Air Accident Investigation Unit Ireland

SERIOUS INCIDENT REPORT
(1) AIRBUS A321-231, G-OZBS
(2) BOEING 737-8AS, EI-DPT
Dublin Airport (EIDW), Ireland
21 May 2011

An Roinn Iompair
Turasóireachta agus Spóirt

Department of Transport,
Tourism and Sport

AAIU Draft Final Report No: 2012-017
State File No: IRL00911044
Report Format: Synoptic Report
Published: 24/10/2012

In accordance with Regulation (EU) No. 996/2010 and the provisions of SI 460 of 2009, the Chief Inspector of Air Accidents, on 21/05/2011, appointed Paddy Judge as the Investigator-in-Charge to carry out an Investigation into this Serious Incident and prepare a Report. The sole purpose of this Investigation is the prevention of aviation Accidents and Incidents. It is not the purpose of the Investigation to apportion blame or liability.

Aircraft Type and Registration:	(1) AIRBUS A321-231, G-OZBS (2) BOEING 737-8AS, EI-DPT
No. and Type of Engines:	(1) 2 x IAE V2533-A5 (2) 2 x CFM 56-7B26
Aircraft Serial Number:	(1) 1428 (2) 35550
Year of Manufacture:	(1) 2001 (2) 2007
Date and Time (UTC):	21 May 2011 @ 16.49 hrs
Location:	Dublin Airport (EIDW) Ireland, Runway (RWY) 16
Type of Operation:	(1) Commercial Air Transport, Non-Scheduled (2) Commercial Air Transport, Scheduled
Persons on Board:	(1) Crew - 6 Passengers - 152 (2) Crew - 6 Passengers - 145
Injuries:	None
Nature of Damage:	None
Commander's Licence:	(1) Airline Transport Pilot Licence (2) Airline Transport Pilot Licence
Commander's Details:	(1) Male, aged 47 years (2) Female, aged 37 years
Commander's Flying Experience:	(1) 9,263 hours, of which 1,321 were on type (2) 6,230 hours, of which 2,800 were on type
Notification Source:	Station Manager Dublin Air Traffic Control (ATC)
Information Source:	Pilot Report Forms submitted by Pilots.

SYNOPSIS

While a Boeing 737-800 was taking off on the active Runway (RWY) 16 at EIDW an Airbus A321 mistakenly taxied onto the latter part of the same runway. The Boeing 737-800, which had almost reached V1, immediately conducted a high-speed Rejected Take-Off (RTO) and stopped approximately 360 metres from the A321. There was no damage or injury.

As part of the on-going development of Air Traffic Management (ATM) systems at EIDW and subsequent to this Serious Incident, Advanced Surface Movements Guidance and Control System (ASMGCS) Level 2 was put into operation. In addition the associated Runway Incursion Monitoring and Conflict Alert System (RIMCAS) and Stop bar Violation Monitoring were implemented at EIDW in order to assist ATC in preventing a future occurrence of this nature. Additional procedures and a new runway incursion hot spot were also designated and published by the Irish Aviation Authority (IAA).

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1. FACTUAL INFORMATION

1.1 History of Occurrence

The A321 (G-OZBS), a Flight MON7562 from Dublin to Tenerife, was parked on Stand 35. The active runway at EIDW was the shorter RWY 16. G-OZBS requested the longer RWY 28 for take-off since the aircraft was heavy. This was granted and G-OZBS was subsequently cleared by Ground Control (121.8 MHz) to push back and start. Thereafter it taxied right on AT4 and stopped short of Link 2 in compliance with ATC instructions. (Figure No. 1 is an extract from the chart provided for the flight crew of G-OZBS).

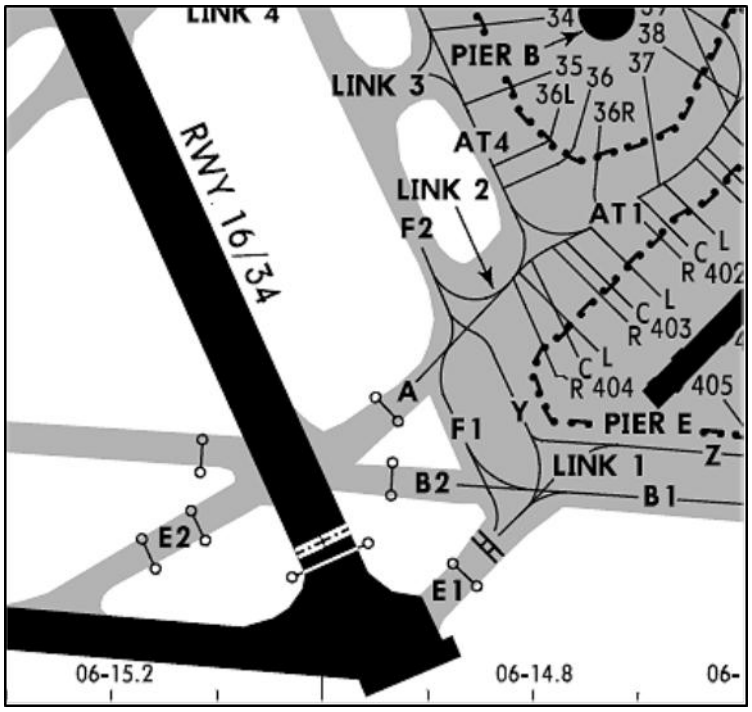


Figure No. 1: Extract Jeppesen EIDW 10-9B (8 Oct 2010)

Subsequently, ATC Ground Control cleared the aircraft to continue taxiing on F1, to hold short of B2 and, when it was at the end of Link 2, via F1 to E1 and to hold short of RWY 28. Instead of turning left from Link 2 onto F1, G-OZBS mistakenly continued straight ahead onto A.

While G-OZBS was approaching the end of Link 2, EI-DPT, a B737-800 flight from Dublin to Vilnius, was cleared on EIDW Tower frequency (118.6 MHz) to take-off on RWY 16. EI-DPT acknowledged the clearance and commenced its take-off run during which G-OZBS entered onto RWY 16 from A and stopped. This was seen by the flight crew of EI-DPT who initiated a high speed rejected take-off and stopped 360 metres from G-OZBS, or 1,455 metres from the threshold of RWY 16

As this was a high speed RTO, EI-DPT returned to stand for a technical inspection of its braking system while G-OZBS later departed from RWY 28 for its destination.

1.2 Interviews

1.2.1 Flight Crew G-OZBS

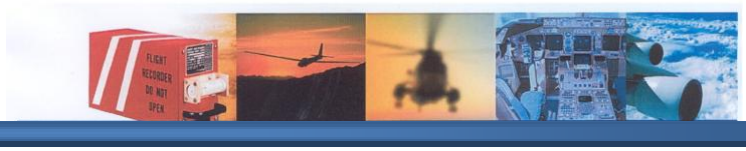
The Pilot Flying (PF), who was also the Commander, stated that the previous flight had arrived on stand 40 minutes late. This was his first flight of the day and he recalled that they were cleared for a straight push back from Stand 35. Although RWY 16 was the active runway they needed RWY 28 due to performance requirements. After start they were cleared to taxi on AT4 and hold short Link 2, which they complied with. They were then told to taxi after a specific aircraft had passed to Link 2, E1 and hold short of RWY 28. They mistakenly thought that this aircraft was on taxiway F2 when it was actually on RWY 16, so after it had passed they taxied to A, believing it to be Link 2. As they approached the edge of RWY 16 the First Officer or Pilot Not Flying (PNF) questioned their position so he stopped the aircraft. Tower ATC, to whose frequency they had just switched, advised them they had infringed RWY 16. After that they were told to enter RWY 16 and to line up RWY 28 and hold. After lining up RWY 28 they completed before take-off checks and three minutes later were cleared take-off on RWY 28.

In assessing the cause of the event, the PF said that one factor that didn't help was a wet surface due to recent rain and bright sunshine reflecting off it, "*making poor markings less visible*". Also, the short distance from the stand to the holding point made for a short busy taxi. When ATC instructed them to taxi after the passing aircraft, he felt that it then went wrong, as he incorrectly assumed due to the slow speed of the aircraft that it was on taxiway F and not on RWY 16 [where it had just landed]. Finally, he felt that if big bright wig-wags[1] were installed on A, it would have been more obvious that they were approaching an active RWY.

