Safety Case for Wake Vortex Encounter Risk due to the Airbus A380-800:

Summary Report

Produced for the A380 Wake Vortex Steering Group
DOCUENT CHANGE RECORD

The following table records the history of the successive editions of this summary report.

<table>
<thead>
<tr>
<th>EDITION NUMBER</th>
<th>EDITION DATE</th>
<th>REASON FOR CHANGE</th>
<th>PAGES AFFECTED</th>
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<tr>
<td>1.0</td>
<td>16 November 2006</td>
<td>Summary report issued to ICAO</td>
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SUMMARY REPORT

Introduction

An ad hoc Steering Group (SG) and a technical Work Group (WG), comprising representatives from the Joint Aviation Authorities (JAA), EUROCONTROL, the Federal Aviation Administration (FAA), Airbus and Det Norske Veritas (DNV), was set up in 2003 to specify scientifically robust safety requirements to ensure Wake Vortex Encounter (WVE) risk from the Airbus A380 will be acceptable. A safety case (A380 SG, 2006a) and supporting documentation has been produced. This report presents a summary of the objectives, scope and results of this work.

Objectives and Application

The objectives of the safety case were as follows:

- To define and justify the safety requirements for the Airbus A380-800 (A388) wake vortex generator aircraft in all phases of flight, for all categories of potential wake vortex encountering aircraft, and for all operational conditions worldwide. The defined safety requirements are those that are necessary in order to ensure that WVE risk due to the A388 is acceptably low. The safety requirements are specified as two sets of WVE separation criteria and two supporting general safety requirements.
- To define and document the basis of the safety requirements.
- To note key assumptions, uncertainties and exceptions.

The overall aim of the safety case was to show, through argument and evidence, that A388 operations will be acceptably safe in principle with respect to WVE risk for all operational conditions (assuming the defined safety requirements are completely implemented), whilst noting any explicit exceptions.
The guiding principle applied in the safety case was to set the minimum separation criteria for the A388 that can be clearly justified by evidence or data, consistent with the requirement of safety regulators that an appropriate level of conservatism is included in system changes during early operations. The starting point for all the safety criteria was the ICAO Interim Guidance (“Wake Vortex Aspects of A380 Aircraft”, ICAO, 2005a), which was based on initial work performed under the authority of the A380 Wake Vortex Steering Group. Where lower separation criteria could be agreed and justified, these were specified in the safety case.

It is anticipated that all the safety requirements, and in particular the separation criteria for approach and departure, will be re-evaluated after 1 year, and again after 3 years, of entry into service of the A388 when sufficient operational wake vortex monitoring results, or other data, are available.

It is emphasised that WVE risk is not the only factor that determines operational aircraft separations. Responsible parties (typically Air Traffic Service Providers that will implement the safety requirements specified in the safety case) need to assess all other relevant factors (for example, runway occupancy times, etc.) as well as the safety requirements defined in the safety case when determining how to adjust their operational procedures to include the A388.

**Scope**

The scope of the WVE risk safety case for the A388 is defined as follows:

- **Generator aircraft.** The safety case applies to passenger and freighter Airbus A380-800 (A388) aircraft with a Maximum certified Take-Off Mass (MTOM, sometimes called maximum take-off weight (MTOW)) of up to 590,000kg and wing-span of 79.8m.
- **Phases of flight.** The safety case is valid for all phases of flight.
- **Encountering aircraft.** The safety case is valid for all categories of encountering aircraft.
- **All conditions worldwide.** The safety case is valid for all weather conditions that may be encountered in any location worldwide.

The strategy for ensuring ATM safety is based on 3 high-level principles:

- Ensuring that airspace design is acceptably safe.
- Ensuring that ATM procedures are acceptably safe.
- Ensuring separation criteria, such as the separation criteria specified in the safety case to ensure WVE risk is acceptable, are acceptably safe.

The scope of the safety case is confined to specifying modifications to a sub-set of the currently defined separations (the third principle above).

This has two important consequences:

- If the current ICAO PANS-ATM WVE separation criteria (ICAO, 2005b) can be applied in a location without modification then the separation criteria for the A388 specified in the safety case can also be applied without modification.
- Responsible parties must assess if the separation criteria recommended in this summary report are consistent with their local airspace design and ATM procedures. The A380 Wake Vortex Steering Group cannot, and has not, performed a comprehensive
evaluation of if the separation criteria defined in the safety case are consistent with all possible local airspace designs or ATM procedures.

This definition of the scope of the safety case supports the global applicability of the safety requirements derived in the safety case.

**Safety Requirements**

The safety requirements stated below and developed in the safety case are considered by the A380 Wake Vortex Steering Group to be mandatory in order to ensure that the operation of the A388 will be acceptably safe in practice with respect to WVE risk.

