The Department of Transportation's Advanced Materials Research and Technology Initiatives

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The Department of Transportation (DOT) **Strategic Plan** of January 1994 emphasized the importance of advanced materials applications and related technologies to the transportation enterprise. Goal 3.3 commits the Department to..."***Support the use of advanced materials in manufacturing and constructing transportation equipment and facilities***". The Research and Special Programs Administration (RSPA) assumed the lead role in coordinating and implementing department-wide research, development, technology transfer and sharing activities related to advanced materials. The Volpe National Transportation Systems Center provided technical support to this continuing effort.

The RSPA initiated the formation of an Advanced Materials subcommittee of DOT's Research and Technology Coordinating Council (RTCC). This subcommittee is chaired by Tom Pasko (FHWA) with staff support from Dr. Aviva Brecher of Volpe Center. Its members are: Dr. R. Shih, RSPA Associate Administrator for Research, Technology and Analysis (RSPA), Dr. Joseph Soderquist (FAA), Capt. Bob Wenzel (USCG), Tom Hollowell (NHTSA), Don Gray (FRA), Bart Mancini (FTA) and Fred Seibold (MARAD). The subcommittee reviewed and improved this report, as one of its products and activities in support of Strategic Goal 3.3.

This report is the first review of materials-related R&D programs across DOT. It was prepared by the Office of Transportation Strategic Planning and Analysis at Volpe Center. It is published as a Technical Assistance document under RSPA's Office of Research Policy and Technology Transfer. It is designed to serve DOT's customers, States, business, academic and industry partners by highlighting some opportunities for joint R&D and for near-future applications of advanced materials and associated technologies to the transportation sector. To complement this report, several outreach activities are planned that will highlight the promise and prospects of advanced materials transportation applications.

The DOT has been an active participant in the national Advanced Materials and Processing Program (AMPP) initiative: DOT R&D programs are included in the federal Program FY93 and FY94 White House publications. The Federal Highway Administration (FHWA) has represented DOT's advanced materials research interests since 1992 on interagency committees, and currently serves on materials-related subcommittees of the Civilian Industrial Technology (CIT) Committee.

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"...One of the greatest challenges we face is to rehabilitate and maintain the huge stock of infrastructure facilities already in place. With this in mind, the Administration will consider establishing an integrated program of research designed to enhance the performance and longevity of existing infrastructure ...This program would systematically address issues of assessment technology and renewal engineering. A strategic program to develop new technologies for assessing the physical condition of the nation's infrastructure, together with techniques to repay and rehabilitate those structures could lead to more cost-effective maintenance of the infrastructure necessary to economic growth."

Clinton-Gore Technology for America's Economic Growth, A New Direction to Build Economic Strength, February, 1993

1.0 BACKGROUND INFORMATION

The transportation infrastructure of the U.S. is a vast network of highways, railroads, waterways, transitways, pipelines and supporting infrastructures worth some $2.4 trillion. These transportation networks are the physical systems that bring people and products together, the foundation on which our economy and society move. The well being and vitality of this infrastructure are essential to the economic prosperity of the Nation. In direct expenditures alone, transportation related activities account for almost 20 percent of the Gross Domestic Product of the U.S., with about 15 percent of that applied to construction, operation and maintenance of the systems. Maintenance of our aging and deteriorating infrastructure systems is more than 80 percent of those expenditures. Transportation infrastructure systems must be not only incrementally restored, renewed, preserved and strengthened, but also expanded in capacity if the ever growing transportation needs of our nation are to be served.

The methods, tools and materials used in vehicles and in transportation infrastructure construction and maintenance change very slowly, limited in part by the desire to avoid the risk of unknown consequences years or decades later, and by the importance in most decision processes of minimizing initial cost. Another constraint is that the supply industries involved may anticipate limited markets and low profits for innovative products, and often exhibit little motivation toward performance of advanced R&D.

However, in sectors such as defense and consumer products, various forces have provided a strong incentive for innovation in sophisticated new materials, structural design concepts, and innovative tools and techniques. The inventory of technological advances worthy of

infrastructure use grows day by day, awaiting only the effort to develop specific applications, demonstrate their effectiveness and long-term viability, and often, reduction of costs to a competitive level. The reality of this concept is already being demonstrated by results achieved in Europe, where American highway professionals observe a much more vigorous program for incorporating new materials in civil works. The degree to which portions of the Nation's aging transportation network is nearing or has already exceeded its nominal life, thereby imposing high maintenance costs and periodic service disruptions, warrants aggressive examination of efficient and practical means of improving materials to renew transportation infrastructure of all types. The National Highway System designated by DOT in 1994, as the foundation for a seamless National Transportation System initiative, will benefit from advanced materials and associated process and construction technologies.

> *"...This transportation infrastructure strengthens America by bringing people and communities closer together, spurring trade and commerce to meet the new demands of a global economy....Our challenge now is to shift our attention from what we've built to how we can make it work better for our country - through the adaptation and modernization of our existing infrastructure....This reinforcing and rebuilding effort can create jobs, improve our quality of life, spur technological development and fuel long-term economic growth."*
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> *"...better quality materials for highways and bridges and other technologies, though available today, have not yet been widely applied in America's transportation system."*
>
> *"Goal 2: Invest strategically in transportation infrastructure, which will increase productivity, stimulate the economy and create jobs."*
>
> **Department of Transportation Strategic Plan, January, 1994**

Obtaining the best life-cycle performance from the nation's physical infrastructure is important to not only the users, but the taxpayers and the government. Materials used, construction practices, climate and use of the infrastructure can all vary dramatically and infrastructure lifetime is normally measured in decades.

Infrastructure renewal is a core element of the Clinton Technology Policy and the **DOT Strategic Plan** (January, 1994). A key objective of the Strategic Plan is to "***support the use of advanced materials in manufacturing and constructing transportation facilities and equipment***". In response to the Technology Policy, the National Science and Technology Council (NSTC) Interagency Coordinating Committee on Transportation R&D delegated to its Infrastructure Renewal Subcommittee the task of defining research priorities for the physical infrastructure of our nation's transportation system. Furthermore, the budget guidance for FY96 reflected the NSTC Transportation Committee's report and set

requirements for crosscut R&D Data Collection and Review. The White House Office of Science and Technology Policy (OSTP) and the Office of Management and Budget (OMB) set eight priority areas, including transportation physical infrastructure R&D, encouraging R&D on new materials and associated technologies for renewal engineering.

This report provides an overview of DOT's current research and technology efforts, as well as those planned for Fiscal Year (FY) 1996, in two major areas: 1) Advanced Materials Research for Transportation Infrastructure Applications, and 2) Advanced Materials Research for Vehicles and Other Applications. This report could also prove valuable to DOT in highlighting common R&D thrusts, intermodally transferrable and multimodally applicable technologies. Certain advanced materials and failure prediction models developed and demonstrated for aircraft structural applications could be applicable to ground vehicles as well.

