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***Dr. Marcus Bauer** is director and founder of MSimulation, which provides iwi® reports. Since 2015 he has been the head of technology at the Center of Competence Additive Manufacturing/3-D Printing at the Digital Factory at Siemens. Prior to that, he was the head of simulation and tools at Airbus Helicopters. He received his Ph.D. and a master of science degree in mechanical engineering from Darmstadt University and a bachelor degree in aeronautics from the University of Applied Sciences of Munich.*

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Certification specifications for small rotorcraft (CS-27) do not mandate that helicopters be equipped with data recorders, nor do operational requirements for a big part of the worldwide 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 follows a twofold approach to improve this situation. Firstly, the Vision 1000 cockpit image and data recorder was developed as standard equipment in Airbus Helicopters helicopters but outside the regulatory requirements, resulting in simplified certification and much lower costs. The features of this device and first applications are presented here, as well as the deployment policy in the fleet.

Secondly, the method "Immersive Witness Interview" (iwi®) is discussed. It provides a qualitative and simple analysis of accident flight path using eyewitness statements. The methodology uses information gained from interviewing multiple eyewitnesses or recorded videos from smartphones or observation cameras to reconstruct and define a vehicle's flight path and aircraft attitudes in a 3-D 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 Google Earth or videos showing the approximated flight path from different perspectives.

Vision 1000

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. The system is compliant with the Helicopter Emergency Medical Services (HEMS) FAA Part 135.607 and the European Aviation Safety Agency (EASA) rulemaking task 0271/0272, mandating a light data recorder for light helicopters and aircraft starting at the 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 (nonrequired safety-enhancing equipment) initiative with the objective to promote the installation of nonrequired safety-enhancing equipment.

The Vision 1000 system is a flight data, audio, and cockpit image data recorder. The imaging recording capability offers advantages over much more expensive, heavier, and maintenance-burdened cockpit voice and flight data recorder (CVFDR) equipment as required for large rotorcraft. It captures pilot/crew actions

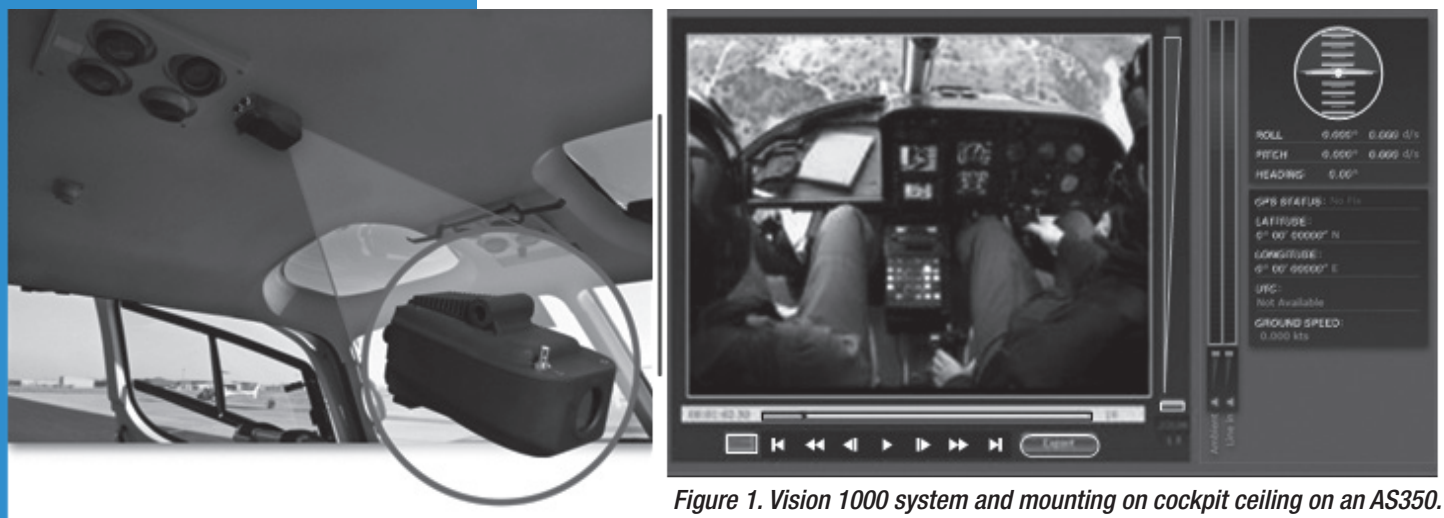

Figure 1. Vision 1000 system and mounting on cockpit ceiling on an AS350.

