FINAL REPORT

AAIU Synoptic Report No: 2005-013
AAIU File No: 2004/0066
Published: 20/06/05

In accordance with the provisions of SI 205 of 1997, the Chief Inspector of Accidents, on 15 December 2004, appointed Jurgen Whyte as the Investigator-in-Charge to carry out a Field Investigation into this occurrence and prepare a Synoptic Report.

Aircraft Type and Registration:	ATR 72 – 202, EI-RED
No. and Type of Engines:	2 x Pratt and Whitney PW 124B
Aircraft Serial Number:	373
Year of Manufacture:	1994
Date and Time (UTC):	15 December 2004 @ 10.47 hrs
Location:	Eastern end of Runway (RWY) 26 Galway Airport (EICM)
Type of Flight:	Scheduled Public Transport
Persons on Board:	Crew - 4 Passengers - 31 + 1 Child
Injuries:	Crew - Nil Passengers - Nil
Nature of Damage:	Nil
Commander's Licence:	Irish ATPL issued by the IAA
Commander's Details:	Male, aged 64 years
Commander's Flying Experience:	Approximately 21,000 hours, of which 3,000 were on type
Information Source:	The Operator, AAIU Incident Report Form submitted by Captain, Field Investigation.

SYNOPSIS

While carrying out a 180º turn (prior to take-off) at the eastern end of RWY 26 at Galway Airport, the nose landing gear (NLG) and the left-hand main landing gear (LH MLG) departed the paved surface, and the aircraft became embedded in soft grassy ground. There were no reported injuries or damage to the aircraft.

FINAL REPORT

1. FACTUAL INFORMATION

1.1 History of the Flight

The aircraft was due to depart Galway Airport at 10.40 hrs on a scheduled public transport flight to Luton Airport, London (EGGW). The weather conditions at 10.15 hrs were; wind 190º/3 kts, visibility 10 km CAVOK[1], with the runway reported as DAMP[2]. The Captain, who was seated in the left hand seat, was the designated pilot flying (PF).

EI-RED exited the ramp through Taxiway Bravo and backtracked along the centreline of RWY 26 towards the displaced threshold[3]. On reaching the displaced threshold, the aircraft commenced a reversal of direction within the area between the displaced threshold and the end of the runway, by initially turning left off the centreline and then right. The turn was normal until approximately through 90º (right) when it was noticed by the PF that the turn was somewhat wide, but not excessively so. The turn was continued. Neither flight crew member was aware of a pavement excursion until it was felt that the aircraft was not turning normally, followed quickly by the LH MLG leaving the runway. The aircraft was immediately stopped and Air Traffic Control (ATC) was advised. The No. 1 engine was shut down, while the No. 2 engine was left in HOTEL mode (engine running with prop brake engaged). The Captain made a public address (PA) advising the passengers that the aircraft had left the runway and was stuck in situ. The passengers and crew made a normal exit from the rear port door and were ferried back to the terminal building. The Captain reported that the passenger's reaction was calm and that no injuries or trauma occurred. In addition, the Captain did not report any skidding or slipping, while performing the turn manoeuvre.

[1] CAVOK is a term used when the following conditions occur simultaneously at the time of observation: Visibility, 10 km or more, no cloud below 5,000 ft, no weather of significance to aviation.
[2] A runway surface is described as DAMP when the surface shows a change of colour due moisture
[3] The threshold is considered the beginning of that portion of the runway useable for landing and is normally located at the extremity of a runway. However, in some cases, due to local considerations, it may be required to displace the threshold down the runway for a distance necessary to provide that the approach surface is cleared of obstacles

An inspection of the site determined that, as the aircraft's turn progressed through approximately 90º (facing south), the NLG departed the paved surface. As the turn continued west, the NLG tracked along the grass close to the runway edge. The LH MLG then left the paved surface by 0.5 of a metre (m) and continued for approximately 3m until the aircraft was stopped. No damage was caused to the aircraft or the undercarriage. Some wheel rutting damage was cause to the ground adjacent to the runway edge.