The report also discusses DOT's role as a partner in national interagency R&D and technology commercialization efforts on advanced materials. A funding table, estimating the amount related to advanced materials research and applications from programs for FYs 1994-1996, appears in **Appendix A** at the end of this report. Whenever possible, only the R&D program portion dealing with advanced materials research or applications has been estimated, rather than citing a misleading overall program funding level. The FY 1996 budget figures are estimates, used for planning purposes only and do not necessarily reflect actual funding levels.

2.0 *ADVANCED MATERIALS RESEARCH FOR TRANSPORTATION INFRASTRUCTURE APPLICATIONS*

> *"Goal 3: Create a new alliance between the nation's transportation and technology industries to make them both more efficient and internationally competitive."*
>
> *"Goal 3.3: Support the use of advanced materials in manufacturing and constructing transportation equipment and facilities."*
>
> **Department of Transportation Strategic Plan, January, 1994**

In the past decade, a national consensus has been reached on economic productivity and quality of life benefits that would result from use of high performance and durability materials for transportation physical infrastructure. The Transportation Research Board (TRB) estimated that even marginal improvements (1%) in durability and performance of pavements, asphalts, coatings and structural elements for the nation's highways and bridges were estimated to save the nation $ 10-30 Billion over 20 years. The Civil Engineering Research Foundation (CERF) estimated that lifecycle cost savings for advanced concrete and asphalt use in highway pavements would offset the higher front-end cost differential by more than a factor of six. At the current annual replacement rate of 800 lane miles, the nation's annual savings on materials alone would come to about half a Billion, due to longer service life and lower maintenance and travel delays costs. Specific DOT R&D programs related to advanced materials or technology applications to transportation infrastructure are described below.

2.1 PIPELINE SAFETY RESEARCH (RSPA)

Major pipeline incidents, such as the November 1994 rupture during a flood in Houston, have created a significant new focus on the need for enhanced technology related to pipelines. RSPA develops reliable technical information and analytical methodologies necessary for planning, evaluation, and implementation of pipeline safety regulations. RSPA also conducts studies and collects data in order to develop measures which address the risks inherent in the transportation of natural gas, including associated liquefied gas facilities, hazardous liquids, and carbon dioxide by pipeline.

2.1.1 Current Research

RSPA's major infrastructure responsibility relative to pipelines is to ensure the safe operation of the nation's network of oil and gas pipelines and underground storage tanks and caverns. Specific ongoing Pipeline Safety R&D programs address: corrosion protection of tanks and pipelines; stronger structural materials including steels, composites and high strength plastics; development and testing of non-destructive testing (NDT) inspection methods; and evaluation

of new pipeline component technologies, coupled with pipeline safety in design and operation criteria.

2.1.2 Planned Research in FY96

New efforts focus on developing analytic tools and advanced automated NDT inspection and diagnostic technology methods (such as self propelled sensing instruments called "smart pigs") for assessing the integrity and predicting failures of pipelines and valves. Strong emphasis will be placed on evaluating advanced materials, stronger and more resistant to corrosion and other environmental effects. In addition, several advanced materials R&D initiatives were proposed with multimodal and crosscutting infrastructure applicability.

2.2 HIGHWAY INFRASTRUCTURE RESEARCH (FHWA)

The effects of an aging and deteriorating highway system are becoming more visible--increased delays, incidents of catastrophic failure, congestion, and reductions in safety, service, and productivity. A significant challenge remains to preserve the existing investment in our infrastructure and improve the strength and life of our pavements and structures to meet the increasing demands for safer and more efficient movement of people and goods. In response to these growing infrastructure needs, FHWA conducts an R&D program designed to preserve and enhance the Nation's highway system. Better quality, longer lasting, and stronger materials equate to fewer repairs, safer highways and longer life cycles. Some of FHWA's research concentrates on identifying new materials technology for the 21st century highway applications. FHWA will continue its emphasis on increasing the understanding of the properties and performance of these materials, and enhancing applications of existing materials for use in highway construction.

FHWA has a substantial R&T program focused on infrastructure assessment and renewal, comprised of pavements and structures research (including new and conventional materials), and a Long Term Pavement Performance Program (LTPP). The following discussion focuses on research aimed specifically at improving highway materials for pavement and structures, ultimately leading to a less expensive and more efficient transportation system.

2.2.1 Pavement Research

2.2.1.1 Current Research

The Pavement research program will improve the quality and productivity of pavement construction, rehabilitation and maintenance. Technology demonstration efforts include constructing the test track for the accelerated testing of performance related specifications for hot-mix asphalt pavements; identifying typical variability for portland cement concrete construction procedures; and evaluating crumb rubber modifier technology as it relates to construction, recycling, and pavement performance.

2.2.1.2 Research Planned in FY96

In FY 1996 research efforts will include:

- Evaluate maintenance/repair materials and procedures for rigid pavements.
- Evaluate advanced design and construction features for rigid pavements.
- Conduct research to further develop guidelines for waste materials
- Expand life cycle cost methodology to perform optimization.
- Demonstrate and construct new test pavements at FHWA's Turner-Fairbanks pavement testing facility.
- Study the fundamental properties of asphalt and modified asphalt.
- Initiate a new contract to provide research support services for the pavements/materials laboratories.

2.2.2 Structures Research

2.2.2.1 Current Research

The Structures research program is focused on obtaining measurable improvement in the lifecycle costs of U.S. highway structures and observable inspection and maintenance cost saving or extensions of service life in all common types of existing structures without degradation of highway safety or the environment. Near-term research efforts include establishing acceptable bridge seismic retrofit performance criteria for increased column strength and ductility; identifying engineering characteristics of bedding materials for the design and construction of culverts; developing details for steel and aluminum structures to enhance corrosion resistance and reduce maintenance needs; and publish reports on the performance of power coatings and of low volatile organic compound paints to reduce corrosion and environmental damage.

2.2.2.2 Research Planned in FY96

Structures research efforts will include:

- Identify engineering characteristics of bedding materials for the design and construction of culverts.
- Develop concrete mix designs to prevent or resist the corrosion of reinforcing steel.
- Release improved specifications for durability of geosynthetic reinforcement elements.
- Publish guides for the design of drilled shafts and spread footings in intermediate quality geomaterials.
- Complete development study for the San Diego advanced composites cable-stayed bridge, which will monitor and demonstrate superior performance.
- Develop scour equations for supporting foundation materials exposed to effects of scour and erosion.
- Quantify the corrosive effects of the environment on bridge steels.

- Develop accelerated test methods to predict the long-term performance of advanced composite materials.

