND. And it shows that the maximum N1 of the No.1 engine was 109 % RPM.



[Fig. 10] Major parameter data

Throttle Lever Position Engine 1	Throttle Lever Position Engine 2	Throttle Lever Position Engine 3	Throttle Lever Position Engine 4	TR Deployed Engine 1 (0-,1-	TR Deployed Engine 2 (0-,1-	TR Deployed Engine 3 (0-,1-	TR Deployed Engine 4 (0-,1-	TR In Transit Engine 1 (0-,1-	TR In Transit Engine 2 (0-,1-	TR In Transit Engine 3 (0-,1-	TR In Transit Engine 4 (0-,1-
35,2	34,5	34,6	35								
35,2	35,5	36,2	44,3								
33,8	24,6	24,4	43,8							INTRNS	
24,8	24,6	24,3	43,6					INTRNS	INTRNS	INTRNS	
22,9	23,2	23,4	43,8	DEPLOY	DEPLOY	DEPLOY					
23	23	22,5	43,4	DEPLOY	DEPLOY	DEPLOY					
22,1	19,7	17,6	43,6	DEPLOY	DEPLOY	DEPLOY					
16,2	16,2	15,5	43,4	DEPLOY	DEPLOY	DEPLOY					
15,1	15,3	14,6	43,1	DEPLOY	DEPLOY	DEPLOY					
14,9	15,1	14,6	43,1	DEPLOY	DEPLOY	DEPLOY					
15,1	15,3	14,8	43,2	DEPLOY	DEPLOY	DEPLOY					
15,1	15,3	14,6	43,2	DEPLOY	DEPLOY	DEPLOY					
14,9	14,9	14,6	43,2	DEPLOY	DEPLOY	DEPLOY					
14,9	14,6	14,6	43,2	DEPLOY	DEPLOY	DEPLOY					
14,9	14,6	13,9	43,2	DEPLOY	DEPLOY	DEPLOY					
14,9	14,1	14,1	43,2	DEPLOY	DEPLOY	DEPLOY					
14,9	14,1	14,4	43,2	DEPLOY	DEPLOY	DEPLOY					
14,9	14,2	14,9	43,4	DEPLOY	DEPLOY	DEPLOY					
15,5	15,6	17,9	45,7	DEPLOY	DEPLOY	DEPLOY					
18,3	19,2	21,1	49	DEPLOY	DEPLOY	DEPLOY					
19,7	19,5	22,5	52,7	DEPLOY	DEPLOY	DEPLOY					
24,6	24,3	25,3	55,2	DEPLOY	DEPLOY	DEPLOY					
25,1	24,1	25,1	54,8	DEPLOY	DEPLOY	DEPLOY					
24,8	23,7	24,6	54,7	DEPLOY	DEPLOY	DEPLOY					
24,8	23,7	25,1	62,9	DEPLOY	DEPLOY	DEPLOY					
34,6	34,6	35	84,4	DEPLOY					INTRNS	INTRNS	
34,6	34,6	34,8	84,9					INTRNS	INTRNS	INTRNS	
41,1	34,5	34,5	84,9					INTRNS			
37,8	34,6	34,6	84,9								
34,8	35,5	35,3	84,7								
24,3	24,6	25,5	84,9							INTRNS	
24,6	24,4	18,8	84,2					INTRNS	INTRNS	INTRNS	
17,8	17,4	16,9	84,2	DEPLOY	DEPLOY	DEPLOY					
17,6	16,9	16,2	84,2	DEPLOY	DEPLOY	DEPLOY					
15,8	16,3	16,3	84,2	DEPLOY	DEPLOY	DEPLOY					
16	16,5	19,5	84,9	DEPLOY	DEPLOY	DEPLOY					
42,4	34,6	35,3	84,9	DEPLOY	DEPLOY					INTRNS	
38,1	34,6	35,3	81,9					INTRNS	INTRNS	INTRNS	
38,1	34,6	35,9	84,9					INTRNS	INTRNS	INTRNS	
38,1	38,3	43,8	68,4					INTRNS	INTRNS	INTRNS	
43,6	43,8	43,9	84,6					INTRNS	INTRNS		

