AIRBUS

Example Application
of
Aircrew Incident Reporting System
(AIRS)

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Preface

This example application has been prepared by Airbus in conjunction with the Global Aviation Information Network (GAIN) Working Group B (Analytical Methods and Tools) (WGB) as one of a number of such examples of the use of analytical methods and tools described in the "*Guide to Methods & Tools for Airline Flight Safety Analysis*". The intent of these example applications is to illustrate how various tools can be applied within an airline flight safety department, and provide additional information on the use and features of the tool and the value of such analysis. GAIN WG B hopes that these example applications will help increase the awareness of available methods and tools and assist the airlines as they consider which tools to incorporate into their flight safety analysis activities.

Each example application of an analytical method or tool is posted on the GAIN website (*www.GAINweb.org*). Readers are encouraged to check the website periodically for a current list of example applications, as further examples will be added as they become available.

Aircrew Incident Reporting System

1 Introduction

1.1 OVERVIEW OF THE TOOL FUNCTIONALITY

The Aircrew Incident Reporting System (AIRS) can be used by an airline or by a manufacturer to capture information about safety incidents and track those events across the operations. AIRS supports the following functions:

- Documenting safety incidents in a database
- Guiding an investigator/analyst in determining cause(s), factors, effects, and human factors issues contributing to the incident
- Tracking of the incident investigation and possible corrective actions needed
- Looking across all incidents in the database for patterns and trends.

An overview of the AIRS process is as follows: the flight crew involved in a safety incident fills out a form to document the event; the AIRS analyst enters that information into the database; the analyst conducts a callback to the reporter(s) to clarify details or gather additional information as needed; and then the analyst assigns codes for cause(s), contributing factors, and effects. The AIRS software helps the analyst track additional steps in the investigation (if needed) and/or the corrective action(s) assigned in reaction to the event. An Event Sequence Diagram (ESD) can be developed to analyze the events and factors in a complex incident. Filtering and trend analysis capabilities in AIRS permit the analyst to look across all reports in the database to analyze particular safety issues or trends and report that information to management.

It is estimated that use of the AIRS program requires about 1 full day per week for an operation generating about 30 HFR reports per month. Some incidents can be readily classified in a short period of time while others require a more rigorous review.

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

Air Safety Reports

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

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

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

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

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

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

Human Factors Reports

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

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

The HFR software can be operated as a standalone capability or in conjunction with any system that manages information on significant technical or operational events submitted through normal reporting channels. As the HFR software is part of BASIS, HFR will ideally interface with the BASIS ASR module to access information from the corresponding Air Safety Reports. The cross-reference between the two systems should however be broken as soon as the incident analysis is completed for the sake of confidentiality. This gives a high degree of protection to the information provider, whilst allowing for the issues involved in the event to be understood in sufficient detail for management to take preventive measures.

The Aircrew Incident Reporting System

The AIRS software provides an automatic association between both BASIS modules so as to offer easy linking between the information in the ASR and HFR reports. The data gathered from the combined reports enables effective investigation and follow-up of occurrences and provides a consistent source of information for all departments.

AIRS relies on an electronic database that allows the AIRS project manager to alert departments to incidents as they occur, and enables the status of any investigation together with required follow-up actions to prevent recurrence to be monitored and audited on demand. The de-identified database can be networked to key departments or offices within Flight Operations, Engineering and Quality Assurance to allow individual department heads and their specialist staffs to access records regularly in order to identify the actions required to achieve satisfactory closure of a particular occurrence. It is the AIRS project manager's responsibility to ensure that requests for action on a particular event are acknowledged and addressed by the department concerned within a specified time-scale.

Once the required actions are judged to be complete and measures have been implemented to prevent recurrence, a final report can be produced from the consolidated database entries. The event can then be recommended for closure.

The AIRS software provides two different analysis methods. The first consists of the assignment of human factors keywords that can be selected from a defined set of keywords to describe the principal aspects of the event using standard terminology. This allows reports from events with similar characteristics to be identified in the AIRS database, and trend statistics to be developed. The second analysis method consists of the development of an Event Sequence Diagram (ESD) that provides a graphical representation of the sequence of active and latent failures and the factors that influenced the relevant actions. The development of this diagram enables the underlying factors that contributed to the occurrence of the event to be more clearly understood, and facilitates subsequent reporting and discussion of the incident.

