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NATIONAL TRANSPORTATION SAFETY COMMITTEE

Aircraft Accident Investigation Report

PT. Aviastar Mandiri
PK – BRD
British Aerospace BAe 146-300
Wamena Airport, Papua
Republic of Indonesia

9 April 2009

NATIONAL TRANSPORTATION SAFETY COMMITTEE
MINISTRY OF TRANSPORTATION
REPUBLIC OF INDONESIA
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This Preliminary Factual Report was produced by the National Transportation Safety Committee (NTSC), Karya Building 7th Floor Ministry of Transportation, Jalan Medan Merdeka Barat No. 8 JKT 10110, Indonesia.

The report is based upon the investigation carried out by the NTSC in accordance with Annex 13 to the Convention on International Civil Aviation, Aviation Act (UU No.1/2009), and Government Regulation (PP No. 3/2001).

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GLOSSARY OF ABBREVIATIONS

AD	Airworthiness Directive
AFM	Airplane Flight Manual
AGL	Above Ground Level
ALAR	Approach-and-landing Accident Reduction
AMSL	Above Mean Sea Level
AOC	Air Operator Certificate
ATC	Air Traffic Control
ATPL	Air Transport Pilot License
ATS	Air Traffic Service
ATSB	Australian Transport Safety Bureau
Avsec	Aviation Security
BMG	Badan Meterologi dan Geofisika
BOM	Basic Operation Manual
°C	Degrees Celsius
CAMP	Continuous Airworthiness Maintenance Program
CASO	Civil Aviation Safety Officer
CASR	Civil Aviation Safety Regulation
CPL	Commercial Pilot License
COM	Company Operation Manual
CRM	Cockpit Recourses Management
CSN	Cycles Since New
CVR	Cockpit Voice Recorder
DFDAU	Digital Flight Data Acquisition Unit
DGCA	Directorate General of Civil Aviation
DME	Distance Measuring Equipment
EEPROM	Electrically Erasable Programmable Read Only Memory
EFIS	Electronic Flight Instrument System
EGT	Exhaust Gas Temperature
EIS	Engine Indicating System
FL	Flight Level
F/O	First officer or Copilot
FDR	Flight Data Recorder
FOQA	Flight Operation Quality Assurance
GPWS	Ground Proximity Warning System
hPa	Hectopascals
ICAO	International Civil Aviation Organization

IFR	Instrument Flight Rules
IIC	Investigator in Charge
ILS	Instrument Landing System
Kg	Kilogram(s)
Km	Kilometer(s)
Kt	Knots (NM/hour)
Mm	Millimeter(s)
MTOW	Maximum Take-off Weight
NM	Nautical mile(s)
KNKT / NTSC	Komite Nasional Keselamatan Transportasi / National Transportation Safety Committee
PIC	Pilot in Command
QFE	Height above aerodrome elevation (or runway threshold elevation) based on local station pressure
QNH	Altitude above mean sea level based on local station pressure
RESA	Runway End Safety Area
RPM	Revolution Per Minute
SCT	Scattered
S/N	Serial Number
SSCVR	Solid State Cockpit Voice Recorder
SSFDR	Solid State Flight Data Recorder
TS/RA	Thunderstorm and rain
TAF	Terminal Aerodrome Forecast
TSN	Time Since New
TT/TD	Ambient Temperature/Dew Point
TTIS	Total Time in Service
UTC	Coordinated Universal Time
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

SYNOPSIS

On the morning of 9 April 2009, a British Aerospace BAe 146-300 aircraft, registered PK-BRD, was being operated by PT. Aviastar Mandiri Airlines as a scheduled passenger and cargo flight from Sentani Airport to Wamena Airport, Papua. The crew consisted of two pilots, two flight attendants, an engineer, and a load master.

The aircraft performed a go-around from the initial landing approach on runway 15 at Wamena. The flight crew positioned the aircraft on a right downwind leg for another landing approach. As the aircraft was turned towards the final approach for the second landing approach at Wamena it impacted terrain and was destroyed. All of the occupants were fatally injured.

The Enhanced Ground Proximity Warning System (EGPWS) manufacturer performed simulations using data from the flight recorders, and two separate terrain data sources. The manufacturer informed the investigation that "the GPWS/EGPWS alerts recorded in the CVR were issued as designed". However the enhanced *Look-Ahead* function appeared to have been inhibited following the go around. There was no evidence from the CVR that the crew had deliberately inhibited the terrain function of the EGPWS. The investigation determined that the EGPWS issued appropriate warnings to the flight crew, in the GPWS mode.

The pilot in command did not take appropriate remedial action in response to repeated EGPWS warnings. The investigation concluded that flight crew's lack of awareness of the aircraft's proximity with terrain, together with non conformance to the operator's published operating procedures, resulted in the aircraft's impact with terrain.

As a consequence of this accident, the operator took safety action to address deficiencies in its documentation for missed approach procedures at Wamena.

As a result of this accident, the National Transportation Safety Committee (NTSC) also issued safety recommendations to the operator and to the Directorate General Civil Aviation (DGCA) to ensure that relevant documented safety procedures are implemented.

During the investigation, safety issues were identified concerning modification of aircraft and DGCA approval of those modifications. While those safety issues did not contribute to the accident, they nevertheless are safety deficiencies. Accordingly, the NTSC report includes recommendations to address those identified safety issues.

1 FACTUAL DATA

1.1 HISTORY OF THE FLIGHT

On the morning of 9 April 2009, a British Aerospace BAe 146-300 aircraft, registered PK-BRD, was being operated by PT. Aviastar Mandiri Airlines on a scheduled passenger and cargo flight from Sentani Airport to Wamena Airport, Papua. The crew consisted of two pilots, two flight attendants, an engineer, and a load master. The pilot in command (PIC) was the handling pilot and the copilot was the support/monitoring pilot.

The aircraft was being operated under the instrument flight rules (IFR)[1] for the sector from Sentani, and a visual[2] descent, approach and landing at Wamena, because there was no published instrument approach procedure at Wamena.

There was low cloud on the final approach track to runway 15 at Wamena. The aircraft was observed conducting a go around from a low height over the runway. It then climbed to a low height along the extended centreline to the south east, before making a right turn onto a low right downwind leg of the circuit.

Witnesses observed the aircraft continuing on the right downwind, however they did not sight the aircraft on the downwind leg. The flight data recorder (FDR) indicated that the aircraft was flown at a height that was lower than the normally expected. The aircraft made a right turn, onto a right base leg and flew through the extended centreline.

During the manoeuvre for the second landing approach, the aircraft impacted Pikei Hill[3] on Tengah Mountain, 3.55 NM to the north west of Wamena Airport at 0743 local time, (2243 Coordinated Universal Time (UTC[4])). The aircraft was destroyed and the occupants were fatally injured.

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[1] IFR: Rules applied when flying in cloud or whenever external cues/references are not available

[2] VFR: Flight with visual reference to external cues; remaining clear of cloud. Visual meteorological conditions are expressed in terms of visibility, distance from cloud, and ceiling, equal to or better than specified minima.

[3] 04˚ 02’ 17.69” S and 138˚ 56’ 46.76” E; 355 degrees from the Aerodrome Reference Point

[4] The 24-hour clock in Coordinated Universal Time (UTC) is used in this report to describe the local time as specific events occurred. Local time in the area of the accident, Eastern Indonesia Standard Time (Waktu Indonesia Timur (WIT)) is UTC +9 hours.

Figure 1: PK-BRD initial impact location

1.2 INJURIES TO PERSONS

Table 1: Injuries to persons

Injuries	Flight crew	Passengers	Total in Aircraft	Others
Fatal	6	-	6	-
Serious	-	-	-	-
Minor	-	-	-	Not applicable
Nil Injuries	-	-	-	Not applicable
TOTAL	6	-	6	-

All the aircraft occupants were Indonesian citizens.

1.3 DAMAGE TO AIRCRAFT

The aircraft was destroyed.

1.4 OTHER DAMAGE

There was no other damage to property and/or the environment.

