Air Accident Investigation Unit Ireland

SYNOPTIC REPORT

SERIOUS INCIDENT
Embraer SA, ERJ 190-200 LR, G-FBEM
Dublin Airport
16 October 2017

An Roinn Iompair
Turasóireachta agus Spóirt
Department of Transport,
Tourism and Sport

Foreword

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

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

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

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

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

AAIU Report No: 2018-019
State File No: IRL00917055
Report Format: Synoptic Report
Published: 11 December 2018

In accordance with Annex 13 to the Convention on International Civil Aviation, Regulation (EU) No 996/2010 and the provisions of SI No. 460 of 2009, the Chief Inspector of Air Accidents on 17 October 2017, appointed Mr Howard Hughes as the Investigator-in-Charge to carry out an Investigation into this Serious Incident and prepare a Report.

Aircraft Type and Registration:	Embraer SA, ERJ 190-200 LR, G-FBEM	
No. and Type of Engines:	2 x General Electric CF34-10E7	
Aircraft Serial Number:	19000204	
Year of Manufacture:	2008	
Date and Time (UTC)[4]:	16 October 2017 @ 07.10 hrs	
Location:	On Approach to Dublin Airport	
Type of Operation:	Commercial Air Transport	
Persons on Board:	Crew - 5	Passengers - 75
Injuries:	Crew - Nil	Passengers - Nil
Nature of Damage:	Nil	
Commander's Licence:	Airline Transport Pilot Licence (ATPL) Aeroplanes (A) issued by the UK CAA[5]	
Commander's Age:	42 Years	
Commander's Flying Experience:	6,400 hours of which 366 were on type	
Notification Source:	Duty Manager, Dublin Airport	
Information Source:	AAIU Field Investigation	

[4] **UTC**: Co-ordinated Universal Time. All timings in this report are quoted in UTC; Local time is UTC + 1 Hour.
[5] **UK CAA**: Civil Aviation Authority of the United Kingdom.

SYNOPSIS

The aircraft was on a scheduled passenger service from Cardiff Airport, UK (EGFF) to Dublin Airport, (EIDW). During its final descent towards EIDW, the Flight Crew noticed a burning smell, which they described as "*sulphurous*". The Commander contacted the Cabin Crew, who informed him that they had also noticed a smell. The Commander noted that the smell appeared to be getting more intense. The Flight Crew donned their oxygen masks, which had integrated smoke goggles, and declared a PAN-PAN (state of urgency) to Air Traffic Control (ATC). During the approach the Flight Crew experienced difficulties communicating with each other and ATC. They also experienced restricted visibility through the smoke goggles. The aircraft continued its approach and landed safely at EIDW, where it was met by the emergency services. There were no injuries.

1. FACTUAL INFORMATION

1.1 History of Flight

The aircraft departed from EGFF at 06.14 hrs for a scheduled passenger service to EIDW. The Commander was Pilot Flying. The Co-Pilot was Pilot Monitoring and was performing most of the radio communication with ATC.

At 06.35 hrs, the aircraft entered Dublin airspace and was cleared on a standard arrival route for runway (RWY) 10. Earlier that morning, weather conditions at EIDW were such that Low Visibility Procedures (LVPs) were in force at the airport. This had resulted in delays, and the subject flight was instructed to take up a holding pattern at reporting point BABON at flight level (FL) 90, descending to FL70. At 07.06 hrs, ATC cleared the aircraft to leave the holding pattern and continue on the standard arrival route to RWY 10 at EIDW.

As the aircraft left the holding pattern at FL70, it entered the top of a cloud layer and the Flight Crew noticed a burning smell, which they described as "*sulphurous*". The Commander contacted the Senior Cabin Crew Member (SCCM) to check the status of the cabin. The SCCM, who was seated at the front of the cabin, initially reported that everything appeared normal. However, CCM 3 who was seated at the rear reported a "*burning smell*" towards the back of the cabin. This was confirmed by CCM 2, who was also seated at the rear. The Commander informed the Co-Pilot that there was a "*smell of smoke*[6] *in the cabin*", and both pilots noted that the smell appeared to be getting more intense in the cockpit.

The Flight Crew then donned their oxygen masks and attempted to establish communications with each other. At 07.12 hrs, ATC instructed the aircraft to descend to 5,000 ft. ATC had to repeat this instruction as there was no apparent response from the aircraft. The instruction was responded to by the Commander, as it appeared to him that the Co-Pilot's oxygen mask microphone had failed. The Commander noted that he did not hear the Co-Pilot's transmissions through his headset, nor could he hear the Co-Pilot's intercom transmissions.

[6] The term smoke in this Report refers to the odour or smell of smoke. There was no visible smoke during this event.

The Commander took over radio communications and at time 07.13 hrs declared a 'State of Urgency' or PAN-PAN[7]. Following receipt of this transmission, ATC commenced vectoring the aircraft towards the localiser for the Instrument Landing System approach (ILS) to RWY 10 at EIDW.

At 07.14 hrs, the aircraft was cleared to descend to 4,000 ft. and this was acknowledged by the Co-Pilot, whose oxygen mask microphone now appeared to be functioning again. With the Co-Pilot now able to resume communication with ATC, the Commander took the opportunity to brief the Cabin Crew, stating that the aircraft was on final approach to EIDW, they would be landing in approximately eight minutes, to expect a normal landing, that he had informed ATC of the situation on board, and to await further instructions on landing. The Co-Pilot's oxygen microphone functioned normally until 07.17 hrs, when an attempted response to ATC by the Co-Pilot was again unsuccessful. From this point, until the aircraft landed, all communications between the aircraft and ATC were carried out by the Commander.

In addition to the difficulties with communication, both pilots experienced restricted visibility through the lens of the smoke goggles due to scratches and an obscuring layer on the lens (Section 1.6.3).

