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RISK CONTROL PRACTICE: EXPOSURE

Falling Aircraft Handbook

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The Art & Science of Risk

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CONTENT

SCOPE

The purpose of this Handbook | Guidance Note is to provide comprehensive technical support to underwriters, risk control engineers and Risk Managers when assessing falling aircraft exposure for a given property risk.

Although this Handbook | Guidance is detailed and deals with a number of perils and potential scenarios, it is not intended to be a comprehensive analysis of every peril and potential scenario an underwriter may be requested to provide cover for. Any estimation or projection of an MPL and final loss amount must be based on reliable, accurate and current values, applicable scenarios, and consideration of the relevant perils.

This document complements the MPL handbook providing technical data justifying the falling aircraft loss estimate scenario in case of relevant exposure. Please refer to the MPL handbook for loss estimate rules and methods.

Only those hazards relating to the standard and emergency operating conditions of aircraft have been taken into consideration. For deliberate action such as terrorist attacks please refer to the MPL handbook (Falling aircraft section, terrorism case sub-section).

The first version of this document was released in May 2003 and updated in 2007 and 2012. This 2022 version considers the latest data from air transportation safety information and available loss records when relevant.

ACKNOWLEDGMENTS

Many thanks to the following people for their invaluable and extensive contributions:

- Pilots, air traffic controllers, flight instructors, flight examinators and air safety investigators
- Nicole Jamieson, Conference Interpreter (AIIC)
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I – EXPOSURE

1. FACTS

Air disasters are relatively rare events.

Falling aircraft impacting a property risk is also a rare event.

People and organizations tend to ignore low frequency, high impact events until they actually happen (common behavioural risk bias).

The following conclusions issue from accident reports, near miss investigations and statistics regarding air transportation.

- For a given property risk located in a given area, the hazard of falling aircraft can exist.
- However, falling aircraft exposure is not the same for all properties.
- Exposure is greater within the vicinity of an airport.
- Commercial aviation (e.g. airliners) is responsible for high severity property losses.
- General aviation (e.g. recreational, corporate) is responsible for relatively low severity property losses.

Based on the above let's focus on critical areas around the airport. This relates to the type of aviation and, therefore, the aircraft involved as summarized below.

2. AIRPORT TYPES

2.1. Commercial Aviation

The purpose of this Handbook | Guidance Note is to provide comprehensive technical support to underwriters, risk control engineers and Risk Managers when assessing falling aircraft exposure for a given property risk.

Commercial aviation mainly involves jet/propeller-driven airliners for passenger and/or freight transportation as well as certain business/corporate aircraft and government aircraft.

Commercial aviation aircraft are mainly operated on an Instrument Flight Rules basis consisting of stipulated flight procedures for navigating aircraft by referring to cockpit instruments and radio navigation aids alone, regardless of visibility. The majority of commercial cruising aircraft are controlled by automatic pilot. More than 30% of the approaches and landings of commercial aircraft are currently processed automatically. In the near future, this will increase with the development and installation of modern navigation systems. Anti-collision systems are also frequently used.

Key points for the proper and safe operation of commercial aviation are:

- Aircraft reliability (regular, specialized maintenance, flight systems/engine redundancies);
- Adequate flight crew training.
- Efficient Air Traffic Control.
- Proper maintenance of runway(s) and related critical facilities.

In airline operations today, a single isolated event rarely results in an accident. Rather, a chain of events develops that changes what may have been an uneventful flight into a disaster. If events had been different at any one link in the chain, the accident may never have happened.

2.2. General Aviation

General aviation mainly involves recreational aircraft as well as certain business/corporate aircraft for passenger transportation /aerial work and flight instruction aircraft.

Most business/corporate aircraft are equipped with autopilot and instrument navigation systems for flying, regardless of visibility. In such cases, a flight plan including specific information relating to the intended flight of an aircraft is completed orally or in writing, with Air Traffic Control.

Recreational aircraft (private pilots, instruction) mainly operate on a Visual Flight Rules basis consisting of stipulated flight procedures for the visual navigation of aircraft, clear of cloud, in visual meteorological conditions. The flight itinerary and cruising altitude are not subject to a flight plan (free style flying according to Visual Flight Rules) except when flying above dangerous or specific areas.

The key points for proper and safe operation of general aviation are:

- Aircraft reliability (regularly approved maintenance, single engine reliability, quality of fuel);
- Proficient pilot training.
- Adequate auto-information between pilots or Air Traffic Control (if any).
- Proper maintenance of runway(s) and related critical facilities.

Most general aviation accidents are reportedly the result of human factors (action or inaction on the part of the pilot-in-command which is normally referred to as “pilot error”). The seasonality of flights plays a major role. Spring and summertime are known as high season in the northern hemisphere and more flights and more accidents are usually reported.

2.3. Military Aviation

Military aviation involves jet fighters and jet/propeller-driven cargo aircraft for freight and trooper transportation, refuelers and or civil airplane types used for VIP transportation (e.g. Air Force One).

The potential for falling aircraft around a military airport is similar to that around a commercial airport.

Military cargo aircraft operations are similar to those for commercial aviation, including advanced navigation instrument systems and anti-collision systems.

Jet fighters normally fly in restricted areas at a sufficient distance from urban areas. Training includes low altitude and high-speed flights in adverse meteorological conditions. Mid-air collisions with recreational planes have been recorded. Special attention should be paid to training areas and ground structures used as visual markers or targets (chimneys, plants, etc.) for jet fighters.

The key points for the safe and proper operation of military aviation are similar to those for commercial aviation. Consequently, in this document, please refer to commercial aviation operations for an assessment of exposure in military aviation operations.

2.4. “Mixed” Aviation

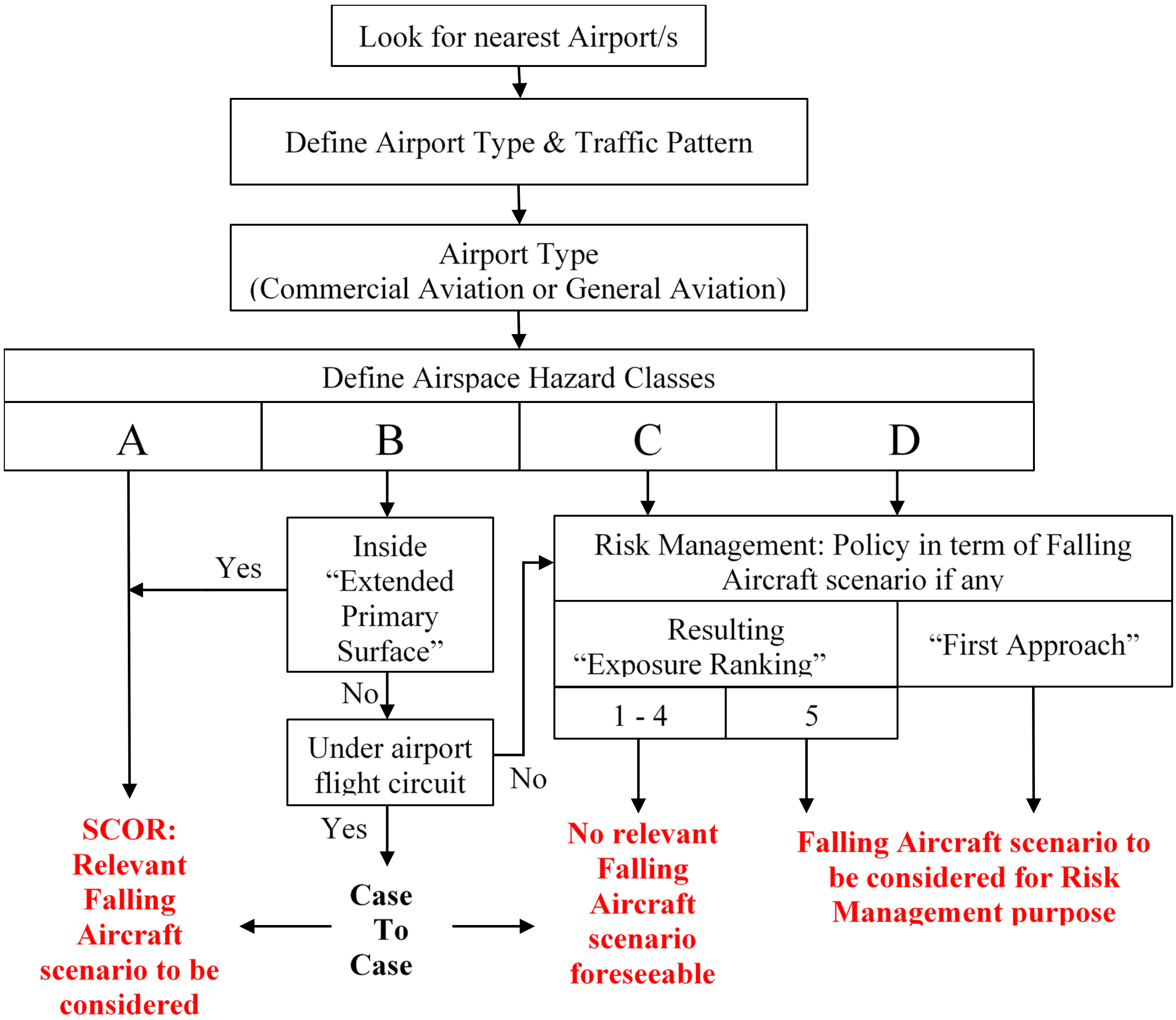
Some airports may include two or more of the above aviation types. In such cases the exposure assessment should be conducted on the basis of the highest exposure (i.e., commercial / military airport).

II – ASSESSMENT

1. FLOW CHART

In this section, a comprehensive methodology is proposed for assessing falling aircraft exposure and calculating the Falling Aircraft MPL in the case where exposure is relevant. The proposed falling aircraft assessment methodology is based on air transportation safety information applied to property risks. However, for easier understanding and in order to ensure the straightforward usage of this tool, special efforts have been made to use understandable non-specialized aeronautical terms and data for each step of the assessment process.

The Falling Aircraft exposure assessment process is summarized in the following flow chart. Assessment should be implemented, step by step:



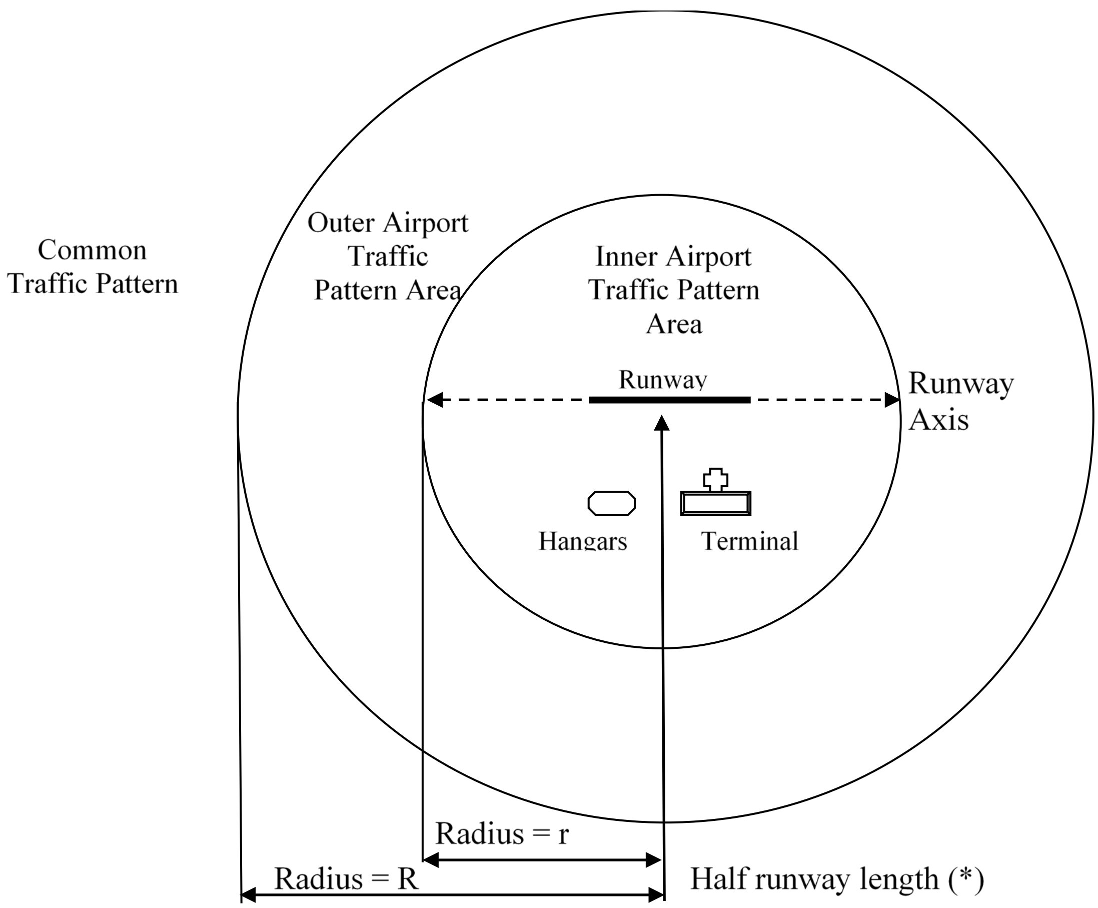
2. LOOK FOR NEAREST AIRPORT(S)

- Look for nearest airport location (flying distance using road atlas, travel guide, geo-software, etc.)
- Indicate direction to airport (NE, SE, NNW, etc.,).
- Define if plane is overflying the risk (during a visit on-site or in a report) and direction & angle of the runway axis.

