Final Report

BOEING B737-400, REGISTRATION HS-KMC
TYRES BLOWOUT DURING TAKE-OFF,
CHANGI AIRPORT

28 SEPTEMBER 2021

TIB/AAI/CAS.200

Transport Safety Investigation Bureau
Ministry of Transport
Singapore

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The Transport Safety Investigation Bureau of Singapore

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GLOSSARY OF ABBREVIATIONS

AFTN	:	Aeronautical Fixed Telecommunication Network
AIS	:	Aeronautical Information Services
ATC	:	Air Traffic Control
CVR	:	Cockpit Voice Recorder
FO	:	First Officer
FOD	:	Foreign object debris
LAE	:	Licensed Aircraft Engineer
PF	:	Pilot Flying
PIC	:	Pilot-in-Command
PM	:	Pilot Monitoring
FO	:	First Officer
psi	:	pound per square inch

SYNOPSIS

On 28 September 2021, as a Boeing B737-400 cargo aircraft was rolling down Runway 02R in Singapore Changi Airport for take-off, both tyres on its left landing gear suffered a blowout. The aircraft took off and continued its flight to Jakarta Soekarno-Hatta Airport, Indonesia.

During taxiing after the aircraft had landed in Jakarta, the flight crew noticed some abnormal aircraft indications. They stopped the aircraft on the taxiway and discovered about the blowout tyres from the ground personnel who had come to attend to the aircraft.

No one was injured in the occurrence.

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

AIRCRAFT DETAILS

Aircraft type	:	Boeing B737-400
Operator	:	K-Mile
Aircraft registration	:	HS-KMC
Numbers and type of engines	:	2 x CFM56-3C1
Date and time of incident	:	28 September 2021, 0734 hrs Local Time
Location of occurrence	:	Changi Airport
Type of flight	:	Scheduled
Persons on board	:	4

1 FACTUAL INFORMATION

All times used in this report are Singapore Local Time unless otherwise stated. Singapore Local Time is eight hours ahead of Coordinated Universal Time.

1.1 History of the flight

1.1.1 On the morning of 28 September 2021, a Boeing B737-400 cargo aircraft (B737) arrived at 0448 hrs at Singapore Changi Airport from Bangkok, Thailand and was scheduled to depart for Jakarta Soekarno-Hatta Airport (Jakarta Airport), Indonesia at 0715 hrs. The flight crew comprised a Pilot-in-Command (PIC) and a First Officer (FO). The PIC was the Pilot Monitoring (PM) and the FO was the Pilot Flying (PF). There were two other crew members on board this flight – a licensed aircraft engineer (LAE) and a mechanic.

1.1.2 The flight was assigned Runway 02R for departure by Singapore Air Traffic Control (ATC). At 0734 hrs, while the B737 was rolling down the runway, the two tyres on the left landing gear suffered a blowout. From the aerodrome operator's CCTV footage, it was noted that the tyre on Wheel #1 had failed first, followed by the tyre on Wheel #2 (the tyres are hereinafter referred to as Wheel #1 tyre and Wheel #2 tyre)[1]. It was also noted that a panel on the left landing gear had detached from the aircraft when Wheel #1 tyre failed. The aircraft lifted off at about 0735 hrs.

1.1.3 The aerodrome's foreign object debris (FOD) detection system (known as iFerret) detected the tyre debris at 0736 hrs and alerted the aerodrome operator, who subsequently arranged with the ATC on the closure of the runway for inspection and recovered the tyre debris. The aerodrome operator informed the ATC about the details of the recovered tyre debris at 0753 hrs. The inspection team also found the detached panel and informed the ATC of this at 0820 hrs. (More on the ATC's follow-up actions in paragraph 1.6.4)

1.1.4 At the time of the aircraft's lift-off, the PIC in the cockpit, as well as the LAE and the mechanic who were seated in the cabin, heard a "thud" sound but they did not know where it had come from. After the aircraft had reached the flight's cruise level, the LAE advised the PIC that he had also heard the "thud" sound. The LAE also carried out a check on the aircraft's instrument panel but found

[1] The outboard and inboard left wheels are numbered as Wheel #1 and Wheel #2 respectively (when looking from the rear of the aircraft).

no anomaly.

