Final Report

B777-300ER (9V-SWH) Low on Final Reserve Fuel

25 October 2022

TIB/AAI/CAS.209

Transport Safety Investigation Bureau Ministry of Transport Singapore

25 September 2023

The Transport Safety Investigation Bureau of Singapore

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Table of Contents

A	BBRE\	/IATIONS	iv
S	YNOP	SIS	1
1	Fac	ctual information	2
	1.1	History of the flight	2
	1.2	Injuries to persons	8
	1.3	Damage to aircraft	9
	1.4	Personnel information	9
	1.5	Aircraft information	10
	1.6	Meteorological information	11
	1.7	Aids to navigation	16
	1.8	Flight recorders	16
	1.9	Organisational and management information	17
	1.10	Other Information	20
2	Ana	alysis	23
	2.1	Flight crew's decision making	23
	2.2	Information on autoland for Runway 04 of Batam Airport	25
	2.3	Understanding of minimum fuel	27
3	Cor	Conclusions	
4			30
5	Saf	ety recommendations	32

ABBREVIATIONS

AFDS	Autopilot Flight Director System
AGL	Above Ground Level
AMC	Apron Movement Control
ATC	Air Traffic Control
ATIS	Automatic Terminal Information Service
EAT	Estimated Approach Time
FCOM	Flight Crew Operations Manual
FMC	Flight Management Computer
FRF	Final Reserve Fuel
GPWS	Ground Proximity Warning System
ILS	Instrument Landing System
ICAO	International Civil Aviation Organisation
PF	Pilot Flying
PFD	Primary Flight Display
PM	Pilot Monitoring
SAC	Singapore Approach Control
TAF	Terminal Aerodrome Forecast
TPAC	Tanjung Pinang Approach Control
VOR	Very High Frequency Omni-Directional Range

SYNOPSIS

On 25 October 2022 at about 0820UTC, a B777-300ER aircraft was diverted to Batam Airport due to inclement weather over Changi Airport. After three unsuccessful attempts to land, the aircraft eventually landed on the fourth attempt with low final reserve fuel.

The Transport Safety Investigation Bureau classified this occurrence as an incident.

AIRCRAFT DETAILS

Aircraft type	:	B777-300ER
Operator	:	Singapore Airlines
Aircraft registration	:	9V-SWH
Numbers and type of engines	:	2 x GE90-115B
Engine hours/cycles since new	:	Engine 1 58683 hours / 7448 cycles
		Engine 2 67120 hours / 8379 cycles
Engine hours/cycles since		
last shop visit	:	Engine 1 2080 hours / 269 cycles
		Engine 2 7805 hours / 1048 cycles
Date and time of incident	:	25 October 2022 0919 hrs (UTC)
Location of occurrence	:	Hang Nadim International Airport Runway 22
Type of flight	:	Scheduled
Persons on board	:	280

1 FACTUAL INFORMATION

All times used in this report are Coordinated Universal Time (UTC) unless otherwise stated.

- 1.1 History of the flight
- 1.1.1 On 24 October 2022, a Boeing 777-300ER was scheduled to depart London Heathrow Airport at 1950 hrs and arrive in Singapore Changi Airport at 0855 hrs on 25 October 2022. The planned alternate destination airports were Paya Lebar Air Base in Singapore, Kuala Lumpur International Airport and Senai International Airport in the state of Johor in Malaysia. The First Officer was the Pilot Flying (PF) and the Pilot-in-Command (PIC) the Pilot Monitoring (PM)¹.
- 1.1.2 Prior to departure, the flight crew reviewed the documents provided by the flight dispatcher. The Terminal Aerodrome Forecast² (TAF) for Changi Airport indicated that there could be temporary light to moderate thunderstorms with rain in the vicinity of Changi Airport for periods of 30 minutes or more but less than 60 minutes. The flight crew accepted the fuel plan provided by the flight dispatcher, with 106,164 kg of fuel at departure. They considered the following factors and were satisfied that there was no requirement to uplift additional fuel:
 - (a) There was no forecasted large weather system along the planned flight route that required large deviation.
 - (b) The forecasted weather situation at Changi Airport around the scheduled time of arrival was above the landing minimas.
 - (c) There was no reported defect with the aircraft systems.
 - (d) Air traffic control would typically shorten the flight track of the aircraft through European airspace.
- 1.1.3 At 0801 hrs on 25 October 2022, while the aircraft was in the Kuala Lumpur Flight Information Region, Singapore Approach Control (SAC) informed the flight crew to expect to land on Runway 20R at Changi Airport. According to the flight crew, at that point, the flight management computer (FMC) indicated that

¹ The flight was operated by an augmented crew comprising two Captains and one First Officer. The second Captain was not in the flight deck at the time of occurrence, as this was not the operator's requirement.

² The TAF is an aerodrome forecast that consists of a concise statement of the expected meteorological conditions at the aerodrome for a specified period.

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their estimated fuel on landing was 7,000 kg, which was above the Final Reserve Fuel (FRF)³ requirement of 3,024 kg.

- 1.1.4 At 0805 hrs, SAC instructed the aircraft to hold over waypoint PASPU because of a tailwind on Runway 20R. A minute later, SAC informed all traffic on the Approach frequency to expect delay as the tailwind on Runway 20R was in excess of 10 kts. The PM indicated that, while in hold, the weather radar system on the aircraft showed that there was heavy precipitation over Changi Airport and the two alternate destination airports (Paya Lebar Air Base and Senai International Airport) and that the weather appeared fine over Hang Nadim International Airport in Batam, Indonesia (Batam Airport).
- 1.1.5 At 0810 hrs, SAC updated all traffic on the Approach frequency that the runway in Changi Airport to be used for landing had been changed to Runway 02L. Shortly after this, SAC informed the aircraft that the landing runway would be Runway 02L.
- 1.1.6 At 0822 hrs, the flight crew established contact with Singapore Arrival Control (hereinafter referred to as Arrival Control). Over the next six minutes, Arrival Control vectored the aircraft towards Runway 02L and informed the flight crew that there was heavy rain over Changi Airport and the visibility was reduced to 2 NM. During this period, the weather condition continued to deteriorate with the visibility reducing further to 500 m while the heavy rain persisted. By 0827 hrs, Singapore air traffic control services decided to hold off arrival traffic landing at Changi Airport, to assess the overall weather condition at that time taking into consideration that:
 - (a) Changi Tower had just initiated coordination with SAC to change the runway configuration from the 20 to 02 direction by repositioning all departure and arrival traffic for Runway 02R and Runway 02L respectively, yet the wind direction had shifted back to the reciprocal direction.
 - (b) The inclement weather had deteriorated further affecting the path for both northern and southern approaches.
 - (c) The erratic surface wind condition and poor visibility had resulted in two

³ The FRF quantity for an aircraft with turbine engine is the mass of fuel on arrival at the destination aerodrome that is equivalent to the amount of fuel required for the aircraft to fly for 30 minutes at holding speed at 1500 feet above aerodrome elevation in standard conditions.

