THE REPUBLIC OF KENYA

MINISTRY OF TRANSPORT, INFRASTRUCTURE, HOUSING, URBAN DEVELOPMENT AND PUBLIC WORKS

STATE DEPARTMENT FOR TRANSPORT

AIRCRAFT ACCIDENT INVESTIGATION

CONTROLLED FLIGHT INTO TERRAIN
INVOLVING
EAST AFRICAN SAFARI AIR EXPRESS LTD
TEXTRON AVIATION INC.
CESSNA 208B GRAND CARAVAN,
KENYAN 5Y-CAC
THE ABERDARE RANGES, KENYA
05 JUNE, 2018

OPERATOR	:	East African Safari Air Express Ltd
AIRCRAFT TYPE	:	Cessna 208B Caravan
MANUFACTURER	:	Textron Aviation Inc.
YEAR OF MANUFACTURE	:	1996
AIRCRAFT REGISTRATION	:	5Y-CAC
AIRCRAFT SERIAL NUMBER	:	208B-0525
DATE OF REGISTRATION	:	7 August 2013
NUMBER AND TYPE OF ENGINE	:	One PWC PT6A-114A
DATE OF OCCURRENCE	:	5 June 2018
LAST POINT OF DEPARTURE	:	Kitale Airstrip
POINT OF INTENDED LANDING	:	Jomo Kenyatta International Airport
TIME OF OCCURRENCE	:	1702 hours
LOCATION OF OCCURRENCE	:	Elephant Hill, Aberdare Ranges
TYPE OF FLIGHT	:	Commercial
NUMBER OF PERSONS ON BOARD	:	Ten (10)
INJURIES	:	10 Fatal
NATURE OF DAMAGE	:	Destroyed
CLASS OF OCCURRENCE	:	Accident
PILOT IN COMMAND	:	CPL
PIC FLYING EXPERIENCE	:	2450
SECOND PILOT	:	CPL
FLYING EXPERIENCE	:	354

All times given in this report is East African Local Time (UTC +3hours)

OBJECTIVE

This report contains factual information which has been determined up to the time of publication. The information in this report is published to inform the aviation industry and the public of the general circumstances of the accident.

This investigation has been carried out in accordance with *The Kenya Civil Aviation (Aircraft Accident and Incident Investigation) Regulations, 2018 and Annex 13 to the International Civil Aviation Organization Convention on International Civil Aviation.*

The sole objective of the investigation of an accident or incident under these Regulations shall be the prevention of accidents and incidents. It shall not be the purpose of such an investigation to apportion blame or liability.

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ABBREVIATIONS

AAID	-	Aircraft Accident Investigation Department
ABM	-	Abeam
ACC	-	Area Control Centre
AD	-	Aerodrome
ADS	-	Automatic Dependent Surveillance
ADS-C	-	Automatic Dependent Surveillance- Contract
ADS-B	-	Automatic Dependent Surveillance- Broadcast
AGL	-	Above Ground Level
AIP	-	Aeronautical Information Publication
AIS	-	Aeronautical Information Service
AMED	-	Airborne Multipurpose Electronic Displays
AMEL	-	Aeronautical Maintenance Engineers License
AMO	-	Aeronautical Maintenance Organization
AMSL	-	Above Mean Sea Level
ANS	-	Aeronautical Navigation Services
AOC	-	Air Operators Certificate
ARP	-	Aerodrome Reference Point
ASS	-	Aviation Safety and Security
ASSR	-	Aviation Safety and Security Regulation
ATC	-	Air Traffic Services
ATFM	-	Air Traffic Flow Management
ATM	-	Air Traffic Management
ATO	-	Aviation Training Organization
ATPL	-	Airline Transport Pilot License
ATS	-	Air Traffic Services
AVENA	-	Navigation Fix point at JKIA
BASA	-	Bilateral Air Service Agreements
CFIT	-	Controlled Flight Into Terrain
COA	-	Certificate of Airworthiness
COR	-	Certificate of Registration
CPDLC	-	Controller Pilot Data Link Communications
CPL	-	Commercial Pilot License
CVR	-	Cockpit Voice Recorder
DME	-	Distance Measuring Equipment
EASA	-	East African School of Aviation
EASA	-	East African Safari Air Limited
EASAX	-	East African Safari Air Limited
ELD	-	Eldoret
ELT	-	Emergency Locator Transmitter
ENRT	-	Enroute
FAA	-	Federal Aviation Administration
FDR	-	Flight Data Recorder
FIR	-	Flight Information Region
FMS	-	Flight Management System
GA	-	General Aviation

GF	-	Ground Flight Safety
GNSS	-	Global Navigation Satellite System
GPS	-	Global Position System
GPWS	-	Ground Proximity Warning System
HF	-	High Frequency
HKEL	-	Eldoret Airport
HKJK	-	Jomo Kenyatta International Airport
HKKT	-	Kitale Airport
HKNW	-	Wilson Airport
ICAO	-	International Civil Aviation Organization
IFR	-	Instrument Flight Rules
IMC	-	Instrument Meteorological Conditions
JKIA	-	Jomo Kenyatta International Airport
KAA	-	Kenya Airports Authority
KAF	-	Kenya Air Force
KAPU	-	Kenya Airport Police Unit
KCAA	-	Kenya Civil Aviation Authority
KFS	-	Kenya Forest Services
KWS	-	Kenya Wildlife Services
LG	-	Landing Gear
LT	-	Local Time
METAR	-	Meteorological Terminal Air Report
MHZ	-	Megahertz
MLG	-	Main Landing Gear
MSL	-	Mean Sea Level
NLG	-	Nose Leading Gear
NM	-	Nautical Mile
NOF	-	The International NOTAM Office
NOTAM	-	Notice to Airmen
NPS	-	National Police Service
NTSB	-	National Transportation Safety Board
PALS	-	Precision Approach Landing System
PAPI	-	Precision Approach Path Indicator
PDC	-	Pre-Departure Clearance
PSR	-	Primary Surveillance Radar
QNH	-	Altimeter setting related to sea level
REL	-	Relative
RFFS	-	Rescue and Fire Fighting Services
RMI	-	Radio Magnetic Indicator
SALS	-	Simple Approach Landing Systems
SAR	-	Search and Rescue
SSR	-	Secondary Surveillance Radar
TAWS	-	Terrain Awareness Warning System
TCAS	-	Traffic Collision Avoidance System
TMA	-	Terminal Maneuvering Area
TOPO	-	Topographic

TSB	-	Transport Safety Board
TSO	-	Technical Standard Order
USA	-	United States of America
UTC	-	Coordinated Universal Time
VFR	-	Visual Flight Rules
VHF	-	Very High Frequency
VNAV	-	Vertical Navigation
VOR	-	High Frequency Omnidirectional Range
WGS	-	World Geodetic System (1984)

SYNOPSIS

On June 5, 2018, at about 1702 hours Kenya daylight time, Flysax flight EXZ102, a turbine-powered Cessna 208B Grand Caravan airplane, registration 5Y-CAC, impacted the steep mountainous terrain of the Aberdare ranges. The two commercial pilots and the eight passengers sustained fatal injuries, and the airplane was destroyed. The scheduled passenger flight operated under instrument flight rules by the East African Safari Air Express Ltd was flying from Kitale to JKIA, Nairobi when radar contact was lost.

The Aircraft Accident Investigation Department (AAID) received information from the operator, which corroborated information established from the Search and Rescue Coordination Centre regarding the disappearance of 5Y-CAC from the radar at 1722 hours the same day. The search and rescue mission was activated immediately. The aircraft wreckage was located at 0645 hours on 7 June 2018. The two commercial pilots and the eight passengers suffered fatal injuries, and the airplane was destroyed by impact forces. There was no pre or post-impact fire, and no emergency locator transmitter signal was received by the Search and Rescue Coordination Centre.

AAID notified the National Transportation Safety Board (NTSB) of the United States of America, the State of manufacture of the C208 aircraft, the Transport Safety Board (TSB) of Canada, manufacturer of the powerplant, and Fiji the State whose citizens suffered fatal injuries. The International Civil Aviation Organization was also notified of the occurrence. Both the NTSB and TSB appointed accredited representatives, but they did not travel to the accident location in Kenya.

The Terrain Awareness and Warning System (TAWS) and global positioning system receiver were recovered and sent to the TSB Canada Engineering Laboratory where relevant data was extracted. The Emergency Locator Transmitter was also recovered and subjected to various tests to establish why it did not deploy on impact as expected.

The investigation determined the probable cause(s) of this accident to be the flight crew's inadequate flight planning and the decision to fly instrument flight rules in fog, at an altitude below the published Minimum Sector Altitude in the Standard Instrument Arrival Chart, and subsequent failure to perform an immediate escape maneuver following terrain awareness warning system alert, which occasioned controlled flight into terrain.

1. FACTUAL INFORMATION

1.1 History of the flight

The aircraft took-off from Kitale Airstrip (HKKT) at 16.05 hours and set course to Jomo Kenyatta International Airport (HKJK) after climbing to FL 110 with ten onboard. Once established, there were slight peripheral variations in groundspeed and track. The aircraft Flight Level was sustained at 110 with some occasional deviations. Aircraft height above ground level (AGL) varied between 1102 feet and 4187 feet. One minute before its impact with the cliff, the aircraft was at 11,100 feet or 3000 feet AGL, 159 knots ground speed, and tracking radial 338 NV. Immediately before radar signal was lost, the elevation of the highest ground level was 12876 feet, the aircraft altitude was 11,200 feet, the ground speed was 156 knots, and track was radial 339 NV.

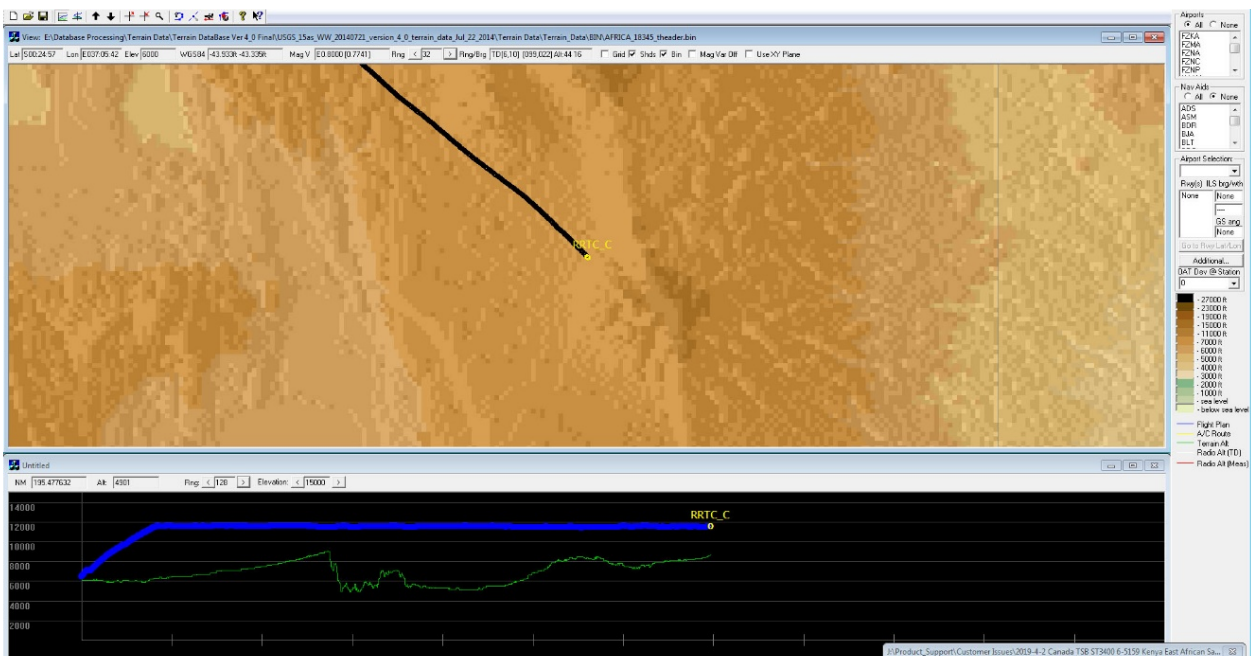

Figure 1: Elevation profile of 5Y-CAC from Kitale to the accident location against the terrain

Information retrieved from the Radar transcript recorded various parameters of the aircraft from 1605hrs up to 1702hrs, the time radar signal was lost. This information was consistent with information extracted from the on-board equipment the ST3400 and the aera GPS.

The radar system transmits information including aircraft position in relation to NV VOR, Flight Level or altitude, groundspeed, vertical speed and heading. Information retrieved from the GPS captured the last recorded time, date and location as 14:00:52, on 06/05/2018 and elevation 3555.57 metres. The aircraft impacted the bamboo-covered terrain at an elevation of 3,645 metres at 0.36’56’’S 36 42’44’’ where the wreckage was sited.

