



U.S. Department of Transportation
Maritime Administration

MARITIME RESEARCH AND TECHNOLOGY DEVELOPMENT

A Report to Congress



June 2002

EXECUTIVE SUMMARY

This Congressionally mandated study reviews transportation research and technology development in the U.S. with special emphasis on the marine transportation system (MTS). The United States relies on the MTS to maintain its role as a global trading nation. The waterways, ports, intermodal connections, vessels, vehicles, manufacturing facilities, and information systems that form the core infrastructure of this system face daunting challenges in the coming years to keep up with the anticipated doubling and tripling of demand and the need for increased security.

Innovation in the ability to move goods, commodities and people is also required to fully realize innovations in production and business transactions. Improving the efficiency and quality of the marine transportation system is critical to realizing the nation's advances in technology and turning changes in the world's business practices to U.S. competitive advantage. The marine transportation system for the future must have not only the ability to meet much greater demands, but must also be flexible enough to deal with outages or interruptions in order to continue to meet national security and economic needs.

Many components of the MTS provide significant quality of life and recreational activities with users and stakeholders looking to the Federal government for leadership and coordination. A proactive Federal role is necessary to insure that the system meets commercial and national security needs and does so in an environmentally responsible and safe manner.

Federal research and development (R&D) funding for the commercial modes of transportation is limited and has remained constant over the past several years. R&D programs of the many Federal agencies that make up the MTS currently focus on individual agency missions whereas coordination of requirements at the systems integration level needs to be more fully addressed. Research by the commercial maritime industry has been minimal due to the characteristically high capital investment and low profit margins of the industry.

For the MTS, government funding supporting the nation's strategic goals of developing a robust maritime infrastructure to improve cargo flow capacity, safety,

and security, has been far less than funds designated for other marine resources and environmental protection. Infrastructure changes in maritime also take decades to achieve. With today's system already strained to serve current cargo movements and with the volumes of goods transported expected to double or triple by 2020, significant attention to addressing future requirements must begin now.

Recently, there have been several initiatives resulting from government, industry, and academic partnerships. The Department of Transportation (DOT) MTS initiative is one such effort. The MTS Interagency Committee (ICMTS) and the MTS National Advisory Council (MTSNAC) have begun to collaboratively develop a comprehensive MTS R&D needs assessment to address the challenges facing the MTS.

Several years ago, our trading partners from the European Union recognized the importance of a coordinated approach to their maritime R&D and established a structured research program to address collective needs. The U.S. would benefit by following suit and developing a comprehensive R&D plan, followed by a commercial R&D infrastructure that leverages use of our public and private resources in a safe, efficient, energy-conservative, and environmentally friendly way. While industry R&D investments have been minimal, a system-wide management structure would facilitate collaboration among stakeholders (involving public and private areas of interest) to overcome current jurisdictional, funding and modal coordination issues. Such coordinated R&D efforts are necessary to assure meeting future capacity, efficiency, and safety needs.

With a structured research program plan, active, participatory partnerships would assure early and effective implementation. Rather than one R&D mechanism, a mix of cooperative funding mechanisms should be utilized to best leverage Federal investments with cost-shared industry R&D efforts. Resultant critically needed research and development will then provide the necessary technological building blocks to enable our transportation system to meet the Nation's strategic goals.

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1. INTRODUCTION*

Origin and Content of Report

This report responds to Section 3505 in the Department of Defense Authorization Act for Fiscal Year 2001 (P.L. 106-398). The Section requires that "The Secretary of Transportation shall conduct a study of maritime research and technology development, and report its findings and conclusions, together with any recommendations it finds appropriate to the Congress within nine months after the date of enactment of this Act." The report addresses the following items:

- The approximate dollar values appropriated by the Congress for each of the 5 fiscal years ending before the study is commenced for each of the following modes of transportation: (A) Highway, (B) Rail, (C) Aviation, (D) Public transit, and (E) Maritime.
- A description of how Federal funds appropriated for research in the different transportation modes are utilized.
- A summary and description of current research and technology development funds appropriated for each of those fiscal years for maritime research initiatives, with separate categories for funds provided to the Coast Guard for marine safety research purposes.
- A description of cooperative mechanisms that could be used to attract and leverage non-Federal investments in United States maritime research and technology development and application programs, including the potential for the creation of maritime transportation research centers and the benefits of cooperating with existing surface transportation research centers.

The Department of Transportation (DOT) developed this report with input from other Federal agencies. DOT currently leads the "MTS Initiative" which brings together key agencies that are involved with the U. S. marine transportation system (MTS)¹. This initiative is focused on all aspects of the system and works through an Interagency Committee and a non-Federal National Advisory Council and their subcommittees. The MTS initiative promises a coordinated approach to meeting

an expected doubling or tripling of transportation demand by the year 2020. Research and technology development efforts will be required to facilitate an expansion that is safe, efficient, and secure.

The Marine Transportation System

The U.S. MTS consists of waterways, ports and their intermodal connections, vessels, vehicles, manufacturing and repair facilities, information systems, and system users. It is an aggregation of State, local, privately owned facilities, and private companies where decision-making and investments are driven by the marketplace. Federal, State, and local governments, however, participate in the management, financing, and operations of the system to insure strategic security and economic interests.

More than 1,000 harbor channels and 25,000 miles of inland, intracoastal, and coastal waterways in the United States support the over 300 ports and 3,700 terminals that handle passenger and cargo movements. The waterways and ports are connected to 152,000 miles of rail, 460,000 miles of pipelines, and 45,000 miles of interstate highways. The MTS also contains shipyards, repair facilities, suppliers, and designers that are crucial to maritime activity along with a talented, trained labor force critical to maintaining the vitality and safety of the marine transportation system.

As the world's leading maritime trading nation, the United States relies on an efficient and effective MTS to maintain its role as a global power. The MTS provides American businesses with competitive access to suppliers and markets in an increasingly global economy with 95% of all overseas U.S. foreign trade moving through the MTS. The MTS also transports people to work and provides them with recreational opportunities. Within the United States, the MTS provides a cost-effective means for moving major bulk agricultural and energy commodities such as grain, coal, and petroleum. It is a key element of State and local government economic development and job-creation efforts, and an essential element in maintaining U.S. economic competitiveness and national security.

The United States is the world's most active trading nation, accounting for one billion metric tons or nearly

* References are found at the end of the document.

20 percent of the annual world oceanborne trade. The existing MTS is currently laboring to keep pace with this volume, and congestion problems are reaching an unacceptable level. With international trade projected to more than double by 2020, the efficiency and capacity of America's marine transportation system, including its infrastructure, must increase substantially to remain competitive.²

Economic Value - America's oceans and navigable waterways are an essential component of this Nation's economic growth and prosperity. They are vital components in the Nation's intermodal transportation system. America's businesses and consumers depend on all-weather marine transportation to ensure that economical goods are available to U.S. citizens and to consumers around the world. Many Americans, however, are unaware of the important contributions of the MTS to their lives and livelihood. For example:

- U.S. ports and waterways handle more than 2 billion tons of cargo each year, a billion tons of domestic and an additional billion tons of foreign.³
- The waterborne cargo moving on the MTS contributes more than \$742 billion to the U.S. gross domestic product and creates employment (direct, indirect, and induced) for more than 13 million individuals.⁴
- Every State relies upon a national network of ports for its goods. On average, a State uses 13 to 15 ports, located throughout the country.⁵
- Commercial and recreational fishing contribute more than \$111 billion to States' economies annually.

National Security Value - Just as our Interstate Highway System was inaugurated in the 1950s to accommodate the swift mobilization of America's national defense, America's MTS plays a vital role in mobilizing and maintaining today's national security efforts. With fewer overseas bases, America's armed forces are more dependent on the MTS to be their lifeline for equipment and supplies both domestically and internationally.

Environmental Value - Our valuable coastal watersheds and marine ecosystems in the MTS are important for commercial and recreational fishing, wildlife watching, and boating; as well as for drinking water. Therefore, it is critical that protection and enhancement of the environment be a central theme to MTS activities. Some important characteristics of the MTS are:

- Ships and barges are among the safest and most environmentally friendly forms of transportation. They routinely load and discharge millions of barrels of petroleum, tons of coal, grain, chemicals, and other essential products throughout the U.S., from Alaska to Maine.

- The MTS provides environmentally sound transportation of people and goods, relieving congestion in other transportation modes.
- America's waterways also transport people. In Puget Sound, ferries carry 23 million passengers each year; in Alaska, ferries are literally the *highways* to and from homes and businesses.
- Many port and waterway improvement projects enhance the environment through beach nourishment, wetland creation, and air quality mitigation. In addition, removal, treatment, and disposal of contaminated sediments from the waterways have significant environmental benefits.
- Transportation by water is more energy efficient than any other transportation mode. One gallon of fuel on inland waterway transport will move one ton of freight 514 miles. The same gallon of fuel will move one ton of freight 492 miles by pipeline, 202 miles by rail, and 59 miles by truck.⁶

Recreational Value - Americans also use the MTS for recreational and leisure purposes.

- In 1997, about 78 million Americans participated in recreational boating using 16 million boats of all types.
- Cruise ships host over 5 million passengers annually.

Principal Elements - The primary integrated elements of the U.S. MTS are extensive and include:

- **Waterways** include the navigable waters of the United States and associated infrastructure (i.e., locks, bridges, aids to navigation) that vessel traffic uses. The three principal waterway components are harbor channels, inland and intracoastal waterways, and locks and dams:
 - ***Harbor Channels:*** There are 926 Federal harbor channel projects (including both deep draft and shallow draft) that support the U.S. port system. In addition, non-Federal interests maintain and improve a network of channels connecting channels and berths.
 - ***Inland and Intracoastal Waterways:*** There are about 25,000 miles of inland, intracoastal, and coastal waterways and channels in the United States. Of this total, nearly 12,000 miles constitute the commercially active inland and intracoastal waterway system.
 - ***Locks and Dams:*** Lock and dam structures allow vessels to move up or down one level when traveling navigable waterways with different water levels. There are 192 commercially active lock sites, with 238 lock chambers in the Federal navigation system.
- **Ports** contain marine facilities where vessels transfer cargo and passengers, and include recreational access facilities and shipyards.

