

AIAA  
R-092-1-2003

# Recommended Practice

## Wind Tunnel Testing — Part 1: Management Volume

AIAA standards are copyrighted by the American Institute of Aeronautics and Astronautics (AIAA), 1801 Alexander Bell Drive, Reston, VA 20191-4344 USA. All rights reserved.

AIAA grants you a license as follows: The right to download an electronic file of this AIAA standard for temporary storage on one computer for purposes of viewing, and/or printing one copy of the AIAA standard for individual use. Neither the electronic file nor the hard copy print may be reproduced in any way. In addition, the electronic file may not be distributed elsewhere over computer networks or otherwise. The hard copy print may only be distributed to other employees for their internal use within your organization.



**AIAA**  
**R-092-1-2003**

# **Recommended Practice**

## **Wind Tunnel Testing – Part 1: Management Volume**

Sponsor

**American Institute of Aeronautics and Astronautics**

### **Abstract**

This recommended practice document is the first of a two-part series intended to provide test project management and practitioners with best practices that maximize the data value of wind tunnel test projects. Part I help managers understand the impact of decision making before and during the development of a test project and provides key activities to help improve the timeliness and cost-effectiveness of future wind tunnel test projects. Part II provides those responsible for test execution with best practices to employ when preparing for and implementing tests.

Library of Congress Cataloging-in-Publication Data

Recommended practice : wind tunnel testing.

p. cm.

pt. 1. Management volume -- pt. 2. Practitioners volume.

Includes bibliographical references and index.

ISBN 1-56347-650-9 (v. 1) -- ISBN 1-56347-651-7 (Electronic) -- ISBN  
1-56347-652-5 (v. 2) -- ISBN 1-56347-653-3 (Electronic)

1. Wind tunnels. 2. Aerodynamics--Research--Standards. 3. Wind  
tunnel models--Testing--Standards. I. American Institute of Aeronautics  
and Astronautics.

TL567.W5R437 2003  
629.134'52--dc22

2003019165

Published by

**American Institute of Aeronautics and Astronautics  
1801 Alexander Bell Drive, Reston VA 20191**

Copyright © 2003 American Institute of Aeronautics and  
Astronautics  
All rights reserved.

No part of this publication may be reproduced in any form, in electronic retrieval system or  
otherwise, without prior written permission of the publisher.

Printed in the United States of America.

## Contents

Foreword .....	v
1 Introduction .....	1
1.1 History and Background .....	1
2 Managing Today's Wind Tunnel Test Programs .....	2
2.1 Planning Issues in Wind Tunnel Test Programs .....	2
2.1.1 Test Requirements .....	2
2.1.1.1 Integrated Test Programs .....	2
2.1.1.2 Test Article Size and Fidelity .....	2
2.1.1.3 Data and Instrumentation Requirements .....	3
2.1.1.4 Facility Selection .....	3
2.1.2 Planning and Scheduling .....	4
2.1.3 Special Issues .....	5
2.1.3.1 Security .....	5
2.1.3.2 Contracting and Procurement .....	5
2.1.4 Advanced Tools and Technologies .....	5
2.2 Keys to Managing a Successful Test Program .....	5
2.2.1 Program Test Plan .....	6
2.2.1.1 Key #1: Establish Goals, Quality, and Success Criteria .....	6
2.2.1.2 Key #2: Understand Program Considerations .....	6
2.2.1.3 Key #3: Involve Test Community Early .....	7
2.2.2 Detailed Test Planning and Execution .....	7
2.2.2.1 Key #4: Establish Test Teams .....	7
2.2.2.2 Key #5: Develop and Execute Detailed Test Plans .....	9
2.2.3 Post-Test Activities .....	9
2.2.3.1 Key #6: Project Reviews/Lessons Learned/Feedback .....	9
2.2.3.2 Key #7: Documentation .....	10
3 Summary .....	10
Annex A Advanced Tools and Methods for Consideration in Test .....	11
A.1 Integrating Testing and Computational Fluid Dynamics (CFD) .....	11
A.2 Rapid Prototype Tools .....	11
A.3 Effective Use of Computer-Aided Design (CAD) .....	11
A.4 Remote-Access Testing .....	11
A.5 Advanced Instrumentation .....	12
A.6 Model Automation .....	12
A.7 Test Simulation Tools .....	13

