Global Aviation Information Network

Role of Analytical Tools in Airline Flight Safety Management Systems

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GAIN Working Group B:
Analytical Methods and Tools

Second Edition

September 2004

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Foreword

This report discusses the role of analytical tools in airline flight safety management systems. It summarizes the findings of several activities that have been undertaken by GAIN Working Group (WG) B to identify and document the use of analytical methods and tools by airline flight safety departments, as well as to identify needs for improved analytical methods and tools. The report also addresses future actions that could be taken by the GAIN Program, to support and facilitate the wider use of such tools. The report is an expanded and updated edition of a previous report *Role of Analytical Tools in Airline Flight Safety Management* that was issued by WG B in June 2003. The current edition gives added emphasis to the increasingly important role of formal Safety Management Systems (SMS) in airline operations, as well as reflecting recent activities of WG B.

Readers interested in more information on the analytical methods and tools referred to in this report, or analytical methods and tools in general, may find it helpful to obtain a copy of another report prepared by WG B, *Guide to Methods and Tools for Airline Flight Safety Analysis*. This report is available on the GAIN website at *www.gainweb.org*. Also on the GAIN website are a number of summary descriptions of example applications of selected tools that have been prepared by the tool developers or vendors in conjunction with GAIN WG B. These example applications provide more detail on typical applications to airline flight safety management.

Acknowledgements

GAIN WG B acknowledges the confidential contribution of the airlines and their flight safety department staff that participated in the surveys described in this report, as well as those airlines that hosted the visits to their flight safety departments in support of the case studies described in this report.

The following GAIN WG B members were primarily responsible for the activities in support of the preparation of both this report and the previous edition:

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Geoff Gosling was the principal author of this report. Jari Nisula, Mike Moodi, Ron Small and Bill Wood played key roles in the conduct of an initial survey of analytical processes and requirements described in Section 3 of this report. Steve Bond, Grant Schneemann, Linda Sollars, Jean-Jacques Speyer, Craig Stovall and Gerard van Es assisted with the follow-up survey also described in Section 3. Geoff Gosling, Margaret-Ann Johnson, Andy Muir, Jari Nisula, Howard Posluns, Grant Schneemann, Linda Sollars, Jean-Jacques Speyer and Alex Suchkov undertook the airline visits in support of the flight safety management case studies.

Other WG B members contributed their ideas and suggestions during the development of the various activities described in this report.

The methodology and findings of the survey of analytical processes and requirements and the development of the hierarchy of analytical tools described in this report were reviewed with members of the GAIN WG B Operational Advisory Group. Tom O'Kane (formerly of British Airways) originally suggested the concept of a hierarchy of analytical tools to WG B and provided valuable comments during its development. Other helpful suggestions were received from Keith Hagy of the Air Line Pilots Association, International.

Executive Summary

Continuing efforts to improve the already remarkable safety record of the airline industry will require a comprehensive and carefully structured approach to the management of all aspects of airline safety, and particularly safety aspects of flight operations. This report examines the role of analytical tools in airline flight safety management systems and discusses some of the issues involved in the collection and analysis of flight safety data in support of airline safety management programs. The report is intended to provide guidance in the role that such tools play in the safety management process and to address some of the implementation issues involved in the effective use of such tools, including training needs of the staff involved and requirements for improvements to existing tools. It has been prepared by the Working Group on Analytical Methods and Tools (Working Group B) of the Global Aviation Information Network (GAIN) to synthesize the findings of several recent activities of the working group and supplement the information contained in the *Guide to Methods and Tools for Airline Flight Safety Analysis* prepared by the working group.

It is increasingly being recognized by both the airline industry and regulatory bodies that there is a need for a formally structured Safety Management System within each airline that ensures that appropriate safety practices are integrated into the airline operations. The Government of Canada has recently taken the lead in this area by requiring that all Canadian airlines establish such a Safety Management System (SMS) in conformance with guidelines developed by Transport Canada. While the requirements of the regulatory agencies in other countries vary and generally do not require a formal SMS as such, many have established similar requirements or are evolving toward them, often in an incremental way. Even where there is no regulatory requirement for a formal SMS, many airlines have begun to view their various safety management activities in an integrated way and have in effect established their own SMS or are in the process of doing so. However, it is becoming clear that standards of practice are evolving toward a common approach to managing safety within the worldwide airline industry, and it is only a matter of time before a formal SMS will be required of all airlines.

Fundamental to every SMS is the principle of collecting and analyzing operational data in order to identify and quantify potential risks and develop and implement corrective actions in a timely way to eliminate or reduce the risk to an acceptable level. An equally important aspect of an SMS is the establishment of formal reporting procedures within the airline management, to ensure that senior management are able to monitor the level of safety performance that is being achieved throughout the organization, are aware of emerging threats or risks, and can take appropriate action to correct these. Clearly this requires both highly detailed data on routine operations and the means to analyze those data in a comprehensive and timely way, as well as the ability to synthesize the information obtained from this analysis so as to allow the airline management to exercise their responsibilities for safety oversight. This report addresses one aspect of this process: the role of analytical tools in the safety management system as it applies to flight operations. While flight safety is not the only concern of airline safety management, it is one of the most visible, and arguably the most important, since aircraft accidents are some of the most catastrophic events that can occur to an airline, often resulting in a large loss of life and understandably intense attention by the media, general public, and regulatory agencies.

Flight Safety Management Processes and Procedures

To address the need for more information on the use of analytical tools in managing airline flight safety, in 2001 GAIN WG B undertook a survey of airline flight safety department staff to identify and document analytical processes and requirements for methods and tools to support airline flight safety management. The initial findings of this survey were documented in a report issued in December 2001. Subsequently, a follow-up survey was conducted of a larger sample of airlines to obtain additional information regarding flight safety staffing levels and analytical processes and tools at those airlines. The findings of this second survey have been documented in a separate report issued in September 2004. The current report summarizes the findings of the two surveys. In particular, it examines flight safety department staffing levels and training, the data sources available to support the safety management process, the use of analytical tools, and the application of the results of flight safety data analysis.

The results of the survey suggest that most, if not all, airlines have established a process for collecting and analyzing air safety reports, and have acquired or developed safety report management and analysis tools to support this process. To a lesser extent airlines have begun to implement flight data analysis programs, and about 70 percent of the airlines in the sample reported having such programs. Confidential human factors reporting programs are almost as prevalent, with about 65 percent of the airlines in the second survey reporting such programs. Beyond the basic set of analytical tools to manage and analyze air safety reports, perform flight data analysis, and manage and analyze human factors reports, the use of more specialized analytical capabilities appears more limited. About a third of the airlines in the most recent survey indicated that they had some formal risk analysis capabilities, and about 20 percent of the airlines reported the use of other analytical tools, including root cause analysis tools, data and text mining tools, and various other specialized tools. However, each of these tools was only used by one airline in the survey and only a handful of respondents had more than one such tool and none had more than two. The absence of more use of advanced analysis techniques appears in part to be a consequence of the typical staffing levels in most flight safety departments and the limited training in the use of analytical techniques that those staff members have received.

In order to get a deeper understanding of the use of analysis in airline flight safety offices than can be gained through surveys, WG B has undertaken a number of visits to airline flight safety offices to discuss their experience in the use of analytical methods and tools and to document the findings for the benefit of other airlines. The objective of the visits was to obtain a better understanding of both the organizational process by which safety related events are examined and flight safety is managed and the technical means that support these safety analyses. The report discusses the findings of these visits and describes some of the more noteworthy organizational processes and analytical techniques that have been implemented by the various airlines, including the types of data collected, the analysis tools used, and the application of a risk management approach.

Analytical Capabilities and Requirements

Fundamental to the safety management process is the reporting and investigation of safety related events. Thus one role of analytical tools is to support the process by which events are reported and 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. WG B has identified a wide range of analytical tools that have potential use to support the airline flight safety management process. These tools are described in a separate report prepared by WG B titled *Guide to Methods and Tools for Airline Flight Safety Analysis*. The current report discusses the role that the various types of analytical tools play in the safety management process and examines the relationship between the flight safety data collected by an airline and the use of analytical tools to exploit that data.

The types of data collected as part of the airline flight safety management process is fundamental to the selection of 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 (FOQA) 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.

The report discusses a hierarchy of different types of analysis tools that can be applied to manage and analyze the various types of flight safety data. There is a wide range of analytical tools that have a 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. There 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 tools, that are used to help assess the effectiveness of alternative safety management actions and strategies.

The survey of airline flight safety personnel and the case study visits to airline flight safety departments identified a number of areas where improvements to the capabilities of existing analytical tools could enhance their usefulness or usability. These fall into three categories:

1. Customization of the tools to perform standard analytical procedures that commonly arise in airline flight safety management;
2. Better integration between existing tools or configuration of these tools to interface with existing airline safety data sets;
3. Improved analytical capabilities for risk analysis and risk management.

The report discusses these in more detail, as well as the implications of these findings for future GAIN activities.

The effective use of analytical tools in the safety management process requires flight safety office staff members who have an appropriate level of familiarity with the use of the tools themselves, a good understanding of analysis in general, and an appreciation of how analysis results can be incorporated in the flight safety management process. The report describes three different types of resources that are available to enhance the skill levels of the flight safety office staff. The first resource is a "Flight Safety Analysis Bookshelf," comprising a list of basic reference material on the use of analysis in airline flight safety. The second is a listing of universities and other training organizations that offer courses in airline safety management. The third resource consists of training courses or user meetings held by the developers of specific analytical tools.

Conclusion

The global airline industry appears to be moving toward an increasingly common approach to the management of flight safety, although differences in implementation exist in almost every airline, reflecting differences in airline size, organizational structure, regulatory requirements, and institutional history. This approach is founded in the recognition that effective safety management rests on the collection and analysis of relevant data on the day-to-day conduct of flight operations. Central to the successful implementation of this approach is the collection and analysis of appropriate flight safety data. Among those airlines that have the most advanced safety management programs, these data collection activities involve three broad types of information:

- Flight crew incident reports
- Aircraft flight data
- Confidential reports.

Beyond these capabilities, the current state of the art of the use of analytical tools in the flight safety management process becomes less clear. Some airlines have begun using special purpose tools to support incident investigation or analyze human factors issues. Others have experimented with data visualization and text mining tools. However, these tools are not yet widely used, nor is the extent to which they can be appropriately utilized in the flight safety management process entirely clear.

Based on the surveys and discussions undertaken by WG B, it appears that there is considerable need for better integration of flight safety information, even among those airlines that already have fairly well-developed flight safety management programs. There is also significant opportunity for the effective use of a wider range of analytical tools to support flight safety decision-making. However, for this to occur, there will need to be more readily available information on how to effectively use these tools and expanded training opportunities to ensure that the flight safety office staff have the necessary knowledge and skills to make use of these capabilities.

In summary, the current state of the art of airline flight safety management is fairly well defined, although many airlines are still developing their capabilities and have some way to go to fully conform to the evolving standards of best practice. However, if the airline industry is to continue to improve its already remarkable level of safety, as many in the industry believe is required, it will in turn be necessary to significantly enhance the analytical capabilities of airline flight safety offices in order to utilize the staff more effectively and take full advantage of the available information to identify potential threats in a timely way and develop appropriate safety strategies and safety management systems to counter them. It is the mission of GAIN and WG B to facilitate this process.

1.0 Introduction

Throughout the world, airlines and their industry organizations and regulatory agencies are engaged in a continuous effort to improve the already remarkable safety record of the airline industry. It is increasingly recognized that this requires a comprehensive and carefully structured approach to the management of all aspects of airline safety, and particularly safety aspects of flight operations. There is a growing acceptance that the traditional focus on compliance with the requirements of the relevant civil aviation regulations, supplemented by investigation of those accidents that do occur in order to identify the causal factors and then take actions to eliminate or reduce those hazards identified in the investigation is no longer sufficient. In addition, airlines need to implement formal safety management systems that gather and analyze safety related data from routine operations, and use the resulting information to proactively identify hazards, develop and implement strategies to reduce or eliminate the risks associated with these hazards, and monitor the effectiveness of these strategies.

This of course requires both the collection of appropriate data and the capability to effectively analyze it to satisfy the information requirements of the safety management process. The need to establish formal procedures to monitor routine operations, identify hazards and assess the risk that they pose, and then develop and implement corrective actions to eliminate those risks or reduce them to acceptable levels has led both airlines and regulatory agencies to develop or require a structured Safety Management System (SMS) within each airline. The central role that analysis of operational data plays in such systems in turn requires appropriate analytical tools. The volume of data in an effective SMS is simply too great to be adequately analyzed by simply reading reports or reviewing operational statistics. Furthermore, a key component of an effective SMS is a process for synthesizing the resulting information on the safety performance of the airline and reporting this in a consistent and usable form to senior management. Even in a small airline, this becomes totally impractical without the support of analytical tools.

The present widespread increase in occurrence reporting practices makes the use of appropriate analytical methods and tools increasingly indispensable, so that operators can accomplish analysis in a timely way and efficiently extract essential safety information. This enables them to take full advantage of the operational experience contained in the reports and to provide feedback to those submitting the reports to demonstrate the value of the reporting process.

This report addresses this critical aspect of establishing an effective Safety Management System by examining the role of analytical tools in airline flight safety management and discussing the issues involved in the collection and analysis of flight safety data in support of airline safety management programs. It has been prepared by the Working Group on Analytical Methods and Tools (Working Group B) of the Global Aviation Information Network to synthesize the findings of several recent activities of the working group and supplement the information contained in the *Guide to Methods and Tools for Airline Flight Safety Analysis* prepared by the working group. That guide documents a range of analytical methods and tools that are used, or potentially could be used, to support the airline flight safety management process. This report is intended to provide guidance on the role that such tools play in the safety management process and address some of the implementation issues involved in the effective use of such tools, including training needs of the staff involved and requirements for improvements to existing tools.

The Global Aviation Information Network (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 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. This report is one of a number of products prepared by WG B, which are available on the GAIN website at *www.gainweb.org*.

The remainder of this report consists of eight sections. Section 2 provides a more detailed discussion of the role of analytical processes and tools in airline safety management systems. Section 3 presents an analysis of the findings of two surveys of airline flight safety departments that were undertaken by WG B in 2001 and 2004 to document analytical processes and requirements for airline flight safety management. Section 4 describes the findings of a series of airline flight safety management case studies that have been conducted since the first survey by WG B to better understand and document the state of the art of current practice. Section 5 presents a discussion of the concept of a hierarchy of analytical tools that has been developed by WG B in the process of documenting available methods and tools to support airline flight safety analysis. This discussion examines the relationship between the safety data that is typically available to support the flight safety management process and the data management and analytical capabilities required to fully exploit the information and knowledge that can be obtained from these data. Section 6 examines the requirements for improved analytical tools that have been identified in the course of the WG B activities to date. Section 7 presents information on a range of resources that are available to support the training of Flight Safety Office personnel in the use of analytical techniques. Section 8 discusses the implications of the findings described in the previous sections for future GAIN activities and suggests future activities that the GAIN program could undertake to facilitate the development of improved analytical capabilities to support airline flight safety management. Finally, Section 9 presents some conclusions on the role of analytical tools in airline flight safety management.

