# APPLIED USE OF SAFETY PERFORMANCE MONITORING IN GLOBAL AVIATION OPERATIONS

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For decades, aviation has been at the leading edge of safety and human factors data collection. These data have provided valuable insights into emerging trends and human-system performance needs. As industry continues to improve its data collection capabilities, stakeholders must develop a common understanding and use of safety performance monitoring (SPM) practices and terms governed by ICAO (ICAO Annex 19, ICAO Doc 9859). SPM is a critical component of Safety Management Systems and State Safety Programs. To understand industry's awareness and use of SPM in current operations, an SPM Survey was administered. Responses were received from 161 domain representatives in six ICAO global regions. Response data revealed the current state of industry SPM practices, SPM variability across domains and regions, and generalizable best practices. This paper will present top safety performance targets (SPTs), safety data analysis methods, and safety data sources utilized by respondents to track, analyze, and measure risk across five areas: Maintenance (n=120), Near Mid-Air Collision (n=95), Runway Safety (n=124), Loss of Control-Inflight (n=92), Controlled Flight into Terrain (n=109). Survey data revealed that the top SPTs set by respondents are: Unstable approaches (83.5%), Runway Excursions (70.1%). The top analysis methods used are: Causal Factor Analysis (68.1%), FDM/FOQA Software (59.7). The top data sources are: Voluntary Reports (93.8%), Mandatory Reports (86.2%). This paper will describe how SPM survey results may be used to develop a supplemental Safety Performance Monitoring Handbook in 2019, which will be intended to drive an industry-wide shift towards proactive and predictive safety risk management.

## Introduction

A Safety Management System (SMS) is defined as a systematic approach to managing safety, including the necessary organizational structures, accountabilities, policies, and procedures. The framework of an SMS consists of four primary components: 1) Safety policy and objectives, 2) Safety risk management, 3) Safety assurance, and 4) Safety promotion. Safety performance monitoring (SPM) is defined as a fundamental element of the "Safety assurance" component. SPM involves selecting, defining, and monitoring multiple safety performance indicators (SPIs) with associated safety performance targets (SPTs) (ICAO, 2013b). These attributes are defined as follows (ICAO, 2013a):

**Safety Performance Indicator**: A data-based parameter used for monitoring and assessing safety performance.
**Safety Performance Target**: The planned or intended objective for safety performance indicator(s) over a given period.

In 2018, Flight Safety Foundation reported a need to provide the global aviation industry with safety performance monitoring guidance materials. This need was a response to identified differences and inconsistencies in global SPM terminology, standards, and practices (Flight Safety Foundation, 2018a). As a first step towards the development of data-driven guidance materials, Flight Safety Foundation initiated research to assess the current state of global aviation SPM. Flight Safety Foundation and Fort Hill Group executed the multi-year research as part of the Global Safety Information Project (GSIP). The United States Federal Aviation Administration (FAA) provided funding for GSIP through Cooperative Agreement 17-G-003.

## Methodology

To develop a baseline understanding of global SPM practices, a panel of aviation, safety, and human factors subject matter experts developed an SPM survey. As part of the development process, panel members conducted literature reviews to inform the development of draft survey questions. Data from previous GSIP surveys and the results from 24 GSIP focus group sessions were also applied as part of the data-driven survey question development process. Panel members vetted each draft survey question during multiple panel review sessions and applied a consensus methodology to down-select a final set of 57 questions. The questions were then integrated into an online survey tool.

Respondents took the survey online using either a computer, tablet, or mobile device. Respondents first completed an initial set of survey questions to determine demographic criteria, such as organization type. Based on these initial responses, a tailored subset of questions was generated from the survey database. In this way, survey respondents were only asked questions germane to their demographic (e.g. air traffic controllers were not asked about aircraft maintenance operations).

### Survey Outline

The SPM survey was organized into three distinct sections: Demographics, General Safety Performance Monitoring, and Risk Areas. Each section contained a set of questions in various forms, including multi-select, free response, and Likert scales.