3. AIRPORT TYPE & TRAFFIC PATTERN

- Define Airport Type as follows:
  - Commercial aviation (international / domestic airport)
  - General aviation (recreational airfield, private jet airstrip)

  For a given airport, consisting of both commercial and general aviation airport activities, consider commercial aviation only.
- Define runway orientation and length (*) (e.g. using Geographic Information System).
- Define air traffic patterns: draw the Inner & Outer Airport Traffic Pattern Circle as follows



- Define traffic patterns: draw the Inner (radius r) and the Outer (radius R) airport Traffic pattern circle as follows:
  - For commercial aviation: r = 9km/5.6mi & R = 20km/12.4mi from center of runway + half runway length (*)
  - For general aviation: r = 5km/3.1mi & R = 10km/6.2mi from center of runway + half runway length (*)

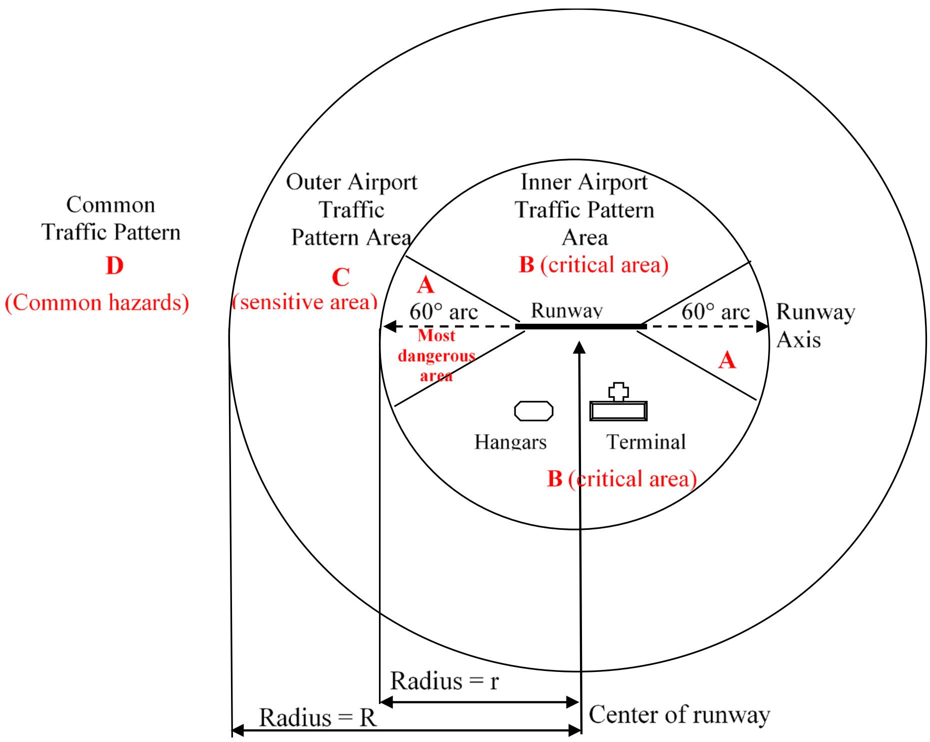
  (*) Half runway length: the "Displaced Portion of Runway" (if any) is excluded from the runway length. The displaced portion of the runway shown in black with white arrows below is immediately to the left of the threshold marked with eight white blocks in two groups of four. The displaced portion of the runway may be used for take-off but not for landing. After landing at the other end, the landing aircraft may use the displaced portion of the runway for roll out.

  Displaced Portion of Runway

- Please refer to the airspace classes diagram (section 2.4) to locate the risk.

4. AIRSPACE HAZARD CLASSES

- Draw the 60° arc: 30° on both sides of the runway axis starting at the runway end (Displaced Portion of Runway excluded – see section 3 bellow) and extending up to the Inner Traffic Pattern area circle (in case of multiple runways e.g. Charles de Gaulle Airport, London Heathrow, JFK, this should be done for each and every runway).
- Plot the Airspace Classes (note that these classes are not official aviation terms. These Airspace Classes are Risk Control terms used for Falling Aircraft exposure assessment).



5. EXPOSURE RANKING

- Locate the risk in the following traffic airport airspaces A, B, C and D (section 2.4 above)
- Use the following table for establishing the Exposure Ranking

<table>
<tr><th>Airport Traffic Pattern Circle</th><th>Airspace Description & Operations</th><th>Potential Hazard and Consequences</th><th>Area Exposure Ranking</th></tr>
<tr><td>A</td><td>Most dangerous area
Inner Airport traffic pattern area – 60° arc:
· Take-off / initial climb
· Final approach / landing</td><td>-Plane crash due to major engine failure and emergency landing
· Or plane break-up due to weak turbulence</td><td>5- Very High
(Relevant Falling Aircraft MPL scenario)</td></tr>
<tr><td>B</td><td>Critical area
Inner Airport traffic pattern area:
· Vertically above & below runway
· Airport circuit</td><td rowspan="4">· Crash due to major engine failure and unsuccessful accuracy in emergency landing
· Or Disintegration and falling debris</td><td>4- High
(Relevant Falling Aircraft MPL scenario especially, but not limited to facilities inside airport perimeter)</td></tr>
<tr><td>C</td><td>Sensitive area
Outer airport traffic pattern area</td><td>3- Moderate</td></tr>
<tr><td rowspan="2">D</td><td rowspan="2">Common hazards area
Common traffic pattern area:
· Airways connection
· Airways</td><td>2- Light</td></tr>
<tr><td>1- Very Light</td></tr>
</table>

6. RELEVANT MPL FALLING AIRCRAFT SCENARIO

A falling aircraft MPL scenario, for a risk with an exposure ranking of 5-Very High, is deemed relevant for the following reasons:

- Exposure ranking 5-Very High means an area where major engine failure, at relatively low altitude, gives the aircraft crew a very short time in which to react, organize and proceed with an emergency landing, whilst taking altitude, runway availability, obstruction and a safe landing area within a 60°C arc ahead of the plane into consideration. The crew must make split-second decisions. Under such conditions, there is no guarantee that the crew can direct the plane to the spot which may offer the best chances for an emergency accuracy landing, limiting damage to both aircraft and ground installations.
- Weak turbulence, due to other planes during take-off, may be responsible for aircraft break-up when a safe distance between aircraft is not respected. Due to the relatively low altitude in class A airport airspace, substantial falling debris resulting from aircraft break-up may severely damage ground installations.

See MPL Handbook section 'Falling Aircraft'- general case, high rise building case and airport case depending on aviation type (i.e. general, commercial).

In other areas, with lower exposure ranking from 1 to 4, the following points should be considered in detail:

- Potential for Falling Aircraft cannot be totally excluded. (Zero risk concepts do not apply).
- In the case of major engine failure, the crew has more time to get organized and proceed accordingly with an emergency accuracy landing in an open area without any obstruction, mitigating exposure to existing ground structures.
- Aircraft break-up due to weak turbulence is not as common in such areas. However, in the case of weak turbulence, due to relatively high altitude, the aircraft will break up into relatively small debris such as an engine. The most likely maximum potential hazard to ground installations may result from an engine falling onto a given risk.

- Consequently, for a risk located in lower exposure ranking areas (1 to 4), after applying aggravating / mitigating factors when using the Risk Ranking method, the MPL scenario should mainly focus on inherent hazards, other surrounding exposure or natural perils.

7. AIRSPACE B – CRITICAL AREA INNER AIRPORT TRAFFIC PATTERN AREA

Airspace B includes the following areas where a potential Falling Aircraft scenario should be considered for a given facility:

7.1. "Extended Primary Surface" around the runway

- Distance (measure on all sides of runway):
  - 350m/1148ft for commercial aviation (international / domestic airport) or military airport with aircraft of a similar size to commercial aircraft
- 175m/574ft for general aviation (recreational airfield, private jet airstrip)
  - extending beyond either end of the runway and connecting with the 60° arc

In the case of multiple runways with different orientations, all the most dangerous areas for all the runways should be considered.

For terminals, control towers, support buildings (i.e. utilities, maintenance, fuel supply, catering, customs, luggage handling, ground vehicles, etc.), hangars, parking lots and any third party facility (if any) located inside this "Extended Primary Surface" (Airspace Class A and B) a plane crash over those structures should be considered. This is a relevant Falling Aircraft MPL scenario.

The MPL should be calculated as per the MPL Handbook, general case and/or High-rise Building case (warning: different scenarios for commercial aviation and general aviation # MPL fire).

Example of "Extended Primary Surface" for commercial aviation (international / domestic airport) or military airport with aircraft of a similar size to commercial aircraft):

- Example below shows an International airport with a single runway for which all critical facilities are located inside the Extended Primary Surface (thus exposed to a Falling Aircraft scenario inside the airport perimeter):

Source of background image: Google Earth ("copyright fair use") - Personalized

See section 3 for more explanation about the origin of the "Extended Primary Surface".

7.2. Airport flight circuit/pattern extending outside airport perimeters

- This is on a case-by-case basis.
- A Falling Aircraft scenario should be considered for facilities located outside airport perimeters located under the airport flight circuit/pattern when known (e.g. New York JFK – AA Airbus, 12 Nov. 2001). Exposure deemed as “High”.
- When the exposure is known and confirmed, the Falling Aircraft MPL scenario should be calculated. See MPL Handbook section ‘Falling Aircraft’, general case, high rise building case depending on aviation type (i.e. general, commercial).
- When no exposure is reported (facilities located outside airport perimeters and NOT located under the airport flight circuit/pattern) the exposure can still be considered and investigated in a Risk Management policy (e.g. “First Approach” or “Exposure Ranking”).
- See chapter IV for more explanation about airport flight circuit/pattern.

8. RISK MANAGEMENT POLICY IN TERMS OF A FALLING AIRCRAFT SCENARIO

Some Risk Managers consider that all facilities located within a distance of 20km/12.4mi (regardless of Airspace) of a major commercial airport may be exposed to a plane crash.

As proposed in this handbook a so called “First Approach” or “Exposure Ranking” may be considered for assessing their exposure based on a Falling Aircraft scenario as follows:

8.1. « First Approach »

As per the Risk Management policy any facilities located within 20km/12.4mi of a major commercial airport (regardless of Traffic Pattern or Airspace Classes - calculated from runway end + half runway length) is deemed as potentially exposed to a plane crash.

See MPL Handbook section ‘Falling Aircraft’, general case, high-rise building case and airport case for an MPL Falling Aircraft scenario depending on aviation type (i.e. general, commercial).

8.2. “Exposure Ranking”

As per the Risk Management policy any facilities located within a distance of 20km/12.4mi (regardless of Airspace classes) of a major commercial airport AND having an exposure rank of 5 is potentially exposed to a plane crash.

The basic Area Exposure Ranking of the facility depends on the Traffic Airport Airspace (B, C and D only) and their corresponding Area Exposure Ranking (i.e. B: 4-High; C: 3 -Moderate; D: 2- Light or 1- Very Light).

Then potential aggravating and mitigating factors can be considered as follows:

<u>Potential Aggravating Factors:</u>

Dedicated for Airspace B, C and D only.

<u>One or more</u> of the following aggravating factors can be considered as follows:

Aggravating Factor	Exposure Ranking Increase
Traffic Path Factor: For an airport with aircraft (of whichever type), **flying over the risk** (e.g. relatively low altitude etc.).	+1
And /or	
Aircraft Type Factor: For an airport with heavy carrier long-range jumbo jets (A380, B747, A340) and regional/domestic airliners carrying 80 or more passengers (B737, A330, MD80) **flying over the risk**	+1
And /or	
For any other special reported conditions: Such as a temporary flight path of special cargo above a given risk, significant crash history reported, extensive temporary jet fighter training, military refueler plane, etc.,	+1, +2, +3 or +4

Potential Mitigating Factors:

Warning:

- The use of mitigating factors should be restricted to cases where reliable information and data are available.
- Mitigating factors do not apply for risks located in airspace A areas (most dangerous area – 60° arc or airspace B without data about runway orientations)

Only one of these mitigating factors can be considered as follows:

