Accident

Aircraft Type and Registration:	Airbus A321-253NX, G-OATW
No & Type of Engines:	2 CFM International SA LEAP-1A33 turbofan engines
Year of Manufacture:	2020 (Serial no: 10238)
Date & Time (UTC):	4 October 2023 at 1151 hrs
Location:	London Stansted Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 11 Passengers - 9
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to several cabin windows and impact damage to the left horizontal stabiliser
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	54 years
Commander's Flying Experience:	4,905 hours (of which 2,300 were on type) Last 90 days - 128 hours Last 28 days - 27 hours
Information Source:	AAIB Field Investigation

Synopsis

A cabin window was seen to be loose shortly after takeoff and several windowpanes were missing after the aircraft landed. The windowpanes fell out because they had been damaged by infrared energy emitted by high-intensity lights during a filming event the previous day.

The investigation found four previous occurrences on other airframes, but knowledge of them was not widespread in the aviation community. The report considers the cause of the damage and how the filming was risk assessed and supervised.

In response to this accident the aircraft manufacturer intends to publish two articles to highlight the damage that can be caused by high-intensity lights. The aircraft operator highlighted the need for a suitable aviation-focused risk assessment when carrying out this type of activity with an aircraft.

History of the flight

The aircraft was scheduled to embark on a multi-sector charter away from base for several weeks. On board were three pilots, an engineer, a load master and six cabin crew. The co-pilot was the PF for the first sector, which was a positioning flight from London Stansted Airport to Orlando International Airport, Florida. Prior to the boarding of the passengers the commander completed a pre-flight inspection of the exterior of the aircraft and noted nothing untoward. At the same time, several engineers were carrying out an external inspection; the daily and ETOPS[1] inspections, prior to departure. In addition to the 11 crew, there were nine passengers on board. The passengers sat together in the middle of the aircraft just forward of the overwing exits.

The aircraft departed a few minutes ahead of schedule and took off from Runway 22. Several passengers recalled that after takeoff the aircraft cabin seemed noisier and colder than they were used to. As the aircraft climbed through FL100, and the seatbelt signs were switched off, the loadmaster, who had been seated just in front of the other passengers, walked towards the rear of the aircraft. He noticed the increased cabin noise as he approached the overwing exits and his attention was drawn to a cabin window on the left of the aircraft. He observed that the window seal was flapping in the airflow and the windowpane appeared to have slipped down[2]. He described the cabin noise as 'loud enough to damage your hearing'. Figure 1 shows the window in flight.

The loadmaster told the cabin crew and then went to the flight deck to inform the commander. At this stage, the aircraft was climbing through FL130, there were no abnormal indications on the flight deck and the aircraft pressurisation system was operating normally. The flight crew stopped the climb at FL140 and reduced airspeed whilst the engineer, and then the third pilot, went to look at the window. Having inspected the window, it was agreed the aircraft should return to Stansted. The cabin crew told the passengers to remain seated and keep their seatbelts fastened and reminded them about the use of oxygen masks if that became necessary.

The cabin was quickly secured and the flight crew initiated a descent, first to FL100 and then to FL90. They established the aircraft in a hold whilst they completed the overweight landing checklist, confirmed landing performance and briefed for the return to Stansted. The commander flew the approach and landing to Runway 22. This was uneventful; landing at 1151 hrs with a total flight time of 36 minutes. With the airport RFFS in attendance the aircraft taxied to the apron, where the passengers disembarked normally.

Having parked and shut down, the crew inspected the aircraft from the outside and saw that two cabin window assemblies were missing and a windowpane and seal were dislodged on a third window. During the flight the crew had only been aware of an issue with a single windowpane. The cabin had remained pressurised normally throughout the flight.

Footnote

1 ETOPs stands for Extended Range Twin Operations.
2 The crew were not aware if this was only the outer pane or both panes.

Figure 1
View of the left side cabin window aft of the overwing exit

Previous activity

The day before the occurrence flight the aircraft had been used for filming on the ground, during which external lights had been shone through the cabin windows to give the illusion of a sunrise. The lights were first shone on the right side of the aircraft for approximately five and a half hours, with the light focused on the cabin windows just aft of the overwing exits. The lights were then moved to the left side of the aircraft where they illuminated a similar area on the left side for approximately four hours. Photographs taken during filming showed six sets of flood lights on both sides of the aircraft. Figure 2 shows the lights positioned on the left of the aircraft.

Figure 2
Flood lighting on the left side of the aircraft

Recorded information

The aircraft was fitted with an FDR and CVR which were removed and successfully downloaded at the AAIB. The flight was captured on both recorders and the CVR confirmed reports from the flight crew interviews.

The aircraft took off from Stansted at 1115 hrs, climbing progressively to a maximum of 14,504 ft[3] at 1123 hrs (Figure 3). The cabin altitude increased during this time, reaching a recorded maximum of 1,536 ft. The aircraft then descended to FL 100 initially, followed by a further descent to FL 90 while circling to the north-west of the airport. No pressurisation warnings were recorded during the flight, which landed back at Stansted Airport at 1151 hrs.

