AIRCRAFT ACCIDENT REPORT

DANA/2018/02/20/F

Accident Investigation Bureau

Report on the Accident involving a Boeing MD-83 aircraft operated by Dana Airlines Ltd with Nationality and Registration Marks 5N-SRI which occurred at Port Harcourt International Airport On 20th February, 2018

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

The report is based upon the investigation carried out by Accident Investigation 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 2016.

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

Safety Recommendations in this report are addressed to the Regulatory Authority of the State (NCAA). This authority ensures enforcement.

Printed in Nigeria for the Accident Investigation Bureau (AIB)

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GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AC	Advisory Circular
AFM	Aircraft Flight Manual
AGL	Above Ground Level
AIB	Accident Investigation Bureau
ALAR	Approach and Landing Accident Reduction
APU	Auxiliary Power Unit
ARA	Arik Air (ICAO 3-letter code)
ARFFS	Airport Rescue and Fire Fighting Services
ASC	Aerodrome Safety Circular
ATC	Air Traffic Control
ATIS	Automatic Terminal Information service
ATPL (A)	Airline Transport Pilot License
BKN	Broken
CARs	Canadian Aviation Regulations
CB	Circuit Breaker
Cb	Cumulonimbus
CDL	Configuration Deviation List
CFME	Continuous Friction Measuring Equipment
CPL (A)	Commercial Pilot License (Aeroplane)
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder

DA	Decision Altitude
DC	Direct Current
DH	Decision Height
DME	Distance Measuring Equipment
DNAA	Location identifier for Nnamdi Azikiwe International Airport, Abuja
DNPO	Location identifier for Port Harcourt International Airport
EPR	Engine Pressure Ratio
FAA	Federal Aviation Administration
FAAN	Federal Airports Authority of Nigerian
FAR	Federal Aviation Regulations
FCOM	Flight Crew Operations manual
FL	Flight Level
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Condition
IR	Instrument Ratings
ISASI	International Society of Air Safety Investigators
KIAS	Knot Indicated Air speed
LDA	Landing Distance Available
LDR	Landing Distance Required
LLWAS	Low Level Wind-shear Alert System

LOC	Localizer
MD	McDonnell Douglas
MDA	Minimum Decision Altitude
MEL	Minimum Equipment List
MSA	Minimum Sector Altitude
NAMA	Nigerian Airspace Management Agency
NAV	Navigation
NCAA	Nigerian Civil Aviation Authority
Nig.CARs	Nigeria Civil Aviation Regulations
NiMET	Nigerian Meteorological Agency
NOTAM	Notices to Airmen
OMB	Operations Manual 'part B'
OMD	Operations manual 'part D'
PALS	Precision Approach Lighting System
PAPI	Precision Approach Path Indicator
PBM	Pressure Bias Modulation
PF	Pilot Flying
PIC	Pilot in Command
PIREP	Pilot Report
PM	Pilot Monitoring
POT	Port Harcourt VOR
RPM	Revolution Per minute

RWY	Runway
S	Serviceable
SARPs	Standard and Recommended Practices
SOP	Standard Operating Procedures
SPECI	Special Weather Report
SQ	Squall
SSFDR	Solid State Flight Data Recorder
TC	Transport Canada
TDZ	Touchdown Zone
TDZE	Touchdown Zone Elevation
TEMPO	Temporary
TRE	Type Rating Examiner
TRI	Type Rating Instructor
TSA	Trans state Airlines
TSRA	Thunderstorm and Rain
TWR	Tower
US	Unserviceable
UTC	Coordinated Universal Time
V_{APP}	Target Approach Speed
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Condition

VOR	VHF Omnidirectional Range
V_{REF}	Reference landing speed

Aircraft Accident Report No.:	DANA/2018/02/20/F
Registered Owner and Operator:	Dana Airlines Ltd
Aircraft Type and Model:	MD-83
Manufacturer:	Boeing McDonell Douglas
Year of Manufacture:	1990
Registration Mark:	5N-SRI
Serial Number:	53020
Location:	Runway 21, Port Harcourt International Airport
Date and Time:	20th February, 2018 at 18:52 h *(All times in this report are local time, equivalent to UTC+1 unless otherwise stated)*

SYNOPSIS

Accident Investigation Bureau (AIB) was notified of the accident by the Nigeria Airspace Management Agency (NAMA) on 20th February, 2018. Investigators were dispatched the following day, arrived on site at 11:00 h. All relevant stakeholders were notified accordingly.

On 20th February 2018, DANA Flight 0363 (DAN0363) a Boeing MD-83 aircraft, operated by DANA Airlines, was on a scheduled flight from Nnamdi Azikiwe International Airport (DNAA) Abuja to Port Harcourt International Airport (DNPO) on an Instrument Flight

Rules (IFR) flight plan. Onboard were 44 passengers, 2 pilots, and 3 flight attendants. Initially, the First Officer was the Pilot Flying (PF) while the Captain was the Pilot Monitoring (PM).

At 18:47 h, the Captain took over control after realizing the Distance Measuring Equipment (DME) 2 was not serviceable.

The aircraft descended through approach minimums (460 feet AGL) on a localizer only approach runway 21, crossed the threshold and did a smooth touchdown on the runway at 7,972 feet from threshold. The reported wind was 360° at 22 kt. The aircraft landed without obtaining landing clearance from the ATC.

The aircraft was on the centreline until it veered off left approximately 200 feet to the end of the runway, exited the paved surface and came to a stop 978 feet from the end of the runway approximately 33 feet left of the extended centreline.

The aircraft was substantially damaged. All persons onboard were evacuated unhurt.

The accident occurred at night in Instrument Meteorological Condition (IMC).

Causal factor

The accident was caused by an underestimation of the degradation of weather conditions (heavy rain, visibility and strong wind on short final and landing) and the failure by the crew to initiate a missed approach which was not consistent with the company's SOP.

Contributory Factors

Other contributing factors to this accident were:

- Non-compliance to company's SOP in meeting crew competency and complement requirements.

- Ineffective two-way communication between the ATC and DAN0363 during final approach prevented the flow of technical information on runway surface condition and other relevant meteorological information essential to safety.
- Failure of the crew to crosscheck the prevailing wind and also to obtain landing clearance from the ATC during final approach after contact with ATC was restored.

Nine Safety Recommendations were made.

1.0 FACTUAL INFORMATION

1.1 History of the Flight

On 20th February 2018, DANA flight 0363 (DAN0363), a Boeing MD-83 aircraft, operated by DANA Airlines, was on a scheduled flight from Nnamdi Azikiwe International Airport (DNAA) Abuja to Port Harcourt International Airport (DNPO) on Instrument Flight Rules (IFR) flight plan. Onboard were 44 passengers, 2 pilots and 3 flight attendants. This flight was the second of four trips to be flown by the crew that day. Initially, the First Officer was the Pilot Flying (PF) while the Captain was the Pilot Monitoring (PM).

The aircraft took off at 18:06 h. Following an uneventful flight enroute, the aircraft was in contact with the DNPO Approach Radar (AR), climbing to Flight Level (FL) 280 direct POT VOR, squawking 0422 as cleared and estimating POT at 18:48 h.

At about 18:20 h, Lagos Area Control Centre cleared DAN0363 to descend FL220. At about 18:22 h, DAN0363 was instructed to continue with DNPO approach. DNPO further re-cleared DAN0363 to FL80. During descent, the PF briefed for the approach (Radar Vectors) localizer RWY 21.

Approach reported the presence of cumulonimbus (Cb) cloud along the approach path of runway 21, and requested DAN0363 to report intention. DAN0363 responded "I will like to come closer then we take our decision I will advise". Meanwhile, DNPO Tower informed Approach that the intensity of the rain had increased to heavy rain.

At 18:43 h, according to the Tower transcript, another aircraft Arik Air (ARA) 766 on approach runway 03 reported a "Go Around Windshear". ATC directed ARA766 to turn to heading 300 and climb to Missed Approach Altitude (2,400 ft). At this time, DAN0363 decided to stop descent at 4,000 ft. Meanwhile, ARA766 requested a further climb to FL050.

At 18:45 h, the aircraft was cleared for LOC approach RWY 21.

At 18:47 h, the Captain took over control after realizing the Distance Measuring Equipment (DME) 2 was unserviceable. ILS frequency was selected on NAV box 1, Auto Pilot switched to No.1 and VOR frequency (113.5 MHz) set on NAV box 2.

At 18:48 h, 12 miles to touch down, Approach transferred DAN0363 to Tower on frequency 119.2 MHz. VOR DME was not showing on NAV box 2 and the set-up was reverted as follows: VOR on NAV box 1, ILS on NAV box 2, Auto Pilot 2 and Auto Throttle ON, and LOC TRACK came ON. Landing gear was selected DOWN, final descent from 2400 ft was initiated and the "Altitude" audio warning came ON and stayed ON until touchdown. Final flap was selected to 40^{o} and the speed was set to 130 knots.

Initial attempt by PM to contact the Tower was not on the correct frequency, during which both Tower and Approach were trying to raise the aircraft. Approximately 1.5 minutes after the first attempt, contact with the Tower was established on the correct frequency of 119.2 MHz.

According to CVR recordings, the Captain instructed the First Officer to watch out for the runway. A few seconds after, the Captain was heard yelling for wipers. After a while, the Captain sighted the runway and instructed the First Officer to report to Tower "Runway in sight...landing". Thirty-two (32) seconds later, an aural warning "Sink rate"! "Sink rate"!! "Sink rate"!!! "Sink rate"!!!! came ON.

The aircraft descended through approach minimums (460 feet AGL), crossed the threshold and did a smooth touchdown on the runway at 7,972 feet from the threshold in high winds of 360^{o}/22 kt. The aircraft landed without obtaining landing clearance from the ATC.

According to the Captain, during landing roll, the brakes were applied while simultaneously deploying thrust reversers to maximum; all spoilers automatically deployed after the nose wheel was lowered to the ground. The crew continued to apply brakes until maximum braking was commanded. The aircraft could not be stopped during brake application and the Captain continued applying the brake pedals to maximum.

The aircraft was on the centreline until it veered off left approximately 200 feet to the end of the runway, exited the paved surface and came to a stop 978 feet from the end of the runway approximately 33 feet left of the extended centreline.

After engine shutdown, emergency power switch was turned ON. Emergency light came ON and all other lights went OFF. The Public Address system did not work, therefore the lead crew had to open the cockpit door to obtain emergency evacuation instructions from the Captain. Emergency evacuation was carried out using the left forward main door only and the escape slide on this door did not deploy.

The crew reported that "the runway had experienced recent rain before arrival, and after touchdown looked and felt contaminated with flood of water that did not drain well".

The Airport Rescue and Fire Fighting Services (ARFFS) arrived during the evacuation and all persons onboard were evacuated unhurt.

The accident occurred at night in Instrument Meteorological Condition (IMC).

1.2 Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal	Nil	Nil	Nil	Nil
Serious	Nil	Nil	Nil	Nil
Minor	Nil	Nil	Nil	Not Applicable
None	Nil	Nil	Nil	Not Applicable
TOTAL	5	44	49	Nil

1.3 Damage to Aircraft

The aircraft was substantially damaged.

1.4 Other Damage

Some runway Approach Lights were broken, and the following NavAids were damaged; ILS Antenna and ILS light stand.

1.5 Personnel Information

1.5.1 Pilot in Command

Nationality:	Nigerian
Age:	59 years
Gender:	Male

License Type:	ATPL (A)
License Validity:	1st December, 2021
Instrument Rating Validity:	24th October, 2018 (MD-80)
Simulator Validity:	24th April, 2018
Medical Validity:	29th October, 2018
Ratings:	MD-80, B737-300/500, MD DC10-30, B707, F28
Proficiency check:	25th October, 2017
Total Flight Time:	18,881.50 h
Hours on Type:	941.67 h
Last 90 days:	216.00 h
Last 28 days:	57.83 h
Last 24 Hours:	02.50 h

The PIC was neither a Type Rating Examiner/Type Rating Instructor (TRE/TRI) nor line Training Captain on the aircraft.

1.5.2 Co-pilot

Nationality:	Nigerian
Age:	31 years
Gender:	Male
License Type:	CPL (A)
License Validity:	23rd July, 2020

Instrument Rating validity:	21st November, 2018
Simulator:	21st May, 2018 (MD-80/83)
Medical Validity:	26th November, 2018
Ratings:	B737-300/500, MD-80/83
Proficiency check:	22nd November, 2017
Total Flight Time:	358.06 h
Hours on Type:	88.9 h
Last 90 days:	88.9 h
Last 28 days:	81.02 h
Last 24 Hours:	02.50 h

The First Officer has flown unsupervised during the last couple of days before the accident with the same Captain without final release from a certified Type Ratings Examiner (TRE).

An extract of a written statement by the Director of Flight Operations, Dana Airlines Limited stated:

The first stage of the pilots' line training in Dana Airlines is with the TRI/TRE captains which may take between 15 to 50 sectors depending on the pilots' performance. He/she then advances to the second stage with designated Line Training Captain for the next 50 to 100 sectors. At this stage the pilot is paired with the line training captain until he/she is competent enough with commensurate experience to be finally released to fly with only experienced line captain which essentially is the final stage of release. Released to fly with all captains takes a little longer depending on the pilots' overall performance.

The First Officer in question was at the tail end of the second stage. His performance was satisfactory and was accelerated on the verge of being finally released to fly with regular MD 83 captains. He was only released to designated line training captain as per our approved manual OMD 2.5.2.8.

