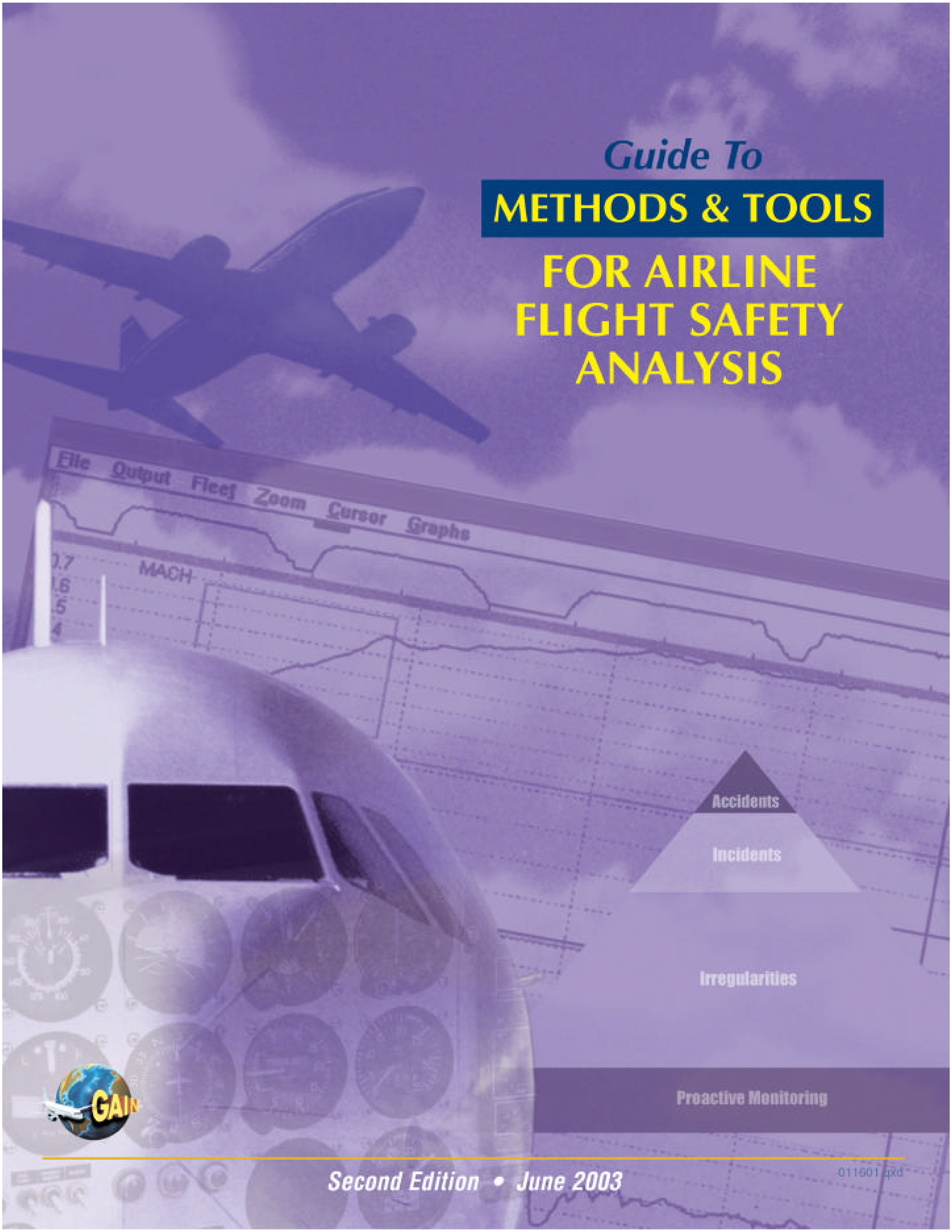
Guide To METHODS & TOOLS FOR AIRLINE FLIGHT SAFETY ANALYSIS



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Guide to

METHODS & TOOLS

FOR AIRLINE
FLIGHT SAFETY
ANALYSIS

Prepared by: GAIN Working Group B, Analytical Methods and Tools

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Foreword

This guide to methods and tools useful or potentially useful for airline flight safety analysis is the first in a continuing series that the Global Aviation Information Network (GAIN) Working Group B (Analytical Methods and Tools) plans to issue. In its efforts to increase the awareness of analytical methods and tools in the aviation community, Working Group (WG) B has begun to identify and review analytical methods and tools to support the major segments of aviation, focusing initially on airline flight safety. WG B has also begun to identify and document analytical methods and tools for safety analysis in air traffic management. In the future, the WG plans to address analytical methods and tools to support other aviation segments such as airline maintenance safety, and airport safety.

This guide is not a comprehensive inventory of analytical methods and tools that could be used in airline flight safety analysis. Rather, the intent of the WG in this second edition of the Guide is to document an expanded set of methods and tools that appear useful to airlines in particular, as well as other aircraft operators, together with some example applications of how these tools could be applied in flight safety analysis. The group would like to receive feedback on the experience that the aviation community has had with the methods and tools included in this issue as well as suggestions for additional methods and tools with which they are familiar. The reader should view this guide as a living document that will be updated periodically with improved coverage of methods and tools.

Acknowledgements

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Andy Muir, FAA Office of System Safety
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Grant Schneemann, Abacus Technology Corporation
Jean-Jacques Speyer, Airbus

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Sergei Ananyan, Megaputer Intelligence Incorporated
Robert Batson, University of Alabama
Jim Blanchard, FleetSecure, LLC
Mark Blazy, FAA Office of System Safety
Jefferey Bogan, Stransim Aeronautics Corporation
David Bristol, Palisade Corporation
Tom Chidester, NASA Ames
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Thom Mayer, Austin Digital Incorporated
Michael McGreevy, NASA Ames
Geoff McIntyre, FAA Office of System Safety
Dominique Mineo, CEFA Aviation
Mike Moodi, Boeing Commercial Airplane Group
Patrick Moylan, Abacus Technology Corporation
Zohreh Nazeri, MITRE Corporation
Jari Nisula, Airbus
Lee Nguyen, FAA Aircraft Certification Service
Tom O'Kane, formerly of British Airways
Michael Poole, Flightscape Incorporated
Alexander Pufahl, SimAuthor Incorporated
Eddie Rogan, British Airways
Alex Richman, AlgoPlus Consulting
Shifra Richman, AlgoPlus Consulting
Simon Rose, Oak Ridge National Laboratory
Edward Skompski, System Improvements
Nigel Summerhayes, British Airways
Brad Wacker, FAA Office of System Safety
Jack Wojciech, formerly of FAA Office of System Safety

1.0 Introduction

1.1 Purpose of Guide

The purpose of this guide is to provide information on existing analytical methods and tools that can help the airline community turn their data into valuable information to improve safety. Summaries are presented for 57 methods and tools that can be used to analyze flight safety data including event reports and digital flight data. Global Aviation Information Network (GAIN) Working Group B (Analytical Methods and Tools) hopes that this guide will help increase the awareness of available methods and tools and assist airlines as they consider which tools to incorporate into their safety analysis activities.

1.2 GAIN Overview

GAIN is an industry and government initiative to promote and facilitate the voluntary collection and sharing of safety information by and among users in the international aviation community to improve safety. GAIN was first proposed by the Federal Aviation Administration (FAA) in 1996, but has now evolved into an international industry-wide endeavor that involves the participation of professionals from airlines, employee groups, manufacturers, major equipment suppliers and vendors, and other aviation organizations. To date, five world conferences have been held to promote the GAIN concept and share products with the aviation community to improve safety. Through 2003, nearly 900 aviation safety professionals from 49 countries have participated in GAIN.

The GAIN organization consists of an industry-led Steering Committee, four working groups, a Program Office, and a Government Support Team. The GAIN Steering Committee is composed of industry stakeholders that set high-level GAIN policy, issue charters to direct the working groups, and guide the program office. The Government Support Team consists of representatives from government organizations that work together to promote and facilitate GAIN in their respective countries. The working groups are interdisciplinary industry and government teams that work GAIN tasks within the action plans established by the Steering Committee. The current GAIN working groups are: Working Group B--Analytical Methods and Tools, Working Group C--Global Information Sharing Systems, and Working Group E--Flt Ops/ATC Ops Safety Information Sharing. The Program Office provides technical and administrative support to the Steering Committee, working groups, and Government Support Team.

1.3 Working Group B: Analytical Methods and Tools

Working Group (WG) B was formed in response to the need expressed by many in the aviation-user community for better analytical methods and tools to help convert data into useable safety information. Members of the community have said that the need to manage and analyze ever-larger amounts of safety-related data will require the use of increasingly sophisticated tools and techniques. These methods and tools will help safety analysts discover patterns and extract lessons learned in order to identify emerging safety issues and support safety decision-making. Responding to these needs the GAIN Steering Committee chartered WG B to foster the use of existing analytical methods and tools and the development of new methods and tools. The WG has four main focus areas:

- Gather requirements for analytical methods and tools from the aviation-user community
- Identify and increase awareness of existing methods and tools
- Assess the usefulness and usability of existing tools in partnership with the aviation community
- Facilitate the development of enhanced or new analytical tools.

This guide was prepared specifically to address the second focus area.

1.4 Scope

This document includes methods and tools that are currently used by one or more airlines around the world to analyze flight safety data or information. It also includes methods and tools that are not known to be used by any airlines at present, but that could easily be applied to airline flight safety analysis in the view of GAIN Working Group B.

This document pertains to analysis of flight safety issues in an airline, the type of work typically performed by an airline's Flight Safety Department or office performing that function. This document does not consider tools that examine other aviation safety domains, including types of system-wide safety analysis performed by a civil aviation authority or aircraft performance analysis that might be performed by an airframe manufacturer. GAIN Working Group B has prepared a separate document looking at another aviation safety domain, "Guide to Methods and Tools for Safety Analysis in Air Traffic Management." In the future, WG B could potentially expand its work to other aviation segments such as airline maintenance safety or airport safety.

It should be noted that this guide contains tools that are commercially available, and others that are in the prototype or development phase. Some tools are commonly used while others are infrequently used. Some of the tools are fairly straightforward and easy to use while others are more advanced and may require specialized analytical expertise. Also included are descriptions of methods that have application to flight safety analysis.

1.5 Definitions

WG B has adopted the following definitions for distinguishing between methods and tools.

Method: An analytical approach or process that may or may not be automated.

Tool: A software-based/computerized application of one or more methods.

1.6 Review of Methods and Tools

To improve its understanding of the analytical responsibilities, capabilities, and needs of airline flight safety offices, WG B surveyed GAIN Steering Committee members and thirteen airline flight safety offices from around the world. The survey respondents provided information on the types of information they collect, tools currently in use, the most useful features of those tools, and gaps in capabilities of current tools. This information was helpful to the WG as it undertook a review in 1999 of methods and tools that are useful or potentially useful for airline flight safety analysis. WG B started its review with a list of over 300 analytical methods and tools from various industries (aviation, nuclear power, chemical, etc.).

The initial list was further refined to about 50 methods and tools that were organized into three areas: Flight Safety Event Reporting and Analysis Systems, Flight Data Monitoring Analysis and Visualization Tools, and Specific Purpose Analytical Tools. The first area includes systems that were designed specifically for and are widely used by aviation operators to report and, in some cases, analyze flight safety events. The second area addresses tools that are specifically designed to analyze digitally recorded flight data, namely Flight Data Monitoring and Visualization Tools. The third area represents methods and tools that, for the most part, were not designed for a particular domain but could be used to enhance the analysis of events contained in the safety event reporting systems mentioned above.

Since the systems/tools in the Flight Safety Event Reporting and Analysis and Flight Data Monitoring Analysis and Visualization Tools are already being used by airlines, WG B did not conduct a detailed review of these systems/tools. WG B prepared a brief summary of each system/tool and requested the system/tool developer or vendor to complete a "standard" checklist of the capabilities/features of interest to airlines.

WG B also prepared brief summaries of the approximately 30 methods and tools contained in the Specific Purpose Analytical Tools area. In addition, WG B conducted a detailed review involving one or more stages on 14 of these tools that appeared to be the most promising. A more detailed discussion of the three-stage review process for the analytical tools was provided in the first edition of the Guide.

For the current edition, the description of each of the tools from the first edition of the Guide was updated in conjunction with the tool developer or vendor, and a description for each new tool was developed in cooperation with the developer or vendor. However, no additional tools were included in the three stage review process.

The method and tool information provided in this guide may not reflect the very latest information. A point of contact is provided for each method and tool so that the reader may obtain further information.

1.7 Organization of this Guide

The remainder of this Guide is organized into six chapters (2 through 7). Chapter 2 provides an overview of the application of analytical tools to airline flight safety. The next four chapters provide a description of each tool with one chapter for each of the following areas: Flight Safety Event Reporting and Analysis Systems; Flight Data Monitoring Analysis and Visualization Tools; Human Factors Analysis Tools, and Special Purpose Analytical Tools. Chapter 7 describes various analytical methods.

This guide also contains six appendices. Examples of the application of selected tools to airline flight safety analysis are contained in Appendix A. The features and capabilities of the Flight Safety Event Reporting and Analysis Systems are contained in Appendix B. The features and capabilities of the Flight Data Monitoring Analysis and Visualization Tools are contained in Appendix C. Information on several methods and tools currently under development is provided in Appendix D. Appendix E contains a list of acronyms used in this guide, and Appendix F contains a feedback form.

1.8 Changes Made to this Edition of the Guide

The first edition of the Guide to Methods & Tools for Airline Flight Safety Analysis has been distributed to over 400 aviation safety professionals around the world. Additionally, the Guide is available on the GAIN website at *http://www.gainweb.org* where it can be viewed online or downloaded.

Encouraged by the feedback received to the first edition of the Guide, WG B has prepared this second edition of the Guide. This edition of the guide incorporates the following changes:

- A new section, "Application of Analytical Tools to Airline Flight Safety"
- Reorganization of the tool categories to reflect the classification of the tools discussed in the new section on the application of analytical tools to airline flight safety
- Summaries of some additional methods and tools
- Deletion of several tools that were no longer supported by their developers or subsequent information suggested were outside the scope of this Guide
- Some examples showing how selected tools can be applied to airline flight safety analysis
- Deletion of the detailed information on the instructions and scorecards for the tool review that was performed prior to the first edition.

The following methods and tools have been added to the Guide since the first edition:

Safety Report Management and Analysis Systems
- First Launch Safety Report System

Descriptive Statistics and Trend Analysis Tools
- HeliStat

Flight Data Monitoring Analysis and Visualization Tools
- AirFASE
- CEFA
- FlightAnalyst
- FlightTracer

Human Factors Analysis Tools
- Cabin Procedural Investigation Tool
- Ramp Error Decision Aid

Occurrence Investigation and Analysis Tools
- Investigation Organizer
- REASON 5

Text/Data Mining and Data Visualization Tools
- PolyAnalyst
- Brio Intelligence 6

Risk Analysis Tools
- Markov Latent Effects Tool for Organizational and Operational Safety Assessment
- Quantitative Risk Assessment System
- RISKMAN
- WinNUPRA

Risk Analysis Methods
- Fault Hazard Analysis
- Failure Mode and Effect Analysis

The following tools that were included in the first edition of the Guide have been removed from this edition:

Safety Report Management and Analysis Systems
- AIRSAFE

Flight Data Monitoring Analysis and Visualization Tools
- Flight Event Analysis Program
- Flight Data Replay Analysis System

Risk Analysis
- Event Risk Analysis and Safety Management

Cost Benefit Analysis Tools
- Airbus Service Bulletin Cost Benefit Model
- Boeing Digital Technologies Cost Model

A human factors analysis tool previously known as "Computer Assisted Debriefing System (CADS)" has been renamed and improved by the vendor and is now listed in this edition of the Guide as "ReVision."

The examples of the application of tools are included in Appendix A, and are intended to provide a better understanding of how the various tools can be used in airline flight safety management. WG B plans to include similar examples of additional tools in future editions of the Guide.

1.9 Guide Update and Feedback

WG B plans to update this guide periodically to include information on additional methods and tools as appropriate. The WG encourages readers to provide feedback regarding their experience with any of the methods and tools contained in the guide and to nominate others for possible inclusion. Suggestions for improving the usefulness of this guide are also requested. A feedback form for this purpose is included in Appendix F.

2.0 Application of Analytical Tools to Airline Flight Safety

Managing flight safety in an airline requires the collection of relevant data on safety-related events and then assessing or analyzing that data. This section provides an overview of the basic concepts involved in applying tools to airline flight safety analysis, first by examining the various types of safety-related data that can be collected and then looking at the types of analysis that can be performed on that data.

Fundamental to the safety management process is the reporting and investigation of safety related events. Once an event is reported, an airline has a duty to investigate the event, decide what corrective actions may be necessary, and then track the implementation of those actions. Beyond this immediate response, an effective safety management process will also analyze the data from past events, to monitor trends and identify potential safety hazards that require attention. Thus one role of analytical tools is to support the process by which events are reported, investigated, actions are assigned, and the incident is eventually closed. Another role is to support the analysis of information assembled on past events in order to undertake proactive safety management activities.

This Guide describes a wide range of analytical tools that have potential use to support airline flight safety management activities, many of which perform quite specialized functions and some of which require the commitment of considerable resources or the development of particular skills to use effectively. As airlines develop their flight safety management process, they will experience the need for more sophisticated tools and hopefully allocate the resources to support their use. At the same time, it should be noted that many of the analytical tools described in this Guide perform the same or similar functions. Thus airlines will generally selected specific tools in the various categories that they judge best meet their needs. These decisions are likely to be influenced by the size of the airline and the resources available to support the flight safety management process, as well as the experience and analytical skills of the flight safety department staff. As an airline acquires more safety-related information on its operations and gains experience with the use of more fundamental tools, it may find the need to perform more sophisticated analysis and make use of wider array of analytical tools.

2.1 Types of Airline Flight Safety Data

The types of data collected as part of the airline flight safety management process is fundamental to the selection of analytical tools. The value provided by specific tools depends on the content and quality of the data being analyzed, and the ability to extract useful information from the safety data that is collected depends on the use of appropriate analytical tools.

In general, airline flight safety data fall into three broad categories: reports of incidents, events or hazardous situations that occurred in the course of routine operations and generally submitted by operational personnel; detailed data on flight operational performance collected as part of a flight data monitoring (FDM) or flight operational quality assurance program; and the results of safety audits of organizational units or line operations undertaken by suitably trained and experienced personnel from within the airline or from outside agencies.

Although not usually considered part of airline flight safety, most airlines also maintain a reporting and audit system for occupational safety and health issues. While this function is typically handled by a separate department, relevant events may get reported through the flight safety event reporting process.

2.1.1 Occurrence Reports

Most airlines have some form of safety event reporting system for flight crew, often termed air safety reports. Increasingly airlines are extending this to safety reports from cabin crew and ground personnel as well. Many airlines also have a parallel system for aircraft maintenance personnel, both to report errors in maintenance procedures as well as airworthiness issues that are uncovered in the course of maintenance or other activities. Some airlines have a separate category of hazard reports that describe potential hazards that operational personnel are concerned about, rather than events that have already occurred.

An important issue with such reports is whether they are treated as confidential or shared with regulatory agencies. Practice varies in different countries. The United Kingdom Civil Aviation Authority has a Mandatory Occurrence Reporting System that has been in place for many years and provides well-defined protections for those filing reports. In the United States, through a program termed the Aviation Safety Action Program (ASAP), occurrence reports that meet certain requirements are shared with the Federal Aviation Administration, which in turn has agreed not to impose regulatory penalties on either the airline or the personnel filing the report.

Some airlines have begun to supplement air safety reports with a confidential human factors reporting system. These reports are designed to address human factors issues in more detail than is typically found in air safety reports, and are typically handled in greater confidence, since they may well address the performance of other members of the flight or cabin crew. Additionally, in order to encourage such reports by crew members and to facilitate an objective and open exchange of safety related information, it is increasingly accepted that these reports must be handled in a non-punitive fashion by both the operator and regulatory authority (if they are shared with the authority).

In summary, an airline may have a formal reporting process for some or all of the following types of occurrence report:

- Air Safety Report (ASR)
- Cabin Safety Report (CSR)
- Ground Damage Report (GDR)
- Confidential Human Factors Report (HFR)
- Maintenance Error Report
- Airworthiness Issues Report
- Hazard Report
- Occupational Safety and Health Report (OSHR)

In the United States, some of the above types of report (typically ASRs, but efforts are underway to extend this to other categories of event reports) may also be classified as ASAP reports. In other countries some types of reports, or more commonly reports for defined types of events, are considered Mandatory Occurrence Reports (MORs), or a similar terminology, and the information is submitted to the regulatory authorities.

2.1.2 Digital Flight Data

Flight data monitoring, often termed Flight Operational Quality Assurance (FOQA) in the United States, collects and analyzes aircraft operational parameters that are recorded on board the aircraft using flight data recorders or quick access recorders (QARs). These can typically record a large number of aircraft flight parameters several times a second for several days at a time, and are downloaded periodically when the aircraft reaches a suitable station or maintenance base. The resulting data is stored in a large database and analyzed with special purpose software to identify anomalous occurrences that exceed defined thresholds, often termed exceedance events, as well as long-term trends in operations. Once the data has been analyzed to identify any such events and trends, the raw data may or may not be preserved. Until recently, the data for each exceedance event was archived. It is a more common practice now to archive data for entire flights. In almost all cases, the data is de-identified to protect the flight crew, although some airlines have established a "gatekeeper" process that allows the flight safety analysts to obtain follow-up information from the flight crew involved in a particular event.

2.1.3 Safety Audits and Assessments

Safety audits are designed to uncover organizational problems or systemic practices that could have adverse safety implications. They include audits performed by personnel from another airline engaged in a code-share relationship, safety audits undertaken by regulatory agencies, and internal evaluations undertaken within an airline to ensure that airline safety policies and procedures are being followed or to identify safety issues that need to be addressed. These audits tend to focus on organization units within an airline.

Another class of audit involves the structured observation of routine flight operations in which specially trained assessment personnel ride in the cockpit on regular flights. This has come to be termed line-oriented safety assessment (LOSA).

2.2 Types of Tools for Airline Flight Safety Analysis

This section discusses seven types of analysis tools that can be applied to manage and analyze the various types of flight safety data.

2.2.1 Flight Safety Event Reporting and Analysis Systems

This category of tool forms the basic safety data management and analysis system that supports the flight safety management process and will generally be the first type of analytical tool that an airline will acquire. There are two broad categories of analytical tools that are used for this purpose. The first category comprises special-purpose tools for managing the flight safety event reporting and investigation process and analyzing the information from airline safety reports. The second category consists of tools used to perform trend and statistical analysis of safety report data, but not necessarily to manage the relevant data

Safety Report Management and Analysis Systems

These systems typically have the capability to store and display a range of different types of safety reports, including ASRs, CSRs, and even audit reports. They typically provide some capability to support the safety event investigation process, record corrective actions that may be assigned to a specific individual and track the status of those actions. This may include the ability to automatically send messages or acknowledgements to those who submitted the report or who have been assigned follow-up actions. They also generally provide some level of trend analysis, with the capability to create charts or generate reports that track the rate of occurrence of specific types of events over time, and the ability to select subsets of the underlying data for analysis or display.

Other capabilities that are provided by some systems include functions to support the classification of events into predefined categories, to assign risk levels to each event, and to filter the information in the event report database to identify subsets of previous reports that have common characteristics and extract relevant information. These capabilities are fundamental to effective safety management, since the allow flight safety personnel to identify areas of significant risk and track the long-term effectiveness of corrective actions. Having an effective event classification system is essential to be able to perform meaningful trend analysis and information filtering. Risk assessment of each event allows flight safety management personnel to identify those incidents that pose the most serious threat to operational safety and to focus appropriate attention on high-risk events.

Some systems are designed with a different module handling each type of report, so that airlines can add the relevant module as they expand the range of reports that they collect, or to allow for the use of different systems to handle different types of report. The extent to which these systems have built-in capabilities to perform trend analysis, generate charts and graphs, or perform other statistical analysis varies. However, most such systems have limited analytical capabilities beyond fairly simple trend analysis, and many airlines find that it is necessary to use the built-in capabilities to select a subset of the data, which is then exported for use with other analysis tools, such as spreadsheet programs or the more advanced tools discussed below.

Trend Analysis and General Statistical Analysis Tools

These tools provide capabilities to analyze statistical data exported from safety data management systems and present this information in tables and charts for use in reports and presentations. Most such tools are general-purpose analysis tools, such as spreadsheet programs or statistical analysis packages, and are not typically designed for airline flight safety use, but have powerful analytical capabilities that can be adapted to this application. Other tools may be more specialized and designed to work with specific safety databases or safety report management systems.

While these tools are often used in conjunction with special-purpose airline safety report management systems, in some cases they may be used to analyze safety report data that is stored in customized databases maintained using general-purpose database management software. Small airlines may even use spreadsheet or statistical analysis programs to store and manage the information submitted on paper safety reports for subsequent analysis using those tools.

2.2.2 Flight Data Monitoring Analysis and Visualization Tools

The next category of tools that many airlines acquire is an FDM and analysis tool. This is essential to be able to make meaningful use of routine aircraft flight data. Typical FDM programs make use of Quick Access Recorders (QAR) to enable a wide range of parameters to be recorded and enable easy removal of data storage media. Associated costs involved with equipping aircraft with QARs can be beyond some organizations' budgets. Alternatively, some FDM programs make use of the limited data set available on the Digital Flight Data Recorders, or ‘black boxes’, required to be installed on every transport aircraft. In either case, an FDM program requires a significant commitment of resources and staff, to equip and maintain aircraft and QARs (or other suitable recorders), to retrieve and download data, and to process and analyze the data.

Most FDM tools allow users to specify thresholds that define exceedances and then identify occurrences where the threshold was exceeded in the data. Many of the advanced tools can now archive all flight data and provide trend analyses of large amounts of data. Most tools allow data to be exported to sophisticated animation packages that provide a graphical representation of a flight or incident in question. This can even extend to an external view of the aircraft, showing the nominal and actual flight paths, an interior cockpit view showing the movement of the controls and current state of the instrument displays, and a tower view which can represent a viewpoint of the aircraft from any fixed location on the ground.

2.2.3 Human Factors Analysis Tools

Once an airline has a good event reporting and analysis system in place and has established a flight data monitoring program, the next area that it may wish to address in a more formal way is the analysis of human factors data. Developing a useful human factors reporting capability first requires a suitable source of data to analyze, such as a confidential HFR program or structured follow-up interviews with people filing event reports. In general it will be very difficult to undertake meaningful human factors analysis of event reports that are not structured to address human factors issues.

Among the important factors in developing a human factors reporting system are the issues of privacy and interpretation. Privacy is an issue that most safety organizations have experience with addressing, and most commercial human factors analysis tools have capabilities to protect the information involved. The issue of interpretation is more complex. Human factors observations are often not quantitative, but qualitative, and therefore the use of most data processing and analysis techniques may not be valid. Further, the absence of information on a particular issue does not necessarily mean that the issue is not relevant, only that the person filing the report did not think to mention it. The problem of incomplete reporting of human factors data is typically addressed by having a human factors specialist perform follow-up interviews. However, this means that the cost of implementing and operating a reliable human factors reporting system can be significant.

Some of the available human factors analysis tools form part of a human factors reporting system that includes the database management functions needed to support the creation and maintenance of the necessary human factors database. Other tools are designed to work with human factors data that may be stored in separate data management systems, such as flight safety event reporting systems.

2.2.4 Special Purpose Analytical Tools

As an airline acquires more safety data and gains experience in the use of the foregoing tools, it may find that it needs additional analytical capacities to make full use of the information contained in the various safety databases. Some of these tools may be integrated into specific products in the three previous categories, such as the flight safety event reporting and analysis systems, but in general they are stand-alone products that are used in conjunction with data that may have to be exported from the data management systems of the other tools.

Occurrence Investigation and Analysis

This class of tools is designed to support the investigation of a specific incident or event and assist in identifying the various causal factors that underlie the occurrence and the relationship between these factors. By guiding the analyst through a structured process of enquiry, and managing the associated information that is assembled in the course of the investigation, the tools both help identify the causes of the occurrence as well as assess the effectiveness of possible corrective actions. The tools typically also include a report generating capability or provide features to simplify the process of preparing an investigation report.

Text/Data Mining and Data Visualization

Text mining tools are designed to analyze freeform text using automated algorithms to identify specific concepts or ideas in the text, and translate these concepts or ideas into standardized terms that can be stored in a more structured way for subsequent analysis. Since a significant amount of the information in flight safety occurrence reports is contained in freeform narratives, it is clearly valuable to be able to search this information in a reliable way. However, conventional text searches are inefficient and cumbersome, since different reports may express the same issue in quite different ways using very different terms. In consequence, simple text searches rely heavily on the intuition of the analyst and may require many different searches to identify all relevant combinations of terms. Text mining tools attempt to overcome these limitations and speed up the process of identifying occurrences of interest in a large set of reports.

Data mining tools are designed to analyze a large amount of data in a structured database using automated algorithms to identify patterns and trends in the data, or to identify specific records that exhibit relationships of interest, as a first step before further analysis or examination. Data visualization tools perform the same function by utilizing graphical displays to allow a human analyst to identify possible patterns, trends or associations. As the amount of data in flight safety databases increases, the ability to search quickly through the data and identify relationships becomes increasingly important. Data visualization tools may also allow an analyst to identify relationships that would not be obvious if the information was presented in any other way. The application of these capabilities is particularly relevant to the analysis of the vast amount of FDM data, but may also be helpful in working with large databases of occurrence reports.

Risk Analysis

Risk analysis tools provide a means to undertake a formal analysis of the change in risk that results from any proposed action, or an assessment of the risk involved in not taking any action. They can be used to complement or corroborate a manager's intuitive assessment of the benefits from any proposed action. They can also be used to support a formal assessment of the magnitude of the safety risks posed by the occurrences that an airline is already experiencing, as well as to help identify which events pose the greatest threat of leading to a serious accident.

Other Special Purpose Tools

There is a range of additional analysis functions that could be performed by special purpose tools, although to date, relatively few of these have been developed and even fewer seen widespread use in airline flight safety analysis. Examples of this type of analysis would be cost-benefit analysis of proposed safety management actions or efforts to measure the safety culture or operational practices in an airline.

Cost benefit analysis tools could provide an analytical framework to support decisions on how to prioritize safety enhancement actions and the cost effectiveness of alternative actions. It is self-evident that corrective actions to perceived safety problems impose operational costs on the airline, and that different corrective actions impose different costs and are likely to reduce the risk of an accident to a different extent. Therefore, recommendations for corrective actions and the prioritization of which potential hazards to address needs to be informed by some assessment of the relative costs and benefits of different courses of action.

There is a growing interest in the field of safety management to develop ways to measure and monitor the safety culture within an organization, in order to identify areas that need specific attention or to assess the effectiveness of measures to encourage safe operating practices. This typically involves the conduct and analysis of safety culture assessment surveys, and special purpose tools are becoming available that are designed to analyze this type of data. A related area of particular application to airline flight safety is the analysis of LOSA data.

2.3 Summary

It is clear that each of the foregoing categories of analytical tools has its place in the technical resources available to support the work of the flight safety department. Some tools will be used on a daily basis while others will be used less often, as analysis needs dictate. Some, such as the flight safety event reporting and analysis tools and the flight data monitoring tools, are primarily *process* oriented. They are typically used on a day-to-day basis to manage and analyze the flow of safety information coming in to a flight safety department, manage the investigation of specific events and implementation of corrective actions, and to identify trends in broad measures of safety performance. Others, such as the human factors tools and occurrence investigation tools, are more *investigative*. They are used to understand *why* something happened, rather than *what* happened. Yet others, such as text mining and data visualization tools, are *exploratory*. They are used to seek out relationships that are not self evident or well understood or to identify emerging issues of concern. Finally, there are *decision support* tools, such as risk analysis and cost-benefit analysis, that are used to help assess the effectiveness of alternative safety management actions and strategies.

The effective use of the full range of tools described in this Guide is not a simple or inexpensive matter. The acquisition cost of the tools themselves is usually the smallest concern. Staff will need to be trained in the use of the tools, and given enough opportunity to use them on a regular basis to retain proficiency in their use, which may well require an increase in staffing levels. The tools themselves may have to be configured or adapted to be able to interface with the airline's data management systems. Finally, it may be necessary to expand the safety data reporting systems and make a significant investment in the reporting culture of the airline in order to improve the quality of safety information that is available to be analyzed. While the costs involved are not trivial, they are also not particularly large on the scale of the entire operating cost of an airline, and they are certainly not large compared to the cost of a major accident. Ultimately, the decision of how many resources to put into enhanced analysis of flight safety data involves a judgment that balances the increase in cost of the safety management process against the reduction in the risk of an accident.

3.0 Flight Safety Event Reporting and Analysis Systems

The first section of this chapter contains summaries of systems that are used by airlines to collect, record, and categorize information about safety events. These systems generally contain capabilities and features to assist the operator in event information storage and management as well as report generation and querying. Some systems also have analysis capabilities along with features to facilitate action assignment, monitoring, and data exchange.

These systems were, for the most part, designed for and are widely used by aviation operators. WG B has therefore not listed a separate category of "airline usage" for each system in this section. All of the systems are also currently available for purchase by airlines. WG B did not obtain cost information for each system since it is highly dependent upon individual requirements and may vary widely from user to user. However, prospective purchasers should keep the factors below in mind when discussing their requirements with a system vendor.

The price charged by some system vendors is a flat fee, which allows multiple users on any one site. For others the rate increases depending on the number of authorized users. Many vendors will link the price to the size of the airline's fleet. Most vendors will charge an additional license fee for extra sites at a reduced rate.

In addition the purchaser will need to take into consideration:

- Installation costs
- Training costs
- Software upgrade costs
- Other software license fees that may be necessary

Most vendors will provide one year of maintenance and support in the original package but charge an annual fee thereafter.

In addition to the summaries provided below, tables containing information on system capabilities and features are contained in Appendix B. This information was provided by the system vendors and has not been independently verified by WG B. (The information in Appendix B was obtained in 2003).

The second section of this chapter covers both general purpose and special purpose tools for statistical and trend analysis of data from flight safety event reporting systems.

3.1 Safety Report Management and Analysis Systems

These systems typically have the capability to store and display a range of different types of safety reports, including ASRs, CSRs, and even audit reports. They typically provide some capability to record corrective actions that may be assigned to a specific incident and track the status of those actions. This may include the ability to automatically send messages or acknowledgements to those who submitted the report or who have been assigned follow-up actions. They also generally provide some level of trend analysis, with the capability to create charts or generate reports that track the rate of occurrence of specific types of events over time, and the ability to select subsets of the underlying data for analysis of display.

Aeronautical Events Reports Organizer (AERO)

Purpose
To organize and manage incidents and irregularities in a reporting system, to provide graphs and reports, and to share information with other users.

Description
AERO is a FileMaker database developed to support the management of the safety department of aviation operators. AERO was created to enhance communication between the safety department and all employees, reduce paper handling, and produce reports easily. The Data Sharing program allows all AERO Certified Users to benefit from the experience of the other users. AERO users review their monthly events and decide which ones to share with the rest of the companies using AERO.

The exported events contained in the global AERO database are automatically depersonalized before they leave the user's computer. Once the data reaches the main office, the events are integrated to the global database. This database, placed on a secure internet site, is accessible by all AERO certified users only. Therefore, every month users will have access to a freshly updated database that contains information about many different subjects such as aircraft type, regions, human factors, etc. There are three different versions of AERO: AERO RT (runtime), AERO NT (network), and AERO NT+ (network+). AERO RT comes with a RunTime of the FileMaker. This means that the user does not have to purchase the engine separately. It comes included in the package. This version of the package is not networkable. It is restricted to sequential access. The user must purchase the mainframe/server from FileMaker to run the networker's version of AERO NT. This version allows up to 10 users to access AERO simultaneously. To run the version AERO NT+ the user needs to purchase the airframe and also the engine FileMaker Pro Serve application from FileMaker. This version allows up to 250 users to access AERO simultaneously.

References Used to Support the Review
AERO web site, http://www.aerocan.com

Point of Contact
Rene Dacier, email: dacier@videotron.ca, http://www.aerocan.com

Aviation Quality Database (AQD)

Purpose

AQD is a comprehensive and integrated set of tools to support Safety Management and Quality Assurance. Provides tools for data gathering, analysis and planning for effective risk management.

Description

AQD was developed on the premise that the key to knowing what action to take to correct quality and safety deficiencies is to understand their root causes. AQD is a tool for implementing and managing comprehensive quality and safety systems. AQD can be used in applications ranging from a single-user database to include operations with corporate databases over wide-area networks.

Features of the system include: the recording and analysis of occurrences, both reportable incidents and others such as Quality Concerns, customer complaints and Occupational Health and Safety; full customization of the Occurrence Reports forms, utilizing unlimited data fields, drop down lists and codes; management of the investigation process; a customizable codified interpretation of the James Reason human factors model for determining causal factors, as developed by the New Zealand CAA; rate based analysis; risk analysis and cost statistics.

A Web Interface is available for the capture of Occurrence Reports over the Internet or the organisation's Intranet.

In addition, AQD has the basic elements of a quality system, including the tools to create an internal audit program and customisable check lists; the recording and tracking of quality improvements; the ability to track corrective and preventative actions; integrate external audit findings; and to analyze trends in quality indicators. This integration of Safety and QA tools allows for the combination of the results of investigations, audits and other QA activities for analysis.

The action tracking facilities allows the follow up and management of corrective actions that result from an investigation, audit or a quality improvement recommendation. This helps to ensure that the investment in Safety and QA activities yields results: because AQD helps identify causes - not symptoms - it can result in more effective corrective actions and this combined with prioritization by risk provides maximum time to devote to investigations and audits.

Other features of AQD include: full on-line help; interface to Microsoft Office facilities such as Word and Excel; and integrated e-mail facilities. In addition, Superstructure can provide facilities to convert existing databases into AQD, to preserve previously collected data.

References Used to Support the Review

Superstructure Development 2000 Ltd. website at http://www.superstructure.co.nz, and Spirent System's AQD brochure. Additional information found within *Aviation Safety Management*, prepared by the Civil Aviation Safety Authority Australia, April 1998.

Point of Contact

New Zealand: Sue Glyde, Director, (mobile phone) +64 25 572 909, e-mail address: sue@superstructure.co.nz or contact Superstructure, PO Box 44-280, Lower Hutt, New Zealand, (phone) +644 570 1694, (fax) +644 570 1695. http://www.superstructure.co.nz/.

AVSiS

Purpose
AVSiS is a safety event logging, management and analysis tool, for Windows PCs (95, 98, NT, 2000 or XP).

Description
Events are divided into two groups, happenings (which are noteworthy but not actual incidents), and incidents. Most events recorded will be incidents. The Flight Safety Officer (FSO) on receipt of an event report consolidates the information into the AVSiS system. Reports may be received and consolidated electronically or entered manually. AVSiS presents easy to follow forms, with standard pick lists (for example, event type, phase of flight, etc.) and text fields to enable detailed descriptions as required. The FSO may then request follow up reports from either internal or external departments (where the cause is assigned to an internal department, the FSO may also assign human factors(s)). A number of ready to use reports are available (for example, showing events graphically by location and severity). Graphical reports have the capability for the FSO to 'drill down' so that the underlying detail may be viewed. An easy to use Query Builder enables powerful queries to be selected and run in seconds. AVSiS enables the FSO to record the reports requested, and the reply by date. AVSiS also enables the FSO to run reports showing the status of requested information by department, thereby helping the FSO to ensure that investigations are conducted in a timely manner.

Event severity is assessed and recorded on two scales, severity and likihood. Once all the information about the event has been obtained, the FSO may record recommendations for actions to rectify any safety system weaknesses identified. As with requested reports, AVSiS enables the FSO to record recommendations made and whether or not they have been accepted and then implemented. All accepted recommendations must be implemented before the status of the event may be switched from open to closed. A flexible security system is also provided, set-up by the system administrator, users are granted rights at field and record level. This capability is ideal for granting limited rights to other departments or operating bases.

AvSoft is also currently developing further advanced features for AVSiS. These include the unique AVSHARE system, which will enable users to share safety information via the Internet with other users. Users decide who may see what information; and the data is encrypted for maximum security. AVSiS benefits airlines because it is easy to use, promotes good practise and is affordable. An optional Data Mining suite of software by Mitre Corp is also planned.

References Used to Support the Review
AvSoft Ltd (Producer and vendor of AVSiS / AvShare), http://www.avsoft.aero

Point of Contact
Tim Fuller, AvSoft, +44 1788 540 898 or US toll free 1-866 348 4503, tfuller@avsoft.aero, http://www.avsoft.aero

British Airways Safety Information System (BASIS)

Purpose
To gather and analyze air and ground safety incident reports and other information, to help manage reported incidents, and to assist those involved with safety to answer questions, like "How safe are we?" "Can we prove it?" and "Where should we put our resources to become even safer?"

Description
BASIS Safety Reporting is part of the BASIS family of aviation safety management products. BASIS was developed by safety professionals to provide a comprehensive and unified approach to Air and Ground safety. Since its inception in 1990, BASIS has evolved in size to include airlines, regulatory authorities and aircraft manufacturers. A primary focus in the design of BASIS has been to produce an application, which is easy to operate and requires minimal training, so that both regular and casual users may easily use it. It has a modular approach allowing organizations to select only those features they need. All modules share relevant data and have a common "look and feel." The following modules are available:

Air Safety Reporting (ASR):

- The original BASIS module, which processes flight crew reports on safety-related events.
- Information can be categorized using the new BASIS Descriptor/Factor classification system, allowing a much better analysis of the causes and consequences of incidents with powerful trend chart, filter and analysis facilities. The original BASIS reference and keyword system is also supported. A built-in risk assessment capability assigns risk weightings to events.
- Incidents may be assigned for action and details recorded of resulting outcomes and action taken to prevent reoccurrence.
- Videos, photographs, flight instrumentation replays and sound recordings can be stored.
- BASIS ASR can be linked to the BASIS Operational Flight Data Monitoring system to provide a holistic approach to air safety management.

Safety Information Exchange (SIE) - this module allows member airlines to share de-identified data extracts of their air safety reports (ASRs) in a standard format. One global database is then shared with all contributor airlines on a periodic basis. This activity is being managed by the Safety Trend Evaluation and Data Exchange System (STEADES).

Ground and Cabin Safety modules allow the recording, analysis and management of safety incidents in the cabin (Cabin Safety Reporting - CSR), of ground handling incidents (Ground Handling Reporting - GHR) and of aircraft maintenance reports raised by ground mechanics (Ground Occurrence Reports - GOR).

Elementary statistical trending assists in the investigation and characterization of safety incidents involving human error issues. Information is derived from flight crew responses to a set of standard questions. If the ASR module is also in use, relevant ASR incident data is automatically loaded into the Human Factors Reporting (HFR) module. Please refer to AIRS tool in section 3.1.5 for additional information.

References Used to Support the Review
British Airways BASIS Team, http://www.winbasis.com/

Point of Contact
Eddie Rogan, British Airways, Tel: +44 (0) 208 513 0225, email: eddie.1.rogan@britishairways.com

First Launch Safety Report System (SRS)

Purpose

SRS provides a way to enter operational reports for both aircrew and ground crew such as Air Safety Reports, Voyage Reports, Ground Occurrence Reports, Ground Handling Reports, Cabin Safety Reports, and Customer Safety Reports that can be entered on-line.

Description

SRS is designed for aircrew and ground crew alike. They can complete their report at a Personal Computer (PC), which then gets distributed to operational and support staff, as well as, safety and quality groups by email. When completed, a printed copy is produced for the originator. The reports are then prioritized and redistributed to the appropriate staff/management. Mandatory Occurrence Reports (MORs) can be sent to the Civil Aviation Authority.

By having crewmembers complete their reports on a PC, it saves them time in reproducing faxed reports. Time saved in processing reports allows for more in depth trend analysis and preventative risk assessments. Also, having an expeditious notification system gives added benefit to an airlines' operational staff/management and safety/quality personnel. Where remedial action is required (i.e. engineering), additional comments and component replacement can be recorded. The amended report is then redistributed.

The email configuration (setup by the SRS administrator) notifies key personnel by "Aircraft Fleet and Type." In this way, personnel selected receive immediate notification of every new report. Safety and quality departments are generally advised of all reports, but are able to track safety events as they happen. SRS administrators prioritize reports and escalation procedures are engaged. Emails are now sent to key staff/management depending upon the level of severity. SRS manages four levels of severity, priority 1 through priority 4.

Audit records of all report changes, is an integral part of SRS. Air Safety Reports can be exported into safety management systems such as British Airway's WinBASIS. An audit trail detailing whom, when, what, and where (PC name) records every action and update on every report.

Occurrence Review Board (ORB) reports are available in a format to suit an airlines meeting requirements. It will also produce action lists for participants, and record changes in occurrence actions as they occur, as well as being able to record ORB meeting minutes.

References Used to Support the Review

First Launch web site, http://www.FirstLaunch.co.uk

Point of Contact

Simon Earthrowl, First Launch, Tel: +44 (0) 1293 562 778, email: Simon@FirstLaunch.co.uk.

INDICATE Safety Program

Purpose

The INDICATE Safety Program was developed to provide simple, cost effective and reliable means of capturing, maintaining, monitoring and reporting information about safety hazards.

Description

The INDICATE (Identifying Needed Defenses in the Civil Aviation Transport Environment) Safety Program provides a company with a structured framework for critically evaluating and continually improving the integrity of aviation safety measures. It provides for a formal communication channel to regularly identify and report weaknesses in aviation regulations, policies and standards.

The basic premise underlying the INDICATE Safety Program is that staff will generally report safety hazards within their work area if they are given sufficient opportunity. The implementation of the program will minimize communication problems by providing a simple, but structured, process to ensure that consistent and high-quality safety feedback is disseminated to all staff. To achieve this, it is necessary to understand how accidents occur and the crucial role that safety defenses play in preventing accidents and incidents. The INDICATE Safety Program is based on three elements, which are critical for the success of any safety program within an organization: safety must be recognized as a priority within the company; senior management must be committed to improving safety standards; and appropriate resources must be allocated for safety management.

The INDICATE Software Program complements, rather than replaces, a company's existing safety measures management system. The INDICATE safety information database has been developed to provide a simple method of managing and communicating important safety information. It provides for the logical and consistent methodology for recording and categorizing hazards; a means of quickly and easily recording recommendations and responses against hazards; a database on which safety hazards can be recorded and tracked quickly and easily, and where nothing can be "lost" or "forgotten"; an automated facility for producing reports about hazards so that information about hazards can be disseminated easily and quickly to everyone who needs to know about them; and it is a useful tool for safety audit purposes.

The INDICATE Software Program V6.3 was created in Microsoft Access and is easily installed on any IBM-compatible personal computer. The only requirements to operate the program are a 486 CPU or better, Windows 95/98 or Windows NT 3.51, 32MB RAM for Windows 95/98, 64 MB RAM for Windows NT, 60 MB free hard disk space, 800x600/256 color screen resolution, Laser or ink/bubble-jet 300 dpi printer, CD-ROM drive. The program has both secure and un-secure versions. The Australian Transport Safety Bureau (ATSB) provides the INDICATE Safety Program/Software Program at no cost.

References Used to Support the Review

ATSB, http://www.atsb.gov.au/, INDICATE web site: http://www.basi.gov.au/wx6y9p/indicate.htm

Point of Contact

Ted Smith, Team Leader, Safety Support, ATSB, http://www.atsb.gov.au/, Phone: 1-800-621-372, email: atsbinfo@atsb.gov.au

3.2 Descriptive Statistics and Trend Analysis

Descriptive statistics refers to the treatment of data that summarizes or describes important features of a data set (such as measures of variability and central tendency). Trend Analysis refers to statistical techniques that identify trends in a set of data. These techniques can be used to identify the existence of a trend, its statistical significance and its consistency over time.

HeliStat

Purpose
HeliStat is an on-line analytic and graphic toolkit designed to help the user improve safety through effective interpretation and use of aviation safety data. Specifically, this web-based subscriber service is linked to Helicopter Association International's Mechanical Maintenance Information Report system (http://www.mmir.com), to enable subscribers to:

- Identify performance history and trends of specific parts
- Spot potential problems
- Track results of interventions
- Display benchmark rates and comparisons with industry-wide norms.

Description
Using a secure Internet connection, HeliStat enables its users to run complex statistical analysis programs through a menu-driven system. No special software is required. The resulting user-defined analysis can then be output, in graph, chart and summary report formats, and downloaded to the subscriber's computer.

Helistat provides its subscribers with:

1. Parts Lists: Detailed listing of part numbers, part name, JASC (ATA) code and name, FAA severity code, and number of reports. Users can readily search this list by sorting on any of the 10 columns:
   - New reports during the previous 120 days for parts not reported during previous 3 years (Frequently or commonly associated with accidents)
   - Persisting reports during the previous 120 days for parts also reported during previous 3 years (Frequently or commonly associated with accidents)
2. Trending: 12-month moving averages plotted monthly, with highlighting of points of significant increases over the previous year.
3. Top Ten Analyses: Number and rates per 1,000 aircraft of ten most frequently used categories.
4. Risk Rates for Specific Models: Annual rates per 1,000 aircraft of various problems.
5. Benchmark Comparisons: Comparison of risk rates for specific Model with system-wide benchmarks.
6. Red Flagging: Top ten aircraft with highest report rates (Password provides access only for the operator providing the information)

References Used to Support the Review
Web site: www.helistat.com; article in ROTOR magazine, Spring 2003.

Point of Contact
Dr. Alex Richman, AlgoPlus Consulting Limited, 902-423-5155, arichman@heliststat.com

Note: AlgoPlus (TM) and HeliStat(c) are trademarks of AlgoPlus Consulting Limited.

Microsoft Excel

Purpose
Microsoft Excel is a powerful general-purpose spreadsheet program that provides a wide range of capabilities to manage, analyze and chart data.

Description
Microsoft Excel stores data in tabular worksheets of rows and columns, each cell of which can contain textual or numerical data. Multiple worksheets can be stored in a single file termed a workbook. Excel provides a large number of built-in functions and data analysis capabilities to manipulate the contents of these cells and define the contents of cells in terms of the contents of other cells on the same or different worksheets, including worksheets in different workbooks. These functions include mathematical and statistical operations and text-manipulation capabilities.

Excel provides a range of capabilities to chart the data contained in the worksheets in a number of different formats, such as trend lines, bar charts, or pie charts. These capabilities allow users to customize the appearance of the charts and add annotations and drawings to the charts. A ChartWizard function simplifies the creation of charts, which can then be modified with the other built-in capabilities. Excel is designed to be seamlessly integrated with other Microsoft Office products, including the Word (word processing) and Access (data base management) programs. Word documents can incorporate charts and tables that have been created in Excel and the contents of which change if the source data is changed in the Excel file. Similarly, data can be easily imported and exported between Access databases and Excel worksheets. Excel also includes capabilities to access other external databases that support Sequential Query Language (SQL) queries, and supports access to web-based data sources through the inclusion of Unified Resource Locators (URLs) in formulae.

In addition to the statistical functions that are included in the basic capabilities of Excel, Microsoft provides a set of more advanced data analysis tools for use with Excel called the Analysis ToolPak that can be used to save steps when developing complex statistical or engineering analyses. The appropriate statistical or engineering macro function displays the results in an output table. The statistics feature includes: linear best-fit trend, exponential growth trend, FORECAST function, fit a straight trend line by using the TREND function, fit exponential curve by using the GROWTH function, plot a straight line from existing data by using the LINEST function, plot an exponential curve from existing data by using the LOGEST function, and a Descriptive Statistics analysis tool.

More advanced customization is possible through the use of built-in programming capabilities using the Visual Basic programming language.

Stage of Review Completed
This tool went through R&M and Value reviews.

(Topics addressed below are applicable to the stage of review completed.)

Airline Usage
A large number of airlines are known to be using this tool for the analysis of flight safety data and for presenting the results in the form of charts.

Documentation
A very well documented tool. Microsoft provides thorough documentation together with an extensive built-in user "Help" function. A large number of third-party user guidance books are available. Numerous training courses are also widely available, although these usually address general capabilities of the software rather than specific airline applications.

Vendor Support
Microsoft provides various support and training.

Potential Benefits to Flight Safety Analysis
Microsoft Excel provides a wide range of general analytical capabilities, but the successful application to flight safety analysis requires the user to develop the detailed elements of the specific analysis desired.

Tool Cost
Purchase Price: $400

(Purchase price does not include installation, operation, maintenance, or training costs.)

References Used to Support the Review
Microsoft Office Web Site, http://www.microsoft.com/office/archive/x197brch/default.htm

Point of Contact
Microsoft Office Web Site, http://www.microsoft.com/office/excel/default.htm

STATGRAPHICS Plus

Purpose
STATGRAPHICS *Plus* is a statistical analysis package that provides a wide variety of analyses, procedures, and capabilities, ranging from basic statistics to highly advanced and sophisticated techniques.

Description
STATGRAPHICS *Plus* has more than 200 powerful statistical analyses to choose from and a host of innovative features. It guides the user through every statistical analysis or graphics choice they make. It has the look and feel of Microsoft Windows, and is compatible with Windows NT, Windows XP, Windows 2000, Windows 98, or Windows 95. STATGRAPHICS *Plus* allows the user access to graphics in every procedure. The product is available in three different configurations: STATGRAPHICS *Plus* Standard Edition, STATGRAPHICS *Plus* Quality and Design, and STATGRAPHICS *Plus* Professional.

The Professional version includes basic statistical analyses and processes, Quality Control, Design of Experiments, Time Series, Multivariate Statistics and Advanced Regression. Several of the main features of STATGRAPHICS *Plus* include: StatAdvisor, gives the user instant interpretations of results; StatFolio, a revolutionary new way to automatically save and reuse analyses; StatGallery, allows the user to combine multiple text and graphics panes on multiple pages; StatWizard, guides users through a selection of data and analyses; StatReporter, allows the user to publish reports from within STATGRAPHICS *Plus*; StatLink, allows the user to poll data at user-specified intervals. These are just a few of the many features available in STATGRAPHICS *Plus*.

Stage of Review Completed
This tool went through R&M, Value, and OR reviews.

(Topics addressed below are applicable to the stage of review completed.)

Airline Usage
No airlines are known to be using this tool.

Documentation

The tool is well documented and comes with on-line help that includes statistics-related resources, information about training courses, technical specifications that list the recommendations for the current version of the software, software patches, and tutorials.

Vendor Support

Always available – In addition to STATGRAPHICS help documentation and on-line help there is 24-hour technical support.

Potential Benefits to Flight Safety Analysis

STATGRAPHICS contains extensive statistical inference and analytical procedures. All available procedures are listed in icons on the toolbar, and their implementation is as easy as point-and-click. This simple set-up makes the tool particularly user-friendly. All analysis results are presented in both graphs and written summaries, which should be very helpful for flight safety analysis. The two built-in features—StatGallery and StatFolio, provide simple and organized report formats for analysis results. These features should help reduce the safety department's labor and also support the safety monitoring process. However, the designs of some of the analysis procedures are somewhat confined to a special type of data and require additional statistical knowledge in its users to make proper modifications.

