Safety Risk Management Methodologies (SRM)

Use of the Risk Matrix

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

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1 Description of the risk assessment matrix

The fundamentals of safety risk management can be found in the ICAO SMM Doc.9859.

The following figure is based on the definition of "safety risk" in the 2nd Edition of ICAO Annex 19: "The predicted probability and severity of the consequences or outcomes of a hazard".

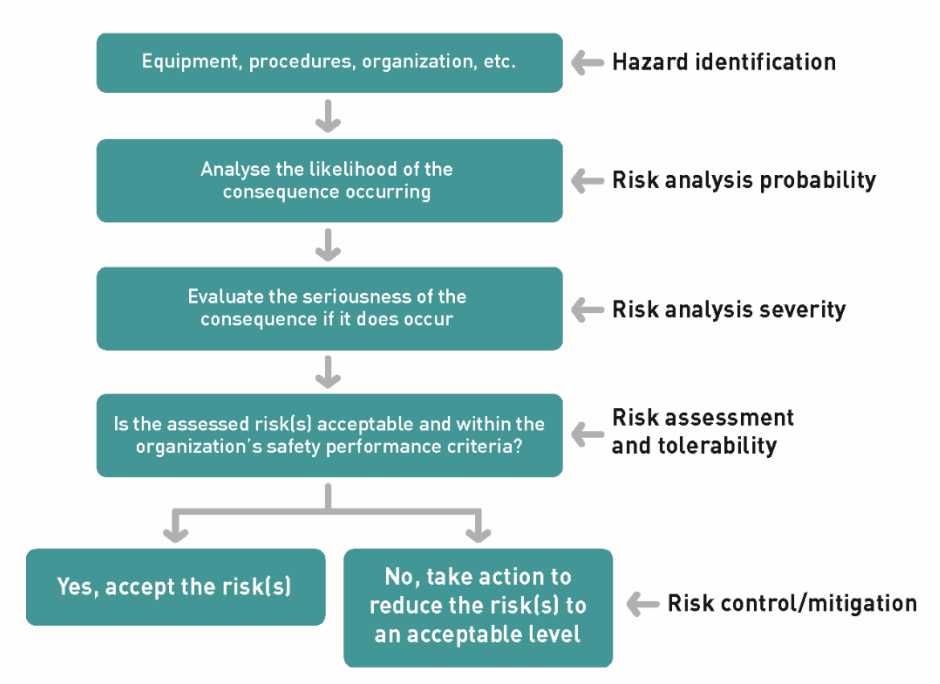


Figure 01 - Hazard identification and risk management process (extracted from figure 24 of the SMM, Ed.4)

By computing the severity and the probability of the consequences of a hazard in a risk matrix, the user will determine the safety risk tolerability and decide whether the entity needs to take actions and deploy risk mitigations strategies. Actions related to mitigations strategies consist of three options: reduce probability, reduce severity or reduce both.

1.1 Purpose of the "risk matrix" methodology

The risk matrix methodology is a practical model to quickly visualize the level of risk and decide whether further actions should be taken.

This simplistic assessment model has been proven to be widely used in many domains, including aviation, helping the owner of the risk or the senior management to understand the level of risk before and after taking mitigation actions.

Note: For the rest of the document, "organization" is used although this may address either a service provider or the Authority.

1.2 Theoretical Basis (Model)

The most common model used for “risk assessment matrix” is a 5 by 5 matrix, as follows:

Safety risk	Severity				
Probability	Catastrophic A	Hazardous B	Major C	Minor D	Negligible E
Frequent 5	5A	5B	5C	5D	5E
Occasional 4	4A	4B	4C	4D	4E
Remote 3	3A	3B	3C	3D	3E
Improbable 2	2A	2B	2C	2D	2E
Extremely improbable 1	1A	1B	1C	1D	1E

Table 01 - Example safety risk matrix (extracted from ICAO Doc.9859, Ed.4).

1.3 Risk acceptance method and criteria (where applicable)

The index obtained from the safety risk assessment matrix should then be exported to a safety risk tolerability table that describes, in a narrative form, the tolerability criteria for the specific organization.

Safety Risk Index Range	Safety Risk Description	Recommended Action
5A, 5B, 5C, AA, AB, 3A	INTOLERABLE	Take immediate action to mitigate the risk or stop the activity. Perform priority safety risk mitigation to ensure additional or enhanced preventative controls are in place to bring down the safety risk index to tolerable.
5D, 5E, 4C, 4D, 4E. 3B, 3C, 3D, 2A, 2B, 2C, 1A	TOLERABLE	Can be tolerated based on the safety risk mitigation. It may require management decision to accept the risk.
3E, 2D, 2E, 1B, 1C, 1D, 1E	ACCEPTABLE	Acceptable as is. No further safety risk mitigation required.

Table 02 - Example of safety risk tolerability (extracted from ICAO Doc.9859, Ed.4).

Note: When “acceptable”, no further safety risk mitigation measures may be required; however, continuously monitoring the effectiveness of these mitigation actions over time may be needed.

A twofold process

Step 1 (immediate outcome of the consequence)

Before applying mitigation strategies, the user will determine the initial level of risk.

Based on the risk index (step 1), the user may decide to:

- Red zone: stop the activity; or
- Yellow zone: not tolerate the risk unless the senior management accept it after a cost-benefit analysis; or
- From red to yellow or green / from yellow to green: implement mitigation measures or changes in the process/procedures/policy to reduce probability and/or severity of the consequences to reach a tolerable or acceptable level.

Step 2 (after implementation of mitigation measures)

When the risk index remains in the yellow zone after the implementation of these mitigation measures, the concept of "ALARP" (A*s Low As Reasonably Practicable)* supported by a cost benefit analysis should help the safety practitioner to determine the needs for further mitigation measures. The final decision as regards to the tolerability should be recorded as well as the mitigation measures, actions or procedural changes to further reduce the severity and the probability (e.g. training to deliver during the next six months to relevant staff in order to reduce the likelihood – in such case, the residual risk remains in the yellow zone until the very last person is trained).

It should be also ensured that the applied mitigating measures or newly established procedures do not have a counter-effect on other risks to manage or do not create new risks (e.g. after 9/11 event, the re-enforcement of the cockpit door created a security concern – see Germanwings accident[1]).

Example – Return to operations of unworthy aircraft following the COVID-19 pandemic:

Situation: As aviation activities stopped, the airline did not know how long it would be necessary to store the aircraft; consequently the (TCH) Type Certificate Holder's instructions about "long-term storage" (i.e. six months) have not been applied. Finally the aircraft were grounded for more than six months; additionally, a significant number of staff managing the continuing airworthiness status of the fleet have been furloughed during the pandemic; however the organization now plans to get the aircraft back from storage as air activities progressively restart.

Note: here the selected example is only for the purpose of the demonstration; the calculation of the risk index is not supported by data or evidence.

