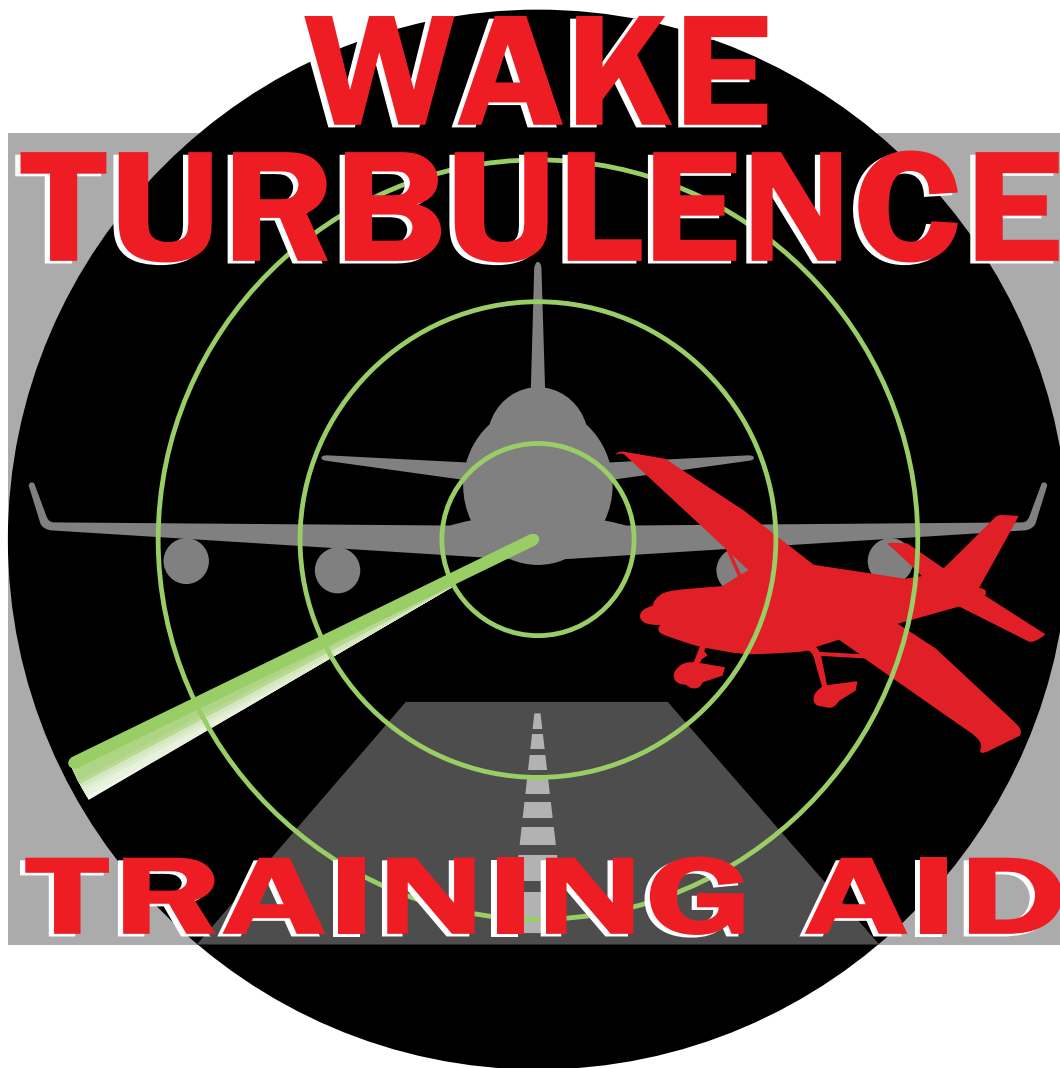




U.S. Department  
of Transportation  
Federal Aviation  
Administration

DOT/FAA/RD-95/6  
DOT-VNTSC-FAA-95-4

Final Report  
April 1995



A cooperative effort between the U.S. Department of Transportation, Federal Aviation Administration, and the international and domestic aviation community in the interest of safety

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U.S. Department  
of Transportation

**Federal Aviation  
Administration**

800 Independence Ave., S.W.  
Washington, D.C. 20591

March 24, 1995

Dear Sir/Madam:

It is a pleasure to recommend this "Wake Vortex Training Aid" for use throughout the aviation industry. This training tool is the culmination of an aggressive, painstaking effort on the part of an industry and Government working group representing a broad segment of the aviation community.

