Safety Risk Management Methodologies (SRM)

Aviation Risk Management Solutions (ARMS) and Event Risk Classification (ERC)

This document was developed by the Safety Management Panel (SMP). It is intended to support safety experts in the application of risk management methodologies. Any comments to this material should be forwarded to safetymanagement@icao.int.

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CONTENTS

1. DESCRIPTION

1.a) Purpose of the methodology

The Aviation Risk Management Solution is a risk assessment methodology that comprises two methods:

1. **ERC –** Event Risk Classification, and
2. **SIRA –** Safety Issue Risk Assessment.

This document considers solely the Event Risk Classification (ERC) element, which is a reactive rather than a proactive approach to risk assessments. The purpose of ERC is therefore to assess past events (e.g., incidents, occurrences, accidents) so they can be given a risk value (also known as a risk index value). This enables different events to be scored in a standardised way and prioritized. Appropriate action can then be taken depending on the risk value. For example, events with a high value may require urgent follow up action to be taken.

Furthermore, ERC enables the aggregation of events: an aggregated 'risk value' can be created that adds up the individual values from multiple events, allowing monitoring over a period of time to determine whether collectively there is a potential increase or decrease in risk within an operation. The risk-oriented view provides a better understanding of specific types of operations and even the safety performance of the whole organization. In this context, ERC builds concrete links among Safety Risk Management, Safety Intelligence and Safety Performance Management.

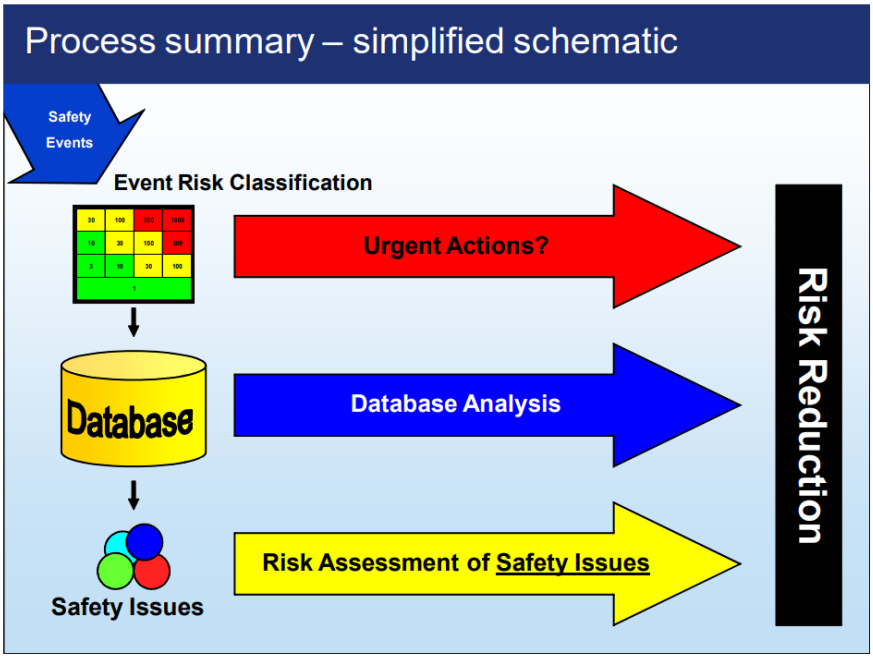


Figure 1 – Overview of the ARMS Risk Assessment process and relationship between ERC (top) and SIRA (bottom)