Usefulness to Flight Safety Analysis

STATGRAPHICS provides an overall moderate level of usefulness for flight safety analysis. Most analysis procedures in STATGRAPHICS are designed for normally distributed data. Users need to exercise extra care when applying the tool to "counts of rare events" and skewed types of data. Although the methods in STATGRAPHICS cover a broad range of applications, in some cases they lead to improper solutions. For example, some analysis results for forecasting and control charting for event rates in two test data sets turn out to be negative. Analysis results are easy to follow and the graphical outputs can be easily organized in StatGallery and StatReporter for presentations.

Usability of Tool for Flight Safety Analysis

STATGRAPHICS is very easy to set up and run. It is straightforward to import data from spreadsheets or an ACCESS database, even though it requires matching the headers of the data. It is extremely easy to generate analysis results. All functions are listed on the toolbar. It is as easy as point and click. However, it doesn't seem straightforward to export analysis results in general. It requires that the formats of STATGRAPHICS be preserved.

Tool Cost

Purchase Price: $749 (Standard Edition - U.S. Customer Cost).

(Purchase price does not include installation, operation, maintenance, or training costs.)

References Used to Support the Review

STATGRAPHICS *Plus*, User Manual, Version 5

Point of Contact

STATGRAPHICS Plus web site http://www.statgraphics.com, 1-800-592-0050, ext. 900 or
e-mail: gsales@manu.com

4.0 Flight Data Monitoring Analysis and Visualization Tools

This chapter contains summaries of sixteen Flight Data Monitoring (FDM) Analysis and Visualization tools. These tools assist in the routine analysis of flight data generated during line operations in order to reveal situations that require corrective action, enable early corrective action before problems occur, and identify operational trends. FDM programs generally involve systems that capture flight data, transform the data into an appropriate format for analysis, and generate reports and visualizations to assist personnel in analyzing the data.

These tools were, for the most part, designed for and are widely used by aviation operators. WG B has therefore not listed a separate category of "airline usage" for each tool in this section. WG B did not obtain cost information for each tool since it is highly dependent upon individual requirements and may vary from user to user. However, prospective purchasers should keep the factors below in mind when discussing their requirements with a tool vendor.

The price charged by some tool vendors is a flat fee, which allows multiple users on any one site. For others the rate increases depending on the number of authorized users. Many vendors will link the price to the size of the airline's fleet. Most vendors will charge an additional license fee for extra sites at a reduced rate.

In addition the purchaser will need to take into consideration:

- Installation costs
- Training costs
- Software upgrade costs
- Other software license fees that may be necessary

Most vendors will provide one year of maintenance and support in the original package but charge an annual fee thereafter.

In addition to the summaries provided below, tables containing information on capabilities and features for ten of the fourteen tools are contained in Appendix C. This information was provided to WG B by the tool vendors and has not been independently verified by WG B. (The information in Appendix C was obtained in 2003)

Aircraft Flight Analysis & Safety Explorer (AirFASE)

Purpose
To perform measurement, analysis and reporting dealing with in-flight operational performance of commercial aircraft.

Description
AirFASE (Aircraft Flight Analysis & Safety Explorer), jointly developed and marketed by Airbus and Teledyne Controls, is designed to be integrated into the airline's FOM (Flight Operations Monitoring) system, also known as FDM (Flight Data Monitoring) or FOQA (Flight Operations Quality Assurance). AirFASE allows an airline's Flight Operations and/or Safety Management departments to review line operations of a specific fleet with a dedicated route structure, by providing the means to analyze operational performance, identify risk precursors, and provide status or risk assessment.

AirFASE processes the data downloaded from the airborne data recording systems and presents a meaningful analysis for operational users. AirFASE decodes the recorded parameters using a process called Transcription. The AirFASE Flight Analysis Process (FAP) then reconstructs the flight of the aircraft and correlates the actual data with the expected or recommended operation. The FAP finds deviations and stores them as "Events". Each event can be validated and is stored in a database, such that the results can be presented in a simple, understandable way (reports, charts, lists, animation).

As the data is processed, it becomes evident that specific events and combinations of events on specific flight segments demonstrate a higher risk potential. AirFASE provides visualization tools that help operations management to isolate and review these flight segments, without compromising the confidentiality of flight crew identification. AirFASE contains a powerful and configurable Reporting module, which identifies trends in the occurrence of events over different selection criteria (airport, aircraft type, phase of flight, aircraft tail, etc).

AirFASE is easily programmable by the user to add or change the Events or data being monitored, so it can also be used to run a maintenance monitoring program, for example, providing the results of the analysis to the airline Maintenance Department.

The developer believes the following are positive aspects of AirFASE:

- Statistical approach to risk assessment
- Integrated means for validation of the flight data and events
- Significant time savings for “Long Term” and “Short Term” analysis of fight data
- User-friendly interfaces provide direct access to meaningful information
- Powerful and accurate flight analysis programs available.

Reference used to support the Review
Teledyne Controls web site, http://www.teledyne.com

Point of Contact
Tamas Igloi, Director, Advanced Programs, +1 (310) 442 4217, tigloi@teledyne.com

Analysis Ground Station (AGS)

Purpose
To provide report generation from automatic and manual data selection for FOQA and MOQA, import/export functions, numerous expanded programming capabilities, advanced analysis, and database management features.

Description
The Analysis Ground Station (AGS) is a Windows 2000 compatible replay and analysis system developed by SAGEM and designed for mono-user or multi-user applications. It can interface with any COTS QARs/FDRs, regardless of the aircraft source. In the operation-oriented application, AGS has flight operations monitoring with routine event detection and exceedance detection capabilities. AGS also has Flight Efficiency Monitoring (FEM) that can calculate the operational costs of the aircraft, fuel burn, and flight time.

In an automatic analysis AGS can analyze and process all data available from a recorder in order to provide a customized report as requested. AGS has a processing time going from 1 to 5 seconds for a 1-hour recording, depending on the number of parameters available. AGS generates an analysis report showing events with classification levels, gives a flight and event data base update, and shows various trend monitoring processes (engine, airplane performance, etc.).

During the manual and on-event analysis, AGS provides an efficient graphic user's interface to view quickly all pertinent data for troubleshooting. AGS has preformatted parameter sets to have quick access to pertinent data including tabular data, cockpit animation, landing graphic representation, and external data file output/input.

The SAGEM AGS has been complemented by a full range of "light" products to fit all the user's needs. For example, the data can be securely dispatched in the airline with the AGS Data Viewers. The Flight Safety Officers are now able to work and present dynamic statistic with the AGS Report Viewers, even though they do not run the AGS on their computer.

The SAGEM Ground Support Equipment (GSE) is the programming tool used to program Digital Flight Data Acquisition Units (DFDAU) and Data Management Unit functions. It is designed to create a work environment similar to the AGS.

References Used to Support the Review
SFIM Inc. web site: http://www.sfim.com/en/, SAGEM web site: http://www.sagem.com

Point of Contact
America's : SFIM, Inc., Laurent Bloch, Sales Director ACMS/AGS Phone: 972-314-3603
Out of America's : SAGEM, Thierry Pfeiffer, AGS Product Manager, Phone : 33-1-5812-4176

Aviation Performance Measuring System (APMS)

Purpose
APMS is a National Aeronautics and Space Administration (NASA) funded program to develop advanced software analysis tools to ease the large-scale implementation of flight-data analyses within each of the air transport users. As a government R&D project, APMS is not a commercially-available package, but a developer of technologies implemented at carriers participating in Space Act Agreements, and transferred

to the FOQA software vendor community. This partnering relationship is made available by the Space Act of 1958, and serves to protect the confidentiality of data accessed through this research.

Description
APMS is both an existing set of data uploading, processing, and analysis tools and an R&D program to conceive, prototype, and transfer new capabilities. APMS develops and documents methodologies, algorithms, and procedures for data management and analyses to enable users to interpret easily their implications regarding the safety and efficiency of operations. It is a developer of analysis concepts and prototype software and an engine of technology transfer to the U.S. aviation industry and to the vendor community that serves it. APMS offers to the air-transport community an open, voluntary standard for flight-data-analysis – a standard that helps to ensure suitable functionality and interchangeability among competing software programs. APMS has the ability to retain de-identified data from all the flights from which the full population can be determined for recorded flight parameters and link this data with other sources of information, such as weather at the time and location of flight events.

APMS is being developed as a set of analytical tools for U.S. Flight Operations Quality Assurance (FOQA) programs. The system will eventually be extended to service the needs of engineering, maintenance, and training in airlines and other operators.

References Used to Support the Review
NASA, Ames, http://infotech.arc.nasa.gov/hfcapabil.html

Point of Contact
Tom Chidester, NASA Ames, (650) 960-6007, Thomas.R.Chidester@nasa.gov

AVSCAN.flight

Purpose
To allow the user to portray informational parameters in any desired combination and time perspective, and view them in engineering unit and graphic formats simultaneously.

Description
The Avionica AVSCAN.flight is an individual flight data review and analysis software and can be used in conjunction with AGS FOQA Analysis software for fleet wide automated data analysis and reporting solution for FOQA. AVSCAN.flight enables the user to display recorded events from selected flights or flight segments only minutes after the FDR is downloaded. AVSCAN.flight tailors to the user's analysis requirements. They can examine parameters in any quantity and combination, using the 'drag and drop' method, and view them immediately and simultaneously in engineering units and graphic formats. AVSCAN.flight was designed to promote safety, enhance maintenance troubleshooting, and simplify the extraction and analysis of data from FDRs and QAR's. It provides the user with a test function that shortens analysis time dramatically and is able to drill down to increments as small as a 1/8th of a second. AVSCAN.flight completes a search of all downloaded data for out-of-tolerance points, and provides a hardcopy of any view in graphic and tabular format.

References Used to Support the Review
Avionica, Inc., website: http://www.avionica.com, AVSCAN products web site: http://www.avionica.com/avscan.htm

Point of Contact
Scott Moore, Director of Marketing, 305-559-9194

British Airways Flight Data Tools

Purpose
To gather and analyze digital data derived from onboard flight data recorders in support of an airline's Flight Data Monitoring (FDM) Programme - known in the U.S. as Flight Operations Quality Assurance (FOQA).

Description
British Airways Flight Data Monitoring is part of the British Airways family of aviation safety management products. It was developed by safety professionals to provide a comprehensive and unified approach to Air and Ground safety. Since its inception in 1990, BASIS has evolved to become the world's most popular aviation safety management tool, used by over 150 organizations including airlines, regulatory authorities and aircraft manufacturers. It has been characterized by more than one Chief Pilot as ".... the system that allows me to sleep at night." The following modules are available:

Flight Data Traces (FDT) - the primary module in the system, which reads raw flight data, automatically detects airline-defined events, saves measurement/event data for future analysis and displays data as a trace or list of values. The module is extremely flexible in its control facilities, may accept data from a variety of media and provides powerful features for the selection and review of data. Data is automatically shared with the other modules in the system, or may be exported to other vendors' systems. FDT is an ideal economic solution for an operator starting an FDM programme.

Flight Data Events (FDE) - this is the Events database that accepts data from FDT, or another vendors' compatible flight replay system. FDE can analyze events by aircraft type, event type, airfield, date, keyword etc. and present the data in the most graphical format appropriate to that particular analysis. There is an integrated risk assessment component to automatically assess the "severity" of all exceedence events.

Flight Data Measurements (FDM) - is a proactive and exciting way of using flight data. Instead of only looking at 'events', FDM analyzes the maximum or worse case values of many parameters on each flight. It then creates distributions over thousands of flights, and performs statistical analysis and modeling. FDM is a powerful way of identifying trends, selecting flight data event limits and, indeed, of validating flight training programmes.

Flight Data Simulation (FDS) - which recreates the flight just as the pilot saw it and produces an animated replay of instruments monitored on a recorded flight. The animation may be viewed in real-time, faster, slower or paused. The autopilot modes and flight director commands are displayed together with aircraft path and basic audio. FDS may be run stand-alone, or viewed within other modules such as Air Safety Reporting and Flight Data Events.

Flight Data Home (FDH) is a "remote viewer" that can be installed on flight management laptops to allow the remote viewing of flight data traces. The flight data can e-mailed to a flight manager to allow him to view data when away from the office.

British Airways Flight Data Monitoring can be linked to the BASIS Safety Reporting System to provide a holistic approach to aviation safety management.

References Used to Support the Review
British Airways BASIS Team, http://www.winbasis.com/

Points of Contact
Nigel Summerhayes, Tel: +44 (0) 208 513 1257, email: nigel.r.summerhayes@britishairways.com

Cockpit Emulator for Flight Analysis (CEFA)

Purpose

To replay and visualize aircraft flights with the help of very accurate virtual instruments and 3D aircraft view by using FDR and QAR data.

Description

CEFA (Cockpit Emulator for Flight Analysis) is software that restores universal flight synthesis as it relies on **all** the precious information extracted from flight data. CEFA instantly emulates a view of the cockpit, just like a synthetic film, and a 3-dimensional outside view of the aircraft moving in flight environment. Thanks to the highly accurate restitution of these instruments displayed on one or several PC screens, CEFA takes you to the heart of the event. Analysis is thus more precise, quicker and provides improved flight safety and enhanced maintenance, thereby saving time and money.

As part of a FOQA program, CEFA, a genuine communication tool, makes it possible not only to understand the incidents but also to prevent them from happening again by laying emphasis on training using previously-created video films.

CEFA can be easily interfaced with most of the common commercially available readout stations. Nevertheless, upon request, CEFA can support any homemade solutions.

References Used to Support the Review

CEFA Aviation, Inc. web site, http://www.cefa-aviation.com

Point of Contact

Dominique Mineo, CEFA Aviation, Inc., 9, Croisee des Lys, 68300 Saint-Louis, France
Phone: +333-8989-8181, Fax: +333-8989-8182, e-mail: dominique.mineo@cefa-aviation.com

Event Measurement System (EMS)

Purpose

The Event Measurement System (EMS) is designed to ease the large-scale implementation of flight-data analysis in support of the Flight Operational Quality Assurance (FOQA) Programs and Advanced Qualifications Programs (AQP).

Description

The EMS is a highly configurable and adaptable Windows 2000 based flight data analysis system. It is capable of easily managing large bodies of flight data, and can effortlessly expand with fleet size and changing analysis needs. As the operations grow, EMS has the capacity to continue to extract maximum analyzed value from the flight data.

The EMS software components provide for configuration, automated processing and interactive analysis. The architecture of EMS has the highest level of automation of any FOQA/MOQA system available. The system has been designed to minimize labor, saving both the analyst's time and the airline's money.

The Austin Digital system strongly supports user configurability, allowing the end user to easily add fleet types and event and measurement definitions. The system was designed from the ground up to be user configurable, and hence the configuration options are complete and logically organized.

EMS includes database analysis software for analysis of the exceedances and measurements databases that allow a user to perform trending, drill-down and characterization of the databases. With the Austin

Digital system, no programming is required for most analyses. The data can easily be exported to Microsoft Excel or Access.

EMS provides well-defined and rigorous security levels, enabling the appropriate amount of access to all users. All flight data is de-identified to all but the highest security level. Sensitive data is encrypted before it is stored. EMS can easily be integrated with systems of even the strictest security specifications.

References Used to Support the Review
Austin Digital, Inc. EMS web site, http://www.ausdig.com/analysis/dat.html

Point of Contact
Ben Prager, Austin Digital, Inc., 512-452-8178, email: bap@ausdig.com/

FlightAnalyst

Purpose
FlightAnalyst is a single-flight and multi-flight analysis solution that integrates tools necessary to load, store, pre-process, analyze, visualize, report, archive, maintain and animate aircraft or simulator flight data files.

Description
SimAuthor's FlightAnalyst is a turnkey, single-flight and multi-flight analysis software application that provides the user with a powerful and comprehensive set of tools to graphically and numerically analyze an entire database of recorded digital flight data. It can be used to analyze routine and special events, categorical events, exceedances, negative safety trends, and other flight training, operational or tactical issues. The results are presented to the end-users in a variety of customizable charts and reports. Using FlightAnalyst, patterns and negative trends can be discovered and coping strategies developed, such as adjusting the training curriculum, procedure optimization, or even equipment modifications. FlightAnalyst fully integrates with SimAuthor's powerful flight data animation software, FlightViz™ to form an all-inclusive data analysis and debrief system.

FlightAnalyst comes pre-installed, configured and tested on the appropriate hardware and is fully scalable from a single-user desktop installation to a distributed and web-enabled client-server application. It is based on Microsoft's highly successful .NET technology and driven by SQL Server. Its modular, object-oriented design provides a high degree of flexibility that ensures reliability, security and maintainability. FlightAnalyst permits exchanging data with other commercially available, off-the-shelf software, such as Microsoft Office products and Adobe Acrobat.

References Used to Support the Review
SimAuthor, Inc. web site: www.simauthor.com

Point of Contact
Dr. Alexander G. Pufahl, SimAuthor, Inc., +1 (303) 545-2132 x2133, alex.pufahl@simauthor.com

FlightTracer

Purpose
FlightTracer is a 3D visualization tool for flight investigations, training, and monitoring programs.

Description
FlightTracer provides 3D visualization of standard ASCII output of flight data recorders and quick access recorders. The data loaded is automatically pre-processed by smoothing and removal of anomalies. The flight can be animated, played back in real-time or with accelerated / decelerated time. Highly detailed aircraft models are presented with indicated rotations and positions. The models have full moving parts with attention placed on their accuracy. Further, flight instrument (including EFIS systems) panels display a snapshot of values at a given time. All data parameters can be graphed, or presented as a false color plot or 3D graph. Derived parameters are automatically generated with no need for interaction. There is an emphasis on approach runs with support for ILS and accurate, flexible airstrip configurations. Aerial photography or scanned sectional maps can be included to create flight scenes that provide insight into spatial relations to ground features. Output can be stored as an animation file (*.avi) or highly portable 3D frames captured for use in presentations. Other features are navaid/obstruction placement, database support, anomaly removal, and flight path adjustments for localizer/speed/heading values. All displays, including instruments and graphs are highly customizable, in order to create a compelling conceptualization of events that occurred during a flight.

References Used to Support the Review
Stransim Aeronautics Corporation. web site: www.stransim.com/ftracer.htm

Point of Contact
Jefferey D. Bogan, President, Stransim Aeronautics Corporation. Phone: (902) 864-6429, email: jbogan@accesswave.ca.

FlightViz™

Purpose
FlightViz facilitates the safety analysis process by allowing analysts to visually recreate a flight – in three dimensions – using actual aircraft or simulator flight data.

Description
FlightViz is a high fidelity, real-time, flight data visualization system that enables non-programmers to quickly and easily visualize and analyze aircraft, simulator, or telemetry data. It provides numerous data display formats whereby analysts, managers, pilots and students can visually examine a flight from a variety of perspectives. Typical applications include Flight Operations Quality Assurance (FOQA), simulator/training brief and debrief, classroom training, and airport familiarization. FlightViz users in the global aviation market include over 50 major international, domestic, and regional airlines, as well as the U.S. military and several U.S. and international government agencies.

References Used to Support the Review
SimAuthor, Inc. web site: www.simauthor.com

Point of Contact

Steve Lakowske, SimAuthor, Inc., +1 303-545-2132 x2111, steve@simauthor.com

FltMaster

Purpose

To provide 3-D animation and flight data replay using a suite of visualization tools able to accept data from simulations, manned-motion simulators, and recorded flight data in virtually any format.

Description

FltMaster tools are being used in aircraft design, airline accident and incident investigations, and in the FOQA program. Development initiatives include advanced mission rehearsal and debriefing systems using real-time, photo-realistic graphics operating on an ordinary PC platform. Other initiatives are flight data analysis using automated event detection by statistical process control and replay with one-touch animation. FltMaster is capable of simulating or animating any air vehic le. It has a comprehensive tool set that provides a common engineering environment for all phases of an aircraft's life cycle, from preliminary design through operational analysis.

The architecture of the software and the graphic -user-interface (GUI) were designed to maximize engineering productivity visualization displays are understandable to anyone. The FltMaster simulation is architected with a simple, but powerful mode library design. It enables the user to rapidly construct simple or sophisticated simulations of any vehicle type. The model library is well stocked with industry-accepted models, but readily integrates any custom user models coded in C++, C, or FORTRAN. FltMaster visualization displays are designed to convey data through use of 2D/3D graphics. The display library includes a real-time view of the flight vehicle, instrument gauges, region maps, flight envelopes, special orientation graphics, and more. A plotting tool is embedded that allows graphical analysis of any set of flight parameters. The visualization is fully adaptable, and accepts any custom user displays.

References Used to Support the Review

Sight, Sound, and Motion FltMaster website: http://www.ssmotion.com

Point of Contact

Doug Barnes, 703-318-0350, website: http://www.ssmotion.com

GRAF-VISION Flight Data Animator

Purpose

To provide a suite of software tools for 3D animation of recorded aircraft data to support operational monitoring (FOQA) programs of the world's airlines.

Description

GRAF-*VISION* Flight Data Animator creates compelling visualizations of real-life events. As a part of a FOQA program, GRAF-*VISION* plays a key role in communicating what happened by showing the data in a format that puts the pilot back in the cockpit.

Utilizing data captured and processed by the GRAF software module, GRAF-*VISION* provides high-fidelity 3-D aircraft views, complete with corporate livery and logos. Multiple windows enable the user to view the situation from a variety of perspectives, including out-of-window, chase plane, and cockpit instrumentation viewpoints. VCR-type replay tools let the user play, fast forward, rewind, pause and frame-step through the data for fast access and extended study. And for heightened realism and effectiveness, accurate airport and runways can be combined with detailed terrain databases. A selectable 3D flight path-plotting feature with height bars provides additional input for more memorable communications and performance improvements.

GRAF-*VISION* Flight Data Animator can be synchronized with a GRAF display, and can be used to create training material for display on *RE VISION* simulator debriefing system.

A critical part of GRAF-*VISION* is the path correction technique. It has a unique and easy-to-use method of accurately positioning the aircraft relative to the ground, based on many years of accident investigation development.

References Used to Support the Review

Spirent Systems, GRAF-VISION Flight Data Animator website: http://www.spirent-systems.com/spirent4/softwaresolns/safetytraining/fda.htm.

Point of Contact

Peter Clapp, Spirent Systems, +44 (0)20 8759 3455, email: peter.clapp@spirent.com

Ground Recovery & Analysis Facility (GRAF) for Windows and PERMIT

Purpose

To obtain precise information about flight operations to help objectively evaluate a wide range of business issues.

Description

GRAF for Windows combines a powerful and extremely flexible replay and analysis engine with an in-depth data investigation tool set. It is designed for Windows NT and can run as a standalone or a networked solution. Performance Measurement And Management Information Tool (PERMIT) turns the event database generated by GRAF into meaningful graphs and tables. The 'drill-down' feature enables further event detail to be quickly retrieved to validate the statistics being presented. PERMIT also includes reporting features.

A key feature of GRAF is the ability to supply a turnkey package, including a set of fully specified, coded and tested analysis routines. The latest release of GRAF incorporates QuickCAMEL, a five step analysis event builder Wizard. This allows addition of new safety and engineering analysis to the core routines without in-depth training.

For users who want more independent capability there is CAMELpro. This is a fourth generation easy-to-use programming language. It gives the user the full capability to write and test their own analysis routines.

To make the best use of computer disk storage, GRAF uses a unique event cache. This automatically stores portions of flight data around each event in an indexed temporary store. Users configure the time period around events and can mark those for permanent storage. All parameters are retained and kept in a compressed form for future investigation.

GRAF produces an event summary database to let the user turn the data into meaningful management information. PERMIT is another analysis tool that uses this database to give the user this information quickly and easily.

GRAFVU is the suite of data investigation tools provided as part of GRAF. These include color graphical traces with on-screen scaling, engineering unit lists, raw data views, data quality reporting, event marking, parameter value searching, 'favorite parameter' profile builder and support for printing and exporting.

GRAF supports a wide range of data recording devices including tape and solid state FDRs, HHDLUs, QARs, DARs, PC cards from DMUs and wireless data links. To increase data throughput and reduce overhead costs, GRAF can be provided with the OQAR Autoloader to automatically handle up to 35 disks at once.

References Used to Support the Review

Spirent Systems, GRAF web site: http://www.spirent-systems.com/spirent4/softwaresolns/safetytraining/graf.htm; PERMIT website: http://www.spirent-systems.com/spirent4/softwaresolns/safetytraining/permit.htm.

Point of Contact

Peter Clapp, Spirent Systems, +44 (0)20 8759 3455, email: peter.clapp@spirent.com

Line Operations Monitoring System (LOMS)

Purpose

To compare flight data, identify exceedances, and monitor events that will lead to improved pilot training and correction of working errors.

Description

LOMS is the Airbus contribution to the FOQA programs. It creates a database containing all flight data recorded in the digital flight data recorder media. It then compares them with the Airbus exclusive flight profile and processing exceedances. From these exceedances it identifies events, i.e. work errors in aircraft handling. It then monitors these events in order to propose: menu-driven reporting (various statistical analyses of these work errors), identification of risk scenario, and trend analysis. LOMS can provide the specific target for remedial action and a follow-up on its effectiveness. Training managers can use LOMS to get effective line feedback for recurrent and transition training.

LOMS has three phases to grade events on its deviation scale. Level one defines a small exceedance indicating a routine error. Level two defines a serious deviation indicating a significant error. Level three defines a major event indicating a major error. Flight Replay is the principal risk assessment tool of LOMS. It is designed to review alert events, unstable departures and approaches and risk scenarios in which a high level of perceived risk appeared in the statistics. De-identification is accomplished according to the company policy by the application of a discreet code maintained by an approved doorkeeper. LOMS is able to detect alert events which are considered as the most critical for operations safety. A standard version of LOMS reports can include a management summary, event category deviations, event occurrences by phase of flight, destination/departure events, unstable approaches, and/or alert events. Customized reports can be created using a report editor. The data processing of LOMS converts the raw DFDR digital and other analog data into engineering structured data using a DECOMMUTATION module. It filters engineering data through the aircraft flight profile algorithms in order to produce event exceedances. LOMS stores the data in expanded database archives, produces statistical reports, and generates REPLAY for flights associated with potential high-risk events.

References Used to Support the Review

Airbus website: http://airbus.com

Point of Contact

Anne Fabresse, Airbus Systems and Services Commercial Department, +33 0 5 61 93 50 22, email: anne.fabresse@airbus.fr.

Recovery, Analysis, & Presentation System (RAPS) & Insight (Flight Animation System)

Purpose
To provide a comprehensive ground data replay and analysis station including flight animation for FOQA programs as well as aircraft accident and incident investigations.

Description
RAPS and Insight provide decoding, analysis, and animation tools that can be used for the investigation of data originating primarily from Flight Data Recorders (FDRs) and Cockpit Voice Recorders (CVRs), as well as secondary sources such as radar and GPS. RAPS and Insight primary strengths are tools that allow the flight data analyst to quickly focus on pertinent information. Analysis of flight data using RAPS is a primary source of information for occurrence investigation as well as routine data monitoring to identify trends and study exceedances. The key features include: real time tape based data recovery; interactive problem data editing; aircraft parameter database configuration; engineering units conversion definition; solid state recorder data import; 2D flight data plotting; tabular data listings; numerical analysis tools; data exceedance search tools; time sequence marking; real time 3D animation - customizable models, texture mapping support, and industry standard 3D model formats; CVR transcription annotation; integrated and synchronized audio support; photo realistic cockpit instrumentation - analog instruments, primary flight displays, and heads up displays; flight path reconstruction and analysis; runway model editor; and industry standard data import/export.
RAPS is an established engineering analysis tool that is used worldwide by leading civilian and military investigation authorities, major airlines as well as major aircraft manufacturers in Australia, Canada, Finland, France, Germany, Korea, Sweden, Switzerland, Taiwan, and throughout the United States. An international User group promotes cooperation among investigators, easy exchange of data and aircraft databases, models, instrument displays, and other information. Users share information online through the secure Flightscape Web (www.flightscape.com/raps). A yearly Users Conference allows users to meet for training and to discuss future system enhancements.

References Used to Support the Review
Flightscape, Inc., http://www.flightscape.com,

Point of Contact
Michael Poole, Managing Partner, Business Development, Flightscape Inc., (613) 225-0070 x229, email: mike.poole@flightscape.com

Software Analysis for Flight Exceedance (SAFE)

Purpose
To help in the analysis of FDR data to identify any exceedances which might have occurred and are beyond the user's predefined range of certain parameters.

Description
To help airlines achieve FOQA compliance, Veesem Raytech Aerospace has developed a Windows-based application to analyze FDR data of every flight. Their approach is that in order to obtain a significant reduction in accident rates, airlines have to be pro-active-that is, look ahead and identify potential accidents so they can be stopped before they happen. Analysis of FDR data can indicate adverse trends creeping in, which can be monitored and preventive action can be taken before a chronic breakdown of

vital systems occurs. Continuous analysis of the DFDR, combined with FOQA helps promote trend analysis, knowledge building, and decision-making that will improve airline safety and savings in operations cost. SAFE can be developed for any airline on a turnkey basis and customized for any type of aircraft fitted with FDR to suit individual airlines monitoring requirements. SAFE has fully specified, coded and tested analysis routines. Flight data is recorded in the FDR during flight and then downloaded using an interface card onto a ground station computer. This data in conjunction with SAFE software helps determine various aspects of the flight.

The data can be printed or viewed graphically or numerically. Regardless of the type of view the user selects, the analysis of exceedances will show warning and extreme values. The statistical capability of SAFE to extract and provide valuable information in pie-chart, bar-chart, or tabular format is useful even for a non-technical executive to understand. The user can visualize the flight by reconstructing the flight path and the corresponding display of the instruments during various phases of flight.

On-line help facility is available to the user at every stage. The versatile report generation facility enables reports generated per the users' requirements. SAFE software is an open-ended design allowing for further expandability as new developments take place, thus saving costs for the user.

References Used to Support the Review

Veesem Raytech Aerospace, LLC, website: http://www.vsmaerospace.com

Point of Contact

CV Prakash, Veesem Raytech Aerospace, LLC, 00 971–9-2281840, email: avaiadata@emirates.net.ae.

5.0 Human Factors Analysis Tools

Human Factors Analysis refers to the study of human performance factors (e.g. cognitive, perceptual, physiological, motor) and the human-machine interface that contribute to incidents, accidents, and other safety-related events.

Aircrew Incident Reporting System (AIRS)

Purpose
To better understand human performance aspects that occur in aircraft incidents and events.

Description
AIRS is a confidential human factors reporting systems that provides airlines with the necessary tools to set up an in-house human performance analysis system. The tool was established to obtain feedback from operators on how well Airbus aircraft operate to identify the significant operational and technical human performance events that occur within the fleet; develop a better understanding of how the events occur; develop and implement design changes, if appropriate and, inform other operators of the "lessons learned" from the events.

AIRS aims to provide an answer to "what" happened as well as to "why" a certain incident and event occurred. The analysis is essentially based on a causal factor analysis, structured around the incorporated taxonomy. The taxonomy is similar to the SHEL model that includes environmental, informational, personal, and organizational factors that may have had an influence on crew actions.

Stage of Review Completed
This tool went through an R&M, Value, and OR review.

(Topics addressed below are applicable to the stage of review completed.)

Airline Usage
Over 20 airlines are using the system and several more are considering it.

Documentation
AIRS is well documented. The definitions are directly displayed in the software when highlighting the causal factor. The documentation allows the user to verify and understand the underlying methodology.

Vendor Support
Training is available on a periodic basis (depending on demand) and is directed to help airlines set-up and run the in-house reporting system and to provide airline personnel with a level of skills to implement the reporting scheme within their respective organizations.

Potential Benefits to Flight Safety Analysis
AIRS provides the necessary tools to collect, analyze, and disseminate human performance (or joint human-machine performance) data obtained from aviation incidents and events. It identifies previously unknown hazards, helps raise visibility or awareness of hazards, and increases knowledge about hazards and possible consequences. It improves quality and consistency of input data by translating the data into useful information by analyzing and updating human factors reports in order to identify trends. AIRS generates reports and can be operated alone or in conjunction with any system that obtains information on significant technical or operational events. AIRS supports airlines to establish an open reporting culture,

where flight crews can voluntarily report and share information and knowledge in a confidential, non-punitive airline environment.

Usefulness to Flight Safety Analysis
The type of data needed to use the tool may be available, but the amount of data available may not be ideal. The analysis process including calculations, formulas, etc. is straightforward, easily understood, and involves a short learning curve. No specialized analytical skills are required to use the tool. AIRS analysis results can easily be understood and interpreted by the layperson, and applied to address areas of interest to the flight safety office. Results point clearly to areas that may need action including an indication of the highest priority items.

Usability of Tool for Flight Safety Analysis
The tool set-up is straightforward and requires little effort ("plug and play"). No additional software, programming, or adaptation is required. AIRS can easily import data in an automated form from various sources and formats. The tool has a "point and click" feature that is very user-friendly. AIRS has features such as a web-enabled capability that make it easy to electronically disseminate analysis results directly to the intended audience.

Tool Cost
Purchase Price: Cost depends on fleet size.

(Purchase price does not include installation, operation, maintenance, or training costs.)

References Used to Support the Review
Airbus AIRS publication, "Incident Investigation and Analysis for E&P Operations", dated 1999.

Point of Contact
Jean-Jacques Speyer, Airbus Flight Operations Support, 33.561.93.30.02, email: jean-jacques.speyer@airbus.fr

Cabin Procedural Investigation Tool (CPIT)

Purpose
To identify the key underlying cognitive factors that contribute to cabin crew errors or procedural non-conformance, and to help the airline industry manage safety risks associated with cabin crew safety security errors.

Description
The CPIT process focuses on a cognitive approach to understand how and why the event occurred, not who was responsible. CPIT depends on an investigative philosophy, which acknowledges that professional cabin crews very rarely fail to comply with a procedure intentionally, especially if it is likely to result in an increased safety risk. It also requires the airline to explicitly adopt a non-jeopardy approach to incident investigation. CPIT contains more than 100 analysis elements that enable the user to conduct an in-depth investigation, summarize findings and integrate them across various events. The CPIT data organization enables operators to track their progress in addressing the issues revealed by the analyses.

CPIT is made up of two components: the interview process and contributing analysis. It provides an in-depth structured analytic process that consists of a sequence of steps that identify key contributing factors to cabin crew errors and the development of effective recommendations aimed at the elimination of similar errors in the future.

The CPIT form, intended to be used by a trained cabin crew safety investigator, is designed to facilitate the investigation of cabin related safety and security incidents.

Tool Cost
Purchase Price: Boeing provides implementation support and training for BSMS tools to Boeing operators free of charge.

References Used to Support the Review
Boeing Co. Flight Technical Services
http://www.boeing.com/commercial/flighttechservices/ftssafety.html

Point of Contact
Mike Moodi, Boeing Co. Flight Operations Engineering, 206-662-7542, mike.m.moodi@boeing.com.

Human Factors Analysis and Classification System (HFACS)

Purpose
To identify causal factors that underlie joint human-system failures and breakdowns in order to better understand their role in incidents/accidents, to better detect their presence and to mitigate the consequences of those factors before an incident/accident occurs.

Description
In the U.S. Navy, the estimated contribution of human errors to incidents/accidents remains far higher (~80%) than those for mechanical failures. This has been the stimulus for the adoption of Reason's Latent Failure Model (1990). The model provides a systematic framework to understand the dynamics and evolution of the conditions that give rise to human-system failures and breakdowns. Reason's Latent Failure Model distinguishes between active and latent failures. Active failures are "unsafe acts" (errors or violations) caused by operators that become immediately apparent to an observer. Latent failures, on the other hand, are decisions whose adverse consequences may lie dormant within the system for a long time, only becoming evident when they combine with other factors to cause an incident/accident. Latent failures extend to supervisors and other organizational factors - people generally far removed from the actual occurrence of the incident/accident. HFACS describes a human factors classification scheme employing Reason's model and first applied to the study of incidents/accidents in Naval aviation.

HFACS employs four levels of analysis to understand the underlying causes of incidents/accident: (1) human error or the willful violation of rules and regulations, (2) the preconditions for the unsafe act; e.g., substandard states of operators (mental, physical, physiological) and substandard practices, (3) unsafe or inadequate supervision, and (4) organizational factors. The rationale is that these four levels of analysis are sufficiently comprehensive and diagnostic to identify and classify the vast majority of human errors that occur in various operational settings. Measures of reliability and validity are continually performed as the model expands to capture additional human factors issues or applied to a greater variety of aviation incidents/accidents (commercial and general aviation). Finally, the usability of HFACS has been established with its extensive use by the U.S. Navy/Marine Corps and Army, by NASA and by the FAA.

Stage of Review Completed
This tool went through the R&M and Value reviews.

(Topics addressed below are applicable to the stage of review completed.)

Airline Usage
No airlines are known to be using this tool.

Documentation
A formal manuscript titled 'Beyond Reason' describes the Human Factors Analysis and Classification System (HFACS) along with a report by Wiegmann, Douglas A., and Scott A. Shappell, "A Human Error Analysis of Commercial Aviation Accidents Using the Human Factors Analysis and Classification System (HFACS)", Report Number DOT/FAA/AM-01/3, Office of Aviation Medicine, Federal Aviation Administration, Washington, D.C., February 2001. Also, a report by Shappell, Scott A., and Douglas A. Wiegmann, "The Human Factors Analysis and Classification System - HFACS", Report Number DOT/FAA/AM-00/7, Office of Aviation Medicine, Federal Aviation Administration, Washington, D.C., February 2000.

Vendor Support
The tool can be customized to any field of endeavor. Currently, it is being used as a data analysis and trending tool for Air Traffic Control Operational Errors in the FAA. Over 300 participants have attended various workshops and professional meetings have been held for groups ranging from: Medicine, Nuclear Power, and other industries.

Tool Cost
Purchase Price: Free

(Purchase price does not include installation, operation, maintenance, or training costs.)

References Used to Support the Review
U.S. Navy Safety Centers website:
http://www.safetycenter.navy.mil/aviation/presentations/presentations.htm

Point of Contact
U.S. Navy Safety Centers website:
http://www.safetycenter.navy.mil/aviation/presentations/presentations.htm

Integrated Process for Investigating Human Factors

Purpose
To conduct human factors analysis.

Description
This tool provides a step-by-step systematic approach in the investigation of human factors. The process is an integration and adaptation of a number of human factors frameworks such as Reason's Accident Causation and generic error modeling frameworks.

The tool can be applied to either type of occurrence – accidents or incidents. The process consists of seven steps" 1) collect occurrence data, 2) determine occurrence sequence, 3) identify unsafe actions (decisions) and unsafe conditions, and then for each unsafe act (decision) 4) identify the error type or adaptation, 5) identify the failure mode, 6) identify behavioral antecedents, and 7) identify potential safety problems.

Stage of Review Completed
This tool did not go through an R&M, Value, and OR review.

(Topics addressed below are applicable to the stage of review completed.)

References Used to Support the Review
"An Integrated Process for Investigating Human Factors," Report by the Human Performance Division, Transportation Safety Board of Canada

Point of Contact
Maury Hill - Transportation Safety Board of Canada, email: maury.hill@bst.gc.ca.

Procedural Event Analysis Tool (PEAT)

Purpose
To identify the key underlying cognitive factors that contribute to procedural non-compliance, and to help the airline industry manage safety risks associated with flight crew procedural deviations.

Description
The PEAT process focuses on a cognitive approach to understand how and why the event occurred, not who was responsible. PEAT depends on an investigative philosophy, which acknowledges that professional flight crews very rarely fail to comply with a procedure intentionally, especially if it is likely to result in an increased safety risk. It also requires the airline to explicitly adopt a non-jeopardy approach to incident investigation. PEAT contains more than 200 analysis elements that enable the user to conduct an in-depth investigation, summarize findings and integrate them across various events. PEAT also enables operators to track their progress in addressing the issues revealed by the analyses.

PEAT is made up of three components: process, data storage, and analysis. It provides an in-depth structured analytic process that consists of a sequence of steps that identify key contributing factors to procedural non-compliance and the development of effective recommendations aimed at the elimination of similar errors in the future. The data are then entered into a database application for future trend analysis. Although designed as a structured tool, PEAT also provides the flexibility to allow for the capture and analysis of narrative information as needed.

The PEAT form, intended to be used by a trained safety officer, is designed to facilitate the investigation of specific types of incidents. Therefore, it addresses all the pertinent analysis elements.

Stage of Review Completed
This tool went through a R&M, Value, and OR review.

(Topics addressed below are applicable to the stage of review completed.)

Airline Usage
Boeing first made PEAT available to the airline industry in the summer of 1999 and has trained 66 airlines in its use as of December 2002. Numerous airlines have participated in testing and validating the PEAT process during its development.

Documentation
The software is distributed on a CD-ROM that includes an extensive user guide. The software is provided after users have completed a 3-day training course that includes a briefing for senior management.

Vendor Support
Based on the information reviewed, Boeing has clearly made a major investment in the development of PEAT and has offered to provide implementation support and training to airlines at no cost.

Potential Benefits to Flight Safety Analysis

PEAT is designed specifically for the airlines. Its use will significantly increase airline safety department capability by introducing a level of analysis not currently undertaken. It provides a structured way to account for a comprehensive range of causal factors, a framework for comparing occurrence rates of those factors, and a methodology for tracking the factors on a consistent basis. PEAT helps identify a broad range of causal factors including organizational and training issues thus enabling the improvement of performance in the future. PEAT primarily focuses on a structured framework for collecting, maintaining and analyzing information on incidents involving flight crew deviation from established procedures.

Usefulness to Flight Safety Analysis

As far as data applicability, PEAT is going after the highest leverage issue in safety. The overall complexity of the process is not difficult, but experience in incident investigation is key to valid interviewing and analysis. PEAT's analysis results can be very high if the investigator can use a systematic approach by using pilot perception and cognition to provide clues about deficiencies, which can point to trendable areas. The trending should help enormously when communicating to management.

Usability of Tool for Flight Safety Analysis

Tool set-up and data importation is easy. There is a tendency in PEAT towards gathering too much data. To easily generate and disseminate analysis results, there is a supplemental manual. PEAT does pave the way for further analysis by the airline. It does this by not focusing on punitive measures, making it easier for organizational learning, and developing investigator skills. The latter being necessary requirements to use this tool effectively.

Tool Cost

Purchase Price: Boeing provides implementation support and training for BSMS tools to Boeing operators free of charge.

Other Comments

The Boeing development of PEAT took place in conjunction with the ATA Human Factors Committee, ALPA and participating airlines. An eight-month field validation was completed by the participating airlines.

References Used to Support the Review

Boeing Co. Flight Technical Services,
http://www.boeing.com/commercial/flighttechservices/ftssafety.html

Point of Contact

Mike Moodi, Boeing Co. Flight Technical Services, 206-662-7542, mike.m.moodi@boeing.com.

Ramp Error Decision Aid (REDA)

Purpose

To identify the key underlying cognitive factors that contribute to ramp crew errors or procedural non-conformance, and to help the airline industry manage safety risks associated with ramp operational incidents.

Description

The REDA process focuses on a cognitive approach to understand how and why the event occurred, not who was responsible. REDA depends on an investigative philosophy, which acknowledges that professional ramp crews very rarely fail to comply with a procedure intentionally, especially if it is likely to result in an increased safety risk. It also requires the airline to explicitly adopt a non-jeopardy approach to incident investigation. REDA contains many analysis elements that enable the user to conduct an in-depth investigation, summarize findings and integrate them across various events. The REDA data organization enables operators to track their progress in addressing the issues revealed by the analyses.

REDA is made up of two components: the interview process and contributing factors analysis. It provides an in-depth structured analytic process that consists of a sequence of steps that identify key contributing factors to ramp crew errors and the development of effective recommendations aimed at the elimination of similar errors in the future.

The REDA form, intended to be used by a trained ramp crew safety investigator, is designed to facilitate the investigation of ramp related incidents.

Tool Cost
Purchase Price: Boeing provides implementation support and training for BSMS tools to Boeing operators free of charge.

References Used to Support the Review
Boeing Co. Flight Technical Services,
http://www.boeing.com/commercial/flighttechservices/ftssafety.html

Point of Contact
Mike Moodi, Boeing Co. Flight Technical Services, 206-662-7542, Maintenance Engineering Technical Services, Phone: (206) 544-8402, Fax: (206) 544-8844, mike.m.moodi@boeing.com

ReVision

Purpose
ReVision is a simulator debriefing system that provides automated capabilities to replay flight information collected during flight simulation training as a means of analyzing human performance. This can provide more immediate feedback and review of flight performance to flight crews, particularly for infrequently encountered maneuvers and procedures; e.g., in failed-engine landings and hence, heighten individual awareness of different aspects of crew performance.

Description
ReVision simultaneously records flight data, cockpit video and audio data from a simulator session. Instructors can mark a session for technical and human factors events using hand-held touch screens. The result is a reconstruction of the 'flight'. Instructors can quickly locate and replay marked events; this will help encourage more crew interaction during debriefing. Detailed analysis of the session, outside of the simulator provides feedback for analysis, reflection, and self-discovery.

ReVision data are stored in a central processing unit, which can replay the simulated flight immediately for training and crew performance evaluation. Video recordings capture flight/navigation/engine instruments, control positions, tactical displays, in-flight tracking of flight data and other selected data. ReVision is currently being used to support flight crew self-critiquing and provide feedback on different aspects of crew performance thereby identifying "problem" areas. By providing extensive video information, ReVision also has the potential to overcome cultural and language differences.

System functionality is currently being expanded to include automated analysis functions aimed at maneuver performance assessment and instructor workload reduction.

Stage of Review Completed
This tool went through an R&M review.

(Topics addressed below are applicable to the stage of review completed.)

Airline Usage

The developer states that the system is in use at a number of sites, including both military and airlines.

Documentation

The tool is well documented. See product web site:
http://www.spirent-systems.com/spirent5/products_services/safety/revision.htm

Vendor Support

Spirent Systems provides customer support.

References Used to Support the Review

Company website and presentation by Captain J.W. Buckner at the Third GAIN World Conference, November 1998, Long Beach, CA.

Point of Contact

Spirent Systems, www.spirent-systems.com; e-mail: bill.duncan@spirent.com.

6.0 Special Purpose Analytical Tools

This chapter contains the summaries of special purpose analytical tools reviewed by GAIN WG B. It is divided into three sections: Occurrence Investigation and Analysis, Text/Data Mining and Data Visualization, and Risk Analysis. While some of the methods and tools may fit into more than one of these categories, each method and tool was placed in the category of its primary utility.

Because many of these tools are not widely used in airline flight safety management, WG B performed a detailed review of fourteen tools that appeared to be the most promising for use in airline flight safety analysis (this review also included some of the tools for generating descriptive statistics and trend analysis described in Section 3.2). This detailed review consisted of one or more stages as described below.

- **Stage 1: Relevance and Maturity (R&M)** addressed whether the tool meets the needs of an airline flight safety office for analysis of safety information and what the experience has been in using the tool. Criteria applied during the R&M review included an assessment of the applicability of the tool to airline flight safety analysis, tool purpose, number of airline users, usage outside of airlines, analytical foundation, documentation, vendor support, and verification and validation.
- **Stage 2: Value** addressed potential benefits of the tool, its versatility, and its affordability. Examples of the criteria used to assess potential benefits include whether the tool helps identify unknown hazards, supports safety monitoring and the prioritization of resources, and whether it helps provide operational improvements. Versatility criteria addressed the usefulness of the tool to airlines of different sizes and types of operations, and whether the tool is useful for analysis of different kinds of safety data. Cost information was also collected reflecting the direct cost or purchase price and indirect cost such as the cost of maintenance and training.
- **Stage 3: Operational Readiness (OR)** involved partnering with an airline to determine if they could use the tool with a minimum of effort to turn available data into a useful information product. During the OR reviews the tools were assessed for usefulness, i.e. to determine if there was a good match between available input data, capabilities of the tool, and airline information needs. Usability was also assessed to see how easy it was to use the tool in terms of set-up, applying input data, generating results, and disseminating the results.

Information on the purpose of the tool, description, references used to support the review, and points of contact are provided for all the tools. Each tool summary also includes information on the stage of review that was completed (R&M, Value, or OR). Tools that were included in the R&M review will have information on airline usage, documentation, and vendor support. Tools that were included in a Value review will also have information on potential benefits to flight safety analysis and purchase price. The reader should note that overall tool cost would include the purchase cost and other indirect costs such as installation, maintenance, and training. However, since the indirect costs are highly dependent on individual requirements, only purchase price is provided in the summaries below. Tools that were included in an OR review will also have information on usefulness and usability to flight safety analysis. Some reviews might also vary in the amount and level of detailed information provided.

6.1 Occurrence Investigation and Analysis

Occurrence Investigation and Analysis refers to the process of analyzing data from accidents, incidents, near misses and other safety-related events as a means to identify and understand the active and latent causes of those safety-related events.

Investigation Organizer

Purpose

Investigation Organizer supports field mishap investigations in real-time as well as providing an analysis capability to optimize the investigation activities, report generation, and generic mishap investigation research.

Description

Investigation Organizer is a web-based information-sharing tool used to support mishap investigations in real-time as well as providing an analysis capability to optimize the investigation activities, report generation, and generic mishap investigation research. The tool functions as a document/data/image repository; a project database; and an "organizational memory" system.

Investigation Organizer permits relationships between data to be explicitly identified and tracked using a cross-linkage mechanism, which enables rapid access to interrelated information. The tool supports multiple accident models to help give investigators multiple perspectives into an incident. Investigation Organizer also incorporates intelligent inferencing capabilities to facilitate knowledge entry, hypothesis testing and maintenance. The tool is configurable to meet distinct needs of mishap investigation teams, and specialized visualization tools support casual modeling.

Stage of Review Completed

This tool did not go through R&M, Value, or OR reviews.

Airline Usage

No airlines are known to be using this tool, however, it is being used for the NASA CONTOUR mishap and the Columbia mishap.

References Used to Support the Review

Yuri Gawdiak, Engineering for Complex Systems Program Manager, NASA Headquarters – PowerPoint Presentation – Investigation Organizer: Collaborative Information Management for Mishap Investigations.

Points of Contact

Yuri Gawdiak, Engineering for Complex Systems Program Manager, NASA Headquarters, +1 202-358-1853, ygawdiak@hq.nasa.gov

Tina Panontin, Task Manager, Ames Research Center, +1 650 604-6757, tpanontin@mail.arc.nasa.gov

REASON 5

Purpose
The REASON process is a standard operating procedure that helps guide investigators to use a step-by-step process designed to ask the right questions at the right time to get the right answers and help determine root causes of events.

Description
The REASON method is to guide the development of concepts, training, and tools to provide a complete Root Cause Analysis system. REASON offers automatic crosschecks during each step of an investigation. This crosschecks for accuracy provides a simple way for the user to quickly verify the accuracy of the data and it's analysis. REASON also provides a standard process that allows all internal prevention options to be identified, modeled, and analyzed for control benefit. The modeling criterion enforces the process, and provides the manager with the ability to review all options at a glance. The REASON method constructs a model of the causal process. Using the system the investigator can measure each factor in an investigation for the significance that it played in producing a problem. The REASON method reports back to the user how effective it will be to act upon each root cause.

REASON 5 is a knowledge management tool that has a number of components designed to help an organization identify, communicate and solve issues:

- A quick risk assessment tool that directs activity when issues arise
- A guided investigation tool that gauges itself to the time prudent to spend on the issue (based upon the risk assessment)
- 15-30 minute mode of investigation (REASON Frontline)
- 2-8 hour mode of investigation (REASON Express)
- 1 day plus mode of investigation (REASON Pro)
- REASON Lesson Learned System
- REASON Situational Profiles for every employee
- Corrective Action Writing
- Corrective Action Tracking

The software is capable of creating a logic tree model of a problem, which graphically shows how different sets of facts came together to cause the problem. In addition, the software offers a case narrative. (This is a step-by-step explanation of the problem in story format.) REASON is also capable of performing analyses on cost effectiveness of a root causes to which root cause is the most beneficial prevention option. Also available are extensive data graphing options. These graphs give clear visual representations resulting form the data input. The graphs are customizable and accessible from within the REASON software or can be exported to a separate word processor.

Stage of Review Completed
This tool did not go through R&M, Value, or OR reviews.

Airline Usage
Several airlines have used this tool.

Point of Contact
Jason Elliot Jones, phone 1-903-236-9973, 802 N High, Longview, TX, 75601

TapRooT

Purpose
To facilitate incident reporting, collect incident information, identify root causes, develop effective corrective actions, provide a standard incident report, trend incident information, and track corrective action.

Description
The TapRooT System (process and techniques) are packaged in a computerized tool that helps investigators focus on what happened and why it happened, and help investigators find the real, fixable root causes of accidents, incidents, near-misses, quality and productivity problems. Although it was not specifically designed for aviation, TapRooT has been applied to airline safety. This tool builds on the Root Cause Tree with an interface that helps an investigator use the tree more consistently for root cause analysis. TapRooT is a complete incident investigation tool applied to a database that includes customizable fields so the user can add information that they think is important. Two standard and five optional techniques are built into the TapRooT Software. The two standard techniques are SnapCharT and the Root Cause Tree. The five optional techniques are Safeguards Analysis, Change Analysis, Critical Human Action Profile, Equifactor, the Corrective Action Helper Module. The software user can add an unlimited number of custom fields to the database to record items of interest. The software has a number of standard reports and one can use Access to develop custom reports. Drawing a SnapCharT is an essential part of the TapRooT process for finding root causes. When the user enters the corrective actions they are automatically entered into their standard report and into the corrective action-tracking database. The application links the corrective action to the corresponding root cause or one can manually link one corrective action to more than one root cause. The database has a built-in capability for approval of reports and corrective actions in separate, secure on-line approval sequences. The database can be used to track the corrective action, the person responsible, and the due date. The user can print reports of what is complete, what is outstanding, and what is overdue. There is also a validation and verification option for corrective actions. Some of the TapRooT tools are available in additional languages beyond English.

Stage of Review Completed
This tool went through R&M and Value reviews.

(Topics addressed below are applicable to the stage of review completed.)

Airline Usage
Four airlines are using this tool for a variety of investigation types (air and ground safety, audit root cause analysis, and worker safety issues). Several others have attended TapRooT training but the extent of their usage of the technique is not known. Also personnel from the FAA, NTSB, and Canadian NTSB, as well as Australian military aviation safety personnel have attended TapRooT training. Also the Medallion Foundation (a group working to improve aviation safety in Alaska) is in the process of licensing TapRooT for the use of all its members in Alaska. There is also a video about the use of TapRooT at an airline available at the vendor's web site.

Documentation
TapRooT is well documented in a hardbound book that has 12 chapters and one appendix. There is also a laminated Root Cause Tree and Root Cause Tree Dictionary that comes with the book. The user can also find information on the company web site. The first TapRooT manual was published in 1990 making the current book, published in 2000, the fifth version of the documentation.

Vendor Support
TapRooT offers extensive support to its customers. The support includes a help line; user support; two newsletters; initial training, continuing education program for users, expert facilitators to assist with

investigations or implementation, and a Summit every 18 months to keep users up to speed. TapRooT uses interactive training to get new users up to speed. There is also advanced training to enhance expertise and a licensing and 'train-the-trainer' program for companies that want to teach their own course. To enhance productivity, TapRooT has optional software including the Corrective Action Helper Module and a relational root causes database with a report generator and corrective action tracking. The company sponsors an annual (once every 16 months) summit to promote the advancement of root cause analysis and the sharing of information among many TapRooT users. Training is supported worldwide with instructors located in the US, Canada, mexico, UK, and Australia. The Root Cause Tree and Root Cause Tree Dictionary have been translated into French and Spanish and a German version is in the process of translation. Also Spanish, French, and German versions of the software are planned. Also, course materials have been translated into Spanish and Spanish speaking instructors are available.

