Preliminary Results from FDR Data Collection Campaign at London Heathrow

Dr. Deborah Rushton

WakeNet EU 2015 Workshop

21st April 2015
Introduction

➢ Time Based Separation (TBS) deployed at London Heathrow on 24th March 2015.

➢ Stabilises time spacings between aircraft on Final Approach across all headwind conditions.

TBS rebalances Wake Turbulence Encounter (WTE) risk across different wind conditions.

➢ Operational monitoring of TBS requires comparison of WTE reporting rate for pre- and post-TBS implementation.
NATS Wake Turbulence Encounter (WTE) Database

› A voluntary WTE reporting scheme.

› Operational conditions resulting in WTE and effect on aircraft.

› Monitor effectiveness of current separation minima and procedures.
Limitations of voluntary reporting scheme

› Relies on pilot’s judgement recognising WTE.

› Relies on pilot cooperation completing reports.

› Expect that the more severe WTEs are reported.

› Subjective nature of reporting:
  – Pilot recall of event.
  – Interpretation of effect on aircraft.

› Missing reports/key information.
London Heathrow FDR data collection campaign

› Flight Data Recorder (FDR) data requested to supplement pilot and ATC WTE reports.

› Used to objectively assess effect of WTE on aircraft.

› Letter requesting FDR data sent to airlines in January 2014.

› FDR data requested for 5 minutes before and after WTE.

› Data must include:
  - Time
  - Altitude
  - Roll angle
  - TAS

› Also useful:
  - Pitch
  - Aircraft mass
  - Autopilot status
  - Captain/First officer corrective roll action
  - Wind vector
  - Latitude/longitude
  - Airline commentary
FDR data received in 2014

> >90 WTEs reported inbound* to Heathrow in 2014.
> WTEs reported by 19 different airlines.
> FDR data received from 14 airlines for 88% of WTEs and 10 aircraft types.
> FDR data usable for 86% of WTEs.
> Pilot reports provided for 72% of WTEs.
> In 4 cases more than one WTE contained in FDR dataset (verified by pilot reports).
> Roll sampling rates:
  4Hz = 68% datasets.
  2Hz = 23% datasets.
  1Hz = 9% datasets.
FDR data received in 2014

Follower Aircraft Types

- A320: 34%
- A319: 27%
- B747: 17%
- B757: 2%
- B737: 2%
- A321: 2%
- B777: 7%
- B767: 8%
- F70: 1%
FDR data received in 2014

Leader Aircraft Types

- B777: 26%
- B767: 8%
- B747: 13%
- B737: 2%
- A319: 10%
- A320: 11%
- A321: 4%
- A330: 5%
- A340: 10%
- A380: 8%
- E190 Unknown: 3%
FDR data received in 2014
WTE detection from FDR data: Two opposite uncommanded rolls

“Wake vortex encounter. Localiser intercepted below glide path. Aircraft banked left, right and left forcefully within a 5 second period with 15 degrees of bank on each occasion.”

- Anon. pilot
WTE detection from FDR data: Two opposite uncommanded rolls

Max. Roll $A_{xx} = -41.22^\circ s^{-2}$
WTE detection from FDR data: Pilot corrective action

"At approx 12nm finals approaching glideslope from below, significant but controllable roll both ways due wake of preceding A319."

- Anon. pilot

Max. Roll $\text{Axx} = 26.68^\circ\text{s}^{-2}$
WTE detection from FDR data – no uncommanded roll

“Approaching the MLS for Rwy 09L, preceding aircraft was 3 miles ahead and 800 feet below when we hit a heavy single bump of wake turbulence.”

- Anon. pilot
WTE detection from FDR data – no uncommanded roll
Reliability of pilot-reported roll data

Variation in pilot-reported and FDR-derived roll

Pilot over-estimation of roll
Selected severity metric

- Metric must be:
  - Meaningful.
  - Easily derived from FDR parameters.
  - Allow direct comparison between follower types.

- **Rolling Moment Coefficient** (RMC) selected.
  - Dimensionless rolling moment-based metric.
  - Accounts for aircraft’s ability to recover from WTE.
  - Rolling moment normalised using aircraft’s TAS, wingspan and wing area.
  - Metric used in RECAT-EU project.
RMC distribution for 2014 DBS operations

![Graph showing RMC distribution with suspect values highlighted.](image-url)
RMC distribution as function of total reported wind band
RMC distribution as function of approach phase
Planned use of FDR data for comparative analysis of DBS vs. TBS operations

- FDR data collection continued into 2015 and following TBS deployment.

- Initial comparison of WTE rates after three months of TBS operations.

- After one year of TBS operations comparison of DBS vs. TBS RMC distributions as function of:
  1. WT category pairs (aircraft type pairs if sufficient data available)
  2. Total wind speed
  3. Altitude/approach phase
  4. TBS vs. DBS distance separation

- Visualise geometries of leader and follower aircraft at encounter.
Conclusions

› FDR data collected and analysed for 2014 inbound Heathrow WTEs.

› Positive response from airlines – FDR data usable for 86% of reported WTEs.

› FDR data provides valuable objective viewpoint about effect of WTE on aircraft.

› Variety of encounter topologies observed.

› RMC calculated as measure of WTE severity.

› Most WTEs have RMC in range 0.01 – 0.04.

› Comparative assessment planned of RMC for DBS and TBS operations in 2016.
Questions?