[1] Report available in DE/EN/ES/FR at Accident to the Airbus A320-211, registered D-AIPX and operated by Germanwings, flight GWI18G, on 03/24/15 at Prads-Haute-Bléone - BEA - Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile

Safety risk	Severity				
Probability	Catastrophic A	Hazardous B	Major C	Minor D	Negligible E
Frequent 5	5A	5B	5C	5D	5E
Occasional 4	4A	4B X	4C	4D	4E
Remote 3	3A	3B	3C	3D	3E
Improbable 2	2A	2B	2C	2D	2E
Extremely improbable 1	1A	1B	1C	1D	1E

Step 1

Some critical maintenance tasks are known to be overlooked. Some Airworthiness Directives (ADs) could not be planned or properly planned because the staff managing the ADs have been furloughed; terminal actions required by some ADs have not been timely completed; life-limited parts (LLPs) are overdue; the software managing the airworthiness status of the aircraft is not up-to-date; the aircraft has not been stored according to the appropriate long-term procedures; the maintenance programme is not adapted to “low-utilization” operations).

From a legal perspective, an organization cannot operate an aircraft that is known to be unairworthy; from a safety perspective, the aircraft is unsafe and the severity could be hazardous; from a technical perspective, the probability to encounter malfunctions during first flight from storage is very high. This situation is “intolerable”– risk index = 4B

Step 2:

The organization may decide to not engage the aircraft in operations until:

- A full status of the airworthiness is available; and
- All due critical maintenance tasks, including ADs, and LLPS are identified, planned and timely carried out.

To achieve that, the organization decides to (re)contract competent staff, update the input on the software; identify and carry out all due maintenance. Or decision is taken to lease an airworthy aircraft from another operator.

Additional mitigation strategies can range from a variety of actions. For instance:

- The organization plans a realistic manpower planning in advance of the de-storage of the aircraft to give sufficient time to the staff to identify the minimum inspection programme to de-store the aircraft – reduction of mistakes under stress or heavy workload;
- A minimum comprehensive maintenance inspection programme is systematically applied, irrespective of the storage procedures that have been applied (severity and probability all reduced at the same time);
- The organization decides to preferably select for de-storage the aircraft that have been properly stored according to the TCH instructions (i.e. reduction of probability) and thus gain experience before de-storing aircraft that have not been properly stored according to the TCH instructions; a feedback system will be established to focus on maintenance tasks where deficiencies are found (further reduce probability)
- The organization will systematically contact the TCH to seek technical support how to de-store aircraft (i.e. reduction of severity);
- The organization decides to systematically conduct a test flight before any commercial operation. Test-pilots will be appropriately selected and trained (further reduction of severity and probability);
- The aircraft will be re-engaged with well-experienced pilots and to destinations where maintenance is available and re-routing can be easily achieved (avoid cumulation of risks)

By doing so, the risk index will move from the red zone towards the yellow zone, even to the green zone depending on the nature of the mitigation strategies addressing severity and probability (see Annex 2 of this document, register No.1).

Comment: The organization has the choice to accept the risk index, as assessed; or reduce the probability; or reduce the severity; or reduce both; and finally, ensure the airworthiness of the aircraft by planning the flight test and correcting all known defects and hidden failures before next commercial flight. Some organizations may decide that the residual risk after the implementation of the selected mitigation measures shall never remain in the yellow zone: this is left to the discretion of the company's policy in coordination with its Authority.

1.4 Key terms and ICAO definitions (e.g. hazard/threat, likelihood/probability, severity)

A **hazard** is a condition or an object with the potential to cause or contribute to an aircraft incident or accident.

Note: It is not uncommon for people to confuse hazards with their consequences. W*hile an in-flight shutdown may be a hazard for a pilot or for a maintenance organization, it could be considered a consequence. A* ***consequence*** *is an outcome that can be triggered by a hazard. For example, a runway excursion (overrun) is a potential consequence related to the hazard of a contaminated runway*.

Safety risk is the predicted probability and severity of the **consequences** or **outcomes** of a hazard.

Safety risk **probability** is the likelihood that a safety consequence or outcome will occur. It is important to envisage a variety of scenarios so that all potential consequences can be considered.

Safety risk **severity** is defined as the extent of harm that might reasonably occur as a consequence or outcome of the identified hazard.

1.5 Data/Information Inputs

ICAO Doc.9859, Edition 4, indicates that the determination of probability can be aided by questions such as:

- Is there a history of occurrences similar to the one under consideration, or is this an isolated occurrence?
- What other equipment or components of the same type might have similar concerns?
- How many personnel are following, or are subject to, the procedures in question?
- What is the exposure of the hazard under consideration? For example, what is the percentage of time the equipment or activity is in use during an operation?

Likelihood	Meaning	Value
Frequent	Likely to occur many times (has occurred frequently)	5
Occasional	Likely to occur sometimes (has occurred infrequently)	4
Remote	Unlikely to occur, but possible (has occurred rarely)	3
Improbable	Very unlikely to occur (not known to have occurred)	2
Extremely improbable	Almost inconceivable that the event will occur	1

Table 03 - Safety risk probability table (extracted from ICAO Doc.9859, Edition 4).

Note: This is an example only. The level of detail and complexity of tables and matrices should be adapted to the particular needs and complexity of each organization. It should also be noted that organizations might include both qualitative and quantitative criteria. See more information in section 3 c) and Annex 1 of this document.

ICAO Doc.9859, Edition 4, indicates that the severity classification should consider, as follows:

a) fatalities or serious injury as a result of:
   i) being in the aircraft;
   ii) direct contact with any part of the aircraft, including parts which have become detached from the aircraft; or
   iii) direct exposure to jet blast;

b) damage:
   iv) aircraft sustains damage or structural failure which:
      1) adversely affects the structural strength, performance or flight characteristics of the aircraft;
      2) would normally require major repair or replacement of the affected component;
   v) ATS or aerodrome equipment sustains damage which:
      1) management of aircraft separation is adversely affected; or
      2) landing capability is adversely affected.

Severity	Meaning	Value
Catastrophic	• Aircraft / equipment destroyed • Multiple deaths	A
Hazardous	• A large reduction in safety margins, physical distress or a workload such that operational personnel cannot be relied upon to perform their tasks accurately or completely • Serious injury • Major equipment damage	B
Major	• A significant reduction in safety margins, a reduction in the ability of operational personnel to cope with adverse operating conditions as a result of an increase in workload or as a result of conditions impairing their efficiency • Serious incident • Injury to persons	C
Minor	• Nuisance • Operating limitations • Use of emergency procedures • Minor incident	D
Negligible	• Few consequences	E

Table 04 - Example safety risk severity table (extracted from ICAO Doc.9859, Edition 4).

Once the severity and the probability have been computed in the matrix, the organization should establish criteria for the risk acceptance in relation with the size of the company and the complexity of its activities. For instance, 3B will not be acceptable due to the severity and its induced costs or the consequences in terms of reputation; 3C will be acceptable only for one month or for 50FH provided a number of mitigation measures to define are applied during that period (e.g. approach minima are raised); 3D would be acceptable provided the issue is reported to the Safety Review Board (SRB) and formally accepted.

