

# Aeronautical Safety Studies. Methodology

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Aerodromes inspector's classroom training and on-the-job training  
together with review of handbooks and procedures - Bilateral Course

22 – 31 July Myanmar

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# Aeronautical Safety Studies

Origin and Background

## Contents of an Aeronautical Safety Study

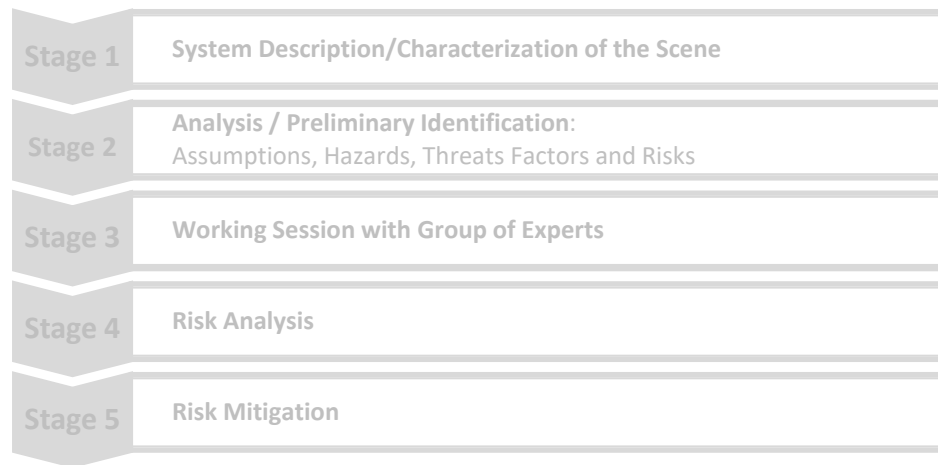
Stage 1	System Description/Characterization of the Scene
Stage 2	Analysis / Preliminary Identification: Assumptions, Hazards, Threats Factors and Risks
Stage 3	Working Session with Group of Experts
Stage 4	Risk Analysis
Stage 5	Risk Mitigation

Case Study

# Aeronautical Safety Studies

## Origin and Background

## Contents of an Aeronautical Safety Study



# Aeronautical Safety Studies

## PURPOSE

An aeronautical study is conducted to :

- assess the impact of exemptions, deviations, limitations and specific conditions operation from the aerodrome standards,
- to present alternative means of ensuring the safety of aircraft operations,
  - to estimate the effectiveness of each alternative
- and to recommend procedures to compensate for the deviation.



# Aeronautical Safety Studies

## TYPES OF NON-COMPLIANCES



Non-compliances related to  
Operating Procedures:

...

Defects in the assigning of  
responsibilities

Insufficient maintenance programs

Lack of procedures

Non-conformities or deviations related  
to the Designing of Aerodromes:

...

Defects in the visual aids

Distance between runways,  
taxiways and insufficient to objects

RESA and insufficient strips

Penetration of obstacle limitation  
surfaces

# Aeronautical Safety Studies

IGNORE THEM

NO! Never!



CORRECT THEM

This is the **most reasonable option** – if it is possible.



ACCEPT THEM (UNDER CERTAIN CIRCUMSTANCES)

When aerodrome standards cannot be met due to physical, topographical or similar limitations related to the location of the aerodrome;

EQUIVALENT LEVEL OF SAFETY NEED TO BE GUARANTEED!



WHAT TO DO WITH THE  
NON-COMPLIANCES?



SAFETY  
STUDIES



# Aeronautical Safety Studies

## SAFETY MANAGEMENT SYSTEM



*Certified aerodrome shall implement a safety management system acceptable to the State/CAA.  
[ref: A14 ICAO]*



Reference documents /guidance material - ICAO



A14 – Aerodromes

A19 – Safety Management

Doc 9774 - Manual on Certification of Aerodromes

Doc 9859 – Safety Management Manual



# Aeronautical Safety Studies

## SMS COMPONENT 2. SAFETY RISK MANAGEMENT



### SMS Element 2.1 Hazard identification

**2.1.1** The service provider shall develop and maintain a formal process that ensures that hazards associated with its aviation products or services are identified.

**2.1.2** Hazard identification shall be based on a combination of **reactive, proactive and predictive methods** of safety data collection.

