Final Report

Boeing 737-8 (MAX), Registration 9V-MBF

Tyre Damage on Landing, Singapore Changi Airport

3 December 2021

TIB/AAI/CAS.202

Transport Safety Investigation Bureau
Ministry of Transport
Singapore

17 November 2022

The Transport Safety Investigation Bureau of Singapore

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GLOSSARY OF ABBREVIATIONS

AFM	Airplane Flight Manual
ATC	Air Traffic Control
ATPL	Air Transport Pilot Licence
BITE	Built-In Test Equipment
CCTV	Close Circuit Television
CVR	Cockpit Voice Recorder
FCOM	Flight Crew Operations Manual
FCTM	Flight Crew Training Manual
FDR	Flight Data Recorder
FOD	Foreign Object Debris
LT	Local Time
MEL	Minimum Equipment List
MLG	Main Landing Gear
MMEL	Master Minimum Equipment List
PF	Pilot Flying
PIC	Pilot-In-Command
PM	Pilot Monitoring
RA	Radio Altitude
SFO	Senior First Officer
UTC	Coordinated Universal Time

SYNOPSIS

On 3 December 2021, at about 1436LT, a Boeing 737-8 (MAX) aircraft while landing at Changi Airport Runway 02L suffered tyre damage to both its wheels on the left main landing gear. The pilots did not notice any anomalies during the landing and the tyre damage was only discovered after the aircraft arrived at the parking bay.

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

AIRCRAFT DETAILS

Aircraft type	:	Boeing 737-8 (MAX)
Operator	:	Singapore Airlines
Aircraft registration	:	9V-MBF
Numbers and type of engines	:	Two engines / CFM LEAP-1B
Engine hours/cycles since new	:	44 Flight Cycles since new
Date and time of incident	:	3 December 2021 / 1436LT
Location of occurrence	:	Changi Airport Runway 02L
Type of flight	:	Scheduled
Persons on board	:	38

1 FACTUAL INFORMATION

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

1.1 History of the flight

1.1.1 On 3 December 2021, a Boeing 737-8 (MAX) operated a scheduled turnaround flight between Changi Airport, Singapore (SIN) and Phnom Penh, Cambodia (PNH). The aircraft departed with its Antiskid system and Autobrake system inoperative, as allowed under the Minimum Equipment List (MEL) items 32-42-01 and 32-42-03[1] respectively.

1.1.2 For the SIN-PNH sector, the Pilot-in-command (PIC) was the Pilot Flying (PF) while the Senior First Officer (SFO) was the Pilot Monitoring (PM). Operating the aircraft with the application of the two MEL items required additional operational steps to be observed. The key points of the MEL's operational requirements are as follows:

MEL 32-42-01 (Antiskid system inoperative):

(a) Base take-off and landing performance in accordance with the aircraft manufacturer's Airplane Flight Manual (AFM) for Antiskid inoperative.

(b) Set Autobrake system OFF.

(c) Operate the speedbrakes manually.

(d) Use AFM antiskid inoperative braking procedure for rejected take-offs and landings, including the following guidance:

(i) Use minimum aircraft braking consistent with runway length and conditions to reduce the possibility of a tyre blowout.

(ii) Do NOT apply aircraft brakes until the nose wheel is on the

[1] Refer to Paragraph 1.5 on the aircraft information for the reason on the application of the MELs. Refer to Paragraph 1.5.4 on the operator's MEL policy.

ground and the speedbrakes have been manually deployed[2].

(iii) Brake initially using light steady pedal pressure and increase the pressure as ground speed decreases. Do NOT pump the brakes.

MEL 32-42-03 (Autobrake system inoperative)

(a) Set Autobrake system OFF

1.1.3 During the approach to PNH, the PIC armed the speedbrake system by moving the speedbrake lever to the “ARMED” position. The “SPEEDBRAKE DO NOT ARM” light[3] on the control panel illuminated. This reminded the flight crew that they would have to manually deploy the speedbrakes as required by MEL 32-42-01. The PIC then returned the speedbrake lever to the “DOWN” position.

