# AIRCRAFT SERIOUS INCIDENT

# FINAL REPORT

# SI 05/20

## Air Accident Investigation Bureau (AAIB)

## Ministry of Transport Malaysia

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**Serious Incident Involving Fixed Wing Aircraft**

**Twin Otter DHC6-400, Registration 9M-SSC**

**at Long Seridan, Sarawak**

**on the 9 May 2020**

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Issued on 10 May 2021
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# AIR ACCIDENT INVESTIGATION BUREAU (AAIB)
# MALAYSIA

**REPORT NO.: SI 05/20**

| | | |
|---|---|---|
| **OPERATOR** | **:** | **MASWINGS** |
| **AIRCRAFT TYPE** | **:** | **TWIN OTTER DHC6-400** |
| **NATIONALITY** | **:** | **MALAYSIA** |
| **REGISTRATION** | **:** | **9M-SSC** |
| **PLACE OF OCCURRENCE** | **:** | **LONG SERIDAN, SARAWAK** |
| **DATE AND TIME** | **:** | **9 MAY 2020 AT 1005LT** |

The sole objective of the investigation is the prevention of accidents and incidents. In accordance with Annex 13 to the Convention on International Civil Aviation, it is not the purpose of this investigation to apportion blame or liability.

All times in this report are Local Time (LT) unless stated otherwise. LT is UTC +8 hours.

## ACKNOWLEDGMENT

AAIB would like to acknowledge the site investigation research work conducted by the Civil Engineering and Mechanical Engineering Department, Faculty of Engineering, UPNM for their valuable research contribution to this aircraft incident investigation.

The research data and analysis had provided conclusive evidence that hydroplaning had occurred which caused the aircraft to skid off the runway. The research work had also provided evidence that major rehabilitation work needs to be carried out by the aerodrome operator to improve the runway pavement condition at Long Seridan for the safe operations of the aircraft.

AAIB would like to thank all the UPNM researchers involved who had directly or indirectly contributed their time and effort to this aircraft incident investigation. The researchers' dedication and commitment to the cause of improving aviation safety is highly commendable. Experience gained and knowledge shared between AAIB investigation team and UPNM researchers were invaluable for future aircraft safety investigation.

Special mention and thanks to the following lead researcher for their contribution:

1. Dr. Ng Choy Peng – Senior Lecturer, Department of Civil Engineering UPNM.
2. Ir. Ts. Dr. Mohd Rashdan Saad – Senior Lecturer, Department of Mechanical Engineering UPNM.
3. Ts. Faridah Hanim Khairuddin – Lecturer, Department of Civil Engineering UPNM.
4. Ts. Sr. Gs. Wan Mohamed Syafuan bin Wan Mohamed Sabri – Lecturer, Department of Civil Engineering UPNM.

# INTRODUCTION

## The Air Accident Investigation Bureau of Malaysia

The Air Accident Investigation Bureau (AAIB) is the air accidents and serious incidents investigation authority in Malaysia and is responsible to the Minister of Transport. Its mission is to promote aviation safety through the conduct of independent and objective investigations into air accidents and serious incidents.

The AAIB conducts the investigations in accordance with Annex 13 to the Chicago Convention and Civil Aviation Regulations of Malaysia 2016.

It is inappropriate that AAIB reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

In accordance with ICAO Annex 13 paragraph 4.1, notification of the serious incident was sent on 10 May 2020 to Civil Aviation Authority of Malaysia as State of Registry/Occurrence, Transport Safety Board of Canada as State of Manufacturer/Design and the Operator. A copy of the Preliminary Report was subsequently submitted to the above organization on 09 June 2020.

In accordance with ICAO Annex 13 paragraph 6.3, a copy of the Draft Final Report was sent on 03 February 2021 to Civil Aviation Authority of Malaysia as State of Registry/Occurrence, Transport Safety Board of Canada as State of Manufacturer/Design, STOLport Operator and the Operator inviting their significant and substantiated comments on the report.

Unless otherwise indicated, recommendations in this report are addressed to the investigating or regulatory authorities of the State having responsibility for the matters with which the recommendations are concerned. It is for those authorities to decide what action is taken.

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## ATTACHMENTS



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| **2** | UPNM Site Investigation for Long Seridan Airport's Runway Part 2 – Skid Resistance Tests | ATT 2-1 TO ATT 2-20 |
| **3** | UPNM Skidding Incident of 9M-SSC Aircraft at Long Seridan Airport: Aquaplaning Analysis | ATT 3-1 TO ATT 3-7 |

## GLOSSARY OF ABBREVIATIONS

**A**

| | |
|---|---|
| AAIB | Air Accident Investigation Bureau |
| AASHTO | American Association of State Highway and Transportation Officials |
| AFIS | Aerodrome Flight Information Service |
| AFRS | Airport Fire Rescue Services |
| AGL | Above Ground Level |
| ANOVA | Analysis of Variance |
| APCH | Approach |
| ASDA | Accelerate Stop Distance Available |
| ATC | Air Traffic Control |

**B**

| | |
|---|---|
| BPN | British Pendulum Tests |

**C**

| | |
|---|---|
| CAAM | Civil Aviation Authority Malaysia |
| CAN | Civil Aviation Notice |
| CCTV | Close Circuit Television |
| C of A | Certificate of Airworthiness |
| Covid-19 | a mild to severe respiratory illness that is caused by a coronavirus identified in Wuhan, China in December 2019 |
| CPL | Commercial Pilot's Licence |
| CRM | Crew Resource Management |
| CVR | Cockpit Voice Recorder |

**D**

| | |
|---|---|
| DIR | Defect/Incident Investigation Report |
| Doc | Document |

**F**

| | |
|---|---|
| FDR | Flight Data Recorder |
| FL | Flight Level |
| FIR | Flight Information Service |
| ft | feet |

**G**

| | |
|---|---|
| GPS | Global Positioning System |

**H**

| | |
|---|---|
| hrs | hours |

**I**

| | |
|---|---|
| ICAO | International Civil Aviation Organisation |
| ie | id est or ‘that is’ |
| in | inches |
| IR | Instrument Rating |

**K**

| | |
|---|---|
| kg | kilograms |
| km | kilometres |
| kts | knots |

**L**

| | |
|---|---|
| lbs | pounds |
| LDA | Landing Distance Available |
| LT | Local Time |

**M**

| | |
|---|---|
| m | metres |
| MAHB | Malaysia Airports Holdings Berhad |
| MASB | Malaysia Airports Sendirian Berhad |
| MAvA | Malaysia Aviation Academy |
| MCO | Movement Control Order |
| METAR | Meteorological Terminal Air Report |
| MHz | MegaHertz |
| mm | millimetre |
| MOR | Mandatory Occurrence Report |
| MOT | Ministry of Transport |
| mph | miles per hour |
| MTD | Mean Texture Depth |
| MTOW | Maximum Take-Off Weight |

**O**

| | |
|---|---|
| OCNL | Occasional |
| OM-C | Operational Manual-C |

**P**

| | |
|---|---|
| PNG | Percentage Normalized Gradient |

**Q**

| | |
|---|---|
| QAR | Quick Access Recorder |

**R**

| | |
|---|---|
| RELA | Jabatan Sukarelawan Malaysia (Volunteers Department of Malaysia) |
| REO | Repair Engineering Order |
| RM | Ringgit Malaysia |
| RMK | Rancangan Malaysia (Malaysia Plan) |
| RWY | Runway |

**S**

| | |
|---|---|
| SEP | Safety Emergency Procedures |
| SI | Serious Incident |
| SIGWX | Significant Weather |
| SN | Skid Number |
| SOC | Statement of Compliance |
| SOP | Standard Operating Procedures |
| STOLport | Short Take-Off and Landing airport |
| SWY | Stopway |

**T**

| | |
|---|---|
| TIBA | Traffic Information Broadcast by Aircraft |
| TOD | Top of Descent |

**U**

| | |
|---|---|
| UPNM | Universiti Pertahanan Nasional Malaysia |
| UTC | Coordinated Universal Time |

**V**

| | |
|---|---|
| Vref | Reference Speed |

**Z**

| | |
|---|---|
| ZFW | Zero Fuel Weight |

## SYNOPSIS

A Twin Otter DHC6-400, bearing registration number 9M-SSC was on a schedule flight MH3622 from Marudi to Long Seridan on the 9 May 2020. Upon landing in Long Seridan on Runway 22, the aircraft veered to the left of the runway and rotated to the starboard, before impacting an embankment tail first ending up on the grass area to the left of Runway 22. Upon the landing incident, RELA members responded to the scene. They assisted the crew, evacuated the passengers and took them to the terminal.

A Mandatory Occurrence Report (MOR) was submitted by the Operator to Air Accident Investigation Bureau, Malaysia (AAIB) and the Civil Aviation Authority of Malaysia (CAAM) on 09 May 2020.

# 1.0 FACTUAL INFORMATION

## 1.1 History of the Flight

On the 9 of May 2020, a MASwings DHC6-400, flight MH3622 from Marudi to Long Seridan veered off the runway on landing at Long Seridan airfield. The flight was the second sector of a series of 8 flights to be flown that day, the preceding flight being MH3622, from Miri to Marudi. The preceding sector had been normal, with both a normal take-off from Miri and a normal landing in Marudi. There were no abnormalities reported by the crew during the take-off for the subsequent sector from Marudi to Long Seridan.

Both crews reported for duty at approximately 0750hrs on the 9 May 2020. The pre-flight was normal and the weather briefing was given.

The aircraft departed from Miri for Marudi at 0844hrs, 9 minutes behind schedule due to reports of low visibility in Marudi. The aircraft landed uneventfully in Marudi at 0904hrs. Once again, the departure from Marudi to Long Seridan was delayed due to low clouds and light rain in Long Seridan. The aircraft finally departed from Marudi at 0934hrs, 24 minutes behind schedule after they received a report that the weather had improved in Long Seridan with visibility reported to be 6 to 8km with light and variable winds. When the aircraft was visual with Long Seridan they were advised by the operations assistant that it had started drizzling again. However, the drizzle had stopped by the time they were on final approach. The aircraft approached Long Seridan Runway 22 normally and was reported to have been stabilized by 500ft AGL with all checklists completed. This is in keeping with the 300ft stabilization height due to the offset approach to Long Seridan. The flap 37 degrees setting was used with the ‘Vref’ being set to 67kts for the landing weight of 9,863lbs.

The crew was advised by the operations assistant that the visibility was 6 to 10km with light and variable winds with cloud base of 2,500ft during approach. The pilot observed that the runway was damp but not wet. However, the pilot had a limited time to assess the runway surface condition as the aircraft only intercepts the extended centreline at 300ft AGL due to the off-set approach.

The aircraft landed in the normal touchdown zone. At touchdown, the aircraft landed on its main wheels first. After the nose wheel was lowered, the pilot attempted to apply brakes and reversers, however the aircraft veered to the left of the runway while rotating to the starboard, finally impacting an embankment tail-first. It had rotated almost 180 degrees from its original landing path.

The point of touchdown was unable to be determined as there were many other tyre marks left by other aircraft. The most prominent tyre marks were from the starboard main wheel and start at 275m from the start of runway 22. The length of the starboard tyre mark is 167m. The port main wheel tyre mark and nose wheel tyre marks are very faint in comparison, with the port main wheel tyre mark only appearing very late and only for a short distance on the tarmac before disappearing. The port main wheel tyre track mark only reappears later on the grass. The aircraft came to rest approximately 108m from the end of the Runway 22 (440m from start of runway 22).

After the impact the pilots were pinned to their seats by the control column due to the damage sustained on the elevator. The RELA team responded very quickly and managed to evacuate the 2 passengers from the aircraft. During passenger evacuation, it started to rain. They were taken to the terminal by RELA motorcycle. Both pilots evacuated the aircraft on their own by moving their seats. All 4 (2 pilots, 2 passengers) were taken to the local clinic for a medical check-up. All sustained no physical injuries.

The aircraft was secured at its position by RELA. However, the tyre marks were degraded by the rain after the incident but still visible. The aircraft tyre tracks were also run-over by the RELA motorcycle tracks. Some of the tracks were also disturbed because there was a miscommunication with Malaysia Airports Sdn Bhd (MASB) that the aircraft could be removed.

The aircraft was removed 2 days later from the site by a Recovery Team from MASwings engineering and parked at the terminal.

## 1.2 Injuries to Persons

| Injuries | Crew | Passengers | Others | Total |
|---|---|---|---|---|
| Fatal | NIL | NIL | NIL | NIL |
| Serious | NIL | NIL | NIL | NIL |
| Minor | NIL | NIL | NIL | NIL |
| None | 2 | 2 | NIL | 4 |

Figure 1: Injuries to Person

## 1.3 Damage to Aircraft

Summary of the damage assessment by the MASwings Recovery Team are as below.

1.3.1 The right side of elevator trailing edge dented.

1.3.2 The starboard outboard fore flap and aileron badly damaged.

1.3.3 The starboard wing tip was dented. Upper starboard wing skin wrinkled outwards to the wing tip.

1.3.4 Flap and control wheel stuck in position due to damage on outboard fore flap, elevator and aileron.


Figure 2: Aircraft final position on left side of Runway 22 at Long Seridan

## 1.4 Other Damage

About 20m of the airfield perimeter security fence on left side of Runway 22 at the location where the aircraft came to rest were damaged.

## 1.5 Personnel Information

### 1.5.1 Captain

| | |
|---|---|
| Age | 29 |
| Sex | Female |
| Date of Joining Company | 3 March 2013 |
| Date Cleared Online | 13 July 2018 |
| License | CPL/IR: 5577<br>Medical Expiry: 28 February 2021<br>Last Base Check: 18 June 2019<br>Last IR: 18 June 2019<br>Last Line Check: 4 July 2019 |
| Flying Hours | Total: 4,057.41<br>Hours on type: 3,847.41 |
| Other Courses/Validities | SEP Expiry: 10 February 2021<br>CRM Expiry: 21 May 2021<br>Passport Expiry: 9 May 2024 |

Figure 3: Personal Information – Captain

The captain was very experienced with over 4,000hrs total and almost all of those hours are on type. She joined the company as a new hire on the DHC6 and was promoted to commander a few years later on the same fleet. She had enough rest prior to the incident and was not fasting.

### 1.5.2 Co-Pilot

| | |
|---|---|
| Age | 25 |
| Sex | Male |
| Date of Joining Company | 17 July 2017 |
| Date Cleared Online | 8 October 2017 |
| License | CPL/IR: 6274<br>Medical Expiry: 30 April 2021<br>Last Base Check: 8 September 2019<br>Last IR: 8 September 2019<br>Last Line Check: 12 July 2019 |
| Flying Hours | Total: 1,884.04<br>Hours on type: 1,723.03 |
| Other Courses/Validities | SEP Expiry: 5 May 2020 (Expired – approved to fly)<br>CRM Expiry: 10 October 2021<br>Passport Expiry: 19 June 2021 |

Figure 4: Personal Information – Co-pilot

The co-pilot was very experienced with almost 1800hrs on type. He joined the company as a new hire and has served on the DHC6 fleet for about 3 years. During the incident, his Safety Emergency Procedures check had expired. He was approved to fly under the Exemption Notice (Civil Aviation Authority Malaysia – Civil Aviation Notice Number CAN 1/2020 issued 10 April 2020) due to the Covid-19 Movement Control Order. The co-pilot had enough rest prior to the incident and was fasting but mentioned during the interview that it was still early in the day and he felt that it didn't impact his performance. Furthermore, the captain was pilot flying for both sectors.

## 1.6 Aircraft Information

### 1.6.1 Aircraft Data

| | |
|---|---|
| Aircraft Type | Twin Otter DHC6-400 |
| Manufacturer | Viking Air |
| Owner | MASwings |
| Registration | 9M-SSC |
| Serial No. | 886 |
| Year of Manufacture | 2013 |
| Certificate of Registration No. | Issued by CAAM on 03 March 2018 valid till 02 March 2021. |
| Certificate of Airworthiness No. | Issued by CAAM on 02 December 2019 valid till 05 December 2020. |
| Total Flight Hours | 10,696 hours (on day of occurrence) |

Figure 5: Aircraft Data

### 1.6.2 Aircraft Airworthiness

The aircraft flown that day was in airworthy condition. There was an entry regarding nose gear vibration on the 2 May 2020. Engineering inspected the nose gear thread wear and found it to be within limits with no abnormalities on the steering collar. A total of 20 flight cycles were accumulated since 2 May 2020. The aircraft had flown until the day of the incident with no further report regarding the nose wheel.

### 1.6.3 Aircraft Weight and Balance

The aircraft departed from Marudi with a Zero Fuel Weight (ZFW) of 8,567lbs, a Maximum Take-Off Weight (MTOW) of 10,104lbs and a projected landing weight at Long Seridan of 9,863lbs. These are well within the aircraft's prescribed limits. The aircraft was very light with only 2 passengers on board.

### 1.7 Meteorological Information

Weather was cloudy at the time of accident. The operations assistant at Long Seridan reported wind was light and variable and approach area was cloudy to the north/north east direction. Visibility was about 6 to 10km. This weather information is observed visually by the operations assistant at the Long Seridan airfield tower.

Earlier that morning, the weather was foggy at Long Seridan. When the aircraft reached Marudi, the operations assistant at long Seridan informed Marudi tower that there was light rain over the airfield. The rain later stopped but started drizzling again when the aircraft reported it was visual with Long Seridan. It stopped drizzling when the aircraft was on approach to land. It started to drizzle again immediately after the incident happened.

METAR for Miri Airport was reported as generally low cloud from 1500ft to FL150. SIGWX forecasted for the area around Long Seridan shows OCNL CB from 1500ft to FL480. This incident occurred in day light.

Figure 6: Low cloud on the approach path of Runway 22 view from Runway 04 taken after the incident. Note the wet runway after rain.

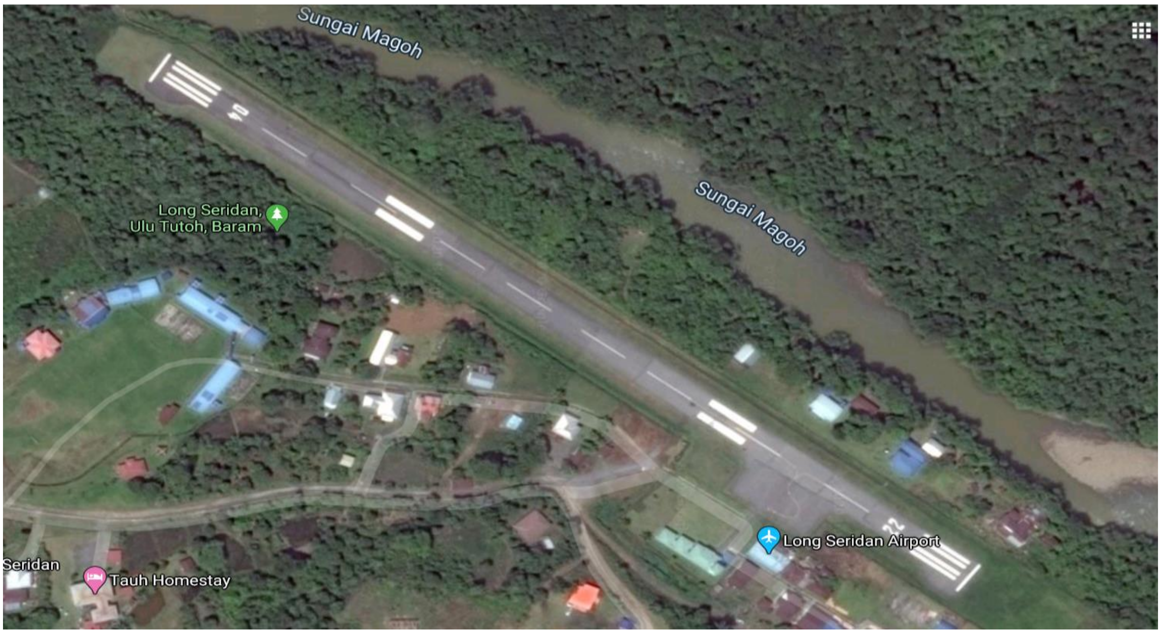
## 1.8 Aids to Navigation

There are no navigational aids for Long Seridan airfield. Navigation and approach are carried out visually with pre-set GPS waypoints as a reference.

## 1.9 Communications

All communications frequencies were operating normally. The crew was in contact with Long Seridan operations assistant and the Kota Kinabalu Terminal Information Broadcast Area on 133.3MHz.

## 1.10 Aerodrome Information




| | |
|---|---|
| Airfield | Long Seridan |
| Runway | 04/22 |
| Length | 548m |
| Width | 19m |
| ICAO Designator | WBGI |
| IATA Designator | ODN |
| Elevation | 633ft |
| Navaids | Nil |
| Radio | Long Seridan Terminal Information Broadcast Area: 133.3MHz |

| | |
|---|---|
| Obstacle | 1. Hill approx. 700 FT (213m) 1.5 mile to the north.<br>2. Long house at left side of approach Runway 22.<br>3. Hill approx. 700ft about half mile on the approach of Runway 04.<br>4. Windsock position 90ft adjacent to the threshold marker on left side of Runway 22. |
| Additional Information from AIP | 1. The southern APCH is through a narrow valley<br>2. Pilot to exercise caution on the aerodrome non-conforming issues:<br>a. Pilot to exercise extreme caution due to protruding of object in vicinity of aerodrome.<br>b. AFRS not complying with critical aircraft requirement (Twin Otter) but minimum firefighting is provided with three-wheel motorcycle with 50kg (4 unit) dry chemical powders. |
| Additional Information | Long Seridan is considered a Category C aerodrome. It necessitates a non-standard approach. Pilots entering Long Seridan must first be route qualified. The stabilized height is 300ft AGL as the aircraft has to manoeuvre to avoid terrain before turning onto the final approach path. |
| MASwings OM-C (Route Manual) | Arrival:<br>TOD is commenced when visual with the ground. Recommended TOD at or after the MULU gap. After the gap, follow the valley towards the left approximate heading of $040^0$ to join left hand downwind RWY 22 and carry out normal circuit pattern. Only RWY 22 should be used for landing. |
| Services provided by MASB | 1. Aerodrome Flight Information Service (AFIS).<br>2. Landside, Terminal and Airside Operations.<br>3. AFRS by RELA personnel (Appointed and trained by MASB).<br>4. Aviation Security by RELA personnel (Appointed and trained by MASB). |

Figure 7: Long Seridan airfield information

### 1.11 Flight Recorders

Aircraft was equipped with Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR). FDR and CVR was impounded for AAIB investigation.

