AIRCRAFT ACCIDENT

FINAL REPORT

SI 01/20

Air Accident Investigation Bureau (AAIB)

Ministry of Transport Malaysia

Serious Incident involving Fixed Wing Aircraft

Twin Otter DHC6-400, Registration 9M-SSE

at Miri Airport, Sarawak

on the 7 January 2020

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AIR ACCIDENT INVESTIGATION BUREAU (AAIB)
MALAYSIA

REPORT NO. : SI 01/20

OPERATOR	**:**	**MASWINGS**
AIRCRAFT TYPE	**:**	**TWIN OTTER DHC6-400**
NATIONALITY	**:**	**MALAYSIA**
REGISTRATION	**:**	**9M-SSE**
PLACE OF OCCURRENCE	**:**	**MIRI AIRPORT, SARAWAK**
DATE AND TIME	**:**	**7 JANUARY 2020 AT 1620LT**

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.

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 accident was sent on 13 January 2020 to Civil Aviation Authority of Malaysia as State of Registry/Occurrence, Transport Safety Board of Canada as State of Manufacturer and the Operator. A copy of the Preliminary Report was subsequently submitted to the above organization on 07 February 2020.

In accordance with ICAO Annex 13 paragraph 6.3, a copy of the Draft Final Report was sent on 15 July 2020 to Civil Aviation Authority of Malaysia as State of Registry/Occurrence, Transport Safety Board of Canada as State of Manufacturer 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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APPENDICES

GLOSSARY OF ABBREVIATIONS

A

AAIB	Air Accident Investigation Bureau
AFM	Aircraft Flight Manual
AFRS	Airport Fire Rescue Services
ATIS	Automatic Terminal Information Service
ATPL	Airline Transport Pilot's Licence

C

C	Celsius
CAAM	Civil Aviation Authority Malaysia
CAS	Crew Alerting System
CPL	Commercial Pilot's Licence
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder

F

FDR	Flight Data Recorder
FEW	few
ft	feet

H

HFACS	Human Factors Analysis and Classification System
Hpa	Hectopascal pressure unit
hrs	hours
HUD	Head-Up Displays

I

ICAO	International Civil Aviation Organisation
ie	id est or 'that is'

ILS	Instrument Landing System
in	inches
IR	Instrument Rating

K

kg	kilogram
km	kilometres
kts	knots

L

lbs	pounds
LT	Local Time

M

m	metres
METAR	Meteorological Terminal Air Report
Mhz	MegaHertz
MTOW	Maximum Take-Off Weight

N

nm	nautical miles
NOTAM	Notice to Airmen
NVD	Night Vision Device

P

PF	Pilot Flying
PM	Pilot Monitoring
POH	Pilot Operating Handbook
PSM	Product Support Manual

Q

QAR	Quick Access Recorder
QNH	aeronautical Q code, indicating the atmospheric pressure adjusted to mean sea level.

S

SEP	Safety Emergency Procedures
SI	Serious Incident
SOP	Standard Operating Procedures

U

UTC	Coordinated Universal Time

V

VOR	VHF Omnidirectional Radio Range
Vref	Reference Speed

Z

ZFW	Zero Fuel Weight

FINAL REPORT SI 01/20

SYNOPSIS

A Twin Otter DHC-6 400 (9M-SSE) was on a schedule flight MH 3517 from Lawas to Miri on the 7 January 2020. Upon landing at Miri Airport on Runway 02, the aircraft veered to the left of the runway, ending up on the grass area to the left of Runway 02. After the incident, the passengers were evacuated by the crews with the help from the airport authorities and were taken back to the terminal. Upon the incident, Airport Fire Rescue Services (AFRS) was notified and they responded and proceed to the scene.

Notification was given to Air Accident Investigation Bureau, Malaysia (AAIB) and the Civil Aviation Authority of Malaysia (CAAM) by the Operator. AAIB Inspectors were immediately dispatched to Miri the following day.

In accordance to ICAO Annex 13, notification of the serious incident was sent on 12 January 2020 to Transport Safety Board of Canada as State of Manufacturer and ICAO as the aircraft involved has a maximum mass of over 2,250kg. A Preliminary Report was subsequently submitted to the Operator on 27 February 2020.

1.0 FACTUAL INFORMATION

1.1 History of the Flight

On the 7 January 2020, a Twin Otter DHC-400, callsign MH 3517 from Lawas to Miri veered off runway 02 upon landing at Miri Airport. The flight was the second sector of a series of 4 sectors to be flown that day, the preceding flight being MH3516, from Miri to Lawas. The preceding sector had been normal, with both a normal take-off from Miri and a normal landing in Lawas. There were no abnormalities reported by the crew during the take-off for the return sector from Lawas to Miri.

Both crews reported for duty at approximately 1405hrs on that day. The pre-flight was normal and the weather was good on that day.

The aircraft departed from Miri at 1442hrs, ahead of schedule for Lawas. All sectors were flown by the captain, as it is company's policy for new captains. The aircraft landed uneventfully at 1535hrs. At 1540hrs, the crew prepared and commenced the return leg to Miri. The aircraft approached Miri Airport runway 02 normally and was fully stabilized by 500ft with all checklists completed. The flap 20 degrees setting was used with the Vref being set to 80kts for the landing weight of 11,755lbs. The crew reported that the weather was fine at the time of landing with the wind at 350/07kts with more than 10km visibility. The tower recorded the weather at the time to be good with the wind being variable at 05kts.

At touchdown, the aircraft landed on its main gears. After the nose gear was lowered, the aircraft continued straight along the runway initially but soon afterwards veered to the left of the runway. The aircraft continued along the runway for 175m in a slight curve to the left. After leaving the runway, it continued on the grass for another 84m, bringing the total distance travelled in a curve to 259m. In a perpendicular line from the runway edge, the aircraft had travelled approximately 40m.

The captain applied full rudder and brake to counteract the veering but was not able to arrest the veer to the left. Nearing the runway edge and upon glancing down, he noticed that the nose wheel steering lever was at full deflection to the left. He immediately, tried to re-centre the steering lever but by then the aircraft was already on the grass and rolled perpendicular to the left and stopped completely in the soft ground. He then shut down and secured the engines. After that the captain, coordinated with the tower for emergency services and proceeded to evacuate the passengers. The passengers were then brought to the terminal after being evacuated.

The wreckage was removed a few hours later by the Operator's Engineering Team after getting approval from the AAIB and was towed back to bay R4 Miri Airport for damage inspection.

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	14	NIL	16

Figure 1: Injuries to Person

1.3 Damage to Aircraft

There was no damage found to the aircraft's structure. All wheels and main wheels' brake units were covered with mud (Figure 2). The nose wheel was found with a heavy spot wear and some heavy wear marks.

Figure 2: Aircraft final position and skid marks from runway edge

1.4 Other Damage

Nil

1.5 Personnel Information

1.5.1 Captain

Age	30
Sex	MALE
Date of Joining Company	1 August 2019
Date Cleared Online	1 December 2019
License	ATPL: 4765 Medical Expiry: 31 July 2020 Last Base Check: 25 October 2019 Last IR: 25 October 2019 Last Line Check: 1 December 2019
Flying Hours	Total: 4351:24hrs Hours on type: 98:06hrs
Other Courses/Validities	SEP Expiry: 22 August 2020 CRM Expiry: 20 August 2020 Passport Expiry: 9 April 2024

Figure 3: Personal Information – Captain

The Captain of the flight was relatively new with very limited hours on type. He had just cleared Initial Line Training the month before the incident. The Captain had sufficient rest prior to the flight and was fit to fly.

1.5.2 Co-Pilot

Age	30
Sex	MALE
Date of Joining Company	15 May 2018
Date Cleared Online	22 September 2018
License	CPL/IR: 6469 Medical Expiry: 31 March 2020 Last Base Check: 31 September 2019 Last IR: 31 August 2019 Last Line Check: 20 October 2019
Flying Hours	Total: 807:20hrs Hours on type: 633:20hrs
Other Courses/Validities	SEP Expiry: 7 April 2020 CRM Expiry: 10 December 2020 Passport Expiry: 9 January 2021

Figure 4: Personal Information – Co-pilot

The Co-pilot has a year and a half experience with the company. The Co-pilot was on medical leave the day prior to the incident but was declared fit to fly the proceeding day. The Co-pilot had sufficient rest prior to the flight.

1.6 Aircraft Information

1.6.1 Aircraft Data

Aircraft Type	Twin Otter DHC6-400
Manufacturer	Viking Air
Owner	MASwings
Registration	9M-SSE
Serial No.	894
Year of Manufacture	2014
Certificate of Registration No.	Issued by CAAM on 03 March 2016 valid till 02 March 2021.

Certificate of Airworthiness No.	Issued by CAAM on 02 June 2020 valid till 11 June 2021.
Total Flight Hours	9,490 hours (on day of occurrence)

Figure 5: Aircraft Data

1.6.2 Aircraft Airworthiness

The aircraft was in airworthy condition. There were previous entries in the Aircraft Technical Log dated 10 December 2019 regarding vibration felt during take-off roll. It was rectified with no recurrence. The crew also reported no abnormalities during the preceding sector from Miri to Lawas.

1.6.3 Aircraft Weight and Balance

The aircraft departed from Lawas with a Zero Fuel Weight (ZFW) of 10,467lbs, a Maximum Take-off Weight (MTOW) of 12,145lbs and an estimated landing weight at Miri of 11,755lbs. These are well within the aircraft's prescribed limits.

1.7 Meteorological Information

1.7.1 Weather was fine at the time of the incident. Tower reported wind to be variable at 5kts; visibility at 10km; Clouds scattered at 1,600ft, scattered at 15,000ft and broken 30,000ft; temperature at 30^{0}C with QNH at 1007Hpa.

1.7.2 ATIS report received at the time of incident indicated wind from 350/07kts backing 260 variable 05kts; visibility at 10km; clouds scattered at 1,600 feet; temperature/dewpoint at 29^{0}C/26; QNH: 1007Hpa.

1.7.3 The incident happened in day light.

1.8 Aids to Navigation

VOR VMI was unserviceable as per NOTAM WMKKD1360/19 dated 31 December 2019. ILS Runway 02 was operational but not used for the approach, as the approach was carried out visually.

1.9 Communications

All communications frequencies were operating normally. The crew was in contact with Miri Tower and thereafter Miri Ground which coordinated the rescue effort. The Operator's Operations was contacted on Borneo 3 Frequency of 131.15MHz post-incident.

1.10 Aerodrome Information

Airport	Miri Airport
Runway	02/20
Length	2745m
Width	60m
ICAO Designator	WBGR
IATA Designator	MYY
Elevation	59ft
Navaids	VOR VMI, ILS IMR
Radio	MIRI GROUND: 121.9MHz MIRI TOWER 123.3MHz MIRI RADAR: 129.9MHz MIRI INFO (ATIS): 127.00MHz

Figure 6: Miri Airport Information

1.11 Flight Recorders

Aircraft was equipped with Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR). Data from Quick Access Recorder (QAR) was download for analysis and CVR has been impounded by AAIB for data downloading.

1.12 Wreckage and Impact Information

Figure 7: Aerial View of Aircraft Position at Miri Aerodrome (Not according to scale)

The aircraft was intact after the incident. It came to rest at about 40m perpendicularly from the runway edge. The aircraft was stuck in soft ground and was extricated later that evening by Operator's Engineering Team with assistance from the airport authorities.

1.13 Medical and Pathological Information

Both crews underwent urine test for substance abuse on the same day of the incident and both passed the test.

1.14 Fire

There was no pre or post impact fire.

1.15 Survival Aspects

There were no fatalities or injuries to passengers and crews.

1.16 Tests and Research

Nil.

1.17 Organizational and Management Information

The Operator operates 10 ATR 72 and 06 Twin Otter DHC-6 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. Viking Air had recommended to the Operator to carry out the Heavy Landing Inspection Part 1 from PSM1-6-7 as additional guidance to the maintenance work done.

Post incident engineering inspection on the nose wheel, wheel bearing, steering cables and steering actuator found no defect. The steering actuator was sent for bench testing and test results indicate no abnormalities.

1.17.2 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		Speed indication	Wind Speed/Wind Direction	Vertical Speed (fpm)	Flaps setting	Remark & Notes
08:16:15	1090	299	4.7	4.6	77	76	105	25/3	-656	0	Aircraft approaching right base runway 02
08:16:33	1000	318	13.6	13.9	94	93	95	21/12	197	10	Flaps 10 set
08:17:39	764	19.4	10.6	11.4	84	84	84	10/8	-65	14	Flaps 20 selected
08:17:45	763	19.5	10.0	10.3	80	80	79	10/2	0	20	Flaps 20 set
08:18:18	505	21.7	8.7	9.0	77	77	77	11/336	-393	20	**Aircraft stabilized by 500 feet AGL**

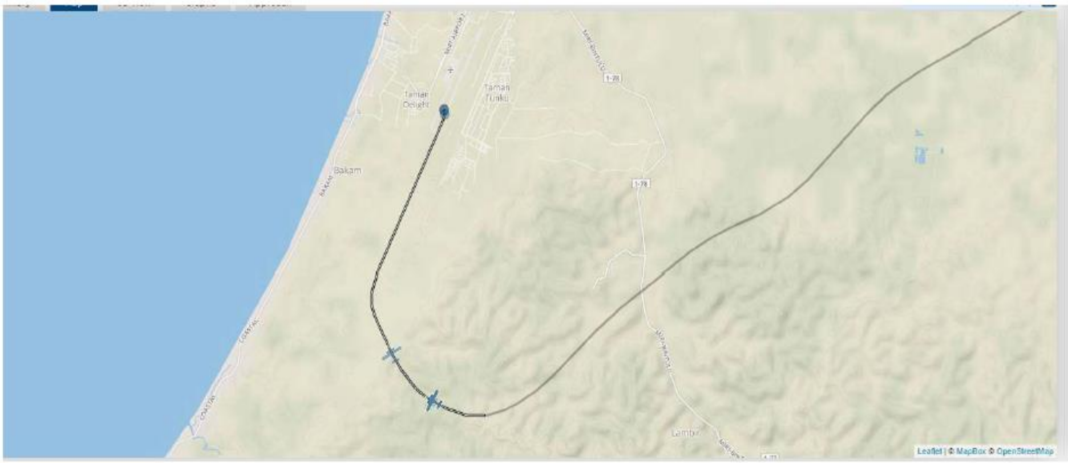


Figure 8: QAR Data Below 1,000ft – Approach Stabilized

Flight Phase: Final Approach to Aircraft Complete Stop: -

Time UTC	Height AFE	Flight Parameters: Heading(M), TQ1&2			Np 1 & 2		Speed indication	Wind Speed/Wind Direction	Vertical Speed (fpm)	Flaps setting	Remark & Notes
08:18:55	100	19.5	9.4	10	77	77	75	11/326	-393	20	Approach Stabilized
08:19:03	50	18.2	4.2	5.0	74	74	73	11/328	-328	20	Flare before touchdown
08:19:17	0	352	7.4	6.6	62	60	46	7/309	0	20.2	Aircraft touchdown
08:19:22	0	3.6	4.3	5.0	48	47	26	7/315	0	20.3	Maximum Yaw at 23 degrees per second
08:19:28	0	41.3	6.0	5.9	47	48	0	0	0	20.9	**Aircraft came to a complete stop.**

