

Working with Flight Deck Image Data

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Jonathan (Jon) Lee is the Western Regional Manager for the Transportation Safety Board of Canada (TSB) located in Edmonton, Alberta. He has been an aircraft accident investigator since 1999 and has been managing the regional office since 2004. He has been involved in 80+ investigations as IIC, 2IC or manager where the TSB has issued a report with findings as to cause and contributing factors. Jon has had the fortunate opportunity to support the TSB mandate by participating in foreign investigations that involve Canadian aerospace products and has worked with the NTSB-USA, ASC-Taiwan, AAIRB-Korea, AAIB-Mongolia and SIA-Finland.

On 01 August 2018, after completing 2 hours of survey work near Penticton, British Columbia (BC), an Aries Aviation International Piper PA-31 aircraft (registration C-FNCL, serial number 31-8112007) proceeded on an instrument flight rules flight plan from Penticton Airport (CYYF), BC, to Calgary/Springbank Airport (CYBW), Alberta, at 15 000 feet above sea level. The pilot and a survey technician were on board. When the aircraft was approximately 40 nautical miles southwest of CYBW, air traffic control began sequencing the aircraft for arrival into the Calgary airspace and requested that the pilot slow the aircraft to 150 knots indicated airspeed and descend to 13 000 feet above sea level. At this time, the right engine began operating at a lower power setting than the left engine. About 90 seconds later, at approximately 13 500 feet above sea level, the aircraft departed controlled flight. It collided with terrain near the summit of Mount Rae at 1336 Mountain Daylight Time. A brief impact explosion and fire occurred during the collision with terrain. The pilot and survey technician both received fatal injuries. The Canadian Mission Control Centre received a 406 MHz emergency locator transmitter signal from the occurrence aircraft and notified the Trenton Joint Rescue Coordination Centre. Search and rescue arrived on site approximately 1 hour after the accident. The final TSB Aviation Investigation Report [A18W0116](#) was released to the public on 01 August 2019.

The accident aircraft was equipped with an Appareo Vision 1000 (Appareo) flight data monitoring system that included flight deck imaging. This paper discusses the challenges that were experienced during the investigation when working with these types of data recorders. Those being:

- the amount of data,
- the amount of time to process that data,
- what data you can get,
- the information that you don't get,
- different resolutions that the imagery can be portrayed in and how that can affect the accuracy of the information being collected,
- techniques that can be used on the imagery data to acquire more information,
- installation and on-going maintenance requirements,
- the requirements for operators and pilot associations to understand the sensitivity of the data and how to manage the data in a just culture, and
- the privilege afforded to images captured on a flight deck.

Although this paper is specific to the experience with the Appareo, other similar units in use in

aviation will present similar challenges. It is hoped that the reader will come away with a set of guidelines with which to work when a flight data recorder with imaging is available for the investigation.

Privilege

It is important that an investigator is familiar with the provisions in ICAO Annex 13 and the State legislation under which investigative work is accomplished with respect to the protection of images recorded on an aircraft flight deck. ICAO Annex 13 (1), describes that a State conducting an investigation, where there are airborne image recordings recovered, shall not make those records available for purposes other than accident or incident investigation. The exception being where a State determines “that their disclosure or use outweighs the likely adverse domestic and international impact such action may have on that or any future investigation.”

The Canadian Transportation Accident Investigation and Safety Board Act (2) aligns with ICAO Annex 13 in that it assigns privilege to on-board recordings that also include video recordings of the activities of the operating personnel of an aircraft. The Act further defines an on-board recording as equipment that is intended to not be controlled by the flight crew on the flight deck of an aircraft. It also states that transcriptions made from the recordings are also privileged.

If privilege is going to be afforded to the images captured from the flight deck, it is important to establish various work flows and information technologies to ensure confidentiality of those images.

As image capturing technology becomes more prevalent on the flight deck it is important that accident investigation agencies, where feasible, educate operators of the privilege afforded to that data and ensure that it is used for flight safety purposes only such as the case with cockpit voice recorders.

