Statistical Detection of Atypical Aircraft Flights

A priori specification of search criteria is not necessary.

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A computational method and software to implement the method have been developed to sift through vast quantities of digital flight data to alert human analysts to aircraft flights that are statistically atypical in ways that signify that safety may be adversely affected. On a typical day, there are tens of thousands of flights in the United States and several times that number throughout the world. Depending on the specific aircraft design, the volume of data collected by sensors and flight recorders can range from a few dozen to several thousand parameters per second during a flight. Whereas these data have long been utilized in investigating crashes, the present method is oriented toward helping to prevent crashes by enabling routine monitoring of flight operations to identify portions of flights that may be of interest with respect to safety issues.

Experience has taught that statistically atypical flights often pose safety issues. Conventional methods of finding anomalous flights in bodies of digital flight data require users to pre-define the operational patterns that constitute unwanted performances. Typically, for example, a program examines flight data for exceedences (e.g., instances of excessive speed, excessive acceleration, and other parameters outside normal ranges). In other words, a conventional flight-data-analysis computer program finds only the patterns it is told to seek in flight data, and is blind to newly emergent patterns that it has not been told to seek. The present method overcomes this deficiency in that it does not require any pre-specification of what to look for in bodies of flight data. The method is based partly on the principle that it is necessary, not only to look for exceedences, but to go beyond exceedences, looking for more subtle data patterns that often cannot be prescribed in advance.

The method involves a series of processing steps that convert the massive quantities of raw data, collected during routine flight operations, into useful information. The raw data are progressively reduced using both deterministic and statistical methods. Multivariate cluster analysis is performed to group flights by similarity with respect to flight signatures derived from parameter values. The process includes analysis of multiple selected flight parameters for a selected phase of a selected flight, and for determining when the selected phase of the selected flight is atypical in comparison with the corresponding phases of other, similar flights for which corresponding data are available. For each flight, there is computed an atypicality score based partly on results from the cluster analysis. The distribution of atypicality scores of all flights is used to identify flights for examination.

The data from each day's flights are processed during the night and summarized in a document, called the "Morning Report," that includes a list of the 20 percent of flights having the highest atypicality scores, ranked in order of descending atypicality score. For each flight, the report includes a plain-language description of what makes the flight atypical. With the help of software designed to be intuitively useable, an analyst works through this list of flights to the finest level of detail where necessary, examining the characteristics that made them atypical, assessing their operational significance, and determining the need for further action.

This work was done by Irving Statler, Thomas Chidester, and Michael Shafto of **Ames Research Center***; Thomas Ferryman, Brett Amidan, Paul Whitney, Amanda White, Alan Willse, Scott Cooley, Joseph Jay, Loren Rosenthal, Andrea Swickard, Derrick Bates, Chad Scherrer, and Bobbie-Jo Webb of Battelle Memorial Institute; Robert Lawrence of Safe Flight; Chris Mosbrucker, Gary Prothero, Adi Andrei, Tim Romanowski, Daniel Robin, and Jason Prothero of ProWorks Corporation; Robert Lynch of Flight Safety Consultants; and Michael Lowe of the U.S. Navy. Further information is contained in a TSP (see page 1).*

This invention has been patented by NASA (U.S. Patent No. 6,937,924). Inquiries concerning rights for the commercial use of this invention should be addressed to the Ames Technology Partnerships Division at (650) 604-2954. Refer to ARC-15041-1

NASA's Aviation Safety and Modeling Project

Capabilities for automated analysis of flight data are under development.

