SERIOUS INCIDENT

Aircraft Type and Registration:	1) Boeing 737-800, EI-FJW 2) Airbus A320-214, OE-IVC
No & Type of Engines:	1) 2 CFM56-7B26E turbofan engines 2) 2 CFM56-5B4/3 turbofan engines
Year of Manufacture:	1) 2016 2) 2016
Date & Time (UTC):	13 August 2018 at 0948 hrs
Location:	Runway 06 at Edinburgh Airport
Type of Flight:	1) Commercial Air Transport (Passenger) 2) Commercial Air Transport (Passenger)
Persons on Board:	1) Crew - 7 Passengers - 159 2) Crew - 6 Passengers - 180
Injuries:	1) Crew - None Passengers - None 2) Crew - None Passengers - None
Nature of Damage:	1) None 2) None
Commander's Licence:	1) Airline Transport Pilots Licence 2) Airline Transport Pilots Licence
Commander's Age:	1) 42 years 2) 37 years
Commander's Flying Experience:	1) 6,800 hours (of which 6,650 were on type) Last 90 days - 160 hours Last 28 days - 30 hours 2) 10,000 hours (of which 9,000 were on type) Last 90 days - 200 hours Last 28 days - 70 hours
Information Source:	AAIB Field Investigation

Synopsis

A landing Boeing 737 closed to within 875 m of a departing Airbus A320 when landing at Edinburgh Airport. The airport air traffic control service provider defined this as a runway incursion as the 737 was over the runway surface when the A320 was still on its takeoff roll.

A combination of factors, including brief delays to the departure of the A320 and the speed of the Boeing 737 being higher than normal, led to the reduction in separation before the controllers became aware of the closeness of the aircraft. The trainee controller lacked the experience to resolve the situation in a timely manner and the supervising On-The-Job Training Instructor judged it safer to let the 737 land than to initiate a go-around in proximity to the departing aircraft.

The Air Navigation Service Provider has conducted a review of High Intensity Runway Operations at Edinburgh and taken a number of safety actions to improve procedures and on-the-job training for trainees.

History of the flight

The crew of EI-FJW were scheduled to operate a flight from New York Stewart Airport, USA (SWF) to Edinburgh Airport (EDI). The crew consisted of a captain under training in the left seat who was new to the company, a training captain in the right seat who was also the aircraft commander, and a training captain on the cockpit jump seat who was acting as the check captain for the left seat pilot[1]. They reported for duty at 0025 hrs, having arrived in New York 26 hours previously. The aircraft was pushed back from the parking position at SWF at 0244 hrs for a flight which was expected to take just under seven hours.

The crew of OE-IVC was on the third sector of a four-sector day. The flight was from EDI to London Luton Airport (LTN). The crew consisted of a training captain who was the aircraft commander in the left seat, with a trainee co-pilot in the right seat.

Edinburgh Tower frequency was being manned by a trainee air traffic control officer (trainee controller) supervised by an On-The-Job Training Instructor (OJTI). The OJTI started his shift at 0500 hrs and the trainee started at 0530 hrs. The OJTI completed a period on ground control between 0500 hrs and 0630 hrs before having a 45-minute break. At 0715 hrs, they plugged into the ground control position together to start a training session. They completed this session at 0830 hrs. After having a routine 45-minute break they then plugged into the tower position together at 0915 hrs. The trainee controller was in the second of three phases of training to qualify as an aerodrome controller at EDI.

At 0936 hrs, EI-FJW's pilot monitoring (PM) contacted Edinburgh Radar and was instructed to expect an ILS approach to Runway 06. The radar controller gave the crew a series of vectors to position them for their approach before clearing them to complete the ILS procedure. He instructed them to maintain at least 160 KIAS until they reached 4 nm from touchdown. At 0944 hrs, the crew were instructed to contact Edinburgh Tower. At this point the aircraft was 8.8 nm from touchdown.

At 0936 hrs, OE-IVC began its pushback from the parking stand and started engines. The commander, who was to be PM for the flight to LTN, called for taxi and was given clearance to taxi down taxiway A to hold at A1 for Runway 06 (Figure 1).

At 0945:55 hrs, with EI-FJW at 6 nm from touchdown, the trainee controller cleared OE-IVC to line up on Runway 06. The trainee controller initially did not extinguish the Stop Bar[2].

Footnote

1 The captain under training in the left seat was undergoing his final line checks having finished the required training.

2 Stop Bar – located at those aerodromes authorised for low visibility operations. A Stop Bar consists of a row of lights spaced equally across the taxiway normally at right angles to the centreline and showing red towards an approaching aircraft when lit. They act in the same sense as traffic lights and therefore pilots must not taxi an aircraft across a Stop Bar that is lit. (CAP 637 Visual Aids Handbook).

At 0946:00 hrs, another aircraft called ready for departure and the trainee controller was occupied with talking to them for nine seconds. Immediately after this, the commander of OE-IVC transmitted “STOP BAR” on the frequency to remind the trainee controller that it was still illuminated. The trainee controller extinguished the Stop Bar and, with this delay, OE-IVC did not move from the holding point until 0946:29 hrs.

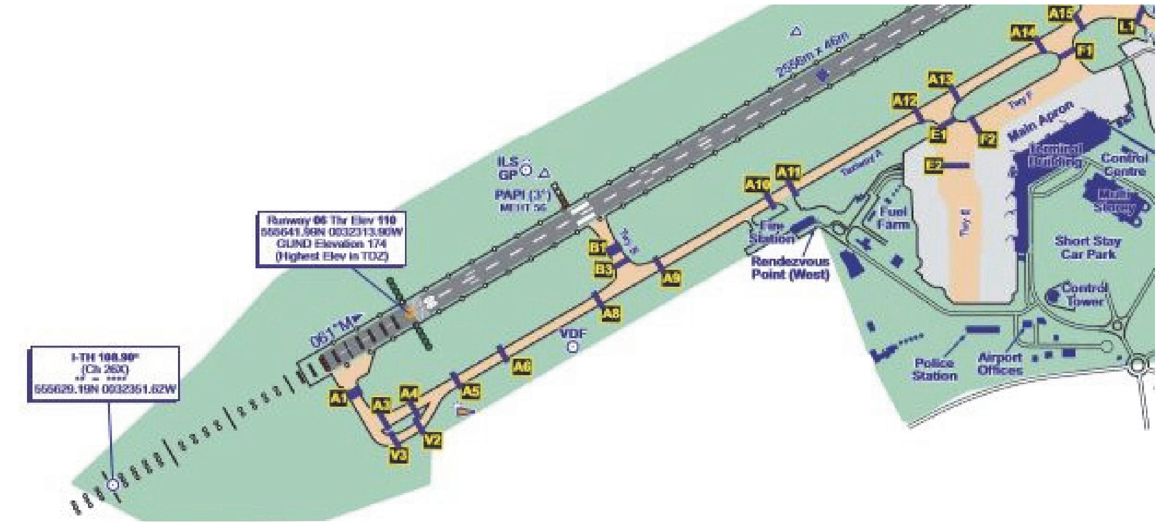

Figure 1
Taxiway layout for Runway 06

At 0947:01 hrs, with EI-FJW at 3 nm from touchdown, the trainee controller cleared OE-IVC for takeoff although the aircraft was not yet aligned with the runway ready to depart. The trainee controller also instructed the crew of EI-FJW that they could expect a late landing clearance.

At 0947:41 hrs, OE-IVC began to accelerate on its takeoff roll with EI-FJW just over 0.5 nm from touchdown. When EI-FJW reached 0.5 nm from touchdown, the PM called the tower to remind them that they were not yet cleared to land. Shortly after EI-FJW called at 0.5 nm, the OJTI took over the tower frequency from the trainee controller.

At 0948:13 hrs, OE-IVC left the ground, at which point EI-FJW was in the landing flare and was given a landing clearance. EI-FJW touched down at 0948:15 hrs.

As EI-FJW was over the runway at the same time as OE-IVC was completing its takeoff roll, the event was classed as a runway incursion by the air navigation service provider (ANSP). At the closest point of approach, the two aircraft were separated by approximately 875 m, with OE-IVC being at 60 ft aal when EI-FJW touched down. Figure 2 shows a CCTV view looking down the runway which, although partially obscured by rain on the camera, shows both EI-FJW and OE-IVC visible in the frame.