Potential Benefits to Flight Safety Analysis

Although the investigators must enter all of the incident information manually, TapRooT provides a Root Cause Tree report as well as identifying each incident and listing corrective action for that incident. TapRooT provides the investigator with a structured format for consistency investigating incidents. Users state that they explore deeper into human performance problems; and they recognize ways to improve performance that are better than the old techniques of incident identification and analysis. The techniques associated with TapRooT are effective and result in time savings because the reports and presentations the investigators give are more efficient and they are required to do less reinvestigating of the incident because they are able to answer all of management's questions the first time. By giving the corrective actions associated with each incident, the number of incidents (and therefore the number of investigations) will decrease over time, which saves the investigator's efforts. All investigators are interested in root causes and latent errors in organizations, and TapRooT can assist with identifying them.

Tool Cost

Purchase Price: $1495 for a single user version of the TapRooT Software. 2-day TapRooT Course attendees can obtain the software for only $795. The software is included in the price of the 3-day TapRooT/Equifactor Training and the 5-day Advanced TapRooT Investigation team Leader Training. There is also an option for a server based software for multiple simultaneous users. Public courses are offered in the US, Canada, Australia, and Europe. The 2-day TapRooT Incident Investigation and Root Cause Analysis Course is $995. The 3-day TapRooT/Equifactor Equipment Failure Analysis Course is $1890 (includes TapRooT Software). The 5-day Advanced TapRooT Investigation Team leader Training is $2195 (includes TapRooT Software). On-site courses are also available throughout the world.

(Purchase price does not include installation, operation, maintenance, or training costs.)

References Used to Support the Review

TapRooT software brochure, TapRooT web site http://www.taproot.com/

Point of Contact

Edward Skompski, System Improvements, (865) 539-2139, skompski@taproot.com

6.2 Text/Data Mining and Data Visualization

Text mining tools are designed to analyze freeform text using automated algorithms to identify specific concepts or ideas in the text, and translate these concepts or ideas into standardized terms that can be stored in a more structured way for subsequent analysis. Since a significant amount of the information in flight safety occurrence reports is contained in freeform narratives, it is clearly valuable to be able to search this information in a reliable way. However, conventional text searches are inefficient and cumbersome, since different reports may express the same issue in quite different ways using very different terms. In consequence, simple text searches rely heavily on the intuition of the analyst and may require many different searches to identify all relevant combinations of terms. Text mining tools attempt to overcome these limitations and speed up the process of identifying occurrences of interest in a large set of reports.

Data mining tools are designed to analyze a large amount of data in a structured database using automated algorithms to identify patterns and trends in the data, or to identify specific records that exhibit relationships of interest, as a first step before further analysis or examination. Data visualization tools perform the same function by utilizing graphical displays to allow a human analyst to identify possible patterns, trends or associations. As the amount of data in flight safety databases increases, the ability to search quickly through the data and identify relationships becomes increasingly important.

Data visualization tools may also allow an analyst to identify relationships that would not be obvious if the information was presented in any other way. The application of these capabilities is particularly relevant to the analysis of the vast amount of FDM data, but may also be helpful in working with large databases of occurrence reports.

Aviation Safety Data Mining Workbench

Purpose

To provide a software application that an aviation safety officer can use to search a collection of incidents or aviation related events to find those most similar to a selected event, to find subsets of data that have interesting correlations, and to determine the distribution of selected incident/event attributes.

Description

The Aviation Safety Data Mining Workbench developed by the MITRE Corporation consists of three data mining techniques for application to aviation safety data. The first technique, FindSimilar, uses both information retrieval and data mining methods to analyze text and structured data. FindSimilar is most often employed to search a collection of incidents to find those most similar to a selected incident. This is useful in determining if similar incidents have occurred before, and if so, how they were addressed.

The second technique is called FindAssociations. This technique searches the collection of incidents to find subsets that have interesting correlation. For example, this tool can identify a set of incidents that occur at a common location, for the same or similar aircraft type and for the same problem. Knowing such a subset exists and what factors are in common may help in determining what action to take to reduce or eliminate those incidents in the future.

The third technique is called FindDistributions. This technique focuses on a selected field or attribute of the incidents. It determines an overall distribution for this field. Subsets of the data are then obtained and the distribution of the selected field is calculated for each subset. Those subsets that differ most from the overall distribution are identified as the most interesting. This technique helps in identifying anomalies that may be candidates for action.

In the workbench, data mining is included with other data manipulation and reporting tools to give the aviation safety officer a more complete suite of useful analysis tools. Because it is built within Microsoft Access, the workbench has capabilities for querying, selecting and reporting data. Access also provides On-Line Analytical Processing (OLAP) capability that complements the 'data-driven' techniques described above. The application is also complementary to certain incident tracking, or data sharing tools.

Stage of Review Completed
This tool did not go through R&M, Value, or OR reviews.

Airline Usage
One airline experimented with an evaluation version of the Aviation Safety Data Mining Workbench. MITRE partnered with another airline and tailored the Workbench to analyze some of their air safety reports. A third airline has been using the Workbench to analyze their safety reports in a proof-of-concept effort sponsored by GAIN.

References Used to Support the Review
Information gathered in Working Group B meetings and at GAIN conferences, with additional information provided by vendor.

Point of Contact:
Zohreh Nazeri, MITRE Corporation, phone: 703-883-5841, e-mail: nazeri@mitre.org, web site: http://www.mitre.org/tech_transfer/

Brio Intelligence 6

Purpose:
Business Intelligence tool, used for drill-down querying, analysis, and report generation (textual and graphical).

Description:
Brio Intelligence is used to scan through large volumes of data, and extract meaningful, often unknown facts about an organization's data. Almost any query can be performed with the results appearing in moments. Results can be drilled-into to their granular level, or drilled back up to more summarized views. Detailed analysis of the returned data set can also be conducted, using a library of built-in functions. Reports that are created by the tools can be distributed in a variety of formats. Brio Intelligence is part of the Brio Performance Suite, which also allows for complex report generation across multiple systems, and hosting interactive data mining workbenches through a web browser.

Stage of Review Completed
This tool did not go through R&M, Value, or OR reviews.

Airline Usage
At least one major US airline is using Brio for safety analysis.

Other Comments
Brio is widely known and very well documented. Extensive documentation is available on their web site (http://www.brio.com). Brio provides training services, as well as expert integration and setup services. Other Brio business partners also provide setup and training services. Tool cost can vary widely, depending on desired setup and existing infrastructure.

Potential Benefits to Flight Safety Analysis
Brio is in use by the airlines, and therefore the expertise to extend its functionality to the safety department is likely to be in-house. A flexible tool for drill-down queries, OLAP, and report generation.

References Used to Support the Review
Brio web site (http://www.brio.com)

Point of Contact
Brio Sales Department, 1-877-289-2746, web site: http://www.brio.com

FERRET Q

Purpose
To enhance the effectiveness and productivity of decision making, problem solving, and learning in aviation.

Description
Q is the knowledge engine in FERRET. Q technology is a rapid and potentially accurate strategy for identifying information of value (IOV) in electronic text. Q reads electronic files in a wide variety of formats (e.g., Word, Excel, Access, PDF) and identifies IOV using a network of concepts constructed to simulate human understanding. The network of concepts forms a Topic Map stored in XML. Q incorporates a “knowledge engineering” tool that enables user-friendly construction of the concept network. It is written in a modular JAVA format, hence, it is essentially platform independent and it can be used as a “plug-in” in support of a broad spectrum of applications.

The original application of Q was to identify sensitive weapons information in electronic text. It has been applied to provide real-time checking of electronic mail, “intelligent” distribution of electronic files and classification (categorize/catalogue) of documents. It is presently being extended to provide fast, accurate (query-based) search of electronic files. Q promises to be useful in pattern recognition, e.g., associated with human factors analysis of safety data, and in expert-guided education.

Stage of Review Completed
This tool did not go through R&M, Value, or OR reviews.

Airline Usage
No airlines are known to be using this tool.

References Supporting Review
Demonstrations and discussions at BWXT Y-12 l.l.c (BWXT Y-12 l.l.c is the Department of Energy management contractor for the Y-12 facility in Oak Ridge).

Points of Contact
Simon D. Rose, 865-574-9494, email: sdr@ornl.gov, Dr. Charles Wilson, 423-263-4983, email: areteq@bellsouth.net, Al Klein, BWXT Y-12 LLC, 865-576-5881, email: ajk@y12.doe.gov

NetOwl

Purpose
SRA's text mining product, NetOwl, provides a tool that analyzes free text, whether contained in newspapers or in mission-critical database records. It automatically analyzes the important events expressed in free text, including such facts as the time of an event, its cause, and other important information. The tool normalizes this information, allowing its insertion in structured format into a database. This enables a user to pose very sophisticated queries and to analyze trends much more easily and accurately.

Description
Traditionally, text or narrative data has been difficult to analyze. SRA's text mining product, NetOwl, is particularly suitable for analyzing such unstructured contexts. NetOwl is based on a technology called Information Extraction, which finds and classifies key phrases in text, such as personal names, corporate names, place names, dates, and monetary expressions. It finds all mentions of a name and links names that refer to the same entity together. Rather than relying on static lists of previously known names, SRA's extraction technology relies on dynamic recognition to achieve high accuracy and coverage at very high speed.

NetOwl also analyzes events in texts. These are more complex than names. For an event, NetOwl identifies the time, the cause, any relevant circumstances (such as, in the case of airplane repair records, the piece of equipment involved). It puts all this information extracted from free text into a structured database format. Once inserted in a database, a user such as an airline safety officer can pose questions that they previously could not. For example, an officer can ask questions—using a standard database query capability—such as how many events with a given cause occurred during a certain time span. In addition, such extracted events can be fed directly to data mining or visualization tools for deeper analysis.

Underlying NetOwl is a general-purpose, extremely fast pattern-matching engine combined with a highly flexible pattern specification language. NetOwl allows the extraction—with minimum effort—of a whole range of events of interest.

Stage of Review Completed
This tool did not go through R&M, Value, or OR reviews.

Airline Usage
NetOwl has been applied to a major commercial airline's narrative descriptions of safety incidents and events. The application identified the factors leading up to the reported event, the event itself, and the results of the event. The information extracted included the airport involved; the aircraft's altitude, airspeed, the type of approach; weather conditions; the type of event; and the consequences of the event.

References Used to Support the Review
Web site: http://www.netowl.com/

Point of Contact
John Maloney, SRA International, phone: 703-803-1553, e-mail: john_maloney@sra.com, web site: http://www.netowl.com/

PolyAnalyst

Purpose

PolyAnalyst is a universal data mining system from MEGAPUTER Intelligence that automates knowledge discovery in large volumes of either structured data or free form text. PolyAnalyst can identify key patterns of terms in text fields and relations between them, extract domain-specific terms and visualize the main correlations between extracted terms and individual values of structured attributes. This enables the user to proactively make informed decisions based on an objective and accurate analysis of *all* available data.

Description

PolyAnalyst is designed to be a comprehensive and user-friendly data and text mining system. It can access data stored in any major commercial database and some proprietary data formats (Excel, SAS), as well as popular document formats. PolyAnalyst offers a broad selection of semantic text analysis, clustering, prediction, and classification algorithms, link analysis, transaction analysis, and powerful visualization capabilities.

PolyAnalyst is built on a conglomerate of powerful and scalable analytical methods including morphological, syntactic and semantic techniques for analyzing free form text; and decision tree, neural network and correlation analysis techniques for processing structured data. This synergetic combination of machine learning and semantic text analysis algorithms allows the user to extract and synchronize the maximum of knowledge hidden in all available data. PolyAnalyst can automatically build semantic taxonomies from text and categorize data records accordingly, extract from textual fields key terms and relations between them, and perform clustering and link analysis for identifying the main patterns in causes and consequences of incidents. For its text processing, PolyAnalyst utilizes a comprehensive semantic dictionary of English, which can be further expanded with user-defined add-on dictionaries.

PolyAnalyst was designed for both business users and data analysts. The user of PolyAnalyst is shielded from the complexities of the performed analysis. Data analysts communicate with the system through a collection of standard dialogs and reports and flexible visualization functions equipped with drill-down capabilities. Business users can receive the results of the analysis over the Internet in a preset reporting template. Reusable analytical scripts can be created and scheduled to execute on new batches of data at a given time.

PolyAnalyst has been used at one airline against a dataset of pilot reports consisting of both structured attributes and textual narratives. The analysis revealed strong correlations between certain incident types, places and aircrafts involved, and specific patterns of values of different attributes. For example, PolyAnalyst helped automatically extract faulty equipment from pilot narratives, map these incidents to the corresponding aircraft, time of the day and flight phase, and visually compare the distribution of problems for different aircraft types. It demonstrated typical patterns of entities and actions associated with different incidents and allowed simple drill down to the original records supporting the discovered patterns.

Stage of Review Completed

This tool did not go through R&M, Value, or OR reviews.

Airline Usage

PolyAnalyst has been applied to the analysis of safety incident data at one airline as a proof-of-concept demonstration.

References Used to Support the Review

Web site: http://www.megaputer.com/

Point of Contact
Richie Kasprzycki, MEGAPUTER Intelligence Inc., +1 812-330-0118, r.kasprzycki@megaputer.com.

QUORUM Perilog

Purpose
QUORUM Perilog methods and tools enable exploratory analysis of large collections of aerospace incident narratives.

Description
QUORUM Perilog (also known as Perilog) exploits the situational structure of "unstructured" narrative incident reports. By modeling the contextual structures of incident narratives, it models the structures of the incidents themselves. This makes it possible to explore narrative databases in an entirely new way. The new methods are patent pending and have been commercially licensed. Perilog is currently being used by the ASRS, and by the ASAP office of a major U.S. airline.

Numerous studies have been conducted since 1995 to develop the methods and to demonstrate their effectiveness. In one key study (McGreevy & Statler 1998), Perilog automatically found incidents relevant to the crash of a Boeing 757 jet in commercial service near Cali, Colombia in December 1995. The accident involved controlled flight into terrain, over-reliance on automation, confusion during descent and approach, problematic operations in foreign airspace, and a number of other factors. All of the text of two accident reports, one from the Colombian government and one from the National Transportation Safety Board, were used as a single query in a QUORUM Perilog search to retrieve relevant incidents from the ASRS database. Experienced analysts judged the relevance of a collection of narratives that included both randomly selected narratives and narratives identified as relevant by Perilog. The analysts independently judged that 84% of Perilog's narratives were relevant to the Cali accident. Subsequent review showed that 92% were actually relevant. Not only were the narratives relevant, they were relevant to the various factors of the accident.

Perilog exploits the situational structures of narrative incident reports to provide capabilities for search by example, keyword-in-context search, flexible phrase search, phrase generation, and phrase discovery (McGreevy 2001). Search by example uses text such as accident or incident narratives as a query to find relevant incident narratives. Keyword-in-context search converts individual query words into detailed topical models and finds relevant narratives. Flexible phrase search accepts any number of phrases of any length as a query to find narratives containing the query phrases and near matches to the query phrases. Phrase generation is a tool for finding phrases in the database that contain a particular word. Phrase discovery finds phrases that are relevant to a query. For example, a query consisting of words like "fatigue" and "sleep" can retrieve hundreds of contextually associated phrases such as "crew duty", "crew rest", "crew scheduling", and "continuous duty overnight". Additional tools include vocabulary review, extraction of phrases from subsets of narratives, and searching within subsets of narratives.

The Perilog tools work together to support exploratory narrative analysis. For example, vocabulary review can suggest words to use as queries in phrase generation or keyword search. Phrases can be extracted from the narratives retrieved by a search, and some or all of those phrases can be used as a query in phrase search. From the narratives retrieved by a keyword or phrase search, narratives of interest can be used as a query in search by example. Further, the results of any search can be defined as a subset, given a name, and used as the scope of any subsequent searches. These interactive and integrated search tools make Perilog particularly useful for investigating problematic situations described in collections of incident narratives, for finding and elaborating operational concepts for taxonomies, and for obtaining a contextual view of incidents for comparison with categorical analyses.

Stage of Review Completed
This tool did not go through R&M, Value, or OR reviews.

Airline Usage
A research version of the Perilog software is currently being used by the ASAP office of a major U.S. airline.

Other Comments
The Perilog methods can be licensed from NASA Ames. An example of software to implement the methods is provided as part of the license package. License fees are negotiated on a case-by-case basis. Further information about licensing can be obtained from David Lackner, NASA Ames Commercial Technology Office, Moffett Field, CA 94035-1000. Tel: (650) 604-5761. E-mail: dlackner@mail.arc.nasa.gov.

References Used to Support the Review
Michael W. McGreevy and Irving C. Statler, *Rating the Relevance of QUORUM-Selected ASRS Incident Narratives to a "Controlled Flight Into Terrain" Accident*, Report NASA/TM-1998-208749, Ames Research Center, Moffett Field, California, September 1998.
Website: http://human-factors.arc.nasa.gov/IHpublications/mcgreevy/ASRS.Cali

Michael W. McGreevy, *Searching the ASRS Database Using QUORUM Keyword Search, Phrase Search, Phrase Generation, and Phrase Discovery*, Report NASA/TM-2001-210913, Ames Research Center, Moffett Field, California, April 2001.
Website: http://human-factors.arc.nasa.gov/IHpublications/mcgreevy/ASRS.search

Point of Contact
Dr. Michael W. McGreevy, System Safety Research Branch, NASA Ames Research Center, Moffett Field, CA 94035-1000. Tel: (650) 604-5784. E-mail: mmcgreevy@mail.arc.nasa.gov

Spotfire

Purpose
Spotfire is a data retrieval, visualization, and analysis software package. It allows the user to select combinations of various data elements for analysis to quickly reveal trends, patterns, and relationships that would otherwise be very difficult to identify.

Description
Spotfire is a tool for visual display of data in many dimensions, using 3-d projections and various sizes, shapes, and colors. This allows the user to spot multi-dimensional relationships that might not be detectable through looking at raw numbers or more limited presentations.

Spotfire's visualization technology provides a unique way of examining data relationships. It has a series of built-in heuristics and algorithms to aid the user in discovering alternative views of data.

Stage of Review Completed
This tool went through R&M, Value, and OR reviews.

(Topics addressed below are applicable to the stage of review completed.)

Airline Usage
At least one airline is known to have used this tool.

Documentation
Spotfire is very well documented and comes with an extensive on-line help feature and a 267-page user guide. Spotfire's website provides additional up to date support information.

Vendor Support
Spotfire provides an extensive support network through its offices in Europe and U.S. Spotfire products can be easily customized to the users needs since the products are based on open system architecture.

Potential Benefits to Flight Safety Analysis
The tool is extremely user friendly and is database independent. It can extract a large volume of data from practically any data source. However, the key is the user's knowledge of the data and expertise in the subject matter that allows him/her to suggest possible combinations to examine. The user's skill and the quality of the data will determine the potential benefit that the user will achieve.

Tool Cost
Purchase Price: $300-$3000 (various software configurations; one-time cost)

(Purchase price does not include installation, operation, maintenance, or training costs.)

Other Comments
Spotfire provides a collaborative repository through which analysts not only share the results of visual analysis with their peers but also provide access to the underlying data. The FAA National Aviation Safety Data Analysis Center (NASDAC) has used Spotfire for over four years as a data visualization tool and as a data integration application to assist in the rapid identification of trends, anomalies, outliers and patterns in aviation safety data.

References Used to Support the Review
Spotfire web site, http://www.spotfire.com

Point of Contact
David Bailey, Director of Marketing Communications, +1 617-702-1809, dbailey@spotfire.com

6.3 Risk Analysis

Risk Analysis is the process by which hazards are identified and analyzed for their likelihood of occurrence and their potential severity. Risk analysis looks at hazards to determine what can happen, when it could happen, and the factors associated with their occurrence.

@RISK

Purpose
@RISK is a risk analysis and simulation add-in (software tool) for Microsoft Excel or Project intended to facilitate quantification and analysis of uncertainty.

Description
@RISK recalculates spreadsheets hundreds of times, each time selecting random numbers from the @RISK functions entered. This not only tells what could happen in a given situation, but how likely it is that it will happen. It is a quantitative method that seeks to represent the outcomes of a decision as a probability distribution. The techniques in an @RISK analysis encompass four steps: (1) Developing a Model – by defining problem or situation in Excel spreadsheet format, (2) Identifying Uncertainty – in variables in Excel spreadsheets and specifying their possible values with probability distributions, and identifying the uncertain spreadsheet results that are to be analyzed, (3) Analyzing the Model with Simulation – to determine the range and probabilities of all possible outcomes for the results of the worksheet, and (4) Making a Decision – based on the results provided and personal preferences @RISK helps with the first three steps by providing a powerful and flexible tool that works with Excel to facilitate model building and Risk Analysis. The decision-maker to help choose a course of action can then use the results that @RISK generates.

@RISK uses the techniques of Monte Carlo simulation for risk analysis. In @RISK, probability distributions are entered directly into Excel as standard worksheet formulas (ex. =RISKNormal(10,2)) using custom distribution functions, or through myriad graphical interfaces such as RISKView and BestFit. For each iteration, the spreadsheet is recalculated with a new set of sample values and a new possible result is generated for output cells - new possible outcomes are generated with each iteration. Advanced analyses in @RISK allow sophisticated analysis of simulation data. One-way and multi-way Sensitivity analyses identify significant inputs relative to the fluctuation of the outputs. Scenario analysis identifies groups of combinations or inputs that lead to output target values. Goal seek enables you to determine starting conditions that lead to a certain result.

Stage of Review Completed
This tool went through R&M and Value reviews.

(Topics addressed below are applicable to the stage of review completed.)

Airline Usage
Palisade customers include the US Air Force, Northwest Airlines, Cessna Aircraft Company, Lockheed Martin, Boeing, NASA, Air New Zealand, Kuwait Airways, Transasia Airways, LOT (Polish Airlines)

Documentation
The tool is well documented. See product web site: http://www.palisade.com/.

Vendor Support
Palisade Corporation offers free, unlimited technical support to all registered DecisionTools software users for 30 days. Maintenance contracts are available.

Potential Benefits to Flight Safety Analysis
@RISK is an add-in for Microsoft Excel. It facilitates a quantitative method for assessing the impacts of risk decisions and determining all possibly outcomes to a model. Since most airline FSOs will have Excel, @RISK seems to be a valuable add-in. Only a basic knowledge of probability theory is required. A new graphical interface makes it easier to decide which distribution to use. Also, reviews of the software note that some learning investment is required to use @RISK. On balance, @RISK seems to be a likely candidate for an analyst to "partner" with an airline FSO to develop a case study.

Tool Cost
Purchase Price: $795 (varies depending on version)

(Purchase price does not include installation, operation, maintenance, or training costs.)

Other Comments
As an add-in to Microsoft Excel or Lotus, add-in appears to be a versatile tool capable of supporting a quantitative risk assessment. Applications to the FSO need to be developed and evaluated.

References Used to Support the Review
@RISK Advanced Risk Analysis for Spreadsheets, Palisade Corporation, 2003

Point of Contact
David Bristol, Palisade Corporation, 31 Decker Road, Newfield, NY 14867 Tel. (607) 277-8000 Fax: (607) 277-8001, e-mail: sales@palisade.com, web site, http://www.palisade.com/

Fault Tree⁺ (Event Tree Module)

Purpose
To organize, characterize, and quantify potential accidents in a methodical manner by modeling the sequence of events leading to the potential accident that result from a single initiating event.

Description
As a built-in Markov analysis module for integration dependencies in fault tree analysis, Event Tree Analysis (ETA) uses "inductive" logic and is helpful in understanding the consequences of an initiating event and the expected frequency of each consequence. ETA is similar to Fault Tree Analysis, but is more general in that events may comprise not only failures, malfunctions, and errors, but also proper operation. ETA involves selecting initiating events, both desired and undesired, and developing their consequences through consideration of system/component failure-and-success alternatives. Identification of initiating events may be based on review of the system design and operation, the results of another analysis such as a Failure Modes and Event Analysis, a Hazardous Operation Analysis, etc., or personal operating experience acquired at a similar facility. The FTA postulates the success or failure of the mitigating systems and continues through all alternate paths, considering each consequence as a new initiating event.

Fault Tree+ is capable of analyzing large and complex event tree models originating from different initiating events, CCF events and consequence tables. Multiple branches are also handled to allow for partial failures. Fault Tree + provides a flexible import/export facility (32-bit operating system) which allows the user to transfer data to and from MS Access databases, MS Excel spreadsheets, text delimited and fixed length files. It is capable of analyzing complex event trees and provides users the capability to construct a single project database containing generic data and event tables, event trees originating from different initiating events, and consequence tables.

Stage of Review Completed
An R&M review was conducted for the method of event tree analysis and a Value review for this specific tool. An OR review was not conducted.

(Topics addressed below are applicable to the stage of review completed.)

Airline Usage
No airlines are known to be using this tool.

Documentation
This tool is well documented. See product website: http://www.isographdirect.com/.

Vendor Support
Isograph presents workshop-training courses that provide users with an in-depth understanding of the methods and theory behind systems reliability methods as well as providing practical instruction on the use of the computer programs. The course instructors have over 18 years experience in providing systems reliability training worldwide.

Potential Benefits to Flight Safety Analysis
Event tree analysis could be helpful to the FSO in pre-incident or post-accident modeling and aid in understanding where safety improvements should be focused. The Fault Tree+ report generator allows the user to select from a range of standard reports and quickly design their own customized repots. This is a systems reliability analysis tool, which allows event tree analysis to be performed in an integrated environment.

Tool Cost
Purchase Price: $6895

(Purchase price does not include installation, operation, maintenance, or training costs.)

Other Comments
Event tree analysis is universally applicable to systems of all kinds, with the limitation-unwanted events (as well as wanted events) must be anticipated to produce meaningful analytical results. Successful application to complex systems cannot be undertaken without formal study over a period of several days to several weeks, combined with some practical experience. Methodology is enormously time consuming and, therefore, should be reserved for systems wherein risks are thought to be high and well concealed (i.e., not amendable to analysis by simpler methods). Additional Reference: Lewis, H.W., and "The Safety of Fission Reactors, " Scientific American, Vol. 242, No. 3, March 1980, Fullwood RR, "Probabilistic Safety Assessment in Chemical and Nuclear Industries," Boston: Butterworth-Heinemann, 2000 (ISBN 0-7506-7208-0).

References Used to Support the Review
Demonstration version of Fault Tree+ from the web, Fault Tree+ user's manual, website: www.isographdirect.com, System Safety Analysis Handbook, System Safety Society, No.26 P3-93 2nd Edition, July 1997.

Point of Contact
Isograph Inc., 4695 MacArthur Court, 11th Floor, Newport Beach, CA, 92660, (949) 798-6114, fax (949) 798-5531. Website: http://www.isographdirect.com/. In U.S., email: sales@isographdirect.com. International address, Isograph Ltd. Malt Building, Wilderspool Park, Greenalls Ave., Warrington, United Kingdom, WA46HL, +44 1925 43 7001, fax +44 1925 43 7010. Email: sales.uk@isograph.com.

Fault Tree+ (Fault Tree Module)

Purpose
To assess a system by identifying a postulated undesirable end event and examining the range of potential events that could lead to that state or condition.

Description
As a built-in Markov analysis module for integration dependencies in fault tree analysis, Fault Tree Analysis is a graphical method commonly used in reliability engineering and systems safety engineering. It is a deductive approach that documents qualitatively the potential causal chains leading to a top (head) event, but it also accommodates quantitative analysis when probability or "rate" information is adjoined to the graphical tool.

Starting with the top event (typically undesirable), the safety engineer goes through causal chains systematically, listing the various sequential and parallel events or combinations of failures that must occur for the undesired top event to occur (a static picture of system failures). Logic gates (AND, OR) and standard Boolean algebra allow the engineer to quantify the fault tree with event probabilities, and lead to the probability (or rate) of the top event. Not all system or component failures are listed, only the ones leading to the top event. Only credible faults are assessed, but may include hardware, software, human failures and/or environmental conditions. Fault Tree + running under a 32-bit operating system is capable of analyzing large and complex fault trees producing the full minimal representation for fault tree TOP events. Fault Tree+ provides importance analysis, uncertainty, and sensitivity analysis.

Stage of Review Completed
An R&M review was conducted for the method of fault tree analysis and a Value review for this specific tool.

(Topics addressed below are applicable to the stage of review completed.)

Airline Usage
No known airlines using this tool.

Documentation
This tool is well documented. See product web site: http://www.isographdirect.com/.

Vendor Support
Isograph presents workshop training courses that provide users with an in-depth understanding of the methods and theory behind systems reliability methods as well as providing practical instruction on the use of the computer programs. The course instructors have over 18 years experience in providing systems reliability training worldwide.

Potential Benefits to Flight Safety Analysis
Fault Tree+ is a systems reliability analysis tool, which allows fault tree analysis to be performed in an integrated environment. There is a very large potential benefit of this program to increase knowledge about the probability of hazard occurrence, however a moderate to extensive amount of R&D time is required as well as expert assessment of probabilities for the various faults. There are scenarios in the Flight Safety Office where Fault Tree Analysis could be useful in assessing where safety improvements could be most needed for a particular type of accident/incident. Fault Tree+ provides a sophisticated report generator, which allows the user to design, preview and print high quality customized reports. The report generator allows graphs and charts to be designed and displayed individually or as a group.

Tool Cost
Purchase Price: $6895
(Purchase price does not include installation, operation, maintenance, or training costs.)

Other Comments
Fault Tree Analysis is universally applicable to systems of all kinds, with the following ground rules: (1) Events that are to be analyzed/abated, and their contributors, must be foreseen. (2) Each of those system events must be analyzed individually. Primary limitations of the technique are: (1) The presumption that relevant events have been identified. (2) The presumption that contributing factors have been adequately identified and explored in sufficient depth. Apart from these limitations, the technique as usually practiced is regarded as among the most thorough of those prevalent for general system application. Significant training and experience is necessary to use this technique properly. Application, though time-consuming, is not difficult once the technique has been mastered.

References Used to Support the Review
System Safety Engineering and Risk Assessment: A Practical Approach, Nicholas J. Bar, Taylor & Francis, Washington, D.C., 1997. Fault Tree Handbook (NUREG-0492 ERR), website: http://www.nrc.gov/NRC/NUREGS/ABSTRACTS/sr0492err.htm; Demo version of Fault Tree + from the web, Fault Tree + user's manual, website (www.isographdirect.com)

Point of Contact
Isograph Inc., 4695 MacArthur Court, 11th Floor, Newport Beach, CA, 92660, (949) 798-6114, fax (949) 798-5531. Website: http://www.isographdirect.com/. In U.S., email: sales@isographdirect.com. International address, Isograph Ltd. Malt Building, Wilderspool Park, Greenalls Ave., Warrington, United Kingdom, WA46HL, +44 1925 43 7001, fax +44 1925 43 7010. Email: sales.uk@isograph.com.

FaultrEASE

Purpose
To facilitate creation, calculation, and display of fault trees, which are a graphical method commonly used in reliability engineering and systems safety engineering

Description
FaultrEASE allows the user to create, edit, and draw fault trees with minimal effort. It performs elementary fault tree mathematics, including mixed probability and frequency calculations, Boolean reduction, and cut sets. When drawing trees with FaultrEASE the user only need be concerned with the tree's content, as its form is adjusted automatically. After each edit is made, FaultrEASE will balance the tree, center labels, and place statistics, transfers and tags.

FaultrEASE also simplifies fault tree editing with the use of cells. A cell is a rectangular region that contains the graphical representation of an event. An event is defined as an atomic unit of fault tree construction, consisting of either a gate or a leaf. Gates logically consist of the gate symbol, itself and the box above it. In FaultrEASE both parts share a single cell. The result is that any tree built with FaultrEASE will always be a proper tree--it is impossible to violate the "no gate-to-gate" rule. The user can save the work to a file, and retrieve it later. The file contains descriptions of the symbols in the fault tree, as well as the values of all changeable parameters. When the user loads the next tree, all of these parameters will be set to the values set for that tree.

Stage of Review Completed
This tool went through R&M and Value reviews.

(Topics addressed below are applicable to the stage of review completed.)

Airline Usage
No airlines are known to be using this tool.

Documentation
The tool is sufficiently documented to give the user confidence in its validity, but all questions may not be thoroughly answered in the documentation. See the FaultrEASE User's Manual, Version 2.0, by ICF Consulting.

Vendor Support
ICF Consulting offers technical and customer support services.

Potential Benefits to Flight Safety Analysis
FaultrEASE is a program for creating, editing and computing fault trees. FaultrEASE performs fault tree mathematics including mixed probability, frequency calculations and cut-sets. For trees with repeated events, reduction is achieved using direct evaluation. FaultrEASE also permits easy tree surgery in which entire branches can be pruned, cloned and grafted. Statistics can also be entered in the form of probabilities, frequencies or multipliers.

Tool Cost
Purchase Price: $1150 as of early 2003

(Purchase price does not include installation, operation, maintenance, or training costs.)

Other Comments
FaultrEASE is available both for the Windows and Macintosh platforms. FaultrEASE for Windows runs on Windows 3.x, 95, 98, NT, 2000, or XP and FaultrEASE for Macintosh runs on OS X and previous versions. FaultrEASE also permits multiple window creation and performs fault tree mathematics including mixed probability, frequency calculations, and cut sets. Most graphical attributes can be modified to produce a variety of custom effects for reports, presentations and overheads.

References Used to Support the Review
FaultrEASE User's Manual, Version 2.0, May 1996. Version 2.2 planned for release in early 2003.

Points of Contact
ICF Consulting, 33 Hayden Avenue, Lexington, MA 02421, web site: www.icfconsulting.com, email: faultrease@icfconsulting.com, Susan Ferola, 781-676-4036, email: sferola@icfconsulting.com.

Markov Latent Effects Tool for Organizational and Operational Safety Assessment

Purpose
The Markov Tool facilitates the quantification of safety effects of organizational and operational factors that can be measured through "inspection" or surveillance.

Description
This tool uses a mathematical method for assessing the effects of organizational and operational factors on safety. For example, organizational system operation might depend on factors such as accident/incident statistics, maintenance personnel/operator competence and experience, scheduling pressures, and safety "culture" of the organization. Many of the potential metrics on such individual parameters could be difficult (and generally uncertain) to determine, but the method includes guidance for their determination. Also, there may be ill-defined interrelations among the contributors, and this is also

addressed through "dependence" metrics. The approach was developed for two main reasons. First, a preponderance of evidence has been accumulating that the "culture" (attitude of employees and management) is frequently one of the major root causes behind organizational failures [1, 2]. Second, nearly all high-consequence operations have some sort of independent assessment review process, and there is a correlation between the quality of this process and the success of the resultant operational performance [3]. Neither of these factors is readily amenable to conventional mathematical analyses, so management judgment has in the past determined the level of each that is appropriate as well as what the response should be in the face of identified weaknesses. While there is undeniable benefit to management judgment, a mathematical structure as an adjunct and contributor to judgment has significant value. For example, a mathematical analysis helps organize thinking by systematically processing data. It can help focus priorities and payoffs through quantification. It can be automated. And it contributes to defensible decision-making.

The Markov latent effects approach is named in honor of A. A. Markov, who was one of the first scientists to formalize the mathematical role of a chain of occurrences in determining subsequent events. A top-down approach is used for decomposing systems, for determining the most appropriate items to be measured, for expressing the measurements as imprecise subjective metrics, and for using the results to optimize organizational factors. A mathematical model facilitates combining (aggregating) inputs into overall metrics and decision aids, also portraying the inherent uncertainty. A major goal of the modeling is to help convey the top-down system perspective. Metrics are weighted according to significance of the attribute with respect to subsystems and are aggregated nonlinearly, which is analogous to how humans frequently make decisions. Dependence among the contributing factors has been accounted for by incorporating subjective metrics on commonality and by correspondingly reducing the contribution of these combinations to the overall aggregation. Dynamics are facilitated in several ways. Information is provided on input "Importance" and "Sensitivity" in order to know where to place emphasis on investigation of root causes and in considering the effectiveness of new controls that may be necessary. Trends in inputs and outputs are tracked in order to obtain significant information, including cyclic information, for the decision and optimization process. Early Alerts are provided in order to facilitate pre-emptive action. The results are compared to soft thresholds for a realistic decision-making process.

References Used to Support the Review

1) James Reason, *Managing the Risks of Organizational Accidents*, Ashgate, 1997. 2) R. L. Long and V. S. Briant, "Vigilance Required: Lessons for Creating a Strong Nuclear Culture," *Journal of System Safety*, Q4 1999. 3) Richard L. Schwoebel, *Explosion Aboard the Iowa*, Naval Institute Press, 1999. 4) Feller, William, *An Introduction to Probability Theory and its Applications*, John Wiley & Sons, 1957.

Airline Usage

A version of this tool that incorporates 119 inputs has been given on a trial basis to two airlines.

Tool Cost

The generic tool is available for trial at no charge. It requires installation by Sandia National Laboratories. Customization is available, but there is a charge for customization.

Point of Contact

J. Arlin Cooper, Sandia National Laboratories, Albuquerque, NM USA, phone (505) 845-9168, e-mail: cooper@sandia.gov.

Quantitative Risk Assessment System (QRAS)

Purpose
QRAS is a PC-based software tool for conducting a Probabilistic Risk Assessment (PRA) on a system. The tool helps in modeling deviations from the system's nominal functions, the timing and likelihood of such deviations, potential consequences, and scenarios leading from initial deviations to such consequences. It was designed for use by NASA for space missions, but could be adapted to other uses, e.g., the air traffic control system.

Description
QRAS provides a user-friendly graphical interface and structured guidance to the user. Elements of the model can be accessed using point-and-click. It includes direct use of Event Sequence Diagrams (ESD), supported by linked Fault Trees. The system hierarchy consists of a structural or functional breakdown of the system, which is not limited in the number of levels. The mission time-line is a representation of the different operational phases that the system goes through during its mission. Different modes of failure exist in each Operational Time Interval (OTI). QRAS has an extensive set of standard reliability models built-in, and allows the user to construct his own, or input existing models designed specifically for the particular system component in question. QRAS also has common cause failure logic, which covers system dependencies.

Once a risk model is completed, it can be analyzed in two stages: First an ESD linking step creates Boolean expressions for each scenario and each end state. Then the results of individual ESD's are aggregated to compute risk levels at the next higher level of the hierarchy. A Reduced Order Binary Decision Diagram (ROBDD) handles the occurrence of the same basic events in multiple fault trees.

The modeling and analysis capabilities are integrated into a single software application that runs as a stand-alone application on a Microsoft Windows platform.

Aviation Usage
None known of as of yet, but the FAA Airways Facilities service is interested.

Potential Benefits to Air Traffic Safety Analysis
The potential application to the physical portion of an air traffic control system is clear. Whether or not this tool could be used to analyze human failure modes has yet to be investigated.

Tool Cost
This tool was developed by the University of Maryland under a US government contract and its availability would depend on US government permission. If granted, the cost would be nominal.

Documentation: *Not determined*

References
This information was derived from "Quantitative Risk Assessment System (QRAS) For Space Mission PRA," by Ali Mosleh, Pete Rutledge, and Frank Groen of the University of Maryland.

Vendor/owner Support: *Not determined*

Points of Contact
Prof. Ali Mosleh, Dept. of Materials and Nuclear Engineering, University of Maryland at College Park, +1 301-405-5215, Mosleh@eng.umd.edu
Pete Rutledge, NASA, prutledg@hq.nasa.gov

RISKMAN for Windows

Purpose

RISKMAN is a general-purpose quantitative risk analysis tool for Windows PCs (NT, 2000, XP)

Description

RISKMAN for Windows consists of four fully integrated modules that have been under development since 1989: data, systems, fragilities, and event trees.

The **event tree module** can solve a linked set of event trees with as many as 300 top events to quantify the frequencies of accident sequences. It has graphics capabilities to the screen and printer. It allows displays of branch point probabilities, and creates a sequence database with over 40 publication-quality reports ranging from the system importance ranking to scenario frequency rankings. Multi-way branching can also be used in RISKMAN. For each sequence or group of sequences, RISKMAN can display the systems, operator actions, key dependencies, cutsets, and basic event importance measures. The event tree results are stored in Microsoft's ACCESS program. A key feature of RISKMAN is that it can calculate importance measures on all sequences quantified rather than just those saved to a database for subsequent processing. This feature means that importance measures can be computed at almost any frequency truncation cutoff. This is not possible for other approaches. The selected cutoff is only limited by computer runtime and the size of the model.

The **systems module** employs fault tree graphics to compute system or event unavailabilities. These unavailabilities are then used in sequence quantification. RISKMAN employs a minimal cutset code and a similar tool for computing prime implicants; i.e. cutsets with complement events. A unique feature is the ability to specify common cause groups separately from the fault tree and have these groups automatically added to the fault tree for quantification. Minimal cutsets may be totaled using the rare-event approximation or the min-cut upper bound approach. Beginning with Version 6.00, the ability to solve fault trees using Binary Decision Diagrams (BDD) is now available. BDD's provide a quantum leap in power and accuracy for fault tree solutions. A "Red Button" feature is also provided to automate and document system model changes and results for sensitivity studies. Changes to the model can be saved, results created, and then the model reset to base case conditions all using a string of commands saved in a batch file.

The **data module** is for developing failure rate distributions and related parameters for fault tree quantification. RISKMAN allows generic industry data to be combined with system-specific data by using Bayesian techniques. Maintenance frequency and duration computations are also available. Batch routines for Bayesian updating have been developed and are easier to implement. The parameter distributions are stored and manipulated as discrete probability distributions so that it is not necessary to restrict the analysis to distributions of a closed analytical form.

A **fragility module** to compute seismic and wind fragilities or other stress-strength structural failure probabilities is provided; i.e. the probability of equipment failure with increasing seismic or wind hazard. The user supplies fragility curves in standard two-parameter lognormal form and then RISKMAN computes the failure probabilities for each component according to the hazard curve information.

In addition to the four modules, RISKMAN includes important model utility features. These utilities permit multiple models to be created, saved, and deleted. Model parts may also be exported from one machine and imported into another model on a different machine. RISKMAN has features to interface with other standard PSA software codes.

Stage of Review Completed

This tool did not go through R&M, Value, or OR reviews.

Airline Usage
No airlines are known to be using this tool.

References Used to Support the Review
Web site: http://www.abs-group.com/

Point of Contact
Donald Wakefield, ABS Consulting (PLG, Inc., who originally developed RISKMAN, is now owned by ABS Consulting), in the USA call (714)-734-2503, email: dwakefield@absconsulting.com.

WinNUPRA

Purpose
WinNUPRA is a computer software tool developed to perform quantitative risk assessment (QRA) and probabilistic risk/safety analysis (PRA/PSA) to assist in the probabilistic aspects of risk and safety evaluation of complex engineered systems and facilities.

Description
WinNUPRA is a product of SCIENTECH, Inc. and was originally developed by NUS Corporation. NUS was acquired by SCIENTECH in 1996. WinNUPRA is designed and developed as the optimal tool to quickly and efficiently solve and manipulate "living" QRA models in support of QRA applications. WinNUPRA consists of 5 major analysis modules (Event Tree, Fault Tree Data, Calculation, Results) and is designed to generate and analyze minimal cutset solutions of fault trees and cutset equations for accident sequences. This product is made in the USA but is currently being used around the world, from Taiwan to the Czech Republic. Within the US, in addition to many industrial users, over a dozen nuclear power plants actively use the WinNUPRA code to support plant operations and engineering analyses. The code is Validated and Verified to the intent of Federal Quality Assurance guidelines to fulfill these roles.

Stage of Review Completed
This tool did not go through R&M, Value, or OR reviews.

Airline Usage
No airlines are known to be using this tool. WinNUPRA has been used by Pratt & Whitney to perform an engine reliability analysis.

References Supporting Review
Information provided by tool vendor.

Points of Contact
Jeff Julius, 253-852-9070, email: jjulius@scientech.com, Dieter Spiegel, 253-852-9070,
e-mail: diters@scientech.com.

7.0 Analytical Methods

This section contains information on general methods for event analysis. Information on the purpose of the method, description, and references used to support the review, as well as points of contact are provided for all the methods. The reviews may vary in the amount and level of detailed information provided. It should be noted that some of the methods have tools associated with them and others may not.

The methods are organized into the same categories as the tools in the previous sections, and the category descriptions are provided in sections 3.2, 5.0, 6.1, and 6.3.

7.1 Descriptive Statistics and Trend Analysis

Characterization/Trend/Threshold Analysis

Purpose
To analyze non-technical operational incidents.

Description
This method when employed properly can assist in identifying trends, outliers, and signal changes in performance. It is used for safety, maintenance, and manufacturing production applications. A multi-layered protocol (involving the front-line operator, the airline, the manufacturer, and the CAA) was established to ensure that relevant information is sent to participating organizations in a timely manner, confidentiality and a feedback system are present, prioritization strategies exist, and keywords and safety principles have common criteria.

This method is widely used particularly for analysis of events, human performance, equipment failure/reliability/maintainability, process systems performance, etc. The method is used to first characterize data, trend it over time to establish a baseline, and then by expert judgment or statistical inference establish thresholds or control points that when exceeded indicate a significant change in the performance of what is being monitored. (The change is not necessarily bad or undesirable). In analyzing infrequent events, users need to ensure that they have an experienced statistician working with them. Once the change is reflected through this process, and then it is incumbent upon the responsible party to understand what is driving the change and take corrective action if warranted. This analytical method is well documented, but typically as part of a report or paper on statistical process control or as a part of guidance on developing performance indicators/measures.

Other Comments
This analytical method is being employed more extensively in all industries for straightforward statistical process control and where Deming techniques are employed. Major federal agencies in the U.S. (Federal Aviation Administration, Nuclear Regulatory Commission, and Department of Energy) have employed some variation of this approach in developing performance indicators/measures on specific data parameters or types of events to monitor key safety issues or occurrences. Once a parameter exceeds/approaches a control point or threshold, typically some type of review or investigation is undertaken. The extent to which FSO's employ this approach is not known. For a given airline, there may not be a sufficient data population. This method when employed properly can assist in identifying trends, outliers, and indicate changes in performance.

References Used to Support the Review
FAA report on Use of Statistical Analysis in FAA, Department of Energy handbook on developing performance measures: *How to Measure Performance; A Handbook of Techniques and Tools* published by DOE's performance-based management special interest group.
http://tis.eh.doe.gov/web/oeaf/oeanalysis.html/.

Point of Contact
Jean Paries 33-148-62-62-04, email: pariesj@worldnet.fr

7.2 Human Factors Analysis

Reason Model

Purpose
James Reason's model of accident causation is intended as an approach toward understanding incidents and accidents and their underlying or contributing factors. Its value, therefore, lies primarily in the orientation or attitude towards investigations it has inspired.

Description
Reason argues that human error is a consequence rather than a cause, and should be the starting point for further investigation rather than the end of the search for incident or accident causes. Reason's key points can be best described as follows:

- Hazards, errors and other threats to aircraft operations happen all the time, but accidents do not -- because most safety threats are caught and corrected by a variety of defenses.
- The aviation environment has multiple or redundant layers of protection -- designed to prevent mistakes or system failures from cascading into accidents.
- Each layer of protection has flaws. As flaws develop in a layer, the risk for an accident begins to increase.
- Accidents occur only when sufficient layers of protection are penetrated.

Reason articulates several key concepts that are relevant to incident or accident investigation, including hazards, defenses, unsafe acts, unsafe local conditions, passive failures, and latent conditions. Those wishing to understand an accident, or to build defenses against future accidents are encouraged to search for hazards, identify flaws in existing defenses, search for unsafe conditions and practices around a system, and examine how the overarching organization approaches and communicates safety expectations to the front line. Reason directs focus beyond the active failures of front line employees in an individual event to the latent, pre-existing conditions that enable them. Individuals will always err at unpredictable times and locations. Looking forward, the greatest potential for accident prevention lies in management action to build defenses and create a culture in which precursor events are reported and corrective actions implemented.

Other Comments
Reason has published and updated his model in a number of books that are commercially available. Reason's concepts have been applied by the majority of U.S. airlines and are evidenced in training programs focused on "Threat and Error Management" and safety monitoring and reporting programs such as ASAP, FOQA, and LOSA. This approach has also inspired the Human Factors Analysis and Classification System (HFACS) methodology and has been highly influential in several key international accident investigations.

References Used to Support the Review

Reason, J. (1997) *Managing the risks of Organizational Accidents*. Aldershot, UK: Ashgate. Woods, D. (1997). "Book review: Managing the risks of organizational accidents, by James Reason." *Focus on Patient Safety*, 1.

Point of Contact

Dr. James Reason, University of Manchester (UK), email: james.reason@man.ac.uk, 44-161-275-2000 (University central operator).

7.3 Occurrence Investigation and Analysis

Integrated Safety Investigation Methodology (ISIM)

Purpose

To support the investigation of transportation occurrences.

Description

ISIM was developed by the Transportation Safety Board of Canada (TSB) to provide a standardized and comprehensive methodology to support the investigation/analysis of multi-modal occurrences in the transportation sector. It focuses on the identification of safety deficiencies.

ISIM integrates the identification of safety deficiencies, with the analysis and validation of those deficiencies. The prime components of ISIM are: occurrence assessment; data collection; events and factors diagramming; use of the TSB's existing integrated investigation process to uncover the underlying factors (safety deficiencies); risk assessment; defense/barrier analysis; risk control options; and safety communications. TSB plans to automate parts of the methodology and tie it more closely to their TSB's database systems.

References Used to Support the Review

Transportation Safety Board of Canada, website: http://www.tsb.gc.ca/

Point of Contact

Maury Hill - Transportation Safety Board of Canada, email: maury.hill@bst.gc.ca

Multilinear Events Sequencing (MES)

Purpose

To develop an understanding and explanation of accident and incident processes, and define changes that would significantly improve future performance of systems.

Description

The MES –based investigation system is an integrated system of concepts and procedures used to investigate a wide range of occurrences, before or after they happen. It treats incidents as processes, and produces descriptions of the actions and interactions required to produce observed process outcomes. The descriptions are developed as matrix-based event flow charts showing the coupling among the interactions with links where sequential, if-then and necessary and sufficient logic requirements are satisfied. The investigations focus on behaviors of people and objects, demonstrating what they did to influence the course of events, and then defining candidate changes to reduce future risks. Procedures provide for the sourcing, acquisition, documentation, organization and analysis of data as data are acquired; guidance for defining data to seek; disciplined hypotheses development when unknowns are identified; an event set-based function for discovering, defining and assessing opportunities for system improvement; development, assessment and monitoring of changes that would reduce future risks; task productivity management; and logic-based quality assurance. The behavior-oriented event descriptions are readily incorporated into other organizational functions and tasks.

References Used to Support the Review
http://www.starlinesw.com/product/MESBrochure.pdf, http://www.starlinesw.com/product/Y2kguides/Y2KGuide00.html, Hendrick, K.M. and Benner, L., Investigating Accidents With Step, Marcel Dekker, 1986 New York, NY

Point of Contact
Ludwig Benner, Starline Software Ltd., benner@starlinesw.com

7.4 Risk Analysis

Fault Hazard Analysis (FHA)

Purpose
To identify and evaluate component hazard modes, determine causes of these hazards, and determine resultant effects to the subsystem and its operation.

Description
The Fault Hazard Analysis is a deductive method of analysis that can be used exclusively as a qualitative analysis or, if desired, expanded to a quantitative one. The fault hazard analysis requires a detailed investigation of the subsystems to determine component hazard modes, causes of these hazards, and resultant effects to the subsystem and its operation. This type of analysis is a form of a family of reliability analyses called failure mode and effects analysis (FMEA) and FMECA. The chief difference between the FMEA/FMECA and the fault hazard analysis is a matter of depth. Wherein the FMEA or FMECA looks at all failures and their effects, the fault hazard analysis is charged only with consideration of those effects that are safety related. The Fault Hazard Analysis of a subsystem is an engineering analysis that answers a series of questions:

- What can fail?
- How it can fail?
- How frequently will it fail?
- What are the effects of the failure?
- How important, from a safety viewpoint, are the effects of the failure?

References Used to Support the Review
System Safety Handbook: Practices and Guidelines for Conducting System Safety Engineering and Management, December 2000. Federal Aviation Administration [On-line], http://www.asy.faa.gov/Risk/SSHandbook/cover.htm.

Point of Contact
Mike Alloco, Program Analyst (Risk Assessment), FAA Office of System Safety, 202-493-4589

Failure Mode and Effect Analysis (FMEA) / Failure Modes, Effects, and Criticality Analysis (FMECA)

Purpose
To identify component and subsystem failures modes, evaluate the results of the failure modes, determine rates and probability, and demonstrate compliance with safety requirements.

Description
FMECAs and FMEAs are important reliability programs tools that provide data usable by the System Safety Professional. The performance of an FMEA is the first step in generating the FMECA. Both types of analyses can serve as a final product depending on the situation. An FMECA is generated from an FMEA by adding a criticality figure of merit. These analyses are performed for reliability, safety, and supportability information. The FMECA version is more commonly used and is more suited for hazard control. Hazard analyses typically use a top down analysis methodology (e.g., Fault Tree). The approach first identifies specific hazards and isolates all possible (or probable) causes. The FMEA/FMECA may be performed either top down or bottoms-up, usually the latter.

Hazard analyses consider failures, operating procedures, human factors, and transient conditions in the list of hazard causes. The FMECA is more limited. It only considers failures (hardware and software). It is generated from a different set of questions than the HA: “If this fails, what is the impact on the system? Can I detect it? Will it cause anything else to fail?” If so, the induced failure is called a secondary failure. FMEAs may be performed at the hardware or functional level and often are a combination of both. For economic reasons, the FMEA often is performed at the functional level below the printed circuit board or software module assembly level and at hardware or smaller code groups at higher assembly levels. The approach is to characterize the results of all probable component failure modes or every low level function.

References Used to Support the Review
System Safety Handbook: Practices and Guidelines for Conducting System Safety Engineering and Management, December 2000. Federal Aviation Administration [On-line], http://www.asy.faa.gov/Risk/SSHandbook/cover.htm.

Point of Contact
Mike Alloco, Program Analyst (Risk Assessment), FAA Office of System Safety, 202-493-4589

Probabilistic Risk Assessment (PRA)

Purpose
To quantify the probabilities and consequences associated with accidents and malfunctions by applying probability and statistical techniques as well as various consequence evaluation methods.

Description
Probabilistic Risk Assessment (PRA) data inputs include actuarial events in combination with logic models to predict frequencies and consequences of events that have or have not happened but which could cause accidents.

Modern PRA embraces event/fault tree analysis, computer models, reliability theory, systems analysis, human factor analysis, probability theory, and statistics. These and the appropriate engineering disciplines are integrated into a formal process that addresses the two components of risk: likelihood and consequences.

PRA provides a systematic, consistent and coherent framework for estimating risks and evaluating them before making decisions. Part of this framework is supported by methods and techniques developed in the scientific areas, known as Reliability Availability Maintainability (RAM) analysis of systems (also referred to as Dependability), Probabilistic Safety Analysis (PSA), and/or Quantified Risk Assessment.

