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Proposed Functional Enhancements for the Flight Crew Human Factors Integration Tool

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Preface and Acknowledgments

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This report is one of three reports documenting the various tasks in the Delivery Order. The other two reports address *Implementation of Analysis Methods and Flight Crew Training Needs Assessment* and *Improving the Representation of Human Error in the Use of the Flight Crew Human Factors Integration Tool*.

The author wishes to acknowledge the support and assistance of Jack Wojciech at the FAA Office of System Safety during the conduct of the research, as well as the contribution of the FAA and industry personnel involved in aviation safety who provided input to the research team and responded to the user needs survey discussed in the report.

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Executive Summary

In May 1996, the FAA announced a new and innovative approach to reach the goal of "zero accidents," known as the Global Analysis and Information Network (GAIN). This would be a privately owned and operated international information infrastructure for the collection, analysis, and dissemination of aviation safety information, that would involve the use of a broad variety of worldwide aviation data sources, coupled with comprehensive analytical techniques, to facilitate the identification of existing and emerging aviation safety problems. A major component of this approach is the application of innovative analysis capabilities to identify the types of human error that contribute to aviation accidents and incidents in order to develop prevention strategies. As part of its Flight Crew Accident and Incident Human Factors Project, the Office of System Safety has developed a prototype website-based Integration Tool (IT) to access, integrate, and analyze flight crew human factors data relevant to safety.

This report documents research activities directed at identifying potential functional enhancements to the prototype Integration Tool that address the safety data access and analysis needs of potential users and would be supported by them. The approach adopted during the study consisted of three components: a review of potential enhancements to the prototype IT identified in prior work and other tasks of the current project; a survey of potential users of the IT, to identify their data access needs and views on the potential usefulness of different features; and discussions with FAA offices that would be involved in the use of the IT or the provision of data accessed by it.

The results of the user needs survey demonstrate a high level of support for the type of data access and analysis capability provided by the Integration Tool, as well as a clear need for almost all the functional enhancements identified in the survey. While some enhancements were perceived as somewhat more useful than others, the differences in the assessment were not great. This suggests that it would

contribute to the value of the IT to implement as many of the proposed enhancements as soon as possible.

Based on the assessment of the survey respondents, there appears to be a very promising opportunity for the FAA to enter into a partnership with the potential users in the industry, in which those organizations would share in the cost of further development of the IT. However, for this to occur the capabilities of the current version of the IT need to be enhanced, so that the tool provides many of the features that respondents identified as desirable. It will also be necessary to continue to support the operational Web site and promote the use of the IT among the user community.

1. Introduction

On May 9, 1996, the FAA announced a new and innovative approach to reach the Administrator's goal of "zero accidents," known as the Global Analysis and Information Network (GAIN). GAIN would be a privately owned and operated international information infrastructure for the collection, analysis, and dissemination of aviation safety information. It would involve the use of a broad variety of worldwide aviation data sources, coupled with comprehensive analytical techniques, to facilitate the identification of existing and emerging aviation safety problems.

A major component of the GAIN approach is the application of innovative analysis capabilities to identify the types of human error that contribute to aviation accidents and incidents in order to develop prevention strategies. As part of its Flight Crew Accident and Incident Human Factors Project, the Office of System Safety has developed a new process that uses a prototype website-based Integration Tool (IT) to access, integrate, and analyze flight crew human factors data relevant to safety. The initial process applies two human error models to the NTSB accident database and the FAA Pilot Deviation System (PDS) incident database and generates human factors patterns and trends. Safety analysts in the Office of System Safety began to use the initial process in October 1996.

In September 1996, the FAA Office of System Safety funded a research grant to the National Center of Excellence for Aviation Operations Research to initiate a program of research to provide human factors support for the GAIN concept. The first phase of this research, consisted of two tasks; first to continue the application and improvement of the IT and lay the foundations for a sound scientific approach to the analysis of human factors issues within the framework of the GAIN concept; and second to review the results achieved to date by the flight crew human factors data contractor and integrate recommendations from this review into a strategic plan.

This report documents research activities directed at identifying potential functional enhancements to the prototype Integration Tool that address the safety data access and analysis needs of potential users and would be supported by them. The objective of the research was to address the benefits and costs of: improving the human error models contained within the IT, improving the analytical tools that can be used in conjunction with the IT, and securely accessing additional remote databases.

Research Approach

The approach adopted during the study consisted of three components:

- A review of the findings of two prior workshops that had been conducted by the MITRE Corporation to discuss the analysis of flight crew human factors, present the development of the IT, and obtain feedback. This was supplemented by the recommendations that formed the basis of the Strategic Plan prepared as part of the first phase of this study, and the results of the research into improved representation of human error undertaken as part of the current phase of the research (Gosling, Roberts & Jayaswal, 1998).

- A survey of potential users of the IT, to identify their data access needs and views on the potential usefulness of different features.

- Discussions with FAA offices that would be involved in the use of the IT or the provision of data accessed by it.

Although not a formal part of the research to identify user needs, a multi-site demonstration and training needs assessment that was performed by Embry-Riddle Aeronautical University as part of the current phase of the project (Blanchard *et al.*, 1998) provided an opportunity to solicit informal feedback from potential users of the IT on desired enhancements.

Structure of this Report

The remainder of this report consists of four chapters. Chapter 2 reviews the proposed functional enhancements that were identified during the first phase of the research, discussions that were held with potential users of the Integration Tool, and

the research into ways to improve the representation of human error undertaken during the current phase of the research. The following chapter describes the design and conduct of a survey to identify safety data access needs of potential IT users, their perception of the usefulness of different potential IT features, and their assessment of the likely willingness of their organization to financially support the continued development of the IT. Chapter 4 presents the recommended future course of action for the continued development of the IT and supporting research. Finally Chapter 5 presents the conclusions from the research performed under this task.

