Section II

A Profile of R&D in the Maritime Industry

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INDUSTRY R&D ACTIVITIES

Tables 2 and 3 display survey data concerning past and present R&D expenditures in the maritime industry. These data provide an overview of the number of firms who fund R&D projects and the relative amount of that funding.

Ship Operators

For operators (table 2), over one-third *(38* to *40* percent) of the respondents said their firms supported some research and development work. The average percentage of operating budgets spent on R&D was 1.2 percent for the current year and 1.3 percent for the past five years. The largest percentage of operating budget spent on R&D was 4 percent for both the current year and the past five years.

Table 2.—U.S. Ship Operators R&D Expenditures: Percent of Operating Budgets Reported for R&D
(Total of 48 Respondents)

Range of percentage of operating budget	Past 5 years		Current year	
	Number	Percent	Number	Percent
None or "nil"	30	63	29	60
up to 1 %	11	23	12	25
Over 1%-2%	4	8	5	10
Over 2%	3	6	2	4
Total respondents	48	100	48	100
Total with some R&D ., ...	18	38	19	40
Average percent spent on R&D . . .	1.3%		1.2%	
Largest percent spent on R&D . .	4.0%		4.0%	

Table 3.—U.S. Shipyard R&D Expenditures: Percent of Operating Budgets Reported for R&D
(Total of 36 Respondents)

Range of percentage of operating budget	Past 5 years		Current year	
	Number	Percent	Number	Percent
None or "nil"	15	42	17	47
up to 1%	13	36	12	33
Over 1%-2%	5	14	4	11
Over 2%	3	8	3	8
Total respondents .	36	100	36	100
Total with some R&D	21	58	19	53
Average percent spent on R&D . .	1.3%		1.7%	
Largest percent spent on R&D . . .	4.0%		8.0%	

NOTE Percentages are rounded and may not add up 10 100 in some tables

The data shows very little difference in R&D expenditures for the current year vs. the past five years and indicate that R&D activity in the ship and barge operating industry has been fairly constant. This suggests that R&D investments probably will not change in the near future. Those firms with no R&D did not indicate that they may start some R&D projects and several indicated that R&D was not appropriate to their line of business.

Shipbuilders

In the shipbuilding industry (table *3), 19* firms responding to OTA's survey reported that they were involved in R&D activities in the current year and 21 firms in the past five years. This is a slightly higher percentage *(53* percent and *58* percent) of firms conducting research than was found in the ship operating industry.

Of those respondents conducting research in the shipbuilding industry, the average amount a firm spent on R&D in the past five years was 1.3 percent of their operating budget. This amount rose slightly to 1.7 percent in the current year. The largest percentage of operating budget spent by a shipbuilding firm on R&D in the past five years was 4 percent. In the current year, the most any shipyard spent was *8* percent of its operating budget,

Thus, of those firms responding, slightly fewer are investing in R&D today than during the preceding five years. At the same time, the fraction of their operating budgets devoted to R&D has increased. These indications of a change in R&D involvement by shipyards is consistent with the apparent growing concentration of U.S. shipbuilders in fewer,

larger firms, as was reported in OTA's "Assessment of Maritime Trade and Technology" in 1983.

Both operators and shipyards parceled their research funds into different types of research. Ship operators spent most of their R&D budgets on improving ship operations (40 percent) and information systems (30 percent). The rest of their budgets were spent on ship design (12 percent), shoreside operations (7 percent), inland operations *(3* percent), and on miscellaneous R&D projects *(8 percent). Table 4* shows the breakdown of these expenditures. Shipyards (table 5) put most of their money—about 49 percent of their expenditures—into R&D on shipbuilding methods and techniques, presumably to increase construction productivity. But they also spent significant portions of their R&D budgets on ship or barge design (30 percent) and subsystem design and development (6 percent). The remainder was spent on miscellaneous R&D (5 percent).

Table 4.—U.S. Ship Operators R&D Expenditures by Category (20 Firms Reporting Some R&D) Average Percent for each Category

Category	Average percent expenditure in category	Highest percent in category
Ship operations (including cargo handling)	40	100
Shoreside operations (terminals)	7	30
Inland operations	3	50
Ship design	12	60
Information management	30	100
Other:		
Market studies	8	50
Equipment safety		
Medical		

Table 5.–U.S. Shipyard R&D Expenditures by Category Average Percent for each Category-For 21 Respondents Who Had Some R&D Expenditures

Category	Average percent expenditure in category
Ship or barge design	30
Subsystem design	16
Shipbuilding/construction technology	49
Other:	
Technology transfer.	5
Materials	
Weapons	
Ocean engineering.	

THE FEDERAL ROLE IN MARITIME R&D

The Federal Government through the U.S. Navy's Manufacturing Technology (ManTech) Office and the Maritime Administration (MarAd) sponsors a substantial Maritime R&D program. Funding by these two agencies is currently about $35 million annually (figure 1). The Navy, of course, sponsors many other research efforts that are of interest to the commercial maritime community, but the ManTech program is the one that deals directly with U.S. shipyards. Appendices A and B describe the MarAd R&D program and the Navy's ManTech program.

As is shown in figure 1, the Navy's ManTech program was initiated in FY 1977 and has grown to be a dominant source of Federal funds for the maritime R&D industry today. It is all directed at improving ship construction technology with the goal of reducing costs and delivery times of naval ships while improving the quality of the end product. Figure 2 illustrates the relative attention (measured by funding) given to various R&D subjects. Very specific manufacturing techniques such as laser metalworking and robotic painting are given high priority because it is felt that these offer the potential for significant cost reduction. The major shipyards and suppliers with naval construction contracts participate in this program. Currently eight shipyards are participating.[2]

The MarAd R&D program elements are illustrated in figure 3. The largest element funds the Kings Point research center and the Computer-Aided Operation Research Facility (CAORF). Funds for CAORF also come from users including

[2]Naval Materials Command, "Navy Manufacturing Technology Program Effectiveness Report, Fiscal Years 1977-1983, " June 1984.