1.2 Aerodrome Reference Code

Galway Airport is categorized (under provisions laid down by International Civil Aviation Organisation (ICAO)) with an Aerodrome Reference Code 2 C. The intent of the Reference Code is to provide a simple method for interrelating the numerous specifications concerning the characteristics of aerodromes so as to provide a series of aerodrome facilities that are suitable for the aircraft that are intended to operate at the aerodrome. This Code is not intended to be used for determining runway length or pavement strength requirements. The Code is composed of two elements, which are related to the aircraft performance characteristics and dimensions. Element (1) is a number based on the aircraft reference field length and Element (2) is a letter based on the aircraft wingspan and the outer main gear wheel span. The Code letter or number within an element selected for design purposes is related to the critical aircraft characteristics for which the facility is provided. With specific regard to Galway Airport, the Code 2 C classification equates as follows:

Code 2 (Aerodrome reference field length) is 800m up to but not including 1,200m

Code C (Wing span) 24m up to but not including 36m and (Outer main gear wheel span) 6m up to but not including 9m.

1.3 Runway Physical Characteristics

The runway at Galway measures 1,296m in length and 30m in width. The surface is made of Bitumen/Macadam. The runway incorporates a displaced threshold and a Stop way/Clear way at either end. The displaced threshold RWY 26 measures 90m, while RWY 08 measures 60m. Neither runway end features a turn pad (See Section 1.5).

Within recent months, a significant amount of work was carried out on the runway and its confines, including among other things, re-surfacing of the runway, new pavement and runway markings, new runway and approach lighting and security fencing.

1.4 Runway Surface Condition

Following the re-surfacing of the runway, the Operator reported to the Airport Operator, that they found the runway to be "slippery when wet".

A runway friction survey was carried out (November 2004) and this determined that at speeds of 65 km/hr and 95 km/hr, the overall average grip number (GN) for each survey run of the re-surfaced runway was above the design objective for a new surface, as specified by ICAO in Annex 14 Aerodromes Volume 1 Aerodrome Design and Operations. It was observed however that the painted runway markings tended to be slippery when wet. A previous investigation (AAIU Report No. 2001-013) into the runway excursion of a B767 at Shannon Airport determined that certain painted runway markings become slippery when wet.

Para 2.9.5 of Annex 14 requires that, *"Information that a runway or portion thereof may be slippery when wet shall be made available"*.

Prior to this particular event, the Airport Operator, set in place a procedure whereby, when the runway was classified as WET[4], the report to aircraft would include a comment that the runway markings maybe slippery. The Operator reduced its crosswind limits by 5 kts when the runway was reported as WET.

As part of the overall runway improvement scheme, it was intended to groove the runway from displaced threshold to displaced threshold, including the painted runway markings, in order to further enhance the runway friction characteristics. Since the runway has been grooved (post this event) the Operator has reported no friction problems with the runway.

It must be noted that the area between displaced threshold and the extremity of the runway has not been grooved nor is it required to be. In addition, this area is free of painted runway makings, except for a centreline arrow on the portion of the runway before the displaced threshold.

1.5 Aircraft Characteristics

1.5.1 General

The ATR 72-200 is a twin-engined turboprop aircraft with a high wing, a T-type tail, with a pannier mounted main landing gear. It has a wingspan of 27.05m, a wheelbase (distance from NLG to the geometric centre of the MLG) of 10.77m and a MLG wheel span of 4.1m. The MLG is not visible from the cockpit.

1.5.2 Turning Radius

Chapter 4 of the ATR 72 Flight Crew Operational Manual (FCOM) provides information on airplane turning capability and manoeuvring characteristics. Section 4.2 provides a figure and table showing the turning radii (R), with no slip angle, for various steering angles ranging from 30º to 60º **(Appendix A)**. R2 measures the turn radius, from the centre point of the turn radius to the outer main undercarriage wheel. R3 of the table measures the turn radius from the same pivot point to the nose wheel.

Additional information is provided in the FCOM with regard to turning capability on the ground **(Appendix B)**. Using a 60º turning angle the minimum pavement width for an 180º turn is given at A as 21.40m.

Table 1 below has been complied by the Investigation in order to bring parts of Appendix A and B together and calculates the minimum pavement width required for steering angles of 30º, 45º, 50º, 55º and 60º. These figures are referenced against the runway width at Galway (30m). The minimum pavement width required includes a safety margin of approximately 0.71m on either side of the 180º turn. Column A refers to the minimum pavement width required and Column B refers to the measured difference (on either side of the turn) between the minimum pavement width required and the actual runway width of 30m.

