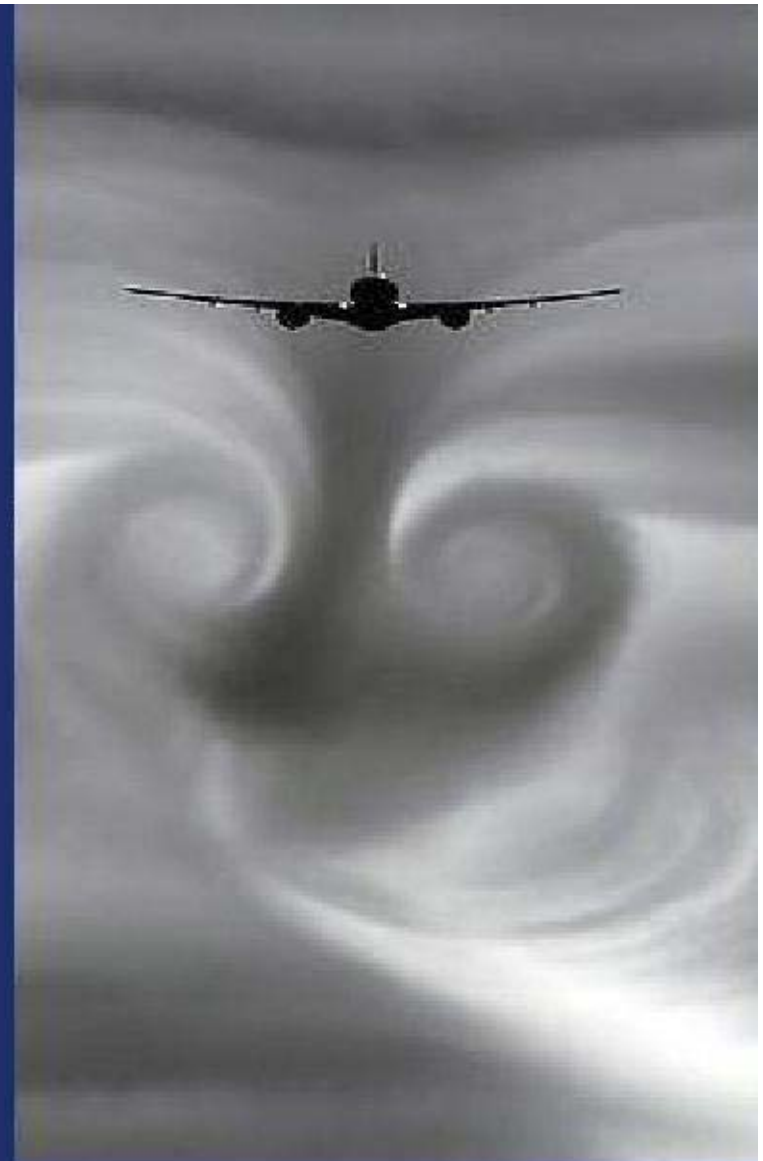


**Project Status:
Characterizing Wake Vortex
Encounters for Hazard Analysis /
Safety Management System
Purposes**

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**Federal Aviation
Administration**

Outline

- I. Questions
- II. Purpose & Intent
- III. Initial Focus
- IV. Methodology
- V. Status & Next Steps



Questions

1. How should we take potential wake vortex encounters (WVEs) into account in lateral route and approach/departure separation safety analyses?
2. What is the frequency of WVEs?
3. Does it make sense to speak of acceptable versus unacceptable WVEs?



Purpose

- Develop a wake hazard severity matrix that conforms to SMS severity and likelihood practices
- Develop standards for determining acceptability of wake vortex encounters from a pilot's perspective
- Develop metric(s) to evaluate WVEs in terms of hazard severity and acceptability



Initial Focus

- IFR application of standards, therefore IFR conditions

- Terminal Area on approach
 - Highest likelihood
 - Potentially significant outcome (closer to ground)
 - Approach flight paths testable
 - Similar to A380 and B747-8 efforts



Methodology

- Identify Acceptable / Non-acceptable WVE and . . .
- Develop Hazard Severity Matrix from simulator tests
- Select parameters and quantify them
- Develop metric(s)
- Screen FOQA data and . . .
- Evaluate / verify severity linkages with frequency
- Validate metric and severity matrix
- Adequately document for SMS



WVE Simulator Tests

- Current and qualified 737-800 and 330-200 pilots
- Full motion flight simulators
- CAMI HF assistance with HITL questionnaires
- Wake scenarios embedded in simulations for other testing purposes so learning effects are minimized
- Manual and AP Control
- Test control of wake circulation, core radius, encounter geometry Eberle