Having declared a PAN-PAN, ATC immediately gave priority to the flight and instructed the aircraft to route directly to point GANET on the final approach to RWY 10. However, the Flight Crew had difficulty programming the FMS to comply with this instruction due to the restricted visibility through the goggles. Therefore, ATC facilitated the Commander's request for vectors to the final approach. The Approach Controller remained in contact with the aircraft throughout the event, until the aircraft had landed.

Due to earlier meteorological conditions at EIDW, the Flight Crew had expected and briefed for a Category 2 approach to RWY 10. However, due to the communication difficulties and restricted vision caused by the smoke goggles, the Commander elected to carry out a Category 1 approach.

In addition, due to the restricted communications and reduced visibility presented to the Flight Crew by the oxygen masks, the approach and landing checklists were conducted by holding the checklist up, pointing to an item and giving a 'thumbs up' signal as a means of confirming the item had been actioned and positively checked as completed. Using this method the aircraft was configured early for landing. The Commander noted that he could see the aircraft flight instruments despite the problems with his goggles.

The Commander conducted the ILS approach to RWY 10 with the autopilot engaged. He stated that he acquired the runway visual references at approximately 300 ft above aerodrome level, at which point he disconnected the autopilot and took over manual control of the aircraft for landing.

The aircraft landed on RWY 10 at EIDW at 07.23 hrs, and was met by the Airport Fire Services (AFS), after it cleared the active runway on to Taxiway H2. The AFS informed the Commander that there appeared to be no signs of fire or damage on the exterior of the aircraft.

[7] **PAN-PAN**: A radio transmission of 'PAN-PAN', made three times, is used to signify that there is a state of urgency on board an aircraft, but that, at the time of transmission, there is no immediate danger to life or to the aircraft itself.

The Flight Crew removed their oxygen masks and noted that the smell of smoke had reduced. The Commander then asked the Cabin Crew for an assessment of conditions in the cabin and was told that the smell of smoke had reduced. Therefore the Flight Crew requested taxi clearance to their allocated parking position. The aircraft parked on stand 207T at 07.31 hrs, where the passengers disembarked normally.

1.2 Other Reports of Smoke

The Investigation was informed by the UK AAIB[8], that there had been a large number of similar reports, from a number of operators, regarding smoke/fumes in aircraft within UK airspace on the same date as the subject event. The UK AAIB informed the Investigation that they were notified of about 32 events[9]. They stated that the smoke/fumes were detected from between 2,000 ft and FL200, and that most of the aircraft either returned to land at the point of departure or expedited their existing approaches. Most crews declared either a PAN-PAN or a MAYDAY and the majority of crews went on oxygen. The first event appears to have been around 06.22 hrs during departure from Liverpool, climbing through FL130; the aircraft returned to land. There were clusters of affected aircraft in the following locations; Channel Islands, Liverpool, Manchester, and later in the day at Heathrow.

1.3 Interviews

1.3.1 General

During interview, both Pilots confirmed that they carried out the pre-flight checks of their respective oxygen masks as per the Operator's standard operating procedures, and the regulator mode selectors were set to 100%. They also stated that as part of the memory items and vital actions for a smoke/fumes drill, they confirmed the regulator was set to 100% as per the Aircraft Checklist.

1.3.2 Commander

The Commander stated that the crew had reported for duty at 05.00 hrs for a 06.00 hrs departure, and that the flight pushed back from its parking stand on time. The Commander made the decision to carry additional fuel due to forecast wind conditions at Dublin, so that they had sufficient fuel to return to EGFF if it became necessary.

The Commander told the Investigation that shortly after the aircraft left the holding pattern to begin the approach, at approximately 07.10 hrs, both pilots noticed a burning smell. The Commander noted that the aircraft was maintaining FL70 at this point and he recalled that "*they had been in and out of IMC*[10]*"*. The Commander reported that the smell was similar to that of "*burning wood or paper*".

As past experience had shown that the kind of smell he was experiencing could originate from aircraft ovens, the Commander said that he contacted the Cabin Crew and asked if "*everything was ok*" in the cabin. The Cabin Crew confirmed that the ovens were not the source, but that they could detect a burning smell also.

[8] **UK AAIB**: Air Accidents Investigation Branch of the United Kingdom.
[9] One particular event investigated by the AAIB, can be found on their website under AAIB Bulletin: 7/2018.
[10] **IMC**: Instrument Meteorological Conditions. The Commander's statement indicated that the aircraft was flying in and out of cloud.

The Commander stated that once he had ordered the donning of the oxygen masks, the Flight Crew established communications between themselves, and the Commander noted that the Co-Pilot made "*a couple of transmissions to ATC before the microphone in the Co-Pilot's mask appeared to fail"*. The Commander also told the Investigation that the lenses of both his and the Co-Pilot's smoke goggles were scratched and *"coated in something"* that impaired their vision.

The Commander stated that once he realised that the Co-Pilot was having difficulty transmitting, he took over communications with ATC and called PAN-PAN, requesting a priority landing, at which point ATC gave them an instruction to navigate directly to a waypoint on the final approach. However, due to the restricted visibility through the masks, they had difficulty complying with the instruction and he asked ATC to give them a vector to the final approach instead.

The Commander informed the Investigation that due to the poor visibility through the lens of his smoke goggles, he briefly removed his mask to check if the smell of smoke was still present. But as he could still smell smoke he put his mask back on.

The Commander noted that the approach controller remained in contact with the aircraft until landing. The aircraft was not transferred over to the tower controller, as is usual, and the Commander said he felt this helped reduce the cockpit workload.

The Commander informed the Investigation that for a short period the Co-Pilot's oxygen mask microphone appeared to be functioning again, so he took the opportunity to brief the Cabin Crew. The Commander stated that as he had given the '*10 minutes to landing*' notification to the Cabin Crew when the aircraft left the holding pattern, he expected that the cabin was already prepared for landing. Therefore, due to the high cockpit workload and short time remaining until landing, the Commander said that he gave an abbreviated briefing to the Cabin Crew, and not a full NITS[11] briefing. Also, due to the short time remaining, the Commander told the Investigation that he did not make an announcement to the passengers.