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aircraft performing go-arounds while attempting to land on Runway 02L while another aircraft requested to discontinue its approach for Runway 02L.

- 1.1.7 At around 0829 hrs, Arrival Control informed all traffic on the Arrival frequency to expect a five-minute delay and that further updates on the weather situation over Changi Airport would be provided. The flight crew were instructed to proceed to waypoint SAMKO and hold⁴. While enroute to SAMKO, the flight crew obtained the Batam Airport Automatic Terminal Information Service⁵ (ATIS) which indicated clear weather in the vicinity of Batam Airport at that time, and informed Arrival Control at 0831 hrs that they could perform only one hold⁶ and would be down to emergency fuel⁷. As the aircraft entered the hold at around 0833 hrs, Arrival Control updated all traffic on the Arrival frequency that the visibility for Runway 02L had deteriorated to less than 500 m.
- 1.1.8 In view that there was no sign of weather improvement over Changi Airport, SAC informed Tanjung Pinang Approach Control (TPAC) in Indonesia at 0834 hrs that the flight might request to divert to Batam Airport and initiated coordination with TPAC for a potential diversion.
- 1.1.9 While the aircraft was in hold and given that Changi Airport, Paya Lebar Air Base and Senai International Airport were still affected by inclement weather whereas the weather over Batam Airport was fine, the flight crew contemplated a diversion to Batam Airport. The flight crew were mindful that, as the aircraft was about the same distance to Batam Airport as to Changi Airport, a diversion to Batam Airport would not aggravate the fuel situation.
- 1.1.10 At 0836 hrs, as the aircraft was about to complete the first hold over SAMKO, the PM asked Arrival Control if there was any update to the situation. Upon being informed that there was no update, the PM informed Arrival Control that they were able to perform one more hold and that if they still could not have the clearance to commence approach to land at Changi Airport thereafter, they would need to divert to Batam Airport. Arrival Control informed the flight crew

⁴ An aircraft flies an oval course at a designated waypoint while in hold when awaiting further air traffic control instructions (e.g. clearance to land).

⁵ ATIS is a continuous broadcast of recorded aeronautical information pertaining to an aerodrome that includes essential information such as weather condition, active runways etc.

⁶ Flying one hold means flying one circuit of the oval course at the designated waypoint.

⁷ The flight crew used the term "emergency fuel" which is not a term in pilot-air traffic control communication phraseology. Air traffic control would typically recognise only "Mayday Fuel" as a fuel emergency situation.

that it could help with the coordination for a diversion to Batam Airport.

- 1.1.11 At around 0839 hrs and while the aircraft was in the first hold, the PM informed Arrival Control again that they could perform one more hold, as mentioned in their earlier communication. Arrival Control acknowledged the flight crew's plan for a second hold and continued with its coordination with TPAC for the aircraft's diversion to Batam Airport.
- 1.1.12 At 0842 hrs, the flight crew informed Arrival Control that they were approaching SAMKO to complete their second hold. They were instructed by Arrival Control to fly heading 180°. The PM queried Arrival Control why the aircraft was being vectored in a direction away from both Changi and Batam Airports. Arrival Control explained to them that Changi Airport was still unable to accept arrivals and that TPAC had not yet approved the aircraft's diversion to Batam Airport. The PM then offered to perform an orbit⁸ (instead of a third hold) over SAMKO, which Arrival Control approved.
- 1.1.13 At 0844 hrs, the PM informed Arrival Control that they needed to divert to Batam Airport⁹. This was the fourth flight to make the decision to divert to alternate airport while three other flights had earlier elected to divert to alternate airports. At this point, the PIC, who had been the PM, took over as the PF while the First Officer, who had been the PF, became the PM. The flight crew made the decision to divert as there was no certainty that they could land at Changi Airport and as they assessed that the flight could divert to Batam Airport and land while complying with the FRF requirement. Arrival Control acknowledged the flight crew's requirement for a diversion and instructed the flight crew to fly heading 180° so as to position the aircraft for landing on Runway 22 at Batam Airport.
- 1.1.14 A minute later, the PM queried Arrival Control again if Changi Airport was accepting arrivals. Arrival Control replied that that Changi Airport was still not accepting arrivals.
- 1.1.15 At 0846 hrs, Arrival Control informed the flight crew that approval for their diversion to Batam Airport was still pending. Arrival Control instructed the flight crew to fly heading 120° and thereafter 90°. At 0848 hrs, Arrival Control transferred the flight to SAC. SAC vectored the aircraft towards the boundary of its control area with the intention for the eventual hand-over of the aircraft to

⁸ An orbit refers to a 360° circular course at a holding point.

⁹ The orbit which the PM offered to perform earlier was eventually not executed.

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TPAC to occur at a position as close to Runway 22 of Batam Airport as possible. The PM informed SAC that they were down to minimum fuel¹⁰. Two minutes later, SAC informed the flight crew that clearance from Batam Airport was still pending.

- 1.1.16 The PF declared "Mayday Fuel" at 0853 hrs when the estimated fuel on landing at Batam Airport was at the FRF. At that point, the aircraft was approximately 13 NM south-east of Batam Airport. SAC vectored the aircraft to an initial heading of 360° and instructed the crew to contact TPAC¹¹.
- 1.1.17 By 0855 hrs, the flight crew had established contact with TPAC and were informed that they had priority for the landing. The PF was also performing communication duties while the PM was configuring the aircraft systems and providing information to the PF, in preparation for the landing at Batam Airport. According to the flight crew, the documents they referred to included the following:
 - (a) Batam Runway 22 Very High Frequency Omni-Directional Range (VOR) approach chart
 - (b) Batam Runway 04 Instrument Landing System (ILS) approach chart
 - (c) Operator's Airport Briefing for Batam Airport
- 1.1.18 At around 0900 hrs as the aircraft was on the approach path for Runway 22, the flight crew were informed by TPAC that there was a tailwind of 14 kts gusting up to 30 kts. The PF opted to discontinue the approach at around 1,600 feet above ground level (AGL) and requested to reposition for another approach onto Runway 04.
- 1.1.19 Over the next few minutes, the PF manoeuvred the aircraft to avoid the weather and repositioned the aircraft with the intention to perform an autoland using the Instrument Landing System (ILS) on Runway 04. At around 0905 hrs, the PM informed TPAC that he had Runway 04 in sight. TPAC instructed the flight crew to contact Nadim Tower (the control tower at Batam Airport) on tower frequency of 118.7 MHz and the PM read back the frequency correctly.

¹⁰ See 1.10.2 for information on minimum fuel declaration.

