



Safety assessments related to infrastructure requirement non- compliances

Iraia Irazabal

Aerodrome Certification

Bangkok, Thailand, 20 to 24 of January 2020

Aeronautical Safety Studies

Origin and Background

Contents of an Aeronautical Safety Study

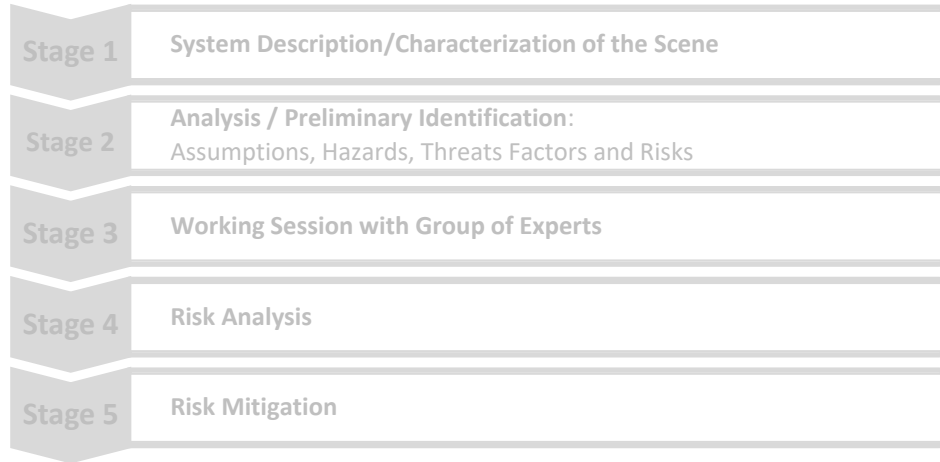


Case Study

Aeronautical Safety Studies

Origin and Background

Contents of an Aeronautical Safety Study



Case 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-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





SMS COMPONENT 2. SAFETY RISK MANAGEMENT

SMS Element 2.1 Hazard identification

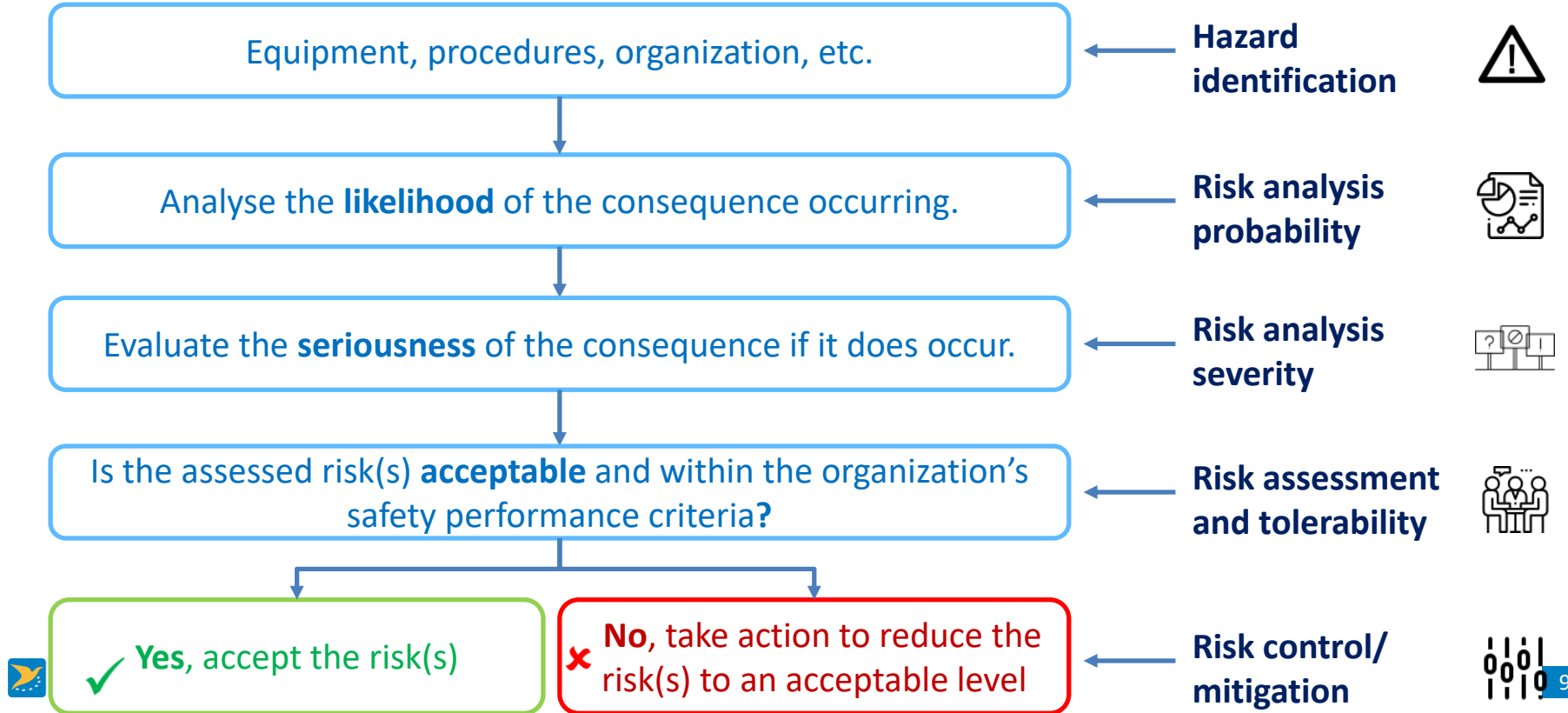
- 2.1.1** The service provider shall develop and maintain a formal process that ensures that hazards associated with its aviation products or services are identified.
- 2.1.2** Hazard identification shall be based on a combination of **reactive, proactive and predictive methods** of safety data collection.