1.1.4 For the landing in PNH, the PIC intended to manually deploy the speedbrakes by moving the speedbrake lever to the “UP” position. However, upon landing, he selected the reverse thrust levers. He noticed that the speedbrake lever was moving to the “UP” position by itself and realised that the reverse thrust selection resulted in the deployment of the speedbrakes[4].

1.1.5 On the PNH-SIN return flight, the PIC was the PM and the SFO was the PF. As the PF, the SFO conducted a briefing for the arrival and approach to Singapore. When the aircraft was on approach, the SFO asked the PIC whether the speedbrakes would move by itself when reverse thrust was selected. The PIC replied that the speedbrakes could be deployed manually or could move by itself to the “UP” position when reverse thrust[5] was selected.

1.1.6 For the landing in SIN, the SFO selected reverse thrust. He expected that, through the selection, the speedbrakes would deploy automatically, although

[2] In the context of a landing or a rejected takeoff, the phrase “to manually deploy speedbrakes” means to manually move the speedbrake lever to the “UP” position which deploys the flight and ground spoilers of the aircraft during landing. Other than in this context, speedbrake deployment will not involve the ground spoilers.

[3] The “SPEEDBRAKE DO NOT ARM” light (in amber) warns a fight crew member that the automatic operation of the speedbrake system is not supposed to be armed. In this case, this light illuminated when the speedbrake lever was in “ARMED” position with an inoperative Antiskid system. Refer to Paragraph 1.10.1 for details on speedbrakes operation.

[4] When the aircraft is on ground, the speedbrakes will be deployed automatically if the reverse thrust is selected (see Paragraph 1.10.1.3 (c)). However, using the reverse thrust levers to deploy the speedbrakes is not considered a manual deployment of speedbrakes.

[5] The PIC gave the SFO this piece of advice basing on his experience during his earlier landing in PNH (see Paragraph 1.1.4).

he was aware of the MEL 32-42-01 operational requirement whereby he should manually deploy the speedbrakes by moving the speedbrake lever to the “UP” position.

1.1.7 According to the SFO, his intention was to execute a gentle touchdown in SIN and to apply as little brake pressure as possible. He was concerned that a positive touchdown would entail excessive braking and induce tyre damage, given that the Antiskid system was inoperative.

1.1.8 During the landing roll, when the SFO selected reverse thrust, the PIC, in his monitoring role as the PM, noticed that the speedbrake lever did not move to the “UP” position by itself and immediately alerted the SFO. In response, the SFO manually moved the speedbrake lever to the “UP” position.

1.1.9 While the aircraft was rolling down the runway, the SFO noticed a dark object flying forward on the right-hand side of the aircraft. The SFO suspected that it could be a foreign object debris (FOD) and he informed the PIC who in turn informed Air Traffic Control (ATC) about the suspected FOD.

1.1.10 At about the same time, the flight crew of a Boeing B747 freighter, which was taxiing in the opposite direction of the landing aircraft on Taxiway W (which is parallel to the runway), informed ATC that smoke was emitting from the left-main landing gear (MLG) wheels of the incident aircraft.

1.1.11 The SFO heard what the B747 freighter flight crew had said to ATC. He stopped the aircraft on the Taxiway W after exiting the runway via rapid exit W5 and requested ATC to verify if there was any fire or smoke from its left MLG. ATC reported that there was no sign of fire or smoke. The crew also checked the landing gear synoptic page and found no anomalies. There was no vibration or veering throughout the landing roll and taxi. No excessive thrust application was needed to taxi the aircraft. When approaching the assigned parking bay, the crew noticed from the brake temperature indicators[6] that the left MLG outboard wheel had a lower brake temperature than the other three MLG wheels.

