AIRCRAFT ACCIDENT REPORT 1/91

Air Accidents Investigation Branch

Department of Transport

Report on the accident to British Aerospace ATP, G-OATP at Ronaldsway Airport, Isle of Man on 23 December 1990

This investigation was carried out in accordance with

The Civil Aviation(Investigation of Accidents) (Isle of Man) Regulations 1974.

LONDON: HMSO

First published 1991

ISBN 0 11 551046 X

LIST OF RECENT AIRCRAFT ACCIDENT REPORTS ISSUED BY AIR ACCIDENTS INVESTIGATION BRANCH

4/89	Boeing 747 N605PE at Gatwick Airport on 1 February 1988	August 1989
5/89	Boeing 747-136 G-AWNM on approach to Runway 27L at London (Heathrow) Airport on 11 September 1988	December 1989
6/89	Concorde 102 G-BOAF over the Tasman Sea, about 140 nm east of Sydney, Australia on 12 April 1989	December 1989
1/90	Sikorsky S61N G-BDES in the North Sea, 90 nm north-east of Aberdeen on 10 November 1988	May 1990
2/90	Boeing 747 N739PA at Lockerbie, Dumfriesshire, Scotland on 21 December 1988	September 1990
3/90	Sikorsky S61N G-BEID 29 nm north-east of Sumburgh Shetland Isles on 13 July 1988	September 1990
4/90	Boeing 737 G-OBME near Kegworth, Leicestershire on 8 January 1989	October 1990
5/90	Bell 206 B Jetranger, G-SHBB 2 miles east south east of Biggin Hill Aerodrome, Kent on 18 December 1989	February 1991
1/91	Report on the accident to British Aerospace ATP, G-OATP at Ronaldsway Airport Isle of Man on 23 December 1990	August 1991

These Reports are available from HMSO Bookshops and Accredited Agents

Department of Transport
Air Accidents Investigation Branch
Royal Aerospace Establishment
Farnborough
Hants GU14 6TD

25 July 1991

The Right Honourable Malcolm Rifkind QC
Secretary of State for Transport

Sir,

I have the honour to submit the report by Mr M M Charles, an Inspector of Accidents, on the circumstances of the accident to British Aerospace ATP, registration G-OATP, which occurred at Ronaldsway Airport, Isle of Man on 23 December 1990.

I have the honour to be
Sir
Your obedient servant

K P R SMART
Chief Inspector of Air Accidents

Department of Transport
Air Accidents Investigation Branch
Royal Aerospace Establishment
Farnborough
Hants GU14 6TD

25 July 1991

His Excellency Air Marshal Sir Laurence Jones, K.C.B., A.F.C., C.B.I.M.
The Lieutenant Governor
Isle of Man

Sir,

I have the honour to submit the report by Mr M M Charles, an Inspector of Accidents, on the circumstances of the accident to British Aerospace ATP, registration G-OATP, which occurred at Ronaldsway Airport, Isle of Man on 23 December 1990.

I have the honour to be
Sir
Your obedient servant

K P R SMART
Chief Inspector of Air Accidents

Contents

Contents (cont.)

GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AAIB	-	Air Accidents Investigation Branch
AAR	-	Aircraft Accident Report
agl	-	above ground level
amsl	-	above mean sea level
AOC	-	Air Operator's Certificate
ATC	-	Air Traffic Control
BAe	-	British Aerospace
°C	-	Centigrade (Celsius)
CAA	-	Civil Aviation Authority
CAS	-	calibrated airspeed
CG	-	centre of gravity
CVR	-	cockpit voice recorder
CWP	-	central warning panel
CWS	-	central arning system
DME	-	distance measuring equipment
EFIS	-	electronic flight instrument system
FDR	-	flight data recorder
ft/min	-	feet per minute
g	-	normal acceleration
ILS	-	instrument landing system
kg	-	kilogram(s)
mb	-	millibar(s)
PA	-	passenger address
PAPI	-	precision approach path indicator
PIO	-	pilot induced oscillation
QNH	-	corrected mean sea level pressure
RTF	-	radiotelephony
°(T)	-	degrees True
TAF	-	Terminal Approach Forecast
UTC	-	universal time coordinated
V_{AT}	-	target threshold speed

Air Accidents Investigation Branch

Aircraft Accident Report No: 1/91
(EW/C1187)

Registered Owner and Operator:	Manx Airlines
Aircraft Type:	British Aerospace ATP
Nationality:	British
Registration:	G-OATP
Place Of Accident:	Ronaldsway Airport, Isle of Man Latitude; 54° 05' N Longitude; 004° 38' W
Date and Time:	23 December 1990 at 1804 hrs All times in this report are UTC

Synopsis

The accident was notified to the Air Accidents Investigation Branch at 1813 hrs on 23 December 1990 by air traffic control at Ronaldsway airport. Preliminary enquiries were made and the cockpit voice and flight data recorders were secured that day. The AAIB team comprised Mr M M Charles (Investigator in Charge), Mr P F Sheppard (Flight Recorders), Mr J J Barnett (Operations) and Mr S R Culling (Engineering).

At the conclusion of a scheduled passenger flight from Luton to the Isle of Man, the aircraft landed in a strong cross-wind which was close to the maximum demonstrated for that type. The aircraft touched down firmly in a flat attitude and bounced into the air. During the attempt to complete the landing, a pitch oscillation rapidly developed which resulted in two more bounces, each ending with a nose-first touch-down. On the fourth touch-down, which again was nose-first, the nose landing gear collapsed and the aircraft slid along the runway with the nose landing gear folded aft under the fuselage and debris punctured the fuselage pressure hull. The propeller tips disintegrated on contact with the runway. The aircraft came to rest on grass adjacent to the runway and no one was injured. The airport Fire Service, which had been on standby, arrived at the scene shortly after the aircraft came to rest. The firemen were able to assure the commander that there was no fire or leaking fuel before the passengers were disembarked through the forward passenger door.

The report identified the following causal factors :

(i) The adverse weather conditions which existed at the time of the landing.

(ii) The commander's decision to fly the approach at an airspeed which exceeded that recommended in the Operations Manual.

(iii) The commander's misjudgement of the landing flare and the recovery from the subsequent bounce.

A contributory factor may have been the distraction of a caution warning which occurred immediately before touch-down.

Five Safety Recommendations were made during the course of the investigation.

1 Factual information

1.1 History of the flight

The aircraft was engaged on scheduled passenger flight JE884 from Luton to Ronaldsway and was being operated by the same crew that had earlier flown the largely uneventful schedule from Ronaldsway to Luton. The co-pilot had been the handling pilot on that sector and there were no unserviceabilities or despatch deviations recorded in the aircraft's technical log. However, during the flight the pilots had noticed four or five short-lived audio caution warnings on the central warning panel (CWP) which they identified as "CHECK HEADING" warnings relating to the electronic flight instrument system (EFIS) and caused by a discrepancy between the two heading reference systems. Each warning lasted for about 5 seconds and self-cleared without corrective action.