The PNF recalled in his interview that the flight was late. The taxi was normal until they mistakenly thought that the aircraft crossing in front of them was on F2. At that time further checks were completed, cabin secured and a frequency change to Tower was received. They continued after the aircraft was clear believing they were still on Link 2 when, in fact, they were on A. As they approached RWY 16 they realised they had gone too far and asked ATC if they had gone the wrong way. They were told to expedite onto RWY 28 and to hold.

In assessing the cause of the event, he stated that, as the tarmac was wet, the yellow markings on the taxiway were difficult to see, as he commented "was usual in Dublin".
The flight crew both held ATPL licences issued by the UK Civil Aviation Authority (CAA). Their licences, ratings and medical certificates were valid. Both stated that they only occasionally flew into EIDW.

[1] Wig-wags: The common name for Runway Guard Lights, or two alternate flashing yellow lights located on each side of a taxiway before entering a runway.



1.2.2 Flight Crew EI-DPT

The PF, who was also the Commander, recalled that during the early stage of the take-off roll from RWY 16 at EIDW, she noticed an aircraft taxiing towards the end of the runway. She mentioned this to the First Officer and asked *"what's that aircraft doing?"* She then saw the Monarch aircraft taxi onto the end of the runway and called "*Stop*" and carried out the RTO manoeuvre. Almost immediately, ATC called them to abort. The First Officer acknowledged the call.

When the aircraft stopped she confirmed that there were no abnormal indications. They taxied back to a stand, briefing the passengers on the way and spoke to her company and its engineering section. When asked by the Investigation if she had carried out an actual RTO before, the Commander said she had not and added that "*all the simulator training works*".

The PNF was the First Officer. He gave a detailed description of the procedural actions taken by the Commander and himself during the RTO and concurred with the Commander's recollection of the event. He too witnessed the encroaching aircraft at the end of the duty runway and shortly after the PF questioned what the aircraft was doing he replied that it was taxying out in front of them.

The flight crew both held ATPL licences issued by the IAA. Their licences, ratings and medical certificates were valid.

1.3 EIDW Air Traffic Control General

Dublin Tower is responsible for the provision of Air Traffic Control at EIDW. Tower personnel include the Ground Controller and the Tower Controller. The Ground Controller provides Surface Movements Control (SMC) at EIDW and controls aircraft ground movement on the ramp and taxiways. The Tower Controller provides Air Movements Control (AMC) and controls aircraft landing and taking off. Both controllers were relieved of their duties after the occurrence as per ATC procedures.

They were subsequently interviewed by the Investigation and found to possess valid, IAA issued, ATC controller licences and ratings appropriate to their operating positions.

1.3.1 SMC Controller

The SMC Controller said that G-OZBS looked for RWY 28 for departure, which she coordinated with her ATC colleagues. She gave pushback and taxi clearance with a right turn to AT4 and to hold short of Link 2. She added that significant coordination was needed between ground and air control to keep a free flowing movement on the one way system in and out of the runway.

As an example, she cited an aircraft landing on RWY 16 might be given one of three instructions to vacate by the controller, depending on the proximity of the nearest exit after aircraft braking was complete.

In this instance, G-OZBS was told to hold short of Link 2 until a landing aircraft had cleared ahead of it through B2 and onto B1. G-OZBS was then told to continue F1, E1, hold short RWY 28 and change to the Tower frequency 118.6. The next thing she recalled was looking out the window and seeing G-OZBS infringing RWY 16.

When asked by the Investigation if she kept visual contact with G-OZBS she replied that she had no reason to think that it would not follow her instructions and, having cleared the aircraft to Tower control, she had diverted her attention elsewhere.
She suggested that the introduction of ASMGCS, Level 2, could be '*a last line of defence*' and putting stop bars on taxiways A and B could assist in preventing such an occurrence in the future.

1.3.2 AMC Controller

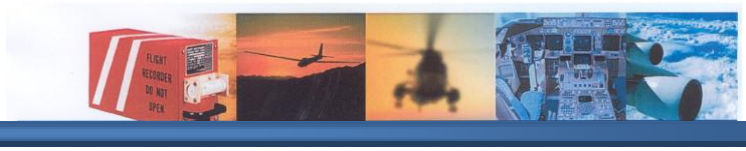
The AMC Controller said that he cleared EI-DPT onto RWY 16 and then for take-off. When he cleared EI-DPT to take-off the runway looked clear. His scan then moved towards the threshold of RWY 16 where one aircraft was on short finals and another ready to line up. He then noticed EI-DPT slowing down on RWY 16, scanned the runway further down and saw that G-OZBS had made a runway incursion. He was in mid transmission to tell EI-DPT to stop but the aircraft transmitted its stopping action first. EI-DPT confirmed that it could stop.

He then asked G-OZBS to vacate the runway as quickly as possible onto RWY 28 while he advised an aircraft on final to continue its approach. Once G-OZBS had moved he cleared EI-DPT to exit via taxiway A and the other aircraft to land. It all happened very quickly, he added.

The Controller said that the traffic level on RWY 16 was moderate that afternoon, but that considerable coordination was required for RWY 16 operations, especially as the new passenger Terminal 2 had a single entry/exit system in place on the South Apron. He thought that the view of RWY 10/28 from the Tower was generally good. However, RWY 16 was in a different direction and it was unclear from the Tower Controller's position exactly which taxiway an aircraft was on unless the controller stood up. Regarding taxiing aircraft in the Link 2 area for RWY 28, he stated that it was sometimes unclear for a short period what the aircraft was doing as aircraft go through a type of "*chicane, turning its nose one way and then back again*".

With regard to G-OZBS, he had been informed that it was coming onto his frequency via the paper strip sent by the SMC. He was aware that G-OZBS had been cleared behind the landing aircraft to E1 and to hold short RWY 28 and commented that ground movements seemed as planned. He added that it is not possible to give any particular aircraft (such as G-OZBS) his undivided attention and that, since the active runway was RWY 16, normal duties required that his attention was generally directed there.

This was the experienced Controller's first experience of a runway incursion by an aircraft. He had not seen one before, even in training, he added. Later, while off duty, he reflected on the afternoon's event and concluded that it had very serious potential.



1.4 Recordings General

The CVR[2] and FDR[3] of EI-DPT were removed and provided to the Investigation.

The FDR of G-OZBS was provided to the Investigation. As the aircraft departed immediately after the incursion, its CVR recording was over-written in flight and therefore not available.

ATC records were preserved and provided to the Investigation. These included the ASMGCS recording and the EIDW Tower audio records.

1.4.1 Flight Data Recorders (FDR)

The FDR data of both aircraft was downloaded. The FDR data from G-OZBS was of good quality and confirmed the accuracy of the ATC ASMGCS recording as detailed in **Section 1.4.3**.

The FDR of EI-DPT recorded a V_1 setting of 128 kts and the events as listed in **Table 1**.

Elapsed time in seconds	Event
0	Ground speed 8kts, the aircraft on runway heading commences take-off roll.
19	First indication of brake pressure rise. Indicated airspeed = 123 kts, Ground speed = 109 kts.
20	First indication of power reduction. Indicated airspeed = 124 kts Ground speed = 110 kts
22	Indicated airspeed = 132 kts, Ground speed = 118 kts
23	Peak Indicated airspeed = 134 kts.
48	Ground speed = 0 kts.

Table 1: FDR EI-DPT

1.4.2 Cockpit Voice Recorder (CVR) EI-DPT

The CVR was downloaded and proved of good quality. The recording disclosed that the aircraft followed its taxi instructions with Standard Operating Procedures (SOPs) being complied with. The Commander was acting as PF when the aircraft was cleared to take-off on RWY 16. The CVR transcript extract in **Table 2** shows the key comments.

[2] **CVR:** Cockpit Voice Recorder
[3] **FDR**: Flight Data Recorder

Elapsed time in seconds	Pilot	Comment
0	PF	*Set take-off*
4	PNF	*Take-off thrust set indications normal*
12	PNF	*80 kts*
17	PF/PNF	*Where's that Mon/Where's that guy going* [Voice Overlap]
19	PNF	*He's taxiing out in front of us*
21	PF/PNF	*Stop /Abandon* [Voice Overlap]

Table 2: CVR EI-DPT

Shortly after the PF called "*Stop*" the PNF transmitted "*We're stopping..*". Deceleration speed calls were called by the PNF at 100 kts and 70 kts. When ATC asked could they stop the PNF responded "*We're stopped*". Following this standard cockpit procedure resumed as the PF set the parking brake.

