AFI Comprehensive Implementation Programme (ACIP)

ICAO Safety Management Systems (SMS) Course

Handout Nº 1 – G1

Anytown City Airport accident

International Civil Aviation Organization

COMPREHENSIVE IMPLEMENTATION PROGRAMME (ACIP)
SAFETY MANAGEMENT SYSTEM (SMS) COURSE

Exercise Nº 02/01 – The Anytown City Airport accident

Scenario

The following fictitious scenario, based on real-life events, fully illustrates all of the safety system components. In the late hours of a summer Friday evening, while landing on a runway heavily contaminated with water, a twin-engine jet transport aircraft with four crew members and 65 passengers on board overran the westerly end of the runway at Anytown City airport. The aircraft came to rest in the mud a short distance beyond the end of the runway. There were no injuries to crew or passengers, and there was no apparent damage to the aircraft as a consequence of the overrun. However, a fire started and subsequently destroyed the aircraft.

Anytown City is a popular summer resort. The predominant weather for a typical summer day is low stratus and fog in the early morning, which gradually develops into convective cloud as the air warms. Severe thunderstorms are common in the early afternoon and persist until the late evening hours. The whole region where Anytown City is situated is *"thunderstorm country"* during summer.

The runway at Anytown is 4 520 feet long. It is a relatively wide runway with a steep downward slope to the west. It is served by a low-power, short-range, non-directional beacon (NDB), unreliable in convective weather. Runway lighting is low-intensity, and there are no approach lights or visual approach aids. It is a classic *"black-hole"* approach during night landings.

The flight had originated at the airline's main base, 400 km away. This was the second-to-last flight for the flight crew that day. They had reported for duty at 11:30 hours and were due to be relieved at 22:00 hours. The crew had been flying a different schedule for the last three weeks. This was the beginning of a new four-day schedule on another route. It had been a

typical summer afternoon, with thunderstorms throughout the entire region. Anytown City had been affected by thunderstorms during the early afternoon. No forecast was available, and the pilot-in-command (PIC) had elected to delay the departure.

The flight schedule was very tight, and the PIC's decision to delay created a number of additional delays for subsequent flights. The dispatcher working the flight did not bring to the flight crew's attention the need to consider a contaminated runway operation at Anytown, and did not review the landing performance limitations with them. After a long delay, the PIC decided to add contingency fuel and depart.

Visual conditions were present at Anytown, although there were thunderstorms in the vicinity of the airport, as well as a persistent drizzle. With no other reported traffic, they were cleared for a night visual approach. After touchdown, the aircraft hydroplaned and overran the end of the runway slightly above taxiing speed.

The PIC was a very experienced pilot. He had been with the airline for many years, accumulating several thousand hours of flying time as a second-in-command (SIC) in two other types of large jet aircraft. However, he had limited experience with the aircraft type he was flying the night of the accident. He had not had the occasion to fly into Anytown before because the larger aircraft types he had been flying previously did not operate into Anytown. This was his first month as a PIC. He was a well-balanced individual, with no personal or professional behavioural extremes.

At the time of the accident the SIC was very inexperienced. He had recently been hired by the airline and had only been flying the line for about a month. He had flown into Anytown on two other occasions with another PIC, but only during the day. His training records indicated standard performance during induction into the airline's operations.

Investigation

Initially, the investigation would focus on determining what actually happened at Anytown. It was learned that it had rained heavily at the airport and that there was standing water on the runway. Readout of the flight recorders disclosed that the PIC flew the approach with excess airspeed which resulted in the airplane touching down smoothly, but well beyond the touchdown zone, and then hydroplaning off the end. It was also determined that the PIC neglected to consult the performance charts in the aircraft flight manual for the correct landing distance on a wet runway. Also, the SIC did not make the required callouts during the approach.

These unsafe flight crew actions could in and of themselves explain the overrun and focus the investigation on a conclusion of *"crew error"* as a cause for the accident. However, if one were to investigate further into the company's operational procedures and practices and look upstream for other factors influencing the crew's performance, one could identify additional active and latent failures which were present during the flight. So the investigation should not stop at the point where the crew made errors.

If the investigation were to determine whether any other unsafe acts occurred in the operation, it would discover that not only did the dispatcher fail to brief the PIC on potential problems at the airport (as required by company procedure), but that the company's agent at Anytown had not reported to the dispatcher at headquarters that heavy rain had fallen. Inspection of the runway revealed poor construction, paving and lack of adequate drainage. It was also discovered that maintenance and inspection of the NDB was not in accordance with prescribed procedures. Over the past month, other flight crews had reported on several occasions that the ground aid had given erratic indications during instrument approaches; no attempt had been made to rectify the problem.

With these facts in mind and by referring to the Reason model, it can be seen that the actions of other front-line operators were also unsafe and had an influence upon the performance of the flight crew and the outcome of the flight. These activities can be classified as active failures and are also linked to line-management and decision-makers' performance.

Next, the investigation should determine if there were any adverse pre-conditions under which the flight crew had to operate. These can be listed as follows:

1) a night non-precision instrument approach to an unfamiliar airport;
2) a poorly lit, short, wide and steeply sloping runway;
3) poor runway pavement and drainage;
4) a lack of reliable information on the performance of the NDB;
5) a lack of reliable information about the wind conditions;
6) a flight schedule which allowed only a 15-minute turnaround at Anytown;
7) an arrival delayed by two hours, compromising crew duty-time requirements;
8) an aircraft not equipped with thrust reversers;
9) an inadequately trained flight crew, inexperienced in the type of aircraft and at the airport; and
10) inadequate crash, fire, and rescue services.

The Reason model classifies these pre-conditions as latent conditions, many of which lay dormant for some time before the accident and which were the consequences of line management and decision-maker actions or inactions. For example, pairing two pilots who were inexperienced in the type of aircraft and allowing the PIC to operate into an unfamiliar airport with a non-precision approach procedure was the result of decisions made by line management. Also, the failure to follow up on reported discrepancies with the NDB and the failure to conduct adequate inspections of the airport indicate either a lack of awareness of the safety implications or a tolerance of hazards by the line management and the regulatory authority. The investigation found that pilots were not briefed on the use of performance charts for contaminated runways, nor did they practice hydroplaning avoidance techniques. These discrepancies can be attributed to both line and upper management's failure to provide adequate training.

At the roots of this occurrence were other decisions made by both upper management levels within the company and in the regulatory authorities that had a downside. Management had decided to operate a scheduled service at an airport with known deficiencies in facilities (poor lighting and approach aids, inadequate weather services). More importantly, they chose to operate without the required level of crash, fire and rescue services available at the airport. In addition, management selected this type of airplane for this route out of marketing and cost considerations, despite its unsuitability for all-weather operations at Anytown. Compounding the problem was the decision by the regulatory authority to certify the airport for scheduled air transport operations in spite of its significant safety deficiencies.

The organizational perspective portrays the interactive nature of the conditions and failures and how they can combine to defeat the defences that one might expect to find within an organizational and operational environment. It also depicts the critical importance of identifying latent failures as they relate to the prevention of accidents.

In summary, the approach to the organizational accident encourages the investigator to go beyond the unsafe actions of front line operators to look for hazards that were already present in the system and which could contribute to future occurrences. This approach has

direct implications for the prevention activities of operators and regulators, who must identify and eliminate or control latent conditions.

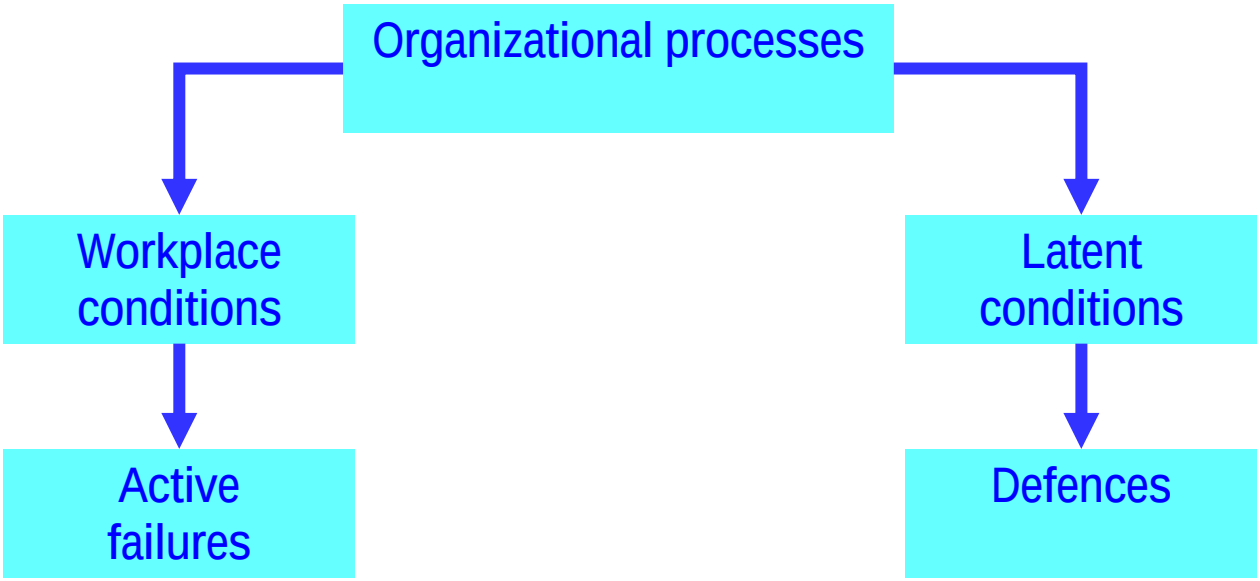
EXERCISE 02/01

Group activity

A facilitator will be appointed, who will coordinate the discussion. A summary of the discussion will be written on flip charts, and a member of the group will brief on their findings in a plenary session.

Required task

1) Read the text related to the accident of the twin-engined jet transport at Anytown City Airport.
2) From the investigation report of the above accident, you should identify:
   a) **Organizational processes** that influenced the operation and which felt under the responsibility of senior management (i.e. those accountable for the allocation of resources);
   b) **Latent conditions** in the system safety which became precursors of active failures;
   c) **Defences** which fail to perform due to weaknesses, inadequacies or plain absence;
   d) **Workplace conditions** which may have influenced operational personnel actions; and
   e) **Active failures**, including errors and violations
3) When you have concluded the above, your task is to complete the Table 02/01 – *Analysis* classifying your findings according to the Reason Model.



Reason Model

Table 02/01 – *Analysis*

Organizational processes *Activities over which any organization has a reasonable degree of direct control*	
1) Certification- airport certificated despite its significant safety deficiencies	**2)** Tolerance of hazards by the operator
3) Oversight – inadequate inspections and tolerance of hazards by the regulator	**4)** Choice of aircraft based on marketing and cost not taking into consideration the suitability for all weather operations
5) Poorly constructed runway	
6) Inadequately maintained NDB	
7) Inadequate navigational aids for the type of weather	
8) Poor crew scheduling	
9) Inadequate crew training	

Workplace conditions *Factors that directly influence the efficiency of people in aviation workplaces*	**Latent conditions** *Conditions present in the system before the accident, made evident by triggering factors*
1) Standing water/waterlogged runway/	**Runway conditions (Pavement/drainage)**
2) Steep and short runway	**Landing performance limitations of the runway**
3) Thunderstorm and fog region	**Poorly lit, short, wide, slippery runway**
4) Long working hours of crew	
5) Inadequate training and experience on aircraft and the airport	**Inadequate crash, fire and rescue services**
6) Inappropriate (low intensity) runway lights and absence of approach lights	**An aircraft not equipped with thrust reversers**
7) The flight schedule was very tight	
8) No visual approach aids	

Active failures *Actions or inactions by people (pilots, controllers, maintenance engineers, aerodrome staff, etc.) that have an immediate adverse effect*	**Defences** *Resources to protect against the risks that organizations involved in production activities must confront*
1) Did not consult charts	**Contaminated runway operation charts**
2) No forecast was available	Airport landing forecast
3) Lack of reliable information about wind conditions	Wind information
4) The approach was flown with excessive speed, and the aircraft did not land at the correct point	Proper use of checklist (SIC did not call out speeds)
5) Lack of briefing about potential problems at Anytown airport	

6) The checklist was not used as appropriate	
7) Crew unfamiliar with route	

- - - - - - - - - - - - - - -

Page left blank intentionally

AFI Comprehensive Implementation Programme (ACIP)

ICAO Safety Management Systems (SMS) Course

Handout Nº 2 – The Anyfield Airport accident

International Civil Aviation Organization

Page left blank intentionally

AFI COMPREHENSIVE IMPLEMENTATION PROGRAMME (ACIP)
SAFETY MANAGEMENT SYSTEM (SMS) COURSE

Exercise Nº 03/01 – The Anyfield Airport accident

Scenario

In the early hours of an autumn Monday-morning, a twin-engined jet transport with 5 crew-members and 63 passengers on board while in its take-off run at Anyfield Airport collided with a small twin-engined propeller-driven aircraft, with only a single crew-member that had intruded the departure-runway. Both aircraft were severely damaged as a result of the collision. The subsequent fire destroyed both aircraft and was the death-cause for most of the passengers.

Anyfield Airport is a medium-sized airport, with a single runway which can be accessed (or vacated) by a number of intersections. It is a controlled aerodrome; the control-tower is located 400 meters north of the middle of the runway. Traffic-numbers are on the rise as quite a few commuter-type airlines have started operating to and from Anyfield.

Although the airport is in a region in which several foggy days a year are common, it is not equipped with a Surface Movement Radar (SMR), nor does it have special taxiway-lighting facilities for use under low visibility-conditions.

Air Traffic Control at Anyfield is slightly understaffed, but so far it was not thought necessary to impose restrictions on operations to and from Anyfield. There is a discrete frequency (Ground Control) to handle taxiing aircraft.

At the time of the collision, the average visibility was around 700 meters with fog-banks, which is just sufficient to allow the tower-controller to see the middle part of the runway. The controllers' view at the intersection where the intruding aircraft entered the runway however was obstructed by the newly constructed extension to the terminal building at Anyfield Airport.

The Air Traffic Controller (ATCO) was a very experienced controller. He had been working in ATC for many years, at several major facilities, and had been transferred to Anyfield to act as an OJT-instructor only eight months before the date of the accident.

At the time of the collision, the **ATCO1** was alone in the control-tower, as his Assistant / Ground Controller **ATCO2** – of far less experience – had briefly left the TWR to answer a call of nature. They were both completing their third consecutive nightshift, had come on duty at 22:00 hours the previous evening and were due to be relieved within thirty minutes when the accident occurred.

The crew of the jet-aircraft was experienced operators to and from Anyfield. From their point of view, on the morning of the accident there was nothing unusual in the way their flight was handled by ATC. They taxied to the runway with the extra caution required by the fog-conditions, and after being cleared for take-off they made certain they were lined up correctly on the runway-centerline before applying take-off power.

The pilot of the twin-engined piston-driven aircraft was unfamiliar with Anyfield Airport, having been sent there at short notice to collect an aircraft that had to divert into Anyfield two days earlier for weather-reasons.