Risk Tables

(FAA Safety Management System Manual, Version 1.0, July 24, 2003)

Table A3 Risk Matrix

	No Safety Effect	Minor	Major	Hazardous	Catastrophic
Probable	Low	Medium	High Unacceptable	High Unacceptable	High Unacceptable
Remote	Low	Low	Medium	High Unacceptable	High Unacceptable
Extremely Remote	Low	Low	Low	Medium	High Unacceptable
Extremely Improbable	Low	Low	Low	Low	Medium



Risk Tables

(FAA Safety Management System Manual, Version 1.0, July 24, 2003)

Table A2 Probability Definitions (Qualitative and Quantitative)

	Quantitative	Qualitative	
		Individual or Local Operation/Item/Procedure	ATC Service/ NAS-level
Probable	Probability of occurrence per operational hour is equal to or greater than 1×10^{-5}	Expected to occur frequently	Continuously experienced
Remote	Probability of occurrence per operational hour is less than or equal to 1×10^{-5} but greater than 1×10^{-7}	Expected to occur several times in life of item	Expected to occur frequently
Extremely Remote	Probability of occurrence per operational hour is less than or equal to 1×10^{-7} but greater than 1×10^{-9}	Unlikely to occur, but possible	Expected to occur several times in system life
Extremely Improbable	Probability of occurrence per operational hour is equal to or less than 1×10^{-9}	So unlikely that it can be assumed that it will not occur	Unlikely to occur, but possible



Risk Tables

(FAA Safety Management System Manual, Version 1.0, July 24, 2003)

Table A1 Severity Definitions Based on the Perspective of the Flying Public

No Safety Effect	Minor	Major	Hazardous	Catastrophic
<p>No effect on flight crew.</p> <p>Has no effect on safety.</p> <p>Inconvenience</p>	<p>Slight increase in workload such as flight plan changes.</p> <p>Slight reduction in safety margin or functional capabilities.</p> <p>Minor illness, Environmental damage, or system damage.</p> <p>Some physical discomfort to occupants of aircraft (except operators).</p>	<p>Significant increase in flight crew workload.</p> <p>Significant reduction in safety margin or functional capability.</p> <p>Major illness, injury, Environmental damage, or system damage.</p> <p>Physical distress to occupants of aircraft (except flight crew) including injuries.</p>	<p>Large reduction in safety margin or functional capability.</p> <p>Serious or fatal injury to small number of persons (other than flight crew).</p> <p>Physical distress/ Excessive workload such that flight crew cannot be relied upon to perform required tasks accurately or completely.</p>	<p>Outcome would result in:</p> <ul style="list-style-type: none"> - Hull loss - Multiple fatalities - Fatal injury or incapacitation



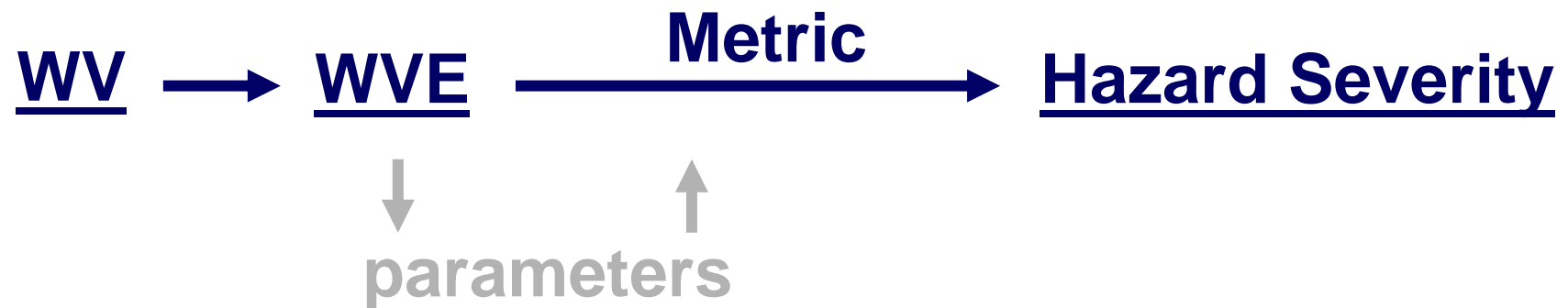
Select and Quantify Parameters

- Roll, Pitch, Yaw
 - Max Angle / Rate / Acceleration
- Level of clarity / refinement required
 - Will 1 DOF, 3 DOF work?
- Use a combination of parameters or forces other than normal?



Develop Metrics

Metric: A rule that takes the state of a system as input and produces a value -- so as to decrease uncertainty about the system.