MODERN TECHNOLOGIES AND METHODOLOGIES IMPROVE HELICOPTER ACCIDENT INVESTIGATION

The Vision 1000 cockpit image and data recorder was developed as standard equipment in Airbus Helicopters helicopters but outside the regulatory requirements, resulting in simplified certification and much lower costs.

By Dr. Thomas Gogel and Seth Buttner, Airbus Helicopters; and Dr. Marcus Bauer, MSimulation

and behaviors during flight, manipulation of flight controls and systems, noise, and even a view of 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.

Description of system

The system features a forward-facing image acquisition of the cockpit using four frames per second, with 2.2 megapixel resolution, audio recording (ambient noise and intercom system), GPS position data, and an inertial measurement unit (IMU) to record attitude. The unit weighs 300 grams. A removable memory can store four hours of image and audio and 200 hours of inertial data (position and attitude). The hardened internal memory is capable of storing two hours of image and audio and 200 hours of inertial data.

The unit is installed in the helicopter to provide a view of the instrument panel and a partial outside view (see Figure 1).

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

A further review capability offering features such as automated event analysis and reporting with a web-based access is provided as well. Vision 1000 is not crash-hardened per a certification requirement. But a review of past accidents indicates a crash survivability of more than 90 percent.

(Adapted with permission from the authors' technical paper entitled Use of Modern Technologies and Methodologies to Improve Helicopter Accident Investigation *presented at ISASI 2015 held in Augsburg, Germany, Aug. 24–27, 2015, which carried the theme "Independence Does Not Mean Isolation." The full presentation, including cited references to support the points made, can be found on the ISASI website at www.isasi.org under the tag "ISASI 2015 Technical Papers."—Editor)*

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 helicopter flight data monitoring (HFDM) features of the device and data reduction software. For accident investigation boards and the helicopter manufacturer, it is a valuable device to establish root causes for accident and incidents that would stay open without this data recording device. Thus, the Vision 1000 deployment is a key element in Airbus Helicopters' "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 an FAA supplementary type certificate (STC) by Airbus Helicopters, Inc. in the United States. Vision 1000 has been 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 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. To stimulate the use of the equipment, specific customer trainings are performed during the delivery of the helicopters. Standalone 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 with 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 strongly promoting the installation of the device into the fleet. It is an important part of the safety policy.

Role overview of Vision 1000

On March 30, 2013, the Safety Department of Airbus Helicopters realized the critical value of Vision 1000 at the ultimate cost. Air safety investigators (ASI) responded to the fatal accident of the Alaska state troopers' AS350 B3 helicopter (N911AA), which crashed in the Talkeetna Mountains of the Alaska Matanuska–Susitna region approximately 80 nautical miles north of Anchorage. The helicopter impacted wooded and mountainous terrain while maneuvering during a night search-and-rescue 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 postcrash 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

