Air Accident Investigation Unit Ireland

SYNOPTIC REPORT

ACCIDENT

Boeing 767-3Q8, N477AX

Shannon Airport (EINN), Co. Clare, Ireland

8 March 2020



An Roinn Iompair
Department of Transport

Foreword

This safety investigation is exclusively of a technical nature and the Final Report reflects the determination of the AAIU regarding the circumstances of this occurrence and its probable causes.

In accordance with the provisions of Annex 13[1] to the Convention on International Civil Aviation, Regulation (EU) No 996/2010[2] and Statutory Instrument No. 460 of 2009[3], safety investigations are in no case concerned with apportioning blame or liability. They are independent of, separate from and without prejudice to any judicial or administrative proceedings to apportion blame or liability. The sole objective of this safety investigation and Final Report is the prevention of accidents and incidents.

Accordingly, it is inappropriate that AAIU Reports should be used to assign fault or blame or determine liability, since neither the safety investigation nor the reporting process has been undertaken for that purpose.

Extracts from this Report may be published providing that the source is acknowledged, the material is accurately reproduced and that it is not used in a derogatory or misleading context.

[1] **Annex 13**: International Civil Aviation Organization (ICAO), Annex 13, Aircraft Accident and Incident Investigation.
[2] **Regulation (EU) No 996/2010** of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation.
[3] **Statutory Instrument (SI) No. 460 of 2009**: Air Navigation (Notification and Investigation of Accidents, Serious Incidents and Incidents) Regulations 2009.



AAIU Report No: 2026-009

State File No: IRL00920004

Report Format: Synoptic Report

Published: 25 November 2026

In accordance with Annex 13 to the Convention on International Civil Aviation, Regulation (EU) No 996/2010 and the provisions of SI No. 460 of 2009, the Chief Inspector of Air Accidents, appointed Kevin O'Ceallaigh on 8 March 2020 as the Investigator-in-Charge to carry out an Investigation into this Accident and prepare a Report. On 24 March 2025, the Chief Inspector reassigned the function of Investigator-in-Charge to John Darcy.

Aircraft Type and Registration:	Boeing 767-3Q8, N477AX	
No. and Type of Engines:	2 X General Electric CF6-80C2B6F	
Aircraft Serial Number:	29390	
Year of Manufacture:	2002	
Date and Time (UTC)[4]:	8 March 2020 @ 19:55 hrs	
Location:	Shannon Airport, (EINN) Co. Clare, Ireland	
Type of Operation:	Commercial Air Transport	
Persons on Board:	Crew – 11	Passengers – 170
Injuries:	Crew – 7 (Minor)	Passengers – Nil
Nature of Damage:	Substantial	
Commander's Licence:	Airline Transport Pilot (ATP) Certificate (A) issued by the United States (US) Federal Aviation Administration (FAA)	
Commander's Age:	36 years	
Commander's Flying Experience:	7,650 hours, of which 879 were on type	
Notification Source:	Shannon Airport Duty Manager	
Information Source:	AAIU Report Form submitted by the Commander. AAIU Field Investigation	

[4] **UTC**: Co-ordinated Universal Time. All times in this report are quoted in UTC unless otherwise stated; local time was the same as UTC on the date of the accident.

SYNOPSIS

The Aircraft, a Boeing 767-3Q8, was on a passenger charter flight from Bangor International Airport (KBGR), Maine, USA, to Shannon Airport, Co. Clare, Ireland. During a dynamic touchdown sequence, in gusting wind conditions, the Aircraft structure was subjected to loads in excess of design limits. Following the landing, the Aircraft taxied to its parking stand and the passengers disembarked normally. A subsequent inspection revealed substantial damage to the upper fuselage of the Aircraft. No injuries were reported to the Investigation at the time of the accident. The Investigation was subsequently informed that seven Cabin Crew Members had sustained minor injuries. There was no fire.

NOTIFICATION AND RESPONSE

The AAIU was notified of the occurrence by the Shannon Airport Duty Manager and the US-based Operator. Three Inspectors of Air Accidents deployed to EINN, and an Investigation was commenced.

PREAMBLE

The Aircraft departed from an airport east of Los Angeles, California, USA at 04:45 hrs on 8 March 2020 (20:45 hrs local time on 7 March) with four pilots, seven Cabin Crew members, and 170 passengers on board. The carriage of additional pilots was to enable a longer duty period, with alternating rest periods. The Aircraft departed with both the automatic speedbrake deployment function and the left engine's thrust reverser inoperative, which was permissible in accordance with the Operator's MEL[5]. Consequently, manual deployment of the speedbrake was required on landing, and the left thrust reverser was not available for deployment. The Aircraft initially routed to KBGR and landed at 09:49 hrs.

1. FACTUAL INFORMATION

1.1 History of the Flight

Following a five-hour delay at KBGR due to passenger clearance requirements, the Aircraft departed at 15:06 hrs for EINN. The Flight Crew had obtained weather information before their departure from KBGR. On contact with EINN Air Traffic Control (ATC), they received in-flight updates on the conditions for the arrival, which indicated gusty conditions at EINN. The First Officer for this flight was seated in the right-hand seat and was the Pilot Monitoring (PM). The Commander, who was seated in the left-hand seat and was the Pilot Flying (PF), briefed the Cabin Crew and arranged for the cabin to be secured for landing at an earlier than usual time due to expected turbulence. The passengers and Cabin Crew were seated with their seatbelts on before the Aircraft descended through 10,000 feet. The Aircraft was radar-vectored for the Instrument Landing System (ILS) approach procedure to Runway (RWY) 24 and was subsequently cleared to land with a reported surface wind of 270 degrees at 20 knots (kt), a recent maximum of 35 kt, and a minimum of 15 kt. Flight data indicated that the approach had been stabilised and that autobrake[6] had been selected for landing.

[5] **MEL**: The Minimum Equipment List is developed by an operator, based on the Master Minimum Equipment List (MMEL) produced by the Aircraft Manufacturer. See **Section 1.7**.

[6] **Autobrake:** A system, which when activated, automatically applies braking to the Main Landing Gear (MLG) wheels as soon as they are on the ground.

During the landing, in gusty conditions, the left and right Main Landing Gear (MLG) touched down simultaneously, following which the Nose Landing Gear (NLG) touched down. The NLG then lifted off the ground again, followed by the left MLG, while the right MLG remained in contact with the runway surface. The NLG touched down again, followed by the left MLG. The Aircraft decelerated, taxied off the runway and continued to its designated parking stand. The passengers disembarked to the terminal building. A subsequent inspection revealed substantial damage to the airframe. There was no fire.

1.2 Injuries to Persons

No injuries were reported to the Investigation. The Investigation subsequently learned that seven Cabin Crew members reported minor injuries approximately 24 hours after landing but did not require immediate medical attention.

1.3 Damage to Aircraft

The Aircraft sustained substantial damage in the occurrence. The Aircraft's skin was buckled, forward of the wing, between frame[7] stations 434 and 654, with frame station 654 sustaining the most significant damage (**Photo No. 1** and **Photo No. 2**).



Photo No. 1: Damage to right side of the Aircraft's fuselage

[7] **Frames**: Frames are structural members used in an aircraft fuselage to provide shape and strength and are identified by an assigned (station) number in a sequence that typically increases from front to rear.



Photo No. 2: Damage to the left side of the fuselage

The damage was such that the upper skin (crown) of the Aircraft was perforated in one area (**Photo No. 3**).

