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The concept of Flight Operational Quality Assurance (FOQA) programs have been widely utilized throughout the aviation industry. The premise behind the concept is to establish thresholds for flight situations based upon company operations specifications, regulatory guidance, aircraft limitations, and standard operating procedures and then monitor performance on the aggregate to determine if operations fall within acceptable boundaries. A singular exceedance may not trigger corrective actions, but if overall exceedances for the company exceed a predetermined acceptable threshold then mitigation strategies are employed to bring performance back within acceptable limits. Does this tell the whole story? Would allowing feedback for performance against idealistic targets be a better method for safety improvements? This paper will discuss the dynamics of investigative analysis of a project for stability of an approach and discuss the pros and cons of using systems that traditionally measure aggregate performance versus a system that determines degrees of performance.

FOQA Programs

The concept of a Flight Operations Quality Assurance (FOQA) program has roots in previous quantitative and qualitative aviation recording programs such as flight data recorders (FDRs), the Aviation Safety Action Program (ASAP), and the NASA Aviation Safety Reporting System. As indicated by program success at the airline level, a FOQA program should be accompanied by safety management systems (SMS) and a sound safety culture (Wiley 2007; FAA, 2006b). Airlines have realized much success from FOQA programs, and there have been recent efforts to bridge that success into the General Aviation sector, and despite the efforts of the FAA to expand FOQA, only 17% of smaller air operators have adopted it (Accardi, 2013).

FOQA is a significantly different program than all previous safety programs discussed. Unlike the ASRS and FAA Aviation Safety Action Programs (ASAPs), FOQA uses quantitative, objective data from flights to enhance trend monitoring and address operational risk issues (FAA, 2004; FSF, 1998). These operational risk issues, as discovered by FOQA data can lead to the development of more specific training programs such as Advanced Qualification Programs (AQPs). Historically only those on the flight deck during the flight know the true events of a given flight in relation to the flight data parameters collected. However, with the increased accessibility of FOQA type data across operations of all sizes, the aviation industry is still determining the best way to understand and utilize this rich data source.

The first workshop attempting to identify the benefits, utilization, and to encourage adoption worldwide of FOQA programs was by the Flight Safety Foundation (FSF) in Taiwan in 1989 (FSF, 1998). According to the Foundation (1998), their blueprint for FOQA has been the backbone for FOQA progress in the United States. However, this was only a starting point and there is potentially more work to be done in order to completely understand its full potential. The FAA took initiative to develop a formal FOQA program in 1990 by hosting a FSF workshop in Washington, DC, and in 2001 developed a rulemaking committee to further work in this area (FAA, 2003; FSF, 1998).

Before FOQA received full support from the FAA, a demonstration project was carried out to assess the costs, benefits, and safety enhancement associated with the program (FSF, 1998). During this project, the FAA provided hardware and software to four airlines which agreed to implement FOQA programs and share data with the FAA. As a result of the success of the project, the FAA determined that FOQA programs would be made voluntary as data collection and use for advanced FOQA programs were still in primitive form. The project demonstrated that the FOQA concept was a success for airlines by allowing enhanced trend monitoring and the identification of operational risks (FSF, 1998). The FAA did not attempt to create a FOQA program for non-commercial use during their three year demonstration project (FSF, 1998), although it is possible that a FOQA program for the general aviation sector would improve safety and operational performance in addition to assisting in flight training (Mitchell, Sholy, & Stolzer, 2007).

For those flight operations that plan to begin a FOQA program, a program development guideline is available in Advisory Circular 120-82, which discusses the benefits, set up, and maintenance of FOQA programs (FAA, 2004). This document also provides a template for the Implementation and Operations (I & O) plan set-up as well as key definitions that must be addressed during program establishment (FAA, 2004)

Airline officials, pilot union representatives and the FAA recognized that data protection issues were the biggest roadblock for FOQA program implementation (FSF, 1998). Initially, pilot unions were reluctant to sign FOQA agreements with airlines as they feared a lack of protection for collected FOQA data. FSF (1998) highlights three concerns airline pilot unions had with program implementation:

> "[first,] that the information may be used in enforcement/discipline actions; [second,] that such data in the possession of the federal government may be obtained by the public and the media through the provisions of FOIA; and [third] that the information may be obtained in civil litigation through the discovery process" (FSF, 1998, p. 7).