2.2.3 Long Term Pavement Performance (LTPP)

2.2.3.1 Current Research

The LTPP is the largest pavement performance research project ever undertaken. It is a national in-service pavement performance monitoring program intended to develop a data base on the effects of pavement design, loading, materials, loading environment, and rehabilitation and maintenance on pavement service life. The total data base will eventually include 20 years of performance data, and involves periodic data collection and condition monitoring of approximately 2,500 in-service pavement test sections, located throughout the U.S.and Canada. The goal of the program is to increase pavement service life by the characterization of long-term performance of various designs of and materials for pavement structures and rehabilitated pavement structures, using different materials and under different loads, environments, subgrade soils, and maintenance practices. Efforts are currently underway to develop testing protocols for portland cement concrete bond strength and thermal coefficient expansion, and creep compliance testing for asphalt mixtures.

2.2.3.2 Research Planned in FY96

In FY 1996 FHWA LTPP research efforts will include:

- Develop nondestructive testing procedure to quantify layer thickness.
- Develop localized expert system for rating preventive maintenance treatments.
- Develop guidelines for preventive maintenance treatments.
- Provide a technically sound assessment of the adequacy of existing procedures for the design of new and rehabilitated pavements.

2.2.4 Advanced Research Program

2.2.4.1 Current Research

An Advanced Research Program established under ISTEA Section 6001 sets priority on innovative, cutting-edge emerging technologies with infrastructure promise, such as robotics for highway state-of- health inspection and pothole filling; self-monitoring systems; high-performance materials for pavements; coatings, adhesives and structures; use of waste and recyclable materials for highway construction; and decision-analysis tools. This program also funds cooperative efforts with other agencies, including the National Institute of Standards and Technology (NIST), the National Science Foundation (NSF) and DOD's Army Corps of Engineers (ACE); and with industry, including the Civil Engineering Research Foundation (CERF)-managed Highway Innovative Technology Evaluation Center (HITEC), designed to enable early application of novel technologies. Technology transfer

activities, both national and international, are included in this R&T initiative.

2.2.4.2 Research Planned in FY96

At this time, the FY 1996 Advanced Research Program remains to be defined. The responsibilities of the existing Advanced Research Program office may be merged with other FHWA R&D Offices; FHWA has yet to detail an out-year research program in this area.

2.2.5 Applied Research and Technology

ISTEA Section 6005 also funds an Applied Research and Technology Program, focused on accelerating, testing, evaluation, and implementation of technologies which are designed to improve the durability, efficiency, environmental impact, productivity, and safety of highway transportation systems. There are concentrated efforts on five identified technologies:

- Heated bridge technologies
- Elastomer modified asphalt
- High performance blended hydraulic cement
- Thin bonded overlay and surface lamination of pavements, and
- All weather pavement markings.

Through the use of demonstration, experimental, and test and evaluation projects, the users--state and local highway agencies and other public and private members of the highway community--will be exposed to new technologies. In many cases, the users are involved in the process, putting them in the position of change agent and ensuring a much greater probability of adoption of the technology.

2.2.6 Strategic Highway Research Program (SHRP) Implementation

The benefits of the FHWA SHRP, a 5-year research program mandated by Congress, are currently being realized through its systematic implementation. Products of this long-term effort are being modularized, packaged and developed under the guidance of a Coordination Group (which includes FHWA field organizations, industry associations, the Transportation Research Board, and users) and four technical Working Groups (Asphalt, Concrete and Structures, Highway Operations, LTPP). Their work includes the following:

- Publish a SHRP Implementation Plan for fielding more than 130 program products and for technical training and technology transfer support.
- Prepare "showcase packages" of technology modules for demonstration and delivery to the states via FHWA's regional offices and through workshops for state planners and industry.

The application of these products by States and local authorities is expected to receive emphasis within the highway community similar to SHRP to ensure that usable and worthwhile products are made available and put into practice by states and local highway agencies. This implementation program will involve the overall highway community, public and private, in the development, evaluation, promotion, and adoption of SHRP technology and involve private industry, when possible, in the manufacturing of SHRP products.

2.2.7 Seismic Research Program

2.2.7.1 Current Research

The FHWA research program for the seismic protection of bridges consists of two contracts awarded to the National Center for Earthquake Engineering Research headquartered at the State University of New York at Buffalo. Improved seismic guidelines for new highway construction will be developed as well as revised seismic retrofit guidelines to provide cost-effective tools for improved evaluation and seismic upgrading of the existing highway network. Research studies on the seismic vulnerability of major highway system components including bridges, tunnels, retaining structures, slopes and embankments will be conducted. FHWA will identify Nondestructive Evaluation (NDE) needs for bridge instrumentation and maintenance prioritization management Systems; publish reports on the performance of powder coatings and of low volatile organic compound paints to reduce corrosion and environmental damage; continue research on sacrificial cathodic protection; establish acceptable bridge seismic retrofit performance criteria for increased column strength and ductility; identify engineering characteristics of bedding materials for the design and construction of culverts; and develop details for steel and aluminum structures, to enhance corrosion resistance and reduce maintenance needs.

2.2.7.2 Research Planned in FY96

In FY 1996, FHWA's seismic research efforts will include the following:

- Develop a series of seismic design guidelines and implementation aids.
- Produce a workshop to train bridge and highway engineers on the use of these aids.
- Develop a series of tools and technologies that can eventually be implemented in future design codes and standards.
- Hold a workshop on seismic design criteria for long span bridges in order to identify the problems that must be addressed in designing bridges and spans greater than 500 feet to resist earthquake loads.

2.3 MATERIALS-RELATED RAIL RESEARCH (FRA)

Changes in railroad equipment and operating speeds and procedures must be evaluated to ensure that they do not erode the safety of both freight and passenger equipment operation.

FRA's infrastructure-related R&D programs focus on such safety improvements, and on rail development and corridor improvement. Materials-related issues and technologies are an integral part of the programs described below.

2.3.1 Equipment and Components Research

2.3.1.1 Current Research

The goals of FRA's Equipment and Components Research program is to improve safety, enhance productivity and effectiveness within the railroad industry by reducing injuries, accidents, and their related costs, caused by: human error, inefficient or ineffective operations; unanticipated and catastrophic equipment or component failures; and, the inadvertent release of hazardous materials. In the near-term, FRA will continue evaluation of required structural integrity of new materials for tank car construction; continue analysis of parameters for acceptable tank car structural integrity, investigation of alternative methods for evaluating continued tank car integrity, and update tank car damage assessment; establish minimum performance standards for locomotive fuel tanks; and develop a database for reportable locomotive accidents/incidents and model them to correlate personal injury probability with collision dynamic parameters.

2.3.1.2 Research Planned in FY96

New materials-related initiatives planned for FY96 include:

- Evaluate impact of advanced light-weight materials on structural integrity of passenger cars.
- Develop and validate NDE methods for inspecting tank car welds.
- Develop an assessment procedure for new tank car designs.

