Occurrence Investigation Report

Runway Excursion

Aircraft Overran the Runway during Landing

Jordan Aviation

Boeing 737-400 JY-JAP

Tombouctou Airport, Tombouctou, Mali

JAV 7843

BKO-TOM

5 May 2017

OBJECTIVE

This investigation has been performed in accordance with Jordan Civil Aviation Law No. (41), 2007, Article 33, and in conformity with ICAO Annex 13. The format of this report is adapted from the Final Report Format as laid down in Chapter 201.85 in CARC Part 2201,Aircraft Accident Investigation Manual, certain subheadings in the Factual Information heading were skipped since they are either not investigated or not been considered as contributing factors.

The sole objective of this investigation is to prevent aircraft accidents and incidents. It is not the purpose of this investigation to assert blame or liability.

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Aircraft Operator: Jordan Aviation

Category of the Occurrence: Aircraft Serious Incident

Aircraft Type: Boeing 737-400

Registration: JY-JAP

Location of Accident: Tombouctou Airport, Tombouctou, Mali

Date and Time: 5 May 2017 at 8:35 am

All times mentioned in this report are in UTC

SYNOPSIS

On the flight from (BKO) Bamako Airport to (TOM) Tombouctou Airport, Mali. After touchdown and before exiting the runway, the aircraft veered to the right of the runway and ended up on the soft area adjacent to the runway and taxi exit.

The investigation showed that while on landing on runway 07 at Tombouctou airport the aircraft touched down just beyond the end of the touchdown zone with manual brakes applied. A tailwind component with an average of 16 knots was recorded when the aircraft was fully configured and aligned with the runway track at 1300 ft AAL and this tailwind effect continued until the aircraft veered right out of the paved area. The aircraft skidded sideways and came to a halt with all landing gears off the runway, shortly before the extended stop way paved surface and left to the taxiway.

The following factors are believed to be the main causal factors of the occurrence:

1. *The unstabilized approach which was a result of the high vertical speed below 500 ft AFE, as the pilot flying was conducting a visual metrological conditions (VMC) approach.*
2. *The higher than allowed tailwind component that recorded a magnitude of 16 knots during final approach and landing phases.*
3. *Inadequate use of the manual braking, as the pilot flying applied asymmetric pressure to the brakes and that in turn resulted in a lower brake efficiency.*
4. *Crew resource management (CRM) was not evident during the approach phase of flight. The pilot monitoring was aware of the tailwind displayed on the electronic horizontal situation indicator and the progress page on the flight management computer display (FMC), and the higher than normal vertical speed; however no call outs were made by him to help in assessing the situation.*
5. *Commander reliance on his experience and technical skills rather than usage of automation as he elected to use manual brakes and usage of differential braking*

3.1 FACTUAL INFORMATION

1.1 HISTORY OF THE FLIGHT

On the 5th May 2017 the flight, JAV 7843, Operated by Jordan Aviation Boeing B737-400 Registration Mark JY-JAP, was scheduled to depart from Bamako (BKO, GABS) to Tombouctou Airport (TOM, GATB), both airports are located in Mali. The aircraft had last flown two days before the accident, and its crew were adequately rested.

The operating crew reviewed the aircraft technical logs, flight documents and weather forecast for TOM that was indicating normal weather with no significant difficulties.

The captain of the flight singed the load sheet of the flight that was prepared by the loadmaster travelling onboard as part of the crew, the load on the aircraft was indicating that the aircraft was loaded so as to operate at all times within its approved Centre of Gravity (CG) envelope.

On the morning of the occurrence the aircraft departed Bamako at 0736 UTC and was flown by the captain on the one-hour flight to Tombouctou Airport (TOM). Before top of descent the crew requested the weather report at TOM aerodrome and the tower reported a surface wind from 250° at 4 kt. Surface visibility was 5 km and local QNH was 1,011 hPa, temperature was 34°C and the runway surface was dry. At 15 NM the crew requested to descent and the tower cleared them to descend to 2500 ft and report final. The crew carried out the checklists and started descending to 2500 ft. at 8 NM from Runway 07 the crew reported final with full configuration. At 7 NM the crew visually captured runway 07 and asked for a clearance to land. The tower cleared them to land on runway 07 and report on ground.

During descent at approximately 5N.M from the airport the first officer stated that he noticed a tail wind component exceeding the operational limitations on the EHSI and FMC displays and he in turns reported that to the captain who acknowledged the information. In his statement to the investigation committee the captain of the flight did not recall this information from the first officer.

The Captain of the flight who was the pilot flying planned to use maximum manual brakes and briefed that maximum reverse thrust would be used during the landing run in order to arrest the aircraft on the short runway of TOM.

The Flight Data Recorder (FDR) analysis indicated that the approach was unstable and that the aircraft crossed the threshold at a speed 15kts higher than the target speed of approximately 141 KIAS and with a tail wind component of 16 knots.

The Aircraft departed BKO with 90 passengers and 11 crew, total on board were 101 persons, 5 tons of cargo, and fuel on board was 9,700 Kg.

The aircraft landed at TOM on runway 07 at 08:35:53 UTC, just beyond the markings of the touchdown zone, approximately 350 m after the runway threshold with a speed of 150 KIAS, flaps 30, landing weight of 55,000 Kg and manually controlled thrust. The speed brakes were set manually to UP position just at touchdown. At touch down the speed reduced to 146 KIAS and engine thrust reversers were deployed manually with the left engine thrust reverser lagging in response with 3 seconds from the right engine resulting in a small drift to the right at 2°. The wheel brakes were applied on the left side only for about 5 seconds in what is believed to be an action from the pilot flying to return the aircraft to the center of the runway. Control column was showing 2.5° pitch up angle which continued for 5 seconds after touchdown. Immediately after the nose wheel touched the ground, the captain applied increased brake pedal displacement and maximum reverse thrust as he considered the rate of deceleration was inadequate. The co-pilot shared the commander’s perception but he did not firmly depress his own brake pedals. The aircraft continued to roll on runway 07 which is 2,170 m long to depart the runway from the taxiway edge located on the right side at the end of runway 25; the aircraft came to rest on the unpaved area southeast to the runway/taxiway intersection. As shown in figure 1.

There were no indications of fire and the captain did not order an evacuation. External steps were brought to the right front door of the aircraft. There were no injuries to the passengers or crew.

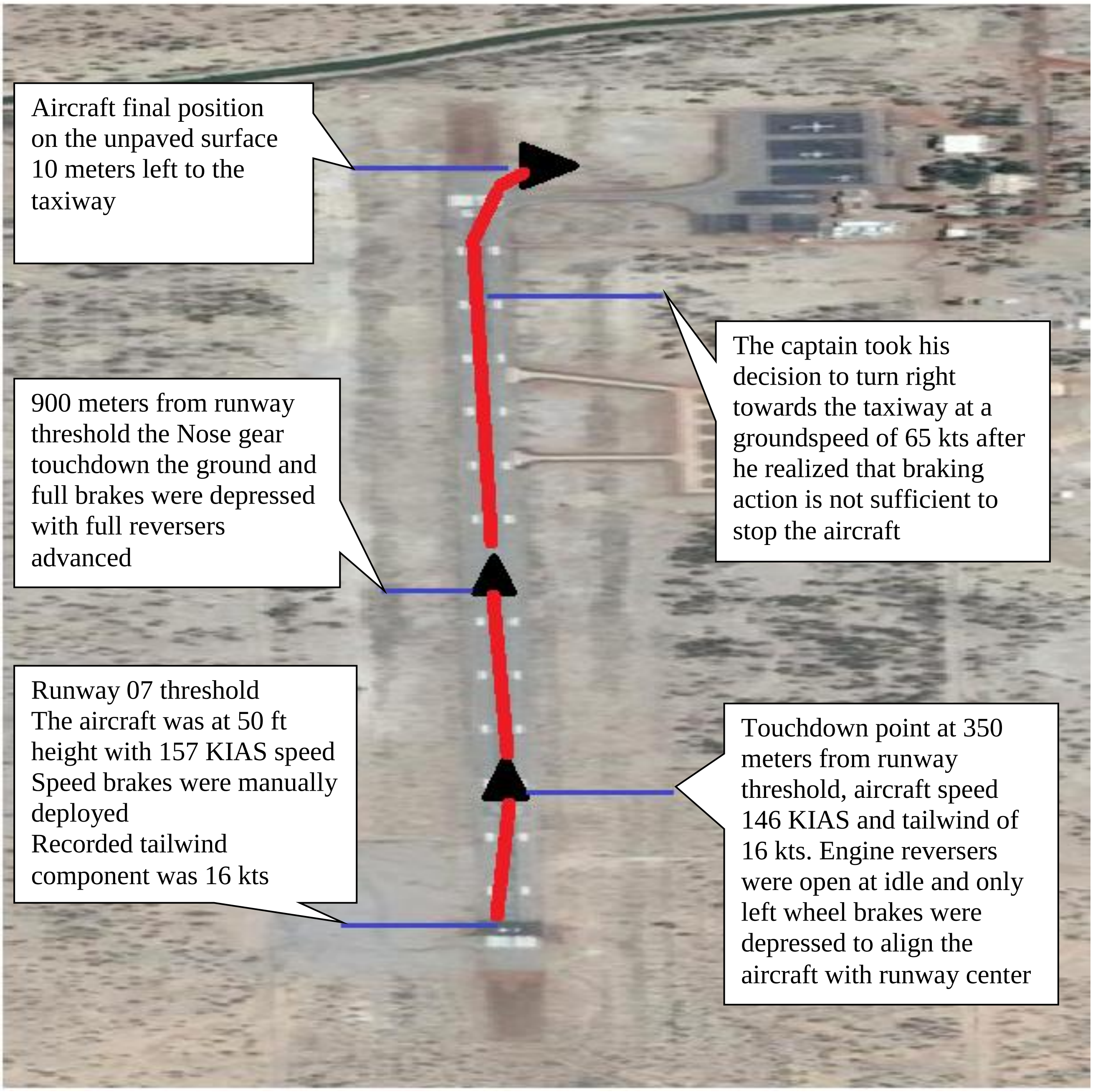


Figure 1

Aircraft ground run

The aircraft was removed out from the soft area by towing it from the back using cables on both main landing gears; since the airport was not equipped with a tow bar.

The aircraft moved to the parking area using its own power from engine No. 2 since engine No. 1 sustained damage on its fan blades due to ingestion of small gravels from the soft area

Aircraft recorders (DFDR and CVR) were removed for the purpose of investigation.

1.2 INJURIES

No injuries to passengers and crew was reported

1.3 DAMAGE TO AIRCRAFT

The aircraft engine No. 1 sustained damage on all fan blades

1.4 OTHER DAMAGE

No other damages were reported

1.5 PERSONAL INFORMATION

Pilot in Command

Age	63
Certificate Type	ATPL / B 737
Date of last Medical	22-04-2017
Hours on Type	9000
Hours Last 90 days	140
Total Hours last 90 days	140
Duty time/Last 24 hours	None
Ratings	B737 / B 747 / B727
Proficiency Check Date	11-02-2017
Line check Date	20-08-2016

First Officer

Age	30
Certificate No & Type	ATPL / B737
Date of last Medical	07-03-2017
Hours on Type	3300
Hours Last 90 days	120
Total Hours last 90 days	120
Duty time/Last 24 hours	None
Ratings	B737
Proficiency Check Date	22-01-2017
Line check Date	06-02-2017

1.6 AIRCRAFT INFORMATION

1.6.1 GENERAL INFORMATION

Aircraft Registration	JY-JAP	**MSN**	24124
Type	B737-400	**Year of Manufacture**	1989
Last Weighing Report	31-Mar-2016	**Center of Gravity**	10.4525 %
AC TSN	64824:59	**AC CSN**	33530

1.6.2 AIRCRAFT DESCRIPTION

The B737 is a twin-engine aircraft of conventional two wheel landing gear. The main wheels are numbered from 1-4, from left to right across the aircraft. The systems used for retardation during the landing ground roll are ground spoilers fitted to the wings; engine thrust reversers and wheel brakes. The ground spoilers are normally set to deploy automatically on landing in order to reduce residual lift from the wings during the subsequent ground roll and thus improve the effectiveness of the wheel brakes. Thrust reversers are selected manually.

