NASA Langley Research Center Wake Vortex Research Supporting VAMS

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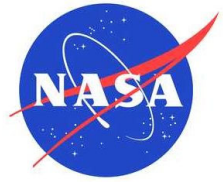
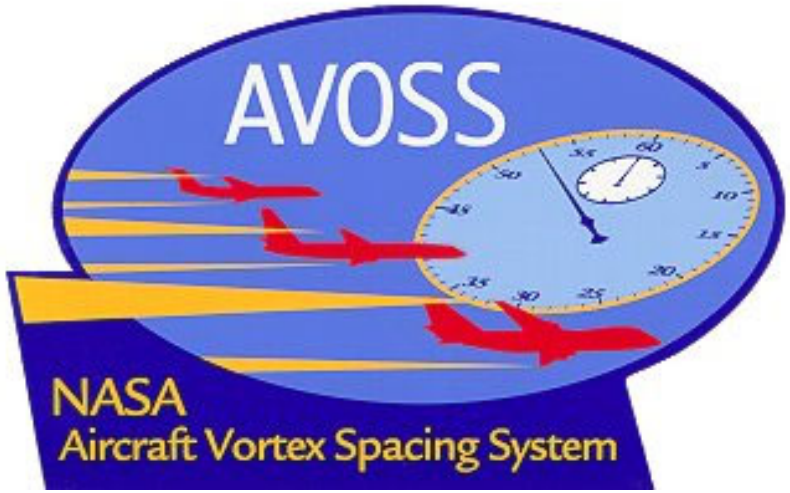
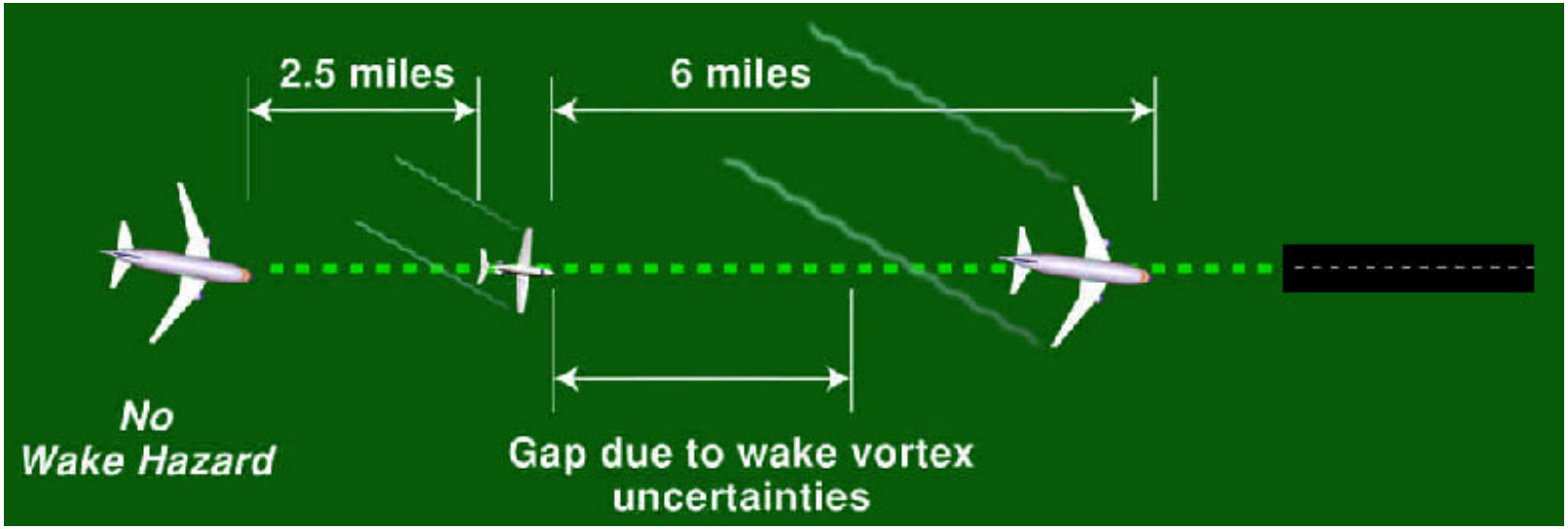


Background: NASA Aircraft VOrtex Spacing System (AVOSS)

- Goal:
  - Demonstrate an integration of technologies to provide weather-dependent, dynamic aircraft spacing for wake avoidance
  - Operate real-time in a relevant environment
- System demonstrated at Dallas Fort-Worth Airport in July 2000; Represented the culmination of six years of field testing, data collection, and development