For the majority of less serious incidents it will generally only be necessary to classify the event by assigning the most pertinent keywords without going into the full fledged development of the chain of influences. This can be accomplished relatively quickly provided the associated human factors principles are understood and proficiency in the use of AIRS is maintained. For more subtle incidents like the one discussed below, the assignment of keywords can be supplemented by the development of a complete event sequence diagram to deepen the analyst's understanding of the event. This should be a rigorous exercise and for the more complex cases it would be appropriate to adopt a two-person approach if not a team review and discussion. In such cases a debriefing with the crewmembers involved and representatives of the relevant departments (operations, training, crew representatives, human factors) would be the preferred approach.

1.2 INTRODUCTION TO THE EXAMPLE APPLICATION

This example application describes the application of AIRS to analyze the following event: During descent to Hannover (HAJ) in an Airbus A320, a speed exceedance occurred under conditions of high workload coordinating with air traffic control in congested airspace. In addition the routing around the airport was different from usual due to an airshow taking place. With an overspeed warning the autopilot dropped out automatically, surprising the crew and requiring the pilot flying (PF) to continue the descent under manual control with the assistance of the other member of the flight crew. After the event, the flight crew filed both an ASR and HFR.

2 Input Data

The basic inputs to the AIRS tool include the event description and narrative submitted by the flight crew on the ASR form, responses to 11 questions related to the human factors involved in the event (on the HFR report form), and a set of codes that describe safety events (categories, BASIS reference codes, keywords, and factors).

First, the basic information on the event from the ASR report, including the flight crew narrative and a title assigned by the AIRS analyst, is entered in the ASR module as shown in Figure 1.

