NASA/DoD Cooperation Initiative
Final Report

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Our vision is to regain world leadership in aeronautical and space test facilities in order to ensure U.S. aerospace preeminence well into the 21st century.

The National Advisory Committee for Aeronautics (NASA's predecessor organization) and the first military aeronautical laboratory in Dayton. Ohio, were established by Congress in 1915 because, although the first powered airplane had been developed in the United States, in the pursuit of World War I the European countries had gained a substantial lead in aeronautics. The resulting U.S. national investment in aeronautical test facilities paid off by recapturing U.S. leadership and maintaining that lead for nearly 75 years. In the 1980's, Europe again challenged U.S. leadership in aeronautics by forming Airbus Industries and by making major investments in new wind tunnel testing capability. As a result, Airbus has now captured more than 30 percent of the commercial air transport market, and European wind tunnels, test technology, and instrumentation capability have in many respects moved ahead of U.S. capability. In the mid 1990's, a national study concluded that an investment of about $3 billion was needed to regain U. S. leadership and insure both military aviation superiority and civil aviation market share. It now appears that this investment will be postponed indefinitely because of government downsizing and budget reductions needed to resolve the national budget deficit.

Similarly, in the period 1955 to 1961, the United States responded to foreign competition in space. There was a realization that for national security and scientific reasons the U.S. needed to assigned the highest priority to its efforts in the development of missile and space defense systems and in the exploration of space. Part of the national reaction to this need led to the formation of NASA in October 1958 and the transfer of existing facilities from NACA and DoD to NASA. The significant investment in infrastructure and facilities that followed, provided NASA and DoD with capabilities that led to NASA's first lunar landing in 1969, the deployment of land- and sea-based strategic missile forces by the DoD, and the further exploitation of space systems for both scientific and national security purposes. As a result, today the United States finds itself clearly leading the world in space systems and space exploration but is beginning to notice challenges from foreign competition. The progress of the last 40 years has been built on the investments of the past and has provided the U.S. with its current level of space technology. Without careful consideration of the existing and planned major facilities, future progress may be in jeopardy.

Given this background and the results of the Major Facilities IPT study, it is imperative that a strategy be developed that in the near term maximizes the efficiency and effectiveness of the national investment in aeronautical and space test facilities and, in the longer term, provides facility investments for needed new test capabilities.

The Major Facilities IPT (MFIPT) was formed to develop recommendations on the coordination and management of major facilities at NASA and DoD installations to:

- Increase cooperation,
- Achieve significant reduction in investment and operations cost, and
- Improve mission effectiveness and efficiencies.

The MFIPT addressed the major facilities at NASA centers and DoD installations that are owned and operated by NASA and DoD for the conduct of research and testing. These facilities included major wind tunnels, air-breathing propulsion test facilities, rocket engine test stands, space environmental simulation chambers, hypervelocity impact ranges, arc-heated facilities and other major facilities located at NASA centers and DoD installations. As originally described in its Terms of Reference (TOR), the IPT was focused on Test and Evaluation (T&E) facilities. Following discussions with the Technology and Laboratories IPT and the Overarching IPT, the IPT was rechartered as the Major Facilities IPT to address research facilities as well. By so doing, this IPT could assure that comparable NASA and DoD large facilities that supported research and/or T&E would be considered equitably regardless of their usage.

A number of observations influenced the work of the MFIPT.

- At most facilities the test complex architecture consists of a plant infrastructure that provides the test medium to a number of test cells. Customer test articles are placed in the cells to acquire data. Plant operations and maintenance costs are relatively large compared to test cell operations and maintenance costs. The amount of savings obtainable from closing test cells will be small if the plant infrastructure continues to support other test cells. These savings will be further eroded if the work from the facility to be closed is shifted to another site with supporting staff.
- A significant proportion of NASA and DoD test cells and plants are fairly old. As consolidation takes place, the stress on these facilities will increase, leading to a higher modernization requirement. Consolidation savings will be partially offset by this need to modernize.
- As consolidation takes place, the remaining facilities must handle more customers in the same time. Therefore, methods to improve productivity should be part of the consolidation and modernization planning process. In a similar vein, consolidation to fewer facilities will increase the distance cost to user programs. Therefore, consolidation and modernization planning should also include remote access features such as video links, direct data output to remote customers, and possible remote control of test parameters and events.
- Since many consolidations have already taken place, and older test facilities have little salvage value, most significant future savings will come from cost-avoidance and investment savings from integrated planning and mutual reliance.
- DoD and NASA have historically operated under significantly different funding and cost accounting policies. Present cost accounting methods do not permit comparative cost-benefit analyses of consolidation options. Cooperative approaches must account for, and possibly change, these diverse and complex policies and practices.

The MFIPT identified and categorized the facilities to be addressed. The MFIPT noted considerable effort had already been expended by each of the agencies in reducing the number of facilities to the minimum required. For example, the number of major aeronautical facilities in the two agencies had already been reduced by 30 percent from the number available in 1993. The MFIPT examined:

- The National Facility Study conducted by NASA, DoD, industry, and others during 1993 and 1994, and resulting actions.
- The Base Closure and Realignment Commissions (BRACs) for DoD downsizing conducted in 1988, 1991, 1993, and 1995.
- The NASA Zero Base Review (ZBR) conducted in 1995 that reduced NASA assets by over 20 percent.