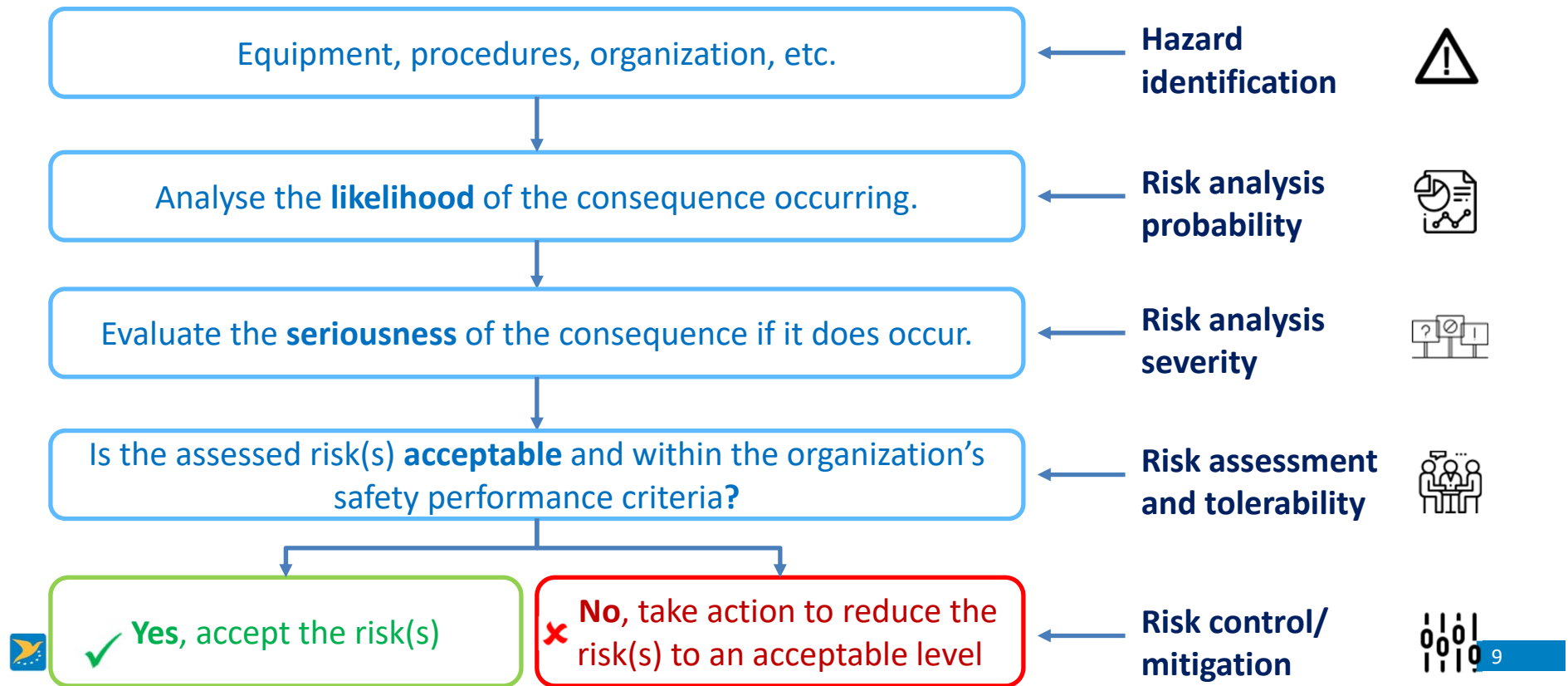
### SMS Element 2.2 Safety risk assessment and mitigation

The service provider shall develop and maintain a process that ensures analysis, assessment and control of the safety risks associated with identified hazards.



