TESTIMONY

Roles and Issues of NASA's Wind Tunnel and Propulsion Test Facilities for American Aeronautics

PHILIP S. ANTÓN

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1776 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
1200 South Hayes Street, Arlington, VA 22202-5050
201 North Craig Street, Suite 202, Pittsburgh, PA 15213-1516
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Statement of Dr. Philip S. Antón[1]
Director, Acquisition and Technology Policy Center
The RAND Corporation

Before the Committee on Science
Subcommittee on Space and Aeronautics
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Chairman Calvert, and distinguished members of the Committee, thank you for inviting me to testify today on the roles and issues of NASA's wind tunnel and propulsion test facilities for American aeronautics. It is an honor and pleasure to be here.

INTRODUCTION

My comments today are informed by a recent RAND Corporation assessment of America's needs for wind tunnel and propulsion test (WT/PT) facilities,[2] and NASA's capabilities to serve those needs. We focused on the needs for, and capabilities of, the large (and, thus, more expensive to build and operate) test facilities in six types of WT/PT facilities—subsonic, transonic, supersonic, hypersonic, hypersonic propulsion integration, and direct-connect propulsion—as well as any management issues they face. RAND conducted this research from June 2002 through July 2003, followed by refinement of our findings, peer review, and the generation of study reports. The results

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[2] Throughout this testimony, I use the term "WT/PT facilities" to mean wind tunnel facilities and propulsion test facilities. Since individual facilities within this designation can be either wind tunnel facilities, propulsion test facilities, or both, "WT/PT facilities" serves as a generic term to encompass them all. That being said, when a specific facility is talked about, for clarity, I refer to it using its owner/operator, size, and type. As well, the term "test facilities" and "facilities" can be substituted to mean "WT/PT facilities." Of course, NASA owns and operates other types of test facilities, but my conclusions and recommendations do not apply to them unless explicitly stated doing so.

of the RAND study were published in 2004.[3] The study methodology involved a systematic review and analysis of national research, development, test, and evaluation (RDT&E) and sustainment needs, utilization trends (historical and projected), test facility capabilities, and management issues.

While some things have changed since our study concluded (particularly declines of NASA's research programs and aeronautics budget and closure of three facilities), our technical assessments and much of our strategic assessments remain valid.

In addition to leading this study, I have also remained active in supporting government assessments of issues and options related to WT/PT facilities. My statements below also reflect analysis and experiences related to those activities.

Study Activities

To answer these study questions, RAND conducted intensive and extensive interviews with personnel from NASA headquarters; personnel from NASA research centers at Ames (Moffett Field, Calif.), Glenn (Cleveland, Ohio), and Langley (Hampton, Va.), which own and manage NASA's WT/PT facilities; the staff of the Department of Defense's (DoD's) WT/PT facilities at the U.S. Air Force's Arnold Engineering and Development Center (AEDC, at Arnold AFB, Tenn.); selected domestic and foreign test facility owners and operators; U.S. government and service project officers with aeronautic programs; and officials in a number of leading aerospace companies with commercial, military, and space access interests and products.

In addition to RAND research staff, the study employed a number of distinguished senior advisers and consultants to help analyze the data received and to augment the information based on their own expertise with aeronautic testing needs and various national and international facilities.

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[3] See Antón, Philip S., Richard Mesic, Eugene C. Gritton, and Paul Steinberg, with Dana J. Johnson, Michael Block, Michael Brown, Jeffrey Drezner, James Dryden, Tom Hamilton, Thor Hogan, Deborah Peetz, Raj Raman, Joe Strong, and William Trimble, *Wind Tunnel and Propulsion Test Facilities: An Assessment of NASA's Capabilities to Meet National Needs*, Santa Monica, Calif.: RAND Corporation, MG-178-NASA/OSD, 2004, available at www.rand.org/publications/MG/MG178/; and Antón, Philip S., Dana J. Johnson, Michael Block, Michael Brown, Jeffrey Drezner, James Dryden, Eugene C. Gritton, Tom Hamilton, Thor Hogan, Richard Mesic, Deborah Peetz, Raj Raman, Paul Steinberg, Joe Strong, and William Trimble, *Wind Tunnels and Propulsion Test Facilities: Supporting Analyses to an Assessment of NASA's Capabilities to Serve National Needs*, Santa Monica, Calif.: RAND Corporation, TR-134-NASA/OSD, 2004, available at www.rand.org/publications/TR/TR134/.

