

Use of Modern Technologies and Methodologies to Improve Helicopter Accident Investigation

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1. Abstract

Helicopters certified under Certification Specification for Small Rotorcraft (CS-27) do not mandate equipment of helicopters with data recorders, nor do operational requirements for a big part of the world wide helicopter fleet. The resulting lack of flight data severely impacts the effort needed for accident investigation and often prevents the identification of root causes or the chain of events leading to an accident, which in turn prevents the establishment of suitable barriers for future avoidance of similar accidents.

Airbus Helicopters (AH) follows a twofold approach to improve this situation. Firstly, the Vision 1000 Cockpit image and data recorder was developed as standard equipment in AH helicopters, but outside the regulatory requirements, resulting in simplified certification with associated much lower costs. The features of this device and first applications are presented, as well as the deployment policy in the fleet.

Secondly, the method 'immersive witness interview' (iwi®) is presented. It provides a qualitative and simple analysis of accident flight path using eyewitness statements. The methodology uses information gained of an event from interviewing multiple eyewitnesses or recorded videos from smartphones or observation cameras to reconstruct and define a vehicles flight path and aircrafts attitudes in a 3D environment. All information is compiled and then processed with the Immersive Witness Analyzer (IWA) software to identify the level of witness error or accuracy. The results can be exported into GoogleEarth or videos showing the approximated flight path from different perspectives.

2. The Vision 1000

In order to provide a solution for Helicopter Flight Data Monitoring for light helicopters, the Vision 1000 system was jointly developed by Appareo Systems and Airbus Helicopters long before the relevant rulemaking process for helicopters was initiated.

It is compliant with the Helicopter Emergency Medical Services (HEMS) FAA Rule 135.607, and the EASA Rule Making Task 0271/0272, mandating a Light Data Recorder for light helicopters and aircraft starting end of 2019. On top of the obvious benefit of creating increased safety through operations quality assurance and training assistance, the device offers great value for incident and accident investigation. Accident causations that remained unknown due to lack of data can now be established by means of this low-cost flight data recording device. This is a basic enabler to develop preventive barriers for accidents in the operator's SMS or measures being launched by aviation authorities. The device is also one forerunner considered in the FAA NORSEE (Non-Required Safety Enhancing Equipment) initiative [1] with the objective to promote the installation of non-required safety enhancing equipment.

The Vision 1000 system is flight data, audio, and cockpit image data recorder. Especially the imaging recording capability even offers advantages over much more expensive, heavier and maintenance burdened CVFDR equipment as required for Large Rotorcraft. It captures pilot/crew actions and behaviors during flight, manipulation of flight controls and systems, noise, and even a view on weather/visibility conditions. The available CVFDR solutions for heavy helicopters do not offer a solution option for the light helicopter range for the above mentioned reasons. A much simpler, low-weight, low-cost, and low implementation effort solution is needed and now provided by the Vision 1000 system.

2.1. Description of the System

The system features a forward facing image acquisition of the cockpit of 4 fps, with 2.2 Mega Pixel resolution, audio recording (ambient noise and intercom system), GPS position data, and an Inertial Measurement Unit (IMU) to record attitude. The weight is 300 g for the unit. A removable memory can store 4 hours of image and audio, and 200 hours of inertial data (position and attitude). The hardened internal memory is capable of storing 2 hours of image and audio, and also 200 hours of inertial data.



Fig 1: Vision 1000 system and mounting on cockpit ceiling on an AS350

The unit is installed in the helicopter to provide a view on the instrument panel, and partially covering also an outside view (Fig. 1).

A visualization software enables a synchronized replay of images, audio and 3D depictions including a display of the flight instruments (Fig. 2)



Fig. 2: Typical replay scene and 3D flightpath/attitude depiction, including instrument view

A further review capability offering features like automated event analysis and reporting with a web based access is provided as well.

The Vision 1000 is not crash hardened per a certification requirement. But a review of past accidents indicates a crash survivability of more than 90%.

2.2. Airbus Helicopters Deployment Strategy

The Vision 1000 system offers a good opportunity for light helicopter operators to enhance their training and move into operations quality control by means of the HFDM features of the device and data reduction software. For the Accident Investigation Boards and the helicopter manufacturer, it is a valuable device to establish root causes for accident and incidents which would stay open without this data recording device. Thus, the Vision 1000 deployment is a key element in Airbus Helicopter's 'Safety First' initiative, which is the company's prime objective.

The strategy is to fit each delivered helicopter with the device and provide affordable retrofit solutions for the in-service fleet, especially the light range. The actual deployment started in 2011 on the AS350 fleet under a FAA STC by Airbus Helicopters Inc. in the USA.

The vision 1000 is fitted as basic equipment in the AS350 final assembly line since 2013. Fleet deployment for the EC130 T2 and EC135 started in January 2014 and the certification for the H145 was achieved in 2015. Since January 2015, it is standard equipment on the H225 and H225e. Note that the equipment is installed on the heavy helicopters on top of the CVFDR. The image recording feature offers information recording on top of the CVFDR requirements, which is extremely valuable. The certification for the AS365 N3+ and EC155 B1 is in progress and expected in 2015. On the new helicopter type H145 it is again standard equipment, on the H175 it is optional equipment. Also, the H160 prototype is equipped with the device.

As for retrofit options, FAA STCs and EASA certifications are done for the light helicopters, and retrofits are offered to the fleet worldwide operators.

In order to stimulate the use of the equipment, specific customer trainings are performed during the delivery of the helicopters. Stand-alone training courses are available as well.