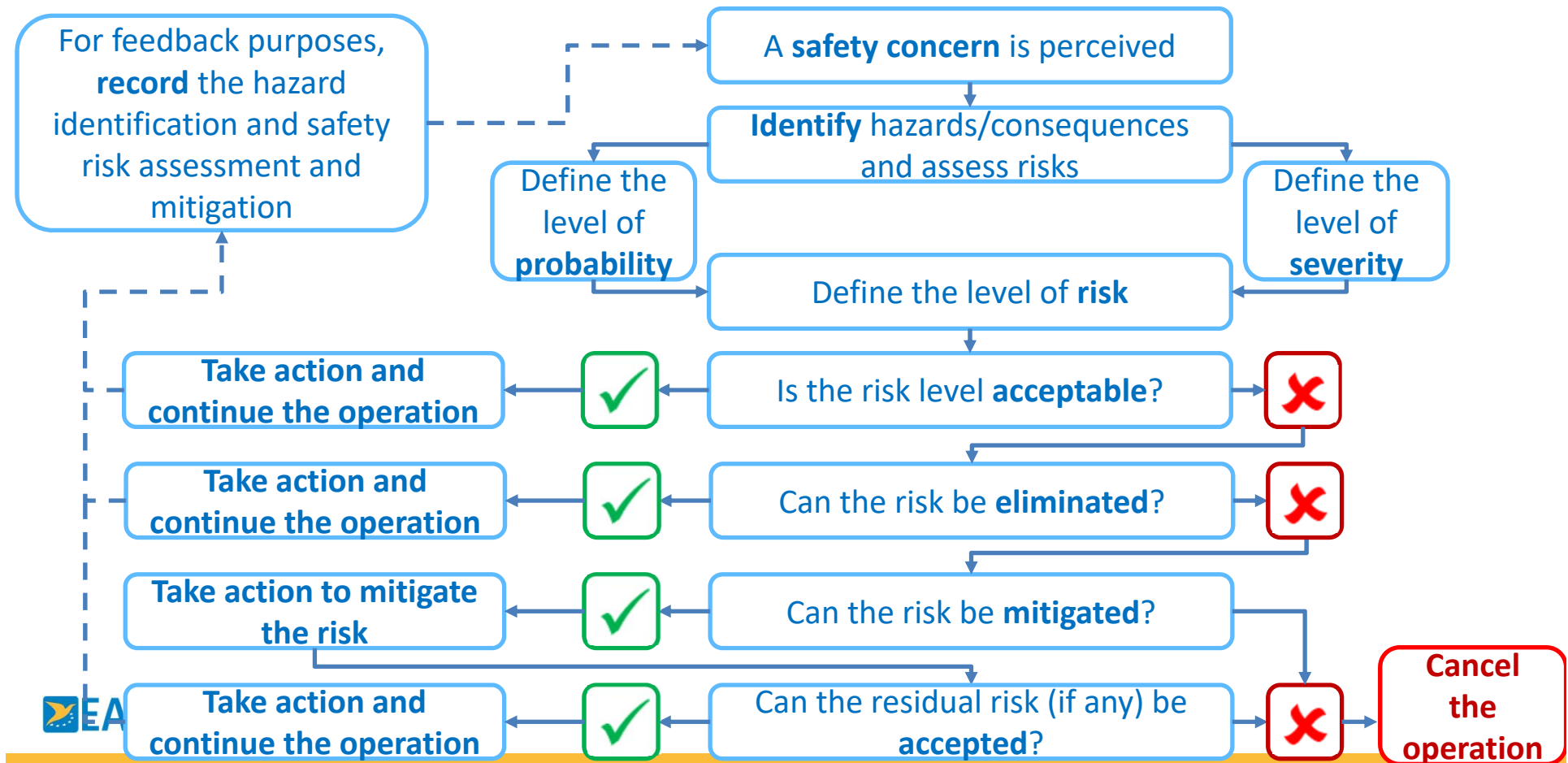
# Aeronautical Safety Studies

## THE SAFETY RISK MANAGEMENT PROCESS



# Aeronautical Safety Studies

## THE SAFETY RISK MANAGEMENT PROCESS



# Aeronautical Safety Studies

## SAFETY STUDIES



REF: ICAO - Document 9774, Chapter 3, Section E - EXEMPTIONS

3E.1.1 The CAA may exempt, in writing, an aerodrome operator from complying with specific provisions of these regulations.

3E.1.2 Before the CAA decides to exempt the aerodrome operator, the CAA must take into account all safety-related aspects.

3E.1.3 An exemption is subject to the aerodrome operator complying with the conditions and procedures specified by the CAA in the aerodrome certificate as being necessary in the interest of safety.

3E.1.4 When an aerodrome does not meet the requirement of a standard or practice specified in regulation 3A.3, the CAA may determine, after carrying out aeronautical studies, only if and where permitted by the standards and practices, the conditions and procedures that are necessary to ensure a level of safety equivalent to that established by the relevant standard or practice.

3E.1.5 Deviation from a standard or practice and the conditions and procedures referred to in regulation 3B.4 shall be set out in an endorsement on the aerodrome certificate.



# Aeronautical Safety Studies



REF: ICAO - Doc. 9774, Appendix 3 –Aeronautical studies



**DEFINITION:** *It is a study of an aeronautical problem to determine the possible solutions and to choose a solution that is acceptable without affecting safety.*



**PURPOSE:** *Evaluate the consequences of deviations, provide alternative means for guaranteeing safety levels, evaluate the effectiveness and recommend procedures.*



**APPLICATION:** *They are usually carried out during the planning stages of a new airport or during the Certification of an existing airport.*



**TECHNICAL ANALYSIS:** *Justification of the deviation on the basis that an equivalent level of safety can be achieved through other means.*



**APPROVAL OF DEVIATIONS:** *On occasions the only way to guarantee an equivalent level of safety is by applying alternative procedures and publishing precautionary warnings.*



