Potential and Capability of Eyewitness Data

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1. Introduction

Accident investigation encompasses a thorough examination of all available information. Alongside technical and material evidence, external observations recorded through videos, as well as eyewitness testimonies, play a crucial role. This paper aims to delve into the specifics of eyewitness information, exploring how these accounts can be utilized to reconstruct flight paths accurately.

In aviation accident investigations, the accuracy and reliability of eyewitness testimonies are paramount. This paper will address the methods and technologies that can be employed to capture, document, and analyze eyewitness information effectively. By examining the nuances of eyewitness accounts, we will identify the key factors that influence their precision and explore innovative ways to document these observations.

Furthermore, this paper will introduce the advancements brought by a software-application designed to enhance the collection and analysis of eyewitness testimonies.

Finally, the paper will provide a forward-looking perspective on how AR technology can further enhance the process of eyewitness interviews. Instead of drawing flight paths on smartphones or tablets, future implementations will allow for these paths to be traced directly using AR glasses. This advancement will enable investigators and eyewitnesses to view and verify the generated simulations on-site, streamlining the verification process.

By leveraging cutting-edge technology, we aim to improve the overall accuracy and efficiency of aviation accident investigations, ensuring that every piece of information is meticulously documented and analyzed.

2. Interview best practice

When conducting witness interviews, following best practices is essential to gather accurate and reliable information that can significantly contribute to the investigation.

First, it is crucial to **interview the witness as soon as possible after the event** to prevent memories from fading or becoming distorted over time. Early interviews help capture details while they are still fresh in the witness's mind, which can be vital for reconstructing the sequence of events accurately.

During the interview, it is important to **ensure that an audio recording is made**. Audio recordings capture not only the content of the witness's statements but also the tone, pauses, and any emotional nuances that might be significant. This comprehensive record is invaluable for later review and analysis. After the interview, **document the facts from the audio recording in written form**. This written documentation serves as a clear and organized account of the witness's testimony, making it easier to reference and cross-check with other evidence. Written records also provide a structured way to highlight key points and discrepancies that may need further exploration.

To preserve the authenticity of the witness’s account, it is essential to **avoid influencing the witness during the interview**. This is best achieved by conducting interviews individually, without the presence of others who might sway the witness's recollection. Additionally, avoid interrupting the witness; allow them to narrate their experience fully before asking follow-up questions. This approach helps ensure that the narrative is their own and not shaped by external suggestions.

Finally, it is important to **validate the witness statement for consistency**. Review the testimony carefully to identify any contradictions or unclear points and seek clarification if necessary. Maintaining contact with the witness after the interview can also be beneficial, as they may recall additional information or details that surface later.

3. Interviewing Eyewitnesses collecting visual information:

In this chapter, the eyewitness interview that aims to analyze witness statements using visual media with immersive validation capability shall be further explained. It introduces new features that approximate flight paths based on witness testimonies. Leveraging current technology and available applications and devices, the chapter describes the concept and explains the witness accuracy.

The witness perception, illustrated in Figure 1, shows the human factors that must be considered when collecting testimony information to describe an aircraft's movement.