[Fig. 11] Thrust Resolver Angle

Computed Airspeed (knots)	Magnetic Heading (degrees)	Rudder Pedal Position (degrees)	FMA Lateral Mode	FMA Vertical Mode	FMA Thrust Mode	N1 Actual Engine 1 (% rpm)	N1 Actual Engine 2 (% rpm)	N1 Actual Engine 3 (% rpm)	N1 Actual Engine 4 (% rpm)	A/T GO AROUND (0=,,1=G/A)
129	331.5	-1	LOC	G/S		46	46	45	45	.
129	331.9	0	LOC	G/S		44	44	43	43	.
128	331.9	-1	LOC			43	42	42	43	.
125	332.2	-2	LOC			41	40	40	46	.
123	332.6	-4	LOC			40	39	39	46	.
119	332.2	-8	LOC			38	38	37	45	.
116	331.9	-9	LOC			37	36	36	45	.
112	332.2	-9	LOC			36	36	37	45	.
110	332.6	-4	LOC			38	42	44	45	.
108	332.2	-13	LOC			45	54	56	44	.
103	332.6	-4	LOC			59	64	66	43	.
99	332.6	-9	LOC			65	63	65	44	.
97	331.9	-14	LOC			63	62	65	44	.
94	331.9	-4	LOC			64	63	65	44	.
93	332.6	-11	LOC			64	64	65	44	.
88	332.2	-13	LOC			64	65	65	44	.
86	332.6	-8	LOC			64	67	67	44	.
81	332.6	-9	LOC			64	67	66	44	.
78	332.6	-13	LOC			64	66	64	44	.
77	332.6	-7	LOC			64	65	61	47	.
72	332.2	-12	LOC			59	59	58	57	.
72	332.2	-15	LOC			56	56	55	63	.
72	331.9	-17	LOC			54	54	53	74	.
70	331.5	-22	LOC			52	52	51	73	.
70	330.8	-22	LOC			50	50	49	72	.
68	330.1	-22	LOC			48	48	46	73	.
69	329.4	-21	LOC			46	46	45	84	.
69	328.4	-8	LOC			44	44	43	96	.
70	325.5	-17	LOC			42	42	41	107	.
67	321.7	-20	LOC			41	40	40	109	.
66	319.2	-22	LOC			39	39	38	108	.

[Fig. 12] The record of Speed, FMA and A/T GO

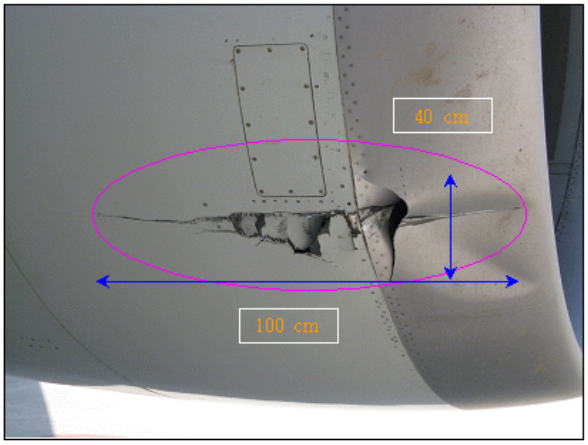
1.12 Wreckage and Impact Information

B2440 made excursion to the left of the runway hitting the 6,000 feet runway distance marker sign, and as shown in [photo 4], stopped near about 2,170 m from the runway 33R threshold.

As shown in [Fig. 5], when the aircraft ran off the runway, the No. 2 engine cowl hit the runway distance marker sign to cause a damage of 100 x 40 cm to the engine cowl. All four engines ingested foreign objects (blades of grass and soil, etc), and two nose tires suffered minor cuts.