The aircraft departed Luton airport at 1655 hrs for Ronaldsway with two pilots, two cabin crew and 69 passengers on board. During the cruise at flight level 160, which was uneventful and free of icing, the pilots discussed the weather at Ronaldsway. There the surface wind was forecast to be from 200° at a mean speed of 30 knots with gusts to 45 knots and occasionally 50 knots. These conditions were likely to create low-altitude turbulence on the final approach and a strong cross-wind on the main instrument runway 27. Runway 22 which was almost into wind was unavailable for night landings because new lighting had not been cleared for use. The commander, appreciating that the approach would be uncomfortable for the passengers, briefed them on the aircraft's passenger address (PA) system to expect a bumpy approach.

The commander discussed with the co-pilot his intention to monitor the wind during the approach and to land if the cross-wind component was within the operating company's limit of 34 knots (which was also the maximum demonstrated by the manufacturer for the type). They discussed the alternative options of going around and holding for up to 33 minutes or diverting to Liverpool if the cross-wind was too strong. The commander considered, but did not discuss with the co-pilot, his intention to approach at V_{AT} (target threshold speed) plus 20 knots reducing to V_{AT} plus 10 knots over the threshold.

About 20 minutes before landing the commander contacted Ronaldsway approach and requested an update on the surface wind; he was given 200° at 34 knots with recent recorded maximum and minimum speeds of 44 and 21 knots. Some two minutes later at 1747 hrs the co-pilot also contacted Ronaldsway approach and asked for the latest weather. He was given the 1720 hrs weather report which included a surface wind of 210°/33 kts, visibility 15 km, no weather and no cloud below 1200 feet. The aircraft was handed over by Manchester ATC to Ronaldsway approach at 1752 hrs and given radar vectors for an ILS approach to runway 27. At 1753 hrs an updated weather report was passed which included rain and a lowest cloud base of one okta at 800 feet. The approach continued normally with the commander handling and the autopilot engaged in the approach mode. The crew were warned that the runway was wet and at 1800 hrs they were instructed to contact the the local controller.

The local controller's view of the runway was partially obscured by driving rain on the windows. Because of his impaired vision and the strong cross-wind, in accordance with airport emergency orders he instructed the Fire Service to adopt a 'weather standby'. This entailed the fire crew manning their vehicles with engines running on the apron in front of the Fire Service buildings.

The pilots saw the approach and edge lights for runway 27 at about 4 miles range and noted that the autopilot approach mode was holding the aircraft slightly upwind of the extended centreline. At a height of approximately 500 feet the commander disengaged the autopilot and aligned the aircraft with the runway centreline whilst the co-pilot completed the landing checklist. During the last minute of the approach the local controller transmitted four wind readings: 200°/35; 200°/35; 210°/33 and 200°/35 knots. In the final stage of the approach the commander converted from the wings-level angled-off approach flown by the autopilot to a wing-down with top rudder technique which essentially aligned the fuselage with the runway.

All four members of the crew noticed a marked increase in turbulence during the last 30 seconds of the approach and the commander had difficulty in reading the airspeed scale on his EFIS. He asked the co-pilot "HOW'S THE SPEED" which prompted him to commence calling out the speed by reference to the weight-dependent threshold speed (VAT) of 110 knots. The co-pilot replied "PLUS 12, PLUS 15 PLUS 20 AT THE MOMENT" all within an elapsed time of 5 seconds and ending 3 seconds before touch-down. About one second before touch-down, the CWP audio caution warning sounded but neither pilot looked to see which caption had triggered the warning (which continued throughout the remainder of the landing sequence). The commander initiated the flare at what seemed to him to be a slightly greater than normal height although the co-pilot thought the flare was normal. Initial touch-down was firmer than the commander had intended and the aircraft bounced back into the air. The co-pilot was aware that the aircraft had bounced but the commander perceived only that the aircraft had eased on the main landing gear. He attempted to prevent the aircraft becoming airborne again by applying nose-down elevator but it bounced a second time. At a time between the second and third touch-downs, when both pilots thought that the aircraft was on the ground, the commander handed over control of the ailerons and elevators to the co-pilot whilst he handled the power levers and nosewheel steering. On the third touch-down both pilots believed that the aircraft had settled on to all three wheelsets before they saw the nose rising rapidly. The commander then became concerned at the possibility of becoming airborne again with decaying airspeed and the end of the runway fast approaching. He instructed the co-pilot to "KEEP THE NOSE DOWN" and selected reverse thrust on both power levers. The nose came down rapidly and the sound of disrupting structure was clearly audible to both pilots. From the proximity of the runway to the cockpit, the co-pilot realised that the nose landing gear had collapsed and he immediately informed the commander. Both pilots applied full right rudder to correct a swing to the left and at the same time the commander applied the wheelbrakes. The aircraft decelerated rapidly but the commander was unable to prevent it weathercocking into wind and departing off the left side of the runway. It came to a halt about 10 metres south of the runway edge and some 300 metres before the end. The commander immediately instructed the co-pilot to shut down both engines and summoned the senior cabin attendant to the flight deck. He then ordered the co-pilot to action the fire drill on both engines before informing the passengers that the aircraft had suffered a nose landing gear collapse.

From their standby position about 200 metres from the touch-down zone, the fire crew watched the aircraft approach with its usual complement of external lights. They saw the aircraft touch down in the normal zone and bounce back into the air. The aircraft then porpoised along on the runway and sparks appeared from under its nose. The Fire Section leader appreciated the abnormality of the landing, informed ATC that they were responding and set off to follow the aircraft with the remaining fire vehicles following him. They reached the aircraft less than one minute after it had come to a halt and observed that there were no signs of fire or leaking fuel. Sixty five seconds after the aircraft had stopped, they opened the front passenger door and informed the commander through his open direct vision window that there was no immediate danger. The commander instructed the senior cabin attendant to commence evacuation through the front passenger door only.

1.2 Injuries to persons

Injuries	Crew	Passengers	Other
Fatal	-	-	-
Non-Fatal	-	-	-
None	4	69	-

1.3 Damage to aircraft

The nose landing gear had separated from the aircraft and had become embedded in the underside of the fuselage, which had also suffered minor damage from debris. The propeller tips were abraded by contact with the runway.

1.4 Other damage

There was a long score in the runway surface caused by the nose landing gear which was trapped between the runway surface and the underside of the fuselage. The deeper sections of the score were temporarily repaired by filling with tarmac and the runway was declared fit for use in time for normal airport movements on 24 December.