References Used to Support the Review

Risk Assessment and Risk Assessment Methods: The State-of-the-Art, NSF/PRA-84016, January 1985.
"PRA Procedures Guide", U.S. Nuclear Regulatory Commission, (Vols. 1 and 2) January 1983.
http://www.hq.nasa.gov/office/codeq/qnews/pra.pdf
http://smo.gsfc.nasa.gov/crm/crm_publications/presentation_1.pdf

Point of Contact

Dr. James Luxhoj - Rutgers University, 732-445-3625, email: jluxhoj@rci.rutgers.edu

Appendix A

Example Applications of Selected Tools

This appendix provides illustrative examples of the application of several of the analytical tools described in earlier sections of the Guide. These examples have been developed to provide a better understanding of how the various tools can be used in airline flight safety analysis as well as to provide a more detailed explanation of the various features of the specific tools.

The appendix contains example applications for the following tools:

Page

Additional details on each of these tools, including contact information and website links where available, and given in the relevant section of this Guide.

A.1 Aviation Quality Database

1 Introduction

1.1 OVERVIEW OF THE TOOL FUNCTIONALITY

The Aviation Quality Database (AQD) is a comprehensive and integrated set of tools to support Safety Management and Quality Assurance. Functional components include:

- Occurrence/Incident Report capture using customisable data entry forms and an optional Web Interface
- Investigation tracking and management
- Investigation Result capture, including Causal Factors, and the distribution of results
- Audit Program development including customisable check lists
- Audit scheduling and management
- Audit Result capture, including Causal Factors, and the distribution of results
- Corrective/Preventive Action tracking and management
- On line Enquiries for Occurrences, Investigations, Audits, Findings and Actions
- Management status and summary reports
- Analysis tools.

Features include e-mail interfaces, support for multi media attachments, customisable codes for analysis, interfaces to Word and Excel and full on line help.

Although used primarily by Airlines, AQD is also used by other sectors of the Aviation Industry, such as Airport Operators, Maintenance Organizations and Air Traffic Service Providers.

1.2 INTRODUCTION TO THE EXAMPLE APPLICATION

The following sections present a case study of how AQD is currently being used by a real airline. This airline is a domestic operator, which started operation only several months before the time of writing. The data shown in the example has been de-identified.

It should be kept in mind while reviewing this case study that AQD has a number of customisation facilities and configuration options that alter the way AQD can be used, including the values used for categorization. For example, AQD can be configured to not require the entry of Causal Factors if this does not suit the organisation, or should it wish to phase in their introduction. The Causal Factors can also be customised, allowing methodologies such as TapRoot and Boeing's MEDA to be adopted instead of the James Reason model codes referred to.

2 Input Data

Our two main sources of data for AQD are from occurrence reports or reports highlighting deficiencies that are reported both internally or externally, together with the outcome of any resulting investigation. The second is from quality or safety audits and other such inspections.

2.1 OCCURRENCES

2.1.1 Occurrence Reports

We use a series of paper forms to allow staff to capture and submit various Occurrences, both safety and quality related. These reports are then entered in to AQD as an occurrence report. We have not yet purchased the AQD Web Interface to allow report submission to be done electronically.

We have customised the categorization of these occurrences in AQD to suit the way we wished to analyse them. Our organisation presently utilises our regulatory Authority's classification for occurrences that are required to be notified to the Authority (mandatory occurrence type, or MOR, in flow diagram shown in Figure 1 below). In addition, we use a System Improvement Report to report on other occurrences and deficiencies within the organisation, and an Accident Report to report on Occupational Health and Safety occurrences. Both of these have various sub-categories (called Event Descriptors, and again customised to suit our needs) so that the reports can be further broken down for analysis purposes.

Once the occurrences are entered in to AQD, we make an assessment as to whether an investigation is required. If so, the functionality of raising an investigation is straight forward, and the investigation is assigned to an investigator that has been trained in this function.

The flow diagram shown in Figure 1 (from our existing procedure manual) details how this information is obtained, entered into AQD and attached to an investigation. The next step in this process, shown in the flow chart for Para 3.4 of the procedure manual in Figure 2 below, is described in the next section.

Two examples of occurrence reports for which investigations were raised are shown below, and will be followed through the process in the remainder of this example.

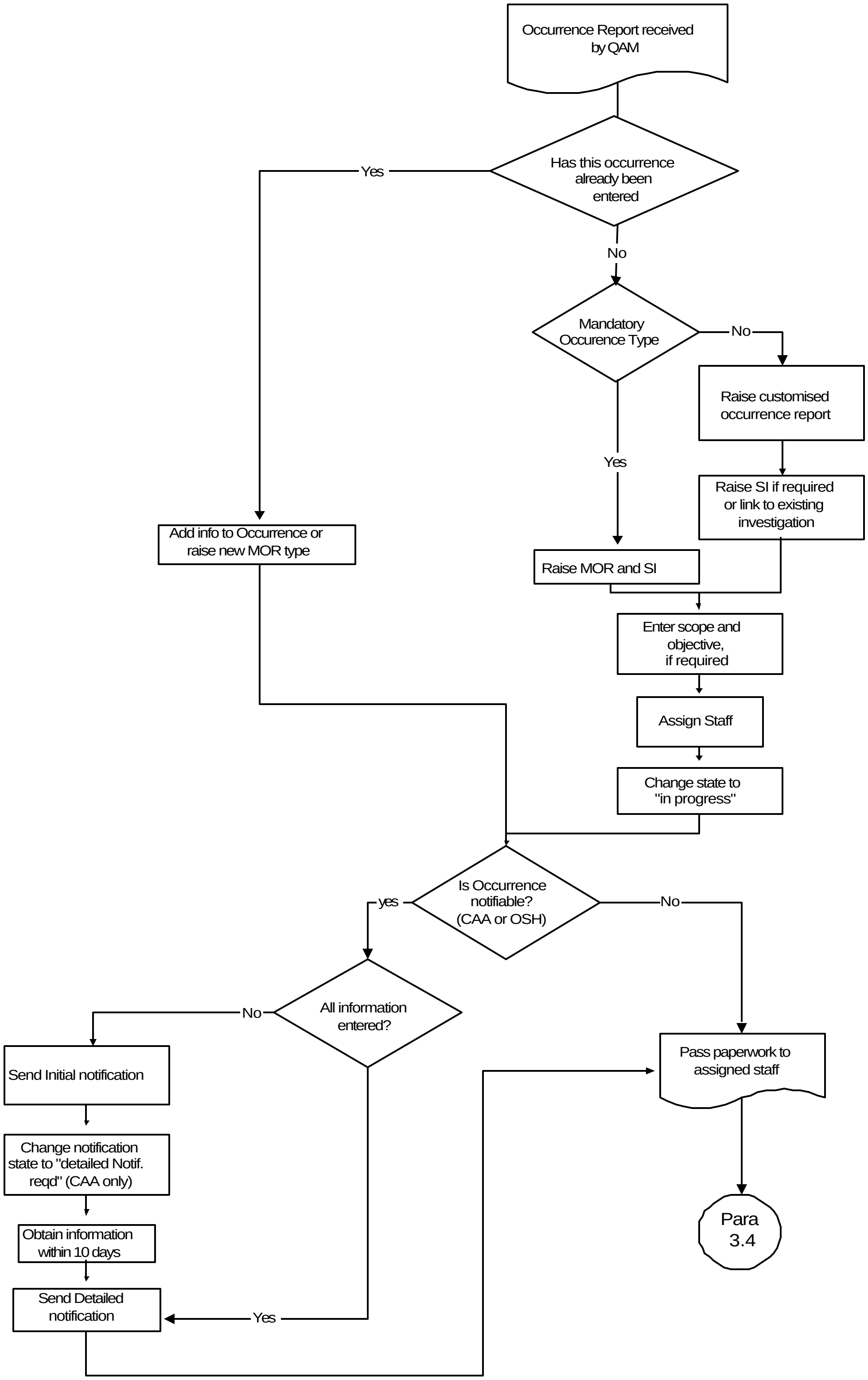
- Enroute from XXX-YYY, we were slowly overtaken by a B747 which was vectored around us direct to ZZZZZZZZ. Despite being progressively slowed both in cruise and descent, at ZZZZZZZZ we were directly behind and above the 747, and concerned with possible wake turbulence, we queried ATC as to the separation. The answer given was about 6 nm, although our TCAS indicated possibly less than this, and our descent profile was held purposely high. Shortly after, we encountered moderate wake turbulence, our aircraft rolling rapidly right. Roll was stopped at about 40 degrees AOB with full left aileron. The aircraft then rolled rapidly left to about 30 degrees AOB. Power was applied and the rate of descent reduced to depart the wake turbulence area. ATC were informed and the aircraft continued for landing. There were no injuries.

  Event Descriptor: "Operational incident, Other loss of control"

- During pushback from Stand 21, at the disconnect point, the tow bar safety pin sheared. The engineer on headset called for the brakes to be parked, but the captain, not realising that the pin had sheared, refused to park the brakes as the aircraft was still moving. The aircraft rolled forward over the towbar, and the radome was punctured by the tractor mirror frame.

  Event Descriptor: "Operational incident, Collision/strike - vehicle"

Both of these incidents were classified within AQD as severity – "major" but probability of recurrence – "low". They were therefore classified as low risk, but an investigation into both incidents was carried out.



Occurrence Report received by QAM
Has this occurrence already been entered
Yes
No
Mandatory Occurence Type
No
Raise customised occurrence report
Yes
Raise SI if required or link to existing investigation
Add info to Occurrence or raise new MOR type
Raise MOR and SI
Enter scope and objective, if required
Assign Staff
Change state to "in progress"
Is Occurrence notifiable? (CAA or OSH)
yes
No
All information entered?
No
Send Initial notification
Pass paperwork to assigned staff
Change notification state to "detailed Notif. reqd" (CAA only)
Obtain information within 10 days
Para 3.4
Send Detailed notification
Yes

Figure 1

2.1.2 Investigations

Once the investigation was conducted, the report was entered into AQD using a customised Word template, which automatically picked up some of the information from the AQD database. At this point the Findings and corresponding corrective Actions were also entered in to AQD. As part of this process, Causal Factors were identified, using the James Reason model. We have configured AQD to record Casual Factors as we find that this approach is advantageous - users are forced to classify the Causal Factor before being able to record the Action, which is important for effective determination of Actions. The Causal Factors are also very important for subsequent analysis, as shown in Section 3 below. We have found that consideration should be given to training staff who are entering Causal Factors so that a standardized classification is used to increase the value of the output data.

Shown on the next page is a flow diagram outlining how the investigation results and findings are entered, how the relevant authorities are notified and the closure of the investigation. Although the investigation may be closed, the action items continue to be tracked separately through to closure, which is shown on a subsequent flow chart.

The following example shows the Findings, Causes and Actions from the first occurrence noted above.

Finding: F28-03

Our Boeing 737 encountered quite severe wake turbulence, following a 747 in descent, despite being correctly separated.

Department:	***Flight Operations***		
Entered By:	***Name removed***	*Date Discovered:*	***99/99/99***
Category:	***Safety Related Concern***	*Severity:*	***Major***
Rule Ref:		*Likelihood:*	***Low***
Manual Ref:		*Risk:*	***Low***

Cause: 1

There are no wake turbulence separation minima set for aircraft in descent.

Person/Org:	***ATS Provider***
Category:	***Organisation Factors***
Item:	***Inadequate specifications/requirements***

Action: **A32-03** *Due:* ***99/99/99***

The ATS provider is to issue an instruction, requiring controllers to advise aircraft of possible wake turbulence in the situation where a medium aircraft is following a heavy.

Type:	***Preventive***	*Status:*	***Closed***	*Registered On:*	***99/99/99***
Department:	***ATS provider***			*Closed On:*	***99/99/99***

Action: **A33-03** *Due:* ***99/99/99***

Airways will bring this up during the next user meeting, to ascertain if operators wish to have a wake turbulence minima imposed on them in such cases.

Type:	***Preventive***	*Status:*	***Closed***	*Registered On:*	***99/99/99***
Department:	***ATS Provider***			*Closed On:*	***99/99/99***

Para 3.4 continued from Para 3.3

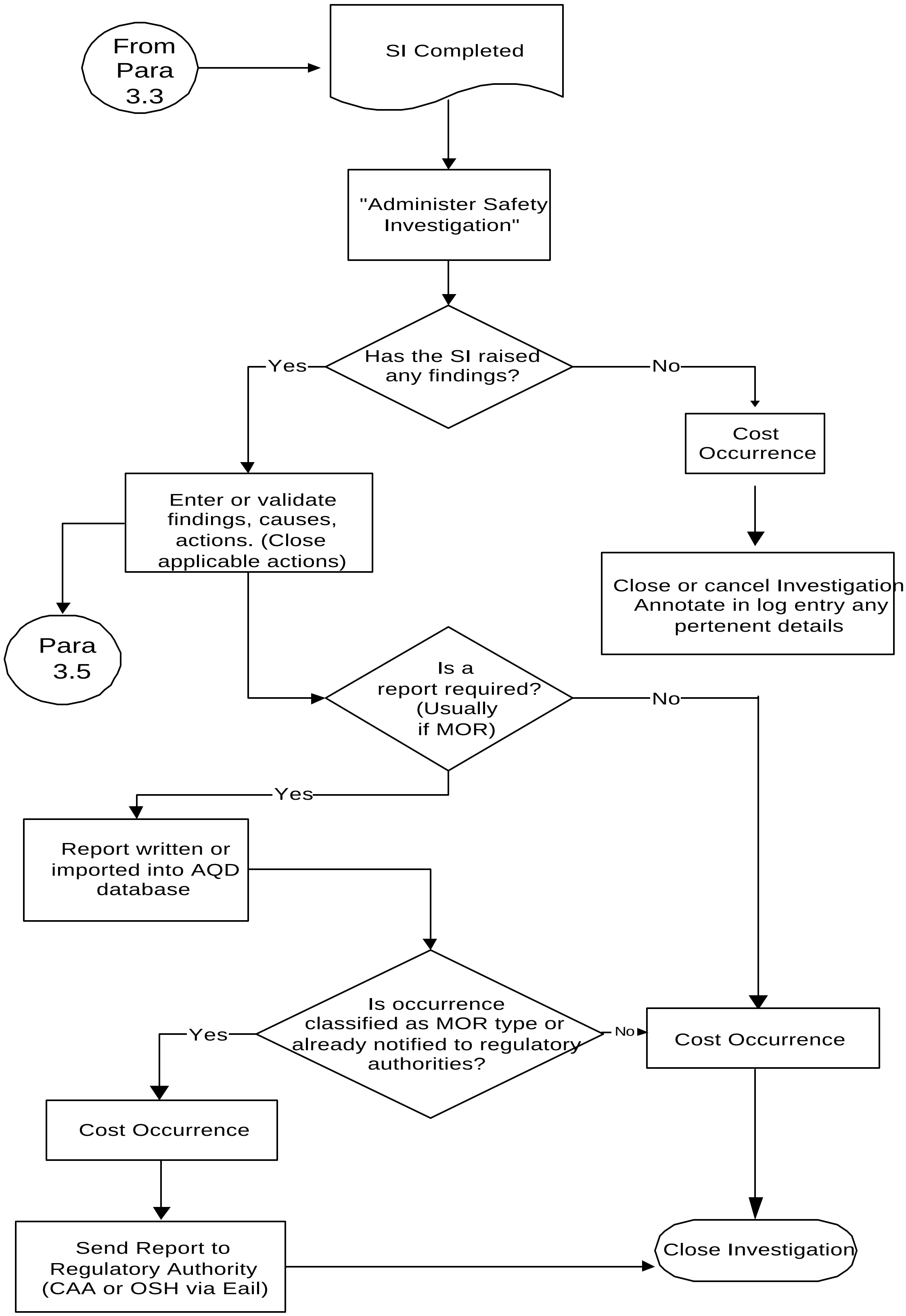


Figure 2

The second occurrence was investigated jointly by ourselves and our contracted ground handling agent. The outcome was that the tug was inadequate for the task and the towbar had unacceptable wear on the coupling. These were raised as findings within their system and were not included in ours. However, an additional finding regarding cockpit to ground communications was raised by ourselves and is shown below:

Finding: F36-03

Ground handling agent do not have an emergency stop command to be used during pushbacks.

Department:	***Ground handling agent***		
Entered By:	***Name removed***	*Date Discovered:*	***99/99/99***
Category:	***Safety Related Concern***	*Severity:*	***Major***
Rule Ref:		*Likelihood:*	***Medium***
Manual Ref:		*Risk:*	***Medium***

Cause: 1

This was omitted during the development of the computer based manual, as it was not recognized as being necessary.

Person/Org:	***Unit Mgmnt/supervisory (Acft Operator)***
Category:	***Local Error Factors***
Item:	***Risk misperception***

Action: **A42-03** *Due:* ***99/99/99***

Ground handling agent are to develop and advise *operator* of an emergency stop command to be used during pushback for abnormal occurrences.

Type:	***Corrective***	*Status:*	***In Progress***	*Registered On:*	***99/99/99***
Department:	*Ground handling agent*			*Closed On:*	

2.2 AUDITS

Our annual audit program has been set up as a series of Audit Modules within AQD. These modules are then activated when due (using the AQD scheduling tools) and are assigned to trained auditors. The audit check lists have also been set up in AQD. Rule references, Manual references and ISO categories have been assigned to each checklist item, thereby preventing this from having to be done at each audit. The checklist can be modified at any time, but has the advantage of providing a stable base so that each subsequent audit is carried out against similar guidelines.

When preparing for an audit, we use AQD to view all the relevant data for the department about to be audited. This includes all Findings and Actions raised during and since the last audit, including as a result of investigations into occurrences.

After the audit has been conducted, the audit report is entered into AQD, along with any Findings that were raised during the audit. The process for identifying the Findings and Actions follows standard audit practices. AQD however uses the same Causal Factor process for audits as it does for investigations, and therefore Causes are identified as well. This means that the Causes from both processes can be combined for analysis.

The following flow diagram shown in Figure 3 details how our organisation handles the audit process. Not all steps are done within the AQD system – those that are done using AQD are marked with an *.

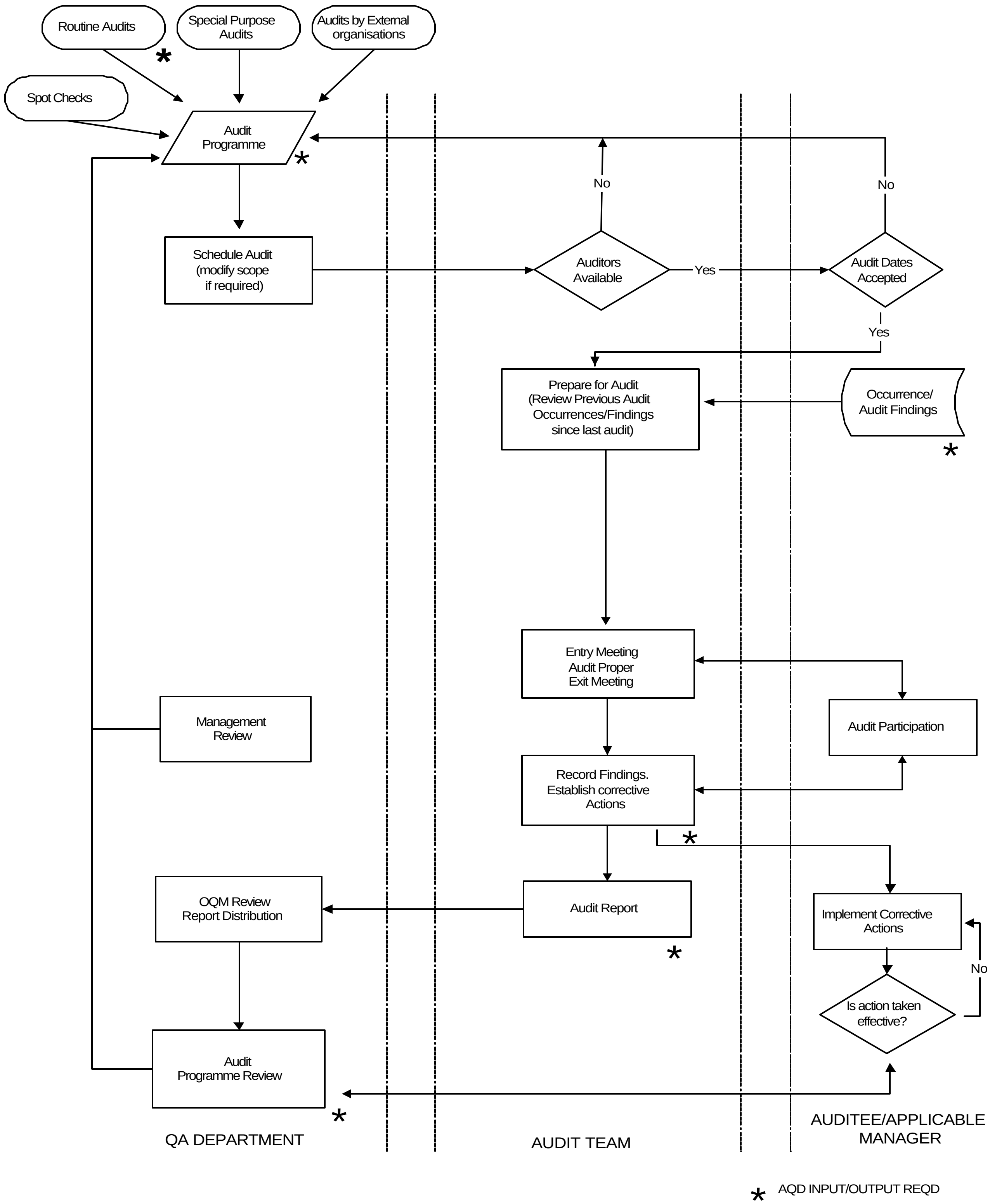


Figure 3

Actions that are entered into AQD from all sources are treated in the same fashion, and are tracked using the AQD reports until evidence is received that the action can be closed.

When the action is closed, it is still the responsibility of the responsible manager to monitor and ensure that the action is being effective in preventing a recurrence. This is also backed up during audits, in that all actions raised against the auditee since the last audit are assessed during the audit for effectiveness. The following flow diagram from our manual, shown in Figure 4, details the action closure process we have adopted.

Para 3.5, continued from Para 3.4

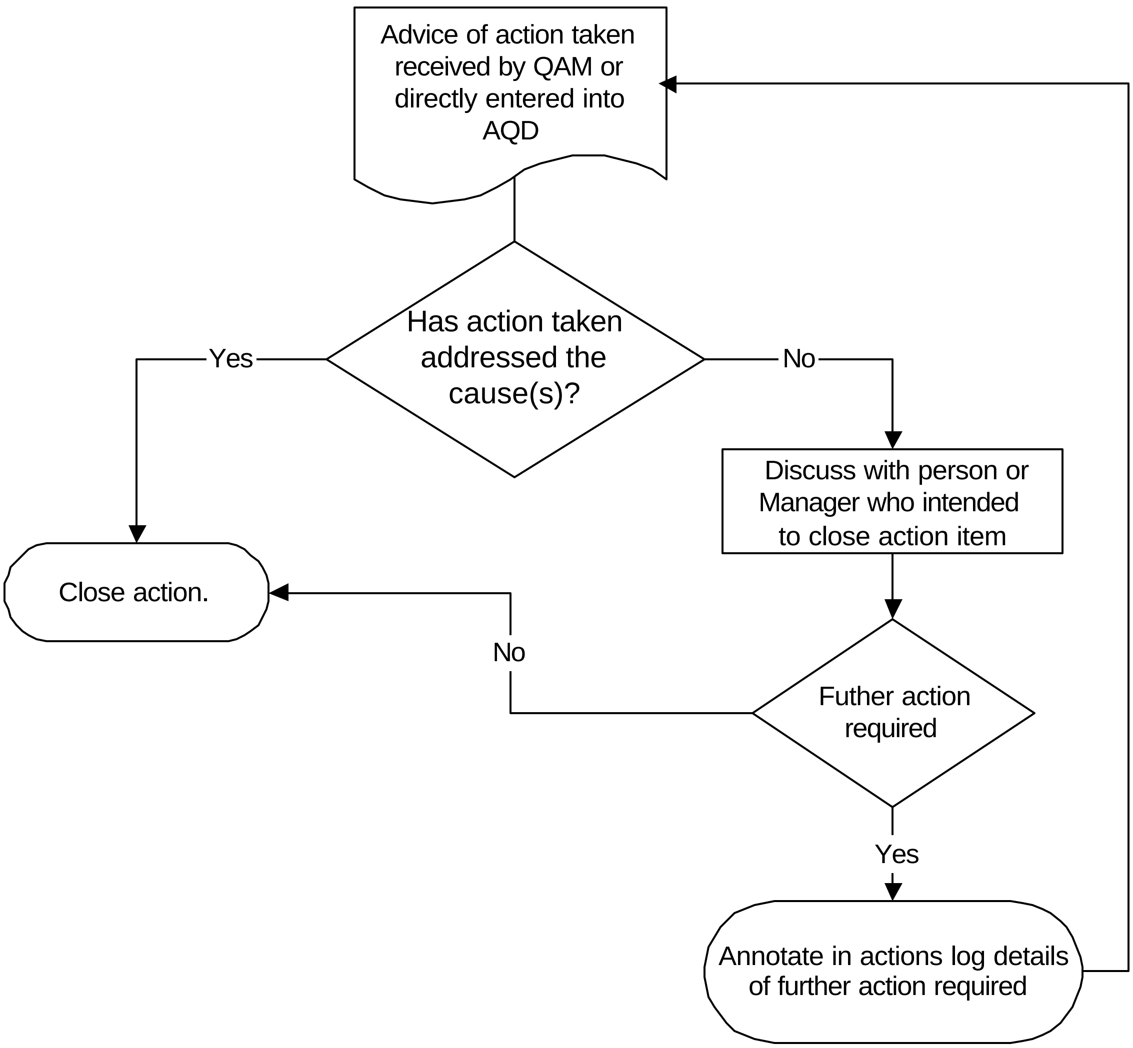


Figure 4

3 Tool Output and Application of the Results of Analysis

On a monthly basis we monitor our Occurrences by type to look for trends, or unexpected peaks. Shown below in Figure 5 is the form we use to request the graphs, while Figure 6 shows the output we receive:

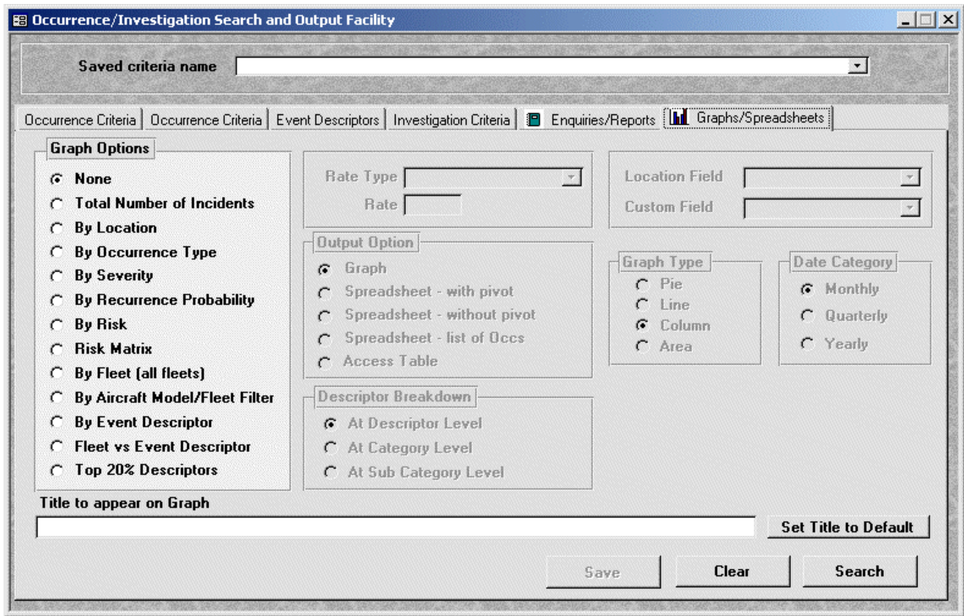


Figure 5

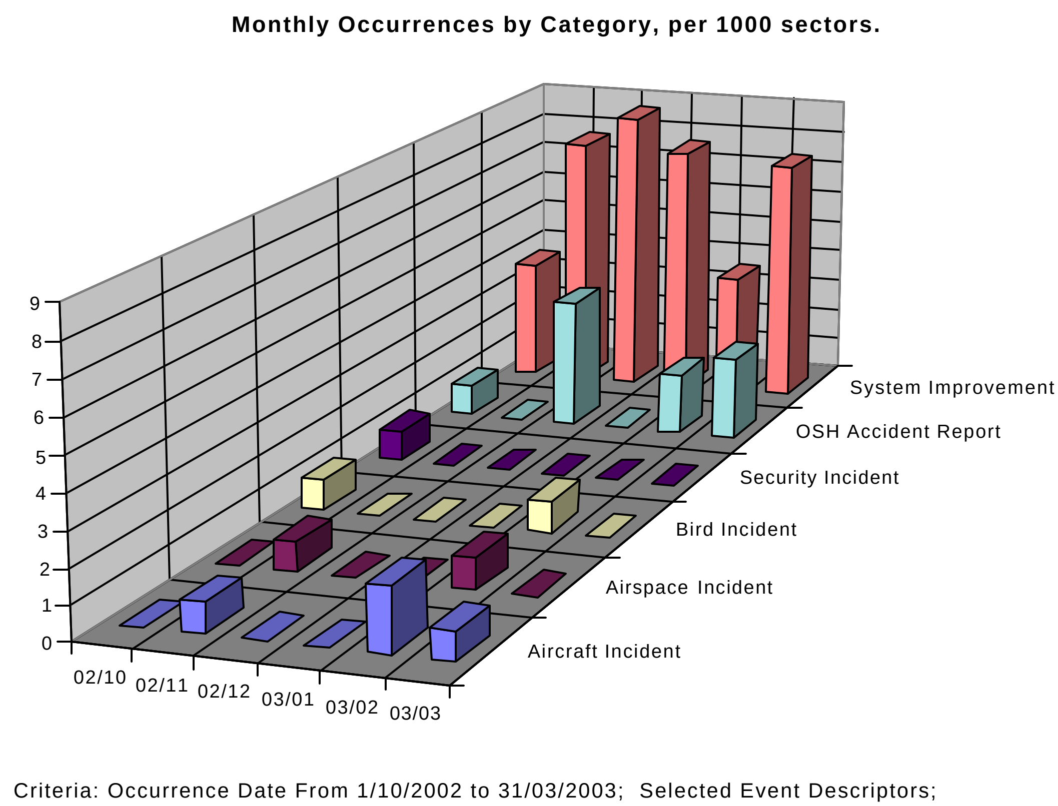
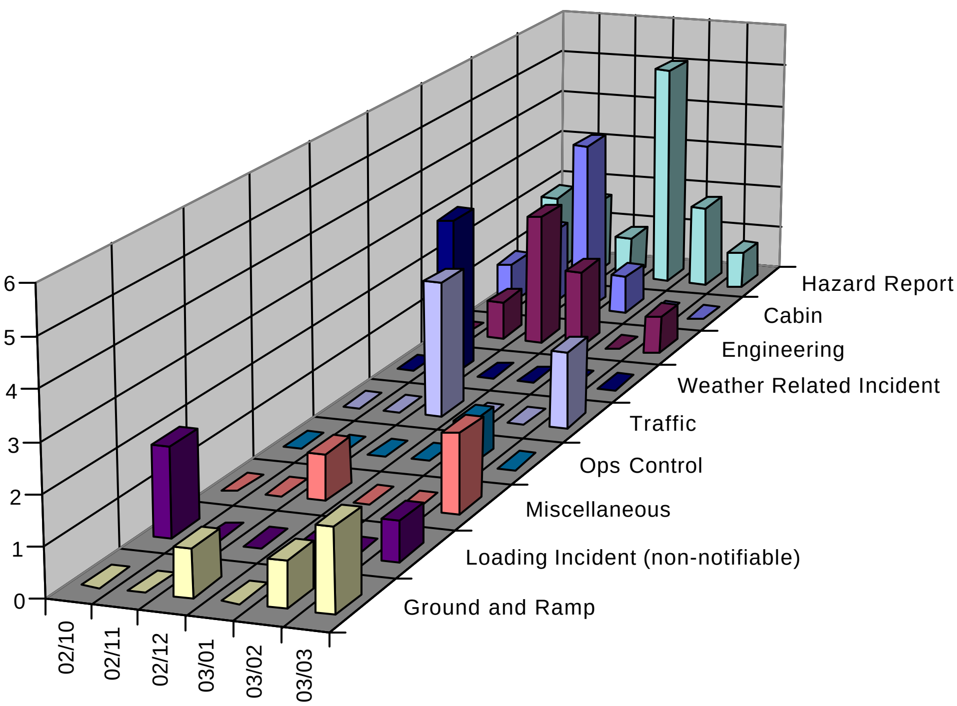


Figure 6

As can be seen our System Improvements are our main category of occurrence. We then analyse this by Event Descriptor to ascertain if there are any areas in this category that are of concern. The chart is shown below in Figure 7.

System Improvement Reports by Category, per 1000 sectors



Criteria: Occurrence Date From 1/10/2002 to 31/03/2003; Selected Event Descriptors;

Figure 7

As can be seen by this chart, the hazard reports, which are the pro-active reports, are steady, but could be improved. The only other category which is giving concern at this stage is ground and ramp incidents, which are increasing and are being monitored. Miscellaneous reports, due to there higher than normal occurrence, were individually assessed, but there were no common incidents evident.

We also look at causal factors that are allocated with findings. The predominant output used is a Pareto analysis of the causal factors, which highlight the 20% most common causal factors. Figure 8 shows the form used to generate causal factor statistics.

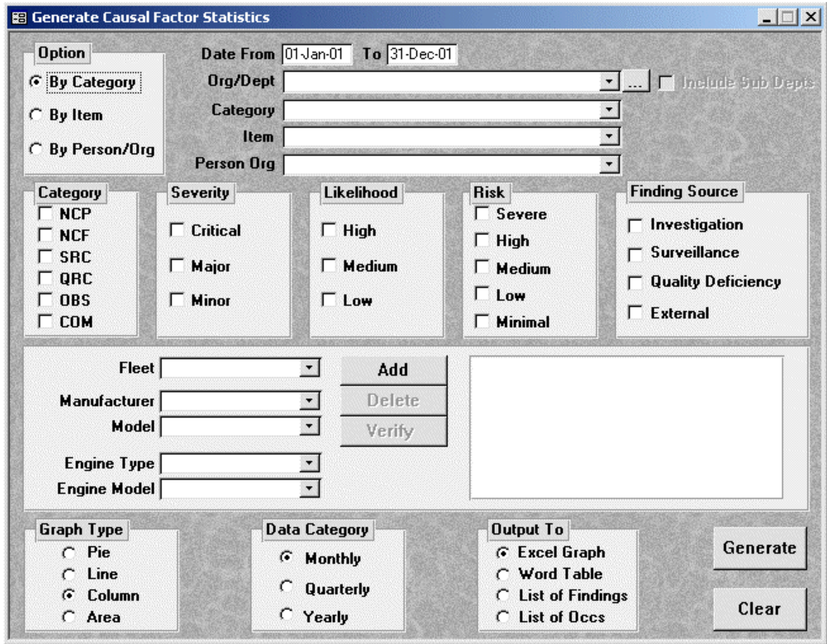


Figure 8

The following graph (Figure 9) shows the resulting output:

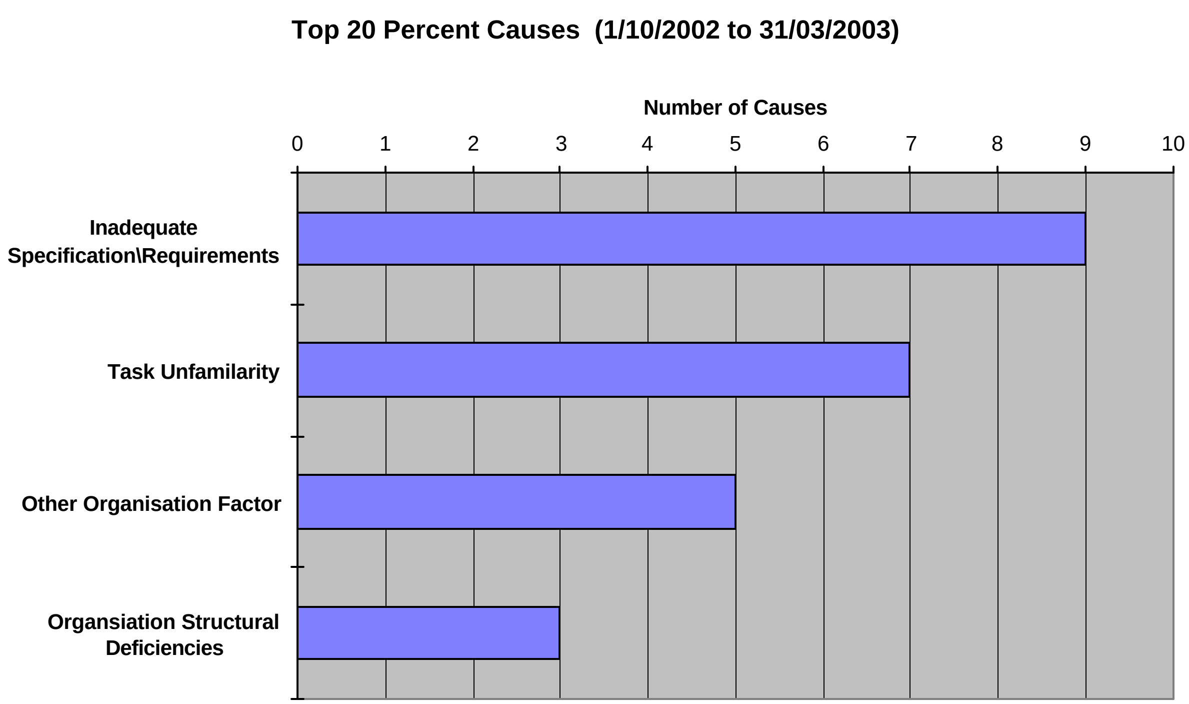


Figure 9

This highlights that at present our main issue is inadequate specifications or requirements. This can be further broken down to see where in the organization these issues are occurring. Figure 10 below shows a breakdown of causal factors against persons or organizational levels.

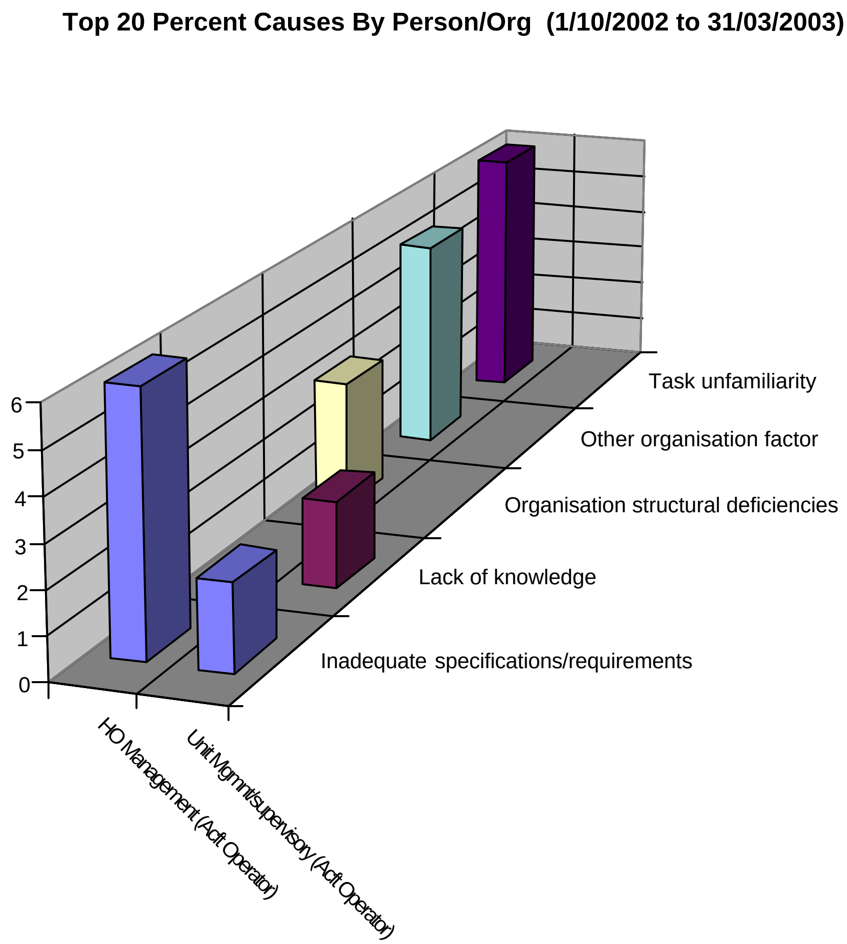


Figure 10

As can be seen, the main area of inadequate specifications is with head office management. This chart also shows that task unfamiliarity is also a high factor in head office management. As our organisation is in its infancy, these results are not surprising, but must be considered by management. These graphs were therefore presented and discussed at our monthly Quality, Risk and Safety Meeting and action plans have been put in place to address these. Any major actions arising from this meeting are documented in AQD to be managed along with the Actions arising from audits and investigations.

The implementation of these action plans will hopefully result in a reduction in the number of causal factors in this area – AQD will be used to produce a trend over time for a given causal factor to illustrate the degree of success.

A.2 AVSiS

1 Introduction

1.1 OVERVIEW OF THE TOOL FUNCTIONALITY

AVSiS has been in use with a number of the world's airlines for many years now, during this time it has continued to grow and develop as AvSoft respond to customers' requests and suggestions. However, it still continues to fulfill its original role, of enabling Flight Safety Officers to log all safety related incidents, manage any investigations and subsequently monitor trends and recurring events.

After a safety related incident has taken place, the captain usually files an Air Safety Report (ASR) detailing the incident, his actions, then any consequences such as unscheduled landing, injuries, delays etc. These reports are passed to the safety officer and the report details are then entered into AVSiS.

(Note: AVSiS 2, which is soon to be released, will enable electronic reporting.)

The paper report, usually filled in by the captain but possibly by other crew or staff members, is input directly into AVSiS by the Flight Safety Office staff. There is no need to format or edit the data. Simply input all the facts into the system. Much of the data is stored in special fields, which makes sorting and viewing the data much easier later. For example there are boxes into which users can input the speed and altitude, while many of the selections are from drop-down lists to promote consistency. Users can also add free text descriptions of the event.

This system is of greater benefit to airlines than simply filing the paper reports as it allows for easy review of past incidents, providing a log of all reported incidents which can be sorted, filtered and viewed in a number of ways. Reports and queries can be run to quickly analyze the data and spot trends or reoccurring events.

Within AVSiS there are three methods which the Flight Safety Officer can use to analyze the data: Standard Reports, Query Builder and AVSiS Data Mining Tools (Supplied by Mitre™ Corp.) All of these can produce results in a matter of seconds by simply using the mouse to point and click. AVSiS already has a number of pre-written reports and graphs built into the software, to enable very quick and easy analysis of the data.

The second way to analyze data in AVSiS is by using the Query Builder. This tool allows users to extract data, sort it, filter it and arrange it any way they like. Users can choose which fields you would like to see in the final table, the filter is selected using simple and easy to understand syntax, and finally select how they would like the data sorted in the final table. The filter can be as simple or as complex as desired. Users can also choose to save particular views and filters to be used again in future.

AvSoft, in association with Mitre Corp, can now provide an optional data mining module, with three additional tools for analyzing large quantities of data in AVSiS. The three tools are:

- Find Similar. This is probably the most frequently used tool. It enables the user to search through data and find events with similar characteristics. It searches through free text fields as well as those where selections are not free text. When searching text, it looks for synonyms, not just exact text matches. For a given event the tool will find all other events with similar characteristics and rank them in order with the most similar events first. This allows the user to identify situations where an event is more likely to occur and pursue preventative actions to reduce future risks.

- Correlations. This tool looks for correlations between events. For example, does a certain type of event occur more frequently at a particular airport, or a particular time of year? Do certain problems keep happening on the same aircraft?
- Discrepancies. This tool looks for anomalies and discrepancies in data. For example, is there an unusual number of events are one location, or are there an unusually high number of events during a particular time period?

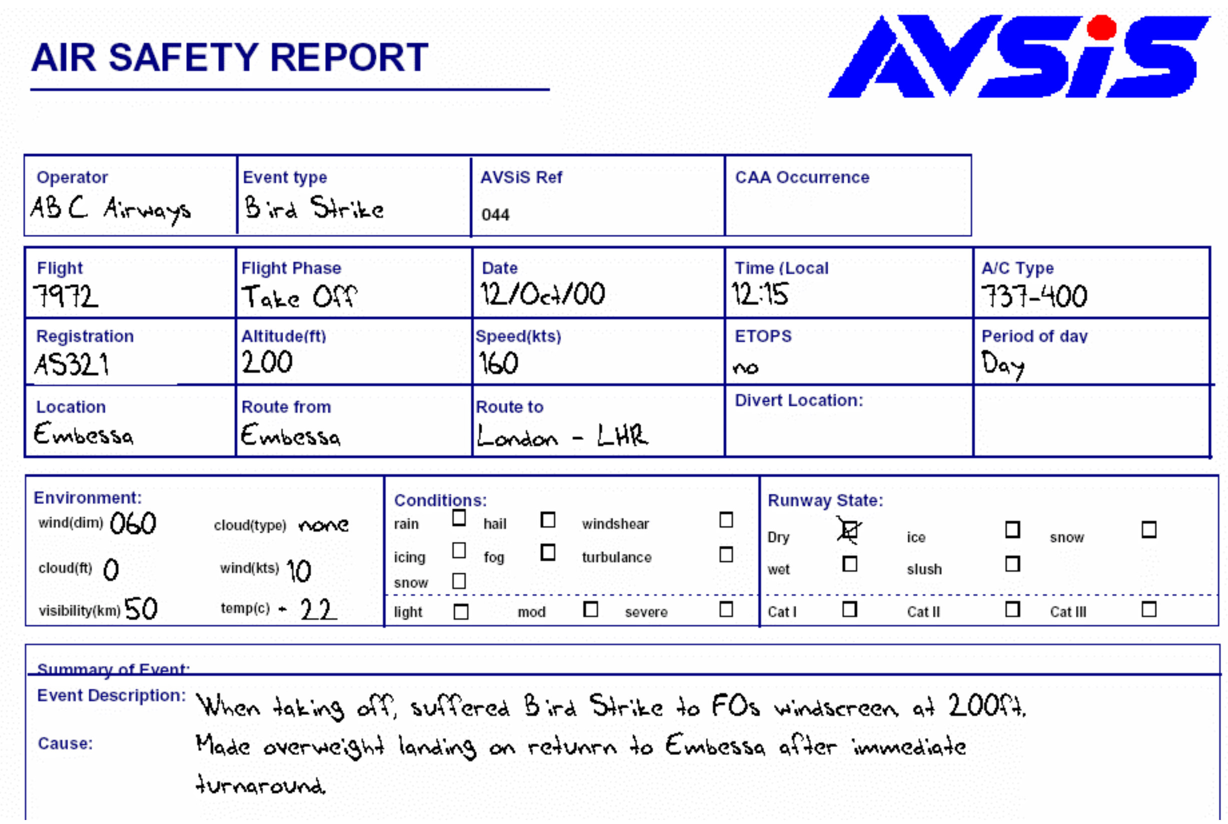
All of these tools are ideal for looking at large quantities of data, and can look for correlations or similarities in the data which would not be possible to do manually due to the sheer quantity of data. Another advantage of the data mining tools is that they and do not require any knowledge of the data by the user, so a new safety officer could generate the same results and identify the same relationships as someone who had worked with the data for a long time.

1.2 INTRODUCTION TO THE EXAMPLE APPLICATION

This example illustrates the use of AVSiS through a typical event reported to the Flight Safety Officer, involving a bird strike at a foreign airport. In this example, the important things for the crew to note in the ASR would be the location of the event, time and date, weather conditions, speed, and altitude.

2 Input Data

Figure 1 shows part of the ASR for the example incident.



AIR SAFETY REPORT

AVSiS

Operator	Event type	AVSiS Ref	CAA Occurrence	
ABC Airways	Bird Strike	044		

Flight	Flight Phase	Date	Time (Local	A/C Type
7972	Take Off	12/Oct/00	12:15	737-400
Registration	**Altitude(ft)**	**Speed(kts)**	**ETOPS**	**Period of day**
AS321	200	160	no	Day
Location	**Route from**	**Route to**	**Divert Location:**	
Embessa	Embessa	London - LHR		

Environment:
wind(dim) 060 cloud(type) none
cloud(ft) 0 wind(kts) 10
visibility(km) 50 temp(c) - 22

Conditions:
rain ☐ hail ☐ windshear ☐
icing ☐ fog ☐ turbulance ☐
snow ☐
light ☐ mod ☐ severe ☐

Runway State:
Dry ☒ ice ☐ snow ☐
wet ☐ slush ☐
Cat I ☐ Cat II ☐ Cat III ☐

Summary of Event:
Event Description: When taking off, suffered Bird Strike to FOs windscreen at 200ft.
Cause: Made overweight landing on retunrn to Embessa after immediate turnaround.

Figure 1

3 Tool Output and Application of the Results of Analysis

Figure 2 shows the standard reports available. The option highlighted, Incident By Event Type, produces a bar chart listing all the differing types of events that have been recorded, ranked by the number of occurrences of each, as shown in Figure 3.

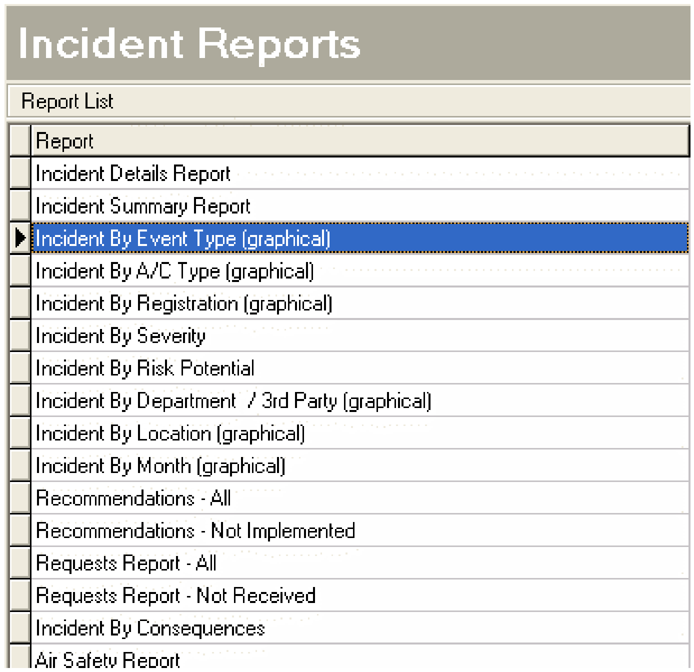


Figure 2

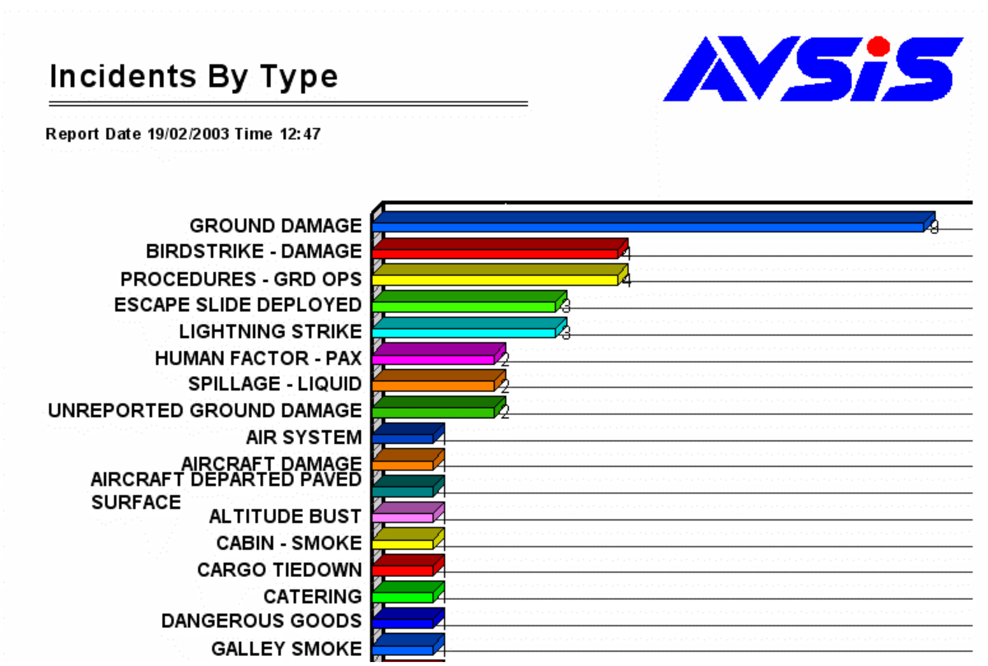


Figure 3

By double clicking on the relevant bar (e.g. the red bar next to Birdstrike - Damage), the Flight Safety Officer (FSO) can drill down and view the relevant events in detail. In this instance, all the events categorized as birdstrike damage would be listed in detail, as shown in Figure 4. It is then easy to review these and look for common threads between them, such as whether a high number of birdstrikes occur at one airport, or at a certain time of day.

Incidents By Type

AVSiS

Total Incidents 54 **Page 1 of 1**

Total BIRDSTRIKE - DAMAGE Incidents 4

Reference :	043	**Status :**	Open	**Severity :**	1	**Flight :**	156
Date :	11/Oct/2000	**Time :**	10:20			**Reg :**	AS111
Incident :	BIRDSTRIKE - DAMAGE					**A/C Type :**	737
Owner :						**A/C Model :**	
Location :	Unknown					**Serial :**	500
Risk :	Stage 1 - Possible injury and/or aircraft damage.					**Phase :**	GROUND
Description :	Evidence of birdstrike found on arrival LHR						
Cause :	Under investigation						

Reference :	044	**Status :**	Open	**Severity :**	5	**Flight :**	7972
Date :	12/Oct/2000	**Time :**	12:15			**Reg :**	AS321
Incident :	BIRDSTRIKE - DAMAGE					**A/C Type :**	737
Owner :						**A/C Model :**	400
Location :	Embessa					**Serial :**	1234
Risk :	Stage 1 - Possible injury and/or aircraft damage.					**Phase :**	TAKE-OFF
Description :	Birdstrike on 1st Officers windscreen						
Cause :	Under investigation						

Figure 4

Without a computerized system such as this, which the safety officer can easily view and manipulate, it would take a long time to go through the paper reports looking for similar events. The speed and simplicity of the system enables the FSO to spot trends quickly and focus on seeing that action is taken. Similarly, the FSO could drill down to view the ground damage events; and see whether they mainly happen at one or two airfields.

Figure 5 shows the AVSiS Query Builder. All the fields in the system are listed down the left hand side. The options selected in Figure 5 will filter the reports to show those events that have occurred in the last six months.