It is thus incumbent to the organization to establish criteria for risk acceptance (see Annex I, example 9, as proposed later in this document). Acceptability of risk is always a business, executive decision; the staff should know what to do when different patterns occur. Edition 1 of Annex 19, Appendix 2, section 1.2 requires that the organization define, based on the outcome of the risk assessment, what is tolerable or not and which additional actions to take to further mitigate the risk. A cost-benefit analysis can support such a decision to be taken at the right level of authority within the organization. It might even be possible that the organization will have to inform its competent authority of the taken decision.

1.6 Tools available (where applicable)

Due to its simplicity, no tool or software for the use of the risk matrix is needed. The methodology is appropriate for small organizations that cannot or do not want to invest too much on safety management tools. A paper template with instructions or procedures how to use it, can suffice. A software will have the advantages to make its use more harmonized within the organisation, recording every use.

Some consultants propose software on the market. Youtube also proposes some "free of charge" tutorials to create risk maps in Excel such as here[2]. ICAO SMI example No.260[3] proposes a hazard identification and risk management tool based on the risk matrix, which was developed by Singapore.

Note that other tools supporting the identification of hazards and/or the determination of severity and likelihood, are available (e.g. brainstorming, ISHIKAWA, fault tree, event tree) and can complement the risk matrix methodology. Bow tie models can help to monitor the effectiveness of the barriers, should they be "preventive" or for "recovery".

2 User Factors

2.1 Applications

The risk matrix is the safety risk assessment methodology most used, not only in aviation but also in some other domains. This methodology is very general and can apply to all aviation sectors.

2.2 Users

The risk matrix methodology can be used by any staff; helps to easily measure and visualize the level of risk.

2.3 Evaluation of complexity

The risk matrix methodology does not contain outstanding level of complexity. However, this does not mean that its use does not contain pitfalls for which caution should be exercised (see Chapter 3 of this document). Procedures how to use the risk matrix should be developed and the staff using the risk matrix should be trained thereof. As a matter of fact, its use is more complex that it initially seems to be and calls for some skills. Notably, attention should be paid on how to design the company's risk matrix methodology; and develop procedures how to use it.

2.4 Availability of training

Literature or many videos on the use of risk matrix are available on Internet, as mentioned earlier in the document or in section 4b).

[2] https://www.youtube.com/watch?app=desktop&v=N8J-t9JxQbA

[3] https://portal.icao.int/SMI/Lists/Example/Item/displayifs.aspx?List=baeb8a3b%2D98dc%2D4e6a%2Da1ff%2D7407614c7cfe&id=260&Web=4bf44131%2D0870%2D4b9f%2D9f40%2Daf428761b000

3 Quality and Consistency

3.1 Consistency / Differences from SMM Concepts, Terms and Definitions (e.g. flow from, hazard/source of risk, immediate outcome and ultimate consequence)

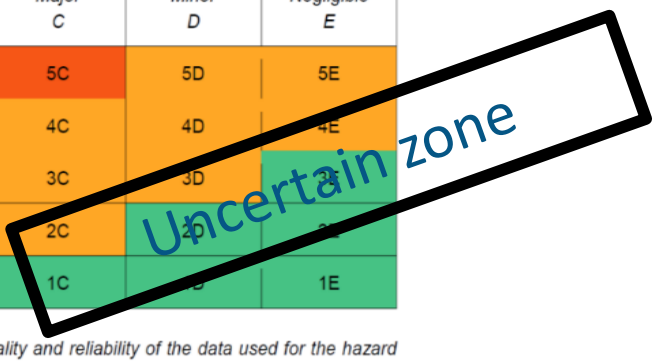
This document is based on the methodology described in the SMM (ICAO document 9859, Edition 4) and provides further details or caution how to develop and use risk matrix. No differences from the ICAO principles are proposed in this document.

3.2 Validity and reliability of inputs and outputs

According to the adage, “wrong inputs” may lead to “wrong output”: ambiguous inputs should be avoided. Unfortunately, mapping “severity” and “likelihood” cannot be made objectively for uncertain consequences or consequences with a certain level of uncertainty or worst possible consequences versus “what could reasonably occur”. Inputs to risk matrices and resulting outputs may be subjective to interpretation or influence by the context or the environment; different users may obtain opposite ratings of the same quantitative risks.

For instance, the color code is too simple and can be misleading: according to the risk matrix, there is no difference between 5E (i.e. frequent and negligible for which no mitigation action is necessarily needed - tolerable) and 3B (i.e. remote but hazardous for which it is likely to take actions to reduce the severity – “not tolerable”). In addition, the yellow zone can be too thin to a point that variability can allow to move too quickly from the red zone (i.e. not tolerable) to the yellow zone (could be acceptable – actions to consider) or from the yellow zone (could be acceptable – actions to consider) to the green zone (no further mitigation actions needed).

Safety Risk		*Severity*				
Probability		*Catastrophic A*	*Hazardous B*	*Major C*	*Minor D*	*Negligible E*
Frequent	5	5A	5B	5C	5D	5E
Occasional	4	4A	4B	4C	4D	4E
Remote	3	3A	3B	3C	3D	3E
Improbable	2	2A	2B	2C	2D	2E
Extremely improbable	1	1A	1B	1C	1D	1E



Note.— In determining the safety risk tolerability, the quality and reliability of the data used for the hazard identification and safety risk probability should be taken into consideration.

To mitigate these drawbacks and reduce the “uncertain zone”, it is fundamental that:

- Clear, detailed definitions and instructions are given, so to guide the user. This is basically the purposes of the ICAO note just below the matrix in the SMM Edition 4 (see figure just above);

- Risk matrices should be used with caution and consistency, only with careful explanations of embedded judgments; a team of safety practitioners are better than one individual working in isolation. It is also good practice to get the staff (from the operational department at stake) involved in the risk assessment. In large organizations, the assessment team can be completed by safety, quality, security and environment practitioners to address the interfaces and foster an integrated risk management process;
- Consistent use of the risk matrix and its definitions should be enhanced by the safety practitioners when rigorously assessing. The safety manager should monitor this consistent application across the board (e.g. "unstable approaches" that would be assessed as less risky than "untrained catering staff");
- Avoid 3x3 matrix where the uncertainty zone is too large. Matrices broader than the traditional 5x5 matrix with customized definitions appropriate to the size and operations of the organisation may be useful. Additional elements should be factored such as the complexity of the activities; the context (social, economic, environment, financial etc.) can be used. An advanced colour code system ranging from dark green, light green, light yellow, amber, to red, can be used; an example is proposed in the CASA document SM3[4].
- When data, numbers, formulas or figures etc. are provided for the use of the matrix for the determination of the severity or the likelihood such as FH, FC, average, median, probability, data from the FDMS, it is important that:
  - Guidance is developed how to understand and use these factors;
  - Sources are tracked and justifications for the design of these data are recorded. These data shall be appropriate, based on the size, the complexity of the organization, type of operations and the nature of the risks to measure - "One size does not fit all": for instance, aerial photography does not carry the same level of risk that transporting passengers.
  - Numerical ranges are accurately defined.
- The matrix may not only focus on safety but can also factor other aspects such as security, environment, legal aspects, finances, reputation, ethics as this contributes to the overall level of acceptability.
- Uncertainty should be reduced as much as possible. Measurement is better than intuition. Data useful for the determination of the risk index is essential to the process.
- Vulnerability and sustainability of the mitigation measures shall be evaluated before going to the final assessment of the residual risk. Human performance shall be properly taken into consideration.
- All decisions, assumptions, determination etc. should be recorded. This will be useful, when, after a new occurrence or an incident, there is a need to revisit the risk assessment.

