



**KOMITE NASIONAL KESELAMATAN TRANSPORTASI  
REPUBLIC OF INDONESIA**

**FINAL**

**KNKT 15.10.21.04**

**Aircraft Accident Investigation Report**

**PT. Aviastar Mandiri**

**DHC-6 Twin Otter; PK-BRM**

**at coordinate 3° 25' 52.80" S, 120° 4' 12.10" E**

**District of Luwu, South Sulawesi**

**Republic of Indonesia**

**2 October 2015**



**2016**

This Final report was produced by the *Komite Nasional Keselamatan Transportasi* (KNKT), Transportation Building, 3<sup>rd</sup> Floor, Jalan Medan Merdeka Timur No. 5 Jakarta 10110, Indonesia.

The report is based upon the investigation carried out by the KNKT in accordance with Annex 13 to the Convention on International Civil Aviation Organization, the Indonesian Aviation Act (UU No. 1/2009) and Government Regulation (PP No. 62/2013).

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## ABBREVIATIONS AND DEFINITIONS

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AirNav	:	Indonesia Air Traffic Service Provider
AMSL	:	Above Mean Sea Level
AOC	:	Air Operator Certificate a commercial transport license for airlines
AFML	:	Aircraft Flight and Maintenance Log
ATC	:	Air Traffic Control
ATS	:	Air Traffic Services
ATPL	:	Air Transport Pilot License is the highest level of aircraft pilot license
ATIS	:	Automatic Terminal Information Service
ATS	:	Air Traffic Service
BMKG	:	<i>Badan Meterologi Klimatologi dan Geofisika</i> (Metrological Climatology and Geophysical Agency)
BASARNAS	:	<i>Badan SAR Nasional</i> (National Search and Rescue Agency)
°C	:	Degrees Celsius
COM	:	Company Operation Manual
CRM	:	Crew Resource Management
CVR	:	Cockpit Voice Recorder
DGCA	:	Directorate General of Civil Aviation of Indonesia
DME	:	Distance Measuring Equipment
DVI	:	Disaster Victims Identification
EGPWS	:	Enhance Ground Proximity Warning System
ELT	:	Emergency Locator Transmitter
EMMA	:	Equal Maintenance for Maximum Availability
FAA	:	Federal Aviation Administration
FDR	:	Flight Data Recorder
GPS	:	Global Positioning System
HF	:	High Frequency
ICAO	:	International Civil Aviation Organization
IFR	:	Instrument Flight Rules
Kg	:	Kilogram (s)
Km	:	Kilometer (s)
KNKT	:	<i>Komite Nasional Keselamatan Transportasi</i> (National Transportation Safety Committee)
Kts	:	Knots (Nm/hours)

LOFT	:	Line Oriented Flight Training
LT	:	Local time
m	:	Meters
mbs	:	Millibars
MHz	:	megahertz
mm	:	Millimetre(s) is a unit of length in the metric system
Nm	:	Nautical mile(s)
PF	:	Pilot Flying
PIC	:	Pilot in Command
PM	:	Pilot Monitoring
PNF	:	Pilot Non flying
P/N	:	Part Number
SA	:	Situational Awareness
SIC	:	Second in Command
TAD	:	Terrain Awareness Display
TAWS	:	Terrain Awareness and Warning System
TSO	:	Technical Standard Order
UTC	:	Universal Time Coordinate
VFR	:	Visual Flight Rules
VHF	:	Very High Frequency
VOR	:	Very High Frequency Omni-directional Range

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## INTRODUCTION

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On 2 October 2015, a DHC-6-300 Twin Otter, registered PK-BRM was being operated by PT. Aviastar Mandiri on a scheduled passenger service flight from Masamba (WAFM) to Makassar (WAAA) with flight number MV 7503. The aircraft departed from Masamba at 0625 UTC (1425 LT), cruised at altitude 8,000 feet and estimated time of arrival Makassar at 0739 UTC. On board on this flight were 10 persons consist of two pilots, one company engineer and seven passengers (four adults, one child and two infants).

The flight from Masamba to Makassar was the 6<sup>th</sup> flight sector of the day and the weather on the previous flights were clear. During cruising, at approximately 22 Nm from Masamba, the pilots decided to deviate the flight from the company VFR routes to fly direct to BARRU.

At 0651 UTC, the CVR stopped recording. The CVR did not record Enhanced Ground Proximity Warning System (EGPWS) aural caution and warning prior to the impact. The investigation could not determine the reason of the absence of the EGPWS aural warning.

On 5 October 2015, the aircraft wreckage was found on top of Bajaja Mount, Dusun Gamaru, Desa Ulusalu, Kabupaten Luwu, South Sulawesi on the coordinate of 3° 25' 52.80" S, 120° 4' 12.10" E. The BASARNAS did not receive any signal from the aircraft Emergency Locator Transmitter (ELT).

All occupants were fatally injured and the aircraft was destroyed by impact force and post impact fire.

The investigation concluded the contributing factors to the accident: deviation from the company visual route without properly considering the elevated risks of cruising altitude lower than the highest terrain and instrument meteorological condition in addition with the absence of the EGPWS warning resulted in the omission of avoidance actions.

PT. Aviastar Mandiri had been performed several safety actions following this occurrence. Komite Nasional Keselamatan Transportasi (KNKT) considered that the safety actions were relevant to improve safety. In addition, KNKT issued safety recommendation to PT. Aviastar Mandiri and Directorate General of Civil Aviation.



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# 1 FACTUAL INFORMATION

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## 1.1 History of the Flight

On 2 October 2015, a DHC-6 Twin Otter, registered PK-BRM, was being operated by PT. Aviastar Mandiri as a scheduled passenger flight with flight number MV 7503. The aircraft departed from Andi Jemma Airport, Masamba (WAFM)<sup>1</sup> with the intended destination of Sultan Hasanuddin International Airport, Makassar (WAAA) South Sulawesi, Indonesia. On board the flight were 10 persons consisting of two pilots and eight passengers, including one company engineer.

The previous flights were from Makassar – Tana Toraja – Makassar – Masamba – Seko - Masamba and the accident flight was from Masamba to Makassar which was the 6<sup>th</sup> sector of the day.

The aircraft departed from Masamba at 1425 LT (0625 UTC<sup>2</sup>) with an estimated time of arrival at Makassar of 0739 UTC. The Pilot in Command (PIC) acted as Pilot Flying (PF) while the Second in Command (SIC) acted as Pilot Monitoring (PM). The flight was conducted under the Visual Flight Rules (VFR) and cruised at an altitude of 8,000 feet.

At 0630 UTC, the pilot reported to Ujung Pandang Information officer that the aircraft passed an altitude of 4,500 feet and was climbing to 8,000 feet. The Ujung Pandang Information officer requested the pilot of the estimate time of aircraft position at 60 Nm out from MKS VOR/DME.

At 0632 UTC, the pilot discussed about the calculation of estimate time to reach 60 Nm out from MKS and afterward the pilot informed Ujung Pandang Information officer that the estimate at 60 Nm was at 0715 UTC.

At 0633 UTC, the Ujung Pandang Information officer informed the pilot to call when reaching 8,000 feet and was acknowledged by the pilot.

At 0636 UTC, the pilot informed the Ujung Pandang Information officer that the aircraft had reached 8,000 feet and requested the squawk number (ATC transponder code). The Ujung Pandang Information officer acknowledged and gave the squawk number of A5616, which was acknowledged by the pilot.