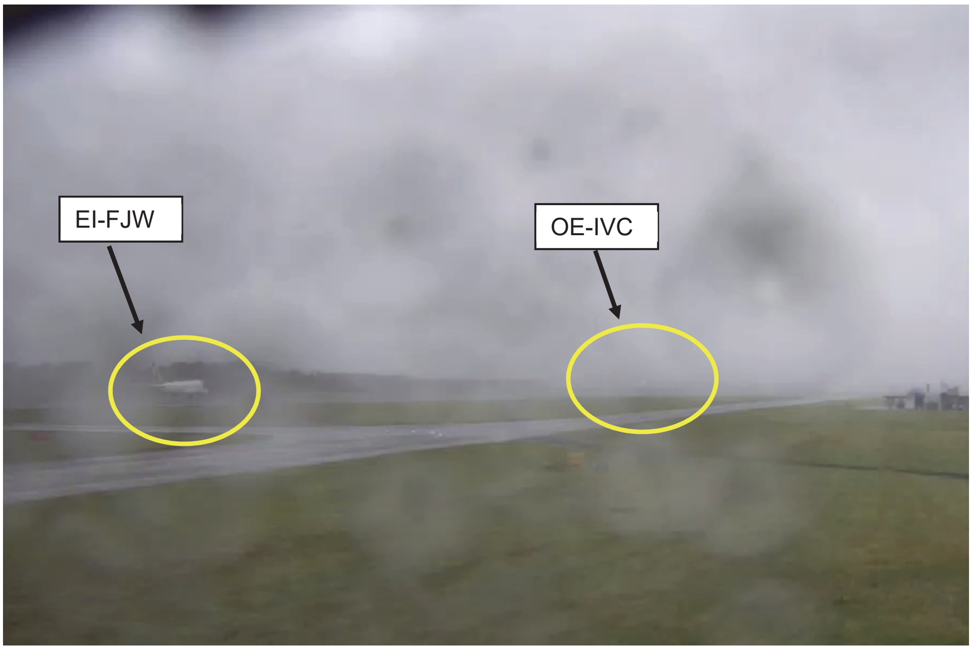

Figure 2
CCTV showing both aircraft over the runway

Recorded information

Data was available from several sources including radar and ATC recordings, as well as closed-circuit television (CCTV) equipment installed at EDI, and the Quick Access Recorder (QAR) installed on each aircraft. However, due to the delay in reporting the event to the AAIB, both cockpit voice recorders were overwritten and were not downloaded.

Radar

EDI is equipped with a radar-based approach surveillance capability. This shows the tower controller the arriving traffic, and other traffic near the airport, with a textual information block for relevant aircraft showing their callsign, altitude above airfield elevation (in hundreds of feet) and groundspeed (GS) in kt (prefixed with the letter G). In addition, the display shows local airspace boundaries, areas of airspace with restrictions (circled in dark red) and a distance scale aligned with the runway axis marked at 2 nm intervals. Part of this display is shown in Figure 3 depicting EI-FJW, as IBK1601 and circled in yellow, on approach at 8 nm.

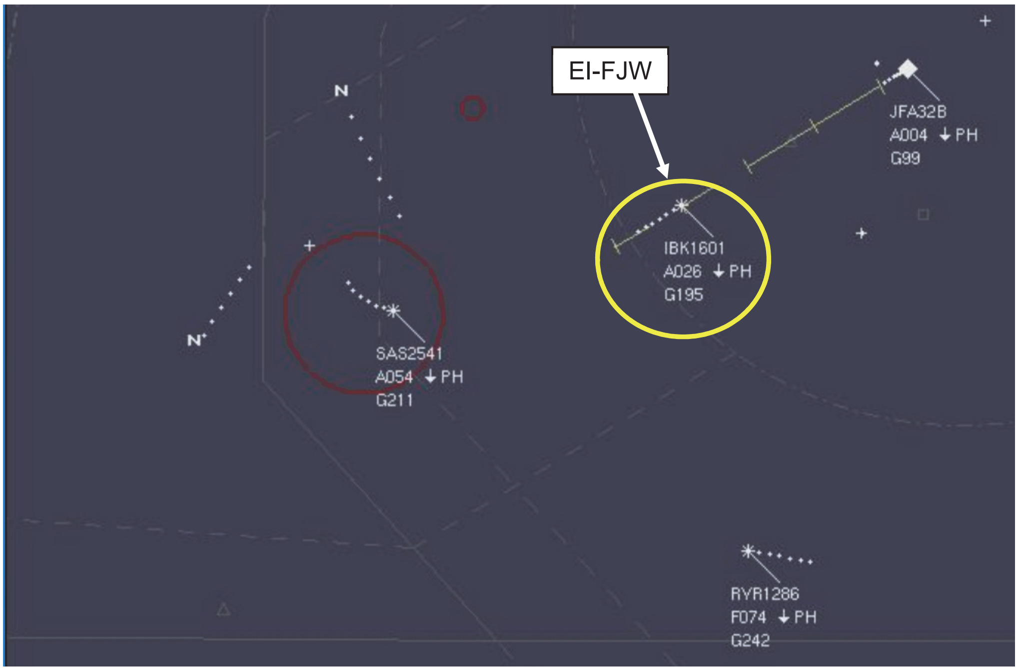

Figure 3

Approach surveillance at EDI, showing EI-FJW on approach at 8 nm

EDI also has a Surface Movement Radar (SMR) which shows radar imagery, updated once per second, overlaid on plans of the airport's taxiways and runway. Figure 4 shows an example of a typical SMR display at EDI. All radar data and ATC communications at EDI are recorded.

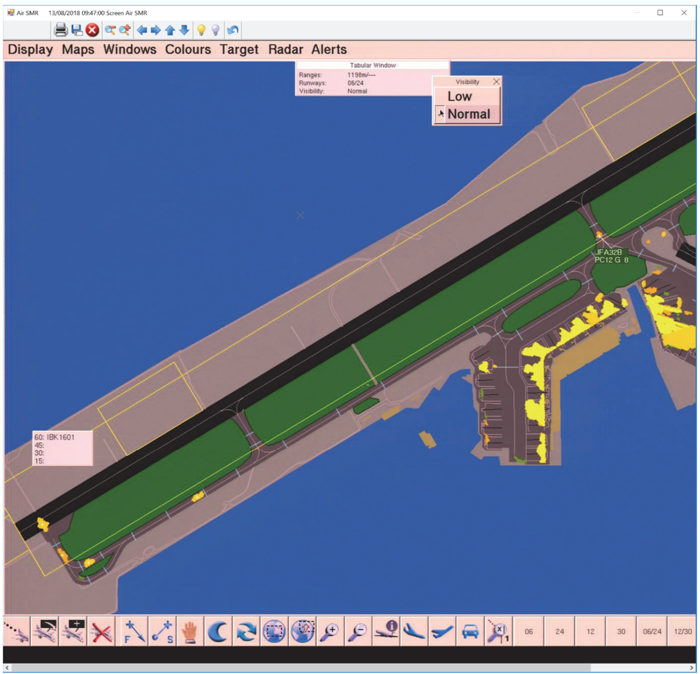

Figure 4

A typical SMR display at EDI

Runway Incursion Monitoring and Collision Avoidance System

The SMR installation at EDI incorporates a Runway Incursion Monitoring and Collision Avoidance System (RIMCAS) which monitors, within a pre-determined area, the separation between aircraft approaching and occupying the runway, and between ground vehicles operating on the airport. The system provides time-to-touchdown information to the controller, as shown in Figure 4, where EI-FJW is represented as IBK1601 at 60 seconds to touchdown. Other times to touchdown which can be shown are 45, 30 and 15 seconds. In addition, RIMCAS can generate alerts to the controller; the first level of alert is termed a Stage 1 alert, which is generated 30 seconds prior to a predicted collision, and is purely a visual alert of a conflict between radar returns. This results in the textual information block for each aircraft being highlighted in amber and, if appropriate, the time-to-touchdown display. An example of an active Stage 1 alert is shown in Figure 5.

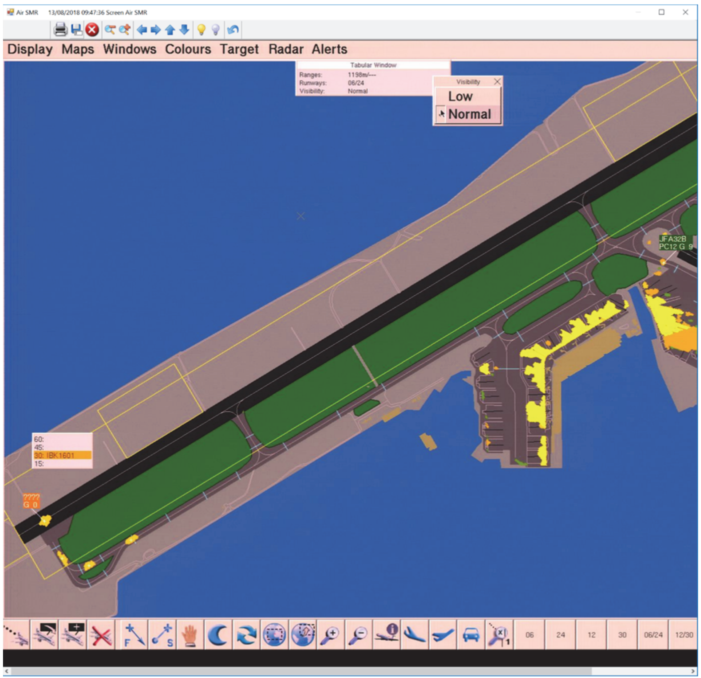

Figure 5

An active Stage 1 RIMCAS alert at EDI

Stage 2 alerts can also be generated by RIMCAS at 15 seconds prior to a predicted collision. These alerts result in the textual information block for each aircraft being highlighted in red and, if appropriate, the time-to-touchdown display. In addition, an aural warning is given over a loudspeaker. This consists of a computer-generated voice announcing “RIMCAS Alert, RIMCAS Alert.” The warning continues to sound until acknowledged or the conflict which caused the alert no longer exists.

