الهيئة العامة للطيران المدني
GENERAL CIVIL AVIATION AUTHORITY

United Arab Emirates

Air Accident Investigation Sector

Incident

- Final Report –

AAIS Case Nº. AIFN/0002/2012

Attempted Takeoff from Runway Edge

Operator: Etihad Airways
Make and model: Airbus 330-243
Nationality and registration: The United Arab Emirates, A6-EYE
Place of occurrence: Abu Dhabi International Airport
State of Occurrence: The United Arab Emirates

Air Accident Investigation Sector
General Civil Aviation Authority
The United Arab Emirates

Incident Brief

GCAA AAI Report №:	AIFN/0002/2012
Occurrence classification:	Incident
Occurrence categorization:	Attempted Takeoff Runway Edge
Operator:	Etihad Airways
Aircraft Type and Model:	Airbus Industries, A330-243
Registration Mark:	A6-EYE
MSN	688
Date and Time:	30 January 2012, 0346 Local Time
Location:	Abu Dhabi Airport Runway 31L
Type of Flight:	Commercial Air Transport
Persons On-board:	227
Injuries:	None

Investigation Objective

This Investigation is limited to the aspects related to the low visibility operations at Abu Dhabi International Airport, the flight crew low visibility procedures, the airport lighting specific to the CAT III operations and the requirements for post-occurrence crew medical testing.

The sole objective of this Investigation is to prevent aircraft accidents and incidents. It is not the purpose of this activity to apportion blame or liability.

Investigation Process

The occurrence involved an Airbus A330 Passenger Aircraft, registration A6-EYE, and was notified to the United Arab Emirates (UAE) Air Accident Investigation Sector (AAIS) through the Duty Investigator (DI) by phone call to the Hotline Number +971 50 641 4667.

As the State of Occurrence, the AAIS led the investigation and issued this Final Report. The AAIS assigned an Investigator in Charge (IIC) together with an Investigation Team and commenced the investigation on 30 January 2012, the day of the Incident.

In accordance with *Annex 13 to the Convention on International Civil Aviation*, the State of the Manufacturer, France (Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile /BEA), was notified and assigned an Accredited Representative to this Investigation.

After the Onsite/Initial Investigation phase, the occurrence was classified as a “Serious Incident”. However, during the investigation process, taking into consideration all available data and information, this occurrence was re-classified as an Incident.

This Final Report is available to the public at the below link:

https://www.gcaa.gov.ae/en/epublication/pages/investigationreport.aspx

Notes:

1 Whenever the following words are mentioned in this Report with first Capital letter, they shall mean the following:

(Aircraft)- the aircraft involved in this incident.

(Investigation)- the investigation into this incident

(Incident)- this investigated incident

(Report)- this Incident Final Report

2 Unless otherwise mentioned, all time utilized in this report is local UAE Time (UTC +4 = UAE local time).

3 Photos used this Final Report are taken from different sources and are adjusted from the original for the sole purpose to improve the clarity of the Report. Modifications to images used in this Report are limited to cropping, magnification, file compression, or enhancement of color, brightness, contrast, or addition of text boxes, arrows or lines.

Abbreviations

AAIIB	Aircraft Accident & Incident Investigation Board of Cyprus
AAIS	The GCAA Air Accident Investigation Sector of UAE
AGL	Airfield Ground Lighting
ACFT	Aircraft
ADIA	Abu Dhabi International Airport
AIFN	Accident/incident file number
ALCMS	Airfield Lighting Control and Monitoring System
ANA	General Civil Aviation Authority Air Navigation and Aerodromes
ANS	Abu Dhabi Airport Company Air Navigation
ASMGCS	Advanced Surface Movement Guidance & Control System
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATIS	Automatic terminal information service
ATPL	Air Transport Pilot License
AVOL	Aerodrome visibility operational level
BEA	Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile
CAAP	UAE CIVIL AVIATION ADVISORY PUBLICATION
CAS	Calibrated Air Speed
CAT	Category
CAVOK	Ceiling and Visibility are OK
CCR	constant current regulators
C.G.	Centre of Gravity
CL	Centerline
cm	Centimeter
C of A	Certificate of Airworthiness
C of R	Certificate of Registry
CPL	Commercial Pilot License
CVR	Cockpit Voice Recorder
CSN	Cycles Since New
ECAM	Electronic Centralized Aircraft Monitor
ECT	Emergency Continuation training
ETD	Estimated Time of Departure
E.W.	Empty Weight
FAA	The Federal Aviation Administration of the United States
FAR	The Federal Aviation Regulations
FDR	Flight Data Recorder
FMV	Follow-Me Vehicle
ft	Feet (distance unit)
GCAA	General Civil Aviation Authority of the United Arab Emirates
hrs	Hours
HUD	Head Up Display
IAS	Indicated Air Speed
ICA	Instructions for Continued Airworthiness
ICAO	International Civil Aviation Organization
kgs	kilograms
kts	Knot(s)
lb	Pound(s) (weight unit)

LG	Landing Gear
LH	Left Hand
LIH	Light Intensity High
LIL	Low Intensity Approach Light System
LO	Low
LT	Local time of the United Arab Emirates
LVO	Low Visibility Operations
LVP	Low Visibility Procedures
m	Meter(s)
METAR	A format for reporting weather information
MIM	Minimum
MSN	Manufacturer Serial Number
MLG	Main Landing Gear
NLG	Nose Landing Gear
NM	Nautical Miles (distance unit)
No.	Number
NTSB	The National Transportation Safety Board of the United States
OAT	Outside Air Temperature
OPC	Operator's Proficiency Check
PIREP	Pilot Weather Report
RTIL	Runway Threshold Identification Light
RH	Right Hand
RVR	Runway Visual Range
SA	Situational Awareness
SI	Standard Instruction
TDZ	Touch Down Zone
TWY	Taxiway
SMGCS	Surface Movement Guidance and Control System
UAE	The United Arab Emirates
UTC	Coordinated Universal Time

Synopsis

On 30 January 2012, Etihad Airways Airline Airbus A330, was scheduled to operate a commercial passenger flight ETD045 from Abu Dhabi International Airport, the United Arab Emirates, to Dublin International Airport, Ireland, with 11 crew and 216 passengers onboard. The scheduled departure was delayed by 68 minutes as the departure airport was in low visibility operations (LVO) due to fog. The visibility during taxi and takeoff was 175 meters. During takeoff at 0346 LT, the flight crew rejected the takeoff at 86 knots ground speed after the Commander heard unusual loud thumps coming from the nose gear. After the Aircraft came to a stop, the crew noticed that the Aircraft was aligned on the left hand edge of runway 31L instead of the runway centerline. The Aircraft had travelled a distance of approximately 775 meters. Eleven left hand edge runway lights were damaged and one of the Aircraft nose wheel tires was punctured. There were no injuries to the crew, or passengers.

The Air Accident Investigation Sector determines that the cause of aligning the Aircraft with the left hand edge of runway 31L instead of runway centerline was the loss of situation awareness by the crew. The root cause of the loss of situation awareness was not determined.

Following this Incident, the Aircraft Operator and the Air Traffic Control Unit implemented safety actions to avoid a reoccurrence.

The Investigation has also made several safety recommendations to the General Civil Aviation Authority (GCAA) and the International Civil Aviation Organization (ICAO) addressing runway edge lighting, runway lights testing, procedural verification of Aircraft takeoff position and medical testing.

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1. Factual Information

1.1 History of Flight

The flight crew, consisting of a line captain (Commander) and a copilot, reported for duty at 0030 LT for an initial planned flight departure of 0215 LT. This was the first time that the Commander was flying with the copilot. During the debriefing, the forecast weather, published at 2100 LT, provided to the crew did not forecast any fog and indicated that the visibility was 8000m, with no significant clouds. The copilot was briefed that he would be the pilot flying (PF).

1.1.1 Before taxi

All timings are UAE local time, LT.

0115 - While onboard the Aircraft, and after the flight preparation was completed, the flight crew noticed a deterioration in the weather as the fog had increased with runway visual range (RVR) at 200m and this was confirmed by listening to the Automatic Terminal Information Service (ATIS). As per the Operator's procedures during reduced RVR, the Commander took over responsibility as the pilot flying (PF).

0200 - Due to the implementation of low visibility operations at the airport, the crew was informed by the ground air traffic controller (ATCO) that the departure would be delayed for 45 minutes due to the prevailing fog.

0252 - Flight crew was told by the Operator's flight operations department that they were into discretion time as their flight time period had expired 25 minutes ago.

0318 – The Commander confirmed to the ground ATCO that minimum RVR for departure was 125 meters. Pushback clearance was given by the ATCO.

0323 – The pushback and engine start was completed. The flight crew requested taxi clearance and the ground ATCO told them to standby.

0325 – The ground ATCO shift change occurred and a new ground ATCO took over.

0327 - A non-operating deadheading company flight crew member entered the cockpit with the permission of the Commander, and he remained there for the rest of the flight. He occupied the observer's seat.

1.1.2 Taxi to Echo 9 to Echo 15 holding point

During this taxi phase, the Commander taxied the Aircraft at an average speed of 7 knots.

0331 - Taxi clearance was given to follow taxiways Echo 9 (E9) to Echo (E) and to the Echo 15 (E15) CAT III holding point stop bar (figure 1). The flight crew followed their company airport charts for taxiing, which were up-to-date. The ground ATCO did not offer follow-me vehicle (FMV) assistance to the crew. The crew did not request any follow-me assistance to the E15 CAT III taxi holding point.

0338 - After Echo 14, the Commander asked: "CAT III to the left or straight.", and the copilot mentioned that "He would be looking outside."

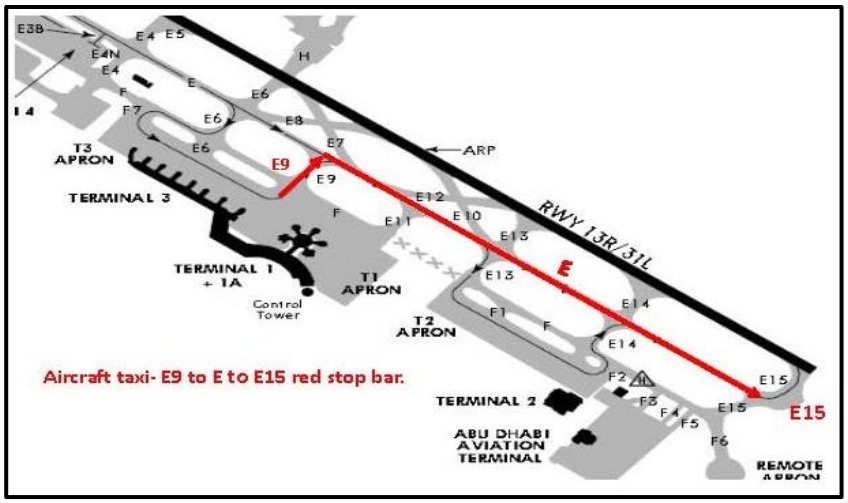

Figure 1. Taxi route E9 to E15

0340 – The ground ATCO informed the crew that they were approaching the holding point and to contact the tower ATCO on 119.20 Mhz frequency.

0341 - The crew contacted the tower ATCO and were informed that the first one third (A) RVR of RWY 31L, was 175 m, the second third (B) was 200 m and the last third (C) of the runway was 175 m. The Aircraft average speed decreased from 7 to 3 knots.

1.1.3 Taxi beyond holding point Echo 15 to the runway

The Aircraft average speed after crossing E15 stop bar was 6 knots.

0343:32 – The crew informed the tower ATCO that the stop bars were in sight and the tower gave clearance to line-up and wait on runway 31L.

0344:02 – The crew asked the tower ATCO if they were cleared to cross the stop bar.

0344:04 - The tower ATCO stated that he was trying to switch the stop bar off and he requested the crew to confirm that it was off.

0344:08 – The crew confirmed to the tower ATCO that “The green lights are back on for the runway.”

0344:15 - The Commander continued to taxi the Aircraft in a straight heading without any turn input for the next 14 seconds (until 0344:29). The Aircraft was on a magnetic heading of 36 degrees.

0344:18 - The ATC ground surface movement sensor 17/6 detected the Aircraft.

0344:25 - The Commander requested the *before takeoff below the line* checklist.

0344:28 - The ATC ground surface movement sensed that the Aircraft had passed sensor 17/6.

0344:32 - The Commander interrupted the checklist and stated: “I can’t see.”

0344:34 - The Commander instructed the copilot: “Can you ask him to switch on the runway lights?”

0344:37 - The Commander applied a nose wheel steering input to turn the Aircraft to the left.

0344:38 - The ATC ground surface movement sensor 17/7 detected the Aircraft.

0344:38 – The tower ATCO called the crew and gave clearance for takeoff.

0344:47 - The copilot read back the tower ATCO clearance but did not request that the runway lights be turned on. The Commander did not repeat his request to turn on the runway lights.

0344:51 - The Aircraft was now on a magnetic heading of zero degrees, 14 seconds after the Commander stated that he could not see.

0344:55 - The ATC ground surface movement sensed that the Aircraft had passed sensor 17/7.