1.6.2.1 BRAKE SYSTEM

Each main gear wheel has a multi–disc hydraulic powered brake. The brake pedals provide independent control of the left and right brakes. The nose wheels have no brakes. The brake system includes:

Normal Brake System

The normal brake system is powered by hydraulic system B.

Alternate Brake System

The alternate brake system is powered by hydraulic system A. If hydraulic system B is low or fails; hydraulic system A automatically supplies pressure to the alternate brake system.

Brake Accumulator

The brake accumulator is pressurized by hydraulic system B. If both normal and alternate brake system pressure is lost, trapped hydraulic pressure in the brake accumulator can still provide several braking applications or parking brake application.

Antiskid Protection

Antiskid protection is provided in the normal and alternate brake systems. The ANTISKID control switch controls power to the antiskid controller.

The normal brake hydraulic system provides each main gear wheel with individual antiskid protection. When the system detects a skid, the associated antiskid valve reduces brake pressure until skidding stops. The alternate brake hydraulic system works similar to the normal system. However, antiskid protection is applied to main gear wheel pairs instead of individual wheels.

The normal and alternate brake systems provide skid and hydroplane protection.

Locked wheel and touchdown protection is available only with the normal braking system.

Antiskid protection is available even with loss of both hydraulic systems.

Autobrake System

The autobrake system uses hydraulic system B pressure to provide maximum deceleration for rejected takeoff and automatic braking at preselected deceleration rates immediately after touchdown. The system operates only when the normal brake system is functioning. Antiskid system protection is provided during autobrake operation.

Rejected Takeoff (RTO)

The RTO mode can be selected only when on the ground. Upon selection, the AUTO BRAKE DISARM light illuminates for one to two seconds and then extinguishes, indicating that an automatic self–test has been successfully accomplished.

To arm the RTO mode prior to takeoff the following conditions must exist:

• Airplane on the ground

• Antiskid and autobrake systems operational

• AUTO BRAKE select switch positioned to RTO

• Wheel speed less than 60 knots

• Forward thrust levers positioned to IDLE.

The RTO mode is activated when wheel speed reaches 60 knots. If the takeoff is rejected while wheel speed is between 60 and 90 knots, the AUTO BRAKE DISARM light illuminates, autobraking is not initiated. If the takeoff is rejected after reaching a wheel speed of 90 knots, maximum braking is applied automatically when the forward thrust levers are retarded to IDLE. Braking force is the equivalent of full manual braking.

The RTO mode is automatically disarmed when the right main gear strut extends.

The AUTO BRAKE DISARM light does not illuminate. The selector switch must be manually positioned to OFF. If a landing is made with RTO selected, no automatic braking action occurs and the AUTO BRAKE DISARM light illuminates two minutes after touchdown. To reset, position the selector to OFF.

Landing

When a landing autobrake selection is made, the system performs a turn–on– self–test. If the turn–on–self–test is not successful, the AUTO BRAKE DISARM light illuminates and the autobrake system does not arm.

Four levels of deceleration can be selected for landing. However, on dry runways, the maximum autobrake deceleration rate in the landing mode is less than that produced by full pedal braking.

After landing, autobrake application begins when:

• Both forward thrust levers are retarded to IDLE, and

• The main wheels spin–up.

To maintain the selected landing deceleration rate, autobrake pressure is reduced as other controls, such as thrust reversers and spoilers, contribute to total deceleration. The autobrake system brings the airplane to a complete stop unless the braking is terminated by the pilot.

Autobrake – Disarm

The pilots may disarm the autobrake system by moving the selector switch to the OFF position. This action does not cause the AUTO BRAKE DISARM light to illuminate. After braking has started, any of the following pilot actions disarm the system immediately and illuminate the AUTO BRAKE DISARM light:

• moving the SPEED BRAKE lever to the down detent

• advancing the forward thrust lever(s) after touchdown, or

• applying manual brakes.

Parking Brake

The parking brake can be set with either A or B hydraulic systems pressurized. If A and B hydraulic systems are not pressurized, parking brake pressure is maintained by the brake accumulator. Accumulator pressure is shown on the HYDRAULIC BRAKE PRESSURE indicator.

The parking brake is set by depressing both brake pedals fully, while simultaneously pulling the PARKING BRAKE lever up. This mechanically latches the pedals in the depressed position and commands the parking brake valve to close.

The parking brake is released by depressing the pedals until the PARKING BRAKE lever releases. A fault in the parking brake system may cause the ANTISKID INOP light to illuminate.

1.6.2.2 THRUST REVERSER

Each engine is equipped with a hydraulically operated thrust reverser, consisting of left and right translating sleeves. Aft movement of the reverser sleeves causes blocker doors to deflect fan discharge air forward, through fixed cascade vanes, producing reverse thrust. The thrust reverser is for ground operations only and is used after touchdown to slow the airplane, reducing stopping distance and brake wear.

Hydraulic pressure for the operation of engine No. 1 and engine No. 2 thrust reversers comes from hydraulic systems A and B, respectively. If hydraulic system A or B fails, alternate operation for the affected thrust reverser is available through the standby hydraulic system. When the standby system is used, the affected thrust reverser deploys and retracts at a slower rate, and some thrust asymmetry can be anticipated.

The thrust reverser can be deployed when either radio altimeter senses less than 10 feet altitude, or when the air/ground safety sensor is in the ground mode.

Movement of the reverse thrust levers is mechanically restricted until the forward thrust levers are in the idle position.

When reverse thrust is selected, an electromechanical lock releases, the isolation valve opens, and the thrust reverser control valve moves to the deploy position, allowing hydraulic pressure to unlock and deploy the reverser system. An interlock mechanism restricts movement of the reverse thrust lever until the reverser sleeves have approached the deployed position. When either reverser sleeve moves from the stowed position, the amber REVERSER UNLOCKED light on the center instrument panel illuminates. As the thrust reverser reaches the deployed position, the reverse thrust lever can be raised to detent No. 2. This position provides adequate reverse thrust for normal operations. When necessary, the reverse thrust lever can be pulled beyond detent No. 2, providing maximum reverse thrust.

Downward motion of the reverse thrust lever past detent No. 1 commands the reverser to stow. Once the thrust reverser is commanded to stow, the control valve moves to the stow position allowing hydraulic pressure to stow and lock the reverser sleeves. After the thrust reverser is stowed, the isolation valve closes.

The REVERSER light, located on the aft overhead panel, illuminates when the thrust reverser is commanded to stow and extinguishes 10 seconds later when the isolation valve closes. Any time the REVERSER light illuminates for more than approximately 12 seconds, a malfunction has occurred, and the MASTER CAUTION and ENG system annunciator lights illuminate.

When the reverser sleeves are in the stowed position, an electromechanical lock and a hydraulically operated locking actuator inhibit motion to each reverser sleeve until reverser extension is selected. Additionally, an auto–restow circuit compares the actual reverser sleeve position and the commanded reverser position. In the event of incomplete stowage or uncommanded movement of the reverser sleeves toward the deployed position, the auto–restow circuit opens the isolation valve and commands the control valve to the stow position, directing hydraulic pressure to stow the reverser sleeves. Once the auto–restow circuit is activated, the isolation valve remains open and the control valve is held in the stowed position until the thrust reverser is commanded to deploy or until corrective maintenance action is taken.

Thrust Reverser Schematic

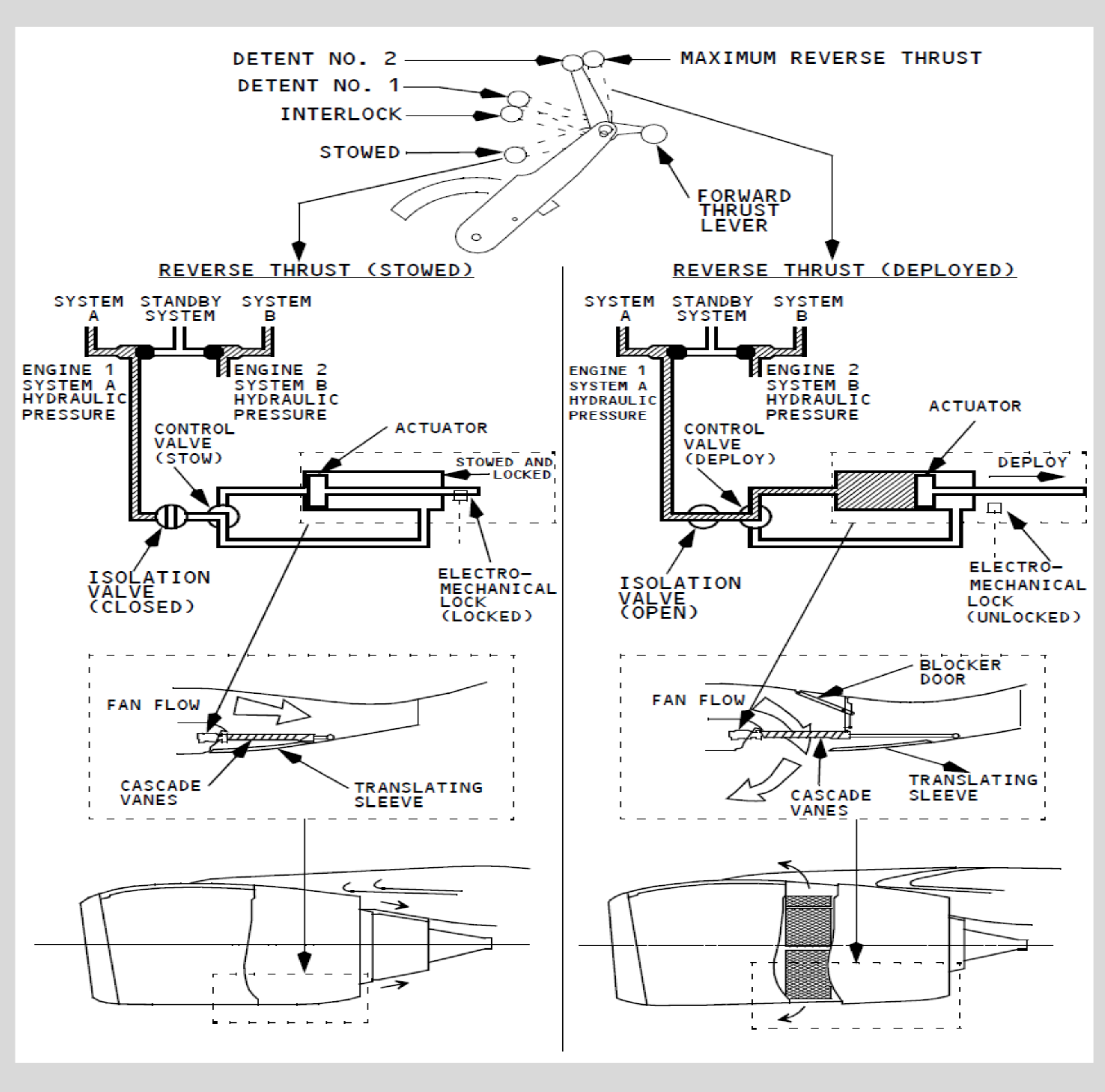


Figure 2

B737-400 Thrust Reverser Schematic

1.6.2.3 SPEED BRAKES

The B737-400 speed brakes consist of flight spoilers and ground spoilers. Hydraulic system A powers all six ground spoilers, three on the upper surface of each wing. The SPEED BRAKE lever controls the spoilers. When the SPEED BRAKE lever is actuated all the spoilers extend when the airplane is on the ground, and only the flight spoilers extend when the airplane is in the air.

