



*ICAO Safety Management  
Systems (SMS) Course  
Handout N° 4 – Accident  
Boeing 747-412 – Taipei  
International Airport*



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## SAFETY MANAGEMENT SYSTEMS (SMS) COURSE

### *Exercise 05/01 – Accident Boeing 747-412 –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 taxiing 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.

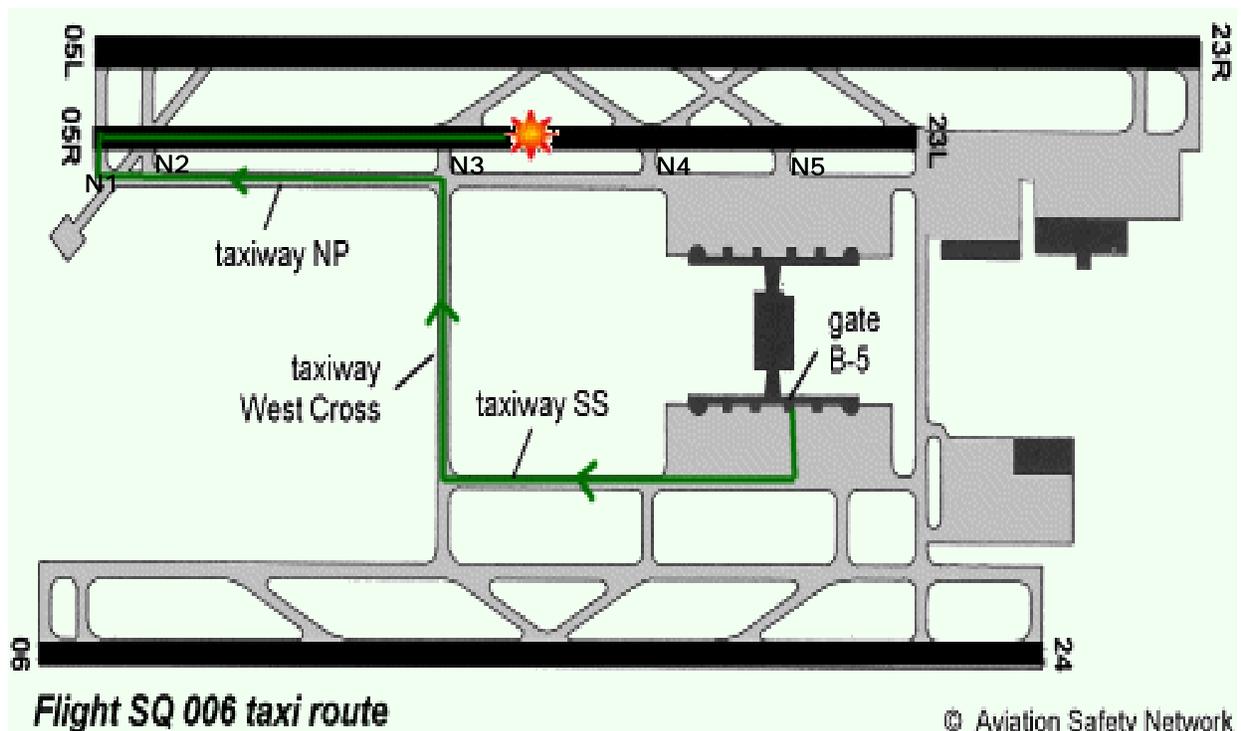
As SQ006's PIC taxied down **N1** and approached **05R**, he was *"focused on the image of the runway to his right, and he did not notice any further green lights ahead and along the extension of N1,"* he told investigators.