Finally, the study reviewed and benefited from numerous related studies conducted over the past several years.

Perspectives on the Study Approach Used by RAND

The analytic method used in the study to define needs did not rely on an explicit national policy and strategy document for aeronautics in general or for WT/PT facilities in particular because they do not exist. Lacking such explicit needs documents, we examined what categories of aeronautic vehicles the United States is currently pursuing, plans to pursue, and will likely pursue based on strategic objectives and current vehicles in use.

Also, as *enabling infrastructures*, WT/PT facility operations are not funded directly by specific line items in the NASA budget.[4] The study's determination of WT/PT facility needs and the resulting conclusions and recommendations are therefore not based on the federal budget process as a direct indicator of policy dictates of facility need. We determined WT/PT facility need by identifying what testing capabilities and facilities are required given current engineering needs, alternative approaches, and engineering cost/benefit trade-offs. This, of course, can lead to a bias in the findings in that these assessments may be overly reflective of what the engineering field determines is important rather than what specific program managers are willing to spend on testing because of program budget constraints. Thus, when a needed facility is closed because of a lack of funding, there is a disconnect between current funding and prudent engineering need. This indicates that the commercial and federal budget processes may be out of step with the full cost associated with research and design of a particular vehicle class, indicating a lack of addressing long-term costs and benefits.

Finally, while the study's focus was on national needs and NASA's WT/PT facility infrastructure, national needs are not dictated or met solely by NASA's test infrastructure; DoD, U.S. industry, and foreign facilities also serve many national needs. Our study did look at *technical* capabilities of alternate facilities. However, the study was *not* chartered or resourced to examine the entire sets of cost and other data for these alternative facilities to fully understand consolidation opportunities *between NASA and*

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[4] The *construction* of government WT/PT facilities are, however, very large expenditures that require explicit congressional funding, and certain facilities such as the National and Unitary facilities have associated congressional directives regarding operation and intent.

non-NASA WT infrastructures. Based on our findings, however, such a broader study is important and warranted.

WHAT WOULD BE THE CONSEQUENCE TO AMERICAN AVIATION OF NASA CLOSING ONE OR MORE WIND TUNNELS?

> ***When NASA closes one or more strategically important wind tunnel and propulsion test facilities, it eats away at our aeronautic future.***

Closing facilities needed for strategic reasons cuts off the country's options for research and development of current and future concepts and vehicles. Even if current budgetary priorities limit on-going aeronautic research, we should not "eat our seed corn" given that it often takes a decade to build these kinds of major facilities, more years to fund them; and replacing all these facilities would cost billions. Does the country want to have a future in advanced aeronautics, or will it decide to relegate future aeronautic leadership to foreign countries who are aggressively pursuing our position and its economic fruits?

To understand why this is so, let me review why this country needs wind tunnel and propulsion test facilities. In particular, I would emphasize that this concern applies to strategically important facilities, not simply all facilities regardless of current need.

Background

Wind tunnel and propulsion test facilities continue to play important roles in the research and development (R&D) of new or modified aeronautic systems and in the test and evaluation (T&E) and sustainment of developmental systems. The nation has invested about a billion dollars (an unadjusted total) in NASA's existing large, complex WT/PT facilities[5] (some dating from the World War II era), which has created a testing infrastructure that has helped secure the country's national security and prosperity

[5] The Book Value of 26 of the 31 NASA facilities that fell within the scope of RAND's study amounted to about $0.9 billion dollars based on data identified in the NASA Real Property Database. The book value is the simple sum of unadjusted dollars invested in past years in facility construction or modernization. Because, in many cases, decades have passed since construction, the book value is significantly lower than the cost it would take to build these facilities today.

through advances in commercial and military aeronautics and space systems. Replacing these facilities would cost billions in today's dollars.[6]

Many of these test facilities were built when the United States was researching and producing aircraft at a higher rate than it does today and before advances in modeling and simulation occurred. This situation raises the question of whether NASA needs all the WT/PT facilities it has and whether the ones NASA does have serve future needs. In fact, over the past two decades, NASA has reduced its number of WT/PT facilities by one-third. More recently, the agency has closed additional facilities. In addition, some of the remaining facilities are experiencing patterns of declining use that suggest they too may face closure.

