FINAL REPORT

REPORT ON THE INCIDENT TO BOEING 737-400, 9M-MQK AT CHANGI AIRPORT, SINGAPORE ON 6 OCTOBER 2003

AIB/AAI/CAS.015

Ministry of Transport
Singapore

26 April 2005

The Air Accident Investigation Bureau of Singapore

The Air Accident Investigation Bureau (AAIB) is the investigation authority in Singapore responsible to the Ministry of Transport for the investigation of air accidents and serious incidents to Singapore and foreign civil aircraft in Singapore. The AAIB also participates in overseas investigations of accidents and serious incidents involving Singapore aircraft or aircraft operated by a Singapore air operator.

The mission of the AAIB is to promote aviation safety through the conduct of independent and objective investigations into air accidents and incidents consistent with Annex 13 to the Convention on International Civil Aviation.

The AAIB conducts the investigations in accordance with the Singapore Air Navigation (Investigation of Accidents and Incidents) Order 2003 and Annex 13 to the Convention on International Civil Aviation, which governs how member States of the International Civil Aviation Organization (ICAO) conduct aircraft accident investigations internationally.

The investigation process involves the gathering, recording and analysis of all available information on the accidents and incidents; determination of the causes and/or contributing factors; identification of safety issues; issuance of safety recommendations to address these safety issues; and completion of the investigation report.

In carrying out the investigations, the AAIB will adhere to ICAO's stated objective, which is as follows:

"The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability."

CONTENTS

GLOSSARY OF ABBREVIATIONS

ATC	Air Traffic Control
ATIS	Aerodrome Terminal Information Service
CAS	Calibrated Air Speed
CRM	Crew Resource Management
IAS	Indicated Airspeed
ILS	Instrument Landing System
knot	A speed of 1 nautical mile per hour
ICAO	International Civil Aviation Organisation
PF	Pilot Flying
PIC	Pilot-in-Command
PNF	Pilot Not Flying
psi	pounds per square inch
SARP	Standard and Recommended Practices
SOP	standard operating procedures
UTC	Coordinated Universal Time
VFR	Visual Flight Rules
Vref	Minimum speed based on a percentage of the stall speed of aircraft

BOEING 737-400, 9M-MQK

Classification	: Serious incident
Aircraft Type	: Boeing 737-400
Aircraft Serial Number	: 27384
Registration	: 9M-MQK
Number and Type of Engines	: 2 CFM56
Place	: Singapore Changi Airport
Date & Time (Local Time)	: 6 October 2003 at 12.09 pm
Type of Flight	: Public Transport (Passenger)
Persons on Board	: 152 (145 passengers and 7 crew members)
Point of Departure	: Kuala Lumpur, Malaysia
Destination	: Singapore Changi Airport

SYNOPSIS

After a normal flight from Kuala Lumpur, a B737-400 aircraft landed on Runway 20R at the Singapore Changi Airport at about 1158 hours. The flight was cleared to exit the runway via Taxiway W9. However, the aircraft was not slowed down enough to enable a turn into Taxiway W9. Hence an attempt was made to exit at Taxiway W10 which was adjacent to Taxiway W9. The aircraft departed the paved surface at the intersection of Taxiway W10 and the runway and came to a stop in the soft ground, about 8 metres from the edge of Taxiway W10 and 50 metres from the runway.

All the 145 passengers and seven crew members evacuated through the left hand forward door using a mobile step. None of the persons on board was injured.

The starboard engine of the aircraft ingested some mud and grass while the outboard tyre of the left hand main landing gear had a deep gouge. Some first stage rotor blades of the right hand engine suffered tears.

1. FACTUAL INFORMATION

All times used in this report are Singapore times. Singapore time is eight hours ahead of UTC.

1.1 History of Flight

1.1.1 A Boeing 737-400 aircraft was operated on a scheduled passenger flight from Kuala Lumpur (KUL), Malaysia to Singapore (SIN). The captain was the pilot flying (PF) the KUL-SIN sector and the first officer was the pilot not flying (PNF). The flight was normal until the landing.

1.1.2 The runway in use was Runway 20R for arrivals. Runway 20R is 4000 m in length and has a displaced threshold of 740 m. The landing distance available is 3260 m with a stop way of 60 m at the end.

1.1.3 The crew were aware of the displaced landing threshold and the landing distance available on Runway 20R. The captain and co-pilot operated regularly to Singapore Changi Airport.