1.4.3 ASMGCS Recording

ASMGCS is an ICAO approved system designed to supplement ATC visual observations. It takes data feeds from the surface movements radar, the approach radar and also incorporates a multi-lateration system consisting of 32 sensors located around the airfield. Its information is displayed on a labelled radar display at each controller's position in EIDW Tower where it displays all aircraft and vehicles on the manoeuvring area[4]. It was operational at the time with a display provided at both the SMC and AMC positions.

The ASMGCS recording showed the tracks of both aircraft and also their ground speeds. It showed that after start and push back, G-OZBS turned right to taxi on AT4 and stopped short of Link 2. After 37 seconds it resumed progress and turned right at a slow speed onto Link 2. While it was taxiing slowly along Link 2, an aircraft that had landed on RWY 16 turned off the runway onto B2. It passed by the left hand side of G-OZBS, which was then at the FI intersection. At that point G-OZBS, then clear of the incoming traffic, continued straight ahead on A and accelerated slightly to a ground speed of 14 kts. It then went straight across the Link 2/FI intersection and taxied along A.

At 16.47:39 hrs the ASMGCS recorded G-OZBS at the edge of RWY 16, which it then entered and stopped. In the meantime EI-DPT was accelerating in its take-off run. At 16.47:48 hrs the recording showed that EI-DPT reached a peak ground speed of 118 kts and commenced decelerating; it was then 820 metres from the threshold RWY 16.

[4] **Manoeuvring area:** That part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, excluding aprons. [ICAO definition].

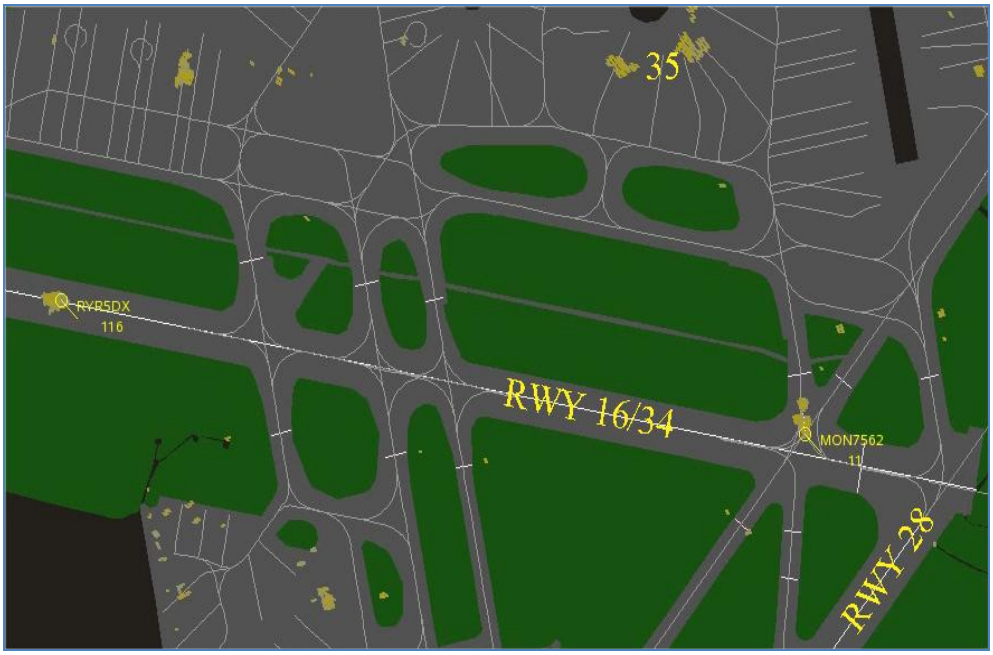


Figure No. 2: ASMGCS Recording of Occurrence

1.4.4 EIDW ATC Audio Recordings

At 16.06:28 hrs while on Stand 35, G-OZBS acknowledged its en route clearance from Dublin Clearance Delivery and advised, that for flight performance reasons, it could not accept active RWY 16 and that they would wait and use RWY 28 instead. This request was accepted by ATC who gave the surface wind as 200 degrees 22-30 kts.

At 16.32:45 hrs, before push back from Stand 35, G-OZBS confirmed their requirement to ATC for use of RWY 28. They were then issued with a new en route clearance, which was acknowledged.

At 16.44:20 hrs, after start and push back, G-OZBS requested taxi clearance. This was given as "*turn right taxi Apron 4 hold short of Link 2*" which they acknowledged.

At 16.45:45 hrs, while stationary on AT4, ATC advised G-OZBS to "*continue taxi Fox I and hold short of Bravo 2 please*"; this was acknowledged. At 16.46:42 hrs ATC advised "*after the Aer Lingus from your right taxi Echo 1 hold short RWY 28*"; this was again acknowledged. G-OZBS at that time was on Link 2, 60 metres from intersection of taxiways F1 and A. At 16.47:12 hrs G-OZBS, which was at the intersection of Link 2 & FI [where the aircraft should have turned left], was advised by ATC to "*hold short RWY 28, monitor Tower on 118.6*" which it acknowledged.

At the same time (16.47:15 hrs) on the Tower frequency EI-DPT was cleared to take-off on RWY 16. EI-DPT acknowledged the clearance and commenced its take-off run.

At 16.47:48 hrs, EI-DPT called "*stopping*" and three seconds later a crossed transmission was recorded.

At 16.47:56 hrs ATC advised EI-DPT that there had been a runway incursion and asked could it stop. Shortly afterwards at 16.48:02 hrs EI-DPT advised that it was stopping. Almost immediately ATC cleared G-OZBS to enter RWY 28 and later cleared EI-DPT back to the ramp.

1.5 Weather Information

The Aviation Division of Met Éireann provided the following meteorological information for Dublin Airport for the afternoon of the event as follows:

EIDW 211500Z 20020KT 9999 –RA SCT018 BKN 35 15/12 Q1007 NOSIG
EIDW 211700Z 19016KT 9999 –RA SCT013 SCT 018 BKN040 14/12 Q1004 NOSIG
EIDW 211730Z 20019G31KT 9999 FEW015 BKN020 BKN 060 14/11 Q1004 NOSIG

At the time of the occurrence, the sun was in the western quadrant of the sky at 23° altitude (angle of elevation) and 269° azimuth i.e. a bearing of 274°M.

1.6 Aerodrome Information

EIDW has two runways, the primary RWY 10/28 is 2,637 metres long and the shorter RWY 16/34 being 2,072 metres. RWY 16/34 has six taxi exits to the left for landing aircraft, of which three are towards the runway's end, one of which includes taxiway A. (Note: The Jeppesen Airport EIDW Charts 10-9 and 10-9B, which were in use by the crew of G-OZBS and EI-DPT, displayed the taxiway and runway layout).

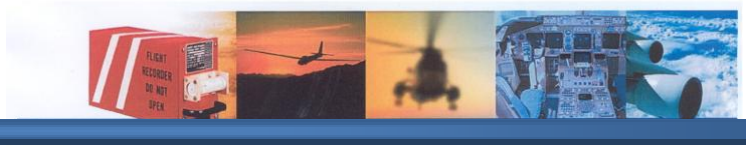
Both RWY 16/34 and RWY 10/28 can be viewed from the Tower. The thresholds of both RWY 16 and RWY 28 are approximately 0.5 nm away but there is a 140° difference in direction.

1.6.1 Taxiway A - Area Inspection

The Investigation inspected taxiway A shortly after the occurrence and noted a number of signs in the area due to the confluence of taxiways A, B2 and E1 and the co-located thresholds of RWY 28 and RWY 34. The orientation of Link 2 and taxiway A were both 230°M. The Investigation noted that the pavement markings at the area of Link 2 were complex. The taxiway, markings and signage conformed to the requirements of Annex 14 Aerodromes, Volume I, Aerodrome Design and Operations.

Taxiway A was also equipped with Runway Guard Lights before entering the RWY 16. The red "34-16 CAT I RWY" warning of the runway ahead and taxiway signs at the same location were clearly visible and conformed to Annex 14, Volume 1, Section 5.4 specifications.

The Investigation was informed that the wig-wag lights on A, which are associated with RWY 16 runway edge lights, were switched on at the time as RWY 16 was active. As RWY 28 was about to be used for take-off its runway edge lights and the associated stop bar on E2 was active. Since E2 is in line with taxiway A this stop bar is visible from A.



The Investigation observed three Unserviceability Marker Boards (also known as "Daylight Markers"), with alternate red and white vertical stripes, which blocked the entrance to taxiway Y from Link 2. These marker boards also conformed to the requirements of Annex 14.