The savings from these reductions had already been realized and as a result, additional future savings were going to be more difficult to identify. The MFIPT concluded that further closures or consolidations of major NASA and DoD facilities would be unlikely to provide significant cost savings. This would be particularly true if the host installation remains open and the workload, with its associated cost, is shifted to another facility.

The MFIPT concluded that the most expeditious way to achieve the IPT's objective was to implement cooperative management agreements for specific classes of major NASA and DoD facilities. These management agreements will form NASA/DoD alliances that would provide improved coordination of facility investments and upgrades, better assessments of facility capability and requirements, and more efficient and effective facility operations. The IPT has defined procedures and agreements for use by the proposed alliances.

Additional MFIPT activities were directed at providing the tools for future cooperation. The IPT prepared a joint national facility database and installed the database on the World Wide Web.

The MFIPT recognized that for any consideration of facility consolidations, agreement on facility operations costs must be achieved. Therefore, the development of consistent/comparable cost models for DoD and NASA facilities must be developed. The MFIPT began to develop a common cost study methodology. In addition, DoD is starting an independent study of test facility costing, while NASA has initiated the implementation of full cost accounting. Whatever solutions result from these activities, they must accommodate a wide range of uses for the major facilities—research, technology, development, engineering, operations, and production. The MFIPT did some work toward establishing a common set of definitions for facility costs. (See MFIPT Volume II.)

The IPT was organized into two major sub-groups. An Aeronautics Sub-Group examined wind tunnels and air-breathing propulsion facilities. A Space Sub-Group was organized into four panels representing rocket propulsion facilities, space environment simulation facilities, hypervelocity ballistic range/impact facilities, and arc-heated facilities. To ensure its work was properly coordinated, the MFIPT had a membership exchange with the Technology and Laboratory IPT, and coordinated its activities with the Base Support and Interagency Agreement IPTs.

NASA and DoD have complementary capabilities in a number of facility classes, and defined reliance opportunities in both arc-heated aerothermal facilities and hypervelocity ballistic range/impact (HBR/I) facilities. There exist potential consolidation and closure options in the arc-heated and HBR/I areas that should be further considered by the respective agencies.

A. IPT ACTIVITY SUMMARY

The following sections summarize the MFIPT activities and results. The sections describe the general approach used in the MFIPT investigations, the organizational structure used by the MFIPT, organizations that were represented on the working teams and sub-groups, deviations from the Terms of Reference provided to the IPT, and finally the methodology used to reach the MFIPT recommendations.

1. Approach

The objective of the MFIPT, as stated in its TOR, was "develop specific recommendations for increased cooperation in major facilities in order to achieve a significant reduction in investment and operations costs and improved mission effectiveness and efficiencies."

The Aeronautics Sub-Group and the Space Sub-Group went through the following process:

1. Developed an up-to-date listing of the major NASA and DoD facilities, building on the data collected by the National Facility Study and other past studies.
2. Assessed the capabilities of the facilities.
3. Assessed current and projected facility utilization.
4. Identified recommended actions, including management alternatives and

proposals for consolidations and/or closure of excess capacity.

2. Organization

The Aeronautics Sub-Group was composed of 21 representatives from 13 different NASA and DoD organizations. It was further divided into teams to address wind tunnels and air-breathing propulsion facilities. The Space Sub-Group had 37 representatives from 19 organizations in its membership. It was organized into four teams to address rocket propulsion facilities, space environment simulation facilities, hypervelocity ballistic range/impact facilities, and arc-heated facilities. The number of major facilities examined by the sub-groups is shown in Table XX.

Table XX. Facility Classes Assigned to Sub-Groups

Sub-Group and Assignments	Number of Facilities
Aeronautics Sub-Group	
Wind Tunnels	60
Air Breathing Propulsion Facilities	23
Space Sub-Group	
Rocket Propulsion Facilities	89
Space Environmental Simulation Facilities	27
Hypervelocity Ballistic Range/Impact Facilities	18
Arc-Heated Facilities	15

The MFIPT also addressed the future ownership of Wallops Island Flight Facility, considering the forecasted usage by NASA and DoD. Since both aeronautical and space activities are present at Wallops and the many considerations involved in any transfer of ownership from NASA to DoD, the MFIPT placed this question in a special category. A separate group for this special subject was formed with co-chairs from NASA Headquarters and the Naval Air Warfare Center, Aircraft Division. The conclusion from this activity is Wallops Flight Facility should remain a NASA facility for the foreseeable future.

The MFIPT also formed a working group to coordinate the activity in the business practices area. Members of this working group assisted each of the sub-groups and teams in areas related to business practices.

3. Representation

The MFIPT was co-chaired by the Deputy Associate Administrator, Space Flight, NASA Headquarters, and the Deputy Director, Test Facilities and Resources, under the Director, Test, Systems Engineering, and Evaluation in the Office of the Secretary of Defense. The Aeronautics Sub-Group was co-chaired by the Deputy Director, Test and Evaluation and Technology Requirements, Office of the Chief of Naval Operations, and the Assistant Director for Research and Engineering, Langley Research Center. The Space Sub-Group was co-chaired by representatives from the Office of the Secretary of Defense (Test Facilities and Resources) and the Chief Engineer, Langley Research Center.

In the MFIPT activities, including the two Sub-Groups and the various working groups and teams, there were a total of 55 participants representing 32 different organizations. The major organizations represented are listed in Table XX.

