Air Accident Investigation Unit Ireland

SYNOPTIC REPORT

ACCIDENT
Boeing, 737-8AS, EI-EMH/EI-EKK
LINK 2, Dublin Airport, Ireland

7 October 2014

An Roinn Iompair
Turasóireachta agus Spóirt

Department of Transport,
Tourism and Sport

Foreword

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

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

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

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

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

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In accordance with Annex 13 to the Convention on International Civil Aviation, Regulation (EU) No 996/2010 and the provisions of SI 460 of 2009, the Chief Inspector of Air Accidents Mr Jurgen Whyte on 7 October 2014, appointed himself as the Investigator-in-Charge to carry out an Investigation into this Accident and prepare a Report.

Aircraft Type and Registration:	(1) Boeing, 737-8AS, EI-EMH (2) Boeing, 737-8AS, EI-EKK
No. and Type of Engines:	2 x CFM56-7 for each aircraft
Aircraft Serial Number:	(1) 34974 (2) 38500
Year of Manufacture:	(1) 2010 (2) 2010
Date and Time (UTC)[4]:	7 October 2014 @ 05.45 hrs
Location:	LINK 2, Dublin Airport (EIDW)
Type of Operation:	Commercial Air Transport/Scheduled/Passenger
Persons on Board:	(1) Crew - 6 Passengers - 88 (2) Crew - 8[5] Passengers - 100
Injuries:	Crews - Nil Passengers - Nil (On either aircraft)
Nature of Damage:	(1) Damage to tip of port winglet (2) Damage to starboard elevator
Commander's Licence:	(1) ATPL[6] issued by the Irish Aviation Authority (IAA) (2) ATPL issued by the IAA
Commander's Details:	(1) Male, aged 51 years (2) Male, aged 40 years
Commander's Flying Experience:	(1) 11,000 hours, of which 7,000 were on type (2) 7,120 hours, of which 6,310 were on type
Notification Source:	Dublin Air traffic Control (ATC)
Information Source:	AAIU Report Forms submitted by Flight Crews of eachl aircraft, AAIU Field Investigation

[4] **UTC:** Coordinated Universal Time. All times in this report are quoted in UTC; to obtain the local time add one hour.
[5] Total includes two supernumerary cabin crew members.
[6] **ATPL:** Airline Transport Pilot Licence.

SYNOPSIS

While turning right from Taxiway (TWY) F2 via LINK 2 and taxiing towards TWY A to hold short of runway (RWY) 34 at EIDW, the tip of the port side winglet of EI-EMH struck the starboard side elevator of EI-EKK. At the time, EI-EKK was stationary on LINK 2 at the entrance to TWY F1 awaiting sequenced departure off RWY 28. The winglet of EI-EMH and the elevator of EI-EKK were substantially damaged. There were no injuries.

NOTIFICATION

Shortly after the occurrence, EIDW ATC notified the AAIU directly that a collision had taken place between two aircraft at LINK 2. AAIU Inspectors arrived at EIDW within approximately one hour of the notification and commenced the Investigation.

SUBSEQUENT EVENT

On 1 April 2015, a second similar ground collision occurred between two B737-8AS in the vicinity of LINK 2. This occurrence happened in the same area as the subject event and was very similar in nature. The second collision is the subject of a separate investigation by the AAIU.

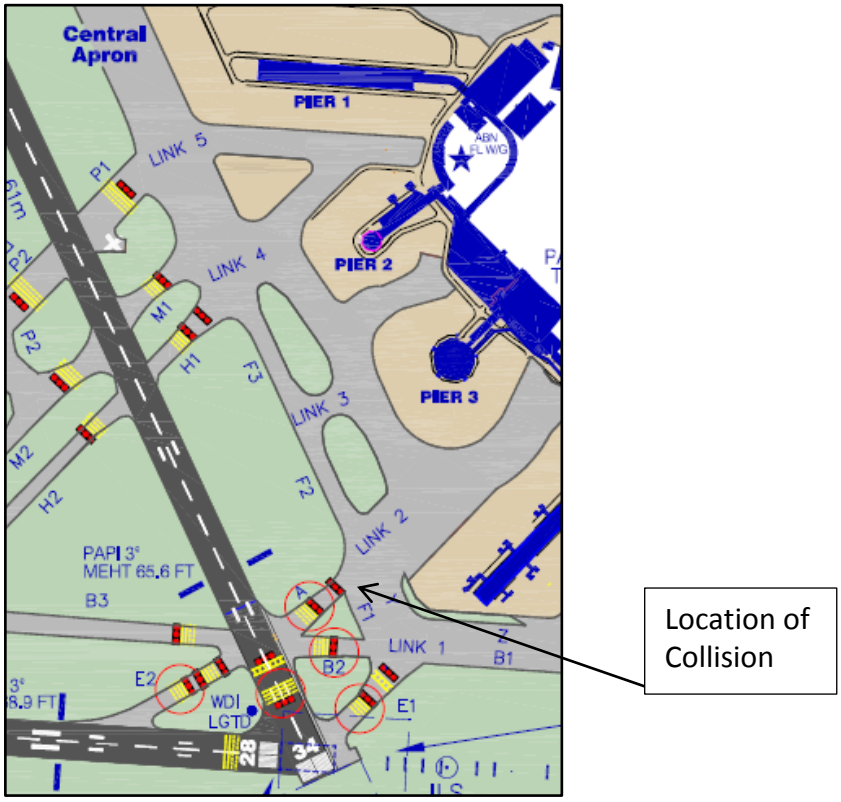
1. FACTUAL INFORMATION

1.1 History of the Flight

At the time of the occurrence 'Dual Runway Operations' were in progress from RWY 28 and RWY 34 at EIDW (**See Section 1.6.2**). The ambient lighting conditions were early morning darkness. An aerodrome chart of Dublin Airport is presented at **Appendix A** and a close-up of the relevant area is presented as **Graphic No. 1** below.

The first aircraft, EI-EKK, with a planned destination of Charleroi (EBCI) Belgium, was number four for departure off RWY 28 and was initially cleared by the Surface Movement Controller (SMC) from the central apron, for taxi to Foxtrot Outer/LINK 5 and to hold short of LINK 5. On approaching LINK 5, the aircraft was further cleared to TWY E1 via the Foxtrot taxiways and to hold short of both runways (RWY 34 and RWY 28). On entering LINK 2, the SMC advised EI-EKK to monitor Tower (TWR) on frequency 118.6 MHz. Just prior to entering TWY F1, EI-EKK stopped (with the parking brake set) on LINK 2 behind two other aircraft, which were queuing in sequence on LINK 1 (between TWY F1 and TWY B1) and TWY E1 for departure from RWY 28.

The second aircraft (EI-EMH), with a planned destination of Edinburgh (EGPH), was following behind EI-EKK in sequence but was due to depart from RWY 34. EI-EMH had been cleared to taxi, LINK 5 onto the Foxtrots and TWY A to hold short RWY 34. When the aircraft was approaching LINK 2, the SMC advised EI-EMH to continue onto TWY A, hold short RWY 34, and monitor TWR 118.6 MHz. As EI-EMH turned right onto LINK 2 and taxied towards TWY A, the tip of the port side winglet struck the outer portion of the starboard elevator of the stationary aircraft, EI-EKK.



Graphic No. 1: Close-up of Aerodrome chart/Collision area

On realising that physical contact had been made with another aircraft, the Commander and Pilot Flying (PF) of EI-EMH, immediately stopped his aircraft and said to the First Officer (FO) that they had hit the other aircraft and asked her to advise ATC that they needed to return to stand. As the Air Movements Controller (AMC)[7] cleared EI-EMH to line up and wait RWY 34, the FO responded, "*We actually need to go back onto stand*". After a number of transmissions between the AMC and EI-EMH it was determined that a ground collision had in fact occurred between two aircraft. The AMC then advised both aircraft to "*hold position we will get assistance to the area to you very quickly*".

The flight crew of EI-EKK, on sensing movement of their stationary aircraft, initially thought it was as a result of jet blast from the taxiing aircraft ahead on LINK 1. However, on hearing the ATC transmissions between the AMC and EI-EMH, it became apparent to them that their aircraft had in fact been struck by another aircraft. EI-EKK then advised Tower (TWR) "….*we want to confirm that we've some sort of impact*". ATC replied, *"Roger hold position"*.

Passenger announcements (PAs) were made on both aircraft explaining what had happened and requesting them to remain seated. On the request of ATC the engines of both aircraft were shut down and ground power units (GPUs) were sought. The front airstairs of both aircraft were deployed in order to allow access for the emergency services and to improve air circulation for the passengers. When buses became available, all passengers were returned to the departures area. The flight crew and cabin crew remained in their respective aircraft to await the arrival of the AAIU.

[7] **AMC:** Also referred to on ATC transcript as Tower.

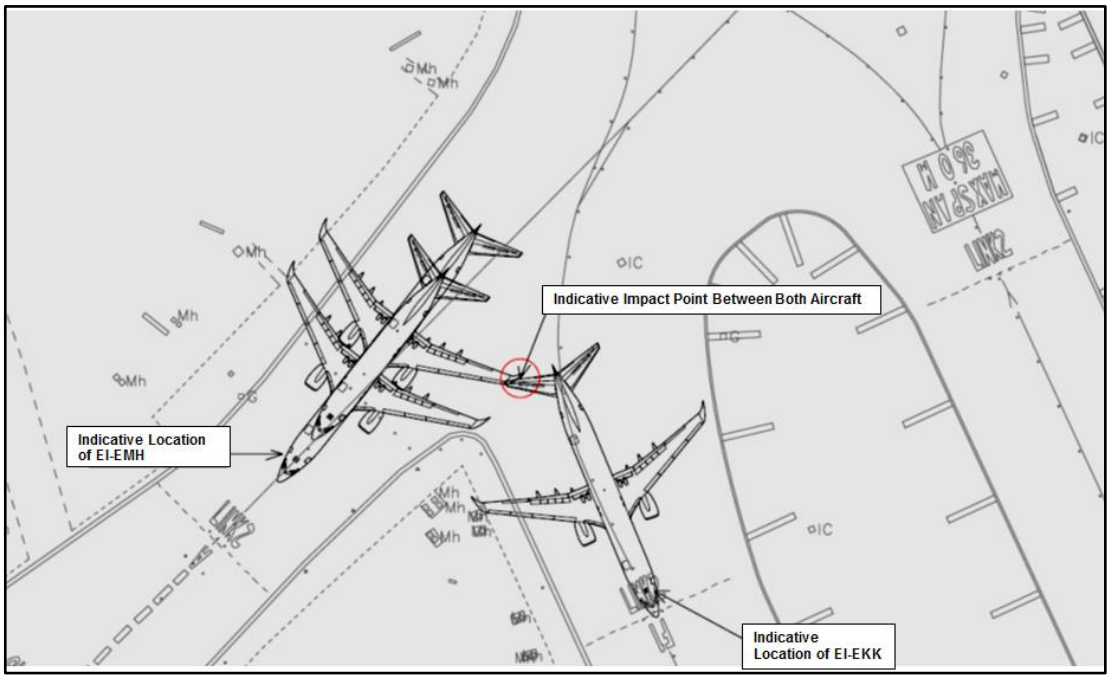
Operations at EIDW were suspended. The airport emergency services responded immediately to the occurrence site and confirmed that both aircraft were secure. They provided emergency cover until the aircraft were released by the Investigation (08.18 hrs) following which both aircraft were towed to maintenance hangars 1 and 2. Category 9 Fire Cover was restored at 06.02 hrs thereby enabling RWY 28 operations to recommence. TWYs A, LINK 2, F1 and adjoining areas were swept before being returned to service at 08.59 hrs.

1.2 On-site Investigation

1.2.1 Position of Aircraft

Two Inspectors of Air Accidents arrived on site approximately one hour after the occurrence. The first aircraft, EI-EKK, was found in its original parked position with its nose tip just over the demarcation line between LINK 2 and TWY F1 and with the nose wheels slightly left of the taxiway centreline. The main undercarriage wheels were predominantly to the left side of the taxiway centreline as the aircraft tracked to complete the turn onto the centreline. The rearmost section of the starboard elevator was in line with the southern edge of TWY A/LINK 2 (**Graphic No. 2**).

The second aircraft, EI-EMH, stopped a short distance (approximately five metres) from its first point of contact with EI-EKK, approximately 15 metres (m) short of the demarcation line between LINK 2 and TWY A. The nose wheels were slightly right of the taxiway centreline and the main undercarriage wheels were predominately to the right side of the taxiway centreline as the aircraft tracked to complete the turn onto the centreline. **Graphic No. 2** depicts, for indicative purposes only, the approximate positions of both aircraft at the time of impact and the final parked position of EI-EMH following impact.



Graphic No. 2: Approximate position of both aircraft at impact and the final parked position of EI-EMH

1.2.2 Cockpit View

Shortly after the occurrence, the Commander of EI-EMH took a photograph of EI-EKK from his rear portside cockpit window and on request the Commander provided the photograph to the Investigation (**Photo No. 1**). This photograph shows EI-EKK in the foreground. The side cockpit window is covered in rain drops and diffused ramp lighting can be seen in the background. Light conditions are early morning darkness. However, it was not raining at the time of the collision.

