



*NLR Air Transport Safety Institute*

*Research & Consultancy*

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**Assessment of wake turbulence incidents**

**Using existing incident/accident data repositories**

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# Introduction

Study performed in the context of the CREDOS project.

- To provide an estimate of current wake vortex related incident rate
  - **per flight phase;**
  - **for each flight phase the aircraft combinations involved (leader/follower);**
- To identify critical flight phases and aircraft combinations
- To be used as benchmark in safety assessment/monitoring



# Databases available

## Accident / Incident data

### NLR Air Safety Database, comprises:

- Airclaims (CASE, Ascend online)
- ICAO ADREP (available through ECCAIRS)
- FAA Accident/Incident Data (AIDS, SDR, ASRS)
- NTSB (partly covered in the ADREP data set)
- Specials like Robert E. Breiling Associates Business aircraft, ALPA undershoot/veer off/overrun data, Boeing overrun data, RGW Cherry and Associates database
- Airline safety reports (approx 30 airlines, mostly European)

## Exposure data

- EASA Data Warehouse (or the separate underlying source data)

**Other data, like airport data, weather data, Service Difficulty Reports, etc.**

## ECCAIRS format

## WV Accident Query

- 30 wake turbulence encounters between 1970 and 2009, classified as serious incident or accident (W>5600 kg)
- Of which 5 fatal (last in 1992, DC-9 2.25 nm behind DC-10)
- Insufficient to estimate current accident rate
- For wake turbulence studies, focus on incident rate.

## Airline Safety Report database:

- Provides largest amount of wake vortex incident data
- Provides exposure data per aircraft type
- Provides sufficient details for analysis: Date, aircraft type, flight phase, summary:
- “ACFT abruptly rolled approx 75 degrees to the left. I applied full right rudder, full right aileron, disconnected auto pilot, disconnected autothrottles, and I disengaged the yaw damper. The ACFT then rolled back to the right and control was re-established. TCAS indicated an ACFT at the same altitude and 15 miles directly south of our position. I asked Jacksonville center what type of ACFT it was. She said that we were following a 747 at 15 miles out. She then decended the 747 to FL280. Two FAs received injuries, and one PAX was struck in the head with a suitcase when an overhead bin opened. On arrival to PHL paramedics examined the PAX, and the FAs. One FA was removed from the trip in Orlando.”



# Data selection

- **Dataset of 1906 incidents**

- **Inclusion criteria:**

- The incident is considered by flight crew or Air Traffic Control (ATC) as the result of a wake turbulence encounter;
- Incident data comprise main airports in the United States, Canada, Europe, Australia, Far East and Africa.

- **Non-relevant reports are excluded from the analysis, such as:**

- Jet blast from taxiing aircraft;
- Turbulence attributed to weather or mountain waves;
- Helicopter rotor wash.

## • Indicators of wake turbulence:

- Roll angle (left/right, or both successively)
- Yaw angle (left/right, or both successively)
- Increase/loss of speed
- Pitch up/down
- Loss of altitude
- Stall warning (stick shaker)
- Sink rate warning (during approach and landing)
- Bank angle warning
- Increased rate of descent
- Compressor stall
- Engine shutdown
- A/P (Auto Pilot) and A/T (Auto Throttle) disengage