1.6.2 Taxiway A - Stop Bar

A stop bar consists of a row of red unidirectional in-pavement lights spaced at intervals of 3 metres across a taxiway which, when activated, show red to an aircraft or vehicle moving in the intended direction of approach to an ***intersection*** or a ***runway-holding*** position.

A single stop bar was installed on taxiway A at the entrance from Link 2. ATC informed the Investigation that this stop bar was not illuminated as, at the time of the event, the stop bars on A and B2 were only used during low visibility procedures; in this case normal visibility operations were in force and therefore the stop bar was not in use. The Investigation was advised that the location of the stop bar at the entrance to taxiway A was intended to prevent aircraft straying from the Low Visibility taxi route from F2 to F1 and vice versa.

1.7 Hot Spots

The ICAO Manual on the Prevention of Runway Incursions, DOC 7870, defines a Hot Spot as:

A location on an aerodrome movement area[5] with a history or potential risk of collision or runway incursion, and where heightened attention by pilots/drivers is necessary".

It further says:

3.4.2 Aerodrome charts showing hot spots should be produced locally, checked regularly for accuracy, revised as needed, distributed locally, and published in the Aeronautical Information Publication (AIP).

3.4.3 Once hot spots have been identified, suitable strategies should be implemented to remove the hazard and, when this is not immediately possible, to manage and mitigate the risk.

At the time of the occurrence three hot spots were published in the Aeronautical Information Publication (AIP) for Ireland.

These were depicted on Jeppesen chart EIDW 10-9 (**Figure No. 3**). Hot spots were not depicted on the larger scale EIDW 10-9B charts (**Figure No. 1**).

[5]**Movement area:** That part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, consisting of the manoeuvring area and the apron(s). [ICAO definition].

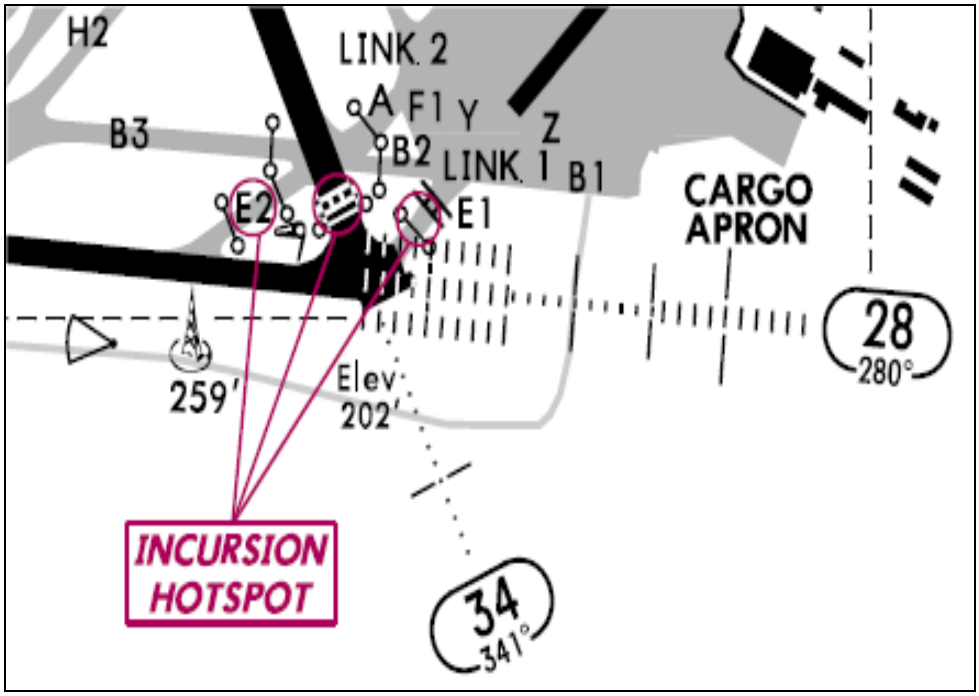


Figure No. 3: Extract from Jeppesen Chart EIDW 10-9 (8 Oct 10)

Subsequent to this occurrence hot spots on taxiway A and B have been published in the AIP Chart 2-24-2 for Dublin Airport with the result that five hot spots are now depicted in current Jeppesen EIDW 10-9 and 10-9b (**Appendix B**) charts.

1.8 EIDW ASMGCS

ASMGCS Level 1 was brought into service at EIDW in October 2009 to assist controllers by displaying the surface movements of aircraft and vehicles equipped with Mode A and S transponders. It also displays any non-transponder equipped targets utilising surface movements radar.

ASMGCS Level 2 was undergoing testing at the time of the occurrence that is the subject of this Investigation and became operational on the 8 August 2011, three months after the event. Subsequent to ASMGCS Level 2 becoming operational, the additional functionalities of RIMCAS and Stop bar Violation Monitoring were introduced.

1.8.1 RIMCAS

RIMCAS uses vector calculations to predict possible active runway conflicts between aircraft and other objects. This information assists air traffic controllers by providing both visual and audio alerts and warning of evolving runway incursions that may result in traffic conflicts or collisions. Although RIMCAS was not operational at the time of the occurrence, a replay of the data through its test configuration correctly captured and flagged the active runway incursion by Flight 7562 (G-OZBS) as shown in **Figure No. 4.**

Figure No. 4: RIMCAS Alert in Test Configuration

Although RIMCAS can detect the incorrect presence and provide an audio warning of an aircraft, vehicle or person on the protected area of a surface designated for aircraft landing and taking-off, it does not provide advance warning of an imminent runway incursion.

1.8.2 Stop bar Violation Monitoring (SVM)

SVM was also introduced with ASMGCS Level 2. SVM generates an audio and visual alert when an aircraft or vehicle, whether transponder equipped or not, crosses an active (i.e. lit) stop bar (**Figure No. 5**). This separate system complements RIMCAS by utilising ASMGCS functionality with the Airfield Ground Lighting (AGL) system.

When the runway edge lights are switched on, the AGL system activates the stop bars associated with that runway. If a stop bar is 'ON' and an aircraft or vehicle then crosses the stop bar, an alert sounds in the control tower, and a visual display appears on the ASMGCS Tower and Station Manager displays. Alternatively, no alert is generated if the stop bar is off. Alerts are only generated if a stop bar is crossed in the direction that it faces e.g. no alert is generated for an aircraft vacating the active runway.

SVM functions in all weather conditions. In normal visibility conditions Cat I stop bars are lit and the SVM system functions only on those stop bars.

During Low Visibility Operations, when Low Visibility Lighting is selected, the system functions on Cat III stop bars, which are further away from the active runway, and on all operational stop bars (including those on the apron). Stop bars are individually selectable by the ATC controller, in which case they are deactivated for 40 seconds in low vis conditions and 35 seconds in normal vis conditions following which they automatically re-activate. This allows sufficient time for an aircraft or vehicle to cross.

Figure No. 5: SVM Alert in Test Configuration

As SVM detects the incorrect presence of an aircraft, vehicle or person before it enters the protected area for aircraft landing and taking-off, it can provide advance warning of a potential runway incursion.

1.9 Runway Incursions - ICAO

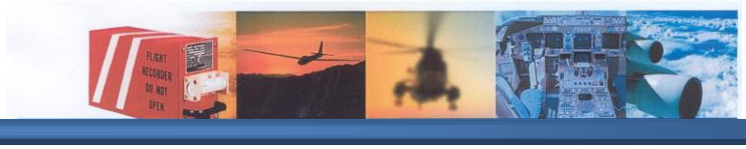
ICAO PANS-ATM, Doc 4444 defines a Runway Incursion as:

> *Any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and take-off of aircraft*.

ICAO Annex 14 – Aerodromes, states in Section 5.3.19 Note 2, that:

> *Runway incursions may take place in all visibility or weather conditions. The provision of stop bars at runway-holding positions and their use at night and in visibility conditions greater than 550 m runway visual range can form part of effective runway incursion prevention measures.*

The ICAO Manual on the Prevention of Runway Incursions, Doc 9870, classifies Runway Incursions on a scale of A to E, with A being most serious. It also states, inter alia, that:



1.2.3.c. many aerodrome improvement projects have resulted in a more complex aerodrome layout which, together with inadequate aerodrome design standards, signage, markings and lighting, and the lack of standard taxi routes and availability of improved aerodrome diagrams, has worsened the situation.

1.3.1 One aspect of situational awareness is pilots knowing where they are and where they want to go, as well as visualizing a picture of the airport traffic in the vicinity. Even during daylight and in good visibility, pilots can get lost. Even worse is the situation where pilots think they know their position, but find themselves elsewhere.