# Aeronautical Safety Studies

Origin and Background

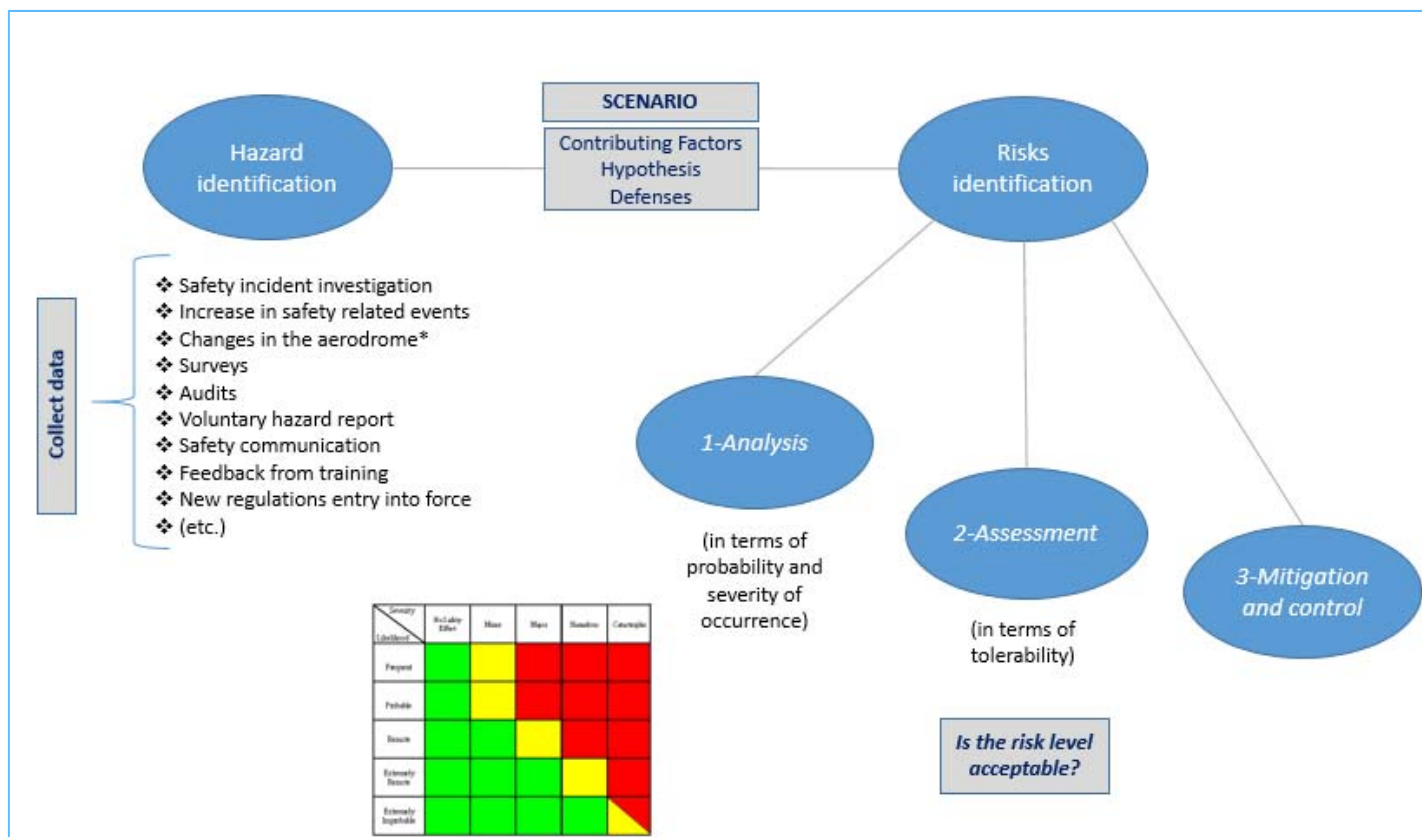
## Contents of an Aeronautical Safety Study

Stage 1	System Description/Characterization of the Scene
Stage 2	Analysis / Preliminary Identification: Assumptions, Hazards, Threats Factors and Risks
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Case Study

# Aeronautical Safety Studies

## Contents of an Aeronautical Safety Study



# Aeronautical Safety Studies

## Stage 1

## System Description/Characterization of the Scene

The **characterization of the scenario** is carried out through an **analysis** (in accordance with the scope of the aeronautical study and focused on how may affect to the **safety aspects**), that is extended to:

- *The **airport** and the **surrounding environment**.*
- *The technical and operational **resources** that are employed.*
- *The special characteristics of the **demand** (current and future).*

**Conclusions** shall be expressed at the end of each evaluated part.



# Aeronautical Safety Studies

## Stage 1

### System Description/Characterization of the Scene



**AIRPORT**: configuration of the movement area and its components (runway and taxiways system, and apron). Physical data of the airfields and define their reference codes + manner in which their components are used (operating limitations and conditions of use according to the type of aircraft, strategy for using the runways, etc.).