# WV classification and separation criteria

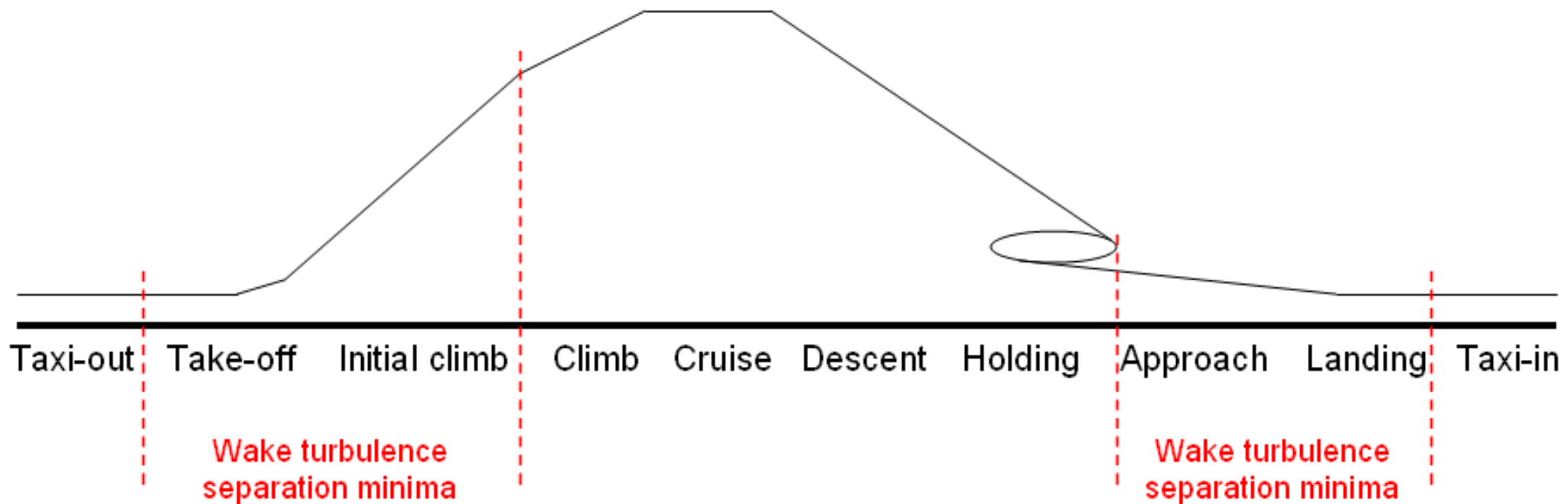
## •Classification according ICAO wake turbulence categories

- Heavy (H) > 136000 kg
- Medium (M) > 7000 but < 136000 kg
- Light (L) < 7000 kg

## •Wake turbulence separation minima apply during:

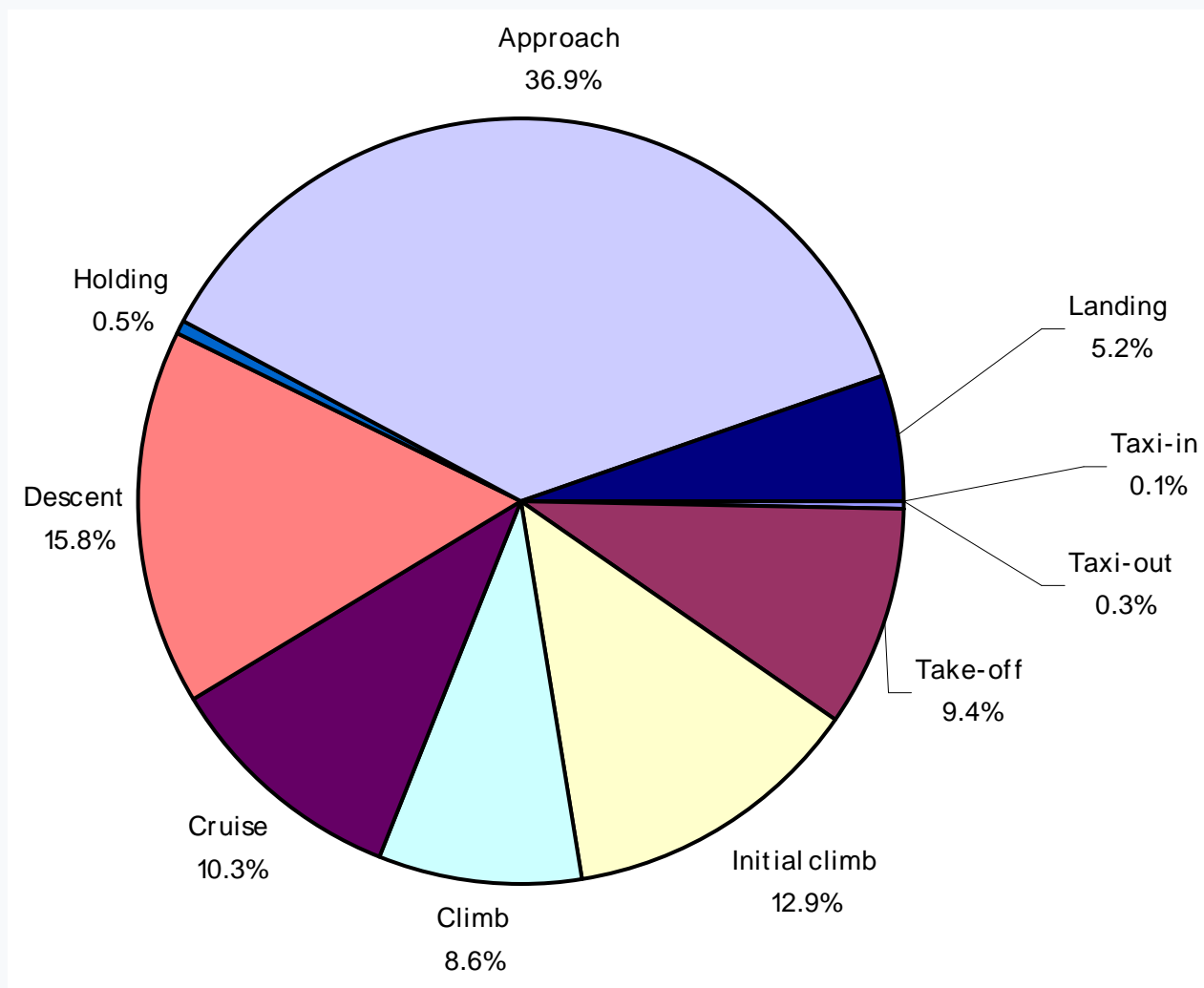
- Departures (take-off & initial climb)
  - Light or medium aircraft behind heavy aircraft, or light aircraft behind medium aircraft
- Arrivals (approach & landing)
  - All categories behind heavy aircraft, or light aircraft behind a medium aircraft