1.5 Personnel Information

1.5.1	*Commander:*	Male aged 57 years	
	Licence:	Airline Transport Pilot's valid until 30 May 1998	
	Aircraft ratings:	Part 1: BAe ATP, B707-300, SD3-30, Auster Part 2: DC6, L1011	
	Instrument Rating:	Instrument rating valid to 14 March 1991	
	Medical Certificate:	Class One valid to 31 January 1991 with the limitation that the holder shall wear spectacles to correct for near/distant vision.	
	Flying experience:	Total all types:	21,480 hours
		Total on type:	395 hours
		Total last 28 days:	50 hours
		Total last 24 hours:	2 hours 15 minutes
	Last base check:	12 July 1990	
	Last line check:	25 February 1990	
	Last emergencies check:	02 March 1990	
	Previous rest period:	21 hours 15 minutes	
	Duty time:	3 hours 50 minutes	

1.5.2	*Co-pilot:*	Male aged 30 years	
	Licence:	Commercial Pilot's Licence valid to 12 October 1999	
	Aircraft ratings:	Part 1: BAe ATP, SD3-60, PA23/34/44 Part 2: No entries	
	Instrument Rating:	Instrument rating valid to 5 January 1992	
	Medical Certificate:	Class One issued 16 July 1990	
	Flying experience:	Total all types:	1,444 hours
		Total on type:	183 hours
		Total last 28 days:	27 hours
		Total last 24 hours:	4 hours
	Last base check:	5 December 1990	
	Last line check:	8 December 1990	
	Last emergencies check:	6 December 1990	
	Previous rest period:	17 hours	
	Duty time:	3 hours 50 minutes	
1.5.3	*Flight Attendants:*	There were two cabin attendants on the aircraft, both of whom met company proficiency and medical requirements.	

1.6 Aircraft Information

1.6.1 General Data

Aircraft Type:	BAe ATP
Date of Manufacture:	11 February 1988
Constructor's No:	2005
Certificate of Registration:	G-OATP/R2
Certificate of Airworthiness:	SR 2536-2, Transport Category (Passenger) Valid until 20 March 1991

Flying Hours:	3262 hours
Number of landings:	5212
Last Maintenance Check:	'A' check at 3242 hours, on 20 December 1990

1.6.2 *Weights*

Maximum weight authorised:	22,930 kg
Maximum landing weight:	22,250 kg
Actual take-off weight:	21995 kg
Actual landing weight	21302 kg

1.6.3 *Centre of Gravity*

The centre of gravity was at 23% Mean Aerodynamic Chord which was within the permitted operating range yet close to the forward limit for take-off and landing.

1.7 Meteorological Information

1.7.1 *Pre-flight briefing*

The commander obtained a routine briefing prior to departure for Luton from the meteorological briefing officer at Ronaldsway. He was informed of a deep low pressure system near Iceland with a cold unstable south-westerly airstream covering the Isle of Man area. There was also a cold-frontal trough lying north-south over the west coast of Ireland which was moving east at 20 knots and expected to cross the area at 2000 hrs. The 1200 hrs TAF (terminal approach forecast) for Ronaldsway was:

Period (hrs)	*Surface Wind (knots)*	*Visibility (km)*	*Cloud (oktas)*	*Weather*
1300 to 2200	200°/30	over 10	4/1800	Nil
Temporarily 1600 to 2200		5	6CB/1200	Heavy showers and 10% chance of a thunderstorm

1.7.2 *Actual weather conditions for Ronaldsway*

Time (hrs)	*Surface Wind (knots)*	*Visibility (km)*	*Cloud (oktas)*	*Weather*	*Temp (°C)*	*QNH (mb)*
1720	190°/32 max 43 min 20	15	1/1200 7/1800	Nil	+10	1000
1750	190°/32 max 42 min 21	10	1/800 3/1500 8/2000	Rain	+9	1000
1814	190°/31 max 42	6	1/800 5/1000 8/2000	Rain	+9	1000

No thunderstorm activity was reported at Ronaldsway during the above period. Reports of thunderstorms died out as the trough crossed Ireland. It had reached the west coast of Ireland at the time of the accident.

1.7.3 *Meteorological Recordings*

Ronaldsway airfield has a single anemometer mounted on a 10 metre mast near the centre of the airfield; this instrument drives displays in the met office and in ATC. The anemograph recording for the period 1730 to 1830 hrs showed a mean wind direction of 200° with excursions in direction to 165° and 225° (T). The wind speed recording showed occasional gusts to 44 knots and lulls to 20 knots. The anemometer head had been inspected and cleaned earlier on the day of the accident. Post accident calibration revealed no significant directional error and a speed tolerance of ± one knot.

At the time of the accident, the rainfall recorder showed that rain had been falling at a rate between 3 and 4 mm/hr and the barograph showed that surface pressure was steady at 1000.5 mb.

1.8 Aids to Navigation

All the aids to navigation at Ronaldsway airport and within the aircraft were serviceable. The Category 1 ILS/DME guidance to runway 27 was aligned with the runway centreline and the glidepath was set to 3°. The performance of the navigation aids was not a factor in this accident.

1.9 Communications

Radio communications between the aircraft and Ronaldsway ATC were normal and a transcript of recorded radio telephone (RTF) messages was prepared.

1.10 Aerodrome and ground facilities

Ronaldsway airport is located on the south coast of the Isle of Man. The shoreline is generally within 500 metres of the airport's southern perimeter and there are few natural obstacles in the final approach area to impede or re-direct a southerly wind. There are two runways suitable for take-off and landings by the ATP (04/22 and 09/27) plus a third runway (18/36) suitable for taxiing and light aircraft operations only. Runway 27 is level and surfaced with asphalt and concrete; the touch-down elevation is 33 feet amsl and its magnetic heading is 265°. It has a landing distance available of 1631 metres and precision approach path indicators (PAPIs) set to a 3° glidepath. There are high intensity centreline and 2 bar approach lights. The runway is lit with high and low intensity white edge lights and high intensity green threshold lights. There are no centreline lights and no touch-down zone lights.

The alternative runway 22, which was more in line with the prevailing wind, was out of service for night landings because the recently installed PAPIs had yet to be flight checked and pronounced fit for use by the CAA.

There is one passenger terminal. The Fire Service is equipped to category five standards and the staff are equipped and trained to use a transportable inshore rescue boat. The airport has its own Police Service but no ambulance and no bus for transporting passengers.

1.11 Flight recorders

1.11.1 Flight data recorder

The aircraft was equipped with a Plessey PV1584F combined data acquisition and recorder unit. This sampled and recorded a total of 25 parameters plus 5 discretes (on/off positions).