At 0637 UTC, the pilots discussed to fly direct to BARRU. BARRU is a town located at about 45 Nm north of Makassar. Both pilots agreed to fly direct and the SIC explained the experience of flying direct on the flight before.

At 0651 UTC, the PIC told the SIC that he wanted to climb and one second later the CVR recorded the sound of impact (Figure 1).

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<sup>1</sup> Andi Jemma Airport, Masamba will be named as Massamba for the purpose of this report

<sup>2</sup> The 24-hour clock used in this report to describe the time of day as specific events occurred is in Coordinated Universal Time (UTC). Local time for Masamba is Central Indonesia Standard Time /*Waktu Indonesia Tengah* (WITA) is UTC + 8.



Picture courtesy of Google Earth

**Figure 1: Shows the Masamba Airport, accident site and Makassar Airport (circled)**

## 1.2 Injuries to Persons

Injuries	Flight crew	Passengers	Total in Aircraft	Others
Fatal	2	8	10	
Serious	-	-	-	
Minor/None	-	-	-	
<b>TOTAL</b>	<b>2</b>	<b>8</b>	<b>10</b>	

## 1.3 Damage to Aircraft

The aircraft was destroyed by impact force and post-impact fire.

## 1.4 Other Damage

There was no other damage reported.

## 1.5 Personnel Information

### 1.5.1 Pilot in Command

Gender	: Male
Age	: 40 years
Nationality	: Indonesia
Marital status	: Married
Date of joining company	: 3 June 2009
License	: ATPL
Aircraft type rating	: DHC-6 Twin Otter
Instrument rating	: 25 November 2014

Medical certificate	: First Class
Last of medical	: 15 September 2015
Validity	: 31 March 2016
Medical limitation	: Holder shall possess glasses that correct for the near vision
Last line check	: 06 June 2015
Last proficiency check	: 25 November 2014
<b>Flying experience</b>	
Total hours	: 2,911 hours 58 minutes
Total on type	: 2,911 hours 58 minutes
Last 90 days	: 209 hours 25 minutes
Last 60 days	: 138 hours 24 minutes
Last 24 hours	: 6 hours 8 minutes
This flight	: Approximately 25 minutes

#### 1.5.2 Second in Command

Gender	: Male
Age	: 39 years
Nationality	: Indonesia
Marital status	: Married
Date of joining company	: 15 January 2015
License	: ATPL
Aircraft type rating	: DHC-6 Twin Otter
Instrument rating	: 29 January 2015
Medical certificate	: First Class
Last of medical	: 9 July 2015
Validity	: 09 January 2016
Medical limitation	: Holder shall wear corrective lenses
Last line check	: 21 February 2015
Last proficiency check	: 29 January 2015
<b>Flying experience</b>	
Total hours	: 4,035 hours 36 minutes
Total on type	: 4,035 hours 36 minutes
Last 90 days	: 180 hours 19 minutes

Last 60 days : 136 hours 54 minutes  
Last 24 hours : 6 hours 8 minutes  
This flight : Approximately 25 minutes

## **1.6 Aircraft Information**

### **1.6.1 General**

Registration Mark : PK-BRM  
Manufacturer : de Havilland Canada  
Country of Manufacturer : Canada  
Type/ Model : DHC-6-300  
Serial Number : 741  
Year of manufacture : 1981  
Certificate of Airworthiness  
Issued : 15 January 2015  
Validity : 16 January 2016  
Category : Normal  
Limitations : None  
Certificate of Registration  
Number : 3606  
Issued : 30 December 2014  
Validity : 29 December 2015  
Time Since New : 45,242.8 hours  
Cycles Since New : 75,241 cycles  
Last EMMA<sup>3</sup> : 45,196.78 hours  
Next EMMA : 45,321.78 hours

The aircraft was certified for both Instrument Flight Rules (IFR) and Visual Flight Rules (VFR).

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<sup>3</sup> Equal Maintenance for Maximum Availability (EMMA) is a scheduled maintenance program based on 6000 flight hours outlined in the manual PSM1-6-7-IC issued by aircraft manufacture. It was divided into 48 inspections (EMMA check) at 125-hour intervals. Each inspection was numbered and had a corresponding work card outlining the scope of inspection.

## 1.6.2 Engines

Manufacturer	:	Pratt & Whitney, Canada
Type/Model	:	PT6A-27
Serial Number-1 engine	:	PCE-41835
▪ Time Since New	:	16,795.1 hours
▪ Cycles Since New	:	27,154 cycles
Serial Number-2 engine	:	PCE-50853
▪ Time Since New	:	1,525.28 hours
▪ Cycles Since New	:	1,338 cycles

## 1.6.3 Enhanced Ground Proximity Warning System (EGPWS)

The aircraft was equipped with a Honeywell EGPWS KGP-560, Garmin GMX200, and GNS430. These were installed by Australian Avionic Pty Ltd using the approved document number CG-DH6-34-AA1S19-02-01 on 12 September 2011 prior to delivery to the operator.

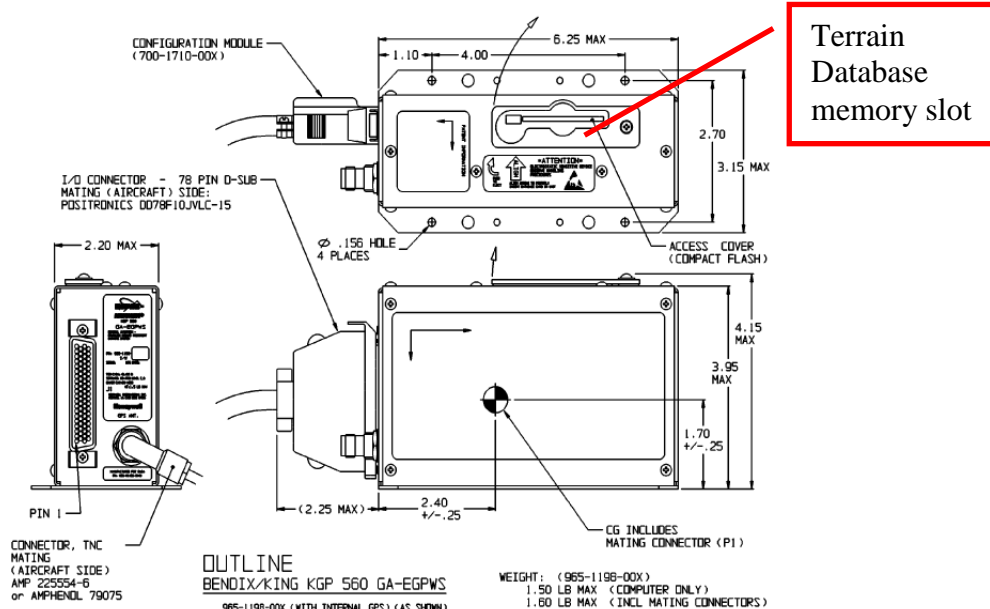
EGPWS KGP-560 is the primary Terrain Awareness Warning System (TAWS) processor and requires the latest terrain database. The investigation could not determine the installation and the latest revision of terrain database installed.

The KGP-560 is suitable for General Aviation – EGPWS (GA-EGPWS) complies with the requirements for TAWS Class B as defined by FAA TSO C151b. The TAWS class B system is TAWS that does not have terrain display feature as TAWS class A system. Since the TAWS class B is not equipped with the terrain display, the aircraft was installed with a Garmin GMX200 which has the features of terrain image that displays the aircraft position relatives to the surrounding area. To be able to determine the aircraft position, the Garmin GMX200 requires additional position navigational sensor, therefore the GPS Garmin GNS 430 was installed as the position source.