Once the Commander had completed the briefing for the Cabin Crew, he re-established communications with the Co-Pilot, but shortly after this the Co-Pilot's mask microphone failed again, so the Commander took over the communications with ATC. The Commander told the Investigation that during the descent, as they approached EIDW, the weather was such that they expected to be carrying out a Category 2 Low Visibility Approach to RWY 10. However, due to the issues encountered with the oxygen masks, the Commander stated that he elected to revert to a Category 1 approach, which he executed using the autopilot until he acquired sufficient visual references for landing. He informed the Investigation that he '*obtained sufficient visual references at 300 ft above the runway*'.

The Commander stated that the Co-Pilot could hear outgoing transmissions from his (the Commander's) microphone. Thus the Landing Checklist was completed by a combination of the Commander vocalising the checklist item, whilst pointing to it on the paper checklist, and the Co-Pilot responding with appropriate hand signals to indicate confirmation that the item was actioned correctly. As this process was going to take longer than normal to complete, the Commander stated that they began configuring the aircraft early for landing.

[11] **NITS**: An Acronym used for an emergency briefing given by the Flight Crew to the Cabin Crew. N: Nature of the situation, I: Intentions of the Commander, T: Time remaining to landing, S: Special Instructions, if any.

The Commander informed the Investigation that once the aircraft was safely on the ground he made a 'standby' call to the Cabin Crew. The Commander said this was '*a standard call used to inform the Cabin Crew that the Flight Crew were OK, were addressing the issue, and that no immediate action was required from the cabin crew*'.

He also stated that the Flight Crew removed their masks and noted that the smell of smoke was clearing, at which point the Co-Pilot took over communications with ATC using a hand held microphone.

1.3.3 Co-Pilot

The Co-Pilot informed the Investigation that her oxygen mask lens was scratched and had a "*waxy contamination"* that impaired vision. She stated that initially, following the donning of the masks, both pilots established communications between themselves momentarily before communications failed. The Co-Pilot could hear communications from the Commander and ATC, but the microphone on the Co-Pilot side was not working, so neither ATC nor the Commander could hear her speak.

The Co-Pilot confirmed that the landing checklist was completed by holding a paper copy of the list up, pointing and giving 'thumbs up' sign to confirm each item had been actioned. Despite difficulties seeing the checklist, the method was successful, and the aircraft was configured early for landing. She stated that they "*became visual with the runway at 300 ft"*.

After landing the Co-Pilot said both Pilots took off their oxygen masks and she then established communications using a hand microphone and informed ATC that they would vacate the runway. She then contacted the fire service directly on a dedicated AFS frequency once the aircraft was on the taxiway. The AFS reported that there was no sign of fire or smoke from the exterior of the aircraft or engines.

Once the passengers had disembarked the Co-Pilot said she "*put her headset back on, and everything worked, which suggested that the issue was with the oxygen mask unit and not with the push-to-talk buttons or any other part of the system"*.

1.3.4 Cabin Crew

The two Cabin Crew members stationed at the rear of the aircraft both noted the burning smell before the Commander called from the flight deck. Initially the SCCM, at the front of the aircraft, could not smell burning. However, a short time later he did notice the smell at the front of the aircraft too. He stated that he checked the ovens, which can sometimes be a source of burning smells, but they appeared normal. He also checked the lavatories, but found nothing untoward.

The SCCM stated that the Commander gave "*a mini-NITS"* briefing and told him that they would be landing in eight minutes. The SCCM noted that the cabin was already secure as the '*10 minutes to landing*' call had already been made. He further stated that he contacted CCM 2 and 3, went over the briefing the Commander had given, and "*advised them to go over their drills in their heads, in case they need to take action on landing*".

He also informed the Investigation that there were no further communications before landing. Upon landing he said the Commander gave the '*Standby*' PA, which indicated that the Flight Crew was OK, and that no immediate action was required.

The SCCM noted that the emergency call from the Commander was hard to hear initially but he attributed this to the fact that the Commander was wearing an oxygen mask.

The Cabin Crew noted that the smell of smoke had reduced before landing.

1.3.5 Operator's Safety Training Department

The Operator's Safety Training Department informed the Investigation that flight crew and cabin crew are made aware that the smell of smoke and fumes on board an aircraft can be the result of combustion and that even though visible smoke may not be present, certain hazardous products of combustion may be present, which could be toxic and lead to crew incapacitation. As a precaution, crews are advised to wear oxygen masks if such conditions are identified or suspected.

1.4 Injuries

There were no injuries reported to the Investigation. As part of the Operator's procedures following such an event, the aircraft crew attended a medical facility near Dublin airport for a check-up. No adverse findings were reported to the Investigation.

1.5 Damage to Aircraft

There was no damage to the aircraft.

The aircraft was inspected by a member of the Operator's maintenance organisation, and other than the faults noted concerning the flight crew oxygen masks, no defects were found.

1.6 Personnel Information

The Commander's total flight hours are set out in the **Table No. 1**.

Personal Details:	Age 42 years
Licence:	ATPL issued by the UK CAA
Total all Types:	6,400 hours
Total on Type:	366 hours

Table No. 1: Commander's Flying Experience

The Co-Pilot's total flight hours are set out in the **Table No. 2**.

Personal Details:	Age 27 years
Licence:	CPL issued by the UK CAA
Total all Types:	1,604 hours
Total on Type:	213 hours

Table No. 2: Co-Pilot's Flying Experience

1.7 Aircraft Information

1.7.1 General

The Operator's fleet included eleven Embraer ERJ 170-200 STD, and nine Embraer ERJ 190-200 LR aircraft. Both types are a single aisle, twin-engine aircraft manufactured by Embraer S.A. The ERJ 190-200 LR is a stretched variant of the ERJ 170-200 STD. It was powered by two General Electric CF34-10E7 turbofan engines. The cockpit was fitted with two pilot seats and one observer seat. Each seat position had access to an oxygen mask. G-FBEM was an ERJ 190-200 LR.