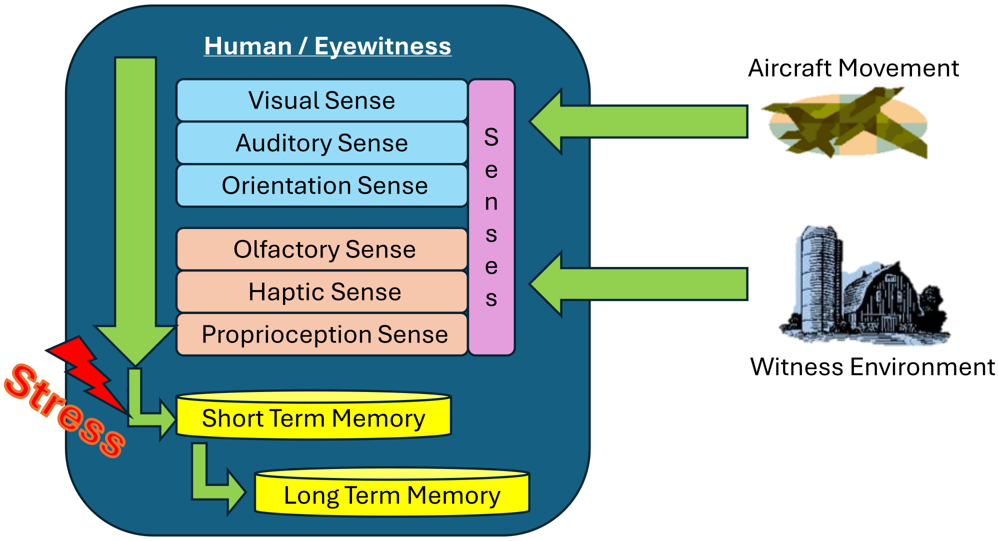

Figure 1: Sensory Perception and Memory

3.1 Physiology and Psychology of a Witness

A witness perceives their environment through *natural stimuli*. Figure 1 illustrates the **sensory modalities** of a witness. Besides *visual* and *auditory* perception, the *sense of orientation* also plays a crucial role in observation. The aircraft's flight path is stored along with information about the witness's perceived environment. The individual sensory modalities are detailed as follows:

- **Visual Perception:** Key for observing the aircraft's movement and position. Information like Brightness, color, movement, etc.

- **Auditory Perception:** Helps in detecting and localizing aircraft noise, often drawing initial attention. Information like sound intensity, pitch, form, timbre, localization.

- **Orientation Sense:** Assists in understanding the aircraft's trajectory relative to the witness's location.

- **Other Sensory Modalities:** Include olfactory (taste and smell), haptic (pressure, tension, temperature sensors) and proprioception senses (pain, hunger, tension, etc.).

The witness perception to describe an observed aircraft movement is mainly perceived by the visual and auditory channel. Typically, an observer becomes aware of an aircraft due to its noise or unusual visual movements, which helps localize the initial aircraft position. The movement is visually tracked by the testimony. Poor visibility conditions, like fog, can negatively impact visual contact. The orientation sense and visual memory allow witnesses to perceive the aircraft's position and trajectory relative to their location, storing reference objects visually. Humans perceive their environment visually through the eyes, with sensory stimuli processed in the brain. The eye lens adjusts for sharp imaging, a process called accommodation, which slows with age. Visual acuity depends on factors like light intensity, distance, object movement, contrast, and age. Strong light sources can impair form perception, and effective eye movement coordination is crucial for tracking moving objects.

The human visual field has a central area for focused vision and a peripheral area for detecting brightness and movement, aiding orientation and balance.

The **witness physiology** emphasizes that the witness's sensory inputs are fundamental to the observation process, impacting how *accurately* the flight path and related events are recorded and recalled.

Olfactory and haptic sensory modalities, though secondary, can record environmental characteristics, the witness's location and may trigger long term memory information when the witness is back in the observed location and environment. However, these channels may become relevant in very specific witness interviews. The observed information is stored in the human’s short-term memory. Depending on the impressions and situational emotional strength, information may be stronger stored with more details into humans’ long-term memory.

Human memory involves the ability to acquire, store, and retrieve information, consisting of short-term memory (STM) and long-term memory (LTM). Sensory stimuli are held briefly in STM before potentially transferring to LTM, which has a large capacity. Effective memory storage requires attention; otherwise, unheeded information degrades. STM can lose information due to new stimuli and interference. LTM comprises episodic (personal experiences), semantic (facts), and procedural (skills) memories. STM formats information through cellular and neural changes, holding it for about 10 to 20 seconds. Rich associations improve the transfer from STM to LTM. Information retrieval is a two-phase process:

Identifying key features and accessing the complete memory. Recognition is easier than recall, with sensory cues aiding memory retrieval. Emotions and stress can impact memory storage, sometimes leading to repression or loss of memories.

Psychological factors such as stress and event attention influence information processing. Emotional involvement during accident description can indicate statement credibility. A stored emotional response, evident when witnesses relive the incident emotionally, can support the authenticity of their testimony but the accuracy of the information must be closely reviewed as witness. Psychological studies indicate that stress during observation can negatively impact perception and information processing. Additionally, both psychological and physical fatigue, which can be quantified in degrees, can lead to reception and perception disturbances. Perception should be viewed as a hypothesis tested against sensory inputs. All this may explain, why witness statements are been taken with care during accident investigation and must be closely reviewed with additional time effort and statements must be checked about the consistency and how statements match with other available information.