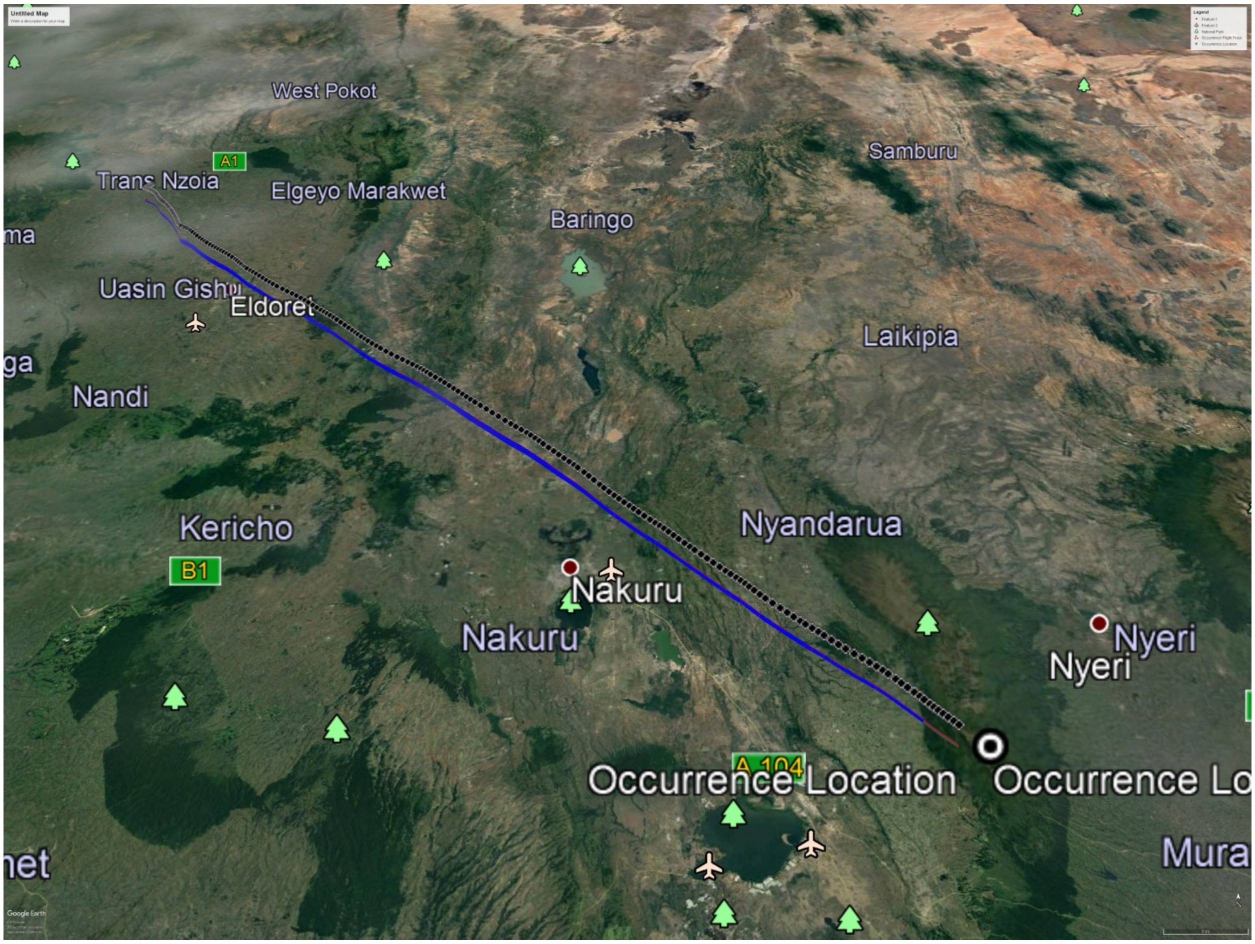

Figure 2: Aircraft Track from Kitale to the Accident Site

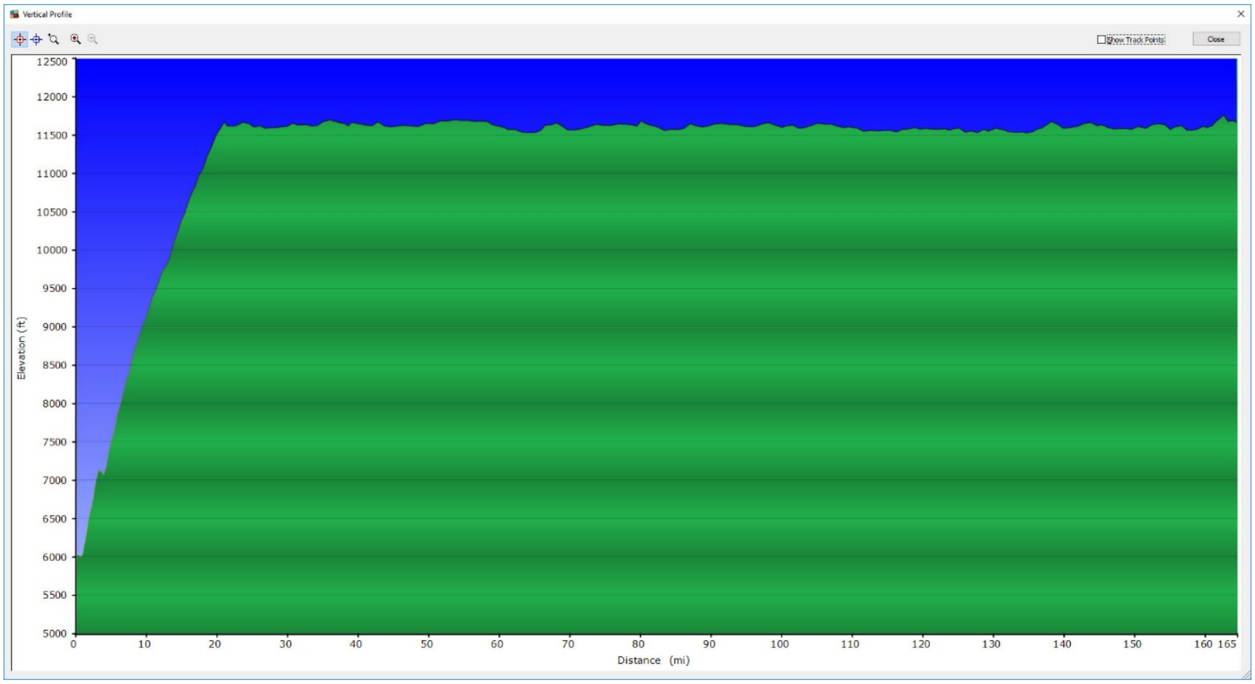

Figure 3: Flight elevation profile from Kitale

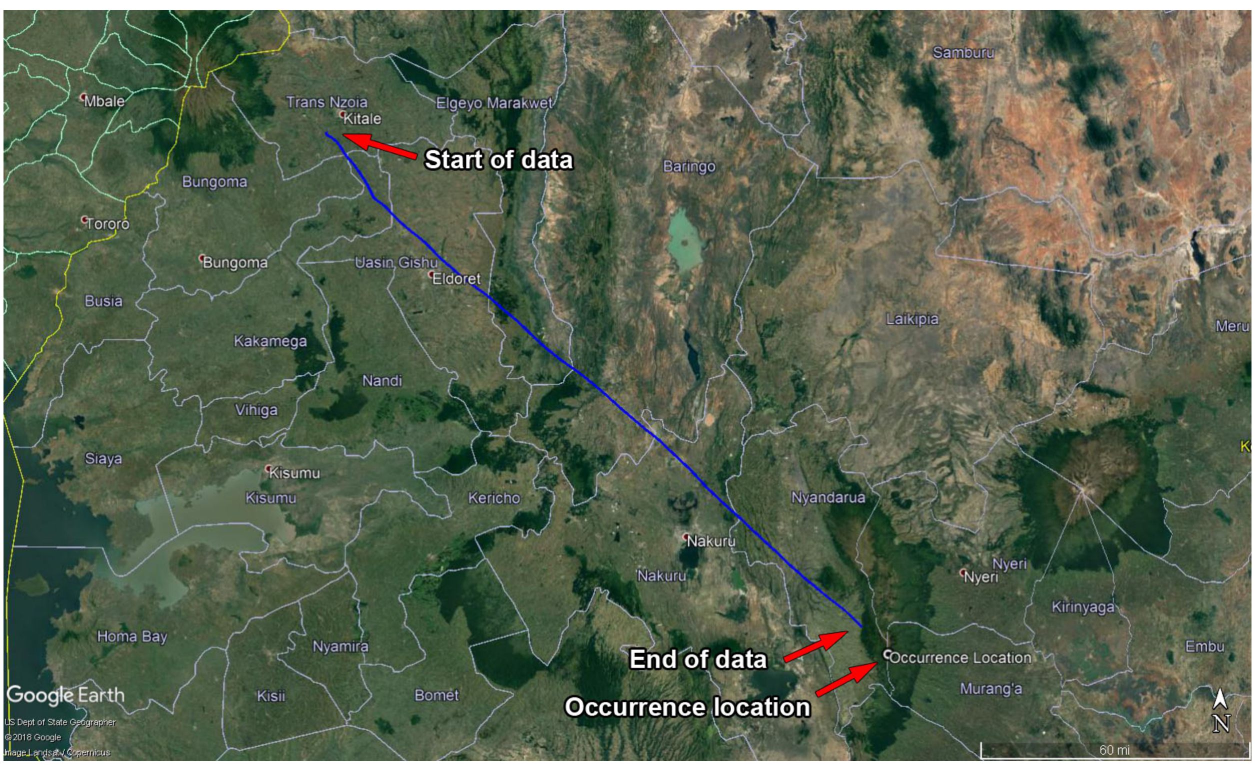

Figure 4: Plot of occurrence flight – TAWS data

1.1.1 Previous flights

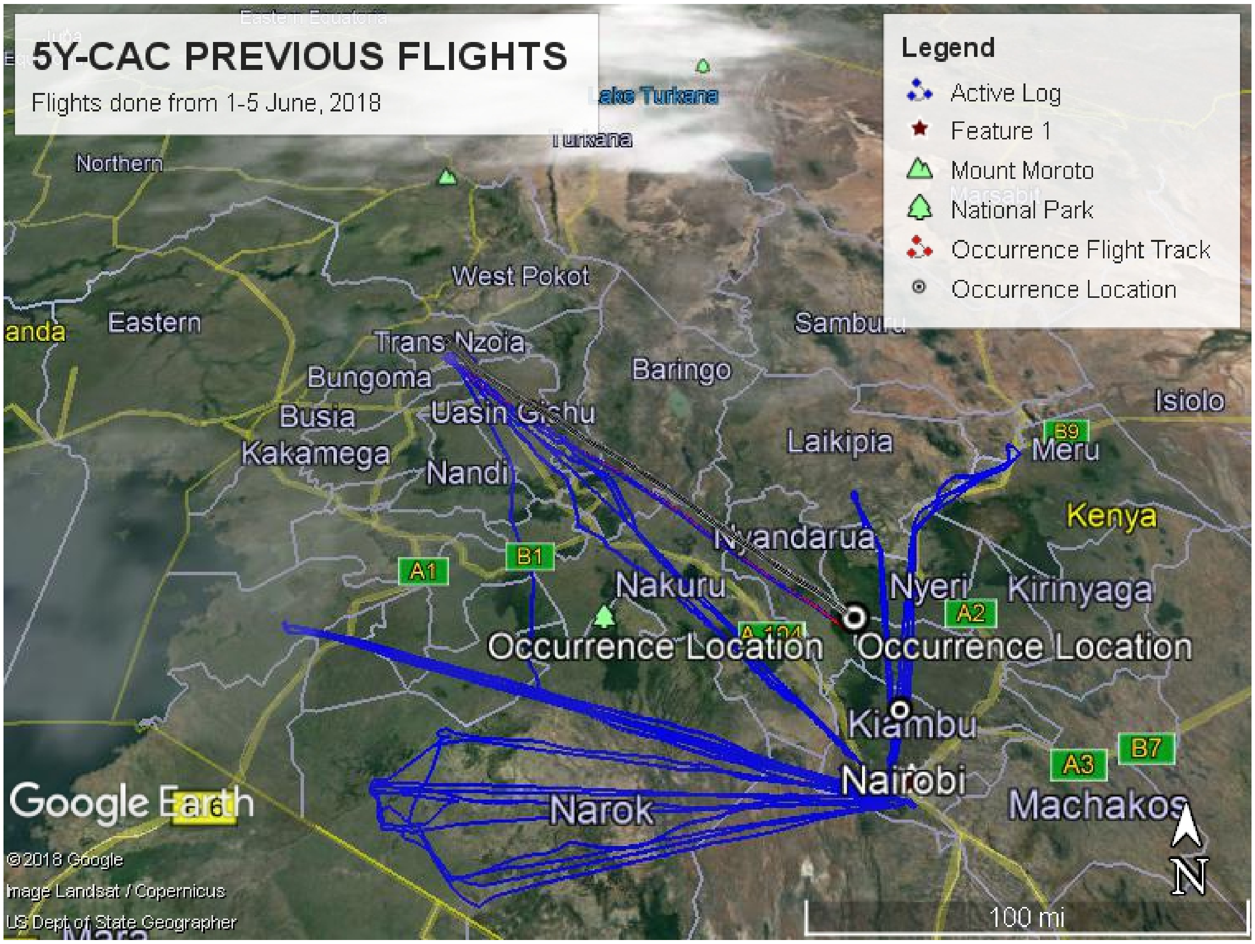

Figure 5: Aircraft Tracks depicting previous flights prior to the accident flight

Flysax operates a daily scheduled flight from Wilson airport, Nairobi to Kitale and back to Wilson airport, Nairobi. The accident flight was delayed because of the prevailing weather conditions of the day that necessitated delays in various scheduled flights of the day. The two passengers onboard EX302 from Kitale were scheduled for an international flight at JKIA. Due to the delay of the flight, Flysax elected to fly direct to JKIA instead of the usual Wilson airport in order to enable the two passengers to arrive in time for the international flight.

Earlier on the morning of the accident, the crew flew 5Y-CAC from Wilson airport to Homabay and back to Wilson airport, before taking off once again from Wilson airport and making various intermediary landings at Ngerende, Angama, Olare, Olkiombo, Keekorok and back to Wilson airport at 1313 hours. The cumulative elapsed time from the first flight up to and including the return flight from Keekorok to Wilson airport was 4 hours and 16 minutes.

1.2 Injuries to Persons

Injuries	Crew	Passenger	Total in the aircraft	Others
Fatal	2	8	10	0
Serious	0	0	0	0
Minor/none	0	0	0	Not applicable
Total	**2**	**8**	**10**	**0**

Table 1: Injury chart

1.3 Damage to Aircraft

The aircraft was destroyed by impact forces.

Figure 6: The wreckage of 5Y-CAC

1.4 Other Damage

There was no damage sustained by other objects, including the environment other than the aircraft and a slight post-crash fire that incinerated an insignificant portion of the surrounding woodland and foliage.

1.5 Personnel information

1.5.1 Pilot in Command

Records indicate that the pilot in command was born in the year 1988 and held a Commercial pilot license; CPL issued on 09/10/2010 by the KCAA and employed by the company in the year 2014.The CPL expiry date indicated 15/05/2019. The endorsements under group \`A\` on the CPL are BE55, C208, C172, PA28 and BE200. Beech 1900 endorsed under group \`B\` The instrument rating renewal check out was done and endorsed on the license on 11/04/2018. The last license renewal records from KCAA indicate that the pilot had accumulated 2352.9 flight hours as at 11/05/2018.

Flysax employed newly licensed pilots would initially be placed in first officers' position in Cessna 208. The pilots would gain operations experience and knowledge in the industry, and the company would benefit from assessing the suitability of prospective pilots.

The accident PIC progressed through this program after obtaining a commercial pilot license, followed by company line indoctrination on type. Records indicate that the pilot went through the command upgrade company training as from May, 2017 progressively until August, 2018 when she was satisfactorily recommended by the instructor for the check-out test. The command check-out test was done on 5th September, 2017 and passed. The pilot was qualified for the flight, and had a valid instrument rating as well as medical and pilot proficiency certification. The pilot's flight and duty time limits were not exceeded. The pilot had just returned to work on 30th April, 2018, after 10 days off, and there were no indications that fatigue affected the pilot's performance.

Records from the company indicated that the pilot had undergone training in firefighting drills, aviation security, dangerous goods awareness, and crew resource management in 2015. The latest refresher course on crew resource management training was conducted in March, 2017.

1.5.2 The Second Pilot

The first officer was born in the year 1992 and held a Commercial pilot license; CPL issued on 28/09/2016 by the KCAA and employed by the company in the year 2017. The CPL expiry date indicated 26/09/2018. The endorsements under group `A` on the CPL are C150, PA34 and C208. The initial instrument rating practical test was conducted and endorsed on the license on 13/02/2017. The pilot had logged a total of 354 flight hours at the time of the accident. Pilot records from the company did not indicate that the pilot had undergone training in both the dangerous goods awareness and crew resource management courses.

1.6 Aircraft Information

1.6.1. General

The Cessna 208B airplane was, single-engine turboprop, unpressurized, fixed-tricycle landing gear high-wing, equipped with a Pratt & Whitney PT6A-114A engine that produces 675 shaft horsepower(503 kW) with a belly cargo pod with service ceiling of 25,000 ft (7,600 m). It was outfitted with a Hartzell three-bladed Constant speed, full feathering, and reversible pitch propeller and configured with 13 passenger-cabin seats.
Records retrieved from KCAA indicate that the aircraft type Cessna 208B serial number 208B-0525 was owned by 720 Investment Ltd and Leased to the East African Safari Air Ltd as per KCAA Certificate of Registration number 2350-B. The aircraft was issued with a Certificate of Airworthiness (COA) number 2776 under Commercial Air Transport Category with an expiry date of 17 August 2018.

The aeroplane was equipped for IFR operations, and included a GPS receiver with no terrain awareness features; however, the aircraft was fitted with SANDEL ST3400 with terrain awareness features. 5Y-CAC was non-data-link equipped.

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The Cessna 208B's paint scheme consisted of a base color of white at the lower section of the fuselage, with black accent striping which extended along both sides of the fuselage. The upper part of the fuselage from the engine compartment, the wings and the empennage all consisted of red coating. A Grey belly cargo pod, a chrome propeller spinner, and grey Hartzell propeller with two span wise white strips.

1.6.2. Fuel

The type of fuel used and type of fuel authorized is Jet fuel. The amount of fuel onboard before taking off from Wilson airport was 636 kgs. The amount of fuel onboard on takeoff from Kitale was 454 kgs.

1.6.3. Propellers

All the three propellers were accounted for at the accident site. They had sheared off from the main hub in a manner consisted with high setting. The spinner got embedded into the crater created by the impact forces and furrowed. The bulkhead failed in a manner typical of existence of high torsion forces.

Figure 7: The severed and sheared portion of the bulkhead

The pitch change actuator, the primary control, or the governor, and the overspeed governor, were all accounted for at the accident location.


Figure 8: The propeller blade at the accident location

1.6.4 Sandel ST3400

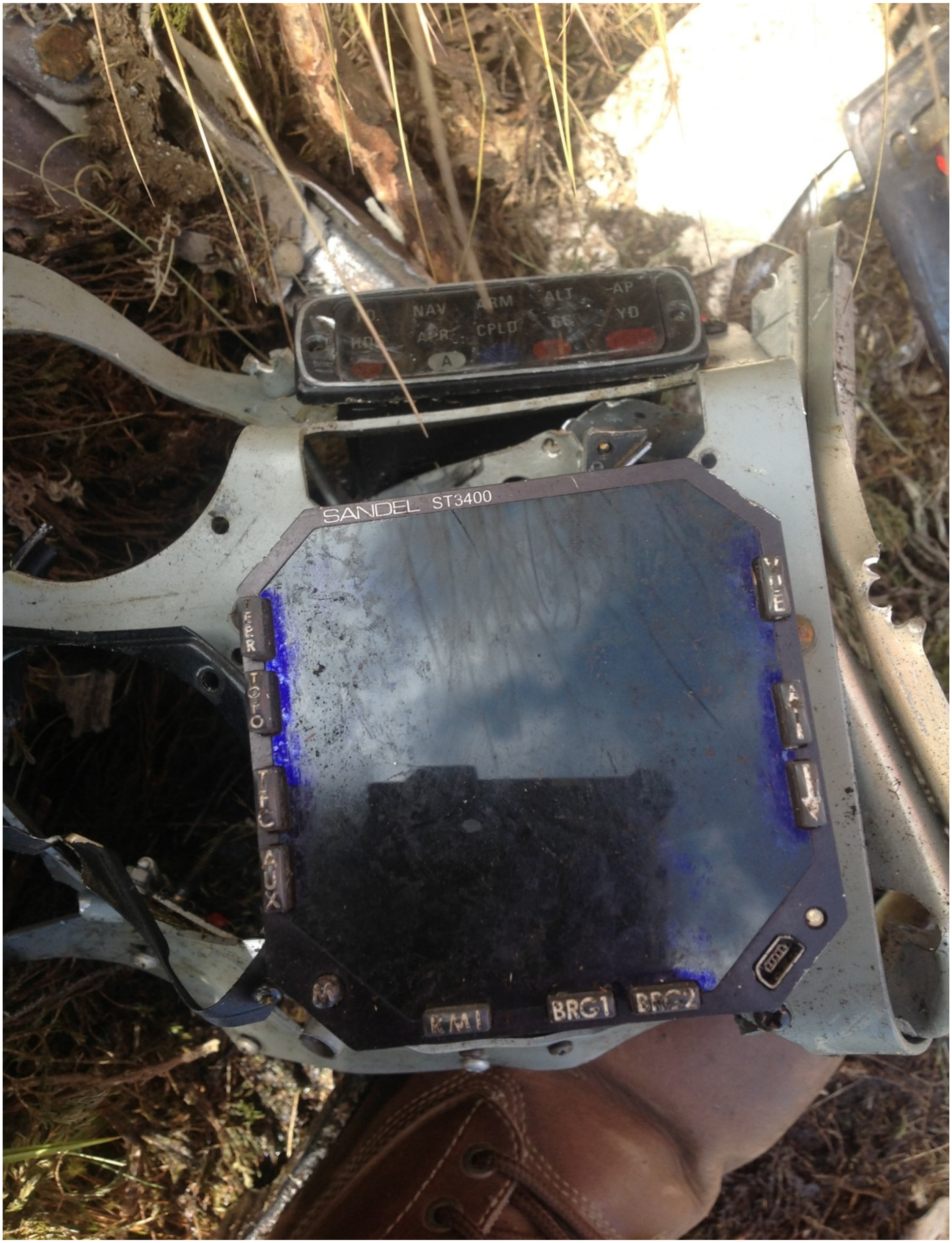


Figure 9: The SANDEL ST3400 before recovery from the wreckage of 5Y-CAC

5Y-CAC was equipped with SANDEL ST3400. The ST3400 TAWS/RMI meets FAA (Federal Aviation Administration) Class A TAWS equipment standards and Class B equipment standards for GA (General Aviation) and commercial air carriers.

The ST3400 is approved by the FAA under the following TSO (Technical Standard Orders):

TAWS/GPWS Functions:

TSO-C151B: TAWS (Terrain Awareness and Warning System)

Multipurpose Displays:

TSO-C113: AMED (Airborne Multipurpose Electronic Displays)

The ST3400 is a multi-function display with a self-contained TAWS (Terrain Awareness Warning System) system. It includes a TAWS computer, graphics symbol generator and an integrated full-color screen, built within a standard 3-inch instrument chassis. It includes bearing- pointer features to directly replace an existing mechanical RMI (Radio Magnetic Indicator), and has the optional capability of acting as a Primary or secondary Traffic indicator, showing traffic either in standard TCAS format or overlaid on terrain when connected to an external traffic detection system.

