AUTOMATED OPERATIONS AND SAFETY DATA COLLECTION AND USAGE IN CONTEMPORARY FLIGHT OPERATIONS QUALITY AUDIT PROGRAMS

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Summary

Flight Operations Quality Audit (FOQA) programs are becoming more common to airlines of today. Flight data recording devices modified for repeated and daily data readouts have been demonstrating their unquestionable advantages in FOQA programmes. They demonstrate the interest of airlines, that use them, to transport people, cargo and mail in safe and efficient way. The paper will present general FOQA structure, historical developments in this field together with common obstacles when introducing FOQA to an airline. It also brings the latest data and understanding of benefits that FOQA has on airlines operation with potential applications of similar concepts to other means of transportation as well.

1. INTRODUCTION

"Safety first!" is a common slogan that aviation industry participants repeat almost like magic words constantly. It is common denominator in all activities related to aviation: design, construction, operation, and maintenance of aircraft; ground handling of passenger and cargo; air traffic control. Aviation being not completely exclusive and becoming more common and affordable means of transportation has not lost almost exclusive attention of public. This same public is potential customer so any mishap or catastrophic event has a large impact on the destiny of any airline and industry itself. Aviation as a system is still developing and growing in its size. International Civil Aviation Organisation (ICAO) is forecasting a rise of 25% in airline departures by 2005 [1]

Transport service to people, mail, and cargo is a commodity that airlines offer to their customers. Aircraft is a commodity that aircraft manufacturers offer to airlines. All involved parties are interested to give practical value to their respective commodities: safe and quality service or safe and reliable equipment. The more specialised commodity or service the higher quality criteria for them [8] In order to reach and maintain the quality of service or commodity within aviation industry it is of major importance to establish Quality Control system. This system is characterised by Plan–Do–Check–Act cycle [2]

Aircraft manufacturers have always been keen to see how is the equipment that they have created behaving in the real world. That started from the earliest days of aviation. Wright Brothers' flight carried primitive flight data recorder that recorded engine revolutions, distance flown through air and the duration of flight.[3] If that piece of equipment had not been present then there will not be evidence of those historic events at all.

The more complex equipment has become the more difficult has been to foresee all the possible problems or incompatibilities between different part of it. As the final product has always been intended to behave immaculately in all circumstances prevention of such behaviour was crucial task for the aircraft designers. Early auto pilot devices on the Douglas DC 3 (very common aircraft during and after the Second World War) have been adjusted and developed using primitive barometric altitude recording devices [4]

More recently there has been a fundamental change in the nature of the hazards to air travel. As systems have grown in complexity, aircraft have become vulnerable to malfunctions that - though minor in themselves - can cause a larger breakdown. There is a new trend in aviation. Problems are increasingly a result of complex system issues that need to be addressed by all fractions of the system working together, rather than primarily a result of individual issues. In the years ahead, it is imperative that aviation finds ways to ensure that these systems are as robust and fail-safe as the industry can make them.

This has lead to introduction of Flight Operations Quality Audit (FOQA) programs in airlines. FOQA programs are needed at individual airlines. Although these programs are essential to all operations functions within a carrier that is particularly true for flight operations and aircraft maintenance/overhaul departments.

Fundamental change to the use of Flight Data Recorders (FDR) came with the introduction of FOQA programs. Regardless of the name, that particular program has in different airlines worldwide, these programs are meant to use the data of aircraft FDR for purposes other than aircraft accidents investigation. It is very important to emphasise that this is done without any damage to the aeroplane or loss of human life. Acronym FOQA was used by the Flight Safety Foundation (FSF) about six years ago for the first time [4]

Using appropriate technology, for frequent data collection, routine flights are monitored systematically in order to capture and analyse operational irregularities. Collected data is analysed and shared in order to improve flight crew proficiency, air carrier training programs, air carrier operating procedures, air traffic control procedures, airport maintenance and design, aircraft operations and design [1]

Today, 580 aircraft, which comprise 13 aircraft types, are collecting FOQA data. This is about 15 percent of the major airlines' fleet.[5] FOQA can bring many benefits and its potential as a tool to warn all involved to prevent aircraft accidents is still not used to the full extent. This paper is intended to give general structure of the FOQA system and to emphasise potential benefits that can be gained implementing it in an airline and aviation industry. In order to do that authors have gathered and presented information from the industry and related agencies or authorities.

