CASE STUDIES

AERODROME

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Practical Case # 1.1: Hazard Identification

Aerodromes

An airport is performing an initial safety review of the procedures in the context of SMS implementation.

The aim of this review is the detection of hazards associated with current operating practices following proactive SMS methodologies (ICAO Doc. 9859 2.13.11 b, which involve actively seeking hazards in the existing processes).

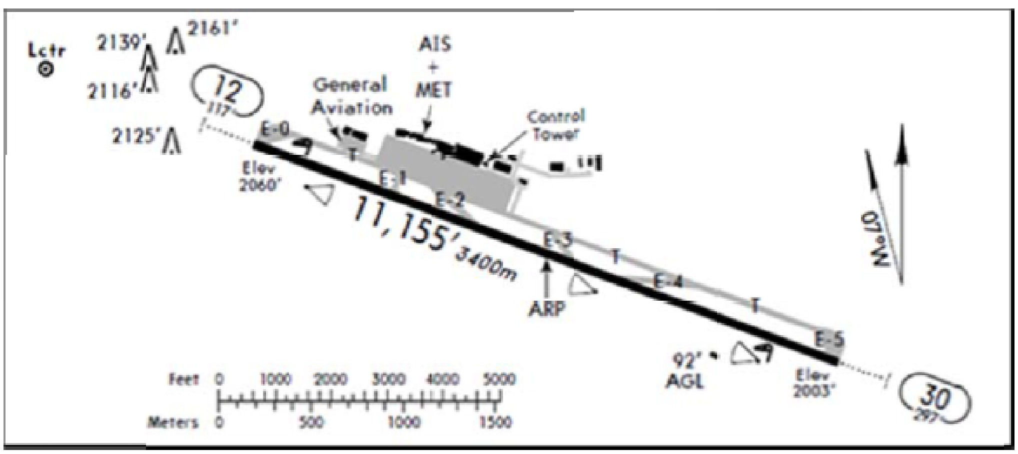
The operating procedure subject to review is related with the preparation of the aerodrome in case of Low Visibility Conditions.

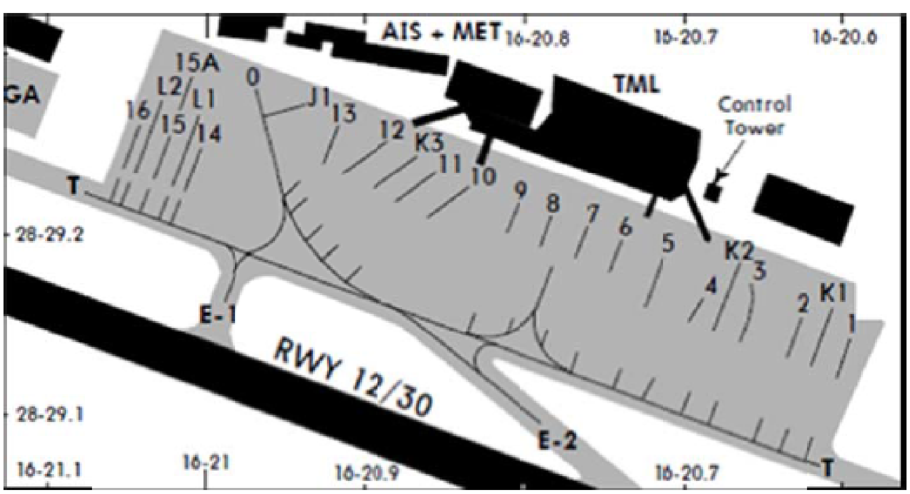
The layout of the aerodrome, a d the special characteristics of local weather generate a steady pace of clouds that can reduce visibility partial or totally in the airfield, apron and/or control tower.

Low ceiling and reduced visibility are safety hazards for all types of aviation. NTSB Statistics indicate that ceiling and visibility are contributing factors in 24 percent of all general aviation accidents between 1989 and early 1997. They were present in 37 percent of commuter/air taxi accidents during the same period.