2. Proposed Functional Enhancements

The first phase of the study included a review of the findings of two prior workshops that had been conducted by the MITRE Corporation to discuss the analysis of flight crew human factors, present the development of the prototype Integration Tool, and obtain feedback from potential users. This information formed the basis for the recommendations for the future development of the Integration Tool that were developed during the first phase, and that identified potential functional enhancements to the prototype Integration Tool to address the safety data access and analysis needs of potential users. As part of the current phase of the study, these enhancements were organized into five categories:

- data access
- data interpretation and use
- analysis functions
- integration with human error models
- application support.

The specific enhancements not already supported by the prototype IT are shown in Table 2-1.

Table 2-1

Potential Functional Enhancements to the Integration Tool

Data access	Access to data maintained on internal corporate databases Access to risk exposure data
Data interpretation and use	On-line glossary of abbreviations On-line definitions for database codes
Analysis functions	Capability to download record count and search criteria for off-line analysis Capability to download database records matching search criteria Capability to specify search in terms of **events** or **reports** Capability to specify search in terms of **accidents** or **incidents** Capability to tabulate count of search results using user-defined categories of events Capability to tabulate count of search results as relative frequency (percent of all such events) Capability to tabulate search results in terms of exposure (events per unit of activity) Capability to search text in narrative fields and flag records for subsequent analysis Capability to analyze the sequence of events
Integration with human error models	Provision of expanded explanation of the theory behind human error models used by the system Capability for users to specify their own human error model
Application support	Access to on-line documents describing the theory behind the use of human error models in flight crew safety data analysis Detailed examples of how the IT can be used to better understand causes of human error

3. User Needs Survey

In order to identify the views of current and potential users of the Integration Tool as to the usefulness of the various proposed functional enhancements identified in the previous chapter, as well as the provision of access to additional databases, a survey of safety data access and analysis needs was undertaken. In addition to data access needs and the functionality of data access and analysis tools, the survey was also designed to investigate how familiar the aviation safety analysis community is with the prototype IT, and their willingness to financially support the future development of the IT.

Since not all respondents to the survey would be familiar with the IT, a short description of the prototype IT was included with the survey, and the questions were designed to address data access and analysis needs in general, so that they could be answered whether or not the respondent was familiar with the existing capabilities of the tool. A draft of the survey questionnaire was reviewed with the project sponsor and pretested by distributing it to selected safety analysts at the FAA, NASA Ames Research Center, and FAA and NASA contractors. Based on their comments the wording of some of the questions were revised. The final survey questionnaire is included as Appendix A. The attached information on the Integration Tool is included as Appendix B.

The survey was distributed to about 150 aviation safety professionals, comprising members of the GAIN Working Group 1, participants in the first and second FAA Workshop on Flight Crew Accident and Incident Human Factors, held in June 1995 and June 1996 respectively, and selected participants at the FAA Safety Roundtable on Runway Incursion Prevention held in October 1997. These recipients were supplemented by other selected FAA and industry experts identified by the project sponsor or the research team.

A slightly modified version of the survey questionnaire that omitted the questions on the willingness of the respondent's organization to contribute

financially to the development of a data access and analysis tool was used for FAA personnel.

Survey Response

Some 29 responses were received by the date of this report, distributed as shown in Table 3-1. Although this only represents about 19 percent of the survey recipients, the responses form a fairly broad sample of the various sectors of the industry. Furthermore, in several cases the recipients of the survey included multiple people from the same organization. Thus some recipients may not have responded knowing that a colleague had done so.

Table 3-1

Distribution of Survey Responses

Industry Sector	Responses	Percent
Federal Aviation Administration	7	*24*
Other Government	6	*21*
Industry Associations	2	*7*
Airlines	3	*10*
Manufacturers	3	*10*
Research Centers / Contractors	6	*21*
Universities	2	*7*

Survey Results

The survey results provide a useful insight into the data access and analysis needs of the aviation safety community, as well as the extent to which the respondents were already familiar with the Integration Tool.

Familiarity with the Integration Tool

The survey asked respondents to indicate how familiar they were with the Integration Tool prior to receiving the survey, and whether they have access to the World Wide Web (Internet) from the computers on which they perform aviation safety analysis. The responses are given in Table 3-2.

Table 3-2

Familiarity with Integration Tool

	Responses	**Percent**
Familiarity with Integration Tool		
Have used it	7	*24*
Have seen it demonstrated	5	*17*
Have seen descriptions	6	*21*
Aware of it, but no knowledge	10	*34*
Never heard of it	6	*21*
Access to World Wide Web	28	*97*

Most respondents had some level of awareness of the prototype IT, although only about 24 percent had actually used it. A further 17 percent had seen it demonstrated. At the other end of the scale, 34 percent were aware of it but had no knowledge of its capabilities, while 21 percent had never heard of it. All but one respondent had access to the World Wide Web from the computer on which they perform safety analysis.

Aviation Safety Data Access Needs

Respondents were asked how important aviation safety analysis is in their work, and which aviation safety databases they need to access. They were also asked which safety data access and analysis tools they currently use or have access to. Their responses are shown in Tables 3-3, 3-4 and 3-5.

