GLOBAL SAFETY INFORMATION PROJECT

Data Collection Toolkit

MARCH 2017

Global Safety Information Project
Data Collection Toolkit

Welcome

Thanks for your interest in enhancing aviation safety data collection and processing systems (SDCPS). This toolkit offers insights recently gained by Flight Safety Foundation into typical data collection challenges and solutions among aviation service providers and their regulators in the Pan America and Asia and Pacific regions.

As noted in the *GSIP Toolkits Introduction,* research and development for the Global Safety Information Project (GSIP) are being carried out in a 2015–2017 time frame under a cooperative agreement between the Foundation and the U.S. Federal Aviation Administration (FAA), supported by FAA funding. Generous contributions of expertise from aviation risk-management specialists and other professional stakeholders have made its compilation possible.

In civil aviation, as in many other global industries, the use of operational data to accelerate improvement of safety performance is growing rapidly. This pace can have inconsistent results. The frameworks we discuss here, therefore, are intended to help you objectively and confidently decide what types of data to collect within your safety management system (SMS, including SMSs within state safety programs), based on selected best practices and on new FSF proposals.

This toolkit urges you to consider the framework of a *bow-tie analysis* of your most probable risks — ideally combined with mathematical and statistical methods prior to making your data collection decisions. Moreover, we recommend mapping a strategy for the evolution of what we call your organization's relative *level of intensity* in risk management and, consequently, optimizing your organization's safety culture, capabilities and effectiveness.

A basic assumption linking this and three other GSIP toolkits is that, like other aviation stakeholders, your organization requires reliable streams of accurate data and information from which to identify, generate and prioritize risk mitigations. You cannot afford to wait, faced with fast-paced flight operations in dynamic environments, for results of an investigation into an accident, an incident or a precursor issue. You need to predict and to get ahead of the most probable threats.

Applying world-class knowledge of risks and countermeasures in flight operations — derived from accurate data collection, then analyzed and shared with proven methods — opens the path to improved safety performance using valid metrics. The GSIP toolkits show how such improvements to safety performance indicators (SPIs) can be the most likely outcome in the aviation domain where you take responsibility for acceptable levels of risk.

Toolkit Introduction

Our *Data Collection Toolkit*, partly based on input to Flight Safety Foundation from focus group participants and/or workshop participants, envisions and advocates continual risk-management enhancements as a priority as important as updating your crewmember training or procedures in flight operations.

Other toolkit aims are responding to SDCPS stakeholders' calls in several countries for guidelines on automated and voluntary data collection at all levels of an organization to enable trustworthy and meaningful data analysis; coping with extremely high data volumes; involving neutral third parties in the data collection process; and adhering to data collection standards while enabling details to be customized to reflect each organization's likely risks. Also desirable, they told us, is an enhanced common technical language for SDCPS across the globe so that any stakeholder can easily exchange dependable information on risks, current status on SPIs and other best practices internally and at the level of individual aviation service providers, safety domains, states, regions and the whole world.

Collecting risk data for SDCPS has become the norm in several parts of the Asia Pacific and Pan America regions, FSF GSIP researchers found. Participants in focus groups and workshops, however, raised concerns about how effectively some stakeholders derive benefits from the collected data.

As noted, the quantity, complexity and/or unsuitability of data sources reportedly has been overwhelming at times. Some participants voiced a desire for a high level of global standardization in SDCPS practices to help them decide how to achieve the right balance of quality and quantity of data collected. Others said they struggle with the best ways to optimize data collection for assessment of their most critical risks. No participants said they already have an ideal overall perspective of risk data or the risk assessments that need to be performed as a high priority.

This toolkit's frameworks have been influenced by GSIP participants' experience that collecting large amounts of data, while simpler than ever with current information processing technology, can be pointless if they lack an objective risk-management strategy, fail to select suitable data or lack quality standards, possibly leading to flawed conclusions. A researcher at one research session summarized, "It is unclear to participants how to prioritize the disparate data types and to know which data types add the most value. SDCPS — which can involve voluminous, scattered and sometimes confusing analyses and conclusions — is no small transition for the aviation industry."

The hazards and risks that affect each flight are dynamic and fast-paced, making it difficult for some safety professionals — for example, some of those representing charter/on-demand air carriers, business aviation and helicopter operators — to collect data that clearly will support risk management. Even relatively small organizations are expected to utilize data to objectively and routinely assess SPIs. Others say they feel the strongest pressure to adopt best practices in risk management when introducing new aircraft types, technologies and systems — before discovery of a significant unknown risk surprises them.