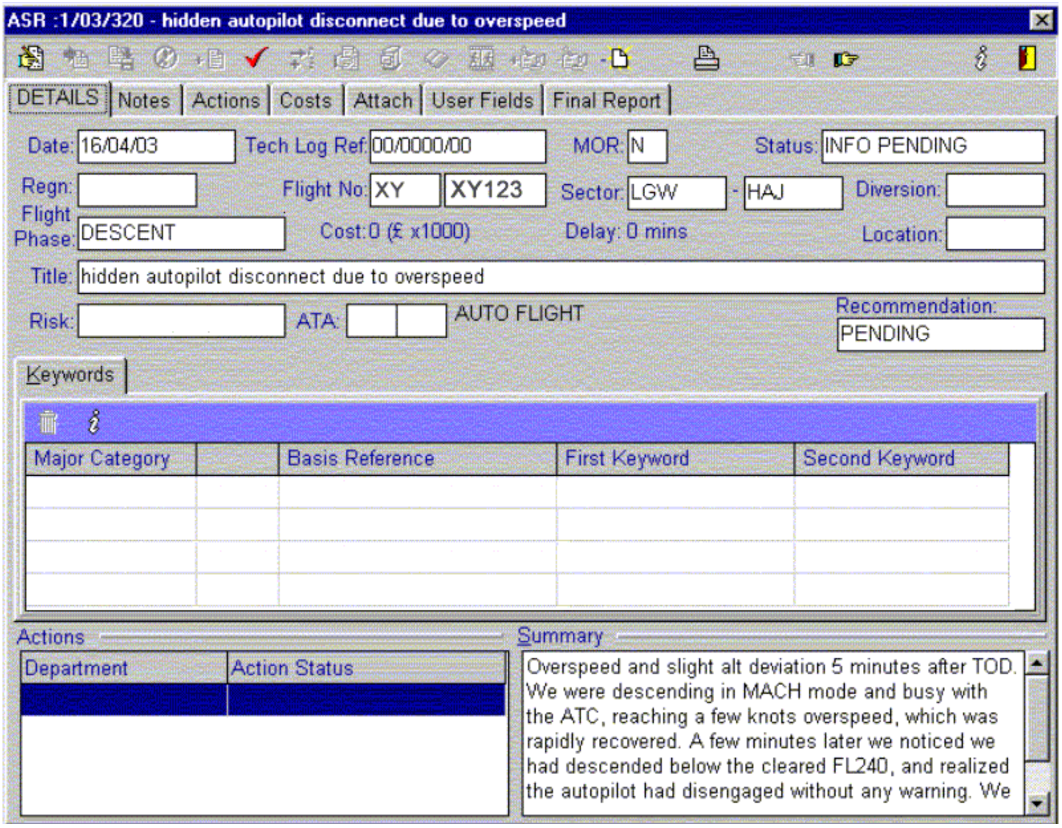

Figure 1 **ASR Event Details**

The AIRS analyst then enters the information from the HFR report(s). Figure 2 shows the screen display of the Event Details page for an HFR report for the example incident after the information for the event has been entered in the ASR module by the analyst. The upper part of the Event Details page displays the AIRS reference code and title of the event in the page header followed by a number of fields including the date of the incident, status of the event investigation, location of the event, flight phase and risk assessment, which are carried over from the ASR module. The central area of the Event Details page is used to display the human factors codes that are assigned in subsequent steps of the analysis, followed by the BASIS reference codes and keywords that are assigned to the Air Safety Report as described below, and the flight crew narrative of the event.

Once the factual information on the event has been transferred to the Event Details page, the Questions page is used to enter the responses given by the reporter to the questions on the HFR questionnaire.

Figure 3 shows the Questions page after the responses for the example event have been entered by the analyst. The header of the Questions page consists of two fields, the AIRS reference number and the title assigned to the incident on the ASR event details page. The analyst fills in the main body of the page, simply by copying the HFR questionnaire responses.

3 Analytical Process

Once the information has been entered in the system for an event, the analyst performs an assessment of the level of risk associated with the event and assigns event reference codes and a number of keywords that allow multiple events to be classified according to common characteristics. Then the analyst performs two major steps in the process of analyzing the human factors involved in a particular event: assignment of human factors codes to the various actions described in the report, and then inter-linking causal factors and immediate consequences in an event sequence diagram.