¹¹ Earlier at 1647 hrs, TPAC had informed that should the flight declare an emergency, SAC could proceed to route the aircraft directly to Batam Airport.

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- 1.1.20 Shortly after the last communication with TPAC, the PF disengaged the autopilot system when the aircraft was 1,195 feet AGL. The PF recalled that he attempted to manually fly the aircraft to capture the glideslope and localiser signals with the intention to perform an autoland.
- 1.1.21 At around 0906 hrs, Nadim Tower informed TPAC that the flight crew had not made contact on the tower frequency and the tower controllers did not have the aircraft in sight because of heavy rain and the visibility for Runway 04 was 500 m. Nadim Tower did not issue any landing clearance for the aircraft as the flight crew did not contact Nadim Tower.
- 1.1.22 At around this time, the PF managed to position the aircraft on the localiser final approach course for Runway 04 and armed the autopilot Approach mode. The lateral and vertical mode of the aircraft's autopilot flight director system managed to capture the localiser and glideslope mode respectively. The PF engaged the autopilot system when the aircraft was 668 feet AGL but was met with a "NO AUTOLAND" message on the Primary Flight Display (PFD). According to the PF, he was startled by the appearance of the "NO AUTOLAND" message and shortly after, he noticed that the localiser and glideslope deviation pointers were showing almost a full-scale deflection on his PFD, indicating that the aircraft was away from the centreline and glidepath of the runway. The PF disengaged the autopilot and, 20 seconds later, executed a go-around when the aircraft was 132 feet AGL.
- 1.1.23 At 0907 hrs, Nadim Tower informed TPAC that there was an aircraft going around at Runway 04. Three seconds after this communication, the PF informed TPAC that he was executing a go-around.
- 1.1.24 At 0909 hrs, while the PF was repositioning the aircraft for another attempt to land on Runway 04, he requested TPAC for information on the tailwind at Runway 22. TPAC had to relay this request to Nadim Tower and was only able to reply to the flight crew 90 seconds later, informing that the visibility for Runway 04 and Runway 22 was 500 m and six kilometres respectively and that wind information was 340° at seven knots.
- 1.1.25 In response, the PF informed TPAC that the aircraft did not have sufficient fuel to be repositioned for Runway 22 and that his next landing attempt on Runway 04 had to be successful. At that point, the aircraft was approximately abeam the threshold of Runway 04 and the flight crew was about to commence a right turn for the final approach to Runway 04.

- 1.1.26 At about 0911 hrs, TPAC informed the flight crew that the visibility for Runway 04 was 800 m and that the flight crew had the discretion to continue the approach. The PF confirmed to TPAC that he would maintain his original intention to land on Runway 04.
- 1.1.27 Over the next two minutes, TPAC and Nadim Tower coordinated the movements of other traffic to keep the runway clear. TPAC continued to relay information between the flight crew and Nadim Tower, which included the landing clearance.
- 1.1.28 According to the PF, when the aircraft broke cloud cover on the second approach to Runway 04, the aircraft was above the glidepath and offset to the left of the extended centreline of the runway. The PF increased the descent rate in an attempt to position the aircraft on the glidepath and extended centreline of the runway. However, the Ground Proximity Warning System (GPWS) generated a warning for excessive sink rate when the vertical speed exceeded -1,400 feet per minute. At 0914 hrs, the PF initiated another go-around in response to the GPWS warning, in line with the operator's procedures, when the aircraft was at about 212 feet AGL.
- 1.1.29 At around 0915 hrs, the PF informed TPAC that they were going around and would perform a teardrop turn to reposition the aircraft to perform a visual landing on Runway 22. Subsequently, TPAC gave wind information as wind direction 330° at 15 kts to the fight crew. The PF was aware that the aircraft's tailwind certification limit was 15 kts for landing and the operator's procedure was not to land with a tailwind exceeding 10 kts. Considering that the remaining fuel quantity had reached critically low level, the PF decided to proceed with the approach to land on Runway 22.
- 1.1.30 The aircraft subsequently landed at Batam Airport and taxied to a parking bay. The aircraft touched down at Batam Airport at 0919 hrs with fuel remaining significantly below the FRF of 3,024 kg.
- 1.2 Injuries to persons
- 1.2.1 There was no injury to any person in this incident.

1.3 Damage to aircraft

1.3.1 There was no damage to the aircraft.

1.4 Personnel information

1.4.1 PIC

Age	55
Licence type	Air Transport Pilot License
Issuing authority	Civil Aviation Authority of Singapore
Licence validity date	10 January 2020
Medical certificate	Class One
Medical certificate validity	Date of expiry: 31 January 2023
Medical operational proviso	Corrective lenses for near vision
Last Base Check date	24 March 2022
Last Line Check date	14 March 2022
Total flying hours	14,371.5
Aircraft types flown	B747, B777
Total hours on type	10,075.6
Flying in last 90 days	246hr 32min
Flying in last 7 days	40hr 10min
Flying in last 24 hours	13hr 44min
Duty time in last 48 hours	21hr 13min (Comprising 5hr 59min on standby on 23 October 2022, and 15hr 14min on SQ319)
Rest period in last 48 hours	Rest from 22 October 2022 1556z to 24 October 2022 1850z (except standby period on 23 October 2022 as stated above)

1.4.2 FO

Age	31
Licence type	Air Transport Pilot License
Issuing authority	Civil Aviation Authority of Singapore
Licence validity date	18 April 2022
Medical certificate	Class One

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Medical certificate validity	30 April 2023
Medical operational proviso	Corrective lenses for distant vision
Last Base Check date	12 June 2022
Last Line Check date	20 January 2022
Total flying hours	2,261.9
Aircraft types flown	B777
Total hours on type	2,261.9
Flying in last 90 days	203hr 25min
Flying in last 7 days	27hr 40min
Flying in last 24 hours	13hr 44min
	21hr 13min
Duty time in last 48 hours	(Comprising 5hr 59min on standby
Duty time in last 48 hours	on 23 October 2022, and 15hr 14min
	on SQ319)
	Rest from 22 October 2022 1556z to
Rest period in last 48 hours	24 October 2022 1850z (except
	standby period on 23 October 2022
	as stated above)

- 1.5 Aircraft information
- 1.5.1 Autopilot Flight Director System (or autopilot system)
- 1.5.1.1 The Autopilot Flight Director System (AFDS) has these two purposes:
 - (a) To automatically control the airplane attitude when the autopilot is engaged.
 - (b) To supply indications so the flight crew can manually control the airplane attitude.
- 1.5.1.2 When the Approach (APP) switch on the mode control panel is pushed, it arms the localiser in roll mode and glideslope in pitch mode. Once the localiser and glideslope signs are captured, the approach mode becomes engaged.
- 1.5.1.3 In the approach mode of the AFDS, the aircraft automatically captures and tracks the localiser and glideslope signals. If the autopilot approach continues and certain criteria are met by the aircraft systems and aerodrome

infrastructure¹², the aircraft is able to land automatically as the glideslope signals guides the aircraft along the descent path to the touchdown point on the runway while the localiser signal guides the aircraft along maintain a lateral path that is centred along the extended centreline of the runway.