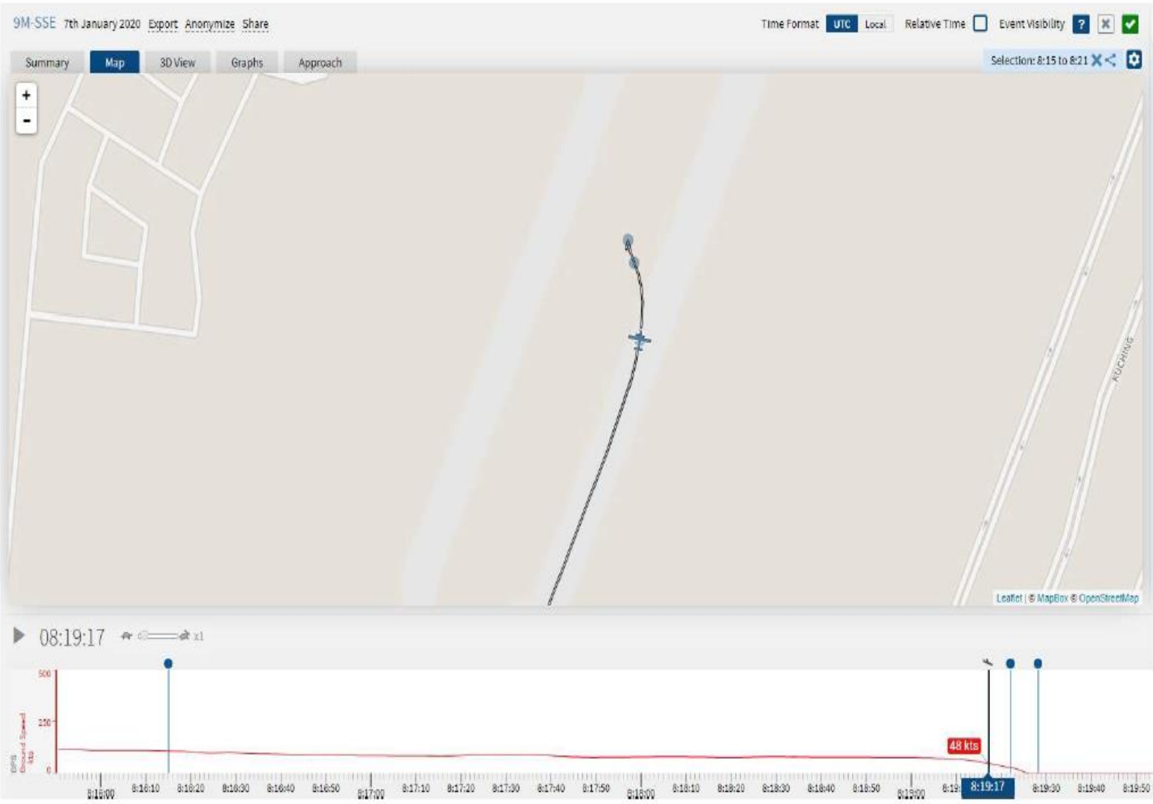


Figure 9: QAR Data Final Approach to Aircraft Complete Stop – Aircraft Veered Left after Touch Down

QAR data shows that the aircraft had stabilized at 500ft during the approach to land in accordance to the DHC-6 Series 400 SOP. The data also found no significant event during the approach to land phase (Figure 8). The incident occurred after the aircraft touchdown on the runway before veering to the left with a maximum yaw rate of 23^0 per second (Figure 9).

1.17.3 Aircraft Cockpit Voice Recorder (CVR)

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

a. The checklist procedures were not carried out in accordance with DHC-6 Series 400 SOP. (refer paragraph 1.17.6.1)

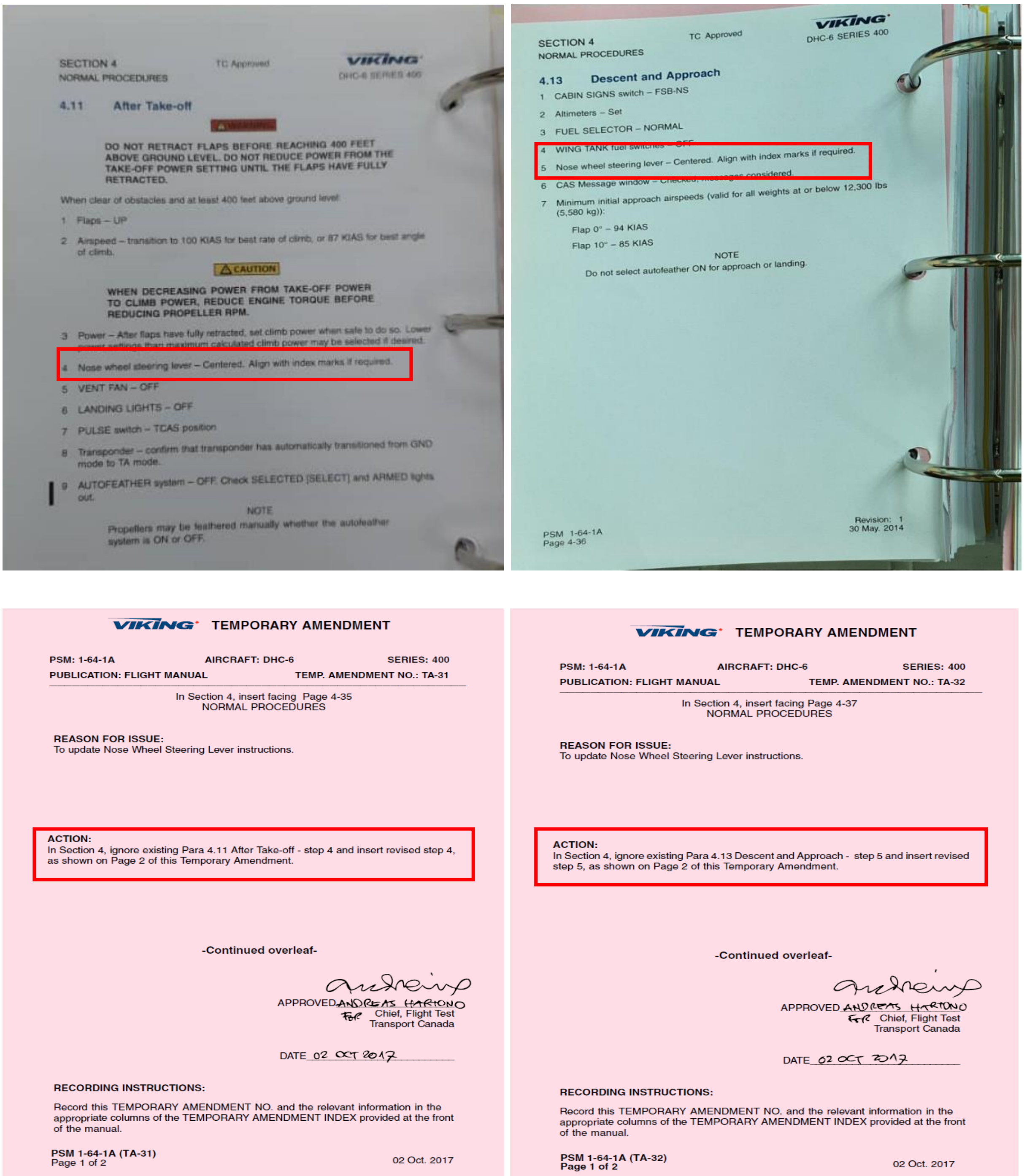
b. The checklist reading was carried out in a mumbling tone which was barely audible.

c. Take-off and departure brief were not recorded. Approach brief was not carried out in accordance with DHC-6 Series 400 SOP (refer paragraph 1.17.6.2).

1.17.4 Temporary Amendment to Nose Wheel Steering Lever Checklist

It was observed that the paper checklist in use by the pilots were not updated (Figure 10). The temporary amendment to the checklist was omitted although the amendment was issued by the manufacturer dated 02 October 2017. The checklist amendment concerned an update on the Nose Wheel Steering Lever for After Take-off (temporary amendment no: TA-31) and Descend/Approach Checks (temporary amendment no: TA-32) (Figure 11).

The paper checklist amendment required actions from the pilot to apply slight upward and downward pressure to the nose wheel steering lever to confirm that the nose wheel is centred and locked (Figure 11). It is slightly different from the current practice to wiggle[1] the steering lever centre and align with index mark.



SECTION 4
NORMAL PROCEDURES
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VIKING
DHC-6 SERIES 400

4.11 After Take-off

WARNING

DO NOT RETRACT FLAPS BEFORE REACHING 400 FEET ABOVE GROUND LEVEL. DO NOT REDUCE POWER FROM THE TAKE-OFF POWER SETTING UNTIL THE FLAPS HAVE FULLY RETRACTED.

When clear of obstacles and at least 400 feet above ground level:

1 Flaps – UP
2 Airspeed – transition to 100 KIAS for best rate of climb, or 87 KIAS for best angle of climb.

CAUTION

WHEN DECREASING POWER FROM TAKE-OFF POWER TO CLIMB POWER, REDUCE ENGINE TORQUE BEFORE REDUCING PROPELLER RPM.

3 Power – After flaps have fully retracted, set climb power when safe to do so. Lower power settings than maximum calculated climb power may be selected if desired.
4 Nose wheel steering lever – Centered. Align with index marks if required.
5 VENT FAN – OFF
6 LANDING LIGHTS – OFF
7 PULSE switch – TCAS position
8 Transponder – confirm that transponder has automatically transitioned from GND mode to TA mode.
9 AUTOFEATHER system – OFF. Check SELECTED [SELECT] and ARMED lights out.

NOTE

Propellers may be feathered manually whether the autofeather system is ON or OFF.

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4.13 Descent and Approach

1 CABIN SIGNS switch – FSB-NS
2 Altimeters – Set
3 FUEL SELECTOR – NORMAL
4 WING TANK fuel switches – OFF
5 Nose wheel steering lever – Centered. Align with index marks if required.
6 CAS Message window – Checked, messages considered.
7 Minimum initial approach airspeeds (valid for all weights at or below 12,300 lbs (5,580 kg)):
Flap 0° – 94 KIAS
Flap 10° – 85 KIAS

NOTE

Do not select autofeather ON for approach or landing.

PSM 1-64-1A
Page 4-36
Revision: 1
30 May. 2014

VIKING TEMPORARY AMENDMENT

PSM: 1-64-1A AIRCRAFT: DHC-6 SERIES: 400
PUBLICATION: FLIGHT MANUAL TEMP. AMENDMENT NO.: TA-31

In Section 4, insert facing Page 4-35
NORMAL PROCEDURES

REASON FOR ISSUE:
To update Nose Wheel Steering Lever instructions.

ACTION:
In Section 4, ignore existing Para 4.11 After Take-off - step 4 and insert revised step 4, as shown on Page 2 of this Temporary Amendment.

-Continued overleaf-

APPROVED ANDREAS HARTONO
For Chief, Flight Test
Transport Canada

DATE 02 OCT 2017

RECORDING INSTRUCTIONS:
Record this TEMPORARY AMENDMENT NO. and the relevant information in the appropriate columns of the TEMPORARY AMENDMENT INDEX provided at the front of the manual.

PSM 1-64-1A (TA-31)
Page 1 of 2
02 Oct. 2017

VIKING TEMPORARY AMENDMENT

PSM: 1-64-1A AIRCRAFT: DHC-6 SERIES: 400
PUBLICATION: FLIGHT MANUAL TEMP. AMENDMENT NO.: TA-32

In Section 4, insert facing Page 4-37
NORMAL PROCEDURES

REASON FOR ISSUE:
To update Nose Wheel Steering Lever instructions.

ACTION:
In Section 4, ignore existing Para 4.13 Descent and Approach - step 5 and insert revised step 5, as shown on Page 2 of this Temporary Amendment.

-Continued overleaf-

APPROVED ANDREAS HARTONO
For Chief, Flight Test
Transport Canada

DATE 02 OCT 2017

RECORDING INSTRUCTIONS:
Record this TEMPORARY AMENDMENT NO. and the relevant information in the appropriate columns of the TEMPORARY AMENDMENT INDEX provided at the front of the manual.

PSM 1-64-1A (TA-32)
Page 1 of 2
02 Oct. 2017

Figure 10: Checklist – After Take-off and Descent/Approach Checklist before Amended Procedure

[1] Definition from Collins Dictionary of 'wiggle' - move or cause to move up and down or from side to side with small quick movements.

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NORMAL PROCEDURES DHC-6 SERIES 400

5 Nose wheel steering lever – Centered and locked. Align with index marks if required, then apply a slight upward and downward pressure to the nose wheel steering lever to confirm that the nose wheel is locked in the center position.

⚠ CAUTION

EXCESSIVE PRESSURE ON THE STEERING LEVER WHILE AIRBORNE SHOULD BE AVOIDED IN ORDER TO PREVENT UNNECESSARY LOADS ON THE STEERING LOCK MECHANISM.

02 Oct. 2017 PSM 1-64-1A (TA-32) Page 2 of 2

Figure 11: Checklist - Amended Procedure for After Take-off and Descend/Approach Checks.

1.17.5 Differences between Aircraft Electronic and Paper Checklist

The DHC-6 Series 400 SOP detail that the electronic checklist may be used instead of paper checklist (Figure 12). The Pilot Operating Handbook and Aircraft Flight Manual (POH/AFM) remains the primary reference for checklist and implementation of the electronic checklist is the responsibility of the operator (Figure 13).

MASwings DHC-6 Series 400 Standard Operating Procedures

2.6.3 ELECTRONIC CHECKLIST

2.6.3.1. The electronic checklist may be used instead of the paper checklist. Generally speaking, it is faster and easier to use the paper door pocket checklists. The electronic checklist is useful for the DESCENT checklist, because the items on this checklist are often not all completed at the same time.

Figure 12: SOP – Electronic Checklist

VIKING DHC-6 SERIES 400 | TC Approved | SECTION 2 LIMITATIONS

the boundary between Canadian Southern Domestic Airspace and Canadian Northern Domestic Airspace.

In the Southern hemisphere, flights or portions of flights carried out south of S82°, and south of S55° between E120° and E160°, must be planned based on using track made good referenced to True North only.

2.13.10 Electronic Checklists

With respect to airworthiness approval, the AFM remains the primary reference for checklists. Implementation of an electronic checklist is the responsibility of the operator, and use and operational approval is dependent on the rules of operation imposed by the appropriate Regulatory Authority. Provision of the electronic checklist feature does not imply operational approval.

Electronic checklists may be used for Normal procedures only. It is prohibited to use the electronic checklist for abnormal and/or emergency procedures.

Figure 13: POH/AFM – Electronic Checklists

Observation revealed that there are differences in the sequence of checks between the electronic and paper checklist example in the After Take-Off and Descend/Approach checks. The POH/AFM under ‘Warning’ note states that in case of differences, the POH/AFM (paper checklist) shall prevail (Figure 14). It also states that it should not be used during initial pilot training or familiarization.

SECTION 4 TC Approved VIKING
NORMAL PROCEDURES DHC-6 SERIES 400

4.1.1 Electronic Checklists

WARNING

IN CASE OF DIFFERENCES BETWEEN THE ELECTRONIC CHECKLIST DISPLAYED ON THE APEX SYSTEM AND THE CONTENTS OF THIS AIRCRAFT FLIGHT MANUAL, THE CONTENTS OF THE AIRCRAFT FLIGHT MANUAL SHALL PREVAIL.

SOME SERIES 400 AIRCRAFT ARE EQUIPPED WITH AN ELECTRONIC CHECKLIST SYSTEM. BECAUSE OF THE INHERENT LIMITATIONS OF THE ELECTRONIC CHECKLIST (FOR EXAMPLE, TEXT DISPLAY IS LIMITED TO 18 CHARACTERS PER LINE), THE CONTENTS OF THE ELECTRONIC CHECKLIST HAVE BEEN CONDENSED. ACTIONS AND/OR DESIRED STATUS STATEMENTS FOLLOWING EACH CHALLENGE ITEM HAVE BEEN ABBREVIATED TO FIT WITHIN THE LIMITATIONS OF THE DISPLAY SYSTEM.