Respondents were divided fairly evenly between those for whom aviation safety analysis occupies most of their time and those for whom it is an occasional or intermittent activity. Some 76 percent of all respondents needed access to the

Table 3-3

Aviation Safety Data Access Needs

	Responses	Percent
Importance of Aviation Safety Analysis		
Occupies most of time	13	*45*
Occasional or intermittent	15	*52*
Rarely perform analysis	1	*3*
Aviation Safety Database Access Needs		
NTSB Accident and Incident database	22	*76*
NASA Aviation Safety Reporting System	22	*76*
FAA Pilot Deviation System	12	*41*
Other	18	*62*

National Transportation Safety Board Accident and Incident database and the same proportion needed access to the NASA Aviation Safety Reporting System data (although not necessarily the same respondents). About 41 percent needed access to the FAA Pilot Deviation System database. Some 62 percent identified other databases that they needed to access. These are listed in Table 3-4. The most widely reported of these databases was the National Aviation Safety Data Analysis Center (NASDAC). However, this is not a database *per se*, but rather a collection of individual databases, including those identified in the question.

Half of all respondents identified specific safety data access and analysis tools that they used or to which they had access, including NASDAC (which can also be regarded as a data access system). The British Airways Safety Information System (BASIS) was used by 17 percent of respondents, while another 14 percent had access to it. The Airbus Aircrew Incident Reporting System was used by 10 percent of

respondents. The various other systems mentioned were each used by only one respondent.

Table 3-4

Other Aviation Safety Databases

	Responses	Percent
Activity data	1	*3*
Air Transportation Oversight System	1	*3*
FAA Administrator's Daily Bulletin	1	*3*
FAA Incident Database	1	*3*
FAA/NTSB Safety Recommendations	1	*3*
National Airspace Information Management System	2	*7*
Near Mid-Air Collisions	3	*10*
Operational Errors	4	*14*
Runway Incursions	1	*3*
Vehicle/Pedestrian Deviations	1	*3*
Safety Performance Analysis System	1	*3*
Service Difficulty Reports	2	*7*
NASDAC	1	*3*
Accident summaries	1	*3*
AIDS	1	*3*
Airclaims	4	*14*
ALPA Incident Database	1	*3*
Boeing	1	*3*
CASE	1	*3*
CHIRP	1	*3*
ICAO	1	*3*
Weather Archives	1	*3*
Internal corporate databases	1	*3*

Table 3-5

Aviation Safety Data Access and Analysis Tools

	Use *Percent*	**Have Access** *Percent*
Airbus Aircrew Incident Reporting System	*10*	
British Airways Safety Information System	*17*	*14*
SABRE Risk Event Management and Tracking	*3*	
	Responses	*Responses*
NASDAC	5	
Allied Signal Global Data Center (GDC)		1
ATA Aviation Safety Exchange System (AASES)	1	
Data Direct Explorer	1	
FACTS (Delta Inflight Service Reporting System)	1	
GENESIS (Delta Crew Reporting System)	1	
Topic Agents	1	

Data Access Tool Functionality

A series of questions asked respondents to assess the usefulness of a range of possible features for a data access and analysis support environment, using a five level scale from "highly desirable" to "no use foreseen." The possible features included the proposed enhancements discussed in Chapter 2, as well as some already implemented in the Integration Tool, in order to determine the respondents perception of the value of the basic concept behind the IT. The results of this assessment are shown in Table 3-6, which shows the distribution of responses for each feature across the five categories, together with a mean score obtained by assigning a value for each response, ranging from 1 for "highly desirable" to 5 for

“no use foreseen”. A clear majority of respondents found all the proposed features highly desirable or potentially useful. There was less perceived need for access to internal corporate databases, than to public data and risk exposure data.

Table 3-6

Data Access Tool Functionality

	Percent Response					
	Highly Desirable	May be Useful	Neutral	Unlikely to Use	No Use Foreseen	**Mean Score**[1]
Data access						
a) Provides access to public accident and incident data via the Internet	*72*	*21*	-	*7*	-	1.4
b) Provides access to data maintained on internal corporate databases	*41*	*41*	*7*	*3*	*7*	1.9
c) Provides access to risk exposure data	*69*	*21*	*3*	-	*7*	1.6
Data interpretation and use						
a) Provides on-line glossary of abbreviations	*52*	*31*	*3*	*7*	*7*	1.9
b) Provides on-line definitions for database codes	*59*	*31*	-	*3*	*7*	1.7
c) Provides on-line explanations for database fields	*52*	*34*	*7*	*7*	-	1.7
Analysis functions						
a) Capability to determine number of records matching search criteria	*69*	*24*	*3*	*3*	-	1.4
b) Capability to download record count and search criteria	*45*	*45*	*3*	*3*	*3*	1.8
c) Capability to download database records matching search criteria	*55*	*31*	*3*	*3*	*7*	1.8
d) Capability to specify search in terms of events or reports	*52*	*38*	*3*	*3*	*3*	1.7
e) Capability to specify search in terms of accidents or incidents	*62*	*24*	*7*	*7*	-	1.6
f) Capability to tabulate search	*55*	*38*	-	*3*	*3*	1.6

	results using user-defined event categories						
g)	Capability to tabulate search counts as relative frequency	*59*	*31*	*7*	*3*	-	1.6

Table 3-6 (cont.)

