FLIGHT SAFETY FOUNDATION

GLOBAL SAFETY INFORMATION PROJECT

Level 3 Intensity Toolkit

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Toolkit Introduction

What Is the Purpose of the Toolkits?

The Global Safety Information Project (GSIP) toolkits continue Flight Safety Foundation's leadership of innovative safety initiatives within the industry. They add to a legacy of pioneering U.S. and international aviation safety conferences, establishing formal education for accident investigation, and other consensus building on standards and guidance. We believe tomorrow's risk-mitigation advances will come from the way we use comprehensive safety data collected before accidents happen — not just isolated forensic or auditing data. We must know far more than which countries aren't passing International Civil Aviation Organization (ICAO) Universal Safety Oversight Audit Programme (USOAP) audits or what airline failed to meet standards of an International Air Transport Association (IATA) Operational Safety Audit (IOSA) audit, whether airlines appear on a blacklist, or when organizations experience a safety event that becomes headline news. Today's focus must be on combined, in-depth knowledge of both immediate and long-term risks, such as those in the safety reports that frontline operations staff are submitting to their safety departments, their analysis of routinely recorded data from all flights over time, and operational risk assessments by local and regional organizations around the world.

Aviation organizations like yours increasingly perform detailed safety studies of their operations. Their analyses of aircraft flight data re-corder parameters, for example, reveal insights that show where safety programs could be strengthened to avoid a hazard or mitigate an event. These studies are intensifying, and their pace is quickening. At the same time, given the human factors risks and the related necessity for procedural consistency, no organization should manage operations by making changes to procedures after every flight. So the longer-term trends are important, and changes need to be considered carefully — perhaps tested before they are even introduced to assure an acceptable level of risk.

Our GSIP toolkits consider critical components of the risk management process so you can make good decisions and share information among stakeholders that benefit the entire safety management system.

Who Are the Toolkits for?

We've designed the toolkits for any one of the multitude of aviation industry stakeholders.

Regulators, for example, want to make sure that the safety performance of their country steadily improves. They want to ensure that service providers are learning and applying safety insights. They want to trust that the industry is doing the right thing, while holding individuals and organizations accountable to standards that address critical risk issues. Data will help them set their priorities.

Airlines, too, want to manage their risk using the best data they can get their hands on. They realize improved safety performance is not assured solely by their compliance with standards or by creating more standards.

Air navigation service providers (ANSPs) want to ensure that hazards and risks affecting air traffic have been identified and managed to ensure safety.

Airports want to make sure their runways are in service and in a safe condition at all times for takeoff, landing and taxiing without confusion. Airport signage, marking and lighting to be clear and unobstructed, and communications must be clear to minimize the risk of runway or taxiway incursions. Preventing aircraft ground damage is critical for safe operations.

Aircraft and engine manufacturers want fleets to operate reliably and to be recognized throughout world markets as extremely safe. They perform safety analyses before any aircraft is built, and they continue to monitor operations globally to identify emerging safety challenges. They also proactively issue recommendations and respond to trends as operators report events or conditions, or ask for assistance with other technical issues.

Data Collection

Our objective in data collection at GSIP Level 3 intensity is to provide your organization tools and techniques to gather direct and indirect evidence of factors that contribute positively and/or negatively to operational outcomes. This includes data from safety events or nominal (routine) operations. Our recommended tools and techniques yield insights about current risk management effectiveness and the integrity of your aviation operations.

Table 1 shows the four intensity levels of data collection detailed in GSIP toolkits.

At Level 2 intensity, you focus on collecting outcome-based data from automated/system-based data sources (such as flight data monitoring, air traffic control radar data). You typically use the data to identify the primary causal factors of a safety event or risk. At Level 3 intensity, you focus on collecting, integrating and analyzing observational data that help build a complete risk picture, studying the individual effects and the overall impact of causal and contributory factors. To expand Figure 1's description, Level 3 data collection emphasizes:

- Collecting observational data to understand why a nominal operation or safety event had an acceptable or unacceptable outcome;
- Collecting robust event data with advanced techniques; and,
- Conducting "deep dives" to find and collect specifically targeted, detailed data and information.

We based our examples on commercial aviation scenarios, but you may prefer to tailor our underlying approaches to your needs.

Gathering Data for Nominal and Off-Nominal Operations

Robust techniques to collect data from routine operations rapidly advance risk management capabilities within ICAO-defined safety data collection and processing systems (SDCPS). As noted, this type of data helps you understand why a safety event occurred and whether the outcome is acceptable. Your analysts also gain an objective baseline for measuring and assessing variability of human-system performance.

Focus first on routine operations most likely to yield insights into what went right and what went wrong in the sequence of events, regardless of your assumptions about the risk acceptability or outcome. For example, things often go wrong during a routine aviation operation but have an acceptable safety outcome. Conversely, the routine operation can go right, yet result in an unacceptable safety outcome.

We tend to assume that all our systems are performing as designed and as intended, and will produce expected safety outcomes. We also assume our people are performing optimally and will produce acceptable safety outcomes. The human factors include proper task execution, procedural compliance and effective responses to routine operational conditions.

The following example — an air traffic controller coordinating and issuing a pre-departure clearance (PDC) — illustrates human factors in what experts call *cross-domain, human-system interactions* of pilots and controllers. In Figure 1 (p. 5), we've color-coded each participating entity (for example, the flight crew, PDC controller and aircraft automation) and their associated actions in a nominal PDC. We've also numbered the steps in the sequence of events and described each step or action.

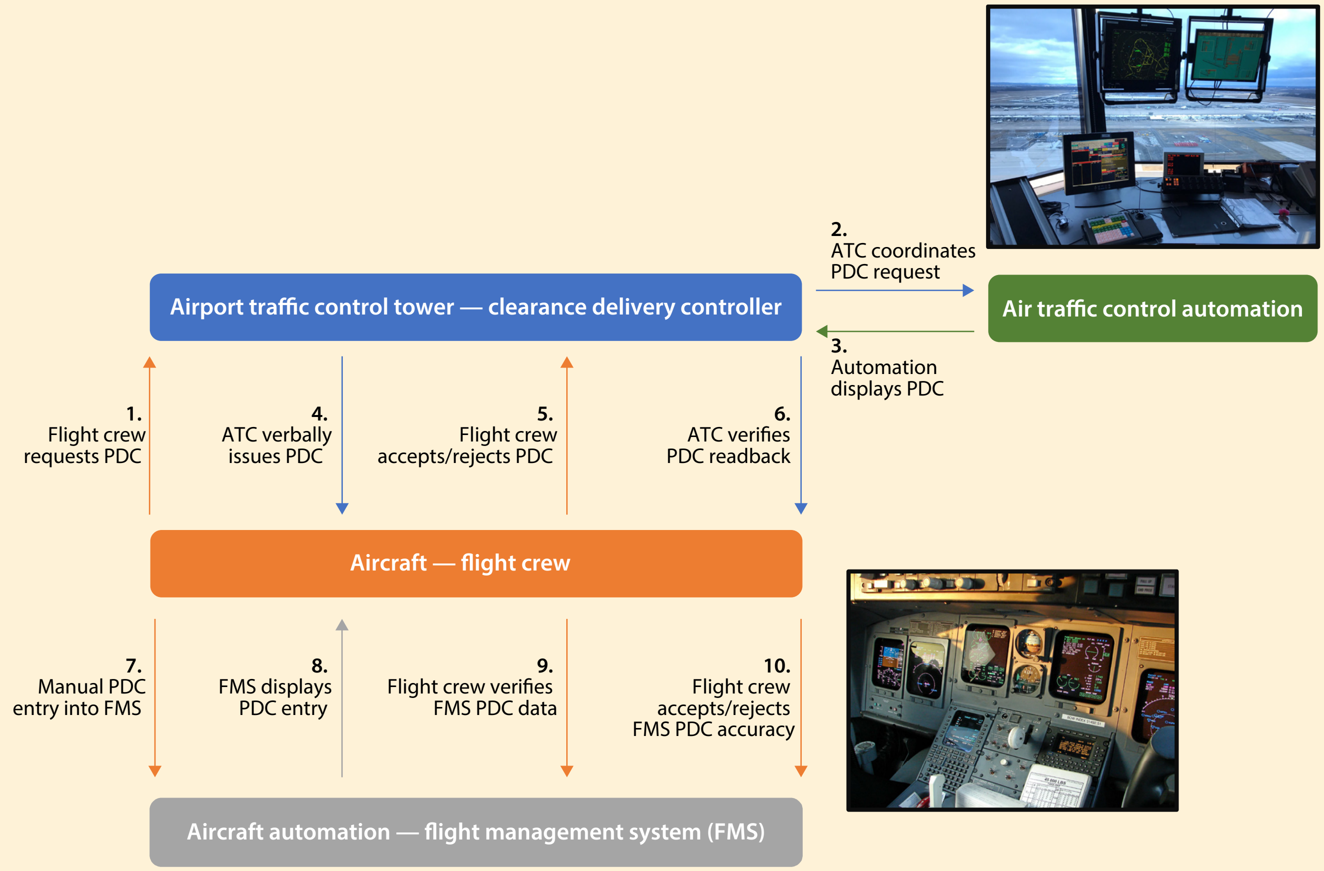
For our flow diagram of human-system interaction during an off-nominal PDC, we've assumed that a significant deviation occurred, compared with Figure 1's nominal system and operator performance. Note that despite this deviation, you must consider the possibilities of either an acceptable or an unacceptable safety outcome. In broad terms, causes of such a deviation could be erroneous system alerts, degraded system modes, task overload and emergency operations. Our Figure

Table 1 — Level 3 Intensity in the Data Collection Matrix

GSIP Toolkit Matrix	Level 1	Level 2	Level 3	Level 4
Data Collection	Data are collected to adequately identify and monitor the normal hazards an organization may encounter, and to support a functioning SMS.	Data are collected to understand hazards, the exposure of operations to those hazards, and primary causal factors (for example, through flight data acquisition systems).	Data are collected to advance a comprehensive understanding of causal and contributory factors (for example, data collected through LOSA).	TBD

LOSA = line operations quality assurance; SMS = safety management system; TBD = to be determined

Figure 1 — Nominal Interactions in Coordinating a Pre-Departure Clearance



ATC = air traffic control; PDC = pre-departure clearance

Note: The steps are numbered and the flow of information is color coded.

2 (p. 6) flow diagram shows a case of off-nominal interactions while coordinating a PDC.

Comparing the PDC sequence in Figure 2 with the sequence in Figure 1, it's clear that a human performance deviation caused the off-nominal interactions. Furthermore, both examples of PDC interaction could produce an acceptable or unacceptable safety outcome but we have not provided enough information for you to decide which would occur. Again, starting with a baseline understanding of the nominal operation makes it possible to easily identify the performance deviation. This concept is a key aspect of SDCPS.