NO SYSTEM TEST OR FUNCTION CHECK PROCEDURES ARE PUBLISHED IN THE ELECTRONIC CHECKLIST. DETAILED PROCEDURES, SUCH AS STARTING ENGINES FROM BATTERY OR EXTERNAL POWER, OR TAKE-OFF, LANDING, GO-AROUND AND MISSED APPROACH PROCEDURES ARE NOT PUBLISHED IN THE ELECTRONIC CHECKLIST.

THE ELECTRONIC CHECKLIST IS A 'QUICK REFERENCE' MEMORY AID THAT IS PROVIDED FOR USE BY FULLY TRAINED AND EXPERIENCED PILOTS WHO ARE THOROUGHLY FAMILIAR WITH THE CONTENTS OF THIS AIRCRAFT FLIGHT MANUAL. IT DOES NOT REPLACE OR SUPERSEDE THE CONTENTS OF THIS AIRCRAFT FLIGHT MANUAL. IT SHOULD NOT BE USED DURING INITIAL PILOT TRAINING OR FAMILIARIZATION.

Figure 14: POH/AFM – Electronic Checklist

1.17.6 Aircraft Standard Operating Procedure (SOP)

The following non-compliance to DHC-6 Series 400 SOP by the pilots were observed during the CVR analysis:

1.17.6.1 Checklist Procedures

a. The captain who was Pilot Flying (PF) did not call for the required checklist. The co-pilot who was Pilot Monitoring (PM) performed the checklist action items without being call for by the PF, contrary with the DHC-6 Series 400 SOP in Figure 15.

2.6.1.4. For all normal checklist procedures, the procedure is called for by the **PILOT FLYING** (PF), and carried out by the PILOT MONITORING (PM). Once the pilot monitoring has completed the procedure, he or she then visually checks the CAS List to ensure that the messages (or absence of messages) on the CAS List indicate that all of the necessary actions for that particular phase of flight (pre-start, pre-takeoff, etc.) have been correctly carried out.

Figure 15: SOP – Checklist Procedures

b. The PM did not perform checklist action items in a clear audible voice and did not announce clearly which checklist was completed after checklist actions are taken contrary to DHC-6 Series 400 SOP in Figure 16.

DHC-6 Series 400 Standard Operating Procedures — MASwings

2.6.1.5. After the **PILOT MONITORING** (PM) has completed the "procedure", and after this pilot has reviewed the CAS List to confirm that all necessary actions have been completed, **PILOT MONITORING** (PM) will confirm that all appropriate checklist items have been completed, by using either the paper checklist or the electronic checklist. With the single exception of the Descent Checklist, which takes the form of a briefing between the two pilots, all of the checklists are completed with clear audible voice by the **PILOT MONITORING** (PM). When the **PILOT MONITORING** (PM) has completed the review of the paper or electronic checklist and is satisfied that all the required actions for that phase of flight have been carried out, the **PILOT MONITORING** (PM) will announce "(Name of Checklist) Complete". This advises the **PILOT FLYING (PF)** that the necessary work has been completed.

Figure 16: SOP - Checklist Procedures (continue)

c. The After Take-off checklist procedures were not complied with contrary to the DHC-6 Series 400 SOP in Figure 17. Division of responsibilities and coordination between the two pilots during the take-off were not strictly adhered to. Evidence from CVR revealed there was no instruction heard from the PM to ask the PF to check the nose wheel steering lever locked in centre (Figure 18).

3.13.2. AFTER TAKEOFF CHECKLIST

3.13.2.1. The PILOT FLYING calls for the After Take-off checklist when he or she believes that it is appropriate to do so. Because there are no especially urgent actions on the After Take-off checklist, the PILOT FLYING may elect to delay calling for this checklist until the aircraft is well established in the climb and away from busy traffic areas, or well clear of hazardous weather or hazardous terrain.

3.13.2.2. The PILOT MONITORING completes the After Take-off procedures, and announces "After Take-off Checklist Complete" when finished. If the PILOT MONITORING is in the right seat, it will be necessary to ask the left seat pilot to wiggle the nosewheel lever to ensure that the nosewheel is locked in the centre position.

3.13.2.3. Either pilot can easily confirm that the After Take-off checklist has been completed by looking at the CAS list. The CAS list should be completely empty after completion of the After Take-off checklist.

3.13.2.4. Like all other checklists, the items on the After Take-off checklist should be completed in the exact order that they are listed. In particular, this means that turning off the autofeather system should be the last action taken.

Note: As the nose wheel is not self centering type the PIC (Pilot in command) / COMMAND TRAINEE shall gently wiggle the nose wheel steering slightly past the neutral band in order to ensure that the Nose wheel is align centred and in lock position.

Figure 17: SOP – After Take-Off Checklist Procedures

DHC-6 Series 400 Standard Operating Procedures

PILOT FLYING (LEFT SEAT)	CONDITION	PILOT MONITORING (RIGHT SEAT)
Trims aircraft to maintain 80 knot initial climb to minimum of 500 feet AGL	80 knots	Ensures that power remains set at 50 PSI. Silently monitors airspeed.
Climbs to minimum 500 feet AGL at 80 knots	Climbing at 80 knots. *Note; No more and no less than 80 knots, because 80 knots is V_Y for 10° flap*	At 500 FEET AGL (or other higher briefed altitude) when this altitude is reached. Call … "500 FEET AGL"
Commands 'FLAPS UP'		Selects Flaps Up
	After flaps have fully retracted	Call … "FLAPS UP"
Commands 'CLIMB POWER'		Sets climb power (typically 75% N_P and 50 torque, but may vary depending on what was briefed)
	Climb Power Set	Announces "CLIMB POWER SET" "YOUR POWER"
"MY POWER" Commands 'After Take-off Checklist'		Completes After Take-off Procedures. Confirms CAS List is empty. Asks left seat pilot to check nosewheel tiller is locked in centered position. Announces "AFTER TAKE-OFF CHECKLIST COMPLETE"

Figure 18: SOP - Division of Responsibilities and Coordination between the two pilots during the take-off

d. Following the completion of Descend/Approach checklist, it is the responsibility of both crews to ensure the nose wheel steering is aligned with index mark after performing the Landing Checklist as required by the DHC-6 Series 400 SOP in Figure 19.

3.14.14 LANDING CHECKLIST

3.14.14.1. There are only two items on the Landing checklist, these are flap extension and propellers forward. An amber CAS message will be presented if the airspeed is below 87 KIAS for more than 5 seconds and the propellers have not been moved forward. Crew should plan their activities so that props are put forward at or shortly after initial extension of flaps to 10° to avoid being presented with this CAS message. If landing flap is not set prior to approximately 500 feet AGL, the TAWS will voice a 'TOO LOW – FLAPS' message.

3.14.14.2. The two item landing checklist can be completed from memory. Both crew are to ensure the nosewheel steering is aligned. If it is safe to do so, the weather radar should be selected to STBY prior to landing, to secure the antenna dish in the parked position prior to touchdown. Turning the weather radar STBY prior to touchdown prolongs the life of the moving components in the radome.

Figure 19: SOP – Landing Checklist

1.17.6.2 Take-off, Departure Brief and Approach Briefing

The take-off (Figure 29) and departure brief (Figure 21) were not recorded by the CVR as all these briefs were completed before the battery is turned 'ON' as practiced by MASwings. Since the take-off and departure briefs were not recorded by the CVR, there is no avenue for the investigation team to verify if the briefs were carried out as required by the DHC-6 Series 400 SOP.

The PF did not give the PM the approach brief (Figure 22). This is a non-compliance to standard procedure as mandated in the DHC-6 Series 400 SOP.

MASwings DHC-6 Series 400 Standard Operating Procedures

3.8. TAKEOFF AND DEPARTURE BRIEF

3.8.1. The PIC (Pilot in command) shall give the standard company procedures and callout briefing for every first flight of the day and after any crew change. In principle, a crew change should be treated as a "first flight of the day" by the crew receiving the aircraft.

3.8.2. The PILOT FLYING shall give the PILOT MONITORING a Take-off / Departure briefing before the take-off. The briefing shall include take-off procedures, departure procedures, and what action the crew will take in the event of an engine failure.

3.8.3. For subsequent flights the same day, if no deviations from the engine failure procedures discussed in the previous briefing are considered necessary, the term '**Standard Briefing**' can be used. But, the (normal) take-off procedures and departure procedures must be briefed for every take-off.

3.8.4. Any deviation from the standard procedures should be clearly pointed out by the PILOT FLYING.

3.8.5. The standard take-off briefing for actions the crew will take in the event of an engine failure shall consists of a brief review of the Engine Failure on Take-off procedures that are set out in Section 3 of the AFM/POH.

3.9.2. The following briefing is the standard take off briefing and is to be given word for word.

3.9.2.1. Left Hand Seat Sector:

"Standard company procedures and call outs. Call 'V1, Rotate' at 75 knots, monitor engine and flight instruments. Any malfunction occurs BEFORE V1 call out the system and condition. If I decide to abort the take-off, I will announce 'ABORT', simultaneously close power levers, apply maximum braking and select reverse as required. Any malfunction occurs AT or AFTER V1, the take-off will continue. No actions below 400' AGL. Actions on my command only."

3.9.2.2. Right Hand Seat Sector:

"Any malfunction occurs BEFORE V1 and I decide to abort, I will announce 'ABORT', take over and you will revert to support duties. Any malfunction occurs AT or AFTER V1, you will continue flying until I announce 'I HAVE CONTROL' at which point you will hand over control and revert to support duties".

"At any time should you have any doubt on the safety of the flight, do not hesitate to bring it to my attention immediately"

Figure 20: SOP – Take-off Brief

DHC-6 Series 400 Standard Operating Procedures MASwings

3.9.3. Prior to each departure, the Pilot flying shall give a departure briefing, which must include but not be limited to the following items:

a) Threat, Error and Management.
b) Bay no./ pushback procedure.
c) Taxi route to departure runway.
d) Expected departure clearance.
e) SID (where applicable).
f) Chart no/date/validity.
g) MSA/MEA.
h) Intended track.
i) Speed restriction.
j) NAV/COM
k) Plans in the event of in-flight return/single engine procedure.
l) Initial climb out path.
m) Acceleration altitude.
n) Planned path to come back or divert (according to weather).
o) Expected type of approach and associated chart.

3.9.4 Visual Departure

3.9.4.1 The visual departure briefing should only be given when the weather conditions can guarantee a visual departure, or alternate aerodrome. An example of a visual departure briefing is as follows:

"This will be my sector to Lawas, visual departure runway 02, runway HDG 024. 500' turning right to intercept FMS track / 068 radial VMI, climbing to 7000'. Nav one and Nav two set VMI (112.4), ADF set to MYY (209). Should a malfunction occurs after take-off we will return to MIRI for a visual approach onto runway 02, flaps 20 and Vref 80KTS. Are there any question or suggestion?"

Figure 21: SOP – Departure Brief

3.14.6 VISUAL APPROACH BRIEFING

3.14.6.1 A visual approach should only be briefed when an actual weather report has been received from an authorized observer on the ground indicating that a visual approach can be anticipated. An example of a visual approach briefing is as follows

"This will be a visual approach to Miri, top of descent will be FMS generated, descending as directed to join left base runway 20. Flaps 20 landing Vref 77KTS, Nav one and Nav two remain set to VMI. ADF set to MYY. In case off a go around we will proceed to right hand downwind runway 20 to continue landing. The alternate is Bintulu, and minimum diversion fuel is 690 lbs, now we have on board ....lbs. Any questions or suggestion?"

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Figure 22: SOP – Approach Brief

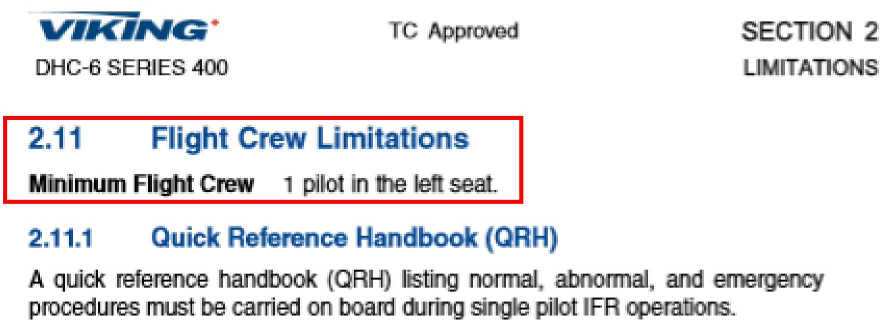
1.17.6.3 Sterile Cockpit Procedures

There is no guidance to the crew with regards to sterile cockpit procedures as the DHC-6 Series 400 SOP does not have one. It was observed there was unnecessary chattering between the pilots when aircraft was on final. Potential miscommunication between pilots will arise when standards terminology is not used during critical phases of flight and emergency situation.

1.17.7 Challenge and Response Procedure

The POH/AFM states that the minimum flight crew for this aircraft is one pilot in the left-hand seat (Figure 23). Evidence from CVR shows that the current practice by the operator is tailored to a one person read and actioned items on the checklist as stated in the SOP. This practice is also explained in paragraph 1.17.6.1.

Since the aircraft is flown by two pilots, implementing a challenge and response procedure in performing checks between PF and PM will provide better check and balance to prevent human errors.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SECTION 2

DHC-6 SERIES 400

LIMITATIONS

2.11 Flight Crew Limitations

Minimum Flight Crew 1 pilot in the left seat.

2.11.1 Quick Reference Handbook (QRH)

A quick reference handbook (QRH) listing normal, abnormal, and emergency procedures must be carried on board during single pilot IFR operations.

Figure 23: POH/AFM – Flight Crew Limitations

1.17.8 Aircraft On-board Documentation

A copy of the POH/AFM is mandated by the manufacturer to be placed onboard the aircraft (Figure 24). The POH/AFM onboard the aircraft was incomplete and had pages missing. This is probably caused by the flight or ground crew operating the aircraft misplacing the pages after use or due to fair wear and tear.

VIKING — DHC-6 SERIES 400 — TC Approved — SECTION 2 LIMITATIONS

2.13 Honeywell Primus Apex® System Limitations

2.13.1 Documentation

The Aircraft Flight Manual (this publication, PSM 1-64-1A) must always be on board the aircraft.

The Honeywell Primus Apex® Integrated Avionics System Pilot Guide for the DHC-6 Series 400, Honeywell publication number D200810000022 must always be on board the aircraft.

For L3 GH-3100 ESIS (Pre Mod 6/2170) equipped aircraft, the L3 GH-3100 ESIS Pilot Guide publication number TP-560 at Revision F, or later revision, must always be on board the aircraft.

For L3 GH-3900.2 ESIS (Post Mod 6/2170) equipped aircraft, the L3 GH-3900.2 ESIS Pilot Guide publication number 0040-34400-01 at Revision E, or later revision, must always be on board the aircraft.

The INAV map display and/or the electronic display of Jeppesen terminal and approach charts on the Honeywell Primus Apex® display screens is not an approved substitute for the conventional paper maps, charts, and books that are normally required to be carried on board the aircraft for navigation purposes.

Figure 24: POH/AFM - Documentation

1.17.9 Conversion and Recurrent Training

During conversion and recurrent training, brief explanation was given to pilots on the nose wheel steering system as per the POH/AFM (Figure 25). It was observed that insufficient emphasis was placed to explain the working principles and operations of the nose wheel steering system and centring mechanism to the pilots.