## 1.12 Wreckage and Impact Information

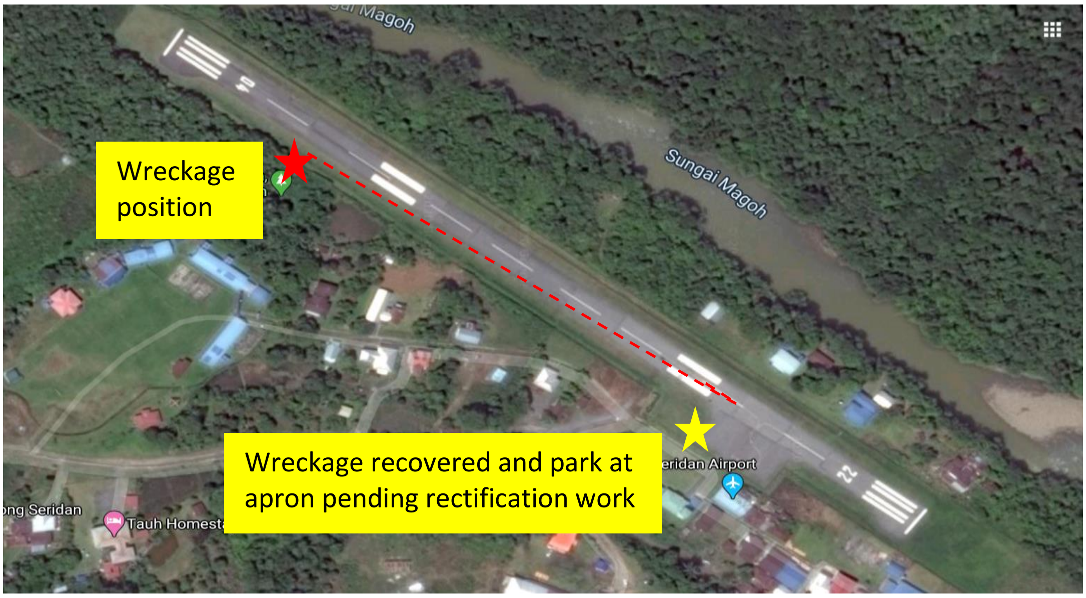



Figure 8: Aerial view of aircraft position at Long Seridan airfield
(Not according to scale)

The aircraft remained intact after the incident, albeit with damage. The aircraft had veered to the left side of the runway while rotating to the starboard, coming to a rest after impacting an embankment tail first. Damage was largely confined to the starboard wing and right side of elevator which impacted the ground and a fence post.

The aircraft recovery was performed on 11 May 2020 and was successfully removed from the soft ground and parked at Long Seridan apron. Pending the rectification work, the aircraft had been secured and put under storage condition at Long Seridan.

## 1.13 Medical and Pathological Information

Both crews underwent urine test and results were both negative for substance abuse.

## 1.14 Fire

No fire to the aircraft was reported before, during and after the incident.

## 1.15 Survival Aspects

There were no fatalities or injuries to passengers and crews.

## 1.16 Tests and Research

UPNM researchers had conducted a site investigation at Long Seridan airfield to collect data for research and analysis work to provide evidence to support preliminary investigation finding that hydroplaning had occurred in this incident. Full research report is provided in **Attachment 1, 2** and **3** of this report.

## 1.17 Organizational and Management Information

The Operator operates 8 ATR 72 and 06 Twin Otter DHC6 aircrafts. The airline headquarters is in Kota Kinabalu, Sabah with a secondary hub at Miri, Sarawak. The Operator is a rural air services provider and therefore, flies to the interior of Sabah and Sarawak.

### 1.17.1 Post Incident Aircraft Inspection and Maintenance

The Operator had undertaken and completed the post incident inspection and maintenance tasks to recover the aircraft. All findings had been consolidated and shared with Viking Air, Canada for the total restoration and for the aircraft’s return to an airworthy state.

Post incident engineering inspection and operational check on the main and nose wheel, brake system, steering system, engine reverse power (Beta) and rudder system found no defect.

### 1.17.2 Aircraft Recovery to Airworthy State

The aircraft was repaired at Long Seridan as per repair instructions provided by Viking Air, Canada through their Repair Engineering Order (REO). The repair schemes were approved by CAAM on 04 December 2020 as in the Statement of Compliance (SOC). The repairs are deemed as permanent repair and no further repair is needed.

The aircraft Certificate of Airworthiness (C of A) was also renewed on 07 December 2020 by CAAM following the completion of repairs at Long Seridan.

The aircraft was flown and position at Miri on 11 December 2020. It was flown to Kota Kinabalu on 16 December 2020 for additional maintenance prior to the aircraft being returned into commercial services.

### 1.17.3 Aircraft Quick Access Recorder (QAR) Data

**Flight Phase: Approach (Below 1000 feet): -**

| Time UTC | Height AGL | Flight Parameters: Heading(M), TQ1&2 | | | Np 1 & 2 | | Calibrated Speed / **Ground Speed** kts | Wind Speed/Wind Direction | Vertical Speed (fpm) | Flaps setting | Remark & Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 01:58:53 | 1038 | 325 | 2.6 | 3.3 | 76 | 77 | 75/ **85** | 19/175 | -196 | 19 | Aircraft approaching right base runway 22 |
| 01:59:25 | 925 | 243 | 4.3 | 5.2 | 78 | 78 | 73/ **88** | 18/124 | -590 | 19 | Flaps 20 selected |
| 01:59:34 | 817 | 220 | 9.8 | 10.9 | 81 | 82 | 69/ **86** | 25/108 | -656 | 20 | Flaps 20 set |
| 01:59:40 | 699 | 209 | 7.7 | 8.2 | 77 | 76 | 67/ **82** | 26/93 | -459 | 34 | Flaps 30 set |
| 02:00:00 | 515 | 216 | 8.7 | 9.1 | 75 | 75 | 68/ **84** | 22/67 | -721 | 35 | **Aircraft stabilized by 500 feet AGL** |

Figure 9: QAR data below 1,000ft – approach stabilized

## Flight Phase: Final Approach to Aircraft Complete Stop: -

| Time UTC | Height AFE | Flight Parameters: Heading(M), TQ1&2 | | | Np 1 & 2 | | Calibrated Speed/ **Ground Speed** kts | Wind Speed/Wind Direction | Vertical Speed (fpm) | Flaps setting | Remark & Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 02:00:42 | 108 | 213 | 4.0 | 4.6 | 72 | 72 | 72/ **82** | 26/63 | -787 | 36 | Approach Stabilized |
| 02:00:47 | 52 | 211 | 1.5 | 1.5 | 68 | 68 | 66/ **75** | 25/62 | -459 | 36 | Flare before touchdown |
| 02:00:53 | 0 | 213 | 1.4 | 1.1 | 66 | 65 | 52/ **61** | 24/60 | 0 | 36 | Aircraft touchdown |
| 02:00:57 | 0 | 206 | 2.1 | 2.0 | 62 | 60 | 22/ **44** | 24/54 | 0 | 36 | Yaw at 7 degrees per second |
| 02:01:05 | 0 | 290 | 2.8 | 2.7 | 51 | 49 | 0 | 0 | 0 | 36 | **Aircraft came to a complete stop. Yaw at 20 degrees per second** |


Figure 10: QAR data final approach to aircraft complete stop – aircraft veered left after touch down

QAR data shows that the aircraft had stabilized at 500ft during the approach to land in accordance to the SOP DHC-6. The data found no significant event during the approach to land phase (Figure 9). The incident occurred after the aircraft touchdown on the runway before veering to the left at about halfway down the runway and rotated starboard after exiting the runway with a yaw rate of 20° per second (Figure 10).

It was observed that the QAR and FDR recorded an approximate tail wind of an average of 25kts (Figure 10) below 500ft AGL. Nevertheless, interview statement from the pilot and operations assistant Long Seridan airfield states that the wind was light and variable from visual observation. It would be impossible for the aircraft to land on such strong tailwind and not logical for the pilot and operations assistant not to realised such strong wind at the aerodrome.

### 1.17.4 Aircraft Cockpit Voice Recorder (CVR)

CVR data was downloaded and translated by the investigating team. The main observation made are as follows:

a. The reading and action of checklist action items by the crew is a one person read and action as stated in the SOP DHC6.

b. All checks were well carried out by the crew with emphasis on checking and confirming the nosewheel steering lever position during the after take-off, descent approach, and landing checks.

c. Weather was marginal with low clouds as observed by co-pilot on approach to land. Wind was light and variable as reported by the operations assistant.

### 1.17.5 Aircraft Standard Operating Procedure (SOP)

At the time of this incident, the SOP in used was Issue 4 Revision 1 dated 30 April 2019. Following the Serious Incident SI 01/20 on aircraft 9M-SSE on 07 January 2020, a newly amended SOP Issue 5 Revision 0 dated 01 March 2020 was drafted and readied. The amended SOP was approved for used by CAAM effective 25 June 2020 ie after the incident. The amendment made to the SOP is in line with the Safety Recommendations issued in the Aircraft Accident Final Report SI 01/20 dated 07 October 2020.

It was observed in the CVR recording that the reading and action of checklist action items by the crew is a one person read and actioned procedure. With the amended SOP being in effect from 25 June 2020, the new checklist challenge and response procedure will supersede the one person read and action procedure.

### 1.17.6 Aircraft Checklist

Following the Serious Incident SI 01/20 on aircraft 9M-SSE on 07 January 2020, the Miri Twin Otter Fleet Manager issued 3 Circulars as follows:

a. New procedures on nosewheel steering checklist issued on 10 January 2020.

b. Paper checklist usage issued on 21 January 2020.

c. Proper checklist reading issued on 19 March 2020.

It is observed that the checklist reading and nosewheel steering checklist procedures were well carried out by the crew. It was found that the temporary paper checklist to replace the electronic checklist too long with unnecessary check details included as highlight by the crew during the interview session.

A new paper checklist Issue 1 dated 01 March 2020 was drafted. The new paper checklist was approved for used by CAAM effective 25 June 2020 ie after the incident. The use of the new paper checklist is as recommended in the Safety Recommendations issued in the Aircraft Accident Final Report SI 01/20 dated 07 October 2020.

### 1.17.7 Flying Operations into ASDA[1]/LDA[2] Limited STOLport

Flying operations into STOLport are highly risky due to the short and narrow runway, high elevation and high terrain couple with very unpredictable weather condition. Below is the actual landing distance for the aircraft calculated as in Figure 11 for Long Seridan runway based on the conditions stated as a guide on how critical the landing distance are especially in wet conditions.

[1] Acceleration Stop Distance Available - The length of the take-off run plus the length of the Stopway, where provided.
[2] Landing Distance Available - The length of the runway which is declared available by the appropriate authority and is suitable for the ground run of an aeroplane landing.

*****Conditions**: Elevation: 626ft, **LDA: 1,798ft**, OAT: 30°C, Wind: 0 kts (light & variable), **Landing Weight: 9,863lbs**

| **Weight (lb)** | **Actual Landing Distance (ft)** | | **Regulated Landing Distance (ft) (Actual = 70% of Regulated)** | | **Dispensation Landing Distance (ft) (Actual = 85% of Dispensation)** | |
|---|---|---|---|---|---|---|
| | **Dry** | **Wet** | **Dry** | **Wet** | **Dry** | **Wet** |
| 9500 | 1425 | 1639 | 2038 | 2344 | 1677 | 1928 |
| 9863 | 1425 | 1639 | 2038 | 2344 | 1677 | 1928 |
| 10000 | 1425 | 1639 | 2038 | 2344 | 1677 | 1928 |
| 10500 | 1425 | 1639 | 2038 | 2344 | 1677 | 1928 |
| 11000 | 1475 | 1697 | 2110 | 2426 | 1735 | 1995 |
| 11500 | 1525 | 1754 | 2181 | 2508 | 1795 | 2063 |
| 12000 | 1575 | 1812 | 2253 | 2590 | 1853 | 2131 |
| 12300 | 1615 | 1858 | 2310 | 2656 | 1900 | 2185 |

Figure 11: Landing distance required calculation for Long Seridan runway (Source: Technical Services, Operations Engineering of Aircraft Operator)

From Figure 11, based on the actual aircraft configuration on the day of the incident, it was observed that the landing distance required to land on a wet runway is 1,928ft. The landing distance is actually longer than the actual distance of the runway (1,798ft). Therefore, the aircraft can only land safely on a dry runway which requires a distance of 1,677ft. From the data above, it can be summarised that the aircraft can only land safely at Long Seridan on a dry runway only and up to a maximum landing weight of 11,500lbs[3].

To mitigate the above flying operations risks safely, the operator presented a risk management action plan to CAAM on 01 November 2019. CAAM agreed for the operator to operate into these STOLports with certain operations condition. These STOLports are as follows:

a. Long Seridan.

b. Long Banga.

c. Bario.

d. Bakelalan.

[3] By regulation, actual landing distance should be only 70% of regulated landing distance. The operator is given dispensation from CAAM to increase to 85% for STOLports.

The operations condition including the approval to reduce weight (reducing to maximum 9 ticket seats) were met in this incident except for operations on dry runway criteria. The pilot stated the aircraft landed on a damp (not wet) runway as observed on approach before landing. Interview statement from the Long Seridan operations assistant concurred with the observation of the pilot.

### 1.17.8 Immediate Actions Taken by the Operator after the Incident

Two Circulars were sent out to all pilots as an immediate action to mitigate STOLport operations flight safety risk since this is the second runway excursion incident for year 2020. The Circulars are as below.

a. Circular dated 15 May 2020 send out by Chief Pilot Flight Safety to maintaining stabilized approach, understanding of the prevailing weather and wind conditions, apply the correct landing techniques to lower the risk of a runway excursions.

b. Circular dated 4 June 2020 send out by Miri Fleet Manager (DHC6-400) forbidding entry into Long Banga, Long Seridan, Bario and Bakelalan when runway is wet. It was observed that the definition for wet condition in the Miri Fleet Manager's Circular differs from the definition describe in the SOP DHC6 (Figure 12) and ICAO Annex 14 Volume 1 (Figure 13) which is the standard description used.

### 1.17.9 Description of Runway Surface Conditions whenever Water is Present

The current SOP DHC6 provides definitions for contaminated runway as in Figure 12. The definitions provided are subjective to be verify by the pilot in-flight. The definition on wet runway which states when water layer does not exceed 3mm depth, there is no substantial risk of hydroplaning is also inaccurate. Hydroplaning is dependent on several factors like runway surface conditions, speed of aircraft, tyre thread depth and pressure. Hydroplaning requires a water thickness of water film above 2.5mm or equals (or larger) than the tyre thread depth. The analysis at paragraph 2.4.2 provide evidence that hydroplaning risk do exist when water thickness is more than 3mm (about 4mm) which equals the tyre thread of the aircraft.

With reference to Figure 13, ICAO Annex 14, Volume 1 provides a clear guidance on the description of the runway surface conditions when water is present on the runway. These standardised descriptions should be adopted by the aircraft operator and aerodrome operations attendant for clear understanding and safety purposes.

| MASwings | DHC6-400 STANDARD OPERATING PROCEDURES (SOP DHC6) | Revision: 5.0.0<br>Date: 01-Mar-2020 |
|---|---|---|
| | 6 ADVERSE WEATHER OPERATIONS<br>6.1 CONTAMINATED RUNWAY | |

**6 ADVERSE WEATHER OPERATIONS**

**6.1 CONTAMINATED RUNWAY**

6.1.1 A runway is considered contaminated when more than 25% of the surface is covered with a contaminant. Contaminants are water, slush, snow and ice.

| DEFINITIONS | |
|---|---|
| **Damp** | A runway is damped when the surface is not dry, but when the water on it does not give it a shiny appearance. |
| **Wet** | A runway is considered as wet when the surface has a shiny appearance due to a thin layer of water. When this layer does not exceed 3mm depth, there is no substantial risk of hydroplaning. |
| **Standing water** | Is caused by heavy rainfall and/or insufficient runway drainage with a depth of more than 3mm. |
| **Slush** | Is water saturated with snow, which spatters when stepping firmly on it. It is encountered at temperature around 5oC and its density is approximately 0.85kg/liter (7.1 lb/US GAL). |
| **Wet snow** | Is a condition where, if compacted by hand, snow will stick together and tend to form a snowball. Its density is approximately 0.4 kg/liter (3.35 lb/US GAL). |
| **Dry snow** | Is a condition where snow can be blown if loose, or if compacted by hand, will fall apart again upon release. Its density is approximately 0.2 kg/liter (1.7 lb/US GAL). |
| **Compacted snow** | Is a condition where snow has been compressed (a typical friction coefficient is 0.2). |
| **Icy** | Is a condition where the friction coefficient is 0.05 or below. |

Figure 12: SOP DHC6 – Definition of contaminated runway

*Water on a runway [applicable until 4 November 2020]*

2.9.5 **Recommendation.—** *Whenever water is present on a runway, a description of the runway surface conditions should be made available using the following terms:*

*DAMP — the surface shows a change of colour due to moisture.*
*WET — the surface is soaked but there is no standing water.*
*STANDING WATER — for aeroplane performance purposes, a runway where more than 25 per cent of the runway surface area (whether in isolated areas or not) within the required length and width being used is covered by water more than 3 mm deep.*

Figure 13: ICAO Annex Volume 1 – Description of runway surface conditions

### 1.17.10 Landing and Adverse Weather Braking Procedures

The SOP DHC6 clearly provides the normal landing and adverse weather braking procedures to be practice as in Figure 14. Evidence from QAR data shows that the aircraft approach to land was stable until touchdown. Evidence from CVR shows all relevant checklist procedures were complied with and operations attendant's information acknowledge. The Long Seridan operations assistant stated that the aircraft touchdown on both main wheels firmly which collaborated with pilot and co-pilot's statement. The pilot applied reverse power and brakes simultaneously to stop the aircraft. It had roll straight initially before the pilot lost directional control when the aircraft most probably started skidding on the wet runway. The use of brakes to stop and steer the aircraft to the centreline during skidding most probably aggravated the situation.

The use of differential reverse thrust for direction control and both reverse thrusts to stop the aircraft on a wet runway is recommended as brakes are rendered ineffective in a skidding situation (Figure 14). The investigation revealed that the pilot had complied with all the relevant landing procedures as stated in the SOP DHC6 to make a safe landing before the skidding incident.

| MASwings | DHC6-400 STANDARD OPERATING PROCEDURES (SOP DHC6) | Revision: 5.0.0<br>Date: 01-Mar-2020 |
|---|---|---|
| | 4 NORMAL PROCEDURES<br>4.16 LANDING | |

| FLAP ANGLE | 1.3 Vs KNOTS IAS | | | | | |
|---|---|---|---|---|---|---|
| | 12,300 LB (5,580 kg) | 11,500 LB (5,218 kg) | 10,500 LB (4,764 kg) | 9,500 LB (4,310 kg) | 8,500 LB (3,857 kg) | 7,500 LB (3,400 kg) |
| 20° | 80 | 77 | 73 | 70 | 66 | 64 |
| 37° | 74 | 70 | 67 | 64 | Not Authorized | |

***Graphic 4-10 : 4.16.2a***

2. PROP levers – Check MAX RPM (96% Np). Confirm RESET PROPS caution CAS message is not present.

3. When crossing runway threshold at 50 feet AGL: Power Levers – promptly move to IDLE

4. Touchdown – On main wheels

5. Brakes – Apply as required after nose wheel contact

| CAUTION | DUE TO THE MECHANICAL INTERLOCK, REVERSE POWER CANNOT BE APPLIED UNLESS THE PROP LEVERS ARE AT MAX RPM. DURING THE USE OF REVERSE, ENGINE POWER MAY INCREASE ASYMMETRICALLY. |
|---|---|

6. Zero Thrust or Reverse power – As required

7. Nose wheel steering lever- Use as required. Coarse application of rudder should be used as the primary control for heading until the aircraft has decelerated to taxi speed.

***Note:*** *The shortest landing distances and the best quality landings are achieved when the VREF in the table above is maintained with precision and the power levers are brought sharply back to idle when crossing the runway threshold at 50 feet AGL. Do not carry any power into the flare as this will greatly increase both the touchdown speed and the landing distance required.*

| MASwings | DHC6-400 STANDARD OPERATING PROCEDURES (SOP DHC6) | Revision: 5.0.0<br>Date: 01-Mar-2020 |
|---|---|---|
| | 6 ADVERSE WEATHER OPERATIONS<br>6.2 BRAKING | |

## 6.2 BRAKING

6.2.1 There are two ways of decelerating an aircraft:

1. The primary way is with the wheel brakes. Wheel brakes stopping performance depends on the load applied on the wheels and on the slip ratio. The efficiency of the brakes can be improved by increasing the load on the wheels.
2. Secondly, reverse thrust decelerates the aircraft by creating a force opposite to the aircraft motion regardless of the runway condition. The use of reverse thrust is indispensable on contaminated runways.

Figure 14: SOP DHC6 – Normal landing and adverse weather braking procedures

### 1.17.11 Full Runway View Block by Building

It was observed that the operations assistant was unable to see the full length of the runway from the airfield tower. A building which was situated about half way just outside the security parameter fence on the left side of Runway 22 totally block the view of the end of Runway 22 or threshold Runway 04 (Figure 15 and 16).

It is noted that all landings for Long Seridan Airfield is on Runway 22 as stated in MASwings OM-C (Route Manual). As in this incident, the operations assistant did not physically see the aircraft veered out of the runway. Vital witness information on the incident was lost as the investigation team could not verify the detail movement of the aircraft when the aircraft started to veer off the runway.

From interview with the operations assistant, it was noted that the building was already in existence before the runway was constructed in December 2000. Future upgrading of this airfield needs to address this issue for safety reasons as it involved private property and regulatory matters.


Figure 15: View from the airfield tower. Building blocking the view of incident site and threshold Runway 04

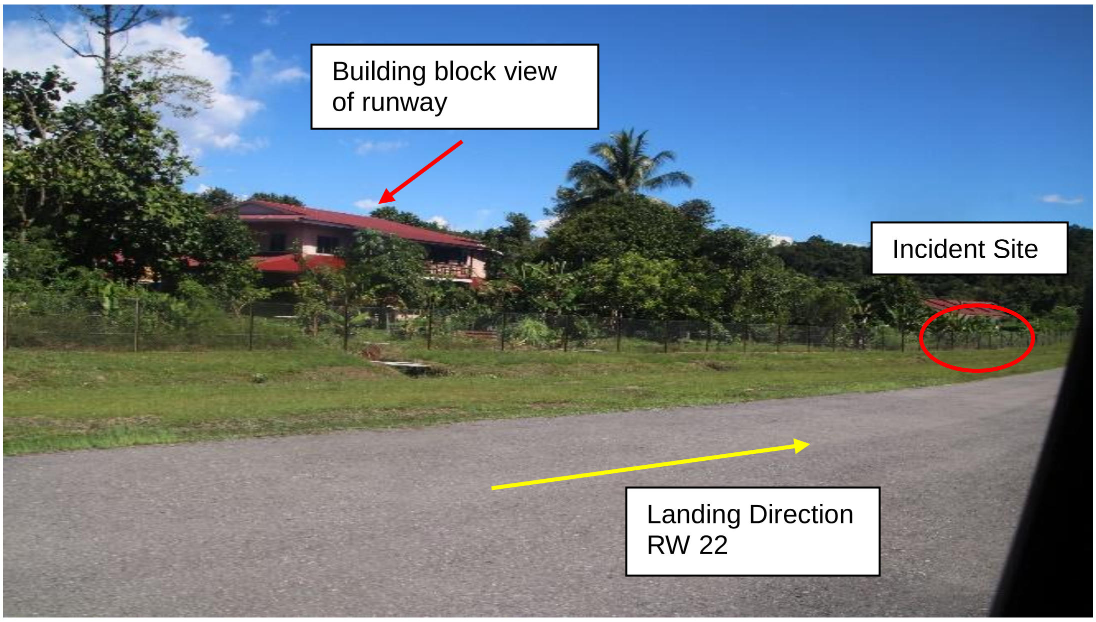



Figure 16: Building blocking the sight of the incident site

### 1.17.12 Site Observation on Long Seridan Runway Condition

Long Seridan airfield was built in December 2000. The runway has an asphalt surface and the last resurfacing work on the surface was in December 2012.

The following are the site observation on the runway pavement surface by UPNM research team which conducted a site survey together with the investigation team on 21 August 2020[4].

a. Cracking in asphalt pavement due to axle load, changes in weather, excessive precipitation and poor drainage.

b. Pavement disintegration due to ravelling and stripping resulting in dislodgement of aggregate particles at pavement surface.

