

#### ***4.7 ICAO VIEWS ON THE APPLICATION OF HUMAN ERROR MODELS TO ACCIDENT AND INCIDENT DATA - STEPHAN J. CORRIE***

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##### **Summary**

Human factors data pertaining to flight crew error is obtained by ICAO primarily from reports of accident and incident investigations conducted by Contracting States. In return, this data is provided to all Contracting States for their use in preventing accidents. The international provisions which deal with the investigation and reporting of aviation occurrences is provided in *Annex 13* to the Chicago Convention and in the *Manuals Of Aircraft Accident Investigation and Accident/Incident Data Reporting (ADREP)*. Human factors data elements were upgraded and incorporated into the ADREP computer data base system in 1984. The work reflected the state-of-the-art of investigation authorities in the early 1980's. This initiative resulted from recommendations from the 1979 Accident Investigation and Prevention Divisional Meeting and the ADREP Study Group formed after the meeting.

While many models of human error have been developed for various purposes, there are limitations in the ability to conduct error analyses from human factors data in accident/incident data bases. The causes of human error can be complex and any examination must include the entire scenario in which the error occurred. As a result, it can be very difficult to select a common error model to cover all conditions and circumstances under which error will occur and from which it can be analyzed.

The quantity and quality of human factors information produced in an investigation is dependent on the methodology used to, collect, organize and analyze the data gathered. Of the 183 Contracting States in ICAO, there are vast differences in their investigation capabilities and cultures, and thus in the extent of human factors information contained in their reports. Furthermore, inconsistent ADREP reporting has resulted in ICAO placing more emphasis on human error associated with known accident/incident precedents and scenarios, from which to learn how to mitigate human error, rather than on attempting to look for trends and conduct research using such data.

In 1993, ICAO established the ADREP 2000 Study Group to assist the Secretariat in making several enhancements to the present system. One of these areas pertains to human factors which will involve reviewing the present classifications for adapting it to advances in the human factors field. This work has stagnated and ICAO is eager to obtain the additional support needed from those States which nominated the members on the study group in order to successfully complete the work.

ICAO will continue to improve its ADREP system and is interested in any further progress made by States and the industry to improve the reporting, collection and classification of human performance data for understanding the nature of human error and for accident prevention

purposes. In view of the limitations of data models, ICAO must emphasize the importance of activities leading to the development of standardized methods of exchanging safety data as a means to improve international capabilities to identify hazards and safety deficiencies and for formulating accident prevention strategies.

## **ICAO Safety Activities**

### **Accident Prevention**

Of the many issues facing the air transport field, the relationship between economics and safety is enduring. While governments and the aviation industry strive to ensure that commercial air transport operations are conducted in a manner that does not adversely affect safety, economics inescapably plays an important role in the major decisions of organizations in their pursuit of this endeavor. The task of balancing the production goals of an organization against safety considerations is difficult. Yet, managers are in control of finances and resources and, therefore, are directly responsible for managing safety. Accordingly, ICAO has tried to emphasize the need for decision makers to be continually aware of the risks involved in their decisions and of the overall impact these decisions have on the safety of their operations. In this context ICAO established the Flight Safety and Accident Prevention and Flight Safety and Human Factors programs designed to educate and influence the decision makers into becoming better safety managers.

In 1984, ICAO published the *Accident Prevention Manual* to assist States and their industry, to understand the concepts and activities involved in accident prevention and to develop a system and programs designed to identify, eliminate or control aviation hazards before they result in accidents. Attempts are being made to update this manual based on successful prevention initiatives in States. In addition, a draft Assembly Resolution has been prepared calling on States to improve accident prevention and it will be on the Assembly agenda for its meeting this September.

### **Human Factors**

As a result of Assembly Resolution A26-9 in 1986, ICAO implemented the Flight Safety and Human Factors program. The objective of the program is to improve aviation safety by making States more aware and responsive to the importance of human factors in civil aviation through the publication of practical human factors material and the successful measures developed and taken on the basis of experience in States. It focuses on the organizational aspects of the aviation system and on the essential role played by management in fostering a system tolerant to unavoidable human errors. In this regard, ICAO recently published Digest No. 10 - *Human Factors, Management and Organization*. ICAO is also fostering the development and use of practical tools which will help management balance effectively production goals and safety considerations. The program has developed several other digests which provides additional guidance for enhancing the examination of human factors stemming from accidents and

incidents. The program complements the guidance material in the *Accident Prevention Manual* and helps to integrate current human factors knowledge in prevention methodology.

