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ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION FISCAL YEAR 1978 AUTHORIZATION

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HEARING

BEFORE THE

COMMITTEE ON ARMED SERVICES

UNITED STATES SENATE

NINETY-FIFTH CONGRESS

FIRST SESSION

ON


S. 1339

A BILL TO AUTHORIZE APPROPRIATIONS TO THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION FOR NATIONAL DEFENSE PROGRAMS FOR THE FISCAL YEAR 1978, AND FOR OTHER PURPOSES

MARCH 25, 1977

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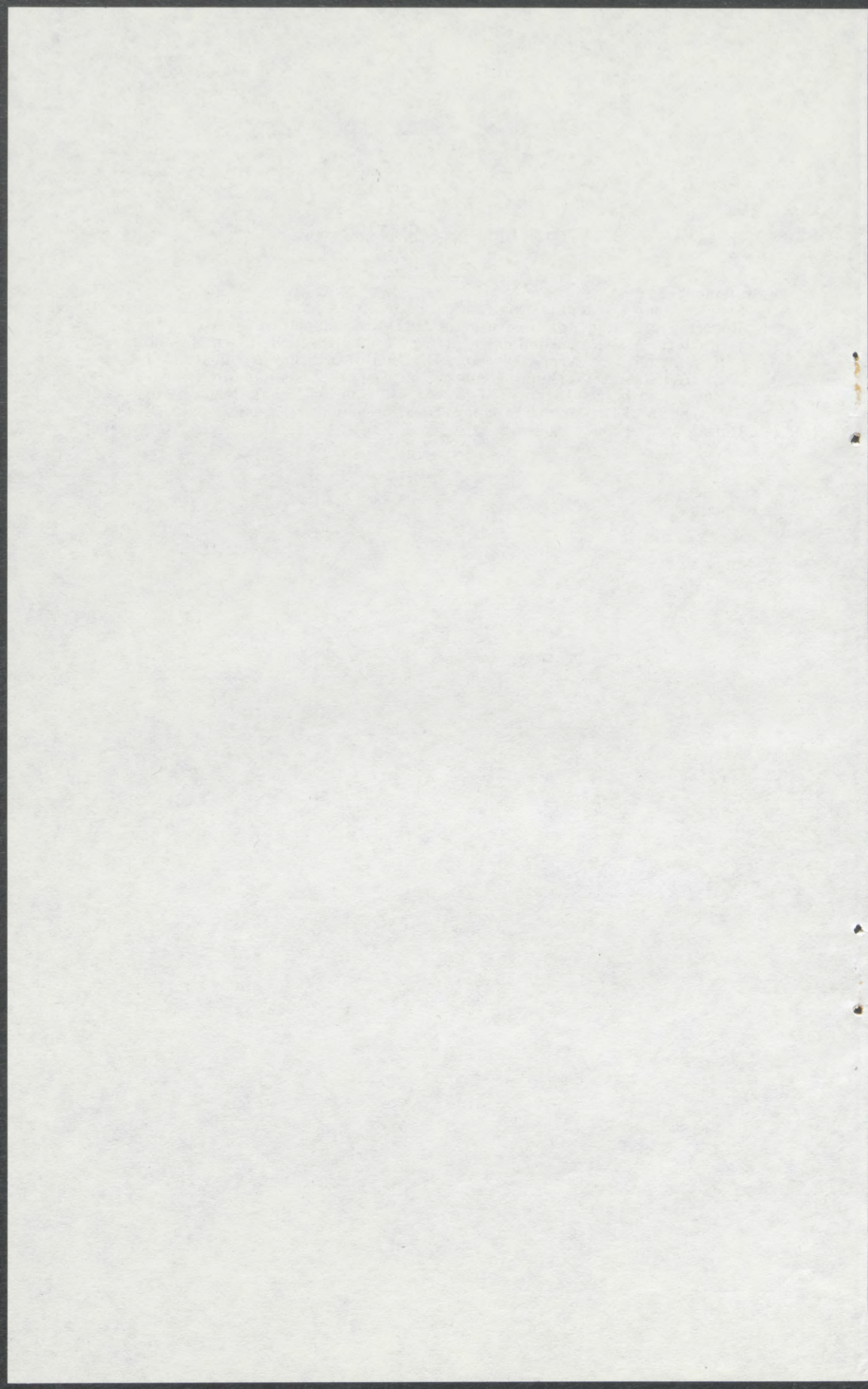
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ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION FISCAL YEAR 1978 AUTHORIZATION

FRIDAY, MARCH 25, 1977

U.S. SENATE,
COMMITTEE ON ARMED SERVICES,
Washington, D.C.

The committee met, pursuant to notice at 11:30 a.m., in room 212, Russell Senate Office Building, Hon. John C. Stennis, chairman, presiding.

Present: Senators Stennis, Jackson, McIntyre, Nunn, Hart, Anderson, Tower, and Bartlett.