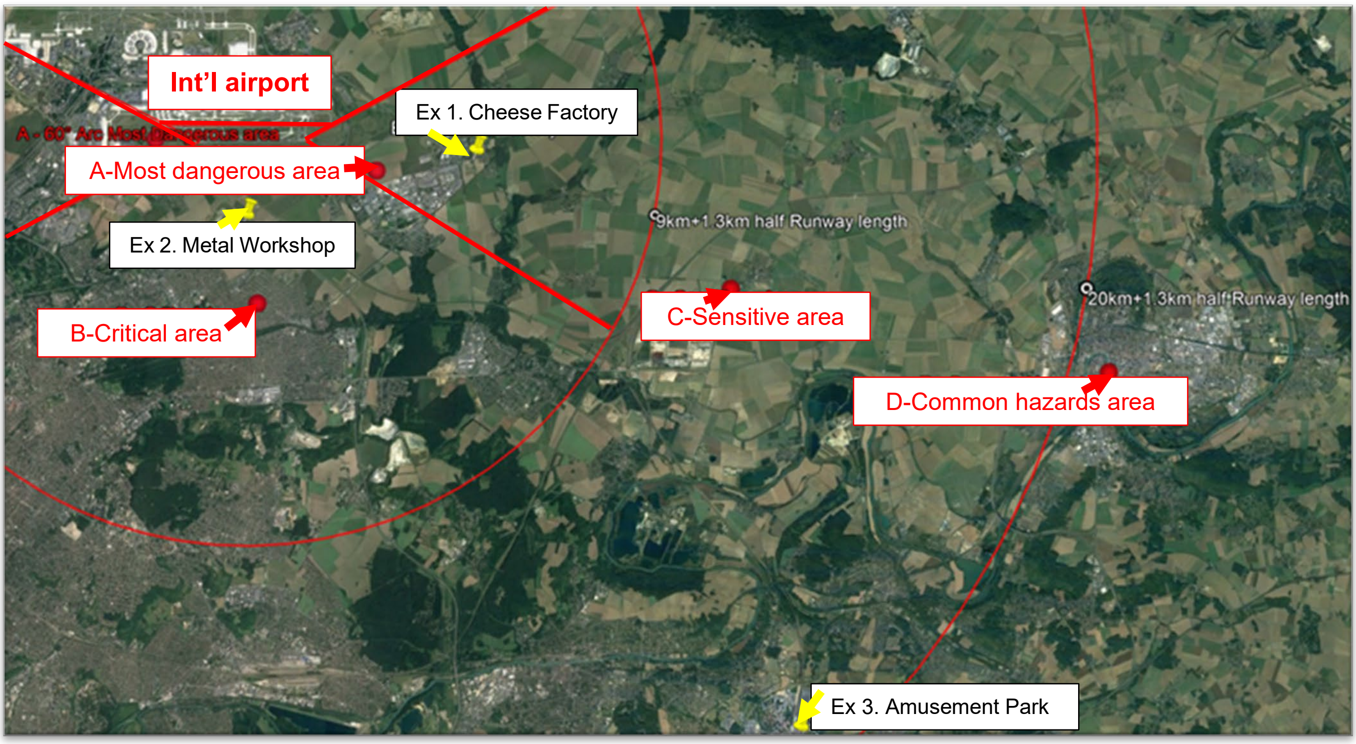
Mitigating Factor	Exposure Ranking Decrease
For risks located in the airspace D (Common traffic area) or airspace C (Outer airport traffic area): Risk located in a large open area (rural area with small built-up areas less than 1,200m/3937ft in mean width) without any obstruction (a lot of fields and small villages) allowing the crew to organize and proceed accordingly with an accuracy emergency landing.	-1
Or	
For risks located within the airspace C (Outer airport traffic area) or airspace B (Inner airport traffic area): Risk located in an area where flying over is prohibited unless the altitude is safe, sufficient for a plane losing power above the city to glide outside the city limits and prepare for an emergency landing.	-1

Resulting Ranking:

- For a given facility with an exposure ranking of 5: See MPL Handbook section ‘Falling Aircraft’, general case, high-rise building case and airport case for MPL Falling Aircraft scenario depending on aviation type (i.e. general, commercial). (same as section 2.6 above)
- For a given facility with an exposure ranking between 1 and 4: No relevant Falling Aircraft scenario foreseen subject to the risk management policy.

9. EXAMPLES

All given examples 1, 2 and 3 are located within the Inner and Outer airport traffic pattern circles of an international commercial airport as shown on the sketch below.



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9.1. Example 1: Cheese factory

A 60,000m² surface area multi-location cheese factory located east of the airport.

Nearest airport location and direction:

- End of southern runway 26L of the international airport situated 4km/2.5mi to the west.

Airport type and traffic pattern:

- The international airport is used for commercial aircraft (international / domestic).
- Airspace B of 9km/5.6mi + half runway length and Airspace C of 20km/12.4mi + half runway length to be considered from the center of runway for the international airport southern runway 08R-26L. Runway orientations for the international airport are indicated on the map. The 60° arcs were drawn on the map for the southern runway 08R-26L. Planes from the international airport are reportedly flying right over the risk.

Airspace classes & exposure ranking:

- The risk is located in the airspace A of the international airport (60° most dangerous area).
- The exposure ranking is 5- Very High

MPL Falling Aircraft:

- A relevant Falling Aircraft MPL scenario is considered.
- See MPL Handbook section Falling Aircraft, commercial aviation, general case.

9.2. Example 2: Metal Workshop

A 45,000m² surface area, 2 stories high (6m/20ft) mono-bloc metal workshop located south of the international airport.

Nearest airport location and direction:

- Southern runway 26L of the international airport situated 2.2km/1.4mi to the north.

Airport type and traffic pattern:

- The international airport is used for commercial aircraft (international / domestic).
- Airspace B of 9km/5.6mi + half runway length and Airspace C of 20km/12.4mi + half runway length to be considered from the center of runway for the international airport southern runway 08R-26L. Runway orientations for the international airport are indicated on the map. The 60° arcs were drawn on the map for the southern runway 08R-26L.
- Planes from the international airport are reportedly flying right over the risk.

Airspace classes & exposure ranking:

- The risk is located in the airspace B of the international airport.
- The exposure ranking is 4- High

MPL Falling Aircraft:

- A potential Falling Aircraft MPL scenario should be investigated as follows:
- The risk is outside the “Extended primary surface” as shown below:
- Risk facilities are reportedly located outside airport perimeters but located under the airport flight circuit/pattern.
- As a result, a relevant Falling Aircraft MPL scenario should be calculated. See MPL Handbook section’ Falling Aircraft’, commercial aviation, general case.

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9.3. Example 3: Amusement park

A multi-location (low-rise and high-rise buildings) complex (3.4km2/340ha) located inside the limit of the airspace C (20km/12.4mi + half runway length) to the south east of the international airport.

Nearest airport location and direction:

- Southern runway 26L of the international airport situated 20km/12.4mi to the north west

Airport type and traffic pattern:

- The international airport is used for commercial aircraft (international / domestic).
- Airspace B of 9km/5.6mi + half runway length and Airspace C of 20km/12.4mi + half runway length to be considered from the center of runway for the international airport southern runway 08R-26L. Runway orientations for the international airport are indicated on the map. The 60° arcs were drawn on the map for the southern runway 08R-26L.
- Planes from the international airport are reportedly NOT flying over the risk.

Airspace classes & exposure ranking:

- The risk is located in the airspace C of the international airport.
- The exposure ranking is 3- Moderate

MPL Falling Aircraft:

- No relevant falling aircraft worst case scenario foreseen
- However, the exposure can still be considered and investigated in a Risk Management policy as follows:
  - "First Approach": See MPL Handbook section 'Falling Aircraft', general case, high rise building case for commercial aviation.

OR

  - "Exposure Ranking":
    - No obvious aggravating factor reported
    - Mitigating factor (-1) Risk located in a large open area (rural area with small built-up areas less than 1200m/3937ft in mean width) without any obstruction (a lot of fields and small villages) allowing the crew to organize and proceed accordingly with an accuracy emergency landing.
    - Resulting Exposure Ranking is 2 – Light
    - NO Worst-case Falling Aircraft scenario considered

9.4. Example 4: Recycling Facility

A Recycling Facility (off site – remote from the main site) owned and operated by a large industrial site. This Recycling Facility is critical for the industrial site - part of its Environmental, Social and Governance (ESG) commitment - and is occupied for the treatment of process wastes (metal and organic compounds removal). About USD 60M investment, single location (low-rise, 8m high, chimney stack, reactor, rotary kiln) located inside the airspace A (most dangerous area) of a military airport.

Nearest airport location and direction:

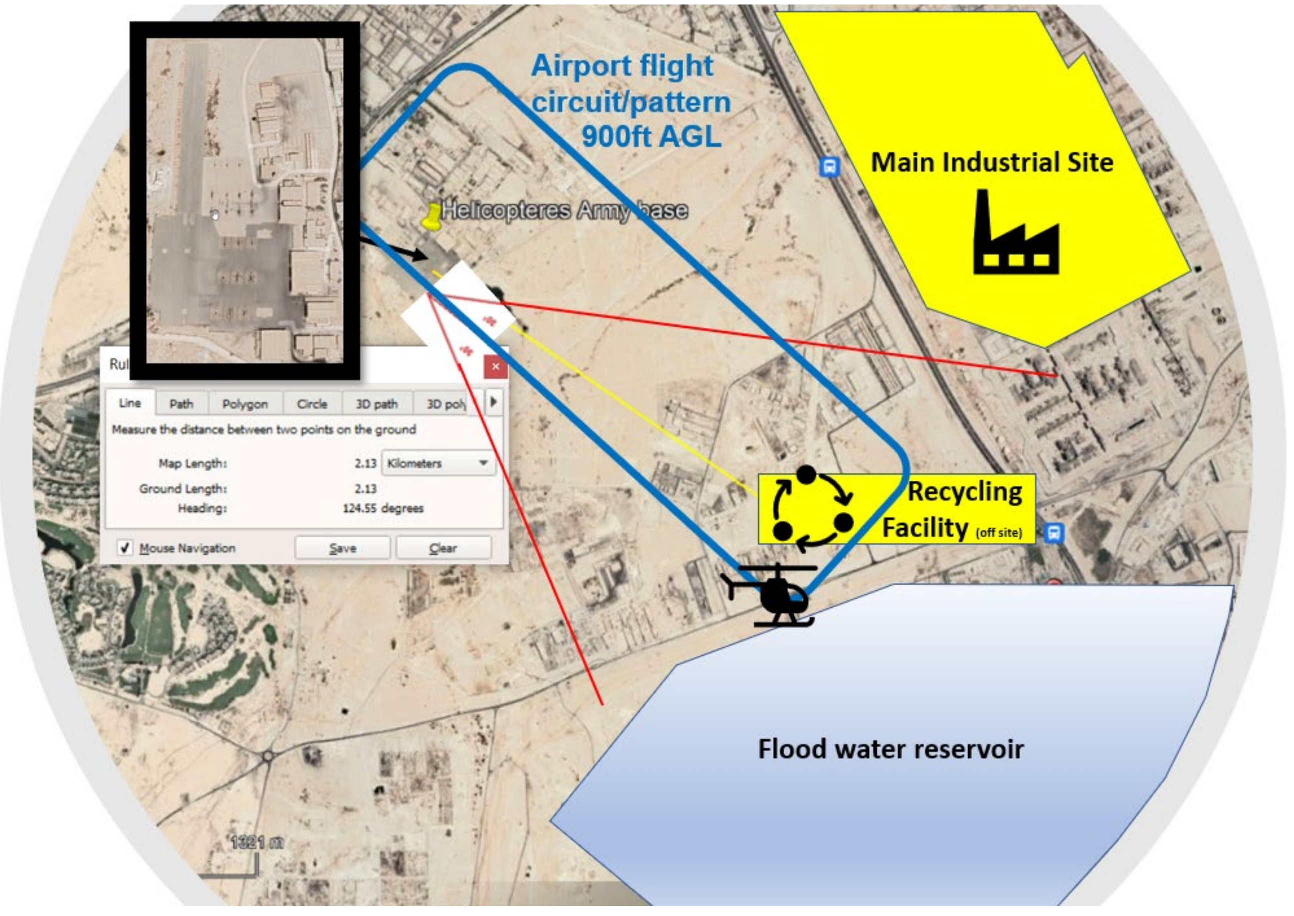
- Runway 13-31 of a military airport situated 2.13km to the north-west of this recycling facility

Airport type and traffic pattern:

- Army airport mostly used by large military helicopters and some vertical and/or short take-off and landing (V/STOL) aircrafts (airplanes able to take-off or land vertically or on short runways).

- Airspace - inner airport traffic pattern area – 60° arc: take-off / initial climb and final approach / landing. The 60° arc facing the Recycling Facility was drawn on the map for the runway 13.
- Aircrafts from the military airport are reportedly flying over the risk (airport flight circuit/pattern) at relatively low altitude (i.e. 500ft).

Left hand side: Helicopter launch Flickr - CC Creative Commons license - Attribution 2.0 Generic (CC BY 2.0). Right hand side: V/STOL 0050 Osprey © Evelyn Simak. Geograph Britain and Ireland Attribution - CC Creative Commons license - ShareAlike 2.0 Generic (CC BY-SA 2.0).



Airspace classes & exposure ranking:

- The risk is located in the airspace A of the military airport and right below the airport flight circuit/pattern.
- The exposure ranking is 5- Very High

MPL Falling Aircraft:

- Relevant falling aircraft worst case scenario foreseen.

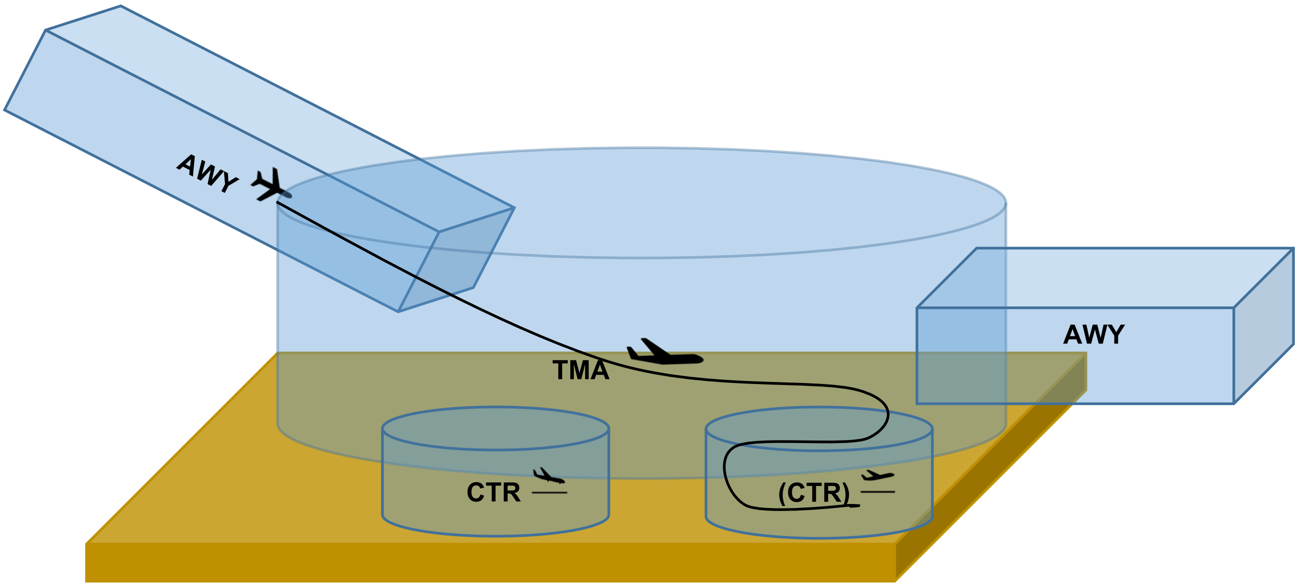
IV – SUPPORT FOR ASSESSMENT

The purpose of this section is to provide an overview of air traffic operations, related hazards, safeguards and comprehensive data regarding Falling Aircraft exposure and assessment.