1.1.5 The PIC suspected that the aircraft had suffered a flat tyre. He decided to continue the flight to Jakarta Airport and to carry out the landing in accordance with the operator's flat tyre landing procedure. He prepared the flight crew for a flat tyre landing accordingly. The flat tyre landing procedure calls for the use of maximum reverse thrust without brake application. The PIC was comfortable with adopting this procedure as Jakarta Airport has a sufficiently long runway of 3,600 m.

1.1.6 The flight to Jakarta was uneventful. The aircraft landed at Jakarta Airport on Runway 25L at 0854 hrs (0754 hrs Jakarta time). The PIC did not notice anything abnormal during the landing roll.

1.1.7 When vacating the runway, the PIC noticed from the aircraft's instrument panel that the aircraft was tilting slightly toward the left side (i.e. the left side of the aircraft was lower). The PIC also saw that the leading edge flap warning light had illuminated, indicating that the leading edge flap had not fully retracted. The PIC also felt some vibration during the taxi.

1.1.8 Given these anomalies, the flight crew decided to stop taxiing and called Jakarta ATC for towing assistance. The ground crew who came to assist them found and reported to the flight crew that the left landing gear's two tyres had suffered a blowout. The aircraft was subsequently towed to a parking bay.

1.2 Injuries to persons

1.2.1 No person was injured in this incident.

1.3 Damage to aircraft

1.3.1 The Indonesia National Transportation Safety Committee (NTSC) assessed the damage to the aircraft for the investigation team. The damage was as follows:

(a) The two tyres on the left landing gear had suffered a blowout and a panel on the left landing gear was missing (see **Figure 1**). Tyre debris and the panel were recovered at Changi Airport (see paragraph 1.3.2).

Figure 1: Damage to the left landing gear (left photo, view from the rear of aircraft) and the left landing gear panel retrieved from Changi Airport (right photo)

(b) There was impact damage to the skin of the underside of the left wing in several areas near the left landing gear and the mid and outer flaps (see **Figure 2**).

Figure 2: Damage to the underside of the left wing

(c) The landing light at the root of the left wing was damaged and the left wing trailing edge above the flap was deformed (see **Figure 3**).

Figure 3: The left landing light was damaged (left photo) and trailing edge of left wing was deformed (right photo)

(d) The link of the left wing inboard leading edge flap was broken (see **Figure 4**).

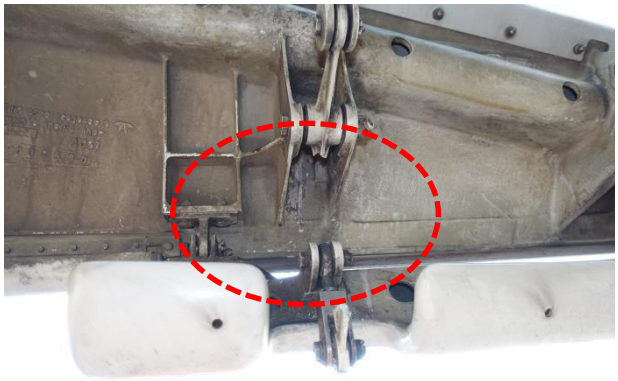

Figure 4: Link of left wing inboard leading edge flap broken

1.3.2 **Figure 5** shows the tyre debris pieces recovered from Runway 02R of Changi Airport. The debris pieces were identified to their respective wheels by means of the serial number and/or retreading[2] status that was marked on the side of the tyres.

[2] Tyre retreading is a process of replacing the tread or rubber surface of a worn tyre to extend the service life of the tyre.