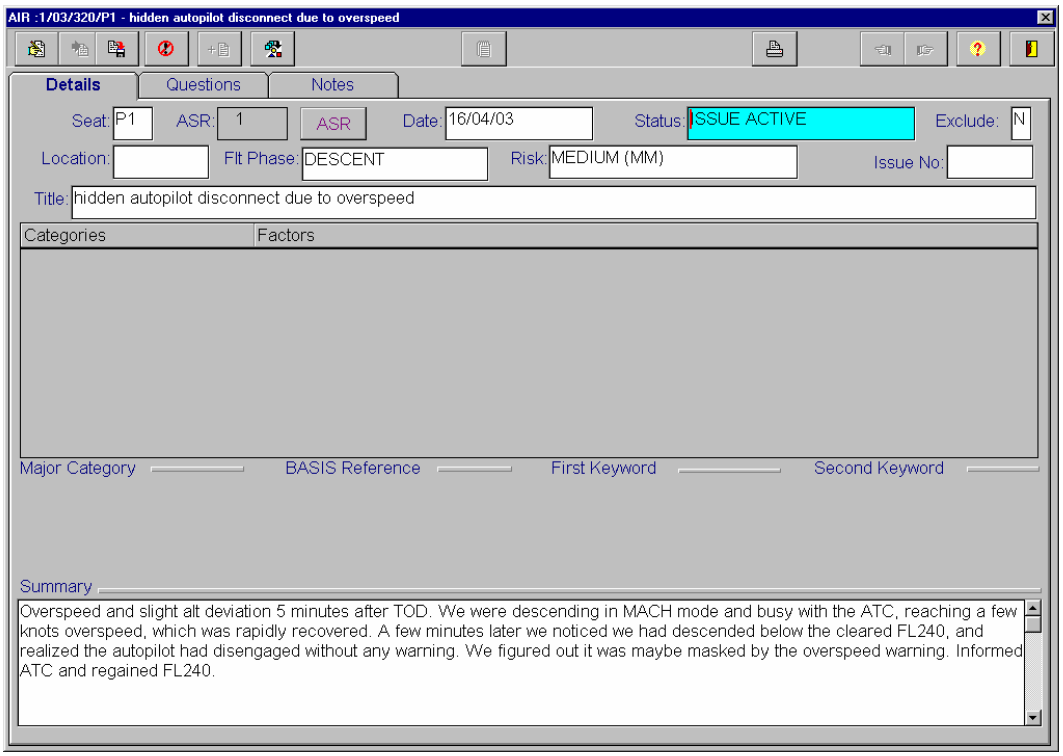

Figure 2 **HFR Event Details Page**

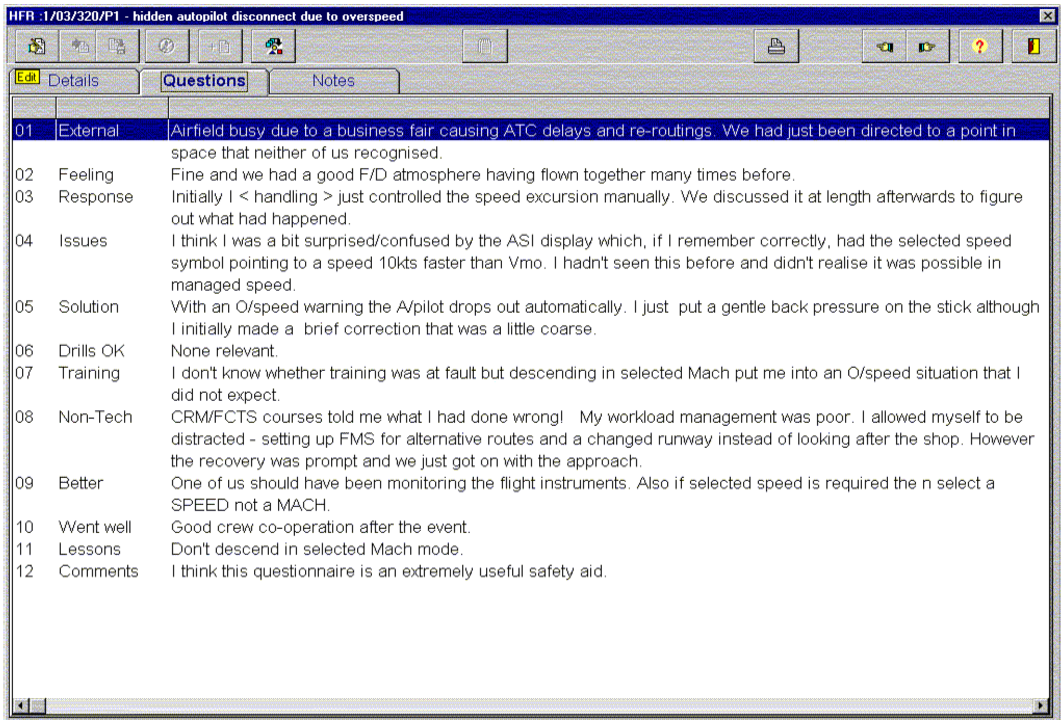

Figure 3 **HFR Questions Page**

3.1 KEYWORDS & CODING

Air Safety Report Module

Based on the information about the event, the analyst assesses the potential severity of damage and probability of recurrence that combine into minimal, low, medium, high and severe risk levels. The analyst enters the resulting risk level, assigns an Air Transport Association (ATA) code to the event, and selects a number of BASIS reference codes and keywords that describe the event. These are entered using pull-down menus or entering the values directly on the screen, and are displayed on the Event Details page of the ASR module as shown in Figure 4.