[Photo 4] After runway excursion

As B2440 ran off the runway, it hit one runway distance marker sign and one runway edge light to break as shown in [Photo 6] and [Photo 7], and as shown in [Photo 8] and [Photo 9], due to the tires and engine blast, the grass area was damaged and one stop sign was broken.



[Photo 5] Damaged No. 2 engine cowl

[Photo 6] Runway distance marker sign damaged

[Photo 7] Runway edge light damaged

[Photo 8] Grass area damaged

[Photo 9] Stop sign damaged

1.13 Medical and Pathological Information

The B2440 flight crew members held valid class 1 aviation medical certificates and stated that they did not consume any alcoholic drink or any medication before the flight.

1.14 Fire

There was no fire in this incident.

1.15 Survival Aspects

1.15.1 Responses of the Control Tower

According to the air traffic control communication record, B2440 ran off the runway during landing roll after touchdown on the runway 33R at 20:50:00 and stopped on the grass at 20:50:41, and at 20:50:54, B2440 notified to the control tower “JAE7432, we had a locked reverser, we are off the runway."

To this, the controller responded at 20:50:58 "Stand by" and asked continuously to the pilot of B2440 11 times until 21:06:44 to exactly understand what happened.

According to the Incheon Control Tower crash phone record, at 20:51:12 the controller notified by crash phone "This is Control Tower. The Jade Cargo aircraft that has just landed has run off the runway," and then called the names of the respondents of seven addressees[43)].

To this, the Aeronautical Information Office and Medical Office responded "Yes, we have received" but the remaining five addressees including the Main Fire Station responded "Yes", "Yes, this is the Main Fire Station," or "Yes, thank you. This is the Fire Branch Station."

According to the record of the watchroom of the Main Fire Station direct telephone, the duty officer of the watchroom called the Control Tower controller at 20:53:50 to say, "Just a while ago the crash phone sounded so I answered it. What kind of situation is it? It was cut before I answered the phone, so I could not receive the message." So, in the process of talking to find out what happened, it took one minute and 25 seconds and at 20:55:15 the dialogue ended.

1.15.2 Responses of the Fire Station

At 20:55:27 an order to move was issued from the watchroom to the Main Fire Station and the Fire Branch Station by broadcasting, and between 20:59:27 and 21:00:00 eleven fire engines, two ambulances and forty nine fire fighters including the fire chief from the Main Fire Station and Fire Branch Station A arrived at the site. But when they arrived at the site, there was nothing to do with the fire fighting or rescue operations.

1.16 Tests and Research

Investigators of the ARAIB and the personnel of the Jade Cargo International Company made visual inspection and operational inspection on 9 May 2009 on the thrust lever parts[44)] in the B2440

43) Ramp control, Situation Management Center, Fire Detachment, Fire Branch Office, Mobile Local Management Office, Aviation Information Office, Medical Office

44) Thrust Lever Assembly, Autothrottle Brake Assembly, Thrust Lever Position Resolvers, etc.

parked at the Incheon Airport in accordance with the Task Card (SWC76-2009-01) issued by the Jade Cargo International Company on the basis of the inspection instruction provided by the Boeing Company and found nothing abnormal.

Following the recommendations of the NTSB, it was checked whether the throttle components of the thrust lever to be free and operated normally. A BITE (Built-In-Test-Equipment) test was made on the autothrottle computer and the central maintenance computer, and confirmed no abnormalities.

1.17 Organization and Management Information

The Jade Cargo International Company is a venture company founded in October 2004 by joint investment[45)] by the Shenzhen Airlines, Lufthansa Cargo and the German Development Finance Institute and its main office is located at the Shenzhen, Gwangdong Province, China.

The Jade Cargo International Company started flight operation in August 2006, and at present provides air services with six B747-400 ERF[46)] to 14 cities, including Seoul, of China, Europe, India, Pakistan, the Middle East and Africa.