0344:57 - The copilot commented, as if asking a question: “The centerline lights supposed to have more space than that [silence of two seconds] no?” The Aircraft heading was 323 degrees.

0345:03 - The Commander stated: “I see only two lights.” The Aircraft was now on a heading of 311 degrees, which is the heading of runway 31L.

0345:07 - The Aircraft came to a stop

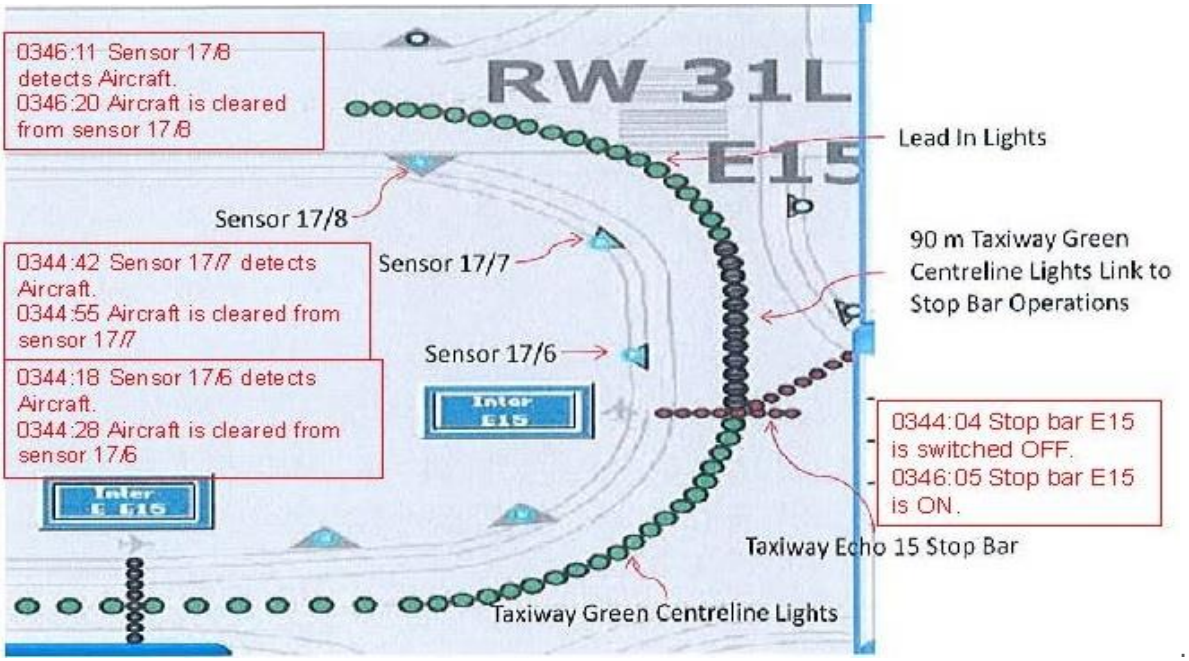

Figure 2. E15 Sensors and taxiway lead-in lights

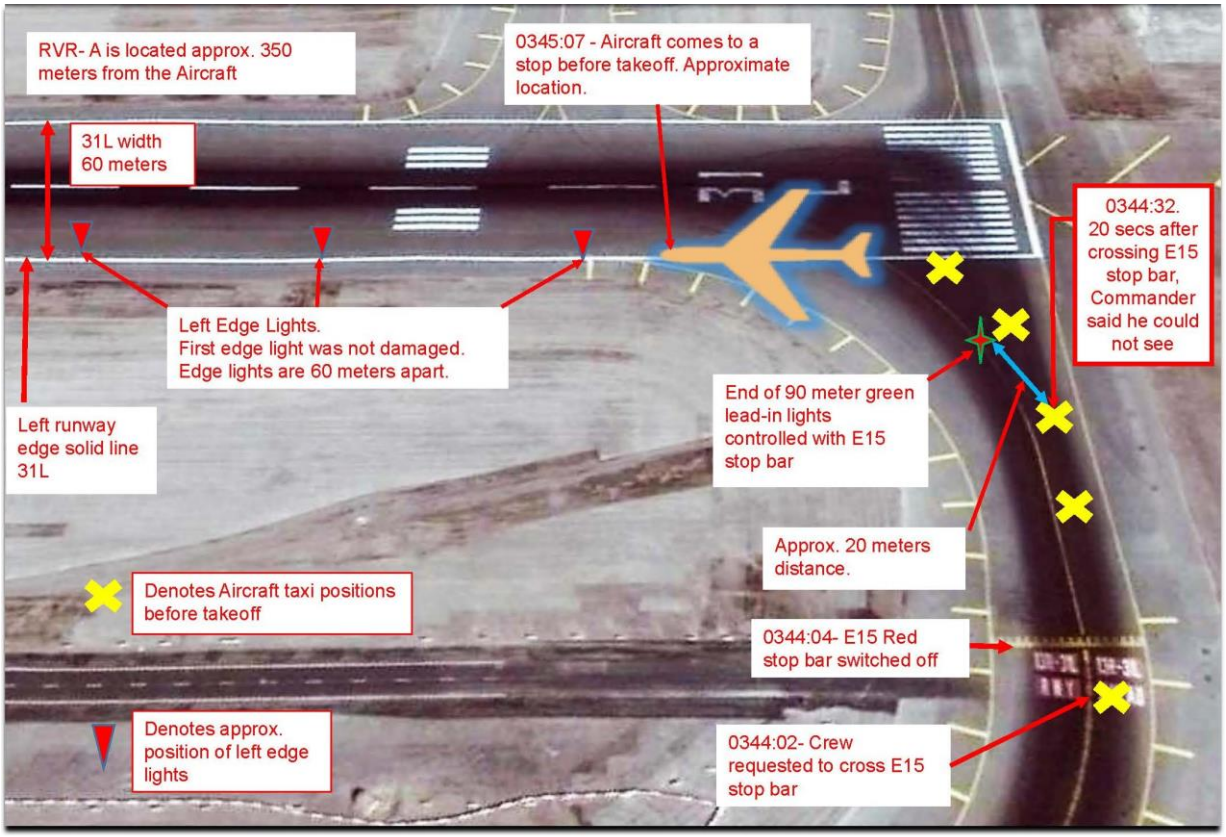

Figure 3. Incident flight taxi to runway31L

1.1.4 Attempted takeoff

0345:07 - The Commander called for the *before takeoff checklist* which was completed after 38 seconds (0345:45).

0345:58 - Thirteen seconds after the checklist was completed, the Commander asked the copilot and the other non-operating pilot if they were ready. It was noted by the Investigation that there was no mention, or confirmation, of the Aircraft position, or the runway lighting, nor were these items part of the Operator's procedures.

0346:01 - The Commander started the take-off roll.

0346:11 - The ATC ground surface movement sensor 17/8 detected the Aircraft.

0346:20 - The ATC ground surface movement sensed that the Aircraft had cleared sensor 17/8.

0346:12 to 0346:32 - There were 11 loud sounds and thumps, spaced approximately every two to three seconds coming from the nose of the Aircraft.

0346:26 - After the Aircraft had reached 86 knots ground speed, the Commander initiated a rejected takeoff and the Aircraft came to a stop in 11 seconds (0346:37 LT). He stated that he heard loud sounds from the nose gear, and was not confident of the Aircraft position.

The Aircraft had travelled approximately 775 m and stopped adjacent to the E14 taxiway intersection and the crew reported to the tower ATCO that the Aircraft was stopped on the runway.

There was discussion in the cockpit and the Commander realized that the Aircraft was not on the RWY 31L centerline. This was confirmed when the crew observed that the illuminated runway centerline lights were to the right of the Aircraft.

During an attempt to taxi the Aircraft back to the centerline, the crew received an Electronic Centralized Aircraft Monitor (ECAM) message indicating nose wheel low pressure and they stopped the Aircraft adjacent to the E13 taxiway intersection.

During the post-Incident radio transmission to the tower ATCO, the ATCO informed the crew that: “A couple of company aircraft mentioned that the lead-in lights were not ON but another company as well reported that they are ON, so I am not sure what happened to them once you lined up on the runway.” The crew informed the tower ATCO “The lead-in lights were on half way into the runway, but once on the runway after the stop bar after a few meters they went out and they seem to line up but the centerline lights themselves were not ON.”

The Commander mentioned to the Investigation that he confirmed seeing the lead-in lights after the E15 stop bar was switched off and followed the lights to the runway. It was mentioned that he had an impression that the full length of the lead-in lights were not ON. After he asked the copilot to request the tower ATCO to turn on the runway lights, he saw one white light and aligned the Aircraft with that light, thinking that this was a runway 31L centerline light. The Commander stated that he did not realize that the Aircraft was aligned on the left edge lights and the takeoff was rejected due to the unusual noise coming from the nose landing gear, and due to that he was not confident of the Aircraft position. As the Aircraft came to a complete stop, he noticed the centerline lights to his right. He said that he did not see any other lights, prior to takeoff that may have given an indication that the Aircraft was not on the centerline.

The copilot stated to the Investigation that he saw the green lead-in lights after the E15 stop bar was switched off. As the Aircraft passed the stop bar, he noticed that the taxiway lead-in lights went off before they taxied to the actual runway. He confirmed seeing the right hand edge lights and said that both crewmembers were looking for the centerline lights. When they saw the white light to the left, they thought that was the centerline lights and aligned the Aircraft with these lights. He said that at the start of the take-off roll, he did not see any other lights that may give indication that the Aircraft was not on the centerline.

1.1.5 Runway inspection after the occurrence

The following photos were taken after the Aircraft was cleared from runway 31L.

Figure 4 shows the first left hand edge light with the imprint of the right hand nose landing gear tire marks.

Figure 4. Edge light with tire marks

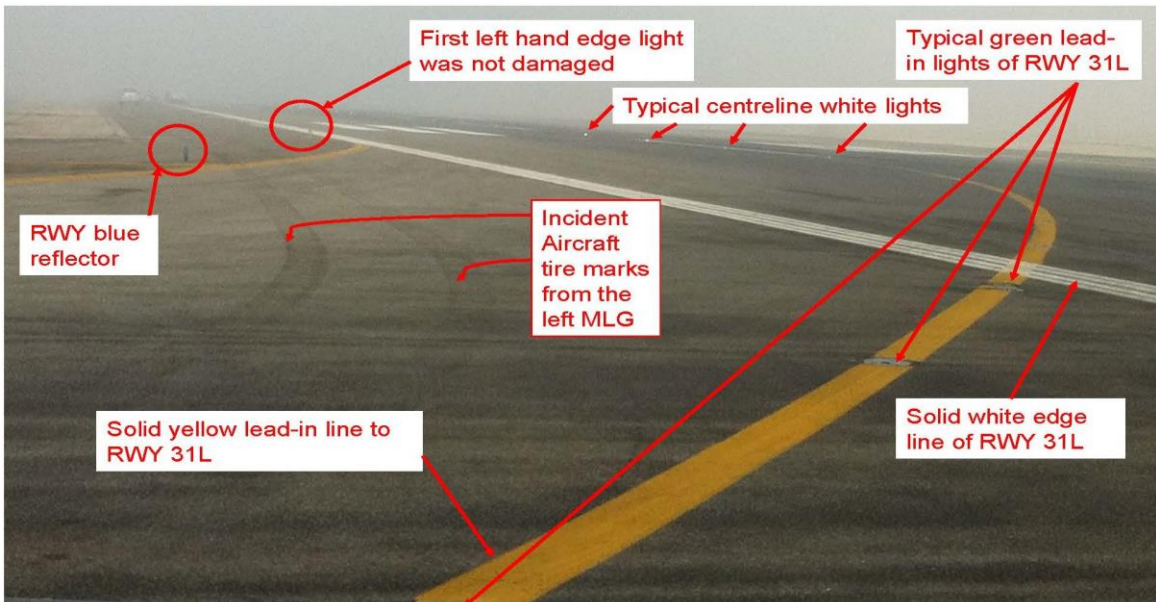

Figure 5. Left hand main landing gear tire marks

Figure 5 shows the imprint of the left hand main landing gear tires on the runway as the Aircraft was turned away from the centerline lead-in yellow line in order to align with the left hand edge light. The first left edge light was not damaged during the attempted takeoff. The figure also shows that the left main gear outer tire passed less than one meter from runway blue reflector.

Figure 6 shows the imprint of the Aircraft nose gear tires, and the left and right main landing gear tires during the attempted takeoff.

Figure 6. Aircraft NLG and MLG tire tracks

1.2 Injuries to Persons

There were no injuries to the passengers or the crew members.

Table 1. Injuries to persons

Injuries	Flight Crew	Cabin Crew	Other Crew On-board	Passengers	Total On-board	Others
Fatal	0	0	0	0	0	0
Serious	0	0	0	0	0	0
Minor	0	0	0	0	0	0
None	2	9	1	215	227	0
Total	2	9	1	215	227	0

1.3 Damage to Aircraft

Because of the Incident, the left hand (LH) nose landing gear tire was punctured. Seven main gear tires were found with glass pieces embedded.