In Flight Operation

Operating the SPEED BRAKE lever in flight causes all flight spoiler panels to rise symmetrically to act as speed brakes. Caution should be exercised when deploying flight spoilers during a turn, as they greatly increase roll rate. When the speed brakes are in an intermediate position the roll rates increase significantly.

Moving the SPEED BRAKE lever past the FLIGHT detent causes buffeting and is not recommended in flight.

Ground Operation

During landing, the auto speed brake system operates when these conditions occur:

- SPEED BRAKE lever is in the ARMED position
- SPEED BRAKE ARMED light is illuminated
- Both thrust levers are retarded to IDLE
- Main landing gear wheels spin–up (more than 60 kts) – SPEED BRAKE lever automatically moves to the UP position, and the flight spoilers deploy
- Right main landing gear strut compresses on touchdown, causing the mechanical linkage to open the ground spoiler bypass valve, and the ground spoilers deploy If a wheel spin–up signal is not detected, when the air/ground system senses ground mode, the SPEED BRAKE lever moves to the UP position, and all spoiler panels deploy automatically.

During a rejected takeoff (RTO), the auto speed brake system operates when these conditions occur:

- Main landing gear wheels spin–up (more than 60 kts)
- Takeoff is rejected, both thrust levers are retarded to IDLE and the reverse thrust levers are positioned for reverse thrust – SPEED BRAKE lever automatically moves to the UP position and all spoilers deploy.

After a RTO or landing, if either thrust lever is advanced, the SPEED BRAKE lever automatically moves to the DOWN detent and all spoiler panels retract. The spoiler panels may also be retracted by manually moving the SPEED BRAKE lever to the DOWN detent.

The SPEED BRAKE caution light, if installed, flashes continuously if the Speed Brake Lever is aft of the ARMED position, the air/ground sensor is in the air position, and the flaps are extended beyond position 10.

Speed Brakes Schematic

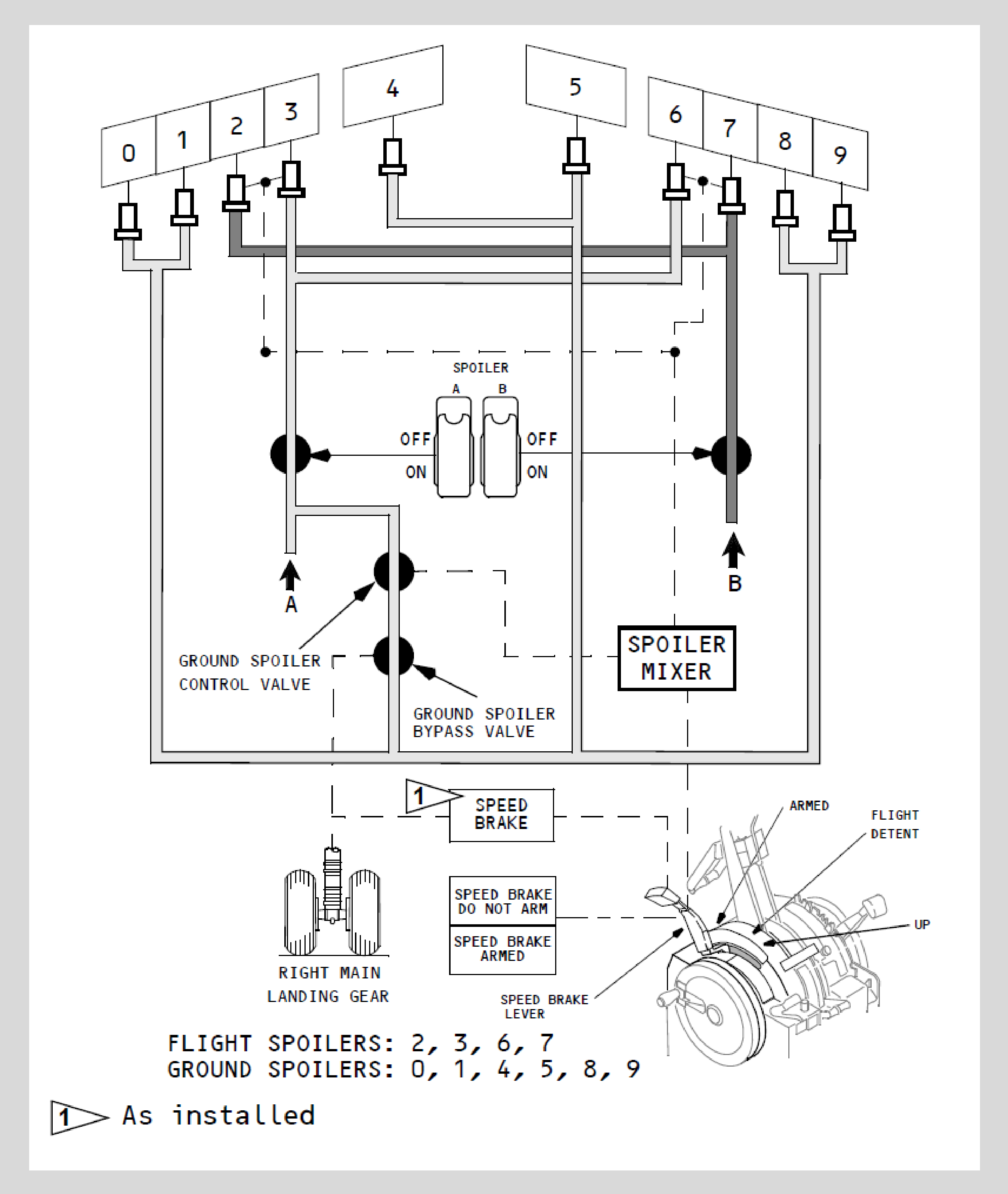


Figure 3
Speed Brakes Schematic

1.6.3 MAINTENANCE DATA
1.6.3.1 AIRCRAFT MAINTENANCE DATA

Check Type	Date accomplished	@ A/C TT	@ A/C TC
A-check	23-feb-2017	64730:54	33463
C-Check	26-mar-2014	61344	31479
TT form last C check	3481	TC from Last C check	2051

A/C flight 67 FC and 95 FH with following maintenance (A-Check) was performed during the operation:

- Preflight Check, latest one done on 5-MAY-2017,at STA BKO, Ref. TLS #24851
- Daily Check, Latest one dated 5-MAY-2017, at STA BKO Ref. TLS #24850
- Weekly check; latest one dated 29-APR-2017 at STA AMM, REF TLS 24834
- 2A check dated 23-Feb-2017 STA AMM – Certificate Ref.#024/2017

1.6.3.2 ENGINES MAINTENANCE DATA

(CFM56-3B2)

Position	ESN	LSV date	Engine TSN	Engine CSN	CSO	TSO
#1	726479	28-Oct-2015	46466	43529	487	704
#2	722141	18-Sep-2016	57119	35825	313	440

1.6.3.3 WHEEL BRAKES MAINTENANCE DATA

Position	Description	Part No.	Serial No.	Installation Date	TSI	CSI
#1	Brake Assy.	2-1474-7	5489	20-OCT-16	300 FH	216 FC
#2	Brake Assy.	2-1474-7	3322	19-SEP-16	416 FH	301 FC
#3	Brake Assy.	2-1474-7	7362P	22-JUL-16	715 FH	502 FC
#4	Brake Assy.	2-1474-7	0943	20-OCT-16	300 FH	216 FC

Remark: All Brakes were installed as repaired Ref. attached ARC CARC Form 18-0227 for each Serial No.

OEM Ref.: GOODRICH CMM 32-40-30 REV. 12 Dated OCT.13/08

Note: all above given data are Up to the date of the Occurrence that took place in Tombouctou Airport, Tombouctou, Mali JAV 7843 BKO-TOM 5 May 2017

1.6.4 AIRCRAFT WEIGHT

Before the flight the crew received details of the passenger load; it comprised 90 passengers all adults and 5000 kg of baggage load. The commander signed a trim sheet indicating that the aircraft was loaded so as to operate at all times within its approved Centre of Gravity (CG) envelope. The signed loadsheet indicated that the landing weight of the aircraft would be 54,652 kg. The investigation used the actual landing weight of approximately 55,000 kg in assessing the landing performance of the aircraft.

The Maximum Certified Landing Weight for this aircraft is 56,245 kg.

1.6.5 LANDING PERFORMANCE

The B737 Flight Crew Training Manual (FCTM) and Quick Reference Handbook (QRH), contains advice on the selection of retardation devices to achieve adequate stopping performance. Tables provided shows approximate actual landing distance to be expected under various conditions. The published tables for a flaps 30 landing assume that Reference distance is based on sea level, standard day, no wind or slope, VREF30 approach speed, two-engine detent No. 2 reverse thrust, and auto speedbrakes. For max manual braking and manual speedbrakes, reference landing distance is to be increased by 300 ft. Reference Distance includes an air distance allowance of 1000 ft from threshold to touchdown.

A calculation made based on a landing weight of 55,000 kg, flaps 30, tailwind of 16 knots with the use of Maximum Manual Brakes; the published figures indicate that the aircraft would have come to a complete stop before the end of the paved runway surface.

