AIRCRAFT BRAKE TESTING

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The Boeing Company

ALPA 52nd Annual Air Safety Forum

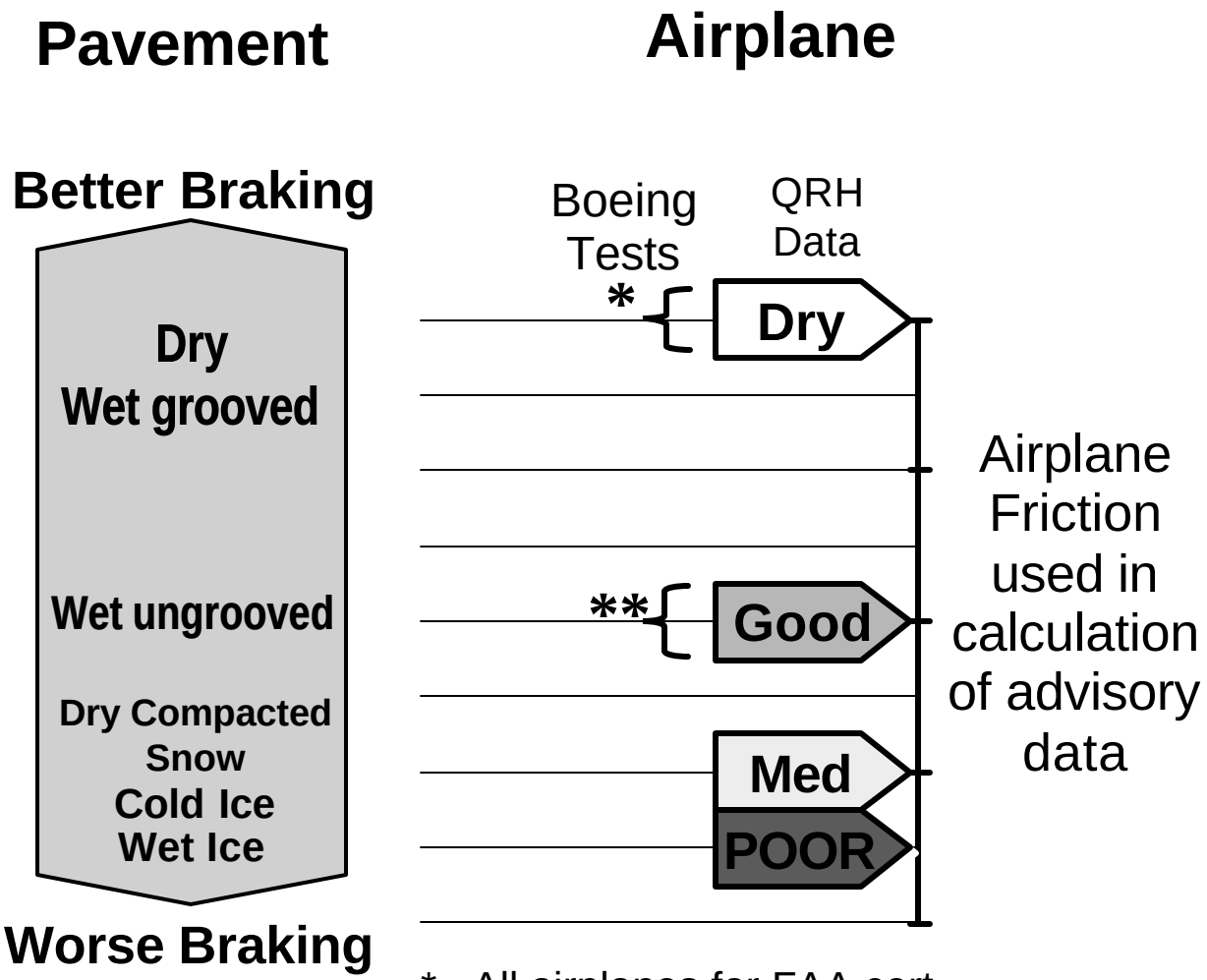
Agenda

- Terminology
- Certified vs. Advisory data
- Brake testing (Lab and Flight)
- Boeing Recommendations

