

Runway Incursion Risk and Resilience Assessment (RIRRA)

Proactive Safety Intelligence in Practice

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Executive Summary

Runway incursions remain a serious threat to aviation safety due to their complex causes and catastrophic potential. However, their low occurrence at individual aerodromes—together with the need for multi-stakeholder coordination and challenges in resource allocation—often limits learning and prevention efforts. A risk- and resilience-based approach is essential, focusing not only on past incidents but also on aerodrome-specific risks and known operational best practices. This is the foundation of the **Runway Incursion Risk and Resilience Assessment (RIRRA)**.

This document introduces the RIRRA concept and methodology, outlining the three tools used across reactive, proactive, and predictive applications. It also provides case studies that demonstrate how these tools are applied in practice.

A major strength of RIRRA lies in its direct engagement with operational and safety personnel, enabling the integration of local expertise into structured analysis. The case studies show how RIRRA supports evidence-based, knowledge-driven safety management and lays the foundation for future use of advanced learning technologies.

Organizations that apply RIRRA achieved improved prioritization of safety interventions and increased confidence in their proactive safety strategies. By participating in a RIRRA study, stakeholders gain actionable insights into traffic-related risks and system resilience specific to their environment.

RIRRA offers practical use cases for a wide range of stakeholders, including airport operators seeking to prioritize mitigation efforts, air traffic control units aiming to address operational pressures, runway safety teams enhancing scenario-based analysis, and regulators monitoring risk and resilience trends across the network.

Aviation executives and professionals are encouraged to contact Flight Safety Foundation for more details, for application of the RIRRA methodology, and for support in building the relevant organizational and state capacity.

Flight Safety Foundation offers a range of support and knowledge-transfer options, including:

- **Introductory Awareness**—A complimentary webinar designed to introduce the RIRRA methodology to regional and local aviation professionals, including a review of implementation benefits and requirements.
- **Case Study Application**—A collaborative engagement to apply RIRRA at a specific aerodrome, including development of a baseline toolset and capacity-building for local teams.
- **Integration and Alignment**—Ongoing support for embedding RIRRA within safety management systems, national and regional programs, or oversight authorities.

Introduction

Developed within the framework of the [Global Action Plan for the Prevention of Runway Incursions \(GAPPRI\)](#), RIRRA is a knowledge-based, data-driven methodology that supports safety management systems (SMS) across three levels of safety maturity: reactive, proactive, and predictive. It also incorporates Flight Safety Foundation's [Learning From All Operations](#) strategy, expanding the safety focus beyond negative outcomes to include operational strengths and successful practices. RIRRA represents a practical application of safety intelligence in the context of runway incursion risk, offering a structured approach to turning data and operational knowledge into effective safety action.

Proactive, Aerodrome-Specific Risk Assessment

RIRRA moves beyond incident-based analysis by identifying probable incursion scenarios tailored to each airport's unique layout, traffic flows, and operational pressures. This enables targeted risk mitigation before incidents occur, fully aligning with proactive and predictive safety management principles. Crucially, RIRRA examines not only the events themselves but also the systemic pressures and adaptive processes that influence them.

Integrated Risk and Resilience Perspective

Unlike traditional tools focused solely on hazards, RIRRA also evaluates the strength and availability of safety barriers—providing a dual view of risk exposure and system resilience. This supports smarter decision-making about where to invest in defenses and how to maintain safety performance under operational stress.

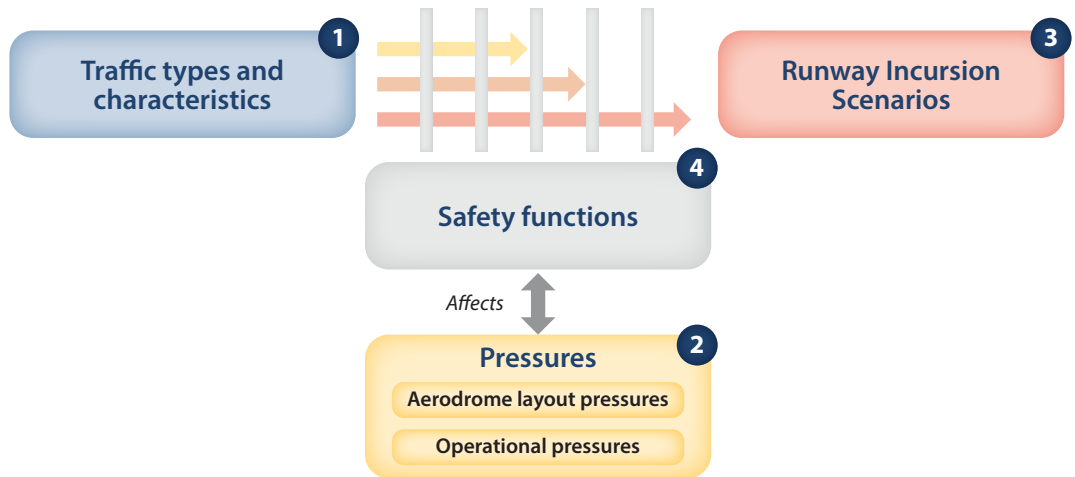
Support for Ongoing Safety Monitoring and Strategy