[4] See Ts. Faridah Hanim Khairuddin, UPNM Site Investigation for Long Seridan Airport's Runway Part 1 – Site Reconnaissance Survey dated 28 October 2020.

c. Pavement aggregate particles becomes polished due to repeated traffic application.

d. Water bleeding due to poor drainage.

e. Earth drainage are located at both of runway but no proper water discharge identified.

### 1.17.13 Operator Air Safety Report on Runway Pothole

An Air Safety Report ASR34-20 was raised on 12 June 2020 and submitted by the aircraft operator's pilot to the aerodrome operator on discovery of a big pothole forward of threshold Runway 22 touchdown area (Figure 17).

The pothole was observed to have appeared over time due to the distresses stated in paragraph 1.17.12 (Figure 18). There is no evidence that the operations assistant had raised a request for repair action to Miri Airport maintenance team in his daily routine runway inspection. Actions to repair the pothole was taken after an Air Safety Report was submitted by the aircraft operator. The repair work was carried out using 'Cool Mix Asphalt' by the aerodrome operator's personnel at Long Seridan (Figure 19). The repair work was carried out by non-competent personnel.


Figure 17: Aerial view of the location of the pothole and location of the pothole on the runway close to centreline

Figure 18: Close up view of the pothole. The pothole appears over time due to disintegration in asphalt pavement.

Figure 19: Repair carried out by Long Seridan staff using 'Cool Mix Asphalt'. Asphalt aggregate is observed to be loose and uneven.

### 1.17.14 STOLports Maintenance and Operations

Malaysia Airports Holdings Berhad (MAHB) as the aerodrome operator was issued with a licence by the Ministry of Transport valid till year 2034 to operate and maintain 10 STOLports in Sarawak. The STOLports are managed by MAHB's subsidiary, Malaysia Airports Sdn Bhd (MASB) under the responsibility of the Miri Airport Manager. The STOLports are namely Bario, Marudi, Lawas, Bakelalan, Mulu, Long Seridan, Long Banga, Long Lellang, Long Akah and Long Semado. These STOLports are classified as Category 1 aerodromes[5].

All the above STOLports are not certified aerodromes as required by ICAO Annex 14[6] and Civil Aviation Regulations 2016[7]. MASB and CAAM is currently working on the process to certify these STOLports. MASB is obligated to maintain or operate the STOLports in accordance with the Civil Aviation Regulations 2016[8] although these STOLports had not been certified yet.

The applicability of specifications in ICAO Annex 14 Volume 1 clearly states that the specifications in this volume shall not apply to STOLport. Chapter 1, paragraph 1.2.2 in this volume state "although there are at present no specifications relating to STOLport, it is intended that specifications for these aerodromes will be included as they are developed. In the interim, guidance material on STOLport is given in the STOLport Manual Doc 9150".

Whereas, the applicability of specifications in STOLport Manual Doc 9150 states that guiding specifications in this manual conforms to international standards. Chapter 1, paragraph 1.2.2 in this manual state "although the specifications of Annex 14 Volume I - Aerodrome Design and Operations do not apply to these STOLports, much of the guidance material in this manual conforms to the International Standards and Recommended Practices set forth

[5] Category 1 - government aerodromes available for use by commercial transport.
[6] International Civil Aviation Organization (ICAO), 2018. Annex 14 Aerodromes, Volume 1 - Aerodrome Design and Operations, 8th Ed, paragraph 1.4.
[7] Malaysia Civil Aviation (Aerodrome Operations) Regulations 2016, Regulation 6.
[8] Ibid, Regulation 12.

in that Annex. It is recommended that references to specifications for STOLport be made to ICAO Annex 14 in conjunction with STOLport Manual. Other useful guidance for reference are the Aerodrome Design Manual Doc 9157 and the Airport Services Manual Doc 9137”.

Therefore, the above documents will be used as reference in the investigation and analysis on STOLport maintenance and operations.

#### 1.17.14.1 STOLports Maintenance

From the interview with Miri Airport Head of Engineering, in the presence of the newly appointed Miri Airport Manager, the main points observed on the maintenance of STOLport are as follows:

a. There is no STOLport aerodrome maintenance program developed by the aerodrome operator as required by ICAO Annex 14 Volume 1[9] and Civil Aviation Regulations 2016[10]. Miri Airport maintenance personnel conducts inspection on all STOLport at least twice a year for preventive and corrective maintenance work on the aerodrome and runway.

b. There is no evidence of a documented plan inspection schedule and a runway maintenance schedule for Long Seridan aerodrome to properly conduct and managed the inspection and maintenance of the aerodrome and runway.

c. There is no STOLport Runway Maintenance Standard Operating Procedures (SOP) developed to provide procedures guidance to carry out runway maintenance. The SOP for runway maintenance is still being developed. The current practice is to refer to available documents at Miri Airport as guide.

[9] International Civil Aviation Organization (ICAO), 2018. Annex 14 Aerodromes, Volume 1 - Aerodrome Design and Operations, 8th Ed, paragraph 10.1.1.
[10] Malaysia Civil Aviation (Aerodrome Operations) Regulations 2016, Regulation 47 & 48.

d. Minor maintenance work such as removal of foreign object debris are carried out by STOLport personnel.

e. Runway repainting works are carried out by STOLport personnel with the assistance from Miri Airport maintenance team during runway maintenance visits.

f. Rectification of potholes on the runway, taxiway or apron are carried out by Miri Airport maintenance team using 'Cool Mix Asphalt'. These maintenance personnel are competent to carry out minor maintenance work on the runway. It was observed that the repair work on the pothole at Long Seridan was carried by personnel who are not competent to do such repair. This is due to unavailability of a SOP to provide proper guidance on runway repair work.

g. Major rectification works on STOLport runway are carried out by appointed contractors.

h. No record of runway surface friction assessment being periodically measured on Long Seridan runway as required by ICAO Doc 9137 Airport Services Manual Part 8[11].

i. Runway centreline markings repainting at Long Seridan was carried out in April 2020.

j. Runway designation and threshold markings repainting at Long Seridan was carried out in September 2020.

The investigation team was informed that any future upgrade of STOLport runway to safely meet the Twin Otter DHC6 aircraft operations

[11] ICAO Doc 9137, Airport Services Manual Part 8, Airport Operation Services, 1st Ed, 1983, Chapter 7.

will be a mid-term solution. The aerodrome operator had requested through the Ministry of Transport a budget of RM19.963 million in RMK-12 (Year 2021 to 2025) to extend/upgrade the runway from the current length of 548m to 990m to cater for Twin Otter DHC6 aircraft operations.

#### 1.17.14.2 STOLports Operations

Operations assistant are placed in all STOLport to ensure the aerodrome operations are conducted safely. The job responsibility of the operations assistant fulfils the requirements for the tasks to be performed effectively. The job responsibilities however do not include providing AFIS to aircrafts.

Currently, the aerodrome operator is entrusted with the additional responsibility to provide air traffic and actual visual weather information to departing and arriving aircraft at 6 of the STOLports. They are are Bakelalan, Bario, Long Seridan, Long Lellang, Long Akah and Long Banga.

Two operations assistants are station in Long Seridan to perform these duties in addition to their daily job responsibilities. Most of the training to perform these additional duties are mostly trained in-house by senior operations assistant at various STOLport while the more senior personnel were trained by CAAM ATC at Miri Airport.

The operations assistant responsibilities other than providing traffic information are to provide weather updates and reporting runway surface conditions. Currently, these personnel are not trained formally and there are no formal courses to train them to competently perform these duties especially the reporting and assessing of runway surface conditions and providing visual weather conditions. ICAO Annex 14[12]

[12] International Civil Aviation Organization (ICAO), 2018. Annex 14 Aerodromes, Volume 1 - Aerodrome Design and Operations, 8th Ed, paragraph 2.9.4.

states that personnel assessing and reporting runway surface conditions and providing weather conditions must be trained and competent to perform their duties. ICAO Annex 14[13] provides a training syllabus guide on the relevant subject to train these personnel to provide assessed information on runway surface conditions to aircraft.

#### 1.17.15 Safety Inspection Program

There is no evidence to show a safety inspection program on STOLport have been establish and maintain by the aerodrome operator to ensure compliance to safety procedures in operating and maintaining the aerodrome as required by Civil Aviation Regulations 2016[14].

#### 1.17.16 Safety Regulatory Oversight Program

There is no evidence to show a safety regulatory oversight on STOLports have been carried out by CAAM to determine regulatory compliance on aerodrome operations and maintenance practices on the aerodrome operator in accordance with Civil Aviation Regulations 2016[15].

### 1.18 Additional Information

#### 1.18.1 Interview and Statements

This aircraft incident occurred when the Movement Control Order (MCO) was enforced by the government in the state of Sarawak due to the Covid-19 pandemic which banned traveling to the state. The AAIB investigation team was not able to travel to the incident site and a AAIB Special Investigator[16] was appointed from MASwings to assist in the collection of evidence on-site, to

[13] Ibid, Attachment A Section 6.
[14] Malaysia Civil Aviation (Aerodrome Operations) Regulations 2016, Regulation 37.
[15] Ibid, Regulation 65.
[16] A Twin Otter DHC6-400 Captain who is a Safety Pilot from Flight Safety Department, Flight Operations at MASwings Miri, Sarawak was appointed as a AAIB Special Investigator for this incident investigation.

interview and record statement from witness and to assist AAIB in the investigation.

The AAIB investigation team later conducted separate interview sessions with the Head of Engineering, Miri Airport on 19 August 2020 and the pilots on 20 August 2020 at Miri Airport after the traveling ban was partially lifted for official and essential travel only. The interview sessions were recorded under the express knowledge of all the parties. All of the personnel had also submitted a written statement including the Air Traffic Controller of Marudi Airport and the Operations Assistant of Long Seridan Airfield.

## 1.19. Useful or Effective Investigation Techniques

### 1.19.1 On-Site Investigation

The aircraft was not fitted with electronic sensors to monitor and record the critical systems of the aircraft in particular the nose wheel steering and brakes. Therefore, there were no data from the FDR or QAR on the actual operations of these critical systems to assist in the investigation.

Initial on-site investigation was conducted by the AAIB Special Investigator. AAIB Investigation Team and Special Investigator visited the site later together with researchers from UPNM to conduct further site investigation, collect data and look for evidence which will assist in reconstructing the probable chain of event leading to this incident. The delay was due to Movement Control Order imposed by the government due to the Covid-19 pandemic which restricted travel to the incident site.

### 1.19.2 Hydroplaning Technical Analysis and Site Investigation by Researchers from Universiti Pertahanan Nasional Malaysia (UPNM)

AAIB had requested researchers from UPNM Department of Civil Engineering, Faculty of Engineering to conduct a site investigation at Long Seridan Airfield on 21 August 2020 to assist in the investigation as follows:

a. The Department of Mechanical Engineering conducted a technical study and analysis from data and evidence gathered at the incident site to support preliminary evidence that the aircraft encountered hydroplaning on landing.

b. The Department of Civil Engineering conducted a survey and test at Long Seridan Airfield to gather data to support the above technical analysis. The site survey and test consist of tasks as follows:

i. Site Reconnaissance Survey.
ii. Skid Resistance Tests.
iii. Field Surveying Works.

## 2.0 Analysis

### 2.1 The Problem

The pilot stated that the aircraft landed on both the main wheels first before lowering the nose wheel at the normal touch down point. Reverse power and braking were applied simultaneously to stop the aircraft. The aircraft started to veer left a few second after touchdown. The pilot applied right rudder and right brake to steer the aircraft to the centreline but the aircraft did not response to the pilot control input. The momentarily release and re-applying of both brakes was followed by heavier application of right brake in an attempt to steer the aircraft back to centreline. Aircraft continued skidding and exited the left side of the runway. Runway was observed by the pilot to be damp and wind was reported to be light and variable by the Long Seridan operations assistant.

### 2.2 On-Site Investigation

Aircraft runway excursion will always provide on-site evidence especially tyre track marks which are usually very obvious. These track marks will assist in providing crucial evidence and information on what actually happened. Sequence of event of the incident can be traced and reconstructed as in paragraph 2.2.1.

### 2.2.1 Sequence of Tyre Track Marks on Runway


Figure 20: Aircraft landed on centreline and rolling straight after landing before starting to veered left. Pilot applied right rudder and right braking to counter left veering as seen in the initial light starboard main wheel tyre marks. No visible tyre marks for nose and port main wheel during initial veering.

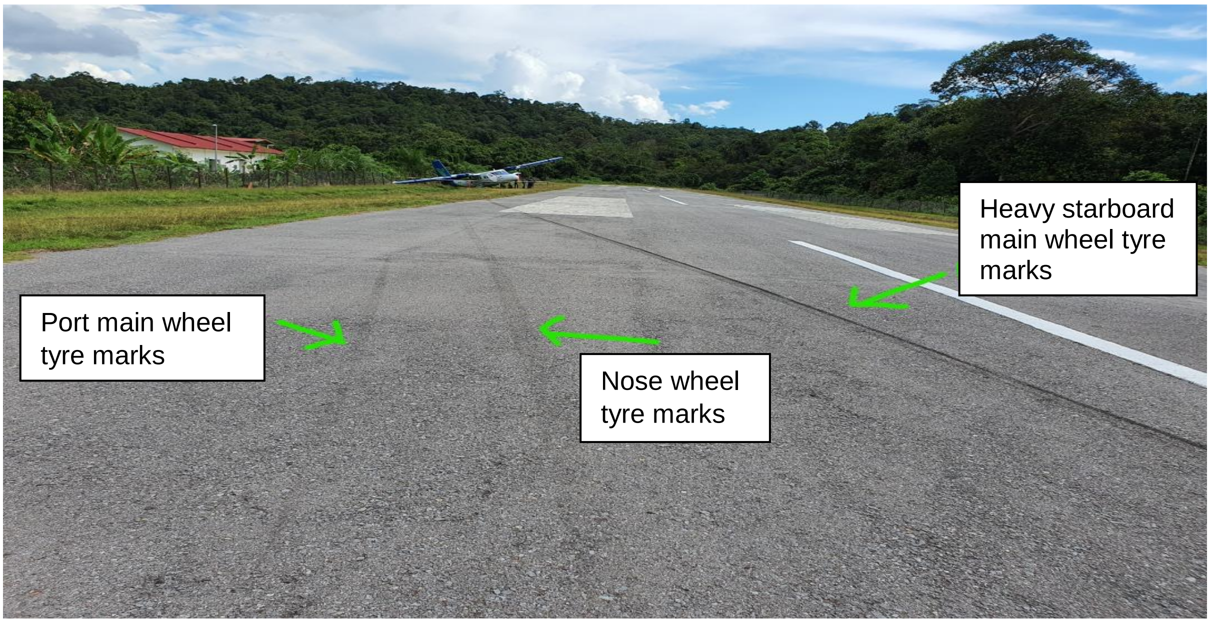



Figure 21: Pilot momentarily release and re-apply of both brakes was followed by heavier application of right brake in an attempt to steer the aircraft back to centreline. Aircraft continue to veer left and started to skid. Pilot maintain right rudder and continue to applied heavier braking on the starboard main wheel. Starboard tyre most probably locks up as seen in the heavy tyre marks on the runway. Visible nose wheel and port

main wheel tyre marks due to skidding as aircraft closing to exiting runway. No visible scalloping of nose wheel tyre marks which will indicate an off-centre (cock) nose wheel.

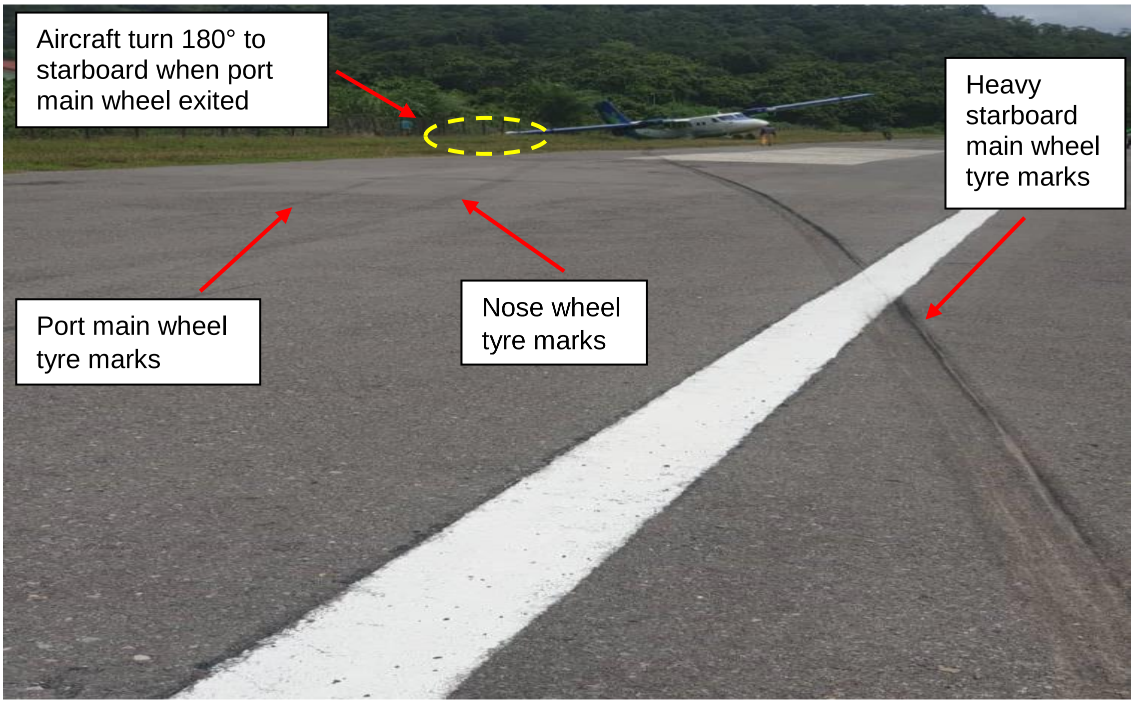



Figure 22: Aircraft continue veering left nearing to left edge of runway. Continuous heavy starboard main wheel tyre marks seen till aircraft exited runway. Light port main wheel tyre marks visible initially due skidding and disappear before wheel reach runway edge. This is probably due to port main wheel tyre momentarily regaining traction on the runway. Light nose wheel tyre marks visible till runway edge probably due to skidding. Aircraft turn 180° to the starboard when port main wheel regain traction just before exiting the runway.

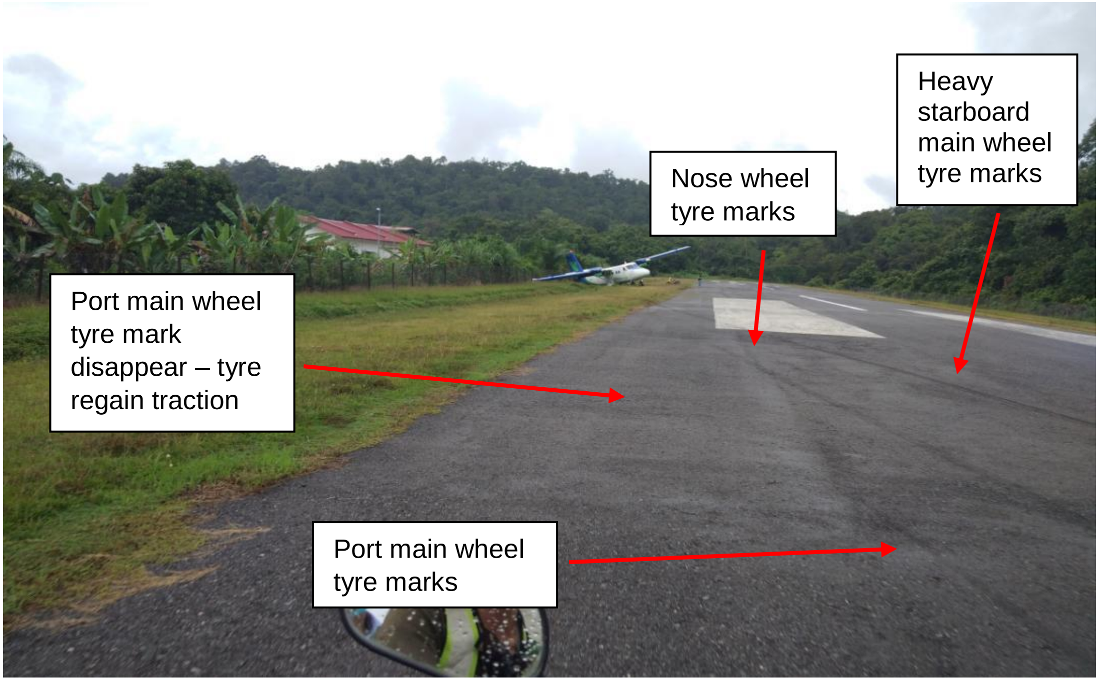



Figure 23: Port main wheel tyre marks which disappear just before aircraft exited runway indicating port main wheel tyre most probably regain traction just before aircraft exited runway.


Figure 24: Aircraft continue with its forward momentum sliding sideways on the wet and soft ground to its final stop position facing close to the reciprocal heading of the landing direction.


Figure 25: Aircraft final stop position after the starboard main wheel landed in the earth drain beside the runway.


Figure 26: Aircraft was recovered from incident site and secured at airfield terminal parking area pending rectification work.

### 2.2.2 Heavy Wear Spot Mark on Starboard Main Wheel Tyre

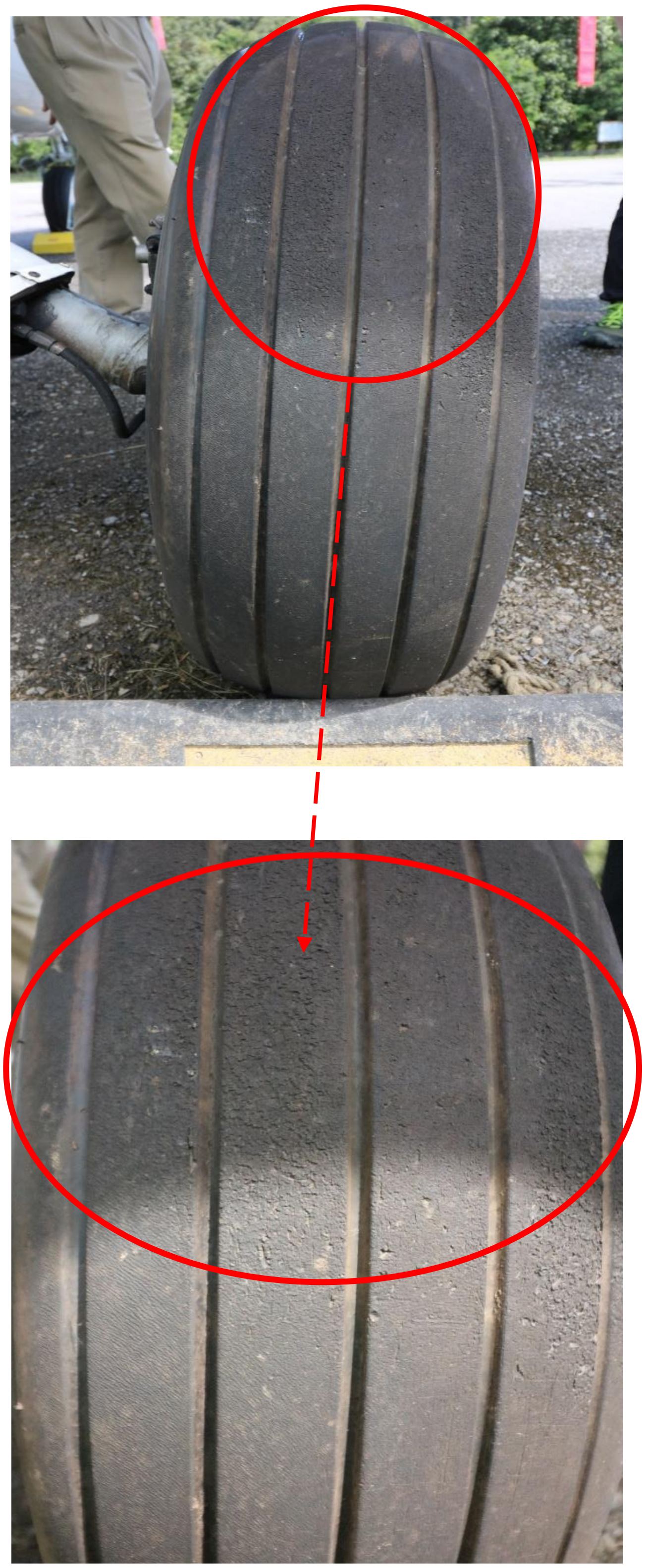


Figure 27: Heavy wear spot mark on the starboard main wheel tyre consistent with dark tyre marks seen on the runway.