Terrain protection is enabled during all airborne phases of flight - Departure, Enroute, Terminal, and Approach and in any selected display mode.

The ST3400 is a situational awareness tool and an alerting and warning device. It is not intended to be used for primary navigation of the aircraft. During normal flight operations the system remains essentially silent. It uses GPS, radar altitude, barometric altitude, and other relevant data in combination with its internal database information to provide the pilot with a full-time terrain display. The look ahead function compares the aircraft flight path to terrain and obstacle database information and distance to known runways.

Runway Awareness√, Virtual Approach Path√, Safe Operating Area√, and Predictive Altitude√ are smart and exclusive Sandel features that provide the pilot with fast access to usable information, maximizing relevant data and reducing nuisance alerts. Pilot workload in interacting with the system during normal flight is minimal. In PRED (Predictive) mode, the ST3400 can show only terrain that represents a potential threat during an emergency climb in an easily interpreted format.

The ST3400 includes a built-in caution and warning system providing annunciation and aural alerts. Provision is made for all the traditional/standard Ground Proximity Warning System (GPWS) alerts, new enhanced terrain alerts, and various advisories. All of the alerts are automatically displayed. The unit supports optional external caution and warning annunciators.

An internal recorder automatically records a minimum of the last ten hours of flight data. Oldest data is automatically overwritten with most recent data.

In addition to the six GPWS alerts, the ST3400 provides predictive “look ahead” warnings by comparing its internal terrain and obstacle database to position information provided by the GPS or FMS navigator.

The internal terrain and obstacle database provides the basis to look ahead of the aircraft and detect terrain or obstacle conflicts. This is accomplished based on aircraft position, phase of flight, flight path angle, track, and speed relative to the terrain database image forward of the aircraft.

Through sophisticated look-ahead algorithms, alerts are generated if terrain or an obstacle conflict with the flight path angle of the aircraft. This potential conflict area projects forward and to the side of the aircraft.

During enroute operations, a caution typically occurs approximately 60 seconds ahead of the terrain conflict. A caution will turn into a warning if evasive action is not taken. During other operations the alert times are shorter but cautions are always designed to occur prior to warnings. A warning does not indicate a higher severity of threat, but simply that less time exists for evasive action.

Topographic (TOPO) and Predictive Altitude (PRED) features provide the pilot with fast access to new types of useful information maximizing the pilot’s understanding of the relationship between the aircraft and the ground in different flight situations. An image of the surrounding terrain is represented in various colors. Terrain (inclusive of obstacles) forward, behind and to the side of the aircraft is displayed.

If any terrain alert occurs, the TAWS Alert text is shown at the bottom of the screen and an audible alert message will occur on the cockpit audio system. The REL (RELative Altitude) terrain display screen is automatically selected at an appropriate range to put the alerting terrain on- screen. This action occurs on any alert, including GPWS. If the pilot has previously selected TAWS INH, GPWS alerts are still enabled but no terrain will be shown.

Pilots should train to react properly to all alerts, cautions and warnings, just as one would train to react to an aircraft stall, engine failure or any other potential or actual emergency situation.

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

The ST3400 is not the pilot or the pilot's judgment; it is a display and computer. However, because it is designed to only alert when the aircraft is outside normal flight envelopes in relation to terrain, we recommend that all alerts should result in immediate and appropriate action by the pilot. A Warning should always result in an evasive maneuver. Please see the section on Cautions and Warnings.

During enroute flight (not on approach to a runway or airport) the nominal color coding is:

Dark Red: Greater than 1500' **above** the aircraft

Light Red: Within 100' of the aircraft to 1500' **above** the aircraft Yellow: Between 1000' and 100' separation below the aircraft Green: Between 2000' and 1000' separation below the aircraft Black: Greater than 2000' separation below the aircraft

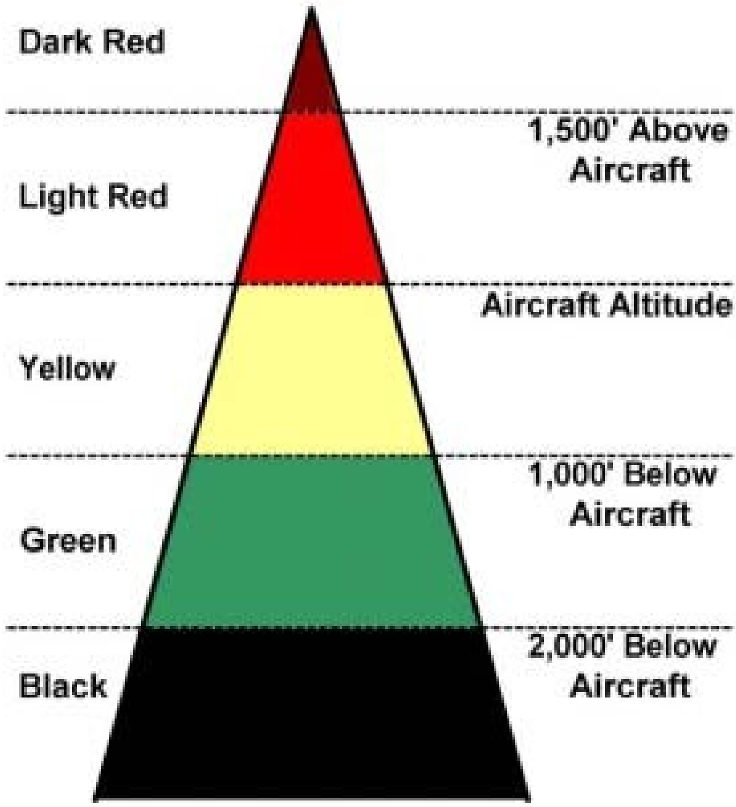


Figure 10: The ST3400 enroute the nominal color coding

The FLTA Alert Area is an internal computation that covers an area mostly in front of and somewhat to the side of the aircraft.

Through sophisticated look-ahead algorithms, alerts are generated if terrain or an obstacle conflict with the flight path angle of the aircraft.

Range and altitude of the aircraft are computed along the projected flight path at one-second intervals. The projected range is based on current aircraft location and the aircraft's ground speed. The projected altitude is based on current aircraft altitude and the aircraft's vertical speed. Within the Alert Area the aircraft's projected flight path and each terrain cell's elevation are compared to check for terrain threats. This area of potential conflict projects forward and to the sides of the aircraft. In turning flight, the covered alert area grows in the direction of the turn.

During enroute operations, a caution typically occurs approximately 60 seconds ahead of the terrain conflict. A caution will turn into a warning if evasive action is not taken. An audible and visual alert will be produced at the closest cell in which a threat is detected.

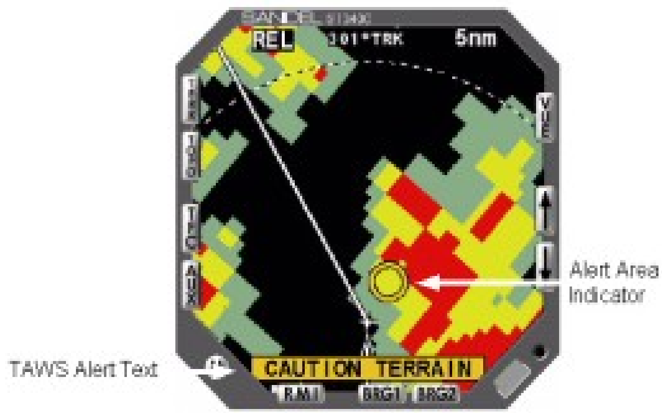


Figure 11: The ST3400 cockpit display

An AMBER annunciator indicates CAUTION

Responding to an Alert

Every alert should be considered valid and requires appropriate action.

> An AMBER annunciator indicates CAUTION and requires immediate pilot attention.
>
> A RED annunciator indicates a WARNING and requires immediate aggressive pilot action.

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

Pilots should train to react properly to all alerts, cautions and warnings, just as one would train to react to an aircraft stall, engine failure or any other emergency situation.

RESPONDING TO AN ALERT		
Text / Alert	**Source**	**Pilot Action**
Caution Terrain (FLTA caution)	FLTA	If level, apply power, establish a climb attitude, and climb out of the alert. Check position on terrain display. If descending, apply power and level off. If caution continues, apply power and establish a climb attitude.
Don't Sink (GPWS caution)	ALAT	Immediately level wings, apply full power, and establish a climb attitude.
Five Hundred	Callout	500' AGL or above runway
Glide Slope (GPWS caution)	EDGSD	Arrest descent rate and rejoin the glide slope.
Pull Up (GPWS warning)	ERD ECRTNL ECRTL	Disengage autopilot/immediately level wings. Apply full power, establish a climb attitude. Continue maneuver until alert ceases or terrain clearance is assured.
Sink Rate (GPWS caution)	ERD	Arrest sink rate and fly out of the alert area

1.6.5 Emergency Locator Transmitter, ELT

5Y-CAC was equipped with a Kannad 406 AS- COMPACT ELT, part number S1820506-01, serial number 15260294. After recovery from the wreckage, during field examination of the wreckage, the ELT was noted to have been dislodged from its mounting tray with both the batteries and the antenna cable still attached to it.

The switch was still in the 'ARM' position. The remote control panel wires were broken near the plug on the ELT. The antenna had been broken off by ground contact, and its cable was continuous from the antenna base to the ELT. Due to loss of the antenna, no 406 MHz signal was recorded by the Search and Rescue Coordination Centre, nor was a 121.5 MHz signal received.

Figure 12: The ELT with the batteries still attached at the accident site

Figure 13: The ELT after recovery in the armed position

1.6.6 The AERA 500 GPS

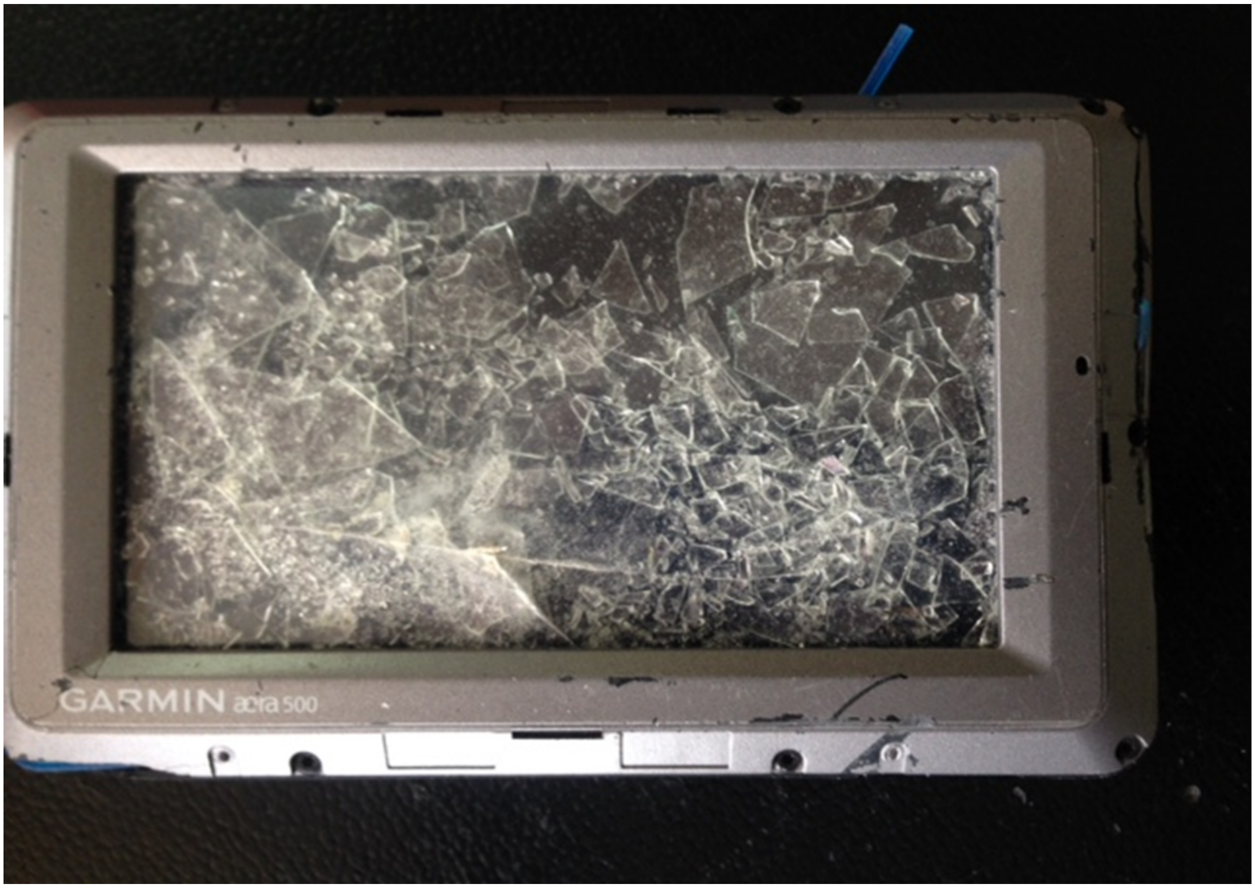


Figure 14: The GPS Garmin Aera 500 after recovery from the wreckage

2.3 Vertical Navigation (VNAV)

The VNAV function provides settings for the vertical navigation. These settings create a three-dimensional profile from the present location and altitude to a final (target) altitude at a specified location.

When the VNAV profile is defined, the pilot is informed of the progress by message alerts. The teal bar on the HSI (when displayed) shows the VNAV profile.

The Vertical Navigation feature is only available when navigating a Direct To or flight plan, and the ground speed is greater than 35 knots.

The “Approaching VNAV Profile” message appears one minute prior to the initial descent point. The descent angle locks to prevent changes in speed from altering the profile. The VNAV feature does not take into account any changes in groundspeed that occur during the transition from level flight to descent or climb.

3.1 Flight Planning

Introduction

Flight planning on the aera consists of building a flight plan by entering waypoints one at a time and inserting approaches as needed. The flight plan is displayed on maps using different line widths, colors, and types, based on the type of leg and the segment of the flight plan currently being flown.

Up to 50 flight plans with up to 300 waypoints each can be created and stored in memory. One flight plan can be activated at a time and becomes the active flight plan. The active flight plan is erased when the destination is reached and the system is turned off. When storing flight plans with an approach, the aera uses the waypoint information from the current database to define the waypoints. If the database is changed or updated, the aera automatically updates the information if the procedure has not been modified. If an approach is no longer available, the procedure is deleted from the affected stored flight plan(s), and an alert is displayed.

Whenever an approach is loaded into the active flight plan it replaces the destination airport with a sequence of waypoints for the selected approach. The airport must have a published instrument approach and only the final course segment (usually from final approach fix to missed approach point) of the published approach is available in the aera.

4.2 Terrain

- The Terrain function displays altitudes of terrain and obstructions relative to the aircraft position and altitude with reference to a database that may contain inaccuracies. Terrain and obstructions are shown only if they are in the database. Terrain and obstacle information should be used as an aid to situational awareness. They should never be used to navigate or maneuver around terrain.
-

- Note that all obstructions may not be available in the terrain and obstacle database.
- No terrain and obstacle information is shown without a valid 3-D GPS position.
- The aera GPS receiver provides the horizontal position and altitude of the aircraft. Aircraft GPS altitude is derived from satellite position. GPS altitude is then converted to a mean sea level (MSL)-based altitude (GPS-MSL altitude) and is used to determine terrain and obstacle proximity. GPS-MSL altitude accuracy is affected by satellite geometry, but is not subject to variations in pressure and temperature that normally affect pressure altitude sensors. GPS-MSL altitude does not require local altimeter settings to determine MSL altitude. It is a widely-used MSL altitude source.

Terrain and obstacle databases are referenced to MSL. Using the GPS position and altitude, the Terrain feature portrays a 2-D picture of the surrounding terrain and obstacles relative to the position and altitude of the aircraft. GPS position and GPS-MSL altitude are used to calculate and predict the aircraft's flight path in relation to the surrounding terrain and obstacles. In this way, the pilot can view predicted dangerous terrain and obstacle conditions.

Alert windows appear to inform the pilot of proximity to the terrain and obstacles, as well as an unsafe descent rate. These alerts depend on user-defined parameters in the Terrain Setup.

Terrain Information

Two views are displayed by the Terrain function: the Map View, and the Profile View. The areas of the terrain shaded red are predicted to be within 100 feet below or above the aircraft. The yellow terrain areas are between the user-defined Caution Elevation and 100 feet below the aircraft. By default, the Caution Elevation is 1,000 feet; therefore, the areas in yellow are between 1,000 feet and 100 feet below the aircraft. The black areas are further than the Caution Elevation. A projected point of impact is marked with an “X” symbol.

Obstacle Information

Obstacles are shown on the Terrain Map View, at or below the map range of 12 nm. Obstacles are also shown on the Navigation Map when the map range is set to 5 nm or below.

Standard aeronautical chart symbols are used for lighted or unlighted obstacles taller than 200 feet Above Ground Level (AGL). Refer to the Obstacle Icons legend below.

When selecting an obstacle with the Map Pointer, each obstacle displays the altitude at the top of the obstacle, or Mean Sea Level (MSL). Each obstacle also lists the actual height of the obstacle, or Above Ground Level (AGL).

Terrain Alerts & Setup

Enabling/Disabling terrain alerts:

1) From the '**Home**' Screen touch the **Terrain** Icon.

2) Touch the **Menu** Icon.

3) Touch the '**Enable Alerts**' or '**Disable Alerts**' menu option.

Use the Terrain Setup Menu to set levels for terrain alerts as well as obstacles in or near your flight path.

- Caution Elevation—The aera will provide an alert if the terrain or obstacle is within the default Caution Elevation or user-defined Caution Elevation

- Look Ahead Time—Determines the maximum time when an alert annunciation occurs. For example, if 120 seconds is selected, the aera provides an alert up to 120 seconds before you reach the terrain or obstacle

- Alert Sensitivity—The three Alert Sensitivity settings (Terrain, Obstacle, and Descent Rate) determine what level of alerts are annunciated. The aera defaults to 'High' sensitivity, which annunciates all red and yellow alerts at the time set in Look Ahead Time. 'Medium' sensitivity annunciates all of the red and the highest priority of yellow alerts. 'Low' only annunciates red alerts. 'Off' disables the alert.