Investigation

Although **ATCO1** was very experienced, he had only worked a limited number of solo-shifts in Anyfield TWR. Having validated his TWR-rating in early summer, he had been involved in giving on-the-job-training (OJT) instruction on most of his shifts after that. As a consequence of the staff-shortage he was required to work his share of nightshifts like all other controllers. The shift in which the accident occurred was only his second where he had worked at Anyfield TWR under foggy/low visibility conditions; the first had been the previous night, when there was hardly any traffic as it was the night from Saturday to Sunday.

A number of years ago there had been an incident at Anyfield involving runway-intrusion by a vehicle, under similar meteorological conditions as in this case. One of the recommendations at that time was the installation of a SMR, together with stop-bars at all runway-intersections. The authorities decided that in view of the limited number of days (with fog) that would warrant the use of a SMR, the benefit of having a SMR didn't match the costs of having one installed. The same applied for the installation of stop-bars, but in lieu of those, painted signs had been put in the grass next to the runway-intersections, informing those who noticed them there was a *"runway ahead".*

As the early morning-traffic began to come alive, **ATCO1** and **ATCO2** were each working an independent R/T-frequency. When **ATCO2** announced he had to visit the men's room for a second, **ATCO1** told him to go ahead, intending to work both frequencies by himself. In order to do so, **ATCO1** had to physically move between two control-positions in the TWR that are about three meters apart, for Anyfield TWR isn't equipped with a frequency-coupling installation. Transmissions on one frequency can't be heard by stations on the other frequency.

The piston-engined aircraft's pilot had arrived in Anyfield late the night before. After a short sleep he went to the airport quickly in order to waste as little time as possible, for his company wanted the aircraft back at its home base a.s.a.p. After the minimum of preparation needed, he went to his aircraft and called ATC for approval to taxi to the runway. He obtained the clearance and began taxiing, but soon found himself lost at the foggy, unfamiliar airport. The fact that there were no signs denominating the various taxiway-intersections didn't help much either.

The R/T-tapes showed that the piston-pilot then called G/C (by R/T) and asked for *"progressive taxi-instructions".* **ATCO2** replied by asking his position. The pilot said: *"I believe I'm approaching Foxtrot-intersection"*, to which **ATCO2** answered: *"At Foxtrot taxi straight ahead".* In fact the pilot had already passed Foxtrot, and should have turned onto the parallel taxiway. The instruction from **ATCO2**, though technically correct, caused the pilot to taxi onto the runway where the jet was in its take-off roll. Since the communications to both aircraft took place on different frequencies, neither pilot was aware of what was happening.

After the collision, it took **ATCO1** several minutes to realize something was wrong. Of course he hadn't observed the departing jet passing on the section of the runway that was

visible to him, but he initially blamed that on the fog patches and/or being distracted by traffic on the G/C frequency.

And apart from the fog, **ATCO1** was unable to see the part of the runway where the collision had taken place because of the newly built extension of the terminal building blocking his view. So it was not until he wanted to transfer the departing jet to the next controller (Departure Control) that he became aware things weren't as they should be, when his transmissions to the jet remained unanswered.

ATCO2, who returned shortly after the accident, at the same time reported having no contact with the taxiing twin-prop. **ATCO1** then decided to alert the fire-brigade, but as he had no idea where to send them, more precious time was lost as the rescue-vehicles tried to make their way across the foggy airport. When they finally arrived at the accident-site, they found there was little they could do as the wreckage of the aircraft had almost burnt-out completely already.

Had a SMR been installed following the recommendation after the other incident, this would have provided the following lines-of-defense (in declining order):

- Proper taxi-instructions could have been given to the *"lost"* aircraft.
- The ATCOs would have observed the runway-intrusion.
- The collision-site would have been easily identified.
- Adequate instructions could have been given to the rescue-vehicles.

This goes for the stop-bars as well. Had they been installed, the twin-prop more likely than not wouldn't have entered the runway.

At the very least, special procedures for Low Visibility Operations (LVO) at Anyfield should have been developed and in force, limiting the number of movements at the field. The ATCOs should have been trained in working with these special procedures, ideally on a simulator, to help them cope with the unusual situation once it occurred.

In their talks with the airport-authorities, ATC management should have firmly opposed the plans for extension of the terminal-building. But, as a result of not having any input from the operational ATCOs (who were not available to attend the meetings due to staff-shortage), management wasn't even aware it would constitute a line-of-vision problem from the TWR.

ATCO1 shouldn't find himself in a position where he was forced to work two positions by himself. At all times ATC-positions should be sufficiently staffed to allow the traffic to be handled in a safe manner.

The installation of a frequency-coupler might have helped prevent the collision from occurring. As it is, these systems are considered *"optional"* by the aviation-authorities, so only few ATC-facilities have them.

Management should ensure that OJT-instructors are given the opportunity to stay current at the positions where they are supposed to teach, by scheduling the instructor for duties without trainees at regular intervals. Such duties should be sufficiently challenging of nature to allow the

instructor to practice his skills (in other words: shifts without traffic may look good in a roster, but are of no value for currency-maintaining purposes)

Had there been a well-devised training-curriculum that was correlated with the duty-roster, management would have recognized that **ATCO1**, although qualified, hadn't been able to acquaint himself with working at Anyfield TWR under low visibility-conditions. Ideally, they wouldn't have scheduled him for unsupervised duty when low visibility was forecast.

Dedicated LVO-training would have made **ATCO2** aware of the dangers involved, alerting him to be more positive in guiding the lost taxiing pilot. At the very least he probably wouldn't have given the pilot irrelevant information.

It is a scientific fact that when consecutive nightshifts are worked, the performance of persons engaged in cognitive tasks (such as ATC) decreases dramatically in the second and later nights, especially between 03:00 hrs and 07:00 hrs. **ATCO1** at Anyfield was on his third nightshift in a row, which could explain why he failed to recognize a potentially dangerous situation that he wouldn't have missed under other circumstances. When designing shift-rosters for ATCOs it is advisable to keep the number of consecutive nightshifts to an absolute minimum.

Based on the meteorological forecast, and taking into account the propeller-aircraft's pilot was unfamiliar with Anyfield, it may be argued that the air operator would have done better to send two pilots to collect the aircraft. Even with limited knowledge of CRM-principles, a second pilot could have prevented the other pilot from acting the way he did.

EXERCISE 03/01

Group activity

A facilitator will be appointed, who will coordinate the discussion. A summary of the discussion will be written on flip charts, and a member of the group will brief on their findings in a plenary session.

Required task

1) Read the text related to the accident of the twin-engined jet transport at Anyfield Airport.

2) From the investigation report of the above accident, you should identify:

   a) **Organizational processes** that influenced the operation and which felt under the responsibility of senior management (i.e. those accountable for the allocation of resources);

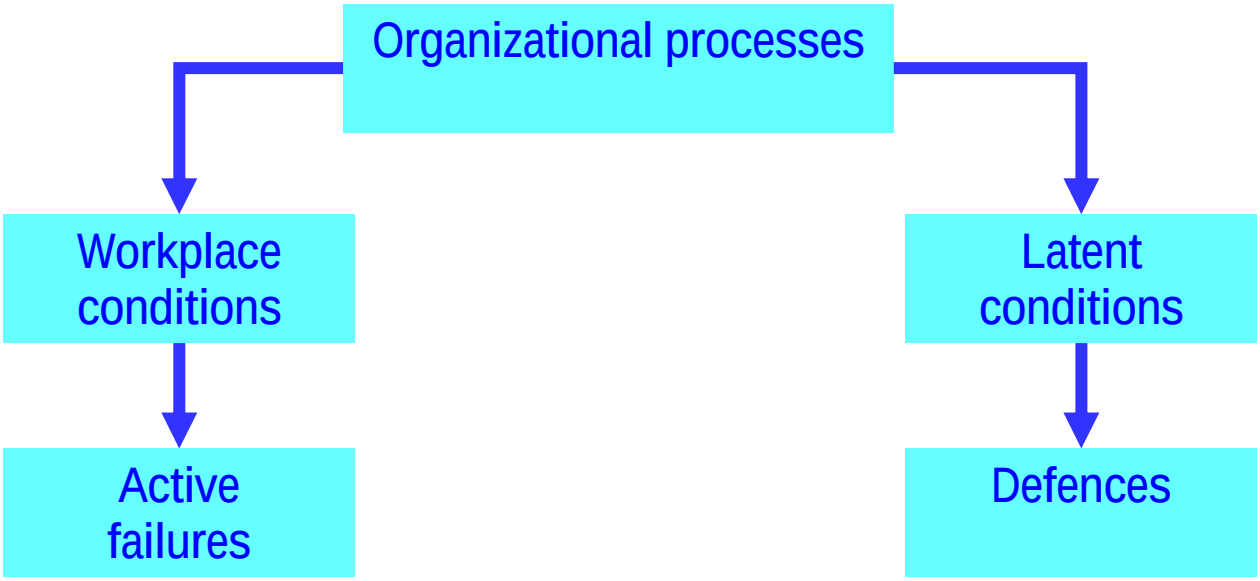
   b) **Latent conditions** in the system safety which became precursors of active failures;

   c) **Defences** which fail to perform due to weaknesses, inadequacies or plain absence;

d) **Workplace conditions** which may have influenced operational personnel actions; and

e) **Active failures**, including errors and violations

3) When you have concluded the above, your task is to complete the Table 03/01 – *Analysis* classifying your findings according to the Reason Model.



Reason Model

Table 03/01 – *Analysis*

Organizational processes *Activities over which any organization has a reasonable degree of direct control*	
Planning – Construction of the Terminal building extension blocking the ATCOs view	Oversight – Airport continuing operations
Poor Scheduling of ATCO and the Crew from the operators of the piston aircraft	Airfield not equipped with a Surface Movement Radar – allocation of resources
Commercial Pressure – Piston Aircraft required at home base	Airport Management did not develop the airport to accommodate the rise in traffic
Low Visibility Operational Procedures	
Authority Certification – Airport authorised to operate with safety deficiencies	

Workplace conditions *Factors that directly influence the efficiency of people in aviation workplaces*
OJT - ATCO1 could not acquaint himself with anyfield airport since he had not worked solo shifts under low visibility conditions
Insufficient workforce
Fatigue – ATCO and Piston Pilot
Ergonomics – controller moving from one radio to another
Obstruction of the controllers view
Pressure of work – Pilot of piston aircraft was required to get it to home base
Foggy weather

Latent conditions *Conditions present in the system before the accident, made evident by triggering factors*
ATC understaffing
Absence of Surface Movement Radar
Absence of adequate signage to indicate various taxiway intersections
Absence of special taxiway lights
Underdeveloped facilities, unable to cope with the rise in traffic

Active failures *Actions or inactions by people (pilots, controllers, maintenance engineers, aerodrome staff, etc.) that have an immediate adverse effect*
ATCO did not challenge ambiguous position report by twin-engine pilot
Failure to send 2 pilots by the operator of the piston aircraft
Failure by the pilot of the piston aircraft to

Defences *Resources to protect against the risks that organizations involved in production activities must confront*
Progressive taxi instructions
SMR Installation
Painted Signs indicating runway ahead

familiarize himself with anyfield airport	
Proceeding to taxi while uncertain of position	Taxiway lights
Fire brigade	Training in LVO procedures
Having only one controller on duty	Installation of the stop bars
	Installation of the frequency coupling
	Develop a well devised training curriculum for ATC

- - - - - - - - - - - - - - -

TABLE 04/01 – HAZARD IDENTIFICATION (PHASE I)

Nº	Type of operation or activity	Generic hazard (hazard statement)	Specific components of the hazard	Hazard-related consequences
1	***Air Traffic Services***	***Aerodrome construction***.	- *Single runway operation*	- *Collisions between aircraft*
			- *Runway congestion*	- *Runway incursions* - *Collisions between aircraft*
			- *Construction equipment*	- *Collisions with equipment*
			- *Holding aircraft (air)*	- *Delays (leading separation breakdown)*
			- *Holding aircraft (ground)*	- *Delays (leading to separation breakdown)*
			- *Closed taxiways*	- *Situational awareness* - *Collisions with equipment* - *Collision with other aircraft*
			- *Low Visibility Ops*	- *Situational awareness* - *Collisions with equipment, etc.*
			- *ATC Radio Frequency congestion*	- *Missed clearances*
			- *ATC Work pressure due to congestion*	- *Degraded human performance*
			- *Increased risk of wake vortices*	- *Damage to aircraft*
2	***Aerodrome Operations***	***Aerodrome construction***	- *Construction equipment*	- *Runway incursion*
			- *Apron congestion*	- Collisions between aircraft and between aircraft and objects - Increased space demand

Nº	Type of operation or activity	Generic hazard (hazard statement)	Specific components of the hazard	Hazard-related consequences
				- Marshaller workload increased
			- *Construction personnel*	- Fire (due smoking,, etc.)
			- *FOD (foreign object debris)*	- Engine damages
3	*Aircraft operations*	***Aerodrome construction***.	- *Single runway operation*	- *Collisions between aircraft*
			- *Runway congestion*	- *Runway incursions* - *Collisions between aircraft*
			- *Construction equipment*	- *Collisions with equipment*
			- *Holding aircraft (air)*	- *Delays (leading separation breakdown)*
			- *Holding aircraft (ground)*	- *Delays (leading to separation breakdown)*
			- *Closed taxiways*	- *Loss of Situational awareness* - *Collisions with equipment* - *Collision with other aircraft*
			- *Low Visibility Ops*	- *Loss of Situational awareness* - *Collisions with equipment, etc.*
			- *ATC Radio Frequency congestion*	- *Missed clearances*
			- *Delays/pressure*	- *Degraded human performance*

TABLE 04/01 – HAZARD IDENTIFICATION (PHASE II)

Nº	Type of operation or activity	Generic hazard (hazard statement)	Specific components of the hazard	Hazard-related consequences
1	***Air Traffic Services***	***Aerodrome construction***.	- *Single runway operation*	- *Collisions between aircraft*
			- *Runway congestion*	- *Runway incursions* - *Collisions between aircraft*
			- *Construction equipment*	- *Collisions with equipment*
			- *Holding aircraft (air)*	- *Delays (leading separation breakdown)*
			- *Holding aircraft (ground)*	- *Delays (leading to separation breakdown)*
			- *Closed taxiways and back tracking*	- *Situational awareness* - *Collisions with equipment* - *Collision with other aircraft*
			- *Low Visibility Ops*	- *Situational awareness* - *Collisions with equipment, etc.*
			- *ATC Radio Frequency congestion*	- *Missed clearances*
			- *ATC vision (partial) obstruction by equipment*	- *Loss of visual contact with aircraft*
			- *ATC Work pressure due to congestion*	- *Degraded human performance*
			- *Increased risk of wake vortices*	- *Damage to aircraft*
2	*Aerodrome Operations*	*Aerodrome construction*	- *Construction equipment*	- *Runway incursion*