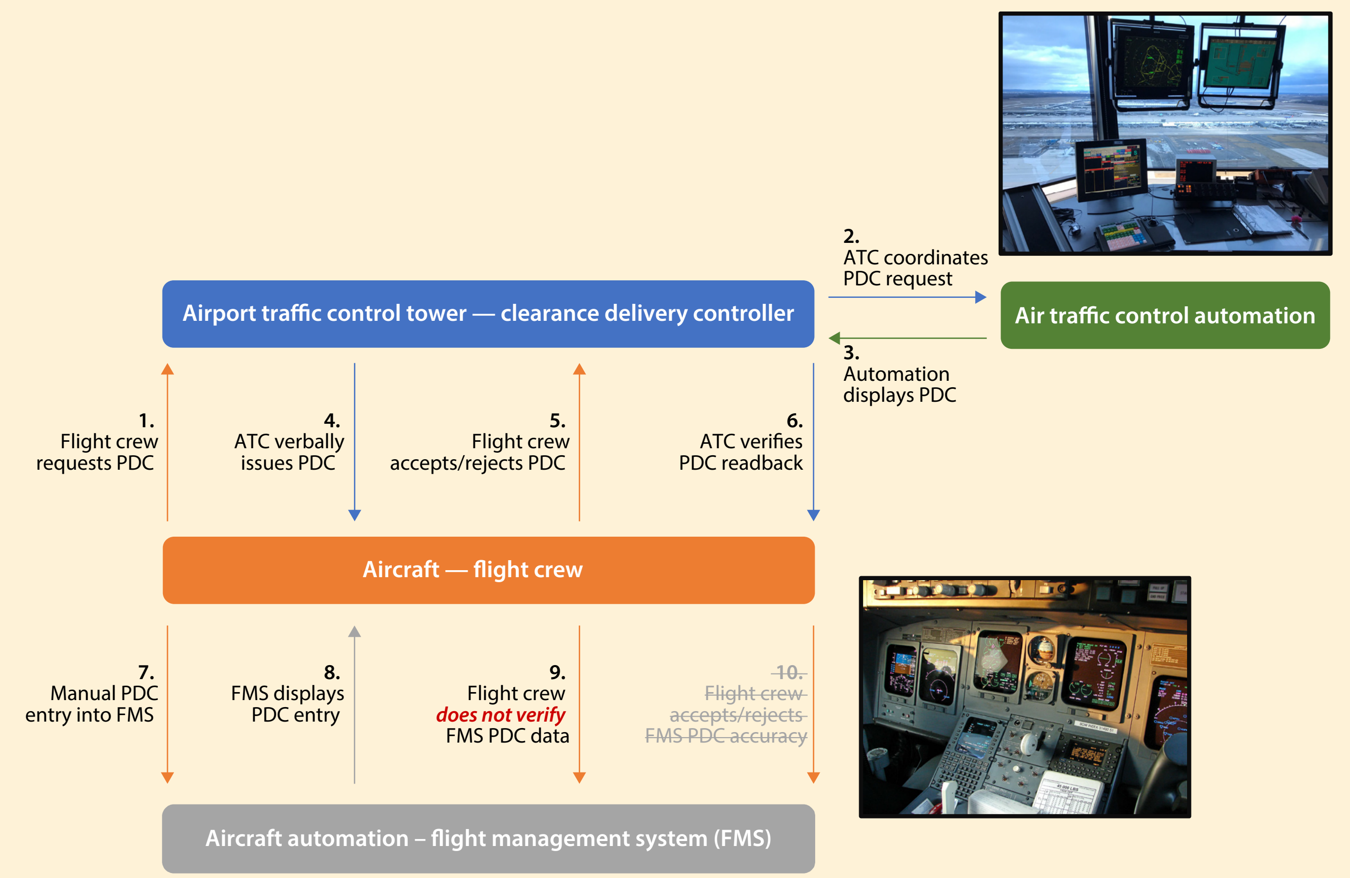
In this toolkit, we will introduce specific Level 3 data collection tools and techniques suitable for effectively analyzing your nominal aviation operations and your off-nominal safety events.

Types of Safety Data

For risk analysis at Level 3 intensity, your sources must provide data suitable for gaining detailed insights into nominal operations, off-nominal operations and the probable causes and contributing factors of safety occurrences. Compared with data sources suitable for analysis at GSIP Level 1 and Level 2 intensities — mainly *quantitative* in nature (for example, studying exceedances of flight operational quality assurance [FOQA],–flight data monitoring [FDM]– flight data analysis program [FDAP] parameters and rates of mandatory occurrence reports) — data sources for Level 3 analysis add qualitative considerations and introduce third-party involvement to your organization.

Line operations safety audit (LOSA) and normal operations safety survey (NOSS) observations, for example, show the interactions among people, systems and operational environments in nominal and off-nominal conditions. You will combine these types of Level 3–suitable data with internal and publicly available data sources to accomplish robust, informative and advanced analysis. We describe the techniques in the Data Analysis section of this toolkit.

Figure 2 — Off-Nominal Interactions in Coordinating a Pre-Departure Clearance



ATC = air traffic control; PDC = pre-departure clearance

Note: The steps are numbered and the flow of information is color coded.

Data Sources

The following subsections describe specific sources of data that you'll want to consider as you conduct SDCPS at Level 3 intensity. Our intention is that this toolkit suggest a few Level 3 data sources. Your organization may find those listed useful, or you may decide to collect data from alternate sources.

Level 3 Example — Data Sources for Airlines/Aircraft Operators: LOSA, M-LOSA and R-LOSA

As most airline safety specialists know, LOSA is a safety assessment process for routine (line) flight operations in which trained and calibrated observer pilots monitor and record data about a flight crew's performance. (Derivatives of the original process are maintenance LOSA [M-LOSA] and ramp LOSA [R-LOSA]). The framework of LOSA observations is the threat and error management (TEM) concept. TEM examines the relationships among human performance and safety factors in the context of flight operations. TEM emphasizes flight crew awareness of the presence of threats and errors in the operational environment and flight crew response to those threats and errors with countermeasures to avoid undesired aircraft states.

LOSA observers record information in a variety of categories. Their data are typically written on a LOSA observation form, which may be a paper document or software application such as a laptop computer program or a tablet app. Ultimately, this data should be relatively easy to retrieve and converted for analysis. Observations are quantitative (for example, departure time,

Figure 3 — LOSA Observation

Source: Phil Derner Jr.

phase of flight) and qualitative (for example, narrative descriptions of crew behaviors, safety events or other occurrences). LOSA data are de-identified to help protect from any disciplinary/punitive uses by companies or civil aviation authorities (CAAs).

LOSA is highly compatible with your GSIP Level 3 intensity of data analysis. One reason is that observers record data about nominal aspects and off-nominal aspects of flight operations. They also may observe many flights without seeing any abnormal occurrences. In other words, these flights were conducted according to standard operating procedures and had no off-nominal events.

As noted earlier, comprehensive nominal event data facilitate Level 3 comparisons to off-nominal event data. Moreover, the data are recorded from the third-party perspective of an objective observer, whether a company pilot as a part of its own internal LOSA program or a pilot provided by an external LOSA provider, such as "The LOSA Collaborative." As such, the data are typically less prone to variation between observers or personal biases than a flight crew's self-reported data. To learn more about the LOSA Collaborative see the website: <www.losacollaborative.org>.

LOSA data sets closely mirror the flight crew behaviors that would occur during unobserved flights for several reasons. In this type of research, subjects typically modify their normal behavior in the presence of observers. This influence — known as the Hawthorne effect or "observer effect" — still may affect LOSA observations to some degree but the effect is minimized. One reason is the strictly nonpunitive research design. Flight crews, since the late 1990s, have accepted and trusted the effectiveness of the anonymity protections. Therefore, they are not incentivized — by threat of reprimand, disclosure of their errors or other negative repercussions — to modify their normal behavior patterns or habits because of being observed.

As noted, some airlines and business aircraft operators collect LOSA data from their maintenance operations and/or ramp operations. These M-LOSA and R-LOSA programs follow the same concepts as flight deck observations (for example, TEM, non-disciplinary results, data de-identification), and they tailor observations to the unique characteristics of each research domain.

See the following resources for more details:

- ICAO Doc 9803, *Line Operations Safety Audit*;
- FAA Advisory Circular 120-90, *Line Operations Safety Audits*; and,
- FAA Report No. DOT/FAA/AM-12/9, *Implementation Guideline for Maintenance Line Operations Safety Assessment (M-LOSA) and Ramp LOSA (R-LOSA) Programs.*

Level 3 Example — NOSS, A Data Source for Air Navigation Service Providers

NOSS is a data source in air traffic control and similar in concept to LOSA. NOSS is a method of observing air traffic controllers and recording data from nominal occurrences and off-nominal occurrences. The ICAO NOSS Study Group, with representatives from eight ANSPs, played a large part in pioneering the method. NOSS is a relatively recent application of the TEM framework, compared with LOSA.

An ICAO preliminary circular, Threat and Error Management (TEM) in Air Traffic Control, provides an in-depth analysis of TEM, including ANSP case studies. The studies outline threats and errors related to specific undesired states (for example, air traffic control (ATC) issues clearances for two aircraft to occupy the same runway at the same time).

As described in ICAO Doc 9910, *Normal Operations Safety Survey (NOSS)*, NOSS involves training ATC staff as observers and collecting data over one to two months for approximately one hour at a time. The emphasis is on collecting data representing nominal and off-nominal operations. The survey's result is a de-identified data set that contains detailed threats, defenses and recovery measures. ICAO Doc 9910 covers benefits, best practices and suggestions for developing and managing a NOSS program. The following supplement — Finavia NOSS Trial Report — details the NOSS experience of the Finnish ANSP, Finavia, including implementation methods, challenges and general findings .

Level 3 Examples — A Data Source for Airports: Self-Inspection Programs and Targeted Audits

For airports conducting risk management at Level 3 intensity, we recommend self-inspection programs and targeted audits, which aim to achieve specific risk-reduction goals.

Self-inspection programs encompass all types of routine inspections conducted by airport personnel. They include runway surface inspections, periodic examinations of airport equipment and airport rescue and firefighting assessments. These inspections are a routine part of airport operations. The resulting types of records vary in detail, from inspection forms simply marked "completed," to detailed narrative reports of findings. This variation means Level 3 analysis first will require an assessment of your airport's data sources and the levels of detail they contain. The following excerpts from a presentation by the FAA may be useful in assessing your airport's safety program:

- *Airport Safety Self-Inspection Overview.*

Targeted audits enable your airport to reduce risk in specific areas. To facilitate audits, airports often develop self-audit checklists to accurately assess whether, and how, selected parameters influence risk. ICAO developed the following linked checklist for runway excursions:

- *ICAO Airport Self-Audit Checklist for Runway Excursion Risk Reduction.*

You can apply the basic principles to mitigate other risks. For example, you may choose to develop a checklist aimed at reducing foreign object debris (FOD) events or wildlife incursions.

Level 3 Example — A Data Source for Manufacturers: QA/QC Audits

Level 3 data sources for aviation manufacturers typically encompass the results from quality assurance (QA) audits and quality control (QC) audits within a quality management system. In general, QA audits target the actual manufacturing process, while QC audits attempt to identify and correct errors in a completed product.