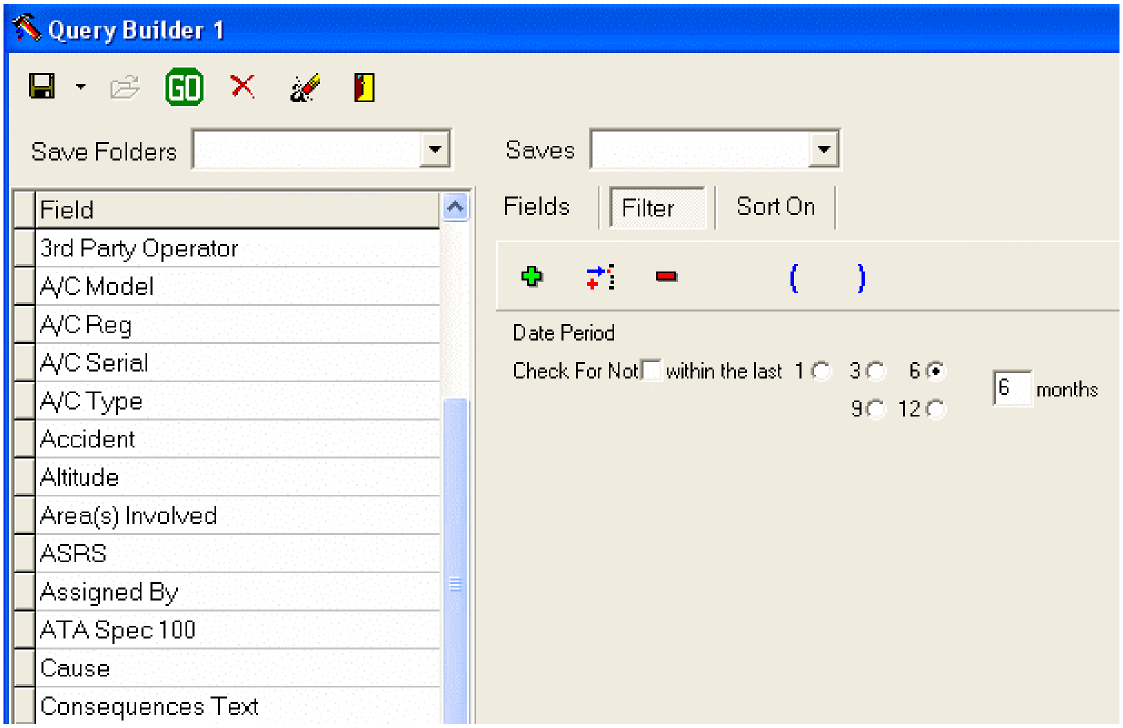
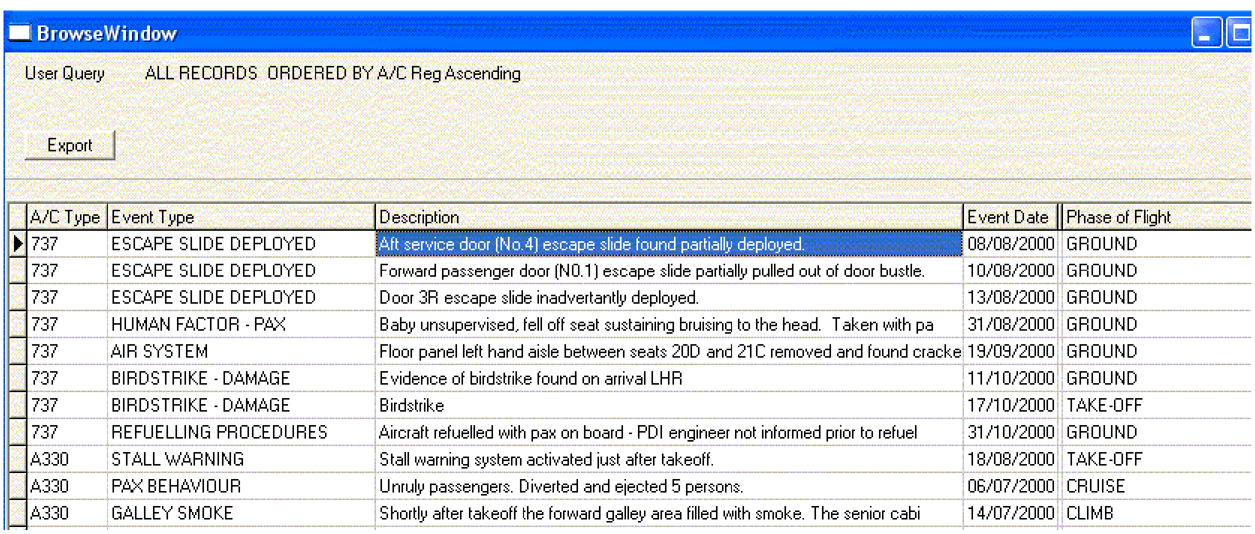


Figure 5

Once the user has made the desired selections, clicking on GO causes the query to be processed and the results displayed, as shown in Figure 6.



A/C Type	Event Type	Description	Event Date	Phase of Flight
737	ESCAPE SLIDE DEPLOYED	Aft service door (No.4) escape slide found partially deployed.	08/08/2000	GROUND
737	ESCAPE SLIDE DEPLOYED	Forward passenger door (N0.1) escape slide partially pulled out of door bustle.	10/08/2000	GROUND
737	ESCAPE SLIDE DEPLOYED	Door 3R escape slide inadvertantly deployed.	13/08/2000	GROUND
737	HUMAN FACTOR - PAX	Baby unsupervised, fell off seat sustaining bruising to the head. Taken with pa	31/08/2000	GROUND
737	AIR SYSTEM	Floor panel left hand aisle between seats 20D and 21C removed and found cracke	19/09/2000	GROUND
737	BIRDSTRIKE - DAMAGE	Evidence of birdstrike found on arrival LHR	11/10/2000	GROUND
737	BIRDSTRIKE - DAMAGE	Birdstrike	17/10/2000	TAKE-OFF
737	REFUELLING PROCEDURES	Aircraft refuelled with pax on board - PDI engineer not informed prior to refuel	31/10/2000	GROUND
A330	STALL WARNING	Stall warning system activated just after takeoff.	18/08/2000	TAKE-OFF
A330	PAX BEHAVIOUR	Unruly passengers. Diverted and ejected 5 persons.	06/07/2000	CRUISE
A330	GALLEY SMOKE	Shortly after takeoff the forward galley area filled with smoke. The senior cabi	14/07/2000	CLIMB

Figure 6

The data for the selected records shown on the screen can be exported to create graphs or charts in other programs.

If the database had a large number of birdstrike events, the data mining tools could be used to examine the underlying data in more detail. The Find Similar tool could be used to identify events with similar characteristics, such as location, time, speed or altitude, and rank them in order with the most similar events first. The Correlations tool could be used to explore whether birdstrike events are happening more often at particular airports, or only happening in the late evening at a particular time of year. The Discrepancies tool could be used to investigate whether there appears to be an unusual number of events are one location, or during a particular time period. This can help the FSO identify situations where a birdstrike event is more likely to occur and develop preventative actions to reduce future risks.

A.3 HeliStat©

1 Introduction

1.1 OVERVIEW OF THE TOOL FUNCTIONALITY

HeliStat© is a new on-line early warning system designed for use with Helicopter Association International's Maintenance Malfunction Information Report (MMIR) sharing system. MMIR is a shared data system to which helicopter operators report mechanical problems detected during maintenance, and may file Service Difficulty Reports (SDR), Mechanical Interruption Summary Reports (MIS), and warranty claims electronically. HeliStat© allows subscribers to quickly and easily analyze and graph MMIR data, compare their helicopter models to industry norms, and identify potential problems through data analysis. Although not all operators report their mechanical problems affecting helicopter safety to MMIR, when combined with the HeliStat© analytical software, MMIR becomes a unique and valuable source of information to answer the following questions:

- How frequent are these problems per 1,000 aircraft per year? How does one model compare with the rest of the fleet? (Benchmarks)
- What are the most frequent problems reported for a specific model? ("Top Ten" analyses)
- Are there system wide trends over time?
- Parts List related issues:
  - Has the mechanical problem happened before and how often?
  - What new and serious problems are being reported now?
  - What persisting, serious problems are being reported now?
  - What lessons can be learned?

HeliStat© is an analytical tool through which users can quickly and easily use MMIR data on-line. Near-real-time analysis identifies potential problems or gives an early alert of troubling statistical trends. This is achieved by using the state-of-the-art HeliStat© software. HeliStat© adapts to the data source rather than having to adapt the data source to the application. No data formatting or cleansing are required and operator confidentiality is maintained. It should be emphasized that while industry aggregate data is available to all HeliStat© subscribers, specific company data is restricted to the contributing subscriber. This same rule applies to all MMIR users. HeliStat© uses the latest data posted on the MMIR web site.

HeliStat© uses MMIR data not only for assessing reliability, but also for enhancing safety and quality. HeliStat© makes the statistical analyses more readily available (in graph form) for further review by maintenance specialists. It red flags (brings to attention) specific areas warranting further attention.

However, HeliStat© does not end with data analysis. Accurate, detailed, professional graphs can be output and downloaded to the user's desktop in seconds. HeliStat© combines MMIR data with new sophisticated analytical and graphing software, to enable the user to run complex data analysis programs, and download the output in report graph format with the click of a mouse button in near-real-time.

Like any statistical analysis, the size of the fleet and the number of reports affect the reliability of the statistical results. Some analyses are more reliable when larger operators or manufacturers make internal comparisons.

HeliStat© is an advanced analytical on-line software program designed to be easy to use. It is entirely menu driven and its intuitive, user-friendly design allows the user to quickly and easily undertake complex statistical analysis, and download the results. The HeliStat© analytical and output system is available on a subscription basis through the HeliStat© web site, no further programming or extensive training is required. The process is designed to be intuitive, accurate, effective and fast. The software enables users to use their time efficiently in identifying potential problems, preparing graphic reports and fulfilling the requirements for documenting activities.

HeliStat© uses system-wide benchmarks to identify areas where significant changes can and should be made. HeliStat© users get a structured process for identifying factors that could ultimately lead to an accident/incident. HeliStat© can be the analytic component of a Risk/Safety Management System which identifies potential problems, suggests priorities, tracks changes in their frequency and monitors whether program changes are effective.

1.2 INTRODUCTION TO THE EXAMPLE APPLICATION

The data used in this example are real but the operator has been deidentified and the narrative fictionalized.

Operator XYZ has recently acquired two Heli001 helicopters and a new Quality, Reliability, Safety (QRS) Officer. Maintenance, having seen previous Airworthiness Directives concerning the Tail Rotor Drive Shaft, asks the QRS Officer whether the experience of other operators indicates that there is justification to give this component particular attention.

2 Input Data

Operator XYZ has a subscription to HeliStat©, which the QRS Officer uses to access the MMIR data and respond to the question from Maintenance. The QRS Officer logs on to HeliStat© and selects the BENCHMARK option to generate a comparison between the report rates for the Heli001 model and benchmark system-wide report rates for all models. (The comparisons can be adjusted for non-reporting operators). This displays the menu shown in Figure 1, which the QRS Officer uses to specify the dataset, manufacturer, model, variable to be graphed, and severity.

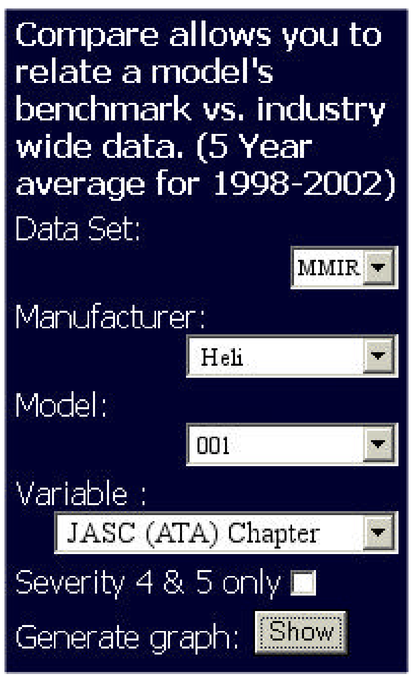


Figure 1

The QRS Officer then selects the SHOW button to generate a graphical display of the comparative report rates.

3 Analytical Process and Tool Output

HeliStat© generates the graph shown in Figure 2, which compares report rates for the Heli001 model with system-wide benchmarks. The scale shows the relative variation of the Heli001 rate with the system-wide rate for all other models. Report rates for tail rotor drive shaft are higher (3394%) for Heli001s than for other models. The QRS Officer notes that the Heli001 also has above average report rates for other components.

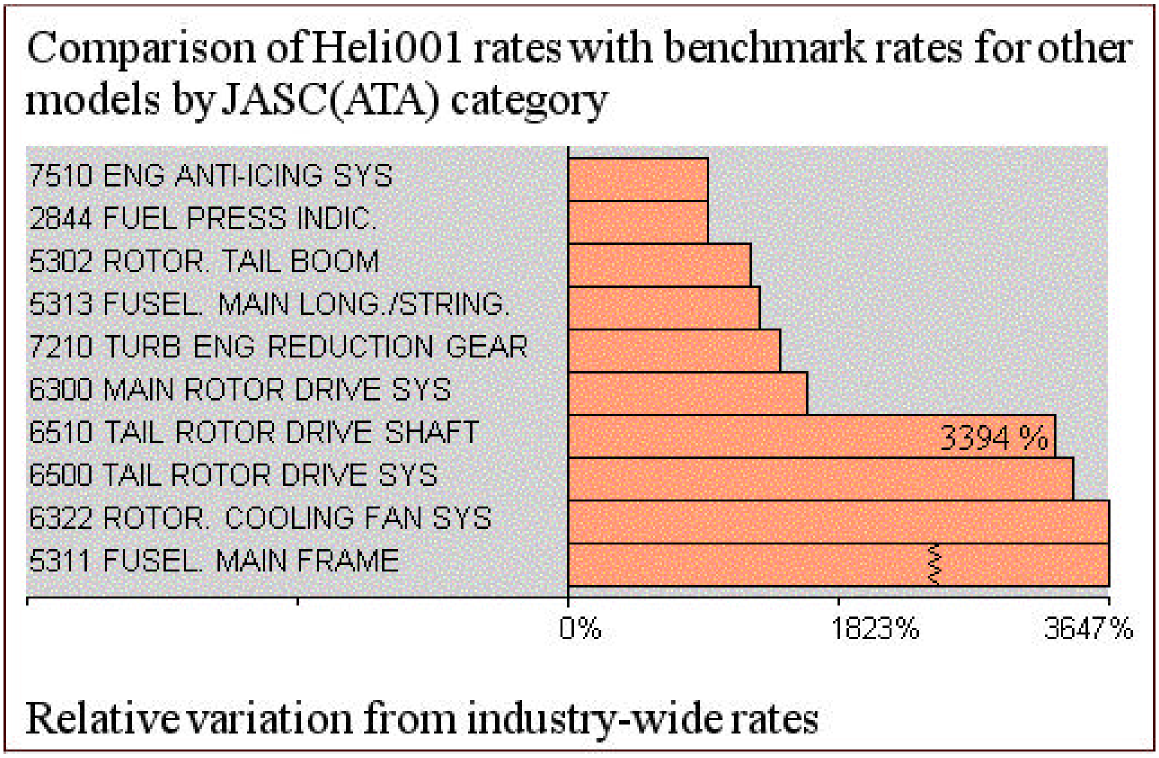


Figure 2

In order to explore the issue in more detail the QRS Officer uses HeliStat© to perform the following three analyses:

1. “Top ten” analysis that focuses on the 10 most frequent items within the category selected. The Pareto principle states that, in many cases, relatively few types of problems produce the majority of reports.
2. Trending analysis. This graph shows whether the number of reports have changed over time. Since the monthly number of reports may be sparse, the analysis shows the total number of reports over the previous 12 months.
3. Parts listings. This tabulation has 9 columns showing part number and name, Joint Aviation Statistical Code (JASC-ATA) name and number, FAA severity code (likelihood of being associated with an incident or accident), number of reports, aircraft model, dates of earliest and latest reports. The user can change the sequence in which the rows are displayed by selecting any of the 10 columns for sorting.

The first of these three HeliStat© analyses generates the chart shown in Figure 3, which shows the top ten models with tail rotor drive shaft problems. These problems predominate in Heli 001s in comparison to other models.

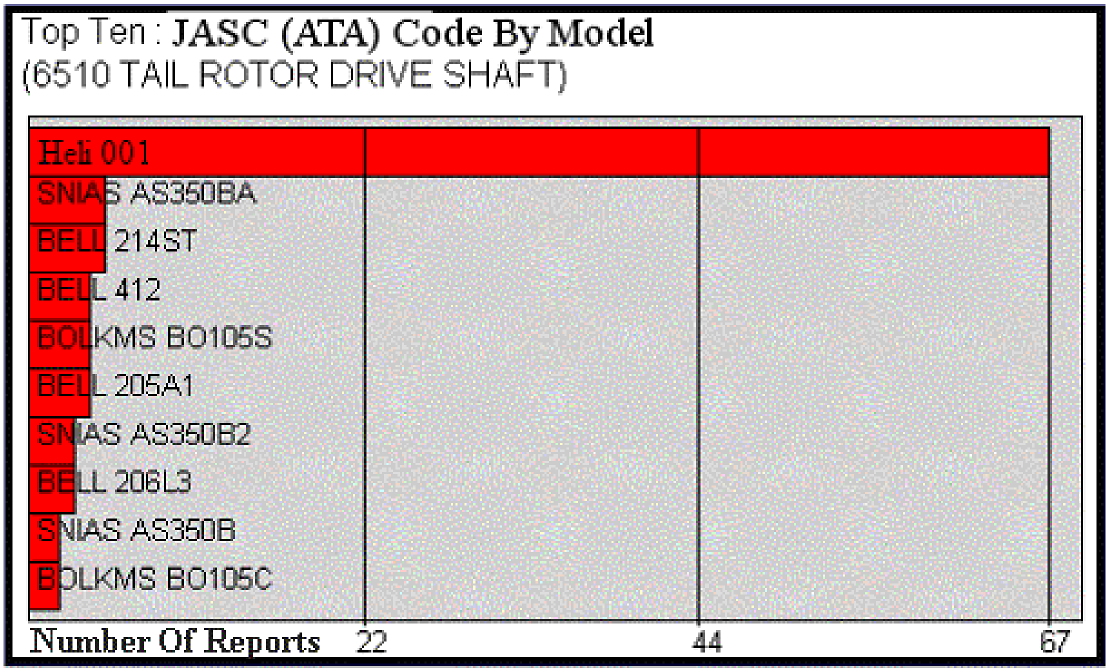


Figure 3

The second of the more detailed analyses generates the chart shown in Figure 4, which shows the moving total for tail rotor drive shaft problems in Heli001s. Each point shows the total number of reports over the previous 12 months. There has been a recent decrease in the number of reports since the peak in May 2002. The enlarged points indicate that the value for that date is more than 20% higher than 12 months earlier.

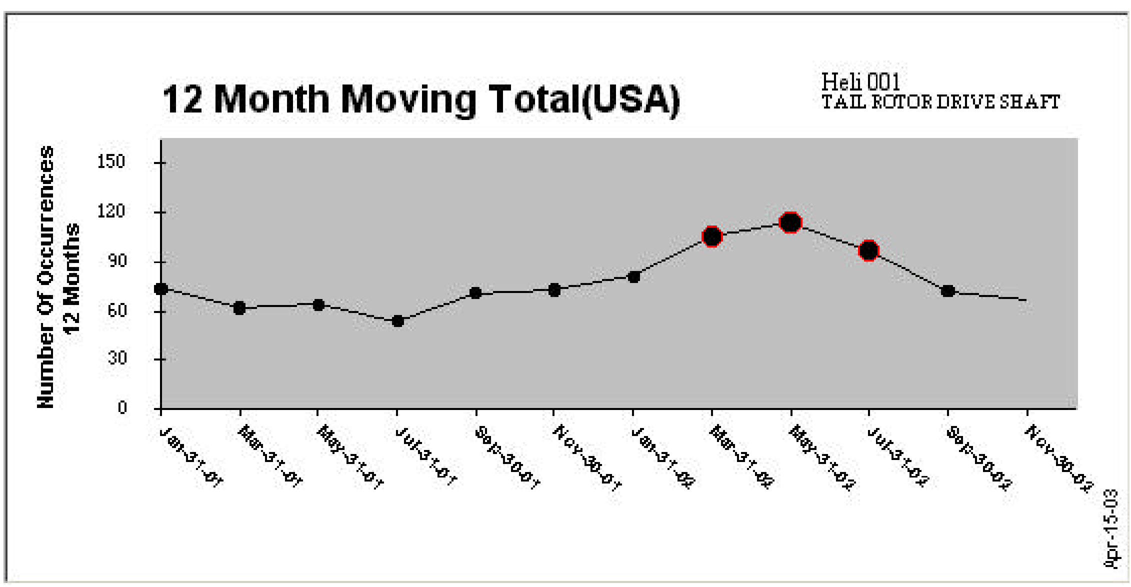


Figure 4

Finally, the QRS Officer uses HeliStat© to generate the detailed list of reports by part number for Heli001s shown in Figure 5. The rows are ranked by number of reports in ascending order. Six of the 12 most frequent reports are for tail rotor drive shaft parts. In terms of recency, reports were received for tail rotor drive shaft "Housing" and "Disc Pack" during December 2002, the latest month for the dataset.

Part Number	Part Name	ATA	SEV	ATA (JASC) Name	SDR #	Model	Earliest	Latest
001375006101	INDICATOR	2841	2	FUEL QUANTITY INDIC.	17	001	1998-02-09	2002-02-25
001061432121	HOUSING	6322	3	ROTOR. COOLING FAN SYS	19	001	1999-02-10	2001-04-12
001340339103	BEARING	6300	4	MAIN ROTOR DRIVE SYS	19	001	1999-05-19	2002-02-26
001375003107	INDICATOR	7712	1	ENG BMEP/TORQUE INDIC.	19	001	1998-02-02	2002-08-30
001063001101	EXHAUST STACK	7810	3	ENG COLLECT./TAILPIPE/NOZZ	21	001	1998-02-02	2002-06-27
001373901103	SOLENOID VALVE	3212	2	EMERG FLOTATION SECT.	22	001	1999-05-24	2002-06-27
	BRUSHES	2435	2	STARTER-GENERATOR	24	001	2001-04-03	2002-06-26
001310203101	MOUNT	6420	5	TAIL ROTOR HEAD	24	001	1999-02-09	2002-06-27
001362005103	SWITCH	2840	2	ACFT FUEL INDIC.	24	001	1999-03-29	2002-05-15
001050247138	COVER	3212	2	EMERG FLOTATION SECT.	25	001	1998-05-22	2002-06-26
001310405101	UNIVERSAL	6710	5	MAIN ROTOR CONT.	25	001	1999-05-24	2002-06-27
001340340103	DISC PACK	6510	5	TAIL ROTOR DRIVE SHAFT	25	001	2001-08-20	2002-12-11
001015001117	BLADE	6210	5	MAIN ROTOR BLADES	27	001	1999-03-05	2002-12-13
001073905001	GAUGE	3212	2	EMERG FLOTATION SECT.	29	001	1998-04-29	2002-06-26
001050247135	COVER	3212	2	EMERG FLOTATION SECT.	33	001	1998-05-22	2002-06-26
001040340101	DISC PACK	6510	5	TAIL ROTOR DRIVE SHAFT	33	001	1998-05-10	2001-07-14
001312100101	BEARING	6420	5	TAIL ROTOR HEAD	39	001	1998-04-06	2002-12-11
001061432121	HOUSING	6510	5	TAIL ROTOR DRIVE SHAFT	41	001	1999-01-15	2002-12-06
001040340101	DISK COUPLING	6510	5	TAIL ROTOR DRIVE SHAFT	44	001	1998-01-09	1999-01-15
001310405101	UNIVERSAL	6300	4	MAIN ROTOR DRIVE SYS	47	001	1998-05-22	2002-12-11
001312103101	LINK	6720	5	TAIL ROTOR CONT. SYS	53	001	1998-04-30	2002-06-10
001340340101	DISC PACK	6510	5	TAIL ROTOR DRIVE SHAFT	69	001	1999-06-13	2002-05-23
001340339103	BEARING	6510	5	TAIL ROTOR DRIVE SHAFT	70	001	1999-05-24	2002-03-14

Figure 5

4 Application of the Results of Analysis

The QRS Officer takes these outputs to the Maintenance Chief, explains the graphs and discusses what steps should be taken to revise inspection schedules and procedures, as well as the need for additional analyses to address similar types of questions involving quality, reliability or safety.

A.4 Microsoft Excel

1 Introduction

1.1 OVERVIEW OF THE TOOL FUNCTIONALITY

Excel is a flexible too which can be used for many purposes and in many different ways. A brief overview of the general functionality of the software is provided earlier in this Guide in Section 3.2. Since most readers will already be familiar with the general use and capabilities of the software, this will not be repeated here. However, some more advanced features, which readers may not have used before, are discussed in the example application below.

1.2 INTRODUCTION TO THE EXAMPLE APPLICATION

This example illustrates one potential use of Excel for safety analysis in an airline environment.

In a very small-scale flight operation it may be possible to perform the safety analysis using only paper reports and no formal analysis software, at least for some time. On the other hand, in a large operation, this is impractical and special-purpose data management and analysis tools become necessary. In between the two situations, a fairly simple approach using general-purpose software, like the one described here, may provide the transition from a manual system to a more advanced tool. The aim of this example is to show how some Excel functions can be used to make the data management and analysis task significantly more efficient and reliable than when done manually. Most organizations already have Excel (or a similar tool), which means that there is no extra cost in starting to use it more efficiently.

In the example, the airline has collected data on safety related events, and is inputting the data to an Excel table. We will follow, step-by-step, how Excel can be used at the different stages of the analysis process: data input, analysis, output, and application of the results. The example does not by any means try to be exhaustive in demonstrating Excel functions; the idea is to show some examples and to encourage the reader to discover more.

2 Input Data

It is assumed that the flight safety office receives the source reports (e.g. Air Safety Reports) on paper. The criteria for filing a report have been specified by the airline (and the aviation authority, as some of these reports may require Mandatory Occurrence Reporting to the authority). The responsibility of the flight safety office (and the Flight Safety Manager in particular) is to ensure that all reports are correctly processed, all concerns in them are addressed and all necessary corrective actions take place.

This requires two different analysis processes to be run in parallel: a case-by-case analysis to analyze all significant reports one by one, and another process to treat all the reports together for identifying any worrying patterns, e.g. problem airports.

In this example, the airline is collecting Air Safety Reports (ASRs), which all have a reference number in the format “nn/yy/ttt” where nn is a running number, yy is the year and ttt is the aircraft type. The reports come from different departments of the airline. The data need to be analyzed both case-by-case and with a longer-term cumulative perspective.

In order to provide a means to identify similar situation in the data, it is common practice to define a set of common keywords or descriptors. The keywords or descriptors can be very detailed items or rough categories, also depending on the quantity of the data and the chosen analysis method. They usually evolve in time, making it necessary to make updating them easy. In this example, the airline is using quite broad descriptors (like “crew meals quality” or “navigation database”) and also inputs the flight phases during which the event was caused and took effect. For case-by-case investigation and follow-up, the airline needs to assign a responsible person for each event (i.e. report) and track the status of the investigation and agreed actions.

Data input should be fast, easy and reliable. A typical tabular display of the ASR data is presented in Figure 1.

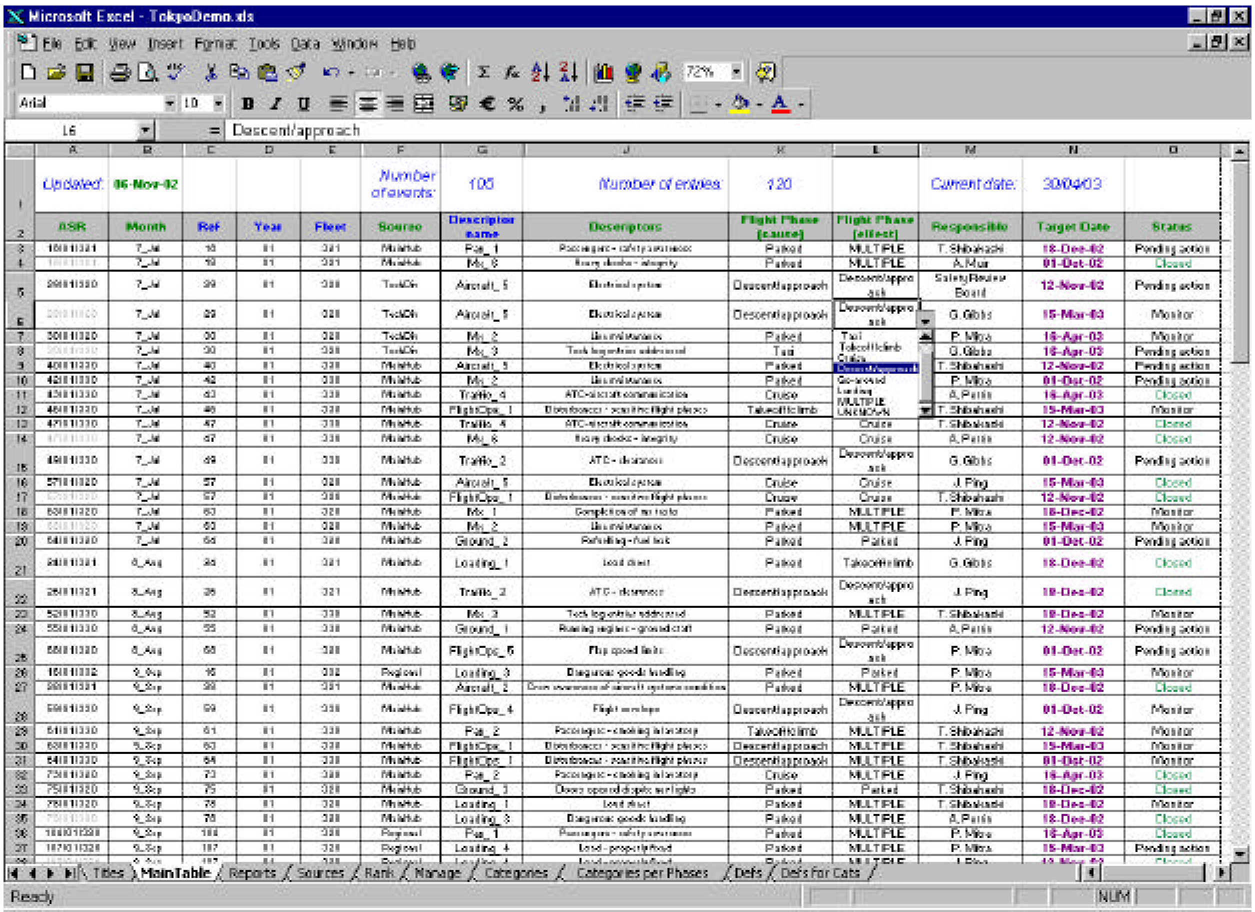


Figure 1 **Air Safety Report Data Table Showing a Drop-down Menu**

The data table shown in Figure 1 has been created using the following Excel features:

- Drop-down menus ensure fast and reliable entry for columns “month”, “source”, “descriptors”, “flight phase”, “responsible” and “status”. In screenshot 1, the user is filling in the “flight phase” cell by picking “descent/approach” from the drop-down menu.
- The “descriptor name” is filled automatically by Excel based on the entry in the respective “descriptors” column (using the VLOOKUP command and the lists on a separate worksheet).

The database should contain all the information in such a format that the database can also be used for effective long-term analysis. One of the requirements is sorting the database in different ways. Sorting by aircraft type, event date or year would be difficult because the relevant information is embedded in the reference and not initially in its own column. To solve this, the reference number is automatically split into three respective columns. For example, the top row for these three columns contains the following formulas for extracting the corrects parts of the reference number:

- =VALUE(LEFT(A3,FIND("/",A3)-1))
- =MID(A3,FIND("/",A3)+1,2)
- =RIGHT(A3,3)

All the options for the drop-down menus are specified on a separate worksheet which makes updating them easy (see Figure 2). The drop-down menus have been created using the command DATA/VALIDATION/ALLOW LIST and the lists have been defined on the separate worksheet using the INSERT/NAME/DEFINE command.

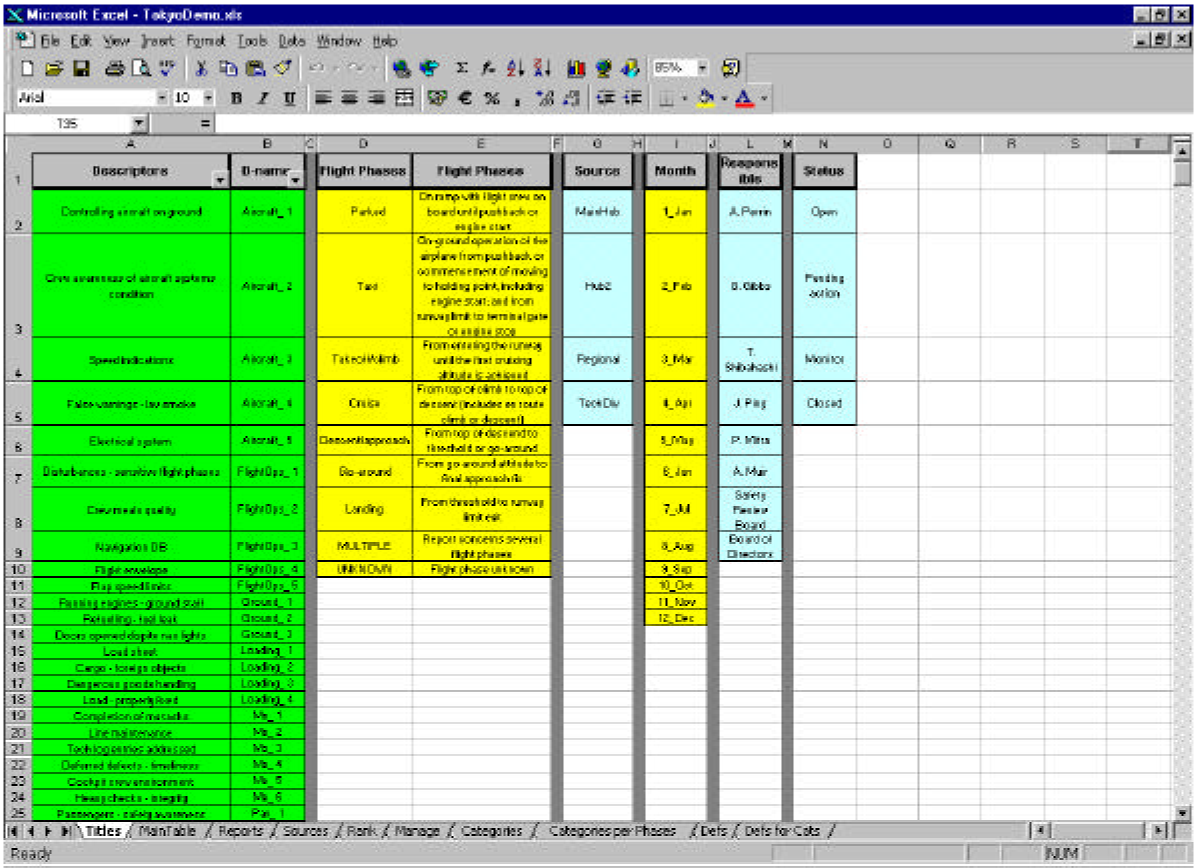


Figure 2 **Definition of Lists for the Drop-down Menus on a Separate Worksheet**

Additional features can be added to help data entry and spotting errors. In the example table, the same event may be entered several times to allow specifying different descriptors to the same event. To help visualize when the same report is repeated on two consecutive rows, the reference number on the second line will turn gray. Similarly, to help managing the data, target dates which have been passed turn violet and all closed items turn green. These features have been created with the CONDITIONAL FORMATTING function.

3 Analytical Process

The example table supports both case-by-case and long-term analysis.

3.1 CASE-BY-CASE ANALYSIS

The case-by-case analysis is in practice a technical investigation with several contributing experts from different parts of the airline, coordinated by a nominated responsible person. The process is straightforward but may take some time, and the challenge for the Flight Safety Manager is to monitor the progress.

The data table supports this process through the last three columns. These allow the user to specify <u>who</u> is in charge of the analysis (investigation), what is the <u>agreed target date</u> for closing, and what is the <u>status</u> of the investigation today. The user can either scan through the main table to check the status of specific reports, or use a dedicated monitoring table on a separate worksheet to get an overall picture of investigations (see Figure 3).

FOLLOW-UP OF ACTIONS PER RESPONSIBLE

Count of Month	Status				
Responsible	Closed	Monitor	Open	Pending action	Grand Total
A. Muir	2				2
A. Perrin	8	1		1	10
Board of Directors	1	1			2
G. Gibbs	9	5		7	21
J. Ping	18	7		2	27
P. Mitra	16	10		7	33
Safety Review Board	1			1	2
T. Shibahashi	8	10	1	4	23
Grand Total	63	34	1	22	120

To see related reports, double-click on numbers

Figure 3 **A Pivot-table for Monitoring Progress on Case-by-case Analyses**

The table has been created using the PIVOT TABLE command, and it has the advantage that clicking on any cell in the table will automatically create a new worksheet listing the events in question. For example, clicking on the cell “pending action” of “T.Shibahashi” containing the number “4” would create a worksheet listing the 4 reports pending action, for which T.Shibahashi is responsible (see Figure 4). This function is available for all pivot tables created with Excel.

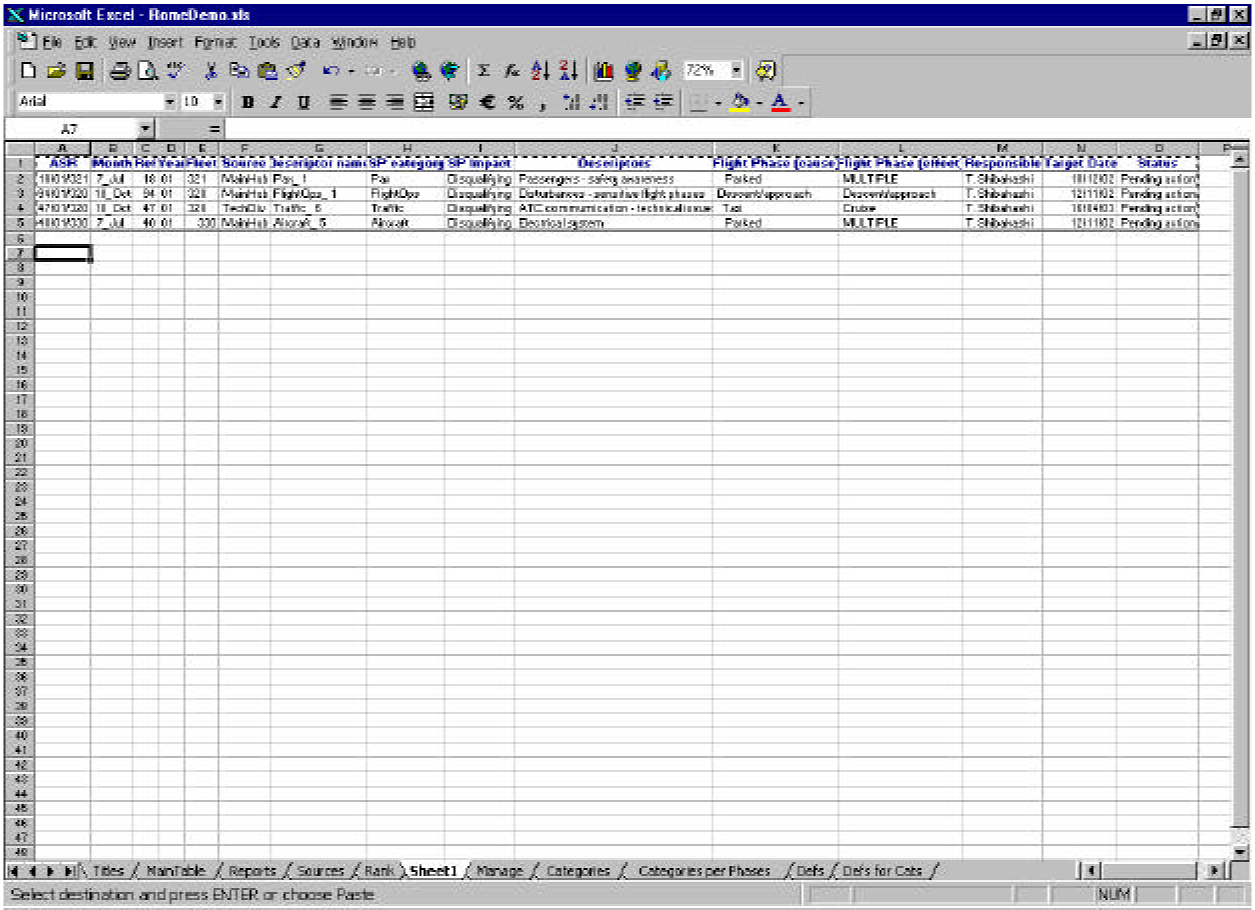


Figure 4 **Drill-down to One Cell in the Action Monitoring Table**

3.2 LONG-TERM ANALYSIS

Classically, the long-term analysis involves the flight safety manager directly. He/she has to use different sorting and visualization techniques to try to identify similarities between events, or other interesting matters in the safety data. This is hardly possible in a paper-based system. Usually this analysis is based on keywords or other descriptors, which is also the case in our example.

The descriptors can be used in combination with the basic event data (month, phase of flight, a/c type) to create useful tables and charts for making the analysis. First approach is to create a table where issues are ranked based on number of reports per descriptor, sorting the list from the highest count to the lowest. Another way is to follow the number of events per descriptor each month, visualizing a monthly trend.

Figure 5 shows a chart constructed by combining the information about the descriptor category and the flight phase. Excel offers many options for visualizing the data this way and the options to use depend on the exact needs of the analyst.

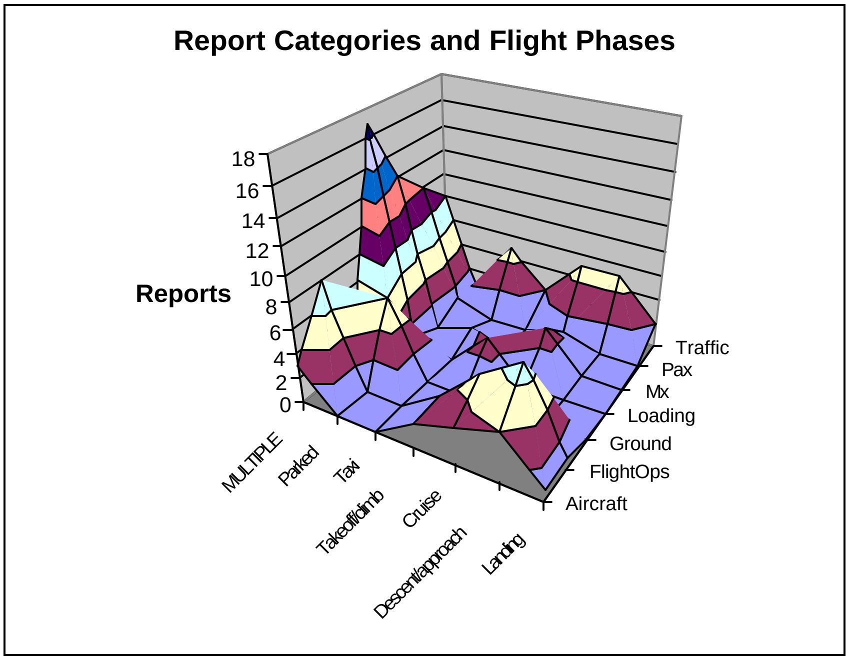


Figure 5 **Analysis by Combining Different Data Fields**

Data can also be analyzed simply by studying the main data table with the help of the DATA/FILTER/AUTO FILTER command. This function allows the user to specify a filtering criterion for each column and show only rows (events) which fulfill all filtering criteria. An important difference between analysis using the auto-filter and using the pivot tables is that the auto-filtering is a one-time action leaving no trace for later consulting (unless manually carried out each time) whereas the pivot table is a permanent source, and can be specified to update itself automatically each time the file is opened.

4 Tool Output

The tool can be considered to have two kinds of outputs. The most valuable output are the different tables and chart which can be used for analyzing the data. The second kind of output are the charts and tables which are used in safety reporting and communication.

All these outputs can be specified using all the versatile graphical functions of Excel; for example bar charts, pie charts, 3D charts and graphs. It is also possible to automate the creation of regular safety reports/communications to a high degree, by creating the analytical elements with Excel pivot tables and then inserting them to a ready template using a specific Excel MACRO. This only leaves the analyst the task of commenting the results. In fact, Excel is so flexible, that many people use it for presenting results from other safety tools.

Typically, a safety communication would include a set of standard charts and tables (usually showing some parameters as a function of the time period). These would then be commented by the analyst. Occasionally some issue could be highlighted with the help of additional charts, graphs or tables. It may be necessary to create several different (standard) safety communic ation reports addressing the different needs: management, operational units, and aviation authorities.

5 Application of the Analysis Results

The analysis results often point to some actions which are considered necessary for maintaining an acceptable safety level. The timely implementation and effectiveness of the measures can then be followed using the same database: the former through the "status" column, or the latter by ensuring that similar events do not re-occur at an unacceptable frequency.

A.5 FlightTracer

1 Introduction

1.1 OVERVIEW OF THE TOOL FUNCTIONALITY

Flight Tracer is an affordable application designed to display a recorded flight, through 3D animation and simulation of the aircraft and flight deck. It is primarily for use within a Flight Operational Quality Assurance (FOQA) program, Advanced Qualification Program (AQP), or Flight Data Monitoring Program (FDM).

Data is recorded by required equipment such as a DFDR (Digital Flight Data Recorders), FDR (Flight Data Recorders using magnetic recording media), QAR (Quick Access Recorders using removable storage media such as PCMCIA cards or optical disks) or more recently wireless telemetry. The data must be transferred and translated into useable form. The intermediary software for this task is the GDRAS (Ground Data Replay and Analysis System). The translation converts the data from binary formats such as ARINC 429, 573, 717 into engineering unit-based values. The GDRAS isolates sections of the data, based on exceedance criteria, then exports to a text file for further analysis.

Some of the functionality commonly associated with the GDRAS is incorporated into Flight Tracer. Graphing of all parameters and grouping is supplied. In addition, there is a search function that allows easy location of critical points in the data.

1.2 INTRODUCTION TO THE EXAMPLE APPLICATION

This report will examine an engine failure in a DHC8 aircraft in cruise at 14000 feet, 20 min from Pittsburgh International Airport (KPIT). This is demonstrated in the context of an instructional display within a debriefing or later training sessions. In the case of an engine failure, a debriefing would be mandatory.

2 Input Data

The top section of the data file for the example application is shown below (with any possible identification removed or altered).

TITLE: Sample Data READOUT NO.: 5
DHC 8200, RECORDER TYPE : dar DATE MOUNTED: 01JAN02 PRINT DATE: 01JAN02
A/C REG.: C_XXXX REC/CASSETTE NO.: 1014 DATE REMOVED: 01JAN03
ACMS OPERATOR: PROFILE USED: 1221 _ APPR FAST, 1000_500 RATE: 1 SEC FRAME: 2356

ALT	ATTpitch	ATTroll	HDG	IAS	ENG1nh	ENG2nh	ENG1ff
FEET	DEG	DEG	DEG	KTS	%RPM	%RPM	
8960	8.09	0.7	243.6	158	94	94.3	121
8992	8.09	0.44	243.6	157.5	94.2	94.4	121
9024	7.95	0.09	243.6	157	94.4	94.6	122
9056	7.78	-0.18	243.3	157	94.3	94.5	122
9056	7.56	-0.53	243.3	157	94.5	94.6	122
9088	7.38	-0.79	242.9	157	94.7	94.9	122
9120	7.25	-1.23	242.6	157	94.8	95	122
9152	7.12	-1.76	242.6	157.5	94.8	95	121
9152	7.03	-2.11	242.2	157.5	94.8	94.9	122

In general, the columns can be in any order and the parameters can vary according to the make of aircraft, FDR specifications and any filtering previous to export.

3 Analytical Process

An analysis of this engine failure is begun by loading and viewing the data. Anomaly removal and data smoothing techniques are used that render the flight more fluid and improve the consistency of the data. Data is displayed as a set of graphs and 3D view, and combined with navaid, ILS and runway data. Geographic details are added, such as topography or waypoints in the locality of the flight, as shown in Figure 1.

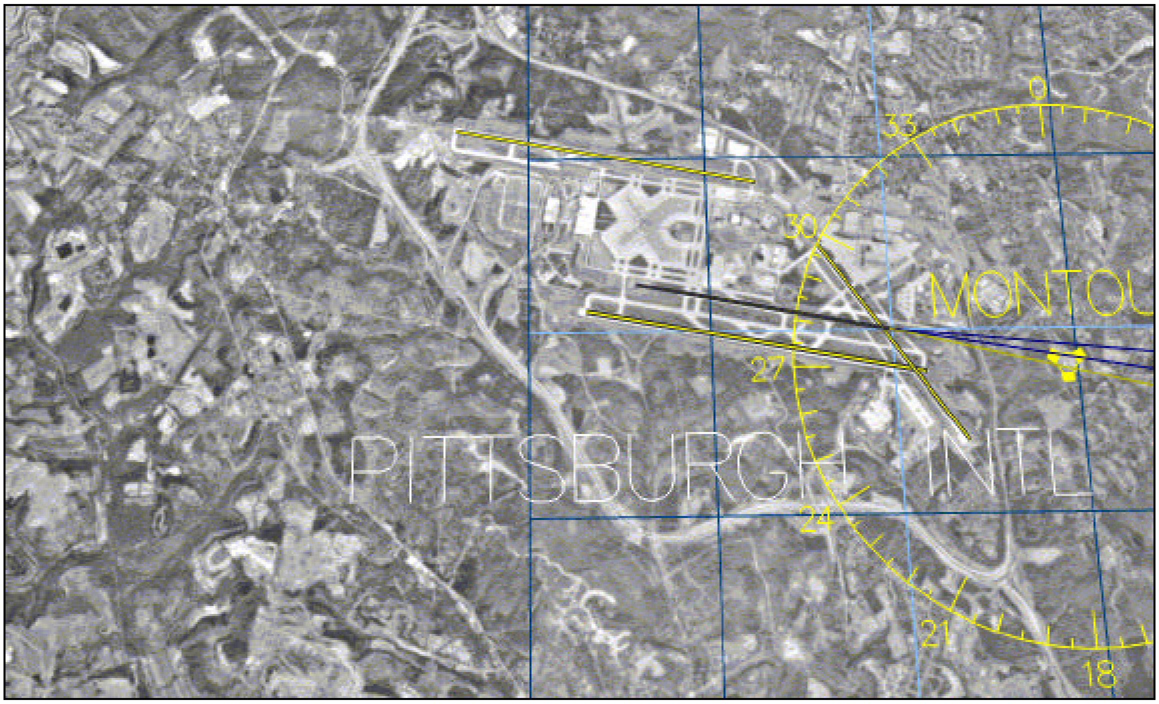


Figure 1 **Overhead View of KPIT and Navaids**

The parameters are also displayed in the form of a flight deck of a DHC8, as shown in Figure 2. Thus, the practiced aviator can easily absorb and understand the sequence of events in a familiar context.

The sequence of events can be seen or inferred by observing the playback. The following is a description of the events as observed through the animation. The failure is evidenced by an almost instant decrease in NH and torque in engine #1. The crew quickly identified the failure, revealed by an increase in drift angles that appear to be compensated for within seconds. It was observed that the yoke (ailerons) was used to correct the yaw instead of the use of the rudder. In the context of the animation this is immediately apparent.

RPM increases somewhat, due to loss of drag due to engine parts as the propeller windmills. Airspeed decreases, levels off, and then recovers to a degree, as power is increased, indicated by an increase in torque and in the remaining engine. Approximately one minute later, propeller RPM values drop to nil, indicating feathering of the propellers. After this, the crew descends to 3000 ft, until entering final approach.

4 Tool Output

The tool's primary output is the animation that is displayed to the monitor. This can be captured as an AVI movie file and included in electronic presentation such as a PowerPoint file or displayed with the Windows animation viewer. In addition, the configuration, as well as the flight data, can be saved, loaded, and then replayed at a future time within the Flight Tracer software.

The screen capture shown in Figure 2 displays the turning of the yoke after the engine failure.

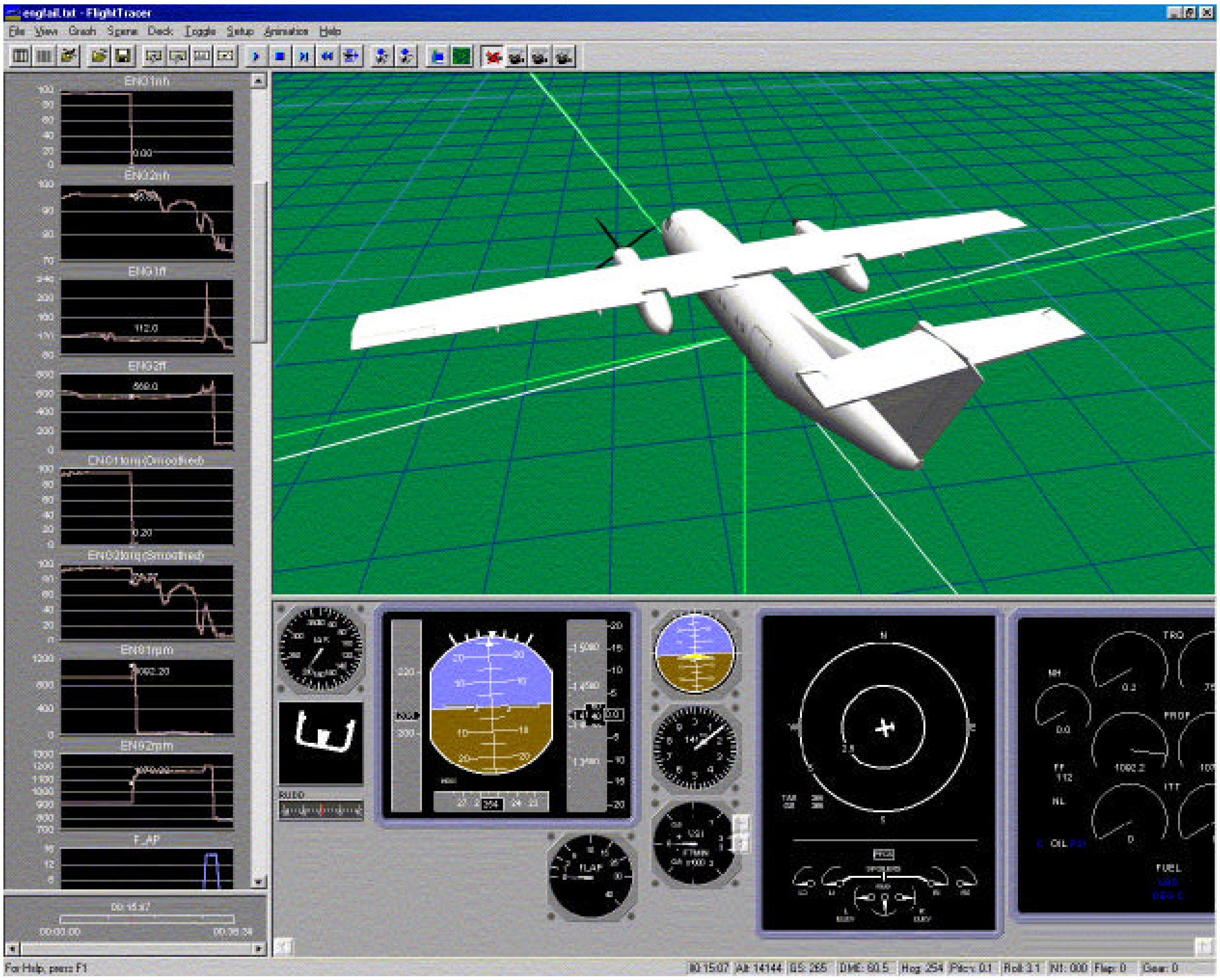


Figure 2 **Screen Capture, after Engine #1 Failure**

Localizer and glideslope deviation parameter data are absent in this case. However, in these cases, the flight trace can be observed visually relative to the glideslope. Thus, the flight can be gauged for proper approach procedures in the absence of ILS parameter data. This examination revealed that during approach, the flight path had very little lateral deviation from the glideslope. There were no signs of a short landing. This can be observed from the glidepath flight trace shown in Figure 3.