1.5 PERSONNEL INFORMATION

1.5.1 Pilot in Command (PIC)

Age	: 56 years
Gender	: Male
Type of licence	: Airline Transport Pilot License
Valid to	: 31 August 2009
Rating	: BAe 146
Total flying time	: 8,305 hours 28 minutes
Total on this type	: 958 hours 9 minutes
Total last 90 days	: 186 hours 34 minutes
Total on type last 90 days	: 186 hours 34 minutes
Total on type last 7 days	: Not provided
Total on the type last 24 hours	: Estimated 40 minutes
Last proficiency check	: 13 February 2009
Medical class	: Class one
Last medical examination	: 5 January 2009
Valid to	: 31 July 2009
Medical limitation	: Must wear corrective lenses

The investigation was unable to determine if the PIC was wearing the corrective lenses at the time of the accident.

There was no evidence that the PIC had received simulator training in the operation and use of EGPWS in the BAe 146 aircraft.

1.5.2 Copilot

Age	: 49 years
Gender	: Male
Type of licence	: Airline Transport Pilot License
Valid to	: 30 June 2009
Rating	: BAe 146
Total flying time	: 12,389 hours 27 minutes
Total on this type	: 191 hours 45 minutes
Total last 90 days	: 191 hours 45 minutes
Total on type last 90 days	: 191 hours 45 minutes
Total on type last 7 days	: Not provided
Total on the type last 24 hours	: 5 hours 30 minutes

Last proficiency check	: 10 December 2008
Medical class	: Class one
Last medical examination	: 15 December 2008
Valid to	: 30 June 2009
Medical limitation	: Must wear corrective lenses

The investigation was unable to determine if the copilot was wearing the corrective lenses at the time of the accident.

There was no evidence that the copilot had received simulator training in the operation and use of EGPWS in the BAe 146 aircraft.

1.6 AIRCRAFT INFORMATION

1.6.1 General

Aircraft manufacturer	: British Aerospace
Model	: BAe 146-300
Serial number	: E3189
Year of manufacture	: 1990
Nationality and registration mark	: Indonesia, PK-BRD
Name of the owner	: PT. Aviastar Mandiri
Name of the operator	: PT. Aviastar Mandiri
Certificate of AirworthinessIssued	: 3 January 2009
Valid to	: 4 July 2009
Certificate of Registration Issued	: 4 December 2008
Valid to	: 3 December 2011
Total flying hours since manufacture	: 22,225 hours
Total flying hours since last inspection	: 12 hours

Engine data were not relevant in this occurrence.

The aircraft engines used aviation turbine-engine fuel. There was no evidence of any engine malfunctions that would have required fuel testing as part of the investigation.

The investigation determined that the aircraft had no recorded defects before the accident.

1.6.2 Aircraft configuration

The aircraft was originally manufactured and certified as a passenger aircraft. During September 2008, the operator modified the aircraft to a combined passenger and cargo configuration.

The modification was designed and carried out by the operator's maintenance organization under Aviastar Engineering Order No. AVIA-D/BAE 146-300-00, and approved by the Directorate General of Civil Aviation (DGCA).

During the investigation it was determined that the aircraft manufacturer had not issued a manufacturer-approved modification for a combined passenger and cargo version of the aircraft type.

The investigation was therefore unable to determine whether the operator's *ALTERATION DESCRIPTION & DESIGN DATA* document, AVIA-D/BAE 146-300-00, affected the following matters:

- Type Certificate Data
- Continuous Airworthiness Maintenance Program
- Aircraft Loading Manual
- Weight and Balance Manifest Chart for the combined passenger and cargo aircraft configuration
- Fire detection and suppression system Class D
- Passenger safety with cargo carried aft of the passengers in the aircraft cabin
- Passenger safety with dangerous goods carried as cargo in the aircraft cabin.

The investigation also found that there were two versions of the *ALTERATION DESCRIPTION & DESIGN DATA* document, AVIA-D/BAE 146-300-00 in use by the operator. Those versions contained different combined passenger and cargo load configurations for the aircraft.

The aircraft was in the 42-passenger and cargo configuration. However, the weight and CofG boundary chart[5] used for the accident flight was the chart for the aircraft in a 110-passenger configuration. That was therefore the incorrect chart for calculation of the actual CofG for the accident flight.

The investigation found that the approved document did not have a weight and balance Trim Sheet. Furthermore, Appendix 4 Weight and Balance Evaluation, contained a section on CONFIGURATION OF LOADING. That section listed the design weights before and after modification.

[5] The C of G boundary chart may also be referred to as the C of G 'envelope'.

Accordingly the design weights differed, as follows:

Weights	***BeforeMod.***	***Post-mod***
Maximum design ramp weight	44,452 kg	43,132 kg
Maximum design take-off weight	44,255 kg	42,935 kg
Maximum design landing weight	38,328 kg	37,008 kg
Maximum design zero fuel weight	35,606 kg	34,286 kg

Because there was no Weight and Balance and Trim Sheet for the modified aircraft, the operator was using the incorrect version of the weight and balance sheet for the accident flight.

1.6.3 Enhanced Ground Proximity Warning System

The aircraft was equipped with an enhanced ground proximity warning system (EGPWS).

Manufacturer : Honeywell

Part number : 965-1076-020-217-217(as supplied by the operator)

Serial number : 331

The EGPWS was designed to provide *Look-Ahead* warnings.[6]

The EGPWS provided warnings during the first landing approach and subsequent go around, right circuit and attempted second approach. However, from the time of the go around to the impact with terrain the EGPWS voice aural alert 'WHOOP WHOOP, PULL UP' did not sound.

1.6.4 Flight Crew Operations Manual and EGPWS Terrain System

The BAe Flight Crew Operations Manual (FCOM)[7], Volume 3 Part 1, Page 5 states:

> The terrain EGPWS features are inhibited by pressing the TERR SYST switch on the right instrument panel.

It also states:

> If there is no source of aircraft position data meeting the accuracy required for the enhanced functions of the EGPWS, then the enhanced functions are automatically inhibited... When the terrain system is inhibited and the EGPWS is otherwise serviceable, the EGPWS reverts to providing basic GPWS functions. In this state, the EGPWS gives little or no advance warning of flight into precipitous

[6] See Appendix B.

[7] See Appendix A to this report for a copy of the applicable section of the FCOM.

> terrain where there are few or no preceding obstructions. This particularly applies if the aircraft is in the landing configuration...

There was no FCOM procedure detailing when it was appropriate to use the TERR SYST switch to inhibit the terrain features of the EGPWS.

1.6.5 Terrain database

The EGPWS manufacturer informed the investigation that their database group made a comparison of the Digital Chart of the World terrain data and the Shuttle Radar Terrain (SRTM) data. The review found large differences and led to an update in the Terrain Database 455, based on the SRTM data. On 18 September 2009, the manufacturer issued a Service Information Letter titled *Terrain Database 455 and Envelope Modulation Database B07 for Mk V Enhanced Ground Proximity Warning System (EGPWS), PN 965-0779-00X, PN 965-0976-0XX-XXX-XXX, PN 965-1676-00X, and PN 965-1690-05X.*

However, the manufacturer informed the investigation that the revision was not relevant to the aspect of Enhanced alerts, and confirmed that the EGPWS operated as designed.[8]

1.6.6 EGPWS manufacturer's simulation from recorded data

The EGPWS manufacturer developed a simulation using the EGPWS data, to examine the operation of the EGPWS. The Flight Data Recorder (FDR) data used for the simulation included a table of data with a time stamped listing of EGPWS warnings for the approach to runway 15 at Wamena, the go around, and the right circuit to the point of impact with terrain.

The information used to develop the simulation included the following relevant FDR data: heading; airspeed; pitch and roll attitude; uncorrected altitude; radio altitude; temperature; landing gear position; flap position/angle; time before impact; and time stamped EGPWS warnings. The EGPWS manufacturer also used the following information: coordinates of the accident site; a list of aural warnings taken from the cockpit voice recorder, with no time stamp; as well as data derived from the FDR data including QNH, Altitude, true airspeed, groundspeed, and track.

The simulations extending back along the aircraft's track from the accident site, using the FDR data, were correlated with the chronological listing of the CVR recorded EGPWS warnings. The actual timing had very slight variations due to the limitations of the data.

[8] See Section 2 of this report.

Additional simulations were performed in the manufacturer's laboratory using an EGPWS of the same make/model as the unit from the accident aircraft. Separate simulations were made using different databases; Digital Chart of the World terrain data, and the Shuttle Radar Terrain (SRTM) data.