Aerodromes

AERODROME CHARTS





LOW VISIBILITY PROCEDURES

1. INITIATION AND TERMINATION

A. Besides general procedures, Low Visibility Procedures (LVP) shall be applied when:

a) RVR values of any transmissometer are 1.700 m or below.

b) Cloud base height is 350 ft RWY 12 or 450 ft RWY 30, or below.

c) Under ATC/TWR criteria, when rapid deterioration of meteorological conditions recommends so.

B. Preparation Phase:

a. It will be activated by ATC/TWR if conditions provided by MET Office (forecasted or observed) reach visibility values below 2.000 m and/or height of cloud base# at or below 500 ft in RWY 12 (or 600 ft RWY 30 or below).

b. ATC/TWR will inform the Aerodrome Operations and CNS Departments about the activation of Preparation Phase and ask them to interrupt any task that may affect the operations

c. ATC/TWR will communicate through the frequency to all the ground vehicles in the aircraft maneuvering area and request them to leave the movements area.

d. ATC/TWR will activate runway and taxiway Stopbars

e. Aerodrome Ops will check that the Obstacle Free Zones (OFZ), ILS Critical Areas (LCAs) and Localiser Sensitive Areas (LSAs) are cleared

f. Aerodrome Ops will activate lighting systems, including LVP lights and ramp/service roads lights

C. Operations Phase:

a. The operations phase will be commenced when the RVR falls to 1.700 m or the height of cloud base# is below 350 ft. RWY 12 or 450 ft RWY 30, or below

b. ATC/TWR will notify the start of this phase to Aerodrome Ops/CNS Departments.

c. Ground operations will be restricted during this phase. If, exceptionally, some vehicle needs to access the maneuvering area, entries shall be made only through the taxiways and guided by a "FOLLOW ME" vehicle.

D. Cancellation Phase:

a. Low Visibility Procedures shall be cancelled when meteorological conditions, provided by MET Office, are as follow:

- RVR values reported by all transmissometers are above or equal to 2.000 m.
- Cloud ceiling is above or equal to 800 ft.
- Strong trend towards improvement of meteorological conditions, as indicated by the MET Office.

b) ATC/TWR will inform the Aerodrome Operations and CNS Departments about the cancellation of the LVP

c) CNS will remove the ATIS message indicating LVP Operation

2. GENERAL

A. Runways 12/30 are authorized for take-off in low visibility conditions.

B. Any notified or detected incident that may affect the LVP, as well as the variations of the operational minimum, shall be immediately communicated to the aircraft and ATC units implicated.

C. When RVR is 600 m or below, the criteria of “only one aircraft in the maneuvering area” shall

2.1. Ground Operations

A. Under LVC, ground vehicles access to the movement area will be restricted as much as possible. The following actions will be taken by Aerodrome Ops:

a) Support vehicles will be placed at the entrance of the Southern perimeter road (access to RWY 30) and Northern perimeter road (access to RWY 12). They will stay there during LVP operation phase to prevent any vehicle access by those points to the perimeter road.

b) A “Follow me” car will inspect runway and taxiway entry points, as well as OFZs, LSAs and LCAs

c) Another “Follow me” car will guide aircraft to its assigned position and operate the aircraft bridges

d) The Electrical Power Plant will not perform preventive maintenance tasks that could compromise the availability of lighting systems.

e) Ground handling agents (ramp, fuel, catering, etc.) shall maximize caution and strictly observe compliance with the Ramp Safety Procedures.

B. In particular, the movement of vehicles (including Security car by the perimeter road is prohibited, except in emergencies or extraordinary cases, always with permission from ATC.

3. COMMUNICATIONS FAILURE

A. Whenever a vehicle operating in the manoeuvering area suffers a communication failure shall proceed as follows:

a) Departing aircraft, taking extreme caution, shall continue taxiing up to its clearance limit, hold position and wait for a “Follow me” vehicle that will guide the aircraft to the appropriate parking stand.

b) Arriving aircraft, once the runway and the ILS sensitive area are vacated, shall hold position entering the taxiway, where it shall wait for a "Follow me" vehicle in order to be guided to the appropriate parking stand.

c) Vehicles at runway shall vacate it to the South, maintaining runway and taxiway vacated and shall stay with all the lights on. Vehicles at taxiway shall vacate it northwards, maintaining taxiway vacated

6. CNS SYSTEMS

A. It is key to have information on the correct functioning of radio and communications equipment and report any incidence. The following issues will be considered while LVP are in force:

a) No maintenance tasks are allowed;

b) Continuous monitoring of the operation of the various ILS subsystems, communications systems ground/air, hot lines, recording equipment, etc.