The next generation of flight data recording devices for light helicopters is presently under development at Airbus Helicopters. It will feature a recording capability of more parameters and a higher degree of integration and crash protection by means of the Airbus Helicopters' new Avionics Suite HELIONIX.

Overall, Airbus Helicopters is promoting the installation of the device into the fleet strongly. It is an important part of the Safety Policy.

2.3. Alaska State Trooper AS350 Accident 2013 – Role of Vision 1000

2.3.1 Overview

On March 30 of 2013, the safety department of Airbus Helicopters realized the critical value of the Vision 1000 at the ultimate cost. Air Safety Investigators (ASI) responded to the fatal accident of the Alaska State Troopers' AS350 B3 helicopter (N911AA) that crashed in the Talkeetna mountains of the Alaska Matanuska-Susitna region, approximately 80 NM north of Anchorage (Fig. 3). The helicopter impacted wooded and mountainous terrain while maneuvering during a night SAR operation at 2320 Alaska Daylight Time (ADT). The pilot, the tactical flight observer (TFO), and the rescued snowmobiler were killed. The helicopter was destroyed by impact forces and post-crash fire. Instrument meteorological conditions (IMC) prevailed in the area at the time of the accident. This was the first fatal accident investigation benefiting from the data captured with the Vision 1000 cockpit imaging and flight data recording device [2].

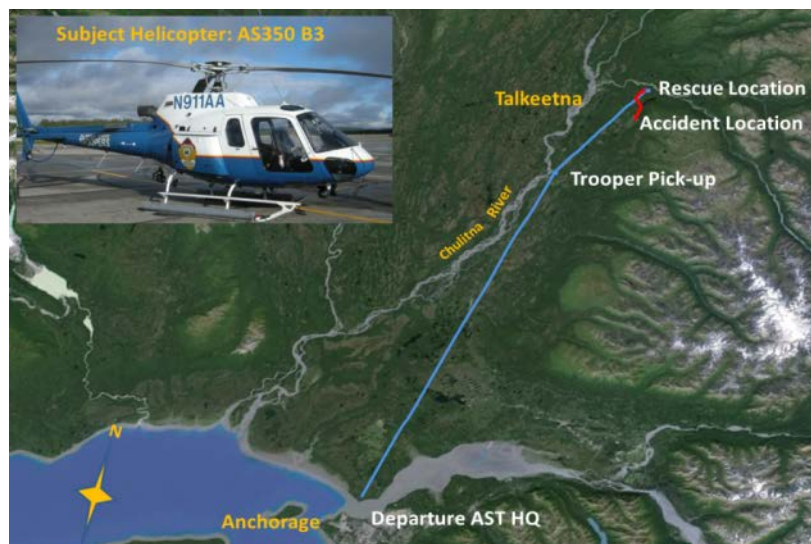


Fig. 3: Helicopter and location map of the accident flight

With no survivors, no witnesses, and no reported or recorded radio communication, and without air traffic radar coverage in this remote region of Alaska, the information recovered from the aircraft's Vision 1000 proved to be critical to investigators. This is best illustrated with the following statement

from the NTSB Executive Summary of the accident

(http://www.nts.gov/news/events/Pages/2014_Alaska_State_Trouper_BMG-Abstract.aspx):

It is important to note that the investigation was significantly aided by information recovered from the helicopter's onboard image and data recorder, which provided valuable insight about the accident flight that helped investigators identify safety issues that would not have been otherwise detectable. Images captured by the recorder provided information about where the pilot's attention was directed, his interaction with the helicopter controls and systems, and the status of cockpit instruments and system indicator lights, including those that provided information about the helicopter's position, engine operation, and systems. Information provided by the onboard recorder provided critical information early in the investigation that enabled investigators to make conclusive determinations about what happened during the accident flight and to more precisely focus the safety investigation on the issues that need to be addressed to prevent future accidents

2.3.2. The Accident

At 2019 the pilot received the notification for a rescue mission involving a stranded, hypothermic snowmobiler in a remote location approximately 80 NM north of Anchorage. The helicopter and the pilot were restricted to a VFR operation, and current weather information available to the pilot presented a high risk due to night / low lighting conditions with possible snow showers in the area.

According to the data collected from the Vision 1000 after the accident, the following information was witnessed and later assembled with the other information collected by the investigative team from witness and police dispatchers. At 2111 the flight departed the Anchorage International Airport (ANC) in night VFR conditions and flew to pick up a tactical flight observer (TFO) 15 NM south of Talkeetna. Now with just the two state troopers onboard, the helicopter departed to the reported rescue location coordinates, under VFR conditions with the pilot utilizing night vision goggles (NVG's). The recorded data shows the aircraft landed at 2156, on a frozen pond just 200 meters west of the given coordinates, and shut down. Almost an hour later at 2313, with the injured snowmobiler now on board, the flight departed the rescue location. This leg of the flight was reportedly destined for the staging area / landing site just south of Talkeetna where the TFO was previously picked up. At 2320, seven minutes after departures, the recorded Vision 1000 data ended. The accident site was located the following day just 2.5 NM south of the rescue location during the search after the aircraft was recorded missing.

2.3.3. Reviewing the Information Obtained from the Vison 1000

The aircraft was totally destroyed from the impact forces and post-crash fire. However, the helicopter's Vision 1000 unit was recovered from the rubble at the accident scene (Fig. 4). The unit had been mounted on the cockpit ceiling center between the two forward seats, but became separated from the aircraft structure during the impact event and found lying amongst the wreckage debris. Although the unit exhibited impact damage on the exterior case and power connector; the crash hardened memory module and removable card were still intact and undamaged.