1.4 Other Damage

Figure 7: Starting with the second light, 11 consecutive left hand edge lights on runway 31L were damaged as a result of the Aircraft nose gear tires colliding with the lights as the Aircraft accelerated for the attempted takeoff.

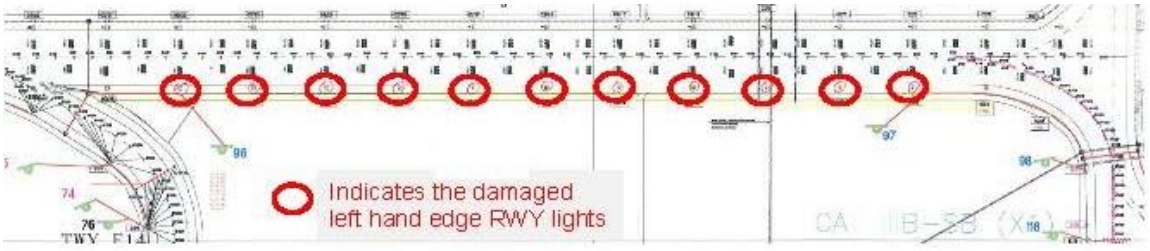

Figure 7. The red circles indicate the damaged edge lights

Figure 8: Typical damage found to the 11 edge light base fittings that held the light fixture in position. The glass that surrounded the lights were all broken.

Figure 8. Typical edge light damage

1.5 Personnel Information

1.5.1 Flight Crew

Table 2. Crew Information

	Commander	Copilot
UAE license number	Valid UAE License	Valid UAE License
UAE license category and rating	ATPL-A; M/E LAND, A330, A340	ATPL-A; M/E LAND, A320(P2), A330(P2)
Medical license	Valid Class 1	Valid Class 1
Total all types	9663 hrs 51 minutes	6173 hrs 29 minutes
Total Command on all types	3495 hrs 58 minutes	2828 (S/E & M/E aircraft)
Total on type	4408 hrs 36 minutes	399 hrs 18 minutes
Total last 30 days	87 hrs 51 minutes	47 hrs 37 minutes
Total last 24 hours	0	0
Last Line and proficiency check	OPC: 05/11/2011; Line Check: 25/04/2011	OPC: 17/12/2011; Line Check: 13/08/2011
English language proficiency	Level 5	Level 6

The Commander operated his previous flight from Sydney, Australia to Abu Dhabi two days before the Incident, and he had obtained adequate rest before the Incident flight. In addition, he had an approximately two-hour nap, six hours before his reporting time.

The Commander reached the required standard for his Operator's proficiency check (OPC) on 5 November 2011, following successfully completed training, approximately three months before the Incident, and he was qualified for the flight.

The Commander completed LVO recurrent training on 15 April 2011, with satisfactory results. His initial training took place on 12 October 2010. The Incident flight was his first LVO departure from Abu Dhabi.

The copilot had two days off duty and he was adequately rested before the Incident. He stated that he had an approximately three-hour nap, before his reporting time.

The copilot completed his A330 transition training on 17 June 2011. Previously he had operated the A320 aircraft type for the same Operator. Review of his available training records revealed that he had performed his training and evaluations at a satisfactory level. He had successfully completed LVO training several months before the Incident flight but he could not recall when he had last performed an LVO flight.

1.5.2 Air Traffic Controllers (ATCOs)

The ATCO staffing was in accordance with the air traffic unit roster.

The tower ATCO, following handover at 2326 LT, was working his second night shift (2215-0630 LT) of a six shift cycle. His last competency check was successfully performed on 31 May 2011, and his last emergency certification training course was conducted on 27 October 2011. The ATCO was re-validated for low visibility procedure (LVP) with the previous LVP assessment completed on 24 January 2012.

The ground ATCO was on his second night shift (2215-0630 LT) of a six shift cycle. He had successfully completed his last competency check on 17 July 2011, and his last emergency certification training course was conducted on 15 January 2012. The ATCO was LVP validated and his previous LVP assessment was completed on 16 September 2011.

1.6 Aircraft Information

1.6.1 Aircraft General Information

The A330-243 is a subsonic, medium to long range, transport aircraft, with two high bypass turbofan engines, mounted under the wings

Figures 9 illustrate the main dimensions of the Aircraft and Aircraft data.

<table>
<tr><td rowspan="2">  </td><td>  </td></tr>
<tr><td>Overall length 58.82 m</td></tr>
<tr><td>  </td></tr>
<tr><td>Wing span 60.30 m</td><td>Height 17.39 m</td></tr>
</table>

Figure 9. A-330-200 key figures

All Aircraft certificates were current.

Table 3. Aircraft data	
MSN	0688
C of A- date of issue	30 September 2005
C of R- date of issue	30 September 2005
Noise Certificate Issue	30 September 2005
Noise Certificate number 1211	06 December 2010
Aircraft Station License No. 0071180/11	18 September 2011 (date of issue) 17 September 2012 (date of expiry)
Next maintenance review	15 April 2012
Maximum Take-Off Weight Authorized	233,000 kgs

The Operator's *deferred defect log* was reviewed, and it indicated that there was no deferred defect that could have affected the Aircraft's operation.

A detailed review of the *aircraft technical log* entries for the previous 30 days did not show any rectification that could have adversely affected the performance of the flight crewmembers or the Aircraft.

1.7 Meteorological Information

The METAR[1] at 0200 LT on 30 January 2012 indicated the actual weather as:

Wind blowing from 350^0 at 02 kts, Visibility of 100 m, RVR for Runway 13R 300m No change, RVR for Runway 31L 150m No Change, Fog, Few Clouds at 800 ft, Temperature 15^0C and Dew Point 14˚C, QNH 1016 mb, or 30.02 inHg, No Significant Change expected within the next two hrs.

The Special METAR at 0239 LT on 30 January 2012 indicated the actual weather as:

Wind blowing from 110˚ at 04 kts, Visibility of 100 m, RVR for Runway 13R 175 m No Change, RVR for Runway 31L 125 m No Change, Fog, Broken Clouds at 100 ft, Temperature 13˚C and Dew Pont 13˚C, QNH 1016 mb or 30.03 inHg, No significant Change expected within the next 02 hrs.

The METAR at 0300 hrs on 30 January 2012 indicated the actual weather as:

Wind blowing from 130˚ at 03 kts, Wind Direction Varying from 090˚ to 180˚, Visibility of 100 m, RVR for Runway 13R 175 m No Change, RVR for Runway 31L 150 m No Change,

[1] **METAR** is a format for reporting weather information

Fog, Broken Clouds at 100 ft, Temperature 13^{0}C and Dew Point 13˚C, QNH 1016 mb, or 30.02 inHg, No Significant Change expected within the next 02 hrs.

The METAR at 0400 hrs on 30 January 2012 indicated the actual weather as:

Wind blowing from 120˚C at 04 kts, Visibility of 15 m, RVR for Runway 13R 175 m No Change, RVR for Runway 31L 200 m No Change, Fog, Broken Clouds at 100 ft, Temperature 13˚C and De Point 13˚C, QNH 1016 mb or 30.02 inHg, No Significant Change expected within the next 02 hrs.

1.8 Aids to Navigation

No navigation aids were used during the time of the occurrence.

1.9 Communications

The communication with the appropriate ATC units was normal, without any problems.

All communications performed between the Aircraft and ATCOs, and among the involved ATCOs controlling the departing flights were made available to the Investigation.

1.9.1 ATC Communications during LVO on 30 January 2012

A review of the ATC communications after the Airport went into LVO operations indicated that from 0142 LT until 0346 LT, there were a total of eight departures, including the Incident flight. Of the seven flights prior to the Incident flight, there were three flights that had queried either the Echo 15 stop bar, or the runway centerline lighting. The following table is a summary of what occurred with the eight flights after LVO came into effect.

Table 4. LVO departing flights lighting queries with ATC

Flight	Time (Local Time)	Remarks
Flight 1	0142	Departed without any queries about lighting
Flight 2	0212 to 0214	1. Advised ATCO that the stop bar was still ON 2. ATCO said he was trying to switch the stop bar to OFF 3. Crew requested the centerline lights intensity to be increased 4. Aircraft took off without further incident
Flight 3	0242	Departed without any queries about lighting
Flight 4	0300 to 0301	1. Crew reported E15 stop bar in sight and were given take-off clearance by ATCO 2. After 31 seconds crew advised ATCO they “Don’t have the runway light now.” 3. ATCO advised crew if they had lost the lights and wanted to hold position. 4. Crew then reported that they were now seeing the lights 5. Aircraft took off without further incident
Flight 5	0306	Departed without any queries about lighting
Flight 6	0324 to 0326	1. ATC clearance to line up and wait 2. After 40 seconds crew asked if there were any lights for the runway 3. ATCO said the lights were ON

		4. Crew then advised that "Yeah it was the lead on lights there was a gap." 5. Aircraft took off without further incident
Flight 7	0328	Departed without incident. The crew confirmed to ATCO that the lead-in lights were operational.
Flight 8- Incident flight	0343:32 to 0345:07	1. Crew informed tower ATCO that the stop bars were in sight. and tower gave clearance to line up and wait on runway 31 2. After 30 seconds crew asked tower ATCO if they were "Cleared to cross the stop bars." 3. Tower ATCO stated that he was trying to switch the stop bar off and requested the crew to confirm if the stop bar was OFF. 4. Crew confirmed to tower ATCO that "The green lights are back on for the runway." 5. 20 seconds after crossing the stop bar the Commander said he could not see 6. The crew did not inform tower ATCO about the lighting 7. The crew lined up on the left hand edge lights 55 seconds after crossing the stop bar

1.10 Aerodrome Information

1.10.1 Airport General Information

Abu Dhabi International Airport is certified by the GCAA. The GCAA exercises oversight functions on the airport for continuous compliance with the requirements. All facilities including the lighting system are in accordance with the regulations.

The aerodrome has two parallel runways and at the time of the Incident, runway 31L, the southern runway, was certified for CAT IIIB during low visibility operations with a minimum of 125 meters' visibility.

The runway centerline is marked with a broken white line whilst each runway edge is painted with a continuous white line. The taxiway centerline is marked with a continuous yellow line consistent with the requirements of UAE CARs, Par IX, Appendix 12, Paragraph 12.8.

The runway has asphalt shoulders capable of supporting an aircraft if it runs off the side of the runway. The width of the runway shoulders is consistent with the requirements of the UAE *CAR Part IX, Appendix 8, Paragraph 8.3.9.8 b (i) A*.

1.10.2 Runway Visual Range (RVR)

Runway 31L is equipped with RVR sensors, A, B and C. The RVR reading is continuously updated and at the time that take-off clearance was issued for the Incident flight, RVR A for the first one third was 175m, RVR B for the second third was 200m and RVR C for the last third of the runway was 175m.

The location of RVR A is approximately 350m away from the 31L threshold, as shown in figure 9. When the Commander said that he could not see during the taxi after stop bar E15, the Aircraft was approximately 425m from RVR A.

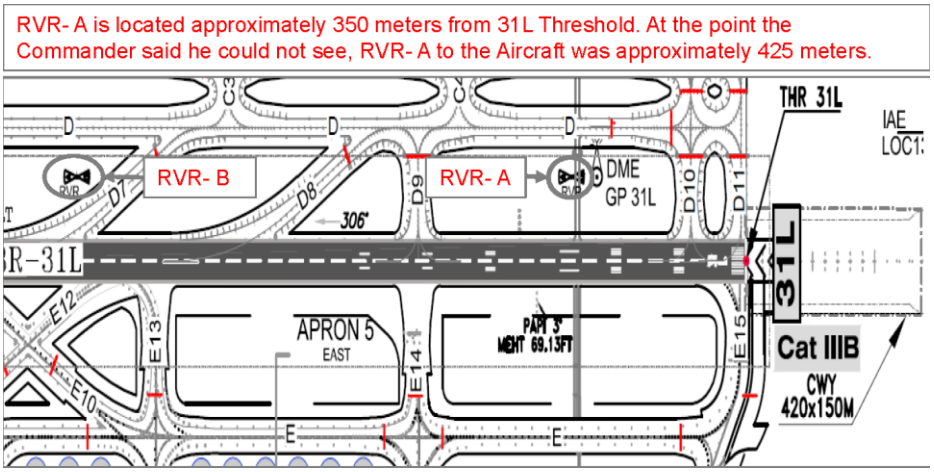

Figure 9. RVR A location

1.10.3 Airfield lighting description for runway 31L

The lighting of taxiways and runways at Abu Dhabi International Airport was in accordance with the UAE *CAR Part IX*.

These regulations include provisions for the taxiway light intensity, beam spread of illumination and spacing, depending on the curvature and the length of the taxiway.

Preventive maintenance was performed as per the applicable regulations, which required control and measurement of the electrical characteristics of each runway lighting system. This included control of the correct functioning of light intensity, settings used by air traffic control, measurement of intensity, beam spread and orientation (known as photometric testing in accordance with the specific Isocandela diagram) along with the frequency of inspections.

Runway 31L has an ICAO CAT II/III precision approach lighting system. The runway centerline lights are light intensity high (LIH) bi-directional with 15m spacing, color-coded with first 3200m white, next 600m white/red and last 300m red.