We have included as attachment photocopies of Training Record and Logbook for your attention in this investigation. He was released to fly as per OMD 2.5.2.8 with designated Line Training Captain to accumulate necessary experience for final release. **See Appendix 3.**

1.5.3 Flight Attendant (Purser)

Nationality:	Nigerian
Age:	34 years
Gender:	Female
License type:	Cabin Crew License
License Validity:	6th May, 2022
Medical Validity:	10th April, 2018
Ratings:	B737-300/500, MD-80/83

1.6 Aircraft information

1.6.1 General information

Aircraft Type:	MD-83
Registration Marks:	5N-SRI
Manufacturer:	Boeing McDonell Douglas

Serial No:	53020
Year of manufacture:	1990
Operator:	Dana Airlines Limited
Total airframe time:	66,109.72 h
Total landing/cycle:	41,794
Certificate of Insurance:	28th February, 2018
Certificate of Airworthiness validity:	14th April, 2018
Category:	Transport
Certificate of Registration:	2nd April, 2008

The investigation team calculated the landing weight of the aircraft as 107,907 pounds, using actual baggage weights and standard passenger weights from the load/trim sheet.

1.6.2 Engines

	Engine No. 1	**Engine No. 2**
Manufacturer:	Pratt & Whitney	Pratt & Whitney
Type/Model:	JT8D-217C	JT8D-217A
Serial number:	696368	P709713D
Time since New:	63,581.8 h	63,698.6 h
Cycle since New:	51,353	36,838

1.7 Meteorological Information

On 20th February, 2018 thunderstorm was reported in the 1600 UTC, 1630 UTC and 1800 UTC aviation routine weather reports. From the 1700 UTC observation, there was presence of thunderstorm and rain at DNPO. At 1730 UTC, the weather observed a deteriorating visibility to 5,000 m in thunderstorm, rain and squall. The rain continued to fall after the accident occurred. The 1749 UTC special weather observation issued by NiMeT reported the following conditions: Wind 360° at 22 knots, Visibility 0600 m, +TSRA, SQ, BRKN 180 m, FEW 540 m CB, Temperature 24 °C, Dew point 24 °C, Altimeter 1009 hPa. TEMPO 0350 m. SPECI- Visibility Deteriorating in Thunderstorm with Heavy Rain + Squall at DNPO.

DNPO :	**1630 UTC**
Wind :	200°/06 kt
Visibility:	10 km
Weather:	Thunderstorm (North West)
Cloud :	Broken 330 m, Few 600 m CB South East-North
Temp/Dew:	32°C/24 °C

DNPO:	**1730 UTC**
Wind:	300°/15 kt
Visibility:	8 km
Weather:	Thunderstorm
Cloud:	Broken 270 m, Few 570 m CB
Temp/Dew:	28°C/22°C

QNH:	1007 hPa
TEMPO:	5,000 m, Light Thunderstorm Rain

1.8 Aids to Navigation

The conditions of the Navigation Aids at the Port-Harcourt International Airport on the day of the occurrence were as follows:

VHF 119.2 MHz (TWR)	-Serviceable (S)-
VHF 118.6 MHz (TWR STBY)	-S-
VHF 124.9 MHz (APP)	-S-
VHF 121.7 MHz (DOM)	-S-
VHF 121.5MHz (EMERG)	-S-
VHF 122.35 MHz (ATIS)	-S-
'POT' 113.5 MHz VOR/DME	-S-
'IPC' 110.3 MHz ILS/DME	-Unserviceable (US)-
'PR' 385 KHz Locator	-US-
VSAT/SATCOM/GSM LINKS	-S-
TOTRON STANDBY RADIO	-S-
LLWAS/BINOCULARS	-US-
ATM MANUAL OPERATIONS	-AVB-
TWR/APP INTERLINK	-S-
ATC DIGITAL CLOCK	-S-

1.9 Communication

There was no effective communication between the Tower and the aircraft. The information on prevailing wind, other runway condition and landing clearance could not be transmitted to the aircraft before the landing.

1.10 Aerodrome Information

Port Harcourt International Airport (DNPO) has Aerodrome Reference Point 05°00’56”N, 006°56’58”E and an elevation of 87 ft/27 m. The aerodrome has a runway with an orientation of 03/21. The length and width of the runway are 3,000 m (9,843 ft) and 60 m (197 ft) respectively, with an asphalt/concrete ungrooved surface and a blast pad of 120 m (393.7 ft) at both ends. Both runways have Precision Approach Lighting System (PALS) and Runway 21 has Precision Approach Path Indicator (PAPI). The glide slope at the time of the occurrence was not serviceable while the localizer was serviceable. The runway surface was wet as at the time of the occurrence.

1.11 Flight Recorders

The aircraft is fitted with Solid-State Flight Data Recorder (SSFDR) and Cockpit Voice Recorder (CVR).

	Flight Data Recorder	**Cockpit Voice Recorder**
Manufacturer	Sunstrand Data Control Inc.	L3 Communication
Model	UFDR Digital Flight Data Recorder	FA 2100
Part Number	980-4100 FWUS	2100-1010-00
Serial Number	2987	000292937

The SSFDR and CVR were retrieved and downloaded at the Flight Safety Laboratory of Accident Investigation Bureau (AIB) Nigeria.

1.12 Wreckage and Impact Information

Tyre marks on the runway indicated that the aircraft touched down at 7,972 feet from the threshold of runway 21. Initially, the tyre marks were characterized by brief black rubber marks. The runway tyre marks and subsequent off-runway marks in the soft soil, on the grasses beyond the stopway were consistent with the track of the aircraft landing gear tyres leading to the aircraft final resting position.

The aircraft was on the centreline until it veered off left approximately 200 feet to the end of the runway, exited the paved surface, into the grass area and came to a stop 978 feet from the end of runway 21, approximately 33 feet left of the extended centreline. Some runway Approach Lights were broken, and the following NavAids were damaged: ILS Antenna and ILS light stand.

The aircraft was substantially damaged; the nose wheel collapsed into the fuselage, the right wing trailing edge flap was damaged, and the right main wheel tyres burst.

During post-accident inspection by the Bureau’s safety investigators, two circuit breakers (Anti-Skid Test and VHF No. 2) were found popped out.

Figure 1: Final resting point of the aircraft after the accident

Figure 2: Collapsed nose wheel of the aircraft

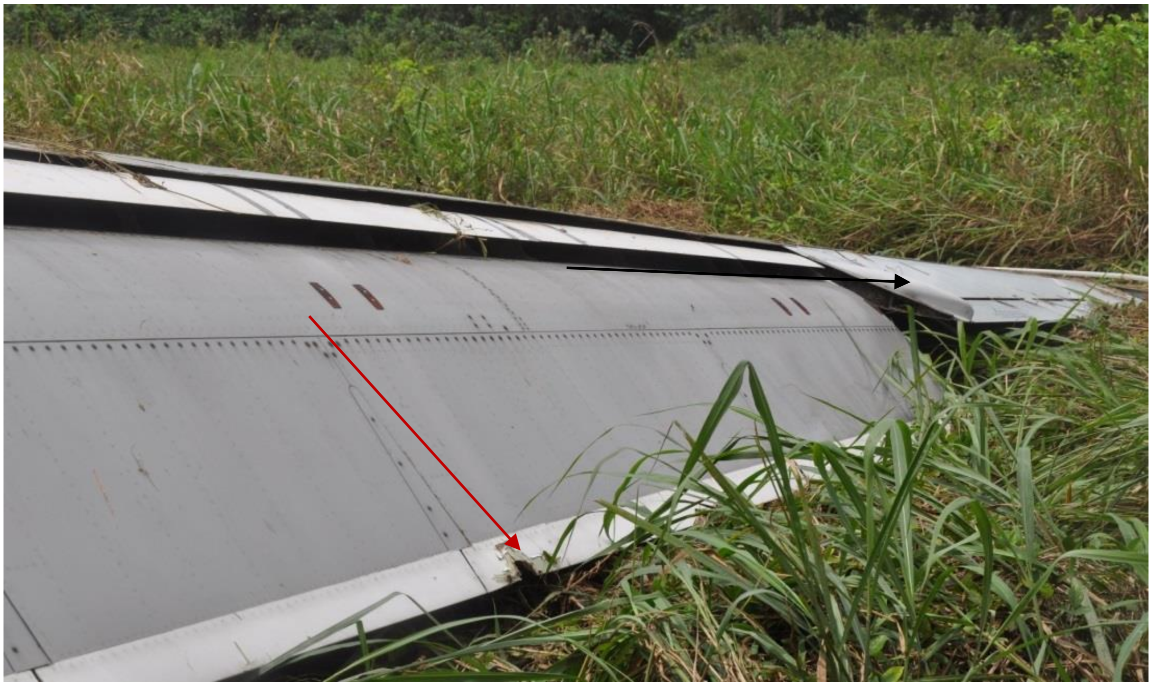


Figure 3: Damage on the right-wing trailing edge flap

Figure 4: Tyre marks from the right main landing gear of the aircraft

1.12.1 Main Wheel (MW) Tyres

The conditions of the main wheel tyres were taken during the post-impact inspection; MW No. 1 tyre remained inflated after the post-crash impact but had multiple cuts. MW No. 2 tyre was worn to third ply in several spots, had cuts but remained inflated after the post-crash impact. MW No. 3 tyre had a deep cut and deflated after the post-crash impact. MW No. 4 tyre was worn to second ply, had a deep cut and deflated after the post-crash impact. **See Figures 5, 6, 7, and 8 below.**

Figure 5: Photo of Main wheel No. 1 tyre

Figure 6: Photo of Main wheel No. 2 tyre

Figure 7: Photo of Main wheel No. 3 tyre

Figure 8: Photo of Main wheel No. 4 tyre

1.13 Medical and pathological Information

No medical or pathological test was conducted.

1.14 Fire

There was no pre or post impact fire.

1.15 Survival Aspect

When the aircraft came to a complete stop, emergency light came ON. The crew accomplished the cockpit emergency drill; the Public Address (PA) system did not work, so the Captain ordered "Evacuate" through the cockpit door. Also, the VHF COM did not work. Therefore, the Captain could not contact the Tower.

While trying to evacuate using the left forward main door, the Purser tried arming the slide but was over powered by a passenger who forced his way out. However, it was discovered during the post-accident inspections that the right forward service door escape slide was not installed.

The passenger and the Captain later assisted the purser in the evacuation process. The Airport Rescue and Fire Fighting Services (ARFFS) arrived within three minutes during the evacuation and all persons onboard were evacuated unhurt.

The accident was survivable as there was liveable volume of space in the cabin. Only the left forward main door was used for passenger evacuation.

1.16 Test and Research

Nil.

1.17 Organizational and Management Information

Dana Airlines Nigeria Limited was incorporated as a Private Limited Liability Company in Nigeria, a member of Dana Group of companies. The company was issued an Air Operator Certificate (AOC) on 11^{th} December, 2006 in accordance with the requirements of the provisions of the Nigerian Civil Aviation Regulations (Nig.CARs). The Airline commenced operations on the 10^{th} of November, 2008.

The operations and principal maintenance base is located in Ikeja, Lagos where it maintains operational and airworthiness support facilities appropriate for the area and type of operation and from where it undertakes scheduled passenger service, chartered service and carriage of cargo.

The Airline has six (6) aircraft in its fleet, which include four (4) MD-83, one (1) MD-82 and a Bombardier Learjet 45XR aircraft.

1.18 Additional Information

1.18.1 Approach and Landing

The guidance given by Boeing MD-80 Flight Crew Operations Manual (FCOM) for Wind Additives and Approach Speeds should be applied using the following formula:

"Add to V_{REF} the greater of ½ of the reported steady state wind greater than 20 knots, or all of the gust increment above the steady state value. Add only the greater of the two. The maximum additive is 20 knots."

The wind correction is considered to be one half of the headwind component plus the full gust increment. The prevailing winds for 1749UTC at the airport were 360°M 22 knots.

DANA Airlines Operations Manual Part B sub-paragraph 1.15.3.2 (Landing Speed calculation) defines:

V_{APP} as the target approach speed.

V_{REF} as the speed at which the aircraft should cross the threshold of a runway at 50 feet AGL.

The flight crew have access to a landing V-speed card (**See Appendix 1A**) in the cockpit as well as in the SOP. This chart has the landing weights listed, as well as the V_{REF} speeds for flaps 28° and flaps 40°. MD-83 aircraft operations manual indicates that "Wind correction = 1/2 steady headwind component + gust increment above steady wind."

For a landing weight of 107,800 pounds and a flaps setting of 40°, the card gives a V_{REF} of 120 KIAS and a V_{APP} of 125 KIAS. The V_{APP} speed planned by the crew was 129 KIAS (for 116,000 pounds). **See Appendix 1B.**

Boeing provides guidance in the MD-80 Flight Crew Operations Manual (FCOM), Section 40, Procedures & Techniques Approach and Landing (Stabilized Approaches), which states: *airplane should be stabilized in the final landing configuration on the descent flight path within +10/-5 knots of the pilot selected approach speed, no later than 1000 feet above the runway when in IMC. If ATC speed requirements caused air speed to be higher than the stabilized target speed, or if a visual approach is being conducted, speed, path, and sink rate stabilization should be achieved no later than 500feet above the runway, stability criteria should be maintained until flare initiation."*

The FCOM further states that *"momentary deviations in path or speed may be tolerated provided corrections towards stabilized criteria are immediately applied. If deviations are diminishing, a go around may not be immediately required. If deviations increase or corrections are not effective, strong consideration should be given to executing a go around."*

Other relevant sections from DANA Airline's Operations Manual 'Part B' (OMB) pertinent to this report are quoted below: -

1.18.1.1 Runway Field Length Limits Sub-paragraph 1.15.3.5

The runway distance needed for landing can be affected by the following:

- *Pressure altitude*
- *Temperature*
- *Wind component*
- *Runway gradient or slope*
- *Airplane weight*
- *Runway Climatic Conditions (contamination, wet runway, etc.)*
- *MEL/CDL*

The use of reverse thrust is not used in computing required landing distances.