Table XX. Major Organizations represented in MFIPT Activities

DoD	NASA
OSD, Test Facilities and Resources	NASA Hq, Office of Comptroller
Office of the Chief of Naval Operations	NASA Hq, Mgt Systems and Facilities
HQ USAF Test Resources	NASA Hq, Space Flight
Ballistic Missile Defense Organization	NASA Hq, Aeronautics
Air Force Materiel Command	NASA Hq, Space Science
Army Test and Evaluation Command	NASA Hq, Space Access and Technology
Army Redstone Technical Test Center	NASA Hq, Mission to Planet Earth
Naval Air Warfare Center, Pax River	Ames Research Center
Naval Air Warfare Center, Trenton	Goddard Space Flight Center
Naval Air Warfare Center, China Lake	Johnson Space Center
Naval Research Laboratory	Kennedy Space Center
Naval Surface Warfare Center	Langley Research Center
Air Force Flight Test Center	Lewis Research Center
Air Force Phillips Lab, Edwards	Marshall Space Flight Center
Air Force Phillips Lab, Kirtland	Stennis Space Center
Arnold Engineering Development Center	White Sands Test Facility
Jet Propulsion Laboratory	
Institute for Defense Analyses	
Laboratory and Technology IPT	

4. Deviation from the TOR

The original TOR called for an IPT to focus on T&E Facilities. Initial discussions within the IPT centered on the distinction between large research facilities and large T&E facilities within NASA and DoD, and how to determine which facilities were within the scope of the IPT. As a result of discussions with the Technology and Laboratories IPT and with the approval of the Overarching IPT, the co-chairs of the T&E IPT and the Technology and Laboratories IPT signed a Memorandum of Agreement, renaming this IPT as the "Major Facilities IPT." This change refocused the MFIPT's efforts on major facilities, defined as those large national facility assets supporting both T&E and research, and ensured that comparable major research and development (R&D) facilities in NASA and DoD are considered on an even basis.

5. Methodology To Reach Recommendations

The MFIPT members reviewed past studies germane to the TOR, and identified major facilities for further analysis. The previous studies that were considered included:

National Facility Study (NFS)

NASA and DoD Federal Laboratory Reviews

NASA Centers' Facility Consolidation Assessments

DoD Reliance Studies

National Science and Technology Council (NSTC) Laboratory Review

The centers and installations involved updated the information in the NFS database and thereby provided a current database for the major facilities. This joint national facility database was made available on the World Wide Web for revision and use during the study. The MFIPT also examined other longer-term solutions to the need to maintain a joint facility database. Non-NASA and non-DoD facilities were not formally included in this study beyond what had been done previously in the NFS. This was because the AACB has no authority over these facilities and in some technical areas they represent only a small number of facilities beyond those being examined. The analysis did not address any facilities being planned or studied. Facility utilization was assessed to justify the classification of facilities as active or inactive, and to identify potential consolidations and/or closures for consideration.

NASA and DoD cost analysts examined the cost accounting methods used by the two agencies and developed common cost definitions for use in studying facility costs. The MFIPT documented present and future facility investments to better assess current capabilities and avoid unwarranted duplication in the future. The MFIPT members believe that, in general, formal facility management alliances between NASA and DoD are very desirable. As a step toward formalizing the alliances, the MFIPT prepared proposed alliance procedures, and in some areas, draft alliance agreements. To enhance coordination of its activities, the MFIPT instituted a membership exchange with the Technology and Laboratory IPT, and coordinated its activity with the Base Support and Interagency Agreement IPTs.

a. Aeronautics Sub-Group

The Aeronautics Sub-Group examined all major wind tunnels and air breathing propulsion test facilities that were active in 1993. A detailed summary of the activities of the Aeronautical Sub-group is contained in Volume II of the MFIPT report. To aid in the evaluation, the wind tunnels were divided into the four categories: subsonic, transonic, supersonic, and hypersonic.

Tables XX and XX show the current status of the 83 wind tunnel and aeropropulsion facilities that were active in 1993. At the time of the Sub-Group's review, the number of active facilities had already been reduced to 58.

Table XX. Current Status of Wind Tunnels

	Subsonic	Transonic	Supersonic	Hypersonic
Total Active in 1993	17	10	10	23
Currently Active	12	7	8	12[1]
Included in Active, but requiring further study	[3]	[1]	[3]	[4]
Inactive				
Abandoned	4	1	1	2
Mothballed	0	0	0	3
Standby	1	2	1	6

[1] One hypersonic wind tunnel will become standby in 1998.

Table XX. Current Status of Air-breathing Propulsion Test Cells

Aeropropulsion	Number of Test Cells
Total Active in 1993	23
Currently Active	19
Included in Active, but to be abandoned in 1998	[2]
Inactive	
Abandoned	0
Mothballed	4
Standby	0

Subsonic Facilities

The Sub-Group identified 17 subsonic facilities and determined the current status of each facility. A major subsonic facility was defined as having operating speeds up to Mach 0.6 with a test section at least six feet in one dimension. Twelve of the subsonic facilities are currently active, and 5 facilities have been placed on inactive status since 1993.

Nine of the active subsonic facilities were considered to offer essential capabilities that must be retained. The three remaining active tunnels, Ames 7x10#1, Wright Laboratory SARL 7x10, and Wright Laboratory Vertical Tunnel, were referred to the Laboratory and Technology IPT for their input regarding the facility needs to support the programs being considered by that IPT. The Laboratory and Technology IPT found that these 3 subsonic tunnels were all needed to support ongoing programs at this time and into the near future

Transonic Facilities

A major transonic facility was considered if it operated over the Mach range of 0.6 to 1.5, with a test section at least four feet in one dimension. Ten transonic facilities were active in 1993. Seven of these facilities are currently being used with the 3 remaining facilities having been placed on inactive status since 1993. Of the 7 active transonic facilities, 6 offer essential capabilities that must be maintained. One of these 6 facilities, the Lewis 8x6 tunnel, is primarily utilized for propulsion research testing, but can also serve as a back-up for the AEDC 16T tunnel.