**PHYSICAL SCENARIO**: set of impacts introduced by the **aerodrome's environment**. Terrain, weather, restrictions of an environmental nature and the Master Plan or Airport Development Plan are elements to be studied. **Up-to-date data shall be considered.**



# Aeronautical Safety Studies

## Stage 1

### System Description/Characterization of the Scene



**CNS/ATM SCENARIO:** Technical and operational resources used to provide service to aircraft (current state and predictable evolution of the ANS at the aerodrome). Description of the air traffic services, the surrounding air space and its categorization, the listing of the types of radio navigation aids and procedures available....



**TYPE OF OPERATIONS:** Type of the **aircraft** that are intended to use the airport, type of the **operations expected** (visual / instrument, commercial / recreational, etc.), **volume and distribution** of the operations (number of movements, peak hours, etc.) and **composition of the fleet** (turboprops / jets, heavy / medium / light, etc.).

# Aeronautical Safety Studies

## Stage 2

## Analysis / Preliminary Identification

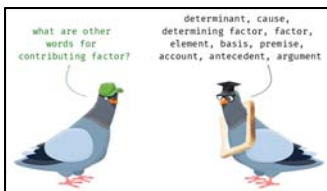
### 1- Initial assumptions and hypotheses



### 2- Hazard Identification



### 3- Identification of contributing factors, threats and defenses



### 4- Preliminary identification of risks



# Aeronautical Safety Studies

## Stage 2

## Analysis / Preliminary Identification



### 1- Initial assumptions and hypotheses:

- *Established by the authors of the Study, it allows for the simplification of certain analysis; however, it shall be determined that said assumptions are well founded.*
- *A **detailed description** shall be provided of the initial assumptions specified in the study, which may have an impact on the conclusions thereof.*

# Aeronautical Safety Studies

## Stage 2

## Analysis / Preliminary Identification



### 2- Hazard Identification:

*COLLECT DATA: A **preliminary identification** of hazards shall be carried out using **similar situations***

- *In the Safety Studies done to justify deviations from Standards, the existing **non-compliances are the hazards** used as a basis to develop the **risk assessment**.*

- ❖ Safety incident investigation
- ❖ Increase in safety related events
- ❖ Changes in the aerodrome\*
- ❖ Surveys
- ❖ Audits
- ❖ Voluntary hazard report
- ❖ Safety communication
- ❖ Feedback from training
- ❖ New regulations entry into force
- ❖ (etc.)



# Aeronautical Safety Studies

## Stage 2

## Analysis / Preliminary Identification



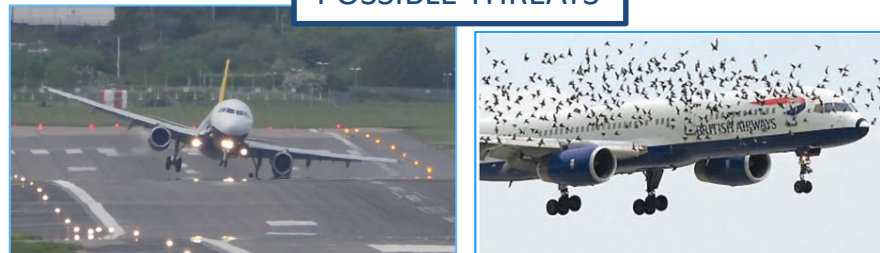
### 3- Identification of contributing factors: threats and defenses

- The **contributing factors** represent all those aspects relative to **infrastructures, facilities, operating procedures, prevailing weather conditions, traffic types and density, etc.**, described in the characterization of the scenario section, which may be related to the identified hazards and their consequences.

#### POSSIBLE DEFENCES



#### POSSIBLE THREATS



# Aeronautical Safety Studies

## Stage 2

## Analysis / Preliminary Identification



### 4- Preliminary identification of risks:

- *All the hazards shall have an associated risk, the probability and severity analysis will determine their tolerability; a priori, no risk associated with the identified hazards shall be ruled out.*
- *On occasions it may not be easy to define the final risks based on the hazards; in other cases, defining some potential risks is required, which will be a tool used to facilitate the identification and evaluation of said **final risks**.*



# Aeronautical Safety Studies

## Stage 2

## Analysis / Preliminary Identification

*Assumptions, Hazards, Threats, Factors and Risks*

Example of stage 2 – analysis / preliminary identification

HAZARDS	DEFENSES	FACTORS	POTENTIAL RISKS	FINAL RISKS
Inadequate design of the stopbar lights electrical system, allowing all the lights to fail simultaneously	Horizontal signalling maintenance system	Low visibility	Runway incursion	Collision of an aircraft operating on the runway with another aircraft
	Taxiway centreline lighting system			
	ATC Tower support	Night operations		
	Publication of airfield information in AIP	Traffic density		
No signs at runway holding points	Monitoring of the stopbar lights' electrical circuit			Slight increase in ATC workload
	LVP with taxiing "in blocks/partitions"			
	A preliminary lights check is conducted and 1 per hour in LVC			