RIRRA creates a structured living knowledge base that can be used continuously—not just as a one-off study. RIRRA is not a statistical black box. It's a transparent, traceable methodology—grounded in operational realities, not just in data models. The structure allows users to clearly see how risk assessments are derived and to engage with the logic, not just the output. This makes it a powerful tool for both operational learning and dialogue. It supports ongoing continuous risk monitoring, change management, and strategy development, making it a practical tool for runway safety teams, airport operators, and program offices to sustain and evolve their safety efforts.

1 RIRRA Conceptual Framework

The proposed Runway Incursion Risk and Resilience Assessment (RIRRA) methodology is based on the following conceptual premise: “Traffic movements can lead to runway incursion scenarios when safety functions, under operational pressures, do not prevent them.” The RIRRA Conceptual Framework is illustrated in Figure 1. The Framework maps the interplay between traffic, pressures, and safety functions to proactively assess risk and resilience.

Figure 1: RIRRA Conceptual Framework



The framework specifies that specific traffic segments—each with their own operational characteristics—can lead to various runway incursion scenarios, including both incidents and accidents. These scenarios are influenced by the effectiveness of the overall safety barrier structure maintained by all relevant actors.

Key components of the framework include:

- **Traffic Types and Characteristics.** Example: A taxiing-in business aviation aircraft crossing a parallel runway.
- **Operational Pressures.** Example: A low-vigilance arrival crossing a parallel runway during segregated parallel operations, using a short taxiway with a sharp-angle intersection with the departure runway, and lacking enhanced centerline markings, stop bars, or elevated guard lights.
- **Runway Incursion Scenarios.** Example: A taxiing-in aircraft correctly receives ATC clearance but misapplies it—overlooking the RWY holding point and entering the RWY protected area without clearance.
- **Safety Functions.** Example: Flight crew routing, traffic awareness, collision avoidance; ATC conflict resolution and collision avoidance.

2 Introduction to RIRRA Methodology

The Runway Incursion Risk and Resilience Assessment (RIRRA) methodology offers a structured, data-driven approach to evaluating runway incursion risk and resilience at aerodromes. It puts the RIRRA Conceptual Framework into practical application.

RIRRA enables reactive, proactive, and predictive safety assessments through a modular framework built around three tools:



This methodology evolves beyond incident-based analysis, incorporating both scenario-based risk profiling and resilience forecasting to support continuous safety improvement across all operational contexts.

The detailed methodology for each tool is described separately in the following sections of this document, providing step-by-step guidance on their practical application and use cases.

2.1 Case Study 1 — RIRRA Canvas (Reactive + Proactive)



RIRRA Canvas is the foundational tool for structuring and conducting scenario-based risk assessments. The RIRRA Canvas provides a scenario-based structure to assess operations, pressures, and barrier effectiveness—making risks and resilience visible in a structured way.

The RIRRA Canvas presents all probable specific incursion scenarios (PSIS), along with qualitative and color-coded assessment of their associated pressures, frequency, runway conflict exposure, and an indication of whether a similar incident has occurred in the past. RIRRA Canvas focuses on specific operational scenarios, not generic ones. It systematically covers all possible scenarios across all traffic segments within the aerodrome.

Figure 2 (p. 5) illustrates an example of a RIRRA Canvas for a hypothetical aerodrome.