To address these concerns, 14 CFR Part 13 Section 13.401 was created. This document mandates FOQA data be stripped of any information that may identify the submitting airline before the data is passed to the FAA (FAA, 2004). The FAA ensures that "aggregate data that is provided to the FAA will be kept confidential and the identity of reporting pilots or airlines will remain anonymous as allowed by law" (FAA, 2004, p. 1). It is believed that relatively little exposure or experience with FOQA programs in any context will directly impact the perceptions of the individual within the flight program utilizing FOQA.

Traditional FOQA Data Analysis

With the data analysis focus of FOQA operations geared toward aggregate data, the natural inclination is to capture outliers from the normal operations rather than an analysis of the data to determine degrees of performance from a pre-determined objective. In a traditional FOQA program the system is set up with thresholds of measurements based upon one or more measures. For approach stability access these measures could be airspeed, vertical speed, roll rate, pitch rate, g-forces, or a combination of individual measures and the flight path angle. It is common for a FOQA program to establish "gates" along an approach flight path where flight parameters and aircraft configuration have to be within predetermined thresholds or a missed approach/go-around is warranted. If the aircraft goes beyond the boundaries of the flight path angle or exceeds the limits at an individual gate then an exceedance is recorded. The organization then follows up with a mitigation strategy to reduce the number of exceedances and continues to monitor the trends within the system. Of course, part of this understanding includes clarifying more contextually specific details that might offer a better interpretation of why these exceedances occurred. Upon looking at Figure 1a and 1b the framework of this system can be seen in a representation for approaches to an example runway. Looking at the blue line that

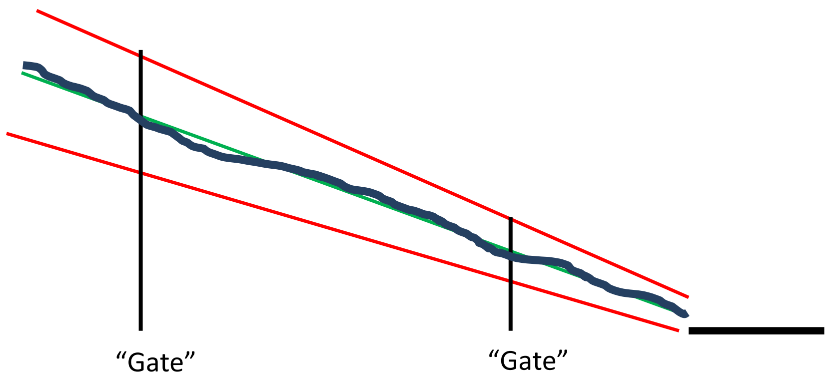

Figure 1a. FPA Analysis

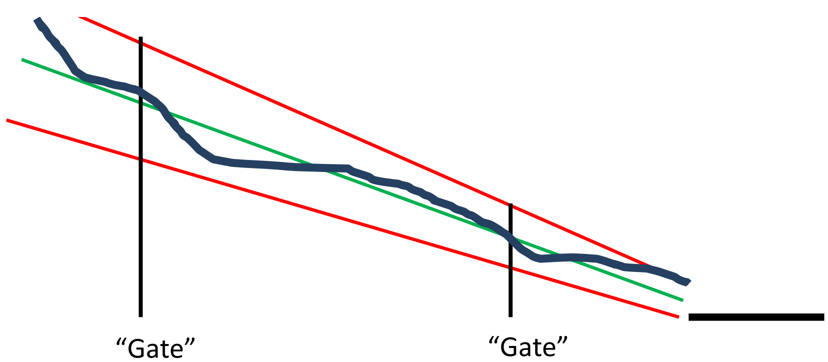

Figure 1b. FPA Analysis

represents the flight path it can be seen that Figure 1a stays relatively close to the center line and

Figure 1b varies along the flight path but never exceeds the outer boundaries. If the aircraft had met the criteria at the given "gates" then the FOQA system might not have recorded either approach as an exceedance even though the aircraft in Figure 1a could be considered more stable.