Also present: Francis J. Sullivan, staff director; John T. Ticer, chief clerk; Robert Q. Old, James C. Smith, and Larry K. Smith, professional staff members; Marie F. Dickinson, clerical assistant; Jeffrey Record, assistant to Senator Nunn, and Dorothy Fosdick, assistant to Senator Jackson.

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

Chairman STENNIS. Gentlemen, we are going into that part of the budget now that relates to the ERDA activities and we will examine a program of over \$2 billion presented by these witnesses. Over half of it goes for the development and production of nuclear weapons, and \$671 million is requested for production of special nuclear materials required for the weapons and other national security activities.

[A copy of S. 1339 follows:]

[S. 1339, 95th Cong., 1st sess.]

A BILL To authorize appropriations to the Energy Research and Development Administration for national defense programs for the fiscal year 1978, and for other purposes

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "ERDA Authorization Act of 1978—Military Applications".

SEC. 2. In accordance with section 261 of the Atomic Energy Act of 1954, as amended (42 U.S.C. 2017) and section 305 of the Energy Reorganization Act of 1974 (42 U.S.C. 5875), there is hereby authorized to be appropriated to the Energy Research and Development Administration for fiscal year 1978, subject to titles I, II, and III of this Act, the following:

(1)

TITLE I—NATIONAL DEFENSE PROGRAMS

OPERATING EXPENSES

SEC. 101. For operating expenses, \$1,598,400,000.

PLANT AND CAPITAL EQUIPMENT

SEC. 102. For plant and capital equipment, including construction, acquisition, or modification of facilities, including land acquisition; and acquisition and fabrication of capital equipment not related to construction, as follows:

(1) Weapons Activities:

Project 78-16-a, cruise missile production facilities, various locations, \$18,100,000.

Project 78-16-b, full fuzing option (FUFO) bomb production facilities, various locations, \$43,000,000.

Project 78-16-c, high explosive flash radiography facility, Lawrence Livermore Laboratory, California, \$10,900,000.

Project 78-16-d, weapons safeguards, various locations, \$28,000,000.

Project 78-16-e, new weapons production installations, various locations, \$5,000,000.

Project 78-16-f, replace 10-inch water main, Bendix Plant, Kansas City, Missouri, \$2,000,000.

Project 78-16-g, radioactive liquid waste improvement, Los Alamos Scientific Laboratory, New Mexico, \$12,500,000.

Project 78-16-h, Tonopah Test Range upgrade, Sandia Laboratories, New Mexico, \$4,000,000.

Project 78-16-i, laboratory support complex, Los Alamos Scientific Laboratory, New Mexico (A-E only), \$2,000,000.

Project 78-17-a, production component warehouse, Pantex Plant, Amarillo, Texas, \$4,000,000.

Project 78-17-b, surface water control system, Rocky Flats Plant, Colorado, \$2,800,000.

Project 78-17-c, core facilities office building, utilities and roads, Lawrence Livermore Laboratory, California, \$12,300,000.

Project 78-17-d, steam plant improvements, Y-12 Plant, Oak Ridge, Tennessee, \$18,500,000.

(2) Special Materials Production:

Project 78-18-a, high level waste storage and waste management facilities, Richland, Washington, \$27,000,000.

Project 78-18-b, high level waste storage facilities, Savannah River, South Carolina, \$42,000,000.

Project 78-18-c, fifth set of calcined solids storage bins, Idaho Chemical Processing Plant, Idaho National Engineering Laboratory, Idaho, \$12,500,000.

Project 78-18-d, new hydrofracture facility, Oak Ridge National Laboratory, Oak Ridge, Tennessee, \$5,400,000.

Project 78-18-e, environmental, safety and security improvements to waste management and materials processing facilities, Richland, Washington, \$15,500,000.

Project 78-18-f, powerhouse emission control improvements, Richland, Washington, \$6,500,000.

Project 78-18-g, fan house and increased fan capacity, H chemical separations area, Savannah River, South Carolina, \$3,400,000.

Project 78-18-h, plantwide fire protection, Savannah River, South Carolina, \$6,300,000.

Project 78-18-i, improved emergency coolant supply in reactor areas, Savannah River, South Carolina, \$3,500,000.

Project 78-18-j, N-reactor environmental improvements, Richland, Washington, \$7,500,000.

(3) Capital Equipment Not Related to Construction, \$117,700,000.

AMENDMENTS TO PRIOR YEAR ACTS

SEC. 103. (a) Section 101 Public Law 91-273, as amended, is further amended by striking from subsection (b) (9), project 71-9, fire, safety, and adequacy of operating conditions projects, various locations, the figure "\$240,000,000" and substituting therefor the figure "\$287,000,000", which is an increase of \$47,000,000 over the amount authorized by Public Law 94-355.