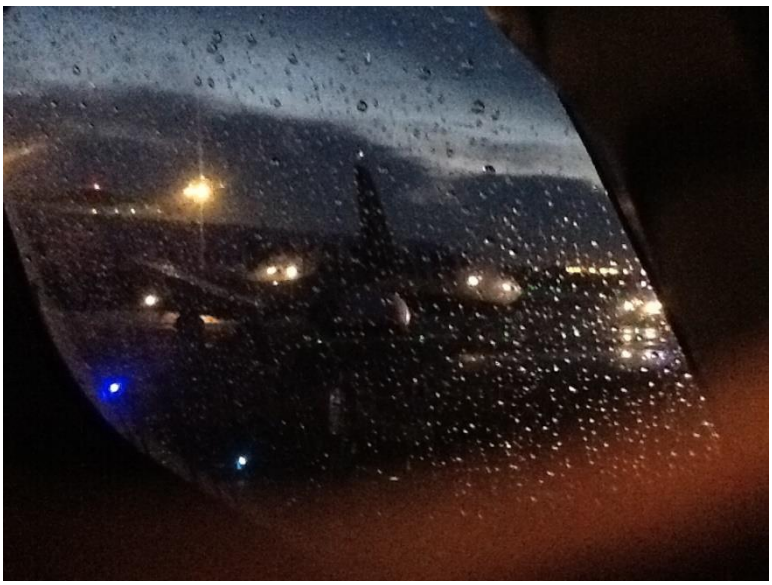


Photo No. 1: Post collision view of EI-EKK from side cockpit window of EI-EMH

1.2.3 Damage

The tip section of the port side winglet of EI-EMH struck the outer portion of the starboard elevator of EI-EKK and then sheared from the main part of the winglet as the aircraft continued forward. The underside of the elevator and horizontal stabilizer on EI-EKK suffered scuffing and scrape marks as a result of the stub of the winglet remaining in contact with the aircraft structure as it passed underneath and across the elevator and horizontal stabiliser **(Photo No. 2)**. Both the winglet and elevator were extensively damaged and subsequently replaced.

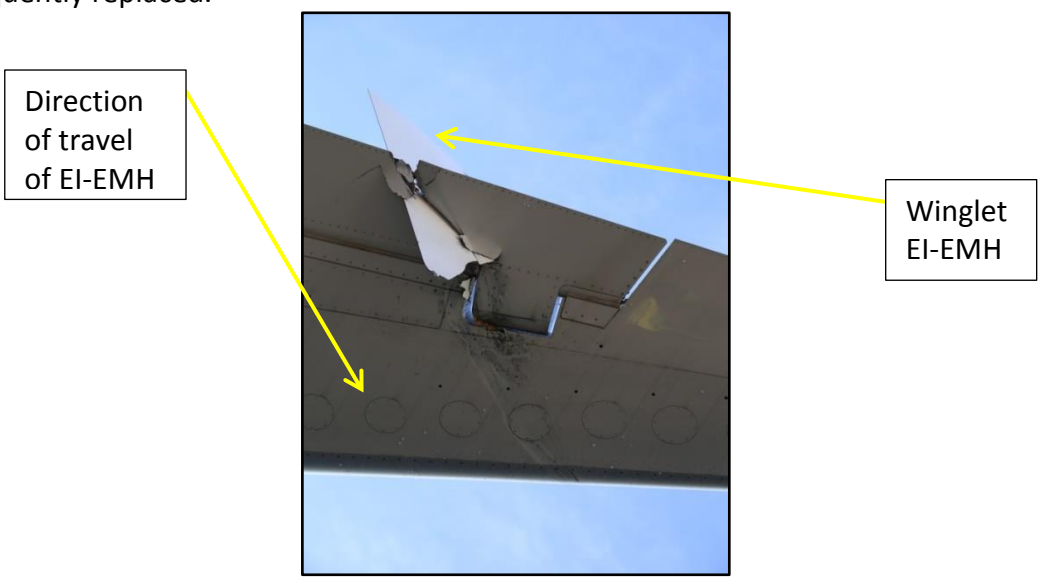


Photo No. 2: Tip of winglet embedded in elevator of EI-EKK and associated scuff marks

1.3 Interviews/Reports

1.3.1 EI-EKK

The aircraft Commander and PF of EI-EKK, who had a valid licence, stated that he followed ATC clearance; from stand to LINK 5 to TWY E1 to hold short of both runways for departure from RWY 28. On joining the queuing traffic ahead, with two stationary aircraft on LINK 1 and E1, he brought the aircraft to a halt on LINK 2/F1, set the parking brake and monitored TWR frequency 118.6 MHz. As the aircraft in front started to move, he felt a bump, but thought this was associated with jet blast coming from the aircraft ahead.

He then heard another aircraft report that they had "*clipped an aircraft"* and realised that they had in fact been struck by another aircraft. The PF confirmed with ATC that they had been struck. A PA was made to the passengers and they were told to remain seated and to await the arrival of the buses. Both engines were shut down and a GPU was requested. The Auxiliary Power Unit (APU) was not started because of concern for possible damage to the tail area. The forward entry door was opened to improve air circulation and the airstairs were lowered to allow the emergency services on board.

The Commander reported no injuries to persons on board and he stated that he had no technical issues with the aircraft prior to contact. The passengers deplaned through the forward entry door onto buses that arrived 20-30 minutes after the occurrence. He and his crew then awaited arrival of the AAIU.

1.3.2 EI-EMH

The Commander of EI-EMH, who had a valid licence, stated that push back was normal; conditions were early morning darkness and visibility was good. He followed ATC clearance; from stand, via LINK 5 and the Foxtrots onto TWY A to hold short RWY 34. He was aware of aircraft ahead on TWY F1 and the fact that another aircraft had taxied onto TWY A and took-off from the RWY 34 intersection, while other aircraft were holding on TWY F1.

He stated that his taxi speed was around 10 kts prior to entry onto LINK 2 and he slowed for the turn. He saw the other aircraft parked ahead at F1 and considered that he had sufficient separation from the other aircraft. He was monitoring the wingtip through the rear port cockpit window, which had rain droplets on it but it was not raining at the time. He felt a jolt and said to his FO that he thought he had tipped the other aircraft. He set the parking brake and directed the FO to advise ATC. A PA was made to advise passengers what had happened and to request that they remain seated. The engines were shut down and a request was made for a GPU. The emergency services checked both aircraft on arrival and they confirmed that all was safe. The passengers deplaned down the airstairs to buses approximately 30 minutes after the occurrence. The Commander confirmed that there were no injuries to persons on board and that he had no technical issues with the aircraft. He and his entire crew then awaited arrival of the AAIU.

In a general comment in his AAIU Report Form, the Commander stated that, *"Whilst taxiing out for departure from RWY 34 at Dublin during dual runway operations we received an instruction from ATC to taxi onto Taxiway A. This reinforced our opinion that we had sufficient clearance to pass behind the other aircraft which was queuing for departure from RWY 28".*

1.3.3 Surface Movements Control (SMC)

The SMC, who had a valid licence, was on an out of sequence rostered night duty at the request of the roster office but as he had been off for the previous 10 days, he said that he was well rested and considered himself fit for duty. He commenced duty the previous evening at 23.00 hrs, received a one hour fatigue break and had resumed position at 04.40 hrs.

When describing the operations leading up to the event the SMC stated that it was exceptionally busy at the time as LVPs[8] had been in force for the first wave of departures and when cancelled at approximately 05.10 hrs he had been busy amending flight strips and clearances for the commencement of dual operations. When dual operations commenced, it brought the usual level of complexity to the operation.

The SMC stated that he cleared EI-EKK along the Foxes and Echo 1 to hold short of both runways. He added that he was aware that EI-EKK was in a sequence for departure but expected continuous movement as the AMC had been releasing aircraft off RWY 28 without delay.

The SMC then cleared EI-EMH along the Foxes and Alpha to hold short of RWY 34. He did so in the expectation that EI-EKK would not stop on TWY F1 and so the clearance was both safe and efficient. When asked if he was observing the movement of EI-EKK aircraft he stated that he was, using the Advanced Surface Movement Guidance and Control System (ASMGCS) and was confident that everything was operating smoothly. He added that he looked at EI-EKK, saw it moving, issued a clearance to another aircraft holding on LINK 5 for RWY 28 and reconfirmed the clearance to EI-EMH.

He believed that it must have been during these transmissions that EI-EKK stopped on TWY F1. Following these observations and transmissions he returned to his other SMC duties which included board management, changing of Standard Instrument Departures (SIDs) for dual runway operations and planning the next departure sequence. He then heard the AMC mention that there had been a collision on LINK 2 between two aircraft and realised that EI-EMH and EI-EKK had collided.

With regard to taxiing restrictions which are in place for the occurrence area (**Section 1.6.3.1**) the SMC said that every effort was made to fully comply with taxiing restrictions. However, where aircraft are in a queuing scenario, it is not possible to fully implement such restrictions without serious implications for traffic flow and efficiency.

1.3.4 Air Movements Controller (AMC)

The AMC, who had a valid licence, reported that he had just started work at 05.30 hrs, was well rested and considered he was fit for duty. He had been releasing departures off RWY 28 and cleared EI-EMH to line up on RWY 34 as he believed that EI-EMH was on TWY A ready for departure and clear of all other aircraft. It was only when the pilot of EI-EMH stated that they wished to return to stand that he requested the aircraft to confirm its position so that he could determine the best route to stand. When made aware of the collision, he immediately instructed the ground controller (SMC) to contact the fire station.

[8] **LVPs:** Low Visibility Procedures

1.4 Weather

Weather conditions at the time of the occurrence were reported as:

Surface wind:	270°/11 kts
Visibility:	3,000 m in mist
Cloud:	Few at 100 ft and Broken at 20,000 ft
Environmental:	Early morning darkness
Precipitation:	Nil

1.5 Recordings

1.5.1 Aircraft Recordings

Both the Flight Data Recorder (FDR) and the Cockpit Voice Recorder (CVR) on each aircraft were preserved by the Flight Crews after the occurrence. All four recorders were subsequently removed by the Investigation and were downloaded at the AAIU.

Prior to the collision the CVRs portrayed a sterile and unrushed environment in both cockpits. An audible 'thump' was clearly heard on the cockpit area microphone channel of EI-EKK's CVR, but no such sound was recorded in EI-EMH.

The FDR for EI-EKK confirmed that the aircraft was stationary at the time of impact, with the parking brake set. In addition, the FDR for EI-EMH showed that the aircraft's ground speed at the time of impact was approximately 5 kts.

1.5.2 ATC Recordings

All ATC transmissions and surface movement radar recordings specific to the occurrence were impounded by EIDW ATC and were subsequently reviewed by the Investigation. An ATC transcript specific to the two occurrence aircraft is presented at **Appendix B.**

EIDW ATC utilises ASMGCS. This system provides for routing, guidance and surveillance for the control of aircraft and vehicles in order to maintain the declared surface movement rate under all weather conditions within the aerodrome visibility operational level (AVOL), while maintaining the required level of safety.

Replay of the ASMGCS data confirmed the movements of both aircraft from push back to the final resting positions. As EI-EMH taxied through LINK 2 it tracked slightly right of the taxiway centreline at a ground speed of approximately 5-6 kts.

The ASMGCS radar returns (as seen by the SMC) do not specifically 'paint'[9] the extremities of the aircraft wings or wingtips, but rather display a circle (which is the aircraft transponder position) and primary radar returns in the form of a collection of boxes **(Graphic No. 3)**.

Each aircraft has a unique label identifier which includes the flight number, aircraft type, weight category, assigned departure routing and ground speed.

[9] **Radar Paint:** A term used to identify a synthetic return/display of an object on a radar screen

Graphic No. 3: ASMGCS return at point of contact

A review of a series of ASMGCS recordings identified that it was not uncommon for aircraft to stop on the demarcation line LINK 2/F1 when queuing aircraft were ahead on LINK 1/E1.

1.6 Aerodrome Information

1.6.1 Control Tower

The control tower, from which both the SMC and the AMC were operating, is located approximately one kilometre northwest of LINK 2 where the collision took place.

1.6.2 Dual Runway Operations

In order to maximise throughput during the morning departure flow at Dublin Airport, when RWY 28 is active, runway operations can also take place from RWY 34 for Medium and Light wake turbulence category departures on routes to the east, northeast, northwest and west. Departures on routes to the south, southwest and southeast can depart from RWY 28. RWY 34 is available for departures only between the hours of 06.30 and 08.00 hrs (Local), subject to Visual Meteorological Conditions (VMC) and ASMGCS serviceability. Such operations are referred to as dual runway operations.

Aircraft departures opting for RWY 34 are expected to depart from the intersection with TWY A without a back-track. Aircraft unable to comply with RWY 34 departure limitations will depart from RWY 28. It is noted that when dual runway operations are in force, the STOPBAR lights for TWY A are inhibited.

