REPUBLIC OF RWANDA

Ministry of Infrastructure

Aviation Accident and Incident Investigation Directorate General

Report on the Runway Excursion Incident to RwandAir Flight WB 464, a CRJ 900, Registration 9XR-WI, at Entebbe International Airport on 20th April, 2022.

Ref AAID 2022-06

The sole objective of investigations carried out by the AAID is to prevent aircraft accidents and incidents. It shall not be the purpose of such an investigation to apportion blame or determine liability.

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List of abbreviations used in this report

AAID	Aviation Accident and Incident Investigation Directorate General (Rwanda)
APU	Auxiliary Power Unit
ATC	Air Traffic Control
ATIS	Automated Terminal Information Service
CVR	Cockpit Voice Recorder
FDR	Flight Data Recorder
GRF	Global Reporting Format
HUEN	Entebbe International Airport
ICAO	International Civil Aviation Organization
OEM	Original Equipment Manufacturer
PA	Public Address
RCAA	Rwanda Civil Aviation Authority
RCAR	Rwanda Civil Aviation Regulation
S/N	Serial Number
UCAA	Uganda Civil Aviation Authority
SNOWTAM	Special Series of Notice to Airman

Synopsis

On 20 April, 2022 a RwandAir Ltd CRJ 900 aircraft, registration number 9XR-WI, was enroute from Nairobi to Entebbe. The aircraft flight number was WB 464 was carrying forty-four passengers, including one infant, and seven crew.

After establishing contact with Entebbe ATC, the flight was cleared for the approach onto runway 17 at Entebbe International Airport.

The reported weather conditions for the previous two hours were strong south-easterly winds, moderate rain, and thunder-storms in the area. The aircraft was cleared for the ILS 17 Z approach, and cleared to land on runway 17.
The final approach segment was stable, but as the aircraft descended through 100 feet, the left crosswind shifted into a tailwind and this caused an increase in groundspeed, which caused the aircraft to touchdown further down the runway than intended. There were no wind-shear advisories in effect, nor were the crew alerted of the tailwind.
The aircraft touchdown was smooth, and directional control problems developed immediately. Reverse thrust, and manual braking were both applied. The crew attempted to regain directional control with nose wheel steering.

Based on the available information the Investigators have identified the Root Cause of the incident as Hydroplaning, and the contributory factors include:

1. Flight Crew had inadequate information concerning standing water, wind velocity, and rain intensity to apply the appropriate actions prior to landing.
2. On final approach, the aircraft encountered an unannounced tailwind at 100 feet above the runway that exceeded the aircraft's design limitations.

The Investigators developed findings in relation to the incident and also formulated safety recommendations to RwandAir, and the RCAA to prevent re-occurrence of such an incident.

1. FACTUAL INFORMATION

1.1. History of the Flight

1.1.1. General

On 20 April, 2022 a RwandAir Ltd CRJ 900 aircraft, registration number 9XR-WI, was enroute from Nairobi to Entebbe. The aircraft flight number was WB 464 was carrying forty-four passengers, including one infant, and seven crew.

After establishing contact with Entebbe ATC, the flight was cleared for the approach onto runway 17 at Entebbe International Airport.

Reported weather conditions for the previous two hours were strong south-easterly winds, moderate rain, and thunder-storms in the area. The aircraft was cleared for the ILS 17 Z approach, and cleared to land on runway 17.

The final approach segment was stable, but as the aircraft descended through 100 feet, the left crosswind shifted into a tailwind.

This caused an increase in groundspeed, which caused the aircraft to touchdown further down the runway than intended. There were no wind-shear advisories in effect, nor were the crew alerted of the tailwind.

The aircraft touchdown was smooth, and directional control problems developed immediately. Reverse Thrust and manual braking were both applied. The crew attempted to regain directional control with nose wheel steering, but to no effect.

The aircraft skidded off the runway to the right, destroying runway light 51. The aircraft paralleled the runway, and continued to skid for approximately 800 meters before coming to rest.