Part 121 regulations state that the required actual landing distance starting at a point 50' height above the threshold cannot exceed 60% of the landing field length. In all *cases, the minimum airspeed allowed at 50-foot height must be no less than 1.3 times the airplane's stalling speed in the landing configuration. This speed is commonly called the airplane's V_{REF} speed and varies with landing weight.*

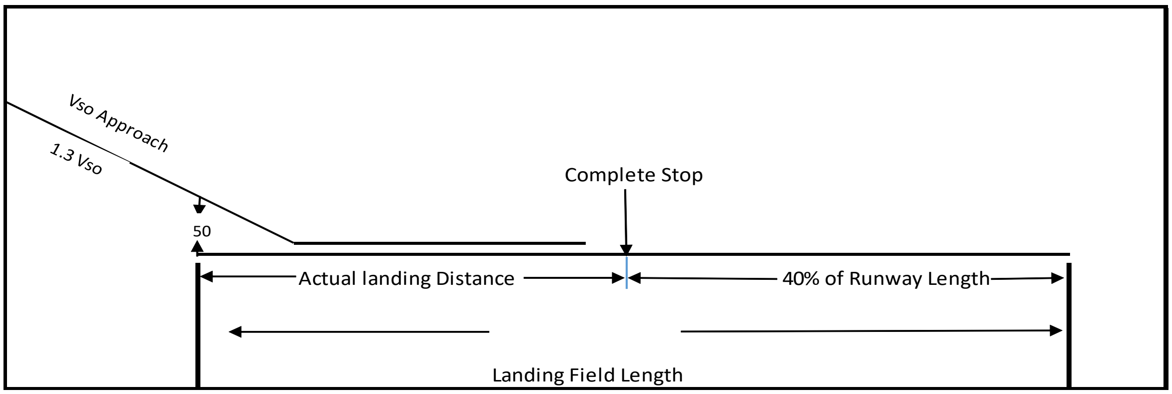


Figure 9: Sketch showing landing runway requirements

1.18.1.2 Landing Distance Requirement Paragraph 1.16.1

An aircraft must take off so as to arrive at the destination at a weight that allows the aircraft to be landed within 60% of the effective length of the runway. This is measured from the point 50 feet above the intersection of the obstruction clearance plane and the runway. The rule assumes that:

- *In still air the operator may select the most favourable runway and the most favourable direction and*
- *If there is forecast to be winds upon arrival, the airplane is landed on the most suitable runway considering the probable wind velocity and direction, ground handling characteristics of the aircraft, and other conditions such as landing aids and terrain.*

1.18.1.3 Pilot Operating Limitations Paragraph 1.16.2

A. Pilot Operating Limitations and Requirements:

(1) DANA Airlines requires each newly upgraded captain to make all takeoffs and landings until the crewmember has accumulated 100hours of pilot in command Experience.

(2) If the second in command has fewer than 100hours of flight time as second in command in commercial operations in the type airplane being flown, and the pilot in command is not a check airman, then the pilot-in command must make all takeoffs and landings at special airports designated by NCAA or DANA Airlines and in the following situations:

a) The prevailing visibility in the latest weather report is at or below 3/4 mile.

b) The runway visual range for the runway to be used is at or below 4000feet.

c) The runway to be used has water, snow, slush or similar conditions that may adversely affect airplane performance.

d) The braking action on the run way to be used is reported to be less than ''good''.

e) The crosswind component for the runway to be used is in excess of 15knots.

f) Wind shear is reported in the vicinity of the airport.

g) Any other condition in which the PIC determines it to be prudent to exercise his prerogative.

(3) For all commercial operations, a DANA Air Pilot in command or second in command must have at least 75hours of line operating flight time either as PIC or SIC in the type aircraft being operated.

B. (3) Pilot Operating Limitations and Pairing Requirements:

For all commercial operations, a DANA Air Pilot in Command or Second in Command must have at least 75 hours of line operating flight time either as PIC or SIC in the type aircraft being operated.

OMB Section 1: Limitation (Page 35)

A. *During all approaches and landing, the Pilot flying will conduct an approach briefing including the following;*
   1) *For an IMC approach - date of the approach plate–type of the approach and runway to be used – navigation aids and frequencies – headings and or bearings – minimum sector altitudes (MSA) – altitudes / fixes – timing – winds – appropriate DA, MDA or DH – visual descent point – missed approach point and procedure – runway length / field elevation / TDZE – all other pertinent information.*
   2) *For a VMC approach - the runway elevation and TDZE - Navigation aids as backup- minimum sector altitudes (MSA) – wind – all other pertinent information*

   During all approaches and landings, the PNF will call out:

   1) *When localizer and glide slope become active*
   2) *If the localizer or glide slope exceeds a one dot deflection*
   3) *Any significant deviations from the desired airspeed and / or rate of descent.*

B. *For an IMC approach – call out 500 feet above DH / MDA, and 100 to 200 feet above DH / MDA DH or MDA, the PNF calls out "Approaching Minimum, Runway insight or No contact"*
C. *The pilot flying should not attempt to establish visual contact until the pilot not flying has the runway / landing area in sight. If the runway is in sight and the aircraft is in a position to land, the flying pilot will call out "landing". If not, he will call out "going around".*

D. *For a VMC approach- at 1000 feet and 500 feet- the altitude, airspeed, and rate of descent, any significant deviations from desired airspeed and/or rate of descent.*

E. *For all approaches, Dana Air's policy requires that you be stabilized by 1000 feet AGL when IFR, and 500 feet AGL when VFR. This means the aircraft must be in an approved landing configuration, maintain the proper approach speed with engines spooled-up, and must be established on the proper flight path before descending below minimum "stabilized approach height" specified for the type of operation being conducted. These conditions must be maintained throughout the rest of the approach to be considered a stabilized approach.*

1.18.1.4 Touch Down Paragraph 1.16.9

The normal aiming point for landing is approximately 1000 feet down the runway. An acceptable touchdown should occur between 500 to 1500 feet down the runway. If this feat cannot be achieved, a missed approach should be executed.

1.18.1.5 Windshear Paragraph 1.16.11

Airplanes are not capable of safely penetrating all intensities of low-level Windshear. Therefore, it is Company policy to not to operate through areas where strong low level Windshear is present or suspected.

- *Do not attempt a takeoff or an approach when there is evidence of thunderstorm gust front on or near the runway in use. Gust fronts can extend a considerable distance of a storm cell and at different direction from the cell movement.*
- *Do not attempt a takeoff or an approach when an airspeed loss of more than fifteen (15) knots is reported below 1000' AGL by similar size aircraft flying departure/approaches to the same runway.*

- *Go around may be appropriate at any point on the approach when Windshear is encountered. However, execute a go around immediately if at or below 1000 feet AGL and the approach becomes unstable because of an uncontrolled change from the normal steady state parameters in excess of the following: - 15 knots indicated airspeed – 500 feet per minute vertical speed – 5^0 pitch attitude – 1 dot displacement from the glide slope – abnormal power requirement to regain control.*
- *It is not possible to define all cases where a takeoff or approach should not be attempted. The flight crew should use good judgement, remembering delaying or diverting may be the best action they can take.*

1.18.1.6 Flight Precautions Sub-paragraph 1.16.13.1

These precautions are used by the flight crews when there is reason to believe the Windshear to be encountered does not exceed the Company policy limits. For both take offs and landings, even if the policy limits are not exceeded, the Flight Crew may still decide that delaying the takeoff, holding or diverting may be the best course of action.

1.18.1.7 Landings on Wet/Slippery or Contaminated Runways Sub-paragraph 2.1.5.18.3

Landing on a contaminated or slippery runway must always be considered critical. Since the runway conditions for a wet runway differs from airport to airport, it is impossible to give a guideline for all situations.

When a runway is grooved however, the friction characteristics are such that it may be regarded as dry, for the portion, which is grooved.

If the runway is contaminated to such an extent that ingestion of runway deposit may be expected during the landing roll, start and connect the auxiliary Power Unit (APU) as a back-up in case of generator failure due to engine RPM spool down.

The approach and landing must be flown according to the normal techniques. The threshold must be crossed at a correct height and speed. Avoid a long float and make a positive landing. Check that spoilers extend immediately.

Lower nose-gear without delay. Upon nose-wheel touch down immediately apply reverse thrust.

If the aircraft deviates from centreline:

- *Bring aircraft back to centreline by use of rudder pedal*
- *Release brakes*
- *Select reverse or idle forward thrust*
- *Regain runway centreline*
- *When aircraft is under control resume braking and reversing as required.*

Do not attempt to leave the runway with a speed higher than taxi speed anticipated for the expected taxiway conditions.

DANA Airlines, Operations Manual Part A Sub-paragraph 8.3.2.5 (Crosswind Components):

States that "maximum permissible crosswind components are detailed in fleet type specific manuals. The maximum permissible components quoted for landing are only to be exceeded in an emergency.

i. *Quoted figures are normally those up to which the aircraft has been demonstrated, as stated in the Aircraft flight manual. They take account of average pilot skills applied to the control limits of the aircraft and, unless otherwise stated, apply only in otherwise ideal conditions (i.e. dry runway and steady wind conditions).*

ii. *The Captain is only to operate up to the limiting wind component if the conditions are considered suitable, and is always to have regards to his personal experience on type, knowledge of airfield characteristic, wind/gust behaviour and runaway surface conditions,(e.g. dry ,wet or slippery)before attempting to takeoff or landing. The maximum reported gust speed and change of wind direction is to be taken into account when computing the crosswind component.*

iii. *Whenever reported winds appear critical, the captain is to request the ATC to report surface wind continuously during the final approach.*

The Flight Safety Foundation, in its study on approach-and-landing accidents, found that a 5% increase in final-approach speed increases the landing distance by 10% if a normal flare and touchdown are conducted with deceleration of the aircraft on the ground. The study also found that extending the flare and allowing the aircraft to float and bleed off excess airspeed can also increase the landing distance, because the excess speed must be bled off in the transition from the threshold crossing to the touchdown. This measure typically uses 3 times more runway than decelerating on the ground. Some references associated to this section are:

Flight Safety Foundation, Briefing Note 8.3: Landing Distances, Approach and Landing Accident Reduction (2009).

Flight Safety Foundation, Briefing Note 8.1: Runway Excursions, Approach and Landing Accident Reduction (2009).

DANA Airline's Operations Manual 'Part D' (OMD) pertinent to this report are also quoted below:

1.18.1.8 Period of validity Paragraph 2.1.4

2.1.4.1 Dana air Proficiency check

The period of validity of a company proficiency check shall be six calendar months in addition to the remainder of the month of issue. If issued within the final three calendar months of validity of a previous company proficiency check, the period of validity shall extend from the date of issue until six calendar months from the expiry date of that previous company proficiency check.

2.1.4.2 Line check

The period of validity of a line check shall be 12 calendar months, in addition to the remainder of the month of issue. If issued within the final three calendar months of validity of a previous line check the period of validity shall extend from the date of issue until 12 calendar months from the expiry date of the previous line check. The line check must be conducted on the aircraft type.

1.18.1.9 Flight Training Sub-section 2.5

Dana Air shall not use anyone to serve as a flight crewmember, unless that person is qualified for the operations for which he or she is to be used and shall have completed the initial flight training approved by the authority for the aircraft type which focused on manoeuvring and safe operation of the aircraft in accordance with the approved procedures for normal, abnormal and emergencies.

2.5.0.1 Flight training will be structured and sufficiently comprehensive to familiarise the flight crew member thoroughly with all aspects of limitations and normal operation of the aircraft type, including the use of all cockpit equipment, and with all abnormal /emergency procedures and should be carried out by suitably qualified check flight crew.

2.5.0.2 When planning flight training on aircraft with a flight crew of two or more, particular emphasis will be placed on the practice of LOFT with emphasis on CRM and the use of correct crew co-ordinate procedures, including coping with incapacitations.

2.5.0.8 All flight crew must successfully complete the company's proficiency check with a TRE before they are assigned to line duties.

1.18.1.10 Flights Tests and Checks Paragraph 2.5.1

Flight crew members, prior to an evaluation, shall be familiar with those manoeuvres and/or malfunctions that may be presented during the evaluation, but are not given information that reveals the sequence and the circumstances under which such manoeuvres or malfunctions will be presented.

2.5.1.1 The following mandatory tests and checks will be carried out on or prior to completion of the conversion training and prior to commencing line flying under supervision:

a. Emergency and Safety Equipment Check

b. Pilot type rating proficiency test

c. Dana Air Proficiency Check

d. IR Renewal.

2.5.1.2 The Emergency and safety Equipment Check must be completed before the candidate flies the aircraft.

2.5.1.3 The initial Base Check is to be flown from the seat in which the pilot will normally be employed and is to include an Instrument Rating Renewal.

2.5.1.4 Before a Pilot may fly under supervision for the purpose of public Transport he must satisfactorily complete an initial line check. This may be short check, starting and finishing at the same field if convenient. When passed, the test should be certified "Initial".

2.5.1.5 When the company Proficiency Check is conducted in an approved synthetic training device, crew shall also demonstrate their proficiency in conducting ILS approach to Category II/III aerodrome operating minima, when applicable.