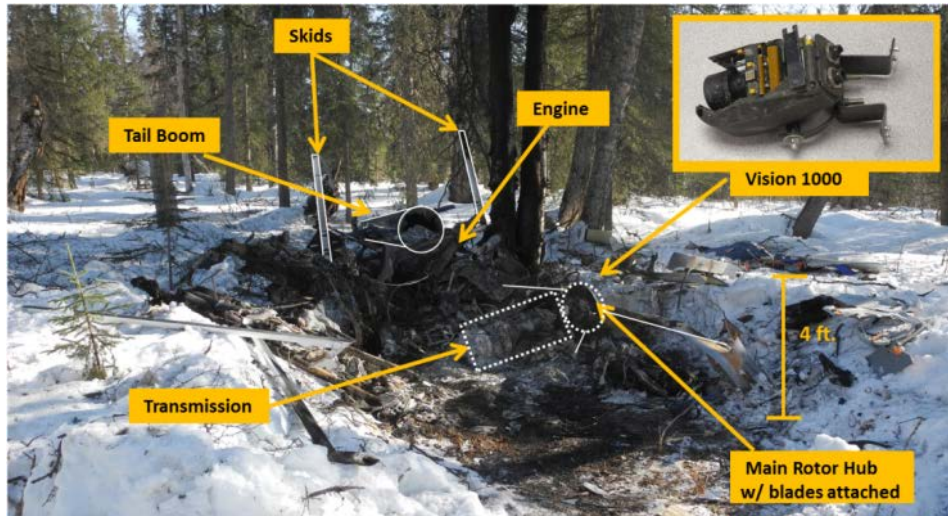


Fig. 4: Accident site and location of wreckage and Vision 1000

The unit was shipped to the NTSB's Recorders Laboratory in Washington D.C. where its data was downloaded, reviewed and analyzed. The extracted data was plotted by the NTSB's recorders lab in the same manner as the parametric data reports of traditional flight data recorders are processed. Several plots were created to cover the entire flight. The recovered data included approximately 2 hours of image and ambient audio data and 100 hours of parametric data. The images captured a forward looking view of the cockpit from behind the pilot that included the navigation and system instruments and displays, the master caution warning panel, and a partial view out the cockpit windscreen. Additionally it captured some of the pilot's left arm and head motions and the TFO's right shoulder (the pilot was seated in the right seat and the TFO was seated in the left seat).

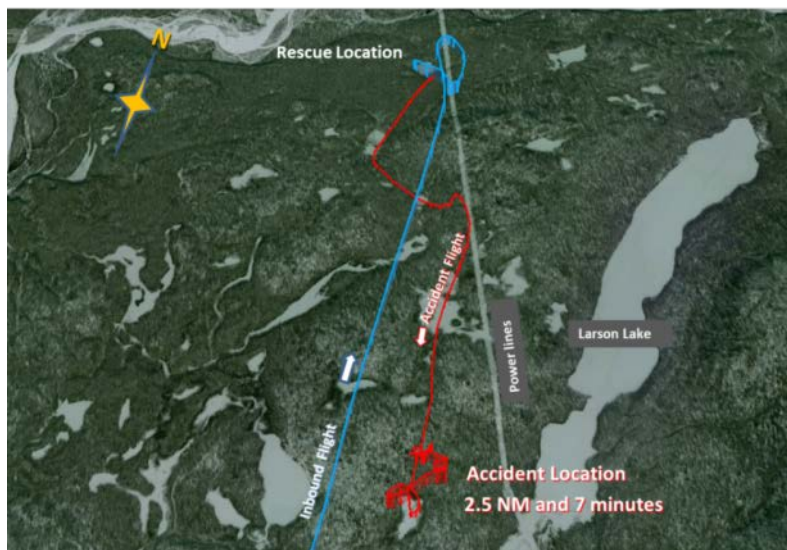


Fig. 5: Inbound flight track and Accident leg flight path

The Vision 1000 images allowed investigators to see the activities of the crew, both before and after they picked up the injured snowmobiler; even in the dark night conditions.

The images data revealed that after the aircraft was started up in Anchorage, the pilot configured both of his available map displaying navigation systems, the Garmin 296 and the Avalex system. To the Garmin 296, he entered a “track up” map with a course line to his northerly destination. Consequently, the pilot then made adjustments to the Avalex system, by changing the map display (which powered up in a “north up” orientation), to a “track up” display. He further reduced the brightness, and switched from a street map display to a topographic map display.

Similarly, after starting the helicopter for the departure from the rescue location at the frozen lake (the mishap flight), the pilot made inputs to his Garmin 296 unit to display a “track-up” map with a magenta course line that extended to the southwest (capable to showed terrain features like rivers and lakes), representing a direct route to his destination. However, this time the pilot did not make adjustments to the Avalex system, which then remained in the “north up” map orientation and a street map display that showed the outlines of rivers and lakes. Unlike his initial flight up to the rescue location, the two displays were presented with different orientations.

The Garmin 296 was physically located closest to the pilot’s ease of view under his NVG’s on the right side of the instrument panel; whereas the Avalex was on the far left side of the panel. With the images showing the TFO and the pilot pointing to the map display on the Avalex, and constant head movement across the panel, different from a regular instrument scan, it became apparent that the pilot was handling all the navigational tasks himself during the accident flight, and that he did not optimally configure the helicopter’s navigational equipment and flight instruments before departure. Furthermore, it was evident that the only the pilot was using NVGs on both legs of the flight. The pilot’s hands were seen raising, lowering, and adjusting his NVGs several times during the entire flight.