(b) Section 101 Public Law 93-276, as amended, is further amended by striking from subsection 101(b)(1), project 75-1-c, new waste calcining facility, Idaho Chemical Processing Plant, National Reactor Testing Station, Idaho, the figure "\$27,500,000" and substituting therefor the figure "\$65,000,000", which is an increase of \$28,500,000 over the amount authorized by Public Law 94-355.

(c) Project 77-11-a, safeguards and research and development laboratory facility, Sandia Laboratories, Albuquerque, New Mexico, authorized by Public Law 94-355, is increased by \$4,300,000 for a total authorization of \$8,300,000.

(d) Project 77-11-b, safeguards and site security improvements, various locations, authorized by Public Law 94-355, is increased by \$7,800,000 for a total authorization of \$13,500,000.

(e) Project 77-11-c, 8-inch artillery fired atomic projectile production facilities, various locations, authorized by Public Law 94-355, is increased by \$12,600,000 for a total authorization of \$22,600,000.

(f) Project 77-13-a, fluorine dissolution process and fuel receiving improvements, Idaho Chemical Processing Plant, Idaho National Engineering Laboratory, Idaho (A-E and long-lead procurement), authorized by Public Law 94-355, is increased by \$5,000,000 for a total authorization of \$15,000,000.

(g) Project 77-13-d, high level waste storage and waste management facilities, Savannah River, South Carolina, authorized by Public Law 94-355, is increased by \$31,000,000 for a total authorization of \$56,000,000.

(h) Project 77-13-e, high level waste storage and handling facilities, Richland, Washington, authorized by Public Law 94-355, is increased by \$22,000,000 for a total authorization of \$40,000,000.

(i) Project 77-13-f, waste isolation pilot plant, site undesignated (A-E, land acquisition, and long-lead procurement), authorized by Public Law 94-355, is amended by striking the words "site undesignated" and substituting therefor the words "Delaware Basin, Southeast New Mexico" and is increased by \$22,000,000 for a total authorization of \$28,000,000.

(j) Project 77-13-g, safeguards and security upgrading, production facilities, multiple sites, authorized by Public Law 94-355, is increased by \$8,700,000 for a total authorization of \$16,400,000.

TITLE II—GENERAL PROVISIONS

SEC. 201. Except as otherwise provided in this Act—

(1) no amount appropriated pursuant to this Act may be used for any program in excess of the amount actually authorized for that particular program by this Act,

(2) no amount appropriated pursuant to this Act may be used for any program which has not been presented to, or requested of, the Congress, unless (A) a period of thirty calendar days (not including any day in which either House of Congress is not in session because of adjournment of more than three calendar days to a day certain) has passed after the receipt by the appropriate committees of the House of Representatives and the Senate of notice given by the Administrator of the Energy Research and Development Administration containing a full and complete statement of the action proposed to be taken and the facts and circumstances relied upon in support of such proposed action, or (B) each such committee before the expiration of such period has transmitted to the Administrator written notice to the effect that such committee has no objection to the proposed action.

SEC. 202. The Energy Research and Development Administration is authorized to start any project set forth in sections 102 (1) and (2) only if the currently estimated cost of that project does not exceed by more than 25 per centum the estimated cost set forth for the project. The total cost of any project undertaken under such section shall not exceed the estimated cost set forth for such project by more than 25 per centum unless and until additional appropriations are authorized by law. The provisions of this section shall not apply to any project with an estimated cost of less than \$5,000,000.

SEC. 203. Subject to the applicable requirements and limitations of this Act and when so specified in appropriations Acts, amounts appropriated for the Administration pursuant to this Act for operating expenses or for plant and capital equipment may be merged with any other amounts appropriated for like purposes pursuant to any other Act authorizing appropriations for the Energy Research and Development Administration.

SEC. 204. When so specified in appropriations Acts, amounts appropriated pursuant to this Act for operating expenses or plant and capital equipment may remain available until expended.

SEC. 205. The Administrator of the Energy Research and Development Administration is authorized to perform construction design services for any construction project of the Energy Research and Development Administration whenever (1) such construction project has been included in a proposed authorization bill transmitted to the Congress by such administration, and (2) such administration determines that the project is of such urgency in order to meet the needs of national defense or to protect life and property or health and safety that construction of the project should be initiated promptly upon enactment of legislation appropriating funds for its construction.

SEC. 206. When so specified in appropriations Acts, any moneys received by the Energy Research and Development Administration may be retained and used for operating expenses (except sums received from disposal of property under the Atomic Energy Community Act of 1955 (42 U.S.C. 2301) and the Strategic and Critical Materials Stockpiling Act (50 U.S.C. 98) and fees received for tests or investigations under the Act of May 16, 1910 (30 U.S.C. 7)), notwithstanding the provisions of section 3617 of the Revised Statutes (31 U.S.C. 484), and may remain available until expended.

SEC. 207. When so specified in appropriations Acts, transfers of sums from the operating expenses appropriation may be made to other agencies of the Government for the performance of the work for which the appropriation is made, and in such cases the sums so transferred may be merged with the appropriations to which transferred.