1.1.4 The flight was cleared by the Singapore ATC to land on Runway 20R and the crew were informed that they may exit by Taxiway W9 which was the last operational taxiway at the end of the runway. Taxiway W9 is perpendicular to the runway and is not a high-speed exit taxiway. The ATC also informed MH601 that the runway was wet. This was acknowledged by the crew.

1.1.5 During the descent and approach phases, the PF armed the autobrakes[1] system at setting 1 because he had planned to exit the runway via Taxiway W6, a high-speed exit taxiway. However, prior to touching down the PF disarmed the autobrakes with the intention of using manual braking, as he had decided to roll to the end of the runway and exit via Taxiway W9 instead. The PF said that the company permits its pilots discretionary use of the autobrakes for landing.

1.1.6 According to both flight crew members, the approach was stable. The localiser and glide slope indicators on the Instrument Landing System (ILS) were centred and the ILS correctly identified. Both crew members said that the wind was light and variable, the visibility was good and there was no rain at the time of landing. All call-outs required by the company were made by the PNF during the final approach phase.

1.1.7 Both pilots said the touchdown was normal. The company manual requires the crew to verify the automatic deployment of the speedbrakes. The PNF had called out to the PF, regarding the speedbrakes, the PF then extended them manually immediately after touchdown.

[1] The aircraft is equipped with an autobrake system designed to optimise braking performance and reduce tyre wear. There are five positions, namely Selections 1 to MAX and RTO (Rejected Take Off), on the autobrake system that provide different deceleration rates. RTO is only used during the take off roll. Selection 1 provides the least hydraulic pressure on the brake units giving the lowest deceleration to the aircraft while MAX provides the maximum hydraulic pressure. Manual input of the brake pedal will cancel the autobrake system automatically.

1.1.8 During the landing roll, the PF decided not to deploy the thrust reversers. He also retracted the speedbrakes to adjust the deceleration of the aircraft. When asked if he often retracted speedbrakes during the landing roll, he confirmed that given the long runways at the Kuala Lumpur International Airport and whenever he had to 'roll to the end' he often retracted the speedbrakes.

1.1.9 Both pilots said that they could not recall noticing the runway markers or any centreline lights as they were approaching the end of the runway. According to the pilots, at about 80 to 90 knots the PF applied maximum braking and also selected full reverse thrust. When he noticed the braking was not effective, he tried to steer the aircraft onto Taxiway W10, which was not operational, to stay on the paved surface.

1.1.10 One of the duties of the PNF, as stated in the companies' Operations Manual, is to draw the PF's attention to any particular factor that may have been overlooked. The PNF had made the required call-outs during the final approach to Runway 20R. However, when the aircraft was rolling on the runway, he did not alert the PF of their high speed and they were nearing the end of the runway. The PNF said that at about 80 knots when he realised that the aircraft might not be able to stop on the runway, he assisted the PF by applying brakes as well, but to no avail.

1.1.11 The PNF said that their speed was about 60 knots when the aircraft departed the paved surface at the intersection of Runway 20R and Taxiway W10 and came to a stop on the grass verge about 50 m from the runway and about 8 m from the edge of the closed Taxiway W10 (See Appendix 1). The nose gear became ensnared with airfield lighting cables that were temporarily laid on the grass verge.

1.1.12 There were very faint tyre marks on two of the Runway Threshold markings. However, there were no tyre marks on the runway between the Threshold markings and the grass verge to suggest skidding.

1.1.13 After the aircraft had come to a stop, the engines were shut down. The PF informed ATC and asked whether there was any sign of fire on the aircraft. The ATC replied that no signs of fire were observed.

1.1.14 The Airport Emergency Service personnel arrived at the scene shortly after the aircraft had come to a stop and confirmed that there was no fire present. The passengers were evacuated through the forward left hand door using a mobile step.

1.1.15 There were no injuries to passengers, crew or people on the ground.

1.1.16 The flight data recorder (FDR) data indicated that the speedbrakes had been deployed for about 15 seconds after touchdown before they were retracted.

1.1.17 Approximately eighteen seconds after the speedbrakes were retracted, brake application was initiated.

1.1.18 The thrust reversers were deployed when the aircraft was estimated to be abeam of Taxiway W8. (Full reverse thrust appears to have been achieved 12 seconds after deployment due to engine spool up time.)