Many examples are provided in Annex 1 of this document.

[4] https://www.casa.gov.au/sites/default/files/_assets/main/sms/download/2012-sms-book3-safety-risk-management.pdf?acsf_files_redirecthttps://www.casa.gov.au/sites/default/files/_assets/main/sms/download/2012-sms-book3-safety-risk-management.pdf?acsf_files_redirect

To conclude, consistent use, avoiding disparity and ensuring reproducibility will thus require attention. It is important that the user be trained and that an assurance system verifies how consistent the risk matrix is used across the organization.

3.3 Overall pros and cons (i.e. strengths and limitations) – outcome of surveillance

Strengths

The following pros can be mentioned: simple and practical to use; diverse applications; easy to visualize the outcome of the consequences, compare them (distribution in terms of severity and likelihood) and determine the worst scenarios. It helps to catch participants' attention during a meeting.

The use of the risk matrix helps to visualize in a concise manner for the senior management and support the decision-making, notably on the identification of the highest priorities or areas of greater risks. It is quite common to use a risk matrix for showing the risk before and after implementation of mitigation measures. When complemented by risk registers as proposed in Annex 2 of this document, the records and monitoring of the risk is made easier.

The tool allows to quickly determine whether there is a need to take further actions to mitigate the risk. Once the barriers are determined and implemented, the risk matrix allows to see whether the residual risk is acceptable or not; whether the controls in place are assumed to be effective.

Limitations

In addition to the previous section on the validity and reliability of the inputs/outputs, the following items are identified:

- The risk matrix does not allow to see the precursors to the consequences and its safety performance measurement. For that reason, other methodologies may be preferred where such precursors can be made more visible.
- The risk matrix methodology may not properly address the interfaces e.g. runway incursions may require actions from different entities such as the Air Navigation Safety Provider, airport operator, airlines and even the government: in case safety solutions cannot be solely managed by a single organization, the use of the risk matrix is not practical in a complex situation with different consequences and different mitigation measures owned by different entities, with possibly different definitions or calculations of "likelihood" or "severity". To mitigate this, in large organizations, the assessment team can be completed by safety, quality, security and environment practitioners to address the interfaces and foster an integrated risk management process. This will also foster the reproducibility of the assessment; operational staff (or team of safety relevant experts) should participate to the assessment of "certainty".
- In comparison with the Bowtie model, the use of the risk matrix does not allow to easily visualize the effectiveness of mitigation measures (or barriers); as well as the effective allocation of resources for the barriers ("who" does "what"?; "who" monitors which barrier(s) and "how"?). To mitigate this, it is good practice to complement steps 1 and 2 of the process (see section 1c of this document) with a risk register capturing the mitigations measures, the owner of these measures and possible associated SPIs/alert levels to measure the safety performance. Templates are proposed in Annex 2 of this document.

- The human performance is difficult to consider for the evaluation of “severity” and “likelihood”.
- Subjectivity in the assessment of “severity” and “likelihood” may lead to significantly different assessments by different people.
- Setting the zones of risk acceptability:
  The different zones in the matrix (red, yellow, green) are important as they define the risk that an organization considers acceptable (the ‘risk appetite’ of the organization). The zones associated with the risk acceptance criteria should therefore be tailored to the organization. Which combinations of severity and probability are defined as acceptable, tolerable and intolerable risk is a decision that must be made at the highest management level; must be documented and periodically reviewed; and must be consistent with the safety policy of the organization.
- Attention to the consistency in the use of measurements should be paid;
- Combinations and sequences of multiples risks are not appropriately or easily taken into consideration when using the risk matrix.
- Discerning risk levels among different hazards is a relevant task in risk management and is not simple using risk matrices. The same risk level can be assigned to significantly different risks.
- The use of risk matrices may lead to higher qualitative risk ratings for lower quantitative risks.
- Consistency among different assessments of the same risk may be limited by creating more detailed guides and criteria to evaluating “severity” and “likelihood”.

Further thoughts on the pros and cons of risk matrices can be found here[5].

Usual findings found during surveillance activities:

The following pitfalls are often cited by assessors:

- Absence or too vague instructions how to use the matrix, resulting in inconsistent use and no-weighted approach e.g. same level of risk for collision on the taxiway and collision on the runway; staff not trained on Safety Risk Assessment Methodology;
- Matrix instructions and definitions copied/pasted from one organization to another without considering the context - the root causes are often that the same consultant sold a “standard” matrix to several organizations without customization; or one organization just copied the Safety Management Manual from another organization; in other words, consider that “one size does not fit all”.
- Reverse engineering or intellectual bias: the user’s objective is to land in the green zone so that the organization has no action to take; the user thus “cooks” the definitions or the data in order to achieve that; another standard mistake is to only consider a harmless consequence and not the consequence(s) that could realistically occur (for sure more severe or more probable);
- No monitoring and no updating: the risk assessment is not reviewed when events that occurred should be taken into consideration to review the likelihood and/or the severity (or the nature of the consequences);

[5] https://www.juliantalbot.com/post/2018/07/31/whats-right-with-risk-matrices

- For step 2 (see section 1c): mitigations measures to implement should not allow the reduction of the severity or likelihood until the mitigations measures are completed (for instance, the likelihood should not be reduced until the very last person has been trained);
- Absence of justifications or inappropriate justifications to reduce the severity or likelihood between step 1 and step 2 (residual risk after implementation of additional mitigation measures);
- Not enough challenge by the safety manager and/or the competent authority's assessor.

3.4 Team assessment of usability

The risk matrix methodology is a practical model to quickly visualize the level of risk and decide whether further actions should be taken. Risk matrices are among the most used tools for risk prioritization and management.

It removes complexity to understand the level of risks and is proven to be "simple to use" for the sake of demonstration in a meeting or for large audience. It will be easily interpretable for the persons who must take decisions.

No significant financial investment is needed to implement this risk assessment methodology.

However, the apparent simplicity of the use of risk matrices may hide the relevant, detailed elements of the risk management process as earlier explained in this document. Surveillance inspections in Europe have revealed cases of incorrect use that have not been challenged by the safety assurance of the organization or by the regulator.

Precautions shall be thus exercised in its design and in its use to foster its good implementation and reproducibility. For that purpose, a checklist is proposed in Annex 3 of this document.

Other more complex methodologies will be preferred instead, when the safety practitioners want to have a more detailed picture of the risk assessment, such as the visualization of all the consequences, its mitigation measures and their effectiveness; actions to take and to monitor as well as their owners (responsibilities); indicators and targets to set up; and finally understand how to manage the risk.