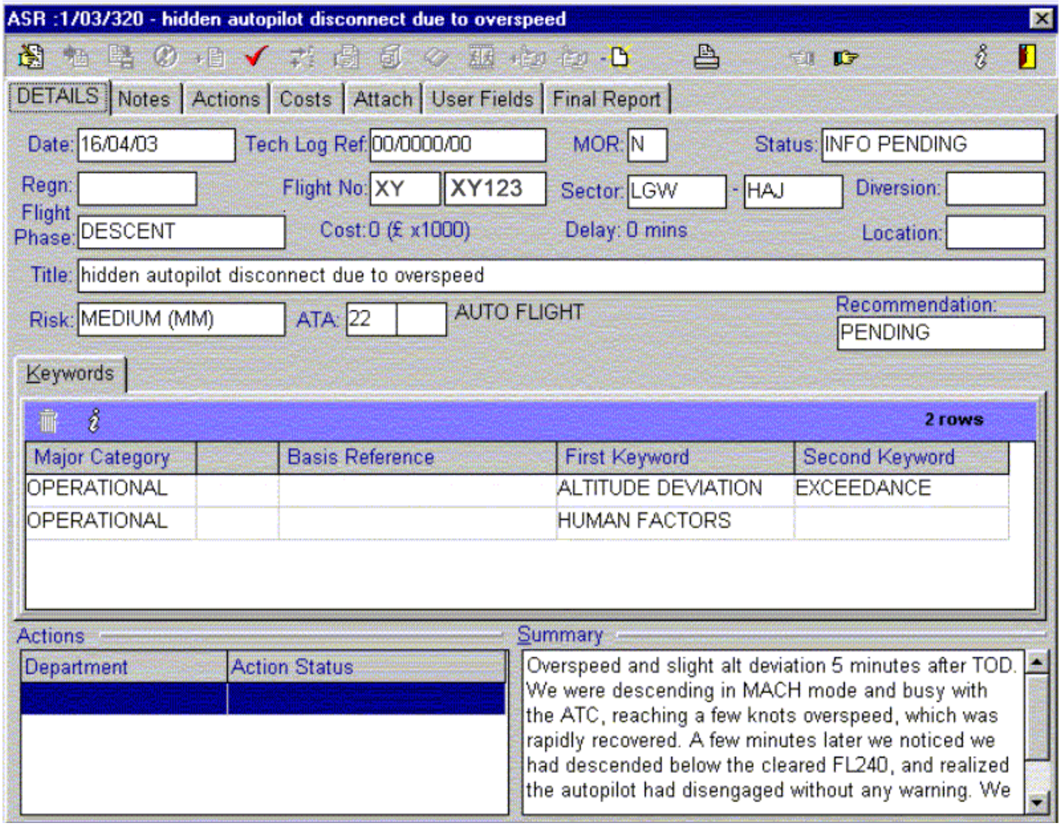

Figure 4 **ASR Event Details with Codes and Keywords**

Human Factors Report Module

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

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

Crew Actions

These are of three distinct types. One type concerns the activities of handling the aircraft and its systems, e.g., System Handling. A second concerns the potential error types reflecting the Reason model of human error (Reason, 1990), e.g., Action slip. Third is the largest set of factors, which are derived from the NASA/UT CRM Team Skills. These describe a number of activities involved in the safe management of flight, e.g., Workload Management.

Personal Influences	These describe the subjective feelings of emotion, stress, motivation, and attention as described by the reporter. Examples are Boredom, Personal Stress, Tiredness and Situational Awareness.
Environmental Influences	These are those behavioral influences over which neither the reporter nor the airline has any control. Examples are ATC Services, Technical Failure and Other Aircraft.
Organizational Influences	These are those influences, which are directly controlled by the company. For example, Training, Technical Support and Commercial Pressure.
Informational Influences	These are also under the company's control but are a subset of the organizational influences dealing with operational information. Examples are QRH, Electronic Checklists and Navigational Charts.

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

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

The assignment of factors to specific responses to the HFR questions is accomplished through the use of the Factor Selection page of the AIRS HFR module, as shown in Figure 5. This presents possible categories, factors, and factor types in a menu format, and allows the assignment to be made by selecting the appropriate values. Definitions of the factors are provided when they are highlighted on the screen to assist in the selection process.

Assuming that the reporter had indicated that another crewmember's mode awareness was poor, the analyst would select the Mode Awareness factor in the Personal category and the software will displays the definition of the factor as shown below. The analyst would then select the factor category as Negative, 3rd party.

After all the factors have been assigned, the HFR Event Detail page will display these grouped by category, as shown in Figure 6.