1.6.7 Corrected altitude calculations

The recorded data from the flight data recorder provided altitude as pressure altitude, which has a range of -2,900 feet to +20,900 feet. The overall accuracy of this parameter is about +/-150 feet at about 5,000 feet pressure altitude. The aerodrome QNH of 1010.3 hPa was used to calculate the corrected altitude. That correction put the aerodrome altitude closer to the Aerodrome Reference Point elevation of 5,084 feet as promulgated in the Aeronautical Information Publication at the time of the accident. The corrected altitude of the last recorded data (time of impact) was 5,560 feet. Terrain data charts, including Google Earth, and the latest Directorate General of Civil Aviation survey data, list the Aerodrome Reference Point as 5,430 feet.

1.6.8 Defects

The maintenance documents revealed no evidence of mechanical defects that could have contributed to the accident.

1.6.9 Weight and Balance

Maximum take -off weight at Sentani	: 42,935 kg[9]
Actual take-off weight at Sentani	: 39,789 kg
Maximum landing weight at Wamena	: 37,008 kg[10]
Planned landing weight at Wamena	: 38,319 kg

The aircraft was not being operated within the maximum weight limitations for the DGCA-approved passenger and cargo configuration modification.

1.7 METEOROLOGICAL INFORMATION

The Wamena Airport meteorological report for takeoff and landing issued at 2200 indicated that the wind was calm, visibility was 8 km. There was haze and broken cloud; base 300 meters, temperature was 17 degrees C, and the QNH 1010 hPa.

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[9] Refer Section 1.6.2.

[10] Refer Section 1.6.2

The meteorological report for takeoff and landing issued at 2300 (26 minutes after the accident) indicated that the wind was calm, visibility was 9 km. There was haze and broken cloud; base 300 meters. Temperature was 18 degrees C and the QNH 1010.3 hPa.

Figure 2: View of weather taken from the Wamena Airport shortly after the accident

1.8 AIDS TO NAVIGATION

Not relevant to this accident.

1.9 COMMUNICATIONS

The crew had no difficulty communicating with the Wamena Advisory Flight Information Service during the flight.

1.10 AERODROME INFORMATION

Airport Name	:	Wamena
Airport Identification	:	WAJW
Aerodrome Reference Point	:	04°05' 51" S, 138°57' 04 E
Elevation	:	5,084 feet as promulgated at the time of the accident. (Amended by NOTAM on 1 December 2009 to 5,430 feet.)[11]

[11] See section 4, of this report titled *Safety Action*.

Airport Operator	:	Directorate General Civil Aviation
Runway Direction	:	15/33
Runway Length	:	1,650 meters
Runway Width	:	30 meters
Surface	:	Asphalt

1.11 FLIGHT RECORDERS

The flight recorders were recovered from the aircraft on 10 April 2009 under the supervision of NTSC investigators. The recorders were sent to the Australian Transport Safety Bureau in Canberra on 14 April 2009 for replay and analysis.

1.11.1 Digital Flight Data Recorder (DFDR)

Manufacturer : The Plessey Company

Type/Model : PV 1584 MI

Part Number : 650/1/14040/112

Serial Number : 10081

Figure 3: Data plate on Flight Data Recorder from PK-BRD

The FDR tape was not spooled correctly, presumably since previous maintenance on the recorder. However, good quality data was recovered.

1.11.2 Cockpit Voice Recorder (CVR)

Manufacturer : L3 Communications

Type/Model : Fairchild FA2100

Part Number : 2100-1020-02

Serial Number : 000265885

Figure 4: Data plate on Cockpit Voice Recorder from PK-BRD

The CVR contained good quality data that was transcribed and synchronised with the FDR recorded data.

1.11.3 Notable facts from the FDR and CVR

The cockpit voice recorder (CVR) contained good quality data that was transcribed and synchronised with the flight data recorder (FDR) recorded data.

The data revealed that the EGPWS operated normally, and provided the appropriate alerts and warnings[12].

During the first landing approach, another Aviastar pilot in an aircraft on the ground at Wamena preparing for takeoff, advised the crew of PK-BRD, "*kalo pake one five di right track di final bisa insight" [if you use one five, you should fly off track to the right of the final approach to get the runway insight]*.

[12] Refer Appendix A for the alerts and warnings generated by the EGPWS fitted to the aircraft.

The FDR data showed that the aircraft tracked parallel to, and to the right of the extended runway 15 centreline.

During that approach, and while descending through 6,234 feet (790 feet by radio altimeter[13]), the EGPWS voice aural alert 'TERRAIN TERRAIN' sounded.

When the aircraft was passing 6,200 feet (991 feet by radio altimeter) on descent, the EGPWS voice aural alert 'WHOOP WHOOP, PULL UP' sounded. The FDR data showed that the aircraft started turning left toward runway as it was passing 5,719 feet (540 feet radio altimeter) on descent.

As the aircraft passed 5,693 feet (516 feet radio altimeter) on descent, the crew informed the controller that they had the runway in sight. The FDR data showed that the aircraft then turned left to intercept the final approach track. During their attempt to intercept the final approach track, while passing 5,531 feet (320 feet radio altimeter) the PIC commented to the copilot "*wah nembak lagi*" *[we are overshooting again]*.

During the interception towards the runway an EGPWS voice aural alert 'SINK RATE', sounded. This was immediately followed by the voice aural alert 'WHOOP WHOOP, PULL UP' sounding five times. The CVR indicated that the copilot instructed the PIC "*overshoot, overshoot"* after the second of the five 'WHOOP WHOOP, PULL UP' sounds. The FDR showed that the aircraft commenced a go around from a low height above the runway. The controller offered the crew a choice of a landing on runway 33, but the crew elected to make a right circuit for runway 15.

The circuit was flown at a height of between 150 and 350 feet above the aerodrome elevation.

The CVR provided evidence that during the downwind leg the EGPWS fitted to the aircraft provided the flight crew with eight 'DON'T SINK' and one 'TOO LOW TERRAIN' voice aural alerts. The flight crew did not respond to any of those alerts.

As the aircraft passed abeam the threshold of runway 15, the landing gear was lowered for the second landing approach.

During the right base turn the aircraft was initially flown at a constant 30 degree angle of right bank.

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[13] Radio altimeter – Instrument giving a readout of height above ground level by time varying frequency and measuring the difference in frequency of received waves, this being proportional to time and hence to height. (Cambridge Aerospace Dictionary).

About 100 degrees from runway heading, the copilot said *"OK, sungai ketok" [OK river in sight]*. Four seconds later, when about 85 degrees from runway heading the copilot said *"Pike clear" [Pike Hill visible]*.

As the aircraft's heading passed 65 degrees from the runway heading, the copilot called *"be careful pak" [be careful sir]*. A third person in the cockpit commented *"di kiri ada bukit" [there is a hill on the left]*.

This was immediately followed, as the aircraft banked through 41 degrees right, by the copilot calling out with increasing concern, *"pak, pak, pak, open pak, kiri, kiri" [sir, sir, sir, open, sir, left, left]*.

The engine power was rapidly increased immediately after the copilot called *"open pak" [open sir]*. The FDR showed that the power settings rapidly increased to 92% on engines 2 and 4, and 87% on engines 1 and 3.

The copilot commanded *"kiri pak"[left sir]* as the PIC rolled the aircraft into a left bank and the EGPWS voice aural alert 'DON'T SINK, DON'T SINK' sounded.

As the bank angle exceeded 40 degrees, it entered a 10-degree nose-down pitch attitude. The copilot warned the PIC *"don't sink"*. The PIC immediately responded *"ya, ya"*. Three seconds later the copilot said *"left turn"*. The EGPWS then sounded the following voice aural alerts in rapid succession: 'TOO LOW – TERRAIN', 'BANK ANGLE - BANK ANGLE', 'TERRAIN – TERRAIN'. At the same time as the EGPWS sounded the 'TERRAIN – TERRAIN' warning, the copilot called with high intonation *"pak, pak, pak" [sir, sir, sir]*.

The nose-down pitch attitude reached 6 degrees when the aircraft reached 49 degrees left bank. As the aircraft reached 49 degrees left bank, landing gear retraction commenced. The EGPWS voice aural alert then sounded TERRAIN, and one second later the copilot called *"pak" [sir]*.

At the point of impact with the terrain, the landing gear was half way through the retraction cycle, the left bank was 16 degrees, and the aircraft pitch was 12 degrees nose up. The indicated airspeed at impact was 146 knots.

1.12 WRECKAGE AND IMPACT INFORMATION

The impact site was located 3.55 NM to the north west of Wamena Airport. The aircraft was destroyed by the impact forces and the post-impact fuel-fed fire. The wreckage was distributed in the general direction of the last recorded heading of the aircraft prior to its impact with terrain.