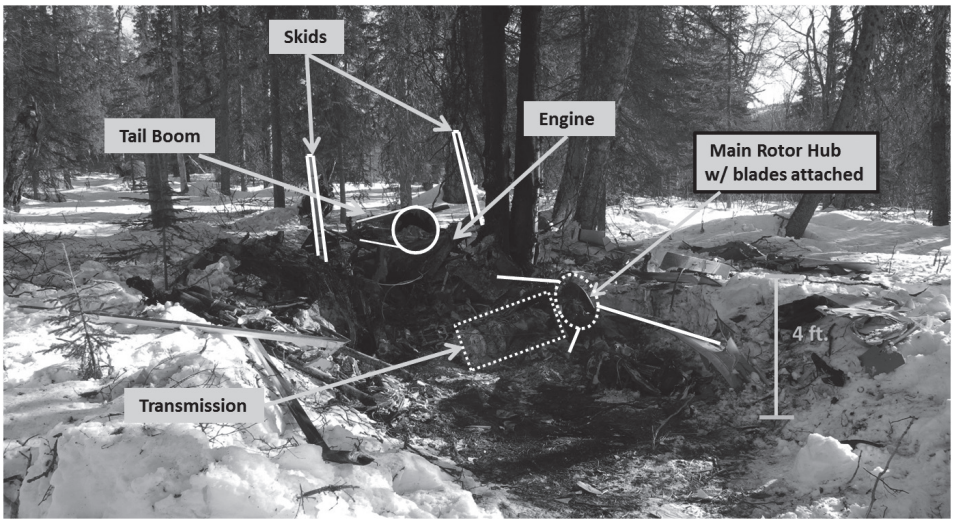

Figure 2. Accident site and location of wreckage and Vision 1000.

Vision 1000 cockpit imaging and flight data recording device.

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's executive summary of the accident:

"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."

The accident

At 2019, the pilot received notification of a rescue mission involving a stranded, hypothermic snowmobiler in a remote location approximately 80 nautical miles 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 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 Anchorage International Airport (ANC) in night VFR conditions and flew to pick up a TFO 15 nautical miles south of Talkeetna. With just the two state troopers on board, the helicopter departed to the reported rescue location coordinates under VFR conditions with the pilot utilizing night vision goggles (NVGs).

The recorded data show 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 departure, the recorded Vision 1000 data ended. The accident site was located the following day just 2.5 nautical miles south of the rescue location during the search after the aircraft was recorded missing.

Information obtained from Vision 1000

The aircraft was totally destroyed from the impact forces and postcrash fire. However, the helicopter's Vision 1000 unit was recovered from the rubble at the accident scene (see Figure 2). The unit had been mounted on the cockpit ceiling centered between the two forward seats, but became separated from the aircraft structure during the impact event and found lying among 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.

The unit was shipped to the NTSB's recorders laboratory in Washington, D.C., where the data were downloaded, reviewed, and analyzed. The extracted data were plotted by the NTSB's recorders lab in the same manner that the parametric data reports of traditional flight data recorders (FDR) are processed. Several plots were created to cover the entire flight. The recovered data included approximately two 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).

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 image 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 (able to show 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 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 NVGs 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 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.

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 IMC that had accumulated in the area during the time of the rescue.

With just the track information from Vision 1000 overlaid with a mapping software, like Appareo's AS-Flight Analysis or even Google Earth, the investigation team was able to retrace the flight (see Figure 3). 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 pickup 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

ISASI Joins IHST

Thanks to an initiative by Capt. Richard Stone, ISASI executive advisor, and Dr. Robert Matthews, ISASI has been invited to join the International Helicopter Safety Team (IHST).

Stone said the initiative results from numerous discussions about the role ISASI should take in the current challenge of lowering the accident rate in helicopter operations of all types, including medical, law enforcement, business, commercial, etc. Many technical papers concerning the subject have been presented at ISASI's annual international accident investigation and prevention conference.

"Our thoughts were presented to the FAA's Dr. Steven Sparks, who is leading the effort of the International Helicopter Safety Team. Dr. Stevens asked me and Robert Matthews to join their large committee of helicopter representatives," said Stone.

"Our ISASI contribution will be to put together a comprehensive look at helicopter accidents in the recent past. We plan to present the complete report of our findings at ISASI 2017, which will be held in San Diego, California. Our database will cover more than 676 helicopter accidents from 2001 to 2015 in many of parts of the world."

The IHST was established following the International Helicopter Safety Symposium (IHSS) held in September 2005 in Montreal, Canada, where the central theme was the recognition that long-term helicopter accident rates have remained unacceptably high, and trends have not shown significant improvement over the last 20 years. A call to action was unanimously accepted by those in attendance at IHSS 2005.

