AI2019-2

AIRCRAFT SERIOUS INCIDENT INVESTIGATION REPORT

POLAR AIR CARGO WORLDWIDE, INC.
N 8 5 2 G T

March 28, 2019

JTSB Japan Transport Safety Board

The objective of the investigation conducted by the Japan Transport Safety Board in accordance with the Act for Establishment of the Japan Transport Safety Board and with Annex 13 to the Convention on International Civil Aviation is to prevent future accidents and incidents. It is not the purpose of the investigation to apportion blame or liability.

Kazuhiro Nakahashi
Chairman
Japan Transport Safety Board

Note:

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

AIRCRAFT SERIOUS INCIDENT

INVESTIGATION REPORT

CASE EQUIVALENT TO RUNWAY OVERRUN
(LIFT-OFF IN THE VICINITY OF
THE END OF DEPARTURE RUNWAY)
ON RUNWAY 16L AT NARITA INTERNATIONAL AIRPORT
AT 22:41 JST, JULY 15, 2017

POLAR AIR CARGO WORLDWIDE, INC.
BOEING 747-8F, N852GT

February 22, 2019

Adopted by the Japan Transport Safety Board

SYNOPSIS

<Summary of the Incident>

On Saturday, July 15, 2017, at 22:41 JST, a Boeing 747-8F, registered N852GT, operated by the Polar Air Cargo Worldwide Inc. as the company's scheduled flight 213, lifted off after performing its take-off roll all the way of the vicinity of the end of runway when taking off from runway 16L at Narita International Airport, resulting in a case equivalent to runway overrun.

The Captain and the First Officer were on board the aircraft, but nobody suffered injuries and the aircraft had no damage.

<Probable Cause>

It is probable that in this serious incident, the aircraft commenced a take-off roll by using the take-off thrust lower than the thrust required for the Aircraft to take off, causing it to take a longer take-off roll distance to lift off; and its lifting off in the vicinity of the end of departure runway resulted in a case equivalent to runway overrun.

It is probable that the aircraft commenced a take-off roll by using the take-off thrust lower than the thrust required for the Aircraft to take off, because the Captain did not correctly change the FMC settings for the take-off thrust at the time of take-off from the runway different from what the Captain and the FO had assumed, the Captain did not correctly change the FMC settings for the take-off thrust, in addition, the Captain and the FO did not ensure to verify the take-off thrust by the time when they commenced the take-off.

This report uses the following abbreviations:

ACARS	: Automatic Communications Addressing and Reporting System
AIP	: Aeronautical Information Publication
ATM	: Assumed Temperature Method
CDU	: Control Display Unit
CG	: Center of Gravity
CVR	: Cockpit Voice Recorder
EICAS	: Engine Indication and Crew Alerting System
FAA	: Federal Aviation Administration
FCOM	: Flight Crew Operating Manual
FDP	: Flight Deck Performance
FDR	: Flight Data Recorder
FMC	: Flight Management Computer
FMS	: Flight Management System
MAC	: Mean Aerodynamic Chord
MCP	: Mode Control Panel
PF	: Pilot Flying
PFD	: Primary Flight Display
PM	: Pilot Monitoring
QAR	: Quick Access Recorder
SOP	: Standard Operating Procedure
TLR	: Takeoff and Landing Report

Conversion table

1 ft	: 0.3048 m
1 kt	: 1.852 km/h (0.5144 m/s)
1 nm	: 1,852 m
1 atmospheric pressure	: 1,013 hPa (29.92 inHg)

1. PROCESS AND PROGRESS OF THE INVESTIGATION

1.1. Summary of the Serious Incident

On Saturday, July 15, 2017, at 22:41 Japan Standard Time (JST: UTC + 9 hours), a Boeing 747-8F, registered N852GT, operated by the Polar Air Cargo Worldwide Inc. as the company's scheduled flight 213, lifted off after performing its take-off run all the way of the vicinity of the end of runway when taking off from runway 16L at Narita International Airport, resulting in a case equivalent to runway overrun.

The Captain and the First Officer were on board the aircraft, but nobody suffered injuries and the aircraft had no damage.

1.2. Outline of the Serious Incident Investigation

The occurrence covered by this report falls under the category of case equivalent (as stipulated in Item XVII, Article 166-4) to "Overrun" as stipulated in Item III, Article 166-4 of the Ordinance for Enforcement of the Civil Aeronautics Act (Ordinance of the Ministry of Transport No. 56 of July 31, 1952) and is classified as a serious incident.

1.2.1. Investigation Organization

Upon receipt of the occurrence of this serious incident, on August 9, 2017, the Japan Transport Safety Board (JTSB) designated an investigator-in-charge and two other investigators to investigate the serious incident.

1.2.2. Representatives and Advisor of the Relevant State

An accredited representative and an advisor of the United States of America, as the State of the Operator, Design and Manufacture of the aircraft involved in this serious incident, participated in the investigation.

1.2.3. Implementation of the Investigation

The investigation by means of documentations was conducted after August 9, 2017 when this serious incident was notified, interviews with the parties relevant to the cause of the serious incident and on-site investigation around Narita International Airport were conducted on February 19, 2018.

1.2.4. Comments from the Parties Relevant to the Cause of the Serious Incident

Comments on the draft report were invited from parties relevant to the cause of the serious incident.

1.2.5. Comments from the Relevant State

Comments on the draft report were invited from the relevant State.

2. FACTUAL INFORMATION

2.1. History of the Flight

On Saturday, July 15, 2017, a Boeing 747-8F (hereinafter referred to as "the same type of aircraft"), registered N852GT (hereinafter referred to as "the Aircraft"), operated by the Polar Air Cargo Worldwide Inc. (hereinafter referred to as "the Company"), as the company's scheduled flight 213 (hereinafter referred to as "the Flight"), performed an operation from Narita International Airport (hereinafter referred to as "the Airport") bound for Shanghai Pudong International Airport.

The Captain sat in the left seat as the PF*1 and the First Officer (hereinafter referred to as "the FO") in the right seat as the PM*1 in the cockpit of the Aircraft.