In this toolkit, we suggest that all data sources within the industry can be categorized into three main areas defined below: public safety information, reportable occurrences and safety program information. Each category can be used alone or with others at some times to focus your efforts in risk management.

The category title *public safety information* refers to the collection and analysis of publicly available information to improve a stakeholder's SDCPS capabilities. Additionally, the stakeholder may study this information to identify lessons learned from historical occurrences to improve future operations. Public safety information is available from many sources such as Airbus, Boeing, the International Civil Aviation Organization (ICAO), the International Air Transport Association, civil aviation authorities and accident investigation authorities.

Reportable occurrences include information in reports about an operational event or hazard that meets the criteria defined by the state and requires documentation and/or investigation. This information is obtained primarily from internal data produced by investigators or safety analysts or from participation in an investigative process. Reportable occurrence data is typically collected in response to a relevant category of aircraft accident (e.g., controlled flight into terrain [CFIT]), serious incident (e.g., runway incursion) or significant air proximity event.

Safety program information is the result of an aviation service provider's internally generated and managed safety programs aimed at improving operational safety. This includes safety assurance programs with ongoing auditing or inspections of operational processes, and employee voluntary safety reporting programs. The title recognizes that an organization also will make use of any risk data generated from its own accidents, incidents or mandatory reports as part of its own state safety program or SMS.

As covered in detail in the *GSIP Toolkits Introduction,* you ideally will recognize the data collection by your organization as occurring along an intensity continuum (see the matrix on page 6). You can apply this concept to perform a self-assessment of your airline's, air navigation service provider's, airframe/engine manufacturer's or other entity's risk-management practices in relation to intensity levels defined by GSIP.

- When we say your organization performs at the first (basic) level of intensity, we mean that you collect risk data primarily to understand the most probable and significant threats your organization faces, according to SMS principles. This essentially involves comparing SPIs inside your organization in light of standards and recommended practices published by ICAO in Annex 19, *Safety Management,* or more specifically under your state's Annex 19–compliant civil aviation regulations and related guidance. If you work for a commercial air carrier, you are bound to gather data related to key accident categories such as loss of control–in flight (LOC-I), runway excursion, runway incursion, CFIT and midair collision, for example, but these are determined by looking at the most recent five- to 10-year history for your industry sector and any key SPIs noted by the civil aviation authority.

- As a safety professional conducting risk management at a second (higher) level of intensity, you also collect risk data to understand your organization's most probable and significant threats in relation to the known probable (i.e., primary) causes of accidents and to known hazardous aircraft states. Your risk management extends to comparing your SPIs with aggregate rates or trends of local peer organizations, or an entire subsector, regional sector or worldwide sector of the civil aviation industry. These can be determined by examination of a bow-tie diagram–based breakdown of each of your most relevant data streams. For example, this could prompt you to extend your data collection to capture flight crew errors/failures in operational communication during taxiway navigation as a primary driver of runway incursions.

- At a third (higher) level of intensity, your data collection efforts support understanding of your organization's most significant safety events in relation to probable causes and contributing factors. This might mean, for example, that your data collection must be extended to compliance with the standard operating procedures specifically related to operational communication during taxiway navigation as a contributing factor in runway incursions.

- At GSIP's fourth (top tier) of intensity, you apply the most far-reaching risk-management practices. You collect data appropriate for understanding the most prominent risks at the global level. One preferred way to do this is to ensure that data streams you establish reflect accident categories of internationally respected authorities, such as the U.K. Civil Aviation Authority and its Significant Seven bow-tie analyses of fatal accident types throughout commercial air transport. This might mean you extend your data collection to all of your key pathways on bow-tie analysis within an accident category. You then understand where your operational system interfaces with other organizations and what those organizations have in terms of occurrence rates that you can expect to encounter across your operations.

As also noted in the *GSIP Toolkits Introduction* — regardless of your organization's relative level of intensity — you can apply simple mathematical and statistical techniques to "reverse engineer" an unknown variable within a bow-tie diagram–based analysis. For example, you can calculate, from the probability of the specific threat and the probability of a known unsafe outcome, how effective the existing risk barriers will be.