Nº	Type of operation or activity	Generic hazard (hazard statement)	Specific components of the hazard	Hazard-related consequences
			- *Apron congestion*	- Collisions between aircraft and between aircraft and objects - Increased space demand - Marshaller workload increased
			- *Construction personnel*	- Fire (due smoking,, etc.)
			- *FOD (foreign object debris)*	- Engine damages
3	*Aircraft operations*	***Aerodrome construction***.	- *Single runway operation*	- *Collisions between aircraft*
			- *Runway congestion*	- *Runway incursions* - *Collisions between aircraft*
			- *Construction equipment*	- *Collisions with equipment*
			- *Holding aircraft (air)*	- *Delays (leading separation breakdown)*
			- *Holding aircraft (ground)*	- *Delays (leading to separation breakdown)*
			- *Closed taxiways*	- *Situational awareness* - *Collisions with equipment* - *Collision with other aircraft*
			- *Low Visibility Ops*	- *Situational awareness* - *Collisions with equipment, etc.*
			- *ATC Radio Frequency congestion*	- *Missed clearances*
			- *Delays*	- *Degraded human performance*

TABLE 04/01 – HAZARD IDENTIFICATION (PHASE III)

Nº	Type of operation or activity	Generic hazard (hazard statement)	Specific components of the hazard	Hazard-related consequences
1	***Air Traffic Services***	***Aerodrome construction***.	- *Single runway operation*	- *Collisions between aircraft*
			- *Runway congestion*	- *Runway incursions* - *Collisions between aircraft*
			- *Construction equipment*	- *Collisions with equipment*
			- *Holding aircraft (air)*	- *Delays (leading separation breakdown)*
			- *Holding aircraft (ground)*	- *Delays (leading to separation breakdown)*
			- *Closed taxiways*	- *Situational awareness* - *Collisions with equipment* - *Collision with other aircraft*
			- *Low Visibility Ops*	- *Situational awareness* - *Collisions with equipment, etc.*
			- *ATC Radio Frequency congestion*	- *Missed clearances*
			- *ATC Work pressure due to congestion*	- *Degraded human performance*
			- *Increased risk of wake vortices*	- *Damage to aircraft*
2	***Aerodrome Operations***	***Aerodrome construction***	- *Construction equipment*	- *Runway incursion*
			- *Apron congestion*	- Collisions between aircraft and between aircraft and objects

Nº	Type of operation or activity	Generic hazard (hazard statement)	Specific components of the hazard	Hazard-related consequences
				- Increased space demand - Marshaller workload increased
			- *Construction personnel*	- Fire (due smoking,, etc.)
			- *FOD (foreign object debris)*	- Engine damages
			- *Short runway*	- *Overruns (take off and landing)* - *Collision with barricades*
			- *Jet Blasts over construction personnel*	- *Injuries to personnel*
3	*Aircraft operations*	***Aerodrome construction***.	- *Single runway operation*	- *Collisions between aircraft*
			- *Runway congestion*	- *Runway incursions* - *Collisions between aircraft*
			- *Construction equipment*	- *Collisions with equipment*
			- *Holding aircraft (air)*	- *Delays (leading separation breakdown)*
			- *Holding aircraft (ground)*	- *Delays (leading to separation breakdown)*
			- *Closed taxiways*	- *Situational awareness* - *Collisions with equipment* - *Collision with other aircraft*
			- *Low Visibility Ops*	- *Situational awareness* - *Collisions with equipment, etc.*

Nº	Type of operation or activity	Generic hazard (hazard statement)	Specific components of the hazard	Hazard-related consequences
			- *ATC Radio Frequency congestion*	- *Missed clearances*
			- *Short runway*	- *Overruns (take off and landing)* - *Collision with barricades*
			- *Delays*	- *Degraded human performance*
			- *Reduced payloads/necessity for equipment change due to shorter runway*	- *Less resources to safety*

AFI Comprehensive Implementation Programme (ACIP)

ICAO Safety Management Systems (SMS) Course
Handout N° 4 – Accident Boeing B-747 at Taipei International Airport

International Civil Aviation Organization

Page left blank intentionally

AFI COMPREHENSIVE IMPLEMENTATION PROGRAMME (ACIP)
SAFETY MANAGEMENT SYSTEM (SMS) COURSE

Exercise 05/01 – Accident Boeing 747 –Taipei International Airport

1. Narrative

Singapore Airlines Flight **SQ006** with Singapore registration **9V-SPK** departed Singapore for a flight to Los Angeles (**LAX**) via Taipei (**CKS**) on October 31, 2000. Scheduled departure time at Taipei was 22:55. The flight left **Gate B-5** and taxied to taxiway **NP**, which ran parallel to runway **05L** and **05R**. The crew had been cleared for a runway **05L** departure because runway **05R** was closed due to construction work. CAA had issued a NOTAM on 31 August 2000 indicating that part of runway **05R** between taxiways **N4** and **N5** was closed for construction from 13 September to 22 November 2000. Runway **05R** was to have been converted and re-designated as taxiway **NC** effective 1 November 2000. After reaching the end of taxiway **NP**, SQ006 turned right into taxiway **N1** and immediately made a 180-degree turn to runway **05R**. After approximately six (6) second hold, **SQ006** started its takeoff roll at 23:15:45. Weather conditions were very poor because of typhoon *"Xiang Sane"* in the area. METAR at 23:20 included Wind 020 degrees at 36 knots gusting 56 knots, visibility less than 600 meters, and heavy rainfall.

On takeoff, 3.5 seconds after V1, the aircraft hit concrete barriers, excavators and other equipment on runway **05R**. The plane crashed back onto the runway, breaking up and bursting into flames while sliding down the runway and crashing into other objects related to work being done on runway **05R**. The aircraft wreckage was distributed along runway **05R** beginning at about 4,080 feet from the runway threshold. The airplane broke into two main sections at about fuselage station 1560 and came to rest about 6,480 feet from the runway threshold.

2. Findings related to probable causes

- At the time of the accident, heavy rain and strong winds from typhoon *"Xiang Sane"* prevailed. At 23:12:02 Taipei local time, the flight crewmembers of SQ006 received Runway Visual Range (RVR) 450 meters on runway **05L** from Automatic Terminal Information Service (ATIS) *"Uniform".* At 23:15:22 Taipei local time, they received wind direction 020 degrees with a magnitude of 28 knots, gusting to 50 knots, together with the takeoff clearance issued by the local controller.
- On 31 August 2000, the CAA issued a Notice to Airmen (NOTAM) A0606 indicating that a portion of the runway **05R** between taxiway **N4** and **N5** was closed due to work in progress from 13 September to November 2000. The flight crew of **SQ006** was aware of the fact that a portion of runway **05R** was closed, and that runway **05R** was only available for taxi.
- The aircraft did not completely pass the runway **05R** threshold marking area and continue to taxi towards runway **05L** for the scheduled takeoff. Instead, it entered runway **05R** and the Pilot-in-command (**PIC**) commenced the takeoff roll. The pilot second-in-command (**SIC**) and the third pilot did not question the PIC's decision to take off.
- The flight crew did not review the taxi route in a manner sufficient to ensure they all understood that the route to runway **05L** included the need for the aircraft to pass runway **05R**, before taxiing onto runway **05L**.
- The flight crew had CKS Airport charts available when taxing from the parking bay to the departure runway; however, when the aircraft was turning from taxiway **NP** to taxiway **N1**

and continued turning onto runway **05R**, none of the flight crewmembers verified the taxi route. As shown on the Jeppesen "20-9" CKS Airport chart, the taxi route to runway **05L** required that the aircraft make a 90-degree right turn from taxiway **NP** and then taxi straight ahead on taxiway **N1**, rather than making a continuous 180-degree turn onto runway **05R**. Further, none of the flight crewmembers confirmed orally which runway they had entered.

- The PIC's expectation that he was approaching the departure runway coupled with the saliency of the lights leading onto runway **05R** resulted in the PIC allocating most of his attention to these centreline lights. He followed the green taxiway centreline lights and taxied onto runway **05R**.
- The moderate time pressure to take off before the inbound typhoon closed in around CKS Airport, and the condition of taking off in a strong crosswind, low visibility, and slippery runway subtly influenced the flight crew's decision influencing the ability to maintain situational awareness.
- On the night of the accident, the information available to the flight crew regarding the orientation of the aircraft on the airport was:

  a) CKS Airport navigation chart

  b) Aircraft heading references

  c) Runway and taxiway signage and marking

  d) Taxiway **N1** centreline lights leading to runway **05L**

  e) Colour of the centreline lights (green) on runway **05R**

  f) Runway **05R** edge lights most likely not on

  g) Width difference between runway **05L** and runway **05R**

  h) Lighting configuration differences between runway **05L** and runway **05R**

  i) Para-Visual Display (**PVD**) showing aircraft not properly aligned with the runway **05L** localizer

  j) Primary Flight Display (**PFD**) information

The flight crew lost situational awareness and commenced takeoff from the wrong runway.

The Singapore Ministry of Transport (MOT) did not agree with the findings and released their own report. They conclude that the systems, procedures and facilities at the CKS Airport were seriously inadequate and that the accident could have been avoided if internationally-accepted precautionary measures had been in place at the CKS Airport.

3. Discussion

Weather at the time of the crash, which happened at 11:17 p.m. local time October 31, was rainy and windy due to a typhoon bearing down on CKS. Visibility was about 500 meters.

Facts gathered by investigators and released by CAA show that, because of the poor weather and night-time conditions, the PIC and SIC elected to switch on the PVD. The PVD, a mechanical instrument mounted on a panel in front of each pilot position that helps the pilot’s line up and stays on a given runway's centreline, works with the plane's instrumentation to monitor a runway's Instrument Landing System (ILS) signal.

The PVD resembles a barber pole sitting on its side, with black stripes on a white background. It is not mandatory equipment, and carriers that use it only require it to be activated

when visibility is much worse - 50 meters or below, in most cases - than the visibility the SQ006 crew was faced with.

When the aircraft gets in range of the ILS runway signal that the plane is tuned to, a small shutter on the PVD opens, revealing the black-and-white pattern. The stripes remain stationary so long as the plane is on the runway centreline. When it moves left or right, the stripes move in the direction of the runway centreline, helping guide the pilots back to the middle of the runway.

Both the PIC and SIC switched on their PVD at the gate, investigators found. When the aircraft taxied into position at what the crewmembers thought was the end of **05L**, all three pilots - including a relief pilot sitting in the cockpit - noticed the PVD had not activated. But since visibility was well above the level that requires PVD usage and they could all see centreline marking lights clearly, the pilots decided to proceed.

"The PVD hasn't lined up," the SIC said as the plane turned onto 05R, according to the cockpit voice recorder transcript.

"Never mind, we can see the runway," the PIC responded. *"Not so bad."*

The visual takeoff may have caused the pilots to miss two other clues on their instruments that could have indicated a problem. When a 747's ILS is tuned for a specific takeoff runway, two indicators appear on the plane's PFD. A pink diamond shows the aircraft's position relative to the runway's ILS localizer, and a green trapezoid shows the runway, which should be centred and just below the PFD's horizon when the plane is aligned properly. When the plane is not aligned with the runway centreline, both indicators are well off to the display's side.

The centreline lights could have served as another clue to the pilots. The PIC told investigators that he *"followed the curved centreline lights"* onto **05R**, report said. *"He commented that he was attracted to the bright centreline lights leading onto the runway."*

The centreline lights that run all the way down **05R** are green, designating it as a taxiway. Centreline lights on runways are white at the beginning and later change to red near the end. While a similar set of green taxiway lights leads from **N1** onto **05L**, the lights running down the middle of **05L** are white.

Both **05L** and **05R** have bi-directional runway edge lights that appear white, yellow, or red, report said. The two sets of lights are identical. The CKS ground controller working on the night of the accident told investigators that the **05L** edge lights were on, but the **05R** edge lights were not. Soon after the accident, the PIC told investigators that he was *"80% sure"* he saw edge lights along 05R, but in follow-up interviews, he was *"less sure"* report said.

While the pilots may have missed some clues regarding their wrong-runway mistake, they were almost surely hampered by airport surface marking deficiencies.

As they followed taxiway lights down **NP** and turned right onto **N1**, they did not see any centreline lights straight in front of them that would have led them to **05L**. They did, however, clearly see the curving set of taxiway centreline lights, spaced about 7.5 meters (25 feet) apart, leading to **05R** from **N1's** south end.

When investigators surveyed CKS four days after the crash, they found that the two taxiway lights designed to lead aircraft further down **N1** past the inactive **5R** to the active **5L** runway were not working perfectly. One was not illuminated at all, and the other was *"less intense than the other lights."* The lights, spaced about 25m apart, run straight down **N1's** centreline and meet up with another set of curved, green taxiway lights that connect **05R's** centreline with **N1's** north end.

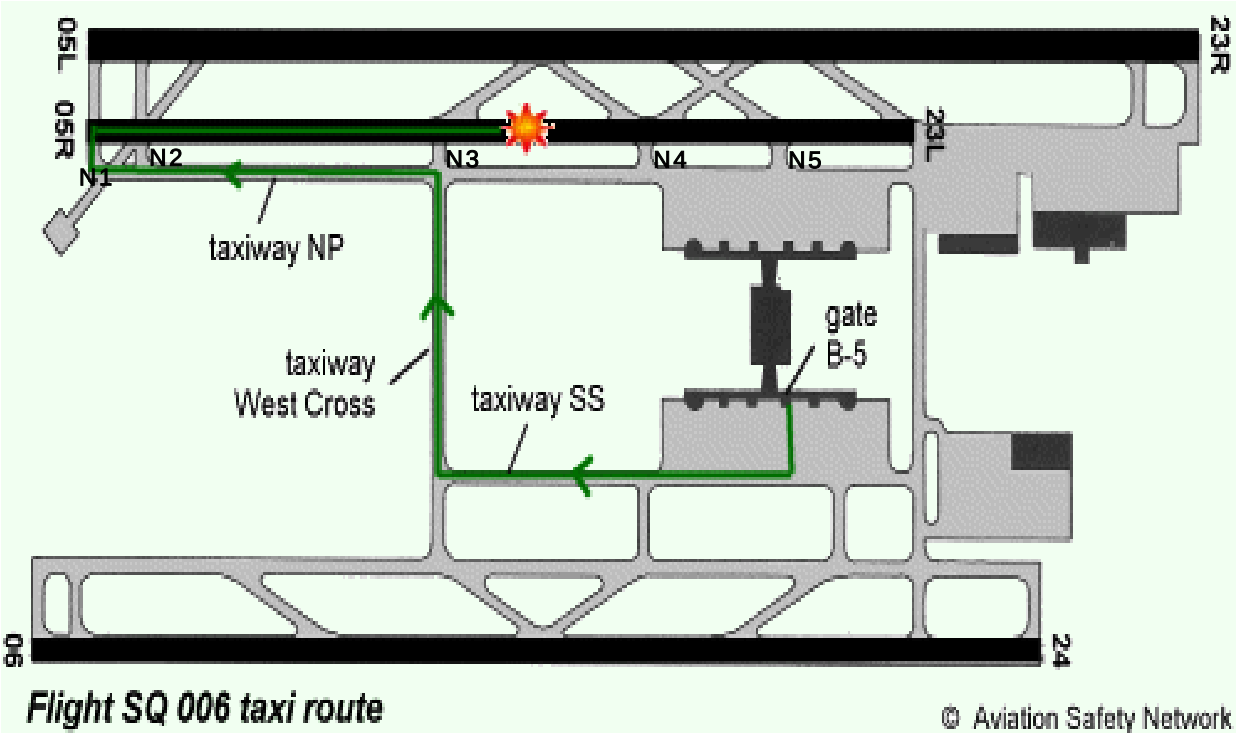
As SQ006's PIC taxied down **N1** and approached **05R**, he was *"focused on the image of the runway to his right, and he did not notice any further green lights ahead and along the extension of N1,"* he told investigators.