Appareo Vision 1000

The Appareo Vision 1000 is a self-contained flight data recording system that only requires a power and ground lead from the aircraft's electrical system to operate. The information captured includes the following:

- Attitude data (pitch, roll, yaw, etc.)
- WAAS [wide area augmentation system] GPS [global positioning system] (latitude, longitude, ground speed, vertical speed, GPS altitude, etc.)
- Flight deck imaging
- Ambient audio
- Intercom system audio for crew and ATC communications (optional) (3)

In total, the unit can record up to 8GB data which includes approximately 2.6 hours of still images at 4 frames per seconds (about 37 500 jpeg images), 2.6 hours of 2 channels of audio and 200 hours of flight parameter data. Please refer to this ISASI *Forum* article (4) which provides more details about what the Appareo can do and how it can benefit accident

investigation.

The unit is not crash worthy or fireproof; however, in this occurrence, despite significant impact forces and exposure to a brief fire, the unit had minimal damage. There was an issue in recovering images from the last few minutes of the flight. Appareo suggested using their internal engineering software in order to recover the missing files. This software was shared with the TSB and the remaining images were recovered.

Visualizing the flight deck images

Since the Appareo records still images there are a few ways to view the data. Individual images can be viewed one at a time but that is not practical for 37 000+ images. Appareo provides software that can play back the still images like a video. The TSB Laboratory provided the IIC videos of this playback to use at the investigator's work station. The playback screen also contained flight path data as well.

The images can also be used along with the flight path data to produce a combined view of all the data. CAE Flightscape Insight software was used for this particular option of viewing multiple data sets.

The process of creating a video from the source data/still images compresses the images and some data is lost. During the investigation it was found that data that was pixelated could be recovered or "seen" when the original JPEG images were viewed. The filename for the Appareo images were related to time so a spreadsheet formula was created from which the time in the video could be converted to the file name in order to find the appropriate still image.

Workflow for analyzing images

If a multimedia investigation specialist is available, it would be advantageous to enlist their expertise. If a specialist is not available, the following are some suggestions on how to go about reviewing the data in sufficient detail so information isn't missed. Keep in mind that human beings have a tendency to see what they are looking for and as a result, may miss other valuable data. A methodical process is required to prevent missing important information. To assist the review, detailed pictures of the actual flight deck should be available or if there is too much destruction, a "before" picture of the flight deck or even representative images from a similar aircraft.

Step 1: Watch the entirety of the images/video to know what you are dealing with. Pay attention to where in time the video starts and where it stops and note areas of missing data. Does the video even capture the accident? If not, the video still may hold important clues.

Step 2: Watch the images again and create a sequence of events of where major events occur (take-off, climb, level-off, descent – etc.) and note the time at which they occurred. This will help in getting to specific areas of the data quickly.

Step 3: For those areas of interest or where safety significant events occur, select the relative area and commence a methodical review of the images. This may take several viewing sessions

in order to focus on certain items in the image area. For example, you may concentrate only on the engine gauges and note their readouts. Or, the autopilot mode annunciator panel. Another area of interest are those portions of the panel that reflect light and what can you see in the reflections of instrument faces, windscreens and other reflective surfaces. This level of review can take many hours. Save a copy of the important JPEG images and paste them into image viewing software, such as PowerPoint, for easy labelling and basic image manipulation such as zooming, cropping, brightness and contrast.

Obtaining additional data from the images

For this particular investigation, several analogue instrument readings were required to support the aircraft performance analysis. Unlike a flight data recorder, visual images representing numerical values of gauge readings are not user friendly for performance analysis and to manually record the values for each image was not practical. A method was developed to convert the image of the position of the needle to an angular numerical value and then convert that to the numerical value on the actual instrument face.