7.16.2 Nose Wheel Steering

The nose wheel is steerable over a range of 60°s to left and right of the center position for purposes of low speed ground maneuvering. Steering is controlled from a steering lever which pivots about the hub of the left control wheel and is labelled N.W. STEER, with directional arrows R and L. The nose wheel is swivelled by a hydraulically-operated steering actuator mounted on the nose gear strut; the actuator being connected to a steering collar and torque links at the lower end of the strut. The steering lever is connected by a cable and pulley system to a drum on the actuator steering valve,

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which controls the direction and amount of turn in response to steering lever up or down movement. A spring-loaded latch retains the nose wheel in the centered position in flight. For ground handling purposes, the nose gear leg torque links may be disconnected by removing a pip pin so that the leg can caster freely.

Unnecessary pressure on the steering lever while airborne should be avoided in order to prevent unnecessary loads on the steering lock mechanism.

Figure 25: POH/AFM – Nose Wheel Steering

1.17.10 Nose Wheel Steering System and Operations

The aircraft nose wheel is not the self-centring type. The nose-wheels must be centred into a “notch” after the aircraft is airborne. A spring-loaded tab will fit into a recession in the steering collar. This is done manually by the pilot by manipulating the nose wheel steering lever to the left and right, once after take-off and again, before descent as a fail-safe. The convention is that if the nose wheel is not in the notch due to be off-set from centre, moving the nose wheel steering will place it in the notch (Figure 26).

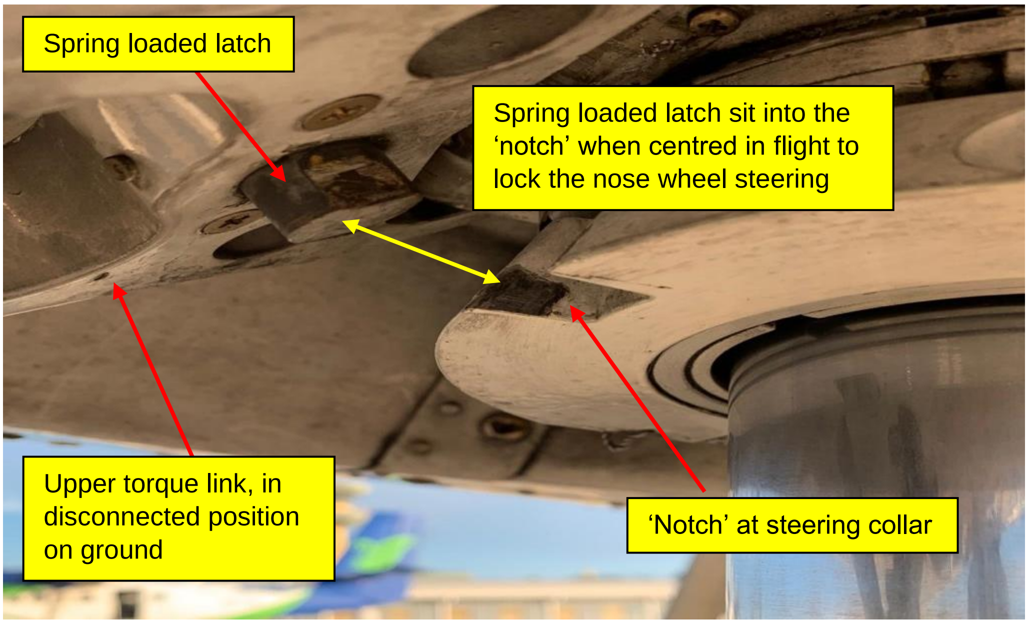

Figure 26: Nose wheel steering centring mechanism

The technique taught during conversion and recurrent training to pilots to centre the nose wheel steering was to wiggle the lever (Figure 27). Pilots must be train on how to operate the lever with emphasis on the correct technique and a standard method as the wiggle action is very subjective.

It is noted that the wiggle action was practice as the amendment instructions to apply upward and downward pressure on the nose wheel steering lever was omitted and not amended.

It was observed that the conversion syllabus for landing gear system, aircraft visit and flight training on the aircraft in the DHC6-400 Training Manual shows very brief emphasis given to the nose wheel steering system subject.

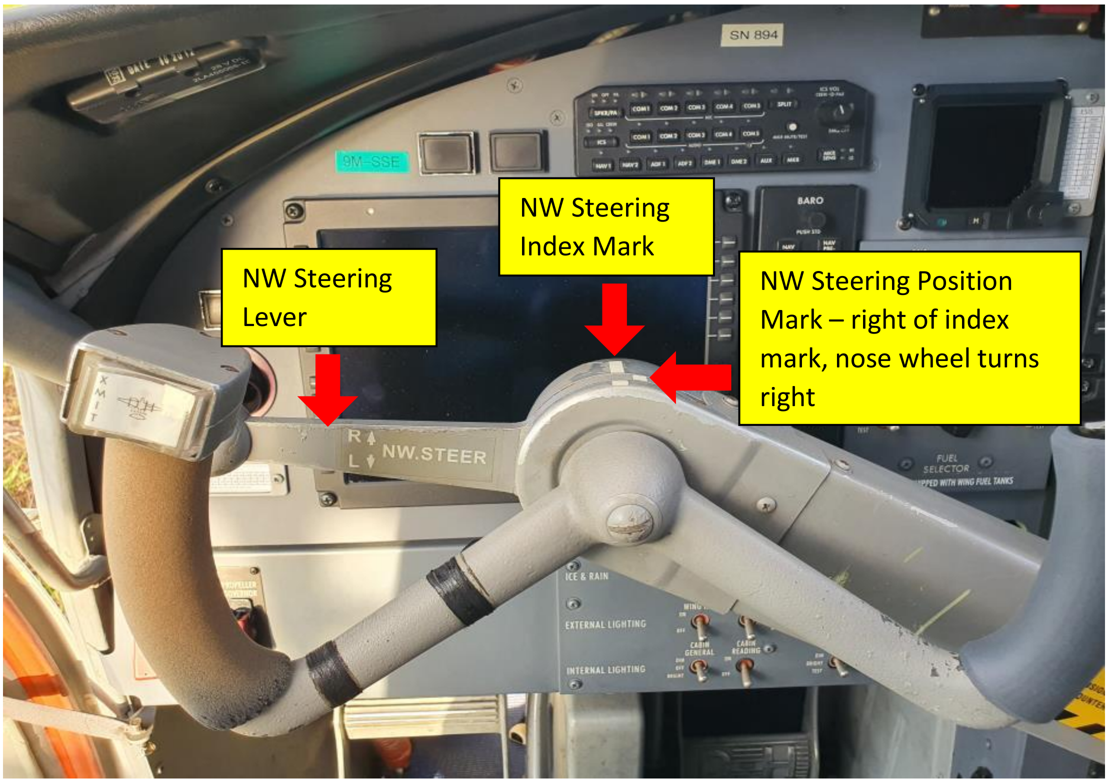

Figure 27: Nose Wheel Steering Lever Centre Index Mark and Position Mark

1.18 Additional Information

1.18.1 Interview and Statements

The investigation team conducted separate interview sessions with the Pilots and Duty Air Traffic Controllers. The interview sessions were all recorded under the express knowledge of all the parties. All of the personnel had also submitted a written statement.

1.18.2 Previous Incidents of Aircraft Veering Off the Runway After Touch Down

Two previous incidents when the aircraft veered off the runway after touch down are listed as follows:

a. Aircraft (9M-SSB) veered off to the left side of runway at Mukah Airfield, Sarawak, Malaysia on 26 August 2015.
(Reference: MASwings Incident No. O3607-15)

b. Aircraft (9M-SSB) veered off to the left side of runway at Marudi Airfield, Sarawak, Malaysia on 27 August 2016.
(Reference: MASwings Incident No. 03757-16)

1.18.3 Previous Air Safety Reports on Unexpected Veering/Vibration on Landing or Take-Off

Five Air Safety Report on previous occurrences with regards to unexpected veering or vibration on landing or during take-off. The occurrences are listed in as follows:

a. **<u>20-AUG-11 (9M-MDM)</u>**

Nose wheel vibration after take-off and steering moved to the right on its own in flight. Upon landing aircraft veered sharply to the right of runway but the veer was recovered. Engineering checked on the nosewheel steering cable tension and retorqued steering collar.

b. **<u>24-FEB-19 (9M-SSF)</u>**

Nose wheel centred by crew. Upon touchdown aircraft veered to the right as soon as nose wheel was lowered. Control regained. Upon taxi, aircraft continued veering with engineer on board with nose wheel centred. Engineering action was to rig the nose wheel steering. Found satisfactory. Operations test carried out, found satisfactory. Nil creeping observed.

c. **<u>22-APR-17 (9M-SSE)</u>**

During initial take-off run, the nose wheel tiller veered to the right maximum with a loud “bang” sound. Speed less than 30kts, take-off aborted in Bario. Reset for take-off run and aircraft returned to Miri. Maintenance Report raised. Engineering found the nose wheel was out of round.

d. **<u>11-DEC-17 (9M-SSE)</u>**

Aircraft veers right on landing. Nose wheel visibly moved. Engineering action, Nose wheel torsion link disconnected and steering system monitored for 30 minutes. Nil un-commanded actuator movement. Both main wheels tire pressure equalized. Steering cables run and tension checked. Nil finding. Nose wheel slightly out of round and replaced.

e. **<u>23-OCT-19 (9M-SSD)</u>**

A/c veered right on landing when nose wheel lowered on to the runway. Applied maximum rudder and brake on the left side was applied to regain control. Engineer inspected the nose gear and found it skewed to the right although tiller was centred. Cable tension was low and readjusted. Nose wheel centred and nose wheel steering functional test performed satisfactorily.

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.

On-site investigation was conducted to look for evidence which will assist in reconstructing the probable chain of event leading to this incident.

1.19.2 Human Factor - Reason's Swiss Cheese Model

The Reason's Swiss Cheese Model is used to analyse human factor issues related to this incident (Figure 28). The model is used to describe the layers of defences at which active failures/conditions and latent failures/conditions may have occurred in this incident.

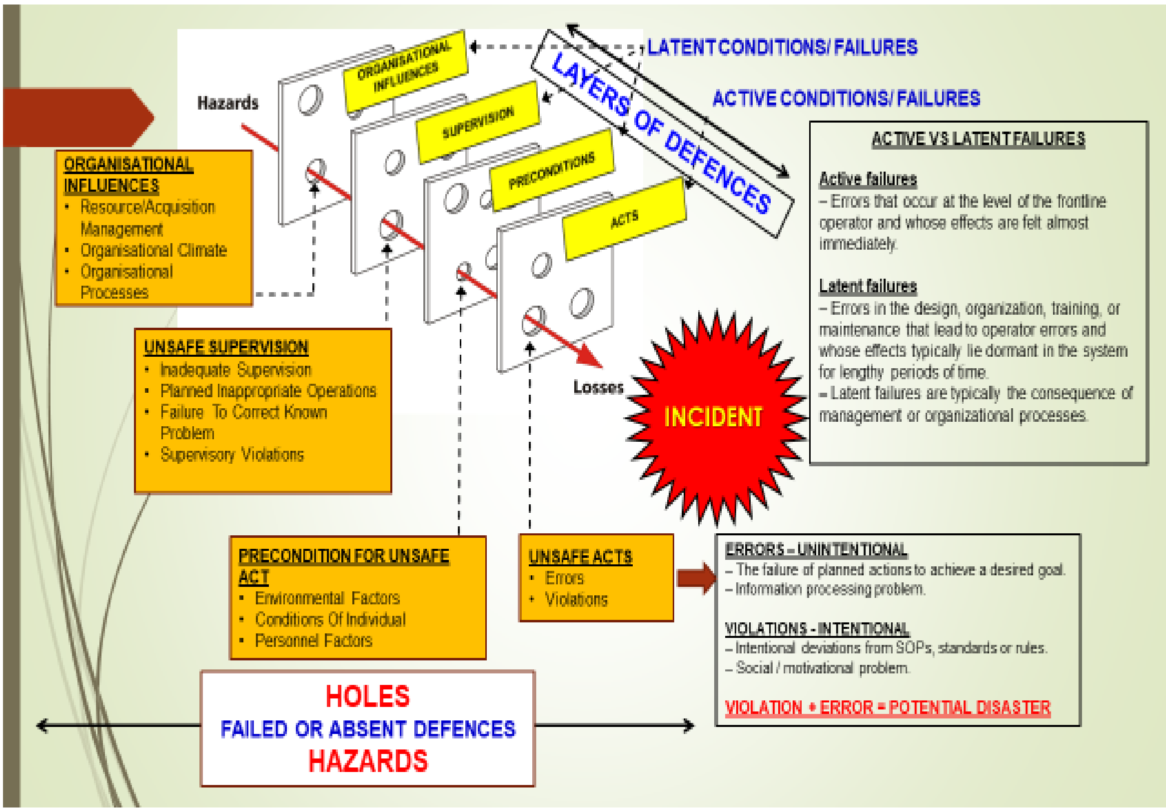

Figure 28: Reason's 'Swiss Cheese' Model

From the describe layers of defences in the Swiss Cheese model at which active failures/conditions and latent failures/conditions may had occur in this incident, Human Factors Analysis and Classification System

(HFACS) will be used to evaluate and rule in or eliminate the various preconditions that resulted in the unsafe act. It will then evaluate the supervisory and subsequent organizational issues that had contributed to the precondition. Finally, this will provide a detailed human factors picture of all the event that led up to the incident as in Figure 29.

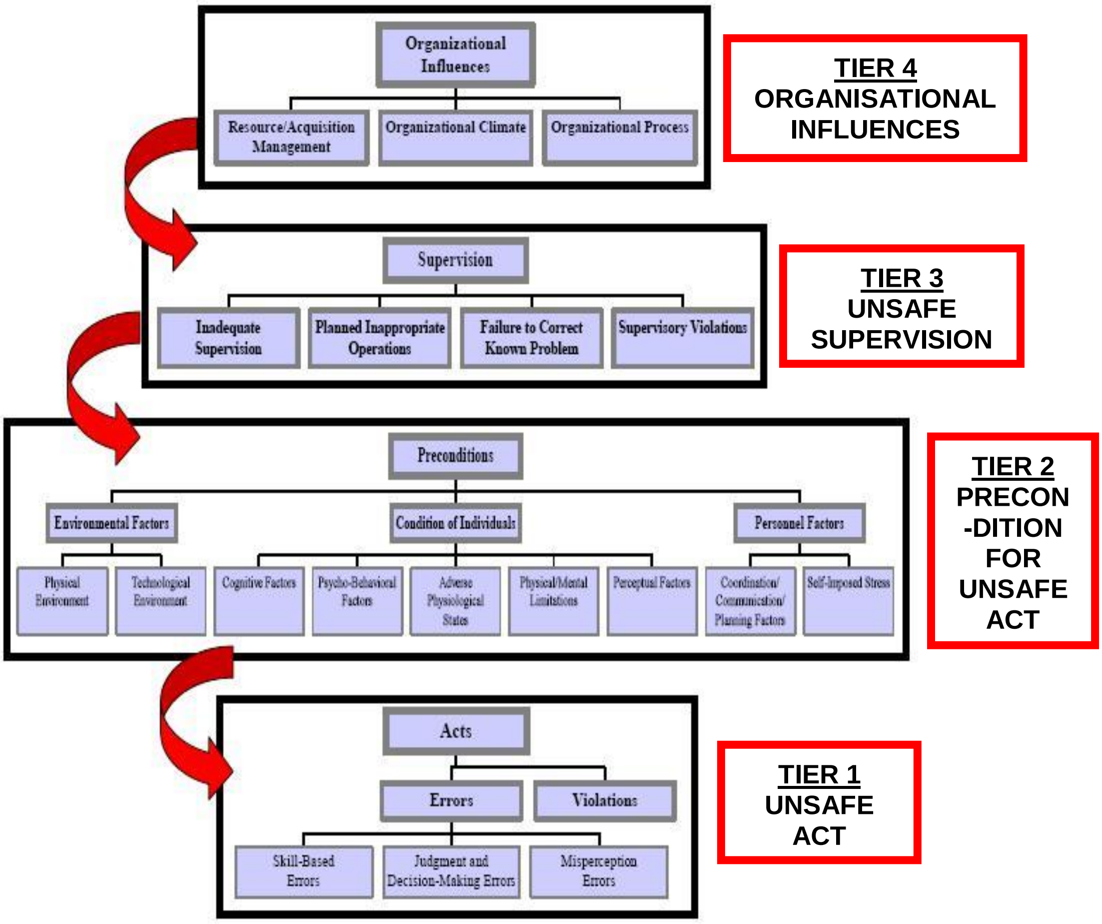

Figure 29: Human Factors Analysis and Classification System (HFACS)

2.0 ANALYSIS

2.1 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 2.1.1.