- Marine terminals are the transfer points between our water and surface modes of transportation.
- There are over 1,900 terminal facilities located in our deep-draft seaports and Great Lakes ports.
- The inland waterway system contains approximately 1,800 terminal facilities.
- **Intermodal connections** are linkages at the land-water boundary that allow the transfer of cargo and passengers between transportation modes. Intermodal connections include pipelines, road, and rail access routes. Intermodal connections tend to be the points that have the greatest impact on the efficiency of the entire transportation system.
- **Vessels and vehicles** make up the key transportation equipment moving goods and people within the system. These include oceangoing, coastal, and inland vessels, trains and trucks.
 - *Vessels:* The U.S. domestic fleet includes more than 30,000 vessels (ships and barges) that transport goods and people between U.S. ports with an additional 454 U.S.-flagged vessels serving our foreign trade.
 - *Rail:* The domestic rail system consists of nearly 1.3 million freight cars, and 20,000 locomotives.
 - *Highway:* There are nearly 5 million trucks serving our freight needs.
- **Design, manufacturing, and repair facilities** include an infrastructure of design companies, shipyards, suppliers, and others who develop and produce the innovative vehicles and equipment necessary for the systems.
- **Manufacturing and System Operational Personnel** are trained individuals that produce and operate the many components of the MTS.
- **MTS users** are the people who depend on the system for their livelihood and recreational access.

By virtue of the volume of goods that enter and leave this country through the MTS, everyone in the U.S. is an indirect MTS user.

Our Nation depends heavily on its marine transportation system. It is a key element of our economic competitiveness, national security, and recreation. The challenge is to find ways to harness the creativity and innovation of the diverse MTS users and service providers to ensure that the MTS can adapt to meet the Nation's expanding transportation needs. As stewards of this great system, we must work together to ensure America's marine transportation system is technologically advanced, safe, secure, efficient, effective, accessible, globally competitive, dynamic, and environmentally responsible.

However, current and planned national infrastructure improvement projects are encountering significant delays resulting from concerns over impacts on the environment and quality of life to nearby communities. A new way to proceed must be found which allows for more rapid introduction of technological improvements to the system. There must be a comprehensive systematic management structure developed, both formally and informally, which crosses private and public arenas to overcome the current jurisdictional, funding and modal fragmentation problems.

For additional information on the MTS, refer to the U.S. Department of Transportation report, *An Assessment of the U.S. Marine Transportation System*⁷ (<http://www.dot.gov/mts/report/>).

Outline of Report

This report follows the ordering of items from Section 3505 of Public Law 106-398. The report has been kept concise with materials referenced where appropriate, rather than appended. Documents referenced at the end of this report can be made available upon request.

2. FEDERAL INVESTMENTS IN TRANSPORTATION RESEARCH AND TECHNOLOGY DEVELOPMENT

This section presents research and technology development budgets for Department of Transportation modal agencies and shows general funding trends. Some R&D information addressing maritime-related activities from other non-DOT agencies is also included. The following section provides a brief explanation of the differing focus and the types of work underway in these agencies and how their work supports or leverages what private interests accomplish. The DOT tables and explanations do not separate efforts that specifically contribute to the MTS.



DOT Agency Investments

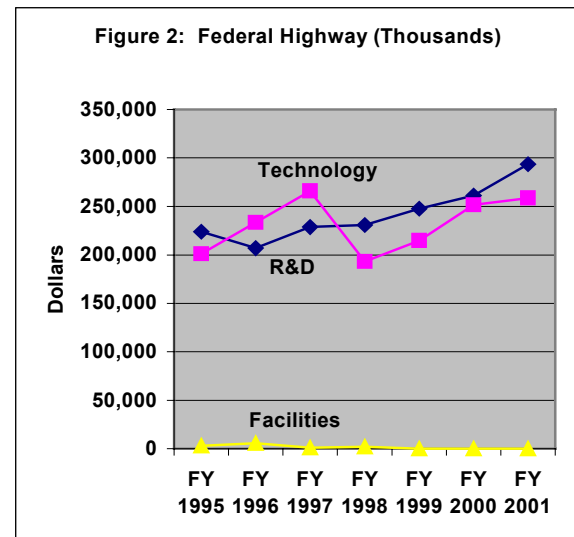
Budget authority for research, development and technology programs under each agency of the Department of Transportation over a five-year period is presented in Appendix A and identifies major areas of effort:

- Research and Development
- Technology
- Facilities

Table 1 summarizes this data at a higher level and shows the investments by the categories with some trends depicted in Figures 1-2.

Funding for the different DOT modes has generally remained constant over the past five-year period with the exceptions of the Federal Highway Administration and the National Highway Traffic Safety Administration (NHTSA). Work by each agency supports agency missions. For further details on the focus of each agency, see Section 3.

Funding for R&D since FY 1995 for the Coast Guard (USCG) has remained rather constant. While the USCG's primary focus is on internal performance improvement, some of their R&D efforts do have a direct affect on MTS performance, e.g. risk management, human error, etc. (see Table 6 on p. 14).



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Table 1: Research, Development & Technology
Department of Transportation
Budget Authority (Enacted)
(In thousands of dollars)

	FY 1995	FY 1996	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001
Research and Development							
Federal Highway Admin	223,848	206,910	228,605	231,064	247,580	261,393	267,964
Federal Motor Carriers	0	0	0	0	0	5,574	10,784
National Highway Traffic Safety	39,676	33,163	36,539	41,621	50,350	50,569	58,313
Federal Rail	23,999	21,953	19,672	19,985	21,864	24,507	27,001
Federal Transit	24,851	17,053	16,541	23,216	16,685	12,014	8,031
Federal Aviation	277,185	209,298	232,515	227,886	211,254	207,272	287,388
Research and Special Programs	8,220	7,008	9,453	6,195	6,991	7,199	9,360
U.S. Coast Guard	20,169	17,476	20,200	20,210	18,229	19,927	22,201
Maritime Administration	2,450	0	0	0	0	0	0
Office of the Secretary	3,951	2,808	2,687	3,530	8,779	5,142	10,976
SUB TOTAL	624,349	515,669	566,212	573,707	581,732	593,597	703,583
Technology Investment							
Federal Highway Admin	201,118	233,560	266,110	193,290	214,772	251,784	269,163
Federal Motor Carriers	0	0	0	0	0	0	1,565
National Highway Traffic Safety	16,563	17,105	20,247	21,247	22,041	21,871	22,321
Federal Rail	12,368	22,855	23,176	20,395	20,494	27,771	25,945
Federal Transit	26,439	28,871	29,475	34,187	41,550	48,068	52,185
Federal Aviation	0	0	0	0	0	6,062	7,364
Research and Special Programs	0	0	0	0	0	0	0
U.S. Coast Guard	0	0	0	0	0	0	0
Maritime Administration	0	0	0	0	0	0	0
Office of the Secretary	0	0	0	0	0	0	0
SUB TOTAL	256,488	302,391	339,008	269,119	298,857	355,556	376,978
Facilities							
Federal Highway Admin	3,000	5,713	900	2,000	0	0	0
Federal Motor Carriers	0	0	0	0	0	0	0
National Highway Traffic Safety	0	0	0	0	0	0	0
Federal Rail	3,700	3,400	3,420	770	500	500	923
Federal Transit	0	0	0	0	0	0	0
Federal Aviation	21,690	20,600	17,200	14,290	14,290	12,800	13,657
Research and Special Programs	0	0	0	0	0	0	0
U.S. Coast Guard	0	525	280	260	260	266	272
Maritime Administration	0	0	0	0	0	0	0
Office of the Secretary	0	0	0	0	0	0	0
SUB TOTAL	28,390	30,238	21,800	17,320	15,050	13,566	14,852
DOT TOTALS	909,227	848,298	927,020	860,146	895,639	962,719	1,095,413

Source: U. S. Department of Transportation

NOAA Investments

The National Oceanic and Atmospheric Administration (NOAA) estimated research and development funding for the Coast Survey Development Laboratory and the Joint Hydrographic Center of the Coast Survey as shown in Table 2 below. Other parts of NOAA conduct research and development that are related to marine transportation issues such as invasive species, satellite positioning, search and rescue systems, and marine weather. Often, however, the amount of funding for research also supports non-maritime related purposes or is embedded in an overall budget from which it is difficult to accurately extract maritime-related work.

Table 2: NOAA Coast Survey Development Laboratory R&D Investments (Estimated)

FY	Survey Lab (\$m)	Hydrographic Center (\$m)
1997	3.8	0.0
1998	3.7	0.0
1999	3.6	2.2
2000	3.4	2.4
2001	3.2	2.6

U.S. Customs Service Investment

The FY 2001 research investment for the U.S. Customs Service was \$4.5 million. This investment supports all U.S. Customs Service research, development, and evaluation efforts related to inspection, enforcement, and investigative missions for traffic entering by all modes of transportation.

Department of Defense (DOD)

One of the DOD's maritime related research efforts is the Center for the Commercial Deployment of Transportation Technologies (CCDoTT). This program seeks to leverage technological developments to benefit both the commercial maritime industry and defense interests (see Table 3). The program is managed jointly by MARAD, the U.S. Transportation Command (USTRANSCOM), and the California State University at Long Beach.

Table 3: CCDoTT R&D Investments

FY	\$m
1995	0.0
1996	2.8
1997	4.5
1998	4.5
1999	0.0
2000	4.0
2001	7.5

U.S. Army Corps of Engineers (USACE)

Annual navigation research and development (R&D) investments by the Army Corps of Engineers are shown in Table 4. They are focused on those aspects of navigation, which constitute the Corps' navigation mission – to provide safe, effective, and environmentally sustainable Federal navigation projects – and include R&D on lock and channel design, construction, operation and maintenance. The Corps also conducts research relative to its other missions, and that is not reported here.

Other Agencies

R&D information addressing maritime-related activities of other agencies was only included where provided and corroborated. Other key agencies performing research and development activities that directly contribute to the advancement of MTS include the Environmental Protection Agency, Minerals Management Service of the Department of Interior, and other parts of DOD. DOD, in particular, performs extensive research and development in transportation areas with varied applicability to the MTS.

The Department of Commerce is currently developing a comprehensive survey of MTS research and technology. That study is a follow on from their 2001 assessment of the U.S. shipbuilding and repair industry. It is focused, however, on providing a comprehensive look at both private and public R&D in the entire U.S. marine industry. Completion is expected in FY 2002.