The flight plan of the Aircraft was as follows:

Flight rule:	Instrument flight rules
Departure aerodrome:	Narita International Airport
Estimated off-block time:	22:05
Cruising speed:	498 kt
Cruising altitude:	FL*2 340
Destination aerodrome:	Shanghai Pudong International Airport
Total estimated elapsed time:	2 hours 19 minutes
Fuel load expressed in endurance:	6 hours 56 minutes

The history of the flight leading from readiness for departure up to this serious incident is summarized below, based on the documentations, statements as well as the records of the air traffic control facility and QAR*3 records.

2.1.1. History of the Flight up to Take-off Based on the Records of Air Traffic Communications and QAR Records

21:52:52	The Aircraft in Spot No. 207 requested the Clearance Delivery controller of Narita Aerodrome Control Facility (hereinafter referred to as "the Narita Delivery") for a clearance by data communications.
21:53:07	The Narita Delivery issued a clearance with runway 16L as its take-off runway to the Aircraft.
22:07:57	The Aircraft started pushback from Spot No. 207 after gaining a clearance from the Narita Ramp Control.
22:15:03	The Aircraft made initial contact with the Ground controller of Narita Aerodrome Control Facility (hereinafter referred to as "the Narita Ground") on taxiway Q6.
22:15:14	The Narita Ground issued a taxi clearance for runway 16L to the Aircraft.
22:27:40	The Aircraft was transferred to the Tower controller of Narita Aerodrome Control Facility (hereinafter referred to as "the Narita Tower") around

*1 PF and PM are the terms to identify pilots on the basis of role sharing when operating aircraft by two pilots: The PF (Pilot-Flying) is mainly in charge of aircraft control and the PM (Pilot-Monitoring) is mainly in charge of monitoring the flight status, cross-checking of PF's operations and performing tasks other than flying.

*2 "Flight Level (FL)" refers to the pressure altitude of the standard atmosphere. It is the altitude indicated by value divided by 100 of the index of the altitude indicator (unit: ft) when QNH is set to 29.92 inHG. FL is usually applied when flight altitude is 14,000 ft or above in Japan. E.g., FL 340 indicates an altitude of 34,000 ft.

*3 "Quick Access Recorder (QAR)" refers to a recording device capable of storing flight data almost equal to FDR. It is also possible for operators to establish their own parameters.

	taxiway E7 on taxiway G.
22:39:53	The Narita Tower had issued a take-off clearance from runway 16L to the Aircraft, and the flight crew read back it.
22:40:16	The thrust levers of the Aircraft were advanced forward and the Aircraft commenced take-off from runway 16L.
22:40:37	The airspeed of the Aircraft went up to 80 kt (see 2.12.4).
22:41:06	The Aircraft lifted off.
22:41:07	The Aircraft passed the departure end of runway 16L at the radio altitude of about 16 ft.
22:41:14	The gear lever was moved to its up position.
22:41:24	The Narita Tower instructed the Aircraft to transfer its radio communication to the Narita Departure controller of the Tokyo radar approach control facility, and the flight crew read back the instruction.

2.1.2. Statements of Relevant Persons

(1) Captain

Assuming take-off from runway 16R, by using FMS*4 CDU (hereinafter referred to as "CDU") the Captain programed the FMC*5 because he had been often instructed to use runway 16R as a take-off runway at the Airport, and the taxiing time from its parking spot to runway 16R was shorter. The Captain thought that all procedures including the change in the FMC take-off data entries following the runway change would be able to be completed during taxiing to runway 16L because the parking spot was away from runway 16L, even if he was instructed to use runway 16L as its take-off runway.

In addition, as being aware of runway operation procedure (see 2.13) during the hour from 21:00 to 23:00 at the Airport, the Captain thought it would be possible to take off from in terms of the aircraft performance when the Aircraft at parking spot obtained a clearance and was instructed to use runway 16L as its take-off runway; therefore, the Captain did not request the Narita Delivery to issue a clearance for take-off from runway 16R, and was thinking of the complicated taxi route to runway 16L.

At the parking spot, before pushback, the Captain changed the settings related to the take-off by himself in the changes of FMC setting associating with the change from runway 16R to runway 16L, and instructed the FO to change the settings related to the flight route including standard departure procedures.

The Captain changed only Assumed temperature (see 2.9) without changing to the Rated Take-off Trust (see 2.9) from the De-rated Take-off Thrust (see 2.9) that was selected on the THRUST LIM page (see 2.12. 1 (1)). After changing the necessary FMC settings associating with the runway change, the Captain briefed the taxi route to runway 16L and others, but did not brief on the verification of the take-off data by using CDU; and the Captain instructed the FO to verify that there was no discrepancy of take-off data between CDU and FDP (see 2.10).

The taxi route to runway 16L from the parking spot of the Aircraft was so long and complicated that the Captain carefully taxied the route instructed by ATC while checking it on a chart.

After gaining clearance for take-off from the Narita Tower and commencing a take-off roll from

*4 "Flight Management System (FMS)" supports flight crew members with regard to navigation, performance, fuel monitoring, and display in the cockpit.
*5 "Flight Management Computer (FMC)" is a flight management computer that constitutes FMS.

runway 16L, the Captain verified the engine indications of EICAS*6 for the N1 values*7; and he did not see the values as abnormal because they were almost the same with those for take-off from runway 16R.

During the take-off roll, the Captain felt that the acceleration of the Aircraft was a little slow but not so abnormal, while recognizing that they were approaching the end of departure runway, and performed the normal take-off procedures. The Captain felt that the Aircraft lifted off in the vicinity of the end of departure runway and the take-off path became lower, therefore, he discussed with the FO what he felt that the take-off path was low during the flight.

The Captain fully rested himself before the Flight and had no problems physically and mentally.

(2) FO

The FO had joined the Company in 2016 and completed the training as a first officer of the same type of aircraft in December 2016. The FO fully rested himself before the Flight and did not feel any fatigue.

When the serious incident occurred, the FO knew the runway operation procedure in which runway is assigned from 21:00 to 23:00 at the Airport, but he assumed that the Aircraft would be able to take off from runway 16R, which was closest from its parking spot of the Aircraft, because many other aircraft were taking off from runway 16R. When the FO was informed that their take-off runway was runway 16L, he thought a take-off from runway 16L would be possible, however, its taxi route to runway 16L could be longer and more complicated.