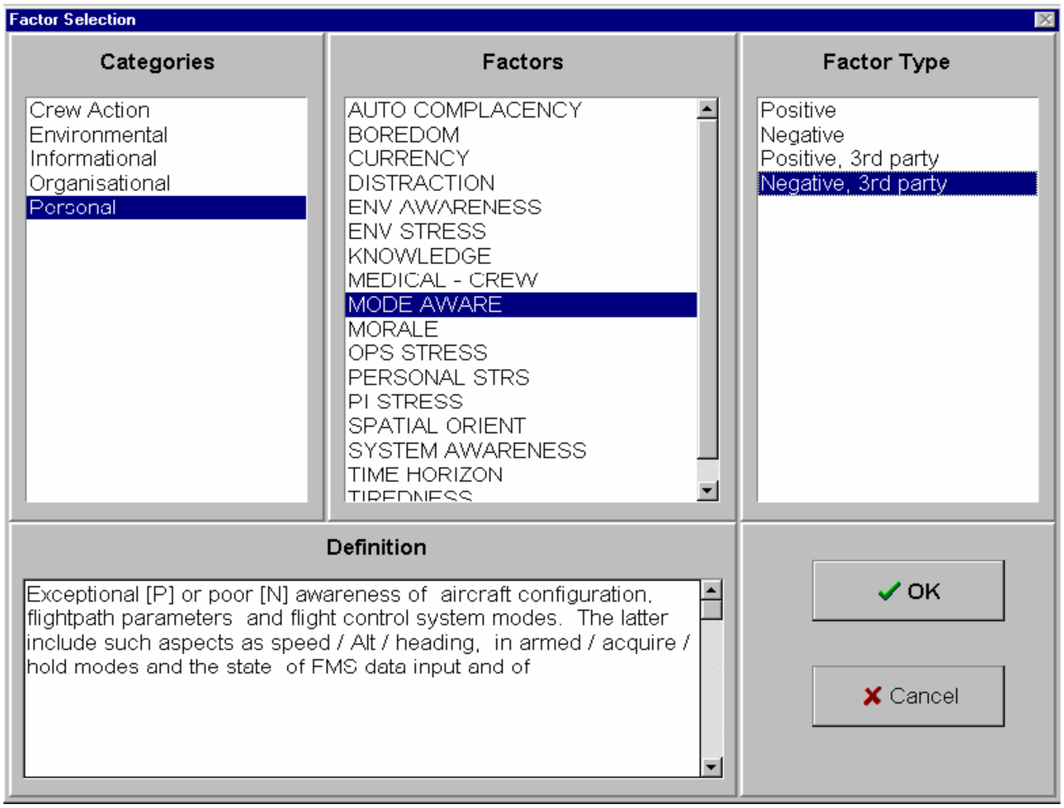

Figure 5 **HFR Factor Selection Page**

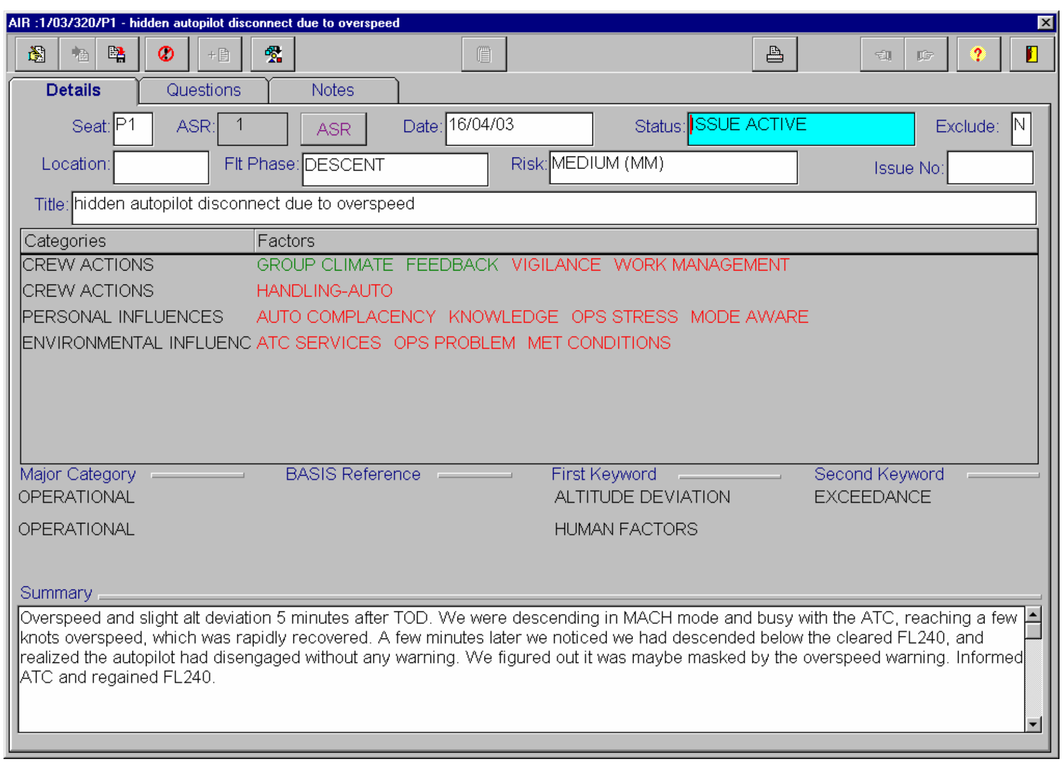

Figure 6 **HFR Event Page with Human Factor Codes**

The factors are color-coded green or red depending on whether the analyst determined that they enhanced or degraded safety. In the current example, as shown in Figure 6, the Crew Actions category has five factors: Group Climate and Crew Feedback (both positive), Vigilance, Work Management, and Handling-Automation (all three negative). Below Crew Actions, factors from the other categories, in this case Personal, Informational and Environmental influences are displayed. The HFR Event Page allows up to thirty factors to be displayed. In this case, Automation Complacency, Knowledge, Operational Stress, and Mode Awareness were identified for the Personal Influences, with ATC Services, Operational Problem, and Meteorological Conditions identified for Environmental Influences.

As shown in Figure 6, the HFR Event Details page will also display the BASIS reference codes and keywords from the ASR module, once these have been assigned.

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

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

As an example, a “rough sketch” of the incident is shown in Figure 7, an event sequence diagram that is produced within the AIRS system. In this A320 HF event, a speed exceedance occurred due to poor monitoring and incorrect expectations of aircraft auto-flight behavior. This happened as a result of poor management of high ATC workload in congested airspace and some turbulence. With an overspeed warning the autopilot dropped out automatically, surprising the crew and creating a situation that was manually coped with by PF with good crew cooperation. The crew learnt from this experience that they should not have selected Mach Mode for the descent but rather should have selected Speed Mode where the overspeed protection would have worked.