Normally during descent, the engines would not be providing thrust to any large degree, therefore the effect of one engine inoperative would be less noticeable than in cruise or during takeoff. This may be used as an instructive point.

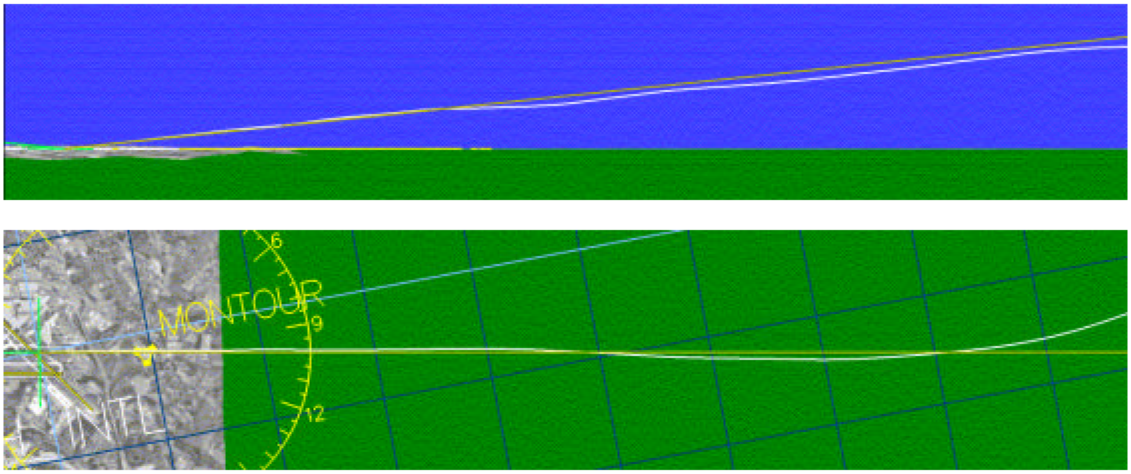


Figure 3 **Side and Top Views of the Flight Trace**
(Centerline of the Glidepath Beam shown in Yellow, with the Flight Trace in White)

Rollout distances can be easily obtained using a combination of graphics and analytical functions. Because the parameters are assembled into one flight trace, the starting and stopping points - which require the observation of pitch, ground speed, altitude, proximity to the runway and taxiways - can be determined. This can be transferred to a debriefing situation for display to flight crews or other interested parties.

Critical points, such as the touchdown, can be examined in detail frame by frame, as shown in Figure 4. Observation of the sequence of frames for this case shows that the touchdown was wobbly, but without incident.

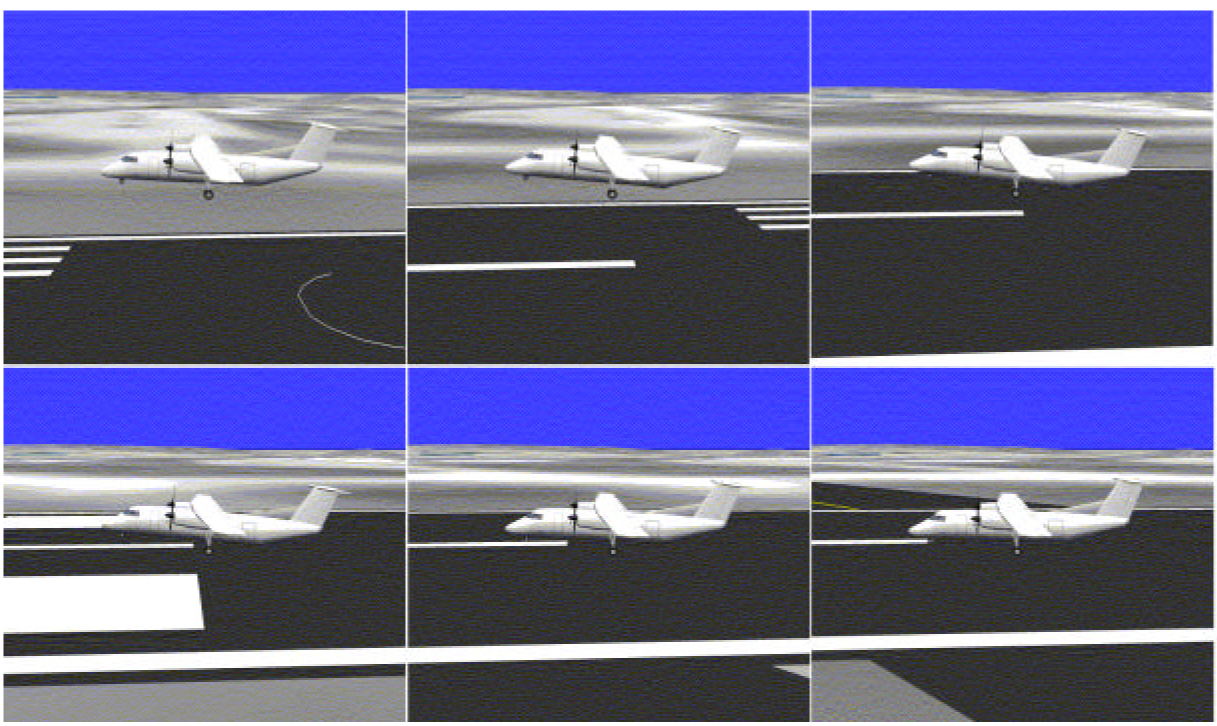


Figure 4 **Six Capture Frames at 1-second Interval, Showing the Touchdown**

5 Application of the Analysis Results

The reconstruction of the flight path from speed, heading and wind data allows judgements based on a graphical representation of the flight. Details, such as the flight juxtapositioned against the glide path, would not have been possible without analysis in 3D graphical form, and allowed a high fidelity playback in relation to the glideslope. Analyses of distances derived from the speed and headings allow a value-added analysis of events, and are put in the context of runway and navaid locations. The added dimension of time allows gauging of events in the proper sequence and with a familiar context.

In this case the crew reacted to the yawing of the aircraft by use of aileron and elevator controls as opposed to use of the rudder. An examination of the resulting aircraft yaw, pitch and roll allows the crew and other parties to examine and discuss the effects of this use of the controls in relation to the flight, using this application as a focal point.

This example shows how the interpretation of an assemblage of parameters into graphical form allows a deeper and more accessible analysis of events. Discussion and understanding of facts is key to flight safety. Examining these events in an accessible context, such as within an animation, contributes to an environment in which flight safety can be markedly improved.

A.6 Aircrew Incident Reporting System

1 Introduction

1.1 OVERVIEW OF THE TOOL FUNCTIONALITY

The Aircrew Incident Reporting System (AIRS) consists of the Air Safety Report (ASR) and the Human Factors Report (HFR) modules. AIRS which was jointly developed by Airbus and by British Airways, combines both ASR and HFR from the British Airways Safety Information System (BASIS). These respectively deal with the "what" and with the "why" of an incident. While filing the former may be mandatory, depending on the incident, filing the latter is voluntary and provides clarification by going into the human factors behind the incident. Whereas one ASR will report on the incident, there can be two or more HFRs, i.e. one from each crewmember.

Air Safety Reports

ASRs are used to process flight crew generated reports of any safety-related incident. The crew's narrative account is transformed via keywords into a database, which can be filtered or searched for trends. Data fields include aircraft type, phase of flight, risk assessment, and descriptive incident keywords as discussed below and illustrated in Figure 1, which shows the event summary screen display for a typical incident, which is discussed further below in the example application.

Risk assessment is made with reference to seriousness of the risk to the company, and the likelihood of recurrence. The risk is quantified according to a simple 3x3 matrix (low, medium, high).

Incidents are initially categorized as technical, operational or environmental. Technical incidents are incidents in which something physical has developed a fault. For example an engine has surged, or an instrument has failed. Operational incidents are those that are a result of a person or a procedural error on the part of a member or members of the airline's staff or staff contracted to the airline and operating to its standard. Environmental incidents are those events which have occurred due to factors outside the company's direct control, for example, a problem with air traffic control, bad weather or other aircraft.

Each incident can be assigned up to three categories, reflecting the **cause**, a contributing **factor**, and the **effect**. Typically, the effect will be categorized as operational, although the cause and contributing factor could be any of the three categories.

Next, the cause, factor and effect for each incident can be assigned a reference classification derived from the British Airways Safety Information System. These so-called BASIS reference terms are based on a standard list of factors developed by the Air Transport Association, with items such as Engines, Flying Controls, and Auto-flight. The BASIS reference summarizes the primary causal factor of the incident. This list of 43 keywords has been expanded to include weather, airmiss, GPWS, go around, etc. For example, an incident may be a GPWS followed by a go-around. Both BASIS references should be applied so that both aspects would influence their respective trends.

Finally, the analyst can choose up to six keywords from an exhaustive list of 114 technical, environmental and operational keywords, up two each for the cause, factor and effect. These keywords were selected as being featured in numerous reports investigated prior to BASIS.

Human Factors Reports

The principal difference between the Human Factors Report (HFR) and the Air Safety Report (ASR) is the voluntary and confidential aspect of the HFR reporting system. Filling in an ASR can be mandatory for certain types of incident, whilst filling in an HFR questionnaire is completely voluntary. HFR questionnaires should be provided in the cockpit, alongside the ASR forms. Pilots, who want to report more on an incident, are asked to complete the human factors questionnaire form. Part of the questionnaire asks whether the reporter agrees to be identified. If the reporter does accept, the completion of an identification slip enables the event analyst to make confidential contact. In this way, the AIRS coordinator can seek additional information in order to understand the event more fully.

All reported forms are returned to a central secure storage point. The forms are then retrieved by the relevant fleet coordinator who performs the analysis of the event. Similar to the ASR system, all crewmembers are automatically informed about the investigation process. This encourages further feedback and may provide yet another quality check. After the completion of the analysis, the reporter is informed about the investigator's assessment. The incident is then completely de-identified and stored in the database.

1.2 INTRODUCTION TO THE EXAMPLE APPLICATION

During descent to HAJ in an Airbus A320, a speed exceedance occurred due to poor monitoring and incorrect expectations of aircraft auto-flight behavior. This happened as a result of poor management of high workload in congested ATC airspace. In addition the routing around the airport was different from usual due to the annual airshow taking place. With an overspeed warning the autopilot dropped out automatically, surprising the crew and requiring the pilot flying (PF) to continue the descent under manual control with the assistance of good crew cooperation. Figure 1 below presents the basic information for the example incident, as shown on the ASR event page. It has been assumed that both an ASR and an HFR have been filed for this event. The AIRS software caters for an automatic association between both BASIS modules so as to offer easy linking. The following discussion focuses on the entry and analysis of the HFR data.

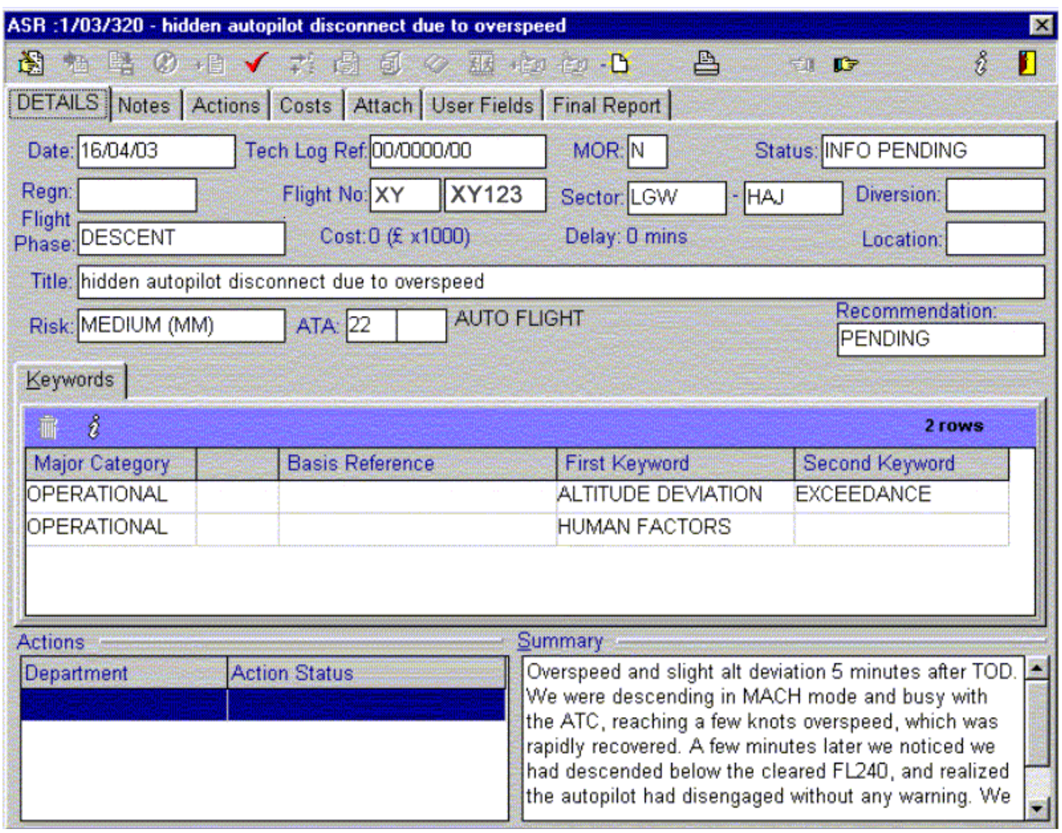


Figure 1 **ASR Event Page**

2 Input Data

This section uses the example incident to illustrate the process of entering information for an HFR report.

Figure 2 shows the screen display of the event page for an HFR report for the example incident. The upper part of the event page consists of a number of fields, including the AIRS reference, date of the incident, status of the event investigation, location of the event, flight phase and risk assessment, which have to be filled in by the analyst. The central area of the event page is used to display the assigned factors and the categories from which they were drawn. In the left column are the categories that have supplied factors for the analysis and in the three columns to the right are the factors chosen from the respective categories.

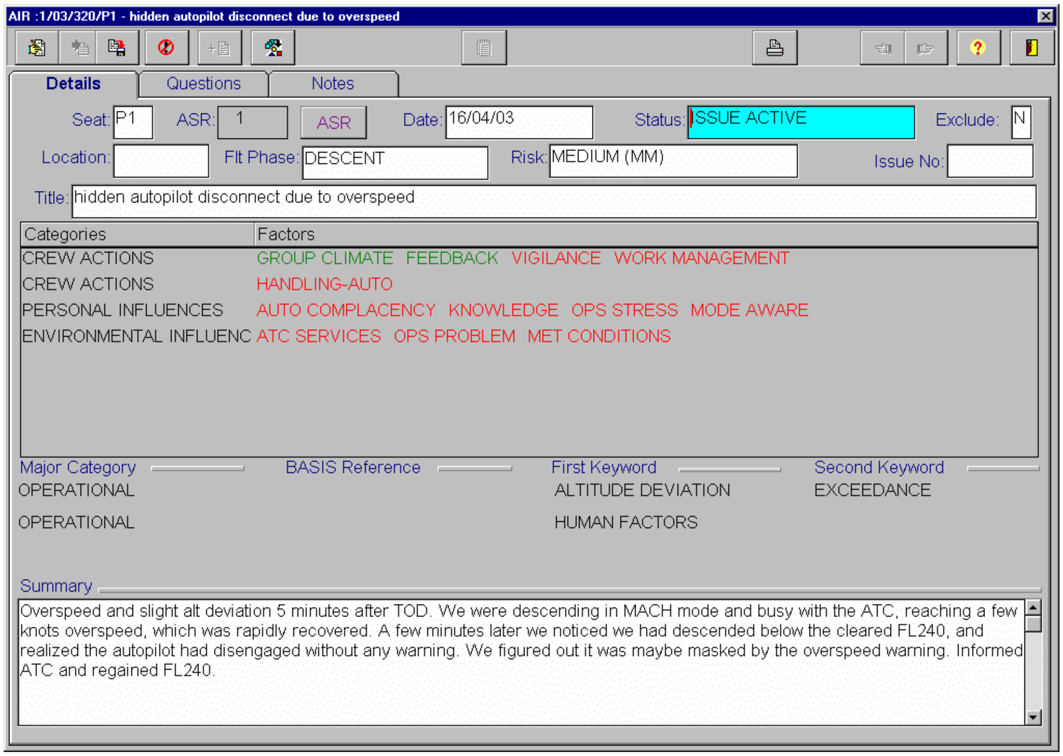


Figure 2 **HFR Event Page**

The factors are color-coded green or red depending on whether they enhanced or degraded safety. The # sign denotes a third party factor, i.e. one that the reporter uses to describe another crew member's actions or their personal influence. In this example, the Crew Actions category has five factors: Group Climate and Crew Feedback (both positive), Vigilance, Work Management, and Handling-Automation (all three negative). Below Crew Actions, factors from the other categories, in this case Personal, Informational and Environmental influences, are displayed. The page allows up to thirty factors to be displayed. In this case, Automation Complacency, Knowledge, Operational Stress, and Mode Awareness were identified for the Personal Influences, with ATC Services, Operational Problem, and Meteorological Conditions identified for Environmental Influences.

Below the categories and factors is the event summary. This is completed after analysis and callbacks are completed and should briefly describe both the technical and human factors in the report. While only three lines of the summary are displayed there is no practical limit on its length.

Once the factual information on the event has been entered on the event page, the Questions page is used to enter the responses given by the reporter to the questions on the HFR questionnaire. Figure 3 shows the Questions page after the responses for the example event have been entered. The top of the questionnaire answer page consists of two fields, the AIRS reference number and the title. Below the analyst fills in the main body of the page, simply by copying the HFR questionnaire form. The assignment of the human factors codes in the second column of the page occurs in the subsequent step described below.

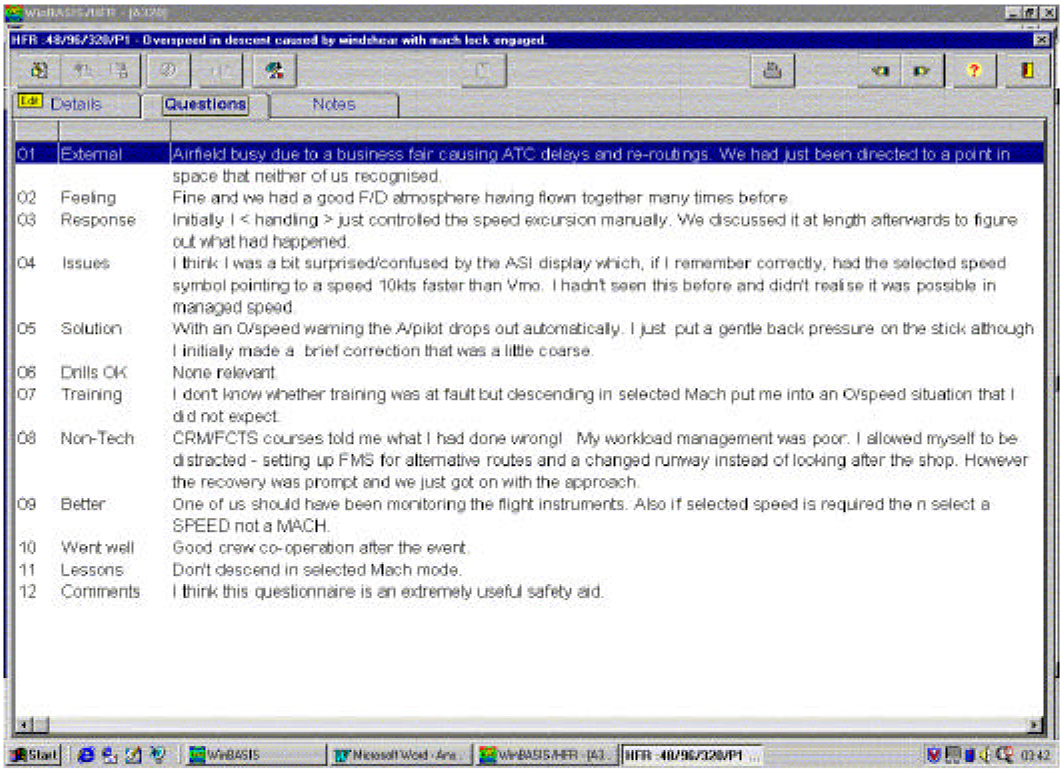


Figure 3 **HFR Questions Page**

3 Analytical Process

Once the information has been entered in the system for an event, the analyst performs an assessment of the level of risk associated with the event and assigns human factor codes to the various actions described in the report. The analyst hereby assesses severity of damage and probability of recurrence that combine into minimal, low, medium, high and severe risk attributions.

3.1 KEYWORDS & CODING

The major analytic step in the AIRS HFR process is the assignment of 'human factors' which describe the events and influences in the reported incident. The purpose of factor assignment is to describe the actions of the flight crew and the influences on those actions. The assignment process uses sets of factors describing behavior or influences on behavior. Using this common 'language', problems common to many incidents can be discovered and therefore more efficiently remedied.

The taxonomy is based on five groups or categories of factors. The first category is concerned with observable crew behavior and actions that can be defined as safe or unsafe. Four further categories are devoted to different kinds of influences on crew behaviors.

Crew Actions	These are of three distinct types. One type concerns the activities of handling the aircraft and its systems, e.g., System Handling. A second concerns the potential error types reflecting the Reason model of human error (Reason, 1990), e.g., Action slip. Third is the largest set of factors, which are derived from the NASA/UT CRM Team Skills. These describe a number of activities involved in the safe management of flight, e.g., Workload Management.
Personal influences	These describe the subjective feelings of emotion, stress, motivation, and attention as described by the reporter. Examples are Boredom, Personal Stress, Tiredness and Situational Awareness.
Environmental influences	These are those behavioral influences over which neither the reporter nor the airline has any control. Examples are ATC Services, Technical Failure and Other Aircraft.
Organizational Influences	These are those influences, which are directly controlled by the company. For example, Training, Technical Support and Commercial Pressure.
Informational Influences	These are also under the company's control but are a subset of the organizational influences dealing with operational information. Examples are QRH, Electronic Checklists and Navigational Charts.

Crew actions differ from the influences in that they are generally observable and reportable. Most keywords, depending on their meaning, can be used in both the positive and the negative sense. In other words if they enhanced safety they are coded as positive and otherwise, if they degrade safety, as negative. For example "handling skills" can have a positive or negative meaning, depending whether exceptional handling skills helped in the recovery or inadequate handling caused the incident to occur. On the other hand, keywords like “action slip” can only have a negative influence.

In this example, the analyst assigns Crew Action factors to the incident. The Influences affecting the actions are determined thereafter. The analyst normally aims to establish some kind of sequence of the chosen factors in an iterative process. The factors are input in a rough sequence, which is derived from a preliminary paper and pencil analysis. However, a single continuous sequence or chain rarely represents the structure of an incident. Thus generally incident chains have sections that branch outwards or converge.

The assignment of factors to specific responses to the HFR questions is accomplished through the use of the Factor Selection page of the AIRS HFR module, as shown in Figure 4. This presents possible categories, factors, and factor types in a menu format, and allows the assignment to be made by selecting the appropriate values. Definitions of the factors are provided when they are highlighted on the screen to assist in the selection process.

Assuming that the analyst encodes that the reporter had indicated that another crewmember's Mode Awareness was poor, the software will displays the definitions of the factors as shown below.

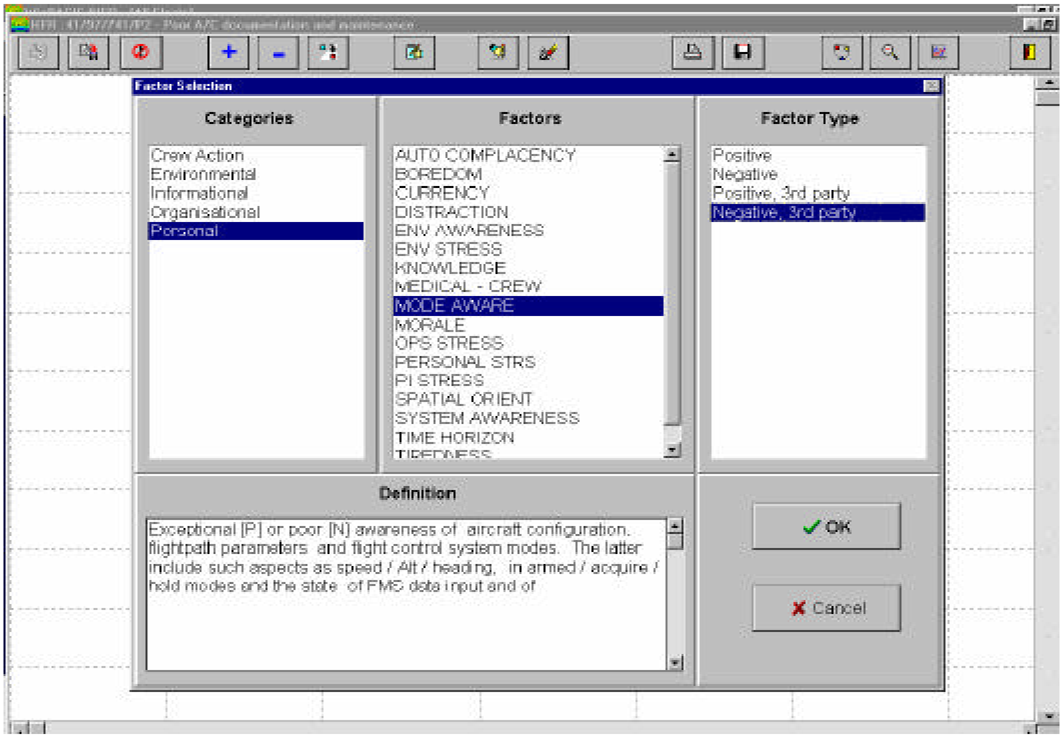


Figure 4 **HFR Factor Selection Page**

3.2 WHAT DO WE DO WITH THIS? INTER-LINKING CAUSAL FACTORS AND IMMEDIATE CONSEQUENCES

With AIRS, it is possible to plot error chains, which represent active and latent failures instrumental to an incident (or accident) scenario. Deciphering incidents should certainly not be based on negative experiences only. However, it is anticipated to learn from those factors that encourage effective behavior and direct remedial action at influences that are less successful in promoting system safety. Moving from mere descriptions to the mapping of both positive and negative behaviors and influences offers greater insight into the underlying processes. In this concept the analyst develops a model of the incident through a process in which factor assignment and factor linking interact. This is achieved simply by linking the factors selected from the taxonomy.

As an example, a "rough sketch" of the incident is shown in Figure 5, a sequence diagram that is produced within the AIRS system. In this A320 HF event, speed exceedance occurred due to poor monitoring and incorrect expectations of aircraft auto-flight behavior. This happened as a result of poor management of high workload in congested ATC airspace and some turbulence. With an overspeed warning the autopilot dropped out automatically, surprise manually coped with by PF and good crew cooperation. The crew learnt from this not to descend in selected Mach Mode but rather in selected Speed Mode where the protection would have worked.

Event Sequence Diagrams (ESD's) as the one in Figure 5 are created for major reports in a graphics page in the HFR database. The software enables to perform a trial and error approach to facilitate the construction of this ESD to establish a mental model of the reported event. Which helps to define exactly what the core problem was. Having established the identity of the problem, the analyst can then focus on the causes of the problem and then on how the problem can be solved. It is believed that the inter-linking of causal factors and immediate consequences can create a network of serial, parallel causal factors to appreciate the inductive context that created a scenario. As indicated earlier, extensive analysis of this type could transform information into interesting recurring patterns. Some of these would be relevant to procedures and training, some to aircrew or organizational errors, some even to design and engineering.

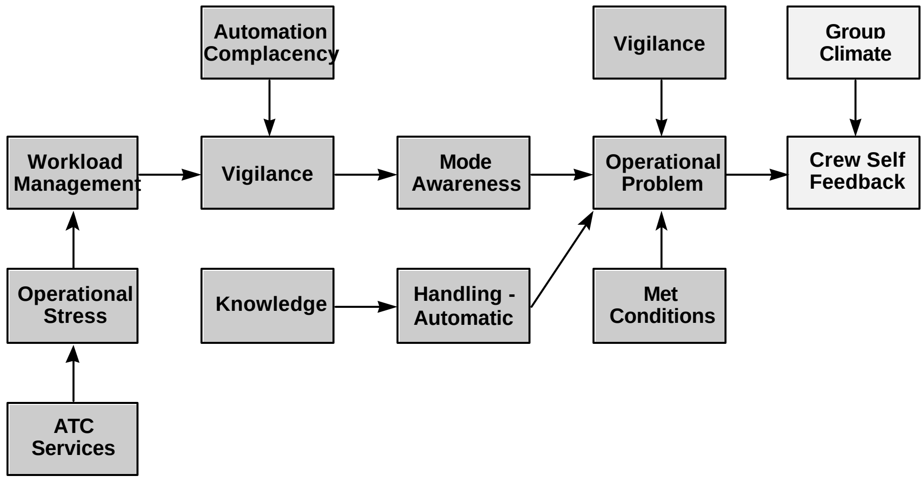


Figure 5 **Event Sequence Diagram – Overspeed in Descent**

4 Tool Output

The results of the human factors analysis for a specific incident are displayed on the various pages of the AIRS HFR module. However, the information for all HFR events is maintained in the underlying database and can be analyzed using the filtering capability described above and then exporting the resulting selected data for further analysis as follows. Figure 6 provides an overall review of all Human Factors that come into the database resulting from using the AIRS software and then exporting the data to a Microsoft Excel file.

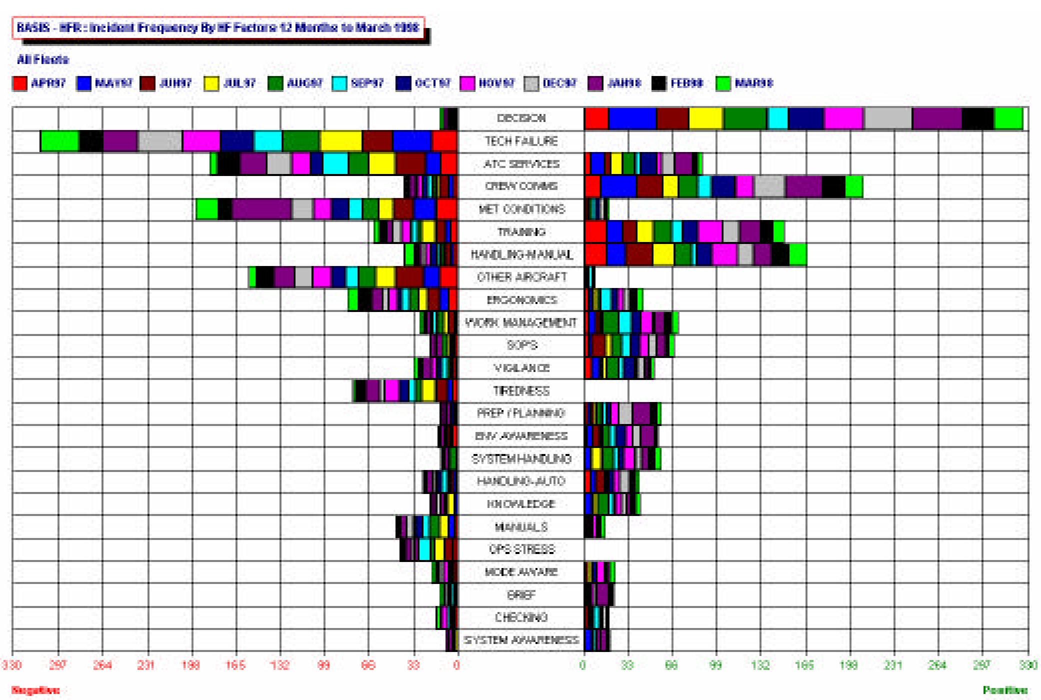


Figure 6 **Balanced Trend Analysis on Human Factors (Positive and Negative)**

Trending human factors incidents, displaying them as color graphical charts on the screen, and printing them can be best be achieved by using standard statistical tools such as Microsoft Excel. In fact, trend analysis is a practical probing into all available data with the intention of uncovering the unknown and undesirable. Conducting trend analysis requires a search on for instance the most frequent Human Factors keyword by using the filtering analysis as described above and copying the numbers into an Excel spreadsheet. The final result can be represented in a variety of chart types such as scatter, pie charts, line charts, doughnut chart, radar chart and bar diagram. Each can be produced in color, on screen or paper, for selected time periods as defined in the filter option.

Reviewing Figure 6, in the context of the mode awareness factor of the previously treated incident, one appreciates the balance between positive and negative trends (also for environmental and system related awareness).

5 Application of the Analysis Results

In summary, charts that present relationships between the occurrence of specific human factors and other aspects of the system allow hypotheses about the role of suspected causal factors to be examined, and often make the answer obvious. Incidents may be examined within a single fleet, all fleets, or a combination of fleets, (useful when examining equipment common to more than one aircraft type).

For example, a list may be obtained with all incidents where a particular busy airfie ld increased the workload in the pre-flight phase and where distraction from third party led to omitting the setting of the flaps. One event can be considered an isolated incident; two similar events could imply the start of a trend. If an event recurs after preventive measures are in place the cause must be determined to ascertain whether further corrective action is necessary or whether the steps in a particular operating procedure or maintenance schedule have been ignored.

For proper return of experience, the manufacturer also needs to receive reports like these to properly feed back corrective and preventive actions. With regard to the overspeed in descent analysis, the cure not only consisted in addressing this in training but also to update the Flight Crew Operating Manual and foremost to enable protections to function in Mach mode for future designs. Small contributions like this one are tantamount to every manufacturer's and every airlines' return of experience.

Several airlines have indeed compla ined about VMO/MMO overshoots in descent phase. This occurred on A320 family aircraft without Global Speed Protection as well as on A330 and A340 aircraft with Autopilot (AP) engaged, mainly in DES mode, and above descent path or during path capture from above, sometimes leading to AP disconnection and automatic nose-up order. VMO/MMO is the maximum operating Speed/Mach of the flight envelope (*VMO = 350 kts / MMO = 0.82 on A320; VMO = 330 kts / MMO = 0.86 on A340).* It is not authorized to fly intentionally above this limit. In exceptional circumstances, it can happen, that this speed is temporarily overshot without major safety issues. At High Speed Protection activation, the AP will automatically disconnect. This may occur when operating at High Cost Indices (*i.e.* flying faster to reduce flight time rather than minimize fuel burn), leading to managed speed close to VMO/MMO, and in DES mode with Managed Speed, particularly if the aircraft is above path, or during path capture from above, or on path with turbulence. With the autopilot engaged, this can occur in the descent or open descent mode without Global Speed Protection function, whereby the autopilot pitch authority is limited to 0.1g for passenger comfort (and to +0.15g in expedite descent mode). If turbulence conditions are encountered, all these conditions combined together may prevent the autopilot from efficiently counteracting the speed increase and create a surprise to the pilots. Using the following reworded FCOM procedure prevents such an exceedance during descent : "*When the current speed is close to VMO, monitor the speed trend symbol on the PFD. If the speed trend reaches or slightly exceeds the VMO limit, use the FCU immediately to select a lower speed target. If the speed trend significantly exceeds the VMO red band, without high speed protection activation, select a lower target speed on the FCU and, if the aircraft continues to accelerate, consider disconnecting the autopilot. And, before re-engaging the autopilot, smoothly establish a shallower pitch attitude.*"

The Global Speed Protection – which is an autopilot function – does not totally avoid some VMO/MMO overshoots when encountering turbulence or wind gusts at low pitch attitude. In order to avoid large VMO/MMO exceedance induced by a dive or a vertical upset, the High Speed Protection (HSP) – which is basic on all fly-by-wire aircraft – is activated at or before VMO +6kt / MMO +0.015 depending on the flight conditions. When the HSP activates, the pilot should not interfere with it. If needed, he should smoothly pull the side-stick to recover a proper speed below VMO/MMO.

The flight crew can perform the following preventive drills prior to the descent: *"Insert Descent Winds when important wind changes are expected and insert Managed Speed in PERF DES …. /300 to increase the speed margin between VUM = 320 kts and VMO. As a result, in above path conditions, the autopilot would have an extra 10 kts buffer before VMO, which suppresses 99% exceedance. Hence the DES mode has more flexibility to keep the A/C on path as A/C speed can then vary up to 20kts above speed target."*

On the design side, new FMS2 modifications will cater for an improvement of the vertical guidance law so that in DES mode, whilst above path, or during path capture from above or on path with turbulence, FMS guidance law has been re-tuned to strengthen its robustness against turbulence. This also consists in an increase of Speed Margins versus VMO/MMO. These are increased firstly widening the margin between Managed Descent Speed ($V_{ECON\ DES}$) and VMO/MMO from 10 kts to 15 kts, secondly the margin between the Upper Margin Speed (V_{UM}) and VMO/MMO which is increased from 5 kts to 10 kts.

A.7 Procedural Event Analysis Tool

1 Introduction

1.1 OVERVIEW OF THE TOOL FUNCTIONALITY

The objective of the Procedural Event Analysis Tool (PEAT) is to identify specific contributing factors to flight crew error. Contributing factors are conditions under management control that lead to procedural non-compliance. Procedural non-compliance is broadly defined as any action that the flight crew should or should not have taken. PEAT was specifically developed to investigate serious operational events that involve flight crew procedural non-compliance errors.

Whether or not an act of non-compliance might be intentional, in very few cases does a non-compliant crewmember intend a potentially negative outcome. In most cases, multiple contributing factors beyond the flight crew's control lead to erroneous acts. Obviously, cases of intended consequences or reckless disregard for possible consequences are not considered human error in the context of PEAT analysis.

It is common knowledge that attributing blame to involved flight crews complicates investigations of serious events. When incidents occur, immediate blame attribution is the norm in every culture. The effects of unfounded blame are familiar to all of us. In the blame environment, the potential for misunderstanding the underlying reasons for the incident is high. Therefore, it is essential that airline managers apply the PEAT process to events in which amnesty and confidentiality are guaranteed to the employee.

The essential data for the PEAT process are flight crew-generated contributing factors to procedural non-compliance errors. The overall objective of the investigation is to learn how similar errors can be prevented in the future. The first step in the process is to ask each involved crewmember for recommendations that, in his opinion, would prevent that type of incident in the future. This approach of soliciting crewmember recommendations further empowers the crewmember and sets the stage for determining what actions (i.e., procedural errors) led to the event and, finally, what the conditions (i.e. contributing factors) were that influenced flight crew decisions.

In summary, the goal is to break down the event into individual crew actions and the underlying reasons for the actions. Once the casual relationship is established between the crew errors and the contributing factors, it is possible for the investigator to develop a set of general recommendations aimed at reducing or eliminating the effect of the validated contributing factors identified from the discussion with the flight crew. The events and errors are the preventable through the management of the contributing factors.

1.2 INTRODUCTION TO THE EXAMPLE APPLICATION

The Chief Pilot was informed that a company aircraft had overrun a runway on landing. Airplane damage was minimal and no injuries were reported. However, there were some passenger complaints about excessive confusion prior to deplaning. The resulting damage was repaired in a few hours and the airplane was returned to service the following day. Flight crewmembers were tested and found to be free of unauthorized drug/alcohol use. Both crewmembers had records of excellent performance prior to this event.

Because the event was contained and the flight crewmembers passed an administrative investigation, the Chief Pilot determined that a PEAT investigation should be conducted with the appropriate level of amnesty.

2 Input Data

A Flight Safety Investigator and pilot familiar with the type of aircraft were assigned to investigate the event. They compiled available event information, applicable approach/landing procedures, and copies of aircrew reports made immediately after the event. They found:

a. Thunderstorms were in the area and the runway was wet.

b. The thrust reversers had been deactivated by maintenance.

c. The airplane had been dispatched with adequate fuel reserves for the forecast weather. Landing was conducted during daylight.

d. Weight and balance figures were normal.

e. Captain was high time in type and First Officer was low time in type.

f. Both pilots had recently completed recurrent training.

g. This was the third and last sector of their duty day.

h. Runway was short, but not extremely short for this aircraft type.

i. The ILS was out of service. A VOR approach was conducted.

j. The aircrew reports indicated that they were number one in a three airplane-holding stack over the final approach fix waiting for a thunderstorm to pass over the airport. After the thunderstorm had passed, the approach clearance put them high on final. Ceiling was 1,000 feet; Captain was flying the airplane; touchdown was a "few hundred feet" long, braking action was poor; spoilers were deployed manually. Another weather build up was identified and expected to be over the airport in one hour.

The Flight Safety and pilot investigators developed a list of several potential crew errors. They discussed a few potential scenarios (preliminary event summaries), but wisely withheld judgment until they could get more conclusive evidence from the flight crew.

The Flight Safety investigator contacted the pilots and familiarized them with the company policy regarding the use of PEAT. Because the program was relatively new to the company, the Chief Pilot gave personal assurances to both pilots that amnesty would be granted to them for this particular event. The First Officer agreed to an interview at the Safety Office and the Captain agreed to an interview at a local lounge.

3 Analytical Process

The basis of the PEAT methodology is called the Cognitive Process. This is distinct from traditional inferential processes that generally require both extensive job knowledge and analytical skill on the part of the investigator.

Another aspect of the Cognitive Process is that the investigator does not have to "pull" information from the employee. When an investigator labors to extract the information from the employee, the investigator can reach a point of frustration and begin recreating the story himself. With the Cognitive Process, the burden of identifying contributing factors is primarily on the employee who actually experienced those factors and made the erroneous actions. The investigator is not the author of the story, just systematic organizer and describer of the story. Obviously, this process can rarely be applied to most aircraft accidents.

3.1 PROCESS STEPS

After an event happens and a preliminary event summary is assessed,

1. Management determines if amnesty will be granted to each crewmember involved. The PEAT philosophy maintains this should automatically be the case with most events that are contained within the airline's jurisdiction. Management then authorizes the PEAT investigation.
2. The investigator/manager assigned to the event will prepare for the structured interview by reviewing:
   a. Preliminary event information
   b. Procedures that should have prevented the event
   c. Initial employee reports, if any

   The investigator will develop a list of potential errors that the flight crew may have committed, *but will avoid speculating about the contributing factors to those errors*. This list may be helpful to the crewmember as he recreates the event description during the interview.
3. The investigator should arrange an interview time and location that is as comfortable as possible for the crewmember. The condition of amnesty should be clearly reviewed, understood, and accepted by the employee. Management assurances given directly to the employee may be required. The employee should also be informed about the limits of amnesty (i.e. drug use, criminal activity, reckless behavior, etc.).
4. As mentioned already, the investigator should start by asking the employee:
   a. What management should do to prevent this incident in the future?
   b. What the crewmember (as well as other employees) should do to prevent this kind of incident in the future.
5. Given those recommendations, the investigator should identify what contributing factors the crewmember's recommendations would address. Crewmember recommendations may or may not effectively remedy the effects of contributing factors. However, the process of proposing recommendations/improvements naturally leads the crewmember to think about the contributing factors to his errors.
6. Given the initial list of contributing factors identified by the crewmember, the investigator will organize those contributing factors by the errors they induced. Discussing errors is generally an uncomfortable experience. Therefore the investigator should emphasize that the focus of the investigation is not on the errors, but on how those factors (and other factors that the crewmember may later identify) "worked together" to induce the errors.
7. The investigator should use the actual flight crew procedural errors to completely describe the event. The investigator may find that he and the crewmember will need to thoroughly review the sequence of procedural steps that applied to this event. The product will be a factual sequence of actions leading to the outcome called the "event summary".
8. The investigator should thank the crewmember for his help and maintain an avenue for follow-up contact with the employee.
9. Based on the event summary and list of contributing factors, the investigator will provide general recommendations to relevant managers. While the investigator's report alone may often be sufficient, the investigator should be available to facilitate the development of specific recommendations with the applicable managers.

This process is illustrated in Figure 1.

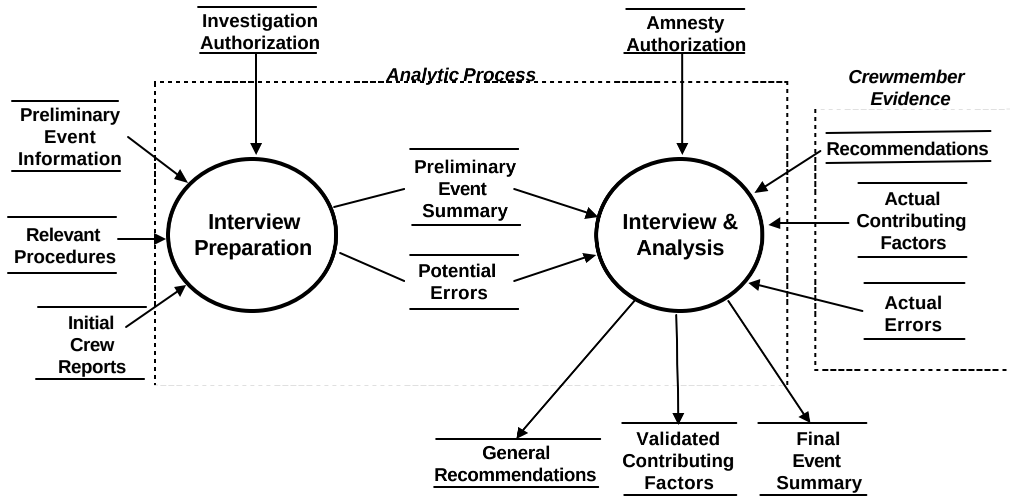


Figure 1 **PEAT Data Flow**

3.2 EXAMPLE CASE

For brevity, this example will reflect only the Captain's interview. At the beginning of the interview, the investigator reminded the Captain who was the Pilot Flying (PF) of what behaviors were outside the limits of amnesty and that the PEAT investigation would be terminated if criminal/reckless behavior were indicated.

The Captain disclosed his procedural non-compliance errors along with their contributing factors.

a. (Error #1) The PF did not request sufficient holding fuel for this sector although he was within company limits.
   i. Weather forecasts for this season tend to be variable.
   ii. The procedure to request fuel from dispatch is cumbersome.
b. (Error #2) The PF did not initiate a diversion during the hold when the fuel quantity reached the divert level.
   i. Approach clearance came at the time the divert fuel level was reached.
   ii. The weather at the Alternate airport was becoming marginal.
c. (Error #3) The PF did not fully arm the spoilers during the before landing checklist. This resulted in late spoiler deployment upon landing.
   i. The "armed" indication for this type of aircraft is difficult to see. Note: since the thrust reversers were disarmed, spoiler arming is essential to automatic spoiler deployment.
   ii. The approach was rushed due to the fuel level, position in the holding stack, and impending reclosure of the airport due to approaching thunderstorms.

While the PF's list of errors and contributing factors was extensive, further discussion revealed that the Captain did not make an immediate announcement to the cabin instructing the passengers to remain seated. This resulted in many passengers getting out of their seats prematurely. The shock of the outcome temporarily distracted the Captain from informing the passengers as well as subsequent radio communication with ATC/company to support the egress.

The Captain (PF) made the following recommendations:

a. Management should streamline the current fuel upload request process.

b. Management should add at least one more enroute alternate for this sector.

c. Management should inform the local ATC facility of the performance limits of this aircraft.

d. The spoiler "armed" indication for this aircraft is difficult to see.

e. This Captain plans to add one hour of holding fuel to the normal flight planned amount for this sector given similar seasonal weather conditions.

At the close of the interview, the Flight Safety investigator asked the Captain to call him if he remembered any additional information relevant to understanding this event. The investigator assured the Captain that the investigation findings would be shared with the Captain. The Captain was encouraged to explain how PEAT worked to other pilots whenever the opportunity arose.

4 Tool Output

While the erroneous actions are necessary to link the contributing factors to the outcome, the key output is an organized description of the contributing factors and general recommendations for how to address those factors. The contributing factors to errors constitute threats, hazards, or system imbalances managers will want to consider in their risk management processes. Additionally, the output will include a complete event summary that presents the "whole story" of what happened.

4.1 GENERAL RECOMMENDATIONS

After a brief analysis, the investigative team proposed that:

d. The company should review the pilot-requested fuel upload process since two signatures from dispatch are required to authorize any upload.

e. The company should review the thrust reverser deactivation policy in terms of how often deactivations occur and if revenue flights should be restricted in those cases.

5 Application of the Analysis Results

In this particular example, management may develop a specific policy that allows 30 minutes of fuel reserves to be added without additional authorizations at dispatch. If the Captain develops a personal policy to be more conservative (adding one hour reserve to this sector) just because he was "burned," then airline efficiency might be compromised. However, it might seem reasonable to management in such cases to allow pilot-requested uploads up to 30 minutes without question.

The above example highlighted the value of using open communication with limited amnesty to obtain an in-depth understanding of the contributing factors to errors that led to an incident. By seeing the relationships between the errors and the factors, management can take more precise actions to prevent the effects of significant contributing factors in the future. The effects are, of course, procedural non-compliance errors that cover up or lead to system inefficiencies, not to mention potential incidents and accidents.

5.1 WHAT MIGHT HAVE HAPPENED WITHOUT PEAT

It is important to note that the typical course of management action to an event such as in this example is to blame and train the involved employees. Without other investigative options, management might have been compelled to send that crew to the simulator. More training would have not addressed the fuel planning contributing factor, which was a strong contributor to the other errors. More training only for these employees would have been a waste of company resources.

Had the event been more serious, the crewmembers might have been disciplined and the problem of fuel planning processes would have remained undetected. One significant side effect of such inferential (or "unjust") administrative action could be a further drain on efficiency. Because of fear those pilots, as well as other employees, might resort to career-protecting behaviors that may not be in the interest of the airline's safety.

5.2 PEAT DATABASE STORAGE AND ANALYSES CAPABILITIES

The information from this investigation can be stored in the PEAT database for further analysis, generating reports/graphs and for secure electronic distribution, etc.

A.8 Aviation Safety Data Mining Workbench

1 Introduction

1.1 OVERVIEW OF THE TOOL FUNCTIONALITY

The MITRE Corporation Aviation Safety Data Mining Workbench comprises three tool modules: FindSimilar, FindAssociations, and FindDistributions.

FindSimilar – This tool searches both the structured fields and free-text narratives in the data and finds reports that are similar to a report selected by the user (as the target). For example, consider a case where the user is focusing on a report that involves an altitude deviation due to distraction of the cockpit crew. The user could enter the report's ID as the target and run the FindSimilar tool to see what similar cases exist in the data and what has been the cause of distraction in each case.

FindAssociations – This tool searches the structured fields in the reports. FindAssociations would be used when users want to discover outstanding associations in the data. The tool could be run on the entire data or on a selected subset. In either case, the user does not need to specify which associations in the data to look for. The tool examines all possible associations and returns the ones that are above the specified thresholds.

FindDistributions – This tool searches the fields in the reports, and identifies unusual distributions of incidents. To run this tool, users need to select the field they want to focus on (Focused Attribute, as shown in Figure 7 below). For example, to search for anomalies in distribution of *Aircraft Type*, select *Aircraft Type* as the Focused Attribute. The tool then calculates distribution of subsets of incidents over the selected field (*Aircraft Type* in this case). Those subsets that differ most from the overall distribution are identified as unexpected.

1.2 INTRODUCTION TO THE EXAMPLE APPLICATION

The purpose of this application was to use the Data Mining Workbench (DMW) to analyze pilot-submitted air safety reports in order to discover any trends or patterns that might be useful for preventing future incidents.

The analysis was undertaken by the MITRE Corporation in partnership with a U.S. airline. The MITRE access to and analysis of safety reports was in full compliance with the objectives, spirit, intent, and confidentiality of the company's existing Aviation Safety Action Program (ASAP) Memorandum of Understanding (MOU) and its Data and Information Policy. It was understood and agreed by both parties that all proprietary information shall remain so, and is for the sole use of compliance with the purpose, intent, and requirements of the ASAP MOU to assist in the proactive prevention of accidents and incidents.

The following sections describe the data, necessary preparation steps, application of the Workbench tools, and examples of findings by each tool.

2 Input Data

A subset of Aviation Safety Action Program (ASAP) data, collected and maintained by a U.S. airline, was selected for this analysis. The selected data covered a period of four consecutive months, and consisted of structured fields (such as phase of flight and aircraft type) as well as free text (narratives).

The two parts of the data, structured fields and the free text, were first saved in two separate text files since they came from different data tables (relating to each other by a unique ID). A parser program was written (in C language) to read both text files and write them together in a unified text file such that the free text of each report was attached to the end of its structured fields.

Another program was written and run to clean the data; for example, any END_OF_LINE or CARRIAGE_RETURN characters were removed from the free text field since this would cause the tools to stop reading the rest of the text in that field. For the structured fields, the program checked their values, and entered a “NULL” if the value was missing. This input file was then reformatted to meet the DMW input requirements; for example, the DATE field was parsed into separate fields of YEAR, MONTH, and DAY.

When the input file was ready, it was loaded into the DMW by starting the Workbench and running the load option. The LOAD program as well as other features of the DMW, such as Browse, Field Selection, Weights screens, and the code for generating automated reports and charts were modified to match the ASAP data schema.

3 Analytical Process

Once the data was loaded in the DMW, the following three tool modules were run on it: FindSimilar, FindAssociations, and FindDistributions.

The ***FindSimilar*** user interface screen in shown in Figure 1. The DMW provides an interface for assigning and saving the weights, which can be accessed by pressing Select Weight Set, shown on the left side of the screen. Users also need to specify a THRESHOLD between 0 and 1 to show the minimum degree of similarity they want to see. A higher threshold will limit the discovered reports to the highly similar ones only.

