Application of Innovative Investigation Technologies

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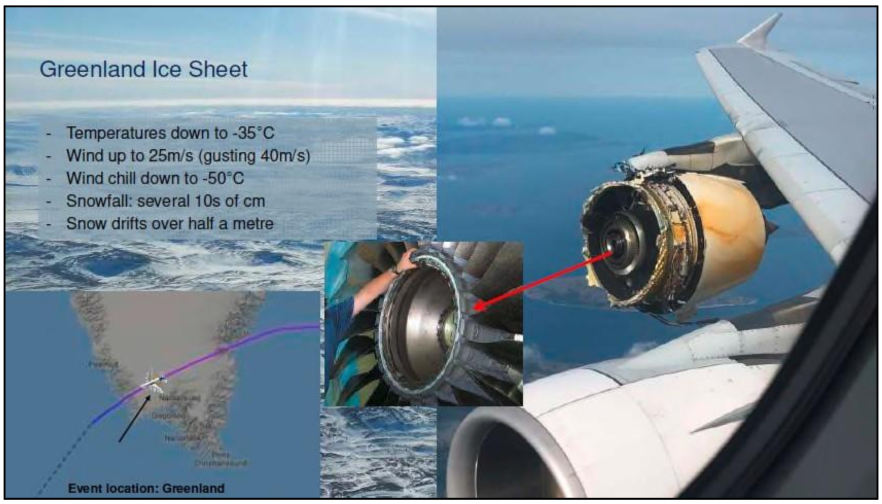
Event Synopsis

On the 30th September 2017, an A380 fitted with Engine Alliance GP7200 engines suffered an uncontained engine failure while cruising at 37,000ft over Greenland.

Engine parts were liberated onto the ice sheet below, including the fan hub, fan blades and fan casing. The aircraft diverted uneventfully to Goose Bay.



Retrieval of the engine components is crucial to understanding the root cause, the key component of interest being the fan hub, a 250kg piece of titanium 80cm in diameter. The fan hub is the central rotating component to which the fan blades are attached. The investigation team faced a huge challenge due to the geography and the extreme climatic weather and looked to technology to help search for the fan hub.

The annex 13 investigation was delegated by the AIB of Denmark to the French BEA (Bureau d'Enquête et d'Analyse), assisted by accredited representatives and advisors[1]. Airbus, as nominated advisors, deployed resources & technologies in order to support the investigation and the search for the liberated parts on the Greenland ice sheet.

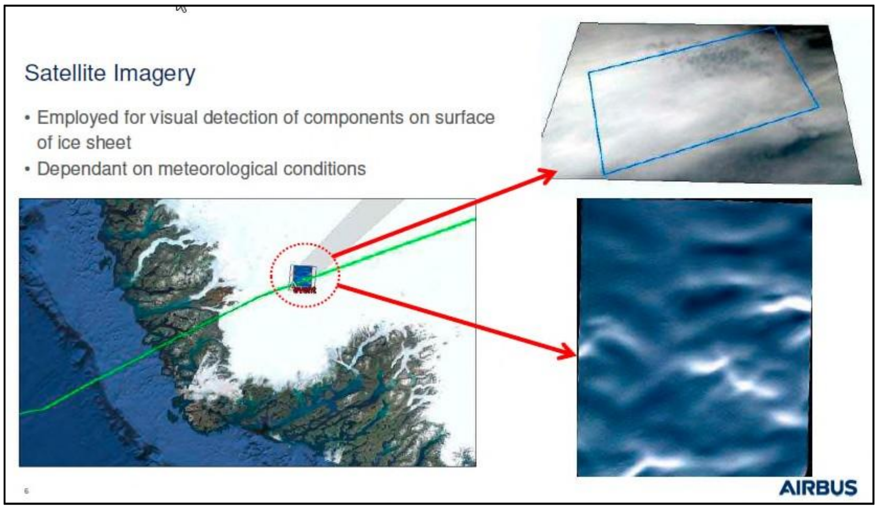
[1]Accredited Representatives – Denmark Accident Investigation Bureau (AIB), US NTSB, and TSB of Canada
Nominated Advisors – Air France, Engine Alliance, FAA, EASA, Transport Canada and Airbus

Innovative Investigation Technologies:

Satellite Imagery

In order to visually identify the location of any parts, Airbus immediately launched satellite imagery of a 20km x 20km area using the PLEIADES satellite constellation, owned and operated by Airbus Defence & Space. The two satellites are in continual orbit around Earth and can be programmed to take images at a resolution of 50cm of any given area in ~6 hours.