Figure 1 .—Maritime Administration and Navy "ManTech" R&D Program Expenditures, Fiscal Years 1975-85

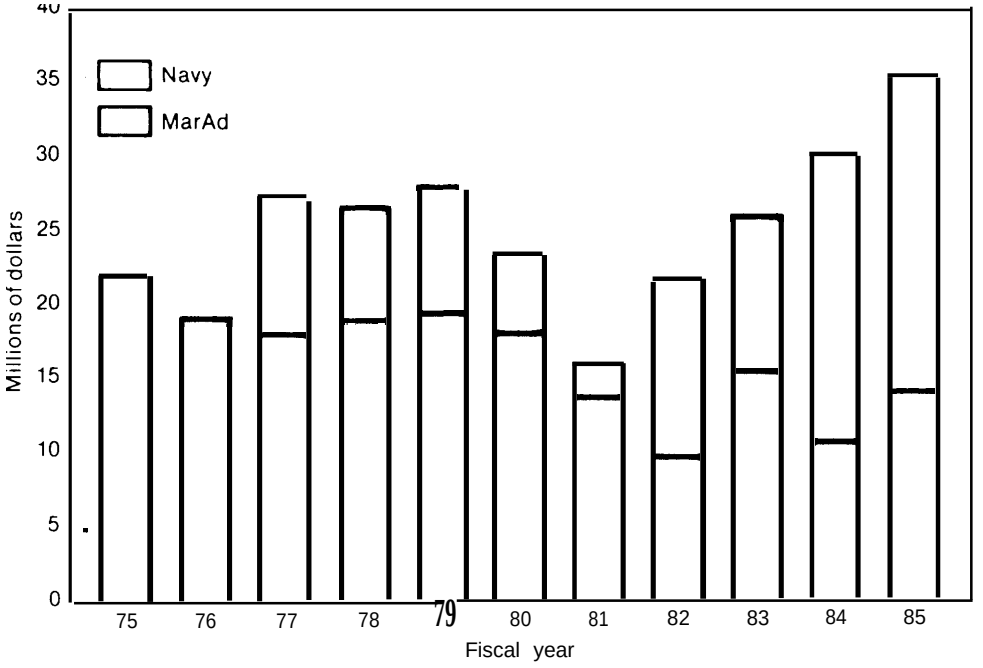
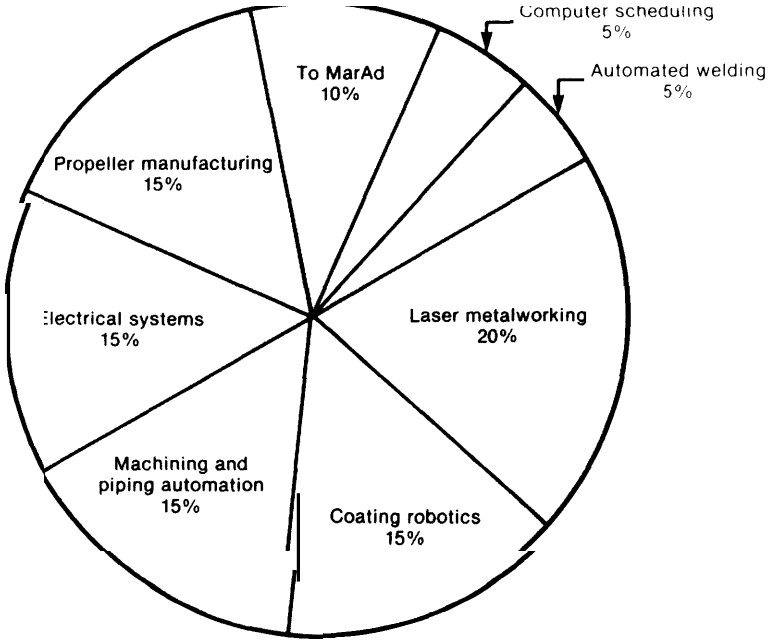


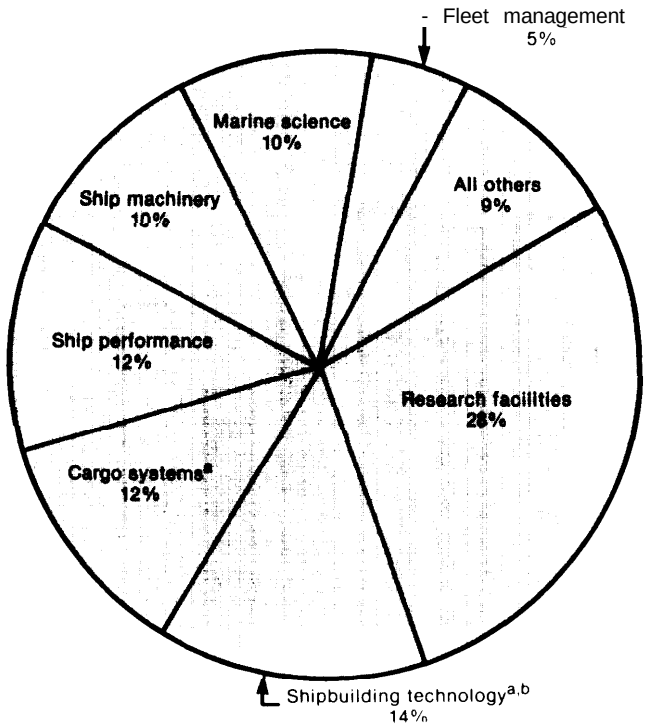
Figure 2.—Navy ManTech Program Fiscal Year 1985 Breakdown of R&D Subjects



NOTE Ail subjects are elements of shipbuilding technology development with goals of reducing costs or improving the product at those yards building Naval ships

SOURCE: Naval Material Command

Figure 3.—MarAd R&D Program Major Elements in Fiscal Year 1985



[a]These two programs incorporate cooperative industry cost—sharing projects with current participation of six shipyards (shipbuilding) and seven liner operators (cargo).
[b]This program, at $2 million in fiscal year 1985, also has an additional $2 million contribution from the Navy ManTech Program.

SOURCE: MarAd.

other agencies. The shipbuilding technology (NSRP) element is also a major focus. MarAd funds plus equal Navy ManTech funds support this joint government/industry cost sharing effort which has similar goals to the entire ManTech program. The National Shipbuilding Research Program *(NSRP)—[also* discussed later in this study]—currently funds cooperative projects at six to eight of the major shipyards. During FY 1985, over two-thirds of NSRP funding goes to three major shipyards. The shipyards participating in the NSRP are, with few exceptions, the same as those participating in the Navy's ManTech program.

Another government/industry cooperative effort with participants from the liner industry is also funded under the MarAd R&D program. This is the Cargo Handling Cooperative Program—listed as part of "cargo systems" in figure 3. This program funds a joint industry cooperative which currently includes seven of the major liner operators. Two other MarAd R&D program elements (Ship Performance and Fleet Management) include projects with industry participation—but not through a cooperative group such as NSRP or the cargo handling cooperative. These other projects have participants including barge operators, tanker operators, and liner operators. Descriptions of these and other MarAd program elements are included in appendix A.