There are some aviation related acronyms in the paper. Here are their meanings for the reader out of that professional field.

JAA = Joint Aviation Authority is the associated body of the European Civil Aviation Conference (ECAC) representing civil aviation regulatory authorities of a number of European states. Their cooperation is intended to provide high and consistent standards of safety and a "level playing fields" for competition in Europe.

ICAO = The International Civil Aviation Organisation. Organise together civil aviation authorities from the countries subscribers to the Chicago convention. This world governing body for civil aviation promotes safe, efficient and reliable operations in aspects of air transportation.

JAR OPS1 = JAR-OPS 1 JAA regulation intended to ensure a common level of safety in a global (mostly Eropean) market, implementing common standards within the member states and allowing open, reciprocal recognition among the various Aviation Authorities.

CAA=United Kingdom Civil Aviation Authority

2. FOQA

FOQA is the voluntary collection, analysis, and sharing of routine flight operation data, obtained by analysis of flight data recorder information. At a minimum, FOQA involves the analysis of flight data on a routine basis to reveal situations requiring corrective actions before problems occur. Even more as Clapp defines "...the FOQA process as unlocking the value of flight data." [6].

Over the years, the number of airlines that have implemented FOQA-type program has steadily risen. Many of these airlines are convinced that FOQA is a critical component in their safety efforts and that the program has paid valuable safety dividends over the years. Flight Operations management needs to know how well it performs its duties. Operating safety is assessed by measuring work errors. Criteria for measuring are: established work standards, and selected flight parameters. These are either internal airline documentation, manuals, and data, or manuals created and endorsed by airworthiness authorities at the state of aircraft manufacturing.

The concept of safety management and quality assurance is basic and fundamental to FOQA. Quality management systems are established following clearly defined steps. In aviation, these are found in: JAR OPS1/ CAA requirements and ISO 9000.[7] Every production process (for commodities or services) has to be mapped. Each phase has to be planned, documented, supervised, and archived. Apart from continuous process control, there must be random documentation, equipment, personnel and procedure checks [8] In case of failures there must be corrective action to affected system. That will secure that all processes are performed satisfactory, and improved continuously.

2.1 The Structure

There are several requirements to implement FOQA. Airlines need methods to: capture flight data, transform the data into the appropriate format for analysis, and generate reports and visualisations to assist personnel in analysing the data.

Typical program is managed and operated by a FOQA Manager, one or more analysts, and FOQA

Monitoring Team. They manage FOQA ensuring the confidentiality of pilots' identities. They are responsible for defining and refining parameters, reviewing and analysing data, determining and monitoring corrective actions.

There is no consensus on where and who started FOQA first. One of the reasons for this might be difference in program names or maybe different official purposes stated in early programs. Developments in this sense were most intensive on both sides of the North Atlantic in the USA and the Great Britain. Only later on there were some moves at the Far East in Japan.

The earliest documented use of flight recorders mandated by authorities is found by CAA in 1958. Early 60s were marked by monitoring routine flights in order to validate airworthiness criteria. British Airways program in 1962. contained the seeds of modern safety oriented FOQA. Mid 60s have brought customised data recording to the other side of the Atlantic Ocean as well. Prest states that "…Trans World Airlines (TWA) developed a program that permitted them to analyse literally millions of approaches and landings using FDR. Their analysis resulted in modified Air Traffic Control procedures and revised airline operating policies and procedures." [4] Data was retrieved as flight data recorders received periodic maintenance.

More than one source agrees that FOQA concept was pioneered by the CAA in the 1970s. [9] British Airways FOQA program started in 1972., and only two years later All Nippon Airways began a program to analyse flight data. At that moment, FDRs have already made monumental contributions to aviation safety. As aircraft operations systems and performance become ever more sophisticated, the characteristics of the recorded data changed [10]

2.2 Getting Data

Even though FDR continuously record parameters during every flight, they typically are not designed to provide frequent access to their data but rather to survive the extreme conditions during and after crashes to preserve flight data for accident investigations. Obtaining frequent access to FDR for FOQA purposes, however, would produce increased wear on internal mechanisms and result in shortened mechanical life and increased expense for a very specialised device.