## 2.3 On-Site Investigation Analysis

From the aircraft tyre track marks as shown in Figure 20 to Figure 24, it was analysed that when the aircraft touch down on the runway, it rolls straight on the runway centreline for about 4 seconds (See Figure 10 QAR Data) before it started to veer to the left. Tyre marks on the runway shows the aircraft started to veer left about the half way distance from threshold Runway 22 (concurred with captain interview statement).

The aircraft decelerated when reverse and braking were applied. When the aircraft started to veer left, the pilot applied right rudder and right braking to steer the aircraft back to centreline as seen in the light tyre marks for starboard main wheel (Figure 20).

Subsequently, the aircraft started to skid on all wheels as seen in the appearance of light tyre marks for the nose and port main wheel. The pilot momentarily releases and re-apply both brakes was followed by heavier application of right brake in an attempt to steer the aircraft back to centreline (captain interview statement). No visible scalloping seen on nose wheel tyre marks which will indicate an off-centre (cock) nose wheel (Figure 21).

This heavier right braking most probably caused the starboard wheel to lock up as seen in the heavy tyre marks for the starboard main wheel till the aircraft exited the runway. The nosewheel taking some weight of the aircraft when the pilot continues braking, continue to skid ahead till the edge of the runway. This is most probably the reason the aircraft is not responding to the pilot's directional control. When the port main wheel reaches close to the edge of the runway, the port main tyre skid marks disappear. This is most probably due to the port main tyre regaining traction before it exited the runway (Figure 22 and 23).

When the port main wheel regain traction at the edge of the runway, with the right rudder fully applied and heavy right braking, the aircraft veered sharply about 180° to the starboard side. With both main wheels now on the soft and wet ground after exiting the runway, it continues to slide sideways on both main wheels due to the aircraft’s forward momentum (Figure 24). The aircraft stop at the final position when the starboard main wheel landed in the earth drain beside the runway (Figure 25).

The Operator’s Aircraft Recovery Team recovered and cleared the aircraft from the incident site two days after the incident. Aircraft was towed and secured at the airfield terminal parking area pending rectification work (Figure 26).

Inspection on the starboard main wheel tyre after recovery actions shows a heavy wear spot mark consistent with the heavy tyre marks observed on the runway (Figure 27).

Post incident engineering inspection and operational check carried by the operator’s engineering recovery team on the wheels, brake system, steering system, engine reverse power (Beta) and rudder system revealed no abnormality as reported in the Defect/Incident Investigation Report.

In conclusion, based on evidence of tyre skid marks on the runway, the wet runway condition after drizzle, captain interview statement, Defect/Incident Investigation Report, data from QAR and CVR transcript, it was concluded that the aircraft had most probably encountered dynamic hydroplaning on landing. This resulted in the pilot losing directional control of the aircraft although corrective actions to regain control was taken immediately. Evidence shows that the pilot corrective braking input to steer the aircraft back to centreline further aggregated the situation in the wet condition. Evidence from tyre track marks shows that by momentarily releasing the brakes, the port main tyre momentarily regain traction. In a skidding situation, caution use of brakes must be emphasised. The primary use of asymmetric reverse power or both reverse power to maintain direction control and stop the aircraft over the use of brakes is recommended.

### 2.4 Hydroplaning Conditions Analysis

Hydroplaning is defined as the condition in which the tyre footprint is lifted off the runway surface at speed by the action of water on the runway surface. This results in the loss of tyre traction which can be significantly lower than on a dry runway. The

**critical ground speed** at which this condition occurs is referred to as the dynamic hydroplaning speed.

Control of the aircraft on the ground depends on the contact between the tyres and the surface and on the friction provided by that surface. Various factors like runway wetness, water depth, tyre inflation pressure, tyre tread, runway macrotexture[17] and microtexture[18] will determine whether hydroplaning had occurred and how significant its influence is on the braking capabilities of a tyre. These factors will be analysed with the data collected from site investigation carried out by the investigation team and researchers from UPNM at Long Seridan Airfield on 21 August 2020 as below.

### 2.4.1 Runway Wetness Analysis

The wetness of a runway is determined by the amount of rain falling, the duration of the rainfall, the surface wind, the macrotexture of the runway, the cross slope of the runway and the longitudinal slope of the runway.

Evidence to determine the runway wetness when the incident happened is from the pilot and operations assistant visual observation. Photograph taken by witness immediately after the incident provided a good indication of the surface condition. There were no CCTV recording available at the aerodrome.

Long Seridan airfield does not have a meteorological station. The actual weather report is by visual reporting with reference to prominent land marks and also dependent on the experience of the operations assistant at the airfield tower.

The weather was foggy at Long Seridan airfield in the morning. There was light rain over the airfield when the aircraft landed at Marudi. The rain stopped but started drizzling again when the aircraft reported it was visual with

[17] Macrotexture refers to the large-scale texture of the pavement as a whole due to the aggregate particle arrangement (which controls the escape of water from under the tyre and hence the loss of skid resistance with increased speed).
[18] Microtexture refers to the small-scale texture of the pavement aggregate component (which controls contact between the tyre rubber and the pavement surface).

Long Seridan airfield. It stopped when the aircraft was on approach to land. It started to rain lightly again immediately after the incident happened. The wind was reported light and variable with the approach area cloudy to the north/north east direction. Photograph at Figure 6 provides a good guide to the wetness of the runway during the incident.

In conclusion, the runway was wet with possible patches of water on the surface during the aircraft landing. These conditions meet the requirement for hydroplaning to occur. The pavement texture condition analysis at paragraph 2.7 will provide further evidence that the wetness condition on the runway had resulted in low skid resistant on the runway which contributed to the aircraft tyres hydroplaning.

### 2.4.2 Water Depth and Tyre Tread Analysis

For dynamic hydroplaning to occur, the conditions below must be met:

a. Condition 1 - Thickness of water film equals (or larger) than the tyre tread depth[19].

b. Condition 2 - Thickness of water film of 2.5 mm and above[20].

Data obtain from the port main tyre indicates a tyre tread depth of minimum 4mm (Figure 28) while the starboard main tyre is 6mm (Figure 29). The nose tyre has a minimum tyre tread depth of 3mm only (Figure 30).

[19] Hydroplaning of H-Type Aircraft Tires – SAE Technical Paper Series, 2004 World Aviation Congress, Reno, Nevada.
[20] G-XLAC-G-WDA G-EMBO Section 1 – Air Accidents Investigation Branch (AAIB) UK 2009.

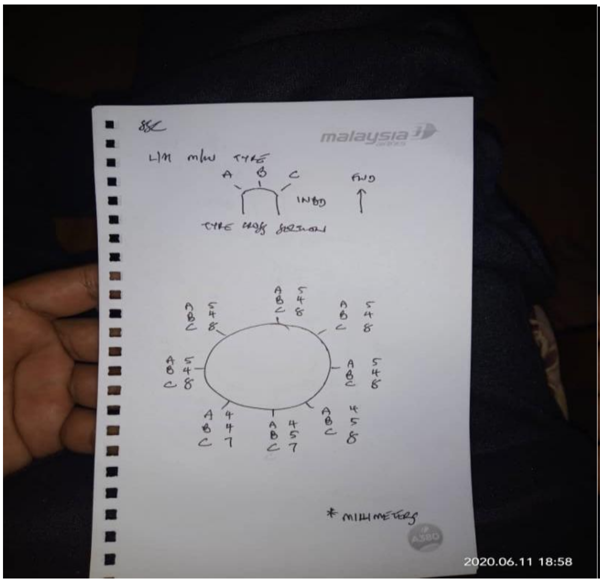



Figure 28: Port main tyre minimum tyre tread - 4 mm mid-section.

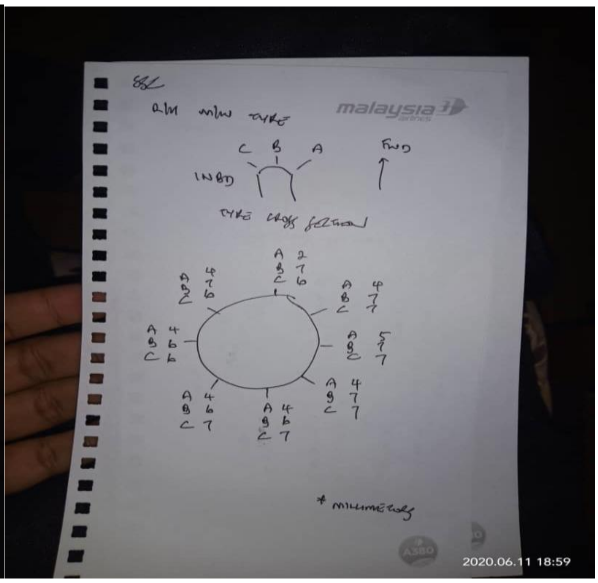



Figure 29: Starboard main tyre minimum tyre tread - 6 mm mid-section

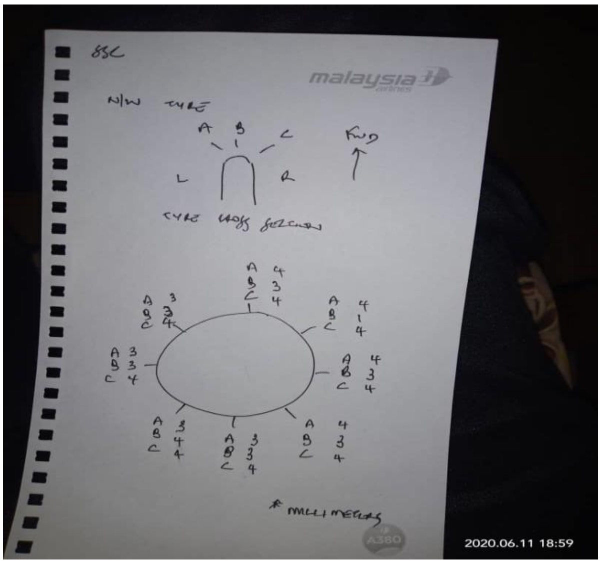



Figure 30: Nose tyre minimum tyre tread - 3 mm mid-section

It requires water film thickness of a minimum of 4mm or more to meet the dynamic hydroplaning conditions for the port main wheel tyre. It was observed that the nose wheel tyre meets the required dynamic hydroplaning condition if the water film thickness is a minimum of 4mm.

The intermittent rain and drizzle in the morning before the aircraft arrival at Long Seridan, the poor pavement condition of the runway and lack of proper drainage (refer paragraph 2.5 & 2.6), it is highly possible for 4mm water film thickness to exist on the runway surface when the aircraft landed.

In conclusion, condition 1 had been met and condition 2 which requires thickness of water film of 2.5 mm and above is also met for dynamic hydroplaning to occur.

## 2.5 Runway Pavement Conditions Analysis (Refer Attachment 1 – UPNM Site Investigation for Long Seridan Airport's Runway Part 1 – Site Reconnaissance Survey)[21]

A site investigation was conducted by researchers from UPNM together with the investigation team at Long Seridan on 21 August 2020. Actual observation of the runway was conducted and mapping of the airfield using DJI Phantom 4 Pro Version 2.0 Drone was also carried out as seen in Figure 31.


Figure 31: Site reconnaissance and mapping on Long Seridan runway using DJI Phantom 4 Pro Version 2.0 Drone

[21] See Ts. Faridah Hanim Khairuddin, UPNM Site Investigation for Long Seridan Airport's Runway Part 1 – Site Reconnaissance Survey dated 28 October 2020.

Summary of observation from the report are as follows:

### 2.5.1 Water Bleeding Distress

Water bleeding is a phenomenon when water seeps out of joints or cracks or through an excessively porous asphalt layer. The water sources are typically rain water, surface run-off and subsurface water from high ground water table.

Long Seridan airfield is situated very near a big river and most likely to have a high-water table. It was observed that black spots were clearly seen on most part of Long Seridan runway especially around both the runway threshold area (Figure 32). The appearance of the black spots on the pavement surface are the effects of vapour rising from the ground water table in addition to surface run-off water.

Inadequate drainage system at Long Seridan is a major caused of water bleeding. Inadequate drainage system had caused most parts of the pavement subgrade on the runway to become saturated, thus loosing strength and stability. It will result in the overlying pavement structure to break up under imposed loads during an aircraft take-off and landing.

It is concluded that water bleeding distress is quite severe on Long Seridan runway. The distress is caused by inadequate drainage which will result in the poor drainage of run-off water and will contribute to low skid resistance of the runway.

Figure 32: Water bleeding (black spots) distress occurrence on Long Seridan runway

### 2.5.2 Pavement Cracking Distress

Cracking occurred from variety of causes like stresses from axle loads, changes in weather and excessive precipitation. Poor drainage system can also cause the pavement to severely deteriorate and crack under the pressure.

From Figure 33, it was observed that Long Seridan runway is experiencing quite severe alligator or fatigue cracking[22]. Most of the cracking had occurred at areas where the aircraft touchdown and where the aircraft make turns on the runway. These areas are prone to this type of distress because of the extra stress on the pavement surface when the aircraft touches the pavement or during braking on landing or turns.

[22] Medium severity alligator cracking is defined by interconnected cracks forming many sided sharp, angled pieces that develop into a pattern resembling the back of an alligator or crocodile.

It is concluded that the Long Seridan asphalt pavement alligator cracks are severe and the cracks will continue to deteriorate until they are repaired. These cracks had allowed water to penetrate beneath the pavement and reach the base. When the water erodes the base, it allows areas of the pavement to sag or subside. The pavement sag will result in poor water drain-off on the runway surface which will contribute to low skid resistance of the runway.

Figure 33: Cracking distress on Long Seridan runway

### 2.5.3 Pavement Disintegration Distress

There are 2 types of pavement disintegration distress. They are ravelling[23] and stripping[24]. Ravelling will cause pavement problems due to loosen debris on runway surface, roughness and water collecting in the ravelled locations which results in loss of surface friction.

From Figure 34, it was observed that Long Seridan pavement is experiencing ravelling in most part of the runway. If there are no action taken to correct ravelling on the pavement, it will lead to stripping and decreased structural support as seen in the pothole on the runway in Figure 18.

[23] Ravelling is the progressive disintegration of a Hot Mix Asphalt (HMA) layer from the surface downward as a result of the dislodgement of aggregate particles.
[24] Stripping is the disintegration that occurred because of the loss of bond between aggregates and asphalt binder that typically begins at the bottom of the HMA layer and progresses upward.

It is concluded that ravelling had occurred at many areas of the Long Seridan runway. Urgent rehabilitation and repair work are needed to ensure the runway retains the surface friction needed for safe aircraft operations especially during wet condition.

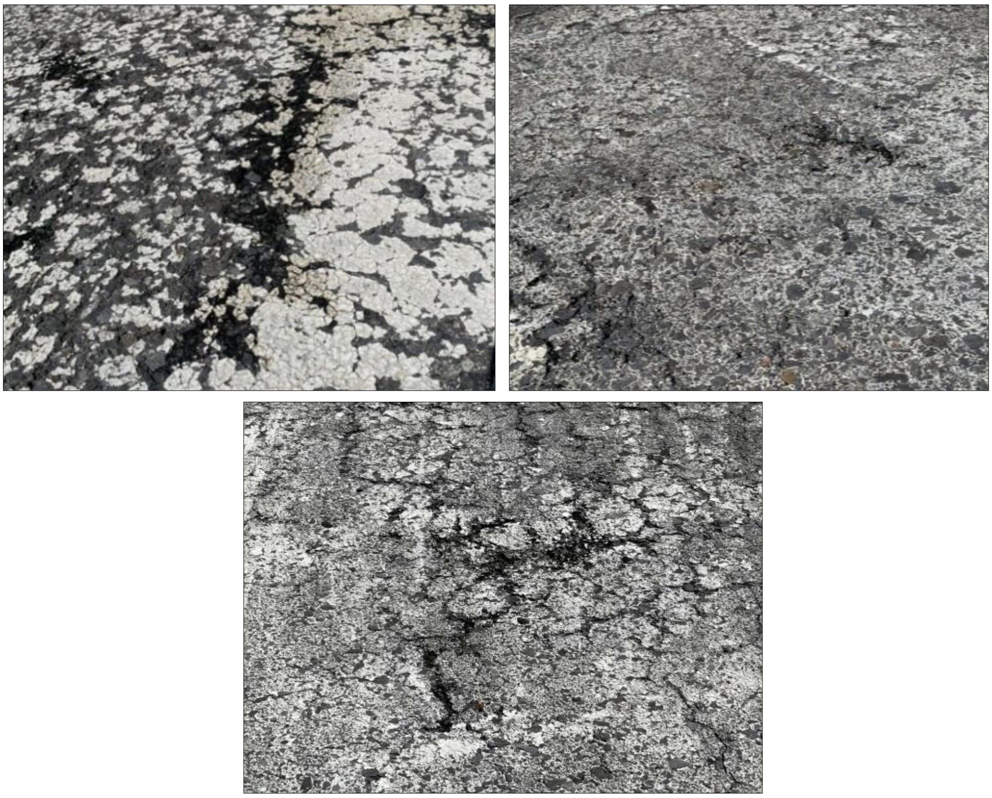


Figure 34: Ravelling distress on Long Seridan runway

### 2.5.4 Polished Aggregate Distress

Polished aggregate occurred is due to repeated traffic application. Polished aggregate had occurred when a pavement reveals the portion of aggregate extending above the asphalt is either very small or there are no rough or angular aggregate particles to provide good pavement surface friction.

From Figure 35, it was observed that Long Seridan runway shows this distress where it is clearly seen that the portion of aggregate had extend above the asphalt. The distress surface will provide more area for water ponding which will contribute to poor pavement surface friction.

Figure 35: Polished aggregate distress on Long Seridan runway

It is concluded that the polished aggregate distress condition is severe at Long Seridan runway. The distress condition result in poor pavement surface friction which contributes to low skid resistance of the tyres during take-off and landing especially in wet conditions. With this distress condition, the probability of skidding incident occurring in dry conditions is also high as the pavement surface friction will be at very minimum level.

## 2.6 Runway Slope Analysis (Refer Attachment 2 – UPNM Site Investigation for Long Seridan Airport's Runway Part 2 – Skid Resistance Tests)[25]

Long Seridan airfield falls under aerodrome reference code 1B[26]. The slope of RWY-SWY (longitudinal) for Runway 04 is +0.368% and Runway 22 is -0.368%[27]. The longitudinal slope changes should not exceed 2% while the transverse slope should ideally be 2% as stated in ICAO Annex 14[28]. This is to promote rapid drainage of water for aerodrome which are exposed to heavy or torrential rainfall throughout the year like Long Seridan.

It was observed that earth drainage is located at both side of the runway, approximately 5m from the edge of runway with no proper water discharge identified. The area was surrounded by river and type of soil is believed to be sandy. Figure 36 showed the actual condition of Long Seridan runway captured from top view.

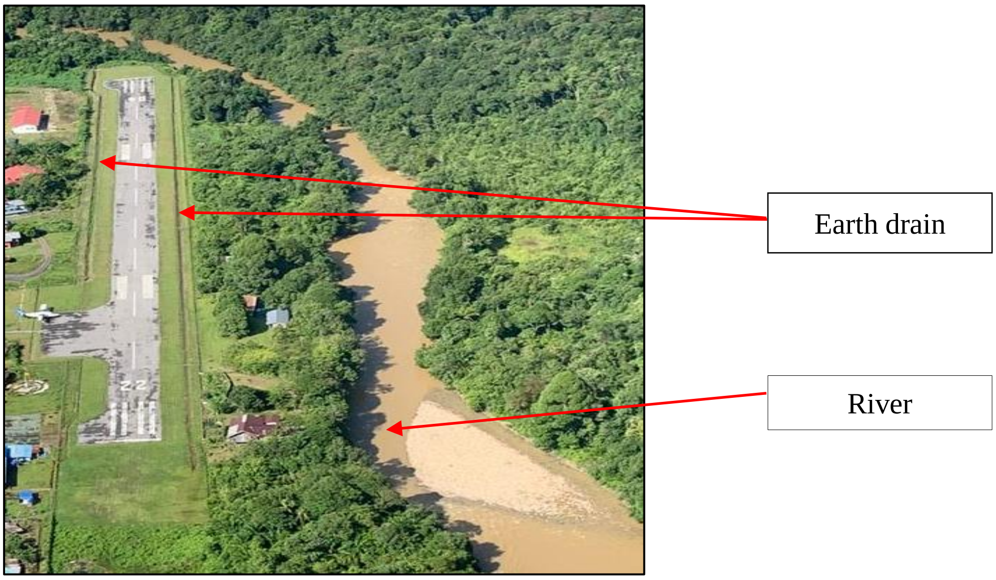



Figure 36. Long Seridan runway from top view

[25] See Dr.Ng Choy Peng, UPNM Site Investigation for Long Seridan Airport's Runway Part 2 – Skid Resistance Tests dated 15 October 2020.

[26] International Civil Aviation Organization (ICAO), 2018. Annex 14 Aerodromes, Volume 1 - Aerodrome Design and Operations, 8th Ed, Chapter 1, paragraph 1.6.4.
Code Number 1 - Aerodrome Refence Field Length less than 800m.
Code Letter B - Wingspan 15m up to but not including 24m.

[27] AIP Malaysia AD-2-WBGI-1-1 dated 16 August 2018.

[28] International Civil Aviation Organization (ICAO), 2018. Annex 14 Aerodromes, Volume 1 - Aerodrome Design and Operations, 8th Ed, Chapter 3, paragraph 3.1.9

From the field surveying data, various cross-sections along the runway were analysed to determine the transverse slopes of the runway as shown in Figure 38 and 39. Figure 37 show the summary of data for the transverse slopes at Long Seridan.

| Cross-Section | Transverse Slopes | |
|---|---|---|
| | Left-Hand Side | Right-Hand Side |
| T1T2 | 2.1% | 1.9% |
| T3T4 | 3.3% | 1.9% |
| 3ULUR | 4.2% | 2.6% |
| 4ULUR | 4.3% | 2.7% |
| 5ULUR | 3.2% | 2.7% |
| 6BLBR | 3.3% | 2.5% |
| 7BLBR | 3.8% | 2.1% |
| SM1 | 3.7% | 1.7% |
| SM2 | 2.8% | 1.8% |
| SM3 | 3.3% | 2.2% |
| SM4 | 3.1% | 2.2% |
| SM5 | 2.8% | 1.9% |
| SM6 | 3.3% | 2.2% |
| SM7 | 3.3% | 1.6% |
| SM8 | 3.5% | 2.0% |

Figure 37: Transverse Slopes at Various Cross-Sections along the Runway

From Figure 37, Long Seridan runway meets the transverse slope requirement of 2% as stated in ICAO Annex 14 which states "in any event should not exceed 1.5 per cent or 2 per cent, as applicable, nor be less than 1 per cent except at runway or taxiway intersections where flatter slopes may be necessary"[29].