The Langley 16 Foot Transonic Tunnel is an atmospheric facility that has been traditionally used in propulsion integration studies. Even though this tunnel is currently fully utilized on a two-shift basis, it was referred to the Laboratory and Technology IPT for their input regarding the requirement for this facility to support propulsion integration programs. The Laboratory and Technology IPT responded that the facility was needed to support ongoing programs at this time and into the near future, and that closure would result in adverse cost and schedule impacts on current programs.

Supersonic Facilities

A supersonic facility was considered if it operated in the Mach range of 1.5 to 5.0 with a test section at least two feet in one dimension. Ten supersonic facilities were active in 1993. Eight facilities are currently being used with 2 facilities having been placed on the inactive list since 1993. Of the 8 active supersonic facilities, 5 were considered to offer essential capabilities that must be maintain.

The 3 remaining facilities, (AEDC VKF A and the 2 Langley Unitary tunnels) were referred to the Laboratory and Technology IPT for input regarding facility needs to support on-going national research programs. The Laboratory and Technology IPT found that the 3 facilities were all needed to support ongoing programs at this time and into the near future. The current and projected demand for the facilities is high and alternative facilities cannot absorb the demand without significant cost and schedule impact.

Therefore closure of these facilities would result in adverse cost and schedule impacts on current programs.

Hypersonic Facilities

A major hypersonic facility was considered if it operated at Mach numbers greater than 5.0 and the test section was at least 1 foot in one dimension. Twenty-three facilities were active in 1993. NASA and DoD are currently utilizing 12 facilities with the 11 remaining facilities having been placed on the inactive list since 1993. The team determined that all 12 active hypersonic facilities were needed to support National needs.

The National Facility Study had considered the AEDC Aerodynamic and Propulsion Test Unit (APTU) and the Langley 8 Foot High Temperature Tunnel (HTT) to overlap in capability. This overlap, however, was contingent upon an upgrade to the APTU tunnel and this modification is not presently scheduled. Any future modifications will require a joint review by the proposed wind tunnel alliance before proceeding. Therefore, the APTU and 8 Foot HTT remain complementary facilities for propulsion testing covering a large Mach number range.

Air-Breathing Propulsion Facilities

The 23 air-breathing propulsion facilities active in 1993 have been studied in great detail over the past few years under both the Defense Base Closure and Realignment Commission (BRAC) activity and the DoD Test and Evaluation Reliance initiatives. These 23 test cells included 11 cells at AEDC, 9 cells at Naval Air Warfare Center (NAWC) Trenton, and 3 cells at Lewis. Four cells have been mothballed since 1993, 3 at Trenton and 1 at AEDC.

As a result of BRAC decisions, the Navy's Trenton facility will close in 1998, and all DoD air breathing propulsion work will be consolidated at AEDC. Two Trenton medium sea-level cells and two small altitude cells will be moved to AEDC. Two other small altitude cells at Trenton will be abandoned. With the closing of the Trenton facilities, all remaining DoD and NASA air-breathing propulsion facilities are needed to support both government and industry needs.

Summary of Aeronautical Facilities

The Aeronautics Sub-Group conducted an assessment of the major wind tunnel and aeropropulsion facilities in the U.S. It determined that significant downsizing in these areas since 1993 resulted in the presently active facilities representing nearly the right set of facilities. Seven facilities were identified for future study as program needs evolve.

Figure XX illustrates the reduction of aeronautical facilities over the five-year period from 1993 to 1998. As shown, the savings realized and accounted for by each organization is estimated to total about $14.2 million per year. About $37 million was saved by not carrying out planned facility upgrades. There were also costs associated with closing facilities. Because of the different accounting systems and estimating methods, the level of accuracy of the cost numbers displayed in Figure XX could not be estimated.

