

Approach and Landing - TEM Analysis

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This article reviews the threats and errors that could lead to a landing overrun. It provides guidance of how to manage threats and errors, thus how to avoid an overrun accident. Threat and Error Management (TEM) is an active process that involves avoiding the threats and opportunities for error, detecting new threats or errors and mitigating their effects, and finally managing the consequences of any threats and error. Avoid - Trap - Mitigate

Threats

Threats are those contingencies that add complexity to the operation, and thereby increase the potential for error. Threats can be:

- overt, subtle or hidden (latent)
 - eg late runway change, inaccurate flight plan winds, incorrectly-coded navigation database.
- expected or unexpected - eg inclement weather, operational pressures, unusual or demanding ATC instructions.

Unrecognised, unmanaged or poorly managed threats significantly increase the potential for error - as detailed in several incidents in this edition of Kai Talk.

Threats are effectively managed by crews who:

- Anticipate the threat,
- Are vigilant for threats,
- When uncomfortable, acknowledge & respond to their own mental '**Master Caution**' and identify the cause of the concern,
- Work together to develop threat management strategies.

An analysis of worldwide landing overrun incidents reveals that an overrun is likely to be characterised by

- Fast approach and landing in excess of $V_{ref} + 15\text{kts}$

- High approach, exceeding the 50 ft threshold crossing height
- Aircraft is 'floated' or is held off the runway for a smooth touchdown
- Touchdown point is deep
- Runway surface is wet or contaminated
- Tailwind component

The analysis shows that these incidents were by no means confined to landings onto 'limiting' or 'critical' runways.

The manufacturer's minimum landing distance is based on;

- Crossing the threshold at 50 ft at the landing reference speed (V_{ref}).
- The runway is dry, with known friction coefficient.
- Maximum braking is applied after touchdown.
- Certified landing distances have additional safety factors to account for operational variability and runway conditions.

This distance should be regarded as a theoretical minimum, requiring a high level of pilot skill under favourable conditions, and using a level of braking that may be considered excessive from a passenger comfort point of view.

The minimum landing distance is increased to obtain the various

Flight Manual (FCOM 2) landing distances. These factors account for the operational variability that can be expected in day-to-day operations, (wet runways, excess approach speed, etc). This distance depends on landing weight, aerodrome altitude, temperature, runway slope and forecast winds.

Plan Ahead

Carefully review the expected landing performance during the approach briefing. The pre-planned data uses forecasts and predictions made at the time of dispatch. Recheck these and consider:

- Runway choice – available length, surface condition, dry / wet / contaminated.
- Wind - tailwinds can significantly increase landing distance.
- Maximum landing weight allowed - note the considerable differences in allowable landing weight headwind and tailwind conditions.
- Check how close (%) the actual landing weight is to the allowed landing weight; adjust the planned braking level accordingly.
- Consider any effects of non-normal operations (eg., MEL).
- Carefully recheck the pre-planned performance when landing at alternate or diversion airports.

Approach Threats

The most significant threats during the approach are:

- **Fast approach air speeds in excess of the planned value**
- **High ground speeds, not appreciating wind effects**
- **High or steep approach above the desired flight path**

High energy is the combination of these conditions; early control of energy can reduce these threats.

Plan and brief the approach; use 'approach gates' that define the distance or height where the correct airspeed and height (energy) must be achieved

Consider the effect of any speed correction for gusting wind and windshear. Recheck the landing distance required and adjust the planned braking level according to the ground speed.

Landing Flare

A fast approach or excess height above the threshold are threats to a safe landing:

- The speed element of energy is the most critical variable: **Energy ~ Mass x Speed²**
- An extended flare can lead to a deep landing. Aim to touchdown within the relevant fixed distance markers.
- Downhill slopes may give a long touchdown.

Aim for a 'safe' landing, not always a 'soft' landing. Remember that aircraft decelerate quicker on the ground than in the air.

Amber threats
For every 10 ft excess height at the threshold, an additional 200 ft of runway is required.