AIAA R-092-1-2003

Annex B Subcontracting Mechanisms .....	14
Figures	
Figure 1 Key Activities and Their Alignment to Test Program Phases.....	6
Figure 2 Illustration of a Test Team Structure during Preparation Activities.....	8
Figure 3 Illustration of a Team Arrangement During Testing.....	8

## Foreword

The American Institute of Aeronautics and Astronautics (AIAA) Ground Test Technical Committee (GTTC) began looking at best practices associated with test article development as a way to recommend improvements in wind tunnel test efficiency, cost, and cycle time. It became apparent early on that trying to separate test article development from overall wind tunnel test process was not a productive and useful activity. The highly integrated nature of the processes, organizations, and personnel involved in wind tunnel test programs requires that a broader viewpoint of the wind tunnel test process be evaluated in order to develop successful techniques and methods. This two-volume effort, "Recommended Practice for Successful Wind Tunnel Testing," is the result of that evaluation.

Part I was written to provide test program managers with clear insight into achieving technically focused, affordable, and low-risk test programs to support the development of aerodynamic vehicles and technologies. This recommended-practices document will help managers understand the impact of decision making before and during the development of a test program and will provide key activities to help improve quality, timeliness, and cost-effectiveness of wind tunnel test programs.

Part II provides additional detail about successful methods for personnel who are directly involved in developing and executing test programs.

Neither volume is intended to be a totally comprehensive document on successful wind tunnel testing. Instead, they represent a compilation of best practices to provide a strong foundation for the successful development of a test program or test effort. While these practices focus on wind tunnel test processes, the information is applicable to many other ground test activities.

The GTTC Test Processes Working Group consisted of a diverse group of industry and government experts in the fields associated with wind tunnel testing. During the development of these documents, this group consisted of:

Mr. Mark Melanson, Chairman	Lockheed Martin Aeronautics
Mr. Tom Aiken	NASA Ames Research Center
Mr. Allen Arrington	QSS Group Inc./NASA Glenn Research Center
Mr. Chris Athaide	Tri Models Inc.
Mr. Rene Barakett	Bombardier Aerospace
Mr. Mark Betzina	NASA Ames Research Center
Ms. Jean Bianco	NASA Glenn Research Center
Mr. Jim Brunges	
Mr. Steve Craft	NASA Langley Research Center
Mr. Roger Crites	Boeing Company, St. Louis
Mr. Drew Hope	NASA Langley Research Center
Mr. Mark Kammeyer	Boeing Company, St. Louis
Mr. Ray Knowis	
Mr. Dan Marren	AEDC White Oak
Ms. Laura McGill	Raytheon Missiles
Mr. Dave Minto	Holloman High-Speed Test Track

AIAA R-092-1-2003

Mr. Michel Ouellette	Bombardier Aerospace
Mr. Barry Price	NASA Langley Research Center
Mr. Al Roberts	Tri Models Inc.
Mr. Matt Ruegers	Boeing Company, St. Louis
Mr. Lew Scherer	Northrop Grumman
Mr. Rob Sheehan	Northrop Grumman
Dr. FrankSteinle	Sverdrup/Jacobs Engr. at Arnold Engineering Development Center
Mr. Bill Straka	Penn State University
Mr. Steven Westmore	Boeing Company, Seattle

Many others also contributed to this document during its development.

On the recommendation of the Test Processes Working Group, the following knowledgeable individuals reviewed this document and provided valuable critiques. Approval of the document was unanimous.