1. AIRSPACE

Airspaces have been created in order to protect IFR flights (Instrument Flight Rules - mostly commercial airliners operating on autopilot or on manual mode using instrument guiding systems). In these airspaces, the traffic is controlled by Air Traffic Controllers. These controlled airspaces include airways (AWY-radio navigation systems), Terminal Areas (TMA – intermediate phase of IFR flight) and Control Terminal Regions (CTR – approach and departure from airport), as follows:

When policy makers decide to remove life safety and property protection provisions from codes, they have substituted politics for technical requirements that were determined after extensive input from across the spectrum of knowledgeable people.



AWY: An airway or air route is a defined corridor that connects one specified location to another at a specified altitude along which an aircraft that meets the requirements of the airway may be flown. Airways are defined with segments within a specific altitude block and/or corridor width, and between fixed geographic coordinates for satellite navigation systems or between ground-based Radio transmitter navigational aids (navaids; such as VORs or NDBs) or the intersection of specific radials of two navaids.

TMA: A terminal control area (TMA, or TCA in the U.S. and Canada), also known as a terminal maneuvering area (TMA) in Europe, is an aviation term to describe a designated area of controlled airspace surrounding a major airport where there is a high volume of traffic. TMA airspace is normally designed in a circular configuration centered on the geographic coordinates of the airport and differs from a control area in that it includes several levels of increasingly larger areas, creating an "upside-down wedding cake" shape.

CTR: A control area (CTA) is the volume of controlled airspace that exists in the vicinity of an airport. It has a specified lower level and a specified upper level. It usually is situated on top of a control zone and provides protection to aircraft climbing out from the airport by joining the low-level control zone to

the nearest airways. Control areas are particularly useful where there are busy airports located close together. In this case a single CTA will cover all of the individual airports' CTRs.

1.1. Special Use Airspace

Other airspace areas include:

Prohibited Area – Prohibited Areas have been established in the interests of national security.

Restricted Area – Entering restricted airspaces without prior permission may be extremely hazardous due to activities such as aerial gunnery and guided missiles.

Warning Area – A warning area is legally an international airspace (beyond the 5km offshore limit) and may not be charted as restricted airspace but is equally as dangerous.

Military Operations Area – Prior permission is not required to enter an MOA. However, fast moving aircraft shall exercise caution and be vigilant.

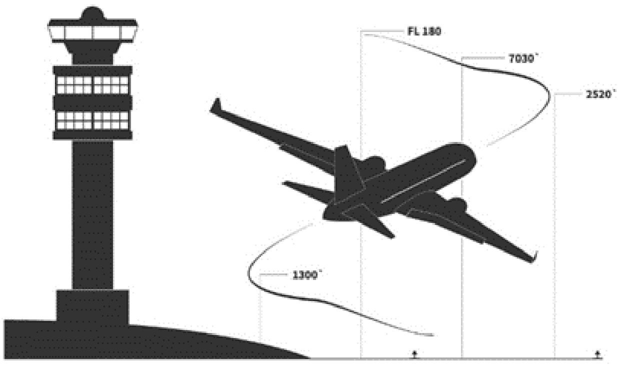
For current military activity, please contact the Flight Information Center.

Alert Area – An Alert Area indicates an unusual type of aerial activity or high volume of pilot training. All aircraft, both participating and non-participating, are responsible for collision avoidance.

Military Training Routes – MTRs are charted on sectional charts as light gray lines with an associated VR or IR number (visual or instrument routes). Routes may be several miles wide. MTRs indicate possible high-speed military activity, as follows.

2. AIRPORT TRAFFIC PATTERN

An airfield traffic pattern is a standard path followed by aircraft when taking off or landing while maintaining visual contact with the airfield.



At an airport, the pattern (or circuit) is a standard path for coordinating air traffic. It differs from "straight-in approaches" and "direct climb-outs" in that aircraft using a traffic pattern remain close to the airport.

Patterns are usually employed at small general aviation (GA) airfields and military airbases. Many large, controlled airports avoid the system unless there is GA activity as well as commercial flights.

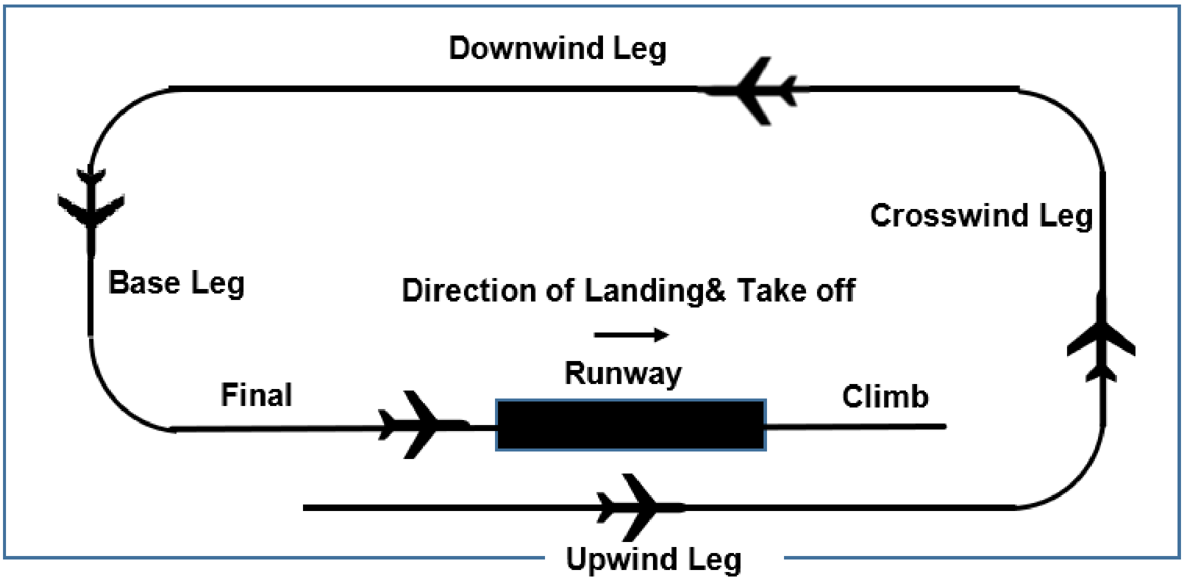
However, some kind of a pattern may be used at airports in some cases such as when an aircraft is required to circle, but this kind of pattern at controlled airports may be very different in form, shape and purpose to the standard traffic pattern as used at GA airports.

The use of a pattern at airfields is for aviation safety. By using a consistent flight pattern, pilots will know from where to expect other air traffic and be able to see and avoid it. Pilots flying under visual flight rules (VFR) may not be separated by air traffic control so this consistent predictable pattern is a vital way to keep things orderly. At tower-controlled airports, air traffic control (ATC) may provide traffic advisories for VFR flights on a workload permitting basis.

Pilots prefer to take off and land facing into the wind. This has the effect of reducing the aircraft's speed over the ground (for the same, given airspeed), hence reducing the length of runway required to perform either manoeuvre.

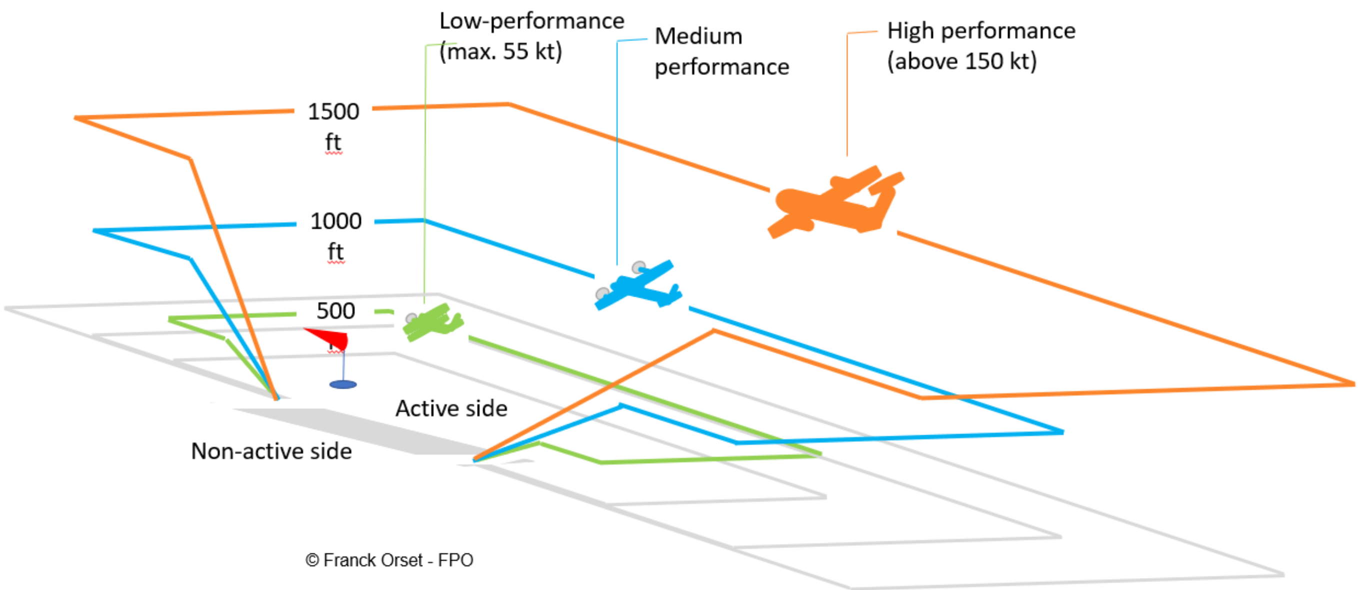
Runway orientation is determined from historical data of the prevailing winds in the area. This is especially important for single-runway airports that do not have the option of a second runway pointed in an alternative direction. A common scenario is to have two runways located at (or close to) 90 degrees to one another, so that aircraft can always find a suitable runway. Almost all runways are reversible, and aircraft use whichever runway in whichever direction is best suited to the wind. In light and variable wind conditions, the direction of the runway in use might change several times during the day.

Traffic patterns can be defined as left-hand or right-hand according to which way the turns in the pattern are performed. They are usually left-hand turns because most airplanes are piloted from the left seat (or the senior pilot or pilot-in-command sits in the left seat), and so the pilot has better visibility out the left window. Right-hand patterns will be set up for parallel runways, for noise abatement, or because of ground features (such as terrain, towers, etc.).



Propeller-driven aircraft enter the traffic pattern at 1,000 feet above ground level (AGL).

Large and turbine-powered aircraft enter the traffic pattern at an altitude of not less than 1,500 feet AGL or 500 feet above the established pattern altitude.