Terminology

- **Runway Friction is not the same as Airplane Friction**
- **Airplane friction is calculated by Boeing**
- **Runway Friction is measured by friction vehicles**

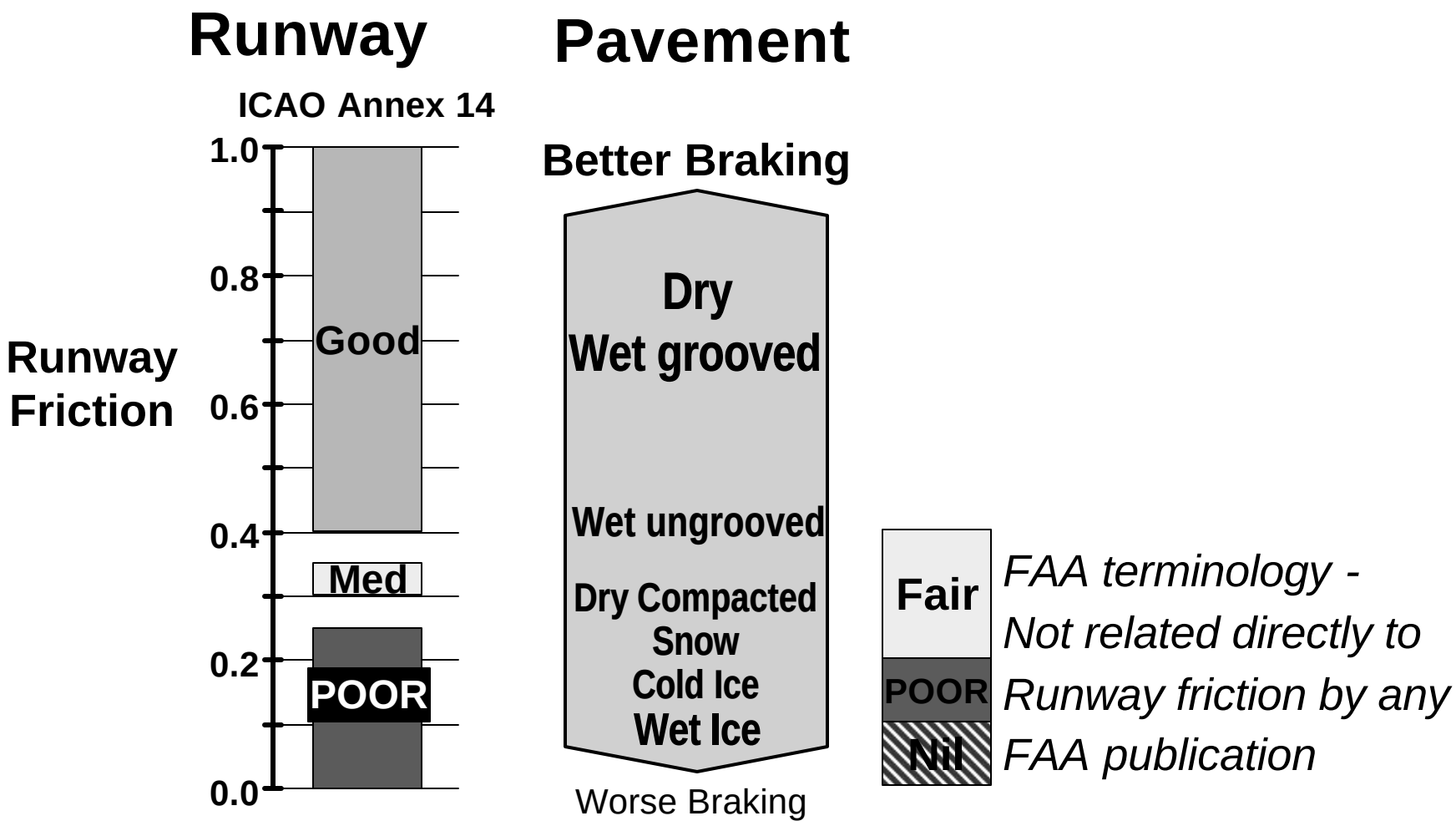
Airplane Terminology



* All airplanes for FAA cert

** 707/727/737-200/ADV/747-100 for CAA cert

Runway Terminology