Alternative FOQA Data Analysis

Because of the aforementioned limitations to a more strictly exceedance based approach, an alternative method for FOQA approach analysis is to measure the Flight Path Angle (FPA) at 1 second intervals along the approach, calculate the absolute value of the difference between a given second and its subsequent second value, and then the sum of the variations in the FPAs for the last 30 seconds could be calculated. An approach that maintained a perfectly consistent FPA would have no difference in the FPAs at each second interval and then the sum of the variations in the FPAs for the last 30 seconds would equal zero. An approach that had a lot of variation would end up with a larger sum of the variation in the FPAs for the last 30 seconds. It is this measure that could then be used to determine the stability of an approach path. Therefore, this technique will give an overall dynamic view of an approach trend, rather than a measure of FPA boundaries. Aircraft that exhibit high variations in FPA will be considered less stable and will warrant further review just as the approaches that trigger an exceedance require further inquiry. This type of analysis also allows comparisons of all approaches, and can identify trends for operational improvements.

A system similar to the one described above was developed at the NASA Ames Research Center is the Aviation Performance Measuring System (APMS) (Chidester, 2003). According to Chidester (2003), the mission of APMS has three major thrusts; moving beyond exceedance-detection to routine analysis of all the data, providing focused analysis of higher risk phases of flight, and mining the data for atypical, potential precursors of incidents and accidents. The major movement from APMS is a shift from waiting until an aircraft operates outside of established parameters (exceedance) and recording it, seeing if there is a trend in recorded exceedances, and then identifying if it's a systemic problem in the operation or isolated to a given airport or aircraft. The system works by analyzing data and grouping operations into "normal" and "outliers". If the preponderance of operations to a given airport all look the same it is assumed that the operation is normal and therefore safe. If an operation is grouped outside of the typical performance parameter then it is flagged for follow-up by an aviation safety professional. This prevents needless oversight and focuses efforts to the operations that have a higher likelihood of needing analysis. In 2004 APMS was put to into action and was able to take more than 16,000 flights over a two year period and narrow it down to the most statistically extreme 5% of the dataset (Chidester, 2004). These flights were further analyzed and it was found that they fell into 8 different categories; high-energy arrivals, turbulence and accommodation, go-arounds, landing rollout anomalies, atypical climbs, takeoff anomalies, TCAS resolution advisories with escape maneuvers, unusual arrival paths (Chidester, 2004). This is a significant step forward in data analysis for FOQA efforts but there is still room for improvement. Of the 95% of the flights that fell into the "normal" operation category there is still variability from the target or ideal operation. Even though the parameters evaluated in the APMS system tend to fall around the mean for each parameter, the approaches conducted are still measured at "gates" or intervals at 1500, 1000, 500, and 100 feet above the runway

(Chidester, 2003). By measuring the change in performance at subsequent intervals the variability or change in performance can be determined which could be a better indicator of operational stability for certain types of procedures.

Conclusion

FOQA programs continue to evolve and are becoming more robust as the technology affords opportunities to analyze data in different ways. A significant barrier to consider moving past traditional FOQA analysis is the desire to group flight operations into a binary mode. "Stable" versus "unstable" categorizations or "normal" versus "extreme" can be replaced by measurements from targeted objectives. It will be necessary to avoid the temptation to label operations that fall within a "stable" category but are determined to have room for improvement to be considered "unstable". The focus of every professional pilot should be to want to improve their performance beyond what has already been achieved. Professionals should also want to identify when their performance deviates from the target beyond what they normally achieve. The individual performance may still be considered acceptable and within normal parameters, but these types of evaluations can assist pilots in determining reasons for why their performance is decreasing. Hindrances to performance such as fatigue, recency of experience, aircraft familiarity, and environmental conditions could all be qualified as to how they affect a particular pilot from their target objective. These types of measurements could provide robust feedback as a step toward process improvement.

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