Similar to the design of most turbofan and turboprop powered aircraft, the Embraer ERJ series of aircraft, incorporates a bleed air system to provide conditioned, pressurised air to the aircraft cabin and cockpit. Air from the atmosphere is taken in by the compressor section of the engine and some of this air is bled from the compressor (prior to the combustion section of the engine) and, using a network of ducts, valves and regulators, medium to high pressure air is conducted to various locations within the aircraft.

Bleed air is not filtered, so impurities such as smoke or fumes in the atmosphere may enter the aircraft.

1.7.2 Airworthiness Review Certificate

The aircraft's Airworthiness Review Certificate in force at the time of the occurrence was issued on 8 August 2017 and was valid until 27 August 2018. The aircraft had operated for a total time of 16,509 hours from the date of manufacture until the occurrence date.

1.7.3 Oxygen Masks

1.7.3.1 General

Cockpit oxygen systems are installed for the provision of emergency oxygen in the event of smoke, fire, fumes or loss of pressurisation. The three cockpit oxygen masks installed in the aircraft are supplied from a pressurised oxygen bottle, which provides oxygen to the user through a regulator. When not in use the masks are held in individual, closed, stowage containers beside each seat. Many large commercial air transport aircraft now use masks similar to the type installed on the subject aircraft. Pre-flight inspection of such masks can be performed without taking the mask out of its stowage container. An example of the flight crew oxygen mask pre-flight check procedure is given in **Appendix A**.

In some installations, including this case, oxygen masks may also incorporate a clear plastic visor or lens to protect the eyes in the event of smoke. **Figure No. 1** illustrates the main components of the masks in use on G-FBEM.

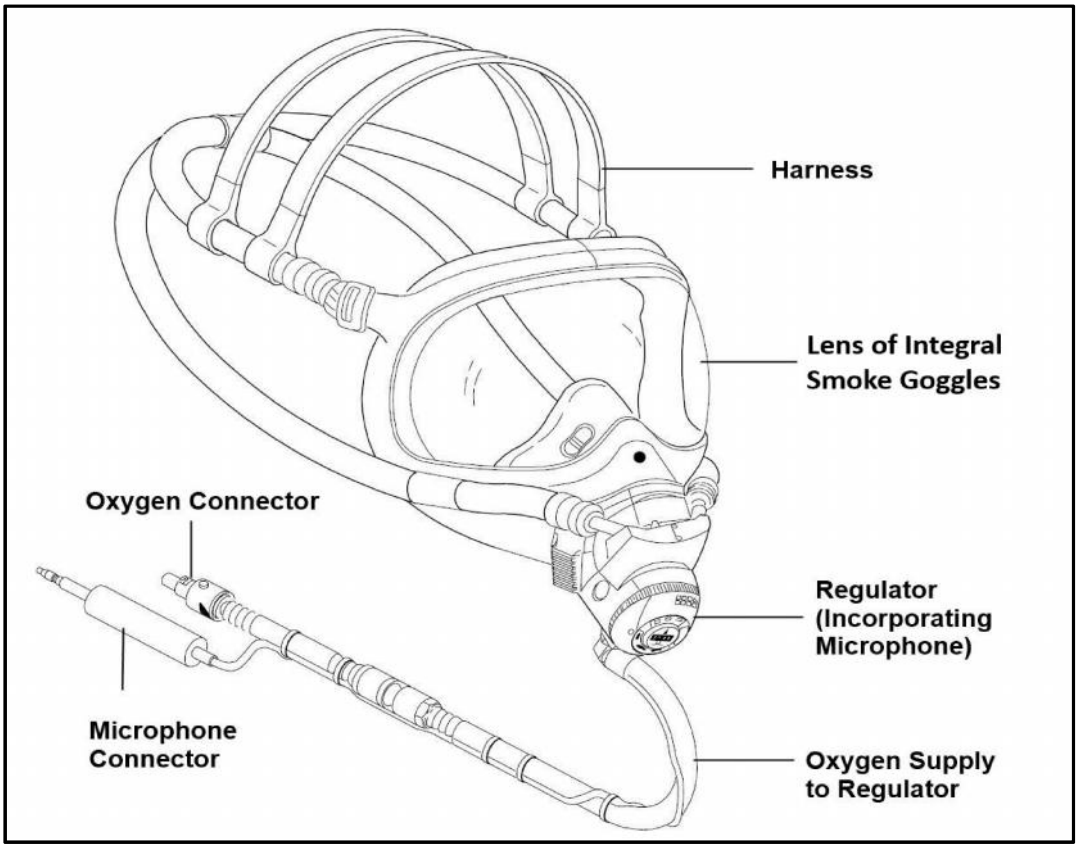

Figure No. 1: Diagram of the sweep-on oxygen mask

1.7.3.2 Oxygen Regulator Modes

The crew oxygen masks have three operating modes, which can be selected by its rotary knob, Normal, 100% and Emergency.

Normal: Normal Mode provides supplemental oxygen diluted with cabin air according to the cabin pressure altitude until a pre-set point where the user inhales 100% oxygen. This feature is to conserve the amount of oxygen consumed from the supply source while still maintaining protective physiological levels.

100%: 100% Mode provides non-diluted oxygen to the crew regardless of cabin altitude.

Emergency: The "EMER" setting provides non-diluted oxygen regardless of cabin altitude, with a slightly positive pressure. This setting should be used to eliminate condensation or to purge smoke and toxic fumes that may get into the mask.

When the mask is on emergency mode, the air pressure and flow make communication more difficult. To avoid communication disruption it is recommended not to use the EMER setting continuously, selecting the mode back to 100% or Normal after the mask is clear of smoke, fumes or condensation.

1.7.3.3 Inspection of Occurrence Masks

Following the event, the Investigation requested that the aircraft and the flight crew oxygen masks be quarantined at EIDW for inspection by the Investigation. Two Inspectors attended the aircraft, and in the presence of an engineer from the Operator, examined the subject masks. The visibility through the lenses of both the Commander's and Co-Pilot's masks was found to be severely restricted by scratching on the outer surface and an obscuring layer on the inner surface, **Photo Nos. 1** and **2**. Both mask regulator mode selectors were found at the 100% setting.