To ensure the correct configuration and installation of the TAWS (EGPWS KGP-560, GMX200 and GNS 430), the functional<sup>4</sup> test was included in the installation document number CG-DH6-34-AA1S19-02-01. However, the investigation could not find the functional test result document after the installation of the TAWS.

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<sup>4</sup> Functional test: is a detailed examination in which a complete system, sub-system or component is checked to determine if specific operating parameters are within limits of movement, rate of flow, temperature, pressure, revolutions per minute, degrees of travel, etc., as prescribed in the manufacturer/vendors Maintenance Manual.



In regard to the operation of the EGPWS, the operator provided a special briefing to all flight crews.

The operator procedures stated the pilot shall report any detected malfunction in the Aircraft Flight and Maintenance Log (AFML) when a malfunction was detected during operational<sup>5</sup> test or while being operated. However, the operational test of the TAWS system was not included in the pilot checklist.

According to operator, there was no system failure reported during the operation. The investigation could not determine the proper TAWS installation and configuration including the updating terrain database and proper functional system test since there was no functional test results available.

#### 1.6.4 Emergency Locator Transmitter (ELT)

The aircraft was equipped with Emergency Locator Transmitter (ELT) type Artex, part number C406-2. The ELT operates on frequency of 406 MHz.

### 1.7 Meteorological Information

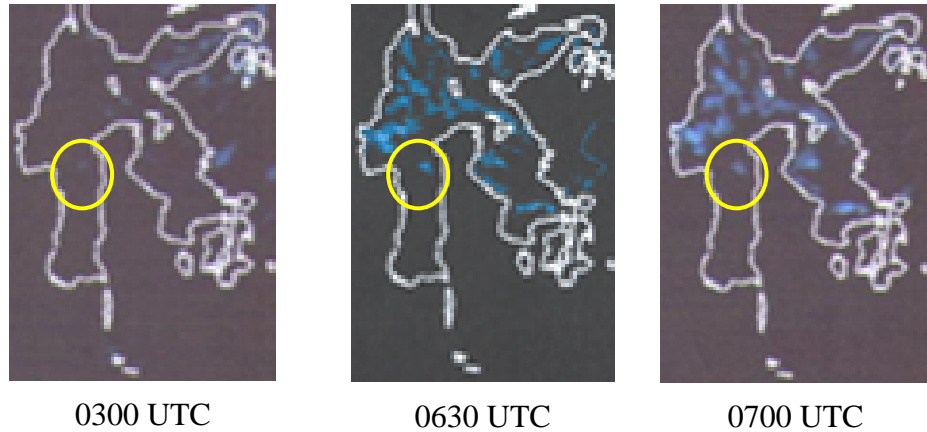
The weather report for Andi Jemma Airport, Masamba, issued on 2 October 2015, at 0600 UTC was as follows:

Wind	: 260 / 02 knots
Horizontal visibility	: 9 km
Weather	: Nil
Temperature	: 33°C
Dewpoint	: 18°C
Humidity	: 49%

<sup>5</sup> Operational test is to determine the operational condition of a system or component

QNH : 1013 mbs  
QFE : 1006 mbs

The satellite weather image over the centre of Sulawesi which was provided by BMKG on the day of the accident at 0300 UTC, 0630 UTC and 0700 UTC, and the circles showed the clouds formation at around the crash site (Figure 2).



**Figure 2: Satellite weather images at the accident site (yellow circle)**

The satellite image published by *Badan Meteorology, Klimatology dan Geofisika* (BMKG – Meteorology, Climatology and Geophysics Agency) at 0630 UTC and 0700 UTC, showed partial cloud formation at about 60 Nm from Masamba on the direct track to Makassar around Mount Bajaja and Mount Latimojong.

According to the information from the local villagers of the nearest village to the accident site, the weather phenomenon on the area on that period the mountain was normally covered by clouds between 1100 LT to 1600 LT. The local villager stated that at the time of the accident the mountain was covered by clouds.







## 1.10 Aerodrome Information

Airport Name	: Andi Jemma Airport
Airport Identification	: WAFM
Airport Operator	: Directorate General Civil Aviation
Coordinate	: 2°33'35''S 120°19'50''E
Elevation	: 122 feet / 37.2 meters
Runway Direction	: 02-20
Runway Length	: 900 m
Runway Width	: 23 m
Surface	: Asphalt

## 1.11 Flight Recorders

The aircraft was not equipped with a Flight Data Recorder (FDR) as it was not required by current Indonesian aviation regulations. The aircraft was equipped with a Cockpit Voice Recorder (CVR).

Manufacturer	: L3 Communication
Type/Model	: FA2100
Part Number	: 2100-1020-00
Serial Number	: 000802149

On 6 October 2015, the CVR was recovered from the accident site and was handed over from BASARNAS to KNKT.

On 8 October 2015, the CVR was successfully downloaded at the KNKT recorder facility. The CVR contained two hours of good quality recording data including the previous flight and the accident flight.

During the approach to Masamba, the CVR recorded the crew communication and coordination, checklist reading and the environment. The CVR did not record EGPWS altitude callouts and preflight self-test.

The excerpts of the CVR data of the accident flight are as follow:

*Note: The recorded CVR time was not the real time of the flight, therefore the time synchronization used on the transcription referred to the time of the crew made first contact to Ujung Pandang Info officer.*

CVR Time	UTC Time	Description
01.03.18	06:24:16	The sound of engines spooled up indicated that the aircraft took off runway 20 Masamba.
01.04.03	06:25:01	The crew performed after takeoff checklist

<b>CVR Time</b>	<b>UTC Time</b>	<b>Description</b>
01.08.28	06:30:26	The crew contacted Ujung Pandang Info officer informed climbing passed 4,500 feet to maintain 8,000 feet, departure Masamba at 0625 UTC and estimated time arrival Makassar at 0739 UTC. The Ujung Pandang Info officer acknowledged the message and requested the estimate time reaching 60 Nm MKS VOR which was replied the estimate was at 0715 UTC.
01.12.58	06:34:56	The aircraft reached cruising altitude of 8,000 feet. The Ujung Pandang Info officer acknowledged and provided squawk number of A 5616.
01.15.15	06:37:17	The PF suggested to fly direct to point BARRU from the current position and was agreed by the PM based on his experience on previous flight.
01.21.58	06:45:00	The crew mentioned that the air speed was indicated 128 knots and outside temperature was 14°C
01.24.18	06:47:20	The crew discussed that they were at 109 Nm from Makassar.
01.27.29	06:51:15	The pilot flying stated that he intended to climb.
01.27.30	06:51:16	<i>Sounds of impact</i>
01.27.32	06:51:18	<i>End of recording</i>

## 1.12 Wreckage and Impact Information

The aircraft wreckage was found on top of Bajaja Mount, Dusun Gamaru, Desa Ulusalu, Kabupaten Luwu, South Sulawesi on the coordinate of 3° 25' 52.80" S, 120° 4' 12.10" E at elevation of approximately 7,734 feet Above Mean Sea Level (AMSL).

Based on the observation of the accident site area, there were signs of impact marks on several trees starting from about 100 meters from the main wreckage on approximate direction of 200° toward the impact point (Figure 4).