The Wake Vortex Issue

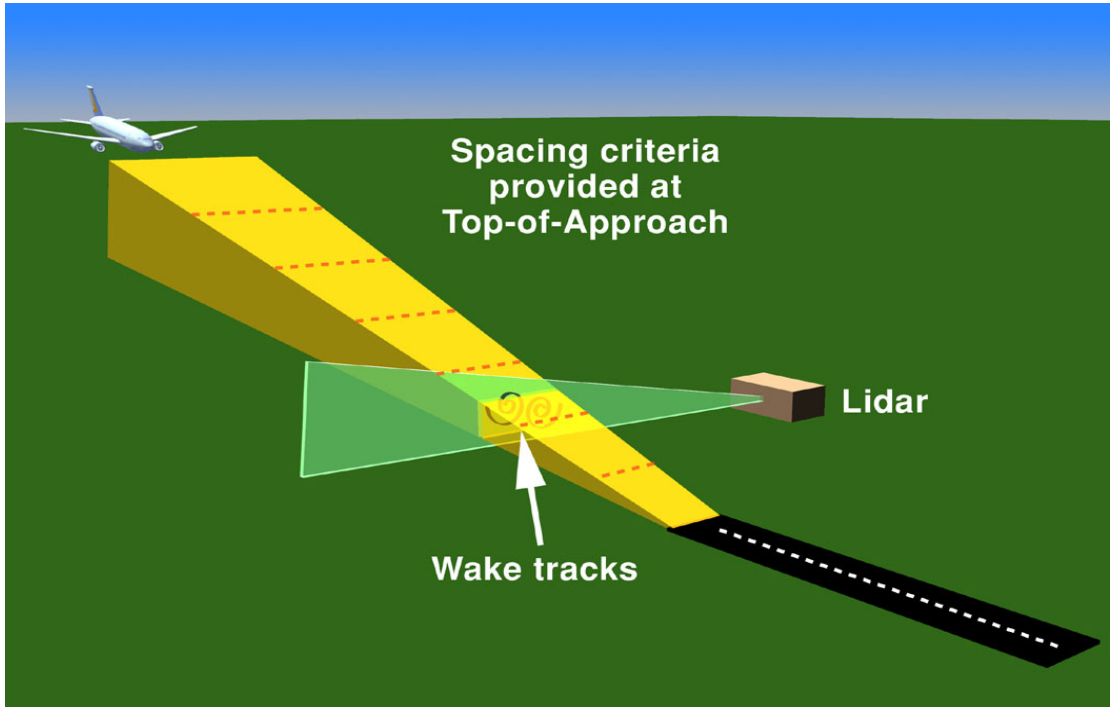


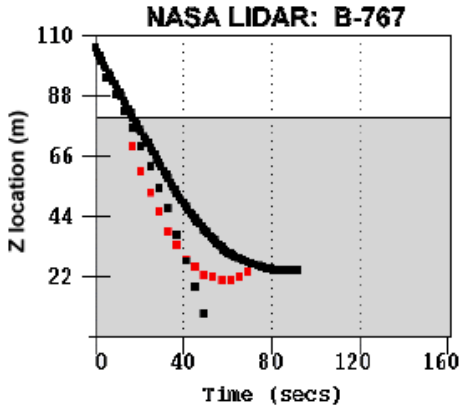
Following Aircraft Gap, (nm)	Lead Aircraft			
	Small	Large	B757	Heavy
Small	2.5	4	5	6
Large	2.5	2.5	4	5
Heavy	2.5	2.5	4	4

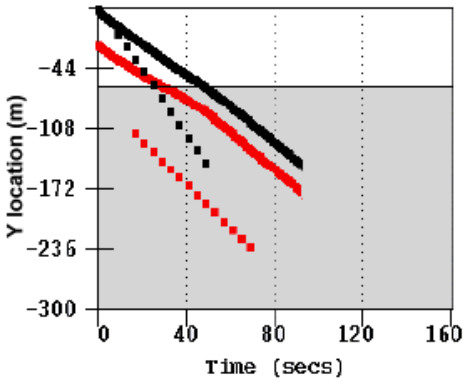
- **US Minimum spacing when operating under IFR (Gap in nm)**
- **757 special case as a lead aircraft**
- **Small <= 41,000 lbs, 41,000 lbs < Large <= 255,000 lbs, Heavy > 255,000 lbs**