2.1.1 Sequence of Tyre Track Marks on Runway

Figure 30: View of the nose wheel tyre track marks near touchdown point. Note how the nose wheel tyre track marks transit from light to dark, increasing in thickness as the veering worsened. The initial scalloping marks indicate possible nose wheel off-set off-centre during landing.

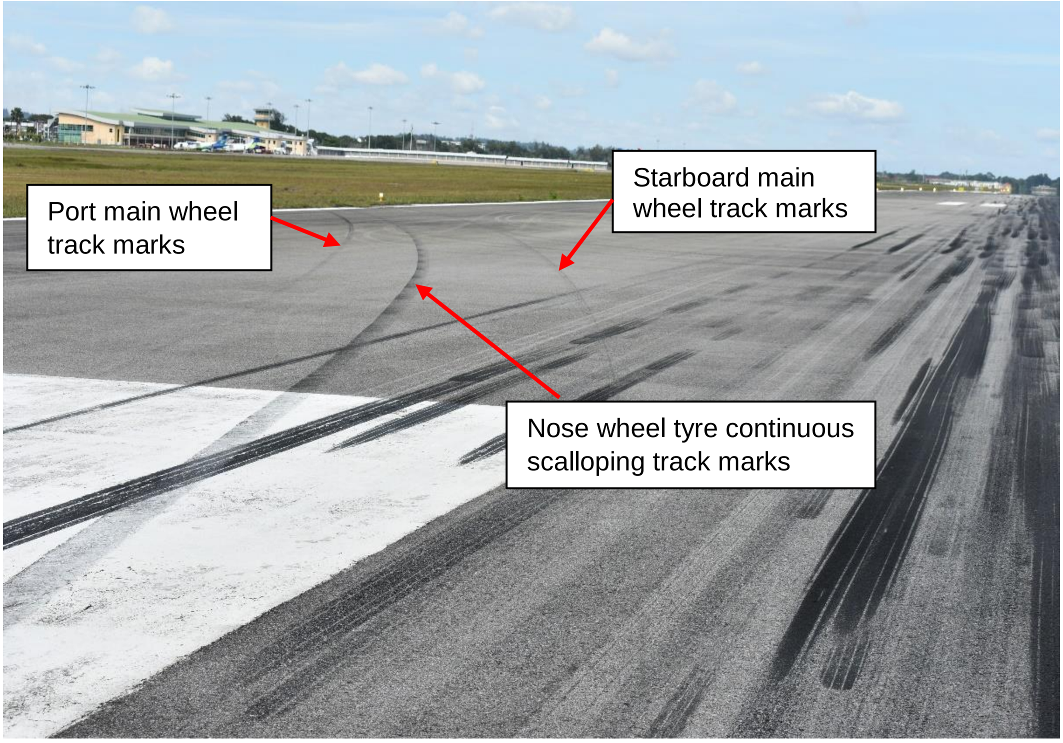

Figure 31: The nose wheel tyre scalloping marks continued before exiting the runway.

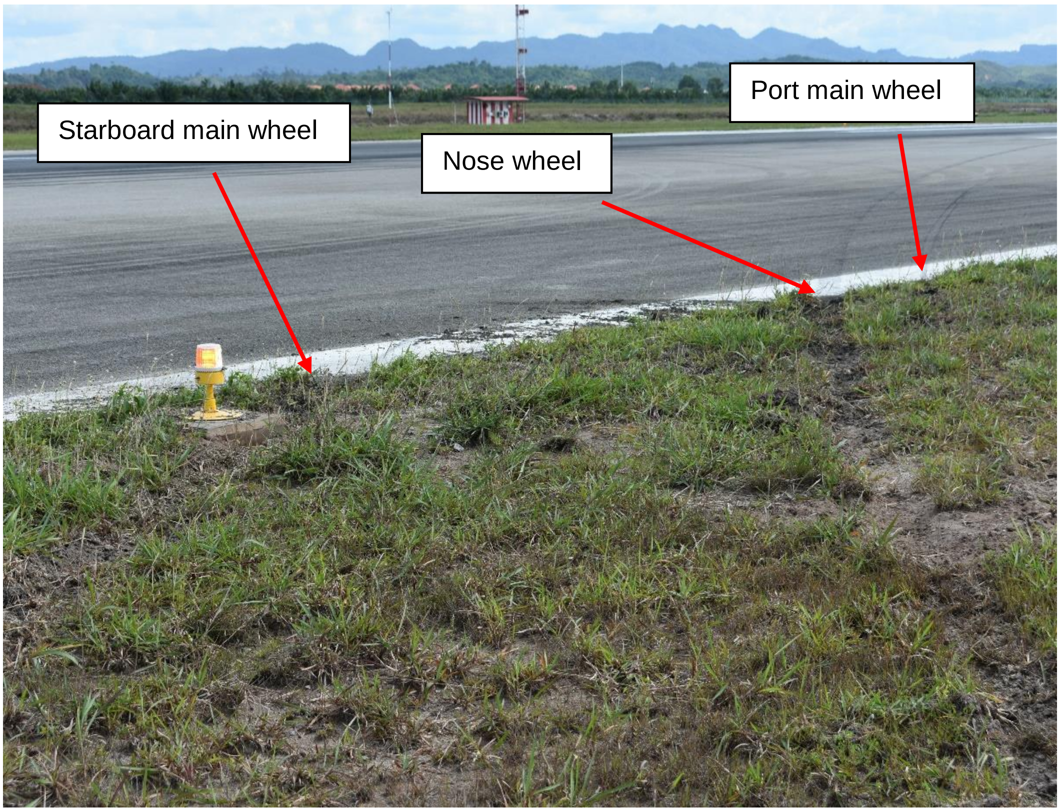

Figure 32: Aircraft tyre marks exiting runway into grass.

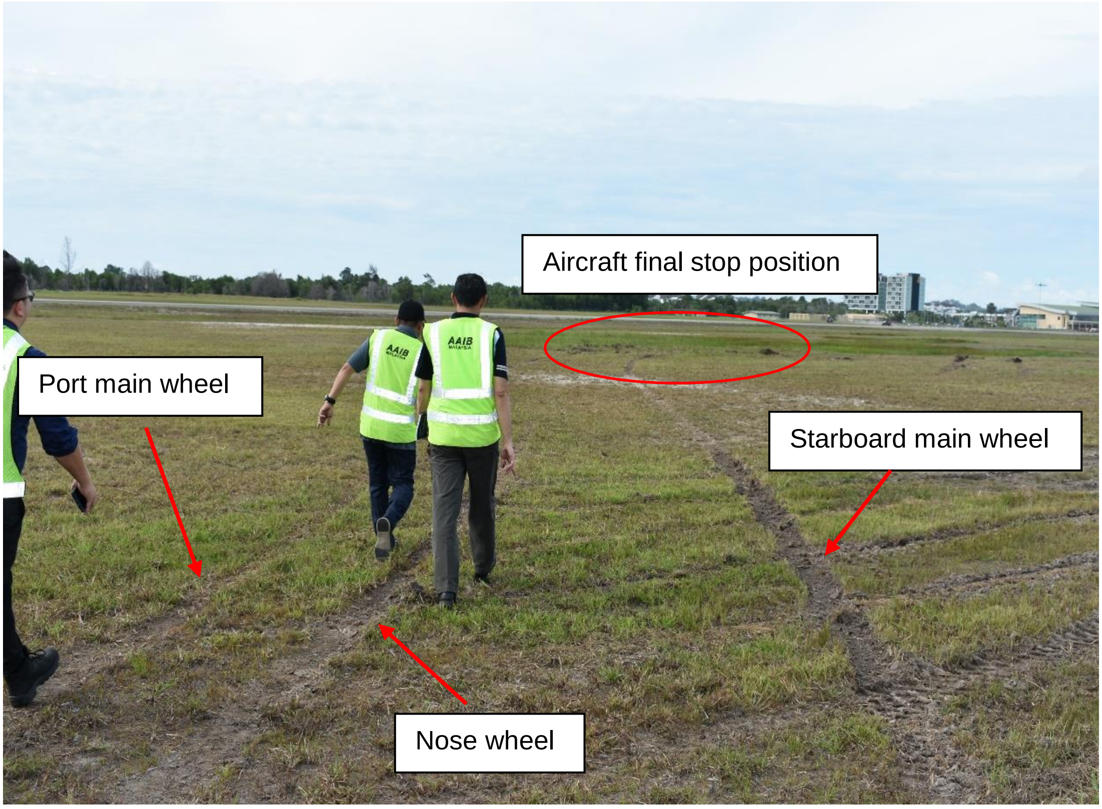

Figure 33: Tyre marks after exiting runway towards aircraft final stop position.

Figure 34: Tyre marks at aircraft final stop position.

Figure 35: Rear View of Aircraft at Final Stop Position

Figure 36: Front View of Aircraft at Final Stop Position

2.1.2 Heavy Wear Spot Mark on Nose Wheel Tyre

Figure 37: Heavy wear spot mark on the nose wheel tyre consistent with scalloping marks seen on the runway.

2.2 On-Site Investigation Analysis

From the aircraft tyre track marks as shown in Figure 30 to Figure 34, it was analysed that when the nose attitude was lowered upon touch down, the nose wheel initially contacted the runway with a probable off-set left from centre position as seen in the light tyre tracks marks on the runway (Figure 30).

When the aircraft starts to decelerate slowly and the nose wheel begin to support the weight of the aircraft, the forward momentum drags the off-set nose wheel along the runway which resulted in the initial scalloping tyre track marks. Subsequently, with full weight resting on the nose wheel which had off-set to left, the aircraft started to veered to the left as seen in the transition to darker tyre marks (Figure 30).

The forward momentum of the aircraft most probably turns the nose wheel further off-set to the left while the captain assisted later by the co-pilot tried to recover the situation by applying right rudder and brakes. This counter actions by the pilot probably resulted in the nose wheel being stuck in the off-set position and veered the aircraft further left as seen in the continuous nose wheel tyre scalloping track marks before exiting the runway (Figure 31 & 32). This is supported by the captain’s interview statement that the nose wheel steering lever was at maximum left position when the aircraft was about to exit the runway.

After exiting the runway, the captain moves the nose wheel steering lever to centre (refer captain’s interview statement) and the aircraft started to recovered its direction albeit on the grass area (Figure 33). It continued about straight until it got stuck in soft ground veering slightly to the right in its final stop position (Figure 34, 35 & 36).

Inspection on the nose wheel tyre shows a heavy wear spot mark consistent with the scalloping tyre marks observed on the runway (Figure 37).

Post incident engineering inspection on the nose wheel, wheel bearing, steering cables and steering actuator revealed no abnormality. The steering actuator was sent for bench testing and result revealed no fault on the steering actuator (refer paragraph 1.17.1).

2.3 Human Factors Analysis

Human factor issues related to this incident were examined using the Reason's Swiss Cheese model and HFACS worksheet as per **Appendix A**. From the HFACS worksheet in **Appendix A**, evidence statement will be provided for rating of 2,3, and 4 as shown in paragraph 2.3.1 to 2.3.4. Subsequently an Investigation Analysis Summary is tabulated in paragraph 2.4.

2.3.1 Tier 1 - Unsafe Acts

AE	**Errors**	
AE 2	**Judgement and Decision-Making Errors**	
AE 2.3	**Necessary Action (Rushed).** Necessary Action – Rushed is a factor when the individual takes the necessary action as dictated by the situation but performs these actions too quickly and the rush in taking action leads to an unsafe situation.	- One crew read and action on all checklist items. Not asking Captain to wiggle nosewheel steering lever upon completion of After Take-off checklist. - The crew rushed in carrying out their checklist to the point of mumbling unintelligibly. - Captain did not positively ensure nose wheel steering lever centre and locked position.

Analysis Tier 1 – Unsafe Acts

A chain of latent failures as described in paragraph 2.3.1 to 2.3.4 had led to an unsafe act as describe above which caused the aircraft to veer off the runway on landing.

In accordance to the SOP, calling for checklist is the duty of PF not PM, while PM’s duty is to carry out the checks and announce which checklist had been completed. Evidence from the CVR shows that the PM call for and completed the After Take-off checklist by himself.

The division of responsibilities and coordination between the two pilots during take-off were not strictly adhered to. Evidence from CVR revealed there was no instruction heard from the PM to ask the PF to check the nose wheel steering lever locked and centred upon completion of the After Take-off checklist. There was no audio evidence heard that the PF had acknowledge the PM to check the nose wheel steering lever.

There was also no audible call for Descend/Approach checks by the PF although there was an audible ‘Completed’ by the PM before aircraft requested for descend. It is assumed that the Descend/Approach checks was completed by the PM but there was no audible instruction to ask the PF to check the nose wheel steering lever. There was no audible response that the PF had check the nose wheel steering lever locked and centred during the Descend/Approach checks. Finally, as stated in the SOP, it is also the responsibility of the crew to ensure the nose wheel steering is align and centre upon completion of Landing checklist as stated in the SOP.

Although there is a checklist procedure to be adhered to by the pilots, these procedures did not provide adequate check and balance to prevent an unsafe act by the crew. The procedure of PM self-reading and completing the checks, the rush and mumbling tone of the PM, not calling for ‘Checks Completed’ and not asking the PF to check the nose wheel steering lever centre and locked further aggravated the situation.

These unsafe acts were compounded by the unavailability of a check and balance system ie a multi crew checklist challenge and response procedures, and a cockpit sterile procedure in the DHC-6 Series 400 SOP.

2.3.2 Tier 2 - Preconditions for Unsafe Acts

PE	**Environmental Factors**	
PE 2	**Technology Environment**	
PE 2.2	**Instrumentation and Sensory Feedback Systems.** Instrumentation and Sensory Feedback Systems is a factor when instrument factors such as design, reliability, lighting, location, symbology or size are inadequate and create an unsafe situation. This includes NVDs, HUD, off-bore-site and helmet-mounted display systems and inadequacies in auditory or tactile situational awareness or warning systems such as aural voice warnings or stick shakers.	- The design of the nose wheel steering system makes it difficult for the captain to confirm if the nose-wheel was centre and locked in the notch prior to landing although the steering lever is aligned with the index mark.
PC	**Conditions of Individual**	
PC 2	**Psycho-Behavioural Factors**	
PC 2.8	**Complacency.** Complacency is a factor when the individual's state of reduced conscious attention due to an attitude of overconfidence, under-motivation or the sense that others "have the situation under control" leads to an unsafe situation.	- No proper brief and checklist callout during flying. - A lot of chattering between captain and co-pilot.
PP	**PERSONAL FACTORS**	
PP 1	**Coordination/Communication/Planning Factors**	
PP 1.2	**Cross-Monitoring Performance.** Cross-monitoring performance is a factor when crew or team members failed to monitor, assist or back-up each other's actions and decisions.	- The co-pilot did not cross check the captain's action to centre the nose wheel steering during after take-off and descend/approach checks. - No challenge and response procedures were practice due to non-availability of procedure in the SOP. This limited the ability of the pilots to cross check each other when performing checks.