According to the calculation, if the brakes were used immediately after the touchdown and with the use of full reversers, then the required landing distance would be as following:

Performance Inflight - QRH
General

BOEING

737-400/CFM56-3_22K
FAA

737 Flight Crew Operations Manual

VREF

WEIGHT (1000 KG)	FLAPS		
	40	30	15
70	155	159	177
65	149	154	171
60	143	147	164
55	137	141	156
50	130	134	149
45	124	127	141
40	116	119	132
35	109	111	123

Table 1
B737-400 QRH-Performance Inflight – V_{ref} determination

Performance Inflight - QRH
Advisory Information

BOEING

737-400/CFM56-3_22K
FAA

737 Flight Crew Operations Manual

ADVISORY INFORMATION

Normal Configuration Landing Distance
Flaps 30

BRAKING CONFIGURATION	LANDING DISTANCE AND ADJUSTMENTS (FT)								
	REF DIST	WT ADJ	ALT ADJ	WIND ADJ	SLOPE ADJ	TEMP ADJ	APP SPD ADJ	REVERSE THRUST ADJ	
	52000 KG LANDING WEIGHT	PER 5000 KG ABV/BLW 52000 KG	PER 1000 FT ABOVE SEA LEVEL	PER 10 KTS HEAD/ TAIL WIND	PER 1% DOWN/ UP HILL	PER 10°C ABV/ BLW ISA	PER 10 KTS ABOVE VREF30	ONE REV	NO REV
Dry Runway									
MAX MANUAL	2740	330/-160	60	-100/340	30/-30	60/-60	210	40	140
AUTOBRAKE MAX	3510	260/-230	80	-130/430	0/0	80/-80	340	0	20
AUTOBRAKE 3	4950	380/-380	130	-220/730	20/-30	130/-130	510	40	50
AUTOBRAKE 2	5950	510/-520	170	-280/960	90/-130	160/-160	480	200	200
AUTOBRAKE 1	6450	600/-580	200	-330/1130	190/-210	180/-180	470	660	990
Good Reported Braking Action									
MAX MANUAL	3750	270/-270	90	-170/590	90/-80	90/-90	290	180	630
AUTOBRAKE MAX	4000	290/-290	100	-170/610	70/-60	90/-90	340	210	690
AUTOBRAKE 3	4960	380/-380	130	-220/740	30/-40	130/-130	510	50	190
AUTOBRAKE 2	5950	510/-520	170	-280/960	90/-130	160/-160	480	200	200
AUTOBRAKE 1	6450	600/-580	200	-330/1130	190/-210	180/-180	470	660	990
Medium Reported Braking Action									
MAX MANUAL	5000	420/-400	140	-260/950	210/-170	130/-130	370	490	1980
AUTOBRAKE MAX	5030	430/-410	140	-260/950	180/-140	130/-130	420	490	1970
AUTOBRAKE 3	5380	440/-430	150	-270/990	150/-120	140/-140	510	380	1910
AUTOBRAKE 2	6100	520/-530	180	-310/1090	170/-180	170/-170	480	290	1250
AUTOBRAKE 1	6480	600/-590	210	-330/1170	250/-220	180/-180	470	680	1540
Poor Reported Braking Action									
MAX MANUAL	6330	580/-550	200	-380/1460	470/-320	160/-160	420	990	5350
AUTOBRAKE MAX	6330	580/-550	200	-380/1460	470/-310	160/-160	450	990	5380
AUTOBRAKE 3	6370	590/-560	200	-380/1470	450/-300	170/-170	480	1020	5400
AUTOBRAKE 2	6710	610/-590	210	-400/1510	430/-310	180/-180	470	790	5030
AUTOBRAKE 1	6940	650/-640	220	-410/1550	470/-350	190/-190	470	980	4960

Reference distance is based on sea level, standard day, no wind or slope, VREF30 approach speed, two-engine detent No. 2 reverse thrust, and auto speedbrakes.
For max manual braking and manual speedbrakes, increase reference landing distance by 300 ft.
Reference Distance includes an air distance allowance of 1000 ft from threshold to touchdown.
Actual (unfactored) distances are shown.

Table 2
B737-400 QRH-Performance Inflight – Normal Configuration Landing Distance- Flaps 30

The calculation gives the following results:

Air distance allowance – 1000 ft	Reference distance 52,000kg landing weight	Weight adj. (55,000kg)	Altitude adj. (915 ft)	Wind adj. 16 kts tailwind	Slope adj. 0%	Temp adj. 34 deg	APP speed adj. 158 kts	Total landing distance required
1,148 – 1,000 = 148 ft	2,740 + 148 = 2,888 ft	2,888 + 198 = 3,086 ft	3,086 + 55 = 3,141 ft	3,141 + 544 = 3,685 ft	No Slope= 3,685 ft	3,685 + 60 = 3,745 ft	3,745 + 357 = 4,102 ft	4,102 + 300 = 4,402 ft

The calculated required landing distance is 4,402 ft, while the available landing distance at TOM is 7,118 ft, which means that if the aircraft made the landing using the maximum brakes without applying differential braking or pumping the brakes, and using the thrust reversers at detent No. 2 with normal enforcement to the nose landing gear to touch the ground and with speed brakes in UP position; all these conditions is sufficient to stop the aircraft before the end of the paved surface of the runway. Even when counting for 150% of the tailwind component, the required landing distance would be 5,194 ft of ground run.

Use of AUTOBRAKE MAX selection would also result in arresting the aircraft within the paved area of the runway if the techniques recommended by the manufacturer are followed without intervention of the pilot.

1.6.6 FLIGHT CREW TRAINING MANUAL

The FCTM, produced by the aircraft manufacturer, describes standard operating procedures and provides information about aircraft performance in various phases of flight. In relation to the selection of autobrake it states:

Wheel Brakes

Braking force is proportional to the force of the tires on the runway and the coefficient of friction between the tires and the runway. The contact area normally changes little during the braking cycle. The perpendicular force comes from airplane weight and any downward aerodynamic force such as speedbrakes.

The coefficient of friction depends on the tire condition and runway surface, (e.g. concrete, asphalt, dry, wet or icy).

Automatic Brakes

Use of the autobrake system is recommended whenever the runway is limited, when using higher than normal approach speeds, landing on slippery runways, or landing in a crosswind.

For normal operation of the autobrake system select a deceleration setting.

Settings include:

• MAX: Used when minimum stopping distance is required. Deceleration rate is less than that produced by full manual braking

• 3: Should be used for wet or slippery runways or when landing rollout distance is limited. If adequate rollout distance is available, autobrake setting 2 may be appropriate

• 1 or 2: These settings provide a moderate deceleration suitable for all routine operations.

Experience with various runway conditions and the related airplane handling characteristics provide initial guidance for the level of deceleration to be selected.

Immediate initiation of reverse thrust at main gear touchdown and full reverse thrust allow the autobrake system to reduce brake pressure to the minimum level.

Since the autobrake system senses deceleration and modulates brake pressure accordingly, the proper application of reverse thrust results in reduced braking for a large portion of the landing roll.

The importance of establishing the desired reverse thrust level as soon as possible after touchdown cannot be overemphasized. This minimizes brake temperatures and tire and brake wear and reduces stopping distance on very slippery runways.

The use of minimum reverse thrust as compared to maximum reverse thrust can double the brake energy requirements and result in brake temperatures much higher than normal.

After touchdown, crewmembers should be alert for autobrake disengagement annunciations. The PM should notify the PF anytime the autobrakes disengage.

If stopping distance is not assured with autobrakes engaged, the PF should immediately apply manual braking sufficient to assure deceleration to a safe taxi speed within the remaining runway.

Manual Braking

The following technique for manual braking provides optimum braking for all runway conditions:

The pilot's seat and rudder pedals should be adjusted so that it is possible to apply maximum braking with full rudder deflection.

Immediately after main gear touchdown, smoothly apply a constant brake pedal pressure for the desired braking. For short or slippery runways, use full brake pedal pressure.

• do not attempt to modulate, pump or improve the braking by any other special techniques

• do not release the brake pedal pressure until the airplane speed has been reduced to a safe taxi speed

• the antiskid system stops the airplane for all runway conditions in a shorter distance than is possible with either antiskid off or brake pedal modulation.

The antiskid system adapts pilot applied brake pressure to runway conditions by sensing an impending skid condition and adjusting the brake pressure to each individual wheel for maximum braking. When brakes are applied on a slippery runway, several skid cycles occur before the antiskid system establishes the right amount of brake pressure for the most effective braking.

If the pilot modulates the brake pedals, the antiskid system is forced to readjust the brake pressure to establish optimum braking. During this readjustment time, braking efficiency is lost.

Low available braking coefficient of friction on extremely slippery runways at high speeds may be interpreted as a total antiskid failure. Pumping the brakes or turning off the antiskid degrades braking effectiveness. Maintain steadily increasing brake pressure, allowing the antiskid system to function at its optimum capability.

Landing Roll

Avoid touching down with thrust above idle since this may establish an airplane nose up pitch tendency and increase landing roll.

After main gear touchdown, initiate the landing roll procedure. If the speedbrakes do not extend automatically move the speedbrake lever to the UP position without delay. Fly the nose wheels smoothly onto the runway without delay. Control column movement forward of neutral should not be required. Do not attempt to hold the nose wheels off the runway. Holding the nose up after touchdown for aerodynamic braking is not an effective braking technique and results in high nose gear sink rates upon brake application and reduced braking effectiveness.

To avoid possible airplane structural damage, do not make large nose down control column movements before the nose wheels are lowered to the runway.

To avoid the risk of a tail strike, do not allow the pitch attitude to increase after touchdown. However, applying excessive nose down elevator during landing can result in substantial forward fuselage damage. Do not use full down elevator. Use an appropriate autobrake setting or manually apply wheel brakes smoothly with steadily increasing pedal pressure as required for runway condition and runway length available. Maintain deceleration rate with constant or increasing brake pressure as required until stopped or desired taxi speed is reached.

Speedbrakes

The speedbrakes can be fully raised after touchdown while the nose wheels are lowered to the runway, with no adverse pitch effects. The speedbrakes spoil the lift from the wings, which places the airplane weight on the main landing gear, providing excellent brake effectiveness.

Unless speedbrakes are raised after touchdown, braking effectiveness may be reduced initially as much as 60%, since very little weight is on the wheels and brake application may cause rapid antiskid modulation.

Normally, speedbrakes are armed to extend automatically. Both pilots should monitor speedbrake extension after touchdown. In the event auto extension fails, the speedbrakes should be manually extended immediately.

Pilot awareness of the position of the speedbrake lever during the landing phase is important in the prevention of over-run. The position of the speedbrakes should be announced during the landing phase by the PM. This improves the crew's situational awareness of the position of the spoilers during landing and builds good habit patterns which can prevent failure to observe a malfunctioned or disarmed spoiler system.

Directional Control and Braking during Landing Roll

If the nose wheels are not promptly lowered to the runway, braking and steering capabilities are significantly degraded and no drag benefit is gained. Rudder control is effective to approximately 60 knots. Rudder pedal steering is sufficient for maintaining directional control during the rollout. Do not use the nose wheel steering wheel until reaching taxi speed. In a crosswind, displace the control wheel into the wind to maintain wings level which aids directional control. Perform the landing roll procedure immediately after touchdown. Any delay markedly increases the stopping distance.

Use a combination of rudder, differential braking, and control wheel input to maintain runway centerline during strong crosswinds, gusty wind conditions or other situations. Maintain these control input(s) until reaching taxi speeds.

Stopping distance varies with wind conditions and any deviation from recommended approach speeds.

Factors Affecting Landing Distance

Advisory information for normal and non-normal configuration landing distances is contained in the PI chapter of the QRH. Actual stopping distances for a maximum effort stop are approximately 60% of the dry runway field length requirement. Factors that affect stopping distance include: height and speed over the threshold, glide slope angle, landing flare, lowering the nose to the runway, use of reverse thrust, speedbrakes, wheel brakes and surface conditions of the runway.

Reverse thrust and speedbrake drag are most effective during the high speed portion of the landing. Deploy the speedbrake lever and activate reverse thrust with as little time delay as possible.

Speedbrakes fully deployed, in conjunction with maximum reverse thrust and maximum manual antiskid braking provides the minimum stopping distance.

Floating above the runway before touchdown must be avoided because it uses a large portion of the available runway. The airplane should be landed as near the normal touchdown point as possible. Deceleration rate on the runway is approximately three times greater than in the air.

Height of the airplane over the runway threshold also has a significant effect on total landing distance. For example, on a 3° glide path, passing over the runway threshold at 100 feet altitude rather than 50 feet could increase the total landing distance by approximately 950 feet. This is due to the length of runway used up before the airplane actually touches down.

Glide path angle also affects total landing distance. As the approach path becomes flatter, even while maintaining proper height over the end of the runway, total landing distance is increased.

Figure 4 shows typical increase in landing distance due to improper landing techniques compared to the proper (baseline) condition. These data are based on dry runway, sea level, standard day conditions with landing weights up to the maximum landing weight. Data exclude wet or contamination effects. When increased landing distance is shown as a range, it reflects variations in airplane weight and model variants (if applicable). These calculations are intended for training discussion purposes only.