In Figure 2, we can see, for example, that PSIS 3 is an ATC-induced incorrect presence involving the Normal Operations Traffic Segment (NOTS) “taxiing out aircraft from the main ramp of the aerodrome to Runway 09.” During this segment, ATC pressure that has not been mitigated centers on the fact that ground control keeps runway traffic while it crosses the runway and that there is no procedure for GND to call out immediately before RWY crossing. The frequency of the underlying NOTS is assessed as “intense” and the runway conflict exposure, in case of a runway incursion is assessed as “probable high-energy RWY conflict.” Finally, an incident has been recorded during the past five years involving similar PSIS. The overall qualitative assessment is represented by color codes, and the resulting three red and one yellow combination signifies a high priority for addressing the PSIS.

Figure 2: RIRRA Canvas for a hypothetical aerodrome

												
PSIS #	NOTS #	Traffic Type	Normal Ops Traffic Segment (NOTS)	Probable RWY Incursion Scenario	Aerodrome Layout Pressures (Likelihood)	ATC Pressures (Likelihood)	Other Pressures (Likelihood)	Possible RWY Conflict	NOTS Frequency	Incursion Likelihood Pressures	RWY Conflict Exposure	Occurrence the last 5 years
1	TXI1	Taxiing-in	Taxi-in 09 Main Ramp	S4, PIL-VAC			Low alertness phase of flight	Landing 09	Intense	One pressure	Probable conflict	No
2	TXO2	Taxiing-out	Taxi-out Main Ramp 09	S2, PIL-TXI (09)		Hold short instruction with no traffic info	High workload phase of flight	Landing 09	Intense	No pressure	Probable high-energy conflict	Yes
3	TXO2	Taxiing-out	Taxi-out Main Ramp 09	S2, ATC-TXI (09)		No procedure for GND call out immediately before RWY crossing		Landing 09	Intense	One pressure	Probable high-energy conflict	Yes
4	TXO3	Taxiing-out	Taxi-out Main Ramp 09 via TWYB	S2, PIL-TXI (09 intersection)	Short taxi distance from ramp/apron to line-up hold short (holding position).	Hold short instruction with no traffic info	High workload phase of flight	Landing 09, Taking off 09	Continuous	More than two pressures	Probable high-energy conflict	No
5	TXO3	Taxiing-out	Taxi-out Main Ramp 09 via TWYB	S2, ATC-TXI (09 intersection)		No procedure for GND call out immediately before RWY crossing		Landing 09	Continuous	One pressure	Probable high-energy conflict	No
6	LND1	Landing	RWY09	S9, PIL-LND (09)			High workload phase of flight	RWY 09 busy	Intense	One pressure	Probable conflict	Yes
7	LND1	Landing	RWY09	S9, ATC-LND (09)				RWY 09 busy	Intense	No pressure	Probable conflict	Yes
8	LUP1	Lining up	RWY09	S7, PIL-DEP (09)			High workload phase of flight	RWY 09 intersection departure	Intense	One pressure	Probable high-energy conflict	Yes
9	LUP INTER1	Lining up	RWY09 via TWYB	S7, PIL-DEP (09)			High workload phase of flight	RWY 09 busy	Continuous	One pressure	Unlikely conflict	Yes
10	INV1	RWY Inspection	Any RWY	S3, VEH-TXI		No standard inspection procedure		RWY busy	Regular	One pressure	Probable high-energy conflict	Yes
11	INV1	RWY Inspection	Any RWY	S2, ATC-TXI				RWY busy	Regular	No pressure	Probable high-energy conflict	Yes

Here below are the specific processes steps used to develop a RIRRA Canvas:

- 1. Define all NOTS** at the aerodrome. For example, “*Taxiing-in aircraft from the main ramp to RWY 09,*” or “*RWY inspection by an aerodrome vehicle along RWY 09–TWY B to TWY D.*”
- 2. Define the frequency for all the NOTS.** The frequency for NOTS can be determined by monitoring actual operations or through expert judgment. Expert judgment may use the following categories as reference:
 - **Rare** — Very infrequent; a few times per month (e.g., < once per week);
 - **Occasional** — Irregular but expected weekly (e.g., 1–5 times per week);
 - **Regular** — Routine; occurs several times daily (e.g., 3–10 times per day);
 - **Frequent** — Common; several occurrences daily (e.g., 11–70 times per day);
 - **Continuous** — Consistent across daily operations (e.g., 71–200 times per day);
 - **Intense** — High-density, near-constant movement (e.g., 200–400 times per day); and,
 - **High-Intense** — Very high density; constant movements (> 400 times per day).