All in all, the risk matrix methodology is a simplistic approach to assess a risk, which has the disadvantages of its advantages: easy to use but not a comprehensive management tool with an unfortunate degree of uncertainty and reproducibility when a detailed process is not used.

4 Additional information

4.1 a) Main abbreviations used in this document

Abbreviations	Meaning	Notes
SRM	Safety Risk Management	
SRA	Safety Risk Assessment	
SMM	Safety Management Manual	ICAO Document 9859; the Edition used for this document was the fourth one
TCH	Type Certificate Holder	
ALARP	As Low As Reasonably Practicable	Concept - There is wide acceptance that not all risk can be eliminated. There are practical limits to how far the industry and the community will go in paying to reduce adverse risks

4.2 b) Literature – reference

- → Improving the risk matrix (i.e. "customization)[6] - Prof. Nancy Leveson, MIT Department of Aeronautics and Astronautics
- → The misuse of risk matrices by Baines & Simmons[7]
- → Customisation of the risk matrix : US National Library of Medicine to customise the matrix[8]
- → Cox Jr., L.A., 2008. What's wrong with risk matrices? [9]Risk Anal. 28, 497–512.
- → CASA Australia, SMS book 3 – Safety Risk Management[10].
- → The risk of using risk matrices[11] by some US universities
- → A dynamic risk assessment modelling based on Fuzzy ANP[12] for SMS
- → ISO 31000 - International Standard on "risk management", which contains useful guidelines on how to address definitions, risk acceptance and criteria for the use of the risk matrix.

[6] http://sunnyday.mit.edu/Risk-Matrix.pdf
7 https://www.bainessimmons.com/papers/
8 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6256304/
9 https://doi.org/10.1111/j.1539-6924.2008.01030.x
10 https://www.casa.gov.au/sites/default/files/_assets/main/sms/download/2012-sms-book3-safety-risk-management.pdf?acsf_files_redirect
[11] https://www.researchgate.net/publication/266666768_The_Risk_of_Using_Risk_Matrices
[12] https://journals.vilniustech.lt/index.php/Aviation/article/view/6983

Annexes

Annex 1 – Customization of the risk matrix

As explained in the core document, it is important to guide as much as possible the safety practitioner when using the risk matrix. Without such caution, reproducibility of the outcome and coherence of risk assessments within the organization will be impaired.

The best approach consists in giving the highest degree of definitions [e.g. severity, likelihood, figures to support severity and likelihood definitions acceptability of risk and criteria for the management whether this is tolerable or not, and whether further action(s) should be taken to reduce the risk; evaluation of these mitigation measures].

The user can also play with more rows and columns than the traditional 5x5 matrix model using more variation of colors (e.g. from red, red amber, yellow, light yellow, light green, green).

Here after several examples for inspiration and consideration.

Example 1 – Different descriptions of severity

Severity LEVEL	S5	S4	S3	S2	S1
NATURE	Extreme	High	Medium	Low	Minor
INJURY					
NON ROUTINE INCIDENT (modified ICAO definition)	Total loss or hull loss	Accident with serious injuries or fatalities, or significant damage to aircraft	Serious incident with injuries and or substantialdamage to aircraft	Incident with minor injury and or minor aircraft damage	Incident with discomfort and/or less than minor system damage
A/C DAMAGE	> 20 Mio EUR	400.000 EUR to 20 Mio EUR	10.000 EUR to 400.000 EUR	300 EUR to 10.000 EUR	< 300 EUR
REPUTATION AND PUBLIC CONFIDENCE	Fundamental change in public perception of EN as a quality airline	Extended nationwide negative media coverage or international negative media coverage	Short term nationwide negative media coverage	Negative local media coverage	None
CUSTOMER IMPACT	Extensive shut down of services for an extensive period. All customers affected	More than 40 flights cancelled, rescheduled or delayed. Thousands of customers affected	Between 1 and 40 flights cancelled, rescheduled or delayed. Hundreds of customers affected	Between 2 and 5 flights rescheduled or delayed. Dozen of customer affected	1 flight rescheduled or delayed. Small number of customers affected
OPERATIONAL IMPACT	Fleet grounding for extended period	Brief fleet grounding up to 2 days	Aircraft grounding more than 2 days	Aircraft grounding 4 to 48 hours	Aircraft delay less than 4 hours
EQUIPMENT	Loss of critical equipment, shut down of organization	Major damage results in major slowdown and/or downtime	Minor damage leads to organizational slowdown	Mionr damage potential organizational slowdown	No adverse consequences
COMPLIANCE	Significant disruption to scheduled services over an extended period of time	Substantial fine and disruption to scheduled services	Substantial fine but no disruption to scheduled services	No fine and no disruption to scheduled services	Minor breaches by individual staff members
PROCESS BREACH	Several steps of flight critical process not followed or flight critical process non-existent	No steps of documented process followed or process no-existent	Majority of steps of documented process not followed or process unkown	Contiguous steps of documented process not followed or process partly unclear	Some single steps of documented process not followed
KNOW-HOW LOSS	Dramatic loss resulting in fully new build-up requiring more than 2 years	Heavy loss resulting in substantial build-up and/or renweal requiring 1-2 years	Worryig loss resulting in substantial build-up and/or renweal requiring up to 1 year	Loss resulting in noticeable build-up and/or renwal requiring 3/6 months	Slight loss that can be easily absorbed within the existing organization within 3 months
SAFETY AWARENESS IGNORANCE	Intolerable total absence of safety awareness demanding immediate dismissal	Unusually high level of safety awareness ignorance needing immediate correction or dismissal	Unacceptable attitude toward safety awareness needing imediate correction or dismissal warning	Generally acceptable attitude toward safety awareness with occasional blackout needing pronounced and lasting correction	Sound attitude toward safety awareness with occasional and isolated misjudgment needing clarification and lasting educational influence

Example 2 – Different descriptions of severity

	Insignificant	Negligible	Moderate	Extensive	Significant
People	Minor injury or first aid treatment	Injury requiring treatment by medical practitioner and/or lost time from workplace.	Major injury / hospitalization	Single death and/or multiple major injuries	Multiple deaths
Information	Compromise of information otherwise available in the public domain.	Minor compromise of information sensitive to internal or sub-unit interests.	Compromise of information sensitive to the organizations operations.	Compromise of information sensitive to organizational interests.	Compromise of information with significant ongoing impact.
Property	Minor damage or vandalism to asset.	Minor damage or loss of <5% of total assets	Damage or loss of <20% of total assets	Extensive damage or loss <50% of total assets	Destruction or complete loss of >50% of assets
Ecomonic	1% of budget (organizational, division or project budget as relevant)	2-5% of annual budget	5-10 % of annual budget	> 10% of budget	> 30% of project or organizational annual budget

	Insignificant	Negligible	Moderate	Extensive	Significant
Reputation	Local mention only. Quickly forgotten. Freedom to operate unaffected. Self-improvement review required	Scrutiny by Executive, internal committees or internal audit to prevent escalation Short term local media concern. Some impact on local level activities	Persistent national concern. Scrutiny required by external agencies. Long term 'brand' impact.	Persistent intense national public, political and media scrutiny. Long term 'brand' impact. Major operations severely restricted.	International concern, Governmental Inquiry or sustained adverse national/international media. 'Brand' significantly affects organizational abilities.
Capability	Minor skills impact. Minimal impact on non-core operations. The impact can be dealt with by routine operations.	Some impact on organizational capability in terms of delays, systems quality but able to be dealt with at operational level	Impact on the organization resulting in reduced performance such that targets are not met. Organizations existence is not threatened, but could be subject to significant review.	Breakdown of key activities leading to reduction in performance (eg. service delays, revenue loss, client dissatisfaction, legislative breaches).	Protracted unavailability of critical skills/people. Critical failure(s) preventing core activities from being performed. Survival of the project/activity/organization is threatened.