The FO remembered to have verified the FMC settings according to an instruction of the Captain, but not in detail.

The FO paid a lot of attention to accurately taxiing the route that was instructed by ATC. During the take-off, the FO felt the take-off roll distance a little longer, but did not feel either it was abnormal or the take-off path became lower.

This serious incident occurred at 22:41 on July 15, 2017, in the vicinity of the end of runway 16L at the Airport (35° 47' 09" N, 140° 23' 32" E).

2.2. Injuries to Persons

Nobody suffered injuries.

2.3. Damage to the Aircraft

The aircraft had no damage.

2.4. Personnel Information

(1) Captain Male, Age 60

Airline transport pilot certificate (Airplane)

Type rating for Boeing 747-4*8 March 24, 2008

Class 1 aviation medical certificate

Validity October 31, 2017

*6 "Engine Indication and Crew Alerting System (EICAS)" is a system that indicates the operation condition of the engine and systems, and provides the pilot with visual and auditory information on the occurrence of abnormal conditions if they occur in the various systems.

*7 "N1" refers the number of revolutions of the fan, low-pressure compressor and low-pressure turbine, expressed in percent (%). In the same type of aircraft, it is a parameter indicating the thrust of the engine.

*8 According to the competence certificate of the Federal Aviation Administration (FAA), Boeing 747-400 and Boeing 747-8 belong to the same type rating, being described as B-747-4.

Total flight time			14,896 hours 00 minutes
Flight time in the last 30 days			75 hours 31 minutes
Total flight time on the same type of aircraft			5,178 hours 04 minutes
Flight time in the last 30 days			75 hours 31 minutes
Experience at the Airport			
In the last one year	Departure 11 times (3 times)	Arrival 11 times (0 time)	
In the last 90 days	Departure 4 times (2 times)	Arrival 5 times (0 time)	
In the last 30 days	Departure 0 time	Arrival 0 time	

(2) FO Male, Age 42

Airline transport pilot certificate (Airplane)	
Type rating for Boeing 747-4	November 14, 2016
Class 1 aviation medical certificate	
Validity	March 31, 2018
Total flight time	13,568 hours 00 minutes
Flight time in the last 30 days	73 hours 29 minutes
Total flight time on the same type of aircraft	408 hours 06 minutes
Flight time in the last 30 days	73 hours 29 minutes

Experience at the Airport		
In the last one year	Departure 2 times (1 time)	Arrival 4 times (0 time)
In the last 90 days	Departure 2 times (1 time)	Arrival 3 times (0 time)
In the last 30 days	Departure 0 time	Arrival 1 time (0 time)

Note: Number in parentheses indicates the number of Departures or Arrivals during the hours from 21:00 to 23:00.

2.5. Aircraft Information

2.5.1. Aircraft

Type	Boeing 747-8F
Serial number	37571
Month of manufacture	September 2012
Certificate of airworthiness	
Date of issuance	September 28, 2012
Validity or Expiration date	Not specified
Category of airworthiness	Airplane, Transport T
Total flight time	20,942 hours 00 minutes
Flight time since last periodical check (A check on May 12, 2017)	857 hours 59 minutes

(See Appended Figure 2 Three Angle View of Boeing 747-8F.)

2.5.2. Weight and Balance

When the serious incident occurred, the Aircraft's weight and position of center of gravity are estimated to have been 367,377 kg and 24.6 % MAC*[9] respectively, within the allowable range (maximum takeoff weight of 373,023 kg and 13 to 26 % MAC corresponding to the weight at the time of the serious incident).

*[9] "MAC" abbreviates Mean Aerodynamic Chord, which is a chord representing aerodynamic characteristics of a wing and given by a length of the typical wing chord if the chord is not constant as in the case of a sweptback wing. 32.0 % MAC indicates a position located at 32.0 % distance from the leading edge of the mean aerodynamic chord.

2.6. Meteorological Information

The aerodrome routine meteorological report (METAR) at the Airport when the serious incident occurred was as follows:

22:30	Wind direction: 170°,	Wind speed: 4 kt,	Prevailing visibility: 10 km or more,
	Cloud: Amount: 1/8,	Type: Cumulus,	Cloud base: 2,000 ft
	Amount: 5/8,	Type: Unknown,	Cloud base: Unknown
	Temperature: 24℃,	Dew-point: 22℃	
	Altimeter setting (QNH): 29.90 inHg		

2.7. Information on Flight Recorder

The Aircraft was equipped with a flight data recorder (hereinafter referred to as "FDR") capable of recording for a duration of about 25 hours and a cockpit voice recorder (hereinafter referred to as "CVR") capable of recording for a duration of about 2 hours, manufactured by Honeywell of the United States of America.

Even after the serious incident had occurred, the Aircraft continued the flight without removing the FDR and the CVR more than 25 hours; therefore, as it was clear that the data in the FDR and the CVR recorded at the time of the occurrence of the serious incident had been overwritten and thus erased, the FDR and the CVR were not removed.

2.8. Serious Incident Site Information

The Airport is established and managed by the Narita International Airport Corporation (hereinafter referred to as "NAA").

As shown in Appended Figure 1, the Airport is at an elevation of 135 ft, having two runways. Runway 16R/34L is 13,123 ft (4,000 m) in length, 60 m in width and 157°/337° in magnetic direction, and runway 16L/34R is 8,202 ft (2,500 m) in length, 60 m in width and 157°/337° in magnetic direction.

At around 22:41:08 on the day when this serious incident occurred, the security camera the NAA installed around the Airport recorded the images of the Aircraft flying over the area in the vicinity of Appended Figure 1 <a>. After that, it was confirmed that some of the intrusion warning sensors were disconnected in the vicinity of both <a> (about 150 m south of the end of departure runway) and <b> (about 450 m south of the end of departure runway) in Appended Figure 1.

(See Appended Figure 1 Narita International Airport and Estimated Taxi Route of the Aircraft.)