1.6.3 Local Traffic Regulations

1.6.3.1 Aeronautical Information Publication (AIP)[10] Ireland

AIP Ireland provides, inter-alia, under EIDW AD 2.20 the following Local Traffic Regulations for ground movement of aircraft:

EIDW AD 2.20 LOCAL TRAFFIC REGULATIONS

1. Ground Movement

[10] **AIP:** The AIP is contained within the IAA's Integrated Aeronautical Information Package (IAIP)

1.1 General

i. Pilots should use the minimum power necessary while taxiing. In apron areas, pilots should operate at the minimum power commensurate with the intended manoeuvre, due to the effect of jet blast on personnel, equipment and buildings.

ii. Flight crew are responsible for wingtip clearance and are reminded of the importance of maintaining a careful lookout at all times, regardless of location and visibility conditions.

iii. ATC may require aircraft to manoeuvre in close proximity to other aircraft. Avoidance of other aircraft is the responsibility of the flight crew involved. If doubt exists as to whether an aircraft can be passed safely, the flight crew should stop, advise ATC, and request alternative instructions if available.

iv. In order to assist in the maintenance of safe separation of aircraft, when flight crew are instructed to stop at any runway-holding or intermediate holding position they should position the aircraft as close as possible to the relevant pavement marking while ensuring that the marking remains visible from the cockpit.
[…]

1.3 Taxiing Restrictions

Location	***Situation***	***Restriction***
TWY A	*Outbound aircraft holding on TWY A*	*Aircraft movement not permitted between TWY F1 and LINK 2/TWY F2 or vice versa*
TWY B1	*Aircraft with wingspan 36m or greater operating on TWY B1*	*Aircraft not permitted on TWY Z*
TWY B2	*Outbound aircraft (wingspan less than 36m) holding on TWY B2*	*Aircraft movement not permitted between TWY F1 and TWY E1/TWY B1 or vice versa*
TWY B2	*Outbound aircraft (wingspan 36m or greater) holding on TWY B2*	*Aircraft movement not permitted between TWY F1 and TWY E1/TWY B1 or vice versa and Aircraft are not permitted to taxi between TWY E1 and TWY B1/TWY Y/TWY Z or vice versa*
TWY B2	*Inbound aircraft (wingspan less than 36m) holding on TWY B2*	*Movement between TWY A and RWY16-34/TWY B3/ TWY E2 or vice versa restricted to aircraft with wingspan less than 36m*
TWY B2	*Inbound aircraft with wingspan 36m or greater holding on TWY B2*	*Aircraft movement not permitted between TWY A and RWY16-34/TWY B3 / TWY E2 or vice versa*
TWY E1	*Outbound aircraft (wingspan less than 36m) holding on TWY E1*	*Movement between TWY B1 and TWY B2/TWY F1 or vice versa restricted to aircraft with wingspan less than 36m*
TWY E1	*Outbound aircraft (wingspan 36m or greater) holding on TWY E1*	*Aircraft movement not permitted between TWY B1 and TWY B2/TWY F1 or vice versa*
TWY E4	*All operations*	*Restricted to daylight hours only and aircraft with wingspan 30m or less*

TWY E5	*All operations*	*Restricted to aircraft with wingspan less than 36m*
TWY E6	*Outbound aircraft (wingspan less than 36m) holding on TWY E6*	*Movement between TWY B6 and TWY B7 or vice versa restricted to aircraft with wingspan less than 36m*
TWY E6	*Outbound aircraft (wingspan 36m or greater) holding on TWY E6*	*Aircraft movement not permitted between TWY B6 and TWY B7 or vice versa*
TWY E7	*Outbound aircraft (wingspan less than 36m) holding on TWY E7*	*Movement between TWY B6 and TWY B7 or vice versa restricted to aircraft with wingspan less than 36m*
TWY E7	*Outbound aircraft (wingspan 36m or greater) holding on TWY E7*	*Aircraft movement not permitted between TWY B6 and TWY B7 or vice versa*
TWY F1	***Aircraft travelling towards LINK1/TWY B1/TWY E1 holding on TWY F1***	***Aircraft movement not permitted between TWY A and LINK 2/TWY F2 or vice versa***
TWY F1	***Aircraft travelling towards LINK 2/TWY F2 holding on TWY F1***	***Aircraft movement not permitted between TWYs B1 and B2 or vice versa or between TWY E1 and TWY B1/TWY Y/TWY Z or vice versa***

Note: Restrictions relevant to TWY F1 in bold type face.
[…]

8. RUNWAY INCURSION HOTSPOTS - Aerodrome Facilities in vicinity of thresholds Runways 28 and 34

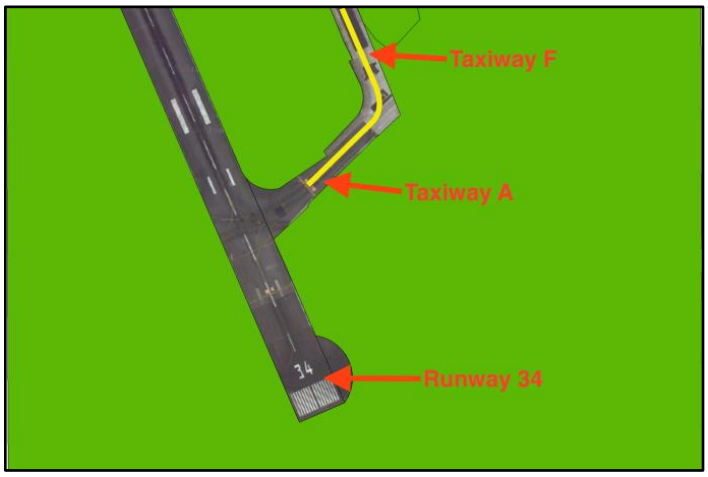
8.1 The following résumé and associated diagram **(see Appendix C)** *are provided for ease of familiarity with aerodrome facilities on this complex area of the aerodrome.*

The attention of all aircrews is drawn to the layout of taxiways, the location of holding positions, and the proximity of the thresholds of Runway 28 and Runway 34. Close attention must be paid to visual aids (markings, lighting, signage).

1.6.4 Evolution of Taxiways in the area of LINK1/LINK 2

The runway, taxiway and ramp infrastructure have developed over the years at Dublin Airport in order to meet the on-going capacity demands. The following diagrams are for illustrative purposes only and are not to scale. For ease of description the current names of taxiways and runways have been used (even though taxiway and runway designators have changed with time).

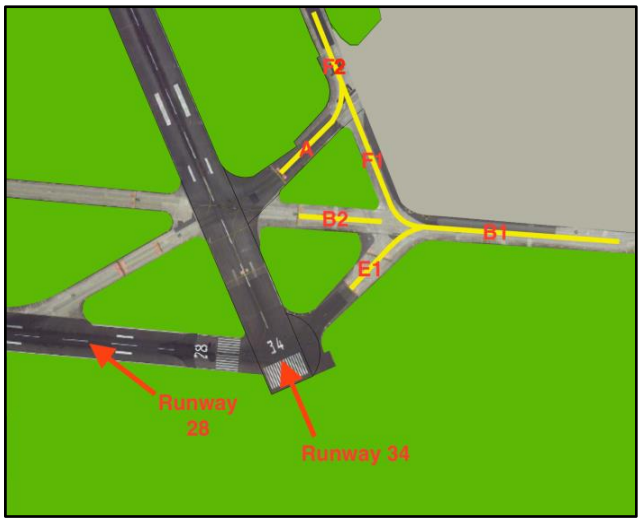
Graphic No. 4 shows RWY 34 prior to the development of RWY 28 (pre-1989) and the new Pier 4. TWY F led directly to TWY A, which was the normal access onto RWY 34. Aircraft entered the runway approximately 200 m north of the threshold, and those requiring full length would backtrack to a turning circle at the RWY 34 threshold.



Graphic No. 4: RWY 34 with Taxiway A

RWY 28 was opened in 1989. It was built from the threshold of RWY 34 in a westerly direction. Additional taxiways were also constructed to service the new runway.

The threshold of RWYs 28 and 34 was accessed by TWY F1 and E1. TWY B, parallel to RWY 28, was constructed, crossing RWY 34 abeam TWY A and intersecting the vertex of F1 and E1 (**Graphic No. 5**).

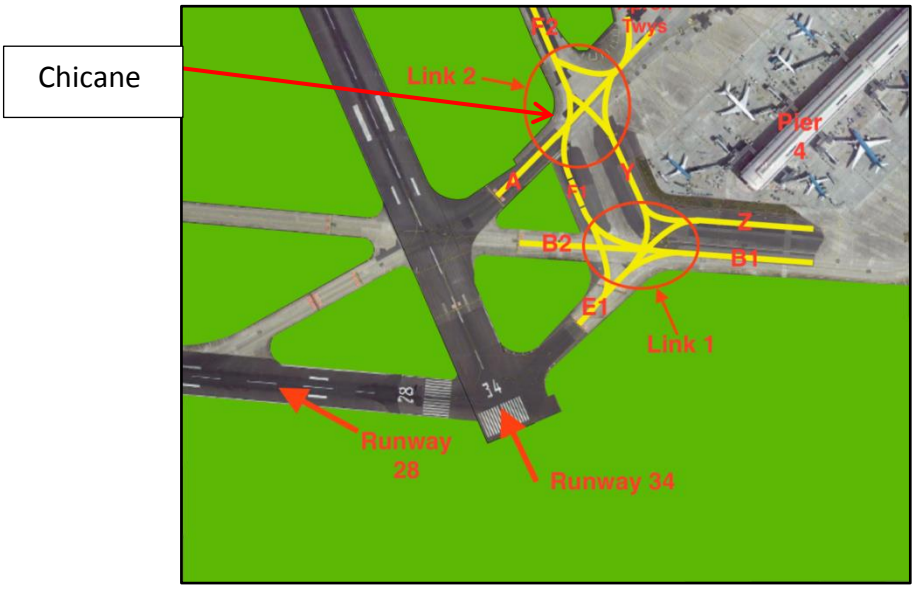


Graphic No. 5: New RWY 28 with TWY access through F2/F1/E1

The construction of Pier 4 (November 2010) on the south apron resulted in the following changes between F2 and E1/B2: TWY F1 was repositioned southwest of its original line, on a new paved area. A new taxiway, TWY Y, was introduced, parallel and north east of F1. TWY Z was introduced parallel and north of B1. Two 'LINK' taxiways, LINK 1 and LINK 2, were introduced.

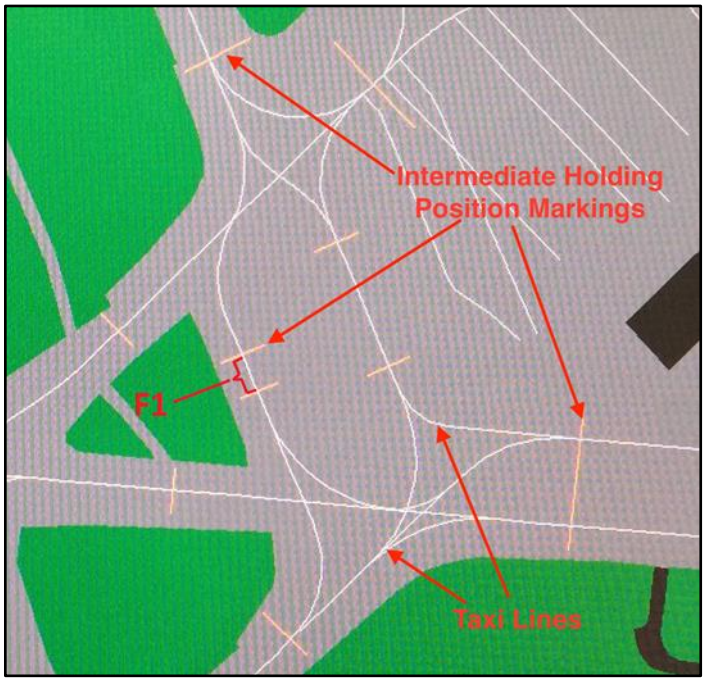
Departing aircraft using TWY A or TWY E1 to access either RWY 28 or RWY 34 were required to taxi through one, or both, of the LINK taxiways. LINK 1 and LINK 2 were joined by TWY F1 and TWY Y. In total 10 Intermediate Holding Position Markings (IHPM) demarcate LINK 1 and LINK 2.

These changes resulted in the introduction of a chicane taxiway centreline formation from TWY F2 through LINK 2 to TWY F1 and the shortening of TWY F1 to 20 m (**Graphic No. 6 and No. 7:**). It should be noted that TWYs Y and Z had been withdrawn from service prior to the subject event.



Graphic No. 6: Taxiway formation LINK 1/LINK 2

Graphic No 7 represents a close-up of the LINK 1/LINK 2 area with the IHPMs, taxi lines, and TWY F1 shown.



Graphic No 7: Intermediate Holding Position Markings LINK 1/LINK 2

TWY F1 is a short taxiway, connecting LINK 2 to LINK 1. It is bounded at either end by an IHPM, one between F1 and LINK 1 and the other between F1 and LINK 2. TWY F1 measures 20 m in length. When an aircraft taxies in a southerly direction on F1, and stops at the southern IHPM between F1 and LINK 1, there is sufficient clearance for aircraft up to Category E[11] to taxi from TWY B2 onto LINK 1.

[11] **ICAO aircraft size category:** Category-E aircraft wingspan defined as 52 m up to but not including 65 m

Likewise, when taxiing in a northerly direction, the northern IHPM between F1 and LINK 2 is designed to give the required clearance for aircraft up to Category E taxiing from TWY A onto LINK 2 and vice versa. The dimensions of TWY F1 mean that any aircraft greater than 20 m in length cannot hold at either of the two IHPMs on F1 without infringing on the LINK taxiway behind it.

1.6.5 LINK 1/LINK 2 Taxiway System

The Investigation spoke confidentially to a number of controllers and national commercial transport pilots who operate regularly at EIDW, regarding the LINK 1/LINK 2 taxiway system.

In general terms, the controllers consider that while the taxiing restrictions (**Section 1.6.3.1**) were operationally helpful, the restrictions specific to the LINK 1/LINK 2 were complex and difficult to fully implement when aircraft were in a queuing scenario. Furthermore, it was said that visiting foreign pilots regularly sought additional routing information from ATC when taxiing within the vicinity of LINK 1/LINK 2. Also, pilots familiar with operating regularly through the LINK 1/LINK 2 taxiway system considered the taxiway system to be complex and that the designations are confusing compared to other airports.

