AIRCRAFT ACCIDENT REPORT

NCAT/2013/05/21/F

Accident Investigation Bureau

Report on the Serious Incident involving Nigerian College of Aviation Technology (NCAT) TBM 850 Aircraft with Registration 5N-BZA, Near Kaduna Airport, Kaduna, Nigeria on 21st May, 2013

This report was produced by the Accident Investigation Bureau, Murtala Muhammed International Airport, Ikeja, Lagos.

The report is based upon the investigation carried out by the Bureau in accordance with Annex 13 to the Convention on International Civil Aviation, Nigerian Civil Aviation Act 2006, and Civil Aviation (Investigation of Air Accidents and Incidents) Regulations.

In accordance with Annex 13 to the Convention on International Civil Aviation, it is not the purpose of aircraft accident/serious incident investigations to apportion blame or liability.

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As the Bureau believes that safety information is of great value if it is passed on for use of others, readers are encouraged to copy or reprint for further distribution, acknowledging Accident Investigation Bureau as the source.

Recommendations in this Report are addressed to the Regulatory Authority of the State (NCAA).

Printed in Nigeria for the Accident Investigation Bureau (AIB)

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GLOSSARY OF ABBREVIATION USED IN THIS REPORT

AIB	Accident Investigation Bureau
AMP	Approved Maintenance Programme
AMSL	Above Mean Sea Level
ATPL	Airline Transport Pilot Licence
CB	Cloud Broken
CBs	Cumulonimbus Clouds
CPL	Commercial Pilot Licence
CRM	Crew Resource Management
CT	Control Tower
FSPM	Flying School Procedures Manual
FSTM	Flying School Training Manual
GPS	Global Positioning System
HFCAS	Human Factor Analysis Classification System
IFR	Instrument Flight Rules
ITT	Inlet Turbine Temperature
NAMA	Nigeria Airspace Management Agency
NAIA	Nnamdi Azikiwe International Airport Abuja
NAVAIDS	Navigational Aids

NCAA	Nigerian Civil Aviation Authority
NCAT	Nigerian College of Aviation Technology
ND	Normal Display
Nig. CARs	Nigeria Civil Aviation Regulations
NIMET	Nigerian Meteorological Agency
SOP	Standard Operating Procedure
UTC	Universal Time Coordinated
QNH	Altimeter Setting that Causes Altimeter to Indicate Altitude above Sea Level
VOR	VHF Omnidirectional Range

Aircraft Accident Report No.:	NCAT/2013/05/21/F
Registered Owner and Operator:	Nigerian College of Aviation Technology (NCAT)
Aircraft Type and Model:	TBM 850
Manufacturer:	Daher-Socata
Year of Manufacture:	2010
Registration Number:	5N-BZA
Serial Number:	534
Location:	3NM Southeast of KU (VOR), between 13000ft and 9000ft Above Mean Sea Level (AMSL)
Date and Time:	21st May 2013 at about 1745hrs *All times in this report are local time (UTC +1) unless otherwise stated*

SYNOPSIS

Accident Investigation Bureau (AIB) was notified of the occurrence on the 16th of June 2013. Investigators were dispatched to carry out a preliminary investigation on the occurrence.

At about 1705hrs, on 21st May, 2013, TBM-850 (turbo prop aircraft certified for 1-pilot operation) with registration 5N-BZA, operated by Nigerian College of Aviation Technology (NCAT), Zaria as admin-flight[1], departed Nnamdi Azikiwe International

[1]Flights conducted to transport management personnel are known in NCAT as admin-flight.

Airport, Abuja (NAIA) to Zaria Aerodrome, with two persons on board (pilot and an observer).

Shortly after it commenced descent and while passing FL130, the aircraft entered an intense area of hail associated with a CB cloud. The encounter caused damage to the aircraft's radome, landing lights and other parts of the engine but the flight continued to its destination, Zaria Aerodrome and landed safely.

The occupants of the aircraft sustained minor injuries. Instrument Meteorological Conditions (IMC) prevailed at the time of the occurrence and the flight was operating on an Instrument Flight Rules (IFR) flight plan.

The following causal and contributory factors were identified:

Causal Factor

The decision of the crew to depart NAIA with the knowledge of weather forecast, and failure to follow the guidance provided by the weather radar advisory to avoid the impending adverse weather.

Contributory Factors

i. Late recognition of the icing/hailstorm encountered by the pilot during the flight.
ii. Failure of the pilot to adequately follow aircraft certification standards (procedures/limitations) for turbulent air, storms and icing conditions penetration.

The safety issues in this report focused on TBM-850 procedures for the use of ice protection systems, radar system, turbulence and icing penetration, airspeed limitations and information, stall warning/protection system capabilities, operation of the autopilot in icing conditions, aircraft icing certification requirements, and icing-related research as

per NCAT's Approved Operations Manual (AOM) and Airplane Flight Manual (AFM), duty and rest period compliance.

Six Safety Recommendations were made.

1.0 FACTUAL INFORMATION

1.1 History of the Flight

On 21st May, 2013, TBM 850 (turbo-prop aircraft certified for 1-pilot operation) with registration number 5N-BZA owned and operated by NCAT, departed Zaria Aerodrome at 1520hrs on an admin-flight, to convey the Rector/CEO of NCAT to NAIA. The flight was uneventful and landed in Abuja at 1555hrs.

The pilot reported "we went ahead to prepare the airplane for a quick turnaround. This was not possible because we had to pick up fuel and wait for ITT to drop before starting the engine."

At about 1705hrs on the same day, the aircraft departed NAIA to Zaria on an Instrument Flight Rules (IFR), with two persons on board (pilot and an observer). The aircraft was operating a positioning flight. At departure, the aircraft was cleared to climb and maintain FL190 by the Tower; thereafter the pilot was transferred to Radar Control which further transferred him to Kano Control. The pilot was instructed by Kano Area Control to report LOTSO[2] before subsequently released to Kaduna Tower, even though according to the pilot the last instruction by Kano Area Control sounded strange to him. On establishing two-way communication with Kaduna Tower, the Controller further instructed the pilot to maintain FL190 on reaching and to report Kilo Uniform (KU).

At about 1735hrs, the pilot requested descent. The aircraft was cleared to descend to FL090 initially which the pilot acknowledged.

[2] LOTSO is a reporting point on the airway or air route.

At about 1740hrs, during descent through FL130, the aircraft encountered and penetrated through a hailstorm. The storm at that time was severe as reported by Nigerian Meteorological Agency (NiMET).

After passing through the storm, the crew observed that both landing lights had popped out. On reaching FL090, the pilot reported his level and the aircraft was cleared for further descent, hence transferred to Zaria Aerodrome Tower for approach clearance and subsequent landing instructions.

At about1755hrs, the aircraft landed safely at Zaria Aerodrome.

In the course of the investigation, the pilot said he checked the weather radar during the pre-flight before the first flight from Zaria to Abuja; but the weather radar was not used on the flight. However, the pilot asserted that the weather radar was ON during the return flight from Abuja to Zaria.

1.2 Injuries to Persons

Injuries	**Crew**	**Passengers**	**Others**
Fatal	Nil	Nil	Nil
Serious	Nil	Nil	Nil
Minor/None	1	1 (Observer)	Nil

1.3 Damage to Aircraft

The aircraft was substantially damaged.