Despite the major Navy and MarAd R&D programs and many other Federal R&D efforts, only a portion of the respondents to the OTA survey reported that they received any Federal support for R&D. Tables *6* and 7 show the number and percentage of responding ship operators and shipbuilding firms which received Federal R&D funding and which Federal programs provided that funding.

For U.S. ship operators (table *6),* most respondents received no Federal support for R&D efforts. In the current year only two respondents (4 percent of the total respondents and 11 percent of

Table 6.—U.S. Ship Operators R&D Firms Reporting Federal Funding Support for R&D

	Past 5 years		Current year	
	Number	Percent	Number	Percent
Total respondents	48		48	
Respondents with no R&D	30		29	
Respondents with some R&D	18	100	19	100
Respondents engaged in R&D and receiving Federal funding	8	44	2	11

Table 7.–U.S. Shipyard R&D Firms Reporting Federal Funding Support for R&D (Past 5 Years and Current Year are the Same)

	Number	Percent
Total respondents	36	
Respondents with no R&D	15	
Respondents with some R&D	21	100
Respondents engaged in R&D and receiving Federal funding	11	52

NOTE Percentages are rounded and may not add up to 100 in some tables

Table 6a.—U.S. Ship Operators R&D Firms Responding to Question of Whether to Increase Direct Federal R&D Funding

	Number	Percent
Should Government increase direct R&D to the private sector?		
No	4	27
Yes	11*	73
	15	100
No response	33	
	48	
Which agencies should provide R&D development funding?		
MarAd	1	9
Navy and MarAd (together)	10	91
	*11	100

NOTE Percentages are rounded, and may not add up to 100 in some tables

the respondents with their own R&D) received any Federal funding. These numbers were down substantially from those of the past five years where 17 percent of the total respondents and 44 percent of the respondents with their own R&D received some Federal funding. Also of interest is the wide variation in the percentage of Federal support provided to operating firms—between 3 and 67 percent of a firms' total R&D expenditures. The Federal programs from which respondent U.S. ship operators received R&D funding were all within the Maritime Administration.

OTA also asked whether the respondents would advocate an increase in direct Federal R&D funding. Table 6a displays the operator's responses. Seventy-three percent of the firms that responded to this question replied yes, and all but one recommended joint Navy and MarAd funding. Some firms, however, qualified their affirmative reply. Three stated that the MarAd funding should be directed only at more basic research, primarily through universities and in support of educational programs. Two stated that MarAd funding should be subject to industry participation both in establishing goals and priorities and in selecting the most appropriate projects.

Table 7 displays the data on Federal funding for R&D in the U.S. shipbuilding industry. Only 11 respondents (30 percent of the total and 52 percent of shipbuilders with some R&D of their own) reported receiving Federal support. These percentages were the same for the current year as for the past five years. Of those who received funds, the average amount received was 21 percent of the total funds spent by the firm on R&D but the range was from a low of 1 percent to a high of 71 percent. This large variation indicates very different approaches to Federal involvement in shipyard R&D among these firms. Many firms find no support for the type of R&D they consider necessary; others find a mixture of Federal and private initiatives will meet their needs; while still others depend upon Federal funding for almost all of their R&D work.

The shipyard survey respondents received R&D support from both Navy and MarAd programs in roughly equal numbers. It is interesting to note from these data that the MarAd National Shipbuilding Research Program (NSRP) reached only 22 percent of the respondents to the OTA survey. Since the survey sample included a substantial portion of the U.S. shipbuilding industry, one conclusion is that NSRP probably reaches only one-quarter of the U.S. shipyards. Since this one Federal program is considered by many to be very successful in the areas where it does work, it may be useful to consider how it could be broadened to include more of the industry.

Table 7a presents data on whether shipyard respondents advocate increasing Federal R&D funding. Of the firms that replied to this question, 64 percent said yes and 36 percent said no. Of the nearly two-thirds that favored increased direct funding, eight firms thought MarAd should be the funding agency; however, these firms are the same U.S. shipyards who presently participate in the MarAd program. Several firms qualified their call for increased Federal support by suggesting that: 1) MarAd should develop new policy directions before increasing any R&D funding; 2) future R&D should be focused on fewer, more important problems; and *3)* Navy and MarAd should combine their R&D programs.

The OTA survey also questioned the industry about access to R&D results of the U.S. Navy and its foreign counterparts and asked for any suggestions of ways to improve that access. Tables *8* and 9 show the responses to these questions. Only *30* percent of the ship operators reported that they had access to U.S. Navy R&D, and *52* percent reported access to technological advances from foreign R&D. Although some respondents thought that the Federal Government should not become involved or more involved in this area, several operating firms made suggestions of Federal action to improve access to R&D results. Most of the suggestions were for MarAd or another central agency to screen and select the most useful reports, to translate foreign documents

Table 7a.– U.S. Shipyard R&D
Firms Responding to Question of Whether to Increase Direct Federal R&D Funding

	Number	Percent
Should Government increase direct R&D to the private sector?		
No	*8*	*36*
Yes	14*	*64*
	22	*100*
No response	14	
	36	
Which agencies should provide R&D funding?		
MarAd (national shipbuilding R&D program)	8	*57*
Navy	3	*21*
Navy and MarAd (together)	3	*21*
	14	100

NOTE Percentages are rounded, and may not add up to 100 in some tables Percentages in each row are calculated using the total number of firms responding to the item in that row

Table 8.–U.S. Ship Operators R&D
Firms Reporting Status of Access to Other R&D

Do you have access to technical advances from:	U.S. Navy R&D?		Foreign R&D?	
	Number	Percent	Number	Percent
Yes	*7*	*30*	12	52
No	16	70	11	48
	23	100	23	100

Suggestions reported for Federal action to improve access:

1. MarAd or other Federal agency should screen, translate, publish, and disseminate useful reports abstracts/ catalogs (through SNAME, NTIS, Industry Journals, or trade organizations such as AWO, FACS) . . . . . 8 firms
2. Establish cooperative information exchange among Government agencies (Navy-MarAd), SNAME, and universities . . . 1 firm
3. Allow Government work to be used in civilian application . . . . . 1 firm

NOTE: 3 firms stated that there is no need for government involvement in this area.