Landing Distance Data

Boeing provides two distinct and different data sets:

Certified Data

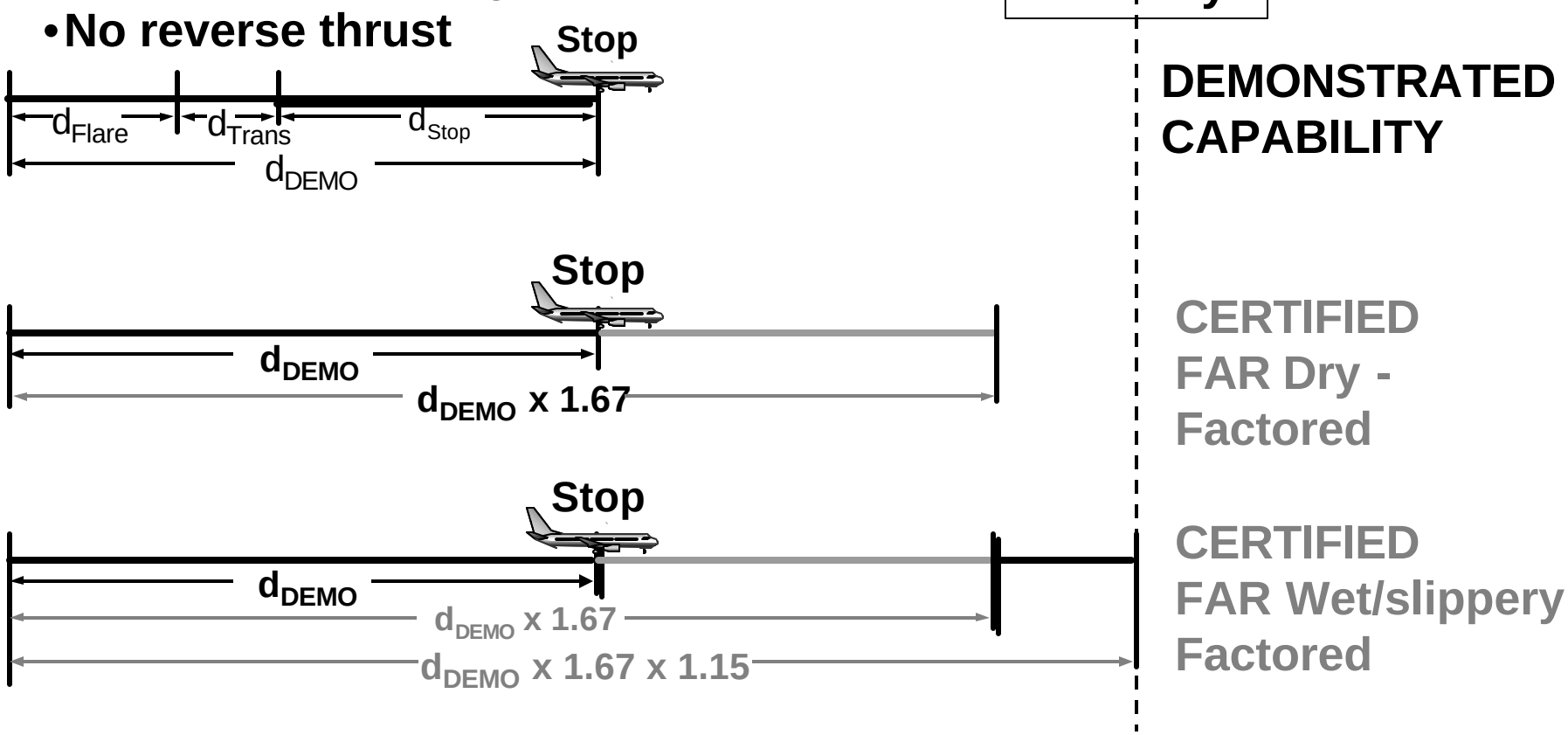
- Purpose
  - Provide landing distance as required by regulations
- Requirements
  - FAR Parts 25 and 121
  - JAR Part 25 and JAROPS 1
- Use: AFM
  - Determine landing distance requirements prior to dispatch