- 1.5.1.4 The AFDS provides inputs to control the elevators, ailerons, flaperons and spoilers. During approach and landing, the AFDS would also provide inputs to control the rudder. After an automatic landing, the AFDS also provide inputs to control the nose wheel steering and rudder to follow the localiser signal.
- 1.5.1.5 According to the aircraft manufacturer, some of the situations where the "NO AUTOLAND" message may be shown on the PFDs include:
 - (a) If the APP switch has been selected but the engaged status has not been annunciated by 600 feet AGL.
 - (b) If the AFDS is in approach mode and the aircraft track is not aligned with the runway heading that is stored in the flight management computer's navigation database.
- 1.6 Meteorological information
- 1.6.1 According to meteorological records, there was a thunderstorm on 25 October 2022 at 0800 hrs north of Changi Airport. The thunderstorm moved southwards and affected the aerodrome between 0815 hrs and 0915 hrs. During this period, the thunderstorms continued to develop and intensified over the southern parts of Singapore as well as the eastern side of the Batam island, where Batam Airport was located.
- 1.6.2 The summary of the Meteorological Aerodrome Reports (METARs) for Changi Airport around period of occurrence is provided in **Table 1**.

¹² The runways at Changi Airport are equipped for Category II ILS operation. Based on Singapore Air Traffic Services' procedures, Category II ILS approaches can be made available in times of prolonged periods of reduced visibility and forecasted to deteriorate further. Pilots can request to perform a Category II ILS approach but Changi Airport will require one hour for all stakeholders to prepare the aerodrome to ensure that glideslope and localiser signals are protected to accurately guide the aircraft to the touchdown point on the runway. The visibility around the period of the incident flight's arrival did not deteriorate to the criteria of Category II ILS operation, it was the unstable wind conditions that had resulted in temporary holding off of arrival flights.

Time (UTC)	METAR
0800	METAR WSSS 250800Z 16007KT 9999 VCSH FEW014 FEW016CB FEW017TCU SCT040 30/25 Q1008 TEMPO TL0930 4500 TSRA= Summary: Mean winds of 7 kts blowing from the south-southeast direction were reported and no significant weather was observed. Moderate thunderstorm with precipitation and a prevailing visibility of 4500 m was forecasted until 0930 hrs.
0807	SPECI ¹³ WSSS 250807Z 14005KT 020V170 9000 -TSRA FEW014 FEW016CB SCT017TCU 29/25 Q1008 TEMPO TL0930 3000 TSRA= Summary: Mean winds of 5 kts blowing from the southeast direction were reported. Light thunderstorm with a prevailing visibility of 9000 m was observed. Moderate thunderstorm with precipitation and a prevailing visibility of 3000 m was forecasted until 0930 hrs.
0811	SPECI WSSS 250811Z 33010KT 300V360 9000 4000E -TSRA FEW014 FEW016CB SCT017TCU 29/23 Q1008 TEMPO TL0930 3000 TSRA= Summary: Mean winds of 10 kts blowing from the northwest direction were reported. Light thunderstorm with a prevailing visibility of 9000 m and minimum visibility of 4000 m to the east was observed. Moderate thunderstorm with precipitation and a prevailing visibility of 3000 m was forecasted until 0930 hrs.
0815	SPECI WSSS 250815Z 26008KT 230V300 3500 TSRA FEW012 FEW014CB BKN015TCU 26/22 Q1009 TEMPO TL0930 2000 +TSRA= Summary: Mean winds of 8 kts blowing from the west-southwest direction were reported. Moderate thunderstorm and a prevailing visibility of 3500 m was observed. Heavy thunderstorm with precipitation and a prevailing visibility of 2000 m was forecasted until 0930 hrs.

¹³ SPECI is a special weather report issued beyond the normal update frequency of the METAR, when there is significant deterioration or improvement in airport weather conditions.

0830	METAR WSSS 250830Z 32009KT 230V360 1000 R02L/P2000N R02R/P2000N +TSRA FEW008 FEW014CB BKN015TCU 24/22 Q1009 BECMG FM0900 TL0915 4500 TSRA BECMG FM1000 6000 NSW=
	Summary: Mean winds of 9 kts blowing from the northwest were reported. Heavy thunderstorm with a prevailing visibility of 1000 m was observed. The observed weather conditions were forecasted to last until 0900 hrs and expected to gradually improve from 0900 hrs to 0915 hrs to moderate thunderstorm with precipitation and a prevailing visibility of 4500 m.
0900	METAR WSSS 250900Z 20005KT 170V260 1500 +TSRA FEW008 FEW014CB SCT015TCU BKN130 23/23 Q1009 BECMG TL0930 4500 TSRA BECMG FM1000 TL1030 6000 NSW=
	Summary: Mean winds of 5 kts blowing from the south-southwest direction were reported. Heavy thunderstorm with a prevailing visibility of 1500 m was observed. The observed weather conditions were forecasted to improve to moderate thunderstorm with precipitation and a prevailing visibility of 4500 m by 0930 hrs.

 Table 1: Summary of METAR for Changi Airport

1.6.3 The summary of the METARs for Batam Airport around period of occurrence is provided in **Table 2**.

Time (UTC)	METAR
0800	METAR WIDD 250800Z 18004KT 9999 FEW013CB SCT014 30/24 Q1010 NOSIG RMK CB TO NW DUPE= Summary: Mean winds of 4 kts blowing from the south direction were reported. Cumulonimbus clouds were observed in the north-west direction.

0830	METAR WIDD 250830Z 17004KT 9999 FEW013CB SCT014 30/24 Q1010 NOSIG RMK CB TO N AND NW= Summary: Mean winds of 4 kts blowing from the south direction were reported. Cumulonimbus clouds were observed in the north and north-west direction.
0900	METAR WIDD 250900Z 04010KT 9999 FEW013CB BKN014 30/23 Q1010 NOSIG RMK CB TO N AND NW= Summary: Mean winds of 10 kts blowing from the north-east direction were reported. Cumulonimbus clouds were observed in the north and north-west direction.
0930	METAR WIDD 250930Z 35004KT 6000 -TSRA FEW013CB BKN014 26/23 Q1011 NOSIG RMK CB TO N AND SE AND NW= Summary: Mean winds of 4 kts blowing from the north direction were reported. Light thunderstorm and a prevailing visibility of 6000 m was observed. Cumulonimbus clouds were observed in the north, south-east and north-west direction.
1000	METAR WIDD 251000Z 29006KT 8000 -TSRA FEW013CB BKN014 25/23 Q1011 NOSIG RMK CB TO SE AND S AND NW= Summary: Mean winds of 6 kts blowing from the west-northwest direction were reported. Light thunderstorm and a prevailing visibility of 8000 m was observed. Cumulonimbus clouds were observed in the south-east, south and north-west direction.
1030	METAR WIDD 251030Z 30004KT 9000 -TSRA FEW013CB BKN014 25/24 Q1011 NOSIG RMK CB TO SE AND S AND NW= Summary: Mean winds of 4 kts blowing from the north-west direction were reported. Light thunderstorm and a prevailing visibility of 9000 m was observed. Cumulonimbus clouds were observed in the south-east, south and north-west direction.