Example 3 – Different descriptions of likelihood

Probability LEVEL	Occurrences in XYZ			One out of ____ flights	Probability	Description
	Upper Boundary	Mean	Lower Boundary			
P5	Always	10 per day	3,5 per day	140	7,3E-03	**Probability:** Almost certain, very high **History:** Significant past history, has occurred many times and is considered most likely to happen in these circumstances **Context:** Has occurred innumerable times at XYZ
P4	3,5 per day	Once per day	2,9 per week	1.100	9,0E-04	**Probability:** Likely, high **History:** Past history and will probably occur in most circumstances **Context:** Has occurred many times at XYZ
P3	2,9 per week	Once per week	1,3 per month	10.000	1,0E-04	**Probability:** Possible, medium **History:** Some past history, has occurred occasional and is considered quite likely to happen in these circumstances **Context:** Has occurred several times at XYZ
P2	1,3 per month	Every two months	2,2 per year	100.000	1,0E-05	**Probability:** Low, possible under certain circumstances **History:** Some past history and considered possible in these circumstances **Context:** Has occurred at XYZ
P1	2,2 per year	Every year	Every 3,2 years	500.000	2,0E-06	**Probability:** Very low, unlikely **History:** Has occurred rarely, has happened, but a credible statistic frequency is hard to establish **Context:** Has occurred sporadic at XYZ
P0	Every 3,2 years	Every 10 years	Every 32 years	5.000.000	2,0E-07	**Probability:** Quite unlikely, rare **History:** In most circumstances no past history, but possible in exceptional circumstances **Context:** Has occurred in the aviation industry
Pe	Every 32 years	Every 100 years	Every 320 years	50.000.000	2,0E-08	**Probability:** Extremely unlikely, mishap basically impossible **History:** No past history and considered very unlikely to occur **Context:** Not yet heard of in the aviation industry

Example 4 – Different descriptions of likelihood

Note: the difference between "frequency" and likelihood is that "frequency" refers to an amount of time or a period.

	Chance	Frequency	Probability
Almost Certain	Is expected to occur in most circumstances	Has occurred 9 or 10 times in the past 10 years in this organization or circumstances are in train that will almost certainly cause it to happen	>95%
Likely	Will probably occur in most circumstances	Occurred more than 7 times over 10 years in this organization or in other similar organizations or circumstances have such that it is likely to happen in the next few years	>65%
Possible	Might occur at some time	Has occurred in this organization more than 3 times in the past 10 years or occurs regularly in similar organizations or is considered to have a reasonable likelihood of occurring in the next few years	>35%
Unlikely	Could occur at some time	Has occurred 2 or 3 times over 10 years in this organization or similar organizations	<35%
Rare	May occur only in exceptional circumstances	Has occurred or can reasonably be considered to occur only a few times in 100 years.	<5%

Example 5 – Different design of the risk matrix with more than 3 colors

Note 1: here using definitions used above in examples 1 and 3

Note 2: Using more than 3 colors make the risk matrix's use more difficult to explain.

	S5	S4	S3	S2	S1	S0
P5	A	A	B	C	D	E
P4	A	A	B	C	D	E
P3	A	B	C	D	E	E
P2	A	B	C	D	E	E
P1	B	C	D	E	E	E
P0	C	C	D	E	E	E
Pe	C	D	E	E	E	E

Example 6 – Different design of the risk matrix with a wide range of colors to better assess the acceptability of risk

https://www4.icao.int/demo/SMI/Risk_matrix.pdf

This is an example of a safety risk matrix used by Incheon airport that includes severity expressed in terms of human loss (casualties), Hardware loss (cost in $) and operational loss (airport closure for example). Stakeholders visualize better when they can see what it will cost them. Using the cost approach has improved the safety culture, ground handlers for example are more careful on the airside.

Example 7 – Different design of the risk matrix with a wide range of colors to better assess the acceptability of risk

https://www4.icao.int/demo/SMI/Risk_Management.pdf

The Dominican Civil Aviation Institute proposes customized probability definitions as well as severity definitions factored on:

- Aircraft safety;
- Physical injury;
- Damage to assets;
- Potential profit loss;
- Environmental damage;
- Corporate image

Please note that the proposed "%" in the probability table must be justified and adapted to the operations or services as it may widely depend from one organization to another. The same applies for the "damage to assets" and "potential profit loss" in the severity table, for which no values are proposed: a significant event will impact more a small company than a large one.

Example 8 – Different design of the risk matrix adapted to the size of the organization and the complexity of its operation.

Probability	Severity: Catastrophic (1)	Critical (2)	Marginal (3)	Negligible (4)
Frequent (A)	High	High	Serious	Medium
Probable (B)	High	High	Serious	Medium
Occasional (C)	High	Serious	Medium	Low
Remote (D)	Serious	Medium	Medium	Low
Improbable (E)	Medium	Medium	Medium	Low
Eliminated (F)	Eliminated			

Description	Severity Category	Mishap Result Criteria
Catastrophic	1	Could result in one or more of the following: death, permanent total disability, irreversible significant environmental damage, or monetary loss equal to or exceeding $10 million.
Critical	2	Could result in one or more of the following: permanent partial disability, injuries or occupational illness that may result in hospitalization of at least three personnel, reversible significant environmental impact, or monetary loss equal to or exceeding $1 million but less than $10 million.
Marginal	3	Could result in one or more of the following: injury or occupational illness resulting in one or more lost work day(s), reversible moderate environmental impact, or monetary loss equal to or exceeding $100,000 but less than $1 million.
Negligible	4	Could result in one or more of the following: injury or occupational illness not resulting in a lost work day, minimal environmental impact, or monetary loss less than $100,000.

Description	Level	Specific Individual Item	Fleet or Inventory
Frequent	A	Likely to occur often in the life of an item.	Continuously experienced.
Probable	B	Will occur several times in the life of an item.	Will occur frequently.
Occasional	C	Likely to occur sometime in the life of an item.	Will occur several times.
Remote	D	Unlikely, but possible to occur in the life of an item.	Unlikely, but can reasonably be expected to occur.
Improbable	E	So unlikely it can be assumed occurrence may not be experienced in the life of an item.	Unlikely to occur, but possible.
Eliminated	F	Incapable of occurrence. This level is used when potential hazards are identified and later eliminated.	Incapable of occurrence. This level is used when potential hazards are identified and later eliminated.