B. Any circumstance which may affect LVP procedures will be immediately informed to ATC

Question: Practical Case # 1.1: Hazard Identification

In the context of the case scenario described mentioned above review the applicable procedure of Practical Case 1.1 “Hazard Identification” and fill the Hazard Log included below with at least four (4) hazards:

1. Identify hazards associated to elements of the procedure
2. Classify hazard Generic Component in accordance with the CICTT Hazard taxonomy
3. Formulate Hazard Specific Component
4. Identify Unsafe Events
5. Select proper Outcome and Ultimate Consequences that can be generated as a result of the hazards release for the worst credible scenario

Annex. Hazard Log

Hazard Log							
Operation/System	**Hazard Nº**	**Hazard Taxonomy**		**Unsafe Event**	**Potential Outcome/ Ultimate Consequence**		**Comments**
		Generic Component	**Specific Component**				
1.B c)	EXAMPLE -ADR	ENV. Adverse weather conditions	Activation of LVP by ATC	Late activation due to rapid deterioration of visibility	RI	Aircraft seriously damaged and/or single fatalities and multiple injuries	Collision between A/C1 leaving RWY and A/C 2 TWY

Practical Case # 2.1: Hazard Analysis

Aerodromes
An aerodrome operator is requested by its CAA to draft a safety action plan to prevent Runway Incursions (RI). The aerodrome has decided to develop a hazard analysis based on a bowtie model. The scope of the bowtie will be focused on RWY Incursions associated to ground vehicle operations. Take the following elements as inputs for the bowtie: • Hazard: ORG. Operational Policies & Procedures / Ground vehicle(s) circulating in the proximity of protected areas of an active RWY • Unsafe Event: Incorrect presence of ground vehicle in RWY protected area

A Runway Incursion (RI) is defined as "Any occurrence at an aerodrome involving the incorrect presence of an aircraft vehicle or person on the protected area of a surface designated for the landing and take-off of aircraft". (ICAO Doc 4444 - PANS-ATM). It should be noted that this 'incorrect presence' may be a consequence of a failure of a pilot to comply with a valid ATC clearance or their compliance with an inappropriate ATC clearance

The effect of a RI is an increased risk of serious collision for aircraft on the ground:

- When collisions occur off the runway, the aircraft and/or vehicles involved are usually travelling relatively slowly
- When a collision occurs on the runway, at least one of the aircraft involved will often be travelling at considerable speed which increases the risk of significant aircraft damage and the severity of the consequences therefrom, including serious or fatal injury
- Types of RI:
  - Ground vehicle runway access contrary to ATC clearance
  - Issued ATC taxi clearance in conflict with another ATC clearance
  - Towed aircraft runway crossing contrary to ATC clearance
- Typical Scenarios:
  - Driver-related situation. Procedures at an airport allow the driver of a contractor's vehicle to operate airside without an escort (or the prior receipt of appropriate training and formal approval dependent upon satisfactory completion thereof). A driver of such a vehicle enters an active runway without first obtaining ATC clearance.
- Operational Performance
  - According to FAA sources (see Ref. below), the most common type of operational error/deviation involved an air traffic controller temporarily forgetting about an aircraft or vehicle. The second most common type of operational error/deviation is inadequate coordination among air traffic controllers, usually concerning runway crossings. Readback/hearback errors complete the picture of operational deviations that resulted in runway incursions.
  - From the ground vehicle perspective, the majority of the runway incursions involve airport vehicles, construction and emergency response vehicles, maintenance taxis and private vehicles. In most of the cases, the driver never contacted air traffic control. In other occasions, the driver read back the clearance correctly, but then executed a different maneuver

[Ref: www.skybrary.aero and FAA RWY Safety Report 2008]