Table 9.–U.S. Shipyard R&D
Firms Reporting Status of Access to Other R&D

Do you have access to technical advances from:	U.S. Navy R&D?		Foreign R&D?	
	Number	Percent	Number	Percent
Yes	12	55	9	41
No	10	45	13	59
	22	100	22	100

Suggestions reported for Federal action to improve access (15-firms reporting):

i. Publish/distribute reports, abstracts, catalogs (through SNAME, industry groups, GPO) . . . . . 10 firms
2. Sponsor seminars and meetings—present and update specific R&D results (invite all shipyards) . . . . . 5 firms
3. Establish institution responsible for collection and dissemination of all maritime R&D
   (2 firms suggest "NASA" model)
   (1 firm suggests part of larger maritime R&D facility)
   (1 firm suggests joint Navy/industry study group) . . . . . 3 firms
4. Establish Government-controlled technical library with broad direct access . . . . . 1 firm
5. Disseminate through Federal bid requests . . . . . 1 firm
6. Fund additional education and training through SNAME ship production committee . . . . . 1 firm

NOTE Percentages are rounded, and may not add up to 100 in some tables Percentages in each row are calculated using the total number of firms responding to the item in that row

when of significant use, to publish abstracts or catalogs or reports, and to actively disseminate these materials to the industry. Suggestions were made to use professional organizations, industry and trade organizations, and journals whenever possible.

Shipbuilders reported better access than operators to U.S. Navy R&D results (55 percent), but only 41 percent had access to technological advances from foreign R&D. Many more suggestions of Federal action to improve access, however, were made by the shipyards. As with operators, the most frequently offered suggestion was to screen, publish, and disseminate reports, abstracts, and catalogs. Several firms suggested more elaborate approaches including: sponsoring regular seminars; establishing a new technology transfer institution similar to the National Aeronautics and Space Administration (NASA) model; and forming a joint Navy/Industry study group to solve the problem.

One shipyard wrote: "It is recommended that the Navy sponsor periodic reviews . . . to present to invited shipyards the results of recent projects . . . These meetings would not only encourage a dialogue between the Navy R&D community and the shipbuilding industry, but also better enable the shipyard to plan their own R&D programs. " It was suggested that both publications and seminars might be offered through the major industry trade associations. Alternatively, these might be offered through the government/industry sponsored maritime research facility described elsewhere. One shipyard also suggested that the maritime industry needed an organization equivalent to NASA, which would collect and disseminate research information on an industry-wide basis. (The possibility of such an organization is discussed later.) On an intra-agency basis, organizations such as MarAd and the U.S. Navy might periodically review their own completed and ongoing research and report on its progress through widely distributed publications or seminars. In any case, it was pointed out that greater information exchange among the U.S. Navy, SNAME, MarAd, the naval architectural schools, and others was needed.

Several distinct sources of R&D are applicable to the maritime industry, In addition to MarAd research, the U.S. Navy, the foreign maritime industry, and industries related to the maritime industry are all potential sources of applicable technologies and processes. The U.S. Navy, for instance, also conducts R&D applicable to the civilian merchant marine. In 1978, for instance, over *$64* million in the Navy research budget was judged to be applicable to the commercial sector.[3] In part, the results of this R&D find their way into commercial application because some shipyards conducting Navy R&D also build commercial ships. In theory, all of the shipyards could have access to the results of Navy research which have commercial application, even if such research is conducted at one particular shipyard.

One mechanism for disseminating Navy R&D results to the civilian sector is U.S. Navy representation on SNAME's Ship Production Committee; the Navy representative is supposed to track Naval R&D applicable to shipbuilding and keep the Committee informed of ongoing developments.[4]

In addition to the Navy representative on the Ship Production Committee (SPC), there are several other formal mechanisms for reviewing and disseminating R&D to the civilian sector. For example, through the industry Independent Research and Development (IRAD) program, DOD personnel advise participating firms of DOD needs which industry could address in their respective IRAD programs. Both informal and formal shipyard and industry reviews are conducted by DOD representatives to critique IRAD programs and make industry aware of complementary DOD efforts. Also, the Navy's ManTech Program includes End of Project Demonstrations at the research facility with invitations extended to all interested parties. The Ship Structures Committee, much like the SPC, disseminates technical information. Navy laboratories conduct var-

[3]Booz-Allen and Hamilton, Inc., Analysis of Foreign Maritime Research, Contract Report for the Maritime Administration, NTIS #PB81-176364, 1981, p. 228.

[4]Robert Shaffron, MarAd National Shipbuilding Research Program, personal communication, Apr. 30, 1984.

ious onsite technical reviews and briefings. However, because of the size and decentralization of the Navy, it is extremely difficult for some private firms to monitor these R&D activities. Respondents to the OTA survey indicated that the Navy R&D programs were very difficult to monitor and that results were difficult to obtain.

Maritime Administration program managers are responsible for monitoring foreign military R&D results; however, as the OTA survey confirms, it is difficult to give this responsibility adequate attention when it is essentially a secondary priority. More formal approaches for gaining information on foreign technology have been employed from time to time. The National Shipbuilding Research Program, for instance, has sponsored teams of industry experts to visit overseas shipyards to investigate foreign technologies. These teams typically are interested in specific technologies (e.g., welding). There is, however, no formal, ongoing civilian effort to monitor foreign maritime technologies. The Navy's Office of Naval Research also maintains scientific liaison offices in Japan and Europe, but not with the express purpose of providing foreign maritime technology to private industry.

Finally, technologies developed in other industries, such as the aerospace and automotive industries, may be borrowed by the maritime industry. Many industries may share a common technological base, each drawing upon a common pool of information, and each making its own contribution to the pool. While the professionals of the maritime industry, both within Government and in industry, are no doubt aware of major developments in other industries, there is at present no systematic attempt to collect and disseminate this information to the maritime industry.

It should be noted that the results of the OTA survey suggest a different conclusion about the Federal role in maritime R&D than a number of other recent studies.

Somewhat surprisingly, most of the shipyards and operators did not report receiving Federal funds. Within some industry and government groups, it has been a widely shared belief that most long-term research conducted by industry and government is tied to Federal R&D programs. This belief was supported by a 1978 survey of private shipbuilding and ship operating firms, which found that the U.S. Government underwrote *82.8* percent of the $114.1 million spent on maritime R&D in that years In addition, most shipbuilding productivity-related research and development was thought to exist today largely as the result of the National Shipbuilding Research Program, * which is funded by MarAd, the U.S. Navy, and the shipbuilding industry.[6] The OTA survey shows that while an important segment of the industry is directly involved with Federal R&D programs, a large number of firms are not.

'Naval Materials Command, op. cit.

● The National Shipbuilding Research Program (NSRP)-Ship Production Committee (SPC) is jointly sponsored by MarAd ($2.0 million per year), the U.S. Navy ($2.0 million per year) and shipbuilding industry (equivalent $2.0 million in management and support). The program is contracted via MarAd and is administered by SPC panels. The NSRP-SPC as a broad-based committee representing the shipbuilding industry has direct influence over these shipbuilding productivity related developments.

[6] National Research Council, "Productivity Improvements in U.S. Naval Shipbuilding," National Academy Press, 1982, p. 2.