**General Safety Requirements**

1. WVE reporting, analysis of reports and international dissemination of WVE experience data are required consistent with safety management system principles adopted by ICAO (ICAO Annex 11, 2.26 with guidance contained in the “Safety Management Manual”, Doc 9859; ICAO, 2006a). This safety requirement has 5 component parts:

   a) Responsible parties (normally Air Traffic Service Providers) are required to implement a WVE reporting system for all encountering aircraft, all phases of flight and for all generator aircraft.
   b) Responsible parties are required to review and investigate the WVE reports collected locally.
   c) Responsible parties are required to identify and implement any corrective actions which may be identified as necessary following local review of WVE reports.
   d) Responsible parties are required to send all WVE reports to ICAO’s Air Navigation Bureau so that isolated incidents observed locally may be reviewed to determine if they are indicators of a general safety issue. Responsible parties are required to also notify ICAO of any local corrective actions issued.
   e) ICAO is responsible for ensuring regular review of all WVE reports and local corrective actions and for disseminating any corrective actions that may be identified by that review.

The overall objective of this safety requirement is to ensure that any unsafe incidents are identified before an accident occurs so that corrective action is applied internationally to prevent the cause(s) of the incident from re-occurring. It is essential that this requirement should be implemented without delay.

2. Responsible parties must assess if the separation criteria recommended in this summary report are consistent with their local airspace design and ATM procedures. If they are not consistent then the responsible party must perform an appropriate safety assessment.
3. The minimum required radar separations for approach for the A388 are specified in Table 1 together with the current ICAO PANS-ATM radar separations for existing aircraft categories (shaded).

### Table 1 Radar Wake Turbulence Separation Criteria for Approach
(Nautical Miles (NM), current ICAO criteria are shown shaded)

<table>
<thead>
<tr>
<th></th>
<th>A388 Encounterer</th>
<th>Heavy Encounterer</th>
<th>Medium Encounterer</th>
<th>Light Encounterer</th>
</tr>
</thead>
<tbody>
<tr>
<td>A388 Generator</td>
<td>Not required a b c</td>
<td>6NM</td>
<td>8NM</td>
<td>10NM</td>
</tr>
<tr>
<td>Heavy Generator</td>
<td>Not required b c</td>
<td>4NM</td>
<td>5NM</td>
<td>6NM</td>
</tr>
<tr>
<td>Medium Generator</td>
<td>Not required c</td>
<td>Not required</td>
<td>Not required</td>
<td>5NM</td>
</tr>
<tr>
<td>Light Generator</td>
<td>Not required c</td>
<td>Not required</td>
<td>Not required</td>
<td>Not required</td>
</tr>
</tbody>
</table>

Notes:
- a Not required = when a wake turbulence restriction is not required then separation reverts to a Minimum Radar Separation as prescribed by the appropriate Air Traffic Services authority.
- b A wake constraint is not required by the safety case. However 4NM has been specified by ICAO (“Wake turbulence aspects of Airbus A380-800 aircraft”, ICAO 2006b) pending possible amendment to the PANS-ATM.
- c When the A388 is the encounterer the requirement is stated as “Not required”. WVE risk has been evaluated down to a minimum distance of 2.0NM and it has been determined that an additional WV separation is not required down to this minimum distance.

The justification of these safety requirements is provided in the safety case.

### Cruise Safety Requirements

4. The work that supports the safety case has shown that the WVE risk that results from an A388 generator aircraft in cruise is not noticeably different from those WVE risk levels that result from existing Heavy aircraft. Therefore, the currently specified vertical or horizontal separation criteria, as prescribed by the ICAO Procedures for Air Navigation Services — Air Traffic Management (PANS-ATM, Doc 4444; ICAO, 2005b), are applicable to the A388.

Furthermore the work that supports the safety case has shown that the current PANS-ATM vertical separations currently applied to all aircraft can also be applied in relation to the A388 generator aircraft in all phases of flight without modification. This is based on measurements of the A388 performed at cruise speeds (Mach 0.85) and at typical holding/terminal control area speeds (250knots).
Departure Safety Requirements

ICAO PANS-ATM (ICAO, 2005b) specifies minimum WVE departure separations in terms of time-based and radar separations. The time-based separations are applied on and near the runway(s) in conjunction with take-off and approach as per PANS-ATM 5.8. The radar separations are applied to aircraft in the approach and departure phases of flight as per PANS-ATM 8.7.4.4.

5. The required minimum time-based separations for departure for the A388 are specified in Table 2 together with the current ICAO time-based separations for existing aircraft categories (shaded).