2.0 Role of Analysis in Airline Safety Management Systems

It is increasingly being recognized by both the airline industry and regulatory bodies that there is a need for a formally structured Safety Management System within each airline that ensures that appropriate safety practices are integrated into the airline operations. The Government of Canada has recently taken the lead in this area by requiring that all Canadian airlines establish such a Safety Management System (SMS) in conformance with guidelines developed by Transport Canada. Two publications by Transport Canada, *Introduction to Safety Management Systems*, TP 13739 E, April 2001, and *Safety Management Systems for Flight Operations and Aircraft Maintenance Organizations: A Guide to Implementation*, TP 13881 E, March 2002, provide guidance on the features and implementation of an SMS. The second of these two publications describes components of a Safety Management System, including a Safety Management Plan, relevant documentation, safety oversight processes, training requirements, a Quality Assurance program, and an Emergency Response Plan. These documents are available on the Transport Canada website at *www.tc.gc.ca/civilaviation/SMS/guidance.htm*.

The GAIN Government Support Team (GST) has recently undertaken a survey of the status of efforts in member countries to promote or require the establishment of an SMS by airlines and other aviation organizations in those countries. The results of the survey are presented in a report *Status of Safety Management Systems and Related Reporting Methodologies in GST Member Organizations*, June 2003, available on the GAIN website (*www.gainweb.org*).

As an example of national efforts to promote the establishment of an SMS within aviation organizations, the United Kingdom Civil Aviation Authority (UK CAA) does not define SMS requirements for organizations but provides guidance on SMS policy and principles. The CAA has prepared a brochure *Guidance for Developing and Auditing a Formal Safety Management System*, October 2002, and a more detailed publication *Safety Management Systems for Commercial Air Transport Operations*, CAP 712, April 2002. The brochure provides a set of SMS policy statements and typical safety management principles, that address such considerations as safety accountability, arrangements for conducting safety incident investigations and implementing remedial actions, arrangements for monitoring the overall safety standards of the organizations, and arrangements for early detection of deviations from intended practices and procedures that degrade safety. The second publication provides a guide to the implementation of an SMS, including organizational aspects and establishment of systems to achieve safety oversight. Both publications are available on the UK CAA website at *www.caa.co.uk/publications*.

While the requirements of the regulatory agencies in other countries vary and generally do not require a formal SMS as such, many have established similar requirements or are evolving toward them, often in an incremental way. Even where there is no regulatory requirement for a formal SMS, many airlines have begun to view their various safety management activities in an integrated way and have in effect established their own SMS or are in the process of doing so. However, it is becoming clear that standards of practice are evolving toward a common approach to managing safety within the worldwide airline industry, and it is only a matter of time before a formal SMS will be required of all airlines.

Fundamental to every SMS is the principle of collecting and analyzing operational data in order to identify and quantify potential risks and develop and implement corrective actions in a timely way to eliminate the risk or reduce it to an acceptable level. An equally important aspect of an SMS is the establishment of formal reporting procedures within the airline management, to ensure that senior management are able to monitor the level of safety performance being achieved throughout the organization, are aware of emerging threats or risks, and can take appropriate action to correct these. Clearly these aspects of a SMS require both highly detailed data on routine operations and the means to analyze those data in a comprehensive and timely way and to synthesize the information obtained from this analysis in a way that allows the airline management to exercise their responsibilities for safety oversight. These responsibilities take two forms. The first is the legal, financial and moral responsibility to ensure that required safety procedures are being followed throughout the airline and that known problems are being addressed in an effective and timely way. However, beyond this responsibility, which is common to most organizations and is often shaped by the need to ensure compliance with regulatory requirements, is the need for senior management to determine whether adequate resources are being devoted to the safety management process. In the case of airlines, this can be a particularly difficult question, since major aircraft accidents are fortunately quite rare, and is discussed further below.

Although the need for analytical capabilities exists for all aspects of an airline SMS, this report focuses one specific aspect: the role of analytical tools applied to flight safety data. While flight safety is not the only concern of airline safety management systems, it is one of the most visible, and arguably the most important, since aircraft accidents are some of the most catastrophic events that can occur to an airline, often resulting in a large loss of life and understandably intense attention by the media, general public, and regulatory agencies. Flight operations are also characterized by a major and unique source of information on routine operations, the digital flight data available on all modern aircraft. An increasing number of airlines have been collecting this data using quick access recorders (QARs) installed on the aircraft and analyzing it through formal programs known as flight data monitoring (FDM) or flight operational quality assurance (FOQA). The International Civil Aviation Organization has recently issued a standard and recommended practice (SARP) that states "*From 1 January 2005, an operator of an aeroplane of a certificated take-off mass in excess of 27 000 kg shall establish and maintain a flight data analysis (also known as FDM/FOQA) programme as part of its accident prevention and flight safety programme.*" (Annex 6 to the International Convention on Civil Aviation, Part 1, Chapter 3, Paragraph 3.2.3). In addition, flight operations have also been the first area in most airlines where some form of formal employee safety reporting has been established. While this type of reporting by aircraft flight crews, typically referred to as an air safety report or similar term, has since been extended in many airlines to other employee groups, such as flight attendants, aircraft maintenance personnel, dispatchers, and ground staff, safety reporting practice in these other functional areas is much more variable, and many airlines still only collect safety reports on a routine basis from flight crews.

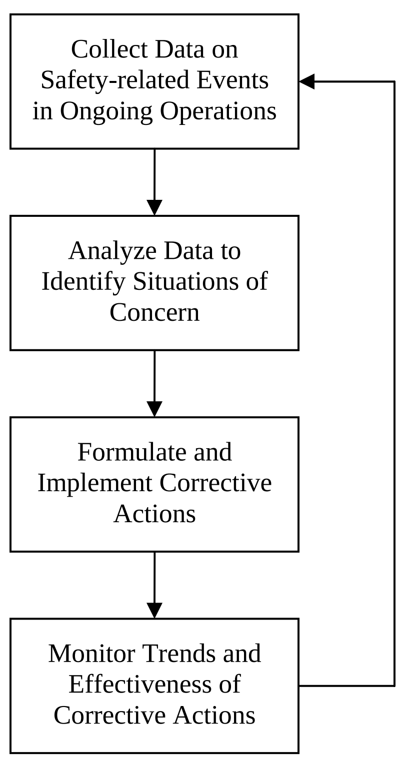
Even so, many of the analysis tools that are applicable to airline flight safety data are also applicable to analyzing safety data from other operational functions. This is particularly true for analysis tools that are designed to work with data from safety reports, such as safety report management systems and text mining tools, as well as tools designed to perform formal risk analysis. Thus while this report is focused on the role of analytical tools in flight safety management, much of the discussion is more broadly applicable to other aspects of safety management as well.

2.1 The Safety Management Process

Establishment of an effective safety management system (whether formalized as an SMS or not) requires both a safety management process and the associated data and analytical capabilities to support that process. The goal of the safety management process is to identify situations in the course of routine or irregular operations that present an unacceptable risk of accident, injury or damage and implement corrective actions that eliminate that risk or reduce it to acceptable levels. Since it is unreasonable to expect safety managers to be able to anticipate every situation that could arise and correctly assess the associated risk, it follows that the identification of situations of concern as well as the assessment of their likelihood of occurrence should be based on the collection and analysis of data derived from the operations themselves. Furthermore, it is not sufficient to simply make a good faith effort to define an appropriate corrective action, or set of corrective actions, and then assume that this will be effective. Rather, it is necessary to monitor the ongoing operations of the airline to determine whether the corrective action has been effective, and implement additional (or substitute) actions if not. Indeed, the process of monitoring ongoing operations serves two purposes: identifying situations of concern and assessing the effectiveness of corrective actions that have been implemented.

This process can be represented by the flow chart shown in Figure 2-1.

Figure 2-1
Safety Management Process



In practice this process is not so much iterative sequence of steps as a continuous process, with activity proceeding in parallel in each step at any given time, although the analysis of different issues may be at different stages of the process. Thus some situations may have been identified but corrective actions have not yet been implemented, corrective actions for other situations may have been implemented but it is not yet known how effective they have been, and yet other situations may have had corrective actions implemented that appear to have been effective but the data on ongoing operations is being monitored to ensure that they do not reoccur.

There are thus four aspects to this process that require data management and analytical capabilities: the collection and management of data on on-going operations; the analysis of these data to identify the existence of situations of concern and the trend in the rate of occurrence of these situations; the assessment of the risk posed by those situations; and the assessment of the likely effectiveness of potential corrective actions. With the exception of the fourth aspect, there is a range of analytical tools available to support this process, as discussed at length elsewhere in this report.

The fourth requirement, the assessment of the likely effectiveness of potential corrective actions, has not thus far seen much application of formal analytical methods, and is typically addressed by relying on the experience and judgment of the airline safety personnel, combined with a certain amount of trial and error. One aspect of this that must not be overlooked is the potential that a corrective action for one problem might itself create a new problem.

2.2 Measuring Safety Performance

An airline management would be considered highly deficient if it did not implement a formal process for tracking the profitability of the airline, establish financial targets, and take appropriate actions if the airline was not meeting those targets. This is basic business practice and how to do this is well understood in airline industry (although the ability to meet the financial targets may be constrained by external factors). Yet the comparable process for monitoring the overall safety level in the airline and deciding whether the existing programs are adequate or new initiatives are needed is nowhere near as clearly understood. It is not even clear how the overall level of safety should be measured. What is clear is that compliance with regulatory requirements alone is not sufficient. While some aircraft accidents are due (at least in part) to failure to fully comply with stated regulatory requirements, there are others that occur in spite of full compliance with all relevant requirements. Similarly, monitoring accidents rates is hardly a realistic strategy when major aircraft accidents occur so infrequently and minor accidents involving aircraft (such as ground damage) are due to totally different factors from those that affect the likelihood of an accident in flight.

Monitoring the rate of reported or observed incidents is obviously better, since this at least offers the prospect of detecting hazardous situations before they result in an accident and can take account of the relative risk imposed by different types of incident. However, there are difficult implementation questions that still need to be addressed. Is an increase in reports of a particular type of incident due to an actual increase in those events, or does it simply reflect an increased propensity to report such incidents (perhaps due to efforts to make personnel aware of the risks involved or encourage safety reporting in general)? How can managers ensure that trends in the occurrence of events that pose a particularly serious risk do not get lost amid the much larger volume of less serious events? It is clear that any attempt to monitor the overall safety performance of an airline should have two attributes:

1. An assessment of the risk presented by each event that the airline is aware of;
2. Some means to cross-check apparent trends in the rate of occurrence of particular events based on reports by operational personnel in order to determine whether the reported occurrence rate may be biased by changes in the number of such events that are being reported.

These requirements imply both a formal process to assess the risk associated with each event, as well as multiple streams of independent information, preferably including some that are not subject to the discretion of operational personnel on whether they report them or not. The latter issue is one reason why airlines have increasingly been implementing both flight data monitoring programs as well as programs to conduct safety assessments during line operations by trained observers in the cockpit. However, each of these programs has its limitations. Flight data monitoring programs only collect certain types of information (for example they generally provide no information on communications between the flight crew members or with air traffic control), while line operational safety assessments can only be performed on a limited number of flights and the flight crews in question may behave differently when they know they are being observed.

Even so, it is clear that any robust attempt to measure safety performance should be based on as many different sources of information as possible, and should attempt to integrate this information in order to provide an overall assessment of the level of safety. To do this effectively requires significant analytical capabilities and an adequate number of staff. The remainder of this report attempts to explore what these two requirements might involve.

3.0 Survey of Analytical Processes and Requirements

In 2001, GAIN WG B undertook a survey of airline flight safety department staff to identify and document analytical processes and requirements for methods and tools to support airline flight safety management. The purpose of the survey was to better understand the need for, and potential benefits from, better analytical methods and tools, as well as to identify opportunities to improve the dissemination of information about existing analytical methods and tools. The initial findings of this survey were documented in a report titled *Survey of Analytical Processes and Requirements for Airline Flight Safety Management – Summary Report*, issued in December 2001. This report is available on the GAIN website at *www.gainweb.org*.

The first survey consisted of interviews conducted with flight safety department personnel from 15 airlines, representing a wide range of size, type of operation, and nationality. It was recognized that the number of carriers in the survey limited the extent to which any findings for a particular subset of the sample can be considered representative of other airlines in the same category, but informal feedback from flight safety staff at other carriers since issuing the Summary Report suggest that they found the findings broadly consistent with their experience.

In order to develop a better understanding of the issues identified in the first survey, WGB undertook a follow-up survey in 2004. This second survey used a questionnaire that could be completed by airline flight safety personnel without being interviewed in person and was sent to a much larger sample of airlines. It focused on some of the factual aspects regarding staffing levels and experience, available data, use of analytical methods and tools, and flight safety management procedures and strategy that were addressed in the first survey. It also gathered information on training courses utilized by the responding airlines. Detailed findings of this survey are documented in a report titled *Second Survey of Analytical Processes and Requirements for Airline Flight Safety Management – Interim Report*, issued in September 2004. This report is also available on the GAIN website.

This section explores the findings of the two surveys. In particular, it examines flight safety department staffing levels and training, the data sources available to support the safety management process, the use of analytical tools, and the application of the results of flight safety data analysis. It is recognized that the organizational structure and terminology varies from airline to airline. In some airlines the flight safety management function may be an office, division, or branch within a larger department, such as a Corporate Safety Department. However, for the purposes of the discussion in this section, the term flight safety department will refer to the organizational unit primarily responsible for flight safety activities.

In order to understand whether the survey findings appear to vary by carrier size, the airlines were divided into three groups: small, medium, and large, as follows:

Small	-	Less than 30 aircraft
Medium	-	From 30 to 70 aircraft
Large	-	Greater than 70 aircraft or greater than 60 aircraft where all are twin aisle wide body aircraft and the airline's operations are all scheduled international flights.

These carrier size criteria were selected based on what appeared to be natural groupings from a review of the interview results from the first survey.

3.1 Overview of the 2001 Survey Findings

The first survey resulted in a sample of 15 airlines, divided into 4 large, 7 medium, and 4 small carriers.

3.1.1 Flight Safety Staffing Levels

Six of the airlines in the survey used a combination of full-time staff and part-time staff with flying or other duties, five had entirely full-time staff, and three used only part-time staff. Two of those using only part-time staff reported that paid staff were supplemented with volunteer flight crew. One airline using both full-time and part-time staff also reported the use of interns. The use of both full-time and part-time staff makes comparison of staffing levels difficult, since it was not stated how much time the part-time staff spend on flight safety duties. One large carrier did not report its flight safety department staffing levels.

The survey results suggest that the majority of the small airlines had a staffing level equivalent to between 2 and 3 full-time positions, with one carrier having a staffing level more than twice this. The majority of the medium carriers had a staffing level equivalent to about 3 full-time positions, with two carriers possibly having a somewhat higher staffing level although comprised mostly (or entirely) of part-time positions or volunteer staff. Two of the large carriers reported staffing levels equivalent to between about 5 and 10 full-time positions. One large carrier reported several full-time positions but did not state how many.