Table 2: Summary of METAR for Batam Airport

1.6.4 The rain intensity over both Changi and Batam Airports from the time the aircraft entered the hold over SAMKO until it landed in Batam Airport is shown in Figure 1.

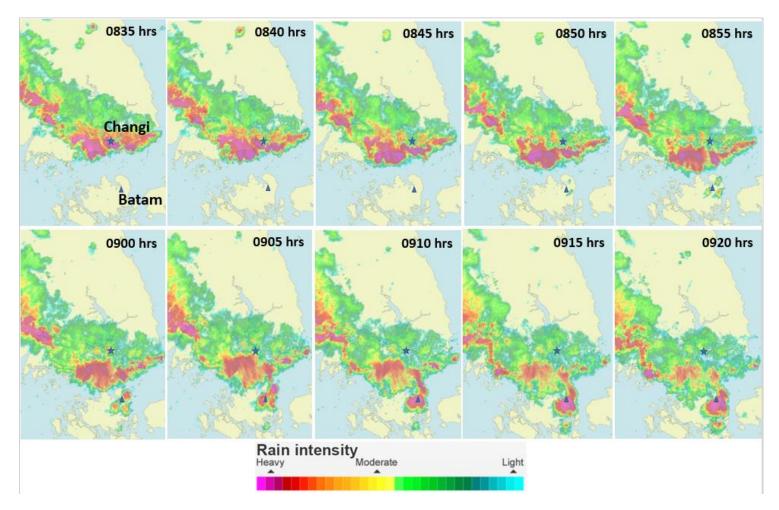


Figure 1: Rain intensity over Changi and Batam Airports

- 1.6.5 Changi Airport was affected by heavy rain during the period when the aircraft was vectored towards Runway 02L. During the period when the flight was holding over SAMKO, there was no rain over Batam Airport but the weather system was moving south from Singapore towards Batam.
- 1.6.6 The weather system moved south towards Batam Airport, located approximately 16 NM south-east of Changi Airport. Weather radar records showed that light rain was observed in the vicinity of Batam Airport at 0850 hrs. The rain continued to develop and intensify during the period when the flight diverted and made the landing attempts. When the flight crew declared "Mayday Fuel", the weather

condition over Batam Airport had deteriorated with a wider spread of moderate rain intensity.

- 1.6.7 By 0900 hrs, when the flight arrived for the first approach on Runway 22, there was moderate to heavy rain over Batam Airport. Over the next 20 minutes where the PIC attempted thrice to land the aircraft, the weather deteriorated with the rain intensity increasing and becoming more widespread.
- 1.7 Aids to navigation
- 1.7.1 For the approach to Runway 04 of Batam Airport, an ILS is available. The localiser frequency of the ILS is 110.1 MHz with the identifier IBTM. The heading for the final approach course of the localiser signal is 41°, a 1° offset from the heading of Runway 04 which is 42°. According to the aircraft manufacturer, this difference is likely the result of the two magnetic courses being surveyed at different times and the aircraft would have been able to follow the localiser signal and perform an autoland if certain criteria are met by the aircraft systems and aerodrome infrastructure. Nevertheless, the operator's procedures (refer to Para 1.9.2) indicate that its flight crew should not attempt an autoland if the published approach charts indicate that there is an offset.
- 1.7.2 Even in situations where autoland is not available, the ILS localiser and glideslope signals can be used by the AFDS to guide the aircraft along the appropriate vertical descent and lateral profile for the approach. As they approach the decision altitude¹⁴, they can disconnect the autopilot and land the aircraft manually.
- 1.8 Flight recorders
- 1.8.1 The aircraft was installed with a Cockpit Voice Recorder (CVR) and a Flight Data Recorder (FDR). After the aircraft arrived at the parking bay at Batam Airport, the flight crew shut down the engines but left the auxiliary power unit (APU) running to provide conditioned air to the aircraft cabin when the passengers waited for the aircraft to take off again for Changi Airport. The flight crew did not deactivate the CVR and FDR.
- 1.8.2 As the CVR had a recording capacity of only two hours, audio data around the

¹⁴ Decision altitude is a specific altitude during a precision approach where the pilot must discontinue the approach if the required visual reference to continue the approach has not been established.

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time of the diversion occurrence was over-written and was not available for analysis by the investigation team.

- 1.8.3 Fight data from the FDR, which had a recording capacity of 25 hours, was downloaded and analysed. The data around the time of the diversion occurrence was available and used for analysis by the investigation team.
- 1.8.4 The FDR data was reviewed by the aircraft manufacturer. It was observed that in the first approach to Runway 04, the aircraft intercepted the localiser signal at a 15° angle slightly less than 2 NM from the runway threshold. The autopilot was engaged just as the aircraft crossed the centre of the localiser beam and the aircraft passed through the localiser beam before it could turn to align with the localiser given the short range. The AFDS identified the increasing localiser deviation and set the "NO AUTOLAND" message to indicate that the aircraft track was out of alignment with the runway heading and that autoland could not be engaged.
- 1.9 Organisational and management information
- 1.9.1 Operator's fuel policy
- 1.9.1.1 The operator's fuel policy contained within the operations manual states that:
 - (a) The PIC shall request delay information from ATC when unanticipated circumstances may result in landing at the destination airport with less than the FRF plus any fuel required to proceed to an alternate airport or the fuel required to operate to an isolated airport.
 - (b) When the maximum delay or an Estimated Approach Time (EAT) is known, the flight may continue to hold, as long as landing at destination is assured and the fuel remaining at touchdown is not less than the FRF.
 - (c) The PIC shall advise ATC of a minimum fuel state by declaring "minimum fuel" when, having committed to land at a specific airport, the pilot calculates that any change to the existing clearance to that airport may result in landing with less than FRF.
 - (d) The declaration of "minimum fuel" informs ATC that all planned airport options have been reduced to a specific airport of intended landing and any changes to the existing clearance may result in landing with less

than FRF. This is not an emergency situation but an indication that an emergency situation is possible should any additional delay occur.