The runway edge lights are elevated above the runway surface with a spacing of 60m and are bi-directional with light intensity low (LIL) omni-directional component white LIH.

The E15 stop bar lights are LIH uni-directional red colour.

There are Cata-dioptric reflectors along the straight taxiway edges.

The taxiway centerline lights are green and are spaced 7.5m apart and lead to the runway centerline.

The E15 red stop bar is linked to 90m of green taxiway centerline lights forward of the stop bar. When the stop bar is ON, the 90m green taxiway centerline lights will be OFF.

Figure 10. Typical taxiway low protrusion runway lead-in lights

The runway edge lamps, spaced at 60m, feature an omnidirectional component for circling guidance. They are 30mm in height and are mounted above the runway surface. It is designed to withstand the heaviest jet blast with a minimum number of parts. There is an inner lens and the outer dome remains clamped to the upper body for fast re-lamping as it is only necessary to undo two wingnut-screws. The light inside the lamp is a precision quartz halogen bulb which is pre-focused and accurately positioned in the lower body. Stability of the lamp is normally ensured through attachment to heavy material such as concrete. Levelling and aiming in azimuth of the lamp are performed using a specialized aiming device. The lamp is designed to be frangible in case of impact.

Figure 11. Runway edge lamp

1.10.4 Airfield lighting control and monitoring system

The condition of the airfield ground lighting (AGL) is monitored by the Airfield Lighting Control and Monitoring System (ALCMS). A post-Incident historical report was provided to the Investigation which showed the operation of the lights based on the measurement of voltage.

The report indicated that from the time the Aircraft was cleared for takeoff, the AGL at taxiway E15 and runway 31L were functioning, and no failures had been logged.

The historical report, provided to the Investigation, showed that the intensity of the runway centerline lights was set to ‘step 4’ out of five steps with step 5 is the brightest setting. The recommended setting of the intensity step during LVO conditions, or at night is ‘step 2’.

The historical report indicated that the lead-in lights from the stop bar on taxiway E15 to the runway centerline were functioning from the time the Aircraft received the clearance to enter the runway, to the time it stopped, after the takeoff was rejected.

1.10.4.1 Human machine interface

As per the Airport's *ATC Instruction Manual*[2] the Abu Dhabi aerodrome lighting control and monitoring system operation is performed on 24-inch liquid-crystal display (LCD) touch screen monitors at the ATCT, and on other LCD monitors throughout the rest of the system (figure 12). The monitors provide real time information to the ATCOs and to the maintenance personnel on the status of the runway and taxiway lighting as well as information on failures at the time of their occurrence.

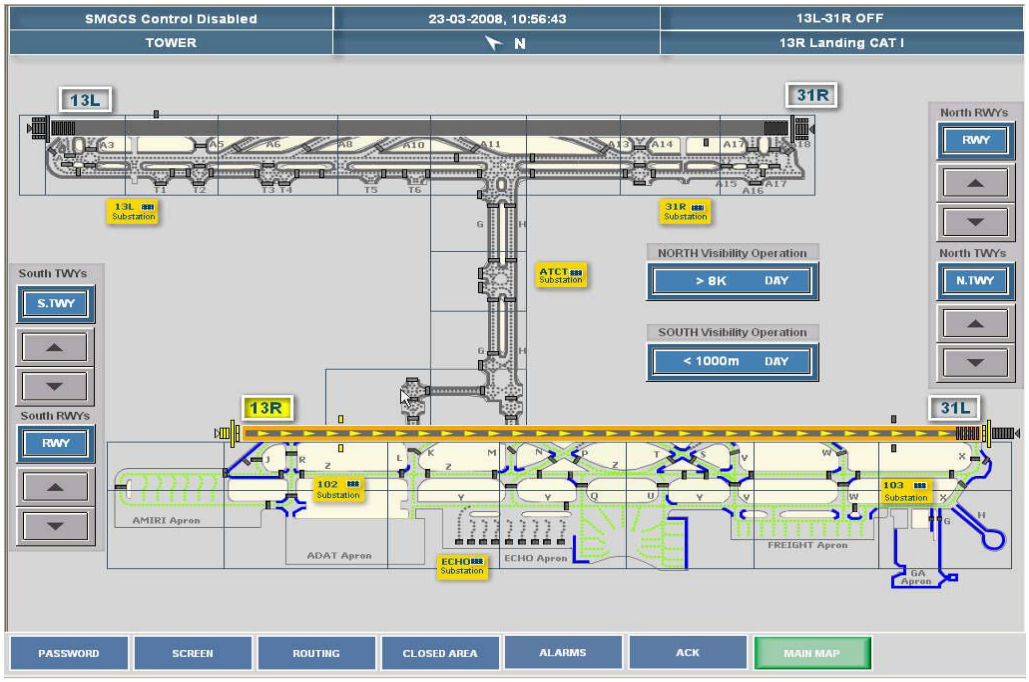

Figure 12. Control of the Airfield lighting system, ATCO interface

ATCOs could control the system, called Human Machine Interface (HMI)[3], using the screen shown in figure 12, as well as enabling maintenance personnel to remotely operate the system, or part of the system.

Through the Human Machine Interface (HMI), which has a real time clock, the ATCO and the maintenance personnel may monitor, activate or deactivate all lighting runway lighting systems, and change the light intensity

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2 Document TAUH1-000-1-63 Ver. 1.1, Dated March 2008

3 Definition: (Human Machine Interface). The user interface in a manufacturing or process control system. It provides a graphics-based visualization of an industrial control and monitoring system

The ALCMS feature enables a single operation to automatically activate all the lighting systems required for the runways, according to the current visibility. The lights are automatically turned on at the brightness predefined for the visibility condition setting.

Two methods can be used to activate/deactivate aerodrome lighting:

(a) Separate activation/deactivation of each lighting system, or

(b) An operation that automatically activates/deactivates a group of lighting systems according to a pre-defined setting.

1.10.4.2 Stop bar operation

Figures 13 to 16 indicate how the ATCO managed the stop bar operation. This technique is also applicable to the E15 stop bar.

For the Incident flight, when the ATCO wanted to operate the E15 stop bar, he had to touch the stop bar indicator in the screen which would have popped up the page shown in figure 13 indicating that the stop bar is ON and the green lead-in lights are OFF. Initially the ON button was red indicating that the stop bar was ON. Additional selectable options are ON, GO and CANCEL.

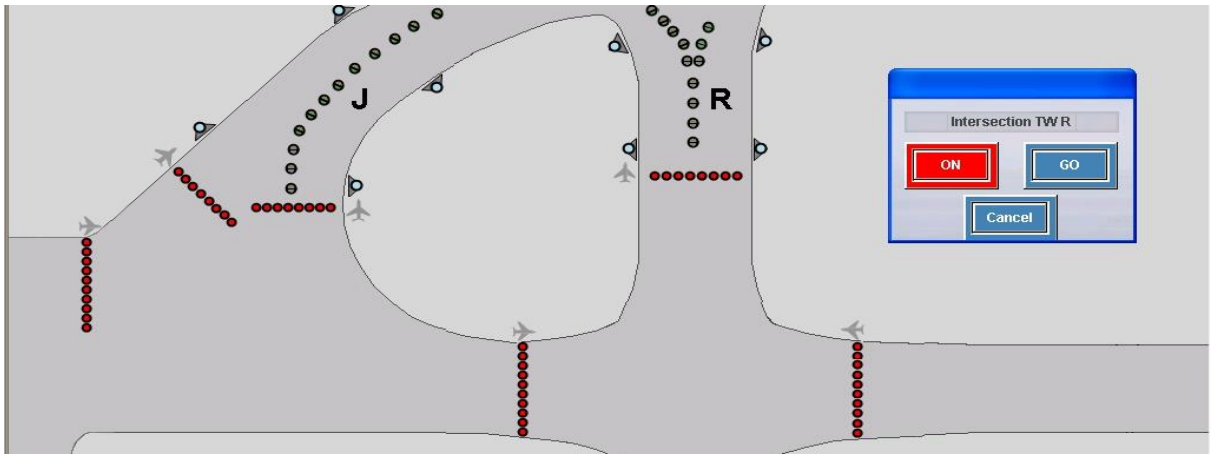

Figure 13. Viewing an intersection stop bar

When the GO button was pressed, the colour changed to green (figure 14). The green lead-in lights came ON and the E15 stop bar lights went out. Then the ATCO instructed the Aircraft to proceed onto the active runway.

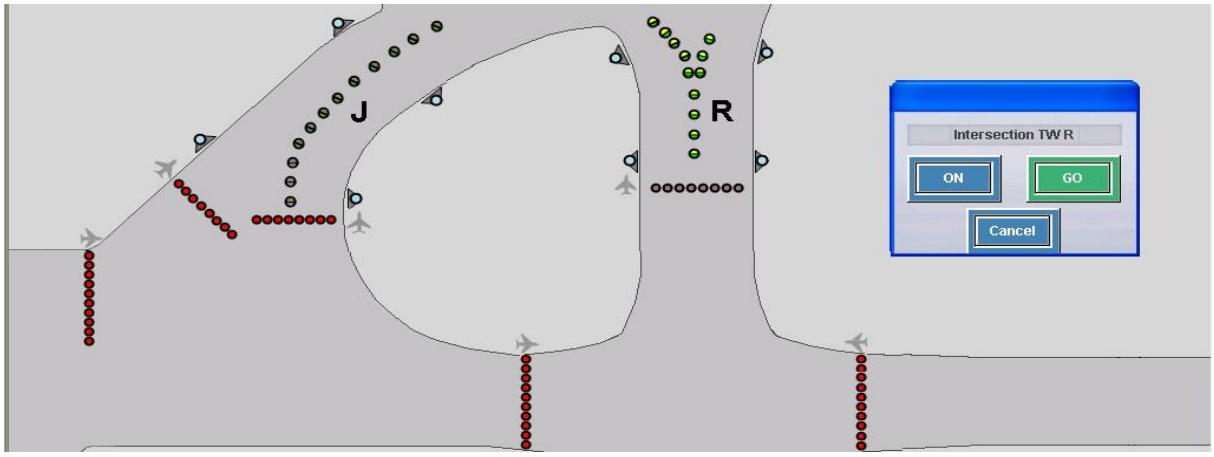

Figure 14. Activating an intersection stop bar

When the Aircraft passed through the first sensor, a blue aircraft symbol appeared (figure 15) which indicated to the ATCO that the Aircraft had passed the stop bar. As per the ALCMS historical report provided to the Investigation, the E15 stop bar was switched ON two minutes and one second after it was OFF by the ATCO. The operation of the stop bar was done by manual selection as automatic selection was not available to the ATCO.

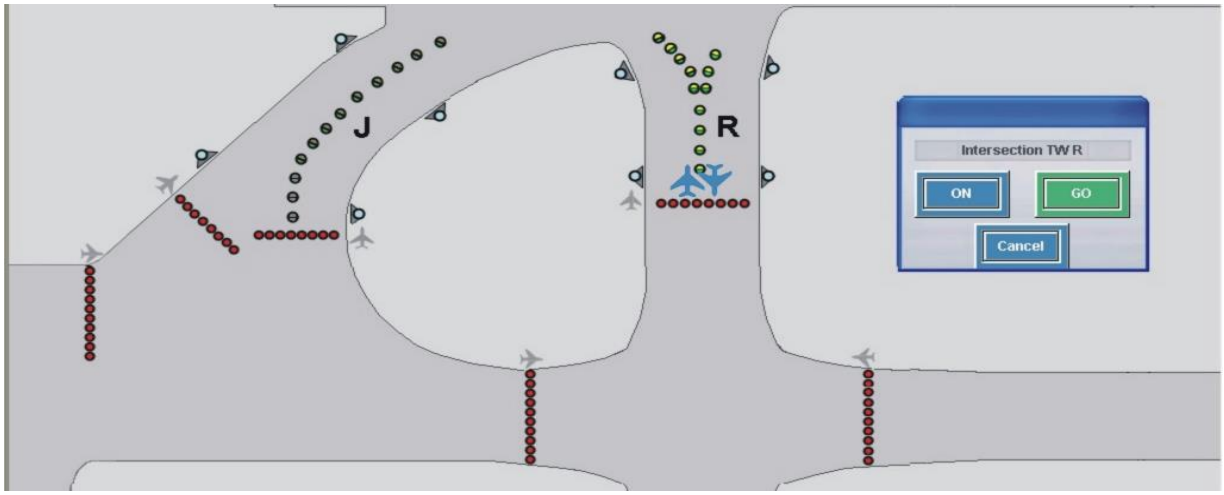

Figure 15. Aircraft passes the first sensor

If the system was set to automatic, figure 16, the difference was that the stop bar would have turned back ON when either the Aircraft passed the second sensor 17/7, or a period of 45 seconds had elapsed since the command to GO was issued.