Footnote

3 Pressure altitude is recorded to a reference pressure of 1013 hPa.

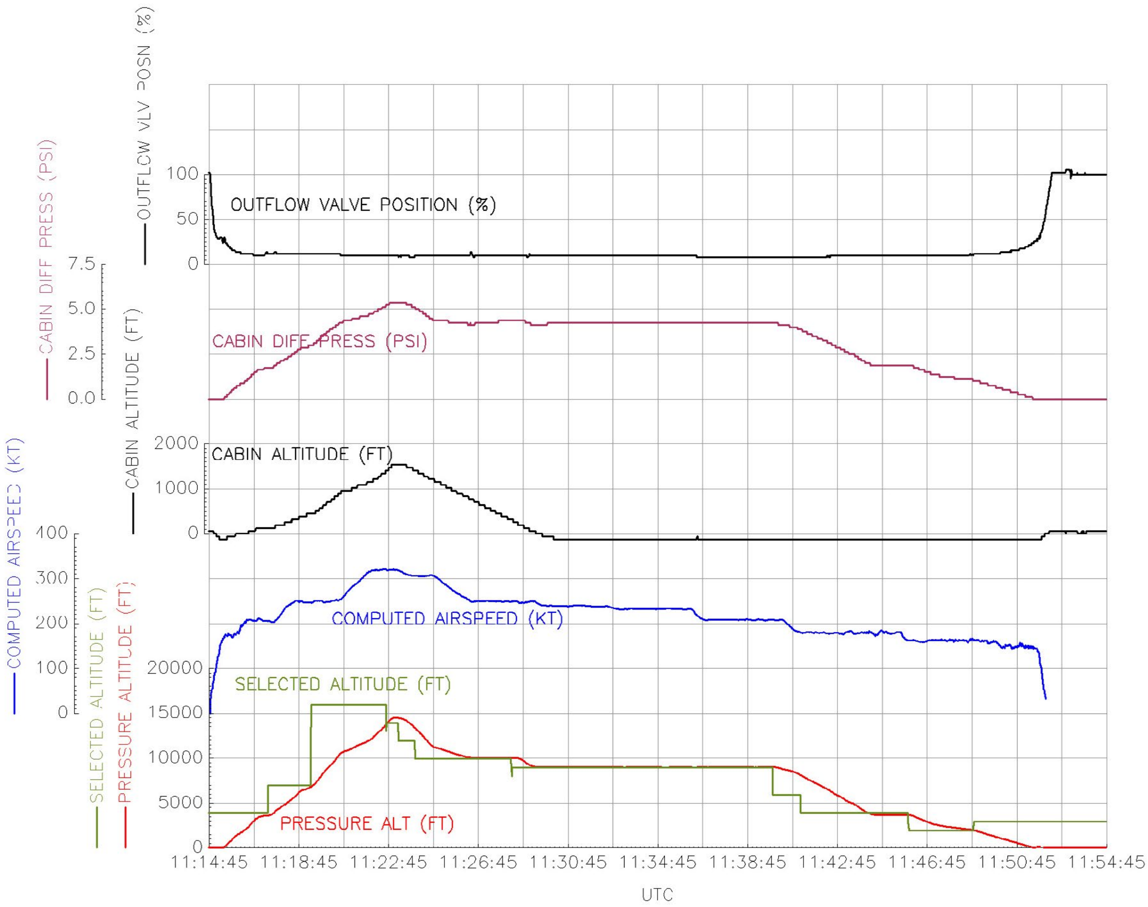

Figure 3
G-OATW FDR data

Cabin windows description

Construction

Each cabin window assembly consists of two windowpanes and a rubber seal. The windowpanes fit into two slots in the rubber seal to form a 'dry' assembly, meaning that no adhesives or sealants are used. The window assembly is held in compression against the window frame using a metal retainer, six eyebolts and six nuts (Figure 4). The outer surface of the cabin window is flush with the outer surface of the fuselage.

A vent hole through the inner pane lets cabin pressure into the space between the inner and outer panes. Both panes can both carry the full differential pressure across the fuselage, providing redundancy if either pane should fail.

A third windowpane is attached to the cabin trim. This is commonly referred to as a scratch pane, and this is the windowpane that passengers can touch. It is sacrificial and protects the inner windowpane from damage. It does not form part of the load bearing structure.

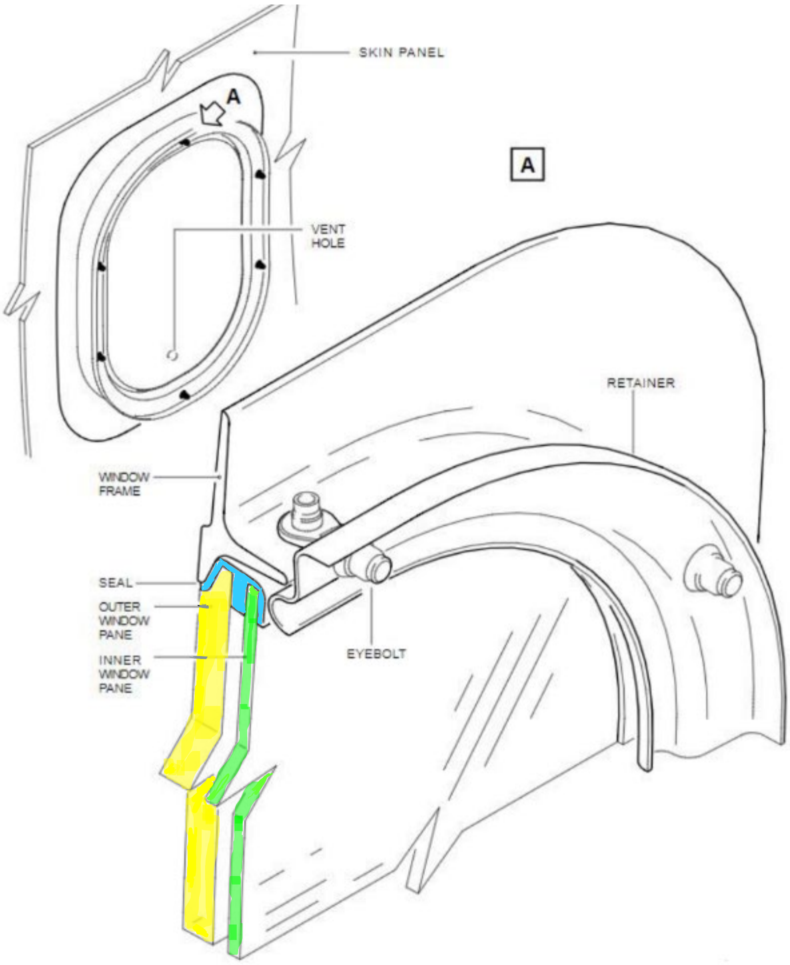

Figure 4

Schematic of the cabin window assembly – scratch panel is not shown (outer pane, inner pane and rubber seal are highlighted)

Manufacturing process and specification requirements

The Airbus A321 is certified to operate in a maximum outside air temperature of 55°C. The specification for the cabin windows requires them to withstand a maximum temperature of 80°C, thereby providing a safety margin.

The outer and inner windowpanes are made of stretched acrylic. This requires cast acrylic to be heat soaked near its softening point whilst it is stretched into its finished shape. The performance specification[4] includes post-production dimensional stability properties and there are two requirements relating to thermal relaxation (Table 1).

Footnote

4 Performance specification MIL-PRF-25960.

Temperature	Allowable thermal relaxation (shrinkback)
110°C	10% maximum
145°C	37.5% minimum

Table 1

Extract from performance specification MIL-PRF-25960

Aircraft examination

Cabin windows

Two cabin window assemblies were missing in their entirety, and the inner pane and seal from a third were displaced but partially retained (Figure 5). The forward edge of a fourth window protruded from the left side of the fuselage (Figure 6). The four windows were adjacent to each other, just aft of the left overwing exit. All the scratch panes remained in place, so there was no direct, unrestricted aperture into the passenger cabin.

A shattered inner windowpane was recovered from the entrance to a rapid-exit taxiway during a routine runway inspection after the aircraft landed. This windowpane would have separated during takeoff as this location was not passed by the aircraft during the landing roll. The airport operations team reported that no other parts were found during follow-on routine checks of the paved surfaces or additional checks of the grass around the rapid-exit taxiway.