1.18 Additional Information

1.18.1 Captain's Statements

According to the captain, a normal approach was conducted to the runway 33R at the Incheon Airport. The weather was very good. The autopilot and autothrottle were disconnected at around 600 feet, and normal landing using Autobrake 2 was accomplished.

He tried to operate all reversers after touchdown on the runway, but the No. 4 did not go over the detent. After about three attempts, on approaching 80 knots, once he stowed all reversers, the No. 4 forward thrust lever came up abruptly, and the aircraft veered to the left. An attempt was made to regain a directional control, but the aircraft left the runway onto the grass. No one was injured.

1.18.2 First Officer's Statements

The aircraft touched down at 11:50 after a normal approach. Decreasing through 80 knots, the second captain called “No reverse on the No. 4 engine.”

The captain closed the reversers, and the aircraft began to veer off the runway centerline. Even though I applied full right rudder after the captain, the aircraft left the runway and proceeded onto the grass.

---

45) Shenzhen Airlines (51%), Lufthansa Cargo AG (25%), the German Development Finance Institute DEG (24%)

46)) Extended Range Freighter

2. Analysis

2.1 General

The flight crewmembers of B2440 were certified and qualified, and took appropriate rest prior to the scheduled flight, and no medical abnormal conditions which might have adversely influenced their performance, were found.

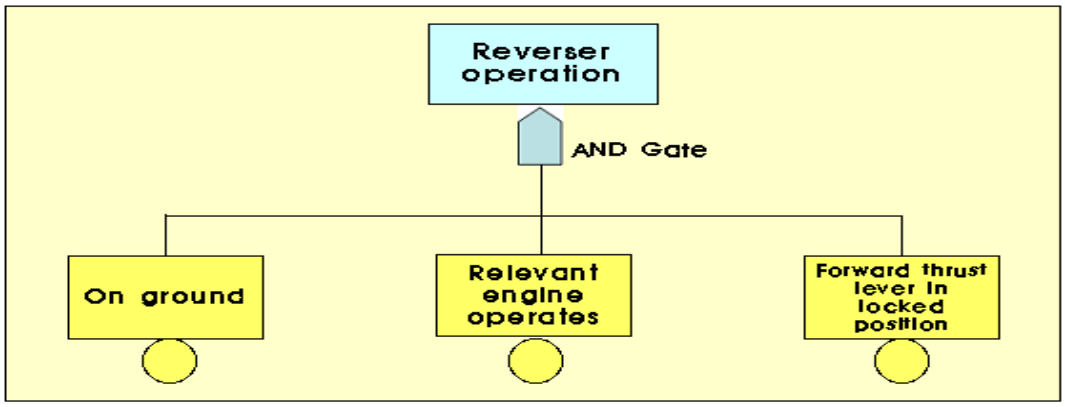
The aircraft held valid certificate of airworthiness and operating limitations specification. The flight was performed with proper fuel loaded, and the landing was conducted within the regulatory limitations of the weight and balance. No maintenance factors that could directly contribute to this incident were found.

2.2 System Operation

2.2.1 Reverse Thrust Lever

As shown in [Fig. 13], the reverse thrust lever can be raised only when the aircraft is on the ground and when the relevant engine is operating and when the forward thrust lever is in the closed position. The forward thrust lever angle shall not be in the position exceeding 36.88° to raise the respective reverse thrust lever.

But because the angle of the No. 4 thrust lever moved from 35° to 43.8° when the reversers started to deploy, the No. 4 reverse thrust lever was not able to be raised. Therefore the statement of the captain that “I tried to raise the No. 4 reverse thrust lever several times but it was not able to be raised” is admitted.



[Fig. 13] Reverser operation condition

The ARAIB confirmed that the thrust levers were moving normally when inspecting the operation condition of the thrust levers, and did not found any failure record on the central maintenance computer. And it was suspected that the captain was holding all the four thrust levers during landing.