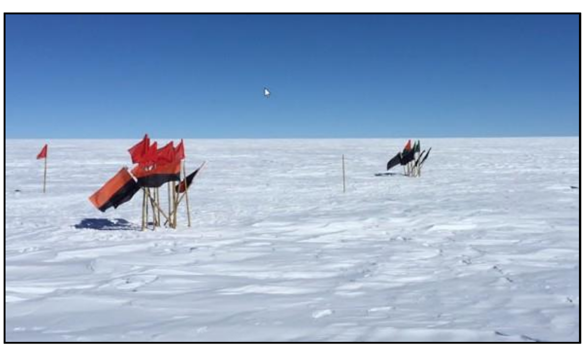
The first images received were obscured due to cloud cover. The satellite continued to take images daily and over the next few days, the cloud disappeared and we received first images of the visible ground beneath. However, a blanket of snow had fallen, making it impossible to visually detect any engine parts.



Greenland has a climate where the snow never melts back to its previous level. Only a percentage of the annual snowfall melts each year, meaning any parts covered by snow will never surface again.

While satellite imagery did not provide any tangible results during this investigation, it may prove useful for other events such as locating an accident site in remote or inaccessible areas, mapping large accident sites or runway excursions.

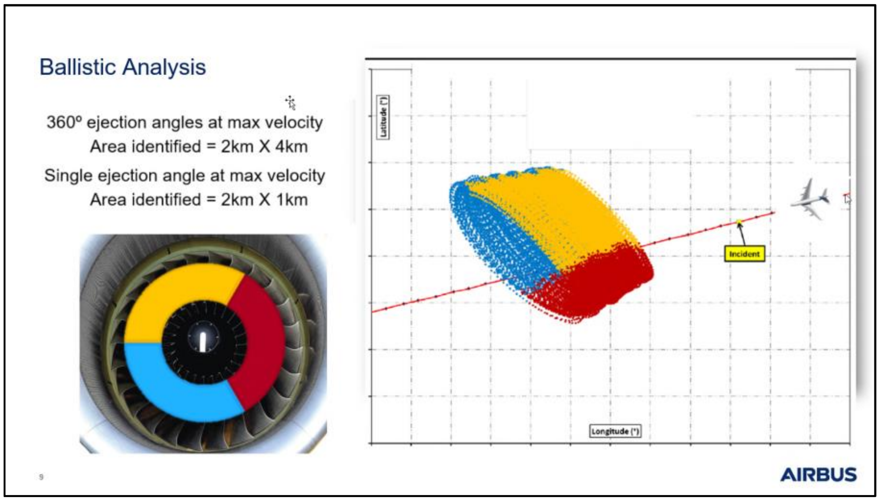
Below is an example of the image resolution achievable. Flags left on the Greenland ice sheet later in the investigation were captured by the satellite images.