**Figure 4: The collapsed trees shown the aircraft direction**

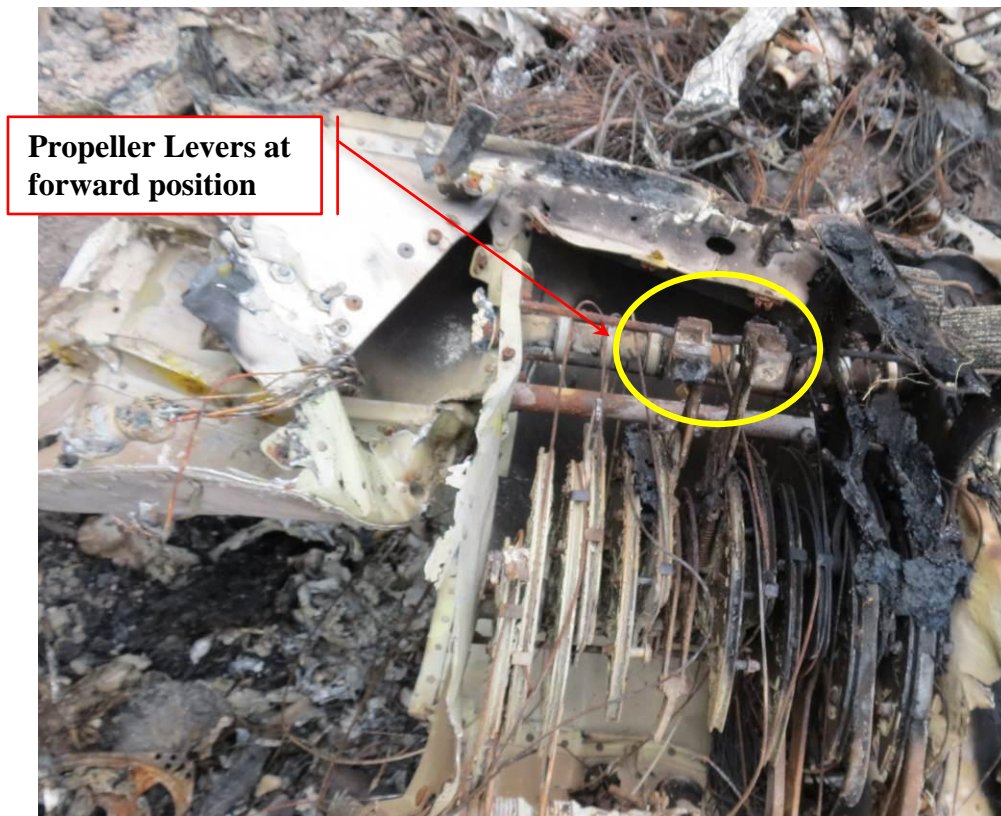


**Figure 5: Part of the right wing found approximately 100 meters from the main wreckage**

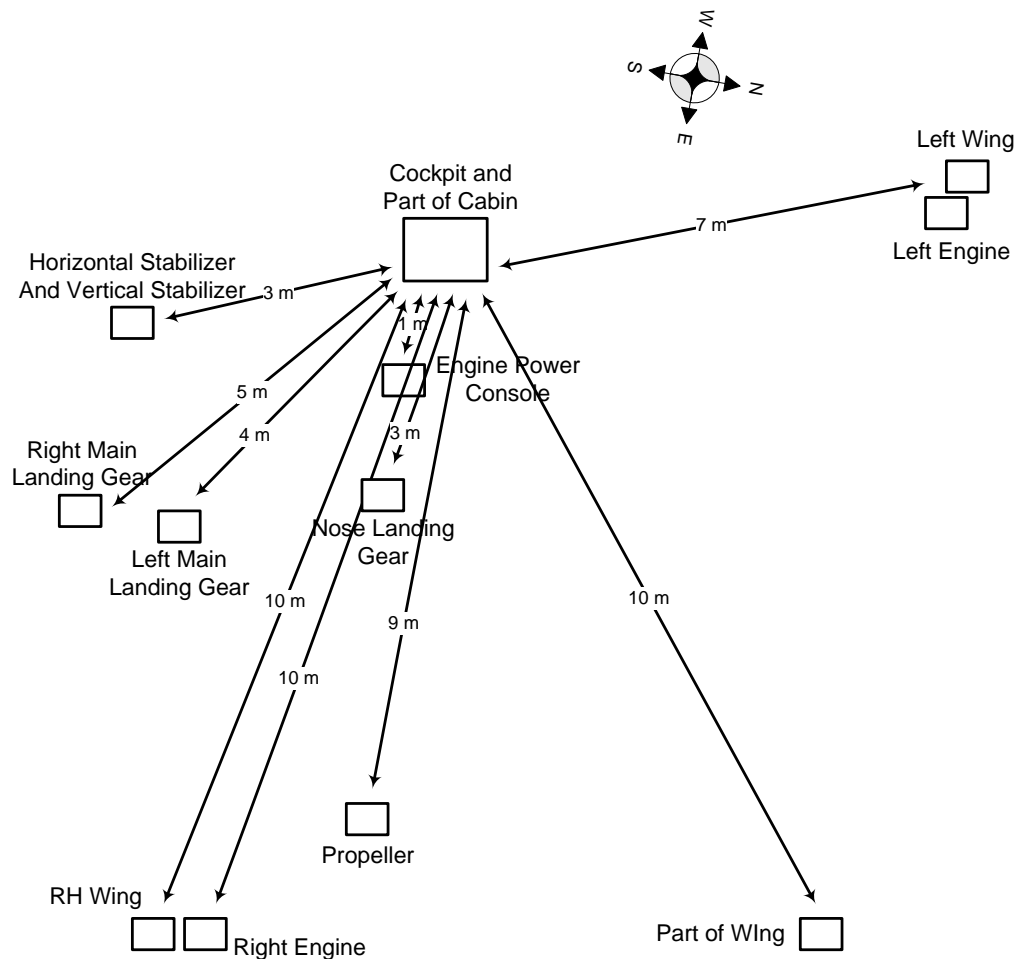




**Figure 6: Main wreckage and the distribution of aircraft part**



**Figure 7: The power console (upside down) showed propeller lever position and the throttle levers were missing**



**Figure 8: The illustration of the wreckage distribution diagram**

### **1.13 Medical and Pathological Information**

All occupants were fatally injured and recovered from the accident site on 6 October 2015, and then evacuated to Bhayangkara Hospital in Makassar for identification purposes.

On 7 October 2015, all victims had been identified by Indonesian Disaster Victim Identification (DVI) Team.

### **1.14 Fire**

There was no indication of in-flight fire and the fuselage wreckage was destroyed by post-impact fire.

### **1.15 Survival Aspects**

At 0718 UTC, Ujung Pandang Information officer called the pilot of PK-BRM but there was no reply. At 0735 UTC, Ujung Pandang Air Traffic Services (ATS) operational coordinator contacted the company branch officer at Makassar, to confirm whether the pilot had made a contact to the company branch officer. There was no communication between the company branch officer and the pilot.

The Ujung Pandang ATS operation coordinator contacted Masamba Airport officer to confirm whether the aircraft returned to Andi Jemma Airport or diverted to other airports nearby such as Tana Toraja, Mamuju, Bua or Bone. The Masamba Airport officer did not have any information from the pilot and advised that the aircraft did not return to Masamba.

At 0742 UTC, the Ujung Pandang ATS operation coordinator contacted the *Badan SAR Nasional* (BASARNAS – the Indonesia Search and Rescue Agency) and informed them that they had lost contact with PK-BRM. The emergency operation of search and rescue team was assembled. The team consisted of the SAR Agency, PT. Angkasa Pura I, Airport Authority Regional Office V, AirNav (Air Traffic Services provider), local government, police, and army. The BASARNAS did not receive any signal from an Emergency Locator Transmitter (ELT).