Despite Aeronautic Maturity, Test Facilities Are Still Critical

Some argue that the facility testing capabilities that have been built up over the years are no longer needed. They assert that the aeronautics industry has matured and that any test capability needs can be met through computer simulation or other means.

Our research generally confirms industry maturity, but that maturity *relies on* the test facility infrastructure. No vehicle classes have gone away, and for each new design in a class, it will still be necessary to predict airflow behavior across a range of design considerations.

Although applied aeronautics encompasses relatively mature science and engineering disciplines, there is still significant art and empirical testing involved in predicting and assessing the implications of the interactions between aeronautic vehicles and the environments through which they fly. Designers are often surprised by what they find in testing their concepts despite decades of design experience and dramatic advances in computer modeling and simulation known as computational fluid dynamics (CFD). This is, of course, especially true for complex new concepts that are not extensions of

[6] The current replacement value (CRV) of 26 of the 31 NASA facilities that fell within the scope of RAND's study totaled about $2.5 billion dollars based on data identified in the NASA Real Property Database. The CRV is derived by looking at similar types of buildings (e.g., usage, size) within the Engineering News Magazine's section on construction economics. The magazine uses a 20-city average to come up with rough estimates of how much a building would cost to replace. Most NASA finance and facilities people believe that this average underestimates the actual cost of replacing WT/PT facilities, since they are more complex buildings than the "similar" building types available through engineering economics. Unfortunately, NASA has not found a better metric to compare buildings across the various field centers.

established systems with which engineers have extensive practical design and flight experience. But even improving the performance at the margin of well-established and refined designs—for example, commercial jet liners in areas such as reduced drag, fuel efficiency, emissions, noise, and safety (e.g., in adverse weather)—depends on appropriate and sufficient WT/PT facility testing.

Insufficient testing or testing in inappropriate facilities can lead to erroneous estimations of performance. Missed performance guarantees can impose extremely costly penalties or redesign efforts on airframe manufacturers, overly conservative designs from low estimations prevent trade-offs such as range for payload, and even a seemingly small one-percent reduction in drag equates to several million dollars in savings per year for a typical aircraft fleet operator.

For engineers to predict with sufficient accuracy the performance of their vehicles during design and retrofit, they need a range of capabilities during testing, including high Reynolds number (Rn),[7] flow quality, size, speed, and propulsion simulation and integration. These capabilities cannot be met by a single test facility but rather require a suite of facilities.

While CFD has made inroads in reducing some empirical test requirements capabilities, this technology will not replace the need for test facilities for the foreseeable future. Flight testing complements but does not replace WT/PT facilities because of its high costs and instrumentation limitations. The aeronautic engineering community does not have well-accepted handbooks of facility testing "best practices" or even rules of thumb from which to deduce testing requirements, nor is it possible from historical data to accurately predict returns on specific facility testing in terms of programmatic cost savings or risk reduction.

Thus, *aeronautic maturity does not nullify the need for test facilities but in fact relies on the availability and effective use of test facilities to provide important*

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[7] The Reynolds number is a nondimensional parameter describing the ratio of momentum forces to viscous forces in a fluid. The Mach number is a more familiar nondimensional parameter, describing the ratio of velocity to the sound speed in the fluid. When the flows around similarly shaped objects share the same nondimensional Rn and Mach parameters, the topology of the flow for each will be identical (e.g., laminar and turbulent flow distribution, location of separation points, wake structure), and the same aerodynamic coefficients will apply. Airflow behavior changes nonlinearly and unpredictably with changes in Rn. Thus, it is important to test the flow conditions at flight (or near-flight) Rn to ensure that the flows behave as expected and that conditions such as undesired turbulence, separations, and buffeting do not occur.

capabilities. The nation continues to need general-purpose WT/PT facilities across all speed regimes, as well as for specialty tests facilities. These facilities advance aerospace research, facilitate vehicle design and development, and reduce design and performance risks in aeronautic vehicles.