3. For each NOTS, identify PSIS, noting that more than one PSIS may apply to a single NOTS. For example, “*pilot-induced incorrect entry of a taxiing aircraft onto the runway safety area (RSA)/RWY protected area,*” or “*incorrect presence of a vacating vehicle on the RSA/RWY protected area.*”
4. For each PSIS, document:
 - **Pressures:** Categorized into:
 - » **Aerodrome layout pressures.** For example, “Taxiway intersecting runway at sharp angle,” or “Availability of efficient exit TWYs.”
 - » **ATC operational pressures.** For example, “Line up and wait and no traffic information,” or “One or more intersection along the taxi route after line-up clearance and before the line-up.”
 - » **Other pressures** (e.g., flight phase-specific factors). For example, “High workload phase of flight” or “Low alertness phase of flight.”
 - **Runway Conflict Exposure:** Potential conflicting traffic on the runway in case of PSIS, for example:
 - » **Unlikely conflict** — Runway not used in the relevant configuration; or traffic density is very low (few movements per day); or any probable conflict occurs outside the expected landing roll or departure run.
 - » **Probable Conflict** — Runway is part of the relevant configuration, with medium or high traffic density (above low levels), and the probable conflict falls within the expected landing roll or departure run.
 - » **Probable High-Energy Conflict** — A probable conflict located in the high-energy part of the runway (depending on landing or departure operations, runway length, and specific traffic and operational characteristics).

The RIRRA Canvas qualitative assessment could be augmented by a specific to each PSIS index, which enables a quantification of the PSIS risk priority.

Here are the specific processes steps used to develop the PSIS Index

5. Use RIRRA Canvas tool and score the following parameters:
 - **NOTS Frequency** (f): for example, rare, occasional, regular, frequent, continuous, intense, high-intense;
 - **Number of Pressures** (p): for example, 1, 2, >2;
 - **Runway Conflict Exposure** (c): for example, unlikely, probable, probable high-energy; and,
 - **Recent Occurrence** (o): for example, 0 if no similar incident in last four years, 1 if a similar incident occurred in last four years

Each PSIS is then calculated using the formula:

$$RIRRA_PSIS_Index = f \cdot p \cdot c \cdot (1 + k \cdot o)$$

Where:

- **Frequency score** (f): e.g., rare = f_1 , occasional = f_2 , ..., high-intense = f_7 ;
- **Number of pressures** (p): 1 = p_1 , 2 = p_2 , more than 2 = p_3 ;
- **Conflict exposure** (c): unlikely = c_1 , probable = c_2 , high-energy = c_3 ;
- **Occurrence score** (o): o_1 if no incident in the last four to five years, o_2 if there was an incident in that time; and,
- **Coefficient** (k): to adjust the score in case of a past occurrence.

Figure 3 illustrates an example of a RIRRA Canvas with RIRRA_P SIS_INDEX for a hypothetical aerodrome.

Figure 3: RIRRA Canvas with RIRRA_P SIS_INDEX for a hypothetical aerodrome



PSIS #	NOTS #	Traffic Type	Normal Ops Traffic Segment (NOTS)	Probable RWY Incursion Scenario	Aerodrome Layout Pressures (Likelihood)	ATC Pressures (Likelihood)	Other Pressures (Likelihood)	Possible RWY Conflict	NOTS Frequency	Incursion Likelihood Pressures	RWY Conflict Exposure	Occurrence the last 5 years	RIRRA PSIS Index
1	TX11	Taxiing-in	Taxi-in 09 Main Ramp	S4. PIL-VAC			Low alertness phase of flight	Landing 09	Intense	One pressure	Probable conflict	No	0.9
2	TX02	Taxiing-out	Taxi-out Main Ramp 09	S2. PIL-TXI (09)		Hold short instruction with no traffic info	High workload phase of flight	Landing 09	Intense	No pressure	Probable high-energy conflict	Yes	3.24
3	TX02	Taxiing-out	Taxi-out Main Ramp 09	S2. ATC-TXI (09)		No procedure for GND call out immediately before RWY crossing		Landing 09	Intense	One pressure	Probable high-energy conflict	Yes	9.72
4	TX03	Taxiing-out	Taxi-out Main Ramp 09 via TWYB	S2. PIL-TXI (09 intersection)	Short taxi distance from ramp/apron to line-up hold short (holding position).	Hold short instruction with no traffic info	High workload phase of flight	Landing 09, Taking off 09	Continuous	More than two pressures	Probable high-energy conflict	No	11.34
5	TX03	Taxiing-out	Taxi-out Main Ramp 09 via TWYB	S2. ATC-TXI (09 intersection)		No procedure for GND call out immediately before RWY crossing		Landing 09	Continuous	One pressure	Probable high-energy conflict	No	3.78
6	LND1	Landing	RWY09	S9. PIL-LND (09)			High workload phase of flight	RWY 09 busy	Intense	One pressure	Probable conflict	Yes	1.08
7	LND1	Landing	RWY09	S9. ATC-LND (09)				RWY 09 busy	Intense	No pressure	Probable conflict	Yes	0.36
8	LUP1	Lining up	RWY09	S7. PIL-DEP (09)			High workload phase of flight	RWY 09 intersection departure	Intense	One pressure	Probable high-energy conflict	Yes	9.72
9	LUP INTER1	Lining up	RWY09 via TWYB	S7. PIL-DEP (09)			High workload phase of flight	RWY 09 busy	Continuous	One pressure	Unlikely conflict	Yes	0.055
10	INV1	RWY Inspection	Any RWY	S3.VEH-TXI		No standard inspection procedure		RWY busy	Regular	One pressure	Probable high-energy conflict	Yes	0.176
11	INV1	RWY Inspection	Any RWY	S2. ATC-TXI				RWY busy	Regular	No pressure	Probable high-energy conflict	Yes	0.059