Because of the inherent complexity of manufacturing, your company likely already has a quality management system in place. A common framework is ISO 9001–Quality Management Systems. If your company is among smaller manufacturers with limited resources, ISO 9001 certification may be beyond your scope. However, ISO 9001 principles serve as a reference for developing an effective quality management system. The TEM framework also is valuable to develop custom auditing and self-inspection programs with safety management aspects.

Data Collection Triggers

This section describes prompts (or "triggers") for you to select sources and to collect safety data for analysis at Level 3 intensity.

Routine Data Collection

Many organizations collect Level 3 safety data on a recurring and consistent basis. For example, your airline might schedule a certain number of LOSA audits per year, or your ANSP might specify a minimum total time required for NOSS observations. The frequency and quantity of your recurrent data collection activities depend on your organization's types of operations, resources and safety goals.

To define these activities, consider soliciting input on best practices from other organizations and your CAA. We included examples of opportunities and methods of developing information-sharing relationships in our Level 3 Information Sharing section.

When you select groups for your observations and data collection, representative samples from a variety of operation types are essential. For example, your airline — when selecting flights for LOSA audits — ideally would sample flight crews of wide-body aircraft and narrow-body aircraft, day and night flights and short-haul and long-haul flights. You would not want to under-sample a key portion of your operations.

Conversely, over-sampling one portion of your operation, such as the long-haul flights, might overemphasize the impact of some risk factors, such as fatigue, in your organization. Yet, if fatigue is a key risk already only associated with long-haul operations, a predominance of LOSA audits in this area may be appropriate based on the objectives of the study. Selecting samples from diverse groups enables your analyses to identify statistically significant variations between them (for example, risks in short-haul versus long-haul operations).

We also recommend sample groups of a sufficient size for statistical validity, and randomly selecting members of groups (such as pilots, controllers or flights). You can choose from a variety of statistical methods of sampling, such as sample size tables, to ensure appropriately sized groups based on required confidence levels and acceptable margins of error.

To reiterate, random selection of members of the group — whether flights or ATC personnel — yields the most statistically valid analytical results. ICAO Doc 9803, *Line Operations Safety Audit (LOSA)*, suggests the following general rule:

> *Only smaller airlines with limited numbers of fleets would find it reasonable to attempt to audit their entire flight operation. … At a major airline and in large fleets, around 50 randomly selected flight crews will provide statistically valid data. … If less than 25 flight crews are audited, the data collected should be considered as 'case studies' rather than representing the group as a whole.*

Collecting Data on Causes and Contributing Factors

Another data collection trigger might be your organization's need for safety data on significant findings and contributing factors. At Level 2 intensity, you would be collecting data on significant findings such as automated/system-based data sources and employee reporting systems. Level 3 data sources enhance your understanding of causal data and also enable you to collect contributing factors data.

Causal data/significant findings and contributing factors data combine as an effective resource to target many kinds of safety issues and to develop effective risk mitigation strategies. As discussed in our Data Analysis section, the combination supports advanced bow-tie models. In turn, the models help you develop an overall picture of organizational risk and a mature safety management system (SMS).

In GSIP toolkits, Flight Safety Foundation also applies the more specific terms *causal factor* and *contributory factor* as defined by Fort Hill Group in a publication titled *Understanding Human*

Performance: The Air Traffic Analysis and Classification System. Your organization may adapt these or define different terms:

- Causal Factor: An immediate/direct factor that identifies an active error or failure of critical components of equipment or systems, or human error. *Causative: If "A" occurs, then "B" will occur.*
- Contributory Factor: An underlying/root factor that identifies latent errors or failures related to human performance, operating environment, task procedures, training, supervision or policy that influences the presence of causal factors *Probabilistic: If "A" occurs, then the probability of "B" occurring increases.*

Our Level 2 toolkit recommended that you adopt a causal factor taxonomy to organize and standardize your process of collecting causal factor data. To guide your data collection at Level 3 intensity, also consider using a taxonomy that helps you focus on contributory factors data. Examples of such taxonomies include the ICAO Accident/Incident Data Reporting System (ADREP) taxonomy and the Commercial Aviation Safety Team/ICAO Common Taxonomy Team (CICTT) Occurrence, Positive and Human Factors taxonomies. You can adopt one or more of these taxonomies in their entirety.

Alternatively, you can modify, add or delete taxonomy elements to your organization's priorities and needs. The purpose of a taxonomy during data collection (as opposed to during data analysis) is to clearly define elements of interest so that the safety data collection is as useful as possible to your organization. The structure of taxonomies allows for repeatably consistent and standardized data across your organization and permits effective intra-organizational data sharing. For example, having a single, cross-organizational definition of the risk factor *task saturation* enables you to make robust comparisons of instances across a multitude of data sources.

Conducting Targeted Deep Dives

Your need for in-depth study of specific risk areas should be another trigger for your organization to collect risk data using an especially effective technique. As noted earlier, targeted deep dives yield data detailing causal factors and contributory factors. Rather than focusing on a single flight or a single event during a flight, for example, targeted deep dives offer comprehensive ways of studying specific topics (such as fatigue or loss of separation events). The data may come entirely from your organization's internal data sources, or you might combine those sources and external data sources. You also can regularly schedule targeted deep dives or trigger this type of study based on unforeseen operational outcomes. For example, your airline may prefer an annual targeted deep dive into a top risk area, such as fatigue or loss of control–in flight. You could then use the results to inform your Level 3 data analysis strategy and to refine your ICAO safety performance indicators (SPIs). Alternatively, an airline might initiate a targeted deep dive in response to a safety trend, as follows:

> *The airline's automated safety data collection systems indicate a sudden increase in altitude deviations in the descent phase of flight during a newly introduced RNAV [area navigation] arrival procedure. The airline identifies a need for in-depth study of highly detailed data from these events. The need triggers a targeted deep dive, augmenting internal data (from FOQA-FDM-FDAP or voluntary safety reports) with public safety information sources (i.e., reports from a publicly available database of voluntary safety reports) involving this RNAV procedure. Subsequent Level 3 data analysis shows that the recent spike appears limited to one airline and determines that the primary causal factor is flight crews' inadequate approach briefings.*

Before you begin targeted deep dives, here are a few key considerations. First, make a dive plan that recognizes your limitations in using the available data. A commonly reported limitation is that the data set or samples prove to be too small. You may be tempted to draw conclusions from such samples until you realize the insufficient information for statistical reliability.

For example, your targeted deep dive into risks of controlled flight into terrain (CFIT) near airports in mountainous terrain will be limited to a subset of data collected during mountainous airport operations. Depending on your operations, this subset also might be a very small fraction of total flights in a period. As noted, augmenting your company's data with publicly available safety data can help mitigate this limitation. Review the Routine Data Collection subsection of this toolkit, and consider statistical methods that provide suitable error margins and confidence levels.

Instead of having a safety data set too small for a targeted deep dive, your biggest issue may be isolating the useful data sources from too many possibilities. At Level 3 intensity, your organization collects high volumes of data from many sources, complicating choices of which sources are most suitable. For a targeted deep dive on fatigue issues, for example, the dive plan would have to be highly specific in outlining internal data needs and incorporating a high-level assessment of the public source priorities before Level 3 data collection.

Here are some examples of public data sources (note, however, that without conversion/adaptation, they may not adhere to your company's taxonomies):

- Australian Transport Safety Bureau (ATSB) National Aviation Occurrence Database;

- United Kingdom Mandatory Occurrence Reporting;
- FAA Aviation Safety Information Analysis and Sharing (ASIAS) System;
- Transport Canada Civil Aviation Daily Occurrence Reporting System (CADORS); and,
- South African Civil Aviation Authority, Confidential Aviation Hazard Reporting System (CAHRS).

Improved Error Checking and Data Storage

Typically, for aviation risk management at Level 3 intensity, your data storage systems and error checking procedures build upon our Level 2 recommendations. We assume you already have formal quality assurance processes to handle safety data collection and data storage. At Level 3, however, your organization collects far greater quantities of data and new data types. Your data storage and error checking systems must grow and adapt accordingly.

Network links among data sources often will grow in complexity as well as scale. For example, software dashboards (consolidated control panels described in the Data Analysis section of this toolkit) typically display summaries of the latest safety data compiled from many local and remote databases. As your data systems become more robust, comprehensive and interlinked, error checking becomes critically important. The reason is that erroneous or corrupted data — and derived information — from a single source can now flow easily throughout interconnected systems, disrupting essential processes in your SMS.

In risk management at Level 3 intensity, you routinely collect a high volume of safety data but primarily emphasize the quality — that is, you primarily focus on getting the "right data." You'll seldom struggle with having too low a volume of data. Inherently, many data elements that you could collect would offer little or no benefit. Rather than pursuing all available data, collect and store only data elements that, although comprehensive, you value most for quality and usefulness.

Collecting and storing accurate and error-free data also require timely data collection. Some data sources may be available only for a set period of time. For example, someone could overwrite FOQA-FDM-FDAP data if they are not downloaded from the aircraft before a deadline. In this event, the overwritten data usually are irretrievable.

Effective data collection also requires accurately sourced and identified safety data (for example, accurate recording of the data source[s], dates, times and other identifying characteristics). These characteristics and traceability have critical importance in data storage systems that rely on logical relationships between data sets. Often, these characteristics are the only way two or more data sources can be linked and correlated. For example, analyzing weather data and FOQA-FDM-FDAP data may rely solely on matching date and time to generate a relationship (for example, precipitation type at the time of a FOQA-FDM-FDAP recording). Erroneous or missing source data and/or identification data jeopardize the completion and integrity of your analysis. Keeping a master log of the data attributes from all source data sets may also be adviseable.

As your storage evolves, ensure appropriate data-protection mechanisms are in place to instill confidence that confidential data will remain secure, as discussed in the Information Protection section of this toolkit. At Level 3 intensity, your data sources require extra safeguards, such as assigning people to be data gatekeepers. They may work outside your organization (for example, pilot union representatives), and their work may necessitate technical modifications to your data storage systems.

Creating Your Plan for Success

- ☐ Collect observational data for insights into nominal operations and off-nominal operations, such as identifying causal factors and contributory factors. Data sources such as LOSA, NOSS, airport self-inspection programs and quality management systems facilitate this work. Review this toolkit's best practices and how to tailor implementation to your domain (see "Types of Safety Data," p. 5).
- ☐ Establish definitions by adopting or developing a taxonomy of contributory factors (see "Collecting Data on Causes and Contributing Factors," p. 8).
- ☐ Define criteria that trigger data collection and create data collection time intervals that leverage all your SDCPS (see "Data Collection Triggers," p. 8).
- ☐ Ensure that your data storage reliably accepts, stores and maintains information to be accessible as authorized. Confirm that your data-integrity procedures and data error–checking procedures are adequate. These steps mitigate the risks of distributing erroneous data (for example, changing your SPIs based on inaccurate information [see "Improved Error Checking and Data Storage," p. 10]).
- ☐ Test methods and technologies that prevent unauthorized disclosure or uses of safety data. Test results often motivate technical modifications to your data storage, such as improved access controls (see "Improved Error Checking and Data Storage," p. 10).