Terrain, Obstacle, and Descent Rate Alerts are issued when flight conditions meet parameters that are set within the software algorithms. Terrain alerts typically employ a CAUTION or a WARNING alert severity level, or both. When an alert is issued, visual annunciations are displayed and aural alerts are simultaneously issued. When the aircraft descends through 500 feet above the destination airport an audible "Five Hundred" altitude reminder occurs.

The Terrain Alert Annunciation is shown to the lower left corner of the screen. If the Terrain Map is not displayed, a pop-up alert appears. The Range Rings on the pop-up alert are spaced every whole mile/kilometer/nautical mile. Touch the Terrain Alert Annunciation to acknowledge the pop-up and/or aural alert.

Aural Alerts

"Five Hundred"—when the aircraft descends through 500 feet above the destination airport.

The following aural terrain alerts are issued when flight conditions meet parameters that are set within the software algorithms, and are dependant on the sensitivity level set in the Terrain Setup Menu

Alert Severity	Terrain	Obstacle	Descent Rate
Caution	"caution, terrain" "caution, terrain ahead"	"caution, obstacle" "caution, obstacle ahead"	"caution, sink rate"
Warning	"terrain ahead! pull up!" "terrain! terrain! pull up! pull up!"	"obstacle ahead! pull up!" "obstacle! obstacle! pull up! pull up!"	"sink rate, pull up!" "pull up!"

Aural Alerts Summary

1.7 Meteorological Information

1.7.1 Synoptic weather

The Graphical Area of the Satellite image for 1700hrs indicated that the Aberdare region was under the influence of a trough of warm air aloft with overcast low-level clouds.

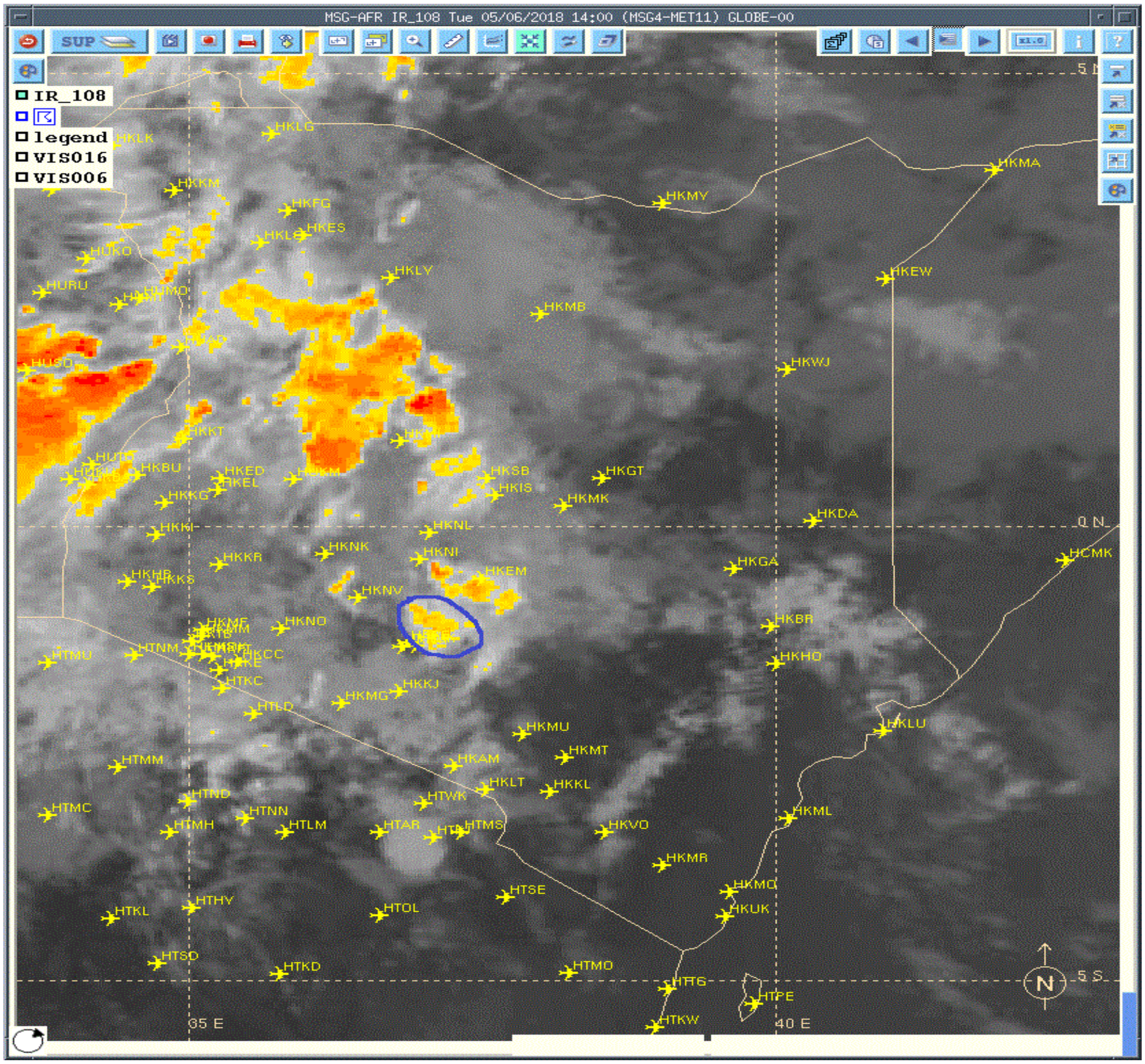


Figure 15: Satellite Image at 05/06/2018: 1700hrs (courtesy of Meteorological Department of Kenya)

Description:

Orange/ brown/ red background: Convective (Thunder) clouds.

White background: Low-level clouds.

Black background: Area with no clouds.

1.7.2 JKIA:

The terminal forecast for JKIA, was valid for the period from 0500hrs until 1700hrs on 05 June. For the period of the flight, the weather was forecast to be wind 220° at 9 knots; visibility more than 10km; sky condition few Cumulonimbus cloud at 2400 feet AGL, broken at 9000 feet AGL., the predicted condition remained essentially the same up to 1730hrs.

1.7.3 Kitale

The aviation routine weather report (METAR) for Kitale, HKKT reported calm wind; visibility more than 10km in light rain; sky condition 1500 feet AGL broken, 8000 feet AGL overcast; temperature 16°C, dew point 16°C.

1.8 Aids to Navigation

1.8.1 HKJK Runway 24 Standard Arrival Chart Instrument RNAV (GNSS) (STAR)-ICAO

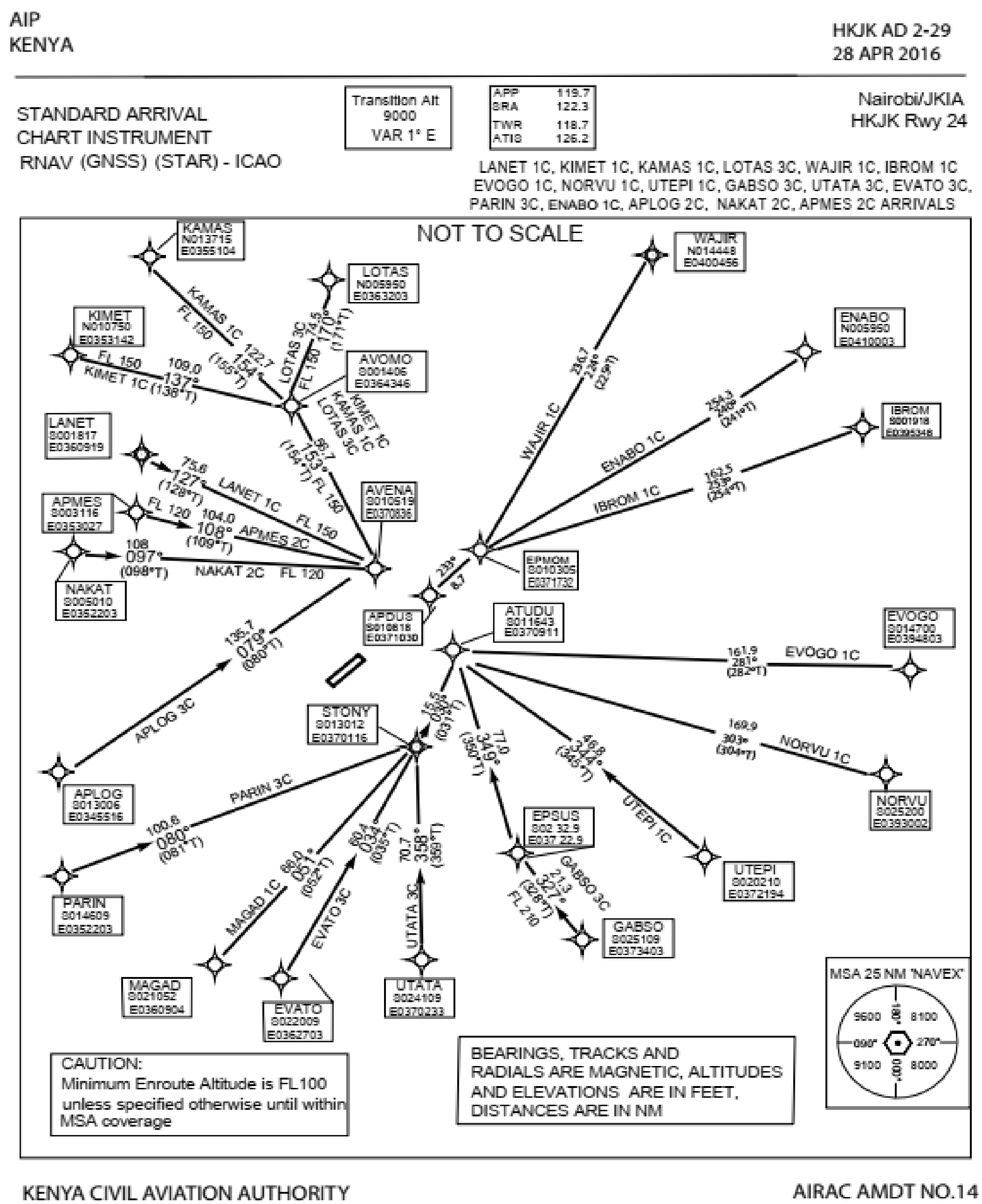


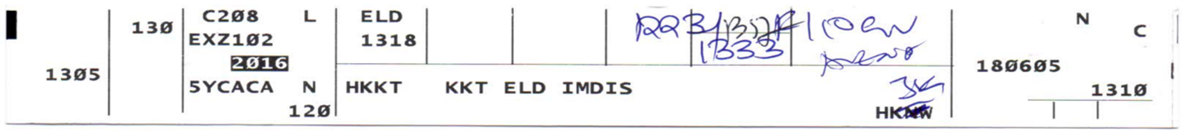
Figure 16: **HKJK Runway 24 Standard Arrival Chart Instrument RNAV (GNSS) (STAR)-ICAO**

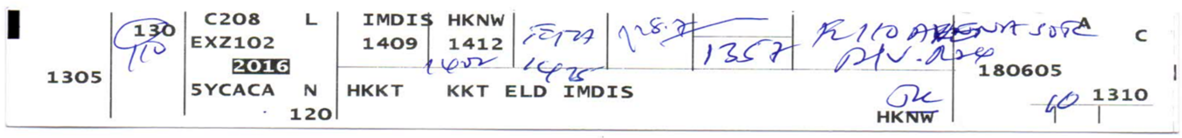
1.9 Communication

5Y-CAC with call sign EXZ102 was first in a two-way radio contact with Eldoret Approach after taking off from Kitale, and then made contact with Enroute North, Jomo Tower, and subsequently Jomo Approach when radar contact was lost. Radar coverage was available in the accident area at the flights' altitudes.

Excerpts from communication logs and transcripts of recordings indicate that 5Y-CAC was airborne Kitale at 1305, with total of one zero on board, requested and was cleared by Eldoret Approach for level one one zero golf victor with three and half hours QBD on sqwuak two zero one six, "subject to own terrain clearance". At 13.15, 5Y-CAC revised to route via AVENA which was cleared by Eldoret Approach.

1.9.1 Communication logs


1305 | 130 | C2Ø8 L | EXZ1Ø2 | 2Ø16 | 5YCACA N | 12Ø | ELD 1318 | HKKT KKT ELD IMDIS | HKNW | N C | 18Ø6Ø5 | 131Ø


1305 | 130 | C208 L | EXZ102 | 2016 | 5YCACA N | 120 | IMDIS 1409 | HKNW 1412 | HKKT KKT ELD IMDIS | HKNW | A C | 180605 | 1310

1.9.2 Transcripts of recordings

RADIO TRANSMISSION BETWEEN ELDORET APPROACH AND EXZ102 ON 5TH JUNE 2018		
TIME(UTC)	**STATION**	**RADIO TRANSMISSIONS**
1306:46	**EXZ**	**Eldoret from twiga one zero two?**
	APP	**Twiga one zero two Eldoret?**
	EXZ	**Good evening, just airborne from Kitale time 1305, a total of…….. A total of one zero on board, we are requesting flight level one one zero golf victor with three and half hours QBD sqwuaking two zero one six.**
	APP	**Twiga one zero two ..Roger, cleared flight level one one zero golf victor subject own terrain clearance and standby for your sqwuak.**
	EXZ	**One one zero to the golf victor subject own terrain clearance standing by sqwuak twiga one zero two.**
1315:21	**EXZ**	**And Eldoret twiga one zero two?**
	APP	**Twiga one zero two?**
	EXZ	**We are zone in this time and requesting to route direct AVENA.**
	APP	**One zero two aah roger..direct AVENA is approved.**
	EXZ	**Direct AVENA is approved and still standing by sqwuak.**
	APP	**Maintain two zero one six.**
	EXZ	**Maintain sqwuak of two zero one six,… twiga one zero two.**
1320:28	**APP**	**Twiga one zero two what is your crossing level radial echo lima delta?**
	EXZ	**Radial zero eight eight.**
	APP	**Roger and distance from echo lima delta?**
	EXZ	**One zero**
1323:16	**EXZ**	**We are crossing your centerline now!**
	APP	**Say again?**
	EXZ	**Just crossing the extended centerline.**
	APP	**Roger**
1323:16	**APP**	**Twiga one zero two next report three zero miles out of echo lima delta.**
	EXZ	**Call you next three zero miles echo lima delta,..twiga one zero two.**
1325:22	**APP**	**Twiga one zero two just confirm the crossing radial now?**
	EXZ	**Crossing zero eight eight.**
	APP	**Roger**
1331:24	**EXZ**	**And Eldoret twiga one zero two distance three zero echo lima delta.**
	APP	**One zero two…….roger released to Nairobi one two one decimal three have a good evening.**
	EXZ	**Released to Nairobi on one two one decimal three good evening,…..twiga one zero two.**
KEY: APP-Eldoret approach, EXZ – EXZ102 (Twiga One Zero Two). All times are in UTC		

TAPE TRANSCRIPT EXZ102 5YCAC C208
HKKT-HKJK 5 June 2018

13:08:03	ENRT NORTH	HKEL	Yes, Eldoret	TL
13:08:07	HKEL	ENRT NORTH	We have twiga one zero two airborne Kitale one three zero five for Nairobi Wilson, requesting one one zero	TL
13:08:15	ENRT NORTH	HKEL	one one zero golf victor for Nairobi Wilson	TL
13:08:19	HKEL	ENRT NORTH	Golf victor one one zero, thank you, squawking two zero one six now	TL
13:08:23	ENRT NORTH	HKEL	Twiga one zero two?	TL
13:08:25	HKEL	ENRT NORTH	Yes its a Charlie two zero eight	TL
13:08:28	ENRT NORTH	HKEL	Ati seven?	TL
13:08:30	HKEL	ENRT NORTH	Squawking two zero one six	TL
13:08:33	ENRT NORTH	HKEL	Hhmmm break break ….	TL
13:08:35	HKEL	ENRT NORTH	And type is a Charlie two zero eight five yankee Charlie alpha Charlie	TL
13:08:38	ENRT NORTH	HKEL	Ahh *kumbe ni ndege ndogo sawa*	TL
13:08:41	HKEL	ENRT NORTH	*Haya*	TL
13:32:37	EXZ102	ENRT NORTH	Area north twiga one	
13:32:58	ENRT NORTH	BROADCAST	Calling	
13:33:01	EXZ102	ENRT NORTH	Twiga one zero two good evening	
13:33:03	ENRT NORTH	EXZ102	Good evening to you climb flight level one three zero to the golf victor	
13:33:11	EXZ102	ENRT NORTH	Confirm one three zero golf victor?	
13:33:14	ENRT NORTH	EXZ102	Affirm, for visual break Nairobi Wilson	
13:33:18	EXZ102	ENRT NORTH	Ehh we are landing in Jomo	
13:33:23	ENRT NORTH	EXZ102	I copied to Jomo fly direct AVENA	
13:33:29	EXZ102	ENRT NORTH	Direct AVENA one one zero maintaining	
13:33:34	ENRT NORTH	EXZ102	(unintelligible)	
13:49:54	ENRT NORTH	EXZ102	Twiga one zero two Nairobi	
13:49:57	EXZ102	ENRT NORTH	Go ahead for twiga one zero two	
13:49:59	ENRT NORTH	EXZ102	VFR traffic twelve o'clock fifteen correction seven miles at level one one five	
13:50:06	EXZ102	ENRT NORTH	Ok copied traffic twiga one zero two	
13:50:08	ENRT NORTH	EXZ102	Thats correct confirm your destination is Jomo or Wilson	
13:50:12	EXZ102	ENRT NORTH	Destination is Jomo	
13:50:14	ENRT NORTH	EXZ102	Roger proceed to AVENA	
13:50:19	EXZ102	ENRT NORTH	Direct AVENA twiga one zero two	
13:55:55	ENRT NORTH	EXZ102	Twiga one zero two contact radar one two two decimal three	
13:55:59	EXZ102	ENRT NORTH	One two two three good evening twiga one zero two	
13:56:01	ENRT NORTH	EXZ102	Good evening	
13:56:21	EXZ102	APPROACH	And radar from twiga one zero two good evening	
13:56:35	APPROACH	BROADCAST	Break break other calling … traffic calling	
13:56:37	EXZ102	APPROACH	Twiga one zero two good evening	

