Padmanaban and Mahendran, J Aeronaut Aerospace Eng 2015, 4:2
DOI: 10.4172/2168-9792.1000143

Journal of Aeronautics & Aerospace Engineering

ISSN: 2168-9792

Research Article | Open Access

Enhancing Flight Data Monitoring and Analysis can Increase Flight Safety

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Abstract

The scope of the project is to Enhancing Flight Data Monitoring and Analysis can increase Flight Safety assists an operator to identify, quantify, assess and address operational risks. This analysis can be effectively used to support a range of airworthiness and operational safety tasks. The scope of this project is to de-code the recorded avionics parameter of interest based on the OEM's recommendation by using the logical extraction of data from the data frame of the recorder based on ARINC standard and Air born software standard. This project involves different processes from Data down loading from the DFDR, Raw data extraction, Optimum Parameter configuration, Logical Event configuration, Logical calculation of various flight scenarios, Comparison with FCOM, Flight Health monitoring, Exceedance Analysis based on regulatory guidance, Statistical analysis of various avionics parameter's impact on flight safety. The recommendation and solution found will be represented by various graphs and chart. Graphs of the checked parameters to show their evolution during cruise, take-off and landing phases of a same flight and an analysis of the validity of parameters based on graphs and corresponding tables, A check on the chronological structure of the complete recording, based on the aircraft flight history. It will be used for identifying and defining the risk index, and the inclusion and exclusion of the necessary maintenance programs based on the OEM.

Keywords: Flight data analysis; Exceedance; Airworthiness; Flight; Safety

Introduction

Over the past several years, airlines have initiated or participated in a number of safety data programs. Each involves collection of voluntary safety reports or the monitoring of flight data. These initiatives grew from recognition that mitigating safety risks requires monitoring a variety of data streams – reports, observations, and flight data. They have spawned technologies within air carriers, including Airline Safety Action Programs (ASAP), Line Operational Safety Audits (LOSA), improved analysis of training and checking data through the Advanced Qualification Program (AQP), and Flight Operational Quality Assurance (FOQA) programs. This paper will discuss the functions that can be served by flight data analysis [1-6].

The aviation community is under constant pressure to achieve safety improvement. Operational Flight Data Monitoring(OFDM) offers an efficient solution to this challenge. OFDM is to some extent aquality assurance process but also has a vital Safety Management dimension. It involves the downloading and analysis of aircraft flight recorder data on a regular and routine basis. It is widely used by aircraft operators throughout the world to inform and facilitate corrective actions in a range of operational areas by offering the ability to track and evaluate flight operations trends, identify risk precursors, and take the appropriate remedial action [7-11]. The potential of OFDM programmes has been materially enhanced by the rapid expansion in the number of data parameters which can be captured using digital recorders now routinely carried on aircraft.

To ensure the highest levels of safety each flight crewmember must carefully monitor the aircraft's flight path and systems, as well as actively cross -check the actions of each other. Effective crew monitoring and cross-checking can literally be the last line of defense; when a crewmember can catch an error or unsafe act, this detection may break the chain of events leading to an accident scenario. Conversely, when this layer of defense is absent the error may go undetected, leading to adverse safety consequences [12-15].

Methodology

Systematic flight data monitoring

The systematic approach of the FDM system allows an operator to compare their Standard Operating Procedures (SOPs) with those actually achieved in everyday line flights [16].

The analysis will be done for the recommended parameter and the methodology involves the process as follows:

- Parameter Configuration
- Validation Of Raw data
- Raw data extraction
- Phase configuration
- Exceedence monitoring
- Parameter grouping
- Parameter analysis

Parameter configuration is the process where the information about the parameter like analog, discrete and documentary will be defined based on the data frame layout with specific information like which sample per second, most significant bit and least significant bit to locate the parameter. After the configuration of parameter it is mandatory to audit for verifying and validation of the parameter

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Received April 20, 2015; **Accepted** October 05, 2015; **Published** October 15, 2015

Citation: Padmanaban S, Mahendran SME (2015) Enhancing Flight Data Monitoring and Analysis can Increase Flight Safety. J Aeronaut Aerospace Eng 4: 143. doi:10.4172/2168-9792.1000143

configuration based on the data frame layout to ensure that the configured parameter values are matching to the recommended values [17-19]. The raw data extraction is decoding of the recorded parameter based on the parameter configuration and decoding law. During the raw data extraction flight phases will be defined based on the configuration of different phases of flight like taxi out, takeoff, climb, top of climb, cruise, top of descent, descent, approach, final approach, landing, touchdown, taxi in. Exceedence monitoring of the parameter will be based on the parameter limit range defined based on the safety standard and SOP's. Limit range defines the safe range of operation and it is further classified in to three categories as below:

- Green – Safe range
- Yellow – Acceptable range of operation
- Red – Danger range

Parameter analysis is based on the excedence or event definition, the event logic will be configured in to the software, based on the exceedence definition the exceedence range will be monitored and predicted as and when it exceeds the limit range. The analysis will result the total number of exceedence occurred and also it will help to predict the problem occurred in the system. The parameter analysis will help to find the problem occurred due to pilot behavior like human error.The trend monitoring of the parameter will predict the exact nature of the error and malfunction of the system or component this will improve the safety measure and help us to define the performance indicator or index value [20].