Section 1, “Demographics,” enabled the grouping of survey responses based on organization type, respondent role, and International Civil Aviation Organization (ICAO) region. This section contained 5 questions.

Section 2, “General Safety Performance Monitoring,” included high-level questions about safety performance monitoring, such as familiarity with ICAO definitions/terminology and organizational practices. This section contained 14 questions.

Section 3, “Risk Areas,” solicited information concerning the risk areas of Runway Safety, Controlled Flight into Terrain (CFIT), Loss of Control – Inflight (LOC-I), Near Mid Air

Collision (NMAC), and Maintenance. For each risk area, respondents were asked to identify the data sources used to gather information, to detail the tools and techniques applied to analyze the data, and to state the metrics used to monitor safety performance and set SPTs. This section contained up to 40 questions, depending upon whether the survey respondent indicated their organization tracks risk in each of the five risk areas.

## Survey Results and Discussion

A total of 161 survey responses were received between March 26, 2018 and September 12, 2018. As shown in Figure 1, Airlines accounted for 41.9% of responses, followed by Other Aircraft Operators (30.4%). The "Other Domains" category included responses from consultants, auditors, and aircraft management companies.

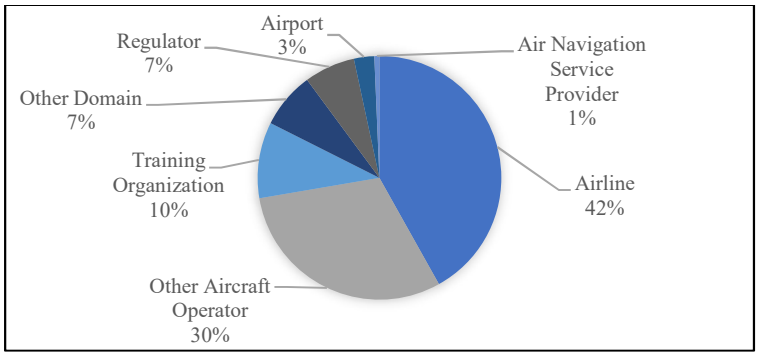


***Figure 1.*** **Response breakdown by organization type**

Figure 2 displays the percentage of survey respondents (n=161) who reported that their organization measures risk in each risk area. Runway Safety was the most commonly tracked risk area, monitored by 77.0% of respondents. According to ICAO, the Runway Safety risk area accounted for the highest percentage of all accidents that occurred in 2017. Along with Runway Safety, ICAO identifies the Loss of Control – Inflight and Controlled Flight into Terrain risk areas as their top safety priorities in the 2017-2019 Global Aviation Safety Plan (ICAO, 2018).

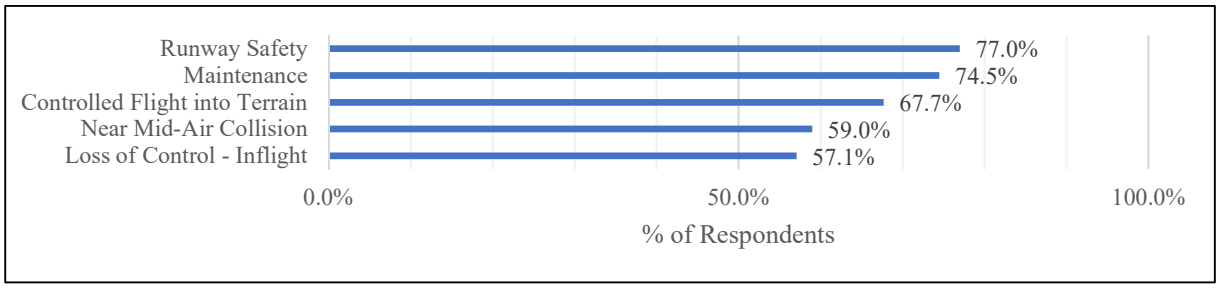


***Figure 2.*** **Percentage of organizations measuring risk by area**

Figures 3, 4, and 5 respectively present the top five safety performance targets, safety data analysis methods, and safety data sources utilized by survey respondents across all risk areas (n=161). Safety performance targets for unstable approaches were set by 83.5% of respondent organizations. Unstable approaches are characterized by vertical, lateral, and/or speed deviations during approach and landing and can contribute to the risk of Loss of Control – Inflight and Runway Safety events (IATA, 2016). Causal Factor Analysis was the most