1.18.1.11 Line Training under Supervision Paragraph 2.5.2

2.5.2.4 All flight crew members will operate a minimum number of sectors and/or flying hours under the supervision of a nominated check pilot who is also serving as PIC shall occupy a pilot station. The normal minima for Line Flying under supervision (in addition to any base training) will be:

- Aircraft Commanders/Co-Pilot on type	*50 hours (min. 20 sectors)*
- Aircraft Commanders/Co-pilot	*100 hours (min. 30 sectors)*

Non-reducible transiting to a new aircraft type

For pilots with more than 500 hrs on type and recent experience on equivalent jets in the area of operations, these criteria may, at the Flight Training Manager's discretion, be reduced by up to 40%.

2.5.2.5 After completing the sectors and/or flight hours under supervision, a final line check for the requirement of para.2.1.4.2 will be completed.

2.5.2.6 Before a pilot may fly unsupervised for the purpose of Public Transport, the final Release and, in the case of Commanders, the Area Competency Release must be signed.

1.18.1.12 Route/Role/Area Competence Training Sub-section 2.7

Dana Air shall not use a person as a pilot unless, within the preceding 12 calendar months, that person has passed a route check in which he or she satisfactorily performed his or her assigned duties in one of the types of aircraft that he or she is to fly. No person shall perform PIC duties over a designated special operational area that requires a special navigation system or procedures unless their competency with the system and procedures has been demonstrate to the airline within the past 12 calendar months. Each PIC shall demonstrate special operational competency by navigation over the route or area as PIC under the supervision of a check pilot and, on a continuing basis, by flights performing PIC duties

1.18.1.13 Crew Resource Management (CRM) Paragraph 2.9.5

2.9.5.1 The successful resolution of aircraft emergencies requires effective co-ordination between the flight and cabin crew.

2.9.5.2 Combined training will be provided for flight and cabin crew, as applicable for the purpose of enhancing onboard coordination and mutual understanding of CRM and the human factors involved in addressing emergency situations and security threats.

2.9.5.3 There will be an effective liaison between flight crew and cabin crew training sections to promote consistency of drills and procedures, *provision will be made for flight and cabin crew instructors to observe and comment on each other's training.*

2.9.5.4 CRM training is the effective utilization of all available resources i.e. Crew members, aircraft systems and supporting facilities to achieve safe and efficient operations.

2.9.5.5 Emphasis will be placed on the importance of effective co-ordination and two-way communication between flight crew and cabin crew in various emergency situations. Initial and recurrent CRM training will include joint practice in aircraft evacuations so that all who are involved are aware of the duties other crew members must perform. When such practice is not possible, combined flight crew and cabin crew training will include joint discussion of emergency scenarios.

1.18.2 Final Approach and Touchdown

An approach to land on a contaminated runway requires a fully stabilized final approach and a firm (but not hard) touchdown within the prescribed touchdown zone. If either is not achieved, a go around or rejected landing is appropriate. The challenges of achieving a successful contaminated runway landing are such that there should be no indecision in either case.

Touchdown vertical speed needs to be sufficient to break through the layer of contaminant and find at least some friction so that wheel rotation speeds can reach normal levels quickly. This is necessary so that they will exceed the minimum required to prevent operation of the anti-skid-system. A theoretical target for touchdown rate of descent is in the range 2 to 3 feet per second/120 to 180 fpm. Once main gear touchdown has occurred, derotation should start and thrust reverser deployment should occur. Both actions will increase wheel loading, which will ensure the achievement and/or continuation of wheel rotational speeds sufficient to allow lift spoiler deployment and brake activation.

1.18.3 Landing on Contaminated Runway

Landing on contaminated runways involves increased levels of risk related to deceleration and directional control. Aircraft landing performance data takes account of the deceleration issues in scheduling the Landing Distance Required (LDR), and the aircraft limitations specified in the AFM can be expected to impose a reduced maximum crosswind limitation. Operator procedures may further restrict all such operations or impose flight crew-specific restrictions or requirements. Despite all procedural precautions, contaminated runway landings are rare events for most flight crew and although this serves to ensure a full focus on the task, the lack of real experience, and the limited ability to create realistic scenarios in most simulators, means that a full understanding of the issues involved can be an additional safeguard. Aircraft type procedures are the correct source of detailed knowledge.

1.18.4 Deceleration

This is a function of both wheel spin up and braking efficiency. Once manual or automatic braking begins, its efficiency may also be indirectly affected by use of thrust reversers/reverse pitch and the manual or automatic deployment of lift spoilers. Spoiler activation will also be constrained by aircraft on ground logic and probably also by a wheel rotational speed, although usually a lower one than that needed to allow brake application. Absence of sufficient deceleration during a contaminated runway landing is much more likely to be due to low wheel rotational speeds than to brake system failure, (unless there are specific annunciations of this and/or related prior indications which have initiated doubt as to brake system integrity). Any memory drill action to select emergency braking channels should therefore only be followed strictly in accordance with the associated criteria, since one of the effects is likely to be the de-activation of the anti-skid system and an attendant increased risk of locking the wheels; on surfaces contaminated with liquid water, this increases the risk of reverted rubber aquaplaning.

Reverse thrust represents approximately 20% of the total available braking force when braking on a slippery runway. The international guidelines for operation on contaminated runways are not in accordance with the strict requirements for certification of aircraft which are based on documented performance on dry runways without the use of thrust reversers. Nevertheless, operations on contaminated runways are permitted on the basis of 'advisory' (not 'certified') friction data and the use of thrust reversers.

1.18.5 Directional Control

Effective directional control, on a contaminated runway surface during landing, requires that all wheels are firmly on the ground without undue delay and that the control column/side stick is then promptly centralized both longitudinally and laterally, so as to avoid inducing asymmetric main gear wheel loading and achieve adequate nose landing gear wheel loading. However, the main initial means of directional control during the landing roll is likely to be the rudder, which on most aircraft types will remain effective until around 80 KIAS, sometimes even less.

If directional control problems are experienced at high speed, then it is normally recommended to cancel reverse thrust/pitch until satisfactory control is regained. If auto brake has been selected and is producing differential brake release which is aggravating directional control, then selection of manual braking is usually recommended with full brake pedal release on one side being a usual way to achieve this quickly. Manual differential braking will usually need complete release of brake pedal pressure on one side.

Once rudder effectiveness is lost at lower speeds, directional control difficulties on a contaminated surface may increase, in contrast to what would be expected on a landing roll on a normal friction surface. This is because:

- The effects of even minor differential manual braking are likely to be greater
- Thrust Reversers/Reverse Pitch are likely to be more de-stabilizing
- Reduced nose landing gear wheel adhesion directly limits both steering input options and the usual directionally-stabilizing effect of the nose landing gear
- Yaw effects arising from any differential braking effectiveness are exaggerated.

1.18.6 Hydroplaning

Hydroplaning, also referred to as aquaplaning, occurs when a layer of water builds between the aircraft tires and the runway surface, leading to a loss of traction and preventing the aircraft from responding to control inputs such as steering or braking. Landing at higher than recommended touchdown speeds will expose the aircraft to a greater potential for hydroplaning. Once hydroplaning starts, it can continue well below the minimum initial hydroplaning speed. Generally, 3 types of hydroplaning are distinguished: dynamic, viscous and reverted rubber.

Dynamic hydroplaning is caused by the build-up of hydrodynamic pressure at the tire-pavement contact area. The pressure creates an upward force that effectively lifts the tire off the surface. When complete separation of the tire and pavement occurs, the condition is called total dynamic hydroplaning, and wheel rotation will stop. Total dynamic hydroplaning usually does not occur unless a severe rain shower is in progress.

There must be a minimum water depth present on the runway to support the tire. The exact depth cannot be predicted since other factors, such as runway smoothness and tire tread, influence dynamic hydroplaning. Both smooth runway surface and smooth tread tires will induce hydroplaning with lower water depths. While the exact depth of water required for hydroplaning has not been accurately determined, a conservative estimate for an average runway is that water depths in excess of 0.1 inch (2.54 mm) may induce full hydroplaning.

Viscous hydroplaning is more common than dynamic hydroplaning. Viscous hydroplaning may occur at lower speeds and at lower water depths than dynamic hydroplaning. Viscous hydroplaning occurs when the pavement surface is lubricated by a thin film of water. The tyre is unable to penetrate this film, and contact with the pavement is partially lost. Viscous hydroplaning often occurs on a smooth runway pavement or where rubber deposits are present, usually in the touchdown area where a thin water film can significantly reduce the coefficient of friction.

1.18.7 Antiskid System - Description and Operation (Aircraft Maintenance Manual Section 32-43-00)

1.18.7.1 General

The antiskid system is an automatic, electrically controlled means of preventing main gear wheels from skidding during brake application. Each wheel is controlled independently. The system consists of a solid state circuitry control box, four speed sensing transducers, four dual servo valves, four failure annunciator displays, a system arming switch and a test switch.

Skids are detected by comparing present wheel speed (as sensed by a transducer mounted in the axle) to a reference velocity. This reference velocity is based on past wheel speed and deceleration and is determined by the control circuitry. When wheel *speed drops below this reference level an error signal is generated. When the error signal reaches a predetermined threshold, a control signal is sent to the servo valves which reduces the brake pressure to that wheel. As the wheel begins to spin up following the skid, pressure is gradually reapplied. Both the error threshold and reapplication note are chosen to maximize friction between tire and runway and thereby minimizing stopping distance. Note that the antiskid system operates only when the pressure applied by the pilot is sufficient to cause a skid condition. If the antiskid system is inoperative (not armed), the pilot's metered pressure will be applied directly to the brakes regardless of skidding.*

1.18.7.2 Operation

The antiskid system is armed by placing the control switch to ARM position. In flight, this is accomplished after the gear has been extended. During ground roll, the wheel speed signal from the transducers is monitored by the control box.
Changes in wheel speed are detected by the wheel control cards and signals are sent to the control valves to release pressure at the brake. The pressure is then gradually reapplied until another skid is detected. By constantly creating skids and releasing pressure accordingly, the antiskid system can optimize tire-runway friction and minimize stopping distance. It should be noted that the antiskid system cannot increase brake pressure beyond that which is supplied by the pilot's metering valve. Thus, if the pilot's applied pressure is insufficient to cause a skid, then the antiskid has no controlling effect.
The antiskid self-test may be run at any time (antiskid armed, gear down) in the air or on the ground as well as automatically at main gear extension. When the TEST CKT switch is placed in the TEST position, four antiskid lights shall illuminate. Lights shall go off when TEST CKT switch is moved to OFF. If a light remains on, a fault has been

detected. In addition, continuous monitoring capability allows detection of loss of power to the system.

An electrical switch is coupled to the shutoff solenoid valve plunger and is closed when the flow to the return line is shut off. The switch completes a circuit to the parking brake light indicating that the brake is set. The wheel not rolling light provides a warning to the pilot that a wheel is not rolling and provides information to allow brakes to be released momentarily on low friction runways to allow the wheel to spin-up. The light may also be useful in detecting a locked brake that might exist on takeoff ground roll.

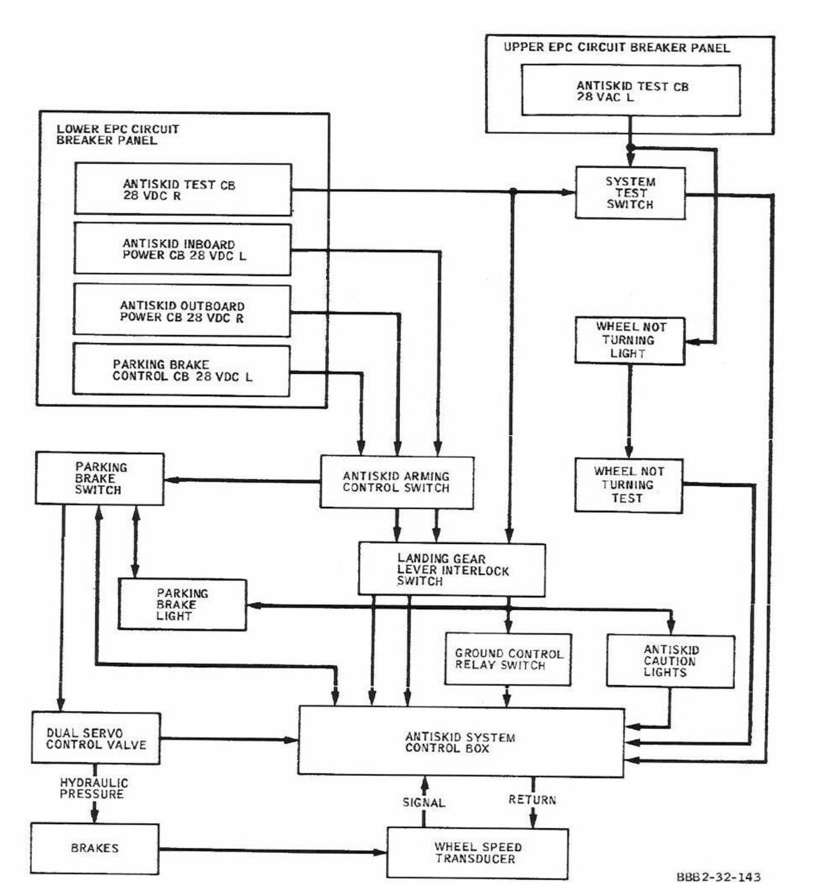


Figure 9: Anti-skid system block diagram

1.18.7.3 Anti-Skid Test CB

There are two Antiskid Test circuit breakers, B-214 and B-215.