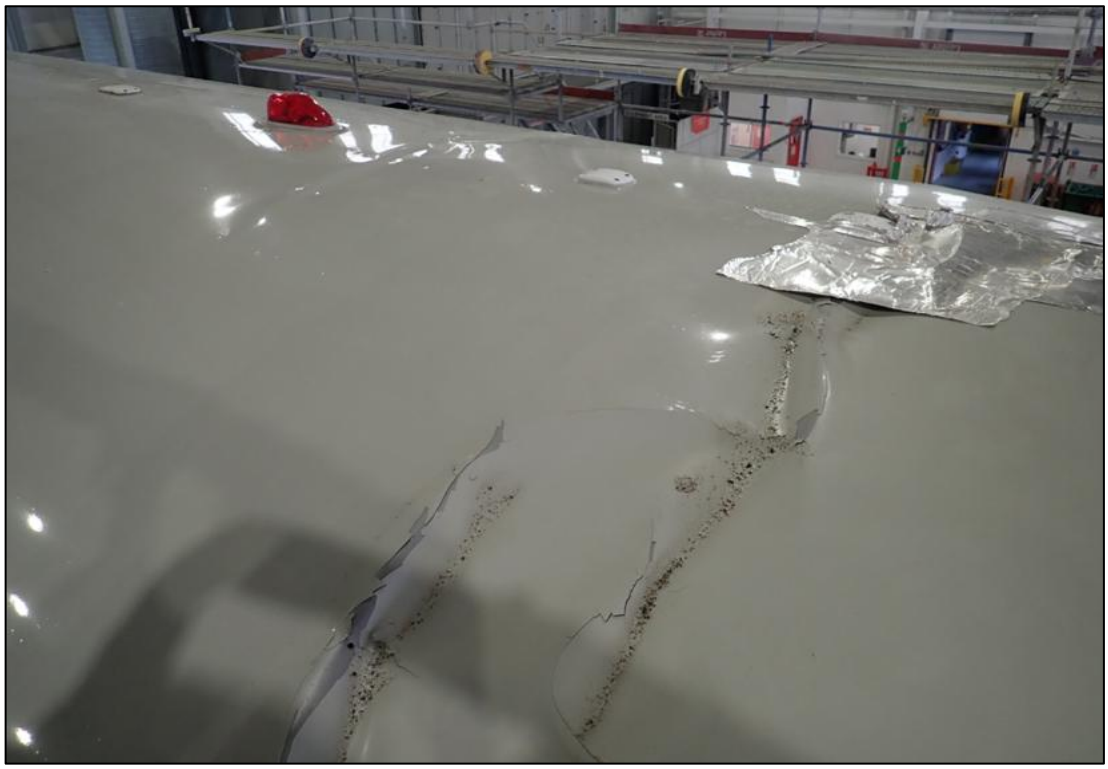


Photo No. 3: Damage to crown of the Aircraft (perforation masked by tape)

There was corresponding damage to the frames and stringers[8] in this area around the perforation (**Photo No. 4** and **Photo No. 5**). The NLG was removed and replaced. The left and right MLG were inspected and found to be serviceable.



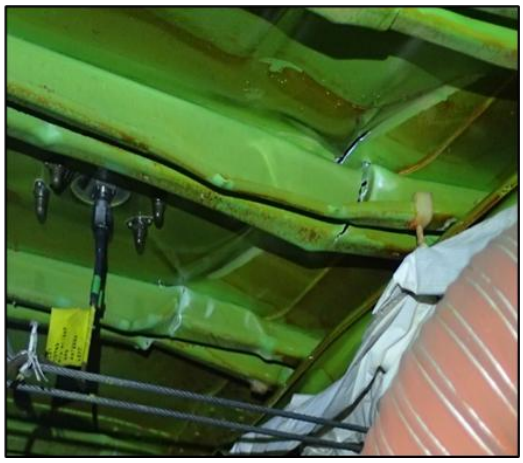


Photo No. 4 (left) and **Photo No. 5** (right): Internal Aircraft structural damage

1.4 Personnel Information

There were four Flight Crew members and seven Cabin Crew members on board the Aircraft. At the time of the occurrence, all four Pilots were seated in the flight deck. Two were relief Pilots, who were first officers, and were seated in jumpseats[9] located behind the PF and PM. Each of the four pilots held a valid Airline Transport Pilot Certificate and current first-class medicals. The Commander had been upgraded to command on 11 November 2019 and was the only pilot on board qualified to act as Pilot-in-Command (PIC) on the Aircraft type.

1.4.1 Flying Experience

The Commander's and First Officer's flying experience is shown in **Table No. 1**.

	Commander	First Officer
All types:	7,650 hrs	22,583 hrs
PIC:	5,399 hrs	21,979 hrs
Co-pilot:	2,251 hrs	604 hrs
Occurrence type:	879 hrs	72 hrs
PIC:	123 hrs	0 hrs
Co-pilot:	756 hrs	72 hrs
Last 90 days on type:	130 hrs	72 hrs
Last 28 days on type:	14 hrs	36 hrs
Last 7 days on type:	11 hrs	11 hrs

Table No. 1: Commander's and First Officer's Flying Experience

[8] **Stringer**: Stringers are longitudinal members that provide strength and together with the frames, they support the aircraft's skin.

[9] **Jumpseat**: A folding or auxiliary seat in the flight deck for temporary use by non-operating crew members or for observation/training.

An extract from the Operators '*General Operations Manual – General Policies 2.25 100-HOURS CONSOLIDATION OF KNOWLEDGE & SKILLS - FAR 121.434, FAR 121.438*' stated:

> '*When qualifying on a new aircraft type, Pilot-in-Command and First Officer crewmembers must each acquire at least 100 hours of line operating flight time within 120 days after satisfactory completion of their initial proficiency check in that aircraft.*
>
> […]
>
> *If the 100 hour requirement is not satisfied within the 120 day period,* [The Operator] *may extend the period to 150 days provided:*
> *1. The pilot continues to meet all other applicable FAA required crewmember qualifications delineated in FAR 121, Subpart O; and*
> *2. On or before the 120th day, a Check Airman determines that the pilot has retained an adequate level of proficiency after observing that pilot in a supervised line operating flight. Or, the pilot satisfactorily completes refresher training conducted by a qualified instructor or Check Airman as provided in the* [Operators] *Training Manual.*
>
> […]
>
> *For* […] *trips, the combined operating experience of the Pilots at the controls must total at least 250 hours, for all phases of flight.*
>
> *If the First Officer has fewer than 100 hours of Part 121 flight time in the type airplane being flown, and the Pilot-in-Command is not a Check Airman, the Pilot-in-Command must make all takeoffs and landings in the following situations:*
>
> […]
>
> *2. In any of the following conditions:*
> *A. The prevailing visibility value in the latest weather report for the airport is at or below ¾ mile.*
> *B. The RVR for the runway to be used is at or below 4,000 feet.*
> *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 runway to be used is reported to be less than "good".*
> *E. The crosswind component for the runway to be used is greater than 15 knots.*
> *F. Windshear is reported in the vicinity of the airport.*
> *G. Any other condition in which the PIC determines it to be prudent to exercise the PIC's prerogative.'*

The Operator informed the Investigation that the First Officer had completed a Proficiency check on 16 February 2020 with a qualified Check Airman (Examiner), which the Operator deemed to have fulfilled the FAA requirement as per the Operators manual to retain an adequate level of proficiency within the 120th day.

The First Officer had completed their initial proficiency check within the previous 134 days. US Code of Federal Regulations (CFR), Title 14, Chapter I, Sub-chapter G, Part 121, Sub-part O, Crewmember Qualifications, Section 432, Paragraph (a) states:

'*Except in the case of operating experience under § 121.434 and ground training for mentoring required by §§ 121.419, 121.420, 121.427, and 121.429, as applicable, a pilot who serves as second in command of an operation that requires three or more pilots must be fully qualified to act as pilot in command of that operation.*'

As the First Officer was obtaining his operating experience under Section FAR 121.434, this would have exempted him from the requirement in Section FAR 121.432.

1.5 Aircraft Information

1.5.1 General

The Boeing 767-3Q8, is a twin-engine, long-range, wide-body aircraft. It has a wingspan of 47.57 m, a length of 54.94 m, and a maximum total height of 16.03 m. The Aircraft has four wheels on each of its two main landing gear bogies[10] and two wheels on the nose gear. Its maximum take-off mass is 186,880 kilograms. The subject Aircraft was manufactured in 2002 and was fitted with two General Electric CF6-80C2B6F turbofan engines. It had a valid Certificate of Airworthiness issued by the FAA on 30 July 2016. The maximum recommended crosswind for a wet runway as outlined in the Operator's Flight Crew Training Manual (FCTM) is 40 kt, based on a steady wind with no gusts. This guideline is also contained in the Boeing FCTM.

1.5.2 Spoilers/Speedbrakes

There are six spoiler panels located on the upper surface of each wing (**Figure No. 1**). Spoilers on opposite wings are symmetrically paired.

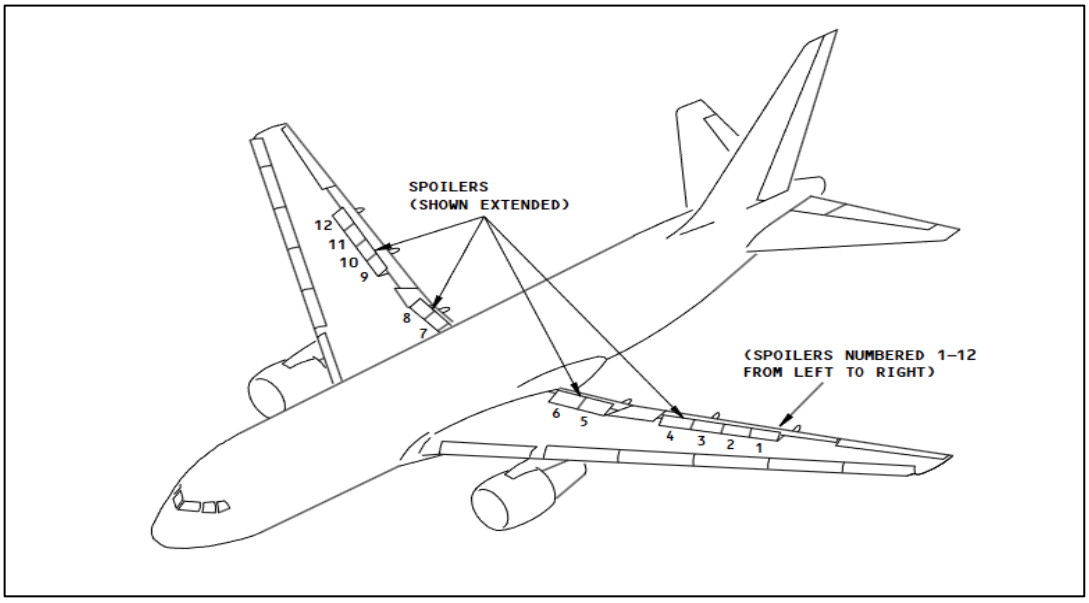


Figure No. 1: Spoiler panels on the B767

[10] **Bogie/Bogey:** An arrangement of two or more tandem wheels. It is sometimes referred to as a '*truck*'.