Investigators found several other lighting and marking problems. Some of the runway edge lights on both **05L** and **05R** were either broken or *"aligned away from the direction of the runway length,"* report said. Also, there was nothing over the **05R** threshold markings that indicated the runway was closed.

Runway **05R** had been closed since mid-September for needed pavement repairs. The plan was to convert it into a full-time taxiway on November 1, but the timeline was pushed back before the SQ006 crash. Before being closed, it was used for visual departures only.

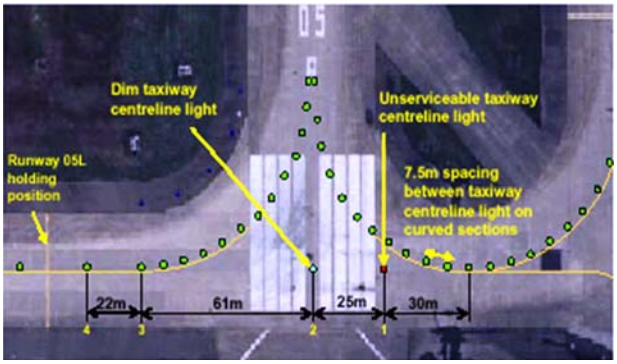
The SQ006 PIC told investigators he was aware of **05R's** status. He had used the runway in the past; his last departure on it was *"two or three years"* ago, report said. The PIC's last flight to CKS Airport before October 31 was sometime in early to mid-September, the report said.

Singapore Airlines most often used runway **06**, the parallel runway south of CKS Airport terminal, because it is *"closer to the parking bays used by the company,"* the SQ006 PIC told. But runway **06** is a Category I ILS runway, and the weather on October 31 persuaded the pilot to request runway **05L**, a Category II runway, because it is *"longer and would therefore afford better margins for the prevailing wet runway conditions."*

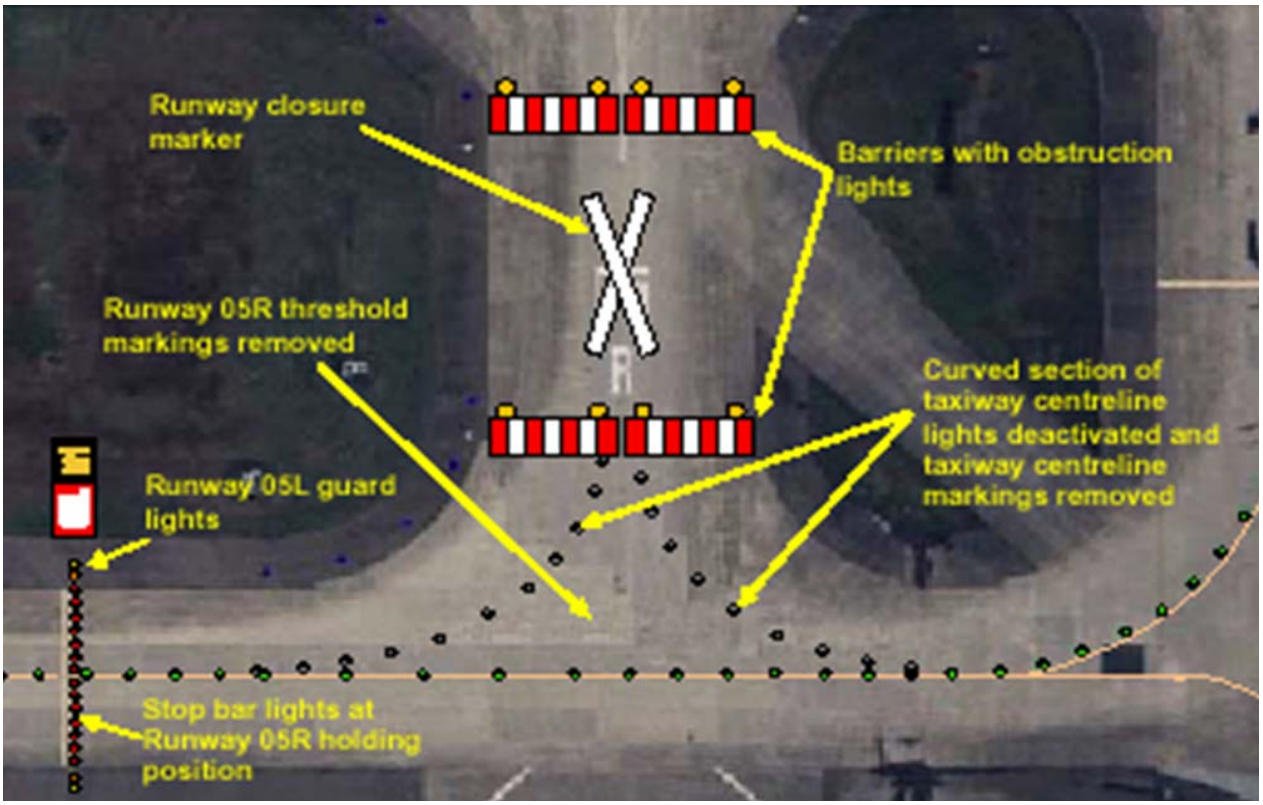


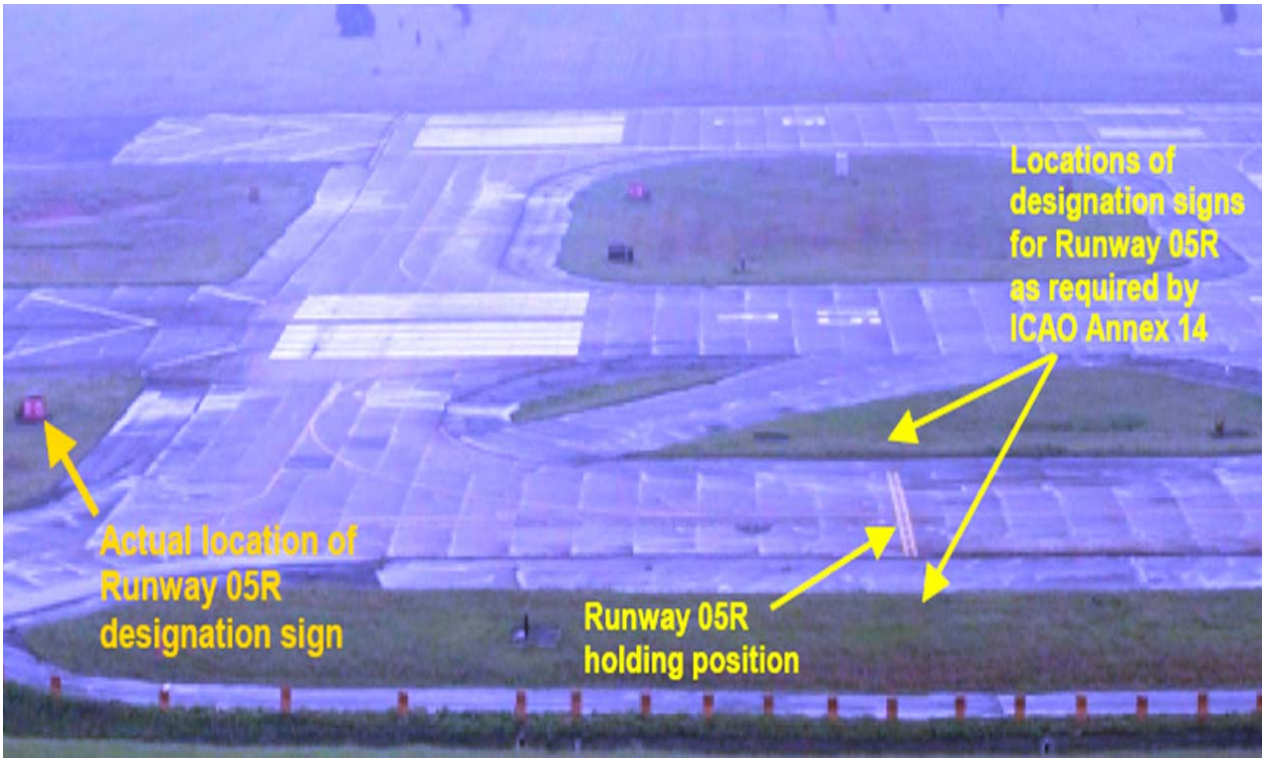

Stop Bar lights (Inset) as required by ICAO Annex 14
Flashing Guard Lights on both sides of the holding line of Runway 05L as required by ICAO Annex 14


Missing section of taxiway centreline marking


Dim taxiway centreline light
Unserviceable taxiway centreline light
Runway 05L holding position
7.5m spacing between taxiway centreline light on curved sections
22m
61m
25m
30m


Taxiway centreline markings as required by ICAO Annex 14


Runway closure marker
Barriers with obstruction lights
Runway 05R threshold markings removed
Curved section of taxiway centreline lights deactivated and taxiway centreline markings removed
Runway 05L guard lights
Stop bar lights at Runway 05R holding position

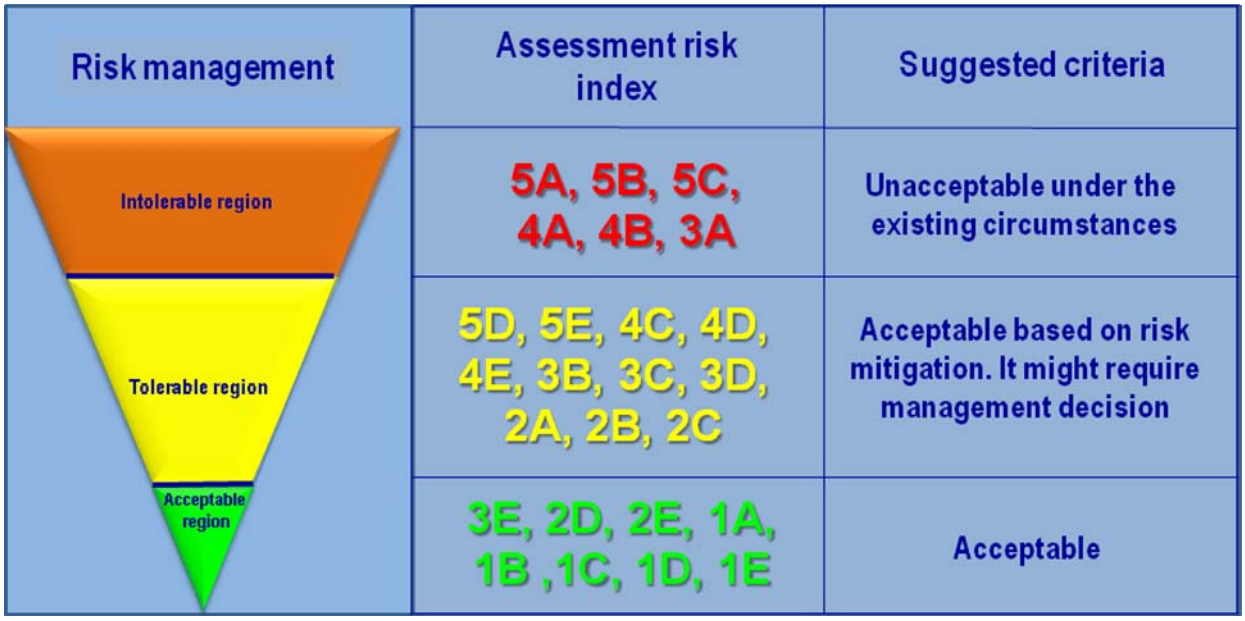


4. Risk assessment matrix

Probability of occurrence		
Qualitative definition	**Meaning**	**Value**
Frequent	Likely to occur many times *(has occurred frequently)*	**5**
Occasional	Likely to occur some times *(has occurred infrequently)*	**4**
Remote	Unlikely, but possible to occur *(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**

Severity of occurrences		
Aviation definition	**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 damage.	**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 increase in workload, or as a result of conditions impairing their efficiency. ➢Serious incident. ➢Injury to persons.	**C**
Minor	➢Nuisance. ➢Operating limitations. ➢Use of emergency procedures. ➢Minor incident.	**D**
Negligible	➢Little consequences	**E**

Risk probability	Risk severity				
	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



EXERCISE 05/01

4. Group activity

A facilitator will be appointed, who will coordinate the discussion. A summary of the discussion will be written on flip charts, and a member of the group will brief on their findings in a plenary session.

5. Your task

1. Read the text related to the accident of the Boeing 747 at Taipei International Airport.
2. List the type of operation or activity.
3. State the generic hazard(s)
4. State the specific components of the hazard(s).
5. State the hazard-related consequences and assess the risk(s).
6. Assess existing defences to control the risk(s) and resulting risk index.
7. Propose further action to reduce the risk(s) and resulting risk index.
8. Complete the attached log *(Table 05/01).*

TABLE 05/01 – HAZARD IDENTIFICATION AND RISK MITIGATION

Nº	Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index
1	*Aerodrome operations*	*Foreign object* *(Example only, not related to the present case study)*	*Piece of metal on the runway* *(Example only, not related to the present case study)*	*Damage to aircraft* *(Example only, not related to the present case study)*	1. *Daily runway inspection* 2. *Aerodrome operations manual* *(Example only, not related to the present case study)* *Risk index: 3B* *Risk tolerability: Risk control/mitigation requires management decision*	1. *Review policies on aerodrome inspections* 2. *Review procedures in the aerodrome operations manual* 3. *Reinforce frequency of runway inspections* 4. *Update training for aerodrome operations personnel* *(Example only, not related to the present case study)* *Risk index: 1B* *Risk tolerability: Acceptable after review of the operation*

Nº	Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index
2	*Aerodrome operation*	*Runway construction*	*Construction equipment*	*Collision with equipment*	*Runway closed signage* *Taxi Charts* *Taxi lighting: (1) leading straight to 5L (2) 5R centre lights green indicating taxiway* *NOTAM* *Airport heading references*	*- Physical barrier at threshold 5R* *- Ground controller contribution* *- SMR* *- Signage at 5R/N1 intersection that 5R is closed*
			Barriers	*Collision with barriers*	*5R Runway lights off*	
			Inadequate signage	*Loss of situational awareness*		
			Partially serviceable taxiway lighting	*Loss of situational awareness*		*Inspection and maintenance of lighting*
			Poor positioning of runway closed signage	*Use of closed runway*		
			Runway 5R closure	*Loss of situational awareness*		
					Risk index: 3A *Risk tolerability: Intolerable*	*Risk index:2A* *Risk tolerability: Risk control/mitigation requires management decision*