# Aeronautical Safety Studies

## Stage 3

### Working Session with Group of Experts



- The result of the analysis conducted in stages 1 & 2 has to be exposed and discussed into a **GROUP OF EXPERTS** of a multidisciplinary nature.
- It is important to invite all the **possible stakeholders** to collect their opinions and experiences (pilots, air traffic controllers, etc.).
- The technical and operational knowledge of the **experts** may play an **essential role** in identifying and evaluating hazardous situations and the factors involved, which require a thorough understanding of the system and the specific operating scenario.



# Aeronautical Safety Studies

## Stage 3

### Working Session with Group of Experts

The **tasks** that must be carried out by the group of experts in the different meetings must be determined. Which are the **following**:



*Validation of the initial hypothesis.*



*Evaluation of the identified hazards and the factors, threats and defenses associated with them.*



*Additional identification of the hazards and their effects on the operation of the aircraft, tailored to the specific operational environment and the object of the study.*



*Initial validation of the preliminary identified risks and additional identification.*

# Aeronautical Safety Studies

## Stage 3

### Working Session with Group of Experts

The **tasks** that must be carried out by the group of experts in the different meetings must be determined. Which are the **following**:



*Validation of the probability of occurrence of each one of the identified risks in the case that qualitative methods are used.*



*Validation of the severity associated with each one of the identified risks.*



*Validation of the mitigating measures proposed.*

# Aeronautical Safety Studies

## Stage 3

## Working Session with Group of Experts

### Registers and documents – as a result of the working session



**PRELIMINARY DOCUMENTATION RELATED TO THE STUDY:** *Presentation of the object of the study, assumptions, defenses, preliminary identification of the hazards and risks, preliminary analysis, mitigating measures, etc., that the organizer provides to the experts along with the invitation to the meeting so that they can analyze this documentation prior to the meeting in order to better prepare and carry out the tasks expected of them during the meeting.*



**FINAL AND APPROVED MEETING MINUTES,** *which must serve to prove that the specified tasks have been carried out.*

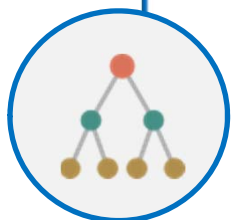


**SIGNED LIST OF ATTENDEES:** *All relevant personnel from the airport manager's office shall be convened, as well as safety, operational and SMS experts, and other involved personnel such as the supplier of air navigation services and air carriers. The names of the attendees will be included as well as the organization they belong to, the position they hold in the organization, and a brief description of each professional profile as it relates to the object of the study.*

# Aeronautical Safety Studies

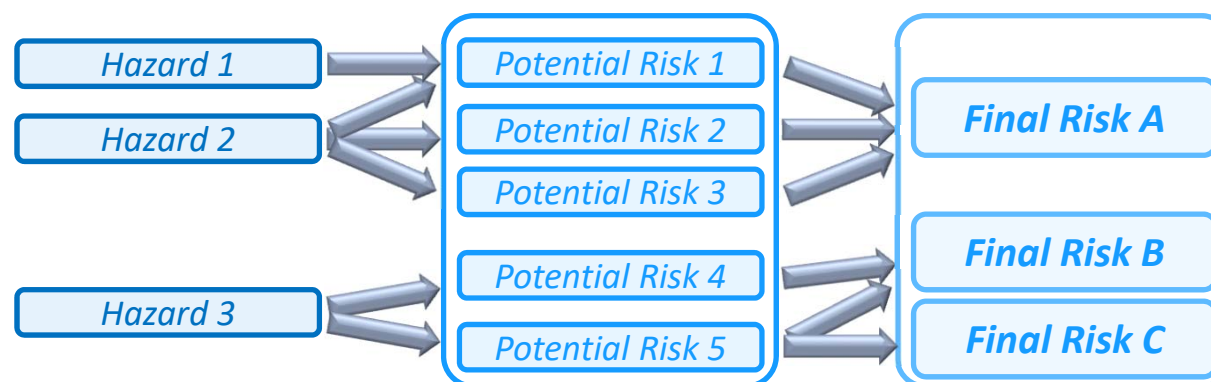
## Stage 4

## Risk Analysis



### Classification and Grouping of Risks:

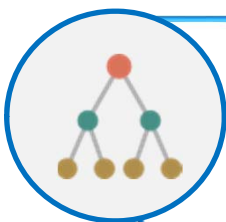
- *Prior to the assessment/evaluation of the risks, a classification and/or grouping shall be carried out to facilitate the subsequent treatment of these risks.*
- *For the purpose of providing a better foundation to the categorization and classification of said defined risks, it is recommended that **Fault Tree Analysis (FTA)** or similar techniques be used whenever possible:*