The Analysis will be based on the exceedence limit defined for the parameter,Safe range is mentioned as exceedence limit'1'and marked as Green, which is in the boundary of safe range of operation limit and it should within range of less than 5 percent of the recommended value and this percentage will vary depend on the parameter nature and performance and also it is defined in the SOP's of the operator. Acceptable level range is mentioned as exceedance limit '2' and marked as Yellow, which is in the boundary of acceptable level of safety but little away from the safe range still this is acceptable for minimum occurrence but this has more tendency to become risk if it is not considered properly and it should be within range deviation not more than 10 percent of the exceedence limit value and this percentage will vary depends on the parameter nature and performance and also it is defined in the SOP's of the operator.Unacceptable or Danger zone or level range which is mentioned as exceedence limit '3' and marked as red, which is away from the boundary of acceptable level of safety and away from the acceptable range still this is acceptable for minimum occurrence but this has more tendency to become risk if it is not considered properly and it should be within range deviation is more than 10 percent of the exceedence limit value and this percentage will vary depends on the parameter nature and performance and also it is defined in the SOP's of the operator.Trend monitoring of this analysis will be taken for the defined period like quarter-early, Half-early, and yearly and sometime based on the annual statistical analysis will predict the problem naturebased on the occurrence and place of occurrence which will be used to find the exact problem and allow taking the decision on recommendation and this will have the direct impact on the Sop's.

Six sigma methodology

Six sigma is a structured, data -driven approach to eliminating defects. The primary objective of the Six Sigma methodology is the implementation of a data based strategy that focuses on variation reduction and process improvement through the application of Six Sigma improvement projects. DMAIC – Define, Measure, Analyze, Improve, and Control – is the method used to engage in process improvement [21]. It was asserted that Six Sigma methods might be effectively used in FOQA programs, especially for addressing very infrequently occurring events.A disciplined quality approach to improving safety is needed in the airline industry. Airlines would benefit by increasingly embracing and employing quality principles in designing, implementing, and managing safety programs, including FOQA. Six Sigma is one quality-based program that may be used to increase the effectiveness of FOQA, particularly for process improvement initiatives. Whether an airline employs Six Sigma or various other methods in its safety improvement efforts, quality in airline safety must be the goal.

Six sigma techniques applied for FOQA

The parameters recorded during flight allow for a FOQA air carrier to monitor adherence to standard flight protocols. Each parameter can be monitored for variance based on set tolerance thresholds as determined by the air carrier upon appropriate validation. For example, a target value of 165 knots could be established for a certain phase of flight, with a maximum allowable variation of ±10 knots. Any exceedance (which in Six Sigma terms can be considered a 'defect') of these limits is flagged as an 'event', which is differentiated by severity levels. Therefore, a recorded parameter of 172 knots might be considered a level 1 severity event, while an exceedance of 180 knots could be considered a severity 3.

When excessive numbers of severity 1 and 2 events are detected by the FDM software, airline managers might elect to re-evaluate the tolerances since they might be too strict. However, when a severity 3 is detected, it usually points to a potentially dangerous violation of standard procedures; thus, they usually warrant close examination. If an airline continues to detect excessive numbers of severity 3 or other events after adjusting severity thresholds, the potential for an incident or accident may be indicated. FOQA's proactive nature means that it functions by concentrating on level 1 and 2 events, proactively implementing remedial action and standardizing the operations in order to avoid level 3 events from occurring. In the commercial air transportation is already highly standardized and level 3 events are rare, but they do occur. Examples of level 3 events are tail strikes during takeoff, and overshooting or undershooting runways during final approachdue to energy mismanagement. The rarity of these events makes it problematic to utilize rate based methods that depend on events that have already occurred in order to estimate the chances of any future occurrences. To illustrate, for an air carrier operating thousands of flights per month, FOQA trend data will be increasingly abundant with commonly occurring events such as speed or pitch violations. As data is collected and analyzed, the distribution will eventually become normalized, allowing for proper predictive statistics. However, for extremely rare events such as tail strikes, the distribution will not likely be normal, but rather highly skewed due to the extended amount of time without any occurrence. There will not be enough data to support proper predictive statistics.

