TECHNICAL GUIDANCE MATERIAL

for

How to Conduct Aviation Safety Risk Assessment

SUBJECT: **TECHNICAL GUIDANCE MATERIAL FOR HOW TO CONDUCT AVIATION SAFETY RISKASSESSMENT**

EFFECTIVE DATE: 20 MARCH 2023

APPLICABILITY:

This document applies to the SACAA's all technical operational audit areas, to be used by all personnel in those areas when undertaking safety risk assessment in the scope of aviation safety. At the same time the TGM will be used by the industry where it is realised to be appropriate for use. The service providers operating in with the applicability requirements given under CAR Part 140.01.1

PURPOSE:

The purpose of this document is to provide guidance and knowledge to all technical personnel undertaking safety risk assessment. This document explains how the identified risks are analysed in terms of probability and severity of occurrences and assessed for their tolerability.

REQUIREMENTS:

CAR 140.01.3 and CATS Part 140.01.3. (2.5) read together, the "SRM" shall be included as a component in the service providers Safety Management Systems. As recommendation it is encouraged to also read or familiarises with the TGM: Aviation Safety Hazard Identification which is accessible through the SACAA website under folder "Safety Management System" located on the tab "Industry".

1. REFERENCE:

1.1 The following references would have to be accessed for the proper execution of the procedures and tasks in this chapter.

i. CAR 2011, as amended
ii. CATS 2011, as amended
iii. Civil Aviation Act 13 of 2009
iv. ICAO Doc 9859
v. ICAO Doc 9735

2. TERMS AND ABBREVIATIONS:

TERM	DEFINITION
Hazard	Situation or an object with the potential to cause death or injury to a person, damage to equipment or a structure, loss of material, or a reduction of ability to perform a prescribed function.

TERM	DEFINITION
Safety Management System	Systematic approach to managing safety, including the necessary organizational structures, accountabilities, policies and procedures.
State Safety Programme	an integrated set of regulations and activities aimed at improving safety.
Hazard Identification	A process used to determine all possible situations, event and circumstances that may expose people to injury, illness, disease or death or may cause damage or loss of equipment and property, or damage to the environment.

ABBREVIATION	DESCRIPTION
E: ASO	Executive Aviation Safety Operations
ICAO	International Civil Aviation Organisation
M: QC & AIIR	Manager: Quality Control and Accident Incident Investigation Review
SACAA	South African Civil Aviation Authority
SACAR	South African Civil Aviation Regulations
SACATS	South African Civil Aviation Technical Standards
SM: CSD	Senior Manager Consistency and Standardisation
SMS	Safety Management System
SMS TO	SMS Technical Officer
SRM	Safety Risk Management
SSP	State Safety Programme
TGM	Technical Guidance Manual

3. GENERAL

3.1 This technical guidance material (TGM) is one of the documents forming part of the SACAA's processes and procedures in aviation safety risk management which is the primary function of Safety Management Systems (SMS) under the endorsement of the State Safety Programme (SSP). The TGM was developed with the aim of assisting and guiding the industry when evaluating aviation safety risk and all SACAA's operational audits areas whenever executing aviation safety oversight function as part of its mandate. This TGM can be used in conjunction with any other available Manual(s) that are deemed relevant by the departmental personnel.

3.2 Safety risk management (SRM) is one of the core activities that supports the management of safety and contributes directly to the related organisational processes. The objective of SRM is to provide the foundation for a balanced allocation of resources between all assessed safety risks and the control and mitigation of which are viable.

3.3 This TGM outlines the required steps that are relevant when undertaking the process of safety risk assessment (SRM). Further on, it is intended to enhance the level of knowledge and the actual practical process of undertaking SRM.

3.4 Therefore, all Service Providers/Operators and SACAA are advised to use the risk assessment method explained in this technical guidance manual when the tolerability of the identified risks in their systems are assessed.

3.5 This document is a living document and should be amended to include any developments in, or amendments to, the scope and functions of the various SACAA Departments. All those affected by this Manual are encouraged to propose ideas and changes to this document for the improvement of both the content and of the professional execution of their duties.

3.6 Should the contents of this TGM conflict with the requirements of an existing SACAA, procedure, process of manual then the more restrictive requirement will apply.

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Table of Contents

CHAPTER 1: DEFINITION OF SAFETY RISK

1. Safety risk management is a core activity that supports the management of safety and contributes to other, identified related organisation processes. The term SRM, as opposed to the more generic risk management, is meant to convey the notion that the management of safety does not aim – directly – at the management of financial risk, legal risk, economic risk and so forth, but restricts itself primarily to the management of aviation safety risks.