3.1.2 Flight Safety Staff Background, Experience and Training

Formal training in flight safety management varied widely across the 15 airlines. Two airlines had flight safety staff with a degree or certificate in safety management, while one of these and one other airline had flight safety staff that had attended a military safety officer school. Flight safety staff from eight airlines had attended various 1-2 week short courses on safety-related topics. Some respondents specified course topics and some indicated which staff had received specific training, but in several cases it was not possible to determine from the responses which courses had been attended and by how many of the staff. Respondents from four airlines mentioned attendance at workshops, seminars, or similar events as part of staff training, although respondents from four other airlines mentioned attendance at such meetings in the context of other questions. Three respondents mentioned attendance at training courses for specific analytical tools, while one of these respondents and two others mentioned in-house training activities.

There appeared to be no relationship between the size of the carrier or the flight safety department and the extent of formal training of the flight safety staff. The large carrier with nine full-time staff reported that three of those had attended an air safety investigation course and the part-time staff member had attended a crew resource management course. In contrast, the small air carrier with just two full-time staff reported that both those people had a Certificate in Air Safety Management from Embry Riddle Aeronautical University, while the more senior person also held a Masters degree in safety from the University of Southern California and had attended a military aviation safety officer school.

It is of course possible (or even likely) that respondents only mentioned some of the training activities that the flight safety personnel from their airline participated in. Even so, it was clear that there was no consistent pattern of training activities across the different airlines and that the breadth of training within most of the airlines can only be described as sparse. Only one airline reported staff with an academic degree in aviation safety and only two airlines reported staff with a certificate in aviation safety from a recognized academic institution (one of which was the same airline that reported staff with an academic degree in aviation safety). Similarly, only two airlines reported staff with prior training from a military air safety school (and as noted above, one of these was the same airline that reporting staff with both a certificate in aviation safety and a degree in aviation safety). The most commonly reported formal training was a 1-2 week short course in aviation safety management, which was mentioned by five of the 15 airlines (but notably by none of the large airlines, although this could have been included in "other courses" mention by one large airline).

From the perspective of the use of analytical tools, only three airlines mentioned participation in training courses for specific tools and one airline mentioned attendance at a user conference for the British Airways Safety Information System (BASIS). One airline mentioned in-house training courses on Flight Operational Quality Assurance (FOQA) analysis and "other safety systems in use." It is possible that some exposure to flight safety analysis takes place in more general courses on safety management, such as certificate programs or short courses on aviation safety management, but it appeared that most of the airline flight safety staff learned their analytical skills on the job.

Particularly striking was the fact that only four airlines mentioned attendance at workshops, seminars or conferences as training activities. It is possible that some respondents did not think of this as training and therefore did not mention their attendance. However, of the four that did mention it, two explicitly mentioned that only some of the flight safety staff had attended such events. Thus it would appear that attendance at such events is far from being considered an essential part of the professional development of flight safety staff at many airlines.

3.1.3 Flight Safety Data

The flight safety data and information available to the flight safety department affects both the requirement for analytical tools and the potential to make use of particular analytical techniques. The survey asked respondents what data and information sources they had available.

Most airlines responding to the survey reported that they received air safety reports from flight crew. Although three airlines did not explicitly mention these reports, in a subsequent question about their use of analytical tools all three airlines mentioned air safety report management systems, suggesting that in fact all the airlines in the survey received these reports and the respondents for the three airlines simply forgot to mention this. The next most common source of data was flight data analysis programs, which were mentioned by eight airlines. One other airline did not explicitly mention this data source but reported the use of flight data analysis tools, implying that it too had a flight data analysis program. Only five airlines reported receiving human factors reports separate from air safety reports. Three airlines mentioned having a safety hot line and three airlines mentioned technical reports or entries in the aircraft technical log. One airline mentioned accident and incident reports, although presumably all airlines would receive reports on any accident that occurred. Survey respondents also mentioned a wide range of other information sources that they use, including information from various industry sources.

It was notable that the small and medium sized carriers appeared to make greater use of information from a wide range of industry sources than did the large carriers, although a larger proportion of the large carriers reported use of information from industry organizations and manufacturers. All four of the large carriers had implemented flight data analysis programs. Surprisingly, three of the four small carriers had also established these programs, while only two of the seven medium carriers had. Confidential human factors reports were received by two of the large carriers and two of the small carriers, but only one of the medium carriers.

3.1.4 Use of Analytical Tools

The survey asked about the use of specific analytical tools within each airline flight safety department. One airline did not respond to the question and one airline mentioned the lack of suitable tools to work with industry data sources but did not mention which tools were in use in the airline, if any. Of those carriers that did respond, all had some tool or system for tracking and analyzing air safety reports. Six airlines used BASIS, two used Aviation Quality Database (AQD), and two used AVSiS. One airline used Microsoft Access to manage the database and Microsoft Excel to perform analysis and one airline used Excel for both functions. Two airlines had an internally developed or unspecified incident reporting system. One of these reported that they were in the process of changing to AVSiS.

Those airlines that had flight data analysis programs used a variety of tools to analyze these data. Five airlines did not identify the specific tool they used. Of the three airlines that mentioned specific tools, each used a different tool or combination of tools. One airline used the SAGEM flight data analysis tools, one used the Spirent Systems Ground Recovery and Analysis System (GRAF) and Performance Measurement and Management Information Tool (PERMIT) tools, and one used the Teledyne Controls Flight Data Replay and Analysis System (FLIDRAS) in conjunction with the Avionica AVSCAN.flight software.

Other than these two categories of tools, use of other analytical tools was very limited. Six airlines reported some analytical capability to handle human factors reports. Two airlines were using the Aircrew Incident Reporting System (AIRS), one airline was using the BASIS Human Factors module, and two airlines had an unspecified human factors reporting system. One airline was about to start using the Procedural Event Analysis Tool (PEAT). Apart from human factors analysis tools, one airline reported the use of REASON 4.16 for root cause analysis of incidents.

The results of the survey suggested that the use of analytical tools other than for the management and analysis of air safety reports or support for flight data analysis programs was still relatively limited and did not appear to be a function of carrier size. Half of the small carriers in the sample used human factors analysis tools as did half of the large carriers, although these tools were used by a smaller proportion of the medium size carriers. However, the only other type of analytical tool mentioned by respondents was used by a medium size carrier.

The survey also asked respondents about the advantages and disadvantages of the various tools that they used. Not all respondents answered this question and those that did only mentioned one or two aspects. Three respondents mentioned that the time required to use the tools or enter data was a disadvantage, while two respondents stated that the special purpose tools generally worked well. Other positive comments mentioned ease of generating reports from the data, the ability to track follow-up actions, and the ability to access data across the airline. Negative aspects included the difficulty of linking flight data analysis with air safety reports and the lack of suitable tools to efficiently search industry databases. The respondents from carriers using Access and Excel to manage and analyze air safety reports noted that spreadsheet tools were easy to use but the databases were time-consuming to maintain and the process of generating reports from the data was not particularly user-friendly.

3.1.5 Application of Flight Safety Analysis Results

The survey explored how the results of the analysis of flight safety data were used in each airline. While the specifics of the responses varied widely across the different airlines, they generally fell into seven broad categories:

- Briefings or reports to company management
- Periodic summaries of safety reports and incidents
- Articles in company safety magazine or other publications
- Briefings at training courses and safety seminars
- Provision of information to other departments
- Provision of information to flight crews
- Recommended revisions to manuals or procedures.

The frequency at which periodic summaries of safety reports and incidents were produced varied from weekly to quarterly, with one airline producing both a weekly summary and monthly digest of air safety reports. Another airline reported producing a monthly digest of air safety reports and a quarterly summary that combined information from incident reports with other sources and often focused on a specific topic. Three airlines reported producing periodic digests of flight data analysis, in two cases bimonthly and in one case twice per year. One airline reported producing a publication summarizing confidential human factors reports five or six times per year. Twelve airlines reported the use of flight safety analysis results in articles in company safety magazines or other publications. Five airlines mentioned briefings at training courses and safety seminars.

3.2 Findings from the Second Survey

As of early September 2004, 50 responses to the second survey had been received, consisting of 23 large, 9 medium, and 18 small carriers, using the same size criteria as the first survey. The aircraft fleet for each of these carriers varied from under 10 aircraft to over 400, with an average fleet size of 102 aircraft. The median fleet size was somewhat smaller, at 58 aircraft, reflecting a fairly large number of quite small airlines. Some 65 percent of the carriers operated a fleet that included wide-body aircraft, about 70 percent operated a fleet that included narrow-body jet aircraft, about 30 percent operated a fleet that included regional jet aircraft, and about 35 percent operated a fleet that included turboprop aircraft. The carriers include airlines based in North America, Central and South America, Europe, the Middle East, Africa, and the Asia/Pacific Region. They thus represent a wide range of airline size, fleet composition, and global diversity.

The second survey attempted to obtain data on a large enough sample of airlines to further group the results by the following categories of carrier:

- United States Major/National Airline
- International Airline
- Low-Cost Airline
- Charter Airline
- Cargo Airline
- Regional Airline

It was recognized that these categories were not necessarily mutually exclusive (for example some low-cost airlines and most U.S. major airlines operate internationally). However, the categories were chosen to reflect some of the broad differences in the type of service offered or the primary markets served, to see if these affected the way in which flight safety was managed. The U.S. major/national airlines were selected as a category for two reasons. The first is that even though they may have international service, the majority of their traffic is domestic, in contrast with most international airlines (i.e. airlines from other countries). The second is that they are all subject to the same regulatory requirements. It was thus hoped that the distinction between U.S. major/national airlines and large airlines from other countries would allow the survey to examine whether the regulatory environment appears to affect the flight safety management process and procedures.

Of the 50 responses received as of early September 2004, 25 were international airlines, 11 were regional airlines, 7 were charter airlines, 5 were U.S. major airlines, and 2 were low-cost airlines. No responses had been received from cargo airlines. In view of the limited response in several of the categories, an analysis of the differences between the various categories of carrier was deferred until additional responses have been obtained and the following results combine the responses for all carriers.

3.2.1 Flight Safety Department Staff

Having an adequate number of staff with appropriate training is clearly important to an effective flight safety management program. The required staffing levels will depend on the size of the airline, whether the staff are full-time or not, and the division of duties between the flight safety department and other departments (such as flight operations, training, and maintenance). Many airlines make use of experienced flight crew as part-time flight safety department staff. This has the advantage of providing staff with current operational experience, and may be less costly than full-time staff, depending on the compensation arrangements. However, it can have the disadvantage of loss of continuity when these staff members are performing flying duties.

Flight Safety Staffing Levels

The second survey provided more detail on the composition of the flight safety staff. In addition to stating the number of full-time and part-time staff, the average number of hours worked each month by the part-time staff was also given and whether the part-time staff had flying duties. In addition the survey provided information on the allocation of staff time to different flight safety management duties as well as the number of staff with flight safety duties in other departments, such as flight operations.

As could be expected from the wide range of fleet size of the different airlines, the headcount of flight safety department staff also varied widely, from 1 person to over 70 individuals. About 90 percent of the airlines had at least one full-time member of the flight safety department staff, about 60 percent of the airlines utilized some part-time staff with flying duties, and about 35 percent of the airlines utilized other part-time staff. The average flight safety department staff headcount across all the carriers was about 11 people. Of course, due to the use of part-time staff the average level of equivalent full-time staff was lower, averaging about 7.5 full-time positions. This ranged from a low of only one person spending about a third of the time on flight safety duties to one carrier reporting over 35 equivalent full-time positions. The median headcount of about 7 people and staffing level of about 5.5 equivalent full-time staff was somewhat lower than the average levels, reflecting the number of smaller airlines in the sample.

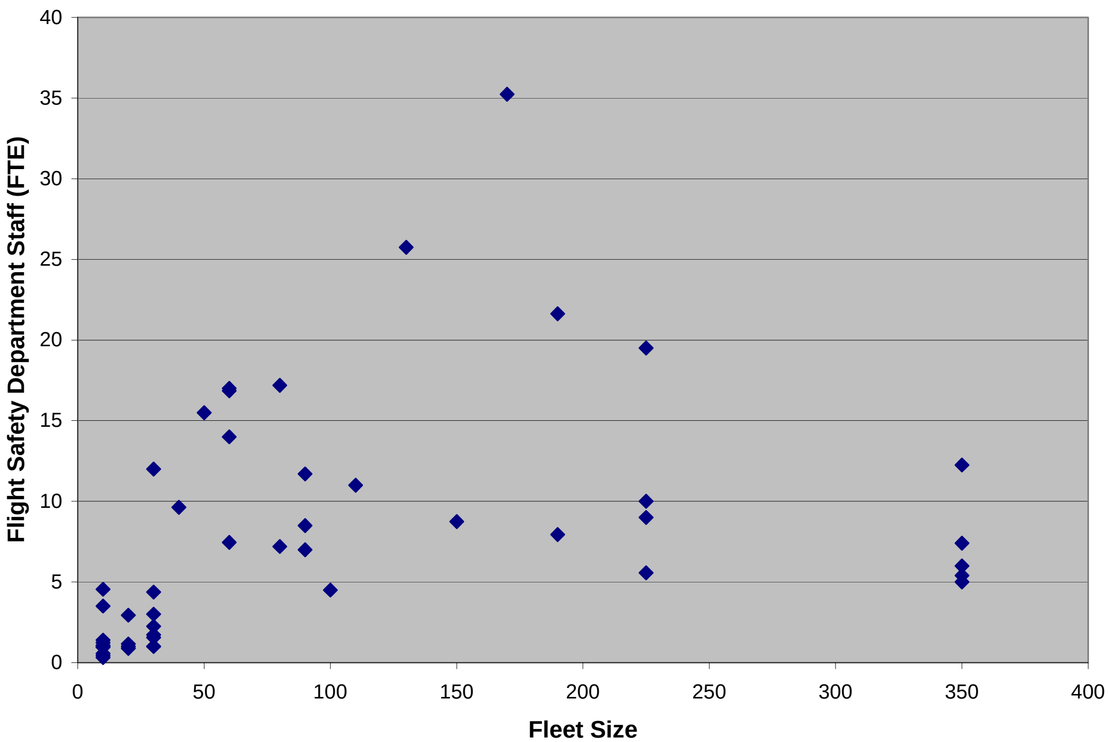
It became clear from the results of the survey that the allocation of safety responsibilities between the flight safety department and other departments was often a significant factor in the differences in staffing levels between carriers. In particular, in some airlines the flight safety department is responsible for performing safety audits whereas in other airlines this function is performed by a separate Quality Assurance Department or by staff distributed throughout the organization in different departments.

The relationship between the number of flight safety department staff, expressed in terms of the number of full-time equivalent (FTE) positions, and the airline fleet size is shown in Figure 3-1 (in order to de-identify the specific airlines, the fleet sizes have been rounded to the nearest 10 aircraft, with fleets between 200 and 250 aircraft shown as having 225 aircraft and airlines with a fleet larger than 250 aircraft shown as having 350 aircraft). It can been seen that although flight safety department staffing levels generally increase with increasing fleet size up to a fleet of about 200 aircraft, they tend to decline somewhat with fleet size above that level. Particularly striking is the large variance in staffing levels at all fleet sizes.