Example 9 – Matrix customized for an Authority

On the ICAO SMI website, under Chapter 8 "State safety management", Transport Canada has posted a customization of the ICAO matrix[13] for their own needs, using the following elements:

Severity (S) ***The sequence of events has happened. How serious is the severity of the consequences?***	
A **Negligible**	• Little to no impact on TCCA program or system objectives • Less than minor injury and/or less than minor system damage ***Personnel**: No injuries.* ***Operations**: Minor operational delay with no immediate costs.* ***Equipment**: No damage or minor technical delay with no immediate costs.* ***Environment**: Minor contained release that does not significantly threaten the quality of life of humans and/or the habitat.* ***Media attention**: No media attention.* ***Public confidence**: No loss of public confidence.*
B **Minor**	• Minimal questioning of TCCA program or system objectives • Nuisance / Operating limitations / Use of emergency procedures / Minor incident • Minor injury and/or Minor system damage ***Personnel**: First aid injury, no disability or lost time.* ***Operations**: May result in operating limitations, or emergency procedures; operational delay incurring relatively minimal costs.* ***Equipment**: Technical delay requiring grounding of aircraft and causing the operator to incur relatively minimal costs.* ***Environment**: Contained release that may reduce the quality of life of humans and the habitat. Full recovery period will be less than 5 years* ***Media attention**: Media attention that requires Briefing and/or Question Period notes and Minister's attention.* ***Public confidence**: May be lowered, but public accepts situation.*
C **Moderate**	• Significant questioning of TCCA program or system objectives • Injuries to persons / Serious incident / Significant reduction in safety margins / Reduction in the capacity to cope with adverse operating conditions / Increase in workload ***Personnel**: Lost time injury or passenger injuries (i.e. broken bone), no disability. Difficult for crew to cope with adverse conditions.* ***Operations**: Operational delay requiring grounding of an aircraft and causing the operator substantial costs. May result in significant reduction in safety margins.* ***Equipment**: Technical delay requiring grounding of an aircraft and causing the operator relatively substantial costs.* ***Environment**: Small uncontained release that threatens lives of humans and the habitat with effects lasting up to 15 years* ***Media attention**: Media attention that elevates occurrence to High profile status requiring Minister's action and/or results in Parliamentary debates.* ***Public confidence**: Significantly lowered with high profile media coverage and numerous ATIP requests.*
D **Major - Critical**	• Necessitates modifications to TCCA program or system objectives • Major damages to equipment / Serious injuries / large reduction in safety margins / Physical distress or excessive workload such that the operation cannot be conducted safely, accurately or completely • Severe injury and/or major system damage ***Personnel**: Disability or severe injuries. Crew extended because of workload or environmental conditions.* ***Operations**: Operational delay grounding air operator's fleet. May result in a large reduction in safety margins.*
	***Equipment**: Technical delay grounding aircraft fleet causing substantial costs and long delays to return the aircraft to service.* ***Environment**: Moderate uncontained release that kills and/or threatens lives of humans and the habitat with effects lasting up to 30 years.* ***Media attention**: Media attention that initiates legal action against the Crown and/or public servants, Parliamentary debate.* ***Public confidence**: Decreased; significant reduction in travelling public flying on a particular aircraft type or airline.*
E **Catastrophic - Extreme**	• Necessitates a significant change to and/or revocation of portions of TCCA program or system objectives • Equipment destroyed / multiple fatalities • Results in fatalities and/or loss of the system ***Personnel**: Fatal injuries to personnel or passengers. Public exposed to life threatening hazard.* ***Operations**: Operational delay grounding all operating certificates for the subject aircraft/ engine/ major component. Removal of the operating certificate for subject aircraft/engine/major component or airline.* ***Equipment**: Loss of aircraft.* ***Environment**: Large uncontained release that kills and threatens lives of humans and the habitat with irreversible effects lasting for more than 50 years.* ***Media attention**: Media attention having severe repercussion for the Minister, and/or public servants.* ***Public confidence**: Public demonstrations organized against the Crown.*

***Note**: Where the level of media and public levels are speculated operational and technical consequences should be considered (and stated). These descriptors are meant to help differentiate between levels it is not necessary to have all descriptors to determine a level.*

[13] https://portal.icao.int/SMI/Lists/2020NewList/Attachments/41/Appendix%208%20-%20RDIMS%206000379%20RISK_INDEX_MATRIX_REFERENCE%20-%20CANADA.pdf

Likelihood (L)	
What is the Likelihood of that sequence of events/situation/activities happening during the exposure interval?	
1 – Improbable - Rare	• Almost inconceivable that the event will occur during the exposure interval
	• statistically impossible [10^{-9} and below]
	• Event is almost never expected to occur
2 – Remote - Unlikely	• Unlikely, but possible to occur during the exposure interval
	• Statically 10^{-7} – 10^{-9}
	• Event is not expected to occur very often
3 – Occasional	• Likely to occur sometimes during the exposure interval
	• Statistically 10^{-5} – 10^{-7}
	• Event is expected to occur in some circumstances
4 – Probable - Likely	• Will occur several times during the exposure interval
	• Statistically 10^{-3} – 10^{-5}
	• Event is expected to occur in majority of circumstances
5 - Frequent - Almost certain	• Likely to occur often during the exposure interval
	• Statistically 10^{-1} – 10^{-3}
	• Event is expected to occur in almost all circumstances

Note: *- Qualitative or quantitative measures can be used as deemed appropriate.*
- The numerical values for the statistics found above were obtained from engineering certification standards. These quantitative values may not apply in cases where there is no available data or the values may have to be adjusted appropriately to the activity.
- The descriptors above do not all have to be met to identify the level of likelihood. They are meant to help differentiate between the different levels.

Risk Indicator	*Risk Level*	*Suggested decision*
4E, 5D, 5E	Very High	**Stop the activity**: Extensive management of situation is essential 1. Safety action shall be taken to reduce the risk to an acceptable level: *Use Delegation of Authority (DoA) and take immediate action as required.* 2. Do not proceed until sufficient control measures and action plans have been managed to an acceptable level.
3E, 4D, 5C	High	**Immediate actions shall be taken** to reduce the Risk Level. These actions shall include tangible measures to mitigate the likelihood and/or the severity.
2E, 3D, 4C, 5B	Medium-High	**May proceed**: risk elements must be considered carefully to prevent the situation from escalating to a higher level. Considerable management is required. In the case of 2E, specific measures must be taken in order to reduce the severity. The same approach must be followed in the case of 5B, but in order to reduce the likelihood.
1E, 2D, 3C, 4B, 5A	Medium	**May proceed** after considering risk elements; manage and monitor risk. However, as much as possible, 1E and 5A might be subjected to a special attention to have respectively their severity and likelihood reduced.
1D, 2C, 3B, 4A	Low-Medium	**Proceed** after considering risk elements. Management effort worthwhile.
1C, 2B, 3A	Low	**Proceed**: risk may be worth accepting with monitoring. Consideration of mitigation strategy optional.
1A, 1B, 2A	Very Low	**Proceed**: Accept risk

Annex 2 – Hazard logs and Risk registers

The results of the assessment of the potential adverse consequences or outcome of each hazard may be recorded by the operator in a risk register, two examples of which are provided below. Such document should be customized to the organization's needs.