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Table 4: Corps of Engineers Budget Authority (Enacted) - Thousands of dollars

	FY 1995	FY 1996	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001
Coastal Engineering	4,854	3,387	4,309	4,000	3,929	5,080	3,100
Inland Channel Hydraulics	815	702	866	1,000	1,035	915	1,050
Innovations for Navigation Design & Construction	0	0	0	1,948	2,681	3,473	2,500
Dredging Operations and Environmental	0	0	1,500	3,297	4,843	6,305	6,470
Coastal Inlets	3,907	1,923	1,225	2,455	2,422	2,425	2,200
Long Term Effects of Dredging Operations	1,450	1,054	1,057	1,100	1,000	1,031	889
Repair, Maintenance, and Rehabilitation	2,930	721	735	982	0	0	0
Supporting Technologies - Structural, Geotechnical, Mapping, etc. (Navigation)	2,078	1,779	2,503	2,394	2,746	2,362	2,775
TOTAL	16,034	9,566	12,195	17,176	18,656	21,591	18,984

Source: U.S. Army Corp of Engineers

3. HOW FEDERALLY APPROPRIATED RESEARCH FUNDS ARE UTILIZED

This section describes how Federal funding for transportation research and technology development is carried out and used to facilitate transportation advancements.

Research Strategy

The Government-wide strategy for transportation research established in 1997⁸ is illustrated in Figure 3. National goals are met by building upon a base of education and training with two types of research efforts: "enabling" and that done in partnership with industry. The focus is to leverage basic and applied R&D work done elsewhere and "enable" it for use in transportation and then partner with industry to facilitate the development of practical innovations in the short to mid-term.



Figure 3: Strategic Planning Approach⁸

Enabling Research

Funding for research of \$5 billion per year⁹ is spent on basic transportation science mostly by agencies focused on the longer term (DOD, NASA, and Department of Energy, for instance). These research efforts foster transportation breakthroughs by advancing technologies, concepts, and systems. They are characteristically longer term, interdisciplinary, and can be cross modal in nature. Agencies focusing on the MTS can then leverage those investments with work that readies the discoveries for practical application in the MTS (commercial as well as national policy and security areas). Seven key enabling research areas where transportation agencies have been working collaboratively⁹ over the past few years are:

- Human performance and behavior
- Advanced materials and structures

- Computer, information, and communication systems
- Energy, propulsion, and environmental engineering
- Sensing and measurement
- Analysis, modeling, design, and construction tools
- Social and economic policy issues

Partnership Initiatives

Partnerships ensure that research ideas and concepts come to an effective and early implementation and do not result in products that sit on the shelf. In today's world, involving stakeholders (developers, users, government groups, and others such as associations and environmental groups) early on with the research and development work is the only way to assure that the research has a high probability of being practical and utilized in the near term. The established partnerships in transportation are detailed in the National Transportation Technology Plan¹⁰:

- Aviation Safety Research Alliance
- Next Generation Global Air Transportation
- National Intelligent Transportation Infrastructure
- Intelligent Vehicle Initiative

The key to accomplishing early innovative success is to bring enabling research results and technologies to a stage ready for implementation and then partner with stakeholders at all levels to make the innovation happen in an effective and timely manner.

Several other partnership efforts are in different stages of development:

- Next Generation Transportation Vehicles
- Transportation and Sustainable Communities
- Transportation Infrastructure Assurance
- Enhanced Goods and Freight Movement at Domestic and International Gateways
- Maritime Safety Research Alliance
- Next Generation Space Transportation Technology
- Accessibility for Aging and Transportation-Disadvantaged Populations
- Enhanced Transportation Weather Services

These latter eight programs are envisioned to encompass important areas of focus where work can be moved forward in a cooperative fashion.

Multi-Agency Programs

Within DOT, a number of research activities have evolved into programs with increased sharing of direction and results. The University Transportation Centers (UTC) program is a multimodal program where both FHWA and FTA are provided funding to support transportation education and career development as well as R&D at universities. The DOT Research and Special Programs Administration (RSPA) manages the program on behalf of all DOT agencies. The UTCs seek to focus our universities on transportation research issues and develop people (students and teachers) and research areas of value to the transportation system. There are currently 33 UTCs around the country (see <http://utc.dot.gov/> for the research themes of the UTCs).

The DOT Human Factors Coordinating Committee is another example where agencies have been sharing modal research efforts to avoid duplication and leverage funding. This decade-old effort has evolved to a DOT-wide research program developed and managed by the committee and addresses common needs synergistically through involvement of stakeholders from the different transportation modes. The focus of current efforts is in the area of managing fatigue.¹¹

Agency Specific Programs

Government and Department wide efforts focus on those research initiatives where agencies can collaborate on enabling research and work together with stakeholders. There are many other important agency-specific programs, however, that are less appropriate for collaborative pursuit. DOT's Research and Development Plan for Fiscal 2002¹² and its predecessors provide an overview of research and development activities within the Department, detailing funding and programs for each agency. The general focus areas of each agency are summarized in the following paragraphs.

Federal Highway Administration (FHWA)

Highway development in the United States changed the face of the country with the implementation of the interstate highway system in the 1960s. State focus on highway transportation worked around Federal matching funding and shared plans for development of the national system and connections. Today the American Association of State Highway and Transportation Officials (AASHTO) formulates most of the highway research and technology development for the nation. Funding comes from Congress through FHWA and from States through their Departments of Transportation. AASHTO committees develop, approve, manage, and share the research that is accomplished through coordination with the National Academies' Transportation Research Board.

AASHTO has expanded its research efforts beyond strictly highway-related efforts to encompass intermodal needs that would improve the national transportation system. AASHTO's Port and Intermodal Committee strives to introduce marine perspectives and their relationships to highway design and development. However, most of the research work at AASHTO remains focused on improving pavement durability, safety, and other efforts to improve vehicle operations, including human performance.

A relatively new item in the FHWA budget is the Intelligent Transportation Systems (ITS) program within which FHWA is working to implement advanced and integrated information systems for our roads and vehicles. This major effort accelerates the implementation of intelligent systems in the U.S. highway system through early deployment of advanced vehicles, development of ITS standards, performing operational tests, and other developmental research.

Federal Motor Carrier Safety Administration (FMCSA)

The FMCSA was formed in 2000 from the Office of Motor Carriers within FHWA. Challenged with making major improvements in motor carrier safety over the coming years, FMCSA is focusing its R&D efforts in the safety arena.

National Highway Traffic Safety Administration (NHTSA)

NHTSA's R&D program focuses on all aspects of traffic safety. It supports the Department's goals of improving highway safety and reducing injuries and fatalities by improving occupant protection, eliminating crashes, assessing human injury tolerances, developing crash dummies, studying new methods to increase seat belt usage and decrease alcohol usage, and collecting high quality large-scale vehicle accident databases. NHTSA operates an independent in-house R&D test laboratory and also supports the Department's Intelligent Vehicle Initiative program.

Federal Transit Administration (FTA)

FTA research is focused on supporting the development of safe and efficient transit systems in local communities. The key areas of effort include: policy and planning, equipment and infrastructure, specialized customer services, fleet operations, professional capacity building, and safety and security. Pioneering new applications of propulsion, innovative applications of information technologies, and sharing in the support of education through the UTC program, are some of the approaches underway to improve efficiency and safety of transit systems. A Transit Cooperative Research Program managed by the National Academies is one avenue used to coordinate research in a manner that involves local transit agencies and supporting research communities.

Federal Aviation Administration (FAA)

Major research efforts are dedicated to improving aircraft structures and materials as well as developing explosive detection and other security research. Improving weather information, addressing environmental issues, human factors, and safety issues are other key areas that have been a continual part of aviation research and the basis for the excellent safety record of air transportation. Specialized FAA laboratories and cooperative programs, which NASA built up over the years, are a mainstay to the success of aviation as a safe and efficient form of transportation for people and freight.

Federal Railroad Administration (FRA)

The FRA R&D program addresses nine topics: railroad system issues (safety, security, environment), human factors, rolling stock and equipment, track and structures, track/train interaction, train control, grade crossings, hazardous materials transportation, and train occupant protection. FRA also manages the Next Generation High-Speed Rail technology demonstration program to foster the implementation of high-speed passenger service on existing corridors.

Research and Special Programs Administration (RSPA)

RSPA focuses on pipeline safety and on improving the handling of hazardous materials; coordinates and advances transportation research, technology and education activities to promote innovative multi-modal transportation solutions; and manages the Department's transportation-related emergency response and recovery responsibilities. Its research programs promote safe and efficient transportation of hazardous materials, improved responses to emergencies affecting the transportation system; R&D strategic planning & management studies; improved human performance and transportation infrastructure; and, assist in maintaining the integrity of pipeline systems operation and management.

U.S. Coast Guard (USCG)

The Coast Guard intends to utilize emerging technologies as it moves toward the Commandant's vision of *Coast Guard 2020*. Attaining this vision requires appropriate integration of technology as part of the solutions that will close gaps in the performance of Coast Guard operations and missions. Research efforts are focused largely on marine safety along with the other key USCG missions of search and rescue, law enforcement, national security, and marine environmental protection.¹³ The core of the research program is currently composed of several main investment areas that represent the principal activities required of the service:

- Detect, Identify and Classify Marine Targets
- Future Communications and Tactical Data Exchange Concepts
- Intelligent Waterway Systems
- Risk Management/ Decision Support/ Resource Allocation
- Alternate Energy Technologies
- Human Error Reduction/Fatigue
- Interdiction Technologies
- Aquatic Nuisance Species
- Oil Spill Response

The current R&D Plan of November 2000 provides a description of these investments. The Research and Development Center located in Groton, CT, executes the R&D Plan. The Coast Guard also operates the Fire and Safety Test Detachment in Mobile, AL, which conducts specialized shipboard fire-related testing.

Maritime Administration (MARAD)

MARAD pursues a number of activities that examine emerging technologies that could improve the components of the commercial maritime industry. One of those was creation in 1990 of the National Maritime Enhancement Institute (NMEI) program of academic centers focused on maritime research. Five NMEIs have been designated and a number of projects completed in the first couple of years. Projects included examining competitive manning levels on U.S. vessels, looking at access conflicts at inland waterway ports, studying feasibility of short-sea vessel operations, developing an inland waterways data base, and studying inspection and maintenance of marine structures and structural integrity problems.