1. *A ground test is initiated via the antiskid switch S1-493 in the cockpit overhead panel. The switch is moved to the TEST position by the flight crew when performing the Before Start Checklist prior to flight and is normally in the ARM position during flight. The TEST position is a momentary position, so the switch must be manually held in that position to initiate the test. After testing, when finger pressure is removed from the switch, it will automatically return to the ARM position. When the test is initiated, all four antiskid lights will briefly illuminate, then extinguish, indicating all four wheel positions have passed the test.*
2. *An in-flight test is initiated when the landing gear is selected down in preparation for landing. An automatic power up test sequence is initiated when 28VDC is provided to the Brake Control Unit contact 35. This power is provided by Circuit Breaker B1-215 through relay R2-85 contact C, Nose Gear Squat Left and Nose Gear Squat Right. Should the automatic power up test sequence detect a failure, the related antiskid light(s) will illuminate in the overhead annunciator panel B5-6, indicating a system failure to the flight crew (See figure 10)*

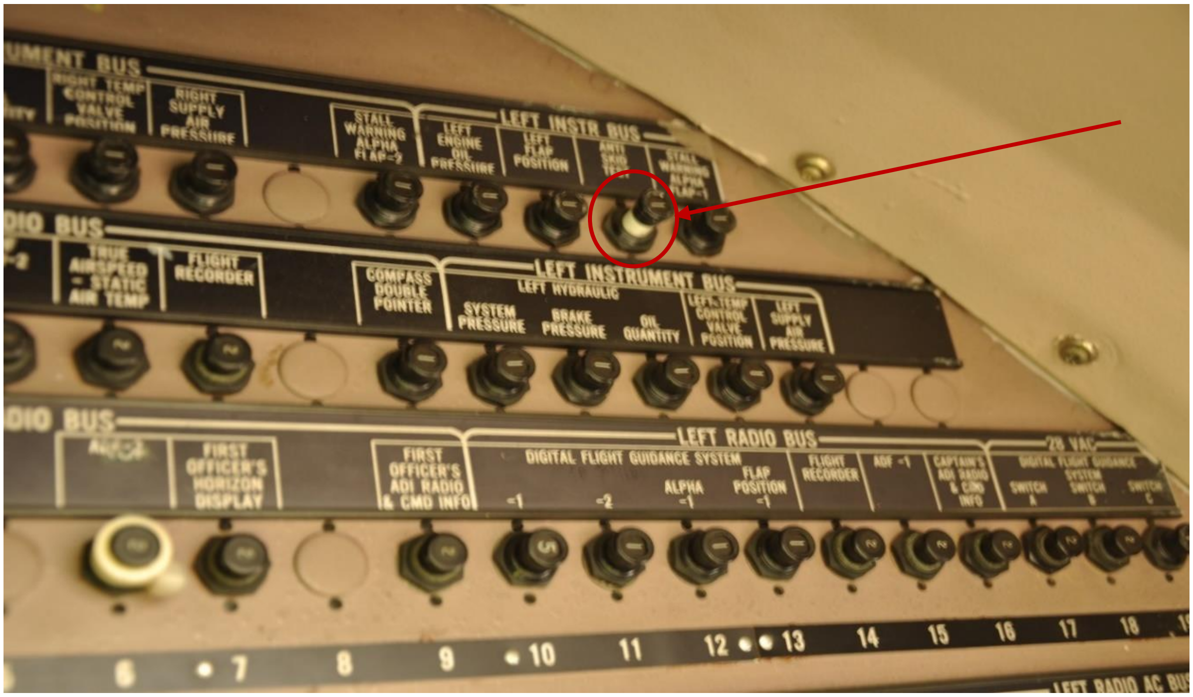


Figure 10: Popped-out anti-skid test circuit breaker

1.18.8 Aircraft Performance

Before departure, the crew received a flight-release package from the company dispatch. The flight-release package contained all information pertinent to the flight, including current and forecast weather, winds aloft, notices to airmen (NOTAMs).

The flight-release package depicts performance data in the form of aircraft weight for take-off or landing, and any additional restrictions that may apply. On the day of the occurrence, the maximum landing weight permitted (regulated) for Runway 21 at DNPO, with a flaps setting of 40, was estimated at 139,500 pounds**.** The landing weight calculated by the dispatch was 107, 907 pounds, which was far less than the regulated landing weight.

AIB requested calculation of the aircraft's landing performance from DANA Airlines based on calculations of aircraft configuration of flaps 40, a speed of 120 KIAS at 50 feet over threshold, the relevant runway data and the environmental conditions that existed at the time of the occurrence. Using only brakes and spoilers (landing performance excludes the use of thrust reversers). According to DANA Airline's result, the aircraft should have come to a stop 6,793 feet from the threshold, with 3050 feet of runway remaining if it landed within the required landing distance. **See Appendix 2.**

1.18.9 Port Harcourt International Airport Runway Maintenance

Federal Airport Authority of Nigeria (FAAN) is the agency responsible for the maintenance and operation of Port Harcourt International Airport. During the course of the investigation FAAN did not provide the Bureau with any information regarding the Standard Maintenance Programme implementation at Port Harcourt International Airport to evaluate the condition of the runway surface; for example, the airfield-pavement structural-condition surveys and runway friction testing. However, according to FAAN, maintenance is carried out as the need arises. Both the surface condition and surface quality of runways are evaluated. Daily, periodic visual inspections of the airfield are supervised by the airport authorities and conducted by field engineers and other airfield operations personnel.

Over time, the skid resistance of runway pavement deteriorates due to a number of factors, such as mechanical wear, polishing action from aircraft tyres rolling or braking on the runway surface, and accumulation of contaminants. Runway contaminants include rubber deposits, dust particles, jet fuel, oil spillage, water, snow, ice, and slush, all of which can cause loss of friction on runway pavement surfaces. The effect of these factors is directly dependent on the volume and type of aircraft traffic.

When done on a regular basis, runway friction testing assists in determining whether corrective maintenance action is required to restore runway's friction characteristics, or whether such maintenance must be planned. The runway coefficient of friction is measured using a Surface Friction Tester with a self-wetting capability.

Nigerian Civil Aviation Authority (NCAA)'s Advisory Circular NCAA-AC-ARD014 issue No. 1 of September, 2012 which relates specifically to Part 12.6.4(d) of Nigerian Civil Aviation Regulations (Nig.CARs) 2007 refer to the Aerodrome Standards and Recommended Practices.

Civil Aviation Authority of New Zealand also issued an Advisory Circular AC139-13 Aerodrome maintenance: Runway surface friction characteristics and friction testing (18 July 2008). The Purpose of this Advisory Circular is to provide guidance material and information on runway friction testing, assessment criteria and equipment requirements. This Advisory Circular relates to Civil Aviation Rule Part 139 - specifically to rule 139.103(c).

Also, Part 3 subpart 2 of the Canadian Aviation Regulations, more specifically provision 302.07 refer to the Aerodrome Standards and Recommended Practices, which are described in this 5th edition of Transport Canada Publication, *Aerodrome Standards and Recommended Practices;* (TP 312). TP312E contains the following standards, which require the airport to react when the average friction values for a runway fall below specified levels:

TP312E Sections 9.4.2.4 and 9.4.2.5; and Transport Canada (TC) Aerodrome Safety Circular (ASC) 2004-024 Appendix A, Table 1, note 6

Runway friction values are recorded on a scale from 0 to 100, whereas the runway coefficient-of-friction scale is from 0.0 to 1.0 (e.g., a runway friction value of 50 equates to a coefficient of friction of 0.50).

9.4.2.4 Standard – Corrective maintenance action shall be taken *[emphasis added]* when:

a) The average coefficient of friction for the entire runway is below 0.50; or

b) Any areas of a runway surface that are 100 metres or greater in length have an average coefficient of friction less than 0.30.

9.4.2.5 Standard – Corrective maintenance action shall be programmed *[emphasis added]* when:

a) The average coefficient of friction for the entire runway is below 0.60; or

b) Any areas of a runway surface that are 100 metres or greater in length have an average coefficient of friction less than 0.50.

The Port Harcourt International Airport conducts friction tests of Runway 03/21 through a contractor. According to NCAA 2018 audit report of DNPO, FAAN claimed to have conducted the last friction test on Runways 03/21 in 2012. However, there is no documentary evidence provided by FAAN to support this claim. **See Appendix 3.**

Before the accident, there was no record of any corrective maintenance action that took place on the runway. The most recent de-rubberization exercise of runways 03/21 was conducted on 22nd December, 2017 by a contractor. The result of the exercise was satisfactory. **See Appendix 3.**

However, many countries use the ICAO recommended 1.0 mm layer of water when measuring the runway coefficient of friction.

Guidelines for establishing the design objective, maintenance planning level and minimum friction levels of runways in use (Table 1.) were developed using different Continuous Friction Measuring Equipment (CFME) surface-friction tester vehicles with a smooth tire, between pressures of 70 to 210 kPa, travelling at 65 km/h to 95 km/h.

Table 1: Continuous Friction Measuring Equipment (CFME) Result

Test Equipment	**Test tire**		**Test Speed (km/h)**	**Test water Depth (mm)**	**Design objective for new surface**	**Maintenance Planning level**	**Minimum friction level**
	Type	Pressure (kPa)					
(1)	(2)		(3)	(4)	(5)	(6)	(7)
Mu-meter Trailer	A A	70 70	65 95	1.0 1.0	0.72 0.66	0.52 0.38	0.42 0.26
Skiddometer Trailer	B B	210 210	65 95	1.0 1.0	0.82 0.74	0.60 0.47	0.50 0.34
Surface Friction Tester Vehicle	B B	210 210	65 95	1.0 1.0	0.82 0.74	0.60 0.54	0.50 0.41
Runway Friction Tester Vehicle	B B	210 210	65 95	1.0 1.0	0.82 0.74	0.60 0.54	0.50 0.41
TATRA Friction Tester Vehicle	B B	210 210	65 95	1.0 1.0	0.76 0.67	0.57 0.52	0.48 0.42
GRIPTESTER Trailer	C C	140 140	69 95	1.0 1.0	0.74 0.64	0.53 0.36	0.43 0.24

1.18.10 Runway Surface Texture

Runway surface texture is considered to be the main factor in the braking friction coefficient of a wet runway. Runway surfaces contain both macro-textures and micro-textures.

Macrotexture is the coarse texture evidenced by the aggregate or by artificially applied texture such as grooving. Its primary purpose is to enhance bulk-water drainage, thereby reducing the tendency for aeroplane tyres to be subjected to dynamic hydroplaning.

Microtexture is the texture of the individual stones and is hardly detectable by eye. It can be felt, but cannot be directly measured, and it is one of the most important factors in reducing the onset of viscous hydroplaning.

Degradation of microtexture, caused by the effects of traffic, rubber deposits, and weathering, may occur within a comparatively short period compared with the time required for degradation of surface macrotexture.

ICAO Annex 14, Volume I recommends that the average macrotexture depth of a new surface should be not less than 1mm, to provide good friction characteristics when the runway is wet. Although a depth of less than 1mm may still provide good drainage, a depth greater than the minimum value must be chosen when constructing a new surface, because normal wear will result in surface deterioration.

1.18.11 Runway Surface Condition

ICAO Annex 14, Volume 1, Chapter 2 recommends that:

Whenever water is present on a runway, a description of the runway surface conditions on the centre half of the width of the runway, including the possible assessment of water depth, where applicable, should be made available using the following terms:

DAMP — the surface shows a change of colour due to moisture.

WET — the surface is soaked but there is no standing water.

WATER PATCHES — significant patches of standing water are visible.

FLOODED — extensive standing water is visible.

TP312E states, in section 2.5.1.1:

Standard Information on the condition of the movement area and the operational status of related facilities shall be provided to the appropriate aeronautical information service units, and similar information of operational significance to the air traffic services units, to enable those units to provide the necessary information to arriving and departing aircraft. The information shall be kept up to date and changes in conditions reported without delay.

The term "wet," when referring to the condition of a runway surface, is used in many publications, including the *Canadian Aviation Regulations* (CARs) and the TC *Aeronautical Information Manual*. However, there is no common definition in Canada. NAV CANADA, in its *Air Traffic Control Manual of Operations*, defines a wet runway as one that "is covered with sufficient moisture to cause it to be reflective, but is not contaminated." The word "contaminated" is not defined. A paper submitted to the 2009 conference of the International Society of Air Safety Investigators (ISASI) stated that "the only information that a pilot gets is based on the assumption that the water depth is less than 3mm when the runway is reported wet." The 3mm depth of water appears to be the generally accepted dividing line between a wet runway and a contaminated runway. According to the FAA *Aeronautical Information Manual* Pilot/Controller Glossary, "a runway is considered contaminated whenever standing water, ice, snow, slush, frost in any form, heavy rubber, or other substances are present." Some references associated with this section of the report are:

Ranganathan, *Wet Runway Overruns: Pilot Error? System Deficiency?* A paper presented to International Society of Air Safety Investigators (ISASI) Forum (January to March 2006)

FAA *Aeronautical Information Manual* (AIM), Pilot/Controller Glossary

Transport Canada has drafted a notice of proposed amendment, NPA 2005-034, for CAR Standard 725.55: General Requirements – Runway Operations, which is currently undergoing legal review. In this proposed standard, the terms "damp runway," "wet runway," and "contaminated runway" are defined. The proposed definitions of "damp runway" and "wet runway" include:

1.18.11.1 Damp Runway

a. A damp runway is considered to be a wet runway.

b. A damp, properly designed, constructed and maintained grooved runway is considered to be a dry runway.