3	Aircraft Operations	Runway construction	Construction equipment	Collision with equipment	NOTAM	- Improved CRM Training - New SOP for use of PVD - SMR
			Barriers	Collision with barriers		
					Taxi Chart	
					PVD	
					PFD	
					ILS	
					Other heading references	
					Number of Crew	
					Crew training	
					Airport heading references	
					Signage, markings and lighting (taxi and runway)	
					Ground controller	
					CRM	
			Inadequate signage	Loss of situational awareness		
			Partially serviceable taxiway lighting	Loss of situational awareness		
			Poor positioning of runway closed signage	Use of closed runway		
			Closure of Runway 5R	Loss of situational awareness		
			Poor CRM	Poor crew coordination		
		Adverse Weather (Rain and approaching	Very low visibility and	Loss of situational awareness		
			Strong cross winds	Hurried preparation		
				Time pressure to depart		
			Slippery runway	Loss of control of aircraft		

		typhoon)				
					Risk index: 3A *Risk tolerability: Intolerable* *Risk tolerability: Intolerable*	*Risk index: 2A* *Risk tolerability: Risk control/mitigation requires management decision*

- - - - - - - - - - - - - - -

Nº	Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index
1						
2	*Air Traffic Services*	*Runway construction*	*Reduced available Runway operations*	*Increased workload*	*- NOTAM* *- Charts* *- Ground controller* *- ATC* *- Weather information* *- RVR information*	*- SMR* *- SOPs* *- Progressive taxi* *-*
			Closed runway	*Unclear taxi clearances*		
		Adverse Weather (Rain and approaching Typhoon	*Low visibility*			
			Reduced movements			
					Risk index: 3A *Risk tolerability: Intolerable* *Risk tolerability: Intolerable*	*Risk index: 2A* *Risk tolerability: Risk control/mitigation requires management decision*

AFI Comprehensive Implementation Programme (ACIP)

ICAO Safety Management Systems (SMS) Course
Handout N° 5 – Cuzco
International Airport operation

International Civil Aviation Organization

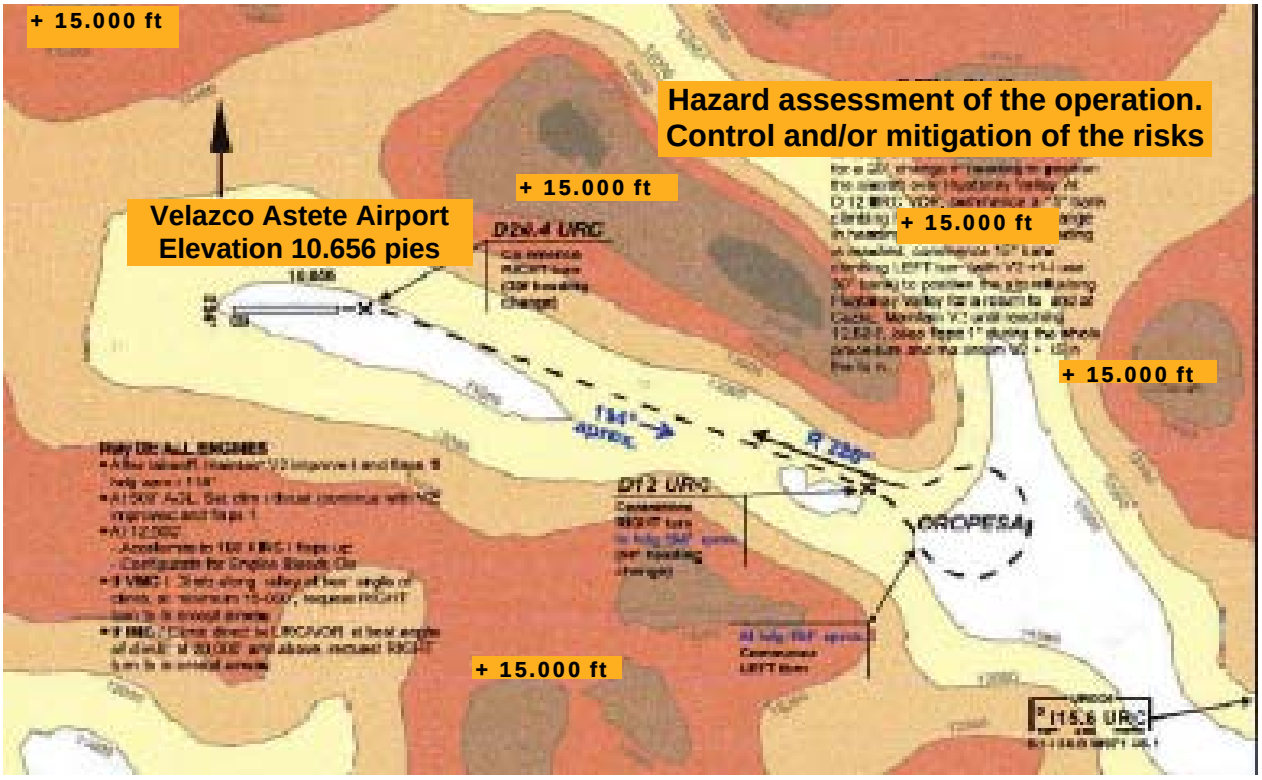
Page left blank intentionally

AFI COMPREHENSIVE IMPLEMENTATION PROGRAMME (ACIP)
SAFETY MANAGEMENT SYSTEM (SMS) COURSE

Exercise 08/01 – Cuzco International Airport operation

Scenario

This is a proposed airline operation with a commercial twin-engine jet aircraft (e.g. B-737, MD-80, A-320, etc.) at Cuzco International Airport.

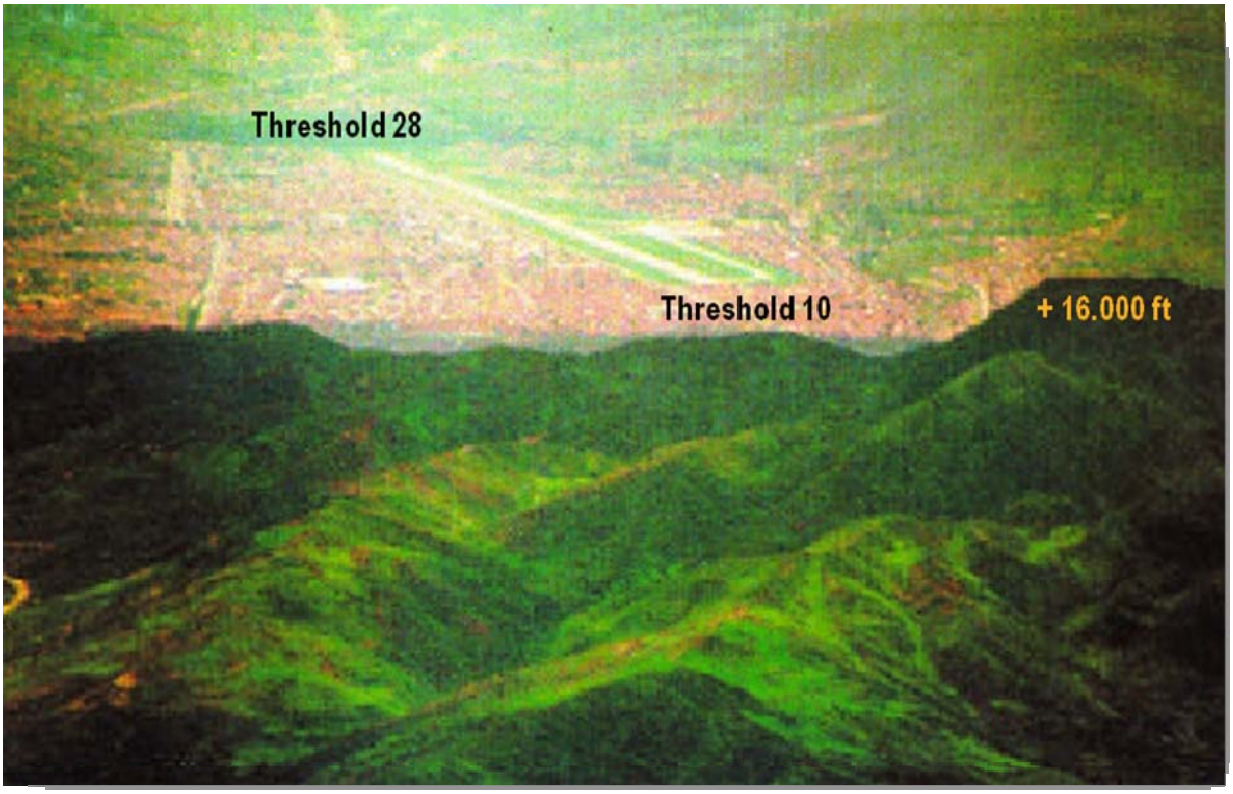


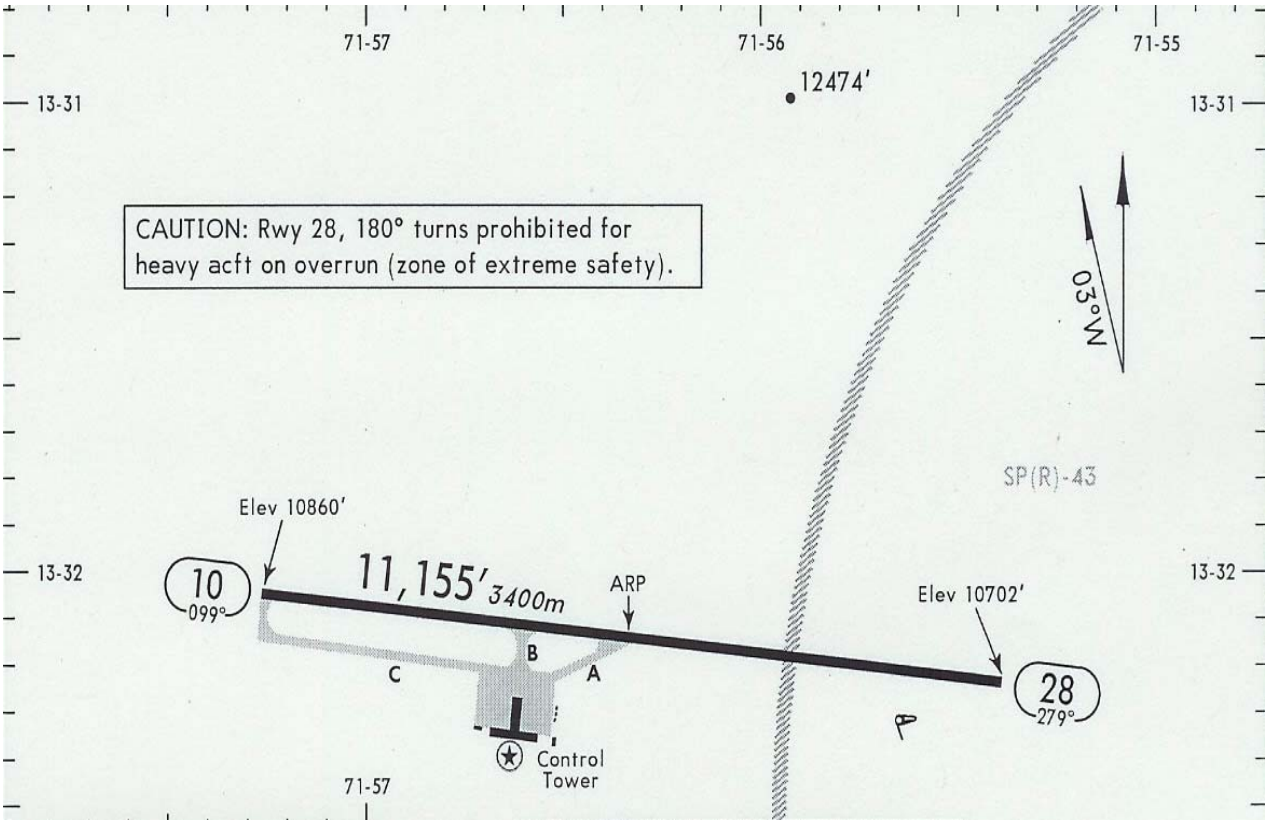
1. Cuzco Airport characteristics and operation

- VMC and day-light aircraft operation
- Landing on runway 28 only.
- Take-off on runway 10 only.
- In case of engine fire, engine-out or emergency condition return to airport is mandatory, except if the aircraft's weight and performance allow the aircraft to comply with obstacle clearance net trajectory.
- Katabatic wind forces tailwind take offs from approximately 16:00 hours daily.
- No ILS approach is available.
- VOR used for instrument letdown (URCOS) not located at the aerodrome.


Velazco Astete Airport
Elevation 10.656 ft
Threshold 28


+ 16.000
Threshold 10
Velazco Astete
City of Cuzco
Threshold 28


Threshold 28
Threshold 10
+ 16.000 ft


71-57
71-56
71-55
13-31
12474'
13-31
CAUTION: Rwy 28, 180° turns prohibited for heavy acft on overrun (zone of extreme safety).
03°W
SP(R)-43
Elev 10860'
13-32
10
099°
11,155'3400m
ARP
Elev 10702'
13-32
B
C
A
28
279°
Control Tower
71-57

2. What is the safety concern?

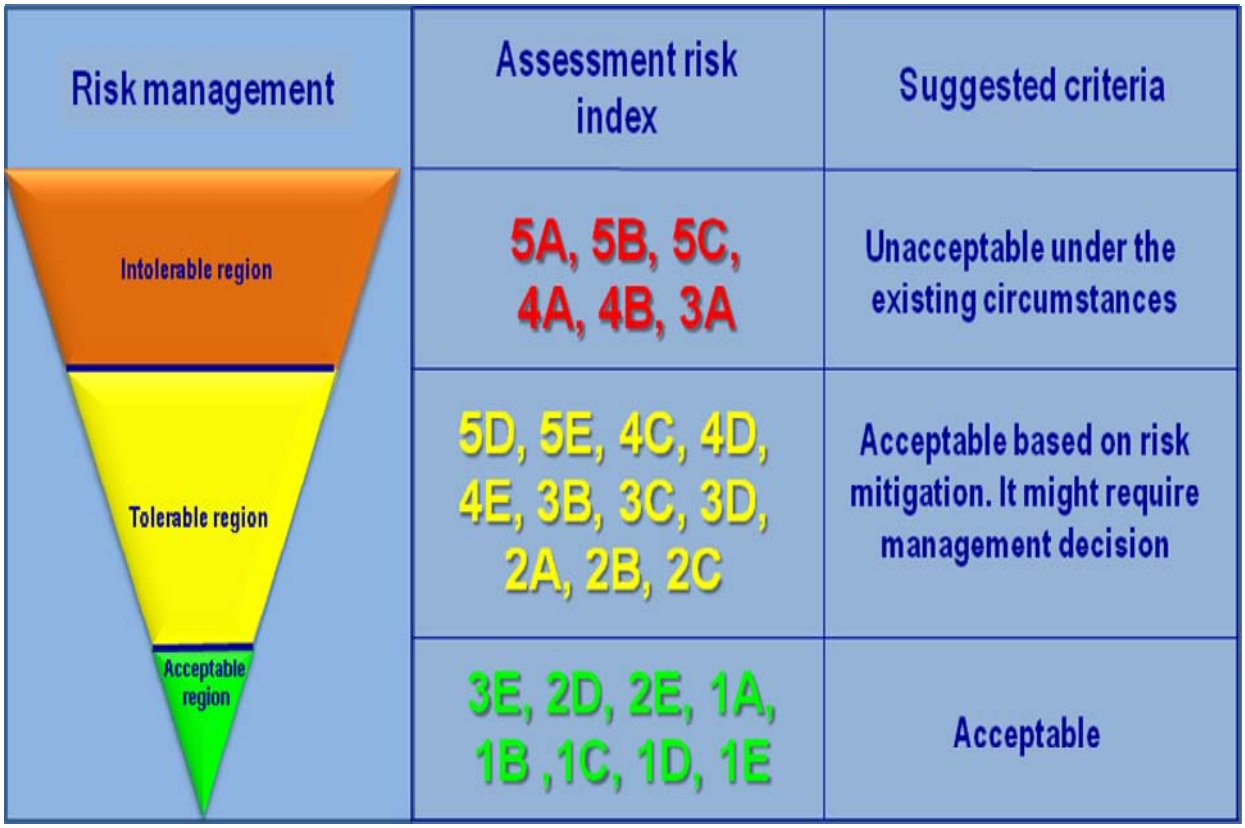
- Issues to be considered:
  - Aerodrome infrastructure
  - Navigational radio aids
  - Weather conditions
  - Aircraft performance
  - Take-off obstacle clearance net path
  - En-route obstacle clearance net path (trajectory)
  - In-flight procedures
  - Documentation
  - Training
    - Pilots and cabin crew
    - Flight dispatchers
    - Safety ground crew