On 5 October 2015, the wreckage was found by ground search team on top of Bajaja Mount, Dusun Gamaru, Desa Ulusalu, Kabupaten Luwu, South Sulawesi at coordinate of 3° 25' 52.80" S, 120° 4' 12.10" E, at elevation of 7,734 feet AMSL.

All occupants were fatally injured and the aircraft was destroyed by impact force and post-impact fire.

On 6 October 2015, the CVR was recovered and handed over from BASARNAS to KNKT.

## **1.16 Tests and Research**

There was no test and research conducted for the investigation.

## **1.17 Organizational and Management Information**

Aircraft Owner and Operator : PT. Aviastar Mandiri  
Address : Puri Sentra Niaga. Blok B, No. 29  
Jl. Raya Kalimalang, Jakarta 13620  
Certificate Number : AOC 135-029

### **1.17.1 Flight Operation**

PT. Aviastar Mandiri had seven DHC-6 aircraft, including the accident aircraft, of which two aircraft operated on Sulawesi, two operated on Kalimantan, two operated on Maluku and one operated on Papua. Most of the flight operations were conducted under Visual Flight Rules (VFR). Some aircraft were approved for Instrument Flight Rules (IFR).

According to the management statement, some of the DHC-6 pilots had been briefed for the operation of the TAWS and EGPWS, including the accident pilots, while some other had not yet been given the briefing.

Flight following was performed by the operator using High Frequency (HF) radio communication and it covers Java and Kalimantan.

## 1.17.2 Crew Resources Management

The Company Operation Manual (COM) chapter 6.6.4 on the subject of Crew Resource Management (CRM) Training / Loft stated that:

*Company has the authorization to conduct Crew Resource Management (CRM) training / Line Oriented Flight Training (LOFT) program. Every crew member shall receive Crew Resource Management training every 12 calendar months of ground recurrent. And also every 12 calendar months in simulator LOFT covering not only development of non-technical skills but also preventive and the best safety practices.*

– CRM training program consists of the following discussion:

- *Communication/interpersonal skills.*
- *Situational awareness*
- *Problem solution*
- *Leadership*
- *Stress management*
- *Critique and Joharry Windows*
- *Small Organized Group*
- *Perception*
- *Culture and Working Style*
- *Decision-Making*
- *Conflict*
- *Managerial skill*

– *LOFT refers to aircrew training which involves a full mission simulation of situations which are representative of line operations, with special emphasis on situations which involve communications, management and leadership. In short, LOFT means realistic, "real-time", full mission training.*

## 1.18 Additional Information

### 1.18.1 Enhanced Ground Proximity Warning System (EGPWS)

#### General

The Ground Proximity Warning System (GPWS) function consists of the following basic mode:

1. Mode 1, Excessive Descent Rate
2. Mode 2, Excessive Closure to Terrain
3. Mode 3, Altitude Loss After Takeoff
4. Mode 4, Unsafe Terrain Clearance
5. Mode 5, Excessive Deviation Below Glide slope
6. Mode 6, Advisory Callouts which consist of advisory call out for the bank angle and the altitude with regard to radio altimeter.

In conjunction with GPWS Mode 2, if the closure rate into terrain is more than 2000 feet per minute, a warning alert will be provided to the flight crew. On the situation the distance roughly corresponds between 30 and 60 seconds of advance alerting. The 60 seconds to the terrain will trigger callout “CAUTION TERRAIN” and the 30 second will trigger “TERRAIN TERRAIN PULL-UP”.

The Terrain Awareness and Warning System (TAWS) or Enhanced Ground Proximity Warning System (EGPWS) is a basic GPWS with addition of features that enhance the basic modes by alerting the pilot if the aircraft is facing towards the terrain or descends below a defined terrain clearance floor. This system is intended to provide an advanced warning with adequate time for the flight crew to react safely.


With the addition of an internal terrain database, the TAWS has the ability to look-ahead and provide image of the surrounding terrain or Terrain Alerting Display (TAD). When a compatible Weather Radar, EFIS, or other display is available, the TAD features the surrounding terrain displays in various colors and intensities on those screens. The color display of the terrain varies depends on the aircraft position or flight path angle, track, and speed relative to the terrain surrounding the aircraft. The red color displays the terrain at least 2,000 feet higher than the aircraft altitude. The yellow color displays for terrain very near or above aircraft altitude and green color displays the terrain below the aircraft altitude.

### EGPWS KGP 560

The Honeywell Enhanced Ground Proximity Warning System (EGPWS) had the function and architecture to represent the TAWS functionality providing terrain alerting and display features. It uses aircraft inputs and internal databases to predict a potential conflict between the aircraft flight path and terrain or an obstacle.

According to Honeywell/Bendix, the KGP 560 is suitable for General Aviation – EGPWS (GA-EGPWS) and complies with the requirements for TAWS Class B as defined by FAA TSO C151b. The TAWS class B system is a TAWS that does not have terrain display feature as TAWS class A system. Since the TAWS class B is not equipped with the terrain display, the terrain information will be provided by annunciator light to the flight crew.

Typical terrain annunciator light is as follows:



INDICATOR/CONTROL	COLOUR	FUNCTION
<b>TERR TERR</b> lamp/switch	RED AMBER	Indicates Terrain Warnings. Indicates Terrain Cautions Press for test function of GA-EGPWS
<b>TERR INHIBIT OFF ON</b> lamp/switch	WHITE GREEN WHITE	GA-EGPWS alerting enabled GA-EGPWS alerting inhibited Press to change between <b>OFF</b> & <b>ON</b>
<b>TERR N/A</b> lamp	AMBER	Indicates GA-EGPWS inoperative

**Figure 9: Typical TAWS Class B annunciator lights**



The operation of the Enhanced Ground Proximity Warning System (EGPWS) is described in the Aircraft Flight Manual Supplement: Bendix/King KGP560 EGPWS Fitted to DeHavilland DHC6-300, published by Australian Avionic Pty. Ltd. The significant excerpts are as follows:

**Section 2 – Limitation**

- a) *Navigation must not be predicated upon the use of the Terrain Awareness Display. The Terrain Awareness Display is intended to serve as a situational awareness tool only and may not provide the accuracy and/or fidelity on which solely to base terrain or obstacle avoidance manoeuvring decision.*

**Section 3 – Emergency Procedures**

- a) *Emergency Procedures*

*For ditching or other off-airport landings, inhibit the Terrain Awareness Alerting and Display (TAAD) and the Terrain Clearance Floor (TCF) function by selecting the TERR INHIBIT or TERR INHB switch (ON or TERR INHB enunciated)*

**Section 4 – Normal Procedures**

- b) *System activation*

*The GA-EGPWS is active when electrical power is supplied, the amber TERR N/A annunciator is extinguished and the following systems are operational:*

- *Enhanced Ground Proximity Warning Computer (EGPWC)*
- *Encoding altimeter*
- *Weather Radar Indicator or MFD (if configured for display)*
- *If the aircraft horizontal position derived from the internal GPS (or other on-board GPS) receiver is invalid, the GA-EGPWS will not be available*

***Perform a system self-test on the ground prior to every flight to verify proper operation of the KGP 560 GA EGPWS.***

- e) *System Self-Test*

*Proper operation of the EGPWS can be verified when the aircraft is on the ground as follows:*

*Ensure that the TERR INHIBIT ON (TERR INHB) switch is NOT ENGAGED, and momentarily push the TERR TERR (test) switch:*

*The following events may not occur exactly in the order shown.*

*The red TERR, amber TERR, amber TERR N/A lights illuminate.*

*The red TERR, amber TERR, amber TERR N/A lights extinguish.*

*An aural “EGPWS SYSTEM OK” message is enunciated over cockpit speaker.*

*A terrain self-test pattern appears on the radar indicator or MFD.*

*The terrain self-test pattern disappears after several sweeps of the terrain display.*

Activate annunciator test switch; ensure all annunciators illuminate and dim correctly with the bright/dim switch.

g) Advisory callouts (mode 6)

The following advisory callouts are provided in this installation:

“FIVE HUNDRED” (smart callout) occurs at 500 feet AGL.

i) Use or terrain awareness display (if fitted)

Note: This is used as example only; refer to respective MFD or radar indicator pilot guide and/or flight manual for further information.