Figure 1: Picture showing dented Left Exhaust stack

Figure 2: Picture showing dented Right Exhaust stack

Figure 3: Picture showing damaged Right Landing Lamp housing

Figure 4: Picture showing damaged Left Landing Lamp housing

Figure 5: Picture showing dented Lower Engine Cowl assembly

Figure 6: Picture showing dented Right Wing root Leading Edge section (red arrow)

1.4 Other Damage

Nil.

1.5 Personnel Information

1.5.1 Pilot

Nationality:	Nigerian
Age:	46 years
Gender:	Male
Licence No.:	3988 (ATPL)
Licence Validity:	25/01/2017 (Instrument 08/11/2012)
Aircraft Ratings:	C-172, TB-9, B-58 and TBM-850
Medical Certificate/Validity:	CLASS 1 (14/07/13)
Total Flying Time:	3202hrs
Total On Type:	60hrs
Last 90 Days:	90hrs 25mins
Last 28 Days:	45hrs 50mins
Last 7 Days:	1hrs 25mins
Last 24 Hours:	Nil

The pilot reported for duty at about 0630hrs, completed pre-flight and received weather information by phone from the tower. However, the pilot waited for about 9 hours before departure. He flew for 50 minutes, waited for about 30 minutes for ITT to cool down, refuel, file flight plan and obtain weather information, then flew back to Zaria for another 50 minutes. He cumulatively had about 12hrs total duty period.

1.5.2 Observer

Nationality:	Nigerian
Age:	26 years
Gender:	Male
Licence No.:	5225 (CPL)
Licence Validity:	11/12/2012 (Instrument N/A)
Aircraft Ratings:	TB-9, B-58
Medical Certificate/Validity:	14/07/2013
Total Flying Time:	280hrs
Total on Type:	Not type rated
Last 90 Days:	10hrs
Last 28 Days:	8hrs
Last 7 Days:	Nil
Last 24 Hours:	Nil

1.6 Aircraft Information

1.6.1 General Information

Aircraft manufacturer:	Dohar - Socata
Model:	TBM 850
Serial No.:	534
Year of manufacture:	2010
Nationality:	Nigeria
Registration marks:	5N-BZA
Owner and Operator:	NCAT
Certificate of Registration:	Issued 5th August 2010
Certificate of Airworthiness:	5th August 2013

Certificate of Insurance:	30th November 2013
Airframe Flying Time:	721.20hrs
Cycles since New (CSN):	706

1.6.2 Engine

Manufacturer:	Pratt & Whitney
Type:	Turbo Prop PT6A-66D
Year of Manufacture:	2010
Serial No:	PCE-RV0194
Hours/Cycles:	721.20hrs/706
Fuel Type Used:	Jet A-1

1.6.3 General Maintenance Records

Check "A"/annual inspection (A+) was completed on 5th April 2013, (only 45 days before the incident). Regarding this inspection, AIB verified that the aircraft had been maintained in accordance with manufacturer's schedules and inspections. The last "A" check was carried out on the aircraft at the airframe time of 671.40 hours and total cycles of 655 at the NCAT hangar, Zaria Aerodrome after which a Certificate of Release to Service was issued. The next scheduled maintenance ("A" check) will be at the airframe time interval of 200 hours or a calendar period of 12 months whichever occurs earlier.

However, there was no evidence to show that NCAT has an Approved Maintenance Programme for TBM 850.

1.7 Meteorological Information

1.7.1 Meteorological Conditions

A summary of actual weather observation over Kaduna for the period under consideration revealed that at about 1600Z there was Cumulonimbus cloud observed towards North to Northeast of the station. This was followed by dry thunder heard to the East. Meteorological conditions as obtained from NiMET before and after the occurrence were as follows:-

21/05/13:	**Before the Incident**
Time:	1600Z
Wind:	210/12 KTS
Visibility:	15km
Weather:	TS
Clouds:	FEW 420m FEW CB 720m (N-SE)
Temperature:	33/22 (Degrees Celsius)
QNH:	1014hpa

21/05/13:	**After the Incident**
Time:	1800Z
Wind:	300/10 KTS
Visibility:	500m
Weather:	TSRA
Clouds:	BKN 210m FEW CB 540m (N-NW)
Temperature:	21/19 (Degrees Celsius)
QNH:	1017hpa

1.7.2 Satellite Weather Imagery

The recorded weather statistics of 21st May, 2013, showed that there was widespread incidence of thunderstorm activities which affected a greater part of the airspace along the pilot's route, between 1500Z and 1800Z.

The Infrared Satellite Imagery of 1645Z to 1745Z of 21st May, 2013 also indicated that there was a massive active thunderstorm cell over the region. The serious incident occurred at about 1740Z.

1.8 Aids to Navigation

1.8.1 Navigational Aids

At the time of the incident, Non-directional Radio Beacon (NDB), Very High frequency Omni-directional Radio Range (VOR) and also the visual ground aids at Zaria and Kaduna respectively, were serviceable.

1.8.2 Global Positioning System (GPS)

The aircraft is equipped with Global Positioning System (GPS) and was serviceable.

1.9 Communications

The main Kaduna Tower frequency 118.8MHz was serviceable and there was good communication between the aircraft and the Control Tower up to the time it was transferred to Zaria Aerodrome Control Tower.

Communication between Zaria Control Tower and the aircraft was also good throughout the duration of the remaining flight. However, the pilot did not report the incident to either Control Tower before and after landing.

1.10 Aerodrome Information

Not Applicable.

1.11 Flight Recorders

The aircraft was not equipped with a Flight Data Recorder (FDR) or a Cockpit Voice Recorder (CVR). Neither recorder was required on this aircraft category by the relevant aviation regulations (Nig.CARs).

1.12 Wreckage and Impact Information

The aircraft had an encounter with hailstorm in-flight while descending through FL130, resulting in damage to parts of the aircraft: dents on engine upper cowling, engine lower cowling, left and right exhaust stacks, complete damage on left and right landing lamp housings and left and right VOR antenna gaskets, abrasion and dents on radome/weather radar structure cover plates.

1.13 Medical and Pathological Information

Nil.

1.14 Fire

There was no evidence of in-flight or post impact fire.

1.15 Survival Aspect

This occurrence was survivable and the crew operated the aircraft to a safe landing, taxied and parked normally. Though the damage to the aircraft was substantial, both the airframe and engine were intact. The occupants survived the incident with minor injuries.

1.16 Test and Research

Not Applicable.