2.3.2 Track, Structures, and Train Control

2.3.2.1 Current Research

The goals of the Track, Structures, and Train Control research program are to reduce train accidents due to track and signal defects; develop technology to allow discovering such defects well before failure; develop methodologies for predicting service life of track and signal components and how they behave under dynamic conditions; develop protocols to improve efficiency in inspection, preventive maintenance, repair, and renewal actions; and develop technology to enable safe train operation in heavy tonnage environments.

Research efforts related to advanced materials modeling or applications include: operation and test support for heavy axle load tests; the performance of wood ties with fiber-composite wrap; and determination of conditions under which dynamic interactions between vehicle and track can cause derailment.

2.3.2.2 Research Planned in FY96

In FY 1996, FRA research efforts will include:

- Quantify and test resistance of concrete-tie track to lateral buckling from heat and load stress.
- Heavy Axle Load tests of track components and improved freight car truck suspensions.
- Establish causal factors in long-term processes leading to failure of rail and track components.
- Test and evaluation of new technology as a means for increasing the sensitivity and quality of ultrasonic measurement of rail internal condition

2.4 MATERIALS-RELATED AIRPORT TECHNOLOGY RESEARCH (FAA)

2.4.1 Airport Pavements Research

Two of the main goals of the Airport Technology program are to reduce the cost of pavement expenditures and to eliminate runway accidents due to incursions and slipperiness. Airport pavement advances lag behind current aircraft technologies. FAA is responsible for encouraging and fostering safe and efficient national airport system development. The Airport Technology R&D Program assists in developing new and improved standards, criteria, and guidelines to plan, design, construct, operate, and maintain the Nation's airports, heliports, and vertiports.

2.4.1.1 Current Research

Current efforts include the development of layered- elastic predictive modeling of high-performance pavements, able to sustain with minimal wear frequent landings of heavy aircraft, and to be rapidly deiced and maintained; and formulation of design/performance standards for advanced pavements. In the near-term, FAA plans to issue an interim standard and design specification for the National Pavement Test Machine.

2.4.1.2 Research Planned in FY96

FAA plans to complete its layered elastic pavement design report and software in FY 1996. In addition, the agency will:

- Continue to collect and analyze data that relates pavement performance to FAA design and construction standards.
- Issue annual report on pavement response and performance studies.
- Develop pavement design tools based on finite element analysis.
- Conduct research on nondestructive pavement test techniques and analysis methods.

2.4.2 Airport Security Technology

Although this R&D program is not directly related to advanced materials, advanced security technologies, such as the Explosives Detection Systems (EDS) and hardened containers to be developed and deployed, require application of material science models, sensors, materials properties and interaction with penetrating electromagnetic radiation, and practical behavior under explosive loading stress. Tough, fiber reinforced containers for baggage have multimodal applications in transportation.

3.0 ADVANCED MATERIALS RESEARCH FOR VEHICLES AND OTHER APPLICATIONS

One of the most important functions assigned to DOT at its inception was to assure the safety of the nation's transportation system. This mandate covers all modes, including road, rail, transit, water, air, pipelines and hazardous materials. It also includes physical infrastructure; command, control, communications and navigation systems; and vehicles which operate on this network. Given this basic emphasis, many of the Department's vehicle-related R&D activities are aimed primarily at safety issues. For example, NHTSA is responsible for R&D covering passenger highway vehicle safety, a responsibility it shares with FHWA for motor carriers. FRA and FTA also maintain safety responsibilities for rail and transit vehicles, locomotives and passenger buses, as well as related safety research and technology development programs.

The Department's focus for vehicles, however, has been expanded considerably beyond safety assessment and regulations in recent years. The manufacture, sale and maintenance of transportation vehicles, especially automobiles and commercial aircraft, is one of the largest single segments of the U.S. economy, and aircraft exports are a major generator of trade surpluses for the nation. At the same time, the transportation function is increasingly being expected to help meet important energy and environmental goals for our society, including higher fuel efficiency, drastically reduced levels of harmful emissions, and a reduction in long-term solid waste disposal requirements. In response to these concerns, the Federal government and States DOT's are increasingly becoming engaged in programs designed to apply state-of-the-art technological advances in transportation in order to meet these combined economic, energy and environmental goals simultaneously.

3.1 HAZARDOUS MATERIALS CONTAINERS (RSPA)

RSPA's Office of Hazardous Materials (hazmat) Safety is responsible for the development and enforcement of regulations governing the design, construction, testing , certification, inspection and use of containers used for shipping hazardous materials and compressed gases. It works cooperatively with industry to enable and encourage use of advanced materials (carbon fiber composites, or titanium alloys) for containers that afford weight savings with improved performance at a comparable or better safety level. The Hazardous Materials

research program is designed to provide a scientific methodology for classifying, routing and tracking transported hazardous materials. This research stresses the use of computers and modern communications to implement the new scientific methodology, coupled with use of new, stronger and lighter advanced materials for hazmat containers to prevent hazmat releases.

3.1.1 Current Research

Near term efforts related to materials aspects include: developing evaluation criteria and classification schemes for dry batteries, thermally unstable substances, and radioactive material communication systems; and reporting on identification of factors for selecting modes and routes for shipping high-level radioactive waste and spent nuclear fuel.

3.1.2 Research Planned in FY96

In FY 1996, RSPA will:

- Complete: Molybdenum 99 radiation dose reduction study, evaluation of RAM specification packaging; development of small scale testing for classification of explosives; and report to Congress on "Identification of Factors for Selecting Modes and Routes for Shipping High-Level Radioactive Waste and Spent Nuclear Fuel."
- Complete "Guideline for Conducting Surveys on the Highway Transportation Patterns of Hazardous Materials."

3.2 PARTNERSHIP FOR A NEW GENERATION OF VEHICLES (NHTSA)

In September 1993, President Clinton, Vice President Gore and Chief Executive Officers of Chrysler, Ford and General Motors announced an historic new "Partnership for a New Generation of Vehicles" program, or PNGV, aimed at strengthening U.S. competitiveness and protecting the environment. The overall goals of this effort include: developing a range of technologies to yield automobiles with a three-fold improvement in fuel efficiency and reduced emissions, without compromising other features such as performance, safety and utility; as well as developing and introducing manufacturing technologies and practices that will reduce the time and cost associated with designing and mass producing this new vehicle.

The DOT is an active participant in this program, along with other federal agencies such as DOC, DOD, DOE, EPA, NSF, and NASA. DOT's role will be to provide technical support to the PNGV initiative.

