A380

Presented by

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A380 wake vortex working processes and status

Brussels, 16 September 2008

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Stakeholders and their roles

A380 WV Working Group

- Agrees on methodology
- Airbus performs flight tests
- Analyses test results and steers safety analysis measurements
- Delivers data and analyses to the Steering Group

Test results

A380 WV Steering Group

- Created in 2003
- Provides direction & task perimeter to the WG
- Agrees on recommendations and submits them to ICAO

EUROCONTROL

JAA / EASA

FAA

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Observer

Recommendations

ICAO

- Analyses recommendation
- Issues State Letters to all member states for interim guidance
- Submit changes to current rules (PANS-ATM) to all member states

State Letter, PANS-ATM

Member states aviation authority

- Issue wake vortex separation guidance to local ATM
- ICAO State Letter and PANS-ATM applied , adapted or not applied

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International A380 wake vortex Steering Group

- In place since mid-2003, co-chaired by EUROCONTROL and JAA.
- Involves FAA, EUROCONTROL, JAA/EASA and AIRBUS. ICAO participates as observer.
- Tasks:
  - Select methodologies for evaluation of A380 wake turbulence
  - Make necessary funding and resources available to perform the work
  - Assess A380 wake turbulence in comparison to other aircraft of the Heavy category (to provide a **relative basis** for comparison)
  - Establish recommendation for A380 wake turbulence separation to ICAO. Recommendations are based on a Safety Case and Safety Assessment Report produced by the Working Group, in accordance to EUROCONTROL Safety Regulatory Requirement 4 (ESARR 4).
- **The Working Group** is a group of experts put in place to validate the methodology, perform the work, and report their assessment to the **Steering Group**

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Discussion of analysis methods

- Initial common proposal based on simulation models
  - A combination of FAA and Airbus tools (ASAT and VESA).
  - Working Group determined that level of validation for these tools was insufficient.
- Specific flight tests were finally required
  - Approach, take-off and holding: Lidar flight test measurements were used to establish current separation standards.
  - Cruise: Wake encounters and Lidar allowed to conclude.
  - Approach, take-off: In order to further reduce the separation, Airbus performed wake encounters flight test. Data are currently under review by Working Group
- Flight test requirements and analysis methods agreed upon
  - Specific atmospheric conditions required.
  - Tests to be conducted back-to-back with representative reference aircraft.
  - Choosing the right methods to analyze the data without being over-conservative has proven to be challenging

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A380 wake vortex flight test campaign - overview

- May 2005 – December 2007
- 77 total flights (all aircraft)
- 308 total flight hours
- ***627* ground based LIDAR runs**
- Airborne LIDAR measurements in cruise
- 167 actual wake encounters at cruise
- 874 actual wake encounters during approach
- ***1041* total wake encounters**

This is the *largest campaign ever* conducted to investigate all aspects of the wake vortex characteristics of one specific aircraft

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Approach: back to back LIDAR data collection