13:56:39	APPROACH	EXZ102	Twiga one zero two good evening golf victor level correction AVENA one one zero subject to own terrain clearance	
13:56:45	EXZ102	APPROACH	One one zero direct AVENA subject to own terrain clearance twiga one zero two	
13:56:50	APPROACH	EXZ102	Correct confirm destination	
13:56:52	EXZ102	APPROACH	Jomo	
13:56:54	APPROACH	EXZ102	Roger	
14:03:53	APPROACH	EXZ102	Twiga one zero two?	
14:03:58	APPROACH	EXZ102	Twiga one zero two	
14:04:05	APPROACH	EXZ102	Twiga one zero two from radar	
14:04:25	APPROACH	EXZ102	Twiga one zero two radar	
14:04:48	APPROACH	EXZ102	Twiga one zero two how do you read radar	
14:05:55	APPROACH	EXZ102	Twiga one zero two	
14:06:14	APPROACH	EXZ102	Twiga one zero two radar	
14:06:15	TOWER	APPROACH	Yes radar	TL
14:06:16	APPROACH	TOWER	Yeah ehh could twiga one zero two have called you	TL
14:06:20	TOWER	APPROACH	Not yet	TL
14:06:21	APPROACH	TOWER	Not yet?	TL
14:06:23	TOWER	APPROACH	Yes	TL
14:06:24	APPROACH	TOWER	Thank you	TL
14:06:29	APPROACH	SVA433	Saudi four three three	
14:06:31	SVA433	APPROACH	Go ahead Saudi four three three	
14:06:33	APPROACH	SVA433	How is the weather around ehh… the your area?	
14:06:41	SVA433	APPROACH	On the left between ten o'clock and eight o'clock my position ranging for thirty miles we can see some CB	
14:06:53	APPROACH	SVA433	Roger I lost some traffic around that area to your twelve o'clock position around seven miles she was maintaining level one one zero. If you could get in touch with the traffic she is called twiga one zero two	
14:07:07	SVA433	EXZ102	Twiga one zero two how do you read saudi four three three	
14:07:17	SVA433	APPROACH	Ehhh no reply	
14:07:20	APPROACH	SVA433	Ehh Roger	
14:07:28	HKNW	APPROACH	*Jambo* go ahead *umetuita?*	TL
14:07:28	APPROACH	HKNW	Has twiga one zero two called you?	TL
14:07:30	HKNW	APPROACH	Negative negative	TL
14:07:31	APPROACH	HKNW	*Hajakuita?*	TL
14:07:32	HKNW	APPROACH	*Aa aa*	TL
14:08:22	APPROACH	EXZ102	Twiga one zero two radar	
14:08:23	APPROACH	APPROACH	*Eastleigh nao line yao ni mbaya*	FAILED CALL TO HKRE
14:10:01	APPROACH	EXZ102	Twiga one zero two radar	
14:10:03	PRF726	EXZ102	Twiga one zero two from precision air seven two six	
14:13:13	APPROACH	EXZ102	Twiga one zero two	
14:13:20	APPROACH	EXZ102	Twiga one zero two from radar	

1.10 Aerodrome Information

1.10.1 Kitale Airport, (Departure Aerodrome)

Kitale airport is without ATC, but managed and operated by the Kenya Airports Authority. It is located at Coordinates: N0°58.32' / E34°57.51' with an elevation is 6070.0 feet above mean sea level.

Dimensions: 4757 x 75 feet / 1450 x 23 meters
Surface: Hard
Runway: 04/22
Coordinates: N0°58.01' / E34°57.26'
Elevation: 6070
Runway Heading: 040° 220°

Figure 17: Google map showing HKKT aerodrome

1.10.2. Jomo Kenyatta International Airport (Destination Aerodrome)

Jomo Kenyatta International Airport (HKJK) is the country's main international airport operated by Kenya Airports Authority located in Nairobi County. It has a bitumen runway surface length 4117m and width 45m located at WGS coordinates S 01°19'09.2'' E 036°55'39.9'' with an elevation of 5330ft agl. It has PAPI lights on both runway 06 and 24. Runway 06 has Precision Approach Landing Systems (PALS) and runway 24 has Simple Approach Landing Light Systems (SALS).

1.10.3. Clearance issued to 5Y-CAC

The forecast weather that prevailed for the entire day on 5 June 2018 indicated winds 300° at 9 knots. The runway in use at HKJK was 24. 5Y-CAC, inbound JKIA was cleared by Approach at time 16:56 to route direct to AVENA at flight level 110, subject to own terrain clearance in order to initiate an approach to land on runway 24.

1.10.4 Route information

JKIA is located 182 nautical miles (nm) south east of Kitale on a bearing of 142°T. The highest obstacle from Kitale-JKIA route via AVENA stands at 12876 feet .The company operations manual contained a general published guidance on the choice of a suitable flight altitude on any route in order to provide minimum clearance from obstacles. This provides a minimum of 2000 feet of terrain clearance from the highest elevation within the vicinity of the selected route.

1.11. Flight Recorders

The aircraft was not equipped with a flight data recorder or a cockpit voice recorder. Neither recorder was required by the Kenya Civil Aviation regulations to be fitted on the accident aircraft.

1.12. Wreckage and Impact Information

1.12.1 Structural Damage

The Aberdare Ranges is a section of the eastern rim of the Great Rift Valley running roughly north to south. On the west, the range falls off steeply into the Kinangop Plateau and then into the Great Rift Valley. On the east, the ranges slope more gently. The terrain consists of densely covered Bamboo forest with the highest point Mount Satima of the cliff with an elevation of 3,999 metres (13,120) feet above mean sea level. The second-highest peak, at the southern end of the range, is Mount Kinangop at 3,906 metres (12,815 ft). The point of impact was at an elevation of 3,645 metres (11300ft) of the Elephant hill.

Figure 18: Accident site depicting three summits

The general description of the site of the accident depicts three summits; the Elephant hill, the Kinangop and Oldonyolesatima with their respective elevations of 12,145, 12,815 and 13,120 feet above mean sea level

Figure 19: Aerial view of the accident site

The first point of impact was at an elevation of 3,645 metres asl, below the top of the Elephant peninsula. First ground impact was by the landing gear and the belly cargo pod followed by the propeller, all of which separated from the aircraft on impact. The aircraft continued and impacted the rising slope and came to rest in upright position. The cockpit was crushed, and the forward passenger cabin was distorted, with the forward cabin bulkhead mostly dislodged from its attachments. The aircraft seemed to have impacted the obstacle in a straight and level configuration.

The distribution pattern of the wreckage was confined to a distance of 30 metres from the point of first ground impression. Some parts of the wreckage, such as the starboard wing were strewn backwards after the impact because of the high gradient of the locale. The final portion of the flight path and the impact path was the same about 160 degrees. The starboard wing was completely detached from the wreckage and lay on the flight path in an upside down position.

The wreckage had extensive ground impact with no fire damage. Part of the fore main fuselage, cockpit/cabin area, and engine were found embedded in a large crater.

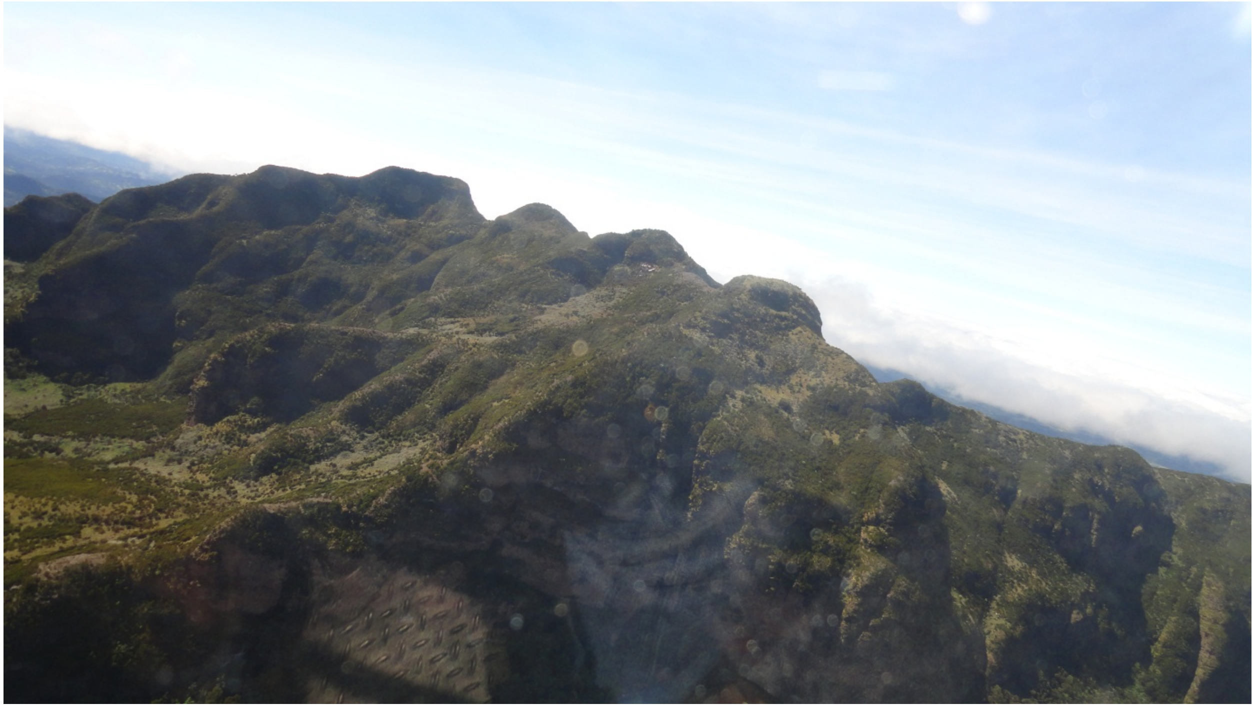
The Pratt & Whitney PT6A-114A turbine engine was found imbedded, horizontally, into the terrain, leaving only the aft portion of the engine accessory gearbox detached and visible.

Portions of the incinerated fuselage structure and the wings of the airplane were in a horizontal, nose-level attitude. The longitudinal axis of the fuselage was oriented on a magnetic heading of about 158 degrees. (All heading/bearings noted in this report are oriented toward magnetic north.)

The entire fuselage of the airplane was separated into several main groups. The wings were separated from the fuselage and displayed extensive span wise, leading-edge-aft crushing and folding.

The forward spar of each wing was compressed to its respective aft spar. The wings were oriented in a horizontal. Each aileron and flap assembly remained attached to the trailing edges of their respective wings with a fifth portion of it partly separated from the wing root. Both wing lift struts were isolated from the wings and fuselage-attach points as a result of the incineration.

The empennage was still intact with bends on the leading edges of the horizontal stabilizer. The Empennage was inclined at 40 degree to the left hand side and located just aft of the incinerated fuselage.



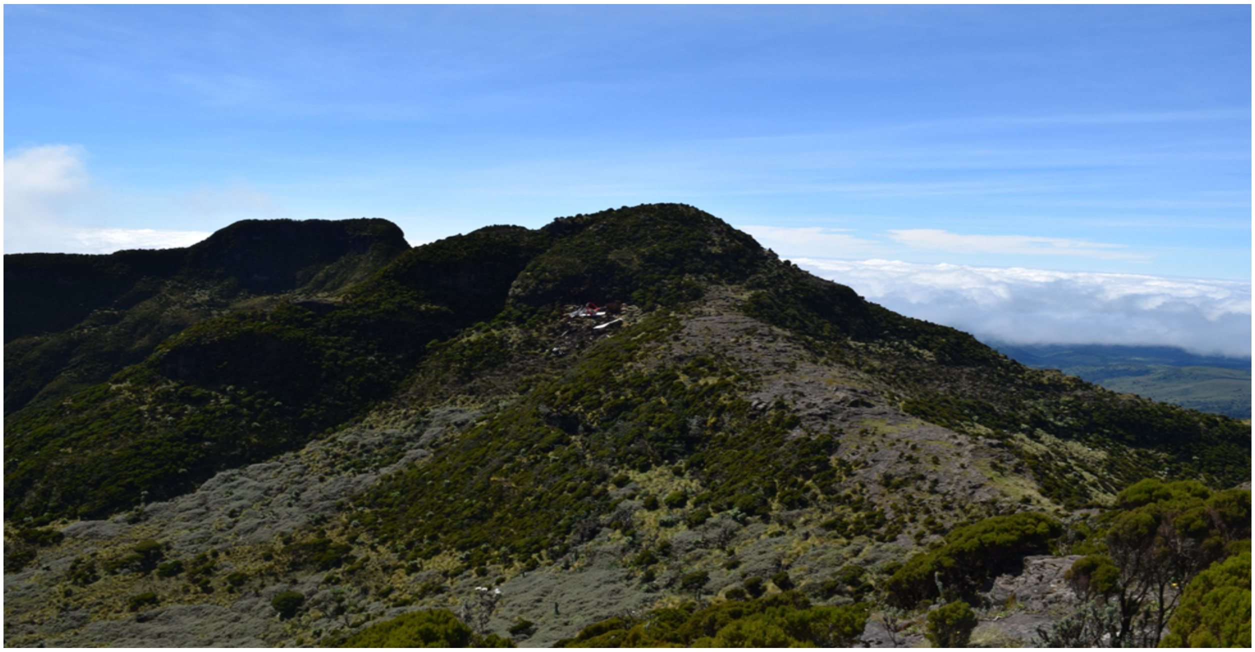


Figure 20: Accident pictures of the site

1.13 Medical and pathological information

There was no evidence that physiological factors or incapacitation affected the performance of flight crew members.

1.14 Fire

There was no evidence of fire in flight or after the impact.

1.15 Survival aspects

5Y-CAC, EXZ102 last communicated to Nairobi Approach at 13:56:52 and thereafter Radar contact was lost. Efforts by Radar to trace EXZ102 by other traffic were unsuccessful. The last radar information recorded indicates that the aircraft was cruising at 156 Knots (289km/h). Onsite examination of the wreckage revealed that the aircraft collided with terrain at a high impact angle. The accident was not survivable. Search and rescue (SAR) exercise coordinated by KCAA that involved the Kenya Wildlife Service (KWS), the Kenya Air Force (KAF), National

Police Services (NPS), the Kenya Forestry Services (KFS) and other State organs was activated immediately. By evening of 5th June, 2018 the search exercise had not yielded any positive results.

The last radio call heard from 5Y-CAC was at 1657hrs on NV Radial 333 with DME of 53 (indicating a distance of 53 miles from NV Ground station) at 11,100ft, Ground speed of 157 Knots and heading 128°. The last known position appearing on the Radar database indicated that 5Y-CAC was on NV Radial 339° 40 DME at 11,200ft Coordinates 004227S 0364201E. The ELT did not deploy as required on impact and therefore it was not effective for the SAR exercise. The forecast weather for the area indicated rain and low level clouds that hampered the search and rescue exercise.

Figure 21: The SAR team accessing the Elephant hill where the crash occurred

The search and rescue exercise resumed at 6.00 am on 6th June, 2018 with a command post being set up at Njambini Primary School for appropriate coordination. The SAR exercise which was being done by both aerial and ground was greatly hampered by rainfall, forest cover, rugged topography, and limited visibility due to fog.

The wreckage was cited by a SAR mission helicopter on 7th June, 2018 at around 0645 hours at Elephant Point in the Aberdare ranges and appropriate teams of ground specialist were directed to the accident location where they accessed the wreckage and found no survivors.

The greatest disintegration occurred to both the exterior and interior of the aircraft from the impact point the nose all the way up to where the empennage is adjoined to the fuselage. The accident was not survivable; the cabin structural integrity was distorted.
It was not possible to establish location of crew members and passengers in relation to injuries sustained. The first responders extricated the bodies from the wreckage. The investigation did not access any pictures taken before the recovery was done.

1.16 TESTS AND RESEARCH

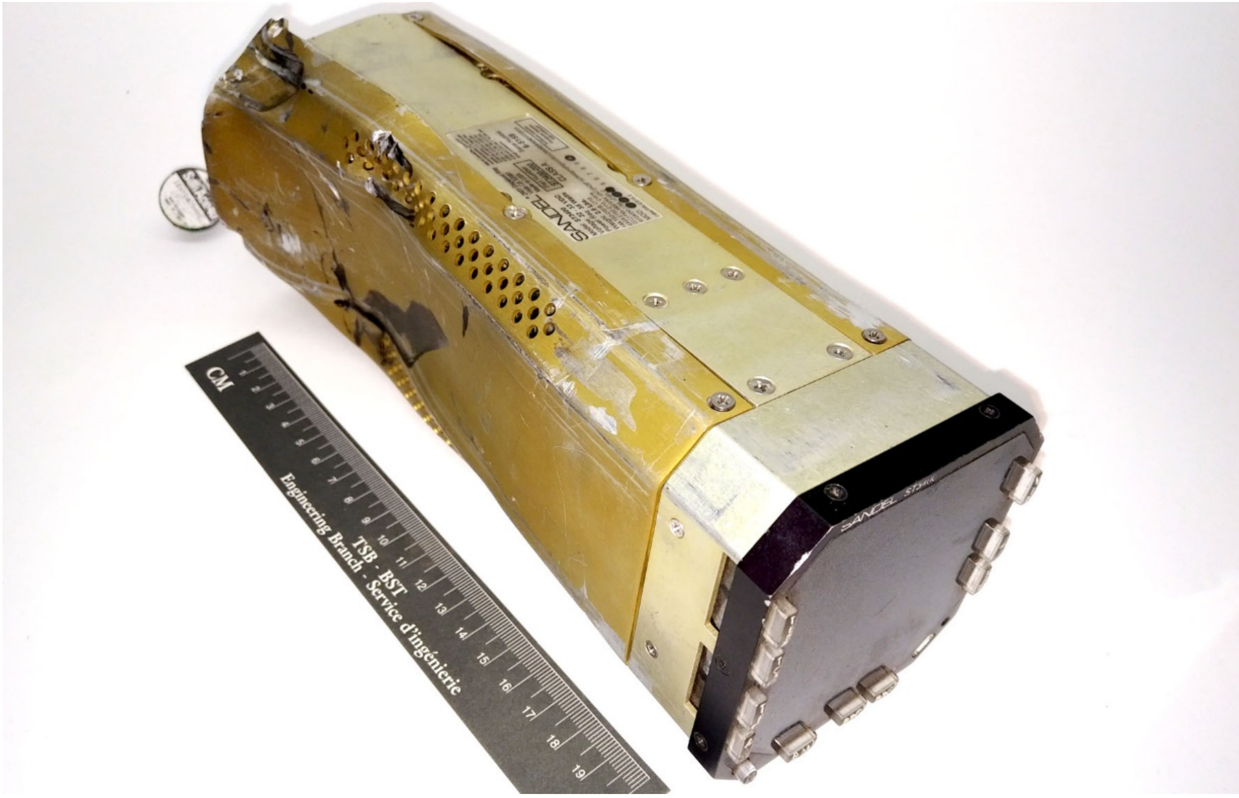
1.16.1 Engineering Services Requested

The terrain awareness and warning system (TAWS) and global positioning system (GPS) receiver were recovered and sent to the Transportation Safety Board of Canada (TSB) Engineering Laboratory to extract any data relevant to the occurrence.