1.17 Organizational and Management Information

1.17.1 NCAT Flying School Organogram[3]

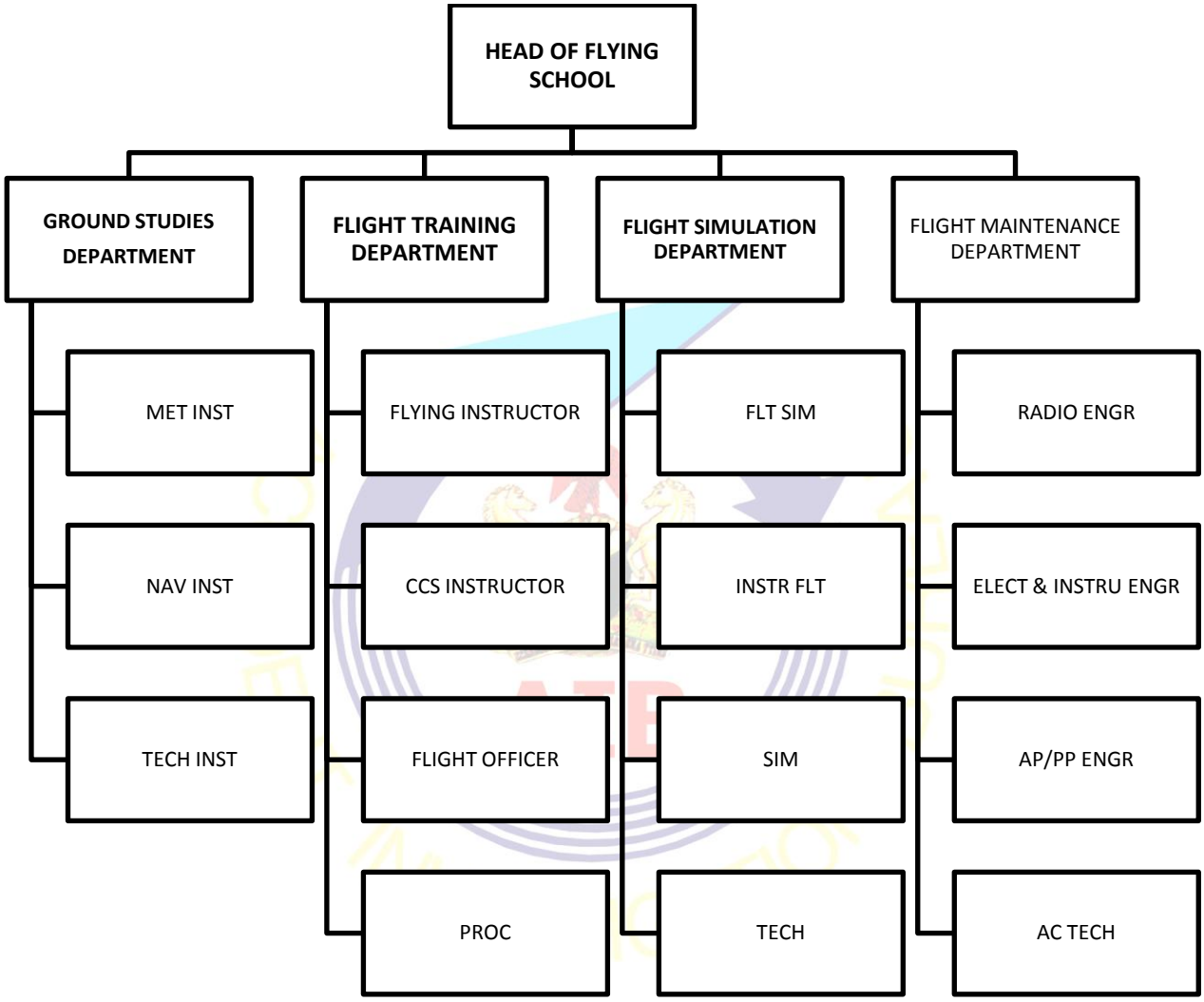

Figure 7: Outline of the structure for NCAT Flying School

[3] The updated Flying School Organogram is as attached in the Appendix.

1.17.1.1 Chief Flying Instructor/Head of Flying School

Duties

The Head of Flying School is responsible for the day-to-day administration of the Flying School. He is responsible for ensuring quality and safety in all activities of the school and is a member of the management review meeting.

The position carries the following responsibilities:

- *Organizing and coordinating all training activities including examination in flying school.*
- *Coordinating, supervising and updating syllabi of courses in flying school.*
- *Conducting proficiency/quality control checks on both Instructors & Students from time to time to monitor the training standards.*
- *Preparing annual budget and statement of expenditure of flying school.*
- *Preparing annual report on activities of flying school.*
- *Maintaining accurate training records for both staff and students at flying school.*
- *Establishing and maintaining liaison between all the departments/units in flying school with other schools and service departments.*
- *Taking full responsibility for proper maintenance and control of the stores in flying school.*
- *Supervising and coordinating the proper use of training aids, materials, laboratories, workshops and classrooms in flying school.*

- *Participating in the recruitment of staff and students for flying school.*
- *Maintaining liaison with the Deputy Rector& Registrar on all matters affecting training and personnel of flying school respectively.*
- *Performing instructional duties and any duties that may from time to time be assigned to the Head of flying School.*
- *Drawing up course for the training development and recurrency of instructors in flying school.*
- *Coordinating with Nigerian Civil Aviation Authority (NCAA) through the Rector/Chief Executive on all matters affecting the flying school and NCAA.*
- *Representing proposals, advices and inputs to the Chief Executive for the effective, safe and efficient running of flying school.*
- *Representing flying school in any function.*
- *Conduct Administrative and test flights.*
- *Any other duty that might be assigned to him by the management of the college from time to time.*

1.17.1.2 Head of Flight Training Department

- *Accountable to the Head of School.*
- *Coordinates flight programs and training in flight training department.*
- *Takes responsibility for all the activities in the department.*

- *Ensures the effective running of flight training department.*
- *Involves in interviews with student pilot (SP) Courses.*
- *Keeps accurate record of staff, student and course running in the department.*
- *Represents the Head of Schools when necessary.*
- *Coordinates management meetings.*
- *Carries out progress checks for student.*
- *Carries out Admin, Ferry and Test flights.*
- *Present proposals, advices and inputs for efficient running of the department.*
- *Involves in the training of student pilots.*
- *Any assignment that will be delegated to him by the school/college management from time to time.*
- *Responsible for drawing out budget and training proposal for the Department.*

1.17.1.3 NCAT Flying School Procedures Manual

1.13 FLYING DUTY PERIOD AND FLIGHT TIME LIMITATIONS (FLYING INSTRUCTORS)

In order to eliminate excessive fatigue in aircrew whilst flying, NCAT lays down specific working hours and rest periods. These periods must be used sensibly and properly adhered to in order that no flights are made when fatigue is likely to endanger the safety of the aeroplane or persons therein. When reporting for duty, instructors must report at least ½ hour before their student is booked in order that they have sufficient time to check their aircraft, study student training records, etc.

The normal working day – for flying instructors – commences at 7:00am. Shift working and night flying will be programmed by the HFTD and OM. Duty periods commence from the time at which the individual concerned commences an activity required by NCAT to such a time that activity ceases.

STAFF INSTRUCTOR LIMITATIONS

The maximum continuous duty period will be 10 hours.

If a split duty period is being operated the maximum period will be 12 hours (after a 6 hour minimum rest period).

In any one duty period a limit of four flights may be undertaken. With the permission of the HFTD/OM this can be extended to an absolute maximum of 5 in exceptional circumstances.

When completing a duty period from day into night (uninterrupted) the maximum period is 8 hours.

With a split day into night duty period the maximum period will be 10 hours providing a minimum of 6 hours is given as rest.

1.17.2 The Nigeria Civil Aviation Regulations (Nig.CARs)

NCAA is the agency responsible for the regulation of civil aviation in Nigeria. As part of its statutory duties and responsibility, NCAA reviewed the Nigerian Civil Aviation Regulations (Nig.CARs) and it was published in 2009. Below are some of the regulations pertinent to this occurrence as guided by Nig.CARs.

High Altitude Aircraft Endorsement (Nig.CARs 2.3.2.8)

(a) No person shall act as pilot in command of a pressurized aircraft capable of operating at high altitudes (an aircraft that has a service ceiling or maximum operating altitude, whichever is lower, above 25,000 feet MSL) unless the person has:

1. *Receive and logged ground training from an authorized instructor and received an endorsement in the logbook from the instructor certifying the person has satisfactorily accomplished ground training in at least the following subjects:*
   - *(i) High-altitude aerodynamics and meteorology*
   - *(ii) Respiration*
   - *(ii) Effects, symptoms, and causes of hypoxia and any other high-altitude sickness;*
   - *(iv) Duration of consciousness without supplemental oxygen*
   - *(v) Effects of prolonged usage of supplemental oxygen*
   - *(vi) Causes and effects of gas expansion and gas bubble formation*

(vii) Physical phenomena and incidents of decompression; and any other physiological aspects of high-altitude flight.