3. Risk assessment matrix

Probability of occurrence		
Qualitative definition	**Meaning**	**Value**
Frequent	Likely to occur many times *(has occurred frequently)*	**5**
Occasional	Likely to occur some times *(has occurred infrequently)*	**4**
Remote	Unlikely, but possible to occur *(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**

Severity of occurrences		
Aviation definition	**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 damage.	**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 increase in workload, or as a result of conditions impairing their efficiency. ➢Serious incident. ➢Injury to persons.	**C**
Minor	➢Nuisance. ➢Operating limitations. ➢Use of emergency procedures. ➢Minor incident.	**D**
Negligible	➢Little consequences	**E**

Risk probability	Risk severity				
	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



4. Group activity

A facilitator will be appointed, who will coordinate the discussion. A summary of the discussion will be written on flip charts, and a member of the group will brief on their findings in a plenary session.

5. Your task

1. List the type of operation or activity.
2. State the generic hazard(s)
3. State the specific components of the hazard(s).
4. State the hazard-related consequences and assess the risk(s).
5. Assess existing defences to control the risk(s) and resulting risk index.
6. Propose further action to reduce the risk(s) and resulting risk index.
7. Establish individual responsibility to implement the risk mitigation
8. Complete the attached log *(Table 08/01).*

6. Utilization of the hazard identification and risk management log

- From Table 08/01 – *Hazard identification and risk management* log below is used to provide a record of identified risks and the actions taken by nominated individuals. The record should be retained permanently in order to provide evidence of safety management and to provide a reference for future risk assessments.
- Having identified and ranked the risks, any existing defences against them should be identified. These defences must then be assessed for adequacy. If these are found to be less than adequate, then additional actions will have to be prescribed. All actions must be addressed by a specified individual (usually the line manager responsible) and a target date for completion must be given. The *Hazard identification and risk management log* is not to be cleared until this action is completed.
- An example is given to facilitate the understanding in the use of the table.

- - - - - - - - - - - - - - - - - -

TABLE 08/01 – HAZARD IDENTIFICATION AND RISK MANAGEMENT

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person
Flight operations	All weather operations at an aerodrome where one of the two parallel runways is closed due to a construction work. *(Example only, not related to the present case study)*	Aircraft taking off or landing on a closed runway. *(Example only, not related to the present case study)*	Aircraft colliding foreign object. *(Example only, not related to the present case study)*	1. NOTAM issued by the aerodrome manager to notified users on the construction work on the closed runway. 2. ATIS 3. Aerodrome layout available in the national AIP 4. New signage and lighting 5. Company operations manual 6. Dispatch performance manual 7. Aircraft operating manual 8. Flight crew competency requirements in AWOP. 9. Recurrent training 10. CRM training *(Example only, not related to the present case study)* *Risk index: 3A* *Risk tolerability: Unacceptable under the existing circumstances*	1. Ensure that flight dispatchers and operations officers inform flight crew on the risk of taking mistakenly the closed runway. 2. Ensure that flight crew is aware of the current layout of the aerodrome. 3. Issuance of company NOTAM concerning the closed runway and new routing on the movement area. 4. Review of the Low Visibility Operations (LVO) during training sessions. 5. Review procedures in the Company Operations Manual and Route Manual. *(Example only, not related to the present case study* *Risk index: 1A* *Risk tolerability: Acceptable after review of the operation*	1. Director of the operations control centre (OCC) 2. Chief pilot 3. Head of Flight operations engineering 4. Flight training manager 5. Head of Documentation Department *(Example only, not related to the present case study)*

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person
Flight operations	Mountainous Terrain	Katabatic winds	Overruns Crash into the city Collision with terrain	-Aircraft flight manual -Aircraft type restriction -VOR -Aircraft type restriction -VMC and daylight only restrictions -Landing from East and takeoff to East -Operations limited to 16:00 hours Local -ATC Services -Aerodrome charts -Airport emergency procedures -Training	-Special/specific crew training for the airport -New, high performance aircraft -New Nav. technology (GPS, etc.) Airport specific flight operating procedures -WGS – 84 (Coordinate system) GNSS Procedures -VHF Sat communication Improved Airport emergency Procedures	- Flight training manger Director of flight Operations -Chief aircraft engineer Director of flight Operations Chief of Air Navigation Airport Manager
		Terrain Obstacles	Collision with terrain CFIT			

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person
		VHF line of sight shortcomings	Comm. interruptions	Risk index: 3A Risk tolerability: Intolerable	Risk index: 2A Risk tolerability: Risk control/mitigation, requires management decision	

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person
				Risk index: *Risk tolerability:*	*Risk index:* *Risk tolerability:*	
				Risk index: *Risk tolerability:*	*Risk index:* *Risk tolerability:*	

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person
				Risk index: *Risk tolerability:*	*Risk index:* *Risk tolerability:*	

- - - - - - - - - - - -

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person
Flight operations	High elevation Airport	Reduced aircraft performance				
				Risk index: *Risk tolerability:*	*Risk index:* *Risk tolerability:*	

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person
				Risk index: *Risk tolerability:*	*Risk index:* *Risk tolerability:*	
				Risk index: *Risk tolerability:*	*Risk index:* *Risk tolerability:*	

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person
				Risk index: *Risk tolerability:*	*Risk index:* *Risk tolerability:*	

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person
Flight operations	*Weather*					
				Risk index: *Risk tolerability:*	*Risk index:* *Risk tolerability:*	

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person
				Risk index: *Risk tolerability:*	*Risk index:* *Risk tolerability:*	
				Risk index: *Risk tolerability:*	*Risk index:* *Risk tolerability:*	

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person
				Risk index: *Risk tolerability:*	*Risk index:* *Risk tolerability:*	

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person
Flight operations						
				Risk index: *Risk tolerability:*	*Risk index:* *Risk tolerability:*	

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person
				Risk index: *Risk tolerability:*	*Risk index:* *Risk tolerability:*	
				Risk index: *Risk tolerability:*	*Risk index:* *Risk tolerability:*	

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person
				Risk index: *Risk tolerability:*	*Risk index:* *Risk tolerability:*	

AFI Comprehensive Implementation Programme (ACIP)

ICAO Safety Management Systems (SMS) Course
<u>Handout N° 6</u> – Collision between two aircraft at Milano-Linate International Airport

International Civil Aviation Organization

Page left blank intentionally

AFI COMPREHENSIVE IMPLEMENTATION PROGRAMME (ACIP) SAFETY MANAGEMENT SYSTEM (SMS) COURSE

Exercise 10/02 – Collision between two aircraft at Milano-Linate International Airport

1. Narrative

A brand new Cessna 525A Citation Jet 2, **D-IEVX**, arrived at Milano-Linate International Airport following a flight from Köln, Germany. The Cessna was to carry out a return flight to Paris-Le Bourget, carrying two pilots, a Cessna sales manager and a prospective customer. The plane arrived at 06:59 and was taxied to the general aviation apron, also known as **"West apron"** *(See diagram below).* It was a foggy morning at Milano-Linate International Airport and one of the passenger flights parked on the **"North apron"** was **SAS MD-87** flight **SK686,** which was being prepared for a flight to Copenhagen, scheduled to depart at 07:35. At 07:41, the pilot of the MD-87 **SK686** contacted **Linate Ground Control** for his engine start clearance, as the boarding of 104 passengers had been completed. The Ground Controller cleared the pilot to start engines and advised that the slot time for takeoff of the flight was at 08:16. Thirteen minutes later flight **SK686** was cleared to taxi to runway **36R**: *"Scandinavian 686, taxi to the holding position Cat III, QNH 1013 and please call me back entering the main taxiway."*

A few minutes later, the Cessna Citation pilot requested permission to start the engines. The Ground Controller then gave start-up clearance. The Ground Controller then requested flight **SK686** to contact the Tower Controller. From this moment on, the MD-87's crew and the Cessna's crew were tuned on two different radio frequencies. At 08:05 the pilots of the Cessna received taxi clearance: *"Delta Victor Xray, taxi north via **Romeo 5**, QNH 1013, call me back at the stop bar of the ... main runway extension."*

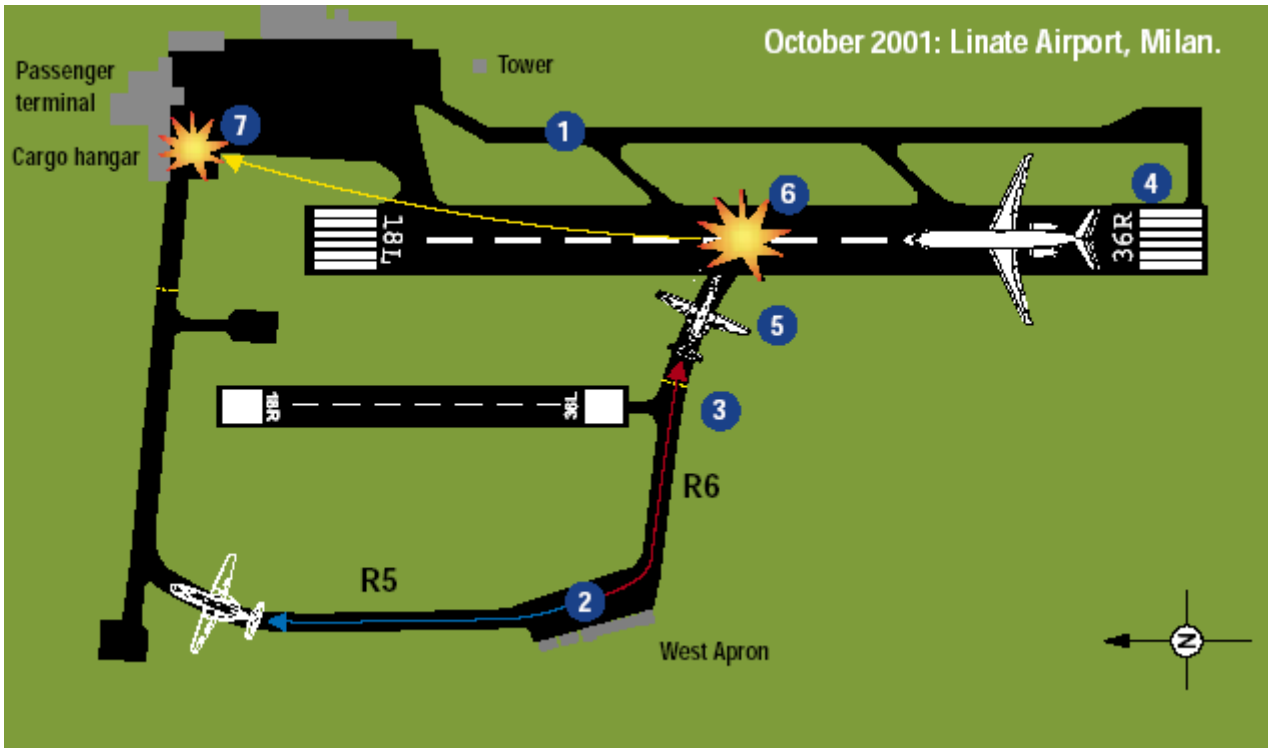
The pilot acknowledged by saying: *"Roger via **Romeo 5** and ... 1013, and call you back before reaching main runway."*

The Cessna started to taxi from the general aviation parking position, following the yellow taxi line. After reaching the position where the yellow taxi line splits into two diverging directions, the pilot erroneously took the taxi line to right and entered taxiway ***Romeo 6***. At 08:09 the Ground Controller cleared the Cessna to continue its taxi on the **North Apron**. At the same time the Tower Controller cleared the MD-87 for takeoff: *"...Scandinavian 686 Linate, clear for takeoff 36, the wind is calm report rolling, when airborne squawk ident."* The pilot advanced the throttles and acknowledged the clearance: *"Clear for takeoff 36 at when...airborne squawk ident and we are rolling, Scandinavian 686."* When the MD-87 was speeding down the runway, the Cessna crossed the runway holding sign and entered the active runway **18L/36R**.

At 08.10:21 the nose landing gear of the MD-87 had left the ground and main gears were extending the shock absorbers but the main wheels were still on the ground at airspeed of 146 knots (270, 5 km/h).

At that moment the MD-87 crew probably saw a glimpse of the Cessna through the fog and reacted with additional large nose-up elevator. At that moment the MD-87 collided with the Cessna Citation Jet. The right wing of the MD-87 sustained damage at the leading edge and the right hand main landing gear leg broke off. It damaged the right flap and struck the N° 2 engine which then separated from the pylon. The pilot of the MD-87 gradually advanced the throttles and then the aircraft was airborne for a total of 12 seconds, reaching an estimated height of about 35 feet (11 meters). The left hand engine suffered a noticeable thrust reduction as a result of debris ingestion, which became insufficient to sustain flight.

The airspeed had increased up to 166 knots (307,6 km/h), but the MD-87 descended abruptly making contact with the runway with the left hand main gear, the truncated right hand main gear leg and the tip of the right hand wing. Prior to touch down the pilot reduced engine thrust and after ground contact the engine reverse levers were activated and deployed (on the left hand engine only). Maximum available reverse thrust was selected and the brakes applied. The plane skidded past the grass overrun area, across a service road, crashing sideways into a baggage handling building, which partly collapsed. This building was located 20m/67 feet to the right of the runway, and 460m/1500 feet from the runway end.