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

For feedback purposes, **record** the hazard identification and safety risk assessment and mitigation

A **safety concern** is perceived

Identify hazards/consequences and assess risks

Define the level of **probability**

Define the level of **severity**

Define the level of **risk**

Is the risk level **acceptable**?

Take action and continue the operation



Can the risk be **eliminated**?

Take action and continue the operation



Can the risk be **mitigated**?

Take action to mitigate the risk



Can the residual risk (if any) be **accepted**?

Take action and continue the operation



Cancel the operation



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



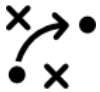
REF: ICAO - Doc. 9774, Appendix 3 –Aeronautical studies



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.*



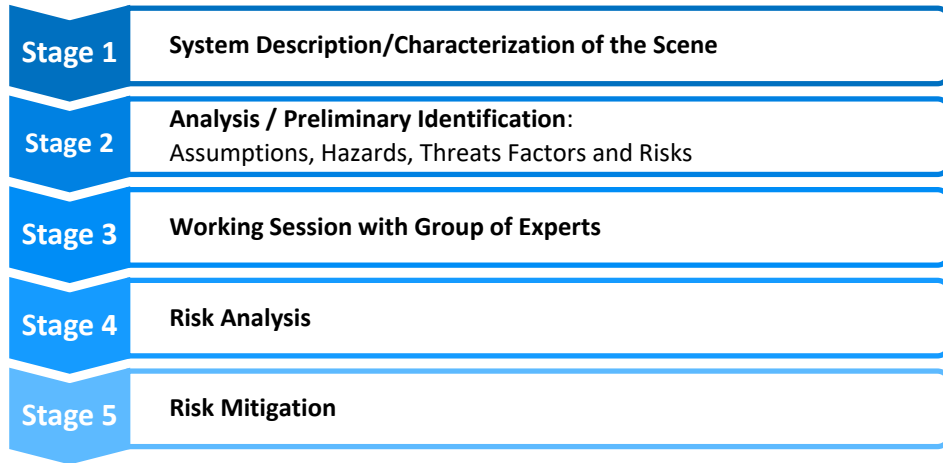
APPROVAL OF DEVIATIONS: *On occasions the only way to guarantee an equivalent level of safety is by applying alternative procedures and publishing precautionary warnings.*