A satisfactory replay was obtained using the AAIB replay facilities. Nominal conversion data as supplied by the manufacturer were used initially to convert the recorded information into engineering units. There were some anomalies in the recorded control position parameters and fixed (datum) errors for these parameters were estimated using a number of the pre-flight "full and free" checks and also the recorded positions during steady level cruise. Corrections for these datum errors were then incorporated into the conversion equations, however there is still a possibility of some residual errors remaining.

There were some areas of "corrupt" data around the touch-down on the accident flight. As these were in a significant area, printouts were made of the raw signal from the tape. These indicated that in these areas the tape had undergone rapid fluctuations in tape speed and the automatic replay system could not keep up with these. This was most likely due to the loading the aircraft was experiencing affecting the tape motion. A manual process was therefore used to decode the binary data in an attempt to recover the corrupt data. It proved possible to recover all of the corrupt data, apart from a quarter of a second near the fourth impact.

When interpreting the quoted recorded values, the resolution (engineering units value equivalent to one bit) of the significant parameters should be borne in mind, and these, together with an estimate of the absolute accuracies, are :-

Elevator angle	0.35°	(absolute accuracy ±1°)
Pitch	0.35°	(absolute accuracy ±1°)
Airspeed	1.0 kt.	(absolute accuracy ±2 kt)
Altitude	0.5 ft.	(absolute accuracy ±20 ft)
Normal Acceleration	0.009 g	(absolute accuracy ±0.05 g)
Heading	0.35° M	(absolute accuracy ±2°)
Engine Torque	0.1 %	(absolute accuracy ±1 %)

1.11.2 *Presentation of the data*

A corrected readout for the period commencing 33 seconds prior to the first touch-down and ending 9 seconds later is shown at Appendix A. The timescale of the print commences at an arbitrary time zero.

Graphical plots of elevator angle versus fuselage pitch angle and engine torque versus airspeed are shown at Appendix B, Figures 1 and 2. The timescale of these graphs has been expanded to show clearly the period of the landing flare and the four touch-downs. The timescale digits of these graphs relates to the timescale digits shown on the main plot at Appendix A.

A numerical printout of FDR data whilst the aircraft was loaded but stationary on the ground at Luton prior to commencing the accident flight, showed a pitch attitude of 1.0° (nose-up) and a normal g of 1.0. Another numerical printout of steady cruising flight showed random differences between the recorded left and right elevator angles of one or 2 data bits equivalent to 0.35° and 0.70°.

Analysis of previous recorded landings showed that the landing at Luton, which preceded the accident landing, to be typical of normal landings in the ATP. Graphs of elevator angle versus fuselage pitch angle and airspeed versus torque for this landing are shown at Appendix B, Figures 3 and 4.

1.11.3 *Cockpit voice recorder*

The aircraft was fitted with a Fairchild A100 cockpit voice recorder. This is the usual 4 track endless loop type of recorder with a duration of 30 minutes. The allocation of the four tracks was as follows:-

Track 1 - Captain's Headset audio and "live" microphone
Track 2 - Cockpit Area Microphone
Track 3 - Cabin address
Track 4 - Co-Pilot's Headset Audio and "live" microphone

A satisfactory replay of all four tracks was obtained using the AAIB's replay equipment. A timed transcript of the final stages of the approach was produced and the CVR information was synchronised with the FDR data by aligning the sounds of touch-downs with the Normal Acceleration data and the radio transmissions from the aircraft with the recorded press-to-transmit actions on the flight deck.

1.11.4 *Interpretation of the data*

Before the events shown at Appendix A, the aircraft had been established on the localiser and glidepath of the ILS approach to runway 27. Four touch-downs are identified by the corresponding normal g peaks which correlate with the CVR sounds between the 33 and 40 second points on the timescale.

The transition from the wings-level approach flown by the autopilot to the wing down with top rudder technique adopted by the commander for landing is shown by the application of significant right rudder between the 17 second and 31 second points. Rudder deflection was reduced to near zero just before the first touch-down. The heading trace shows the aircraft approaching the runway on an initial heading of 250° increasing to 261° at touch-down; the roll angle during this yaw did not exceed 10° and was near zero at touch-down. The derived rate of descent during the 20 seconds prior to first touch-down was fairly steady at 560 ft/min The indicated rate of descent in the last five seconds is unreliable because of the influence of ground effect on static pressure. The fuselage pitch attitude on the first touch-down was 0°.

During the 34 seconds before landing, the airspeed varied between 132 and 114 knots. On the trace there are several rapid changes in airspeed which do not have associated changes in engine torque or rate of descent. Between the 5 second and 27 second points the engine torques remained fairly constant at about 47% on the left engine and 43% on the right. Five seconds before the first touch-down, engine torque started to reduce towards zero. At that time the airspeed was 126 knots and it reduced almost linearly to 114 knots at touch-down. Engine torques reached idle one second after touch-down.

The plot of elevator angle at Appendix A requires explanation. The elevators of the ATP are normally coupled together but can be separated to overcome a control jam. For this reason, the FDR samples the left and right elevator angles separately and alternately at half second intervals. From pre-accident data recorded during the cruise, it was noted that in steady level flight with elevators coupled the right elevator angle was greater than the left by one or two data bits. Because there was no evidence to indicate that the elevators had been separated during the accident, it is assumed that this difference was due to transducer tolerances. Although there may be random differences typically of up to 0.7° between successive left and right elevator angle samples, the effect on the plots in Appendix A and B, is considered to be not significant.

At Appendix B, Figure 3 the plot of elevator angle versus pitch angle for the previous landing at Luton shows a negative pitch angle prior to the nose-up elevator input which initiates the landing flare. The pitch angle on touch-down appears to be greater than +1° and then it reduces to zero or thereabouts as the aircraft decelerates with the nose landing gear on the ground.

1.12 Wreckage and impact information

The nose landing gear had been torn from its mountings and had become embedded in the lower fuselage where it was abraded by the runway during the course of the aircraft's deceleration.

Damage to the nose landing gear is identified in Appendix C and consisted of :

> Fracture and twisting of the shortening mechanism attaching the top of the nose landing gear sliding member to the main fitting crossbeam. This mechanism causes the nose landing gear to shorten during retraction and its failure allowed the sliding member to travel beyond its normal range of operation and to contact the base of the main fitting.

The base of the main fitting carried an impression caused by its contact with the collar attached to the sliding member. It was estimated that a force of approximately 50,000 lbs would be required to form this impression.

Both axle beams had failed in an upwards and rearwards direction with the load applied approximately at 45° to the leg vertical axis. The load necessary to cause both these failures was estimated to be between 45,000 to 60,000 lbf.