Control on the Runway

As soon as the aircraft is safely on the runway, commence the deceleration; brakes, spoiler, thrust reverse. Effective landing distance available may reduce due to:

- Delayed lowering of nose-wheel.
- Late application of brakes or reverse thrust.
- Failed or late application of spoilers.

When the aircraft is at its highest ground speed, any delay in deceleration uses significant landing distance.

100 kts uses 169 ft of runway every second - that's 1000ft in 6 seconds

Managing Deceleration Threats

Do not delay lowering the nosewheel. Braking depends on ground reaction, which requires all wheels on the runway.

- Automatic spoiler / brake may depend on 'weight' switches.
- Make a firm touchdown especially on a wet or contaminated runway.
- Be prepared for aquaplaning with ground speeds above: **9 x $\sqrt{\text{tyre pressure (psi)}}$**

Although, Boeing have stated that aquaplaning can occur at any speed on a wet runway.

- Anticipate increased rudder input to control any crosswind effects.

Amber threats
For every 1 kt excess speed above Vref, an additional 1-2% of runway is required

- Monitor spoiler and thrust reverse deployment.

Passenger comfort and brake wear considerations often induce a reluctance to utilise the aircraft's full braking potential. This is acceptable in favourable conditions (eg., braking action is good, the runway is long, a long roll-through may be required, etc.). However, reduced braking will result in the reduction of the safety factors built into the landing distances and is not appropriate where the margin has been eroded for other reasons.

Landing on Contaminated Runways

A runway should be considered as being contaminated when it is covered with ice, snow, slush, or more than 3 mm of standing water. Attempts to land on contaminated runways involve considerable risk and should be avoided whenever possible. Ideally, if the destination aerodrome is subject to these conditions the departure should be delayed until conditions improve, or an alternate used.

Advisory data in the FCOM 2 and FCTM concerning landing weights and techniques on slippery or contaminated runways should be used to determine whether there is an adequate margin above the normal Landing Distance Required.

The main threats to stopping the aircraft is the lack of braking effectiveness, this depends on:

1. Level of braking
 - Plan and use of the required level of braking for the conditions.

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- Commence braking at high speed, dissipate energy early.
 - Use full braking when required; safety before comfort.
2. Runway friction
- Wet runways have much lower friction levels than dry runways.
 - The friction depends on the runway surface, materials, and condition.
 - Contamination (water, slush, snow, or ice) reduces friction to very low levels.

Level of braking : Brake for safety not for comfort

Landing Threats:

- **Fast; above Vref+15**
- **High at the threshold**
- **Long/Deep landing**
- **Wet Runway**



INVESTIGATION REPORT

December 2005, A Southwest Airlines B737-700 landed at Chicago Midway Airport in snowy conditions, overran the runway, departed the airfield and rolled across a road, killing a child in a car. At the time braking had been reported as poor, and there was a tailwind component of 8 kts.

The NTSB determined the contributory factors as not managing the landing threats:

- slow response to use reverse thrust,
- improper use of autobrakes,
- failure to calculate landing distance required,
- failure to divert despite poor braking and tailwind conditions
- (the airline's) failure to include any margin of safety in the arrival assessment to account for operational uncertainties.

Landing Threat Management

- Plan - self briefing, crew briefing
- Stabilised approach - through the gates
- Adjust braking levels - wet runways, tailwind

Be aware of additive values

(figures for guidance only):-

- Fast + 15%
- Tailwind + 15%
- No spoiler +20%
- Long flare + 25%
- High + 25%
- Wet + 30 %

ERRORS

We have to acknowledge that humans make errors and that everything does not always proceed as expected. Crew error is defined as an action or inaction by the crew that leads to deviations from intentions or expectations. Operationally, errors tend to reduce the margin of safety and increase the probability of accidents.

Error management

It is human nature to make errors, thus error management is a vital safety device - the process is similar to threat management:

1. Identify & avoid situations that could lead to errors.
2. Identify and trap the error.
3. Mitigate the error - take corrective action.

