International Conference on Aerospace Science and Technology
26-28 June 2008, Bangalore

CONFIGURABLE FLIGHT DATA ANALYSIS FOR TRENDS AND STATISTICS ANALYSIS OF AVIONICS SYSTEMS-AN EMBEDDED PERSPECTIVE OF AN EFFICIENT FLIGHT DATA ANALYSIS

Ananda CM, Rakesh Kumar
Aerospace Electronics Division, National Aerospace Laboratories, Bangalore, India,
ananda_cm@css.nal.res.in,rakeshojha@css.nal.res.in

ABSTRACT: Federal Aviation Administration (FAA) policy on Flight Operations Quality Assurance (FOQA) indicates that FOQA is a voluntary safety initiative encouraging airline participation in FOQA. It is in the public interest with a necessary requirement that Airlines must document procedures for taking corrective action, when necessary in the interest of safety and airlines must provide FAA with access to aggregate trend data. FAA issues final FOQA rule, in what it called a major step towards reaching its "Safer Skies" goal of cutting the commercial aviation accidents rate by substantially. FOQA programs currently are conducted by airlines, certification authorities and engineering groups of airlines. FOQA is primarily a data collection, processing and analysis system used to improve the various disciplines of flight operations. The Digital Flight Data Recorder (DFDR) onboard provides a wealth of information for rest of the analysis. This information can lead to improvements in aircrew training, maintenance and conduct of safer flight operations. The system can analyze and report the various events, exceedences and reports including statistics for the airline operators.

National Aerospace Laboratories (NAL), Bangalore has designed and developed a software tool called NALFOQA, which is being used by major airlines in the country for flight safety operations and quality assurance activities. Airlines that have started using NALFOQA system have documented a great deal of financial benefit, operational efficiency, reduced insurance premium, better safety levels as well as improved training and safety of operations. NALFOQA focuses on the criticality issues to expose the hidden aspects of flight safety part of aircraft information management system in terms of its design criticality, flight operational features with justified

Usage, quality assurance facts and figures as focused on the recorded data and a voluminous types of reports, charts, graphs and statistical information for very effective flight operations with professionally documented results.

The paper presents the methodology of data processing for various fleet of aircrafts with controlled parameter limits and conditions with logical envelops bounded by derived mathematical approaches for the trends and statistics of various systems and components of aircraft using NALFOQA. The quality assurance in terms of flight operations and avionics system diagnostics is realized by flight data analysis, which is the heart of the system. This Paper also presents about the flight safety issues of the aviation industry in particular to the quality assurance areas of aviation using the techniques of data processing and database management for the history of each and every aircraft including the engineering database

1. INTRODUCTION

DFDR's / Solid State Flight Data Recorders (SSFDR's) are being successfully used on civil aircraft for decades. They're proven survival strategy of deploying away from the aircraft and hence the crash site, allows for quick location and economical recovery of recorder information, particularly in marine incidents, where the floating recorders can readily be retrieved from the surface of the ocean. Changes in the needs of accident investigators, and in aircraft use, application, performance monitoring, routing, and avionics have resulted in the current initiatives underway to revise aviation recorder standards, their quality and data analysis. Vast majority of information gained by FOQA cannot be found in any other way as it provides objective and "actionable" data for all equipped flights.

FOQA serves as a catalyst for voluntary information exchanges in a way that the periodic line checks conducted by check airmen cannot provide the same level of insight into daily operations as the continuous monitoring of FOQA data. A program for obtaining and analyzing data recorded in flight (operations) to improve flight-crew performance, air carrier training programs and operating procedures, Air Traffic Control (ATC) procedures, airport maintenance and design, aircraft operations and design. In practice, a FOQA program is a subset of a total in- flight data system that includes engine maintenance and aircraft-systems monitoring. FOQA is, however, separately managed, has separate data requirements, specific hardware and software requirements (some measurement-system hardware and recording-system hardware may be shared), and is subject to a separate, more secure management process.

2. ROLE OF FOQA IN AIRLINES OPERATION/ CIVIL AVIATION

The reason why the aircraft accident rate has stayed fairly flat since the mid-70' has caused many to speculate as to why. First of all, - is it at an acceptable level? Or is "Zero Accidents" an attainable goal to strive for. If we look back the history of civil aviation operations, there has been a remarkable developments in terms of technology change from 1970's to current day and at the same time the airspace operations also has increased tremendously with various kinds of airplanes and systems. Present day concepts of Integrated Aircraft Monitoring Systems (IAMS) plays a very important role in monitoring and processing of various levels of aircraft data online and offline. FAA Advisory Circular FAA AC 120-82 [1] provides the base for the FOQA functionalities and responsibilities in terms of operation and importance.