ARE THERE PARTICULAR WIND TUNNELS THAT IT WOULD BE ESPECIALLY DETRIMENTAL TO CLOSE?

> ***It would be detrimental to close any 29 of the 31 NASA test facilities that serve national needs. Nine facilities—for which no alternatives exist within the U.S. regardless of cost—would be especially detrimental to close.***

Identifying Facilities Detrimental to Close: a "Minimum Set"

RAND used four factors to assess which NASA facilities constitute the minimum set of strategically important facilities: alignment with national needs, technical competitiveness, redundancy, and usage.

First, facilities in the minimum set must serve national needs. Thus, facilities that no longer meet national needs are discarded from consideration out of hand.

Next, the *primary* NASA facilities that serve national needs are included in the set. These are the primary facilities that NASA has to serve each national need. Until the need disappears or analysis can determine that it is better served outside NASA (see the discussion on collaboration and reliance below), the agency should include it in the minimum set.

Finally, facilities that are redundant to the primary facilities may or may not be included in the set depending on their technical competitiveness and utilization.

Nearly All of NASA Facilities Serve Strategic National Needs

We examined how well NASA's portfolio of 31 test facilities aligns against national strategic needs in each of six categories—subsonic, transonic, supersonic, hypersonic, hypersonic propulsion integration, and direct-connect propulsion. Nearly all existing NASA facilities serve at least one strategic need category important to the nation's continuing ability to design aeronautic vehicles. We found very little overlap and very few gaps in coverage.

NASA's WT/PT facilities have been generally consistent with the testing needs of NASA's research programs, as well as with those of the broader national research and development programs. Currently, redundancy is minimal across NASA. Facility closures in the past decade have eliminated almost a third of the agency's test facilities in the categories under review in this study. In nearly all test categories, NASA has a single facility that serves the general- or special-purpose testing needs, although some primary facilities also provide secondary capabilities in other test categories. We found two noncritical WTs: (1) the Langley 12-Foot Subsonic Atmospheric WT Lab, which is redundant to the Langley 14×22-Foot Subsonic Atmospheric WT, and (2) the Langley 16-Foot Transonic Atmospheric WT, which is generally redundant to the Ames 11-Foot Transonic High-Rn and Langley National Transonic Facility WTs run in low-Rn conditions.

There are gaps in NASA's ability to serve all national needs. In most of these cases, though, DoD or commercial facilities step in to serve the gaps.

Finally, some of NASA's facilities that serve national needs have been mothballed or closed. While mothballing an important facility is preferred to abandonment, mothballing involves the loss of workforce expertise required to safely and effectively operate the facility. Thus, mothballing is not an effective solution for dealing with long periods of low utilization, and it puts capabilities at risk.

29 of 31 Facilities Should Be in NASA's "Minimum Set"

Based on RAND's assessment of national needs, survey data of test users' strategic needs to produce the kinds of vehicles they research or develop, technical capabilities within NASA, and usage data, RAND's study concluded that 29 of the 31 existing major NASA test facilities constitute the "minimum set" of facilities important to retain and manage to serve national needs. Thus, the test complex within NASA is both responsive to serving national needs and mostly "right sized" to the range of national aeronautic engineering needs. Closing any of the 29 would be detrimental.

It is important to bear in mind that, while not the case within NASA, a few of NASA's facilities are redundant when considering the technical capabilities of the larger set of facilities maintained by commercial entities and by the DoD's AEDC. All such NASA facilities had strategic advocacy resulting from unique features such as cost effectiveness (e.g., due to their smaller size), technical capabilities, and proximity to researchers. Whether these redundancies amount to the "unnecessary duplication" of facilities prohibited by the National Aeronautics and Space Act of 1958 was beyond the scope of RAND's study. Further analysis of technical, cost, and availability issues is required to determine whether WT/PT facility consolidation and right-sizing across NASA and AEDC to establish a national reliance test facility plan would provide a *net* *savings* to the government and result in a smaller minimum set of WT/PT facilities at NASA.