MARAD also facilitates industry coming together to cooperatively accomplish research and development through "Research Cooperatives." Membership dues are collaboratively used to accomplish research. The Ship Operations Cooperative Program (SOCP, www.socp.org) and the Cargo Handling Cooperative Program (CHCP, www.marad.dot) are long standing programs with very active industry and union participation

Office of the Secretary

The Office of the Secretary has a small research budget, which is focused on supporting intermodal efforts and coordinating or complementing modal efforts.

National Oceanic and Atmospheric Administration (NOAA)

NOAA's mission is to describe and predict changes in the Earth's environment, and conserve and manage wisely the Nation's coastal and marine resources to ensure sustainable economic opportunities. Included in this mission is a suite of services that support the marine transportation system and promote safe

navigation. The focus is directed at providing real time, high accuracy data to the mariner. Advances in these areas are beneficial to safety and efficiency of operations. While promoting a strong marine transportation system, NOAA also is charged with maintaining and sustaining living marine resources and healthy coastal environments. Among other activities, these missions often require NOAA to quantify the effects of marine transportation on the environment, to find opportunities where the environment can be improved, and to design methods for minimizing conflicts.

U.S. Army Corps of Engineers (USACE)

The U.S. Army Corps of Engineers is a partner in the improvement of the marine transportation system. Research is focused on accomplishing the navigation mission in design, construction, operation, and maintenance of shipping channels and locks, while maximizing opportunities for environmental enhancement.

U.S. Customs Service (USCS)

The U.S. Customs Service is charged with review and clearance of imported commerce entering the U.S. to ensure the health and safety of the public. Customs has a major influence on the MTS given the sheer volume of goods that pass through our ports. Technology is used to support the USCS decision-making process and improve overall efficiencies. Procedures and technology-assisted processes have a significant impact on the flow of goods through our ports. Customs does have a strong Applied Technology and Research and Development organization and substantial funding is provided for the acquisition and deployment of technology supporting all areas of mission needs. Marine R&D funding is specifically related to maritime security, inspection, and enforcement. Marine RD&E funding, however, is minimal and focused on evaluation and, if required, modification of available technologies rather than on the development of new technologies. A financially sound USCS RD&E program is imperative to support the growing flow of goods in the MTS.

Environmental Protection Agency (EPA)

The EPA performs research to address a myriad of environmental protection issues. MTS related research and development by EPA focuses primarily on protecting estuaries, identifying threats, setting water

quality criteria, reducing air emissions, and creating, enhancing, and/or restoring wetlands.

EPA works closely with the Coast Guard, NOAA, USFWS, Aquatic Nuisance Species Task Force, and the Invasive Species Council to encourage the development of new technologies which can be used to help keep ships from spreading aquatic non-indigenous species in their ballast water. As part of this effort, EPA has been working to develop ballast water treatment standards that will be environmentally protective, and provides a useful benchmark for the industry as it seeks to perfect some of these new technologies. In addition to developing new technologies, EPA, with Federal and non-Federal partners, coordinates and funds education and research programs focused on the prevention of the spread of invasive species. EPA is also conducting an assessment of cruise ship waste streams and management practices.

EPA and the U.S. Army Corps of Engineers (USACE) support environmentally responsible dredging and dredged material planning and management. They use regional dredging teams and local planning groups in the development of comprehensive management plans. Both agencies advocate the beneficial use of dredged material and the development of decontamination technologies.

Department of Defense (DOD)

Many elements within DOD perform research and development. DOD research is developed and carried out for defense purposes, however, and further effort is usually required to make the work applicable in the commercial area when it can apply. An example of the latter is the DOD funded Center for the Commercial Deployment of Transportation Technologies (CCDoTT) managed by MARAD, USTRANSCOM, and the California State University at Long Beach. This consortium was organized to pursue a broad range of technologies that address joint defense and commercial maritime transportation needs.

The U.S. Navy, through the Office of Naval Research (ONR) and the Naval Sea Systems Command, performs work that is of value to the marine transportation system. ONR funded the MARITECH program for shipbuilding described in the next section as a five-year development effort.

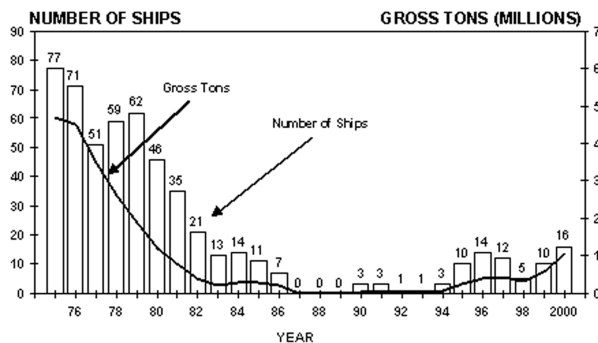
4. SUMMARY DESCRIPTION OF MARITIME RESEARCH AND TECHNOLOGY INITIATIVES

This section provides examples of cooperative maritime-related research and technology initiatives to illustrate how the Federal research investments are able to complement and leverage industry investments. Cooperation and leveraging of investments can take place even where agency funding is minimal.

Maritime Administration (MARAD)

MARITECH Program - MARITECH was a five-year (FY 1994-1998) Federal cost-shared program to encourage the shipbuilding industry to direct and lead in the development and application of advanced technology to improve its competitiveness and preserve its industrial base (See Fig. 4 showing the health of the industry over time). The program was funded by DOD's Defense Advanced Research Projects Agency (DARPA) with 50/50 industry matching of funds. DARPA administered the program in collaboration with MARAD.

Figure 4: Commercial U.S. Shipbuilding Orderbook History (Ships of 1,000 gross tons and over as of December 31)



DOD's Defense Advanced Research Projects Agency (DARPA) administered the program in collaboration with MARAD. MARITECH had both near-term and long-term objectives. In the near term, it assisted industry in penetrating the international marketplace with competitive ship designs, market strategies, and modern shipbuilding processes and procedures. In the long term, the program encouraged advanced ship and shipbuilding technology projects to promote continuous product and process improvement to maintain and enlarge the U.S. share of the commercial and international market. This approach was to ensure the availability of an experienced industrial shipbuilding base vital to national security in times of crisis.

MARITECH projects covered a wide range of themes from the design of various types of small vessels and large oceangoing ships to shipyard technology and advanced material technology. These projects were awarded to 24 companies and their subcontractors in 40 States, the District of Columbia, Puerto Rico, and nine foreign countries (Table 5 shows the funding levels and project awards).

Table 5: MARITECH Projects by Fiscal Year (millions of dollars)

FY	Number Of Projects	Govt. Funding	Industry Match
1994	19	43.3	45.2
1995	26	46.9	53.2
1996	11	38.5	45.2
1997	9	36.6	43.1
Total:	65	165.3	186.7

Since 1994, a total of 65 projects, valued at \$357 million, were accomplished (Information on MARAD-administered projects is available on the internet at <http://www.marad.dot.gov/nmrec/>). MARAD managed 40 of the 65 projects.

Examples of benefits from MARITECH include:

- Electric Boat Division: \$14 million in production savings per ship and \$7 million in design savings per ship class were achieved.
- Avondale Industries: New steel production facility and processes reduced cycle time and unit construction costs on T-AKR class sealift ships; 20 percent productivity improvement in future military vessels (LPD-17). ARCO tanker orders resulted from this project.
- National Steel & Shipbuilding Company: MARITECH funded design resulted in award of a two-ship ro/ro contract.
- Atlantic Marine: Accuracy control improved by using CAD/CAM software and workstations. Reduced interference and rework saved 20 percent on production labor hours.
- Todd Pacific Shipyard Corporation: Overall, productivity was increased by 30 percent on ferry production.

Funding for MARITECH ended in FY 1998. Recognizing the need to build on MARITECH's success, the industry worked with the Navy, DARPA, the Coast Guard, and

MARAD to develop a successor program called the National Shipbuilding Research Program (NSRP) Advanced Shipbuilding Enterprise (ASE). This program, now under the Department of Navy, seeks to lower the cost of naval ships.

The Center for Advanced Ship Repair and Maintenance (CASRM) and the Tributyltin (TBT) problem facing the Commonwealth of Virginia - The Commonwealth of Virginia imposed a 50 part per trillion (ppt) limit on water discharges of TBT from Virginia shipyards, as part of the Virginia Pollutant Discharge Elimination System (VPDES). Virginia was the only State with any limit on TBT water discharges and if the shipyards could not comply with the permit, commercial ship repair would cease in Virginia. However, there was no technology available to remove TBT to these levels and accurate measurement of TBT at these levels could not be guaranteed.

MARAD initiated a project with CASRM to address the control of TBT and storm water runoff during ship repair. Through MARAD's facilitating efforts the initiation of a \$65,000 project led to the subsequent funding by EPA of \$1.5 million, the Commonwealth of Virginia of \$1.2 million and the NSRP with in-kind funding. Although this multi-year project is ongoing, significant interim reductions in TBT levels have been realized.

Maritime Energy and Clean Emission Program R&D - MARAD is providing assistance with program development, including potential project descriptions and schedules for technology demonstration projects, performance and emission measurement projects, maritime energy and emission studies, industry outreach events, and initiation of a web-site (<http://www.marad.dot.gov/nmrec/energy-emissions>) currently under development:

Workshop on Alternative Fuels for Ferries and Other Vessels – MARAD organized and hosted the subject workshop on the San Francisco Bay in cooperation with the Federal Highway Administration who provided the funding. One hundred industry personnel attended. Results include evaluation of the potential for alternative fuels for ferries, examination of new technologies and emission regulation trends within the industry, and the fostering of Federal, State, local and private partnership program activities.

Study on the Use of Natural Gas Ferries in the Golden Gate National Recreation Area – This study accomplished a preliminary assessment of the economic feasibility and environmental impacts of using natural gas ferries in that National Park site using FTA funding.

T/V KINGS POINTER Natural Gas Conversion Design Effort - Performed a first of a kind engineering design for the conversion of a vessel, the Training Vessel, "T/V Kings Pointer," to dual fuel, natural gas/diesel with

USCG funding. Approval of the approach was received from the regulatory bodies.