The IHST was created to lead a government and industry cooperative effort to address the unacceptably high long-term helicopter accident rates. The IHST chose to pursue the goal of reducing the worldwide civil and military helicopter accident rates by 80 percent in 10 years by adopting the methods that have been used by the Commercial Aviation Safety Team (CAST) to substantially reduce the worldwide fatal accident rate in the commercial air carrier community. The process used by CAST was directly linked to real accident data, used a broad spectrum of industry experts to analyze it, and included objective success measurements to ensure that the actions taken were having the desired effect.

The all-volunteer IHST effort is coordinated by an executive committee that is co-chaired by a senior representative of the FAA's Rotorcraft Directorate and by the president of the Helicopter Association International. Other members represent the America Helicopter Society International, the Helicopter Association of Canada, the European Helicopter Association, the European Helicopter Safety Team, the National Aeronautics and Space Administration, helicopter manufacturers, and the International Association of Oil and Gas Producers.

The initial effort focused on the U.S. helicopter fleet and has grown to encompass international partners in Brazil, Canada, India, Australia, the Gulf Cooperative Council, and Japan. In addition, the European Helicopter Safety Team joined in 2007 to cover the European helicopter fleet. Outreach efforts are under way in Russia, Mexico, South Africa, and Korea.

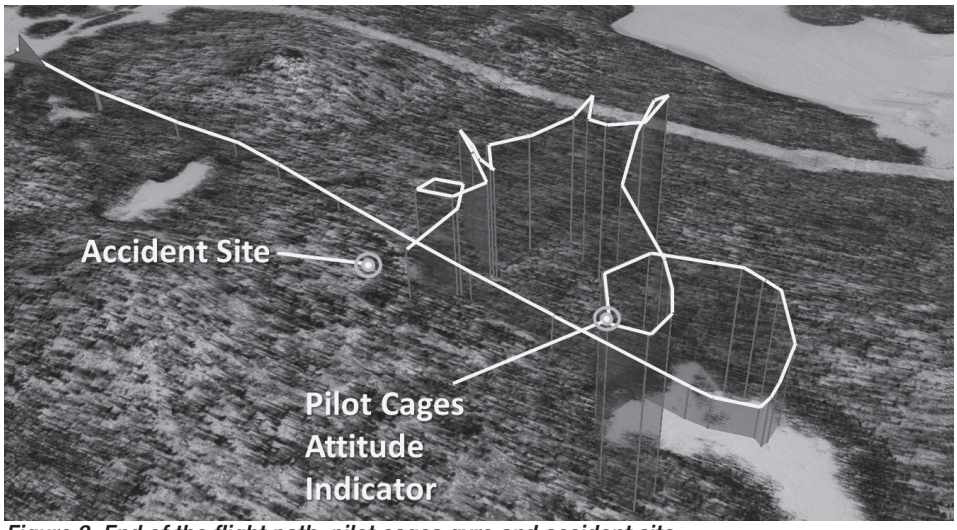

Figure 3. End of the flight path; pilot cages gyro and accident site.

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 had been realigning with cross-country high-tension power lines that run generally north to south. Then the flight continued at a low level with a southerly heading. After approximately two miles, the flight came to a clearing in the trees where the final stages of the track were shown making noncoordinated maneuvers in both direction and altitude. In close proximity to this area, the flight track ended 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 realignment back to the south when the pilot saw a power line pole directly out in front of him. Determining the cause of the sporadic noncoordinated maneuvers at the end of the flight was a focus of the investigation. The parametric data from the digital gyro information of the Appareo unit was correlated with the aircraft's analog instrument readings that were obtained from the captured image information to further understand the mishap sequence (see Figure 3, page 21).

The actions of the pilot as seen in the image information revealed the "why" and "what" that contributed to the ultimate peril of the flight. At approximately 2318, just after the helicopter flight path was seen to slow 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 degrees pitch and 0 degrees 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, unaccelerated flight. After this event, the helicopter entered a series of erratic turns, climbs, and descents.