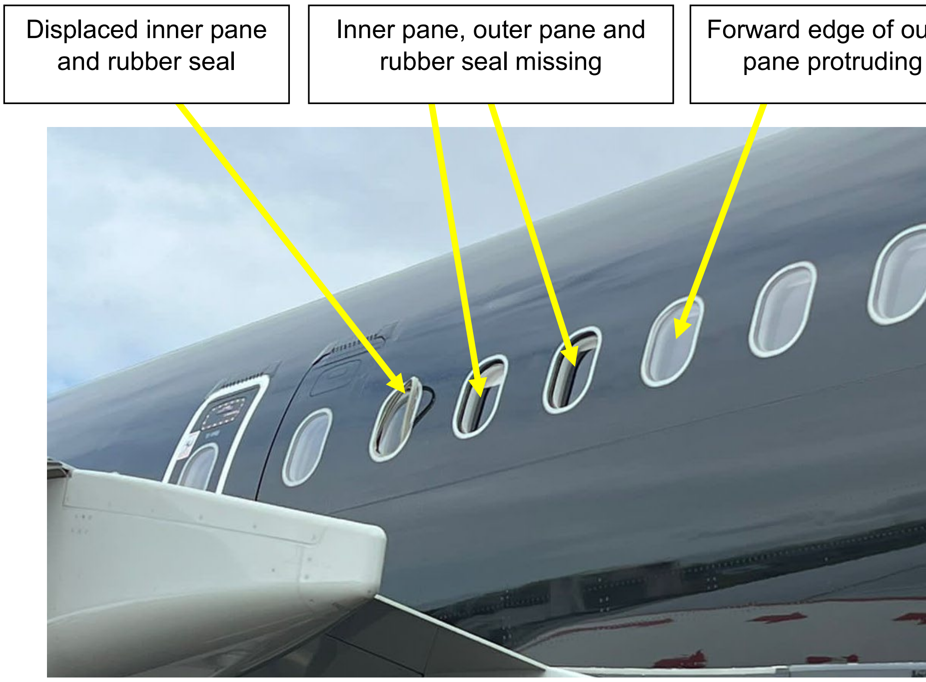

Figure 5

Displaced and missing windowpanes on the left side of the aircraft

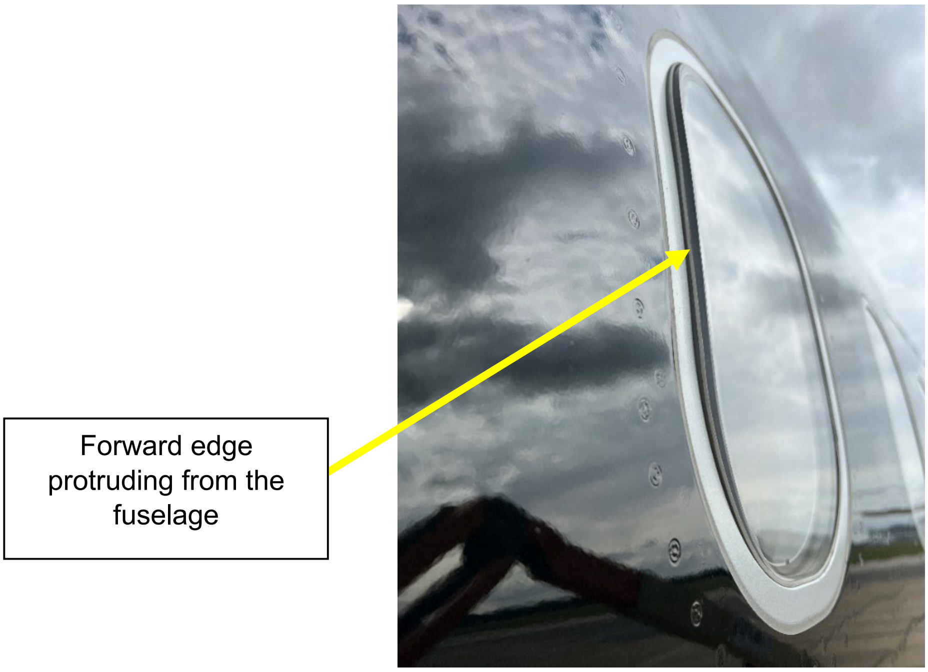

Figure 6

Forward edge of the outer pane protruding from the fuselage

Removal of the cabin lining inside the passenger cabin revealed that, despite the missing and dislodged windowpanes, the window retainers were in good condition and correctly installed (Figure 7).

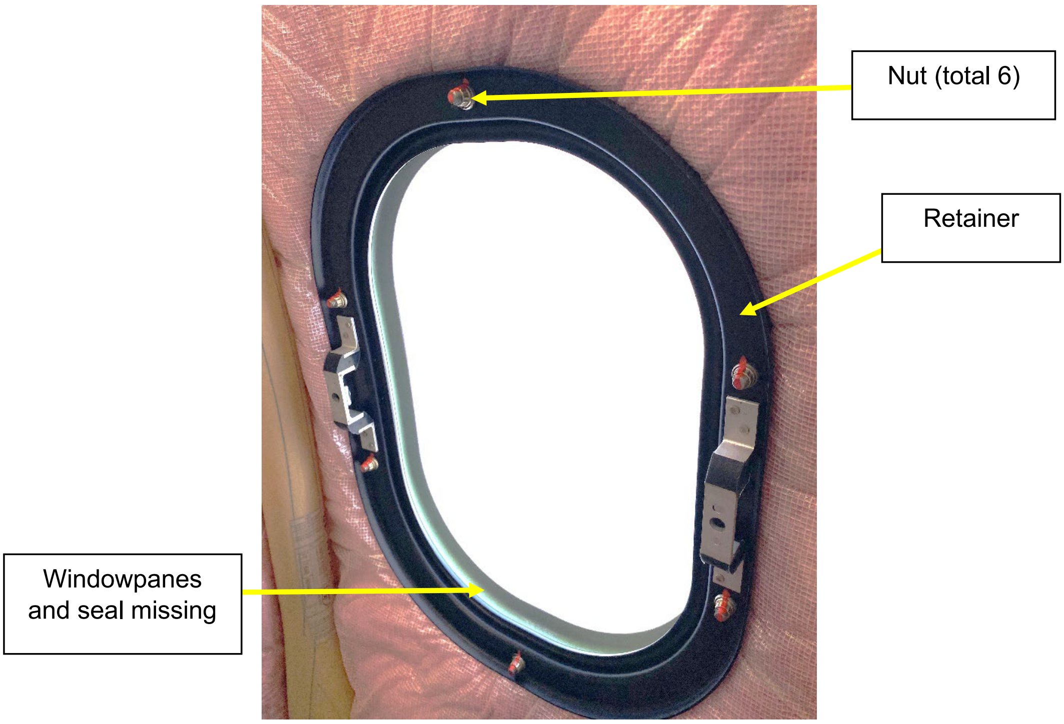

Figure 7

Correct installation of the retainer but the window assembly is missing

The foam ring material on the back of the cabin liners was found to be melted in the areas adjacent to the windows that were damaged or missing (Figure 8).

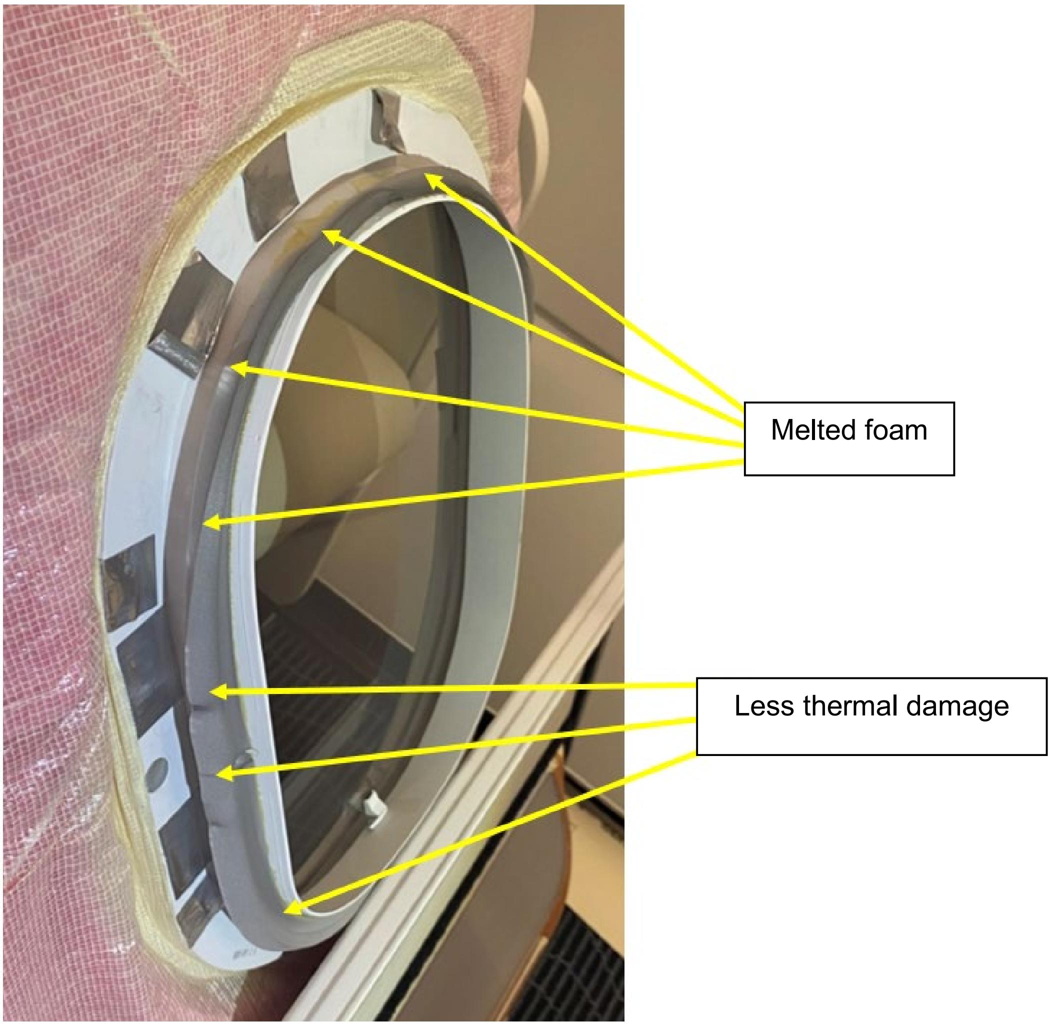

Figure 8

Foam ring material affected by elevated temperatures

With the AAIB in attendance, the operator removed several cabin liners from the right side of the passenger cabin. This revealed additional thermal damage and window deformation in the area around the overwing emergency exit, but to a lesser extent than the left side of the aircraft.