2. It is a common pitfall that safety management activities oftentimes do not progress beyond hazard identification and analysis or, in other cases, jump from hazard identification direct to mitigation deployment, bypassing the evaluation and prioritisation of the safety risks of the consequences of hazard. After all, once sources of danger or harm are identified, and their consequence analysed and agreed, mitigation strategies to protect against the consequence can certainly be deployed. This view would be correct if one were to adhere to the notion of "safety as the first priority" and focus on the prevention of bad outcomes. However, under the notion of safety management, agreeing on the consequences of identified hazards and describing them in operational terms are not enough to engage in mitigation deployment. It is necessary to evaluate the seriousness of the consequences, for the purpose of defining priorities for the allocation of resources when proposing mitigation strategies.

3. It is essential to somehow measure the seriousness of the consequences of hazards. This is the essential contribution of SRM to the safety management process. By "putting a number" on the consequences of hazards, the safety management process provides the organisation with a principled basis for safety risk decisions and the subsequent allocation of organisational resources to contain the damaging potential of hazards.

4. The first step in addressing the confusion is narrowing down the use of the generic term risk to the very specific term safety risk. It is essential from the outset to establish a clear definition of safety risk and to link such a definition to the concepts of hazards and consequences expressed in operational terms.

5. Safety risks are not tangible or visible components of any physical or natural environment, it is necessary to think about Safety risks to understand or form an image of them. Hazards and consequences, on the other hand, are tangible or visible components of a physical or natural environment, and therefore intuitive in terms of understanding and visualisation. The notion of a safety risk is what is known as a construct, i.e. it is an artificial convention created by humans. In simple words, while hazards and consequences are physical components of the natural world, safety risks do not really exist in the natural world. Safety risk is a product of the human mind intended to measure the seriousness of, or "put a number" on, the consequences of hazards.

6. Safety risk is defined as the assessment, expressed in terms of predicted probability and severity, of the consequences of a hazard, taking as references the worst foreseeable situation. Typically, safety risks are designed through an alphanumeric convention that allows for their measurement.

1. Safety risk management is a generic term that encompasses the assessment and mitigation of the safety risk of the consequences of hazards that threaten the capabilities of an organisation, to a level as low as reasonably practicable (ALARP). The objective of safety risk management is to provide the foundation for a balanced allocation of resources between all assessed safety risks and those safety risks the control and mitigation of which are viable.

2. Figure 2-1 depicts a broadly adopted generic visual representation of the safety risk management process. The triangle is presented in an inverted position, suggesting that aviation (just like any other socio-technical production system) is "top heavy" from a safety risk perspective: most safety risk of the consequences of hazards will be assessed as initially falling in the intolerable region. A lesser number of safety risk of the consequences of hazards will be assessed in such a way that the assessment falls straight in the tolerable region, and an even fewer number will be assessed in such a way that the assessment falls straight in the acceptable region