Highway Ferry Integration Study – This MARAD-led study funded by DOT, Department of Energy, and the Gas Research Institute is underway and will evaluate the best methods and technologies for integrating a large new ferry system into an existing transportation infrastructure from a low air emission perspective.

Emission Measurement Comparison from Natural Gas and Diesel Ferries - This project will determine a protocol for measuring air emissions from vessels in operating conditions. Also, two sister ferries, one natural gas fueled and one diesel fueled, will be outfitted and monitored. Funding support came from the USCG.

U.S. Coast Guard (USCG)

The vast majority of the USCG initiatives focus on improving USCG operational performance. The improvement of operational performance in USCG mission areas of marine safety, waterways management, law enforcement, national security and protection of natural resources has a direct effect on MTS performance. Table 6 is a summary of USCG R&D Investment Areas. The investment areas that include initiatives that affect MTS performance are marked with a double asterisk (**). These investment areas are described in more detail in the following paragraphs. MTS related initiatives are discussed within the investment area description. While one third of the \$20M USCG R&D budget is attributable to advancing and supporting MTS, this is still less than 0.3% of the overall DOT R&D budget.

Intelligent Waterway Systems - This research and development area is to provide U.S. waterway users with the critical information they need to effectively and efficiently use our waterways. Waterway information systems include a combination of digital information (e.g. electronic charts, radar imagery), voice broadcast information, visual/audible aids to navigation, radio aids to navigation, etc. The primary research focus is the evaluation of technology and techniques for ensuring navigation safety and mobility at reduced Coast Guard operating costs.

Efforts in this investment area include technology to:

- Reduce the number of short range aids to navigation
- Integrate risk-based management processes for resource allocation based on a balance of affordability and waterway performance
- Develop waterway designs and marine information systems that together facilitate efficient and safe movement of people and goods in transit, especially where this movement transitions between different modes of transportation.

Table 6: USCG Investment Area Summary Table

Description	Approximate % of Budget	
	Overall	MTS Portion
Investment Areas:		
Detect, Identify and Classify Marine Targets	15	
Future Communications & Tactical Data Exchange Concepts	9	
Intelligent Waterway Systems **	8	8
Risk Management/Decision Support/Resource Allocation **	15	7
Alternate Energy Technologies	5	
Human Error Reduction/Fatigue **	8	3
Interdiction Technologies	14	
Aquatic Nuisance Species **	7	7
Oil Spill Response **	4	4
Total	85	
Special Services: Include Fire Prevention and Ship Structures Committee	15	4
TOTAL	100	33

** Denotes investment areas that include initiatives that affect MTS performance.

MTS Related Initiatives:

- Waterways Management: Traffic & Navigation Assessment
- Vessel Traffic Management
- System Analysis of Aids to Navigation

Risk Management, Decision Support, and Resource Allocation - Proper development, implementation and use of risk methodologies and decision support tools will help the Coast Guard achieve its goals using the resources it has at its disposal.

MTS Related Initiatives:

- Predictive Models for Improved Spill Response
- International Maritime Information Safety System
- Port State Control Targeting Matrix
- Exploration of concepts USCG can use as the basis for programs to lower Coast Guard personnel injury, increase time spent "on the job" and improve work productivity.

Human Error Reduction and Fatigue - A major cost associated with performing any of the Coast Guard's duties is the personnel required to do the job. USCG mobile platforms, especially the larger cutters, need to be operated effectively and safely by smaller crews. Proper regulation of maritime industries is also an area where USCG is struggling to lower operating costs while continuing to deliver quality products. This requires research in this investment area to effect lowered incidence of maritime mishaps and therefore fewer deaths and injuries. This will improve long-term productivity for U.S. maritime industries.

As concluded in a number of studies, human error was either the direct cause or a major contributing factor in roughly 80% of all maritime accidents. In

many of these instances, members of vessel crews were suffering from the effects of fatigue. Research is needed to better understand the mechanisms that contribute to crew fatigue and other factors that lead to human error.

MTS Related Initiatives:

- Commercial Vessel Qualifications and Training
- Watchstanding Alertness in Towing Operations
- Improving Crew Alertness on Commercial Vessels

Aquatic Nuisance Species Prevention

The problems caused by aquatic nuisance species (ANS, such as Zebra Mussels) have existed for some time. As international trade continues to increase, the threat from aquatic nuisance species increases and the U.S. is faced with making many, often complex, decisions regarding regulations that are designed to prevent the introduction of ANS into our waters.

Research in the ANS area should help determine the most cost-effective methods for dealing with this problem. Avoidance of ANS problems like those that have resulted from the Zebra Mussel will save the United States billions of dollars in lost productivity.

MTS Related Initiatives:

- Ballast Exchange Identification
- ANS Prevention
- Ballast Water Management Practices for Coastal Shipping

Research partners include counterparts in agencies from several other nations facing the same ANS difficulties. The USCG also partners with members of industry facing similar ANS issues.

Oil Spill Response - Pollution continues to be an acute problem needing focused attention in order to prevent its worsening, as increased demands are placed on the nation's waterways. While pollution prevention is addressed in other R&D investment areas, pollution response remains an important component to any solution to the overall pollution issue.

Prevention efforts will likely pay the largest dividend in minimizing damage from oil spills. However, when a spill does happen, the Coast Guard must be ready and able to efficiently and effectively manage and conduct clean-up operations and to exploit emerging technology to that end. The faster and more effective the clean-up method, the smaller the negative effects on the environment and, in general, the lower the cost of the clean-up operation.

MTS Related Initiatives:

- Improved Product Off-Loading at Sea
- Innovative Tools for Spill Response Training

This R&D Program works closely with the National Strike Teams, Coast Guard field units, industry, and other government agencies and their foreign counterparts.

Special Services - Fire Prevention: USCG conducts R&D efforts in all areas of fire science including fire behavior, smoke movement/control, fire fighting agents, halon replacements, fire fighting hardware, and others. These efforts provide the technical information required by the Coast Guard when formulating and promulgating sound fire safety regulations and carriage requirements. These efforts also provide industry experts and other government agencies an excellent platform for performing tests and evaluations of new products and techniques for use in the marine environment. While issues related to fire safety do not require investment for change or improvement, they require a core of expertise and competency that must be sustained as long as the Coast Guard administers fire safety regulations. At this time, much of that core expertise, and facilities for its support, reside in the R&D Program.

MTS Related Initiatives:

- Fire Resistance of Divisions
- Smoke Leakage Through Divisions
- Improved Fire Safety measures for Tank Vessels
- Fire Suppression Requirements for Machinery and Other Spaces

Interagency Ship Structure Committee (SSC): USCG provides support and guidance to the SSC for research planning, through periodic joint meetings with other Federal and Canadian agencies. The research contributes to better understanding of the design, production technologies, and life-cycle risk management of marine structures.

National Oceanic and Atmospheric Administration (NOAA)

MTS related research, development, and the application of technology by NOAA focuses primarily on providing new and improved products and services, but also includes mitigation of the effects of oil spills and other possible adverse environmental effects in our nation's waterways. Programs which NOAA's National Ocean Service (NOS) is responsible for include:

- Producing and updating the nation's nautical charts
- Conducting hydrographic and shoreline surveys of U.S. waters
- Maintaining a real-time national water level observation network and predicting tides and currents, as well as developing and partnering in the deployment of Physical Oceanographic Real-Time Systems (PORTS) in major harbors
- Participating in the maintenance of the nation's geodetic and geographic spatial data infrastructure, including the GPS-based national spatial reference system
- Supporting the Coast Guard in the prevention, response, assessment, and clean up of hazardous material spills in the marine environment

R&D is carried out by NOS to provide improved real-time and *forecast* information in modern electronic forms, such as electronic navigational charts (ENCs), and to improve the efficiency by which they are produced and the data obtained. Current R&D efforts to develop an underkeel clearance forecast system for deep-draft tankers and cargo ships illustrates the multi-disciplinary nature of the research. Oceanographic forecasting models are driven by weather forecasting models and involve special GPS instrumentation of ships for dynamic draft prediction models, vector ENC development, and obtaining high-resolution bathymetric data using the latest acoustic and laser techniques from ships, airplanes, and satellites. The National Weather Service (NWS) provides marine weather information and forecasts to the mariner, which includes a national system of weather buoys. Its forecast models and real-time meteorological data support NOS's oceanographic modeling. The Office of Oceanic and Atmospheric Research (OAR) carries out research that primarily supports NWS, but also has supported NOS's oceanographic forecast models and its measurement technology. The National Marine Fisheries Service (NMFS) and Sea Grant in OAR carry out and support research on invasive marine species brought to the U.S. in commercial ship ballast water.

Department of Defense

Center for the Commercial Deployment of Transportation Technology (CCDoTT) Program -

CCDoTT is a Congressionally-sponsored consortium of public, private, and academic activities that seeks to leverage commercially available advanced technology to enhance defense mobility by increasing the throughput of our nation's ports and intermodal transportation system.

CCDoTT is part of the California State University, Long Beach Foundation (Foundation) and is governed by two agreements – a cooperative agreement between MARAD and the Foundation (on behalf of CCDoTT), and a memorandum of agreement between USTRANSCOM and MARAD. MARAD and USTRANSCOM serve as technical managers for CCDoTT. In addition, MARAD has responsibility for administering the cooperative agreement.

The CCDoTT program is structured around four areas: Agile Port, High Speed Sealift (HSS), Rapid Deployment Technologies, and Command and Control.

- Agile Port focuses on state-of-the-art material and cargo-handling technologies, cargo systems,

tagging, tracking, and information management systems to expand the ability of ports and the commercial transportation system.

- HSS is defined as dual use ocean going, coastal and ferry vessels with speed capabilities of approximately 40 knots or greater, using high technology hulls, ship control systems and propulsion machinery systems.
- Rapid Deployment Technologies are those technologies that improve the end-to-end flow of military unit equipment and cargo through ocean ports, airports and intermodal interchange points.
- Command and Control technologies are being explored to support interactive planning and to afford intermodal assessments and analysis.

U.S. Environmental Protection Agency

U.S. EPA marine-related research addresses many areas related primarily to protecting and restoring water and air quality. See the examples provided in the description in Section 3.

5. COOPERATIVE MECHANISMS TO LEVERAGE FEDERAL FUNDS

This section describes examples of cooperative mechanisms that could be used to attract and leverage non-Federal investments. The range of possible mechanisms is broad, as are the approaches to using funding to accomplish the needs of the stakeholders involved.