Therefore, that the forward thrust lever moved from the 35° to 43.8° position when the captain raised the reverse thrust levers, is assumed to be made by an unconfirmed force in the flight deck, and it was difficult to think that it occurred by the reason that the friction of thrust levers or the tension of cable was loose.

At the time the reverser was used two times, only No. 1, 2 and 3 reversers operated in both times, and especially while the No. 4 forward thrust lever was raised to the maximum thrust position by an unconfirmed force and the aircraft was veering off the runway, the No. 1, 2 and 3 reversers operated[47] again.

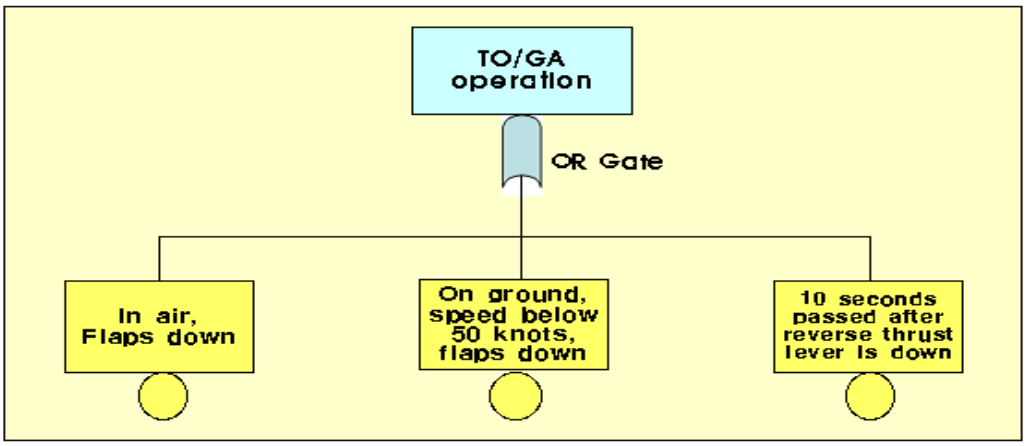
Therefore, based on these facts, the ARAIB does not exclude the assumption that [the captain missed the No. 4 reverse thrust lever at the time when he raised the reverse thrust levers after landing and, after that, he must not have held the No. 4 reverse thrust lever.], even though it recognizes the statements of the captain that "I tried to raise the No.4 reverse thrust lever several times but it was not raised."

2.2.2 Forward Thrust Lever

According to the FDR record, the No. 4 thrust lever angle increased from 35° to 43.8° at the stage where the reverser started to deploy after touchdown, after that, it rose to 62.9° with the reverser deployed, and when the reverse started to close it increased to the 84.9° position.

The ARAIB has confirmed that the thrust lever moved normally in the operating condition inspection on the thrust lever, found no abnormalities in a BITE test, and did not find any failure record on the central maintenance computer.

Therefore, in order to define the reason that the No. 4 forward thrust lever could be increased to the 84.9° position, the ARAIB has reviewed the possibility in which while the captain pushed down the reverse thrust levers, he pressed TO/GA switches by mistake, and so the autothrottle operated.



[Fig. 14] Conditions for TO/GA operation

As shown in [Fig. 14], the TO/GA switch operates[48] when the aircraft is in the air and flaps are out of up position, or the speed is below 50 knots with the flaps down on the ground, or 10 seconds have passed after the reverse thrust lever is down.

But the time when the No. 4 forward thrust lever came up was when the aircraft was on the ground, and the reverse thrust levers was raised, and the speed was above 50 knots, so the TO/GA switch was in a systematically inoperable status.

---

47) The captain did not clarify the reason why he used reserve thrust again.
48) The autothrottle activates in thrust reference (THR REF)

And if the autothrottle had operated, the auto thrust mode of the flight mode annunciator (FMA) should have been annunciated and there must be a record of the autothrottle G/A mode. But the auto thrust mode was not annunciated and there was no record of the autothrottle G/A mode.