Legend

1. Flight **SK686** taxied to the holding point for runway 36R. Heavy fog had delayed the flight by more than one hour. While the visibility was improving, RVR was still only 225 metres.
2. The Cessna Citation parked at the West Apron was cleared to taxi via taxiway **Romeo 5** and to report reaching the first holding point. The pilot read the clearance back correctly, but entered taxiway **Romeo 6**.
3. The Cessna Citation's pilot called for clearance to proceed from the **Romeo 5** holding point though it was in fact at the **Romeo 6** holding point.
4. Flight **SK686** was cleared for take-off.
5. The Cessna Citation crossed the holding point for runway **36R-18L**.
6. The two aircraft collided.
7. The stricken MD-87 skidded off the runway into a baggage hangar adjacent to the passenger terminal.

2. Investigation

After analysis of evidence available and information gathered, it can be assumed that the immediate cause for the accident has been the runway incursion in the active runway by the Cessna Citation. The obvious consideration is that the human factor related action of the Cessna Citation crew – during low visibility conditions – must be weighted against the scenario that allowed the course of events that led to the fatal collision; equally it can be stated that the system in place at Milano-Linate Airport was not geared to trap misunderstandings, let alone inadequate procedures, human errors and faulty airport layout.

The following list highlights immediate and systemic causes that led to the accident:

- The visibility was low, between 50 and 100 meters.
- The traffic volume was high.
- The lack of adequate visual aids.
- The Cessna Citation crew used the wrong taxiway and entered the runway without specific clearance.
- The failure to check the Cessna Citation crew qualification.
- The nature of the flight might have exerted certain pressure on the Cessna Citation crew to commence the flight despite the prevailing weather conditions.
- The Cessna Citation crew was not aided properly with correct publications (AIP Italy-Jeppesen) lights (red bar lights and taxiway lights), markings (in deformity with standard format and unpublished, S4) and signs (non-existing TWY R6) to enhance their situational awareness.
- Official documentation failed to report the presence of unpublished markings (S4, S5, etc.) that were unknown to air traffic managers, thus preventing the ATC staff from interpreting the ambiguous information from the Cessna Citation crew, a position report mentioning **S4**.
- Radio communications were not performed using standard phraseology (read back) or were not consistently adhered to (resulting in untraced misunderstandings in relevant radio communications).
- Operational procedures allowing high traffic volume (high number of ground movements) in weather conditions as were current the day of the accident (reduced visibility) and in the absence of technical aids.
- Radio communications were performed in Italian and English language.
- ATC personnel did not realize that Cessna Citation was on taxiway **Romeo 6**.
- The ground controller issued a taxi clearance toward north (main) apron although the reported position **S4** did not have any meaning to him.
- Instructions, training and the prevailing environmental situation prevented the ATC personnel from having full control over the aircraft movements on ground.
- The aerodrome standard did not comply with ICAO Annex 14; required markings lights and signs did not exist (**Romeo 6**) or were in dismal order and were hard to recognize especially under low visibility conditions (**Romeo 5** - **Romeo 6**), other markings were unknown to operators (**S4**).

- No functional Safety Management System (SMS) was in operation.
- The competence maintenance and requirements for recent experience for ATC personnel did not comply fully with ICAO Annex 1.
- The Low Visibility Operations (LVO) implementation by ENAV did not conform to the requirements provided in the corresponding and referenced ICAO Doc 9476.

The combined effect of these factors, contemporaneously present on the 8th of October 2001 at Milano-Linate Airport, have neutralized any possible error corrective action and therefore allowed the accident.

3. Epilogue

In April 2004 four officials accused of negligence and multiple manslaughter were sentenced to jail terms ranging from 6½ to 8 years. Judges gave eight-year prison sentences to the director of the Milano-Linate Airport and the air traffic controller who was on duty at the time. The former CEO of Italy's air traffic control agency ENAV and the person who oversees Milan's two airports, there were sentenced to six years and six months each.

4. Risk assessment matrix

Probability of occurrence		
Qualitative definition	**Meaning**	**Value**
Frequent	Likely to occur many times *(has occurred frequently)*	**5**
Occasional	Likely to occur some times *(has occurred infrequently)*	**4**
Remote	Unlikely, but possible to occur *(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**

Severity of occurrences		
Aviation definition	**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 damage.	**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 increase in workload, or as a result of conditions impairing their efficiency. ➢Serious incident. ➢Injury to persons.	**C**
Minor	➢Nuisance. ➢Operating limitations. ➢Use of emergency procedures. ➢Minor incident.	**D**
Negligible	➢Little consequences	**E**

Risk probability		Risk severity				
		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	2E

Risk management	Assessment 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	Acceptable based on risk mitigation. It might require management decision
Acceptable region	3E, 2D, 2E, 1A, 1B ,1C, 1D, 1E	Acceptable

EXERCISE 10/02

5. Group activity

A facilitator will be appointed, who will coordinate the discussion. A summary of the discussion will be written on flip charts, and a member of the group will brief on their findings in a plenary session.

6. Your task

Task N° 1

1. List the type of operation or activity.
2. State the generic hazard(s)
3. State the specific components of the hazard(s).
4. State the hazard-related consequences and assess the risk(s).
5. Assess existing defences to control the risk(s) and resulting risk index.
6. Propose further action to reduce the risk(s) and resulting risk index.
7. Establish individual responsibility to implement the risk mitigation
8. Complete the attached log *(Table 10/01).*

7. Utilization of the hazard identification and risk management log

- From Table 10/01 – *Hazard identification and risk management* log below is used to provide a record of identified risks and the actions taken by nominated individuals. The record should be retained permanently in order to provide evidence of safety management and to provide a reference for future risk assessments.
- Having identified and ranked the risks, any existing defences against them should be identified. These defences must then be assessed for adequacy. If these are found to be less than adequate, then additional actions will have to be prescribed. All actions must be addressed by a specified individual (usually the line manager responsible) and a target date for completion must be given. The *Hazard identification and risk management log* is not to be cleared until this action is completed.
- An example is given to facilitate the understanding in the use of the table.

8. Task Nº 2

1. The Accident Investigation Board has identified that no functional Safety Management System (SMS) was in operation at Milano-Linate International Airport. Therefore you should:
   a) Develop a SMS implementation plan for Milano-Linate International Airport.
   b) Complete the attached Gantt chart *(Table 10/02).*

- - - - - - - - - - - - - - - - - -

TABLE 10/01 – HAZARD IDENTIFICATION AND RISK MANAGEMENT

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person
Flight operations	All weather operations at an aerodrome where one of the two parallel runways is closed due to a construction work. *(Example only, not related to the present case study)*	Aircraft taking off or landing on a closed runway. *(Example only, not related to the present case study)*	Aircraft colliding foreign object. *(Example only, not related to the present case study)*	1. NOTAM issued by the aerodrome manager to notified users on the construction work on the closed runway. 2. ATIS 3. Aerodrome layout available in the national AIP 4. New signage and lighting 5. Company operations manual 6. Dispatch performance manual 7. Aircraft operating manual 8. Flight crew competency requirements in AWOP. 9. Recurrent training 10. CRM training *(Example only, not related to the present case study)* *Risk index: 3A* *Risk tolerability: Unacceptable under the existing circumstances*	1. Ensure that flight dispatchers and operations officers inform flight crew on the risk of taking mistakenly the closed runway. 2. Ensure that flight crew is aware of the current layout of the aerodrome. 3. Issuance of company NOTAM concerning the closed runway and new routing on the movement area. 4. Review of the Low Visibility Operations (LVO) during training sessions. 5. Review procedures in the Company Operations Manual and Route Manual. *(Example only, not related to the present case study* *Risk index: 1A* *Risk tolerability: Acceptable after review of the operation*	1. Director of the operations control centre (OCC) 2. Chief pilot 3. Head of Flight operations engineering 4. Flight training manager 5. Head of Documentation Department *(Example only, not related to the present case study)*

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person
Aerodrome Operation	Adverse weather	*Low visibility (fog)*	*Loss of situational awareness* *Runway incursions* *Collision between aircraft*	*1) Signage and markings* *2) WX information* *3) LOV Procedures* *4) International standards* *5) Regulations* *Risk index: 3A* *Risk tolerability: Intolerable*	*1) International standard signage*	Airport manager
					2) Low visibility lighting	Airport manager
					3) LOV procedure improvement	Manager of air navigation
					4) Improved operations infrastructure maintenance	Aerodrome Engineering manager
					5) SMR	Aerodrome Engineering manager
					6) Follow me car *Risk index:2A* *Risk tolerability: Risk control/mitigation, requires management decision*	Airport manager

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person
	Inadequate safety oversight	*Inadequate aerodrome visual aids* *Non standard signage and markings*	*Loss of situational awareness* *Loss of situational awareness* *Collision between aircraft*	*1) SARPs* *2) CAA Regulation* *3) Safety Oversight* *4)* *Risk index: 3A* *Risk tolerability: Intolerable*	*1) Implementation of SARPS* *2) Safety oversight including enforcement* *Risk index: 2A* *Risk tolerability: Risk control/mitigation, requires management decision*	1-Director General (CAA) 2- Director General (CAA)

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person
		Unclear aerodrome signage *Vegetation management*	*Loss of situational awareness* *Loss of situational awareness* *Collision between aircraft* *Bird strikes* *Obstruction of visual aids*	*-SARPs* *-CAA Regulation* *-Safety Oversight* *Risk index: 3A* *Risk tolerability: Intolerable*	*-Implementation of SARPS* *-Safety oversight including enforcement* *-Effective vegetation management* *Risk index: 2A* *Risk tolerability: Risk control/mitigation, requires management decision*	-DG of CAA DG of CAA Airport manager
ATS Operations	In adequate safety oversight	*Non standard ATC Communication*	*Loss of situational awareness* *Dangerous clearances* *Collisions*	*-ATC Training* *-ATC SOPs* *-SARPs* *-Regulationa and oversight* *Risk index: 3A* *Risk tolerability: Intolerable*	*1-Systematic training* *2-Review and update Regulations* *3-Effective Safety oversight* *Risk index: 2A* *Risk tolerability: Risk control/mitigation, requires management decision*	1-ATS Training manager 2- Director General of CAA 3- Director General of CAA

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person
		Non standard LVO Procedures		*Risk index:* *Risk tolerability:*	*Risk index:* *Risk tolerability:*	
	Adverse weather	*Traffic congestion*	*Work pressure* *Reduced human performance* *Delays*	*-LOV procedures* *-Training* *Risk index: 3A* *Risk tolerability: Intolerable*	*1-Improved standard LOV procedures* *2- Increased qualified ATC personnel* *Risk index: 2A* *Risk tolerability: Risk control/mitigation, requires management decision*	1- Manager of Air Navigation 2-ATS Manager

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person
Aircraft Operations	Adverse weather	*Loss of situational awareness* *Runway incursions*	*Collision between aircraft* *Collision between aircraft*	*Training* *Aerodrome visual aids* *Charts* *Risk index: 3A* *Risk tolerability: Intolerable*	*Improved training* *SOP improvement* *Risk index: 2A* *Risk tolerability: Risk control/mitigation, requires management decision*	Training manager Director of operations
		Delays	*Passenger complaints*	*Loss of revenue*		

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person

TABLE 10/02 – GANTT CHART FOR THE SMS IMPLEMENTATION PLAN

Nº	Component/element	Date: 2009				Date: 2010				Date: 2011				Date: 2012			

Nº	Component/element	Date: 2009				Date: 2010				Date: 2011				Date: 2012			

AFI Comprehensive Implementation Programme (ACIP)

ICAO Safety Management Systems (SMS) Course
<u>Handout N° 6</u> – Collision between two aircraft at Milano-Linate International Airport

International Civil Aviation Organization

Page left blank intentionally

AFI COMPREHENSIVE IMPLEMENTATION PROGRAMME (ACIP) SAFETY MANAGEMENT SYSTEM (SMS) COURSE

Exercise 10/02 – Collision between two aircraft at Milano-Linate International Airport

1. Narrative

A brand new Cessna 525A Citation Jet 2, **D-IEVX**, arrived at Milano-Linate International Airport following a flight from Köln, Germany. The Cessna was to carry out a return flight to Paris-Le Bourget, carrying two pilots, a Cessna sales manager and a prospective customer. The plane arrived at 06:59 and was taxied to the general aviation apron, also known as **"West apron"** *(See diagram below).* It was a foggy morning at Milano-Linate International Airport and one of the passenger flights parked on the **"North apron"** was **SAS MD-87** flight **SK686,** which was being prepared for a flight to Copenhagen, scheduled to depart at 07:35. At 07:41, the pilot of the MD-87 **SK686** contacted **Linate Ground Control** for his engine start clearance, as the boarding of 104 passengers had been completed. The Ground Controller cleared the pilot to start engines and advised that the slot time for takeoff of the flight was at 08:16. Thirteen minutes later flight **SK686** was cleared to taxi to runway **36R**: *"Scandinavian 686, taxi to the holding position Cat III, QNH 1013 and please call me back entering the main taxiway."*

A few minutes later, the Cessna Citation pilot requested permission to start the engines. The Ground Controller then gave start-up clearance. The Ground Controller then requested flight **SK686** to contact the Tower Controller. From this moment on, the MD-87's crew and the Cessna's crew were tuned on two different radio frequencies. At 08:05 the pilots of the Cessna received taxi clearance: *"Delta Victor Xray, taxi north via **Romeo 5**, QNH 1013, call me back at the stop bar of the ... main runway extension."*

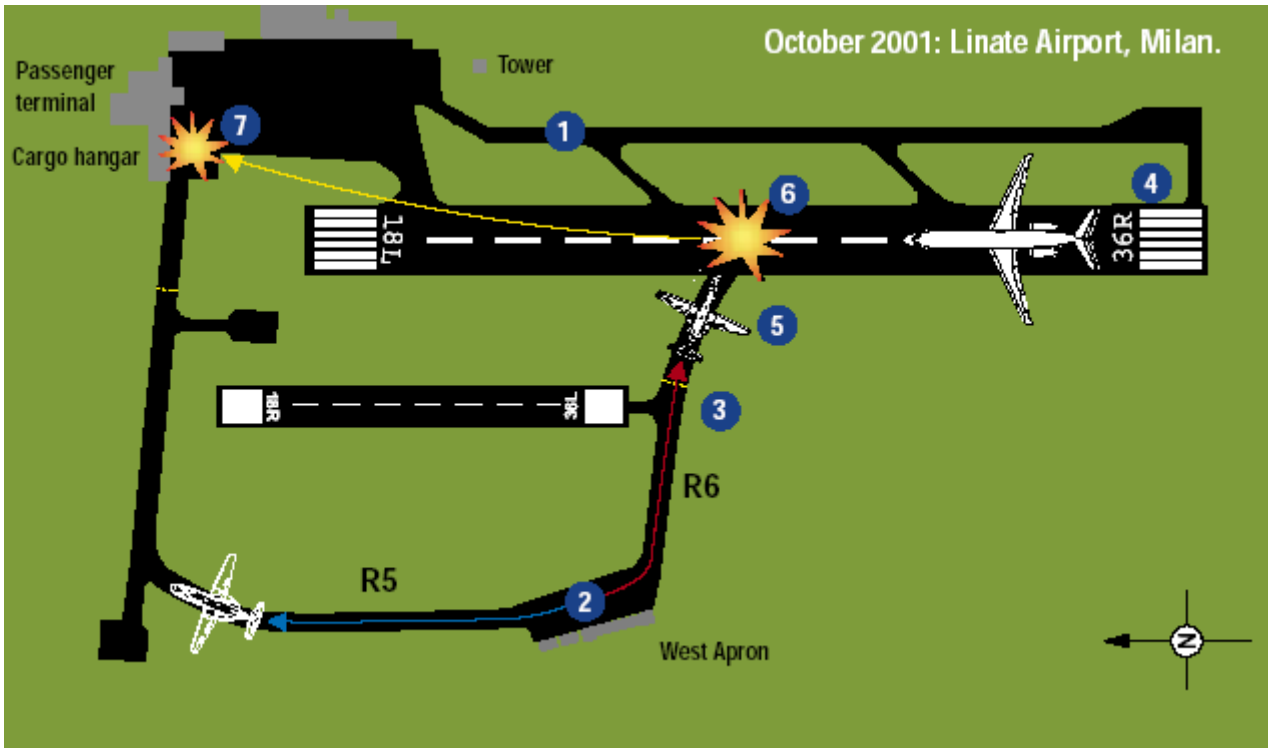
The pilot acknowledged by saying: *"Roger via **Romeo 5** and ... 1013, and call you back before reaching main runway."*

The Cessna started to taxi from the general aviation parking position, following the yellow taxi line. After reaching the position where the yellow taxi line splits into two diverging directions, the pilot erroneously took the taxi line to right and entered taxiway ***Romeo 6***. At 08:09 the Ground Controller cleared the Cessna to continue its taxi on the **North Apron**. At the same time the Tower Controller cleared the MD-87 for takeoff: *"...Scandinavian 686 Linate, clear for takeoff 36, the wind is calm report rolling, when airborne squawk ident."* The pilot advanced the throttles and acknowledged the clearance: *"Clear for takeoff 36 at when...airborne squawk ident and we are rolling, Scandinavian 686."* When the MD-87 was speeding down the runway, the Cessna crossed the runway holding sign and entered the active runway **18L/36R**.