Advisory Data

- Purpose
  - Provide landing distance capability for different runway conditions and braking configurations
- Requirements
  - FAR 121 and JAROPS 1
- Use: QRH
  - Determine landing distance for making operational decisions

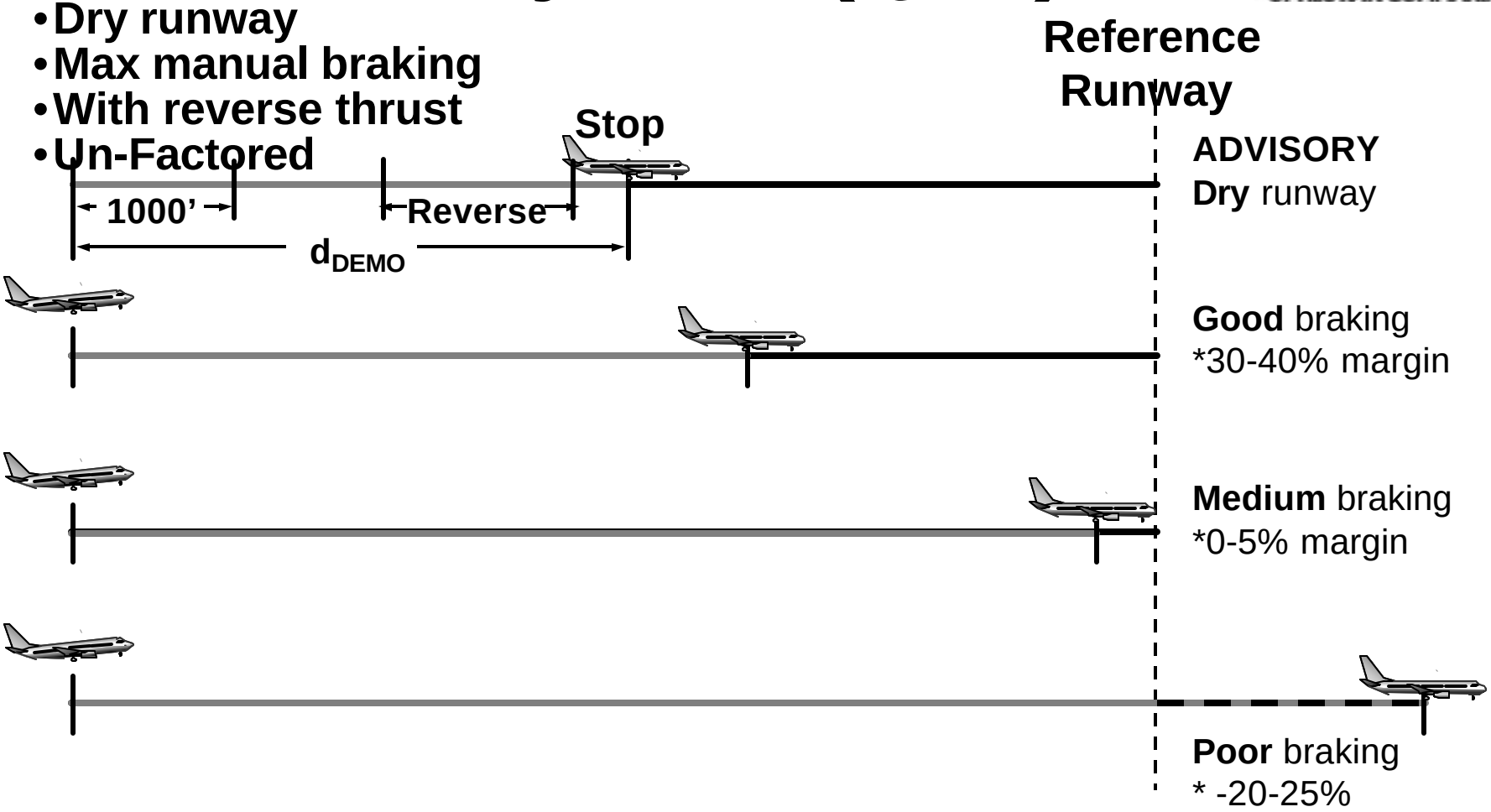
Certified Data (AFM)