1.1.12 Just before the aircraft turned into the parking bay, the SFO handed over the control of the aircraft to the PIC as required by the aircraft operator’s

[6] For this aircraft, each MLG wheel has a brake temperature indicator and there are four brake temperature indicators in total.

procedures, and the PIC taxied the aircraft to the parking bay. At the parking bay, the flight crew requested the ground crew to inspect the left MLG and was informed by the ground crew that the left MLG outboard tyre had burst and inboard tyre deflated (see Paragraph 1.3.1 for details of the damage to the MLG wheels).

1.2 Injuries to persons

1.2.1 No one was injured in the occurrence.

1.3 Damage to aircraft

1.3.1 After the aircraft was parked, the following damage was found:

(a) The outboard tyre of the left MLG had burst. It had a worn-through flat spot (**Figure 1**).

(b) The inboard tyre of the left MLG had a flat spot (**Figure 2**).

(c) The frame of the fixed door of the left MLG was damaged (**Figure 3**).

Figure 1 - Outboard tyre on left MLG (viewed from aft of aircraft)

Figure 2 – Inboard tyre on left MLG (viewed from aft of aircraft)

Figure 3 – Damaged frame on fixed door of left MLG

1.4 Personnel information

1.4.1 Pilot-in-Command (PIC)

Role during incident flight	PM
Age	45
Gender	Male
Nationality	Singaporean
Licence Type	Air Transport Pilot Licence (ATPL)
Issuing authority	Civil Aviation Authority of Singapore
Licence validity date	31 March 2022

Aircraft rating	• Beechcraft B58 • Boeing B777 • Airbus A320 • Boeing B737-800 • Boeing B737-8 (MAX)
Medicate certificate	Class 1
Medical certificate expiry date	31 March 2022
Last base check	08 August 2021
Last line check	13 October 2021
Total flying time	9090 hours
Total flying on the B737 type	3880 hours • 3673 hours for B737-800 • 207 hours for B737-8
Flying in last 90 days	36 hours 25 minutes
Flying in last 7 days	7 hours 46 minutes
Flying in last 24 hours	3 hours 52 minutes
Duty time in last 48 hours	6 hours
Rest period in last 48 hours	42 hours

1.4.2 Co-pilot – Senior First Officer (SFO)

Role during incident flight	PF
Age	36
Gender	Male
Nationality	Singaporean
Licence Type	ATPL
Issuing authority	Civil Aviation Authority of Singapore
Licence validity date	30 April 2022
Aircraft rating	• Beechcraft G58 • Airbus A320 • Boeing B737-800 • Boeing B737-8 (MAX)
Medical certificate expiry date	30 April 2022
Last base check	28 November 2021
Last line check	14 March 2021
Total flying time	4187 hours
Total flying time on the B737 type	1729 hours • 1623 hours for B737-800 • 106 hours for B737-8 (MAX)
Flying in last 90 days	27 hours 27 minutes

Flying in last 7 days	3 hours 52 minutes
Flying in last 24 hours	3 hours 52 minutes
Duty time in last 48 hours	6 hours
Rest period in last 48 hours	42 hours

1.5 Aircraft information

1.5.1 The aircraft was delivered on 5 March 2019. It had accumulated 100 flight hours by the time of the incident[7]. The four tyres on the left and right MLGs were on the aircraft since delivery.

1.5.2 The aircraft had operated for the following six flights prior to the flights on 3 December 2021. Three of these flights had reported issues of uncommanded disengagement of the autobrake upon touchdown and this was followed by the illumination of the autobrake disarm light during the landing roll (see **Table 1**). The maintenance crew performed ground tests on the Antiskid Autobrake Control Unit (AACU) following the aircraft maintenance manual.

S/No.	Date of flight	Sector	Report on uncommanded disengagement of the autobrake upon touchdown, followed by illumination of autobrake disarm light and result of AACU tests
1	30 November 2021	SIN-PNH	Nil
2	30 November 2021	PHN-SIN	Yes. No faults detected during ground test.
3	30 November 2021	SIN-PNH	Yes. No faults detected during ground test.
4	30 November 2021	PNH-SIN	Nil
5	2 December 2021	SIN-HKT	Nil

[7] Between March 2019 to November 2021, the aircraft was grounded in view of the worldwide suspension of B737-8 (MAX) operations and the COVID situation. The aircraft returned to revenue service on 24 November 2021.