In addition to that, FDR may not capture a sufficient number of parameters to be useful for FOQA purposes. Minimal safety requirements are from 16 to 29 parameters. Typical FOQA program would likely capture many more parameters to allow for a more comprehensive set of conditions to be monitored (200-500 parameters are available on modern digital aircraft). [11] There are five main parameter groups: aircraft attitude, speed and acceleration, aircraft configuration, engines, and miscellaneous parameters.

Initial move toward more easily retrievable data capture started sometime at early 90s when Maintenance Recorders (MR) were introduced. These devices were capable of recording as many as 200 parameters [3]. Although the more frequent use was envisaged on large two crew airliners, in order to make up for the reducing the crew and third member capability of data recording during the flight, they have been installed despite the size of the aircraft.

Today, the most common data recording devices for FOQA purposes are Quick Access Recorders (QAR). Data is recorded on a removable magnet or optical disk or Personal Computer Memory Card International Association (PCMCIA) cards. Recorded flight data are output from the aircraft's Digital Flight Data Acquisition Unit (DFDAU), the same device that feeds parameters to the FDR. On average, QAR holds 200 or more parameters from 100 to 200 hours of flight data [11]. The combination of easy data collection and the numerous parameters available makes the QAR very valuable tool in monitoring flight operations. As Chao states " Thanks to QAR, we can know, in detail, how our planes are behaving, even long after flight." [12]

2.3 Transferring And Analysing Data

Once data have been collected it has to be transferred to ground analysis station. At the beginning of FOQA systems this has been done in the same manner as it is done in the majority of FOQA systems today. When an aircraft receives periodic servicing, the medium (optical disk or PCMCIA card) containing flight data is removed from the QAR and sent to a central location. Airlines retrieve the data on schedules ranging from 3 to 20 days.

As Garvey [5] states, "New communication, navigation and surveillance technologies now being developed, along with new cockpit systems, show us that new and better concepts for flight data collection are possible." An alternative to physical recording media is the use of datalink systems to transmit information directly to the ground-based system, eliminating the need to retrieve data from the aircraft. The other alternative is to download them via wireless link on a designated frequency once the aircraft reaches gate and airport local access network. This network will transfer the data to ground analysis station. Data encryption would be used to protect the data and ensure its integrity after the transfer.

After data retrieval flight data ground based analysis software de identifies it and transforms it in a form usable for processing.[1] It also filters out any marginal or transitory irregularities. Raw data is kept for 30 days, or less, usually. Trend data is kept indefinitely.

The flight data analysis component of the ground analysis system categorises operational events comparing them to a set of parameters that indicate normal operating envelope. Associated thresholds for these parameters vary by the type of aircraft and associated operating limits, accepted practices for safe operations, the phase of flight, and the duration of any irregularity. When analysis is completed, information on any detected irregularity, representing deviation from normal operating practice, is generated.

Initial limits for each event are defined by FOQA monitoring team and can be modified after the introductory implementation according to the findings. They are subject to an ongoing evaluation and refinement process. All events are classified according to the level of severity. Usually there are three groups of events. In United Airlines they call it informational-alert-safety.[13] In Emirates Airline they are referred as minor deviation – undesirable - unacceptable deviations.

Depending on the level of severity there are consequences. First level events are addressed through general training material and simulator training. Second level events are analyse in detail and more closely monitored in future. Third level events that place passenger and aircraft at safety risks are analysed with identified crew and addressed through their additional training and sharing the knowledge with other crew members through modified procedures and training. Corrective action can even call for the redesign of equipment.

Events collected over a period are plotted against time scale to identify airline performance against established control limits. This type of analysis provides valuable information to the airline, especially in terms of whether the airline's performance is improving, holding steady, or deteriorating. As Diegers states, "Centre line represents typical values. Control limits represents atypical values. No tendency, within control limits shows that performance is in control. Trending or outside control limits demonstrates operations out of control." [14]

Trends do not imply accidents. Accidents have not happened because they have been corrected either accidentally or because of redundancies. Maybe they have been avoided this time because of human skills. Yet, these trends identify potential problems and allow to introduce corrections before accidents happen.[5] In the example of Japan Airlines trends monitoring shows their wide band events reduced by 50% over the 1992 to 1996 time frame through evaluating trends and monitoring safety. [15]