Therefore, there was a possibility of pushing the TO/GA switch by mistake while he was pushing down the reverse thrust lever, nevertheless there was no evidence that the autothrottle was operated due to this.

In order to define a possibility that the No. 4 forward thrust lever could be increased to the 84.9° position, the ARAIB has reviewed the results of inspection on the relevant parts, the record of the central maintenance computer, the operating principles of the relevant systems, the FDR data, etc, but it could not find out the cause exactly.

Thus, in view of the increased time and the moving speed of the lever, that the No. 4 forward thrust lever came up to 84.9° in two stages, is presumed to be made by a certain force in the cockpit, namely, one of the flight crew members or a certain unfixed thing, but the ARAIB could not find out any evidence that could prove this.

2.3 Flight Crew Performance

According to the statements of the flight crew members and the data of the flight data recorder, B2440 touched down at a normal speed of 129 knots on the runway centerline at about 1,700 feet from the runway 33R threshold by manual flight.

According to the data of the flight data recorder, the record of the cockpit voice recorder and the thrust lever system, it is judged that when the captain raised the reverse thrust levers in accordance with the procedures after touchdown, only No. 1, 2 and 3 reverse thrust levers were raised, but the No. 4 thrust lever was not raised from the beginning because the No. 4 thrust lever angle positioned at 43.8°.

Visualizing the flight situation of that time, due to the asymmetric thrust generated, and because the No. 4 reverse thrust did not operate, the aircraft started slowly veering off the centerline, and the captain started to use the right rudder to correct this.

In such a situation the No.4 thrust lever was increased to the 62.9° position by an uncertain force, and because of this, the aircraft was running off the runway all the more quickly. But immediately before running off the runway, the thrust lever was increased again momentarily to the 84.9° position by an unconfirmed force, and due to this, it is presumed that the aircraft turned more abruptly and ran off the runway.

According to the captain’s statements, he attempted to raise the No. 4 reverse thrust lever several times while the No. 1, 2 and 3 reverse thrust system were operating but he did not inform the other crew of it. And if there was a problem with directional control when the captain used the reverse thrust, he should stop using reverse thrust first of all.

But the captain pushed down the reverse thrust levers immediately before the aircraft ran off the runway, and when it ran off the runway he used reverse thrust again, and also at that time he used only No. 1, 2 and 3 reverse thrust levers, which increased the turning speed of the aircraft all the more.

The first officer said “centerline, centerline” immediately before the aircraft ran off the runway, and although he pushed the right rudder, the captain was already pushing it to the maximum. But it was judged that he did not check the operating condition of the reversers and might not have recognized that the No. 4 thrust reverser did not operate, until immediately before the aircraft ran off the runway.

The second captain who was sitting on the observer seat said “be careful” immediately before the aircraft ran off the runway, and after the aircraft ran off the runway, he said “reverser, reverser, pull it back, pull it back.” If put together the statements of three flight crew, the data of the flight data recorder and the records of the cockpit voice recorder, the time when the second captain pointed out “reverser, pull it back” was after the aircraft ran off the runway. This is judged that the pointing out to stop all reverse thrust would have had more meaning than pointing out that any reverser did not operate.

The captain did not recognize that the forward thrust lever was increased regardless of the captain’s intention and he could not prevent this either. And even when the aircraft had already run off the runway, the No. 1, 2 and 3 reversers were operating continuously, and even when the aircraft stopped completely the No. 4 engine was in its maximum operation. By putting all these circumstances together, it is judged that the captain suffered a temporary loss of situational awareness since he firstly operated the reverse thrust after touchdown.

3. Conclusions

On the basis of the factual information and the analysis of the B2440 incident investigation, the Aviation and Railway Accident Investigation Board determines the findings[52] in three categories: findings related to probable causes[49], findings related to risk[50] and other findings[51].