Horizontal stabiliser

The underside of the left horizontal stabiliser leading-edge panel was punctured. Small pieces of acrylic were found inside the stabiliser when the leading-edge panel was removed.

Detailed examination of the cabin windows

Displaced windowpane and seal

The inner windowpane that was loosely retained after the aircraft landed was found to be shrunk and deformed around its periphery (Figure 9). The corresponding rubber seal was undamaged, but the deformed windowpane no longer formed an effective interface with it.

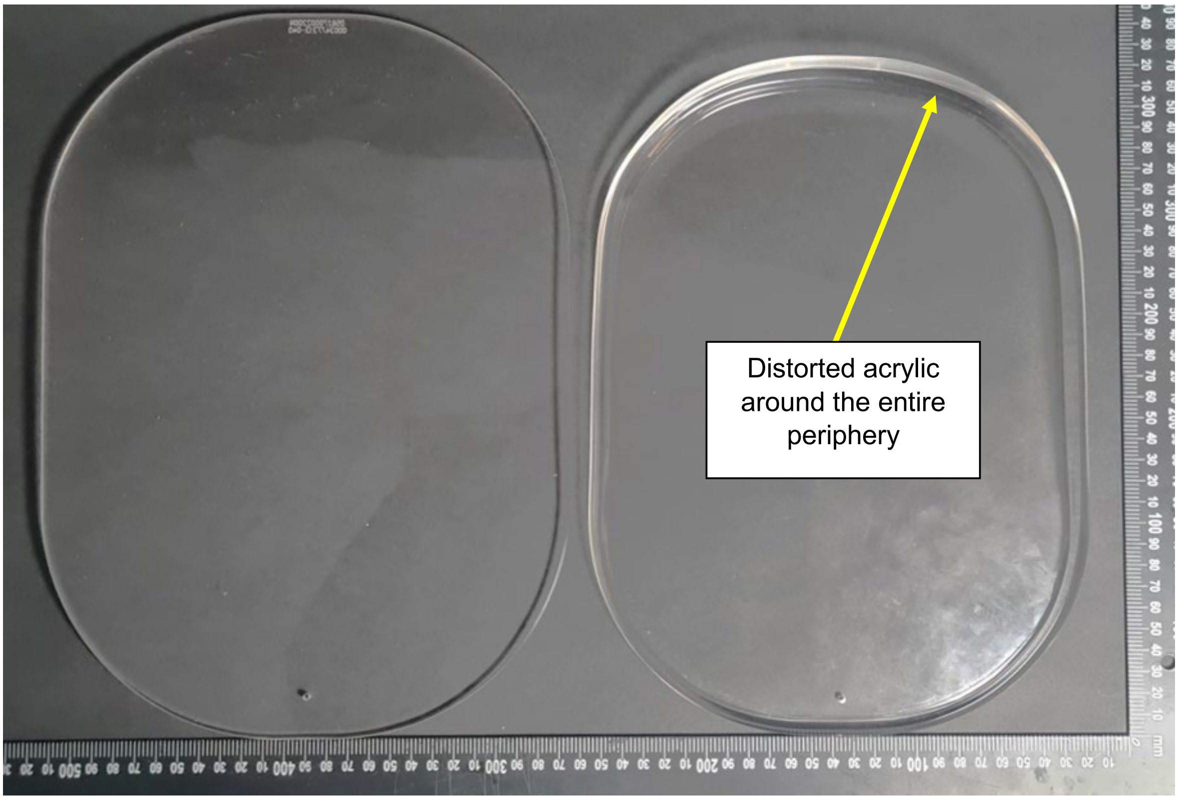

Figure 9

A serviceable inner windowpane (left) and the damaged inner windowpane (right)

Protruding window

The inner and outer windowpanes were both distorted in the area that protruded from the fuselage. The outer windowpane was more damaged than the inner, and the distortion affected the interface with the slot in the rubber seal (Figure 10). After the windowpanes were removed from the rubber seal, they could not be refitted because of the distortion. The rubber seal appeared undamaged.

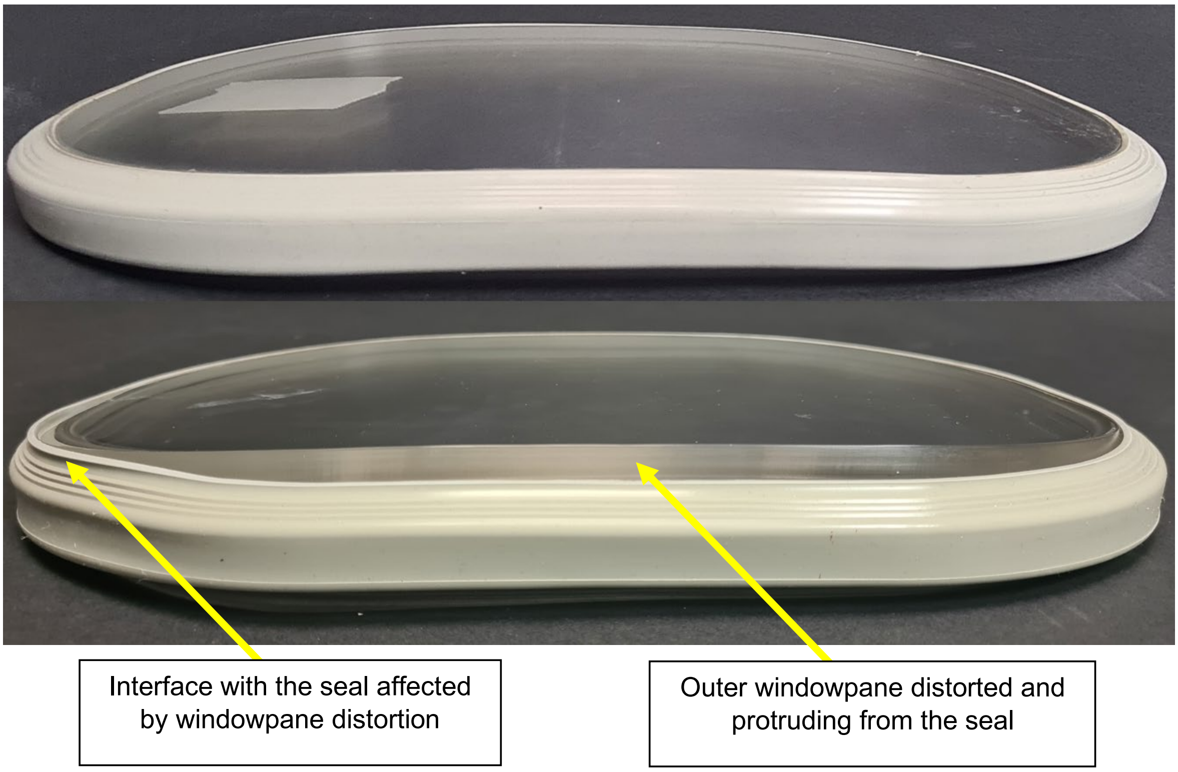

Figure 10
A serviceable window assembly (top) and the protruding assembly (bottom)

Shattered windowpane

A vent hole in one of the broken parts showed that the shattered remains were from an inner windowpane[5] (Figure 11). The window was distorted around its periphery and had shrunk.