Question: Practical Case # 2.1: Hazard Analysis

Perform a hazard analysis based on Bow Tie through in accordance with the scenario selected above. Follow the approach below:

a. Formulate the Hazard and Identify the associated Unsafe Event
b. Identify Safety (Triggering) Events.
c. Identify Potential Outcome and Consequences
d. Identify Preventive and Recovery Barriers/Controls

Complete the results in the form presented in Annex

Annex. Hazard Analysis Template

Hazard:					
Safety Events	**Preventive Controls/Barriers**	**Unsafe (Top) Event**	**Recovery Controls/Barriers**	**Potential Outcome / Ultimate**	**Comments**

Practical Case # 2.2: Risk Assessment

Aerodromes
As part of the development of a safety action plan for the prevention of RWY Incursions, an aerodrome operator is performing a risk analysis. During the 14-year period from 1995 through 2008 [Ref.1], commercial transport aircraft were involved in a total of 1,429 accidents with major or substantial damage. Of those, 14 accidents (1%) were RWY Incursions, being 50% of them fatal accidents (7) with a total of 129 victims. The FAA divides runway incursions into three error types: pilot deviations, ATC operational errors/deviations, and vehicle/pedestrian deviations. These error types typically refer to the last event in a chain of pilot, air traffic controller, and/or vehicle operator actions that led to the runway incursion. During the period 2004-7, such distribution of error types in the US was the following [Ref.2]: o Pilot deviation 55% o ATC Deviation: 29% o Vehicle / Pedestrian 16% The airport´s statistics have registered more than 20 RI incidents in the last 10 years. Most of them were rated with low severity and only two (2) were rated as Hazardous.

Safety Metrics (Severity)

VALUE	SEVERITY	QUALITATIVE
A	Catastrophic	Significant degradation, failure, or loss of aerodrome essential service provision (e.g: aircraft separation when taxiing)
B	Hazardous	Degradation of the safety or integrity of the aerodrome service provision (e.g: failure of communications)
C	Major	Significant performance degradation or aerodrome system failure without effects on safety (e.g: failure of redundant system)
D	Minor	Degradation of aerodrome system performance with no effect on safety (e.g: increase in delay or congestion)
E	Negligible	No effect on performance or safety of the aerodrome system

Safety Metrics (Likelihood)

VALUE	LIKELIHOOD	QUALITATIVE	QUANTITATIVE
1	Extremely Improbable	Not yet heard in the applicable aviation sector in the last 20 years	At least one in 100 years = 1/(300.000 flights x 100 years) = 3,0 x 10^{-6} Maximum once every 20 years = 6,0 x 10^{-6}
2	Improbable	Has occurred in the applicable aviation domain, once for the last 5 years	At least one in 20 years = 1/(300.000 flights x 20 years) = 3,0 x 10^{-6} Maximum once every 5 years = 1,5 x 10^{-6}

3	Remote	Has occurred in the organisation, once in last 20 years (or in accordance to memory of involved personnel)	At least one in 5 years = 1/(300.000 flights x 5 years) = 1,5 x 10^{-6}) Maximum once per year = 3,0 x 10^{-5}
4	Occasional	Has occurred several times in the applicable aviation domain, at least once per year	At least once per year = 1/(300.000 flights x 1 years) = 3,0 x 10^{-5} Maximum once per quarter = 7,5 x 10^{-4}
5	Frequent	Has occurred several times in the organisation, several times per year	At least once per quarter = 1/(300.000 flights x 0,25 years) = 7,5 x 10^{-4} Maximum once per month = 300.000 flights /12 = 2,5 x 10^{-4}

	RISK CLASSIFICATION MATRIX				
	A	B	C	D	E
5	5A	5B	5C	5D	5E
4	4A	4B	4C	4D	4E
3	3A	3B	3C	3D	3E
2	2A	2B	2C	2D	2E
1	1A	1B	1C	1D	1E

UNACCEPTABLE	Stop operation if necessary. Perform priority safety analysis to ensure that additional or enhanced preventive controls are put in place to bring down the risk index to tolerable or acceptable region
TOLERABLE	Perform safety analysis and propose mitigations to bring down the risk index in accordance with ALARP.
ACCEPTABLE	Acceptable as is. No further risk mitigation required

Question: Practical Case # 2.2: Risk Assessment

a. Estimate the risks associated to the hazards described above by using the risk classification scheme and metrics.