2.6.1 Complex or inadequate aerodrome design significantly increases the probability of a runway incursion. The frequency of runway incursions has been shown in many studies to be related to the number of runway crossings and the characteristics of the aerodrome layout.

4.2.6 All communications associated with the operation of each runway (vehicles, crossing aircraft, etc.) should be conducted on the same frequency as utilized for the take-off and landing of aircraft.

4.5.8 Standard taxi routes should be developed and utilized to minimize the potential for pilot confusion.

Survey data have shown that pilots, drivers and controllers consider runway incursions and the potential for collisions to be the most significant risk in aerodrome operations" and that "*Successful prevention of runway incursions requires the collaboration of air traffic controllers, pilots, vehicle drivers and aerodrome management".*

1.10 EIDW ATC Procedures

EIDW Tower ATC procedures for take-off clearances were published in the Dublin Manual of Air Traffic Services (MATS) Part II B - Section 3, Issue Date: 21/12/10. This stated that take-off clearances must be issued in accordance with the procedures specified in ICAO Doc 4444 Chapter 7 paragraph 7.9.2, as follows:

A departing aircraft will not normally be permitted to commence take-off until the preceding departing aircraft has crossed the end of the runway-in-use or has started a turn or until all preceding landing aircraft are clear of the runway-in-use.

Paragraph 7.9.3.1 further states, inter alia, that:

Take-off clearance may be issued to an aircraft when there is reasonable assurance that the separation ..... will exist when the aircraft commences take-off.

MATS II B-Section 3-Chapter 7 contained procedures for Dual Runway Operations. The procedures are supplemented by Section 3, Chapter 8, Manoeuvring Area Operations. The procedures contained in that chapter describe the runway protection measures to be followed by ATCO's issuing taxi instructions.

Although Chapter 7 of the Manual contained procedures for Dual Runway Operations on RWY 28 and RWY 34, it did not address Dual Runway Operations on RWY 28 and RWY 16.

1.11 Rejected Take-Off Guidance for Flight Crew

Regarding the Go/Stop Decision near V1, the Boeing 737 NG Flight Crew Training Manual states that;

Making the Go/Stop decision starts long before V1. Early detection, good crew co-ordination and quick reaction are the keys to a successful take-off or stop.

1.12 Previous Runway Incursions

Three previous events were recorded in the IAA Mandatory Occurrence Report (MOR) System where aircraft cleared from Link 2 to F1 incorrectly taxied straight ahead onto taxiway A; two of these entered RWY 16. The incidents occurred in 2007, 2008 and 2010 respectively but were not investigated by the AAIU as there was no safety impact. As RWY 16 is active only about 8% of the total operational time at Dublin Airport, due to the prevailing winds, it was not envisaged that a hot spot designation was necessary.

The AAIU investigated a runway incursion at EIDW, on 16 October 2010, in which a Boeing 737-800 taxied onto RWY 28 while an Airbus A319 aircraft was about to land on that runway. The Report of the Investigation (Report No 2011-019), published on the 11 November 2011, made a Safety Recommendation regarding the provision of stop bar lights on E1. Subsequently, stop bar lights were introduced into service on E1 at the combined CAT 1 holding position for RWY 34 and RWY 28.

1.13 Additional Provisions

ATC EIDW has informed the Investigation that, as a consequence of this and the previous runway incursion on the 16 October 2010, the following additional preventative safety measures have been taken at EIDW:

- Simultaneous use of Runways 28 & 16 is not allowed.
- Conditional line up clearances have been discontinued.
- RWY 10/28 has now been protected by CAT I stop bars over its entire length.
- An independent, 5 level brightness control for stop bars has been installed with a minimum selectable to maintain brightness during daytime operation.
- Lead on lights for RWY 28, associated with E1 stop bar, have been installed. This should militate against aircraft lining up on the wrong runway at the RWY 34/28 intersection.
- Apron Centreline Lighting is now illuminated H24.
- Guidance material covering operations in the vicinity of runway incursion hot spots has been included in MATS Part II B.
- Information cautioning the hot spot areas is now broadcast on EIDW ATIS.
- Hot spot charts are available in the Tower.

1.14 Airport Authority

The Dublin Airport Authority (DAA) informed the Investigation that, as a consequence of this serious incident, the following measures were implemented during 2012:

- All necessary Airfield Ground Lighting control system adjustments have been installed to facilitate the 24-hour operation of stop bars on taxiways A and B2, as referred to in **Section 1.13**.

- Additional taxiway directional pavement paint markings have been provided to supplement existing elevated taxiway directional signage in the vicinity of taxiways F1, Y and A (as depicted in **Photo No. 1**)

Photo No. 1: New Taxiway Directional Pavement Markings Installed at Link 2

- The Runway Incursion Hot Spot areas currently promulgated in the AIP EIDW 2.24-2 Aircraft Parking/Docking Chart have been included in the AIP EIDW 2.24-1 Aerodrome Chart with specific attention focused on the 'Hot Spot' areas (see **Appendix C**). Both charts have been reformatted in full colour to enhance the presentation of the details they contain, for the benefit of users and became effective from 28 June 2012.

Stop bars have already been installed on taxiways A, B2, E1, and B7 and close to the threshold of RWY 34 to protect RWY 10/28. Furthermore, the DAA stated that it is intended later this year to commence work on the installation of stop bars at the CAT I hold points on all taxiways intersecting RWY 16-34, not so equipped to date. This follows on from the installation of stop bars on all taxiways intersecting RWY 10-28 and will provide a consistent set of safety measures protecting aircraft operations on both runways at the airport, thus reducing the risk of further runway incidents and incursions, whilst accepting that it will not eradicate such events completely.

The DAA further stated that the Dublin Airport Local Runway Safety Team (LRST), comprised of representatives from the airline operators, the airport operator and ATC, are proactively engaged in identifying ways of addressing runway incursion incidents and have focused on the "Hot spot" areas on the manoeuvring area, being guided by the Eurocontrol European Action Plan for the Prevention of Runway Incursions and the ICAO Manual on the Prevention of Runway Incursions. The group is currently engaged in several activities including:

(1) Reviewing the existing taxiway designation system in place, with a view to simplifying designations where feasible, thereby helping to reduce complex taxi instruction communications between Air Traffic Control and aircraft flight crew/vehicle operators, and;

(2) Assessing the layout of the taxiway infrastructure in the vicinity of taxiways F1, Y and A. This includes considering short and long term options to reduce the complexity of the layout, from a safety perspective, while at the same time ensuring that airside capacity is maintained to accommodate current and future system demand.

The DAA is also investigating opportunities to enhance the pavement paint markings present on the manoeuvring/movement areas and is installing trials with a view to providing greater conspicuity against the back drop of:

(a) The different pavement types present on the manoeuvring area (both concrete and bituminous pavements).

(b) Both wet and dry pavement surface conditions.

(c) Daylight and hours of darkness.

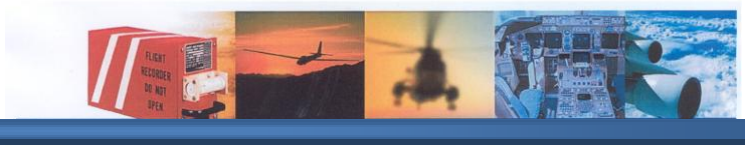
2. ANALYSIS

This Serious Incident occurred when G-OZBS mistakenly continued straight ahead from Link 2 onto taxiway A and inadvertently entered an active runway when EI-DPT was taking off. The flight crew of EI-DPT saw this during their take-off run and promptly carried out a rejected take-off, stopping 360 metres short of G-OZBS. Had they not done so the outcome might have been very different.

The crew of G-OZBS candidly admitted that they had made a mistake when they taxied on to A believing it to be Link 2, which they were already on. However, there were a number of factors that contributed to that mistake.

2.1 Human Factors

G-OZBS was running late and pre-take-off checks had to be completed by the flight crew during the short taxi. This coupled with ATC instructions resulted in a period of relatively high workload. Until G-OZBS continued straight ahead from Link 2 onto taxiway A, its crew correctly acknowledged and complied with ATC instructions.



The Investigation noted that at that time three unserviceability markers were positioned on the left hand side of Link 2, which may have contributed to their assumption that they would continue to taxi straight ahead.