Partnering with stakeholders (government, industry, labor, associations, academia, etc.) is an effective approach to successful innovation. This is because not only are resources leveraged, but more importantly because implementation demands stakeholder buy-in and close relationships that come from in-kind and funding involvement. Moreover, inclusion of industry as a full and equal partner promotes technical advancements through industry leadership and provides a strong voice regarding developmental funding expenditures. The academic perspective adds value to the group by providing access to research resources not available in the private sector and provides a viewpoint that is generally longer term and more analytical. Academic participation also leads to better preparation of students to enter the field. Cooperative partnerships encourage teaming and partnering with diverse organizations moving towards a common goal, making all stronger through the process. Government investment is often the catalyst permitting diverse interests to work together to address common needs. The government role in cooperative mechanisms also enables stability and continuity for R&D efforts that provide the ability to build effectively on previous group developments.

Cooperative Mechanisms

The following paragraphs describe cooperative mechanisms that have proven effective in the maritime industry and could be models for facilitating and advancing an effective maritime R&D program.

Cooperative Organizations – "Cooperatives" are membership groups that contribute funding and support to solve common problems and develop products to satisfy the needs of the members. Industry/government cooperative organizations (such as those shown in Table 7 on p. 18) are effective because, in most cases, industry partners directly lead the organization and determine how R&D funds are spent. The governing instrument is usually a cooperative agreement that is supported by a set of bylaws to provide structure and guidance on the operation of the cooperative.

Selected projects and issues are those identified by members as having highest priority and value to the membership. In addition, the projects are developed and led by the members. Projects serve to improve the competitiveness and operations of its members.

Cooperatives focus on initiatives in areas such as:

- Industry improvement projects
- Facilitation of industry dialogue
- Product/technology testing and evaluation
- Product development

The government, by capitalizing on funding, work, and initiative taken on by a cooperative, can effectively leverage Federal investment to improve the operation, efficiency and safety of the industry. The government can participate as a member of the cooperative to take direct advantage of its programs. In addition, the government has the ability to selectively provide support to programs it believes are for the general benefit of the industry, as well as to the nation's economic and national security.

Cooperatively Focused Broad Agency Announcements (BAA) - Agencies can identify technical development needs in broad focus areas and issue solicitations for BAA proposals that encourage stakeholder involvement. The BAAs give the participants the flexibility to form tailored consortiums and propose specific projects that will fulfill research needs. Proposals are submitted to the agency or organization for evaluation and review. Proposals having the best potential of meeting industry and Governmental needs are selected for award. Consortium partners then work with the agency to develop a satisfactory statement of work, a schedule of milestones, and then sign a cooperative agreement to carry out the research. The administering agency and the consortium have the flexibility to make adjustments as needed to ensure the project is beneficial to consortium partners as well as the industry in general. Programs such as this allow the government to identify critical need areas, request project proposals to address the need, select and award projects that will effectively meet the need, and leverage Federal investment with industry funding to effect a solution.

Agency Identified/Directed Research & Development - This method addresses R&D work that an agency has identified as important and needs early implementation. Contract or cooperative agreements can be crafted to meet research needs and work proactively with stakeholders to encourage early implementation. Agencies perform R&D activities to address Government requirements that usually involve industry and academia in some way. Funding can be applied in a focused fashion through a contract, cooperative agreement, or grant to involve industry and academia in a manner most appropriate to address specific agency needs. Arrangements with stakeholders to leverage Federal funds can be set out

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in the agreement so that the programs mutually benefit commercial and government interests.

Unsolicited Proposals - Unsolicited proposals are occasionally received by an agency or cooperative for conducting cost-shared R&D. This is another method where industry and academia can initiate research efforts to meet needs. Where industry, academia, and

other stakeholders have identified and specified how to effectively address an area critically important to national needs and cost sharing and commitment exists then Federal funds can be leveraged to address these non-Governmental initiated efforts.

Table 7: Example Cooperative Mechanisms

Cooperative Organizations	R&D oriented Agencies Issuing BAAs for Focus Area Development	Agency identified Programmatic R&D Focus Areas
SOCP (Ship Operations Cooperative Program, www.socp.org) CHCP (Cargo Handling Cooperative Program, www.marad.dot) MTS (Marine Transportation System Initiative, www.dot.gov/mts) GRIP (Gulf/Rivers Intermodal Partnership, www.marad.dot.gov/programs/grip.htm) CCDoTT (Commercial Deployment of Transportation Technologies, www.ccdott.org)	NCHRP (National Cooperative Highway Research Program, www.tfrc.gov/focus/archives/27nchr.htm) TCRP (Transit Cooperative Research Program, www.bts.gov/tmip/projects.htm) AASHTO (American Association of State Highway Officials www.fhwa.dot.gov/aaaa/csd/aashto.htm) NSRP (National Shipbuilding Research Program, www.nsrp.org) National Ocean Service Partnership Program	VOSS (Vessel Optimization and Safety System, www.marad.dot.gov/nmrec/maritech/proj12.html) Ship Structure Committee

6. PROPOSALS FOR MARITIME RESEARCH AND TECHNOLOGY

Changing Face of Transportation

During the last few years, there have been several studies and conferences that have identified maritime research and infrastructure needs. In The Changing Face of Transportation,¹⁴ published by the DOT in December 2000, many issues were identified as keys to the future of successful transportation systems. U.S. ports and their intermodal connectors were specifically mentioned as facing significant problems due to changing business practices, the need to preserve ecosystems threatened by present operations, and the need for expansion. Among the other MTS related issues identified were:

- Ports need for financial resources for terminal expansion and channel deepening projects to accommodate the new generations of bigger, faster cargo ships
- Need to improve performance in "environmental streamlining" to ensure timely completion of projects under the regulatory purview of several interests
- Need to improve staffing, skills, data and planning tools to support freight planning and investment at all levels of government
- Need for energy, propulsion and environmental engineering advances which provide options to deliver improved transportation service that is less costly, more energy efficient and environmentally safe taking into account the needs of our natural ecosystems and livable communities
- Need for advanced simulation systems to enable better evaluation of technological alternatives and allow more informed transportation investment decision making
- Intelligent infrastructure needed to leverage emerging technologies integrated into multimodal traffic control systems linking air, land, and water movements of people and goods

Many of those keys to success are echoed in other studies and reports and form the basis for areas of study that should be the framework from which to identify necessary maritime research and technology development initiatives.

Marine Transportation System Report

DOT's congressionally mandated report, "An Assessment of the Marine Transportation System,"¹⁷ represents the views of industry, stakeholders and academia. The assessment established guiding perspectives that are the focus of MTS activities today. The report also made several recommendations for

what needs to be accomplished to achieve the vision expressed for the U.S. MTS in the year 2020, which was:

"Vision 2020" - The U.S. MTS will be the world's most technologically advanced, safe, secure, efficient, effective, accessible, globally competitive, dynamic and environmentally responsible system for moving goods and people.

The report also set forth approaches and areas of concentration thought to yield the greatest improvements in current system performance, including:

- Agencies establish one-stop shopping for inspection and reporting requirements - including coordinating and streamlining multiple agency inspections and procedures
- Establish a National Cooperative Research program to:
 - Coordinate current and planned MTS related research by government agencies, educational institutions, and the private sector
 - Foster research to assess and address mobility, safety, environmental protection, and security issues
 - Ensure, through research and technology development, that the MTS has adequate capability to accommodate projected cargo and passenger traffic patterns
- Employ new technology and develop effective communication tools designed to share best practices, personnel training, and collective approaches among the maritime user community and across government agencies
- A series of recommendations calling for continued improvement in traffic management systems
- A series of recommendations calling for stakeholders to be proactive to reduce environmental impacts from industry activities

As recommended in the 1999 report to Congress, two committees were established: the Interagency Committee on the Marine Transportation System (ICMTS), with members from 17 Federal agencies and a private sector advisory committee and the Marine Transportation System National Advisory Committee (MTSNAC), with representatives from 30 businesses and non-Federal organizations. Both committees have initiated Research and Technology subcommittees to work together on assessing and improving research

and technology to solve MTS-related problems. Currently, these subcommittees are assessing MTS R&D requirements in relation to designing a National Cooperative MTS Research Program. Among their other activities is the hosting of a biennial national MTS Research and Development Coordination Conference.

MTS R&D Coordination Conference

Following the MTS assessment, the first Conference on MTS Research and Development Coordination¹⁵ was convened on November 2-4, 1999. This conference, organized by the 17 Federal agencies of the ICMTS, featured key areas of research organized by:

- System Competitiveness and Mobility
- Marine Transportation Infrastructure
- Information management
- Environmental protection
- Safety Systems and Operations
- Coordination and Leadership
- Security

This conference also involved a mini-workshop to discuss the design and implementation of a National Cooperative MTS Research Program. Numerous topic statements developed and presented at this conference are included in the published conference report (<http://www.marad.dot.gov/proceedings.html>) and provide a sampling of important areas for further development and research.

A second conference took place on November 14 - 16, 2001, to review progress and focus priorities further. MTS industry and Governmental subcommittees on Research and Development continue to meet and assess needs and coordinate activities. While many needs have been determined during these deliberations, a national plan with priorities and a method for funding has not yet been developed.

Agriculture Blueprint Report

Concerns about the ability of the national marine transportation system, and the transportation system as a whole, to support the economic growth of the nation have been expressed in many forums. An October 2000 paper prepared for discussion by the U.S. Department of Agriculture "21st Century Agricultural Transportation - A Blueprint to Meet the Challenges"¹⁶ sums up the concerns of those dependent on the transportation system for their future well-being and reflects user "needs" that should be addressed:

- Innovations in production and business transactions are not fully realizable without improved technology and systems to move goods and commodities from production sites to final customers. Improved efficiency and quality of freight movements domestically and internationally is critical to realizing the gains from improved agriculture production and e-commerce methods.

- The U.S. needs to reduce cross-border delays and deal with associated air quality degradations by improving infrastructure, streamlining inspection procedures, and funding more effective drug trafficking deterrents. Foreign free trade zones need to be established to improve the flow of goods through ports.
- A more flexible transportation infrastructure is needed to meet larger and unforeseen demands for products and to deal with infrastructure outages (natural disasters, accidents, strikes, terrorism, etc.).
- Striving to achieve "livable" communities is a continuing challenge with transportation adequacy affecting the ability to attract new business and unintended or poorly planned development affecting a community's quality of life.
- Age of inland waterways infrastructure and growing congestion are problems that impede the flow of commerce.