FACTORS AFFECTING R&D

Market Demand and Financing

The OTA survey asked ship operators and shipyards about the extent to which interest rates, availability of finance capital, Government policies and programs, market demand, and competitive pressures affected their decisions to invest in R&D. Tables 10 and 11 present the responses. Ship operators and shipyards both responded that market demand and competitive pressure overshadowed other factors. The vast majority of respondents indicated that both market demand and competitive pressure are very influential factors.

In a recent analysis of the Federal role in R&D, the Congressional Budget Office wrote, 'The most

Table 10.—U.S. Ship Operators R&D—Factors Reported to Influence R&D Investment

Factor	Very Influential		Somewhat Influential		Not Influential	
	Number	Percent	Number	Percent	Number	Percent
Interest rates	2	10	6	29	13	62
Availability of capital	6	29	7	33	8	38
Government policies and programs	8	38	9	43	4	19
Market demand	15	68	4	18	3	14
Competitive pressure	13	59	6	27	3	14
Other:						
Operating efficiency	1					
MarAd R&D budget	1					
Profitability	1					

Table 11 .—U.S. Shipyard R&D—Factors Reported to Influence R&D Investment

Factor	Very Influential		Somewhat Influential		Not Influential	
	Number	Percent	Number	Percent	Number	Percent
Interest rates	O	0	14	64	8	36
Availability of capital	2	9	17	77	3	14
Government policies and programs	11	50	7	32	4	18
Market demand	20	91	2	9	0	0
Competitive pressure	17	77	5	23	0	0
Other:						
Environmental	1					
Probable future use	1					

NOTE Percentages are rounded, and may not add up to 100 in some tables Percentages in each row are calculated using the total number of firms responding to the item in that row

potent factors that affect private innovation decisions are probably beyond the reach of specific R&D policies. Expectations about macroeconomic conditions and the intensity of competition within an industry may be the most significant determinants of its technological performance. In a strong economy, firms have the funds and the market prospects to justify increased commitments to R&D. Robust sectoral markets may have a counteracting effect, however, since they lessen the urgency to pursue other new products and processes. This implies that private innovation is likely to be strongest under dual conditions of a healthy macroeconomy and strong sectoral competition."[7]

Some of the most important conditions necessary for stimulating R&D investment include a strong aggregate demand, relatively stable demand growth, and predictable earnings. When business conditions are good, and incomes and demand are growing rapidly and predictably, business firms can anticipate an expanded market, and make their investments accordingly. When demand is stagnant, or uncertain, investment in new plant and equipment is deterred, and R&D aimed to tap new markets may look like a very risky proposition. Some economists have suggested that R&D is so much riskier than other forms of investment that firms are loathe to rely on borrowing to finance R& D.*

To determine the effects that borrowing might have on the maritime industry in particular, OTA asked survey respondents whether the availability of finance capital and interest rates were "very, " "somewhat," or "not influential" factors in their decisions to invest in R&D. The answer was slightly different in the two sectors of the maritime industry (tables 10 and 11). The ship-

[7]Congressional Budget Office, "Federal Support for R&D Innovation," April 1984, p. 71.

[8]Ibid., note 6.

building sector clearly viewed interest rates and capital availability as somewhat influential factors, though not as important as market demand and competition. On average, the ship operators, on the other hand, tended to look on these factors as unimportant, although a significant minority of the operators indicated that capital availability was influential.

Thus, for those firms responding to the OTA survey, private R&D investment is primarily a function of profitability and demand. Since the major U.S. shipbuilding industry has traditionally been an industry of low profits and low and unsteady demand, these conditions have resulted in a conservative investment strategy on the part of many shipbuilding companies. Certain shipbuilding companies have been able to reinvest more of their profits than they normally would only because they are owned by large conglomerates which are willing to take the risks associated with the investments.[9]

The key factor driving profits in some sectors of the commercial shipbuilding industry appears to be the lack of an orderly, sustained demand for U.S.-built ships. The lack of demand stems from two interrelated factors: 1) the high cost of building a ship in the United States; and 2) the high cost of operating U.S.-flag ships. Wage scales are one cause of these high costs in these shipbuilding and sea transport industries, although the high cost of U.S. materials has also contributed to the shipbuilding dilemma.[10] Some shipbuilders claim an even more basic causal factor of lack of demand; that is, no sustained Government policy to build ships as part of a defense strategy for sea lift in the event of an extended conflict.

In the inland barge and towboat industry, as well as the so-called "second tier" shipyards, a somewhat different problem is evident. During the 1970s, high growth and expanding markets coupled with tax incentives to invest in capital equipment, spurred an explosion in new building. In the past few years the markets contracted due to export declines and the strong dollar. At present, the industry is struggling to dispose of a large excess supply of vessels and barges.

Federal Policies/Regulations

The OTA survey asked firms to select those Federal policies or regulations which they felt either encouraged or discouraged R&D investment and then to rank order the selections. The response data are shown in tables 12 and 13 for operators and shipyards respectively. The data are widely scattered. Most firms reported that most factors have little or no effect. However, two factors having an encouraging ranking for both operators and shipyards were the tax code and patent law.

For most operators responding to the question, rail and truck deregulation and OSHA safety regulations appear to have little effect. The Federal subsidy phase-out did not appear to have an effect for most of these operators either. Coast Guard manning regulations seem to have a somewhat discouraging effect on investment. For responding shipyards, however, subsidy phase-out was seen as a more important factor discouraging investment.

The survey, thus, does not support any strong conclusions about the effect of these policies. It may be useful, however, to discuss a few of these policies which have been given attention in other analyses and reports. For this reason, the following discusses antitrust law, patent law, and subsidy phase-out, in turn.

Antitrust Law

Many of the U.S. maritime industry's foreign competitors do not function under laws that restrict research collaboration. Japanese antitrust law does not prohibit firms from conducting cooperative research in targeted areas such as computers, microelectronics, electronic instruments, lasers, optical communication, robots and aerospace. French antitrust law does not bar joint research in such areas as aerospace, telecommunications, microelectronics, energy, and conservation equipment. Similarly, West Germans have not been prevented from conducting joint research and development.

[9] Edward M. Kaitz & Associates, Inc., "The Capital Budgeting Process of the U.S. Shipbuilding Industry: An Analysis of Defense Industry Behavior," 1979, p. 3.

[10] Edward M. Kaitz & Associates, Inc., "The Profitability of the U.S. Shipbuilding Industry (1947-1976)," 1978, p. 61.