TITLE III—AUTHORIZATION OF APPROPRIATIONS FOR FISCAL YEAR 1979

SEC. 301. There is hereby authorized to be appropriated to the Energy Research and Development Administration, to be available no earlier than October 1, 1978, such sums as may be necessary:

- (1) For operating expenses.
- (2) For plant and capital equipment.

SEC. 302. All of the provisions of this Act which are applicable to amounts appropriate pursuant to title I shall apply in the same manner to amounts appropriated pursuant to section 301 (1) and (2).

Chairman STENNIS. I have a statement here and I ask that it be placed in the record, even though it is brief.

[The prepared statement follows:]

PREPARED STATEMENT OF JOHN C. STENNIS, CHAIRMAN

The Committee meets this morning to consider ERDA's national security programs for fiscal year 1978.

The ERDA activities we will examine today total \$2,595 billion in requested additional budget authority for next year. Over half (\$1,466 billion) of these funds are requested for the development and production of nuclear weapons. Major current programs include significant new strategic warheads for the Trident I missile, the Minuteman III and cruise missiles. They also include new tactical nuclear weapons designed to be more flexible and secure.

Another quarter (\$671 million) of the total is requested for the production of the special nuclear materials required for these weapons and other national security activities of ERDA. The remainder of the request under examination today would support naval reactor development, the laser fusion program, space and terrestrial nuclear applications, and management and support for ERDA's national security activities.

This is, of course, the first year this Committee has assumed the responsibility for reviewing these programs. I know the Committee shares my pride and appreciation for the decades of distinguished service rendered by the Joint Atomic Energy Committee in its Congressional oversight of these and related activities. That Committee has set a high standard for Congressional leadership and devotion to duty and the Armed Services Committee will do its best to meet this standard.

The importance of the questions at stake deserve no less. The security of our nation and the nuclear peace of the world depend on our maintenance of the certain strength of our nuclear deterrent. We must, therefore, make every effort to ensure that our technical and financial resources be efficiently, effectively applied to maintain this deterrent. Beyond this, there are other troubling and urgent policy matters of the first order—the proliferation of nuclear weapons, their security, the management of nuclear waste, and the definition of secure arms and test ban agreements—which we will confront as we review ERDA's national security activities.

Altogether, these are challenging problems which will require our best efforts.

Chairman STENNIS. This morning's witnesses will include Mr. Robert Fri, Acting Administrator of ERDA; Mr. Alfred D. Starbird, Assistant Administrator for National Security; Gen. Joseph K. Bratton, U.S. Army, Director, Division of Military Application of ERDA; George W. Cunningham, Acting Deputy Assistant for Nuclear Energy; Adm. Hyman G. Rickover, Director, Division of Naval Reactors of ERDA; and Dr. Martin Stickley, Director of Laser Fusion.

Gentlemen, we will proceed.

**STATEMENT OF ROBERT FRI, ACTING ADMINISTRATOR OF ERDA;
ACCOMPANIED BY ALFRED D. STARBIRD, ASSISTANT ADMINIS-
TRATOR FOR NATIONAL SECURITY; GEN. JOSEPH K. BRATTON,
U.S. ARMY, DIRECTOR, DIVISION OF MILITARY APPLICATION OF
ERDA; GEORGE W. CUNNINGHAM, ACTING DEPUTY ASSISTANT
FOR NUCLEAR ENERGY; ADMIRAL RICKOVER, DIRECTOR,
DIVISION OF NAVAL REACTORS, OF ERDA; AND DR. MARTIN
STICKLEY, DIRECTOR OF LASER FUSION**

Mr. FRI. I have a brief statement, Mr. Chairman, which I would like to enter for the record and just touch a few key points for a couple of minutes and take any questions you have of me. Generals Starbird and Bratton will be here to discuss the weapons program with you.

Chairman STENNIS. We want to get to all of you, of course, and I hope the committee will sit as long as necessary. Admiral Rickover was to be here on some phases of these matters. Is he here?

Mr. FRI. He is on his way.

Chairman STENNIS. That will be all right.

FISCAL YEAR 1978 AUTHORIZATION

Mr. FRI. Thank you, Mr. Chairman and members.

Let me briefly summarize our budget request for this year in the national security area and other programs being considered by this committee.

As background, ERDA's total budget request for 1978 is about \$7.8 billion. Of this amount, approximately \$2.6 billion is for ERDA's military-related programmatic effort, and therefore is presented to this committee for consideration.

These programs break down as follows: first of all, for the weapons program, in which we develop, produce, and maintain the nuclear weapons for the Department of Defense, we are requesting nearly \$1.5 billion in budget authority.

I think it is important to point out in this program that General Starbird reports directly to me on the adequacy of our efforts and of the weapons complex itself, laboratories and production facilities, to assure that these essential national nuclear weapons programs are conducted properly.

At the same time our experience shows our capability of these laboratories, which are extraordinary, can support many aspects of the Nation's energy program.

