Infrastructure Recommendations for Implementation of Executive Order 13419—National Aeronautics Research and Development

An AIAA Position Statement

Authored by the AIAA

Ground Test Technical Committee

and approved by the

AIAA Board of Directors

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Executive Summary

As required by Executive Order 13419 and the NASA Authorization Act of 2005 (PL 109-155), the Aeronautics Science & Technology Subcommittee (ASTS) of the National Science and Technology Council (NSTC) is developing a new National Aeronautics Research and Development Plan ("the Plan").

The goals of the Plan, as set forth in the Executive Order, include: Maintaining and advancing U.S. aeronautics research, development, test and evaluation infrastructure to provide effective experimental and computational capabilities for aeronautics R&D; ensuring appropriate federal coordination with other entities, including academic and research institutions and private organizations.

A working group convened by the Ground Test Technical Committee (GTTC) of the American Institute of Aeronautics and Astronautics (AIAA) has developed comments and recommendations for the ASTS to consider as it develops the Plan. In particular, the comments and recommendations of the working group stress the following points:

- Wind tunnel testing forms the basis for most aerodynamic development and validation, and will continue to be required to support aerospace development for the foreseeable future, through and beyond at least 2020.

- Strategic investment in wind tunnel test capabilities is required for continued progress in aeronautics, as the need for long range and rapid strike capability will require supersonic and hypersonic testing, and as commercial pressures for increased fuel efficiency will drive propulsion and airframe integration testing requirements.

- To ensure adequate wind tunnel test infrastructure through and beyond the 2020 horizon, strategic investments are required in workforce development, infrastructure, and test technology. In particular: (1) stable federally-funded R&D is needed to facilitate development of knowledgeable new staff prior to the retirement of the current aging workforce; (2) improved test technology will be needed for future system development, and this will require stable funding of test technique and technology research; (3) maintaining and improving key test assets is needed to reverse the atrophy and decline of the federal aerodynamic test infrastructure over the last twenty years; (4) divesting redundant and non-essential test infrastructure will be needed, to focus limited resources on critical capabilities and new infrastructure requirements; and (5) new high-speed test infrastructure will be required to meet the anticipated needs for future systems.

- To manage the required infrastructure in support of aerospace R&D, the National Partnership for Aeronautical Testing (NPAT) should be strengthened by the addition of an Industry Board. Among other things, such a board would help clarify the needs for testing, facilitate the evaluation of critical capabilities and redundant facilities, and help facilitate R&D investment.

- To further strengthen the infrastructure supporting aerospace R&D, operational management of NASA test infrastructure should be consolidated, and strategic investments, including capital, maintenance, and overheads associated with operational effectiveness and staffing at critical and required test facilities, should be stabilized with a view toward long-term viability.

Background

The Ground Test Technical Committee (GTTC) of the American Institute of Aeronautics and Astronautics (AIAA) sponsors the U.S. Industry Aeronautics Test Facilities Working Group (hereafter referred to as the "working group") to provide a forum for development of strategic recommendations on aeronautical test facilities (specifically wind tunnels) required to support current and future aeronautic development activities. The overall intent of the working group is to provide a mechanism for the U.S. aerospace industry to develop and offer input into the strategic planning by NASA and DOD agencies that are tasked with stewardship of national test facility assets. Specific details regarding the working group's charter and membership are included in Appendix A.

The Aeronautics Science & Technology Subcommittee (ASTS) of the National Science and Technology Council (NSTC) is currently working to implement the provisions of Executive Order 13419, and of the National Aeronautics and Space Administration Authorization Act of 2005 (PL109-155), that require the federal government to establish a new National Aeronautics Research and Development Plan. Included in the plan is a coordinated approach to managing U.S. Government aeronautics research, development, and test and evaluation infrastructure identified as critical national assets required to maintain and advance world-class U.S. experimental and computational R&D capabilities.

The working group is pleased to provide input to the ASTS as it develops a cohesive and comprehensive plan for implementation of the Executive Order. Specifically, the working group will focus on goals listed in Section 2 topics of the Executive Order and in PL109-155:

> (iv) Maintain and advance United States aeronautics research, development, test and evaluation infrastructure to provide effective experimental and computational capabilities in support of aeronautics R&D;

(vii) Ensure appropriate Federal Government coordination with State, territorial, tribal, local, and foreign governments, international organizations, academic and research institutions, private organizations, and other entities.