CCTV

Two CCTV cameras captured the event and the recordings were used to provide an overview of the event, and to verify the timings derived from other data sources. A screenshot from one of these cameras is shown in Figure 6.

Figure 6

CCTV screenshot of the event showing both aircraft

Quick Access Recorders

The operators of EI-FJW and OE-IVC provided flight data recordings from the QAR installed on each aircraft. These were analysed to establish that the separation distance between the aircraft decreased to a minimum of approximately 875 m horizontally, when EI-FJW was six seconds from touchdown and 40 ft above the runway, and OE-IVC was accelerating through 148 kt during its takeoff roll, 4 seconds prior to becoming airborne.

Incident timeline

Using the data from radar and the radio transmissions recordings, a timeline (Table 1) was generated of the incident. This information was then used to compare the incident against other similar operations at the airport.

Time	ATC	OE-IVC	EI-FJW	Other
0945.55	Clears OE-IVC to line up	Acknowledged	6nm from t/d GS 181 kt	
0946:00 to 0946:09				RT between another aircraft and ATC
0946.11		"STOP BAR"		
0946.29		Begins to move on SMR		
0946.34		Crosses Stop Bar	4nm from t/d GS 171 kt	

Time	ATC	OE-IVC	EI-FJW	Other
0946.56				Landing aircraft vacates
0947.00	**RIMCAS 60s**			
0947.01	OE-IVC cleared for takeoff	Acknowledges clearance. 90 degrees to runway.	3 nm from t/d GS 155 kt	
0947.12	EI-FJW told to expect late landing clearance		<2.5 nm from t/d GS 150 kt	
0947.20		Lined up		
0947.20	RIMCAS 45s			
0947.36	**RIMCAS 30s**			
0947.41		Moving on SMR		
0947.51	EI-FJW told to continue approach		"HALF A MILE"	
0947.52	**RIMCAS 15s**			
0948.10		Nosewheel off		
0948.13		Main gear off		
0948.14	EI-FJW cleared to land		Acknowledged	
0948.15			Touchdown	

Note: All RT clearance times refer to the end of the ATC transmission.

Table 1

Incident timeline

Incident timeline comparison

Figure 7 shows the incident timeline compared to two uneventful examples. In both examples there was a 6 nm gap between the landing aircraft and another aircraft which departed in the gap without incident. The comparison examples were taken from a training session with the trainee controller conducted with Runway 24 in operation, in the evening in dark conditions, without low visibility procedures (LVPs) or safeguarding[3] in operation. The Stop Bars were in use because it was dark. Although the examples are for Runway 24, the layout of the holding points in relation to the runway at Edinburgh is symmetrical.

Footnote

[3] Safeguarding is when the airfield protects the Localiser Sensitive Area (LSA) which is a rectangular area contained within parallel lines 127 m either side of the runway centreline between the beginning of the runway and the localiser aerial (EDI MATS Part 2).

Each example starts at the point where the first approaching aircraft crosses the runway threshold with the second approaching aircraft at 6 nm behind and an aircraft is given clearance to take off in the gap. The examples are shown on a synchronised timescale for ease of comparison. The timing and duration of all RT is shown as black shaded areas on the timeline and all times for clearances correspond to when the ATCO finishes the relevant transmission.

AAC1 is first approaching aircraft, AAC2 is second approaching aircraft, DAC is departing aircraft. Black shaded areas represent radio transmissions.

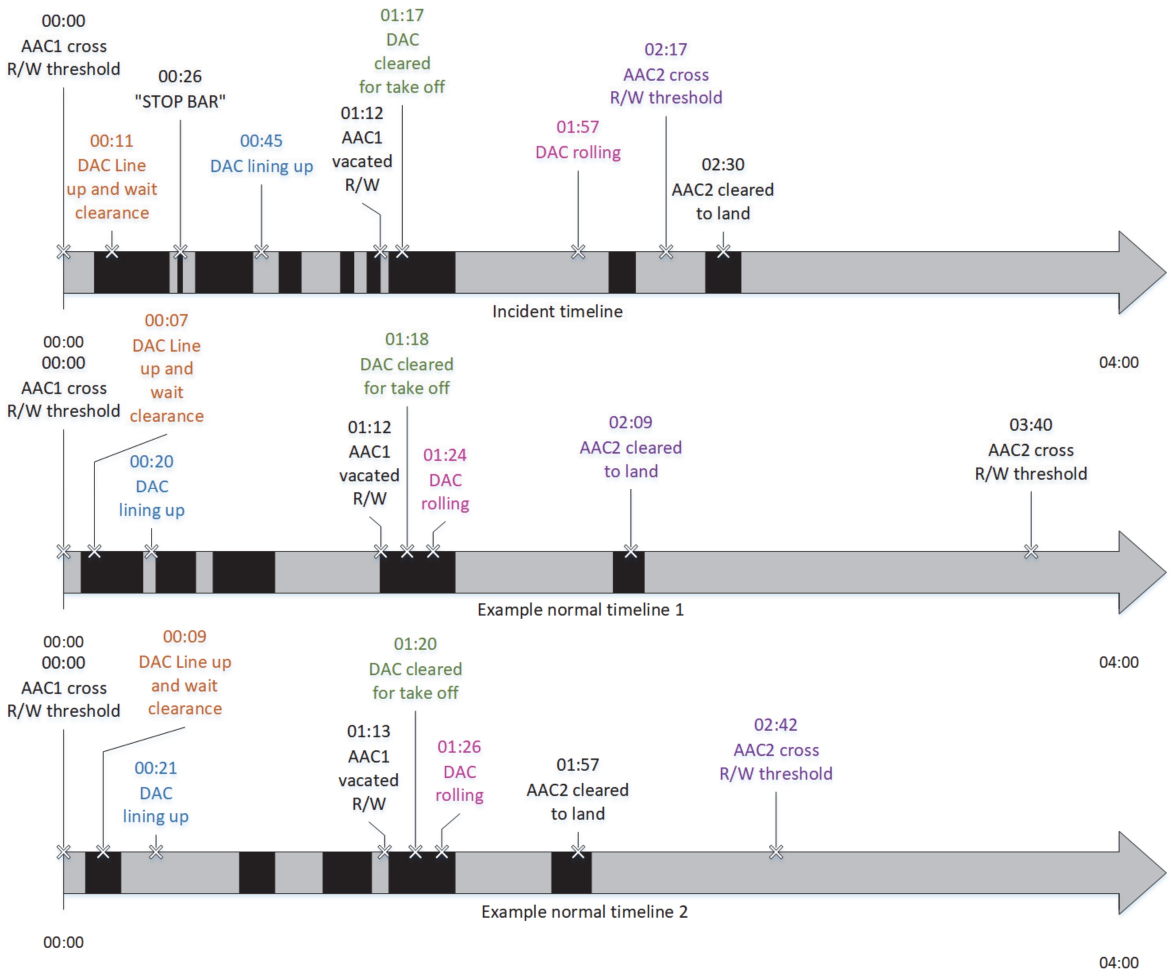

Figure 7

Incident timeline compared to normal examples

The comparison shows three significant timeline differences between the incident and the two normal examples:

- In the incident example, the approach speed of EI-FJW resulted in the aircraft arriving at the runway threshold quicker than in the examples.
- In the normal examples, the time between line up clearance being issued and starting to line up was 12 to 14 seconds as opposed to 34 seconds in the incident.

- In the normal examples, the time between receiving takeoff clearance and starting the takeoff roll was six seconds compared to 40 seconds in the incident.

In the time between the first approaching aircraft crossing the threshold and the second approaching aircraft being issued a landing clearance, the controllers were occupied with making or receiving transmissions for 52% of the time in the incident example and for 50% and 46% of the time in the normal examples respectively.

TCAS

Both EI-FJW and OE-IVC were fitted with TCAS which was operational at the time of the incident. Neither crew received a TCAS resolution advisory (RA) as both aircraft were at radio heights below which the system is inhibited. For EI-FJW, all RAs are inhibited below 1,000 ft radio altitude, with all aural alerts inhibited below 500 ft radio altitude. For OE-IVC, all RAs are inhibited below 1,100 ft radio altitude, with all aural alerts inhibited below 600 ft radio altitude.

Meteorology

The EDI forecast for 13 August 2018 was for an easterly wind with the airport affected by low cloud and drizzle for much of the day. The forecast also included the possibility of fog, particularly overnight from 12 August and into the morning of 13 August.

The METAR reports for EDI showed the cloudbase to be at 200 ft aal at 0820 hrs and 0850 hrs, 400 ft aal at 0920 hrs, before becoming 300 ft aal from 0950 hrs.