- Define the worst credible scenario
- Determine the severity of its consequences
- Estimate the frequency of the event
- Determine the risk index and its tolerability

Annex 1. Hazard Log

Worst Credible Case

Case	Severity	Likelihood	Risk Index	Tolerability

Practical Case # 2.3: Control and Mitigate Risk

Aerodromes
As part of the development of a safety action plan for prevention of RWY Incursions, an aerodrome operator is performing a hazard analysis. After categorizing safety risks as tolerable, the provider must identify mitigation measures to avoid such events and their consequences.

Mitigation Options

	Aerodromes
TRAINING	Review of training procedures for maintenance personnel, airport drivers, etc. : • Introduce a formal driver training and assessment program, or where already in place review against driver training guidelines. Introduce formal communications training and assessment for drivers and other personnel who operate on or near the runway • Where practicable, ensure that specific joint training and familiarization in the prevention of runway incursions, is provided to Maneuvering Area Vehicle Drivers. This may include visits to the maneuvering area to increase awareness of signage and layout where this is considered necessary
PROCEDURES	Ensure a clear and robust procedures are in place to: • Avoid the possibility of call sign confusion, use full vehicle call signs for all communications with runway operations • Verify the use of standard ICAO RTF phraseologies • Improve situational awareness, when practicable, by conducting all communications associated with runway operations using aviation English. • Significant aerodrome information which may affect operations on or near the runway, in addition to that found in NOTAMS and on the ATIS, should be provided to Maneuvering Area Drivers • Works in progress - Ensure that information about temporary work areas is adequately disseminated and that temporary signs and markings are clearly visible, adequate and unambiguous in all relevant conditions • Ensure all maneuvering Area Vehicle Drivers are briefed at the start of a shift and that situational awareness is maintained throughout the shift
TECHNOLOGY	Use appropriate technology to show when a runway is occupied, obstructed or unavailable: • Airport Surface Movement Radar (ASDE-X) provides surface surveillance to controllers by using radar and multilateration to detect aircraft and vehicles on the airport surface. It provides digital color map displays for visual and audio alerting and uses safety logic to prevent collisions within the runway environment • Moving Map Displays for Ground Vehicles a moving map display with own-ship position and airport traffic displayed (e.g., ADS-B/TIS-B/VHF Data Link). Further enhancements such as runway occupancy alerting and graphical taxi clearances provide additional benefits.

Ref: European Action Plan For The Prevention Of Runway Incursions (EAPRI)

Question: Practical Case # 2.3: Control and Mitigate Risk

Complete the hazard log with the outcome obtained from the practical cases (2.1 and 2.2)

a. Hazards to Risk Controls fields adequately filled

b. inherent Risk Assessment fields adequately filled

c. Safety Actions and residual Risk Assessment fields adequately filled

Annex 1. Hazard Log

Operation/System		
Hazard No		
Hazard Description		
Safety/Triggering Events	**1**	
	2	
	3	
	4	
	5	
	6	
Unsafe Event		
Potential Outcomes and Ultimate Consequences		

Risk Controls (Preventive and Reactive)		
No	**Description**	**Responsible**
1		
2		
3		
4		
5		
6		
7		
8		
9		

Inherent Risk Assessment (Worst Foreseeable Scenario)	
Outcome Likelihood	

Consequence Severity			
Inherent Risk			
Safety Actions			
No	Description		Responsible
1			
2			
3			
Residual Risk Assessment (Worst Foreseeable Scenario)			
Outcome Likelihood			
Consequence Severity			
Residual Risk			
Safety Performance Monitoring Requirements			
No	Description	Obtainment	Provided by
1	Do not fill		Do not fill
2			
3			
4			
5			
Management Approval	Name:	Post:	Signature:

Practical Case # 3.1: Safety Occurrence

Aerodromes
An aerodrome operator performs a safety screening on the occurrences captured by the SMS through its internal reporting system

REPORT REPORT ADR Nº1

Date	3rd October 2010 – 10:05 UTC	Status	Open
AIRCRAFT	Cessna Turbo Stationair 6	LOCATION	New place

I was issued and acknowledged a takeoff clearance by TWR for Runway 11L at C12. Part way through my takeoff roll approximately 5 KTS below Vr I observed a White and Green construction truck with an Orange and White checkered flag enter the runway ahead of my location from C10 onto the middle of Runway 11L. I aborted the takeoff and brought the aircraft to a stop between the 1,000 FT and 1,500 FT markers.