[4] A runway surface is described as WET when the surface is soaked but there is no standing water.

Steering Angle	R2	R3	Safety Margin	A	RWY	B
30º	20.70m	21.53m	0.71m	42.94m	30m	-6.47m
45º	12.82m	15.23m	0.71m	28.76m	30m	+0.62m
50º	11.08m	14.05m	0.71m	25.84m	30m	+2.08m
55º	9.59m	13.14m	0.71m	23.44m	30m	+3.28m
60º	8.26m	12.43m	0.71m	21.40m	30m	+4.30m

Table 1

From Table 1 it can be calculated that the minimum steering angle necessary to remain within the 30m-runway width is 42º.

1.6 Turn Pads

Section 3.3 of ICAO Annex 14 – Aerodromes specifies as a Standard[5] at 3.3.1 that, *"Where the end of the runway is not served by a taxiway or a taxiway turnaround and where the code letter is D, E or F, a runway turn pad shall be provided to facilitate a 180-degree turn of aeroplanes*."

Section 3.3.2 of Annex 14 specifies as a Recommendation[6] that, *"Where the end of the runway is not served by a taxiway or a taxiway turnaround and where the code letter is A, B, or C* (Galway Airport is coded C)*, a turn pad should be provided to facilitate a 180-degree turn of aeroplanes."*

A graphic illustration of a runway turn pad is presented below as Fig 1. The initiation of the turn would be facilitated by locating the turn pad on the left side of the runway, since the left seat is the normal position of the pilot-in-command. Guidance on the design of runway turn pads is available in the ICAO Aerodrome Design Manual, Part 1

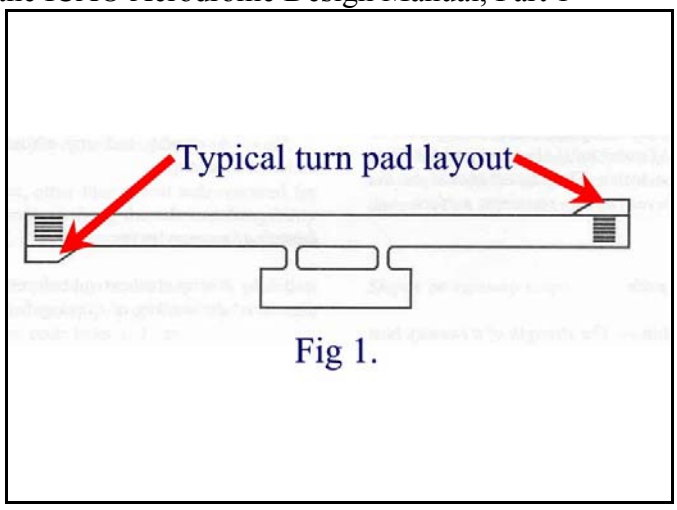


Fig 1.

[5] **Standard**: Any specification for physical characteristics, configuration, material, performance, personnel or procedure, the uniform application of which is recognized as necessary for the safety and regularity of international air navigation and to which Contracting States will conform in accordance with the Convention; in the event of impossibility of compliance, notification to the Council is compulsory under Article 38

[6] **Recommended Practice**: Any specification for physical characteristics, configuration, material, performance, personnel or procedure, the uniform application of which is recognized as desirable in the interest of safety, regularity, and to which Contracting States will endeavour to conform in accordance with the Convention.

2. ANALYSIS

While a 180º taxiing turn is a relatively straight forward manoeuvre, a number of factors must be considered, including, the overall size of the aircraft, its wheel base and the outer main wheel span, the available angles of steering, the rate of turn, the pavement available, the surface conditions, the wind conditions, and the point at which the reversal of direction commences.

The wind condition reported as 190º/03 kts is not considered to be a factor in this event.

The runway friction concerns expressed by the Operator, as outlined at Section 1.4 of this report, related specifically to the painted runway markings on the re-surfaced runway becoming slippery when WET. The grooving of the entire runway, (displaced threshold to displaced threshold) has since resolved this issue.