In support of plan development, the working group will offer its perspectives on near term industry wind tunnel test requirements over the next five years, a long range "vision" of future test needs (through and beyond 2020), and recommendations on facilitating coordination between the U.S. Government stewards of test infrastructure and other entities such as the U.S. aerospace industry.

This statement reflects the expert views of Ground Test Technical Committee and the working group, and not necessarily the views of AIAA as a whole.

Near Term Wind Tunnel Requirements

Wind tunnel testing continues to form the basis for most aerodynamic development and validation. **This trend will continue over the next five years**.

The working group has evaluated historical wind tunnel test usage trends and anticipated near term needs over the next five years and can provide the following industry-related testing predictions. Due to the highly cyclical nature of wind tunnel testing (large peaks and valleys in test requirements), the working group used an average of the last five years industry usage to produce a "baseline"; anticipated future needs are produced from that baseline.

Figure 1 provides annualized average test requirements, in User Occupancy Hours (UOH) for the next five years. It is important to note that these requirements reflect only those requirements that are U.S. industry based – no test requirements that DOD or NASA execute directly are included. These requirements are not tied to specific facilities (national, international, commercial, private, etc.) and reflect the overall level of test requirements that are anticipated. Classes of air vehicle are identified (in the left hand column) along with anticipated test requirements by speed regime.

Class	Low Speed (M<.4)	Transonic (M<1.6)	Supersonic (M<5)	Hypersonic (M>=5)	Notes
General Aviation	200	0	0	0	
Business Jets (5-20 pass)	1250	1250	150	0	
Regional Jets	500	550	0	0	
Commercial Aviation	2850	4500	0	0	includes large business jets
Tactical Aircraft, fighters	2400	2900	900	450	includes UAV's
Military Transports and Tankers	2050	1400	0	0	
Bombers, Strategic	1250	1100	350	0	includes UAV's
Suborbital Aircraft	0	0	0	0	**no forecast available**
Orbital Access/Reentry	200	600	950	350	industry requirements only (prime), no NASA or DOD conducted testing; includes launch vehicles
Conventional Helicopters	2050	150	0	0	
High Speed Rotorcraft (Tilt…)	1200	0	0	0	
Air-breathing weapons	350	850	150	0	includes targets
Rocket or unpowered weapons	400	1000	900	700	includes targets
Propulsion Systems	750	1400	750	200	includes internal aerodynamic testing/integration
Technology Development/Other	300	350	150	0	test technology, etc, not tied to a program
Recon platforms	900	850	50	0	
totals	***16650***	***16900***	***4350***	***1700***	

Figure 1. Anticipated Annualized Industry Wind Tunnel Test Requirements (in User Occupancy Hours)

Figure 2 presents the same data in incremental form (percentages) relative to the five-year annualized baseline. Color codes are used to indicate decreasing, constant, or increasing needs. Overall trends identified are:

1. Increases in both propulsion systems testing and test-related technology development.

2. Decreases in reconnaissance platform development.

3. Increases in high speed testing (supersonic and hypersonic) for several classes of systems.

4. Decreases in tactical aircraft testing.

Class	Low Speed (M<.4)	Transonic (M<1.6)	Supersonic (M<5)	Hypersonic (M>=5)
General Aviation	0%			
Business Jets (5-20 pass)	22%	18%	100%	
Regional Jets	0%	0%		
Commercial Aviation	10%	0%		
Tactical Aircraft, fighters	-20%	-20%	50%	50%
Military Transports and Tankers	13%	8%		
Bombers, Strategic	63%	63%	167%	
Suborbital Aircraft				
Orbital Access/Reentry	44%	44%	44%	44%
Conventional Helicopters	60%	7%		
High Speed Rotorcraft (Tilt…)	50%			
Air-breathing weapons	0%	0%	0%	
Rocket or unpowered weapons	-3%	0%	0%	100%
Propulsion Systems	0%	40%	50%	100%
Technology Development/Other	13%	13%	13%	
Recon platforms	-7%	-8%	-17%	

Legend

Yellow	Decreasing Need
Green	Constant Need
Blue	Increasing Need

Figure 2. Wind Tunnel Test Requirement Trends for the Next Five Years

In summary, it is anticipated that wind tunnel testing needs will continue at rates slightly above the five-year annualized baseline. Historical peaks and valleys, resulting from individual program plans, will continue to impact actual requirements and schedules. The long-term forecast indicates that subsonic and transonic testing will remain constant or possibly increase slightly; there will likely be increased emphasis on supersonic and hypersonic testing.