- (e) The PIC shall declare a situation of fuel emergency by broadcasting "mayday, mayday, mayday, fuel" when the calculated usable fuel predicted to be available upon landing at the nearest airports where a safe landing can be made is less than the FRF.
- 1.9.2 Operator's autoland policy
- 1.9.2.1 The operator's flight crew operations manual (FCOM) states that:

An autoland should not be attempted unless the localiser final approach course is aligned with the runway centreline, except for runways that have CAT II or III ILS charts published.

1.9.2.2 In the published approach charts available to the flight crew, there is no explicit mention that an autoland should not be attempted. During the occurrence, the flight crew had made reference to the Batam Runway 04 ILS and Batam Runway 22 VOR approach charts. They would have looked at specific areas of both charts (see Figure 2) to recognise that the heading for the final approach course of the localiser signal is 41°, which is a 1° offset from the heading of Runway 04 which is 42° to arrive at the conclusion that an autoland should not be attempted.

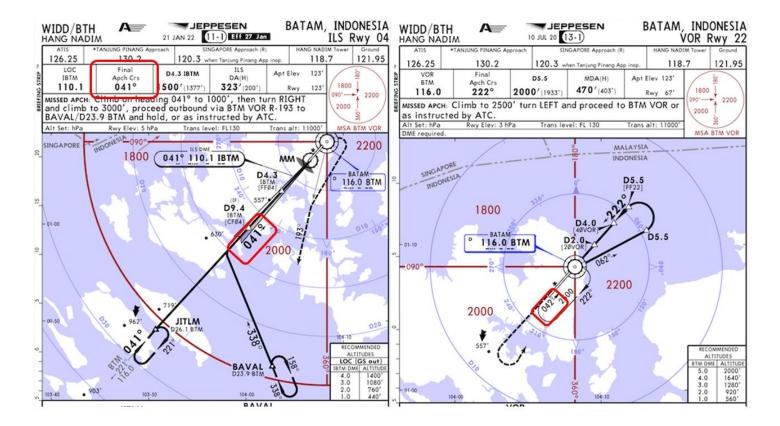


Figure 2: (Left) ILS chart indicating 41° heading for the localiser signal (Right) VOR chart showing 42° heading for Runway 04

- 1.9.3 Airport briefing document
- 1.9.3.1 The operator provides, in respect of every airport that it operates to, an airport briefing document to provide useful operational information (e.g. common hazards, ground movement/parking limitations) to its flight crew about the specific airport that they are operating into. The airport briefing is a value-add initiative by the operator that is over and above the regulator's requirements.
- 1.9.3.2 For some airports where autoland is not permitted because the localiser signal is not aligned to the runway heading, this information is reflected in the critical section of the airport briefing document, as shown in **Figure 3** for Phuket Airport.

CRITICAL	
AUTOLAND	Automatic landings are <u>not permitted</u> on RWY27 due to the offset localizer.

Figure 3: Information showing autoland is not permitted on Runway 27 of Phuket Airport

1.9.3.3 In the case of the critical section of operator's airport briefing for Batam Airport, there is no information reflecting autoland is not permitted for Runway 04, as shown in **Figure 4**.

CRITICAL		

Figure 4: No information in the critical section of Batam Airport briefing

- 1.9.3.4 The operator indicated that information within the airport briefing documents is derived from several formal and informal sources, including crew and ATC feedback. According to the operator, the inclusion or omission of any information in the airport briefings is not intended to supplement or detract from its published policies, hence the level of details in one airport brief document may defer from another.
- 1.10 Other Information
- 1.10.1 Diversion Coordination
- 1.10.1.1 When SAC first initiated diversion coordination with TPAC at 0834 hrs for the aircraft to divert to Batam Airport, the flight crew had not indicated that it was in a "Mayday Fuel" situation. The coordination between both SAC and TPAC was based on the procedures to coordinate the normal movement of an arrival aircraft in a non-emergency situation. A typical coordination process usually takes between 10 and 20 minutes and it involves:
 - (a) SAC contacting TPAC and providing details of the diverting aircraft and the abbreviated flight plan.

- (b) TPAC informing Nadim Tower on the diversion request.
- (c) Nadim Tower coordinating with Batam apron movement control (AMC) on the diversion request. Factors that both Batam Tower and Batam AMC have to consider if they can accept the arrival of aircraft include, but not limited to:
 - (i) If the aerodrome is certified to support the operation of the aircraft type
 - (ii) If the aerodrome rescue and firefighting services can support emergency response involving a particular aircraft type
 - (iii) The availability of parking area for the unscheduled arrival aircraft
 - (iv) Manoeuvring space for the aircraft movement in the apron
- (d) Nadim Tower and Batam AMC reach a decision if the diversion can be accepted.
- (e) Nadim Tower updates TPAC if the diversion can be accepted.
- (f) TPAC informs SAC if aircraft can be accepted.
- 1.10.1.2 When TPAC first informed Nadim Tower for the possible diversion of the occurrence aircraft at 0834 hrs, both air traffic control units were in the midst of coordinating the movement of two other aircraft scheduled to depart Batam Airport. By 0844 hrs when TPAC asked for updates on the diversion for the occurrence flight, they were informed that Batam AMC was still processing this request. At around the same time when the flight crew informed SAC that they have decided to divert to Batam, SAC provided TPAC with information on the aircraft's flight plan to which TPAC replied to wait for their update.
- 1.10.1.3 At 0847 hrs, SAC informed TPAC that the flight had already decided to divert to Batam Airport and again checked if the diversion for the flight had been accepted. TPAC replied that Nadim Tower had received the earlier information but not provided any updates. TPAC further informed that should the flight declare an emergency, SAC can proceed to route the aircraft directly to Batam Airport.
- 1.10.1.4 By 0848 hrs, SAC informed TPAC that it would continue to vector the aircraft

closer to Batam Airport, while waiting for updates on the diversion request.

- 1.10.1.5 SAC contacted TPAC at 0850 hrs again but there were still no updates on the diversion request. SAC proceeded to inform and passed on information to TPAC to coordinate the diversion of another two aircraft to Batam Airport and highlighted that it would like to hand over movement control of the occurrence aircraft once Nadim Tower accepts the earlier diversion request.
- 1.10.1.6 The investigation team understood that when the Batam AMC initially received the diversion request, it noted that the aircraft type (B777) does not usually operate into the airport. Nadim Tower was unable to provide updates on the outcome of the diversion request when queried by SAC, as Batam AMC was in the midst of verifying if it could facilitate the non-emergency diversion request.
- 1.10.1.7 At 0854 hrs, immediately after the flight crew declared "Mayday Fuel", SAC informed TPAC of the situation. TPAC immediately accepted aircraft's diversion and informed SAC that the flight was given priority to land ahead of all other arrivals.
- 1.10.2 Minimum fuel information
- 1.10.2.1 When the flight crew informed SAC that they were at minimum fuel, it was in line with the operator's fuel policy which is meant to inform air traffic control that all planned airport options have been reduced to a specific airport of intended landing and any change to existing clearance my result in landing with less than the FRF. A minimum fuel declaration is not an emergency situation but an indication that an emergency situation is possible should any additional delay occur.
- 1.10.2.2 Based on the standard operating procedures of SAC, when being informed of an aircraft in a minimum fuel situation, the air traffic controllers will avoid extending the track miles of the aircraft with the aim of not aggravating the aircraft's fuel situation. However, as a minimum fuel situation is not an emergency situation vis-à-vis a "Mayday Fuel" declaration, the routing provided to the aircraft will be based on the prevailing traffic condition. Direct routing will only be provided in the event when an aircraft declares emergency.