- Dry runway
- Max manual braking
- No reverse thrust

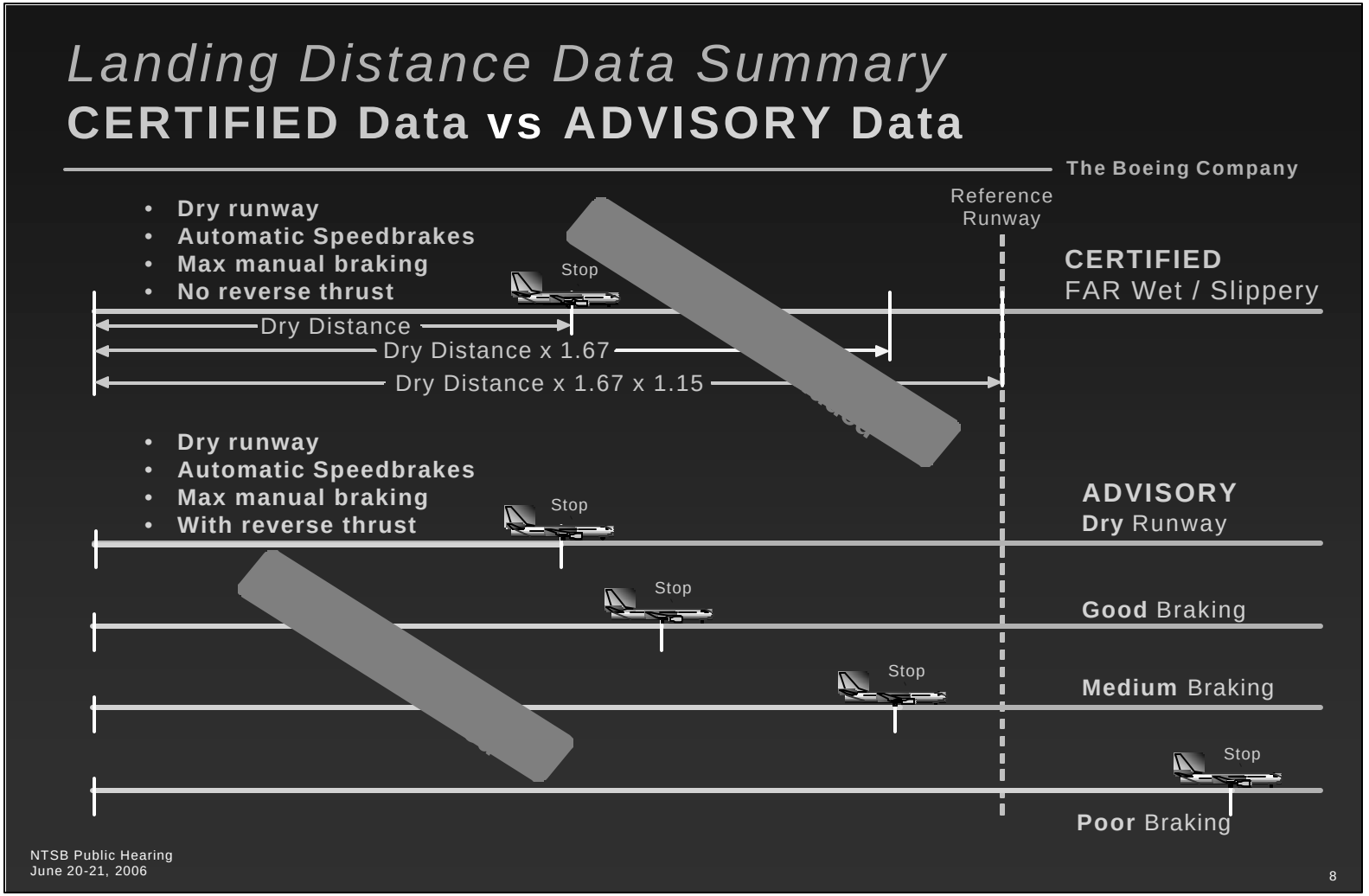


Advisory Data (QRH)

- Dry runway
- Max manual braking
- With reverse thrust
- Un-Factored



CERTIFIED vs ADVISORY



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Brake Testing

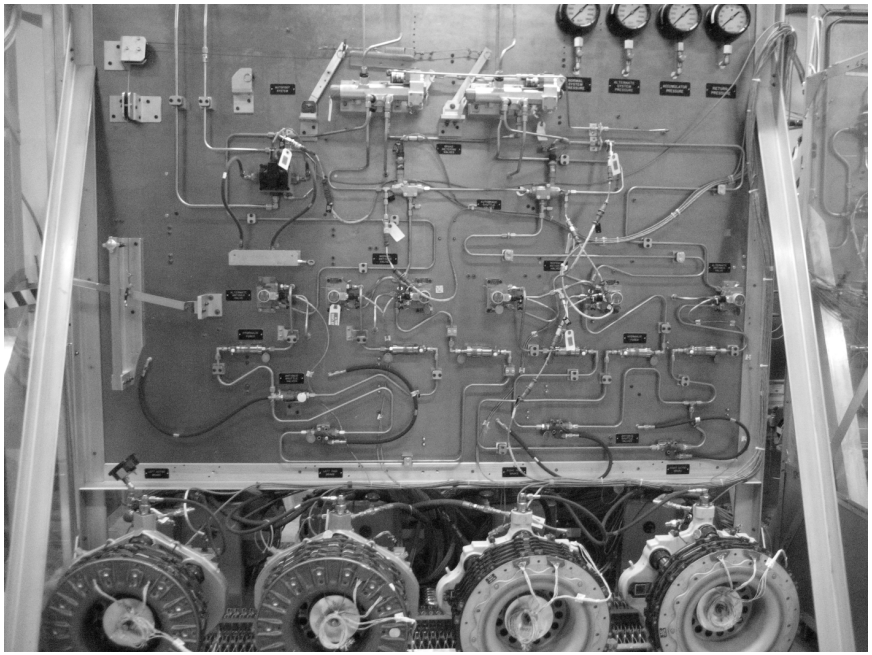
- **Begins in the Brake Lab**

Brake Lab

- **Objective – Tune the antiskid system to achieve 90 % efficiency over a range of runway conditions**

Brake Lab

- **Hardware in the loop with a dynamic simulation of the airplane**



Braking Lab

- Conducts thousands of simulated landings.
- Can vary many parameters such as runway friction
- Can tune the Antiskid to increase efficiency