The runway was reported by ATC as DAMP for the departure of EI-RED. The Captain made no report of skidding or slipping during the turn manoeuvre, primarily because he did not notice the usual "rumble" sounds that would normally be associated with nose wheel skidding/slipping. In addition, the area in which the manoeuvre was performed was free from painted markings, except for a centreline arrow on the portion of the runway before the displaced threshold.

The runway end at Galway is not served by a taxiway, taxiway turnaround or a turn pad. Therefore, it is necessary, when completing an 180º turn, to taxi off the centreline, track towards the runway edge and turn back towards the centreline. Normally the aircraft will pass through the centreline at 90º before it can re-intercept the centreline from the other side.

It is clear from Appendix A, B and Table 1, that an aircraft the size of the ATR 72 is well capable of carrying out a 180º turn on a 30m wide runway such as Galway, once the steering angle is greater than 45º and up to 60º. However, when using the shallower steering angles (45º- 50º), it does require that the reversal of direction be initiated relatively close to the runways' edge. Where this is not done and/or if the steering angle is set below 45º or a higher angle is not maintained throughout the manoeuvre, safety margins are likely to be compromised. In the case of EI-RED, it is considered that, any one or a combination of all three of these factors, contributed to the aircraft leaving the paved surface. While it is considered unlikely that the nose wheel suffered from some loss of traction during the turn manoeuvre on the DAMP surface, the Investigation cannot entirely rule this possibility out.

ICAO Recommends that, where the end of the Code C runway is not served by a taxiway or a taxiway turnaround, a turn pad should be provided to facilitate a 180-degree turn of aircraft. A Recommendation is recognized as desirable in the interest of safety, regularity, and to which Contracting States will endeavour to conform in accordance with the Convention. The Investigation accepts that an aircraft the size of the ATR 72 can carry out an 180º turn on the runway at Galway, without a compromise in safety, once the manoeuvre is performed properly.

However, the Investigation does recognise that the main advantage of a taxiway, taxiway turnaround or a turn pad, is that the aircraft can turn/intercept directly onto the runway centreline and that a turn pad will also provide more pavement to conduct the manoeuvre, thereby increasing the safety margin.

In the spirit of the ICAO Recommendation for Turn Pads, the Investigation concludes that for any further runway development in Galway, the Airport Management should consider the inclusion of Turn Pads at either end of the runway. A Safety Recommendation has been made to that effect.

3. SAFETY RECOMMENDATIONS

The Investigation Recommends that:

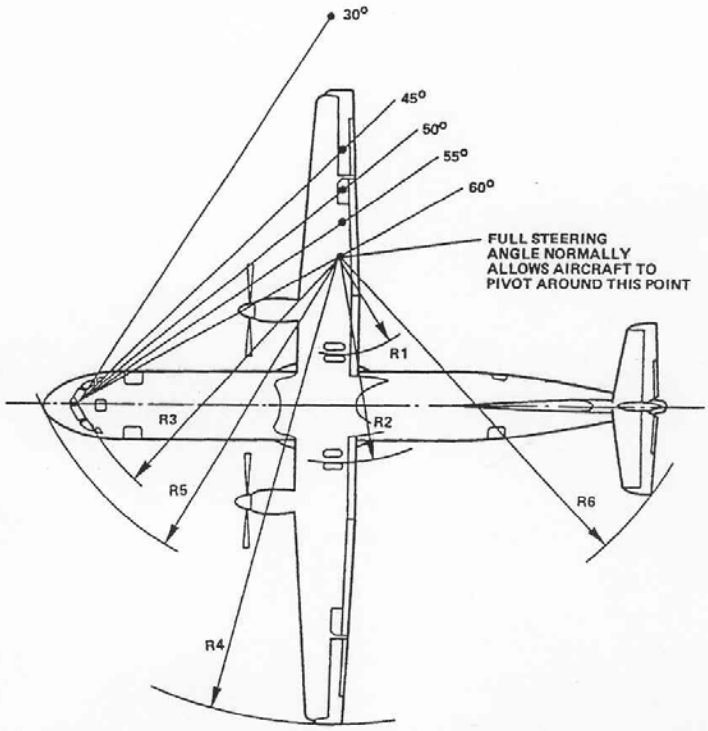
3.1 The Galway Airport Management Board should consider, in any future runway extension or improvement plan, the inclusion of Turn Pads at either end of the runway. **(SR 07 of 2005)**

Response

The Galway Airport Management Board has accepted this Safety Recommendation.