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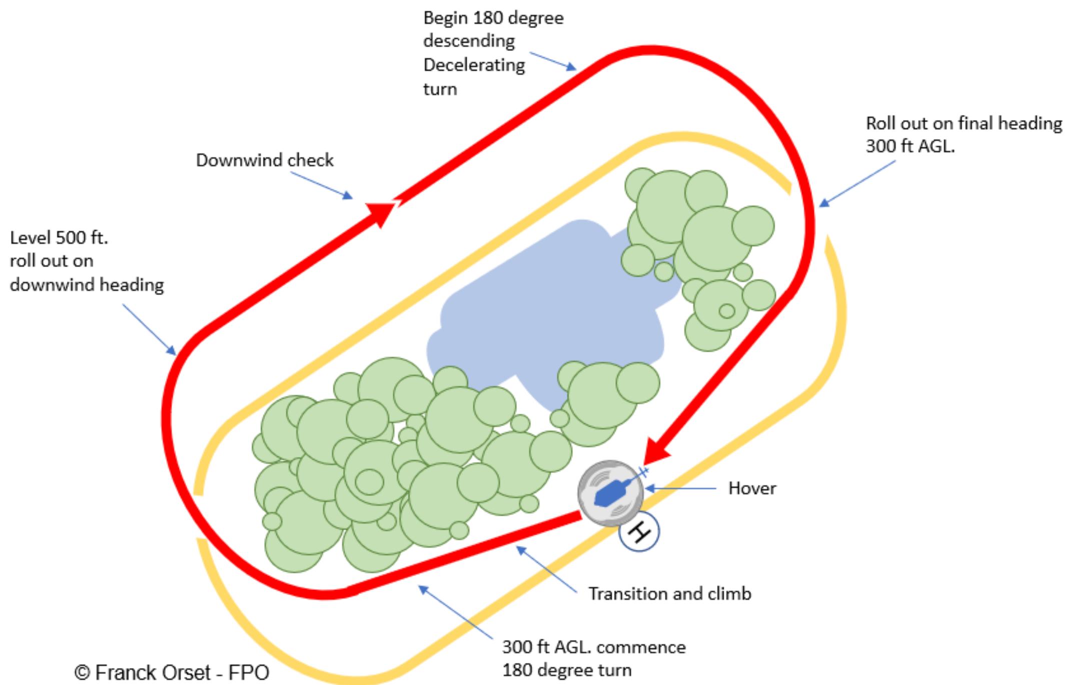
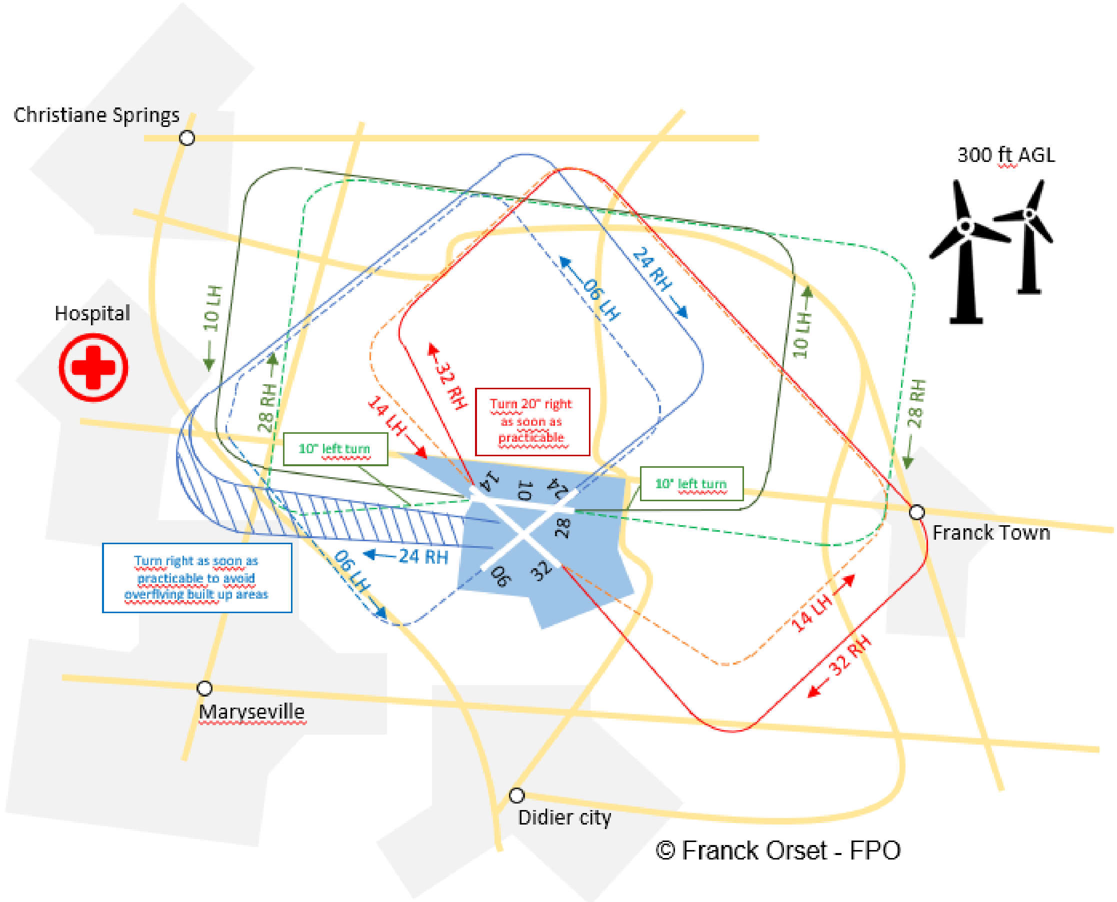
Helicopters and light-sport aircraft (LSA or lightweight aircraft that are “simple to fly”) operating in the traffic pattern may fly a pattern similar to the fixed-wing aircraft pattern, but at a lower altitude (500 AGL) and closer to the runway. This pattern may be on the opposite side of the runway from fixed-wing traffic when airspeed requires or for practice power-off landings (autorotation) and if local policy permits.

Most helicopter pilots sit in the right seat. It does depend of the type of helicopter, and even if there are some advantages when it comes to the control of the aircraft there is also a historical reason behind it. When Igor Sikorsky built the world's first mass-produced helicopter, the R-4, weight was a serious issue. The R-4 was intended as a trainer but was so underpowered that Sikorsky was looking for any potential savings, so Igor and his engineers decided to let the instructor and student share a single collective. The only place to put it then was in the middle between the two seats. Given the coordination and strength required to manipulate an R-4 cyclic for any length of time, the student always flew from the right.



Airport with multiple runways include dedicated airport traffic pattern o each and every runway:



3. AIRPORT CATEGORY

There are different systems used around the world. For US airports the category can be given by overall length and width of aircraft as shown in the table below. Correspondence with international classifications and the NFPA classification (giving fire protection level requirements) is also indicated.

NFPA: The National Fire Protection Association (NFPA) is an international non-profit organization devoted to eliminating death, injury, property and economic loss due to fire, electrical and related hazards. In 2018, the NFPA claimed to have 50,000 members and 9,000 volunteers working with the organization through its 250 technical committees (of which one is dedicated to aviation).

FAA: The Federal Aviation Administration (FAA) is a governmental body of the United States with powers to regulate all aspects of civil aviation in that nation as well as over its surrounding international waters. Its powers include the construction and operation of airports, air traffic management, the certification of personnel and aircraft and the protection of U.S. assets during the launch or re-entry of commercial space vehicles. Powers over neighbouring international waters were delegated to the FAA by authority of the International Civil Aviation Organization.

ICAO: International Civil Aviation Organization (ICAO; French: Organisation de l'Aviation Civile Internationale; Chinese: 国际民航组织) is a specialized agency of the United Nations.

It changes the principles and techniques of international air navigation and fosters the planning and development of international air transport to ensure safe and orderly growth. Its headquarters is located in the Quartier International of Montreal, Quebec, Canada.

The ICAO Council adopts standards and recommended practices concerning air navigation, its infrastructure, flight inspection, prevention of unlawful interference, and facilitation of border-crossing procedures for international civil aviation. ICAO defines the protocols for air accident investigation that are followed by transport safety authorities in countries signatory to the Chicago Convention on International Civil Aviation.

Airport Category US			Overall Length of Aircraft up to but Not Including		Maximum Exterior Width up to but Not Including	
NFPA	FAA	ICAO	ft	m	ft	m
1	A(*)	1	30	9	6.6	2
2	A(*)	2	39	12	6.6	2
3	A(*)	3	59	18	9.8	3
4	A	4	78	24	13.0	4
5	A	5	90	28	13.0	4
6	B	6	126	39	16.4	5
7	C	7	160	49	16.4	5
8	D	8	200	61	23.0	7
9	E	9	250	76	23.0	7
10	E	10	295	90	25.0	8

Legend:

A = Utility runways = aircrafts of less than 5,670kg (12,500lbs)
B = Runways larger than utility = aircrafts of more than 5,670kg (12,500lbs)
C = Visibility Minimums Greater than ¾ Mile
D = Visibility Minimums as low as ¾ Mile
(*) = Precision Instrument Approach Slope is 50:1 for inner 10,000 feet and 40:1 for additional 40,000 feet

4. IMAGINARY SURFACES

Aerodromes / airports' designs incorporate various "imaginary surfaces" intending to protect aircraft in flight from any obstacle such as terminals, control towers, support buildings and hangars as follows:

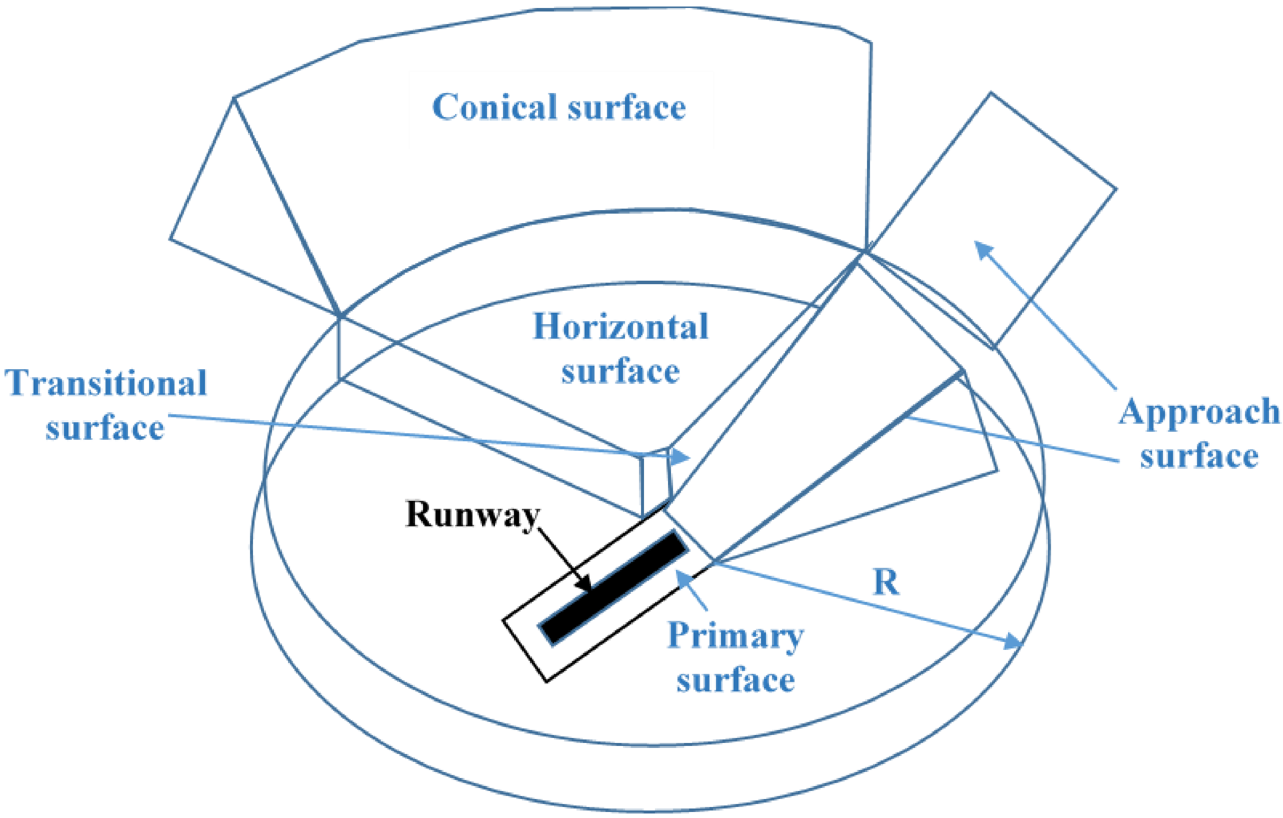
- Assuming that the aircraft is operating normally
- Providing volumes of airspace around and above an airport for an aircraft in normal flight

4.1. Obstacle Limitation Surface (OSL)

As per Federal Aviation Regulation Part 77, an object constitutes an obstruction to navigation

- If it is 60m/200ft above ground level or 60m/200 ft above the airport elevation (whichever is greater) up to 5 km/3mi (for runway lengths > 1060m/3200 ft) from the airport.
    - This increases 30m/100ft every mile up to 150m/500ft at 10km/6mi from the ARP (airport reference point)
- If it is 150m/500ft or more above ground level at the object site
- If it penetrates an imaginary surface (a function of the precision of the runway)
- If it penetrates the terminal obstacle clearance area (including initial approach segment)
- If it penetrates the en route obstacle clearance area (including turn and termination areas of airways)

So-called "Imaginary Surfaces" are drawn around airports for obstruction evaluation. See Graphical depiction below:



Dimensions of all FAR 77 imaginary surfaces are given in the following table:

OBSTRUCTION IDENTIFICATION SURFACES
FEDERAL AVIATION REGULATIONS PART 77

DIM	ITEM	DIMENSIONAL STANDARDS (FEET)					
		VISUAL RUNWAY		NON - PRECISION INSTRUMENT RUNWAY			PRECISION INSTRUMENT RUNWAY PIR
		A	B	A	B		
					C	D	
A	WIDTH OF PRIMARY SURFACE AND APPROACH SURFACE WIDTH AT INNER END	250	500	500	500	1,000	1,000
B	RADIUS OF HORIZONTAL SURFACE	5,000	5,000	5,000	10,000	10,000	10,000
		VISUAL APPROACH		NON - PRECISION INSTRUMENT APPROACH			PRECISION INSTRUMENT APPROACH
				A	B		
		A	B		C	D	
C	APPROACH SURFACE WIDTH AT END	1,250	1,500	2,000	3,500	4,000	16,000
D	APPROACH SURFACE LENGTH	5,000	5,000	5,000	10,000	10,000	*
E	APPROACH SLOPE	20:1	20:1	20:1	34:1	34:1	*