The airport has equipment to measure the cloudbase automatically and this system showed that the measured cloudbase varied between 600 ft aal and 300 ft aal during the 10 minutes before and after the incident.

The crew of EI-FJW saw, from the initial ATIS that they obtained, that the airport was in LVPs due to the cloud base and so prepared for an automatic landing on Runway 06 from the ILS. Company procedures required that, for an automatic landing, the left seat pilot would become PF for the approach and landing. As they approached the airfield, the weather improved, and LVPs were no longer in force. This meant the crew could revert to a manually-flown landing, with the right seat pilot continuing as PF.

Airfield information

EDI operates using a single runway orientated 06/24. The runway has a CAT3 ILS at both ends.

In 2005, the airport began a project to build a new air traffic control tower. Progressive development at the airport meant that the sightlines from the old control tower were being eroded and the building was no longer suitable. A new 57 m tall tower was built with the visual control room (VCR) on the top floor. The VCR has sightlines across the whole airport site. The airport has its own radar control room which provides approach control services to arriving aircraft as well as radar services for aircraft looking to cross through controlled airspace around the airport. Following a public tender in 2016, the ANSP at EDI changed, with the changeover occurring at the end of March 2018. The company that took over the contract also runs the air navigation services at London Gatwick Airport (LGW).

The airport had an average of 353 aircraft movements a day in 2017, making it the sixth busiest airport in the UK.

ATC workstations

The VCR at Edinburgh has three workstations: ground control, tower control and an assistant's station.

The tower control workstation is the middle of the three workstations. It has an unobstructed view of the runway and the approaches at both ends. This workstation is shown at Figure 8. In front of the controller, mounted on the desk, is an interactive screen which displays information about the flights, both on the ground and on approach to the airport. Each flight has a 'strip' which contains details of the flight and the controller amends the strip as the flight progresses through a departure or an arrival. Mounted vertically in front of the controller is a screen showing the radar picture of the arriving and departing traffic. This allows the controller to see the sequence and spacing of the aircraft on the approach (see Figure 3 earlier in this report).

On the right of the controller are two screens which are the ground lighting panel and the support information screen; the latter shows ancillary information such as the latest weather at the airport. To the left of the radar screen is a wind direction and speed display. Further to the left is the SMR/RIMCAS display screen (see Figure 4 earlier in this report).

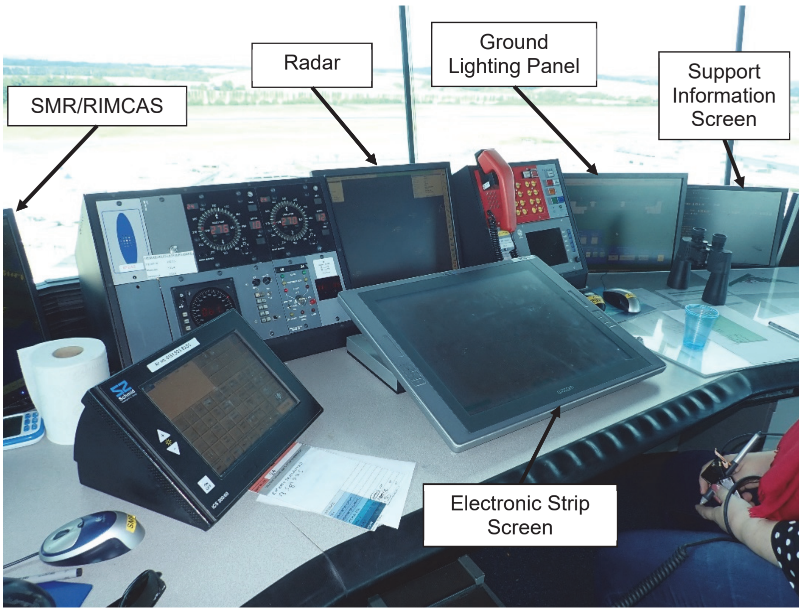

Figure 8

Tower controller's workstation at Edinburgh as viewed from the OJTI's approximate position

Figure 9 shows the electronic strip screen. When an approaching aircraft is issued a speed instruction by the radar controller, the instructed speed is shown on the strip as shown on Figure 10.

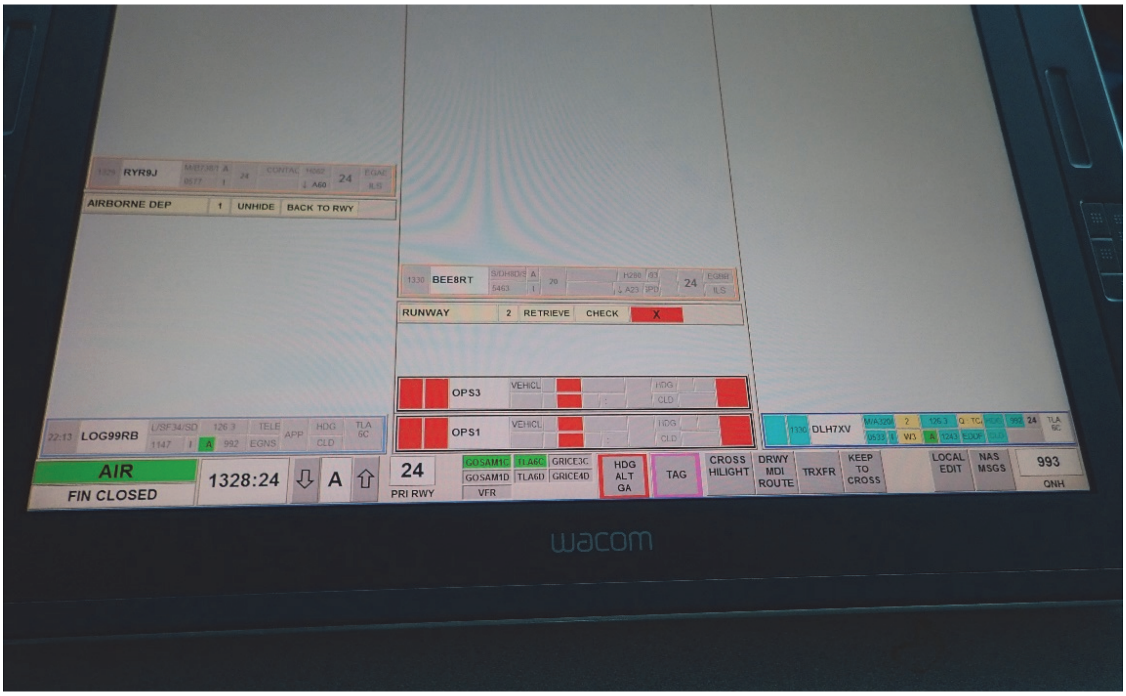

Figure 9

Electronic strip screen

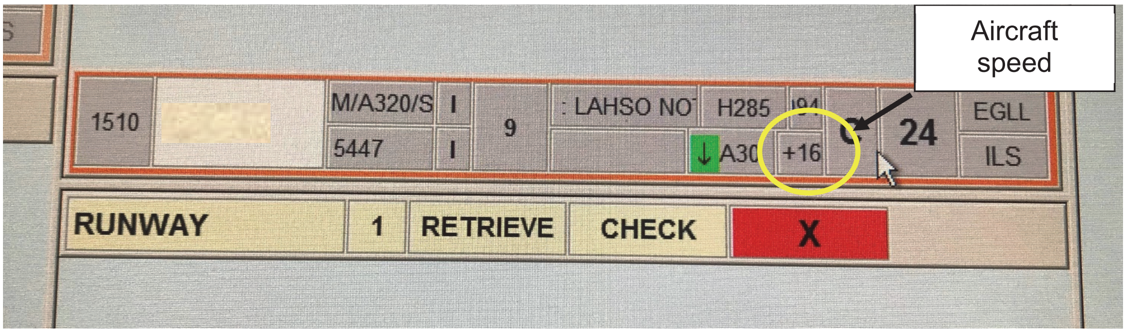

Figure 10

Electronic strip showing an instructed speed of 160 kt or greater

The lighting control panel is interactive. The controller selects different boxes on the screen using a mouse to turn on and off lights and change the intensity of some. Turning off the Stop Bar for the holding point A1 for Runway 06 requires the controller to click accurately inside the A1 box followed by a click in the box at the start of the runway.