2. *Receive and logged flight training from an authorized instructor and received an endorsement in the logbook from the instructor certifying the person has satisfactorily accomplished flight training in an aircraft or in a flight simulation training device that is representative of a pressurized aircraft, in at least the following subjects:*

(i) Normal cruise flight operations while operating above 25,000 feet MSL;

(ii) Proper emergency procedures for simulated rapid decompression without actually depressurizing the aircraft; and

(iii) Emergency descent procedures.

Flight Crew Qualification (Nig.CARs 8.4.1.2)

(a) The PIC shall ensure that the licenses of each flight crewmember have been issued or rendered valid by the State of Registry, contain the proper ratings, and that all that the flight crewmembers have maintained recency of experience.

Authorisation in Lieu of a Type Rating (Nig.CARs 8.4.1.3)

(a) The Authority may authorize a pilot to operate an aircraft requiring a type rating without a type rating for up to 60 days, provided -

(1) The Authority has determined that an equivalent level of safety can be achieved through the operating limitations on the authorization;

(2) The applicant shows that compliance with this subsection is impracticable for the flight or series of flights;

(3) The operations-

(i) Involve only a ferry flight, training flight, test flight, or skill test for a pilot licence or rating;

(ii) Are within Nigeria, unless, by previous agreement with the Authority of the other State, the aircraft is flown to an adjacent contracting State for maintenance;

(iii) Are not for compensation or hire unless the compensation or hire involves payment for the use of the aircraft for training or taking a skill test; and

(iv) Involve only the carriage of crewmembers considered essential for the flight.

(4) If the purpose of the authorization provided by this paragraph cannot be accomplished within the time limit of the authorization, the Authority may authorize an additional period of up to 60 days.

Reporting of Hazardous Conditions (Nig.CARs 8.5.1.21)

(a) The PIC shall report to the appropriate ATC facility, without delay and with enough detail to be pertinent to the safety of other aircraft, any hazardous flight conditions encountered en route, including those associated with meteorological conditions.

Submission of a Flight Plan (Nig.CARs 8.6.1.1)

(a) Before operating one of the following, a pilot shall file a VFR or IFR flight plan, as applicable for-

(1) Any flight (or portion thereof) to be provided with ATC service;

(2) Any IFR flight within advisory airspace

(3) Any flight within or into designated areas, or along designated routes, when so required by appropriate ATC authority to facilitate the provision of flight information, alerting and search and rescue services;

(4) Any flight within or into designated areas, or along designated routes, when so required by appropriate ATC authority to facilitate co-ordination with appropriate military units or with ATC facilities in adjacent States in order to avoid the possible need for interception for the purpose of identification; and

(b) Any flight across international borders.

(c) The PIC shall submit a flight plan before departure or during flight, to the appropriate ATC facility, unless arrangements have been made for submission of repetitive flight plans

(1) Unless otherwise prescribed by ATC authority, a pilot shall submit a flight plan to the appropriate ATC facility-

(2) At least sixty minutes before departure; or

(3) If submitted during flight, at a time, which will ensure its receipt by the appropriate ATC facility at least ten minutes before the aircraft, is estimated to reach-

(i) Intended point of entry into a control area or advisory area; or

(ii) The point of crossing an airway or advisory route.

1.18 Additional Information

1.18.1 Socata TBM 850 Aircraft

Socata TBM 850 Pilot Operating Manual explains in detail procedures for the safe conduct of the aircraft (including normal and abnormal) operations in icing conditions.

1.18.2 Aircraft logbooks

Aircraft logbooks, is one of the documents required, like the aircraft forms and records which are used to provide complete history of aircraft inspections, flight hours or hours of operation, modifications and major repairs. These records provide maintenance personnel with a source of information for scheduling future periodic inspections and component replacement. In addition, these logs, records, and forms, when maintained properly, provide management with information related to the aircraft's and equipment's service age.

1.18.3 Crew Resource Management

This is a set of training procedures which encompasses a wide range of knowledge, skills and attitude including communication, situational awareness, problem solving, decision making and team work. Its use is primarily for improving air safety.

1.18.4 Weather Radar Operating Principles and Interpretation

Although some aircraft are equipped with one or two airborne weather radar, incursions into very active Cumulonimbus (CB) still occur, resulting in injuries or substantial aircraft damage. The aim of this discussion is to provide additional information about weather radar capabilities and limitations, in order to improve the pilot's overall understanding of the system, and to help prevent such incidents from occurring.

Weather radar is only helpful, if the pilot is able to fully use the capability of the system and interpret the screen display. The image of the radar returns on the Navigation Display (ND) is a representation of what is detected by the radar. Decisions that are taken, based on this information, will vary depending on the flight crew's interpretation

of the ND radar image, and thus, on the experience of the flight crew and their knowledge of the weather radar's limitations.

I. Goals of the Radar:

a. Find the distance to an object (often called a radar target)
b. To find the direction to the target
c. To determine the target's reflection characteristics.

II. Cumulonimbus (CB) Structure

In flight, CB structures can be a major source of danger due to turbulence and heavy precipitation

III. Hail

Hail represents a major threat, because of its effect and because weather radar do not indicate the nature of returns. Only the knowledge of the CBs' structures and the observation of different clues can help. The presence of hail within a CB, varies with altitude and wind:

- Below FL100, hail is equally likely to be encountered under storm, in the cloud or around it (up to 2 NM)
- Below FL100 and FL200, 60 percent of hail is encountered in the CB and 40 percent is encountered outside the cloud, under the anvil.
- Above FL200, hail is most likely to be encountered inside the cloud.

Usually, the threat of hail is greater downwind of a CB: actually, moisture is driven upward by strong drafts. It then freezes and transformed into hail, before being blown downwind. It is better to try to avoid a storm by flying on the upwind side of the CB. However, there is less risk of hail in humid air than in dry air. In fact, moisture in the air behaves as a heat conductor, and helps to melt the hail.

IV. Turbulence

Turbulence associated with a CB is not limited to inside the cloud. Weather radar cannot detect turbulence in clear air, so it is therefore necessary to take precautionary measures. A CB should be cleared by a minimum of 5000 ft vertically and 20 NM laterally, to minimize risk of encountering severe turbulence.

1.18.5 Weather Radar Detection Capability

Weather radar detects precipitation droplets. How much it detects depends upon size, composition and number of droplets. Water particles are five times more reflective than ice particles of the same size.

Weather Radar detects:

- Rainfall
- Wet hail and wet turbulence
- Ice crystals, dry hail and dry snow.

Weather Radar does not detect:

- Cloud, fog or wind (droplets are too small, or no precipitation at all)
- Clear air turbulence (no precipitation)
- Wind shear (no precipitation except in microburst)
- Sandstorms (solid particles are almost transparent to the radar beam)
- Lightening

I. Reflectivity

Radar echo returns are proportional to droplet size, and therefore, precipitation intensity. Droplets that are too small (fog droplets) will return no echo, whereas heavy droplets (thunderstorms droplets) will return majority of radar waves. Reflectivity also depends on the type of precipitation. Precipitation that contains water will return a stronger return than dry precipitation.