The RIRRA_P SIS_Index enables the prioritization of PSIS and supports scenario-based risk assessments.

By adjusting key factors—such as NOTS frequency, aerodrome layout pressures, ATC pressures, other operational pressures, or runway conflict exposure—the RIRRA_P SIS_Index dynamically reflects changes. The assessment is performed at the level of each PSIS, allowing users to analyze the specific risks and resilience associated with each scenario.

These adjustments can result from investments in different safety barriers or operational changes, allowing users to evaluate the impact of various intervention strategies, future traffic scenarios, and operational distributions.

2.2 Case Study 2 — RIRRA Index (Quantification at Aerodrome Level)



The RIRRA Index enables us to quantify and track resilience and risk across time—identifying trends and measuring progress.

RIRRA Index is derived by summing across all PSIS:

$$RIRRA_Index = \sum RIRRA_PSIS_Index_i$$

In this formula, i denotes the number of PSIS identified during the RIRRA assessment at the aerodrome.

This results in an **Overall RIRRA Index**, representing the quantified risk and risk-resilience profile of the aerodrome.

Figure 4 (p. 9) illustrates an example of a RIRRA Index for a hypothetical aerodrome.

The RIRRA Index provides a single, non-dimensional measure of incursion risk and systemic resilience based on the structure created in RIRRA Canvas. It enables:

- Risk prioritization across PSIS and NOTS;
- Progress tracking over time; and,
- Cross-aerodrome benchmarking (if harmonized inputs are used).

2.3 Case Study 3 — RIRRA Shift (Predictive)

RIRRA Shift builds on an established RIRRA Canvas baseline to explore **resilience sensitivity** to future operational states, including:

- Traffic growth or redistribution;
- Removal, addition, or modification of safety barriers;
- Procedural changes; and,
- Infrastructure development.

Users modify selected parameters (e.g., f , p , c) to represent future conditions. The model then:

- Recalculates the **projected RIRRA Index**; and,
- Provides **RIRRA Shift values** for each PSIS and segment:

$$RIRRA_SHIFT = \frac{RIRRA_Index_{baseline} - RIRRA_Index_{new}}{RIRRA_Index_{baseline}} \cdot 100\%$$