1.16.2 Examination

1.16.2.1 Terrain Awareness and Warning System (TAWS)

The TAWS unit received was significantly damaged with portions of the unit missing. It would not have been possible to repair the unit and power it on to perform a download of the stored data. The motherboard (Figure 2) was removed from the unit and the memory chips were inspected (Figure 3), it was determined that the memory chips were physically undamaged. The four chips were then removed from the circuit board, cleaned, and then reballed.



TAWS as received.

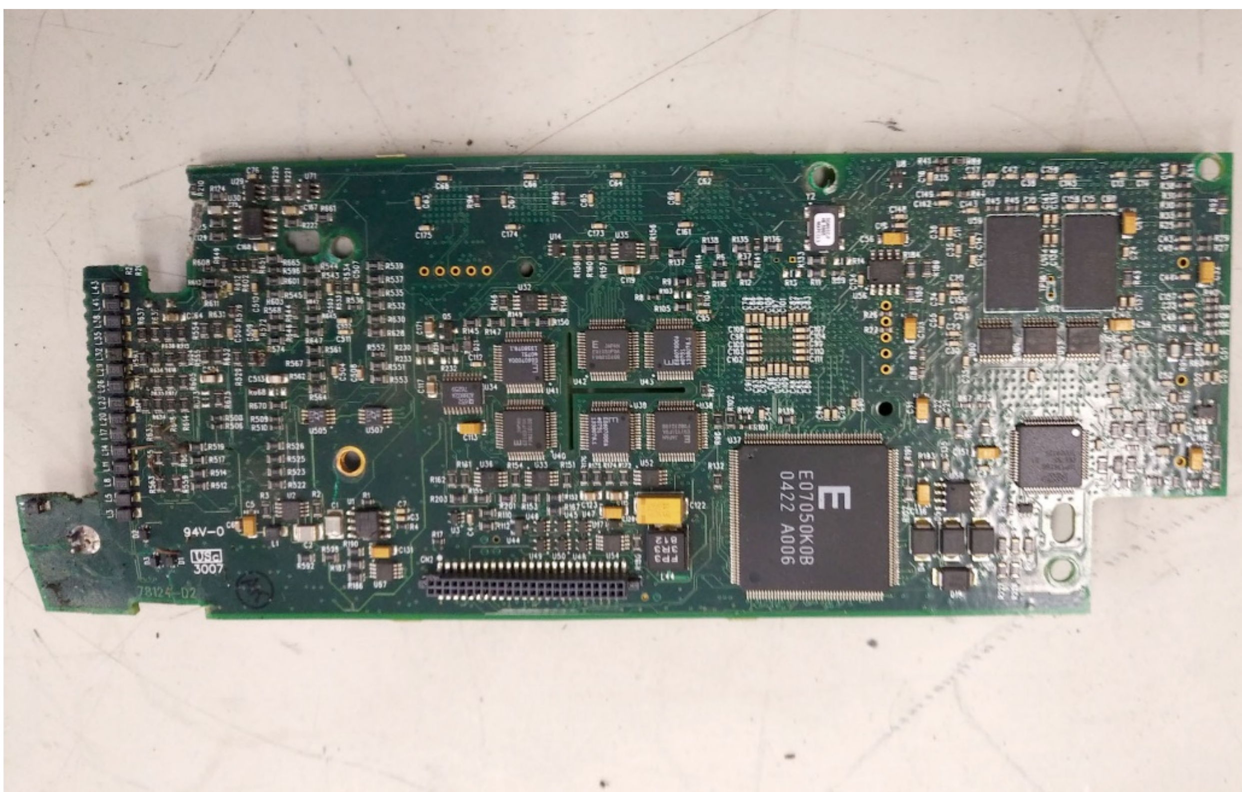


Fig: Damaged motherboard

As the recovery and decoding of the non-volatile memory (NVM) required the memory to read out directly from a functional unit and the use of proprietary software, the reballed chips were taken to Sandel's manufacturing facilities to perform a download of the recorded data on 02 April 2019. Present for the recovery work were representatives from Sandel and the TSB.

A known good lab unit was powered up, its settings were examined, and its memory was downloaded to ensure that it was performing as designed prior to any internal rework that was to be performed, and to see that the settings recorded internally matched the lab unit. The motherboard was removed from the unit, the lab memory chips were removed, and the occurrence memory chips were installed on the motherboard.
The unit was powered up in maintenance mode to prevent the unit from deleting any of the previously recorded data. The settings were examined and it was noted that the parameters now matched the occurrence unit and no longer had the lab unit settings; this confirmed that any data downloaded would be from the occurrence unit.

Settings for occurrence unit

It was noted that in the setup information, the terrain database version loaded into the system was dated 13 October 2008; the newest available version is from 2018. The unit was configured to use units as defined in the following Table.

Table: TAWS Configuration

Input	Configured Unit
Radar Altimeter	KRA405
GPS/FMS1	FreeFlight 1201
GPS/FMS2	None
Speaker Level	20%

All data was successfully downloaded from the unit. The data was then decoded; it included data for four flights, including the last flight, which was determined to be the occurrence flight as it started near the Kitale airport and ended near the occurrence location. The occurrence flight was plotted.

During a review of the data, it was noted that the data field for the radar altimeter remained flagged as “Timed Out” for the entire flight; however, the altitude data appeared to be valid. There was also an issue with the barometric altitude information being fed from the ADS as it did not change significantly during the entire flight. The GPS altitude appeared to be valid.
A terrain caution alert occurred 4 seconds prior to the end of the recorded data; this predictive alert occurs 60 seconds prior to a predicted impact with terrain based on the current flight path. No other cautions or warnings were recorded.

1.16.2.2 Global Positioning System (GPS) Receiver

The GPS receiver

The GPS received was significantly damaged. Some component and board repairs were performed and a lab power supply was connected directly to the main circuit board. The unit was connected to a lab computer and all data was successfully extracted.

The data consisted of 85 waypoints, 50 routes, and 1 track, which comprised 9999 points. The track started at 10:23:53 UTC on 01 June 2018 and ended at 14:00:52 UTC on 05 June 2018. The last flight of the track consisted of 242 points and was consistent with the occurrence flight, starting at 13:01:07 UTC on 05 June 2018, and ending just under 1 hour later at 14:00:52 UTC. The occurrence track was plotted.

Combined plots of the GPS and TAWS data were done. The two data sets matched well; it was noted that the data ended approximately 7 nm from the reported occurrence location.

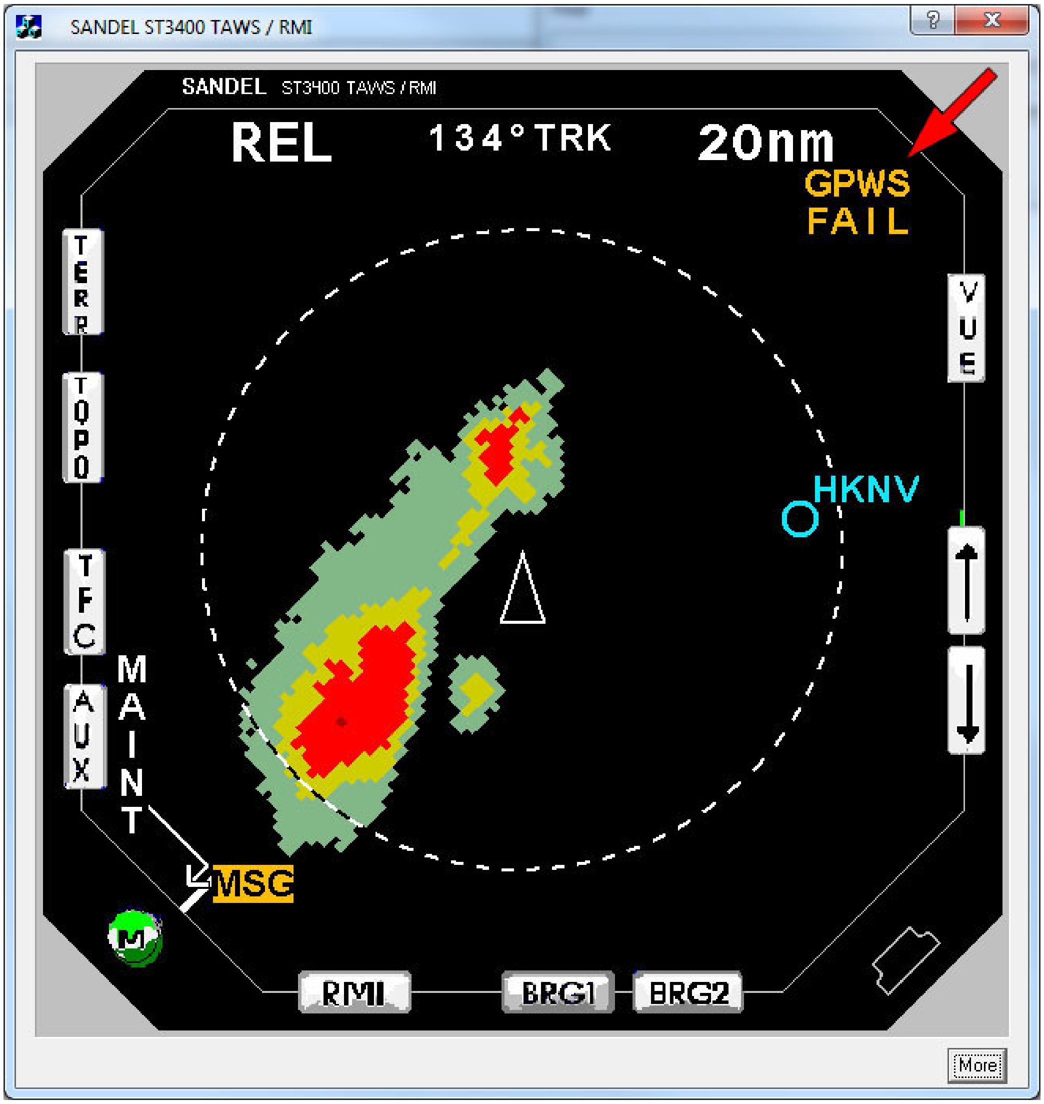
1.16.3 Analysis

All data recorded on both the TAWS and GPS units was successfully extracted.

The terrain database installed in the TAWS unit was 11 years old. The occurrence flight was plotted on both the installed terrain database (2008) and the current terrain database (2018) in the area of the occurrence to determine if there was any discrepancy in the displayed terrain (Figures 14 and 15); there were no significant differences noted. Therefore, the database version would have had no effect on the alerting properties of the unit in the area of the occurrence.

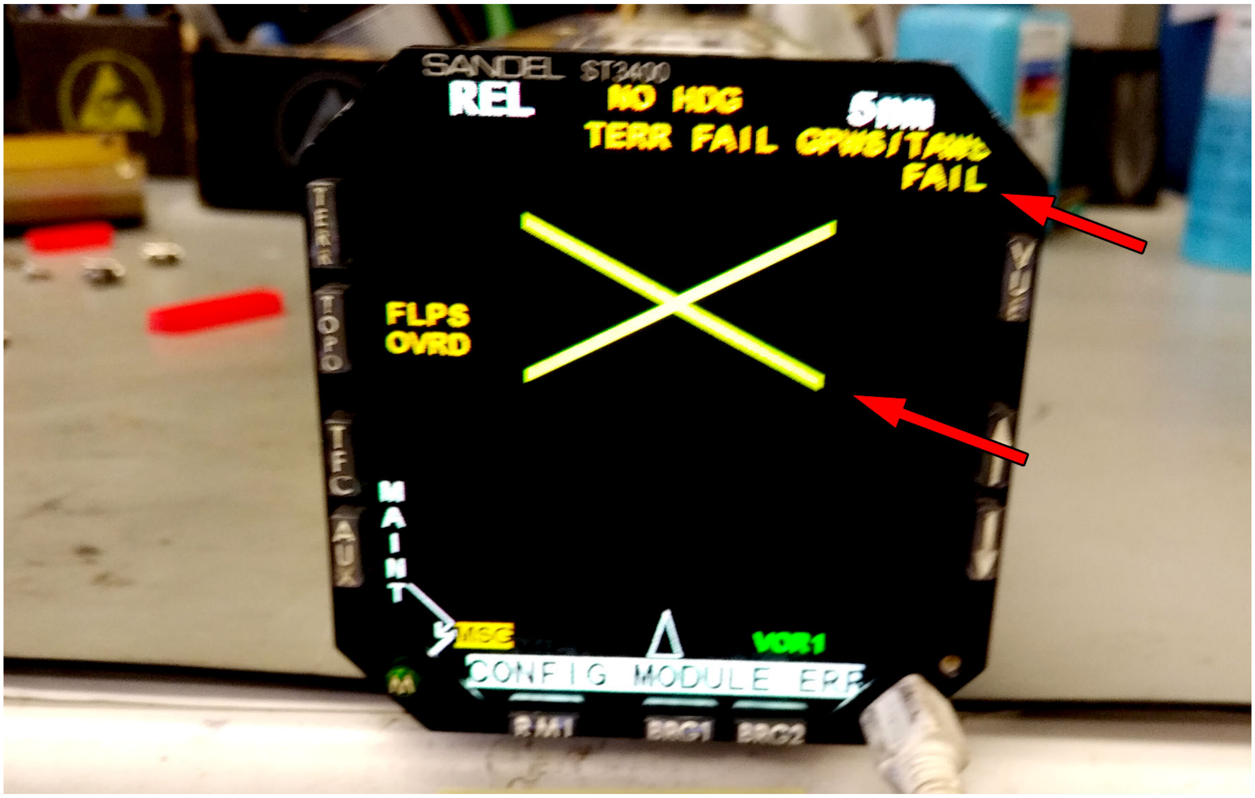
The data for the radar altimeter remained flagged as "Timed-Out" for the entire flight; however, it was still sending altitude information to the TAWS unit. The altitude data coming in matched well with the GPS altitude data, therefore, it appears that the unit was functioning properly in terms of altitude reading. For the data to be flagged as "Valid", the TAWS waits to sense a power line signal, nominally +28V, but can be as low as +9V, to determine that the radar altimeter is being properly powered. If after 6 seconds the unit does not sense this power line signal, the data will be flagged as "Timed-Out". This could possibly be an issue with the connector or wiring from the radar altimeter, or an issue with the sensing circuitry in the TAWS unit. As the TAWS was significantly damaged when received, it was not possible to determine the origin of the fault.

The data from all four flights recorded in the TAWS unit were examined and it was noted that the radar altimeter was timed-out for all four flights and was not unique to the occurrence flight. The failure of the barometric altitude data was also noted on all recorded flights. These failures would have been noticeable to the pilots, as the timed-out state would have produced "GPWS Fail" message on the screen as shown in Figure below;



GPWS failure screen – 20 nm

The relative terrain screens were emulated with the last recorded data from the occurrence flight. It is possible that the missing inputs also induced a TAWS failure which would have produced a large "X" on the top half of the TAWS screen and a "GPWS Fail" message on the screen as shown below, but as there was a terrain caution produced at the end of the flight this mode is unlikely.



TAWS failure screen with "X".

Due to the failed inputs, the unit would default to a Class B installation even though it was configured as Class A; it would still give forward looking alerting as seen by the unit giving a terrain caution alert towards the end of the recorded data.

Both the GPS and the TAWS data for the occurrence flight stop about 7 nm from the occurrence location with the GPS stopping slightly earlier than the TAWS. At the last recorded speed of 155 knots, this would equate to a loss of data of about 2.75 minutes.

The data gap may be possible if both units lost power at the same time, for example if they were both powered by the same source and that source became unpowered. The GPS has a battery that could power it for an extended period (hours), but if the battery were not installed, it could be powered through aircraft power. The TAWS unit does not have a battery. If aircraft power is lost, the GPS will turn off quickly and no further data will be collected, the TAWS has a capacitor that maintains some power (seconds) to the unit to allow it to write any data captured prior to the power loss into its non-volatile memory. It is possible that this could account for the GPS data ending slightly before the TAWS data. The data gap is too long to have been caused by data loss due to impact damage to the units.

1.16.4 Conclusion

All data was successfully extracted from both the TAWS and the GPS received.

The terrain database version installed in the TAWS was a 2008 database; the newest available version is from 2018.

The TAWS had some input failures related to the radar altimeter and the barometric altitude.

The TAWS and GPS occurrence flight data ends about 7 nm from the occurrence site; this equates to a data gap of about 2.75 minutes.

1.17 Organizational and Management Information

1.17.1 East Africa Safari Air Limited (FLYSAX) Operator;

FLYSAX is a Kenyan registered air operator issued with an Air Service License number 1572 issued on 23rd May, 2016, with effect from 17th December, 2015 to 19th July, 2018. The Air Service License number 1572 was granted as a variation of license number 1520. The license entitled FLYSAX to operate C208, DHC8, B1900, DC9, FK28, CRJ, MD87 and BE20 types of aircraft for nonscheduled and domestic scheduled air services for both passengers and freight. Records indicate that the East Africa Safari Air Limited was issued with AOC NO 157 on 1st April, 2018 and was due to expire on 31st March, 2019.

The EASAX management structure includes the Accountable Manager, the Director of Operations, the Chief Pilot Deputy Chief Pilot, Fleet Captain Chief Training Captain Training Captains and Check Captains. The Chief Pilot reports to the Director of Operations and is responsible for ensuring that all East African Safari Air Express (EASAX) pilots and other flight crew are trained and checked to ensure safe and efficient flight operations for the company.

The company's General Operations Manual Part D states that EASAX has developed training syllabi for and checking programmes for all operations personnel assigned to operational duties in the preparation and/or conduct of a flight to meet respective requirement of the KCAA.