Non-Normal Landing Distance

Because of the higher approach speeds and the possible degraded capability of deceleration devices (spoiler, brakes, and reversers) associated with the non-normal landing condition, the actual landing distance is increased. The Non-Normal Configuration Landing Distance table in the PI chapter of the QRH shows VREF and landing distances for various non-normal landing configurations and runway conditions

It should be noted that the landing under investigation is not categorized as a Non-Normal landing. Hence; this part of the investigation report was only introduced for better understanding.

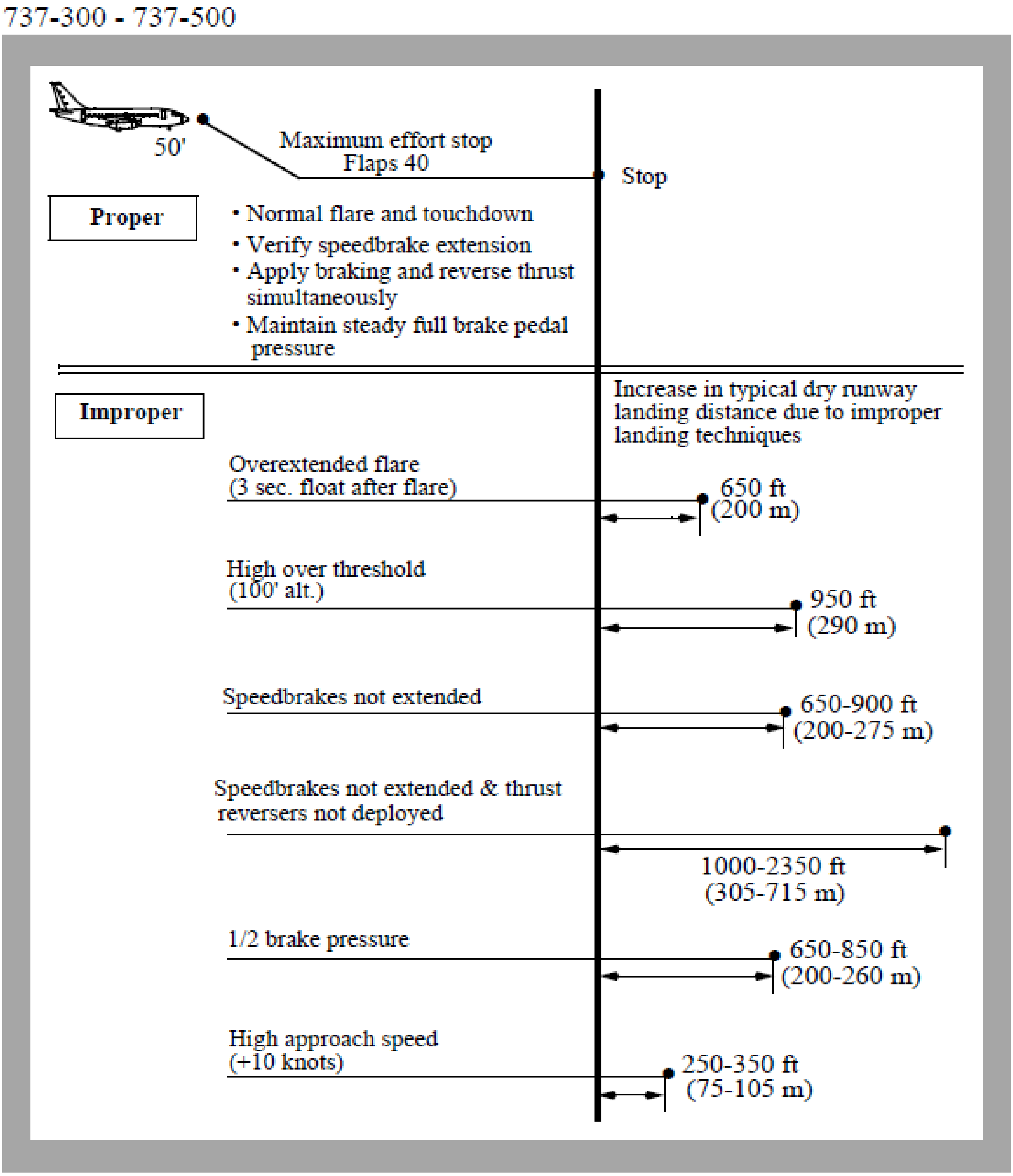


Figure 4
Increase in Landing Distance due to Improper Landing Techniques

1.7 METROLOGICAL INFORMATION

The landing forecast weather information received by the crew from TOM tower was indicating a surface wind from 250° at 4 kts. Surface visibility was 5 km and local QNH was 1,011 hPa, temperature was 34°C and the runway surface was dry.

However; the indicated wind on the aircraft instruments was showing a tailwind component of 16 knots from the time the aircraft was aligned with the landing track with full configuration to the point where the aircraft was in landing roll.

1.8 AIDS TO NAVIGATION

TOM airport is equipped with distance measuring equipment (DME) and with RNAV (GNSS) approach and landing system at runway 07. The runway was previously equipped with an ILS but this system was removed from operation after 1st of February 2017, according to the NOTAM published at that date.

The Aircraft navigation system consists of inertial reference system IRS very high frequency omnidirectional range (VOR) receivers, DME receivers, ILS receivers, air traffic control transponder, weather radar, and flight management system (FMS) with two flight management computers (FMC) and two automatic direction finders (ADF). The Aircraft is also equipped with an autopilot flight director system.

Hence; the crew options of JAV7843 was limited to visual approach as the aircraft is not equipped with RNAV GNSS utility

A0132/17 NOTAMN

Q) DRRR/QPIXX/I/NBO/A/000/999/1644N00300W005

A) GATB B) 1702011732 C) PERM

E) REF ATLAS ASECNA AIP PAGES 909 B-2, 909 B-3 AND 909 B-4 THE PROCEDURES:

1-ILS X OR LOC-RWY 07

2-ILS Y OR LOC-RWY 07

3-ILS Z OR LOC-RWY 07

ARE COMPLETLY WITHDRAWN

1.9 COMMUNICATIONS

The communication with TOM tower cannot be discussed in light of the fact that No voice recorder data is available to the investigation committee.

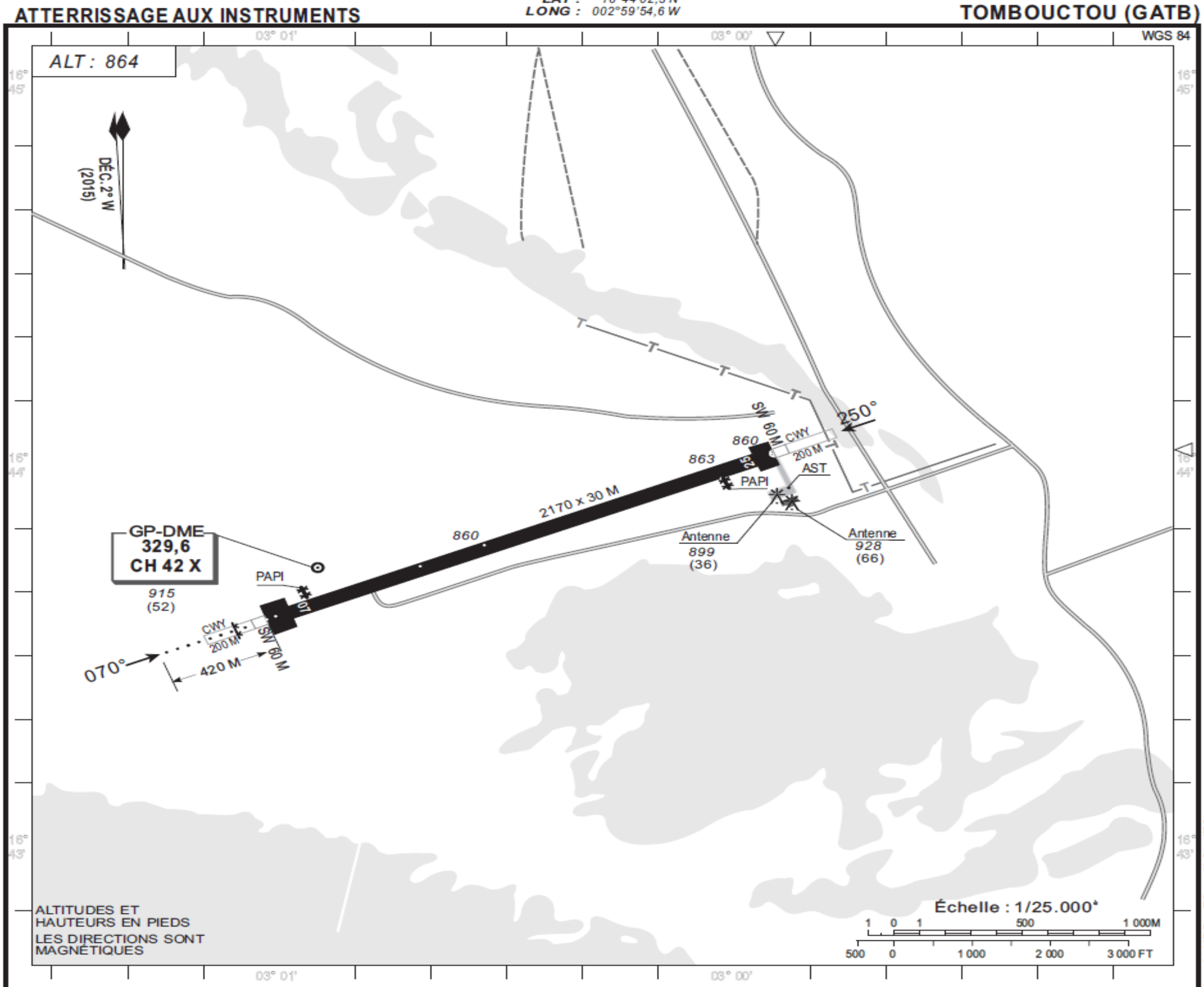
However, in general, the communication with TOM tower is known to be simple and using the standard phraseology of aviation communication. The AIP of Mali states that the used language with TOM tower is French language, but collected statements from different pilots who had flow to this airport previously shows that English language is used by tower controllers.

1.10 AERODROME INFORMATION

Tombouctou airport is located south to the city of Tombouctou in GAO region, in the central area of MALI; the aerodrome is used for both military and civilian aircraft. The civilian traffic is limited at this airport. It consists of a single runway and two aprons. The apron used for civilian aircraft is the one adjacent to runway 25 end, the runway length is 2170 m and the width is 30 meters.

Because of its runway narrow width, Tombouctou runway 07/25 was assessed for a previous operation and the safety controls and procedures were distributed to the crew flying to TOM airport in pilot briefing file. The occurrence flight crew did not review the controls developed in the assessment. The crew stated that they were not made aware of the assessment.