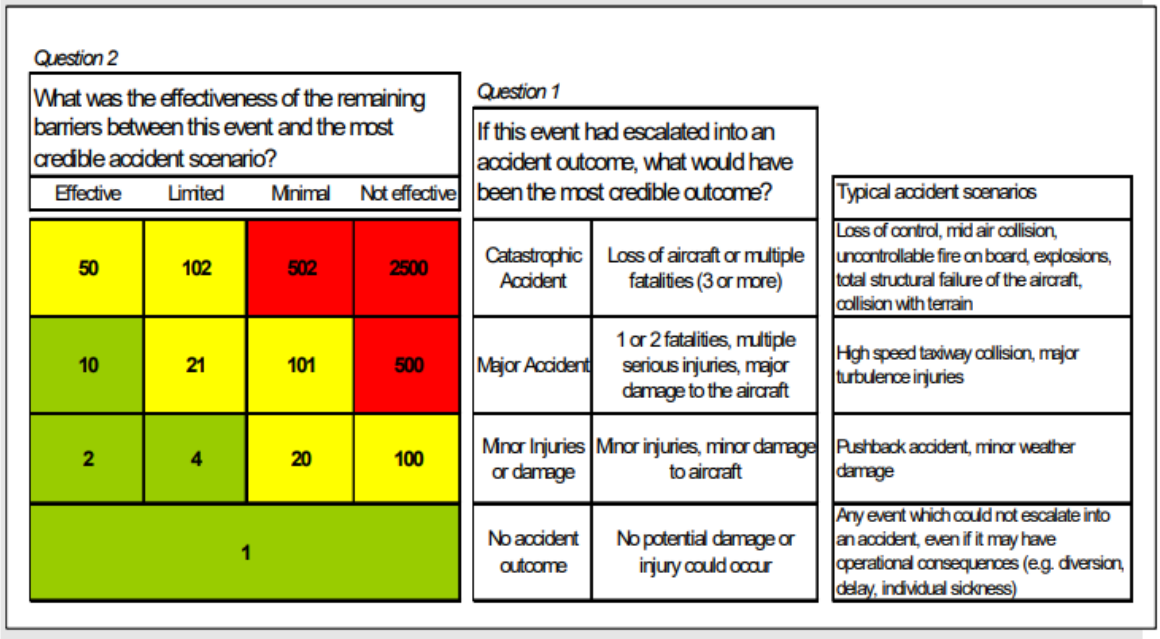
1.b) Theoretical basis

The ERC approach is comparable to a classical risk matrix based upon likelihood and severity, but with some enhancements. The approach facilitates the assessment of an event using two criteria that are linked to the event outcome and the risk mitigations in place for the given event.

While the assessment of severity is fairly similar, the assessment of probability differs from that carried out in the ICAO matrix method: in the ERC method, it corresponds to the assessment of the effectiveness of the remaining barriers between the event and the most credible accident scenario.

A 'four by four' risk matrix is used for ERC, similar to that of a classical 5x5, although the bottom row is merged to indicate any event assessed as being in one of the four boxes is scored equally.

Unlike a classical risk matrix, the risk value is not linear but is exponential. The risk matrix uses weightings with the result being the lowest risk value for a benign event is '1' with the highest risk value being '2500'. (Although ERC also allows the range of values to be customized).



Question 2

What was the effectiveness of the remaining barriers between this event and the most credible accident scenario?

Effective	Limited	Minimal	Not effective
50	102	502	2500
10	21	101	500
2	4	20	100
1			

Question 1

If this event had escalated into an accident outcome, what would have been the most credible outcome?

		Typical accident scenarios
Catastrophic Accident	Loss of aircraft or multiple fatalities (3 or more)	Loss of control, mid air collision, uncontrollable fire on board, explosions, total structural failure of the aircraft, collision with terrain
Major Accident	1 or 2 fatalities, multiple serious injuries, major damage to the aircraft	High speed taxiway collision, major turbulence injuries
Minor Injuries or damage	Minor injuries, minor damage to aircraft	Pushback accident, minor weather damage
No accident outcome	No potential damage or injury could occur	Any event which could not escalate into an accident, even if it may have operational consequences (e.g. diversion, delay, individual sickness)

Figure 2 – ARMS risk matrix

1.c) Risk acceptance method and criteria

The ERC approach proposes risk tolerability bands in the risk matrix. However, these may be adapted by the end user. The 13 different risk values are divided into three bands of tolerability: green, yellow and red.