Long Term Wind Tunnel Requirements (Vision)

Continued progress in aeronautics is essential to America's economic success and the protection of America's security interests at home and around the globe.

The working group evaluated longer term trends (both within and outside the aerospace community) to develop a vision of the future for wind tunnel testing. Based upon a variety of future scenarios, we offer our vision of future needs as summarized below:

1. **Wind tunnel testing will continue to be required to support aerospace development for the foreseeable future (through/beyond at least 2020).**

2. Computational tools will continue to mature and provide highly synergistic data solutions.

3. Changing defense requirements and commercial market conditions will change systems test requirements.

4. Investments are required to:
    a. maintain and develop a knowledgeable workforce as experienced staffs retire.
    b. significantly advance test techniques to more accurately understand complex aerospace systems.
    c. maintain and improve key capabilities.
    d. divest capabilities that are not needed.
    e. develop new facilities/capabilities that are not available today.

Wind tunnel testing is anticipated to continue to provide a large percentage of development and validation data needed in the pursuit of new technologies and systems of aerospace vehicles. While aerodynamic development is considered a somewhat mature science, productive and capable tools like wind tunnels and computational methods will continue to provide the bulk of required data in the future. Aerospace vehicle development will continue to push the boundaries of our knowledge, increasing the need for tools that can accurately (and efficiently) predict aerodynamic effects.

Computational Fluid Dynamics (CFD) and other analytic tools will continue to grow in their use as a source of aerodynamic information. It is anticipated that the continued refinement of computational methods, computational power, and improved user interfaces will significantly increase the use of CFD as a data source in future systems. However, at the same time, the performance boundaries of physical systems will continue to expand, limiting the absolute reliance on computational tools as a measure of flow phenomena. Wind tunnels will remain a key source of development and validation of aerospace systems through at least 2020.

Evolving defense and commercial needs will also continue to drive the need for effective wind tunnel testing. In the defense environment, the need for long range and rapid strike capability will significantly increase requirements for higher speed testing (supersonic and hypersonic). Increased commercial efficiency will drive future development of propulsion and airframe designs. Across the industry, increased pressure to reduce the reliance on traditional fossil fuels will drive propulsion and airframe integration testing requirements.

Strategic investment in wind tunnel test capabilities is required to enable continued progress in aeronautics. Five key investment areas are described below:

1. Development of a knowledgeable test workforce is critical for the national infrastructure. It is anticipated that the industry-wide trend of losing expertise will particularly impact the test community. Investment, in the form of stable federally funded research and development programs which use the test infrastructure, will significantly enhance the ability of the operators to seek and retain new staff prior to the retirement of the current aging workforce. Stable

facility funding profiles (e.g. overheads, maintenance, and test technology development), will also aid in developing and retaining knowledgeable staff.

2. Improved test technology is crucial to enabling future system development. Huge advances in the ability to mine flow field and other data from wind tunnel tests are possible (through the advance in computational capabilities and integration, instrumentation and non-intrusive flow field measurement techniques) with strategic and coordinated investment. Stable funding of test technique/technology research would also support the development of the test workforce, as described in item 1 above.

3. Maintenance and improvement of key test assets is a vital component of enabling future test capabilities. Key facilities include those that provide unique, or nearly unique, capabilities and may or may not have full utilization (such as the National Full Scale Aerodynamic Complex (NFAC)). Atrophy and decline in a robust federal aerodynamic test infrastructure in the last twenty years has been significant; only recent emphasis by the DOD and NASA has slowed the decline in our aging infrastructure. Identification of key (and required) capabilities is best addressed through a coordinated national approach which is described in the section below on Management of the Test Infrastructure.

4. Divestment of redundant and non-essential test infrastructure is required to focus limited resources on critical capabilities and new infrastructure requirements.