B747-400

Spacing > 5 min

A380

In ground effect
260 ft

LIDAR

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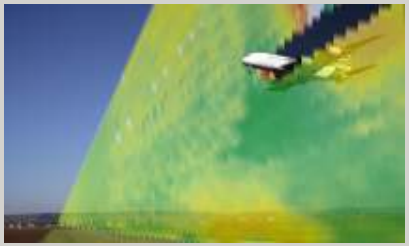
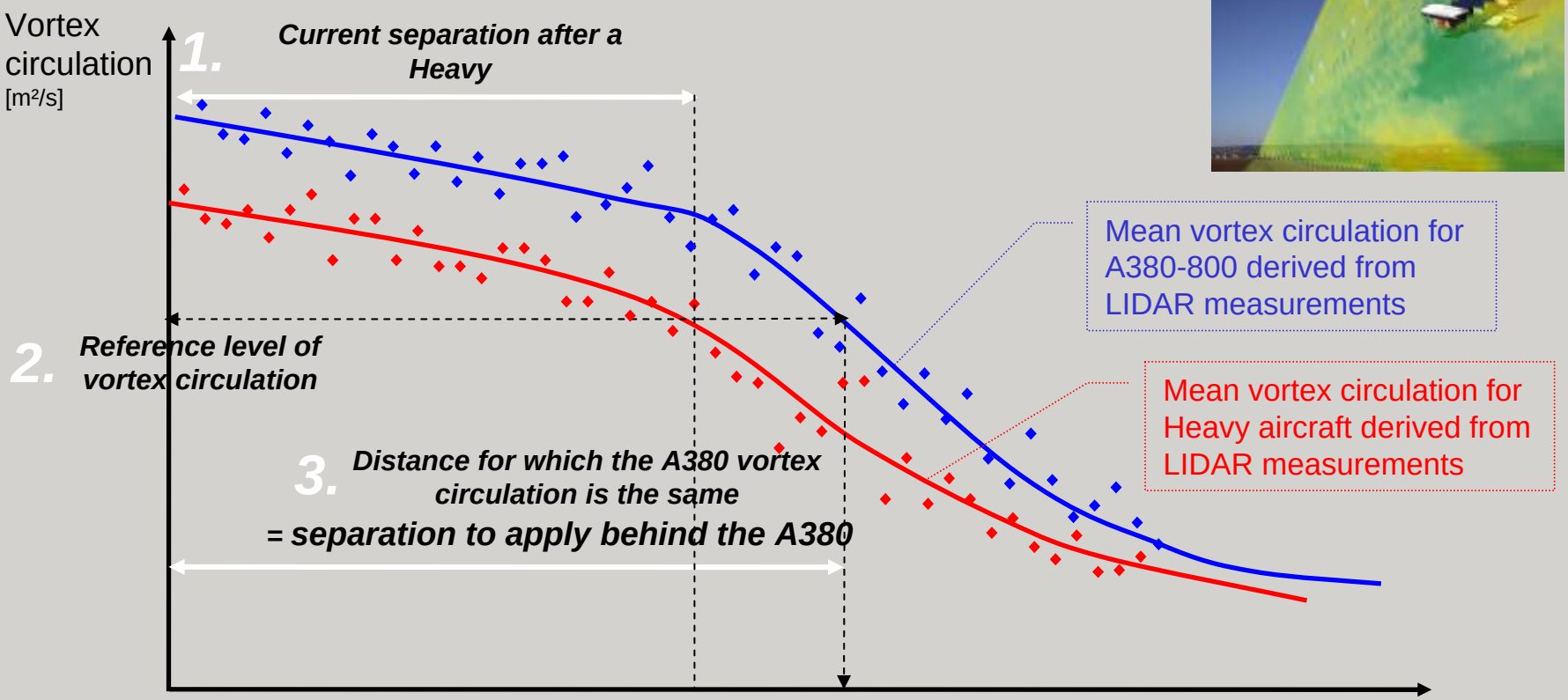
Example of LIDAR data analysis

Comparison of circulation decay curves

Basic assumption: separation for heavy aircraft is today's reference and has proven to be safe





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Comments on Lidar tests

- Numerous back to back runs have been performed at Istres end 2005 with A380, B777 and B747. But, after analysis, the Working Group could not agree to use B747 runs due to the light turbulence which could have hide the worst case. Therefore, for the first ICAO letter, B777 tests were used, which was more penalizing for Airbus due to lighter weight and smaller size of the B777 compared to the B747.
- Some more comparative runs between A380 and B747 were performed later on at Tarbes (some runs have even been eliminated by lack of turbulence due to stratification!).
- Similar back to back runs have been performed to validate take off and holding separations.