Footnote

[5] This was believed to be an outer windowpane when AAIB Special Bulletin S2/2023 was issued in November 2023.

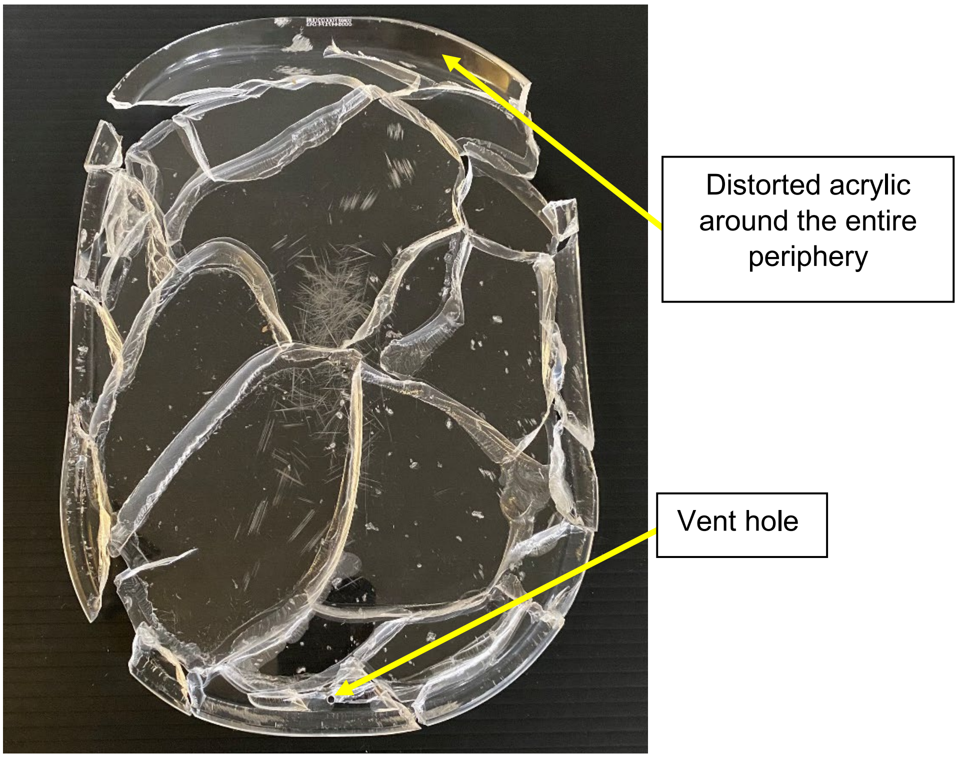

Figure 11

Reconstructed remains of the shattered windowpane

Dimensional checks

The approximate dimensions of the windowpanes were compared with serviceable items (Table 2).

Description	Inner pane		Outer pane	
	height (mm)	width (mm)	height (mm)	width (mm)
Serviceable window	346	250	346	250
Window displaced from fuselage	322 (~7% reduction)	235 (~6% reduction)	Not recovered	Not recovered
Shattered window	322 (~7% reduction)	235 (~6% reduction)	Not recovered	Not recovered
Window protruding from fuselage	344	245 (~2% reduction)	345	240 (~4% reduction)

Table 2

Comparison between window dimensions

Filming activities

Organisations involved in the filming

The aircraft was owned by the operator and operated exclusively for a tour company offering all-inclusive jet expeditions. The operator was responsible for airworthiness and maintenance. The tour company commissioned a video production company to film an advert on the aircraft. The video production company contracted various other individuals required for the filming, including the director of photography and the gaffer (see below), and hired the required equipment, including the external lighting. The filming was organised by the tour company in collaboration with the operator, video production company, airport authority, fixed base operator and the contractors. A permit from the airport authority was required to conduct the filming airside at Stansted. It took place outside the hangar of the fixed base operator who provided facilities during the filming such as catering and escort to and from the aircraft.

Key roles

A gaffer's role is to set-up electrical equipment for a film shoot to realise the look defined by the director of photography. For the filming on G-OATW, the gaffer chose the lights that would be hired and co-ordinated a team of electricians to set them up to ensure that requirements were met. He described his responsibility for safety as covering the electrical equipment and the safety of the personnel using it. He had worked with aircraft during previous filming, but he did not have an aviation background.

The producer of the film shoot is responsible for overall coordination and management during the filming. For the work on G-OATW, the producer was responsible for monitoring health and safety on location.

Lighting set-up

The gaffer said that the original plan was to film the aircraft in a hangar. Ideally, diffuser material[6] would be held in frames and mobile platforms would be used to support the lights so that the windows could be illuminated. This concept was rejected because of the risk of something falling onto the wing, so larger, directional lights were chosen. He had used similar lights previously and they could be positioned further from the aircraft whilst still providing sufficient illumination. The characteristics of the lights meant that they would be able to replicate the lighting conditions during a sunrise.

Eventually, the filming was conducted outside. The plan to use the higher power lighting remained but the free-standing frames and diffusers could not be used because of the risk of damage due to wind. They were unable to attach the diffuser material to the aircraft exterior because this could damage the paintwork, so it was attached to the scratch panes inside the aircraft.

Footnote

[6] A light diffuser spreads out light to eliminate unwanted glare.

Safety management of the filming activity

The video production company produced a risk assessment for the filming on G-OATW which was reviewed by the tour company, operator, airport authority, fixed base operator and the gaffer. These parties did not produce separate risk assessments for the activity. The operator explained that there is a risk assessment process in place for any department to use for activities like this. In this case the responsible department decided it was unnecessary because filming was being conducted on the ground and was similar to activities conducted by the tour company in the past.

The video production company's risk assessment focused primarily on the health and safety of people involved in the filming work. The risk assessment included a hazard checklist. For most hazards identified from the checklist, further detail described persons at risk; control measures and level of risk with and without the controls (categorised as low, medium or high). The specific nature of the risk associated with each hazard was not explicit. Not all the identified hazards were assessed in detail. For example, '*Scenic / set materials – non-fire retardant / toxicity tested / glass / polystyrene*' was marked as a hazard on the checklist but not discussed further.

The use of electricity and lighting feeds was identified from the hazard checklist. The focus of the control measures was around procedures for dealing with faulty electrical equipment and the use of a diesel generator truck. A copy of a contractor's specific risk assessment for the temporary connection of the generator was included. The use of lights shining through the aircraft windows was mentioned in association with this hazard, but no specific risks or controls were described.

A licenced engineer employed by the operator was assigned to stay on board the aircraft during the filming. He supervised the APU, which was running to provide air conditioning, and ensured that no one entered the flight deck and interfered with any switches or controls. He sat on the flight deck for most of the time. Other representatives of the operator were present at times but did not have specific instructions to supervise the filming. A representative of the tour company was present throughout the filming.

External lighting

Six halogen Maxibrute 12 lights[7] were used for the filming, with a combined lighting capacity of 72,000 W. The filming company reported that the lights were switched on for four hours on the left side of the aircraft and five and a half hours on the right side. The lights on the left side were focused on six windows behind the overwing emergency exit. The lights on the right side were spread over a larger area.

Photographs of the filming showed that the lights were approximately 6 to 9 m from the window areas where damage occurred (Figure 12).