1.2 Injuries to persons

Nil

1.3 Damage to aircraft

1.3.1 The outboard wheel on the left hand main landing gear suffered a gouge while the right hand engine suffered some first stage rotor blade tears due to ingestion of mud and grass. (See Appendix 2)

1.4 Other damage

1.4.1 There was no damage to the surface of the runway. One taxiway edge light, one runway guard light, one taxiway guidance sign and a microwave barrier detector at the intersection of Taxiway W10 and the runway were broken. Forty temporary airfield lighting cables that were ensnared with the nose gear had to be cut to facilitate aircraft recovery. Thirty of the cables were later spliced while the remaining ten had to be replaced.

1.5 Personnel information

1.5.1 Pilot-in-command

Age	: 33 years (Male)
Licence	: Airline Transport Pilot's issued by the Department of Civil Aviation, Malaysia.
Aircraft rating	: B737-400
Licence expiry date	: 28 February 2004
Total flying experience	: 6,500 hours
Flying experience on type	: 3,100 hours (2,300 hours as commander)
Last Base Check date	: 22 June 2003
Last Instrument rating date	: 22 June 2003
Last medical check	: 20 February 2003
Medical certificate expiry	: 28 February 2004
SEP expiry	: 21 November 2003

1.5.2 Co-pilot

Age	: 24 years (Male)
Licence	: Airline Transport Pilot's Licence issued by the Department of Civil Aviation, Malaysia.
Aircraft rating	: B737-400
Licence expiry date	: 31 January 2004
Total flying experience	: 3,000 hours
Flying experience on type	: 1,500 hours
Last base check date	: 16 August 2003
Last instrument rating date	: 16 August 2003
Last medical check	: 27 January 2003
Medical certificate expiry	: 31 January 2004
SEP expiry	: 11 September 2004

1.6 **Aircraft information**

1.6.1 Airworthiness of Aircraft

1.6.1.1 The aircraft was serviceable and had a valid Certificate of Airworthiness.

1.6.1.2 There were no recent records of problems in the following systems:

-The engine thrust reversers
-The automatic braking system
-The speedbrake control system
-The anti-skid system

1.6.2 Weight and balance

1.6.2.1 The baggage and cargoes were weighed following the incident. They were found to be correctly loaded and the weight and balance of the aircraft was found to be within the limits laid out in the aircraft flight manual.

1.6.3 Aircraft Landing Performance

1.6.3.1 The landing weight of the aircraft was about 52,000 kg.

1.6.3.2 According to the Boeing "Landing Field Length Chart" (Appendix 3) the minimum landing distance required for the above landing weight was approximately 1,876 m (6,153 ft[2]) for a wet runway when using manual speedbrakes and Flaps 30º. The landing distance available was 3260 m (10,695 ft).

[2] 4800 ft is the Landing Field Length required for a dry runway. An additional 550 ft is needed for manual speedbrake deployment followed by a 15% increase in the distance for wet runway conditions.

1.7 Meteorological information

1.7.1 At the time of the incident, the weather condition was overcast with light and variable surface wind, predominantly westerly at less than 5 kts. The visibility was good. There was no rain.

1.7.2 At about 10 minutes before the incident, the weather was reported as follows:

Runway surface wet
Rain over airfield
Wind calm visibility 10 km
Light rain
Few clouds at 1000 ft
Temp 27 º
Dew point 26 º
QNH 1011
NOSIG (no significant weather)

1.8 Aids to navigation

1.8.1 All navigational aids and runway lighting systems at Singapore Changi Airport required for IFR operations were operating normally at the time of the incident.

1.9 Flight recorders

1.9.1 The aircraft was equipped with a solid state flight data recorder (part number 980- 4700-001; serial number 0459). The recorder was removed intact for reading out.

1.9.2 A Honeywell solid state memory cockpit voice recorder (part number: 980-6020-001 and serial number 0509), with a duration of 30 minutes, was installed on the aircraft. The recorder was removed intact from the aircraft. The outputs of the microphones of the PIC, co-pilot, observer and the cockpit area were recorded on four separate tracks. The recording which lasted 30 minutes was read out satisfactorily. However, the portion covering the touchdown and landing roll was over-written.

1.10 Communications

1.10.1 There were no ATC communication problems reported by the MH601 crew or the Singapore ATC.

1.11 Aerodrome information

1.11.1 Singapore Changi Airport has two parallel runways, Runway 02L/20R and Runway 02R/20L. At the time of the incident, Runway 20R was designated the landing runway which MH 601 used.