The terrain awareness display is selected by depressing the TERR function key on the MFD or on the weather radar display using a RADAR/TERR switch. The display is intended to enhance situational awareness with respect to separation from terrain or obstacles.

The display is not intended to be used for navigation purposes.

### Garmin GMX200

The aircraft was installed with Garmin GMX200 which has the features of terrain image that displays the aircraft position relative to the surrounding area. To be able to determine the aircraft position, the Garmin GMX200 requires an additional position navigational sensor, therefore the GPS Garmin GNS 430 was installed as the position source. Typical displays of Garmin GMX200 are as follows:



Figure 10: Normal display of GMX200

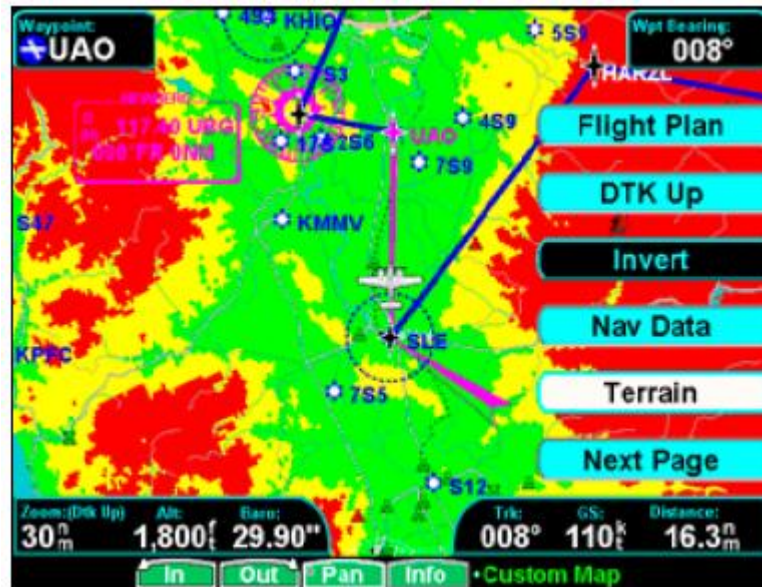


Figure 11: Typical display of GMX200 on terrain mode



Figure 12: Garmin GNS430

### 1.18.2 Basic Principle of Crew Recourse Management (CRM)

The techniques that help build good CRM habit pattern on the flight deck are discussed. For example, situational awareness and communication are stressed. Situational Awareness or the ability to accurately perceive what is going on in the flight deck and outside the airplane, requires ongoing monitoring, questioning, crosschecking, communication, and refinement of perception.

It is important that all flight deck crewmembers identify and communicate any situation that appears unsafe or out of the ordinary. Experience has proven that the most effective way to maintain safety of flight and resolve these situations is to combine the skills and experience of all crewmembers in the decision making process to determine the safest course of action.

### 1.18.3 Situational Awareness

#### ***What Is SA?***

*Most simply put, SA is knowing what is going on around you. Inherent in this definition is a notion of what is important. SA is most frequently defined in operational terms. While someone not engaged in a task or objective might have awareness (e.g. sitting under a tree idly enjoying nature), this class of individuals has been largely outside the scope of human factors design efforts. Rather, we have been concerned mostly with people who need SA for specific reasons. For a given operator, therefore, SA is defined in terms of the goals and decision tasks for that job. The pilot does not need to know everything (e.g. the co-pilot's shoe size and spouse's name), but does need to know a great deal of information related to the goal of safely flying the aircraft (Endsley & Garland, Situation Awareness Analysis and Measurement, 2000).*

*A general definition of SA that has been found to be applicable across a wide variety of domains describes SA as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future"(Endsley,1988,p.97) (Endsley & Garland, Situation Awareness Analysis and Measurement, 2000)*

#### ***Long-term Memory & Working Memory Connection***

*To view SA as either a function of working memory or long-term memory would probably be erroneous. In Endsley (1990, 1995a), for instance, I showed that experienced pilots could report on relevant SA information for five to six minutes following freezes in an aircraft simulation without the memory decay that would be expected from information stored in working memory (Endsley and Garland, Situation Awareness Analysis and Measurement 2000).*

#### ***Situation Awareness, Decision Making, and Performance Disconnect***

*Good situation awareness should increase the probability of good decisions and good performance, but does not guarantee it. Conversely, poor situation awareness increases the probability of poor performance, however, in many cases does not create a serious error. For instance, being disoriented in an aircraft is more likely to lead to an accident when flying at low altitude than when flying at high altitude. Lack of situation awareness about one's opponent in a fighter aircraft may not be a problem if the opponent also lacks situation awareness. In relation to situation awareness measurement, these issues indicate that behavior and performance measures are only indirect indices of operator situation awareness (Endsley and Garland, Situation Awareness Analysis and Measurement 2000).*

### 1.18.1 Civil Aviation Safety Regulation (CASR) requirements

#### *91.119 Minimum safe altitudes: General*

*Except when necessary for takeoff or landing, no person may operate an aircraft below the following altitudes:*

- a) Anywhere. An altitude allowing, if a power unit fails, an emergency landing without undue hazard to person or property on the surface.*

*c) Over other than congested area. An altitude of 500 feet above the surface, except over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 200 meters to any person, vessel, vehicle, or structure.*

*91.153 VFR Flight Plan: Information required*

*(a) Information required. Unless otherwise authorized by ATC, each person filling a VFR flight plan shall include in it the following information:*

*(1) The aircraft identification number and, if necessary, its radio call sign.*

*(4) the point and proposed time of departure.*

*(5) The proposed route, cruising altitude (or flight level), and true airspeed at that altitude.*

*(9) Any other information the pilot in command or ATC believes is necessary for ATC purposes.*

*135.319 Terrain awareness and warning system*

*(a) No person may operate a turbine-powered airplane configured with 10 or more passenger seats, excluding any pilot seat, unless that airplane is equipped with an approved Terrain Awareness and Warning System (TAWS) that meets the requirements for Class A equipment in the FAA Technical Standard Order (TSO)–C151 or its equivalent. The airplane must also include an approved terrain situational awareness display.*

*(b) No person may operate a turbine-powered airplane configured with 6 to 9 passenger seats, excluding any pilot seat, unless that airplane is equipped with an approved Terrain Awareness and Warning System (TAWS) that meets as a minimum the requirements for Class B equipment in the FAA Technical Standard Order (TSO)–C151 or its equivalent.*

*(c) Airplane Flight Manual. The airplane Flight Manual shall contain appropriate procedures for—*

*(1) The use of the Terrain Awareness and Warning System (TAWS); and*

*(2) Proper flight crew reaction in response to the Terrain Awareness and Warning System (TAWS) audio and visual warnings.*

## **1.19 Useful or Effective Investigation Techniques**

The investigation was conducted in accordance with the KNKT approved policies and procedures, and in accordance with the standards and recommended practices of Annex 13 to the Chicago Convention.