At 08.10:21 the nose landing gear of the MD-87 had left the ground and main gears were extending the shock absorbers but the main wheels were still on the ground at airspeed of 146 knots (270, 5 km/h).

At that moment the MD-87 crew probably saw a glimpse of the Cessna through the fog and reacted with additional large nose-up elevator. At that moment the MD-87 collided with the Cessna Citation Jet. The right wing of the MD-87 sustained damage at the leading edge and the right hand main landing gear leg broke off. It damaged the right flap and struck the N° 2 engine which then separated from the pylon. The pilot of the MD-87 gradually advanced the throttles and then the aircraft was airborne for a total of 12 seconds, reaching an estimated height of about 35 feet (11 meters). The left hand engine suffered a noticeable thrust reduction as a result of debris ingestion, which became insufficient to sustain flight.

The airspeed had increased up to 166 knots (307,6 km/h), but the MD-87 descended abruptly making contact with the runway with the left hand main gear, the truncated right hand main gear leg and the tip of the right hand wing. Prior to touch down the pilot reduced engine thrust and after ground contact the engine reverse levers were activated and deployed (on the left hand engine only). Maximum available reverse thrust was selected and the brakes applied. The plane skidded past the grass overrun area, across a service road, crashing sideways into a baggage handling building, which partly collapsed. This building was located 20m/67 feet to the right of the runway, and 460m/1500 feet from the runway end.



Legend

1. Flight **SK686** taxied to the holding point for runway 36R. Heavy fog had delayed the flight by more than one hour. While the visibility was improving, RVR was still only 225 metres.
2. The Cessna Citation parked at the West Apron was cleared to taxi via taxiway **Romeo 5** and to report reaching the first holding point. The pilot read the clearance back correctly, but entered taxiway **Romeo 6**.
3. The Cessna Citation's pilot called for clearance to proceed from the **Romeo 5** holding point though it was in fact at the **Romeo 6** holding point.
4. Flight **SK686** was cleared for take-off.
5. The Cessna Citation crossed the holding point for runway **36R-18L**.
6. The two aircraft collided.
7. The stricken MD-87 skidded off the runway into a baggage hangar adjacent to the passenger terminal.

2. Investigation

After analysis of evidence available and information gathered, it can be assumed that the immediate cause for the accident has been the runway incursion in the active runway by the Cessna Citation. The obvious consideration is that the human factor related action of the Cessna Citation crew – during low visibility conditions – must be weighted against the scenario that allowed the course of events that led to the fatal collision; equally it can be stated that the system in place at Milano-Linate Airport was not geared to trap misunderstandings, let alone inadequate procedures, human errors and faulty airport layout.

The following list highlights immediate and systemic causes that led to the accident:

- The visibility was low, between 50 and 100 meters.
- The traffic volume was high.
- The lack of adequate visual aids.
- The Cessna Citation crew used the wrong taxiway and entered the runway without specific clearance.
- The failure to check the Cessna Citation crew qualification.
- The nature of the flight might have exerted certain pressure on the Cessna Citation crew to commence the flight despite the prevailing weather conditions.
- The Cessna Citation crew was not aided properly with correct publications (AIP Italy-Jeppesen) lights (red bar lights and taxiway lights), markings (in deformity with standard format and unpublished, S4) and signs (non-existing TWY R6) to enhance their situational awareness.
- Official documentation failed to report the presence of unpublished markings (S4, S5, etc.) that were unknown to air traffic managers, thus preventing the ATC staff from interpreting the ambiguous information from the Cessna Citation crew, a position report mentioning **S4**.
- Radio communications were not performed using standard phraseology (read back) or were not consistently adhered to (resulting in untraced misunderstandings in relevant radio communications).
- Operational procedures allowing high traffic volume (high number of ground movements) in weather conditions as were current the day of the accident (reduced visibility) and in the absence of technical aids.
- Radio communications were performed in Italian and English language.
- ATC personnel did not realize that Cessna Citation was on taxiway **Romeo 6**.
- The ground controller issued a taxi clearance toward north (main) apron although the reported position **S4** did not have any meaning to him.
- Instructions, training and the prevailing environmental situation prevented the ATC personnel from having full control over the aircraft movements on ground.
- The aerodrome standard did not comply with ICAO Annex 14; required markings lights and signs did not exist (**Romeo 6**) or were in dismal order and were hard to recognize especially under low visibility conditions (**Romeo 5** - **Romeo 6**), other markings were unknown to operators (**S4**).

- No functional Safety Management System (SMS) was in operation.
- The competence maintenance and requirements for recent experience for ATC personnel did not comply fully with ICAO Annex 1.
- The Low Visibility Operations (LVO) implementation by ENAV did not conform to the requirements provided in the corresponding and referenced ICAO Doc 9476.

The combined effect of these factors, contemporaneously present on the 8th of October 2001 at Milano-Linate Airport, have neutralized any possible error corrective action and therefore allowed the accident.

3. Epilogue

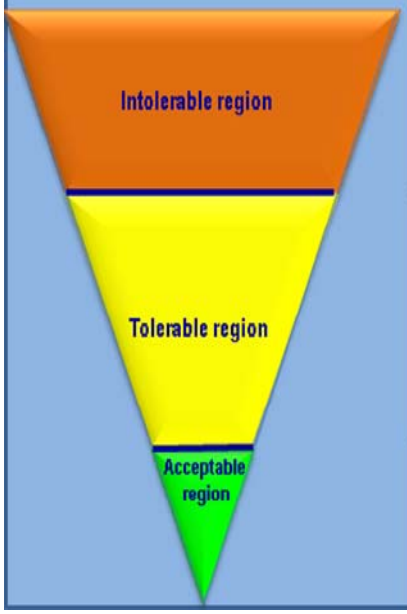
In April 2004 four officials accused of negligence and multiple manslaughter were sentenced to jail terms ranging from 6½ to 8 years. Judges gave eight-year prison sentences to the director of the Milano-Linate Airport and the air traffic controller who was on duty at the time. The former CEO of Italy's air traffic control agency ENAV and the person who oversees Milan's two airports, there were sentenced to six years and six months each.

4. Risk assessment matrix

Probability of occurrence		
Qualitative definition	**Meaning**	**Value**
Frequent	Likely to occur many times *(has occurred frequently)*	**5**
Occasional	Likely to occur some times *(has occurred infrequently)*	**4**
Remote	Unlikely, but possible to occur *(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**

Severity of occurrences		
Aviation definition	**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 damage.	**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 increase in workload, or as a result of conditions impairing their efficiency. ➢Serious incident. ➢Injury to persons.	**C**
Minor	➢Nuisance. ➢Operating limitations. ➢Use of emergency procedures. ➢Minor incident.	**D**
Negligible	➢Little consequences	**E**

Risk probability	Risk severity				
	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	2E

Risk management	Assessment risk index	Suggested criteria
	5A, 5B, 5C, 4A, 4B, 3A	Unacceptable under the existing circumstances
	5D, 5E, 4C, 4D, 4E, 3B, 3C, 3D, 2A, 2B, 2C	Acceptable based on risk mitigation. It might require management decision
	3E, 2D, 2E, 1A, 1B ,1C, 1D, 1E	Acceptable

EXERCISE 10/02

5. Group activity

A facilitator will be appointed, who will coordinate the discussion. A summary of the discussion will be written on flip charts, and a member of the group will brief on their findings in a plenary session.

6. Your task

Task N° 1

1. List the type of operation or activity.
2. State the generic hazard(s)
3. State the specific components of the hazard(s).
4. State the hazard-related consequences and assess the risk(s).
5. Assess existing defences to control the risk(s) and resulting risk index.
6. Propose further action to reduce the risk(s) and resulting risk index.
7. Establish individual responsibility to implement the risk mitigation
8. Complete the attached log *(Table 10/01).*

7. Utilization of the hazard identification and risk management log

- From Table 10/01 – *Hazard identification and risk management* log below is used to provide a record of identified risks and the actions taken by nominated individuals. The record should be retained permanently in order to provide evidence of safety management and to provide a reference for future risk assessments.
- Having identified and ranked the risks, any existing defences against them should be identified. These defences must then be assessed for adequacy. If these are found to be less than adequate, then additional actions will have to be prescribed. All actions must be addressed by a specified individual (usually the line manager responsible) and a target date for completion must be given. The *Hazard identification and risk management log* is not to be cleared until this action is completed.
- An example is given to facilitate the understanding in the use of the table.

8. Task Nº 2

1. The Accident Investigation Board has identified that no functional Safety Management System (SMS) was in operation at Milano-Linate International Airport. Therefore you should:
   a) Develop a SMS implementation plan for Milano-Linate International Airport.
   b) Complete the attached Gantt chart *(Table 10/02).*

- - - - - - - - - - - - - - - - - -

TABLE 10/01 – HAZARD IDENTIFICATION AND RISK MANAGEMENT

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person
Flight operations	All weather operations at an aerodrome where one of the two parallel runways is closed due to a construction work. *(Example only, not related to the present case study)*	Aircraft taking off or landing on a closed runway. *(Example only, not related to the present case study)*	Aircraft colliding foreign object. *(Example only, not related to the present case study)*	1. NOTAM issued by the aerodrome manager to notified users on the construction work on the closed runway. 2. ATIS 3. Aerodrome layout available in the national AIP 4. New signage and lighting 5. Company operations manual 6. Dispatch performance manual 7. Aircraft operating manual 8. Flight crew competency requirements in AWOP. 9. Recurrent training 10. CRM training *(Example only, not related to the present case study)* *Risk index: 3A* *Risk tolerability: Unacceptable under the existing circumstances*	1. Ensure that flight dispatchers and operations officers inform flight crew on the risk of taking mistakenly the closed runway. 2. Ensure that flight crew is aware of the current layout of the aerodrome. 3. Issuance of company NOTAM concerning the closed runway and new routing on the movement area. 4. Review of the Low Visibility Operations (LVO) during training sessions. 5. Review procedures in the Company Operations Manual and Route Manual. *(Example only, not related to the present case study* *Risk index: 1A* *Risk tolerability: Acceptable after review of the operation*	1. Director of the operations control centre (OCC) 2. Chief pilot 3. Head of Flight operations engineering 4. Flight training manager 5. Head of Documentation Department *(Example only, not related to the present case study)*

Type of operation or activity	Generic hazard	Specific components of the hazard	Hazard-related consequences	Existing defences to control risk(s) and risk index	Further action to reduce risk(s) and resulting risk index	Responsible person
				Risk index: *Risk tolerability:*	*Risk index:* *Risk tolerability:*	
				Risk index: *Risk tolerability:*	*Risk index:* *Risk tolerability:*	

TABLE 10/02 – GANTT CHART FOR THE SMS IMPLEMENTATION PLAN

Nº	Component/element	Date: 2009				Date: 2010				Date:2011				Date:2012			
1	Identify Accountable Executive																
2	Identify accountabilities of managers																
3	Appoint Safety Manager to be responsible for implementation																
4	Develop Safety Policy and Objectives																
6	Indicate the Time Frames																
7	Identify All the operations of the system																
8	Conduct gap analysis																
9	Coordinate ERP																
10	Establish Communication Means and documentation																
1	Establish Reactive Reporting																
2	Training for above																
3	Documentation for Reactive Processes																
1	Implementation of Proactive and Predictive																
2	Training																

Nº	Component/element	Date: 2009				Date: 2010				Date:2011				Date:2012			
3	Documentation for proactive																
1	Indicators, Targets																
2	Monitoring																
3	Training for assurance																
4	Documentation for assurance																

Nº	Component/element	Date: 2009				Date: 2010				Date:2011				Date:2012			

Model SMS Regulation

SCOPE AND APPLICABILITY

These regulations describe all the safety management processes and requirements which are applicable to:

1. Approved training organizations that are exposed to safety risks during the provision of their services
2. Aircraft operators
3. Approved maintenance organizations
4. Organizations responsible for design and/or manufacture of aircraft
5. Air traffic services providers (Annex 11)
6. Certified aerodromes

In order to, as a minimum

a) *identify safety hazards;*

b) *ensure that remedial action necessary to maintain safety performance is implemented;*

c) *provide for continuous monitoring and regular assessment of the safety performance;*

d) *aim at a continuous improvement of the overall performance of the SMS.*

These regulations shall come into effect from January 2010

DEFINITIONS

Safety

SMS

SSP

ALoS

Hazard

Hazard Identification

Consequence

Risk

Risk Management

Risk Mitigation and Control

ALARP

Tolerability

Probability

Severity

Safety Performance Indicators

Safety Targets

CONTENTS

The Service provider shall develop Safety policy and objectives which shall clearly outline

-Management commitment and responsibility

-Safety accountabilities

-Appointment of key safety personnel

-Coordination of emergency response planning

-SMS documentation

The service provider shall have in place a system for Safety risk management which incorporates

-Hazard identification

-Risk assessment and mitigation

The service provider shall have in place a system of Safety assurance encompassing the following

-Safety performance monitoring and measurement

-The management of change

-Continuous improvement of the SMS

The service provider shall ensure that he conducts Safety promotion in his organisation by

-Training and educating

-Safety communication