3. EMBEDDED PERSPECTIVE OF FOQA – INTEGRATED MONITORING SYSTEMS

Close monitoring of aircraft flight operations and systems has made continuous refinement of reliable designs and increased performance. Enabling this operational monitoring has been the continual development of even more sophisticated data recording analysis with growing capabilities to handle huge amount of raw data. Feedback into engineering and maintenance processes and into crew training has raised safety levels. Coupled with accident investigation information, operational data extracted from the Flight Data Recorder have made it possible to refine the air transport operation to very high standards of efficiency, while at the same time, reducing accident risk exposure. The FOQA developed from flight safety foundation (FSF) studies, is being adopted by many airlines throughout the world as an internal system of operations monitoring.

4. NAL FLIGHT OPERATION QUALITY ASSURANCE (NALFOQA) SOFTWARE

NALFOQA is window-based software [2] with database support. Database forms the base for all the trend analysis system with lot of information processed and archived. The software needs to be equipped / configured for the aircraft behavior in terms of the parameter details, phase limits and event limits. The Sequence of operations to be carried out are Aircraft / Configuration creation, Parameter Configuration, Phase Configuration, Event Configuration, Airlines fleet cycle configuration.

Aircraft and its configuration form the basis for all the subsequent operations of incident / accident / operations analysis as part of the Aircraft Information Management System (AIMS). NALFOQA has the provision to have database facilities for the configuration [3]. This will be derived from the Aircraft Maintenance Manuals (AMM)[4][5] of respective aircraft. The configuration of parameters in NALFOQA is exercised with special security password to protect the integrity of the database. The Digital Flight Data Recorder / Solid State Digital Flight Data Recorder parameter decoding is done after the parameter information is configured into NALFOQA. The decoding system with the digital display of continuous flight data will be displayed for incident/accident/operations analysis to the second level resolution. To investigate the incident for specific time of flight in terms of flight phases, the NALFOQA need to be configured for the cutting limits of various phases of the specific aircraft family. The investigation will be carried out with reference to the configured phases only. An event is an Exceedance of a parameter or a set of parameters constituting the functionality of the aircraft scenario in specified conditions deviating the norms. Each event has a set of limits to be checked during the event detection process. The Event configuration parameters are defined based on the dynamics of the aircraft and its behavior.

Parameter, event and phase configuration of NALFOQA completes the configuration activity and is ready for incident/accident analysis activity. The aircraft downloaded data [6] directly from the DFDR is fed to NALFOQA for data processing and analysis. The data processing facility and its output as consolidated result of NALFOQA is as shown in Fig 1. This is the first level of analysis, which provides the basic information, aided for further analysis. Event detection and monitoring is the most important activity of the analysis system with the event monitoring report for the full length of flight data or for each sector separately. The entire processed data is stored into the master database for all statistical report generation. A typical monthly trend analysis report and event rate report is shown in Fig 2. NALFOQA can be used for other types of report like Event Rate, Trend Rate, Trend Analysis, Counseling, Daily, Monthly, Quarterly, Half yearly, yearly Reports etc.

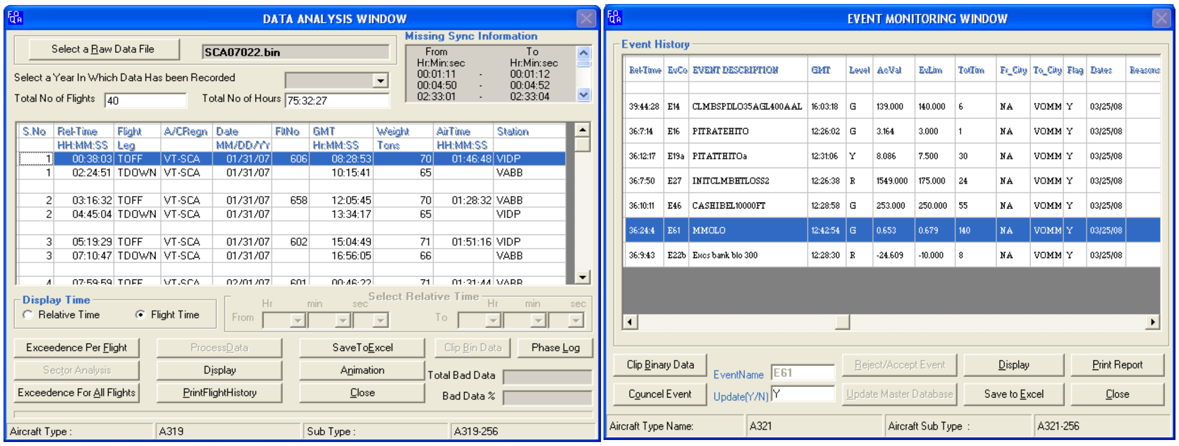

Fig 1: Data Analysis window of NALFOQA after processing the raw data.