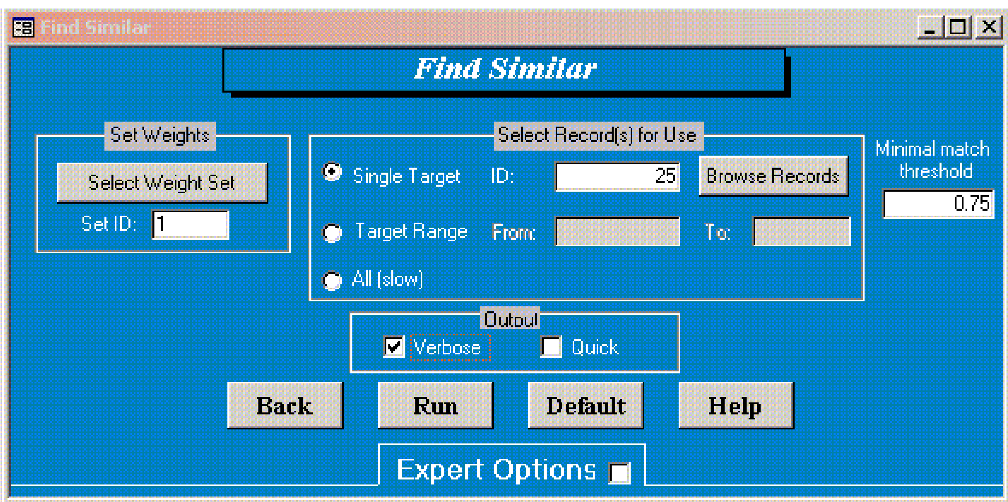


Figure 1 **The *FindSimilar* User Interface Screen**

The user can indicate which fields (structured or free text) are more important in determining the similarity by assigning weights to the fields. The value entered for the weight should be a positive number. Assigning a weight of zero for a field, indicates the field should not be considered for comparison and determining similarity. On the other hand, a weight of 1 or higher indicates the field should be considered. To consider all the fields equally for determination of similarity, assign a weight of “1” to all fields. If some fields are assigned higher weights than others, then a similarity in those fields is considered more important than other similar fields.

The FindSimilar tool searches the fields with a weight of 1 or higher in all reports and compares them to the specified target. Depending on the frequency of the common words and the weight of each field, a similarity score is computed for each report. The reports with a similarity score equal to or higher than the THRESHOLD will be returned as discovered matches.

The ***FindAssociations*** user interface screen is shown in Figure 2. The user-specifies thresholds for SUPPORT and CONFIDENCE, as shown on the screen. SUPPORT is the minimum number of times a field value (or combination of values) should exist in the data in order to consider its associations. For example, a support of 0.5 (or 50%) indicates the user is interested in associations of field values that appear in at least 50% of the data records. The CONFIDENCE indicates the strength of the association. For example, a confidence of 0.5 means the user wants to see associations for field values that appear together at least 50% of the time.

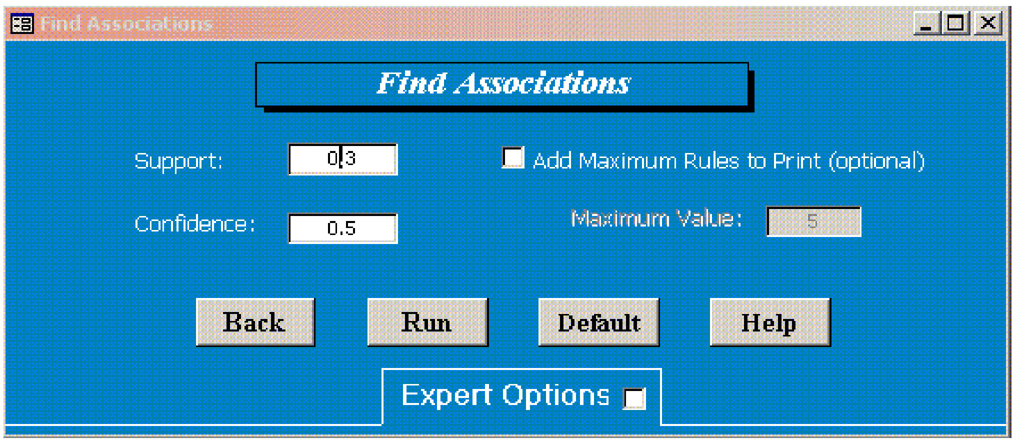


Figure 2 **The *FindAssociations* User Interface Screen**

Users could also check the 'Expert Options' box (at the bottom of the screen) and access the following additional options:

Add Attribute Value: Allows users to select a field to focus on the associations of values of that particular field. For example, selecting the individual field *phase* will search for associations of different *phases* of flight with other fields.

Add Focused Individual Value: Allows users to select a value of a field to focus on. For example, selecting *phase* with the value *takeoff* will search for associations of (*phase = takeoff*) with other fields.

The ***FindDistributions*** user interface screen is shown in Figure 3. The user selects the focused attribute (month in this case), as shown on the screen. The tool uses three other parameters as explained below. Users can use the provided default values for these parameters or change them as desired.

Count: A positive number determining the minimum number of values to be in any data subset for the Focused Attribute. For example, if the count is three and a data subset has only two values, that subset will be ignored.

Number of tests in results: A positive number indicating the maximum number of tests performed by the algorithm before concluding the result.

Top unusual distributions: A number determining whether to see only the very unusual distributions or to see the slightly unusual distributions as well. Enter a number between 0 and 1 (exclusive) or a percentage between 0% and 100% (exclusive) in this field. A small number in this field returns only the distributions that are very unusual. A bigger number allows less unusual distributions to be displayed also.

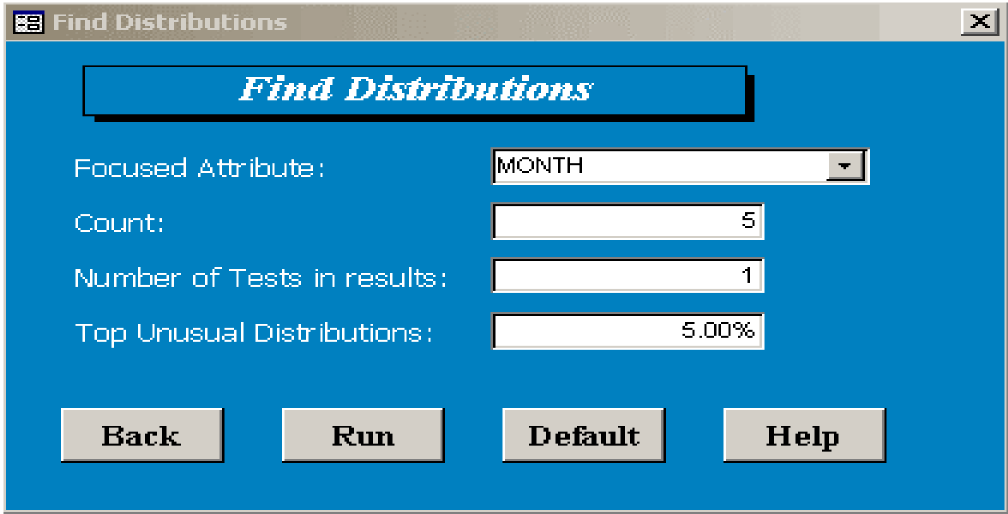


Figure 3 **The *FindDistributions* User Interface Screen**

4 Tool Output

The following are examples of FindSimilar findings. In these examples, altitude deviation reports were selected as the data subset to analyze. The weights in the FindSimilar Weight Set were selected such that only the narratives in the reports are compared for similarity and the other fields are not considered. This is because we were interested in similar causes (described in the narratives) and not, for example, similar flight dates or airports. The following report was selected as the target.

> **text description**: … AIRPORT CLEARANCE TO 7000 FEET AFTER T.O. WE WERE DISTRACTED BY DEPT CONTROL CLEARANCE DIRECT TO A POINT AT LEVEL OFF TIME. FO WAS BUSY ENTERING IN THE BOX AND CA WAS BUSY CHECKING TO SEE WHAT THE FO WAS DOING AND LOOKING OUT THE WINDOW FOR TRAFFIC. A/C WAS FLOWN TO 7400 FEET UNTIL WE DESCENDED BACK DOWN TO 7000 FEET.

Figure 4 **Selected Target Record for the *FindSimilar* Tool**

The target report describes an altitude deviation due to the cockpit crew being busy with other tasks and therefore distracted from monitoring the altitude. The first similar report returned by the tool is shown in Figure 5. This report also describes a similar cause, the cockpit crew being busy and distracted.

> **text description**: … ASSIGNED 11000- AIRCRAFT WENT TO 11-300 DUE TO PF DISTRACTED BY PROBS WITH RADIO. PF WAS HANDFLYING HAD A NEW FO. SHOULD HAVE USED AUTOPILOT TO REDUCE WORKLOAD- BETTER HELP NEW FO.

Figure 5 **First Similar Report Returned by the *FindSimilar* Tool**

Below is another pair of similar altitude deviation reports. Again, the cause of distraction is described as cockpit crew being busy with other routine tasks they have to perform.

text description: …CENTER CLEARED US TO CROSS HANDY INTERSECTION AT FL230 – WE WERE AT FL330 APPROXIMATELY 40 MILES FROM THE FIX WITH A TAILWIND OF 170KTS. I RECOMMENDED THE FO START DOWN WHICH HE DID. I WAS OFF MAKING A PA AND FAILED TO NOTICE THAT THE DESCENT RATE THE FO WAS USING WOULD BE INADEQUATE TO MAKE THE CROSSING. RETURNING TO THE LOOP AFTER MAKING THE PA I NOTICED THAT WE WERE DESCENDING THROUGH FL240 AND WERE AT HANDY INT. WE LEVELED AT FL230 APPROXIMATELY 5 MILES LATE. CENTER QUESTIONED OUR ALTITUDE AT THIS POINT TO WHICH I RESPONDED FL230 WAS ANY DOUBT ABOUT MAKING A CROSSING RESTRICTION TO TELL ME OR TO ASK FOR RELIEF FROM THE CONTROLLER. NO OTHER COMMUNICATION WITH CENTER WAS MADE REGARDING THE MISSED CROSSING AND WE SHORTLY THEREAFTER SWITCHED TO APPROACH CONTROL IN RETROSPECT ESPECIALLY WITH AN INEXPERIENCED FO I SHOULD HAVE WAITED TO MAKE MY PA UNTIL I WAS SURE THAT THE CROSSING RESTRICTION WAS GOING TO BE MADE.

Figure 6 **Target Report for the *FindSimilar* Tool**

text description: …IT WAS THE FIRST OFFICER*S LEG- WHEN ATC GAVE US A PILOT*S DISSCRETION/PD/ FOR DESCENT TO FL 240. AS WE WERE LEVELING AT FL 240- WE WERE GIVEN A CLEARANCE TO CROSS CCT AT FL 200. AS WE LEVELED FL200-ATC GAVE US A CLEARANCE TO CROSS HEHAW AT 11-000. AS WE DESCENDED THROUGH FL200- THE CAPTAIN LEFT THE RADIOS TO MAKE A PA TO THE PASSENGERS. AFTER THE PA WAS COMPLETE AND NEARING HEHAW WE RESET ALTI-METERS FROM 29.92 TO 30.57 IN ADDITION ATC AMENDED OUR CLEARANCE TO MAINTAIN 11-000 AS WE CROSSED HEHAW AT APPROXIMATELY 11-400.

Figure 7 **Similar Report Returned by the *FindSimilar* Tool**

The following are examples of types of findings that could be obtained using the ***FindAssociations*** tool. PLEASE NOTE THAT THE FIELDS AND VALUES IN THESE EXAMPLES ARE NOT BASED ON THE ACTUAL DATA. The actual fields and values are not shown here as they contain data that is proprietary to the partnering airline.

Examples of what the FindAssociations tool could discover are:

- 55% of {event = ALT_DEVIAITON, Aircraft Series = 300} coincide with {phase=APPROACH} (55% of the altitude deviations with 300-series aircraft have occurred during the APPROACH phase of flight)
- 78% of {departure = FLORIDA} coincide with {event = ALT_DEVIATION} (78% of flights departing Florida have had altitude deviation)

The findings might be explained by other facts about the data (such as total number of 300-series aircraft in the airline's fleet, and total number of flights departing Florida in the time period under analysis) and therefore high associations might be expected. It is also possible that the findings don't have an obvious explanation and further investigation might be necessary to determine the cause of high associations. For example, further investigations, focusing on flights departing from Florida in the time period under analysis, might reveal that a certain problem in communication with the tower, certain equipment malfunction in the aircraft, or certain pilot behavior is consistently causing the deviations.

Note that the values in the above findings were not specified by the user ahead of time. For example the user didn't ask for associations between altitude deviations and Florida departures. Only the thresholds are specified by the user. The tool identifies outstanding associations among all values and brings them to the user's attention.

Figure 8 below, indicates an example of the ***FindDistributions*** findings. PLEASE NOTE THAT THE FIELDS AND VALUES IN THE EXAMPLE ARE NOT BASED ON THE ACTUAL DATA. The actual fields and values are not shown here as they contain data that is proprietary to the partnering airline.

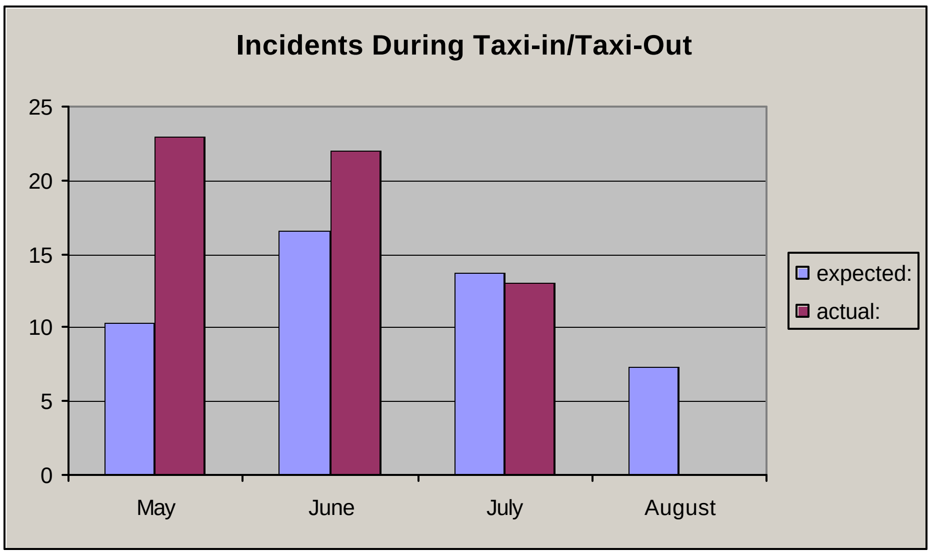


Figure 8 **Output of *FindDistributions* tool**

In the example shown in Figure 8, the field MONTH was selected as the Focused Attribute. The findings returned by the tool were displayed in EXCEL spread sheet from which the graph indicated in Figure 8 was generated. The light-color bars on the graph indicate a pattern based on the distribution of all incidents over the four-month period. This overall distribution is used as the base or expected distribution for any subset of the incidents. The dark-color bars indicate the distribution of a subset of incidents that occurred during the taxi-in or taxi-out phase of flight; it is the actual distribution for this subset. Since actual and expected distributions for the taxiing incidents do not follow the same pattern, the tool has brought it to the user's attention. Why the number of incidents during taxi-in/taxi-out is much higher than expected in the month of May and has gone down to zero in August? Is the total number of flights in these months a factor? Have same airports been flown to and from during the four months under analysis? Have different taxiways been used in the months of July and August? Or has there been a change in the taxiways, policies, or pilot trainings immediately before the month of August? These questions could be investigated further to find the explanation for the unusual increase/decrease of taxiing incidents in these four months. Maybe the identified factors could then be used for further prevention of these incidents.

5 Application of the Analysis Results

The following comments were provided by the partnering airline regarding application of the Data Mining Workbench.

The three tools offer benefits when used independently or in conjunction with each other. The Distributions and Associations tools can provide unexpected correlations that call for further investigation. The distributions in this review showed various apparently sporadic deviations from expected distributions. While such results do highlight a particular area as warranting review, it can be seen as affirming a lack of consistent undetected or unattended to weaknesses. The distribution peaks revealed in this look-back study did relate to specific problem areas that had been recognized and addressed with corrective actions by the Event Review Team. Distribution comparisons over several year periods of data may reveal seasonal factors not otherwise recognized.

The results of the Associations show great promise for application to the broader set of data fields coming with the new reporting system. This should lead to statistical support for relationships between particular errors and related crew and situational factors. Presenting documentation of these associations should assist our operational department managers in identifying and modifying training, procedures, or operating environment to improve performance. The Find Similar tool did provide immediate grouping of reports having similar factors. In seconds it achieved what was previously hours of work to collect reports for study or presentation in support of a risk warning or recommended change to policy.

In short, we are thrilled to have the speed, flexibility, and accuracy of these tools - especially for application on our coming field rich data base of self-reported crew errors and safety concerns. They will greatly enhance our responsiveness to analyze and report significant concerns, deviations, and correlations.

A.9 PolyAnalyst

1 Introduction

1.1 OVERVIEW OF THE TOOL FUNCTIONALITY

Aviation safety experts surmise that accidents are usually a culmination of a series of unsafe events that had gone unnoticed. For every accident and major event report that is thoroughly investigated, there can be 300 incident reports (Heinrich's triangle) that could have contained information about the impending accident. These reports can be in the form of pilot reports, maintenance reports, incident reports or other reports of unsafe occurrences. These safety event reports represent a combination of structured data and free form text narratives stored in a database.

PolyAnalyst™ is a data and text mining system that provides capabilities ranging from data importing, cleansing and manipulation, to visualization, modeling, scoring and reporting. PolyAnalyst can access data stored in major commercial databases and some proprietary data formats (Excel, SAS), as well as popular document formats. It offers a selection of semantic text analysis, clustering, prediction, and classification algorithms, link analysis, transaction analysis, and visualization capabilities. PolyAnalyst can directly access data from any major commercial database through standard OLE DB and ODBC protocols.

Results obtained with PolyAnalyst can provide key insights into happenings in different aviation processes, helping safety officers to:

a) Reveal hidden problem issues (irrespective of data type – structured or unstructured)
b) Generate strategic overview charts for the management across different parameters
c) Identify bottlenecks in processes and highlight quality / supplier related issues.

PolyAnalyst provides a set of tools that can address many analytical tasks that safety officers are facing and can be tailored to a specific application domain. A major portion of the user's involvement is in providing direction to the analysis process and defining their areas of interest. User-defined parameters for running analysis engines are entered in the corresponding dialog boxes.

In more advanced implementations of PolyAnalyst™ on top of the WebAnalyst™ integration platform, power users of the system record reusable analytical scripts for typical data exploration scenarios. Business users then execute these scripts with a push of a button and view resulting reports in preset template format.

1.2 INTRODUCTION TO THE EXAMPLE APPLICATION

This example application illustrates how PolyAnalyst can be applied for the analysis of safety databases containing data in both structured and narrative formats and how it can expedite the process of identifying hidden trouble spots to help improve aviation safety.

The Aviation Safety Reporting System (ASRS) is a cooperative voluntary, confidential and anonymous incident reporting system funded by the FAA and administered by NASA. ASRS receives, processes, and analyzes reports of unsafe occurrences and hazardous situations that are submitted by pilots, air traffic controllers, and others. Information collected by the ASRS is used to identify hazards and safety discrepancies in the National Airspace System. PolyAnalyst has been applied to analyzing ASRS data from the Federal Aviation Administration's (FAA) National Aviation Safety Data Analysis System (NASDAC). The period chosen for the analysis covered October and November of 2001 and included 7,500 records and 61 attributes (including free form text in narrative fields).

2 Input Data

The ASRS data was imported in PolyAnalyst using a built-in Data Import Wizard. To ensure the most explicit interpretation of the results obtained from free text fields, user-made dictionaries of domain-specific synonyms, stop-words that are automatically excluded from further analysis and abbreviation expansions were also imported in the system. Figure 1 shows the data as it appears after being imported into the system. The data contains both structured and narrative fields.

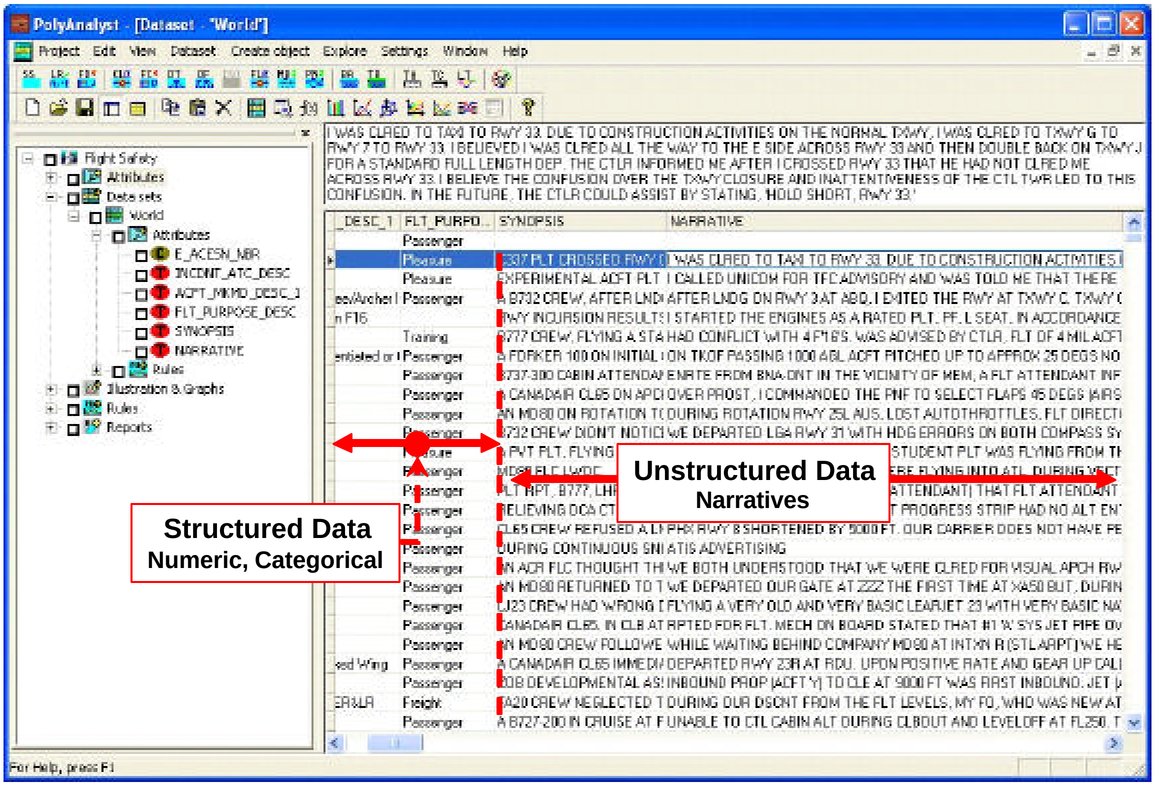


Figure 1 **Snapshot of the Investigated Data**

3 Analytical Process

Broadly, the process of gaining knowledge from narratives involves two main steps: extraction and interpretation of knowledge. The remainder of this example application will primarily concentrate on the analysis of the unstructured portion of ASRS data, as it often contains over 80% of the useful information.

3.1 IDENTIFY AND EXTRACT ALL TERMS OF INTEREST IN NARRATIVES

Figure 2 illustrates simple steps performed by the user to run the PolyAnalyst Text Analysis (TA) engine to identify important concepts being discussed in the narratives. Text analysis can be carried out in two modes:

- Unsupervised TA Mode: In this mode, the TA engine extracts important concepts occurring in the text, delivered by the semantic text analysis algorithm based on an unbiased data-driven analysis of narratives in ASRS data.
- Supervised TA Mode: The user can guide the TA engine to only search and extract concepts of interest to them to better understand particular safety concern issues. For example, by defining the broad concept '*equipment*' the user can force the system to return a list of all equipment or

device results like '*radar*', '*horn*', '*pump*', '*valve*' and '*rudder*' that have been mentioned in the narrative.

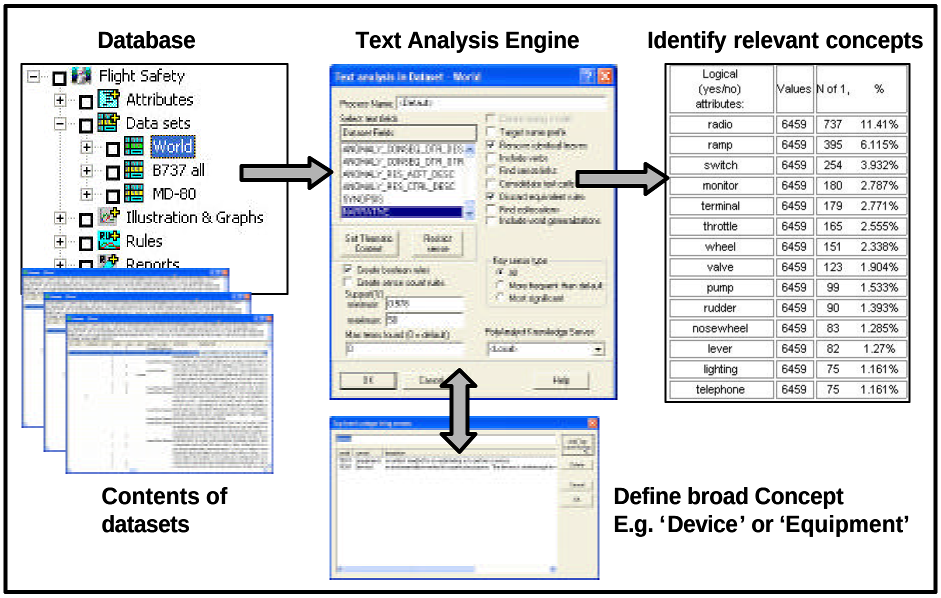


Figure 2 **Automated Text Analysis Exploration**

Once the main terms are extracted, the user becomes able to either simply export the concepts to a Microsoft Excel sheet or conduct further advanced analysis and visualization within PolyAnalyst.

3.2 GENERATE ACTIONABLE REPORTS FOR MANAGEMENT

The system incorporates different visualization techniques that enable the user to generate explicit and actionable results. Figure 3 illustrates two visualization graphs the user can employ to better understand patterns of terms and relations between them that had been identified in the previous step.

The Snake Chart provides a comparative overview of concepts across different business entities. For example, Flight Safety Officers (FSOs) can quickly compare relative frequencies of various pieces of equipment being mentioned in ASRS narratives across different aircraft types. The Link Terms engine conducts 'n-dimensional' correlation analysis and visual layout of the results to help reveal close associations and patterns of terms in the data. It can help FSO reveal interesting patterns of terms occurring together in ASRS narratives for further in-depth investigation.

In addition to the above two processes, PolyAnalyst provides numerous other analysis and visualization capabilities and scenarios based on the needs and desires of the analyst. Overall, it offers sixteen different analytical engines and a few dozen visualization techniques that can be used either independently or sequentially to derive new knowledge from data. This broad range of analytical engines also allows the user to conduct the analysis irrespective of the type of data (Numeric, Boolean, Categorical or Textual).

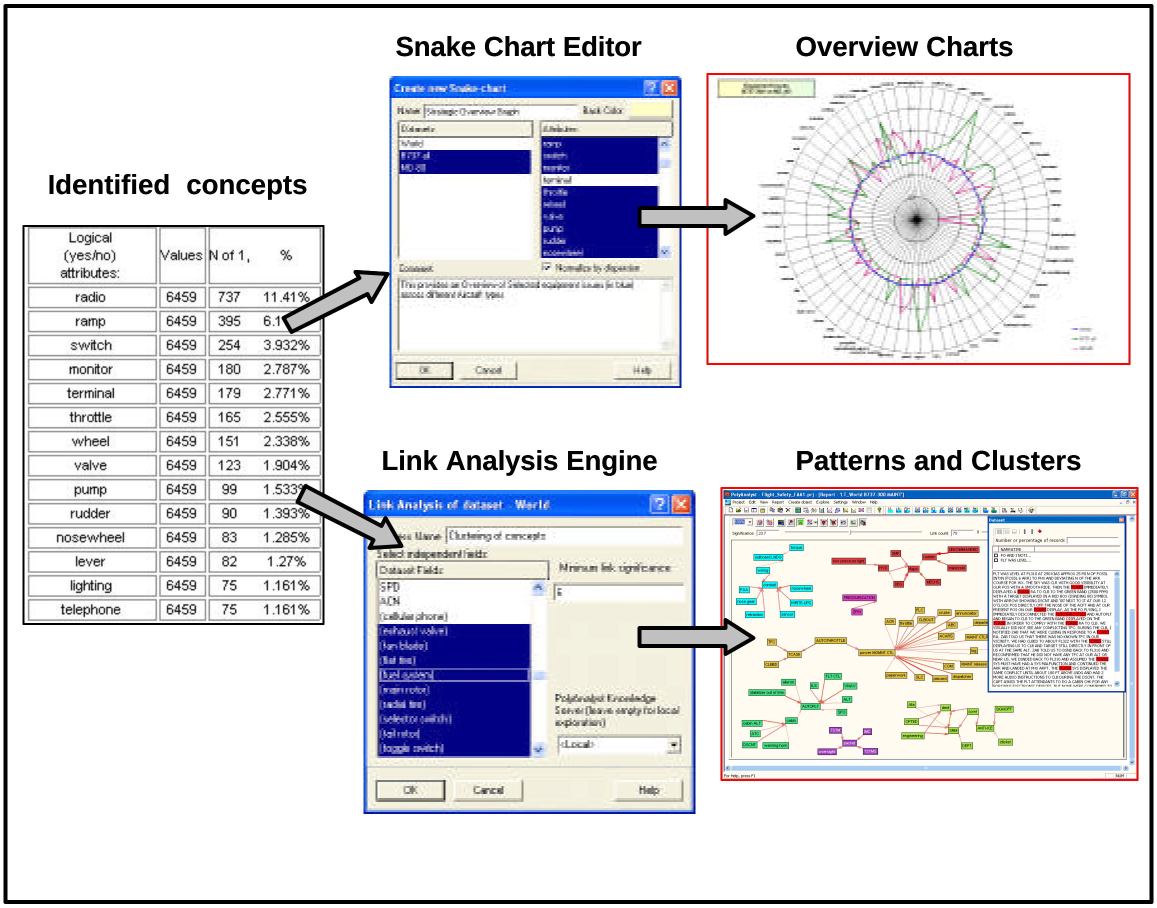


Figure 3 **Possible Steps of Typical Data Analysis Scenarios**

4 Tool Output

4.1 INTELLIGENT TEXT ANALYSIS

An example of supervised analysis would be to identify only equipment related issues mentioned by in ASRS narratives. For this example PolyAnalyst was instructed to focus on the specific concept of "equipment" and "device." Being instructed to focus on specific concepts ('*equipment*' and '*device*' in this project), the Text Analysis (TA) engine sifts through the entire Narrative portion of the database and automatically returns concepts like '*radio*', '*switch*', '*brakes*', and '*nosewheel*'. Figure 4 pictorially presents this process of intelligently extracting chosen categories of concepts (in this case, *Equipment*).

Note that the system is smart enough to understand the '*equipment*' query and then identify all related words and phrases. The system enables specific user-desired charts and visualizations.

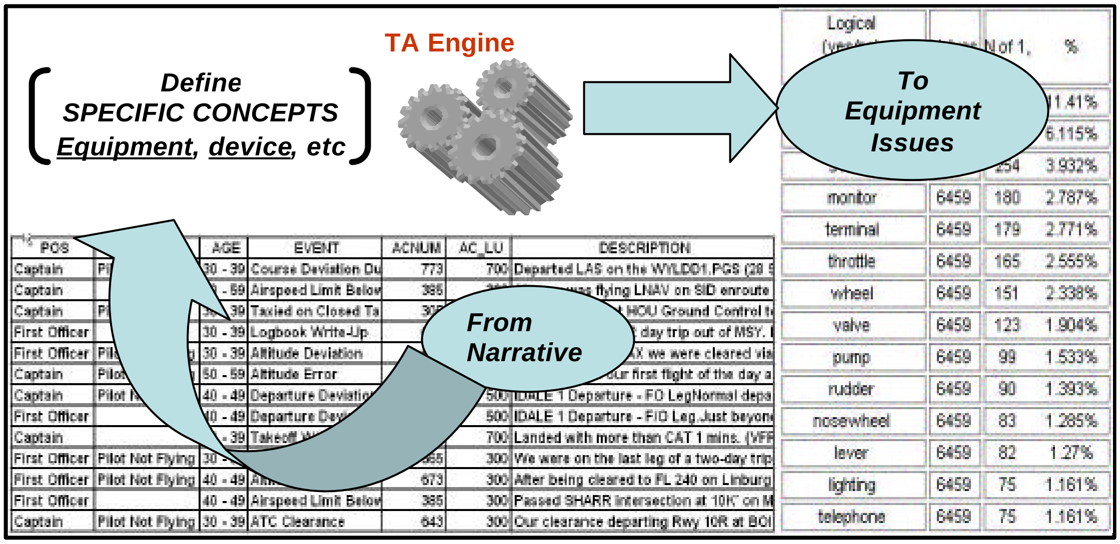


Figure 4 **Process of Searching for Specific Concepts**

4.2 GAIN STRATEGIC INSIGHT

Airline managers seek better understanding of how safety issues differ across various attributes such as flight phase, time of day, and aircraft type. For example, Figure 5 below shows how individual '*Equipment*' concerns (identified by the TA engine, as illustrated in Figure 4 above) can be compared across different aircraft types, in this case – B737 and MD-80.

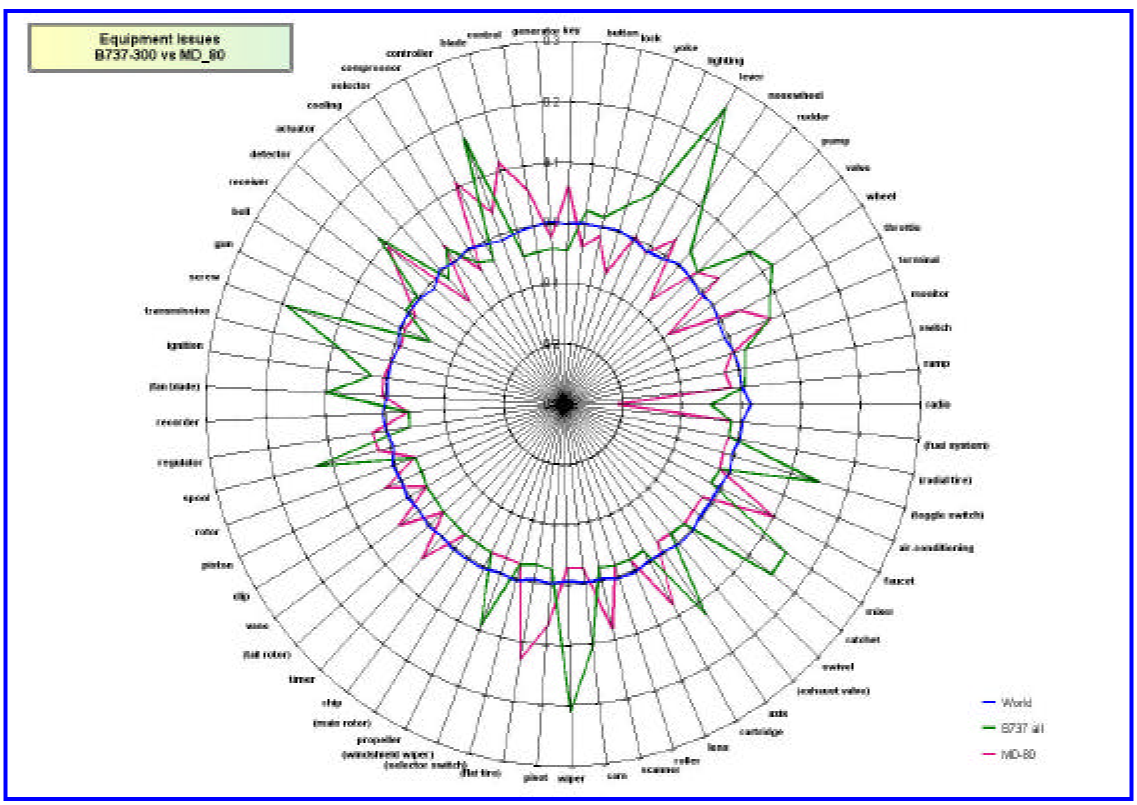


Figure 5 **Compare Relative Importance of Equipment-Related Issues Across Different Aircraft Types**

The blue line represents an overall average frequency occurrence across all aircraft (World data set contains all incident reports). Green and pink lines represent relative frequencies of 'Equipment' concerns for B737 and MD-80 compared to their overall background. The spikes indicate that the occurrence of these terms is relatively more frequent than average. For example, B737 (green line) has issues related to '*screw*', '*controller*', '*lever*', '*toggle switch*', '*wiper*' and '*spool*' while MD-80 (pink line) has issues related to *'flat tire'*, *'blade'*, *'receiver'*, *'faucet'*, etc.

The user can drill down on a chosen concept, say '*lever*' issue associated with Boeing 737 to view the associated records with the concept of interest highlighted in original narratives.

4.3 IDENTIFY HIGH CORRELATION ENTITIES

Calculating and visualizing mutual correlations of attribute values, one gains knowledge of stable patterns of co-occurrences of different values of individual attributes. Figure 6 suggests a quick way to view the most important correlations between items of interest, and determine if terms derived from the narratives have a high correlation with specific aircraft types.

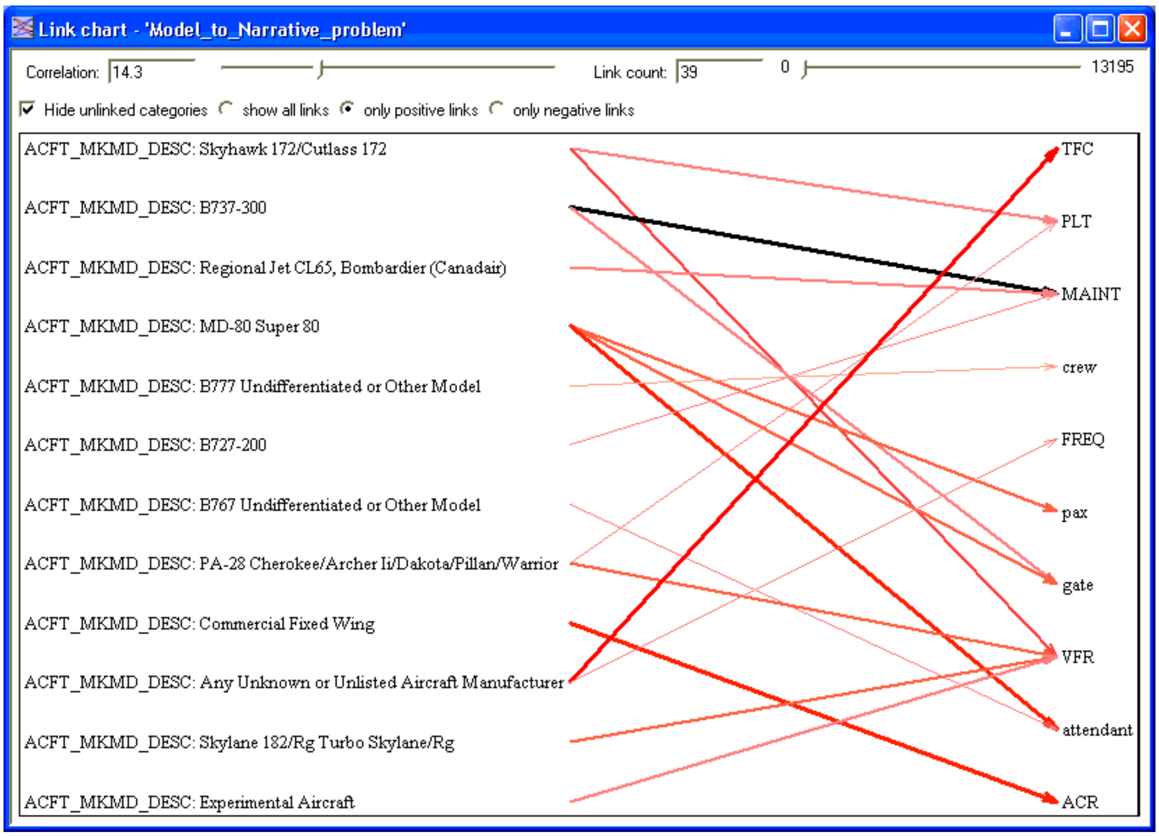


Figure 6 **Correlations between Aircraft Type and Pilot Concerns Extracted from Free Text Narratives**

The intensity of the line is a measure of the strength of the corresponding correlation. The user can infer that *B737-300, B727-200 and Regional Jet CL65* aircraft types (on the left side) have high correlations with the term *'MAINT'* identified in the narrative (right side of the Link Chart). Another inference from the above chart could be the high correlation of the concepts *'pax'*, *'gate'* and *'attendant'* to *MD-80 Super 80* aircraft type. Note that the user can easily visualize correlations between important items from both structured and unstructured parts of the database.

4.4 IDENTIFY PATTERNS OF CONCERNS

An ability to capture stable patterns of terms derived from analysis of unstructured data can provide valuable insights for quick comprehension of past experience and save time of an FSO for more advanced analysis. PolyAnalyst Link Terms engine can be used to reveal clusters of terms from the narrative portion of ASRS reports. Figure 7 displays the discovered patterns of terms and relations between them.

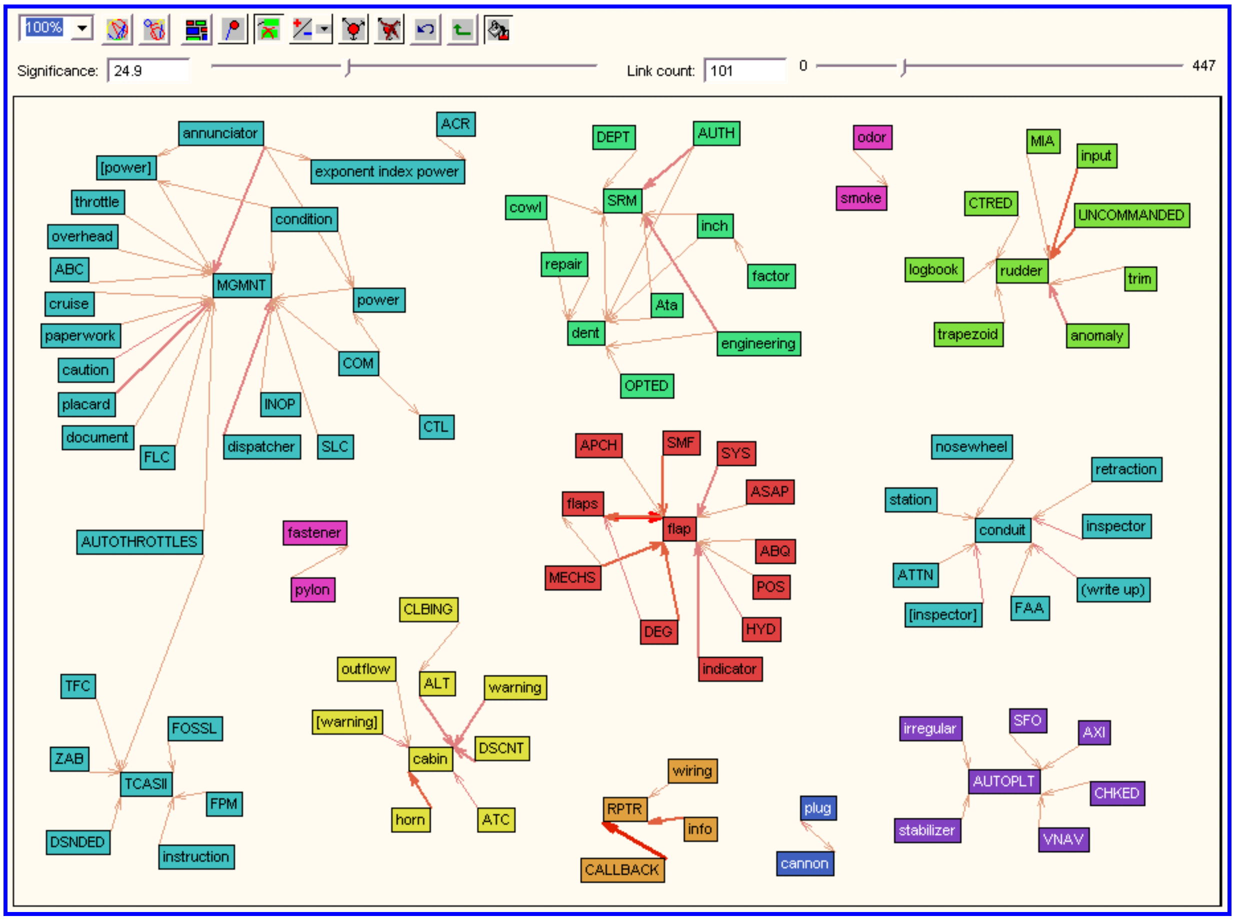


Figure 7 **Discovered Patterns of Terms and their Relationships Derived from ASRS Narratives**

Link Terms produced ten clusters, each denoted by a different color. These clusters now prompt the user to further investigate the relationships and ask questions such as:

- Why is 'Rudder' highly correlated with 'UNCOMMANDED', 'trim', 'trapezoid', 'anomaly' and 'logbook' (cluster shown in light green)?

This can be accomplished by drilling down into the corresponding reports. Figure 8 presents the results of drilling down on the *'UNCOMMANDED'* <--> *'rudder'* link from the "rudder" (light green) cluster of the above Link Terms diagram, thus giving an analyst the ability to quickly verify significance of patterns of interest.

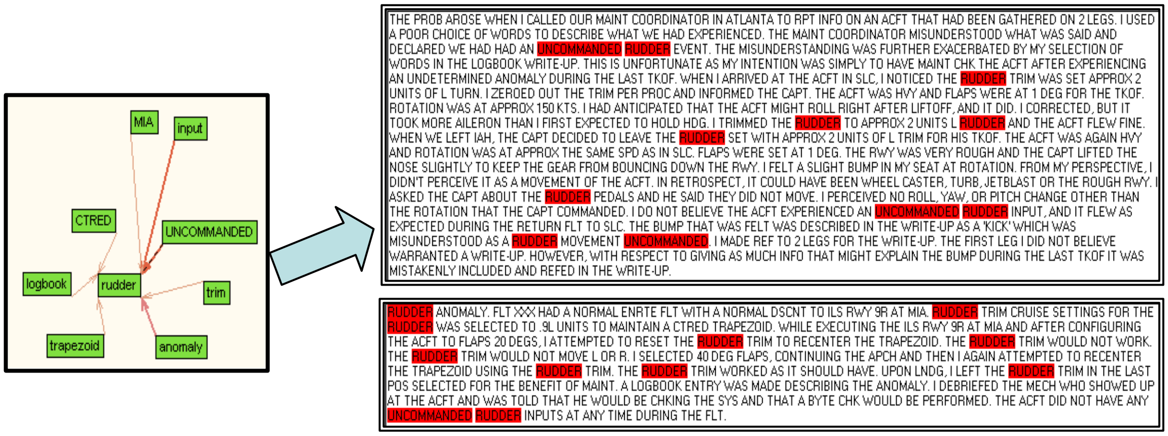


Figure 8 **Example of Drill-Down Capability of Link Term Cluster**

The number of ASRS reports may increase over time causing the relevance of concepts to change too. Correspondingly, Link Terms diagrams calculated sequentially can serve as a valuable tool for knowing whether there are changing patterns as time progresses.

5 Application of the Analysis Results

The outputs of the link analysis and snake charts deliver explicit and actionable results that can be used by the safety manager to rectify observed anomalies. The results can be further investigated and manipulated within the system and exported in a report, while the discovered predictive models can be scheduled for online execution or applied to data in the original database to store the predicted outcome of future situations.

This example application outlined just a few standard scenarios for safety data analysis that can be performed with the help of PolyAnalyst. The example demonstrated that a synergetic combination of automated text analysis and visual presentation of discovered clusters and correlations can significantly reduce the latency and bias of the analysis, automate the most time-intensive operations and increase the thoroughness and quality of the results.

Appendix B

Capabilities and Features of Flight Safety Event Reporting and Analysis Systems

This appendix contains detailed information on capabilities and features of the six Flight Safety Event Reporting and Analysis Systems contained in section 3.0 of this guide. The appendix contains a table for each system. An "X" in the column labeled "Available" indicates that the system has that particular capability or feature. Contact information for the individual who supplied the information to WG B is contained at the end of each table.

The reader should note that the information on the Flight Safety Event Reporting and Analysis Systems contained in this appendix was provided by the pertinent system developer or vendor without further verification by WG B.