Although the allocation of staff resources to different duties also varied by airline, there was a fairly consistent pattern. For the average flight safety department of about 7.5 full-time positions, about 1.8 staff positions were devoted to flight safety program management, about 1.7 staff positions were devoted to incident and safety report investigation, about 1.6 staff positions to internal or external audits, about 1.7 staff positions to flight data analysis, and about 0.5 staff positions to other duties. However, not all airlines reported flight safety department staff performing some functions, so the average staffing level devoted to those functions in those airlines that did report staff performing those functions was somewhat higher. For those airlines with less than two equivalent full-time staff in the flight safety department, the division of duties across functions become somewhat arbitrary. For those airlines reporting more than two equivalent full-time positions across all functions, every airline had some staff time allocated to flight safety program management and almost every airline had some staff time allocated to incident and safety report investigation, some 75 percent had some staff time allocated to internal or external audits, about 80 percent had some staff time allocated to flight data analysis, and about 40 percent reported some staff time allocated to other duties. The range of the percentage of staff resources allocated to each function is shown in Table 3-1.

The median values of the allocation of staff positions to the different functions, as shown in Table 3-1, are lower for some functions and higher for others, reflecting the fact that not all respondents had staff performing every function.

Figure 3-1
Flight Safety Department Staffing Levels
2004 Survey



Of the 50 airlines, some 50 percent indicated that in addition to the flight safety department staff, there were staff positions with flight safety duties in other departments. Of these airlines, about 70 percent reported the existence of some staff with full-time flight safety duties in these other departments, about 55 percent reported that some of the staff in other departments combined part-time flight safety duties with flying duties, and about 25 percent reported the use of other part-time staff with flight safety duties in those departments.

The corresponding headcounts and staffing levels for staff in other departments with flight safety duties are also summarized in Table 3-1.

Table 3-1
Flight Safety Department Staffing Levels
2004 Survey

	Airlines Reporting	Average	Median	Min	Max
Staffing Levels					
Flight Safety Department					
Full-time staff	88 %				
Part-time staff w/ flying duties	62 %				
Other part-time staff	34 %				
Headcount		11.0	7	1	74
Equivalent full-time positions		7.6	5.6	0.3	35
Other Departments with flight safety staff	48 %				
Full-time staff	68 %				
Part-time staff w/ flying duties	56 %				
Other part-time staff	24 %				
Headcount		6.4	4	1	24
Equivalent full-time positions		4.1	3.0	0.03	18
		Equivalent Full-Time Positions		Staff Time Allocation	
Allocation of Staff Duties		Average	Median	Min	Max
Flight Safety Department					
Safety program management	100 %	1.8	1.0	7 %	43 %
Incident/safety report investigation	97 %	1.7	1.6	5 %	50 %
Internal/external audits	73 %	1.6	2.0	4 %	59 %
Flight data analysis	79 %	1.7	2.0	11 %	54 %
Other flight safety duties	39 %	0.5	1.5	5 %	40 %
Total		7.4	5.6		
Other Departments with flight safety staff					
Safety program management	40 %	0.4	1.0	11 %	33 %
Incident/safety report investigation	60 %	1.1	1.5	19 %	100 %
Internal/external audits	73 %	2.1	2.6	33 %	100 %
Flight data analysis	27 %	0.4	1.1	11 %	57 %
Other flight safety duties	20 %	0.3	2.2	9 %	100 %
Total		4.4	3.5		

Note: Range of staff time allocation to different duties based on airlines reporting more than 2 staff assigned to flight safety duties in each department.

The average headcount with flight safety duties in other departments, where such staff exist, was about 6.5 people, with average staffing level of about 4 equivalent full-time positions. The average staffing level of those airlines that provided information on the flight safety duties of the staff in other departments was somewhat higher at about 4.5 equivalent full-time positions. On average, about 0.4 staff positions was devoted to flight safety program management, about 1.1 staff positions to incident investigations, about 2.1 staff positions to internal and external audits, about 0.4 staff positions to flight data analysis, and about 0.3 staff positions to other duties. Median values of the equivalent staff positions across those airlines that had staff performing that function in other departments were naturally somewhat higher.

Flight Safety Staff Background, Experience and Training

In order to obtain a better understanding of the type of background, experience and training of flight safety department staff, the second survey asked explicit questions about this. In addition to the categories of training discussed in the first survey, airlines were asked to provide information on the professional background of the flight safety department staff.

Of the 50 airlines responding to the second survey by early September 2004, some 80 percent had flight safety department staff who had experience as a flight instructor, check pilot or line pilot. Obviously, this included all the airlines that had part-time staff with flying duties. Some 45 percent had staff with experience as a maintenance inspector, 40 percent had staff with experience as a flight attendant, and some 55 percent indicated that the flight safety department included staff with other experience as well. The latter included dispatchers, aircraft engineers, computer software specialists, and air traffic controllers.

The survey respondents were asked to indicate the most extensive flight safety training that each of their flight safety department staff had received. Almost 70 percent of the airlines reported that the flight safety department included staff with a degree or certificate in safety management, some 40 percent reported that the flight safety department included staff whose most extensive flight safety training was obtained through attending a military safety officer school, while some 40 percent had staff whose most extensive training was to obtain safety auditor credentials. Across all the flight safety department staff in the responding airlines, some 17 percent had a degree or certificate in safety management, while another 10 percent had attended military safety officer school as their most extensive flight safety training. Safety auditor credentials formed the most extensive flight safety training for some 24 percent of all flight safety department staff, while a 1 to 2 week short course formed the most extensive training for a further 29 percent. Two to four day short courses formed the most extensive flight safety training for 12 percent of flight safety department staff, while workshops or seminars provided the most extensive flight safety training for an additional 8 percent.

The survey respondents were asked to list specific training courses that flight safety department staff had attended in the past three years, with the number of staff who had attended each course, as well as other courses that the flight safety department staff had taken more than three years ago. Some 80 percent of airlines indicated that their flight safety department staff had attended specific training courses in the past three years, with an average of 3.7 courses listed and an average of 12.5 participants from each of those airlines attending the courses. The average number of participants is inflated by those airlines that reported sending large numbers of people to a single course, presumably including staff from other departments. The median number of participants from each airline was only 5. It was not possible to determine from the way the question was posed how many people attended more than one course. The survey questionnaire provided space to list four courses, and although some respondents used additional space to list more than four courses, it is possible that other respondents limited their list of courses to the space provided, even though their staff had attended more than four courses. The questionnaire specifically asked how many courses had been taken during the past three years, but many respondents did not complete this part of the question.

About 65 percent of airlines indicated that their flight safety department staff had attended specific training courses more than three years ago, with an average of 2.5 courses listed and an average of about 18 staff from each of those airlines attending the courses. However, this average is distorted by one airline that reported that 130 of its staff had attended a course on performing safety audits. Excluding this course, the average number of flight safety staff from each airline attending courses more than three years ago was about 6.5 people.

In addition to formal training, the second survey asked what guidance the flight safety department staff receive on how to manage safety within the airline. Some 80 percent of respondents reported that their company safety manual provides detailed procedures to be followed. About 90 percent of respondents indicated that they get recommendations from their company Safety Committee, while a similar percentage mentioned interaction with senior management on a regular basis, varying from two or four times per year to daily or weekly meetings. However, the difference may partly reflect the respondent's interpretation of "senior management". Some 70 percent of respondents mentioned interaction with flight safety staff at a parent company or code-share partners, while 95 percent identified information from industry associations, civil aviation authorities, and similar sources. Some 55 percent mentioned training of flight safety staff in the use of in-house analytical tools, while about 20 percent identified other sources of guidance, such as safety meetings with other departments and interaction with safety specialists in other industries.

3.2.2 Flight Safety Management Strategy

The second survey asked respondents to describe their company's safety management strategy. Almost all respondents indicated that this included monitoring safety reports, identifying risks, and implementing corrective actions. Some 90 percent reported the use of policies to preserve confidentiality and foster a non-punitive safety culture. About 75 percent identified the use of programs to analyze flight data from quick access recorders, identify exceedences from nominal performance, and implement follow-up actions. Only about 60 percent indicated that they conducted regular safety meetings with flight crews, while some 40 percent mentioned other strategies, such as the use of a safety culture survey or safety review boards within each operational department.

3.2.3 Flight Safety Data

The second survey asked respondents to indicate whether their flight safety department collects and analyzes specific safety data or information, or makes use of specific sources of information. The responses are summarized in Table 3-2.

Table 3-2
Reported Use of Different Sources of Flight Safety Data and Information
2004 Survey

	Proportion of Airlines Reporting Use
Safety Data and Information	
Air safety reports	96 %
Cabin safety reports	86 %
Ground damage reports	86 %
Aircraft flight data	70 %
Aircraft technical log	68 %
Confidential human factors reports	66 %
Hazard identification reports	56 %
Safety hot line	50 %
Other	30 %
Other Sources of Information	
Informal reports from flight crews and other personnel	88 %
Feedback from flight crews during training or safety briefings	76 %
Internal evaluation assessments	70 %
Line operations safety assessments	36 %
Information from manufacturers or industry associations	100 %
Information from civil aviation authority	96 %
Safety bulletins and magazines	94 %
Conferences, seminars and workshops	88 %
Internet, e-news	86 %
Consolidated safety information from other airlines	44 %
Other	6 %

The “other” sources of safety data and information identified by survey respondents included an employee error reporting system and employee job improvement suggestion program, Captain’s reports, daily operational and technical reports, reports from operational safety audits by outside parties, crew resource management reports from line check captains and training instructors, and crew scheduling and fatigue reports. Since reporting procedures vary by airline, in some cases these sources of information may have been included by some airlines in the various defined categories identified in the questionnaire.

3.2.4 Use of Analytical Tools

The second survey asked about the use of a number of specified analytical tools, as well as broader categories of tool. Respondents were asked to identify the specific tools that they used in the more general categories. They were also asked which aspects of the work in the flight safety department could benefit from increased automation or better integration between existing systems and tools.

The specific analytical tools identified by the respondents to the second survey as of early September 2004 are shown on Table 3-3, together with the proportion of airlines reporting their use. It can be seen that over 90 percent of the carriers had some form of air safety report management system, although in contrast to the findings of the first survey the most widely used product was an internally developed system. In several cases, respondents mentioned use of both an internal company air safety reporting system and a commercial system. It is unclear whether different systems are in use for different purposes, or the respondents misunderstood the question and counted the same system twice. The most widely reported commercial system in use was BASIS/ASR, the air safety report management module of the British Airways Safety Information System (BASIS), mentioned by about 45 percent of all respondents.

The use of flight data monitoring/FOQA analysis tools is consistent with the number of airlines reporting the collection and analysis of aircraft flight data. The most widely reported tools were the Teledyne Flight Data Replay and Analysis System (FLIDRAS) and Aircraft Flight Analysis & Safety Explorer (AirFASE) products, although a number of other products were also widely used. Some airlines reported the use of products from more than one vendor, such as a flight data analysis package from one vendor and a flight visualization tool from another. In addition to the more widely used tools listed on Table 3-3, several other tools were mentioned by only one respondent and some respondents did not identify the analysis tools used.

In contrast to the findings of the first survey, 40 percent of respondents reported using a human factors analysis tool and about a third of all respondents reported using a risk analysis tool, although several respondents counted the risk assessment functions of their air safety report management software as a risk analysis tool and others referred to an internal company system, the functionality of which is unknown. It is also not known to what extent users of the Aircrew Incident Reporting System (AIRS) are making use of its human factors analysis capabilities or are just using it as an air safety report management system. Never the less, there appears to be an increasing interest in having human factors analysis and risk analysis capabilities.

In response to the question about aspects of the flight safety department work that would benefit from increased automation or better integration between existing systems and tools, about 75 percent of respondents mentioned preparing routine reports, while some 70 percent mentioned getting information from flight crews and others. About 65 percent mentioned data entry while some 60 percent mentioned transferring data between different analysis programs or reformatting data to match the requirements of specific analysis software. Some 50 percent mentioned correcting reports in a database, and about 15 percent of respondents mentioned other aspects, including the need for better analysis tools, the ability to correlate information from flight crew reports with flight data monitoring (FDM) data, cleaning FDM data, and the need for active and interactive management information systems.

Table 3-3
Reported Use of Analytical Tools
2004 Survey

Analysis Tool	Proportion of Airlines Reporting Use
General purpose analysis tools	
Microsoft Excel	68 %
Microsoft Access or similar database software	48 %
SPSS	4 %
Air safety report management systems	92 %
BASIS/ASR	*44 %*
AQD	*10 %*
AvSIS / Systemware	*6 %*
Internally developed system	*50 %*
Other BASIS safety report management modules	8 %
Flight data monitoring/FOQA analysis tools	66 %
Teledyne FLIDRAS/AirFASE	*16 %*
Spirent GRAF/GRAF Vision	*14 %*
Sagem AGS	*12 %*
Austin Digital GDRAS/EMS	*8 %*
Flightscape RAPS	*8 %*
BASIS Flight Data Tools	*6 %*
Airbus LOMS	*6 %*
Human factors analysis tools	40 %
Aircrew Incident Reporting System (AIRS)	34 %
Procedural Event Analysis Tool (PEAT)	14 %
Risk analysis tools	32 %
Risk Analysis Tool (RAT) / TRACE	*6 %*
Risk assessment functions in BASIS/AQD	*8 %*
Internal company system / unspecified	*18 %*
Other analysis tools	
TapRooT / ICAM / Internal incident analysis tool	6 %
Data/text mining (PolyAnalyst / Starlight)	4 %
Fatigue Audit Interdyne (FAID)	2 %
Maintenance Error Decision Aid (MEDA)	2 %
Q-Pulse (quality system software)	2 %

3.2.5 Application of Flight Safety Analysis Results

The second survey asked about the outputs of the flight safety department analysis in a more structured way than the first survey, and included the exchange of information with other airlines. The proportion of the respondents that reported producing each type of output is shown in Table 3-4.

Table 3-4
Application of Analysis Outputs
2004 Survey

Flight Safety Department Output	Proportion of Airlines Reporting Use	Median Number per Year
Briefings to senior management	100 %	12
Briefings to Board Safety Committee	88 %	4
Periodic safety report or incident digest	88 %	6
Periodic safety summary	78 %	8
Exchange of information with other airlines	78 %	
Pilot and department bulletins	74 %	12
Presentations at training courses	72 %	8
Articles in company safety magazine	70 %	
Flight crew briefings	56 %	12
Other	16 %	

The “other” outputs included internal reports on specific incidents and exchange of safety information with industry organizations. Although relatively few airlines mentioned these, other respondents may have considered these to be included in the various categories specified in the question.

The frequency with which these various outputs were produced varied widely. Briefings to senior management ranged from weekly to annually. Briefings to the Board Safety Committee were generally less frequent, varying from bi-weekly to every six months. Periodic safety reports or incident digests were produced between 1 and 12 times per year, while periodic safety summaries varied from weekly to annually. The number of flight crew briefings ranged from one to 70 per year, while presentations at training courses ranged from one to 60 per year. The frequency of pilot or department bulletins varied from quarterly to about twice a month.

Respondents were also asked if their airline attempted to measure the overall safety level, and if so were asked how they did this. Some 70 percent indicated that they did, although the approaches used varied widely and some responses were simply a restatement of the various outputs identified in the previous question. Respondents were also asked if they shared flight safety information with other airline, and if so what type of information and how it was shared. Some 80 percent stated that they did. The type of information shared included the results of safety investigations and data analysis, safety issues of concern, and details of specific incidents. The means by which this was done varied from formal incident reporting systems, such as the BASIS Safety Information Exchange (SIE) and the IATA Safety Trend Evaluation and Data Exchange System (STEADES), to discussions at industry meetings and informal contact via e-mail.