Aeronautical Safety Studies

Origin and Background

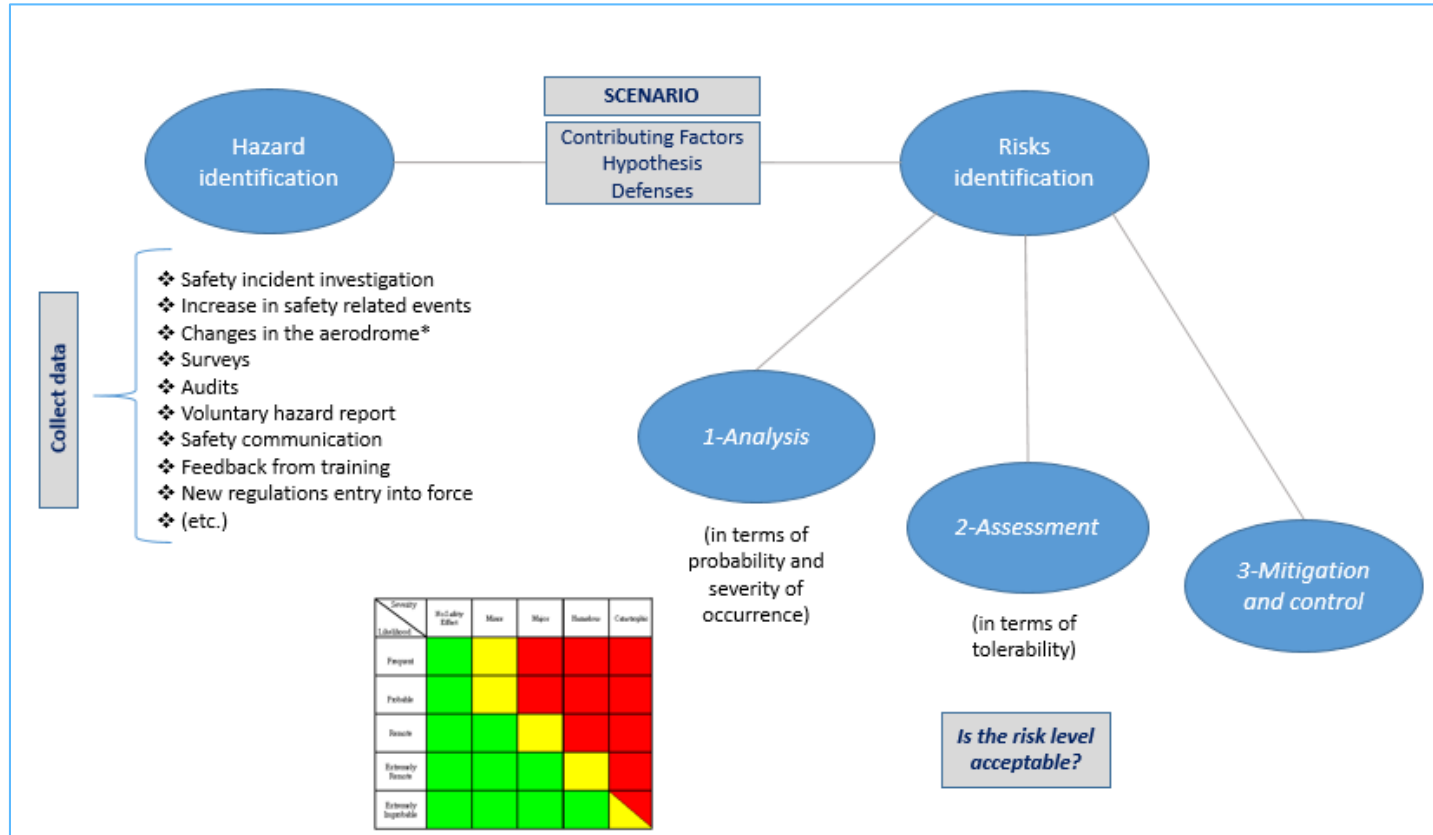
Contents of an Aeronautical Safety Study



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

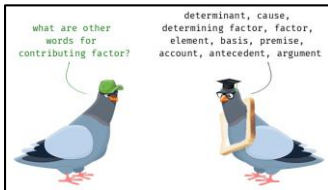
1- Initial assumptions and hypotheses



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



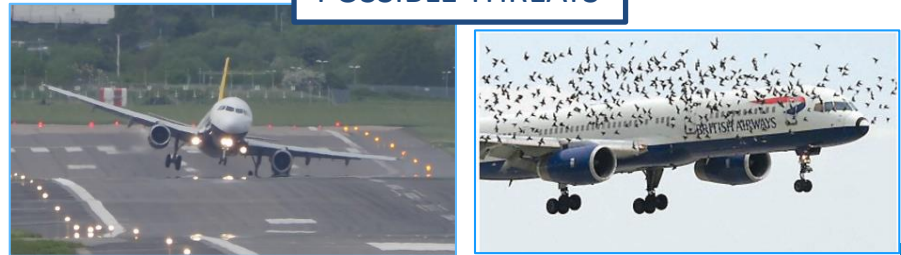
3- Identification of contributing factors: threats and defenses

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

Aeronautical Safety Studies

Let's see an example...



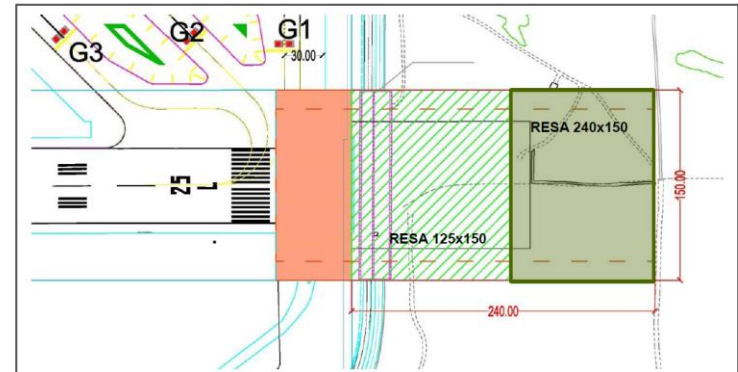
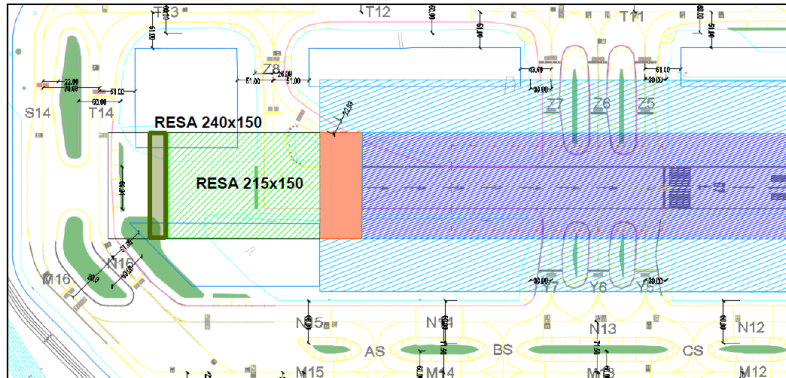
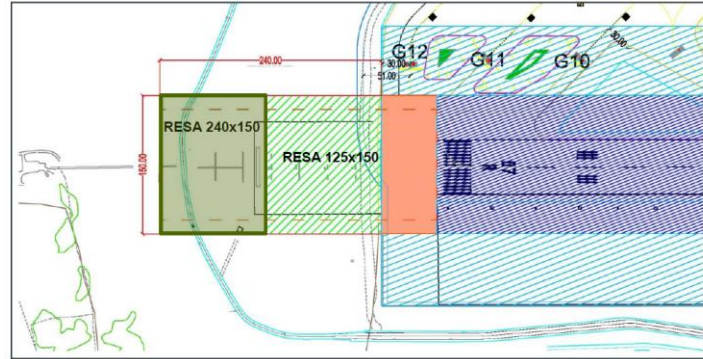
Aeronautical Safety Studies

