TESTIMONY

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

Addendum

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Before the Committee on Science
Subcommittee on Space and Aeronautics
United States House of Representatives

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The subsequent questions and answers found in this document were received from the Subcommittee for additional information following the hearing on March 16, 2005, and were submitted for the record.

IS AERONAUTICS MATURE?

> ***Parts of aeronautics are mature while others are evolving. Some aeronautic sectors have shown marked reductions in new vehicle development rates, and the aeronautic engineering discipline is relatively mature compared to where we were decades ago. However, we have not exhausted all aeronautic design opportunities, and aeronautic engineering discipline maturity relies on the test infrastructure that America has developed.***

Some have argued that aeronautics is a "mature" industry and thus the federal government should no longer invest in aeronautics R&D or test infrastructures.

Earlier in my testimony I noted that the aeronautics industry has matured, but the question of industry maturity consists of two major components: *market maturity* (i.e., whether aeronautic vehicle designs have stagnated), and *engineering maturity* (i.e., the

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degree to which engineers know how to research, design, and produce new aeronautic concepts).

While some aeronautics markets are mature in that they are "no longer the subject of great expansion or development"[2] in raw design numbers, other markets are expanding to explore continued evolutionary development or even revolutionary concepts.

There has been a marked decline in the number of new major civil and military aircraft designs since the 1950s.[3] However, the U.S. and foreign countries are continuing to push the design envelopes in the vehicles it is developing (including efficiencies, noise reductions, capacity increases, increased aeronautic performance, reductions in takeoff and landing length requirements, and hybridization of vertical-takeoff-and-landing capabilities with traditional jet flight.) Also, the U.S. is exploring new vehicle types and concepts. For example, many unmanned air vehicles and unmanned combat air vehicle concepts are being researched, developed, and produced. Military concepts for larger vertical-takeoff-and-landing (VTOL) and super-short take-off-and-landing (SSTOL) transport require continued R&D. Interests in commercial supersonic business jets require additional R&D for vehicle designs and sonic boom reduction. Air-breathing hypersonic concepts employing ramjet and scramjet engines are in their infancy yet hold potential for space access, aerospace planes, and military missiles.

The aeronautics community itself has been grappling with the question of how many potentially valuable opportunities await our examination. Professor Ilan Kroo of Stanford University, for example, laid out the data that seems to indicate a lack of innovation giving the appearance of maturity, but he also outlined some innovative concepts that indicate the field has significant expansion and development opportunities.[4] Also, the NASA Blueprint[5] discusses a number of R&D concepts that NASA is

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2 The definition of *maturity* offered for an industry, market, or product by *The American Heritage College Dictionary*, third edition, 1997.

3 See, for example, Figure 2.1, p. 15, of Antón et al., *Wind Tunnels and Propulsion Test Facilities: An Assessment of NASA's Capabilities to Serve National Needs*, Santa Monica, Calif.: RAND Corporation, MG-178-NASA/OSD, www.rand.org/publications/MG/MG178/, 2004.

4 See Kroo, Ilan, "Innovations in Aeronautics," 2004 AIAA Dryden, Lecture, #AIAA-2004-1, *42nd AIAA Aerospace Sciences Meeting*, Reno, NV, January 5-8, 2004.

5 www.aerospace.nasa.gov/aboutus/tf/aero_blueprint/ (last accessed 4/20/05).

considering. Other aeronautic trends and interests are listed in the RAND Corporation's study on test facilities.[6]

There are technical challenges in many of these concepts, but that is the nature of R&D, requiring careful consideration, exploration, and engagement on these challenges to understand their ultimate viability and benefits.

Thus, U.S. aeronautics industry "maturity" (lack of great expansion or development) is less a question of needs and opportunities and more a question of national intent, investment levels, and policy. For example, the cost to produce new vehicle designs continues to rise, and that has a constraining effect on development rates but not absolute cessation of development opportunities.

Conversely, while only parts of the aeronautics *industry* are relatively mature, the *discipline* of aeronautics engineering shows a level of maturity. In particular, while we do not have complete, closed-form understanding of the aeronautic physics in which our vehicle components operate, we know how to use test techniques to experimentally explore the new physical realms in which new vehicle concepts operate. This is especially true for revolutionary new concepts that are not extensions of established systems with which engineers have extensive practical design experience, computational models, and flight experience. Even improving the performance at the margin of well-established and refined designs depends on appropriate and sufficient testing at wind tunnel and propulsion test facilities. Thus, aeronautic engineering *discipline* maturity *relies on the test infrastructure* that America has developed.

DID THE DOD ATTEMPT TO USE, AND THEN ABANDON, FULL-COST RECOVERY FOR ITS TEST FACILITIES? IF SO, WHY?