Data Access Tool Functionality

	Percent Response					
	Highly Desirable	May be Useful	Neutral	Unlikely to Use	No Use Foreseen	**Mean Score**[1]
Analysis functions (cont.)						
h) Capability to specify search results in terms of exposure	*54*	*36*	*3*	*7*	-	1.6
i) Capability to search text in narrative fields and flag records	*66*	*31*	-	*3*	-	1.4
j) Capability to analyze sequence of events	*59*	*31*	*3*	*7*	-	1.6
Integration with human error models						
a) Capability to use human error models to select records for analysis	*38*	*38*	*7*	*14*	*3*	2.1
b) Explanations of the theory behind human error models used	*31*	*38*	*17*	*10*	*3*	2.2
c) Capability for users to specify their own human error model	*31*	*41*	*17*	*7*	*3*	2.1
Application support						
a) Access to on-line documents with theory behind human error models	*24*	*34*	*24*	*14*	*3*	2.4
b) Provides examples of how tool can be used to understand causes of error	*31*	*38*	*10*	*17*	*3*	2.2

NOTE: 1) Mean Score calculated by assigning a value from 1 (Highly Desirable) to 5 (No Use Foreseen) to each response. Lower values of the mean score therefore represent stronger support for the usefulness of the feature.

There was fairly solid support for the concept of integrating safety data with human error models, with well over half the respondents finding the concept highly desirable or potentially useful. However, respondents appeared to feel that these capabilities were somewhat less useful than enhanced functionality to work directly with the data. Similarly, although a majority found the proposed on-line application support features desirable or potentially useful, these were perceived as less important than the analytical capabilities.

Support for Data Access Tool Development

Perhaps a surprising finding of the survey was the extent to which the respondents felt that their organization would be likely to provide financial support for continued development of data access and analysis tools that provide the features addressed in the survey. The intent of the survey was for each respondent to assess the range of options presented in each question. Not all respondents appeared to have realized this, and some simply answered the option they felt most likely.

The results of the respondents' assessment are presented in Table 3-7. While a significant number of respondents felt that it was most unlikely that their organization would contribute financially to the development of safety data access and analysis tools, a reasonable number felt that it was possible or even quite likely. As could be expected, respondents felt that the likelihood declined at higher contribution levels. They also seemed to feel that their organizations would prefer paying an annual license fee to a higher one-time license fee. There also seemed to be a preference for a lower license fee per registered user than a higher fee per organization to subscribe to a user consortium.

In order to assess the implications of these responses for the likely financial contribution to future development of the IT, the qualitative responses were assigned the following probabilities:

Quite likely	0.75
Possible	0.5
Not very likely	0.25

Most unlikely	0.05

Table 3-7

Support for Data Access Tool Development

	Percent Response			
	Quite Likely	Possible	Not Very Likely	Most Unlikely
Subscribe to a user group consortium				
$5,000 per year	*10*	*35*	*25*	*30*
$10,000 per year	-	*21*	*26*	*53*
$25,000 per year	-	-	*26*	*74*
Pay an annual license fee				
$1,000 per registered user	*15*	*40*	*20*	*25*
$5,000 per registered user	-	*16*	*21*	*63*
$10,000 per registered user	-	-	*21*	*79*
Pay a one-time license fee				
$10,000	-	*30*	*20*	*50*
$25,000	-	*5*	*25*	*70*
$50,000	-	-	*15*	*85*

It is recognized that terms such as “quite likely” may mean different things to different respondents, and the foregoing probabilities are thus somewhat arbitrary. A response of “possible” was assumed to imply that the respondents thought that it was as likely that their organization would contribute as not, and was thus assigned a probability of 0.5. This may be a somewhat conservative interpretation. The terms “quite likely” and “not very likely” were then assigned probabilities midway between 0.5 and the natural limits of the scale (*i.e.* 1 and 0). It was assumed that even among those organizations where the respondent felt it most unlikely that they would contribute, there could be a small proportion where others in the

organization felt differently. It was also recognized that the decision could well depend on the functionality of the tool, and a good marketing effort might sway some of those who were skeptical of the value of the tool. Therefore this response was assigned a probability of one fifth that of those who thought it "not very likely."

Using these probabilities, the expected revenue for each option can be calculated, as shown in Table 3-8. Obviously, the total revenue depends on the number of organizations participating. Since the survey was not sent to all possible users of the tool, it was assumed that there are 100 potential user organizations, with an average of two users in each for individually registered users. It should be noted that this is not the number of organizations contributing, since only a proportion of the *potential* users will actually participate, as indicated by the survey responses. While this estimate of the potential market may be conservative, the survey was directed at those organizations most likely to be interested, and any assessment of the potential interest of other organizations becomes rather conjectural.

Table 3-8

Potential Level of Industry Support

Option	Potential Users	Expected Users	Total Revenue
Subscribe to a user group consortium			*$*
$5,000 per year	100	33	165,000
$10,000 per year	100	20	200,000
$25,000 per year	100	10	250,000
Pay an annual license fee			
$1,000 per registered user	200	75	75,000
$5,000 per registered user	200	33	165,000
$10,000 per registered user	200	18	180,000
Pay a one-time license fee			

$10,000	100	23	230,000
$25,000	100	12	300,000
$50,000	100	8	400,000

It can been seen from the information on Table 3-8 that under each option, the greatest revenue is generated by the highest fees scale. The drop in the number of organizations participating is more than offset by the higher fee. However, the increase in total revenue from the middle fee scale to the highest fee scale is very sensitive to the assumptions about the probability of organizations contributing where the respondents felt that it was not very likely or most unlikely. It can also been seen that the highest revenue on an annual basis would be generated by fees that were paid on the basis of the organization rather than individual users. However, this conclusion is very sensitive to the assumption about the average number of users in each organization. One strategy would be offer two scales: a lower one for individual registered users and a higher one for an organizational subscription. Smaller organizations would typically choose the former, while larger organizations would find it more economical to choose the latter.