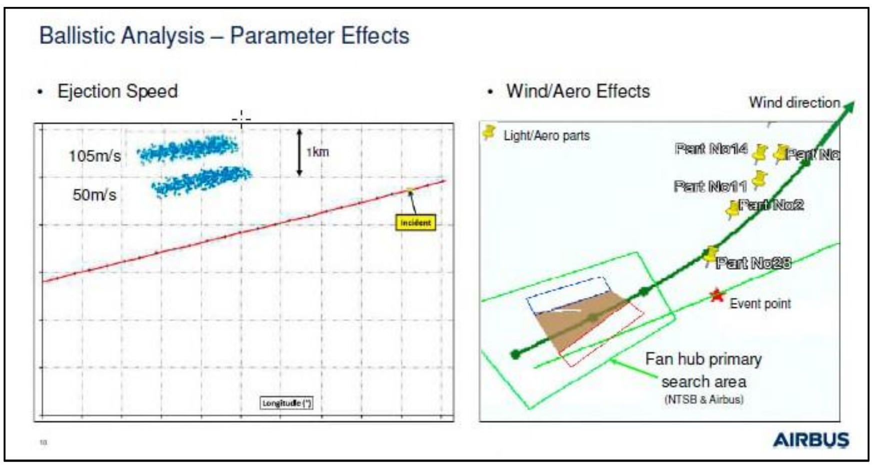
Ballistic Analysis

The potential search zone covers hundreds of square kilometres. To narrow down the search area, the Airbus advisors worked with Ariane Group specialists to quantify the most likely trajectory of the components from their release at 37,000ft to landing on the ice sheet.

Examination of the engine revealed that the fan hub had ejected in several pieces. Ariane Group's analytical models were able to narrow the primary search area down to 2km x 4km when provided with properties of a fragment, such as altitude, aircraft speed, wind, etc.



The ongoing investigation established the fragment ejection angle and ejection speed. This allowed the area to be refined to 1km x 2km. The parameters of the liberated parts has an effect on the ballistic analysis. Smaller heavier parts will be projected forward of the event point while lighter, larger parts which have aerodynamic drag will be carried rearwards of the event point in the direction of the wind.



The fan hub primary search area shown above was identified using both Ariane and NTSB ballistic analyses, which were largely consistent.

Given the extreme climatic conditions, searching the identified area with ground teams remains a challenge. The investigation team therefore looked to try and locate the fan hub using airborne radar scanning.

Synthetic Aperture Radar (SAR) Scanning

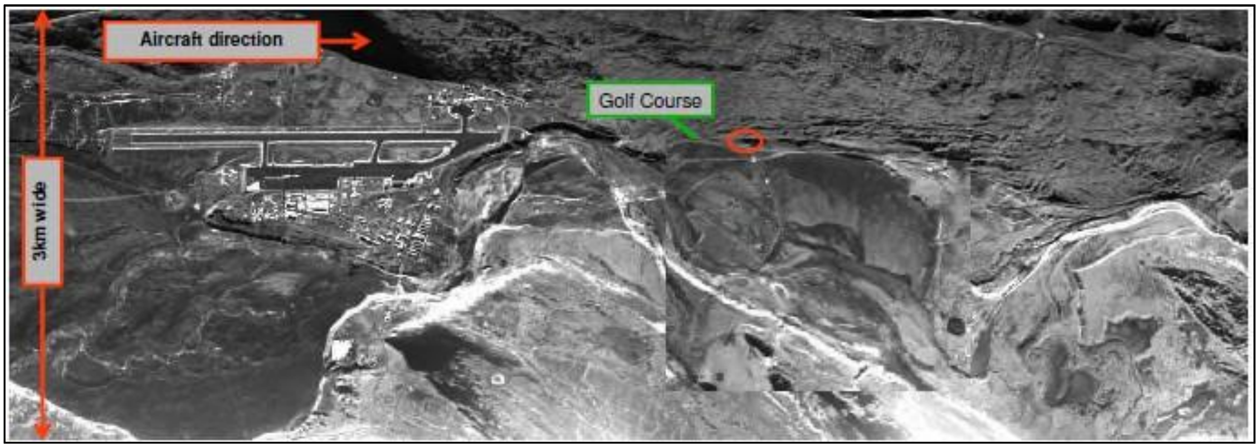
Synthetic aperture radar is normally used for geographical surveys. This is the first time it would be used to detect metallic objects buried under snow.

ONERA, a French aerospace lab provided 2 radar pods equipped with 3 radars, each scanning at a different bandwidth. These were mounted on to a Falcon 20 aircraft provided by AVDEF, part of the Airbus Defence and Space portfolio.