1.6.6 Dublin Airport Activity

Dublin Airport has seen significant growth over the years and in 2014 the airport handled over 21.7 million passengers, equating to an average of 60,000 passengers per day. During busy periods ATC handle approximately 47 aircraft runway movements per hour.

1.7 International Provisions

1.7.1 Annex 2 - Rules of the Air

Annex 2 to the Convention on International Civil Aviation provides Standards and Recommended Practices for the Rules of the Air.

Section 3.2 Avoidance of collisions provides that:

> *Nothing in these rules shall relieve the pilot-in-command of an aircraft from the responsibility of taking such action, including collision avoidance manoeuvres based on resolution advisories provided by ACAS equipment, as will best avert collision.*
>
> *Note 1.- It is important that vigilance for the purpose of detecting potential collisions be exercised on board an aircraft, regardless of the type of flight or the class of airspace in which the aircraft is operating, and while operating on the movement area of an aerodrome.*

1.7.2 Annex 11 – Air Traffic Services

Annex 11 to the Convention on International Civil Aviation provides Standards and Recommended Practices for Air Traffic Services (ATS).

Section 2.2 prescribes that the objectives of an ATS shall be to:

(a) prevent collisions between aircraft;

(b) prevent collisions between aircraft on the manoeuvring area and obstructions on that area;

(c) expedite and maintain an orderly flow of air traffic;

(d) notify appropriate organizations regarding aircraft in need of search and rescue aid, and assist such organizations as required.

Section 3.1 requires, inter-alia, that Air Traffic Control Service shall be provided:

[…]

d) to all aerodrome traffic at controlled aerodromes

Section 3.3 requires, inter-alia, that an Air Traffic Control unit shall:

[…]

c) issue clearances and information for the purpose of preventing collisions between aircraft under its control.

1.7.3 Annex 14 Aerodromes - (Volume 1 Aerodrome Design and Operations)

Annex 14 to the Convention on International Civil Aviation provides Standards and Recommended Practices that prescribe the physical characteristics and obstacle limitation surfaces to be provided for at aerodromes, and certain facilities and technical services normally provided at an aerodrome.

Section 3.9 Taxiways, requires under 3.9.1 General that:

Taxiways should be provided to permit the safe and expeditious surface movement of aircraft. Guidance on the layout of taxiways is given in the Aerodrome design Manual (Doc 9157), Part 2.

1.7.4 ICAO Aerodrome Design Manual Part 2

The ICAO Aerodrome Design Manual Part 2 provides guidance for the layout of taxiways, aprons and holding bays. Section 1.1 Taxiway System provides for the functional requirements for taxiways and identifies at 1.1.2 that:

The taxiway system should be designed to minimize the restriction of aircraft movement to and from the runways and apron areas. A properly designed system should be capable of maintaining a smooth, continuous flow of aircraft ground traffic at the maximum practical speed with a minimum of acceleration and deceleration.

Section 1.1.5 specifies principles that should be considered in the planning the general layout of the taxiway system, including inter-alia that;

[…]

b) taxiway routes should be as simple as possible in order to avoid pilot confusion and the need for complicated instructions;

c) straight runs of pavement should be used wherever possible;

d) taxiway crossings of runways and other taxiways should be avoided whenever possible.

1.8 Previous Relevant Occurrences Investigated by the AAIU

1.8.1 General

The AAIU has conducted previous investigations into occurrences that were associated with the general area of LINK 1, LINK 2, TWY A and TWY E1 at Dublin Airport.

On 16 October 2010, the AAIU investigated a runway incursion 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 11 November 2011) made a Safety Recommendation regarding the provision of STOPBAR lights on E1.

The Dublin Airport Authority (DAA) has since undertaken an extensive 'safe-guarding' project and has installed switchable STOPBARS on specific taxiways to protect against runway incursions (**Appendix C: Runway Incursion Hotspots and STOPBARS**).

On 21 May 2011, the AAIU investigated another runway incursion in which a Boeing 737-800 was taking off on the active Runway (RWY) 16 at EIDW and an Airbus A321 mistakenly taxied onto the latter part of the same runway from TWY A.

The Boeing 737-800 conducted a high-speed Rejected Take-Off (RTO) and stopped approximately 360 m from the A321. The Report of the Investigation (Report No 2012-017 published on 24 October 2012) made two safety recommendations to the DAA relating to a review of taxiway designation, and consideration for aligning TWY F1 and F2.

Both safety recommendations were accepted by the DAA and the following is an update on the status of implementation as provided by the DAA:

Safety Recommendation IRLD2012005 – relating to a review of taxiway designation at Dublin Airport.

- *The review considered options and endorsed a plan and drawing to rename most of the existing taxiway system at Dublin in order to simplify taxi instructions. Such a proposal involves replacement of a large number of existing light signage and bases across the airfield.*
- *The first of these projects has since commenced on site (December 2014).*
- *Work has commenced on several projects that integrate enabling works for the signage modifications required in various areas.*
- *As part of the work packages, detailed survey works to identify the number and positions of the new signage will commence in Q2 2015.*
- *Replacement of signage and associated promulgation programme will commence on a phased basis from Q3 2015.*

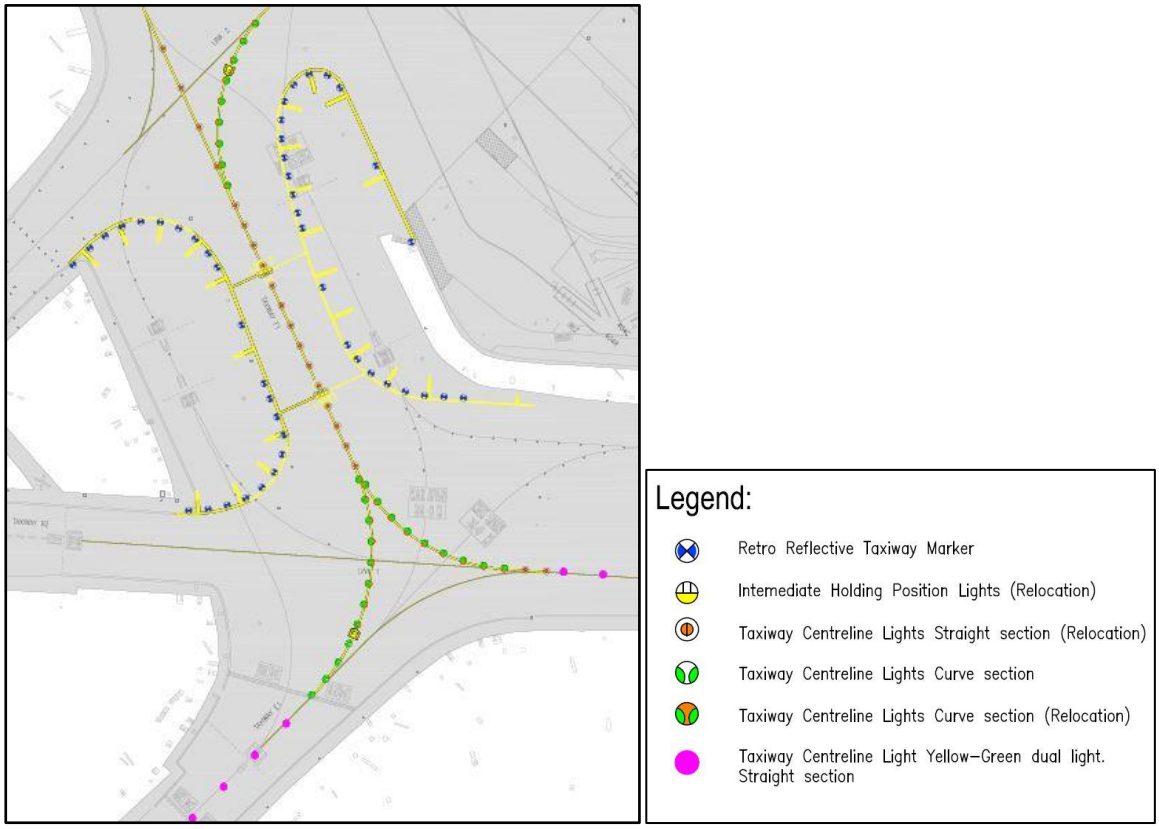
Safety Recommendation IRLD2012006 – relating to aligning taxiways F1 and F2 at Dublin Airport.

- *A comprehensive review of operations in this area has been conducted by the DAA. This considered safety, occurrence history, outcome of occurrence investigation, capacity issues as well as current and future operational requirements.*

- *A DAA cross-functional risk assessment group assessed the operational process in this area. The group concluded that the NOTAM advising that TWY Y & Z are not in service should remain.*
- *Extensive consultation to evaluate other options for the taxiway layout in the area was carried out with key stakeholders through the Dublin Airport Operations Planning Group (DAOPG). A sub-group of the DAOPG was formed in November 2014 to consider these issues in detail.*
- *The group recently concluded that TWY Y will be decommissioned and the alignment of TWY F1 & TWY F2 will be progressed in line with the AAIU recommendation.*
- *Re-alignment of the Taxiway centreline, with the associated works and promulgation, is planned for Q4 2015.*
- *DAA is also planning to realign TWY E1 so that a realigned TWY E1 will present traffic to RWY 28 at a ninety degree angle instead of at an obtuse angle. This is a triggered project that is approved by the Commission for Aviation Regulation for the Regulatory period 2015 to 2019.*
- *In the context of the updated Capital Investment Programme, DAA is proposing a number of projects which will have positive implications from the perspective of safety, pavement rehabilitation and capacity enhancement. DAA commits to fully implementing the safety recommendation during 2015.*

1.8.2 Alignment F1 and F2 Taxiways

A further update was provided by the DAA's development section on the 30 June 2015 with regard to the TWY F1-F2 alignment. A detailed design (**Graphic No. 8**) has been completed. The project has been sent out to tender and it is anticipated that the project will commence in Q3, 2015.



Graphic No. 8: Alignment F2 and F1 taxiways

The project involves the following scope of works:

- The removal of light fittings on TWY Yankee (the line markings have already been removed to reduce complexity in the area)
- The installation of a centreline lighting and marking (with taxiway designators) along the re-aligned F1 taxiway
- Removal of line marking and centreline lighting from the existing F1
- Introduction of taxiway "shoulders" with retro-reflective edge markers to further delineate the new F1 taxiway.

This is phase one of a two phase project with the second phase connecting the new TWY F1 configuration with TWY Z and associated above ground level installations.

1.9 Safety Actions

1.9.1 Airport Authority

In addition to information provided at **Section 1.8**, in their response to the Draft Report, the airport authority advised the Investigation of the following:

- *Following extensive consultation with stakeholders including airlines, IAA-ATC and IAA-SRD in the last year, Dublin Airport is currently finalising a plan to implement a revised taxiway designation system. New signage infrastructure will be in place by end 2015 in the vicinity of Taxiway A and the proximate Apron 5G area. The full campus taxiway re-designation will be implemented in the course of the next three years as part of the apron and taxiway upgrade projects.*
- *In addition, following discussions with relevant stakeholders, the alignment of taxiway F1 and F2 is currently underway and is due for completion within the next month.*

1.9.2 Airline Operator

Since this occurrence the Operator advised the Investigation that the following safety actions have been taken:

- *Information pertaining to Ground Collisions (G COL) included in all presentations by Base Captains to ATC Units at their respective bases, including details of this particular event.*
- *G COL presentation (Ground damage during taxi with the introduction of winglets) to be part of Annual Roadshow rolled out across all bases commencing April 2015.*
- *The Operators risk model on G COL was updated following this occurrence, including escalation factor night time operations with glare from lighting equipment.*
- *Safety Bulletin published on pilot crew dock highlighting a brief synopsis of the occurrence.*
- *Memo issued re 'Wingtips – Caution when parking'.*

1.9.3 ATC

Dublin ATC operations advised the Investigation that they attended the DAOPG meeting on 29th October 2014. Also in attendance were representatives from the DAA, and a number of local airline representatives.

The DAA reported on simulations which were on-going to assess the safety and efficiency of ground operations, in particular in the complex area to the west of Pier 4. These simulations included assessment of a re-alignment of Taxiways F1 and F2. At this meeting it was agreed that a new sub-group should be established urgently to examine and make recommendations for the improvement of operations in the vicinity of taxiways Y/Z/F1/B1/A/B2 & E1 and Links 1 & 2 at Dublin Airport. This was supported by all the other attendees at this DAOPG meeting and the DAA agreed to chair this new subgroup. The first meeting of the sub-group was held on 10th November 2014.

As part of this new group's work the AIP EIDW AD 2.20 - Section 1.3 (Local Traffic Regulations) was reviewed, and there was an understanding that it did not apply when aircraft were queuing for departures from both RWY 28 and RWY 34. This understanding was also confirmed by the airline operators who attended the meeting. Operators were also reminded of their obligations in relation to AIP AD 2.20 - Section 1.1 and all attendees acknowledged that the responsibility for wingtip clearance rested with the pilot.

Dublin ATC subsequently reviewed the operation in this area and developed a new procedural aerodrome notice outlining additional procedures and phraseology to be used for aircraft taxiing in this area. These new procedures were analysed under the safety management system and submitted to the IAA Safety Regulatory authority for review and acceptance.

Following regulatory acceptance of this new procedure, discussion and agreement with the DAA and airline operators and a requirement for the DAA to update and amend AIP EIDW AD 2.20 - Section 1.3, the procedure was introduced.