2.3.4. The Mishap Leg

The Vision 1000 recorded flight track data were overlaid with weather depiction charts. Thus, the investigators were able to see the flight’s encounter with instrument meteorological conditions (IMC) that had accumulated in the area during the time of the rescue.

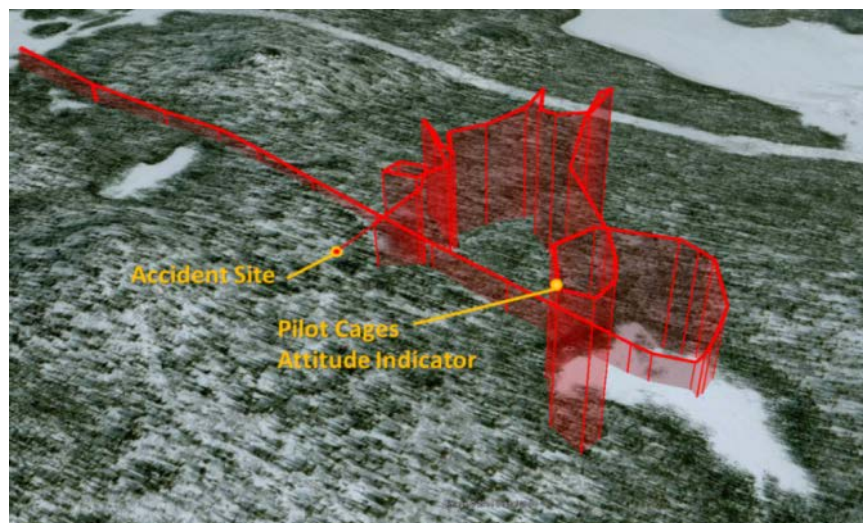


Fig. 6: End of the flight path; pilot cages gyro and accident site

With just the track information from the Vision 1000 overlaid with a mapping software, like Appareo's AS-Flight Analysis or even GoogleEarth, the investigation team was able to retrace the flight (Fig. 5 and Fig. 6). The first leg was a straight and level flight path at a fixed altitude (~1,200 feet MSL) from Anchorage to the staging area for the TFO pick-up, and again a direct leg to the frozen lake near the rescue location. However, when the mishap flight departed the frozen lake in a southwest direction, it was noted that its flight path track was at a much lower altitude (~700 feet MSL), apparently tracking a nap-of-the-earth profile. Approximately one mile out from the departure point, the pilot made an abrupt 90 degree turn to the east. This was the first indication that the pilot may have been disorientated. Shortly after the turn, it appears that the track has been re-aligning with cross-country high-tension power lines that run generally north-south. Then, the flight continued low-level with a southerly heading. After approximately two miles the flight comes to a clearing in the trees where the final stages of the track are shown making non-coordinated maneuvers in both direction and altitude. In close proximity to this area the flight track ends at the accident site on a heading of 030 degrees.

The inclement weather may have explained the 90 degree left turn to the east and then realigned back to the south when the pilot saw a power-line pole directly out in front of him. To determine the cause of the sporadic non-coordinate maneuvers at the end of the flight was in the focus of the investigation. So the parametric data from the digital gyro information of the Appareo unit was correlated with the aircraft's analog instrument readings obtained from the captured image information for further understanding of the mishap sequence (Fig. 6). The actions of the pilot seen in the image information is what revealed the 'why' and what contributed to the ultimately peril of the flight. At approximately 2318, just after the helicopter flight path was seen slowed down and almost began to hover in the clearing of trees, the helicopter began to drift up and turn back and to the left, as the pilot reached out and caged the attitude indicator gyro during the flight. Caging an attitude indicator sets its display to a level flight attitude (0° pitch and 0° roll). This action is intended to be performed only when an aircraft is in a level flight attitude, such as on the ground or in straight-and-level, un-accelerated flight. After this event, the helicopter entered a series of erratic turns, climbs, and descents.