Throughout 1994, this ATA sponsored, Boeing led, joint Government/industry team comprised of both domestic and international experts, representing a wide range of knowledge and interests, developed this consensus document. This fact gathering effort led to the group's recommendations that pilots and air traffic controllers share the responsibility for reducing aircraft encounters with wake turbulence. The Federal Aviation Administration supports this view and offers this aid as a means of enhancing wake turbulence training for both pilots and air traffic controllers.

This training aid represents the most recent information available on wake turbulence avoidance in addition to providing a comprehensive discussion of the characteristics of this hazard. We are continuing to examine this threat; therefore, you should be alert for changes to existing wake turbulence guidance.

My thanks to the members of the Wake Turbulence Working Group. I strongly support the industry and Government partnership represented by the group's activities. Through efforts such as these we can effectively and efficiently promote safety for the flying public.

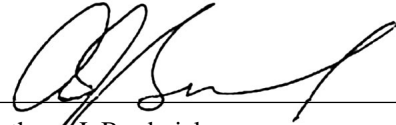
Sincerely,

A handwritten signature in cursive script that reads "David R. Hinson".

David R. Hinson  
Administrator



Albert H. Prest  
V. P., Operations  
Air Transport Association (ATA)



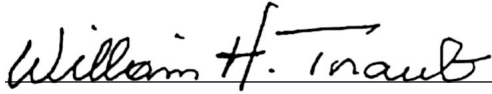
Anthony J. Broderick  
Assoc. Administrator  
Regulation & Certification, AVR-1  
Federal Aviation Administration (FAA)



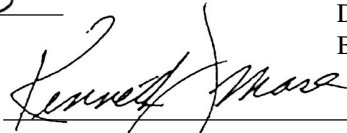
Pierre Baud  
V. P., Flight Operations Support Division  
Airbus Industrie



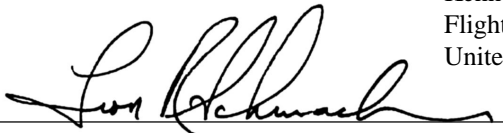
Chester L. Ekstrand  
Director, Flight Training & Regulatory Affairs  
Boeing Commercial Airplane Group



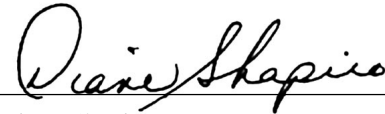
William H. Traub  
V. P., Flight Standards & Training  
United Airlines (UA)



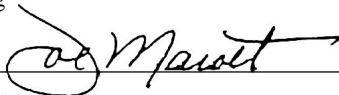
Kenneth J. Mase  
Flight Training Manager  
United Parcel Service (UPS) Training Center



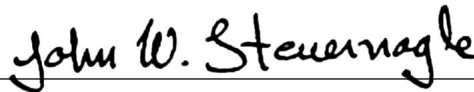
Lee R. Schumacher  
Managing Director, Flight Training  
American Airlines (AA)



Diane Shapiro  
General Manager, Flight Operations  
McDonnell Douglas Aircraft Co.