6	2 December 2021	HKT-SIN	Yes. Faults detected (see Paragraph 1.5.3)

Table 1: Summary of six flights prior to 3 December 2021

1.5.3 The test of the AACU after the HKT-SIN flight on 2 December 2021 revealed a fault message "Box AB/B" which indicated that there was an internal fault within the AACU or the antiskid valve. The aircraft manufacturer's Fault Isolation Manual required testing of the antiskid valve and the autobrake shuttle valve, replacement of the AACU as well as wiring checks. However, as there would not be enough time to carry out all these maintenance actions before the next flight, the maintenance crew applied MEL items 32-42-01 and 32-42-03 and despatched the aircraft with the Antiskid[8] and Autobrake systems inoperative.

1.5.4 MEL policy

1.5.4.1 In order to maintain an acceptable level of safety and reliability, the MEL establishes limitations on the duration of and conditions for aircraft operation with inoperative equipment. The MEL is intended to permit aircraft operation with inoperative items of equipment for a period of time until repairs can be accomplished[9].

1.5.4.2 The aircraft operator's MEL is adapted from the aircraft manufacturer's Master Minimum Equipment List (MMEL) for the aircraft type and is approved by local civil aviation authority when the aircraft type is brought into service for the first time.

1.6 Meteorological information

1.6.1 There was no precipitation over Changi Airport during the period of the aircraft landing. The prevailing visibility was more than 10 kilometres.

1.7 Aerodrome information

1.7.1 There were no reports of FOD at PNH prior to the aircraft take-off nor any FOD reports at Changi Airport prior to the aircraft landing.

[8] The maintenance crew deactivated both antiskid channels.
[9] The repairs are to be accomplished at the earliest opportunity.

1.7.2 The aircraft took off from Runway 05 in PNH which is 3000 metres long and landed on Runway 02L in SIN which is 4000 metres long.

1.7.3 Changi Airport's recordings of the occurrence by the CCTVs installed near Runway 02L were made available to the investigation team. The investigation team noted from the CCTV recordings that, during the landing, the aircraft's left MLG wheels contacted the runway surface before the right MLG wheels[10], and that the left MLG's outboard wheel was not spinning and smoke was emitting from it.

1.8 Flight recorders

1.8.1 The flight data recorder (FDR) and cockpit voice recorder (CVR) were available for readout by the investigation team. The reading out of the recorders was successful.

1.8.2 The FDR recorded the following events pertaining to the landing in SIN:

Time	Aircraft position (distance in metres from Runway 02L threshold (Point A))	Event description (See **Figure 4** for positions of aircraft)
14:36:07	205	The aircraft was at about 10 feet radio altitude (RA)[11] above the runway surface. The aircraft was in a landing pitch attitude and thrust levers were at forward idle.
14:36:10	414	The aircraft was at the touch down zone with nose up pitch attitude and left wing down. Normal load factor peak was 1.1 g. All air/ground sensors of the landing gears were

[10] This is consistent with the data from the flight data recorder (FDR), which shows that the aircraft was at the touch down zone with nose up pitch attitude and left wing down at 14:36:10LT (see Paragraph 1.8.2).
[11] Radio altitude (RA) is the aircraft height above ground level as measured by an on-board receiver/transmitter system.

		in “AIR”[12] mode.
14:36:15	760	Asymmetric braking was recorded with brake pressure of about 1500 psi on the left MLG and about 550 psi on the right MLG[13]. All air/ground sensors of the landing gears were in “AIR” mode.
14:36:17	860	The reverse thrust levers were selected[14]. The aircraft was still in “AIR” mode[15] and the thrust reverser sleeves were in stowed position.
14:36:20	1061	The speedbrake lever moved from “DOWN” to “UP” position[16]. It was followed by the air/ground sensors changing from “AIR” to “GROUND” mode. Flight spoilers were subsequently deployed[17].
14:36:23	1257	The thrust reverser sleeves were fully deployed[18]. Thereafter, the aircraft was not at wings level and had a slight tilt to the left.