3.2.1 Current Research

Within the Department, the National Highway Traffic Safety Administration (NHTSA) is the focal point for PNGV support. Its role is to ensure that the PNGV vehicles will meet existing and anticipated safety standards and that the overall crash and other safety attributes

of the PNGV vehicles are not compromised by use of new advanced materials that have not yet been tested in service. Towards this end, the agency is developing advanced computer models and acquiring the computing capacity necessary to evaluate the crashworthiness characteristics of alternate vehicle designs and new lightweight materials, such as proposed advanced composites. NHTSA is conducting a Peer Review study of the conceptual designs developed by the program. The Department will also create a comprehensive knowledge base and conduct analyses of the impact of this new vehicle on the U.S. economy, transportation system and motor vehicle industry.

3.2.2 Research Planned in FY96

Currently, a list of possible technologies for the National multi-agency PNGV has been prepared and a "master schedule" was established. The PNGV master plan calls for the narrowing the range of candidate technologies between 1995 and 1998 before a concept vehicle is developed. The choices that will be made during this process of "narrowing" may have long-term profound impacts on the Department's constituencies (i.e., vehicle users and manufacturers), and on the transportation and transportation fuels infrastructures.

It is the purpose of the program element to initiate an activity that will augment the PNGV Systems Analysis tasks and provide the Department with data for active participation in the PNVG decision making processes. The multi-year tasks include the following:

- Characterization of vehicle propulsion system components.
- Weight reduction potential assessments.
- Assessment of vehicle consumer acceptance attributes.
- Fuel economy and vehicle performance bounds.
- Identification of variables affecting infrastructure requirements and industry cash flows.

Only some of these elements involve advanced materials, but integration of their cost and safety performance attributes must be understood in a systems context. Data will be obtained from ongoing research activities and/or by establishing upper and lower bounds for missing attributes, and system trade-offs will be performed. Opportunities and risks will be assessed, as well as the reliability of available data. The emphasis for NHTSA in FY 1996 will be on obtaining data on vehicle subsystem performance and component requirements, and on the development of vehicle models for performing the requisite safety analyses.

3.3 AIRCRAFT SAFETY RESEARCH AND SECURITY TECHNOLOGY (FAA)

Materials of particular interest to the aviation community are advanced metals and polymer matrix composites (including high temperature polymers for such applications as the High Speed Civil Transport, HSCT) and high-temperature polymeric, intermetallic, and ceramic matrix composites for use in subsonic and supersonic gas-turbine engines. Validating the technical feasibility of manufacturing these structures and lowering the cost of engineered

materials are challenges that require sustained effort to achieve. Traditionally, these areas have been addressed by industry and NASA or DOD. However, materials science and technology does have a critical role in FAA's R&D programs because issues in aircraft safety, security and airport technology (see 2.4 above) are not adequately addressed by those organizations.

An important element for public confidence in the air transportation system is the aircraft fleet's continued safety. FAA's *Aircraft Safety Technology* research program consists of several major thrust areas related to advanced materials, i.e. aircraft systems fire safety, long term fire research, advanced structural materials, structural crashworthiness, aging aircraft, power plant safety, aircraft catastrophic prevention and aircraft hardening. The most important purpose of this FAA R&D effort is to develop technical requirements for aircraft safety improvements in an evolving aviation environment. examples of this evolution are numerous and include greater composite materials utilization for weight reduction, enhanced fuel efficiency and better performance.

Aircraft safety improvements will reduce fatalities and injuries, reduce losses, improve aircraft designs and impact maintenance and inspection procedures. The most important purpose of FAA's aircraft safety research is to develop technical requirements for safety improvements needed to maintain or improve the safety level in an evolving aviation environment. Examples of this evolution include greater composite materials utilization.

The goal of the *Advanced Materials Research Program* is to enable modeling and prediction of the response of a given material system to anticipated in-service chemical, thermal and mechanical environments. Current emphasis is on Fiber-Reinforced Polymer-Matrix Composites (FRP) and their derivatives currently in service and in production. Long term objectives include evaluation and integration of new laboratory advancements in the safety certification assessment for new components or aircraft applications (e.g., metal matrix and ceramic matrix composites for engine applications).

The purpose of the *Structural Safety Research* effort is to increase protection for both occupants and crew during an accident and focuses on advanced composites materials structure safety. Structural crashworthiness encompasses improvements in passenger restraints and crash energy absorption, as well as facilitating escape by maintaining the integrity of the cabin interior.

One of the main thrusts of FAA's *Propulsion Systems Research* is powerplant safety. Engine structural safety R&D addresses failure of high energy or high temperature engine components in a manner that could lead to catastrophic loss of an aircraft. Of prime concern are first, the structural integrity of blades, spacers, seals and disks during engine operation at high rotational speeds; and second, the integrity of the engine case which contains the high pressure combustion zone of the engine. Advanced materials issues relate to the fact that low wear, high temperature engine parts involve ceramics or ceramic matrix composites, and also high performance alloys.

The 1990 Aviation Security and Improvement Act prompted modification and expansion of FAA's security R&D program beyond its original focus on weapons detection. FAA's program is concerned not only with structural sabotage from onboard explosive devices, but also with spurious electromagnetic security signals that can sabotage or interfere with the flight control of an aircraft. The *Aircraft Hardening* (sec. 3.3.4) portion of this research program will identify methods to increase aircraft survivability by reducing damage caused by small explosive detonation on a commercial airliner.

3.3.1 Aging Aircraft Research Program

The goal of this FAA is to develop the theoretical understanding and technologies needed to maintain the structural integrity of older, in-service aircraft through a reassessment of current aircraft design, maintenance and inspection programs. New methods will enable: extended safe in-service life, prediction of the effects of aging, and improved ability to detect reliably and then remedy structural fatigue and corrosion.

3.3.1.1 Current Research

Aging airframe structures have shown increasing susceptibility to widespread fatigue damage (WFD) and corrosion that could pose a threat to their structural integrity. Instances of structural failures point to the need for increased reliability in inspection methods. Furthermore, the demands on the aviation safety inspectors due to the aging aircraft fleet require automated data tracking improvements. This research effort will develop the means for evaluating and ensuring safety and reducing the risks associated with aging aircraft structures. The three thrust areas of Aging Aircraft research are: structural design, maintenance and inspection, and automated methods for surveillance of information relating to the aging aircraft fleet. Research efforts will include developing methods to predict corrosion and corrosion fatigue interaction in airframe materials; and verifying failure criteria and residual strength predictions.

3.3.1.2 Research Planned in FY96

In FY 1996, the Aging Aircraft research projects will develop: inspection and maintenance requirements for non-rotating, safety critical components of aircraft engines; and an integrated widespread fatigue damage (WFD) initiation and residual strength risk methodology. Other efforts will evaluate and validate nondestructive inspection equipment; and develop an integrated safety network for FAA and industry use in exchange of maintenance and inspection data.