The components of the EGPWS fitted to the aircraft were not recovered from the wreckage.

Figure 5: Empennage section of PK-BRD

Figure 6: Cockpit section of PK-BRD

1.13 MEDICAL AND PATHOLOGICAL INFORMATION

No medical or pathological investigations were conducted.

1.14 FIRE

There was no pre-impact fire. A post-impact fuel-fed fire consumed the wing and centre fuselage. The accident site was remote from the airport, and no rescue fire fighting services attended the accident site.

1.15 SURVIVAL ASPECTS

The accident was not survivable.

1.16 TESTS AND RESEARCH

None required.

1.17 ORGANIZATIONAL AND MANAGEMENT INFORMATION

1.17.1 P.T Aviastar Mandiri Airlines

Aircraft Owner : PT. Aviastar Mandiri Airlines

Aircraft Operator : P.T Aviastar Mandiri Airlines
Puri Sentra Niaga Blok B no.29, Kalimalang,
Jakarta 13620, Indonesia

Aircraft Operator Certificate number: AOC/135-029

1.17.2 The Operator's BAe-146 Flight Crew Operating Manual

The operator's BAe-146 Flight Crew Operating Manual contained information about the operating procedures of the EGPWS fitted to the aircraft. The procedures included information on visual and aural alert warnings, and cautions generated by the EGPWS.[14]

[14] Refer to Appendix A for detailed information on the operation of the EGPWS.

1.17.3 The Operator's Company Operation Manual

The operator's Company Operation Manual (COM) contained instructions about flight crew responsibilities during a visual approach, as follows:

Visual Approach

A visual approach is an approach by an IFR flight when all or part of an instrument approach procedure is not completed and the approach is executed in visual reference to terrain.

PiC may request to make a ***"VISUAL APPROACH"*** *when:*

- *The pilot has the runway in sight and can maintain visual reference to terrain; and*

- *Visual Approach*

- *A visual approach is an approach by an IFR flight when all or part of an instrument approach procedure is not completed and the approach is executed in visual reference to terrain.*

PiC may request to make a "VISUAL APPROACH" when:

- *The pilot has the runway in sight and can maintain visual reference to terrain; and*

- *The reported ceiling is not below the approved initial approach level; or*

- *He/she reports at the initial approach level or at any time during the instrument approach and he/she has reasonable assurance that the landing can be accomplished.*

The PiC shall not cancel his/her IFR flight plan to make a visual approach and separation therefore shall be provided between the aircraft cleared for a visual approach and other arriving and departing aircraft.

The visual approach procedure may save some flying time but also introduces the risk of an undershooting or landing at wrong airport.

Moreover, it may create terrain clearance hazards if continuous good visibility is not assured.

Therefore, if choice of runways is available, preference should be given to a runway equipped with glide slope guidance, with due regard to other operational factors.

Experience has shown that full use of available aids is the most effective means to prevent an undershooting or a landing on the wrong runway or airport.

When a visual approach is made, and particularly when over dark terrain at night, special emphasis must be placed on the familiarity with terrain, elevation and obstruction data from the approach chart.

A descent below minimum sector altitude shall not be made until both pilots are certain of the aircraft's position and the safety of this descent. Moreover, ample terrain and obstacle clearance must be maintained until final descent it started.

The PiC must prepare for an overshoot from any point of the visual approach.

The COM also contained the instructions of crew coordination during approach and landing as follows:

Careful planning of the approach and close cooperation between flight crews are necessary to achieve a safe approach and landing. The techniques and procedures to be used shall be discussed in advance, in order to avoid errors and misunderstandings.

Both pilots shall therefore familiarize themselves thoroughly with the relevant data such as descent altitude restrictions, weather conditions, aircraft serviceability, ground facilities holding and approach procedures runway data, missed approach procedures etc.

The crew briefing should be completed well in advance of terminal area penetration and be updated if changing circumstances so require.

Normally the PF, monitors the aircraft configuration, flight path and airspeed control, and gives the necessary commands (e.g. checklist, flaps, etc).

The PNF monitors the approach, keeps lookout, executes the allocated system operation on command of the PF and confirms its execution, does the radio communication and checks for visual reference.

The PNF therefore, shall be fully familiar with the intentions of the PF, and shall have facts and figures ready when needed. The use of facilities shall be planned beforehand, and on passing one facility, the PNF shall inform the PF and be ready to retune to the next facility immediately.

During the descent phase, at altitudes below approximately 10000 feet, and during taxi, all flight crewmembers shall concentrate on cockpit procedures, cockpit monitoring and lookout, and refrain from non-essential matters.

The COM also contained the instructions of crew response to EGPWS alerts and cautions, which included:

> Every alert should be considered valid and requires appropriate action.
>
> Pilot reactions to alerts and warnings differ according to weather conditions, visibility, and type of warning, phase of flight and aircraft performance considerations. Pilot should be thoroughly familiar with FAA, company, or other approved operational procedures as required by their aircraft and type of operation.

AURAL ALERT OR WARNING	Required response
'DON'T SINK'	• Immediately level wings, apply full power, and establish a climb attitude
'PULL UP'	• Disengage autopilot/immediately level wings. • Apply full power, establish a climb attitude. • Continue manoeuvre until alert ceases or terrain clearance is assured.
'SINK RATE'	• Arrest sink rate and fly out of the alert area.
'TERRAIN, TERRAIN	• Apply power, level wings, and establish a climb attitude.
'TOO LOW TERRAIN'	• Immediately arrest sink rate and fly out of the alert area.

There was no COM procedure detailing when it was appropriate to use the TERR SYST switch[15] to inhibit the terrain features of the EGPWS.

The operator informed the investigation that while there was no procedure, it was practice to activate the TERR SYST inhibit switch when flying visually, if repeated terrain warnings became a distraction.

1.17.4 The Operator's BAe-146 Flight Simulator Training Program

The operator's BAe-146 Flight Simulator Training Program for the flight crew did not cover training and checking of pilot actions and responses to the EGPWS aural alerts and warnings.

1.17.5 The Operator's Company Training Manual

The operator's Company Training Manual (CTM) contained the ground training curriculum for flight crews.

[15] Refer Section 1.6.4

The curriculum included the description of basic ground proximity warning systems (GPWS), but did not include detailed information about EGPWS fitted to the BAe-146 procedures.

The investigation found no evidence that either of the flight crew members had received the GPWS training specified in the CTM.

1.18 ADDITIONAL INFORMATION

There was no additional information required.

1.19 USEFUL OR EFFECTIVE INVESTIGATION TECHNIQUES

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

2 ANALYSIS

2.1 INTRODUCTION

At the time of the accident, it was reported that the final approach to runway 15 at Wamena was obscured by low cloud. The aircraft's first landing approach to Wamena was discontinued because the flight crew did not get the aircraft established on the final approach until too late, and a safe landing could not be accomplished.

The flight crew elected to go around for another attempt to land on runway 15. The right circuit was flown at a height of between 150 and 350 feet above the aerodrome elevation.

The cockpit voice recorder (CVR) provided evidence that during the downwind leg of the right circuit, the EGPWS fitted to the aircraft provided the flight crew with eight 'DON'T SINK' and one 'TOO LOW TERRAIN' voice aural alerts. The flight crew did not respond to any of those alerts.

The CVR also provided evidence that during the right base-leg turn, the EGPWS provided the flight crew with four 'DON'T SINK', two 'TOO LOW TERRAIN', two 'BANK ANGLE', and one 'TERRAIN TERRAIN' voice aural alerts. The flight crew did not respond to any of those alerts.[16]

Following the go around the EGPWS voice aural alert 'WHOOP WHOOP, PULL UP' did not sound.

During the right base-leg turn, it was evident that copilot was becoming increasingly concerned about the way the pilot in command (PIC) was handling the aircraft.

The CVR provided evidence that the copilot expressed those concerns with increasing levels of anxiety.

Another person in the cockpit also expressed concern about high terrain to the left of the aircraft. The investigation was unable to determine if either of the flight crew heard that person's expression of concern.

As the base leg turn continued, the copilot called *"be careful pak" [be careful sir]*. The investigation was unable to determine why the copilot called *"be careful pak"*.

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[16] Refer section 1.11 above for the narrative sequence in which those alerts issued.

The bank angle to the right increased, and the copilot warned the PIC: *"pak, pak, pak, open pak, kiri, kiri" [sir, sir, sir, open, sir, left, left]*.