A - UTILITY RUNWAYS

B - RUNWAYS LARGER THAN UTILITY

C - VISIBILITY MINIMUMS GREATER THAN 3/4 MILE

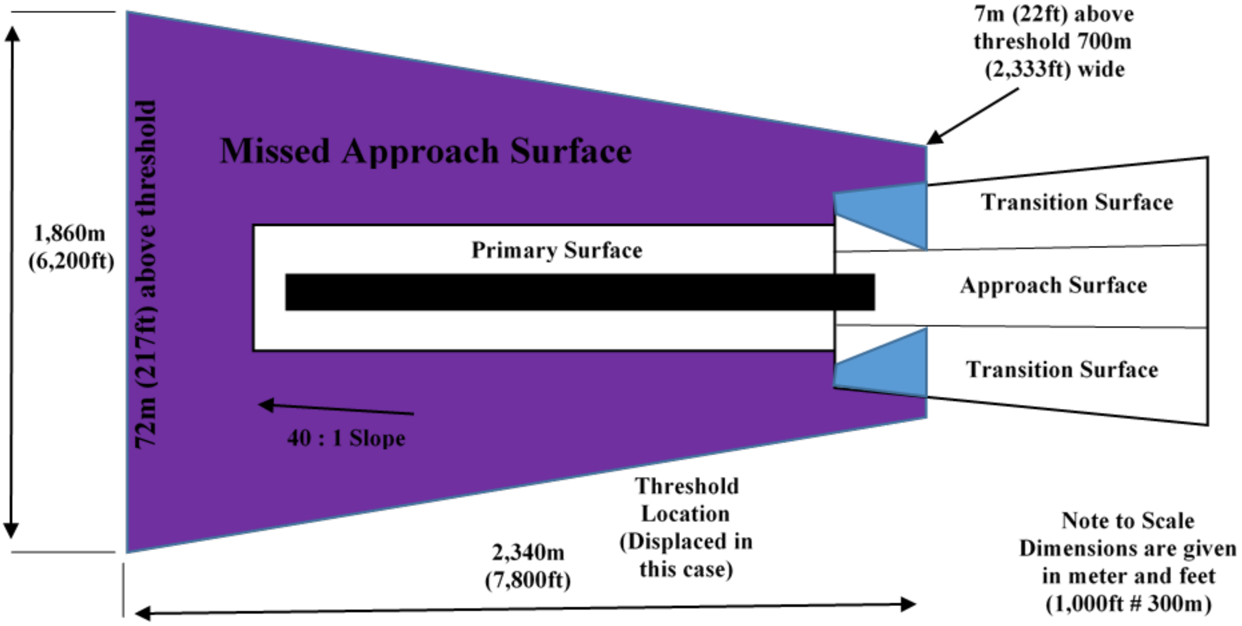
D - VISIBILITY MINIMUMS AS LOW AS 3/4 MILE

* - PRECISION INSTRUMENT APPROACH SLOPE IS 50:1 FOR INNER 10,000 FEET AND 40:1 FOR AN ADDITIONAL 40,000 FEET

http://www.ngs.noaa.gov/AERO/oisspec.html

4.2. Missed Approach Surface (MAS)

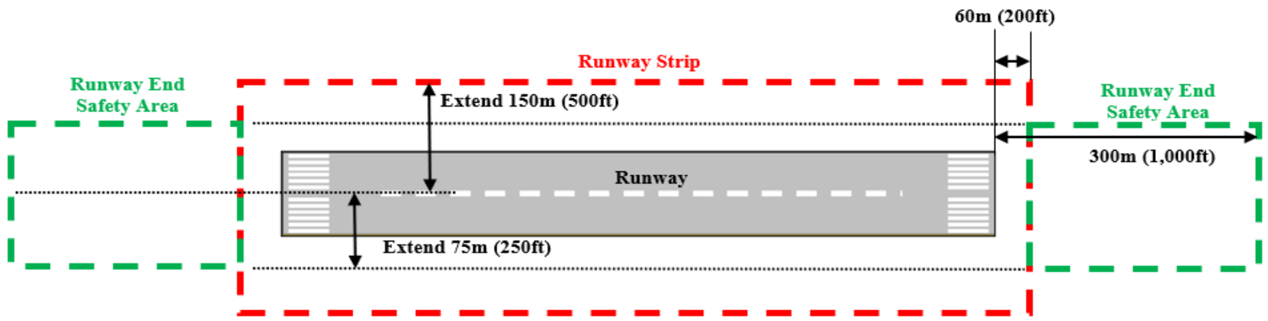
The "Missed Approach Surface" is a surface longitudinally centered on the extended centerline of the runway, beginning at 330m/1300ft outboard from the approach runway threshold. The surface width is 700m/2333ft and 7m/22ft above the threshold elevation, the surface extending outward and upward at a slope of 40:1 (2.5 percent) for a horizontal distance of 2340m/7800ft. The surface width is 700m/2333ft at the beginning of the missed approach and increases uniformly to a width of 1860m/6200ft at a distance of 2340m/7800ft from the end of the Primary Surface.



Source AREA NAVIGATION APPROACH OIS (ANA OIS, conversion feet to metric on the diagram rounded by authority for convenience– as per standard 1m#3.28ft)

4.3. Runway Strip & Runway End Safety Area (RESA)

As per Aerodrome Design manual (ICAO):



- No Fixed Objects other than frangible visual aids permitted in Runway Strip within 60m/200ft.
- No objects should be situated in RESA that may endanger planes.

5. "EXTENDED PRIMARY SURFACE" FOR MPL PURPOSES:

The so-called "Extended Primary Surface" is not an official aviation term. This is a Risk Control term used for Falling Aircraft exposure assessment within an airport area. However, the "Extended Primary Surface" is based on enhanced "Imaginary Surfaces" used by civil aviation.

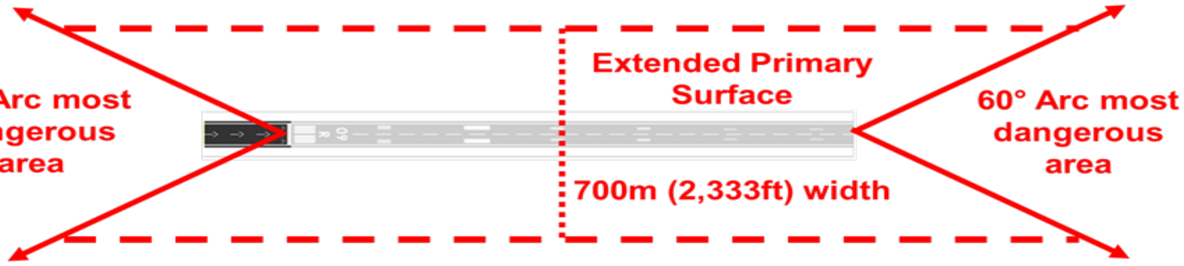
“Imaginary Surfaces” (i.e. OLS, MAS, RESA see above) intend to protect aircraft in flight from any obstacle such as terminals, control towers, support buildings and hangars as follows:

- Assuming that the aircraft is operating normally
- Providing volumes of airspace around and above an airport for an aircraft in normal flight

As a result of the above, as far as the MPL Falling Aircraft – Airport case is concerned, a critical zone around the runway - so-called the “Extended Primary Surface”, based on the “imaginary surface” above but also considering the emergency situation (worst case outside of normal operations) - is defined as follows:

- Distance (measure on all sides of runway):
  - 350m/1148ft for commercial aviation (international / domestic airport) or military airport with aircraft of a similar size to commercial aircraft
  - 175m/574ft for general aviation (recreational airfield, private jet airstrip)
- Extending beyond either end of the runway and connecting with the 60° arc

For commercial aviation:



In the case of multiple runways with different orientations, all the most dangerous areas should be considered for all runways.

For terminals, control towers, support buildings (i.e. utilities, maintenance, fuel supply, catering, customs, luggage handling, ground vehicles, etc.), hangars, parking lots and any third party facility (if any) located inside this “Extended Primary Surface” (Airspace Class A and B), a plane crash occurring over those structures should be considered. This is a relevant MPL scenario.

The MPL should be calculated as per the MPL Handbook 4.2.2 general case and/or 4.2.3 High-rise Building case (warning: different scenarios for commercial aviation and general aviation # MPL fire).

6. AIRCRAFT ACCIDENTS CAUSAL CHAIN

After examining several decades of commercial aviation accident data from around the world, researchers have found that as the severity of accidents increases, so does the number of links in the causal chain. In other words, the worst accidents provide the greatest opportunities for breaking the accident chain and are, therefore, the most preventable, at least theoretically.

System failures rarely cause an aircraft accident. Instead, it is the action or inaction of the crew which is the ultimate precipitator of the majority of aircraft mishaps.

7. MOST HAZARDOUS PHASES OF FLIGHTS

Phases of flight where emergencies begin (in descending order):

- Landing
- Take-off
- Approach
- Cruise
- Static (ground)
- Other

Phases of flight where accidents occur (in descending order):

- Landing
- Descent
- Take-off
- Approach
- Cruise
- Static (ground)
- Unknown
- Other

8. MID-AIR COLLISION

Mid-air collisions between large aircraft are extremely rare because most planes carry avoidance equipment which triggers off an alarm or automatically changes course if another aircraft is too close.

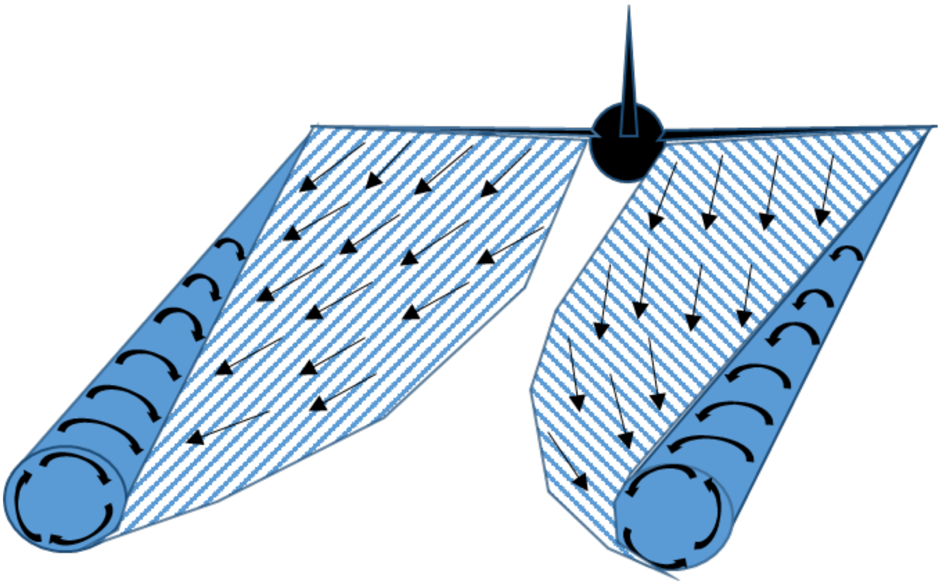
9. IN-FLIGHT BREAK-UP

In-flight reported break-up mainly results from sudden depressurization (e.g. cargo door failure, structural), explosion (e.g. terrorist bombing, accidental failure of pressurized load), equipment malfunction (e.g. engine explosion, critical pressure differential on plane cell due to command failure).

The majority of cases of flight break-up result in the aircraft's disintegration into relatively small sized parts, up to the size of an engine. Parts are usually spread over a wide area from 1km² to more than 12 km², depending on aircraft altitude at the time of the break-up and on whether the aircraft plunged into the ground before total disintegration

10. WEAK TURBULENCE

When lift is generated by the wings of an aircraft, there is a lower pressure area located above the wing and a higher-pressure area located below it. At the wingtip, there is a tendency for the higher-pressure air to “roll” over the wingtip to the lower-pressure area above it. This rolling air generates a vortex of air that trails behind and below the aircraft. Vortexes have a sink rate of approximately 165m per minute (500 feet per minute) and tend to level off at about 300m (900 feet) below the aircraft which generates them.



This vortex, which is also called weak turbulence, is strongest when an aircraft is heavy and slow. As a result, when aircraft take off and land, they generate the greatest amount of weak turbulence. Large, heavy aircraft will generate a stronger vortex than smaller, lighter planes.

The weak turbulence from a large aircraft may be strong enough to cause the aircraft behind to roll. There are many instances where general aviation aircraft have crashed due to loss of control after being caught in the rotating forces of weak turbulence behind a larger aircraft. This also applies to commercial aviation where jet airliners crashed or were broken up. The last crash involving a jet airliner caught in weak turbulence was recently recorded in New York (cf. aviation loss record section).

In certain situations, tower controllers warn pilots of the potential for encountering weak turbulence. Tower controllers also ensure the proper separation of aircraft. However, it is always the pilot’s responsibility to adjust the operation and flight path of the aircraft in order to avoid weak turbulence. This is true, irrespective of whether a warning has been received or not.

11. BIRD HAZARD

A bird strike, bird ingestion (for an engine), bird hit, or bird aircraft strike hazard (BASH)—is a collision between an airborne animal (usually a bird or bat) and an aircraft.

Bird strikes are a significant threat to flight safety and have caused a number of accidents with human casualties. There are over 13,000 bird strikes annually in the US alone. However, the number of major accidents involving civil aircraft is quite low and it has been estimated that there is only about 1 accident resulting in human death in one billion (109) flying hours. The majority of bird strikes (65%) cause little damage to the aircraft.

More particularly, the Canada goose has been ranked as the third most hazardous wildlife species to aircraft with approximately 240 goose-aircraft collisions in the United States each year. 80% of all bird strikes go unreported.

Most accidents occur when a bird (or birds) collides with the windscreen or is sucked into the engine of jet aircraft.

The International Civil Aviation Organization (ICAO) received 65,139 bird strike reports for 2011–14, and the Federal Aviation Authority counted 177,269 wildlife strike reports involving civil aircraft between 1990 and 2015, with a growth of 38% in seven years from 2009 to 2015.

Bird strikes happen most often during take-off or landing, or during low altitude flight. However, bird strikes have also been reported at high altitudes, some as high as 6,000 to 9,000 m (20,000 to 30,000 ft) above the ground.