1.11.2 Runway 20R is 4,000 m (13,123 ft) long and 60 m (197 ft) wide. There is a stopway of 60 m (197 ft) at the end of the runway. With a displaced threshold of 740 m (2,428 ft), the runway has a declared "Landing Distance Available" (LDA) of 3,260 m (10,695 ft) and a distance of 2,930 m (9,600 ft) from the glideslope touchdown point to the end of the runway. The runway was marked with distance markers, etc in accordance with ICAO Annex 14 Part 1.

1.11.3 The runway surface was wet[3] at the time when MH 601 landed.

1.11.4 A runway surface friction test was carried out on 7 October 2003 (the following day). The mean friction value was 0.6, which was above the maintenance friction level of 0.47 recommended in Attachment A to Volume 1 of Annex 14 to the Chicago Convention, a level below which corrective maintenance action will have to be initiated.

1.11.5 At the time of the incident, Taxiway W10 was closed to facilitate the construction of Taxiway South Cross 2.

1.12 Wreckage and impact information

1.12.1 Not Applicable

1.13 Medical and pathological information

1.13.1 The flight crew were sent for medical examination immediately after the incident. The medical reports indicated there was no evidence of any use of alcohol or toxicological substances by the crew.

1.14 Fire

1.14.1 There was no fire.

1.15 Survival aspects

1.15.1 This was a survivable incident. There was no fire and the aircraft fuselage was intact. All the passengers evacuated in an orderly manner from the front door on the left side of the aircraft using a mobile step.

1.15.2 The Airport Emergency Services arrived at the crash site shortly after the aircraft came to a stop.

[3] According to Singapore AIP AD 1.1-4 Section 6.3, a "wet runway" is a runway where, the surface is soaked but no significant patches of water are visible.

1.16 Tests and research

1.16.1 The following systems were tested after the incident and were found to be operating satisfactorily:

- No.1 and No.2 engine thrust reversers systems
-Automatic braking system
-Speedbrake control system
-Anti-skid system

1.17 Organisational and management information

1.17.1 Malaysia Airlines is an airline based in Kuala Lumpur, Malaysia. Malaysia Airlines operates regular flights to Singapore using B737-400 aircraft.

1.18 Additional information

1.18.1 Section 4.13 'LANDING' of the Flight Operations Policy Manual stated the following:

Landing Roll Reverse Thrust and Braking

All automatic stopping devices/systems will be armed for touchdown and used as standard procedure for landings.

At locations where noise considerations are paramount, reverse thrust may be left at the reverse idle position from touchdown provided the required Performance Manual landing field length increment has been considered and other stopping devices are serviceable. Commanders should utilise the full runway length for lower resultant brake temperatures.

1.19 Useful or effective investigation techniques

1.19.1 Nil

2 ANALYSIS

The analysis by the investigation team covered the following areas:

- Standard operating procedures
- Crew situational awareness
- Crew landing roll technique
- Crew coordination

2.1 Standard operating procedures

2.1.1 All relevant company documentation and manuals do not contradict the requirement as stated in Section 4.13 of the Flight Operations Policy Manual (See 1.18.1). The PF has no discretion in the arming and use of the stopping devices/systems as they are mandated for all landings. The PF can only choose the amount to use, for the stopping devices/systems, based on the expected type of landing, such as airports with noise considerations and brake life improvement techniques, to ensure a safe landing rollout. However, both pilots stated it was not mandatory to arm the autobrakes system for landing. The decision to cancel or not use the stopping devices/systems meant the following were not used to slow down the aircraft:

a) The autobrakes system
b) The thrust reversers system
c) The speedbrake[4] system

2.2 Crew situational awareness

2.2.1 The air traffic controller alerted the crew about the wet runway when the aircraft was cleared to land. When landing on a wet runway it is prudent to use all automatic stopping devices. The crew should have considered the fact that braking action is reduced on a wet runway due to the reduced coefficient of friction.

2.2.2 The crew did not adequately monitor the deceleration during the landing roll and were not situationally aware of the runway remaining. Both pilots said that they could not recall noticing the runway markers or any centreline lights as they were approaching the end of the runway. Corrective actions such as brake application and thrust reverser deployment were not carried out early to slow the aircraft down.

[4] Although speedbrakes are not specifically mentioned in Section 4.13 they assist in slowing the aircraft by reducing the lift over the wing and increasing the braking effectiveness by means of increasing the normal (vertical) force on the landing gear.