It is concluded that the transverse slope at Long Seridan runway meets the requirement to drain run-off water satisfactory. It is observed that there is earth drainage system on both sides of the runway but with no proper water discharge identified. This means that run-off water will not be able to be discharge away rapidly although the transverse slope meets the required requirements.

[29] International Civil Aviation Organization (ICAO), 2018. Annex 14 Aerodromes, Volume 1 - Aerodrome Design and Operations, 8th Ed, Chapter 3, paragraph 3.1.9

## 2.7 Pavement Texture Conditions Analysis (Refer Attachment 2 – UPNM Site Investigation for Long Seridan Airport's Runway Part 2 – Skid Resistance Tests)[30]

Information on the texture condition will assist in the investigating of wet runway related accidents. The runway micro and macrotextures play an important role as both have a significant influence on the skid resistance and therefore hydroplaning on the runway. An assessment of both surface micro and macrotexture condition are necessary to fully relate skid resistance to pavement condition.

Skid resistance is the force produced when a tyre is prevented from rotating slides along the pavement surface[31]. Skid resistance is an important pavement evaluation parameter as inadequate skid resistance will lead to higher incidences of skid related accidents.

Skid resistance depends on a pavement surface's microtexture and macrotexture[32]. Microtexture refers to the small-scale texture of the pavement aggregate component (which controls contact between the tyre rubber and the pavement surface) while macrotexture refers to the large-scale texture of the pavement as a whole due to the aggregate particle arrangement (which controls the escape of water from under the tyre and hence the loss of skid resistance with increased speed)[33]. Skid resistance changes over time. Generally, it increases in the first two years after construction as the pavement is worn away by traffic and when rough surfaces aggregate become exposed. It decreases over the remaining pavement life as aggregates become more polished to usage and weather element.

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[30] See Dr. Ng Choy Peng, UPNM Site Investigation for Long Seridan Airport's Runway Part 2 – Skid Resistance Tests dated 15 October 2020.
[31] National Cooperative Highway Research Program Synthesis of Highway Practice 14: Skid Resistance. Highway Research Board, National Academy of Sciences, Washington, D.C.
[32] Friction and Surface Texture Characterization of 14 Pavement Test Sections in Greenville, North Carolina. Transportation Research Record 1639. Transportation Research Board, National Research Council. Washington, D.C.
[33] Task Force for Pavement Design of the AASHTO Operating Subcommittee on Design (AASHTO). (1976). Guidelines for Skid Resistant Pavement Design. American Association of State Highway and Transportation Officials. Washington, D.C.

Skid number (SN) is an indication of the skid resistance by taking into consideration the microtexture and macrotexture condition. The British Pendulum Number (BPN) readings in Figure 42 to 47 are results from the British PendulumTests carried out at Long Seridan runway. It is associated with the microtexture pavement condition which could be used to calculate the skid number at zero speed. Even though the sand patch tests for macrotexture pavement condition were not carried out on Long Seridan runway, the percent normalized gradient (PNG) could be estimated based on calculation[34].

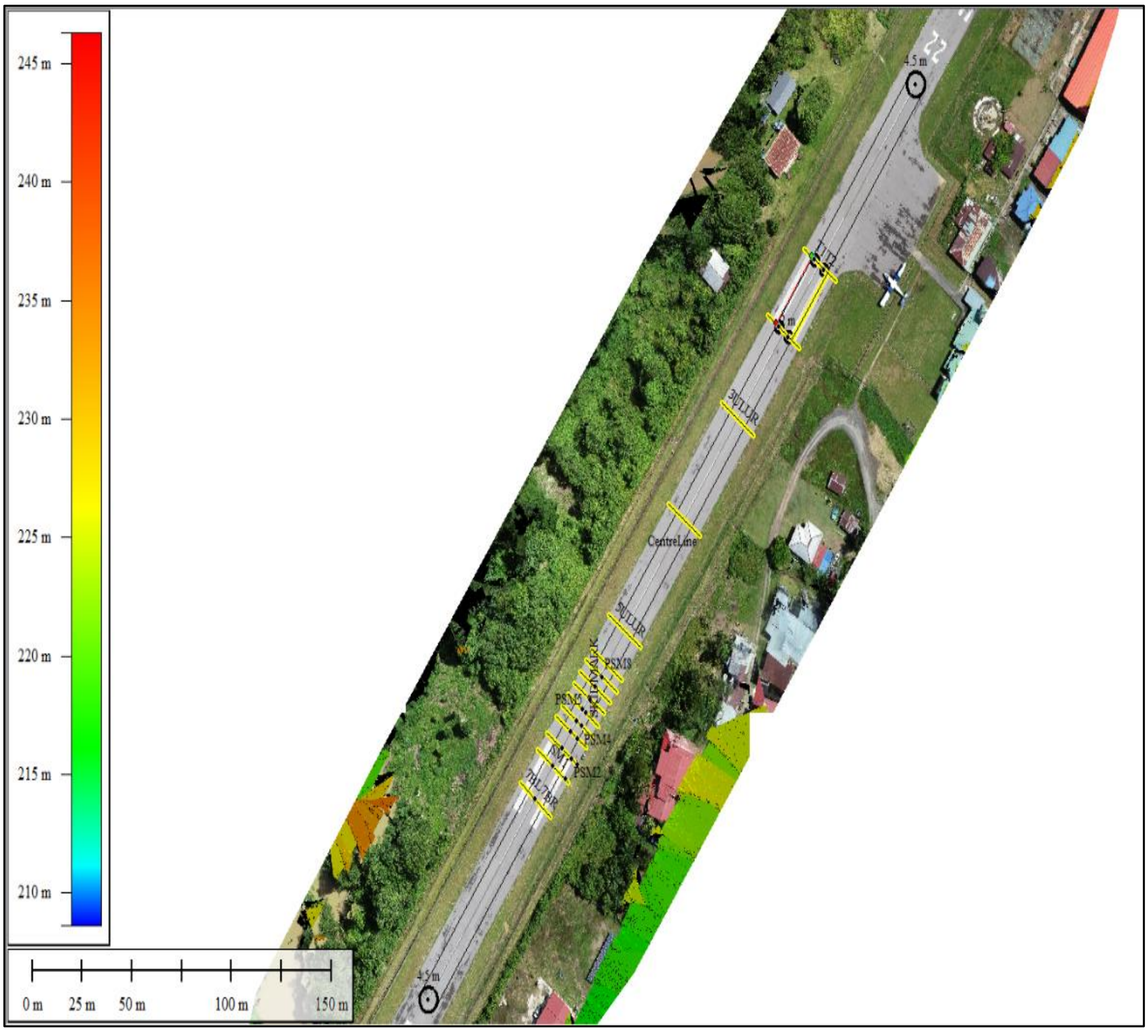


Figure 38: Layout Plan for Skid Resistance Tests at Long Seridan

[34] Leu, M.C., Henry, J.J., 1978. Prediction of skid resistance as a function of speed from pavement texture measurement. Transportation Research Record, 666, 38-43. Transportation Research Board.

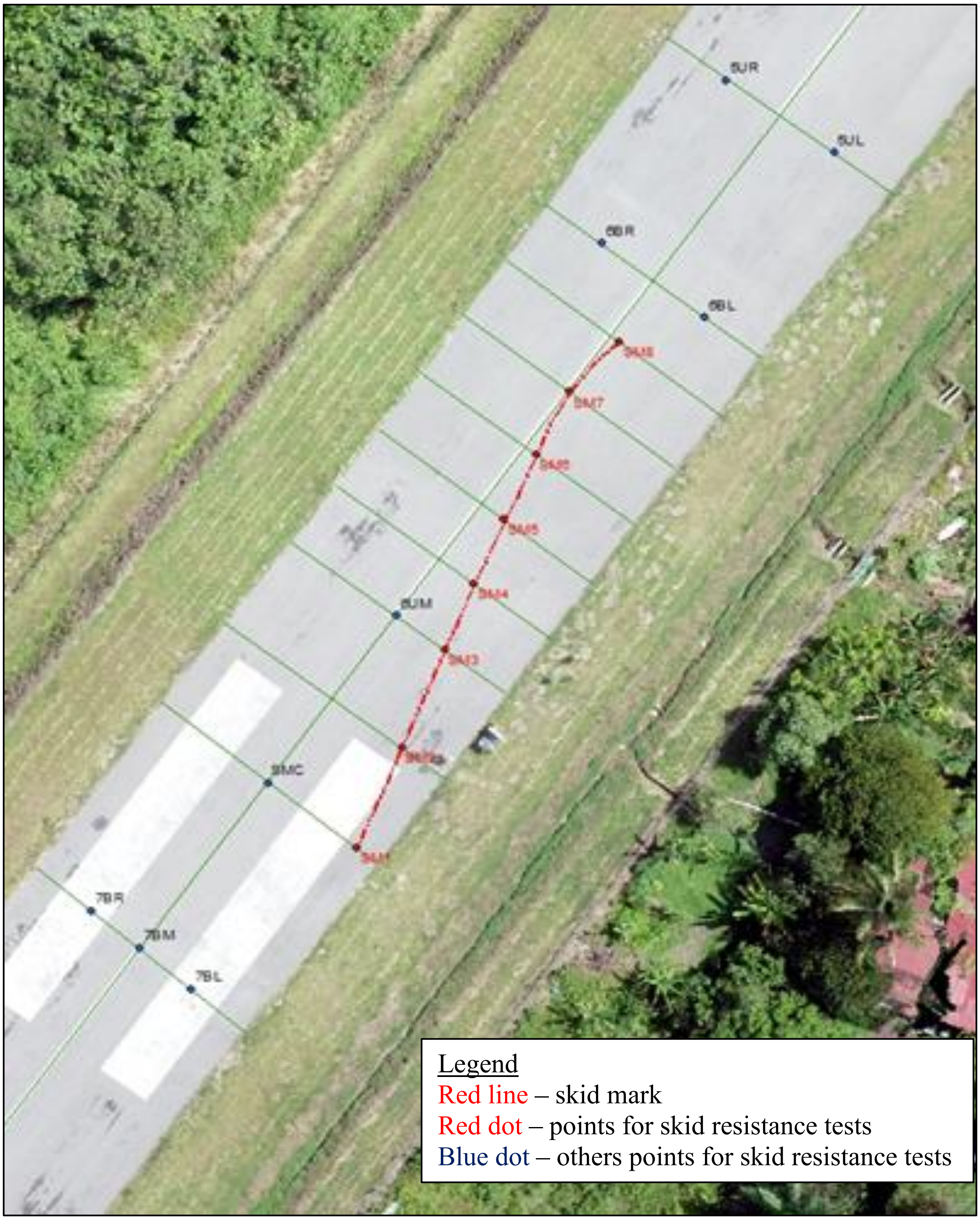


Figure 39: Layout Plan for Skid Resistance Tests at Long Seridan

Figure 38 and 39 shows the dry and wet BPN readings where the skid resistance tests were performed at Long Seridan runway. These readings were separated into different groups, (1) BPN readings at centreline, (2) BPN readings at the left-hand side of the runway, (3) BPN readings at the right-hand side of the runway and (4) BPN readings at the skid marks location.

The relationship between skid number at zero speed ($SN_0$) and the British Pendulum Number (BPN), and between percent normalized gradient (PNG) and mean texture depth (MTD) are as follows[35]:

$$SN_0 = 1.32BPN - 34.9$$ - Equation 1

$$PNG = 0.157MTD^{-0.47}$$ - Equation 2

$SN_0$ = skid number at zero speed

BPN = British Pendulum Number

PNG = percent normalized gradient in mile/hour

MTD = mean texture depth in inches

Figure 40 shows the skid number corresponding to the indication when pavement maintenance and rehabilitation work are required. A skid number of 31 or less will also indicate that skid incident is likely to occur on the stated pavement illustrated in the data at Figure 42 to 47 for Long Seridan runway if no actions are taken to correct the pavement texture or condition.

| **Skid Number (SN)** | **Indication (pavement maintenance and rehabilitation requirement)** |
|---|---|
| < 31 | Take measures to correct the pavement texture |
| ≥ 30 | Acceptable for pavement with light (low) traffic loading |
| 31 – 34 | Monitor pavement frequently |
| > 35 | Acceptable for pavement with heavy (high) traffic loading |

Figure 40: Typical Skid Number with Pavement Maintenance and Rehabilitation Requirement
(Source: Wambold et al., 1990; Jayawickrama et al., 1996)

Figure 41 shows the pavement condition corresponding to the mean texture depth which shows the lower the mean texture depth, the poorer the condition of the pavement. With reference to ICAO Annex 14, Aerodromes Volume 1[36], the mean

[35] Meyer, W.E., 1991. Pavement texture significance and measurement. Standardization News, ASTM, February, 28-31.

[36] International Civil Aviation Organization (ICAO), 2018. Annex 14 Aerodromes, Volume 1 - Aerodrome Design and Operations, 8th Ed, Attachment A, paragraph 8.3.10.

texture depth of a normal wet runway should be at least 0.25mm or 0.01in to provide adequate drainage and friction qualities.

| Pavement Condition Indication | Mean Texture Depth (MTD) |
|---|---|
| Good | 0.76mm or 0.03in. |
| Average | 0.51mm or 0.02in. |
| Poor | 0.25mm or 0.01in. |
| Very Poor | 0.13mm or 0.005in. |

Figure 41: Pavement Texture Condition and Corresponding Mean Texture Depth (Source: Leu, M.C.; Henry, J.J., 1978)

For analysis on the skid number at Long Seridan runway, the landing speed (ground speed) of the aircraft was used to simulate the possibility of a skid incident. The flare before touching down speed, the touch down speed and the aircraft speed when aircraft yaw at 7 degrees per second at 75kts (86.3mph), 61kts (70.2mph) and 44kts (50.6mph), respectively, were used to simulate the SN. Figure 42 to 44 show the wet estimations and Figure 45 to 47 show the dry estimations of the SN.

The important factor to analyse in Figure 42 to 47 is the skid number below 31 corresponding to a mean texture depth of 0.25mm (0.01in) or lower according to the aircraft stage of flight ground speed which will show a high possibility of a skid incident on Long Seridan runway due to poor pavement friction qualities.

### 2.7.1 Estimation Skid Number Using Wet BPN Readings

The resulted estimated SN using the wet BPN readings in Figure 42 to 44 are used to analyse the skid resistance of Long Seridan runway.

| Condition | Good | Average | Poor | V.Poor |
|---|---|---|---|---|
| British Pendulum Number, *BPN* | 74.31 | 74.31 | 74.31 | 74.31 |
| Speed of aircraft, *V (mph)* | 86.3 | 86.3 | 86.3 | 86.3 |
| Skid number at zero speed, $SN_0 = 1.32BPN - 34.9$ | 63.19 | 63.19 | 63.19 | 63.19 |
| Mean texture depth, *MTD (inches)* | 0.03 | 0.02 | 0.01 | 0.005 |
| Percent normalized gradient, $PNG = 0.157MTD^{-0.47}$ | 0.82 | 0.99 | 1.37 | 1.89 |
| Skid Number, $SN = SN_0 e^{-\left(\frac{PNG}{100}\right)V}$ | 31.25 | 26.95 | 19.42 | 12.32 |

Figure 42: Estimation of Skid Number Using Wet BPN Readings (Speed = 86.3mph)

Referring to Figure 42, the estimated SN based on four different pavement conditions respectively were 31.25, 26.95, 19.42 and 12.32. The data shows that the probability for a skid incident to happened at the Long Seridan runway is high even before the aircraft touchdown as the estimated SN is below 31 (26.95) corresponds with an average pavement condition (mean texture depth of 0.02in). It means that the probability of a skid incident to happen is higher if the pavement condition is worse than the average (mean texture depth of 0.01 and below).

| Condition | Good | Average | Poor | V.Poor |
|---|---|---|---|---|
| British Pendulum Number, *BPN* | 74.31 | 74.31 | 74.31 | 74.31 |
| Speed of aircraft, *V (mph)* | 70.2 | 70.2 | 70.2 | 70.2 |
| Skid number at zero speed, $SN_0 = 1.32BPN - 34.9$ | 63.19 | 63.19 | 63.19 | 63.19 |
| Mean texture depth, *MTD (inches)* | 0.03 | 0.02 | 0.01 | 0.005 |
| Percent normalized gradient, $PNG = 0.157MTD^{-0.47}$ | 0.82 | 0.99 | 1.37 | 1.89 |
| Skid Number, $SN = SN_0 e^{-\left(\frac{PNG}{100}\right)V}$ | 35.64 | 31.60 | 24.20 | 16.72 |

Figure 43: Estimation of Skid Number Using Wet BPN Readings (Speed = 70.2mph)

From Figure 43, the estimated SN indicated that when the aircraft is at touchdown speed of 61kts (70.2mph), skid incident is likely to occur when the mean texture depth of the pavement is below 0.01in. In this incident, the aircraft started to veer left just as it slows after touchdown which corresponded with the estimated SN of 24.20 and a mean texture depth of 0.01in and below. It indicates that Long Seridan runway had very poor surface friction qualities to prevent the aircraft from skidding.

| **Condition** | **Good** | **Average** | **Poor** | **V.Poor** |
|---|---|---|---|---|
| British Pendulum Number, *BPN* | 74.31 | 74.31 | 74.31 | 74.31 |
| Speed of aircraft, *V (mph)* | 50.6 | 50.6 | 50.6 | 50.6 |
| Skid number at zero speed, $SN_0 = 1.32BPN - 34.9$ | 63.19 | 63.19 | 63.19 | 63.19 |
| Mean texture depth, *MTD (inches)* | 0.03 | 0.02 | 0.01 | 0.005 |
| Percent normalized gradient, $PNG = 0.157MTD^{-0.47}$ | 0.82 | 0.99 | 1.37 | 1.89 |
| Skid Number, $SN = SN_0 e^{-\left(\frac{PNG}{100}\right)V}$ | 41.82 | 38.34 | 31.63 | 24.23 |

Figure 44: Estimation of Skid Number Using Wet BPN Readings (Speed = 50.6mph)

From Figure 44, when the aircraft experienced skidding at the speed of 44kts (50.6mph), the skid number (24.23) clearly indicates that the surface friction qualities of Long Seridan runway had failed to provide adequate friction to prevent the skid incident from occurring. The data shows that the mean texture depth (0.005in) is below the required standard (0.01in) as stated in ICAO Annex 14.

In summary, Figure 42 shows that skid incident is likely to happen at Long Seridan runway at above touchdown speed as the estimated SN is below 31 for an average runway pavement condition. Any condition below average will increase the risk of skid incident happening. Figure 43 shows that when the aircraft starts to veer left, it corresponds with a pavement condition that is poor. Finally, when the aircraft starts to skid, Figure 44 provide evidence that Long Seridan runway is in a very poor condition. The very poor condition represents a mean texture depth of 0.005in which correspond with very poor skid resistance characteristic.

It is concluded that the Long Seridan runway mean texture depth is in a very poor condition (0.005in). The poor condition had resulted in very poor surface friction qualities which had contributed to the skid incident.

### 2.7.2 Estimation Skid Number Using Dry BPN Readings

The resulted estimated SN using the dry BPN readings as shown in Figure 45 to 47 are used to analyse the skid resistance characteristic of Long Seridan runway for comparison purposes.

| **Condition** | **Good** | **Average** | **Poor** | **V.Poor** |
|---|---|---|---|---|
| British Pendulum Number, *BPN* | 81.61 | 81.61 | 81.61 | 81.61 |
| Speed of aircraft, *V (mph)* | 86.3 | 86.3 | 86.3 | 86.3 |
| Skid number at zero speed, $SN_0 = 1.32BPN - 34.9$ | 72.83 | 72.83 | 72.83 | 72.83 |
| Mean texture depth, *MTD (inches)* | 0.03 | 0.02 | 0.01 | 0.005 |
| Percent normalized gradient, $PNG = 0.157MTD^{-0.47}$ | 0.82 | 0.99 | 1.37 | 1.89 |
| Skid Number, $SN = SN_0 e^{-\left(\frac{PNG}{100}\right)V}$ | 36.01 | 31.07 | 22.38 | 14.20 |

Figure 45: Estimation of Skid Number Using Dry BPN Readings (Speed = 86.3mph)

| **Condition** | **Good** | **Average** | **Poor** | **V.Poor** |
|---|---|---|---|---|
| British Pendulum Number, *BPN* | 81.61 | 81.61 | 81.61 | 81.61 |
| Speed of aircraft, *V (mph)* | 70.2 | 70.2 | 70.2 | 70.2 |
| Skid number at zero speed, $SN_0 = 1.32BPN - 34.9$ | 72.83 | 72.83 | 72.83 | 72.83 |
| Mean texture depth, *MTD (inches)* | 0.03 | 0.02 | 0.01 | 0.005 |
| Percent normalized gradient, $PNG = 0.157MTD^{-0.47}$ | 0.82 | 0.99 | 1.37 | 1.89 |
| Skid Number, $SN = SN_0 e^{-\left(\frac{PNG}{100}\right)V}$ | 41.07 | 36.42 | 27.89 | 19.27 |

Figure 46: Estimation of Skid Number Using Dry BPN Readings (Speed = 70.2mph)

| Condition | Good | Average | Poor | V.Poor |
|---|---|---|---|---|
| British Pendulum Number, *BPN* | 81.61 | 81.61 | 81.61 | 81.61 |
| Speed of aircraft, *V (mph)* | 50.6 | 50.6 | 50.6 | 50.6 |
| Skid number at zero speed, $SN_0 = 1.32BPN - 34.9$ | 72.83 | 72.83 | 72.83 | 72.83 |
| Mean texture depth, *MTD (inches)* | 0.03 | 0.02 | 0.01 | 0.005 |
| Percent normalized gradient, $PNG = 0.157MTD^{-0.47}$ | 0.82 | 0.99 | 1.37 | 1.89 |
| Skid Number, $SN = SN_0 e^{-\left(\frac{PNG}{100}\right)V}$ | 48.19 | 44.19 | 36.46 | 27.93 |

Figure 47: Estimation of Skid Number Using Dry BPN Readings (Speed = 50.6mph)

The estimated SN in dry surface conditions in Figure 45 to 47 does not show significant difference as compare to the estimated SN in wet conditions in Figure 42 to 44. Estimated SN in dry conditions for touchdown speed (SN 27.89) and when aircraft skidded (SN 27.93) indicates that Long Seridan runway is in a poor condition. It corresponds with a mean texture depth of 0.01in and below which indicates that the runway pavement will not provide adequate surface friction qualities during dry condition.

It is concluded that skid incident is likely to occur at Long Seridan when runway surface is dry due to poor skid resistance characteristic which relates to the finding of a very poor mean texture depth of the pavement (0.005in).