Figure 4: RIRRA Index for a hypothetical aerodrome

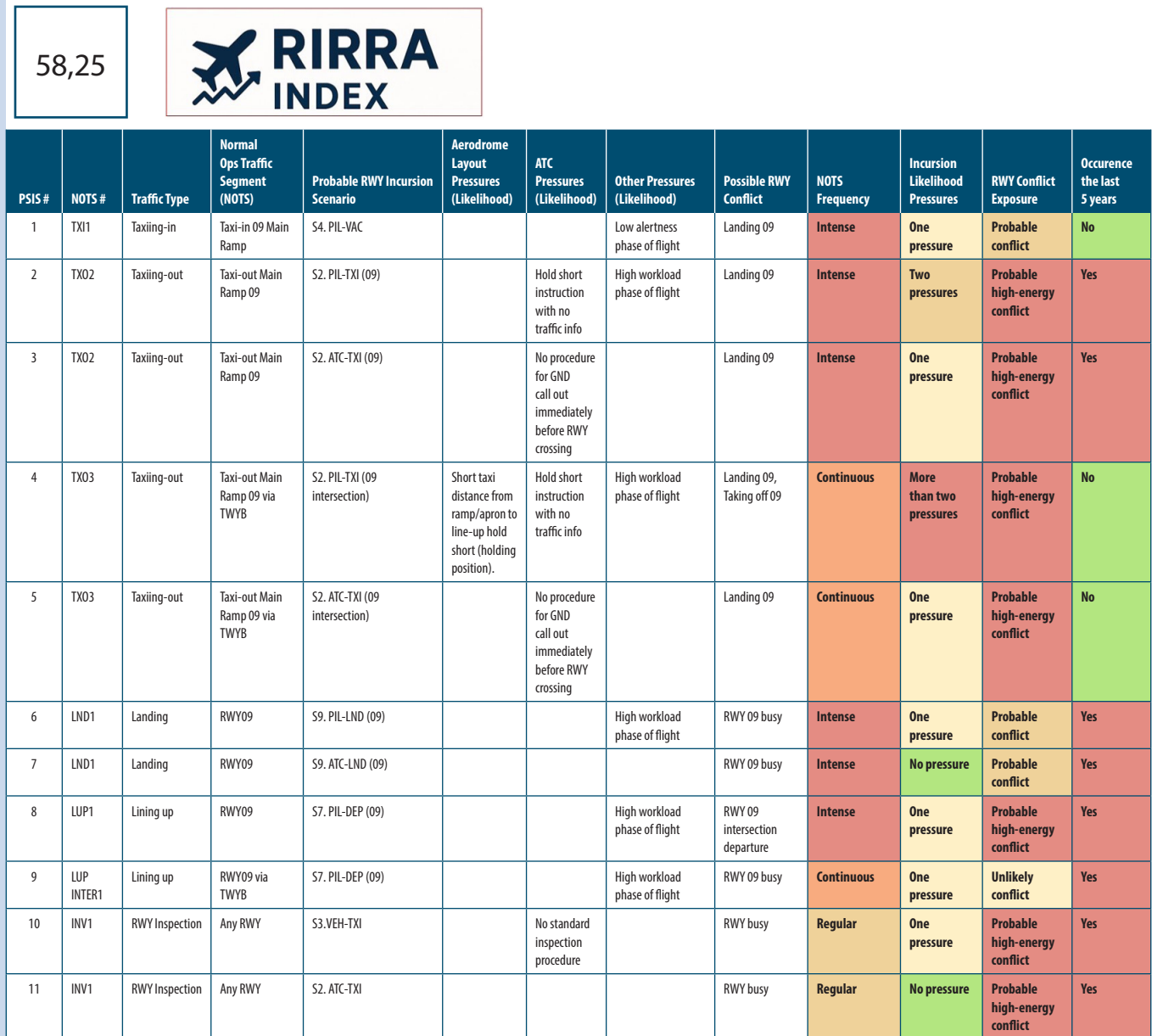


Figure 5 (p. 10) illustrates an example of a RIRRA Shift for a hypothetical aerodrome. RIRRA Shift supports **predictive safety management** by visualizing where and how resilience may degrade or improve under alternative futures.

2.3.1 Application Across Safety Maturity Levels

The RIRRA methodology supports a structured approach to safety management by enabling reactive, proactive, and predictive risk assessments. Each application uses different RIRRA tools to enhance understanding of runway incursion risks and resilience across operational scenarios.

2.3.2 Reactive Safety (using RIRRA Canvases)

- Map past runway incursions to the corresponding PSIS.
- Identify which safety functions (barriers) were effective, which were ineffective, and the operational pressures present.