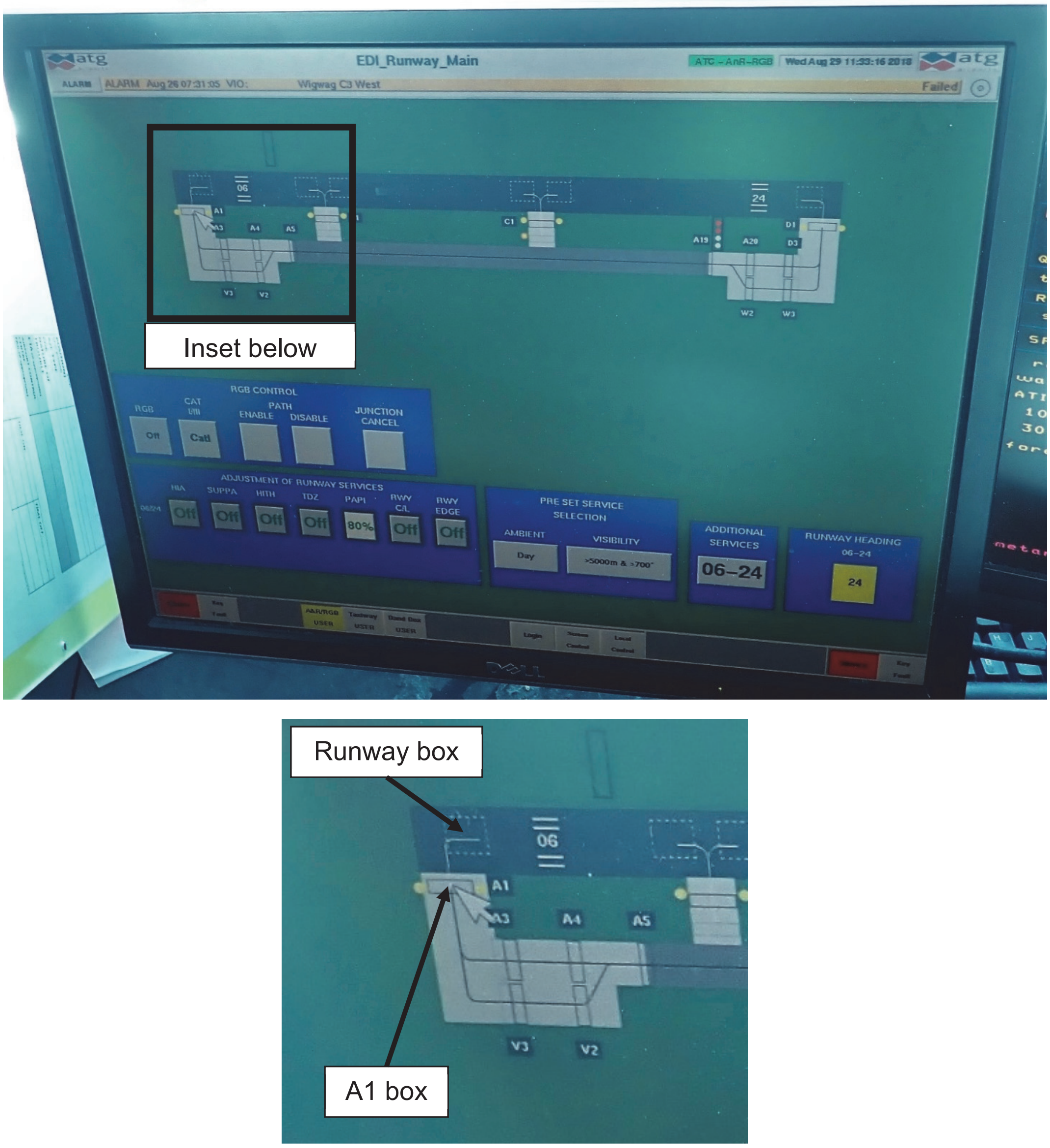

Figure 11
Lighting control panel

During training, the trainee controller sits in the main seat central to the workstation. The OJTI plugs in a headset and sits behind and to the left of the trainee. The OJTI usually uses a higher chair than the controller to get a better view of the various screens.

On a day with poor visibility and/or low cloud, less information is available out of the window and both the OJTI and the controller need to rely more on information presented on the screens. The design of the screens is such that there is not a good view of them from any position other than the controller's position. Therefore, the OJTI may need to be more active in changing positions to see the information they need to effectively monitor the trainee controller. Figure 8 illustrates the difficulty of seeing the information on the screens if not seated in the controller's position.

Airfield procedures

Manual of Air Traffic Services (MATS) Part 1

MATS contains procedures, instructions and information which form the basis of Air Traffic Services (ATS) within the UK. The manual is divided into two parts. Part 1 contains instructions that apply to all Air Traffic Service Units (ATSU) within the UK, whilst Part 2 contains instructions for a specific ATSU. Part 1 is produced and published by the UK CAA as CAP 493, with Part 2 being produced by the ATSU and approved by the CAA.

MATS Part 1 defines a runway incursion in Section 2, Chapter 1[4] as:

> *'A runway incursion is any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for aircraft take-off and landing. The protected area of a surface for aircraft take-off and landing is determined by the existence and location of the runway strip, clear and grades area, obstacle free zone and ILS sensitive areas. The precise configuration of these areas is dependent on the aerodrome layout and the operations taking place.'*

This definition reflects that stated in International Civil Aviation Organisation (ICAO) Document 4444, Air Traffic Management[5]. Whilst, in this event, the two aircraft were not on the runway surface at the same time and did not therefore meet the definition of a runway incursion, the separation had been significantly eroded.

MATS Part 1 also specifies that[6]:

> *'Unless specific procedures have been approved by the CAA, a landing aircraft shall not be permitted to cross the beginning of the runway on its final approach until a preceding aircraft, departing from the same runway, is airborne.'*

No specific procedures have been approved for EDI.

MATS Part 1 also has instructions for the controller on cancelling a takeoff clearance[7] which state:

> *'The cancellation of a takeoff clearance after an aircraft has commenced its takeoff roll should only occur when the aircraft will be in serious and imminent danger should it continue. Controllers should be aware of the potential for an aircraft to overrun the end of the runway if the takeoff is abandoned at a late stage.'*

Footnote

4 MATS Part 1, Section 2, Chapter 1, 10C.2.
5 ICAO Doc 4444 '*Procedures for Air Navigation Services Air Traffic Management*', Sixteenth Edition, 2016, Chapter 1.
6 MATS Part 1, Section 2, Chapter 1, 19.2.
7 MATS Part 1, Section 2, Chapter 1, 16.3.

Furthermore, it states:

> *'As the aircraft accelerates, the risks associated with abandoning the takeoff increase significantly. For modern jet aircraft, at speeds above 80 kt flight deck procedures balance the seriousness of a failure with the increased risk associated with rejecting the takeoff…. The typical distance at which a jet aircraft reaches 80 kt is approximately 300 m from the point at which the takeoff roll is commenced. The unit MATS Part 2 shall contain further guidance on the likely position on the runway at which those aircraft types commonly using the aerodrome typically reach 80 kt.'*

MATS Part 2

EDI specifies standard final approach spacing for each runway and radar configuration in MATS Part 2[8]. The spacing used is dependent upon whether the airport is operating under LVPs, and upon what radar and secondary surveillance systems are active. At the time of the incident, the airport was not using LVPs and all surveillance equipment was functioning. This meant that the minimum proscribed spacing between landing aircraft with no departure in between (pack mode) was 4 nm, with the distance increasing to 6 nm if a departure was required between the two landing aircraft (gap mode).

Section 3[9] describes what the controller should consider if the spacing is not sufficient between two landing aircraft (pack mode) before stating:

> *'However, in both modes, only if radar separation cannot be maintained, an aircraft is dangerously positioned on the approach or the runway is obstructed should the aircraft be sent around.'*

Section 3 also contains further guidance on cancelling a takeoff clearance as described in MATS Part 1 above. On Runway 06, 300 m from the start of the takeoff roll is approximately abeam the glide path aerials. This is the point to be used when assessing whether to cancel a takeoff clearance.

MATS Part 2 also describes the use of the airfield RIMCAS system. In the event of a Stage 2 (red) alert[10]:

> *'A 'go-around' shall be issued to the arriving aircraft unless it is positively known (for example, from visual observation) that there is no actual runway infringement.'*

Footnote

8 EDI MATS Part 2, Section 4, Chapter 2.10.3.
9 EDI MATS Part 2, Section 3, 2.8.
10 EDI MATS Part 2, Section 6, 3.6.3.3.1.

RTF Procedures

United Kingdom Radiotelephony Manual (CAP 413) sets out standardised phraseology to be used within UK airspace. Specific phraseology can be used when the controller needs an aircraft to depart immediately[11]:

> *'For traffic reasons a controller may consider it necessary for an aircraft to take off without any delay. Therefore, when given the instruction 'cleared for immediate take-off', the pilot is expected to act as follows:*
>
> 1. *At the holding point: taxi immediately on to the runway and commence take-off without stopping the aircraft.*
> 2. *If already lined up on the runway: take-off without delay. Should an immediate take-off not be possible, the pilot is to advise the controller.'*

The CAP 413 does not specify the use of 'expect late landing clearance' but EDI MATS Part 2[12] specifies:

> *'If landing clearance has not been issued at 2nm from touchdown, the pilot shall be instructed to "continue approach" and advised to expect a late landing clearance together with the reason, e.g. "aircraft to vacate".'*

Use of Stop Bars

Stop Bars are only used at EDI when safeguarding is in operation. In MATS Part 2 this sets out that this will occur whenever the '*meteorological conditions are likely to fall to 1,000 metres or below*'[13]. At other airfields the Stop Bars may be used at all times.