Eyewitness testimony is often used in event evaluation, relying on the brain's complex memory storage and retrieval processes. Studies in criminology have assessed eyewitness credibility under lab and realistic conditions, showing that longer observation times lead to more accurate and detailed descriptions of events and perpetrators.

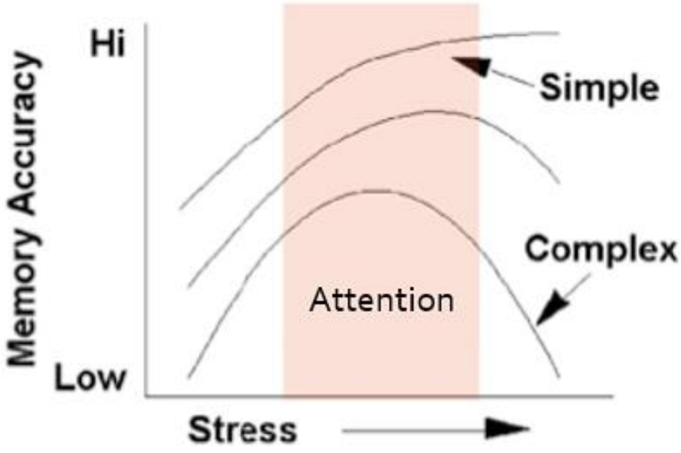

Figure 2: Graphical representation of the relationship between memory accuracy and stress levels

However, stress negatively affects the accuracy of eyewitness accounts, with high stress levels leading to more errors. Moderate stress can enhance attention and concentration, but both very low and very high stress levels impair memory. The complexity of the observed situation also impacts memory quality; simple movements are easier to remember than complex, dynamic ones. Stress during complex observations further degrades memory quality.

Credibility of testimony is linked to stress and observation duration. Longer observation times generally result in better recall. Older adults have reduced short-term memory capacity and slower information processing, while young children can provide credible testimony, though a psychologist's involvement is recommended in legal contexts.

3.2 Documenting the Witness Observation

The witness interview starts with the documentation of the witness location, where the event was observed. GPS information is logged with GPS precision.

Images are taken on site that represent the field of view of the witness, as the event was observed. The images laid out side by side, represent the witness's field of view at the location. The witness marks on the image the initial position where the aircraft was observed with T0 and the last position where the aircraft was seen with T2. The witness then connects these points T0 and T2 with a line, representing the flight path from the witness perspective. An additional position T1 between T0 and T2 may finally be added by the witness, if any special observation, like visible smoke, shall be documented. This process helps assess the credibility of witness statements and could be used in future accident analyses to compare witness observations with flight data recorder information. Multiple witness statements can be recorded and saved in the application for further analysis.

These images with the marks are then digitized and the resulting lines of sight can be used to reconstruct flight path or validate consistency of different witness statements.

Figure 3: Flight-Path-Description by witness

The accuracy of the flight path description is evaluated by measuring the distance between the described position and the contour of reference objects like trees or objects. The accuracy of the witness GPS position, distance to the objects in meters and the distance of the described flight path to the object in degrees drive the error calculation to estimate the accuracy of the witness statement.

3.3 Exemplary results of witness interview

The methodology was applied first in 2009 to demonstrate the potential collecting witness statements with images taken on site.

3.3.1 “Neuhausen ob Eck”, Germany, 2009

On the 3rd of October 2009, shortly after take-off, a microlight aircraft crashed 160m north from the runway into a hangar at the Airfield in “Neuhausen ob Eck” in Germany. The wreckage burned out and the flight path was unknown. Therefore, the flight-data had to be reconstructed using iwi®.

On site several witnesses had been interviewed together with BFU and local police. Images were taken at the position of the witnesses and the observed flight path was marked in each picture (T0 – First observed location, T2 – Last observed location, T1 – Observed location between T0 and T2). The flightpath could be reconstructed with the iwi® methodology based on the interview information of the witness that were nearby to the hangar and of the airfield’s tower personal.