Figure 5: RIRRA Shift for a hypothetical aerodrome

17,00%



Reset to Baseline

PSIS #	NOTS #	Traffic Type	Normal Ops Traffic Segment (NOTS)	Probable RWY Incursion Scenario	Aerodrome Layout Pressures (Likelihood)	ATC Pressures (Likelihood)	Other Pressures (Likelihood)	Possible RWY Conflict	NOTS Frequency	Incursion Likelihood Pressures	RWY Conflict Exposure	Occurrence the last 5 years
1	TXI1	Taxiing-in	Taxi-in 09 Main Ramp	S4. PIL-VAC			Low alertness phase of flight	Landing 09	Intense	One pressure	Probable conflict	No
2	TXO2	Taxiing-out	Taxi-out Main Ramp 09	S2. PIL-TXI (09)		Hold short instruction with no traffic info	High workload phase of flight	Landing 09	Intense	Two pressures	Probable high-energy conflict	Yes
3	TXO2	Taxiing-out	Taxi-out Main Ramp 09	S2. ATC-TXI (09)		No procedure for GND call out immediately before RWY crossing		Landing 09	Intense	One pressure	Probable high-energy conflict	Yes
4	TXO3	Taxiing-out	Taxi-out Main Ramp 09 via TWYB	S2. PIL-TXI (09 intersection)	Short taxi distance from ramp/apron to line-up hold short (holding position).	Hold short instruction with no traffic info	High workload phase of flight	Landing 09, Taking off 09	Continuous	More than two pressures	Probable high-energy conflict	No
5	TXO3	Taxiing-out	Taxi-out Main Ramp 09 via TWYB	S2. ATC-TXI (09 intersection)		No procedure for GND call out immediately before RWY crossing		Landing 09	Continuous	One pressure	Probable high-energy conflict	No
6	LND1	Landing	RWY09	S9. PIL-LND (09)			High workload phase of flight	RWY 09 busy	Intense	One pressure	Probable conflict	Yes
7	LND1	Landing	RWY09	S9. ATC-LND (09)				RWY 09 busy	Intense	No pressure	Probable conflict	Yes
8	LUP1	Lining up	RWY09	S7. PIL-DEP (09)			High workload phase of flight	RWY 09 intersection departure	Intense	One pressure	Probable high-energy conflict	Yes
9	LUP INTER1	Lining up	RWY09 via TWYB	S7. PIL-DEP (09)			High workload phase of flight	RWY 09 busy	Continuous	One pressure	Unlikely conflict	Yes
10	INV1	RWY Inspection	Any RWY	S3.VEH-TXI		No standard inspection procedure		RWY busy	Regular	One pressure	Probable high-energy conflict	Yes
11	INV1	RWY Inspection	Any RWY	S2. ATC-TXI				RWY busy	Regular	No pressure	Probable high-energy conflict	Yes

- Validate and adjust the RIRRA Canvas based on actual incident outcomes and identify additional safety mitigations where needed.

2.3.3 Proactive Safety (using RIRRA Canvas + Index)

- Apply the Canvas structure across all NOTS, regardless of incident history.
- Assess risk levels even in the absence of past incidents.
- Generate a comprehensive risk and resilience profile covering all operational segments and use it to inform targeted safety actions where needed.

2.3.4 Predictive Safety (using RIRRA Shift)

- Modify the baseline model to simulate future operational and technological changes.
- Predict potential resilience degradation or improvement under different scenarios.
- Inform long-term planning, safety investment, and change management.

2.3.5 Integration with Safety Management Systems

RIRRA supports SMS by providing a practical framework for applying safety intelligence, enabling:

- **Safety Policy.** RIRRA provides a structured, data-driven methodology that supports organizational safety objectives and reinforces commitment to proactive runway incursion risk management. It also helps formalize roles, responsibilities, and processes for scenario-based risk and resilience assessments within the aerodrome's safety framework.
- **Safety Assurance.** RIRRA enables periodic updates, monitoring of operational changes, and analysis of risk and resilience trends, helping to measure and validate the effectiveness of safety performance and risk controls.
- **Safety Promotion.** By serving as a central reference for runway incursion knowledge and information, RIRRA fosters stakeholder engagement, encourages knowledge sharing, and enhances operational transparency.
- **Safety Risk Management.** Through the RIRRA Canvas and Index, RIRRA facilitates hazard identification, risk mapping, and resilience assessment. Additionally, RIRRA Shift allows simulation of future operational scenarios, supporting proactive risk mitigation, safety investment decisions, and long-term operational planning.

3 A Typical Full-Scope RIRRA Study

This section outlines the key activities involved in a full-scope RIRRA study supported by Flight Safety Foundation. It includes an on-site workshop and a series of desktop analyses and preparatory materials developed to support the creation of the aerodrome-specific RIRRA Canvas and to facilitate structured, scenario-based discussions.