3.2.6 Training Requirements

The second survey asked the respondents to identify needs for additional training, and these are summarized in Table 3-5. The most widely reported need was for human factor training, followed by risk assessment and statistical analysis.

Table 3-5
Flight Safety Staff Training Needs
2004 Survey

Training Need	Proportion of Airlines Reporting Need
Human factors analysis	80 %
Risk assessment	76 %
Root cause analysis	66 %
Incident investigation	60 %
Statistical analysis	60 %
Use of specific tools	22 %
Other	14 %
Air traffic control procedures	*2 %*
Aircraft systems and procedures	*2 %*
Audit database and analysis	*2%*
Flight data recorder analysis	*2 %*
Flight simulation software	*2 %*
Linkage between quality and safety	*2 %*
Report preparation and communication	*2 %*

The survey also asked what impediments limit the ability of the flight safety department staff to get needed training. Perhaps not surprisingly, about 75 percent of respondents noted that too much workload prevented staff from taking time away from the office. Some 70 percent of respondents mentioned the cost of attending courses, while about 20 percent indicated a lack of appropriate courses.

3.3 Summary

To the extent that the survey findings can be generalized beyond the sample of airlines that participated in the survey, the results of the two surveys suggest that most, if not all, airlines have established a process for collecting and analyzing air safety reports, and have acquired or developed safety report management and analysis tools to support this process. To an increasing extent airlines have begun to implement flight data monitoring programs, and about 60 percent of the airlines in the first survey reported having such programs, while this had increased to about 70 percent in the second survey. Although this difference may be simply a consequence of the two samples, the use of flight data monitoring has been increasing over time, which is consistent with the survey results. Confidential human factors reporting programs are somewhat less prevalent, with only a third of the airlines in the first survey reporting such programs, although this had increased to about 65 percent in the second survey. This too may indicate an increasing use of these programs. The use of analytical tools reflected the types of data available within each airline, with almost all the airlines having some type of air safety report management system, those airlines with flight data monitoring programs having the necessary analysis tools to support those programs, and some use of analytical tools for managing human factors reports, such as the Aircrew Incident Reporting System (AIRS) and the Procedural Event Analysis Tool (PEAT).

Beyond the basic set of analytical tools to manage and analyze air safety reports, perform flight data analysis, and manage and analyze human factors reports, there were almost no further analytical capabilities reported by the carriers in the first survey, with only one carrier mentioning any other tools. This lack of more advanced analytical capabilities is not surprising given the survey findings on the staffing levels and training of the flight safety department staff at most of the airlines in the sample. The majority of these airlines had no more than 3 full-time staff, and three airlines had only part-time staff. While the flight safety staff at most airlines appeared to have received some formal training, in most cases this was limited to 1 or 2 week short courses on various aviation safety topics or attendance at safety workshops and seminars. Only three airlines reported that their staff had received any training on specific analytical tools.

The situation was somewhat different in the airlines responding to the second survey. Not only did their flight safety departments in general have more staff with more formal safety training, but they made use of a wider range of analytical tools, including risk analysis tools (RAT, Total Risk Assessing Cost Estimate (TRACE), and internally developed tools), root cause analysis tools (TapRooT and Incident Cause Analysis Method (ICAM)), and data/text mining tools (PolyAnalyst and Starlight). While this may in part reflect the particular airlines participating in the two surveys, it may also reflect the increasing awareness of both the need for more advanced analytical capabilities as well as the available tools.

Given the analytical capabilities available in the majority of the airlines, which in most cases consists of a safety report management system that provides some trending and filtering capabilities and in some cases flight data analysis software that can identify events of interest and record statistics on the frequency of such events, it appears that the application of the results of the analysis is primarily oriented to reporting trends in types of incidents and summarizing the details of recent incidents. Although serious incidents are presumably investigated and corrective actions formulated and implemented, the respondents to the first survey made very little reference to this, and only two of these airlines reported the use of analytical tools designed to support this process (PEAT and REASON). Some of the safety event and human factors analysis tools mentioned by the survey respondents, such as BASIS, AIRS and AQD, have the capability to classify reports according to levels of risk or causal factors, but it was not possible from the survey responses to determine the extent to which these capabilities were used.

The second survey provides more information on how the airline flight safety departments make use of the results of their analysis of the safety data, as well as the extent to which airlines attempt to measure the overall safety level and exchange information with other airlines. It appears that most airlines have some formal periodic reporting process to senior management, although the frequency with which this takes place varies widely. Slightly less common is a formal reporting process by the flight safety department to the Board of Directors, although this might occur indirectly through senior management. Similarly, periodic safety reports and summaries, and exchange of information with other airlines were mentioned by about 80 percent of respondents. Pilot or department bulletins, presentations at training courses, and articles in safety magazines were mentioned by between 70 and 75 percent of respondents. Somewhat surprisingly, only about 55 percent of respondents indicated that the flight safety department gave briefings directly to flight crew.

Attempts to measure the overall level of safety in the airline appear to be fairly widespread, with about 70 percent of respondents indicating that they did this in some way.

In summary, it appears that the data and analytical infrastructure is in place at many airlines to implement an effective flight safety management system, and indeed many of the airlines responding to the second survey had already begun to view their flight safety management process as a formal safety management system, although they may not have used the term.

4.0 Airline Flight Safety Management Case Studies

In order to better understand and document the current use of analytical tools in airline flight safety analysis, Working Group B has undertaken a number of visits to airline flight safety offices to discuss their experience in the use of analytical methods and tools and to document the findings for the benefit of other airlines.

The objective of the visits was to obtain a better understanding of both:

- the organizational process by which safety related events are examined and flight safety is managed,
- the technical means that support these safety analyses, *i.e.* the analytical methods and tools that are being used in the airline.

The following specific questions and issues were discussed with the host airlines:

1. What is the corporate safety organization? How is safety managed within the airline? What are the roles and responsibilities of the different departments, and the chain of command?
2. What sources of safety data are available to the Flight Safety Office? What is the process by which these data are obtained?
3. What is the "lifecycle" of an incident at the airline? Discuss the process that is followed from the time an incident report is received, with particular focus on the analysis issues.
4. Where does the analysis fit in the full Safety Management System? Discuss the relationship between Flight Safety Office activities and those of other departments. How do operational recommendations that result from the analysis of incidents or events get approved and implemented? How is the incident management and analysis process documented in the corporate safety manual?
5. What analytical tools are used, including both those used on a routine basis and those used occasionally to address specific issues?
6. How are these tools used? Discuss specific examples of recent analyses using the various tools.
7. How would the Flight Safety staff like to see these tools improved?
8. What else would they like to have?
9. Are there analytical tools that the Flight Safety Office used to use? Why are they no longer used?
10. What training has the flight safety staff had in analysis procedures or the use of specific tools? How frequently do the flight safety personnel turn over? How much training is obtained while in the position, versus prior training or experience?
11. What additional training would the airline like the flight safety personnel to receive or at least be informed about?

In order to allow a frank discussion of capabilities and procedures it was agreed with the host airlines that they would not be identified. Thus the following discussion has been edited to avoid mentioning any identifying characteristics. Over the past two and a half years, WG B members have undertaken case study visits to 12 airlines: six U.S. airlines, four European airlines, and one each in the Middle East and the Asia-Pacific region. The airlines range in size from some of the largest in the world, through medium-sized national flag carriers with global route networks, to new entrant low-fare airlines and a U.S. regional airline. Using the fleet size criteria discussed in the previous section, four of the airlines are medium-size airlines and eight are large airlines. However, the large airlines varied greatly in size, with the largest of these carriers having a fleet more than five times the size of the smallest.

The following discussion summarizes the findings of the visits from the perspective of identifying common practices as well as differences in approach across the various airlines. For consistency in discussion, the organizational unit responsible for flight safety management has been termed the Flight Safety Office (FSO) and the larger unit responsible for all aspects of safety within the airline has been termed the Corporate Safety Department (CSD), although actual terminology varied across the airlines. The manager or director of the Flight Safety Office has been termed the Flight Safety Manager (FSM), although again terminology varied across the airlines. Similarly, terminology for other departments varied. For the purposes of the discussion, the department responsible for aircraft maintenance has been termed Engineering. Other department names, such as Flight Operations and Training are generally self-explanatory.

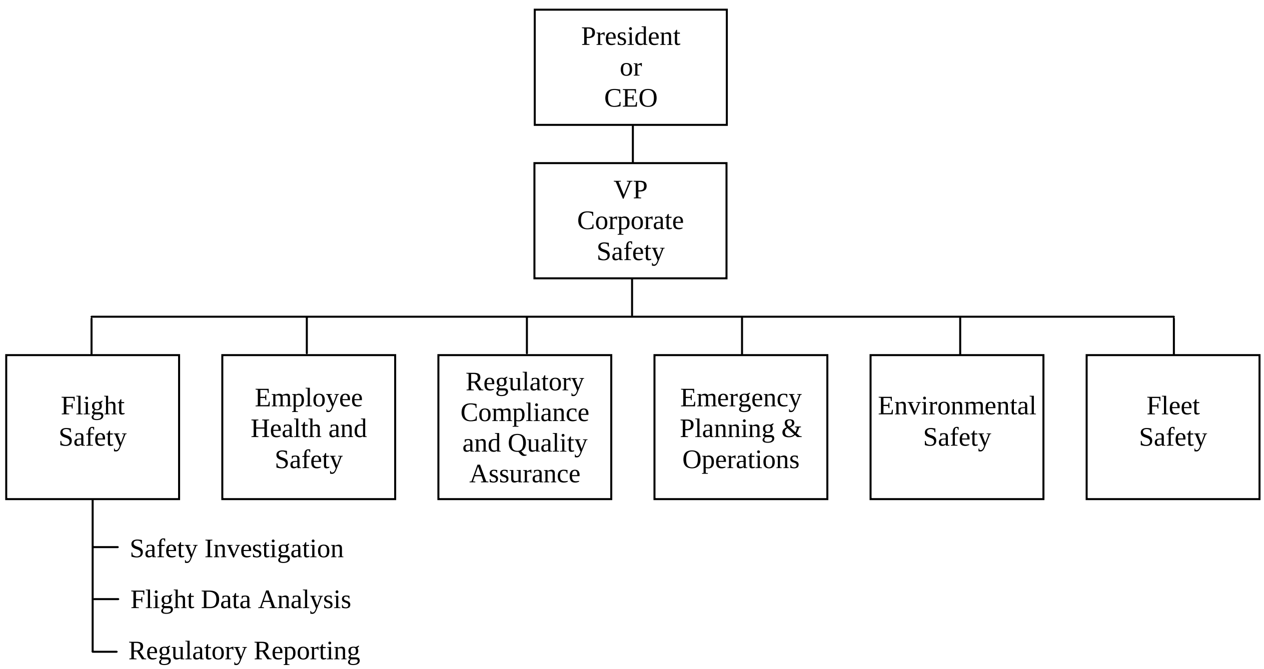
4.1 Organization

In the majority of the airlines visited, the Flight Safety Office was one of several offices within a Corporate Safety Department, as illustrated by the organizational chart for one such airline shown in Figure 4-1. In this case the Vice President (VP) for Corporate Safety reports directly to the President or Chief Executive Officer (CEO). The Flight Safety Office coordinates its activities with the other offices within the Corporate Safety Department, which include employee health and safety, regulatory compliance and quality assurance, emergency planning and operations, environmental safety (hazardous materials), and fleet safety (aircraft maintenance and engineering). In some cases, the fleet safety function was located in the Engineering Department. Cabin safety was generally the responsibility of a safety office within the In-Flight Services Department. Responsibility for ramp safety varied across the airlines, but was typically located within the Employee Health and Safety Office of the CSD. In one of the smaller airlines visited, the Flight Safety Office included both the Cabin Safety and Ground Safety functions and also handled regulatory compliance matters related to flight safety.

Most of the airlines had a separate office responsible for regulatory compliance and quality assurance. This office undertakes internal safety audits of all other units within the airline, including the FSO, to ensure that all regulatory requirements are being complied with and corporate policies and procedures are being followed.

The organizational structure within the FSO varied across the airlines, largely as a result of their different sizes and staffing levels. In the smaller airlines different functions were typically assigned to different individuals within the FSO. In the larger airlines, which had several staff assigned to each function, the FSO was divided into separate branches responsible for each function. A typical division of responsibility was between performing safety investigations and analysis of incident reports and performing flight data analysis. Those airlines that had regulatory requirements or agreements to report certain classes of incident to the regulatory authority (such as the Aviation Safety Action Program in the United States or Mandatory Occurrence Reports in some other countries) typically had one or more staff members assigned to this function.

Figure 4-1
Example of a Corporate Safety Organization



4.1.1 Flight Safety Office Staffing

The FSO staffing levels varied widely across the airlines, largely as a function of their relative size. Most airlines made use of a combination of full-time staff and part-time or volunteer flight crew, particularly to support the flight data analysis program. It was difficult to compare staffing levels across the different carriers in a meaningful way due to the different organizational structure within the CSD and the resulting different division of responsibilities within the FSO. A significant factor in overall staffing levels was whether the carrier had implemented a flight data analysis program, since this typically involved at least two full-time staff and a number of part-time flight crew. One of the larger carriers, which had several crew bases, also had a part-time flight safety coordinator at each base.

4.1.2 Coordination with Other Departments

The airlines had implemented various arrangements to maintain effective coordination with other departments, particularly Flight Operations. In the smaller carriers this tended to be less formal.

The FSM in one such carrier had an office adjacent to the offices of the Fleet Chiefs who supervise the pilots, instructors and check airmen for a specific aircraft type, which facilitated face-to-face contact. The FSM reported that he also met on a regular basis with the Chief Pilot and Chief Flight Attendant. The flight safety staff of another of the smaller carriers participated in a monthly operations/maintenance coordination meeting that was attended by both the VP for Flight Operations and the VP for Engineering.

At one of the larger carriers, the FSO holds separate monthly meetings with the VP for Flight Operations and the VP for Engineering. A monthly briefing is given to the VP for Corporate Safety and a quarterly briefing is given to the Chief Pilots for each crew base. A quarterly briefing on flight safety is also given to the Chief Executive Officer and an annual briefing is given to the Board of Directors. At another of the larger carriers the FSO works closely with the Flight Operations Department at two levels. Flight safety staff members participate in flight operating management reviews that are held by the Chief Pilot and attended by the General Manager for flight training and the Fleet Managers for each aircraft type. They also participate in Type Operating Committee meetings that are held by each Fleet Manager and attended by the training captain, training manager and technical captain for each fleet.

4.1.3 Role of Line Managers

In addition to the flight operating management reviews and type operating committee meetings discussed above, the latter airline has begun a process of devolving some elements of the safety management program out of the specialist units within the CSD to the line managers, with the goal of obtaining their involvement and ownership in the identification and analysis of safety issues. This has generated a requirement for safety data to be integrated into the performance measurement process relevant to the aspects of the operation that the line managers control. It also has implications for the support tools needed to assist in managing the workflow involved and to provide data query and presentation capabilities that can be easily used by the line managers throughout the organization.