Information Source: https://www.iwiation.com/uploads/7/2/7/0/72702293/bericht_09_3x169_ul-zodiac_neuhaus-ob-eck.pdf

Figure 4: Witness interview showing view with observed aircraft movement from T0 to T2

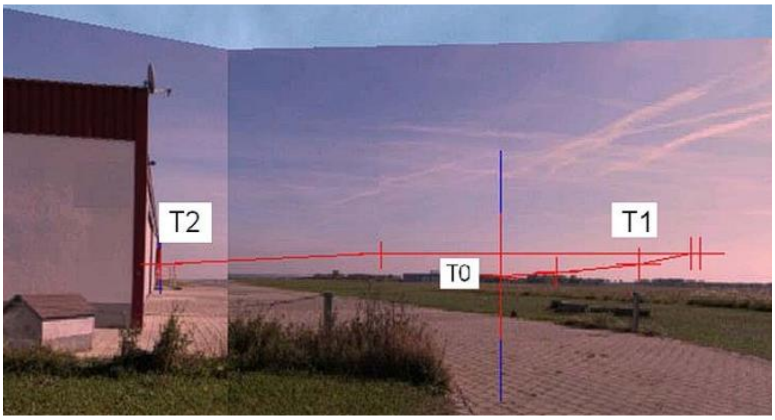

Figure 5: Witness interview showing view with observed aircraft movement from T0 to T2

The application of iwi® successfully showed its capabilities to reconstruct flight path information based on eyewitnesses. Further we can see the advantage by documenting eyewitness information in form of images with the marked witness information in the report.

A picture is worth more than a thousand words !

3.3.2 Achensee, Austria 2011

In the morning of the 30th of March 2011, an Austrian police helicopter of the type of EC 135P2+ crashed into the lake of Achensee. The accident report was recently published in November 2019, including the reconstruction of the overall flightpath as well as the visualization of the pilot’s perspective using the iwi® methodology.

The flight path of the helicopter was reconstructed in 2011, based on eyewitness information, being completed within a few days after the accident. The iwi® results could be confirmed with the recovered FDR data, when the wreckage was retrieved from the lake. As the last 9 seconds of the flight data recorder were incomplete, the eyewitness information was used to reconstruct the full flight path as well as the impact location of the helicopter in the lake.

The first eyewitness was sitting at the lake for fishing, highlighting the flat and calm water surface. The lake had crystal-clear water surfacing, mirroring the mountains surrounding it.

The eyewitness watching the helicopter flying two 360 degrees circles over the city, then heading to the lake (starting T1 marked position) in a linear, stable and reducing altitude towards impact position (green circle T2 marked in the image on the left). The observed duration from T1 to T2 was estimated by the eyewitness at approximately 7 seconds. The helicopter impacted at T2 in the water and flipped over.

Information Source: https://www.bmk.gv.at/dam/jcr:054ccb3c-52d9-4ca0-8d8c-1fbd0abaa914/85173_abschlussbericht_v2.pdf

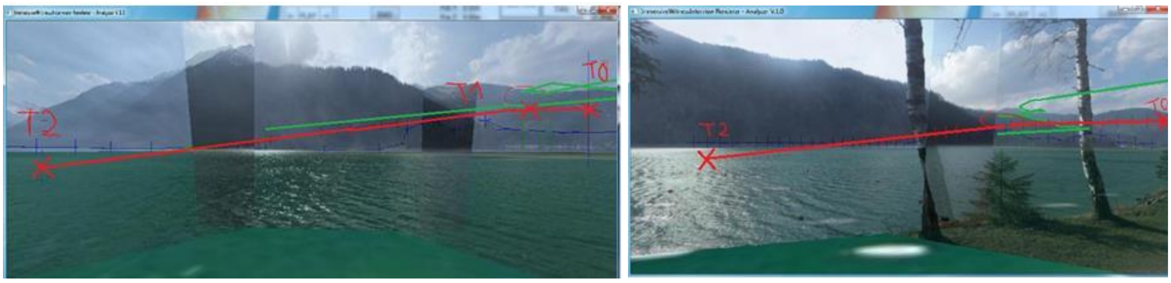

Figure 6: Eyewitness views with marked flight path that was observed (red) and FDR data (green)

The third eyewitness was working on site, sitting in an excavator. The helicopter flew over the witness from T0 to T2 in a steady linear flight. The time between the observed positions was estimated to be 7 to 8 seconds. He saw the helicopter hitting in the water at T2 and then flipping over. Interesting is the observed mirror of description, that the helicopter FDR data shows flying over coming from the right, but the witness described the helicopter flew over from the left. This phenomenon was also observed in other interviews when the witness was looking ahead in the sky with light disorientation.