Joe Marott  
Manager, Flight Training  
Southwest Airlines Training Center



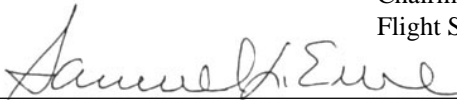
John W. Steuernagle  
Director, Program Development  
AOPA Flight Safety Foundation



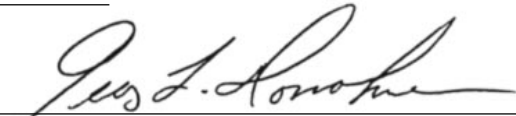
Jack Thompson  
Manager, Flight Operations  
National Air Transportation Association (NATA)



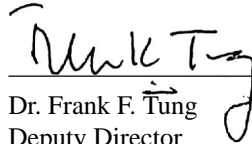
Stuart Matthews  
Chairman, President, & CEO  
Flight Safety Foundation



Mr. Samuel L. Eure  
Program Manager  
Science and Technology Corp.



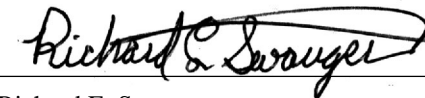
Dr. George L. Donohue  
Associate Administrator  
Research and Acquisitions, ARA-1  
Federal Aviation Administration (FAA)



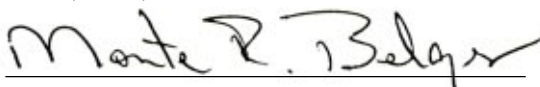
Dr. Frank F. Tung  
Deputy Director  
Volpe National Transportation Systems Center  
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REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
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4. TITLE AND SUBTITLE  Wake Turbulence Training Aid			5. FUNDING NUMBERS  FA527 A5072	
6. AUTHORS Prepared under the direction of: Project Manager: George C. "Cliff" Hay and Assoc. Project Manager: Robert H. Passman				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Department of Transportation Volpe National Transportation Systems Center Office of Operations Engineering and Assessment Surveillance and Sensors Division Kendall Square Cambridge, MA 02142-1093			8. PERFORMING ORGANIZATION REPORT NUMBER  DOT-VNTSC-FAA-95-4	
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13. ABSTRACT (Maximum 200 words)  Wake-turbulence accidents and incidents have been, and continue to be, a significant contributor to worldwide safety statistics. The National Transportation Safety Board (NTSB), in a report on safety issues related to wake-vortex encounters, stated that between 1983 and 1993 there were at least 51 accidents and incidents in the United States that resulted from probable encounters with wake vortices.  The goal of the Wake Turbulence Training Aid is to reduce the number of wake-turbulence related accidents and incidents by improving the pilot's and air traffic controller's decision making and situational awareness through increased and shared understanding and heightened awareness of the factors involved in wake turbulence. The major three objectives of the Wake Turbulence Training Aid are: (1) to educate pilots and air traffic controllers on wake turbulence and avoidance of the phenomenon; (2) to increase the wake-turbulence situational awareness of pilots and air traffic controllers; and (3) to provide usable information to develop a ground training program.				
14. SUBJECT TERMS  Wake Vortex, Wake Turbulence, Training, Pilots, Air Traffic Controllers, Accidents, Incidents			15. NUMBER OF PAGES 448	
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## METRIC/ENGLISH CONVERSION FACTORS

### ENGLISH TO METRIC

#### LENGTH (APPROXIMATE)

1 inch (in) = 2.5 centimeters (cm)  
 1 foot (ft) = 3.0 centimeters (cm)  
 1 yard (yd) = 0.9 meter (m)  
 1 mile (mi) = 1.6 kilometers (km)

#### AREA (APPROXIMATE)

1 square inch (sq in, in<sup>2</sup>) = 6.5 square centimeters (cm<sup>2</sup>)  
 1 square foot (sq ft, ft<sup>2</sup>) = 0.09 square meter (m<sup>2</sup>)  
 1 square yard (sq yd, yd<sup>2</sup>) = 2.6 square kilometers (km<sup>2</sup>)  
 1 acre = 0.4 hectares (he) = 4,000 square meters (m<sup>2</sup>)

#### MASS - WEIGHT (APPROXIMATE)

1 ounce (oz) = 28 grams (gr)  
 1 pound (lb) = .45 kilogram (kg)  
 1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)