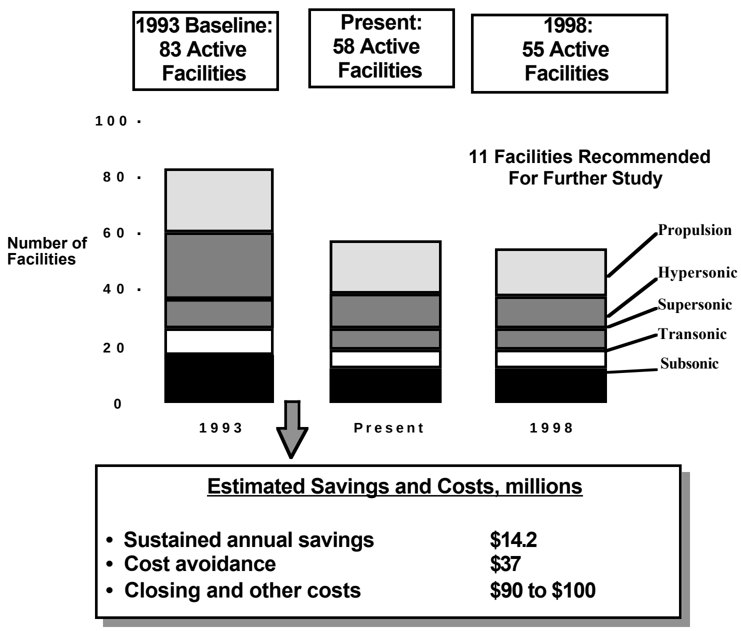

Figure XX. Aeronautical Facility Status

Over the last few years, DoD, NASA, and industry have all been closing facilities as an effort to reduce costs. While the MFIPT did not address the industry capability, it did recognize that industry's reliance on government facilities has significantly increased. In the judgment of the MFIPT, the present number of major aeronautical test facilities represents the minimum number of facilities this country should maintain in active status to support a viable and competitive industry. However, the need for specific facilities and further investments should be re-evaluated on a continuing basis as programs and requirements change. Alliance activities between Government organizations, and eventually with industry, offers the best opportunity to efficiently use this country's facilities.

To summarize, the Aeronautics Sub-Group reviewed the major DoD and NASA wind tunnels and aeropropulsion facilities, developed an up-to-date database, and described the status of each inactive facility as either standby, mothballed, or abandoned. The Sub-Group documented a 30 percent reduction in active aeronautical facilities since 1993 with an annual savings of $14.2 million. The Sub-Group identified eleven facilities that warranted additional study as candidates for consolidation, and four facilities (2 AEDC and 2 Langley Research Center) were selected to cost a common test program. This cost study was initiated but not completed because of different accounting procedures at the two organizations that could not be resolved in the time frame of the current activities. This costing study can be completed by the alliance if warranted. In response to a Sub-Group request, the Laboratory and Technology IPT stated that the seven facilities selected for further study were currently needed to support existing programs. Thus the Sub-Group concluded that present facilities very nearly represent the minimum required, but that future requirements and examinations might cause a different conclusion.

b. Space Sub-Group

The Space Sub-Group divided its activities into four teams. This allocation of work was in recognition that the variety of facilities assigned to the Space Sub-Group would not allow an examination of all types by the same group of specialists and that most major facilities fell easily into one of four categories. The four teams that were formed addressed rocket propulsion facilities, space environmental simulation facilities, hypervelocity ballistic range/impact facilities, and arc-heated facilities. The teams were formed with representation from the affected centers and installations that operated facilities in these four categories. Detailed discussion of the teams' activities are contained in Volume II of the MFIPT report.

(1) Rocket Propulsion Facilities

The Space Sub-Group formed a rocket propulsion team of NASA and DoD representatives. This team had the advantage of building on activities already underway within NASA and DoD. These activities included the alliance proposals being considered within NASA with the invited participation of DoD, the DoD T&E Reliance process that had been underway since 1993, and the National Facilities Study that was completed in April 1994. DoD T&E Reliance is an ongoing process that was particularly emphasized when the DoD T&E Board of Directors (BoD) directed consolidation studies that were conducted between October 1993 and March 1994. In May 1994, the DoD T&E BoD directed Reliance studies for Space and Ballistic Missiles areas. In the Fall of 1994, the Space and Ballistic Missile T&E Reliance Panel initiated development of their Test Capability Master Plan (TCMP). In early 1995, the NASA Zero-Based Review made a recommendation for Stennis Space Center to form a national alliance of rocket propulsion test sites, which would ultimately include NASA and DoD facilities. Representatives of NASA sites that conduct rocket propulsion testing met for the first time in July 1995 to discuss the alliance proposal. They met again in August and September and agreed an effective alliance would be beneficial to all parties, and could help eliminate unnecessary redundant facilities. When the Major Facilities IPT was formed by the AACB in August 1995, the proposed rocket propulsion alliance was seen as an effective avenue to bring about discussions between NASA and the DoD on the allocation and use of rocket propulsion test facilities.

The team evaluated all facilities associated with rocket propulsion testing. This included system or motor test stands, engine test stands, component test stands, and associated support facilities. Each site identified a point of contact as the team member for that site, and identified all existing and planned facilities. Upcoming test activities were identified and evaluated against the facilities in the database to determine a "first cut" best fit. Modifications to facilities were evaluated to determine if alternative testing locations or approaches were available. This review provided insight as to the anticipated quantity and type of testing and the projected funding for these activities.

The existing rocket propulsion test facilities were categorized as shown in Table XX.

Table XX. NASA/DoD Rocket Propulsion Facilities

	Number of Facilities	Number Currently Active
Liquid Engine, Ambient/Low Altitude	16	7
Liquid Engine, Altitude	22	7
Propulsion Boost Stage Level	8	0
Solid Rocket Motor	31	18
Components and Miscellaneous	12	9
Total number of facilities	89	41

Inter- and intra-agency cooperation will ensure the best use of existing testing facilities. Once fully implemented, information vital to effective and efficient test operations and capital expenditures will be shared with organizations that can benefit from that information. The long term benefit of alliance members cooperating with peer organizations is a better overall understanding of testing needs and how to optimize the national testing assets to meet those needs.

The following five products were developed by the rocket propulsion team to support its recommendation for a rocket propulsion test alliance.

1) A draft NASA/DoD Memorandum of Agreement (MOA) providing the framework for operations of the Alliance.
2) A rocket test facilities database that identifies current test capabilities and condition, as well as potential test sites for evaluation.
3) The start on a facility utilization projection database and scheduling system to identify and track facility activities. Information was gathered directly from the centers and sites and integrated to provide a top-level view of activity at the rocket propulsion facilities.
4) A list of proposed common cost elements that will enhance effectiveness when conducting a complete detailed evaluation of the testing processes and identifying all associated costs.
5) A detailed report that documents rocket propulsion testing facilities and operations.