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Approach: applicable separations for Heavy aircraft

Heavy following a Heavy	***747: 4 nm***
ICAO State letter Nov 05	***+ 6 nm*** ; ***A380: 10 nm***
ICAO State letter Oct 06	***+ 2 nm*** ; ***A380: 6 nm***
ICAO State Letter July 08	***+ 2 nm*** ; ***A380: 6 nm***
2009	**Potential reduction pending current Working Group analysis of the Airbus wake encounter flight test data**

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Approach: applicable separations for Medium aircraft

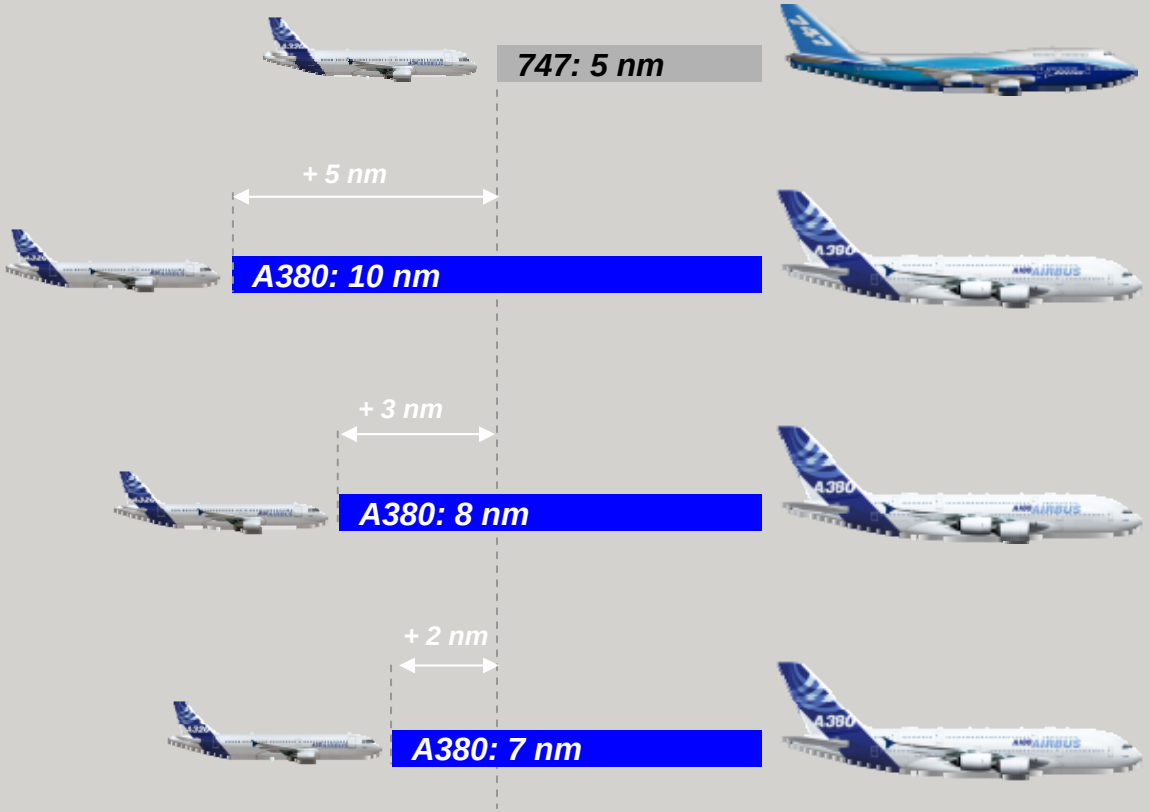
Medium following a Heavy

ICAO State letter Nov 05

ICAO State letter Oct 06

ICAO State letter July 08

2009



Potential reduction pending current Working Group analysis of the Airbus wake encounter flight test data