1.9.4 Safety Regulation Division (SRD) of the IAA

Subsequent to this occurrence, the SRD conducted a review of ATC procedures and documentation and found that with regard the TWY F1 restrictions, the instructions and guidance provided to ATC staff should be improved. The SRD then required that Dublin ATC propose corrective action to ensure that the guidance and instruction available to ATC staff was clear and precise. ATS Operations Notice (AON 084-14) on 'Wingtip Clearances' was produced by Dublin ATC as part of their corrective action plan and was accepted by SRD. The AON came into effect on the 22 December 2014 and had detailed instructions and guidance related to wingtip clearances at Dublin Airport. Specific to Taxiing Restrictions for TWY F1 (EIDW AD 2.20, 1.3) additional text was provided as per **Table No. 2** below to take account of a 'Queuing Scenario'.

Location	IAIP RESTRICTION	FREE-FLOWING SITUATION	**QUEUEING SCENARIO DIFFERENCE**
TWY F1	Aircraft travelling towards LINK 1 /TWY B1 /TWY E1 holding on TWY F1	Aircraft movement not permitted between TWY A and LINK 2/TWY F2 or vice versa	**Caution must be issued to pilots when taxiing between TWY A and LINK 2 /TWY F2 or vice versa**
TWY F1	Aircraft travelling towards LINK 2 /TWY F2 holding on TWY F1	Aircraft movement not permitted between TWYs B1 and B2 or vice versa or between TWY E1 and TWY B1 / TWY Y / TWY Z or vice versa	**Caution must be issued to pilots when taxiing between TWYs B1 and B2 or vice versa or between TWY E1 and TWY B1/TWY Y /TWY Z or vice versa**

Table No. 2: Additional instructions specific to TWY F1 (bold type face)

1.9.5 Air Navigation Service Provider (ANSP) of the IAA

In their response to the Draft Report, the IAA's ANSP advised the Investigation of the following:

- *New procedures were implemented to permit the conditional clearance of an aircraft onto TWY A whilst an A/C is on TWY F1. This procedure is only applicable during dual runway operations (06:30 – 08:00z) and exclusively to* [specific Irish Operators]. *B2 is closed whilst this procedure is in use. The procedure was accepted by ANSD and is supported by the aforementioned operator's SOPs. The local airline SOPs ensure that the conditions are met and that the appropriate AIP restriction is applied.*

- *Outside of dual runway operational hours, TWY A is closed and TWY B2 re-opened. The operation of B2 is subjected to restrictions regarding the movement of aircraft on 16/34, B1, F1, Link 1 and E1. This procedure was also accepted by ANSD and is supported by the local airline operators.*

- *Appropriate staff notices were issued and all ATCO's were formally briefed on these procedures.*

- *An ATIS message now broadcasted: "Flight Crew are responsible for wingtip clearance and shall exercise particular caution in hotspot areas. ATC instructions may not ensure wingtip clearance". All hotspot areas are defined on the aerodrome chart in the AIP.*

- *In addition, the IAA ANSP has played a very proactive role at DAOPG (Dublin Airport Operations Planning Group) and LRST (Local Runway Safety Team) meetings where solutions to wingtip incidents have been extensively discussed.*

1.10 Additional Information

1.10.1 Winglets/Blended Wings

Wingtip devices such as winglets and blended wings were introduced to improve aircraft performance by reducing drag, which in turn reduces fuel burn and associated emissions. There are several types of wingtip devices, and although they function in different manners, the intended effect is always to reduce the aircraft's drag by partial recovery of the tip vortex energy. Wingtip devices can also improve aircraft handling characteristics. Such devices increase the effective aspect ratio of a wing without significantly increasing the wingspan.

For aircraft such as the occurrence aircraft and aircraft of similar configuration, the addition of winglets does increase the wing dimensions of the aircraft. However, they do not extend upwards perpendicular to the horizontal plane, but rather extend upwards, backwards and outwards from the wing itself. Specific to the occurrence aircraft type, the winglet extends the wing by 1.52 m from the wing joint, adds 0.75 m to the normal wing length and rises to a height of 2.77 m above the wing (**Figures No. 1 and No. 2**).

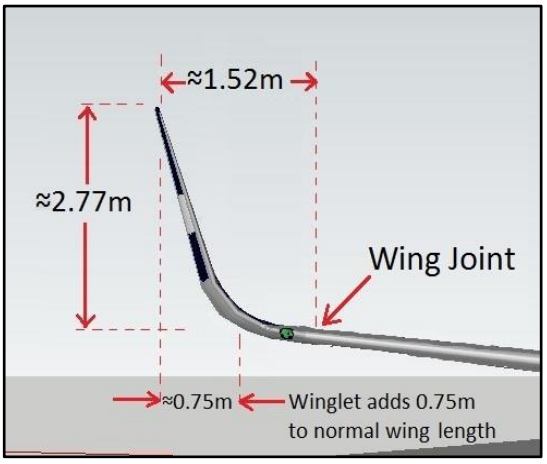
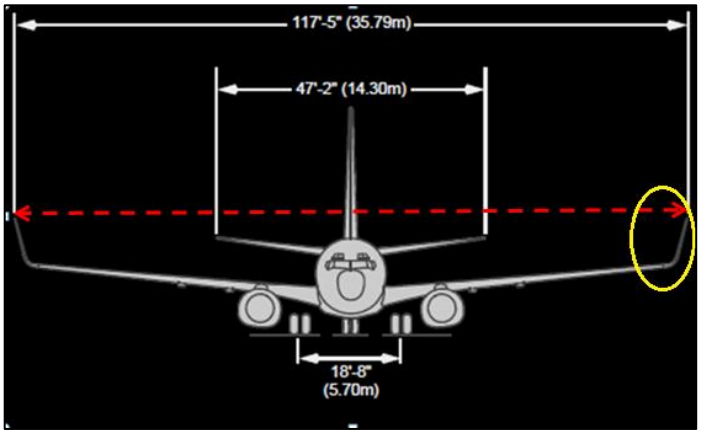


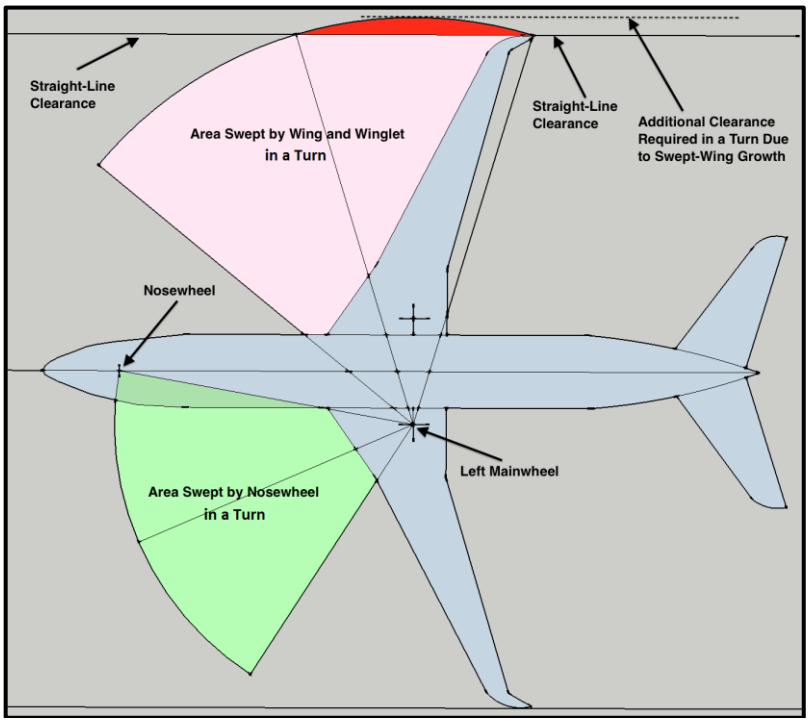
Figure No. 1: Side view of Winglet. **Figure No. 2:** View of Winglet from leading edge.

The increase in height is significant as it extends above the height of the aircraft's horizontal stabiliser (**Graphic No. 9**). Prior to the introduction of winglets, wingtips would have had sufficient vertical clearance to pass underneath the horizontal stabilizer of the same aircraft type.



Graphic No. 9: Winglet extending above the height of the aircraft's horizontal stabiliser

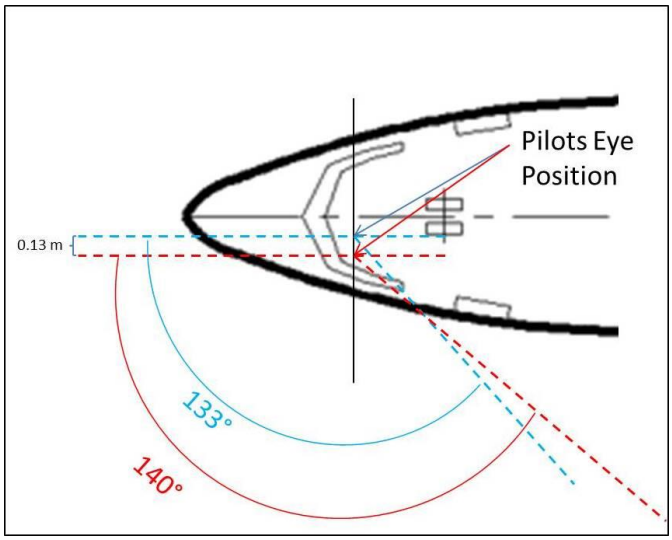
Most modern transport aircraft have swept wings which are subject to a phenomenon known as 'swept wing growth' or 'wing creep'. This occurs during a turn when the wingtip describes an arc greater than the normal wingspan due to the geometry of the aircraft and the arrangement of the landing gear (**Graphic No. 10**).



Graphic No. 10: Turning radius 'wing creep' depicted in red

1.10.2. Cockpit Visual Angles in the Horizontal Plane

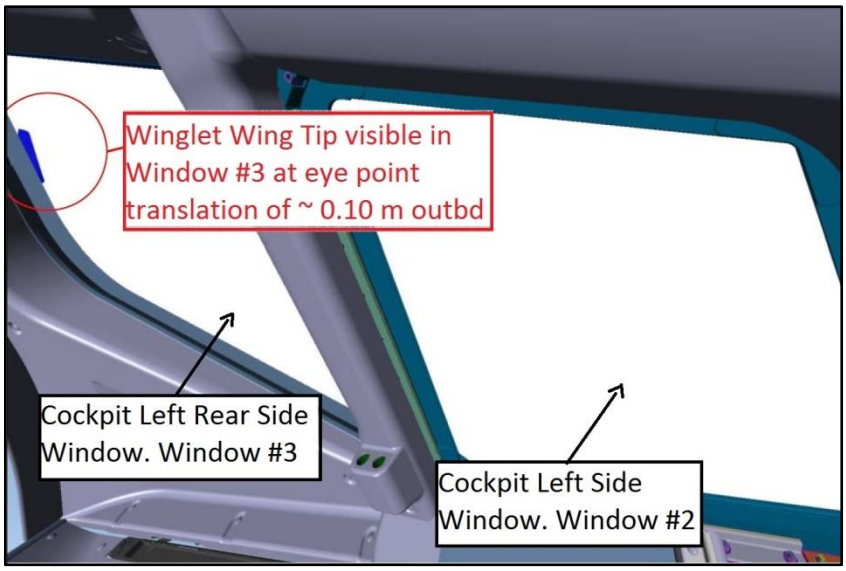
Specific to the occurrence aircraft type and while seated in the left-hand seat, the visual angle in the horizontal plane through the pilot's normal eye position and looking towards the wingtip is 133°. If the pilot moves his head 0.13 m outboard of the normal pilot's eye position the visual angle in the horizontal plane increases to 140° (**Graphic No. 11**).



Graphic No. 11: Cockpit visual angles in the horizontal plane

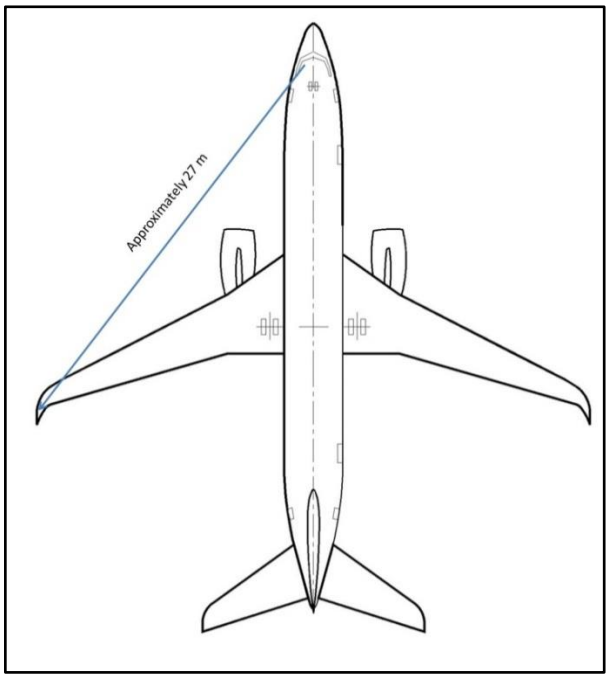
The aircraft Manufacturer was asked by the Investigation to analyse how much of the winglet was visible from the seating position of the Commander (left-hand seat). The Manufacturer provided a graphic, which is reproduced in **Graphic No. 12**.

This approximation shows that the left winglet of the B737-800 is just visible from the seated position in the pilot's seat, when the viewer's head is turned and moved 0.10 m outboard to the left.