In flight, the system operates the surfaces (panels) as spoilers to provide lateral control of the aircraft in conjunction with the ailerons. The system also operates the surfaces as speedbrakes to increase drag and reduce lift in flight and during landing. The spoiler/speedbrake system is electrically controlled and hydraulically powered. Separate power control actuators operate the twelve spoiler surfaces. In Manual operation, the speedbrakes are controlled by the speedbrake lever located on the cockpit pedestal. The speedbrake lever has three marked positions as illustrated in **Figure No. 2**:

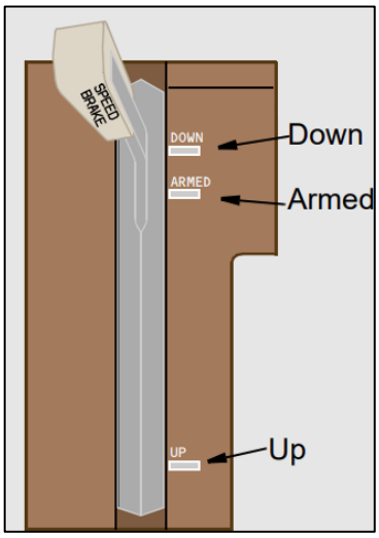


Figure No. 2: Schematic of the speedbrake lever positions

In flight, the speedbrake lever can be manually placed in intermediate positions between ARMED and UP to control airspeed and to assist with descent.

During normal touchdown, when the speedbrake lever is in the ARMED position, the main landing gears are '*on ground*' and the thrust levers at idle, the speedbrake lever is automatically driven aft to the UP position and the spoiler panels are fully extended. In addition, when either reverse thrust lever is moved to the reverse idle detent, the speedbrake lever is automatically driven to the UP position, resulting in the spoiler panels being fully extended.

1.5.3 Thrust Reversers

The engines are fitted with thrust reversers which are controlled by secondary levers connected to the thrust levers. When reverse thrust is selected, doors within each engine's cowlings are pneumatically operated to block the rearward moving air from the engine fan and re-direct it forwards, which assists in reducing aircraft speed. Reverse thrust is only available when the Aircraft is on the ground.

A warning contained in the Operator's Flight Crew Operating Manual (FCOM) '*Landing Roll Procedure'* states: '*After the reverse thrust levers are moved, a full stop landing must be made*'. When selected, the thrust reverser may take several seconds to deploy before full reverse thrust is applied.

1.5.4 Autobrake

The main landing gear braking system incorporates an autobrake system which is managed using an eight-position switch that can be set to one of the following settings: RTO (rejected take-off), OFF, DISARM, 1, 2, 3, 4 and MAX AUTO. Each setting (apart from OFF and DISARM) corresponds to a different level of deceleration. The Flight Crew on the accident flight had selected Autobrake setting '*3*' as recommended in the FCTM for use with a crosswind, or on wet runways or when using higher approach speeds. The recorded data from the Aircraft showed that the MLG brakes were automatically applied shortly after MLG touchdown. This has the secondary effect of pitching the nose down.

1.6 Flight Crew Training Manual

The Operator provided the Investigation with its Flight Crew Training Manual (FCTM) which was extant at the time of the accident. Pertinent extracts from Section 6, titled '*Landing*', are included below:

> ***6.5.5 BOUNCED LANDING RECOVERY***
>
> *'If the airplane should bounce, hold or re-establish a normal landing attitude and add thrust as necessary to control the rate of descent. Thrust need not be added for a shallow bounce or skip. When a high, hard bounce occurs, initiate a go-around. Apply go-around thrust and use normal go-around procedures. Do not retract the landing gear until a positive rate of climb is established because a second touchdown may occur during the go-around.*
>
> *If higher than idle thrust is maintained through initial touchdown, the automatic speedbrake deployment may be disabled even when the speedbrakes are armed. This can result in a bounced landing.*
>
> *If the speedbrakes started to extend on the initial touchdown, they will retract once the airplane becomes airborne again on a bounce, even if thrust is not increased. The speedbrakes must then be manually extended after the airplane returns to the runway'.*
>
> […]
>
> ***6.6 LANDING ROLL***
>
> *'Avoid touching down with thrust above idle since this may establish an airplane nose up pitch tendency and increase landing roll.*
>
> *After main gear touchdown, initiate the landing roll procedure. Fly the nose wheels smoothly onto the runway without delay. If the speedbrakes do not extend automatically move the speedbrake lever to the UP position without delay. Control column movement forward of neutral should not be required. Do not attempt to hold the nose wheels off the runway. Holding the nose up after touchdown for aerodynamic braking is not an effective braking technique and results in high nose gear sink rates upon brake application and reduced braking effectiveness.*

To avoid possible airplane structural damage, do not make large nose down control column movements before the nose wheels are lowered to the runway.

To avoid the risk of a tail strike, do not allow the pitch attitude to increase after touchdown. However, applying excessive nose down elevator during landing can result in substantial forward fuselage damage. Do not use full down elevator. Use an appropriate autobrake setting or manually apply wheel brakes smoothly with steadily increasing pedal pressure as required for runway condition and runway length available.

Maintain deceleration rate with constant or increasing brake pressure as required until stopped or desired taxi speed is reached.'

6.6.1 SPEEDBRAKES

'The speedbrakes spoil the lift from the wings, which places the airplane weight on the main landing gear, providing excellent brake effectiveness. If the speedbrakes are not raised after touchdown, braking effectiveness may be reduced initially as much as 60%, since very little weight is on the wheels and brake application may cause rapid antiskid modulation.

The speedbrakes can be fully raised after touchdown while the nose wheels are lowered to the runway with no adverse pitch affects. Normally, speedbrakes are armed to extend automatically. Both pilots should monitor automatic speedbrake extension after touchdown. In the event auto extension fails, the speedbrakes need to be manually extended. After touchdown, fly the nose wheels smoothly to the runway while slowly raising the speedbrake to the up position.

Pilot awareness of the position of the speedbrake lever during the landing phase is important in the prevention of over-run. The position of the speedbrakes should be announced during the landing phase by the PM. This improves the crew's situational awareness of the position of the speedbrakes during landing and builds good habit patterns which can prevent failure to observe a malfunctioned or disarmed speedbrake system'.

1.7 Minimum Equipment List

The Minimum Equipment List is developed by an operator and is approved by the competent authority in the state of the operator. It is based on the Master Minimum Equipment List (MMEL) produced by the Aircraft Manufacturer and lists the items which may be temporarily inoperative and the associated maintenance and/or operating procedures as applicable, for a specific aircraft type or model. It allows an operator to determine whether, and with what limitations, a flight may be safely dispatched in the event of a component or system unserviceability which cannot be rectified prior to dispatch.

When a system or item that is listed in the MEL becomes unserviceable, it is recorded in the technical logbook to inform flight crews to review the MEL and establish whether any specific operational procedures or limitations are prescribed.

On the subject Aircraft, the auto speedbrake and the left thrust reverser were unserviceable, and associated entries were made in the technical logbook.