Vision 2050 Transportation Report

Within the same time period, another high level group comprised of government, industry, and academic representatives was formed to study the longer-term future needs of the transportation system. This Federal Transportation Advisory Committee reviewed what research and development would have to be initiated now to enable an advanced transportation system in 2050. This effort resulted in a report "Vision 2050: An Integrated National Transportation System".¹⁷ The major conclusion presented is that infrastructure changes take decades to achieve. With the volumes of goods to be transported expected to double or triple over the flow in today's system which is straining to serve current movements, significant attention to addressing future requirements must begin now.

To overcome these difficulties the 2050 study recommended that steps should be taken to:

- Significantly increase funding for long-term, high-risk, enabling type research.
- Create a Government-Industry-University task force to identify ways to eliminate the regulatory and legal barriers to innovation.
- Improve operational management by creating new inter-institutional arrangements (both formal and virtual) crossing public and private lines to overcome current jurisdiction and modal fragmentation.
- Develop effective and efficient means for selecting and completing infrastructure projects and to rationalize system design and operations at a level above individual modes.

Common Ground

It is important to note that regardless of the approach or how the areas of need are aggregated, the common theme is that increased attention and R&D development

should focus on improving the capabilities of existing infrastructure. Capacity, flow, and effectiveness must be increased without doing damage to the environment or adversely affecting the livability of our communities. Since over 95 percent of our international trade is carried by water, our domestic transportation system will face countless challenges in the coming years.

Research and Development Planning Efforts of Others

This nation has not developed a cohesive, structured maritime plan as our global competitors have. For example, early in the 1990's, member states of the European Union recognized the need to work together to address the needs of their own infrastructure for the marine system. Their efforts have evolved into the "European Union Research and Development Master Plan." It is structured into six areas of research and development activities grouped into two sections, the marine transport chain and marine resources. These areas are subdivided as follows:

Marine Transport Chain

Area 1 Shipbuilding - improvement of competitiveness and productivity

- Design Tools
- Production processes and technologies (Technology, processes, and human element)
-

Area 2 Shipping and Waterborne Operations

- Mobility and inter-modality
- Increases efficiency of operations and complying with international rules

Area 3 Related and supporting activities

- Education and training
- Technology

Marine Resources

Area 4 Offshore

- Energies including hydrocarbon, renewable (current, tech, wave & wind)
- Deep water development and design of floating structures

Area 5 Living Resources

- Fisheries, aquaculture and other living resources

Area 6 Other Marine Resources and Supporting Technologies

- Provision of fresh water
- Exploitation of coastal and sea space

Research areas are pursued in an organized structure though a combination of private and public areas not unlike what has been prescribed in previously cited studies of the U.S. marine system. There are strong parallels to what has been identified in the documents cited in this report. Research and development funds in the U.S. are parceled out without focusing on a system-wide marine plan, while others, such as the EU, are proceeding and preparing to modify and further improve their plans.

Efforts Underway

A few of the many study efforts identifying needs in various areas have been outlined here and an organized structure through which to pursue a comprehensive R&D effort is being developed. The Department of Transportation's (DOT) Research and Development Plan¹² sets forth a longer term vision of what needs to be done in a comprehensive and systematic manner within each of the five DOT strategic plan goal areas. The Plan synthesizes the ideas expressed in each of the publications cited above into a comprehensive structure. The plan addresses topical areas for each departmental strategic goal. Important maritime areas falling under each goal include the following:

- Safety: Boating and marine safety, passenger and worker safety
- Mobility: Port productivity, navigation channels, and shipbuilding
- Human and Natural Environment: Oil spills, fisheries protection, emissions, environmental justice
- National Security: Sealift capacity, mariner availability, drug and migrant interdiction, maritime boundary incursions, infrastructure protection, energy efficiency

The areas lend themselves in time to technology sharing. To pursue these tasks over \$1.1 billion was shown as DOT R&D spending in FY 2001 (Table 1) with planned 2002 maritime efforts included at the \$20 million level and allocated to USCG operations and missions focusing primarily on marine safety. To be successful, DOT modal administrations must be aggressive in their efforts to consult and partner with other Federal Agencies, State and local governments, the private sector, and academia.

The new DOT R&D plan also identified 14 priority areas for technology partnerships. The maritime industry has a direct interest in nine of these areas, each of which represents an area where intermodal efforts can leverage value and yield mutual benefits:

- Next Generation Transportation Vehicles - including Ships
- National Intelligent Transportation Infrastructure
- Transportation and Sustainable Communities
- Transportation Infrastructure Assurance

- Enhanced Goods and Freight Movement at Domestic and International Gateways
- Infrastructure Renewal Partnership Initiative
- Maritime Safety Research
- Commercial Remote Sensing Technologies - Application to Transportation
- Enhanced Weather Services

Next Steps

There is no shortage of organizations that have carefully thought out workable plans for research and development in preparation for the projected challenging demands of tomorrow. In the present environment, groups are proceeding almost

independently to accomplish what they can within the resources currently available to them. The richness of ideas and approaches merely underscores the need for significant, comprehensive and systematic efforts to address the identified issues and areas of concern.

The maritime community hopes to support and participate in ICMTS and MTSNAC efforts and help lead this industry's planning efforts. A comprehensive research and technology structure that crosses agency and appropriation committee lines needs to be developed to provide systematic funding and guidance.

7. CONCLUSION

Our nation will continue to depend on its marine transportation system as a key element of our national security, economic competitiveness, environmental improvement, and recreation. The challenge remains to harness the creativity and innovation of diverse stakeholders. This ensures the system not only adapts to meet the Nation's changing passenger and freight transportation requirements, but also continues to enable and support economic growth and trade in future years.

The vision for the nation's marine transportation system set forth in 1999 remains unchallenged:

"Vision 2020 – The U.S. MTS will be the world's most technologically advanced, safe, secure, efficient, effective, accessible, globally competitive, dynamic and environmentally responsible system for moving goods and people."¹⁷

An overarching structure to achieve the vision needs to be set in place. We must remain mindful that innovations in production and business transactions cannot be fully realized without innovation in the ability to move goods, commodities and people. Improving the efficiency and quality of the marine transportation system is critical to realizing the nation's advances in technology and turning changes in the world's business practices to U.S. competitive advantage. Similarly, the marine transportation system for the future must have the ability to meet much larger demands, be flexible enough to deal with outages or interruptions, and be environmentally responsible.

The maritime agencies responsible for overseeing the commercial maritime industry will continue to provide a leadership role in developing the transportation system of the future to accelerate the progress of ongoing

initiatives and to enable transfer of knowledge and applications across present transportation industry boundaries.

A comprehensive marine transportation research and technology development structure is being developed which incorporates all stakeholders and interests referenced in this report. It will recognize the need to develop commercial infrastructure while protecting marine resources. This structure will incorporate the work currently ongoing as part of Federally-sponsored research efforts in the MTS initiative, MARITECH-ASE, the university transportation research centers, and the other research and development cooperatives, all of which are presently working semi-independently.

A National Cooperative Research Program, analogous to those already established for highway and transit, could be created as recommended in the September 1999 report to Congress⁷. This program could be set up under the auspices of the on-going MTS initiative and leverage efforts of the Interagency Committee for the Marine Transportation System (ICMTS) and the Marine Transportation System National Advisory Council (MTSNAC).

Development efforts could seek to address unnecessary overlaps in jurisdiction and funding issues that impact the progress of the development of the national transportation infrastructure for the future. Efforts could also address the lack of balance that presently exists and insure that all appropriate agencies are funded and authorized to participate fully in these endeavors. Whatever form, the important concept is to recognize the importance of all parts of the transportation system and ensure the participation in planning and development by all key stakeholders.

APPENDIX A DOT RESEARCH AND DEVELOPMENT BUDGET SUMMARY

This appendix provides a summary of the past five years of research and development investments by the different modal agencies at the Department of Transportation. These are the funded amounts as enacted. The subtotals provide summaries of the individual elements according to their individual classification as being:

- Research and Development
- Technology Investment, or
- Facilities

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Research, Development & Technology
Department of Transportation
Budget Authority (Enacted)
(In thousands of dollars)

	FY 1995	FY 1996	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001
FEDERAL HIGHWAY ADMINISTRATION							
Research and Technology Program							
A. Surface Transportation	65,663	75,776	80,935	84,647	85,208	78,477	85,515
B. Technology Deployment Program (T)	13,360	41,000	41,000	31,185	30,905	34,840	39,468
C. Training and Education	15,384	15,693	15,096	12,474	13,245	13,935	15,787
D. Intelligent Transportation Systems	200,800	203,829	232,441	174,636	176,600	183,958	191,200
E. University Transportation Research	12,250	10,713	12,250	22,854	22,650	23,735	23,900
F. Other	111,195	89,696	103,867	89,772	122,000	166,487	169,539
G. Administrative Expenses	9,314	9,476	10,026	10,786	11,744	11,744	11,718
Subtotal, Research & Development	223,848	206,910	228,605	231,064	247,580	261,393	267,964
Subtotal, Technology Investment (T)	201,118	233,560	266,110	193,290	214,772	251,784	269,163
Subtotal, Facilities (F)	3,000	5,713	900	2,000	0	0	0
Total FHWA	427,966	446,183	495,615	426,354	462,352	513,177	537,127
FEDERAL MOTOR CARRIER SAFETY ADMINISTRATION*							
Research and Technology	0	0	0	0	0	5,574	10,784
Technology Investment	0	0	0	0	0	0	1,565
Total FMCSA	0	0	0	0	0	5,574	12,349
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION							
A. Research and Analysis	39,506	32,199	39,063	45,063	52,500	49,751	57,938
1. Crashworthiness	12,650	11,800	16,422	21,422	26,509	22,090	23,453 ⁺
2. Crash Avoidance	9,544	2,517	1,595	1,595	3,000	4,840	11,214
3. Data programs (T)	16,523	17,065	20,207	21,207	22,001	21,871	22,321
4. Technology Transfer Programs (T)	40	40	40	40	40	0	0
5. Vehicle Research and Test Center	749	777	799	799	950	950	950
B. Highway Safety Research	3,733	5,069	5,123	4,723	5,437	7,152	7,277
C. Administrative Expenses	13,000	13,000	12,600	13,082	14,454	15,537	15,419
Subtotal, Research & Development	39,676	33,163	36,539	41,621	50,350	50,569	58,313
Subtotal, Technology Investment (T)	16,563	17,105	20,247	21,247	22,041	21,871	22,321
Subtotal, Facilities (F)	0	0	0	0	0	0	0
Total NHTSA	56,239	50,268	56,786	62,868	72,391	72,440	80,634
FEDERAL RAILROAD ADMINISTRATION							
A. Railroad Research and Development	18,078	22,386	17,911	18,325	19,718	22,464	25,269
1. Equipment, Operations & Hazmat	5,413	5,535	5,545	5,659	7,468	9,300	11,424
2. Track & Vehicle-track Interaction	9,165	7,078	7,346	7,246	6,950	7,864	8,282
3. Railroad Systems Safety & Security	0	0	0	0	0	4,800	4,640

* The Federal Motor Carrier Safety Administration was established on January 1, 2000.