I advised Tower of my aborted takeoff and the vehicle on the runway at which point I observed the vehicle exit the runway back onto C10. I was advised by TWR that the vehicle failed to adhere to instructions from ground control to hold clear of the runway.

I was subsequently advised by TWR that they were in contact with the vehicle which would remain clear of the runway and I was issued a new takeoff clearance. I believe the cause of the event was the failure of the construction equipment driver to maintain and realize the severity of proper communication with TWR. I believe a re-occurrence could be prevented by having a Safety Officer on the ground at locations requiring construction equipment to cross active runways.

The safety database registered another similar Runway Incursion occurrence in the last two months

REPORT ADR Nº2

Date	3rd October 2013 – 11:26 UTC	Status	Open
AIRCRAFT	B777	LOCATION	New place

The crew had just landed on Runway 20C in daylight and under normal ground visibility, when they saw a vehicle ahead and were able to manoeuvre to avoid it although the aircraft left wing still passed over the moving vehicle.

The airport safety database does not contain any incident of these characteristics in the airport historical record.

Question: Practical Case # 3.1: Safety Occurrence

*I*n the context of the scenario described above, estimate individual risk by using:

1. ICAO safety risks metrics and matrix used in practical case #2.2
2. Event Risk Classification Process (ERC)

Fill the results in the templates included in the Annex (Safety Risk Report)

a.

Fill the results in the templates included in Annex (Internal Investigation Report)

Annex. Records Template

Safety Report #1			
ICAO		**ARMS ERC**	
Severity[1]		**Q1**	
Likelihood		**Q2**	
Risk Index		**Risk Index**	
Acceptability/Tolerability:		**Acceptability/Tolerability:**	
Safety Report #2			
ICAO		**ARMS ERC**	
Severity[1]		**Q1**	
Likelihood		**Q2**	
Risk Index		**Risk Index**	
Acceptability/Tolerability:		**Acceptability/Tolerability:**	

Practical Case # 3.2: Internal Investigation

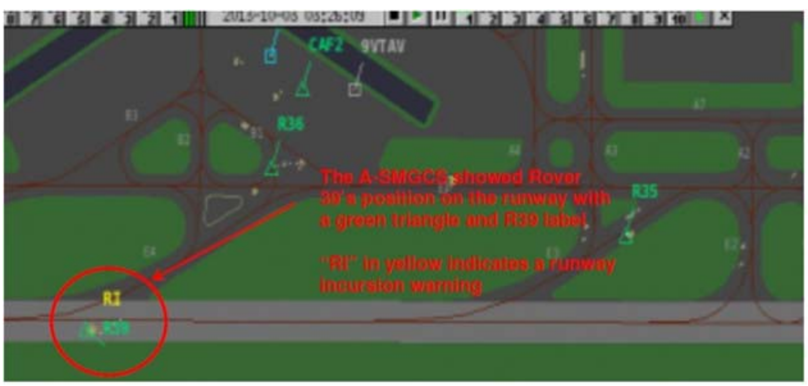
Aerodromes (Report #2)
The vehicle involved was being operated by a runway maintenance company contracted by the aerodrome operator and at the time had been occupied by a driver who held an appropriate permit which included R/T use and an assistant who did not hold one (and was not required to).

The vehicle involved was being operated by a runway maintenance company contracted by the aerodrome operator and at the time had been occupied by a driver who held an appropriate permit which included R/T use and an assistant who did not hold one (and was not required to).

The First Officer was PF on the aircraft; both pilots reported not having seen the vehicle until after touch down when the aircraft was decelerating through approximately 100 knots. As a result of the sighting, well to the left of the runway centreline, the aircraft commander had taken control, substituted manual braking for autobrake to increase the deceleration rate and made a deviation to the right to ensure clearance so that only the outer left wing passed over the vehicle.