### 2.8 Dynamic Hydroplaning Speed Analysis (Refer Attachment 3 – UPNM Skidding Incident of 9M-SSC Aircraft at Long Seridan Airport: Aquaplaning Analysis)[37]

Dynamic hydroplaning is a relatively high-speed phenomenon that occurs when there is a film of water on the runway that is at least 2.5mm deep. When the speed of the aircraft increases and the depth of the water rises, the water layer builds up an increasing resistance to displacement, resulting in the formation of a wedge of water beneath the tyre.

[37] See Ir. Ts,Dr. Mohd Rashdan Saad, Skidding Incident of 9M-SSC Aircraft at Long Seridan Airport: Aquaplaning Analysis dated 27 October 2020.

Dynamic hydroplaning generally relates to tyre inflation pressure. Tests have shown that for tyres with significant loads and enough water depth for the amount of tread so that the dynamic head pressure from the speed is applied to the whole contact patch, the minimum speed for dynamic aquaplaning Vp in knots can be established. The equation that relates hydroplaning speed with the tyre inflation pressure are plotted in Figure 48 based on Horne's[38] and Cepic's[39] empirical equation.

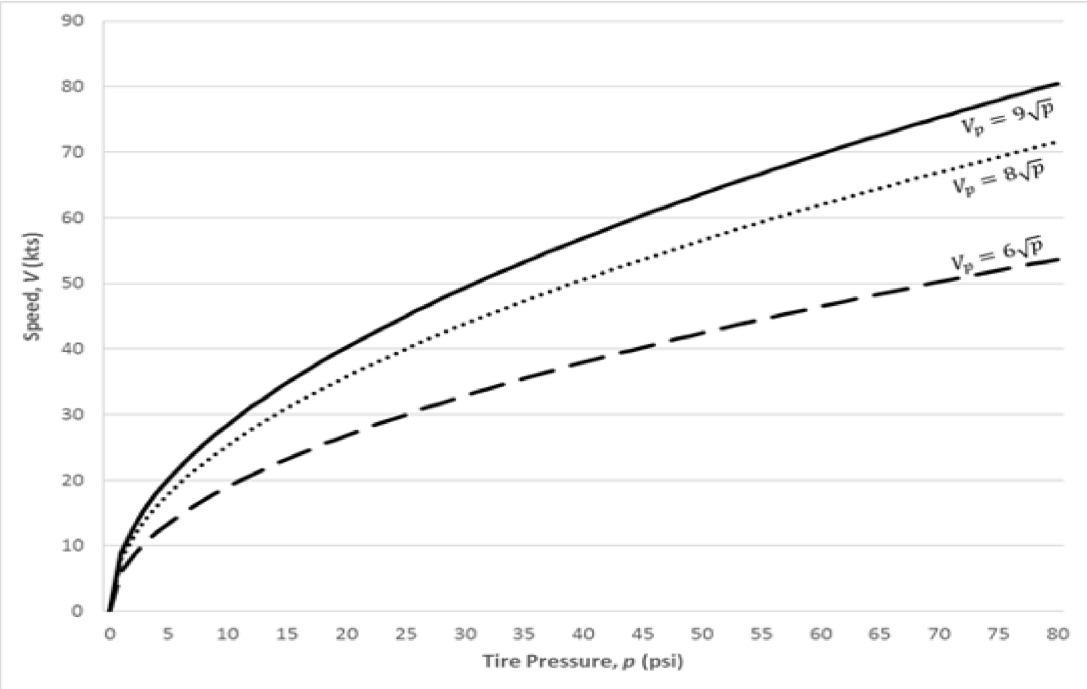


Figure 48: Relation between aircraft tyre pressure with hydroplaning velocity of aircraft

To analyse the hydroplaning speed, **ground speed** of the aircraft was extracted from the QAR (Figure 49) and plotted on a graph form to show the chronology of events in Figure 50.

[38] R.C. Dreher and W.B. Horne. Phenomena of pneumatic tire hydroplaning. Technical Report TN D-2056, NASA, 1963.
[39] A Cepic. Hydroplaning of H-Type Aircraft Tires. Technical Report 2004-01-3119, SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001 U.S.A, 2004.

**Flight Phase: Final Approach to Aircraft Complete Stop: -**

| Time UTC | Height AFE | Flight Parameters: Heading(M), TQ1&2 | | | Np 1 & 2 | | Calibrated Speed/ **Ground Speed** kts | Wind Speed/Wind Direction | Vertical Speed (fpm) | Flaps setting | Remark & Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 02:00:42 | 108 | 213 | 4.0 | 4.6 | 72 | 72 | 72/ **82** | 26/63 | -787 | 36 | Approach Stabilized |
| 02:00:47 | 52 | 211 | 1.5 | 1.5 | 68 | 68 | 66/ **75** | 25/62 | -459 | 36 | Flare before touchdown |
| 02:00:53 | 0 | 213 | 1.4 | 1.1 | 66 | 65 | 52/ **61** | 24/60 | 0 | 36 | Aircraft touchdown |
| 02:00:57 | 0 | 206 | 2.1 | 2.0 | 62 | 60 | 22/ **44** | 24/54 | 0 | 36 | Yaw at 7 degrees per second |
| 02:01:05 | 0 | 290 | 2.8 | 2.7 | 51 | 49 | 0 | 0 | 0 | 36 | **Aircraft came to a complete stop. Yaw at 20 degrees per second** |

Figure 49: QAR data in ground speed

From the analysis of the QAR using **ground airspeed**, it can be seen that at 02:00:42, the aircraft approach was stabilized as it reached 108ft above field elevation at 82kts and flared before touch down at the recorded time 02:00:47 at 75kts. The aircraft touchdown on the runway at 61kts at the recorded time of 02:00:53 and proceeded to decelerate to 44kts and was found to yaw at 7 degrees per second to the left at 2:00:57 and finally came to a complete rest at 2:01:05.

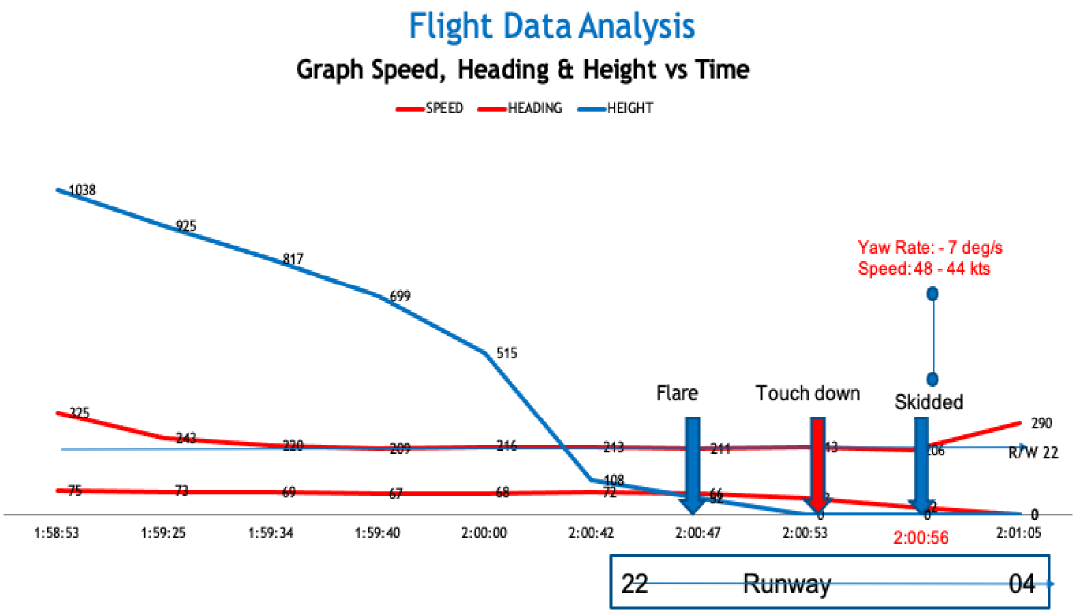


Figure 50: Flight data analysis showing the incident chronology of events

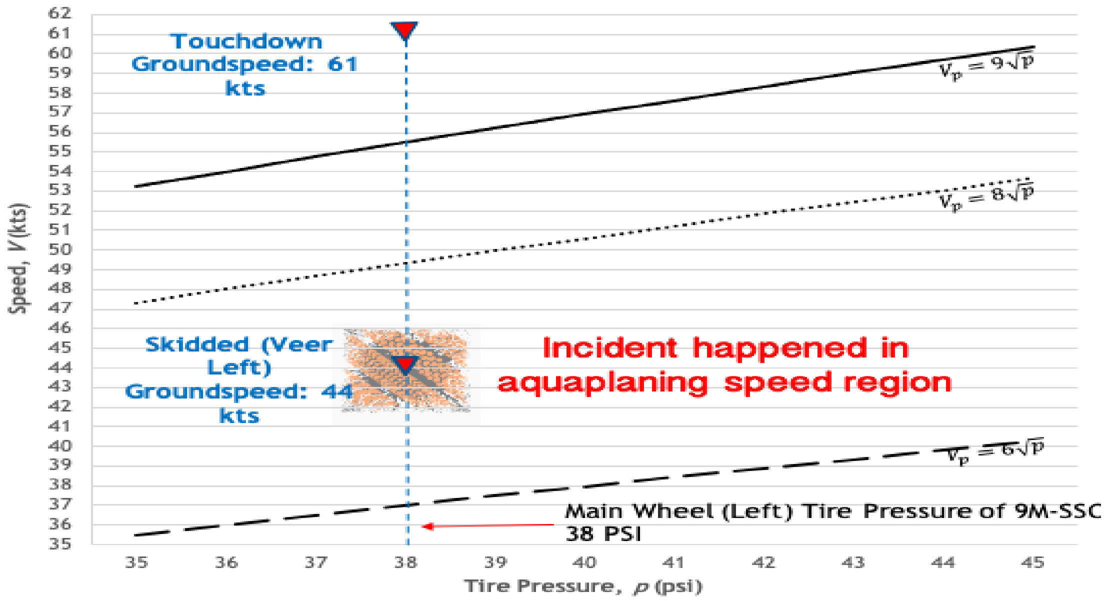


Figure 51: Hydroplaning speed plot with respect to aircraft speed

From Figure 51, using the main tyre pressure of 38psi, the touch down ground speed of the aircraft was 61kts which was above the hydroplaning region on the upper limit equation of the plot, 9√p. When the aircraft touch down, reverse power and brakes were applied to slow down the aircraft. As the aircraft slows down, it started to encounter hydroplaning and the aircraft started to veer left. When the speed slow to 44kts, the aircraft started to yaw sharply to the starboard. The aircraft was identified to be in the hydroplaning region, below upper limit 9√p but above the lower limit of 6√p.

It is concluded that the above analysis provides a theoretical confirmation that the aircraft was in the dynamic hydroplaning speed region when the incident happened.

## 2.9 Tyre Marks Analysis (Refer Attachment 3 – UPNM Skidding Incident of 9M-SSC Aircraft at Long Seridan Airport: Aquaplaning Analysis)[40]


Figure 52: Photograph of the runway taken after the incident showing the tyre marks of the aircraft

To support dynamic hydroplaning speed analysis at paragraph 2.8, tyre marks are analysed to provide empirical evidence to support the above analysis that hydroplaning actual happened to the aircraft and caused the pilot to lose directional control on landing.

Referring to Figure 52, the starboard wheel tyre marks is noted by R, L for port wheel tyre marks and finally N represents the nose wheel tyre. The aircraft touchdown normally and after 4 seconds, the port main wheel started to engaged in hydroplaning, which is shown by the vivid and light tyre marks depicted by L.

This caused the port main wheel to be lifted off the surface of the runway, putting the whole weight of the aircraft on the starboard main wheel. To counter the left veer due to hydroplaning, right brake was also applied at the same time by the pilot. Immediately after the aircraft entered the grass sideway on the left of the runway, the port main wheel restored grip on the ground. Since the right brake was still being applied, it resulted in a sharp starboard yaw and turned the aircraft facing the runway before it came to complete stop. The summary of the events is illustrated in Figure 53.

[40] See Ir. Ts,Dr. Mohd Rashdan Saad, Skidding Incident of 9M-SSC Aircraft at Long Seridan Airport: Aquaplaning Analysis dated 27 October 2020.

When the tyres hydroplane and lift off the runway, its ability to steer and stop the aircraft was practically lost. This is evident in this incident where braking by the pilot to steer the aircraft back to centreline actually aggravated the situation. This is compounded by the poor runway surface friction qualities at Long Seridan which contributed to the hydroplaning incident.

In conclusion, based on the hydroplaning speed analysis in paragraph 2.8, the touchdown speed of the aircraft was found to be within the range of hydroplaning. This shows that the aircraft was exposed to the risk of the skidding incident as early as the touchdown if any thin layer of water existed on the surface of the runway. Based on tyre marks analysis above, the difference in the intensity of the tyre marks found on the runway was also a strong evidence that the port main wheel was slightly lifted off from the runway surface due to hydroplaning. From the evidence adduced above, it can be concluded that dynamic hydroplaning had caused this incident.

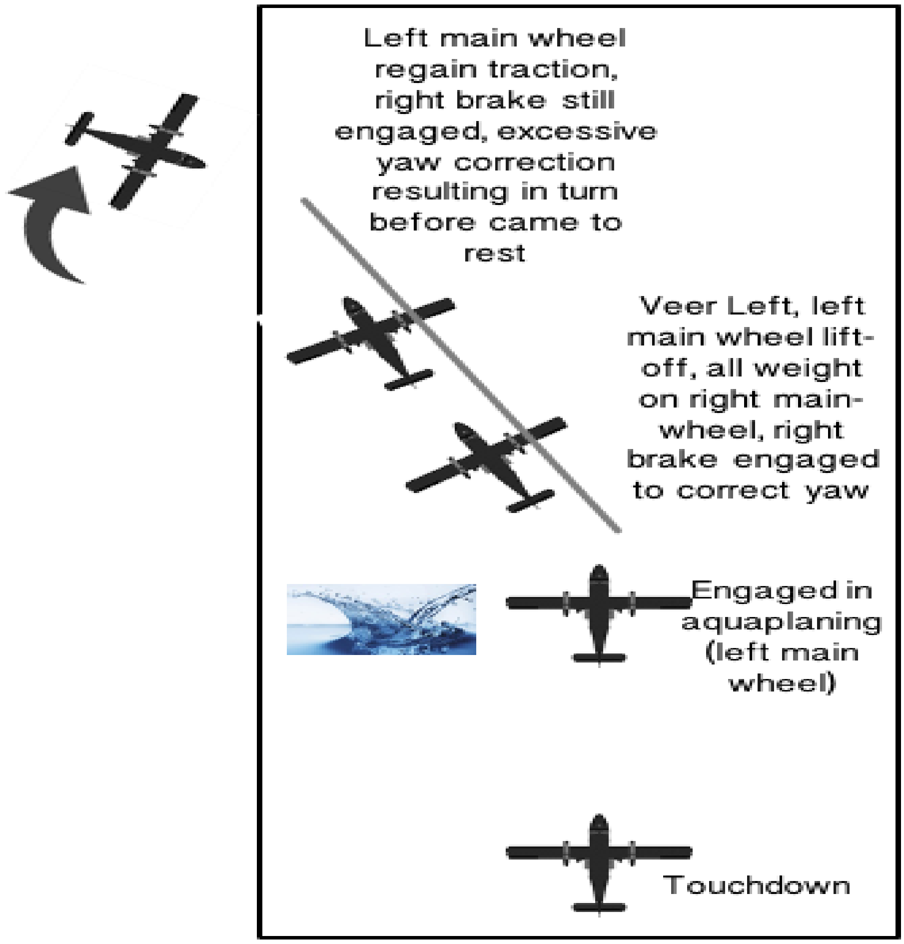


Figure 53: Illustration of series of event experienced by the aircraft starting from touchdown until final stop position

## 2.10 Runway Maintenance Analysis of Long Seridan Airfield

Generally, the aerodrome operator did not fulfil its obligation to maintain the runway according to the required maintenance standards. Reference to the UPMN Site Investigation Report for Long Seridan **(see Attachment 1 & 2),** evidence clearly shows very poor maintenance practices by the aerodrome operator which do not meet the requirement as stated in ICAO Annex 14[41] and Civil Aviation Regulations 2016[42].

The nature of flying operations into STOLports are highly risky due to surrounding high terrain, high elevation, unpredictable weather conditions couple with very short and narrow runway. Figure 11 shows the landing distance required for Long

[41] International Civil Aviation Organization (ICAO), 2018. Annex 14 Aerodromes, Volume 1 - Aerodrome Design and Operations, 8th Ed, Chapter 10.

[42] Malaysia Civil Aviation (Aerodrome Operations) Regulations 2016, Regulation 47 & 48.

Seridan runway based on wet and dry conditions at various landing weight. It will provide a guide as to how critical the runway landing distance available is for landing especially in wet conditions. Data shows that the aircraft can land safely in Long Seridan only on a dry runway surface.

The risk in landing on Long Seridan runway is further aggravated by the poor runway maintenance practices where the runway pavement condition had deteriorated badly and the majority of the pavement are showing various types of distress like water bleeding, disintegration, cracking and polished aggregate. These pavement defects had directly contributed to very poor surface friction qualities which had affect braking effectiveness of the aircraft. It had contributed to hydroplaning occurring which caused the aircraft to skid and exited the runway.

The texture of the surface of a STOLport runway requires special attention in view of the short-field landing requirements. A rough texture surface that is conducive to braking should be used as it has been shown to be effective in providing braking action on wet runways. In order to ensure the texture of the surface meets the required standards, it is crucial that runway surface friction assessment is carried out as stated in the ICAO Airport Services Manual Part 8[43]. From investigation, there was no evidence to show that the aerodrome operator had carried out any friction assessment since the runway was resurface in year 2012. Record shows that the most recent maintenance work carried out on Long Seridan runway was runway centreline markings repainting in April 2020, and runway designation and threshold markings repainting in September 2020.

The analysis on the skid number which give indication to the skid resistance characteristic (braking effectiveness) of Long Seridan runway during the aircraft landing at various speed clearly shows very poor skid resistance characteristic (SN below 31) which relates to the finding of very poor mean texture depth (0.005 inches) of the pavement. These findings show that the poor mean texture depth of the

[43] ICAO Doc 9137, Airport Services Manual Part 8, Airport Operation Services, 1st Ed, 1983, Chapter 7.

pavement was the main contributing factor to cause the aircraft wheels to hydroplane and resulted in it skidding off the runway.

Long Seridan runway meets the transverse slopes requirement to ensure rapid drainage of run-off water to the earth drainage at both side of the runway. It was observed that both these drainage does not have a proper water discharge point. Without proper discharge point, there will be a possibility of water ponding at the earth drainage which will prevent rapid drainage of run-off water from the runway during heavy rain.

Water bleeding on the pavement is another point of concern as this will cause continuous dampness on the runway even on a very hot day. This distress was very prominent during the site investigation which was conducted on a very hot day. It is analysed that water bleeding distress couple with poor mean texture depth of Long Seridan runway will further reduce the skid resistance characteristic of the runway. Data from site investigation had shown that skid incident will occur even on a hot day on Long Seridan runway.

In conclusion, the poor runway condition at Long Seridan can be attributed to organisational influences factor and unsafe supervision factor. The organisational influences factors are the unavailable of a STOLport aerodrome maintenance program and a STOLport runway maintenance SOP. A STOLport aerodrome maintenance program will provide proper maintenance guidance which includes the maintenance schedule and inspection routines to ensure the aerodrome continues to meet the safety requirements, the technical inspections that confirm runway is safe for operations, and the compliance to administrative and regulatory oversight requirements. Budget allocation for procurement, repair and maintenance works can be plan to ensure that the runway is maintained accordingly to avoid compromising safe flight operations. The implementation of an aerodrome maintenance program specifically for STOLport to improve aerodrome maintenance management and practices especially the maintenance of the runway by the aerodrome operator is paramount to ensuring safe flight operation at all STOLports.

Another document that needs to be develop by the aerodrome operator is the STOLport runway maintenance SOP. The SOP will give guidance on what are the procedures to follow and how to carry out the maintenance and repair actions correctly. These will avoid repair actions that do not follow correct procedures and repair work carried out by non-competent personnel as observed in the pothole repair at Long Seridan.

The lack of the above documents had led to unsafe supervision factor where the runway maintenance inspection and repair were not properly planned, monitored and implemented. The repair works were not carried out when needed and by competent personnel according to procedures. The unsafe supervision factor had greatly contributed to the deteriorating conditions of Long Seridan runway where the pavement suffered multiple distresses and the mean texture depth is categorised as very poor due to the polish aggregate condition. The poor mean texture depth will give poor pavement surface friction qualities which will directly affect the skid resistance on the runway. This will directly influence the braking effectiveness of the aircraft during landing especially when the runway surface is wet.

The most important program to provide defences or a check and balance system to prevent the organisation influence and the unsafe supervision factor from occurring is to have a Safety Inspection Program and Safety Regulatory Oversight Program. Both these programs were not implemented by the aerodrome operator and CAAM respectively.

### 2.11 Aerodrome Operations Analysis of Long Seridan Airfield

Generally, the aerodrome operator had fulfilled its obligation to operate the aerodrome according to the required regulation. To ensure safe operations, the aerodrome operator had provided AFIS to aircraft at 6 of the 10 STOLport. The aerodrome operator is not obligated by Civil Aviation Regulations 2016 to perform the responsibility of providing AFIS at STOLport. Providing air navigational services in this context AFIS is the primary responsibility of CAAM.

It was observed that this responsibility had been entrusted to the aerodrome operator since the STOLport existence due to several factors like light traffic, remoteness of aerodrome, practicability, logistical and manpower issues. This arrangement had provided a win-win solution and had benefited both the aerodrome operator and CAAM. Therefore, to continue with this arrangement and to enhance the safety of flight operations in these STOLports especially in adverse weather conditions, formal training must be provided to enhance the operations assistant's competency.

For a win-win solution, CAAM is to assist the aerodrome operator by developing a training syllabus specifically for STOLport operations assistant, and to train and qualify them to meet the requirement in accordance with ICAO Annex 14[44].

In conclusion, the enhance competency level of the STOLport operations assistant will provide confidence to the aircraft operators in their assessment of weather and runway surface conditions. This will certainly improve their skill in performing their duties and improve flight operations safety awareness at their respective aerodrome.

## 3.0 Conclusion

Preliminary investigation from QAR data did not reveal any abnormalities on the aircraft performance and data shows the pilot approach was stabile till touchdown. Aircraft was rolling straight for about 4 seconds before it started to veered left and subsequently exited the left side of the runway. QAR does not provide data for the aircraft critical system for this investigation ie the brakes and nose-wheel steering system as the aircraft design does not incorporate sensor to these systems.

CVR did not reveal any abnormalities throughout the flight. On approach to Long Seridan, the pilots acknowledge visual with the airfield but low clouds and marginal weather on final. Prior to the flight to Long Seridan, the aircraft had delayed

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[44] International Civil Aviation Organization (ICAO), 2018. Annex 14 Aerodromes, Volume 1 - Aerodrome Design and Operations, 8th Ed, paragraph 2.9.4.

departure at Marudi due to marginal weather in Long Seridan. It was report by the Long Seridan operations assistant that there were intermittent rain and drizzle in the morning prior to the aircraft arrival. Pilot reported runway was damp during landing with wind light and variable.

From on-site preliminary investigation, there were prominent tyre track marks forward of the touchdown area especially for the starboard main wheel which was light initially and became darker till the aircraft exited the runway consistent with heavy braking to steer the aircraft back to centreline. The port main wheel tyre track marks were clear and light but disappear as the marks progress closer to the left edge of the runway consistent with aircraft port tyre skidding initially and regaining traction later before the aircraft exited the runway. The nose wheel tyre marks were clear and light till the aircraft exited the runway with no evidence of scalloping marks which will indicate a nosewheel off-centre (cock) landing. The nosewheel tyre marks indication are consistent with tyre skidding and the loss of traction to steer the aircraft.