(2) Space Environmental Simulation Facilities

The Space Environmental Simulation team limited its study to large (integrated payload size) NASA/DoD thermal-vacuum and acoustic test chambers. Table XX shows the number of simulation facilities that were considered in the team's activities.

The chambers examined were limited to those large enough to accommodate at least a four foot cube (spacecraft) with adequate space surrounding the structure for safe, easy access while inside the chamber. Chambers with minimum dimensions on the order of 10 by 10 feet will generally meet this provision. Thermal vacuum chambers should have the capability of providing pressures less than $1x10^{-6}$ torr, and thermal shrouds capable of LN2 temperatures or lower. Solar simulation capabilities and contamination-free pumping are optional features. Acoustic chambers should be capable of producing 150 dB at frequencies between 25 to 1000 Hertz.

Table XX. Environmental Chambers

Chamber Type	Number of Chambers
Thermal Vacuum Chambers	21
Acoustic Chambers	6

The group formulated plans for a space environmental simulation facility alliance and proposed a charter. The alliance should be formed by the test chamber operating organizations. Because this effort was initiated by NASA and DoD, initial participation should be limited these two agencies. After the alliance has demonstrated success, other federal agencies, such as Department of Energy (DoE), that operate similar chambers, should be invited to join the alliance. Since many of the country's large environmental test chambers are owned and operated by private enterprise, contact with these activities should be maintained to explore common objectives. After a government alliance has proven successful, expanding to include private industry can be evaluated.

(3) Hypervelocity Ballistic Ranges/Impact Facilities

The Hypervelocity Ballistic Ranges/Impact (HBR/I) team conducted a review to develop specific recommendations for increased cooperation in the area of HBR/I facilities. This study focused on the use of light gas guns and ballistic range facilities to perform impact testing, and built on a mid-1995 examination of NASA's hypervelocity impact test requirements and facilities by a NASA/DoD Facility Interagency Team. That study recommended focusing the work and consolidating NASA HBR/I test sites. Its recommendations were documented in the NASA Hypervelocity Impact Test Facility Assessment Final Report, dated August 25, 1995. After review of the study within NASA, a Hypervelocity Impact (HVI) Test Facility Responsibilities Alignment Document, dated October 1995, directed implementation.

Under the MFIPT, an HBR/I team reviewed requirements and assessed current DoD facilities (listed in Table XX) to meet these requirements. The review also considered options for cooperative DoD-NASA activities to meet each agency's requirements as effectively and efficiently as possible. There are currently 4 HBR/I facilities operational within NASA with overlapping capabilities in the smaller caliber guns. The WSTF site has the capability for hazardous test operations, that is, impacts into targets which produce hazardous (explosive or chemical) consequences which must be controlled or contained. There are 3 DoD HBR/I facilities currently operational with some overlapping capabilities. In addition, a fourth facility, belonging to the University of Alabama at Huntsville, was considered part of the evaluation since it also performs testing for the Ballistic Missile Defense Organization (BMDO). AEDC ranges can test projectiles that are larger than those that can be tested at NRL, and can provide the flight path length needed to recover the projectiles and to orient them to prescribed attitudes prior to impact as required. The NRL Chesapeake Annex facility has the largest TNT equivalent hazardous test capability in DoD, but may be limited in the future by housing development encroachment and increasingly stringent environmental rules. AEDC is currently pursuing an upgrade to its hazardous material testing certification.

Table XX. Current HBR/I Facilities

	Number of Ranges	Number of Guns
NASA Facilities		
Ames Research Center	2	6
Johnson Space Center	3	5
Marshall Space Flight Center	2	4
White Sands Test Facility	2	3
DoD Facilities		
Arnold Engineering Development Center (AEDC)	3	7
Naval Research Lab (NRL)	2	2
Naval Research Lab (NRL) - Chesapeake Bay Annex	1	1
Academia		
University of Alabama at Huntsville	3	3

The team's study determined that both NASA and DoD currently meet mission needs with complementary hypervelocity impact test facilities. Currently, DoD requirements concentrate on scaled testing to validate ballistic missile defense intercept systems. These tests use projectiles larger than an inch to strike sophisticated targets. NASA's concentration is primarily on meteoroid/orbital debris (M/OD)-sized particles, mostly less than an inch in diameter, impacting on space structures and hardware. There appears to be opportunity for cross-sharing of expertise and perhaps instrumentation and equipment.

Impact phenomenology is a common interest area. NASA is formulating a Hypervelocity Impact Technology Plan coupled with its future experimentation efforts and has invited DoD participation. It should be possible to expand this plan to include DoD interests, to coordinate theoretical studies, and to provide a further opportunity to leverage resources in both agencies.

As a result of its 1995 study, NASA has initiated a consolidation to a single site, White Sands Test Facility, by FY1998. The basic methodology used in the MFIPT study built on the NASA activity and consisted of a comparison of requirements, potential alternatives, and advantages and disadvantages. DoD and NASA capabilities were compared to determine potential overlap and a minimum required capacity.

It was noted that, similar to NASA, there is some overlapping capability and excess capacity in DoD. The team recommends that DoD consider consolidation of its HBR/I test capability and testing to AEDC in order to retain technical expertise and eliminate unnecessary duplication as testing needs diminish.

