



**NTSB** National Transportation Safety Board

*Office of Aviation Safety*



# Aircraft Performance

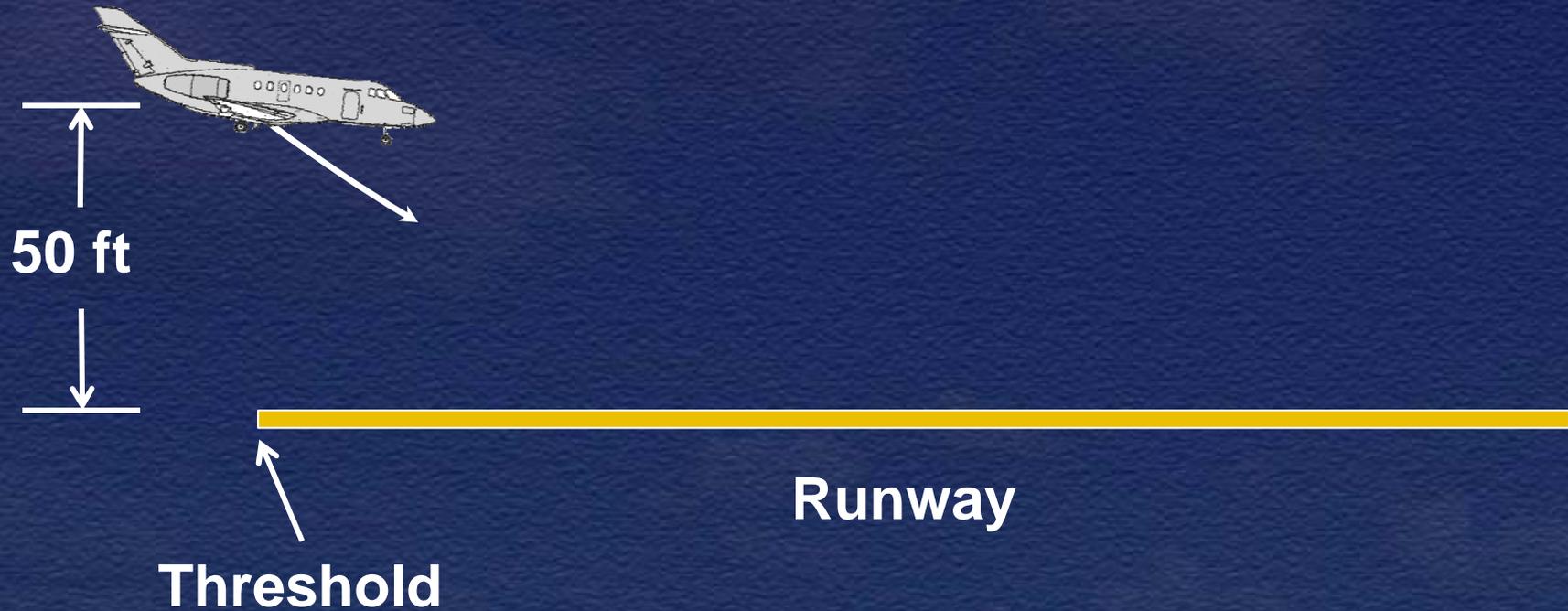
John O'Callaghan

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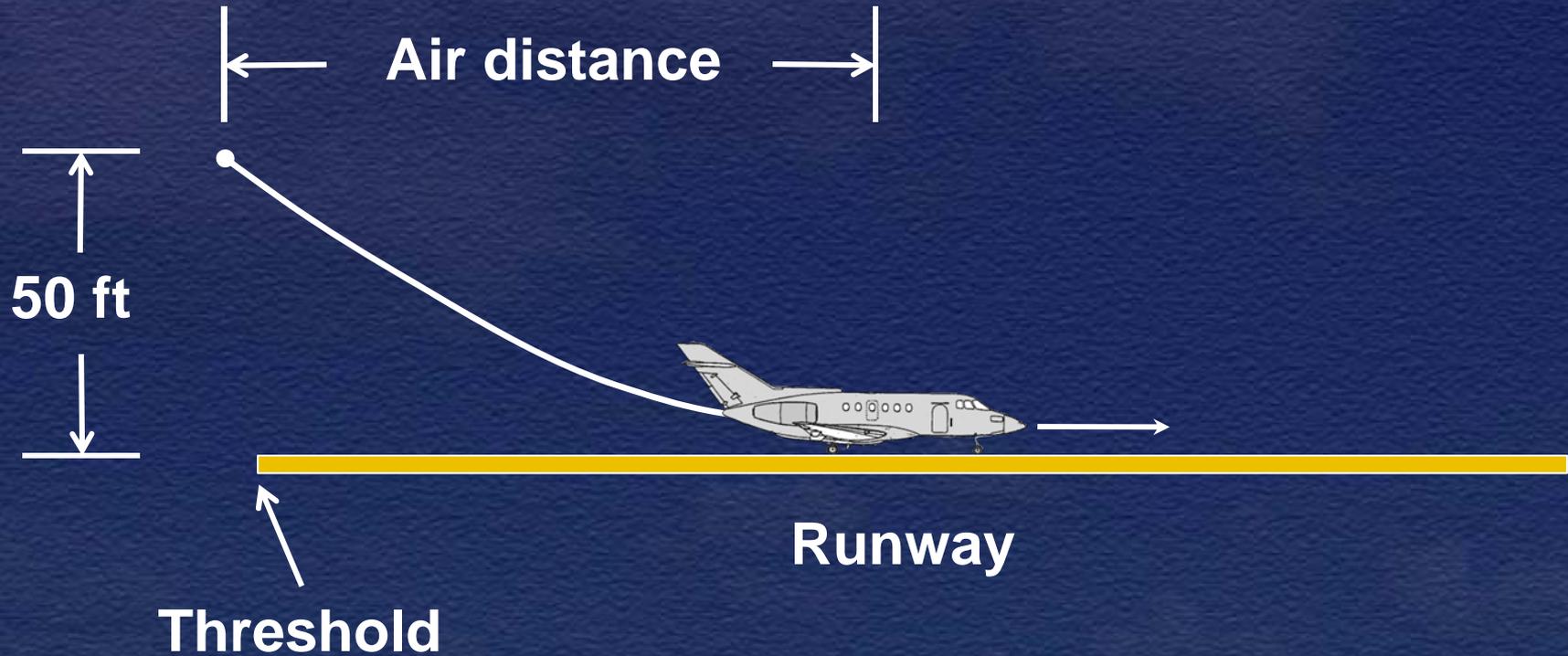
# Topics

- Landing distance components
- Factors affecting landing distance
- Airplane deceleration devices
- Runway friction models
- Landing distance comparisons
  - Effect of the following:
    - deceleration devices
    - friction models
    - wind direction