⁺ Shadowed areas present a further breakdown of the areas of research in the category.

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	FY 1995	FY 1996	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001
4. R&D Facilities & Equipment	200	400	420	770	500	500	923
B. Next Generation High-Speed Rail	19,868	24,127	26,176	20,395	20,494	27,097	25,045
1. HS Train Control Systems (T)	0	0	0	0	0	15,000	10,976 +
2. Non-Electric Locomotives (T)	0	6,000	6,000	9,300	9,800	7,000	6,785
3. Grade Crossing & Innov.Tech (T)	0	4,500	5,000	5,600	4,600	3,897	4,291
4. Track/Structures Technology (T)	0	0	6,500	1,200	1,200	1,200	1,297
5. Corridor Planning (T)	0	0	0	0	0	0	1,696
C. Safety and Operations	2,121	1,695	2,181	2,430	2,646	3,217	3,555
1. Salaries and Expenses (R&D)	2,121	1,695	2,181	2,430	2,646	2,543	2,655
2. Salaries and Expenses (T)	0	0	0	0	0	674	900
D. MAGLEV (T)	0	0	0	0	0	0	0
Subtotal, Research & Development	23,999	21,953	19,672	19,985	21,864	24,507	27,001
Subtotal, Technology Investment (T)	12,368	22,855	23,176	20,395	20,494	27,771	25,945
Subtotal, Facilities (F)	3,700	3,400	3,420	770	500	500	923
Total FRA	40,067	48,208	46,268	41,150	42,858	52,778	53,869

FEDERAL TRANSIT ADMINISTRATION

A. National Program	27,004	22,000	22,000	32,750	27,500	29,257	29,435
1. Safety and Security	800	1,100	725	2,500	2,200	5,450	6,087
2. Equipment and Infrastructure	19,743	13,725	15,900	18,729	9,750	13,692	9,713
3. Fleet Operations	0	0	0	550	4,250	1,236	999
4. Specialized Customer Services (T)	0	2,970	3,000	4,950	6,400	4,447	5,787
5. Information Management Technology	0	1,500	1,580	3,509	2,300	100	2,504
6. Metropolitan / Rural Policy Development	3,922	650	275	1,100	850	0	637
7. Planning and Project Development	1,989	1,900	295	1,312	1,700	544	3,091
8. Human Resources (T)	550	155	225	100	50	0	217
9. Performance and Review	0	0	0	0	0	2,800	100
10. International Mass Transit Program	0	0	0	0	0	988	300
B. Transit Cooperative Research Program	8,475	8,250	8,250	4,000	8,250	8,250	8,232
C. National Transit Institute (T)	3,000	3,000	3,000	3,000	4,000	4,000	3,991
D. Rural Transit Assistance Program (T)	4,613	4,500	4,500	4,500	5,250	5,250	5,238
E. Fuel Cell Bus & Bus Facilities (T)	0	0	0	4,850	4,850	4,850	4,839
F. University Transportation Centers	6,000	6,000	6,000	6,000	6,000	6,000	5,967
G. Administrative Expenses	2,198	2,174	2,266	2,303	2,385	2,475	2,494
Subtotal, Research & Development	24,851	17,053	16,541	23,216	16,685	12,014	8,031
Subtotal, Technology Investment (T)	26,439	28,871	29,475	34,187	41,550	48,068	52,185
Subtotal, Facilities (F)	0	0	0	0	0	0	0
Total FTA	51,290	45,924	46,016	57,403	58,235	60,082	60,216

FEDERAL AVIATION ADMINISTRATION

A. Research, Engineering and Development	251,585	182,298	204,612	199,183	150,000	156,495	186,589
1. System Development and Infrastructure	8,818	10,000	13,660	14,654	15,784	17,139	17,375
2. Weather	4,431	6,493	13,000	15,300	18,684	19,300	24,751
3. Airport Technology	8,136	6,000	5,200	5,000	0	0	0 +
4. Aircraft Safety Technology	46,946	37,978	36,504	49,202	34,886	44,457	62,542

+ Shaded areas present a further breakdown of the areas of research in the category.

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	FY 1995	FY 1996	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001
5. System Security Technology	35,477	36,045	57,055	44,225	51,690	50,147	54,401
6. Human Factors and Aviation Medicine	31,855	23,682	23,504	26,550	25,065	21,971	24,047
7. Environment and Energy	5,200	3,800	3,600	2,891	2,891	3,481	3,473
8. Strategic Partnerships	4,768	1,500	2,000	2,000	1,000	0	0
B. Facilities and Equipment	21,690	20,600	17,200	14,290	14,290	55,496	104,936
C. Airport Improvement Program	0	0	0	0	0	6,062	7,364
D. Operations **	25,600	25,915	27,103	28,103	60,654	7,481	8,921
E. Commercial Space Transportation***	0	1,085	800	600	600	600	599
Subtotal, Research and Development	277,185	209,298	232,515	227,886	211,254	207,272	287,388
Subtotal, Technology Investment (T)	0	0	0	0	0	6,062	7,364
Subtotal, Facilities (F)	21,690	20,600	17,200	14,290	14,290	12,800	13,657
Total FAA	298,875	229,898	249,715	242,176	225,544	226,134	308,409

RESEARCH & SPECIAL PROGRAMS ADMINISTRATION

A. Research and Special Programs	4,016	4,866	7,809	4,882	5,119	5,125	6,426
1. Hazardous Materials	1,554	1,385	1,000	1,200	1,200	1,200	1,193
2. Research and Technology	2,396	1,866	5,200	2,050	2,235	2,085	3,535
3. Emergency Transportation	66	50	50	50	50	235	235
4. Administrative Expenses	0	1,565	1,559	1,582	1,634	1,605	1,463
B. Pipeline Safety	4,204	2,142	1,644	1,313	1,872	2,074	2,934
1. Pipeline Safety	4,204	2,000	1,500	1,165	1,719	1,894	2,744
2. Administrative Expenses	0	142	144	148	153	180	190
Total RSPA	8,220	7,008	9,453	6,195	6,991	7,199	9,360

US COAST GUARD

A. Research, Development Test & Evaluation	20,169	18,000	20,480	19,260	17,260	18,993	21,273
1. Improved Search & Rescue Capability	1,285	932	1,872	1,875	570	1,162	456
2. Waterways Safety, Management & ATN	2,175	2,189	1,385	1,225	1,716	1,444	1,193
3. Marine Safety	2,122	2,700	3,825	2,955	2,398	3,108	5,437
4. Support for Interagency Ship Structure Committee	285	0	223	437	289	159	380
5. Marine Environmental Protection	1,796	1,354	1,791	1,525	1,494	2,263	1,139
6. Maritime Law Enforcement	1,096	1,229	791	1,250	0	3,213	4,412
7. Technology Advancement and assessment	0	0	1,000	0	2,489	3,746	3,982
8. Safety & Environmental Compliance	2,022	2,318	2,452	3,125	0	0	0
9. Human Resources Management	517	100	147	0	0	0	0
10. Comm., Contr., Commun., Comp., & Intel. Integ.	2,938	928	928	1,050	0	0	0
11. Technology Advancement	1,523	500	1,000	1,463	0	0	0
12. R&D Personnel, Program Support & Operations	4,410	5,225	4,786	4,095	3,044	3,632	4,002
13. R&D Facilities (F)	0	525	280	260	260	266	272
14. Supplemental, Military Readiness, Overseas Contingency	0	0	0	0	5,000	0	0

2000 reflects OPS portion of R,E&D. * Funded in OPS, but not included.

+ Shadowed areas present a further breakdown of the areas of research in the category.

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		FY 1995	FY 1996	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001
B.	Oil Spill Recovery, Prince William Sound	0	0	0	1,210	1,229	1,200	1,200
	Subtotal Research & Development	20,169	17,475	20,200	20,210	18,229	19,927	22,201
	Subtotal Technology Investment (T)	0	0	0	0	0	0	0
	Subtotal Facilities (F)	0	525	280	260	260	266	272
	Total, USCG	20,169	18,000	20,480	20,470	18,489	20,193	22,473

MARITIME ADMINISTRATION

Research & Development	Total, MARAD	2,450	0	0	0	0	0	0
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OFFICE OF THE SECRETARY (TPR&D)

Transportation, Planning, Research & Development		2,721	2,808	2,687	3,530	8,779	5,142	10,976
Commercial Space Transportation***		1,230	0	0	0	0	0	0
Total, OST		3,951	2,808	2,687	3,530	8,779	5,142	10,976

DOT SUBTOTALS

Research & Development	624,349	515,668	566,212	573,707	581,732	593,597	703,583
Technology Investment (T)	256,488	302,391	339,008	269,119	298,857	355,556	376,978
Facilities (F)	28,390	30,238	21,800	17,320	15,050	13,566	14,852

DOT GRAND TOTAL	909,227	848,297	927,020	860,146	895,639	962,719	1,095,413
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Notes:

1. Numbers include funds used for basic research, applied research, development, research facilities, technology, education and training and related DOT research efforts.
2. Subtotals sum those items within the listed categories by their focus: R&D, Technology, or Facilities. The subtotals are developed from a less aggregated version of this table showing the particular category for each individual effort.

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