2.4 Introduction to Airline Environment

Introducing FOQA programs in an airline is neither simple nor easy. Multiple barriers exist. Although programs bring numerous advantages, there are hurdles to overcome and differences to reconcile. Flight operations as most common source of data can put FOQA finding in use through other departments only. Direct involvement of different airline departments generates problems. Engineering and Maintenance, Flight Training, and Flight Safety are the most direct clients of FOQA data. Differences in department specific reporting procedures, goals, and core belief can only be solved if they agree that safety and efficiency requires trade offs [16]

Airline equipment adds its burden as well. Hardly any airline has only one aircraft type in its fleet. Although similar at a glance aeroplanes can differ in configuration and the sophistication of equipment built in them. This has to be reconciled with the goal of specific FOQA program. If a program's goal is to identify broad trends in flight operations and safety, the airline may choose to equip only a portion of its fleet with QAR. If a program's goal, however, is to more closely monitor the flight operations and performance of individual aircraft, the airline may want to equip more or all aircraft in its fleet.

Airlines with active FOQA programs have usually begun their programs by equipping their more modern, technically advanced aircraft with QARs. Some new aircraft, for example, are even delivered with QARs as standard equipment. Airlines have cited several advantages in having new aircraft delivered with factory-equipped QARs. One advantage is that aircraft are not taken out of service to be retrofitted with equipment. Another advantage is that the additional cost of a QAR can be spread over the finance period of the new aircraft. Generally, these airlines do not plan to equip any of their older, analogue-based aircraft, such of them in the near future. "Unfortunately, there are still a number of older aircraft flying around with flight data recording systems which are not up to the task" [6]

3. PRESENT FOQA STATUS AND APPLICATIONS

Currently there are not more than 35 airlines in the world with FOQA programs. At lease eight of non USA, airlines have FOQA type programs in operation for more than 25 years. Some of them use it on only few aircraft. There are only four airlines in the US that has active FOQA program.

Not so large number of US FOQA programs is the result of fear that FOQA data can be used against pilots or other involved parties, although they shared information for the benefit of safety with FOQA personnel. As Prest states "You can also go one step further and develop legislative protection against public disclosure of safety data obtained during the discovery process." [4]

Aviation is intensively competitive. However, on the issue of safety aviation has always worked together. While businesses are using knowledge management for strategic advantage against their competitors, the situation in aviation is different regarding safety information. In safety matters, aviation is using cooperation approach to achieve a collective advantage. Aviation is trying to use every tool available to enhance safety. In the past, this cooperation has usually been brokered by civil aviation authorities, both national and international.

The first step is to share information internally within airlines. Once that has been accomplished, information can be shared externally with other airlines, manufacturers, and aviation organisations. As only the data owner/data provider really understands their own raw data only processed information can be shared. Only then, this data sharing and action based on maximum information available will by synergy effects bring new quality and safety to operations.

Information is the linchpin to decreasing accidents. Some applications of FOQA are improved approach procedures at more than a dozen airports worldwide, solved unusual autopilot disconnects, solving GPWS alerts, reducing excessive take off angles, avoiding unstable, or hard landing

Other applications of FOQA data are seen in the field not so directly related to accident prevention or safety level increase. There are some initiatives to use FOQA data for other than safety purposes. FOQA data can cut operating costs through monitoring fuel efficiency and engine condition. Delta airlines sate that they use it to capture system anomalies: improve system efficiency and reliability.[16]

4. CONCLUSION

There have already been a number of important efforts where government and industry have been partners. FOQA - the routine analysis of the information captured on FDR is another one. It has data and powerful analysis tools. It is one of the richest sources of data. With FOQA available, there is a need for greater pooling of aviation resources around the world. Promoting the free-flow of safety related information, all parties involved must develop trust of one to another, and agree to take some risk and ensure that the right people have the right information at the right time.

Constant automated recording of operational data is applicable in other transportation modes as well. Continuous recording, interpretation, and the sharing of well chosen operations data can generate conclusions that have multiple direct and indirect applications. Adopting such practice aviation and any other mode of transportation can benefit in bringing safety, efficiency, and economics level to higher level.

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