[12] During landing, when the wheels of the nose or main landing gears come into contact with runway and sufficient aircraft lift has been dumped, the aircraft will start to rest on its wheels and the landing gear struts will be compressed. The corresponding landing gear air/ground sensors will change from “AIR” to “GROUND” mode. This mode information is used as an input to the logics for the operation of several aircraft systems.

[13] This could mean that the pilot stepped more on the left brake than on the right brake.

[14] In other words, the reverse thrust levers were positioned for reverse thrust. See Paragraph 1.10.1.3(c) for the automatic deployment of speedbrakes when the speedbrake lever is in “DOWN” position and not in “ARMED” position.

[15] In contrast, it was observed from the FDR data that the aircraft was in “GROUND” mode when the reverse thrust levers were selected after the aircraft landed in PNH.

[16] The SFO moved the speedbrake lever to “UP” in response to the PIC’s alert. See Paragraph 1.1.8.

[17] The positions of the ground spoilers are not parameters that are recorded in the FDR. Based on the logics for the operation of the speedbrakes system, the investigation team deduced that the ground spoilers had deployed together with the flight spoilers at this time.

[18] The thrust reverser sleeves can move out of its stowed position when either one of the radio altimeter systems senses less than 10 feet RA combined with an air/ground sensor in “GROUND” mode.

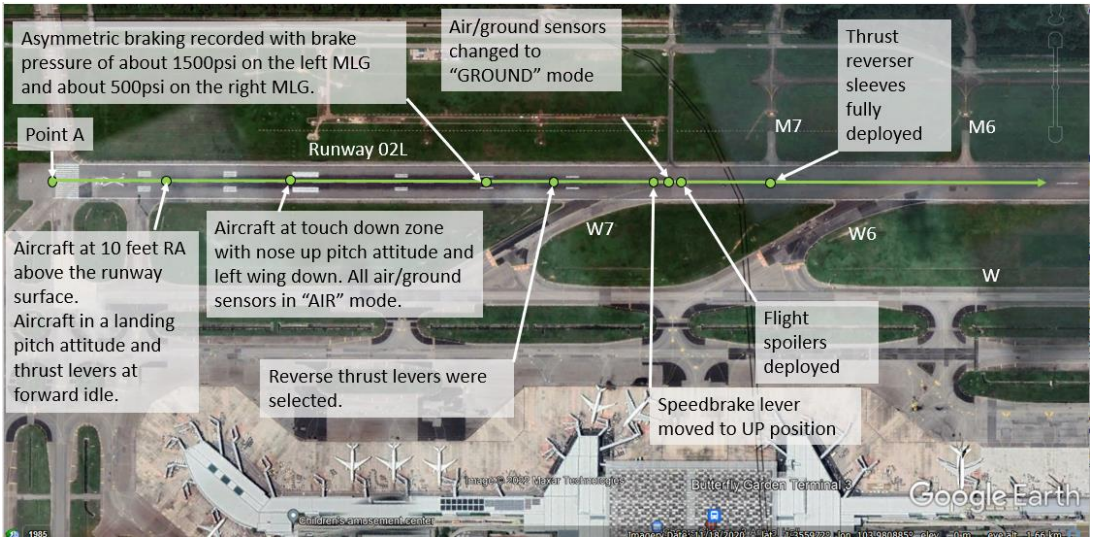

Figure 4 – Positions of aircraft (Source: Google Earth, annotated by TSIB)

1.8.3 The FDR data indicated that that the SFO applied aircraft wheel brakes (at 14:36:15LT) before the speedbrake lever moved from "DOWN" to "UP" position. Immediately after the speedbrake moved to the "UP" position, the air/ground sensors changed from "AIR" to "GROUND" mode (at 14:36:20LT).