Photo No. 1: Exterior of Commander's Smoke Goggles showing scratches

Photo No. 2: Co-Pilot's Smoke Goggles showing obscuring layer on inner surface

Using the aircraft's interphone and VHF radio, a communications check was carried out on the Co-Pilot's mask to test the built-in microphone. The microphone was found to function normally.

The masks were sent to the Original Equipment Manufacturer (OEM) for inspection and overhaul following the event. No faults were found with the microphone of the Co-Pilot's mask.

1.7.3.4 Maintenance of Occurrence Masks

The Maintenance Planning Document (MPD), issued by the Aircraft Manufacturer, sets out the interval for checking of the Flight Crew Oxygen System, which includes two checks: an Operational Check, and a Detailed Visual Inspection Check. The inspection interval for both checks, as stated in the MPD, was every 3,750 flight hours. The maintenance records show the last inspection was performed on 18 December 2016, and that the aircraft had flown 1,936 hours since the last mask inspection.

1.7.3.5 Fleet inspection of Masks

Immediately following the occurrence, the Investigation requested that the Operator carry out a fleet inspection of all ERJ 170-200 STD and ERJ 190-200 LR masks. The Operator carried out a visual check of remaining lenses, and reported to the Investigation, that out of the 57 masks (the occurrence masks were not included), 17 were found serviceable, 36 required "*cleaning to remove deposits on the surface of the lens, and four required both cleaning to remove deposits, and polishing to remove scratches to the surface of the lens"*.

The Operator further advised that one other flight crew that had experienced smoke in the cockpit on the same day as the subject event, and had donned their oxygen masks, also experienced intermittent microphone performance with one of the oxygen masks.

1.7.3.6 Further Action by Operator Following Occurrence

On 7 February 2018, the Operator advised the Investigation that, '*following a fleet wide inspection, the majority of masks showed a build-up of dust, or debris, which necessitated cleaning of the lenses. The inspection did not identify any specific cause of the contamination, and it was considered, just time related insofar as the build-up* [blooming[12]] *is concerned. The mask inspection was in accordance with the Aircraft Maintenance Manual and included a mask microphone function check'.*

In addition, following the fleet-wide inspection, the Operator informed the Investigation that they had '*requested an amendment changing the frequency of the mask inspection task from every 3750 flight hours, to every A-Check*[13]*. A formal amendment to the Aircraft Maintenance Programme (AMP) will be processed*'.

[12] Blooming is a condition of the lens in which additives in the base material (polymer) have migrated and collected on the surface of the lens, thereby causing a reduction in visual clarity.

[13] **A-Check**: A maintenance check interval that in this case the operator stated was every 750 flight hours.

1.7.3.7 Further Action by Mask Manufacturer

The OEM of the oxygen mask informed the Investigation that it was their opinion that the mask lenses were affected by '*blooming*'. The OEM further stated that:

> *This kind of effect has been reported by some other operators as well and we have issued SIL[14] 1746XX-SIL-001 to inform operators about proper methods for cleaning. Additionally a training video for cleaning can be accessed through our tech publication portal. The procedure as per SIL 1746XX-SIL-001 should be performed at standard maintenance intervals or as required on condition during routine inspections.*
>
> *For new production masks built from October 2017 on we have implemented an ultrasonic cleaning for the lenses during our production process. This step is intended to eliminate the blooming.*

During the Draft Report Comment phase, the Investigation was informed that consultation had begun between the OEM and the US FAA, and that the outcome of this consultation will be the issuing of a comprehensive Service Bulletin (SB) by the OEM.

1.7.3.8 Mask Contamination Report by Another Operator

The Investigation received information from another operator that used similar masks to the subject masks. This operator also had issues with mask lens obscuration due to '*blooming'*. Scheduled mask check intervals were similar to the original 3750 hour interval of the subject Operator.

1.7.3.9 14 CFR[15] 121.333

Part 121 (Operating Requirements: Domestic, Flag, and Supplemental Operations), section 121.333, *Supplemental oxygen*, paragraph (c), *Use of oxygen masks by flight crewmembers*, sub-paragraph (4), states:

> *Before the takeoff of a flight, each flight crewmember shall personally preflight his oxygen equipment to insure that the oxygen mask is functioning, fitted properly, and connected to appropriate supply terminals, and that the oxygen supply and pressure are adequate for use.*

The FAA informed the investigation that the above legislation may potentially mean that prior to each flight a flight crew member would physically inspect a mask, by placing it on their face to check fit and function. Thus, by default, visibility through integrated goggles, if fitted, would also be checked.

[14] **SIL**: Service Information Letter.

[15] **CFR**: Code of Federal Regulations. The Federal Aviation Regulations, or FARs, are rules prescribed by the Federal Aviation Administration (FAA) governing all aviation activities in the United States. The FARs are part of Title 14 of the CFR.