It is important to note that reflectivity of particles is inversely proportional to the hazard that may be encountered in a cell.

II. Attenuation

Because weather radar display depends on signal returns, heavy precipitation may conceal even stronger weather. The major part of the signal is reflected by frontal part of the precipitation. The aft part returns weak signals.

Weather radar should not be used as a tool to penetrate, or navigate around areas that are displayed as severe. It should only be considered as a tool to be used for weather avoidance.

1.18.6 Operational Standards and Best Practices

Weather reports provided at flight dispatch (e.g. SIGMET), as well as in-flight (e.g. VOLMET, ATIS), inform the flight crew of potential in-flight weather. The best way to use weather radar is to use it in conjunction with weather reports and weather forecasts. Thus, it can then be used in flight to detect, analyse and to avoid significant weather.

The flight crew uses four features to operate the radar:

I. ***Antenna tilt: -*** that is the angle between the centre of the beam and the horizon. On all weather radars, particularly on X-band/flat antenna weather radars, effective management of the antenna tilt, along with adequate selection of ND range, will avoid over/under scanning, thus ensuring optimum detection and visualization of weather on ND.

II. ***Range control of the ND*: -** this has an essential influence on the optimum tilt setting. To avoid a large storm the flight crew must make decisions while still 40 NM away from it. Therefore, the flight crew should select adequate ranges on the NDs:

- PF adequate ranges to tactically avoid adverse weather, and monitors its severity (in cruise, typically 80 NM and below)
- PNF adequate ranges to plan long-term weather avoidance course changes (in cruise, typically 160 NM and below). Course changes to avoid adverse weather, should be determined using both higher and lower ranges. This technique prevents the "blind alley" effect.

III. ***Gain control: -*** this is the adjustment of the sensitivity of the receiver (and should usually be set to AUTO). The sensitivity of the receiver may vary from one type of radar to another. If gain is used manually for in-depth weather analysis, it must be reset to CAL (AUTO) when analysis is complete.

IV. ***Radar modes:*** -weather (WX), weather + turbulence (WX + T).

1.18.7 Operational and Human Factors Affecting Optimum Use of Weather Radar

Flight crew may wrongly disregard weather radar display in the following conditions:

- Near the destination airport
- When following another aircraft
- When more than 15 minutes behind schedule
- At night.

On the other hand, and as explained before, the weather radar if not correctly used or interpreted may mislead the flight crew when:

- An area of strong activity is hidden behind heavy rain
- A small ND range is not sufficient for the flight crew to determine if an elected trajectory between clouds is blocked by adverse weather further ahead.
- Dry hail precipitation returns a weaker echo than water droplets.
- The antenna tilt is not correctly adjusted.
- Gain is left in a manual position.

1.18.8 Adverse Weather Prevention Strategies

Weather radar is a tool for detecting and avoiding adverse weather and turbulence. As with any other tool, adequate skills are needed in order to use it efficiently. Each type of radar has its own peculiarities and does not display a given weather situation in the same way as another type of weather radar. These peculiarities are outlined in the weather radar user guide. It is therefore necessary to study the manufacturer's user guide in order to gain a good knowledge of weather radar capabilities and limitations.

The shapes of radar echoes as well as their colour should be observed to identify storms containing hail. The gain function should be used for deeper analysis, but should

then be reset to CAL or AUTO position. The TURB function can be used when closing in on active weather to identify the most turbulent area.

The flight crew should periodically scan:

- Vertically, using the antenna tilt function.
- Horizontally, using the range change.

As a general rule, the following prevention strategies apply:

- Use the weather radar to detect/analyse/avoid significant weather
- Shape/colour/size of returns are factors that should be considered to interpret weather
- Effective management of antenna tilt along with an appropriate ND range selection are key tools to obtaining an informative weather radar display on the ND
- Gain is used in CAL/AUTO mode for detection and initial evaluation of displayed weather. Manual gain is used to analyse the weather
- Wet turbulence can be detected up to 40 NM with TURB function.

1.19 Useful or Effective Investigation Techniques Used

Human Factors Classification Analysis System (HFCAS) was used to analyse the serious incident. Aircraft accident investigation reports are usually presented in two forms:

(1) The factual investigation report, which is a preliminary, interim and descriptive report, consists of rudimentary information pertaining to the accident. It does not contain information of causal factors, but basically enlists information such as the case number, location, date, aircraft/operator, meteorological conditions, number of passenger/air crew,

(2) The final investigation report, which contains details of the information presented in the factual report. It also reports the causal factors associated with the accident. While a factual report may be prepared and released within 3 months, final reports may take as long as 2 years depending on several factors, such as unavailability of funds, magnitude of effects of accidents and certain complexities associated with forensic investigations and communication gaps between collaborating agencies. However, not all aspects of causal factors are covered in the final investigation reports in some cases observed.

As mentioned earlier, HFACS framework is predicated on the strength of a well-documented accidents/incident investigation report, thus a representative final aircraft accident investigation report was exploited for the demonstration.

2.0 ANALYSIS

2.1 Conduct of the Flight

The flight departed NAIA in IMC and operating under IFR. Accordingly, normal flight plan should have been filed for this flight and weather information sought appropriately from ATC and NiMET respectively. However, there was no evidence available to AIB confirming these. It should be noted that the pilot hastened the preparation of the aircraft for the return flight to Zaria. This was confirmed by the fact that he filed the flight plan and received weather information by phone.

Given the weather conditions for the departure, the investigation could not establish if the weather radar was being used in accordance with the Airplane Flight Manual (AFM). It could also not be ascertained where the hail encounter had occurred but according to the pilot's recollection, they encountered the hail at an altitude of about 9000ft. This suggests that the weather radar was OFF, on STBY or unserviceable, as the weather radar was supposed to pick the signals depicted from the hailstorm encountered. It is considered that the aircraft probably flew through the larger, active storm cell, which the pilot turned to avoid. However, whilst the damage was relatively severe, the aircraft remained in a safe condition and was able to continue to the intended destination. A major limitation of the aircraft's weather radar systems is that ice crystals or hail may only produce small, or no, returns. Only rain or soft hail is detected and the intensity is displayed as colours ranging from green (low intensity) to red (high intensity).

In keeping with Standard Operating Procedure (Section 4.5 of TBM-850 Pilot Operating Handbook), it is required that when turbulent air is encountered or expected, the airspeed be reduced to manoeuvring speed to reduce the structural loads caused by gusts and to allow for inadvertent speed build-ups which may occur as a result of the turbulence or of distractions caused by the conditions. However, the pilot flew through

the hailstorm with a speed in excess of the aircraft published turbulence target penetration speed.

It is pertinent to note that the pilot neither reported the incident to the controllers nor reported as pilot report (PIREP) to further safeguard other flights flying the same route.

2.2 Meteorological Factors

The satellite weather imagery received from NiMET showed cloud development on 21st May, 2013 at 30-minute intervals beginning from 1645Z to 1745Z. It was apparent that the isolated convective cell developed sometime around 1500Z and grew rapidly. Given the intensity, vertical development and the movement of the cell over Kaduna, it produced hailstorm, rain and lightning activities.

This satellite weather imagery indicated the pictorial weather (thunderstorm) as passed to the pilot. The information was obtained by phone, which is not in accordance with the regulation (Nig.CARs 8.6.1.1). The crew had sufficient time and opportunity to avoid the severe storms by delaying the departure time, since avoidance is the best option in this situation. The pilot was not prepared when he flew into the clouds containing hailstorm and scattered or embedded CBs characterised by gusty winds, thunder hails, rain, etc., as shown in Figures 8, 9 and 10 below.