1.17.2 Maintenance organization; Five Forty Aviation

Maintenance for the aircraft operator was being handled by Five Forty Aviation KCAA-AMO Approval Certificate No.K/AMO/L/037 which is a sister company of the Aircraft Operator, EASAX. The two companies share the same Accountable Manager. The AMO is suitably staffed and equipped to effectively carry out the tasks it undertakes and utilizes the AMEL system as the basis for maintenance certification.

1.17.3 Kenya Civil Aviation Authority

KCAA discharges its mandate through four directorates: Aviation Safety and Security Regulation, Air Navigation Services, East African School of Aviation and Corporate Services. The Aviation Safety and Security Regulation is responsible for oversight of the aviation industry; the Air Navigation Services and East African School of Aviation Directorates provide Air Navigational services and Aviation Training services respectively. The Corporate Services Directorate provides the shared services for the KCAA. The detailed mandate is provided for in the Civil Aviation Act No. 21 of 2013.

1.3. Functions of the Kenya Civil Aviation Authority

The detailed functions of KCAA as provided for in the Civil Aviation Act No. 21 of 2013 as amended in 2016 are as follows:

i) Licensing of air services;

ii) Provision of air navigation services.

iii) The establishment and maintenance of a system for the registration and the marking of civil aircraft;

iv) Securing sound development of the civil aviation industry in Kenya;

v) Advising the Government on matters concerning civil aviation

vi) Coordination and direction of search and rescue services;

vii) Facilitation and provision of all the necessary support for the aircraft accident and incident investigations conducted by the investigator in charge;

viii) Carrying out investigations on incidents that are not classified as accidents and serious incidents;

ix) Safety, security and economic and technical regulation of civil aviation;

x) Dealing with incidents of unlawful interference with aviation security;

xi) Establishment, coordination and maintenance of State Safety Security Programmes;

xii) Certification of aircraft operators;

xiii) Enforcement of approved technical standards of aircraft;

xiv) Licensing and monitoring of aeronautical personnel;

xv) Provision of technical services for the design; installation, and modification of electronic, radio, and other equipment used in the provision of air navigation services;

xvi) Ensuring integrity of the systems, equipment and facilities of the Authority;

xvii) Issuance and dissemination of the publications referred to in the civil Aviation Act;

xviii) Production of accurate, timely comprehensive and relevant air transport information for planning and decision making purposes;

xix) Approval, certification and licensing of aircraft maintenance organisations and regulation of aviation training institutions

xx) Establishment, management and operation of training institutions for the purposes of the Authority

xxi) Registration of rights and interests of aircraft;

xxii) Planning, development and formulation of the airspace master plan for the safe and efficient utilization of Kenya Airspace;

xxiii) Establishment, coordination and maintenance of state aviation safety and security programmes;

xxiv) Licensing and certification of aerodromes, regulated agents and air navigation service providers;

xxv) Performing economic oversight of air services, protecting consumer rights, environment and ensuring fair trading practices;

xxvi) Giving effect to the Chicago Convention and other international agreements relating to civil aviation to which Kenya is party; and

xxvii) Performance of such other functions as may, from time to time, be conferred on it by the Cabinet Secretary or by any other written law

1.4. Services offered by KCAA

1.4.1. Aviation Safety and Security Regulation (ASSR)

The main function of this directorate is to ensure compliance with the regulations by the industry through development and implementation of an effective aviation safety and security oversight system and carrying out economic regulation of the industry in Kenya. This function is discharged through six departments whose specific functions are listed below:

i) Flight Operations: Responsible for issuance of Air Operators Certificate (AOC), in-charge of aircraft operation safety oversight, approval and monitoring of AOC holder training programmes, station facility inspections, evaluation/approval of flight training simulators and authorisations of Transport of Dangerous Goods by Air;

ii) Airworthiness: Responsible for overseeing aircraft inspections, airworthiness of aircraft approvals, licensing of Aircraft Maintenance Organisations (AMOs) and Aircraft Maintenance Engineers (AMELs), and continual monitoring and surveillance of AMOs, AOCs, Aviation Training Organizations(ATOs) and AMELs;

iii) Personnel Licensing: Responsible for aircraft registration, aviation personnel licensing, surveillance, ATO certification and oversight of aviation medical requirements;

iv) Aviation Security: Responsible for Airport Aviation Security system audits, Operator Aviation Security Programmes approvals, Certification of cargo handlers, Management of the Kenya National Civil Aviation Security Programme, and continual monitoring and surveillance of operators' security programmes oversight of Transport of Dangerous Goods by Air;

v) Aerodrome, ANS and Meteorology: Responsible for Licensing, certification and surveillance of aerodromes, ANS operations and aviation meteorology;

vi) Air transport and Economic Regulation: Responsible for economic regulation of the air transport sector, issuance of air service licenses, ad hoc clearances, aircraft lease approvals, and participation in Bilateral Air Service Agreements (BASAs).

1.4.2. Air Navigation Services (ANS)

This Directorate is responsible for providing air navigation services within the Kenyan airspace and other airspaces delegated to Kenya by ICAO which include:

1.4.2.1. Air Traffic Management Services

There are various types of services offered by air traffic control for the purposes of ensuring safe and expeditious flow of air traffic;

i) En-route Control: These are offered at JKIA by Area Control Centre These services enable aircraft to navigate through the airspace and are backed by ground and space based equipment

ii) Approach Control: these are offered in all the airports manned by KCAA except Lokichoggio and Wajir;

iii) Aerodrome Control: These are offered in all the eight major airports.

iv) Air Traffic Flow Management (ATFM): The objective of this service is to ensure optimum flow of Air Traffic within the region.

v) Search and Rescue: this involves the coordination and direction of search and rescue services with all partner agencies for aircraft in distress.

1.4.2.2. Aeronautical Information Services

These entail timely collection, processing and dissemination of aeronautical data/information on safety, regularity, and efficiency of air navigation. These services are offered through five core units namely:-

i) The International NOTAM Office (NOF): Responsible for the promulgation of NOTAM and facilitates the international exchange of NOTAM;

ii) AIS aerodrome: This facilitates flight plan management and pre-flight briefing services at the 8 airports manned by KCAA;

iii) AIS Headquarters: Responsible for collection, collation, compilation, processing and dissemination of aeronautical data through regular updates to the AIP and issuance of AIP Supplements, Aeronautical Information Circulars and lists of valid NOTAM.

iv) Cartography unit: the unit develops and maintains aeronautical maps and charts, coordinates WGS 84 surveys and manages electronic terrain and obstacle database to support Satellite Based Navigational System.

v) PANS Ops unit: Involved in construction and maintenance of visual and Instrument flight procedures within Kenya airspace.

1.4.2.3. Engineering Services

It is responsible for planning, development, implementation and maintenance of appropriate CNS/ATM facilities in line with ICAO ASBU Methodology. Through aeronautical communications, it is also responsible for reception and transmission of aeronautical information.

1.4.3. The East African School of Aviation (EASA)

The East African School of Aviation is structured into three departments namely; Academics, Finance and Administration, and Business Development. The academic department comprises of three units namely Air Navigation Services (ANS), Aviation Safety and Security (ASS) and Aviation Business Management (ABM).

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The functions of EASA include:-

i) To provide competency based training for the Authority and aviation industry

ii) To develop and implement standardized curricula for aviation professional programme

iii) Establish and implement Training Policies that are relevant to the Approved Training Organization;

iv) To establish &co-ordinate research and development

v) Establish and implement training policies that meet the requirements of TVET

Air traffic services; The ATS is provided by the KCAA, service provider part of the KCAA, headed by a Director. At the time of the accident, when 5Y-CAC disappeared from the radar, it was under one Controller right from the time it was handed over from ENRT North.

Records obtained from the ATS indicated that the Air Traffic Controller who last handled 5Y-CAC when it collided with terrain was born in the year 1974 and employed by the KCAA in the year 2000, having trained and attained Air Traffic License number 781 with Aerodrome control rating issued in 2000. The license entitled the holder to carry out Air Traffic Control Duties under the supervision of a qualified Air Traffic Control Officer, in order to complete the necessary period of training in order to qualify for an Air Traffic Control License. The Approach, Approach radar and Aerodrome ratings were subsequently endorsed in 2003, 2009 and 2013 respectively.

Records indicated that the license has been kept validated since it was first issued by appropriate medical renewals. The last medical examination was done on 21/02/2018 and the license expiry date was 02/03/2019.

KCAA is a Certification, licensing and regulatory authority;

Flight Operations-

Flysax presented a copy of AOC no 157 valid until 31 March, 2019. The file obtained from the certification and licensing authority, flight operations section did not have documented process of the renewal of the current AOC. The AOC Initial/Renewal Inspection Checklist

KCAA/FOPS/AOC/001 dated 05/22/2017 did not have; details of the company pilots/cabin crew/operations or dispatch personnel and the list of aircraft operated by Flysax, nor was there any pertinent list accompanying the document as indicated in the remarks section.

ATS

The Air Traffic Control (ATC) services in Kenya comprise of three separate services, which is provided according to particular circumstances and class of airspace. The service involves:

Aerodrome control service

Aerodrome services are provided at JKIA, MIA, Eldoret, Wilson, Kisumu, Malindi, Wajir and Lokichoggio

Approach control service with or without the use of ATS surveillance systems; Approach Radar Services are provided by an Approach Radar Control unit at JKIA and MIA. In Addition MIA and ELD provides approach non-radar services.

Area control service with or without the use of ATS surveillance systems.

i. Area control service within the Nairobi flight information region comprises radar and non-radar. The area control center (ACC) at JKIA, is sub-divided into 2 sectors; Area North and Area South.
ii. Area controllers provide the following services:
    1. Area Control service,
    2. Flight information service,
    3. Alerting service and assistance to organizations involved in SAR

RADAR SERVICES AND PROCEDURES

1. Radar Operations

Radar unit normally operates as an integral part of the parent ATS unit and provides radar services to aircraft, to the maximum extent practicable, to meet the operational requirement. Many factors, such as radar coverage, controller workload and equipment capabilities, may affect these services, and the radar controller shall determine the practicability of providing or continuing to provide radar services in any specific case.

Nairobi FIR is fully covered with Mode S surveillance radar. Full approach radar services are available within Nairobi TMA daily on a 24 Hour basis. Radar units are situated and classified as follows-:

Nairobi Area radar Unit

Nairobi Approach

Mombasa Radar Unit

Eldoret Radar unit

Nairobi approach control service operates:

a) Station at Nairobi Airport, range 100NM

b) Mua hills 150NM

c) Poror 200 NM

d) Station at Mombasa Airport, covering approach sector to RWY 03.

1.2 The application of radar control service

1.2.1 Radar control service is provided in controlled airspaces to aircraft operating .within the Nairobi TMA, and Mombasa TMA. This service may include:

a) Radar separation of arriving, departing and en-route traffic.

b) Radar monitoring of arriving, departing and en-route traffic to provide information on any significant deviation from the normal flight path,

c) Radar vectoring when required,

d) Assistance to aircraft in emergency,

e) Assistance to aircraft crossing controlled airspace,

f) Warnings and position information on other aircraft considered to constitute a hazard,

g) Information to assist in the navigation of aircraft,

h) Information on the location of heavy precipitation and storms.

j) Conduct of surveillance radar approaches

1.2.2 The minimum horizontal radar separations are:

a) 5 NM when SSR only;

b) 5NM when using primary radar only.

1.2.3 Levels assigned by the radar controller to pilots will provide a minimum terrain clearance according to the phase of flight.

1.2.4 Many factors such as limitations of the radar, weather effects and volume of traffic, may prevent the Radar Controller from providing all or some of these services.

1.2.4.1 The number of aircraft simultaneously provided with radar services shall not exceed that which can safely be handled under the prevailing circumstances, taking into account:

a) The structural complexity of control area or sector concerned;
b) the radar functions to be performed within the control area or sector concerned;
c) assessments of controller workloads and sector capacity;
d) The degree of technical reliability and availability of the main radar and communication systems;
e) the possibility of a radar equipment failure or other emergency that would eventually require reverting to back-up facilities and/or non-radar separation; and
f) the degree of technical reliability and availability of the back-up radar and communication system

1.2.5 Radar separation from unidentified aircraft will normally be provided except:
In the sector of Area III of Nairobi Control Zone located above Area II, when the unidentified aircraft are assumed to be operating to and from Wilson Aerodrome at a restricted altitude within the promulgated confines of Area II.

1.2.6 General radar services will be provided;
a) at the request of the aircraft;
b) at the request of the procedural controller.
c) at the stipulated time of full radar environment

1.2.7 Terrain Clearance

1.2.9.1 After identification, levels assigned by Radar Controllers on the en route, initial intermediate and departure phases will provide 1000 feet vertical clearance above any fixed object within 5NM of the track of the aircraft.

2. Data link services in the Nairobi Flight Information Region (FIR)

2.1 Introduction

2.1.1 Data link services are available to FANS1/A equipped aircraft operating in the Nairobi FIR on a 24-Hr basis.

2.1.2 Controller Pilot Data Link Communications (CPDLC) and Automatic Dependent Surveillance- Contract (ADS-C) data link applications will be used to provide services to FANS 1/A equipped aircraft, in the designated oceanic area as a primary means of communication. Elsewhere the services will be available as secondary means of communication.

2.1.3 The designated primary data link airspace is in the oceanic area of the Nairobi FIR from FL245 to unlimited. The lateral limits are S020113.57 E0440019.65, S083400.85 E0440002.22, S043958.97 E0395426.94, S043944.41 E0391245.23, S024454.51 E0400620.28, S013631.95 E0413441.34, S014501.81 E0414100.72, S020113.57 E0422409.80 to S020113.57 E0440019.65 (See ENR 6-5 - Data link airspace in the designated oceanic area of Nairobi FIR)

2.1.4 The Data link services will not affect current procedures for non-data-link equipped aircraft operating in Nairobi FIR.

2.1.5 Messages will be transferred by satellite data links.

2.1.6 CPDLC will be used for the following services:

i. Controller to Pilot uplink of ATC clearances and instructions;

ii. Pilot to controller downlink of position reports and clearance requests;

iii. Free text as a supplement to pre-formatted message elements.

iv. The use of free text message elements shall be restricted to non-routine and emergency situations.
v. Alerting services and Emergencies.

2.1.7 The provision of Pre-Departure Clearance (PDC) via CPDLC will NOT be available.

2.1.8 ADS-C will be used for the following services
i. Automatic reporting by the aircraft Flight Management System (FMS) of aircraft position and intent information. The FMS will report the required information in accordance with parameters selected by ground system.
ii. Alerting services and Emergencies.

2.3 CPDLC APPLICATION

2.3.1 Aircraft having established data link connections will maintain CPDLC as the primary means of communication in the designated primary data-link airspace.

2.3.2 When using CPDLC, VHF or HF voice frequencies will be used as back-up communication medium.

2.3.3 To ensure correct synchronization of messages, controller/pilot dialogue opened by voice must be closed by voice and dialogue open on CPDLC must be closed by CPDLC except in emergency.

2.3.4 Due to inherent integrity checks and a coded reference to any proceeding related messages contained within CPDLC messages, a clearance issued by CPDLC requires only the appropriate CPDLC response.

2.3.5 To avoid potential ambiguity, the use of multiple message elements should be avoided, except when message elements are dependent on each other.

2.3.6 If multiple clearance requests are contained in a single downlink message and the controller cannot approve all requests, the uplink message will be sent as a response to the entire message. A separate message containing a response to those requests that can be complied with will be sent by the controller.

2.3.7 If any ambiguity exists as to the intent of a particular message, clarification should be sought by voice.

2.3.8 Standard pre-formatted message elements will be used whenever possible. Free text messages SHOULD ONLY be used when an appropriate pre-formatted message element does not exist or to supplement the pre-formatted message element.

2.3.9 The use of free text should be kept to a minimum.

2.3.10 When CPDLC connection is established, aircraft will be instructed to transfer from voice to CPDLC. The phraseology used is: to Nairobi control on datalink monitor. (Frequency).

2.3.11 CPDLC connections will be terminated at the FIR Boundary position or as instructed by the ATS Unit.

2.3.12 The contact (unit/name) (frequency) message and the END SERVICE message will be sent as separate messages. The END SERVICE message will be sent as soon as possible after receipt of the WILCO response message to a contact message.

2.3.13 Pilots shall ensure that all uplink messages have been responded to before termination or transfer of CPDLC to another data authority.

2.3.14 When CPDLC fails and communication reverts to voice, all CPDLC messages outstanding should be considered not delivered and effort made to re-commence dialogue by voice (VHF or HF).

2.4 ADS-C Application

2.4.1 ADS Periodic and events contracts will be established automatically after a successful LOGON.

2.4.2 The periodic reporting interval is 15 minutes and the event reporting is compulsory reporting points.

2.4.3 The periodic reporting interval may be varied by ATC for a specified period when need arise.

2.4.4 ADS Contract connections will be terminated at the FIR Boundary position or as instructed by ATS Unit.

1.18 Additional information

On Saturday 19 July 2003, at approximately 18:00 aircraft type Swearingen SA226-TC Metro II Registration ZS-OYI serial number TC-349 with two Garrett TPE331-3UW-303G engines operated by Ryan Blake Air Charter crashed on Mount Kenya with 14 people suffering fatal injuries.

The Swearingen Metro plane, carrying 12 American tourists and two South African crew members, departed Nairobi-Wilson Airport at 15:58 for a flight to the Samburu national park. The flight plan was to allow the crew to fly round Mount Kenya before landing at a private airstrip in the game park.

The airplane crashed into the eastern slope of Point Lenana (16,450 feet), which is the third highest peak of Mount Kenya. The crash site was located approx. 450 feet below the snow-capped top. Debris scattered into the adjacent valleys of the peak, and then burnt throughout the night.

Investigation established the probable cause of the accident was the pilots' failure to maintain horizontal and vertical situational awareness of the aircraft's proximity to the surrounding terrain, resulting in inadequate clearance, and controlled flight into terrain

And the contributing factors:

Unfamiliarity with the airspace and the route in particular and the existence of high ground on the planned flight route.

Inadequate flight planning by the pilots and distraction of their attention when they were instructed to contact Nanyuki.
Poor pilot briefing by the Wilson ATC briefing office.
Poor communication between the air traffic control units.
Failure of the radar controller to advise the pilot of termination of radar service.
Lack of a radar system minimum safe altitude warning to the radar controller
Poor civil military coordination during transit through the military airspace.

2.0. ANALYSIS

When 5Y-CAC departed for JKIA, the route weather was IMC persisted by both Low cloud and low visibility for the entire flight.

