



## **Virtual Wreckage Mapping Using Public Media Photos**

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Jacob has 15 years of experience with Boeing in production support engineering, modification programs, and field service roles, and joined the air safety investigation team in 2018. In his role as investigator, Jacob has participated in the field phase of a number of accidents and incidents. Jacob received a Bachelor of Science degree in aerospace engineering from the University of Missouri – Rolla (now the Missouri University of Science and Technology). Prior to joining Boeing, Jacob worked as an airline dispatcher and in general aviation. He also holds an FAA Commercial Pilot certificate.

A blank version of the photo review catalogue discussed in this presentation is available for free from the author. Please email [Jacob.N.Zeiger@boeing.com](mailto:Jacob.N.Zeiger@boeing.com) to request a copy. Suggestions for improvements or feedback from “field” use is strongly encouraged.

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## Introduction

In the early stages of any aircraft accident investigation, one critical task is the security and collection of perishable evidence, particularly with respect to the airplane wreckage itself. The hours immediately after an investigative team is notified of an event represent a critical time where the team is managing multiple logistical tasks. Travel to the accident site must be arranged and the local official agencies must be contacted to help secure the site in preparation for the team's arrival. During this period, local authorities are also busy with handling potential disruptions to infrastructure (roads, power lines, etc.) and managing a potentially large number of casualties.

Professional media are normally quick to seek out information about an accident (including photos and videos) as well in order to provide critical initial information to the general public. As social media posts receive increased attention and wider distribution, both on their own and with the help of professional media, the general public becomes incentivized to document and post information about newsworthy events that they encounter.<sup>1</sup> The collective result of these combined media can be a wave of photos and video being published about an event like an aviation accident in the very early hours after it happens, during the time when the investigative team may still be gathering information and preparing to travel.

Additionally, investigation teams are occasionally hindered in their ability to arrange timely travel to an accident site, despite local citizens having immediate access to the site. While the reasons for travel restrictions may stem from diplomatic or political circumstances at the site, international and domestic travel can also be restricted by internal company or agency travel policies, or by a variety of other reasons. The COVID-19 pandemic demonstrates one major way in which site access can be restricted to local citizens and press in the initial hours after an accident takes place. Even in cases where the investigation team is able to deploy to an accident site rapidly, wreckage in populated areas can be disturbed by civilians prior to first responders' or investigators' arrival. In these cases, the available media from professional outlets and social posts can still be valuable in viewing a wreckage field and making observations about the components that are photographed.

In nearly all accident cases, a minimum of an investigator-in-charge or a designated representative is able to visit the wreckage site and gather relevant photos and evidence. As long as an official resource is given access to a secure site, restricted travel on the part of a particular support organization can be easily resolved with good communication and the sharing of investigative data in accordance with ICAO Annex 13.<sup>2</sup> These cases can present a different set of challenges for an investigative team from those discussed in this paper – while the source of the photos is normally verified and trustworthy, the team can instead be faced with a large number of images from investigators that must then be sorted on a larger scale.<sup>3</sup>

The information in this paper is intended to provide an overview of one example event where professional and social media provided valuable information into understanding a wreckage field that could not be accessed by an investigation team in the initial days after an event. In the January 2020

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<sup>1</sup> Browne, Malachy; Stack, Liam; and Ziyadah, Mohammed. Streets to Screens: Conflict, Social Media, and the News. *Information, Communication & Society Journal* 25 Aug 2015.

<sup>2</sup> International Civil Aviation Organization. Annex 13 to the Convention on International Civil Aviation – Aircraft Accident and Incident Investigation. Twelfth Edition, July 2020.

<sup>3</sup> Gisolf, Floris; Geradts, Zeno; and Worrying, Marcel. Analysing Large and Complex Image Collections During a Safety Investigation. International Society of Air Safety Investigators technical paper, 2019 Seminar.

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accident involving a Ukraine International Airways 737-800, Boeing collected publicly available photos and videos for review in order to create a virtual wreckage map that could be studied within Boeing. The virtual wreckage map also provided an efficient method for Boeing's observations of the wreckage field to be shared with the government investigation.

### Investigation Protocol

As an airframe manufacturer, Boeing assists government investigations by providing technical advisors to the US National Transportation Safety Board (NTSB) under the protocols and reporting structure of International Civil Aviation Organization Annex 13. This participation also allows Boeing to review investigative findings as part of a formal internal safety process to identify and correct safety-related findings quickly. For the event discussed in this paper, Boeing used the observations from media photos to help inform that safety process in the early stages of the investigation. Those observations were shared with the Annex 13 investigation as part of Boeing's involvement as a technical advisor to the investigation.