Software Implementation

Flight data monitoring and analysis FDMA tool is used for the analysis of the Avionics parameter analysis for monitoring flight safety This incorporates the programming method used by the data acquisition system location of parameters, number of bits used to encode parameters, type and method of encoding the functions used to convert the recorded value into the actual physical value. For each parameter, the conversion function is checked with the calibration of the measuring and processing channel, Data acquisition systems output a binary file sequenced in four-second frames, depending on the FDR's The entire set of recorded data are copied for analysis and then converted into engineering units using decoding software which is programmed according to data frame layout documents here calibration is made because conversion functions provided by OEM's are only theoretical therefore differ from the ones of the actual aircraft. Calibration checks demonstrate if conversion equations identified are appropriate. These equations should convert recorded binary words into parameters expressed in engineering units. If conversions are shown to be inappropriate, acquisition channel elements or conversion equations should be adjusted. The processes are as follows shown in Figure 1.

- Data Frame
- Data Frame Structure
- Data conversion
- Algorithm
- DFDR recorded parameters decoding law

A. Data process flow

Raw data extraction will be done based on parameter configuration and flight slicing will be based on the phase configuration and exceedance analysis will be done based on the exceedance configuration, the data process flows as per the below chart shown in Figure 2.

B. Monitoring performance can be improved

As an industry, we seem to have accepted the axiom that, "Humans are not good monitors". While it may be true that humans are not naturally good monitors, we firmly believe that crew monitoring performance can be significantly improved through policy changes and crewmember training.Traditional CRM courses have generally improved the ability of crewmembers to challenge others when a situation appears unsafe or unwise; however, many of these courses provide little or no explicit guidance on how to improve monitoring. "First, we must change our approach to monitoring. Instructors must insist that the non-flying crewmember monitors the flier effectively. A system that grades monitoring must be established. Good monitoring skills are not inherent in a pilot as they progress in their careers. Therefore, effective monitoring techniques must be trained and rewarded.

Systematic Flight Data Monitoring

The systematic approach of the FDM system allows an operator to compare their Standard Operating Procedures (SOPs) with those actually achieved in everyday line flights.

- Identify areas of operational risk and quantify current safety margins.
- Identify and quantify changing operational risks by highlighting when non-standard, unusual or unsafe circumstances occur.
- To use the FDM information on the frequency of occurrence, combined with an estimation of the level of severity, to assess the risks and to determine which are or may become unacceptable if the discovered trend continues.
- To put in place appropriate risk mitigation to provide remedial action once an unacceptable risk, either actually present or predicted by trending, has been identified.
- Confirm the effectiveness of any remedial action by continued monitoring.
- FDM is a closed loop system enhances the systematic approach to fulfill the problem statement.
- A feedback loop that should be part of a Safety Management System.
- (SMS), will allow timely corrective action to be taken where safety may be compromised by significant deviation from SOPs.

Advantage of Proposed System over the Existing System

- Gives knowledge of actual operations rather than assumed.
- Gives a depth of knowledge beyond accidents and incidents.
- Setting up an FDM program gives insight into operations.
- Helping define the buffer between normal and unacceptable operations.
- Indicates potential as well as actual hazards.
- Provides risk-modeling information.
- Indicates trends as well as levels of risk.
- Can provide evidence of safety improvements.
- Feeds data to cost-benefit studies.
- Provides a continuous and independent audit of safety standards.
- Can help identify area where flight crew training can be further improved.

Conclusion

FDM has increased gradually over the last 30 years as analysis techniques and data recording technologies have improved. The processes used in the past have tended to be rather ad hoc, locally implemented and controlled by informal procedures with less than ideal 'check and balance' records after issues have been raised and acted upon. Having said that, despite this lack of established process, many significant safety issues have been raised and resolved. The systematic approach should provide a more quantitative risk picture to the organization to help it manage its risks and measure the success of its mitigation actions.Parameter Analysis for Monitoring Flight Safety covers the basic Parameter configuration rules and methodology with clear understanding of the parameter type and decoding procedures.

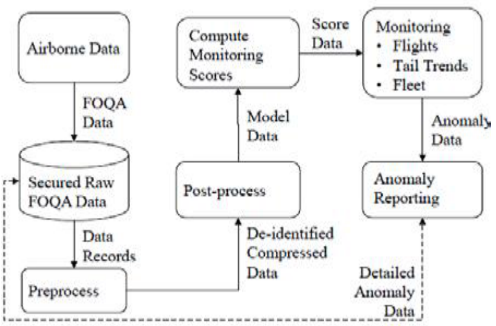

Figure 1: Data Flow Block Diagram.