The parametric data confirmed the pilot's action of caging the attitude indicator gyro that was seen in the recorded images. 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

Vision 1000 data results

- Human factors—Typically investigators have only been able to gather personality, health, and ability information from family, friends, or doctors. In addition, to understand how pilots and crews would normally utilize or interact 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. Now with Vision 1000, investigators are able to see the actual human condition and engagement at the time of event. With flight data monitoring (FDM) history, investigators can see flight operational/behavior trends as well. Trends that are an important aspect of the investigators' collection process include the pilots' 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 further review can show fatigue or actual pilot handling.
- Mechanical factors—Typically investigators have only had aircraft engineering records or logbook information, culminated with tedious forensic analysis on postaccident 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—Generally investigators have 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 Vision 1000, recorded images show segments of the weather around the aircraft at the time of the event.

Vision 1000 data value for this accident investigation

- Investigators were able to capture the entire flight on both image and digital parametric data and were able to replay the flight for detailed analysis.
- The image recording was instrumental in determining the accident circumstances by enabling investigators 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.
- The images showed that the pilot caged the attitude indicator in flight. This discovery resulted in developing important safety recommendations related to pilot recurrent training and attitude indicator limitations. It also highlighted the dangers of instrument panel information overload in using multiple mapping tools by identifying the difference in navigating with one unit displaying track up versus north up. The discovery is also

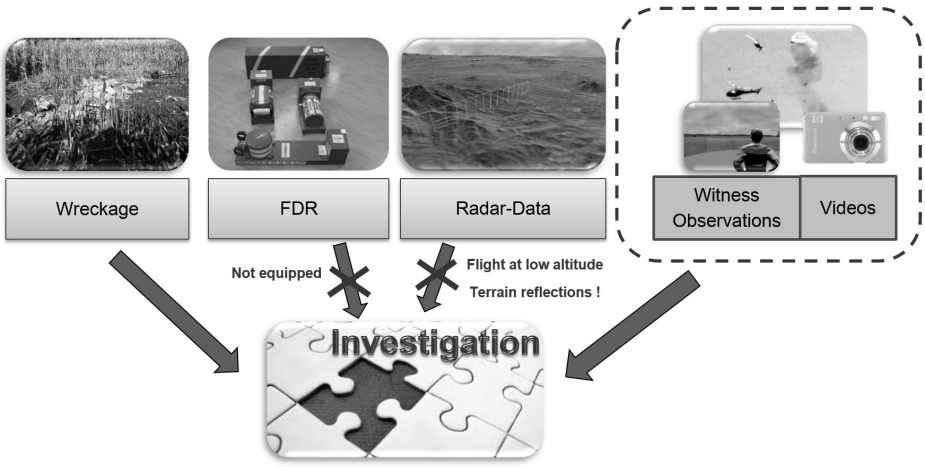

Figure 4. Overview of available information for accident reconstruction.