Flight Crew – EI-FJW

The crew of EI-FJW were experienced on the Boeing 737. They had all operated into and out of EDI on previous occasions and were familiar with the airport and procedures. Some of the crew also had significant experience of LGW. The captain under training had experience as a commander at his previous operator so was not new to the role. Both training captains had more than a year's worth of training experience on the Boeing 737.

The flight from SWF to EDI was slightly longer than normal as the aircraft had a technical defect which prevented it from taking the usual more direct routing across the Atlantic.

The dynamics of a training flight with three captains in the flight deck can be challenging. In the right seat is the aircraft commander as the left seat captain is not yet fully qualified. However, for the purposes of the check flight, the left seat pilot acts as if he were the commander to demonstrate he has the required levels of skills to complete his training

Footnote

[11] CAA CAP 413, Chapter 4, 4.31.
[12] EDI MATS Part 2, Section 3, Chapter 2.7.
[13] EDI MATS Part 2, Section 3, Chapter 4.1.1.

and act as an unsupervised commander. The captain on the jumpseat must observe without comment unless he believes the aircraft to be at risk.

All three pilots of EI-FJW were familiar with operations at LGW. LGW also operates using a single runway[14]. The average movements per day in 2017 were 772, making it the second busiest airport in the UK, and the busiest single runway airport by movements in the world. Being familiar with operations at LGW meant all three of the crew were used to very high movement rates and were familiar with receiving landing clearance late or very late on the approach.

EI-FJW flight crew interviews

The flight crew of EI-FJW were interviewed both separately and together. They all stated that they were visual with OE-IVC from approximately 800 ft. At this point, they remembered it being at 90 degrees to the runway. From the point that they could see OE-IVC, all three reported that they were monitoring the situation and considering whether to go around.

All three commented that they have a high level of trust in UK ATC. The trainee captain was PM at the time of the incident. He reported that he made a call at 0.5nm to remind ATC of their position and prompt them for a go-around instruction if required. When they received an instruction to continue their approach, they interpreted this to mean that ATC were fully in control and they followed the instruction accordingly while continuing to monitor the situation.

The aircraft commander, who was PF, reported that he felt tired at the time of the incident having flown through the night from SWF. His roster pattern was compliant with the operator's approved flight time limitation scheme. Nevertheless, his sleep and work history for the seven days leading up to the incident was reviewed and assessed using the SAFTE-FAST biomathematical fatigue model. This model considers duration of duties, timing of duties, circadian rhythms, sleep duration and sleep inertia. The model produces a predicted 'effectiveness score' expressed as a percentage. Effectiveness scores of 90 - 100% are what would be expected for someone sleeping eight hours per night and working during the day. The commander's predicted effectiveness score at the time of the incident was 77.6%[15].

At the time of the incident, he was working on the final day of a seven-day roster block that included two return trips to SWF from the UK. The amount of sleep obtained overall in a combination of main sleep periods and planned naps was in line with what the commander reported as his normal sleep need. The pattern of shifts and the time zone changes resulted in several large changes to the start time of his main sleep periods over the course of the seven-day block. At the time of the incident he had been awake for approximately 13 hours following a planned nap.

Footnote

[14] Although the airport has a standby runway which can be used when the main runway is not available.

[15] The default threshold for this model, below which people are considered fatigued is 77%. In laboratory conditions, people at a predicted effectiveness score of 77% display impaired task performance such as increased reaction time. The model also indicates equivalence with the Samn-Perelli crew status check scale. The equivalent predicted level was 5.43. 5 = '*moderately tired, let down*', 6 = '*extremely tired, very difficult to concentrate*'.

Flight crew - OE-IVC

The commander of OE-IVC was an experienced line trainer for the operator. The co-pilot in the right seat was undergoing line training having joined the operator from flight school and had completed around 70 hours flying in the A320 family with the operator. The commander of OE-IVC commented that an inexperienced pilot may take 10 – 15 seconds longer to line up on the runway.

The crew of OE-IVC were not given any instruction to expedite their line up or takeoff by ATC and were unaware of how close EI-FJW was at touchdown.

Air traffic controllers - trainee

The trainee controller attended the initial ATCO training course between July 2017 and April 2018 and had a Student Air Traffic Controller Licence that was issued in May 2018. The trainee controller started training at Edinburgh in May 2018 and was in the second of three levels of training.

Trainee training record

During the second level training prior to the incident, the trainee controller had completed 20 training sessions on a mixture of ground and air over a period of seven weeks. At the start of the session when the incident occurred the trainee controller had completed a total of 167 hours which included the core level training and the level two training undertaken so far.

The training record only includes details of the weather and the procedures practiced if an OJTI records it in the comments section. During the core and second levels of training, the use of LVPs was only referred to once and the use of safeguarding only once. On the two training days immediately before the day of the incident, the trainee controller worked at night. The comments noted that the trainee controller needed to be reminded to use the Stop Bars.

'*Control go arounds safely*' was only assessed on one occasion out of 20 during the second level training.

During the second level of training, the trainee controller and OJTI had worked together on five days. On the two days they last worked together prior to the incident, the trainee received highly positive written comments from the OJTI.

Trainee's interview comments

The trainee controller was interviewed together with the OJTI and then individually early in the investigation. Another individual interview was conducted several months later. The trainee controller had little experience working in the weather conditions that were present on the day of the incident and said that it was the "worst cloudbase" experienced while controlling. The trainee controller reported that there was no brief from the OJTI prior to the session and that this was common practice. Furthermore, it was normal for trainee controllers to perform a 'self-brief' covering NOTAMs etc. and then plug straight in for the session.

The trainee controller was aware of the need to catch up after the delay caused by not turning off the Stop Bars, but the developing situation was not fully apparent until EI-FJW appeared to break through the cloud.

The trainee controller heard EI-FJW make a transmission at 0.5 nm but did not hear what they said and so turned to the OJTI for advice; he advised to respond "negative". The trainee controller transmitted "NEGATIVE" and "CONTINUE APPROACH" to the crew of EI-FJW.

The trainee controller had not been aware of EI-FJW's groundspeed on approach or the speed instruction that had been issued to EI-FJW by the Edinburgh radar controller. During the second individual interview, the trainee controller reflected that the speed instruction was on the strip and the groundspeed was on the radar display but, being unfamiliar with the conditions, the trainee's strategy still focussed most attention out of the window instead of using information on the screens.

Air traffic controllers - OJTI

The OJTI had a valid Air Traffic Controller Licence and he was initially validated at Edinburgh in 2012. His licence included an OJTI endorsement valid until March 2021. The OJTI had completed a CAA approved practical instructional techniques[16] course during March 2018 and so, at the time of the incident, he had been working as an instructor for five months.

OJTI interview comments

The OJTI was interviewed initially with the trainee controller and then twice individually during the investigation.

He stated that, at the time of the incident, two training sessions were taking place, one on the tower position and one on the ground position. The trainer instructing on ground was using the only higher chair available so the OJTI used a standard lower chair. The OJTI stated that it is not possible to read the radar label readouts, including aircraft ground speeds, when seated in either chair due to glare and reflections on the screen. From the higher chair, it is possible to read the information on the strips but the radar screen label readouts are still not legible.

The OJTI commented that when planning to depart an aircraft in the gap between two landing aircraft he is looking for a 6 nm gap between landing aircraft and for the takeoff clearance to be issued to the departing aircraft by the time the second approaching aircraft is at 3 nm. He stated that he actively checked this was met and would have stood up and leaned over as necessary to see. The OJTI had worked with the trainee controller on many occasions before. He judged the trainee controller to be quite far through the training and at the point where less OJTI input was needed. Therefore, he recalled that, once he had checked the gap and takeoff clearance were sufficient, he had returned to his normal seated position.

Footnote

[16] Regulation (EU) 2015/340 of 20 February 2015 laying down technical requirements and administrative procedures relating to air traffic controllers' licences and certificates refers.

He said that he became aware of the situation a few seconds before the time that EI-FJW called 0.5 nm. From his perspective, this was when the aircraft appeared to suddenly come out of the cloud. He recalled that OE-IVC was at the threshold and had just started its takeoff roll.

The OJTI admitted that he was surprised to see EI-FJW so close and did not immediately react. By the time he was able to do so, he felt that it was too late to stop OE-IVC from taking off as it was beyond the glide path aerials and he was reluctant to send EI-FJW around. He feared that this would result in having two aircraft, over which he had limited control, close together in cloud.

The OJTI explained that with OE-IVC at speed and beyond the glide path aerials during the takeoff and EI-FJW at a very late stage of their approach he decided the best solution was to allow EI-FJW to land. He took control from the trainee controller and issued the landing clearance. He did recall the RIMCAS alert sounding.

After the incident, the OJTI retained control for a short time before handing back to the trainee and continuing the training session until the next break.