commonly cited analysis method (68.1%). Flight Data Monitoring/Flight Operations Quality Assurance (FDM/FOQA) Software, Contributory Factor Analysis, and Safety Reporting Analysis Tools were each reported by slightly more than half of all respondents. Voluntary and mandatory reports were the top two most common data sources used to address risk, utilized by 93.8% and 86.2% of respondent organizations respectively.

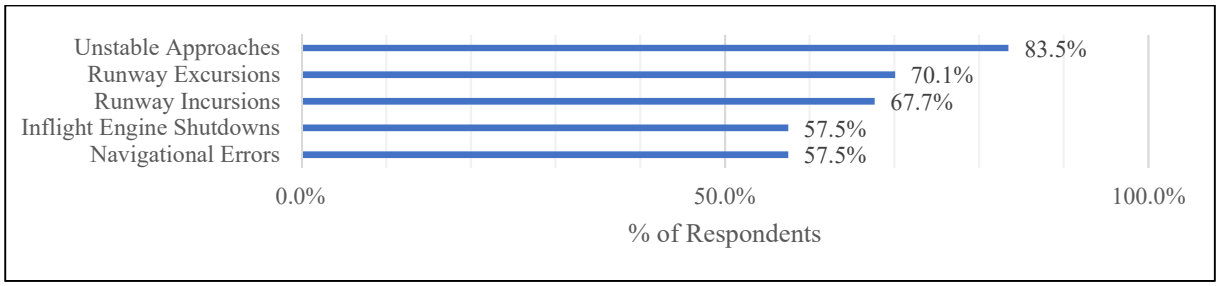


***Figure 3.*** **Top five safety performance targets**

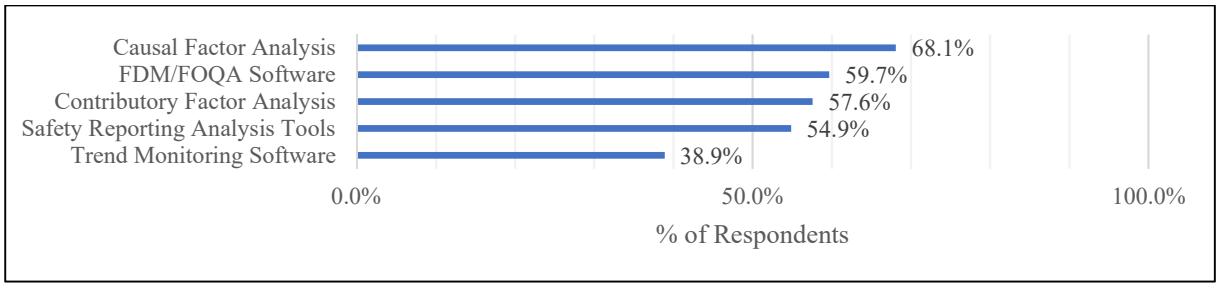


***Figure 4.*** **Top five data analysis methods**

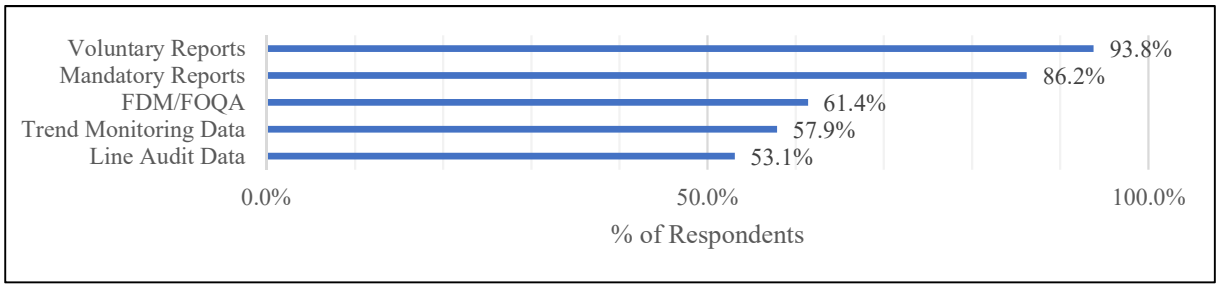


***Figure 5.*** **Top five safety data sources**

## Lagging versus Leading Indicators

A noteworthy finding from survey results was the prominence of lagging SPIs and lack of leading SPIs. SPIs are often classified as either leading or lagging. Lagging SPIs are reactive metrics that indicate historical performance and provide evidence of how effective an organization's interventions have been by observing whether the expected outcomes of changes are observable (Wreathall, April 2009). In contrast, leading indicators are "proactive, preventative, and predictive measures that monitor and provide current information about the effective performance, activities, and processes of a…system that drive the identification and elimination or control of risks" (National Safety Council, 2013).

The prevalence of lagging indicators is illustrated in Figure 3. The top five safety performance targets set by respondent's organizations are each reactive, lagging indicators of safety. Unstable approaches, runway excursions, runway incursions, inflight engine shutdowns, and navigational errors are all undesirable operational outcomes that have already occurred. Although some isolated examples of leading SPIs were found in the survey data, such as aircraft bank angle exceedances to indicate potential Loss of Control – Inflight risk, researchers identified an opportunity to encourage increased use of leading SPIs in future SPM guidance materials. A mix of both leading and lagging SPIs will equip aviation organizations with a broader range of metrics with which to measure risk in both current and future operations. "Safety can never be guaranteed by relying only on lagging indicators; rather it needs a continuous focus on lagging indicators of past deficiencies, leading indicators of current technical, organizational and human conditions and leading indicators of technical, organizational and human processes that drive safety forward" (Reiman & Pietikäinen, 2012).