Below are extracts from the Operator's MEL regarding the Auto Speedbrake System:

'*27-62-01-01 Auto Speed Brake System:*

[…]

May be inoperative provided:

a) System is deactivated, and
b) AFM [Aircraft Flight Manual] *decrements are applied if landing performance requires use of auto speedbrakes.*'

The dispatch requirements associated with this item being inoperative were included in the Operator's MEL:

'*For airplanes certified based on landing field length credit for auto speedbrakes, use AFM penalties for manual speedbrake operation.*

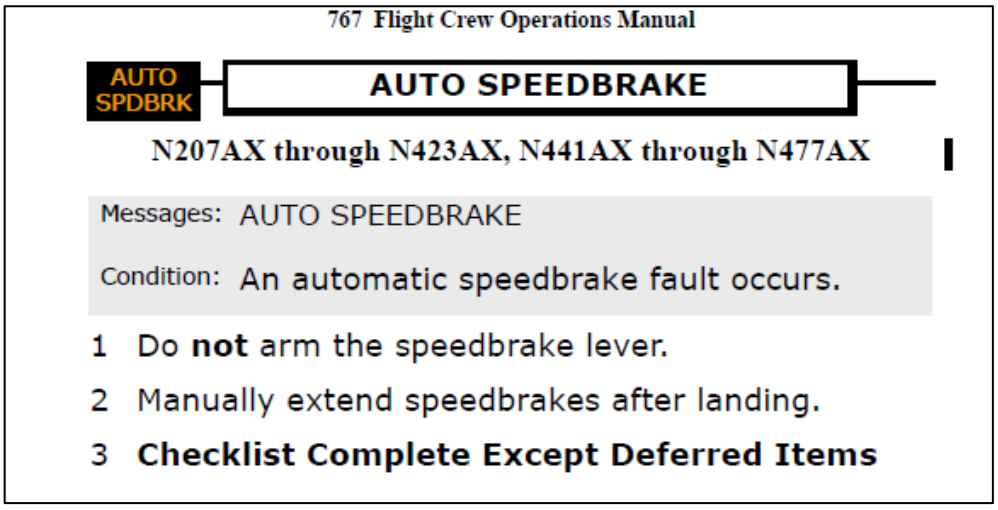
[…]

Extend speedbrakes manually for rejected takeoff or landing

[…]

For landing, do the AUTO SPEEDBRAKE Non-Normal Checklist.'

An extract from the non-normal checklist, which is contained in the FCOM, is reproduced in **Figure No. 3**.


767 Flight Crew Operations Manual

AUTO SPDBRK

AUTO SPEEDBRAKE

N207AX through N423AX, N441AX through N477AX

Messages: AUTO SPEEDBRAKE

Condition: An automatic speedbrake fault occurs.

1 Do **not** arm the speedbrake lever.

2 Manually extend speedbrakes after landing.

3 **Checklist Complete Except Deferred Items**

Figure No. 3: Extract from the Operator's non-normal checklist

1.8 Aerodrome Information

Shannon Airport (EINN) is located 13.5 nautical miles (NM) west of Limerick city, Co. Clare, at an elevation of 46 feet (ft) above mean sea level. The Aircraft landed on RWY 24 at EINN, which has a Landing Distance Available (LDA) of 3,059 metres (m). The runway has an Instrument Landing System[11] (ILS) which was in use at the time of the approach. The ILS chart for RWY 24 contains a caution regarding turbulence and/or windshear on approach (**Figure No. 4**).

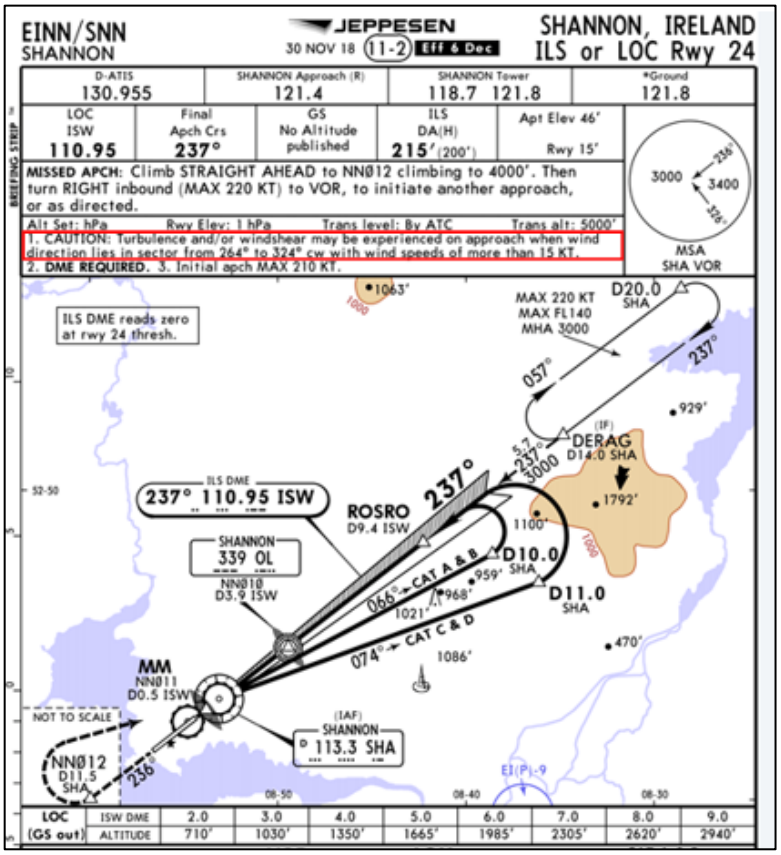


Figure No. 4: Part of the ILS chart for RWY 24 at EINN (*Jeppesen*) (red border added by Investigation for emphasis)

1.9 Meteorological Information

Met Éireann, the Irish meteorological service, was asked to provide an aftercast of the estimated weather conditions prevailing at EINN at the time of the accident. The details are reproduced in **Table No. 2**.

[11] **Instrument Landing System**: A ground-based precision runway approach aid employing two radio beams to provide pilots with vertical and horizontal guidance during the landing approach.



Meteorological Situation:	A strong and unstable westerly airflow covers Ireland.
Surface Wind: **Wind at 2,000 ft:** **Wind between surface and 300 ft:**	Westerly 20-25 kt with gusts 35-40 kt Westerly 40 kt An unstable airmass with the presence of CBs[12] would have caused downdrafts, wind shear and turbulence.
Visibility:	6,000 metres
Weather:	Light showers of rain
Cloud:	Few (1-2/8th oktas) of stratus with bases at 900 ft, broken (5-7/8th oktas) of cumulonimbus with bases at 1,800 ft and broken layer of stratocumulus with bases at 4,500 ft
Surface Temperature/Dew Point:	7/4 degrees Celsius
Mean Sea Level (MSL) Pressure:	1005 Hectopascals (hPa)
Freezing Level:	3,000 ft

Table No. 2: Estimated weather conditions at EINN at the time of the accident

The Meteorological Aerodrome Report (METAR) published for EINN at a time either side of the accident contained the following information:

> METAR EINN 081930Z 26021G32KT 9999 FEW009 FEW020CB BKN060 07/04 Q1005 TEMPO 4000 SHRA=

This indicates the following:

METAR: Meteorological Aerodrome Report
EINN: Station ID, Shannon
081930Z: Date and time, day: 08; time: 19:30 UTC
26021G32KT: Wind velocity, direction: from 260°, speed: 21 kt, gusts: 32 kt
9999: Visibility, more than 10 kms.
FEW009: Cloud layer, few (FEW) 900 ft Above Ground Level (AGL)
FEW020CB: Cloud layer, few (FEW) 2,000 ft AGL cumulonimbus
BKN060: Cloud layer, broken (BKN) 6,000 ft AGL
07/04: Temperature: 7 °C, dewpoint: 4 °C
Q1005: Altimeter setting, air pressure is 1005 hPa
TEMPO: Conditions are expected to change temporarily within the next 2 hours
4000: Visibility, 4,000 meters.
SHRA: Showers (SH) rain (RA)

[12] **CB**: Cumulonimbus, a heavy and dense cloud with considerable vertical extent in the form of a tower that is associated with extreme turbulence, thunderstorms and strong downdrafts.

METAR EINN 082000Z 26023G38KT 6000 -SHRA FEW009 BKN018CB BKN045 07/04 Q1005 TEMPO 4000 BKN045=

This indicates the following:

METAR: Meteorological Aerodrome Report
EINN: Station ID, Shannon
082000Z: Date and time, day: 08; time: 20:00 UTC
26023G38KT: Wind velocity, direction: from 260°, speed: 23 kt, gusts: 38 kt
6000: Visibility, 6,000 meters.
-SHRA: Light (-) showers (SH) rain (RA)
FEW009: Cloud layer, few (FEW) 900 ft AGL
BKN018CB: Cloud layer, broken (BKN) 1,800 ft AGL cumulonimbus
BKN045: Cloud layer, broken (BKN) 4,500 ft AGL
07/04: Temperature: 7 °C / dewpoint: 4 °C
Q1005: Altimeter setting, air pressure is 1005 hPa
TEMPO: Conditions are expected to change temporarily within the next 2 hours
4000: Visibility, 4,000 meters.
BKN045: Cloud Layer, broken (BKN) 4,500 ft AGL

An aerodrome warning, for strong winds at EINN, was in operation:

EINN AD WRNG 01 VALID 081700/082200 WIND SFC W 25-30KT MAX 35-40 FCST=

This decodes as follows:

Shannon Aerodrome warning 01 valid on the 8th from 17:00 until the 8th at 22:00, westerly wind at the surface, mean wind speeds of 25 to 30 kt and gusts of 35 to 40 kt forecast, end of report.