1.8 Meteorological Information

1.8.1 Surface Conditions at EIDW

Report Time	06.30 hrs
Surface Wind	090 degrees at 17 kts
Visibility	3500 m
Precipitation	Light rain and drizzle
Cloud	Scattered Cloud at 100 ft Broken cloud at 200 ft
Surface Temp / Dew point	14/14 degrees centigrade
Mean Sea Level Pressure	1004 hPa
Expected change	Trend during the next 2 hours; visibility becoming 10 km or more; cloud becoming FEW at 1,000 ft
Report Time	07.00 hrs
Surface Wind	100 degrees at 17 kts
Visibility	3500 m
Precipitation	Light drizzle
Cloud	Scattered Cloud at 100 ft Broken cloud at 200 ft
Surface Temp / Dew point	14/14 degrees centigrade
Mean Sea Level Pressure	1003 hPa
Expected change	Trend during the next 2 hours; visibility becoming 10 km or more; cloud becoming FEW at 1,000 ft

1.8.2 Meteorological Conditions in Dublin Area

Met Éireann, the Irish meteorological service, provided an analysis of the meteorological conditions over the Dublin area at the time of the occurrence and the source of smoke in the atmosphere. The report stated, *inter alia,* that:

> *The* […] *source area for the air which was over the east of Ireland (and much of the UK) at that time* […] *was very mild subtropical air which was dragged up from northwestern Iberia around the edge of Ophelia*[16]*. Between the 13th and 18th of October 2017 there were significant wildfires (up to 8000 individual fires) across northern Portugal and northwestern Spain which were made more serious by the winds generated by Ophelia passing close by.*
>
> *The sheer scale of the wildfires in that area meant that the air quickly became highly concentrated with dense smoke. With this being the source area for the air mass over Dublin at 0700z and the strong winds dragging this air quickly northward, it is perhaps unsurprising that the smoke was dense enough to register in the cockpits of commercial aircraft flying at the time.*
>
> *As a result* […] *it is clear that the detection of smoke on numerous commercial aircraft on that date can be attributed to the rapid advection*[17] *of air laden with particulates from Iberian wildfires northward over Ireland and the UK by ex-Ophelia.*

[16] **Storm Ophelia**: Originating as Hurricane Ophelia in the Atlantic on 11 October 2017 it made landfall in Ireland as Storm Ophelia at approximately 08.00 hrs on 16 October.

[17] **Advection**: In meteorology and physical oceanography, advection refers to the horizontal transport of some property of the atmosphere or ocean, such as heat, humidity or salinity.

1.8.3 Satellite Imagery of Wildfires

The Investigation examined satellite data available from EUMETSAT, which included an animation that showed the extent of the wildfires that were over Portugal on 15-16 October, along with the track of ex-hurricane Ophelia across Ireland and the United Kingdom. **Figure No. 2** is a screen-grab from the animation for time 07.00 hrs, on 16 October 2017, and shows the air mass containing smoke, being drawn by ex-hurricane Ophelia, from Portugal over the Bay of Biscay towards the east coast of Ireland (dashed red line).

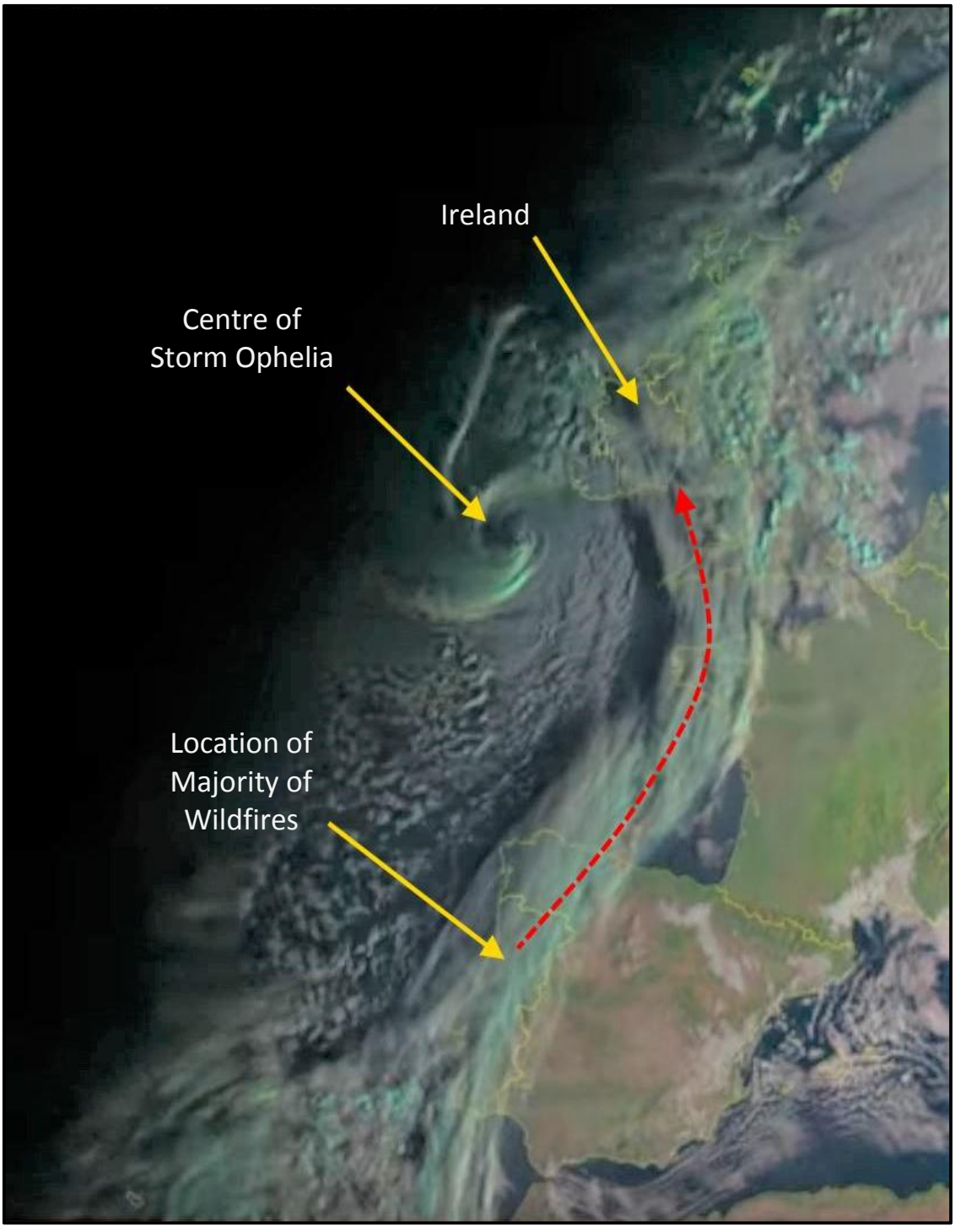

Figure No. 2: Satellite image showing path of air (dashed red line) containing smoke from wildfires.