Stage 2

Analysis / Preliminary Identification

2- Hazard Identification

PELIGRO	DESVIACIÓN
P1. Dimensiones de RESA 25R (215 x 150)	CS-ADR-DSN-C.215 (a)
P2. Dimensiones de RESA 25L(125 x 150)	
P3. Dimensiones de RESA 07R (125 x 150)	



Aeronautical Safety Studies

Stage 2

Analysis / Preliminary Identification

1- Initial assumptions and hypotheses

General hypotheses

GENERALES	
1	<p>Base de datos: período comprendido desde enero 2016 hasta diciembre 2016. La tipología de la flota se estima que no variará de forma significativa los años futuros.</p>
2	<p>Simplificación de flota:</p> <ul style="list-style-type: none">- Unificación de modelos de la misma familia.- Las operaciones cuya pista era desconocida, se han repartido de forma proporcional a la operación de cada modelo de aeronave, en cada pista del aeropuerto.- Las aeronaves sobre las que se desconocía el modelo, pero se conocía la compañía que lo operaba se han asignado a la aeronave de dicha compañía que más ha operado en el 2016 en el Aeropuerto de Barcelona-El Prat. <p>En el Aeropuerto de Barcelona-El Prat la aeronave que registra el mayor número de operaciones es el Airbus A320.</p>
3	<p>Las condiciones meteorológicas en el Aeropuerto de Barcelona-El Prat no suponen un agravante para los riesgos considerados, ya que cuenta con procedimientos específicos de control de meteorología adversa que mitigan sus efectos.</p>
4	<p>Los servicios de tránsito aéreo, las ayudas visuales y el servicio meteorológico existente establecen un escenario CNS/ATM adecuado para que la seguridad operacional no se vea afectada como consecuencia de los incumplimientos relativos a zona de operaciones en pista.</p>
5	<p>Las características generales del aeropuerto (en cuanto a campo de vuelos, detalle del área de movimiento, iluminación, configuraciones preferentes y capacidades) son adecuadas y no añaden peligros a los riesgos detectados.</p>

Aeronautical Safety Studies

Stage 2

Analysis / Preliminary Identification

1- Initial assumptions and hypotheses

Particular hypotheses

PARTICULARES	
6	<p>Para el cálculo de probabilidades las operaciones consideradas por obstáculo son las que se han considerado en los riesgos individuales y siguiendo las siguientes premisas:</p> <ul style="list-style-type: none">- Elementos ubicados más allá del extremo de pista, les aplicará la salida por extremo de pista en despegue y/o aterrizaje (DEP-ARR OVERRUN).- Elementos ubicados anteriores al umbral de pista, les aplicará la posibilidad de un aterrizaje corto (UNDERSHOOT).
7	<p>Probabilidades de ocurrencia del orden de 10^{-9} se consideraran como extremadamente improbable.</p>