Graphic No. 12: Approximate visibility of winglet wingtip through window No. 3 - 0.10 m outboard of the normal seating position (Boeing Proprietary Copyright © Boeing - Reprinted with permission of The Boeing Company)

The Investigation also carried out its own examination of the view of the wingtip from the Commander's seat. The direct line of sight distance from the Commanders normal seating position to the winglet was approximately 27 m (**Graphic No. 13**).



Graphic No. 13: Line of sight distance between cockpit and winglet

It was noted that in order to obtain a view of the complete winglet, a pilot would need to move their head closer to the No. 2 window, and then look back through the No. 3 window. This is not a natural seating position, and takes the pilot's visual attention away from the straight ahead view. The Investigation further noted that the thickness and depth of the pillar dividing the No. 2 and No. 3 window interfered with the view.

Note: The steering (tiller) on the subject aircraft is located on the left side of the cockpit; all taxiing is performed from the left hand seat.

1.10.3 Wingtip Proximity Warning Aids

Having undertaken 12 investigations (since 1993) into accidents in which large public transport aircraft wingtips collided with other aircraft or objects on the taxiway, the National Transport Safety Board (NTSB) of the USA, issued (Sept 2012) two Safety Recommendations (SRs) on the matter to the Federal Aviation Administration (FAA). A full version of the case made for both SRs can be found at http://www.ntsb.gov/safety/safety-recs/recletters/A-12-048-049.pdf . The same SRs were also issued to the European Aviation Safety Agency (EASA).

In general terms, the first SR sought that the FAA: "*Require the installation of an anti-collision aid, such as a camera system, on all newly manufactured and newly type-certificated large airplanes and other airplane models where the wingtips are not easily visible from the cockpit to provide a cockpit indication that will help pilots determine wingtip clearance and path during taxi".*

The second SR *sought that the FAA: "Require all existing large airplanes and other airplane models where the wingtips are not easily visible from the cockpit to be retrofitted with an anti-collision aid, such as a camera system, to provide a cockpit indication that will help pilots determine wingtip clearance and path during taxi".*

In response from the Addressee (May 2013), it was stated that: "*the FAA examined the potential safety benefit and feasibility of these recommendations as well as current alternatives to mitigate the risk of wingtip collisions during taxi operations of large transport airplanes.*

The wingtip collision accidents cited by the Board, while resulting in damage to the aircraft involved, did not result in any passenger, flight, or ground personnel injuries. We continue to find that while a camera system may provide a small benefit at very low speeds, the two-dimensional image and limited field-of-view make it unlikely that wingtip cameras would provide a measurable reduction in wingtip collision incidents at normal taxi speeds. From a safety risk management perspective, the limited safety benefit of a taxi anti-collision system, such as wingtip cameras, does not justify the cost burden of an FAA mandate for their installation on the transport airplane fleet. As previously noted, the FAA remains committed to continued improvement of ground operational procedures by monitoring industry research and development of other technologies to mitigate the risks of taxi collisions with other aircraft and ground equipment. We also foster the installation of such new technologies through the FAA's Design Approval Process. We carefully reconsidered our actions, and we continue to find that our response to these safety recommendations reflect the best interests of aviation safety. Accordingly, we will take no further action in direct response to these safety recommendations".

In a closing response from the NTSB (July 2013) it was recorded that: "*Although none of the wingtip collision events described in our recommendation issuance letter resulted in any injuries or deaths, we continue to believe that a collision during taxi between the wingtip of a large aircraft and another aircraft or object is a dangerous event that the FAA needs to address. However, the FAA reiterated that the limited safety benefit of a taxi anti-collision system, such as wingtip cameras, does not justify the cost burden of mandating such a system's installation and that, as a result, the FAA's decision not to take the recommended actions "reflect the best interests of aviation safety." Consequently, Safety Recommendations A 12-48 and A 12-49 are classified CLOSED—UNACCEPTABLE ACTION".*

In their response (March 2013) to the same SRs, EASA *"acknowledges NTSB's concern regarding determining wingtip clearance during taxi operations and has examined the potential safety benefit and feasibility of this Safety Recommendation. All the wingtip collision events cited in the NTSB letter, while resulting in damage to the aircraft involved, did not result in any passenger, flight, or ground personnel injuries. From a safety risk management perspective, the limited safety benefit of a taxi anti-collision system, such as wingtip cameras, does not justify the cost burden of an EASA mandate for their installation on the transport airplane fleet".*

In a closing response from the NTSB it was recorded that: *"Although none of the wingtip collision events described in our recommendation letter resulted in any injuries or deaths, we continue to believe that a collision during taxi involving the wingtip of a large aircraft and another aircraft or object is a dangerous event that EASA needs to address. However, Mr [name removed] letter indicated that, because no injuries or deaths have occurred, EASA cannot justify (from a cost-benefit perspective) mandating the recommended installation, and therefore, it does not plan to do so. Consequently, Safety Recommendations A 12 - 50 and A 12- 51 are classified CLOSED—UNACCEPTABLE ACTION".*

1.11 Database Review

1.11.1 General

A review of the AAIU Accident and Serious Incident database determined that a total of 11 wingtip ground collisions involving commercial transport aircraft were recorded on the system since April 1996, of which three occurred in Ireland and the remaining eight were related to Irish registered aircraft operating abroad. No prior collisions were recorded for the area LINK 1, LINK 2, TWY A and TWY E1 at Dublin Airport.

A review of the European Commission's Joint Research Centre (JRC) database for the period 2007 - 2014 determined that for the entire European region, excluding collisions with parked aircraft, a total of 139 reports were recorded for aircraft ground collisions with other aircraft or obstacles. Including collisions with parked aircraft, there were a total of 341 reports.

1.11.2 Recent Investigation

The UK AAIB recently published a report (AAIB Bulletin: 4/2015 EW/C2014/06/04) relating to a wingtip collision between two Boeing 737 aircraft. It was determined that: "*The right winglet of a taxiing Boeing 737-8AS detached when it collided with the tail of another Boeing 737-8AS being pushed back from the apron at London Stansted Airport. Both aircraft were manoeuvring in accordance with ATC instructions. The APU of the aircraft being pushed back was severely damaged and some fuel leaked onto the apron".*

1.12 Human Factors

1.12.1 Depth Perception.

Humans gauge depth and distance by obtaining visual cues from the observed environment and then interpreting these cues to form a judgement of distance. The sources of visual cues can be divided into binocular and monocular.

With binocular vision, because the eyes are 50-60 mm apart, they each receive a different image of the same object on their respective retina. As each eye moves and focuses on the object, the brain uses a combination of the muscle tone of lens accommodation and eyeball convergence to obtain an indication of depth. The merging of the images from each eye and changes in muscle tone are used to form a three-dimensional picture of the environment. This process is known as Stereopsis. However, it is less useful when objects are far away because the images on the retina become more similar with increasing distance.

Ernsting's Aviation Medicine states: *"The brain considers optical infinity to be anything more than 6 m away from the observer, and so accommodation and eyeball convergence are limited to within a 6 m range".* It goes on to say *"Binocular cues of stereopsis mediate the perception of relative distance, i.e. one object is in front or behind another, at distances of up to about 60 m but are only of value for the perception of the absolute distance of objects that are about 10 m or less away from the observer".* For stereopsis to work, both eyes must have an un-obscured view. There are a number of monocular cues including:

- **Relative Size:** The relative size of an object projected on the retina. For this to be a useful cue requires the knowledge of the size of the object from previous experience. Then the brain can gauge the distance based on the size of the object on the retina.
- **Overlapping:** A more distant object will appear partially hidden by a nearer object.
- **Moving Parallax:** When the head is moved from side to side, objects that are close appear to move more rapidly than objects that are further away. A similar effect occurs when an observer views objects from a moving vehicle.

"Overlapping" and "Moving Parallax", when used in conjunction, can give a good indication of the relative positions of two objects, but motion is required, and the objects being judged must be one behind the other for this technique to be effective.

1.12.2 Cognitive Biases

There are a number of cognitive biases which describe the inherent shortcomings in thinking to which humans are susceptible and which may adversely affect the decision making process:

- **Confirmation bias:** The tendency to search for, interpret, focus on and remember information in a way that confirms one's preconceptions.
- **Expectation bias:** Eurocontrol defines expectation bias as *"Having a strong belief or mind-set towards a particular outcome".* An insidious effect of Expectation Bias is that if a person repeatedly performs a task with a successful outcome, an expectation may develop that future attempts at the task will have a successful outcome.

2. ANALYSIS

2.1 General

During early morning outbound departures, with Dual Runway Operations in progress at the time from RWY 28 and RWY 34, a ground collision occurred between two commercial passenger transport aircraft in the general area of LINK 2 at Dublin Airport.

The operation of an Air Traffic Control Service requires, amongst other things, that an ATC Unit shall issue clearances and information for the purpose of preventing collisions between aircraft under its control and prevent collisions between aircraft on the manoeuvring area and obstructions on that area. During ground manoeuvring, the responsibility for avoidance of a collision with other aircraft or obstructions rests with the flight crew of the taxiing aircraft. In designing the layout of a taxiway system, airport operators should, as a basic planning principle, endeavour to ensure that taxiway routes are as simple as possible in order to avoid confusion and the need for complicated instructions.

2.2 The Collision

The first aircraft, EI-EKK, was number four for departure off RWY 28 and was following ATC clearance via the Foxtrot taxiways and TWY E1 to hold short of RWY 28. The second aircraft, EI-EMH was behind EI-EKK, and was number two for departure off RWY 34. It was following ATC clearance via the Foxtrot taxiways and TWY Alpha, to hold short of RWY 34. Some other transmissions took place between the SMC and another aircraft holding short of LINK 2 from the East Piers and then as EI-EKK approached LINK 2, the aircraft was transferred by the SMC to the Tower frequency.

The SMC observed EI-EKK continuing to taxi onto LINK 2 and towards TWY F1. In anticipation that traffic would continue to flow through TWY F1, he reconfirmed the clearance given to EI-EMH and instructed them to monitor the tower frequency. However, unbeknown to the SMC and while he was managing the aircraft on his frequency, EI-EKK stopped at the entrance to LINK 2/TWY F1. As EI-EMH taxied through LINK 2 towards TWY A, contact was made with the stationary EI-EKK.

The initial ATC taxi clearance for the impacting aircraft EI-EMH, to taxi via the Foxtrots taxiways, TWY A, to hold short of RWY 34, was an unconditional clearance. There was other sequenced traffic taxiing ahead via the Foxtrot taxiways, through LINK 2 to TWY E1 to hold short of RWY 28 and aircraft holding short of LINK 2 from the East Pier. Therefore, this particular clearance indicates an expectation bias that traffic would continue to flow freely, as it had already done up to the time of the collision, and that no other aircraft ahead would impinge on such a clearance. Furthermore, the unconditional clearance did not take account of or anticipate the prerequisite to assure compliance with the prescribed Local Traffic Regulations, which require, inter-alia, that no aircraft movement is permitted between TWY A, LINK 2/TWY F2 or vice versa when aircraft are travelling towards LINK 1/TWY B1/TWY E1 or holding on TWY F1.

The decision by the Commander of EI-EKK to stop at the demarcation line (IHPM) between LINK 2 and TWY F1 was due to the fact that two other aircraft were holding ahead on LINK 1 and TWY E1 awaiting sequenced departure off RWY 28.

A general review of ASMGCS data indicated that it is not uncommon for aircraft to stop at this position when other aircraft are holding ahead at LINK 1 and E1. With TWY F1 being only 20 m in length and positioned between LINK 2 and LINK 1, it is considered by the Investigation that flight crews are most likely stopping at the demarcation line between LINK 2 and TWY F1 in order that they retain sight of the F1/LINK 1 demarcation line and to ensure that they do not encroach into LINK 1 ahead.

The Commander of EI-EMH confirmed to the Investigation that he was aware of the stationary aircraft ahead as he entered LINK 2 and was of the firm belief that he had sufficient separation to pass and thus continued towards TWY A as instructed.

The ground radar returns show that the aircraft tracked slightly right of the taxiway centreline. As the aircraft nose wheel re-established the taxiway centreline from the right side and while the aircraft was passing abeam the tail section of EI-EKK, at a groundspeed of approximately 5 kts, the tip of the port side winglet of EI-EMH struck and embedded into the outboard section of the starboard elevator of the other aircraft.

In general, rules of the air prescribe for pilots the importance of vigilance on board aircraft for the purpose of detecting potential collisions, regardless of the type of flight or the class of airspace in which the aircraft is operating, and while operating on the movement area of an aerodrome. Furthermore, Local Traffic Regulations at EIDW identify that: "*ATC may require aircraft to manoeuvre in close proximity to other aircraft. Avoidance of other aircraft is the responsibility of the flight crew involved. If doubt exists as to whether an aircraft can be passed safely, the flight crew should stop, advise ATC and request alternative instructions if available".*

2.3 Human Factors

The Commander of EI-EMH, who was an experienced airline pilot, was familiar with the LINK 1/LINK 2 area and with the use of 'Dual Runway Operations' at Dublin. Leading up to the collision the CVR revealed a professional, sterile cockpit environment and that there was no sense of urgency for departure. The FDR confirmed that the taxiing groundspeed was approximately 5 kts at the time of the occurrence.