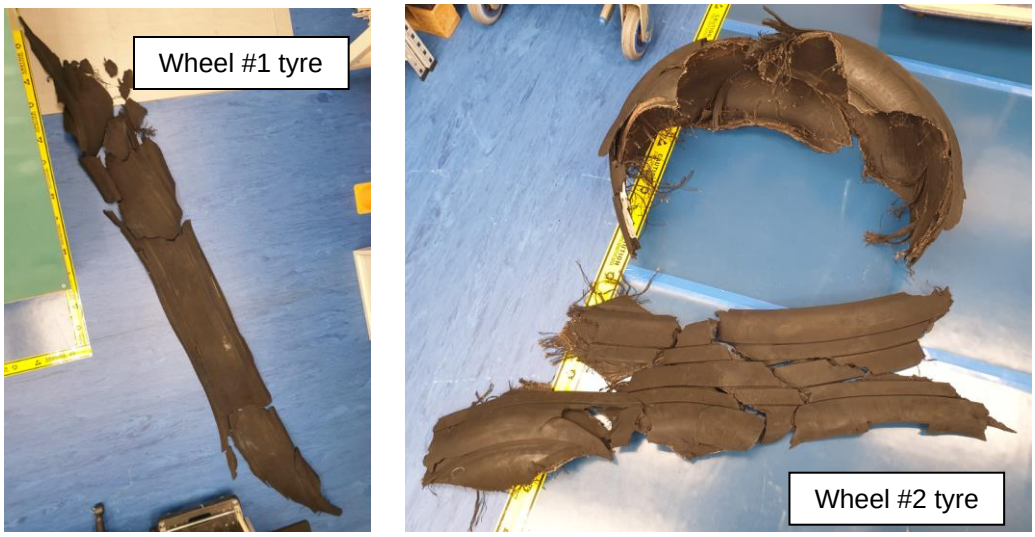

Figure 5: Debris of Wheel #1 and #2 tyres

1.3.3 **Figure 6** shows the over-pressure relief valve of Wheel #1 hub which was found to be broken off and showing signs of corrosion.

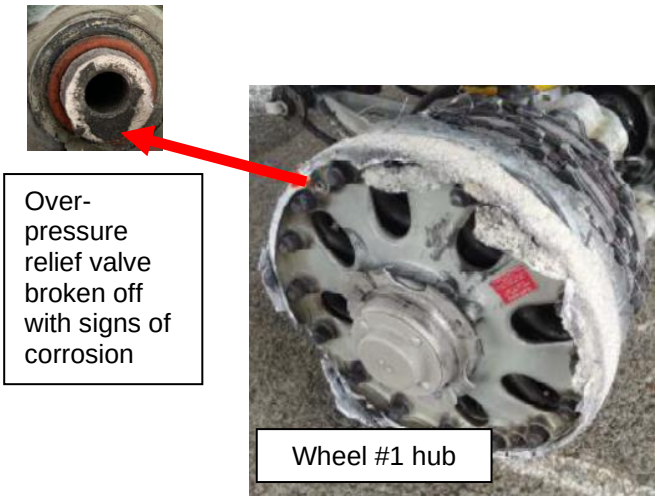

Figure 6: Corrosion found on the over-pressure relief valve of Wheel #1 hub

1.4 Personnel information

1.4.1 Pilot-in-Command (PM)

Age	42
Licence type	Air Transport Pilot Licence
Issuing authority	Civil Aviation Authority of Thailand
Licence validity date	1 April 2025
Medical certificate	Class 1
Medical certificate validity	17 July 2022
Medical operational proviso	NA
Last Base Check date	12 November 2019
Last Line Check date	6 October 2020
Total flying hours	7,301 hours
Aircraft types flown	B737
Total flying hours on type	4,080 hours
Flying in last 90 days	121 hours
Flying in last 7days	10 hours
Flying in last 24 hours	0 hour
Duty time in last 48 hours	0 hour
Rest period in last 48 hours	48 hours

1.4.2 First Officer (PF)

Age	49
Licence type	Commercial Pilot Licence
Issuing authority	Civil Aviation Authority of Thailand
Licence validity date	14 February 2024
Medical certificate	Class 1
Medical certificate validity	14 February 2022
Medical operational proviso	NA
Last Base Check date	12 December 2017
Last Line Check date	1 October 2020
Total flying hours	1,899 hours
Aircraft types flown	B737
Total flying hours on type	1,716 hours
Flying in last 90 days	122 hours
Flying in last 7days	10 hours
Flying in last 24 hours	0 hour
Duty time in last 48 hours	3 hours
Rest period in last 48 hours	45 hours