1.9 Tests and research

1.9.1 After the event, the maintenance personnel performed a test on the air/ground sensors installed on the nose and main landing gears (MLGs) and did not find any faults.

1.9.2 The aircraft operator then sent the damaged left MLG tyres to the tyre manufacturer for further examination. The examination concluded the following:

(a) The cause of the flat spots on both tyres was aircraft skidding.

(b) The outboard MLG tyre had burst as a result of the flat spot grinding through the tyre material.

(c) There was no suspect FOD that would have caused the damage to both tyres.

1.9.3 The right MLG tyres were also sent to the tyre manufacturer for examination. No abnormalities were found.

1.10 Additional information

1.10.1 Speedbrakes operation according to the aircraft manufacturer's manuals[19]

1.10.1.1 The speedbrakes consist of flight spoilers and ground spoilers. When the speedbrake lever is moved to "UP" position, all the spoilers extend when the aircraft is on the ground. The deployment of spoilers dumps the lift from the wings, which places the aircraft weight on the main landing gears, thus enhancing brake effectiveness. If the speedbrakes are not raised after touchdown, braking effectiveness may be reduced initially by as much as 60%, since very little weight is on the wheels and brake application may cause rapid antiskid modulation. With the Antiskid system inoperative, there is no protection from a wheel lock if the brakes are applied prior to deploying the speedbrakes.

1.10.1.2 The speedbrake lever has the following positions and functions (see **Figure 5**):

Position	Functional description
DOWN (detent)	All flight and ground spoilers in stowed position.
ARMED	Automatic speedbrake system is armed.
FLIGHT DETENT	All flight spoilers are extended to their maximum position for inflight use.
UP	All flight and ground spoilers are extended (or deployed) to their maximum position for ground use.

[19] Namely, the Flight Crew Training Manual (FCTM) and Flight Crew Operations Manual (FCOM).

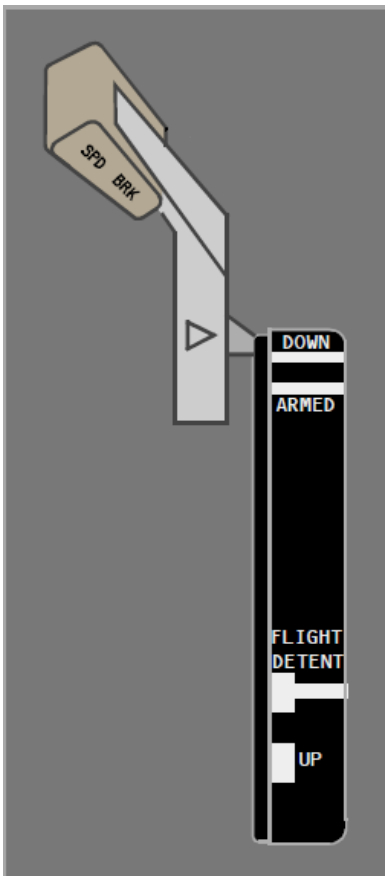

Figure 5 – Speedbrake lever positions and corresponding functions

1.10.1.3 The speedbrakes can be fully raised after touchdown while the nose wheels are lowered to the runway with no adverse pitch affects, or during a rejected take-off. The speedbrakes will deploy in three instances as follows:

(a) Manual deployment when the speedbrake lever is moved to the “UP” position

(b) Automatic deployment when in the speedbrake lever is in “ARMED” position

The Auto speedbrake system will operate under these conditions: (i) Speedbrake lever is in ARMED position

(ii) "SPEED BRAKE ARMED" light is illuminated

(iii) RA is less than 6 feet.

(iv) Landing gear strut compresses on landing

Note: Wheel spin up or compression of any landing gear enables the flight spoilers to deploy. Compression of both left and right MLG struts enables the ground spoilers to deploy.

(v) Both thrust levers are retarded to "IDLE" position.

(vi) Main landing gear wheels spin up (more than 60 knots)

The speedbrake lever automatically moves to "UP" position and the spoilers deploy.

