Agenda Item 6:
Threat and Error Management (TEM)
Reducing Accidents by Identifying Threats and Avoiding Errors
Threat and Error Management

- A conceptual framework
- Focused on aviation operations and human performance
- Viewed as the Last Line of Defense in controlling risks
- Applicable throughout the aviation industry
  - Pilot read back of correct runway, but landed on wrong runway
  - Late runway change from control tower
TEM Model Components

- Threats
- Errors
- Undesired Aircraft States

If improperly managed, result is an Unsafe Outcome
Threats: Environmental or Organizational

- Weather
- Maintenance errors
- Ground crew errors
- Heavy traffic
- Unfamiliar airports
- Cabin crew errors
- Distractions
- Passenger events
- ATC clearances
- Terrain
- Runway Conditions
- Time pressures
- Flight diversions
- System malfunctions
- Automation events
- Missed approaches

Threats: Environmental or Organizational
Threats: Anticipated / Unexpected / Latent

- Weather
- Time pressures
- System malfunctions
Threat Management

The most proactive option to maintain the margin of safety

1. Missed (not identified)
   - Result: safety margin reduced or lost
   - This potential is reduced or eliminated with procedures, checklists, experience and training

2. Identified
   - Decision required- monitor, avoid, or mitigate threat
   - Countermeasures deployed
Threat Management Strategies

Possible threat management strategies:

- Monitor (for low risk threats)
  Threat not considered to be a hazard, or very low risk

- Avoid
  Choose a course of action that eliminates the threat

- Mitigate
  Change actions that reduce the overall risk
Example: Runway Construction

Threat management strategy from a Flight Operations perspective:

- **Monitor** (for low risk threats)
  - Continue using the runway after assessing available length
  - Continually check NOTAMs and watch for construction vehicles

- **Avoid**
  - Airline can require all flights to use a different runway

- **Mitigate**
  - Use a smaller type aircraft
  - Limit conditions:
    - Headwinds only
    - Dry runway
    - Day VFR weather only
Example: Runway Construction

Threat management strategies from an ANSP/Airport perspective:

- Monitor (for low risk threats)
  - Publish NOTAMs
  - Update ATIS
  - Provide awareness radio calls from ATC to arriving flights
- Avoid
  - Close the runway (limit construction to night time)
- Mitigate
  - Require all users to acknowledge construction
  - Add temporary lighting (VASI)
  - Turn off approach lights or approach radio aids (ILS)
  - Restrict aircraft types
  - Limit conditions:
    - Headwinds only
    - Dry runway
    - Day VFR weather only
Errors

- Errors, which are “deviations from flight crew or organizational expectations.”
- Consequences of an action or inaction
- Increase the probability of accidents or incidents
  - NOTE: errors do not always result in accidents!
- Procedures should anticipate that humans will make errors, and therefore errors need to be identified and corrected (“trapped”)
Errors

Common Types of Errors

- Situational Awareness Errors
  Not understanding or being aware of the the situation, leading to: No decision or a wrong decision

- Decision Errors
  Choosing the wrong course of action, due to failures of:
  Discipline, memory, training, or by violating rules and procedures, or giving in to time peer pressure
Error Management

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

- Identify situations that could lead to errors
- Avoid the situations and circumstances that promote errors
- Identify an error, trap the error, take corrective action, and check effectiveness
Outcomes

- Outcomes are reportable events:
  - Incidents
  - Accidents
Runway construction Example:

- Runway construction started
- No NOTAM
- No ATIS warning, No ATC communication with flight
- Flight touches down fast, long
- Successful go-around

No event
Narrative

XYZ Airways Flight 344 was planned for a routine flight from (AAA to BBB) in good weather. The ATIS listed runway 22 as for departure, with a wind of 300 at 20 knots (a nearly direct crosswind).

- Runway 22 is 11,200 feet long, with a noise sensitive community directly off the departure end

Flight 344 was cleared to taxi to runway 22, and the FO requested weight data via ACARS for runway 22.

The crew briefed the noise sensitive departure, which required:

- Significantly reduced takeoff thrust
- Aircraft bleeds off
- A normal takeoff flap setting
- Additional thrust reduction right after takeoff
- Immediate turn after takeoff with very precise navigation

The FO programmed the FMS with these requirements and set the flaps as normal
Threats & Errors

**Threats**

1. Noise abatement departure
2. Reduced thrust takeoff
3. Aircraft bleeds off
4. Thrust reduction after takeoff
5. Precise navigation after takeoff

**Threat Management**

1. Briefing and review
2. Loaded in FMS
3. Briefed for PNF to accomplish
4. Briefed PNF callout
5. Navigation chart available

All threats were identified during the crew briefing with a management plan implemented

**Results: safe operation**
As Flight 344 approached runway 22, the Air Traffic Control tower noted a line of traffic approaching runway 22. To expedite traffic, they changed their runway to 19, with a runway threshold in the same area.