Flight testing

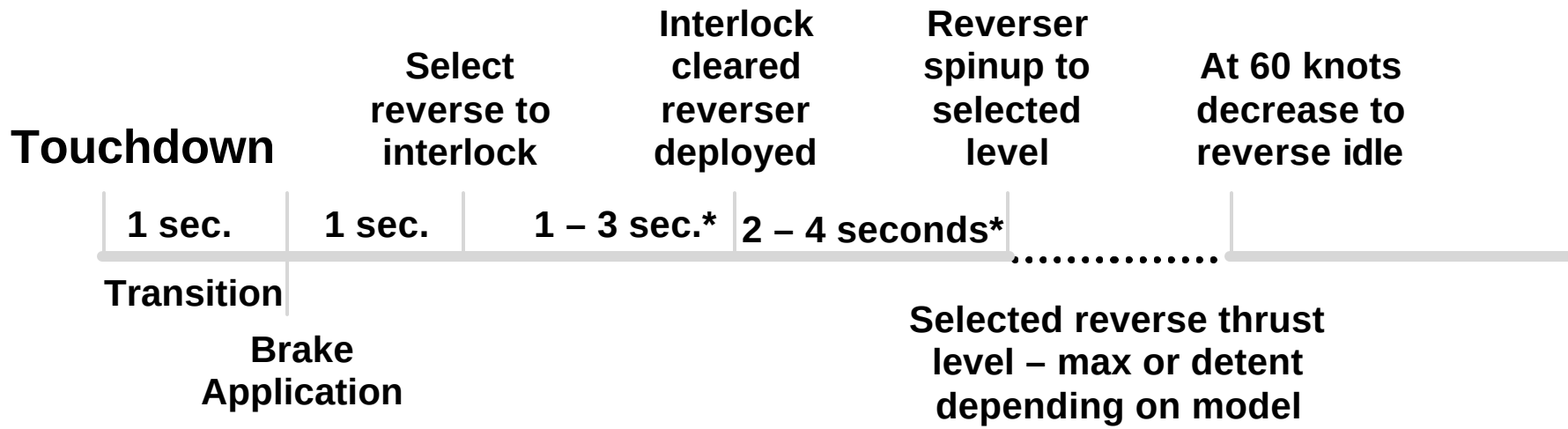
Flight test technique

- 3 degree approach angle
- Land clear of rubber
- Sink rate 3 to 6 Ft/sec
- Max manual brakes < 1 sec
- Nose down with no delay
- No Thrust Reverse

Boeing Recommendations

- Reference – Boeing Flight Crew Training Manual
  - Chapter 6 – Landing
    - Landing techniques
    - Factors affecting landing distance
    - Slippery runway landing

Touchdown sequence



*** Actual time dependent on engine/airframe**

Braking techniques

Factors Affecting Landing Distance

- Approach, Flare and Touchdown
  - Fly the airplane onto the runway
    - On Glideslope, On Speed
  - Do not allow the airplane to float
  - Do not extend flare by increasing pitch attitude
  - Do not attempt to hold the nose wheel off the runway
    - Deceleration on the runway is approximately 3 times greater than in the air (dry runway)

Braking techniques

- Transition
  - –After main gear touchdown - initiate landing roll procedure
    - Speedbrakes (manually raise speedbrakes if they do not extend automatically)
      - – Increase load on the gear for brake effectiveness
      - – Drag
    - Fly the nose wheel on to the runway smoothly
    - Use appropriate autobrake or manually apply wheel brakes