Organisational information

ANSP changeover

The changeover of ANSP at EDI resulted in the need for a period of sustained training due to a turnover of controllers. In the 15 months leading up to the ANSP transition, a total of eight controllers with previous experience elsewhere were recruited and trained at EDI. This training was completed by the previous ANSP under a commercial arrangement. A further five ab-initio controllers were recruited by the ANSP and began their training after the changeover. This was unusual for EDI and saw a total of 13 new controllers trained within 18 months. Usually, EDI would see around one new controller a year. This pace of training required the ANSP to qualify a significant number of the controllers already working at EDI as trainers and a small number of these had little or no previous experience in training new controllers. The ANSP contracted a third-party to provide a trainer's course which was designed and approved in accordance with the requirements in Section 5 of Commission Regulation (EU) 2015/340. The OJTI in this incident was a new trainer who had completed this course.

Training procedures at Edinburgh

According to the Edinburgh Unit Training Plan, the OJTI's responsibilities include:

> *'The safety of the air traffic control service that the trainee is providing under his supervision.*
>
> *Briefing the trainee before and after each session and outlining what is expected of them.'*

On-the-job training is divided into three levels. The differentiation between the levels is primarily in terms of what amount of OJTI support is required for trainee controllers to meet the competency standard.

At the core (first) level, in medium or high traffic or complex conditions, the trainee controller is expected to be able to perform to the required standard with '*some support*' from the OJTI. '*Some support*' is defined as '*The OJTI will direct and prompt as necessary*'.

At the second level, in medium traffic/medium complexity conditions '*minimal*' support is expected. '*Minimal*' means '*minor support where necessary, e.g. make reference to complex problems or ask the trainee to develop a course of action in time.*' In high traffic or high complexity conditions, '*some*' support is expected.

At the final level, the trainee controller is expected to be able to perform all tasks with no input from the OJTI.

At all levels, during LVPs or emergencies, additional OJTI support is expected to be necessary for the trainee to perform at the required standard.

OJTI training

Regulation (EU) 2015/340 required that the training of practical instructors '*Shall include a practical instructional techniques course… including an assessment.*' The training provider and the course must have been approved by a competent authority which, in the UK, is the CAA.

CAP 624 '*Air Traffic Controllers Performance Objectives Part 11 OJTI*' specified the performance objectives required for OJTIs. These included:

- OJT1.2 Determine the student/trainee's current level of ability
- OJT2.1 Conduct a pre-session briefing
- OJT3.1 Conduct the Training Session
- OJT3.2 Monitor the Training Session
- OJT3.3 Correct Errors

There were no EU regulatory requirements for the content of the practical instructional techniques course but Eurocontrol have published guidance[17] which includes a recommended syllabus for OJTI training.

The OJTI completed his practical instructional techniques at a third-party provider. The training provider and course were approved by the CAA. The course content was consistent with the Eurocontrol guidance and was designed to teach new OJTIs to meet the performance objectives specified in CAP 624.

Footnote

[17] Eurocontrol (2009). EUROCONTROL-GUID-133: '*EUROCONTROL Guidelines for ATCO Development Training OJTI Course Syllabus*'. Edition 2.0.

The course included:

- 90 mins classroom session on the briefing.
- 45 mins classroom session on error correction.
- 45 mins computer-based training on post-training session report writing.

It also included seven 45-minute practical exercises with mock trainees who simulated different levels of experience and different attitudes. The 45-minute practical period included time for briefing, de-briefing and assessment of the OJTI and 20 minutes for OJTIs to practice the training and monitoring of mock trainees. Four out of the five days of the course were devoted to such practical exercises. When trainee OJTIs were not doing practical exercises themselves, they observed the other trainee OJTIs doing so.

The OJTI's monitoring was assessed as good on all practical exercises. There was evidence that the OJTI had experienced trainee errors during the exercises and had made corrections or taken control appropriately.

OJTI practice at Edinburgh

Trainee controllers were supervised by a team of OJTIs, working with different people on different training sessions as required. The trainee controllers and the OJTIs were in regular contact and were considered to know each other well. Therefore, there was no expectation that a pre-training briefing would be conducted prior to each session and no time was provided for it.

Reporting procedures

After the training session during which the incident occurred, the OJTI reported the event to the Unit Competency Assessor and later, the Watch Manager. The conclusion from these conversations was that the incident could be reported on a voluntary basis.

The Unit Competency Assessor said that the event was reported to him as a "late landing clearance" which was a common occurrence. Although he recalled that the OJTI had used the word "incident", he was not aware that the landing clearance was given after the aircraft crossed the runway threshold or that another aircraft was involved and so he did not recognise how serious the event was. The Unit Competency Assessor and OJTI agreed that the OJTI should file a voluntary observation report. When they parted, the Unit Competency Assessor believed that the OJTI was on his way to file the report.

The Watch Manager also said that the event was reported to him as a "late landing clearance". He said that the OJTI's concern had been focused on the performance of the trainee controller. The Watch Manager was aware that the OJTI had already spoken to the Unit Competency Assessor and presumed that the Unit Competency Assessor had judged that the event was not serious. He did not follow up by talking to the trainee controller or to the Unit Competency Assessor.

MATS Part 1 specifies that a Mandatory Occurrence Report (MOR) should be filed within 72 hours of a serious incident occurring[18]. It allows an ATSU to use an approved programme for submitting an MOR which puts the report in the correct format for uploading on the database. EDI ATSU uses a programme known as TOKAI[19] for submitting MORs. The changeover of ANSP meant that user access for reporting events via TOKAI changed. The login for TOKAI required an employee email address and password. The OJTI had difficulty logging onto the system as this was the first time since the ANSP changeover that he had needed to do so. This difficulty, combined with days off, meant that the report was not completed using TOKAI for a number of days.

This delay meant that the recollections of the parties involved in the incident were not fresh and they had had time to reflect on the events, which may have altered how they recalled what had happened. It also meant that neither aircraft's CVR was available to the investigation.

Analysis

Introduction

At 0945:55 hrs, the preceding aircraft landed at EDI. At this point EI-FJW was 6 nm from touchdown, which was exactly the spacing required in the EDI MATS Part 2 for gap mode. The trainee controller then preceded to give OE-IVC line up clearance as had been planned for the gap before EI-FJW landed. Due to a combination of factors, the gap rapidly closed and the departing aircraft was at only 60 ft aal when the landing aircraft touched down.

Factors leading to the gap closure

Stop Bar

The airfield was in safeguarding due to the meteorological conditions and, therefore, the Stop Bars were in use. The trainee controller did not have much experience of working in conditions similar to those of the day of the incident and had little experience of using the Stop Bars. The Stop Bar was not turned off expeditiously and, as a result, OE-IVC could not move from the holding point to line up. There are two possible explanations; the trainee controller may have forgotten to do it or may not have activated the Stop Bar controls correctly. Turning off the Stop Bar requires a controller to move a cursor using a mouse and click within a very small box, before moving the cursor to the beginning of the active runway and clicking again. During this process, the cursor may have been mispositioned or the selection may have been performed in the wrong order, leading to the Stop Bar remaining illuminated.

Having been cleared to line up but with the Stop Bar still illuminated, it was natural for the crew of the departing aircraft to then question the illumination of the Stop Bar with the controller. However, before the crew of OE-IVC could do this, another aircraft on the same

Footnote

18 MATS Part 1 Section 6, Chapter 3.
19 TOKAI - Tool Kit for ATM Occurrence Investigation.

frequency began a transmission. As a result, there was a 16 second delay between OE-IVC being cleared to line up on Runway 06 and the crew asking the controller to turn off the Stop Bar so they could proceed onto the runway. This delay caused a significant part of the gap closure.

Speed of landing aircraft on approach

EI-FJW had been instructed by EDI approach to maintain a speed of at least 160 KIAS on the approach until 4 nm to assist with the spacing between it and the following aircraft. It would have been more usual for an aircraft on the approach to be instructed to maintain a speed of exactly 160 KIAS until 4 nm from touchdown, so the instruction given to EI-FJW permitted the aircraft to be flown at a higher speed than was normally expected. The crew complied with the instructions and were at 181 kt ground speed at 6 nm when the preceding aircraft touched down on the runway. EI-FJW complied with all the operator's requirements for a stable approach, having begun to slow after they passed 6 nm from touchdown. The higher than normal speed of EI-FJW on the approach may have caught the trainee controller by surprise.

Any speed control given to an approaching aircraft by the radar controller was displayed on the strip information, and the groundspeed was displayed on the radar picture display at the tower controller's station. However, the trainee controller was more familiar with being able to see the aircraft on the approach and to judge the gap visually rather than relying on the screens provided. With the weather conditions, the trainee controller was unable to see the aircraft until it was inside 2 nm from touchdown. The higher speed of the approaching aircraft combined with the less familiar need to refer to the radar display meant that the closure of the gap went unnoticed until the late stages of the approach.

The OJTI, seated or standing behind the trainee controller could not see the screens in detail without making a deliberate attempt to move his position, so the developing situation may also have not been obvious to him.

Time taken for the departing aircraft to take off

The crew of OE-IVC were unaware of the closing gap. They had not been instructed to expedite their line-up, nor had they been cleared for an immediate takeoff. Had either of the tower controllers issued these instructions it is likely that the training captain would have taken control of the aircraft and conducted the takeoff. The training captain estimated that this could have saved 10-15 seconds.