APPENDIX A

ATR72 AIRPLANE CHARACTERISTICS



STEERING ANGLE (DEGREES)	R1	R2	R3	R4	R5	R6
	ft in. / m	ft in. / m	ft in. / m	ft in. / m	ft in. / m	ft in. / m
30	54 5.5 / 16.60	67 11 / 20.70	70 7.5 / 21.53	105 7 / 32.18	73 8 / 22.45	86 2 / 26.27
45	28 7 / 8.72	42 1 / 12.82	49 11.5 / 15.23	79 9 / 24.30	54 1.5 / 16.50	65 8 / 20.02
50	22 11 / 6.98	36 4 / 11.08	46 1 / 14.05	74 / 22.56	50 7 / 15.42	61 8 / 18.80
55	18 / 5.49	31 5.5 / 9.59	43 1.5 / 13.14	69 1.5 / 21.07	47 11 / 14.60	58 6 / 17.83
60	13 8 / 4.16	27 1 / 8.26	40 9 / 12.43	64 9 / 19.74	45 9.5 / 13.96	55 10.5 / 17.03

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4.2 TURNING RADII, NO SLIP ANGLE

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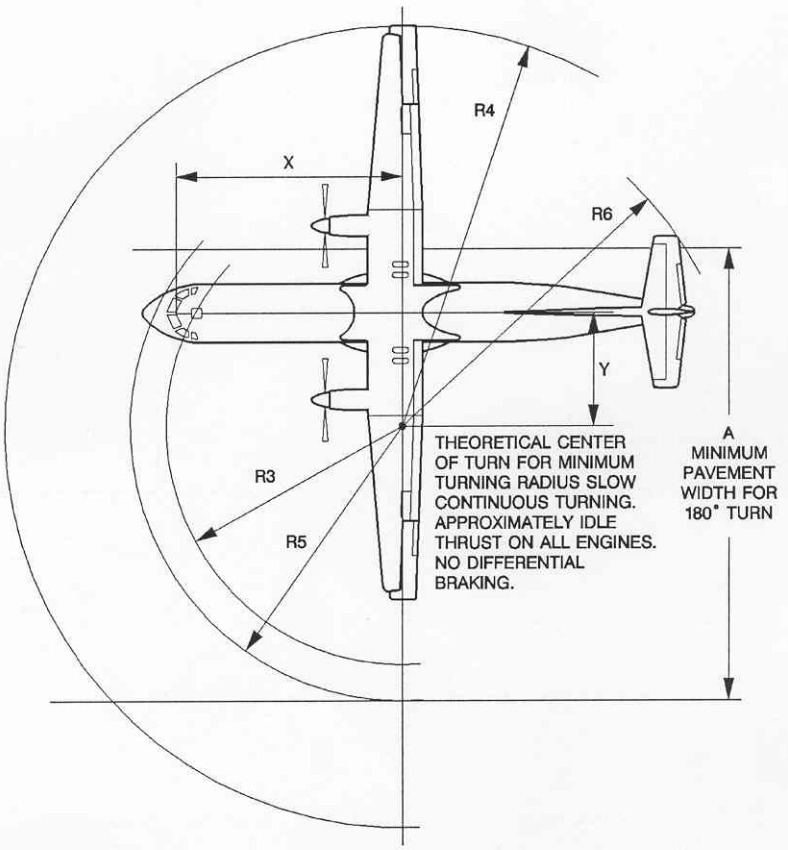
APPENDIX B

AA

TURNING CAPABILITY ON GROUND



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FEET / INCH / METER

TURN-ANGLE	X	Y	A	R3	R4	R5	R6
60°	35Ft 4in. / 10.77	20Ft 4.5in. / 6.21	70Ft 2.5in. / 21.40	40Ft 9.5in. / 12.43	64Ft 9in. / 19.74	45Ft 9.5in. / 13.96	55Ft 10.5in. / 17.03

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