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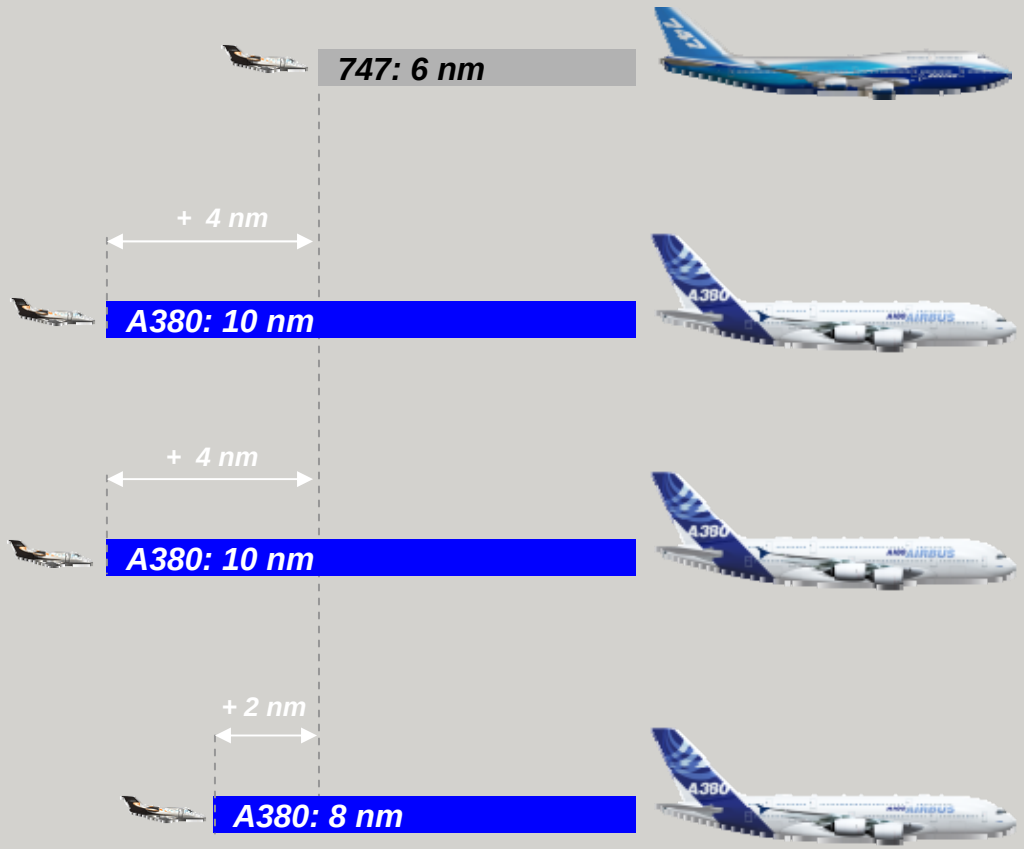
Approach: applicable separations for Light aircraft

Medium following a Heavy

ICAO State letter Nov 05

ICAO State letter Oct 06

ICAO State letter July 08



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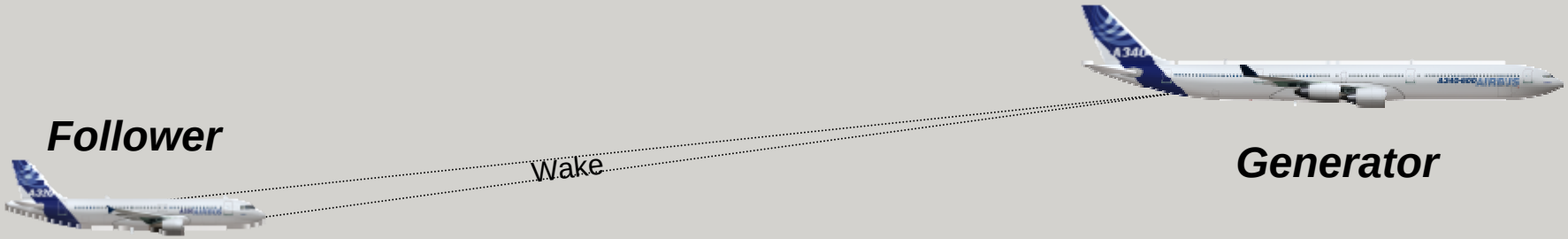
Encounter test principle



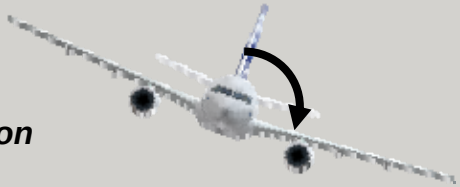
- Encounter test consists of physically flying an aircraft through the wake of another to measure specific parameters.
- The probe aircraft flies encounters alternatively behind A380 and a suitable reference aircraft, with both wake generators flying side by side.
- Many parameters recorded with focus on the following flight parameters:

Altitude loss

Vertical acceleration

Roll rate

Roll acceleration



- <u>Technique used and agreed for cruise</u>, now also proposed by Airbus for further reduction of separations in approach and take off.