2 ANALYSIS

The investigation looked into the following:

- (a) Flight crew's decision making
- (b) Information on autoland for Runway 04 of Batam Airport
- (c) Understanding of minimum fuel
- 2.1 Flight crew's decision making
- 2.1.1 The operator has indicated that there is no set policy or procedure for initiating a diversion and provides its flight crew with the discretion to initiate a diversion as required, as they are in the best position to evaluate the dynamic factors of each individual flight.
- 2.1.2 The operator's fuel policy is clear in the guidance to its flight crew that if the maximum delay or an EAT is known, the flight may continue to hold, as long as landing at destination is assured and the fuel remaining at touchdown is not less than the FRF. However, the situation faced by the flight crew on the day of occurrence where information on the maximum delay or EAT was not available does not necessarily mean that a diversion should be initiated immediately.
- 2.1.3 The decision to initiate a diversion when an aerodrome is unable to accept arrivals is not always straightforward. The flight crew would have to balance the possibility of potentially holding a while longer and possibly landing with more than the FRF requirement at the scheduled arrival airport against the possibility of diverting earlier but landing below the FRF requirement at the diversion airport.
- 2.1.4 In this occurrence, the flight crew appeared to have preferred to land at the scheduled arrival airport, Changi Airport, and held off deciding to divert based on the following decisions that were made:
 - (a) They offered to perform another hold over SAMKO at 0839 hrs even though Arrival Control was unable to offer any update when queried by the PM earlier at 0836 hrs and they had previously indicated that they could only perform a single hold.
 - (b) They indicated that they could perform an orbit at 0842 hrs, as they were

about to complete the second hold, when informed by Arrival Control that Changi Airport was not accepting any arrivals and was in the midst of coordinating a diversion for the aircraft to Batam Airport.

- (c) They queried if Changi Airport was accepting arrivals at 0845 hrs despite declaring that they would divert a minute earlier and had accepted Arrival Control's instruction to be vectored towards Batam Airport.
- 2.1.5 With the decision taken to stay in hold as much as possible in hope that the scheduled arrival airport starts to accept arrivals again, the trade-off for any flight crew is the reduced safety margins available to them when the decision to divert is eventually made and should they need to perform more than one landing attempt due to unforeseen events such encountering windshear during short finals that requires a go-around to be performed.
- 2.1.6 The operator opines that the decision taken by the flight crew to stay in hold as much as possible in the hope that the scheduled arrival airport starts to accept arrivals again does not compromise safety margins. It further opines that had the pertinent information been given to the crew, a more informed decision could have been made to extend the hold or to initiate a diversion. Such pertinent information should be in the form of SAC explicitly stating it was holding off arrival.
- 2.1.7 The investigation team is of the opinion that the repeated information on Changi Airport being unable to accept arrivals should be interpreted that a landing at the airport was not assured and the flight crew could have made a decision based on this information. Between 0820 - 0844 hrs, three other aircraft were presented with similar information by SAC and were able to make a decision to divert earlier.
- 2.1.8 In this occurrence, the flight crew had identified Batam Airport as a viable alternate destination with fair weather when Changi Airport, Paya Lebar Air Base and Senai International Airport were all affected by heavy precipitation. Unfortunately, when the flight crew persisted with their decision to hold as long as possible, the weather system affecting Changi Airport started to move in the South Easterly direction towards Batam Airport. Had the flight crew initiated a diversion after the first hold based on their original intention as communicated to Arrival Control, when they were first instructed to hold over SAMKO, it is reasonable to believe that they would have arrived at Batam Airport earlier and would be able to attempt a successful landing on Runway 22 in a better weather

condition.

- 2.1.9 Recent studies identified that one of the effects of climate change is more intense and more frequent storms in many regions exacerbated by extreme rainfall and flooding. This may likely result in pilots operating into areas where the weather conditions exceed the limits to conduct a safe landing or results in loss of capacity of an airport that may impact the regional airspace system.
- 2.1.10 The effects of climate change are also expected to make the operating environment for pilots more unpredictable. The events in this occurrence suggest that it may be prudent for pilots to interpret operating procedures in a more conservative manner to conclude that landing at a scheduled destination is not assured if the air traffic controllers are not able to provide definitive updates. This will allow pilots to make an earlier decision to divert, with higher safety margins, especially when weather conditions are favourable, to increase the chances of conducting a safe landing at the diversion aerodrome.
- 2.2 Information on autoland for Runway 04 of Batam Airport
- 2.2.1 According to the operator's FCOM, an autoland should not be attempted when information contained within the published charts indicates that the localiser signal is not aligned to the runway heading. Hence, an autoland should not have been attempted on Runway 04 of Batam Airport as the heading for the final approach course of the localiser signal is 41°, which is a 1° offset from the runway heading of 42°.
- 2.2.2 The flight crew had intended to perform an autoland in their first attempt to land on Runway 04 of Batam Airport. They appeared not to have determined that an autoland should not be attempted, in accordance with the operator's FCOM, as:
 - (a) It appears that while looking through the approach charts for Batam Airport in preparation for the approach for Runway 04, they did not recognise the 1° offset between the final approach course and the heading of Runway 04 to realise that an autoland should not be attempted; and
 - (b) The operator's airport briefing document for Batam Airport did not indicate autoland is not permitted even though such information may be reflected for some other airports where the localiser signal is not aligned

to the runway heading.