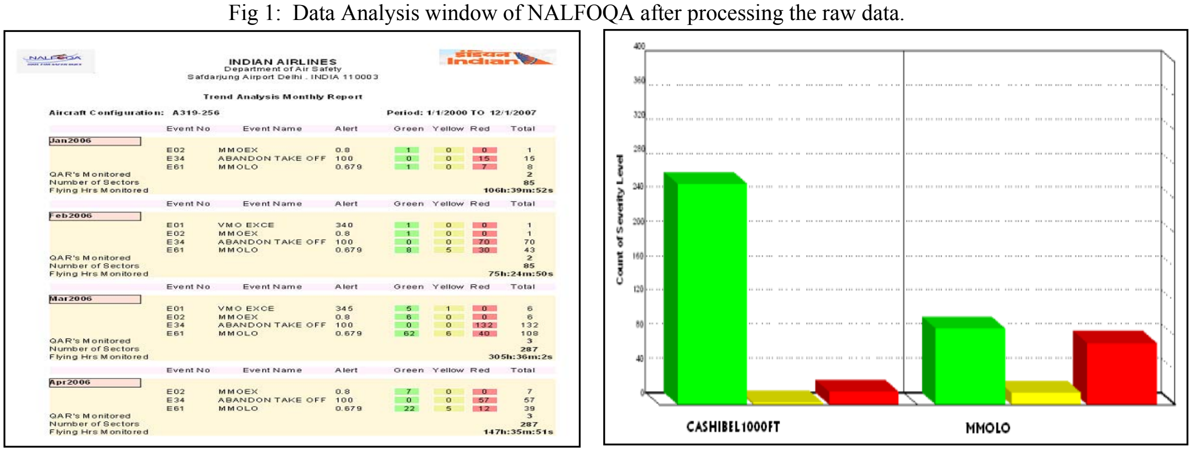

Fig 2 Typical Monthly Trend analysis and Event Rate Report of NALFOQA

Each of the analysis and the resulting report are being exhaustively used at various airlines for operations and incident/accident analysis point of view. Benchmark figure of NALFOQA for 200 hours of flight data is less than 90 seconds for complete analysis. Results of all reports and data analyzed are validated against the FDAU specifications for SARAS [7]. Further, NALFOQA has feature of displaying the engineering values of the stored parameter to a correct accuracy as per Airbus standard. The software is validated with Airbus's similar software for the performance and accuracy of the Engineering value.

4.1 Growing steps of configurable NALFOQA towards Aircraft Integrated Management System concept

NALFOQA [2] is being used at airlines for variety of aircrafts from Boeing and Airbus industry covering 64, 128,256 and 512 words per second format. It has proved to be one of the best tools for aircraft integrated data monitoring and analysis system. The software is designed to be an universal tool which can be easily configured for any aircraft with the characteristics of aircraft is known in terms of the Digital Flight Data Recorder (DFDR) / Solid State Flight Data Recorder (SSFDR) parameter specifications. The tool can be used as

- Aircraft integrated data monitoring and analysis system and Aircraft performance monitoring system
- Incident / Accident analysis and report generation tool and Post flight analysis and councelling tool
- Pilots operations and quality monitoring and evaluation system
- Airlines statistics management system and Airlines efficiency management system
- Operations and quality control and management system

Incident:

NALFOQA software can be used for incident analysis in an efficient way. Annex 13 to the International Civil Aviation organization (ICAO) Chicago Convention defines an incident as an event linked to the operation of an aircraft, which is different from an accident and jeopardized or could jeopardize the safety of the operation. It defines a serious incident as an incident whose circumstances indicate that an accident almost happened, and clarifies that the difference between an accident and a serious incident lies merely in the final outcome. Also an incident [1] defines as an occurrence, other than accident, associated with the operation of an aircraft, which affects or could affect the safety of operation. Indeed Incident analysis is a major step, which will un-earth many issues of maintenance, operations and crew performance. Many practical examples reveal that if the incident analysis is carried out in systematic un-biased methodology, the operations efficiency and quality assurance objectives will definitely be fulfilled. This process enhances the systems efficiency in terms of maintainability, maintenance, preventive actions and reliability of the system.