#### VOLUME (APPROXIMATE)

1 teaspoon (tsp) = 5 milliliters (ml)  
 1 tablespoon (tbsp) = 15 milliliters (ml)  
 1 fluid ounce (fl oz) = 30 milliliters (ml)  
 1 cup (c) = 0.24 liter (l)  
 1 pint (pt) = 0.47 liter (l)  
 1 quart (qt) = 0.96 liter (l)  
 1 gallon (gal) = 3.8 liters (l)  
 1 cubic foot (cu ft, ft<sup>3</sup>) = 0.03 cubic meter (m<sup>3</sup>)  
 1 cubic yard (cu yd, yd<sup>3</sup>) = 0.76 cubic meter (m<sup>3</sup>)

#### TEMPERATURE (EXACT)

$$[(x - 32)(5/9)]^{\circ}\text{F} = y^{\circ}\text{C}$$

### METRIC TO ENGLISH

#### LENGTH (APPROXIMATE)

1 millimeters (mm) = 0.04 inch (in)  
 1 centimeters (cm) = 0.4 inch (in)  
 1 meter (m) = 2.2 feet (ft)  
 1 meter (m) = 1.1 yards (yd)  
 1 kilometer (km) = 0.6 mile (mi)

#### AREA (APPROXIMATE)

1 square centimeter (cm<sup>2</sup>) = 0.16 square inch (sq in, in<sup>2</sup>)  
 1 square meter (m<sup>2</sup>) = 1.2 square yards (sq yd, yd<sup>2</sup>)  
 1 square kilometer (km<sup>2</sup>) = 0.4 square mile (sq mi, mi<sup>2</sup>)  
 1 hectares (he) = 10,000 square meters (m<sup>2</sup>) = 2.5 acres

#### MASS - WEIGHT (APPROXIMATE)

1 gram (gr) = 0.036 ounce (oz)  
 1 kilogram (kg) = 2.2 pounds (lb)  
 1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons

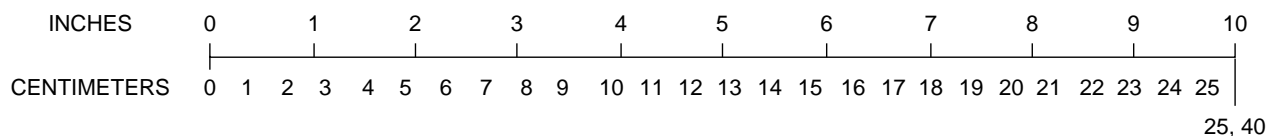
#### VOLUME (APPROXIMATE)

1 milliliters (ml) = 0.03 fluid ounce (fl oz)  
 1 liter (l) = 2.1 pints (pt)  
 1 liter (l) = 1.06 quarts (qt)  
 1 liter (l) = 0.06 gallon (gal)  
 1 cubic meter (m<sup>3</sup>) = 36 cubic feet (cu ft, ft<sup>3</sup>)  
 1 cubic meter (m<sup>3</sup>) = 1.3 cubic yards (cu yd, yd<sup>3</sup>)

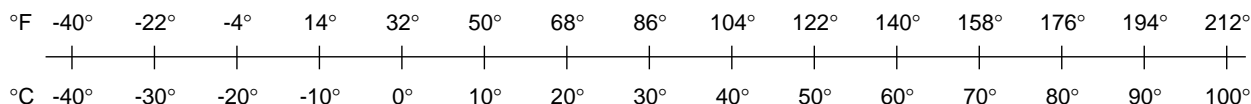
#### TEMPERATURE (EXACT)

$$[(9/5)(y + 32)]^{\circ}\text{C} = x^{\circ}\text{F}$$

### QUICK INCH-CENTIMETER LENGTH CONVERSION



### QUICK FAHRENHEIT-CELCIUS TEMPERATURE CONVERSION



For more exact and or other conversion factors, see NBS Miscellaneous Publication 286, Units of Weights and Measures. Price \$2.50. SD Catalog No. C1310286.