2.9. Take-off Thrust

If the same type of aircraft has sufficient take-off performance capabilities for the length of the runway to be used, during take-off it is possible to use different levels of engine thrust such as Rated Take-off Thrust, which is the maximum thrust authorized to be used during take-off, and two types of De-rated Take-off Thrust whose power are reduced by 10 % or 20 % from that of Rated Take-off Thrust.

In the FCOM*10 of the Company, they are described that the Rated Take-off Thrust is as TO,

*10 "Flight Crew Operating Manual (FCOM)" is a set of rules stipulated by an operating company that describes the information on operating limitations, procedures, performance and systems for flight crew members to ensure safe and efficient aircraft operations.

and each De-rated Take-off Thrust is as TO1 or TO2 respectively.

In addition, it is possible to use a reduced take-off thrust (Assumed Temperature Method) (hereinafter referred to as “ATM”) which is lower than Rated Take-off Thrust obtaining by FMC calculation using an assumed temperature higher than the actual ambient temperature (hereinafter referred to as “Assumed temperature”).

It is possible to use ATM in combination with TO, TO1 and TO2.

TO, TO1 and TO2, which are combined with ATM, are described as D-TO, D-TO1 and D-TO2, respectively in the FCOM.

In this report, when combined with the ATM, take-off thrust is expressed with Assumed temperature (in case of 38℃) such as D-TO (38) and D-TO2 (38).

2.10. Take-off Data of the Aircraft

Directly from the Company’s computer through the ACARS*[11], the flight crew members of the Company obtain the FDP (Flight Deck Performance) data such as maximum take-off weight, flaps, take-off thrust, take-off speed and others, which are calculated based on the latest weather information and required for take-off.

The flight crew members verify the contents of the FDP data and input the FMC data by referring to the FDP data. Figure 1 shows the FDP data to which the flight crew members referred, and its contents are summarized in Table 1.

In addition, the Company provides the flight crew members with the data called TLR (Take-off and Landing Report) after calculating the performance relevant to take-off and landing when dispatchers make a flight plan. The FDP data become available when the TLR is created. The printed TLR of the Flight was provided to the flight crew members with its flight plan and others. The TLR describes a planned runway as PRWY (Planned Runway) when the dispatchers create a flight plan. The dispatchers can select the PRWY according to the environmental conditions such as wind and ambient temperature, and other conditions of runways and aircraft, however, at the time of this serious incident, the TLR put runway 16R, which had been set as the default in performance calculation for the Airport, as its PRWY.

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QU ANPOC5Y
.PERFF5Y 151159
M31
AN N852GT/FI 5Y0213
-  288.7
051.8

RJAA             GENX-2B67
FLT NO     RLS NO     TIME
0213          5      1159Z
WIND KTS   OAT C       QNH
190/01      +25      29.90
--------------------------
GRWT 369.2      VREF30 164
FUEL  80.5
ZFW  288.7

REMARKS
NONE

RJAA   16R           13123
MTOW   369.2    SMRGN  850
FLAPS  10         PACKS ON
ATM    40C          V1 159
THR    D-TO 2       VR 168
N1     88.4         V2 178
CG     24.0

DT H157       ACCEL   1000

RJAA   16L            8202
MTOW   369.2    SMRGN  544
FLAPS  20         PACKS ON
ATM    38C          V1 137
THR    D-TO         VR 150
N1     97.2         V2 165
CG     24.0

DT H157       ACCEL   1000

BED6
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Figure 1 FDP data

*11 “ACARS” stands for Aircraft Communication Addressing and Reporting System, which is a data communication system to support aircraft operations

Table 1: FDP

Runway	Maximum take-off weight (x 1,000 kg)	Flaps	Assumed Temperature (℃)	Take-off thrust	N1 values (%)	V1[*12] (kt)	VR[*13] (kt)	V2[*14] (kt)
16R	369.2	10	40	D-TO2	88.4	159	168	178
16L	369.2	20	38	D-TO	97.2	137	150	165

2.11. QAR Records and the Estimated Values by the Manufacturer

According to the QAR records of the Aircraft, the Aircraft used Flaps 20 when taking off, the Aircraft lifted off at the position about 7,720 ft from the starting position of take-off roll and about 7,860 ft from the threshold of runway 16L. Besides, the Aircraft passed the end of runway 16L at the radio altitude of about 16 ft, and the N1 value was 89.1 % when the Aircraft reached the airspeed of 80 kt.

On the other hand, according to the data related to runway 16L in Table 1, when the Aircraft used Flaps 20 and D-TO (38), the horizontal distance from the starting position of take-off roll to the position of lifting off was about 5,370 ft, and the altitude was about 230 ft when the Aircraft reached the end of runway 16L.

Figure 2 shows the take-off path of the Aircraft according to the QAR records (red line) and the calculations by using D-TO (38) (97.2 % N1) (green line). L/O indicates the lift-off position of the Aircraft.

The radio altitude of the same type of aircraft is corrected to be at 0 ft when the main landing gears touch down on the runway in the landing attitude.

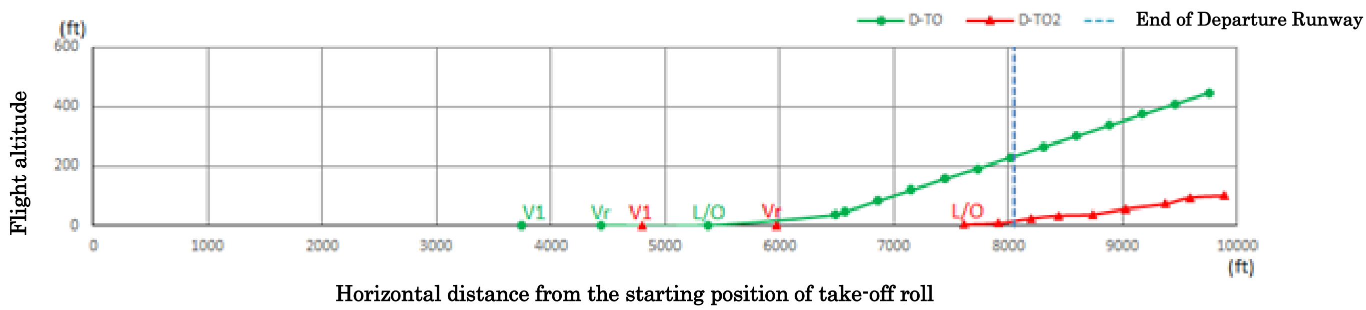

Figure 2 Take-off Path

2.12. Normal Operating Procedures Described in the FCOM

CDU is used for FMC settings before departure. Either the PF or the PM can input the data into FMC; however, it is necessary for both pilots to verify the contents of the entry data. Regarding the procedures are described as below in the Company's FCOM "Normal Procedures-Preflight ACARS and FMC Initialization and Verification Procedure".