The conduct of the flight and the nature of the impact were characteristic of a CFIT event: the aircraft struck rising terrain under the pilot's control at cruise speed, with a wings-level attitude and a heading generally consistent with the direct track to the destination-AVENA, the navigation fix point. Because no effective evasive manoeuvres were made before impact, it is likely that the crest of the Elephant Peninsula was obscured in fog, and not visible to the crew.

2.1.1. The Pilot in Command

The pilot was born in 1988 and obtained her CPL in South Africa in 2009 and converted to a Kenyan CPL in 2010. The C-208 type rating was endorsed on her CPL in 2010, became a command pilot on the Cessna 208 Caravan with Flysax in 05/09/2017. There were no limitations on her Class 1 medical certificate which was valid until 11th April, 2018.
There was no evidence of any pre-existing medical or behavioural conditions which may have adversely affected the pilot's performance during this flight. Training records show that the pilot went through fire fighting drills, aviation security, dangerous goods and crew resources management. She had 2450 total flying time and approximately 1200hrs on the Caravan, with 750 hours being command time. The last Aircraft Proficiency Check (APC) and Instrument

Proficiency Check (IPC) were successfully done on aircraft type on 5th September, 2017 and 11th April, 2018 respectively.

2.1.2. The Second Pilot

The pilot was born in 1992, acquired her CPL in 2016, and obtained a Cessna 208 Caravan rating on 20th April, 2017. There were no limitations on her Class 1 medical certificate which was valid until 15 September, 2018.

There was no evidence of any pre-existing medical or behavioural conditions which may have adversely affected the pilot's performance during this flight.

There were no Training records to show that all required training was successfully completed.

She had 2396:00hrs total flying time and approximately 1200hrs on the Caravan, with 750hrs being command time.

The last Aircraft Proficiency Check (APC/IPC) was successfully done on aircraft type on 30th December, 2014. The next check was due in July 2015.

Route and airstrip checks were regularly done.

Her last Route and Airstrip Check to Matthews Ridge was done on 1

6th April, 2014 and the next check is due on 1stMay, 2015.

He was qualified and experienced to conduct the flight.

2.2. The Aircraft

Review of the airplane's maintenance records indicated that the aeroplane was certified, equipped, and maintained in accordance with existing regulations and approved procedures. It had no known mechanical discrepancies with the airframe, engine, or propeller before the first flight of the day, and at the time of the occurrence the aircraft weight and balance was within the prescribed limits. There was no indication of pre-impact structural failure or failure of flight control systems. Damage to the propeller and engine indicated that the engine was developing power, and that immediately before impact high engine power had been applied. Maintenance records indicated that the aircraft was maintained as per the established procedures. The aircraft's Certificate of Airworthiness was due for renewal on 17th August, 2018. There was no documented mechanical problem that could have contributed to this accident. The aircraft mass and balance was within the prescribed limit. The fuel onboard the aircraft was sufficient for the flight from Kitale to JKIA.

5Y-CAC was installed with ST3400 type of terrain awareness and warning systems (TAWS) serial number 00065159 as and an effective, last line of defense against CFIT accident. These systems are designed to provide aural and visual alerts to flight crews when the path of the aircraft is predicted to collide with terrain, water or obstacles, allowing the flight crew sufficient time to take evasive action. In the accident flight, a terrain caution alert occurred 4 seconds prior to the end of the recorded data; this predictive alert occurs 60 seconds prior to a predicted impact with terrain based on the current flight path. No other cautions or warnings were recorded.

2.3. The East African Safari Air Limited Company

Records retrieved from KCAA Form KCAA/FOPS/AOC/OO1 for AOD renewal dated 22nd May, 2017 indicated that the senior technical staff of the company were found to be qualified and skilled for their various portfolios. The Accountable Manager also doubles as the Director of Operations. The relevant form for AOC and COA submitted to KCAA by EASA did not enlist the company pilots and other company operations/dispatch personnel. According to the company's manual, the minimum safe altitudes to be flown between two fixes that meets obstacle clearance requirements is computed from current ONC or WAC charts.

2.4. Meteorological Information

The Meteorological Weather forecast issued by the Meteorology Department of Kenya was as follows:
Weather Forecasts for 5th June, 2018
Over Western, Nyanza, Central and South Rift Valley regions (in which Kitale lies) rains were expected over few places in the morning while showers and thunderstorms were expected over several places in the afternoon.
Over Central, Nairobi and parts of the Eastern Regions (where JKIA and 004227S 0364201E lie) the morning was expected to be cloudy with rains over few places giving way to sunny intervals.

Showers were expected over several areas in the afternoon. The department further issued an advisory note:

A Heavy Rain Advisory was also issued on 4th June, 2018 at 0900 UTC warning of heavy rainfall of more than 40mm in 24 hours that was expected to occur from the afternoon of Monday 4th June, 2018 to Wednesday 6th June, 2018 in parts of Central and North Rift Valley, Northern and Central highlands regions. The counties that were expected to be affected included Turkana, Marsabit, Samburu, West Pokot, Elgeyo Marakwet, Trans Nzoia, Uasin Gishu, Bungoma, Baringo, Nakuru, Laikipia, Isiolo, Nyandarua, Kirinyaga, Meru, Tharaka Nithi, Embu, Kiambu, Nairobi, Murang'a and Nyeri.Weather conditions at the destination were reported by a lay person. This individual reported the weather as being "85%, light rain in and out, clearing." This is interpreted as 85% cloud coverage with rain moving in waves across the area, which was reportedly an improvement from 1½hrs earlier.

The investigation did not establish the availability of the forecast weather to the pilots.

2.5. ATC Clearance

5Y-CAC having departed Kitale to JKIA was routed to fly via a navigation Fix point 'AVENA' in order to execute landing on runway 24. This was necessitated by the prevailing weather of the day at that time. 5Y-CAC was flying IFR and ATC approved the request to maintain FL110, to AVENA.

Nairobi Flight Information Region (FIR) is covered entirely by surveillance systems. Flights occasionally are sanctioned by ATC to operate below minimum sector altitudes under IFR 'Subject to Own Terrain Clearance', a procedure that is termed as good practise, but not documented in ATC operations manual.

This clearance is similar to the issued to aircraft type Swearingen SA226-TC Metro II Registration ZS-OYI serial number TC-349 with two Garrett TPE331-3UW-303G engines operated by Ryan Blake Air Charter crashed on Mount Kenya with 14 people suffering fatal injuries on 19 July 2003, at approximately 18:00 as described in section 1.18.

Information received regarding ATC clearance 'Subject to Own Terrain Clearance' for IFR operation makes presumption that traffic should do so under Visual Meteorological Conditions (VMC). Those flights should be cleared by ATC Subject to Own Terrain Clearance. Where unable, the flights should proceed under Visual Flight Rules. In essence, if the pilot is unable to maintain VMC, then she has to fly IFR above minimum sector altitudes.

2.6. KCAA Surveillance

A review of KCAA surveillance activities revealed that aviation safety inspectors had performed numerous inspections and repeatedly noted deficiencies within the company. Enforcement Information System records indicated that KCAA inspectors observed multiple incidences of the operator's noncompliance related to both CoA and AOC applications; however, the non-satisfactory issues were left unclosed with no action taken. Therefore, although KCAA inspectors were providing surveillance and noting discrepancies within the company's procedures and processes, the KCAA did not hold the operator sufficiently accountable for correcting the types of noted deficiencies.

2.7 JKIA Radar Service

JKIA is served by Primary Surveillance Radar (PSR), Secondary Surveillance Radar (SSR), and Surface Surveillance Radar (SMR). The PSR was not serviceable at the time of the accident. Investigations established that PSR system was not in operation since 2nd October, 2017. The SMR was operating, but relying on only one channel because of a faulty antenna motor number one channel.

2.8. The Aerodrome

The Kenya AIP JKIA approach chart shows that IFR traffic enroute AVENA on a track of 153 should fly at FL 150.

The scheduled passenger flight departed Kitale for JKIA. The weather on this material day was wet and cloudy and deteriorated. The pilot requested and received IFR clearance from Eldoret

Approach into JKIA, the destination airport via AVENA at FL 110. Review of the data captured by both the radar and GPS showed that, after the clearance was issued, the airplane's track proceeded in a direct line to AVENA, a navigation fixed point to destination airport runway 24.

Post-accident examination of the accident location indicated that the pilot appeared to be in control of the airplane up to the point of impact. Given the restricted visibility due to fog that prevailed at the time and location of the accident; the pilot likely lost situational awareness of the airplane's geographic position which led to subsequent controlled flight into terrain.

The terrain awareness and warning system (TAWS) and global positioning system (GPS) receiver were recovered and sent to the Transportation Safety Board of Canada (TSB) Engineering Laboratory to extract any data relevant to the occurrence. The terrain database installed in the TAWS unit was 11 years old. The occurrence flight was plotted on both the installed terrain database (2008) and the current terrain database (2018) in the area of the occurrence to determine if there was any discrepancy in the displayed terrain (Figures 14 and 15); there were no significant differences noted. Therefore, the database version would have had no effect on the alerting properties of the unit in the area of the occurrence.

The data for the radar altimeter remained flagged as “Timed-Out” for the entire flight; however, it was still sending altitude information to the TAWS unit. The altitude data coming in matched well with the GPS altitude data, therefore, it appears that the unit was functioning properly in terms of altitude reading. For the data to be flagged as “Valid”, the TAWS waits to sense a power line signal, nominally +28V, but can be as low as +9V, to determine that the radar altimeter is being properly powered. If after 6 seconds the unit does not sense this power line signal, the data will be flagged as “Timed-Out”. This could possibly be an issue with the connector or wiring from the radar altimeter, or an issue with the sensing circuitry in the TAWS unit. As the TAWS was significantly damaged when received, it was not possible to determine the origin of the fault.

The data from all four flights recorded in the TAWS unit were examined and it was noted that the radar altimeter was timed-out for all four flights and was not unique to the occurrence flight. The failure of the barometric altitude data was also noted on all recorded flights. These failures would have been noticeable to the pilots, as the timed-out state would have produced “GPWS Fail” message on the screen as shown in Figures 16 and 17; these relative terrain screens were emulated with the last recorded data from the occurrence flight. It is possible that the missing inputs also induced a TAWS failure which would have produced a large “X” on the top half of the TAWS screen and a “GPWS Fail” message on the screen as shown in Figure 18, but as there was a terrain caution produced at the end of the flight this mode is unlikely. Due to the failed inputs, the unit would default to a Class B installation even though it was configured as Class A; it would still give forward looking alerting as seen by the unit giving a terrain caution alert towards the end of the recorded data.

Both the GPS and the TAWS data for the occurrence flight stop about 7 nm from the occurrence location with the GPS stopping slightly earlier than the TAWS. At the last recorded speed of 155 knots, this would equate to a loss of data of about 2.75 minutes.

The data gap may be possible if both units lost power at the same time, for example if they were both powered by the same source and that source became unpowered. The GPS has a battery that could power it for an extended period (hours), but if the battery were not installed, it could be powered through aircraft power. The TAWS unit does not have a battery. If aircraft power is lost, the GPS will turn off quickly and no further data will be collected, the TAWS has a capacitor that maintains some power (seconds) to the unit to allow it to write any data captured prior to the power loss into its non-volatile memory. It is possible that this could account for the GPS data ending slightly before the TAWS data. The data gap is too long to have been caused by data loss due to impact damage to the units. 2.1.8 A terrain caution alert occurred 4 seconds prior to the end of the recorded data; this predictive alert occurs 60 seconds prior to a predicted impact with terrain based on the current flight path. No other cautions or warnings were recorded.

According to the ST 3400 manual; during enroute operations, a caution typically occurs approximately 60 seconds ahead of the terrain conflict. A caution will turn into a warning if evasive action is not taken. During other operations the alert times are shorter but cautions are always designed to occur prior to warnings. A warning does not indicate a higher severity of threat, but simply that less time exists for evasive action. The ST3400 is not the pilot or the pilot’s judgment; it is a display and computer. However, because it is designed to only alert when the aircraft is outside normal flight envelopes in relation to terrain, we recommend that all

alerts should result in immediate and appropriate action by the pilot. A Warning should always result in an evasive maneuver.
The investigation did not establish why the crew did not react to the terrain caution alert towards the end of the recorded data. Pilots should train to react properly to all alerts, cautions and warnings, just as one would train to react to an aircraft stall, engine failure or any other emergency situation.

Various attempts by Nairobi Approach to contact the pilot by radio went unanswered. When there was no forthcoming response from the aircraft, both the GSM and the aircraft flight tracking software were used to locate the last point of signal emission and noted that the airplane's last reported position was in the area of the airplane's observed flight path.

The search and rescue team proceeded to search the area where they believed the airplane was located as per the last signal received by both the GSM provider and the radar.

The wreckage was located from aerial view and found at 0645LMT on 7^{th} June, 2018 by a search and rescue mission helicopter.

Post-accident examination of the airframe and engine of the aircraft revealed no mechanical malfunctions or anomalies that would have precluded normal operation.

According to the company's General Operations Manual (GOM), operational control was held by the flight coordinator for the accident flight, and the flight coordinator and pilot-in command (PIC) were jointly responsible for preflight planning, flight delay, and release of the flight, which included the risk assessment process. There was no evidence to indicate the assigned risk level for the accident flight.
There was no evidence to indicate company training on the risk assessment program. At the time of the accident, no signoff was required for flight coordinators or pilots on the risk assessment form, and the form was neither available nor was it integrated into the company manuals.

2.9. Crew decision making

On the day of the accident, aspects of the crew's planning, flying technique and decision-making were inconsistent with regulatory and administrative requirements, the company operations manual policy, and safe flying practices. These included flight in IMC without adequate ground clearance and non-response on the aural warning of the impending collision with the ground by the TAWS, which possibly warned in sufficient time to prevent the accident.

2.10. ELT

Due to a loosely fastened hook and loop retention strap on the ELT installation, the ELT was ejected from its mounting tray during the impact. Since instructions do not describe a method for determining the required degree of tightness to retain the ELT in its mount, the installer's own judgement is relied upon to determine this. As a result, a wide variation in the quality of installation of ELTs that are retained by this method could increase the possibility of inadequate retention. In this accident, in the absence of a transmitted 406 MHz signal, the on-board GPS-based flight-following equipment (SkyTrac), GSM and Nairobi Radar was effective in directing the search party to the accident site and reduced the time for the search and rescue of the survivors.

2.11. Kannad Aviation

5Y-CAC was equipped with a Kannad 406 AF- COMPACT emergency locator transmitter (ELT), part number S1820506-01, serial number 15260294. During field examination of the wreckage, the ELT was noted to be out of its mounting tray having been dislodged and ejected from mounted antenna and the remote cockpit switch. The remote control panel wires were broken near the plug on the ELT. The antenna had broken off by ground contact, and its cable was detached from the assembly. No ELT 406 MHz signal was recorded by the Rescue Coordination Centre (RCC), nor was a 121.5 MHz signal received by search and rescue aircraft. The recovered ELT went through shop testing following the accident. Tests confirmed that the unit was shown to be capable of producing effective signals.

Kannad Aviation (Orolia Group) developed a new type of ELT called Integra, which received EASA, FAA and Transport/Industry Canada certification. The ELT is equipped with an internal integral antenna. When circuits detect a low standing wave ratio due to a lost connection with the external antenna, as in this occurrence, the ELT automatically switches to the internal antenna. To enhance accuracy in position detection, the Integra ELT is also equipped with an internal GPS antenna and receiver.

European Aviation Safety Agency,

EASA issued a safety information bulletin, "Hook and Loop Style Fasteners as Mounting Mechanism for an Emergency Locator Transmitter (ELT)", consistent with the Federal Aviation Administration (FAA) Special Airworthiness Information Bulletin (SAIB) HQ-12-32, dated 23 May 2012 and published at http://ad.easa.europa.eu

3.0 CONCLUSIONS

3.1 Findings

i. The flight crew was licensed and qualified for the flight in accordance with existing regulations;

ii. The maintenance records indicated that the aircraft was equipped and maintained in accordance with existing regulations and approved procedures;

iii. The aircraft was conducting a scheduled flight from Kitale to Nairobi;

iv. the aircraft was in IMC in a Mountainous/hilly terrain;

v. The aircraft was flown and maintained at FL110, which was below the IFR sector minima altitude;

vi. The aircraft was equipped with Ground Proximity Warning System, GPWS; the TAWS ST3400, provided aural warning.

vii. The terrain database version loaded into the ST3400 system was dated 13 October 2008; the newest available version is from 2018.

3.2 Causes

3.2.1 Probable Cause

The Aircraft Accident Investigation Department determines the probable cause(s) of this accident to be: The flight crew's inadequate flight planning and the decision to fly instrument flight rules (IFR) at an altitude below the published Minimum Sector Altitude in the Standard Instrument Arrival Chart under instrument meteorological conditions (IMC), and their failure to perform an immediate escape maneuver following TAWS alert, which resulted in controlled flight into terrain (CFIT).

3.2.2 Contributing Factors

1. Contributing to the accident were the operator's inadequate crew resource management (CRM) training, inadequate procedures for operational control and flight release.
2. Also contributing to the accident was the Kenya Civil Aviation Authority's failure to hold the operator accountable for correcting known operational deficiencies and ensuring compliance with its operational control procedures.
3. There was no requirement for crew to be trained in CFIT avoidance ground training tailored to the company’s operations that need to address current CFIT-avoidance technologies.
4. Use of non-documented procedure and Clearance by the ATC to fly below the published minimum sector altitude.
5. Lack of situational awareness by the radar safety controller while monitoring flights within the radar service section.

4.0 SAFETY RECOMMENDATIONS

i. KCAA to ensure that air operators which operate under IFR or night VFR to provide flight crews with initial and biennial recurrent CFIT avoidance training.

ii. KCAA to ensure that prior dispatching an aircraft for a mission, safety risk assessment is conducted by AOC holders for each flight and documented by appropriately qualified personnel.

iii. KCAA to ensure that ATS clearances to aircraft conform to published or documented charts.

iv. KCAA Airworthiness to ensure that besides ensuring serviceability of aircraft equipment/instruments; the equipment and instruments should be updated with the latest version and data.

v. KCAA to ensure compliance of the five phase certification process by Air Operators.

Martyn Lunani
CHIEF INVESTIGATOR OF ACCIDENTS
03 August, 2019