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Overview of flight tests performed for cruise

Flight tests to develop the flight test techniques:

C1: 11 JAN 2006: A380, A318 for wake encounters

C2: 23 FEB 2006: A380 and A346 side-by-side, A318 for wake encounters

C3: 07 MAR 2006: A380 and A346 side-by-side, DLR LIDAR on-board Falcon, A346 encounters in trail of A380

C4: 09 MAR 2006: A346, DLR LIDAR on-board Falcon

Comparison evaluation flight tests:

C5: 23 JUN 2006: A380 and A346, A318 for encounters, simultaneously DLR LIDAR on-board Falcon

C6: 25 JUN 2006: A380 and B744, A318 for encounters, simultaneously DLR LIDAR on-board Falcon

Generator aircraft

Follower aircraft

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Encounters flight test procedure in cruise

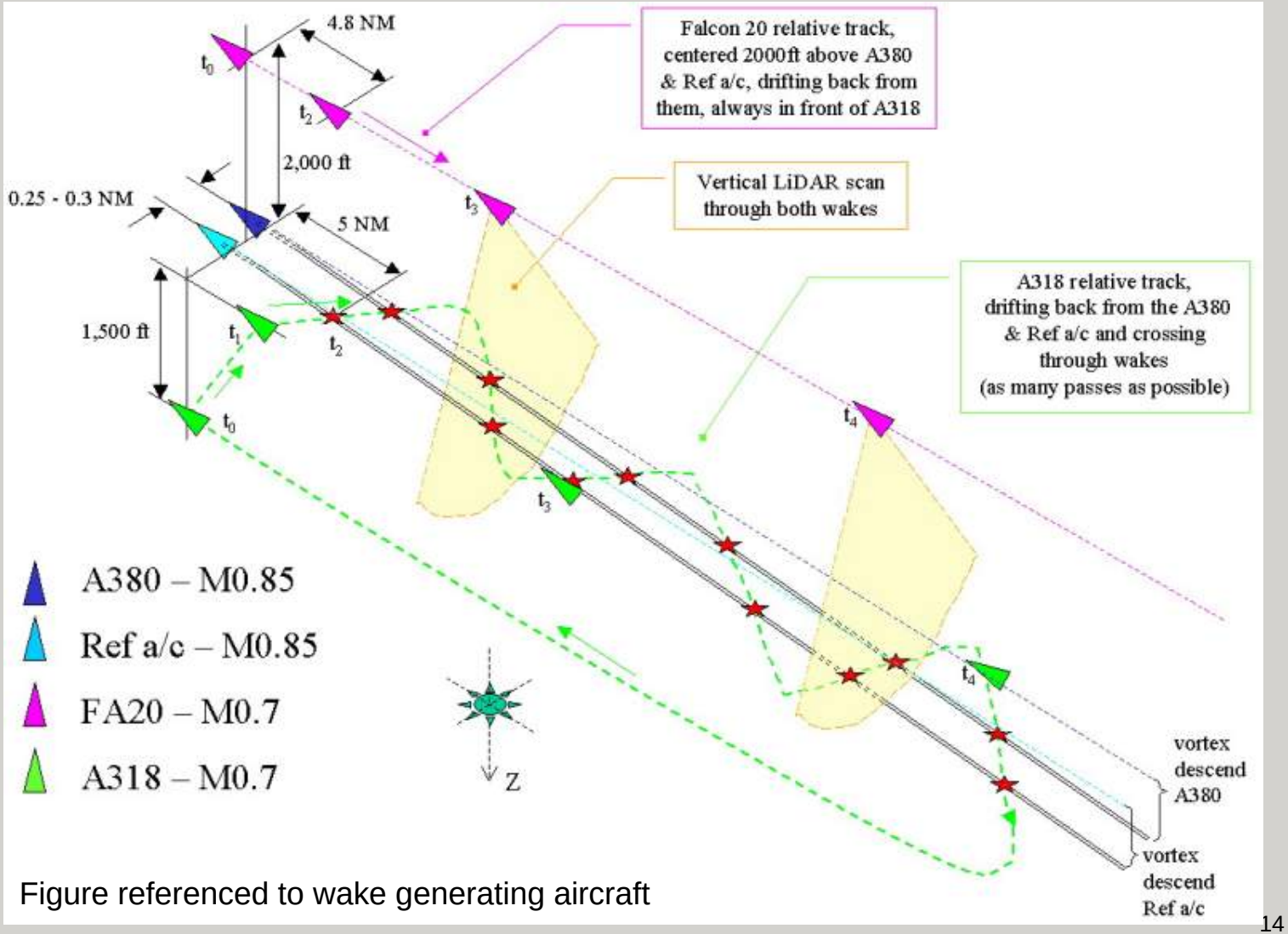

Figure referenced to wake generating aircraft

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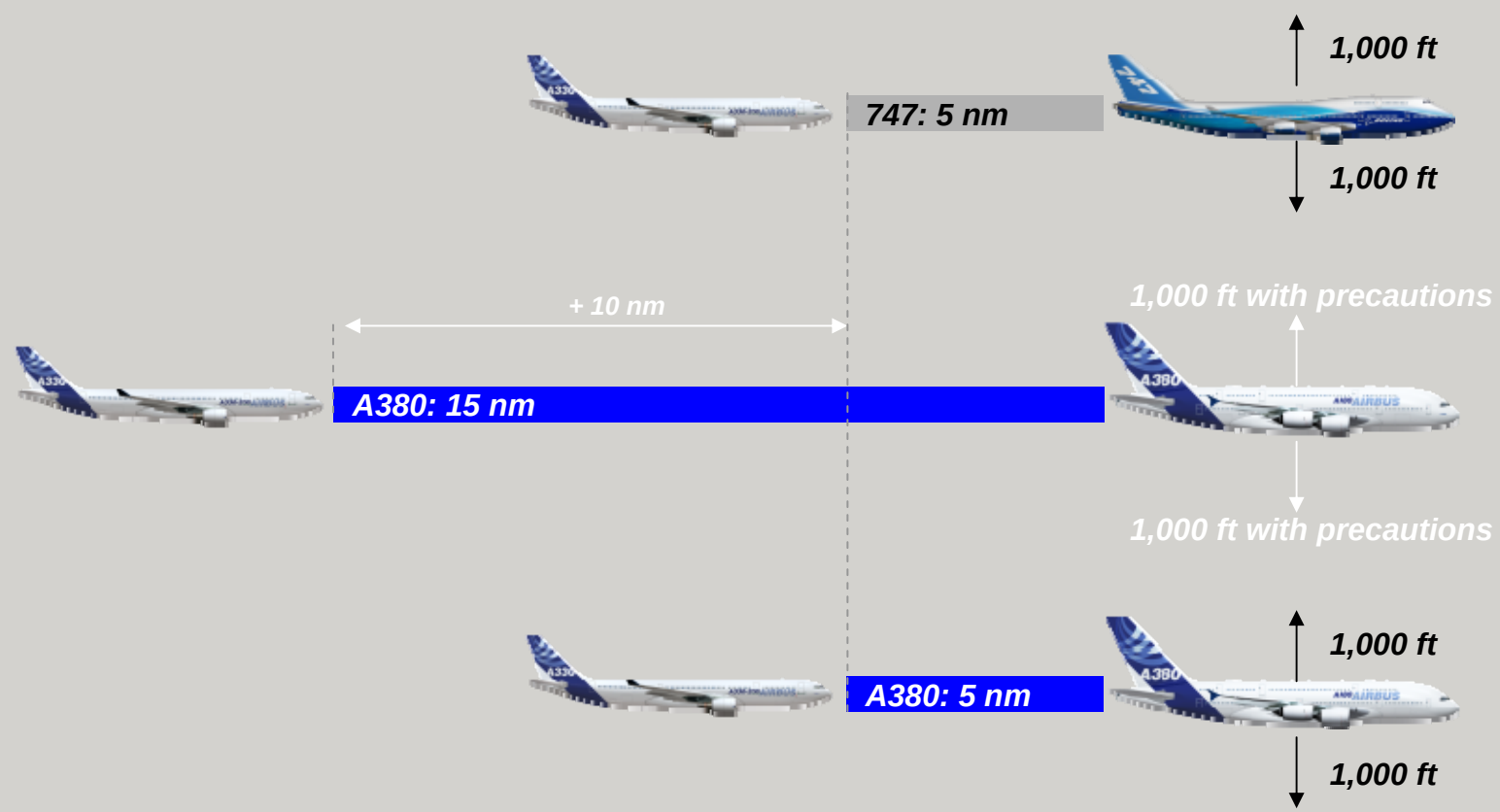
Cruise: applicable separations for all aircraft