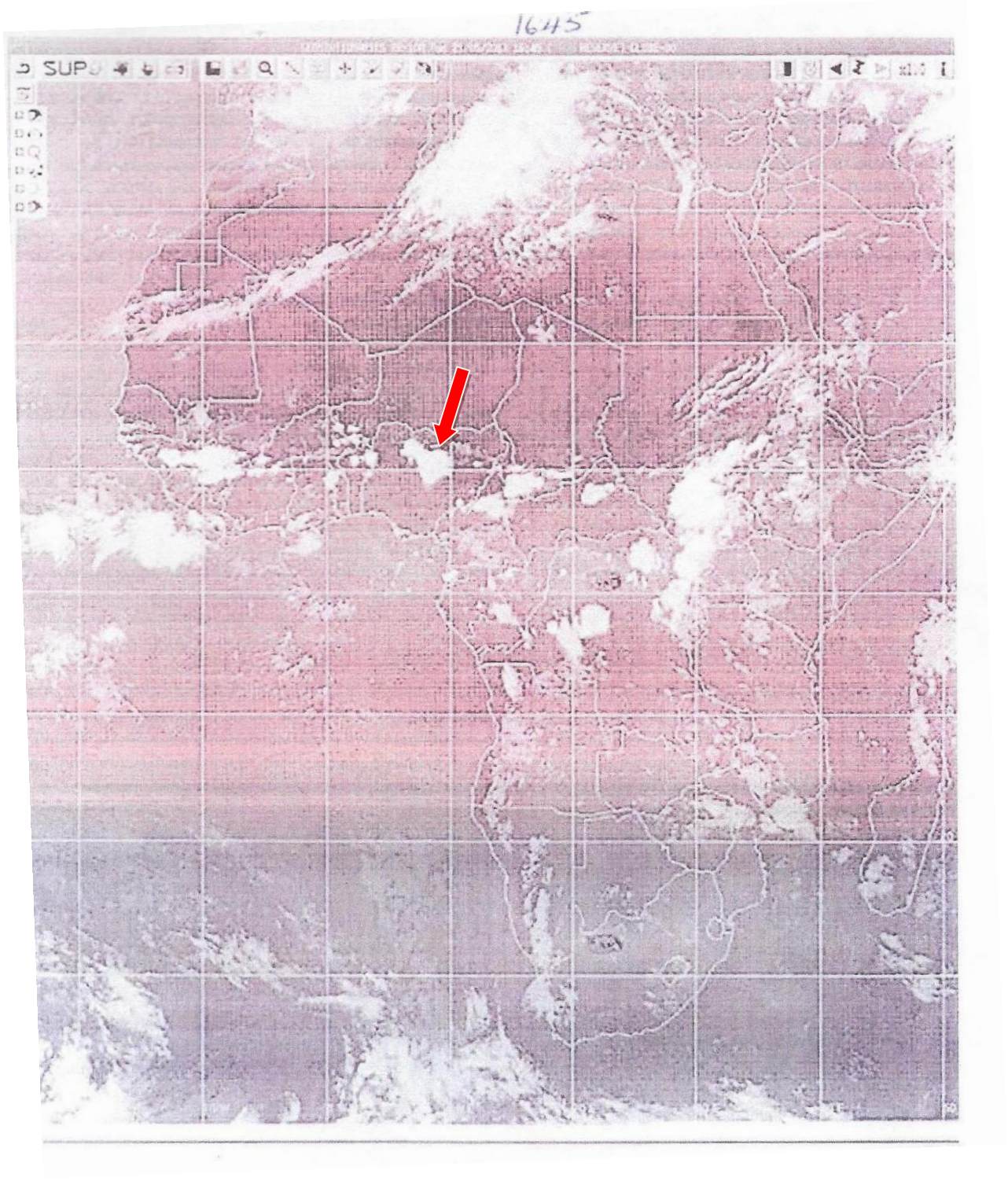

Figure 8: Satellite Weather Imagery for 1645Z

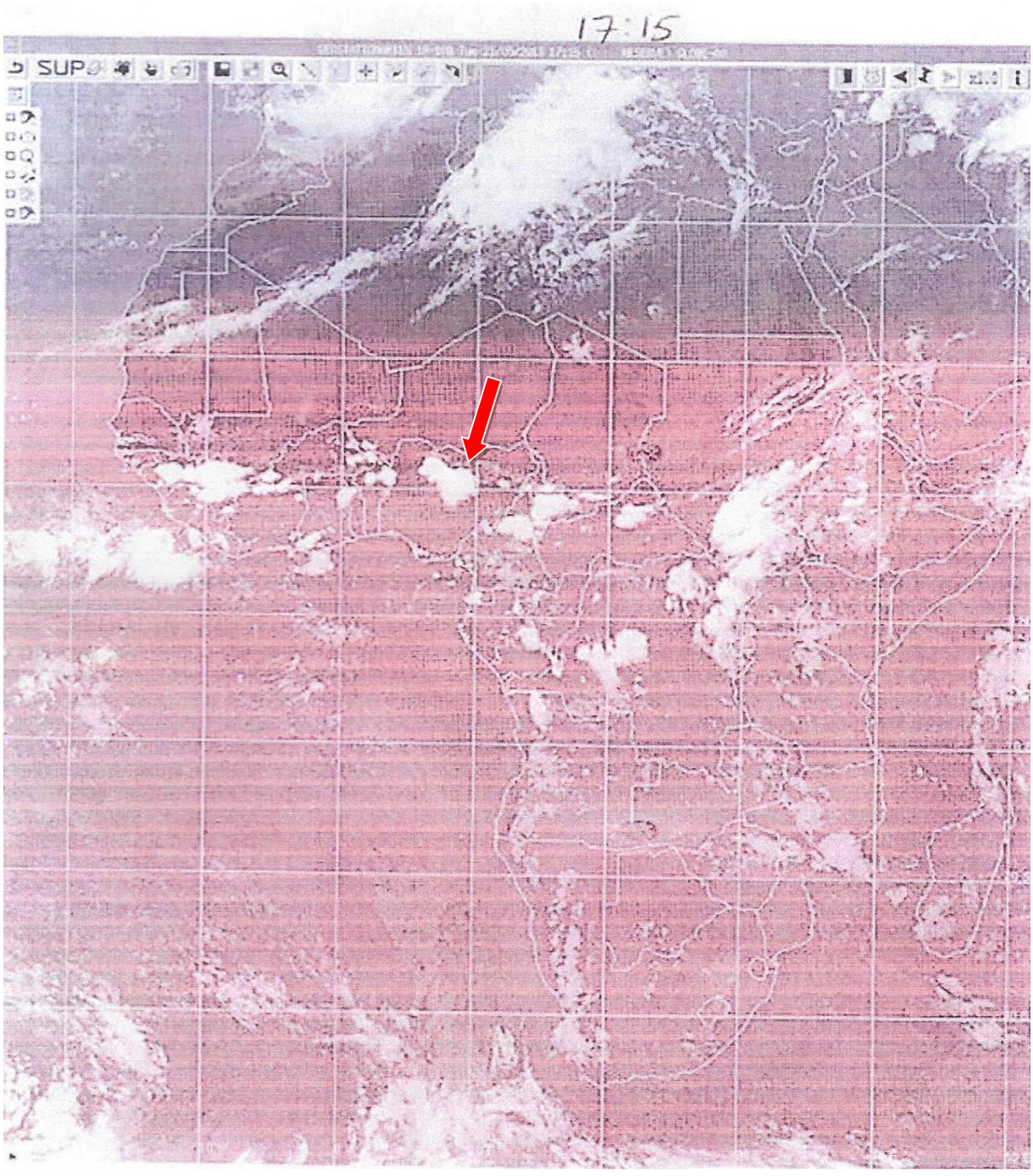

Figure 9: Satellite Weather Imagery for 1715Z

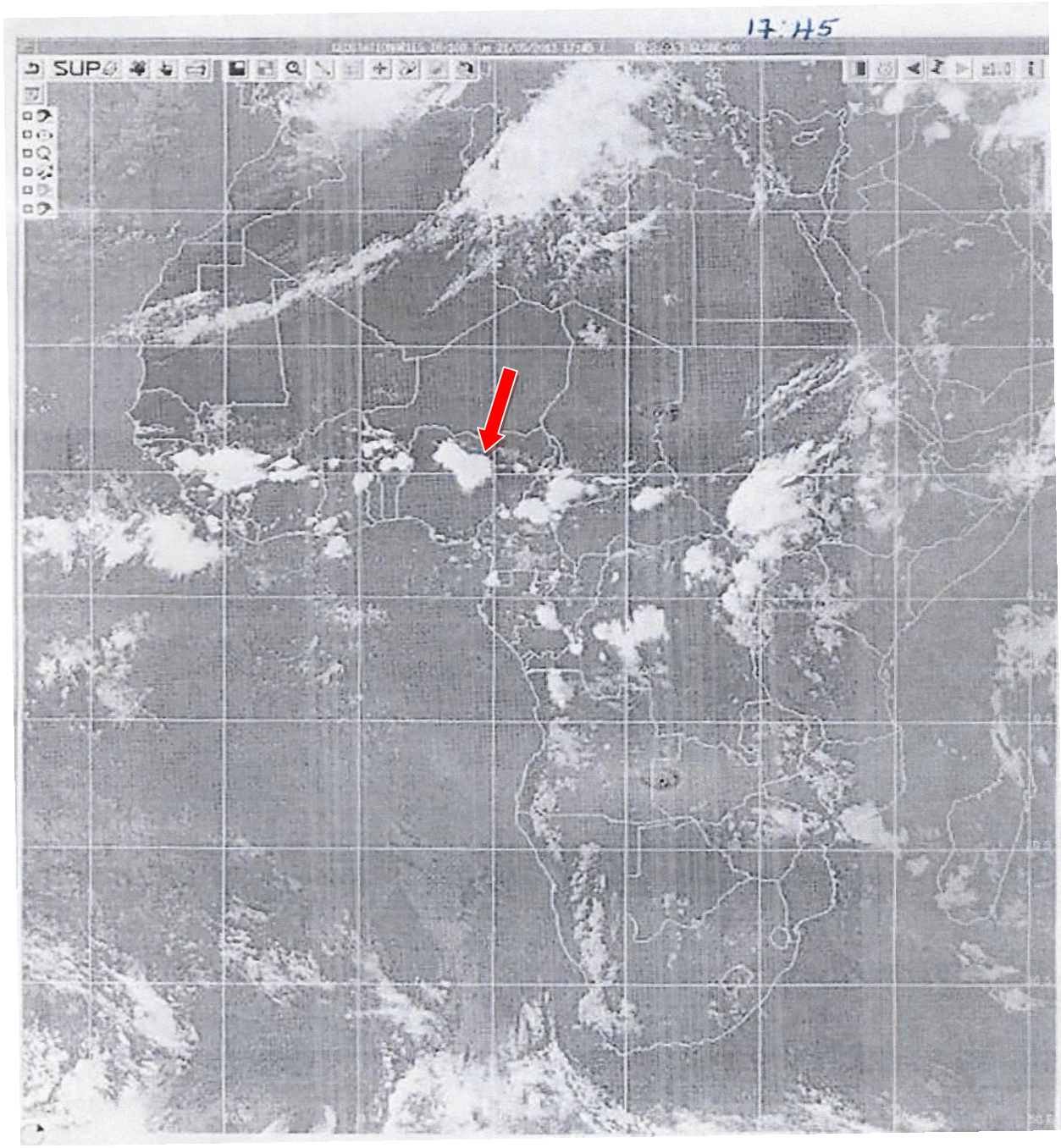

Figure 10: Satellite Weather Imagery for 1745Z

2.3 Crew training on High Altitude/Adverse Weather Operation

From the records presented to AIB, there was no indication that the pilot attended any adverse weather operation training before the incident; which could have been incorporated in the TBM-850's training package since the aircraft is categorized as high performance aircraft in its class with a ceiling of up to 31000ft Above Mean Sea Level (AMSL) operational capability.

The training would have enhanced the pilot's knowledge of adverse weather recognition, recovery/escape manoeuvre; it would have also enhanced the pilot's practical knowledge of weather radar operation and procedures for weather avoidance.

2.4 Human Factor Elements in this Occurrence

In accordance with the approved NCAT Flying School Procedures Manual (FSPM016 Section 1.13), the stipulated duty period for instructors is a maximum of 10hrs continuous duty. The investigation revealed that the pilot had been on duty for a period of about 12hrs. It was reported by the pilot, that the day before the occurrence, he had been engaged with extra-official activities that caused him to return home later than normal. This is not in accordance with the Nig.CARs and NCAT FSPM. In addition, it might adversely affect the operational performance of the pilot.

Evidence available to AIB revealed that the pilot reported for duty at about 0630hrs on the day of the occurrence, completed pre-flight and received weather information by phone from the Tower. However, the pilot waited for about 9 hours before departure. Long waiting and idleness are usually demanding and exhausting to flight crew. The pilot was tired and this was confirmed during his discussions with the observer before the incident flight. The long wait by the crew on ground Abuja for about 30 minutes for ITT to cool down, the refuelling of the aircraft and the weather forecast received by phone added anxiety and further tiredness.