1.4.3 Licensed Aircraft Engineer (LAE)

Age	34
Qualification	B737-300/400/500 (CFM56) (Airframe, Powerplant, Avionics)
Total experience (in years)	6 years
Time on duty	6 hours
Duty time in last 48 hours	0 hour
Rest period in last 48 hours	48 hours

1.4.4 Mechanic

Age	40
Qualification	NA
Total experience (in years)	14 years
Time on duty	6 hours
Duty time in last 48 hours	12 hours
Rest period in last 48 hours	36 hours

1.5 Flight recorders

1.5.1 The aircraft had a two-hour cockpit voice recorder (CVR) that recorded all voice communications to and from the flight deck and environmental sounds/noise (e.g. warnings) within the cockpit.

1.5.2 The CVR was removed at Jakarta Airport and sent to TSIB where its recorded data was downloaded. The voice recording pertaining to the take-off, cruise and landing phases of the flight was available.

1.5.3 A review of the CVR recording revealed a loud sound just before the aircraft lifted off.

1.6 Additional information

1.6.1 Wheels information

1.6.1.1 Wheel #1 and Wheel #2 were replaced by the aircraft operator on 20 June 2021 and 25 June 2021 respectively. Wheel #2 was replaced again on 27 September 2021 due to a leaking air valve. According to the aircraft operator, the mechanic who replaced Wheel #2 recalled that Wheel #2 tyre's pressure was 177 psi prior to removal. However, this tyre pressure reading was not recorded anywhere[3].

1.6.1.2 After this incident, the previous Wheel #2 (with the leaking air valve) was inspected and, aside from the leaking air valve, no damage was found.

1.6.1.3 At the time of the incident, Wheel #1 tyre and Wheel #2 tyre were from different

[3] Following a loss of tyre pressure owing to a leaking air valve, the Aircraft Maintenance Manual required a measurement of this tyre pressure loss to determine whether follow-up maintenance action is needed for the adjoining tyre as well. A standard maintenance practice is to record the measured tyre pressure in the relevant maintenance document such as the aircraft technical log. Such a record shows the basis as to whether further maintenance action is needed.

manufacturers. Both tyres had been retreaded by the manufacturer of Wheel #1 tyre. Wheel #1 tyre had been retreaded two times and Wheel #2 tyre three times.

1.6.1.4 The tyre records for Wheel #1 and Wheel #2 tyres provided by the aircraft operator to the investigation team showed that both tyres had undergone daily checks for pressure. The tyre pressure appeared normal other than the low pressure that arose from the Wheel #2 leaking air valve detected on 27 September 2021 (see paragraph 1.6.1.1).

1.6.2 Tyre pressure maintenance practices

1.6.2.1 The aircraft manufacturer recommends that main landing gear tyres be maintained at a maximum pressure of 192 psi and nose landing gear tyres at a maximum pressure of 184 psi. According to the aircraft operator, its practice is to have its aircraft tyres' pressure topped up to the maximum allowed during daily checks whenever nitrogen carts[4] are available from the aerodrome where the daily check is to be conducted.

1.6.2.2 The daily check record form requires the recording of, among others, the following tyre pressure information[5]:

MAINTENANCE SERVICE (PSI)	NOSE		MAIN LANDING GEAR			
	LH	RH	NO. 1	NO. 2	NO. 3	NO.4
BEFORE						
INFLATION						
DIFF.						

1.6.2.3 The record, as provided by the aircraft operator to the investigation team, of the tyre pressure measured during the daily check in Phnom Penh, Cambodia on 27 September 2021 prior to the aircraft's flight from Phnom Penh to Bangkok was as follows:

MAINTENANCE SERVICE (PSI)	NOSE		MAIN LANDING GEAR			
	LH	RH	NO.1	NO.2	NO.3	NO.4
BEFORE	180	180	190	190	190	190
INFLATION	"	"	"	"	"	"
DIFF.	"	"	"	"	"	"

[4] Tyres are filled with nitrogen gas.