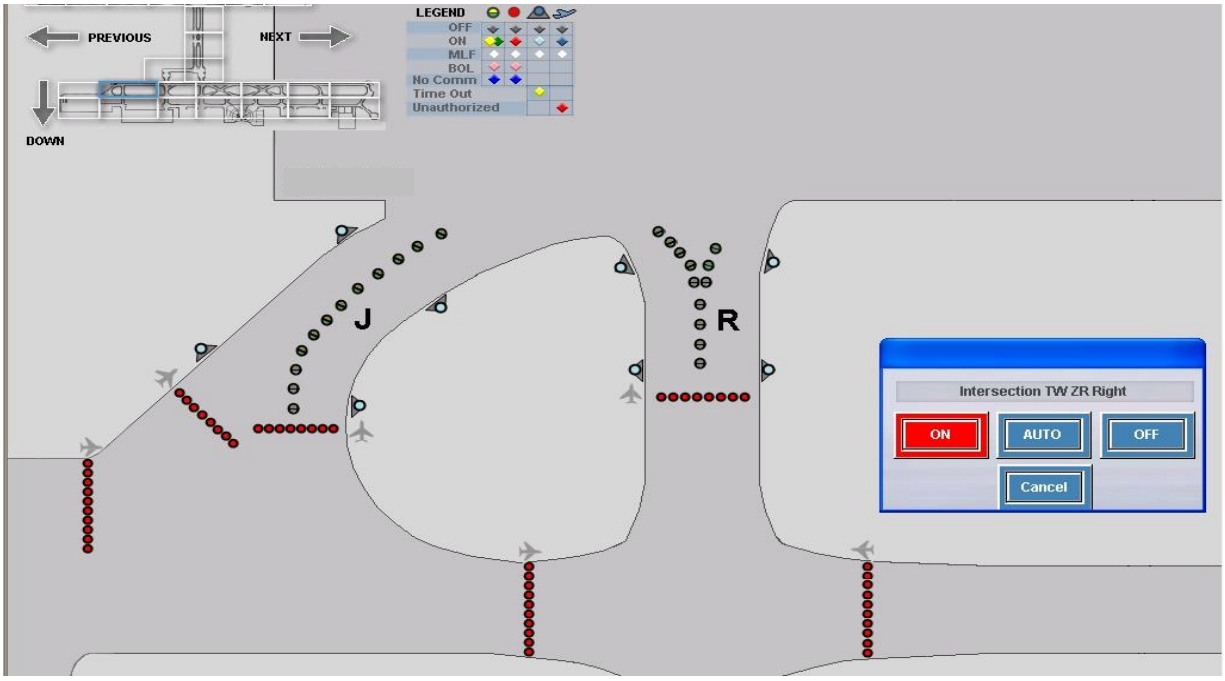

Figure 16. Activating a timed intersection

1.10.4.3 Ground Sensors for aircraft movement

Table 5 lists the sensors that provided the ATCO with information as to where the aircraft was located on the taxiway, or runway. The table also gives the selectable route, however, this was not available on the night of the Incident flight. For the Incident flight see figure 2.

Table 5. List of Sensors nearby E15 Stop bar

S/N	Sensor Name in DCCMS	Sensor No.	Area	FMV	Selectable Route (If available)
1	E-E15	16	E-E15	Sensing only	Switch ON Stop bar E-E15 and Switch OFF Lead ON Light behind the Aircraft up to E-E14
2	E-E15	17	E-E15	Sensing only	Switch OFF Lead ON Light Behind the Aircraft
3	31L TW E15 SB	2	E15 SB	Sensing only	To switch Stop bar Light ON behind the Aircraft
4	31L TW E15 RW	1	E15 RW	Sensing only	Switch OFF Lead ON Light Behind the Aircraft
5	31L TW E15 RW End	19	E15 RW End	Sensing only	Switch OFF Lead ON Light Behind the Aircraft

1.10.5 CAT III B Routing

As per the Airport Operator's *standard operating procedure (SOP)*, when RVR conditions are below 2,500m, low visibility procedures (LVP) safeguard is activated. The LVP operations commence only when the RVR is 1,000m or below. If the RVR improves to greater than 2,500m on an upward trend, LVP Safeguard may be lifted.

At the time of the Incident, the CAT III B AGL routing system that was operational at the airport was termed CAT III B AGL FMV. This lighting system differs significantly from the selectable CAT III B AGL routing system.

When CAT III B AGL FMV is activated, the taxiway green centerline lights along taxiways Echo, Echo 02, Echo 06, Echo 09, Echo 13, Echo 14 and Echo 15 will illuminate and all lights on the other taxiways will distinguish.

Whereas, in CAT III B Selectable Routing, for landing/departing aircraft, only the selected taxiway centerline lights to/from the stand will be illuminated i.e. point to point follow the green lights, without the assistance of an FMV. This system was not available to the ATCO on the night of the Incident flight.

The CAT III B AGL FMV routing system connects the taxiways to aprons 2 and 3. In this system, only two stop bars are selectable by the tower, one is located on taxiway Echo before taxiway Echo 03, and the other is located on taxiway Echo 15, before entering runway 31L.

1.10.6 Activation of FMV operations by ATC

As of November 2008, the GCAA accepted the Airport Operator for arrivals and departures by the use of Follow-Me Vehicle (FMV) procedures for RVR down to 125m for landing (runway 31L only) and taxiing to all terminal 3 stands via the designated LVP route. During the FMV procedure FMV assists the flight crew in taxiing, while advising the ATCO that a taxiing aircraft is following the correct path.

Following the initial invocation of LVP (below 1,000m RVR), the apron control would initiate preparation for FMV procedures. When taxiing conditions go below 350m but are not less than 125m, FMV procedures are put into actual operation. ATC then advises all operational units, including AGL when such conditions exist.

Table 6 is a guideline for AGL lighting and FMV operations:

Table 6. FMV Deployment

RVR	Condition	FMV	TWY Centerline
1000m-350m	CAT I & II	If required	ATC decision
350m-200m	CAT IIIA	Deployed	All TWY Centerline ON
200m-125m	CAT IIIB	Deployed	TWY Centerline ON only on designated LVP Route by CAT IIIB button in ALCMS

For RVR conditions, RVR between 1,000m to 350m, there is no change to the AGL operations by ATC, but taxiing operations may be backed up by the FMV vehicles.

For CAT IIIA conditions, RVR between 350m to 200m, FMV will be deployed, but taxiway centerline lights are still ON.

For CAT IIIB conditions, RVR between 200m and 125m, the ALCMS has been improvised in the interim with a CAT IIIB activation button at the ATC console. When this button is pressed, designated LVP constant current regulators (CCRs) for taxiway centerline lighting

along the LVP route will be remotely switched on, while other CCRs controlling taxiway centerline lighting will be switched off.

Except for the stop bars, all other AGL, including runway lights retain their last setup.

Departing aircraft must be guided by the FMV along taxiway Echo to the E15 stop bar. With the stop bar switched on, 90m of taxiway green centerline lights ahead of the stop bar will go off. The lead-in lights ahead of this 90m are always ON and lead to the runway centerline.

1.11 Flight Recorders

The Aircraft was equipped with flight recorders as follows:

a) Cockpit voice recorder (CVR), L3-Comm FA2100,

Part Number: 2100-1020-02

Serial Number: 000317872

b) Digital flight data recorder (DFDR) L3-Comm FA2100

Part Number: 2100-4043-02

Serial Number: 000446135

The data contained in both recorders was successfully downloaded at the AAIS Flight Recorder Analysis Laboratory and both contained valid data.

A transcript was made of the two-hour cockpit voice recording. Approximately one hour of voice recording was relevant to the Incident flight.

1.11.1 DFDR/CVR data

The digital flight data recorder data for the Incident flight and six previous flights were reviewed. Besides the Incident flight, another previous flight that departed Abu Dhabi from runway 31L on 29 January 2012 at 1000 LT, in CAVOK[4], the ILS localizer data was compared with the Incident flight. As shown in Table 8, the localizer on the Incident flight shows a deviation when the Aircraft was aligned on the left edge lights. The comparison flight had a one-degree deviation when aligned on runway 31L centerline for takeoff and during the take-off roll.

As recorded by the CVR, the Commander for the Incident flight had noted a deviation of the ILS prior to takeoff but thought that his physical position may have influenced the deviation noted on the ILS.

Tables 7 and 8 illustrate Aircraft information from the time the flight crew reported the stop bar E15 in sight until the Aircraft came to a stop after the takeoff was rejected. Data was retrieved from the Aircraft FDR, CVR and the AGL report provided to the Investigation.

[4] CAVOK: **C**eiling **a**nd **V**isibility **OK**

Table 7. FDR/CVR/AGL data from stop bar E15 to before takeoff

Local Time	Ground Speed (knots)	Magnetic Heading (degs)	ILS Localizer(óA)	N1%	NWSSLV (DA)	BRKPDL (DA)	CVR/ATC/AGL report
0343:34	4	110	375	22	14	0	Crew stated stop bar in sight
0343:43	4	97	356	23	14	0	ATCO instructed to line up and wait 31L
0344:02	5	57	251	22	17	18	Crew requested to cross stop bar E15 and informed ATCO that the stop bar is still on. ATCO said that he was trying to switch off the stop bar
0344:04	5	54	257	22	17	26	Stop bar E15 is switched off by ATCO
0344:08	4	47	237	22	18	0	Crew confirmed green lights were back on for the runway
0344:18	7	38	169	22	2	22	Ground sensor 17/6 detected the Aircraft
0344:25	7	36	147	22	1	20	Crew started the before takeoff below the line check
0344:28	7	36	126	22	1	20	Aircraft is cleared of sensor 17/6
0344:32	6	34	113	22	5	20	Commander stated “he cannot see” and requested the FO to ask ATCO to turn the runway lights on
0344:38	6	28	85	22	14	20	ATCO gave clearance for takeoff
0344:42	6	18	62	22	18	20	Ground sensor 17/7 detected the Aircraft
0344:47	5	7	43	22	13	20	FO read back the ATCO clearance
0344:55	7	347	27	22	30	14	Aircraft cleared sensor 17/7
0345:00	7	323	27	22	30	24	Comments by the crew about the light spacing and remarks that only 2 lights can be seen.
0345:07	0	309	27	22	1	42	Aircraft came to a stop and crew started the before takeoff check list.

Table 8 illustrates when the “thump” sounds are heard, as recorded by the CVR, indicating when the nose wheel contacts the left hand edge lights.

Table 8. FDR/CVR/AGL Attempted Takeoff

Local Time	Ground Speed (knots)	Magnetic Heading (degs)	ILS Localizer (óA)	N1%	NWSSLV (DA)	BRKPDL (DA)	CVR/ATC/AGL Report
0346:01	2	309	32	41.2	4	0	Commander started takeoff
0346:11	26	305	38	77	0	0	Aircraft detected by ground sensor 17/8
0346:12	30	305	40	79.3	-1	0	1st thump sound
0346:15	42	306	32	80.8	1	0	2nd thump sound
0346:17	51	306	39	80.8	0	0	3rd thump sound
0346:19	59	306	34	80.8	1	0	4th thump sound
0346:20	63	306	34	81.1	0	0	Aircraft cleared by ground sensor 17/8
0346:21	71	306	34	81.1	0	0	5th thump sound
0346:23	78	306	35	81.1	0	0	6th thump sound
0346:24	82	306	36	81.1	0	0	7th thump sound
0346:26	86	306	37	81.1	1	36	8th thump sound
0346:27	81	306	35	68.4	1	40	9th thump sound Commander says “Stop”
0346:28	73	306	40	58.6	0	40	10th thump sound
0346:30	54	306	37	44.0	1	44	11th thump sound
0346:37	0	307	41	26.7	-2	4	Aircraft came to a stop

1.12 Wreckage and Impact Information

The Aircraft was intact.

1.13 Medical and Pathological Information

Neither the Operator nor the GCAA made a request to an entity to provide post occurrence medical or pathological information from the crew. Thus, no medical or pathological information was made available to the Investigation.

1.14 Fire

There was no signs of fire during or after the Incident.

1.15 Survival Aspects

All persons on-board disembarked the aircraft uneventfully.

1.16 Tests and Research

The Investigation performed an operational test of the ALCAMS lighting control system operation. There were no alarms recorded on the ALCAMS system associated with the crossing of stop bars.

In addition, the Investigation unsuccessfully tried to test the lighting system during similar environmental conditions which would involve similar night, visibility, moon light angle, etc. However, for two subsequent seasons, the Investigation was unable to simulate similar environment conditions. After the two seasons, the lead-in lights and the Surface Movement Guidance and Control System (SMGCS) were removed due to runway reconstruction. The Investigation was unable to simulate the environmental conditions to test the lighting system.

1.17 Organizational and Management Information

The Aircraft Operator is based in Abu Dhabi, UAE, and commenced commercial operations in November 2003. The Operator is an air operator certificate (AOC) holder issued by the GCAA. At the time of the occurrence,

The Aerodrome Operator holds an aerodrome certificate holder issued by the GCAA.

1.18 Additional Information

1.18.1 Medical examinations (*CAR Part VI*)

The following text has been copied from the UAE *Civil Aviation Regulations*[5]: with regards to medical examinations:

> "5.14 MEDICAL EXAMINATIONS
>
> 5.14.1 When appropriate, the GCAA, when conducting the investigation, shall arrange for the medical examination of the crew, passengers and involved aviation personnel by a physician experienced in accident investigation. These examinations should be expeditious."