Although the one-time license fee would generate the most revenue initially, it is clear that annual license fees would quickly generate more revenue over subsequent years. This would also provide a consistent source of revenue to pay for technical support, system maintenance, and continuing upgrades.

General Comments

The survey form provided an opportunity for respondents to add any comments they wished on the issues raised in the survey. While few did so, those comments that were received added to the understanding of user needs and perceived priorities. The comments can be broadly divided into those addressing analysis tools and those addressing the quality of the underlying data.

Analysis Tools

- The Integration Tool needs more flexibility in selecting the matrix appearance and attributes.

- ASRS has been involved in linking its activities with the Aviation Performance Measurement System (APMS) program under NASA direction. Many of the questions in this survey that apply to aviation data sources ideally might apply to the sources of flight data recorder (FDR) data being developed under APMS. Expansion of the Integration Tool to FDR data and parameters would be extremely valuable. Alternatively a similar capability could be developed within APMS.

- Because accidents and incidents are such rare events, human error models provide value mostly in broad terms. The aviation environment is so very dynamic that individual accidents must be looked at to a level of high specificity to gain meaningful information.

- We continue to have doubts concerning any methodology which uses as a starting point the assumption that there was some form of human error failure without a full understanding of the environment which may have contributed to the error. This seems quite similar to the recent Boeing investigation aid which was also biased to investigation of the error mechanics. The design of the search would seem critical, and opening it to users based only on ability to pay seems certain to spawn abuse. In the hands of qualified investigators without an ulterior motivation to prove a point, the tool would be useful. In the hands of litigators or press, the results could be most unfortunate.

Data Quality

- No tool can provide higher quality information than the data that feeds it. The Pilot Deviation data is not suitable for analysis by the Integration Tool, and gives very misleading results.

- A legal framework to protect reporters is important to achieve sufficient high-quality data capture. Only then does analysis become effective.

- There are potential shortcomings in the proposed analysis tool due to variation in interpretation of analysis elements that may exist between accident or incident investigators. A lack of consistency between various reports may make the analysis less reliable.

4. Recommended Course of Action

It is clear from the results of the survey of user needs that there is widespread support for all of the enhancements identified in the survey, as well as for the availability of data access and analysis tools with the type of capabilities provided by the Integration Tool. Some of the enhancements were perceived as more useful than others, which provides a basis for prioritizing their implementation. In addition, there appeared to be an encouraging degree of support among the potential users for having their organization contribute financially to the development and support of the Integration Tool. However, it should be noted that to date the prototype Integration Tool has only been available to a limited number of users, and that therefore most of the respondents were assessing their potential use of the IT without any direct experience. This suggests that the FAA should pursue a threefold course of action:

1. Implement an initial set of enhancements identified by the user needs survey;

2. Promote the use of the Integration Tool by maintaining an operational Web site, establishing an active user group, and conducting training courses;

3. Develop a cost-sharing mechanism to allow non-FAA users to support the on-going use and development of the Integration Tool.

Implementation of an Enhanced Version of the Prototype IT

The results of the user needs survey provide a roadmap for the future development of the IT. However, some of the capabilities addressed by the survey are already being implemented. As part of the current phase of the research, the University of California at Berkeley is modifying the current version of the prototype IT, Version 2.1, to implement two capabilities identified in the survey:

- the ability to download the record count appearing in the results matrix for a query together with the search criteria used to generate the matrix (item 3b);

- the ability to download database record field values for records matching specific search criteria (item 3c).

This implementation will be designated Version 2.2, and could be referred to as the Enhanced Prototype IT.

The research into improving the representation of human error undertaken as part of the current phase of the research (Gosling, Roberts & Jayaswal, 1998) has identified a need for three other capabilities discussed in the survey:

- the capability to allow users to define their own human error models, using a rule-based format that can access any desired field in the underlying databases (item 4c);

- the ability to access other databases over the Internet using secure methods for the transmission of sensitive data (item 1);

- the ability to search text in narrative fields and flag records for subsequent analysis (item 3i).

Depending on the availability of appropriate databases, the combination of the first two of these capabilities could also allow users to implement some of the other capabilities discussed in the survey, such as expressing search results as relative frequency (item 3g) or performing the analysis in terms of exposure (item 3h). However, these capabilities are sufficiently fundamental to the way that the IT is used that it is probably worth building them into the tool directly.

Since the combination of the three capabilities described above would provide such a major enhancement to the value of the IT, it is recommended that they form the basis of the next significant upgrade of the enhanced prototype IT, which would become the production version of the IT. This version could also include a number of the other analysis functions identified in the survey, such as the ability to distinguish between events and reports (item 3d) or between accidents and incidents (item 3e), where these could be implemented relatively easily through minor modifications of the database access routines.

Promoting the Use of the IT

In order to ensure that the aviation industry is able to benefit from the investment that the FAA has made to date in the prototype Integration Tool, and that the capabilities of the IT are made as widely available as possible, the FAA needs to take appropriate steps to promote the use of the IT. This will require the maintenance of an operational Web site on an on-going basis, with some technical support to answer user requests for information, troubleshoot problems, and provide users with technical assistance.

The use of the IT would also be enhanced through the formation of an IT Users Group, that could sponsor an electronic newsletter to share information on successful applications of the IT, exchange tips on using the analytical capabilities of the IT, and identify needs for future enhancements. The Users Group could also sponsor periodic workshops on the analysis of flight crew human factors, to continue the contributions made by the first two FAA-sponsored workshops on Flight Crew Accident and Incident Human Factors (FAA, 1995; FAA, 1996).