Footnote

[7] Maxibrute_12 (filmgear.net) [accessed 13 October 2023].

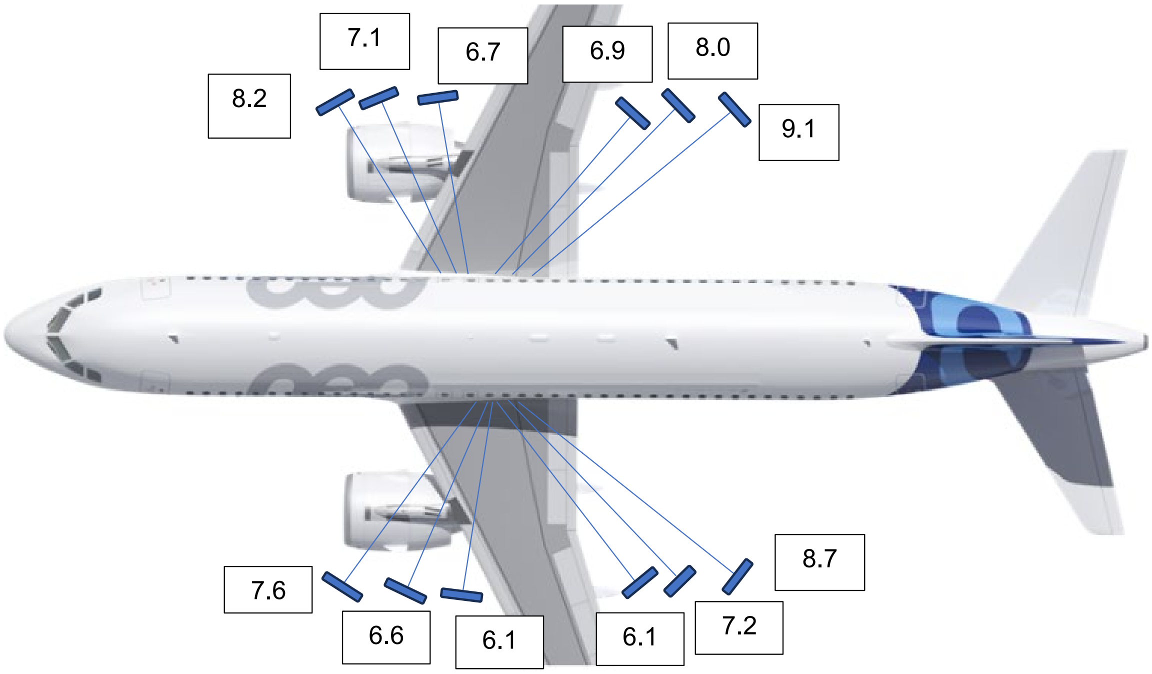

Image for illustration only – not to scale

Figure 12

Approximate distance of the flood lights from the fuselage during the filming activity

An online datasheet for the lights included the information in Table 3.

Parameter	Value
Lighting capacity	12,000 Watts
Minimum distance from object to be illuminated	10 m
Minimum distance from a flammable object	1.5 m
Maximum surface temperature	200°C

Table 3

Data extracted from the flood light datasheet

The minimum recommended distance from the object to be illuminated is based on the lighting manufacturer's test data. According to this test data, when an object is illuminated by a single Maxibrute 12 light from 10 m, the surface temperature will increase by 30°C after 30 minutes. The temperature will then remain constant. If the light is 8 m from the object, the surface temperature will increase by 45°C and, if the light is 6 m away, the temperature will increase by 64°C. The combined effect of six Maxibrute 12 lights, with some of their output overlapped, is unknown.

The gaffer was not aware of the manufacturer's datasheet or any other written guidance or limitations on how the Maxibrute 12 lights should be used. The company that rented the equipment to the filming organisation said that the lights were not accompanied by any operating limitations or datasheets. The only cautions and warnings that were displayed on the lights related to:

- Disconnecting the power before changing a bulb
- The maximum temperature of the housing
- Not mounting the fixture on a combustible object
- Not covering the vents

Personnel

The gaffer was an electrician who had worked in the filming industry for more than 30 years. There are no technical qualifications or requirements to become a gaffer, but most people progress to the role via the electrical trade.

Other information

Heating effects of solar energy and halogen lights

<u>Spectral power distribution and absorptivity</u>

A typical spectral power distribution for a halogen bulb[8] shows that most of the energy is in the infrared (IR) wavelengths (Figure 13). Energy from the sun is filtered by the atmosphere, dust and humidity, and mostly arrives at lower altitudes in the visible spectrum.

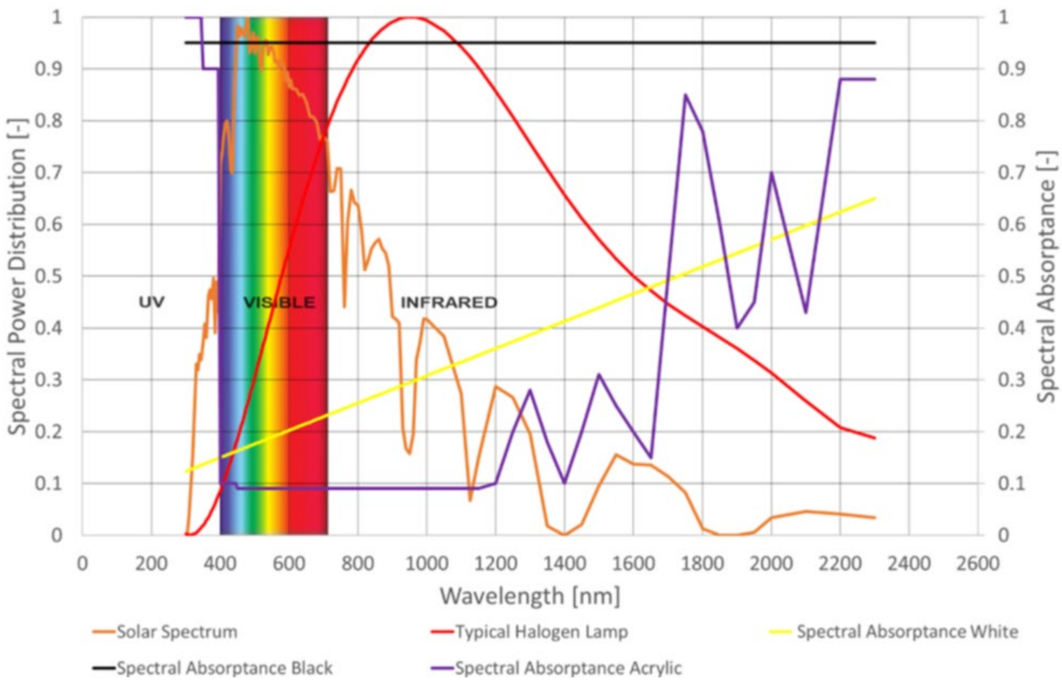

Figure 13

Spectral power distributions and material absorptivity
(used with permission)

Footnote

[8] Graphical representation provided by the aircraft manufacturer. The halogen data is based on black body radiation of a tungsten filament at 3,100 K, which is similar to the properties of the bulbs that were used during the filming.

The amount of heat absorbed by a material is proportional to its absorptivity. Black paint has a high absorptance across the entire spectrum whereas the absorptance of white paint increases with increasing wavelength. Acrylic transmits most visible wavelengths but is more absorbent in the IR spectrum. These absorption properties explain why acrylic and white painted structures remain relatively cool in sunlight, but black painted structures become hotter. In the IR spectrum, all three materials absorb energy.

Thermal conductivity

The thermal conductivity of a material is a measure of how effectively it can conduct, and therefore dissipate, heat. Table 4 shows the aircraft manufacturer's data for the thermal conductivity of the aluminium alloy and acrylic.