Once stopped, the Captain made an announcement on the PA system, “Crew On Stations, Passengers Remain Seated”. The Control Tower was within line of sight of the aircraft and called to ask if everyone was alright, and advised the crew that emergency services were on the way.

The only abnormal indication showing on the fault panel was “Right Reverser Unlocked.” All other systems indicated normal.

The Flight Crew started the APU, and shutdown the engines. At this time Fire Trucks were positioning around the aircraft.

The Captain decided not to evacuate the passenger, but to conduct a normal exit. He advised the Cabin Crew using the intercom system, “Operations Normal.” “We will wait for the Passenger Busses and normal exit”.

In the cabin after the aircraft stopped. The Cabin Crew received the command from the Captain, “Crew on stations, Passengers remain seated.” This message advised the Cabin Crew of two things. That the Captain was alive and conscious and that the Cabin Crew were to await further orders.

The Cabin Crew heard passengers screaming, and some passengers were trying to open the overhead bins and head for the exits. The Purser made a second PA announcement and advised the passengers to remain seated.

The Captain opened the Flight Deck door, and instructed the Engineer on-board to conduct an exterior inspection of the aircraft. The Engineer opened the Left Cabin Exit door and conducted the inspection, reporting no major damage to the Captain.

The airport passenger busses arrived and parked on the runway. Passenger began to exit the aircraft, and were guided by ground staff to the vehicles. The Crew remained on-board to assist in moving the aircraft.

The aircraft recovery exercise started, and it took 16 hours to complete. The coordination was conducted professionally.



Figure 1: Aircraft was on right side on the runway 17 after landing

1.2. Injuries to Persons

There were no injuries to passenger, or Flight Crew during this serious incident.

1.3. Damage to aircraft

The aircraft is classified to have received minor damages from this incident:

(a) Fan blade damage was observed on the number one, and number two engines.

(b) The right inboard trailing edge flap was damaged.

(c) All landing gear tires, and brakes to be replaced.

(d) Number two Thrust Reverser damaged.

(e) Centre fuel tank vent damaged.

1.4. Other damage

The 51st right edge light of Entebbe airport runway 17 was destroyed by the aircraft.

1.5. Personnel information

1.5.1. Description of qualifications, experience and history of the Flight Crew of Flight WB 464:

The Flight Crew, and Cabin Crew were all highly experienced. The Captain and First Officer were furloughed during the COVID-19 pandemic.

The Captain was furloughed for 20 months, before being recalled in November 2021. He completed 12 hours of simulator training, and aircraft systems training at the Lufthansa Aviation Training Centre in Berlin before line training on the aircraft.

A. Captain

Age:	59
License type:	Airline Transport Pilot License (ATPL)
Date of issue:	6 January 2022
Valid until:	31 January 2024
Medical certificate	Valid to 6 December 2022
Total flying experience	12,340 hours
Total flying experience on type	8200 hours
Total flying hours in last 90 days	120 hours
Previous rest period	17 hours

B. First Officer

Age:	54
License type:	Airline Transport Pilot License
Date of issue:	07th September 2021
Valid until:	30th September 2023
Medical certificate:	Valid
Total flying experience	7914 Hours
Total flying experience on type	4949 Hours
Total flying hours in last 90 days	132 hours
Previous rest period	Day-off on 21st January 2022

1.6. Aircraft Information

1.6.1. 9XR-WI—CRJ900

Manufacturer	Bombardier Aerospace
Type	CL-600-2D24 (CRJ 900NG)
Manufacturer's Serial Number	15287
Registration as marked on the exterior	9XR-WI
Registration as marked on identification plate in cockpit	9XR-WI
Engines	CF34 – 8C5
Date of Manufacture	28-10-2012
Certificate of Airworthiness	Issued by CAA of Rwanda Date of issue: 31/01/2022 Date of expiry: 31/01/2023
Last Maintenance Check	16/04/2022
Total Airframe Cycles	15471 cycles
Total Airframe Hours	17435 hours

1.6.2. Aircraft Servicing Information

The Aircraft Investigators identified that aircraft servicing records were current in accordance with approved maintenance procedures.