3.1 Findings Related to Probable Causes

After touchdown, when the captain was operating the reversers, because the No. 4 forward thrust lever had been moved forward out of the full retarded position while not being recognized by the flight crew, the No.4 reverse thrust lever was unable to be raised, right after that, the No. 4 forward thrust lever was moved again to the maximum position while not being recognized by the flight crew, generating a greater asymmetric thrust, and as the result, the aircraft rapidly ran off the runway to the left.

3.2 Findings Related to Risk

1. Since the captain firstly operated the reversers, he temporarily lost the situational awareness, so he failed to push down the reverse thrust levers early enough, and neither recognize the forward thrust lever was increasing nor prevent it from increasing.

2. When the captain operated the reversers after touchdown, the first officer failed to check the operation status of the thrust reversers.

3.3 Other Findings

1. The flight crewmembers of B2440 were properly licensed and adequately rested to conduct the flight, no medical factor which might have adversely influenced their performance, was found.

2. The aircraft held a valid airworthiness certificate, and the landing was performed within the regulatory limitations of the weight and balance. No maintenance factor that could directly contribute to this serious incident was found.

3. The weather at the time when B2440 was landing was in visual meteorological conditions, and there was no gust, precipitation or adverse weather that exceeds the landing limitations.

---

[52] Findings are a key part of this report and are published solely to identify safety deficiencies and risk for the prevention of future accidents. Any use of the findings to assign blame or liability would be a violation of international aviation law and international best practices, including those contained in Annex 13, Chapter 3, Paragraph 3.1, and Chapter 5, Paragraph 5.4.1, to the Convention on International Civil Aviation.

[49] Findings related to probable causes identify elements that have been shown to have operated in the incident, or almost certainly operated in this incident. These findings are associated with unsafe acts, unsafe conditions or safety deficiencies associated with safety significant event that played a major role in the circumstances leading to this incident.

[50] Findings related to risk identify elements of risk that have the potential to degrade aviation safety. Some of the findings in this category identify unsafe acts, unsafe conditions, and safety deficiencies, including organizational and systematic risks that have the potential to degrade aviation safety; however, they cannot be clearly shown to have operated in the incident. Further, some of the findings in this category identify risks that are unrelated to this incident, but nonetheless were safety deficiencies that may warrant future safety actions.

[51] Other findings identify elements that have the potential to enhance aviation safety, resolve an issue of controversy, or clarify an issue of unresolved ambiguity. Some of these findings are of general interest and are not necessary analytical, but are often included in the ICAO format of accident reports for informational, safety awareness, education, and improvement purposes.

4. The thrust levers moved normally at the operating condition inspection, no abnormality was found in a BITE test on the autothrottle computer and the central maintenance computer, and no failure record was found on the central maintenance computer.

5. No. 4 reverse thrust lever was in an inoperable condition because the No. 4 forward thrust lever was not in the closed position at the time the captain raised the reverse thrust levers.

6. The forward thrust lever can be moved manually even when the autothrottle is operating. The reverse thrust lever can be only raised when the relevant forward thrust lever is in the closed position.

7. The TO/GA switch can not be operated on the ground, so even if the captain pushed it by a mistake in the process of pushing down the reverse thrust levers, the forward thrust lever cannot go up to the maximum position with the autothrottle operating.

8. No. 1, 2 and 3 reversers were operating even after the aircraft ran off the runway, and all engines were not stopped even after it stopped on the grass. And especially the No. 4 engine thrust was in maximum for about 10 seconds.

9. The flight data recorder had no operation records of the take off/go-around mode and the automatic thrust mode which were to be displayed in the flight mode annunciator if the TO/GA switch was operated.

4. Safety Recommendations

As a result of its investigation of the B2440 incident occurred on 16 April 2009 at the Incheon International Airport, the Aviation and Railway Accident Investigation Board makes the following safety recommendations.

To the Jade Cargo International Company Ltd.

1. Review the thrust reverser operation procedures and the related standard call-out procedures, and reflect them on the Flight Operation Manual (AIR-F0901-1)

2. Provide the case study of this incident and similar incidents to the flight crew ground school (AIR-F0901-2)