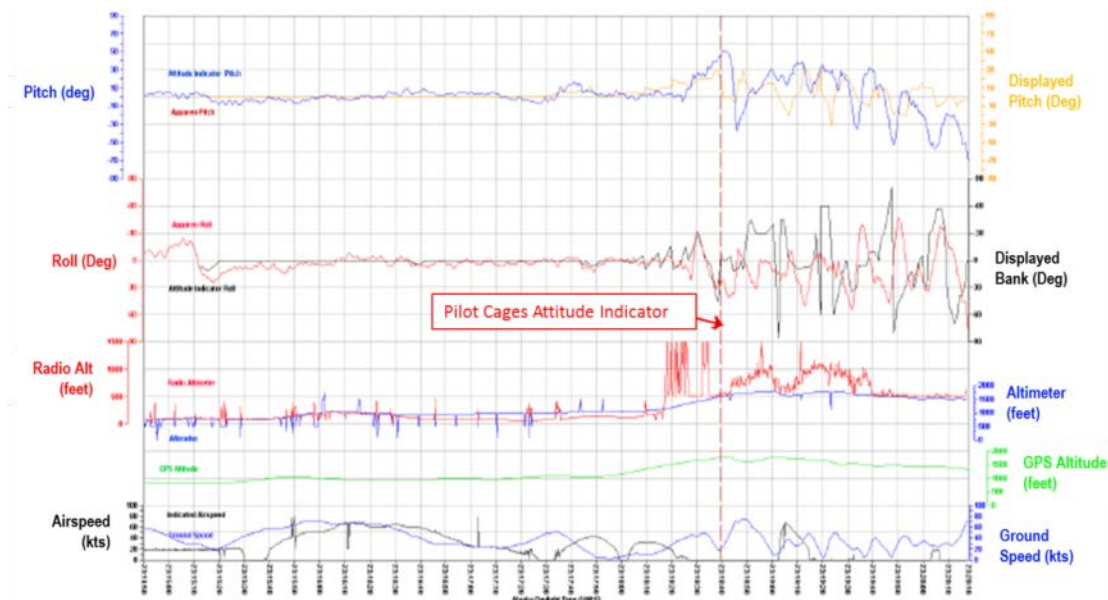


Fig. 7: Plot of last 5 Min. Combined Appareo & Image Derived Data

In Fig. 7 the parametric data confirms the pilot's action of caging of the Attitude Indicator gyro that was seen in the recorded images. This is indicated by the dashed red vertical line.

Without the imagery and parametric data obtained from the Appareo unit, we would never have known this pilot action; and would have lost critical information on the contributing factors leading to the accident.

2.3.5. Investigation Areas and the Improvements Resulting from Vision 1000 data

➤ Human Factors

Typically investigators have only been able to gather personality, health and ability information from family, friends or doctors. As well, to understand how pilot's and crew would normally utilize or interacted with the aircraft and its systems, they would glean from statements of other employees, friends or colleagues who have worked with the crew in the past. Versus now, with the Vision 1000, investigators are able to see the actual human condition and engagement at the time of event. As well, with FDM history, investigators can see flight operational/behavior trends. Trends that are an important aspect of the investigators collection process include the pilot's recent experience or their 72-hour history. Typically investigators only know what is reported by friends, family or employers. However, with FDM history, the trends are logged with time-stamped records that show the workload expressed in the flight activity levels, and with further review can show fatigue or actual pilot handling.

➤ Mechanical Factors

Typically investigators have only had aircraft engineering records or logbook information, culminated with tediously forensic analysis on post-accident parts and pieces for operational integrity or failure modes analysis. However; now with the onboard Vision 1000, investigators are able to see many of the aircraft's mechanical, electrical or pneumatic systems function from the pilot's point of view. As well, with FDM history we can see at what time components or systems failed or began to weaken or disprove speculation on technical failures if the systems were recorded healthy during the flight.

➤ Environmental Factors

Investigators have generally only had meteorological information that was reported and/or collected by weather service outlets at varying times and distances away from the accident site. With the Vision 1000, recorded images show segments of the weather around the aircraft at the time of the event.

2.3.6. The Value of the Vision 1000 Data for this Accident Investigation

1. Investigators were able to capture the entire flight on both image and digital parametric data and able to replay the flight for detailed analysis.
2. The image recording was instrumental in determining the accident circumstances by enabling to identify 'why' the event happened and not just 'what' happened. Also, it confirmed the absence of mechanical malfunctions as determined during the traditional wreckage examination
3. Identification safety issues: The images allowed to determine that the pilot caged the attitude indicator in flight. This discovery resulted in the development of important safety recommendations related to pilot recurrent training and attitude indicator limitations, as well as the dangers of instrument panel information overload in using multiple mapping tools by identifying the difference in navigating with one unit displaying "track up" vs. "north up" and to prevent future accidents from procedures practices like the caging of the gyro in flight.
4. It provided strong information about where the crew's attention was directed.

5. It showed the pilot's interaction with the helicopters input flight controls and systems.
6. It showed the cockpit configuration; i.e. GPS/mapping units, the status of the cockpit instruments, switches, and indicator lights; including those that provided information of the aircraft's systems, navigation and position, engine operation, and tools in use by the pilot like his lip light and NVG's.
7. It excluded any technical issues on the helicopter without the necessity for a detailed and expensive post-crash investigation analysis.
8. Although the intercommunication system audio recording was not installed, the ambient audio recording allowed the resonation of the main rotor blade RPM and transmissions to be heard.

3. Immersive Witness Interview (iwi®) Methodology and Application for Flight-Path Reconstruction

The analysis of aircraft accidents can be complicated and time consuming, especially when limited information about the flight path and the accident situation are available. Eyewitnesses can be taken into account, but it is often difficult to find out which witness tells the truth and who can provide a good statement regarding the observed accident. However, more and more accidents are recorded by witnesses with their smartphones or by surveillance cameras. The Immersive Witness Interview (iwi®) is designed to compensate for inaccuracies in witness information and to quickly approximate the available information.

The method iwi® has been developed in 2009 to make use of available witness information for accident reconstruction with reduced time and costs, especially for accident case with limited information available (missing radar data due to low flight altitude and/or FDR data not available) as shown in Fig. 8