### Forming a Team

Boeing was first notified of an event involving a 737 hull loss in the Islamic Republic of Iran on 8 January 2020, the day the accident happened. It was clear from the outset that company travel to the accident site would take far longer than typical to arrange, if indeed a site visit by Boeing investigators were to happen at all. In response, Air Safety Investigation prioritized finding what could be learned from publicly available sources, beginning with the photos found on public media. While one investigator was assigned to support the Annex 13 investigation that was initiated by Iran's Aircraft Accident Investigation Board using the company's typical process, an additional investigator was assigned to the dedicated task of collecting and cataloguing the photos from the various social and professional media sources that were covering the event.

Boeing's process for reviewing these photos involved collecting six experts in relevant areas of the investigation – in this case, internal experts in structures, systems, and propulsion were invited to participate, as well as a fire marshal.<sup>4</sup> The team convened the following day to begin reviewing photos.

### Creating an Image Catalogue

In order to track the images that were used in the team's observations, as well as the parts that were identified and the relevant observations themselves, an image catalogue was created in standard spreadsheet software as a main record of the review process. The layout of the catalogue was adjusted

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<sup>4</sup> "Fire Marshal" in this paper refers to a position at the company that is tasked with ensuring new designs meet regulations for fireworthiness, and reviews in-service data to identify potential areas of improvement.

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and expanded during the team's work, with the final version of the spreadsheet satisfying three overall goals:

1. Maintain as much of the original image as possible (metadata, source URL, filename, type of source)
2. Provide traceability from key wreckage observations back to the specific images from which they were derived
3. Allow for filtering/searching by key stakeholders (by focus group or component)

The final format of the spreadsheet is shown in figure 1.

FIRST 48 HOURS		24 HOURS +				Engineering Review										
Photo Information		Part Information														
Photo Number	URL Source	Source Type	Part Class (choose 1)	Part ID Number	Part description	AT	Part Number	STA	W	B	Stringer	Notable damage	Propulsion	Structures	Fire Marshal	Systems
	(choose 1)	Media Source											Review	Review	Review	Review
MED0001	<a href="http://www.cnn.com/2015/01/19/news/airline/2130/">www.cnn.com/2015/01/19/news/airline/2130/</a>	News Outlet	Engine (ENG)	ENG-001	Left engine core with some fan blades							Notable damage	Propulsion Notes Visible fan blades bent in the direction opposite rotation consistent with engines operating on impact?	Structures Notes Engine fair panels show damage consistent with drag overload	Fire Marshal Notes Scuffing evidence on exterior but no evidence on surrounding ground	Systems Notes No corrosion or pre-impact damage observed on inner cylinder
MED0002	<a href="http://www.twitter.com/boeingboe737/">www.twitter.com/boeingboe737/</a>	Private Citizen	Systems (SYS)	SYS-001	Hydraulic Actuator - Possibly Elevator						2830 215 L32	Heavy impact damage				
MED0003												Impact damage - exterior scuffing				

Figure 1: Image Catalogue Overview

### First 24-48 Hours: Photo Collection and Cataloguing

The team's focus during the first 1-2 days of work was to collect as many images of the airplane wreckage from as many sources as possible. Public websites and news organizations were monitored by the team, looking for photo and video documentation that could

1. Reasonably be shown to be of the event airplane's wreckage, and
2. Provided information that was relevant to the investigation

Images and videos that met the criteria were downloaded for retention. In order to save as much source data as possible for future reference, filenames and metadata were kept intact, and a cataloguing index in the format "MED#####" was added to the beginning of the filename.

### Adding Images to the Catalogue

Images were added to the catalogue in the order that they were obtained, along with the following information:

1. **MED#### Index** – Allowing each image to be located in the folder of saved photos
2. **URL Source** – Providing a link to the relevant source news article or social media post in case follow-up was needed later
3. **Source Type** – Indicating whether the image originated with a News Outlet, Private Citizen, or Official Investigative Agency
4. **Media Source** – Noting the specific source of each image (e.g., Associated Press, CNN, Twitter)

The overall intent during this phase was to keep as much of the original source information as possible intact, in the event that questions about the source of a particular finding or image arose later. During this phase, news organizations with reports of the event continuously updated their articles with new information, occasionally replacing photos with new ones. Because of these updates, accurate recording of the source material even more important, in order to retain traceability if the original source of information was later changed or removed.

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FIRST 48 HOURS			
Photo Information			
Photo Number	URL Source	Source Type	Media Source
MED0001	<a href="http://www.cnn.com/exampleevent/13k0">www.cnn.com/exampleevent/13k0</a>	News Outlet	CNN
MED0002	<a href="http://www.twitter.com/exampleuser//i43">www.twitter.com/exampleuser//i43</a>	Private Citizen	Twitter
MED0003			

Figure 2: Catalogue with first section filled in. Note: Included data is exemplar in nature and not indicative of the subject event.