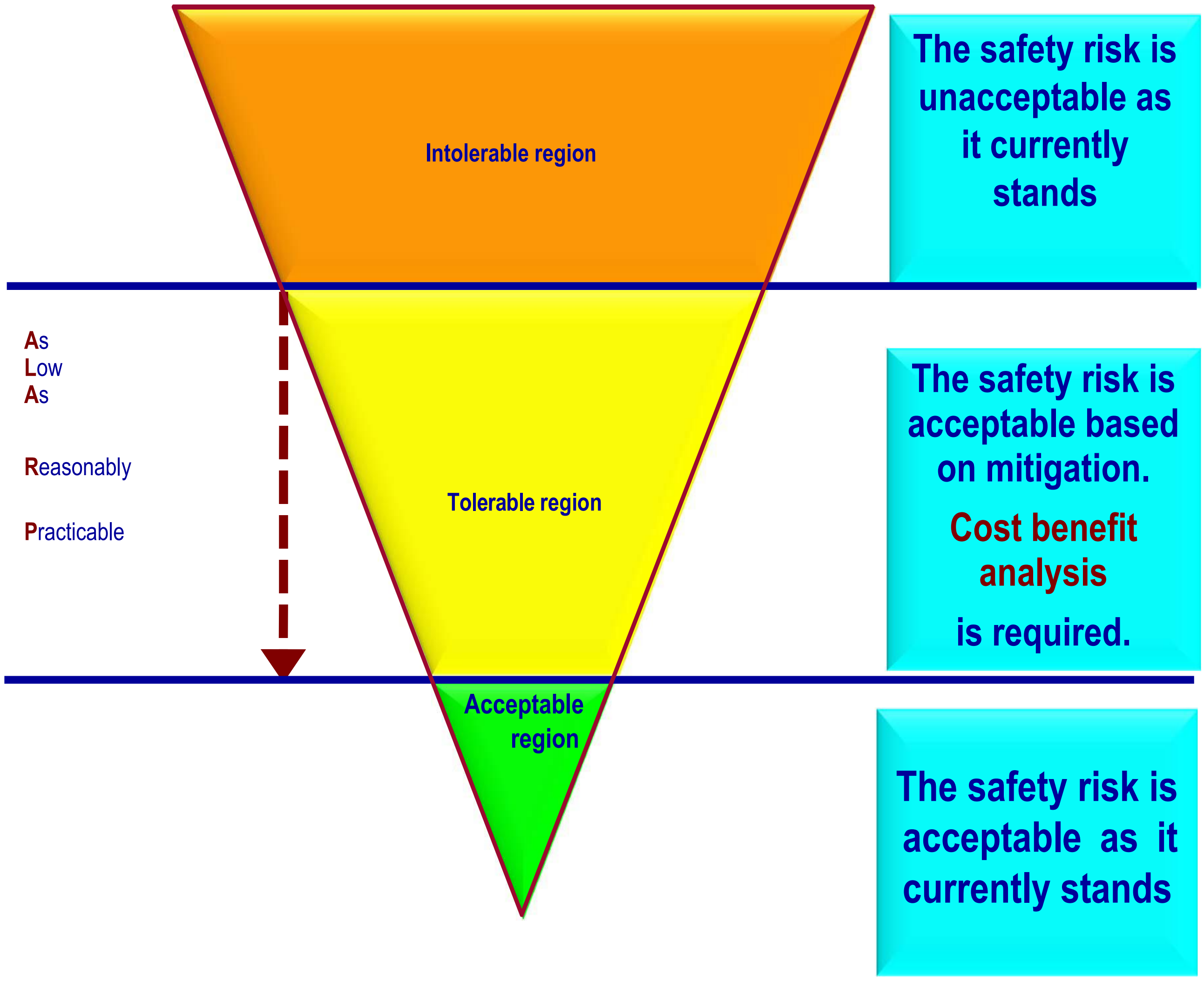

Figure 2-1. Generic visual representation of the safety risk management process

3. Safety risks assessed as initially falling in the intolerable region are unacceptable under any circumstances. The probability and/or severity of the consequences of the hazards are of such a magnitude, and the damaging potential of the hazard poses such a threat to the viability of the organisation, that immediate mitigation action is required. Two alternatives are available to the organisation to bring the safety risks to the tolerable or acceptable regions:

3.1 Allocate resources to reduce the exposure to, and/or the magnitude of, the damaging potential of the consequences of the hazards; or

3.2 If mitigation is not possible, cancel the operation.

4. Safety risks assessed as initially falling in the tolerable region are acceptable, provided mitigation strategies already in place guarantee that, to the foreseeable extent, the probability and/or severity of the consequences of hazards are kept under organisational control. The same control criteria apply to safety risks initially falling in the intolerable region and mitigated to the tolerable region. A safety risk initially assessed as intolerable that is mitigated and slides down to the tolerable region must remain "protected" by mitigation strategies that guarantee its control. In both cases a cost-benefit analysis is required:

4.1 Is there a return on the investment underlying the allocated of resources to bring the probability and/or severity of the consequences of hazards under organisational control? Or

4.2 Is the allocation of resources required of such magnitude that will pose a greater threat to the viability of the organisation than bringing the profitability and/or severity of the consequences of hazards under organisational control?

5. The acronym ALARP is used to describe a safety risk that has been reduced to a level that is as low as reasonably practicable. In determining what is "reasonably practicable" in the context of SRM, consideration should be given both to the technical feasibility of further reducing the safety risk, and the cost. This must include a cost-benefit analysis. Showing that the safety risk in a system is ALARP means that any further risk reduction is either impracticable or grossly outweighed by the cost. It should, however, be borne in mind that when an organisation "accepts" a safety risk, this does not mean that the safety has been eliminated. Some residual level of safety risk remains; however, the organisation has accepted that the residual level of safety risk is sufficiently low that it is outweighed by the benefits.

6. Safety risks assessed as initially falling in the acceptable region are acceptable as they currently stand and require no action to bring or keep the probability and/or severity of the consequences of hazards under organisational control.

7. Cost-benefit analysis are the heart of SRM. There are two distinct costs to be considered in Cost-Benefit Analysis: Direct Costs and Indirect Costs.