Congress has expressed interest in collaboration between NASA and the DoD.[8] NASA and the DoD (through the National Aeronautics Test Alliance—NATA) have made some progress in their partnership,[9] but NASA's recent unilateral decision to close two facilities at Ames without high-level DoD review shows that progress has been spotty. Some in industry have expressed an interest in exploring collaborative arrangements with NASA and hope that RAND's study will reveal to others in industry the risks to NASA's facilities and the need for industry to coordinate its consolidations with those of NASA and the DoD. Our study provides insights into the problem but offers only glimpses into the wider possibilities and issues surrounding broader collaboration.

Which Are Especially Detrimental to Close?

In an attempt to identify which of those 29 facilities would be *especially* detrimental to close, I utilized the data from the RAND study using the following criteria:

> *The facilities most detrimental to close are those that serve national needs that cannot be met by any other U.S. facility regardless of cost, moderate improvements, or access concerns.*

In using these criteria to form a list of those facilities especially detrimental to close, it is important to note the following:

1. If the facilities that did not make this list are closed, then the testing costs to go to other U.S. facilities may be much higher, and relying on them may, in the long run, cost this country more money, especially in future research programs that would probably have to spend more on testing in alternative facilities than they would otherwise. In many cases, alternative facilities are more sophisticated and have more capabilities than needed (e.g., they are larger or have additional technical features that cost more). An analogy would be to eliminate the ability of a consumer to use a compact pickup truck, leaving them the only alternative of

[8] See, for example, the GAO report on NASA and DoD cooperation entitled *Aerospace Testing: Promise of Closer NASA/DoD Cooperation Remains Largely Unfulfilled*, 1998.

[9] For example, NATA has produced a number of joint NASA and DoD consolidation studies.

driving a semi truck to work despite the fact that the added capabilities of the semi were not needed in all cases.

2. Higher testing costs at alternative U.S. facilities may drive users to cheaper foreign facilities, reducing the amount of domestic facility business and incurring risks discussed later related to foreign facility testing.
3. Each test facility is unique in some way, so this list does not consider all technical differences.
4. The facilities most detrimental to close would affect any strategic national need from all sectors—NASA research, civil aviation, military, and space—not just NASA research needs. Therefore, this list in some way assumes that NASA, as a "National" agency, still has a role in supporting not just NASA's own research needs but the nation's aeronautic needs. With a lack of a recent national aeronautics policy, it is difficult to see if there has been an objective, long-term policy shift away from NASA having a role as a national steward of government infrastructure, or whether there has been just a *short-term* budgetary prioritization forcing NASA to focus on infrastructure needed for its own current research.

There are nine facilities meeting these criteria based on the data available from the RAND study that would be especially detrimental to close:

- *Subsonic*
  - Ames 12-Foot High-Reynolds number pressure wind tunnel, needed, for example, for high-lift vehicle research and development such as super-short take-off and landing commercial and military passenger, cargo, and tanker transports,[10]
  - Ames National Full-Scale Aerodynamics Complex (NFAC), needed, for example, for rotorcraft and noise reduction research and development, and
  - Glenn Icing Research Tunnel, needed for icing research and certification testing, for example, to prevent accidents from flying in icing conditions.
- *Transonic*

[10] This facility is currently closed but is the only U.S. capability in this category and has been historically important for civil, space, and military vehicle RDT&E. Currently, however, the facility has some undesirable features and limitations that render it unacceptable for both commercial transport and tactical aircraft development when compared with the two superior facilities in Europe: the QinetiQ 5-Metre in the United Kingdom and the ONERA F1 in France. Users are currently using facilities in Europe, particularly the QinetiQ 5-Metre.