1.d) Key terms and definitions

Term	ARMS Definition
Credible Outcome	"*If this event has escalated into an accident outcome, what would have been the most credible outcome*". It should be noted this is subtly different to asking what is the worst outcome that is typically assessed in a classical 5x5 risk matrix, for the severity aspect.
Event Risk Classification (ERC)	The initial risk classification of operational safety events, using the ERC matrix.
Event	Incident, occurrence, accident, serious incident
Hazard	Condition, object or activity with the potential of causing injuries to personnel, damage to equipment or structures, loss of material, or reduction of ability to perform a prescribed function.
Operational Risk Assessment (ORA)	Assessment of operational risks in a systematic, robust, and intellectually cohesive manner.
Risk	*"A state of uncertainty where some of the possibilities involve a loss, catastrophe, or other undesirable outcome."* (Doug Hubbard) Probability of an accident x losses per accident. (classic engineering definition) The predicted probability and severity, of the consequence(s) of hazard(s) taking as reference the potential outcomes. (adapted from ICAO by ARMS)
Risk Control	Measures to avoid or to limit the bad outcome; through prevention, recovery, mitigation. (SHELL) Measures to address the potential hazard or to reduce the risk probability or severity. (ICAO)
Risk Value (Risk Index Value)	A numerical weighting given to each square of a risk matrix to enable differentiation of risk for the purpose of quantitative analysis.
Safety Assessment	A risk assessment focusing on a predicted or planned change to a specific part of the operation.
(Safety) event	Any happening that had or could have had a safety impact, irrespective of real or perceived severity (ARMS)
Safety Issue	A manifestation of a hazard or combination of several hazards in a specific context. The Safety Issue has been identified through the systematic Hazard Identification process of the organisation. A SI could be a local implication of one hazard (e.g. de-icing problems in one particular aircraft type) or a combination of hazards in one part of the operation (e.g. operation to a demanding airport).
Safety Issue Risk Assessment (SIRA)	The risk assessment of Safety Issues, which includes the risk controls (barriers) in the assessment. The conceptual framework for this risk assessment is one where risk is calculated as the product of four factors, (prevention, avoidance, recovery, and minimisation of losses) instead of using the old severity x likelihood formula.
Triggering Event	In Safety Issue Risk Assessment (SIRA) the first of the four factors - the event or condition, which triggers the accident scenario by introducing the initial risk factor. Whether the sequence will then escalate into an UOS or Accident will depend on the avoidance and recovery barriers.
Undesirable Operational Stare	The stage in an Accident Scenario where the scenario has escalated so far that (excluding providence) the accident can be avoided only through successful recovery measure(s). Risk Controls prior to the UOS are part of Avoidance and post-UOS are part of Recovery.

Table 2 – Key terms and definitions

1.e) Data/Information Inputs

The ARMS ERC methodology can utilize a variety of safety data derived from an organisations hazard identification process. ERC is used to consider the risk of individual events that have occurred (even when there is no actual consequence). The ERC provides an assessment of the risk associated with *that one event* and not the risk associated with *all similar events*. Safety data/information input is therefore limited to hazard identification methods that are derived from events (specific things that have already happened). Event-based hazard identification data can include:

- Safety Reporting:
  - Air Safety Reports
  - Cabin Safety Reports
  - Maintenance Safety Reports
  - Mandatory Occurrence Reports
  - Ground Safety Reports
  - Confidential Reports
  - Human Factors Reports
- Flight Data Analysis/Monitoring (FDA/FDM)
- Line Operations Safety Audit (LOSA)
- Line Operations Assessment System (LOAS)

1.f) Tools available

The ARMS working group published the *ARMS Methodology for Operational Risk Assessment in Aviation Organisations* which aims to deliver a complete description of the ARMS methodology. The conceptual framework is thoroughly explained along with the risk management process and each of its steps. Worked examples are provided for all parts of the process along with an explanation of how the methodology can be appropriately customised for an individual organisation.

The ERC methodology is readily able to be incorporated into risk management software tools depending on the nature of the tool an organisation is utilizing for risk assessment and/or aviation safety reporting etc.

2. User Factors

2.a) Applications

The ARMS ERC methodology is an aviation specific methodology that was developed and is primarily designed for use by airlines and other air operators (across any sector) when considering operational *flight safety* risks. The methodology can also be utilized by other aviation organisations (directly or indirectly) linked to flight operations, provided that a barrier model adapted to the domain is developed (e.g., maintenance organisations or air traffic control organisations).

The ARMS ERC methodology was not designed or envisaged to be applied to any industry other than aviation.

2.b) Users

The ARMS ERC methodology relies on access to an organization's safety data (e.g., safety reports, Flight Data Monitoring, etc.) to identify hazards and applying the ERC methodology to prioritise effort. For this reason, the users of the ERC methodology would typically be those personnel responsible for operational safety within an organization. This could include safety department personnel, flight operations management and technical staff, or other flight operations subject matter experts, as required.

2.c) Evaluation of complexity

The ARMS ERC methodology is not overly complex, and the main concepts can be quickly understood. To apply the ARMS ERC methodology, however, users should first be familiar with how to use a classical risk matrix (such as the 5x5 in ICAO Doc 9859).

Users may find that they can gain a reasonable understanding of the approach by simply reading the associated ARMS manual. On the job training or classroom/online training is generally recommended though to ensure the theory is being applied correctly.

2.d) Availability of training

The ARMS ERC methodology is not a licensed or commercial product, therefore there is no restriction for any organization to provide training in its usage or application.