# Flight phases



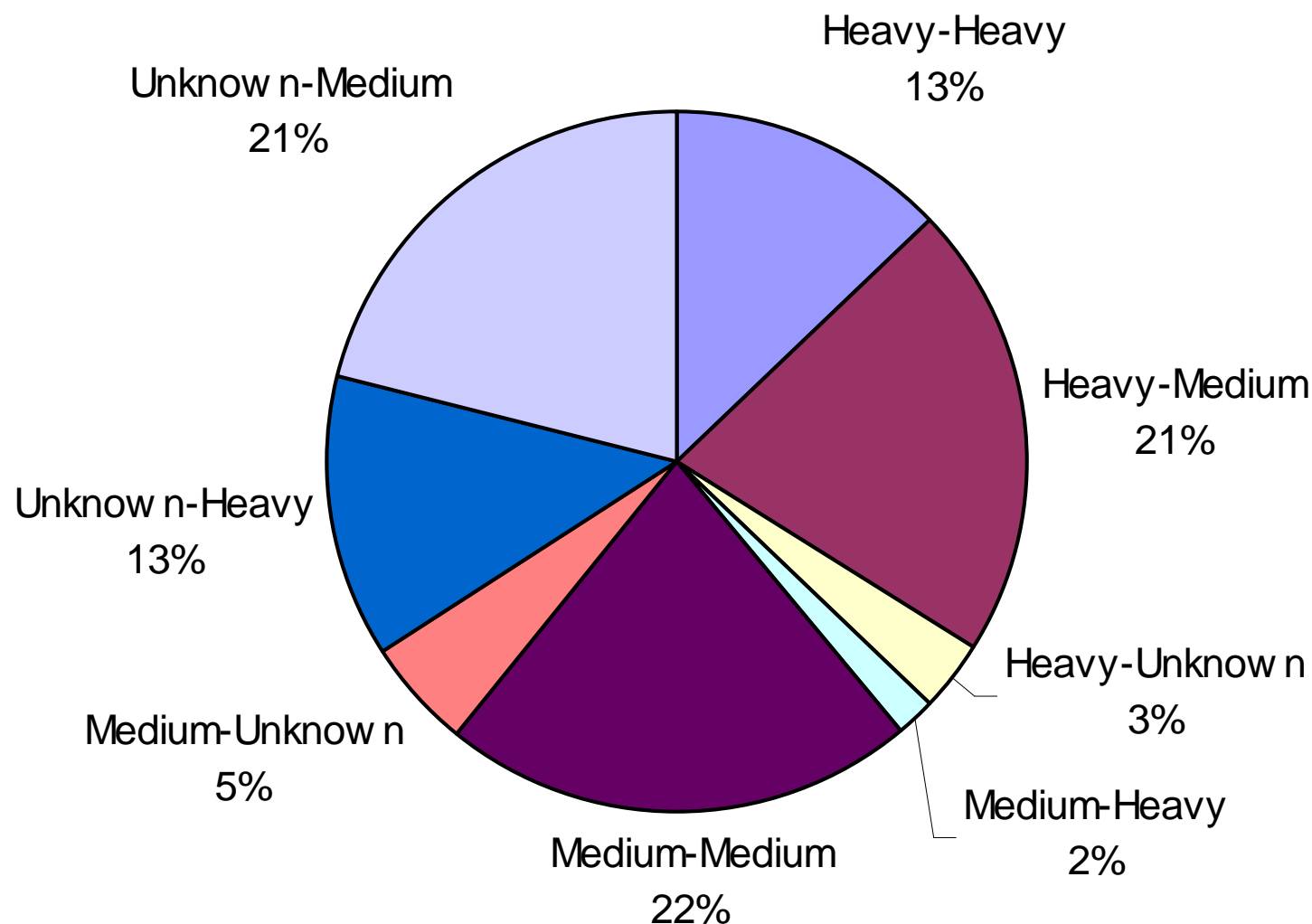


# Results – Incidents per flight phase





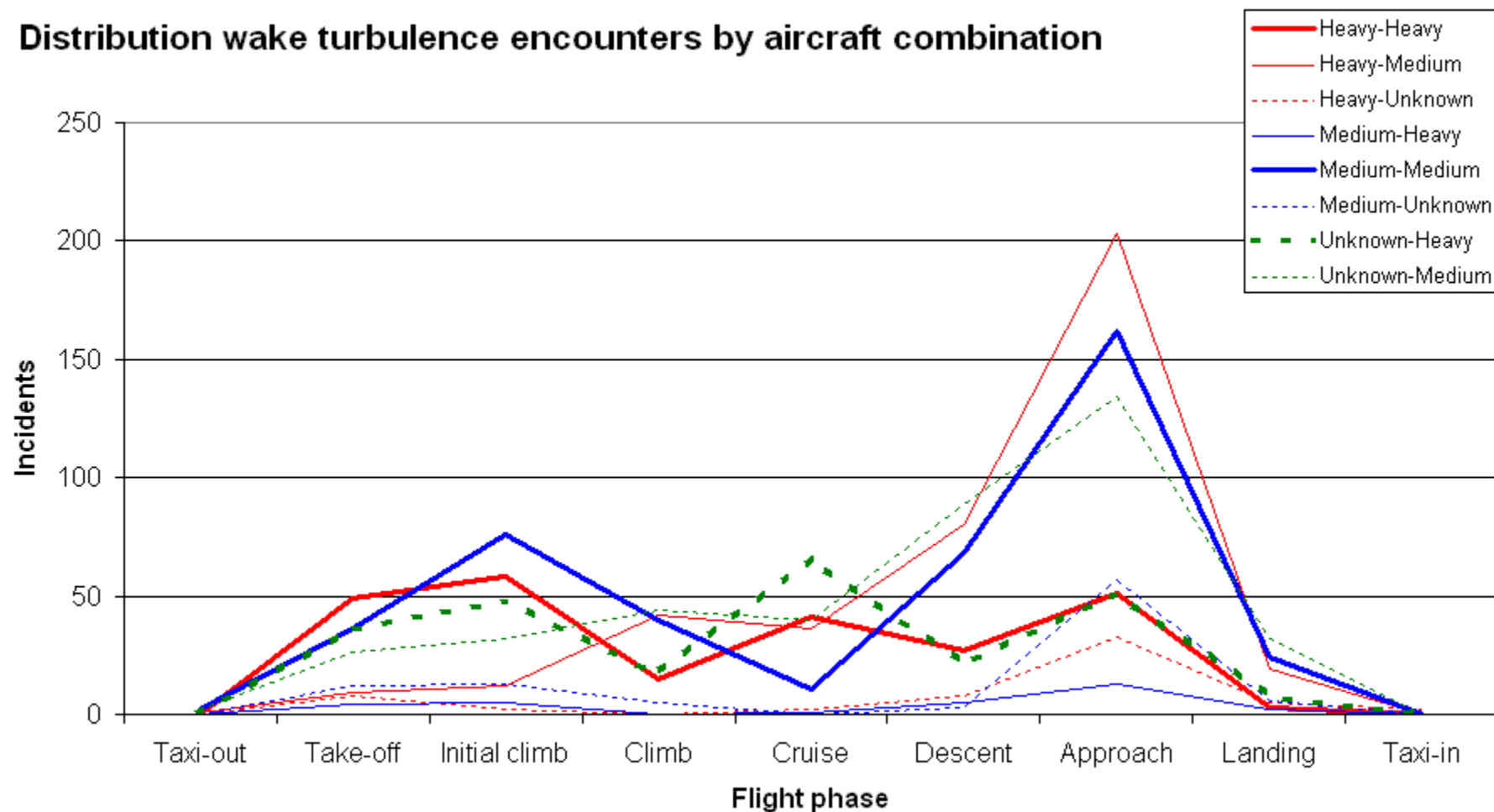
## Results – Aircraft combinations