On-site investigation also observed that the runway pavement had deteriorated over time and was in poor condition. Preliminary evidence gathered from the QAR, CVR, on-site tyre marks, the runway pavement and the wet landing conditions showed that the aircraft had most probably encountered dynamic hydroplaning which cause it to lose traction and braking efficiency resulting in the incident.

To provide evidence that hydroplaning had occurred, AAIB had engaged the Faculty of Engineering UPNM to conduct site investigation on Long Seridan runway which consists of site reconnaissance survey, skid resistance tests and field survey works. The site investigation will provide data and evidence that relevant conditions are met for hydroplaning to occur in this incident.

The wetness on the runway had met the criteria for thickness of water film of 2.5 mm and above or thickness of water film equals (or larger) than the tyre tread depth for hydroplaning to occur. Measurement on the port main wheel tyre shows a thread depth of 4mm. Photographic evidence of the runway condition immediately after the incident shows that this criterion had most probably been met as the weather condition were raining or drizzling intermittently in the morning till the aircraft arrived at Long Seridan.

The site investigation provided evidence that the runway pavement condition had deteriorated over time due to poor maintenance practices. The runway is suffering from various types of distress which had contributed to the poor surface friction qualities. Poor pavement condition had also contributed to the problem of rapid drainage of run-off water from the runway during rain.

To provide evidence that the runway surface friction qualities are poor, skid resistance tests were conducted on Long Seridan runway pavement surface. Data from the test clearly shows that the skid number for various critical phase of flight at various speed measured is 31 and below which corresponded to a pavement mean texture depth of 0.01 inches and below which is below the minimum requirement as stated in ICAO Annex 14 Volume 1. The data also provide evidence that the aircraft is exposed to the risk of skidding even on a dry surface as the skid resistance data results show only minor differences between wet and dry surface readings. These data conclusively show that the runway pavement at Long Seridan had poor surface friction qualities which equates to low skid resistance. The poor runway maintenance practices were the main cause to the above pavement condition problems and was a contributing factor to this incident.

With the physical evidence of the tyre track marks, evidence of pavement distress and analysis of skid resistance test, investigation needs to determine if the touchdown speed of the aircraft was within hydroplaning region to conclude that dynamic hydroplaning had occurred in this incident. Dynamic hydroplaning is subjected to a minimum thickness water film of 2.5 mm on the runway and the aircraft tyre pressure. Analysis of the data shows that the speed of the aircraft when it started to skid (44kts) was in the hydroplaning speed region.

Finally, from all the evidence adduced and to conclusively proof that dynamic hydroplaning had occurred in this incident, the investigation analysed the tyre track marks of the aircraft by combining it with the chronology of events from the QAR data.

The chronology of events matches the tyre track marks that hydroplaning had occurred in this incident.

In conclusion, the poor maintenance practice by the aerodrome operator over a period of time had led to the deteriorating condition of Long Seridan runway pavement. The provision of suitable pavement texture and good surface drainage are the essential requirements to minimize the risk of hydroplaning and to enhance generally the wet surface friction qualities. The pilot incorrect braking input to maintain directional control and stop the aircraft further aggravated the hydroplaning situation. These two factors had contributed to this incident.

In summary, the current Long Seridan poor runway condition is a potential hazard to landing aircraft both in dry and wet conditions. The short-term solution is to temporary prohibit the landing of Twin Otter DHC6 aircraft at Long Seridan in wet conditions until the aerodrome operator completes rehabilitation work on the runway. The mid-term solution is to pursue for a budget allocation from the Ministry of Transport to upgrade/extend the runway from 548m to 990m to cater for the safe operations of Twin Otter DHC6 aircraft at Long Seridan airfield.

Based on the analysis of physical evidence, QAR and CVR data, evidence and data from site investigation conducted by UPNM researchers, it is concluded that the aircraft experience dynamic hydroplaning when landing on the wet runway surface at Long Seridan which caused it to skid off the runway.

## 3.1 Findings

3.1.1 The Captain and Co-pilot were properly licensed to fly this schedule flight.

3.1.2 The rest periods for the crews preceding the flight were sufficient as per company policy.

3.1.3 The aircraft was maintained and airworthy in accordance with existing regulations and approved procedures.

3.1.4 The crew reported no abnormalities during the preceding sector from Miri to Marudi.

3.1.5 The mass and centre of gravity of the aircraft were within the aircraft's performance limits.

3.1.6 The pilot landed the aircraft on a wet runway. Weather conditions during landing were cloudy with intermittent drizzle and wind reported light and variable.

3.1.7 QAR and FDR recording a tailwind of about 25kts during landing is not consistent with observation of light and variable wind conditions reported by the pilot and Long Seridan operations assistant.

3.1.8 Post incident engineering inspection and operational check on the main and nose wheel system, brake system, steering system, engine reverse power (Beta) and rudder system found no abnormalities.

3.1.9 All STOLport had not been certified by CAAM to determine their compliance to regulation in accordance with Civil Aviation Regulations 2016.

3.1.10 STOLport Safety Inspection Program was not established and implemented by the aerodrome operator to monitor safety compliance in accordance with Civil Aviation Regulations 2016.

3.1.11 Safety Regulatory Oversight had not been carried out by CAAM on the aerodrome operator to determine the compliance to regulations in accordance with Civil Aviation Regulations 2016.

3.1.12 STOLport Aerodrome Maintenance Program was not established by the aerodrome operator to manage aerodrome maintenance works in compliance with Civil Aviation Regulations 2016 and ICAO Annex 14 Volume 1.

3.1.13 STOLport Runway Maintenance SOP was not established by the aerodrome operator to ensure standard runway maintenance practices are implemented in compliance with Civil Aviation Regulations 2016.

3.1.14 The pavement condition and surface friction qualities of Long Seridan runway are very poor with various types of distress like cracking, water bleeding, disintegration and polished aggregate.

3.1.15 There is no documented plan inspection schedule and runway maintenance schedule established to manage and conduct inspection and maintenance for STOLport runway as required by ICAO Doc 9137 Airport Services Manual Part 9.

3.1.16 Surface friction assessment was not carried out on Long Seridan runway since the runway was resurface in year 2012 as required by ICAO Annex 14 Volume 1.

3.1.17 The Long Seridan operations attendant did not attend any formal training course to competent him to provide weather information, and to assess and report runway surface conditions to aircraft as required by ICAO Annex 14 Volume 1.

3.1.18 The aerodrome operator provides AFIS to aircrafts in 6 of the 10 STOLports namely Long Seridan, Long Akah, Long Banga, Long Lellang, Bakelalan and Bario.

3.1.19 The Twin Otter DHC6-400 aircraft is safe to land only on a dry runway surface at Long Seridan until the runway is fully rehabilitated by the aerodrome operator.

3.1.20 The aircraft encountered dynamic hydroplaning when landing on a wet runway at Long Seridan.

### 3.2 Causes/Contributing Factors

The serious incident was caused by the aircraft wheels hydroplaning during landing on the wet and poorly maintained runway pavement. The poorly maintained runway pavement over a period of time resulted in poor surface friction qualities. The poor mean texture depth of the aggregate and the various type of pavement distresses occurring had drastically reduced the skid resistance characteristics of the runway pavement and the braking efficiency the aircraft. The braking actions by the pilot to maintain directional control when the wheels hydroplane further aggravated the situation.

The contributing factors to this incident are poor runway maintenance practices by the aerodrome operator and pilot not adhering to the braking technique as stated in the SOP DHC6 for adverse weather operations.

## 4.0 Safety Recommendations

4.1 The Operator is to carry out the following safety recommendations:

4.1.1 To temporary prohibit all the Twin Otter DHC6-400 aircraft from landing in Long Seridan when the runway surface is wet until the runway is fully rehabilitated by the aerodrome operator.

4.1.2 To emphasis during conversion and recurrent training on aircraft directional control and braking procedures when landing on wet surface conditions as stated in the SOP DHC6 Chapter 6, Adverse Weather Operations.

4.1.3 To amend the SOP DHC6 for contaminated runway definition for damp, wet and standing water in Chapter 6 paragraph 6.1.1 to the stated description in ICAO Annex 14 Volume 1 Chapter 2 paragraph 2.9.5.

4.1.4 To verify the accuracy of the FDR and QAR wind parameters of the aircraft (9M-SSC) and take necessary rectification actions.

4.2 The Aerodrome Operator is to carry out the following safety recommendations:

4.2.1 To develop and implement the following:

a. STOLport Aerodrome Maintenance Program.

b. STOLport Runway Maintenance SOP.

c. STOLport Safety Inspection Program.

4.2.2 To conduct site survey and inspection to evaluate all STOLport runway pavement to determine the pavement condition status for repair and maintenance actions.

4.2.3 To evaluate all the STOLport runway pavement condition status at paragraph 4.2.2 and formalise an action plan to rehabilitate all the runway pavement where required to ensure aircraft safe operations at all STOLport aerodromes.

4.2.4 To take appropriate actions to rehabilitate Long Seridan runway pavement condition immediately to ensure aircraft safe operations.

4.2.5 To formulate an inspection schedule and a runway maintenance schedule for the proper management of inspection and maintenance of all STOLport runway.

4.2.6 To ensure all repairs on the STOLport runway pavement are carry out by competent personnel.

4.2.7 To take appropriate actions to improve Long Seridan runway earth drainage by constructing proper water discharge point at both side of the runway to drain run-off water from the runway rapidly during heavy rain.

4.2.8 To request and coordinate with CAAM to organise basic training courses to all operations assistant in order to qualify them in providing AFIS functions, weather report, and to assess and report runway surface conditions to aircraft competently.

4.2.9 To take into consideration to ensure the airfield tower has full runway view (presently partially block by building) when planning for the propose upgrade/extension of Long Seridan runway as submitted for in Twelve Malaysia Plan (RMK-12).

4.3 CAAM is to carry out the following safety recommendations:

4.3.1 To formulate an instruction to temporary prohibit all Twin Otter DHC6-400 aircraft or same category aircraft (with similar weight and configuration) from landing in Long Seridan when the runway surface condition is wet until the runway is fully rehabilitated by the aerodrome operator.

4.3.2 To take appropriate actions to certify all STOLport in compliance to Civil Aviation (Aerodrome Operations) Regulations 2016.

4.3.3 To conduct a Safety Regulatory Oversight on the aerodrome operator to determine compliance to regulations on STOLport operations and maintenance.

4.3.4 To review AIP Malaysia Part 3 – Aerodromes (AD) to include AFIS as a service provided to aircrafts at respective STOLports.

4.3.5 To organise local AFIS courses for MASB STOLport operations assistant with the collaboration from MASB, Meteorological Department and MASwings. The local AFIS course shall be the minimum official qualification to perform AFIS function for STOLport operations assistant.

The release of this Final Report was slightly delayed due to AAIB's efforts to seek clarification and to understand the safety issues highlighted by all stakeholders (CAAM, MASB & MASwings) after receiving comments on the Draft Final Report. Comments from all stakeholders are highly appreciated to improve the investigation. These comments are analysed to assist in providing appropriate safety recommendations for the prevention of accidents and incidents to meet the sole objective of the investigation.

In accordance with ICAO Annex 13, paragraph 6.10, the stakeholders are to inform AAIB within ninety days of the date of transmittal correspondence of this Final Report, of the preventive action taken or under consideration, or reasons why no action will be taken on the safety recommendations received. Stakeholders are also required to implement procedures to monitor the progress of the action taken in response to the safety recommendations received in accordance with ICAO Annex 13, paragraph 6.12.

## 5.0 COMMENTS TO DRAFT FINAL REPORT AS REQUIRED BY ICAO ANNEX 13 PARAGRAPH 6.3

In accordance with ICAO Annex 13, paragraph 6.3, the Draft Final Report was sent to State of Registry/Occurrence (CAAM), State of Manufacturer/Design (Transport Safety Board of Canada), STOLport Operator (MASB) and the Operator (MASwings) inviting their significant and substantiated comments on the Report. The following are the status of the comments received: -

| Organisations | Status of Significant and Substantiated Comments |
|---|---|
| MASwings | Report accepted and no comments |
| Malaysia Airports Sdn Bhd | Report accepted and no comments. MASB had provided safety recommendations action plans which are feedback for Final Report. |
| Civil Aviation Authority of Malaysia | Comments that are accepted had been amended accordingly in this report.<br><br>Comments not agreed upon had been appended in **Appendix A**. |
| Transport Safety Board of Canada (TSBC) | Report accepted and no comments. |
| Transport Canada (TSBC Technical Advisor) | Report accepted and no comments. |
| Pratt and Whitney Canada (TSBC Technical Advisor) | Report accepted and no comments. |
| Viking Air (TSBC Technical Advisor) | Report accepted. Comments are accepted and had been amended accordingly in this report. |

Figure 54: Status of significant and substantiated comments

## 6.0 AAIB'S FEEDBACK AFTER COMMENTS RECEIVED FROM STAKEHOLDERS (CAAM, MASB and MASwings) ON THE DRAFT FINAL REPORT

The main focus of this Final Report are the Findings, Cause/Contributing Factors and the Safety Recommendations issued to the three main stakeholders (CAAM, MASB and MASwings). The discussion herein is solely focus on the legitimacy of AFIS services provided by MASB at STOLports raised by CAAM in the Draft Final Report comments. AAIB would like to put on record in this Final Report issues raised by the three main stakeholders after receiving the substantiated comments and additional information to the Draft Final Report. AAIB held a meeting with CAAM on 14 April 2021 to clarify comments raised in the Draft Final Report. A Video Conference was also organised by MASwings on 27 April 2021 to present and discuss the importance of AFIS function provided by MASB for MASwings safe operations in STOLports. It was participated by the three main stakeholders concern.

It has to be emphasised that the main issue raised by CAAM with regards to MASB providing AFIS contrary to AIP is neither the cause nor the contributing factors to this incident. This issue was not discussed in depth as information received in the course of investigation revealed that MASB had been providing this service as a legacy function since 1992 without any safety issues raised by the three main stakeholders and objection from CAAM as the regulatory body for airspace management in Malaysia.

The investigation did not observe any safety concerns to the AFIS provided by MASB except to improve the competency of its operations attendant as highlighted by MASB during the investigation. MASB's concern was the lack of a proper course to train the current operations attendant to be adequately competent to perform the AFIS function since the first course conducted by the then DCA was in July 2010 some 10 years ago. The present AFIS provided by MASB was observed to be in line with the AFIS concept, as stated in the AIP, "no 'control' of aircraft is exercised nor are instructions passed to pilots. Pilots will be given the information they require but will be expected to decide for themselves what action they should take." Therefore, the onus of responsibility to any decision and actions made lies on the pilot and not the operations attendant at STOLports.

Comments from states that are accepted had been amended accordingly in this report. The details of the comments to the Draft Final Report from CAAM that are not agreed upon by AAIB are as in **Appendix A**. A summary to the issues raised during the meeting and video conferencing which have direct and indirect consequences to flight safety from the 3 main stakeholders on the current AFIS provided by MASB are as follows:

| NO | STAKEHOLDER | ISSUES |
|---|---|---|
| 1 | MASwings | 1. Propose the continuous presence of operations attendant at STOLports (current arrangement) due to factors below:<br><br>a. Unpredictable weather movement and change.<br>b. Strong and erratic wind due mountain effect.<br>c. STOLports are located at mountainous valley. Aircraft unable to go-around when committed to land.<br>d. Unable to communicate on TIBA VHF radio once leaving cruise altitude due to line of sight effect at mountainous area. MASwings's aircrafts are not equipped with HF radios.<br>e. Wildlife crossing or on runway during landing which are difficult to spot from the air during landing.<br>f. Increased traffic movement due to non-scheduled movement (Military, Police, Medical & Logging helicopters).<br><br>2. Increased operations risk from Medium to High without AFIS provided by MASB.<br><br>3. Withdrawal of AFIS services will result in much lower levels of safety which affect flight operations resulting in negative social economic impact. |
| 2 | MASB | 1. Have been providing operations attendant to perform AFIS function at nominated STOLports since 1992 when DCA was privatised. A legacy function taken over from DCA (now CAAM).<br><br>2. The AFIS function provided is not a provision in the MAHB Operating Agreement and MAHB Licence. A liability issue to MASB. |

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| | | 3. Only one official AFIS course was organised by MAvA, DCA in year 2010 to train the operations attendant till this incident.<br><br>4. Operations attendant have been providing the following services for the safe flight operations of aircrafts flying into STOLports:<br><br>a. Relay traffic and clearance information by TIBA.<br>b. Provide latest traffic information to aircraft on ground.<br>c. Provide weather information to aircraft and MASwings Operations before aircraft departure to STOLport.<br>d. Provide temperature information to pilots prior departure for performance and weight calculations due to limited runway length.<br>e. Advise pilots on the availability of parking space to incoming traffic due to high traffic at STOLports.<br>f. Advise on whether the topographical "Gaps" are open to the crew prior to their descent to the STOLports. This is critical to safe operations due to surrounding high terrain. |
| 3 | CAAM | 1. Non-agreeable to investigation report on AFIS function provided by MASB as it contradicts with the information published in AIP due to the following:<br><br>a. No AFIS job description stated in the job responsibilities of the operations attendant. The data in AIP states that there is no AFIS provided at the 6 STOLports mention.<br>b. Meteorological information is the main item under AFIS requirement.<br>c. Non-availability of meteorological stations or any weather observation equipment in these STOLports to provide meteorological data for the provision of AFIS.<br><br>2. Non-agreeable to develop a basic syllabus and conduct basic training courses for STOLport operations assistant to competently provide AFIS, weather report, and to assess and report runway surface conditions to aircraft safely with following reasons:<br><br>a. AFIS training is feasible if AFIS is provided.<br>b. Weather reporting is not the responsibility of CAAM and CAAM is not in the position to develop such training syllabus.<br>c. Assessing and reporting of runway surface condition is the responsibility of MAHB as the operator and MAHB shall develop the training syllabus for the operations assistant. |

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| | | d. MAHB is more than capable to train their own staff to function as required in the job description of operations assistant.<br>e. The Critical Elements 1 to 5 of the safety oversight function need to be established prior to approving or qualifying any person to perform any function. |

Figure 55: Issues from respective stakeholders after comments in Draft Final Report

AAIB would like to raise the above issues as a safety concern. It is analysed that the above issues if not highlighted in this Final Report will face serious challenges to resolved. CAAM, the primary stakeholder and regulator for airspace management had questioned the legitimate role of MASB in providing AFIS at STOLports when it states that AFIS is not provided for at STOLports as stated in the AIP.

With legitimacy issue raised, liability issues become a concern to MAHB[45] as the AFIS provided had not been formally recognised by CAAM and listed in the AIP. There is also a policy issue where AFIS function had not been provision in MAHB Operating Agreement and MAHB Licence. If AFIS is withdrawn due to the above issues raised, it will result in much lower levels of flight safety at STOLports. Consequently, MASwings flight operations (Public Service Obligation) will be affected, impacting the social economic wellbeing of the people in the interior of Sarawak and Sabah. The primary aim of Public Service Obligation Flights, an initiative by the government of Malaysia and operated by MASwings is to provide air communication and to improve the social economic wellbeing of the people living in and around the STOLports areas of Sarawak and Sabah.

There is no denying that AFIS had contributed greatly to the safe flight operations of MASwings as the main operator into STOLports. Statistic supporting this shows that with an average of 96,200 STOLports flights in a 10-year period from year 2011 to 2020, there are only 9 serious incident/accidents that had occurred at STOLports with MASB providing AFIS. MASB must be commended for diligently providing this service despite facing various challenges.

[45] Malaysia Airports Holdings Berhad (MAHB) as the aerodrome operator was issued with a licence by the Ministry of Transport valid till year 2034 to operate and maintain 10 STOLports in Sarawak. The STOLports are managed by MAHB’s subsidiary, Malaysia Airports Sdn Bhd (MASB) under the responsibility of the Miri Airport Manager.

It was observed that the AFIS provided by MASB had not been formally recognised by CAAM although MASB had been providing this service since 1992. CAAM had rightly highlighted that the AFIS is not provided and not stated in the AIP for the STOLports concerned. The question is what measures and effort had CAAM taken as a regulatory body for airspace management to address and resolve this issue whereas the fact is that the AFIS provided by MASB had been in operation for such a long period of time? The legitimacy of this service was only highlighted by CAAM when this investigation provided a safety recommendation to improve the competency of the MASB operations attendant in providing AFIS. AAIB is of the view that the AFIS function provided by MASB to all aircrafts and in particular MASwings as the main operator to STOLports is very beneficial to safety. The list of AFIS function provided by MASB and the justification for the AFIS requirement at STOLport by MASwings are listed in Figure 55.

Looking at the concept of AFIS as stated in the AIP in Figure 56, AAIB is of the view that the current AFIS provided by MASB meets the concept as stated. Points raised by CAAM that meteorological information is the main item under AFIS requirement and no meteorological stations nor any weather observation equipment in STOLports to provide meteorological data for the provision of AFIS are contradictory to what is stated in the AIP ENR 1.1.5.15 Aerodrome Flight Information Service.

At these STOLports aerodrome, weather information is provided via visual observation. For example, at STOLport Marudi and Lawas where CAAM ATC controllers are stationed instead of MASB operations attendant, aerodrome weather information is provided via visual observation as there is no meteorological office at site. It is very obvious that it is not economically viable to have a meteorological office and station at these STOLports due to the remoteness of the area.

These STOLports are also equipped with basic equipment like High Frequency (HF) and Very High Frequency (VHF) radios, thermometer and wind scock for AFIS function. Some STOLports for instance Long Seridan are even equipped with basic firefighting equipment such as a three-wheel motorcycle vehicle equipped with Dry Chemical Powder 50KG (4 unit).

The statement by CAAM stating that the aerodrome operator is entrusted with the responsibility to provide AFIS in these STOLports contradicts with the information published in AIP is correct, but the evidence shows that MASB have been providing this service and the operations attendant have been communicating AFIS information with the pilots, MASwing operations centre, ATC controller at Kota Kinabalu and Miri on TIBA for the past 29 years without any objection from CAAM till investigation of this incident.

Not taking responsibility to conduct an AFIS course by stating various excuses and passing the buck to MASB on this issue does not absolve CAAM from the fact that AFIS service is a main function under the jurisdiction of CAAM as the sole regulatory body of airspace management while MASB's main function is to operate and maintain aerodromes. Therefore, CAAM needs to take leadership as the responsible stakeholder to organise AFIS courses and formally recognise it while the conduct of the course can be undertaken by MASB with collaboration from Meteorological Department and MASwings as the main beneficiary of this service, similar to the first local AFIS course conducted in year 2010. A mutually agreeable syllabus taking guidance from ICAO's recommendations in **Appendix B** and the First Aerodrome Flight Information Service Course in **Appendix C** will provide the basic requirement for this locally developed training course.

The other option which is within CAAM authority as a regulatory body is to withdraw the AFIS services provided by MASB. From the analysis made in this investigation, statistics on incident/accident at STOLports, feedback received and presented by MASB and MASwings during the video conferencing meeting, it is concluded that the benefit towards safety with AFIS services far out weight the issues raised by CAAM that AFIS is not stated in AIP, ie the legitimacy of the service provided by MASB all these years. This legitimate issue can be solved internally by stakeholders concern ie, MASB, CAAM and Ministry of Transport Malaysia.