Screen FOQA Data & Compare Frequencies

- Continue to collect FOQA data
- Develop screening tool
- Use severity metric to measure hazard category frequency
- Compare empirical frequency with hazard likelihood matrix
- Validate and refine matrix categories
- Scale and validate scaling



Status & Next Steps

→ Hazard Severity Matrix

- 4th Draft
- Not final

→ Parameters and Metrics

- Nothing to report

→ Data Collection

- Focusing on encounter at breakout (DA / DH)
- Using data from previous tests to refine test plans
- Organizing FOQA data collection effort
- Initial data from planned tests starting 7 June, 2010
- 2 Year effort



Observable Results	WVE Severity Definitions [(final approach phase), (1000-200 ft AGL, HAT)]				
	No Safety Effect	Minor (light)	Major (moderate)	Hazardous (severe/extreme)	Catastrophic
Aircraft Attitude Changes	<ul style="list-style-type: none"> • Negligible 	<ul style="list-style-type: none"> • Within normal company policy guidelines (15 AOB average) • Minor pitch / yaw deviations 	<ul style="list-style-type: none"> • Within stabilized approach parameters: • 30 degrees max bank angle • Significant pitch / yaw deviations 	<ul style="list-style-type: none"> • TBD – Simulator • (Exceeds aircraft upset parameters: aob 45, pitch up 25, pitch down 10 ???) 	<ul style="list-style-type: none"> • Out of controlled flight • Exceeds aircraft operating limitations
Aircraft Altitude Deviation / Rate of Descent	<ul style="list-style-type: none"> • Negligible 	<ul style="list-style-type: none"> • Minor altitude deviations (+ or – 300 feet) • Maximum RoD – 300 fpm 	<ul style="list-style-type: none"> • Within stabilized approach parameters: • Maximum 1000 fpm rate of descent 	<ul style="list-style-type: none"> • TBD – Simulator • (Exceeds stabilized approach parameters: Sustained rate of descent greater than 1000 fpm ???) 	<ul style="list-style-type: none"> • Ground impact imminent
Approach Path Deviation	<ul style="list-style-type: none"> • Normal bracketing corrections 	<ul style="list-style-type: none"> • Within IAP limits • Needle deflection within normal limits (one dot deviation) • LNAV or VNAV 	<ul style="list-style-type: none"> • Significant flight path deviation • Less than (<) full scale deflection • LNAV or VNAV 	<ul style="list-style-type: none"> • Greater than (>) full scale deflection • LNAV or VNAV 	<ul style="list-style-type: none"> • Obstacle clearance violation • Collision imminent
Missed Approach	<ul style="list-style-type: none"> • No 	<ul style="list-style-type: none"> • No 	<ul style="list-style-type: none"> • Likely 	<ul style="list-style-type: none"> • Mandatory 	<ul style="list-style-type: none"> • N/A



Observable Results	WVE Severity Definitions [(final approach phase), (1000-200 ft AGL, HAT)] (cont.)				
	No Safety Effect	Minor (light)	Major (moderate)	Hazardous (severe/extreme)	Catastrophic
Flight Crew Reaction / Aircraft Control	<ul style="list-style-type: none"> Minimal No loss of control 	<ul style="list-style-type: none"> Slight increase in workload Slight un-commanded motion 	<ul style="list-style-type: none"> Significant increase in workload Significant un-commanded motion 	<ul style="list-style-type: none"> Recoverable Aircraft momentarily out of control 	<ul style="list-style-type: none"> Unrecoverable Total loss of aircraft control
ASRS Report	<ul style="list-style-type: none"> None 	<ul style="list-style-type: none"> Not Likely 	<ul style="list-style-type: none"> Likely 	<ul style="list-style-type: none"> Mandatory 	<ul style="list-style-type: none"> N/A
Effect on Passengers	<ul style="list-style-type: none"> None 	<ul style="list-style-type: none"> Minimal 	<ul style="list-style-type: none"> Potential injuries to unsecured passengers 	<ul style="list-style-type: none"> Potential major injuries Potential fatalities 	<ul style="list-style-type: none"> Hull loss Multiple fatalities
WVE Distinguishable from Atmospheric Anomalies	<ul style="list-style-type: none"> No 	<ul style="list-style-type: none"> Possible 	<ul style="list-style-type: none"> Most likely 	<ul style="list-style-type: none"> Yes 	<ul style="list-style-type: none"> Yes

Current State

- ➔ No established, acceptable wake vortex encounter tolerance criteria

- ➔ Consistently arises as an issue:
 - Re-Cat, NLA, Introduction of new Operations and Procedures
 - WVE Census

- ➔ Such safety criteria are essential to:
 - Safety Management System requirements
 - Absolute Safety Cases to support changes
 - Implementation of NextGen initiatives