- 2.2.3 The unexpected appearance of the "NO AUTOLAND" message on the PFD appeared to have affected the flight crew's operating capacity in the following manner:
 - (a) The PIC (who was the PF for landing at Batam Airport) indicated to the investigation team that he was startled by the appearance of the "NO AUTOLAND" message and took a while to recover before eventually deciding to perform a go-around. Based on the recorded FDR data reviewed by the aircraft manufacturer, when the PF engaged autopilot at 668 feet AGL, the AFDS was providing pitch and roll inputs to the flight control systems to guide the aircraft towards the centre of the glideslope and localiser signal. Had the flight crew been aware that an autoland should not have been attempted, instead of disconnecting the autopilot when the "NO AUTOLAND" message appeared, it was possible for them to maximise the use of automation to allow the autopilot to guide the aircraft to descend to the decision altitude (which was 200 feet AGL) before disengaging the autopilot and manually land the aircraft, if the runway could be sighted.
 - (b) It distracted the flight crew as they did not realise that they did not make radio contact with Nadim Tower although instructed to do so by TPAC at around the same period when the "NO AUTOLAND" message appeared. Subsequently, they also did not realise that they had not received landing clearance for their first attempt to land on Runway 04.
- 2.2.4 In this occurrence, the only means for the pilots to determine if autoland can be performed, would be for them to look at specific areas of two different documents, recognise the offset of the localiser signal and heading of Runway 04 and arrive at the conclusion that an autoland should not be attempted, as prescribed by the operator's procedures. There is no information in any of the approach charts that explicitly indicates that an autoland should not be attempted. Pilots have to be mindful and systematically make such a determination if they intend to perform an autoland. It is all the more important that pilots be periodically reminded of the operator's requirement as it is easy to overlook this process, more so in a high stress situation such as running short of fuel.

2.2.5 As part of its initiative to improve their pilot's awareness of the airports they are © 2023 Government of Singapore

operating into, the operator provides airport briefing document that highlights useful operational information which is over and above the regulator's requirements. However, there was a lack of consistency in the level of details when comparing one airport briefing document to another.

- 2.2.6 In the case of Runway 27 of Phuket Airport where the localiser signal is not aligned to the runway heading, the critical section of this airport briefing document clearly indicated that autoland is not permitted. However, this information was not present in the Batam Airport briefing document even though the information within the approach charts indicates that the localiser signal was similarly offset to the runway heading. Undoubtedly, it is important for information contained within documents which are provided to the pilots, to make operational decisions, to be consistent in the level of detail.
- 2.2.7 Had this information been included in the Batam Airport briefing document, the flight crew would have been aware that an autoland is not permitted by the operator's procedures when the FO (who was the PM for the landing at Batam Airport) referred to it while preparing for the approach. As the aircraft descended past 1,195 feet AGL, the flight crew indicated that they could sight the runway when queried by TPAC for the first approach on Runway 04. It is reasonable to believe that the PIC would be able to continue the approach manually if he had been aware that autoland was not permitted instead of being startled by the "NO AUTOLAND" message and eventually performing a go-around.
- 2.3 Understanding of minimum fuel
- 2.3.1 The flight crew had informed SAC and Arrival Control about the progressively deteriorating state of their fuel situation by mentioning that:
 - (a) They would be down to emergency fuel after one hold at 0831 hrs
 - (b) They were at minimum fuel at 0850 hrs
- 2.3.2 During the interviews with the investigation team, the flight crew indicated that they had expected the air traffic controllers to have accorded priority for their flight after they had indicated their fuel situation and provided a direct route when they made the decision to divert.
- 2.3.3 According to Singapore ATS procedures and operator's fuel policy, a minimum fuel condition is not an emergency situation. As such, SAC provided the flight

crew with a routing based on the prevailing traffic condition.

- 2.3.4 The instruction by SAC for the flight to fly heading 180°, increased the distance between the aircraft and Batam Airport. It is reasonable to believe that had the flight crew been more assertive to inform SAC that they were unable to comply with the given vector and reiterated their minimum fuel situation, SAC would have facilitated by making adjustments to the overall traffic condition to provide a more direct route to position the flight for an approach for Runway 22 at Batam Airport.
- 2.3.5 Pilots should keep in mind that they have the prerogative to request air traffic controllers to provide a more direct routing if they assess that safe operation of their flight is compromised.

3 CONCLUSIONS

From the information gathered, the following findings are made. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

- 3.1 The flight crew appeared to have given preference to land at Changi Airport over diverting to Batam Airport where the weather was good.
- 3.2 The flight crew offered to perform an additional hold and an orbit despite informing SAC that they could only perform a single hold and would be down to minimum fuel.
- 3.3 The weather over Batam Airport started to deteriorate shortly after the flight crew decided to divert.
- 3.4 The flight crew did not realise that an autoland should not be performed on Runway 04 of Batam Airport in accordance with the operator's procedures as information contained in the approach charts indicated that the heading for the final approach course of the localiser signal is 41°, a 1° offset from the runway heading.
- 3.5 The operator's Batam Airport briefing document did not indicate that an autoland should not be performed on Runway 04 as the approach charts indicate that the localiser final course is offset from the runway heading even though such information is included in its airport briefing document of other airports.
- 3.6 The appearance of the "NO AUTOLAND" message on the PFD startled the PF who eventually decided to perform a go-around even though the flight crew were able to sight the Runway 04 as they were descending past 1,195 feet AGL.
- 3.7 The appearance of the "NO AUTOLAND" message, coupled with a low fuel situation, likely intensified the flight crew's workload as they did not establish communication with Nadim Tower and did not realise that no landing clearance was given for their first attempt to land on Runway 04.

4 SAFETY ACTIONS

Safety actions taken by organisation(s) concerned arising from discussions with the investigation team.

- 4.1 The operator reviewed the event and conducted sharing sessions with all its pilots covering the following:
 - The appropriate application of the operator's threat and error model in respect to this occurrence. The threats from the operating environment, weather and automation were reinforced.
 - How the pilots can employ active communication to inform other parties of information in a timely manner and ensuring the message is understood by the receiver.
 - Reiterating that compliance with the operator's procedures is essential to maintain operational safety.
 - How to recognise high workload situations and the associated human factors such as attentional tunnelling which could result in errors in decision making.
- 4.2 The operator has incorporated lessons learnt from this occurrence as a microlearning module in its evident based training program focusing on inflight fuel management, diversions to alternate airports and declaration of low fuel state.
- 4.3 The operator has incorporated this occurrence as a scenario in its line-oriented flight training module in the simulator to ensure that its pilots are able to review their understanding and appropriately apply the operator's fuel policy.
- 4.4 The operator has initiated an exercise to review the contents of all the airport briefing documents to ensure consistency in the level of details contained within each document. The operator has decided to remove information indicating if an autoland is permitted and reminded pilots to make this assessment by using the published charts to determine if the localiser signal is aligned with the runway heading.
- 4.5 The operator and air traffic services provider have initiated efforts to explore possibilities to expedite the coordination process with nearby alternate airport

and consider setting up a team for real time operations management during inclement weather.

5 SAFETY RECOMMENDATIONS

A safety recommendation is for the purpose of preventive action and shall in no case create a presumption of blame or liability.

In view of the safety actions already undertaken by the operator and the air traffic services provider, the TSIB investigation team does not have safety recommendations to propose.