PP 1.7	**Standard/Proper Terminology.** Standard/proper terminology is a factor when clear and concise terms, phrases hand signals, etc per service standards and training were not used.	- The captain did not call the checklist required. The co-pilot did not perform checklist action items in a clear audible voice and did not announce clearly which checklist had been completed after checklist actions. - Standard terminology was not practice by both pilots during take-off and landing phase after aircraft stabilising height due non-availability of sterile cockpit procedures in SOP.
PP 1.8	**Challenge and Reply.** Challenge and reply are a factor when communications did not include supportive feedback or acknowledgement to ensure that personnel correctly understand announcements or directives.	- No audible call by the co-pilot and response from the captain that action had been positively taken to centre the nose wheel steering lever in the After Take-off and Descend/ Approach checks.

Analysis Tier 2 – Preconditions for Unsafe Acts

The breached in the defence layer precondition for unsafe act were the main contributing factor to the unsafe act. CVR evidence shows the pilots did not comply to standard practices example non audible approach briefings, non-standard calling for and announcing of checklist actions completed, checklist reading is rushed and hardly audible which are all contrary to the aircraft SOP. Evidence from the CVR on the preceding sector, Miri to Lawas shows somewhat the same practices.

Although the checklist reading is unintelligible, most of the chattering between the PF and PM, aircraft public announcement, confirming of CAS callout and radio transmission were mostly clear and audible. To further investigate the non-standard checklist reading practices, a CVR from another aircraft (9M-SSA) was analysed. It was found that the checklist reading practices carried out by the pilots were clear and audible as required by SOP requirements.

It is noted that the captain is new with about 100 hours on type who had just completed his conversion training and did his line check about a month ago from the date of incident. Ideally, after the conversion training and a line check by the examiner, the captain should be well versed and competent to practice and adhere to all the SOP procedures taught.

The design of the nose wheel steering system was factor present but was not a contributory factor to this incident. The design makes it difficult for the pilot to confirm positively if the nose wheel is indeed locked in the notch prior to landing other than ensuring the correct checklist actions are carried out by aligning the nose wheel steering lever centre mark to the index mark. There are no indicator or sensor to show if it was locked in the notch, hence, the pilot wiggles the steering lever by feel, which is subjective and ambiguous.

From previous incidents of aircraft veering off the runway after touch down (refer paragraph 1.18.2) and Air Safety Reports on unexpected veering/vibration on landing and take-off (refer paragraph 1.18.3), the pilots reported veering only after the nose wheel was lowered during landing. The nose wheel steering system were always inspected but no defects were found for the said incidents or occurrences. Viking Air was also consulted and had inspected the nosewheel assembly on one of the affected aircrafts in September 2016 but no defect could be found.

The possibility of implementing a visual indicating or monitoring system to visually confirmed the nose wheel is centred in flight will give confidence to the pilot that the nose wheel is centred before landing. This will help to mitigate the issue of the aircraft veering on landing even after the pilot had completed all the required checklist items.

2.3.3 Tier 3 - Unsafe Supervision

SI	INADEQUATE SUPERVISION	
SI 3	**Local Training Issues/Programs.** Local Training Issues/Programs area factor when one-time or recurrent training programs, upgrade programs, transition programs or any other local training is inadequate or unavailable (etc) and this creates an unsafe situation.	- Conversion and recurrent ground and flight training syllabus lack emphasis on the operations of nose-wheel steering system and how the centring mechanism works. - Proper technique to centre nose wheel steering not emphasis during flight training.
SI 4	**Supervision – Policy.** Supervision – Policy is a factor when policy or guidance or lack of a policy or guidance leads to an unsafe situation.	- Sterile cockpit procedures not implemented as is the norm in all multi crew aircraft. - Challenge and response procedures that involved both pilots were not implemented as is the norm in all multi crew aircraft.

Analysis Tier 3 - Unsafe Supervision

2.3.3.1 Local Training Issues

The importance of aircraft system knowledge and flight training cannot be overemphasised in this incident. Evidence revealed the following:

a. **Ground Training** – A brief knowledge on the nose wheel steering system was taught during the pilot's conversion and recurrent training. Statement from the pilot and co-pilot revealed that some of pilots face occasional problems when operating the nose wheel steering during day to day operations.

The ground conversion and recurrent training syllabus are to be reviewed to include more in-depth explanation on the working operation of the nose wheel steering. Emphasis are to be placed especially on the practical aspects of operating the nose wheel steering at normal and short field runways. Practical explanation should be carried out during aircraft visit on the nose wheel steering detailing its method of operation to enable pilots to gain a deeper understanding of its mechanism and working functions.

` b. **Flight Training** – Statement from the pilot indicates he wiggled the nose wheel steering lever as taught during training. These wiggling actions are subjective and most likely non-standard between each pilot. The amended checklist instructions instruct the pilots to apply slight upward and downward pressure to the nose wheel steering lever to confirm it is locked in centre position.

There is slight difference between the current action (wiggle) of the pilot and the amended instruction as to the correct technique to operate the nose wheel steering lever. It was noted that this amended instruction was not in practice during this incident as the amendment was omitted and not disseminated to the pilots.

To mitigate these unsafe supervisions, more emphasis is to be given to improve the nose wheel system knowledge of the pilots during ground training. During flight training, correct and standardise technique to centre and lock the nose wheel steering lever as instructed by the amendment to the checklist must be taught and practice by all pilots to prevent similar future incidents.

2.3.3.2 Lack of Procedures Guidance in DHC-6 Series 400 SOP

This incident shows the lack of procedures guidance in the DHC-6 Series 400 SOP to ensure proper crew coordination are performed during flight operations. Challenge and response system for checklist reading and sterile cockpit procedures for critical phases of flight are to be implemented to improve crew resource management (CRM) between pilots. These are standard practices in multi crew aircraft operations and provide better check and balance between pilots to ensure safe flight operations.

2.3.4 Tier 4 - Organisation Influence

OR	**Resource/Acquisition Management**	
OR 8	**Informational Resources/Support.** Informational Resources/ Support is a factor when weather, intelligence, operational planning material or other information necessary for safe operations planning are not available.	- DHC-6 POH/AFM was not updated. Latest procedures on the operation of the nose wheel steering system from manufacturer did not reach the end-users (pilot).
OP	**ORGANISATIONAL PROCESSES**	
OP 3	**Procedural Guidance/Publications.** Procedural Guidance/ Publications is a factor when written direction, checklists, graphic depictions, tables, charts or other published guidance is inadequate, misleading or inappropriate and this creates an unsafe situation.	- DHC-6 POH/AFM in the aircraft were found to be incomplete and with pages missing. - Electronic Checklist and Paper Checklist did not tally with each other with some checks not listed in the electronic checklist. - Paper Checklist not updated with latest amendment.
OP 4	**Organisational Training Issues/Programs.** Organisational Training Issues/Programs are a factor when one-time or initial training programs, upgrade programs, transition programs or other training that is conducted outside the local unit is inadequate or unavailable (etc) and this creates an unsafe situation.	- No DHC-6 simulator training to train pilots to experience and take recovery actions from abnormal situation such as this incident.

Analysis Tier 4 - Organisation Influence

2.3.4.1 Publication Management

Investigation revealed shortcomings in publication management of the operator. An amendment to the POH/AFM for nose wheel steering instruction for after take-off checks and descend/approach checks dated 02 October 2017 was omitted and not disseminated to the pilots for more than 2 years. This resulted in the pilots not being trained to practice the correct technique to centre and lock the nose wheel steering lever during after take-off and descend/approach checks.

Similarly, the paper checklist in used was also not updated with the latest amendment as in the POH/AFM. There are also differences in the sequence of checks between the electronic and paper checklist. In accordance with the POH/AFM, any differences between the paper and electronic checklist, the paper checklist content prevails. Therefore, the paper checklist must be the main reference for all normal procedures.

Overall, a good publication management system is paramount to the safe operations of aircraft. This will ensure amendments from the source (manufacturer) reaches the end users (pilots) promptly so that outdated instructions are not used.

2.3.4.2 Flight Simulator Training

Both pilots experienced this situation for the first time during the incident. It was not trained for as there is no DHC-6 simulator available. Training such a scenario in a real aircraft puts both pilots and the aircraft at great risk.

All form of flight training currently practiced on the aircraft can be replicated in a flight simulator. Additional training like abnormal situation flight, practice of crew coordination or procedural training and abnormal weather condition flying like wind shear and cross-wind landing and take-off which cannot be carry out in an aircraft can be practice in a flight simulator.

It is standard practice in current training environment to use flight simulator to train pilots especially multi crew aircraft. The operator should undertake a cost-benefit analysis and to consider the benefit of using flight simulator as a platform option to train its pilots. It would greatly enhanced pilot training, improved flying skills and reduced training risk which will ultimately contribute to the safe operations of the aircraft.

2.4 INVESTIGATION ANALYSIS SUMMARY

FALLIBLE DECISIONS

To land aircraft with nose wheel off-set centre with:

- No cross monitoring between crew, rushing and read checks in unintelligible voice when carrying out checklist procedures.

- Crew not positively ensuring nose wheel steering lever centre and aligned with index mark to centre and lock during checklist action item.

HUMAN FACTORS HFACS

Tier 1-Judgement and Decision-Making Errors.

Tier 2- Technology Environment

Tier 2- Psycho-Behavioural Factors

Tier 2- Coordination/ Communication /Planning Factors

Tier 3-Inadequate Supervision.

Tier 4- Resource/ Acquisition Management

Tier 4-Organisational Processes.

TIER 4 ORGANISATIONAL INFLUENCE

DHC-6 POH & AFM was not updated. Latest procedures on the operation of the nose wheel steering lever from manufacturer did not reach the end-users (pilot).

- The DHC6 POH & AFM in the aircraft were found to be incomplete and with pages missing.

- Electronic and Paper Checklist were not updated and did not tally with each other with some checks not listed in the electronic checklist.

- No DHC-6 simulator training to train pilots to experience and take recovery actions from abnormal situation.

TIER 3 SUPERVISION FAILURES

Conversion and recurrent training syllabus lack emphasis on the operations of nose-wheel steering system and how the centring mechanism works.

- Sterile cockpit procedures were not implemented by the operator.

- Challenge and response procedure were not implemented by the operator.

TIER 2 PRECONDITIONS UNSAFE ACT

The design of the nose wheel steering system makes it difficult for the captain to confirm if the nose-wheel was centre and locked in the notch.

No proper brief and checks during flying.

Non-compliance to standard practices or procedures example briefings, non-standard calling for and response to checklist actions, checklist actions are rushed and hardly audible.

Insufficient in-depth knowledge on the nose wheel steering system and how the centring mechanism works were taught during conversion and recurrent training.

TIER 1 UNSAFE ACT

- The crew rushed in carrying out their checklist to the point of mumbling unintelligibly.

- The crew did not cross check each other to ensure the nose wheel steering lever centre and align with index mark.

BREACHED BARRIERS

The non-compliance to standard checklist procedures as stated in the SOP.

The omission of the amended checklist instruction on the operations of the nose wheel steering lever from the manufacturer in the POH/AFM.

- Publication not distributed and updated.

- A lot of chattering. No sterile cockpit procedures in SOP.

- Self reading checklist with unintelligible voice. No challenge and response procedures in SOP.

INCIDENT

Aircraft veered off runway on landing.

3.0 Conclusion

Data from QAR revealed that the aircraft had stabilised on approach to land. Upon touch down, the aircraft started to veer to the left and exited the runway into the grass area before coming to a stop on soft ground. 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.

Post incident engineering inspection on the nose wheel, wheel bearing, steering cables and bench testing the steering actuator found no abnormalities.

Evidence from on-site investigation found prominent tyre track marks close to the touch down area. The nose wheel tyre marks begin with light marks followed by light scalloping marks. It progresses to darker marks followed by heavier scalloping marks as the aircraft veered more to the left. The scalloping mark stop just before the aircraft exited the runway. The aircraft continue roughly on a straight track before stopping on soft ground turning slightly right.

The initial scalloping tyre track marks are consistent with an off-set centre nose wheel landing. The scalloping tyre track marks became heavier as the aircraft veered more to the left is consistent with the off-set nose wheel being deflected more due to friction between the tyre and runway surface which stop just before the aircraft exited the runway. It continued roughly straight ahead on the grass area which is also consistent with the pilot’s statement that he centred the nose wheel lever on realising the lever was at maximum down deflection (left) position when the aircraft was about to exit the runway.

The aircraft nose wheel is not design to self-centre on take-off. Therefore, built in defence layers in the form of checklist (POH/AFM) and SOP are provided to ensure the nose wheel is centre and lock before landing. There is always a possibility of the nose wheel being off-set from centre after take-off due to the nature of operations and challenging runway condition.

There are only two checks which require the crew to check the nose wheel steering lever ie after take-off and descend/approach checks. The after take-off checks is the most crucial as the SOP clearly requires the PM to ask the PF to check the nose wheel steering lever is locked in centre position. Evidence from the CVR revealed the standard checklist procedures as stated in the SOP were not adhered to by both the crew.

The PF did not command for the checks but the PM carried out the checks by himself without being commanded to do so. The action of commanding for checks is important as the SOP clearly states that the PF should do so when it is appropriate ie when the PF decides it is safe to so in the after take-off activities. The most crucial action which was omitted in the after take-off checks was the PF did not check the nose wheel steering lever lock in centre position. This was the primary unsafe act by the crew which resulted in the incident.

Nevertheless, the second defence layer at the descend/approach checks for the crew to check the nose wheel steering lever was also breached. There was no evidence to indicate that the final requirement by the SOP for the crew to ensure the nose wheel is align after the landing checks was carried out.

Analysis using the Swiss Cheese model revealed there were two preconditions for the above unsafe act. They were the PM's actions to read the checklist action items in a rushing and unintelligible voice. The second precondition were the PM announcing the completion of checks without instructing the PF to check the nose wheel steering lever lock in centre position. Both these preconditions preclude cross monitoring between the crew which led to the unsafe act.

Supervision factors played a contributing role to this incident. The conversion and recurrent training syllabus which the Captain had just completed did not provide sufficient emphasis on the nose wheel steering system knowledge. There was also lack of practical explanation to further explain the function and operation of the steering system during training visit to the aircraft.

The technique taught during conversion and recurrent training to centre the nose wheel steering lever was to wiggle the lever. As this is very subjective, emphasis must be given to the practical action of the pilot by providing training on the correct and standardise technique on how to apply upward and downward pressure on the nose wheel steering lever as recommended in amendment instructions. It is noted that during this incident the amended instructions was not in practice.

It is crucial to implement a challenge and response system between the PF and PM to improve the present checklist procedure. To ensure standard terminology between crew at critical stages of flight are practiced, a sterile cockpit procedure is to be incorporated in the SOP. These two procedures are operating standards in multi crew aircraft operations.

The omission of the latest amendment instruction on the nose wheel steering lever in the DHC-6 POH & AFM was a crucial contributing factor under organisational influence. Latest procedures on the operation of the nose wheel steering lever from the manufacturer did not reach the end-users (pilot). It directly contributed to the crew not practicing the correct technique as recommended by the manufacturer.

Actions to improve publication management must be implement so that amendment to publications are carry out, paper checklist are updated and manual carried onboard the aircraft are properly maintained.