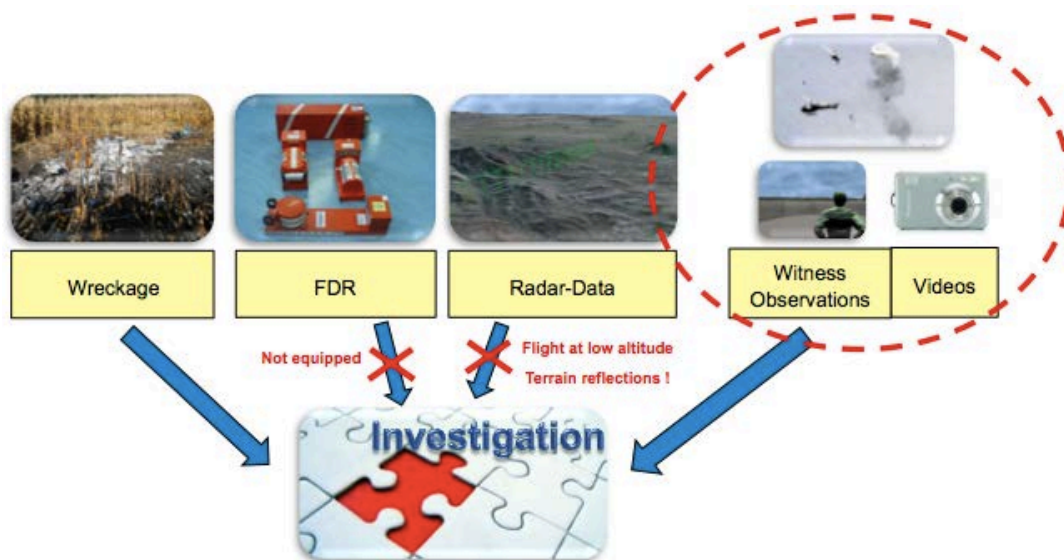


Fig. 8: Overview of available information for accident reconstruction [5]

3.1. Quality and Accuracy of Witness Statements

The quality and accuracy of a witness statement depends on the stimulation of a witness memory, the complexity of the observation and the level of stress that occurred to the person during the situation. Fig. 9 shows the overview of the main senses of a human and in example information of an aircraft observation (observed movements and noises, the environment and conditions surrounding the witness during the observation). An eyewitness uses surrounding objects / reference objects to recall the observed aircraft positions and movements.

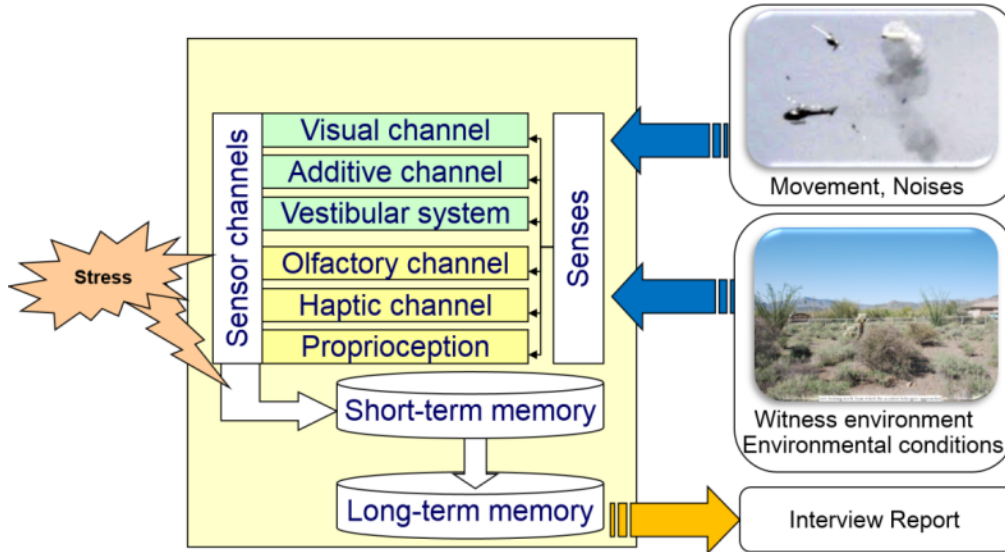


Fig. 9: Witness awareness and memory [5]

The accuracy of a testimony has been differentiated between a simple (linear flight, in example an aircraft flying by) and a complex observation (dynamic flight, in example an acrobatic air show flight with many manoeuvres). According to psychology studies, Fig. 10 shows that the memory accuracy of simple and complex observations differs with higher stress that occurs to the eyewitness.

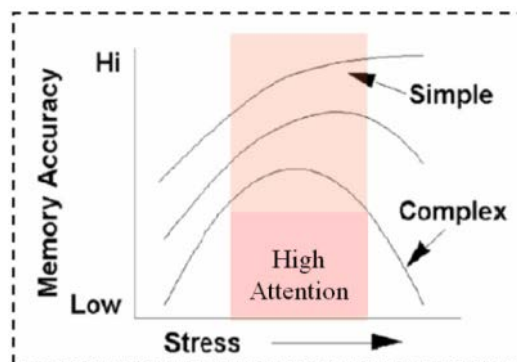


Fig. 10: Human memory and influence of stress [3]

A minimum of stress is required to have a minimum of attention to the observation to gather a necessary amount and content of information. Stress during an observation can also reduce the amount and

quality of the information that is stored in the human memory, in example emotions or a situation that brings the witness in danger.

Today, more and more accident observations are recorded by witnesses with their smartphones or by surveillance cameras, providing a new source for information. In those cases the accuracy of the observation depends mainly on the resolution of the camera, the pixel size of the observed aircraft and the information of the location at attitude of the camera. Many cameras are already equipped with GPS and attitude sensors and are recording these data. It is possible to estimate that information based on camera lenses information and the locations of visible reference objects.

3.2. Witness Information Processing and Flight Path Reconstruction

The witness reports are transformed in three-dimensional coordinates and a flight path of an observed aircraft can be approximated including all potential errors. iwi® has been evaluated in the beginning of 2009 with a test in real circumstances in cooperation with the Federal Armed Forces Flight Safety Division and support by the German Air Force. A real flight was observed and reconstructed based on testimony information. The amount of time between witness observation and interview had been evaluated as well.