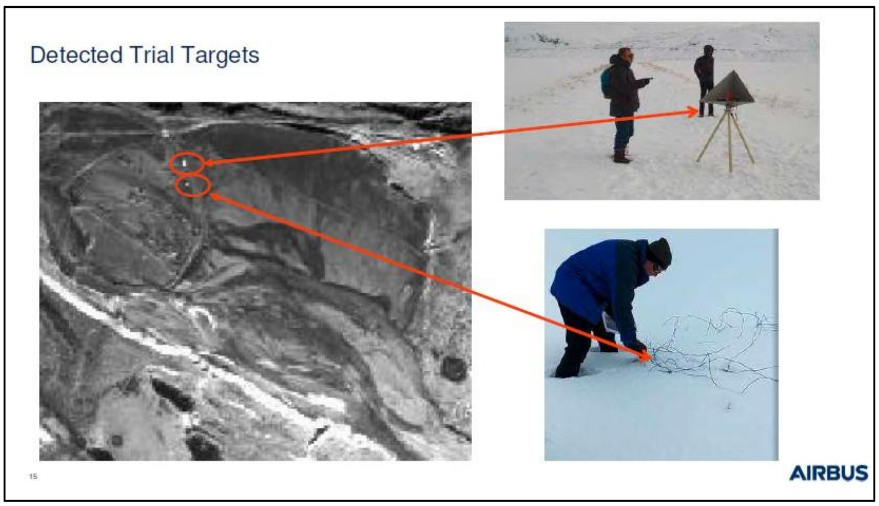
The team assembled in Greenland and first performed a trial to verify equipment functionality and to calibrate the data to the GPS position.

A calibration test piece was mounted on a tripod and positioned on a snow covered golf course with its exact angle and GPS position noted. The aircraft overflew the area at the 2 radar operating altitudes to capture the landscape with all 3 radar bands.

Once the image had been processed, the radar scan revealed the ground beneath the snow and ice.



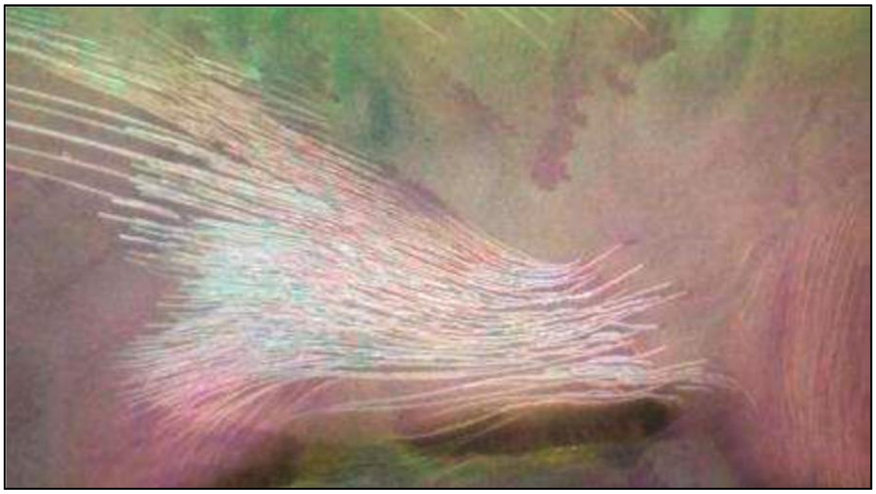
Examination of the image confirmed that the test piece had been detected, indicated by a bright white return on the radar image. A second radar return was seen on the image in the vicinity of the test piece. The cause of this return was not known and when the team returned to the site, we discovered metallic fencing wire buried under the snow.



This demonstrated that the technology is fundamentally capable of detecting metallic objects even when buried under snow.

An extensive are for the hub search was scanned and data collected. However, crevasses were present within the area and created background noise in the radar data. The radars were able to scan ~36 metres below the surface of the ice.

Below is an image covering an area approximately 4km by 2km. Each of the 200 million pixels, each covering 20cm^2 in X-Band, is scanned by a total of 72 images at different angles and polarizations.