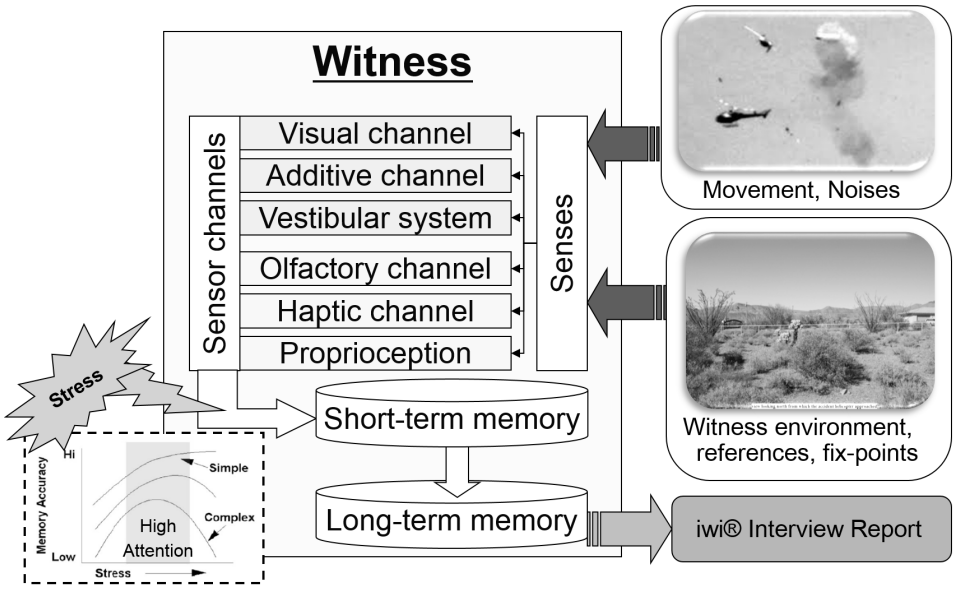

Figure 5. Witness awareness, memory, and the influence of stress on memory accuracy.

useful in preventing future accidents from practices like caging the gyro in flight.

- It provided strong information about where the crew's attention was directed.
- It showed the pilot's interaction with the helicopter's input flight controls and systems.
- It showed the cockpit configuration, e.g., GPS/mapping units; the status of 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, such as his lip light and NVGs.
- It excluded any technical issues on the helicopter without the necessity of a detailed and expensive postcrash investigation analysis.
- 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.

Immersive Witness Interview (iwi®) methodology

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 is giving accurate information and which one 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® was developed in 2009 to make use of available witness information for accident reconstruction with reduced time and costs, especially for accidents with limited information available (missing radar data due to low flight altitude and/or FDR data not available) as shown in Figure. 4

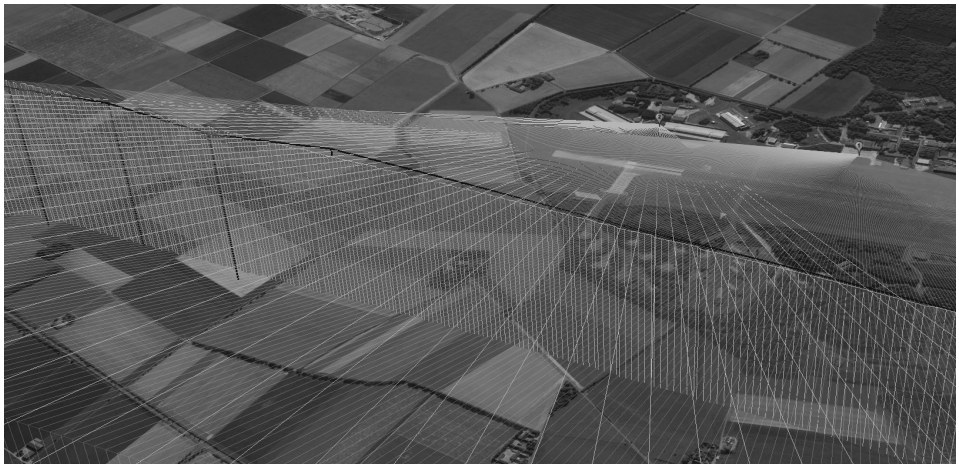

Figure 6. Reconstructed flight path (black line), lines of sight (grey lines), and radar data (grey path).

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. Figure 5 shows the overview of the main senses of a human and information of an aircraft observation. An eyewitness uses surrounding objects/reference objects to recall the observed aircraft positions and movements.

The accuracy of a testimony has been differentiated between a simple (linear flight, for example an aircraft flying by) and a complex observation (dynamic flight, for example an acrobatic air show flight with many maneuvers). According to psychology studies, Figure 5 shows in the lower left that the memory accuracy of simple and complex observations differs with the amount of stress the eyewitness is experiencing.

A minimum amount of stress is required to give a minimum amount of attention to the observation to gather a necessary amount of information. Stress during an observation can also reduce the amount and quality of the information that is stored in the human memory—for example, emotions or a situation that puts the witness in danger.