The clearance was “cleared for immediate takeoff runway 19, traffic on 4 mile final”

The FO quickly:

- Requested new takeoff data via ACARS
- Loaded the new departure runway in the FMS
- Loaded the new departure procedure (for runway 19) into the FMS
- Turned the aircraft bleeds ON

The Captain briefed the new departure procedure and the aircraft departed as cleared
The Result:

- Runway Excursion
- No injuries
- Major Damage
- WHY?
Additional Threats

**Missed Threats**

1. Runway 19 length was 7,500 (vs 11,200 for runway 22)

1. Wind changed from crosswind to quartering tailwind

2. FMS needed reprogramming for new V speeds and thrust

**Threat Management**

1. Additional flaps required; Missed

2. Full thrust required: Missed

   ↗ FMS programming: Missed

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All of these threats did not exist until the runway was changed

**Conclusion:** change causes risk due to potential new threats
- Airlines
- Regulators
- Airports
- Air Traffic Control
Threats by Category

As Identified by the
FSF Runway Safety Team
and RERR Workshops
Flight Operations Takeoff Risks

- Improper $V_1$ decision
- Inadequate directional control
- Non-compliance with SOP
- Aircraft not configured properly (trim, flaps, $V_{speeds}$)
- Aircraft not loaded properly
- Pilot training and techniques (multiple)
- Runway selection error
Flight Operations Landing Risks

- Ineffective braking
- Runway contamination
- Approach fast
- Glideslope/altitude control
- Pilot handling techniques (many)
Airport Threats

- Runways not constructed and maintained to maximize effective friction and drainage
- Late or inaccurate runway condition reports
- Inadequate snow and ice control plan
- Not closing a runway when conditions dictate
- Incorrect or obscured runway markings
- Failure to allow use of wind-preferential runways
- Inadequate runway end safety area (RESA)
- Inappropriate obstacle assessments
Additional Airport Threats

- Inadequate or wrong airport markings
- Inadequate, outdate, or wrong NOTAMs regarding runway construction or condition
- Noise restrictions over-riding safety (reverse thrust limits, use of short runways/tailwind runways instead of best runway)
- Lack of continuous friction measuring devices for contaminated runways
- Lack of standardized runway condition reporting to flight crews
Air Traffic Management (ATM) Threats

- Lack of awareness of the importance of stabilized approaches
  - Lack of awareness of stabilized approach criteria
- Late descent clearance for the approach
- Assignment of inappropriate approach speeds
- Runway selection not based on best length or wind conditions
- Failure to provide timely or accurate wind / weather information to the crew
- Failure to provide timely or accurate runway condition information to the crew
Additional Air Traffic Management Threats

- Late runway changes (takeoff or landing runway changes)
- Lack of a precision approach procedure (ILS or RNP) for all runways
- Non-standard terminology (e.g., line up and wait)
- Airspace design issues
Runway Excursion Risk Awareness Tool

Elements of this tool should be integrated, as appropriate, with the standard approach and departure briefings to improve awareness of factors that can increase the risk of a runway excursion. The number of warning symbols ($) that accompany each factor indicates a relative measure of risk. Generally, the higher the number of warning symbols that accompany a factor, the greater the risk presented by that factor. Flight crews should consider carefully the effects of multiple risk factors, exercise appropriate vigilance and be prepared to take appropriate action.

To recognize the need for and to properly execute a Rejected Takeoff (RTO), Failure to recognize the need for a go-around and to conduct a go-around at any time during an approach, flare or touchdowns is a primary factor in runway excursions.

<table>
<thead>
<tr>
<th>Type of Operation</th>
<th>Air Traffic Services</th>
<th>Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-scheduled/taxi/flight</td>
<td>No airport traffic control service</td>
<td>Visibility restrictions — e.g., darkness, fog, IMC, low light</td>
</tr>
<tr>
<td>Training/observation</td>
<td>Late runway change/unreasonable clearances</td>
<td>Contaminated runway — e.g., standing water, snow, slush, ice</td>
</tr>
<tr>
<td>Flight Crew</td>
<td></td>
<td>Tail wind greater than 5 kt</td>
</tr>
<tr>
<td>Reduced state of alertness — long duty period, fatigue</td>
<td></td>
<td>High crosswind/duponty winds</td>
</tr>
<tr>
<td>Single-pilot operation</td>
<td></td>
<td>Heavy rain/thunderstorm on field</td>
</tr>
<tr>
<td>Airport</td>
<td>Aircraft Equipment</td>
<td>No wind shear warning system</td>
</tr>
<tr>
<td>No current/accurate weather/runway condition information</td>
<td>Operative Procedures</td>
<td>Inoperative braking system — e.g., wheel brakes, anti-skid, spoilers, thrust reversers</td>
</tr>
<tr>
<td>Unfamiliar airport or unfamiliar procedures</td>
<td>Operating Procedures</td>
<td>Cockpit distraction/monotone cockpit</td>
</tr>
<tr>
<td>Familiar airport — potential complacency</td>
<td></td>
<td>Absence of no-fault go-around policy</td>
</tr>
<tr>
<td>Inadequate/obscured runway markings</td>
<td></td>
<td>Schedule pressure/delays</td>
</tr>
<tr>
<td>Excessive rubber/too porous friction coating or grooves on runway surface</td>
<td></td>
<td>Absent/insufficient data/tech briefing(s)</td>
</tr>
<tr>
<td>Minimal or no approach/runway/taxiway lights</td>
<td></td>
<td>Absent/insufficient pre-departure briefing planning for braking management/plan checks</td>
</tr>
</tbody>
</table>

### Expected Approach

<table>
<thead>
<tr>
<th>Air Traffic Services</th>
<th>Expected Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>No airport traffic control service</td>
<td>No vertical approach guidance — e.g., ILS, RNP, VASI/PAPI</td>
</tr>
<tr>
<td>Late runway change/unreasonable clearances</td>
<td>Nonprecision approach, especially with multiple step-downs</td>
</tr>
<tr>
<td>Visual approach in darkness</td>
<td>Visual approach in darkness</td>
</tr>
<tr>
<td>LAH/SO/partial runway closure</td>
<td>LAH/SO/partial runway closure</td>
</tr>
<tr>
<td>Planned long landing</td>
<td>Planned long landing</td>
</tr>
</tbody>
</table>