5. New high-speed test infrastructure is required to meet anticipated requirements for future systems. Increased need for simulation of the hypersonic realm will likely require additional test capabilities not currently available.

Wind tunnel testing will continue as a foundational development activity for aerospace systems beyond the 2020 horizon. Strategic investments in workforce, infrastructure, and test technology are required to facilitate the required progress in aerospace system development.

Management of the Test Infrastructure

A key challenge to enabling continued progress in aeronautics is management of the required infrastructure. Currently, DOD, NASA, private facilities, industry, and to a small extent, academia all make up the national infrastructure resource base. DOD and NASA operate a large percentage of these facilities and it is there that the most immediate attention is required.

Dramatic increases in funding for test infrastructure are not anticipated; therefore an immediate goal should be to improve the coordination and efficiency of the current infrastructure by attaining the following objectives:

1. Strengthened connection between NASA and DOD test facility management.

2. Identification of key/critical national capabilities (regardless of ownership).

3. Identification of unneeded or redundant capabilities (regardless of ownership).

4. Inclusion of key stakeholders with broad perspectives on need and capability requirements in the development of national wind tunnel strategy.

5. Removal of organizational impediments that prevent operational efficiency.

6. Consolidation/improvement of redundant support capabilities (e.g. balance calibrations, instrumentation development, etc.).

7. Improved coordination with other important, non-governmental capabilities and resources (private and foreign facilities).

The working group proposes the following generalized model of wind tunnel management (see figure 3).

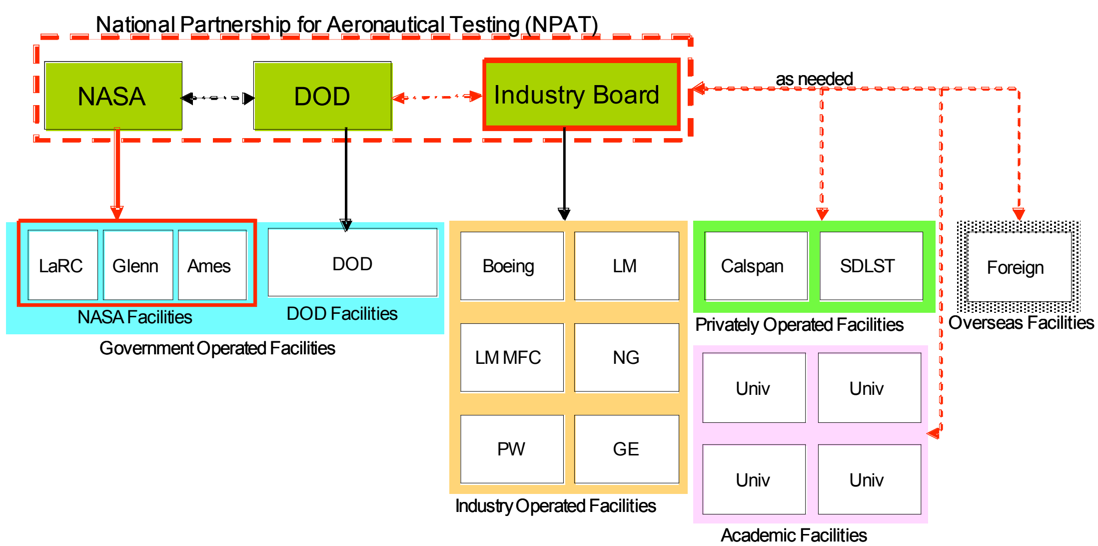

Figure 3. Proposed Management Structure for U.S. Government Test Facilities

Key elements of the model (with significant changes to the current arrangement shown in bold red) include:

1. A National Partnership for Aeronautical Testing (NPAT) strengthened by the addition of an Industry Board. The industry board members would represent the significant industry users of test capability (similar in makeup to the working group). The primary objectives of the industry board would be to:
    a. Provide visibility of near and long term needs for testing.
    b. Participate in evaluating key/critical and redundant capabilities.

c. Coordinate basic test-related research and development investment.
d. Provide insight into industry test facility plans and coordinate the roles of industry facilities within the national framework.
e. Provide insight into industry reliance on private, foreign and academic facilities and coordinate its role within national infrastructure strategy.