Data Analysis

Level 3 Data Analysis

Your objective in data analysis — when your safety program functions at Level 3 intensity — is to understand both the separate and combined impacts of risk factors. Understanding leads to identifying and responding to causal factors and contributory factors with data-driven mitigation strategies. At this level of intensity the analysis is really part of a larger study of all available safety data whereas the analysis at level 1 or 2 is with more limited source. This toolkit recommends techniques that expand SDCPS capabilities. Another intent is to generate deep insights into threats, defenses and recovery measures you identify through bow-tie model–based analysis. You also can evolve SPIs so that they reflect the most current needs and safety goals.

Expanding the idea in Table 2, Level 3 data analysis emphasizes:

- Using nominal and off-nominal operations data to identify contributory factors and to support your advanced bow-tie model development;
- Performing data trend analyses and leveraging your results to proactively manage risk;
- Ensuring that statistically sound analysis validates your organization's analyses;
- At Level 3, the analysis may extend to information shared between stakeholders going beyond the internal organization work of Level 2; and,
- Developing a data-driven process to continually assess and refine SPIs.

Trend Analysis and Proactive Risk Management

Proactive risk management is the defining characteristic of Level 3 data analysis. At Level 3 intensity, your organization anticipates how to collect high volumes of valuable risk data from many sources. Reaching beyond reactive methods focused on safety occurrences in your own operations, you collect data from external sources, as detailed in the Data Collection section and Information Sharing section of this toolkit. By prioritizing and organizing these data sources, you link and study data from routine operations to identify trends and manage potential risks.

Trend analysis essentially uses historical data to predict future safety outcomes. This research method takes advantage of your organization's comprehensive data sources. Your analysis then offers the data-driven look into the future, helping you meet risk management goals. Trend analysis also enables quantitative analysis of risk factors and provides actionable data to refine SPIs (see "Safety Performance Indicators," p. 15). The analysis reveals areas requiring additional safety barriers. The future is uncertain, but evidence-backed trend analyses often become your best tool for predicting undesired states and then achieving buy-in to support new initiatives.

Trend Analysis Guide

You'll typically perform trend analysis with data-visualization methods or statistical methods. Visual trend analysis involves plotting data points and examining their dispersion. Examples are in the Level 1 toolkit; they include bar graphs, line graphs and scatter plots. The benefit of visual trend analysis is simplicity.

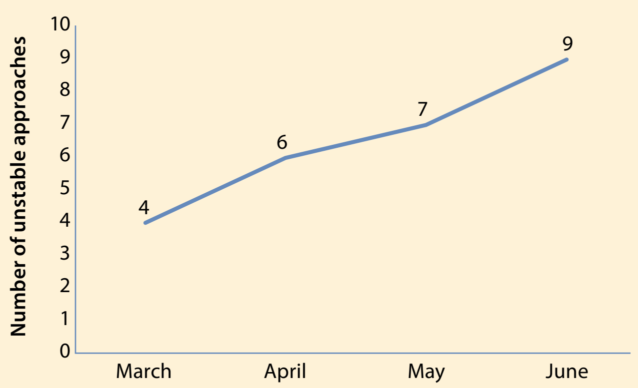
Making inferences based on data visualizations is straightforward. However, this method has limitations. Visual trending shows you the progression of data points dispersed over time but does not incorporate statistical tests of significance or validity. That can mislead your interpretation efforts. For example, see Figure 4 (p. 12), a chart of total unstable approaches per month.

Table 2 — Data Analysis Matrix at Level 3 Intensity

GSIP Toolkit Matrix	Level 1	Level 2	Level 3	Level 4
Data Analysis	Data are analyzed to determine acceptable risks. Safety performance indicators are monitored regularly to display status against objectives.	Data are analyzed to understand all direct hazards and their impact on undesired outcomes. Multiple hazards are examined for their influence on risk.	Data are analyzed to understand all potential direct and indirect hazards and their impact on undesired outcomes.	TBD

TBD = to be determined

Figure 4 — Unstable Approaches Over Four Months



The visualization shows a clear and steady increase in the number of unstable approaches in the period. Even when expressed numerically, the number of unstable approaches increases by approximately 1.67 per month, on average. This could cause concern by signaling an abnormal increase. But consider the Figure 5 chart of unstable approaches — expanded to include three years of data.

Now you see seasonal trends in unstable approaches. They tend to spike in the Northern Hemisphere's summer months and decrease in the winter months. You might be inclined to interpret Figure 4's event-dispersion pattern as reason for a targeted deep dive. But Figure 5 suggests, however, that an increase may not be off-nominal, given the short period in the context of a longer historical trend.

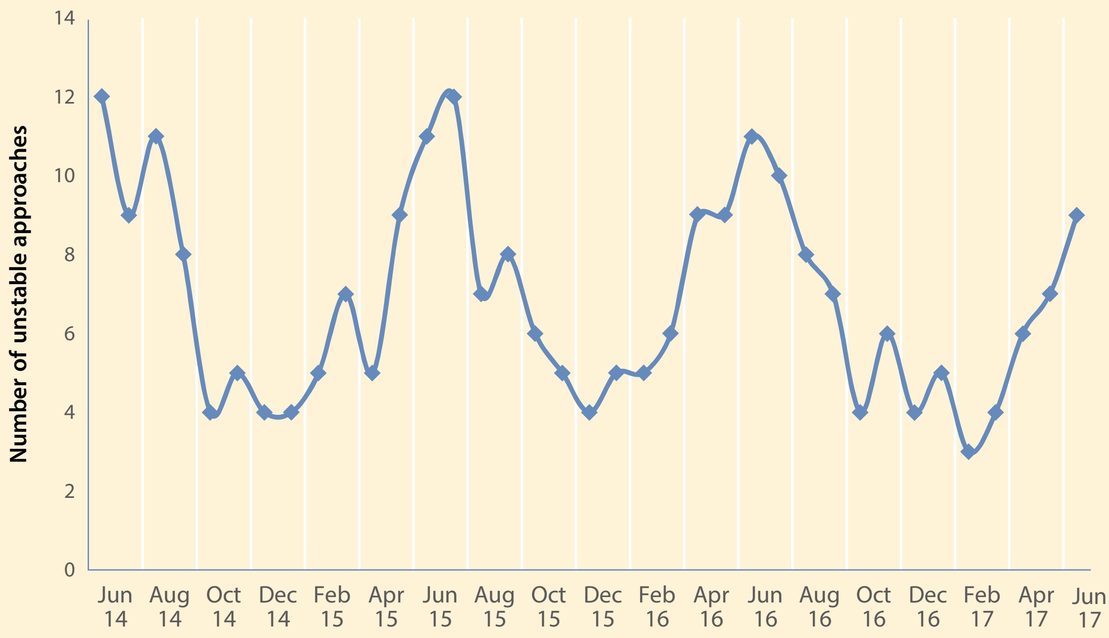
Changes in chart scaling also can slightly or completely change the story you're telling with visual trend analysis. Another significant limitation is the method's tendency to overemphasize *outliers*, which are data points that are far removed from the other values (in other words, much larger or smaller). Outliers on a graph tend to draw attention, even if they would not be considered statistically significant.

Statistical trend analysis overcomes many of the limitations of visual trend analysis. The former applies statistical tests, methods and techniques to objectively characterize your safety data, including mathematical models to represent your data, and methods of combining data to generate inferences.

Statistical trend analysis aims to forecast future performance, to show whether results can be explained by chance, and to compare current data with historical trends. This toolkit does not attempt to discuss or describe an exhaustive list of descriptive and inferential statistics. However, the following are a few examples of specific tests, methods, and techniques that are commonly used by aviation data analysts in trend analysis:

- *Regression analysis* reveals statistical relationships among multiple variables, and you can use the results to predict future values;
- *Variance and standard deviation* describe the dispersion and distribution of your data which can help describe *uncertainty* in probability calculations;

Figure 5 — Unstable Approaches Over Three Years



- *Confidence intervals* show the probability that a specific value lies within a defined range or set of values; and,
- *Hypothesis testing* describes methods for testing the validity of a theory, assumption, proposition or concept that you can express mathematically. We typically test this way to answer a specific question in aviation safety research. Your results often are shown as *P-values* — acceptably accurate measures of the probability that your specific research findings are "true" rather than explained by chance.

Human Performance Assessment Methods

As noted, *human performance* in aviation safety refers to relationships among people and equipment, systems and the environment. Level 3 data sources contain a variety of human performance elements that are not easy to quantify. Assessing human performance, therefore, requires appropriate methods. Aspects of human performance — such as fatigue, complacency and effective crew resource management — often are not well understood by direct "cause-effect" assessment; they demand different approaches. This section of our toolkit details some of these unique aspects and recommends guidance material for analyzing this type of data.

Human performance assessment involves developing inductive arguments, as opposed to deductive arguments. Inductive arguments use observations and patterns as evidence for theories or conclusions. In contrast, deductive arguments are based on factual data and logical conclusions (that is, if A equals B, and B equals C, then A equals C). Although deductive conclusions about human performance are logically true if the premises are true (A truly equals B), you can't expect your inductive conclusions or theories to be perceived or accepted as absolute certainties. Rather, whether others judge your inductive conclusion or theory to be accurate depends on probability that your evidence, arguments and reasoning are valid. So the strength and acceptance of your human performance assessments directly hinge on the accuracy of underlying data and your reasoning during analysis.

In the aviation domain, these examples of inductive and deductive arguments appear in ICAO Circular 240-AN/144, *Investigation of Human Factors in Accidents and Incidents*:

- Deductive argument — "The engine failed because the turbine blade failed, because of metal fatigue which was not detected during inspection, because the inspection procedure was inadequate."
- Inductive argument — "If an investigation revealed that a pilot made an error leading to an accident, and if conditions conducive to fatigue, or a distracting conversation, or evidence of complacency were present, it does not necessarily follow that the error was made because of these conditions. There will inevitably be some degree of speculation involved in arriving at the conclusions, and their viability is only as good as the reasoning process used by the investigator and the weight of evidence available."

ICAO Circular 240-AN/144 also offers guidance on human performance assessment and inductive conclusions. In general, ICAO recommends testing for:

- Existence — What is the probability that a human factors condition exists?
- Influence — What is the probability that the human factors condition influenced or contributed to a sequence of events?
- Validity — How strong is your inductive argument after testing for existence and influence?

The circular's context for the argument examples is the investigation of an off-nominal operation (reported safety event), but you can use data-driven inductive reasoning to assess either nominal operations or off-nominal operations.

ICAO Circular 240-AN/144 also emphasizes the importance of *not* assessing any causal factor or contributing factor in isolation. Most often, you'll find that a combination of elements and an operational context produced the safety outcome. The circular says, "It has been established that occurrences are seldom the result of a single cause. Thus, if the accident prevention aim of an investigation is to be achieved, the human factors analysis must acknowledge that although individual factors may seem insignificant when viewed in isolation, they can produce a sequence of unrelated events that combine to produce an accident."