4.2 Flight Safety Data

All of the airlines maintain a safety event reporting system for air safety reports (ASRs) from flight crew (terminology varied), as well as a range of other types of safety reports. Several of the airlines had undertaken efforts to facilitate and automate the filing of ASRs using the corporate intranet. Two airlines were providing flight crews with laptop computers to use in the cockpit for a variety of tasks. ASRs could be entered on the laptop and downloaded when the crew returned to their base. Another airline has established a web site on the corporate intranet that allows all classes of employee to file a variety of safety reports, including flight crew ASRs, although employees can also file the reports in a variety of other ways, including fax and e-mail. The airline has found that the use of the web site is increasing and that reports filed in this way tend to have longer and more detailed narratives than those submitted on paper forms. This airline also emphasizes the importance of timely follow-up to encourage employees to file reports. As soon as reports are received, the FSO contacts the individuals filing the reports by telephone or mail to thank them and inform them of the process being followed to determine what actions to take in response to the report. Once these actions have been decided, the originators of the reports are again contacted and informed of the action being taken. Then after six months the originators are again contacted to ask if they believe that the problem has been resolved. This not only makes originators feel that they are part of the safety management process, but can also provide useful feedback on whether the actions taken appear to have been effective.

At the time of the visits, six of the airlines had a well-established program to collect and analyze aircraft digital flight operations data, three airlines had recently implemented programs, and one airline was in the process of doing so but was not yet collecting data. One airline had the ability to extract aircraft flight data for investigations, but did not collect data on a routine basis. Those airlines that had recently implemented their programs were still exploring what types of events to monitor and how much information to archive. Also, not all their aircraft fleet were currently equipped with flight data recorders, although efforts were under way to install recorders on the remaining aircraft types, apart from older aircraft that were being phased out. One of the airlines was planning to install optical disk readers in the hangars, so that the flight analysis data could be downloaded from these without having to physically transport the disks to the flight safety department. The same airline was also considering equipping its flight simulators with quick access recorders, so that comparable analysis could be performed on training flights performed on the simulators.

4.3 Analytical Techniques

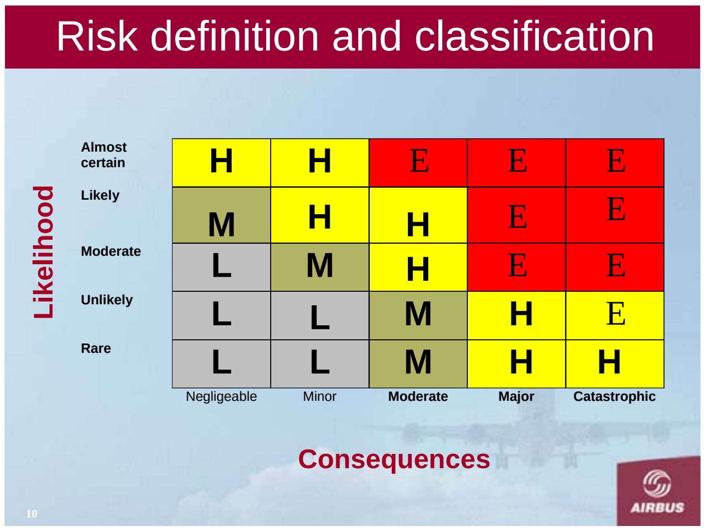
All but one of the airlines were using commercial safety event report management and analysis systems to manage the event investigation and corrective action tracking process, as well as to perform analysis of trends in the occurrence of events. One of the larger airlines was using a combination of an internally developed system for managing all the ASRs and a commercial system for tracking and analyzing the more serious events. Several of the airlines make use of Microsoft Excel to perform more detailed statistical analysis of trends in particular types of events and to prepare charts to illustrate these trends in briefings to management and others. Typically, the filtering capabilities of the safety event report management system are used to select a subset of events of interest and then the data fields for those events are exported to Excel for further analysis.

Each of the airlines performs some formal risk assessment on each incident report in order to identify the severity of the potential threat posed by the event and to prioritize the development of corrective actions. This generally involves the classification of the event on the basis of the potential severity of the consequences and its likelihood of recurrence. Events are then assigned a severity classification based on a matrix that combined the severity of the consequences with the likelihood of recurrence.

One airline divides the potential consequences into five classes (from negligible to catastrophic) and the likelihood of recurrence also into five classes (from rare to almost certain), and then assigned events to four risk levels (low, moderate, high and extreme), based on their combination of consequence and likelihood values, as illustrated in Figure 4-2. Other airlines use a smaller number of severity and likelihood categories (such as three) and a different number of risk levels (such as five), but the general approach remains the same.

Although the assessment of the likelihood of recurrence and even the severity of the potential consequences for a particular type of incident inevitably involves a considerable amount of judgment, some airlines have defined quantitative criteria for the various severity categories in an attempt to achieve more consistent assessments.

Figure 4-2
Typical Risk Assessment Matrix



One of the airlines has developed a formal set of criteria for determining the consequence severity rating that considers the extent of likely injuries, extent and cost of aircraft damage, and implications for regulatory compliance and public confidence. The resulting risk level is then used to determine the appropriate action management process. Moderate and low risk events that only relate to a specific branch or section of the company are subject to local management review. Events that are considered to pose a high risk, or that pose a moderate risk but involve multiple branches or sections, or have a moderate potential for public reaction are subject to a divisional management review that considers the issues and recommended actions identified at the local level. Events that are considered to pose an extreme risk or involve issues that span multiple divisions, or have significant potential for public reaction are subject to a corporate management review by the Executive Safety Committee (ESC). Recommended actions from the ESC are submitted to the Board of Directors, together with a report on the incident.

In addition to the analysis of air safety reports, each of the airlines with a flight data analysis program made use of commercial flight data analysis tools to identify events of interest in flight recorder data and to visualize the associated aircraft flight path and control parameters, although the particular software varied across the airlines.

Some of the airlines had also begun exploring the use of more specialized tools. One airline was starting to make extensive use of an incident investigation tool (TapRooT) that provides a structured approach to entering information from the investigation as well as analysis capabilities to identify the relative role of different causal factors. Another carrier had experimented with a data visualization tool and was using a data mining tool to search the ASR database for incidents with common characteristics. A third carrier had begun to make extensive use of a risk analysis tool (RAT). This carrier had also begun to use an organizational safety culture survey in support of its safety audit program of its code-share partners and was planning to extend the use of the survey to its own operations.

4.4 Application of Analysis Results

The use of the results of the analysis activities in each airline showed both common practices and local differences. Each of the airlines produced a periodic summary report or digest of flight safety events, typically supplemented with more general articles and in some cases statistics on trends from the flight data analysis program. In some of the airlines a monthly summary report was distributed to units within the organization electronically, with a printed version distributed more widely, including to all flight crew, somewhat less often. Some of the airlines produced separate reports summarizing the flight safety event reports and the results of the flight data analysis program.

One airline has started to hold an annual safety summit conference for the Chief Pilots and their staff, Fleet Captains and their staff, base safety coordinators, safety personnel from the pilot union, and the training department staff. The flight safety department provides briefings similar to the regular briefing provided to airline management, with a focus on accident prevention. The conference provides an opportunity to get input from the flight crew and feedback on ways that the flight safety department can enhance the information that they are providing. Another airline uses safety event report analysis to develop a list of the “top ten” or “top twenty” accident precursors in cooperation with the fleet chiefs. The fleet chiefs then discuss these issues on “fleet chief days” that every pilot is required to attend.

In several of the airlines, the flight safety department staff participate in training courses for flight crew, cabin crew, and technical staff (aircraft maintenance and line operations). While the primary focus of these sessions is to explain the flight safety management process and encourage employees to report safety events, the results of analysis can be used to illustrate the process and explain the value of good data. In one of the smaller carriers, the flight safety department staff participate in a working group each year with the training staff to plan the training program for the following year. This allows the training program to be responsive to the incident trends being identified from the flight safety data analysis.

4.5 Summary

The airline visits were helpful in better defining the current state of the art of flight safety management. This involves three distinct activities:

1. The collection and analysis of a wide range of safety related data, both reports of incidents or concerns and aircraft flight operational data, and the analysis of these data to identify trends and develop a system of safety indicators that can be used to monitor the overall safety performance of the airline;

2. The development of a risk management approach to the investigation of specific events or categories of event, and the prioritization of efforts to identify and implement corrective actions targeted at those threats that are considered to pose the highest risk to safety;
3. The development of formal procedures to coordinate the analysis activities of the flight safety department with the business processes of other operating departments, including flight operations, flight crew training, in-flight services, ramp operations, and aircraft maintenance, to enhance the safety culture within the airline, and to engage senior management in flight safety issues.

The analytical tools in use generally consist of a safety event report management and analysis system and flight data analysis tools. Some airlines have been exploring the use of other tools, such as occurrence investigation and human factors analysis tools, but their use is neither widespread nor well defined. In most of the airlines visited, the safety event investigation and analysis activities are managed as a separate function from flight data analysis, and the results of the two analysis activities are not yet particularly well integrated.

5.0 Hierarchy of Analytical Tools

As discussed above, 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.

Working Group B has identified a wide range of analytical tools that have potential use to support the airline flight safety management process. These tools are described in a separate report prepared by WG B titled *Guide to Methods and Tools for Airline Flight Safety Analysis*.

The Guide describes a large number of tools, 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 the Guide perform the same or similar functions. Thus airlines will generally select 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.

5.1 Types of Airline Flight Safety Data

The types of data collected as part of the airline flight safety management process are 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.

5.1.1 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 reports:

- 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 reports (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.

5.1.2 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.

5.1.3 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).

5.2 Types of Tools for Airline Flight Safety Analysis

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

5.2.1 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 they 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 reports. 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.

5.2.2 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.

5.2.3 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 needs to address in a more systematic way is the analysis of human factors data. Developing a useful human factors analysis capability obviously requires an adequate source of data to analyze. Such data can be collected through both a well-designed confidential human factors reporting program and structured follow-up interviews with people filing event reports. In general, it will be difficult to undertake meaningful human factors analysis of event reports that are not structured to address human factors issues, and data collection processes will be required that identify such considerations as the sequence of actions performed, the information available at the time and the decision-making process, competing actions and workload, communications within the flight crew and with outside parties, training and design issues, and so forth. In the absence of a structured data collection process, the omission of information on a particular issue in routine event reports does not necessarily mean that the issue is not relevant, but could be simply because the person filing the report did not think to mention it. The problem of incomplete reporting of human factors data can be addressed by having a human factors specialist perform follow-up interviews. However, this means that an appropriate level of resources is required to implement a meaningful human factors reporting system.

Among the important factors in developing a human factors reporting system are the issues of confidentiality and interpretation. Confidentiality is an issue that most safety organizations have experience in addressing, and most commercial human factors analysis tools have capabilities to protect the information involved. The issue of the interpretation of the data is more complex. Human factors observations are often qualitative in nature, requiring the application of qualitative data analysis techniques, such as qualitative causal analysis, clustering, counting, and factoring, to produce well grounded interpretations and explanations of events. However the findings from such studies can often be organized into a narrative or descriptive format that can prove more convincing to safety managers or flight crew than purely numerical results. Commercial computer programs are available for qualitative data analysis that include software to manage textual databases and perform data coding, search and retrieval, and counting and display functions with structured and free-form text, as well as link categories of information to develop higher-order conceptual structures.

Some of the available human factors analysis tools can 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, such as those based on qualitative analysis techniques, are designed to work with human factors data that may be stored in separate data management systems, such as flight safety event reporting systems.

5.2.4 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 simply the process of preparing an investigation report.

The experience of Alaska Airlines in deploying one such occurrence investigation and analysis tool, TapRooT® developed by System Improvements, Inc., is described in a brochure *Aviation Safety Analysis Tools in Action* that has been prepared by GAIN WG B and is available on the GAIN website at *www.gainweb.org*.

Data Mining and Data Visualization

Data mining tools are designed to analyze a large amount of data in a structured database using automated algorithms to discover hidden patterns and relationships in data. Many such tools utilize automated learning from the data, but the processes still require a human-in-the-loop. Subject matter expertise is needed to review initial results and determine which patterns and relationships are of real value, and which are "commonly understood" or otherwise not valuable. WG B is not aware of data mining tools specifically designed for airline flight safety analysis, but these tools have been used for years in domains such as marketing analysis, fraud detection in banking, and national intelligence. As this report is being written, WG B is working with the FAA's Office of System Safety on two technology demonstration projects that are exploring the application of data mining tools to airline digital flight data. Results of these projects should be posted on the GAIN website (*www.gainweb.org*) by October 2004.

Data visualization tools provide another way to allow a human analyst to identify possible patterns, trends or associations in a data set, this time by utilizing graphical displays. In fact, most data mining tools incorporate several different approaches to data visualization to help display their results. 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.

Text Mining

The area of "text mining" encompasses several information-processing capabilities that include retrieval, summarization, navigation, clustering, trending, etc. All text mining involves the transformation of narrative information that is unstructured ("freeform text") into structured information that is amenable to many of the same algorithms applicable to coded or numerical information. This process usually involves the counting words or word stems and calculating the proximity of those words/stems to other words/stems and the frequencies of various pairings. This counting identifies keywords and common phrases in the text. Certain approaches extract "entities" in the text (company and people names, time/date stamps, geographic information), sometimes based on pre-established "rules" that are domain-specific (finance, pharmaceutical research, aviation safety, etc.). From these word counts and entity extraction, the tools create mathematical representations of the semantic content of the information being analyzed. The approaches for transforming text into structured information include techniques like vector space modeling, latent semantic indexing, and statistical content analysis.

Since a significant amount of the information in flight safety event 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.

Searching with text mining tools typically functions by selecting or defining a *query* or *target* sample of text, record, or group of records, and then identifying other records in a dataset that exhibit a similar occurrence of words and phrases. These tools often provide ways in which the user can limit the search by defining how "similar" a record should be in order to be selected, and commonly include some linguistic capabilities, such as understanding synonyms, grammatical structure, and the significance of word order in a narrative. While it will generally be necessary for an analyst to review the resulting records identified in a search to determine whether their similarities are relevant to the issue at hand, the use of such tools can greatly reduce the number of records that have to be examined, and may identify relevant records that would not have been discovered using more conventional search techniques.

Other text mining algorithms can perform a wide variety of types of analysis that may be helpful in aviation safety analysis. Text mining tools can find relationships such as:

- Links between various terms or concepts, for example, correlations between particular aircraft models and components on the aircraft
- Patterns of terms that frequently appear together in the body of text
- Unusual distributions of incident attributes (e.g., by month, by airport, by aircraft model)
- Associations among incident attributes (co-occurrence among certain equipment problems, types of human errors, etc.).

It is not yet clear how effective text mining tools will be in aviation safety. All text mining tools require some work up-front in "training" the tool to understand and interpret the specific terminology of a particular domain (e.g., aviation safety) and to determine which types of mining algorithms are most appropriate for the questions raised by an aviation safety analyst. Also, the cost/benefit of applying text mining tools to aviation safety has not yet been explored. However, encouraging initial results have been shown in several technology demonstration projects sponsored by FAA's Office of System Safety in cooperation with GAIN. These projects have explored the application of text mining tools in partnership with several airlines and with IATA to apply text mining tools to airline safety reports. Results of two such projects are already posted on the GAIN website (*www.gainweb.org*) and two more project reports should be available by October 2004. In addition, example applications of some of these tools are now included in the Analytical Methods and Tools area of *www.gainweb.org*.