(c) Automatic deployment when the speedbrake lever in the "DOWN" position and not in "ARMED" position (also for use in a rejected take-off)

If the speedbrake lever is in the "DOWN" position during landing or rejected take-off, the Auto speedbrake system operates when these conditions are satisfied[20]:

(i) Main landing gear wheels spin up (more than 60 kts)

(ii) Both (forward) thrust levers are retarded to "IDLE" position

(iii) Reverse thrust levers are positioned for reverse thrust.

1.10.2 Guidance on braking with Antiskid system inoperative

1.10.2.1 In the aircraft manufacturer's Flight Crew Training Manual (FCTM), the

[20] According to the aircraft maintenance manual, if the speedbrake lever is in the "DOWN" position during landing or rejected take-off, the Auto speedbrake system operates when these conditions are satisfied:
i. Both (forward) thrust levers are retarded to "IDLE" position
ii. RA is less than 6 feet
iii. Landing gear strut compresses on landing **OR** main landing gear wheels spin up (more than 60 knots)
iv. Reverse thrust levers are positioned for reverse thrust
For condition iii, the wheel speed signal is invalid when Antiskid and Autobrake systems are inoperative. Only the landing gear strut compression information is used (i.e. the air/ground system senses "GROUND").

following guidance is provided for a situation whereby the Antiskid system is inoperative:

(a) Ensure that the nose wheels are on the ground, and the speedbrakes are extended before applying the brakes.

(b) Initiate wheel braking using very light pedal pressure and increase pressure as ground speed decreases.

(c) Apply steady pressure.

(d) Use minimum braking consistent with runway length and conditions to reduce the possibility of tyre blowout.

(e) Do not pump the brakes - each time the brakes are released, the required stopping distance is increased. Also, each time the brakes are reapplied, the probability of a skid is increased.

2 ANALYSIS

The investigation looked into the following:

(a) Cause of the left MLG tyre damage

(b) Non-deployment of speedbrakes after landing in SIN

(c) Flight crew deviating from MEL requirements

2.1 Cause of the left MLG tyre damage

2.1.1 The damage to the left MLG's tyres were caused by skidding. The wheels skidded because the left MLG wheels were locked (i.e. not spinning) during the landing (see Paragraph 1.7.3), given that the Antiskid system was inoperative. The brake pressure (of 1500 psi) applied to the left MLG wheels by the SFO, before the speedbrakes were manually deployed to ensure the aircraft weight was on the MLGs[21], was sufficient to result in the locked-wheel situation.

2.2 Non-deployment of speedbrakes after landing in SIN

2.2.1 MEL 32-42-01 requires, among others, that the flight crew should, during landing, deploy the speedbrakes manually, i.e. by moving the speedbrake lever to the "UP" position, before applying aircraft brakes. The PIC did not follow this requirement during the landing in PNH and the SFO did not follow this requirement during the landing in SIN.

2.2.2 Although the flight crew did not follow the procedure in MEL 32-42-01, the outcome of the two landings was different. There was no wheel locking and skidding during the landing in PNH but there was for the landing in SIN. The investigation team believes the reasons for the differing outcome are as follows:

(a) Landing in SIN

The SFO elected to do a gentle landing and the MLG struts were not sufficiently compressed to cause the air/ground sensors to switch from the "AIR" mode to the "GROUND" mode. Thus, the condition needed for the automatic deployment of speedbrakes by means of reverse thrust

[21] As described in Paragraph 1.10.1.1, if the speedbrakes are not raised after touchdown, very little weight is on the wheels and brake application may cause rapid antiskid modulation. With the antiskid inoperative, there is no protection from a wheel lock if the brakes are applied prior to deploying the speedbrakes.

selection was not satisfied[22]. The SFO, believing that the aircraft had already touched down, applied brakes. Thus, the brakes were applied before the aircraft weight was on the MLGs. With the Antiskid system inoperative, the brake pressure applied on the MLG wheels was sufficient to cause a locked-wheel situation and resulted in the skidding of the MLG wheels when the aircraft eventually landed on the runway.