The bottom of the sliding tube was abraded at its bottom forward edge. The abraded surface made an angle of 11° with the horizontal.

The right-hand wheel had severe abrasions to the wheel rim and the tyre had been ripped. The left-hand wheel had some damage to its rim, but the tyre was still inflated.

Damage to the rest of the aircraft consisted of:

The right-hand nose landing gear trunnion support had separated from the nosewheel bay bulkhead; the left-hand trunnion support had remained with the airframe, but the bulkhead to which it was attached was severely damaged.

The nosewheel downlock and its support area were severely damaged.

Abrasion and de-lamination was present on the propeller blades due to contact with the runway and the grass area in which the aircraft had come to rest.

The right-hand side of the fuselage pressure skin had been penetrated by a piece of debris.

The nose landing gear was taken to the Dowty Aerospace facility at Gloucester where both axle ends were examined on the day following the accident. Both fracture surfaces were found to be identical and compatible with an overload failure. No pre-existing material defect was found.

Subsequently a strip examination of the nose landing gear, in the presence of AAIB, showed that it had been built to the correct standard and that it had been capable of normal operation up to the time of the incident.

A dynamic analysis of the aircraft's attitude during the landing sequence was carried out by British Aerospace using data obtained from the FDR; this showed that at the last impact with the runway the nose landing gear's vertical velocity had exceeded its design specification. This corroborated the conclusion of the structural assessment that the failure of the nose landing gear and supporting structure was caused by overload.

1.13 Medical and pathological information

Not applicable

1.14 Fire

There was no fire.

1.15 Survival aspects.

The aircraft decelerated rapidly after the nose landing gear collapsed. Although debris from the propeller tips struck the sides of the fuselage and penetrated the outer skin, none penetrated the passenger cabin. The cabin had been secured in anticipation of a turbulent arrival and no loose objects or personal items were seen to move around or break free from their stowages. After the engines had been shut down, the main cabin lights, which had been switched off for landing, were turned on by the No 2 cabin attendant from her position adjacent to the flight deck. The No 1 cabin attendant, who had been strapped into her seat at the rear of the aircraft, had no difficulty in negotiating the length of the cabin which sloped down towards the flight deck. Whilst she was being briefed by the commander, the firemen opened the front passenger door and announced that there was no fire or leaking fuel. The front passenger door escape slide was automatically disarmed by the action of opening the door from the outside and the door sill was between one and three feet above the ground. The commander then instructed the No 1 cabin attendant to evacuate the aircraft using the front door only. She returned to the cabin where the No 2 attendant was re-assuring the passengers of their safety and together they persuaded them to leave the aircraft without their personal belongings. There was no panic and the passengers were helped to the ground by two firemen. They were escorted away from the aircraft and took shelter from the wind and rain in the lee of fire engines. All the crew members remained on the aircraft until all the passengers had disembarked. The passengers and crew were conveyed to the terminal in small groups by fire vehicles and by taxis which had been diverted from outside the terminal.

In ATC the local controller had instigated a ground incident response at 1806 hrs which he upgraded to an aircraft accident at 1808 hrs. Elements of the Island's emergency services were alerted by various measures. Police from Castletown and fire appliances from Douglas and Castletown responded; the first appliances arrived at the airport at 1812 hrs. At 1810 hrs the Island's ambulance service was notified of the emergency and medical teams and ambulance crews were called out under the "Scheme for Medical and Ambulance Services in the event of Aircraft Accidents" dated October 1981. Three ambulances out of a total of eight available were despatched towards the airport but none arrived. They were stood down at

1820 hrs by a message from the police to ambulance control stating that there were no casualties.

On-duty customer services staff and senior off-duty members of Manx Airlines, who had been summoned to the airport under a company contingency plan, supervised the general welfare of the passengers within a discrete area of the terminal where it was established that no one required medical attention.

1.16 Tests and Research

None.

1.17 Additional information

1.17.1 Control surface deflections

Maximum control surface deflections are:

Elevators	22° trailing edge up	(nose-up command)
	12.5° trailing edge down	(nose-down command)
Ailerons	20° either side of neutral	
Rudder	20° either side of neutral	

1.17.2 Central warning system

The central warning system (CWS) accepts failure signals from various essential aircraft systems and displays these warnings via illuminating indicators on the central warning panel (CWP) located above the pilots coaming. Associated with the CWP indicators are two flashing 'attention-getters', one forward of each pilot mounted on the coaming, and an audible two-tone warning device. The CWP warnings are colour coded; red for failure of systems which require immediate action by the pilots to rectify or shut down the faulty system, and amber for failures of systems which require pilot action when convenient. Each CWP warning, allocated to a system, bears a legend denoting the system to which it is dedicated. When the CWP receives a failure signal the relevant indicator is illuminated, the 'attention-getters' flash and the audible warning sounds. Depressing either of the 'attention-getters' cancels the audible warning and stops the 'attention-getters' flashing. The CWP warning remains illuminated until the fault is cleared or the system is inhibited.

There are 28 amber warnings, each of which can trigger the audio caution warning. Of these, five are directly associated with the control, performance and lubrication of each motive power unit and a further three are associated with the electrical power generated by each engine. Two relate to the EFIS displays for each pilot The remaining captions are:

ECS	Environmental control system fault
GPWS	Ground proximity warning system fault
AVIONICS COOLING	Fault within the avionics cooling system
SMOKE	Smoke detected within the toilet compartment
FLAPS	Flap asymmetry
BRAKES LO PRESS	Low hydraulic pressure in either sub-system
DE ICING	Failure of the engine or airframe de-icing systems
STANDBY CONTROLS	One or more of the flying control circuits operating in a reversionary mode
HYD OVERHEAT	Excessive temperature of the hydraulic fluid
HYD LO LEVEL	Low hydraulic fluid level

1.17.3 *Approach speed calculations*

The normal V_{AT} for the all-up-weight and configuration at the time of the accident was 110 knots. The Operations Manual recommended a final approach speed, with 22° flap, of 120 knots reducing to V_{AT}+10 knots at decision height. However, a proviso to this recommendation permitted pilots to fly at a faster speed provided that V_{AT}+10 to 15 knots was achieved by decision height (approximately 200 ft agl). In conditions of turbulence, the manual recommended pilots to add to V_{AT} one third of the wind speed, if it exceeded 10 knots, up to a maximum of 15 knots, and to achieve this amended speed over the threshold.