A DoD-NASA alliance by itself would provide some potential for improved effectiveness by encouraging closer cooperation between the test centers, but will not provide large savings for either DoD or NASA. Economies may be realized if the alliance is used to promote consolidation and/or reduce future facility and equipment operating budgets and investments. Near-term savings, however, appear to be limited due to the small number of personnel involved in HBR/I testing and planned modernization investments.

The team studied several ways for a DoD-NASA HBR/I Alliance to be implemented. The recommended approach is to provide closer integration with each agency maintaining overall control of its own facilities. A Common Advisory Board is recommended to provide effective coordination of investments and modernization activities by encouraging joint test technology planning and coordination of allied research and technology activities. This approach imposes an administrative burden associated with the Common Advisory Board, but the burden should remain small, if properly implemented. A draft MOA for Joint DoD-NASA HBR/I testing has been prepared and is included in the HBR/I report in MFIPT Volume II.

(4) Arc-Heated Facilities

DoD and NASA arc-heated facilities are located at one DoD center, AEDC, and three NASA centers; Ames Research Center, Johnson Space Center, and Langley Research Center. To assess the potential of consolidation and alliances of these facilities, an arc-heated facilities team, co-chaired by representatives from AEDC and NASA Headquarters, developed options for consolidation.

Table XX shows the DoD and NASA arc-heated facilities by location, test stations, maximum power, and pressure. Electric arc-heated facilities have been used for two fundamental purposes, aerothermal testing of materials and structures to simulate the aerodynamic heating environment of hypersonic flight, and aeropropulsion testing of scramjets, principally scramjet combustion research. Arc-heated facilities at both AEDC and Ames can support both forms of testing, but they are not redundant as each simulates distinctly different flight regimes. The arc-heated facility at Langley is currently conducting scramjet research, and the Johnson facility is used exclusively for materials and structures testing.

Table XX. NASA and DoD Arc-Heated Facilities

Facility	Power (MW)	Pressure (Atm)	Status
AEDC			
HEAT-H1	30	120	Active
HEAT-H2	42	100	Active
HEAT-HR	42	100	Active
HEAT-H3	60	150	New
Dust Erosion Tunnel (DET)	7	68	Closed
Ames RC			
Aerodynamic Heating	20	40	Active
Interaction Heating	60	10	Active
Panel Test	20	10	Active
2x9" Turbulent Flow	20	20	Active
Direct Connect Arc-Facility.	50	25	Standby
Giant Planet	70	5	Standby
Johnson SC			
ARMSEF TP-1	10	10	Active
ARMSEF TP-2	10	10	Active
Langley RC			
Arc-heated Scramjet Facility	12	40	Active
Materials Arc Tunnel	20	15	Closed

Over the past decade, significant consolidation in arc-heated facilities has already taken place. Two arc-heated facilities have been closed, the Dust Erosion Tunnel (DET) at AEDC and the Materials Arc Tunnel at NASA Langley. The DoD arc facility testing is consolidated at AEDC, and NASA has consolidated their aerothermal material and structural testing to Ames and Johnson. The arc-heated facilities team addressed the question of whether further consolidation or alliances of NASA and DoD arc-heated facilities will result in improved efficiency and reduced cost. To do this, the team assessed current and future test requirements and basic plant test capabilities.

Because of the high current workload, an immediate consolidation of arc-heated facilities cannot be proposed. The future workload is more uncertain and unpredictable, which suggests the need for a periodic reevaluation of a consolidation. For aerothermal testing, the most likely consolidation appears to be combining Johnson and Ames if their combined workload drops substantially. A consolidation of the AEDC and NASA arc test capabilities is currently not practical due to the difference in test requirements and plant capabilities. Where NASA test needs overlap AEDC test capabilities, AEDC could give relief to the NASA high workload if AEDC workload permits.

Eight consolidation options were considered for the arc-heated facilities. Seven of these options were categorized into two classes: aerothermal and propulsion test capability. The merits of a single site were also discussed. The capital cost of consolidating all existing arc-heated capability at a single site is roughly estimated on the order of $90 to $150 million. A consolidation of existing sites by moving and closing existing equipment is not practical since there are no savings in operations to offset the capital cost in a reasonable period of time. This scenario would cause major adverse impacts on test programs while equipment was being moved. Also, there is no net gain in test capability. If, however, a much larger arc-heated facility test capability were built to support future scramjet development testing, consolidation of all future aerothermal structural and materials and air breathing propulsion test capability at one site warrants consideration and detailed cost benefit analysis.

Of the consolidation options studied, the consolidation of the JSC facilities to Ames warrants further study by NASA. Currently, arc test workloads are high at both centers and are sufficient to justify separate operations. A low workload at either center, however, as has occurred in the past, is justification for considering consolidation of these test capabilities. It appears that the Ames plant utilities are capable of supporting the kind of testing that JSC has historically done, although Ames runtime capability may be of concern. There is also an environmental issue at Ames on total NOX emissions which would have to be addressed prior to a decision.

An alliance in arc-heated facilities was recommended with AEDC and NASA Johnson, Ames, and Langley participation.

c. Alliance Activities

The MFIPT concluded that the formation of alliances between NASA and DoD would provide the management focus for future management of the major facilities and provide the efficiency and effectiveness improvements that are desired. The alliances would be a good way to shape the future for these facility areas. One of the most important results of an alliance would be the development of a trusting, working relationship between participating organizations. The alliances would be expected to coordinate test schedules to spread workload across facilities, coordinate investments to avoid unnecessary duplication, and develop standardized and common processes. Shown below are typical activities for the recommended facility alliances.