ATTERRISSAGE AUX INSTRUMENTS LAT : 16°44'02,3 N LONG : 002°59'54,6 W TOMBOUCTOU (GATB)



RWY	Approche	PAPI	Feux de seuil	Feux de Piste	Feux de fin de piste	Feux de fin de SWY
07	Axiale LIH unidirectionnelle LIL omnidirectionnelle	Pente : 3,00°	Verts LIL unidirectionnels	Blancs omnidirectionnels	Rouges BI unidirectionnels	NIL
25	NIL	Pente : 3,00°	Verts LIL unidirectionnels	Blancs omnidirectionels	Rouges LIL unidirectionnels	NIL

Raquettes QFU 07 et 25, voie de circulation principale : Feux bleus BI omnidirectionnels

CONSIGNES PARTICULIÈRES :

CORRECTIONS : CODAGE LIL/LIH-Déclinaison magnétique - Suppression du NDB « TB » - ILS « ITS »

22 JUIN 2017 SERVICE DE L'INFORMATION AÉRONAUTIQUE - ASECNA 909 C-1

Figure 5

TOM / GATB airport Terminal Layout according to ASCENA AIS

1.11 FLIGHT RECORDERS
1.11.1 DIGITAL FLIGHT DATA RECORDER

Manufacture:	Honeywell
Model:	SSFDR
P/N:	980-4700-033
S/N	1517
Medium:	Solid State
State of the recorder	No damage (visual inspection)
Recording Length:	Approximately 27 hours flight data
Recording quality:	Good

Figure 6

Flight Data Recorder – photo taken at GACA AIB Labs

The data recorded in the DFDR was successfully retrieved and analyzed by CARC investigator in Saudi AIB facilities.

1.11.2 COCKPIT VOICE RECORDER

Manufacture:	L3
Model:	SSCVR
P/N:	2100-1020-02
S/N	000183859
Medium:	Solid State
State of the recorder	No damage (visual inspection)
Recording configuration:	2 hours, 4 channels
Recording quality:	Good and clear
Contents:	
2 hours	Channel 1: CM1
	Channel 2: CM2
	Channel 3: CM3
	Channel 4: AREA

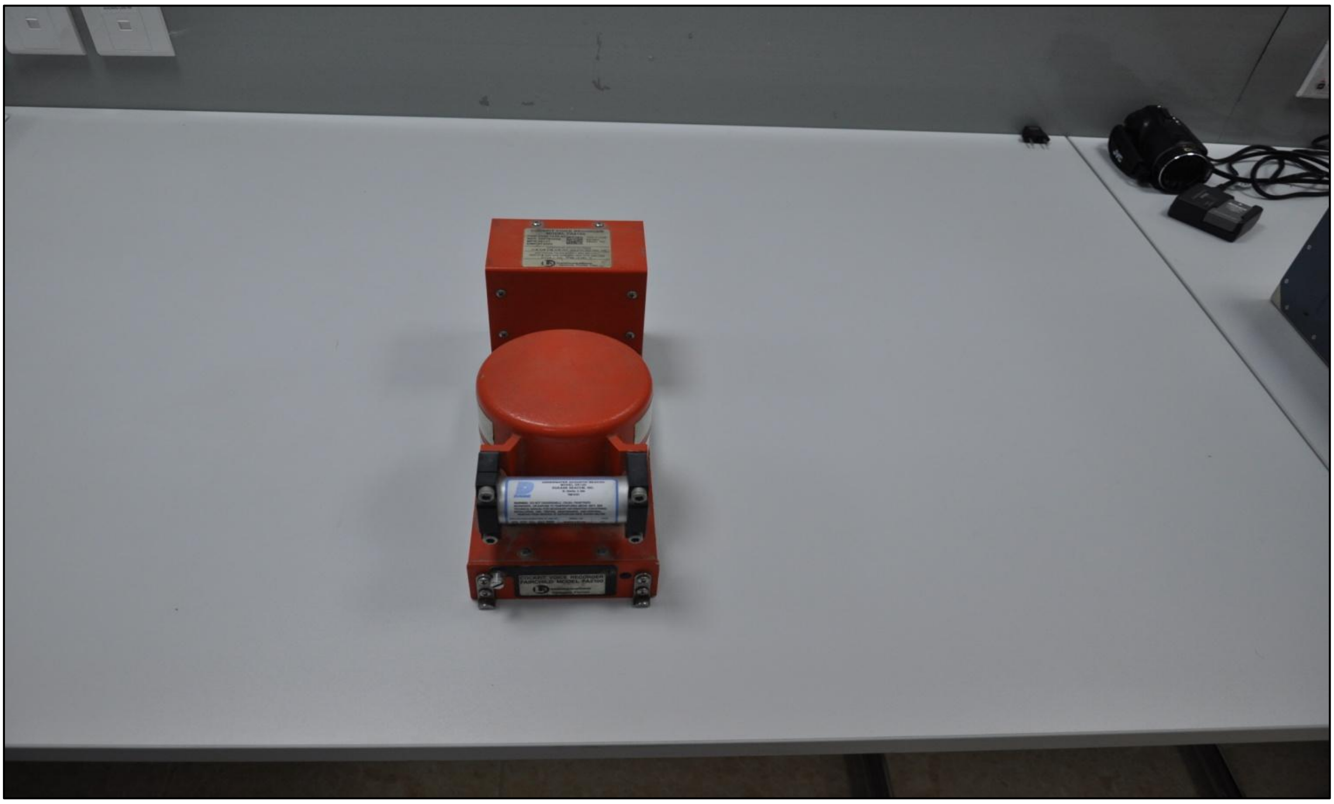


Figure 7

Cockpit Voice Recorder – photo taken at GACA AIB Labs

No transcript is available so far for the investigation committee to make analysis on the human factors part, communication and other relevant matters that can be extracted from voice data recorded as the data was found erased. However; the investigation committee was able to identify some significant impairments that contributed to the incident through interview of the flight crew and collected statements from other parties.

1.12 WRECKAGE AND IMPACT INFORMATION

Not relevant

1.13 MEDICAL AND PATHOLOGICAL INFORMATION

Not Relevant

1.14 FIRE

Not Relevant

1.15 SURVIVALS ASPECT

Normal disembarkation was carried out based on captain decision from Front Right door (R1 Door), no injuries were reported.

1.16 TESTS AND RESEARCHS

An in depth technical inspection was made to the brakes removed from the occurrence aircraft after the event in JAV TECHNIC brake shop facility.

The inspection was made in accordance to brakes manufacturer Component Maintenance Manual (CMM) with no significant findings in which contradicts any brake failure or performance degradation due to technical status scenario.

A copy of the technical inspection of the brakes is attached in the Appendixes part of this report.

1.17 ORGANIZATIONAL AND MANAGEMENT INFORMATION

JAV is Jordanian airlines is a privately owned, has its headquartered in Amman, Air Operator Certificate (AOC) was obtained in October 2000 and commenced operation in November 2000. JAV is a member of the International Civil Aviation Organization (ICAO), the International Air Transport Association (IATA), and the Arab Air Carriers Organization (AACO).

Between the years 2001 and 2003 JAV activities were on charter contracts with the United Nation’s peace keeping troops. During the years 2005 and 2007, JAV operated programmed charter flights from King Hussein International Airport to destinations in the region like Kuwait, Doha, Alexandria, and Bahrain. JAV's charter routes now cover the Globe.

In 2006 JAV started leasing its aircraft to other Arab and foreign airlines on Dry Lease basis especially during the peak periods. On that same year JAV completed the IATA Operational Safety Audit (IOSA).

In June 2016, JAV operated some of flights to TOM airport and made a risk assessment on the hazard identified during the planning period before the commencement of the actual flights, the management of flight operations department found that TOM airport runway is of 30 meters width. Although B737 is certified to land on such runway width, however; the department released a document made by Boeing discussing the risk of narrow runway width operations and the related recommendations that reduce the risks associated.

Copy of Boeing document is attached to the Appendixes part of this report.

1.18 ADDITIONAL INFORMATION ABOUT THIS REPORT

None

1.19 USEFUL OR EFFECTIVE INVESTIGATION TECHNIQUES

None

3.1 ANALYSIS

2.1 GENERAL

The Investigation into this Incident collected data from various sources for the purpose of determining the causes and contributing factors.

This section of the Report explains the contribution of each investigation aspect to the occurrence and to the severity of the consequences. The analysis also contains safety issues that may not be contributory to the Incident but are significant in adversely affecting safety.

Nothing in this section is to be understood as asserting blame or liability.

2.2 FLIGHT DATA RECORDER ANALYSIS

2.2.1 APPROACH ANALYSIS

The FDR Analysis shows that the aircraft approach was unstable as the vertical speed and tail wind component were showing higher than normal readouts and this continued till the point of touchdown.

At 08:34:34 the autopilot was disengaged at an altitude of 2567 ft / 1636 ft AAL, while autothrottles were disengaged at 08:34:47 at an altitude of 2360 ft / 1432 ft AAL, and the descent rate of the aircraft was recording 1800 – 1900 ft/min.

At 08:35:03 the aircraft was at 1010 ft AAL, with landing gears extended and flaps set at 30 deg, engine thrust was at flight idle and recording 35% N1. The vertical acceleration was still above the normal recommended limit as it was recording 1790 ft/min with tail wind component of 16 kts

At 08:35:19 at a height of 507 ft AAL, the vertical speed was indicating 1540 ft/min with an indicated speed of 165 kts which is higher than the approach speed with 24 kts. The stabilized approach criteria give the pilot an acceptable deviation of 10 kts higher than the approach speed if the airspeed is trending towards the selected approach speed. The indicated tail wind component was showing a recorded value of 16 kts, which is 6 kts higher than the maximum operational limitation for this aircraft.

At 08:35:29 at a height of 250 ft AAL, the vertical speed of the aircraft went down, recording a value of 943 ft/min with consistent tailwind component of 16 kts, the indicated airspeed was 156 kts (15kts higher than selected approach speed) and the control column was pushed backwards resulting in 2.5 deg in pitch attitude.

At 08:35:40 the aircraft was at 104 ft AAL, the vertical speed was 727 ft/min and indicated airspeed maintained at 156 kts, with the wind still coming from the tail side with a magnitude of 16 kts. The engine thrust was increased to 72% N1and the control column was pushed forward to reduce the pitch to 1.4 deg.

Figure 8 shows the significant parameters of the flight approach phase.

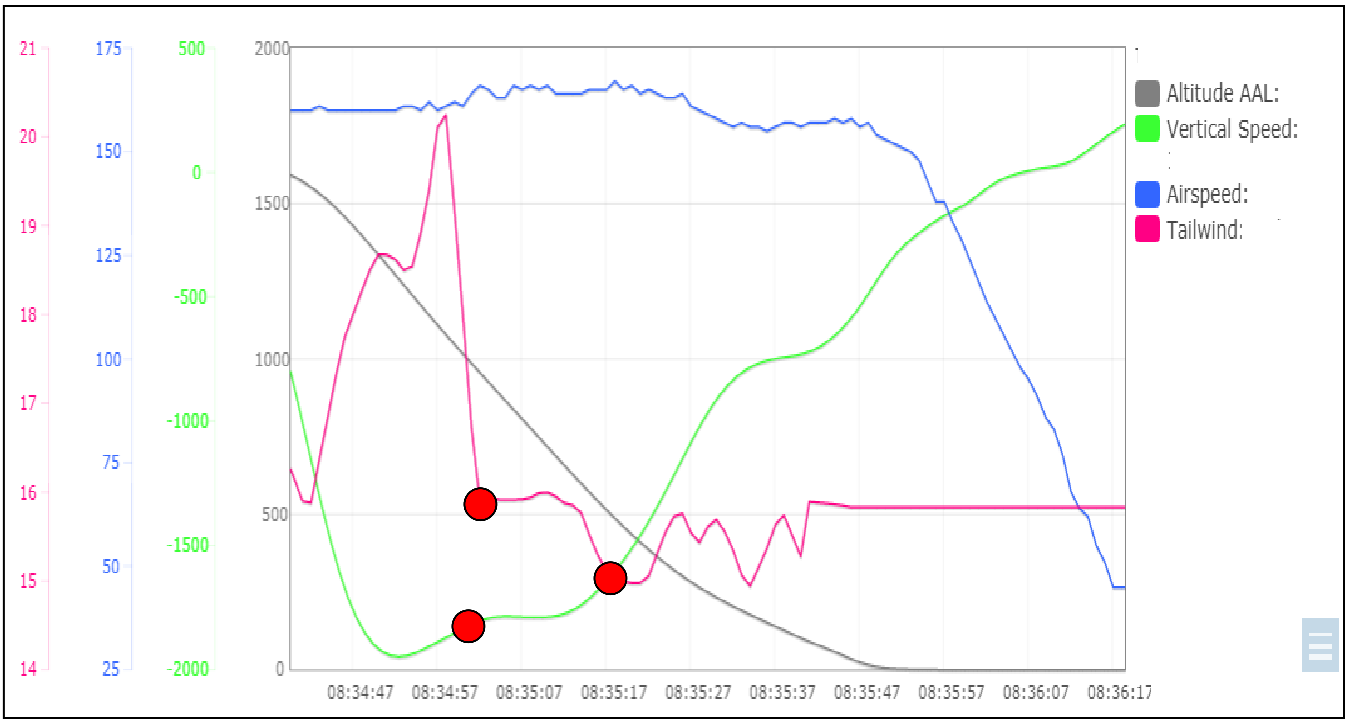


Figure 8

FDR Analysis – approach profile

Jordan aviation has a policy on unstabilized approaches that is based on internationally accepted standards and on the recommendations issued by Boeing, the manufacturer of the aircraft.