Aeronautical Safety Studies

Stage 2

Analysis / Preliminary Identification

1- Initial assumptions and hypotheses

Mathematical methodology

MODELO MATEMÁTICO							
Probabilidad del suceso por aeronave: $P_{SUCESO} = F_{CORRECCION} \cdot P_{OCURRENCIA} \cdot P_{(>X)} \cdot P_{(>Y)} \cdot \eta_i$							
	<table border="1"> <thead> <tr> <th>Probabilidad exceder Y</th> <th>Probabilidad exceder X</th> </tr> </thead> <tbody> <tr> <td>$P_{(>Y)} = e^{-b \cdot y^m}$</td> <td>No aplicable</td> </tr> <tr> <td></td> <td>$P_{(>X)} = e^{-a \cdot x^n}$</td> </tr> </tbody> </table>	Probabilidad exceder Y	Probabilidad exceder X	$P_{(>Y)} = e^{-b \cdot y^m}$	No aplicable		$P_{(>X)} = e^{-a \cdot x^n}$
Probabilidad exceder Y	Probabilidad exceder X						
$P_{(>Y)} = e^{-b \cdot y^m}$	No aplicable						
	$P_{(>X)} = e^{-a \cdot x^n}$						
Salida Lateral							
Salida por Extremo							
a, b, n y m	Parámetros fijos y diferentes para TO y LD obtenidos por procedimiento estadístico						
Pocurrencia	Valor fijo y diferente para TOOR, LDOR, LDUS, TOVO, LDVO (*) obtenido por procedimiento estadístico						
η (fracción de movimientos)	Nº operaciones aeronave / Nº operaciones totales (en un periodo de tiempo)						
PROBABILIDAD DE SUCESO							
SALIDA LATERAL (VEER OFF)	$P_{SUCESO_TOTAL} = \sum_i F_{CORRECCION_i} \cdot P_{OCURRENCIA} \cdot P_{(>Y)} \cdot \eta_i$						
SALIDA POR EXTREMO (OVERRUN, UNDERSHOOT)	$P_{SUCESO_TOTAL} = \sum_i F_{CORRECCION_i} \cdot P_{OCURRENCIA} \cdot P_{(>X)} \cdot P_{(>Y)} \cdot \eta_i$						
Probabilidad TOTAL	Suma de todas las probabilidades por operación (despegue y/o aterrizaje) $P_{SUCESO_TOTAL} = P_{SUCESO_TOTALTO} + P_{SUCESO_TOTALLD}$						
HIPÓTESIS AL MODELO (FACTORES DE CORRECCIÓN)							
Salida Lateral	1 La probabilidad total se divide entre dos: salir por el margen derecho o por el izquierdo son sucesos independientes.						
	2 Factor de corrección relativo a la dimensión de la aeronave y la ocupación de longitud de franja en caso de salida lateral se calcula como: <ul style="list-style-type: none"> - Elementos en altura: diámetro de la circunferencia crítica (máximo entre la longitud y la envergadura) más la dimensión del obstáculo y dividido entre la longitud total de franja. - Elementos de poca altura: batalla de cada aeronave (estimada en un 30 % de la circunferencia crítica) más la dimensión del obstáculo y dividido entre la longitud total de franja. 						
Salida por Extremo	3 Corrección por uso de pista en despegue: $2,28 \cdot e^{-0,0019 \cdot (ASDA-TODR)}$ Corrección por uso de pista en aterrizaje: $2,28 \cdot e^{-0,0019 \cdot (LDA-LDR)}$ Nota: Esta corrección no es aplicable al undershoot, sólo overrun.						
	4 Localización del obstáculo: Elementos en altura: $x' = x - \frac{D_{oc}}{2}$; $y' = y - \frac{D_{oc}}{2}$ Elementos de poca altura: $x' = x - \frac{Batalla_{ave}}{2}$; $y' = y - \frac{Batalla_{ave}}{2}$						

Aeronautical Safety Studies

Stage 2

Analysis / Preliminary Identification

1- Initial assumptions and hypotheses

Incident and accident
assessment

INCIDENTE	NÚMERO
L.- Aeronave que sale del área pavimentada	1
M1.- Incidentes durante aterrizaje o despegue/ Colisión con terreno/ Incendio de aeronave	15
M2.- Hard landing	0

Nº Operaciones (enero de 2007 y diciembre de 2016): 2.981.156 operaciones

Aeronautical Safety Studies

Stage 2

Analysis / Preliminary Identification

3 - Identification of contributing factors, threats and defenses

Defences

MEDIDAS ALTERNATIVAS IMPLANTADAS	RESPONSABLE DE IMPLANTACIÓN
Programas de inspección y mantenimiento del campo de Vuelos: <ul style="list-style-type: none">- Inspección del área de movimiento- Plan de Mantenimiento del área de movimiento	Aeropuerto
Publicación en el AIP de la configuración del campo de Vuelos	Aeropuerto
Programa de inspección y mantenimiento de las ayudas a la navegación	Aeropuerto
Ayudas visuales y no visuales en pista: RWY 07L <ul style="list-style-type: none">• ILS CAT II/III	

Aeronautical Safety Studies

Stage 2

Analysis / Preliminary Identification

3 - Identification of contributing factors, threats and defenses

Physical scenario:
contributing factors

...

Factors related with
CNS/ATM, with the
configuration of the
airport, ...