The Commander of EI-EMH stated that he was monitoring the wingtip and was of the belief that he had "*plenty of room"* to manoeuvre behind and past EI-EKK and thus followed the ATC clearance. Based on the fact that the experienced Commander was familiar with operating in this area; that the aircraft was positioned slightly right of the taxiway centreline and that ATC clearance was given to continue towards TWY A, it is possible that such factors contributed to an expectation bias that it was safe to proceed. The re-confirmed clearance as given to proceed to TWY A may have acted as a confirmation bias that separation was assured.

Medical research identifies that *"The brain considers optical infinity to be anything more than 6 m away from the observer, and so accommodation and eyeball convergence are limited to within a 6 m range […]. Binocular cues of stereopsis mediate the perception of relative distance, i.e. one object is in front or behind another, at distances of up to about 60 m but are only of value for the perception of the absolute distance of objects that are about 10 m or less away from the observer".*

As the line of sight distance from cockpit to wingtip for the subject aircraft is approximately 27 m, it is clear that this distance is well outside the considered value for the perception of absolute distance by sole reference to binocular cues.

Specific to judging distances, when viewing objects, the eye tends to be drawn to angular changes, edges and corners which help the observer define the outline of an object and gauge its orientation and distance. The eye is also drawn to areas of high contrast or colour change. Specific to the wingtip structure in this occurrence, as the surface presented to the pilot does not project at a sharp angle from the wing, but evolves from a blended curve into an upright structure, it presents further difficulties in terms of depth perception. Furthermore, the eye may be drawn to wing features with relief/contrast, such as the navigation light and extended leading edge slats, which are up to 1.5 m closer to the pilot than the winglet tip.

Additionally, the upright portion of the winglet angles outwards from the wing, and is swept back from the pilot's view, compounding the difficulty. The fact that the other aircraft was presented to the Commander at an obtuse angle would have further complicated his ability to judge separation accurately. In addition, the prevailing environmental conditions at the time of the occurrence of morning darkness, a raindrop covered cockpit window, with resultant diffused ramp lighting, may have affected the Commander's ability to accurately judge the separation distance.

The combination of modern aircraft wing sweep, the overall length of the wing and the winglet structure at the end of the wing brings new challenges to flight crew in judging wingtip separation from other aircraft and ground obstructions. Evidence suggests that from the normal seating position in the subject aircraft, it is difficult to view the winglet itself and in fact a head movement outboard towards the rear port window is required to improve the view. This is not a normal viewing position for the pilot as priority is given towards looking ahead, in order to maintain the centreline and to ensure that the aircraft does not encroach beyond specified holding points.

The Investigation is of the belief that for pilots operating winglet equipped aircraft and/or aircraft with large wingspan, it is not possible to accurately judge absolute distance between the wingtip and another object. Therefore, regardless of experience, there is a risk that in attempting to judge separation distance at close quarters to another object, a collision may occur. As such pilots should err on the side of caution and if doubt exists as to whether an aircraft can be passed safely, the flight crew should stop, advise ATC, and request alternative instructions if available. In that regard the AAIU makes the following Safety recommendation to the Operator:

Safety Recommendation No. 1

It is recommended that:

Ryanair Ltd should review the guidance material provided to flight crews regarding the difficulty associated with assessing wing tip clearance.
(IRLD2015015)

2.4 Wingtip Collision Avoidance Systems

Previous safety recommendations by the NTSB seeking that both the FAA and EASA consider the installation of an anti-collision aid in order to help pilots determine wingtip clearance during taxiing were rejected by both on the grounds that, in general, "*the FAA examined the potential safety benefit and feasibility of these recommendations as well as current alternatives to mitigate the risk of wingtip collisions during taxi operations of large transport airplanes. The wingtip collision accidents cited by the Board, while resulting in damage to the aircraft involved, did not result in any passenger, flight, or ground personnel injuries. We continue to find that while a camera system may provide a small benefit at very low speeds, the two-dimensional image and limited field-of-view make it unlikely that wingtip cameras would provide a measurable reduction in wingtip collision incidents at normal taxi speeds. From a safety risk management perspective, the limited safety benefit of a taxi anti-collision system, such as wingtip cameras, does not justify the cost burden of an FAA mandate for their installation on the transport airplane fleet… "*

The Investigation is in agreement that the recorded collision events did not result in any passenger, flight, or ground personnel injuries, however the Investigation considers that there is potential for such collisions to be more serious. A case in point relates to a recent collision and subsequent investigation by the UK AAIB whereby *"The right winglet of a taxiing Boeing 737-8AS detached when it collided with the tail of another Boeing 737-8AS being pushed back from the apron at London Stansted Airport. Both aircraft were manoeuvring in accordance with ATC instructions. The APU of the aircraft being pushed back was severely damaged and some fuel leaked onto the apron".* Therefore, there was potential for a fuel fed ground fire.

Furthermore, it cannot be ignored that there is significant cost associated with such collisions, including repair of the aircraft, downtime of aircraft and ATC disruption.

The increased use of blended wing/winglets across the public transport fleet, coupled with increasing airport capacity demands, will potentially increase exposure to the risk of more wingtip collisions in the future. In that regard, the Investigation is of the opinion that further research is needed in order to assess the requirement for anti-collision aids to help pilots determine wingtip clearance during ground manoeuvring.

The AAIU considers that ICAO, through the Air Navigation Commission (ANC), is the appropriate body to examine this matter and a safety recommendation is therefore made in that regard.

Safety Recommendation No. 2

It is recommended that:

The International Civil Aviation Organisation (ICAO) should, through the work programme of the ANC, assess the need for the provision of anti-collision aids to help pilots of large public transport aircraft determine wingtip clearance during ground manoeuvring.
(IRLD2015016)

2.5 LINK 1/LINK 2 Taxiway System

Dublin Airport has seen significant growth over the years and in 2014 the airport handled over 21.7 million passengers, equating to an average of 60,000 passengers per day. Such activity required substantial investment in infrastructure not only landside to accommodate passengers within the different terminals but also airside to allow parking and movement of aircraft. On average there are 600 aircraft movements per day at Dublin by 57 different scheduled and chartered airlines. During peak times aircraft runway movements are up to 47 aircraft per hour.

The airport utilises two runways, RWY 10/28 and RWY 16/34. While the use of a particular runway is normally associated with wind direction and availability, RWY 28 is recognised as the main runway at Dublin. RWY 28 is normally accessed through the E1 taxiway. As the threshold of RWY 34 is located in the pavement area adjacent to the threshold of RWY 28, when RWY 34 is in use, access is also normally through the E1 taxiway.

Increasing activity and aircraft movements required the utilisation of taxiways A and B2 for traffic flow to and from the apron/runways. In addition, the introduction of Terminal 2 (Pier 4) in November 2010 with the associated parking stands and infrastructure in the south apron, created a need to develop the LINK 1/LINK 2 taxiway system. The LINK 1/LINK 2 area is now being utilised by aircraft taxiing from the Foxtrot inner and outer taxiways, Pier 4, the south apron, TWY A, TWY B2 and TWY E1. As a result, LINK 1/LINK 2 has become a complex area and this is identified as so in the AIP (see **Section 1.6.3.1**).

As previously stated TWY F1 is contained within the LINK 1/LINK 2 taxiway system and is only 20 m long. The majority of aircraft operating at EIDW are longer that this, which means that, even if an aircraft stops with its nose directly behind the F1/LINK 1 IHPM, its tail will extend into LINK 2 behind it. Thus, the majority of aircraft, when taxiing in a southerly direction, stopping on TWY F1, will infringe into LINK 2.

The fact that an aircraft occupies LINK 2 close to TWY F1 is not a particular issue when aircraft are queuing in line for TWY E1 alone. However, when Dual Runway Operations are in progress, or if TWY A is being utilised, the occupancy of LINK 2 becomes a significant factor as aircraft are now crossing behind a stopped aircraft to access TWY A for departure off RWY 34. Furthermore, the layout of the centreline taxiway markings from TWY F2, through LINK 2 and onwards to TWY F1 is in the form of a chicane type design which presents the stopped aircraft ahead at an obtuse angle to the aircraft crossing behind. This likely contributes to the difficulty of judging separation distance.

The introduction of Dual Runway Operations, whereby aircraft are following in line to depart from different runways (RWY 28 and RWY 34), while helping to improve overall runway capacity, has further added to the complexity of the area. It is recognised by the Investigation that the design of the LINK 1/LINK 2 taxiway system does comply with the criteria laid out in Annex 14 and the various ICAO documents relating to Aerodrome design. In addition, it is considered that the close alignment of so many different elements within the general area of the LINK 1/LINK 2 taxiway system has created a level of complexity that can contribute to confusion with regard to taxiing instructions and expose taxiing aircraft to increased risk of an occurrence, in particular when TWY A is being utilised in conjunction with TWY E1.

A previous occurrence at Dublin Airport (21 May 2011) and the subsequent AAIU Investigation (Report No. 2012-017, 24 October 2012) identified through Safety Recommendations, the need for the DAA to *'Review taxiway designation at Dublin Airport and the 'Consideration for the alignment of taxiways F1 and F2'*. Both Safety Recommendations at the time were accepted by the DAA. However, at the time of the subject collision neither recommendation had been fully implemented. Notwithstanding this, the Investigation recognises the progress now being made and as such no additional Safety Recommendation is required in that regard.

2.6 Taxiing Restrictions

The control of ground movements of aircraft at an aerodrome is achieved through a combination of visual and procedural separation. However, due to the distances involved from the Control Tower to the Movement Area, the prevailing weather/light conditions and the fact that the direct view of one aircraft may be obscured by another aircraft, controllers can only give gross separation, and not absolute separation of one aircraft from another. Similarly, ASMGCS, in its current capacity, is only used by controllers to give gross separation and not absolute separation.

Analysis of the regulations governing control of taxiing aircraft indicate that ATC are responsible for issuing clearances that best avoid the risk of collision, but that responsibility for collision avoidance whilst ground manoeuvring rests with the fight crew of an aircraft, in general, and with the Commander of an aircraft in particular.

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In order to minimise the risk of a ground collision a basic planning principle for airport operators is to endeavour to ensure that taxiway routes are as simple as possible in order to avoid pilot confusion and the need for complicated instructions. The evolution in the complexity of the taxiway system in which this particular collision occurred and indeed in other areas of the aerodrome has necessitated the need to incorporate a significant number of taxiing restrictions in the AIP.

Specific to the LINK 2 area, the taxiing restrictions, as laid down in the AIP at the time of the subject event, were not being complied with by ATC or taxiing aircraft. The reasoning offered for this was that it was generally believed by ATC and Operators alike that such restrictions did not apply when aircraft were operating under queuing conditions. However, it is noted that the taxiing restrictions as specified in the AIP for Dublin Airport did not refer to a queuing scenario and as such the restrictions should have been complied with as stated. It is considered that, had the taxiing restrictions specific to LINK 2 area been complied with at the time, it is likely that the collision would not have occurred.

Subsequent to the subject event and prior to the completion of this Investigation, another ground collision occurred at the same location. Following that particular event the AAIU issued a Preliminary Report which included an Interim Safety Recommendation to the IAA stating that:

> *The Irish Aviation Authority (IAA) should ensure that the Taxiing Restrictions as specified under AIP Ireland EIDW AD 2.20 LOCAL TRAFFIC REGULATIONS are restated* ***(IRLD2015007)****.*

A review of the taxiing restrictions themselves and observations from persons who are subject to such restrictions indicate that the restrictions are numerous, complex, ambiguous and difficult to follow. While local pilots would have a level of familiarity with the taxiway layout and such restrictions at Dublin Airport, the same cannot be said for visiting foreign pilots. Furthermore, it is clear that if the stated taxiing restrictions specific to LINK 1/LINK 2 were fully enforced when aircraft were in a queuing scenario, it would have implications on the free flow and throughput of taxiing aircraft and thus affect the airport's ability to maintain its planned departure capacity.

As such the Investigation is of the opinion that a critical review of the taxiing restrictions at Dublin Airport should be undertaken with the aim of reducing the overall number of restrictions in place, while at the same time, simplifying taxiing instructions in the different restricted areas. Therefore the following safety recommendation is made to the DAA:

Safety Recommendation No. 3

It is recommended that:

The Dublin Airport Authority (DAA) conduct a critical review of the taxiway system at Dublin Airport, to ensure that taxiway routes are as simple as possible in order to avoid pilot confusion and the need for complicated instructions.
(**IRLD2015017)**

The Investigation notes the intent of the DAA to realign TWY E1 so that a realigned TWY E1 will present traffic to RWY 28 at a ninety degree angle instead of at an obtuse angle and to incorporate line up holding points adjacent to each other. The Investigation is supportive of this initiative.

3. CONCLUSIONS

(a) Findings

1. The flight crew of both aircraft had valid Irish licences issued by the IAA.

2. The AMC and the SMC had valid licences as issued by the IAA.

3. Prevailing conditions at the time of the occurrence were early morning darkness with no rain. However, rain drops were present on the cockpit windows.

4. The Flight Crew of both aircraft understood and followed the taxiing instructions as provided by ATC.

5. EI-EMH was given an unconditional taxi clearance directly to TWY A to hold short of RWY 34. This unconditional clearance reflected an expectation bias that traffic would continue to flow freely and that no other aircraft ahead would impinge on such a clearance.

6. The unconditional clearance did not take account of, or anticipate the prerequisite to assure compliance with the prescribed Local Traffic Regulations pertaining to taxiing restrictions in the LINK 1/LINK 2 area.

7. In general there was a belief by ATC personnel and Operators alike that Local Traffic Regulations pertaining to the LINK 1/LINK 2 area did not apply when aircraft were in a queuing scenario.