Figure 7: Eyewitness view with marked flight path that was observed (green)

4. Witness Testimony Collection

Over the past 15 years, the iwi® method of recording witness statements have been applied by different international authorities during accident investigation. The method has evolved significantly, now leveraging modern technology. This update introduces possible future applications, supporting smartphones (iOS and Android) and PCs (Windows and Mac), guiding investigators or witnesses through a series of steps at the accident site. This approach shall increase the efficiency dramatically in collecting witness statements and shall increase the number of available witness information. With the increased number of statements, the match of different witness descriptions will help to create additional facts to be considered during the investigation. Finally, the app creates a PDF report of the collecting witness statements that can be used in the annex of the accident report.

4.1 Exemplary Application Content

- **Application Availability**: The application should be available on mobile devices for Android and IOS. This allows the investigator to quickly collect witness statements on site, logging the information in a one database. The mobile phone camera, GPS location and microphone function are used for logging the statement.

- **Weblink Availability**: In specific cases, the witness can provide observed information using a weblink, to send location, camera and drawn flight path to the investigator directly. The data can be imported to the application database.

- **Witness Location and Orientation**: The app records the precise GPS location and orientation of the witness at the time of the observation, ensuring accurate spatial data. The app estimates the captured relevant FOV where the aircraft was observed.

- **Flight Path Documentation**: The witness marks the start and endpoints of the observed flight path on the captured image. This input is crucial for the reconstruction process.

- **Multiple Witness Integration**: The application supports interviewing multiple witnesses, displaying their FOVs in a top-down view. Witness data can be toggled on and off in the menu, and KML data can be imported for comprehensive 3D visualization. All information is included in the generated accident report. Besides witness statements, additional information can also be added or edited.

- **Data Sharing**: The final generated accident scenario can be shared with other app users and imported by them. This facilitates easy and agile sharing of essential data among investigators. Besides witness statements, additional information can also be added or edited. Other investigators can also add further witness statements to the scenario later using the same software.

Figure 8 shows the witness data inserted from chapter 3.3 (Accident Achensee, Austria) exemplary into the new application. In this screenshot you can see the positioning of the two reference points needed to realize the calculation of the FOV and consistency check of the testimony. In addition, you can see the flightpath, which was drawn by the testimony on site together with the investigator. For this the testimony was asked to define three timestamps of the observed aircraft. These are shown in blue as T0, T1 and T2 (same position as Final [Red box]).