During their interviews both flight crew stated that they thought the passing aircraft was on taxiway F when it was actually on RWY 16. This assumption caused them to misjudge their position and once clear of that aircraft G-OZBS's speed increased. It was clear from the subsequent flight crews' interviews that neither noticed the taxiway signage, holding position markings or the illuminated wigwags at the holding position on taxiway A prior to entry onto RWY 16. Furthermore, the fact that the E2 stop bar was illuminated and would have been visible straight ahead on the other side of RWY 16 may have led the flight crew to assume that they had not yet reached an active runway, even though the runway edge signs displayed RWY 16/34. As a result the runway incursion was an inadvertent non-compliance with ATC clearances due to a loss of situational awareness since the flight crew thought that they were at one location on the aerodrome when they were actually elsewhere.

It could be argued that their situational awareness might have been improved had they been on the Tower frequency and heard EI-DPT being cleared to take off. However, it is not practical for larger airports such as EIDW to coordinate all aircraft on the same frequency - to attempt to do so would result in frequency congestion. Nevertheless, the false assumption by the flight crew of G-OZBS regarding their location militates against this argument and it is questionable whether it would have alerted them to their error.

It is probable that the wet pavement surface and strong sunlight from a low sun in the west made the painted surface markings more difficult to see as they entered the intersection Link 2/F1, an area not designated as an 'incursion hot spot' but rather considered as a complex manoeuvring area. While suggesting the above possible extenuating circumstances for the incursion, the flight crew candidly admitted their error in taxiing via A onto RWY 16.

Although both flight crew commented that the pavement markings at EIDW were poor these were inspected by the Investigation and found to conform to international standards. While they were quite clear in the conditions prevailing at the times of inspections, they may well have proved otherwise in the wet, sunlit conditions prevailing at the time of the occurrence. The Investigation found that the DAA is experimenting how to enhance the paint markings, so as to make them more conspicuous. Trial paint marks have already been installed and these are currently under evaluation. In view of this on-going activity no Safety Recommendation is considered necessary in this area.

The Investigation also noted the number of signs in that area due to the confluence of 5 taxiways at the end of Link 2 and the co-located thresholds of RWY 28 and RWY 34. This complex layout has been the result of incremental change over time. Consequently, complicated taxi instructions result.

As evidence, the taxiway instructions for the short distance that G-OZBS taxied included AT 4, Link 2, FI, B2, and E1. For those familiar with the airport's movement area this just increases workload due to ATC communication requirements. For those who are relatively unfamiliar with the layout of the airport, such as the flight crew of G-OZBS, this can also be quite confusing as there is no logical progression in taxiway designation and therefore the probability of error increases.

The Investigation notes that the ICAO Runway Incursion Manual states that in such a case there is an argument that standard taxi routes should be developed and utilized to minimize the potential for pilot confusion. In light of this the Investigation is of the opinion that the taxiway designation at EIDW should be reviewed and issues a Safety Recommendation accordingly.

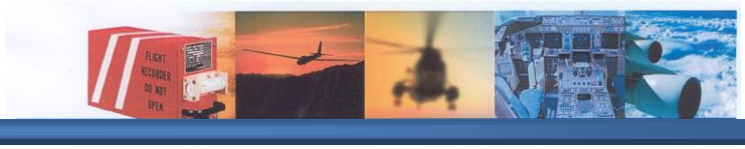
2.2 Rejected Take Off

For the crew of EI-DPT it should have been a routine take-off on RWY 16. As the aircraft accelerated, the PNF made the standard '80 knots' call and immediately following that call both pilots simultaneously made comment regarding the taxiing aircraft approaching from the left towards RWY 16. While this incorrect routing was not noticed by ATC nor realised by G-OZBS, it was seen by the flight crew of EI-DPT on their take-off roll with the First Officer voicing the incursion.

When she realised that the taxiing aircraft had entered the runway the Commander immediately abandoned the take-off, thus breaking an accumulating and potentially threatening chain of events, and instructed the PNF to inform ATC. During the take-off run the FDR showed that the rejected take off commenced at approximately 124 kts indicated airspeed, or 4 kts under V1, and a peak speed of 134 kts was reached.

Following initiation of the rejected take-off the RTO function of the braking system activated ensuring that the aircraft stopped rapidly and safely short of G-OZBS. The whole event, from the ATC clearance to take-off to aircraft stopping, lasted approximately 60 seconds and it reflected very positively on the continuous simulator training provided by the operator and carried out by the flight crew.

It should be noted that no guidance can be provided to pilots taking-off regarding such an occurrence, whether to stop, swerve or attempt to fly. Too much will depend on the circumstances but ultimately a decision must be made quickly and an incorrect decision can be catastrophic. In this case the incursion was detected by the flight crew early enough, there was good crew co-ordination, quick reaction and the outcome was a successful rejected take-off. And, as the Commander commented, training paid off.



2.3 Air Traffic Control

The audio recordings of the instructions given by both the SMC and AMC controllers were found to have been issued in standard ATC phraseology with the single exception of an abbreviated "Foxtrot 1" to "Fox 1", which the Investigation considers had no bearing on the event.

The taxi instructions given by the SMC to G-OZBS were routine, one of the many such instructions given regularly to departing aircraft at Dublin Airport. Equally the request by the aircraft for RWY 28 was not unusual for an aircraft on a long flight which needed a long runway to take off at a high weight. Such a request fell within the scope of Dublin MATS II, which provided for the type of multi runway operation in place at the time of the event. Although it complicated ATC management of aircraft on the movement area, the decision to accede to the request was appropriate.

Equally, the routing given to the aircraft and the restriction to allow another aircraft to clear the runway were normal procedure at EIDW when RWY 16 was the active runway. Shortly afterwards, as G-OZBS was at the intersection of Link 2 & FI, it was cleared to the Tower frequency. At that time G-OZBS was where it was expected to be and the SMC reasonably expected it to continue taxiing as instructed - as it had done previously. Having cleared the aircraft to Tower, the SMC was no longer responsible for controlling it and did not monitor it further.

It then came under the control of the AMC who stated that he was aware of G-OZBS coming onto his frequency. However, he had already given EI-DPT clearance to take-off on RWY 16. The ASMGC and ATC audio recordings confirmed that this take-off clearance was issued in accordance with ATC procedures. RWY 16 was clear at the time and G-OZBS was by then only at the intersection of Link 2 and FI and well short of RWY 16.

The Investigation notes that the 140° difference in direction between the thresholds of RWY 16 and RWY 28 meant that the AMC could not monitor both areas at the same time; if he was looking at his landing traffic he could not physically see G-OZBS approaching the runway.

As the Control tower was a half mile from G-OZBS, the latter's position would have been uncertain when judged visually, particularly since the AMC reported that it was sometimes unclear what aircraft were doing in that vicinity as they went through a type of chicane.

It should be noted also that as taxiway A is short, so too was the time available for the controller to detect the error by G-OZBS and even this would have been difficult to detect initially from half a mile away. Although reference could have been made to the ASMGCS display, if he had observed something amiss, that information is to assist the primary visual and procedural methods of control. As it was, his attention was directed towards the threshold of RWY 16 at the time and he did not notice that G-OZBS had contravened its taxi instructions.

2.4 EIDW Movement Area

The Investigation notes that the complex taxiway system allied to a complicated airport design, where the active RWY 16 had to be crossed to arrive at a take-off runway, renders EIDW more likely to be the subject of a runway incursion. Added to this is an ATC controller uncertainty regarding aircraft turning intentions in the vicinity of Link 2/F1/A/F2 intersection and its complex taxiway markings.

Were F2 and F1 aligned then some of this complexity could be removed. Accordingly the Investigation recommends that the Dublin Airport Authority (DAA) considers this and issues a Safety Recommendation to that effect.

2.5 Air Traffic Control Procedural Changes

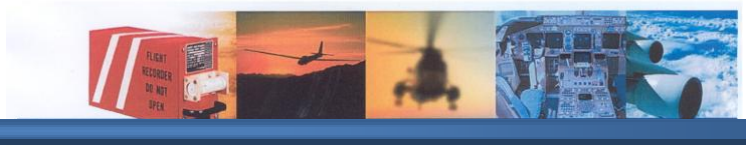
At the time of this occurrence, Dublin MATS II B detailed the procedures to be followed for multi runway operations. These procedures described the restrictions that apply to the control of taxiing aircraft during periods of activity on each runway and during periods of multi runway operations. These procedures did not, however, offer any instruction or guidance on procedures to be followed by ATC when RWY 16 was active and there were departures from RWY 28. This omission was probably due to the infrequency of use of this runway combination. Following this runway incursion Air Traffic Management reviewed procedures in the latter half of 2011 and decided to no longer allow the simultaneous use of RWY 28 and RWY 16. In addition, the use of conditional line up clearances was discontinued.