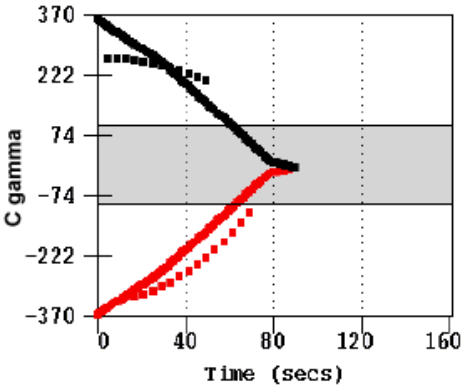
AVOSS Corridor

- Separate aircraft from wake vortex encounters:
  - Define a corridor of protected airspace
  - Windows co-locate predictions and sensor measurements
  - Predict wake motion and decay at all windows for all aircraft
  - Provide safe separation criteria for the entire approach
  - Monitor safety with wake vortex sensor







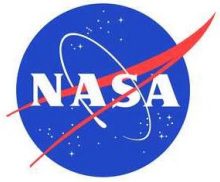


Solid lines: Predictions
Dotted lines: Measured
Red (bottom curve): Left wake
Black (top curve): Right wake

Wake no longer a factor in gray area

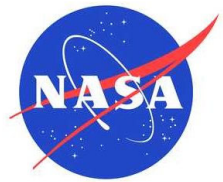
AVOSS DFW Research Results

- Calculated maximum IFR throughput increase
  - Averaged 6%
  - Ranged from 0% to 16%
  - Maximum theoretical gain ~16%
    - 50 second Runway Occupancy Time (ROT)
- From 2301 wake comparisons:
  - 61% of all wakes exited corridor in less than the ROT
    - Transported away by crosswind
    - Sank below the corridor
    - Dissipated (circulation below 90 M^2/sec)
  - 31% Separation reduced with no measurements exceeding predictions
  - 8% the wake observations exceeded the prediction bounds
    - Caused by variances either in weather estimation, wake prediction, or wake sensing, not necessarily a safety concern
    - 7% of the 8% determined to not be operationally significant



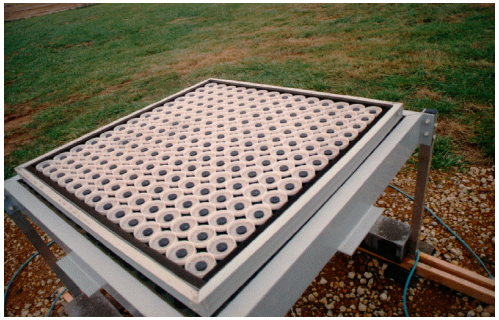
Products of the AVOSS Program

- AVOSS effort represented the most comprehensive wake and weather data collection effort to date
  - Over 10,000 wakes measured with relevant ambient weather parameters captured
  - Measurements collected at three locations over the course of six years
- AVOSS provided platform for subsystem development & integration
  - Major progress made in wake modeling and sensing
  - Weather subsystems were integrated in new ways and data fusing algorithms were developed
- Demonstration of concept for system integration
  - Example guides future operational concept development