3.3.2 Advanced Materials and Structural Safety

3.3.2.1 Current Research

The advanced materials research is focused on developing data on new materials being introduced into the design of current and future civil aircraft. This data will form the national basis for engineering, manufacturing and maintenance/certification rulemaking. This research will also foster continued US leadership in commercial aviation, while promoting safety in a demanding and rapidly changing global environment.

Three technology thrusts of this program are: materials, structures and manufacturing/supportability. The goal in the materials thrust is to predict the response of new materials (fiber-reinforced polymer matrix composites, as well as metallic and ceramic matrix composites) to environmental and operational stresses. The structures thrust requires evaluation of strength, stiffness, durability and damage tolerance in- service repeated loading of all structural elements, components and full scale assemblies. The manufacturing and supportability thrust is concerned with research to enable safe operation of the aircraft throughout its lifecycle. This requires development of suitable inspection methods to detect damage or defects in structures including advanced materials.

Some current research efforts in advanced materials include the following:

- Develop a common standard for materials and processes to repair composite parts;
- Improve repeated load testing and determine load sequencing effects on damage initiation and accumulation;
- Determine response of curved panels to low velocity impacts, such as runway debris or tool drops, by testing and analysis; and
- Complete a feasibility assessment of the probabilistic design and failure prediction methodology, by surveying U.S. and foreign sources, including a case study on how this approach was used in design of military composite aircraft.

3.3.2.2 Research Planned in FY96

In FY 1996, FAA will conduct the following research efforts:

- Continue research on damage accumulation in composites due to repeated loads to establish test protocols for certification of aircraft.
- Initiate a data base on damage tolerance of fuselage structures made of composite materials.
- Develop a computer model for determining the reliability of composite structures.
- Develop a Handbook on acceptable composite material mechanical property test methods.
- Fabricating prototype advanced aircraft energy-absorbing seats.
- Collect data to improve the seat design and analytical model.

3.3.3 *Aircraft Catastrophic Failure Prevention Research*

3.3.3.1 Current Research

This program focuses on advanced means to predict and prevent catastrophic structural failures on future commercial transport aircraft. A goal of this program is to develop technologies and methods of advancing U.S. expertise in turbine engines, airframe structures and flight control systems. Research will be directed toward advanced means to predict and prevent catastrophic structural failures on future commercial transport aircraft. Emphasis will be placed on forming accurate, quantitative definitions of dangerous aircraft loading conditions; structural failure prevention through improved airframe design and maintenance; and structural failure survivability through an improved understanding of failed airframe loading conditions.

In the near term research will focus on completion of flight testing of first generation rotorcraft health and usage monitoring system; continued development of advanced nondestructive inspection concepts for titanium engine rotor alloys; initiation of research in advanced aircraft damage tolerant/smart sensor structure; and completion of a state-of-the-art review of advanced barrier armor materials.

3.3.3.2 Research Planned in FY96

The Aircraft Catastrophic Failure Prevention research program will demonstrate a prototype rotor fragment liberation, barrier penetration, and aircraft damage model in FY 1996. Research will continue on advanced aircraft damage tolerant and smart sensor structures, and in airframe load analysis and testing.

3.3.4 Aircraft Hardening

3.3.4.1 Current Research

The threat to aircraft survival due to an in-flight detonation of a small explosive device continues to be significant. The aircraft hardening program objectives are to determine the minimum size explosive that must be detected to ensure aircraft survivability as well as assessing methods of increasing survivability through a reduction in blast effects and/or an increase in aircraft capability to resist blast through design changes to structures or systems (including hardened luggage containers). Current research efforts include the following: support the testing of alternative containment and blast management designs; validate the analytical vulnerability assessment of wide-body aircraft; and determine realistic, scientifically-based assessment of the minimum amount of explosives that must be detected.

3.3.4.2 *Research Planned in FY96*

In coming years, several technologies may be used to harden aircraft and their contents.

Attention to their initial cost, weight, and durability is needed. If key importance is the promise aircraft hardening holds for reducing explosives detection requirements. Hardening may also benefit from aging aircraft and catastrophic failure prevention R&D projects that augment the scientific understanding of aircraft materials. In FY 1996, FAA will:

- Continue research in the identification and evaluation of potential aircraft hardening techniques.
- Identify, analyze, and test mitigation techniques for projected energy, electromagnetic, and surface-to-air missile threats.

3.3.5 Advanced Fire- Safe Aircraft Materials

This effort focuses on preventing fires from occurring, slowing their growth and suppressing them, as well as providing design features which give passengers sufficient time to escape. This program includes advanced materials in a systems approach to improve cabin fire safety along with fire prevention, detection and control.

3.3.5.1 Current Research

Current research focuses on modeling and testing the fire behavior of materials for aircraft cabins, and on devising guidelines and regulations to prevent and mitigate consequences of fires. Thermoset composites (e.g. fiber-glass reinforced phenolic resin composites and sandwiches) are currently used for interior furnishings. These and other materials (foams, insulation, molded plastics) have to meet stringent fire-resistance, and smoke and toxic byproduct regulations. Fire safety improvements for both structural and interior materials of future aircraft (such as thermoplastic polymers instead of currently used thermosets) require much more research in flammability, heat of combustion, and toxic byproducts, especially if the use of lightweight composites with high potential heat release will increase in future fuel-efficient aircraft. Also, in light of increasing use of advanced communication and electronics in the cabins, more research is needed on fire causation and suppression.

3.3.5.2 Research Planned in FY96

Although this is a long-range R&D program, FY96 efforts will include research on the synthesis, performance characterization, bench-scale fire testing and modeling/simulation of thermo-structural behavior for fire-safe thermoset resins. Also, cooperation with manufacturers for process control sensors and low-cost processing will be initiated.

3.4 SHIP STRUCTURES AND AIRFRAME RESEARCH (USCG and MARAD)

The lack of competitiveness of U.S. commercial shipyards when compared to their foreign counterparts is becoming an issue of increasing concern. This is particularly true in the context both of overall economic competitiveness of the U.S. in a global economy, as well as the need for a strong domestic merchant marine and shipping industry to support vital

national security capabilities. In response to these concerns, President Clinton released a report to the Congress entitled Strengthening America's Shipyards: A Plan for Competing in the International Market in October 1993. Secretary Peña included this issue in the Department of Transportation's Strategic Plan issued three months later. Goal 3.7 of the Strategic Plan commits the Department to "***[I]mplement the President's new shipbuilding initiative to enable American shipbuilding to be more competitive globally.***"

3.4.1 Shipyard Revitalization (MARAD)

3.4.1.1 Current Research

The Shipyard Revitalization Program is meant to provide the means to implement these important commercial and national security goals. This Program, to be undertaken by the Maritime Administration (MARAD) in close coordination with the DOD and the U.S. maritime industry, has four major aspects. First, a Global Market Analysis Program will be formed to gather, analyze and share data on the world's shipbuilding market. Second, ship standards will be assessed, and problems in the development of new standards will be identified and resolved. The advanced materials and processing technology aspects are primarily related to this goal. Third, shipyard initiatives to shorten delivery time, lower costs, and improve quality will be supported. Finally, two Shipbuilding Extension Centers will be established to assist the industry in applying new technologies and improving business practices and work force training. This entire effort will supplement the $ 200 M MARITECH shipbuilding technology modernization initiative, managed by DOD's ARPA with DOT's active participation, which focuses more narrowly on the technological aspects of improved shipbuilding.