Withdrawal of AFIS provided by MASB is akin to the idiom "killing the goose that lays the golden egg". The goose in this context is the MASB operations attendant while the golden egg is the AFIS provided for safe flight operation at STOLports. Concerted efforts must be made by CAAM and MASB to provide the operations attendant with proper training to improve their competency thus ensuring the “goose continues to lay the golden egg” for the continuous safe flight operations at STOLports.

Therefore, based on respective inputs and comments from all stakeholders on the AFIS issue, AAIB recommends the continuation of the present AFIS operations provided by MASB as analysed in this Final Report. All stakeholders ie CAAM, MASB and MASwings must take concerted effort to address the issues highlighted in Figure 55. Two policy issues need to be addressed, one each by CAAM and MASB for the continuation of AFIS provided by MASB.

First, CAAM must take ownership of the AFIS issue and officially recognise the role of MASB in providing AFIS at STOLports. Second, MASB is to pursue and resolve internally the long standing AFIS issue in the MAHB Operating Agreement and MAHB Licence with the Aviation Division, Ministry of Transport Malaysia. These two policy issues are paramount to the continuation of the AFIS provided by MASB which have a direct effect on the flight operations of MASwings as the main service provider for the Public Service Obligation Flights into STOLports.

A change of mindset from authoritative to facilitative by CAAM as a regulatory body by taking ownership and opening barriers will greatly assist the respective stakeholders ie MASB and MASwings in overcoming this AFIS issue. Ultimately, the most important outcome to achieve by all stakeholders is the continuous safe operations of aircraft into all STOLports. This is in line with the objective of the newly minted Malaysia State Safety Policy Statement, wherein to prioritise the reduction of operational risk by maintaining a decreasing trend of fatal accidents per million departures, with a view to achieve an aspirational target of zero fatalities by 2030 in schedule commercial operations.

Statement made in the discussion above are not to assign fault or blame but to provide better understanding of the issues at hand in the course of this investigation. It is the aspiration of AAIB that this long outstanding AFIS issue can be resolved by all three main stakeholders by facilitating each other for the betterment of aviation safety. AAIB will maintain its independence in the course of accident and serious incident investigation and will continue to conduct impartial investigation without fear or favour in line with the Malaysia State Safety Policy Statement.

**1.1.5.15 Aerodrome Flight Information Service**

1.1.5.15.1 A flight information service is provided at certain notified aerodromes where no Air Traffic Control is established.

1.1.5.15.2 This 'Service' is called 'Aerodrome Flight Information Service' and it is operated at some of the less busy aerodromes and airstrips where lack of suitably qualified staff or scarcity of movements precludes the establishment of an Aerodrome Control Service.

1.1.5.15.3 The function of the 'Aerodrome Flight Information Service' is to provide certain vital information to pilots wishing to land. It is not an air traffic control service.

1.1.5.15.4 Pilots will be given the information they require but will be expected to decide for themselves what action they should take. For example, they will be told the wind direction and speed but they will have to make up their own minds which runway should be used. They can however be advised of the direction of the runway nearest into wind, but this need not necessary be used.

1.1.5.15.5 The fundamental difference between the 'Aerodrome Flight Information Service' and an Air Traffic Control Service such as Aerodrome or Approach Control Service is that in the Aerodrome Flight Information Service, no 'Control' of aircraft is exercised nor are instructions' passed to pilots.

1.1.5.15.6 The Aerodrome Flight Information Service will operate as follows:

a) Provision of aerodrome weather information.
b) Information of the state of serviceability of the aerodrome and its facilities.
c) Relay of messages from or to respective FICs.
d) Provision of information on vehicular traffic on the manoeuvring area.
e) Provision of aerodrome crash and fire services and alerting of other local emergency services.
f) Provision of emergency aerodrome lighting.
g) Information of other traffic.

Figure 56: AIP Malaysia - Aerodrome Flight Information Service

## APPENDICES


| | | |
|---|---|---|
| **A** | Comments to Draft Final Report from CAAM That Are Not Agreed Upon | A-1 TO A-10 |
| **B** | Training Syllabus Guide to Providing Assess Information on Runway Surface Conditions | B-1 |
| **C** | First Aerodrome Flight Information Service Course Report | C-1 TO C-6 |


## ATTACHMENTS


| | | |
|---|---|---|
| **1** | UPNM Site Investigation for Long Seridan Airport’s Runway Part 1 – Site Reconnaissance Survey | ATT 1-1 TO ATT 1-16 |
| **2** | UPNM Site Investigation for Long Seridan Airport’s Runway Part 2 – Skid Resistance Tests | ATT 2-1 TO ATT 2-20 |
| **3** | UPNM Skidding Incident of 9M-SSC Aircraft at Long Seridan Airport: Aquaplaning Analysis | ATT 3-1 TO ATT 3-7 |

**APPENDIX A**

## COMMENTS TO DRAFT FINAL REPORT FROM CAAM THAT ARE NOT AGREED UPON

### STATE OF REGISTRY/OCCURRENCE - CAAM

| NO | REFERENCE | STATEMENT | CAAM's COMMENTS | AAIB's FEEDBACK |
|---|---|---|---|---|
| 1 | 1.17.3 Aircraft Quick Access Recorder (QAR) Data | It was observed that the QAR and FDR recorded an approximate tail wind of an average of 25kts (Figure 10) below 500ft AGL. Nevertheless, interview statement from the pilot and operations assistant Long Seridan airfield states that the wind was light and variable. It would be impossible for the aircraft to land on such strong tailwind and not logical for the pilot and operations assistant not to realised such strong wind at the aerodrome. | The source of wind information provided by the operations attendant was not determined. There was no meteorological station or weather observation equipment to confirm the wind data. | This statement is to show the ambiguous wind data recorded by the FDR and QAR as compare to the visually observed wind condition by the operations assistant. Such a vast difference of wind speed between the observed light wind to the recorded 25kts on the FDR and QAR can be differentiated without having a meteorological station. This was discussed to provide safety recommendations in paragraph 4.1.4 |
| 2 | 1.17.11 Full Runway View Block by Building | It was observed that the operations assistant was unable to see the full length of the runway from the airfield tower. | This statement is not relevant as Long Seridan operations assistant job responsibilities did not state the requirement for operations assistant to monitor aircraft landing. | The statement is very relevant to this investigation as the operation attendant who was position at the airfield tower could had provided valuable information on the landing path as an important eyewitness irrespective of whether it is in his job responsibilities. In investigation |

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| | | | | technique, it is used to cross reference the statement of other witnesses to verify information provided on the incident to come to a factual conclusion. |
| 3 | 1.17.14.2 STOLports Operations | Currently, the aerodrome operator is entrusted with the additional responsibility to provide AFIS to departing and arriving aircraft at 6 of the STOLports.<br><br>Two operations assistants are station in Long Seridan to perform this duty in addition to their daily job responsibilities. Most of the training to perform AFIS task are mostly trained in-house by senior operations assistant at various STOLport while the more senior personnel were trained by CAAM ATC at Miri Airport. | The statement that aerodrome operator is entrusted with the responsibility to provide AFIS contradicts with the information published in AIP.<br>The data in AIP stated that there is no AFIS provided at these 6 aerodromes.<br><br>This statement contradicts with the current job description stated in Appendix M. Information stated is not consistent as no AFIS is provided in Long Seridan. The | The statement is a factual information in the course of the investigation. Evidence shows that there are two operations assistants performing this AFIS task on TIBA frequency when the aircraft was enroute from Marudi to Long Seridan.<br><br>This factual information was not disputed by MASB in their substantiated comments on the Draft Final Report.<br><br>CAAM as the regulatory authority of airspace management should be providing an explanation on the contradictory between the AIP and actual AFIS provided at respective STOLports by MASB.<br><br>This issue had been clearly analysed in paragraph 2.11 of this Final Report which states that this arrangement is a win-win solution between MASB and CAAM due to various practical and economical |

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| | | | data in AIP stated that there is no AFIS provided at Long Seridan. | factor to ensure safe flight operations for aircrafts at all STOLports in Sarawak & Sabah. |
| 4 | | The operations assistant responsibilities other than providing traffic information is to provide weather updates and reporting runway surface conditions. | This statement to provide traffic information and weather updates contradicts with job description for operation assistants stated in Appendix M.<br><br>The data in AIP stated that there is no AFIS provided at Long Seridan.<br>For traffic information:<br>- FIS is available through Miri Tower as published in AIP.<br>- An air traffic advisory service procedure published in AIP: Traffic Information Broadcast by Aircraft (TIBA) and Related Operating Procedures Within Class G Airspace in Kota Kinabalu FIR.<br>- There is no meteorological station or weather observation equipment for anyone to provide weather update. | Information provided by MASB after the submission of Draft Final Report comments revealed that this is a legacy policy issue since 1992 when DCA (CAAM now) was privatised.<br><br>MASB stated that there is no provision to provide AFIS in MAHB Operating Agreement and MAHB Licence. This crucial information was only confirmed by MAHB to the investigator after the Draft Final Report comments were received.<br><br>MASB must be commended for providing AFIS for the safe flight operations of all aircrafts at STOLports admirably for the past 29 years despite the various challenges faced.<br><br>In the course of the investigation, MASB had clarify that since the AFIS function is not the primary role of MASB, it was not included in the job description. It was not highlight as an issue in the investigation as it was analysed as |

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| | | | | a win-win solution between MASB and CAAM for the safety of all aircraft operators at STOLports. This issue was not a contributing factor to this incident. |
| 5 | 2.11 Aerodrome Operations Analysis of Long Seridan Airfield | To ensure safe operations, the aerodrome operator had provided AFIS to aircraft at 6 of the 10 STOLport. | There is no AFIS at these 6 aerodromes as stated in the AIP. The data in AIP stated that there is no AFIS provided at these aerodromes.<br><br>Note:<br>- Meteorological information is the main item under AFIS requirement for information. - There were no meteorological stations nor any weather observation equipment in these STOLports to provide meteorological data for the provision of AFIS.<br>- Flight crews shall practice TIBA procedures as published in AIP or contact Miri Tower for traffic information. | CAAM statement is contradictory to the Aerodrome Flight Information Service requirement stated in the AIP ENR 1.1.5.15 which did not list the need for meteorological stations to provide meteorological data for the provision of AFIS. |
| | | It was observed that this responsibility had been entrusted to the aerodrome operator since the STOLport existence due to several factors like light traffic, remoteness of aerodrome, | This statement that aerodrome operator is entrusted with the responsibility to provide AFIS in these STOLports contradicts with the information published in AIP. | Evidence shows the aerodrome operator have been providing this service since 1992 as a legacy function brought upon to MASB. |

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| | | practicability, logistical and manpower issues. | | The evidence was not disputed by MASB in their substantiated comments on the Draft Final Report.<br><br>CAAM as the regulatory authority of airspace management should be providing an explanation on the contradictory between the AIP and actual AFIS provided at respective STOLports by MASB. |
| | | CAAM is to assist the aerodrome operator by developing a training syllabus (refer ICAO recommendations in Appendix N) specifically for STOLport operations assistant, and to train and qualify them to meet the requirement in accordance with ICAO Annex 14 | CAAM does not agree with the statement to develop the training syllabus as it is the responsibility of airport operator to provide training to their staffs to meet any obligations required in Annex 14.<br><br>Note: MAHB has a training centre near KLIA. | The statement made was with reference to information produce by MASB in the course of the investigation that there was a course to train MASB operations attendant jointly initiated by Malaysia Aviation Academy (MAvA), DCA and MASB.<br><br>The Miri Meteorological Department and MASwings as the aircraft operator were invited as subject matter guest lecture.<br><br>The course was named 1st Aerodrome Flight Information Service Course conduct at MASB Miri Airport from 19 July 2010 to 6 August 2010. The course report for the course was produced by MAvA. There were no subsequent |

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| | | | | courses conducted till this Final Report date. The course report was only made available to the investigator after the Draft Final Report.<br><br>As AFIS matters are under the jurisdiction of CAAM, it is recommended that CAAM leads this initiative especially the approval of the training syllabus while MASB will be responsible to coordinate and managed the course with the collaboration from the Meteorological Department and MASwings. |
| 6 | 3.1 Findings | 3.1.18 The aerodrome operator provides AFIS to aircrafts in 6 of the 10 STOLports namely Long Seridan, Long Akah, Long Banga, Long Lellang, Bakelalan and Bario | There is no AFIS provided for these STOLport. This finding contradicts with the information in the AIP. The data in AIP stated that there is no AFIS provided at these aerodromes. | The statement is correct factual information in the course of the investigation.<br><br>The evidence was not disputed by MASB in their substantiated comments on the Draft Final Report.<br><br>CAAM as the regulatory authority of airspace management should be providing an explanation on the contradictory between the AIP and actual AFIS provided at respective STOLports by MASB. |

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| | | | Note:<br>- Meteorological information is the main item under AFIS requirement for information. There were no meteorological stations nor any weather observation equipment in these STOLports to provide meteorological data for the provision of AFIS.<br><br>- Flight crews shall practice TIBA procedures as published in AIP or contact Miri Tower for traffic information. | The statement “meteorological information is the main item under AFIS requirement for information” is contradictory to AIP ENR 1.1.5.15 Aerodrome Flight Information Services.<br>There is no specific statement in the AIP to indicate that meteorological information provided by meteorological office is the main item under AFIS.<br><br>AIP states the AFIS will operate by providing aerodrome weather information. Aerodrome weather information need not come from meteorological office at the aerodrome but can be observed visually by the operations attendant in this incident. Providing meteorological station in every STOLports is contrary to the concept of AFIS due the remoteness, scarcity and availability of suitably qualified staff at these STOLports.<br><br>The AFIS concept of operations stated in the AIP ENR 1.1.5.15 Aerodrome Flight Information Services is the function currently being performed by MASB ie |

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| | | | | providing AFIS due to lack of suitably qualified staff or scarcity of movements. It is to provide vital information for pilots wishing to land and pilots are to decide for themselves what actions are needed to be taken.<br><br>Point to note for STOLports Marudi and Lawas, ATC is provided by CAAM ATC Controllers and aerodrome weather are provided by visual observation. There is no meteorological station to provide weather information there.<br><br>Therefore, the need for meteorological stations or any weather observation equipment in these STOLports to provide meteorological data for the provision of AFIS is contradictory to AIP. The statement by CAAM applies to Flight Information Service (FIS) as stated in AIP ENR 1.1.4.2 Provision of Flight Information Services. |
| 7 | 4.2 Safety recommendations | 4.2.8 To request and coordinate with CAAM to provide a basic training course to all operations assistant to qualify them to | CAAM does not agree with this recommendation.<br>- Weather reporting is not under CAAM responsibility and CAAM is not in position to train | This recommendation is not for CAAM. It is a recommendation to MASB to initiate training to enhance the competency of the |

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| | | provide weather report, AFIS, and to assess and report runway surface conditions to aircraft safely and competently. | personnel to provide weather report;<br>- AFIS training is feasible only if AFIS is provided;<br>- Assessing and reporting of runway surface condition is the responsibility of MAHB as operator and MAHB shall provide the training to the operation assistants. | operations attendant at STOLports in Sarawak and Sabah. |
| 8 | 4.3 Safety recommendations | 4.3.4 To develop a basic training course syllabus to train STOLport operations assistant to competently provide AFIS, weather report, and to assess and report runway surface conditions to aircraft safely. | CAAM does not agree with this recommendation:<br>- AFIS training is feasible if AFIS is provided;<br>- Weather reporting is not the responsibility of CAAM and CAAM is not in position to develop such training syllabus;<br>- Assessing and reporting of runway surface condition is the responsibility of MAHB as operator and MAHB shall develop the training syllabus for the operation assistants. | It is recommended that the three stakeholders (CAAM, MASB & MASwings) with interest on the provision of AFIS for the safe operations of aircraft at STOLports to take concerted effort to facilitate this training. A mutually agreeable syllabus taking guidance from ICAO's recommendations in Appendix N and the 1st AFIS Course will provide the basic requirement for this locally develop training course.<br><br>Policy matters related to MASB performing the AFIS function and provision on the requirement to provide AFIS in MAHB Operating Agreement and Licence need to be collectively address by CAAM and MAHB internally with Aviation Division of MOT Malaysia. |

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| 9 | 4.3 Safety recommendations | 4.3.5 To conduct the basic training course for STOLport operations assistant and to qualify them officially. | CAAM does not agree with this recommendation:<br>- MAHB is more than capable to train their own staff to function as required in the job description of operations assistant.<br>- The Critical Elements 1 to 5 of the safety oversight function need to be established prior to approve or qualify any person to perform any function. | Refer AAIB feedback for reference statement 4.3.4 above. |
| 10 | 4.3 Safety recommendations | 4.3.6 To take into consideration to ensure the airfield tower has full runway view (presently partially block by building) when planning for the propose upgrade/extension of Long Seridan runway as submitted by the aerodrome operator for budgetary allocation in Twelve Malaysia Plan (RMK-12). | CAAM does not agree with this recommendation:<br>- AAIB to clarify the need for an airfield tower to have a full runway view where neither AFIS nor ATC service is provided; and<br>- budgetary allocation for airport development is under the responsibility of aerodrome operator. | This safety recommendation is removed for CAAM and inserted for aerodrome operator's action as in Safety Recommendations paragraph 4.2.9.<br>The airfield tower issue is explained in paragraph 1.17.11 in this Final Report. |

## APPENDIX B

# TRAINING SYLLABUS GUIDE TO PROVIDING ASSESS INFORMATION ON RUNWAY SURFACE CONDITIONS

*6.7* It is important to follow standard procedures when providing assessed information on the runway surface conditions to ensure that safety is not compromised when aeroplanes use wet or contaminated runways. Personnel should be trained in the relevant fields of competence and their competence verified in a manner required by the State to ensure confidence in their assessments.

**8/11/18** **ATT A-10**

*6.8* The training syllabus may include initial and periodic recurrent training in the following areas:

a) aerodrome familiarization, including aerodrome markings, signs and lighting;

b) aerodrome procedures as described in the aerodrome manual;

c) aerodrome emergency plan;

d) Notice to Airmen (NOTAM) initiation procedures;

e) completion of/initiation procedures for RCR;

f) aerodrome driving rules;

g) air traffic control procedures on the movement area;

h) radiotelephone operating procedures;

i) phraseology used in aerodrome control, including the ICAO spelling alphabet;

j) aerodrome inspection procedures and techniques;

k) type of runway contaminants and reporting;

l) assessment and reporting of runway surface friction characteristics;

m) use of runway friction measurement device;

n) calibration and maintenance of runway friction measurement device;

o) awareness of uncertainties related to l) and m); and

p) low visibility procedures.

**APPENDIX C**

**FIRST AERODROME FLIGHT INFORMATION SERVICE COURSE REPORT**

# Malaysian Aviation Academy (MAVA)

# AERODROME FLIGHT INFORMATION SERVICE

# COURSE REPORT

**12 AUGUST 2010**

**1ST AERODROME FLIGHT INFORMATION SERVICE COURSE**

## *Introduction*

The Aerodrome flight information service (AFIS) operators are the only vital link between the pilots and their destinations at the short take-off and landing (STOL) airfields. Although the AFIS operators only provide flight information and alerting services, they hold great responsibilities.

As there is a urgent need to provide training to the AFIS operators, a course was designed, developed, organized and conducted with the co-operation between the Department of Civil Aviation (DCA) and Malaysia Airports Sdn. Bhd ( MASB).

The course started on 19th July 2010 and completed on 6th August 2010 with Miri Airport being selected as the venue because of its location being closer to most of the STOL ports. It was officially opened by the Miri airport manager at the MASB conference room.

## *Duration of the Course*

The main course has been planned for three weeks with one week of theory consisting of subject matters relating to AFIS and two weeks of practical simulation. After the course, there was to be a week attachment at the meteorological office at Miri airport. Unfortunately the attachment could not be implemented as there was a miscommunication as MASB had the impression that the three-week course included the one-week attachment. However some of the trainees have been attached before to the meteorological office during previous arrangement.

## *Venue*

We were given the option to conduct the course at the MASB conference room or at the fire station training room. We opted for the latter as it was already set-up for training and more conducive to conduct lessons as compared to the conference room. If we had chosen the conference room, we were also required to move to the fire station training room whenever there is a meeting which will entail too much of shifting and uncertainty. The only disadvantage at the fire station training room is the high level of noise from aircraft landing and taking off.

***Participants***

A total of eight trainees from Malaysia Airports Sdn. Bhd attended the course.

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| 1. Ahmad bin Bollah | Lawas |
| 2. Kathleen Robin | Long Seridan |
| 3. Kenny Lisa Peterus | Bario |
| 4. Lease Niar | Long Lellang |
| 5. Marcos Riung Gelawat | Miri Airport |
| 6. Michael Racha Agong | Ba Kelalan |
| 7. Rasmat bin Mohamad | Kudat |
| 8. Safri bin Salleh | Mukah |

***Instructors***

Teoh Chean Aun (course manager)
Azmee bin Abdilliah (DCA Miri)

***Guest Instructor and Presenters***

Encik Vincent Sim, head of meteorological office, Miri airport gave a three-hour lessons on topics relating to meteorology.

DCA manager invited two captains from MAS wing to show a video on an approach to a STOL port and also to express their expectations from the AFIS operators.

***Practical Simulation***

The first five practical simulation exercises were based on a generic airfield and subsequent simulations were based on the various STOL ports where the trainees work, with whatever data and information provided by them.

For each simulation exercise, script was prepared where the trainees read out during the role play. The same exercise was repeated later but this time without the use of the script.

***Visits***

Educational visits were arranged to the following organizations during the course:

Control Tower
MAS wing operation room
Meteorological office
Layang Layang air services
Hornbill Skyways

***Examinations***

The trainees sat for the written examination after the theory lessons and all of them passed the test.
As for the practical simulation assessment which was held on the $5^{th}$ of August, they were checked on the following aspects:-

1. Provision of flight information service consisting of traffic information, essential aerodrome information, and weather.
2. Phraseology
3. Co-ordination
4. Strip marking

As for the result of the assessment, all the trainees were successful in passing the assessment.

***Findings***

1. Although most of the trainees are practicing AFIS operators, their knowledge on aviation matters relating to AFIS is very limited.

2. Those who were weak in the English language required a lot of attention and patience.

3. The subject matters are sufficient to cover the provision of AFIS. However during the course, an additional topic on quadrantal cruising levels was included so that the trainees understand how the pilots select their cruising levels.

***Recommendations***

1. The duration of the course should be maintained as it allows those trainees who are weak in the English language, sufficient time to understand the concept and practices of AFIS

2. Two hours of English language and simple aviation English should be included in the syllabus but still maintained within the three-week duration.

3. The one week attachment at the meteorological office is important as the weather at some of the STOL ports changes rapidly and is unpredictable due to their locations in the mountainous regions.

4. Those practicing AFIS operator who have not officially attended the related course should be given the opportunity to attend training as early as possible.

***Closing Ceremony***

The course was officially declared closed by the Miri Airport manager after certificates were presented to the participants by the airport manager and DCA manager.

***Appreciation***

I wish to thank the Miri Airport manager and his staff for their kind hospitalities, support and assistance and also for providing the facilities for the course.
I also like to express my thanks and appreciation to the DCA manager and his staff for their kind co-operation, support and assistance.

***Conclusion***

The success of this course is due to the close co-operation between the Department of Civil Aviation and Malaysia Airports Sdn. Bhd with the aim of enhancing the safety and services that are being provided at the various STOL ports.