ARMS ERC training is widely available, with many training organizations that offer training in aviation safety management systems (SMS) or specifically risk assessments also offering training in how to apply the ARMS ERC methodology. It is typically found within intermediate or advanced courses with it being seen as an evolution of basic/classical risk matrices or as a standalone offering.

Training is offered from many commercial training providers in the form of both classroom and online courses. The ARMS manual itself provides detailed information on how to use the methodology including practical examples with step-by-step guides lending itself to self-study, in support of structured training courses.

3. Quality and Consistency

3.a) Consistency/Differences from SMM concepts, terms, and definitions

The ARMS ERC methodology was designed based on the guidance and approaches detailed in the ICAO Safety Management Manual (SMM) at the time of development (2008). While the ICAO SMM has been through several iterations since 2008, the ARMS approach remains broadly consistent with its concepts, terms, and definitions, albeit with some specific differences. Both ARMS ERC and the SMM share the same objectives and the ARMS methodology can be seen as a further elaboration of the principles that are behind the more generic method given in the ICAO SMM.

The ICAO SMM provides guidelines for a generic risk assessment process that can be applied when considering any risks (reactively to events, or proactively to issues). The SMM approach is not bespoke for assessing events only as is the case with ARMS ERC. However, this does not make the ARMS ERC methodology incompatible with the SMM but could be considered an evolution of the SMM concepts. The SMM emphasizes the importance of each organization tailoring the implementation of safety management (including risk assessments) to fit their specific environment. The ARMS ERC methodology is an example of a methodology tailoring a risk assessment approach to deliver the intended outcome of the relevant ICAO Standards and Recommended Practices (SARP).

3.b) Validity and reliability of outputs

The ARMS ERC methodology is designed to provide a simple, pragmatic approach to deliver more robust risk assessments of aviation events. By only being applied retrospectively to events that have already occurred the inherent subjectivity associated with determining the likelihood of the event occurring has been greatly reduced. A level of subjectivity will still remain when considering the effectiveness of remaining but through the use of subject matter experts this effectiveness assessment is far less subjective than in a typical risk matrix risk assessment.

When conducted by appropriately competent person(s) with (or supported by those with) the relevant operational personnel, the ARMS ERC methodology produces useful and defendable risk assessments that can allow appropriate decisions to be made (e.g. the decision to investigate an event or not).

Organisations need to be aware that ARMS ERC is designed to be applied only to events that have occurred. The methodology is not valid for proactive risk assessments, for which other methodologies can be used (including those noted in the SMM). These methods, whilst requiring a different approach from ARMS ERC, would not be considered incompatible with it. The ARMS working group also developed a proactive risk assessment methodology to complement ERC known as Safety Issue Risk Assessment (SIRA). The SIRA methodology has not been assessed in this paper.

3.c) Overall pros and cons

Pros & strengths	Cons & limitations
• Simple to use. • Broadly compatible with other risk assessment methodologies include ICAO SMM. • Aviation specific – developed by aviation safety professionals for aviation. • Internationally recognized approach. • Considers the effectiveness of barriers relevant to the operation of the organization.	• Requires prior development of a barrier model adapted to the domain/organisation. • Restricted to post-event risk assessment, quantification, and prioritization only (ARMS ERC is only the first step and requires a separate process such as ARMS SIRA to proactively consider risks). • Built on a linear model of accident causation (e.g., at odds with systems thinking). • Process has not been reviewed since 2010 and the methodology has no current custodian (i.e., ARMS Working Group is no longer meeting).

Table 2 – Key terms and definitions

3.d) Team assessment of usability

The ARMS ERC methodology provides organisations and States a simple, pragmatic approach to deliver robust risk assessments of aviation events. Noting the methodology was designed for aviation is readily useable within the aviation industry. While a separate approach is required to proactively consider risk it is assessed that the benefits in reduced levels of subjectivity allowing for more consistent risk assessments are worth the additional effort to implement a separate risk assessment process.

4. Additional Information

4.a) Abbreviations

Abbreviations	Meaning	Notes
ARMS	Aviation Risk Management Solutions	
ERC	Event Risk Classification	
ORA	Operational Risk Assessment	
SIRA	Safety Issue Risk Assessment	
SMM	Safety Management Manual	ICAO Doc 9859

Table 3 – Abbreviations

4.b) Literature, reference

The ARMS Methodology for Operational Risk Assessment in Aviation Organisations (available from SKYbrary): https://skybrary.aero/sites/default/files/bookshelf/1141.pdf

ARMS Methodology for Operational Risk Assessment (available from EASA website): https://www.easa.europa.eu/en/document-library/general-publications/arms-methodology-operational-risk-assessment-presentation