7.1 **Direct costs:** Are the obvious costs and are fairly easy to determine. They mostly relate to physical damage and include rectifying, replacing or compensating for injuries, aircraft/equipment and property damage. The high costs underlaying the loss of organisational control of certain extreme consequences of hazards, such as an accident, can be reduced by insurance coverage. It must be borne in mind, however, that purchasing insurance does nothing to bring the probability and/or severity of the consequences of hazards under organisational control; it only transfers the monetary risk from the organisation to the insurer. The safety risk remains unaddressed.

7.2 **Indirect costs:** Include all those that are not directly covered by the insurance. Indirect costs may amount to more than the direct costs resulting from loss of organisational control of certain extreme consequences of hazards. Such costs are sometimes not obvious and are often delayed. Some examples of uninsured costs that may accrue from loss of organisational control of extreme consequences of hazards include:

- **a.** **Loss of business and damage to the reputation of the organisation*.*** Many organisation will not allow their personnel to fly with an airline with a questionable safety record.
- **b.** **Loss of use of equipmen*t.*** This equates to lost revenue. Replacement equipment may have to be purchased or leased. Companies operating a one-of-a-kind aircraft may find that their spares inventory and the people specially trained for such an aircraft becomes surplus.
- **c.** **Loss of staff productivit*y.*** If people are injured in an occurrence and are unbale to work, labour legislation may still require that they continue to receive some form of compensation. Also, these people will need to be replaced, at least for the short term, with the organisation incurring the costs of wages, training, overtime, as well as imposing an increased workload on the experienced workforce.
- **d.** **Investigation and clean-up*.*** These are often uninsured costs. Operators may incur cost from the investigation including the costs of the involvement of their staff in the investigation, as well as the cost of test and analysis, wreckage recovery and restoring the event site.
- **e.** **Insurance deductibles.** The policyholder's obligation to cover the first portion of the cost of any event must be paid. A claim will also put a company into a higher risk category for insurance purposes and therefore

may result in increased premiums. (Conversely, the implementation of safety mitigation interventions could help a company to negotiate a lower premium).

f. **Legal action and damage claims.** Legal costs can accrue rapidly. While it is possible to insure for public liability and damages, it is virtually impossible to cover the costs of time lost handling legal action and damage claims.

g. **Fines and citation*s.*** Government authorities may impose fines and citations and possibly shut down the unsafe operations.

7.3 Cost-benefit analysis produce. results that can be numerically precise and analytically exact. Nevertheless, there are less exact numeric factors that weigh in a cost-benefit analysis. These factors include:

h. Managerial. Is the safety risk consistent with the organisation's safety policy and objectives?

i. Legal. Is the safety risk in conformance with the current regulatory standards and enforcement capabilities?

j. Cultural. How will the organisation's personnel and other stakeholders view the safety risks?

k. Market. Will the organisation's competitiveness and well-being visa-versa other organisations be compromised by the safety risk?

l. Political. Will there be a political price to pay for not addressing the safety risk?

m. Public. How influential will the media or special interest groups be in affecting the public opinion regarding the safety risk?

CHAPTER 3: SECOND FUNDAMENTAL – SAFETY RISK PROBABILITY

1. The process of bringing the safety risks of the consequences of hazards under organisational control starts by assessing the probability that the consequences of hazards materialise during operations aimed at delivering of services. This is known as assessing the safety risk probability.

2. Safety risk probability is defined as the likelihood that an unsafe event or condition might occur. The definition of the likelihood of a probability can be aided by questions such as:

2.1. Is there a history of similar occurrences to the one under consideration, or is this an isolated one?
2.2. What other equipment or components of the same type might have the similar defects?
2.3. How many personnel are following, or are subjected to, the procedures in question?
2.4. What percentage of the time is the suspect equipment or the questionable procedure in use?
2.5. To what extent are there organisational, management or regulatory implications that might reflect larger threats to public safety?

3. Any or all of the factors underlying these example questions may be valid, underlining the importance of considering multi-causality. In assessing the likelihood of the probability that an unsafe event or condition might occur; all potentially valid perspective must be evaluated.

4. In assessing the likelihood of the probability that an unsafe event or condition might occur, reference to historical data contained in the "safety library" of the organisation is paramount in order to make informed decisions. It follows that an organisation which does not have a "safety library" can only make probability assessments based, at best, on industry trends and, at worst, on opinion.

5. Based on the considerations emerging from the replies to questions such as those listed in 3.2 the probability that an unsafe event or condition might occur can be established and its significance assessed using a safety risk probability table.