Separation apply to all categories aircraft



Work completed. No difference with existing aircraft in cruise
The A380 is fully RVSM capable

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Limitations when using LIDAR data for separation standards

- Vortex circulation was used to provide an indication of the severity of a wake encounter.
- Limitations of this approach: Vortex circulation represents the maximum static rolling moment on a encountering aircraft, assuming the aircraft axis is aligned with the vortex axis and centered in the vortex core
  - This is a theoretical situation
  - Current LIDAR technology has its own specific limitations
- What are the effects of the vortices considering weight, roll inertia, wingspan and roll capability of the follower?

  ⇒This can only be determined by actual encounter testing

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Approach encounter tests

- A380: 14 flights, 53 hours
- A340-600 (reference Heavy aircraft): 5 flights, 21 hours
- A300 (lightest in the Heavy category): 3 flights, 10 hours
- A320 (typical Medium aircraft): 8 flights, 26 hours

In total: 30 flights, 110 flight hours

Including side to side tests:

A320 behind A380 side-to-side with A346

A300B2 behind A380 side-to-side with A346

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Encounters in approach: flight test procedure

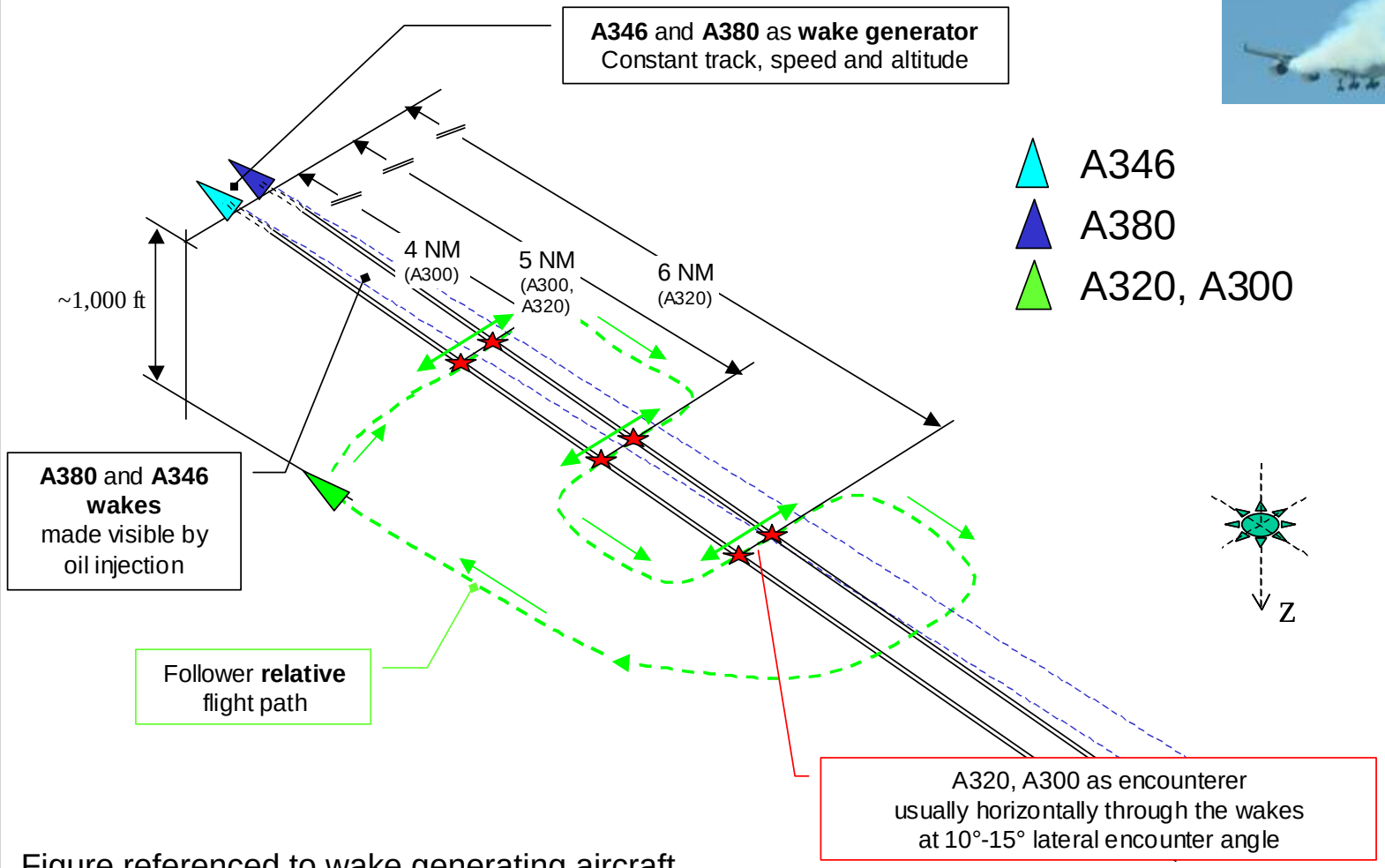

Figure referenced to wake generating aircraft

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Approach: wake encounters flight tests analysis

- Airbus has identified a benefit of using wake encounters in addition to LIDAR measurements to set separation standards for approach and take off.
- The encounter test data have been delivered by Airbus to the A380 wake vortex Working Group.
- Working Group currently assessing feasibility of using the encounters data for a revision of the separation standards.

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A380 wake vortex: status of ICAO recommendations