# Aeronautical Safety Studies

## Stage 4

## Risk Analysis



### Classification and Grouping of Risks:

- *Note about Fault Tree Analysis (FTA)*

- *A Fault Tree is a hierarchical model used to analyze the probability that an event will occur. The event is typically a low probability, high consequence risk or outcome.*
- *A fault tree creates a visual record of a system that shows the logical relationships between events and causes*

# Aeronautical Safety Studies

## Stage 4

## Risk Analysis



### Risk probability assessment:

- For each of the identified risks, an evaluation of its probability or frequency of occurrence shall be conducted according to a **probability of occurrence classification diagram** that has been established as a reference by the aeronautical authority or by international references such as ICAO or other internationally renowned organizations.
- **Qualitative and Quantitative methods** can be used (or mixed), and information about previous accidents, incidents and events has to be considered.



# Aeronautical Safety Studies

## Stage 4

## Risk Analysis

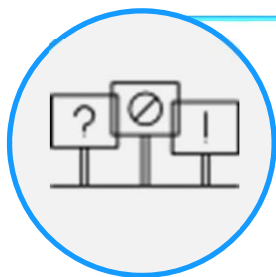
Example of frequency Matrix

	LIKELIHOOD	QUALITATIVE DEFINITION	QUANTITATIVE DEFINITION
5	Frequent	<i>Is expected to occur in most circumstances</i>	$>10^{-3}$ / operation
4	Occasional	<i>Will probably occur at some time</i>	$>10^{-5}$ and $<10^{-3}$ / operation
3	Remote	<i>Might occur at some time</i>	$>10^{-7}$ and $<10^{-5}$ / operation
2	Improbable	<i>Could occur at some time</i>	$>10^{-9}$ and $<10^{-7}$ / operation
1	Extremely improbable	<i>May occur only in exceptional circumstances</i>	$<10^{-9}$ / operation

# Aeronautical Safety Studies

## Stage 4

## Risk Analysis



### Risk severity assessment:

- For each one of the effects of the identified risks an **evaluation of the severity of each risk** will be carried out, which will indicate the seriousness of the occurrence of said evaluated risk.
- In the assigning of severity for **risk of collisions**, the available information shall taken into account dimensions, frangibility, materials, etc. of the obstacles involved.
- **Severity classification references** shall be established by the Aeronautical Authority or as an alternative, documents published by ICAO shall also be considered acceptable.





# Aeronautical Safety Studies

## Stage 4

## Risk Analysis

SEVERITY CLASS	DEFINITION	EXAMPLES
<b>CATASTROPHIC</b>	Accident, equipment destroyed, loss of aircraft and multiple deaths.	<ol style="list-style-type: none"> <li>1. <i>Mid-air collision between aircraft.</i></li> <li>2. <i>Collision between aircraft and/or other object during take-off or landing.</i></li> </ol>
<b>HAZARDOUS</b>	A large reduction in safety margins / no safety barriers remaining, the outcome is not under control, major equipment damage and serious or fatal injury to a number of people.	<ol style="list-style-type: none"> <li>1. <i>Runway incursion, significant potential, (extreme action to avoid collision).</i></li> <li>2. <i>Attempted take-off or landing on a closed or engaged runway.</i></li> <li>3. <i>Take-off / landing incidents, such as undershooting or overrunning.</i></li> <li>4. <i>Controlled Flight Into Terrain is only marginally avoided.</i></li> </ol>
<b>MAJOR</b>	Serious incident or accident, significant reduction in safety margins, serious equipment damages and injury to persons	<ol style="list-style-type: none"> <li>1. <i>Runway incursion, ample time and distance, (no potential for a collision)</i></li> <li>2. <i>Collision with obstacle on apron / parking position (hard collision).</i></li> <li>3. <i>Near Controlled Flight Into Terrain.</i></li> <li>4. <i>Missed approach with ground contact of the wing ends during the touch down.</i></li> <li>5. <i>Large fuel puddle near the aircraft while passengers are on board.</i></li> </ol>
<b>MINOR</b>	Nuisance, operations limitations, minor incident and small damages to aircraft, vehicles or objects.	<ol style="list-style-type: none"> <li>1. <i>Hard braking during landing or taxiing.</i></li> <li>2. <i>Damage due to jet blast (objects).</i></li> <li>3. <i>Collision between maintenance vehicles on service road.</i></li> <li>4. <i>Breakage of drawbar during pushback (damage to the A/C).</i></li> <li>5. <i>Slight excess of MTOW.</i></li> <li>6. <i>Aircraft is rolling into PAX-bridge (slight collision) - forklift is tilting.</i></li> </ol>
<b>NEGLECTABLE</b>	Non-significant consequences and circumstances which may lead to a non-significant reduction of safety and no immediate effect on safety.	<ol style="list-style-type: none"> <li>1. <i>Increase in work load for the crew during taxiing.</i></li> <li>2. <i>Slight increase of braking distance.</i></li> <li>3. <i>Car losing baggage.</i></li> </ol>