Accident:

Accident analysis is more legal oriented where lot of activity need to be produced for verification and validation including the process itself in some cases. The data is looked at in a very critical manner to the bit level in case of corrupted/damaged data. NALFOQA can be used for this purpose in a sector analysis mode with bit wise data extraction capability as an optional analysis.

5. CASE STUDIES USING NALFOQA SOFTWARE:

Two scenarios have been described here to demonstrate the incident analysis process using NALFOQA.

5.1 **Case Study 1: Deviation of Glide Slope (GS) deviation.** Glide slope deviation event during landing phase is quite critical as it can lead to hazardous scenario and hence the monitoring of this event is very important. This event also evaluates the performance skill of pilot and hence a good measurable event. Typical GS event exceedence detection using NALFOQA is shown in Fig 3. NALFOQA monitors the GS in landing phase for its nominal and the set trigger event value. Each trigger value also has severity bands called YELLOW, GREEN and RED indicating the severity of the event.

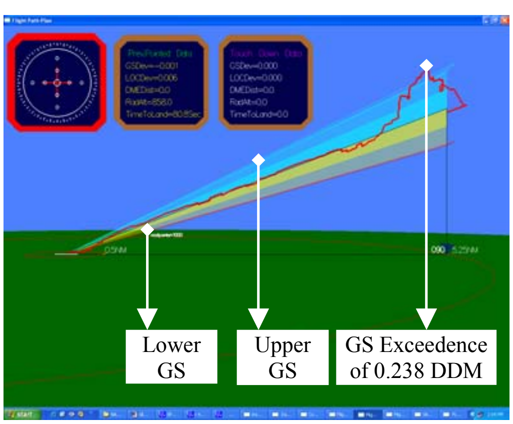

Fig 3: Glide slope deviation event analysis in NALFOQA

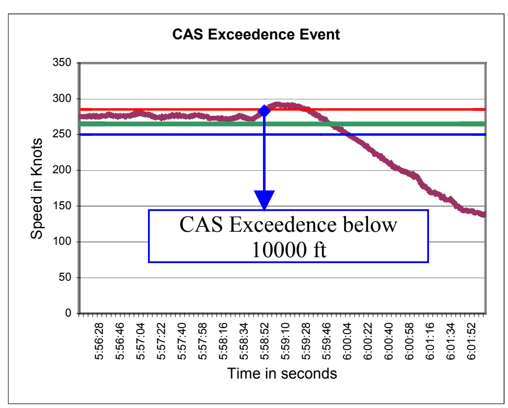

Fig 4 CAS exceedence event in NALFOQA

5.2 **Case Study 2: Calibrated Air Speed (CAS) Exceedence.** CAS exceedence event is also a critical event, which has impact on the structure and other aircraft dynamics. CAS event is dependent on phase of flight, altitude level and other aircraft dynamics. The graph in figure 4 is for a typical A320 commercial flight at an altitude of below 10000 ft. Typical CAS high below 10000 ft of altitude exceedence detection using NALFOQA is shown in Fig 4.

6. CONCLUSION AND FUTURE

NAL Flight Operations Quality Assurance software tools has been successfully used in major airlines like Indian Airlines, Air India, Alliance Air etc,. for their day to day Flight Data Recorder (FDR) data analysis as per DGCA mandate. Use of the tool has enabled airlines for reduced insurance premiums. This is one of the greatest achievements of the NALFOQA tool in the civil aviation industry.
Integration of 3D animation tools along with Terrain databases of all major airports in India, and network version of existing software is a part of future work, which is already initiated at NAL as shown in Fig 5.

Fig 5: NALFOQA Animation work at NAL

7. ACKNOWLEDGMENT

Authors express thanks and appreciation to NALFOQA team of NAL for their efforts in design and development of the tool. Author thanks Dr. MR Nayak, Head ALD and Dr. AR Upadhya, Director NAL for their continued motivation and management support.

8. REFERENCES

[1] FAA AC 120-82, Flight Operations Quality Assurance, December 2004.
[2] Ananda CM, Mahesh R, Shivamurti, Dr.Narasihman SV, Murthy NN, Design Challenges of Flight Operations Quality Assurance (FOQA) System for civil aviation operations and quality – An Embedded perspective, AeSI 2002.
[3] CM Ananda & team, NALFOQA User Manual, 2003.
[4] SARAS Configuration, Aircraft Parameter Manuel, 2002.
[5] Airbus 320, Aircraft Maintenance Manual,
[6] CM Ananda & team, System Description document for Recording System, DR-31, September 2003 and DR-48, January 2007
[7] SARAS FDAU, System requirements and design specification, Flight Data Acquisition system type pa3810j FDAU for SARAS aircraft, 2002.