1.10 Mechanical Turbulence

1.10.1 Introduction

Mechanical turbulence is a type of air disturbance caused by the presence of obstacles such as mountains, buildings or trees, which force airflow to diverge or converge around them, creating eddies and turbulent conditions. The intensity of mechanical turbulence is directly influenced by factors such as the wind speed and direction, the roughness or height of the obstructions, as well as the atmospheric stability near the surface. Mechanical turbulence becomes more significant when surface winds exceed 20 kt.

1.10.2 Effect of Hangar to the North of RWY 24 at EINN

A large hangar is located to the north of RWY 24 (**Figure No. 5**). AAIU report No. 2013-008 dealt with a previous accident which occurred in similar wind conditions at EINN; the report of the investigation into that accident highlighted a study that had been conducted of the combined effects of wind and the hangar to the north of RWY 24.



Figure No. 5: Large hangar to the north of RWY 24 at EINN and wind direction (Google)

Under the heading '*Hangar Wake effect*', the AAIU final report No. 2013-008 stated:

> '*The Hangar had been erected twenty years previously and thereafter frequent reports of turbulence and wind shear reports were made by pilots landing in the TDZ* [touchdown zone] *of RWY 24 in moderate to strong north westerly winds. Subsequently, a study of the likely effects of turbulence generated by the Hangar was conducted in 1996 using a scale model in a wind tunnel.*
>
> *For a wind velocity at the time of the accident the Study stated that the wake effect extends to some 370 to 490 m downwind. This distance includes the TDZ of RWY 24. The study concluded that the Hangar had little effect on the wind regime along the flight path (i.e. on short finals) but that there were slight wind velocity deficits and turbulence intensity changes along the runway close to the hangar.*
>
> *The Investigation therefore concludes that, depending on the prevailing atmospheric conditions at the time (wind velocity, turbulence, turbidity and instability), the wake effect can locally augment turbulence at the TDZ of RWY 24. The continued reports of turbulence recorded by pilots over the years lend validity to the assumption that the wake effect of the Hangar has a local effect at the TDZ of RWY 24 in strong winds between west and northwest and therefore the turbulence caution is considered warranted.*'

1.11 Recorded Information

1.11.1 Introduction

Following the occurrence, the Cockpit Voice Recorder (CVR) and the Digital Flight Data Recorder (DFDR) were downloaded, and the data was analysed by the Investigation.

1.11.2 Digital Flight Data Recorder

Each parameter recorded on the DFDR has a specific sampling interval / rate. It should be noted that not all parameters are recorded at the same rate. This DFDR has a specific sampling interval / rate which the Aircraft manufacturer stated is time aligned within the FDR data frame. The data displayed in **Figure No. 6** contains recorded information specific to the left and right MLG tilt[13], the NLG air/ground status, pitch angle in degrees, control column deflection, rate of change of pitch angle (pitch rate) in degrees per second, speedbrake handle position, the Aircraft's groundspeed in knots and brake pressure of the right MLG in pounds per square inch (psi).

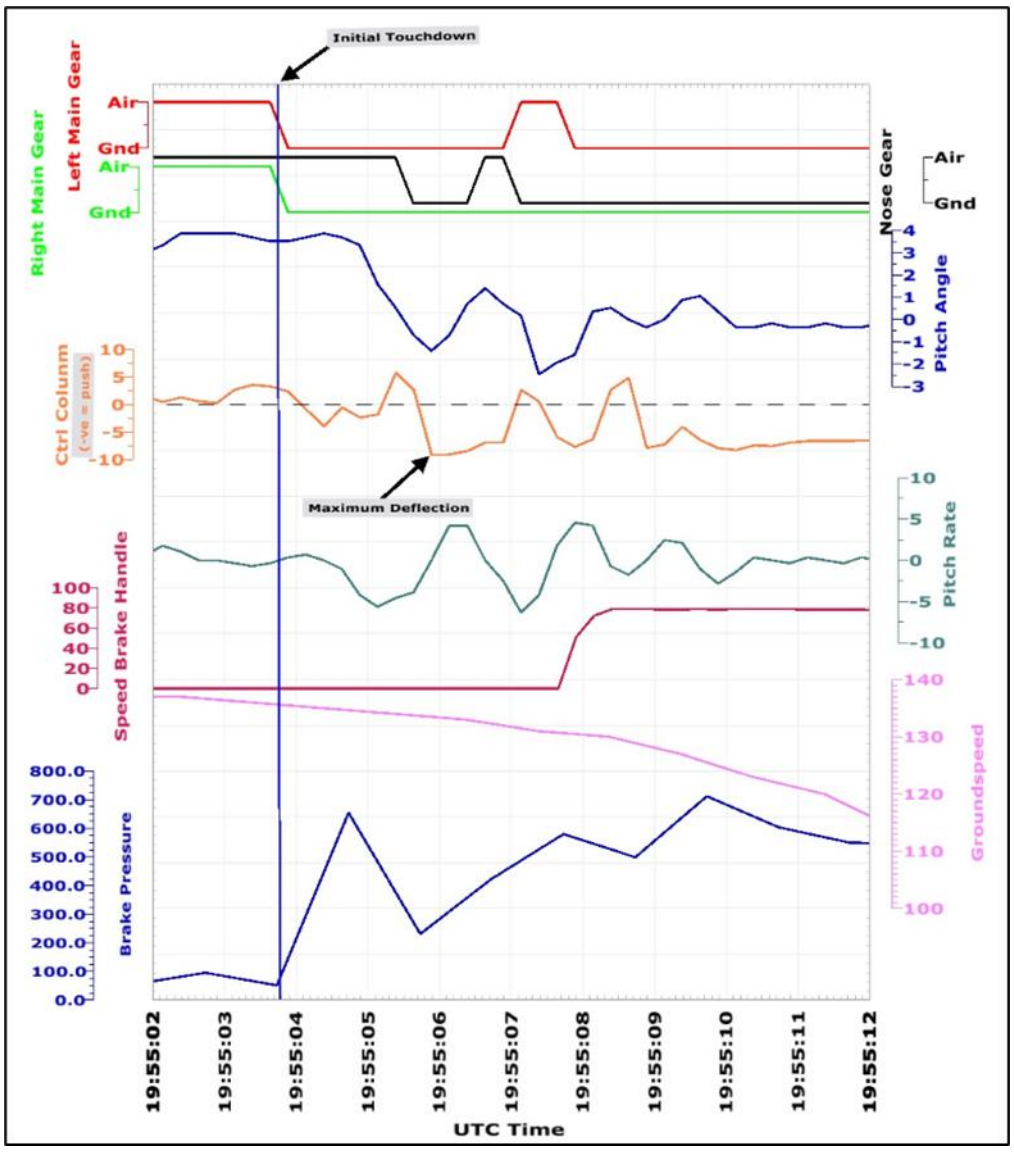


Figure No. 6: Selected DFDR Information during the landing

Flight data indicates that the speedbrake was (manually) deployed approximately four seconds after MLG touchdown and that the right thrust reverser (not shown in **Figure No. 6**) was deployed approximately eight seconds after MLG touchdown. Autobrakes were activated almost immediately on MLG touchdown.

[13] **Tilt**: On this aircraft type, the MLG bogies tilt forward on the extended landing gear before the Aircraft touches down. 'No tilt' indicates that the landing gear is on the ground.



The recorded data shown in **Figure No. 6** indicates the following in the six seconds after first MLG touchdown:

Between time 19:55:03 and 19:55:04

- Both MLG touched down (as indicated by the bogie tilt switches showing 'no tilt').
- The pitch angle was +3.5 degrees.

Between time 19:55:04 and 19:55:05

- The control column was at a 4 degree pull during MLG touchdown (flare manoeuvre) and then pushed to approximately -4 degrees.
- The pitch rate starts decreasing towards a negative value.

Between time 19:55:05 and 19:55:06

- The pitch rate reaches approximately -5.6 degrees per second.
- The control column is pulled to approximately +6.7 degrees and then pushed forward to maximum deflection which is -9.2 degrees.
- At this point the NLG is on the ground.
- The pitch angle is 1.4 degrees negative.

Between time 19:55:06 and 19:55:07

- The pitch rate reaches +4.2.
- The NLG lifts from the ground.
- The control column is slightly relaxed from maximum forward deflection to a nose down push position of -6.8 degrees.
- The pitch angle increases to +1.4 degrees.
- The left MLG is not on the ground (as indicated by the bogie tilt switches showing 'tilt').

Between time 19:55:07 and 19:55:08

- The pitch rate is -6.27 degrees per second.
- Control column pulled to approximately +3 degrees.
- The pitch angle is -2.45 degrees.
- NLG is on the ground.
- Speedbrake lever is deployed manually and speedbrake reaches full deployment approximately one second later.
- Left MLG is recorded as on the ground (as indicated by the bogie tilt switches showing 'no tilt').
- The control column is pushed close to -8 degrees.

Between time 19:55:08 and 19:55:09

- At this point, all landing gear wheels were on the ground.
- The control column was pulled to +5 degrees followed by a further push to -7.7 degrees.