The second program we are presenting today is the laser fusion program, where our request is for \$122 million in budget authority. This program includes broad programs of basic and applied research.

Chairman STENNIS How much was that?

Mr. FRI. \$122 million of broad programs of basic and applied research to obtain an enhanced standing of the physics of laser fusion in order to solve both national security and domestic energy problems.

A third area contained in our request before this committee is the special materials production program. Our request is for \$671 million in budget authority. This program involves, first of all, production of plutonium for weapons, tritium for weapons, plutonium for the space program, and certain other applications.

In addition, the radioactive waste products that are created by these processes are funded under this program, placed in storage tanks, and we are conducting research on various waste forms for ultimate disposal.

The fourth program we want to discuss today is the naval reactor development program for the design and development of improved naval nuclear propulsion plants and reactor cores of higher reliability, maximum simplicity and optimum fuel life. Our request for 1978 in this program is \$243 million.

The final direct program that we will discuss today is the nuclear explosive applications program for which we are requesting \$1 million in budget authority to merit modest studies of energy applications of nuclear explosives.

Finally, we are requesting \$41 million for program management and support activities which covers expenses for personnel, travel, and other support services directly supporting the national security programs that have already been mentioned.

Mr. Chairman, those are the programs that we want to present to you today.

I would be delighted at this point to answer any questions you may have and ask General Starbird and General Bratton and their colleagues to take up the specifics of the national security program.

[The prepared statement of Robert W. Fri follows:]

PREPARED STATEMENT OF ROBERT W. FRI, ACTING ADMINISTRATOR,
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

Mr. Chairman and members of the committee: I appreciate the opportunity to appear before you today to discuss ERDA's National Security related authorization requests for fiscal years 1977 and 1978. My initial comments will concern ERDA's proposed authorization legislation for fiscal year 1977, followed by a more detailed account of our fiscal year 1978 budget request.

FISCAL YEAR 1977 AUTHORIZATION

As you know, ERDA's 1977 Authorization bill was not enacted prior to adjournment of the 94th Congress. Congress subsequently enacted legislation enabling

ERDA to utilize our 1977 appropriations. However, an authorization bill is needed to provide Congressional guidance and authority in several important areas. Thus, we have forwarded a proposed Authorization bill which separately identifies those programs under the cognizance of the Senate Energy and Natural Resources Committee; programs under the cognizance of this Committee and those programs for which there may be a question as to jurisdiction between the Committees under Senate Rule 25.

The bill has been structured with the intent of facilitating Congressional consideration by retaining provisions from last session's conference bill that are consistent with our 1977 Appropriations Acts.

FISCAL YEAR 1978 AUTHORIZATION

We have also submitted proposed 1978 authorizing legislation incorporating the budget changes and policies of the present Administration. This legislation is patterned after our 1977 proposals to facilitate your consideration.

1978 BUDGET REQUEST

Our 1978 Authorization bill will request appropriations totaling \$7.753 billion, of which \$5.696 billion is for operating expenses, and \$2.057 billion is for plant and capital equipment. Revenues primarily from uranium enrichment activities are estimated at \$1.067 billion, assuming necessary legislation to revise our charges for enriching services. Accordingly, total resources of \$8.820 billion would be available to ERDA in 1978.

An analysis of our budget by major functional area and Committee jurisdiction is shown in the attached Tables. Briefly, our request includes:

\$3.921 billion for Energy RD&D, up from \$3.010 billion in 1977, an increase of 30 percent.

\$2.137 billion for National Security Activities, up from \$1.735 billion in 1977, an increase of 23 percent.

A net of \$719 million for uranium enriching activities, which reflect program activities of \$1.685 billion offset by revenues of \$966 million.

\$673 million for Basic Research and Technology Development, up from \$573 million in 1977, an increase of 17 percent.

\$303 million for Program Management and Support, up from \$288 million in 1977, an increase of 5 percent.

As you will note, tables I-IV reflect our functional breakdowns on a consolidated basis. Tables V and VI reflect the breakdown of funding for programs being considered by this committee.

Weapons program

Under National Security activities, the fiscal year 1978 weapons budget request is nearly \$1.5 billion in Budget Authority. The weapons program is the largest national security-related program within ERDA and provides for the design, development, and underground testing of new weapons types; the maintenance and development of test detection methods related to international treaties; the production of nuclear weapons; and the maintenance of stockpile weapons in a state of constant readiness. This is an important National effort in which we are committed to fulfill ERDA's responsibilities under the Atomic Energy Act for providing the nuclear weapons capability upon which the nuclear deterrent posture of this country relies.

Last May, the President transmitted to the Congress a comprehensive report prepared by the Administrator of ERDA, in collaboration with the Secretary of Defense, which addressed funding management alternatives for ERDA's nuclear weapon and restricted data responsibilities—National Security responsibilities which had been transferred to the ERDA from the Atomic Energy Commission by the Energy Reorganization Act of 1974. The report recommended that responsibility for the weapons program remain with ERDA.