1.8.4 ICAO Annex 3, Meteorology

The International Civil Aviation Organization (ICAO) is the international body that develops, establishes and maintains international Standards and Recommended Practices (SARPs) in aviation. SARPS for each area of ICAO responsibility are contained in 19 Annexes, each of which is concerned with a particular subject area.

Annex 3 deals with Meteorology, and includes details of weather and other atmospheric phenomena that should be reported to flight crew. One format used for such reporting is the SIGMET or Significant Meteorological Information. Annex 3 defines SIGMET information as '*Information issued by a meteorological watch office concerning the occurrence or expected occurrence of specified en-route weather phenomena which may affect the safety of aircraft operations'*.

Appendix 6 of Annex 3, titled, '*Technical specifications related to SIGMET*', includes a list of phenomena that may be reported in a SIGMET. The list includes:

- Thunderstorms
- Cyclones (Tropical Revolving Storms)
- Severe turbulence
- Severe icing
- Severe Mountain Waves
- Dust or Sand Storms
- Volcanic Ash

Currently there is no requirement to include the presence of large quantities of smoke in the atmosphere from sources, such as wild-fires, in a SIGMET report[18].

1.9 Recorded Data

1.9.1 ATC

The ATC radar data and radio communications for the period when the aircraft entered the hold at BABON, until after it landed, were quarantined and retained by the Station Manager at Dublin Air Traffic Services for analysis by the Investigation.

1.9.2 Flight Recorders

The aircraft was fitted with two Solid State Digital Voice Data Recorders (SS-DVDR). Each recorder is capable of recording both flight data and voice. One of the SS-DVDR units was isolated and sent to the UK AAIB where voice and flight data was successfully downloaded.

The recorded data confirmed the path of the aircraft, the time at which the smell of smoke was first detected by the crew, and the actions taken by the Flight Crew.

[18] Smoke that causes reduced visibility at an aerodrome may be reported in a Meteorological Aerodrome Report (METAR).

2. ANALYSIS

2.1 General

The meteorological conditions on the day of the occurrence were such that smoke from wild fires over the Iberian Peninsula was drawn over the east coast of Ireland and the United Kingdom. In the Dublin area the smoke-laden air appears to have been present in the atmosphere, from approximately 7,000 ft to near the surface. It was this air that the subject aircraft entered as it left the holding pattern and began its approach into EIDW.

The Flight Crew were not aware of the possible presence of smoke in the atmosphere; therefore it was reasonable, and prudent, for them to suspect that the smoke they perceived had originated from within the aircraft. Consequently, the Flight Crew took the precautionary actions (as trained for), of donning their oxygen masks and declaring a state of urgency.

Once the oxygen masks were put on by the Flight Crew, they were presented with a new set of problems. The lenses of both the Commander's and the Co-Pilot's masks were obscured to the extent that their vision was compromised, and the microphone in the Co-Pilot's oxygen mask was functioning intermittently.

As part of their training to deal with smoke and fumes on an aircraft in flight, crews are cautioned against removing protective breathing equipment even if the smoke and fumes don't appear to be hazardous, as there may also be other products of combustion present that could lead to flight crew incapacitation. Therefore, despite the difficulties presented by the oxygen masks, the Commander elected to continue the approach with the masks on, as he had sufficient visibility through the lens of his integrated smoke goggles to see the flight instruments, and also the runway once the aircraft was clear of cloud.

2.1.1 Meteorology

The Investigation notes that, other than obscuration reports in METARs, there are currently no requirements to issue warnings or notices to flight crew concerning the presence, in the atmosphere, of smoke from large fires. The subject flight was not the only one affected by the presence of smoke from the wildfires in Spain and Portugal. The Investigation acknowledges that it is imperative that flight crews carry out the necessary and appropriate safety actions in response to a smoke/fume event. However, information regarding the presence of atmospheric smoke may have been useful to flight crews to assist in assessing the origin of the smoke being detected in flight. The Investigation therefore makes the following Safety Recommendation to ICAO.

Safety Recommendation 1

ICAO is invited to consider the inclusion, as appropriate, in Annex 3 – Meteorological Service for Air Navigation, of requirements regarding the provision of information to flight crews on the presence of smoke in the atmosphere from ground fires. (**IRLD2018009**).

2.1.2 Safety Actions taken by the Operator

Inspection of the subject masks following the event identified surface '*blooming*' and scratches on the lenses of the integrated smoke goggles. A further check, carried out by the Operator, of its ERJ fleet revealed a significant proportion of masks lenses showing similar signs of '*blooming*'. Although the aircraft Manufacturer's MPD calls for masks to be inspected every 3,750 flight hours, the Operator is processing a formal amendment to the (AMP) to change the inspection frequency to every A-Check. Consequently, no Safety Recommendation is made to the Operator.

2.2 Actions taken by the Mask Manufacturer

The mask Manufacture advised that for new production masks produced after October 2017, they have introduced ultrasonic cleaning of the lenses during the production process, which *'is intended to eliminate the blooming*'.

However, the Investigation notes that '*blooming*' is a known issue for mask lenses produced prior to this date, and is an issue not confined to the subject Operator. Whilst SIL 1746XX-SIL-001 issued by the mask Manufacturer addresses certain issues around mask inspection and cleaning, it also states that mask inspection '*should be performed at standard maintenance intervals or as required on condition during routine inspections'.* Outside of the standard maintenance interval, masks are not normally inspected or visible as they are stored in a closed container. Therefore an 'on condition' inspection is unlikely to arise until the masks are used for an actual smoke/fume/decompression event in flight.

During the Draft Report Comment phase, the Investigation was informed that consultation had begun between the OEM and the US FAA. The outcome of this consultation will be the issuing of a comprehensive Service Bulletin (SB) by the OEM. The SB has been reviewed by the FAA. The Investigation has also reviewed the proposed text of the SB, and is satisfied that it should address all of the mask-related issues raised during the investigation. Consequently, no Safety Recommendation is made to the OEM.