[5] BEFORE is the tyre pressure measured before any topping up of nitrogen gas. INFLATION is the tyre pressure after any top-up. DIFF is the difference between INFLATION and BEFORE.

1.6.2.4 However, subsequently, the aircraft operator provided to the investigation team an amended version of the record, which showed the following:

MAINTENANCE SERVICE (PSI)	NOSE		MAIN LANDING GEAR			
	LH	RH	NO.1	NO.2	NO.3	NO.4
BEFORE	180	180	190	190	190	190
INFLATION	194	194	192	192	192	192
DIFF.	14	14	2	2	2	2

1.6.2.5 The aircraft operator explained as follows:

(a) The manager of its Engineering Department noticed that only the BEFORE tyre pressure figures were recorded, which to him meant that the tyre pressures had not been topped up to the maximum allowed. He could not understand this, given that nitrogen cart had been ordered by the aircraft operator at the Phnom Penh airport for the daily check.

(b) When queried by the manager, the mechanic concerned confirmed that he did top up the tyre pressures to the maximum allowed. Basing on this feedback from the mechanic, the manager filled up the INFLATION and DIFF figures, as shown in paragraph 1.6.2.4.

1.6.2.6 In the course of the investigation, the manager of the Engineering Department made available to the investigation team another 19 records of daily checks carried out prior to the incident. On these 19 daily check records, the manager made similar amendment to the INFLATION and DIFF figures before sharing these records with the investigation team.

1.6.3 <u>Examination of tyre debris</u>

1.6.3.1 The left landing gear's Wheel #1 and Wheel #2 were installed by the aircraft operator on 20 June 2021 and 25 June 2021 respectively. Wheel #2 was replaced on 27 September 2021 due to a leaking air valve. After this incident, the previous Wheel #2 (with the leaking air valve) was sent for an inspection and, aside from the leaking air valve, it was found with no other damage.

1.6.3.2 The recovered tyre debris from Wheel #1 and Wheel #2 were sent for examination by the Wheel #1 tyre manufacturer in the US.

1.6.3.3 The Wheel #1 tyre manufacturer indicated that both tyres had experienced casing rupture and tread separation and that the likely cause for this failure was

over-deflection resulting from an under-inflation and/or overloading of one of or both the tyres.

1.6.4 Attempts to alert the flight crew of the incident aircraft

1.6.4.1 The Singapore ATC was informed of the tyre debris at 0753 hrs and of the detached panel at 0820 hrs. As the aircraft was already under the control of the Jakarta ATC, the Singapore ATC could not directly contact the flight crew of the incident aircraft to alert them of the discovery of the tyre debris and the detached panel which could be from their aircraft.

1.6.4.2 The Singapore ATC therefore sent two AFTN messages[6] to the Jakarta ATC at 0814hrs and 0834 hrs, so that the Jakarta ATC could inform the flight crew of the incident aircraft of the tyre debris and the detached panel. However, the messages used the GG[7] priority indicator, instead of the DD priority indicator and were not immediately processed by the Jakarta ATC. The Singapore ATC could not send AFTN messages to the aircraft as the aircraft was not equipped to receive AFTN messages in flight.

1.6.4.3 At 0854 hrs (0754 hrs Jakarta time), the Singapore ATC made a call to the Jakarta ATC to ascertain whether the latter had received the AFTN messages. However, by then, the aircraft had already landed at Jakarta Airport and the Jakarta ATC had not yet contacted the flight crew.

1.6.4.4 According to the Singapore ATC, the duty watch manager had been consolidating information about the ongoing Runway 02R FOD situation (to prepare for a shift change briefing to the incoming watch manager) while still managing ongoing ATC operations. After the completion of these ongoing tasks, a call was made to the Jakarta ATC at 0854 hrs to ascertain whether the two AFTN messages had been received.