- El clima es mediterráneo con veranos calurosos e inviernos suaves, siendo temperatura media anual de 16,1°C.
- Se presenta una media de 54 días de lluvia al año, con unas precipitaciones medias anuales de 579 mm. Los días de tormentas se producen una media de 19 días año.
- La visibilidad alcanza valores superiores a 800 m el 99,90% del tiempo y por encima de los 400 m el 99,96% del tiempo.
- El techo de nubes se encuentra por encima de los 60 m el 99,94% del tiempo y por encima de 30 m el 100% del tiempo.
- Únicamente se encuentra en condiciones de visibilidad inferior a 400 m o base de nubes inferior a 30 m en un 0,04% de las mediciones.
- La componente del viento perpendicular a las pistas 25/07 es inferior a 20 nudos el 99% de las ocasiones.

Aeronautical Safety Studies

Stage 2

Analysis / Preliminary Identification

4- Preliminary identification of risks

PELIGRO	RIESGO INDIVIDUAL	RIESGO GLOBAL
P1	Ri1. Salida por extremo de pista en despegue (DEP OVERRUN)	Colisión, daños o efectos por salida de pista de una aeronave operando en pista por causa de un elemento o terreno
P2	Ri2. Salida por extremo de pista en aterrizaje (ARR OVERRUN)	
P3	Ri3. Aterrizaje corto (UNDERSHOOT)	

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.*

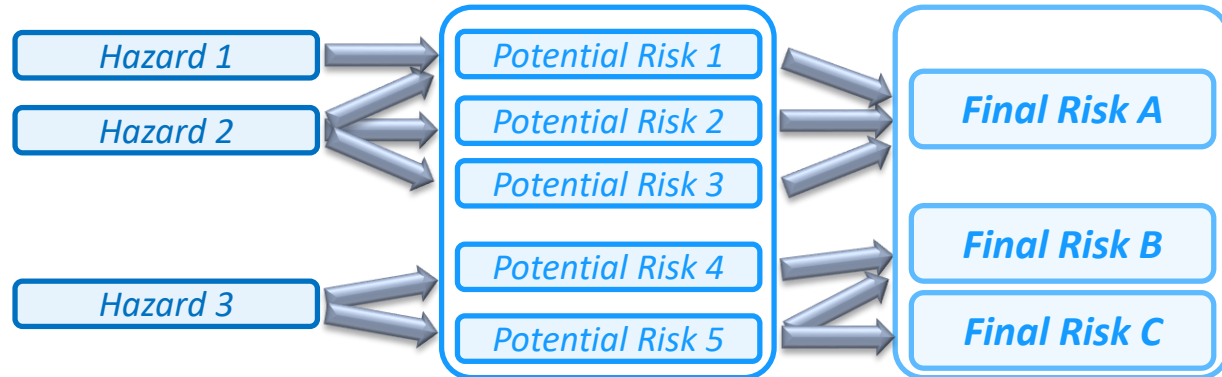
Aeronautical Safety Studies

Stage 4

Risk Analysis

Classification and Grouping of Risks:

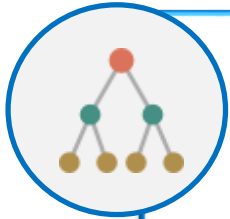
- *Prior to the assessment/evaluation of the risks, a classification and/or grouping shall be carried out to facilitate the subsequent treatment of these risks.*
- *For the purpose of providing a better foundation to the categorization and classification of said defined risks, it is recommended that **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

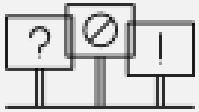
Example of frequency Matrix

	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
CATASTROPHIC	Accident, equipment destroyed, loss of aircraft and multiple deaths.	<ol style="list-style-type: none"> 1. <i>Mid-air collision between aircraft.</i> 2. <i>Collision between aircraft and/or other object during take-off or landing.</i>
HAZARDOUS	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"> 1. <i>Runway incursion, significant potential, (extreme action to avoid collision).</i> 2. <i>Attempted take-off or landing on a closed or engaged runway.</i> 3. <i>Take-off / landing incidents, such as undershooting or overrunning.</i> 4. <i>Controlled Flight Into Terrain is only marginally avoided.</i>
MAJOR	Serious incident or accident, significant reduction in safety margins, serious equipment damages and injury to persons	<ol style="list-style-type: none"> 1. <i>Runway incursion, ample time and distance, (no potential for a collision)</i> 2. <i>Collision with obstacle on apron / parking position (hard collision).</i> 3. <i>Near Controlled Flight Into Terrain.</i> 4. <i>Missed approach with ground contact of the wing ends during the touch down.</i> 5. <i>Large fuel puddle near the aircraft while passengers are on board.</i>
MINOR	Nuisance, operations limitations, minor incident and small damages to aircraft, vehicles or objects.	<ol style="list-style-type: none"> 1. <i>Hard braking during landing or taxiing.</i> 2. <i>Damage due to jet blast (objects).</i> 3. <i>Collision between maintenance vehicles on service road.</i> 4. <i>Breakage of drawbar during pushback (damage to the A/C).</i> 5. <i>Slight excess of MTOW.</i> 6. <i>Aircraft is rolling into PAX-bridge (slight collision) - forklift is tilting.</i>
NEGLECTABLE	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"> 1. <i>Increase in work load for the crew during taxiing.</i> 2. <i>Slight increase of braking distance.</i> 3. <i>Car losing baggage.</i>

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 it is. No further risk mitigation required.