2.12.1. Settings of the Take-off Data

*12 "V1" refers to the maximum speed at which the pilot can initiate aborting a take-off in the event of engine failure, or other events affecting the continuation of safety flight and others during the take-off roll.

*13 "VR" refers to the speed which initiate the rotation to cause the aircraft to lift off.

*14 "V2" refers to the climb speed, which is able to take off safely, and is attained when passing the altitude of 35 ft also meets the required climb gradient when one engine would fail.

Final performance data[PF]....................................SET

(excerpts)

-Use FDP for entries. If FDP is not available, use the Loadsheet and TLR-

THRUST LIM page

Takeoff thrust - Select TO, TO1 or TO2

("D-"indicates assumed temperature used)

Note: Selecting takeoff thrust will remove any previously entered assumed temperature entry.

Assumed Temperature (SEL) - Enter as applicable

N1/EPR Value - Compare with takeoff data

Climb thrust - select

TAKEOFF REF page 1/2

FLAPS - Enter

CG - Select or enter

V speeds - Select or enter

The THRUST LIM page and the TAKEOFF REF page above are summarized (1) and (2), respectively. The FDP data is used for data entry into each page. If FDP is not available, the Loadsheet and TLR are used.

(1) THRUST LIM page (see Figure 3)

<a> Select take-off thrust (TO, TO1 or TO2).

<b> Enter Assumed temperature, if required.

<c> Verify N1 values corresponding to <a> and <b> by using FDP or TLR.

<d> Select climb thrust (CLB, CLB1 or CLB2).

Selecting take-off thrust will remove any previously entered Assumed temperature.

(2) TAKE OFF REF page (see Figure 4)

<a> Select flaps.

<b> Enter CG.

<c> Select or enter take-off speeds (V1, VR or V2).

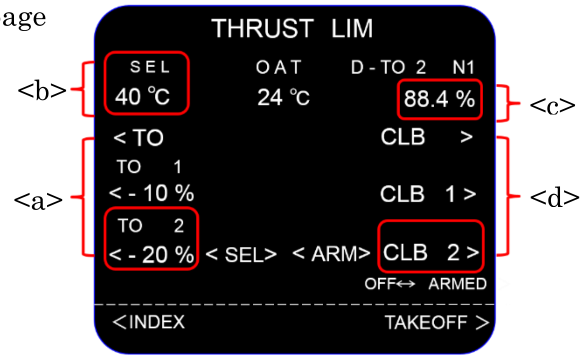

Figure 3 THRUST LIM page
(Image)

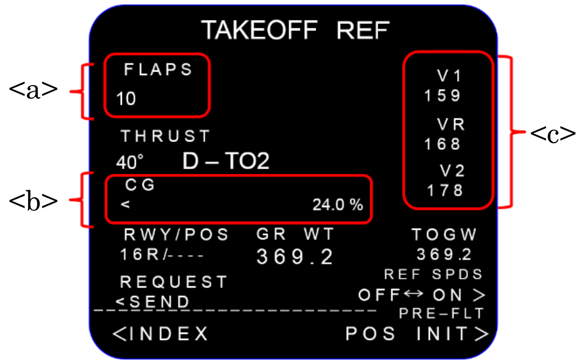

Figure 4 TAKE OFF REF page
(Image)

2.12.2. Verification after Settings

After entering the take-off data, the flight crew members shall verify the entries in accordance with the following procedures. (excerpts)

Performance Verification........................Complete

Resolve any conflicts. Verify entries are accurate and N1/EPR reasonable.

Pilot Flying

Brief the following items from glass.

ZFW, FUEL, FLAPS, SEL, takeoff thrust, N1/EPR, CG, V-speeds, E/O ACCEL HT

Pilot Monitoring

Verify the FMC entries by monitoring the Pilot Flying's performance briefing while cross-

checking the FDP.

2.12.3. Start of Taxiing

The FCOM "Normal procedures-Taxi Out" describes the procedures when starting taxiing including the thrust setting verification on the EICAS performed by the PF and the PM as follows: (excerpts).

TAXI-OUT PROCEDURE

Flight Instruments, Displays [PF, PM]...........Verify

EICAS

・Thrust setting

2.12.4. Take-off Procedures

The FCOM includes the take-off procedures described as "Verify correct takeoff thrust is set" for the PF and the PM to verify that the take-off thrust is set correctly; in addition, it describes the procedures that the PM shall monitor the engine indications on the EICAS, and, if required, adjust the take-off thrust before the speed reaches 80 kt; and when the speed reaches 80 kt, the PM shall call out saying "80 knots, thrust set", and the PF shall call out saying "Check" while verifying the speed.

Figure 5 shows the EICAS indication at the time of take-off.

<a> Take-off thrust set by using the FMC

<b> Assumed temperature

<c> N1 (%) corresponding to the take-off thrust of <a> and <b>

<d> Actual N1 (%)

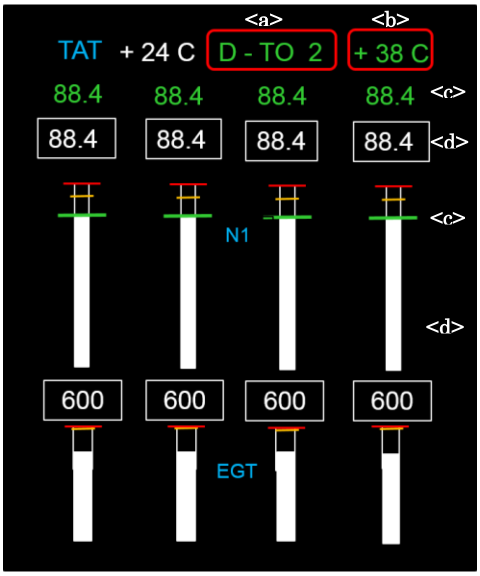

Figure 5 EICAS indication at the time of take-off (Image)

2.13. Runway Operations at Narita International Airport

2.13.1. AIP[*15] Regulations

The runway operations of the Airport are described in 2. Operations of the AIP AD.2.20 LOCAL TRAFFIC REGULATIONS as follows: (excerpts)

〈1〉 *Observance of the runway to be used (1200UTC-1400UTC only)*

Any aircraft taking off from/landing at Narita International Airport shall use the runway specified as a prerequisite for approval or permission of operation during the hour from 1200UTC to 1400UTC, except in unavoidable situation for maintaining a safe operation.