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.

The experience of British Airways in deploying one such risk analysis tool, the Risk Analysis Tool (RAT) developed by Arium Technology, is described in a brochure *Aviation Safety Analysis Tools in Action* that has been prepared by GAIN WG B and is available on the GAIN website at *www.gainweb.org*.

Other Special Purpose Tools

There is a range of additional analysis functions that could be performed by special purpose tools, although to date relative 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 even 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.

5.3 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. There 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 tools, that are used to help assess the effectiveness of alternative safety management actions and strategies.

The effective use of the full range of tools discussed in this section 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 to 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.

In order to assist airlines expand their analytical capabilities by providing information on the application of available tools to flight safety analysis, GAIN WG B has worked with developers and vendors of selected tools to prepare descriptive summaries of example applications of these tools. These example applications illustrate how the tools are used or could be used for flight safety analysis by describing a sample analysis, including the input data needed, the steps in the analysis process, the output of the tool, and the potential value of the results of the analysis. The example applications are available on the GAIN website at *www.gainweb.org*.

6.0 Requirements for Improved Analytical Tools

The surveys of airline flight safety departments described in Section 3 and the case study visits to airline flight safety departments discussed in Section 4 identified a number of areas where improvements to the capabilities of existing analytical tools would greatly enhance their usefulness or usability. These fall into three broad categories:

1. Customization of the tools to perform standard analytical procedures that commonly arise in airline flight safety management;
2. Better integration between existing tools or configuration of these tools to interface with existing airline safety data sets;
3. Improved analytical capabilities for risk analysis and risk management.

6.1 Improved Ease of Use and Increased Automation/Customization

Specific requirements for enhancements to capabilities of existing tools that were identified in the airline flight safety department survey include:

- Routine tasks take too much time. Need more automated tools to allow staff to focus on more long-term and proactive work.
- Automated functions and other improved capabilities are needed for:
  - Data entry and validation, standardize terminology
  - Data queries to third parties
  - Tailored searches, trend identification
  - Powerful analysis functions
  - Easy data export-import between tools (compatibility)
  - Updating between applications
  - Simplified preparation of presentations and reports formats in standard formats (different contents and formats are needed for different client groups)
  - Data exchange between carriers
  - Data sharing standards (or technical bridges)
  - Following up safety actions, status of safety concerns

These requirements can potentially be met by improving existing tools, as well as by developing entirely new tools or new applications of existing tools.

In general, most airline flight safety departments have a small number of staff, who have limited time to spend learning how to use new tools and reformatting their data to enable it to be analyzed by these tools. Enabling the tools to be easily configured to interface with existing airline safety data sets would improve the usability of the tools. Similarly, where the use of a particular tool requires information generated by other tools, the ability of all the tools involved to automatically generate and access the relevant data transparently to the user can greatly reduce the amount of work involved in using the tools.

6.2 Integration of Analysis Tools and Data Systems

The nature of much of the analytical work performed by airline flight safety offices involves monitoring an ongoing stream of safety reports and other safety data to identify changes in trends or the occurrence of new issues of interest, or to prepare periodic reports to management on the safety performance of the airline and the status of actions to resolve previously identified issues of concern. To the extent that analytical tools can be customized to perform these functions more or less automatically, this not only reduces the work involved in using them, and thus makes it more likely that flight safety staff will be able find the time to undertake this analysis, but may even encourage flight safety staff to undertake analyses that they might not otherwise have had the time to do. Improvements in productivity in performing routine analytical tasks may also enable flight safety staff to undertake a broader range of proactive safety management activities.

With an increasing number of airlines supplementing the information from air safety reports with flight data analysis programs and confidential human factors reporting programs, there is a need to develop analytical tools that can integrate the information from all three programs in order to make better assessments of potential safety threats and the effectiveness of corrective actions. At present, the analysis of flight crew reports (both air safety reports and confidential human factors reports) and aircraft flight data is typically performed as two entirely separate processes, using different analytical tools that are often unable to access and make use of the databases created by each process. While the data generated by each process is quite different, the underlying incidents that generate flight crew reports or get identified by flight data analysis programs are essentially the same. While it is likely that a large number of exceedences identified in flight data analysis programs will not result in a flight crew report being filed, and similarly events generating a flight crew report may not show up as a flight data analysis exceedence, it would none the less be useful to be able to analyze the air safety reports that correspond to a given type of exceedence and use flight data analysis programs to assemble statistical information on the occurrence of types of events identified by flight crew reports.

Similarly, a given type of event may generate both an air safety report (ASR) and a confidential human factors report (HFR). In some cases, both types of report will be filed on the same event. Other events may result in either an ASR or an HFR but not both. Some safety report management systems, such as AIRS and BASIS, have the capability to combine information from both ASRs and HFRs that have been filed on the same incident. However, the need to protect the identity of those filing confidential HFRs means that linkages are not typically maintained once the data is in the database. None the less, it is desirable that both types of reports contain relevant fields that are classified in a consistent way, so that retrospective analysis can be performed that combines information from both types of reports for a given type of incident.

In general, the ASR describes *what* happened in a particular event. The HFR describes *why* it happened. From a safety management perspective, the latter is much more useful information, since it provides a basis for suggesting corrective actions that will reduce the chance of a similar event recurring in the future. However, the ASR may also contain information that describes why an event occurred, particularly in the event narrative. It is therefore important to identify and preserve this information so that it can be combined with the information in the HFR database. While this can be done using appropriate event classification fields as part of the event investigation and data entry, this can be limited by the classification system used as well as the ability of the investigator to recognize and classify the relevant factors. Text mining tools appear to offer a promising way to supplement this approach and reclassify large numbers of records using the actual narrative text as the issues of concern change and evolve.

Other tools, such as PEAT and TapRooT, provide analysis capabilities to support the investigation of specific incidents and develop a richer characterization of the underlying causal factors. While these tools may only be used on a limited number of incidents, due to the effort involved in applying them, it would also be valuable to be able to integrate the information contained in the databases generated by those tools with the information in the ASR and HFR databases.

6.3 Improved Risk Analysis and Management Capability

Finally, there is a need to develop and deploy better risk management tools. Currently, the usual practice is to classify the risk posed by a particular incident into one of a limited number of categories using the judgment of the investigator. Typically, this classification combines both the severity of the potential consequences and likelihood of recurrence. The resulting risk classification allows the safety management system to focus particular attention on those types of events that have both severe potential consequences and a high likelihood of recurrence. The difficulty with this approach lies not in how it handles those events that are obviously of high risk, which clearly need to be addressed urgently and usually are, but in how it handles those events where the extent of the risk is not clear or events which under other circumstances could have severe consequences, but in the current circumstances did not appear to have particularly severe potential consequences. There is a need for safety analysts to be able to draw on additional information to support the assessment of both the severity of potential consequences and the likelihood of recurrence. Such information potentially exists in the other safety databases within the airline, including the safety event reporting systems, flight data analysis program, and occurrence investigation databases. This information can be supplemented with more formal risk analysis techniques. However, these techniques are not currently easily integrated with the other safety data within the safety management system.

In addition to the use of more formal risk assessment techniques, there is a need for better information on how to evaluate alternative corrective actions. These are generally not costless, nor are they guaranteed to solve the problem. Rather, for a given threat there is typically a range of possible corrective actions that are likely to have varying effectiveness and impose different costs on the airline. In order to recommend appropriate corrective actions, the flight safety staff needs to have information to support the assessment of both the costs and effectiveness of different potential corrective actions. This can then be integrated with the risk assessment process to help prioritize which problems to address first and how best to go about this.

In summary, improved analytical tools can both enhance the information available to the safety management process, as well as facilitate the use of that information in identifying potential threats, understanding the causal factors that lead to their occurrence, developing recommendations for corrective actions to mitigate those threats, and monitoring the effectiveness of those actions.

7.0 Flight Safety Office Personnel Training

The effective use of analytical tools in the safety management process requires flight safety office staff who have an appropriate level of familiarity with the use of the tools themselves, a good understanding of analysis in general, and an appreciation of how analysis results can be incorporated in the flight safety management process. While many flight safety office staff have acquired considerable knowledge and skill in these aspects through extensive experience on the job, personnel turnover will often result in new people joining the flight safety office staff without the same level of experience. In addition, as airlines decide to implement different types of analysis that they have not done before, such as introducing flight data monitoring or human factors analysis, even staff with considerable experience may find that they need to broaden their professional skills.

The section describes three different types of resources that are available to enhance the skill levels of the flight safety office staff. The first resource is a “Flight Safety Analysis Bookshelf,” comprising a list of basic reference material on the use of analysis in airline flight safety. The second is a listing of universities and other training organizations that offer courses in airline safety management. The third resource consists of training courses or user meetings held by the developers of specific analytical tools. Since the information on these resources needs to be updated on a regular basis to remain useful, WG B is planning to maintain current versions of the first two lists on the GAIN website at *www.gainweb.org*. Current information on training courses or user group meetings for specific tools is generally available on the tool developer’s website given in the *Guide to Methods and Tools for Airline Flight Safety Analysis*, available on the GAIN website.

7.1 Flight Safety Analysis Bookshelf

While formal training has a number of desirable aspects, a large part of flight safety office personnel training occurs on the job. It is therefore desirable that flight safety office staff have access to a reasonable set of basic reference material on the use of analysis in flight safety management. This material should include some books on analysis techniques in general, as well as the application of analysis to flight safety analysis.

This section suggests an initial list that might be found useful to meet this need. It does not address flight safety management in general, for which the interested reader is referred to the bibliography in the *Operators Flight Safety Handbook* available on the GAIN website, but focuses specifically on analysis of flight safety data. Unfortunately, the literature on this topic is somewhat sparse, and WG B would welcome suggestions for additional material that readers have found helpful (these suggestions can be e-mailed to *WGB@gainweb.org*). The reason for the apparent lack of readily identifiable literature dealing specifically with airline flight safety data analysis may be partly due to the relatively small professional community involved in this topic and partly to the fact that much of the analysis that is performed is not published, due to the sensitive nature of the findings.

The following bibliography includes a number of references that do not specifically address airline flight safety or flight safety data analysis, but provide a good introduction to the underlying methodological or technical issues, or include some discussion of safety data analysis in the course of addressing a broader topic.

General Analysis Techniques

There is a wide range of books addressing basic statistics and data analysis techniques, of which the following are representative:

Elzey, Freeman F., A Programmed Introduction to Statistics, 2nd edition, Brooks/Cole, 1971.

A college-level textbook that introduces statistical techniques, their statistical formulae, and the application of those techniques, including both descriptive and inferential statistics.

Tufte, Edward R., The Visual Display of Quantitative Information, 2nd edition, Graphics Press, 2001.

The definitive book on the effective graphical presentation of statistical data.

Tukey, John W., Exploratory Data Analysis, Addison-Wesley, 1977.

Provides an introduction to a wide range of techniques for exploratory analysis of statistical data.

Reference Material on Human Factors Analysis and System Safety Management

Bahr, Nicolas J., System Safety Engineering and Risk Assessment, Taylor & Francis, 1997.

Hawkins, Frank H., Human Factors in Flight, Ashgate, 1993.

Maurino, Daniel E., James Reason, *et. al*, Beyond Aviation Human Factors, Ashgate, 1999.

McIntyre, Geoffrey R., Patterns in Safety Thinking, Ashgate, 2000.

Peterson, Dan, Human Error Reduction and Safety Management, 3rd edition, Van Nostrand Reinhold, 1996.

Reason, James, Managing the Risks of Organizational Accidents, Ashgate, 1997.

Roland, Harold E., and Brian Moriarty, System Safety Engineering and Management, John Wiley, 1990.

Stephans, Richard A., and Warner W. Talso *(eds.)*, System Safety Analysis Handbook, 2nd edition, System Safety Society, Sterling, Virginia, 1999.

Wiener, Earl, and David Nagel *(eds.)*, Human Factors in Aviation, Academic Press, 1988.

Airline Flight Safety Data Analysis

Bloedorn, Eric, Mining Aviation Safety Data: A Hybrid Approach, The MITRE Corporation, McLean, Virginia, 2000.
(available at http://www.mitrecaasd.org/library/papers/afc00425.pdf)

Provides an introduction to the application of data mining techniques to aviation safety data.

Flight Safety Foundation, Air Carrier Voluntary Flight Operational Quality Assurance Program (FOQA), Alexandria, Virginia, 1993.

Provides an introduction to the technical and implementation issues in flight data analysis programs.

Global Aviation Information Network, Guide to Methods and Tools for Airline Flight Safety Analysis, Second Edition, June 2003. (available at http://www.gainweb.org)

Wells, Alexander T., Commercial Aviation Safety, McGraw-Hill, 1997.

Provides an overview of airline safety policies and programs that have developed in the U.S. since the Airline Deregulation Act of 1978. It includes chapters on safety data analysis and human factors. The book is designed as a college-level textbook or on-the-job reference for aviation professionals.

7.2 University and Other Courses in Airline Safety Management

A number of universities offer postgraduate degree programs in aviation safety management. While these programs have a much broader scope than the analysis of safety data, the coursework typically includes some coverage of data analysis techniques. A list of those universities known to WG B that offer postgraduate degrees in aviation safety management is given in Table 7-1, together with their website addresses for more information.

A number of other universities and professional training organizations offer a program of short courses in various aviation safety topics. These courses can range in duration from one or two days to several weeks. Some of these courses specifically address aviation safety data analysis. Others may address safety data analysis in the context of other topics. Some of these organizations offer a certificate program that requires the completion of a specified sequence of courses, although these can typically be taken over a period of time. A list of those organizations known to WG B that offer a program of short courses in aviation safety topics is given in Table 7-2, together with their website addresses for more information on current offerings.

The courses listed in Tables 7-1 and 7-2 do not include those offered by military aviation safety schools, since these courses are not generally available to airline personnel. However, some airlines are able to take indirect advantage of the training provided by these courses by hiring flight safety staff who have completed these courses while serving in the military.

7.3 Training Courses and User Meetings for Specific Tools

Many developers and vendors of specific tools offer training courses for new or potential users of their tools. Some offer more advanced courses that are targeted at users who already have some experience with the tool. Information on such courses is often available on the tool developer's website or in newsletters that are sent to users or potential users, and of course can be obtained by contacting the developer directly. Some tool developers include some training with the purchase price of the tool while others arrange courses on an as needed basis rather than holding courses on a published schedule.

These courses provide an opportunity for new staff to become familiar with a particular tool or for flight safety staff to learn more about a tool that the airline may be considering using. To the extent that a course is directed at airline applications of the tool, or attracts participants from several airlines, the course may also provide an opportunity for staff to exchange ideas on potential uses of the tool in their day-to-day activities.

Some tool developers host periodic user meetings, such as the BASIS User Meeting. These provide an opportunity for staff to become familiar with any recent enhancements to the tool, learn more about the use of features that they may not be familiar with, provide feedback to the tool developer on desirable enhancements, and to exchange ideas on potential applications with other users.