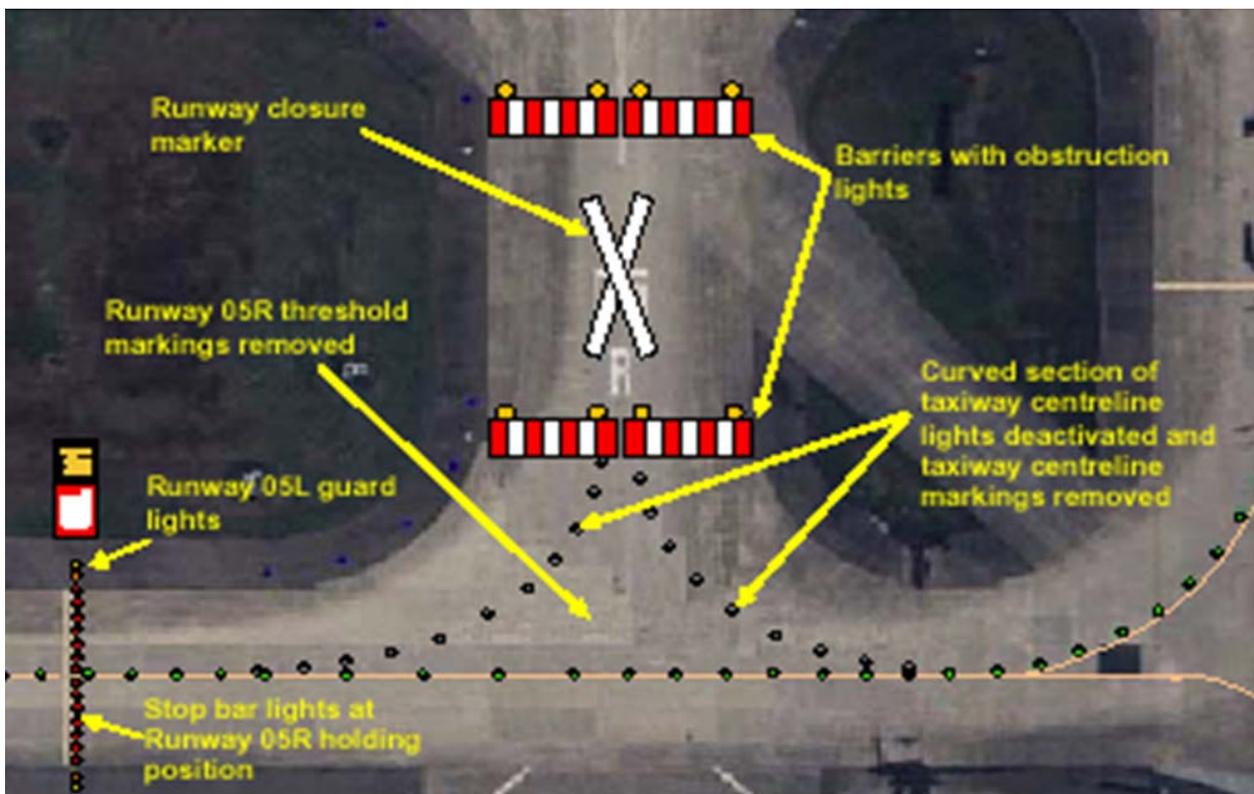
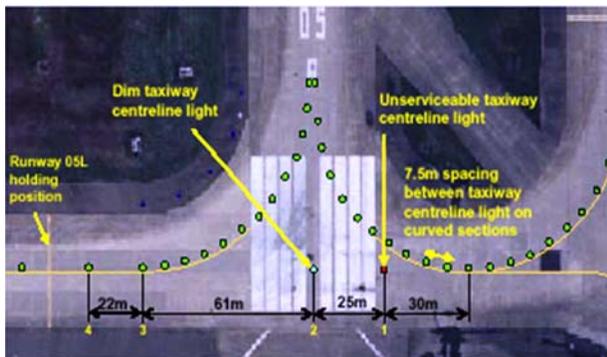
Investigators found several other lighting and marking problems. Some of the runway edge lights on both **05L** and **05R** were either broken or *"aligned away from the direction of the runway length,"* report said. Also, there was nothing over the **05R** threshold markings that indicated the runway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

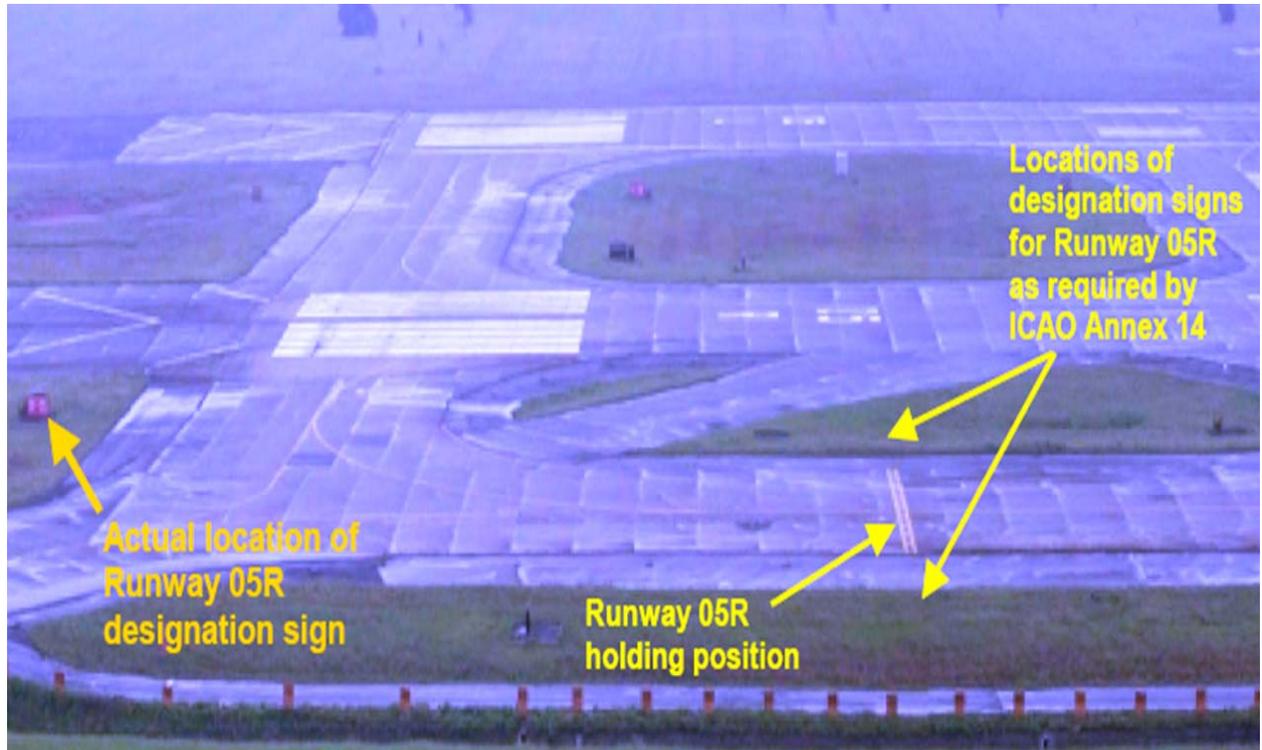
Runway **05R** had been closed since mid-September for needed pavement repairs. The plan was to convert it into a full-time taxiway on November 1, but the timeline was pushed back before the SQ006 crash. Before being closed, it was used for visual departures only.