The majority of bird collisions occur near or at airports (90%, according to the ICAO) during take-off, landing and associated phases.

According to the FAA Wildlife Hazard Management manual for 2005, less than 8% of strikes occur above 900m/3000ft and 61% occur at less than 30m/98 ft.

The point of impact is usually any forward-facing edge of the aircraft such as a wing leading edge, nose cone, jet engine cowling or engine inlet.

Jet engine ingestion is extremely serious due to the rotation speed of the engine fan and engine design. As the bird strikes a fan blade, that blade can be displaced, striking another blade and so forth, causing a cascading failure. Jet engines are particularly vulnerable during the take-off phase when the engine is turning at a very high speed and the plane is at a low altitude where birds are more commonly found.

The greatest loss of life directly linked to a bird strike was in 1960 in the US, when an airliner flew through a flock of common starlings during take-off, damaging all four engines. The aircraft crashed into a harbour shortly after take-off, with 62 fatalities out of 72 passengers. Subsequently, minimum bird ingestion standards for jet engines were developed by the FAA.

In 2009 in New York, an airliner ditched into the Hudson River after experiencing a loss of both turbines. All 150 passengers and 5 crew members were safely evacuated after a successful water landing. On May 28, 2010, the NTSB published its final report on the accident. The engine failure was reportedly caused by running into a flock of geese at an altitude of about 975m/3199ft, shortly after take-off.

12. MINIMUM SAFE ALTITUDE

12.1. General

As per Federal Aviation Regulations Sec. 91.119 - Minimum safe altitudes: except when necessary for take-off or landing, no person may operate an aircraft below the following altitudes:

- Anywhere: An altitude allowing, if a power unit fails, an emergency landing without undue hazard to persons or property on the surface.
- Over congested areas: Over any congested area of a city, town, or settlement, or over any open-air assembly of persons, an altitude of 1,000ft above the highest obstacle within a horizontal radius of 2,000ft of the aircraft.
- Over other than congested areas: An altitude of 500ft above the surface, except over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500ft to any person, vessel, vehicle, or structure.

12.2. Rules for overflying built-up areas

12.2.1 Basic rules according to the extent of the built-up area:

Rules for overflying built-up areas comply with national legislation. For example, in a given country:

Built-up areas	Minimum AGL* height
Small built up-areas less than 1,200m mean width	530m/1600ft
Medium built-up areas between 1,200m and 3,600m mean width	1100m/3300ft
Large built-up areas more than 3,600m (e.g. suburban areas around a major city)	1660m/5000ft
Case of a major city. Cf. section b) special case.	2200m/6600ft AMSL**

* Above Ground Level
** Above Medium Sea Level

12.2.2 The special case of a major city:

This major city is located in a prohibited area, starting at ground level up to 2200m/6600ft altitude above Medium Sea Level.

IFR aircraft (mainly commercial airliners) are allowed to fly over the city at a higher altitude than 2,200m/6600ft. For an aircraft which loses power above the city, this altitude is sufficient for it to glide outside the city limits and prepare for an emergency landing.

However, due to the relative proximity of two commercial airports located north and south of the city and one corporate aviation airport north east of the city, each airport's traffic pattern has been organized so that planes are mainly flying around the city above suburban areas.

The suburban area of the city is located in an area where the minimum overflying height is 1660m/5000ft AGL. Consequently, IFR aircraft from/to the corporate aviation airport usually fly over a business district in the suburban area.

For safety reasons, VFR aircraft (mainly recreational) are not allowed to fly over the city nor the suburban area around the city (whatever the altitude).

13. EMERGENCY LANDING

13.1. Basics

The fact is that aircraft are made to land on hard, smooth surfaces. For the most part, aircraft landing gear cannot withstand landing on rough, uneven surfaces.

If landing at an intended airport becomes ill-advised, an alternative airport, at which the aircraft may land is considered, if at all possible.

In the case where there is no alternative airport, the only remaining solution is to attempt an off-airport emergency landing. The accuracy of the landing is directly dependent on altitude at the time of failure and any possible obstructions in the flight path (whether in the air or on the ground).

Most of the recorded emergency landings have occurred between 2 and 9 kms from the airport, closed around the virtual axis from the runway (about ±30° away from the runway center line).

13.2. Accuracy Landings

Accuracy landings are included in emergency procedures because their main purpose is to land the aircraft on a given spot if the need should arise. They represent a very important part of every crew's training. The ability to land an aircraft on a desired spot, with or without power, is a very important loss mitigating factor in the case of an emergency landing, in order to prevent disastrous crash landings and damage to ground installations.

13.3. Emergency Landing Procedures

Emergency landings are the consequence of a major failure which can occur in different flight phases. It would be impossible to try to cover all the different possibilities here in this chapter. The problem that usually comes to mind first and foremost is engine failure. This particular emergency can be highly dangerous or no big deal, depending on where it occurs and on the crew's readiness, training and reaction to the engine failure.

13.3.1 Engine Loss on Take-off

In most situations, engine loss during take-off is the worst possible time to experience engine failure (e.g. due to bird hazard or mechanical failure) because of low altitude with relatively low airspeed. The crew will have little time to react and there are few options available for landing areas.

One reaction is to attempt a return to the airport by executing a tight 180° turn to get back to the runway. The reasoning behind this is that it is possible to turn the plane around quickly enough to safely arrive at the airport and land.

The second reaction to engine loss is to attempt an off-airport landing somewhere ahead of the aircraft. The rationale behind this method implies that it is unsafe to attempt a steep turn so low to the ground and the chances of success are better by seeking the best place to land ahead of the plane.

A number of studies have been carried out to determine the best course of action the crew should take when faced with engine loss at take-off. In short, in most situations, the safest reaction to engine loss is not to attempt to make it back to the airport for landing ("Impossible Turn"), but rather to find a suitable site, within a 60-120° scan (depending on height above ground) around the initial course of the aircraft.

13.3.2 Engine loss on approaching landing

Engine loss during landing can be very easy to deal with or it can be pressure-filled such as engine loss after take-off.

If the pattern has been flown in a manner that allows the plane to glide onto the runway after engine loss, then it remains very easy to make it to the runway and carry out the landing. However, if the pattern the crew has flown has placed the aircraft sufficiently far away from the runway so that the plane is unable to glide onto it, then a real problem exists.

Open areas (field, water) without obstruction (outside cities and industrial sites) will always be preferable for an emergency landing.

V – Support for Recommendations

Further to the inspection of a plastic processing plant in February 1995, located directly at the end of a runway of a small aerodrome with recreational aircraft flying over the plant for take-off or landing, a recommendation was submitted for relocating the plant or rearranging the aerodrome flight pattern with the Authorities Having Jurisdiction (AHJ).

This recommendation was considered unfeasible by the plant for economic reasons.

In 1999, after the annual re-inspection, in accordance with the insurance company's underwriting department, the recommendation was removed from the report for commercial reasons.

Two months after the re-inspection, a small aircraft crash-landed on the plant. A fire ensued and was fortunately extinguished by plant employees. The plant was severely damaged, to the extent of about 20%, and 3 months were required for processing to be restored.

The loss corresponded to the Normal Loss Expectancy case where the fire was extinguished at its early stage of development.

The same event occurring during an idle period could lead to a Maximum Possible Loss scenario corresponding to a Fire scenario resulting in a 100% PD/BI loss (monobloc facility involving high combustible load and high continuity of combustible).

VI – Aviation Loss Record

More than 40 aviation disaster loss records were studied, from which some disasters were chosen according to the significant phase of flight where the accident occurred. The causes of the accidents have been briefly described. Our concern is mainly focused on the path of the Falling Aircraft and debris and on the extent of damage at ground level. Further data about accident causes are available in Section 3 “Support for Assessment”.

1. 2007 DOMESTIC AIRPORT LOCATED IN A MAJOR CITY - CRASH LANDING

The pilot of an airliner that burst into flames after trying to land on a short, rain-slicked runway apparently tried to take off again, barely clearing rush-hour traffic on a major highway.

The flight cleared the airport fence at the end of the runway and the busy highway but slammed into a gas station and a building, causing an inferno.

The 6362ft runway has been repeatedly criticized as dangerously short. Two planes slipped off it in rainy weather just a day earlier. Pilots call it the “aircraft carrier” — it is so short and surrounded by heavily populated neighbourhoods that they’re told to take off again and fly around if they overshoot the first 1000ft of runway.

By contrast, another airport in the U.S. has a 7003ft runway that accommodates similar planes, according to the Federal Aviation Administration.

A federal court in February of this year briefly banned take-offs and landings of three types of large jets at the airport because of safety concerns at this Airport which handles huge volumes of flights for the massive domestic air travel market.

But an Appeals Court overruled the ban saying it was too harsh because it would have severe economic ramifications and that there were not enough safety concerns to prevent the planes from landing and taking off from the airport.

2. 2006 REGIONAL AIRPORT – CRASH ON TERMINAL AFTER TAKE-OFF

After take-off, a small airplane plunged into an empty SUV parked outside against the terminal wall near the baggage claim area. The explosion and fire destroyed the wall. 3 were killed on board. The terminal suffered structural damage due to smoke, leading to a 24-hour shut-down for cleaning.

Investigation: the twin engines aircraft reportedly lost an engine on take-off and crashed (inverted).

3. 1999 INTERNATIONAL AIPORT ON SEASHORE – CRASH LANDING

While landing during a typhoon, the airliner touched down hard, flipped over and caught fire. Of the 315 people on board, 312 survived and three were killed. It was the first fatal accident to occur at this newly built International Airport since it opened in 1998.

The final accident report blamed it mainly on pilot error, specifically the inability to arrest the high rate of descent existing at the 15m/50ft altitude on the radar altimeter. The descent rate at touchdown was 18–20 feet per second (5.5–6.1 m/s).

The flight data stored in the volatile memory of the aircraft's Quick Access Recorder (QAR) during the last 150m/500ft of the approach could not be recovered due to the interruption of the power supply at impact. Probable wind variations and the loss of the headwind component, together with the early retardation of thrust levers, led to 20 knots (37 km/h; 23 mph) loss in indicated airspeed just prior to touchdown.

Due to the severe weather conditions forecast in the airport area, the flight crew had prepared to divert the flight to another airport if the situation was deemed unsuitable for landing. Extra fuel was carried for this possibility, resulting in a landing weight of 194,844kg/429,557lb, 99.897% of its maximum landing weight of 200,000kg/430,000lb. Based on the initial weather and wind check which was passed along to the crew during the flight, they believed they could land there and decided against a diversion to another airport. However, four earlier flights had carried out missed approaches and five had diverted.

During the final approach, the plane descended along the Instrument Landing System (ILS) glideslope to about 210m/700ft when the crew had a visual on the runway. They disengaged the autopilot but left the auto throttle on. During the flare, the rate of descent was not slowed, and the plane landed with the right wing slightly lower. The right landing gear touched down first, the right engine impacted the runway and the right wing was detached from the fuselage. Since the left wing was still attached, the lift from that wing rolled the fuselage onto its right side, and the plane came to rest inverted in the grass strip next to the runway. The spilled fuel caught fire.

Several suggestions were given to the airline concerning its training. However, the airline disputed the report's findings on the flight crews' actions, citing the weather conditions at the time of the accident and claiming that the aircraft flew into a microburst just before landing, causing it to crash.

4. 2002 - MID- AIR COLLISION

Two large jet aircraft crashed, apparently scattering burning debris over tens of kilometers. The airliner hit a cargo plane belonging to a freight company, at an altitude of about 12,000m/36,000ft. The crash occurred above a town, with debris from the airliner scattered across woods and farmland, while the cargo plane crashed into a lake. Pieces of aircraft were found scattered for kilometers around the crash site. A school, a farm and other buildings were also reported to have caught fire.

The official investigation by the local Bureau of Aircraft Accident Investigation identified, as the main cause of the collision, a number of shortcomings on the part of the Air Traffic Controller (ATC) service in charge of the sector involved, as well as ambiguities in the procedures regarding the use of the Traffic Collision Avoidance System (TCAS), the on-board aircraft collision avoidance system.

5. 2001 - WEAK TURBULENCE AFTER TAKE-OFF

An airliner carrying 265 people crashed into homes in the suburb of a big city, shortly after take-off from an International Airport. An engine fell off the plane shortly before it plunged to the ground. The plane began to break apart long before it came down. The entire vertical tail fin had separated, and the airliner entered an uncontrolled descent from an altitude of about 2500ft. During this descent both engines separated from the wings coming down within 100ft of each other near an avenue and a street crossroad. The aircraft crashed into the street of a residential area. One district of this suburb (about 8,6 km straight flying distance from the airport) was engulfed in flames. Up to 12 buildings were set on fire and at least five residents died.

The crash was reportedly caused by turbulence from another aircraft taking off from this Airport.

6. 2001 - TERRORIST HIJACK AND DELIBERATE CRASH INTO HIGH-RISE BUILDINGS

Relative Roles of Initial Aircraft Impact:

- Impact compromised the sprinkler and water supply systems
- Spread of jet-fuel ignited multi-floor fires over large areas
- Increased air supply into the damaged building
- Damaged “fireproofing” from structural components
- Damaged fire-rated compartments

Relative Roles of Subsequent Fires:

- Reduced the structural capacity of the buildings
- Initiated Collapse

9/11 Further Findings:

- Building codes do not require building designs to take aircraft impact into consideration.
- As a result, buildings are:
    - not specifically designed to withstand the impact of fuel-laden commercial airliners
    - or for fire protection and evacuation under the magnitude and scale of conditions similar to this event.