6. Figure 3-1 presents a typical safety risk probability table, in this case, a five-point table. The table includes five categories to denote the probability of occurrence of an unsafe event or condition, the meaning of each category, and an assignment of a value to each category.

	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 3-1. Safety risk probability table

CHAPTER 4 : THIRD FUNDAMENTAL – SAFETY RISK SEVERITY

1. Once the safety risk of an unsafe event or condition has been assessed in terms of probability, the second step in the process of bringing the safety risks of the consequences of hazards under organisational control is the assessment of the severity of the consequences of the hazard if its damaging potential materialise during operations aimed at delivery of services. This is known as assessing the safety risk severity.

2. Safety risk severity is defined as the possible consequences of an unsafe event or condition, taking as reference the worst foreseeable situation. The assessment of the severity of the consequences of the hazard if its damaging potential materialise during operations aimed at delivery of services can be assisted by questions such as:

2.1. How many lives may be lost (employees, passengers, bystanders and the general public)?

2.2. What is the likely extent of property or financial damage (direct property loss to the operator, damage to aviation infrastructure, third-party collateral damage, financial and economic impact for the State)?

2.3. What is likelihood of environmental impact (spillage of fuel or other hazardous product, and physical disruption of the natural habitat)?

2.4. What are the likely political implications and/or media interest?

3. Based on the considerations emerging from the replies to questions such as those listed in 4.2, the severity of the possible consequences of an unsafe event or condition, taking as reference the worst foreseeable situation, can be assessed using a safety risk severity table.

4. Figure 4-1 presents a typical safety risk severity table, also a five-point table. It includes five categories to denote the level of severity of the occurrence of an unsafe event or condition, the meaning of each category, and the assignment of a value to each category.

SEVERITY OF OCCURRENCE	MEANING	VALUE
Catastrophic	• Equipment destroyed • Multiple deaths	**A**
Hazardous	• A large reduction in safety margins, physical distress or a workload such that the operators cannot be relied upon to perform their tasks accurately or completely • Serious injury • Major equipment	**B**
Major	• A significant reduction in safety margins, a reduction in the ability of the operators to cope with adverse operating conditions 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	• Little consequence	**E**

Table 4-1. Safety risk severity table

CHAPTER 5 FOURTH FUNDAMENTAL – SAFETY RISK TOLERABITLITY

1. Once the safety risk of the consequences of an unsafe event or condition has been assessed in terms of probability and severity, the third step in the process of bringing the safety risks of the consequences of the unsafe event or condition under organisational control is the assessment of the tolerability of the consequences of the hazard if its damaging potential materialise during operations aimed at delivery of services. This is known as assessing safety risk tolerability. This is a two-step process.

2. First, it is necessary to obtain an overall assessment of the safety risk. This is achieved by combining the safety risk probability and safety risk severity tables into a safety risk assessment matrix, an example of which is presented in Figure 5-1. For example, a safety risk probability has been assessed as occasional (4). The safety risk severity has been assessed as hazardous (B). The composite of probability and severity (4B) is the safety risk of the consequences of the hazard under consideration. It can be seen, through this example, that a safety risk is just a number or alphanumerical combination and not a visible or tangible component of the natural world. The colour coding in the matrix in Figure 5-1 reflects the tolerability regions in the inverted triangle in Figure 2-1.

3. Second, the safety risk index obtained from the safety risk assessment matrix must then be exported to a safety risk tolerability matrix that describes the tolerability criteria. The criterion for a safety risk assessed as 4B is, according to the tolerability table in Figure 5-2, "unacceptable under the existing circumstances". In this case, the safety risk falls in the intolerable region of the inverted triangle. The safety risk of the consequences of the hazard is unacceptable. The organisation must:

3.1 allocate resources to reduce the exposure to the consequences of the hazards;

3.1 allocate resources to reduce the magnitude or the damaging potential of the consequences of the hazards; or

3.2 cancel the operation if mitigation is not possible.

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 5-1. Safety risk assessment matrix

Tolerability description	Assessed risk index	Suggested criteria
Intolerable region	5A, 5B, 5C, 4A, 4B, 3A	Unacceptable under the existing circumstances
Tolerable region	5D, 5E, 4C, 4D, 4E, 3B, 3C, 3D, 2A, 2B, 2C, 1A	Acceptable based on risk mitigation. It may require management decision.
Acceptable region	3E, 2D, 2E, 1B, 1C, 1D, 1E	Acceptable

Figure 5-2. Safety risk tolerability matrix

1. In the fourth and final step of the process of bringing the safety risks of the consequences of an unsafe event or condition under organisational control, control/mitigation strategies must be deployed. Both are meant to designate measures to address the hazard and bring under organisational control the safety risk probability and severity of the consequences of the hazard.