2.3 Current Regulations Regarding Pre-Flight Mask Inspection

Part 121.333 of the FARs states that crews will check their oxygen masks, for fit and function, prior to flight. The Investigation was informed by the FAA that there appears to be a 'disconnect' between the wording of the rule and the current approved procedures of most operators. However, the Investigation is aware that, given certain advances in oxygen mask design, including flight-deck stowage, that procedures are in place, whereby checking of oxygen masks can be performed by flight crew, without the need to place the mask over the user's face. Thus, issues such as lens obscuration, on masks with integral goggles, might not be found, until the masks were required in flight.

It would now appear that the custom and practice for checking of such equipment is no longer in line with the legislation. The Investigation therefore makes the following Safety Recommendation to the FAA, as the issuer of the Type Certificate for this type of flight crew oxygen equipment.

Safety Recommendation 2

The Federal Aviation Administration should review the Federal Aviation Regulations relating to pre-flight inspection of flight crew oxygen equipment, to ensure that they address the use of stowed oxygen masks.
(**IRLD2018010**).

2.4 Human Performance

In addition to dealing with the smell of smoke, that the Flight Crew believed originated on their aircraft, they also had to contend with additional problems that were presented when they donned their oxygen masks, that is, lack of voice communication between the pilots and restricted vision through the lenses of the masks. By using a workaround of hand signals, the Flight Crew demonstrated resourcefulness and the ability to quickly adapt to this new situation, in order to complete the necessary checks and prepare the aircraft for landing.

3. CONCLUSIONS

(a) Findings

1. The Flight Crew were suitably qualified to conduct the flight.

2. The aircraft was operating on a valid ARC.

3. Meteorological conditions were such that smoke from wildfires in Spain and Portugal was drawn into the atmosphere over Ireland.

4. There is currently no formal method to notify flight crew of the presence of smoke in the atmosphere, other than by METAR, for reduced visibility by smoke at a specific aerodrome.

5. As G-FBEM approached EIDW the Flight and Cabin Crews smelled smoke on board the aircraft.

6. The Flight Crew donned oxygen masks, confirming the regulators were selected to 100%, and declared a state of urgency to ATC.

7. Visibility through the lenses of both oxygen mask goggles was reduced due to scratches and blooming on the surfaces of both lenses.

8. The Co-Pilot's oxygen mask microphone became unserviceable during the occurrence due to an intermittent fault.

9. The cause of the intermittent fault with the Co-Pilot's oxygen mask microphone was not determined. During subsequent testing on the ground, and during inspection and overhaul by the OEM, no fault was found.

10. Completion of the Landing Checklist required the use of hand signals by the Flight Crew.

11. The Commander had sufficient visibility through his mask lens to see the flight instruments and land the aircraft safely.

12. Post event Inspection of the masks revealed the presence of blooming on the surface of the lenses.

13. The Investigation is aware of similar lens obsucration of this mask type used by another operator on a different aircraft type.

14. The decision of ATC to keep the aircraft on the same frequency during the event reduced the Flight Crew workload.

15. The masks had been inspected within the time interval set out in the Aircraft Manufacturer's MPD.

16. The Operator is processing a formal amendment to the AMP to change the inspection frequency of flight crew oxygen masks, to every A-Check.

17. The mask Manufacturer has issued a Service Information Letter regarding the cleaning of oxygen masks, and has introduced a production process change for masks produced after October 2017 to reduce the likelihood of restricted visibility through mask lenses.

18. The current wording in part 121.333 of US FARs, states that masks and smoke goggles should be physically checked by flight crew on each pre-flight cockpit set-up.

19. It has become custom and practice for masks that are stowed in boxes beside crew stations, not to be physically checked during pre-flight cockpit set-up, but to check oxygen and microphone functions with the masks in-situ in their stowage boxes.

20. The OEM is in the process of issuing an SB in conjunction with the FAA, relating to oxygen mask inspection, cleaning, and a reduced inspection interval.

(b) Probable Cause

Smell of smoke in the aircraft, necessitating the donning of oxygen masks by the Flight Crew, which compromised crew performance due to communications difficulties and obstructed visibility through the mask lenses.

(c) Contributory Cause(s)

1. Smoke from wildfires on the Iberian Peninsula drawn towards Ireland and the United Kingdom.
2. Lack of a formal method to notify flight crew of such atmospheric conditions.
3. Propensity of the surface of oxygen mask lenses to suffer 'blooming'.
4. Inspection frequency insufficient to detect blooming and environmental contamination on the surface of mask lenses.

4. SAFETY RECOMMENDATIONS

No.	It is Recommended that:	Recommendation Ref.
1.	ICAO is invited to consider the inclusion, as appropriate, in Annex 3 – Meteorological Service for Air Navigation, of requirements regarding the provision of information to flight crews on the presence of smoke in the atmosphere from ground fires.	IRLD2018009
2.	The Federal Aviation Administration should review the Federal Aviation Regulations relating to pre-flight inspection of flight crew oxygen equipment, to ensure that they address the use of stowed oxygen masks.	IRLD2018010

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– END –

Appendix A
Typical Oxygen Mask Pre-Flight Check Procedure

Normal Procedures

Table 6.2 – Captain's Set-ups
Captain's Console
Left oxygen masks and regulator ..... Check • Check masks for oxygen supply and microphone functionality as follows: ➢ Set the regulator control knob to 100%. ➢ Press and hold the TEST/RESET button. ➢ Verify a short illumination or "blink" of the flow indicator. ➢ Verify audible oxygen flow in the headset or loudspeakers. ➢ Once the mask fully pressurises, the indicator must go out; this shows that the system is leak free. ➢ Release the TEST/RESET button.

DOCUMENT TED

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

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

Produced by the Air Accident Investigation Unit

AAIU Reports are available on the Unit website at www.aaiu.ie

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