8. The taxiing restrictions, as specified in the AIP for Dublin Airport, were numerous, complex, ambiguous and difficult to follow.

9. EI-EKK, which was following ATC clearance as instructed, stopped on the demarcation line between LINK 2 and TWY F1, as two aircraft were holding in line ahead for departure off RWY 28.

10. The layout of LINK 1/LINK 2 and in particular the length of the F1 taxiway is such that aircraft holding on TWY F1 for either LINK 1 or LINK 2 will infringe the LINK behind it.

11. While this infringement is not an issue for aircraft queuing in line for departures through E1 alone, when TWY A and B2 are being utilised, such an infringement becomes a hazard to passing aircraft.

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12. The Commander of EI-EMH was aware of the stationary aircraft EI-EKK, but was of the belief that he had sufficient separation to pass behind the parked aircraft and continue as instructed towards TWY A.

13. The general 'chicane' type layout of the LINK 2, presented aircraft on TWY F1 at an obtuse angle when viewed from aircraft behind.

14. Medical evidence identifies that binocular cues of stereopsis mediate the perception of relative distance, i.e. one object is in front or behind another, at distances of up to about 60 m, but are only of value for the perception of the absolute distance of objects that are about 10 m or less away from the observer.

15. As the majority of medium and large sized commercial aircraft have a line of sight distance from cockpit to wing-tip far in excess of 10 m (27 m for the subject aircraft) pilots cannot accurately judge absolute distance or separation when at close quarters to other aircraft or objects.

16. The general prevailing conditions of morning darkness, rain-drop covered cockpit windows and diffused high-level ramp lighting were not conducive for judgement of accurate absolute distance or separation at close quarters between two aircraft.

(b) Probable Cause

Insufficient wing-tip clearance achieved while manoeuvring in close proximity to another aircraft.

(c) Contributory Cause(s)

1. Non-adherence to taxiing restrictions as specified in the AIP.
2. General complexity of the LINK 1/LINK 2 taxiway system.
3. Difficulties associated with judging absolute distances beyond 10 m.
4. Prevailing environmental conditions.

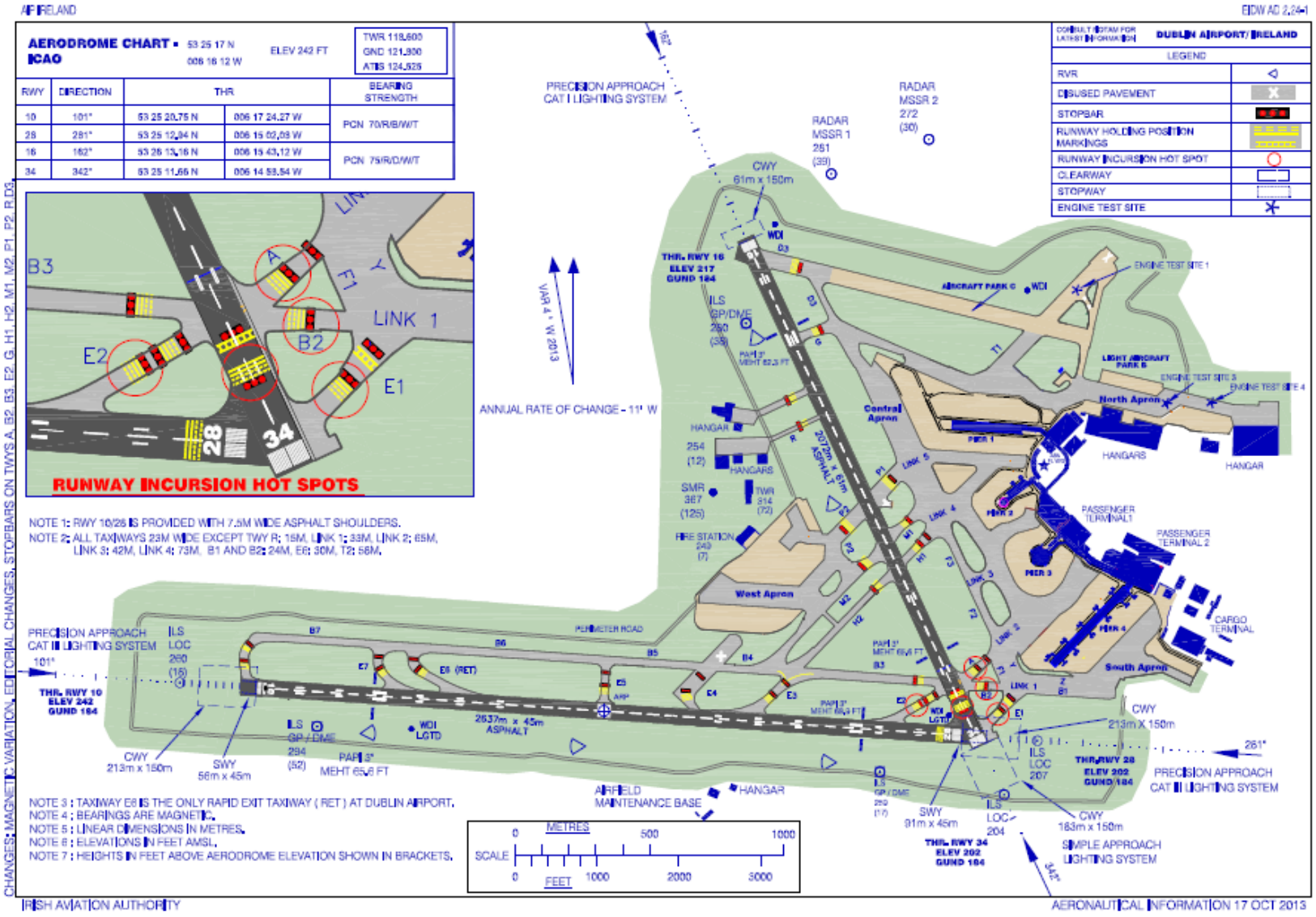
4. SAFETY RECOMMENDATIONS

No.	It is Recommended that:	Recommendation Ref.
1.	Ryanair Ltd should review the guidance material provided to flight crews regarding the difficulty associated with assessing wing tip clearance.	IRLD2015015
2.	The International Civil Aviation Organisation (ICAO) should, through the work programme of the ANC, assess the need for the provision of anti-collision aids to help pilots of large public transport aircraft determine wingtip clearance during ground manoeuvring.	IRLD2015016
3.	The Dublin Airport Authority (DAA), conduct a critical review of the taxiway system at Dublin Airport, to ensure that taxiway routes are as simple as possible in order to avoid pilot confusion and the need for complicated instructions. **Response** During the draft report comment stage, the DAA provided the following response: *Dublin Airport accepts the recommendation and will undertake a critical review of the taxiway system to ensure that taxiway routes are as simple as possible.* *To supplement the work to date, Dublin Airport will now consider what additional steps are required in order to implement the AAIU Safety Recommendation in full, and will keep the AAIU notified of developments in this regard.*	IRLD2015017

View Safety Recommendations for Report 2015-019

Appendix A

Aerodrome Chart Dublin Airport

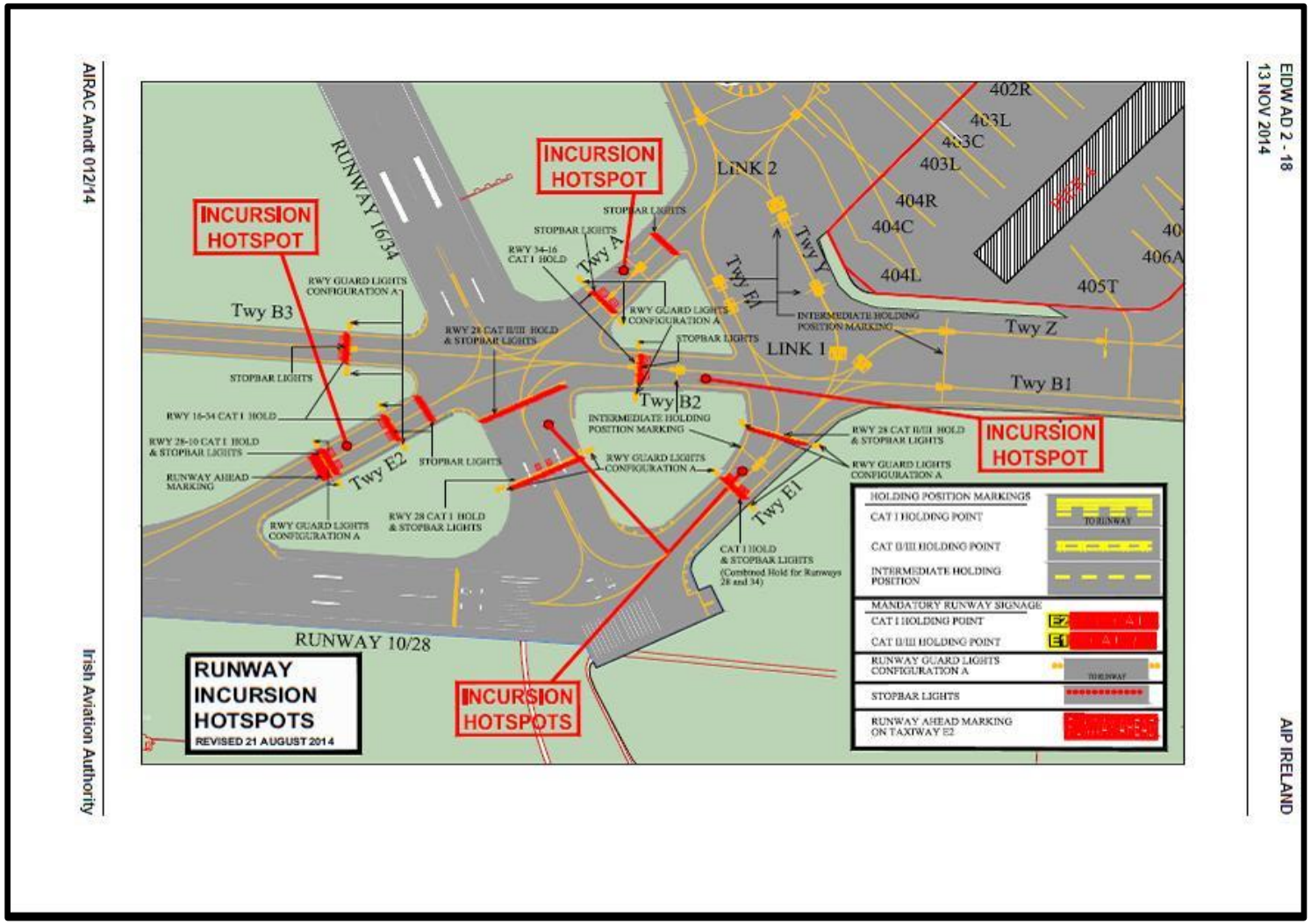


Appendix B

Extract of ATC Transcript specific to EI-EKK (RYR65ND), EI-KMH (RYR812), the Surface Movements Controller (SMC) and the Air Movements Controller (AMC)

Time	From	To	Transmission
0541.45	SMC	RYR65ND	Ryanair Six Five November Delta ground good morning continue down the two foxes for echo one hold short both runways
0541.47	RYR65ND	SMC	Continue down foxes echo one hold short three four two eight Ryanair Six Five November Delta
0541.51	RYR812	SMC	Ryanair Eight One Two standing by for taxi
0541.59	SMC	RYR812	Ryanair Eight One Two roger taxi Link five onto the foxes Alpha and hold short runway three four
0542.07	RYR812	SMC	Link five Foxtrots Alpha to hold short three four Ryanair 812
			Other transmissions between SMC and other taxiing a/c
0543.52	SMC	RYR65ND	Ryanair Six Five November Delta monitor Tower one one eight decimal six bye bye
0543.56	RYR65ND	SMC	Tower one one eight decimal six Ryanair Six Five November Delta good bye
0544.52	SMC	RYR812	Ryanair Eight One Two continue onto Alpha hold short three four monitor tower one one eight decimal six bye
0544.56	RYR812	SMC	On Alpha monitor one one eight decimal six thank you Ryanair Eight One Two
0545.34	AMC	RYR812	Ryanair Eight One Two via Alpha line up and wait runway three four
0545.36	RYR812	AMC	We actually need to go back on stand Ryanair Eight One Two
0545.43	AMC	RYR812	Ryanair Eight One Two are you on Alpha
0545.44	RYR812	AMC	We're on Alpha and we think we just tipped off the aircraft on our left Ryanair Eight One Two
0545.50	AMC	RYR812	Ryanair Eight One Two just say again you think you did what to the aircraft
0545.54	RYR812	AMC	The aircraft on our left Ryanair Eight One Two
0545.57	AMC	RYR812	What about the aircraft on your left
0546.00	RYR812	AMC	Tipped off it
0546.02	AMC	RYR812	Ryanair Eight One Two confirm you think you may have collided with the aircraft on your left
0546.08	RYR812	AMC	That's affirmative
0546.09	AMC	RYR812	Roger that's copied stand bye
0546.13	RYR65ND	AMC	Eh ground Ryanair Six Five November Delta we want to confirm that we've some sort of impact
0546.20	AMC	RYR65ND	Roger hold position
0546.22	RYR65ND	AMC	Hold position roger Ryanair Six Five November Delta
0546.46	AMC	RYR812 & RYR65ND	And Ryanair Six Five November Delta and Ryanair Eight One Two hold position we will get assistance to the area to you very quickly

Appendix C
Runway Incursion Hotspots Diagram



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

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

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