Table 12.–U.S. Ship Operators R&D
Federal Policies/Regulations Reported to Affect R&D Investment

	Encourages investment		Discourages investment		Little or no effect	
Federal policy	Number	Percent	Number	Percent	Number	Percent
Antitrust statutes	1	5	3	14	18	82
Patent law	5	23	0	0	17	77
Tax code	7	32	2	9	13	59
Rail and truck deregulation	4	18	2	9	16	73
OSHA safety regulations	2	10	*3*	*14*	*16*	*76*
C. G. manning regulations	6	27	8	36	8	36
Phase-out ODS/CDS	3	14	7	32	12	55

Table 13.—U.S. Shipyard R&D—Federal Policies/Regulations Reported to Affect R&D Investment

	Encourages investment		Discourages investment		Little or no effect	
Federal policy/regulation	Number	Percent	Number	Percent	Number	Percent
Antitrust statutes	0	0	*3*	*14*	*19*	*86*
Patent law	5	23	1	5	16	73
Tax code	7	32	5	23	10	45
OSHA safety regulations	3	14	3	14	16	73
Phase-out ODS/CDS	1	5	11	58	7	37

NOTE Percentages are rounded, and may not add up to 100 in some tables Percentages in each row are calculated using the total number of firms responding to the item in that row.

One approach to funding expensive, long-term R&D is for one or more firms to share the cost. However, some firms have perceived ambiguities in the antitrust statutes, which have inhibited attempts to establish joint ventures among domestic firms. Although there is neither a statutory prohibition nor any court rulings that explicitly discourage formation of R&D joint ventures, American corporations have been extremely hesitant to enter into research joint ventures, because of the spectre of treble damages for violations of antitrust laws. [11]

A new law may change this situation in the future. The Research and Development Joint Venture Act of 1984 modifies existing antitrust statutes to specify that joint research and development ventures will not violate the law. The Act specifically, however, excludes those ventures that will exchange sales, marketing and similar types of commercial information, and those that restrict or require the participation of any party in another research and development program. In addition to modifying the antitrust statutes in this way, the Act also takes two other steps to encourage joint ventures: first, it permits joint ventures to file a statement of intent, which the Attorney General or Federal Trade Commission is obliged to publish in the Federal Register; second, if this statement of intent has been properly submitted and published in the Federal Register, the Act limits the amount that may be recovered on a claim to the amount of actual damages sustained by the claimant. [12]

While U.S. antitrust laws in the past have been criticized for discouraging research cooperation between U.S. firms, neither shipyards nor ship operators responding to this question on the OTA survey felt that these antitrust laws had a serious effect on their investment in R&D. This may be partly because many in the U.S. maritime industry do not have much desire to collaborate among themselves anyway, presumably because of competitive forces. However, countries like Japan and Korea have found effective ways to cooperate and coordinate their R&D in basic processes, procedures, and standards. They rely on the mainte-

[11] U.S. House of Representatives, Committee on Science and Technology, "Japanese Technological Advances and Possible U.S. Responses Using Research Joint Ventures, " Statement of William Baxter, Department of Justice, June 29-30, 1983, p. 151.

[12] The Research and Development Joint Venture Act of 1984.

nance of competitive positions through management efficiency, labor-management collaboration, marketing, and product design.

Patent Law

A report by the Office of Science and Technology Policy found that existing patent laws do not provide sufficient protection to enable private firms to dependably capture the value of private aeronautical R&D.[13] Since the maritime and aeronautics industries have many similarities, OTA suspected that this conclusion might apply to maritime R&D as well. The OTA survey, however, did not support this view. In the few cases where respondents indicated that patent law does influence investment, it was generally regarded as an inducement.

Phase-out of Subsidies

Two maritime industry subsidy programs—the Construction Differential Subsidy (CDS) and the Operating Differential Subsidy (ODS)—are being phased out by the Reagan Administration, although debate over the need for subsidies continues. The CDS provisions in the Merchant Marine Act of *1936* as amended in 1970 have not been repealed by Congress, but, for the past two years, the Administration has requested, and has been granted, no funding. Funding for existing ODS contracts has continued but the Administration has announced plans to abandon ODS when those contracts expire.

Since the industry itself has been publicly divided on whether the phase-out is a positive or negative step for the maritime industry as a whole, OTA asked the survey respondents whether the phase-out encourages, discourages, or has little or no effect on their R&D investment. Again, the ship operators and shipbuilders responding to the question revealed different views. More than half of the shipbuilders viewed the phase-out as discouraging investment, and about one-third considered it to have little or no effect. Half of the ship operators felt the phase-out would have little or no effect.

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[13] Office of Science and Technology Policy, *Aeronautical Research and Technology Policy, vol. 2,* final report, 1982, pp. VII-17.

Anticipating some industry concern over the phase-out, OTA asked the respondents what alternative Federal incentives might help to revitalize the industry. One of the most common responses to this question from both shipbuilders and ship operators, with shipbuilders somewhat more enthusiastic, was the institution of cargo preference for U.S. shipping. One shipyard wrote:

> A Federal assurance of adequate cargoes for U.S.-flag and U.S.-built ship owners is the only means of ensuring a large, stable and continuing demand for new building from the U.S. shipbuilding industry. Sufficient demand and stability of demand will by itself enable private industry to invest sufficient funds in R&D of new capital equipment to significantly improve efficiency and match foreign shipbuilders' productivity levels.

A suggestion to employ tax credits as an alternative to direct subsidies also was made frequently. One shipyard, for example, suggested that to "offset the higher cost of using U.S. ships, " tax credits should be granted to "companies that use U.S. ships to haul their cargoes." A bill sponsored in 1984 by Congressman Herbert H. Bateman of Virginia and Congresswoman Lindy Boggs of Louisiana, the Competitive Shipping and Shipbuilding Act, would provide tax breaks resulting in estimated credits of $800 million per year. One respondent emphasized that such a program would create the stable market environment necessary to carry out R&D. Both operators and shipyards suggested tax credits as an alternative to direct subsidies.

A number of other suggestions were made by the respondents. For instance, several shipyards recommended providing incentives for productivity increases. While the ManTech Program already does this for shipyards that build Navy ships, it was recommended that similar incentives could be extended to non-Navy construction. It was further suggested that modernization incentives could be offered to the ship operations industry. Finally, a number of respondents referred to the Jones Act. One shipyard advocated an "extension of the Jones Act and closing of loopholes, " while an operator called for "Jones Act" shipowners to be permitted to build abroad without restriction.

Federal Incentives

The OTA survey questioned operators and shipbuilders about possible future Federal policies that might increase incentives to invest in R&D. Such policy suggestions ranged from increasing direct Federal R&D funding to establishing a joint government/industry research facility. The survey also contained two open questions. One asked respondents to suggest other organizational or institutional changes within the Federal Government that might improve the effectiveness of Federal sponsored research; and the other asked for suggestions other than R&D options which might be beneficial to the revitalization of the U.S. industry.