〈2〉 *Efficient Use of 16L/34R*

In order to maximize the operational efficiency of the airport, it is strongly encouraged for pilot to comply with the use of runway instructed by ATC, where ATC has determined its use upon giving due consideration to the overall traffic situation on the ground and in the air.

For this reason, arriving aircraft must be ready to accept landing on 16L/34R (2,500m) if ATC assigns the shorter runway. Departing aircraft, upon giving due consideration of the distance to the

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*15 "Aeronautical Information Publication (AIP)" is a publication issued by the government, which contains the permanent information necessary for the flight of aircraft.

destination as well as aircraft performance, must be ready to accept take-off from the runway assigned by ATC. However, in the event where the assigned runway cannot be accepted due to unavoidable circumstances such as weather conditions, arriving aircraft must notify ATC of its intension 30 minutes prior to the estimated time of arrival (ETA) and departing aircraft must notify ATC when requesting ATC clearance.

2.13.2. Assignment of Runway

In order to ensure the safety of international scheduled flight operations, the International Air Transport Association (IATA), organized by commercial airlines operating international flights, has developed the worldwide IATA guidelines for managing a specific operation day and scheduled time of departure/arrival of an aircraft at an airport (hereinafter referred to as "Slot").

In Japan, the Japan Schedule Coordination Office provides schedule coordination in line with the IATA guidelines, so as not to exceed the airport capacity including the number of take-offs and landings, and the limitations due to environmental issues like aircraft noise.

The Airport is ranked as one of the most congested airports in the IATA guidelines, and the slot allocation is required. In addition, for the slot allocation during the hours from 21:00 to 23:00 at the Airport, the runway to be used for take-offs and landings shall be assigned in advance in accordance with one of the local guidelines of the Airport.

2.13.3. Responses of the Company

At the time of the occurrence of the serious incident, the information on the departure from the Airport, which the Company had provided for the flight crew, contained the following descriptions, where there was no information that the take-off runway had been assigned in advance for the slot allocation from 21:00 to 23:00 at the Airport. (excerpts)

- Utilize the departure runway that is assigned by ATC in the clearance.
- If runway 16L/34R is assigned in the clearance, request runway 16R/34L only if performance requires.
- Do not request runway 16R/34L for the flights to ICN.

According to the information on the arrivals, it is described as the "SLOT RESTRICTIONS" stating that the Company's aircraft use only runway 16L/34R for landings from 21:00 to 23:00.

3. ANALYSIS

3.1. Qualification of Personnel

The crewmembers held valid airman competence certificates and valid aviation medical certificates.

3.2. Aircraft Airworthiness Certificate

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

3.3. Relations to Meteorological Conditions

As described in 2.6, when the serious incident occurred, very weak southerly wind was blowing at the Airport, and it is highly probable that there was no relation between the weather conditions and the occurrence of this serious incident.

3.4. History of the Flight up to Take-off

3.4.1. Assumption of Take-off from Runway 16R

As described in 2.1.2 (1), it is probable that because the Captain had been often taken off from runway 16R in the past and the spot 207 was closer to runway 16R as shown in Appended Figure 1, he set the FMC data assuming the take-off from runway 16R.

As described in 2.13.3, it is somewhat likely that the Captain assumed the take-off from runway 16R, because the information on the departure from the Airport, which the Company had provided for the flight crew, did not state clearly that the take-off runway had been assigned in advance for the slot allocation from 21:00 to 23:00 at the Airport.

3.4.2. Responses to Clearance

It is highly probable that because the Captain had verified the FDP and TLR, as described in 2.10, he recognized the Aircraft would be able to take off from runway 16L with the use of Flaps 20 and D-TO (38). Besides, the Captain was aware of the runway operations procedures, in which an aircraft shall use the assigned runway except for its safety at the Airport.

Based on the above, it is probable that when the Aircraft had been assigned runway 16L, the Captain followed the clearance without requesting a take-off from runway 16R.

3.4.3. Change in FMC Settings Associating with the Assignment of Runway 16L

(1) Runway 16R (2) Runway 16L (3) Actual settings

Figure 6 FMC settings screen (Image)

It is highly probable that the FMC of the Aircraft was set before departure by assuming a take-off from runway 16R. (See Figure 6 (1).)

After that, the Aircraft was instructed to take off from runway 16L at the time of receiving the clearance, therefore, the Captain as the PF had entered assumed temperature 38℃ after selecting the TO on the THRUST LIM page, and had to compare the N1 values to the FDP data. (See Figure 6 (2).)

However, as described in 2.1.2 (1), the Captain changed only Assumed temperature without changing to the TO from the TO2. In addition, as described in 2.12.1, if the Captain had selected the TO on the THRUST LIM page, any previously entered Assumed temperature would have been removed; however, it is somewhat likely that the Captain changed only Assumed temperature from 40℃ that remained on the display to 38℃ that is described in 16L of Table 1. Based on the above, it is probable that the take-off thrust set in FMC was D-TO2 (38) that was lower than D-TO (38) required for take-off from runway 16L. It is also probable that the Captain, afterwards, entered take-off speeds corresponding to take-off flaps and D-TO (38). (See Figure 6 (3): Boxes highlighted in white indicate the take-off data that were not changed correctly).

In addition, it is probable that because FMC settings had not been changed correctly and the take-off thrust had been D-TO2 (38), as described in 2.11, at the time of take-off when the Aircraft reached the airspeed of 80 kt, the N1 value came to 89.1 % which was lower than 97.2 % required for take-off from runway 16L as shown in Table 1.