1.7. Meteorological information

The latest available METAR issued by Jomo Kenyatta International Airport Meteorological Office for the time of incident was:

HUEN 200100Z 12021KT 9000 TSRA BKN022 FEW024CB OVC090 23/21 Q1015 NOSIG

Additionally, once in contact with Entebbe ATC they received the following ATIS from Entebbe International Airport:

(a) 200200-Lima-120/21 Vis 9000m FCB 22 Rain +23/19 1015
(b) 200130-Kilo-120/21 Vis 8000m Rain F2200 +23/19 1016

The approach chart being used for the active runway contained the following advisory message: "The traffic encountered unusual wind phenomena while approaching runway 17. In case pilots notices unusual variations from reported wind, the following data should be reported:

- Wind reported by ATC. (Direction and Speed)
- Speed and Direction of Wind Experienced.
- Position of Encounter (height above ground and distance from touchdown, and any other information relevant) "

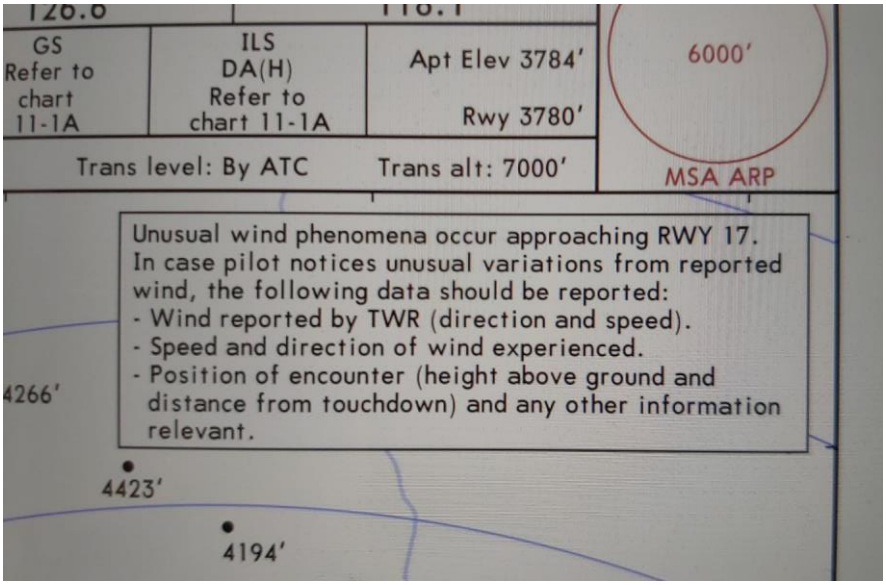


Figure 2: Jeppesen runway 17 Approach Chart

1.8. Aids to Navigation

During the time of the incident the following NOTAMS were issued by the UCAA for Entebbe International Airport:

HUEN A0036/22: ILS/DME CAT II Frequency 110.7 is operational but ground checked only. Awaiting Flight Test

HUEN A0037/22: DVOR/DME NN Frequency 117.5 is operational but ground checked only. Awaiting Flight Test.

HUEN A0041/22: NDB PB Frequency 270 is operational but ground checked only. Awaiting Flight Test.

HUEN A0042/22: NDB EM Frequency 355 is operational but ground checked only. Awaiting Flight Test.

All above Navigational Aids are serviceable, and meet all ground based calibration standards. But they must be tested by airborne equipment per certification guidelines.

Aircraft 9XR-WI had no recorded maintenance defects affecting the aircraft navigation systems.

1.9. Communications

Entebbe International Airport ATC communications with RwandAir WB464 were clear, and concise. During the landing clearance issued by Entebbe ATC to WB464, the controller advised it was raining at the airport, without qualifying the intensity of the rain, or for how long it has been raining. This information would have helped the Flight Crew determine how contaminated the runway was.