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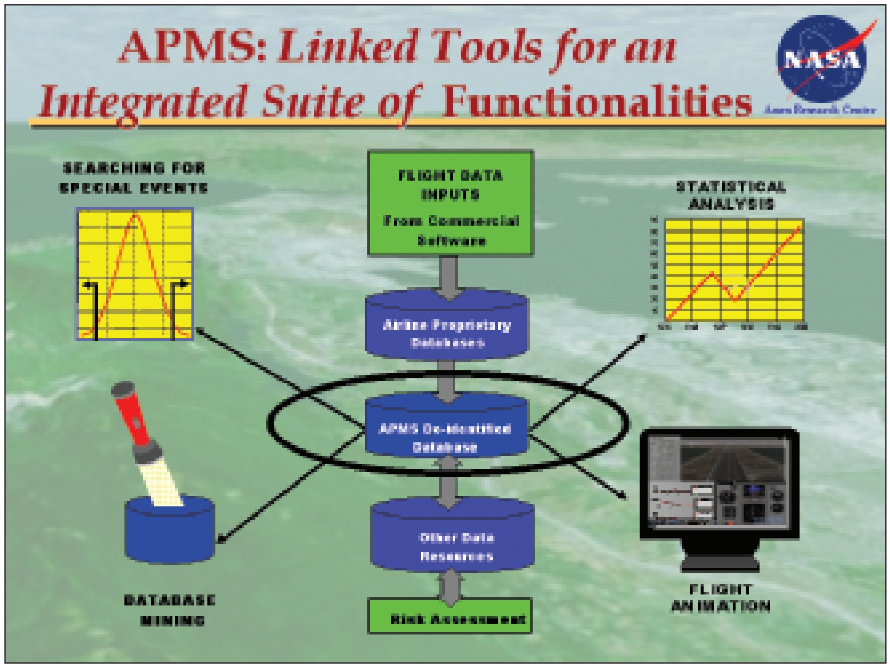
The Aviation Safety Monitoring and Modeling (ASMM) Project of NASA's Aviation Safety program is cultivating sources of data and developing automated computer hardware and software to facilitate efficient, comprehensive, and accurate analyses of the data collected from large, heterogeneous databases throughout the national aviation system. The ASMM addresses the need to provide means for increasing safety by enabling the identification and correcting of predisposing conditions that could lead to accidents or to incidents that pose aviation risks.

A major component of the ASMM Project is the Aviation Performance Measuring System (APMS), which is developing the next generation of software tools for analyzing and interpreting flight data (see figure). Airlines, military units, corporate operators, and others analyze aircraft flight data to identify contributing factors and corrective actions for situations in which aircraft performance parameters exceed normal limits during phases of flight. The programs for performing such exceedance-based analyses are denoted flight operations quality assurance (FOQA in civilian settings) programs and take their inspiration from statistical process control. However, FOQA analysis involves use of only a portion of the data: large quantities of data are scanned to extract and understand a small number of predefined events. The sets of data contain far more information that is potentially helpful for understanding and enhancing the safety, reliability, and economy of flight operations.

The challenge is to find and understand key information from the mass of data generated by aircraft and collected by data recorders. There is a need to automate scanning, analysis, and reporting to produce meaningful information upon which human analysts can act. The APMS software is intended to satisfy this need. Beginning with workload enhancements to exceedance-based FOQA analyses and progressing to sophisticated multivariate statistical analyses, the APMS has developed key software tools to advance the science of flight-data analysis.

Another major component of the ASMM Project is the Performance Data Analysis and Reporting System (PDARS), which is developing networking and analysis hardware and software for application air-traffic-control (ATC) radar data. PDARS, which was developed jointly with the Federal Aviation Administration (FAA) Office of System Capacity, provides ATC decision-makers at the facility level with a comprehensive means of monitoring the health, performance, and safety of day-to-day ATC operations. PDARS enables analysis of daily operation of the National Airspace System (NAS) at local and inter-facility levels. By translating flight-track and flight-plan data into useful performance information, PDARS significantly augments the ability of the FAA to adjust operational procedures and techniques. The net outcomes of these adjustments are quantifiable improvements in safety and efficiency throughout the NAS.



The **Aviation Performance Measuring System** — a component of NASA's Aviation Safety Monitoring and Modeling (ASMM) Project — is developing the means of automated processing of large collections of flight data to help answer questions pertaining to performance and safety.

Future progress in aviation safety can be expected to involve the routine integration of information from APMS, PDARS, and other sources. Such integration will require both greater depth of analysis of individual data sources and automated ability to integrate information extracted from diverse sources to draw sound conclusions on causal factors and risk assessment. It also will be necessary for users to evaluate such integration to determine its usefulness. It is planned to develop capabilities for such integration during the next few years.

This work was done by Thomas R. Chidester and Irving C. Statler of **Ames Research Center**. *Further information is contained in a TSP (see page 1).*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center, (650) 604-5104. Refer to ARC-14362-1.