Key Insights and Considerations

Our GSIP research in 2015 and 2016 identified how data collection practices tend to reflect a given organization's level of data-collection intensity (i.e., its collection scope and sophistication) among the range

of possible SDCPS capabilities available. From these, Flight Safety Foundation concluded that no single data-collection tool or methodology appears to completely meet all the needs and desired capabilities described by states and aviation service providers. Moreover, changes and operational effects during the global scientific/technological evolution can alter any stakeholder's anticipated requirements (including knowledge and skills) for effective data collection, and introduce new circumstances of data collection.

We recommend that you consider pursuing a two-phase course of action, given uncertainties about your organization's future needs and priorities. Establish (or confirm) first that your SDCPS conforms to standards and recommended practices of Annex 19, paragraph 5.1. Then, watch for best practices — as this website is updated — in applying elements covered in this *Data Collection Toolkit*, especially lessons added from practical examples to enhance your safety data collection over time. This should include familiarity, as noted, with public safety information, especially detailed breakdowns of accident/incident rates from international sources.

If your SDCPS function at GSIP's first level of intensity, focus first on collecting relatively basic data and information on known and potential hazards within your operations, including numbers and rates of safety occurrences and outcomes. We highly recommend that your data streams include information closely aligned with the major accident categories for your industry sector that can be found in existing public safety information. For example, in the commercial airline sector, the top categories are LOC-I, CFIT and runway safety.

Your organization should decide, for this level, how many categories are relevant to your operation. Such data/information streams also typically include voluntary safety reporting from your frontline staff. Presumably, your data sources always will include results of any investigations conducted on specially flagged events using regulatory criteria specified by your state's civil aviation authority. For large organizations, your data streams may include at least one specific safety metric for each operational division (i.e., maintenance, ground, in-flight/cabin).

If your SMS already functions or is beginning to function at the second intensity level, you typically will need to add data sources enabling a deeper look into the main drivers of your SPIs, etc. Airlines at this level, for example, typically utilize flight data monitoring data to delve into the main causes of their previously investigated events/subjects, or events/subjects that have been detected through unacceptable risks discovered by safety reporting systems. For large organizations, the data being monitored might be the primary causes behind trends in their operational safety metric. For example, maintenance safety analysts may be monitoring how often recent overnight maintenance work may have contributed to an air turn-back or diversion.

If your organization manages risk at the third intensity level (i.e., with a deeper and relatively sophisticated understanding of underlying factors), you likely will want to collect data on events/situations considered possible contributors to safety events anywhere. This begins to reveal "softer" (i.e., subtle) connections between quality and safety programs. Data may be monitored on fatigue factors and how they connect to your primary safety data streams.

If your organization manages risk at the highest intensity level, that indicates that you are using a framework like a bow-tie diagram–based analysis to understand what data you have, which helps you to understand the frequency of threats, the effectiveness of your barriers, the frequency of all relevant undesired aircraft states, your recovery effectiveness. It also indicates that you are seeking data to understand how your performance can compare with other comparable operations in your industry sector. The urgency of building a complete risk picture may not diminish until you (and senior executives) understand what is happening — i.e., what is the industry SPI baseline — in addressing the same issues as comparable organizations.

Consider the following factors — derived from GSIP surveys, focus group sessions and workshop discussions — in choosing exactly which types of data you will collect routinely from *external* sources. Find other aviation service providers' outcomes data, reflecting their current collective experience in similar flight operating environments. Obtain public safety information. Collect data matching the industry-wide risk and outcomes that you specify, as well as the industry-wide risk of undesired aircraft states

that you specify. Most importantly for data relevance and accuracy, collect data reflecting unwanted outcomes that your organization is most likely to encounter in flight operations. Again, do that in light of bow-tie analyses that you perform at an early stage — alone or with industry safety partners.

Consider the following factors in choosing which data to collect routinely from internal sources. Data from voluntary safety reporting programs (such as the non-punitive, FAA-approved aviation safety action programs in the United States) — offering a view of the frontline of flight operations like yours — can help you answer the question "What looks safe or unsafe?"

Also, check out sources of de-identified auditing/assessment results (especially those reflecting process conformity and process effectiveness) for an entire aviation service provider or perhaps one of its departments. Obtain data derived during internal investigations of events or risk-management issues. Collect data that capture deviations from current standard operating procedures and other operating norms. Track direct inspection programs in flight deck and cabin operations (including line operations safety audits/assessments), maintenance and ramp services. If you are affiliated with an airline or business aviation operator, arrange access to the de-identified flight data monitoring data streams and analyses of the selected parameters.