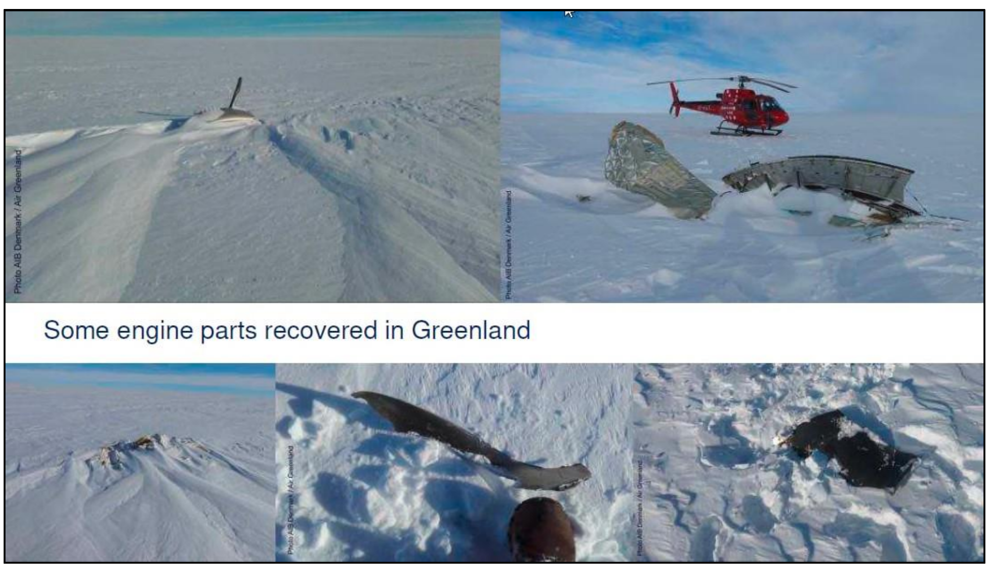
The large amount of data is now undergoing complex post treatment to differentiate crevasse returns and background noise from credible fan hub targets.

Final results are due end of 2018.

3D Laser Scanning

Shortly after the event, the BEA and AIB of Denmark scrambled helicopters along the aircraft track before further snowfall, who were able to locate and recover the larger, aerodynamic engine components that had been liberated during the event. Due to their size, they were easier to spot by the helicopter crew

With their aerodynamic properties, they were blown rearwards of the event point in the direction of the wind, whereas the fan hub trajectory has been analysed to have landed in front of the event point.