The witness interview using iwi® can be performed in an office environment at any time without limits due to weather and day conditions. Only the witness position and the possible area where the witness was standing during observation have to be identified on site. Images of the surroundings are taken to generate a panoramic image for the interview, the panoramic picture is then used to track the observed flight path. All the necessary information is gathered during an interview with the witness and as explained at the following links:

- iwi® questionnaire on paper: http://www.iwi.eu/downloads/iwi_questionnaire_1_6.pdf
- interview on iPad: <http://itunes.apple.com/us/app/iwi-witness/id495551273?mt=8>
- iwi-app how-to document: http://www.iwi.eu/app_media/howto.pdf

The information is loaded into the Immersive Witness Analyzer (IWA) that approximates the flight path with the assigned errors. The performed iwi® studies have shown, that the error of a described aircraft position increases in elevation with the distance of the original aircraft position to a referenced object (in example a tree, house, mountain). The iwi® method takes all relevant errors into account, for example the distance of the witness to the reference objects, which drives the errors in elevation and azimuth. Thus, a reference object being close to a witness causes a bigger error for the reconstructed flight path.

Based on at least two different witness reports or videos taken from different positions, a flight path can be reconstructed by IWA. The result contains the aircraft positions showing the approximated flight path with the estimated error but without time information. The attitude of the aircraft can be individually given due to witness description or video information. The results can be shown to the witness for final verification.

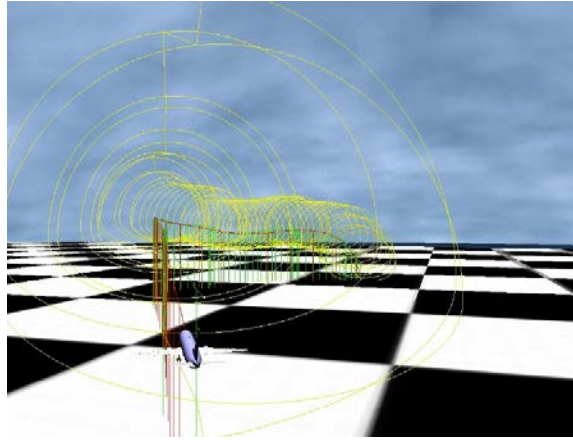


Fig. 11: Approximated flight path (red) with error tunnel (yellow) [5]

As shown in Fig. 11, a yellow error tunnel can be visualized to localize the area where the aircraft was flying with the utmost probability. This approximation considers errors like the accuracy of witness testimony, GPS accuracy, accuracy of location of reference objects, witness area position and photo camera adjustment. A final reconstruction is calculated based on Newton's iterative method and the total residuum declares the maximum error of the reconstructed flight path.

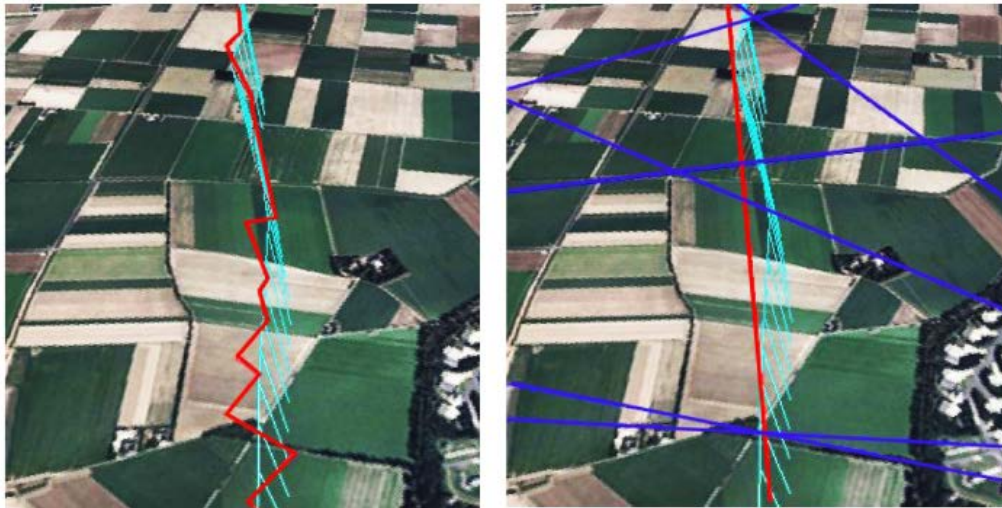


Fig. 12: Reconstructed flight path, approximated (left) and Newton's iterative method (right) [5]

The error calculations had been validated within a trial as shown in Fig. 12, the radar data in light blue and the reconstructed flight path in red. The left image shows the prior rough calculation and the right image the result of the Newton's iterative method with weighted witness lines of sight shown in dark blue.

iwi® has been presented to several international authorities as BFU, BEA, EASA, NTSB and FAA. It has been successfully applied since 2009 with applications in Africa, Australia, Chile, Germany and the USA. Actual information about the method and supported accidents can be found at www.iwi.eu [6].

3.3. Experiences and Lessons Learned Applying iwi® During Accident Investigation

This new method can help especially for accidents of small helicopters and aircraft that are not equipped with an FDR to reconstruct the flight path based. Airbus Helicopters has supported this development to provide as much information as possible to clarify the cause of an accident to maximise the lessons-learned.