(b) Landing in PNH

Although the Antiskid system was inoperative, there was no MLG locked-wheel situation. This is likely because, at the time of the reverse thrust selection, the aircraft had already landed positively on the runway and the MLG struts had been sufficiently compressed to make the air/ground sensors go into the "GROUND" mode, which enabled the speedbrake deployment following the reverse thrust selection (even though the PIC did not manually deploy the speedbrakes). By then, the lift on the wings had been dumped and the aircraft's weight was fully on its wheels to allow the MLG wheels to spin up. The PIC applied brakes at about the time of the speedbrake deployment and thus there was no locked-wheel situation.

2.3 Flight crew deviating from MEL requirements

2.3.1 During the approach to PNH, the PIC initially armed the speedbrake system by moving the speedbrake lever to the "ARMED" position. The "SPEEDBRAKE DO NOT ARM" light on the control panel then illuminated. This reminded the PIC about the need to manually deploy the speedbrakes and he returned the speedbrake lever to the "DOWN" position. However, he did not follow the requirements of MEL 32-42-01 to manually deploy the speedbrakes. Despite his intention to move the speedbrake lever to the "UP" position, he selected the reverse thrust levers.

2.3.2 For the landing in SIN, the SFO anticipated that speedbrakes would deploy automatically upon the selection of reverse thrust. He might have been influenced by the following:

(a) The SFO had seen the deployment of the speedbrakes when the PIC

[22] See Paragraph 1.10.1.3 (c) for conditions required for automatic speedbrake deployment.

selected the reverse thrust levers during the landing in PNH.

(b) During the approach briefing by SFO, the PIC advised the SFO that the reverse thrust selection would result in the deployment of the speedbrakes (see Paragraph 1.1.5).

2.3.3 This incident highlights the importance of following the requirements in the MEL.

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 damage to left MLG wheels was caused by skidding. The wheels skidded because the left MLG wheels were locked during the landing. The locking of the left MLG wheels was due to a brake application on the left MLG wheels by the SFO before the manual deployment of speedbrakes to ensure the aircraft weight was on the MLGs. The brake pressure acting on the left MLG wheels was sufficient to result in the locked-wheel situation.

3.2 For the landing in PNH, the speedbrakes were deployed after reverse thrust selection. Subsequently, aircraft brakes were applied after the air/ground sensors were sensing "GROUND" (i.e. the aircraft had landed), and there were no locked-wheel situations and skidding of wheels.

3.3 For the landing in SIN, although reverse thrust was selected, the speedbrakes did not automatically deploy as the air/ground sensors were still sensing “AIR” when the SFO was performing a gentle landing. Aircraft brakes were applied and this caused the left MLG wheels to lock. Subsequently, the locked wheels skidded on the runway and damaged the left MLG tyres.

3.4 The flight crew’s action of selecting reverse thrust for speedbrakes deployment did not follow the MEL requirements of manually deploying the speedbrakes for the landings in PNH and SIN.

4 SAFETY ACTIONS

Arising from discussions with the investigation team, the organisation(s) has/have taken the following safety action.

4.1 The aircraft operator

(a) conducted a remedial reinforcement training for the incident flight crew on 10 December 2021 which included the following:

(i) A discussion on the procedures and techniques in the MEL, Quick Reference Handbook and FCTM on take-off, rejected take-off and landing with Antiskid inoperative and with deflated tyres

(ii) A simulator training session for the incident flight crew, covering the following scenarios:

(1) A rejected take-off at Maximum Take-Off Weight with Antiskid inoperative

(2) Landing at Maximum Landing Weight with Antiskid inoperative

(3) Crosswind landing at Maximum Landing Weight with Antiskid inoperative

(b) Shared the lessons learnt from the incident to all its pilots for awareness during a B737 fleet dialogue session on 21 December 2021.

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 emphasise to all its pilots the importance of following the operational requirements of the Minimum Equipment List. [TSIB Recommendation RA-2022-006]