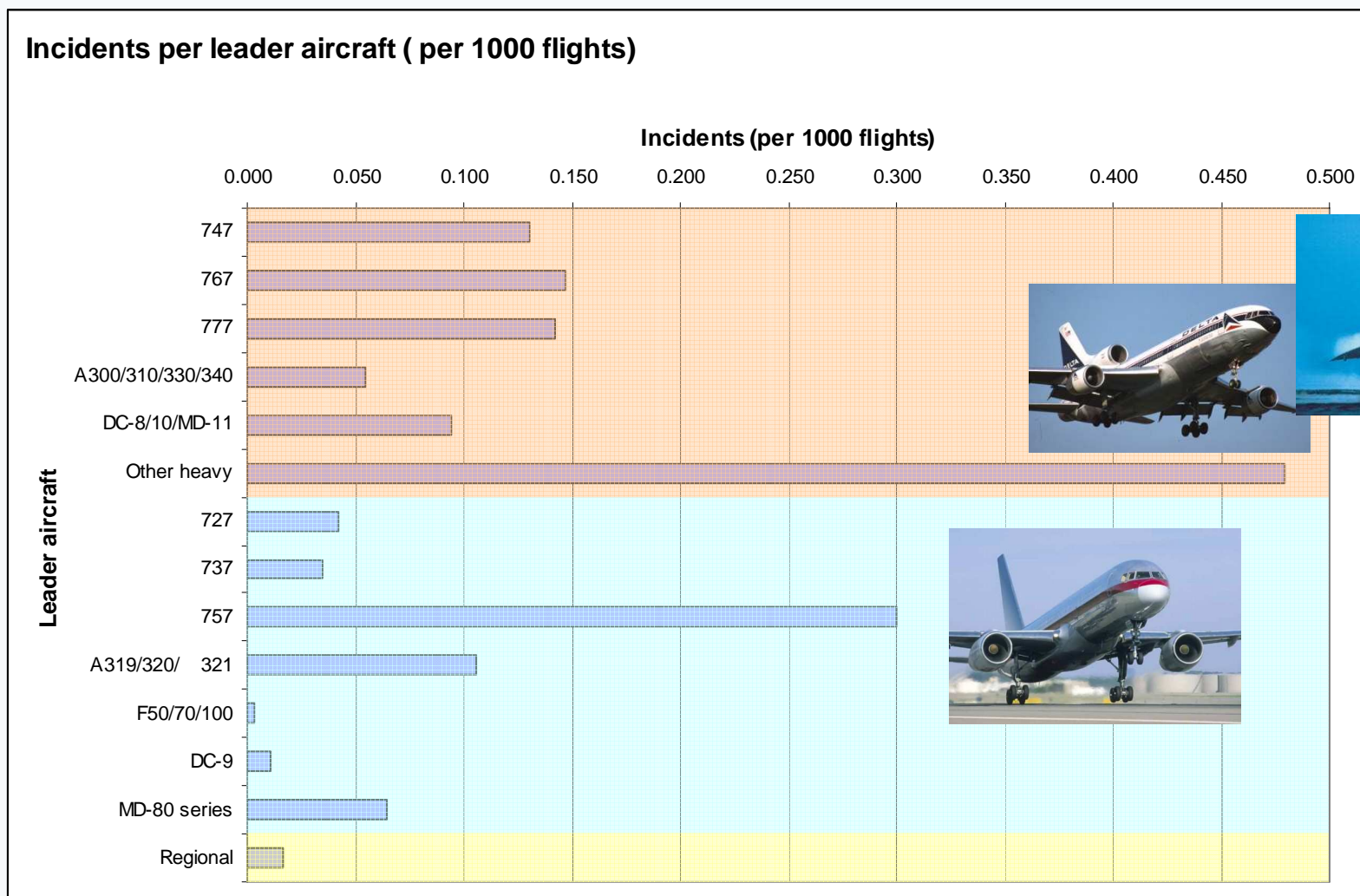
# Results – Incident distribution

**Distribution wake turbulence encounters by aircraft combination**



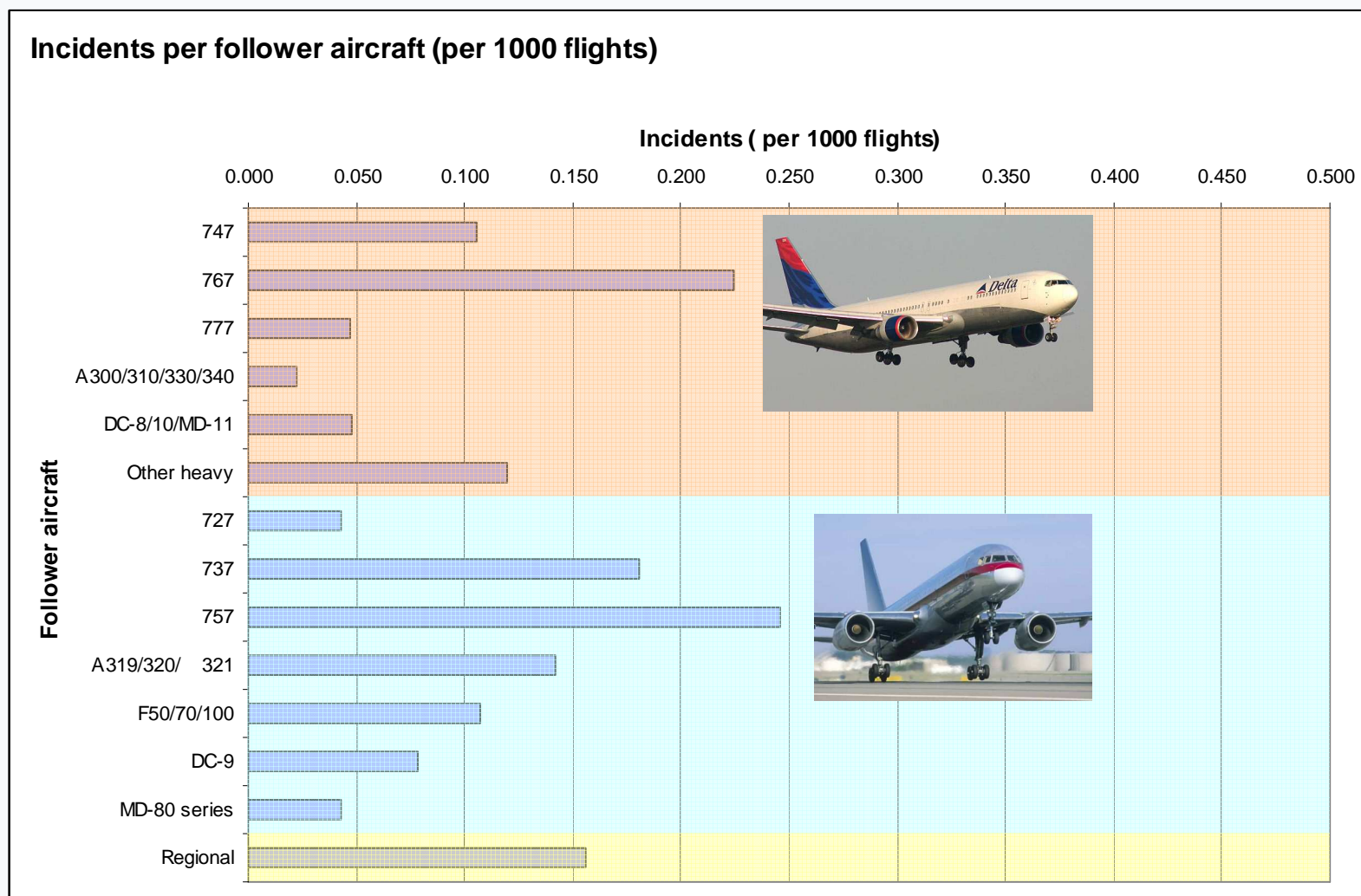


# Results – Incidents per leader aircraft





# Results – Incidents per follower aircraft





# Findings and conclusions

## •Departure:

- Most incidents occur between aircraft of similar wake turbulence category (heavy after heavy & medium after medium);
- Few (4.9%) incidents occur between aircraft with for which wake turbulence separation minima apply (medium after heavy).