1.11.3 Aircraft Manufacturer's Analysis

The Aircraft Manufacturer was asked to provide an analysis of the recorded flight data. The analysis indicated that, during the final phase of the approach, the Aircraft experienced a headwind with a right crosswind component with a mean wind direction from 260° varying from 250° at a speed of 30 kt, decreasing to 20 kt at touchdown. Groundspeed was approximately 136 kt at touchdown

The Aircraft Manufacturer informed the Investigation that when analysing the DFDR data, it used a kinematic consistency algorithm to detect and correct inconsistencies which arise in recorded data from different sensors because of the presence of instrumentation biases due to misalignment in inertial measurements, contamination of pressure and altitude measurements due to flow separation, and sample rate differences.

The output is a consistent set of data with acceleration biases removed, allowing calculations and comparisons of wind data and other parameters. The Manufacturer provided the Investigation with the following salient observations:

> '*Perturbations in key parameters were observed, which include the acceleration parameters, vane angle of attack, and computed airspeed, along with increased control inputs to maintain the desired attitudes and are indicative of a turbulent atmosphere.*
>
> […]
>
> *Touchdown occurred at a computed airspeed of 150 knots (VREF[14]+8) at a pitch attitude of 3.5 degrees, bank angle of 1.5 degrees to the right, and in a slight left crab. The peak normal load factor at touchdown was 1.36 g's. Both main gear tilt discrete parameters transitioned to NO TILT at touchdown. The sink rate (negative calculated vertical speed) at the center of gravity (CG) was 5.3 feet/second and the closure rate (negative vertical speed) of the right main gear with the runway was 3.8 feet/second. After touchdown, the column was pushed to nearly 4 degrees, then pulled to 6.7 degrees as the nose gear transitioned to GROUND approximately 1.5 seconds after the main gear. The maximum instantaneous pitch rate during derotation[15] was -6.5 degrees/second. All gear were on ground for nearly 1 second when the nose gear transitioned to AIR as the airplane rebounded and the pitch attitude* [angle] *increased to 1.3 degrees nose-up as the column was pushed to 9.2 degrees and relaxed to a 6.8 degree push. The maximum instantaneous pitch rate was nearly 6 degrees/second during the rebound. After the nose gear returned to GROUND, the column was pushed to 7.6 degrees and the maximum instantaneous pitch rate was -11.3 degrees/second. As the nose gear returned to GROUND, the left main gear returned to TILT (indicating "in-air") as a right bank angle to 3.2 degrees developed.*

[14] **VREF**: Reference Landing Speed. The speed used during the final approach and landing of an aircraft. VREF is typically calculated as 1.3 times the stall speed in the landing configuration. This value provides a safety margin, ensuring the aircraft maintains a margin of airspeed over the one-g stall speed during the landing approach.

[15] **Derotation**: describes the portion of the landing after main gear touchdown when the pilot lowers the nose to the runway. A column push is not necessarily an indication of de-rotation, a relaxation would be expected. The Boeing FCTM states "*Control column movement forward of neutral should not be required*" while performing the landing roll. All AAIU references to '*de-rotation*' will be hyphenated.

The left main gear returned to NO TILT approximately 0.5 seconds later and all gear were on ground by time 17,985.9 seconds[16]*. After initial touchdown, the normal load factor spiked to about 1.5 g's two times before all gear were settled on ground, and after all gear were on ground, there were two additional normal load factor spikes to nearly 1.5 g's.*

[…]

A derotation rate of -11.3 deg/sec results in a nose gear contact rate in excess of the design limit for the nose landing gear and forward fuselage. Additionally, there was significant nose-down elevator commanded and the left main landing gear AIR/GROUND indicator transitioned to AIR during this second NG touchdown event. This landing event is therefore more severe than the analyzed airplane design conditions and the resulting fuselage damage is consistent with an extremely hard nose gear touchdown event.'



Figure No. 7: Data showing Control Column and Elevator deflection during landing

1.11.4 Cockpit Voice recorder

The Cockpit Voice Recorder (CVR) data was analysed by the Investigation. As part of the approach briefing conducted shortly prior to the initial descent, the Commander can be heard referring to the caution section on the Instrument Landing System (ILS) chart for RWY 24 (**Figure No. 4**). He stated in relation to the conditions described on that caution, '*15 kt*', and that '*this is what we have*'. The Commander further stated that the wind would be right down the runway (this was a reference to the direction of the wind) and that he was not concerned. He added that the VREF would be 143 kt and that because of the wind conditions, he was planning to fly the approach at 150 kt and that if it was '*it was gusty*' he would add to that '*but not more than 15 kt*'[17]. The Flight Crew can then be heard discussing the landing performance penalties that applied due to the auto speedbrake and a thrust reverser not being available. The Automatic Terminal Information Service (ATIS)[18] is then heard, which stated the wind as being 260 degrees at 19 kt.

[16] Time from the start of all available recorded data (in seconds).
[17] Pilots can increase the VREF within an operator's defined limits to account for gusting wind conditions.
[18] **ATIS:** Automatic Terminal Information Service - a continuous, automated broadcast of recorded aeronautical information that provides pilots with essential, updated information, including weather and active runways. Pilots confirm the information's phonetic letter code when contacting air traffic control to ensure they have the most current operational data.

During the descent, the CVR recorded Crew discussions around expected icing conditions during the descent and approach, and the anti-ice systems were activated. The Flight Crew then received a new updated recording of the ATIS broadcast which stated the wind conditions as 260 degrees 21 kt gusting to 35 kt. The Flight Crew are then heard requesting some small deviations to their heading due to weather; ATC acceded to these requests. The Commander can be heard commenting that the Aircraft was in '*icing conditions'*, while the Aircraft's anti-icing systems had already been activated. At approximately 12 NM from touchdown, ATC contact was transferred from the approach controller to the tower controller. At this time, the tower Air Traffic Control Officer (ATCO) transmitted to the crew that the '*surface wind is 270 degrees 20 knots with a recent maximum up to 35 knots, minimum 15 knots, RWY 24, cleared to land*'. After the Crew acknowledged the clearance to land, the ATCO then added '*caution, occasional turbulence,* [in the] *touchdown zone Runway 24*'.

The Radio Altimeter automated voice is heard announcing '*twenty-five hundred*' followed by another transmission by the ATCO, which stated '*surface wind 270 degrees 24 knots, recent max 35 knots*'. A subsequent weather update from the ATCO stated '*surface wind is 270 degrees, 23 knots, recent max 33 knots, minimum 15 knots*'. This was transmitted approximately two minutes before the Aircraft touched down.

The CVR also recorded the Crew performing the landing checklist during which the speedbrake was discussed. As part of this checklist, the PM called out '*speedbrake*' and the Commander responded that this would not be armed '*per MEL*.'

Approximately four seconds after the initial touchdown on both MLGs, the speedbrakes were manually deployed, followed by the PM calling out the status of the speedbrake as being '*up*'.

1.12 Previous Events

There have been several accidents involving the same B767 aircraft type in which similar damage occurred, some of which are listed below (**Table No. 3**):

Location	Date
Cheju Island, South Korea	16 January 1992
Sao Paulo, Brazil	27 October 1992
Warsaw, Poland	31 December 1993
Newark, NJ. USA	22 May 1997
London Heathrow, UK	15 January 1999
Hanoi, Vietnam	19 September 2000
Santa Cruz, Bolivia	07 August 2004
Punta Cana, Dominican Republic	22 May 2005
New York, USA	20 April 2009
Bristol, UK	03 October 2010
Tokyo, Japan	20 June 2012
Portsmouth, NH. USA	27 July 2018
Houston, TX. USA	29 July 2023

Table No. 3: Previous events



Following the accident in Brazil in 1992, the U.S. National Transportation Safety Board (NTSB) convened a special investigation group to review Boeing 767 hard landings and the potential for crown skin distortions. Boeing advised this group that the 767 structure was designed to withstand maximum nose down pitch rates after main wheel touchdown of 8° per second or maximum sink rates of 10 feet per second on all three landing gear. In cases where the main wheels are still airborne after the NLG contacts the runway first, the structure may experience a combination of the two loading components that fall outside the design requirements. The special investigation group noted that the Boeing 767 has sufficient elevator authority to exceed an 8° per second pitch rate at touchdown. The NTSB issued safety recommendations which included, *inter-alia*, amending the content of the manuals available to pilots in relation to de-rotation technique and the potential for excessive pitch rates if pilots use large nose down control column deflections. It was also recommended that training programmes be modified to include discussions about this potential safety risk.