2. A consolidated operational management of NASA test infrastructure to:
    a. Facilitate consolidation of capabilities, staff, and management.
    b. Improve coordination of resources.
    c. Strengthen technical consistency and operational effectiveness.
    d. Improve commonality of processes, tools, and business practices.

3. Stabilization of investments, including capital, maintenance, and overheads associated with operational effectiveness and staffing at critical and required test facilities.

Longer term opportunities could include consolidation of the NASA and DOD facility operation management (common contractor arrangements, consolidation of support capabilities, etc.). Increased coordination between NASA and the DOD can only bring about positive changes, and senior management is to be commended for their efforts thus far to strengthen these relationships through the NPAT arrangement.

Summary of Recommendations

The working group anticipates near term wind tunnel requirements will remain relatively flat. Increased emphasis will be placed on higher speed (supersonic and hypersonic) development. Large peaks and valleys in the workload will continue based upon the ebb and flow of programs and technology development (continuing the long history of wind tunnel work). Wind tunnel testing will continue as a foundational development activity for aerospace systems beyond the 2020 horizon. Strategically focused investment in the workforce, infrastructure, and technologies associated with aerodynamic and propulsion testing is required, as is divestment of redundant and non-essential federal capabilities.

Continued strengthening of the overall management structure by establishing stronger connections between DOD, NASA and the aerospace industry by the addition of an industry board to the NPAT agreement would further facilitate effective and efficient management of the national infrastructure. Consolidation of NASA test capabilities under a single organizational structure is also recommended.

Contact Information

For additional information, please contact:

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Appendix A – The U.S. Industry Aeronautics Test Facilities Working Group

Charter for the U.S. Industry Aeronautics Test Facilities Working Group

Under the Auspices of the

Ground Test Technical Committee (GTTC)
Of the
American Institute of Aeronautics and Astronautics (AIAA)

PURPOSE

The U.S. Industry Aeronautics Test Facilities Working Group (hereafter referred to as "working group") was created to provide a forum for development of strategic recommendations on aeronautical test facilities required to support current and future aeronautic development activities.

The overall intent of the working group is to provide a mechanism for US Industry to develop and offer input into the strategic planning by the National Aeronautics and Space Administration (NASA) and Department of Defense (DOD) agencies that are tasked with stewardship of the national test facility assets.

SCOPE

Activities of the working group shall relate directly to the infrastructure associated with ground testing and evaluation of aeronautics systems including technology development, vehicle or system prototyping, development, qualification, and certification. The scope is limited to wind tunnels used for all forms of aerodynamic and propulsion testing

Specifically, the working group will share information (whenever possible) about test needs (both current and future) and develop input (again wherever possible) to provide industry viewpoints for decision makers within the ground test facility management at both NASA and DOD. Consideration of ground test facilities outside of U.S. government stewardship shall also be part of the industry team activities. Information that is considered sensitive or proprietary to the individual organizations represented by the membership will not be required or shared.

MEMBERSHIP

Any company or corporation based in the United States and substantially involved in test or evaluation of aeronautical systems or technology is eligible to participate in the working group. Academic organizations are not included in the working group.

Current members:

Joel Christians has 20 years of experience in the business aircraft industry as an employee of Hawker Beechcraft Corporation. During his tenure at Hawker Beechcraft, Mr. Christians has been involved in a wide range of aerodynamic disciplines including general aircraft performance, stability and control, wind tunnel testing, flight test/mission planning as well as post-test analysis and the regulatory process and procedures necessary to certify general aviation aircraft. He is currently both a company AR (Authorized Representative) and an FAA DER (Designated Engineering Representative) for both Part 23 and Part 25 aircraft. Mr. Christians is currently recognized as the company Subject Matter Expert for wind tunnel testing.

Mr. Christians is board member of the Aero-Labs Industry Advisor Board of the National Institute for Aviation Research at Wichita State University. He is also an active member of the local chapter of AIAA where he has served as the Pre-College Outreach Chairperson for several years. Mr. Christians has a BS in Aeronautical Engineering from Wichita State University.