The third element of a strategy for promoting the use of the IT would be to offer training courses on the use of the tool. These courses could include a broader treatment of the use of aviation safety data sources and statistical analysis techniques for working with aviation safety data, with an emphasis on human factors analysis. These courses could be offered through the technology transfer program of the National Center of Excellence for Aviation Operations Research.

Development of a Cost-Sharing Mechanism

The results of the user needs survey indicate that there may be considerable opportunity to develop a mechanism by which the IT user community can contribute toward the on-going maintenance and development of the IT. In order to convince organizations to contribute funds, it is clear that there has to be product that they view as worth the expenditure. This suggests that an appropriate strategy would be to first develop an enhanced version that is likely to be perceived as sufficiently capable to justify the funds involved. The more capable this version,

the greater the number of organizations that are likely to contribute, and the greater the level of contribution that could be expected.

This suggests a two-stage strategy. In the first stage, the capabilities described above for the enhanced prototype IT would be made available to users for a fairly nominal one-time fee. The object of this approach would be both to encourage the most use of the system, while offering users a "try before you buy" approach. The fee would need to be large enough to be worth collecting, while hopefully generating a nominal amount of revenue to support on-going development. A figure of $250 would seem about right. Users could be offered a 30-day free trial before they would need to pay a license fee.

In the second stage, the capabilities described above for the production version of the IT would form the baseline configuration for which a more substantial fee would be required (the "industrial strength" model). Based on the results of the user needs survey it is appears that an appropriate balance between maximizing revenue and attracting the most users to the IT would be achieved with fees set at the following scale:

Individual license (per registered user)	$5,000
Organizational site license	$10,000

Users would be free to select whichever fee scale they found more appropriate for their anticipated use and organizational budgeting process. However, it may be worth conducting additional market assessment, once the configuration of the production version of the IT has been determined and marketing materials have been prepared.

Consideration would need to be given to how to provide for FAA uses. The simplest approach would be for the FAA to continue contributing to the support of the project at a reasonable level, in return for unrestricted use. One formula that might have some appeal would be for FAA to commit to match outside contributions on a dollar-for-dollar basis (perhaps up to some defined amount each year to allow funds to be budgeted). This might not only encourage other organizations to contribute, but may help the Office of System Safety justify the on-

going commitment of resources on the grounds that they are being matched by outside funds. This could also be viewed as a positive FAA commitment to the GAIN concept, by which the FAA would continue to support the development of safety data management and analysis capabilities in partnership with the industry.

5. Conclusions

The results of the user needs survey demonstrate a high level of support for the type of data access and analysis capability provided by the prototype Integration Tool, as well as a clear need for almost all the functional enhancements identified in the survey. While some enhancements were perceived as somewhat more useful than others, the differences in the assessment were not great. This suggests that it would contribute to the value of the IT to implement as many of the proposed enhancements as soon as possible.

Based on the assessment of the survey respondents, there appears to be a very promising opportunity for the FAA to enter into a partnership with the potential users in the industry, in which those organizations would share in the cost of further development of the IT. However, for this to occur the capabilities of the current version of the IT need to be enhanced, so that the tool provides many of the features that respondents identified as desirable. It will also be necessary to continue to support the operational Web site and promote the use of the IT among the user community.

References

Blanchard, James, Deborah Osborne, Antonius Widjokongko and Anthony Boyd, Development of the Flight Crew Human Factors Integration Tool: Implementation of Analysis Methods and Training Needs Assessment, Phase II Report, NEXTOR Research Report RR-98-11, Embry-Riddle Aeronautical University, Daytona Beach, Florida, August 1998.

Gosling, Geoffrey D., Karlene H. Roberts and Arpana Jayaswal, Improving the Representation of Human Error in the Use of the Flight Crew Human Factors Integration Tool, Research Report UCB-ITS-RR-98-5, Institute of Transportation Studies, University of California, Berkeley, August 1998.

U.S. Federal Aviation Administration, Proceedings of the Workshop on Flight Crew Accident and Incident Human Factors, June 21-23, 1995, Office of System Safety, Washington, D.C., 1995.

U.S. Federal Aviation Administration, Proceedings of the Second Workshop on Flight Crew Accident and Incident Human Factors, June 12-14, 1996, Office of System Safety, Washington, D.C., 1996.

Appendix A

User Needs Survey Form

FEDERAL AVIATION ADMINISTRATION

GLOBAL ANALYSIS AND INFORMATION NETWORK

Human Factors Data Project

USER NEEDS SURVEY

In June 1996 the Federal Aviation Administration sponsored the Second Workshop on Flight Crew Accident and Incident Human Factors at the MITRE Corporation in McLean, Virginia. Workshop participants were asked to offer comments and recommendations on the process being developed by the FAA Office of System Safety to access, integrate, and analyze flight crew human factors data, in order to better understand the causes of human error and to develop strategies to reduce the occurrence of these errors. A central component of the FAA process is the Integration Tool - a prototype website-based data management system that applies human error models to accident and incident databases to identify types of flight crew error and the context or domains of these errors across accidents and incidents in a consistent and timely manner. Currently the Integration Tool provides access to the National Transportation Safety Board Accident and Incident Database and to the FAA Pilot Deviation System database.

Since that workshop, the FAA has continued to pursue the development of the Integration Tool through research undertaken by the National Center of Excellence for Aviation Operations Research.

This survey is designed to support that research by identifying requirements for safety data access and analysis tools that would be supported by the potential user community, namely aviation safety analysts within the FAA itself and the aviation industry. **We would appreciate it if you would complete and return the attached survey form at your earliest convenience.**

Thank you.