Even if the aircraft was equipped with an FDR or radar data is available, the method allows merging witness information with the available information, thus taken into account all available information.

The Immersive Witness Interview method provides a way for witnesses to provide a more visual, objective recollection of their observations in comparison to conventional techniques. Investigators can leverage this information to better understand the flight path, attitude and manoeuvres of the aircraft prior to impact, which is crucial to understand the causes and contributing factors of accidents.

Experience has shown the following:

1. There is a strong correlation between the number of witnesses and the accuracy of the reconstructed flight path.
2. There is also a strong correlation between the number of different vantage points and the accuracy of the reconstructed flight path.
3. Witnesses, who observe the flight path without any significant reference objects, seem to have difficulty in judging altitude.

To illustrate the usefulness of the method, a flight path of an event has been reconstructed using information obtained from two witnesses ('red' and 'blue' witness). The witnesses described an observed flight path that depicted a relatively horizontal track, seemingly from east to west, only slightly descending as it moved across the horizon from their vanish point, Fig. 13 and Fig. 14.

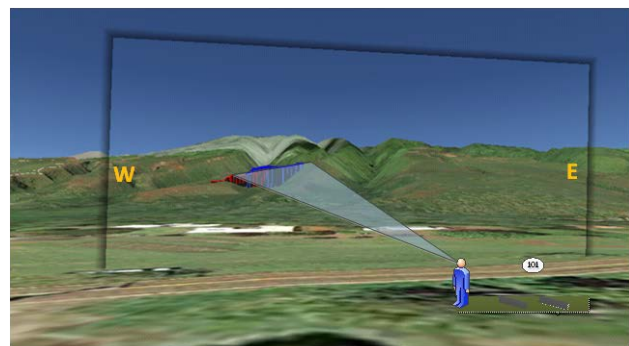
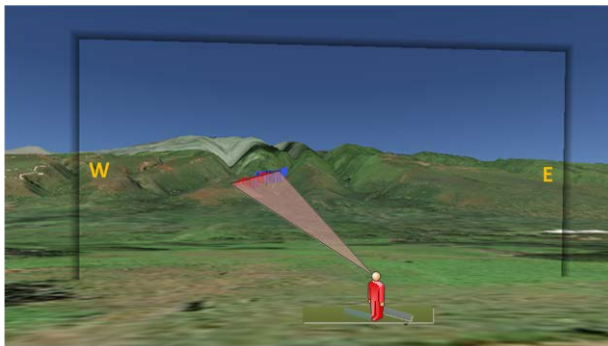


Fig. 13: Illustrated observations of Red Witness

Fig. 14: Illustrated observations of Blue Witness

It is obvious that both witnesses' observation are matching, increasing their credibility; and secondly, that in reality the observed flight path once mapped into the 3 dimensional mountainous terrain was not from east to west, but in fact from north to south, as seen in the top down view of Figure 15. Without the use of this method the written statements alone would have told a wrong story.

Additionally, the flight paths of the two witnesses are merged into a three-dimensional view that can be seen in a virtual earth environment with an error tunnel depicting the accuracy of the location, Fig. 16.



Fig. 15: Actual flight path is north to south

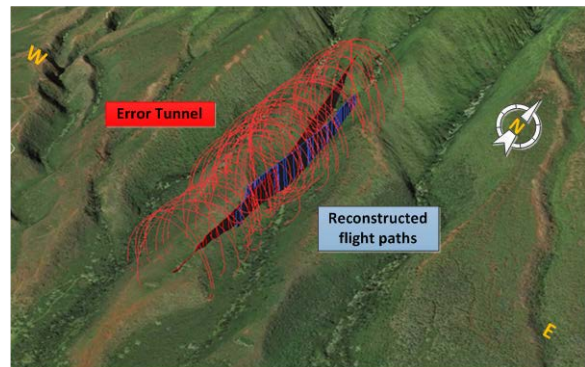


Fig. 16: Combined reconstructed flight path and statistical error tunnel

4. Conclusion

In the absence of data recording equipment on many helicopter operations, it is often extremely difficult to obtain a proper and detailed causation for helicopter accidents. Thus, a strong initiative is taken by Airbus Helicopters to equip the fleet with the 'light' data recording device not only enabling the operators to perform flight operations quality improvement by using the equipment, but also vastly improving the investigation after an accident. The significant added value has been clearly illustrated by the application on the Alaska State trooper accident.

Even in the absence of any recorded flight data, but with witnesses or cameras having observed an accident, a meaningful reconstruction of the flight path can be done using the Immersive Witness Interview (iwi®) method taking into account error in recollection or memory accuracy and reducing the data accordingly with optimizing numerical methods.

Both methods described offer a significant improvement in accident investigation for helicopter accidents or accidents in General Aviation.

5. References

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6. Abbreviations

BEA	Bureau d'Enquêtes et d'Analyses pour la sécurité de l'Aviation civile
BFU	German Federal Bureau of Aircraft Accident Investigation
CVFDR	Cockpit Voice and Flight Data Recorder
EASA	European Aviation Safety Agency
FAA	Federal Aviation Administration
FDR	Flight Data Recorder
GPS	Global Positioning System
HEMS	Helicopter Emergency Medical Services
HFDM	Helicopter Flight Data monitoring
IMU	Inertial Measurement Unit
IWA	Immersive Witness Analyzer
iwi®	Immersive Witness Interview
NTSB	National Transportation Safety Board
NVG	Night Vision Goggles
SAR	Search and Rescue
STC	Supplementary Type Certificate
VFR	Visual Flight Rules