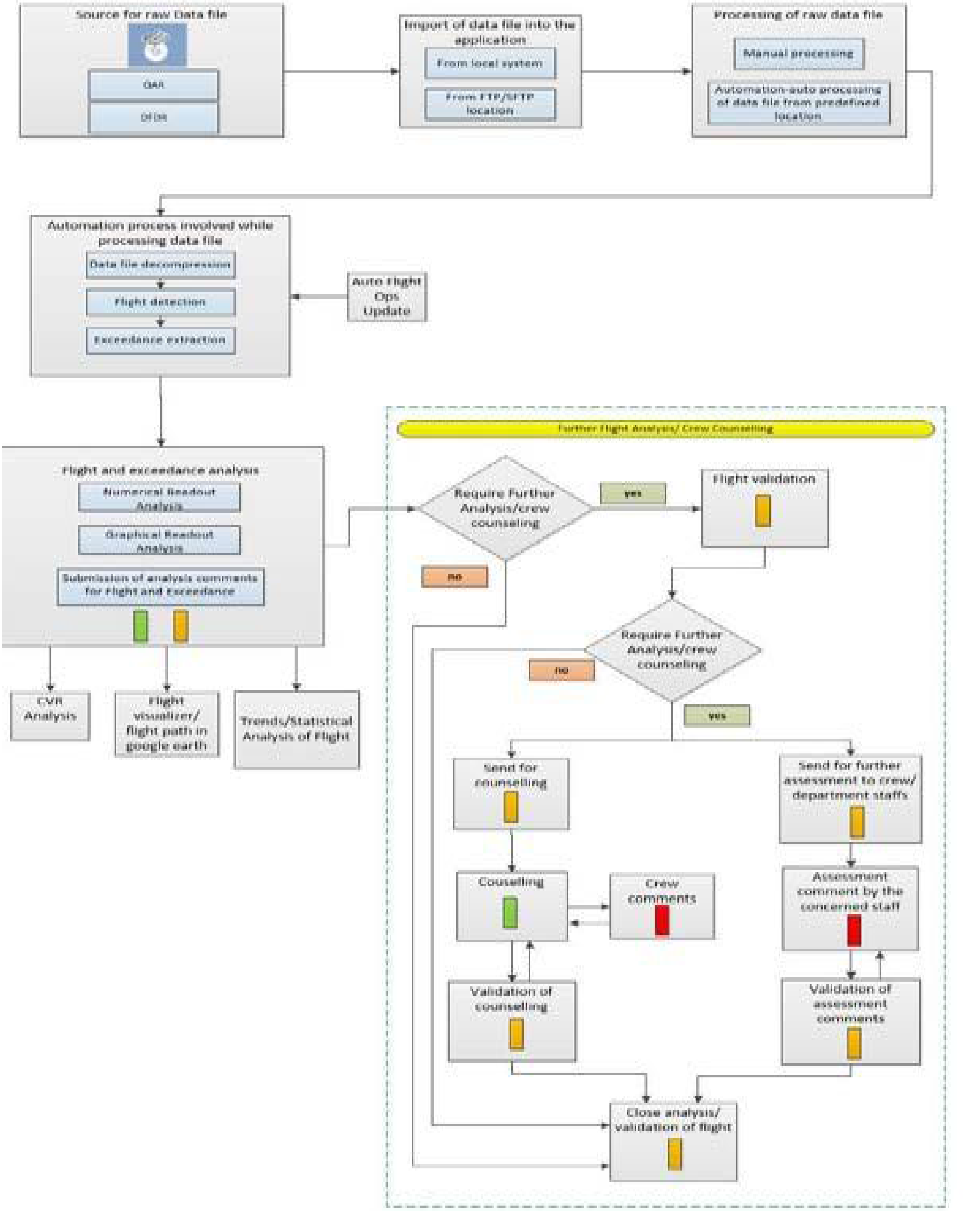

Figure 2: Data process flow.

And also explains the systematic approach for monitoring flight data, the detailed analysis with theprogram triggers, Configuration details and exceedance conditions for event monitoring and parameter analysis. Flight Operations Quality Assurance has been one of the most highly regarded and potentially effective airline safety initiatives to emerge in the past 20 years. It is a program based on quantifiable, objective data collected from the air carrier aircraft's data recording system. On some modern aircraft, over 2000 parameters each second are recorded. The FOQA system uses expert software to analyze the data from individual flights of interest, or aggregated data from multiple flights in order to examine trends that may affect safety. Unfortunately, with very few exceptions, the analysis of FOQA data has been limited to relatively simple statistical methods. It has been surmised that the application of more sophisticated quality and statistical methods may increase the effectiveness of the program and the air carrier's return on investment.

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