1.18.11.2 Wet Runway

a. A wet runway is covered with sufficient moisture to cause it to appear reflective, but is not "contaminated"

b. On a wet runway, the braking friction is reduced compared to that for a dry runway.

c. The braking friction on a wet, properly designed, constructed and maintained grooved runway is higher than on a wet smooth surfaced runway.

1.18.11.3 Slippery When Wet

Information on the condition of the runway surface is important and is required when evaluating factors affecting landing performance. Both ICAO Annex 14 and TP312E address the requirement for airports to conduct sufficient tests and observations of the runway surface to determine whether, based on their results, a runway should be designated as slippery when wet. Action should then be taken by the airport operator to restore friction levels to above the minimum levels specified by ICAO or TP312E. If it is determined that a runway is slippery when wet due to reduced friction levels, the information must then be made available to aircrew, preferably before the flight planning stage. FAAN did not provide information to indicate that Runway 03/21 was to be considered slippery when wet based on the minimum friction criteria published.

1. European Action Plan for the Prevention of Runway Excursions, Edition 1.0 (January 2013), Appendix E: Aircraft Operators.
2. ICAO Runway Excursion Risk Reduction Toolkit - Aerodrome Best Practice (2nd edition).
3. The slip ratio is equal to 1 minus the aircraft wheel speed over the aircraft ground speed (slip ratio = 1 – [wheel speed / aircraft ground speed]). The critical slip ratio is achieved when the friction force between the tire and the runway reaches its highest value.
4. Flight Safety Foundation (FSF) Approach and Landing Accident Reduction (ALAR) Briefing Note.

2.0 ANALYSIS

2.1 General

Records available to the Bureau indicate that the aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures. There was no evidence of any defect or malfunction in the aircraft that could have contributed to the accident.

A post-crash visual examination of the aircraft's main wheel assemblies was carried out and no abnormalities found. The tyres had no sign of reverted rubber, however two of the main wheel tyres were found to have worn to acceptable limits.

The mass and centre of gravity of the aircraft were within the prescribed limits.

A wet runway may be slippery and require additional landing distance over and above that required for a dry runway. The aircraft landed on a wet runway. The crew members were properly licensed, medically fit and adequately rested to operate the flight.

This analysis focuses on crew qualification and competency, crew actions during approach and landing, the Approach and Landing phases of flight, Training, Evaluation of Tyre Marks, Tyre Traction and Hydroplaning, human factors and runway characteristics.

2.2 Crew Qualification and Competency

The crew were certified and medically fit to operate the flight. However, on further examination of the crew status the investigation determined as follows:

1) Captain – was certified, qualified and competent to operate the flight having met all the requirement stipulated in the relevant sections of DANA Airline's

Operations Manual Part B pages 33 and 34 sections A, B subsection (2) and Part D Section 2 (Flight Crew Training Syllabi and Checking Programme), sub-paragraph 2.1.4.2, 2.5-2.5.2.6 in addition to Nigerian Civil Aviation Regulations (Nig.CARs) 2015. However, the Captain was not eligible to conduct the flight with a pilot that is not released to fly unsupervised, because the Captain was neither a Type Rating Examiner (TRE) nor a Check Pilot at the time of the accident. Therefore, the crew complement was not appropriate.

2) First Officer – was certified and qualified to sit on the first officer's seat having met some of the requirements stipulated in the relevant sections of DANA Airline's Operations Manual Part D sections 2.1.3.14, 2.14, 2.5.1 and 2.5.1.1-5 respectively in addition to Nigerian Civil Aviation Regulations (Nig.CARs) 2015. However, he was not competent to operate the flight having not met the minimum requirements stipulated in DANA Airline's Operations Manual Part D Section 1 (Training Programme General) sub-paragraph 1.5.3.3 (a), Section 2 (Flight Crew Training Syllabi and Checking Programme) sub-paragraph 2.1.4.2, 2.5.2.4 - 2.5.2.6 respectively. It should be noted that he met the requirement for minimum of 30 sectors but not 100 hours.

Therefore, the crew complement was inconsistent with section 2.5.2.4 of the OMD since the co-pilot was not eligible to fly with a non-check pilot.

3) Flight Purser – was certified, qualified to operate the flight having met the requirements stipulated in DANA Airline's Operations Manual Parts B and D respectively but was not able to manage the L1 position properly during that flight by allowing the passengers to override authority. In the light of this, the investigation established that:

   I. The L1 (main entry door)'s slide was not armed

II. The passengers forced themselves out of the aircraft before the Flight Purser initiated the emergency evacuation

III. No further action was taken by the Flight Purser to take control of the situation.

2.3 Crew actions during Approach and Landing

Although the First Officer was trained and certified on type aircraft, he was not competent and eligible to operate the accident flight (DAN0363) or any flight categorized by DANA Airlines as Public Transport. The decision by DANA Airline's Flight Operations Department to schedule him on that flight to operate was inconsistent with DANA Airline's Operations Manual Part D section 2 Flight Crew Training Syllabi and Checking Programme as stated in sub-paragraphs 2.5.0.8 and 2.5.2.6 as follows:

2.5.0.8 stated in parts "All flight crew members must successfully complete the company's proficiency check with a Type Rating Examiner (TRE) before they are assigned to line duties."

2.5.2.6 Stated in parts "Before a pilot may fly unsupervised for the purpose of Public Transport, the Final Release and, in the case of Commanders, the Area Competency Release must be signed."

The First Officer has flown over 88 h on type under supervision before the accident. These flight hours neither qualifies him to operate the accident flight with a non-TRE nor to fly without proficiency check and final release signed. The investigation has not established any documentary evidence to indicate the First Officer was released to fly unsupervised.

The Captain took control of the aircraft before the beginning of the approach based on the fact that the workload would be too much on the First Officer. This is consistent with DANA Airline's Operations Manual Part B section 1 Pilot Limitations page 34 "B"

Pilot Operating Limitations sub B (2) which states in parts "if the second in command has fewer than 100 hours of flight time as SIC in commercial operations in the type airplane being flown and the PIC is not a check airman, then the PIC must make all take-offs and landings at special airports designated by the NCAA or DANA Airlines and in the following situations:

"Any other condition in which the PIC determines it to be prudent to exercise his prerogative."

The investigation believes that the first officer's low experience increased the workload of the Captain during the entire remaining flight. During this very busy phase of approach, it was established that the Captain was the only one who was actively alert in the cockpit including runway look-out when he was supposed to focus on the instruments and calculations for appropriate decision making.

2.4 Approach and Landing

At 18:48 h, an initial attempt by PM to contact the Tower was not on the correct frequency during which both Tower and approach were trying to contact the aircraft. Approximately 1.5 minutes after the first attempt, contact with the Tower was established on the correct frequency of 119.2 MHz. The First Officer reported runway in sight to the Tower. The Tower acknowledged and passed the prevailing wind as 22 knots but DAN0363 did not acknowledge.

During the approach, the wind veered from 020° at 22 knots to 360° at 22 kt. The crew was earlier requested for their intention as to whether they would continue with the approach. For various reasons, the crew decided to continue the approach for Runway 21.

DANA Airlines Flight Crew Operations Manual provides the criteria for a stabilized approach and the conditions that would necessitate execution of a missed approach.

Based on the dispatch documents issued by DANA Airline's duty Flight Operations Officer (FOO), the actual landing weight was 107, 907 lbs. This called for a V_{REF} speed of 120 knots indicated airspeed (KIAS) (See Appendix 1A) For a flaps 40° landing, the minimum wind correction is 5 KIAS and the maximum is 20 KIAS.

The landing weight used by the crew was 116,000 lbs. For flaps 40° landing the V_{REF} speed selected by the crew was 124 KIAS (See Appendix 1B) and still added the minimum wind correction of 6 KIAS for a V_{APP} of 130 KIAS. This extra speed had to be managed by the crew in order to cross the runway threshold at their planned V_{REF} speed. The aircraft crossed the threshold at approximately 135 KIAS, or 10 knots faster than that calculated for the actual landing weight of the aircraft. The SOP required crew to initiate a missed approach when the target airspeed was exceeded by plus 10/minus 5 knots.

Also, the investigation determined that due to the high winds, (360°/22 knots) the prevailing component suggested a tail wind of 19 knots and a crosswind of 11 knots for Runway 21 respectively. With this phenomenon, a missed approach should have been appropriate and most likely a change of runway that was most favourable by wind (in accordance with DANA Airline's SOP) and landing aids. It is likely that the crew did not consider the situation to warrant an overshoot; the crew believed that the entire approach was stabilized, and the runway was in sight with disregard to the presence of high winds and other presence of deteriorating metrological conditions.

The aircraft touched down far into the runway at a distance of 7,972 feet which was beyond one third of the available landing distance (3,507 feet). The MD-83 landing performance analysis determined that, even with the higher speed and long touchdown, the airplane should have been able to stop 1,459 feet before the end of the runway. **See Appendix 2.**

The smooth touchdown, combined with a wet runway, increased the risk of hydroplaning. The technique for landing on a wet or contaminated runway is to touch down firmly, at the slowest possible speed, in the touchdown area. The lowest possible speed would have been appropriate to stop the aircraft with the use of flaps 40°.

2.5 Training

Flight operations training at DANA Airlines Sub- paragraph 2.5.0.5 includes training for wet and contaminated runway operations and hydroplaning. Although the Captain has adequate experience flying the MD-83, the crew might have been overwhelmed by the risks involved in landing on a wet, runway. However, in the absence of detailed information and training about smooth or ungrooved runways and specific simulated training on techniques on take-offs and landings on wet runways, there is a risk that the flight crew will not carry out the appropriate landing techniques when these runways are wet.

2.6 Evaluation of tyre marks, tyre traction and hydroplaning

The aircraft touched down at 7,972 feet from the threshold of runway 21. Landing Distance Available (LDA) runway 21 is 9,843 feet which leaves a remaining length of 1,871 feet for the aircraft to stop. The required landing distance for the aircraft mass (107,907 lb) on a wet runway obtained from the landing performance charts is 6,793 feet. **See Appendix 2**.

Initially, the tyre marks were characterized by brief black rubber marks. The runway marks and subsequent off-runway marks in the soft soil and on grasses after the stopway were consistent with the spacing of the aircraft's landing gear tyres and led to their positions at the aircraft final resting position.

The aircraft's tyre marks, where it exited the runway end were black. The position of the marks, with the nose gear tyre marks to the right gear tyre marks, indicates that the airplane initially veered to the left. Traverse scuff marks found on some of the tyres also indicated that they had been subjected to a skid. The offset between the tyre marks and the nose gear and main gears indicated that the airplane was in a near low-degree yaw as it veered to the left.

Although the aircraft ground speed was lower than the dynamic hydroplaning speed (9 times the square root of p where "p" equals tyre pressure in pounds per square inch) at touchdown. If the runway surface had been grooved, it should have channelled away the standing water.

Despite two of the tyres on the left and right main landing gears were found to have tread wear, the investigation does not believe that the condition of the tyres contributed to the loss of aircraft directional control or to a condition of dynamic tyre hydroplaning.

There was no evidence of reverted rubber or overheat on any of the tyres on the aircraft, nor was there reverted rubber on the runway.

The Investigation believes that the tyre marks noted on the runway were not caused by hydroplaning but were erasure marks on the wet runway. There were a large number of similar marks on the runway surface from other landing aircraft that were not hydroplaning.

2.7 Human factors related to the accident

This accident illustrates an encountered situation in which the flight crew had to adapt to rapidly changing weather conditions during landing and manage the flight accordingly. The investigation believed that the active and latent failures in this accident were multiple and interactive.

The active failures included the following:

- Underestimation of weather conditions due to lack of information from ATC.
- Wrong pairing of crew using First Officer that was yet to be released to operate unsupervised on a Public Transport flight with a Captain that is not a TRE.
- The Captain was overwhelmed by open discussions with the First Officer relating to the flight, approach and landing procedures.
- Non-adherence to company SOP.
- Neither the prevailing winds nor landing clearance was requested before landing.
- Non-implementation of proper cockpit resource management (CRM) procedures.
- Failure to arm L1 (main entry door) and improper execution of Emergency Evacuation.

The latent failures included:

- Inadequate risk management strategy by the flight crew as a result of deficient airline procedures and training for landings under wet/contaminated runway conditions.
- Deficiencies in airline organizational processes regarding effective and efficient monitoring of the implementation of appropriate procedures.

2.7.1 Active failures

Several weather reports noted that visibility was falling rapidly on final approach, but these updates were not known to the crew in part due to break in communication with ATC and company radio base, a factor that significantly affected situational awareness. The pilots were not aware of the deteriorating situation, but they were aware that another aircraft had carried out a missed approach during final approach on the opposite runway. They were also aware that the runway was wet but no further information about the braking action on the runway was reported. Therefore, being prepared for a go-around is something that must be coordinated.

It was apparent the crew did not consider that the runway might be contaminated with water and consequently did not identify appropriate options to deal with such a situation. This was due to the absence of adequate procedures and flight crew training for landing on wet/contaminated runway conditions.

The airline flight manuals mentioned wet/contaminated runways in various sections especially operations and training. The investigation identified that many pilots correlated this with operations encountered in winter regions and not at all with rain-contaminated runways in warmer regions. There was no other specific training in the curriculum for simulation in synthetic simulators about landing techniques on wet runways.

The investigation established that, during the landing roll, the tyres did not firmly contact the wet runway. This limited the effectiveness of the brakes. In such conditions if the thrust reversers are operated above 1.3 EPR, it would further degrade the braking effectiveness by reducing the friction between the tyre and the runway surface thereby increasing the tendency for runway excursion.