## •Climb:

- Most incidents occur between aircraft in different wake turbulence categories (medium after heavy).

## •Cruise:

- Most incidents occur between heavy aircraft.

## •Descent:

- Number of incidents for medium aircraft starts to rise, caused by heavy and medium aircraft.

## •Arrival:

- Number of incidents for medium aircraft peaks, caused by heavy and medium aircraft;
- Still 27.6% of the incidents occur between aircraft combinations for which wake turbulence separation minima apply.

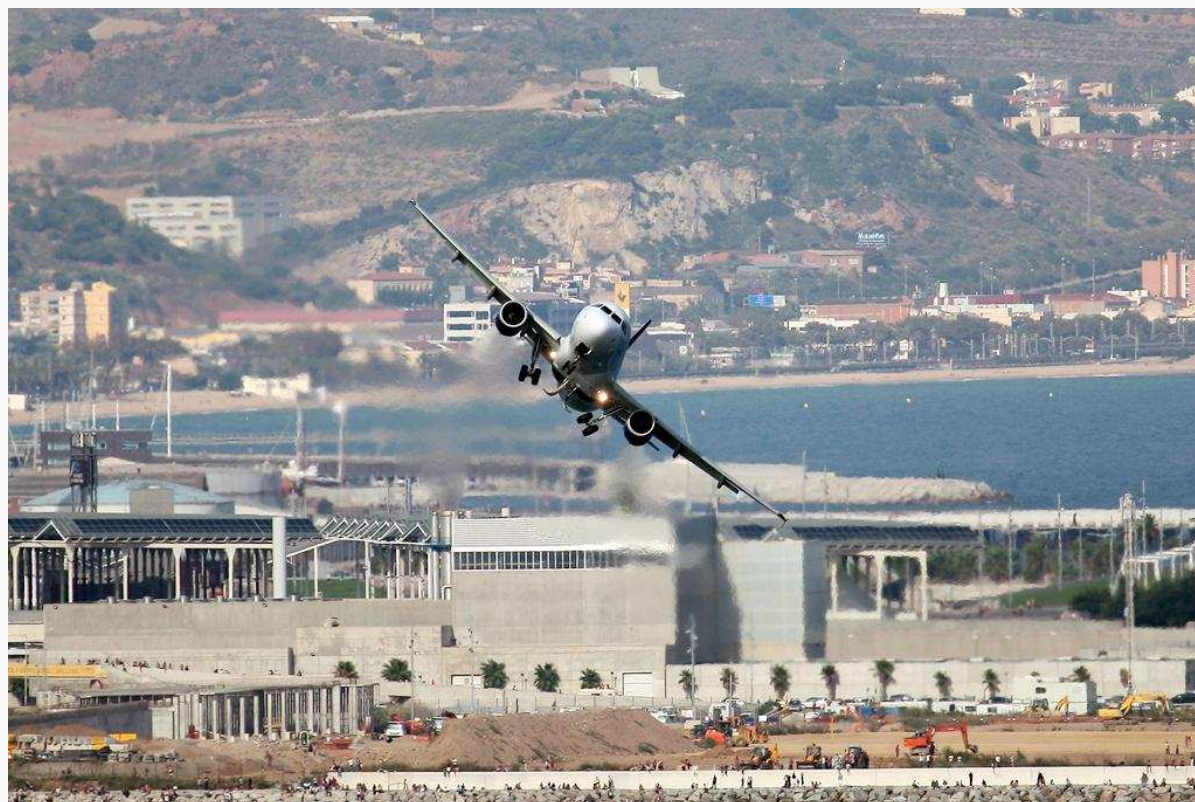




# Findings and conclusions

## ●Recovery by flight crew:

- Aileron input
- Rudder input
- A/P disengage – manual action
- Flying off-track





# Questions?