## Boeing Communications and the Talkwalker Application

In this event, the team was able to leverage other areas of the corporate structure to find assistance in locating unique images and videos. The Boeing Communications department utilizes software called Talkwalker to monitor news and social media sites, gathering relevant news and social media material and displaying it in a user-friendly format. Talkwalker cut down on the total time involved in gathering data, and allowed the team to expand its coverage beyond the “typical” sources of information.



Figure 3: Talkwalker Media Monitoring Page. This application was able to locate photos that the team had not previously seen, and which contributed to the team's understanding of the wreckage field.

As new media continued to be posted to the Internet, the Communications department remained in touch with the team, providing occasional updates and new material. This automated method cut down significantly on the amount of time and effort that individual team members had to put in to traditional search engines, and allowed the team to focus on reviewing photos rather than finding them.

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### Beyond 24 Hours: Building the Wreckage Map

Around 48 hours after the initial notification of the accident, photos and videos were posted and updated less often. The team transitioned to an initial review of the photos that had already been collected to start trying to identify:

1. Any key aircraft components
2. Major landmarks that could be used to locate the wreckage components in space

While convened together, the group reviewed each photo and discussed their initial observations, noting them in the spreadsheet.

### Wreckage Observations

The spreadsheet catalogue of images was updated to include notable information about the parts that were seen in each image. Any identifiable parts were given a unique designation based on the general area of the airplane where they were installed (F-001 for the first identified fuselage part; SYS-012 for the twelfth identified systems part; etc.) and the following basic location and damage information was noted in the spreadsheet:

- **Part Class** – Identifying the “class” of wreckage that was included in the image (Systems, Engine, Fuselage, etc.)
- **Part ID Number** – The specific identifier assigned to the wreckage shown, which allowed for multiple photos of the same piece of wreckage
- **Part Description** – A plain English description of the part
- **ATA Chapter Number** – If known
- **Part Number** – If known
- **Specific Airplane Location** – Using Boeing’s standard three-point location system

Photos that contained multiple identifiable pieces of wreckage were given additional entries in the spreadsheet for each additional component that was included in the image. This allowed for sorting of the spreadsheet by component later. Similarly, if the team recognized a particular component in one photo from a review of a prior photo, the component number would be repeated in the spreadsheet to identify that it had already been identified as being included in two separate photographs. This in turn improved the accuracy by which other components were placed on the final map.

24 HOURS +									
Part Information									
Photo Number	Part Class (choose 1)	Part ID Number	Part description	ATA	Part Number	STA	W	B	Stringer
MED0001	Engine (ENG)	ENG-001	Left Engine core with some fan blades						
MED0002	Systems (SYS)	SYS-001	Hydraulic Actuator - Possibly Elevator			2830	215	L32	
MFD0003									

Figure 4: Spreadsheet updated with basic component information. Note: Included data is exemplar in nature and not indicative of the subject event.

One important benefit of having the whole team review each photo was that the group as a whole could discuss whether components would benefit from a deeper review by any of the individual experts on the team. Components with evidence of fire damage, for example, were marked for follow-up by the fire marshal group, while sections of wing and fuselage were marked for follow-up by the systems group to

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try to identify specific structural damage and narrow down the specific airplane section where the structure might have originated.

### Naming and Orienting Landmarks

Due to its wide distribution and ease of use, Google Earth was chosen to plot the locations of the wreckage that were identified. Using location information in the text of news reports and the most notable landmarks from the initial photos, the team identified an impact point in a recreational area northwest of the Tehran airport near residential apartment complexes, and continuing through an area of walled-in orchards. With the general area of the wreckage field defined, the team could move to labeling particular landmarks in other areas of the photos.



*Figure 5: Example photo with both airplane components and landmarks. Note the vertical concrete walls and water tower in the distance. Source: CC BY Fars News Agency via Wikimedia Commons.*

Labeling these landmarks explicitly in Google Earth proved to be highly beneficial when sharing the photo review with the larger investigative team and discussing observations over the phone. Both sides of the conversation were able to refer to areas of the wreckage field by these predetermined names.