> ***The Air Force experimented with recovering full costs from users during 1969 to 1972 but found the policy to be detrimental to their facilities, causing unstable and unpredictable pricing and resulting in significant drops in usage despite need.***

NASA has recently required full-cost recovery of full operating costs from the users of its aeronautical test facilities. The DoD tried a similar approach long ago, but it

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[6] See, for example, Chapter 2 of Antón, et al., *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, www.rand.org/publications/TR/TR134/, 2004.

rather quickly went back to an approach that established a budget line to provide funding for its test facilities, with users just being charged for the costs of their tests.

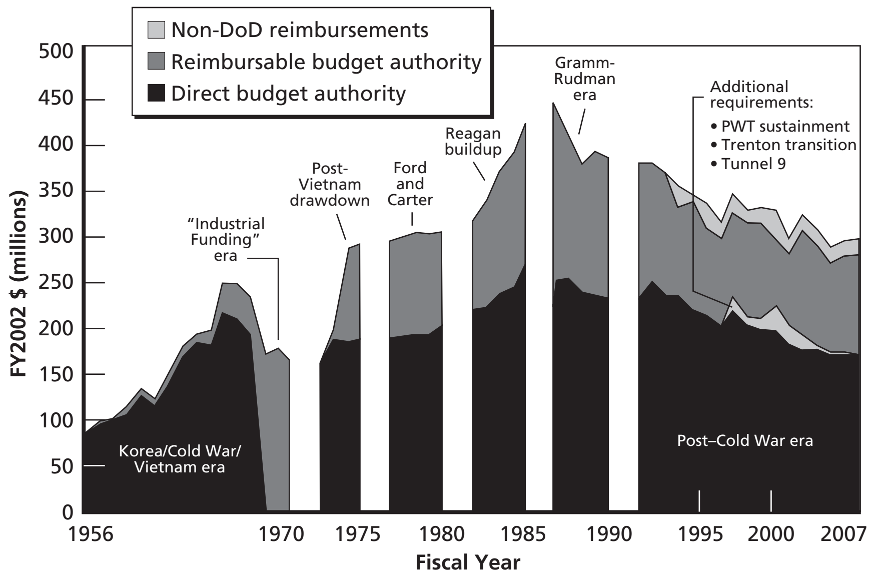
Conceptually, setting test prices to cover all costs is not recommended because it can discourage use and endanger strategic facilities. This approach does give users more information about the full costs for conducting their tests at a facility. If this cost is too high, users can respond by seeking an alternative source of services if it is available; alternatively, users may avoid important testing or test in inferior facilities and obtain degraded or even misleading data. The approach would lead to good outcomes if the alternative facilities are a better value over the long term and strategically important resources are retained. Unfortunately, this approach leads to poor outcomes if a facility is a better long-term value but low near-term utilizations and resulting higher near-term prices mask the long-term value of the facility. The approach is also bad when the remaining users cannot afford the costs to keep open strategic facilities needed in the long term.

When the Air Force experimented with recovering full costs from 1969 to 1972, AEDC found that their prices became inherently unstable and unpredictable because large infrastructure-driven costs had to be spread over an annually variable customer workload base.[7] Also, test customers were not given time to adjust their budgets to accommodate increases in testing prices. As a result, the test workload decreased dramatically (see the "Industrial Funding" era in Figure 1 below). This, in turn, drove up overhead costs and initiated a positive feedback loop that continued driving up prices and driving away users. AEDC found that *testing decisions were being made based on near-term cost considerations rather than strategic considerations to reduce long-term program risks through testing*. The resulting reduced testing loads and reduced income caused significant detrimental effects on AEDC's facilities, including the loss of skilled people, loss of independent analysis and evaluation capabilities, decreased investments for the future, and reduced facility readiness through the loss of maintenance resources.

The financial collapse at AEDC was only halted when shared support through direct budget authority was restored to AEDC. Combined with the need to better account for the full costs of test facilities, the DoD established the Major Range and Test Facilities Base (MRTFB) and advocated that users need to see the cost they impose on a

[7] See Antón et al., *Wind Tunnels and Propulsion Test Facilities: An Assessment of NASA's Capabilities to Serve National Needs*, Santa Monica, Calif.: RAND Corporation, MG-178-NASA/OSD, www.rand.org/publications/MG/MG178/, 2004, pp. 60-62, for a discussion of this topic.

facility while not being asked to pay for unused and underutilized capacity at strategically important test facilities they use. Since 1972 (when direct budget authority was reinstated at AEDC), reimbursements consistently paid for less than half of total operating costs. Thus, over many decades, the DoD has found it vital to provide shared support for its facilities despite fiscal pressures in various eras.



SOURCE: AEDC.
RAND *MG178-4.2*

Figure 1—Historical AEDC Funding