Responses to the specific R&D policy options are given in tables 14 and 15. Responses to the open questions are listed in appendix E. While a number of the respondents thought that policies such as cargo preference, direct subsidies, or forms

Table 14.–U.S. Ship Operators R&D
Firms Reporting Factors Affecting Incentive to Invest in R&D

	Significant incentive		Slight incentive		Negative incentive	
Factor	Number	Percent	Number	Percent	Number	Percent
Extend CCF* to R&D.	4	21	14	74	1	5
Availability of Federal loan guarantees . . .	3	17	13	72	2	11
Amend antitrust laws permitting joint ventures	1	5	16	84	2	11
Expand R&D tax credits	8	40	10	50	2	10
Increase direct Federal support of R&D. . .	8	42	9	47	2	11

"Capital Construction Fund.

Firms Reporting Whether They Would Support New Government/Industry Maritime Research Facility

	Number	Percent
1. Strongly endorse and would participate and provide funding	3	13
2. Endorse but would not participate or fund	15	65
3. Do not endorse*	5	22
	23	100

*One firm said they did not endorse because they were in a specialized field which would probably not be covered in such a facility

Table 15.–U.S. Shipyard R&D
Firms Reporting Factors Affecting Incentive to Invest in R&D

	Significant incentive		Slight incentive		Negative incentive	
Factor	Number	Percent	Number	Percent	Number	Percent
Extend CCF* to R&D.	10	45	11	50	1	5
Availability of Federal loan guarantees . . .	8	38	12	57	1	5
Amend antitrust laws permitting joint ventures	6	27	14	64	2	9
Expand R&D tax credits	18	82	4	18	0	0
Increase direct Federal support of R&D. . .	13	57	9	39	1	4

"Capital Construction Fund

Firms Reporting Whether They Would Support New Government/Industry Maritime Research Facility

	Number	Percent
1. Strongly endorse and would participate and provide funding , , ..., , , , , , , ., , , , , , , , ., ...	5	22
2. Endorse but would not* participate or fund	11	48
3. Do not endorse*	7	30

"Two firms reported they may participate after established if work **was** relevant to their needs,

NOTE: Percentages are rounded, and may not add up to 100 in some tables, Percentages in each row are calculated using the total number of firms responding to the item in that row.

of capital investment assistance would offer more for the industry than any R&D initiative, most of the R&D policies suggested were considered to offer some incentive.

The proposals can be considered in three categories: 1) direct Federal R&D support, 2) encouraging industry R&D, and 3) devising government/industry cooperative approaches. Under "direct Federal R&D support" 42 percent of the operators and 57 percent of the shipyards responding to the question reported this to offer a significant incentive to R&D investment. Under "encouraging industry R& D," the most operators (40 percent) and shipyards (82 percent) reported that a significant incentive would result from expanding R&D tax credits. Other tax or financing incentives for R&D were rated favorably but higher by the shipyards than by the operators.

Direct Federal R&D Support

Survey respondents were asked whether an increase in direct Federal support would be a significant, slight, or negative incentive for investment in R&D. For the most part, both operators and shipbuilders who responded to the question said that increasing Federal support would not discourage their own investment, but rather would provide a positive incentive. Each sector of the maritime industry, however, was divided as to whether increased Federal support would provide a slight or significant incentive. By a slight margin, more shipyards felt Federal support would provide a significant incentive; whereas ship operators also, by a slight margin, tended to think such an action would provide only a slight incentive for R&D investment.

The OTA survey respondents were also asked to suggest changes which might be made to improve existing institutions. While many of these suggestions were very narrowly focused, a few were of a scope that would bear congressional interest. In particular, one frequent request was that a means be found to deal with current institutional arrangements which cause decentralization of research activities. For example, the U.S. Navy has research related to shipbuilding located under three commands: the Assistant Secretary of the Navy Research, Engineering and Systems, the Chief of Naval Operations, and the Chief of Naval Material. One shipyard wrote:

> This highly fragmented R&D organizational structure . . . would not appear to result in the effective and efficient utilization of R&D dollars. Some effort may be made to simplify the organization and consolidate the R&D program.

This respondent recommended that:

> . . . there should be more extensive use of joint efforts in higher cost technology developments and in technology demonstrations.

When questioned about this comment, a U.S. Navy spokesman responded:

> The preceding is a misconception of the Navy R&D organization. There is only one Navy R&D program. All of the above organizations plus others participate in the planning, review, approval and execution as appropriate for the program. For instance the Commander, Naval Sea Systems Command, plans, programs, budgets and implements its portion of shipbuilding R&D projects. The Chief of Naval Material integrates across commands and submits the program to the Chief of Naval Operations, for review and approval, and forwarding through the Assistant Secretary of Navy (RE&S) submission to the Department of Defense.

In general, however, it may be useful to explore a number of alternatives to strengthen and integrate common elements of U.S. Navy, MarAd, and U.S. Coast Guard R&D programs.

Some of the specific recommendations made by the respondents are listed below:

1. Establish a fund for unspecified R&D projects administered by an agency such as MarAd's Office of Advanced Ship Development and Technology for funding those "target of opportunity" projects meeting predefine criteria and limits.
2. Change contract approval procedures to decrease proposal lead time for R&D projects by eliminating red tape delays that, while necessary for normal procurement items, are an impediment to R&D projects (e.g., source approval, advertising), In general, streamline contracting procedures to make R&D efforts time effective.
3. Coordinate all specialized R&D areas (e.g., computer integrated manufacturing systems) through one government agency.
4. Improve control over research funds by uti-

lizing the ship operating and shipbuilding firms themselves as primary contractors.

Several respondents supported the recommendations of a recent National Research Council (NRC) study which reviewed ship operations R&D and found that an arrangement similar to the National Shipbuilding Research Program is needed to improve the efficacy of ship operations research. One of the NRC's primary findings was that the ship operations R&D program of MarAd "has not achieved wide acceptance of its project results, principally because of insufficient industry participation in the direction and management of research." NRC further concluded that "cooperative ship operation R&D should be coordinated and managed not by a government agency but by the private sector."[14]

Encouraging Industry R&D

Extending CCF.—In 1970, Congress adopted a tax measure for the U.S.-flag fleet that instituted the Capital Construction Fund (CCF). This program generally allows U.S. shipping companies to enter into agreements with MarAd to establish CCF for the replacement or addition of vessels for use in the U.S.-flag merchant marine. Earnings from the operation of U.S. merchant vessels can be deposited in the CCF. Federal income taxes on these earnings are then deferred until the funds are withdrawn from the CCF for a purpose not permitted under the agreement with MarAd. Theoretically, the tax deferral can continue on income deposited in the CCF as long as the fundholder continues to acquire U.S.-built ships or to construct, or reconstruct qualified vessels in a U.S. shipyard.