In addition, in the definition section of the GCAA *Civil Aviation Advisory Publication* (*CAAP) 51*[6] stated that:

> "Employees involved in aircraft incident or accidents or who engage in unsafe on-duty job-related activities that pose a danger to others or the overall operation of the aircraft may be subject to testing.

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5 *CAR-PART VI, Chapter 3- Aviation Accident and Incident Investigation*.
6 *CAAP 5 - Information and Policy Regarding Implementation of Alcohol and Drug Testing*

The GCAA will arrange the testing as soon as possible but not later than 32 hours after the accident.

Safety-sensitive employees are subject to drug or alcohol testing in the following situations:

- Pre-employment.
- Reasonable Suspicion/ Cause.
- Random
- Post-Accident."

1.18.2 Other occurrences

The following is a summary of 11 occurrences that were collected from various databases involving aircraft that were aligned with the runway edge for takeoff. This includes an occurrence at the same airport several months after the Incident, which had some similarities to this Incident. This occurrence did not result in an attempted takeoff as the crew communicated with the tower ATCO to confirm the taxiway lighting.

1.18.2.1 Occurrences in the UAE

a) Bombardier Aerospace CL600-2B19, Dubai International Airport 9 May 2011.

b) An Airbus A-340-600 take-off in Low Visibility Operations (LVO) conditions, at Abu Dhabi International Airport, at 0136 UTC on 11 October 2012.

1.18.2.2 From other Investigation Agencies

<u>The Transportation Safety Board of Canada</u>

An Airbus A319-114, operating a scheduled flight from Las Vegas, Nevada, United States, to Montréal, Quebec, 30 January 2006.

<u>The Australian Transportation Safety Board</u>

a) An Airbus A340-300, at Auckland on May 18th 2013.
b) A SAAB 340B, at Sydney Kingsford Smith Airport, New South Wales, on 3 July 2009.

<u>The Directorate General of Civil Aviation, India</u>

A Boeing B757 from Kolkata to New Delhi, 9 June 2010.

<u>The Aircraft Accident & Incident Investigation Board Cyprus</u>

An Airbus A319-200 at Larnaca Airport, 27 October 2010.

<u>The Aviation Safety Council of Taipei.</u>

An Airbus A-340-300, in Anchorage, United States of America, 25 January 2002.

<u>The UK Air Accident Investigation Branch</u>

a) A Gulfstream III, at Biggin Hill, on 24 November 2014

b) An ATR42-300, at Prestwick, on 22 January 2006

c) A Piper PA-34-200T, at Bristol, on 12 December 1996

d) A Fokker F27 Mk 200, at Teeside, on 7 December 1990

1.18.3 ATSB misaligned takeoff research

The Australian Transport Safety Bureau (ATSB) has investigated takeoff and landing occurrences involving aircraft with weights greater than 5,700kg. Because of these events the ATSB initiated an investigation safety report under the title *Factors influencing misaligned take-off occurrences at night* which revealed common factors in all occurrences.[7]

1.18.4 AAIS research

After reviewing the Australian investigation safety report (see 1.18.3) and the published international occurrences, it was revealed that eight common factors were identified in all investigated events. These factors increase the risk of a misaligned take-off or landing occurrence. The factors included: distraction or divided attention of the flight crew; confusing runway layout; displaced threshold or intersection departure; poor visibility or weather; air traffic control clearance/s issued during runway entry; no runway centreline lighting; flight crew fatigue; and recessed runway edge lighting.

1.18.5 The Operator's low visibility procedures

The Operator's *Route Information Manual*[8] provided the following information for the to the flight crew:

> Low Visibility Procedures
>
> "Minimum runway occupancy (ref AIP OMAA AD 2.20)
>
> Arrivals:
>
> Rapid exit from the runway enables the achievement of maximum runway utilization. On exiting the runway, pilots are reminded not to stop until the entire aircraft has passed the runway holding point, unless instructed otherwise by ATC.
>
> Departures:
>
> Pilots are reminded to pay particular attention to conditional line up clearances to avoid runway incursions. Aircraft are assumed to be ready for departure on reaching the holding point unless otherwise stated. Cockpit checks shall be completed prior to completing the line up so that take-off roll can be commenced without delay.

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7 https://www.atsb.gov.au/media/1543486/ar2009033.pdf

8 Route Information Manual, Airport Briefs, Chapter 2, Page 2, Revision 59, Date 04 December 2011

Immediate Take-off clearance (ref ICAO Doc 4444 7.9.3.4):

In the interest of expediting traffic, a clearance of immediate take-off may be issued to an aircraft before it enters the runway. On acceptance of such clearance, the aircraft shall taxi out to the runway and take-off in one continuous movement."

Furthermore, in the company manual the following information is available to the flight crew members:

"Low Visibility Procedures (LVP)

LVP shall be in force when one or more RVR readings or the reported meteorological visibility is less than 1000 m, or when ceiling is less than 300 ft.

During LVP operations pilots are required to use full length departure from the CAT III RWY and associated holding position on TWY E15.

Minimum (MIM) RVR 50m for arriving and departing ACFT at Terminal 2 and 3 apron. Arriving ACFT MIM RVR 200m at Terminal 1 apron.

Departing ACFT MIM RVR 125m at Terminal 1 apron."

The Operator's manual part A (OM-A rev. 12) did not include the UAE regulatory[9] requirement of the pilots to have available 90m visual segment from the cockpit at the start of the take-off run, during LVO.

1.18.6 Other flight crew statements

Following the Incident, one of the crewmembers of an aircraft which had departed from the same runway before the Incident flight stated that:

"I departed in 125 meters about 30 minutes before this incident, and I must say I am not surprised this happened as I had a moment of uncertainty myself when lining up on runway 31L.

It is like a black hole when you go past the Holding Point lights, there is minimum guidance for runway alignment. I actually used the threshold strobe lights initially to ensure we had actually positioned on the piano keys before identifying the centerline lights and lining up on them. I really took my time as I had a student and

[9] UAE *CAR OPS 1.430,* Appendix 1 (4) (i) (D)

a safety pilot, and we all double checked, and even then it was an anxious moment.

My suggestion to reduce the likelihood of a re-occurrence is for the airport authorities to fit green "follow me lights" from the holding point to the runway centerline. These would only be used in Low Vis ops and would only come on when the red stop bars were turned off. These would serve the same function as the high speed turn off lights that are utilized in Low Vis Ops…"

1.18.7 Air traffic control investigation report

Following the Incident, the Airport Operator's Air Traffic Control Safety Unit provided an investigation report[10] which contained safety recommendations addressed to their organisation to which were implemented thereafter::

"Implement a system whereby the deactivation/activation stop bars logs are supplied in a useable format to Safety & Investigation department when requested so that any future incidents involving the deactivation/activation of stop bars can be verified against these logs."

Also to continue the review of ANS SOPs with the focus simplify existing SOPs into more user friendly. The recommendation aimed to include procedures in order to enhance safety by*:*

"

- Aircrew asked for verification that green lead-in lights are active
- No take-off clearance to be issued to aircraft until the aircraft has reported lined-up on the runway centerline and ready
- Stop bars not to be activated until such time as the aircraft has reported lined up or has commenced their take-off roll
- Clarification of required phraseology during LVO
- Inclusion of a "zoomed in" window on the ASMGCS so as to better verify if aircraft are within expected tolerance of the centerline
- Verification during LVO assessments and training that ATCOs understand the activation relationship between the stop bars and the lead-in lights."

Additional safety recommendations were made associated with simulator training to assist in the following conditions*:*

[10] *ROSI 6396-120130-ATC* ADAC ANS investigation report

“

- Training of ATCOs for LVO procedures
- Training of ATCOs following incidents
- Replay of unusual situations allowing all ATCOs, not just those involved, to learn lessons from these situations
- Verification of new procedures/routings/taxiways/operations prior to live operations
- The ALCMAS simulator is updated and made operational so that ATCOs are able to train/refresh on the system instead of relying on OJT and yearly theory testing.
- A review of the definitions with regard to “accident & incident” and the associated ANS call out procedures should take place in conjunction with the GCAA ANA to ensure that ADAC ANS Emergency call out procedures reflect those required by the GCAA.
- Following the finding associated with the issue of no alarms Temporary Instruction 254 was distributed, a hazard report was raised and AGL have been tasked with solving the situation.
- ADAC ANS through the Training & Standards department in conjunction with the Safety & Investigation Department shall, in compliance with the ADAC ANS SMS, ensure that the lessons learnt from the incident are shared within the relevant ANS departments.”

1.18.8 Comments to the Final Report

In accordance with section 6.3 of *Annex 13*, and UAE CARs Part VI, chapter 3 section 7.2; the draft Final Report was sent for comments to the concerned parties.

Comments was received by the Investigation from the Aerodrome Operator, the Aircraft Operator, and the UAE GCAA, and incorporated into the Final Report accordingly. Refer to Appendix A for comments made by the Aircraft Operator.

1.19 Useful or Effective Investigation Techniques

The investigation was conducted in accordance with the Legislation and Civil Aviation Regulations of the United Arab Emirates, and with the AAIS approved policies and procedures, and in accordance with the Standards and Recommended practices of Annex 13 to the Chicago Convention.

2. Analysis

2.1 General

The Investigation sought to determine the reason for the misalignment of the Aircraft with the runway 31L edge lights. It was decided to determine whether lighting failures, AGL system defects, and/or human factors had contributed to the Incident. Consequently, the analysis of the incident focused on the following:

- Airfield Lighting Control and Monitoring System (ALCMS) History Report
- Taxiway and Runway Lighting and Markings
- Incident Flight Departure Sequence along with the crew Interaction
- Other potential solutions
- Post occurrence medical examinations

The Incident was the first recorded instance at the Airport, of an attempted runway edge takeoff, as no other similar occurrence was made available to the Investigation.

Flight crew and air traffic controller fatigue was not identified as a contributory factor in the Incident.

2.2 Aerodrome and ATCO AGL control recordings

The evidence gathered from the Airfield Lighting Control and Monitoring System (ALCMS) history report indicated that the stop bar and sensors at taxiway Echo 15 and runway 31L were functioning and recording between the time the Aircraft crossed the stop bar and the time the Aircraft came to a complete stop after the takeoff was rejected. The report did not include any logs of malfunctions and revealed that all associated lights were functioning normally.

However, there was no recording of the actual switch positions, nor which mode the ATCO had used to manage the aerodrome lighting, nor there was a regulatory requirement that this information be recorded. Having a record of the actual switch positions, or the mode selected by the ATCO to operate the stop bar, either manually or automatically, would have assisted the Investigation in verifying the ATCO's actual selections.

If an automatic/timed operation was selected, the taxiway green lead-in lights would not remain ON throughout the Aircraft taxiing. As per the automatic/timed operation, when an aircraft passes the second sensor (17/7), the stop bar will automatically come ON and the green taxiway lead-in lights to the runway will go OFF. The lead-in lights on the runway itself remain ON at all times. Such a change of lighting conditions would have been recorded in the ALCMS history report, which was not the case, indicating that there was no change in the lighting system. Therefore, the ATCO had selected the ALCMS to 'manual' mode, in which case the taxiway lead-in lights remained ON as the Aircraft taxied onto the runway.

2.3 Incident Flight Departure Sequence

The data obtained from the ALCMS history report, the ATC transcript, the Aircraft FDR, CVR and the flight crew statements were evaluated and utilized to develop a timeline of the

Aircraft track from the time it crossed the stop bar until it had lined up on the runway edge lights. The time that the Aircraft crossed the sensors after the stop bar, informing the ATCO of the Aircraft position, was also noted.

The Incident flight was schedule to depart at 0215 LT and the crew reported for the flight at 0030 LT. During the debriefing, the forecast weather, published at 2100 LT, did not forecast any fog and indicated that the visibility was 8000m with no significant clouds. The copilot was briefed that he would be the pilot flying (PF).

At 0115 LT, while onboard the Aircraft, and after the flight preparation was completed, the flight crew noticed deterioration of the weather as the fog had increased with runway visual range (RVR) at 200m and this was confirmed by listening to the Automatic Terminal Information Service (ATIS). As per the Operator's procedures during reduced RVR, the Commander took over the responsibility as the pilot flying (PF).

At 0323 LT, 68 minutes after the schedule departure, the crew was given push back clearance after confirming to ATCO that the minimum RVR was 125 m required for departure. No FMV was offered to the flight crew. After push back and before taxi, a deadheading pilot joined the operating flight crew and occupied the observer's seat in the cockpit for the duration of the flight.

The Aircraft taxied to the stop bar of runway 31L at taxiway Echo 15. When the crew had the stop bar in sight, they were cleared by the ATCO to line up and wait on runway 31L. The crew queried the stop bar red lights as they were ON. The ATCO informed the crew that he was trying to switch it off and asked the crew to verify if it was OFF. The crew confirmed the stop bar went OFF and that the taxiway green lead-in lights onto the runway came ON.