<u>Typical Major Facility Alliance Activities:</u>

- Coordinate test schedules and facilities workload
- Provide an integrated future requirements and facility specialization plan

- Coordinate capital investment and modernization programs
- Share technical expertise to increase commonality and knowledge
- Share personnel resources and specialized equipment
- Share information on business processes to improve efficiency and reduce operational costs
- Promote DoD/NASA/Industry cooperation and participation at all levels

Goals of Major Facilities Alliance:

- Achieve the most efficient utilization possible of the national investment in world-class DoD and NASA major test facilities
- Maximize government and industry user involvement in facility planning and management

Benefits of Major Facilities Alliance:

- Integrated investment planning
- Commonality of processes and equipment
- Better communication and technology exchange
- Optimal facilities utilization to meet program needs
- Increased NASA/DoD/Industry teamwork and cooperation on national initiatives
- Significant cost savings through more efficient utilization of national assets represented by the NASA/DoD major facilities

d. Major Facilities Automated Inventory

A computerized inventory was updated by the MFIPT to provide a standardized source of data on the characteristics of the major facilities. In addition, this database was placed on the World Wide Web so it would be more broadly available to facility planners and potential facility users.

The starting point for this inventory was the interagency National Facility Study (NFS) that was performed in 1993-1994, and referenced in the IPT Terms of Reference. Although this represented the only computerized database of facilities in common format, the software needed significant changes to be user friendly. The data itself was also found to need review and updating. The database includes 812 DoD facilities and 643 NASA facilities. A total of 850 have been added or reviewed and updated from the original NFS database. Summary characteristic charts as developed by each of the IPT subgroups are included in the database for each of the applicable facilities.

The World Wide Web site address is *http://131.182.171.171/.* Following an Operational Readiness Review, the system will be linked to the DoD and NASA Home Pages. Although it is outside the current scope of the DoD/NASA Cooperation Initiative, the Department of Energy and the National Oceanic and Atmospheric Administration have been invited to provide an update on their facilities that are in the inventory, and they are in the process of doing so.

It is expected that users may want to modify the current software structure or database, and provisions have been incorporated in the database Home Page to permit this feed back. As is true for all databases of this type, the information must be kept current. The MFIPT developed a security procedure so that facility owners may update and add to their own portions of the inventory in the future. The facility owners should assume ownership of the data and exercise their responsibility for its accuracy and completeness.

e. Joint Facility Research and Development

There is potential benefit to both NASA and DoD from working together in the areas of test technology and test capability development. By coordinating the agencies' test technology programs through the proposed alliances, the expertise and resources of both agencies could be brought to bear on areas of mutual interest and benefit. Similarly, the two agencies should share expertise that is available during the management of the acquisition and construction of major facilities that are for the benefit of the two agencies.

f. Products

The products of the MFIPT are:

- A baseline of current cooperation and coordination between NASA and DoD facilities, including development of the National Facility Database.
- Draft MOAs for proposed alliances.
- Recommendations to reduce facility overlap and redundancy. Areas in which cooperation and coordination can have the greatest impact are included with the specific recommendations.
- Recommendations for new personnel exchanges, which were submitted to the Personnel IPT. The purpose would be to coordinate and enhance the wind tunnel testing alliance between the NASA and DoD, to exchange test techniques and technologies, and to gain better knowledge of and utilize the unique test technique and technologies between agencies. This would also enhance joint coordination and development for the Rocket Propulsion

Alliance between NASA and DoD. These exchanges are critical to fostering increased cooperation between the two agencies.

B. RECOMMENDATIONS

[Provided in the form of charts with facing page text, include AACB disposition for each, format attached.]

C. SUMMARY

Our vision is to regain world leadership in aeronautical and space test facilities in order to ensure U.S. aerospace preeminence well into the 21st century. To that end, the MFIPT has recommended the institutionalization of DoD and NASA alliances. The alliances will foster greater efficiency through sharing new technology and processes, pooling and integrating resources, and enhancing partner requirements. The goal is to reach the minimum number of facilities required to accomplish the necessary research, development, testing, and evaluation while maintaining or regaining critical facility capabilities.

Alliance Activities will include:

- coordinating test schedules, downtime, and facilities workload
- integrating NASA-DoD requirements
- developing facility specialization plans
- coordinating capital investment and modernization programs
- sharing expertise, personnel, and equipment
- promoting industry cooperation and involvement

Some progress has been made between NASA and DoD toward developing cost models for facility operations, i.e., a set of costing definitions have been developed. Considerable work is needed to carry these definitions to cost models usable for facility alliance activities.

Many of the facilities reviewed by the MFIPT are one-of-a-kind, or are uniquely suited to the current and projected workload. It would be impossible to duplicate many of these facilities in today's environment. Most are part of a larger complex, and closing them (or reducing operations) would not save large blocks of manpower or funding. Maintenance is not thought to be a significant cost since most locations provide a shared workforce for maintenance of various related facilities.

It has been suggested that reduction or consolidation of the programs that utilize these facilities would provide significant cost savings, but this is beyond the scope of the MFIPT. As alliances are formed, there will likely be a tendency to spend future investment dollars on those facilities that hold the most long-term promise. In this way, there could be a gradual migration of workload to the more recently upgraded facilities, with the eventual closure and de-commissioning of those not modernized. This will require a disciplined process of capital investment review and integrated decision-making between DoD and NASA.

The implementation of the MFIPT recommendations will contribute to the realization of our vision.