In summary, an omission or non-adhere to procedures might seem like a trivial oversight but it can lead to a serious incident or a fatal accident. The importance of adhering to SOP diligently cannot be overemphasize. Adherence to SOP, good knowledge of aircraft systems and correct technique in operating the system, in this incident, the nose wheel steering system is paramount to safe operations of the aircraft. Proper maintenance, timely update and distribution of publications from the organisation were further aid this cause.

3.1 Findings

3.1.1 The Captain and Co-pilot was licensed and qualified for the flight in accordance with existing regulations.

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3.1.2 The rest periods for the Captain and Co-pilot preceding the flight was in compliance with company policy.

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

3.1.4 Post incident engineering inspection on the nose wheel, wheel bearing, steering cables and bench test of the steering actuator revealed no abnormalities.

3.1.5 The flight crews reported no abnormalities during the preceding sector from Miri to Lawas.

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

3.1.7 Checklist amendment instructions for the nose wheel steering lever operation was omitted and not disseminated to all the pilots. The amendment requires the Captain to *"check centred and lock. Align with index marks if required then apply a slight upward and downward pressure to the nose wheel steering lever to confirm that the nose wheel is locked in the centre position".*

3.1.8 The actions taught during flight conversion and recurrent training to wiggle the nose wheel steering lever in response to checklist actions were not updated and contrary to the amendment instructions stated in paragraph 3.1.7.

3.1.9 The normal checklist procedures to call for and announce checks completed in a clear audible voice was not properly and correctly carried in accordance to the DHC-6 Series 400 Standard Operating Procedures.

3.1.10 No audible take-off and departure were recorded in the CVR. The approach brief was not performed in accordance to the DHC-6 Series 400 Standard Operating Procedures.

3.1.11 Lack of a sterile cockpit procedures in the DHC-6 Series 400 Standard Operating Procedures to guide pilots during critical phase of flight ie take-off and landing as practice in multi crew operations aircraft.

3.1.12 Lack of a challenge and response procedure in the DHC-6 Series 400 Standard Operating Procedures to provide check and balance to the checklist reading procedures.

3.1.13 Lack of knowledge emphasis on nose wheel steering system and steering operations during conversion and recurrent training.

3.1.14 The aircraft electronic checklist and the paper checklist were not updated and not identical in the sequence of checks.

3.1.15 The Pilot Operating Handbook/Aircraft Flight Manual carried on board the aircraft were not updated with some of the pages missing.

3.1.16 The aircraft landed with a possible nose wheel off-set left from centre.

3.2 Causes

3.2.1 Evidence from on-site investigation revealed that the aircraft had landed with a possible nose wheel off-set left from centre which resulted with the aircraft veering to the left on landing.

3.2.2 As the aircraft nose wheel is not the self-centring type, built in defence layers as describe in the Swiss Cheese model are provided to ensure the nose wheel is centred and locked before landing.

3.2.3 From the human factor analysis as shown in the summary of the HFACS worksheet in Figure 38, it has been determined that the above incident **primary causes** were attributed to:

a. 1 Unsafe Acts (Tier 1).
b. 2 Preconditions of Unsafe Acts (Tier 2).

3.2.4 The **secondary causes** were attributed to:

a. 1 Preconditions of Unsafe Acts (Tier 2).
b. 2 Unsafe Supervision (Tier 3).
c. 3 Organisation Influence (Tier 4).

UNSAFE ACTS – ERRORS		**4**	**3**	**2**	**1**
AE 1	Skill-Based Errors				6
AE 2	Judgement and Decision-Making Errors	1			5
AE 3	Misperception Error				1
UNSAFE ACTS – VIOLATIONS					
AV 1	Violations - Based on Risk Assessment				1
AV 2	Violations - Routine / Widespread				1
AV 3	Violations – Lack of Discipline				1
UNSAFE ACTS SUB TOTAL		**1**	**0**	**0**	**15**
PRECONDITIONS FOR UNSAFE ACTS - ENVIRONMENTAL FACTORS					
PE 1	Physical Environment				11
PE 2	Technology Environment			1	7
PRECONDITIONS FOR UNSAFE ACTS - CONDITIONS OF INDIVIDUAL					
PC 1	Cognitive Factors				8
PC 2	Psycho-Behavioural Factors		1		14
PC 3	Adverse Physiological State				16
PC 4	Physical / Mental Limitation				5
PC 5	Perceptual Factors				11
PRECONDITIONS FOR UNSAFE ACTS - PERSONNEL FACTORS					
PP 1	Coordination/Communication/Planning Factors	2		1	9
PP 2	Self-Imposed Stress				6
PRECONDITIONS FOR UNSAFE ACTS SUB TOTAL		**2**	**1**	**2**	**87**
UNSAFE SUPERVISION					
SI	Inadequate Supervision		2		4
SP	Planned Inappropriate Operations				7
SF	Failure Correct Known Problem				2
SV	Supervisory Violations				4
UNSAFE SUPERVISION SUB TOTAL		**0**	**2**	**0**	**17**
ORGANIZATIONAL INFLUENCES					
OR	Resource/Acquisition Management		1		8
OC	Organisational Climate				5
OP	Organisational Processes		2		4
ORGANIZATIONAL INFLUENCES SUB TOTAL		**0**	**3**	**0**	**17**
TOTAL UNSAFE ACTS		**3**	**6**	**2**	**136**

Figure 38: Summary of HFACS Worksheet

3.2.5 The primary cause of this incident is attributed to Decision-Making Errors and Coordination/Communication Factors. The **primary cause** is the non-compliance to the DHC-6 Series 400 SOP when performing checklist procedures.

3.2.6 The secondary cause is attributed to Inadequate Supervision and Resource (Publication) Management. The **first secondary cause** is the omission of the amended checklist instruction from the manufacturer on the nose wheel steering. It resulted in the paper checklist not updated and the new instruction not practiced by the pilots when performing their checks.

3.2.7 The **second secondary cause** is due to a lack of a check and balance system in the current normal checklist procedures. There is no system in the DHC-6 series SOP to ensure the PM read the checklist item to challenge and the PF response to confirm the correct checklist actions.

3.3 Breached Barriers

3.3.1 The Captain was a relative new hire with about 100 hours on type. He had just completed his initial line training and did his line check the month before the incident. Therefore, the Captain is very current with all procedures taught during the initial line training.

3.3.2 The nose wheel is not the self-centring type. Therefore, there are possibilities for the nose wheel to be at off centre position especially after take-off as the aircraft operates from airstrip with critical runway length, uneven surface and crosswind conditions. To mitigate this risk, built in barriers are provided to ensure the nose wheel steering lever is centre and align with index mark as provided in POH/AFM, SOP and paper checklist.

3.3.3 Therefore, the breached barriers for this incident are as follows:

a. The non-compliance to standard checklist procedures as stated in the SOP.

b. The omission of the amended checklist instruction on the operations of the nose wheel steering lever from the manufacturer in the POH/AFM.

4.0 Safety Recommendations

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

4.1.1 To review the DHC-6 Series 400 SOP as follows:

a. To implement a challenge and response system in the checklist reading procedures.

b. To implement sterile cockpit procedure to ensure standard terminology are practice during critical stages of flight ie during take-off and after stabilising height till landing.

c. To implement take-off and departure briefs when aircraft is powered up either by battery or aircraft generator to ensure the briefs are recorded by the aircraft CVR.

4.1.2 To review the conversion and recurrent training syllabus in the DHC6-400 Training Manual as follows:

a. To enhance the subject knowledge on the landing gear and brakes systems in the Computer Based Training syllabus.

b. To introduce additional subject on nose wheel steering operations and locking mechanism to the aircraft visit syllabus.

c. To include the teaching of the correct and standardise technique on how to check and ensure the nose wheel steering lever centred and locked position in the initial type conversion and initial operating experience syllabus.

4.1.3 To ensure the standard procedures and coordination between the pilots are emphases and practice correctly in the following phases of flight as stated in the DHC-6 Series 400 SOP Chapter 3, Procedures and Policies during conversion and recurrent training as such:

a. Take-off, departure and approach briefing.

b. Take-off and after take-off procedures and coordination.

c. Approach and landing procedures and coordination.

d. Practice of checklist procedures.

4.1.4 To amend the Pilot Operating Handbook/Aircraft Flight Manual on the nose wheel steering lever instructions (temporary amendment no: TA-31 & TA-32) for after take-off and descend/approach checks.

4.1.5 To update and use the paper checklist as the primary reference for all normal checklist in the Twin Otter aircraft fleet.

4.1.6 To revamp the publication update, maintenance and distribution processes to ensure all amendment or revised procedures related to aircraft operations reaches the end-users promptly.

4.1.7 To study the option of using flight simulator as a training platform for the Twin Otter fleet.

4.2 CAAM is to carry out the following safety recommendations:

4.2.1 To conduct assessment on pilots to ensure the compliance to standard procedures in accordance with the DHC-6 Series 400 SOP Chapter 3, Procedures and Policies during Proficiency and Line Check as such:

a. Take-off, departure and approach briefing.

b. Take-off and after take-off procedures and coordination.

c. Approach and landing procedures and coordination.

d. Practice of checklist procedures.

4.3 Viking Air is to carry out the following safety recommendations:

4.3.1 To liaise with MASwings to study the implementation of a visual indicating or monitoring system for pilot to visually confirmed the nose wheel is centred in flight.

5.0 COMMENTS TO THE REPORT AS REQUIRED BY ICAO ANNEX 13 PARAGRAPH 6.3

As required by ICAO Annex 13, paragraph 6.3, the draft Final Report was sent to State of Registry (CAAM), State of Manufacturer (Transport Safety Board of Canada) and the Operator (MASwings) inviting their significant and substantiated comments on the Report. The following is the status of the comments received: -

Organisations	Status of Significant and Substantiated Comments
Civil Aviation Authority of Malaysia	Accepted and with no significant comments.
Transport Safety Board of Canada	No comments received.
MASwings (Operator)	Comments that are accepted had been amended accordingly in this report. Comments not agreed upon had been appended in **Appendix B**.

APPENDICES

APPENDIX A

HUMAN FACTORS ANALYSIS AND CLASSIFICATION SYSTEM (HFACS) WORKSHEET SI 01/20 TWIN OTTER DHC6-400 9M-SSE

1. This worksheet is on HFACS. It is divided into four (4) sections having question pertaining to that area. There are total 147 statements and each statement is to be rated on a 4-point scale, where:

a. **4 - Primary cause**. Main factors that directly contributed to/responsible for accident/incident.

b. **3 - Secondary cause**. Factor was present but not the most important/ critical factor responsible for accident / incident and contributed indirectly.

c. **2 -** Factor was present but didn't affect the outcome at all, was not contributory.

d. **1 -** Factor was not present.

2. It is mandatory to rate each statement. Wherever the rating is 2, 3 or 4 the explanation has to be provided for the reasons responsible in a narrative form at the end of the rating sheet.

TIER 1 - UNSAFE ACTS

AE - Errors

		4	3	2	1
AE 1	**Skill-Based Errors**				
AE 1.1	Inadvertent Operation				√
AE 1.2	Checklist Error				√
AE 1.3	Procedural Error				√
AE 1.4	Over-control / Under-control				√
AE 1.5	Breakdown in Visual Scan				√
AE 1.6	Inadequate Anti-'G' Straining Manoeuvre				√

		4	3	2	1
AE 2	**Judgement and Decision-Making Errors**				
AE 2.1	Risk Assessment – During Operation				√
AE 2.2	Task Mis-prioritization				√
AE 2.3	Necessary Action – Rushed	√			
AE 2.4	Necessary Action – Delayed				√
AE 2.5	Caution / Warning – Ignored				√
AE 2.6	Decision-making During Operation				√
		4	3	2	1
AE 3	**Misperception Error**				
AE 3.1	Errors due to Misperception				√

AV – Violations

		4	3	2	1
AV 1	Violations - Based on Risk Assessment				√
AV 2	Violations - Routine / Widespread				√
AV 3	Violations – Lack of Discipline				√

TIER 2 - PRECONDITIONS FOR UNSAFE ACTS

PE - Environmental Factors

		4	3	2	1
PE 1	**Physical Environment**				
PE 1.1	Vision Restricted by Icing/Windows Fogging/etc.				√
PE 1.2	Vision Restricted by Meteorology Conditions				√
PE 1.3	Vibration				√
PE 1.4	Vision Restricted in Workspace by Dust/Smoke/etc.				√
PE 1.5	Windblast				√
PE 1.6	Thermal Stress-Cold				√
PE 1.7	Thermal Stress-Heat				√
PE 1.8	Manoeuvring Forces-In-Flight				√
PE 1.9	Lighting of Other Aircraft / Vehicle				√
PE1.10	Noise Interference				√
PE 1.11	Brownout / Whiteout				√

		4	3	2	1
PE 2	**Technology Environment**				
PE 2.1	Seating and Restraints				√
PE 2.2	Instrumentation and Sensory Feedback Systems			√	
PE 2.3	Visibility Restriction				√
PE 2.4	Controls and Switches				√
PE 2.5	Automation				√
PE 2.6	Workspace Incompatible with Human				√
PE 2.7	Personal Equipment Interference				√
PE 2.8	Communications - Equipment				√

PC - Conditions of Individual

		4	3	2	1
PC 1	**Cognitive Factors**				
PC 1.1	Inattention				√
PC 1.2	Channelized attention				√
PC 1.3	Cognitive Task Oversaturation				√
PC 1.4	Confusion				√
PC 1.5	Negative Transfer				√
PC 1.6	Distraction				√
PC 1.7	Geographic Misorientation (Lost)				√
PC 1.8	Checklist Interference				√

		4	3	2	1
PC 2	**Psycho-Behavioural Factors**				
PC 2.1	Pre-Existing Personality Disorder				√
PC 2.2	Pre-Existing Psychological Disorder				√
PC 2.3	Pre-Existing Psychosocial Disorder				√
PC 2.4	Emotional State				√
PC 2.5	Personality Style				√
PC 2.6	Overconfidence				√
PC 2.7	Pressing Beyond Limits				√
PC 2.8	Complacency		√		
PC 2.9	Inadequate Motivation				√
PC 2.10	Misplaced Motivation				√
PC 2.11	Overaggressive				√
PC 2.12	Excessive Motivation to Succeed				√
PC 2.13	Get-Home-It is / Get-There-Itis				√
PC 2.14	Response Set				√
PC 2.15	Motivational Exhaustion (Burn out)				√

		4	3	2	1
PC 3	**Adverse Physiological State**				
PC 3.1	Effects of G-Forces (G-LOC, etc,)				√
PC 3.2	Prescribed Drugs				√
PC 3.3	Operational Injury/Illness				√
PC 3.4	Sudden Incapacitation / Unconsciousness				√
PC 3.5	Pre-Existing Physical Illness/Deficit				√
PC 3.6	Physical Fatigue (Overexertion)				√
PC 3.7	Fatigue – Physiological / Mental				√
PC 3.8	Circadian Rhythm Desynchrony				√
PC 3.9	Motion Sickness				√
PC 3.10	Trapped Gas Disorders				√
PC 3.11	Evolved Gas Disorders				√
PC 3.12	Hypoxia				√
PC 3.13	Hyperventilation				√
PC 3.14	Visual Adaption				√
PC 3.15	Dehydration				√
PC 3.16	Physical Task Oversaturation				√

		4	3	2	1
PC 4	**Physical / Mental Limitation**				
PC 4.1	Learning Ability / Rate				√
PC 4.2	Memory Ability / Lapses				√
PC 4.3	Anthropometric / Biomechanical Limitations				√
PC 4.4	Motor skill / Coordination or Timing deficiency				√
PC 4.5	Technical / Procedural Knowledge				√

