IMPROVING AVIATION ACCIDENT RESEARCH THROUGH THE USE OF VIDEO

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The investigation and analysis of aviation accidents is a critical aspect of aviation safety and a major tool for aviation system improvement. The National Transportation Safety Board is charged with the responsibility of determining the probable cause of aviation accidents, identifying contributing factors, and making recommendations for changes to equipment or procedures as a result of their investigations. The intent is to identify what went wrong and prevent its recurrence -- to learn from the errors of others and, thus, save lives and property.

The investigation process relies on a thorough analysis of a myriad of data, both objective and subjective. The contents of the aircraft flight data recorder (FDR) and cockpit voice recorder (CVR) -- the so-called "black boxes" -- provide invaluable data on the aircraft's flight characteristics -- altitude, attitude, maneuvers, speed, control settings, etc. -- and the activities and sounds in the cockpit during the last thirty minutes of flight. Air traffic control radar track recordings provide additional data on the aircraft's route, altitude, and the proximity of other aircraft, while radio recordings provide a record of the instructions received from air traffic control. Laboratory analysis of aircraft wreckage and debris can reveal further details about control settings and details as minute as whether or not a particular light was on or off at the time of the crash. Interviews with survivors and witnesses supplement the objective data and often provide insight into how and why the accident occurred.

Upon completion of the accident investigation, the major tool for further analysis is the report issued by the NTSB. These reports detail the findings of the investigation and include a transcript of the voice recordings and, frequently, a plot of the aircraft's track as reproduced from radar recordings. The reports are valuable both as an archive of accident data and as a research tool for investigators interested in areas as divergent as aircraft design and human factors analysis.

A second source of aviation safety data is the Aviation Safety Reporting System at NASA Ames Research Center, California. The system collects reports from aviation personnel concerning incidents, i.e. events which involve a violation of regulations and/or safety standards, but do not result in an accident. The reports contain narrative descriptions of incidents submitted by participants. These narratives are often robust and detailed accounts of events leading up to the incident and frequently provide insight into the factors contributing to the event. The data is available through database searches for reports of interest to the researcher and through a series of special reports prepared by ASRS personnel. Information from these searches and reports can be used in much the same way as that from accident reports to research the complex interactions of the air traffic system.

A Technique for Improving Accident Analysis

What has been lacking is a technique for using the results of the accident investigation to dissect the event and reconfigure it to allow examination of the interplay of factors leading up to the accident. Research into aircraft accidents could be facilitated by making the data available in a video format that would provide a good modeling tool for researching issues of interest.

Currently, limited video representation has been used in accident analysis and research, largely restricted to use in

the classroom. In one of the few applications outside the classroom, Z-Axis of Aurora, Colorado has prepared a synthetic video representation of the crash of a Delta Airlines passenger jet at Dallas-Fort Worth Airport for use by the Federal Aviation Administration. The video combines computer graphics and synthetic video based on the aircraft FDR readings to view the aircraft's position, track, speed, and flight attitude throughout the last minutes of the flight with actual recordings of the CVR and air traffic control communications. This provides the researcher with the opportunity to see what was actually happening to the aircraft and to the crew as the accident progressed.

A second approach is that taken by the Canadian Forces Directorate of Flight Safety (DFS). The results of accident investigations are only useful if they are communicated to the field so that other airmen are able to benefit from the information. The DFS uses post-accident video tapes which recreate and explain the accident in a visually compelling way in order to facilitate communication of the lessons learned (Fisher, 1989).

The ability to visualize the aircraft and match that representation against the data contained in the written reports provides the researcher with insights that would perhaps otherwise be missed. However, more can be done. The ability to design such simulations quickly and easily can be enhanced by a library of video building blocks that can be used by designers as a resource base from which to draw (Armstrong and Roske-Hofstrand, 1989). Such simulations will illustrate in a compelling format the findings of the accident investigation and allow researchers to examine the often subtle interactions of events and actions which contribute to accidents.

The video building blocks can be either analog or synthetic video. An ideal storage medium would be digital video interactive (DVI) technology currently under development by the David Sarnoff Research Center and General Electric (Luther, 1988), but computer-controlled laser video disks also provide the direct access and mass storage capabilities such a resource requires.

Principled methods are available for designing and scripting video programs which cohere into meaningful episodes (Roske-Hofstrand, 1988). Such techniques can be used to enhance the usefulness of the video to the researcher. The interactive nature of both DVI and laser disk technology allow the researcher to manipulate events and investigate possible courses of action which might have prevented the accident and thereby develop recommendations for avoiding similar accidents in the future.

Interactive Video and Expert Systems as Research Tools

Interactive authoring systems facilitate the development of episodes using the library of building blocks. Well designed interactive episodes can provide the researcher with multiple perspectives which enables the exploration of the multidimensional nature of the event and allows him to perform a component analysis and see things which cannot usually be seen.

The power of interactive video as a research tool is vastly enhanced by the addition of a hierarchical, rule-based expert system. Expert systems add a new dimension to accident analysis research by providing the researcher with a diagnostic tool for examining the event to detect errors and perform a fault analysis. The researcher can diagnose what went wrong in much the same way that a physician diagnoses what went wrong with a patient's systems to cause disease. Combined with principled design of realistic representations of accident scenarios, this presents the researcher with a powerful new analytical tool which can contribute significantly to the enhancement of aviation system safety.

Constraints

Whenever video recreations are utilized, the designer must be mindful of several potential problems. First, in reconstructing accidents the designer and producer must be careful not to fictionalize the events. To stay as close as possible to the actual events, the designer must resist the temptation to "fill-in" facts where data do not exist, even if the scenario will be incomplete.

A second caveat is to be ever mindful of the power of video. Aviation accidents are inherently dramatic and they inevitably carry emotional impact. In order to derive the most benefit from the video recreation, that drama and emotion should be maintained. But the danger exists that the impact of the video reconstruction of accidents may impair the effectiveness for the researcher. To some degree, the researcher must be able to view the events objectively, and emotional impact will deter objectivity.

A major drawback to the use of interactive video is cost. Design and production of video programs and pressing laser disks are very expensive propositions. This may become less of a factor as new technologies are developed. McDonnell Douglas Electronics offers a "Laser Film" disk which is significantly less expensive to produce than standard laser disks. Also, DVI technology may become far less expensive as its user base grows and video compression techniques improve. In the meantime, this problem may be overcome by sharing the costs of production among users to develop a library of materials available to a broad range of researchers.

Accidents, and particularly aviation accidents, are virtually never the result of a single error or breakdown. More often, they result from a complex interaction of a series of inter-related, complementary factors which snowball into a major system breakdown. Video technology combined with interactive and expert systems can become a significant tool for researching those interactions and breakdowns and lead to a safer, more reliable air transportation system.

References

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