### **Accident and Incident Investigation**

ICAO published many years ago the *Manual Of Aircraft Accident Investigation* to assist States in conducting investigations in accordance with the provisions in Annex 13. The manual outlines the procedures for organizing and conducting an accident investigation and contains detailed information on how to apply many of the specialized areas of investigation. While the manual has been amended, its last major edition was in 1970. Based on recommendations of the 1992 Accident Investigation and Prevention (AIG) Divisional Meeting, an expert group called the Accident Investigation Methodology Study Group (AIMSG) was formed to assist ICAO in improving the format of the final written report, an appendix to *Annex 13*, in order to encourage examination of the deeper, systemic causes of accidents. The group is also tasked with updating the investigation manual. The study group met in April of this year and made substantial progress in these two areas. A complete new edition of the investigation manual is expected to be drafted by the end of 1996 and published in 1997.

### **ADREP System**

The implementation of the ADREP system in 1976, was designed to provide computer-generated information routinely on the circumstances and causes of accidents and incidents, as determined by national authorities, for use in the technical work program of ICAO and for dissemination to Contracting States for prevention purposes. The success of this program is dependent on the consistent reporting of aviation occurrences and on the dissemination of the ADREP bi-monthly Summary reports from ICAO to Contracting States and the industry.

An upgrade of the human factors data elements in the ADREP computer data base system was made in 1984. It reflected the state-of-the-art by investigation authorities in the early 1980's and resulted from recommendations from the 1979 AIG Divisional Meeting and the ADREP Study Group formed after the meeting. As a result of recommendations from the 1992 AIG Divisional Meeting, ICAO established the ADREP 2000 Study Group in 1993 to assist the Secretariat in developing an expanded, integrated incident information system, based on ADREP classifications.

ICAO has co-operated with selected States, through the informal International Data Exchange for Aviation Safety (IDEAS) Group, in the development of a standardized data exchange interface with its members. ICAO has consulted with this group and members of the ADREP 2000 Study Group (ADREPSG) to determine the scope and structure of the additional incident data to be collected. It is envisaged that an integrated accident/incident data base will be created by the end of 1996, but this new data base will require additional support from the study group members to achieve this objective.

It is essential that an integrated system for collecting and disseminating accident and incident information be developed in order to address more effectively safety hazards and deficiencies in

the air transportation system. The study group is reviewing existing accident and incident data bases, on-line access and statistical methods as the basis for developing this new integrated system. One of the other areas under consideration is human factors which will involve reviewing the present classifications for adapting it to advances in the human factors field.

The ADREP system has recently been upgraded with new hardware and software which will provide it with the capability to furnish better access to timely integrated safety information. The AIG Section, which operates ADREP, is now linked to the Internet mail system and is an effort to improve the section's capability to communicate with States more efficiently. This system has been used for about one year on a trial basis. Results are encouraging. States wishing to communicate with AIG are requested to send their communication to: "**rmenzel@icao.org**".

## **Data Issues In Analyzing Human Error**

### **Data Relevance**

The method of determining the relevance of human factors data as it applies to causes of accidents and incidents is linked to the entire investigation process and the quality of the evidence available. How the available evidence is gathered and examined in an investigation is central to that process and occasionally is an issue among aviation investigator circles. Not only can the investigation results differ from what is needed to satisfy the questions on the ADREP system data base forms, but widespread differences between the investigation capabilities of the 183 Contracting States of ICAO results in difficulties in capturing relevant data on the causes of human error.

The prominent accident model used by Contracting States is the chain-of-events, single to multiple cause. The investigation attempts to identify all the causes that contributed to the chain of events that culminated in the accident. There are limitations to this model and the data provided often tends to describe what happened in the accident, but not why nor why it was not prevented. It should be noted, however, that improvements have been implemented to eliminate the single cause concept and to stress the need for identifying systemic causes as a result of the 1992 AIG Divisional Meeting and publication of Amendment No. 9 to *Annex 13*.