		4	3	2	1
PC 5	**Perceptual Factors**				
PC 5.1	Illusion – Kinesthetics				√

PC 5.2	Illusion – Vestibular				√
PC 5.3	Illusion – Visual				√
PC 5.4	Misperception of Operational Conditions				√
PC 5.5	Misinterpreted / Misread Instrument				√
PC 5.6	Expectancy				√
PC 5.7	Auditory Cues				√
PC 5.8	Spatial Disorientation (Type 1) Unrecognized				√
PC 5.9	Spatial Disorientation (Type 2) Recognized				√
PC 5.10	Spatial Disorientation (Type 3) Incapacitating				√
PC 5.11	Temporal Distortion				√

PP - Personnel Factors

		4	3	2	1
PP 1	**Coordination/Communication/Planning Factors**				
PP 1.1	Crew/Team Leadership				√
PP 1.2	Cross-Monitoring Performance	√			
PP 1.3	Task Delegation				√
PP 1.4	Rank / Position Authority Gradient				√
PP 1.5	Assertiveness				√
PP 1.6	Communicating Critical Information				√
PP 1.7	Standard / Proper Terminology		√		
PP 1.8	Challenge and Reply	√			√
PP 1.9	Mission Planning				√
PP 1.10	Mission Briefing				√
PP 1.11	Task/Mission-In-Progress Re-Planning				√
PP 1.12	Miscommunication				√

		4	3	2	1
PP 2	**Self-Imposed Stress**				
PP 2.1	Physical Fitness				√
PP 2.2	Alcohol				√
PP 2.3	Drugs/Supplements/Self-Medication				√
PP 2.4	Nutrition				√
PP 2.5	Inadequate Rest				√
PP 2.6	Unreported Disqualifying Medical Condition				√

TIER 3 – UNSAFE SUPERVISION

SI - Inadequate Supervision

		4	3	2	1
SI 1	Leadership / Supervision / Oversight Inadequate				√
SI 2	Supervision-Modelling				√
SI 3	Local Training Issues / Programs		√		
SI 4	Supervision – Policy		√		
SI 5	Supervision – Personality Conflict				√
SI 6	Supervision-Lack of Feedback				√

SP – Planned Inappropriate Operations

		4	3	2	1
SP 1	Ordered / Led on Mission Beyond Capability				√
SP 2	Crew / Team / Flight Makeup / Composition				√
SP 3	Limited Recent Experience				√
SP 4	Limited Total Experience				√
SP 5	Proficiency				√
SP 6	Risk Assessment – Formal				√
SP 7	Authorized Unnecessary Hazard				√

SF - Failure Correct Known Problem

		4	3	2	1
SF 1	Personnel Management				√
SF 2	Operations Management				√

SV - Supervisory Violations

		4	3	2	1
SV 1	Supervision – Discipline Enforcement (Supervision act of Omission)				√
SV 2	Supervision – Defacto Policy				√
SV 3	Directed Violation				√
SV 4	Currency				√

TIER 4 - ORGANIZATIONAL INFLUENCES

OR - Resource/Acquisition Management

		4	3	2	1
OR 1	Air Traffic Control Resources				√
OR 2	Air Field Resources				√
OR 3	Operator Support				√
OR 4	Acquisition Policies / Design Processes				√
OR 5	Attrition Policies				√
OR 6	Accession/Selection Policies				√
OR 7	Personnel Resources				√
OR 8	Informational Resources / Support		√		
OR 9	Financial Resources / Support				√

OC - Organisational Climate

		4	3	2	1
OC 1	Unit / Organisational Values / Culture				√
OC 2	Evaluation / Promotion / Upgrade				√
OC 3	Perceptions of Equipment				√
OC 4	Unit Mission / Aircraft / Vehicle / Equipment Change or Unit Deactivation				√
OC 5	Organisational Structure				√

OP - Organisational Processes

		4	3	2	1
OP 1	Ops Tempo / Workload				√
OP 2	Program and Policy Risk Assessment				√
OP 3	Procedural Guidance / Publications		√		
OP 4	Organisational Training Issues / Programs		√		
OP 5	Doctrine				√
OP 6	Program Oversight / Program Management				√

SUMMARY OF HFACS WORKSHEET
SI 01/20 TWIN OTTER DHC6-400 9M-SSE

UNSAFE ACTS – ERRORS		4	3	2	1
AE 1	Skill-Based Errors				6
AE 2	Judgement and Decision-Making Errors	1			5
AE 3	Misperception Error				1
UNSAFE ACTS – VIOLATIONS					
AV 1	Violations - Based on Risk Assessment				1
AV 2	Violations - Routine / Widespread				1
AV 3	Violations – Lack of Discipline				1
UNSAFE ACTS SUB TOTAL		**1**	**0**	**0**	**15**
PRECONDITIONS FOR UNSAFE ACTS - ENVIRONMENTAL FACTORS					
PE 1	Physical Environment				11
PE 2	Technology Environment			1	7
PRECONDITIONS FOR UNSAFE ACTS - CONDITIONS OF INDIVIDUAL					
PC 1	Cognitive Factors				8
PC 2	Psycho-Behavioural Factors		1		14
PC 3	Adverse Physiological State				16
PC 4	Physical / Mental Limitation				5
PC 5	Perceptual Factors				11
PRECONDITIONS FOR UNSAFE ACTS - PERSONNEL FACTORS					
PP 1	Coordination/Communication/Planning Factors	2		1	9
PP 2	Self-Imposed Stress				6
PRECONDITIONS FOR UNSAFE ACTS SUB TOTAL		**2**	**1**	**2**	**87**
UNSAFE SUPERVISION					
SI	Inadequate Supervision		2		4
SP	Planned Inappropriate Operations				7
SF	Failure Correct Known Problem				2
SV	Supervisory Violations				4
UNSAFE SUPERVISION SUB TOTAL		**0**	**2**	**0**	**17**
ORGANIZATIONAL INFLUENCES					
OR	Resource/Acquisition Management		1		8
OC	Organisational Climate				5
OP	Organisational Processes		2		4
ORGANIZATIONAL INFLUENCES SUB TOTAL		**0**	**3**	**0**	**17**
TOTAL UNSAFE ACTS		**3**	**6**	**2**	**136**

FINDINGS

1. From summary of the HFACS worksheet above, it has been determined that the above incident **primary causes** were attributed to:

    a. 1 Unsafe Acts (Tier 1) as follows:

        i. Judgement and Decision-Making Errors.

    b. 2 Preconditions of Unsafe Acts (Tier 2) as follows:

        i. 2 Coordination/Communication/Planning Factors.

2. The **secondary causes** were attributed to:

    a. 1 Preconditions of Unsafe Acts (Tier 2) as follows:

        i. Psycho-Behavioural Factors.

    b. 2 Unsafe Supervision (Tier 3) as follows:

        i. 2 Inadequate Supervision.

    c. 3 Organisation Influence (Tier 4) as follows:

        i. 2 Inadequate Organisational Processes.

        ii. 1 Resource/Acquisition Management.

APPENDIX B

COMMENTS TO DRAFT FINAL REPORT FROM THE OPERATOR THAT ARE NOT AGREED UPON

The following are the comments from the Operator to the 9M-SSE Draft Final Report which the Operator suggested for reviewed and to be inserted in the Final Report. Nevertheless, these comments are appended as they are not agreed upon. Comments that are agreed upon had been amended accordingly.

The comments are as follows:

1. Attached is a copy of the NTC in this report which has an entry W/O 722762 regarding the centring of the nose wheel. It was in force at the time of the incident. Even after the implementation of this NTC, there were several other incidents, which leads us to believe that there should be less emphasis on the difference between the old and new checklist centring actions.

MASwings	AIRCRAFT JOURNEY LOG **(9M-SSE STATUS REPORT)**	16.Aug.2020 19:26	Page 6 / 8 2352477

(This Status Report (SR) is valid for 48 hours from its printed time for all departures therein. It must be valid before aircraft off-chock at departure. All time in UTC.)

W/O	DATE	ATA	DESCRIPTION	DELETE BY	SIGN/STAMP/DATE
			ELEVATOR QUADRANT AND SUPPORT BRACKET INSPECTION AS PER CANADIAN AD CF-72-06 R4 BEFORE FURTHER FLIGHT IF THE AIRCRAFT HAS BEEN LEFT STANDING IN WINDS WITH A MEANS VELOCITY ESTIMATED 56 KM/H (35MPH) OR GREATER, VISUALLY INSPECT THE ELEVATOR QUADRANT FOR INDICATIONS OF DISTORTION. DISTORTION OF THE ELEVATOR CAN BE DETECTED VISUALLY BY VIEWING THE QUADRANT FROM THE FWD OR AFT DIRECTION TO OBSERVE ANY WARPING OR BUCKLING, AND/OR BY LOOKING FOR THE EXISTENCE OF SCORE MARKS ON THE QUADRANT TOPSIDE FACE DUE TO ITS CONSTANT RUBBING AGAINST THE SIDE OF THE CABLE GUARD. IF THE QUADRANT IS FOUND DISTORTED, REPLACE IT WITH A SERVICEABLE PART BEFORE FURTHER FLIGHT AND INSPECT THE QUADRANT SUPPORT BRACKET PN C6CFM1142-1 FOR CRACKS USING DIE PENETRANT METHOD. IF THE QUADRANT SUPPORT BRACKET IS FOUND CRACKED, REPLACE IT WITH A SERVICEABLE PART BEFORE FURTHER FLIGHT. DESCRIPTION SIGN 2109954		
722762	Iss.: 27.11.2018 Due.: 31.12.2020	32-50	1 WORKSTEP ADDED BY 2109954 ON 27.NOV.2018, 13:10 DUE DATE: 31-DEC-2020 EFFECTIVE DATE: 20-OCT-2012 TERMINATING: TO RAISE TECHNICAL ASSISTANCE 1 WEEK BEFORE DUE DATE TO MASWINGADM FOR VALIDITY REVIEW FOR MAINTENANCE CREW INFO:// CREW TO ENSURE NOSE WHEEL STEERING TILLER OPERATED SLIGHTLY PAST NEUTRAL BAND WHILE BRINGING BACK FROM EITHER DIRECTION TO LOCK NOSE WHEEL INTO CENTER POSITION. PLS NOTE THAT NOSE WHEEL IS NOT SELF CENTERING. FAILURE TO CENTER NOSE WHEEL WILL RESULT IN VEER DESCRIPTION SIGN 2109954		

2. Below are detail comments on the Draft Final Report which are not agreed upon as table below. Please note that the page numbers are with reference to the Draft Final Report.

NO	PARAGRAPH/ PAGE	STATEMENT	SUGGESTION
1	2.3.1/ Page 37	One crew read and action on all checklist items. Not asking Captain to wiggle nosewheel steering lever upon completion of After Take-off checklist.	One crew read and action on all checklist items. Not asking Captain to wiggle nosewheel steering lever upon completion of After Take-off checklist. Note that there is no stated callout/response in the SOP regarding the centring of the nose gear. The crew may have been signalling to the captain to check the nose gear who likewise signalled back.
2	2.3.1/ Page 37	Captain did not positively ensure nose wheel steering lever centre and locked position.	Captain was not recorded as having "positively" responded to the checklist due to lack of stated "challenge/response" in the SOP regarding the nose-wheel steering. *Explanation: Alternatively, this statement should be removed. There is no way to "positively" ensure the nose-wheel steering level is centred and locked. There is no indication system. The procedures also do not "ensure" that it is locked and are very vague as to their description.* Under recommendations please add: Manufacturer to review manual and specify amount of force normally required to actuate the

			nose wheel lever without causing damage whilst providing reasonable assurance that the nose wheel is centred. A metric like how many Newtons of force or terms like “finger force” or “arm force” may be used. Furthermore, the normal allowed “play” for the nose wheel steering lever once the nose wheel is locked in the notch should be specified (an inch from centring mark? 1 and a half inches?). We have a lot of complaints of “loose” nose wheel levers causing a lot of confusion.
3	2.3.1/ Page 37	A chain of latent failures as described in paragraph 2.3.1 to 2.3.4 had led to an unsafe act as describe above which caused the aircraft to veer off the runway on landing.	According to our analyses a chain of events as described in paragraph 2.3.1 to 2.3.4 possibly caused the aircraft to veer off the runway on landing. However, the picture is incomplete as there is no FDR data from the nose-wheel steering or Brakes.
4	2.3.2/ Page 41	The design of the nose wheel steering system was factor present but was not a contributory factor to this incident.	Please reconsider this statement. It is our belief that the nose wheel steering design did contribute to the incident based on previous incidents. Furthermore, as stated above, there is a lot of ambiguity caused by the design. NTC was also in force during the incident which is clearer than the manufacturer’s checklist. All crew are briefed on this NTC during training. Recommendations as stated above (item 6).

			Under recommendations please add: Manufacturer to review manual and specify amount of force normally required to actuate the nose wheel lever without causing damage whilst providing reasonable assurance that the nose wheel is centred. A metric like how many Newtons of force or terms like “finger force” or “arm force” may be used. Furthermore, the normal allowed “play” for the nose wheel steering lever once the nose wheel is locked in the notch should be specified (an inch from centring mark? 1 and a half inches?). We have a lot of complaints of “loose” nose wheel levers causing a lot of confusion.
5	2.3.3 /Page 41	Proper technique to centre nose wheel steering not emphasized during flight training	Design and Operation of the Nose wheel steering system not emphasized enough during ground training. There is no technique that will ensure the nose wheel steering is centred
6	3.0/ Page 47	There is always a possibility of the nose wheel being off-set from centre after take-off due to the nature of operations and challenging runway condition.	There is always a possibility of the nose wheel being off-set from centre after take-off due to the nature of operations, challenging runway conditions and the design of the system.
7	3.0/ Page 48	The most crucial action which was omitted in the after take-off checks was the PF did not check the nose	The PF’s response to the co-pilot’s action of the checklist was not recorded on the CVR since the SOP does not

		wheel steering lever lock in centre position.	require any verbal response. The PF stated in the interview that he did check the nose gear steering when the item was called. However, this could not be corroborated by any other evidence since the position of the nose wheel steering lever is not recorded by the FDR.
8	3.0/ Page 48	The second precondition was the PM announcing the completion of checks without instructing the PF to check the nose wheel steering lever lock in centre position.	The second precondition was the PF not responding to the PM's call to check the nose wheel steering lever verbally. There was no audible response on the CVR since it was not written in the SOP. Whether or not the PF had checked the nose wheel steering when the checklist was read cannot be confirmed although he did state that he did check it during the interview.
9	3.2.5/ Page 54	The primary cause of this incident is attributed to Decision-Making Errors and Coordination/Communication Factors. The **primary cause** is the non-compliance to the DHC-6 Series 400 SOP when performing checklist procedures.	*Please relook into the Primary/Secondary causes taking into account evidence of nose wheel steering design issues and taking into account from the past incidents.* To reword the **most Probable Cause** of this incident etc. Or According to the analyses, one of the **Probable chain of events** that caused the incident was etc.

10	4.0/ Page 55	Add in recommendations as mentioned above.	Manufacturer to review manual and specify amount of force normally required to actuate the nose wheel lever without causing damage whilst providing reasonable assurance that the nose wheel is centred. A metric like how many Newtons of force or terms like “finger force” or “arm force” may be used. Furthermore, the normal allowed “play” for the nose wheel steering lever once the nose wheel is locked in the notch should be specified (an inch from centring mark? 1 and a half inches?). We have a lot of complaints of “loose” nose wheel levers causing a lot of confusion.
11	4.1.2c/ Page 56	To include the teaching of the correct and standardize technique on how to check and ensure the nose wheel steering lever centre and lock position in the initial type conversion and initial operating experience syllabus.	To include the teaching of the correct and standardized nose wheel centring technique in the initial type conversion or on the initial operating experience syllabus. Without a monitoring system, there can be no positive assurance that the nose wheel is locked in the notch, but the risks can be mitigated.