Non-Interactive Simulation and Data Replay

As noted, your understanding of the operational context is critical in developing a comprehensive human performance assessment. Without context, your assessment could be superficial. In safety management at Level 3 intensity, any single data source — such as a LOSA audit report — appears to

Figure 6 — FDM/FOQA Visualizations

FDM = flight data monitoring; FOQA = flight operational quality assurance

Source: CEFA Aviation

provide a sufficiently complete, detailed picture of a specific flight from the perspective of a third-party observer. You can significantly improve your understanding of details by adding *non-interactive simulation data* and *data replay* to your analysis. Sources of non-interactive simulation and data replay data include, for example:

- ATC recordings (voice and system data);
- ANSP-system event replays;
- Cockpit voice recorder recordings;
- FOQA-FDM-FDAP data visualizations; and,
- Weather data.

For example, FOQA-FDM-FDAP data visualizations provide helpful depictions of an aircraft trajectory. Weather data give you a perspective of the environment during an ANSP's NOSS observation. For example, convective activity data often provide insight into the air traffic controller's decision-making process. Rather than reviewing data sources in isolation, you incorporate these additional layers to conduct accurate human performance assessments compatible with Level 3 intensity of safety management.

Failure Mode and Effects Analysis

Failure mode and effects analysis (FMEA) refers to a method of identifying possible failures in a system or process. Applications are widespread in aviation and other industries. FMEA is a component of the Six Sigma management approach, a methodology based on statistical analysis, rather than guesswork, to improve processes and solve previously unknown problems.

Failure modes are defined as specific ways a system or process might fail. For each identified failure mode, you assess the impact, causes and methods of detection. For example, the failure of an air traffic controller's weather display monitor is a failure mode within the ANSP's display system for the controllers (that is, all monitors and displays at a workstation). FMEA identifies potential causes of this failure, assesses the safety implications, and develops recommended countermeasures. This information directly supports the advanced bow-tie model analysis, as noted in Advanced Bow-Tie Model Applications, the next section of this toolkit.

Your organization also may want to use flight simulator sessions (or other simulators) to test various safety scenarios (that is, to conduct scientific laboratory–type research). Supporting FMEA, simulator sessions can assist you in identifying where failures or breakdowns occur, determining potential impacts, and identifying barriers to prevent them.

For example, you could study checklist-compliance failures. Through simulator testing, you study where these failures occur (for example, in high-workload situations, in low-workload situations, for specific procedure types). You assess whether contributory factors, such as task saturation or complacency, are involved. Then simulator sessions enable you to test proposed defenses and recovery measures for specific circumstances — all within a safe, controlled environment.

You can obtain FMEA guidance and resource materials from Six Sigma-certified consultants.

Advanced Bow-Tie Model Applications

Flight Safety Foundation recommends the basic bow-tie method for any aviation organization's risk management system. At Level 2 intensity, we describe bow-tie models focused on identifying threats, defenses and recovery measures to prevent an undesired state from resulting in undesired outcomes. If you have access to data sources compatible with safety management at Level 3 intensity, however, we recommend advanced bow-tie model applications.

As noted, Level 3 intensity means your organization will collect data from data sources representing nominal operating conditions and off-nominal operating conditions. These data, combined with contributory factors data, are invaluable for deep understanding of the threats, defenses and recovery measures in your bow-tie diagrams. The combination enables you to assess vulnerable areas and develop appropriately targeted mitigations.

Compared with safety management at Level 2 intensity, Level 3 methods assume you have high volumes of data suitable for advanced bow-tie models. For a given undesired state of interest, these Level 3 data sources will provide you with the most comprehensive insights.

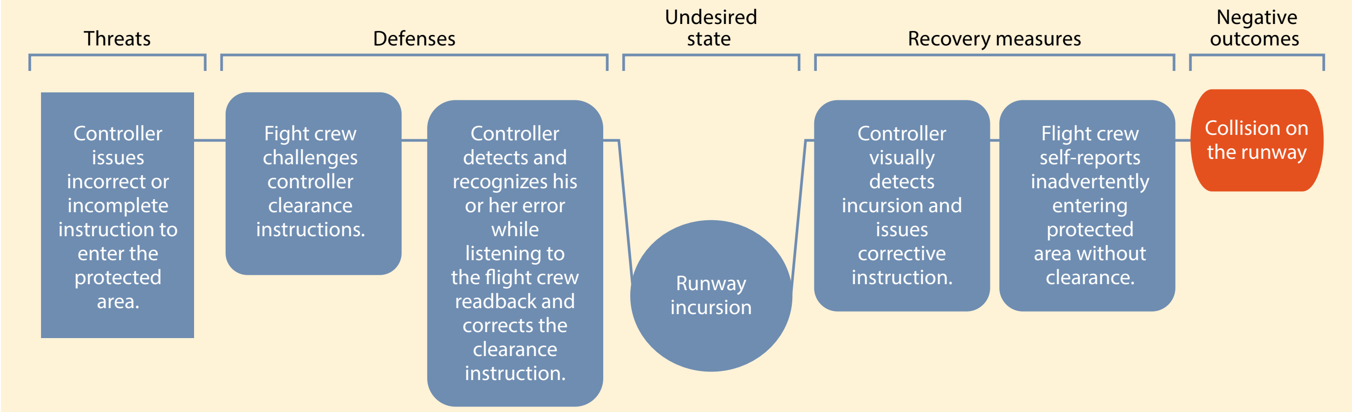
Such analytical granularity (that is, deep access to fine details), while immensely valuable, can be particularly challenging. A key reason is that your organization probably won't be able to conduct an exhaustive analysis of every threat, defense and recovery measure associated with every potential undesired state.

Consequently, you must prioritize and limit analysis according to goals in your SMS. Refining SPI targets, discussed in a later section of this toolkit, can provide such a data-driven perspective of your organization's top risk areas.

Level 3 Example — Advanced Bow-Tie Model of a Runway Incursion

Figure 7 (p. 15) shows a simplified version of advanced bow-tie model analysis applied to a single threat. The figure offers a hypothetical sequence of events, focusing on a specific component of one bow-tie model. (For comparison, Figure 4 in our Level 2 Data Analysis Toolkit used the same runway incursion bow-tie model.) In order to conduct a comprehensive analysis

Figure 7 — Advanced Bow-Tie Model Applied to Runway Safety



Source: Adapted from the U.K. Civil Aviation Authority's Bowtie Library

at this level, data collection from multiple stakeholders and/or multiple data sources is common.

For this bow-tie model, the single causal factor, selected as a threat to analyze, was:

> *"Controller issues incorrect or incomplete instruction to enter the protected area"*

Two defenses tied to this singular threat were identified to prevent the undesired state:

> *"Flight crew challenges controller clearance or instruction."*
>
> *"Controller detects and recognizes his or her error while listening to the flight crew readback and corrects the clearance/instruction."*

To illustrate the types of advanced analysis you can now perform at Level 3, consider the following sequence of events in the scenario.

Level 3 data sources and the types of analysis shown in Figure 8 (p. 16) and Figure 9 (p. 16) are not limited to assessing threats and defenses (shown on the left side of the bow-tie diagram). Your analysis of Level 3 data sources also can reveal contributory factors associated with the recovery measures on the right side of the bow-tie diagram. Recall, for example, this recovery measure from Figure 7:

> *"Flight crew self-reports inadvertently entering protected area without clearance."*

Level 3 data sources, such as LOSA data, were particularly useful in assessing the contributory factors that could influence this recovery measure. If your data, whether from LOSA or other sources, were to indicate that this recovery measure frequently has been ineffective, you might want to perform further analysis of contributory factors.

Note that this recovery measure requires the flight crew to admit their mistake. Your examination of human factors — such as company culture, psychological factors and flight crew interpersonal dynamics — may yield insights about other recovery measures. Our contributory factors checklist, detailed in the next section of this toolkit, can guide this examination.

More examples of bow-tie models are available from sources such as the U.K. Civil Aviation Authority's Bowtie Document Library and CGE Risk Management Solutions' Knowledge Base. These models suggest an initial framework for analysis, assuming you will add specific threats, defenses and recovery measures for your operations.

Contributory Factors Checklist

Our Level 2 toolkit contains a causal factors checklist. This Level 3 toolkit adds a contributory factors checklist (Table 3, p. 17). The checklist helps you contextualize and focus a set of questions about contributory factors.

As in our causal factors checklist, the questions about contributory factors are organized in four categories: people/operator; methods; tools and techniques; and operations environment. We highly recommended that you customize the checklist to fit your needs.

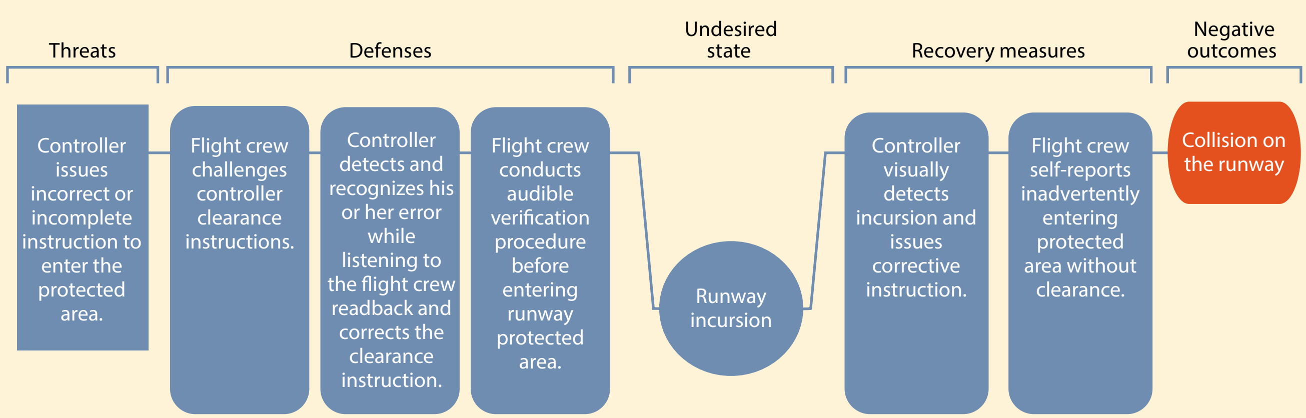
Before you customize the checklist, review the contributory factors taxonomies in the Data Sources section of this toolkit. Then, ensure your checklist adheres to definitions and terminology used by your data sources. For example, if you define the term *workload management* one way in your LOSA data and differently in your checklist, your analyses will be inconsistent and potentially misleading.