1.10. Aerodrome Information

Entebbe International Airport has one primary runway to use for commercial airline traffic. It is runway 17/35, 3658 meters long, 45 meters wide, and contains all required precision, and non-precision instrument approach procedures expected at an international airport.

Runway 17 was in use on the morning of the incident with moderate rain and thunderstorm for the previous two hours.

During a physical inspection of the runway surface conducted after the incident the following details were observed:

1) The touchdown zone of runway 17 has accumulated a layer of rubber deposits.
2) Runway 17 precision approach markings are worn, and illegible.
3) Mid zone area of runway 17/35 showed evidence of stagnant, accumulated, water alongside the runway and taxiway areas.
4) Inefficient drainage system on runway 17.



Figure 3:Aerodrome Picture

Entebbe International Airport issued a SNOWTAM advisory message on 21/04/2022 at 0504Z. The WB464 incident occurred at 0225Z. (the SNOWTAM was issued 2 hours - 39 minutes after the incident)

1.11. Flight Recorder

1.11.1. Flight Data Recorder

A review of FDR data showed four events were triggered by the incident.

1) Two level one events occurred (Level One Events are the least serious):

   a) The aircraft encountered a tailwind at 100 feet before touchdown. The tailwind exceeded the aircraft maximum design limits as established by the OEM.
   b) A longer than normal landing flare occurred.

2) One level two event occurred (Level Two Events are of moderate intensity):

   a) Excessive brakes were applied by the Flight Crew in an attempt to slow the aircraft.

3) One level three event occurred (Level One Events are an Action Point Event):

   a) Thrust Reversers were at a high thrust at a low ground speed.

1.11.2. Cockpit Voice Recorder.

The CRJ900 aircraft is equipped with a solid state, four channel Cockpit Voice Recorder. (CVR) The CVR records Flight Crew conversations, radio communications, PA announcements, and flight compartment sounds. The CVR operates continuously when the aircraft is powered. The CVR stops operating when power is removed from the aircraft, or when a high G-Force Impact Switch is activated after a crash, or ditching. When the Impact Switch is activated it removes power from the CVR, and prevents possible data erasure. The audio signal is recorded for 120 minutes and then is overwritten by the new recorded signal.

1.17. Organizational and Management Aspects

1.17.1. Notification of Occurrence

The State of Occurrence, (Uganda) have not complied with ICAO annex 13 provisions by notifying the relevant parties of a serious incident. Rwanda as State

of Registry and State of Operator, Canada as the State of Manufacturer, and the ICAO were not notified.

1.18. Additional Information

1.18.1. Global Reporting Format (GRF)

The Global Reporting Format is a globally harmonized methodology for assessing and reporting runway surface conditions. The GRF was developed by ICAO to help mitigate the risk of runway excursions. The GRF was mandated globally on 4 November 2021.

The GRF was not used by Entebbe ATC on the morning of the incident. The only information provided to the Flight Crew was that it was raining at the airport, but no information was provided concerning the intensity of rain, nor duration of rain, nor runway condition.

At the time of the incident, RwandAir had not approved flight crew GRF training program.

2. ANALYSIS

2.1. Technical Aspects

2.1.1. Viscous Hydroplaning

Hydroplaning in general and viscous hydroplaning in particular is a dangerous phenomenon that has caused many aviation incidents and accidents over the years.

During the conduct of this investigation, the investigators established that there was standing water on the runway during landing. When an aircraft lands on a runway with standing water, the aircraft can completely lose the ability to brake because the aircraft tires are separated from the runway surface by a layer of water and hence reduce braking effectiveness which can lead to aircraft loss of directional control.

Viscous hydroplaning is due to the viscous properties of water. A thin film of fluid no more than one thousandth of an inch in depth is all that is needed.