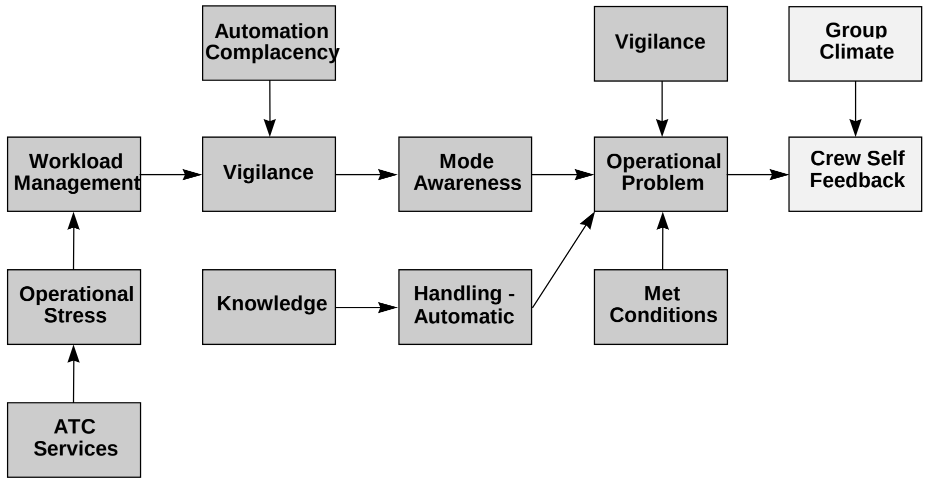

Figure 7 **Event Sequence Diagram – Overspeed in Descent**

Event Sequence Diagrams (ESDs) such as the one in Figure 7 are created for major reports in a graphics page in the HFR database. The software allows a trial and error approach to the construction of an ESD that can help establish a mental model of the reported event and in turn can help to define exactly what the core problem was. Having established the identity of the problem, the analyst can then focus on the causes of the problem and then on how the problem can be solved. It is believed that the inter-linking of causal factors and immediate consequences can create a network of serial, parallel causal factors to appreciate the inductive context that created a scenario. As indicated earlier, extensive analysis of this type could transform information into interesting recurring patterns. Some of these would be relevant to procedures and training, some to aircrew or organizational errors, some even to design and engineering.

4 Tool Output

The outputs of AIRS include the fully coded ASR and HFR pages for each event (such as the examples shown in Figures 4 and 6), event sequence diagrams for selected incidents, and various reports that can be generated across all incident information captured in the AIRS database. These reports can use the filtering capability described above followed by output of various trends. Figure 8 shows one such example--a profile of all the Human Factors that have been assigned to the events in the sample airline's AIRS database using the AIRS software and then exporting the data to a Microsoft Excel file.

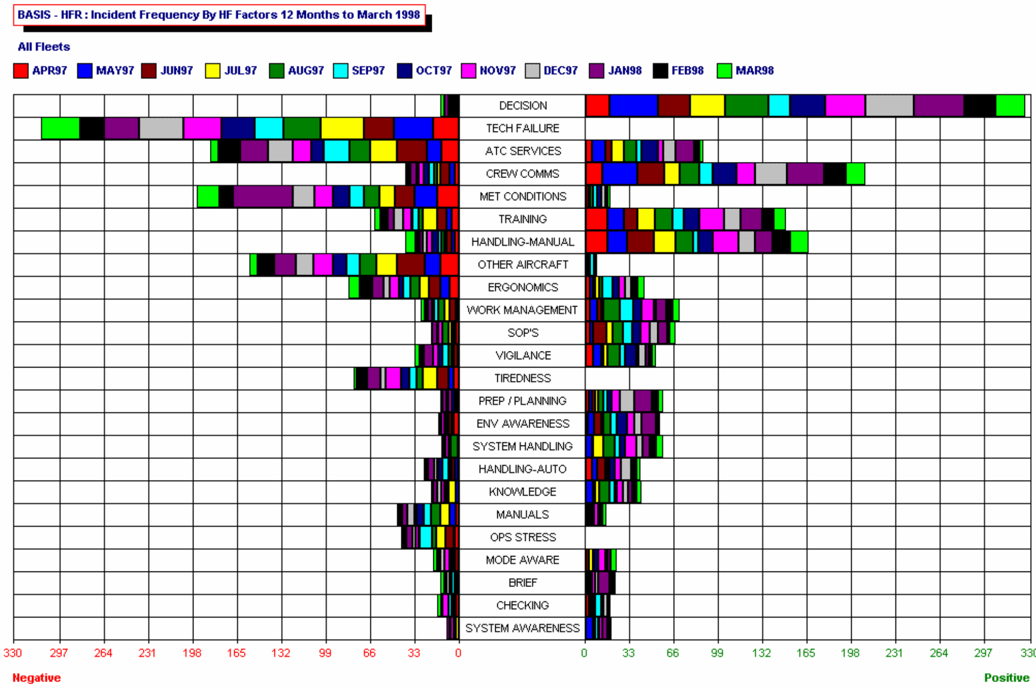

Figure 8 **Balanced Trend Analysis on Human Factors (Positive and Negative)**

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

Reviewing Figure 8 in the context of the mode awareness factor of the current incident, it can be seen that mode awareness appeared as a positive factor in other incidents slightly more often than as a negative factor, while environmental and system awareness appeared much more frequently as a positive factor than a negative one.

5 Application of the Analysis Results

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

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

For proper response to operational experience, the manufacturer needs to receive reports on incidents like the one described in this example to properly feed back corrective and preventive actions to all aircraft operators. With regard to the overspeed in descent analysis, these actions not only consisted of addressing the mode selection issue in training but also updating the Flight Crew Operating Manual and foremost of all enabling protections to function in Mach mode for future designs.