2. Continuing with the example presented in chapter 5 the safety risk of the consequences of the hazard under analysis has been assessed as 4B ("unacceptable under existing circumstances"). Resources must then be allocated to slide down the triangle, into the tolerable region, where safety risks are ALARP. If this cannot be achieved, then the operation aimed at the delivery of services which exposes the organisation to the consequences of the hazards in question must be cancelled. Figure 6-1 presents the process of safety risk management in graphic format.

3. There are three generic strategies for safety risk control/mitigation:

3.1. Avoidance. The operation or activity is cancelled because safety risks exceed the benefits of continuing the operation or activity.

3.2. Reduction. The frequency of the operation or activity is reduced, or action is taken to reduce the magnitude of the consequences of the accepted risks.

3.3. Segregation of exposure. Action is taken to isolate the effects of the consequences of the hazard or build in redundancy to protect against them.

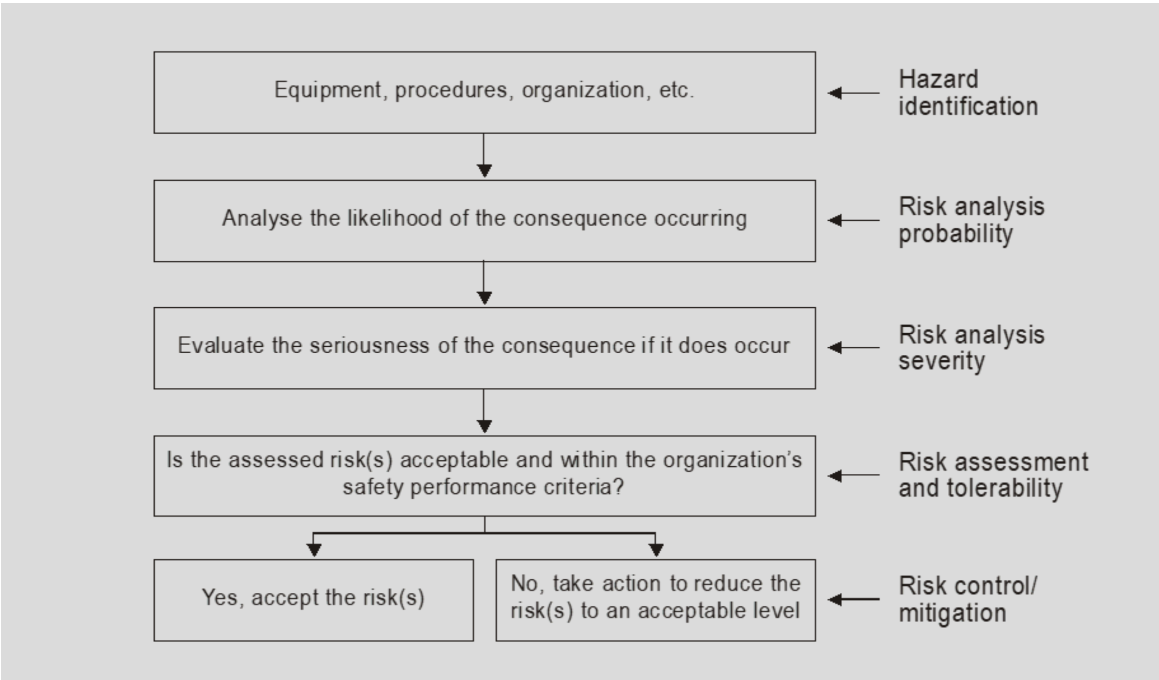

Figure 6-1. The process of safety risk management

4. In evaluating specific alternatives for safety risk mitigation, it must be kept in mind that not all have the same potential for reducing safety risks. The effectiveness of each specific alternative needs to be evaluated before a decision can be taken. It is important that the full range of possible control measures be considered and that trade-offs between measures be considered to find an optimal solution. Each proposed safety risk mitigation option should be examined from such perspectives as:

4.1. Effectiveness: Will it reduce or eliminate the safety risks of the consequences of the unsafe event or condition? To what extent do alternatives mitigate such safety risks? Effectiveness can be viewed as being somewhere along a continuum, as follows:

a) *Engineering mitigations* - This mitigation eliminates the safety risk of the consequences of the unsafe event or condition, for example, by providing interlocks to prevent thrust reverser activation during flight.
b) *Control mitigations* - This mitigation accepts the safety risk of the consequences of the unsafe event or condition but adjusts the system to mitigate such safety risk by reducing it to a manageable level, for example, by imposing more restrictive operating conditions.
c) *Personnel mitigations* - This mitigation accepts that engineering and/or control mitigations are neither efficient nor effective, so personnel must be taught how to cope with the safety risk of the consequences of the hazard, for example, by adding warnings, revised checklist, SOPs and/or extra training.