The tire cannot penetrate the fluid and the tire rolls on top of the film. This can occur at a much lower speed than dynamic hydroplaning, but requires a smooth, or smooth acting surface such as asphalt, or a touchdown area coated with the accumulated rubber of past landings. Such a surface can have the same friction coefficient as wet ice.

Main gear touchdown on a wet runway should always be firm in order to break through the surface water film, and making effective contact with the runway surface to spin-up the wheels. This is important since a stationary wheel can generate a wall of water in front of it on which the wheel will hydroplane.

However, all four crewmembers stated that the touchdown was ‘soft’ or ‘smooth’.

Additionally, the following factors make viscous Hydroplaning a very likely factor in the loss of directional control of flight WB 464:

The runway was wet due to the rain that prevailed for the last two hours and thirty minutes before landing of the flight of WB 464

The touchdown zone of runway 17 was covered by a layer of rubber deposits. In combination with a wet runway this forms a well-recognized circumstance for a lack of runway friction.

2.1.2. Preservation of Cockpit Voice Recorder Data.

Once the aircraft stopped after the runway excursion, electrical power remained on the aircraft by using the Auxiliary Power Unit, and aircraft batteries. Therefore, the CVR continued to run throughout the removal of passengers and cargo, and the beginning of the aircraft recovery exercise. Later, when attempts were made to recover important audio information it was overwritten, and couldn't be recovered by the service provider.

The standard procedure used to avoid loss of FDR / CVR data after an accident, or incident is to pull the appropriate circuit breaker. This will cut power to the system and prevent the loss of data. The circuit breaker is located on the panel behind the Captain/FO seat.

2.1.3. Global Reporting Format Analysis

The investigation team reviewed the GRF effectiveness for RwandAir flights operating into Entebbe International Airport between 21/04 – 12/05 2022 and obtained the following information:

- 61 flights landed, or departed from Entebbe during the 21-day period.
- Rain, and Thunderstorms were reported by ATC during 13 flights. (GRF reporting required)
- For 9 flights ATC provided RwandAir Flight Crew with GRF information before take-off/landing.
- For 4 flights ATC didn't provide RwandAir Flight Crew with GRF information before take-off/landing.

Therefore, during periods of rain when GRF reporting is mandatory, Entebbe ATC provided GRF information 61% of the time.

The above information was verified by a GRF Snowtam printout made available by the ANS Briefing Office at Kigali International Airport.

2.1.4. Flight Data Recorder

Events recorded by Flight Data Recorder were analyzed and classified in three levels based on their severity. The interpretation of the recorded events are Level One, Level Two, and Level Three events.

2.1.4.1. Level One Events (least serious)

Both level one events (1) The aircraft encountered a tailwind at 100 feet before touchdown and (2) A longer than normal landing flare occurred are consistent with pilot reports and other supporting documents. The pilots reported a prolonged flare, and smooth touchdown of the aircraft. Also, the approach charts being used by both pilots contain a notice that sometimes a wind phenomenon occurs when landing on runway 17 at Entebbe.

2.1.4.2. Level Two Events (moderate severity)

The level two event was (1) Excessive brakes were applied by the Flight Crew in an attempt to slow the aircraft. It is consistent with the pilot reports. The Captain was the Pilot Flying, and the First Officer was the Pilot Monitoring. When the aircraft began to slide the Captain suspected hydroplaning and tried to slow down the aircraft as quickly as possible so that the wings would lose lift, and the aircrafts weight would be transferred to the wheels for greater friction. Thus above normal braking, and thrust reverse was used.

2.1.4.3. Level Three Events (serious action point events)

The level three event was (1) Thrust Reversers were deployed at a high thrust setting at a low ground speed. It is consistent with the pilot reports. Consequently, the aircraft received damage to the right engine thrust reverser. The right reverser would not stow, and remained in the reverse position. The # 2

engine thrust reverser received mechanical damage during the incident. This is possible due to damage sustained when the aircraft left the runway and encountered debris.