  - Langley National Transonic Facility (NTF), needed, for example, to validate computational models and test data from lower Reynolds number facilities for transports and high-dynamic fighters,
  - Langley Transonic Dynamics Tunnel (TDT), needed, for example, to test for noise problems and dynamic effects such as the tail buffeting problem not discovered by the F/A-18A program until flight testing.
- *Hypersonic* (needed to pursue future concepts of hypersonic transport or space access vehicles and missiles)[11]
  - Langley 8-Foot High-Temperature Tunnel (HTT), needed for a broad range of moderately high Mach numbers, is the most important hypersonic facility in this list,
  - Langley 20-Inch Mach 6 Tetraflouromethane (M6 CF4) and the companion Langley 20-Inch Mach 6 Air, needed, for example, to understand real-gas effects,
  - Glenn Hypersonic Tunnel Facility (HTF), needed, for example, to understand whether combustion byproducts in other facilities is preventing advances in air-breathing Ramjet and Scramjet that don't require carrying oxygen for combustion.

Note that most of these facilities could not be operated as a commercial venture without shared financial support (as evidence by their low current utilization and financial difficulties). Nearly all would be too expensive for industry to build on their own. Thus, emphasizing the significance of losing them.

ARE THERE WAYS NASA COULD SEEK OUTSIDE FUNDING FOR ITS WIND TUNNELS?

There are outside funding options for NASA, but their viability is unclear.

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[11] Note that users in our surveys rated nearly all of NASA's hypersonic facilities as *essential* for continued progress. Thus, it is particularly difficult to identify those that are especially detrimental to lose given that each facility offers important capabilities. Because hypersonics is still relatively immature, those differences are important in resolving the wide variety of challenges facing the research, development, and production communities. Nevertheless, the Langley 8-Foot HTT is definitely the most advocated facility, and the two Langley Mach 6 tunnels and the Glenn HTF offer significant capabilities not available elsewhere in the U.S.

The RAND study did not explore in depth the question of outside funding mechanisms, but there are some obvious candidates for consideration. Possibilities to explore include retainer or consortia fees from outside users from industry, or opening NASA's facilities to international users (assuming we want to make our national capabilities available to potential economic competitors). NASA is already exploring some of these options with US industry.

NASA could also explore shared funding mechanisms with the DoD, but that, of course, would not reduce the burden on the federal budget and begs the question of who in the federal government is responsible for looking out for the long-term strategic aeronautic needs of the nation.

ARE THERE WAYS NASA COULD CHANGE ITS ACCOUNTING PRACTICES REGARDING ITS WIND TUNNELS?

> ***Elimination of full-cost recovery for test facilities and identifying shared financial support are recommended options.***

Why Are Financial Accounting and Shared Support So Important?

The current full-cost recovery (FCR) accounting policy imposed by NASA on the centers discourages use and endanger strategic facilities by causing wide, unpredictable price fluctuations in a world where government and commercial testing budgets are under pressure and are set years in advance. It appears reasonable to ask users to pay for the costs *associated with their tests* (i.e., to pay for the short-term benefits), but forcing them to pay *all* operating costs (including long-term priorities such as the costs for facility time they are not using) through FCR *direct test pricing* (as is done at Ames) is ill advised.

FCR has especially serious implications for the financial health of those facilities that are underutilized (about one-third of the facilities in general, with variation across the test facility category types). Average-cost-based pricing, decentralized budgeting, poor strategic coordination between buyers and providers of NASA WT/PT facility services, and poor balancing of short- and long-term priorities inside and outside NASA are creating unnecessary financial problems that leave elements of the U.S. WT/PT facility capacity underfunded. With declining usage and FCR accounting, these facilities run the risk of financial collapse. Identifying shared financial support will keep NASA's minimum set of facilities from financial collapse given the long-term need for these facilities.

In the extreme case at Ames, the lack of resident aeronautics research programs, combined with the center management's strategic focus toward information technology and away from ground test facilities, has left Ames WT/PT facilities without support beyond user testing fees. Thus, Ames WT/PT facilities are vulnerable to budgetary shortfalls given low utilization. Two Ames facilities are unique and needed in the United States, yet they have already been closed. One (the Ames NFAC) is in the process of being transferred to DoD operation, but the other remains abandoned.

Shared support would be relatively small. Even the total operating costs of about \$130 million per year for these important facilities make up less than 1 percent of NASA's overall budget and are infinitesimal relative to the \$32–58 billion the nation invests annually in aerospace research, development, test, and evaluation (RDT&E).