Aeronautical Safety Studies

Let's see an example...



Aeronautical Safety Studies

Stage 4

Risk Analysis

Severity assessment:
definition of the
categories

	OPERACIÓN	TRIPULACIÓN	ATC
CATASTRÓFICO	<ul style="list-style-type: none"> Colisión Pérdida de fuselaje Destrucción de equipamiento Pérdida total de control Múltiples muertes 	<ul style="list-style-type: none"> Muertos Heridos graves Incapacitados 	<ul style="list-style-type: none"> Pérdida total de separación Ningún mecanismo independiente puede prevenir esa severidad
PELIGROSO	<ul style="list-style-type: none"> Gran reducción de márgenes de seguridad o capacidades funcionales de la aeronave Lesiones serias, con heridos graves Daños mayores al equipamiento 	<ul style="list-style-type: none"> Excesiva carga de trabajo que no puede asegurar que la tripulación pueda realizar sus tareas adecuadamente 	<ul style="list-style-type: none"> Gran reducción de la separación sin control total de la tripulación o ATC Desviación de una o más aeronaves de su trayectoria deseada provocando maniobras bruscas de evasión
MAYOR	<ul style="list-style-type: none"> Reducción significativa de márgenes de seguridad o capacidades funcionales de la aeronave Lesiones a las personas 	<ul style="list-style-type: none"> Significativo aumento de la carga de trabajo que provoque una reducción en la habilidad del operador en responder a condiciones operativas adversas 	<ul style="list-style-type: none"> Gran reducción de la separación con control total de la tripulación o ATC. Pequeña reducción de la separación sin control total de la tripulación o ATC
MENOR	<ul style="list-style-type: none"> Reducción leve de márgenes de seguridad o capacidades funcionales de la aeronave: interferencias, limitaciones operativas, utilización de procedimientos de emergencia, etc. 	<ul style="list-style-type: none"> Leve aumento de la carga de trabajo 	<ul style="list-style-type: none"> Leve reducción de la separación o capacidad de control de la tripulación o ATC
SIN EFECTO	<ul style="list-style-type: none"> Sin efectos 	<ul style="list-style-type: none"> Sin efectos 	<ul style="list-style-type: none"> Leve aumento de la carga de trabajo ATC

Tabla 6. Probabilidad cualitativa de los riesgos globales

Aeronautical Safety Studies

Stage 4

Risk Analysis

Severity assessment
for the identified risks

PELIGRO	UBICACIÓN	SEVERIDAD
P1. Dimensiones de RESA 25R (215 x 150)	RESA 25R RECOMENDADA	CATASTRÓFICO
P2. Dimensiones de RESA 25L (125 x 150)	RESA 25L RECOMENDADA	CATASTRÓFICO
P2. Dimensiones de RESA 07R (125 x 150)	RESA 07R RECOMENDADA	CATASTRÓFICO

Aeronautical Safety Studies

Stage 4

Risk Analysis

Probability
assessment: definition
of the categories

PROBABILIDAD		DEFINICIÓN CUALITATIVA	DEFINICIÓN CUANTITATIVA
5	Frecuentes	Probable que ocurra muchas veces (ha ocurrido frecuentemente).	$>10^{-3}$ por operación
4	Razonablemente probable	Probable que ocurra algunas veces (ha ocurrido infrecuentemente).	$>10^{-6}$ y $<10^{-3}$ por operación
3	Remoto	Improbable, pero es posible que ocurra (ocurre raramente).	$>10^{-7}$ y $<10^{-6}$ por operación
2	Improbable	Muy improbable que ocurra (no se conoce que haya ocurrido).	$>10^{-9}$ y $<10^{-7}$ por operación
1	Extremadamente improbable	Casi inconcebible que el evento ocurra.	$<10^{-9}$ por operación

Aeronautical Safety Studies

Stage 4

Risk Analysis

Probability assessment for the identified risks

Elemento/ desviación	Riesgo Individual	Severidad	Probabilidad	Probabilidad por obstáculo
DIMENSIONES DE LA RESA 26R (216 x 160)	Aterrizaje corto por 07L (UNDERSHOOT) antes de RESA 25R declarada	CATASTRÓFICO	3,39202E-10	3,092E-09
	Salida por extremo durante el aterrizaje por 25R (ARR OVERRUN) más allá de la RESA 25R declarada		2,71717E-09	
	Salida por extremo durante el despegue por 25R (DEP OVERRUN) más allá de la RESA 25R declarada		3,58959E-11	
DIMENSIONES DE LA RESA 26L (126 x 160)	Aterrizaje corto por 07R (UNDERSHOOT) antes de RESA 25L declarada	CATASTRÓFICO	1,41075E-12	1,949E-08
	Salida por extremo durante el aterrizaje por 25L (ARR OVERRUN) más allá de la RESA 25L declarada		6,55708E-10	
	Salida por extremo durante el despegue por 25L (DEP OVERRUN) más allá de la RESA 25L declarada		1,88317E-08	
DIMENSIONES DE LA RESA 07R (126 x 160)	Aterrizaje corto por 25L (UNDERSHOOT) antes de RESA 07R declarada	CATASTRÓFICO	2,23251E-10	6,444E-09
	Salida por extremo durante el aterrizaje por 07R (ARR OVERRUN) más allá de la RESA 07R declarada		4,09809E-12	
	Salida por extremo durante el despegue por 07R (DEP OVERRUN) más allá de la RESA 07R declarada		6,21623E-09	