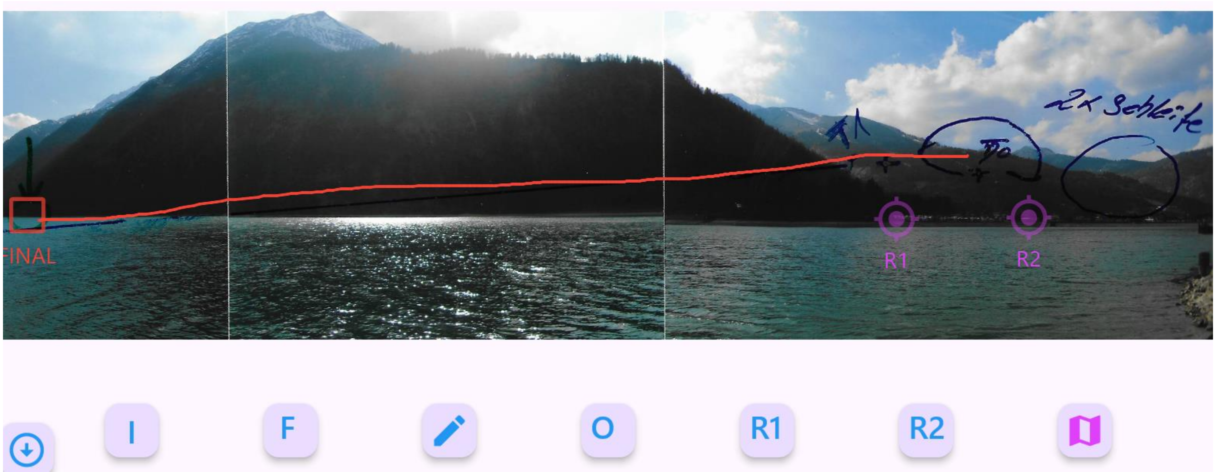

Figure 8: Exemplary app showing witness description capture mode

In the next Figure 9 a screenshot of an exemplary application is displayed, showcasing all the information related to the Achensee accident case. For this the witness’s name is asked to be filled in as well as the date when the information was documented. For more precision the local time of the interview is asked in addition. For supplementary information another field was added below.

Edit Witness Details

Witness Name
Witness 1

Interview Date
8.April 2011

Interview Time
16:45 local time

Witness comment
The eyewitness was sitting at the lake for fishing, highlighting the flat and calm water surface. The lake had a crystal-clear water surfacing, mirroring the mountains surrounded.The eyewitness watching the helicopter flying two 360 degrees circles over the city, then heading to the lake (starting T1 marked position) in a linear, stable and reducing altitude towards impact position (green circle T2 marked in the image on the left). The observed duration from T1 to T2 was estimated by the eyewitness with approximately 7 seconds. The helicopter impacted at T2 in the water and flipped over.

No recorded audio !

Cancel Save

Figure 9: Accident case information Achensee, Austria

In Figure 10 an insight of the map-overview from an exemplary application is displayed. In this you can see three different witness positions, labeled with a person-icon. Reaching out from these positions, you can see the in yellow and cone-shaped FOVs. In these the in red labeled cone is the area, where the aircraft was observed by the witness. In addition, you can see the imported KML data, which represents the flightpath shown in orange.