2.2. Human Factors and Operational Aspects

2.2.1. Flight Duty Times:

A review of the Flight Crew Duty Period from 20 March to 20 April (incident date) shows all crew members flew a mixture of day, and night flights. See Below:

The Captain and First Officer were paired from 15 April. During this time, they conducted the following flights:

(a) 15 April: WB110 - Kigali – Harare - Cape Town (Day Flight)
(b) 16 April: Off duty in Cape Town
(c) 17 April: WB111 – Cape Town – Harare – Kigali (Day Flight, Off duty at 2025Z on 17 April)
(d) 18 April: WB262 – Kigali – Kinshasa – Kigali (Night Flight, Off duty at 0615Z on 19 April)
(e) 19 April: WB464 – Kigali – Nairobi – Entebbe (Night Flight, Incident occurred at 0230Z on 20 April)

Crew Position	Total Flights in 30 Days	Day Flights	Night Flights	Days Off
Captain	15	9	6	5
First Officer	18	11	7	6

3. CONCLUSIONS

3.1. Findings

3.1.1 The touchdown zone of runway 17 was covered by a layer of rubber deposits.

3.1.2 The ATC at Entebbe International Airports communicated to the pilots that it was raining without specifying the intensity of rain.

3.1.3 The ATC at Entebbe International Airport didn't provide the pilots with adequate information on conditions that existed on approach to runway 17.

3.1.4 The crews of the aircraft involved in the serious incident were in possession of valid licenses required to exercise their assigned job functions and responsibilities.

3.1.5 WB464 encountered an 11 Knot tailwind component at 100 feet above runway elevation.

3.1.6 The RwandAir Pilot recurrent training program for Contaminated Runway training has not been implemented. The Flight Crew have not received Contaminated Runway Procedures Training.

3.1.7 The Entebbe International Airport precision approach runways marking are obscure.

3.1.8 In the previous 30 days the crew of WB464 have flown a mixture of day, and night flights.

3.1.9 The Entebbe ATC didn't issue WB464 runway conditions in the GRF as required by ICAO.

3.1.10 The Cockpit Voice Recorder data were not preserved for investigation as required by the standards.

3.1.11 The RwandAir pilots training program for Global Report Format is not approved

3.2. Causal factor

The investigation established that the runway excursion was caused by Viscous Hydroplaning encountered during landing on runway 17 at Entebbe International Airport.

3.3. Contributory factors

The following factors contributed substantially to the cause of the serious incident:

a) The Flight Crew had inadequate information concerning standing water, wind velocity, and rain intensity to apply the appropriate actions prior to landing based on runway 17 conditions.
b) An unannounced tailwind component below 100 feet above touchdown that exceeded the aircraft's design limitations.
c) Once the aircraft began drifting right of the runway center-line, the Flight Crew failed to apply sufficient crosswind correction to arrest the drift.
d) The touchdown zone of runway 17 has accumulated a layer of rubber deposits.
e) Inefficient drainage system on runway 17.
f) The touchdown was very smooth. This permitted a thin film of water to build-up between the runway and tires, reducing braking effectiveness.

4. SAFETY RECOMMENDATIONS

To RwandAir:

1. RwandAir is recommended to implement Contaminated Runway Operations Training Program.
2. RwandAir is recommended to ensure Flight Crew receive the latest available flight information prior to dispatch.
3. RwandAir to establish the acceptable minimums to mix Flight Crew day and night duty assignments.
4. RwandAir is recommended to develop standardized training procedures to re-integrate Pilots that have not been flying for extended periods of time.
5. RwandAir is recommended to develop, and implement procedures for preserving FDR, and CVR information after an accident, or incident.
6. To establish Global Reporting Format (GRF) procedures and provide trainings to the operational personnel.

To RCAA:

1. RCAA is recommended to ensure that operators conduct all essential pilot trainings as approved in the Flight Operations Manuals.
2. RCAA is recommended to improve, and increase safety over-sight obligations.
3. To ensure compliance of the industry with the Global Reporting Format (GRF).