The appropriate approach and landing procedure was flaps 40^{o}, full reverse thrust. The characteristics of this were a lower approach speed, which would have been easier to fly in terms of speed control and runway aim point and providing maximum aerodynamic drag after touchdown when the effectiveness of the brakes could be reduced on wet/contaminated runway, therefore the overrun could probably have been avoided.

2.7.2 Latent organizational failures

Latent organizational failures from the airport operator, airline and the regulatory body overseeing their operations:

- The Airport Operator:
  - After several requests, the investigation has not received the risk assessment plan for the runway from the airport operator. **See Appendix 2.**
- The Airline:
  - Design of operational procedures and training was over reliant on the decision making ability of flight and cabin crew and did not place adequate emphasis on adherence to SOP and other manuals and real time events.
- Civil Aviation Authority:
  - Insufficient oversight on regulations governing the airport operator.

2.8 Aerodrome

2.8.1 Introduction

ICAO, NCAA, FAA, TC and other civil aviation authorities around the world have set standards and recommended practices, so that runways are designed to provide good friction characteristics when wet. Factors that affect the runway coefficient of friction include longitudinal/transverse slopes, macro texture and micro texture. In the event of a runway excursion, the surfaces adjacent to the runway should be constructed to minimize aircraft damage. Runway surface-condition reporting must also be accurate, timely, and disseminated to those who can best use the information in making the decision whether or not to land.

2.8.2 Runway Characteristics

Any factor that results in water retention on the runway or reduced drainage, increases the risk of hydroplaning. The profile of Runway 03/21 at Port Harcourt International Airport (DNPO) was not optimal in this respect, with the result that the runway surface may retain water to an extent than one which meets all NCAA Aerodromes Standards and Recommended Practices (SARPs) (especially with a crosswind from the right as in this accident). Water would drain slowly, making the runway more slippery.

The Bureau has requested for results of the last three friction tests conducted on runways 03/21 on several occasions with follow ups with the airport operator, but up to the time of concluding this report the airport operator was not able to provide any information regarding DNPO to the Bureau. When the Bureau extended the same request to the regulatory authority, there was a positive response with a lot of information but with limited scope on the results of the last friction tests conducted at DNPO**. See Appendix 3**.

Therefore, comparison of values in order to highlight the corrective action would not be possible, which might hinder the guarantee of improved safety and integrity on runway 03/21 to landing aircraft especially during rainy season.

2.8.3 Runway Surface Condition

Effective maintenance of a runway surface is critical to retaining maximum friction characteristics. Periodic friction measurement, using a continuous friction-measuring device with a self-wetting capability, indicates if the surface is becoming more slippery when wet. This indication allows the airport to plan maintenance action, such as rubber removal, to re-establish runway friction levels. Combined with accurate data on the runway surface profile, the friction reading would also give airport authorities an indication of whether a runway should be considered slippery when wet, so that the appropriate Notice to Airmen (NOTAM) information can be disseminated. Company operations personnel, including flight crew, could then be forewarned that appropriate landing techniques should be used to reduce the likelihood of hydroplaning.

Runway friction measurements are not done under conditions when there is only water on the runway surface. The difficulty in defining the runway surface condition, the lack of surface friction measurements, and the subjective reporting of the amount of water on the runway all combine to potentially provide limited or nil information on runway's surface condition to flight crew.

For flight crew to make proper assessment of landing conditions, they should be made aware of the actual conditions on the runway surface especially during rainy season. Unfortunately, the DNPO airport authorities have not provided any information on the policy that requires inspection of the runway surface when rain starts, or that requires periodic inspection while it is raining.

3.0 CONCLUSION

3.1 Findings

3.1.1 Findings as to Causes and Contributing Factors

1. The crew calculated an inaccurate V_{APP} (i.e. target approach speed), and flew the approach faster than recommended.
2. The aircraft crossed the threshold 10 knots above actual V_{REF} (i.e., threshold crossing speed), resulting in an extended flare to a touchdown far into the runway beyond one-third of the available landing distance which was inconsistent with DANA Airline's SOP.
3. The smooth landing on a wet runway at high speed with strong tail winds led to long flare which resulted in poor braking action and reduced aircraft deceleration, contributing to the runway overrun.
4. The crew did not initiate a Go Around when V_{REF} was exceeded by 10 KIAS.
5. The anti-skid brake system operated as designed.

3.1.2 Findings as to Risk

1. In the absence of information and training about ungrooved and wet/contaminated runways, there is a risk that the flight crew will not carry out the appropriate landing techniques under these conditions.
2. Without prompt reporting of an increase in rainfall intensity, flight crew cannot take into account decline in braking performance, and there is an increased risk of hydroplaning.
3. Non-adherence to standards and recommended practices by relevant authorities on periodic runway friction measurement and enhancement,

such as runway grooving, increases the risk of runway overruns on wet runways.

3.1.3 Other Findings

1. The Captain was certified, qualified and competent to operate the flight.
2. The First Officer was certified and qualified to occupy the first officer's seat but not competent to operate the flight unsupervised.
3. The First Officer was the Pilot Flying and the Captain took control at about 12 NM to touch down.
4. The aircraft was dispatched with number 2 radio altimeter inoperative.
5. The Glide slope RWY 21 was unserviceable.
6. The number 2 DME reciever was unserviceable during the approach.
7. The aircraft touched down far into the runway from the threshold.
8. There was no effective communication between the Tower and the aircraft at short finals, therefore full weather information was not passed shortly before landing. Subsequently, no landing clearance was issued to the aircraft
9. The aircraft did not also request for landing clearance.
10. The aircraft touched down in high winds of 360^{o} at 22 kt indicating a tail wind of 19 knots.
11. The approach speed was 10 kt in excess of actual approach speed.
12. The runway surface was wet during landing roll.
13. The Public Address System did not work after the aircraft came to a complete stop.
14. The left forward main door (only) was used for the evacuation.
15. The right forward service door escape slide was not installed.

16. The left forward main door emergency escape slide was not deployed.
17. The L1 (main entry door) slide was not armed.
18. The runway approach lights and landing aids were damaged.
19. The airport operator has confirmed that no friction test has been conducted at DNPO since 2013.

3.2 Causal factor

The accident was caused by an underestimation of the degradation of weather conditions (heavy rain, visibility and strong wind on short final and landing), and, the failure by the crew to initiate a missed approach which was not consistent with the company's SOP.

3.3 Contributory Factors

Other contributing factors to this accident were:

- Non-compliance to SOP in meeting crew competency and complement.
- Ineffective two-way communication between the ATC and DAN0363 during final approach prevented the flow of technical information on runway surface condition and other relevant meteorological information essential to safety.
- Failure of the crew to crosscheck the prevailing wind and also to obtain landing clearance from the ATC during final approach after contact with ATC was restored.

4.0 SAFETY RECOMMENDATIONS

As a result of the investigation of this accident, the Bureau makes the following recommendations:

4.1 Safety Recommendation 2019-011

Dana Airlines should review the guidelines for developing, implementing, reinforcing, and assessing CRM training programs for flight and cabin crewmembers, as contained in DANA Airline's Operations Manual Part D "Training" section. 2.9.5 - 2.9.5.5 and ensure that the CRM program conforms to the provisions contained in Nig.CARs 8.10.1.12.

4.2 Safety Recommendation 2019-012

Dana Airlines should amend its Operations Manual Part D section 2 "Flight Crew Training and Checking Programme", subparagraph 2.5.2.4 Line Training Under Supervision, to state that:

> All flight crew members will operate a minimum number of sectors and/or flying hours whichever comes later under the supervision of a nominated check pilot who is also serving as the PIC shall occupy a pilot station.

The normal minima for Line Flying under supervision (in addition to any base training) will be:

a. Aircraft Commanders/Co-pilots on type 50 hours (minimum 20 sectors).
b. Aircraft Commanders/Co-pilots non-reducible transiting to a new aircraft type 100 hours (minimum 30 sectors).

2. For pilots with more than 500 h on type and recent experience of equivalent jet in the area of operations, these criteria may, at the Flight Training Manager's discretion, be reduced by up to 40%.

3. Conduct risk identification, assessment and reduction processes in a structured proactive and systematic way so that it cuts across all relevant personnel, rather than relying on the crew decision-making abilities when it comes to complying with SOP.

4.3 Safety Recommendation 2019-013

Federal Airports Authority of Nigeria (FAAN) should **c**onduct Friction Tests and de-rubberization of all active Runways under FAAN control in compliance with Part 12.6.4(d) of Nig.CARs 2007 in accordance with NCAA advisory circular NCAA-AC-ARD014 issue No.1.

4.4 Safety Recommendation 2019-014

FAAN should monitor surface friction test schedules on all operational runways on a more frequent basis, including the build-up of rubber on all runways, and perform rubber removal operations as required, in accordance with Part 12.6.4(d) of Nig.CARs 2007.

4.5 Safety Recommendation 2019-015

FAAN should ensure the development of a comprehensive maintenance plan for runways in all airports under its control and ensure effective record keeping for every detail of maintenance carried out.

4.6 Safety Recommendation 2019-016

Nigerian Airspace Management Agency (NAMA) should amend the Manual of Air Traffic Control (MAT-C) Vol. 1, 2nd edition Chapter 4, "Windshear" Section 1, sub section 1.5 to include "Low Level Windshear Advisory," to state that Tower controllers should issue the LLWAS advisory, "Low Level Windshear Advisories in Effect," whether or not the facility is equipped with an ATIS. The advisory should continue to be transmitted by ATC, relative to all runways in operation at the airport, until either the information is confirmed to be on the ATIS, or the prescribed 10-minute time limit from the time the alert has expired.

4.7 Safety Recommendation 2019-017

NAMA should ensure that the Manual of Air Traffic Control (MAT-C), Chapter 4, "Windshear" Section 1, sub section 1.5 is appropriately revised to include "Low Level Windshear Advisory," to require controllers to select for display all sensors on the LLWAS (if installed at the airport) when adverse weather conditions, such as thunderstorms, are forecast or present in the terminal area to improve controller and pilot perception of wind conditions affecting the entire airport.

4.8 Safety Recommendation 2019-018

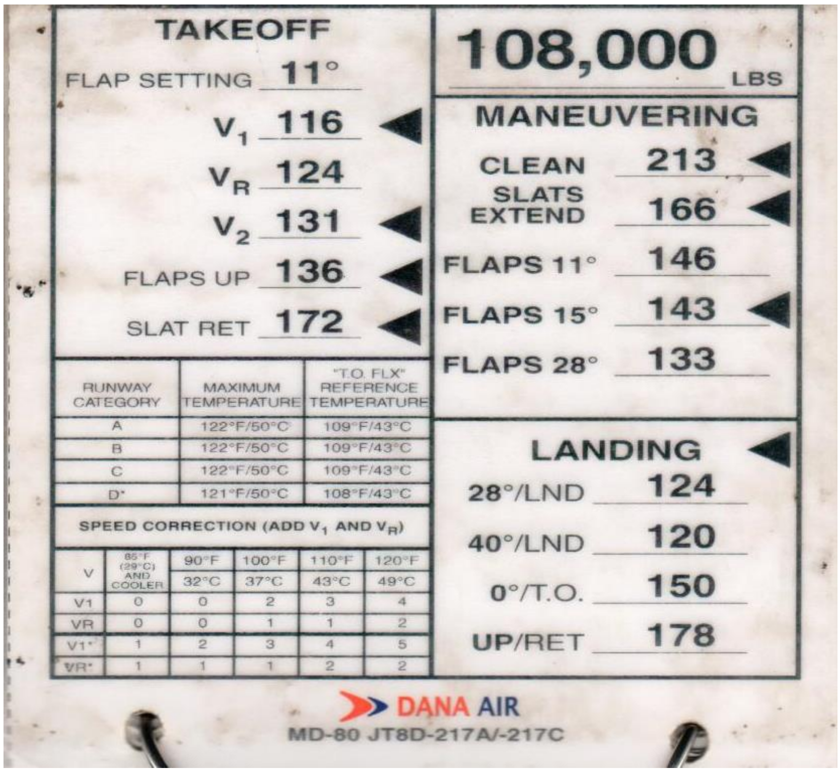
Nigerian Civil Aviation Authority (NCAA) should review the pilot training record keeping systems of DANA Airlines to determine the quality of information contained therein and require the airlines to maintain appropriate information on the quality of pilot performance in training and checking.

4.9 Safety Recommendation 2019-019

NCAA should ensure that all airport operators in Nigeria conduct Runway Friction Tests regularly in accordance with Nig.CARs Part 12.