Braking Techniques

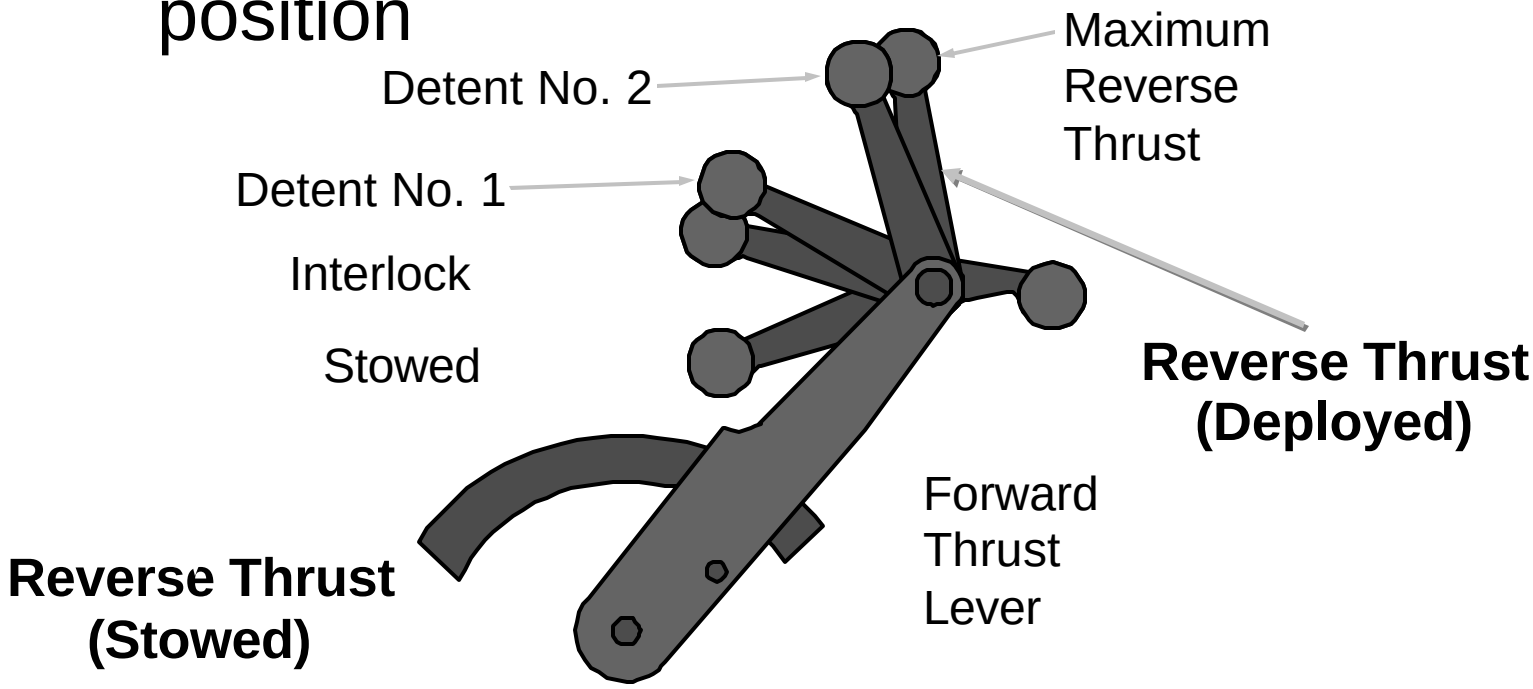
- Automatic Wheel Brakes
  - Level 3 or 4 should be used for wet or slippery runways
  - Immediate initiation of reverse thrust at main gear touchdown
    - Reduces brake pressure to minimum level
    - Reduces stopping distance on slippery runways

Braking techniques

- Manual Wheel Brakes
  - Immediately after touchdown apply a constant brake pedal pressure
  - Short or slippery runways – use full brake pedal pressure
    - Do not attempt to modulate, pump, or improve braking by any other special technique
    - Do not release brake pressure until the airplane has been reduced to safe taxi speed
    - The antiskid system stops the airplane for all runway conditions in a shorter distance than is possible with either antiskid off or brake modulation

Braking techniques

- Reverse thrust
  - After main gear touchdown rapidly raise the reverse thrust levers to the interlock position



Braking techniques

- Reverse thrust
  - After touchdown rapidly raise the reverse thrust levers to the interlock position
  - Apply reverse thrust as required (up to maximum)
  - Reverse thrust always reduces the “brake only” stopping distance
  - Reverse thrust is most effective at high speed