Mr. Roger Chamberlin	NASA Glenn Research Center
Mr. Rick Crooks	Allied Aerospace Inc.
Mr. Chester DeCesaris, Jr.	BMDO Test Resources
Mr. Ralph Klestadt	Raytheon Missile Systems
Mr. David Miller	NASA Langley Research Center
Mr. Gerald Pounds	Lockheed Martin Aeronautics Company
Mr. Kirk Seablom	NASA Glenn Research Center
Mr. Joe Strong	Boeing, Retired
Mr. Jeff Haas	NASA Glenn Research Center
Mr. Robert Voisinet	AEDC White Oak
Mr. Scott Winship	Northrop Grumman

The AIAA Ground Test Technical Committee approved this document (Mr. Allen Arrington, Chairman) in July 2002.

The AIAA Standards Executive Council (Mr. Phil Cheney, Chairman) accepted this document for publication in September 2003.

AIAA Standards Procedures provide that all standards, recommended practices, and guides be advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. In formulating, revising, and approving standards publications, the Committee on Standards will not consider patents that may apply to the subject matter. Prospective users of the publications are responsible for protecting themselves against liability for infringement of patents, copyrights, or both.

# 1 Introduction

Wind tunnel testing is a critical component in the development of aerodynamic vehicles and associated technologies. While the time and expense of wind tunnel testing is significant, it is an essential risk reduction tool before progressing air vehicles and technologies to the more expensive, technically risky flight tests. Decisions made during the evolution and execution of wind tunnel test programs can have far-reaching performance, financial, and schedule implications throughout the life cycle of an air vehicle.

Efforts are being made across all air vehicle development activities to reduce technical risk, cost, and cycle time. Since wind tunnel test programs are critical to those development activities, any successful reductions in wind tunnel risk, cost, or cycle time can have significant positive impacts on the overall air vehicle program.

To accomplish a successful program, managers of wind tunnel test programs must carefully balance the testing needs (objectives), schedules, and cost of the test program. Activities such as developing test requirements, test articles, test preparation, testing, and analysis require significant resource investments and must be carefully managed to accomplish technical goals with minimum resource expenditure.

This volume describes the broader aspects of test program development, implementation, and management. It provides managers with a set of tools (key activities) to help navigate and develop a balanced, successful test program.

## 1.1 History and Background

Wind tunnel testing has been critical to aircraft development since it was first performed by Frank H. Wenham in Great Britain in 1871. Beginning in 1901, the Wright Brothers utilized a tunnel of their own design to increase their understanding of aerodynamic lift and control, which helped them produce the first powered aircraft in 1903.

In today's highly competitive commercial aviation world, small improvements in aerodynamic performance can translate into range and payload gains and, therefore, sales. Wind tunnel testing to develop air vehicle configurations involves extensive aerodynamic testing. Loads, flutter, and propulsion interaction testing are also important aspects of test programs. Military air vehicle development may include additional focus on testing of broad test envelopes, weapons carriage, and highly integrated propulsion effects.

Wind tunnel testing has historically provided the primary ground test mechanism for establishing air vehicle performance prior to committing designs to flying hardware. With increasing emphasis on lower air vehicle development costs and cycle time, people in the test community have been asked to produce higher quality test results, quicker and for less cost.

The desire to reduce cycle time (and cost) seemingly necessitates reductions in allotted span time for wind tunnel model design, fabrication, test preparation, testing, and test analysis. Unfortunately, these pressures can negatively affect the quality and cost of test programs. Therefore, it has become increasingly difficult for test service providers to perform test work in a manner that is consistent with schedule pressures (at a minimum cost) while providing the quality necessary to ensure a totally successful test program.

The tradeoffs between cost, quality, quantity of data, and schedule response, along with the processes employed during test program activities, are the key focus areas for today's wind tunnel test management. To provide managers with the best tools available, it is important to first understand the tradeoffs and techniques that will yield successful test programs. These techniques include:

- Understanding technical goals (therefore data needs) before embarking on a test program
- Getting the right people involved early to minimize risk and cost (including early selection of the test facility and test facility personnel)