Aeronautical Safety Studies

Stage 4

Risk Analysis

Probability assessment for the identified risks

Common Risk Factors in Runway Excursion Events	Aeropuerto de Barcelona - El Prat		
	¿Se aplican medidas para evitar este factor?	Afirmación / Medida	Implantado
Runways not constructed and maintained to maximize effective friction and drainage	SI	2	SI
		6	SI
Late or inaccurate runway condition reports	SI	2	SI
		6	SI
Inadequate snow and ice control plan	SI (*)	2	SI
		5	SI
Not closing a runway when conditions dictate	SI	6	SI
		7	SI
		7	SI
Incorrect or obscured runway markings	SI	4	SI
		7	SI
Failure to allow use of wind-preferential runways	SI	2	SI
		6	SI
		7	SI
Inadequate runway end safety area (RESA) or equivalent system	SI	13	SI
		14	SI
Inappropriate obstacle assessments	SI	14	SI

Recommended Mitigations. Airport Operators	Aeropuerto de Barcelona - El Prat		
	¿Se aplica la medida?	Afirmación / Medida	Implantado
Policies	SI	2	SI
		5	SI
		6	SI
	SI	7	SI
		2	SI
		6	SI
Standard Operating Procedures	SI	11	SI
	SI	11	SI
	SI	4	SI
	SI	4	SI
		6	SI
	SI	7	SI
		2	SI
	SI	6	SI
7		SI	
2		SI	
SI	2	SI	
SI	2	SI	

Tabla 14: Recommended Mitigations. Airport Operators. "Reducing the Risk of Runway Excursions. Report of the Runway Safety Initiative" Flight Safety Foundation

Aeronautical Safety Studies

Stage 4

Risk Analysis

Probability
assessment for
the identified
risks

RIESGO GLOBAL	PROBABILIDAD
Colisión, daños o efectos por salida de pista de una aeronave operando en pista por causa de un elemento o terreno de severidad CATASTROFICA	Extremadamente Improbable

Aeronautical Safety Studies

Stage 4

Risk Analysis

		A	B	C	D	E
		CATASTRÓFICO	PELIGROSO	MAYOR	MENOR	NINGUN EFECTO
5	FRECUENTE	RIESGO ALTO	RIESGO ALTO	RIESGO ALTO	RIESGO MEDIO	RIESGO BAJO
4	RAZONABLEMENTE PROBABLE			RIESGO ALTO	RIESGO MEDIO	
3	REMOTO		RIESGO MEDIO	RIESGO BAJO		
2	EXTREMADAMENTE REMOTO		RIESGO MEDIO			
1	EXTREMADAMENTE IMPROBABLE		RIESGO MEDIO	RIESGO BAJO		

EUROPEAN AVIATION SAFETY

RIESGO	PROBABILIDAD	TOLERABILIDAD
Colisión, daños o efectos por salida de pista de una aeronave operando en pista por causa de un elemento o terreno de severidad CATASTROFICA	EXTREMADAMENTE IMPROBABLE	RIESGO MEDIO (1A)

Aeronautical Safety Studies

Stage 5

Risk Mitigation

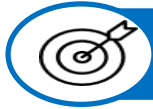


- A detailed description of the proposed **mitigating measures** shall be carried out, including the deadlines established for implementing them.
- During the experts working session an **explicit validation** of each one of these measures shall be carried out, which shall be included in the documents 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

Let's see an example...



Aeronautical Safety Studies

Stage 5

Risk Mitigation

MEDIDAS DE MITIGACIÓN PENDIENTES DE IMPLANTACIÓN	RESPONSABLE DE IMPLANTACIÓN	FECHA DE IMPLANTACIÓN
Mantener un seguimiento dentro del SGS que tenga como finalidad aprovechar cualquier oportunidad de ampliar las dimensiones de la RESA	Aeropuerto	Plan de mejora continua
Difusión de la información en los próximos Comité Local de Seguridad en Pista	Aeropuerto	PRÓXIMO CLSP

Aeronautical Safety Studies



Safety assessments related to infrastructure requirement non-compliances

www.eu-sea-app.org
easa.europa.eu/connect



Your safety is our mission.

An Agency of the European Union 