The copilot commanded *"kiri pak"[left sir]* and the PIC rolled the aircraft into a left bank. The EGPWS voice aural alert 'DON'T SINK, DON'T SINK' then sounded. The PIC did not respond to that EGPWS alert.

The left bank angle increased and exceeded 40 degrees. The aircraft also entered a 10-degree nose-down pitch attitude. The copilot warned the PIC *"don't sink"*. In repeating the words *"don't sink"*, the copilot was alerting the PIC to comply with the EGPWS voice aural alert 'DON'T SINK, DON'T SINK'.

The PIC immediately responded *"ya, ya"*. Three seconds later the copilot commanded *"left turn"* with urgency. The investigation determined that it was likely that the copilot's warning was because it was apparent that collision with terrain was imminent.

The EGPWS voice aural alert then sounded TOO LOW - TERRAIN, BANK ANGLE - BANK ANGLE, TERRAIN - TERRAIN. At the same instant the EGPWS sounded the TERRAIN – TERRAIN warning, the copilot called with high intonation *"pak, pak, pak" [sir, sir, sir]*. The EGPWS voice aural alert then sounded TERRAIN, and one second later the copilot called *"pak" [sir]*.

The aircraft then impacted terrain.

2.2 SIMULATION CONDUCTED BY EGPWS MANUFACTURER

The EGPWS manufacturer informed the investigation that a comparison of the Digital Chart of the World terrain data and the Shuttle Radar Terrain (SRTM) data resulted in an update to the Terrain Database 455, based on the SRTM data.

However, the manufacturer informed the investigation that the revision was not relevant to the aspect of enhanced alerts, and confirmed that the EGPWS operated as designed.

The EGPWS manufacturer performed simulations to analyze the operation of the EGPWS during the flight. One simulation used Digital Chart of the World terrain data and the other used Shuttle Radar Terrain (SRTM) data. The simulations assumed that the TERR SYST switch on the right instrument panel, which could be used to inhibit terrain EGPWS features including the *Look-Ahead* feature, was not used.

The manufacturer reported that based on the simulations, the *Look-Ahead* warning would have first sounded during the crosswind leg turn, and then more pull-up warnings would have been issued throughout the downwind leg and final turns before impact.

If there is no source of aircraft position data meeting the accuracy required for the enhanced functions of the EGPWS, then the enhanced functions are automatically inhibited. However, because both simulations provided *Look-Ahead* warnings, the terrain data from DCW and SRTM were sufficiently accurate for the enhanced functions of the EGPWS to be available. The investigation determined that there were *Look-Ahead* warnings during the first approach. However, as there appears to have been no *Look-Ahead* warnings recorded on the CVR during the right downwind leg, and the final turns before impact, the terrain inhibit switch may have been used to inhibit the warnings and reduce distractions in the cockpit. However, there was no evidence on the CVR to indicate that the crew may have deliberately inhibited the terrain system of the EGPWS.

The manufacturer reported that the simulations demonstrated that "the GPWS/EGPWS alerts recorded in the CVR were issued as designed".

Based on the FDR and CVR recorded data, and the manufacturer's analysis findings, the investigation determined that the EGPWS issued appropriate warnings to the flight crew, in the GPWS mode. However, there was no evidence that the flight crew responded appropriately to the warnings.

2.3 OPERATING PROCEDURES

The investigation noted that the Flight Crew Operating Manual (FCOM), and the Company Operating Manual (COM) instructions with respect to crew responses to terrain alerts differed. The FCOM instructions to DONT SINK alerts said, in effect, adjust the flight path as necessary. However, the COM required a more positive response.

There was insufficient evidence to enable the investigation to determine if the differing instructions may have influenced the crew's actions in response to EGPWS warnings. However, the investigation found no evidence that either of the flight crew members had received the GPWS training specified in the Company Training Manual. It is therefore unlikely that the differences between the manuals affected their decisions.

2.4 WEIGHT & BALANCE

The aircraft was configured in the passenger and cargo configuration. However, the operator was using a passenger-only weight and balance sheet for the aircraft during the accident flight.

The investigation determined that the use of the incorrect weight and balance sheet did not contribute to the development of the occurrence.

2.5 THE CONDUCT OF THE FLIGHT IN THE WAMENA CIRCUIT AREA

The flight crew coordination as the aircraft was being manoeuvred in the Wamena circuit area was less than adequate.

The Company Operations Manual (COM) specified that the crew briefing should be updated if changing circumstances so required. However, the PIC did update the briefing when the first approach was discontinued and the go-around conducted.

The PIC's disregard of the EGPWS alerts that sounded as the aircraft was being maneuvered was in non-conformance with the instructions for crew response to EGPWS alerts and cautions, as published in the (COM).

That, together with their lack of flight crew training in EGPWS, meant that they had not been properly prepared to respond in a timely and appropriate manner to the alerts and warnings provided by the EGPWS.

Had the PIC executed the appropriate responses to those EGPWS alerts it is unlikely that the impact with the terrain would have occurred.

Both flight crew members did not conform with the instructions about flight crew responsibilities during a visual approach, as published in the COM.

This resulted in the flight crew being unable to assure the safety of flight at low level while maneuvering the aircraft in a close proximity with terrain in conditions of reduced visibility.

Both flight crew members did not conform to the instructions about flight crew coordination, as also as outlined in the COM.

Had the flight crew carefully planned the second approach, and closely cooperated with each other, they may have achieved a safe approach and landing.

The flight crew's disregard of the published procedures bypassed the safety criteria and inbuilt risk treatments in the design of those procedures. That disregard directly contributed to the development of the occurrence.

3 CONCLUSIONS

3.1 FINDINGS

3.1.1 Aircraft

3.1.1.1 The aircraft had no recorded defects before the accident.

3.1.1.2 The Enhanced Ground Proximity Warning System functioned normally and provided the crew with the appropriate aural alerts.

3.1.1.3 The aircraft had a valid Certificate of Airworthiness.

3.1.1.4 The operator modified the aircraft to a combined passenger and cargo configuration that was approved by the Directorate General of Civil Aviation (DGCA).

3.1.1.5 The operator was using a passenger only weight and balance sheet for the accident flight.

3.1.1.6 The aircraft operating weights were in compliance with the Directorate General of Civil Aviation (DGCA) approved maximum design weights.

3.1.1.7 There was no evidence of any in-flight fire.

3.1.1.8 The aircraft was destroyed by the impact forces and a post-impact fuel-fed fire consumed the wing and centre fuselage.

3.2 CREW

3.2.1.1 The pilot in command (PIC) and copilot were licensed and qualified for the flight in accordance with existing Indonesian regulations.

3.2.1.2 The flight crew could not accomplish a safe landing from the first landing approach.

3.2.1.3 The copilot instructed the PIC *"overshoot, overshoot"* after the second of the five 'WHOOP WHOOP, PULL UP' sounds on late final during the first approach to runway 15.

3.2.1.4 The PIC conducted an overshoot from the first approach and made a low-level right circuit for a second approach to runway 15.

3.2.1.5 The flight crew did not respond to any of the eight 'DON'T SINK' and one 'TOO LOW TERRAIN' voice aural alerts from the EGPWS during right downwind leg.

3.2.1.6 The flight crew did not respond to any of the four ‘DON’T SINK’, two ‘TOO LOW TERRAIN’, two ‘BANK ANGLE’, and one ‘TERRAIN TERRAIN’ voice aural alerts from the EGPWS during the base leg turn.

3.2.1.7 During the base leg turn, the copilot became increasingly concerned about the way the PIC was handling the aircraft. The concerns were made with increasing levels of anxiety.

3.2.1.8 The flight crew did not respond appropriately to the repeated EGPWS warnings.

3.2.1.9 During the approach and subsequent right circuit, the flight crew’s level of conformance to the operator’s published operating procedures was not effective in preventing the aircraft from impacting terrain.

3.2.2 Flight operations

3.2.2.1 The operator’s Company Training Manual (CTM) curriculum for flight crew ground training included the description of basic ground proximity warning systems (GPWS), but did not include detailed information about EGPWS fitted to the BAe-146 procedures.

3.2.2.2 The investigation found no evidence that either of the flight crew members had received the EGPWS training specified in the CTM.

3.2.2.3 The approach and subsequent right circuit were not conducted in conformance with the published company operations procedures.