AVOSS Weather Subsystems

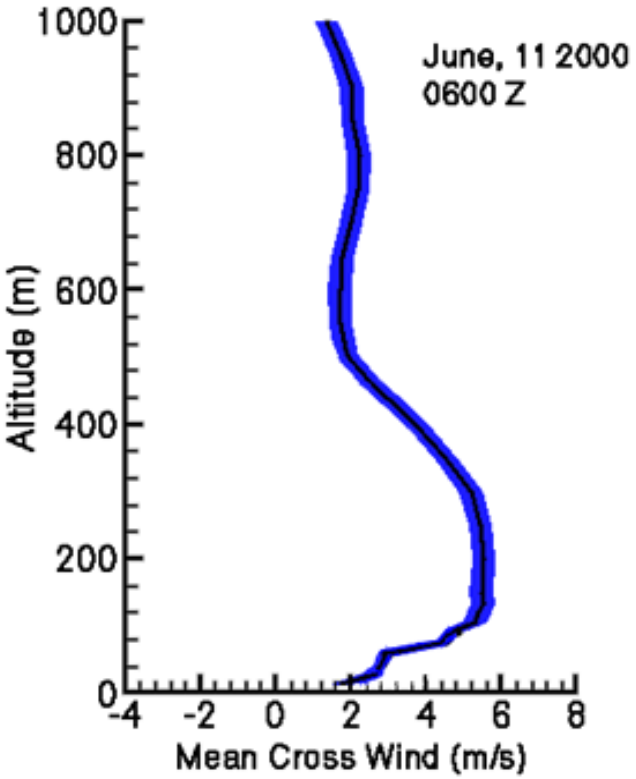
Tower



Sodar

Radar Profiler w/ Radio Acoustic Sounding System

Integrated Terminal Weather System Products



NASA

Wake Sensors Evaluated – Pulsed Lidar

Coherent Technologies, Inc. *WindTracer* Lidar

Wake Sensors Evaluated
- Continuous Wave Lidar

MIT/Lincoln Lab Lidar

Wake Sensors Evaluated
- Windline

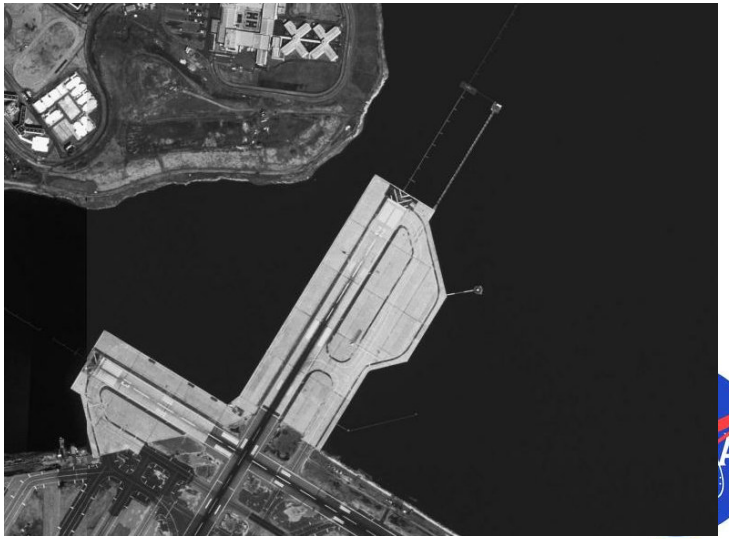
Volpe Anemometer Array

AVOSS Technologies Applicable to all Terminal Operations

Inline Approaches

Departures

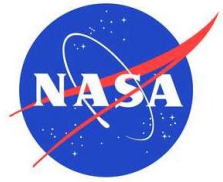
Parallel Runway Approaches



Intersecting Runways

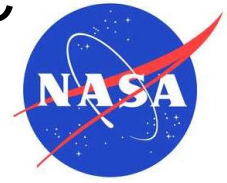
AVOSS Follow-on Work Requirements Support VAMS Vision

- Much work needs to be done in defining operational concepts that apply AVOSS products to the wake problem
- Concepts must be analyzed for costs, benefits, and impacts
- Analysis requires high-fidelity technology models and concept simulation capability
- Concept development method must be conducive to defining a roadmap to implementation



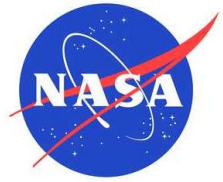
NASA LaRC VAMS Plans

- VAMS work executed by two LaRC organizations, the Airborne Systems Competency (AirSC) and the Aerospace Systems Concepts and Analysis Competency (ASCAC)
- Work focus is on Wake Vortex Avoidance System (WakeVAS) concept development and the modeling that supports the development
- Technology models designed to be compatible with FAA's terminal procedure simulator, providing a clear roadmap to operation
- Technology models developed at LaRC could be used in larger NAS simulations developed at ARC



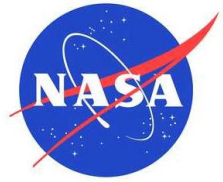
FY2002 VAMS Tasks

- AirSC provides WakeVAS technology and concept models and parameters to ASAC for integration into an airspace simulation
  - Develop an in-house technology simulation capability that parallels the FAA Airspace Simulation and Analysis for TERPS tool
  - Continue evaluation of existing data for WakeVAS subsystem characterization and evaluation
  - Continue enhancements to wake behavior models
    - Improvements to analytical models
    - Development of wake probabilistic models
- Operational Concept development (in-house and solicited)



FY2003 and Beyond

- Continue technology model development, targeting larger, more comprehensive NAS simulations as they are developed
- Continue Operational Concept Development
- Refine technology models and concept designs with the results of ongoing research
- Keep potential paths to concept and/or technology implementation open by maintaining consistency and synergy with FAA/NASA Wake Vortex Research Plan



WakeVAS Concept Models