4.2. Cost/benefit: Do the perceived benefits of the mitigation outweigh the costs? Will the potential gains be proportional to the impact of the change required?

4.3. Practicality: Is the mitigation practical and appropriate in terms of available technology, financial feasibility, administrative feasibility, governing legislation and regulations, political will, etc?

4.4. Challenge: Can the mitigation withstand critical scrutiny from all stakeholders (employees, managers, State administrations, etc)?

4.5. Acceptability to each stakeholder: How much buy-in (or resistance) from stakeholders can be expected? (Discussions with stakeholders during the safety risk assessment phase may indicate their preferred risk mitigation option).

4.6. Enforcement: If new rules (SOPs, regulations, etc) are implemented, are they enforceable?

4.7. Durability: Will the mitigation withstand the test of time? Will it be of temporary benefit, or will it have long-term utility?

4.8. Residual safety risks: After the mitigation has been implemeted, what will be the residual safety risks relative to the original hazard? What is the ability to mitigate any residual safety risks?

4.9. New problems: What new problems or new (perhaps worse) safety risks will be introduced by the proposed mitigation?

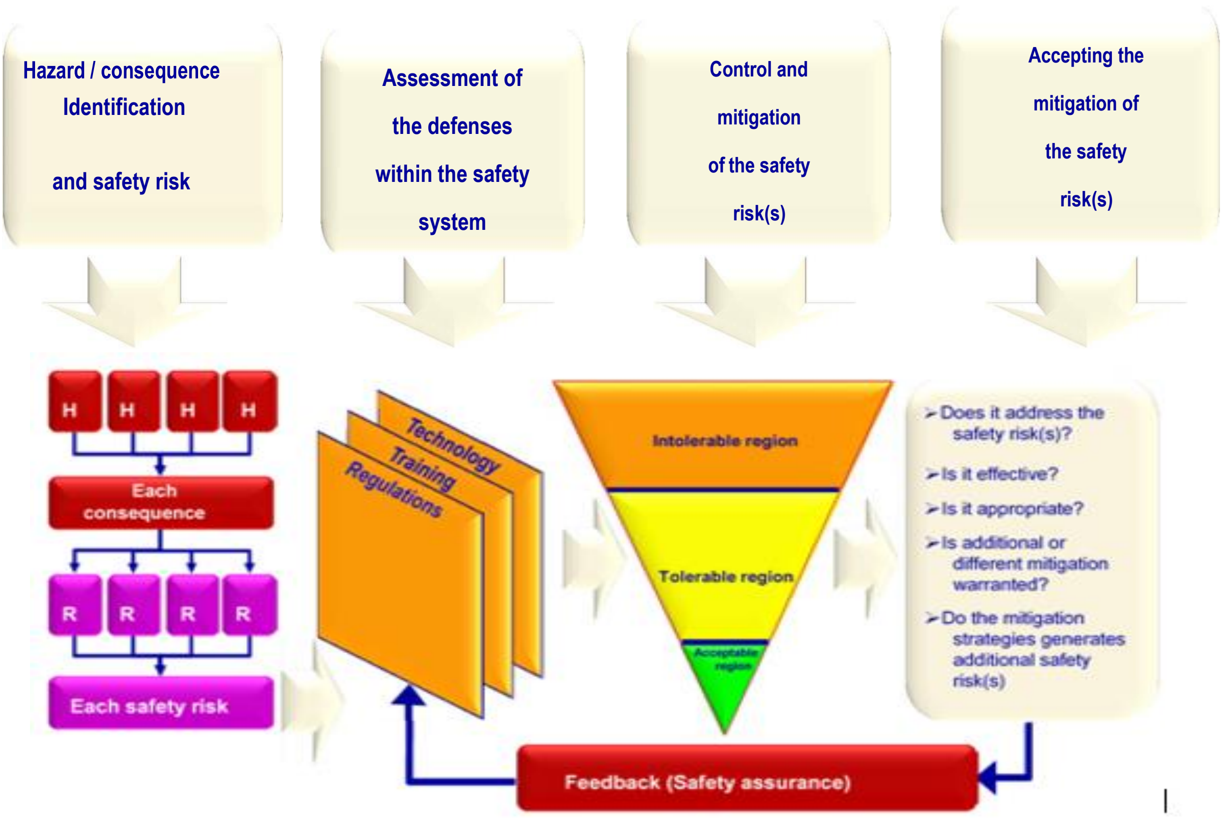

Figure 6-2 safety risk mitigation process

Figure 6-3 Presents Safety Risk Management in its entirety.