As provided in that report, and to ensure that the country's nuclear weapon program is adequate to meet the country's needs, ERDA has defined distinct organizational arrangements for the program's direction and management. These arrangements identify a unique set of ERDA's Government-owned and contractor-operated facilities, including three national laboratories whose primary mission is the accomplishment of the nuclear weapons program. General Starbird, the Assistant Administrator for National Security, reports directly to me on the

adequacy of ERDA's efforts and of the weapon complex to accomplish these essential National nuclear weapons research, development, test, and production and stockpile surveillance requirements. At the same time, the ERDA experience has shown that the tremendous capabilities of the complex can also support aspects of the Nation's energy program. The synergism between weapon and energy programs in the complex has proven to be very beneficial.

Laser fusion program

The Laser Fusion program request is for \$122 million in Budget Authority. This is the principal example of common weapons laboratory efforts having both military and energy applications. The program consists of three categories of participants: the weapons laboratories, private industry, and the university community. Broad programs of basic and applied research are carried out to obtain an enhanced understanding of the physics of inertial confinement fusion in order to solve both national security and domestic energy problems.

Special materials production program

Also under National Security activities, the special materials production program request is for \$671 million in Budget Authority. This program encompasses those activities associated with the production of special nuclear materials for weapons, the reprocessing of reactor fuels, and the management of radioactive waste products generated by our weapons-related activities. These efforts involve the production of plutonium for weapons and reactor development, tritium for weapons, plutonium 238 for the space program, and small amounts of other transplutonium products for medical research and industrial applications. Naval and other fuels are reprocessed for recovery of uranium 235 for recycle to the enriching plants and production reactors. The radioactive waste products are processed and placed in storage tanks or other onsite storage facilities, and research is being conducted on various waste forms and alternatives for ultimate waste disposal.

Naval reactor development program

The Naval reactor development program provides for the design and development of improved naval nuclear propulsion plants and reactor cores having high reliability, maximum simplicity, and optimum fuel life. In fiscal year 1978, the budget request is for \$243 million in Budget Authority. Development will continue on improved reactor concepts, components and materials for application to submarines and surface warships, with particular emphasis placed on obtaining higher power long-life cores necessary for increased ship performance and size, simplifying operating and maintenance requirements, and increasing reliability and maintainability of reactor plant components.

Nuclear explosive applications

The ERDA request for Nuclear Explosive Applications in fiscal year 1978 is for \$1.0 million in Budget Authority. This will permit a modest study effort of energy applications of nuclear explosives.

Program management and support

Our Program Management and Support activities provide Government personnel, travel and other support services for all our programs, including the national security related programs discussed above. We have identified salaries and expenses totaling \$41.1 million that most directly support national security programs under Program Management and Support. Obviously, many of our general management functions such as procurement, personnel, accounting, and field office management, etc. that are included in the funding under the cognizance of the Senate Energy and National Resources Committee also support the national security programs. Since our programs are managed on an integrated basis, we hope that this method for separating the funding will be satisfactory to the committee.

In total, we believe the ERDA programs requested in 1978 offer a reasonable and balanced program for national security and our other activities. With these requests, we believe we can adequately support the DOD in maintaining for this country a viable and sound national security posture.

I appreciate this opportunity to appear before you today.

TABLE I.—ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION FISCAL YEAR 1978 BUDGET REQUEST
[In millions of dollars]

	Budget authority			
	1977	1978		Change
		Previous	Amended	
I. Energy research, development and demonstration:				
Energy R.D. & D. programs.....	2,643	3,303	3,201	-102
Supporting research.....	337	385	390	5
Financial incentive activities.....	30	325	330	5
Subtotal.....	3,010	4,013	3,921	-92
II. Basic research and technology development:				
High energy physics.....	224	269	269	
Nuclear physics.....	81	86	86	
Life sciences and biomedical applications.....	44	39	39	
Naval reactor development.....	200	243	243	
Space applications and other.....	24	36	36	
Subtotal.....	573	673	673	
III. Uranium enrichment activities:				
Uranium enrichment activities.....	1,482	1,685	1,685	
Revenues.....	-699	-966	-966	
Subtotal.....	783	719	719	
IV. National security:				
Weapons activities.....	1,184	1,466	1,466	
Special materials production.....	551	671	671	
Subtotal.....	1,735	2,137	2,137	
V. Program management and support.....	288	298	303	5
Grand total.....	6,389	7,840	7,753	-87

TABLE II.—ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION FISCAL YEAR 1978 BUDGET REQUEST
[In millions of dollars]