Reaction to the closing gap

EI-FJW

The crew of EI-FJW were familiar with the much busier air traffic environment of LGW, where the aircraft spacing is optimised to allow a large number of movements from a single runway. They were not concerned about the closing gap, as they did not consider it unusual. As the aircraft approached 0.5 nm from touchdown, they could clearly see the other aircraft was still on the runway. PM called the tower controller and was told to expect a late landing clearance. This confirmed in the minds of the crew that the controllers were fully aware of the position of both aircraft.

The crew in EI-FJW consisted of three captains, which, for the reasons given earlier, could make the dynamics of decision making challenging especially when considering that the captain who was PM in the left seat was being assessed before completing his training. There may have been reluctance from all three pilots to voice their concerns for fear of jeopardising the assessment.

The aircraft commander reported he was tired due to the overnight flight and his previous roster that included several transatlantic flights. He had had as much sleep as could be expected given his roster pattern and his flying performance was unlikely to be affected by fatigue. However, his feeling of tiredness may have made him hesitant to go around because this would extend the flight time.

The phenomenon of plan continuation bias may also have added to the crew's reluctance to go around even when they had not received a landing clearance at such a late stage. Plan continuation bias is an '*unconscious cognitive bias to continue* [the] *original plan in spite of changing conditions*[20]'. The bias can cause people to discount cues which indicate the situation requires a different course of action and has a stronger effect on behaviour the closer someone is to the completion of their plan; for example, the closer someone is to landing at the planned destination.

Overall, the above factors came together to contribute to the crew of EI-FJW not making a decision to discontinue the approach and go around.

OE-IVC

The crew of the departing aircraft were unaware of the developing situation and so could not react. The absence of any indication from the tower to the contrary resulted in the aircraft departing as planned. Even after takeoff, they were completely unaware of the situation that had developed and the closeness of EI-FJW behind them.

Controllers

The trainee controller was still relying on techniques more suited for use in better weather conditions. The trainee controller was using a rule-based strategy which checked the gap was sufficient as the preceding aircraft touched down and was not effectively monitoring the aircraft speeds or size of the gap as the situation progressed. All this meant that the trainee controller did not become aware of the gap closure until late and so then had little time to react.

As the crew of EI-FJW called at 0.5 nm, the trainee controller responded by instructing EI-FJW to continue the approach. This call also coincided with the RIMCAS Stage 2 visual

Footnote

[20] Dismukes, K. and Loukopoulos, L. (2004). '*The Limits of Expertise: The Misunderstood Role of Pilot Error in Airline Accidents*'. https://humansystems.arc.nasa.gov/flightcognition/article2.htm [accessed 6 March 2019).

and audible alert which would have continued in the background until cancelled. Both the 0.5 nm call and the RIMCAS Stage 2 alert may have been unfamiliar to the trainee controller. Whilst the trainee controller would have been familiar with the instructions in EDI MATS Part 2 stating that a RIMCAS Stage 2 alert requires the issue of a go-around unless it is '*positively known that there is no runway infringement*', the trainee controller did not have the capacity or experience to immediately make that decision.

The trainee controller had little or no experience of instructing a go-around. This inexperience, together with the short time period available to act after becoming fully aware of what was happening resulted in an inability to recover the situation. The lack of experience probably also caused a reluctance to intervene in such a serious situation immediately without confirmation from the OJTI that it was the correct thing to do.

The OJTI was monitoring the trainee controller but had missed the developing situation. He became aware of the seriousness of the situation when EI-FJW came out of cloud a few seconds before the RIMCAS Stage 2 alert began to sound. He was startled by the suddenness of the situation and this caused a further delay in his reaction. His immediate concern was for the separation of the two aircraft. He could see both aircraft out the window and although they were close he was not concerned about them closing together. He considered that it was too late to stop OE-IVC taking off as he considered its speed was above 80 kt because it had passed the glide path aerials as specified in EDI MATS Part 2. His options were therefore to either instruct EI-FJW to conduct a go-around or allow it to land. His biggest concern was that if he instructed the go-around, he would have two aircraft, which he could see were close, disappear into cloud where he could not visually separate them. He made the decision to allow EI-FJW to land, which he did by giving them landing clearance. He considered that the decision was the safest at that point.

An earlier intervention could have enabled EI-FJW to go around whilst keeping OE-IVC on the ground, preventing the risk of two aircraft in cloud without minimum separation.

Had EI-FJW gone around from the approach, both aircraft would have been airborne with limited lateral separation. Given the TCAS inhibits, neither would have received an RA until reaching 1,000 ft radio altitude (737) or 1,100 ft radio altitude (A320). Whether the aircraft would have received an RA after this point would have depended on the actions of the controller to separate the aircraft, and their relative speeds and climb rates. It is not possible to model the flight paths of the aircraft accurately enough to be able to fully understand whether the TCAS RA would have been activated.

Being an OJTI can be a challenging position which requires experience and sound judgement to decide when and how to intervene with a trainee. The OJTI was relatively inexperienced in the role which would have made intervention decisions more challenging. As a trainee controller progresses through the training programme, OJTIs are encouraged to intervene less and less to allow the trainee controller to develop the skills and confidence required to qualify. With the trainee controller a considerable way through the second of three parts of the training, the OJTI would have been expecting the trainee controller to perform with little or no support from him. He had also had two sessions in the days before the incident during which the trainee controller had performed well. These factors and the difficulty of reading the screens could explain why the OJTI was not monitoring the situation closely once the initial gap had been checked and thus it increased the surprise[21] factor when the seriousness of the situation became clear to him.

Other factors

Training reports

The reporting forms used by EDI ATC for their trainee controllers contained the information required by the regulations. The reports, which were filled in by the OJTI after each training day, contained a comments section which the OJTI could use and a grading for each competency area. The comments recorded by the OJTIs were often quite lengthy but rarely included details of the weather conditions that the trainee controller experienced.

There was no summary to show the gradings for each competency over time. This made it hard for OJTIs to quickly get an impression of a trainee controller's recent experience and performance, and what the areas of focus should be for each session. This made it difficult to provide effective training and support at the right level for the trainee controller.

Pre-training briefing

The CAA performance objectives for OJTIs and the OJTI practical instruction techniques training both include conducting pre-session briefings. However, there was no expectation in EDI that this would occur, and no time was set aside for it. Whilst the OJTIs and the trainee controllers were well known to each other, a pre-session brief would allow both parties to understand the expectations for the session. It would also allow the OJTI to assess the experience level of the trainee controller for the prevalent conditions and to discuss the appropriate use of the information available to them.

Conclusion

A succession of short delays to the departure of OE-IVC and the higher than normal speed approach of EI-FJW led to the rapid closure of the gap between EI-FJW and OE-IVC. The loss of spacing went unnoticed by both the trainee controller and the OJTI until EI-FJW came out of cloud which was just before the crew prompted them by calling at 0.5 nm. At this point the OJTI made the decision that it was safer to land EI-FJW than risk having two aircraft that he could not separate visually close to each other in cloud above the airport.

The crew of OE-IVC were completely unaware of the developing situation as they could not see EI-FJW nor had the trainee controller instructed them either to be '*ready immediate*' or cleared them for an '*immediate takeoff*'.

Footnote

21 Surprise is an emotional and cognitive response to unexpected events that are (momentarily) difficult to explain, forcing a person to change his or her understanding of the problem. Landman, A., Groen, E.L., van Passen, M.M. Bronkhorst, A. & Mulder, M. (2017) '*Dealing with unexpected events on the flight deck: A conceptual model of startle and surprise*' in Human Factors, Vol 59 pp 1161-1172.

The crew of EI-FJW were confident in the EDI air traffic controllers and were not initially concerned that they had not received a landing clearance. They were used to operations at LGW where traffic levels are significantly greater than EDI. They became concerned enough to prompt the controller at 0.5 nm but the reply only served to reinforce their confidence that the controller was on top of the situation. As a result, they did not decide to perform a go-around and continued to land once clearance was given. This led to a loss of separation between the aircraft at a critical phase of flight.

Safety actions

The ANSP at Edinburgh has taken the following safety actions in response to this incident:

- Published procedures in the Edinburgh MATS Part 2 regarding what events must be entered as MORs on the TOKAI system.
- Conducted a review of High Intensity Runway Operations at Edinburgh.
- Conducted a review of OJTI competency and introduced refresher training for all OJTIs as an outcome of the review.
- Has introduced additional higher OJTI chairs to provide OJTIs with a better view of the trainee, the screens and the trainee interactions with the equipment.
- Has reminded OJTIs of the requirement in the Unit Training Plan which mandates the requirements for a pre-training briefing between the OJTI and the trainee controller prior to every training session or at least every training day.
- Has incorporated a one-sheet overview of trainee ATCO's experience in their training file covering what key conditions and procedures they have experienced (eg fog, wind, go-arounds, significant slot delays, weather avoiding, snow etc).