Material	Thermal conductivity (W/m/K)
Aluminium alloy	~ 120
Acrylic	~ 0.2

Table 4

Comparison of thermal conductivity

The low thermal conductivity of acrylic means that any heat accumulated by the cabin windows is poorly transferred away by conduction. The aluminium fuselage, however, can spread the heat much more effectively. This explains why the acrylic cabin windows reach higher temperatures than the fuselage when subject to IR energy. The temperature achieved will depend on the duration of exposure, the distance, and the power of the source.

Previous occurrences

The investigation identified four previous occurrences where acrylic cabin windows were damaged by high temperatures during filming activities using high-intensity lights. In those four cases the damage was identified and repaired before the aircraft flew. It would only be reportable as an accident or serious incident if it was identified during a period of operation when there was an intent to fly.

Airbus

An Airbus A321 sustained cabin window damage during a filming event when the aircraft was outdoors. Spotlights were positioned just inboard of the engines, approximately 1.5 to 1.8 m from the cabin windows (Figure 14).

Figure 14

Lighting arrangement during a previous filming event
(image used with permission)

The AAIB does not know the specifications of the lights or how long they were turned on. The window damage was readily visible after the filming (Figure 15).

Figure 15

Thermal damage sustained by an outer windowpane on an Airbus A321
(image used with permission)

When the damage was reported to Airbus, it was not aware of any other occurrences, and considered the circumstances to be outside the anticipated operating conditions. No action was taken apart from providing technical advice to repair the aircraft.

Boeing

One operator informed the AAIB that six cabin windows were damaged on a Boeing 787 during a filming event inside a hangar. The windows were illuminated using three 2,000 W lights positioned on mobile platforms outside the aircraft. The windows suffered significant deformation and one had a hole burned through the windowpanes (Figure 16).

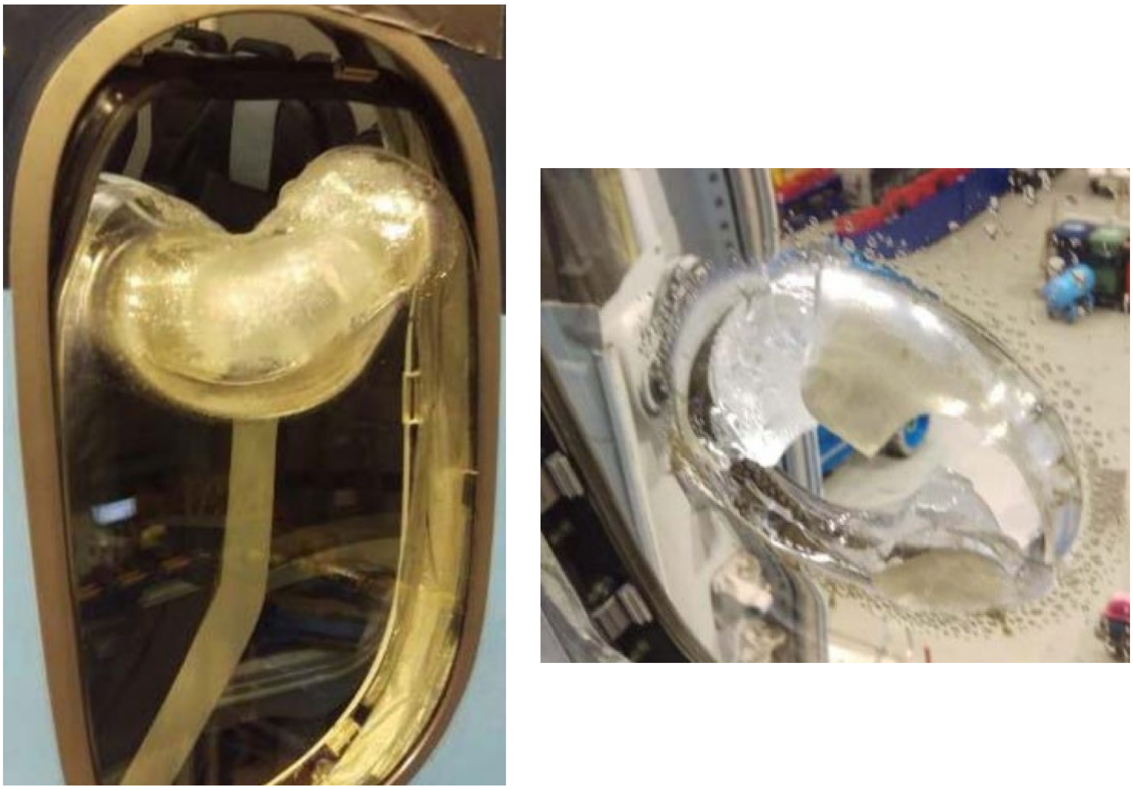

Figure 16

Deformed outer windowpane and a hole through the cabin window
(images used with permission)

The operator carried out a test using a single light and a cabin window mounted in a jig. With the window illuminated from 1 m, the temperature of the acrylic after 35 minutes was stable at 44°C. When the distance was reduced to 30 cm, visible damage occurred after 16 minutes and an acrylic temperature of 127°C. The outer windowpane was penetrated 88 minutes later at a temperature of 155°C.

In March 2020 Boeing issued a Fleet Team Digest article following three reports of acrylic cabin windows of Boeing 787 aircraft sustaining thermal damage during filming. Boeing cited elevated acrylic temperatures due to the absorption of IR energy and recommended that operators avoid using high-intensity lights during filming activities. If high-intensity lights are used, it recommended that operators:

- Keep the lights well away from the cabin windows
- Use lights that do not emit heat or lights that minimise heat generation (low IR)
- Minimise the time the lights are on
- Turn the lights off when they are not required
- Monitor the temperature of the cabin windows

Light Emitting Diode (LED) lighting

LED lights are a more efficient alternative to incandescent lights. They use less power and emit less heat. A LED version of the Maxibrute 12 light is available.

Other operators

The AAIB contacted 12 other UK Air Operator Certificate (AOC) holders to ask about their approach to the safety management of on-aircraft filming. Information was received from six operators and is summarised in Appendix A. Five of the six stated they had some experience with on-aircraft filming. Four of the six have previously produced or would expect to produce a written risk assessment for this activity. One has previously relied on a 'verbal' risk assessment for the activity. Most operators emphasised the importance of engineering supervision for the activity. One operator had identified the risk of heat from external lighting damaging a composite fuselage but none of the operators had previously identified the risk of heat damaging aircraft windows except for an operator that had previously suffered damage from this cause.

Analysis

Pre-flight inspection

The pre-flight inspection was carried out by the commander. Additionally, as the aircraft was going to be away from its base for several weeks, several engineers were also present prior to departure, completing additional checks of the aircraft. They did not identify any cabin window defects before the flight.

In-flight turn back

The aircraft returned to the departure airport because noise levels in the passenger cabin were excessive, and one cabin window was visibly loose. After the aircraft landed, seven parts were missing:

- Three outer windowpanes
- Two inner windowpanes
- Two rubber seals

All the scratch panes remained in place so there was no direct, unrestricted aperture between the passenger cabin and the outside air. There were no symptoms of any pressurisation issues, indicating that for the duration of the flight the amount of air leaking from the passenger cabin remained within the capacity of the pressurisation system.

Broken windowpane recovered from the taxiway

A shattered inner windowpane was recovered from the entrance to a rapid-exit taxiway. The broken remains showed thermal distortion around its periphery, and it was apparent that the windowpane had shrunk. The distortion and shrinkage meant that the windowpane no longer formed an effective interface with the slot in the rubber seal. This made it more likely to fall out due to vibration or the differential air pressure between the passenger cabin and the outside environment.