Time

ICAO recommendations for the A380

A380 tour Asia & Australia — ***Nov 2005***

ICAO interim State Letter *(Ref. 05-0661-EN, November 10th 2005)*
- A380 is a Heavy with Special Conditions
- Very conservative separation requirements
- Not based on data

Oct 2006

ICAO State Letter *(Ref. ES AN 4/44 - 0750, October 9th 2006)*
- Supersedes the previous ICAO State Letter
- Based on 2005/2006 LIDAR data and 2006 cruise tests
- No different separation requirements for A380 than other Heavies in En-Route
- Reduced but still conservative separation requirements in approach and take-off behind A380

A380 Entry Into Service — ***Oct 2007***

Jul 2008

ICAO State Letter *(Ref. TEC/OPS/SEP – 08-0294.SLG, July 8th 2008)*
- Supersedes the previous ICAO State Letter
- Based on 2007 LIDAR data
- Separation requirements in approach and take off behind A380 further reduced but still conservative
- Implementation of Minimum Radar Separation for A380 as follower

Second A380 operator — ***Aug 2008***

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Conclusion

- The A380 wake vortex flight test campaign is an unprecedented effort on this subject.
- Separations in approach behind A380 have already been reduced twice since the first ICAO State Letter, based only on LIDAR data.
- This is the result of the tremendous work performed by the analysis of all the data by the international team of experts of the Working Group: Eurocontrol, JAA/EASA, FAA and Airbus.
- Encounters flight tests have been performed in approach with Heavy and Medium followers and first Airbus analysis indicates that further reductions should be possible with respect to separations from Lidar analysis. The Steering Group has requested a feasibility study which is ongoing within the A380 Working Group to assess the possibility to validate further reduction. Results will be transmitted in the coming weeks to the Steering Group.

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Vielen Dank !
Thank you so much !
Merci beaucoup !
Muchas gracias !