# Aeronautical Safety Studies

## Stage 4

## Risk Analysis



### Risk evaluation matrix:

Risk probability		Risk severity				
		Catastrophic	Hazardous	Major	Minor	Negligible
		A	B	C	D	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

# Aeronautical Safety Studies

## Stage 4

## Risk Analysis



### Risk evaluation matrix:

Risk index range	Description	Recommended action
5A, 5B, 5C, 4A, 4B, 3A	High risk	Cease or cut back operation promptly if necessary. Perform priority risk mitigation to ensure that additional or enhanced preventive controls are put in place to bring down the risk index to the moderate or low range.
5D, 5E, 4C, 4D, 4E, 3B, 3C, 3D, 2A, 2B, 2C, 1A	Moderate risk	Schedule performance of a safety assessment to bring down the risk index to the low range if viable.
3E, 2D, 2E, 1B, 1C, 1D, 1E	Low risk	Acceptable as is. No further risk mitigation required.

# Aeronautical Safety Studies

## Stage 5

## Risk Mitigation



- A detailed description of the proposed **mitigating measures** shall be carried out, including the deadlines established for implementing them.
- During the experts working session an **explicit validation** of each one of these measures shall be carried out, which shall be included in the documents used to record the result of this session.
- Likewise, the effects that the **proposed measures** will have on airport operations shall be explained. Specifically, and as a minimum, it must describe the manner in which compliance with the measures is going to be guaranteed: Responsible personnel from within the organization; procedures, notifications; information in the AIP; inclusion in the Airport Manual and in the Safety Management System.

# Aeronautical Safety Studies

## Stage 5

## Risk Mitigation



*Mitigation measure objective can be:*

- *Eliminate the hazard.*
- *Reduce the probability that an accident takes place.*
- *Reduce the effects or consequences of an accident.*

# Aeronautical Safety Studies

## Stage 5

## Risk Mitigation



### *Types of measure:*

- *About airport's infrastructure and installations*
- *About airport's operational procedures*
- *Others: Training, organizational structure, etc.*

# Aeronautical Safety Studies

## Stage 5

## Risk Mitigation



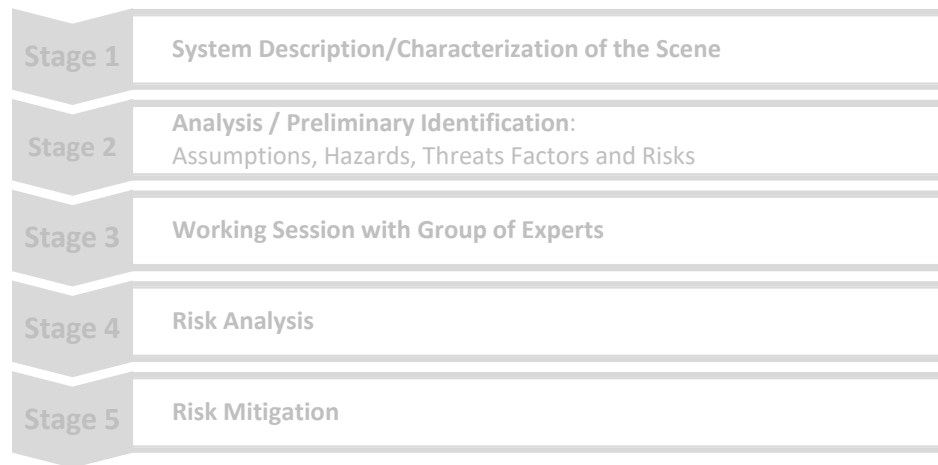
*After mitigation measures has been implemented, their effectiveness has to be checked.*

- ✓ *If the hazard has been eliminated, there is nothing else to do with it.*
- ✓ *If they don't eliminate the hazard, a new risk assessment is required.*
- ✓ *Mitigation measures can result in new hazards. They have to be analyzed.*

# Aeronautical Safety Studies

Origin and Background

## Contents of an Aeronautical Safety Study





# Aeronautical Safety Studies



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