The OTA survey asked ship operators and builders whether extending the CCF concept to R&D expenditures would represent a significant, slight or negative incentive for investing in R&D. A large majority of operators responding to the question reported that this option would be a slight incentive for future R&D investment. Only four operating firms said that this extension of the fund would be a significant incentive, and only one firm indicated that it would be a negative incentive. The shipyards, on the other hand, endorsed this option more enthusiastically. * Ten yards indicated that this would be a significant incentive, while 11 yards reported that extension of the fund would only represent only a slight incentive. Only one yard felt this option would be a negative incentive for R&D investment.

Make Federal Loan Guarantees Available for R&D Expenditures.—The Federal Ship Financing Guarantee program was established in 1938 pursuant to Title XI of the Merchant Marine Act of 1936. It provides for a full faith and credit loan guarantee by the U.S. Government. The program was overhauled in 1972 and is now a financing guarantee program, rather than a mortgage insurance program under which the government guarantees shipbuilding obligations sold to investors.

OTA asked survey respondents whether similarly guaranteeing loans for R&D expenditures would represent a significant, slight, or negative incentive for R&D investment. A majority of both operators and shipbuilders answered that loan guarantees for R&D would create a slight incentive to invest. Relatively more of the shipyards felt that such an option would create a significant incentive (eight yards) than did the ship operators. Only one shipyard and two ship operators reported that this option would create a negative incentive for investment.

Expand Existing Tax Credits for R&D Expenditures.—The OTA survey asked respondents to indicate whether an expansion of tax credits for R&D expenditures would have a significant, slight or negative incentive for R&D investment. Shipbuilders as a whole were more enthusiastic about the positive effects of an expanded tax credit than were ship operators. A large majority of the shipyards indicated that an expanded tax credit would have a significant incentive, while only four yards indicated that it would represent a slight incentive. None of the yards indicated that such a tax credit would have negative effects. In contrast to the shipbuilders, the operators were more equally divided on whether an expansion of tax credits

[14] National Research Council, "Ship Operation Research and Development —A Program for Industry," 1983, p. 39.

* This would, of course, require changes in the law to allow shipyards to establish Capital Construction Funds similar to those now allowed for operators.

would have a slight or significant effect on the incentive to invest in R&D.

The Economic Recovery Tax Act of 1981 instituted major changes in the Nation's tax system. One of the most important changes introduced was the incremental R&D tax credit, which amounts to 25 percent of "qualified" R&D expenditures in excess of outlays in a preceding base period .15 Because of its incremental character, the 25 percent tax credit is designed to be especially cost effective, since it targets changes in a firm's behavior. Whereas a nonincremental credit would reward firms for their existing level of R&D expenditures, an incremental credit encourages increased R&D since only the increase over the base qualifies for credit. The relevant issue in evaluating the incremental credit concerns the relationship between the Federal tax revenue losses it generates and the additional R&D it encourages. Estimates of the benefits of the incremental tax credit—namely, the additional R&D it encourages—tend to be lower than the estimated Treasury Department losses. One study, for instance, suggests that the additional R&D generated by the incremental credit lies somewhere between $227 million and $638 million for 1983, compared to estimated Treasury losses of $645 million. Analyses of similar tax incentives in other countries suggest the same result. Tax credits for R&D do not appear to be a particularly cost-effective mechanism for increasing R&D activity.

The R&D credit is scheduled to terminate at the end of 1985. Such a sunset provision, even with periodic extensions, undermines the credit's effectiveness. From a business planning standpoint, there must be certainty that the credit will be available when the research is performed.

In conclusion, for most of the American economy, the incremental R&D tax credit does provide some incentive for increased R&D. For firms in more extreme circumstances—those that have no tax liabilities in a given year and those that are rapidly increasing R&D spending—the impact of this program may be limited.

[15] The discussion of the incremental tax credits is based on a Congressional Budget Office report, entitled "Federal Support for R&D Innovation," 1984, pp. 72-83.

Devising Cooperative Approaches

Reduce the Risk of Antitrust Violation Associated With Research Joint Ventures.—While the survey respondents indicated that antitrust laws do not have much effect on their investment in R&D, most reported that amending antitrust laws to permit joint research ventures would represent a slight incentive for them to conduct more R&D. Only two operators and two shipyards indicated that such an option would act as a negative incentive for investment. Relatively more shipyards than ship operators reported that revision of antitrust statutes would have a significant effect on investment. Recently, a number of measures have been adopted to encourage joint research, including the Research and Development Joint Venture Act of 1984.

Several other approaches have also been suggested for eliminating the real or perceived antitrust barriers to joint research ventures. It is beyond the scope of this discussion to analyze the pros and cons of these various approaches. However, some approaches are discussed in the next section on R&D approaches in other industries.

Establish a Central Research Facility to be Sponsored Jointly by Industry and Government for Conducting Maritime Research.—The OTA survey asked ship operators and shipyards whether they would endorse the formation of a government/industry sponsored maritime research facility for the purposes of conducting long-term basic and applied research and for serving as a clearinghouse for Navy, foreign, and domestic civilian R&D advances. Specifically, the respondents were asked whether they would: strongly endorse such a facility and be willing to participate and provide funding for cooperative research projects; endorse the facility but not necessarily become actively involved with its research projects; or not endorse such a facility.

The responses are shown on tables 14 and 15. Seventy-eight percent of the operators responded that they would endorse such a facility but only 13 percent indicated strong endorsement including participation and funding. For shipyards, the response was similar, 70 percent endorsement and 22 percent strong endorsement with participation.

Some firms qualified their responses saying they would or might participate if the facility was designed to be relevant to their specific needs.

A comment by one of the shipyards is representative: "Our company would be interested in participating in a *Government sponsored* maritime research facility but is not willing to commit any funding until a charter is firmly established." Only three operators indicated that they would strongly endorse a central facility and actively participate, financially or otherwise. Five operators did not endorse such a facility at all.

The shipyard responses were more equally divided than the operators. Eleven yards endorsed this option, but did not anticipate that they would actively participate. Five yards strongly endorsed the idea of a central facility, seven yards rejected the idea. It appears from these responses that the maritime industry as a whole would have difficulty taking the lead in establishing a joint government/industry institution but that a properly designed institution with competent leadership may be able to attract substantial industry support after it is established.