Lastly, consider pursuing safety-related quality assurance data and any type of auditing data — whether the source is internal or external. Summaries of these data are probably the best known documents within each aviation service provider yet may be incompatible with your needs, depending on the other organization's types of operation.

Another focus of current data collection, GSIP participants said, is how best to gain understanding of issues from multiple simultaneous data streams. Such systems hold promise of enhancing understanding of risks and of correlating events to reveal the greatest risks.

Community Insights

Over time, plans call for our *Data Collection Toolkit* to add links (under this subtitle) to detailed examples of international best practices in data collection as they relate to successful risk analysis, information sharing and safety information protection.

Such stories and lessons learned are among the most beneficial ways of communicating this knowledge and illustrating concepts for practical benefit. Across our set of GSIP toolkits, plans also call for incorporating data analysis illustrations for subjects such as risks involving route networks, topography and airport design. Data visualization examples also are being curated to show the latest ways that event data, rates and correlations between one data stream and others enhance comprehension and inspire replication.

Guidance Resources

Again, regarding international expectations for safety data collection in civil aviation, first check ICAO's standards and recommend practices — starting with Annex 19, *Safety Management.*

GSIP researchers have found that normalized rates of occurrence for just about any risk-management topic have been produced. Often they are available to share with safety professionals as discussed in our *Information Sharing Toolkit.*

Opportunities to Share

From the outset of GSIP, Flight Safety Foundation has requested permission to publish brief de-identified narratives, articles and illustrations about safety data collection experiences from aviation safety professionals and organizations. We welcome you and fellow *Data Collection Toolkit* visitors to take advantage of this website to share with peers worldwide how you have turned data collection theories into best practices. Hundreds of GSIP participants and many others will appreciate the chance to learn from your experiences, and we will follow FAA-FSF confidentiality standards on vetting materials and protecting your privacy.

Overview Matrix Of Intensity Levels

Risk management is a tool for decision making and improving safety performance. As it is executed, additional learning continues to take place, which expands our knowledge on hazards and our horizons of influence. GSIP recognizes this ever-expanding growth of risk management and therefore incorporates a level of intensity across our toolkits. The following chart includes a simplified version of the different levels of intensity across all risk management safety activities.

	SMS Core Level	Expanded Level	Advanced Level	Industry Level
Data Collection	Data are collected to adequately monitor the normal hazards an organization may encounter and to support a functioning SMS.	Data are collected to understand both the hazards and exposure to operations with those hazards (e.g., *flight data acquisition systems).*	Data are collected to advance understanding of primary causes and contributing factors (e.g., *monitored data through LOSA).*	Data are collected to utilize and contribute to a larger industry understanding through bow tie organization of events (e.g., *data collection with industry partners).*
Data Analysis	Data are analyzed to determine acceptable risks. Safety performance indicators with current status against objectives.	Data are analyzed to understand all direct hazards and their impact on undesired outcomes. Multiple hazards are each examined for their influence on risk.	Data are analyzed to understand all potential direct and indirect hazards and their impact on undesired outcomes.	Data are analyzed to understand all industry impacts on safety. The math behind paths leading to and from an undesired state are well understood.
Information Sharing	Information sharing of performance results is comprehensive within an organization (e.g., within one organization).	Information sharing of performance and key areas of linked performance is performed among divisions or industry peers at detailed levels (e.g., ANSP to ANSP).	Information sharing is across the industry for key risks and mitigations. Generally this is through presenting detailed independent investigative work in the data (e.g., ANSP to airline).	Information is shared and managed across the industry for benchmarking capabilities and emerging conditions. Cooperative analysis is conducted (e.g., pooled data).
Information Protection	Individuals and organizations are protected against disciplinary, civil, administrative and criminal proceedings, except in case of gross negligence, willful misconduct or criminal intent.	The protection extends to certain mandatory safety reporting systems. In Annex 13, the protection extends to final reports and investigation personnel.	Further protection mechanisms may be in place to implement just culture principles and cross-industry support for strong safety reporting cultures.	Protection is formalized at the highest level between countries through memorandums of understanding or similar agreements.

ANSP = air navigation service provider; LOSA = line operations quality assurance; SMS = safety management system