[6] The AFTN is a worldwide system for the transmission and exchange of messages between entities like aeronautical information services offices, airports, air traffic control, airlines, etc.
[7] GG priority indicator has a lower priority than the DD priority indicator. The DD priority indicator is used for messages of a more urgent nature.

2 ANALYSIS

The investigation looked into the following issues:

(a) Possible cause of the tyre failure

(b) Maintenance recording practice by the aircraft operator

(c) Transmission of debris information to the flight crew of the incident aircraft

2.1 Possible cause of the tyre failure

2.1.1 Noting the result of the examination of tyre debris (paragraph 1.6.3.2), i.e. both Wheel #1 and Wheel #2 tyres had experienced casing rupture and tread separation, the investigation team opined that the sequence of tyre failures is probably as follows:

(a) Wheel #2 tyre had been operating in an under-inflated condition, as suggested by the air valve leakage problem of the previous Wheel #2 (which was replaced on 27 September 2021) and the purported tyre pressure of 177 psi before a mechanic replaced Wheel #2.

(b) The under-inflation would cause Wheel #1 tyre to be overloaded and to experience increased stress, resulting in tyre failure. After this failure, the load would be transferred to the newly replaced Wheel #2 tyre, which would in turn experience an overloading and a failure subsequently.

2.1.2 The investigation team has considered also two other possible causes but found them unlikely:

(a) Possibility that Wheel #1 tyre was under-inflated

The corrosion found on the over-pressure relief valve of Wheel #1 hub could have caused the wheel to lose pressure progressively over time and the tyre to operate in an under-inflated condition, thus stressing the Wheel #2 tyre. If Wheel #1 tyre had indeed been operating under-inflated over some time, then Wheel #2 tyre should have incurred some damage. However, this was not the case as no damage was found on the previously replaced Wheel #2 tyre.

(b) Possibility of foreign object damage

Wheel #1 tyre might have been damaged by an FOD. However, no FOD damage was identified on the tyre debris and no FOD was recovered from the runway.

2.1.3 On the balance of evidence, the investigation team believes that under-inflation likely existed in the Wheel #2 tyre which had an air valve leakage problem, and was replaced in Bangkok. This under-inflation would then result in the overloading of Wheel #1 and its failure.

2.2 Maintenance practice by the aircraft operator

2.2.1 The aircraft operator's mechanic who replaced the Wheel #2 on 27 September 2021 following the discovery of an air valve leakage problem claimed that he had noticed the tyre pressure to be 177 psi but did not record the tyre pressure before its replacement. This was not in line with good maintenance documentation practice, as the recording of tyre pressure prior to any tyre replacement would serve as evidence as to whether the tyre pressure was or was not beyond tyre pressure limit and would provide a clue as to the reason of any further tyre maintenance actions[8].

2.2.2 In the course of the investigation, the investigation team came across a number of daily check records where only the BEFORE row of the tyre pressure table were recorded with the tyre pressures of the main landing gear and nose landing gear, even though the aircraft operator's mechanics had purportedly performed a top-up of the tyre pressures to the maximum allowed. This gives rise to doubts as to whether the mechanic really did perform the tyre pressure topping up and as to whether, even if they did perform the topping up, they did record conscientiously the measured tyre pressures. The records, as they were, did not allow the investigation team to estimate the condition of Wheel #1 and Wheel #2 tyres prior to the incident and to establish if Wheel #1 and Wheel #2 tyres had been able to maintain pressure over the period of service (i.e. if the tyres had been constantly losing pressure or had operated in an under-inflated condition).

2.2.3 The manager had amended the INFLATION and DIFF figures in the daily check

[8] For example, if the tyre pressure of either Wheel #1 tyre of Wheel #2 tyre has dropped by more than 10% of the maximum tyre pressure allowed, it would be necessary to replace both Wheel #1 and Wheel #2 tyres.

records without proper annotations (e.g. the reasons for the amendment) and countersigning. Again this does not accord with good recording practice and may be misleading as the amended daily check records could be mistaken as part of the original document recording when they were not.