Also, there was the element of organizational pressure to operate the admin-flight, which the pilot accepted as the Head of Flight Training School and a management staff of the college. The pilot had the option to cancel the flight if he wished, based on the college's FSTM and Nig.CARs, but accepted to conduct the flight as all efforts to access another pilot to operate the flight was unsuccessful.

While on ground Abuja, the pilot also had another opportunity to cancel the flight having received the en route weather forecast of build-up activity over Kaduna area, in because even if the flight had been delayed for the storm to pass, Zaria Aerodrome would have closed before the arrival of the aircraft.

3.0 CONCLUSIONS

The aircraft encountered an intense area of hail while in IMC during its descent into Zaria Aerodrome. It was not clear whether the weather radar was in use or unserviceable at the time of the occurrence. Whilst the hail encounter resulted in severe damage to the radome, landing lights and other aircraft components, the flight was safely continued to its destination.

3.1 Findings

i. TBM 850 was not included in NCAT's approved FSTM.
ii. The pilot had exceeded his duty time on the day of the occurrence.
iii. The pilot received weather forecasts from both stations (Zaria and Abuja) by telephone.
iv. There was no evidence to confirm that a flight plan was filed before the incident flight operated.
v. The aircraft encountered a severe hailstorm while descending.
vi. The pilot did not report the occurrence to ATC.
vii. The observer was sitting on the right seat conducting flight crew duties.
viii. The observer does not have a type rating on the aircraft.
ix. The observer logged and credited flight times for TBM-850.