The multimedia investigation specialist from the TSB Engineering Laboratory analyzed the last 6 minutes of the flight (1440 images) to provide digital values for the following analogue instruments:

- Altimeter
- Manifold Pressure for left and right engines
- Propeller Revolutions Per Minute for left and right engines
- Exhaust Gas Temperature for left and right engines
- Fuel Flow for left and right engines
- Fuel Level for left and right fuel tanks (every 2 minutes for two hour span)
- Right side air Speed indicator

Adobe After Effects was used to do the analysis as it has the capability to track pixel position. For each needle on the instrument a separate tracker was used that featured two points representing each end of the needle. The pixel position information was then exported to a spreadsheet where the data was converted to an angular position (0 to 360°). This position was then translated to a numerical instrument value based on the measurements taken from the actual instrument faces recovered from the aircraft. Figure 1.

Figure 1. Example of the manifold pressure gauge value determined from pixel tracking of the manifold pressure gauge needle.

| | | | | | | | | | | First value/angle | 10 | 254.5 |
|-------|----------------|---------|----------------|---------|------|-------|----------|-------|-------------------------------------|-------------------|----|-------|
| | | | | | | | | | | last value/angle | 50 | 465.5 |
| | Track Point #1 | | Track Point #2 | | | | | Angle | Instrument Reading - inches mercury | | | |
| Frame | X | Y | X | Y | Δ X | ΔY | 360 | | | | | |
| 33215 | 513.625 | 1013.25 | 517.875 | 1058.38 | 4.25 | 45.13 | 95.37981 | 354.6 | 28.98 | | | |

Missing information

Although there was considerable information available to the investigation provided by the flight deck image recorder, there were still limitations and omissions of data.

Lighting – There were lighting situations where the data was not conclusive. In particular, when there was bright sunlight in the image and the area desired was in the shadows. Some success was realized when the images were imported to a photo editing program and were manipulated to enhance the information.

Camera resolution – Although good, some details on the instrument faces were pixelated due to their relative small size compared to the area of the flight deck covered by the camera's sensor. Newer generations of these cameras with higher pixel density will eventually overcome this limitation.

Camera vibration – Since the camera was mounted to the airframe, vibrations from the airframe also affected the quality of the still images captured. Especially those readings from instrument faces. Attention to vibration dampening on installation would have a great effect on improving clarity of the images.

Coverage of area – The camera is limited to what it can see and the position of the camera is important. In this occurrence, the camera had been moved/bumped from its original position and as a result, several key areas of the flight deck were not in view. The new position of the camera also introduced errors into the flight data as well. The investigation pointed out that there were no established continuing airworthiness maintenance requirements to recalibrate the camera to ensure that it was pointed at relevant areas of the flight.

Summary

Investigators are driven by the quest for information which is motivated by the desire to understand the events and reasons behind aircraft occurrences in order to prevent reoccurrence. The more information that is available the better the investigation report and hence to requests over the years from many investigation agencies to regulatory authorities to make image capture technology on flight decks mandatory and complimentary to the CVR/FDR.

In this investigation, investigators were given that abundance of information and with it a fairly intense workload due to the amount of data that was actually available. Initially, it was thought that answers would come easily and some did but it also brought many more avenues for investigation due to the sheer volume of information collected.

When working with flight deck images be patient, be thorough and be systematic. As many answers that can be found, many may be missed due to the temptation to only look for the obvious.

End notes

1. International Civil Aviation Organization (ICAO), Annex 13, *Aircraft Accident and Incident Investigation, 11th Edition* (July 2016), Chapter 5-12, Protection of accident and incident investigation records.
2. Government of Canada, *Canadian Transportation Accident Investigation and Safety Board Act* (S.C. 1989, c. 3), Section 28 (1)(b).
3. Appareo, "Vision 1000," at <https://www.appareo.com/aviation/flight-data-monitoring/vision-1000/> (last accessed on 11 May 2020).
4. Dr. Thomas Gogel, Seth Buttner and Dr. Marcus Bauer "*Modern Technologies and Methodologies Improve Helicopter Accident Investigation,*" ISASI Forum, July-September 2016, p.18.