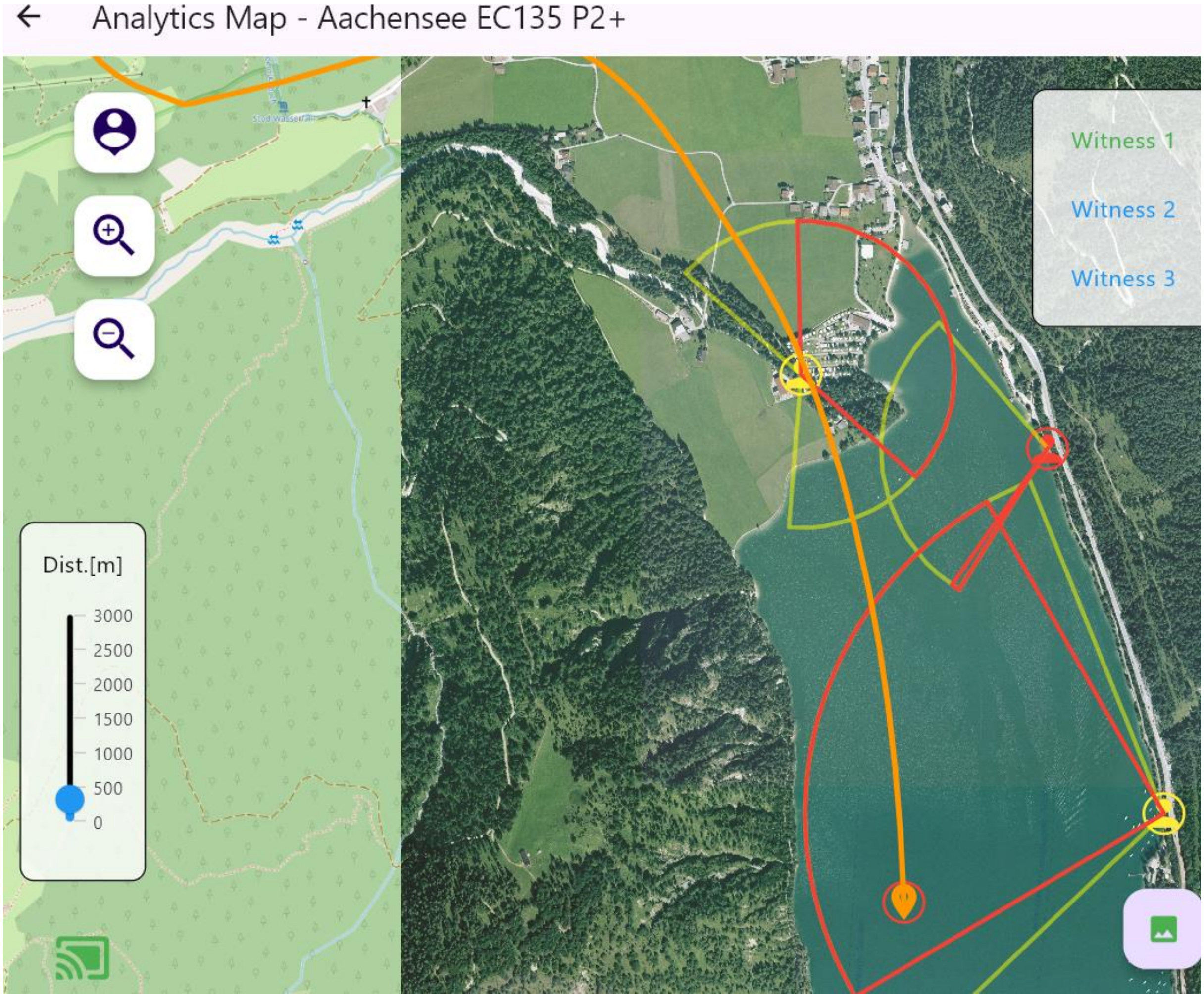

Figure 10: Top-view of the Achensee Accident Case, showing the testimony data and flight path

4.2 Increased Data Leads to Further Details

The modern technological advancements that have enhanced the process of collecting and analyzing witness testimony in accident investigations using exemplary applications.

More statements will create facts when the data of different sources fits. Therefore, creating more witness-based facts simply requires more data. To achieve this, making witness data collection shall get easier, faster, and with less effort. Witness statements should be taken as soon as possible after the accident event, ideally within a few days after.

Timely collection of witness statements is crucial to ensure the accuracy and reliability of the information provided. The use of modern technologies facilitates this process by allowing investigators to quickly and efficiently gather and analyze data from multiple sources. Integrating witness statements with other available data, such as video recordings and physical evidence, enhances the overall understanding of the accident and helps to establish a comprehensive and accurate reconstruction of events. This approach not only streamlines the process but also allows for immediate integration and analysis of multiple data sources, leading to a more comprehensive understanding of the accident based on testimony information. The prompt collection and validation of witness accounts can help establish a clearer sequence of events, ultimately aiding in uncovering the root cause of the incident.

5. Future Application of AR Technology for witness interview:

The next evolution in the collection and analysis of witness testimony involves the integration of Augmented Reality (AR) technology with future application. This advancement will enhance the accuracy and ease of documenting and verifying flight paths at accident scenes.

Instead of drawing the flight paths on a smartphone or tablet, the AR glasses will allow the witness or investigator to draw these paths directly in their field of view. This immersive method ensures that the recorded data aligns precisely with what was observed, minimizing errors caused by spatial misinterpretation.

Using AR technology, the witness or investigator can overlay the generated simulation directly onto the accident scene as shown in Figure 11. This real-time visualization allows for immediate verification and adjustment of the flight path, providing a more accurate and reliable account of the event. The AR glasses will project the simulation in the actual environment where the accident occurred, making it easier to cross-check the information with physical landmarks and reference points. Further the application calculates already the position of the virtual aircraft movement including the concluding ground speed.