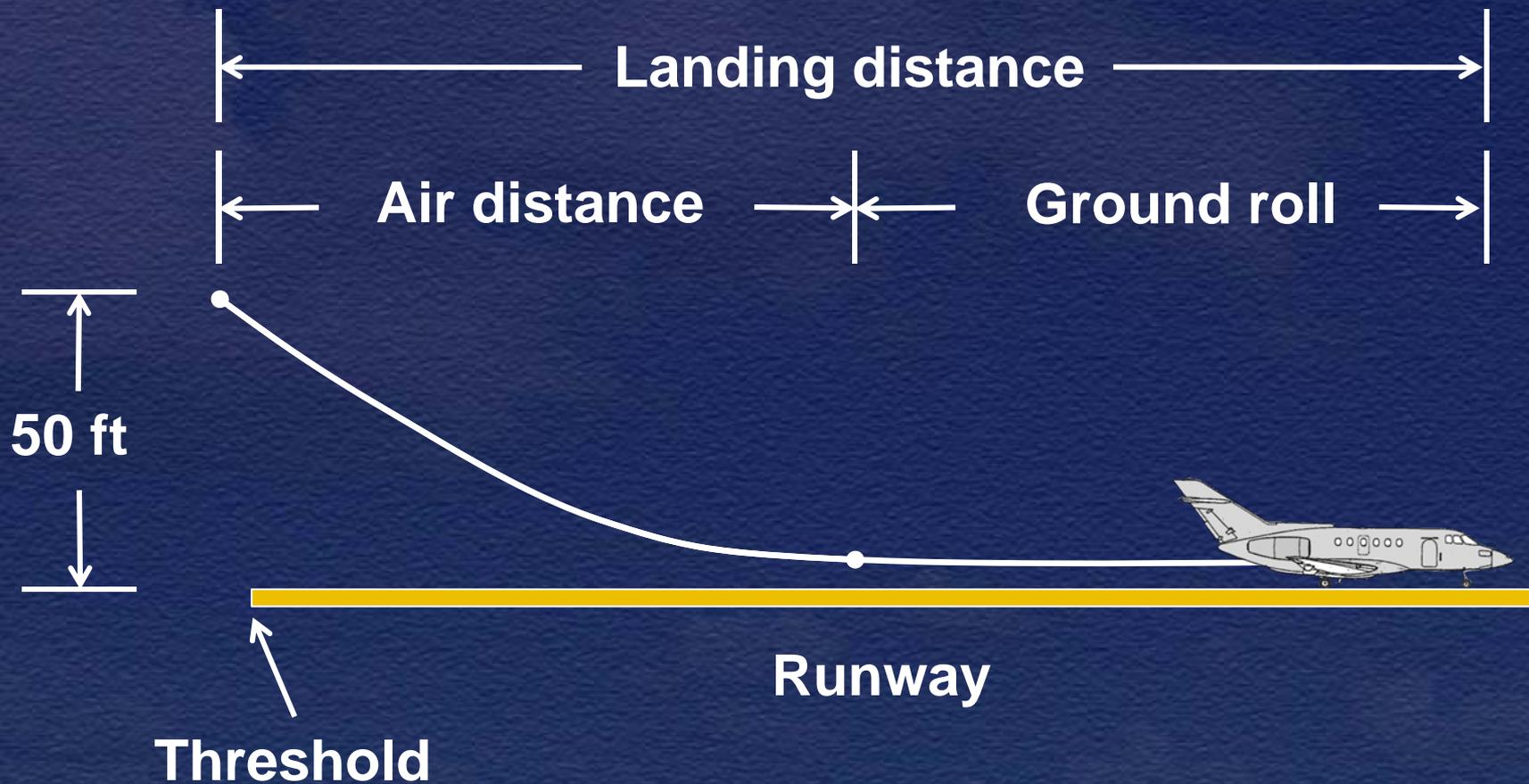
# Landing Distance Components



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# Landing Distance Components



# Landing Distance Factors

- Landing distance increases with
  - Higher groundspeed (airspeed + tailwind)
  - Reduced runway friction (wet or contaminated)
  - Airplane lift while on the ground
- Landing distance decreases with
  - Lower groundspeed
  - Increased runway friction
  - Airplane drag while on the ground

# Airbrakes and Lift Dump

- Airbrakes increase drag and decrease lift
- Lift dump
  - Extends airbrakes beyond in-flight limits
  - Extends flaps from 45° to 75°
- Greater flap extension increases drag