3.4.1.2 Research Planned in FY96

Critical areas in support of the U.S. shipbuilding industry, which are not supported by the MARITECH advanced technology approach, have been identified as being important to ensure the survival of the industry. In FY 1996, MARAD will stress the need for projects which provide immediate benefit, as opposed to those which will not see results for longer periods of time. MARAD research programs will highlight the following related to infrastructure and materials:

- A government-industry cooperative partnership will be formed to improve the competitiveness of the U.S. private shipbuilding and ship repair industry through better understanding of the market, improved data availability and education.
- Will assist in solving problems in the development of new standards. Possible projects could include conducting tests to determine the acceptability of new materials and associated methods.

3.4.2 Ship Structures Research (USCG and MARAD)

3.4.2.1 Current Research

Numerous pressures on maritime operations -- such as cutting crew complements to save money, competitive demands for greater speed and labor productivity, and congestion in harbors and waterways -- all tend to increase safety risks. One means of dealing with these concerns is represented by the Ship Structures Research Program. This is a cooperative research activity supported by U.S. and Canadian government agencies (USCG, MARAD, U.S. Navy and its Military Sealift Command, the Canadian Ministry of Transport and the Canadian Defense Research Establishment), as well as the American Bureau of Shipping. Its goal is to facilitate the design and construction of safer and more cost-effective ship structures through the development and sharing of new materials and technologies. However, lighter, stronger and corrosion-proof ship hull and components, and advanced coating materials for corrosion protection are included.

3.4.2.2 Research Planned in FY96

In FY 1996, emphasis will be placed on improving the safety and integrity of marine structures, reducing marine environmental risks and support R&D to the U.S. maritime industry in shipbuilding, maintenance and repair.

3.4.3 Fire Safety Composite Air Frame Research (USCG)

3.4.3.1 Fiscal Years 1994-1998

The material used in the construction of the HH-65 airframe has not been previously tested to determine the characteristics of the materials that make up the composite when exposed to fire. No historical data exists concerning the fire performance of the materials used in the HH-65 composite airframe. Over 80 percent of the HH-65 airframe is made from advanced composite material (ACM). Review of available ACM thermal decomposition and its potential effects on USCG personnel raises serious health and safety concerns. Research is necessary to determine what toxic and/or carcinogenic by-products are generated by ACM in a fire scenario and what actions must be taken to protect personnel from their effects.

USCG will conduct the following research:

- Conduct a background study to identify the materials used in the airframe, any previous studies involving those composites, and any existing guidelines issued by other agencies such as the Air Force.
- Determine the fire safety, including both structural and toxicity data, of the materials.
- Conduct laboratory scale tests on the various component materials of the HH65-airframe to determine their specific chemical formulas and toxicity.

- Quantify the heats of combustion, rates of heat release, fire spread rates, by-products of combustion, and other fire parameters specific to these materials.
- Investigate potential risks added by composites versus risk due to electronics.
- Prepare test site for full-scale tests and conduct full scale tests as necessary.

3.4.4 Cargo Handling Cooperative Research Program (MARAD)

The Cargo Handling Cooperative Program is a cost-shared industry research and technology consortium for US flag ocean transportation companies, in partnership with MARAD. This R&T consortium has been very effective for the past decade developing innovative maritime cargo handling tools, services and technologies to enhance productivity and improve cargo handling capacity and speed. Several aspects of this program involve applications of advanced materials, such as high-cube lighter multi-modal freight containers that make use of advanced composites or light alloys.

4.0 DOT--PARTNER IN NATIONAL INTERAGENCY R&D AND TECHNOLOGY COMMERCIALIZATION EFFORTS ON ADVANCED MATERIALS

DOT has reached out to other Federal agencies--the White House Office of Science and Technology (OSTP), the Departments of Defense (DOD), Energy (DOE) and Commerce (DOC), the National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), and the Environmental Protection Agency (EPA)--in an aggressive effort to mobilize and coordinate more R&D activities throughout the government for transportation-related research. DOT interagency efforts related to the commercialization of advanced materials are discussed below.

4.1 National Science and Technology Council (NSTC)

The Clinton-Gore Administration has taken a new approach to R&D and issued both a Technology Policy and a Science Policy. In an effort to put the policy process in front of the budget process, the President established the NSTC. The principal purposes of the cabinet-level Council are to establish clear national goals for federal science and technology investments and to ensure that science, space, and technology policies are developed and implemented to effectively contribute to those national goals. Through this interagency process, overlapping and duplicative research will be avoided and technology policy will be given a higher profile. President Clinton is chairman of the Council, whose membership includes the Vice-President; and the Cabinet.

In order to prepare coordinated and balanced R&D strategies and budget guidance, the NSTC created nine interagency coordinating committees. DOT leads the Committee on Transportation R&D and participates in four other Committees: the Civilian Industrial Technologies (CIT), which has a Subcommittee on Infrastructure led by DOT/FHWA; International Science, Engineering and Technology; Education and Training; Environment and Natural Resources. Deputy Secretary of Transportation, Mortimer Downey, chairs the

Committee.

The Transportation Committee is committed to leading an effort to realize the vision of sustainable, seamless, and global transportation, with the goal of balancing different modes of transportation, while taking into account performance, cost, resource use, and social impact.

The Committee has recently completed a report that was submitted to the National Science and Technology Council identifying transportation R&D priority areas and providing strategic R&D budget guidance. Transportation R&D priority areas identified by the Interagency Coordinating Committee on Transportation R&D include greater research on infrastructure renewal materials, methods, and tools and expanded R&D on highway and aviation vehicle technologies with particular emphasis on the applications of advanced materials.

In May 1994, OMB and the Science Advisor to the President issued budget guidance to the heads of all Federal Departments. The guidance highlighted important FY 1996 R&D policies, goals, priorities, and evaluation criteria that were developed through the NSTC Interagency Committee process. Six cross-cutting goal areas were identified: 1) A Healthy, Educated Citizenry; 2) Job Creation and Economic Growth; 3) World Leadership in Science, Mathematics, and Engineering; 4) Improved Environmental Quality; 5) Harnessing Information Technology; and 6) Enhanced National Security.