The form may be returned by mail or fax to:

Geoffrey D. Gosling
Institute of Transportation Studies
109 McLaughlin Hall
University of California
Berkeley, CA 94720-1720

Fax: (510) 642-1246

FEDERAL AVIATION ADMINISTRATION

Human Factors Data Project

USER NEEDS SURVEY

Name:

_____

Organization:

_____

A. Familiarity with the Integration Tool

1. Prior to receiving this survey, how familiar were you with the Integration Tool? *(please check all that apply)*

   Have used it myself ☐
   Have seen it demonstrated ☐
   Have seen printed/on-line descriptions ☐
   Aware of it, but no knowledge of its capabilities ☐
   Never heard of it ☐

2. Do you have access to the World Wide Web from the computer(s) on which you perform aviation safety analysis?

   Yes ☐ No ☐

B. Aviation Safety Data Access Needs

1. How important is aviation safety analysis in your work?

   Occupies most of my time ☐
   Occasional or intermittent activity ☐
   Rarely perform analysis myself ☐

2. Which of the following aviation safety databases do you need to access in your work? *(please check all that apply)*

   National Transportation Safety Board Accident and Incident Database ☐

   NASA Aviation Safety Reporting System ☐

FAA Pilot Deviation System ☐

Other *(please list below)* ☐

_____

_____

_____

3. Which safety data access and analysis tools do you currently use or have access to? *(please check all that apply)*

	Use	Have Access
Airbus Aircrew Incident Reporting System	☐	☐
British Airways Safety Analysis System	☐	☐
SABRE Risk Event Management and Tracking	☐	☐

Other *(please identify)*

_____ ☐ ☐

_____ ☐ ☐

_____ ☐ ☐

C. Data Access Tool Functionality

The following questions relate to features that could be provided in a data access and analysis support environment, such as the Integration Tool. Please indicate how useful these features would be to you in your work, using the following scale:

1. Highly desirable
2. May be useful
3. Neutral
4. Unlikely to use
5. No use foreseen.

	Highly Desirable	May be Useful	Neutral	Unlikely to Use	No Use Foreseen
1. Data access:					
a) Provides access to public accident and incident data (e.g. NTSB, ASRS) via the Internet	☐	☐	☐	☐	☐

b) Provides access to data maintained on internal corporate databases ☐ ☐ ☐ ☐ ☐

c) Provides access to risk exposure data (e.g. flight hours, operations) ☐ ☐ ☐ ☐ ☐

2. Data interpretation and use:

a) Provides on-line glossary of abbreviations ☐ ☐ ☐ ☐ ☐

b) Provides on-line definitions for database codes ☐ ☐ ☐ ☐ ☐

c) Provides on-line explanations for database fields ☐ ☐ ☐ ☐ ☐

	Highly Desirable	May be Useful	Neutral	Unlikely to Use	No Use Foreseen

3. Analysis functions:

a) Provides capability to determine number of records matching specified search criteria ☐ ☐ ☐ ☐ ☐

b) Provides capability to download record count and search criteria for off-line analysis ☐ ☐ ☐ ☐ ☐

c) Provides capability to download database records matching search criteria ☐ ☐ ☐ ☐ ☐

d) Provides capability to specify search in terms of **events** or **reports** (where reports may involve more than one event) ☐ ☐ ☐ ☐ ☐

e) Provides capability to specify search in terms of type of event (**accidents** or **incidents**) ☐ ☐ ☐ ☐ ☐

f) Provides capability to tabulate search results (count) using user-defined categories of event ☐ ☐ ☐ ☐ ☐

g) Provides capability to tabulate search counts as relative frequency (percent of all such events) ☐ ☐ ☐ ☐ ☐

h) Provides capability to specify search results in terms of exposure (events per unit of activity) ☐ ☐ ☐ ☐ ☐

i) Provides capability to search text in narrative fields and flag records for subsequent analysis ☐ ☐ ☐ ☐ ☐

j) Provides capability to analyze sequence of events ☐ ☐ ☐ ☐ ☐

4. Integration with human error models:

a) Provides capability to use human error models to select database records for analysis ☐ ☐ ☐ ☐ ☐

b) Provides explanations of the theory behind any human error models used by the system ☐ ☐ ☐ ☐ ☐

c) Provides capability for users to specify their own human error model (rules for search) ☐ ☐ ☐ ☐ ☐

	Highly Desirable	May be Useful	Neutral	Unlikely to Use	No Use Foreseen

5. Application support:

a) Provides access to on-line documents describing the theory behind the use of human error models in flight crew safety data analysis ☐ ☐ ☐ ☐ ☐

b) Provides detailed examples of how the data access tool can be used to better understand causes of human error ☐ ☐ ☐ ☐ ☐

D. Support for Data Access Tool Development

If the FAA were to continue developing a data access and analysis tool to provide some or all of the above features, how likely do you think it is that your organization would support this effort in the following alternative ways:

	Quite Likely	Possible	Not Very Likely	Most Unlikely
1. Subscribe to a user group consortium on an annual basis, that includes Internet access to the software				
a) $5,000 per year	☐	☐	☐	☐
b) $10,000 per year	☐	☐	☐	☐
c) $25,000 per year	☐	☐	☐	☐
2. Pay an annual licence fee for use of the software, that includes periodic upgrades as features are added				
a) $1,000 per registered user	☐	☐	☐	☐
b) $5,000 per registered user	☐	☐	☐	☐
c) $10,000 per registered user ☐		☐	☐	☐
3. Pay a one-time licence fee for use of the software				
a) $10,000	☐	☐	☐	☐
b) $25,000	☐	☐	☐	☐
c) $50,000	☐	☐	☐	☐