Note: a risk register is only a mental picture for the senior management or the safety manager. Further details about the evaluation of the risks, their justifications, the assumptions done etc. should be somehow and somewhere else recorded.

Risk register - Example 1

Source: EASA rules[14] – GM3 ORO.GEN.200 (a)(3)

Note: the document was filled in in accordance with the proposed scenario case on "de-storage" in section 1c of this document.

Hazard		Incident Sequence Description	Existing Controls	Outcome (Pre-Mitigation)			Additional Mitigation required	Outcome (Post-Mitigation)			Actions and Owners	SPIs / SPTs - Monitoring and review requirements
No.	Description			Severity	Likelihood	Risk		Severity	Likelihood	Risk		
001	Unknown airworthiness status due to improper storage during COVID-19 **(see section 1c of the document)**	None	Partial implementation of the TCH storage procedures	Major	Occasional	4C	Action 1: contact the TCH; set up and apply a comprehensive de-storage programme approved by the competent authority	Remote	Minor	3D	CAMO (DT) and AMO (Prod)	Fix the defects Analyze the root causes of the defects found during the maintenance check Improve the de-storage programme for the next aircraft to de-store Improve the storage procedures for currently grounded aircraft Statistics of defects per ATA chapter etc. / Alert levels Promote /share experience about "de-storage"
							Action 1 + Action 2 (Test flight)	Improbable	Minor	2D	AMO (DT) OPS (OCC)	Set-up a flight test protocol; train the pilots Test fly the aircraft and fix any remaining items before first commercial flight Statistics of defects per ATA chapter etc / Alert levels

[14] https://www.easa.europa.eu/document-library/easy-access-rules/easy-access-rules-air-operations

Risk register - Example 2

Source: CASA – SMS book 3[15] at page 20)

[insert name of organisation]			Risk register					Log number				
Report reference number	The risk • What can happen? • How can this happen?	Date entered in register	Existing controls	The consequences of an event happening			Additional mitigation required	Residual risk			Action and owners	Monitoring and review requirements
				Severity	Likelihood	Level of risk		Severity	Likelihood	Level of risk		
Date: xx/xx/xxxx		Version: x		Form SMS 3								

[15] https://www.casa.gov.au/file/157186/download?token=sTegUXb4

Annex 3 – Checklist of items to verify how the risk matrix should be designed and used

The following list captures the essential items to consider when designing the risk matrix or that can be used by the Authority when checking its appropriateness.

Topics (risk matrix methodology)	What to look for…	User	Inspector
Design of the risk matrix			
Customized definitions - Severity - Probability	Definitions must be customized, appropriate, clear and usable; They should consider factors that can contribute to the determination of the acceptability such as security, environment, legal aspects, finances, reputation, ethics, organization's capacity Are data, numerical figures, percentage, financial assets, occurrences etc. appropriately defined and appropriate for the measurement? Is the use of measurements consistent and good enough considering the significance of the risks to assess?		
Color coding and risk acceptance	Risk acceptability criteria must be defined. The ALARP principle is defined such as "unacceptable region", "what to do" in the tolerable region; further actions in the "acceptable region" depending on the risk index. Are the number of rows and columns adapted to the complexity of the activities and the size of the organization? Are the risk acceptability criteria appropriate for the significance of the risks to assess and the support decision-making process?		
Instructions and training	Instructions how to use the risk matrix are available; criteria for the risk acceptability are well-explained (with a decision tree – "who does what", based on the outcome). Training is available on how to use the matrix; staff who use the matrix have been trained; training records are available		
Use of the risk matrix			
Consequence(s) of the hazard	How is the hazard criticality assessed? Worst scenario versus most credible scenario versus actual consequence (in case of an occurrence) Are all credible consequences considered? *Note: this is not the severity/probability of the occurrence that must be measured but the severity/probability of the consequence**s** of the occurrence*		

Topics (risk matrix methodology)	What to look for…	User	Inspector
Twofold process	Is the risk assessment measured before (immediate outcome) and after the implementation of the supplemental adopted mitigation measures (for the determination of the residual risk – ultimate consequence)?		
Effectiveness of the mitigation measures and monitoring	Is uncertainty reduced as much as possible? Are the vulnerability and sustainability of the mitigation measures properly assessed? How is the human performance taken into consideration? Are there error prevention strategies in place? How effective are they? How is the level of risk ultimately determined? Are SPIs, SPTS and alert levels / thresholds defined and associated to the mitigation measures, when appropriate. Are the safety objectives identified with the mitigation measures when it is upmost importance to monitor and improve the operations within the organization? Are the SPIs SMART?		
Risk assessment and tolerability Cumulative risks – interfaces with other risks	Is the process for the acceptability soundly defined, made in accordance with the acceptance criteria and properly documented? If the risk cannot be accepted (red or yellow zone), what actions have been taken? If the outcome falls and stay in the yellow zone, is the residual risk reduced as low as reasonably practical (ALARP)? How are combinations and sequences of multiple risks taken into consideration?		
Consistency and reproducibility	Is the matrix used in a consistent manner across the organization? Is the use of the matrix reproductible? Was the risk assessment objectively measured by a (small) group? Versus a one-man assessment (avoid subjectivity)? Has the staff been involved in the risk assessment? How is the human performance taken into consideration? Are there error prevention strategies in place? How effective are they?		

Topics (risk matrix methodology)	What to look for…	User	Inspector
	Are the definitions and values proposed in the severity and probability tables appropriate for the specific evaluation, reflecting the organization values, objectives and resources? Should the definitions of the risk criteria be amended to better specify the amount and type of risk (notably on the significance of risk and support decision-making processes)?		
Risk register, monitoring and records	Is a risk register (or equivalent) available before and after the implementation of the mitigation measures? Are decisions recorded along with the owners of the risk, mitigation measures and the actions to take or to monitor? Are the identified hazards dealt with in a timely manner? Are the results of any actions fed back to staff? Are the monitoring actions clearly identified? Is the outcome communicated to the Safety Review Board or whoever else relevant within the organization?		
Continuous improvement Review of previous assessment and update if necessary	The environment is by nature dynamic: are the definitions and the values amended, when appropriate? Should the review of the outcome of the risk matrix be updated, notably when probability and severity need to be revisited after an occurrence or when any associated SPI reaches the target level or threshold? When has the risk assessment been reviewed for the last time? Check if additional event could trigger the review of the whole process such as: benchmark with other organizations; industry standards; best practices sector risk profile; or review according to the SSP and the safety objectives of the associated national safety plan? Does the compliance monitoring function (e.g. after audits) reveal any need to review a specific assessment? Are safety culture and occurrences reporting culture well embedded in the organization? Do staff know how to report?		