2.3 Transmission of debris information to the flight crew of the incident aircraft

2.3.1 When the Singapore ATC received the debris information from the aerodrome operator, the aircraft was already under the control of Jakarta ATC. The Singapore ATC therefore sent two AFTN messages to the Jakarta ATC so that the Jakarta ATC could inform the flight crew of the incident aircraft. The first AFTN message on the tyre debris was sent at 0814 hrs and the second AFTN message at 0834 hrs. Owing to the relatively short flight time and the AFTN messages not having been classified as urgent, the Jakarta ATC did not process the messages immediately and the debris information did not reach the flight crew prior to the landing in Jakarta.

2.3.2 It is essential that flight crew of aircraft be alerted in a timely manner on issues that may potentially affect the safety of their aircraft, so that they could take appropriate course of actions.

2.3.3 According to the Singapore ATC, it follows guidance provided in ICAO Document 4444[9] on the use of priority indicators for AFTN messages. The guidance mentioned that messages of an urgent nature should be classified as urgent. The two AFTN messages were sent using the GG priority indicator, instead of the DD priority indicator meant for urgent messages. Being from an aircraft, the tyre debris and the detached panel could have had an impact to the safe operation of the aircraft. The investigation team opined that the two AFTN messages should have been accorded an urgent priority indicator.

[9] ICAO Doc 4444 or Procedures for Navigation Services – Air Traffic Management contains important guidance information for air traffic services.

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 An under-inflation condition probably existed in the previous Wheel #2 tyre (replaced prior to the flight due to air valve leakage) which led to the overloading and stressing of Wheel #1 tyre. This prolonged stressing of Wheel #1 tyre resulted in it failing first during the take-off roll at Changi Airport. The newly replaced Wheel #2 subsequently failed due to overloading from taking on the full load after Wheel #1 tyre had failed.

3.2 The aircraft operator's recording of tyre pressure was not in line with good maintenance documentation practice. Although the mechanic recalled that the tyre pressure of Wheel #2 tyre was 177 psi, there is no other evidence for the investigation team to corroborate with the mechanic's recollection as this tyre pressure was not recorded. The lack of proper recording of tyre pressure had also resulted in the daily check records being amended without proper annotations and countersigning.

3.3 The flight time was relatively short and the two AFTN messages sent by the Singapore ATC had not been accorded with an urgent priority indicator. Thus, the Jakarta ATC did not process the information on FOD immediately.

3.4 The tyre debris and detached panel, being parts fallen from the aircraft, could have had an impact to safe aircraft operation. Hence the two AFTN messages sent to the Jakarta ATC, which were meant to alert the flight crew, should have been accorded with an urgent priority indicator so that the entity receiving the messages could take timely actions.

4 SAFETY ACTIONS

Arising from discussions with the investigation team, the Singapore ATC has taken the following safety action.

4.1 Singapore ATC has taken the following improvement actions:

(a) Sharing the lessons learnt from this incident with all ATC personnel, such as to expeditiously relay tyre debris information to the flight crew of an incident aircraft.

(b) Briefing sessions were organised to refresh ATC personnel on the following:

- FOD management procedure to be applied upon discovery of aircraft parts on runway with an emphasis on passing the information about the discovery of aircraft parts/tyre debris to pilots of suspected flights as soon as possible.

- Emphasis on relaying information by other means such as contacting the aircraft operator's local office or their local handling agent.

(c) Provision of a new quick reference checklist to guide watch managers in managing FOD situations especially during high workload.

(d) Enhancement of existing procedures to require all AFTN messages concerning FOD suspected to be from aircraft to be classified as urgent.

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.

It is recommended that:

5.1 The aircraft operator consider reviewing its maintenance quality procedure to ensure that wheel tyre pressures and other wheel-related maintenance are accurately reflected on the daily check records. [TSIB Recommendation RA-2022-004]

5.2 The aircraft operator emphasise to their maintenance personnel the need to perform proper documentation for the daily check records, particularly when recording wheel tyre pressures and other wheel-related maintenance. [TSIB Recommendation RA-2022-005]