After the Aircraft passed the stop bar, and based on the Aircraft's average speed, the Investigation calculated that at approximately 70m, after crossing the stop bar, the Commander said that "He could not see." The Investigation believes that when the Commander expressed that, he was, most likely, referring to the green taxiway lead-in lights and other lights in the vicinity. At that time, he had, most likely, lost external visual cues that could have assisted him in taxiing the Aircraft into the correct take-off position. The Investigation could not determine why the crew could not see the external visual cues.

At the same time, the Commander asked the copilot to request the tower ATCO to switch on the runway lights. Immediately after, the tower ATCO called to provide the take-off clearance. The copilot read back the clearance, but he did not request the ATCO to turn ON the runway lights, and the Commander did not repeat his request. The Investigation believes that when this happened the two pilots, most likely, saw an external reference, which was the first light of the left hand runway edge lights. Probably, both of them believed that this was the runway centerline and followed it. That is why there was no challenge of each other's decision.

The Commander continued to taxi and turned the Aircraft to the left of the taxiway centerline and followed the runway left hand edge lights. It is most likely that he believed that following the only visible light was the safest option, not knowing that the Aircraft was away from the actual runway centerline.

When the Aircraft lined up, the copilot stated that "The centerline lights supposed to have more space than that [silence of two seconds] No?" and the Commander explicitly commented on the number of lights visible as being two. The Commander said: "I see only two

lights.", but neither of the other pilots who were in the cockpit effectively challenged their statements to confirm whether they were at their intended position. They could have verified their position by comparing the location of identifiable features to the best of their ability. Identifiable means would had been other lights left and right and runway markings in the Aircraft vicinity.

There was a significant difference in the spacing between the runway edge lights, which are 60 m apart, and the spacing between the runway centerline lights which were 15 m apart.

In the case of the runway centerline lights, with the RVR of 175m and the knowledge of the light spacing, the flight crew should have been able to see about 11 lights. Therefore, applying their knowledge and experience of airfield lighting and markings should have allowed them to confirm the Aircraft position.

Two visible lights on the runway centerline equate to a 30 m RVR, because of their 15 m spacing. If the Aircraft had been located over the runway centerline lights this would equate to a 45 m RVR. This was an indication to alert the crew that the RVR was well below the minimum required for departure.

Since the two lights visible to the crew were runway edge lights, this indicated that they had a visual reference of between 60 m and 120 m. It is possible that the RVR could have been different from the 175 m communicated by the ATCO, as the RVR reading was taken more than 300m away from the Aircraft position.

Furthermore, the direction of illumination and the brightness of the runway edge lights were different to the illumination and brightness of the runway centerline lights. In addition, it should have also been noted the difference between the broken runway centerline and solid runway edge white lines.

As per the ATC Unit report, the lighting intensity was set at a value of 'step 4' instead of the recommended value of 'step 2', which is normally used for night and limited visibility operations. The Investigation was unable to witness the visibility, moon and light conditions experienced by the crew, during the Incident night, in order to better understand the visual conditions.

High intensity runway (edge and centerline) lights create a "flooding", saturation type lighting which limits vision of other objects due to localized light intensity. This would have made it difficult for the pilots to see and recognized physical characteristics that would have provided other opportunities to verify their actual position.

Therefore it was observed that the inclination in human decision making: confirmation bias, which is the "Tendency[11] for people to favor information that confirms their preconceptions

[11] Downloaded from: http://www.princeton.edu/~achaney/tmve/wiki100k/docs/Confirmation_bias.html

or hypotheses regardless of whether the information is true."[12] The crew only accepted the information that was matching their belief that they were on the runway centerline.

Confirmation biases contribute to personal beliefs and can maintain or strengthen beliefs in the face of contrary evidence[13]. It is the tendency to attend only to evidence that supports the default hypothesis, which is natural but can result in flawed analysis. The Incident flight crewmembers allowed themselves only to take into account the facts that were compatible with what they believed. Therefore, their situational awareness was influenced. Situational awareness involves appreciating what all the crewmembers need to know. To a crewmember, situational awareness is knowing the status of the aircraft in relationship to external cues.

For an ATCO, situational awareness means knowing about the positions of all the aircraft that he is controlling, along with their flight plans, and predicting future states which will assist him in detecting and preventing possible conflicts.

Under normal operations, flight crewmembers and ATCOs continuously extract environmental information and integrate it with previous knowledge to form a coherent mental model. Then they use this model to enhance their perception and subsequently anticipate future events.

The Incident crew regained their situational awareness after the rejected takeoff.

After the Aircraft had impacted nine left hand runway edge lights, the Commander rejected the takeoff. The Aircraft continued to impact two additional lights before becoming to a complete stop on the runway edge. The Commander's decision to reject the takeoff was based on the unusual sound and thumps coming from the nose landing gear wheels. The Investigation believes that the thumps were a good triggering event that caused the crew to reject the takeoff. Without the thumps, and if the takeoff had continued, it may have resulted in severe consequences.

The Operator's manual part A (OM-A rev. 12) did not comply with the regulatory requirement of having a 90 m visual reference. Such a reference might have triggered the crewmembers to stop and assess the situation on the preventive phase of the event.

The GCAA could ensure that all UAE air operators and ATC Units have detailed procedures in place to ensure that flight crewmembers stop the aircraft and verify the aircraft position. Position verification should not only confirm that the aircraft is on the correct runway but it is also the correct position on the runway. Such verification can be enhanced by a standard call-out that verifies that both pilots are aware of the runway centerline position. Furthermore, the LVP can be enhanced to require flight crew call out the number of visible lights during takeoff briefings.

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[12] Miller, Frederic; Vandome, Agnes F.; McBrewster, John (2009), Confirmation Bias, VDM Publishing, ISBN 6-13020-015-3

[13] Nickerson, Raymond S. (June 1998). "Confirmation Bias: A Ubiquitous Phenomenon in Many Guises". Review of General Psychology 2 (2): 175–220
Darley, John M.; Gross, Paget H. (2000), "A Hypothesis-Confirming Bias in Labelling Effects", in Stangor, Charles, Stereotypes and prejudice: essential readings, Psychology Press, p. 212

Tuning the instrument landing system, or other onboard equipment, may aid pilots by providing additional tool for enhancing situational awareness. For the Incident flight, the Commander stated that he used the ILS frequency to verify his position and noticed a deviation but he added that his physical position was probably affecting the deviation that was observed.

Moreover, ATCOs can request flight crews to verify the correct position of the aircraft. This provides an additional safety net. Also, in case the aerodrome is equipped with an advanced surface movement guidance and control system, ATCOs may verify the aircraft position prior to issuing takeoff clearance. Similarly, ATCOs procedures can request the crew to verify the number of visible lights on the runway centerline and runway edge.

The Investigation believes that the LVP should be enhanced by ensuring that more detailed safeguards are put in place for both flight crewmembers and ATCOs.

2.4 Taxiway and Runway Lighting and Markings

After the aerodrome initiated LVO, a total of seven flights departed from the same runway prior to the Incident. Three of these flights queried ATC about the condition of the taxiway Echo 15 stop bar, the taxiway centerline lead-in lights, or the runway centerline lights. The commander of one of these flights, stated that he had also lost his outside visual reference. As per his statement, he successfully aligned the aircraft utilizing the strobe lights at the beginning of the runway which provided sufficient reference to align the aircraft correctly on the runway centerline.

It was also stated by the ATCO to the crews of two flights, one of which was the Incident flight, that they were trying to switch off the stop bars.

The Investigation could not determine if there was an actual problem with the lighting and/or the ATCO's switching, as there were no records of the ATCOs' control inputs to the lights.

The history report which was provided by the Airport Operator, revealed two findings: first, the AGL at taxiway Echo 15 and runway 31L were functioning as normal, and second, for the Incident flight the stop bar was switched back on again two minutes and one second, after it had first been switched off.

The Incident flight both flight crewmembers stated that they could see the green lead-in taxiway lights but at a point which was calculated to be before the end of the 90m straight taxiway lights, that is controlled by the stop bar, they saw a white light to their LH, which they followed, believing that this was the runway centerline.

The runway edge lights are more noticeable as they are omni-directional, providing an illumination pattern in all directions. The taxiway and runway centerline lights however, are bi-directional which limits the viewing angle, depending on the position of the observer pilot.

The Investigation could not verify the taxiway lead-in lights beam spread, as there was no photometric testing log nor is it a regulatory requirement. The regulations only required regular photometric testing, in accordance with the Isocandela diagram, for the runway lights.

Hence, as the Aircraft lined up, the flight crew would have been able to see the left hand edge runway lights clearly, immaterial of the viewing angle, but the visibility and brightness of the taxiway and the runway centerline lights would vary depending on the viewing angle and

distance away from the taxiway centerline. However, the crewmembers should have been able to see the taxiway centerline lights irrespective of the Aircraft lateral position on the taxiway.

The Investigation's research into the reasons for runway misalignments revealed factors that were also present during this Incident which include the following:

- There was dark night operations,
- There was reduced visibility, as LVO was in force,
- There was an air traffic control clearance provided as the Aircraft was entering the runway,
- There was flight crew distraction when the Commander requested that the copilot ask the ATCO to turn on the lights, the ATCO, at the same time, provided the take-off clearance which the copilot acknowledged.
- Flight crews lost their external visual cues and
- Flight crews followed a light which was more visible, when they lost their external visual cues

The crew confirmed to the tower ATCO that they could see the green taxiway centerline lights and the Commander continued to taxi the Aircraft along the taxiway. However, before reaching the end of the 90 m straight taxiway section which was calculated to be at approximately 70 m the crew lost external visual reference. The Investigation believes that the crew visual reference was partially regained when they both observed a white light to their left which they mistook as a centerline light and steered the Aircraft towards this light.

The runway centerline is painted with uniformly spaced white lines/stripes and gaps, and the runway edge is painted with a continuous white line. This difference in marking, which was not observed by the Incident crew, could have aided their assessment of the physical position of the Aircraft as they lined up on the runway edge.

Another external visual cue, would have been the actual painting of the runway threshold. It was noticed by the Investigation, that if the Aircraft had followed the green lead-in taxiway lights, the Aircraft would not be lead over the threshold. Thus, the crew would have lost the opportunity for a clear reference of the white lines/stripes, which signify the threshold markings.

Passing over the threshold markings provides an additional reassurance to the crew that they are located at the correct position for takeoff. An additional external visual cue that would minimize runway misalignment would be a restructuring of the taxiway lead-in lines. They could be structured in a way that would place the aircraft over the painted threshold (piano keys). Thus allowing pilots to have an additional cue to verify their position especially during LVO.

2.5 Other Potential Solutions

The common and predominant factor that was observed in all occurrences that the Investigation reviewed, was that during the reduced visibility takeoffs, the crewmembers followed the first light that they saw, which was the runway edge light, thinking that it was the runway centerline lighting. This assumption was made by crewmembers in all occurrences

around the world, operating under different regulatory environments, trained and examined by different instructors/examiners, operating different aircraft types, at different airports.

One of the elements that could minimize the possibility of lighting confusion could be a different color of lights. Pilots are aware that runway center and edge lights are white. However, if pilots knew that the white color is only used for the runway centerline lights and another color for the runway edge lighting, then they would be aware that their visual reference will be a white light indicating the correct alignment on the runway centerline. The alignment or misalignment with the runway would be immediately obvious. Therefore, a change to the color of the lighting might solve some of the takeoff problems, but this solution might create more serious implications, as the issue involves more than one discipline. Human factors, electrical engineers, runway, airport specialists along with pilots, engineers, ATCOs, and manufacturers would be some of the many specialties that should be involved.

The idea of changing the light color, or any other alteration of the runway lighting, may not be endorsed by all organizations. Notwithstanding this, a study that could take into account all possible outcomes, and risks involved, should be undertaken, under the umbrella of a panel of experts, to review and decide as the change of color could create a greater confusion worldwide. This Investigation could not research further the potential outcomes of changing the runway lighting color.

For reduced visibility takeoffs, actual and accurate RVR is important. Flight crews need to know the exact RVR, so that they are fully aware that they can perform a safe takeoff from the specific runway. The RVR information comes from the RVR transmissometers. These transmissometers are located along the runway, measuring the actual RVR. ATC normally communicates this information to the pilots either directly, or by the automatic terminal information service (ATIS).

For the first part of the runway, at the Incident aerodrome, RVR transmissometers are located at a distance of 350m from the threshold of runway 31L which may not cause any problems during landing as this is close to the touch down zone area. But, if accurate information is required for takeoff, then ideally, the RVR measurement should be taken as close as possible to the takeoff area, which is the beginning of the runway. This is critical when the RVR is below 350m, as fog patches could change the RVR locally, without affecting the RVR in other areas.

2.6 Medical and Pathological Information

After the Incident no formal request was made to any entity to provide post occurrence drug, alcohol, medical or pathological testing on the involved Incident crewmembers. Even though the Investigation believes that the Incident crew was not under the influence of alcohol or any other substance, or any other medical or pathological condition that could have impaired their performance.

As indicated in 1.13, of this Report, in accordance with the current at the time of the Incident UAE regulations the GCAA, when conducting a post-accident investigation, shall arrange for a medical examination of the crew, passengers and involved aviation personnel by a physician experienced in accident investigation.