3.4.4. Verification of Take-off Data

3.4.4 (1) Immediately after Changing in the FMC Entries

As described in 2.1.2 (1), when receiving ATC clearance and recognizing runway 16L being assigned the take-off runway, the Captain instructed the FO as the PM to verify that there was no discrepancy of the take-off data between FDP and FMC after completing the changes of the take-off data settings.

It is probable that the FO verified each take-off data, but did not notice that the TO2 was selected on the THRUST LIM page, and moreover he did not notice that the N1 value was significantly different from FDP data and not reasonable, thus cross-checking by the PF and the PM did not function well.

In addition, although the FCOM does not stipulate procedures for runway change, it is probable that flight crew members should have done the procedures in accordance with the normal operating procedures before departure that described in the FCOM again when its take-off runway was changed. After changing the FMC settings, the Captain as the PF should have briefed the FO as the PM on the results from selecting or entering take-off flaps, Assumed temperature, take-off thrust and N1 value by using the values on the CDU according to the procedures described in 2.12.2, and the FO should have verified that there was no discrepancy of the data between FDP and FMC.

However, as described in 2.1.2 (1), it is probable that because normal operating procedures before departure were not followed correctly, both the Captain and the FO did not notice that the take-off thrust settings in the FMC were not changed correctly.

Besides, it is probable that there were plenty of time to change and verify the FMC entries because the Aircraft was instructed to take off from runway 16L before starting pushback at the parking spot; however, their workloads and communication status in the cockpit at that time could not be determined because there were no CVR records.

3.4.4 (2) Start of Taxiing

As described in 2.12.3, the FCOM describes the procedures that the PF and the PM shall verify that the takeoff thrust is set correctly on the EICAS when starting taxiing.

As described in 2.1.2 (1), when being informed from the Narita Delivery that its take-off runway was runway 16L, the Captain was thinking of the complicated taxi route to runway 16L and also held a briefing on the taxi route. Moreover, as described in 2.1.2 (2), the FO was also thinking that the taxi route to runway 16L would be complicated and longer.

Based on the above, it is somewhat likely that because the Captain and the FO paid attention to the taxi route to runway 16L that was different from runway 16R which they assumed, he did not verify sufficiently the take-off thrust on the EICAS and did not notice that the take-off data settings on the FMC were not changed correctly.

The FCOM does not stipulate the procedures of verification on take-off thrust setting after commencing taxiing, however, it is probable that it should have been ensured to verify the take-off thrust setting when commencing taxiing, which will be the last verification before take-off.

3.4.4 (3) Take-off

When commencing the take-off roll, it is probable that the Captain and the FO verified that the actual N1 values <d> would rise and reach to the N1 values <c> calculated by the FMC on the EICAS in Figure 5.

According to the FDP data, N1 value of the thrust required for the Aircraft was 97.2 %; however, based on the QAR records, the N1 value was 89.1 % when the airspeed of the Aircraft reached 80 kt. The Captain did not see this actual value as abnormal because it was close to the N1 value when taking off from runway 16R, which he had assumed. Moreover, the Captain felt that the acceleration of the Aircraft was a little slow but not so abnormal. The FO also felt the take-off roll distance a little longer, but did not feel it was abnormal during the take-off.

Based on the above, it is probable that the Captain and the FO did not see the N1 value, 89.1 % as abnormal, despite being under conditions that the Aircraft was required to take off from runway 16L, which was short in length, with its weight close to the maximum take-off weight.

On the other hand, it is probable that the Captain changed the FMC settings by judging that it would be possible to take off from runway 16L, shorter than runway 16R, with the use of take-off Flaps 20 in reference to FDP data and D-TO (38) whose thrust is greater than D-TO2 (40) that will be selected for take-off from runway 16R; therefore, the Captain could have assumed that N1 value for take-off from runway 16L should be greater than that for take-off from runway 16R; however, the Captain continued to take off without having doubts about the N1 value set by the auto-throttle according to the FMC settings.

3.5. Disconnection of Intrusion Warning Sensors

As described in 2.8, it was confirmed that some of the intrusion warning sensors were disconnected in the vicinity of <a >and <b> in Appended Figure 1 after the Aircraft flew over the area in the vicinity of <a> in Appended Figure 1.

Judging from the facts that it was confirmed that the Aircraft had no damage during the aircraft inspection after arriving at the destination, and that only some of the intrusion warning sensors were disconnected, it is somewhat likely that the disconnection was caused not by the contact with the Aircraft but by its engine blast.

3.6. Case Equivalent to Runway Overrun

As described in 2.11, the Aircraft lifted off at about 7,720 ft from the starting position of its take-off roll, about 7,860 ft from the threshold of departure runway, and about 340 ft from the end of departure runway.

In addition, as described in 2.11, the radio altitude of the Aircraft was corrected to be at 0 ft when the main landing gears touched down on the runway in the landing attitude, therefore, it is probable that the radio altitude of about 16 ft at the time when the Aircraft passed the end of departure runway was the height from the bottom of the main landing gear of the Aircraft to the runway surface.

As described in 3.4.3 and 3.4.4, it is probable that the Captain did not correctly change the FMC settings for the take-off thrust; moreover, without noticing that the FMC settings for the take-off thrust were not changed correctly, the Captain and the FO commenced the take-off roll by using the take-off thrust lower than the thrust required for the Aircraft to take off, causing it to take a longer take-off roll distance to lift off; and its lifting off in the vicinity of the end of departure runway resulted in a case equivalent to runway overrun.

3.7. The Company's Response to Runway Operations Procedures

As described in 2.13.3, at the time of the occurrence of the serious incident, the information on the departure from the Airport, which the Company had provided for the flight crew, did not state clearly that the take-off runway 16L/34R had been assigned in advance for the Flight.

As described in 2.13.1 and 2.13.2, any aircraft shall use the runway specified as a prerequisite for approval or permission of operation at the Airport during the hours from 21:00 to 23:00, it is desirable that the Company establishes the procedures to appropriately and definitely notify the flight crew members of the Company's flights that will take off or land during the hours from 21:00 to 23:00 at the Airport of the information on take-off/landing runways assigned in advance by describing those information as PRWY of the TLR.