1.17.4 *Cross-wind limits*

During 1990 a British Aerospace test pilot demonstrated take-off and landing in cross-winds of 36 and 34 knots respectively. This achievement was notified to ATP operators in the UK by an amendment to Flight Manual 001. Acting on this amendment, on 15 Aug 90 Manx Airlines amended the take off and landing cross-wind limits contained in their fleet instructions. The combined take-off and landing limit of 30 knots was raised to 36 knots for take-off and 34 knots for landing. No guidance was given within the amended instruction regarding an allowance for gusts when determining whether the cross-wind was within limits. However, another Manx fleet instruction regarding operations in high wind conditions stated "pilots will take the whole gust factor into consideration when making their calculations. ie They will not 'factor' the gust factor". This instruction did not define the gust factor.

The Operations Manual stated that "The aircraft may be flown in cross-wind conditions using the 'wing-down' technique, the 'kick-off drift' technique or a combination of the two. The approach should be made with the aircraft lined up with the extended centre line, using normal speeds plus any allowance for turbulence. Towards the end of the flare, with the Power Levers at FLIGHT IDLE, apply the required aileron to prevent a wing lifting as the aircraft touches down. After the main wheels have touched the runway lower the nosewheel to the ground as soon as possible and as the speed decreases gradually centralise the ailerons, maintaining directional control and braking as for a normal landing".

1.17.5 Conversion training

The Manx Airlines conversion syllabus for the ATP did not include simulator flying. All flight training for the pilots had been undertaken on an aircraft because there was no ATP simulator in commission at the time of the pilots' type conversion.

1.17.6 Comparable accidents

The accident to Grumman Gulfstream, G-BMOW at Birmingham on 29 January 1990 showed some similarities with the accident to G-OATP in that this aircraft also porpoised on landing for several cycles before the nose landing gear collapsed. G-BMOW was reported in AAIB Bulletin 4/90 and an extract of the FDR recording of this accident is shown at Appendix D.

2 Analysis

2.1 Weather assessment.

The pilots were well aware of the likelihood of limiting weather conditions for the landing at Ronaldsway and they had discussed the options open to them if the cross-wind exceeded the company's landing limit of 34 knots. The commander had obtained the Ronaldsway TAF and made frequent checks of the surface wind there during the latter stages of the flight. The TAF indicated a likely cross-wind component of 25 knots. Both the 1720 and 1750 hrs observations gave the wind as 190°T at 32 knots with gusts to 43 knots. Based on these observations the mean cross-wind component on landing was likely to be 30 knots and the cross-wind would not exceed the limit except in a gust of 38 knots or more. During the final minute of the approach, the reported wind direction varied between 200° and 210° magnetic and the speed varied between 33 and 35 knots. Taking the worst combinations of speed and direction, the strongest cross-wind component was likely to be 29 knots and the weakest head wind component 14 knots. The scheduled landing distance required was 1140 metres and the landing distance available was 1631 metres. The landing could therefore be made within the cross-wind limits and within the landing distance available.

2.2 The approach plan

The commander's decision to use 22° flap and the 'wing-down with top rudder' technique for landing was in accordance with the company's Operations Manual which permitted him to use either this technique, or the 'kick-off drift' technique, or a combination of both techniques.

Based on the instructions and recommendations in the Operations Manual (see paragraph 1.17.3), a final approach speed of 122 knots (ie V_{AT}+12 knots) down to the threshold would have been appropriate. The commander's decision to fly the approach at V_{AT}+20 (130 knots) tapering to V_{AT}+10 over the threshold required an unnecessary speed change, power reduction and trim change during the last part of the approach.

2.3 The approach speed

Turbulence on the final approach is evident from the perceptions of all four crew members, from the normal g trace and from erratic speed fluctuations in the 15 seconds prior to touch-down whilst the power and rate of descent remained essentially constant. In these conditions, the commander had to estimate the mean speed and make compensatory power changes accordingly. The rate of undemanded speed changes was such that he had no option but to rely on the addition to V_{AT} for short-term protection against gusts, and to allow time for any power changes to show their effect. The mean speed in the period from 20 secs to 5 secs prior to touch-down, when the power remained constant, was 127 knots which was 5 knots greater than the threshold speed of 122 knots recommended in the Operations Manual.

Although the commander had difficulty in reading the EFIS speed during the final few seconds of the approach, he had not apparently experienced any prior difficulty. The co-pilot also found the EFIS speed abnormally difficult to read because both the speed tape and the speed trend symbology were oscillating. However, the co-pilot's speed calls concur with the speeds shown on the FDR trace and his calls were prompt. Therefore he must have been able to read the EFIS speed accurately even though it was abnormally difficult to do so. The commander's difficulty was probably more indicative of his overall workload rather than a deficiency of the EFIS display.

2.4 The CWP audio warning

It is reasonable and proper that both pilots ignored the CWP audio caution warning which sounded one second before touch-down.. Whichever caption triggered the warning, it was one of the group which, according to the Operations Manual, "requires pilot action when convenient". One second before touch-down was not a convenient time to address a minor malfunction. It is possible that the warning may have been caused by a propeller or engine malfunction which occurred as power was reduced and the propeller blades fined off. However, it was not of sufficient importance to produce any abnormality on the FDR record of engine parameters and there is no indication of any abrupt yaw or pitch change on the traces which might accompany a single propeller malfunction. Because the crew had earlier experienced several short-lived warnings due to EFIS heading monitor trips, the caution warning may well have been caused by another monitor trip. However, unlike the previous monitor trips, the warning did not self-cancel within five seconds and, therefore, this cause seems no more probable than an engine defect. Analysis of the probability of any of the other 16 non engine-related CWP warnings occurring is outside the scope of this report. Although the cause of the caution warning cannot be determined, because the pilots ignored it and there is no corresponding symptom of malfunction on the FDR trace, it is unlikely that the condition which caused the warning affected the control of the aircraft, however it could have provided the crew with a momentary distraction.

2.5 The flare

During the co-pilot's sequence of speed readings, the commander closed the throttles. Since he reduced power some five seconds before touch-down, the speed decay of two knots per second before touch-down is indicative of either airframe and propeller drag, or a reduction in the head wind component, or a combination of both factors. The graph at Appendix B, Figure 4 depicting the speed versus torque history of the previous landing at Luton shows that a reduction of speed of two knots per second is normal when torque is reduced for landing. Similar analysis of two other landings recorded on the FDR reinforced this finding. Therefore, it is unlikely that windshear or a sudden reduction in wind speed occurred during the last five seconds before touch-down.

The plot of elevator angle versus pitch angle at Appendix B, Figure 3 shows a negative pitch angle prior to the nose-up elevator input which initiated the landing flare during the previous landing at Luton. It is evident from the graph that a nose-up elevator input of some 8° to 10° in one second during the landing flare does not induce an immediate and corresponding nose-up pitch response. The pitch-up occurs about one second later at a rate of between one and two degrees per second. Analysis of two other landings recorded on the FDR confirmed this characteristic.