These post occurrence medical examinations have to be undertaken in order to identify any potential problems and should be expeditious following the occurrence.

Nevertheless, there should be a clear and concise procedure in place for every crewmember to undertake a medical examination in the form of a blood test, or any other test appropriate to confirm that the person is free from any substance that could influence his ability to perform his duties. Current regulations have the provision for post-accident medical investigation only; however, there is no further guidance and it is not clear, how and by whom these tests would be performed, in case of an incident under investigation. Nonetheless when there is a formal investigation of an occurrence, irrespective of its classification (accident, serious incident, incident, etc.) a medical examination should be performed.

3. Conclusion

3.1 General

From the evidence available, the following Findings, Causes and Contributing Factors were made with respect to this Incident. These shall not be read as apportioning blame or liability to any particular organization or individual.

To serve the objective of this Investigation, the following sections are listed under the "Conclusions" heading:

- **Findings-** statements of all significant conditions, events or circumstances in the sequence of this Incident. The findings are significant steps in this Incident sequence, but they are not always causal or indicate deficiencies.
- **Causes-** actions, omissions, events, conditions, or a combination thereof, which led to this Incident.
- **Contributing Factors-** actions, omissions, events, conditions, or a combination thereof, which, directly contributed to this Incident and if eliminated or avoided, would have reduced the probability of this Incident occurring, or mitigated the severity of its consequences.

3.2 Findings

3.2.1 Findings relevant to the Aircraft

(a) The Aircraft was certificated, equipped, airworthy, and maintained in accordance with the *Civil Aviation Regulations* of the United Arab Emirates.

(b) There were no Aircraft systems anomalies that could have contributed to the misalignment of the Aircraft on the runway edge lights.

3.2.2 Findings relevant to the crew

(a) The flight crewmembers were adequately rested in accordance with the existing *Civil Aviation Regulations* of the United Arab Emirates.

(b) The flight crewmembers were licensed, medically fit, qualified and competent for the flight.

(c) The flight crewmembers were in compliance with the flight and duty time regulations.

(d) No post-Incident medical testing was performed on the crewmembers.

(e) The Commander confirmed that he performed a crew briefing for the takeoff.

(f) A third deadheading pilot entered the cockpit after pushback and occupied the observer seat.

(g) There was no explicit requirement in the *Civil Aviation Regulations* of the UAE regarding the post-Incident medical examinations for the flight crew.

3.2.3 Findings relevant to the operation

(a) The flight was initially planned with the copilot as the pilot flying (PF).

(b) Due to a change in weather affecting visibility, the airport had initiated low visibility operations at 0115 LT.

(c) As a result, the Commander took over as pilot flying, in line with the Operator's policy.

(d) The crew went into discretion time as the flight was delayed for 68 minutes due to fog at the departure airport.

(e) The crew did not request the Follow-Me-Vehicle. This was not a requirement of the Operator.

(f) The Commander taxied the Aircraft to the Echo 15 stop bar of runway 31L.

(g) The crew queried the status of the Echo 15 stop bar lights when they approached the stop bar, as the red lights were still on, even though the crew had been given clearance to cross the stop bar by ATC.

(h) The crew confirmed to ATC that the Echo 15 stop bar lights were now OFF and the green taxiway lead-in lights came ON.

(i) The crew crossed the Echo 15 stop bar and 20 seconds later, as the Aircraft was still on the taxiway, the Commander was recorded on the CVR saying that 'He could not see."

(j) The Commander requested the copilot to contact ATC and ask that the runway lights to be turned ON.

(k) ATC called the crew and gave the takeoff clearance and the copilot read back the ATC clearance correctly.

(l) No request was made to ATC about the runway lights.

(m) The Commander continued to taxi the Aircraft at a ground speed of 6 knots.

(n) Shortly after, the Commander observed a visible white light on his left and he steered the Aircraft toward the light.

(o) The Commander had unknowingly aligned the Aircraft with the runway left hand edge lights.

(p) The visible cues did not match the expectations of the copilot. He said to the Commander that "The centerline lights supposed to have more space than that [silence of two seconds] No?".

(q) The Commander replied that he could see "Only two lights." after the Aircraft had been aligned with the runway edge lights. He did not realize that he was referring to the runway edge lights.

(r) When the Aircraft was lined up, the flight crew did not verify if they could see a line of runway edge lights to their left and to their right.

(s) There was no further discussion about the lights and the crew commenced the *before-take-off checklist.* The checklist was completed 13 seconds before the Commander initiated the takeoff.

(t) The Aircraft struck and damaged 11 runway edge lights during the attempted takeoff.

(u) The position of the localizer symbol was not utilized by the crew to verify the Aircraft position in relation to the runway centerline. This was not an Operator requirement as an aid for takeoff.

(v) The Operator's manuals part A (OM-A rev. 12) did not include the UAE regulatory requirement, during LVO that pilots have available a minimum of 90m visibility from the cockpit at the start of the take-off run.

3.2.4 Findings relevant to air traffic services and airport facilities

(a) Runway 31L was certified as CAT III B, equipped, and maintained in accordance with UAE *CARs, Part IX.*

(b) The Follow Me Vehicle was not deployed by ATC for the Incident flight as required by aerodrome LVO procedures.

(c) The lighting for runway 31L and the adjoining taxiway Echo 15 was activated for LVO and set to the standards for CAT III B AGL FMV.

(d) After the Echo 15 stop bar, there were green lead-in taxiway lights which join the lead-in lights designed to lead the Aircraft directly to the runway centerline.

(e) In accordance with the ALCMS light history log, the lead-in taxiway lights were ON all the time.

(f) As the Aircraft approached the Echo 15 stop bar, the ATCO informed the crew that he was trying to switch the stop bar OFF.

(g) When the Echo 15 stop bar was switched off by ATC, the green lead-in lights on the taxiway centerline came ON.

(h) ATC reported that the RVR was 175 m at position Alpha, 200 m at position Bravo, and 175 m at position Charlie.

(i) There were no lighting failures recorded in the ALCMS light history log.

(j) The ALCMS light history log report recorded the Aircraft passing the 17/6 sensors located after Echo 15 stop bar.

(k) There was no recording of the ATCO control panel switch positions, nor which mode the ATCO had used to control the aerodrome lighting. There was no regulatory requirement that this information be recorded.

(l) There was a noticeable difference in the spacing between the runway edge lights (60m), and between the runway centerline lights (15m).

(m) Had the Aircraft been aligned on the runway centerline lights, the flight crew would have been able to see about 11 lights.

(n) The runway edge line was a solid white line, the runway centerline was a broken white line, and the taxiway centerline was a solid yellow line.

(o) The runway and taxiway edge lights were omni-directional, whereas the runway and taxiway centerline lights were bi-directional.

(p) The current *Civil Aviation Regulation* at the time of the Incident required photometric testing of runway lights, but the *Regulation*s did not require taxiway lights photometrical testing.

(q) The ATCO provided the take-off clearance as the Aircraft was taxiing on the runway.

(r) The ATCO did not verify the Aircraft position prior to takeoff.

(s) As per the ALCMS light history log report, the stop bar was switched back on two minutes and one second after it was first switched off.

3.3 Causes

The Air Accident Investigation Sector determines that the cause of aligning the Aircraft with the left hand edge of runway 31L instead of the runway centerline was the loss of situation awareness by the crew. The root cause of the loss of situation awareness was not determined.

4. Safety Recommendations

4.1 Safety Recommendations

This section of Report, lists are proposed according to paragraph 6.8 of *Annex 13 to the Convention on International Civil Aviation*, and are based on the Findings listed in Section 3 of this Report. The AAIS expects that all safety issues identified by the Investigation are addressed by the appropriate States and organizations.

4.2 Safety Actions Taken

Below is a summary of the safety actions taken.

4.2.1 The Aircraft Operator[14]

"

a) The pilots involved in the Incident were provided with additional training and checking prior to their return to unsupervised line operations.

b) A review of all aspects of the Operator's LVP training was conducted, which resulted in the following actions:

ii. Enhancement of the briefing courseware that is used prior to initial LVP training sessions, and prior to recurrent OPC's, to provide increased focus on the lighting and other visual cues that are available to pilots that will allow them to determine the position of the aircraft during taxi and runway line-up in low visibility conditions.

iii. Modification of the initial LVP training lessons to include taxi-out and runway line-up, to ensure they are able to follow the applicable procedures, and are able to use the available visual cues to maintain awareness of the aircraft position at all times.

c) Inclusion of taxi-out/taxi-in and runway line-up exercises in the recurrent OPC's conducted during the period April 2012 – September 2012, and again during the period October 2012 – March 2013, to ensure that all Etihad pilots were given the opportunity to demonstrate that they were able to follow the applicable procedures at the concerned airports and were

[14] Electronic communication dated: 15 July 2014.

able to use the available visual cues to maintain awareness of the aircraft position at all times.

d) The SOP's were updated to include selecting the runway ILS when the aircraft has lined up as an added measure to confirm the aircraft is on the centerline.

e) A company NOTAM was published to highlight the specific risks associated with takeoffs in RVR less than 150 m in CAT C aircraft or 200 m in CAT D aircraft. The Operator introduced procedures for its pilots prior to commencing a takeoff roll to verify the aircraft's position with visual clues of centerline markings and lights RWY edge lights from both sides, instrument landing system tuning."

The Investigation determined that these safety actions taken by the Operator are sufficient to address the issues raised.

4.2.2 The Air Traffic Control Operator

Refer to section 1.18.7 of this Report for actions taken by the Airport Air Traffic Control Operator.

4.2.3 The Aerodrome Operator

The Investigation was not made aware of any corrective actions taken by the Aerodrome Operator.

4.3 Final Report Safety Recommendations

The Air Accident Investigation Sector recommends that:

4.3.1 The General Civil Aviation Authority of the United Arab Emirates

Promulgate new requirements or enhance existing requirements:

SR31/2016

To ensure that all UAE based AOC holders have procedures in place that require the flight crewmembers to verify their takeoff position with various means during LVO.

SR32/2016

For UAE ATC units to have procedures in place that require ATCOs to verify with flight crewmembers that the aircraft is correctly positioned and the runway lighting is operational during an LVO takeoff.

SR33/2016

For all UAE AOC holders to include in the standard operating procedures, the requirement for pilots to have available visual segment from the cockpit at the start of the take-off run, during LVO.

SR34/2016

The oversight process shall be enhanced to fully capture the requirements for aeronautical ground lighting outputs, to ensure that the specification within the respective Isocandela diagram is achieved and maintained, this includes taxiway lighting and in particular centerline and lead-in lights.

SR35/2016

For all UAE ATC units to record the actual switch positions and modes that ATCOs use to manage the aerodrome lighting.

SR36/2016

Enhance the existing regulations by adding guidance and procedures for involved personnel's medical examination after an occurrence under investigation. The guidance and procedures should describe as a minimum which entity should initiate the medical examination, along with the timeframe.

SR37/2016

Enhance existing regulations and supporting documents to ensure that State investigators can access medical records after an occurrence under investigation.

4.3.2 The International Civil Aviation Organization:

SR38/2016

Initiate a study for the development of a change to the existing runway lighting system, runway stripes and lines described in Annex 14 Vol 1, that would allow flight crewmembers to positively differentiate the runway edge from the runway centerline.

SR39/2016

To ensure flight crewmembers have runway visual range information measured at their takeoff position.

SR40/2016

To initiate a study for the development of taxiway lines described in *Annex 14, volume 1* that would take aircraft over the runway threshold during low visibility operations takeoffs.

This Final Report is issued by:

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Appendix A

Comments submitted by the Aircraft Operator

The following comment is appended to this Report at the request of the Aircraft Operator and acceptance by the Investigation:

> "Both the 'Synopsis' and 'Causes' mention the fact that the cause of aligning the aircraft with the runway edge lights instead of runway centreline was the loss of situational awareness by the crew. It goes on to state that the root cause of this loss of situational awareness could not be determined.
>
> Keeping in view the various other reports (as mentioned in Table 4 –Section 1.9.1), ATC was queried by crew of 3 other aircraft regarding the E15 Stop bar or runway centreline lighting. Similarly, under Section 3.2.4 (b) – Findings relevant to the air traffic services, it is clearly mentioned that the FMV was not deployed by ATC as required under LVO aerodrome procedures.
>
> Based on the above and taking in to account the theory of accident causation which focuses on a chain of events leading to an incident/accident rather than a single factor, Etihad believes that there should also be an air traffic service related contributory factor mentioned under the Causes (and Synopsis) in addition to the loss of crew situational awareness. This will make the report more balanced by mentioning the possibility of an ATC induced causal factor that could have contributed to the loss of crew situational awareness, which eventually led to the incident."

The Investigation reviewed the Aircraft Operator's comments and could not find supportive evidence linking the non-deployment of the FMV to the occurrence. The Investigation believes that even if the FMV had been deployed, it would have escorted the Aircraft only to the E15 stop bar. Thereafter, the flight crew took over the responsibility of taxiing and alignment of the Aircraft for take-off.

Therefore, the Investigation does not agree with the comments received from the Aircraft Operator and thus, no amendment was made to the Final Report.