3.1 Document Review and Data Analysis

A review of the following documents, provided by the aerodrome and ATC, forms the foundation for the RIRRA study:

- Aerodrome charts and hotspot documentation;
- Operational procedures;
- Letters of agreement;
- Runway incursion data; and,
- Traffic volumes, trends, and characteristics.

This review establishes the initial understanding of layout-related pressures and local operational practices, which are critical inputs for the RIRRA Canvas.

3.2 Draft Aerodrome Layout Pressure and Mitigation Template

An initial template outlining aerodrome layout pressures is developed through literature review and desktop analysis. While not exhaustive or validated, the document serves as a discussion prompt for the workshop. It also includes a generic section on mitigation strategies, not tailored to the specific aerodrome.

3.3 Safety Functions Repositories

Three structured repositories are prepared to support discussions on safety barriers:

- ATC runway collision-prevention safety functions;
- Aircraft operator runway collision-prevention safety functions; and,
- Aerodrome vehicle runway collision-prevention safety functions

These documents compile safety practices from global sources and serve as reference materials during the workshop.

3.4 Traffic Types and Taxi Routes

Additional documents are developed to define the following:

- **Traffic types** —illustrating how NOTS are constructed; and,
- **Taxi routes and potential conflicts** —a desktop analysis identifying likely conflict points along taxi-in and taxi-out routes, based on aerodrome layout and operational patterns.

These materials serve as initial placeholders and are subject to review and validation during the workshop.

3.5 On-Site Workshop

A workshop is held at the aerodrome, bringing together key stakeholders, including representatives from ATC, airport operations, aircraft operators, and Flight Safety Foundation. The purpose of the workshop is to validate the findings from the desktop and tabletop analyses conducted in preparation for the RIRRA case study. These findings are documented and shared with participants in advance.

The workshop begins with a discussion of the general operating environment at the airport. Participants describe ATC working positions, inter- and intra-facility coordination processes, and other relevant operational practices. A structured set of guiding questions is used to focus and stimulate discussion.

The group then conducts a detailed assessment of aerodrome layout pressures—such as geometry, taxiway configuration, and hotspot locations—and evaluates the existing mitigations. This assessment forms a foundational element of the risk and resilience analysis.

Next, participants review the full range of traffic types operating at the airport, including aircraft, vehicles, and pedestrians. For each type, they assess its relevance for runway incursion risk and, where applicable, estimate its frequency. These discussions help identify the operational segments most exposed to runway incursion risk and the areas where safety barriers are most critical.

Finally, the group documents the existing mitigations across all operational areas, including procedural, technological, and human performance–related measures. The insights gained through this structured and participatory process are essential to refining the RIRRA model and ensuring its relevance to the aerodrome’s operational reality.

3.6 Post-Workshop Development and Verification

Following the on-site workshop, Flight Safety Foundation conducts a detailed analysis of the information collected, including stakeholder insights, operational context, and scenario assessments. Using this input, the Foundation customizes the three core RIRRA tools: the RIRRA Canvas, RIRRA Index, and RIRRA Shift. These tools are tailored to the aerodrome’s specific traffic patterns, layout pressures, and existing safety functions.

A verification meeting is then held with the original stakeholders to review the draft outputs. During this session, the participants validate the logic, assumptions, and information embedded in the tools.

Based on the feedback received, Flight Safety Foundation adjusts the models to ensure they accurately reflect operational realities and stakeholder understanding. The finalized tools are then delivered to the stakeholders for use in ongoing safety monitoring, strategy development, and integration within the SMS.

4 Future Considerations

Looking ahead, RIRRA presents significant potential as a core tool centrally and for local runway safety teams (RSTs). By embedding RIRRA within the safety management processes of aerodromes, it can serve as a reference and baseline for ongoing risk assessment activities—supporting risk monitoring, analysis, change management, and the development of targeted safety strategies.

To further enhance its impact, the future evolution of RIRRA should incorporate advanced learning technologies. This includes automating the methodology through integrated traffic data pipelines, enabling continuous updates and more efficient application. Incorporating real-time data inputs—such as surveillance-derived movement data—will allow for dynamic assessments of risk and resilience, providing greater awareness and responsiveness.

At a broader level, the establishment of system-wide RIRRA benchmarks will support comparative analyses across aerodromes and facilitate oversight and collaborative learning.

Ultimately, a centralized and scalable use of RIRRA will enable proactive safety prioritization and more comprehensive monitoring of runway incursion risk across the aviation system.