The flight safety office periodically informs crews on unstabilized approaches detected via reports and analysis generated as part of the FDM program. This is intended to promote awareness among crews and encourage them to discontinue landings (execute go around maneuvers) in such cases.

The stabilized approach criteria, as specified in B737 FCTM states the following:

Stabilized Approach Recommendations

Stabilized Approach Recommendations Maintaining a stable speed, descent rate, and vertical/lateral flight path in landing configuration is commonly referred to as the stabilized approach concept.

Any significant deviation from planned flight path, airspeed, or descent rate should be announced. The decision to execute a go-around is not an indication of poor performance.

Note: Do not attempt to land from an unstable approach.

Recommended Elements of a Stabilized Approach

The following recommendations are consistent with criteria developed by the Flight Safety Foundation.

All approaches should be stabilized by 1,000 feet AFE in instrument meteorological conditions (IMC) and by 500 feet AFE in visual meteorological conditions (VMC). An approach is considered stabilized when all of the following criteria are met:

- The airplane is on the correct flight path
- Only small changes in heading and pitch are required to maintain the correct flight path

• The airplane should be at approach speed. Deviations of +10 knots to – 5 knots are acceptable if the airspeed is trending toward approach speed

• The airplane is in the correct landing configuration

• sink rate is no greater than 1,000 fpm; if an approach requires a sink rate greater than 1,000 fpm, a special briefing should be conducted

• Thrust setting is appropriate for the airplane configuration

• All briefings and checklists have been conducted.

Specific types of approaches are stabilized if they also fulfill the following:

• ILS approaches should be flown within one dot of the glide slope and localizer, or within the expanded localizer scale (as installed)

Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilized approach require a special briefing.

Note: An approach that becomes unstabilized below 1,000 feet AFE in IMC or below 500 feet AFE in VMC requires an immediate go-around.

These conditions should be maintained throughout the rest of the approach for it to be considered a stabilized approach. If the above criteria cannot be established and maintained until approaching the flare, initiate a go-around.

At 100 feet HAT for all visual approaches, the airplane should be positioned so the flight deck is within, and tracking to remain within, the lateral confines of the runway edges extended.

As the airplane crosses the runway threshold it should be:

• stabilized on approach airspeed to within + 10 knots until arresting descent rate at flare

• On a stabilized flight path using normal maneuvering

• positioned to make a normal landing in the touchdown zone (the first 3,000 feet or first third of the runway, whichever is less).

Initiate a go-around if the above criteria cannot be maintained.

Maneuvering (including runway changes and circling)

When maneuvering below 500 feet, be cautious of the following:

• Descent rate change to acquire glide path

• Lateral displacement from the runway centerline

• Tailwind or crosswind components

• Runway length available.

In understanding why the flight crew continued the approach and did not consider a go-around, it is important to know that the captain of the flight had experienced some delays in Tombouctou airport in previous flights which according to his statement comes as a result of services non availability in that airport, so; his plan was to continue the approach without affecting the fuel quantity. According to his statement; asking for extra fuel would result in an extra ground time as they have to request that fuel from another air base near to TOM airport and this delay may extend to 2 hours. This would in turn affect the schedule, flight duty time and customer satisfaction.

Flight crews can be subject to a plan continuation bias. Without salient triggers, they will continue with their original plan (that is, to carry out the landing). In this occurrence and according to his understanding there was nothing particularly significant to cause the captain to re-evaluate the original plan of action. Therefore, the flight crew's recognition that the aircraft was unstable at that point during the approach would have been affected because of plan continuation bias and reliance on the captain skills to land the aircraft uneventfully

According to his statement, the First officer who was the pilot monitoring on the occurrence flight said that he did not show an assertive action when he realized that the approach was unstabilized because he had previous experience in which the captain of the occurrence flight continued an unstable approaches to landing and he added that in some cases when he was flying the aircraft in some of these flights the captain was taking the controls over whenever the approach was found unstable.

Some previous flights for the same pair of operating crew were examined and analyzed using the FDM system and revealed that the unstabilized approach policy of conducting a go-around when the approach became unstable was not sufficiently ingrained by them, however these unstabilized approaches continued uneventfully.

2.2.2 FLARE, TOUCHDOWN AND LANDING ROLL

At 08:35:45 the aircraft passed runway 07 threshold at 48 ft AAL, the speed was still higher than the recommended Vapp+10, the indicated airspeed was recording 157 kts and tailwind component was 16 kts with a ground speed of 182 kts. The pitch was recording 2.8 deg while the vertical speed was showing a value of 608 ft/min.

At 08:35:47 the aircraft was at 25 ft AAL and the pilot flying started the flare by pushing the control column to produce a 4.9 deg pitch angle, this slowed the rate of descent to 466 ft/min. the engine thrust was decreased by retarding the thrust levers to 35% N1. The flare continued for 7 seconds at which the vertical speed was bled off to 233 ft/min and the aircraft touched the ground at a distance of approximately 350 m from the runway threshold. However; the indicated airspeed was higher than the recommended approach speed at touchdown and with tailwind recording 16 kts.

At 08:35:53 the aircraft touched down the ground with an indicated airspeed of 148 kts and a ground speed of 173 kts this increase in ground speed is due to the tailwind factor that affected the aircraft during its approach and landing phases. The vertical speed at touchdown was bled off to 233 ft/min which is below the limit of hard landing (360 ft/min) and the gravitational vertical acceleration recorded a maximum value of 1.28 g, which indicates that the landing was not hard. The thrust reversers were deployed immediately at touchdown. The FDR data shows that the left engine thrust reverser lagged for 4 seconds from the right engine, resulting in a drift angle of 2 degrees to the right. At 08:35:56 the nose landing gear touched the ground and after 2 seconds at 08:53:58 the thrust reversers were set to maximum thrust with 95 – 97% N1untill the aircraft came to rest on the unpaved area at which they were stowed to close position.

The pilot flying applied a left brake pedal pressure in an attempt to maintain the aircraft in the center line and to compensate this 2 deg of drift. This left brake application lasted to 6 seconds after touchdown.

The brake pressure on the right side was evidenced 5 seconds after touchdown with a value reaching to 3400 PSI.

At 08:36:00 both brake pedals were released momentarily, the brake pedal release lasted to 2 seconds for left and 4 seconds for right brakes. The right brake pressure was not sufficient to provide proper braking performance in which it reached 2000 PSI.

At 08:36:10 both pedal were depressed to the maximum pressure and were showing a brake pressure of 3200 – 3300 PSI.

According to FCTM, the standard procedure to stop the aircraft using wheel brakes comes as following:

Use an appropriate autobrake setting or manually apply wheel brakes smoothly with steadily increasing pedal pressure as required for runway condition and runway length available. Maintain deceleration rate with constant or increasing brake pressure as required until stopped or desired taxi speed is reached. The crew did not follow the SOP during brake pedal depression.

The FCTM also provide precautionary notes concerning brake pumping and modulating, as following:

• do not attempt to modulate, pump or improve the braking by any other special techniques

• do not release the brake pedal pressure until the airplane speed has been reduced to a safe taxi speed

If the pilot modulates the brake pedals, the antiskid system is forced to readjust the brake pressure to establish optimum braking. During this readjustment time, braking efficiency is lost.

Figure 9 shows the brake pressure on both pedals

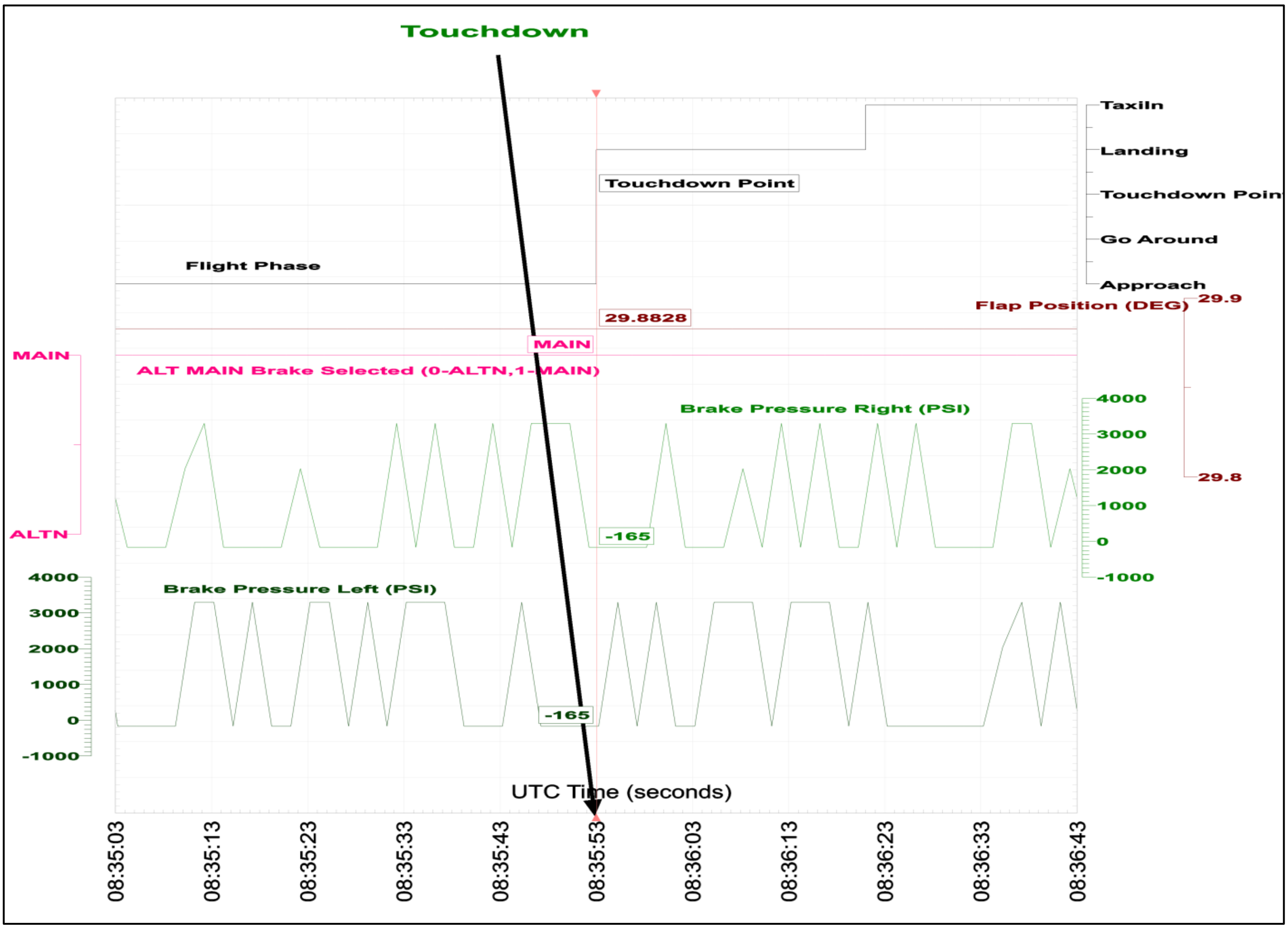


Figure 9

FDR Analysis – Brake Application at Landing Roll

At 08:36:19 the brake pedals were released again and the ground speed was showing 60 kts, the pilot flying turned the nose wheel steering toward the taxiway entrance which is perpendicular to the runway. The total distance travelled on the runway from the point of touchdown to the point at which the pilot flying used the hand wheel steering to turn the aircraft was 4860 ft (the remaining runway length is ((7118-1148) – (4860) = 1110 ft)).