Scott Cruzen is currently Vice President, Advanced Design and Technology at Williams International, headquartered in Walled Lake, Michigan. Mr. Cruzen's organization is responsible for design and development of advanced gas turbine and rocket engines and engine components, including rig, wind tunnel, and flight test research. Mr. Cruzen has 32 years experience in design and development of component, materials, and observables technologies, ranging from analytical studies through development and flight testing of engines for manned aircraft, missiles, hypersonic vehicles, aerial targets, and UAVs. Mr. Cruzen holds a BS in Mechanical Engineering from the University of Michigan, 1978.

Christopher Curnes is currently a Lead Wind Tunnel Test Engineer for Northrop Grumman Corporation in El Segundo, California. In this capacity, he plans and executes wind tunnel tests for NGC advance aeronautics programs including UCAS-N and Oblique Flying Wing. Mr. Curnes has a Bachelor of Science degree in Aerospace Engineering from the Wichita State University (2000). Chris is currently a standing member of AIAA.

John Felter is currently an engineering specialist in the Aerodynamics Department for Cessna Aircraft Company. In this capacity, he leads wind tunnel related activities for the company. Mr. Felter holds a Bachelor of Science (1992) degree in Aeronautical Engineering from

Wichita State University. He is an AIAA senior member and sits on the facilities industry advisory board for Wichita State University.

Mike Foster is Group Head, Applied Aerodynamics and Flight Dynamics for Gulfstream Aerospace Corporation, Savannah, GA. He leads a team of 15 engineers charged with aero design and performance, stability and control, and flying / handling qualities for non-supersonic programs at the company. His technical area of specialty is wind tunnel testing, executing the Gulfstream V, G450, and G550 wind tunnel test programs as well as several Special Mission modification tests for these aircraft. Prior to joining Gulfstream, Mike was Technical Manager of the Northrop B-2 Division Aero Design and Vehicle Performance group. This group was responsible for B-2 aero lines development, aero performance, and static stability and control. Mike spent the first seven years of his career planning and executing the B-2 wind tunnel test program, including force and moment testing, loads, propulsion, air data system development, spin and weapon bay effects / weapon integration. After the wind tunnel program, Mike represented his group at Edwards AFB during the early flight testing of the B-2. Mike has conducted tests at DOD, NASA and commercial test facilities, as well as several foreign facilities. He is continuing this broad exposure to facilities with Gulfstream today on currently developing projects. Mike is an Associate Fellow of AIAA, and has served the Savannah Section as Chair, Communications Chair, and several other positions. He received a BSASE degree from the University of Texas at Austin in 1981.

Wendy Lacy is the Supervisor of Testing Methods, Technologies, Stress and Balances at the Aero/Noise/Propulsion/Structural Dynamics Laboratory (ANPSDL) with Boeing Commercial Airplanes. Wendy leads 17 Engineers and technicians in the advancement of aero, acoustic, and propulsion testing technologies, processes, and methods. Wendy has had a diverse career at Boeing spanning everything from CFD development, to Product Development, to Technology Development and now combines all her experiences at the Wind Tunnel. Wendy has a Bachelor of Science degree (1990) in Mathematics from Western Washington University and a Master of Science degree (1995) in Aeronautics and Astronautics from the University of Washington.

Peter Lorber is currently Manager of Experimental Aeromechanics at Sikorsky Aircraft Corporation, a United Technologies Company. His section is responsible for model design, fabrication, and test (whirl stand and wind tunnel) in support of helicopter development programs (H-53, S-76, S-92, H-60) and advanced rotorcraft concept evaluation. He was previously a Principal Research Engineer and Project Leader at United Technologies Research Center. He received the BS degree from Cornell University (1979), and the PhD in Aerodynamics from MIT (1984). He is a member of AIAA and a past member of the Aerodynamics Committee of the American Helicopter Society.

Michael McWithey currently leads the aerodynamics group at Lockheed Martin Missiles and Fire Control in Dallas, TX. In this capacity, he leads a group of 12 engineers responsible for the aerodynamic design and analysis of tactical and air defense missile systems, including the Guided MLRS artillery rocket, Army Tactical Missile System, and the Patriot PAC-3 air defense missile. Expertise includes transonic and supersonic wind tunnel testing, store separation testing, and dispense flow field survey testing. Michael has a Bachelor of Science degree in Aerospace Engineering from Virginia Tech (1994). Michael is a member of the AIAA Missile Systems Technical Committee.