At the time three runway hot spots were identified at Dublin Airport. The hot spots were described in AIP Ireland charts (AIP Ireland-AD 2 15) but EIDW MATS II B did not contain procedures or guidance material for controllers in respect of those hot spots. Furthermore, hot spot charts were not displayed at either the AMC or SMC working positions in the Control Tower.

Following a review of the procedures in MATS IIB by the ATC Management, guidance material covering operations in the vicinity of runway incursion hot spots has been included and information cautioning the hot spot areas is now 24 hour broadcast on EIDW ATIS when RWY 28 or RWY 34 is active, as these are the runways affected by the hotspot area.

Although there had been three events over the previous four years of mistaken entry by aircraft onto taxiway A from Link 2, none of these were serious incidents and consequently taxiway A had not been identified as a runway incursion hot spot. The Investigation notes that hot spots have now been designated on taxiways A and B and that these have been published on the AIP Chart 2-24-2 for Dublin Airport (**Appendix A**) i.e. five hot spots are now depicted in the charts the flight crew used (**Appendix B**).

The Investigation also notes that new procedures regarding the 24 hour use of controllable stop bars, lead in lighting and apron centreline lighting have been introduced to prevent future runway incursions. These changes, listed in **Section 1.13,** are also intended to prevent, or at least reduce the likelihood of aircraft lining up on the wrong runway at the RWY 34/28 intersection.



The Investigation additionally notes the introduction of ASMGCS Level II with the associated RIMCAS and SVM systems and the associated procedures. Whereas the primary method of ATC control remains unchanged, this technology should assist controllers in detecting and preventing runway incursions.

In view of the actions taken to date the Investigation is of the opinion that no Safety Recommendation is considered necessary in this area.

2.6 Incursion Severity Classification

In accordance with the ICAO Doc 7870 severity classification scheme this occurrence is considered a Class A Runway Incursion, a serious incident in which a collision was narrowly avoided.

3. CONCLUSIONS

(a) Findings

1. G-OZBS requested take-off from RWY 28 when RWY 16 was active, for performance reasons.
2. G-OZBS was subsequently cleared and correctly acknowledged ATC instructions to taxi towards RWY 28 via AT4, Link 2, F1 and E1 to hold short of RWY 28.
3. When the AMC cleared EI-DPT for take-off on RWY 16 the runway was clear.
4. At that time G-OZBS was on a different frequency and its flight crew did not hear the take-off clearance.
5. The flight crew of G-OZBS lost situational awareness after an incorrect assumption regarding the position of another aircraft.
6. They mistakenly taxied from Link 2 onto taxiway A before entering and blocking RWY 16.
7. The wig-wag and runway edge lights at the entrance to RWY 16 from taxiway A were active, but neither they nor the runway signs were observed by the flight crew of G-OZBS.
8. The flight crew of EI-DPT observed that G-OZBS was blocking the runway and carried out a prompt and effective Rejected Take-Off, stopping some 360 metres from G-OZBS on the runway.
9. The flight crew of G-OZBS were possibly distracted by cockpit tasks during a relatively short and busy taxi.
10. G-OZBS was taxied on wet pavement directly towards a bright and low sun. This probably restricted the flight crew's ability to identify both taxiway markings and signs.
11. The pavement markings in the area of Link 2 are complex but in accordance with ICAO specifications.

12. The stop bar on E2 was illuminated and may have led the flight crew to assume that the runway was still ahead.

13. The stop bar on taxiway A was not active as the procedures did not require it in VFR conditions.

14. Some taxiway nomenclature at EIDW is non-sequential.

15. ASMGCS, which was operating at Level 1 at the time of the occurrence, has been upgraded to Level 2 with associated RIMCAS and SVM warning systems in place.

16. Taxiway Alpha has subsequently been designated an Incursion hot spot.

(b) Probable Cause

The flight crew of G-OZBS lost situational awareness, having misidentified their position, and taxied onto an active runway while another aircraft was taking off.

(c) Contributory Causes

1. Sunshine on a wet pavement probably rendered pavement markings and runway signage less visible to the crew as they taxied directly towards a low strong sun.

2. Crew workload and unfamiliarity with the complex taxiway markings and signage.

3. The absence of an illuminated stop bar on taxiway A and the presence of one on E2.

4. SAFETY RECOMMENDATIONS

4. SAFETY RECOMMENDATIONS

It is recommended that:

1. Dublin Airport Authority in conjunction with the Irish Aviation Authority should review taxiway designation at EIDW in order to simplify taxi instructions. **IRLD2012005**

2. The Dublin Airport Authority considers aligning taxiways F1 and F2 in order to reduce complexity at their intersection. **IRLD2012006**

View Safety Recommendations for Report 2012-017

Appendix A

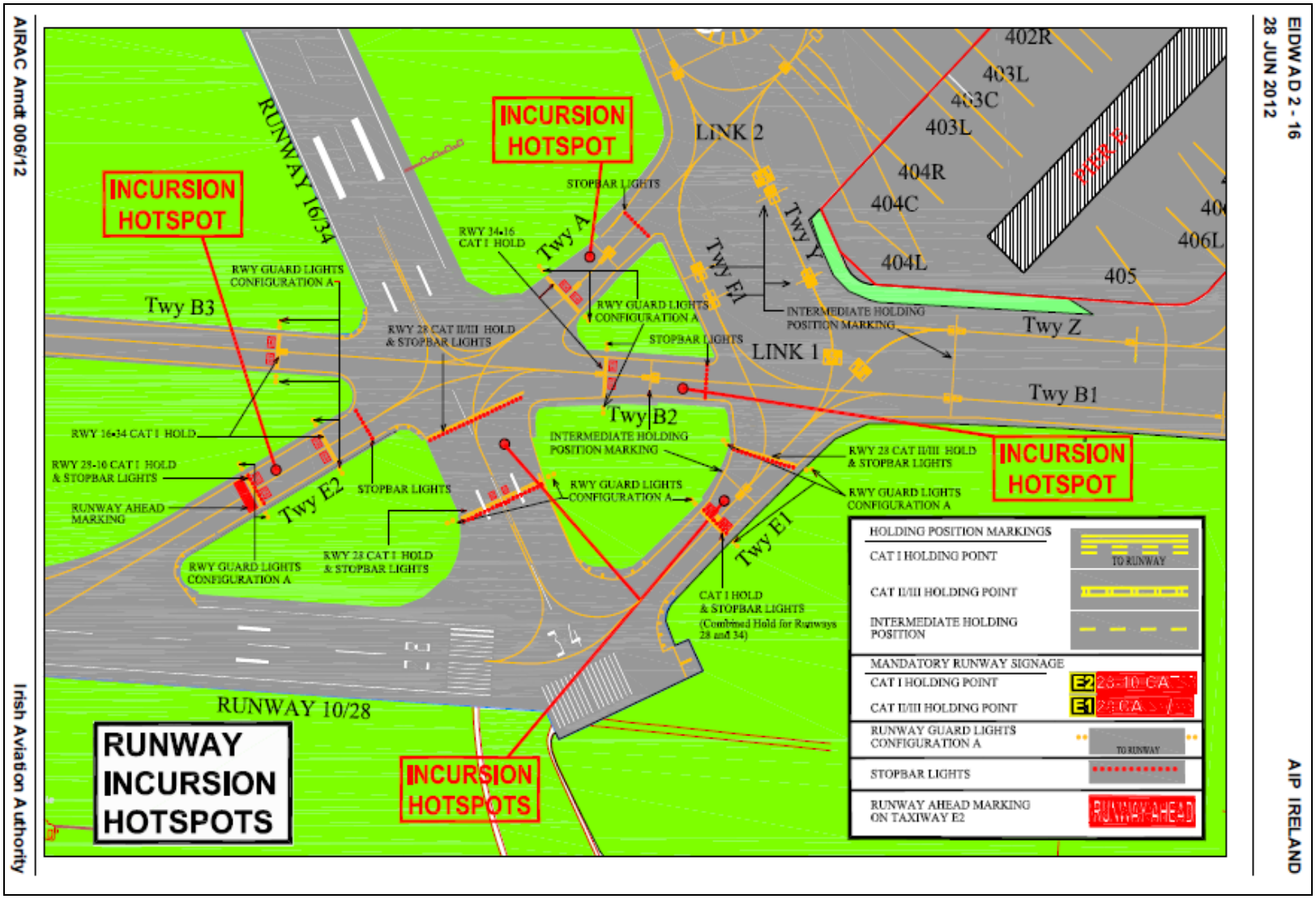


Figure 7: AIP Ireland EIDW, AD2-16 (28 JUN 2012)