In an attempt to provide better guidance to investigators for investigating and reporting on relevant human factors data from accidents and incidents, ICAO produced Digest No.7, *Investigation of Human Factors in Accidents and Incidents*. The digest focuses on using the model developed by Professor James Reason as a means to help guide investigators in the identification of systemic factors. It also mentions the SHELL model, developed by Captain Frank Hawkins, as a means to help the investigator analyze detailed factors which may underlie human error. An example of an analysis method used by a particular State is included in Digest No.7 and the example involves a test for the existence, influence and validity of the human factors evidence for causal determinations.

## Use of Human Error Models

It is difficult to identify all of the foreseeable human factors issues which may require future research. Consequently, it is difficult to design a data base system to answer all potential questions concerning these future issues. The ADREP system contains a wide variety of data elements to satisfy a variety of needs. However, experience has shown that the amount of human factors details presently in ADREP is not adequate for in-depth research into human error. At the same time, it is capable of providing the entire context in which errors occur and can indicate where human factors deficiencies exist in any occurrence. However, the amount of detail found in the ADREP data and final written reports can only reflect the thoroughness and depth of the investigation.

If a human error model is used to develop a data structure for a computer data base, then the data elements needed are collected in an investigation of accidents/incidents to fit the structure required by the model. Consequently, in order to ensure the validity of the data structure, an investigation must be performed so that the expected level of detail concerning human error in an accident/incident sequence can be determined with some level of confidence. This model approach, however, may make it difficult to use the data collected for other purposes and for applying it to other models. More importantly, the model may not provide a full understanding of the accident.

If a model is to be used by ICAO, it must be compatible with the ADREP multi-event causal model and useable by the Contracting States of ICAO. It is essential that data models be kept simple so that they can be easily understood and applied by investigators. Otherwise, investigators may find it difficult to obtain the data elements required by the model. The lack of adequate resources, legal and financial constraints can also preclude collecting all desirable human factors information.

The *ADREP* manual provides guidance to investigators on how to code the evidence gathered in the investigation for input into the computer data base. In addition to the numerous codes that have been developed for gathering routine statistical information, the ADREP system incorporates a multi-event causal model with descriptive and explanatory factors which can describe how and why the accident occurred. As the model applies to the coding of human factors, a variety of subject codes, under the descriptive category, can be used to identify general causal factors. These factors can then be explained further under the category of organizations and persons by using various other subject factors and modifiers. For example, flight crew performance could be identified as a general causal factor by using the ADREP classification, *flight crew procedures/crew co-ordination/inadequate* which could be further explained by using the classification, *operator-training staff-instructor/experience-competence/unacceptable*. The ADREP model is flexible enough to allow for further detail depending, once again, on the depth and methodology used in the investigation. It is only limited to the number of factors which can be developed based on objectives and experience.

The ICAO ADREP causal model is similar to the existing NTSB model. However, NTSB data must be converted using software programs and the results reviewed before the data is added to

the ADREP data base. The ability to use the ADREP system effectively requires training and practice. The manual needs to be updated because of the numerous improvements that have been made since it was published in 1987.

### **Data Quality and Quantity**

In addition to the factors mentioned previously, another fundamental issue affecting quality and quantity of human factors data is whether safety specialists take a statistical approach to identifying safety problems or consider the value of known precedents as more suitable. Depending on which approach is taken will determine, in part, the quality and quantity of data. We do not favor a statistical approach in all cases for reasons mentioned earlier. The use of accident data for statistical purposes is not very helpful because of the limited amount of information available. Moreover, the industry cannot rely on the use of accident data to identify adverse trends. Inconsistent ADREP reporting has resulted in ICAO placing more emphasis on human error associated with known accident/incident precedents and scenarios, from which to learn how to mitigate human error, rather than attempt to look for trends and conduct research using such data. However, the prevalence of incident data is more valuable for prevention purposes and suitable for trend analyses.

There may be limited resources for investigating incidents and minor accidents, thus any data model must also allow for some classification of very general findings so that this limited information is available for analyses. Simplicity is favored. This also helps to ensure that the data collected contains fewer errors.