3.2.2.4 The operator’s BAe-146 Flight Simulator Training Program for the flight crew did not cover training and checking of pilot actions and responses to the EGPWS aural alerts and warnings.

3.2.2.5 There was no procedure detailing when it was appropriate to inhibit the terrain features of the EGPWS.

3.2.3 FLIGHT RECORDERS

3.2.3.1 The flight data recorder tape was not spooled correctly, presumably since previous maintenance on the recorder. However, good quality data was recovered from the FDR.

3.2.3.2 The cockpit voice recorder contained good quality data that was transcribed and synchronised with the FDR recorded data.

3.2.3.3 The GPWS/EGPWS alerts recorded in the CVR were issued as designed, but the enhanced *Look-Ahead* function appeared to have been inhibited.

3.2.3.4 The EGPWS issued appropriate warnings to the flight crew, in the GPWS mode.

3.2.4 SURVIVABILITY

3.2.4.1 The accident was not survivable due to the impact forces.

3.2.5 SAFETY OVERSIGHT

3.2.5.1 The Directorate General of Civil Aviation's approval of the combined passenger and cargo configuration change of the aircraft, did not appear to consider all appropriate matters relating to airworthiness and safety relating to that configuration change.

3.3 CAUSES

The crew did not appear to have awareness of the aircraft's proximity with terrain until impact with terrain was imminent.

The flight crew did not act on the Enhanced Ground Proximity Warning System aural warnings, and did not conform to the operator's published operating procedures.

Together, those factors resulted in the aircraft's impact with terrain.

4 SAFETY RECOMMENDATIONS

4.1 SAFETY ACTIONS

4.1.1 Missed approach procedure for runway 15 at Wamena

As a result of this occurrence, the operator issued Notice to Airmen (No. 005/OPS – NOTAM/IV/2009) on 27 April 2009 regarding the missed approach procedure for runway 15 at Wamena Airport.

The procedure now requires the operator's flight crews to climb and maintain runway heading until the aircraft has climbed through 5,500 ft, then to immediately turn right to join the right downwind leg for runway 15 at 7,500 ft to intercept the 304 bearing from the Wamena non-directional beacon (NDB) radio navigation aid. Once established on the 304 bearing, flight crews are required continue climb to 13,000 ft, then to proceed to the PYRAMID navigation fix.

4.1.2 Revised aerodrome reference point data

On 1 December 2009, the Directorate General of Civil Aviation issued LOCAL NOTAM WRRR-C1310/09, which detailed amended the elevation for the Wamena (WAJW) Aerodrome Reference Point. The NOTAM specified the elevation as 5,430 feet.

4.2 RECOMMENDATIONS

As a result of the investigation into this accident, the National Transportation Safety Committee made the following recommendations.

4.2.1 PT. Aviastar Mandiri

The National Transportation Safety Committee recommends that PT. Aviastar Mandiri should ensure that its documented flight crew training procedures include specific training modules for crew response to all warnings and alerts generated from ground proximity warning systems and enhanced ground proximity warning systems fitted to aircraft that it operates.

4.2.2 PT. Aviastar Mandiri

The National Transportation Safety Committee recommends that PT. Aviastar Mandiri should ensure that its documented flight crew coordination procedures are effectively implemented.

4.2.3 Directorate General of Civil Aviation

The National Transportation Safety Committee recommends that the Directorate General of Civil Aviation should ensure that operators' documented flight crew training procedures include specific training modules for crew response to all warnings and alerts generated from ground proximity warning systems and enhanced ground proximity warning systems fitted to aircraft that it operates.

4.2.4 Directorate General of Civil Aviation

The National Transportation Safety Committee recommends that Directorate General of Civil Aviation should ensure that operators' documented flight crew coordination procedures are effectively implemented.

4.2.5 PT. Aviastar Mandiri

The National Transportation Safety Committee recommends that Pt. Aviastar Mandiri should ensure that its flight crew operating manual (FCOM) and the Company Mperation manual (COM) are consistent, with respect to the required actions and responses to EGPWS alerts and warnings.

4.3 OTHER IDENTIFIED SAFETY ISSUES

During the investigation, other safety issues were identified that did not contribute to the accident, but they were identified as safety deficiencies.

Those safety deficiencies related to the modification of the BAe-146 aircraft to a combined passenger and cargo configuration.

Accordingly, the National Transportation Safety Committee made the following recommendation.

4.3.1 Directorate General of Civil Aviation

The National Transportation Safety Committee recommends that Directorate General of Civil Aviation should review its approval processes which apply to aircraft modifications. The review should include:

4.3.1.1 Type Certificate Data

4.3.1.2 Continuous Airworthiness Maintenance Program

4.3.1.3 Aircraft Loading Manual

4.3.1.4 Weight and Balance Manifest Chart for the combined passenger and cargo aircraft configuration

4.3.1.5 Fire detection and suppression system Class D

4.3.1.6 Passenger safety with cargo carried aft of the passengers in the aircraft cabin

4.3.1.7 Passenger safety with dangerous goods carried as cargo in the aircraft cabin.

APPENDIX

Appendix A : Operator's BaE-146 FLIGHT CREW OPERATING MANUAL

General

The EGPWS has all the basic modes of the older GPWS system together with some enhancements. The enhancements are achieved by accurate knowledge of position and comprehensive databases. The position comes from GPS. The databases are:

- Terrain database; it stores height of terrain against position.
- Airfield database.
- Optional obstacle database.
- Envelope modulation database; it desensitises, where necessary, the alert envelopes to prevent nuisance warnings and expands, where necessary, the alert envelopes for added safety.

The purpose of the EGPWS is to help prevent accidents caused by controlled flight into terrain (CFIT). The prime responsibility for avoiding terrain lies with the flight crew. However, if mistakes have been made, immediately responding to the EGPWS alert will give the best chance of avoiding impact with terrain. This topic covers:

- A summary of EGPWS functions.
- Limitations of the EGPWS.
- Response to EGPWS alerts.

Summary of Alerts

The EGPWS has three categories of alerts:

- Warning.
- Caution.
- Glideslope

All the alerts are given aurally. Warning and cautions are also given by lamps: a red warning lamp on each pilot's glareshield and an amber caution lamp on each pilot's glareshield. The red lamps have a PULL UP legend; the amber lamps have a GROUND PROX legend.

The EGPWS also gives advisory callouts without any visual enhancements.

A full description of the EGPWS is given in the FCOM Volume 1.

Basic Modes

The basic modes are:

- Mode 1 - excessive descent rate.
- Mode 2 - excessive closure to terrain for the height above terrain.
- Mode 3 - altitude loss after take-off.
- Mode 4 - insufficient terrain clearance for the phase of flight.
- Mode 5 - excessive deviation below the glideslope.
- Mode 6 - advisory bank angle and height callouts.

Mode 1

Mode 1 gives protection against excessive aircraft barometric descent rates at low heights. Descent rate is assessed against radio altitude. If the descent rate becomes excessive for the altitude, an alert is given. There are two boundaries: caution and warning. If the caution boundary is crossed, "Sink Rate" calls are given and the GROUND PROX lamps illuminate. If the warning boundary is crossed, "Pull Up" calls are given and the PULL UP lamps illuminate.

Mode 2

Mode 2 gives protection against flight into rapidly rising terrain. Rate of change of radio altitude is assessed against radio altitude. If the rate of change of altitude becomes excessive for the altitude, an alert is given: caution and warning. If the caution boundary is crossed, "Terrain, Terrain" calls are given and the GROUND PROX lamps illuminate. If the warning boundary is crossed, "Pull Up" calls are given and the PULL UP lamps illuminate.

Mode 3

Mode 3 gives protection against loss of altitude after take-off or during a go-around. Loss of barometric altitude is assessed against radio altitude. If the loss of altitude becomes significant for the height, "Don't Sink" calls are given and the GROUND PROX lamps illuminate.

Mode 4

Radio altitude is monitored against aircraft configuration and airspeed. If there is insufficient terrain clearance for the phase of flight, "Too Low Terrain" calls are given and the GROUND PROX lamp illuminates. If an approach is made below 500 ft radio altitude with the landing gear up, "Too Low Gear" calls are given and the GROUND PROX lamps illuminate. If an approach is made below 200 ft radio altitude with the flaps not at the landing setting, "Too Low Flaps" calls are given and the GROUND PROX lamps illuminate.