The following causal and contributory factors were identified:

3.2 Causal Factor

The decision of the crew to depart NAIA with the knowledge of weather forecast, and failure to follow the guidance provided by the weather radar advisory to avoid the impending adverse weather.

Contributory Factors

i. Late recognition of the icing/hailstorm encountered by the pilot during the flight.
ii. Failure of the pilot to adequately follow aircraft certification standards (procedures/limitations) for turbulent air, storms and icing conditions penetration.

4.0 SAFETY RECOMMENDATIONS

As a result of this occurrence, AIB issued five safety recommendations to NCAT regarding TBM-850 minimum airspeed information (turbulent air penetration speed, storm and icing conditions), ice protection system operational procedures, ice detection/warning systems and weather radar equipment; and one safety recommendation to NCAA:

4.1 Safety Recommendation 2017-005

NCAT should classify all kind of storms as hazardous considering the types of airplanes it operates (light weight) and the nature of operations it conducts (training), thereby delaying or cancelling any intended flight with warning for storm or any adverse weather phenomena.

4.2 Safety Recommendation 2017-006

NCAT should develop and incorporate TBM 850 in its FSTM and also basic training on weather radar, its systems and operations procedures and adverse weather recognition and avoidance techniques. These topics would enhance the technical and operational knowledge of weather radar equipment for both the instructors and students.

4.3 Safety Recommendation 2017-007

NCAT should ensure that Instructors and students of turbo propeller-driven airplanes review the guidance contained in their manuals and training programs to include updated icing information and to emphasize that leading edge anti icing/de-icing

systems are activated as soon as the airplane encounters icing conditions or when icing condition is anticipated, as per AFM.

4.4 Safety Recommendation 2017-008

NCAT should ensure that before the commencement of any admin flight, all necessary documentation is completed including flight plan and retrieval of weather information especially where such information is readily accessible.

4.5 Safety Recommendation 2017-009

NCAT should ensure that observers neither perform active crew duty nor log any flight time to that effect, in order to add value to his/her personal flying log book.

4.6 Safety Recommendation 2017-010

NCAA should enhance its oversight on all operators of special and private category aircraft to ensure strict compliance with all provisions of Nig.CARs as related to personnel licencing and other operational activities.

RESPONSES TO SAFETY RECOMMENDATIONS

NCAA Response on AIB Safety Recommendations

The NCAA responded to Safety Recommendation 4.6 (2017-010) as follows:

"The NCAA exercises oversight on all Nigerian and foreign registered aircraft operating in the private and special categories in Nigeria. These aircraft and the Approved Maintenance Organizations (AMO)/personnel that release them to service are subject to continuous surveillance and oversight as required by the Nig. CARs and detailed in the approved Technical Guidance Materials;"

NCAT Responses on AIB Safety Recommendations

NCAT responded to Safety Recommendation 4.1 (2017-006) as follows:

"The safety unit will carry out hazard identification and Safety Risk assessment to reduce or mitigate to an acceptable level the safety risks associated with operations during rainy season."

NCAT responded to Safety Recommendation 4.3 (2017-008) as follows:

"Instructors and students for the operations of the TBM 850 aircraft use the AFM and checklists. The Flying School will issue circular to re-emphasize the use of AFM in icing conditions."

NCAT responded to Safety Recommendation 4.4 (2017-009) as follows:

"NCAT would ensure that all necessary documentation is completed before the conduct of admin flights."

NCAT responded to Safety Recommendation 4.5 (2017-010) as follows:

"NCAT will ensure that no observers perform active crew duty nor log any flight time to that effect. NCAT flight operations will review the logbooks of All pilots not rated on the TBM 850 aircraft that acted as observers on the aircraft. Where the observers logged any flight time, the flight time will be expunged from their logbooks."

APPENDIX

APPENDIX A: Updated NCAT Flying School Organisational Chart

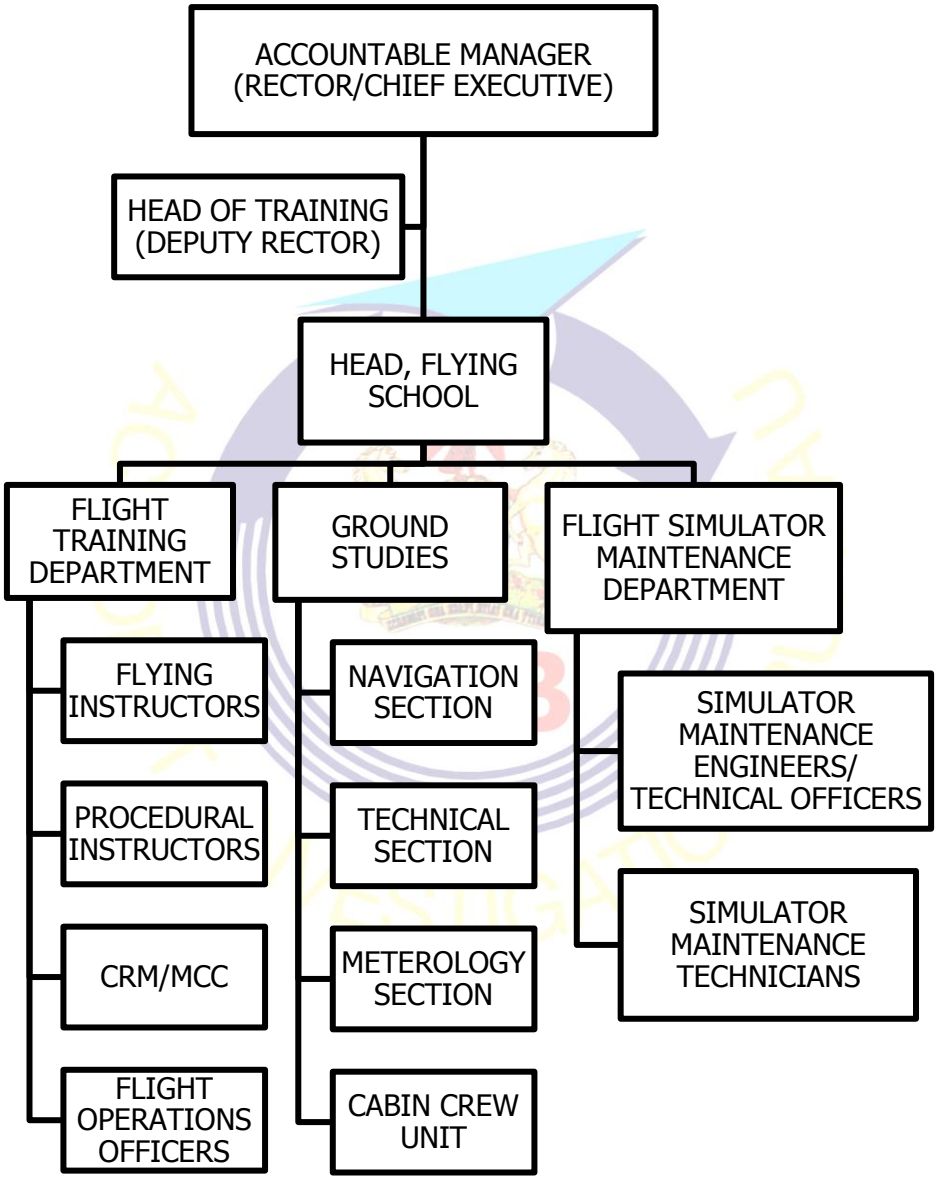

Figure 11: NCAT Flying School Organogram