2.3 Crew landing roll technique

2.3.1 On touchdown the speedbrakes were retracted manually by the PF after about 15 seconds to adjust the aircraft deceleration. The braking force available from the tyres is proportional to the force on the tyres perpendicular to the runway and the coefficient of friction between the tyres and runway. The perpendicular force comes from the aircraft weight and any downward aerodynamic force. If the speedbrakes are not raised after touchdown, braking effectiveness is reduced since there will be reduced weight on the aircraft wheels.

2.3.2 The pilots did not slow the aircraft down to a speed safe for a 90-degree turn onto Taxiway W9. In order to remain on the paved surface the PF attempted to turn the aircraft on to Taxiway W10. However, due to the speed of the aircraft and the wet runway, the turn could not be achieved and the aircraft departed the paved surface at the intersection of Taxiway W10.

2.4 Crew coordination

2.4.1 An opportunity that could have prevented the incident happening was lost when the PNF did not call out to alert the PF of the excessive speed as the aircraft approached the end of the runway.

3 CONCLUSION

3.1 Findings

3.1.1 Aircraft

3.1.1.1 The aircraft had a valid certificate of airworthiness and there was no evidence of any maintenance problems related to the incident.

3.1.1.2 The aircraft's weight and balance was within the normal operating limits at the time of the incident.

3.1.2 Flight crew

3.1.2.1 The flight crew were properly licensed to undertake the flight.

3.2 Cause

3.2.1 The crew did not apply full braking and reverse thrust early enough to decelerate the aircraft sufficiently for a turn onto Taxiway W9.

3.3 Significant Factors

3.3.1 The company's B737-400 Flight Operations Policy Manual procedures were not adhered to regarding the mandated use of stopping devices/systems for all landings.

3.3.2 There was a lack of situational awareness on the part of the crew as the aircraft rolled down the runway.

3.3.3 "Crew Awareness Call-outs" to draw the PF's attention to the excessive speed were not performed during the landing roll to prompt the application of brakes.

4 SAFETY RECOMMENDATIONS

4.1 It is recommended that the airline should remind its pilots that:

a) They must adhere to standard operating procedures to use all automatic stopping devices/systems to slow the aircraft down early.
(AAIB Recommendation R-2005-005)

b) They should, where a long roll out is attempted, be alert to ensure that they are aware of their position on the runway at all times.
(AAIB Recommendation R-2005-006)

c) The PNF should alert the PF of any imminent dangerous situation.
(AAIB Recommendation R-2005-007)