Mode 5

Mode 5 provides warning of excessive deviation below the glide slope below 1 000 ft radio altitude. There are two boundaries: soft and hard. The soft boundary is at 1.3 dots low. The hard boundary is only active below 300 ft agl and is set at 2 dots low. If the soft boundary is penetrated, "Glideslope" calls are given at low volume and the GROUND PROX lamps illuminate. If the hard boundary is penetrated, "Glideslope, Glideslope" calls are given at high volume and the GROUND PROX lamps illuminate. If the deviation below either boundary continues to increase, the aural warnings are given at a faster rate.

Mode 6

There are many options. They are described in the FCOM Volume 1. The Company Operations Manual must be consulted to obtain the actual callouts used.

Enhanced Functions

The enhanced functions are:

- Envelope modulation.
- A terrain clearance floor.
- A runway field clearance floor.
- Terrain look ahead alerting.
- Terrain alerting and display (TAD).

Envelope Modulation

Due to terrain features at or near specific airports, GPWS has given nuisance alerts or failed to give an alert. The terrain database, airport database and the GPS position allow EGPWS to adjust the alerting process to cater for the conditions at a particular airport.

Envelopes are desensitised to cope with nuisance warnings. Envelopes are expanded where necessary to increase safety. This is all done automatically.

Terrain Clearance Floor

The terrain clearance floor (TCF) function alerts the pilot of a descent below a defined floor. The TCF alerting envelope is based on:

- Distance from the nearest runway.
- Radio altitude.

TCF has just one alert boundary. If the boundary is penetrated, the GROUND PROX lamps illuminate and a "Too Low Terrain" call is given.

Runway Field Clearance Floor

The runway field clearance floor (RFCF) function alerts the pilot of a descent below a defined floor. The RFCF alerting envelope is based on:

- Distance from the destination runway.
- Height above the destination runway.

This floor enhances the protection provided by the TCF for approaches to runways that are significantly higher than the surrounding terrain.

TCF has just one alert boundary. If the boundary is penetrated, the GROUND PROX lamps illuminate and a "Too Low Terrain" call is given.

Terrain Look Ahead Alerting

The GPS position allows the EGPWS to look ahead and identify terrain close to or penetrating the aircraft's flight path. The terrain look ahead function has two alert boundaries: caution and warning.

If the caution boundary is penetrated, the GROUND PROX lamps illuminate and a "Terrain Ahead" call is given.

If the warning boundary is penetrated, the PULL UP lamps illuminate and a "Terrain Terrain Pull Up" call is given.

As an option, obstacles are included in the look ahead alerting. The terrain database does not necessarily include all obstacles. The Company Operations Manual must be consulted to establish whether the obstacle feature is enabled.

If the obstacle feature is not enabled, the EGPWS does not provide warnings for man-made obstacles. If the obstacle feature is enabled, the system does not provide warnings for all man-made obstacles.

If the look ahead alerting detects a conflicting obstacle:

- Penetration of the caution boundary is indicated by the GROUND PROX lamps illuminating and a call "Obstacle Ahead".
- Penetration of the warning boundary is indicated by the PULL UP lamps illuminating and a call "Obstacle Obstacle Pull Up".

Terrain Alerting and Display (TAD)

The TAD is presented on the weather radar. The TAD provides an image of the surrounding terrain. The terrain is colour coded. The display is further enhanced by variations in the intensity of the colours.

There are two types of display: non-peaks and peaks. The peaks display is an option. The Company Operations Manual must be consulted to establish whether the peaks display is enabled.

The non-peaks display provides an image of the terrain only when the aircraft is 2 000 ft or less above the terrain. The peaks display enhances the display characteristics to provide a higher degree of terrain awareness independent of the aircraft's altitude.

If the obstacle option is enabled, obstacles are shown as terrain on the display.

If terrain data is unavailable for a particular area:

- Terrain alerting and obstacle alerting are not available for that area.
- The affected display area is coloured magenta.

The EGPWS terrain display is intended to be used as a situational awareness tool only; it does not provide the accuracy or fidelity to be the sole basis for terrain avoidance manoeuvring decisions.

Navigation must not be predicated upon the use of the EGPWS terrain display.

Terrain System Switch

The terrain EGPWS features are inhibited by pressing the TERR SYST switch on the right instrument panel. The white INHIB annunciator on the switch illuminates when the switch is used to inhibit the terrain features.

If the terrain features fail and the system has not been inhibited, the amber FAIL annunciator in the switch illuminates. When the switch is pressed, the FAIL annunciator extinguishes and the INHIB annunciator illuminates.

Terrain Inhibit

If there is no source of aircraft position data meeting the accuracy required for the enhanced functions, then the enhanced functions are automatically inhibited; the FAIL annunciator will be illuminated until the terrain system switch is pressed.

If servo altimeters are fitted:

- The terrain system must be inhibited below the transition altitude unless QNH is set on the altimeters.
- The terrain system must not be used if the left main altimeter has failed.

If ADDUs are fitted, the terrain system may be used below the transition altitude with either QNH or QFE on the altimeters.

The terrain system must be inhibited:

- For take-off if the departure airfield is not in the EGPWS database.
- Within 15 nm of the destination airfield if the airfield or the approach is not included in the EGPWS database.

When the terrain system is inhibited and the EGPWS is otherwise serviceable, the EGPWS reverts to providing the basic GPWS functions. In this state, the EGPWS gives little or no advance warning of flight into precipitous terrain where there are few or no preceding obstructions. This particularly applies if:

- The aircraft is in the landing configuration.
- The aircraft is in a stabilised descent at a normal approach descent rate.

GPWS INOP Caption

An amber GPWS INOP caption on the CWP indicates that the basic GPWS modes are inoperative.

Glide Slope Inhibit

The GROUND PROX caution lamps are also the glideslope warning inhibit switches. The glideslope warning can be cancelled or inhibited by pressing either of the GROUND PROX lamps when the aircraft is below 2 000 ft radio altitude. The mode is automatically reset when the aircraft climbs above 2 000 ft radio altitude or descends below 30 ft radio altitude.

The glideslope warning must be inhibited when an ILS back course approach is made.

Nuisance Warnings

If the flight path is outside normal regulatory standards of terrain clearance and descent rates, nuisance alerts may be given.

Response to a Pull Up Warning

The memory actions for a "Pull Up" warning are:

- Disconnect the AP.
- Pull up.
- Move the thrust levers fully forward.
- Disconnect the TMS.
- Select the airbrake in.

The pull up must be initiated without delay when the warning is given. The actions are completed as near simultaneously as possible. The aim is to quickly establish the aircraft in a climb that will provide maximum terrain clearance. The climb must be continued until all EGPWS alerts cease.

The AP may be disconnected as the pull is applied. There is no need to press the AP button and then initiate the pull.

As the pull is applied, the thrust levers should be moved quickly forward. Either TMS disconnect button should be pressed as the thrust levers are moved forward. This will ensure that maximum thrust is applied.

The pull should smoothly but quickly increase the attitude towards 25°. If stick shaker is encountered, relax the pull. Try to stabilise at an attitude that is just clear of stick shake.

Aircraft with EFIS and a windshear computer have a pitch limit indicator (PLI). The difference between the PLI and the aircraft attitude is the margin to stick shake. The PLI can be of help in maintaining an attitude just short of stick shake. The PLI is only displayed at 2 000 ft and below.

Rolling the wings level will improve the climb performance.

After the pull up warning ceases, continue the climb until at least the minimum safe altitude. Advise ATC of the climb and the new altitude or level.

Only vertical manoeuvres are recommended unless the pilot determines, based on the available information, that turning in addition to the vertical escape manoeuvre is a safer course of action. For example, operating in VMC and it is clear that a turn will result in a safer flight path.

Terrain Caution

The terrain cautions are:

- "Terrain, Terrain"
- "Too Low Terrain"
- "Terrain Ahead"

There is a simple set of memory actions that apply to all terrain cautions. The actions are:

- Disconnect the AP.
- Stop the descent.
- Climb as necessary.
- Adjust the flight path as necessary.

Don't Sink Caution

For a "Don't Sink" caution, there is one memory action: adjust the pitch attitude and thrust to restore a positive rate of climb.

Too Low Gear or Too Low Flaps Caution

The simple memory action is to go-around.

Glideslope Caution

For a "Glideslope" caution, the memory actions depend on whether an ILS approach is being used or not.

If an ILS approach is being flown, then re-establish the glideslope or go-around.

If the aircraft is intentionally below the glideslope, press the GROUND PROX lamp.