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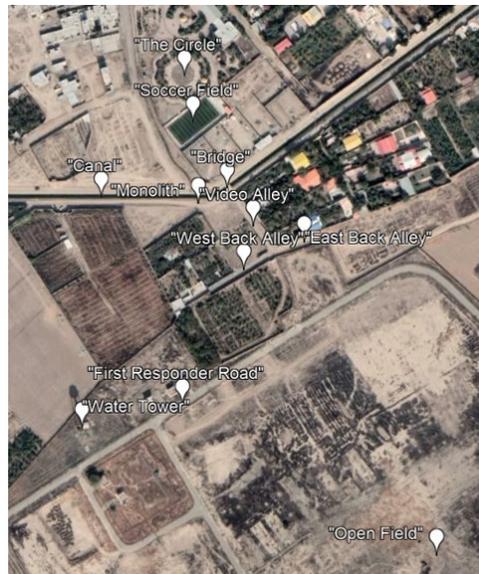


Figure 6: Wreckage map with landmarks labeled. Source: Google Earth

### Follow-On Work: Deeper Engineering Review

Completing the initial review of photos, including identifying components and marking images for follow up by specific groups, took approximately five business days. Following the first two phases, the group was then split into subteams made up of the individual focus areas that were previously identified. The spreadsheet was provided to each team in parallel, and each took additional time to perform a more detailed review of the photos and provide their specific notes on each photo individually. Notes were collected directly in the spreadsheet, aligned with the individual photos and component entries that provided the observations that were recorded. This process provided a basis for recording the data upon which each significant observation was based.

Engineering Review									
Photo Number	Notable damage	Propulsion Review	Propulsion Notes	Structures Review	Structures Notes	Fire Marshal Review	Fire Marshal Notes	Systems Review	Systems Notes
MED0001	Heavy impact damage	x	Visible fan blades bent in the direction opposite rotation - consistent with engines operating on impact	x	Engine fuse points show damage consistent with drag overload				
MED0002	Impact damage - exterior sooting					x	Sooting evidence on exterior but no evidence on surrounding ground - consistent with inflight fire	x	No corrosion or pre-impact damage observed on inner cylinder

Figure 7: Spreadsheet updated with engineering review notes. Note: Included data is exemplar in nature and not indicative of the subject event.

### Virtual Field Notes

Using the observations gathered in all three phases and the virtual wreckage map that was created for this event, the team was able to collect their observations into a set of virtual field notes. In particular, the team was able to provide some key observations to the investigation team at large:

- Observations of the “four corners” of the aircraft, as well as their approximate locations in the wreckage field
- Observations on the state of the engines at impact

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- Observations on the condition and location of fire prior to impact
- An approximate heading and attitude at impact

As Boeing Air Safety Investigation continued to support the official investigation by the Aircraft Accident Investigation Board of the Islamic Republic of Iran, the photo review team was pleased to learn that their observations were supported by evidence gathered and observed by the AAIB team that traveled to the site.<sup>5</sup>

### Notable Challenges

The team encountered some minor challenges in this event that are worth noting.

#### Removal of Images from Social Media

Initial efforts to collect and catalogue the visual media did not include the source of the image or video, under the assumption that the images were likely to remain online in their original location indefinitely. However, as the days progressed it became apparent that some media (particularly those from social media posts) were occasionally being altered or removed entirely from their original locations. In some cases, the images were rebroadcast by other social and professional media sources that gave credit to the original source, but in others the team's downloaded version of the image became the only working copy. As work progressed and further photos were collected,

#### Movement/Removal of Wreckage

As the team continued to monitor additional images and video in the days following the accident, items that were previously imaged and catalogued could sometimes be seen again in new locations and orientations. These changes to the wreckage field were variously detrimental and beneficial to the team: in some cases, the original location or orientation of a piece of wreckage could not be determined with certainty, but in others the movement provided additional and useful data about the state of a component after the accident.



*Figure 8: The vertical tail included key fire evidence. The image on the left was posted in the first 24 hours after the accident but was not republished by many other news agencies. The image on the right, posted later, saw wide distribution. Sources: Anadolu Agency/Getty (left); Hossein Mersadi/FARS News Agency (right)*

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<sup>5</sup> The Aircraft Accident Investigation Board of the Islamic Republic of Iran. Flight PS752 Accident Investigation Final Report, 15 March, 2021.

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### Summary

Collecting perishable evidence is a key step in the first hours and days of any accident investigation. Timely access to the accident site for the firsthand collection of information about the wreckage field should remain the gold standard in the professional, methodical investigation of an aircraft accident. However, not all circumstances around an accident scene can be controlled by the investigator in the first hours and days after an accident. Further, communication between States as prescribed in ICAO Annex 13 may take time to be fully established. The methods described in this paper should not be considered an adequate substitute for traveling to an accident site and making observations in person. But in the event that access to a site is hindered for cultural, geographical, or political reasons, public and social media images and video can provide the opportunity to make key observations about the state of an accident site and the wreckage within it, even without setting foot at the site, or seeing the wreckage firsthand.