Continued on p. 18

Figure 8 — Advanced Bow-Tie Model Applied to Runway Safety

LOSA = line operations safety audit; SOP = standard operating procedure

Figure 9 — Advanced Bow-Tie Model Applied to Runway Safety



Source: Adapted from the U.K. Civil Aviation Authority's Bowtie Library

Table 3 — Contributory Factors Checklist

Identification of Potential Causal Factors	Applicability		Comments Describing the Context of a Causal Factor
	Yes	No	
People/Operator			
Did the operator's physical characteristics (such as height, hearing) contribute to the threat or undesired state?			
Did the operator's physiological factors (such as fatigue, nutrition, impairment by a controlled substance) contribute to the threat or undesired state?			
Did the operator's psychological factors (such as information processing, workload, knowledge) contribute to the threat or undesired state?			
Did psychosocial factors (such as family pressures, lifestyle changes) contribute to the threat or undesired state?			
Methods			
Did rules or regulatory factors (such as surveillance, specific regulations) contribute to the threat or undesired state?			
Did personnel factors (such as crew pairing, policies) contribute to the threat or undesired state?			
Did training (such as frequency, effectiveness) contribute to the threat or undesired state?			
Tools and Equipment			
Did the equipment design (such as instrument design, visibility restrictions) contribute to the threat or undesired state?			
Did automation (such as utilization, task saturation, monitoring) contribute to the threat or undesired state?			
Did written information (such as manuals, charts, checklists) contribute to the threat or undesired state?			
Operations Environment			
Did external factors (such as weather, turbulence, time of day) contribute to the threat or undesired state?			
Did internal factors (such as temperature, fumes, noise) contribute to the threat or undesired state?			
Did infrastructure (such as airport design, airport equipment) contribute to the threat or undesired state?			

Table 4 — SPI Refinement by an ANSP: Loss of Separation

Domain	Risk Category	Objective	Performance Metric Target or SPT	Action Plan
ANSP	NMAC	Reduce the number of loss of separation events.	Reduce the number of loss of separation events to 1 per 10,000 operations.	Promote the effectiveness of standard operating procedures and effective workload management in reducing the risk of loss of separation events.

ANSP = air navigation service provider; NMAC = near-midair collision; SPI = safety performance indicator; SPT = safety performance target

ICAO Circular 240-AN/144, Appendix 1, contains additional examples and resources for your customized contributory factors checklist.

Safety Performance Indicators

ICAO-recommended SPIs define and measure your organization's desired safety outcomes and generate action plans to achieve them. At Level 2 intensity, you develop SPIs by risk categories. A primary objective of safety management at Level 3 intensity is to develop a process for continual SPI refinement by knowing the structure and probability of potential factors leading to undesired states.

Level 3 data analyses help you apply detailed risk data and insights to precisely adjust SPI metrics and targets. As noted, contributory factors data and advanced bow-tie model analyses help you draft effective action plans.

We recommend establishing a standard, recurrent interval for performing SPI refinement. You might choose a quarterly or semi-annual basis with awareness of cross-organizational impact of your SPI.

Table 4 shows a hypothetical ANSP's SPI refinement process, which notes that:

- The ANSP has a recurring SPI refinement activity every six months involving representatives and managers from the relevant, internal lines of business.
- The ANSP reviews all SPIs (in this case, for loss of separation).

Figure 10 — Dashboard for Safety Management at Level 3 Intensity

ATC = air traffic control; NASA = U.S. National Aeronautics and Space Administration

Figure 11 — Dashboard With a User-Filtered Display of Data

ATC = air traffic control; NASA = U.S. National Aeronautics and Space Administration

- Loss of separation performance data show these events decreased to 0.8 per 10,000 operations in the preceding six months; this followed targeted efforts to increase awareness of the effectiveness of standard operating procedures and workload management strategies.
- Level 3 data analysis activities show that loss of separation events could be further reduced through improved use of automated decision-support tools, such as medium-term conflict detection (MTCD).
- The ANSP adjusts the SPI performance metric to 0.06 per 10,000 operations and adjusts the action plan to indicate the expected use of automated tools.
- The ANSP reassesses the applicability and suitability of the SPI at the next SPI-refinement activity in six months.

Best Practices for Representing and Summarizing Data

As data volume and complexity increase, so do the challenges of data sharing and data visualization. This section describes techniques for presenting results of Level 3 data analysis.

A software dashboard display (an interactive visualization, as noted) presents multiple risk data sources at a glance, with real-time summaries of the latest analytical results, and a user-friendly interface. Web-based environments — such as your company's intranet — typically host safety-management dashboards as in Figure 10 (p. 18).

This dashboard (Figure 11) summarizes five years of human factors data from the U.S. National Aeronautics and Space Administration's Aviation Safety Reporting System (ASRS), broken down by categories. Users click on parameters that filter and customize the display of data and analyses. For example, a user interested in safety events during the landing phase of flight in nighttime conditions could select this data display (highlighting of "night" and "landing" indicates the data are filtered).

Dashboards combine multiple data sources into comprehensive and detailed summaries of specific risk areas. The interface enables any user to generate customized displays and reports.

Dashboard technology increases company-wide awareness of your SPIs. Dashboards ingest and present data in a nearly live manner. They give employees a single-source view of how your organization is performing in many risk areas.

Similarly, dashboards are particularly useful for leaders and managers who need a quick, up-to-date summary of risk management performance. To try an interactive version of this dashboard, visit <analytics.forthillgroup.com>.

Dashboards are not the only solution, however. Alternative formats include written case studies; safety newsletters; and data charts, tables and comprehensive computer-generated visualizations of analytical results.

Consider the following tips to present your work to others:

- Ensure that you accurately present deductive and inductive conclusions. You might easily confirm that your fleet experienced four warnings from enhanced ground-proximity warning systems (EGPWS) in the past three months. This indisputable fact comes from FOQA-FDM-FDAP quantitative data. When presenting human performance assessments, however, take care to accurately characterize the limited certainty of inductive conclusions. For example, saying "Analysis activities indicate an improvement in the area of workload management during the approach phase of flight" would be easier to prove than saying "Workload management issues contributed to 15 fewer events."
- When you summarize data, provide all definitions, metrics and parameters. For example, in a presentation of CFIT events, include your definition of CFIT and your data metrics (for example, threshold for counting proximity to terrain, closure rates) used to track such events.
- Clearly identify any limitations in your data sets when presenting summaries or other representations of the work. For example, if source data can't be made available or if the number of data samples for a subset of events had to be limited, disclose those facts or caveats alongside your analysis. Also, as noted, include any measures that reinforce the statistical significance of your summaries or representations (for example, confidence intervals and P-values).

Create Your Plan for Success

- ☐ Proactively use multi-source trend analysis of routine operations and other Level 3 techniques to continually identify risk areas and prioritize data analysis activities (see "Trend Analysis and Proactive Risk Management," p. 11).
- ☐ Develop and adopt a contributory factors checklist to analyze Level 3 data sources. The tool will provide a framework for your line of inquiry, identifying and isolating contributory factors in safety event data (see "Contributory Factor Checklist," p. 15).
- ☐ Develop a process to continually refine your SPIs, including performance metrics and action plans, based on the results of your organization's data analysis activities (see "Safety Performance Indicators," p. 18).
- ☐ Identify your organization's top-priority undesired states. Leverage Level 3 data sources and evaluate them through advanced bow-tie model–based analyses. Advanced models show the contributory factors on the threats and defenses side and on the recovery measures side of the bow-tie diagram. When you select an undesired state and determine your depth of analysis, consider both in relation to resources and safety goals (see "Advanced Bow-Tie Model Applications," p. 14).

Information Sharing

Level 3 Information Sharing

By distributing your de-identified aviation safety data across the aviation industry, you fulfill a key aspect of safety management at Level 3 intensity. In Level 2, we focused on broadening the sharing throughout all lines of business in the operations in a single organization. In Level 3, objectives include expanding industry prospects for eventual global exchange of aviation safety information, especially information about key risks and mitigations. This toolkit recommends steps for confidential and secure information sharing with external stakeholders (that is, stakeholders outside your organization) and for internally sharing your contributory factors data. We also recommend ways to achieve a mature safety partnership with your CAA.

Table 5 shows the GSIP information sharing intensity levels.

The idea in Table 5's Level 3 information sharing is that, as a stakeholder, you will:

- Update internal safety program communications to advocate sharing internal safety data with diverse external parties.
- Identify the external data needs of your cross-organizational safety teams.
- Develop mutually beneficial relationships with other organizations, including other industry stakeholders (airline-ANSP and airport-airline partnerships) and explore opportunities for data sharing and information gathering.
- Continue to develop a strong safety partnership with your CAA, including a method to receive regular, nonpunitive feedback in response to the safety information you share.
- Communicate internally about the role of Level 3 safety data collection, analysis, sharing and protection in your SMS, including the contributory factors you find in safety events during routine operations.

Enhanced Safety Program Communications

As your organization prepares to engage in Level 3 information sharing, assess your internal communications strategy, and be ready to address the implications of expanded external access to your safety data in de-identified, aggregated form. Your objectives are to:

- Build on the communications framework we introduced for safety programs at Level 2 intensity and expand to other industry stakeholders (see the "Information Sharing" section of the Level 2 toolkit which focuses on internal sharing).
- Engage internal stakeholders in an ongoing, constructive dialogue about the importance of safety information sharing.
- Refine strategic, internal communications management for your safety program to enable types of information sharing covered in this toolkit.

Our Level 2 Information Sharing toolkit recommended designating stakeholders from each line of business, defining methods of communicating with each stakeholder and addressing information-sensitivity issues. As you prepare to externally share safety data, consider the following questions:

- "Are safety program stakeholders in each of our lines of business aware of our intention to explore external data sharing relationships?"

Table 5 — Matrix for Information Sharing at Level 3 Intensity

GSIP Toolkit Matrix	Level 1	Level 2	Level 3	Level 4
Information Sharing	Information sharing of performance results is performed within an organization (for example, within one organization).	Information sharing of performance and key areas of linked performance is comprehensive within an organization.	Information sharing is across the industry for key risks and mitigations. Generally, this is through presenting detailed independent investigative work in the data (for example, airline to airline, ANSP to airline).	TBD

ANSP = air navigation service provider; TBD = to be determined

- “Have our safety program stakeholders had an opportunity to discuss, comment and provide input on our safety data sharing intentions?”
- “What types of external safety data or information would be most useful to our safety program stakeholders?” For example, you might suggest wildlife data tracked by airports or airprox data from ANSPs.
- “How will the safety philosophies of external organizations influence our safety information sharing?” For example, if other organizations will not commit to using our information for safety purposes alone — or if they do not have nonpunitive policies — how will this affect the type and/or quantity of information we share?

After this initial assessment, investigate how your internal safety data could be communicated to external organizations. This involves questions of formatting (in other words, written or verbal) as well as the amount (full data sets or random samples) and the type of information (for example, de-identified FOQA-FDM-FDAP data). For example, you may want to share:

- Internal safety bulletins and briefings;
- SPI information;
- De-identified raw data sets;
- Case studies or reports about deep dive analyses;
- Analyses of causal factors and contributory factors; and,
- Safety presentations (that is, in-person presentations by representatives of your organization to external parties).

Safety case studies and reports from deep dive analyses can be particularly useful to external organizations. These studies and reports typically are highly detailed, reflecting in-depth research and multiple data sources. The underlying work could be cost-prohibitive to many external organizations. Small organizations without resources and access to data simply may not be able to conduct these types of safety analyses.

During your assessment of safety information sharing, consider information sensitivity. In our Level 2 toolkit, we noted the potential need for non-disclosure agreements and de-identified data. When your safety program has the characteristics of Level 3 intensity, sensitivity should be addressed again to ensure that proposed protections would be adequate.