Appendix B

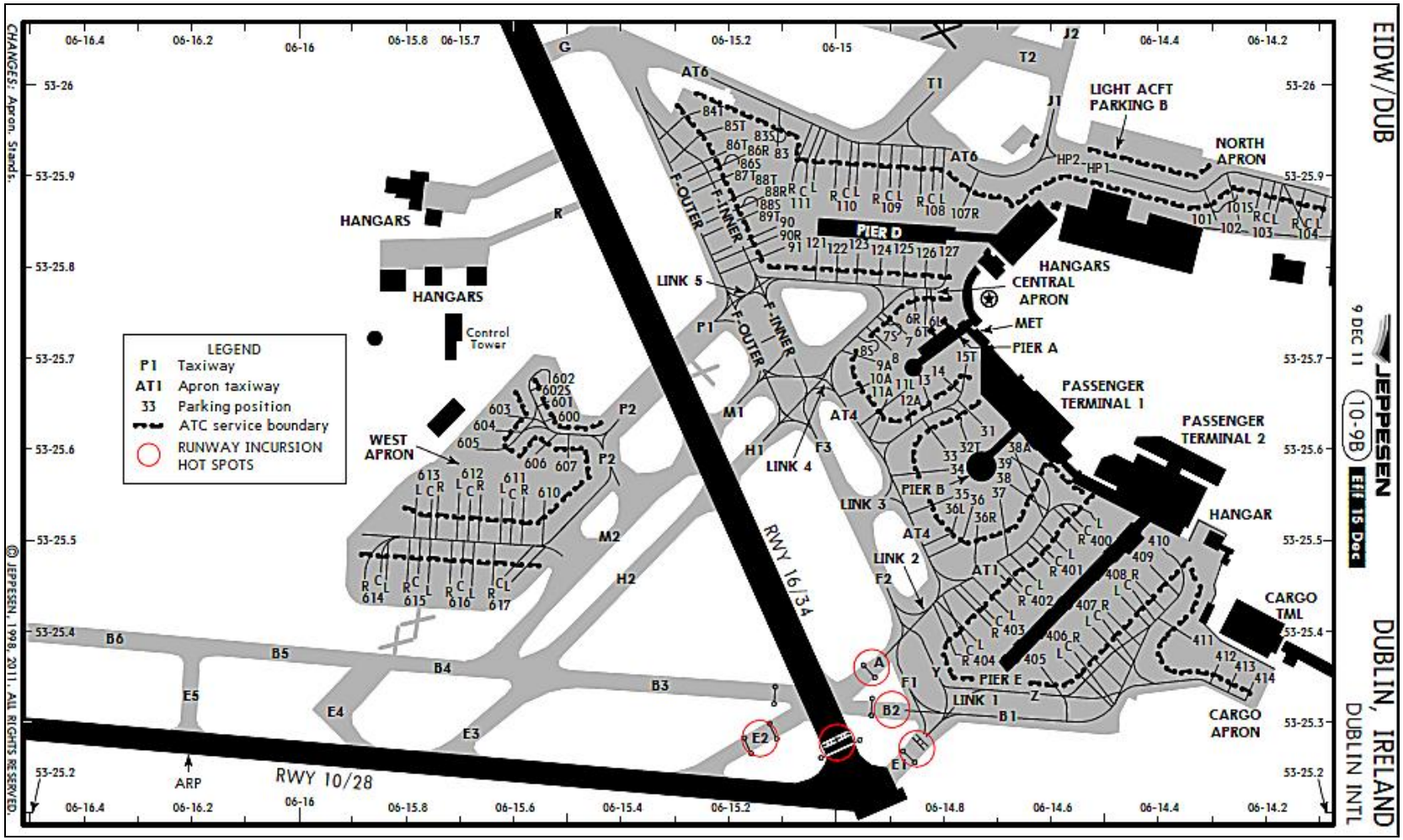
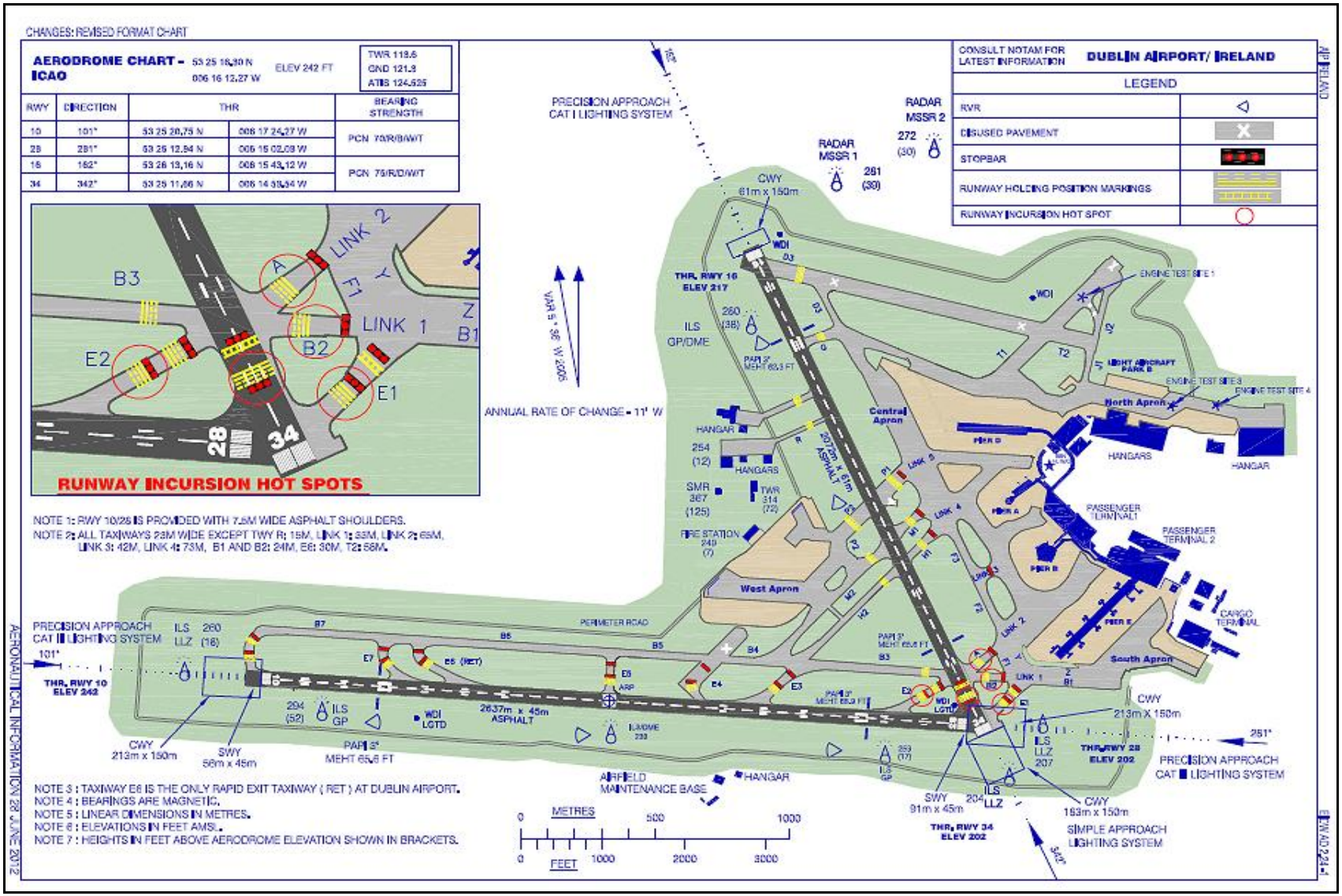


Figure No. 6: Extract from Jeppesen Chart 10-9B for EIDW (9 Dec 2011)

Appendix C



AIP EIDW 2.24-1 Aerodrome Chart (28 June 2012)

-END-

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An Roinn Iompair
Turasóireachta agus Spóirt

Department of Transport,
Tourism and Sport

A.A.I.U.,
Department of Transport Tourism and Sport,
2nd Floor, Leeson Lane,
Dublin 2, Ireland.
Tel (24x7): +353 1 604 1293 or
+353 1 241 1777
Fax: +353 1 604 1514
Email: info@aaiu.ie
Web: www.aaiu.ie