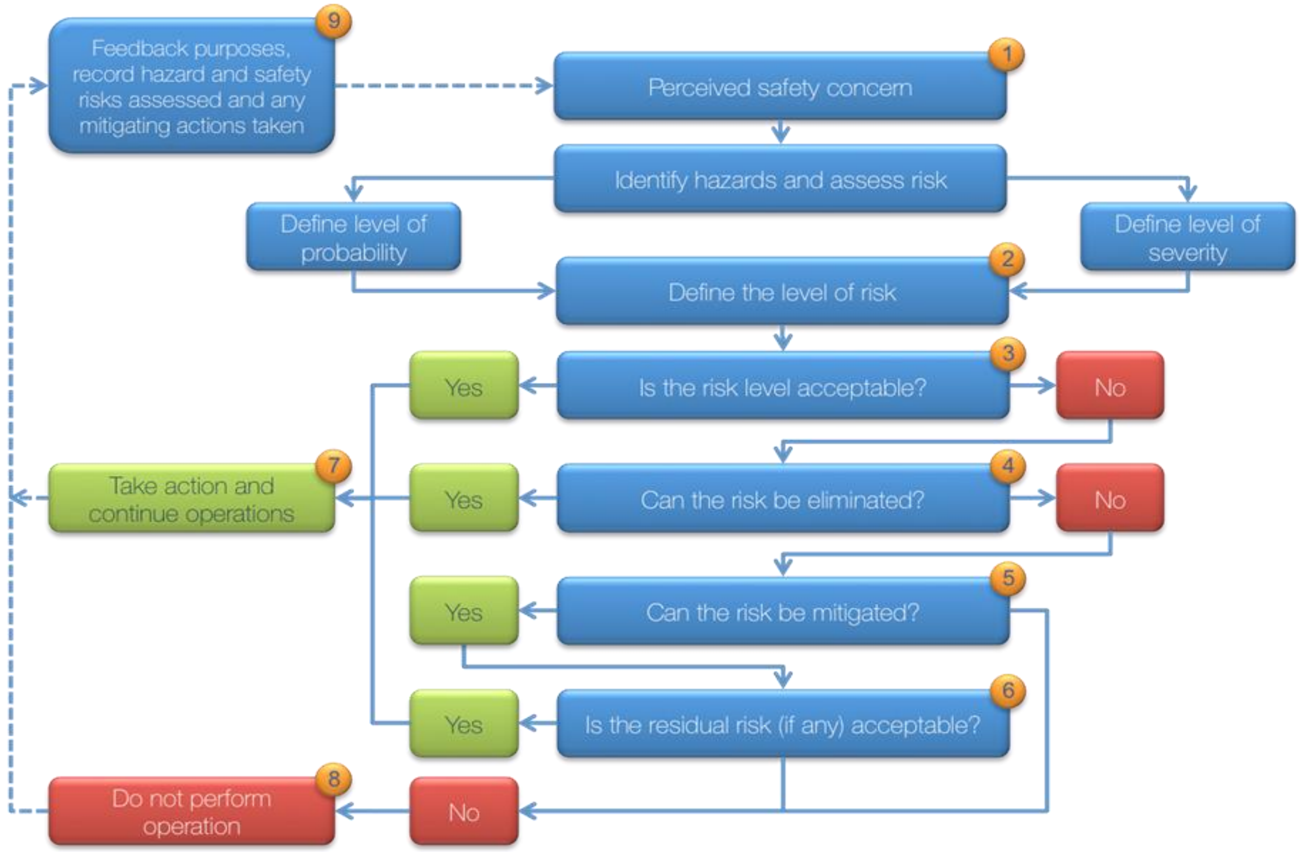

Figure 6-3. The safety risk management process

EXCEPTIONAL CIRCUMSTANCES

Personnel at operational audit area may choose not to follow the prescribes of this TGM should there be other different manual to this and thus, it prescribes otherwise than this and is in conformance to that audit area process.

CONTINUOUS IMPROVEMENT, MEASUREMENT AND ANALYSIS

This TGM will be verified, or continuously improved on, in accordance with SACAA Continuous Improvement, Measurement and Analysis GP001 – Standardised.

END