### **Identifying Performance**

Any taxonomy or model of human error must encompass the psychological, situational and organizational factors which can affect individual behavior. The model should permit assessing the effectiveness of the different controls used by organizations to foster safe and compliant individual behavior. Such controls may be administrative, technical or social in the nature. Errors can be a consequence of inherent human limitations and can result from inadequate communications, policies and procedures. Violations, on the other hand, can either be deliberate or unintentional and occur within a regulated environment. An examination of performance must consider the adequacy of rules and regulations in conjunction with compliant behavior. The objective of assessing human performance should be to encourage and assist organizations to develop controls which are suitable for guiding safe and productive individual behavior within which the organizations operate. This objective should be a part of any accident prevention program. The program will reduce violations by including motivational and organizational remedies, and will foster a safety-oriented corporate culture.

### **Accessibility**

Privacy legislation in several States prohibits the exchange of personnel related information between States. Thus provisions are needed to de-identify the data for international exchange.

Another important problem is the question of whether access should be given to the public at large. Efforts underway to encourage "penalty free" reporting could be jeopardized if the information in human factors related data bases is used for purposes other than accident prevention. In addition, the potential for litigation during the course of an accident investigation can stifle a free exchange of information and prevent access to valuable data.

ICAO is proceeding carefully on the question of making its data publicly available on the "information highway". Information will continue to be provided to authorized officials in ICAO, Contracting States and international organizations in a form suitable for their needs. However, ICAO will have to review its policies on ADREP data dissemination in order to provide more efficient access to this data by the industry.

## Conclusions

The relevance, quantity and quality of human factors information from accidents and incidents is dependent on the methodology used and depth of the investigation, and the capabilities of States. Legal and financial factors also play a role. The potential value of human factors information from incidents versus accidents for prevention purposes is unquestionable. ICAO moved forward to stress the importance of incident investigations through Amendment No. 9 to *Annex 13*.

Insofar as this idea is accepted, it must be recognized that there are limitations to conducting error analyses from human factors data found in final written reports and accident/incident data bases from accident and incident investigations. Difficulty in obtaining consistent reporting from Contracting States is another factor in the quantity of human factors information made available from official government sources.

Additional efforts to develop a human error model that is flexible enough to accommodate all error situations and simple enough for investigators internationally, to use to satisfy the data requirements of the model, is a significant challenge to States and the aviation industry. ICAO is not optimistic about success in developing such a model. In view of the fact that extensive knowledge about human error is already available, there appears to be more justification for applying it to mitigate error and limited value in pursuing further attempts to model and study human error in the short term. Although the causes of human error can be complex, any examination must take into account the complete environment, conditions and circumstances under which error occurred before it can be understood. Thus, ICAO will continue to emphasize and encourage the improvement of investigation and prevention processes in States and the industry.

ICAO will continue to improve its ADREP system through the support of the ADREP 2000 Study Group, coordination with the IDEAS Group and the support from States. Thus, ICAO will appreciate the additional support needed to successfully complete the work on the study group agenda from those States which nominated the members. It is very interested in any further progress made by States and the industry to improve the reporting, collection and classification

of human performance data for understanding the nature of human error. In the long term, such efforts as this workshop, could prove beneficial.

Inasmuch as ICAO recognizes the present limitations of investigations and data models, it must reemphasize the importance of activities leading to the development of standardized methods of exchanging safety data as a means to improve international capabilities to identify hazards and safety deficiencies and for formulating accident prevention strategies.

### **Recommendations**

- 1) Emphasize the importance of improving investigation and prevention methodologies, processes and skills.
- 2) Apply existing human error knowledge aggressively through prevention processes to improve the effectiveness of hazard identification, elimination and control.
- 3) Continue developing knowledge about the causes of human error on a long term basis, consistent with technological and operational changes and integrate this knowledge into operations.
- 4) Develop easy to use human error data models giving consideration to the difficulties in obtaining human factors data through investigations and to their international application and compatibility with the ICAO ADREP system.
- 5) Continue to actively support and participate in the development of standardized methods of exchanging safety data through the IDEAS Group.