	Budget outlays			
	1977	1978		Change
		Previous	Amended	
I. Energy research, development, and demonstration:				
Energy R.D. & D. programs.....	2,179	2,751	2,750	-1
Supporting research.....	312	360	362	2
Financial incentive activities.....	4	10	10	
Subtotal.....	2,495	3,121	3,122	1
II. Basic research and technology development:				
High energy physics.....	200	237	237	
Nuclear physics.....	75	84	84	
Life sciences and biomedical applications.....	42	38	38	
Naval reactor development.....	241	248	248	
Space applications and other.....	24	30	30	
Subtotal.....	582	637	637	
III. Uranium enrichment activities:				
Uranium enrichment activities.....	1,246	1,447	1,407	-40
Revenues.....	-699	-966	-966	
Subtotal.....	547	481	441	-40
IV. National security:				
Weapons activities.....	1,146	1,316	1,316	
Special materials production.....	442	597	597	
Subtotal.....	1,588	1,913	1,913	
V. Program management and support.....	163	306	306	
Grand total.....	5,375	6,458	6,419	-39

TABLE III.—ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION FISCAL YEAR 1978 BUDGET REQUEST
ENERGY RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMS

[In millions of dollars]

	Budget authority			
	1977	1978		Change
		Previous	Amended	
I. Energy R.D. & D. programs:				
Conservation.....	161	158	318	160
Fossil energy.....	483	598	640	42
Solar heating and cooling.....	86	45	90	45
Solar electric and other.....	204	260	215	-45
Geothermal energy.....	55	88	88	
Fusion power development.....	416	513	433	-80
Liquid metal fast breeder reactor.....	686	855	656	-199
Nuclear fuel cycle and safeguards.....	406	636	611	-25
Other fission.....	146	148	148	
Special foreign currency funds.....	0	2	2	
Subtotal.....	2,643	3,303	3,201	-102
II. Supporting research:				
Environmental and biomedical research.....	181	210	215	5
Basic energy sciences.....	156	175	175	
Subtotal.....	337	385	390	5
III. Financial incentive activities:				
Geothermal resources development fund.....	30	30	30	
Alternative fuels demonstration program.....	0	295	300	5
Subtotal.....	30	325	330	5
Total energy research, development, and demonstration programs.....	3,010	4,013	3,921	-92

TABLE IV.—ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION FISCAL YEAR 1978 BUDGET REQUEST
ENERGY RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMS

[In millions of dollars]

	Budget outlays			
	1977	1978		Change
		Previous	Amended	
I. Energy R.D. & D. programs:				
Conservation.....	125	139	244	105
Fossil energy.....	445	500	519	19
Solar heating and cooling.....	61	61	86	25
Solar electric and other.....	122	173	164	-9
Geothermal energy.....	49	68	68	
Fusion power development.....	322	431	392	-39
Liquid metal fast breeder reactor.....	595	736	651	-85
Nuclear fuel cycle and safeguards.....	336	503	486	-17
Other fission.....	122	137	137	
Special foreign currency funds.....	2	3	3	
Subtotal.....	2,179	2,751	2,750	-1
II. Supporting research:				
Environmental and biomedical research.....	175	198	200	2
Basic energy sciences.....	137	162	162	
Subtotal.....	312	360	362	2
III. Financial incentive activities:				
Geothermal resources development fund.....	4	7	7	
Alternative fuels demonstration program.....	0	3	3	
Subtotal.....	4	10	10	
Total energy research, development and demonstration program.....	2,495	3,121	3,122	1

TABLE V.—ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION FISCAL YEAR 1978 BUDGET REQUEST
PROGRAMMATIC EFFORT UNDER CONSIDERATION BY THE SENATE ARMED SERVICES COMMITTEE

[In millions of dollars]

	Budget authority			
	1977	1978		
		Previous	Amended	Change
I. Energy research, development and demonstration: Fusion power development—laser fusion.....	111.6	142.0	122.0	-20
II. Basic research and technology development:				
Naval reactor development.....	200.1	242.7	242.7	
Nuclear explosive applications.....	1.3	1.0	1.0	
Space applications ¹	22.6	35.1	35.1	
Subtotal.....	224.0	278.8	278.8	
IV. National security:				
Weapons activities.....	1,184.2	1,466.1	1,466.1	
Special materials production.....	550.4	671.4	671.4	
Subtotal.....	1,734.6	2,137.5	2,137.5	
V. Program management and support—program direction.....	39.5	41.1	41.1	
Grand total.....	2,109.7	2,599.4	2,579.4	-20

¹ These include the following military-related amounts: Space applications—1977, \$6,100,000; 1978 previous, \$9,300,000; 1978 amended, \$9,300,000; 1978 change, none.