Witness information processing

Witness reports are transformed into 3-D coordinates, and the flight path of an observed aircraft can be approximated considering all potential errors. Iwi® was evaluated in the beginning of 2009 with a test in real circumstances in cooperation

(Continued on page 29)

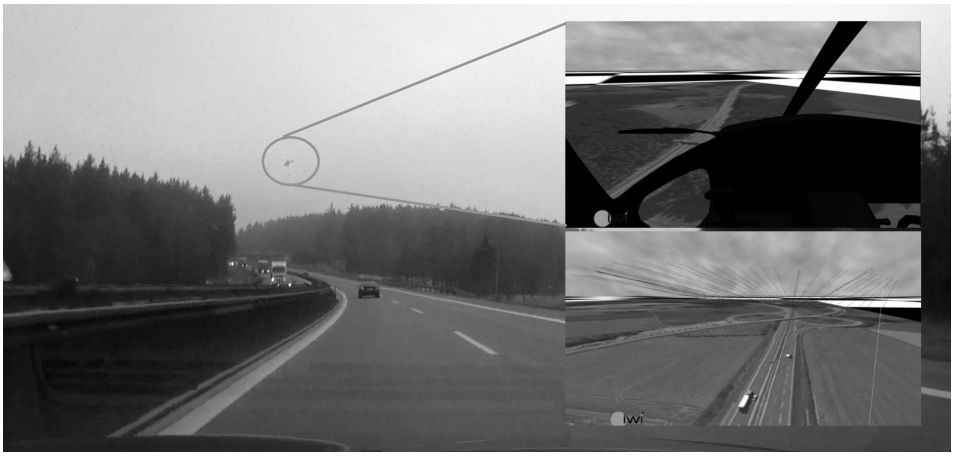

Figure 7. Car camera view with imported lines of sight (lower right), reconstructed helicopter path, and pilot's perspective (upper right).

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. Witness statements can be recorded with the free iwi® app.

The information (witness statements or videos) is loaded into the Immersive Witness Analyzer (IWA), which 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 (for 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 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.

A final reconstruction (see Figure 6, page 23), is calculated based on Newton's iterative method, and the total residuum declares the maximum error of the reconstructed flight path.

All the necessary information is gathered during an interview with the witness. For more information, visit the following links:

- Overview about the method and gathered experiences: http://www.iwi.eu
- Free app to perform interview on iPad: http://app.iwi.eu

Iwi® has been presented to several international authorities, including the Bundesstelle für Flugunfalluntersuchung, the Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile, the European Aviation Safety Agency, the NTSB, and the FAA. It has been successfully applied since 2009 to support different investigations in Africa, Argentina, Australia, Chile, Germany, and the United States. Some published reports can be found at http://www.iwi.eu/references.html.

Iwi® experiences and lessons learned

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

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

The iwi® method provides a way for witnesses to give 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 maneuvers of the aircraft prior to impact, which is crucial to understanding 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 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

It is obvious that both witnesses' observation are matching, increasing their credibility. Yet in reality, the observed flight path, once mapped into the 3-D mountainous terrain, was not from east to west, but in fact from north to south, as seen in the top-down view. Detailed information can be found in the report at http://www.iwi.eu/downloads/hawaii.pdf. Without the use of this method, the written statements alone would have told a wrong story.

Increased quality and accuracy due to video recordings

Today, more and more accident observations are recorded by witnesses with their smartphones, car cameras, or by surveillance cameras, providing a new source of good information. In these cases, the accuracy of the observation depends mainly on the resolution of the camera, the pixel size of the observed aircraft, and the information regarding the location of the camera. Many cameras are already equipped with GPS and attitude sensors

and are recording these data. It is possible to estimate this information based on camera lens information and the locations of visible reference objects as shown in Figure 7, an example showing the capabilities of iwi® to reconstruct a moving object based on moving witnesses.

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 was taken by Airbus Helicopters to equip the fleet with the light data recording device—enabling the operators to perform flight operations quality improvement by using the equipment, and 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 observing or recording an accident, a meaningful reconstruction of the flight path can be done using the Immersive Witness Interview (iwi®) method, taking into account errors 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. ◆