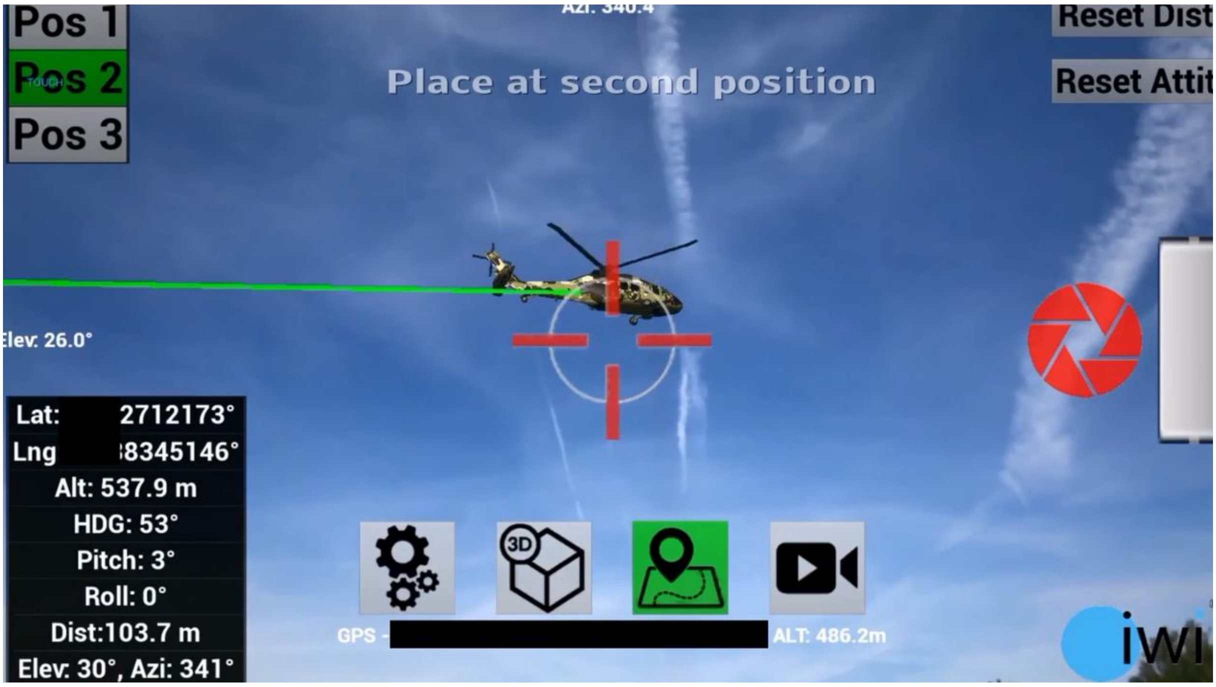

Figure 11: AR application placing virtual helicopter model at witness position

AR technology will facilitate a more interactive and intuitive process for witnesses, as they can visualize and confirm their observations in a manner that closely resembles their real-life experience, by animating the aircraft with the calculated ground speed, position and attitude as shown in Figure 12. Investigators can also benefit from this by having a clear and accurate representation of the witness accounts, which can be crucial for thorough and precise accident analysis.

Figure 12: Animation mode of AR application with calculated groundspeed, position and attitude.

In summary, the integration of AR technology within future application may represent a significant step forward in the field of accident investigation. By enabling the drawing and verification of flight paths directly at the accident scene, AR technology enhances the accuracy, reliability, and efficiency of witness testimony collection and analysis.

6. Conclusion:

In summary, we have seen that eyewitnesses remain relevant in accident investigations, even as video information becomes more prevalent. Not all events are captured by surveillance cameras or smartphones, making eyewitness accounts indispensable. Therefore, modern accident investigations must leverage contemporary technologies to document eyewitnesses more efficiently and promptly after an incident.

The increasing volume of available information and the validation of different information sources for consistency can provide additional facts. These facts are crucial for understanding the root cause of accidents and improving the accuracy and effectiveness of investigations.

By employing exemplary application as described, investigators can integrate eyewitness accounts with other data sources to create comprehensive and reliable reconstructions of events. The potential to use augmented reality (AR) further enhances this process, allowing for real-time verification and simulation directly at the accident site. This not only streamlines the investigation process but also ensures that the gathered data is as accurate and detailed as possible.

In conclusion, embracing advanced technologies and integrating them into eyewitness documentation and accident reconstruction can significantly enhance our ability to investigate and understand accidents. This progressive approach will lead to more efficient investigations and ultimately contribute to improved safety measures and accident prevention strategies in the future.

7. List of figures