7. 2000 - CRASH AFTER TAKE-OFF

During take-off from Runway 26 right (west departure) at this International Airport shortly before rotation, the right front tire of the aircraft ran over a strip of metal which had fallen from another aircraft and was consequently damaged. Debris was thrown against the wing structure which led to tank rupture. A major fire broke out almost immediately under the left wing fuelled by the leak. The aircraft flew for approximately one minute at a speed of 370km/h (200kts) and at a radio altitude of 65m/200ft but was unable to gain height or speed. This started a sequence of events that caused a fire which eventually led to 2 engines failing and the aircraft crashing. All 109 people (100 passengers and 9 crew) on board were killed. 4 people in a local hotel (located 9km from the end of runway) on the ground were also killed.

8. 1992 - CRASH AFTER TAKE-OFF

This flight departed from runway 01L on a northerly heading at 6:22 pm from an International Airport. Once airborne, the aircraft turned to the right on its departure route. Soon after the turn, at 6:27 pm, above a lake, witnesses on the ground heard a sharp bang and saw falling debris, a trail of smoke and a momentary flash of fire on the right wing while the aircraft was climbing to 1950m/6400ft. Engine number three separated from the right wing of the aircraft, shot forward, damaged the wing flaps, then fell back and struck engine number four, tearing it from the wing. The two engines fell away from the aircraft, also ripping out a 10m/33ft stretch of the wing's leading edge. The first officer made a mayday call to air traffic control (ATC) and indicated that he wanted to return to the airport. At 6:28:45 pm, the first officer reported that the aircraft lost number three and number four engine. ATC and the flight crew did not yet grasp the severity of the situation. Although the flight crew knew they had lost power from the engines, they did not see that the engines had completely broken off and that the wing had been damaged.

The aircraft was still too high and close to land when it circled back to the airport. It was forced to continue circling until it could reduce altitude to that required for a final approach to landing. During the second circle, the wing flaps were extended. The inboard trailing edge flaps extended, since they were powered by the number one hydraulic system which was still functioning, but the outboard trailing edge flaps did not extend because they were powered by the number four hydraulic system which failed when the number four engine broke away from the wing. The partial flap condition meant that the aircraft would have a higher pitch attitude than normal as it slowed down. The leading-edge slats extended on the left wing, but not on the right wing, because of the extensive damage sustained when the engines separated, event that had also severely disrupted the air flow over the right wing. That differential configuration caused the left wing to generate significantly more lift than the damaged right wing, especially when the pitch attitude increased as the airspeed decreased. The increased lift on the left side increased the tendency to roll further to the right, both because the right outboard aileron was inoperative and because the thrust of the left engines was increased in an attempt to reduce the aircraft's very high sink rate. As the aircraft slowed, the ability of the remaining controls to counteract the right roll diminished. The crew finally lost almost all ability to prevent the aircraft from rolling to the right. The roll reached 90 degrees just before impact with the apartments.

At 6:35:25 pm, the first officer radioed to ATC that they were going down. In the background, the captain was heard instructing the first officer to raise the flaps and lower the landing gear.

At 6:35:42 pm local time, the aircraft nose-dived from the sky and crashed into two high-rise apartment complexes. It exploded in a fireball, which caused the building to partially collapse inward, destroying dozens of apartments. The cockpit came to rest east of the building, between the building and the viaduct of a metro line. The tail broke off and was blown back by the force of the explosion.

Causes revealed in investigation: In the event of excessive loads on aircraft engines or engine pylons, the fuse pins holding the engine nacelle to the wing are designed to fracture cleanly, allowing the engine to fall away from the aircraft without damaging the wing or wing fuel tank. Airliners are generally designed to remain airworthy in the event of an engine failure, so that they can be landed safely. Damage to a wing or wing fuel tank can have disastrous consequences. The local Aviation Safety Board found that the fuse pins had not failed properly, but instead had fatigue cracks prior to overload failure.

9. 1991 – IN-FLIGHT BREAK-UP

Wreckage (5000m/15,000ft altitude) of an airliner above a jungle. Major debris fell into a 1km² area of jungle. Lighter pieces drifted up to 2kms.

The official investigation, led by the local Aircraft Accident Investigation Committee, took about eight months and was released with the "probable cause" stating: "The Accident Investigation Committee determines the probable cause of this accident to be [an] uncommanded in-flight deployment of the left engine thrust reverser, which resulted in loss of flight path control. The specific cause of the thrust reverser deployment has not been positively identified." Different possibilities were investigated, including a short circuit in the system. Due, in part, to the destruction of much of the wiring, no definitive reason for the activation of the thrust reverser could be found.

10. 1989 – CRASH LANDING

This was a crash landing reportedly due to the misidentification of a failed engine and shutdown of the “good one” prior to landing. The plane crashed at more than 1000m/3280.8ft from the runway. The first impact, on rising ground just short of the eastern embankment of a motorway, was relatively gentle and went almost unnoticed by those seated towards the front of the aircraft. But the blunt nosedive into the lower western embankment slope imposed severe deceleration forces, resulting in the worst head, limb and torso injuries as the cabin floor structure collapsed and passenger seats broke free.

Annexes

Annex A: Technical References

The following main documents were taken into consideration for this study:

- European Civil Aviation Handbook
  https://ec.europa.eu/transport/modes/air/internal_market/handbook/part1_en

- Federal Aviation Regulation Part 77 Basics
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- Federal Aviation Agency (FAA), Runway Strip & Runway End Safety Area (RESA)
  https://www.icao.int/NACC/Documents/Meetings/2016/ACI/D1-05-RESA.pdf

- Rhode Island Airport Corporation, North Central State Airport Master Plan, Chapter 4 – Facility Requirements https://www.pvdairport.com/documents/sfz%20master%20plan/chapter%204%20-%20facility%20requirements%20final%20march%202010.pdf

- Manual of Standards Part 139—Aerodromes Chapter 7, Obstacle Restriction and Limitation

- Planète TP Les servitudes de dégagement http://www.planete-tp.com/les-servitudes-de-degagement-a50.html#:~:text=Les%20surfaces%20de%20d%C3%A9gagement%20sont,massif%2C%20mince%20ou%20filiforme

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- Air Disaster Volume 1, Macarthur Job, 1994
- Air Disaster Volume 2, Macarthur Job, 1996
- Air Safety Foundation, prevention sheets, 2002

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- National Transportation Safety Board, loss investigations, http://www.ntsb.gov

This list is not exhaustive.

Annex B: Glossary of Aeronautical Terms and Abbreviations

Airport vs Aerodrome: Airports and aerodromes are both important locations when speaking of aviation. However, while there are a few instances when they can be used synonymously, it is important to know the differences between the two in order to use them in the correct context:

- An aerodrome is a place where flight operations can take place. In an airport, functions such as the landing and the taking off of helicopters, fixed-winged aircrafts and blimps also occur.
- Airports must meet the standards of the ICAO. Aerodromes have no specific standards except safety guidelines.
- All airports can be referred to as aerodromes, but not all aerodromes can be referred to as airports.
- Airports consist of a large area encompassing at least one runway, a flat surface where aircrafts land or take off, a helipad for helicopter landing and buildings such as hangars and terminal buildings. Aerodromes are basic spaces where flight operations can function.
- Airports include small local airports, heliports, large commercial airports, seaplane bases and STOLport, whereas aerodromes include small general aviation airfields, military airbases and large commercial airports.
- The term airport is widely used all over the world. The term aerodrome is mostly used in the UK and Commonwealth countries, whereas it is almost unheard of in other countries.

AGL: Above Ground Level (reference used to indicate a height).

Air Traffic Control (ATC): system of directing all aircraft operating within a designated airspace by radio. Divided into sectors such as Tower (aerodrome control for take-offs and landings), Departures, Control (en-route aircraft) and Approach.

Airport traffic area: airspace within a horizontal radius of 8km/5mi from the geographical center of any airport at which a control tower is operating, extending from the surface up to - but not including - an altitude of 1000m/3000ft) above the elevation of the airport.

Airstrip: term usually given to a paved runway.

Air transportation: interstate, overseas or foreign air transportation or the transportation of mail by aircraft.

Alternate airport: an airport at which an aircraft may land if a landing at the intended airport becomes inadvisable.

AMSL: Above Medium Sea Level (reference used to indicate an altitude).

Area navigation high route: an area navigation route in the airspace extending upwards from - and including - 6,000m/18,000ft AMSL) to 15,000m/45,000ft AMSL).

Area navigation low route: an area navigation route in the airspace extending upwards from 400m/1200ft AGL) above the surface of the earth, to - but not including - 6,000m/18,000ft AMSL).

IFR (Instrument Flight Rules): stipulated procedures for navigating aircraft by reference to cockpit instruments and radio navigation aids alone. Enables flight regardless of visibility. Normal operating procedure for airline flights.

Nautical mile (nm): measure of distance used for navigation in the air and at sea. Equal to one minute of an arc of latitude on the earth’s surface. Is 244m/800ft longer than a statute mile 1,609km/999.8mi and equivalent to 1,853km/1151mi.

Precision approach procedure: standard instrument approach procedure in which an electronic glide slope is provided.

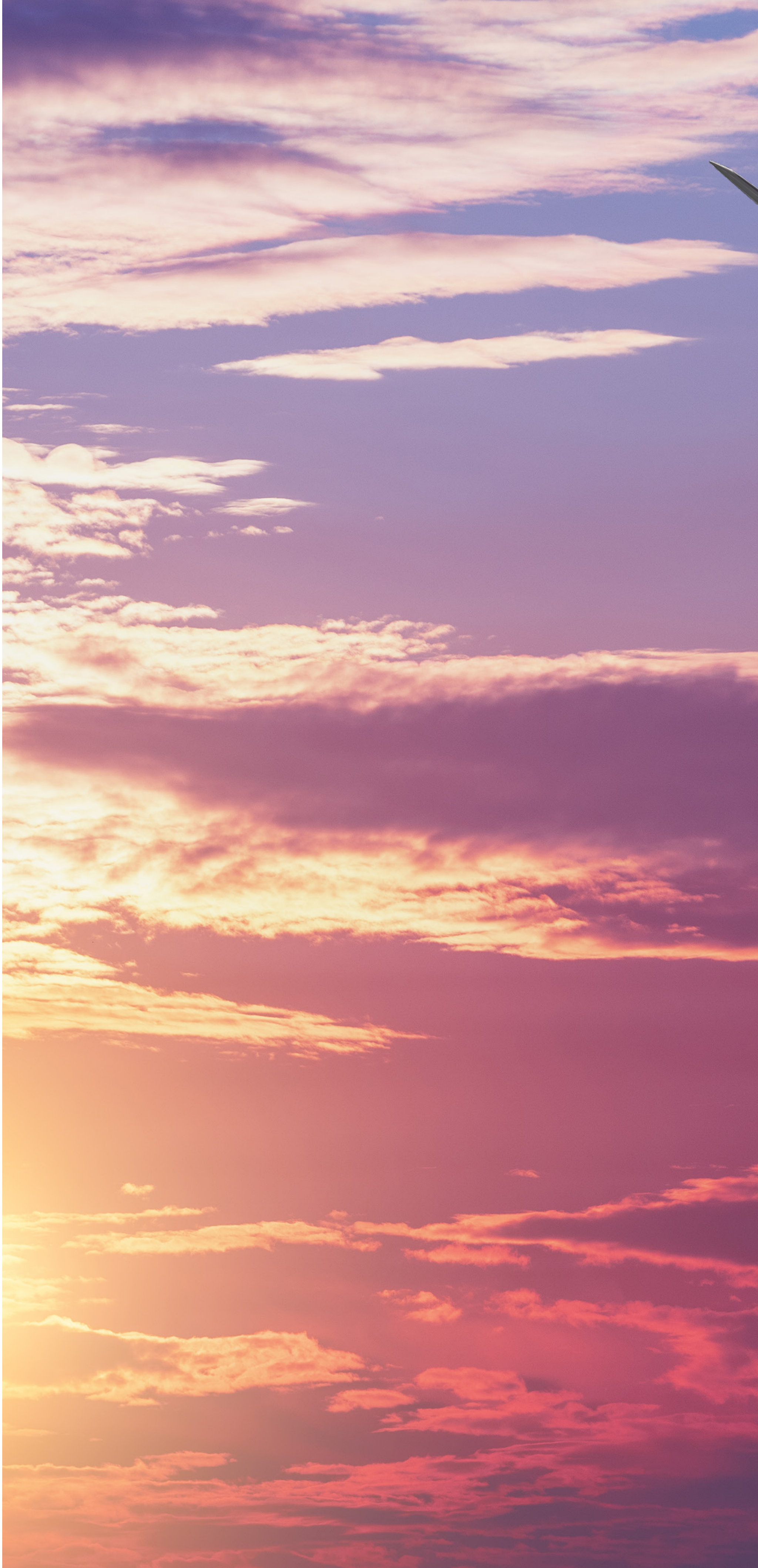
SFC: surface of the earth (reference used to indicate the most elevated of 300m/984ft AMSL altitude or ground level).

Statute mile: measure of distance used for ground navigation, which is equivalent to 1,609km/999.8mi.

Traffic pattern – the traffic flow, which is prescribed for aircraft landing at, taxiing on or taking off from an airport.

VFR (Visual Flight Rules): stipulated flight procedure for visual aircraft navigation, clear of cloud, in Visual Meteorological Conditions.

VMC (Visual Meteorological Conditions): weather providing specified range of visibility, making it possible for pilots to use visual means to avoid obstructing terrain and other aircraft.



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