APPENDICES

Appendix 1A: Takeoff/Landing Data Card



TAKEOFF

FLAP SETTING 11°

V_1 116

V_R 124

V_2 131

FLAPS UP 136

SLAT RET 172

RUNWAY CATEGORY	MAXIMUM TEMPERATURE	"T.O. FLX" REFERENCE TEMPERATURE
A	122°F/50°C	109°F/43°C
B	122°F/50°C	109°F/43°C
C	122°F/50°C	109°F/43°C
D*	121°F/50°C	108°F/43°C

SPEED CORRECTION (ADD V_1 AND V_R)

V	85°F (29°C) AND COOLER	90°F 32°C	100°F 37°C	110°F 43°C	120°F 49°C
V1	0	0	2	3	4
VR	0	0	1	1	2
V1*	1	2	3	4	5
VR*	1	1	1	2	2

108,000 LBS

MANEUVERING

CLEAN 213

SLATS EXTEND 166

FLAPS 11° 146

FLAPS 15° 143

FLAPS 28° 133

LANDING

28°/LND 124

40°/LND 120

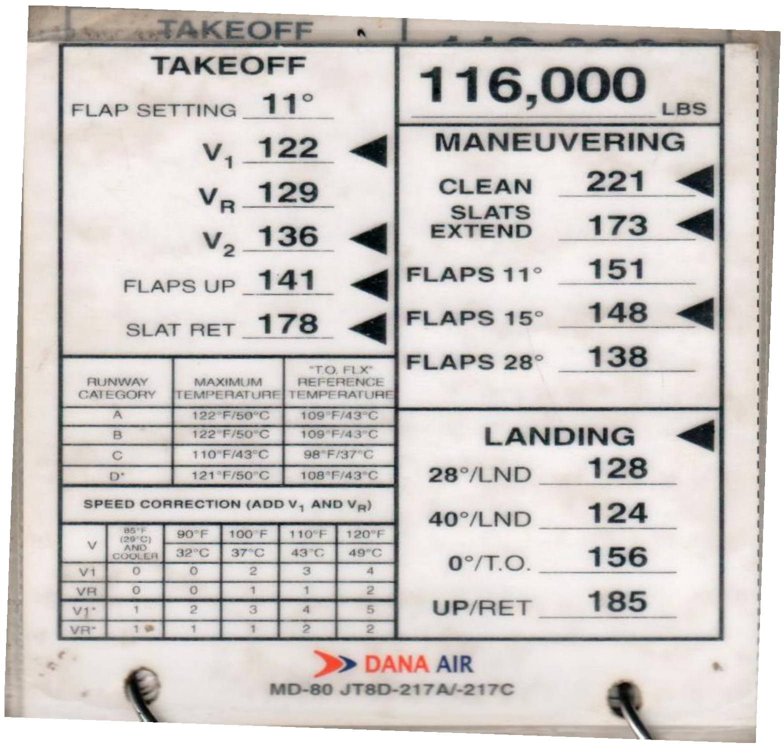
0°/T.O. 150

UP/RET 178

DANA AIR

MD-80 JT8D-217A/-217C

Appendix 1B: Takeoff/Landing Data Card



TAKEOFF

FLAP SETTING 11°

V_1 122

V_R 129

V_2 136

FLAPS UP 141

SLAT RET 178

RUNWAY CATEGORY	MAXIMUM TEMPERATURE	"T.O. FLX" REFERENCE TEMPERATURE
A	122°F/50°C	109°F/43°C
B	122°F/50°C	109°F/43°C
C	110°F/43°C	98°F/37°C
D*	121°F/50°C	108°F/43°C

SPEED CORRECTION (ADD V_1 AND V_R)

V	85°F (29°C) AND COOLER	90°F 32°C	100°F 37°C	110°F 43°C	120°F 49°C
V1	0	0	2	3	4
VR	0	0	1	1	2
V1*	1	2	3	4	5
VR*	1	1	1	2	2

116,000 LBS

MANEUVERING

CLEAN 221

SLATS EXTEND 173

FLAPS 11° 151

FLAPS 15° 148

FLAPS 28° 138

LANDING

28°/LND 128

40°/LND 124

0°/T.O. 156

UP/RET 185

DANA AIR

MD-80 JT8D-217A/-217C

Appendix 2: Calculation of landing distance by DANA Airlines

INVESTIGATION INTO THE OCCURRENCE INVOLVING MD83 5N-SRI BELONGING TO DANA AIRLINE WHICH OCCURRED AT PORT-HARCOURT INT'L AIRPORT ON 20TH FEBRUARY, 2018

From the information provided, using the calculated figure on the loadsheet and the weight seen on the speed card in the cockpit, the following figures in the below table were derived using the MD83 performance.

FACTORS	CALCULATED FROM LOADSHEET	THE SPEED CARD WEIGHT
WEIGHT (LBS)	107,907	116,000
LANDING DISTANCE (DRY RWY) FT.	2,507	2,636

NOTE: Full Reverse thrust (1.6 EPR thrust reduction to reverse idle by 60 KIAS). Standard day, no wind, zero slope, maximum manual anti-skid braking, air run distance approximately 1000 feet, data not factored.

Landing distance therefore with air run distance of approximately 1000 feet factored is:

3,507	3,636

WET RWY FACTOR (1.15 OF DRY)	4,033	4,181
OAT (24^0) = ISA +9 @30'/1^0C	4,033 + 270 = 4,303	4,181 + 270 = 4,451
TAILWIND OF 19KTS @ 110'/KT	4,303 + 2,090 = 6,393	4,451 + 2,090 = 6,541
V_{REF} FLAPS 40/LND	120 KTS	124 KTS
V_{REF} 130 KTS PENALTY @ 40'/KT	6,393 + (40 x 10) = 6,793	6,541 + (40 x 6) = 6,781
FACTORED LANDING DISTANCE REQD. (WET RUNWAY)	6,793 FEET	6, 781 FEET
RWY FIELD LENGTH REQD. BY REGULATION (LANDING DISTANCE REQD DEVIDED BY 0.60	11,322 FEET	11,302 FEET

Port- Harcourt Runway 21 Length is 9843 feet

REMAINING RWY FIELD LENGTH	- 1479	- 1459

Appendix 3: NCAA response regarding Runway friction test

NIGERIAN CIVIL AVIATION AUTHORITY

P.M.B. 21029, 21038, IKEJA-LAGOS.

NCAA

OFFICE OF THE DIRECTOR-GENERAL

Reference Number: NCAA/DG/AIB/9/16/51
Date: 6th June, 2018

The Commissioner
Accident Investigation Bureau (AIB)
P.M.B 016,
Murtala Muhammed International Airport
Ikeja, Lagos.

RE: INVESTIGATION INTO OCCURRENCE INVOLVING MD83, 5N-SRI BELONGING TO DANA AIRLINE, WHICH OCCURRED AT PORT-HARCOURT INTERNATIONAL AIRPORT (DNPO) ON 20th FEBRUARY, 2018

Sir, I have been directed to acknowledge your letter, dated the 8th of May, 2018 on the above subject matter and to inform the Bureau on the following:

1. The most recent de-rubberisation exercise of the runway of the Port-Harcourt International Airport was conducted on the 22nd of December, 2017 by Emmanpop and was found satisfactory. Please find attached a copy of Report, detailing the schedule and result of the subject de-rubberisation exercise; and

2. The Federal Airport Authority of Nigeria (FAAN) claimed to have carried out the last Friction test of the runway in 2012. The NCAA is awaiting the submission of this report by FAAN.

It is pertinent that the Bureau be further informed that Nig. CARs Part 12 IS: 12.4.2 (4.5) (a) details the procedures for the aerodrome operator to inspect the Aerodrome movement area and obstacle limitation surfaces, which shall include the arrangement for carrying out inspections, including runway friction.

The Aerodrome Standards Manual (ASM) 14.3.1(Removal of Contaminants) requires the aerodrome operator to remove rubber deposits and other contaminants from the surface of the runways in use as rapidly and completely as possible to minimize accumulation.

The PHIA Aerodrome Manual (Part 4.4.7) and Standard Operating Procedure for Civil/Building department (1.7.2 & 1.8) provide for the conduct of the de-rubberisation exercise and friction test on a quarterly frequency.

Please find attached Guidelines for establishing the design objective, maintenance planning level and minimum friction levels of runways in use to enable the Bureau in its investigation.

The Director General wishes to thank you for your continuous cooperation and please, do accept the assurances of his highest regards.

NATIONAL COORDINATOR, SSP
FOR: DIRECTOR GENERAL/CEO

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ADO (Name) Date 22—12—2017

Rostered Duty From 1900 To: 0700 Hours

I have the following to report

Time	Report	Remarks
1900	Night watch commenced. Noted previous log details.	
2000	Concluded general inspection. Advised cleaners to dispose filled waste collectors at the check-in hall, compliance met. Check-in on Lufthansa in progress. Domestic flights delayed.	
2105	Noted the departure of Lufthansa.	
2156	Airfrance — A330 — F-GZCN landed, parked at bay 4 of the apron. Identification/collection of luggage was cumbersome due structure of the hall, large number of pax and ineffective cooling systems.	
0200	ATC granted Emmanpop access to the rwy to carry out derubberization exercise. It was completed at 0410hrs, satisfactory.	Noted
0600	Morning checks - Light/water available, preparations for the days activities in top gear.	
	= Smooth flt ops recorded.	
0700	Night watch terminated.	

Seen
25/12/17

Scanned by CamScanner

Appendix 4: AIB letter to FAAN for information on Runway 03/21

ACCIDENT INVESTIGATION BUREAU
Private Mail Bag 016, Murtala Muhammed International Airport, Ikeja, Lagos, Nigeria.
Tel: +234-1-7430099 Hotlines: +234-8077090909, +234-8077090908.
Website: www.aib.gov.ng E-mail: commissioner@aib.gov.ng

31st May, 2018

The Managing Director/CEO
Federal Airports Authority of Nigeria (FAAN)
FAAN Headquarters
MM Domestic Airport
Ikeja-Lagos.

Attention: Director, Engineering Services

RE: - ACCIDENT INVESTIGATION INVOLVING MD-83 AIRCRAFT BELONGINGING TO DANA AIRLINES WHICH OCCURRED AT PORTHARCOURT INTERNATIONAL AIRPORT; PORTHARCOURT ON 20TH FEBRUARY, 2018

Please refer to the above subject matter. As a follow up and to facilitate the timely completion of the report. I am directed by the Commissioner/CEO to request for the following information pertinent to the above occurrence:

1. Detailed maintenance programme for Port Harcourt Runway (03/21)
2. Details of full report on the last maintenance carried out on the Runway (03/21)
3. Details of the full report for the last 3 consecutive Runway Friction Tests on Runway (03/21)
4. Any other information that may assist the facilitation of the report.

Please accept the assurances of the Commissioner/CEO's highest regards.

Director, Operations
For: Commissioner/CEO

Appendix 5: DANA letter in response to AIB inquiry for information

Dana Airlines Limited
RC.674040
Dana House,
116 Oshodi-Apapa Expressway,
Isolo, Lagos, Nigeria
Tel: +234 1 280 0999/0888
ntact@flydanaair.com

DANA AIR
www.flydanaair.com

Ref: DANA/FLT/OPS/AIB/LTR/O1004

November 9, 2018

Commissioner/CEO
Accident Investigation Bureau
Nnamdi Azikwe International Airport
Abuja – FCT

Attention: Director, Operations

RE: ACCIDENT INVESTIGATION INVOLVING MD-83 AIRCRAFT BELONGING TO DANA AIRLINES WHICH OCCURRED AT PORT-HARCOURT INTERNATIONAL AIRPORT; PORT-HARCOURT ON 20TH FEBRUARY, 2018:

REQUEST FOR ADDITIONAL INFORMATION AND VERIFICATION.

We are in receipt of your letter of inquiry on above subject matter. The detailed response to each request as outlined in your letter is hereby documented.

1. **The company procedures for the final check (release) for pilots.**

   The first stage of pilots' line training in Dana Airlines is with the TRI/TRE captains which may take between 15 to 50 sectors depending on the pilots' performance. He/She then advances to the second stage with designated Line Training Captain for the next 50 to 100 sectors. At this stage the pilot is paired with the line training captain until he/she is competent enough with commensurate experience to be finally released to fly with only experienced line captains which essentially is the final stage of release. Release to fly with all captains takes a little longer depending on the pilot's overall performance.

2. **Whether the first officer has been finally checked released by the company TRE to fly MD-83 aircraft unsupervised.**

   The first officer in this question was at the tail end of the second stage. His performance was satisfactory and was accelerated on the verge of being finally released to fly with regular MD83 captains. He was only released to designated line training captain as per our approved manual OMD 2.5.2.8.

3. If he is, please furnish the Bureau with the details of full report on the final check release by the company TRE and the Logbook entry for such check.

We have included as attachment photocopies of his Training Record and Logbook for your attention in this investigation. He was released to fly as per OMD 2.5.2.8 with designated Line Training Captain to accumulate necessary experience for final release.

The OMD 2.5.2.8 is excerpted below from our training manual for easy reference:

"2.5.2.8 CREW PAIRING RESTRICTION
For all revenue operations, no flight crew are pair together unless, either the Captain or First Officer has at least 500 hours of line operating flight time as a Flight Crewmember in the type of airplane flown. The flight time is not seat specific. Flight crewmembers have the responsibility to assist the company in ensuring the requirements are met. Contact Crew Rostering when any deviation is discovered or carry a safety pilot to beef up the experience in the flight deck."

Please accept the assurances of our highest regards

Director of Flight Operations

DANA AIRLINE LIMITED
RC 417070
DFO
MMA2 Ikeja Lagos

SUMMARY OF COMMENTS TO DRAFT FINAL REPORT

The draft final report was submitted for comments to the Nigerian Civil Aviation Authority, Dana Airlines Limited, Federal Airports Authority of Nigeria, Nigerian Airspace Management Agency and the National Transportation and Safety Board, USA.

This is in compliance with sub-section 6.3 of Annex 13 to the ICAO Convention.

Nigerian Civil Aviation Authority agreed with the safety recommendations and also made editorial suggestions.

Dana Airlines Limited proposed amendments to aspects of the Factual Information including statements on company policies for crew rostering, highlighting among other things that the Line Training Captain position is not an NCAA designated position. Some other editorial clarifications and recommendations were proposed.

Accident Investigation Bureau (AIB) Nigeria made necessary amendments to the final report based on the submitted comments.