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## 2 ANALYSIS

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The analysis of this report will discuss the relevant issues resulting in the aircraft impacted with terrain. The CVR did not record any discussion of the crew related to the aircraft system malfunction or abnormality until the end of recording.

The analysis will discuss on the following issues:

1. Impact Analysis
2. Predicted Flight Route
3. EGPWS activation
4. The Decision to fly direct to point Barru

### 2.1 Impact analysis

At 0637 UTC, the pilots agreed to fly direct to point BARRU. The aircraft impacted terrain and the CVR stopped recording at 0651 UTC. The CVR did not record any EGPWS aural warning.

One second prior to impact, the CVR recorded the pilot state his intention to climb. The pilot statement might indicate that the pilot was uncertain of the terrain condition in the vicinity of the flight track. The uncertainty might be triggered by information provided on the visual chart or the displayed terrain on the Garmin GMX 200. Forward visibility may also have been affected by reported cloud in the vicinity.

Any action to avoid collision that would happen in one second would be aggressive and immediate action such as an immediate climb, turn or increase in power.

The absence of avoiding action indicates that the terrain was not visible to the pilot and there was no EGPWS terrain aural warning as recorded on the CVR. These conditions mean that the pilot was not fully aware of the terrain.

The meteorology information provided by BMKG showed that the area of the accident was covered by clouds. This was also supported by the local villager statement that the area was covered by clouds at the time of the accident.

Prior to the final impact, the aircraft hit several tree tops and resulted in a clean cut on the trees along the flight direction for approximately 100 meters on a heading of approximately 200°. These typical of clean cut were caused by a high speed impact. The cuts on the trees were level indicating that the aircraft was in straight and level flight.

The search and rescue agency did not receive any Emergency Locator Transmitter (ELT) signal after the aircraft impact this most likely due to the ELT antenna detached during the impact considering the condition of the aircraft wreckage.

## 2.2 Predicted Flight Route

The investigation predicted the flight route based on CVR data, company route and aircraft performance, with assumptions as follows:

1. Climbing speed 120 knots;
2. After takeoff the aircraft flew on runway heading for 2 Nm, thereafter flew toward Bua;
3. Cruising speed 128 knots;
4. Accident site coordinate and altitude are based on investigator handheld Global Positioning System (GPS).
5. The collapse trees on the accident site shown aircraft flight track on approximately 200°.

Based on the data and assumptions above, the predicted track calculation of the significant CVR excerpt is as follows:

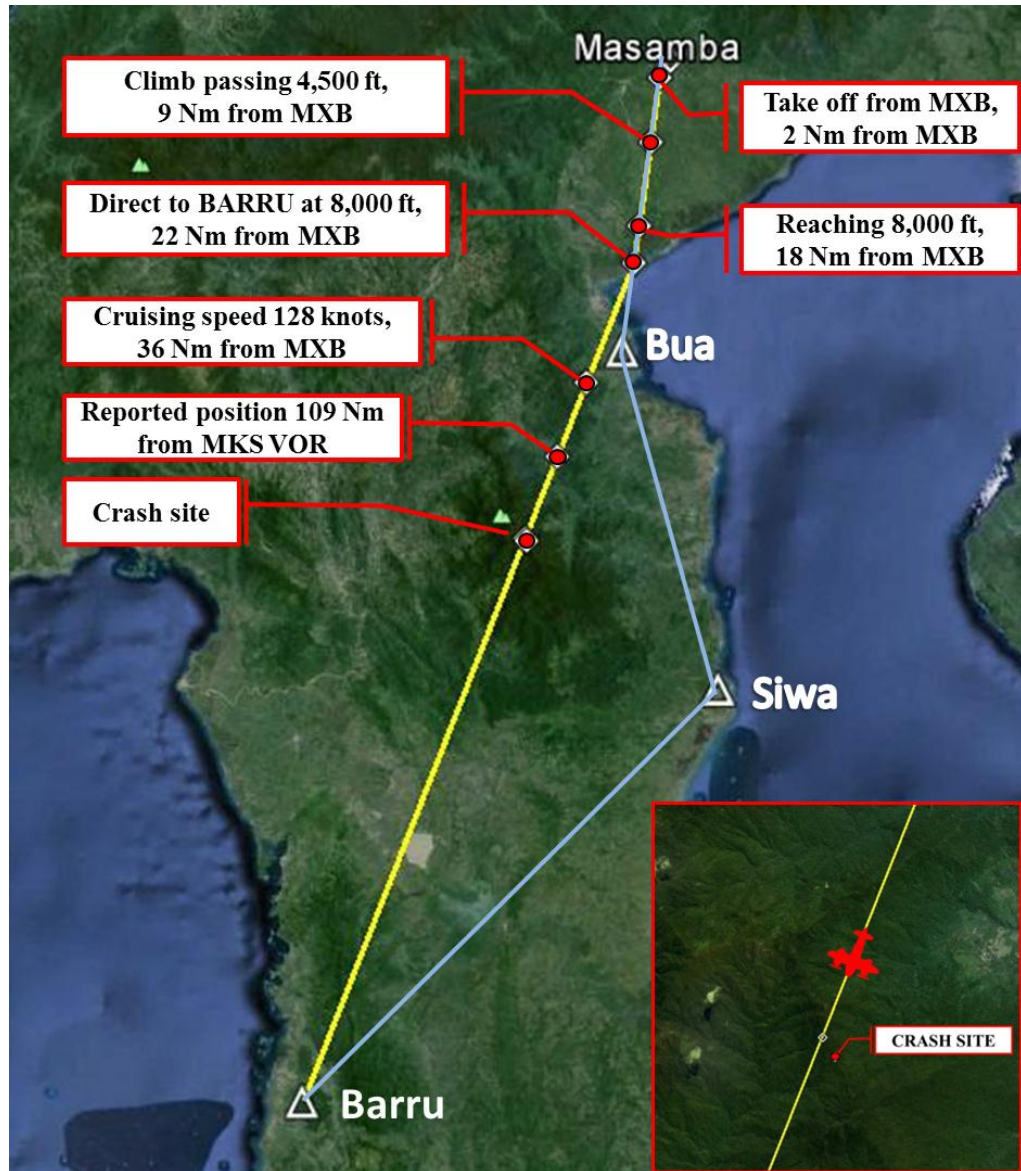
Seq.	TIME (UTC)	Time Interval (min.sec)	Estimated distance from take off	EVENTS
1	0624:16	0.0	0	The aircraft took off runway 20
2	0630:26	6.10	9 Nm	Climb passing 4,500 feet
3	0635:16	4.50	18 Nm	The aircraft reached cruising altitude of 8,000 feet
4	0637:17	1.57	22 Nm	The pilots decided to fly direct to point BARRU
5	0645:00	6.43	36 Nm	The aircraft cruising on speed 128 knots
6	0647:20	3.28	41 Nm	The aircraft position was at 109 Nm from MKS VOR
7	0651:18	3.14	48 Nm	End of recording

Based on the calculation, investigation predicted the flight track was as follows:

1. After the aircraft took off runway 20 of Masamba airport, the flight was maintained on runway heading for approximately 2 minutes, until reached altitude about 1,000 feet.
2. The flight then flew followed company VFR route toward BUA.
3. After reached cruising altitude, at about 22 Nm from Masamba, the flight was turned to direct to BARRU.