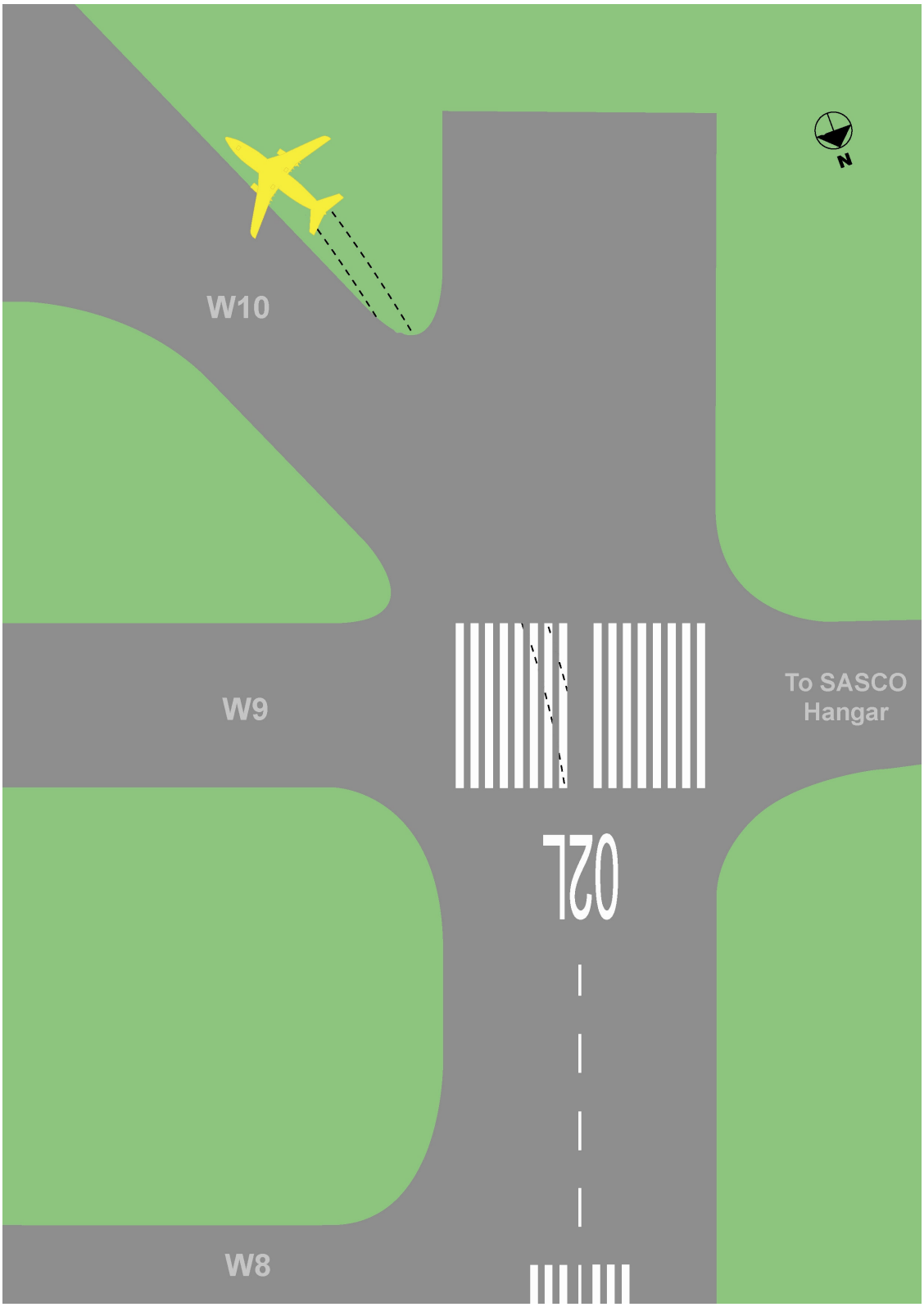
5 APPENDICES

1 Chart showing the final position of aircraft

2 Photographs showing the aircraft position and the damage

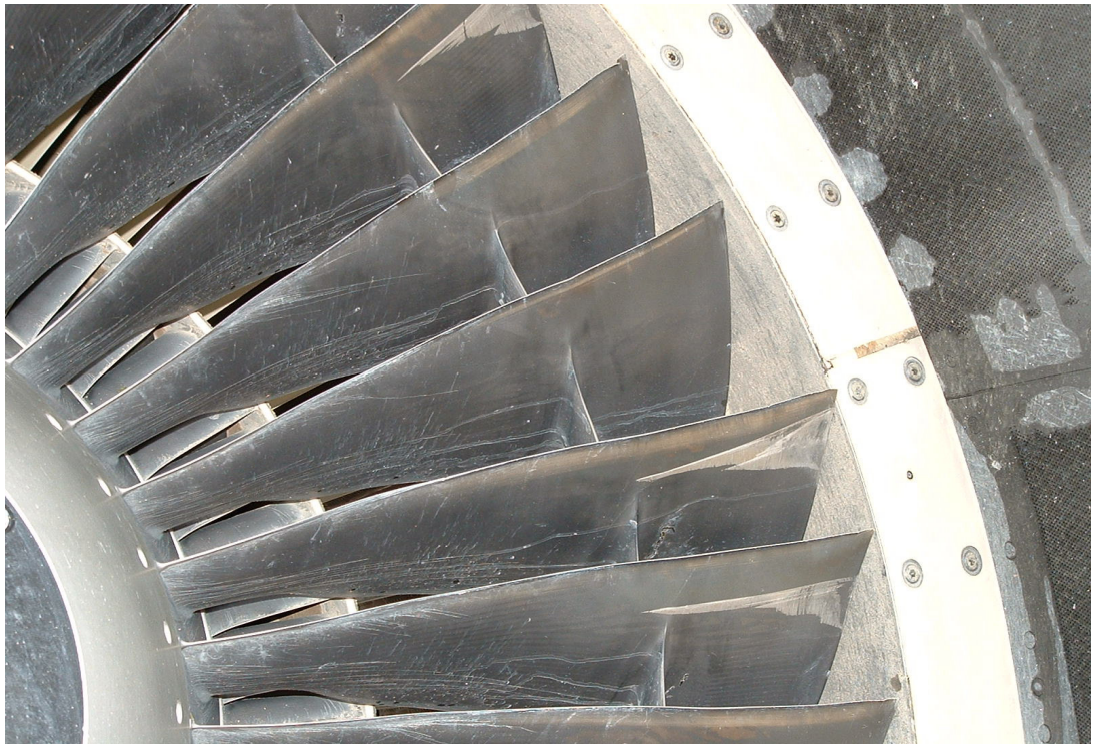
3 Boeing Landing Field Length Chart

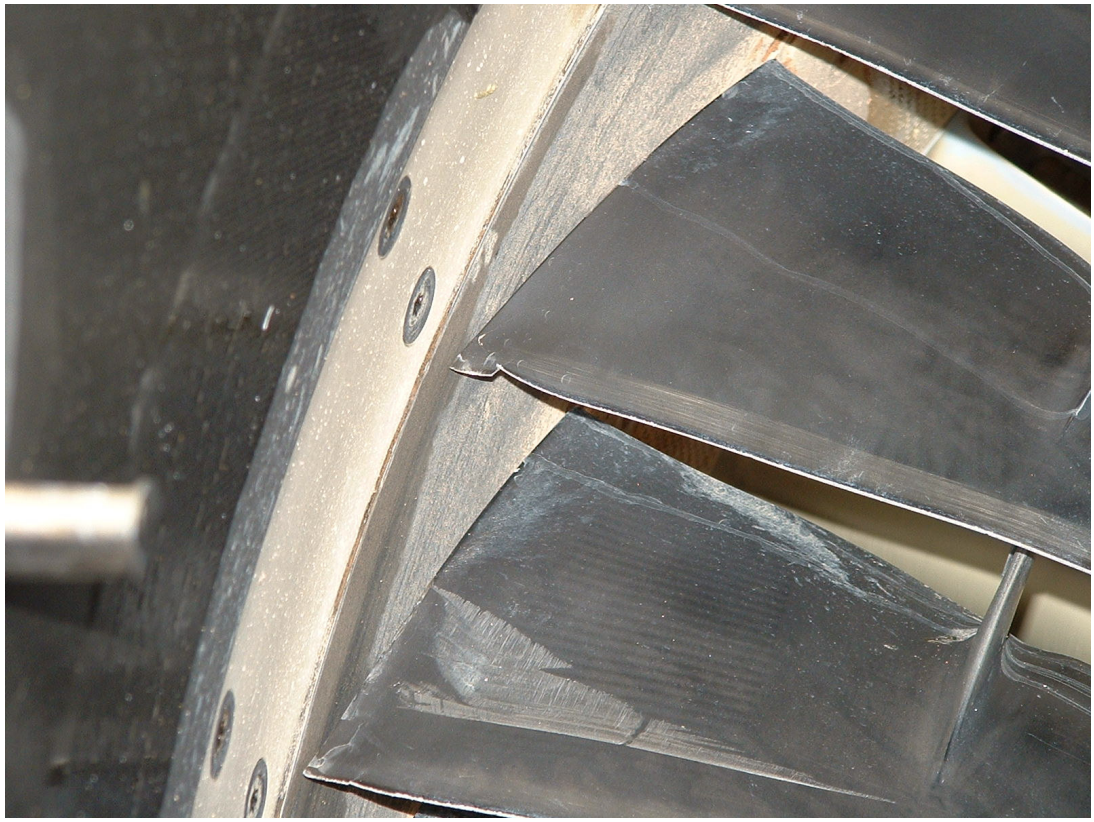
APPENDIX 1



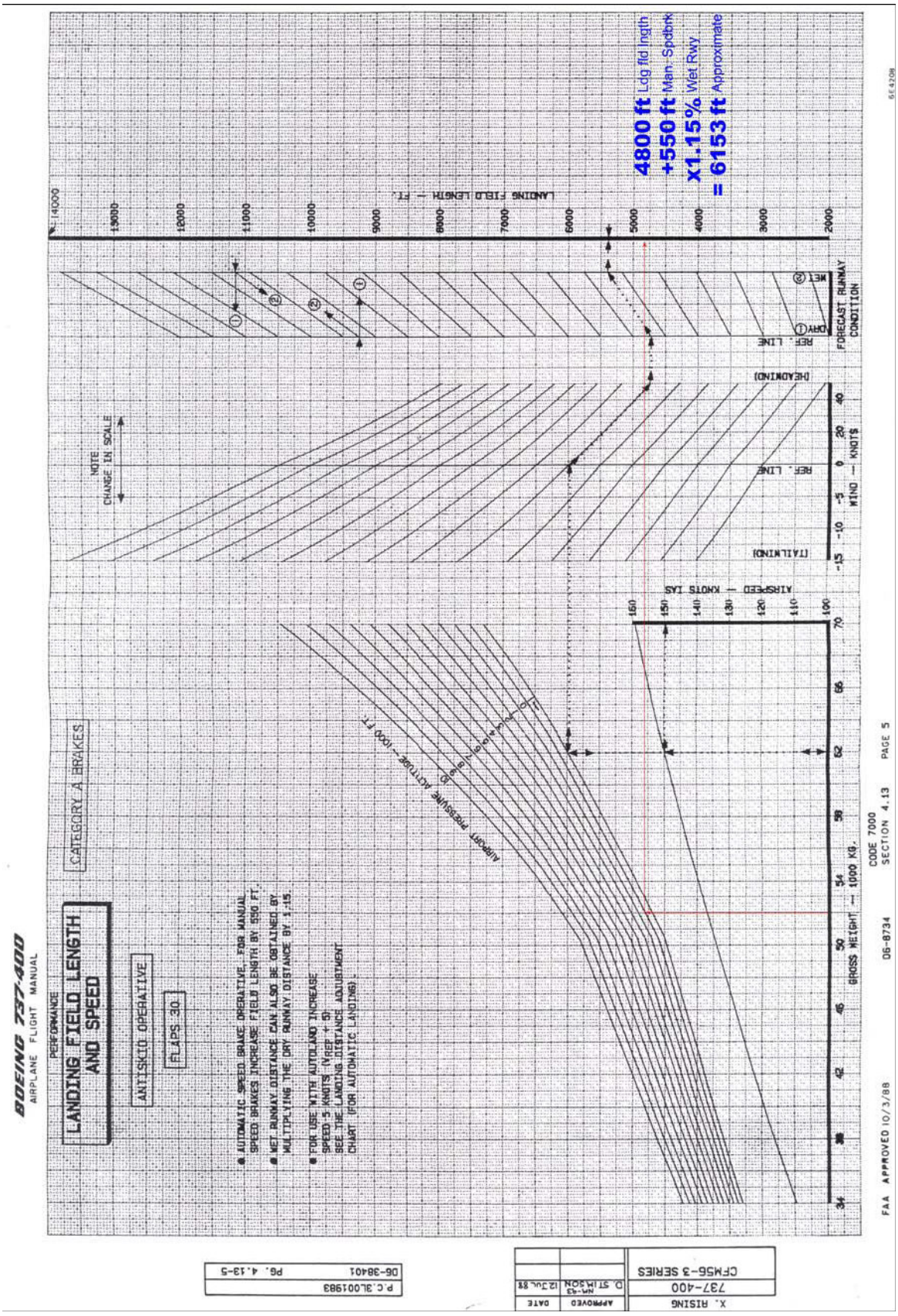
APPENDIX 2


6 10 2003





APPENDIX 3


4800 ft Ldg fld ingth
+550 ft Man. Sbdnk