E. Other Comments

Please feel free to add any comments on the issues raised in this survey:

_____

_____

_____

Appendix B

Integration Tool Description

FEDERAL AVIATION ADMINISTRATION

Office of System Safety

Integration Tool

The prototype Integration Tool (IT) permits safety analysts, accident investigators, human factors professionals, and others to remotely apply two human error models to the NTSB accident/incident and FAA National Airspace Incident Monitoring System (NAIMS)/Pilot Deviation System (PDS) incident databases in a consistent and timely manner. For the NTSB database, the prototype IT produces a cross-tabulation matrix of Type of Flight Crew Error (e.g. slips and mistakes) and the Domain of Flight Crew Error (e.g. aircraft system and weather conditions) during which the error occurred. For the PDS database, the prototype IT produces a matrix of Type of Flight Crew Error and year of the PDS event. For each database-model pair selected the IT will generate a Master Matrix. The user can then create sub-matrices from the master matrix by selecting any combination of year, weather condition, airspace user, aircraft manufacturer (make), phase of flight, and pilot's total hours flown

Each NTSB and PDS cross-tabulation matrix is considered to represent a pattern of human factors across accidents and incidents for a specific population. By comparing population matrices for the same database-model pair, differences or similarities in accident and incident human factors patterns can be observed. By comparing matrices for the same population over time, trends can be detected.

The number in the cells of a matrix represents the frequency of error events. By clicking on an error type-domain matrix cell, the associated report numbers will be displayed. NTSB report numbers include the date of occurrence and airport location. The PDS report numbers indicate the FAA region and facility location along with the date of the incident. By clicking on any one of the report numbers, the analyst can call up the actual report to verify the presence of the type of human error, and to understand more about the context and causality of the accident or incident.

Human Error Models

Two human error models were chosen from the available literature and adopted by the project team for the prototype Integration Tool. The object of these models is to identify and classify human error events in the databases. A series of If-Then decision rules corresponding to the HEM selected look at *all* database records contained in the selected database. The rules are based on coded fields, i.e. fixed data

formats, in each database. An accident or incident record may have more than one human error event.

Human Error Model One (HEM1) classifies accident and incident events as either *slips* or *mistakes* resulting from the intent to act. If the data does not identify intent, and there is human error present, the event is designated as *unclassified*. Slips occur when the actions do not go as planned and are therefore considered execution errors. Mistakes result when the actions go as planned, but fail to achieve the desired outcome. Thus, mistakes are categorized as planning errors.

Human Error Model Two (HEM2) classifies accident and incident records as either *knowledge- based, rule-based,* or *skill-based* errors. If the data does not identify these errors, and there is human error present, the event is designated as *unclassified*. If the data does not show human involvement, the event is classified as *unknown* and do not appear on the matrices. Skill-based slips represent failures with automatic, routine, and familiar behaviors often resulting from the lack of attention or distraction. Rule-based mistakes occur upon the selection of an inappropriate rule set that dictates or governs behavior. Knowledge-based mistakes result from behavior that requires real-time planning in an unfamiliar situation, often occurring when there is incomplete or incorrect knowledge.

Domain of Flight Crew Error

Seven domains of flight crew error have been identified for the NTSB database. These domains are the subjects for the primary non-people related findings associated with the human error event. They include:

- Aircraft System/Components
    - Structure (flight controls, rotors, fuselage)
    - Systems (electrical, hydraulic, oxygen)
    - Powerplant (engine, fuel system, propeller)
    - Miscellaneous (Fluids, Misc. Equipment, Lights, Aircraft Performance, Aerial Application Equipment, Tow/Advanced Equipment, Balloon Equipment)
- Terrain/Runway Conditions (icy, tundra, wet)
- Weather Conditions (fog, tailwind, rain)
- Light Conditions (dawn, dusk, sunglare)
- Airport

    - Facilities
    - Fire/Rescue
- Air Traffic Facilities
    - Navigational Aids
    - Radar
    - Approach Aids
    - Procedures
    - Weather
- Objects (aircraft parked, hangar, animal)

The human error events were not assigned a domain if they do not have one of the primary non-people related findings associated with them.

A PDS report addresses a single human error event (pilot deviation) but may have multiple error types and domain values. Therefore, for the PDS database the year in which the incident occurred was assigned as the domain of flight crew error.

Databases

The National Transportation Safety Board (NTSB) database reflects all the final accidents and incidents in the NTSB files which are releasable to the public. Since the NTSB database contains over 700 data elements, many of which are clerical in nature, the number of useful data elements was reduced to a subset of approximately 200 elements including the narratives in order to minimize the required time to complete a data query. Privacy Act considerations have been made to remove the identity of individuals, both involved with and investigating the event. The IT presently contains 35,190 records from the NTSB database from 1983 through March 1996.

The FAA National Airspace Incident Monitoring System (NAIMS) Pilot Deviation System (PDS) database reflects pilot deviation incidents which are releasable to the public. These include altitude excursions, unauthorized entry into controlled airspace, and failure to follow command. Privacy Act considerations have been made to remove the identity of the individuals, both involved in and investigating the incident. Prior to 1992, the fields for human factors were not available. The IT presently contains 5,840 records from the NAIMS-PDS database from January 1992 through March 1996.

Databases are provided through the FAA, Safety Data Services Division, ASY-100, National Aviation Safety Data Analysis Center (NASDAC). The data is updated periodically, and the results are annotated with the date when the data was received from NASDAC.

ITDESC2.DOC
5/28/98