Based on the data from the CVR and the assumptions, the predicted flight path superimposed to Google Earth is as follows:





**Figure 13: Predicted flight track superimposed to Google Earth**

The predicted flight route profile shown that the aircraft flew on heading 200° toward the area with high terrain and cloud formation based on the BMKG satellite image.

### 2.3 EGPWS activation

The EGPWS has two modes that may trigger the terrain warning which was mode 2 and mode 6, which trigger callout “CAUTION TERRAIN” at 60 seconds and “TERRAIN TERRAIN PULL-UP” at 30 seconds prior to impact. The CVR did not record any terrain warning prior to impact. The CVR also did not record EGPWS altitude callouts during the previous approach to Masamba.

The EGPWS manual requires self-test to be performed prior to every flight to ensure the proper operation of the KGP 560 GA-EGPWS. The CVR did not record the EGPWS self-test completion indicated by an aural “EGPWS SYSTEM OK” prior to the flight from Masamba.



The investigation could not determine if the absence of the “EGPWS SYSTEM OK” on the CVR prior to the accident flight might be caused by a self-test was not performed or the system was not functioning properly.

The KGP 560 GA-EGPWS was equipped with an inhibit switch that deactivated all visual and aural alerts and warnings associated with the GA-EGPWS.

The investigation could not determine the reason of the absence of the EGPWS aural warning, however noted that there were no malfunctions or unserviceability reported for this equipment in the aircraft maintenance documentation.

## **2.4 The Decision to fly direct to point Barru**

At 06:37:17 UTC the aircraft was on cruising at 8000 feet, the PF suggested flying direct to point BARRU and was agreed by the PM which then explained of his experience where he flew safely on a similar direct track on a previous flight.

The operator’s visual route guidance, satellite weather image and the predicted route along the suggested route by the PM showed a mountainous area with approximate terrain heights of between 9,600 and 11,000 feet and partially covered by cloud formation approximately 25 to 30 Nm ahead from the point when the pilot decided to fly direct to Barru. In respect to the aforesaid conditions, the investigation considered the Situational Awareness and the process of the decision making to fly direct to Barru.

Situational Awareness is “the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future”. Situational Awareness is defined in terms of the goals and decision tasks for the job. The pilot needs to know a great deal of information related to the goal of safely flying the aircraft.

The good decision and performance has correlation with working and long term memory. The research to the pilots showed that the working memory related to the relevant Situational Awareness information will be stored for five to six minutes in working memory.

The pilot’s conversation recorded between 0637 UTC when they decided to fly to Barru until 0651 UTC did not indicate any discussion concerning to the environmental condition ahead. Especially on the VFR limitation and the mountain heights which were indicated as being higher than the aircraft cruising altitude. The absence of discussion in regard to the conditions ahead, meant that the pilots had not properly considered the operational implications of flying the direct route, leading to a loss of situational awareness.

The operator’s CRM training program consisted of all the subjects required, which included the Situational Awareness and Decision Making. The recurrent CRM and LOFT in real-time flight were conducted every 12 months.

In this particular decision making process, the pilot’s did not show any evidence that they were concerned of the environment conditions ahead which had more risks, and required correct flight judgment.

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## 3 CONCLUSIONS

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### 3.1 Findings

The investigation determined findings of the accident are as follows:

1. The aircraft had valid Certificate of Airworthiness prior to the accident and was operated within the weight and balance envelope.
2. Both pilots had valid licenses and medical certificates.
3. The accident flight from Masamba (WAFM) to Makassar (WAAA) was the 6<sup>th</sup> sector for the aircraft and the crew that day. The PIC acted as Pilot Flying and the SIC acted as Pilot Monitoring.
4. The satellite image published by BMKG at 0700 UTC showed that there were cloud formations at the accident area. The local villagers stated that the weather on the accident area was cloudy at the time of the accident.
5. The aircraft departed Masamba at 0625 UTC (1425 LT), conducted under VFR with cruising altitude of 8,000 feet and estimated time of arrival Makassar at 0739 UTC.
6. After reached cruising altitude, at about 22 Nm from Masamba, the flight deviated from the operator visual route and directed to BARRU on heading 200° toward the area with high terrain and cloud formation based on the BMKG satellite image
7. The pilots decision making process did not show any evidence that they were concerned to the environment conditions ahead which had more risks and required correct flight judgment.
8. The CVR did not record EGPWS aural caution and warning prior to the impact. The investigation could not determine the reason of the absence of the EGPWS.
9. The CVR data and cut on the trees indicated that the aircraft was on straight and level flight and there was no indication of avoid action by climb or turn.
10. The SAR Agency did not receive any crashed signal from the aircraft ELT most likely due to the ELT antenna detached during the impact.
11. Regarding to the operation of the EGPWS for the flight crew, a special briefing was performed however there was no special training.
12. The operational test of TAWS system was not included in the pilot checklist.
13. The investigation could not determine the installation and the last revision of TAWS terrain database.
14. The investigation could not find the functional test result document after the installation of the TAWS.
15. Some of the DHC-6 pilots have not been briefed for the operation of the TAWS and EGPWS.

### **3.2 Contributing Factors<sup>6</sup>**

Deviation from the company visual route without properly considering the elevated risks of cruising altitude lower than the highest terrain and instrument meteorological condition in addition with the absence of the EGPWS warning resulted in the omission of avoidance actions.

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<sup>6</sup> “Contributing Factors” are those events in which alone, or in combination with others, resulted in injury or damage. This can be an act, omission, conditions, or circumstances if eliminated or avoided would have prevented the occurrence or would have mitigated the resulting injuries or damages.

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## **4 SAFETY ACTION**

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At the time of issuing this draft final report, the KNKT had been informed several safety actions taken by the air operator resulting from this occurrence. The safety actions were as follows:

1. Publishing alert safety notice to emphasize several aspects for pilots as follows:
  - To maintain flight track as describes on the flight plan;
  - To maintain visual condition when flying on mountainous area even when believe able to fly on safe altitude;
2. Completing the Makassar base station with HF radio as flight following facility.
3. Revision of the “Line Pilot Check Procedure” to include complete instructor comment.
4. Briefing to all DHC-6-300 pilots which include enforcement of the implementation of company Route Guidance, VFR flight rules, and TAWS compliance.
5. Performed an alternative ground test for the installed EGPWS on DHC-6 fleet to ensure the system functioning properly.

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## **5 SAFETY RECOMMENDATIONS**

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The Directorate General Civil Aviation is responsible to ensure the implementation of recommendation addressed to the operator.

The KNKT issues the following safety recommendations to address safety issues identified during the investigation to:

### **5.1 PT. Aviastar Mandiri**

- **04.O-2016-64.1**

To evaluate the effectiveness of the CRM training and ensuring the correct pilot implementation.

- **04.O-2016-65.1**

To ensure all pilots are appropriately trained on the operation and testing of the EGPWS/TAWS systems.

- **04.O-2016-66.1**

To ensure EGPWS/TAWS operational test procedure is incorporated into the Operator's Standard Operating Procedures (SOP) and pre-flight checklists.

### **5.2 Directorate General of Civil Aviation**

- **04.R-2016-67.1**

To emphasize the continuity of oversight program to ensure the installed EGPWS/TAWS functioning properly.

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## **6 REFERENCES**

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Endsley, Mica R., and Daniel J. Garland. n.d. *Situation Awareness Analysis and Measurement*. Mahwah, New Jersey: Lawrence Erlbaum Associates, 2000.

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