Consider, too, how you communicate about information protection protocols to all members of your organization. Given the sensitivity of safety information — particularly voluntarily submitted safety information —all your employees must be aware of the protections and their crucial roles.

Value of External Data Sharing

External data sharing can dramatically boost the possibilities for comparing your internal data sources, making possible valuable context and insights. For example, for an airline analyzing runway safety events at one airport, comparing your data with those of the airport’s other aircraft operators can isolate whether a problem might be infrastructure-related (and therefore affecting operators in the same manner) or if it is largely confined to your airline. As discussed in the Data Analysis section of this toolkit, in many instances, this safety data that your organization otherwise would not have can be of great value.

Aviation professionals sometimes presume incorrectly that the term *data sharing* only refers to aviation organizations exchanging their raw data sets (for example, an airline’s spreadsheet containing complete event data on all bird strikes at an airport — including identification of aircraft, flight numbers, crewmembers, companies, etc.). Such safety data may be shared on an exceptional voluntary basis in non-public settings, typically under non-disclosure agreements (such as semi-annual Aviation Safety InfoShare meetings of invited government and industry representatives in the United States). The most prevalent practice, however, is sharing qualitative, de-identified and aggregated information, such as lessons learned and best practices. Aviation industry experience in many countries and regions shows that this type of derivative safety information is far more valuable to most peer organizations, CAAs and other stakeholders than raw identifiable data.

The most widely accepted methods of communication enable you to contribute your experiences, methodologies and strategies to addressing key risk areas for everyone’s benefit. For example, your airline might share a strategy used to reduce instances of ramp personnel improperly entering aircraft engine safety zones. Meetings, presentations and question-and-answer sessions are ideal venues for this type of safety information sharing.

Identifying Data Needs

At Level 3 intensity, as noted, we presume your organization collects a high volume of safety data. These data originate in different areas of your organization, including automated data collection systems, voluntary safety reporting systems and audit reports. The Data Sources section of this toolkit emphasizes the importance of collecting, analyzing and sharing the right data — only the elements useful in accomplishing your risk management goals. That strategy applies equally to selecting external safety data and information sources.

To set these priorities, work with your cross-organizational safety teams, safety management system stakeholders, and data analysts to obtain suggestions and feedback. The GSIP

Level 2 toolkit covered the role of cross-organizational safety teams and their ability to recognize gaps in data and provide insight into what you need. As they become involved in external information sharing, they also will be prepared to communicate internally about that process and to secure the full support and cooperation of your employees.

In summary, we recommend that you:

- Solicit feedback about gaps in safety data from your safety program stakeholders, cross-organizational safety teams and data analysts.
- Collaboratively assess these gaps and identify top priorities — data sources or information that would have the greatest potential value for your analysis.
- Identify organizations that have specific safety data or information you need.
- Develop, or improve, your information-exchange relationship with the source organizations (see the "Developing External Partnerships" section of this toolkit).

Your needs also may require combining contributions from multiple external data sources with your internal data. For example, externally sourced, historical safety data about airport surface conditions (such as runway braking action reports) — along with your FOQA-FDM-FDAP data analysis (for example, parameters such as braking effort and reverse thrust settings) and your ANSP's voice and data recordings (such as air traffic controller–issued braking action advisories) — could yield a new or more thorough understanding of your safety events and risks.

Reaching an internal consensus about top priority data needs can be challenging. For example, your maintenance department likely has different concerns than the flight operations department. Consider directly linking data needs to your SPIs. Ask stakeholders how additional data in a particular area will advance efforts in those risk areas. Again, leverage the broad perspective and insights of your cross-organizational safety teams.

Benefits of Cross-Domain Information Sharing

You'll find that information sharing leads to mutually beneficial relationships with other aviation organizations. For example, collaboration of an airline and an ANSP often leads to operational efficiencies and improved risk mitigations. If you have questions about why an ATC procedure exists or what actions could reduce delays, you're likely to get answers in such a forum. Likewise, the ANSP likely will get answers to comparable questions.

Developing External Partnerships

Information sharing at Level 3 intensity requires partnerships that:

- Leverage existing relationships to begin discussions with prospective partners, including those from segments of the aviation industry that you had not considered.
- Identify points of contact to help internal safety program stakeholders, such as cross-organizational safety team members, to engage with external partners;
- Create a forum to conduct initial discussions of goals, safety topics and information sharing arrangements; and,
- Record action items and assign responsibilities for task completion to the partners.

Ideally, developing partnerships will lead to some in which safety information sharing plays an integral role. Each party should maximize the value of what it offers. This requires a concerted effort over time to build trust and collaborative, good faith relationships.

Also consider using third-party services as an intermediary and facilitator of information sharing. Instead of forming partnerships, organizations also might simply provide information to a trusted third party that manages secure data distribution and information sharing for multiple member organizations. Some third-party services in these arrangements conduct advanced data analyses that individual companies may not have the resources to conduct. Such activities adhere to agreements that govern how the third-party service uses and distributes your information.

Sharing Contributory Factors

Your emphasis on contributory factors also drives internal information sharing at Level 3 intensity. Sharing this type of data should extend across all relevant lines of business. We assume that when your safety management system functioned at Level 2 intensity, you issued regular updates and communicated with employees about safety event data collection and results.

Now, contributory factors data create a comprehensive risk picture. Distributing what you've learned throughout your organization will increase each employee's awareness of his or her role in your risk management strategy and new safety initiatives.

We also recommend sharing diagrams from your advanced bow-tie model-based analyses. Many aviation organizations find that employees quickly and readily understand this graphical depiction of threats, defenses, undesired states and recovery measures. Nevertheless, as your bow-tie models become more complex, continuing education about bow-tie model architecture may be in order. Also consider adding introductory coursework to employee safety training programs to raise everyone's familiarity and comfort level with bow-tie diagrams.

Before internally distributing contributory factors data, consider the implications for your just culture and how to manage employees' perceptions of the purpose. Unlike quantitative Level 2 data, introducing qualitative data about human performance at Level 3 intensity presents new communication challenges. Without an introduction and context, some employees could have concerns about your rationale in distributing off-nominal data with human factors identified and attributed to the behavior of individuals.

We advise adhering to your information protection measures (see our Information Protection toolkits) and ensuring that you de-identify contributory factors data and human performance data as noted. Also emphasize how everyone benefits from collecting, analyzing and distributing contributory factors data.

For example, point out how Level 3 data analyses helped them meet SPI goals and continually improve risk metrics. Cite advancements such as their access to real-time dashboards (see "Level 3 Data Analysis" in this toolkit) and improved briefings and newsletters. Increasing employees' access to this information and the visibility of SDCPS at Level 3 intensity means that:

- You reinforce your organization's just culture;
- You emphasize the specific factors impacting your organization's SPIs and risk metrics; and,
- Employees proactively obtain information, accept best practices and learn from the experiences of others.

As noted, contributory factors awareness positively affects employee training. Information on actual threats, defenses and undesired states — credible data-driven analyses — provide fresh context for course material. For example, consider how you now can create flight simulator scenarios for training flight crew CFIT awareness. You can apply contributory factors data to the training discussion to cover realistic scenarios (as assessed by Level 3 data analysis) most likely to trigger warnings from a terrain awareness and warning system. Contrasted with only generic discussions of basic CFIT risk areas and hypothetical CFIT scenarios, contributory factors data will expand your training department's capabilities.

Enhancing the Safety Partnership With Your CAA

To function at Level 3 intensity, we emphasize improving your safety partnership with the CAA. As it matures, this relationship offers invaluable opportunities for safety improvements.

At Level 3, your CAA's inspectors or other representatives should provide regular, nonpunitive feedback about safety issues that came to their attention while attending your safety meetings and through other interactions with your personnel. This feedback can take many forms such as:

- In person (during meetings and discussions);
- Formal written feedback (in structured reports, letters or official guidance);
- Informal written feedback (such as brief comments about safety data); and,
- Industry forums and large group discussions (in a manner that does not publicly identify any single organization or person.)

The CAA's feedback could be either direct or indirect. If your airline's personnel discussed safety issues involving your engine-maintenance procedures for a specific engine type, the regulator's representative who attended might provide a response directly to you (for example, by meeting and discussing company procedures). Alternatively, the representative — realizing that official feedback applies to other airlines — might publish an official guidance document, such as a safety bulletin.

As your partnership evolves, the just culture framework also should mature. Developing just culture can involve a "bottom-up" approach or a "top-down" approach. In the bottom-up approach, you begin introducing principles that will influence the behavior of frontline employees. In the top-down approach, application of the principles originates from high-level positions of authority and influence, such as company executives or regulatory officials.

Ideally, if the top-down approach is taken, your CAA will champion principles of just culture, encourage information sharing and cultivate collaborative relationships. Specifically, the CAA's constructive, nonpunitive feedback will build trust and instill confidence in your employees. Trust leads to candid discussions and deeper information sharing. In return, the CAA gains key information needed to achieve high-level safety objectives.

In these partnerships, you must consider the capabilities, resources and "bandwidth" (in other words, the capacity to accept new obligations or complete multiple tasks) of each partner. Be realistic about bandwidth needed for data collection, analyses and feedback. For example, as a large airline, you might prepare a formal, in-depth written report about a targeted deep dive into your safety data, and then send this report to the regulator. As a relatively small aircraft operator, you might not have data sources, human resources or bandwidth to prepare such a report. Resource constraints may affect the CAA, too.

Resource constraints may affect the CAA, too. In summary, the just culture intentions and "good faith" feedback efforts by the regulator and the safety information you disclose to the regulator have great importance in the success of the partnership. Both must show proactive, dedicated engagement.

These partnerships provide many opportunities to discuss the CAA's top safety priorities, challenges and goals. Beyond the publicly announced safety objectives, your regulator can discuss the specific details of risk management agendas that affect you.

The regulator also benefits from safety information received through partnership with your organization — especially your best practices and your actions that target key risk areas. This information supports official guidance material and recommendations to other operators.

The CAA also gains constructive feedback about its regulatory oversight from partners when working relationships and trust exist. The authority may ask questions such as: Are our current aviation regulations conducive to achieving your organization's safety goals? Are there changes that we could make to regulations that would be beneficial in terms of operational risk? What actions could we take to assist you in meeting regional and national safety goals?

In summary, Flight Safety Foundation encourages safety partnership with CAAs for optimal collaboration and proactive risk reduction. While, in many cases, aviation organizations already have acceptable risk mitigations in place for their own operations, CAAs see many more opportunities to resolve the relatively intractable issues. Both parties bring to the table a wealth of knowledge and experience in different risk areas. By cooperating and working together, partners can leverage and parlay their respective experience and analytical strengths into significant safety advances.

Level 3 intensity assumes that regulatory safety partnerships will take a variety of forms to suit diverse cultures and regulatory contexts. If the CAA oversees a few aviation organizations, the partnerships can be relatively simple. Safety information sharing practices, in that case, can be specifically tailored to each partnership.