4. PROBABLE CAUSE

It is probable that in this serious incident, the aircraft commenced a take-off roll by using the take-off thrust lower than the thrust required for the Aircraft to take off, causing it to take a longer take-off roll distance to lift off; and its lifting off in the vicinity of the end of departure runway resulted in a case equivalent to runway overrun.

It is probable that the aircraft commenced a take-off roll by using the take-off thrust lower than the thrust required for the Aircraft to take off, because the Captain did not correctly change the FMC settings for the take-off thrust at the time of take-off from the runway different from what the Captain and the FO had assumed, the Captain did not correctly change the FMC settings for the take-off thrust, in addition, the Captain and the FO did not ensure to verify the take-off thrust by the time when they commenced the take-off.

5. SAFETY ACTIONS

The safety actions taken by the Company after the serious incident occurred

After the serious incident occurred, the Company took the following measures to prevent the occurrence of similar cases.

(1) Trainings provided to the Flight's crew members

The Company provided the Captain and the FO with the re-trainings on input and verification of the performance data in FMC, as well as procedures at the time of runway change and others.

(2) Providing information, recurrent trainings and others to the Company's flight crew members

In December 2017, the Company held a safety briefing for all the flight crew members and made a review of this serious incident. In addition, the Company decided to discuss this case in the recurrent trainings in fiscal 2018, which shall be based on the Threat and Error Management (TEM) and the prevention of recurrence of similar cases.

(3) Setting up of runway change checklist

The Company decided to set up a runway change checklist, which summarizes normal operating procedures of the FCOM, and ensure strict compliance with the SOP at the time of runway change.

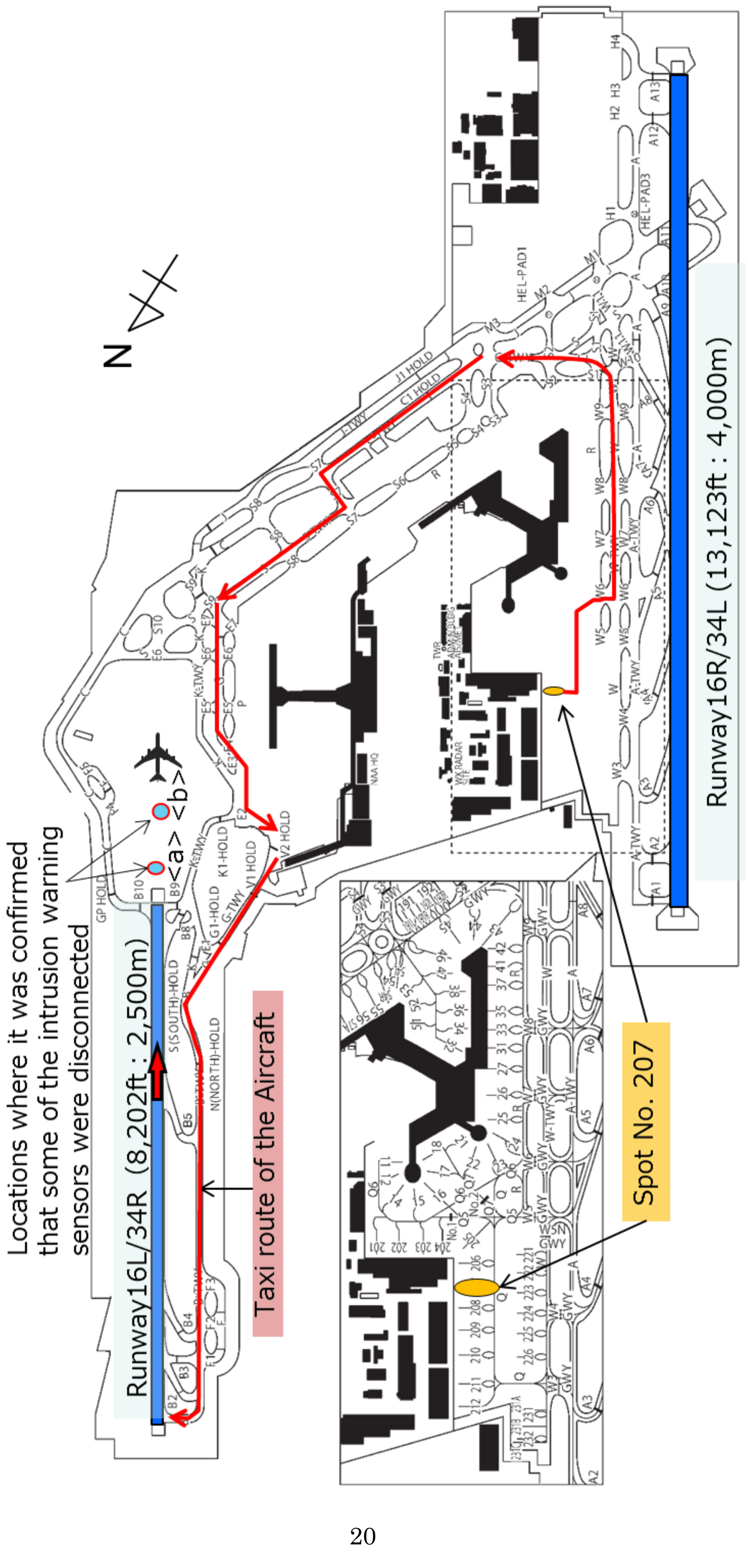
(4) Revision of airport information

On February 16, 2018, the Company revised the information on the Airport and added following information including the runway to be used as precautions at the time of departure from the Airport.

<Approved runway procedures>

- ATC may assign runway 16L/34R to departing aircraft during the hours from 21:00 to 23:00 (JST).
- When the performance capabilities do not permit the aircraft to take off from runway 16L/34R, it is able to request ATC clearance for take-off from runway 16R/34L
- Usually, runway 16L/34R is assigned for departure flights to the Intra-Asian regions.

Appended Figure 1　Narita International Airport
and Estimated Taxi Route of the Aircraft



Appended Figure 2　Three Angle View of Boing 747-8F

Unit: m