Table 7-1

Universities Offering Postgraduate Degree and Diploma Programs in Aviation Safety Management

University	**Program**	**Website**
USA		
Central Missouri State University Department of Aviation Warrensburg, Missouri	Master of Science in Aviation Safety	*http://www.cmsu.edu/aviation/aviationsafety.htm*
Embry Riddle Aeronautical University Department of Safety Sciences Prescott, Arizona	Master of Science in Safety Science	*http://www.erau.edu/pr/degrees/ ma-safetyscience.html*
Florida Institute of Technology School of Aeronautics Melbourne, Florida	Master of Science in Aviation Human Factors	*http://www.fit.edu/AcadRes/aero/*
Purdue University School of Technology West Lafayette, Indiana	Master of Science in Technology with Aviation Emphasis	*http://www.tech.purdue.edu/at/graduate/ mstech-at.html*
Saint Louis University Parks College of Engineering and Aviation St. Louis, Missouri	Master of Science in Aviation Safety Management	*http://parks.slu.edu/msasm/*
Southeastern Oklahoma State University Aviation Sciences Institute Durant, Oklahoma	Master of Science in Aerospace Administration	*http://aviation.sosu.edu/graduate_program/ graduate_program.html*

Table 7-1
(cont.)

University	**Program**	**Website**
Australia		
University of New South Wales Department of Aviation Sydney, New South Wales	Master of Science and Technology (Aviation Management); Graduate Diploma in Aviation Management; Graduate Certificate in Aviation Management	*http://www.aviation.unsw.edu.au/*
France		
Ecole Nationale de l'Aviation Civil Toulouse	Master of Science in Aviation Safety Aircraft Airworthiness	*http://www.enac.fr/*
United Kingdom		
City University, London School of Engineering and Mathematical Sciences	Master of Science in Air Safety Management	*http://www.city.ac.uk/engineering/asm/*

Table 7-2

Universities and Other Organizations Offering Short Courses and Certificate Programs in Aviation Safety Management

University/Organization	**Program**	**Website**
USA		
The George Washington University Aviation Institute Ashburn, Virginia	Aviation Safety and Security Certificate Program	*http://www.gwu.edu/~aviation/safetyandsecurity/safetyandsecurity.html*
Embry-Riddle Aeronautical University Center for Aerospace Safety/Security Education Prescott, Arizona	Management Certificate in Aviation Safety; Courses in aviation safety and accident investigation topics	*http://www.avsaf.org/case/programs_events.html*
The National Test Pilot School Mohave, California	Aviation Safety Course	*http://www.ntps.com/*
Southern California Safety Institute Torrance, California also Albuquerque, New Mexico	Certificate Programs in Aircraft Accident Investigation, Safety Management Systems (Aviation Systems), Aircraft Cabin Accident Investigation, and Aircraft Cabin Safety Management	*http://www.scsi-inc.com/*
University of Southern California Aviation Safety Program Los Angeles, California	Aviation Safety Certificate Program	*http://www.usc.edu/dept/engineering/aviation_safety_program/index.html*
U.S. Department of Transportation Transportation Safety Institute Oklahoma City, Oklahoma	Aircraft Accident Investigation Course; Aircraft Cabin Safety Investigation Course	*http://www.tsi.dot.gov/divisions/Aviation/aviation.htm*
U.S. Federal Aviation Administration FAA Academy Oklahoma City, Oklahoma	System Safety Course; System Safety/ATOS Seminar; Aviation Safety Action Program Course	*http://www.academy.jccbi.gov/*
U.S. National Transportation Safety Board NTSB Academy Ashburn, Virginia	Aircraft Accident Investigation; Other courses related to accident investigation and response	*http://www.ntsb.gov/Academy/academy.htm*

Table 7-2
(cont.)

University/Organization	Program	Website
International		
International Air Transport Association Aviation Training and Development Institute Geneva, Miami and Montreal	Diploma in Safety Management; Courses in a wide range of aviation safety topics	*http://www.iata.org/ps/training/Safety.htm*
United Kingdom		
Cranfield University, Bedfordshire Department of Human Factors and Air Transport	Program of courses in Air Transport Management, Safety and Regulation	*http://www.cranfield.ac.uk/soe/cpd/atm.htm*

8.0 Implications for Future GAIN Activities

The foregoing sections have presented a number of findings from various activities undertaken by WG B. This section examines the implications of those findings for future GAIN activities.

The WG adopted a 3-step approach to defining potential future GAIN activities:

- Identify the needs of airline safety managers
- Assess which needs are in the GAIN domain (across all WGs) and identify the kind of actions that would be needed
- Determine whether the appropriate GAIN WG has the resources and interest to work on the need.

This section primarily addresses the first two bullets. In the following text, the findings from the analysis of the Surveys of Analytical Processes and Requirements for Airline Flight Safety Management discussed in Section 3 are shown in normal font, with potential GAIN actions shown in italics. The relevant working groups with responsibilities that appear to cover each finding or potential action are indicated in parentheses. Issues that span across working groups or address the overall flight safety management process are indicated as potential activities of the overall GAIN program. Some of these issues could be addressed through future revisions to the Operators Flight Safety Handbook produced by the former Working Group A.

Determination of which of these activities should be undertaken by GAIN and their incorporation into the action plans of the appropriate WGs will occur as part of the on-going cycle of defining working group action plans under the direction of the GAIN Steering Committee. The discussion in this section is intended to identify possible GAIN activities for consideration in planning future activities. WG B has identified a number of proposed tasks for potential inclusion in the next revision of its action plan, and these are discussed further below.

8.1 Flight Safety Organization

Survey respondents identified the following limitations and constraints on their ability to deliver a fully effective flight safety management program:

a. Inadequate resources (staffing, tools). Routine tasks take too much time. Need more time for long-term and proactive work.
    - *Develop guidelines on staffing requirements for effective flight safety management. Target at the management level of airlines.* [GAIN]
    - *Promote the importance of the flight safety function to airline management. Collect and disseminate useful publications to help convince airline management of the importance of a well organized and adequately resourced approach to safety management.* [GAIN]

b. Need access to necessary data. Need at least basic data sources and tools.
    - *Identify and document standards of practice for airline flight safety data collection, management, and analysis* [WG B, WG C]

c. Need to improve the reporting culture
   - *Identify and disseminate information on successful efforts to improve safety reporting culture. Identify and document analytical techniques to measure safety culture within an organization* [WG B]

d. Flight safety offices are not consulted as much as they should be
   - *Identify and disseminate information on strategies to improve the coordination between flight safety offices and other departments* [GAIN]

8.2 Safety Management Process

Survey respondents identified the following requirements for a successful flight safety management program or opportunities to enhance the safety management process:

a. Advice on how to do the job in practice and make effective use of analytical methods and tools
   - *Identify and document standards of best practice. Collect and disseminate information on effective use of analytical methods and tools.* [GAIN, WG B]

b. Advice on good management of the information reporting process
   - *Prepare and disseminate guidelines and advice on ways to enhance the management of the information reporting process* [WG B, WG C]

c. Well suited background training which supports everyday work
   - *Identify and disseminate information on training opportunities and resources. Identify unmet training needs and coordinate with training providers to encourage them to expand available training opportunities.* [WG B]
   - *Identify required components of an effective training program for flight safety office personnel. Develop guidelines and advice on implementing training programs for flight safety personnel.* [WG B]

d. Knowledge to build an effective safety management strategy, or to complete existing strategic elements and turn them into a complete strategy. Guidance on ways to implement strategy.
   - *Prepare and disseminate guidelines and advice on the development and implementation of an effective safety management strategy* [GAIN]

e. Importance of effective follow-up of corrective actions
   - *Identify and document best practices for management of corrective actions* [GAIN]

f. Advice on how to create good (written) summaries of the current safety situation in an airline with a broad perspective across all aspects of flight safety
   - *Prepare white paper describing the preparation of safety summaries and the supporting analytical requirements* [WG B]

g. Data exchange between flight safety offices. Good agreements, processes and tools to share data without taking a lot of time.
   - *Disseminate information about the benefits of sharing information and available systems and procedures to support information sharing* [WG C]

h. Shared information needs to be coded with enough information to judge if it is applicable to a particular organization
   - *Identify and document requirements for ensuring the usability of shared information. Disseminate information on industry data classification standards.* [WG C]

i. Advice on efficient use of flight data analysis and related flight crew comments
   - *Identify and document best practices on the integrated use of flight data analysis and flight crew safety reporting* [WG B]

j. Implementation of good practices to enhance the effectiveness of the flight safety management process (location of safety office, company magazines, etc.)
   - *Identify and document best practices* [WG B, WG C]
   - *Promote GAIN deliverables* [GAIN]

k. Need for a professional organization to foster related knowledge and skills
   - *Promote the idea of a professional organization for flight safety personnel* [GAIN]

8.3 Improved Analytical Tools

Requirements for improved analytical tools are discussed in Section 6 above. Potential GAIN activities to support this are listed here.

- *Gather information on user needs for improved analytical tools* [WG B]
- *Ensure user feedback gets to the tool providers and promote related improvements. Organize sessions where users and tool providers can discuss requirements for improved tools.* [WG B]

8.4 Proposed Working Group Actions

WG B has developed a list of proposed tasks to pursue as part of its action plan for future cycles of working group activities following the Seventh GAIN World Conference. These include a number of tasks that respond to many of the potential GAIN activities identified in the preceding discussion, and comprise:

1. Expand the survey of airline flight safety office staff to continue to refine information on requirements for analytical methods and tools
   - Build on current activities, including this report and discussions at the Seventh GAIN World Conference

2. Further development of the *Guide to Methods and Tools for Airline Flight Safety Analysis*
   - Continue to add methods and tools that WG B becomes aware of.
   - Develop a plan to solicit feedback from the industry on the scope and value of the Guide
   - Identify requirements for improved tools

3. Continue to post information on analytical methods and tools on the GAIN website
   - Allow users to display information for selected tools

4. Continue field visits to airline flight safety departments to gather information on the role of analytical tools in safety management practice

5. Pursue additional partnerships with airlines or airline industry organizations to demonstrate the use of analytical tools

6. Support the development of a human factors toolkit to provide airline flight safety personnel with ready access to human factors information and analysis techniques
7. Undertake a requirements study to address the integration of airline safety databases
8. Develop additional example applications of analytical tools and make these available through the GAIN website
9. Continue to collect, document, and distribute stories of airline success with new analytical capabilities.
10. Facilitate training opportunities for airline flight safety personnel
    - Survey airline flight safety offices to identify training needs
    - Post information on training opportunities on the GAIN website
11. Post information on analytical service providers on the GAIN website
    - Expand focus on analytical service providers (will require some outreach to identify providers)
12. Identify and document appropriate skill set and staff mix needed by airline flight safety offices
    - Synthesize information from case study visits
13. Support the establishment of core standards for flight data monitoring programs, pilot reporting programs, and safety event reporting systems.

Following the Seventh GAIN World Conference, this list of potential tasks will be refined in coordination with the GAIN Steering Committee, Government Support Team, and other working groups.

9.0 Conclusions

"You can't manage what you can't measure"
WILLIAM HEWLETT

The global airline industry appears to be moving toward an increasingly common approach to the management of flight safety, although differences in implementation exist in almost every airline, reflecting differences in airline size, organizational structure, regulatory requirements, and institutional history. This approach is founded in the recognition that effective safety management rests on the collection and analysis of relevant data on the day-to-day conduct of flight operations. As implied by the quote attributed to William Hewlett, the co-founder of Hewlett-Packard, without a structured approach to measuring each aspect of an organization's activities, managers are forced to resort to intuition and guesswork, unable to determine whether the situation is getting better or worse, and whether decisions and actions are having the intended effect. This is particularly critical in the case of airline flight safety, where the principal events of concern – accidents – are often catastrophic and yet occur relatively rarely. The traditional approach that shaped aviation safety for most of the first century of powered flight – fly, crash, investigate, fix – is simply not an acceptable basis for modern airline operations. In its place, flight safety managers attempt to monitor operations on a continuous basis, identify problems before they result in accidents, and develop and implement corrective actions.

Central to the successful implementation of this approach is the collection and analysis of appropriate flight safety data. Among those airlines that have the most advanced safety management programs, these data collection activities involve three broad types of information:

- Flight crew incident reports
- Aircraft flight data
- Confidential reports.

The use of confidential reports that protect the identity of the individual making the report allows a more open discussion of human factors and organizational aspects than those involved might be willing to state on the record, whether for fear of jeopardizing their relations with their co-workers or from concern about the consequences for their own career.

These data sources may be supplemented by a range other information, including structured databases derived from incident investigations or other classes of event reports, such as cabin safety reports or ground occurrence reports, but practice on this varies widely.

The effective use of these data sources relies on computer tools to manage and analyze the information. These functions include the ability to manage the process of entering data from safety reports, assigning responsibility to investigate incidents and formulate corrective actions, and tracking the implementation of those actions. They also include the ability to perform trend analysis on subsets of the data, in order to determine whether the frequency of occurrence of particular types of incidents is increasing or decreasing. This generally requires the ability to classify events appropriately when entering the data and performing a selective search of the database to identify subsets of events of interest. The development of aircraft flight data analysis programs requires sophisticated analytical tools to sort through the vast amount of data downloaded from the aircraft flight data recorders, identify events of interest, and present the results in a form that can be comprehended by safety analysts and flight crew. Typically this involves some form of graphical visualization of the relevant portion of the flight, including views of the flight profile, the cockpit controls, and the surrounding environment. The resulting information on each event of interest (typically termed an exceedence) is also stored in a database with capability to sort, select and display statistics on subsets of event of a particular type.

Beyond these capabilities, the current state of the art of the use of analytical tools in the flight safety management process becomes less clear. Some airlines have begun using special purpose tools to support incident investigation or analyze human factors issues. Others have experimented with data visualization and text mining tools. However, these tools are not yet widely used, neither is the extent to which they can be appropriately utilized in the flight safety management process entirely clear.

Based on the surveys and discussions undertaken by WG B, it appears that there is considerable need for better integration of flight safety information, even among those airlines that already have fairly well-developed flight safety management programs. There is also significant opportunity for the effective use of a wider range of analytical tools to support flight safety decision-making. However, for this to occur, there will need to be more readily available information on how to effectively use these tools and expanded training opportunities to ensure that the flight safety office staff have the necessary knowledge and skills to make use of these capabilities.

Another important aspect of the effective use of analytical tools is the balance of effort between the various aspects of the safety management process:

a) Data collection and incident investigation
b) Data analysis and issue identification
c) Information dissemination, action identification, and follow-up.

Since most airlines have limited resources that can be devoted to these activities, and incident investigation can be very time consuming, it is important that appropriate levels of effort are allocated to data analysis and issue identification, information dissemination, and action identification and follow-up. As the safety reporting culture in an airline improves and the volume of reports increases, it will be necessary to prioritize the incident investigation activities to maintain an appropriate balance of effort across the different aspects of the safety management process. Development of information to help determine the appropriate balance of effort in a given situation may be a useful issue for GAIN to address.

In summary, the current state of the art of airline flight safety management is fairly well defined, although many airlines are still developing their capabilities and have some way to go to fully conform to established standards of best practice. However, if the airline industry is to continue to improve its already remarkable level of safety, as many in the industry believe is required, it will in turn be necessary to significantly enhance the analytical capabilities of airline flight safety offices in order to utilize the staff more effectively and take full advantage of the available information to identify potential threats in a timely way and develop appropriate safety strategies to counter them. It is the mission of GAIN and WG B to facilitate this process.

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