Table 2  Time-Based WVE Separation Criteria for Departure
(seconds, current ICAO criteria are shown shaded)

<table>
<thead>
<tr>
<th>A388 Encounterer</th>
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<th>Medium Encounterer</th>
<th>Light Encounterer</th>
</tr>
</thead>
<tbody>
<tr>
<td>A388 Generator</td>
<td>Not required</td>
<td>120s</td>
<td>180s</td>
</tr>
<tr>
<td>Heavy Generator</td>
<td>Not required</td>
<td>Not required</td>
<td>120s</td>
</tr>
<tr>
<td>Medium Generator</td>
<td>Not required</td>
<td>Not required</td>
<td>Not required</td>
</tr>
<tr>
<td>Light Generator</td>
<td>Not required</td>
<td>Not required</td>
<td>Not required</td>
</tr>
</tbody>
</table>

6. The required minimum radar separations for departure for the A388 are specified in Table 3 together with the current ICAO radar separations for existing aircraft categories (shaded). Consistent with radar separations specified by ICAO today, Table 3 is identical to Table 1.

Table 3  Radar WVE Separation Criteria for Departure
(Nautical Miles (NM), current ICAO criteria are shown shaded)

<table>
<thead>
<tr>
<th>A388 Encounterer</th>
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c When the A388 is the encounterer the requirement is stated as “Not required”. WVE risk has been evaluated down to a minimum distance of 2.0NM and it has been determined that an additional distance is not required.
Safety Recommendations

The above safety requirements specify what is necessary and sufficient to achieve an acceptable level of WVE risk.

However, during the performance of this work, a number of items of best practice to further reduce WVE risk have also been noted. These are recorded in the safety case as general safety recommendations, since no A388-specific safety recommendations were identified. Safety recommendations are not mandatory in the safety case.

An important general recommendation is that the performance of this work has identified some opportunities to improve operations as conducted today. It is strongly recommended that the technical evaluation of WVE risk, begun in the safety case, is continued in order to:

- Develop a scientifically transparent and logically rigorous set of WVE risk separation criteria for all current aircraft.
- Further review the current (WVE) separation criteria as applied today and to correct any anomalies identified.
- More straightforwardly introduce new aircraft into the commercial fleet.

In particular, there is general agreement within the A380 Wake Vortex Steering Group that the current ICAO Medium wake turbulence category is too broad to provide a good balance between safety and capacity.

The following specific safety recommendations were made.

General Safety Recommendations

1. Educational material that describes WV behaviours should be updated to reflect the current understanding of wake vortex behaviour. This should include reference to issues such as: WV descent distance; variable approach speeds; and visual approaches.

2. Good situational awareness of pilots and controllers may be enhanced by amending operational procedures to stipulate that initial communication (telephone and radio) concerning heavy aircraft (current Heavy and the A388) should use either the word “HEAVY” (for Heavy aircraft) or the word “SUPER” (for the A388); this recommendation is identical to the revised ICAO interim guidance (ICAO, 2006b).

3. The revised interim guidance (ICAO, 2006b) specifies the use of the expression “SUPER” in initial radiotelephony contacts with the A388 (equivalent to “HEAVY” for contact with Heavy aircraft). It is recommended that the word “SUPER” should be reconsidered.
Cruise Safety Recommendations

The distances, descents and times stated below in recommendation 4 are all approximate.

4. Measurements of WV descent indicate that during the cruise WVs from B744, A346 and A388 aircraft can descend more than 1000 feet; other Heavy aircraft are expected to have similar WV characteristics. WVE frequency is probably highest, but still low in absolute terms, for aircraft flying counter-flow parallel tracks vertically separated by 1000 feet, compared to all other encounter geometries. At cruise speeds measurements indicate that the vortex trajectory crosses the flight level 1000 feet below the generator aircraft at about 10 to 20NM behind the generator aircraft in calm atmospheric conditions. Lighter aircraft should be aware of possible encounters for up to 20NM behind (horizontal longitudinal) and 1000 feet below a Heavy or A388 generator aircraft, especially when the aircraft are flying close to parallel tracks (see also Recommendation 5). Based on current separation criteria, WVE risk is considered to be acceptable at this time; however it is recommended that this issue is investigated further.

Cruise, Climb and Descent Safety Recommendations

5. There are some WVE incident reports that indicate that current operational aircraft can generate moderate to severe WVEs for an encountering aircraft during climb or descent. Such encounters have very low probabilities, but controllers and pilots should be aware that if they occur then the encountering aircraft may experience significant accelerations. These reports are consistent with the limited cruise flight test measurements involving A388, B744 and A346 generator aircraft, and with the intentional encounters that were flown with an A318.

Though this is not an A388 specific issue, and it is beyond the scope of this group, the Work Group strongly recommends review, as a matter of urgency, of spacing for non-Heavy encounterers that climb or descend behind all Heavy aircraft generators (including the A388).

References


ICAO, 2005a Wake Vortex aspects of Airbus A380 aircraft, ICAO Interim Guidance, 10 November 2005, T13/3-05-0661.SLG, issued from all ICAO Regional Offices.


ICAO, 2006b Wake turbulence aspects of Airbus A380-800 aircraft, revised ICAO interim guidance, 9 October 2006, ES AN 4/44 – 0750, issued from all ICAO Regional Offices.