These six priorities were not intended to be a comprehensive list of all R&D projects that merit support. They focus on those R&D areas that the NSTC committees identified as needing new or additional emphasis in fiscal year 1996. The majority of the NSTC Transportation Committee's priorities were included in the goal to promote job creation and economic growth. Those relevant priorities to materials R&D include the following: the Partnership for a New Generation of Vehicles (PNGV); Materials Technology; Transportation System Assessment; Transportation Physical Infrastructure; and Information Infrastructure for Transportation.

4.2 Technology Reinvestment Project

The Clinton Administration's Defense Reinvestment and Conversion program capitalizes on post-Cold War opportunities by investing in community redevelopment, worker retraining and advanced technology. Secretary Peña decided early on to promote the development of transportation-related technologies. The Department is a full partner in DOD's Advanced Research Project Agency's (ARPA) Technology Reinvestment Project (TRP). The TRP is an effort to stimulate the transition of military technologies into competitive commercial products that will both boost U.S. productivity and expand the customer base of defense products; thus lowering unit costs to all consumers. A key facet of the TRP is that proposals receiving awards require 50-50 cost-sharing. As a partner, the Department joined the Defense Technology Conversion Council along with representatives from other federal agencies. DOT has also been active on the Defense Technology Conversion Council

Working Group and the Technology Development Activity Area Panel.

DOD is the largest single customer of commercial transportation in the world and has substantial needs for modernization of its own transportation facilities and equipment. Historically, DOD has created new opportunities for commercial services and has expanded the market for advanced transportation products and dual-use technologies.

Transportation research and DOT have been big winners in the first two years of the TRP. By providing proposal evaluators and supplying ARPA with input about transportation-related areas that could benefit from TRP support, DOT has been able to guide TRP funding into areas that will benefit the nation's transportation system, such as new vehicle technology, advanced materials for infrastructure renewal, and advanced battery technology.

In February 1994, the final awards for the FY 1993 TRP competition were announced. In the Technology Development portion of the program, 69 cost-shared proposals with a total face value of $800 million were awarded. The Federal share of the $800 million has yet to be negotiated, but will be a maximum of 50 percent. Twenty-seven proposals with a total face value of $420 million were directly related to transportation. DOT is the managing agent on nine of these projects, including a $21 million project for Advanced Composites for Bridge Infrastructure Renewal--a project led by the University of California, San Diego, to demonstrate the use of corrosion-resistant, lightweight composites for repair and replacement of the nation's aging bridges, and for seismic reinforcement of support pillars. As managing agent, DOT will receive the TRP funds, negotiate the technical/legal issues in the funding agreements, make the awards, and conduct follow-up monitoring.

The MARITECH segment of the TRP has awarded $200 million in FY 1994 and $40 million in FY 1995 for cooperative, cost-shared technology development to improve the manufacture, operation and repair of ships. MARAD is the executive agent on the $13.9 million Commercial Shipbuilding Focused Development Project. Included in the FY 1993 awards was a Portable Shipbuilding Robotics project to develop a dual-use, portable robotic welding system that would improve the productivity of the U.S. shipbuilding industry. The effort would integrate technical advances in Personal Computers, robotic design, 3-D vision, and weld sensors to provide a portable welding system developed especially for the shipbuilding industry. If successful, these robotics would automate up to 75 percent of ship welding, quickly reducing the cost of shipbuilding.

On October 25, 1994, ARPA announced the 39 winners of the 1994 Focused TRP Competition. DOT will have significant technical involvement in five of these projects which exceed $69 million in face value. All winning projects demonstrate enhancements to both the military and commercial capabilities of the nation, and further the TRP mission to stimulate integration of the nation's defense and commercial sectors.

TRP also announced a third competition for $415 million, including 13 Technology Development areas, including: affordable matrix composites for airframe structures, low-

cost specialty metals processing, and ceramic materials applications. TRP intends that this latest round of awards will be announced by February 1995.

In addition, in FY 1994, DOT reviewed 1200 TRP Small Business Innovation Research (SBIR) proposals and identified those with dual-use transportation promise. DOT is managing in FY 1995 twenty-two SBIR TRP awards with a value of $2.1 million and will guide research through to commercialization. Several projects deal with development and demonstration of advanced materials technologies: The FHWA manages development of a Configurable Automated Pavement Distress Survey system; NHTSA manages advanced processing (Pullform) of titanium and aluminum blades for gas turbine engines; the FAA manages the fabrication of composite turbine powershafts by explosive welding techniques; and also innovative processing of ceramic core/composite skin structures applicable to commercial aircraft.

Advanced Materials Partnerships, new to the TRP in FY 1995, will award $15 million to reduce the cost of components and devices manufactured from advanced materials. This has particular promise for transportation markets.

4.3 Advanced Technology Program

The Advanced Technology Program (ATP), as managed by DOC's National Institute of Standards and Technology (NIST), is helping U.S. industry to fund the development of high-risk, but powerful new technologies that underlie a broad spectrum of potential new applications, commercial products, and services. The ATP, which awarded $200 million in FY 1994, provides support on a cost-sharing basis to industrial R&D projects with a significant potential for stimulating economic growth and improving the competitiveness of U.S. industry. DOT has been working with NIST and the industry to include transportation as a focus area of the ATP.

The ATP will award $200 million in FY 1994 funds. In FY 1995, $450M has been requested for the program, and it is expected to grow to $750M by 1997. In late February 1994, NIST announced the first FY 1994 ATP competition to support industrial research projects. Under this general competition in which all areas of technology are eligible, an estimated $20-25 million in first year funding will be available.

NIST announced five ATP program competitions in 1994, including one on Manufacturing Composite Structures. The Manufacturing Composite Structures topic will receive $160 million over five years and will highlight transportation applications of composite materials to both vehicles and infrastructure. The three primary areas to be explored through this program competition are the use of Composite materials in automobiles, bridges, and offshore oil platforms.

In November 1994, the Commerce Department announced the winners of two ATP competitions: the General Competition and the Program on Manufacturing Composite

Structures. General competition awards related to advanced materials for transportation applications include the following: film technologies to replace paint on aircraft; low-cost elastomeric composites with application to vehicle tires; engineered surfaces for rolling and sliding contacts; and rapid solidification powder metallurgy for high-nitrogen stainless steels. Transportation-related awards made under the program on Manufacturing Composite Structures include: low-cost automotive manufacturing with injection molding PET composites; automotive composite structures: development of high-volume manufacturing technology; low-cost manufacturing and design/sensor technologies for seismic upgrade of bridge columns; manufacturing composite flywheel structures; high-performance composites for large commercial structures; thermoplastic composites for structural applications; structural composites manufacturing process; innovative manufacturing techniques to produce large phenolic composite shapes; and polymer matrix composite power transmission devices.