Regarding the first three accidents referred to above, the NTSB stated:

> '*The impact velocity of the nose gear is the sum of the vertical velocity induced by the pitch rate and the vertical velocity at the CG* [Centre of Gravity]*. When the nose gear impacted the runway, the resulting dynamic bending moments in the fuselage induced large compression loads in the forward fuselage crown structure. In addition, the large nose-down control column deflections created static bending moments in the fuselage and compression loads in the forward fuselage crown structure.*
>
> […]
>
> *All three of these accidents involved significant crosswinds. This may have prompted the pilots to aggressively get the nose gear on the runway thinking that it would give them more directional control. According to the published Boeing landing technique, the same procedures "are applicable to all landings, including crosswind landings and slippery runway conditions." In fact, Boeing urges pilots to use rudder deflection to counteract the effects of crosswind until the airplane has slowed below 60 knots.*
>
> *The investigations revealed that there are various opinions on the use of auto spoilers and auto brakes and their impact on derotation accidents. These devices are pertinent to braking efficiency and do affect airplane handling during the flare/touchdown. However, they do not significantly affect angular nose gear sink rate. Therefore, they were not factors in any of these accidents.*'

The event in January 1999 at London's Heathrow was investigated by the Air Accident Investigation Branch (AAIB) of the UK, and the associated AAIB's Bulletin No: 10/99 states:

> '*It is also possible that the accident may not have occurred if the auto spoilers had been armed and prevented the aircraft bouncing on landing; the manufacturer acknowledged, from their simulation work on the aircraft landing that the bounce may not have occurred if the auto spoilers had been used. While accepting that excessive forward control column movement after touchdown is inappropriate, it is difficult to imagine an experienced airline pilot inputting such a movement during a normal touchdown. However, a bounce requires some correction and excessive forward movement of the control column in that situation is more understandable*'.

The event which occurred in Bristol in 2010 was also investigated by the AAIB and the report contained a Safety Recommendation – 2012-016 which recommended that:

> '*Boeing Commercial Airplanes review archived training and safety information, to ensure that relevant safety information is promulgated, and continues to be promulgated, to operators'.*

The AAIB received the following response to Safety Recommendation – 2012-016:

> *'Boeing has reviewed their current guidance relative to hard nose gear touchdowns and determined it still appropriate and relevant. The Boeing training video titled "Airplane Derotation: A Matter of Seconds" serves as a refresher for flight crews and to increase flight crew awareness of the potential for both nose gear and airframe damage as a consequence of over-de-rotation.*
>
> *The nine-minute video was sent to all Boeing airline customers and continues to be available at any time via the Boeing website (My Boeing Fleet) for all operators'.*

Following receipt of Boeing's response, the AAIB classified the status of the Safety Recommendation as '*Rejected – open*'. However, on 30 Sep 2020, the status of this Safety Recommendation was changed to '*CLOSED*'.

1.13 Manufacturers Actions and Safety Video

As a result of the some of the accidents listed in **Section 1.12**, Boeing took a number of safety actions, including:

- Forward Fuselage Structural Strengthening: The upper crown stringers on the forward fuselage of the 767-300 were strengthened in the area where buckling frequently occurred following over de-rotation. The modified design was incorporated into production aircraft from January 1995. The subject aircraft was manufactured in 2002 and consequently it was fitted with the strengthened upper crown stringers.

- Nose Gear Metering Pin: A modified metering pin was introduced into the nose landing gear. The metering pin device controls the flow of hydraulic fluid within the nose gear oleo strut. This involved the metering pin being further optimized to absorb the energy produced during over-de-rotation events, thereby lowering the load on the nose gear by reducing the peak maximum stroke. The modified design was incorporated into production aircraft from August 1994, and was therefore embodied on the accident aircraft, and is also available for retrofit on earlier 767-300s.

- The Aircraft Manufacturer issued Flight Operations Technical Bulletin number 767-47, dated February 1, 1993, addressing the B767 Landing Techniques. The bulletin informed pilots that sufficient elevator authority is available to develop excessive pitch rates if full nose down elevator is used during landing. It also contained the statement: '*Flight crews should be advised that full nose down elevator during landing is not necessary, and if used, may result in structural damage*.'



- On November 8, 1993, the Aircraft Manufacturer made a presentation entitled '*Avoiding Possible Damage on Nose Gear Touchdown*' at a Flight Operations Symposium in Seattle, Washington, USA.

- The NTSB special investigation group (**Section 1.12**) noted that the Aircraft Manufacturer had published an article on this problem entitled '*Avoiding Airplane Damage on Nose Gear Touchdown*' in '*Airliner*' magazine (July – September 1993 Issue).

- In April 2002, '*AERO 18*', the Aircraft Manufacturer's publication, contained a section called '*Flight Operations*' which discussed hard nose gear touchdowns.

- In 2001, the Aircraft Manufacturer's Company Flight Operations Safety office produced a nine-minute video titled '*Airplane derotation: A matter of seconds*' which had a special focus for Pilots on landing technique and stated that:

> '*Over the past few years, incidents of hard nose gear impacts have been increasing. If the impact is excessive, significant structural damage may result. In most incidences the main gear touchdown was relatively normal. The structural damage resulted from high nose down pitch rates generated by the application of full, or near full forward control column during de-rotation. Several factors can contribute to hard nose gear contact. In most cases where damage is sustained one or more of the following factors is present:*
>
> *Moderate to high crosswinds*
> *The approach is not stabilised*
> *Speedbrakes are not armed for landing*
> *There is a bounce after initial main gear touchdown*
> *There is excessive nose down elevator input*

1.14 Operator's Training Information

The Operator informed the Investigation:

> '*Prior to March 2020, our training for advanced crosswind landings and bounced landing recoveries was guided by three primary sources. The foremost reference was the Boeing Flight Crew Training Manual (FTCM)—specifically Chapter 6, currently titled Crosswind Landings, which served as the foundational material for simulator instruction on landings and crosswind techniques. Additionally, we incorporated guidance from our FAA-approved Extended Envelope Training Course, which includes dedicated training on bounced landing recovery and other critical scenarios. The PIC in this case also participated in a specialized training program* [...]. *As part of that program, pilots were required to demonstrate proficiency in crosswind landings in conditions up to 40 knots.*

The Commander stated that during his initial training he was instructed to fly the nosewheel to the ground and that, in keeping with the FCTM, he was always careful not to allow the NLG to '*slam down*'. He did not recall any further information about the potential for damaging NLG impacts during de-rotation being addressed in training. Neither the Commander nor the First Officer was aware of the Airplane de-rotation video (the Operator also informed the Investigation that the video referenced was not used by their training team).

1.15 Crew Duty Times and Limitations

The Flight Crew was operating under the flight and duty limitations as contained in the US Code of Federal Regulations (CFR) '*PART 117—FLIGHT AND DUTY LIMITATIONS AND REST REQUIREMENTS: FLIGHTCREW MEMBERS*'. The Crew consisted of a four-person Flight Crew which is described as an '*augmented crew*'. The scheduled start time of the duty was 19:30 hrs local time, and there were Class 2 rest facilities[19] on board the Aircraft, which meant that the crew could operate for up to a maximum of 15 hrs 30 minutes, when acclimated[20] (**Table No. 4**). In addition to the maximum flight duty period, the Commander and the Operator may extend this limit by up to two hours if unforeseen operational circumstances arise prior to take-off. Prior to departure from KBGR, the Commander and the Operator (in this case the Director of Operations) agreed to extend the flight duty period by one hour and one minute, due to the unforeseen delay in KBGR associated with passenger clearance requirement.

Scheduled time of start (acclimated time)	Maximum flight duty period (hours) based on rest facility and number of pilots					
	Class 1 rest facility		Class 2 rest facility		Class 3 rest facility	
	3 pilots	4 pilots	3 pilots	4 pilots	3 pilots	4 pilots
0000-0559	15	17	14	15.5	13	13.5
0600-0659	16	18.5	15	16.5	14	14.5
0700-1259	17	19	16.5	18	15	15.5
1300-1659	16	18.5	15	16.5	14	14.5
1700-2359	15	17	14	15.5	13	13.5

Table No. 4: Table C to Part 117 of the Flight Duty Period Augmented Operations

[19] **Class 2 Rest Facility**: Means a seat in an aircraft cabin that allows for a flat or near flat sleeping position; is separated from passengers by a minimum of a curtain to provide darkness and some sound mitigation; and is reasonably free from disturbance by passengers or flight crew members.

[20] **Acclimated**: A condition in which a flight crew member's circadian rhythm is aligned with the local time of the current airport, or where a crew member has had at least 36 consecutive hours free from duty.



2. ANALYSIS

2.1 The Approach

The flight was operated with the automatic speedbrake and the left engine thrust reverser inoperative as recorded in the Aircraft Technical Logbook and as permitted in the Operator's MEL. During the approach to EINN, there were gusty wind conditions, which were last reported before touchdown, from 270° at 23 kt with a maximum of 33 kt and a minimum of 15 kt. This resulted in the following approximate headwind and crosswind components (**Table No. 5**). These were within the limits of the Aircraft type.

Wind Direction	Wind Speed		
270°:	23 kt	Max 33 kt	Min 15 kt
Headwind Component:	19 kt	28 kt	13 kt
Crosswind Component:	13 kt	18 kt	8 kt

Table No. 5: Approximate head and crosswind components before landing

The Flight Crew was coming to the end of a long (16 hours and 31 minutes) flight duty period which had been extended beyond the maximum duty period of 15 hours and 30 minutes in accordance with the permitted flight duty period extension procedure and by agreement with the Operator and the Pilot in Command.