According to the above performance calculation, it is believed that if the crew kept a continuous maximum brake pressure on the brake pedals, the aircraft would stop on the available remaining length of the runway. Baring in mind that the runway is provided with an extra 60 meters as a stopway at both ends of the runway.

The aircraft started to deviate from runway heading towards the taxiway 25 seconds after the landing gear contact with the runway surface.

Figure 10 shows the negative longitudinal acceleration (deceleration) attained as a result of the braking action as recorded by the FDR.

Figure 10

FDR Analysis – Deceleration during Landing

Experience and previous analysis of flight data shows that low braking action produce longitudinal acceleration values of up to 0.20 g, this brake performance is equivalent to autobrake 1 setting. Higher values between 0.20 g to 0.30 g indicate a medium braking performance equivalent to autobrake 2 or 3 setting. Values between 0.30 g to 0.35 g indicate a higher braking performance and this is equivalent to autobrake MAX setting. Values between 0.35 g to 0.40 g indicate a high braking force which is similar to maximum manual brake performance. Values higher than 0.4 g indicate a hard braking action that highly energetic and uncomfortable to passengers.

During the first 10 seconds of the landing run, while the aircraft forward speed was higher than normal due to the high rate of descent and tailwind component effect, the braking efficiency varied between low to medium. It then increased during the following seconds of the landing run reaching the highest value at the end of the run just before heading deviation.

The high brake energy released from the braking action resulted in tires prints on the runway just prior to aircraft turn towards the taxiway track. This is clearly identified in figure 11

Figure 11

Tires Foot Print on the Runway Just before Turning towards the Taxiway Track

2.3 CRM AND HUMAN FACTORS

2.3.1 THE LEADERSHIP OF THE CAPTAIN AND TEAM WORK

The interview held with the operating crew of the occurrence flight revealed that the captain who was pilot flying made every decision and at no time did he ask the F/O his opinion. He decided to continue the approach in spite it was unstable. He eventually decided to land the aircraft using the manual brakes not according to the SOPs and without an assessment to the landing runway. Finally he decided to vacate the runway at higher than allowable speed to the taxiway in spite of the F/O calls not to do that action.

2.3.2 THE F/O LACK OF ASSERTIVENESS

When the captain decided to continue the approach, The F/O did not exhibit the necessary assertiveness to check with the tower for an update to the weather report after he was aware of the deviation in tailwind values that were exceeding the limitations. The F/O lack of assertiveness was also evident in when he did not tell the captain that the rate of descent was going higher than the known stabilized approach limits. The F/O lack of assertiveness to tell the captain that he did not agree with what he was doing is undoubtedly a contributing factor to the development of the incident.

The investigation committee has concluded that this occurrence could have been avoided if it took place in a pressure free environment, in which the crew had several options available to correct the chain of events that resulted in this occurrence.

Available options were summarized in the following points:

OPT 1) The runway in use at the time of the incident was 07, landing on runway was an option available to the crew when they became aware that the tailwind along the approach track was higher than the operational limitation described in the aircraft manual. It was evident that there were no obstacles around the aerodrome that limit their decision to choose the other end of the runway.

OPT 2) Once lined up on the approach until the aircraft have reached to the height of 500 ft AAL, another option was available to carry out a go-around, in light of the worsening situation. The company procedures clearly state that the pilot monitoring must require a go-around if the approach is not stabilized. The approach was obviously unstable as evidenced by the flight data analysis and collected crew statements.

OPT 3) Another option was also available for the crew to avoid this final result if efficient braking techniques were used according to the standard operating procedures provided by the aircraft manufacturer by maintaining a continuous stand on pressure and by avoiding brake modulation. According to his understanding; the captain of the flight used to use manual braking action to reduce brakes and tires wear and deterioration.

OPT 4) It is also believed that if CRM aspects learnt in classes were exercised in the cockpit during the flight, the decision to go for any of the above mentioned options would be more likely to occur and achievable.

3.1 CONCLUSIONS

3.1 FINDINGS

During the course of investigation it was found that:

1. the aircraft was certified, equipped and maintained in accordance with existing civil aviation regulations and procedures.
2. The aircraft had a valid certificate of airworthiness (CoA) and had been maintained in compliance with the regulations.
3. The aircraft was airworthy when dispatched for the flight.
4. The mass and center of gravity of the aircraft were within the prescribed limits.
5. There was no evidence of any defect or malfunction in the aircraft that could have contributed to the incident.
6. both flight crew were licensed and qualified for the flight in accordance with existing civil aviation regulations.
7. Both flight crew were medically fit and adequately rested to operate the flight.
8. Both flight crew were in compliance with flight and duty regulations
9. Tombouctou airport is facilitated with RNAV GNSS approach facilities.
10. the crew options was limited to visual approach as the aircraft is not equipped with RNAV GNSS utility

11. Tombouctou has a narrow width runway which was assessed for a previous operation and the safety controls and procedures were distributed to the crew flying to TOM airport in pilot briefing file.
12. The occurrence flight crew did not review the controls developed in the assessment.
13. The wind conditions in which the pilot landed the aircraft were outside the limits detailed in the flight manual and operations procedures.
14. the indicated airspeed at touchdown was higher than the recommended approach speed and with tailwind recording 16 kts.
15. Braking performance analysis and pilot techniques used to restrain the aircraft after touchdown indicated that the conditions existing at the time of the incident, the aircraft could not have stopped on the available runway distance. however; this occurrence could have been avoided if standard operating procedures and techniques were adhered to.
16. Post incident brake examination revealed that no significant findings in which contradicts any brake failure or performance degradation due to technical status scenario.
17. The continuation of the landing with the airspeed above the threshold speed resulted in high energy at touchdown that result in control difficulties to the pilot to restrain the aircraft.
18. Both pilots did not consider a go around even after realizing the prevailing condition of an unstabilized approach.
19. Captain of the incident flight did not consider a go around because of operational delays that may result from logistics issues as he had previously encountered in this specific airport.
20. The aircraft was equipped with a flight data recorder and a cockpit voice recorder.
21. The CVR records were found erased.
22. CVR erasure responsibility was not identified either as intentional or unintentional.
23. The erasure of a CVR recording covering the period of the incident prevented some details of the event from being confirmed and assured, however the investigation committee was able to address human contributing factors that affected the performance of flight crew and their actions degradation.
24. No hard landing was evidenced at touchdown
25. The pilot flying did not follow the SOP during brake pedal depression, he eventually decided to land the aircraft using the manual brakes not according to the SOPs and without an assessment to the landing runway.
26. The pilot monitoring did not exhibit the necessary assertiveness after he was aware of the deviation in tailwind values that were exceeding the limitations.
27. The pilot monitoring lack of assertiveness was also evident in when he did not tell the pilot flying that the rate of descent was going higher than the known stabilized approach limits.

3.2 CAUSES AND/OR CONTRIBUTING FACTORS

The cause of the occurrence was a high energy unstabilized approach followed by a landing with an excessive speed with higher than operational limit tailwind component, in addition to non-efficient usage of the wheel brakes.

A contributing factor to the incident was a combination of deficiencies involving aspects of crew resource management and human factors in which involved the captain leadership, team work and F/O assertiveness.

3.3 RECOMMENDATIONS

REC 1) It is recommended that Jordan Aviation's Training and Flight Operations departments review and enhance the CRM training of the crew to raise their awareness of the importance of CRM skills.

REC 2) It is recommended that Jordan Aviation's flight operations department increase its monitoring and evaluation of crews abilities in flight through conducting more frequent enroute inspections and incorporating the human based behavior, CRM and Human Factors findings to the inspection report then forwarding this information to training department.

REC 3) It is recommended that Jordan Aviation's flight operations department stress the applicability of unstabilized approach policy, and in particular, the requirement to go around when the approach does not meet the stability criteria.

REC 4) It is recommended that Jordan Aviation stress on the importance of preserving flight data after occurrences and to set a procedure for consulting the management of the company whenever an occurrence take place to confirm the requirement for this data. This procedure is recommended to include administrative guidance to technical staff who may be requested to follow the data preservation and protection procedures to register their actions in the technical log and to sign against these actions.

REC 5) It is recommended that Jordan Aviation and all Jordanian operators emphasize on stabilized approach criterion and to monitor the available flight data to ensure crew compliance to such procedures.

REC 6) It is recommended that Jordan Aviation and all Jordanian operators conduct safety risk assessments of their operations specially in airports that have frequent unstabilized trends that may be extracted from flight data monitoring systems.

3.1 APPENDIXES

4.1 JAV TECHNIC WHEELS AND BRAKES SHOP INSPECTION RESULTS

JAV TECHNIC

Ref.: JAV TECHNIC/17/012
Date: 01st Jun 2017

From: JAV TECHNIC Wheels and Brakes Shop.
To: Jordan aviation Airline CAMO Manager.

Subject: Aircraft Registered Number JY-JAP Brakes involved in occurrence inspection.

JAV TECHNIC'S wheels and Brakes Shop components certifying staff assigned to perform complete inspection as per Components CMM 32-40-30 Revision 12 and found the following Brakes are serviceable without any defects:

Brake PN.2-1474-7 SN.0943 wear indicator pin measured found 15mm.
Brake PN.2-1474-7 SN.5489 wear indicator pin measured found 16mm.
Brake PN.2-1474-7 SN.3322 wear indicator pin measured found 10mm.
Brake PN.2-1474-7 SN.3762P wear indicator pin measured found 10mm.

Passed for your information please

Workshops Manager
Engineer Ahmad Shawesh

Head of Maintenance
Eng. M. Abdullah

CC
AM
QM
SMSM

Building 31 | Queen Alia International Airport | PO Box 39144 | AMMAN 11104 | Jordan

4.2 THE BOEING GUIDELINES FOR NARROW RUNWAY OPERATIONS

The document is available at the following hyperlinked web address,

http://skybrary.aero/bookshelf/books/3566.pdf