X1.15% Wet Rwy
= 6153 ft Approximate
BOEING 737-400
AIRPLANE FLIGHT MANUAL
PERFORMANCE
LANDING FIELD LENGTH AND SPEED
CATEGORY A BRAKES
ANTISKID OPERATIVE
FLAPS 30
AUTOMATIC SPEED BRAKE OPERATIVE: FOR MANUAL SPEED BRAKES INCREASE FIELD LENGTH BY 550 FT.
WET RUNWAY DISTANCE CAN ALSO BE OBTAINED BY MULTIPLYING THE DRY RUNWAY DISTANCE BY 1.15.
FOR USE WITH AUTOLAND INCREASE SPEED 5 KNOTS (VREF + 5). SEE THE LANDING DISTANCE ADJUSTMENT CHART (FOR AUTOMATIC LANDING).
NOTE CHANGE IN SCALE
LANDING FIELD LENGTH — FT.
AIRSPEED — KNOTS IAS
GROSS WEIGHT — 1000 KG.
WIND — KNOTS
HEADWIND
TAILWIND
REF. LINE
FORECAST RUNWAY CONDITION
DRY
WET
AIRPORT PRESSURE ALTITUDE — 1000 FT.
FAA APPROVED 10/3/88
06-8734
CODE 7000
SECTION 4.13
PAGE 5
CFM56-3 SERIES
737-400
X. RISING
APPROVED
DATE
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