If NASA management is not proactive in providing financial support for such facilities beyond what is likely to be available from FCR pricing, then the facilities are in danger of financial collapse. In the near term, this market-driven result may allow NASA to reallocate its resources to serve more pressing near-term needs at the expense of long-term needs for WT/PT facilities. Given the continuing need for the capabilities offered by these facilities for the RDT&E of aeronautic and space vehicles related to the general welfare and security of the United States, the right-sizing NASA has accomplished to date, the indeterminate costs to decommission or eliminate these facilities, the significant time and money that would be required to develop new replacement WT/PT facilities, and the relatively modest resources required to sustain these facilities, care should be taken to balance near-term benefits against long-term risks. Collaboration, reliance, and ownership transferal options for obtaining alternative capabilities in lieu of certain facilities are possible, but even if these options are exercised, many NASA facilities will remain unique and critical to serving national needs. Key to subsequent analysis of these options is the collection and availability of the full costs of operating these facilities as well as the full costs associated with relying on alternative facilities.

Accounting Options

RAND identified a few accounting options to recovering full operating costs through user fees.

Taxing Research Programs. NASA Langley and Glenn tax the resident research programs to supplement user fees and ensure that test facilities are kept open. However, the ability to keep current facilities open through those taxing mechanisms are at risk as the aeronautics research program budgets continue to decline. Also, NASA Ames currently does not have a resident aeronautics research program to tax.

Line Item and MRTFB-Like Model. NASA Headquarters could consider creating a line item in the budget to provide financial shared support for strategic facilities. The DoD's Major Range and Test Facility Base (MRTFB) model, with direct financial support, is the most mature and has served the DoD well. This support has allowed the DoD to keep its strategic facilities open through times of low utilization. The DoD Financial Management Regulation provide lessons learned through its user accounting and management guidelines, essentially charging users for the direct costs associated with their tests but not the full costs to keep the facility open for the year.

UK MOD Outsourcing Model. Finally, another accounting and management option is the facility operations outsourcing model recently enacted by the UK Ministry of Defence (MOD) for its T&E facilities.

Under this model, the MOD identified the T&E facilities it needed for the future and then privatized the operation of those facilities. Ownership of the fixed equipment and land were retained by the MOD for indemnity reasons, but ownership of the movable items was transferred to a private company, QinetiQ.

Under the model, QinetiQ has a 25-year contract for operating the facilities. The contract is structured to encourage the company to implement efficiencies while retaining the long-term health and availability of the facilities. QinetiQ gets to keep the efficiency savings realized during the then-current five-year period of the contract. When the next five-year period is negotiated, the MOD receives the benefits of the efficiencies by adjusting the period funding amount to the new efficiency level.

The key to this model was the MOD's access to all facility costs to ensure that support levels in the contract guarantee the success of QinetiQ and the facilities. In U.S. parlance, this would require open full-cost accounting not only of the facilities but also of the acquisition programs that rely on the facilities.

The model employs shared support for the facilities. In the current five-year period, the MOD centrally funds 84 percent of facility costs to keep the facilities' doors open. Sixteen percent of the funding comes from programs to support direct costs of specific program test activities. In the past, the MOD had to query programs for how much they would put in first. Now, the health of the facilities are ensured and planned for, regardless of the realized utilization in the known-variable environment.

The MOD implemented the model in 2003, so the long-term success of it has yet to be established. Nevertheless, some important observations can be made. The MOD made a conscious, objective decision about which facilities are strategically important in the long term (25 years, in this case). The ministry ensured that it accounted for all the costs to inform its decision. It provided shared support for the facilities to ensure their long-term health, independent of the yearly utilization. While not having to perform the actual operation of the facilities, the MOD provided controls and incentives to realize efficiency and cost savings while ensuring quality and availability of needed facilities. NASA could learn from these observations.

Full-Cost Accounting. Finally, while our study recommended that NASA should change its policy of Full-Cost Recovery (where operators must recover the full annual costs of operating facilities from the users regardless of the actual utilization of those facilities), we applaud NASA's implementation of Full-Cost Accounting (that ensures we know the full costs of operating activities). It is important to know the full costs of operations to inform management analysis and decision-making.