Aeronautical Events Reports Organizer (AERO)
Version 1.0

Capability/Feature	Available	Comments
1. Report Storage and Management		
1.1 Data base can accommodate:		
1.1a Flight safety reports	X	
1.1b Human factors reports	X	
1.1c Cabin safety reports	X	
1.1d Ground handling incidents	X	
1.1e Quality deficiencies or improvements	X	
1.2 Text (narrative) fields available	X	
1.3 Customization of input screens		
1.4 Standard drop-down categories available for data entry (e.g. event type, phase of flight)	X	
1.5 Definitions built into system	X	
1.6 Examples built into system		
1.7 Predefined keywords		*No need for key words*
1.8 Data de-identification capability	X	
1.9 Capability to attach pictures and voice	X	*And QuickTime movies*
2. Action Assignment and Monitoring		
2.1 Records recommendations for corrective and preventative action	X	
2.2 Tracks corrective and preventative actions taken	X	
2.3 Automatic flagging and monitoring of items due	X	
3. Analysis Capabilities		
3.1 Trending	X	
3.2 Statistical analysis	X	
3.3 Graphics	X	
3.3a Drill-down capability to underlying data		
3.4 Risk Assessment	X	
3.5 Filtering	X	
3.6 Outlier analysis		
3.7 Rate information (e.g. events per X No. of Ops)	X	
3.8 Calculates incident costs		
4. Report Generation and Querying		
4.1 Automated report generation	X	
4.2 Customizable outputs (reports, graphs)	X	*Graphs*
4.3 Ad hoc query support	X	
4.4 Stores results of queries for future use	X	
4.5 Generation of reply letters to initiator of report	X	
4.6 Exports results to other systems/tools	X	

Aeronautical Events Reports Organizer (AERO)
Version 1.0

Capability/Feature	Available	Comments
5. System Features		
5.1 Operating system requirements	X	*Mac OS or Windows 9x*
5.2 Security features available	X	
5.2a Different levels of security available	X	
5.2b User configurable security	X	
5.3 Help feature available	X	
5.4 Tutorial available		*Will be available soon*
5.5 Search capability		
5.6 Web interface (Intranet/Internet accessible)	X	*Reporting via Internet / Automatic data entry*
5.7 Data encryption	X	
5.8 Capacity (maximum # of records)	X	*Limited by file size to 2 gigabytes (many thousand records)*
6. Support		
6.1 Ongoing development	X	
6.2 Maintenance support	X	
6.3 Training provided	X	
6.4 Help Desk (both telephone and e-mail)	X	
6.5 Web site	X	
6.6 Periodic customer conference (how often)		*www.aerocan.com*
7. Data Exchange Capability		
7.1 Within organization	X	
7.2 Outside organization	X	

Information Provided By:

Rene Dacier
Videotron
Email: dacier@videotron.ca

Aviation Quality Database (AQD)
Version 4.0

Capability/Feature	Available	Comments
1. Report Storage and Management		
1.1 Data base can accommodate:		
1.1a Flight safety reports	X	
1.1b Human factors reports	X	
1.1c Cabin safety reports	X	
1.1d Ground handling incidents	X	
1.1e Quality deficiencies or improvements	X	
1.2 Text (narrative) fields available	X	
1.3 Customization of input screens	X	
1.4 Standard drop-down categories available for data entry (e.g. event type, phase of flight)	X	*Customisable*
1.5 Definitions built into system	X	*The Help contains definitions, but as the system is fully customizable in terms of keywords, casual factors, etc., organizations will need to develop their own definitions if they move away from the standard codes supplied*
1.6 Examples built into system	X	*A separate training version of the system is supplied with sample data*
1.7 Predefined keywords	X	*Available on request; based on the NZ CAA codes*
1.8 Data de-identification capability	X	*Via Secured fields*
1.9 Capability to attach pictures and voice	X	*Against Occurrences, Investigations, Findings and Actions*
2. Action Assignment and Monitoring		
2.1 Records recommendations for corrective and preventative action	X	
2.2 Tracks corrective and preventative actions taken	X	
2.3 Automatic flagging and monitoring of items due	X	*Automatic in the sense that reports are available, but these must be manually requested*
3. Analysis Capabilities		
3.1 Trending	X	*A number of standard facilities are available*
3.2 Statistical analysis	X	*A number of standard facilities are available*
3.3 Graphics		
3.3a Drill-down capability to underlying data	X	*Not directly at present, but can be achieved via other means*
3.4 Risk Assessment	X	
3.5 Filtering	X	
3.6 Outlier analysis		
3.7 Rate information (e.g. events per X No. of Ops)	X	
3.8 Calculates incident costs	X	*Allows costs to be entered and analyzed*

Aviation Quality Database (AQD)
Version 4.0

Capability/Feature	Available	Comments
4. Report Generation and Querying		
4.1 Automated report generation	X	
4.2 Customizable outputs (reports, graphs)	X	*Via a separate Access database; can be supplied by Superstructure or done in-house*
4.3 Ad hoc query support	X	
4.4 Stores results of queries for future use	X	*Some facilities store the query/report definition for future reuse; all query results can be stored by exporting to Excel*
4.5 Generation of reply letters to initiator of report	X	
4.6 Exports results to other systems/tools	X	*Excel*
5. System Features		
5.1 Operating system requirements		*Win 98, Win NT, Win 2000, Win XP*
5.2 Security features available		
5.2a Different levels of security available	X	
5.2b User configurable security	X	
5.3 Help feature available	X	*Plus Users Guide*
5.4 Tutorial available		*A full training database is supplied with sample data but no tutorial per se*
5.5 Search capability	X	
5.6 Web interface (Intranet/Internet accessible)	X	*For the submission of Occurrence Reports only.*
5.7 Data encryption		*Web Interface data is encrypted, but not the standard database.*
5.8 Capacity (maximum # of records)	Unlimited	*Depends on which database option selected – SQL Server and Oracle for all intents and purposes is unlimited; Microsoft Access has a maximum of 2GB*
6. Support		
6.1 Ongoing development	X	
6.2 Maintenance support	X	
6.3 Training provided	X	
6.4 Help Desk (both telephone and e-mail)	X	
6.5 Web site	X	*Under development – will eventually contain a user group forum, but currently has monthly newsletters and other info.*
6.6 Periodic customer conference (how often)	X	*Annually*
7. Data Exchange Capability		
7.1 Within organization		
7.2 Outside organization		*Under development (via STEADES)*

Information Provided By:

Sue Glyde
Superstructure
Telephone: +644 570 1694
Email: sue@superstructure.co.nz

AVSiS
Version 2.0

Capability/Feature	Available	Comments
1. Report Storage and Management		
1.1 Data base can accommodate:		
1.1a Flight safety reports	X	
1.1b Human factors reports	X	*Human factors are selected from a list; can elaborate in a text box*
1.1c Cabin safety reports	X	
1.1d Ground handling incidents	X	
1.1e Quality deficiencies or improvements		*Planned*
1.2 Text (narrative) fields available	X	
1.3 Customization of input screens		
1.4 Standard drop-down categories available for data entry (e.g. event type, phase of flight)	X	
1.5 Definitions built into system	X	
1.6 Examples built into system	X	*In the manual*
1.7 Predefined keywords	X	
1.8 Data de-identification capability		*Not required*
1.9 Capability to attach pictures and voice	X	
2. Action Assignment and Monitoring		
2.1 Records recommendations for corrective and preventative action	X	
2.2 Tracks corrective and preventative actions taken	X	
2.3 Automatic flagging and monitoring of items due	X	*Need to run a report; automatic planned*
3. Analysis Capabilities		
3.1 Trending	X	
3.2 Statistical analysis	X	Using optional Data Mining tools by Mitre
3.3 Graphics	X	
3.3a Drill-down capability to underlying data	X	
3.4 Risk Assessment	X	
3.5 Filtering	X	
3.6 Outlier analysis	X	
3.7 Rate information (e.g. events per X No. of Ops)	X	Using optional Data Mining tools by Mitre
3.8 Calculates incident costs	X	
4. Report Generation and Querying		
4.1 Automated report generation	X	
4.2 Customizable outputs (reports, graphs)	X	*Query Builder – retrieve data, then use another program (e.g. Excel)*
4.3 Ad hoc query support	X	
4.4 Stores results of queries for future use	X	
4.5 Generation of reply letters to initiator of report	X	
4.6 Exports results to other systems/tools	X	

AVSiS
Version 2.0

Capability/Feature	Available	Comments
5. System Features		
5.1 Operating system requirements	X	*Windows 95, 98, 2000, NT, XP*
5.2 Security features available		
5.2a Different levels of security available	X	
5.2b User configurable security	X	*Full flexibility – highly secure*
5.3 Help feature available	X	
5.4 Tutorial available	X	
5.5 Search capability	X	
5.6 Web interface (Intranet/Internet accessible)	X	*For reporting and remote use*
5.7 Data encryption	X	*High level of security, only authorized users may view*
5.8 Capacity (maximum # of records)		*No practical limit*
6. Support		
6.1 Ongoing development	X	
6.2 Maintenance support	X	
6.3 Training provided	X	
6.4 Help Desk (both telephone and e-mail)	X	
6.5 Web site	X	
6.6 Periodic customer conference (how often)	X	*Informal at this stage*
7. Data Exchange Capability		
7.1 Within organization	X	*Via AvShare or LAN / WAN*
7.2 Outside organization	X	*Via AvShare*

Information Provided By:
Tim Fuller
AvSoft Ltd
Telephone: +44 1788 540 898
Email: tfuller@avsoft.co.uk

British Airways Safety Information System (BASIS)
WinBASIS version

Capability/Feature	Available	Comments
1. Report Storage and Management		
1.1 Data base can accommodate:		
1.1a Flight safety reports	X	*Can also accommodate reporting of employee accidents and injuries in the workplace*
1.1b Human factors reports	X	
1.1c Cabin safety reports	X	
1.1d Ground handling incidents	X	
1.1e Quality deficiencies or improvements	X	
1.2 Text (narrative) fields available	X	
1.3 Customization of input screens	X	*Careful balance is maintained between customization and standardization in order to usefully share safety information*
1.4 Standard drop-down categories available for data entry (e.g. event type, phase of flight)	X	
1.5 Definitions built into system	X	
1.6 Examples built into system	X	*Examples built into demonstration system. Standard events can be defined for ease of data capture*
1.7 Predefined keywords	X	*This is a major feature of BASIS and enables comprehensive filtering, analysis, and sharing of information*
1.8 Data de-identification capability	X	*Multi-level security access levels protects information; lower levels can only see selected information*
1.9 Capability to attach pictures and voice	X	
2. Action Assignment and Monitoring		
2.1 Records recommendations for corrective and preventative action	X	
2.2 Tracks corrective and preventative actions taken	X	
2.3 Automatic flagging and monitoring of items due	X	
3. Analysis Capabilities		
3.1 Trending	X	
3.2 Statistical analysis	X	
3.3 Graphics		
3.3a Drill-down capability to underlying data	X	
3.4 Risk Assessment	X	*Risk assessment matrix helps assign risk so that trends in the total risk can be monitored*
3.5 Filtering	X	
3.6 Outlier analysis		
3.7 Rate information (e.g. events per X No. of Ops)		*Rate information needs to be treated with extreme caution, as consistent reporting of incidents is difficult to achieve. Data can be exported to a spreadsheet to enable rates to be created if desired*
3.8 Calculates incident costs	X	*This is an optional feature which is particularly useful in Ground Handling Incidents where damage o an aircraft is involved*

British Airways Safety Information System (BASIS)
WinBASIS version

Capability/Feature	Available	Comments
4. Report Generation and Querying		
4.1 Automated report generation	X	
4.2 Customizable outputs (reports, graphs)	X	
4.3 Ad hoc query support	X	
4.4 Stores results of queries for future use	X	
4.5 Generation of reply letters to initiator of report	X	
4.6 Exports results to other systems/tools	X	
5. System Features		
5.1 Operating system requirements		*Can run on a standard modern PC and server*
5.2 Security features available		
5.2a Different levels of security available	X	
5.2b User configurable security	X	
5.3 Help feature available	X	
5.4 Tutorial available	X	
5.5 Search capability	X	
5.6 Web interface (Intranet/Internet accessible)		*Incorporated in the new eBASIS Version*
5.7 Data encryption	X	
5.8 Capacity (maximum # of records)		*Depends on the size of attachments; capable of handling all British Airways data*
6. Support		
6.1 Ongoing development	X	*Enhancements and upgrades regularly available*
6.2 Maintenance support	X	
6.3 Training provided	X	
6.4 Help Desk (both telephone and e-mail)	X	
6.5 Web site	X	
6.6 Periodic customer conference (how often)	X	*Every 12-18 months*
7. Data Exchange Capability		
7.1 Within organization	X	
7.2 Outside organization		

Information Provided By:

Eddie Rogan
British Airways
Telephone: +44 (0) 208 513 0225
Email:eddie.1.rogan@britishairways.com

First Launch Safety Report System

Capability/Feature	Available	Comments
1. Report Storage and Management		
1.1 Data base can accommodate:		
1.1a Flight safety reports	X	*Can also accommodate reporting of employee accidents and injuries in the workplace*
1.1b Human factors reports	X	
1.1c Cabin safety reports	X	
1.1d Ground handling incidents	X	
1.1e Quality deficiencies or improvements	X	*with ORB management*
1.2 Text (narrative) fields available	X	
1.3 Customization of input screens	X	*Input screens are customized to clients specific reporting requirements*
1.4 Standard drop-down categories available for data entry (e.g. event type, phase of flight)	X	
1.5 Definitions built into system	X	
1.6 Examples built into system		*Included in user documentation*
1.7 Predefined keywords		
1.8 Data de-identification capability		
1.9 Capability to attach pictures and voice		
2. Action Assignment and Monitoring		
2.1 Records recommendations for corrective and preventative action	X	
2.2 Tracks corrective and preventative actions taken	X	*With Occurrence review Board action and meeting minutes management.*
2.3 Automatic flagging and monitoring of items due	X	*With Occurrence review Board action and meeting minutes management.*
3. Analysis Capabilities		
3.1 Trending		*Ask for details*
3.2 Statistical analysis		
3.3 Graphics		
3.3a Drill-down capability to underlying data		
3.4 Risk Assessment		
3.5 Filtering		
3.6 Outlier analysis		
3.7 Rate information (e.g. events per X No. of Ops)		
3.8 Calculates incident costs		

First Launch Safety Report System

Capability/Feature	Available	Comments
4. Report Generation and Querying		
4.1 Automated report generation	X	
4.2 Customizable outputs (reports, graphs)	X	
4.3 Ad hoc query support		
4.4 Stores results of queries for future use		
4.5 Generation of reply letters to initiator of report	X	
4.6 Exports results to other systems/tools	X	*Reports are exported to WinBASIS*
5. System Features		
5.1 Operating system requirements	X	*Can run on a standard modern PC and server*
5.2 Security features available		
5.2a Different levels of security available	X	
5.2b User configurable security	X	
5.3 Help feature available	X	
5.4 Tutorial available	X	
5.5 Search capability		
5.6 Web interface (Intranet/Internet accessible)	X	*With Citrix*
5.7 Data encryption	X	
5.8 Capacity (maximum # of records)		*Depends on the database being used*
6. Support		
6.1 Ongoing development	X	*Enhancements and upgrades regularly available*
6.2 Maintenance support	X	
6.3 Training provided	X	
6.4 Help Desk (both telephone and e-mail)	X	
6.5 Web site	X	
6.6 Periodic customer conference (how often)		
7. Data Exchange Capability		
7.1 Within organization	X	*Interfaces to local email system for report notification. Interfaces to other safety management systems available. Bespoke interfaces to Engineering systems available. Please ask for details.*
7.2 Outside organization	X	*Email notification of new reports internally, as well as externally for MOR reports to local CAA.*

Information Provided By:

Simon Earthrowl
First Launch
Telephone: +44 (0) 1293 562778
Email: Simon.Earthrowl@FirstLaunch.co.uk

INDICATE Safety Program
Version 6.3

Capability/Feature	Available	Comments
1. Report Storage and Management		
1.1 Data base can accommodate:		*INDICATE can accommodate any of these types of reports and more. It depends entirely on how a company chooses to structure the database. While the database is intended primarily to be used in a proactive sense, it can, and is being used as a database to record accidents and incidents*
1.1a Flight safety reports	X	
1.1b Human factors reports	X	
1.1c Cabin safety reports	X	
1.1d Ground handling incidents	X	
1.1e Quality deficiencies or improvements	X	
1.2 Text (narrative) fields available	X	
1.3 Customization of input screens	X	*In un-secure version only (the un-secure version allows a user to gain access to the underlying coding in order to customize the program)*
1.4 Standard drop-down categories available for data entry (e.g. event type, phase of flight)		
1.5 Definitions built into system	X	*Some definitions including Outcomes, Hazards, and Defenses. Any other relevant definitions can be found in either the Implementation Manual or the Software Manual*
1.6 Examples built into system		
1.7 Predefined keywords	X	
1.8 Data de-identification capability		
1.9 Capability to attach pictures and voice		
2. Action Assignment and Monitoring		
2.1 Records recommendations for corrective and preventative action	X	
2.2 Tracks corrective and preventative actions taken		*Not tracked automatically. It is the Safety Manager's responsibility to follow up and then input progress against a recommendation/corrective action into database*
2.3 Automatic flagging and monitoring of items due		

INDICATE Safety Program
Version 6.3

Capability/Feature	Available	Comments
3. Analysis Capabilities		
3.1 Trending	X	*Limited capability through graphical presentation of information*
3.2 Statistical analysis		
3.3 Graphics		
3.3a Drill-down capability to underlying data		
3.4 Risk Assessment		*Assessment made by Safety Manager, then entered into database*
3.5 Filtering	X	*Keyword filter and filtering to create specific reports/graphs*
3.6 Outlier analysis		
3.7 Rate information (e.g. events per X No. of Ops)		
3.8 Calculates incident costs		
4. Report Generation and Querying		
4.1 Automated report generation	X	
4.2 Customizable outputs (reports, graphs)	X	*Limited capacity – can generate 4 reports types and 2 graph types in relation to matters such as areas of responsibility, Hazards, Vehicle IDs, Defense types, months/years, etc*
4.3 Ad hoc query support		
4.4 Stores results of queries for future use		
4.5 Generation of reply letters to initiator of report		
4.6 Exports results to other systems/tools		
5. System Features		
5.1 Operating system requirements	X	*Minimum requirements – IBM compatible computer, 486 CPU or better, Win 95/98 or Win NT 3.51, 32MB RAM for Windows 95/98, 64 MB RAM for Windows NT, 60 MB free hard disk space, 800x600/256 color screen resolution, laser or ink/bubble jet 300 dpi printer, CDROM drive*
5.2 Security features available		
5.2a Different levels of security available	X	*Limited capacity – 2 levels only; user can not create new levels of security*
5.2b User configurable security		
5.3 Help feature available		
5.4 Tutorial available		*Within software manual*
5.5 Search capability	X	
5.6 Web interface (Intranet/Internet accessible)		
5.7 Data encryption		
5.8 Capacity (maximum # of records)		*Not known*

INDICATE Safety Program
Version 6.3

Capability/Feature	Available	Comments
6. Support		
6.1 Ongoing development		
6.2 Maintenance support	X	*Through Web site and direct (e-mail or phone)*
6.3 Training provided	X	*Ad-hoc on request – generally informal*
6.4 Help Desk (both telephone and e-mail)	X	*Through Web site and direct (e-mail or phone)*
6.5 Web site	X	
6.6 Periodic customer conference (how often)		
7. Data Exchange Capability		
7.1 Within organization	X	*Can be networked*
7.2 Outside organization		

Information Provided By:

Ted Smith
Team Leader, Safety Support
Australian Transport Safety Bureau (ATSB)
Phone: 1-800-621-372
Email: atsbinfo@atsb.gov.au

Appendix C

Capabilities and Features of Flight Data Monitoring Analysis and Visualization Tools

This appendix contains detailed information on capabilities and features of nine of the fourteen FOQA/Digital Flight Data Analysis tools contained in section 4.0 of this guide, based on information that was received from system developers and vendors. Capabilities and features information is presented in table format. An "X" in the column labeled "Available" indicates that the tool has that particular capability or feature. Contact information for the person who supplied the information to WG B is contained at the end of each table.

The reader should note that the information on the Flight Data Monitoring Analysis and Visualization Tools contained in this appendix was provided by the pertinent system developer or vendor without further verification by WG B.

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Aircraft Flight Analysis & Safety Explorer (AirFASE)

Capability/Feature	Available	Comments
1. Data Storage and Management		
1.1 Accepts data in multiple formats	X	
1.2 Capability to filter and sort events by type, date, aircraft type, or other criteria	X	
1.3 Stores events within context of preceding and succeeding timeframes	X	
1.4 Easily add fleet types and event and measurement definitions	X	
1.5 Data de-identification capability	X	
1.6 Airport/Aircraft libraries available	X	
1.7 Stores raw data (typically de-identified)	X	
1.8 Exports data to external tools (e.g. simulations)	X	*Text file with Excel format.*
2. Monitoring and Analysis Capabilities		
2.1 Automatic event detection (operation of an aircraft that is unusual or beyond established limits)	X	*A standard set of verified event detections are furnished with the system. Tools are included to modify or to create additional event detection functions by the user.*
2.2 Flight efficiency monitoring (calculates operational costs of aircraft, fuel burn, and flight time)	X	*Reports fuel burn for each engine.*
2.3 Performs statistical analysis	X	
2.4 Provides graphical analysis of flight parameters	X	
2.5 Identifies trends	X	
2.6 Provides flight data replay	X	
2.7 Flight animation capabilities	X	
3. Report Generation and Querying		
3.1 Automated report generation	X	
3.2 Customized outputs (reports, graphs)	X	
3.3 Ad hoc query support	X	
3.4 Stores results of queries for future use		
3.5 Exports analysis results to other systems/tools (e.g. Microsoft Office products)	X	
3.6 Accepts custom user displays		
4. System Features		
4.1 Operating system requirements	X	*Windows XP, Windows2000*
4.2 User configuration outputs (reports, Graphs)	X	
4.3 Capacity – accommodates large amount of data	X	
4.4 Supports any fleet size	X	
4.5 Supports multi-user applications	X	
4.6 Help feature available	X	
4.7 Tutorial available	X	*Bi-annual training classes at Teledyne & at Airbus.*
4.8 Data encryption		

Aircraft Flight Analysis & Safety Explorer (AirFASE)

Capability/Feature	Available	Comments
5. Support		
5.1 Ongoing development	X	
5.2 Maintenance support	X	
5.3 Training provided	X	
5.4 Help Desk (both telephone and e-mail)	X	
5.5 Web site	X	
5.6 Periodic customer conference (how often)	X	*Annul users conference at Airbus & Teledyne.*

Information Provided By:
Tamas Igloi
Director, Advanced Programs
Teledyne Controls
Telephone: 310-442-4217
Email: tigloi@teledyne.com

Analysis Ground Station (AGS) Version 8.0

Capability/Feature	Available	Comments
1. Data Storage and Management		
1.1 Accepts data in multiple formats	X	*Can read data from every civil aircraft/recorder model.*
1.2 Capability to filter and sort events by type, date, aircraft type, or other criteria	X	*Unlimited*
1.3 Stores events within context of preceding and succeeding timeframes		*A duration can be associated to an event. Value of the parameters can be stored over a time period.*
1.4 Easily add fleet types and event and measurement definitions	X	*Full programming language included.*
1.5 Data de-identification capability	X	*Compress/password protected. Raw data de-identification feature available by the end of 2001.*
1.6 Airport/Aircraft libraries available	X	*JeppsenGlide/Loc/Runway Elevation databases included. Aircraft library included in the 3D module.*
1.7 Stores raw data (typically de-identified)	X	*Stores raw data as compressed/password protected files. Raw data de-identification feature available by the end of 2001.*
1.8 Exports data to external tools (e.g. simulations)	X	*Integrated with the 3D module (SimAuthor, Inc. FlightViz), ASCII file for other 3D tools.*
2. Monitoring and Analysis Capabilities		
2.1 Automatic event detection (operation of an aircraft that is unusual or beyond established limits)	X	*Unlimited through the AGS programming language.*
2.2 Flight efficiency monitoring (calculates operational costs of aircraft, fuel burn, and flight time)	X	*Unlimited formulas can be added through the report generator.*
2.3 Performs statistical analysis	X	*Unlimited through the AGS report generator.*
2.4 Provides graphical analysis of flight parameters	X	*Graphical and statistical analysis on flight parameters (single flight/multi-flight).*
2.5 Identifies trends	X	*Decisional reports included.*
2.6 Provides flight data replay	X	
2.7 Flight animation capabilities	X	*SimAuthor, Inc. integrated module or any other animation tool through ASCII export.*
3. Report Generation and Querying		
3.1 Automated report generation	X	*State of the art drag-and-drop report builder. Print on schedule.*
3.2 Customized outputs (reports, graphs)	X	*Fully customized reports - just like in Excel.*
3.3 Stores results of queries for future use	X	*For future use or as a template to create new similar reports.*
3.4 Exports analysis results to other systems/tools (e.g. Microsoft Office products)	X	*Paste and copy. Export ASCII files. HTML ready.*

Analysis Ground Station (AGS)
Version 8.0

Capability/Feature	Available	Comments
4. System Features		
4.1 Operating system requirements	X	*Win95/98/2000 or above, NT4/200 Workstation or above, NT 4/2000*
4.2 User configurable security	X	*Up to 16 user groups with individual access privileges. Every single window/button of the AGS can be protected according to user privileges. Fingerprint recognition on request.*
4.3 Capacity – accommodates large amount of data	X	*Unlimited*
4.4 Supports any fleet size	X	*Unlimited*
4.5 Supports multi-user applications	X	*Example: 21 workstations at Air France, 15 at Alitalia.*
4.6 Help feature available	X	
4.7 Tutorial available		
4.8 Data encryption	X	*Raw data are compacted and protected by password.*
5. Support		
5.1 Ongoing development	X	*CAPS (Common Aircraft procedure set)*
5.2 Maintenance support	X	*7/7 from 8am to 5pm Central Time*
5.3 Training provided	X	*On site or at SAGEM Paris*
5.4 Help Desk (both telephone and e-mail)	X	*And PCAnywhere*
5.5 Web site	X	*Discussion Forum and on-line vote for evolutions/ Patch, software downloads*
5.6 Periodic customer conference (how often)	X	*Once a year*

Information Provided By:

Mr. Thierry Pfeiffer
SAGEM
AGS Product Manager
Telephone: + 33 1 58 12 41 76
Email: thierry.pfeiffer@sagem.com

Austin Digital, Inc., Event Measuring System (EMS)

Capability/Feature	Available	Comments
1. Data Storage and Management		
1.1 Accepts data in multiple formats	X	
1.2 Capability to filter and sort events by type, date, aircraft type, or other criteria	X	
1.3 Stores events within context of preceding and succeeding timeframes	X	
1.4 Easily add fleet types and event and measurement definitions	X	
1.5 Data de-identification capability	X	
1.6 Airport/Aircraft libraries available		
1.7 Stores raw data (typically de-identified)	X	
1.8 Exports data to external tools (e.g. simulations)	X	
2. Monitoring and Analysis Capabilities		
2.1 Automatic event detection (operation of an aircraft that is unusual or beyond established limits)	X	
2.2 Flight efficiency monitoring (calculates operational costs of aircraft, fuel burn, and flight time)	X	
2.3 Performs statistical analysis	X	
2.4 Provides graphical analysis of flight parameters	X	
2.5 Identifies trends	X	
2.6 Provides flight data replay	X	
2.7 Flight animation capabilities		*EMS is capable of interfacing with animation vendors*
3. Report Generation and Querying		
3.1 Automated report generation	X	
3.2 Customized outputs (reports, graphs)	X	
3.3 Ad hoc query support	X	
3.4 Stores results of queries for future use	X	
3.5 Exports analysis results to other systems/tools (e.g. Microsoft Office products)	X	
3.6 Accepts custom user displays	X	
4. System Features		
4.1 Operating system requirements	X	*Microsoft Windows 2000*
4.2 User configuration outputs (reports, graphs)	X	
4.3 Capacity – accommodates large amount of data	X	
4.4 Supports any fleet size	X	
4.5 Supports multi-user applications	X	
4.6 Help feature available	X	
4.7 Tutorial available	X	
4.8 Data encryption	X	

Austin Digital, Inc., Event Measuring System (EMS)

Capability/Feature	Available	Comments
5. Support		
5.1 Ongoing development	X	
5.2 Maintenance support	X	
5.3 Training provided	X	
5.4 Help Desk (both telephone and e-mail)	X	
5.5 Web site		
5.6 Periodic customer conference (how often)	X	

Information Provided By:

Ben Prager
Austin Digital, Inc.
Telephone: 512-452-8178
Email: bap@ausdig.com

Aviation Performance Measuring System (APMS)
Version 2.0

Capability/Feature	Available	Comments
1. Data Storage and Management		
1.1 Accepts data in multiple formats	X	*APMS accepts data from several of the commercially available off-the-shelf (COTS) Flight Data programs*
1.2 Capability to filter and sort events by type, date, aircraft type, or other criteria	X	
1.3 Stores events within context of preceding and succeeding timeframes	X	
1.4 Easily add fleet types and event and measurement definitions	X	
1.5 Data de-identification capability	X	
1.6 Airport/Aircraft libraries available		
1.7 Stores raw data (typically de-identified)	X	
1.8 Exports data to external tools (e.g. simulations)	X	*Animation software is linked within the program, integration with weather data available*
2. Monitoring and Analysis Capabilities		
2.1 Automatic event detection (operation of an aircraft that is unusual or beyond established limits)		*APMS accepts operator-defined events detected by COTS programs, but provides event processing tools*
2.2 Flight efficiency monitoring (calculates operational costs of aircraft, fuel burn, and flight time)		
2.3 Performs statistical analysis	X	
2.4 Provides graphical analysis of flight parameters	X	
2.5 Identifies trends	X	
2.6 Provides flight data replay		*APMS imports data read by COTS programs*
2.7 Flight animation capabilities	X	*APMS links SimAuthor Inc.'s Animator directly into the program, linkage to other animation tools available through direct output of .CSV files*
3. Report Generation and Querying		
3.1 Automated report generation	X	
3.2 Customized outputs (reports, graphs)	X	
3.3 Ad hoc query support	X	
3.4 Stores results of queries for future use	X	
3.5 Exports analysis results to other systems/tools (e.g. Microsoft Office products)	X	
3.6 Accepts custom user displays		

Aviation Performance Measuring System (APMS)
Version 2.0

Capability/Feature	Available	Comments
4. System Features		
4.1 Operating system requirements		• *PC desktop platform with Windows 2000 operating system (Win2K is required with LAN Ethernet card* • *Processor: single processor – 700 kHz minimum (maximum available process speed recommended)* • *Memory: 512 Minimum* • *21" 1280x1-24 pixel or higher monitor recommended; smaller monitors size and resolution can be use if necessary* • *Video memory: 32Mg minimum; 64Mg or higher if available is recommended to accommodate 3-D animation* • *Storage space: Varies with airline data collection requirements; minimum of two 60 gig Ultra 2 SCSi hard drives recommended; disk farm may be necessary for total storage space of up to on terabyte or more, depending on airline requirements* • *Database backup hardware: recommended* • *Data archive facilities are recommended for those who wish to retain data over longer periods of time* • *Database: Minimum – Microsoft Access; larger databases may require Microsoft Sequel Server or Oracle* • *Standard software: Microsoft Office 2000 Professional Edition* • *Other software may be required for proper APMS program functionality depending on APMS program configuration* • *Printer: Any reliable network color printer capable of 4ppm or more in color*
4.2 User configurable security	X	
4.3 Capacity – accommodates large amount of data	X	
4.4 Supports any fleet size	X	
4.5 Supports multi-user applications	X	
4.6 Help feature available		
4.7 Tutorial available		
4.8 Data encryption		

Aviation Performance Measuring System (APMS)
Version 2.0

5. Support		
5.1 Ongoing development	X	
5.2 Maintenance support	X	
5.3 Training provided	X	
5.4 Help Desk (both telephone and e-mail)		
5.5 Web site		
5.6 Periodic customer conference (how often)	X	*APMS meets directly with partner operators and vendors*

Information Provided By:
Tom Chidester
NASA Ames
Telephone: (650) 960-6007; Email: tchidester@mail.arc.nasa.gov

British Airways Flight Data Tools

Capability/Feature	Available	Comments
1. Data Storage and Management		
1.1 Accepts data in multiple formats	X	*Module can be configured to accept Arinc and other formats*
1.2 Capability to filter and sort events by type, date, aircraft type, or other criteria	X	*Comprehensive filtering capability to sort events by type, location, aircraft type, etc.*
1.3 Stores events within context of preceding and succeeding timeframes	X	
1.4 Easily add fleet types and event and measurement definitions	X	*Events can easily be modified and added by customer*
1.5 Data de-identification capability	X	*Crew confidentiality is protected; each pilot has a unique coded number*
1.6 Airport/Aircraft libraries available		
1.7 Stores raw data (typically de-identified)	X	
1.8 Exports data to external tools (e.g. simulations)	X	*Links to the BASIS Air Safety Reporting Module and can be outputted to FDS modules*
2. Monitoring and Analysis Capabilities		
2.1 Automatic event detection (operation of an aircraft that is unusual or beyond established limits)	X	*Also has a unique severity index calculation for each event. This helps determine risk*
2.2 Flight efficiency monitoring (calculates operational costs of aircraft, fuel burn, and flight time)	X	*FDM module captures selected data from every flight to provide a picture of overall operation of aircraft*
2.3 Performs statistical analysis	X	
2.4 Provides graphical analysis of flight parameters	X	
2.5 Identifies trends	X	
2.6 Provides flight data replay	X	
2.7 Flight animation capabilities	X	*Can be interfaced with SimAuthor, Inc. Flight Visualisation software*
3. Report Generation and Querying		
3.1 Automated report generation	X	
3.2 Customized outputs (reports, graphs)	X	
3.3 Ad hoc query support	X	
3.4 Stores results of queries for future use	X	
3.5 Exports analysis results to other systems/tools (e.g. Microsoft Office products)	X	
3.6 Accepts custom user displays	X	

BASIS Flight Data Tools

Capability/Feature	Available	Comments
4. System Features		
4.1 Operating system requirements		*Can be run on any modern PC or laptop if he information is available on a suitable medium*
4.2 User configurable security	X	
4.3 Capacity – accommodates large amount of data	X	*Copes happily with British Airways data*
4.4 Supports any fleet size	X	*Copes happily with British Airways fleet*
4.5 Supports multi-user applications	X	
4.6 Help feature available	X	
4.7 Tutorial available		*Comprehensive training drawing on the British Airways 30 years of experience in Flight Data Monitoring*
4.8 Data encryption		
5. Support		
5.1 Ongoing development	X	*British Airways are continually enhancing their Flight Data Monitoring capabilities*
5.2 Maintenance support	X	
5.3 Training provided	X	*Comprehensive training drawing on the British Airways 30 years of experience in Flight Data Monitoring*
5.4 Help Desk (both telephone and e-mail)	X	
5.5 Web site	X	
5.6 Periodic customer conference (how often)	X	*Annually:.*

Note: British Airways Flight Data modules include:
FDT - Flight Data Replay and event detection
FDE - Flight Event database with filtering and trending
FDM - Flight Data Measurements
FDS - Flight Data Simulation
FDH Flight Data remote viewer

Information Provided By:
Captain Nigel Summerhayes
British Airways
Telephone: +44 (0)208 513 1257
Email: nigel.r.summerhayes@britishairways.com

Cockpit Emulator for Flight Analysis (CEFA)

Capability/Feature	Available	Comments
1. Data Storage and Management		
1.1 Accepts data in multiple formats	X	*Accepts ASCII or csv*
1.2 Capability to filter and sort events by type, date, aircraft type, or other criteria		
1.3 Stores events within context of preceding and succeeding timeframes		
1.4 Easily add fleet types and event and measurement definitions		
1.5 Data de-identification capability	X	*N/A - product is a visualization*
1.6 Airport/Aircraft libraries available	X	
1.7 Stores raw data (typically de-identified)		
1.8 Exports data to external tools (e.g. simulations)		
2. Monitoring and Analysis Capabilities		
2.1 Automatic event detection (operation of an aircraft that is unusual or beyond established limits)		
2.2 Flight efficiency monitoring (calculates operational costs of aircraft, fuel burn, and flight time)		
2.3 Performs statistical analysis		
2.4 Provides graphical analysis of flight parameters	X	
2.5 Identifies trends		
2.6 Provides flight data replay	X	*On all related cockpit instruments*
2.7 Flight animation capabilities	X	
3. Report Generation and Querying		
3.1 Automated report generation		
3.2 Customized outputs (reports, graphs)		
3.3 Ad hoc query support		
3.4 Stores results of queries for future use		
3.5 Exports analysis results to other systems/tools (e.g. Microsoft Office products)	X	
3.6 Accepts custom user displays	X	

Cockpit Emulator for Flight Analysis (CEFA)

Capability/Feature	Available	Comments
4. System Features		
4.1 Operating system requirements	X	*Windows 2000 or Windows NT 4.0*
4.2 User configurable security		
4.3 Capacity – accommodates large amount of data	X	
4.4 Supports any fleet size	X	
4.5 Supports multi-user applications		
4.6 Help feature available		
4.7 Tutorial available		
4.8 Data encryption		
5. Support		
5.1 Ongoing development	X	
5.2 Maintenance support	X	
5.3 Training provided	X	
5.4 Help Desk (both telephone and e-mail)	X	
5.5 Web site	X	
5.6 Periodic customer conference (how often)		

Information Provided By:

Dominique Mineo
CEFA Aviation, Inc.
9, Croisee des Lys
68300 Saint-Louis
France
Phone : +333-8989-8181
Fax : +333-8989-8182
e-mail : Dominique.mineo@cefa-aviation.com

FlightAnalyst
Version 2.0

Capability/Feature	Available	Comments
1. Data Storage and Management		
1.1 Accepts data in multiple formats	X	*Accepts ASCII, csv or binary input data*
1.2 Capability to filter and sort events by type, date, aircraft type, or other criteria	X	*Provides an extensible Boolean logic event detector*
1.3 Stores events within context of preceding and succeeding timeframes	X	
1.4 Easily add fleet types and event and measurement definitions	X	
1.5 Data de-identification capability	X	*Several de-identification models are available, e.g. at user level through password protection, or at file level by removing information*
1.6 Airport/Aircraft libraries available		
1.7 Stores raw data (typically de-identified)	X	*Raw data, processed data and meta data stored in SQL Server 2000 database; data de-identification and encryption upon request*
1.8 Exports data to external tools (e.g. simulations)	X	
2. Monitoring and Analysis Capabilities		
2.1 Automatic event detection (operation of an aircraft that is unusual or beyond established limits)	X	*Fully automated, one-click data analysis and event detection capability*
2.2 Flight efficiency monitoring (calculates operational costs of aircraft, fuel burn, and flight time)	X	*Non-standard, but can be implemented upon customer request*
2.3 Performs statistical analysis	X	
2.4 Provides graphical analysis of flight parameters	X	
2.5 Identifies trends	X	
2.6 Provides flight data replay	X	
2.7 Flight animation capabilities	X	*Fully integrated with FlightViz, SimAuthor's powerful flight data animation tool*
3. Report Generation and Querying		
3.1 Automated report generation	X	
3.2 Customized outputs (reports, graphs)	X	*Reports and graphs are initially set up to customer specifications and can then be further modified by the user*
3.3 Ad hoc query support	X	*Provides an extensible Boolean logic event detector*
3.4 Stores results of queries for future use		
3.5 Exports analysis results to other systems/tools (e.g. Microsoft Office products)	X	*MS Word (.doc), MS Excel (.xls), Richt Text Format (.rtf), Adobe Acrobat (.pdf)*
3.6 Accepts custom user displays		

FlightAnalyst
Version 2.0

Capability/Feature	Available	Comments
4. System Features		
4.1 Operating system requirements	X	*Windows XP, Windows 2000*
4.2 User configurable security	X	*User group priviledges granted through password securit; based on .NET security model*
4.3 Capacity – accommodates large amount of data	X	
4.4 Supports any fleet size	X	
4.5 Supports multi-user applications	X	
4.6 Help feature available	X	*Microsoft html help section*
4.7 Tutorial available		
4.8 Data encryption	X	*Upon customer request; based on .NET security model*
5. Support		
5.1 Ongoing development	X	
5.2 Maintenance support	X	
5.3 Training provided	X	
5.4 Help Desk (both telephone and e-mail)	X	
5.5 Web site	X	
5.6 Periodic customer conference (how often)		

Information Provided By:
Dr. Alexander G. Pufahl
SimAuthor, Inc.
Telephone: 303-545-2132
http://www.simauthor.com

FlightViz
Version 4.4

Capability/Feature	Available	Comments
1. Data Storage and Management		
1.1 Accepts data in multiple formats	X	*Accepts ASCII, csv or binary input data*
1.2 Capability to filter and sort events by type, date, aircraft type, or other criteria	X	*Provides an extensible Boolean logic event detector*
1.3 Stores events within context of preceding and succeeding timeframes	X	
1.4 Easily add fleet types and event and measurement definitions	X	
1.5 Data de-identification capability		*N/A - product is a visualization tool, and does not perform GDRAS functions*
1.6 Airport/Aircraft libraries available	X	
1.7 Stores raw data (typically de-identified)	X	
1.8 Exports data to external tools (e.g. simulations)	X	
2. Monitoring and Analysis Capabilities		
2.1 Automatic event detection (operation of an aircraft that is unusual or beyond established limits)	X	
2.2 Flight efficiency monitoring (calculates operational costs of aircraft, fuel burn, and flight time)		
2.3 Performs statistical analysis		
2.4 Provides graphical analysis of flight parameters	X	
2.5 Identifies trends		
2.6 Provides flight data replay	X	
2.7 Flight animation capabilities	X	
3. Report Generation and Querying		
3.1 Automated report generation		
3.2 Customized outputs (reports, graphs)	X	
3.3 Ad hoc query support		
3.4 Stores results of queries for future use		
3.5 Exports analysis results to other systems/tools (e.g. Microsoft Office products)	X	
3.6 Accepts custom user displays	X	

FlightViz
Version 4.4

Capability/Feature	Available	Comments
4. System Features		
4.1 Operating system requirements	X	*Windows XP, Windows 2000, Windows NT 4.0*
4.2 User configurable security	X	*Password*
4.3 Capacity – accommodates large amount of data	X	
4.4 Supports any fleet size	X	
4.5 Supports multi-user applications		
4.6 Help feature available	X	
4.7 Tutorial available	X	
4.8 Data encryption	X	
5. Support		
5.1 Ongoing development	X	
5.2 Maintenance support	X	
5.3 Training provided	X	
5.4 Help Desk (both telephone and e-mail)		
5.5 Web site	X	
5.6 Periodic customer conference (how often)		

Information Provided By:
Steve Lakowske
SimAuthor, Inc.
Telephone: 303-545-2132
http://www.simauthor.com

Line Operations Monitoring System (LOMS)

Capability/Feature	Available	Comments
1. Data Storage and Management		
1.1 Accepts data in multiple formats	X	*Tape, PCMCIA, Optical disk, PC File*
1.2 Capability to filter and sort events by type, date, aircraft type, or other criteria	X	*Report Editor provided*
1.3 Stores events within context of preceding and succeeding timeframes		
1.4 Easily add fleet types and event and measurement definitions		*Editor available end of 2001*
1.5 Data de-identification capability	X	
1.6 Airport/Aircraft libraries available	X	*All Airbus + 777 + 737*
1.7 Stores raw data (typically de-identified)		
1.8 Exports data to external tools (e.g. simulations)	X	*Included*
2. Monitoring and Analysis Capabilities		
2.1 Automatic event detection (operation of an aircraft that is unusual or beyond established limits)	X	
2.2 Flight efficiency monitoring (calculates operational costs of aircraft, fuel burn, and flight time)	No	*Other Airbus software for this purpose: Performance Engineers Program (PEP)*
2.3 Performs statistical analysis	X	
2.4 Provides graphical analysis of flight parameters	X	
2.5 Identifies trends	X	
2.6 Provides flight data replay	X	
2.7 Flight animation capabilities	X	
3. Report Generation and Querying		
3.1 Automated report generation	X	
3.2 Customized outputs (reports, graphs)	X	
3.3 Ad hoc query support		
3.4 Stores results of queries for future use		
3.5 Exports analysis results to other systems/tools (e.g. Microsoft Office products)	X	*Software: Microsoft ASED SQL + Office + Direct X*
3.6 Accepts custom user displays	X	

Line Operations Monitoring System (LOMS)

Capability/Feature	Available	Comments
4. System Features		
4.1 Operating system requirements (describe)	X	*PC PIII 300 MHz 128 MO AM/W2000/WNT/W980*
4.2 User configurable security	X	
4.3 Capacity – accommodates large amount of data	X	
4.4 Supports any fleet size		*All Airbus + 777 + 737, other development in progress*
4.5 Supports multi-user applications	X	*Up to 5*
4.6 Help feature available	X	
4.7 Tutorial available	X	
4.8 Data encryption	X	
5. Support		
5.1 Ongoing development	X	*Non Airbus Aircraft + Airport maps + FFS connection*
5.2 Maintenance support	X	
5.3 Training provided	X	*On site one week*
5.4 Help Desk (both telephone and e-mail)	X	
5.5 Web site		
5.6 Periodic customer conference (how often)	X	*Users forum once a year*

Information Provided By:
Anne Fabresse
Airbus Systems and Services Commercial Department
Telephone: 33 0 5 61 93 50 22
Email: anne.fabresse@airbus.fr

Recovery, Analysis, & Presentation System (RAPS), Version 6.0 & Insight Flight Animation System, Version 1.1

Capability/Feature	Available	Comments
1. Data Storage and Management		
1.1 Accepts data in multiple formats	X	*Supports any ARINC standard data frame, solid state data formats*
1.2 Capability to filter and sort events by type, date, aircraft type, or other criteria	X	*Integrated Search engine with on the fly engineering units conversion*
1.3 Stores events within context of preceding and succeeding timeframes	X	
1.4 Easily add fleet types and event and measurement definitions	X	*Fully configurable, users can share display templates and LFLs.*
1.5 Data de-identification capability	X	
1.6 Airport/Aircraft libraries available	X	
1.7 Stores raw data (typically de-identified)	X	
1.8 Exports data to external tools (e.g. simulations)	X	*Fully integrated flight animation.simultation*
2. Monitoring and Analysis Capabilities		
2.1 Automatic event detection (operation of an aircraft that is unusual or beyond established limits)	X	
2.2 Flight efficiency monitoring (calculates operational costs of aircraft, fuel burn, and flight time)		
2.3 Performs statistical analysis		*Easily exports data to third party statistical packages.*
2.4 Provides graphical analysis of flight parameters	X	
2.5 Identifies trends	X	
2.6 Provides flight data replay	X	
2.7 Flight animation capabilities	X	
3. Report Generation and Querying		
3.1 Automated report generation	X	
3.2 Customized outputs (reports, graphs)	X	
3.3 Ad hoc query support	X	
3.4 Stores results of queries for future use	X	
3.5 Exports analysis results to other systems/tools (e.g. Microsoft Office products)	X	
3.6 Accepts custom user displays	X	

Recovery, Analysis, & Presentation System (RAPS), Version 6.0 & Insight Flight Animation System Version 1.1

Capability/Feature	Available	Comments
4. System Features		
4.1 Operating system requirements		*HP-UX 1110-20, HP Visualize Workstation or Windows XP/2000 PC or Laptop with high end graphics card*
4.2 User configuration outputs (reports, graphs)	X	
4.3 Capacity – accommodates large amount of data	X	*No need to convert data to engineering units since there is a built in transcription engine for efficiency.*
4.4 Supports any fleet size	X	
4.5 Supports multi-user applications	X	
4.6 Help feature available	X	
4.7 Tutorial available	X	
4.8 Data encryption	X	
5. Support		
5.1 Ongoing development	X	
5.2 Maintenance support	X	
5.3 Training provided	X	
5.4 Help Desk (both telephone and e-mail)	X	
5.5 Web site	X	
5.6 Periodic customer conference (how often)	X	*Annual Users Conference*

<u>Information Provided By:</u>
MichaelMichel Poole
Managing Partner, Business Development
Flightscape, Inc.
Telephone: (613) 225-0070 x229
Email: mike.poole@flightscape.com

Software Analysis for Flight Exceedance (SAFE)

Capability/Feature	Available	Comments
1. Data Storage and Management		
1.1 Accepts data in multiple formats	X	
1.2 Capability to filter and sort events by type, date, aircraft type, or other criteria	X	
1.3 Stores events within context of preceding and succeeding timeframes	X	
1.4 Easily add fleet types and event and measurement definitions	X	
1.5 Data de-identification capability		
1.6 Airport/Aircraft libraries available	X	
1.7 Stores raw data (typically de-identified)		
1.8 Exports data to external tools (e.g. simulations)	X	
2. Monitoring and Analysis Capabilities		
2.1 Automatic event detection (operation of an aircraft that is unusual or beyond established limits)	X	
2.2 Flight efficiency monitoring (calculates operational costs of aircraft, fuel burn, and flight time)	X	
2.3 Performs statistical analysis	X	
2.4 Provides graphical analysis of flight parameters	X	
2.5 Identifies trends	X	
2.6 Provides flight data replay	X	
2.7 Flight animation capabilities		*2-D Flight Path*
3. Report Generation and Querying		
3.1 Automated report generation	X	
3.2 Customized outputs (reports, graphs)	X	
3.3 Ad hoc query support		
3.4 Stores results of queries for future use		*Being developed*
3.5 Exports analysis results to other systems/tools (e.g. Microsoft Office products)		*Being developed*
3.6 Accepts custom user displays		*Being developed*

Software Analysis for Flight Exceedance (SAFE)

Capability/Feature	Available	Comments
4. System Features		
4.1 Operating system requirements	X	*Windows 98*
4.2 User configuration outputs (reports, graphs)	X	*Being developed*
4.3 Capacity – accommodates large amount of data	X	
4.4 Supports any fleet size	X	
4.5 Supports multi-user applications	X	
4.6 Help feature available	X	
4.7 Tutorial available		*Being developed*
4.8 Data encryption		*Being developed*
5. Support		
5.1 Ongoing development	X	*R.A.T.E. monitoring software, improvements to SAFE*
5.2 Maintenance support	X	*On site and telephonically through e-mail*
5.3 Training provided	X	*Yes, as and when required*
5.4 Help Desk (both telephone and e-mail)	X	*+971-9-2281840/e-mail: help@veesemraytech.com*
5.5 Web site	X	*www.flightinfotech.com*
5.6 Periodic customer conference (how often)		

Information Provided By:
CV Prakash
Veesem Raytech Aerospace LLC
Telephone: 00 971–9-2281840
email: avaiadata@emirates.net.ae

Appendix D

Methods and Tools Under Development

This appendix contains summaries of methods and tools that are still under development.

Flight Crew Human Factors Integration Tool

Purpose
Applies human error models to accident/incident databases.

Description
The prototype Integration Tool (IT) is a web based data access and analysis tool that permits safety analysts, accident investigators, human factors professionals, or others to remotely apply two human error models to the NTSB accident/incident and FAA National Airspace Incident Monitoring System (NAIMS)/Pilot Deviation System (PDS) incident databases in a consistent manner.

For the NTSB database, the prototype IT produces a cross-tabulation matrix of Type of Flight Crew Error (e.g. slips and mistakes) and the Domain of Flight Crew Error (e.g. aircraft system and weather conditions) during which the error occurred. For the PDS database, the prototype IT produces a matrix of Type of Flight Crew Error and year of the PDS event. For each database-model pair selected the IT will generate a Master Matrix. The user can then create sub-matrices from the master matrix by selecting any combination of year, weather condition, airspace user, aircraft manufacturer (make), phase of flight, and pilot's total hours flown.

References Used to Support the Review
"Development of the Flight Crew Human Factors Integration Tool", Phase II Summary Report, G. Gosling, K. Roberts, Nextor Research Report RR-98-10, Institute of Transportation Studies, University of California, Berkeley

Point of Contact
Geoffrey Gosling, Aviation System Planning Consultant, Berkeley, (510) 528-8741,
email: gdgosling@aol.com

Aircraft Performance Risk Assessment Model (APRAM)

Purpose
A software tool that will use recorded aircraft performance data and automatically assess the safety or accident risk associated with aircraft operations.

Description
APRAM is a computer model that uses both empirical data and expert judgment to quantify the risk of an incident and/or accident. The model processes aircraft data available from Digital Flight Data Recorders (DFDRs) and Quick Access Recorders (QARs). The general approach taken is to develop an automated means of analyzing commercial aircraft flight recorder data from routine flights. The model uses the flight data to identify non-normal flight performance, which are called exceedances. Non-normal flight performance is defined here as an occasion when the aircraft exceeds its normal operating limits. The exceedance data is combined with information about the contextual factors that are not directly available from the data recorders. The contextual factors fall into several different categories including environment (e.g. weather), process/procedure (e.g. type of approach), system (e.g. use of GPWS), and human (e.g. pilot fatigue). Expert opinion is incorporated through the use of knowledge-based rules. These rules are used in generating the risk estimates.

The output from the model is a risk estimate that includes consequence, severity, and probability of occurrence, similar to that used for aircraft certification. The model can also assist in causal analysis by identifying causal factors associated with any relative increase in estimated risk. APRAM is designed to be generic in that it can provide risk estimates for all phases of flight and for all types of possible incident and accident types. The development thus far includes knowledge based rules and risk algorithms for Controlled Flight into Terrain (CFIT), unstabilized approach, runway overrun, and hard landing.

References Used to Support the Review
Rannoch Corporation web site, http://www.rannoch.com

Point of Contact
Rick Cassell, Rannoch Corporation, 703-838-9780 x-204

Flight Operations Risk Assessment System (FORAS)

Purpose
To provide a quantitative assessment of any modeled flight operation risk, organized into a hierarchy of risk factors, and summarized by fleet, regions, or routes, etc.

Description
This is a decision support tool for safety managers and others to measure, monitor, and thereby reduce exposure to major accident/incident risks. It is primarily an expert system for generating a relative risk index for certain categories of safety risk for any subset of a flight operation (e.g. by fleet, route, flight, etc). The FORAS modeling process elicits the knowledge of the flight operation experts of an organization, and encodes it into a fuzzy expert system. The FORAS inference component applies the expert system to operational data.

FORAS is a proactive approach that, in its initial developmental phase, is limited to addressing the CFIT risk category. The preliminary model is hierarchical, but allows for mutual dependencies among risk factors. It includes a methodology for eliciting relevant knowledge from domain experts. Software components allow the design of an operation-specific model, and the application of the model to actual flight data.

A report titled "FORAS Flight Operations Risk Assessment System: Model Design Development" dated January 16, 2001 is available from the Flight Safety Foundation. More recent information is available from the point of contact.

A prototype of FORAS has been developed and is currently being evaluated in an operational setting. The concept appears to have potential value to assist an FSO in identifying relative safety risks and risk attributes.

References Used to Support the Review
FORAS website; http://www.nrtmry.navy.mil/foras

Point of Contact
Dr.Hadjimichael, Naval Research Laboratory Marine Meteorology Division, email: hadjimic@nrlmry.navy.mil

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Appendix E

List of Acronyms

ACMS	Aircraft Condition Monitoring System
AERO	Aeronautical Events Reports Organizer
AGS	Analysis Ground Station
AI	Artificial Intelligence
AIRS	Aircrew Incident Reporting System
AirFASE	Aircraft Flight Analysis & Safety Explore
ALPA	Airline Pilots Association
APM	Aircraft Performance Monitoring
APMS	Aviation Performance Measuring System
APRAM	Aircraft Performance Risk Assessment Model
AQD	Aviation Quality Database
AQP	Advanced Qualifications Programs
ASAP	Aviation Safety Action Program
ASR	Air Safety Report
ASRS	Aviation Safety Reporting System
ATA	Air Transport Association
ATEC	Association of Air Transport Engineering and Research
ATSB	Australian Transport Safety Bureau
BASIS	British Airways Safety Information System
CAA	Civil Aviation Authority
CADS	Computer-Assisted Debriefing System
CD	Compact Disc
CD-ROM	Compact Disk - Read Only Memory
CEFA	Cockpit Emulator for Flight Analysis
CERS	Corporate Event Reporting System
CFIT	Controlled Flight Into Terrain
CPIT	Cabin Procedural Investigation Tool
CPU	Central Processing Unit
CVR	Cockpit Voice Recorder
DAR	Digital ACMS Recorder
DFDAU	Digital Flight Data Acquisition Unit
DFDR	Digital Flight Data Recorder
DMU	Data Management Unit
E&CF	Events & Causal Factors
ECM	Engine Condition Monitoring
EMS	Event Measurement System

Appendix E

List of Acronyms
(continued)

ERA	European Regional Airline Association
ERASM	Event Risk Assessment and Safety Management
ERAU	Embry-Riddle Aeronautical University
FAA	Federal Aviation Administration
FDA	Flight Data Animator
FDC	Flight Data Company Ltd.
FDE	Flight Data Events
FDM	Flight Data Measurements
FDP	Flight Data Processing
FDR	Flight Data Recorder
FDS	Flight Data Simulation
FDT	Flight Data Traces
FEAP	Flight Event Analysis Program
FEM	Flight Efficiency Monitoring
FIR	Flight Instrument Replay
FLIDRAS	Flight Data Replay Analysis System
FMEA	Failure Mode and Effect Analysis
FMECA	Failure Modes, Effects, and Criticality Analysis
FOQA	Flight Operational Quality Assurance
FORAS	Flight Operations Risk Assessment System
FSO	Flight Safety Office
FTA	Fault Tree Analysis
GAIN	Global Aviation Information Network
GfW	GRAF for Windows
GRAF	Ground Recovery & Analysis Facility
GSE	Ground Support Equipment
GUI	Graphic User Interface
HFACS	Human Factors Analysis and Classification System
HHDLU	Hand Held Down-Load Unit
HTML	Hyper Text Markup Language
INDICATE	Identifying Needed Defenses in the Civil Aviation Transport Environment
ISASI	International Society of Air Safety Investigators
ISIM	Integrated Safety Investigation Methodology
IT	Integrated Tool
IOV	Information of Value
JCAB	Japan Civil Aviation Board
LOMS	Line Operations Monitoring System

Appendix E

List of Acronyms

(continued)

LOSA	Line-Oriented Safety Assessment
MAI	Macfadden and Associates, Incorporated
MB	Mega Byte
MES	Multilinear Events Sequencing
MOQA	Maintenance Operational Quality Assurance
NAIMS	National Airspace Incident Monitoring System
NASA	National Aeronautics and Space Administration
NASDAC	National Aviation Safety Data Analysis Center
NATCA	National Air Traffic Controllers Association
NRC	Nuclear Regulatory Commission
NTSB	National Transportation Safety Board
OAG	Operational Advisory Group
OFDM	Operational Flight Data Monitoring
OLAP	Online Analytical Processing
OQAR	Optical Quick-Access Recorder
OR	Operational Readiness
OSHA	Occupational Safety and Health Act
PC	Personal Computer
PDS	Pilot Deviation System
PEAT	Procedural Event Analysis Tool
PERMIT	Performance Measurement Management Information Tool
PRA	Probabilistic Risk Assessment
PSA	Probabilistic Safety Analysis
QA	Quality Assurance
QAR	Quick-Access Recorder
REDA	Ramp Error Decision Aid
RAM	Random Access Memory
R&M	Relevance and Maturity
ROI	Return On Investment
SAFE	Software Analysis for Flight Exceedance
SHEL	Software, Hardware, Environment, Liveware
SIE	Safety Information Exchange
SPC	Statistical Process Control
SPSS	Statistical Package for Social Sciences
SRS	First Launch Safety Report System
STEADES	Safety Trend Evaluation and Data Exchange System
TSB	Transportation Safety Board

Appendix E

List of Acronyms
(continued)

URL	Uniform Resource Locator
UTRS	Universal Technical Resources Services, Inc.
WG	Working Group
XML	Extensible Markup Language

Appendix F--Feedback Form

GAIN Working Group B encourages the submittal of any comments and/or suggestions that will improve the content of future issues of this guide. Please submit this form to:

GAIN Working Group B
c/o Abacus Technology Corporation
5454 Wisconsin Ave. NW, Suite 1100
Chevy Chase, MD 20815 USA
Fax: +1 (301) 907-8508

or complete this form at:
http://www.gainweb.org

Name: ______________________________

Title/Position: ______________________________

Company: ______________________________

Mailing Address: ______________________________

Phone/Fax Number: ______________________________

E-Mail: ______________________________

1) How useful is this guide on analytical methods & tools to your organization?
(Please circle one)
not useful - 1 2 3 4 5 - very useful

Comments: ______________________________

____

2) What information contained in this guide is most useful to your organization?

____

____

3) What information would you like to see added to this guide?

____

____

4) Which methods or tools shown in this guide have you or your organization used?

____

____

Please provide any comments that you would like to share regarding these methods/tools:

____

____

____

5) What methods or tools does your organization need but does not have now? ______________

____

____

6) What are the most significant challenges your organization faces in using or implementing analytical methods & tools? *(please circle all that apply)*

Management Support	Money
Time	Resources
Knowledge of Existing Tools	Experience
Training	Software/Hardware Limitations

Other:____

7) Is the section "Application of Analytical Tools to Airline Flight Safety" useful to your organization? *(please circle one)* **YES / NO**

Comments or suggestions for improving this section: _________________________________

____

____

8) Is Appendix A, showing example applications of selected tools, useful to your organization? *(please circle one)* **YES / NO**

Comments or suggestions for improving this section: _________________________________

____

____

9) What activities should WG B undertake that would be most useful to you and your organization? ____

____

____

____

10) Would you or someone in your organization be interested in participating in WG B activities? **YES / NO** Would you like to be added to our mailing list? **YES / NO**

Other Comments/Suggestions: ____

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