# Before Airbrakes and Lift Dump



**Flaps 45°  
Airbrakes stowed**

# After Lift Dump



**Flaps 75°  
Airbrakes deployed**

# Airplane Braking

- Braking force on a tire is equal to

**Weight  
on tire**

**X**

**Friction  
coefficient**

**X**

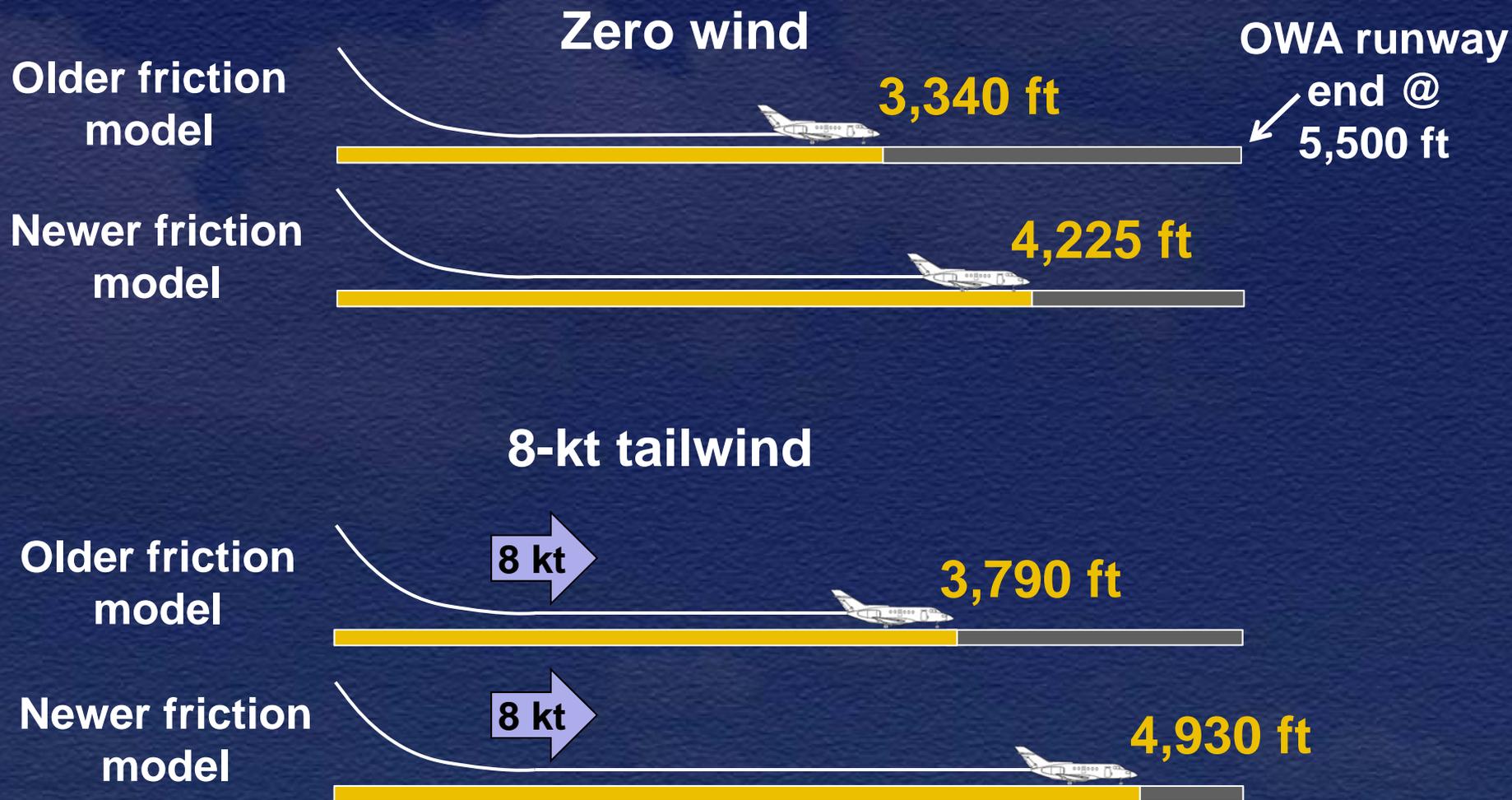
**Anti-skid  
efficiency**

- Anti-skid efficiency defines ability to take advantage of available friction
- Airbrakes increase weight on tire
- Friction coefficient decreases with speed on a wet runway

# Runway Friction Models

- Landing distances in AFM based on friction model current during certification
- Friction demonstrated by flight tests
- Friction can vary greatly for a given runway roughness/tire pressure combination
- New friction model predicts lower friction, longer distances
- Deceleration more consistent with newer model and NASA prediction

# Landing Distance Comparisons



# Air Distance and Lift Dump Effects

8-kt tailwind, nominal air distance and lift-dump timing



8-kt tailwind, accident air distance and lift-dump timing



# Summary

- Wet runway friction assumed in AFM demonstrated in flight tests
- Wet runway friction can be lower, and landing distances longer, than demonstrated values
- With delayed lift dump and 8 kt-tailwind, airplane could not stop on runway



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