WHAT ARE THE DISADVANTAGES OF RELYING ON FOREIGN WIND TUNNELS, AND HOW SERIOUS ARE THEY?

Relying on foreign facilities incurs serious security risks, and unclear access and availability risks.

The RAND study did not explore in depth the policy issues of relying on foreign wind tunnel, but some observations and references can be made. It appears that the main disadvantages are security, access, and availability risks.

As a continuation of my involvement in this area, I have been briefed on an assessment performed by the DoD Counterintelligence Field Activity (CIFA) on foreign test facilities.[12] That report indicated that there are real security risks to testing in foreign facilities. "Without tight controls on access and data management, critical technology is at significant risk for compromise at most, if not all, of the [foreign facilities that CIFA considered,] or in transit to and from them. Despite contractual security specifications, the designs or data deployed to these sites is in a virtual sea of potential collectors whether representing national, commercial or private interests." I commend that report to the committee for its classified details.

[12] "Technology Risk Assessment for European Test Facilities (U)," DoD Counterintelligence Field Activity Report, SECRET, CIFA/DA-218-04, 12 July 2004.

While the RAND study did not analyze them in detail, access and availability are also of concern, especially given an international competitive environment in aeronautics and tensions that arise occasionally (even with allies) and the unstable global business of wind tunnel facility operation. In general, if we rely on foreign facilities for strategically important capabilities, then we put our strategic needs at risk. At the very least, the government should explore reliance agreements to help reduce security risks and establish long-term agreements to ensure access as well as the long-term financial and technical stability of those facility operations.

In the course of our study, RAND did find that there is some reliance on foreign test facilities, particularly on the QinetiQ 5-Metre subsonic high-Reynolds number wind tunnel. If additional NASA facilities are closed, the country will be forced to rely more on foreign facilities for capabilities it cannot find domestically, including those that are inexpensive alternatives to larger, remaining U.S. facilities.

CONCLUSIONS

For NASA leadership, the most critical issues are to:

- develop a specific and clearly understood **aeronautics test technology vision and plan**;
- **identify shared financial support and stop applying full-cost recovery to WT/PT facilities**;
- continue to support developing plans to **very selectively consolidate** and **broadly modernize** existing test facilities; and
- prescribe **common management and accounting directions** for NASA's facilities.

This vision cannot be developed apart from other critical national decisions. It must be informed by the long-term aeronautic needs, visions, and capabilities of both the commercial and military sectors supported by NASA's aeronautical RDT&E complexes. A **national aerospace policy** would greatly inform and guide an aeronautics test technology plan.

Given the inherent inability to reliably and quantitatively predict all needs for RDT&E to support existing programs much beyond a few months out, the tendency of multi-year surges in aeronautic programs, and the trends indicating a continuing decline in needed capacity to support these needs for the foreseeable future, **long-term strategic considerations must dominate**. If this view is accepted, then NASA must find a way to sustain indefinitely and, in a few cases, enhance its important facilities (or seek to ensure reliable and cost-effective alternatives to its facilities) as identified in the RAND study.

While generally not redundant within NASA, a few of NASA's facilities are redundant with those of facilities maintained by the DoD, and others are redundant with commercial facilities. **NASA should work with the DoD to analyze the viability of such a national reliance plan** because it could affect the determination of the future minimum set of facilities NASA must continue to support.

NASA should pursue all three testing approaches—facility, CFD, and flight—to meeting national testing needs; establish the minimum set of facilities important to retain and manage to serve national needs; reassess poorly utilized facilities for strategic, long-term needs rather than eliminate them out of hand; identify financial support concepts to keep its current minimum set of facilities healthy for the good of the country; continue to invest in CFD; eliminate the backlog of maintenance and repair at its facilities; and address hypersonic air-breathing research challenges.

Unless NASA, in collaboration with the DoD, addresses specific deficiencies, investment needs, budgetary difficulties, and collaborative possibilities, the nation risks losing the competitive aeronautics advantage it has enjoyed for decades.

Thank you for the opportunity to contribute to the debate regarding this important issue area in aeronautics. I am happy to answer any questions from the committee.