The heading and roll angle of the aircraft at the first touch-down of the accident sequence indicate that the commander had aligned the aircraft within 4° of the runway heading, with negligible rudder applied, wings level and appreciable 'into wind' aileron. It appears, therefore, that he had used a combination of both cross-wind correction techniques and that he had aligned the aircraft in roll and yaw sufficiently accurately to execute a safe landing.

2.6 The first touch-down

The initial touch-down was unintentionally firm and in a flat or possibly nosewheel first attitude. There are considered to be a number of reasons for this. Firstly, closure of the throttles induced a nose-down trim change and, although the commander applied nose-up elevator as he closed the throttles, he did not maintain the control input, possibly because he believed that he had flared slightly too early. Secondly, the speed loss of 10 knots in 5 seconds would have produced an additional nose-down trim change which was not countered by a pitch trim input; consequently, part of any nose-up elevator applied just before touch-down would have been expended in countering the trim change. Thirdly, with the pitch attitude remaining at or about zero, the rate of descent was likely to increase above the previously steady value. Fourthly, given the pitch response time of the ATP (discussed in paragraph 2.5), the nose-up control input made two seconds before touch-down was too late to have the desired effect.

A contributory factor to the commander's misjudgement of the flare may have been the distraction of the caution warning even though he did not divert his attention to the CWP when the audio warning sounded.

2.7 The landing roll

On touch-down the pitch attitude was rapidly driven nose-up by contact with the runway. The commander, believing that the aircraft had 'lifted a bit on the gear' applied nose-down elevator to keep it on the ground and the FDR trace shows perturbations typical of a bounce into the air. The co-pilot was in no doubt that the aircraft had bounced, although he did not say so at the time. The nose-down control input resulted in a second nose-first touch-down which the commander instinctively tried to correct. Unfortunately, the time delay between the commander's perception of the need for a corrective input and the input having the desired effect, was such that the elevator angle rapidly became out of phase with the pitch angle. This phase lag was typical of a pilot induced oscillation (PIO).

A PIO usually occurs when the aircraft fails to respond to a control input as quickly as the pilot expects and the pilot is therefore induced to make a greater control input than was necessary to produce the intended attitude change. He then encounters the same problem in correcting the larger than intended attitude change and produces a series of cycles of over-control known as PIO. In a PIO, unless the pilot lets go of the control or holds it in one position, the oscillation will continue until some other factor terminates it because the pilot himself drives the oscillation by his attempts to stop it.

The oscillation continued for three cycles and became divergent. From the CVR data, eyewitness evidence and the normal g maxima and minima it is evident that the aircraft touched down during each cycle and that the aircraft was airborne at some time during each cycle. The pitch attitude on the second and subsequent touch-downs was less than -2° and therefore each was nosewheels first. On the fourth nosewheel impact the axles failed and the leg collapsed.

It is unlikely that many pilots would recognise and be able to control a PIO unless they had previous experience of the phenomenon or had been trained to recognise and recover from it. Neither of G-OATP's pilots had previously experienced a PIO and there was no mention of bounced landing recovery techniques in the ATP conversion syllabus or the pilots' training records. It may, however, be argued that the omission is reasonable since recovery from a bounced landing is taught during basic flying training and the topic would have been covered verbally during conversion training if a bounced landing had occurred.

2.8 Operational decisions

The commander's decision to continue with the landing after the first touch-down was reasonable since, although it was abnormally firm, touch-down occurred within the normal touch-down zone, there was ample runway remaining for a normal deceleration and he perceived only that the aircraft had eased on its landing gear although it was evident to the co-pilot that it had bounced back into the air. However, instead of stabilising the pitch attitude and allowing the aircraft to settle on the runway, the commander applied a sizeable nose-down control input which resulted in a second touch-down which was nose-first. After the second touch-down, at a moment when both pilots perceived that the aircraft was in contact with the runway, he handed control of the control column to the co-pilot.

The handover was premature because the aircraft was pitching nose-up and the commander had not established the aircraft in a stable decelerative attitude with all three wheelsets in firm and continuous contact with the runway. The premature handover created two difficulties. Firstly, with wings level and the fuselage aligned with the runway, yet without firm ground contact, the aircraft was bound to drift to the right in the strong cross-wind. Secondly, the act of handing over the main flight controls to the co-pilot effectively deprived the commander of any safe go-around option. Until the handover, airspeed was close to VAT, there was ample runway ahead of the aircraft in which to accelerate and the power levers were still in the normal flight range, albeit at idle power. His reason for handing over control was his desire to use his left hand for nosewheel steering (which is not connected to the rudder pedals) because he foresaw the likelihood of running off the side of the runway in the strong cross-wind, and his right hand for reverse thrust because he foresaw the likelihood of running off the end of the runway unless he reduced speed rapidly. Neither of these problems would have arisen if the commander had initiated a go-around after the second bounce. However, there is no reason to believe that the act of handing over control made the PIO any better or worse.

The commander's instruction to the co-pilot to "keep the nose down" was understandable given that he believed the mainwheels were in contact with the runway. However, at about the same time, he selected reverse thrust. The combination of the co-pilot's nose-down control input and the onset of reverse thrust drove the nose landing gear onto the runway with sufficient energy to cause it and its supporting structure to fail in overload.

2.9 Cross-wind limit philosophy

Whilst the accident cannot be directly attributed to the very strong cross-wind, there can be little doubt that it was the main factor which distinguished this approach from other routine night approaches. The ATP manufacturer had demonstrated that the aircraft could be landed safely in a cross-wind of 34 knots and had, quite properly, disseminated this fact to ATP operators. But this demonstration should have been taken in context by individual operators when setting their company cross-wind limits. The demonstration may well have been performed by experienced test pilots flying by daylight in otherwise favourable conditions. It would be prudent, therefore, for airline operators to bear in mind that their cross-wind limits should be appropriate to line pilots operating in less favourable conditions such as a full passenger load, limiting CG, rain, darkness and the airfield in use at the time. Moreover, lucid guidance regarding how to take account of gusts above the mean wind speed when calculating the potential cross-wind component should be included within the section of the Operations Manual or fleet instructions which addresses cross-wind limits. It is recommended, therefore, that the CAA Flight Operations Directorate should review AOC holders' cross-wind limits to ensure that those limits are appropriate for line operations and include clear instructions on allowance for gusts in excess of mean wind speed.

2.10 Comparable accidents

The graph of the FDR data for the accident to the Gulfstream 1 G-BMOW shown at Appendix D reveals similar divergent pitch and normal g oscillations to that depicted at Appendix B for G-OATP.