### Line Audit Data

Researchers identified opportunities to expand the use of line audit data in the safety risk management processes of respondent organizations. As shown in Figure 5, only 53.1% of respondents indicated their organization addresses risk using line audit data (n=161). Based on the Threat and Error Management (TEM) conceptual framework, programs such as Line Operations Safety Audits (LOSA) provide insights into the interactions that occur between humans, systems, and the operational environment during both nominal (routine) and off-nominal (non-routine) operations. In contrast to other data sources that describe adverse safety occurrences (e.g. mandatory reports), LOSA data describes the myriad operational factors present during routine flights (Klinect, 2005). As a result, line audit data often provides unique insights into the positive human-system resiliency factors that influence routine operational outcomes (Paulsgrove, 2018). Because this data describes the factors that can prevent undesirable outcomes, it can be key to establishing targeted leading SPIs.

## Safety Performance Dashboard

To assist in the development of targeted SPM guidance materials, Fort Hill Group and Flight Safety Foundation developed a safety performance dashboard (Flight Safety Foundation, 2018b). The dashboard enables users to develop on-demand safety performance insights through the data analytics capabilities of Tableau Software. Users can create customized survey response data visualizations by applying sets of filters, including responses by region, risk type, domain, operational safety data sources, and others. This interactive filtering capability enables targeted deep dives into all meaningful aspects of the survey, such as understanding which risk areas are most important to different organization types in different ICAO regions.

## Conclusion

To address industry's identified need for guidance, researchers identified an opportunity to apply the results of the SPM Survey to support the development of a Safety Performance Monitoring Handbook, containing example leading and lagging indicators appropriate for airlines, other aircraft operators, air navigation service providers, airports, and maintenance

providers. By combining research findings with the results of a thorough cross-domain safety science literature review, a Safety Performance Monitoring Handbook would provide the aviation industry with actionable, data-driven information to enhance their safety performance monitoring capabilities and transition from reactive to proactive and predictive safety risk management.

## Acknowledgments

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