Mark Melanson is the Manager of Model Design and Test for Lockheed Martin Aeronautics in Fort Worth, Texas. In this capacity, he leads a group of approximately 50 engineers responsible for the development of wind tunnel and radar cross section models and the planning and execution of wind tunnel tests for LM Aeronautics programs including F-16, F-22, and the Joint Strike Fighter (F-35). Mr. Melanson has a Bachelor of Science degree in Aerospace Engineering from the University of Texas at Austin (1979). Mark is a AIAA Associate Fellow and Chair of the Ground Test Technical Committee (GTTC). Mark also serves as the chair of the U.S. Industry Aeronautics Test Facilities Working Group and chairs the Lockheed Martin Wind Tunnel Test Focus group.

Roger Radomsky is currently a Section Head in the Aerodynamics Department for Raytheon Missile Systems in Tucson, Arizona. In this capacity, he leads a group of 6 engineers responsible for the Strike Product Line with programs including JSOW, Tomahawk and Paveway. Roger holds a Bachelor of Science (1994) and a Masters degree (1996) in Mechanical Engineering from the University of Wyoming. Roger also has a Ph.D. in Mechanical Engineering from the University of Wisconsin at Madison (2000).

Greg Rincker is the Senior Manager of Aerodynamics and Product Analysis at Cessna Aircraft Co. in Wichita, KS. Greg oversees 30 engineers in the process of advancing all new Cessna aircraft designs through conceptual design, wind tunnel testing, development, flight development, support for certification and eventually sustaining. Theses engineers are professionals in computational fluid dynamics, testing, performance, handling qualities, engine integration and simulation. Greg has a Bachelor of Science degree in Aeronautical Engineering from Wichita State University (1976) and a MSOL business degree from Newman University, Wichita KS (2000).

Sheri Smith-Brito is the Strategic Technology Leader for Aerodynamics, Propulsion and Acoustics for the Enterprise Laboratories and Test Technologies group within the Engineering, Operations and Technology organization of The Boeing Company. Sheri integrates the test needs and strategies of sites and business units to optimize test resources, including technology/process investments that support the development of current and future Boeing products. Sheri also leads the Boeing Enterprise Wind Tunnels Center of Excellence. Previously, Sheri has worked as a test engineer, and led a developmental aircraft wind tunnel test program. She has also managed laboratory capital and technology investment portfolios, and wind tunnel operations. Sheri holds a Bachelor of Science Degree in Aeronautics and Astronautics from the University of Washington.

Tom Wayman is currently an Aerodynamicist in Preliminary Design for Gulfstream Aerospace Corporation, Savannah, GA. In this capacity, he leads both experimental testing activities and aero-propulsion computational analysis for a variety of subsonic and supersonic activities. Previously he lead aerodynamic and aircraft airworthiness activities for the Airborne Laser Program (a USAF modified 747-400) and the 767 Tanker Program at Boeing, Wichita, KS. Tom has a Bachelor of Science degree in Aerospace Engineering from the Iowa State University (1988), a Master of Science degree in Aeronautical Engineering from Wichita State University (1993), a Diploma in Aeronautical Engineering from the von Karman Institute for Fluid Dynamics (1994), and is a Ph. D. candidate in Aeronautical Engineering from Wichita State University. Tom is currently a member of the AIAA Applied Aerodynamics Technical Committee and former AIAA Region V Deputy Director of Technical.

Tom Wood is the Technical Director for the Bell-Boeing entry into the Joint Heavy Lift Concept Development Analysis. Previous assignments have involved all aspects of defining and testing both aerodynamic and handling qualities configurations for both helicopters and tilt rotors including wind tunnel and flight. He was responsible for technical content of LH aerodynamic testing, tiltrotor download and forward flight testing, and pressure instrumented rotor testing. Tom received his BS in Aerospace Engineering from University of Texas at Arlington (1969) and his MS in Mechanical Engineering from University of Texas at Arlington (1972). He was awarded the American Helicopter Society's Howard Hughes Award (1984) and Paul E. Hauter Award (2005). He is currently a Designated Engineering Representative for the FAA and holds two active patents.