Appendix B : EGPWS Terrain Caution Warning Envelopes and Boundaries

6.7.3.1 Terrain Caution and Warning Envelopes

The basic terrain caution envelope (or yellow alert envelope) and terrain warning envelope (or red alert envelope) boundaries are illustrated in Figure 6.7-2.

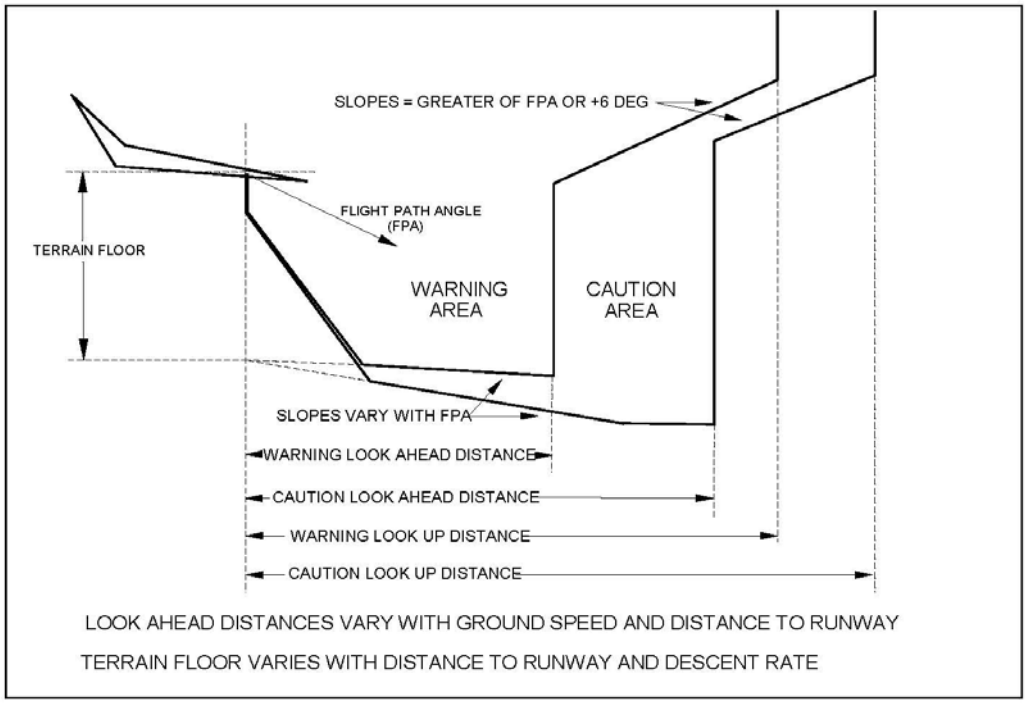


FIGURE 6.7-2: TERRAIN CAUTION AND WARNING ENVELOPE BOUNDARIES

A perspective view of the terrain detection envelope is illustrated in Figure 6.7-3.

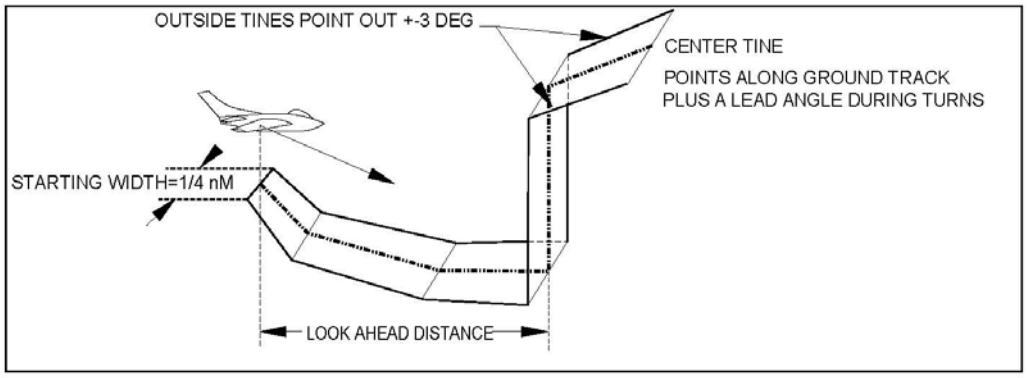
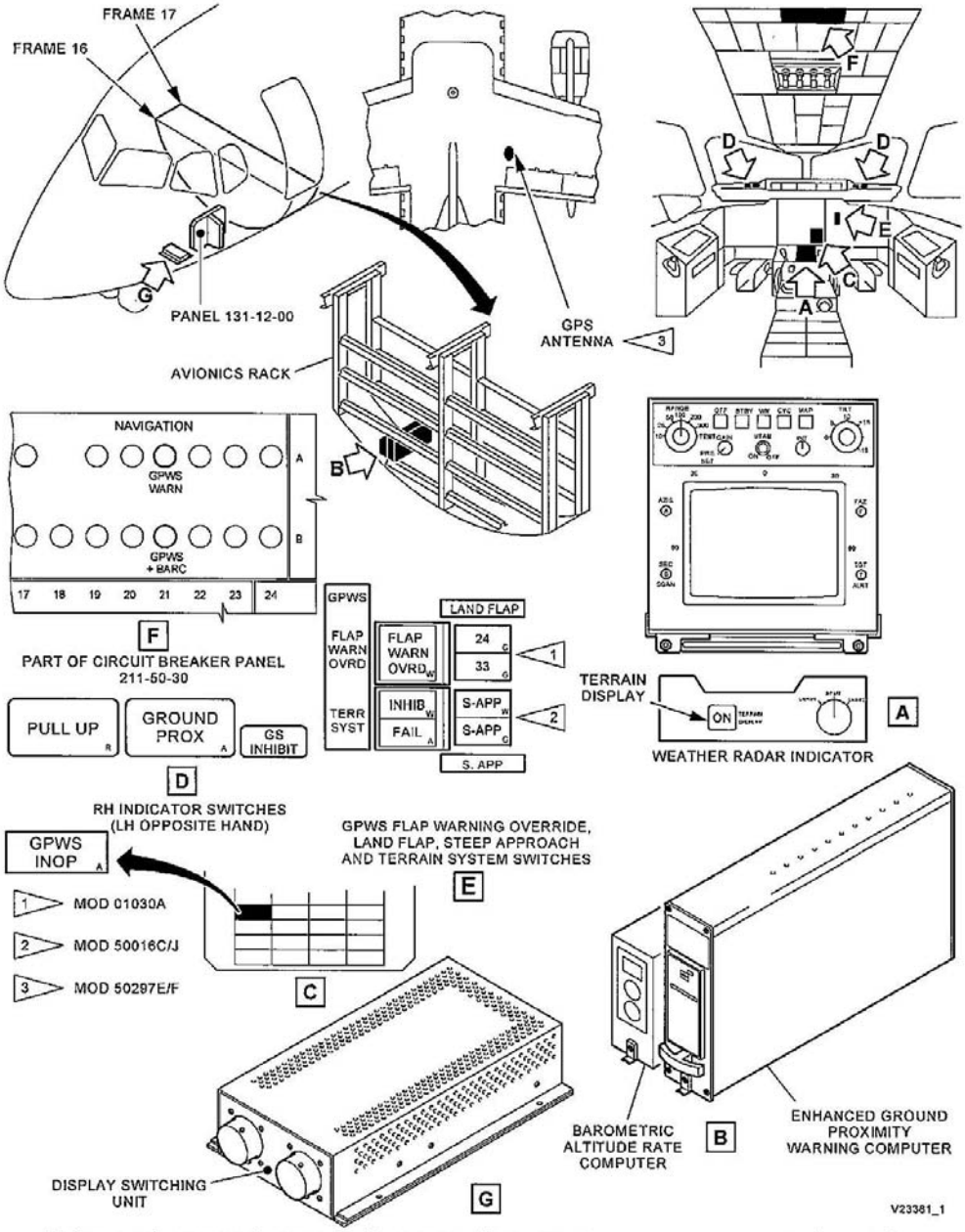


FIGURE 6.7-3: TERRAIN DETECTION ENVELOPE – PERSPECTIVE VIEW

Appendix C : EGPWS Component Location



Enhanced ground proximity warning system - component location
V23381_1 Fig.2

Appendix D : BAe 146 Instrument Panel

Red square on co-pilot panel denotes location of TERR SYST switch as detailed in the diagram taken from Appendix C.