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."*





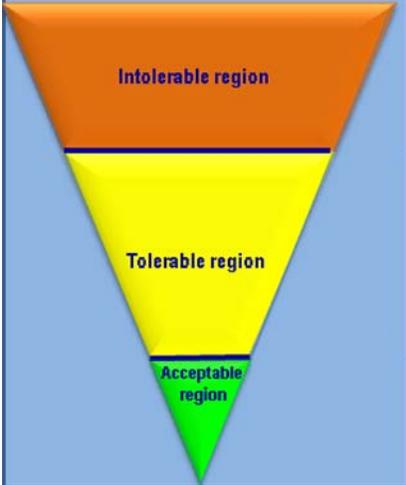


**4. Risk assessment matrix**

Probability of occurrence		
Qualitative definition	Meaning	Value
<b>Frequent</b>	Likely to occur many times ( <i>has occurred frequently</i> )	<b>5</b>
<b>Occasional</b>	Likely to occur some times ( <i>has occurred infrequently</i> )	<b>4</b>
<b>Remote</b>	Unlikely, but possible to occur ( <i>has occurred rarely</i> )	<b>3</b>
<b>Improbable</b>	Very unlikely to occur ( <i>not known to have occurred</i> )	<b>2</b>
<b>Extremely improbable</b>	Almost inconceivable that the event will occur	<b>1</b>

Severity of occurrences		
Aviation definition	Meaning	Value
<b>Catastrophic</b>	<ul style="list-style-type: none"> <li>➤ Equipment destroyed.</li> <li>➤ Multiple deaths.</li> </ul>	<b>A</b>
<b>Hazardous</b>	<ul style="list-style-type: none"> <li>➤ 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.</li> <li>➤ Serious injury.</li> <li>➤ Major equipment damage.</li> </ul>	<b>B</b>
<b>Major</b>	<ul style="list-style-type: none"> <li>➤ 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.</li> <li>➤ Serious incident.</li> <li>➤ Injury to persons.</li> </ul>	<b>C</b>
<b>Minor</b>	<ul style="list-style-type: none"> <li>➤ Nuisance.</li> <li>➤ Operating limitations.</li> <li>➤ Use of emergency procedures.</li> <li>➤ Minor incident.</li> </ul>	<b>D</b>
<b>Negligible</b>	<ul style="list-style-type: none"> <li>➤ Little consequences</li> </ul>	<b>E</b>

Risk probability	Risk severity				
	Catastrophic <b>A</b>	Hazardous <b>B</b>	Major <b>C</b>	Minor <b>D</b>	Negligible <b>E</b>
<b>Frequent 5</b>	<b>5A</b>	<b>5B</b>	<b>5C</b>	<b>5D</b>	<b>5E</b>
<b>Occasional 4</b>	<b>4A</b>	<b>4B</b>	<b>4C</b>	<b>4D</b>	<b>4E</b>
<b>Remote 3</b>	<b>3A</b>	<b>3B</b>	<b>3C</b>	<b>3D</b>	<b>3E</b>
<b>Improbable 2</b>	<b>2A</b>	<b>2B</b>	<b>2C</b>	<b>2D</b>	<b>2E</b>
<b>Extremely improbable 1</b>	<b>1A</b>	<b>1B</b>	<b>1C</b>	<b>1D</b>	<b>1E</b>

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

### 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**

N°	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 <i>(Example only, not related to the present case study)</i>	Piece of metal on the runway <i>(Example only, not related to the present case study)</i>	Damage to aircraft <i>(Example only, not related to the present case study)</i>	1. Daily runway inspection 2. Aerodrome operations manual <i>(Example only, not related to the present case study)</i>  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 <i>(Example only, not related to the present case study)</i>  Risk index: 1B Risk tolerability: Acceptable after review of the operation



N°	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					<i>Risk index:</i> <i>Risk tolerability:</i>	<i>Risk index:</i> <i>Risk tolerability:</i>
3					<i>Risk index:</i> <i>Risk tolerability:</i>	<i>Risk index:</i> <i>Risk tolerability:</i>

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