If the CAA oversees a relatively large number of highly advanced/complex aviation organizations, then some partnerships must be more complex. Figure 3 shows many aviation organizations sending their aggregate, de-identified safety data directly to a third-party intermediary. The third-party then consolidates the information for delivery to the CAA.

In this scenario, the regulator assesses the consolidated data and responds with direct and indirect feedback to the same aviation organizations. This structure suits situations in which the CAA may not have sufficient resources or bandwidth or desire to perform the work of the third party or interact with every aviation organization under its oversight.

Instead, the third-party intermediary's work greatly reduces the overall official effort required for successful safety data collection, data analysis, information sharing and information protection. This requires a comprehensive agreement, signed by all parties, that governs information security and data sharing.

Creating Your Plan for Success

The following checklist items offer a starting point for information sharing partnerships:

- ☐ Create a communications strategy — before externally sharing your organization's safety information — by engaging your internal stakeholders. The strategy should address all types of data your organization will share and measures taken to safeguard sensitive information (see "Enhanced Safety Program Communications," p. 21).

- ☐ Identify and prioritize your organization's needs for external safety data sources. Leverage your safety program stakeholders and cross-organizational safety teams to identify data needed to achieve the top safety goals (see "Identifying Data Needs," p. 22).

- ☐ Develop information sharing partnerships with other organizations. Use opportunities to share information known to be valuable to their risk management efforts (see "Developing External Partnerships," p. 23).

- ☐ Develop mechanisms to share Level 3 safety data, including contributory factor data, within your organization to promote employee awareness of your organization's safety goals and their role in achieving success (see "Sharing Contributory Factors," p. 23).

- ☐ Enhance the safety partnership you've already established with your CAA. Explore opportunities for further collaboration, share information and encourage routine two-way feedback (see "Enhancing the Safety Partnership With Your CAA," p. 24).

Information Protection

In this toolkit, the term *safety information protection* (SIP) at *GSIP Level 3 intensity* describes strategies and methods to formalize and improve protection at the highest levels. That means working within and among countries, regions and aviation organizations around the world.

In Level 2, the focus was on policies and practices that are protected by advance arrangements and protections on mandatory reporting. In Level 3, we build on the advance arrangements that can extend between countries and recommend training and education programs on SIP that promote enhanced just culture environments. As of late 2017, few governments and organizations had implemented all of these methods despite evidence that they are rapidly moving toward global acceptance.

We're confident, however, that innovations in this toolkit — while improving information sharing and SIP — will foster acceptance of just culture principles in commercial air transport and other aviation industry segments. A major challenge is gaining participation by multiple parties in national CAAs, judicial systems and aviation organizations. To succeed as aviation stakeholders, we must commit to enhancing SIP policies and safety enforcement philosophies, and recognizing the critical importance of SIP and just culture to future aviation risk mitigation.

Please note that the "Information Protection" section within each Revision 2 GSIP toolkit — the current toolkits describing Level 1, Level 2 and Level 3 intensity — does *not* imply that your SIP work will follow a linear progression. SIP is unlike other toolkit sections in that respect (in other sections, higher intensity refers to advances in technical complexity and scope).

Recommendations about SIP and just culture also focus on legal concerns about punitive consequences for employees who submit safety reports and how to reassure aviation professionals about these risks. SIP protects individuals and organizations through international and national laws, especially in the context of expanded safety information sharing.

Regional and Global SIP

Our main concept in this subsection is reaching agreements. When sharing safety data and safety information across borders, aviation stakeholders should agree, at the regional and global levels, to expand SIP and strengthen the existing laws, regulations and policies at the state and organization levels.

The most innovative arrangements bring together CAAs, safety investigators, prosecutors' offices, labor unions and aviation industry organizations. The arrangements typically incorporate various SIP policies and philosophies of the participating authorities and other stakeholders that embrace the importance of SIP and just culture.

Examples for Different Levels of Stakeholders

We've already seen a number of countries and aviation organizations sign cross-border memorandums of understanding (MOUs) and other advance arrangements. These agreements often involve CAAs, safety investigators and the state prosecutors' office. They are designed to ensure the protection of safety data and safety information.

In 2011, for example, the French Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA) signed the *Memorandum of Agreement* with the U.S. National Transportation Safety Board (NTSB). The agreement established formal cooperation between BEA and NTSB in accident investigations, including the treatment of accident information under the confidentiality rules of the agency that is providing the information.

Table 6 — Information Protection Level 3 Intensity Matrix

GSIP Toolkit Matrix	Level 1	Level 2	Level 3	Level 4
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.	Protection is formalized at the highest level between countries through memorandums of understanding or similar agreements.	TBD

TBD = to be determined

The agreement also emphasizes the need for confidentiality of sensitive safety information, such as data from cockpit voice recorders and from cockpit image recorders, including readouts, examination and analysis of the data.

Broad industry collaborations under multi-party agreements also have succeeded, including among pilot unions, airlines and CAAs. We see successes demonstrated, for example, by the FAA's ASIAS program and other safety data sharing programs involving The MITRE Corporation. Such multi-party agreements strengthen existing efforts to protect safety data and safety information.

Promoting a Global Just Culture

Our main concept in this subsection is instilling just culture into aviation operations. Developing a strong risk-management environment today requires a deep understanding of just culture principles. Merely adopting a vague concept of just culture will not suffice. You'll find the necessary principles in statements of just culture philosophy and various joint declaration–type documents created by aviation industry stakeholders, including CAAs.

Enforcement Philosophies in Safety Regulation

The FAA Compliance Philosophy, a policy document adopted in 2015, clarifies how the agency applies just culture principles in responding to cases of regulatory violations involving "simple mistakes, lack of understanding, or diminished skills" as the contributing factors.

To address these contributing factors, the FAA encourages aviation safety inspectors and other officials to apply corrective measures through root-cause analysis, training and education. Continued noncompliance or failure to adopt the corrective measures may result in enforcement action.

Another example is the Australian Civil Aviation Safety Authority's (CASA's) Regulatory Philosophy, also adopted in 2015, which comprises 10 enforcement principles. The principles include: embracing the just culture approach to safety oversight; taking enforcement actions that are appropriate to, and commensurate with, the circumstances; exercising fairness and discretion; avoiding punitive measures; focusing on training and education; and identifying and addressing flaws in regulations and human errors in compliance.

Regulatory enforcement philosophies provide CAAs and their personnel with a framework for guidance and common understanding of the agency's approach to cases of noncompliance with safety standards. Rather than automatically choosing punitive enforcement actions, the agency adopts a formal policy preference for corrective approaches that are designed to prevent further violation by individuals or organizations. They also effectively address cases of violations involving factors such as flawed standard operating procedures, as noted, or inadequate training.

Your philosophy also helps managers and frontline employees understand and anticipate the CAA's and the accident investigation authority's just culture approach to risk mitigation, threats, errors and procedural flaws.

Your clear statement of philosophy helps to establish trust between the CAA and the industry, and encourages all aviation stakeholders to report safety occurrences and admit mistakes. These practices allow everyone in the aviation community to learn from mistakes, implement risk mitigations and take corrective actions.

International Declarations

The 2015 *European Corporate Just Culture Declaration* recognizes that a safe aviation system requires continuous exchange of safety information in addition to investigation and mitigation of aviation risks. Signers of the declaration included the European commissioner for transport, the Civil Air Navigation Services Organisation, Airports Council International–Europe and the International Federation of Air Traffic Controllers' Associations.

The declaration's key component is its recommendation that aviation stakeholders develop a just culture environment by adopting and implementing European Union (EU) SIP rules. The signers agreed to apply key principles as they develop guidance and best practices for implementing just culture, including:

- An emphasis on training and education;
- The recognition of the limits of human performance;
- A focus on finding the root causes of reported occurrences as opposed to apportioning blame or liability;
- The protection of the reporter of safety data and safety information;
- The implementation of a trust environment at all levels within the organization and internal rules that document the process to protect safety information; and,
- The continuous improvement of just culture principles and practices throughout the organization.

Currently, we see relatively limited implementation of such declarations, agreements and collaborative innovations around just culture. States, government agencies and aviation organizations must be innovative, however, to collaborate at the regional and global levels. Whatever your affiliation, you also must take into account the characteristics of your culture, your legal system and your existing level of implementation (intensity level).

Figure 12 —Information Sharing Model for CAA-Industry Partnership

CAA = civil aviation authority

Global Agreements

The agreement between the NTSB and the BEA, discussed above, also is an example of inter-agency collaboration necessary for stakeholders to come to a common understanding. Perhaps most important is the joint purpose of an accident investigation. Accident investigators conduct the investigation to determine the causes of an incident or accident, not to apportion blame or liability.

Flight Safety Foundation believes such advance arrangements should be adopted at the regional level wherever multiple countries often collaborate on safety investigations. Through SIP research for GSIP so far, we've become aware of advance arrangements implemented successfully in North America, Asia Pacific and Oceania, Europe and Africa.

Training and Education

Our main concept in this subsection is re-emphasizing the role of continuous training and education — at all operational levels of governments and the aviation industry — to implement SIP and promote a just culture environment. States and CAAs responsible for implementing SIP especially should encourage the participation of other competent authorities (such as judicial authorities and legislatures) and other aviation organizations not yet engaged.

Examples From Different Levels of Stakeholders

Many major airlines have developed just culture courses to raise employees' awareness of the importance of voluntary safety reporting and protecting safety information within the company. Aviation safety consulting firms also offer just culture courses for aviation organizations' specialists in aircraft maintenance, flight operations, quality management and safety management, as well as for the aviation safety officers of CAAs.

In 2012, the Just Culture Task Force in Europe, composed of aviation legal experts and aviation safety experts, proposed the *Model Aviation Prosecution Policy* as guidance for criminal investigations into, and civil prosecution of, aviation incidents and accidents.

This guidance is based on key objectives of EU Regulation No. 996/2010 on the investigation and prevention of accidents and incidents in civil aviation. This guidance emphasizes SIP and just culture principles.

Creating Your Plan for Success

- ☐ Create advance agreements among relevant authorities (signed by leaders of the CAA, the prosecutor's office and the accident investigation bureau), aviation organizations and other competent authorities at the regional and global levels (see "Regional and Global SIP," p. 26).

- ☐ At the state level, develop and implement innovative SIP strategies and methods adapted from existing state-level best practices. Strategies and methods should consider global agreements, regulatory enforcement philosophies, just culture training and education, and internal rules and policies based on a corrective approach rather than a punitive approach (see "Promoting a Global Just Culture," p. 27).

- ☐ At the organization level, develop and implement innovative SIP strategies and methods adapted from existing organizational-level best practices. Strategies and methods should consider just culture training and education programs, SIP declarations, and internal rules and policies that encourage aviation professionals to voluntarily report safety events and risks, and to understand the rationale for protecting them against punitive consequences from their reports (see "Promoting a Global Just Culture," p. 27).

- ☐ Offer multi-stakeholder training and education programs with inter-government organizations, just culture task force–type groups and aviation industry organizations. These programs will raise awareness of the critical need to protect aviation safety information (see "Training and Education," p. 28).