The aircraft did not pass the rapid-exit after landing, so the inner windowpane fell out when the aircraft took off. For this to happen, the outer windowpane must already have fallen out, but neither it nor the rubber seal were found.

Damaged horizontal stabiliser

The underside of the left horizontal stabiliser leading-edge panel was punctured, and small pieces of acrylic were found inside, indicating that it had been struck by at least one cabin windowpane. The damage had no adverse effects on the controllability of the aircraft.

Windowpane damage

The day before the occurrence flight both sides of the aircraft were illuminated by six halogen light arrays with a combined power output of approximately 72,000 W. The lights were positioned closer to the aircraft than the minimum recommended distance and the acrylic windows absorbed IR radiation, with very limited ability to dissipate this energy into the surrounding structure or air. As time progressed, the temperature of the acrylic increased to the point that the material softened and started to deform and shrink. The window retainers apply a compressive force around the periphery so, as the acrylic softened, this force may have exacerbated the distortion. The temperature that the acrylic achieved is unknown, but two of the windowpanes had reduced in size by approximately 6%. The manufacturing process specification indicates a maximum of 10% shrinkage at 110°C so it is likely that these windows achieved a temperature that was approaching this value. This is beyond the aircraft's certified operating limits.

Previous occurrences

There have been at least four previous occurrences (one Airbus A321 and three Boeing 787) where acrylic cabin windows have been damaged by high-intensity lights during filming. The damage was identified and repaired before flight, so it is likely that it was more obvious than G-OATW.

In 2020, Boeing issued a Fleet Team Digest article citing three events where damage was caused by the absorption of IR energy from high-intensity lights. The article was applicable to Boeing 787 operators, but this investigation shows that other aircraft with acrylic windows could also be similarly affected.

Safety action

In response to this accident, Airbus published an In Service Information document to highlight the risk of acrylic window damage when using high-intensity lights. The document is available to all Airbus customers. Airbus also published an article in their online Safety First magazine[9].

EASA published a Safety Information Bulletin[10] to highlight the risk of damage when using high-intensity lights close to an aircraft.

Safety management of filming

The lights were used closer to the aircraft than recommended in their datasheet. It is not known whether the lights could have been placed further away and still achieve the desired look for the filming. The gaffer was responsible for setting up the lighting but was not aware of the datasheet prior to the investigation. According to the gaffer, equipment datasheets are not routinely consulted when hiring equipment and the selection and safe use of such equipment relies on experience rather than data and standard procedures. There are no formal qualifications or training required to undertake the gaffer role and the lighting hire company did not place any restrictions or give any information on how it could be used. Overall, this indicates that an aircraft operator should not rely on a video production company and its contractors to ensure aircraft safety.

The filming on G-OATW was risk assessed by the video production company in collaboration with the other involved parties. As the process was led by the film production company, the focus was on the safety of personnel during filming. However, the potential to damage the aircraft cosmetically or for people to access the flight deck and interfere with controls was identified during the risk assessment or planning and it was managed with the use of engineering supervision during the filming. No one involved anticipated that the lights could damage the acrylic windows. Following this event, the operator reminded the department responsible for the filming of the need to use its own risk assessment process for such activities.

Other operators were consulted after the publication of the AAIB Special Bulletin about this event and provided information about their own approach. Most stated they would do their own assessment with varying degrees of formality. None of them, except for the operator who had suffered previous damage from the same cause, had previously anticipated this type of damage in their assessments. This would require specific technical knowledge of the lighting equipment and the properties of the windows. There could be benefit in using more technical evidence, such as lighting datasheets, as part of the risk assessment process when hazardous equipment is going to be used on or near an aircraft.

Footnote

[9] Safety First | Airbus Link to the Airbus Safety First website [accessed 9 January 2024].
[10] EASA SIB 2024-04 Risks from using high power lights close to aircraft structures [accessed 8 March 2024].

At least four other operators have previously encountered the same issue, but the window damage was identified and repaired before flight, so the events were not independently investigated. Boeing acted to inform other Boeing 787 operators about the events they were aware of but the learning from other events was not spread within the aviation or filming communities. A problem like this is hard to anticipate because it is caused by equipment and material properties that are not visible and information about them is not easily accessible. Openly sharing safety related learning, even if the consequences do not reach the threshold for independent investigation, increases the ability of the aviation community to manage risks.

Conclusion

Several cabin window components were lost during the flight. High-intensity lights that were used during a filming event emitted sufficient IR radiation to heat the acrylic windows to a temperature sufficient to soften them leading to distortion and shrinkage. The distorted windows fell out because of vibration or the pressure differential across them as the aircraft climbed after takeoff. The aircraft returned to the departure airport for an uneventful landing.

Safety actions

The following safety actions were taken:

1) The operator reminded the department responsible for the filming of the need to use the risk assessment process for activities like this.
2) Airbus published an In Service Information document to highlight the potential adverse effects of using high-intensity lighting near an aircraft.
3) Airbus published a Safety First article highlighting the possible adverse effects of using high-intensity lighting near an aircraft.
4) EASA published a Safety Information Bulletin highlighting the risk of damage when using high-intensity lighting near an aircraft.

Appendix A

Summary of six UK passenger operators' approaches to managing filming activities on aircraft

Operator	Summary of response
1	The approach to filming depends on the location, for example, in a terminal, simulator or engineering facility. LED lights are generally used when lighting is required. An example risk assessment was provided. In relation to the aircraft exterior, it identified this risk: '*Aircraft safety critical equipment and features on its exterior which if impacted will impact its airworthiness'.* The listed controls for this were: engineering supervision; keeping a safe distance and awareness of audiovisual equipment being used in the vicinity of the aircraft.
2	Filming is a common activity for the operator and there is a mandatory checklist in the Corporate Safety and Security Manual covering all aspects to be considered. The press office is accountable for the filming overall and engineering retains responsibility for the aircraft. All filming requires a risk assessment covering people, environment, facilities, and aircraft. A health and safety walkaround and briefing is conducted prior to filming including an aircraft engineer, the press office and the filming team. This process sets the conditions for the filming, which is continuously supervised by a licensed engineer who is a health and safety specialist. Heat from the lighting has been a concern in the past, primarily when being used in a hangar in case it triggers the fire protection system. During recent filming of an aircraft with a composite fuselage, LED lights and diffusers were used, and an engineer performed temperature checks on the fuselage side.
3	This operator previously suffered damage to the windows of a Boeing 787 from the heat of lighting used during filming (discussed above in the previous occurrences section). The event was investigated by the operator. A lack of engineering supervision was identified as one of the contributory factors in the event. Now, according to the operator's safety management manual, any change that can impact safety by introducing new hazards, risks, or impacting existing risk mitigation should trigger the management of change process. This process includes risk assessment and escalation to the appropriate level of management.
4	A production company was granted permission to conduct filming on board an aircraft on the ground and during flight. No additional lighting was used. The aircraft commander was briefed. No specific hazard identification or risk assessment process was conducted because it was normal operations that were being filmed.

Operator	Summary of response
5	Filming activity would be managed in accordance with the Safety Management Manual and the Health and Safety Manual. It would require departments to undertake risk assessment, ensure appropriate supplier selection, ensure that all relevant areas are informed, and that appropriate supervision and oversight is in place in relation to both the aircraft and people involved in any undertaking.
6	Filming activity was recently completed by a trusted supplier that has had a relationship with the operator for five years. Low heat LED lights were used internally and externally to the aircraft. A verbal risk assessment was completed prior to filming with input from Head of Marketing, Director of Engineering, Hangar Manager, Production Team and Marketing Agency. The main risk to the aircraft identified was potential collision by heavy equipment being moved around the aircraft. Filming was continuously supervised by an engineer.

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