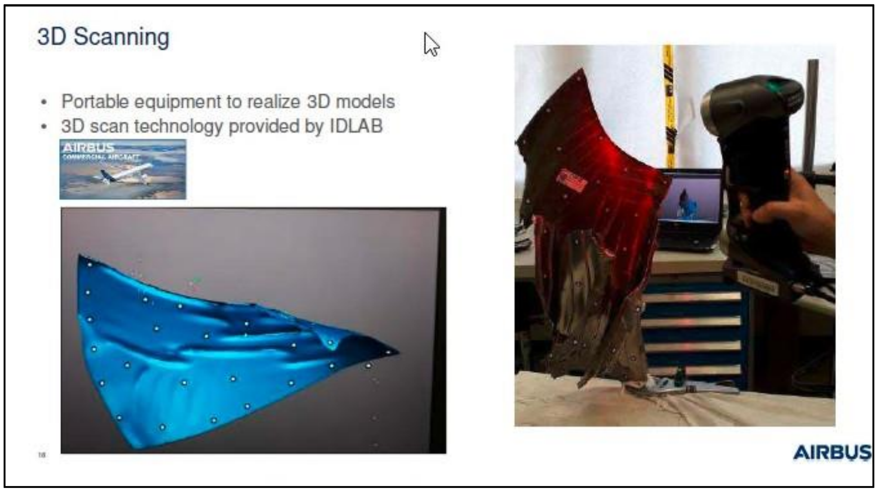


Some engine parts recovered in Greenland

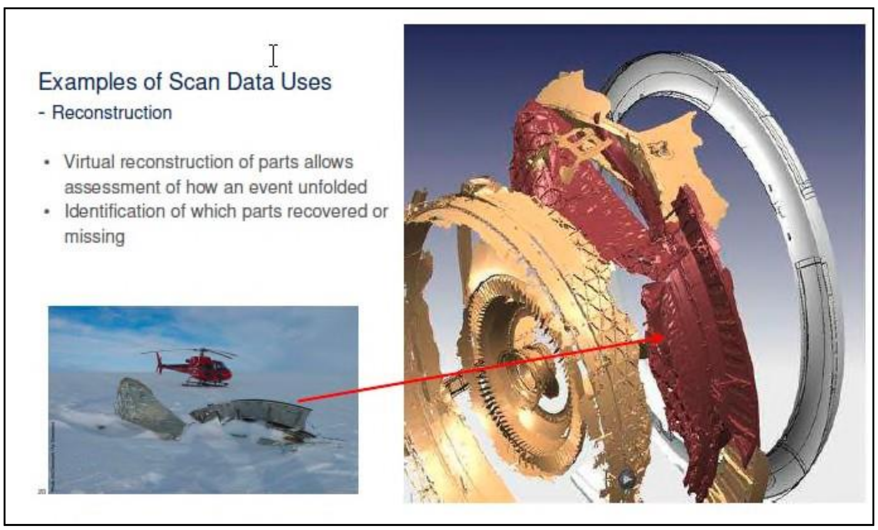
As the fan hub had not been located, the investigation team needed to ensure that maximum data was extracted from these recovered parts. The data would also support any hypothesis put forward and validate any analysis.

Airbus deployed the use of state-of the-art 3D scanning technology was provided by IDLAB, a subsidiary of Airbus commercial.

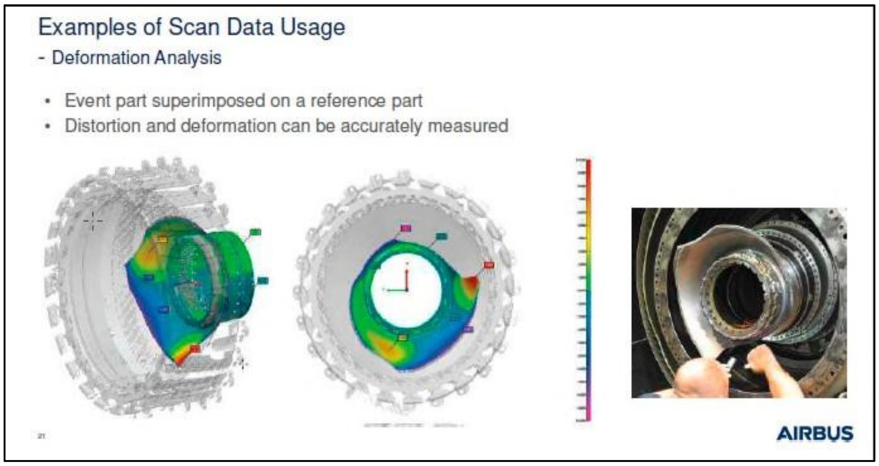
Using 3D laser scanning equipment, all the parts were digitized, creating 3D models of the retrieved components, capturing details with an accuracy of 0.03mm.



The scanned data allowed an assessment of which parts had been recovered and which remain on the ice sheet. A 3D reconstruction was produced which allowed an insight of how the engine event may have unfolded.



Further, 3D models can be overlaid to reference data such as Catia models or scans of reference parts so that an analysis can made on how a part had distorted or deformed.



Advantages of the 3D scanning is that it provides an accurate record of parts as they were recovered and before any disassembly or destructive testing. The data can be made available to all parties of the investigation so that analysis can begin simultaneously. The data can be imported into Catia or viewed as a 3D pdf model.

Any hypothesis can be cross checked against this 3D data.

Summary

The investigation team led by BEA have been working hard to progress the investigation. The engineering analysis to date has allowed mitigating actions to be taken on the A380 fleet powered by EA GP7200 engines. The investigation, search and analysis continues.

When Airbus are engaged in an investigation, in addition to Airbus commercial, we can also engage the resources and expertise of Airbus Helicopters and Airbus Defence & Space domains.

By utilising the resources from across the Airbus Group, Airbus advisors have been able to deploy a number of innovative technologies to gain the maximum amount of knowledge possible from the components already retrieved and to locate the key component to the investigation, the fan hub.