Errors are managed by:

1. **Resistance** from system defences provided by hardware & formal procedures eg TCAS, EGPWS, checklists, SOPs.
2. **Resolution** through crew non-technical and technical skills.

Crew are the final defence and the last filter in preventing the consequence of error becoming an Undesired Aircraft State (UAS).

No two landings are the same. No matter how many times you've landed in HKG, expect a new 'problem' each time.

- The smallest change in conditions may overcome the plan. Monitor the environment, the aircraft and crew for changes or errors in the plan.

- Do not tolerate SOP deviation (even for training flights). Avoid short cuts or thinking that you know better. Avoid hazardous, error provoking situations.
- It is OK to Go-Around

Avoiding Situation Awareness Errors

Situation assessment errors can be of several types: situation cues may be misinterpreted or ignored, resulting in a wrong picture; risk levels may be incorrectly assessed; or the amount of available time may be misjudged.

Use the following questions as a checklist:

Situation Awareness Checklist

- What are the plane, path and people doing now?
- What is likely to be the state of each later?
- Consider all the "what if" possibilities for each.
- Focus attention on details while keeping the big picture;
- Anticipate, stay ahead of the airplane, consider contingencies, have a plan for the "what if situations";
- Pre-brief who will monitor what in busy times;
- Have a plan for handling distractions, especially malfunctions;
- Use all your team members for awareness;
- Create reminders.

Situation cues provide a mental model of what is happening; cues have to be sought out and understood. See to understand; deliberately scan the situation to gain information and compare this with the expected or the normal parameters. Know what to see and when to see it; focus attention on landing threats and opportunities for error. Don't just judge the situation off one parameter such as airspeed, altitude, runway length, surface conditions, wind, etc

Important situation cues for landing are:

- The aircraft's actual approach path and airspeed in comparison with the ideal flight path and the target air speed

- The runway conditions, friction, and the required level of braking
- The landing distance required for the surface conditions, wind, and aircraft weight, speed and configuration

Compare the landing gates, stabilised approach, speed / height over threshold with the SOP and with the plan you briefed.

- Anticipate the next part of the plan
- Go-around if unstable, if missing a gate, or fast at the threshold
- Beware of bad habits – do not deviate from the plan or SOPs
- Change the course of action if a rule is violated

Consider the consequences: Most overruns are accidents, with fatalities, injury and damage. At the very least the overrun results in disruption and delay, consequential cost and dented pride.

Continuing an approach after missing a stabilised approach criteria is not the correct course of action. It's OK to go-around

Make the decision YOUR decision

- Don't depend on previous aircraft landing reports; braking effectiveness varies with aircraft type, equipment availability, and use of brakes.
- Don't have an accident by helping someone else. It is OK to say 'No' to ATC, 'unable to comply'.
- Make time. Reduce speed early; 180 kts is approx 3 NM/min (900ft/min), whereas 120 kts is 2 NM/min (600 ft/min)

SUMMARY

To avoid a landing overrun.

1. Identify, avoid, and trap threats and errors.

- Maintain good situation awareness: airspeed, runway surface.
- Have a plan, give a briefing: compare the situation with the plan.
- Knowledge of 'no-go' areas: flooded, icy or contaminated runways.
- Speed above Vref+15, long landings, strong tailwinds.
- Follow SOPs: use approach gates, speed / height.
- Do not tolerate violations, beware of bad habits.
- Resist peer pressure.
- Training is NOT a valid reason to violate procedures and limits.
- Brake for safety not comfort.

2. Manage the consequences of error

- Revise the plan - **it is OK to go-around.**
- Make time.
- A safe landing is more important than an on-time landing.

How heavy is the aircraft?

How long is the runway?

How fast is the aircraft?

How wet is the runway?

Head / Tailwind?

'On Speed'?

Stabilised approach criteria?

Height over the threshold?

How much braking to use?