The ILS chart for RWY 24 at EINN which the Crew was using, contains a caution relating to potential turbulence and windshear when the wind is coming from a direction of between 260°-320° degrees true and is greater than 15 kt. This may be in part due to the location of a large hangar to the north side of the approach to RWY 24 causing localised turbulence and/or windshear. The effect is sometimes referred to as mechanical turbulence which is more pronounced in wind speeds over 20 kt. This effect could have exacerbated the already gusty conditions.

CVR recordings indicate that the approach and landing checklists were conducted appropriately. During the approach briefing, the Commander stated in relation to the 15 kt caution described on the ILS chart for RWY 24, that '*this is what we have*'. This was likely an acknowledgment that the wind direction would have created turbulence, which he was expecting during this approach and landing. The meteorological aftercast, METAR's and information provided by the tower ATCO to the crew during the approach show that the landing was performed in gusty conditions on a wet night. The presence of turbulence would have made the landing challenging.

2.2 The Touchdown

The recorded data indicates that the Aircraft touched down on both MLGs just prior to 19:55:04. Column relaxation to neutral is typically expected at de-rotation. The application of autobrakes at MLG touchdown would also have contributed to the de-rotation. However, in this case, the control column was pushed to almost -4 degrees which may have been consistent with an attempted input to maintain runway surface contact during the landing.

The auto speedbrakes function was inoperative; therefore, the speedbrakes did not deploy after MLG touchdown. The pitch (de-rotation) rate at this point was recorded as -5.6 degrees per second (nose down). The data indicates that the control column was then pulled to 6.7 degrees (nose up) just prior to NLG touchdown. This was most likely an attempt to arrest the rate of de-rotation. The NLG was recorded as being on the ground approximately 1.5 seconds after both MLGs had touched down, meaning that all three gears were now on the ground. After the initial NLG touchdown, the pitch rate had an increasing trend, i.e. the Aircraft's nose was rebounding into the air, and a full nose-down control column input was then made. This was possibly a reflex response to the pitch rate increasing.

While the control column was still being held in a nose down position, the pitch rate became positive (nose up), and the NLG lifted following its initial contact. This may have been due to the initial NLG contact which occurred at a pitch rate of -5.6 degrees per second, resulting in a rebound effect of the NLG. At this time, the left MLG is recorded as having '*tilt*' which indicated that all four wheels of this bogie were not on the ground. Data indicated that the control column was then pulled to +3 degrees, while at the same time, the pitch rate became negative again with a greater rate of -11.3 degrees per second (this figure was determined by the Aircraft manufacturer using the kinematic consistency algorithm). The NLG is then recorded as being on the ground once again. The NLG touchdown at an -11.3 degrees per second rate of de-rotation resulted in the Aircraft experiencing forces in excess of design limits, resulting in the observed structural damage.

The left MLG is then recorded as being back on the ground, which is followed by another almost full forward nose-down deflection on the control column. However, the data indicates that the pitch rate increased again momentarily as the control column was pulled back, followed by another almost full forward deflection on the control column.

The data indicates that in attempting to correct the Aircraft's pitch attitude, the control column inputs were '*out of phase*' with, or slightly behind the Aircraft's movements. This may have been a result of attempting to ensure that the Aircraft nose was down after an abnormal runway contact, and then over correcting.

2.3 Managing Aircraft Energy

Managing an aircraft's energy is a key aspect of every approach and landing, and automatic spoiler deployment is intended to assist crews with reducing the energy of the aircraft during the landing phase. As the automatic functioning of the speedbrake was inoperative, the speedbrake was required to be deployed manually. This non-normal item was referred to as part of the approach checklist and the Commander gave the correct response when completing this checklist in this circumstance where the auto speedbrake was unavailable.

As described in the FCTM, if spoiler/speedbrake deployment does not happen immediately after main gear touchdown, the effectiveness of the wheel brakes may be reduced by up to 60% as there is very little weight on the wheels. This means that an aircraft's energy is not dissipated as quickly as would normally be expected, and lift is still being generated by the wings.



In this case, the touchdown speed of 150 kt was in excess of the calculated VREF (143 kt). With no speedbrake deployment, significant lift was still being generated, and the aircraft was susceptible to a skip or a bounce (rebound). As discussed in the AAIB Bulletin No: 10/99 regarding an occurrence in London Heathrow in 1999, simulation work performed by the Manufacturer, indicated that an initial bounce in that case may not have occurred if the spoilers/speedbrake had been activated either automatically or manually. The Investigation notes that it is the PM's role to advise the PF as to the status of the speedbrake lever during landing. This was accomplished, however the FCTM states: *If the speedbrakes do not extend automatically move the speedbrake lever to the UP position without delay*.

In this case, the landing would have been challenging due to the gusty conditions and the very dynamic nature of the occurrence; the entire sequence from first touchdown to final touchdown lasting just four seconds. Manual speedbrake deployment did not occur for four to five seconds after initial touchdown, possibly due to startle/surprise.

In normal circumstances, the thrust reversers would be selected immediately after touchdown of the MLG. In this case, the left thrust reverser was known to be inoperative, and the right thrust reverser was not selected until eight seconds after initial MLG touchdown. This delay was likely due to the dynamic touchdown sequence and the potential need to perform a baulked landing. Had the thrust reverser been selected immediately on MLG touchdown, it would have taken several seconds before reverse thrust was effective. The Investigation therefore considers that the delayed thrust reverser application was not a factor in this occurrence.

The Pilot Flying was a recently qualified Commander on type and had been operating in this role for less than four months. The Pilot Monitoring had 72 hours on this Aircraft type. The Investigation notes that both the Pilot Flying and Pilot Monitoring were operating in accordance all applicable CFRs.

The Investigation notes that the Flight Crew operated through the night and were in the 17th hour of their flight duty period at the time of the accident, which included an agreed extension of just over one hour above the maximum permitted flight duty period of 15 hrs and 30 mins.

The Investigation notes previous similar occurrences involving this aircraft type and the actions taken by the Manufacturer to reduce the risk of reoccurrence.

3. CONCLUSIONS

3.1 Findings

1. There were four Flight Crew members on the Flight Deck at the time of the occurrence; their licences and medicals were valid and in date.

2. The Commander, seated in the left seat, was the Pilot Flying at the time of the occurrence.

3. The approach was conducted in turbulent environmental conditions at night and the runway was wet.

4. The Flight Crew carried out a comprehensive approach briefing and demonstrated awareness of the conditions to be expected.

5. The prevailing conditions were within the Operator's crosswind guidelines.

6. The automatic speedbrake deployment function was not available and therefore speedbrakes were not automatically deployed on initial runway contact.

7. The initial touchdown of both MLG was simultaneous.

8. After the initial touchdown of the NLG, the NLG became airborne again followed by the left MLG becoming airborne.

9. Full forward deflection of the control column was applied during the landing.

10. The dynamic landing sequence and the timing of the forward control column inputs resulted in a second NLG touchdown with a de-rotation rate of 11.3 degrees per second.

11. A period of four to five seconds elapsed after the first runway contact before the speedbrakes were manually deployed.

12. The Aircraft experienced forces in excess of design limits and sustained substantial structural damage in the accident.

13. The Aircraft taxied unassisted to its designated stand.

14. Minor injuries were reported by Cabin Crew members which did not require hospitalisation.

3.2 Probable Cause

A nose landing gear contact rate which was in excess of design limits, resulting in substantial structural damage.

3.3 Contributory Cause(s)

1. The Automatic deployment function of the speedbrakes after landing was not available, and speedbrakes were manually deployed four to five seconds after touch down.

2. During the landing, control column inputs forward of neutral contributed to an increased de-rotation rate.

3. The landing was conducted in turbulent environmental conditions at the end of an extended duty period.

4. SAFETY RECOMMENDATIONS

This Report does not sustain any Safety Recommendations.

- END -

In accordance with Annex 13 to the Convention on International Civil Aviation, Regulation (EU) No. 996/2010, and Statutory Instrument No. 460 of 2009, Air Navigation (Notification and Investigation of Accidents, Serious Incidents and Incidents) Regulation, 2009, the sole purpose of this investigation is to prevent aviation accidents and serious incidents. It is not the purpose of any such investigation and the associated investigation report to apportion blame or liability.

A safety recommendation shall in no case create a presumption of blame or liability for an occurrence.

Produced by the Air Accident Investigation Unit

AAIU Reports are available on the Unit website at www.aaiu.ie

An Roinn Iompair
Department of Transport

Air Accident Investigation Unit,
Department of Transport,
Leeson Lane,
Dublin 2,
D02TR60,
Ireland.
Telephone: +353 1 804 1538 (24x7)
Email: info@aaiu.ie
X: @AAIU_Ireland