The vehicle, operating as 'Rover 39' was instructed by the controller "responsible for the movement of ground vehicles on Runway 02/20C" to proceed to a designated holding point and "to wait for three or four minutes". The TWR controller responsible for issuing aircraft clearances to land verified visually that the vehicle had arrived at the holding point. About a minute later, a third controller "in a supervisory role", who was unaware of the earlier clearance issued by the ground vehicle controller but aware that the vehicle needed access to the runway to remove a bird, instructed the vehicle to "proceed for (the runway), prepare to enter (the runway) to pick up a dead bird". This transmission was answered by the vehicle driver's assistant with the words "Roger Tower 39 runway (20) thank you" and this read back was not challenged. Following this clearance, the vehicle entered the runway, crossing the red stop bar in accordance with prevailing practice at the time which only required it to be switched off when a corresponding aircraft clearance was issued.

Eight seconds after the incursion occurred, the TWR controller issued a landing clearance to the 777. This controller advised that he had visually scanned the runway prior to issuing this clearance but that he had not checked the A-SMGCS. It was noted that the incursion would have generated both a visual and an aural warning of the incorrect presence of the vehicle on the runway. The Investigation noted that it was normal practice not to refer to the A-SMGCS display to help assess whether a runway was clear "when visibility is good" and that controllers were able to vary the volume at which audio warnings were broadcast through the associated speakers.



The Investigation concluded that "had there been a more systematic approach to utilise the full capabilities of the (A-SMGCS) system, the controllers might have been alerted by the aural and visual warnings of Rover 39’s runway incursion".

Question: Practical Case # 3.2: Internal Investigation

Perform an internal investigation with the information provided in Practical Case above in accordance with the following steps.

1. Gather facts and chain events
2. Identify contributing safety factors
3. Identify barriers and their behavior
4. Propose safety recommendations

Internal Investigation Report #	
Sequence of Safety Factors	
Contributing Safety Factors	
Safety Barriers	
№	**Barrier Behavior**
Safety Actions	
№	

Practical Case # 4.1: Trend and Statistical Analysis

Aerodromes
An aerodrome operator is performing a monitoring plan to control the risks associated to Runway Incursions caused by ground vehicles. An SPI has been defined to estimate the exposure of the airport to RI-V. The available data for the last three years and the SPI values for the first 6 months of this year are listed in the table below

HISTORICAL DATA			MONITORING PERIOD		
YEAR	MONTH	SPI RATE	YEAR	MONTH	SPI RATE
2013	1	5,1	2016	1	9,1
	2	10,5		2	12,1
	3	5,2		3	10,2
	4	7,7		4	12,0
	5	6,2		5	12,5
	6	9,3		6	12,6
	7	2,5		7	
	8	8,2		8	
	9	8,5		9	
	10	6,7		10	
	11	7,2		11	
	12	10,8		12	
2014	1	8,5			
	2	18,1			
	3	16,9			
	4	21,5			
	5	4,9			
	6	12,9			
	7	11,1			
	8	7,0			
	9	8,9			
	10	6,9			
	11	8,7			
	12	14,0			
2015	1	6,0			
	2	8,1			
	3	13,4			
	4	10,4			
	5	10,7			
	6	9,6			
	7	7,7			
	8	7,8			
	9	6,9			
	10	11,0			
	11	12,8			
	12	4,9			

Question: Practical Case # 4.1: Trend and Statistical Analysis

For a given SPI described above "Trend and Statistical Analysis", a service provider has captured three years of data and is performing a safety monitoring process through the estimation of the SPI on a monthly basis. From these conditions, it is required to conduct:

- A trend analysis including:
  - Graphical display of the SPI series
  - Display the trend line using moving average or any alternate approach
- A monitoring plan based on the definition of alerts:
  - Calculation of the 3 alert limits (based on arithmetic mean μ and typical deviation σ) to be applied in the 4th period
  - Monitoring of the first quarter of the 4th year
- Set of a target level to be achieved in the

fourth year Fill the results in the table in Annex

-END-