In both accidents the aircraft were approaching in strong gusty cross-wind conditions at speeds well in excess of V_{AT}. The aircraft touched down firmly in a flat or nosewheel first attitude and then bounced back into the air. Both aircraft survived the first touch-down intact but their nose landing gears failed after a short period of porpoising which eventually resulted in overloading the nose landing gear. The porpoising shows clear evidence of divergent oscillation in the pitch and normal g traces caused by attempts to complete a landing after a significant bounce.

The tendency to overcontrol in these circumstances may well be affected by the change in airflow over the empennage when power is reduced to idle prior to landing. The reduction in propeller slipstream alters the pitch trim, pitch damping and elevator response of the aircraft. Furthermore, unlike most jet transport aircraft, most turboprop aircraft have unswept wings and no spoilers to reduce wing lift on touch-down. Lacking these features, turboprop aircraft are more likely than jet powered aircraft to touch down nosewheel first and bounce back into the air after a fast, firm touch-down. It would be prudent for pilots converting from jet transport aircraft to turboprop aircraft to be given additional training on bounced landing recovery technique.

It is recommended that the CAA take appropriate measures to remind pilots of turboprop aircraft of the danger of inducing porpoising (PIO) by applying elevator to correct a landing bounce.

2.11 Evacuation

The aircraft decelerated rapidly under the influence of wheelbrakes, reverse thrust and abrasion forces. As it came to rest, the commander instructed the co-pilot to shut down both engines. Without delay he then summoned the senior cabin attendant to the flight deck and instructed the co-pilot to action the fire drill on both engines.

The senior cabin attendant, who was seated at the rear of the aircraft for landing, had to negotiate the length of the passenger cabin to reach the flight deck. She was present when the commander was told by the firemen that there was no fire or leaking fuel. The commander's decision to evacuate using only the front passenger door was not in accordance with the Operations Manual which states that all three escape exits should be used. However, in executing his responsibility to ensure the safety of his passengers in an emergency, a commander may have to evaluate relative risks. The risk to passengers of evacuating through the front door, which was close to the ground and where firemen were available to assist them, was lower than the risk of evacuating from the rear slides which, because of the nose-down attitude, would have been steeply angled. Moreover, there was no reason to suppose that the aircraft was in imminent danger of catching fire but, if it did, the fire crew were ready to deal with it and the passengers would be exiting through the door which was furthest upwind. Therefore, the extra time required to evacuate all the passengers though one door instead of three doors was a reasonable trade-off for the reduced probability of evacuation injuries.

However, the senior cabin attendant's seating position for landing at the rear of the aircraft was not ideal. Had the centre aisle been obstructed by passengers or debris, she could have found it impossible to reach the flight deck. Moreover, if the front door had jammed or had there been a fire in the nose landing gear area, both cabin attendants could have been at the opposite end of the cabin to the two remaining escape slides. Therefore, it is recommended that the senior cabin attendant should sit in the attendant's seat closest to the flight deck.

2.12 Airport emergency and medical cover

Transporting 73 people by taxi and fire vehicles from the aircraft to the terminal was bound to be a slow process. Passengers leaving their coats on the aircraft as instructed would have been cold and wet by the time they reached the terminal. As an ad-hoc substitute for a bus, the method was safe but dependent largely on the availability of taxis. Taxis were a resource over which the airport had little or no control both in terms of availability and manoeuvre. The method of transporting the passengers and crew from the accident site to the terminal was unsatisfactory. It is recommended that Ronaldsway airport be provided with a dedicated passenger bus or buses.

The airport at Ronaldsway regularly handles ATP aircraft which can carry 72 passengers and 4 crew and also BAe 146 aircraft which can carry 90 or more. Although nobody was hurt in this accident there could have been a large number of casualties. The airport no longer has its own ambulance and the Island Health Authority's response of sending three ambulances to what was notified as a major aircraft accident was inadequate since three vehicles could not have coped with more than a few stretcher cases. Moreover, it is doubtful whether all the regular ambulances on the Island would have been sufficient if the majority of survivors from a serious airline accident were stretcher cases. The resource constraints of crews and ambulances on the Island are acknowledged but contingency plans to cope with large numbers of casualties should be available and be practicable. It is recommended that contingency plans for casualty handling at Ronaldsway airport be reviewed.

3 Conclusions

(a) Findings

(i) The crew were properly licensed, rested and medically fit to conduct the flight.

(ii) The aircraft was correctly loaded and its documentation was in order.

(iii) With the exception of nuisance CWS warnings, there were no significant defects in the aircraft.

(iv) The attempt to land was made in difficult conditions of darkness, rain and a strong gusty cross-wind.

(v) The cross-wind component on touch-down was within the limit set by the operator.

(vi) The approach was flown at a speed which exceeded the speed recommended by the operator.

(vii) The event which triggered a CWS caution warning just before touch-down probably did not contribute to the accident.

(viii) The landing flare manoeuvre was misjudged in that the aircraft touched down more firmly than intended and in a flat or possibly nosewheel first pitch attitude.

(ix) The pilot's pitch control inputs following the first touch-down resulted in a divergent pitch oscillation which eventually subjected the nose landing gear to forces in excess of design maximum.

(x) The location of the senior cabin attendant for landing was unsatisfactory.

(xi) The evacuation of the aircraft was sensibly executed.

(xii) The passenger transport facilities available at Ronaldsway airfield were inadequate.

(xiii) Medical contingency plans for coping with a major aircraft accident at Ronaldsway airport were inadequate.

(b) Cause

The following causal factors were identified :

(i) The adverse weather conditions which existed at the time of the landing.

(ii) The commander's decision to fly the approach at an airspeed which exceeded that recommended in the Operations Manual.

(iii) The commander's misjudgement of the landing flare and the recovery from the subsequent bounce.

A contributory factor may have been the distraction of a caution warning which occurred immediately before touch-down.

4 Safety Recommendations

The following Safety Recommendations were made during the course of the investigation:

4.1 That the CAA should review AOC holders' cross-wind limits to ensure that those limits are appropriate for line operations and include clear instructions on allowance for gusts in excess of mean wind speed.

4.2 That the CAA take appropriate measures to remind pilots of turbo-prop aircraft of the danger of inducing porpoising by applying elevator to correct a landing bounce.

4.3 That the senior cabin attendant should sit in the attendant's seat closest to the flight deck.

4.4 That the Isle of Man Authorities should provide Ronaldsway airport with a dedicated passenger bus or buses.

4.5 That the Isle of Man Authorities should review the contingency plans for casualty handling at Ronaldsway airport.

M M Charles
Inspector of Accidents
Air Accidents Investigation Branch
Department of Transport

June 1991

The CAA's response to these Safety Recommendations is published in CAA Follow-up Action on Accident Reports No F1/91.