TABLE VI.—ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION FISCAL YEAR BUDGET REQUEST
PROGRAMMATIC EFFORT UNDER CONSIDERATION BY THE SENATE ARMED SERVICES COMMITTEE

[In millions of dollars]

	Budget outlays			
	1977	1978		
		Previous	Amended	Change
I. Energy research, development, and demonstration: Fusion power development—laser fusion.....	98.0	126.8	120.1	-6.7
II. Basic research and technology development:				
Naval reactor development.....	241.0	248.1	248.1	
Nuclear explosive applications.....	1.0	1.0	1.0	
Space applications ¹	22.6	28.9	28.9	
Subtotal.....	264.6	278.0	278.0	
IV. National security:				
Weapons activities.....	1,146.8	1,316.3	1,316.3	
Special materials production.....	442.0	597.1	597.1	
Subtotal.....	1,588.8	1,913.4	1,913.4	
V. Program management and support—program direc- tion.....	39.5	41.1	41.1	
Grand total.....	1,990.9	2,359.3	2,352.9	-6.7

¹ These include the following military-related amounts: Space applications—1977, \$5,500,000; 1978 previous, \$7,500,000; 1978 change, none.

JOINT COMMITTEE ON ATOMIC ENERGY

Chairman STENNIS. Gentlemen, this was ordinarily, you will recall, considered and authorized heretofore by the Joint Atomic Energy Committee. I am going to yield to Senator Jackson, a long-time member of the Joint Committee for questions at this time.

Senator JACKSON. I think it might be easier, if the two generals make their presentation, and then we can do it all in one package.

Chairman STENNIS. If that is agreeable with the committee, we will proceed, without objection, General Starbird's biographical sketch will be inserted in the record.

[The biography of Alfred D. Starbird follows:]

BIOGRAPHICAL SKETCH OF ALFRED D. STARBIRD (LT. GEN., USA, RET.)

Alfred D. Starbird was born in Fort Sill, Oklahoma, April 28, 1912. He was graduated from the United States Military Academy in 1933 and commissioned a second lieutenant in the Corps of Engineers. Prior to World War II, he served on various engineer assignments, and as an instructor of the United States Military Academy.

In 1942, he was assigned to the War Department General Staff. He served on temporary duty with the 1st Division Staff during its landings in North Africa and with the Fifth Corps during its landings and early operations in Normandy. He commanded an Engineer Combat Group in the Third Army from January through June 1945, and then returned to the War Department General Staff.

Since World War II, General Starbird has served in various assignments in the Pacific, CONUS, and in Europe. While in the Pacific, he served in the first atomic weapons task force at Enewetak Atoll in 1949, and while in Europe, he was the Secretary of SHAPE. After two years in the Office of the Chief of Engineers from May 1953 to June 1955, he was named Director of Military Application of the Atomic Energy Commission and served in that assignment from July 1955 to January 1961. In November 1961, he was called from his assignment as Division Engineer, North Pacific Engineer Division to organize Joint Task Force EIGHT and to command it during the planning, preparation, and execution of Operation Dominic, the 1962 nuclear test series.

He assumed duty as Director, Defense Communications Agency, in October 1962, and additional duty in September 1966 as Director of the Defense Communications Planning Group. He relinquished these duties on 15 November 1967 to become the Sentinel (later Safeguard) ABM System Manager. He retired from active military duty on 31 March 1971.

On 7 June 1971, he took over responsibility for organizing and directing the newly established Office of Test and Evaluation in the Office of the Director of Defense Research and Engineering, Office of the Secretary of Defense. As such, he had across-the-board responsibilities for Defense in test and evaluation matters.

He served in that capacity until 7 May 1975 at which time he was appointed by the President to his present position of Assistant Administrator for National Security (ANS) in the Energy Research and Development Administration. As ANS, he is responsible for directing and developing policy for the agency's nuclear weapons, international security, safeguards and security, laser fusion, and classification programs.

**STATEMENT OF ALFRED D. STARBIRD, ASSISTANT ADMINISTRATOR
FOR NATIONAL SECURITY, ERDA**

NATIONAL SECURITY

Mr. STARBIRD. I am General Starbird. I am retired from the military services. I am ERDA's Assistant Administrator for National Security. I have a short statement. However, in the interest of saving time, I will insert that for the record.

Chairman STENNIS. How long is it?

Mr. STARBIRD. It is about 5 minutes.

Chairman STENNIS. Suppose you read it?

Mr. STARBIRD. Yes, sir.

It is a privilege to appear before you today on behalf of the Energy Research and Development Administration to discuss ERDA's weapons and laser fusion programs and the related budget requests for fiscal year 1978. If it pleases the committee, I would like to provide brief introductory comments on these programs and then have my responsible program directors present the details of ERDA's fiscal year 1978 authorization requests for their respective programs.

After my comments, Maj. Gen. Joseph Bratton, Director of Military Application, will discuss the weapons program. Dr. Martin Stickley, Director of the Division of Laser Fusion will then discuss that program's objectives, approach, and ERDA's authorization request.

Gen. William Maxson from the Office of the Assistant to the Secretary of Defense—Atomic Energy—will be with us during this hearing to respond to any questions which can best be addressed from the DOD's perspective.

NUCLEAR WEAPONS PROGRAM

As ERDA's Assistant Administrator for National Security, I have overall responsibility for successfully accomplishing ERDA's nuclear weapons program of research, development, testing, production, surveillance and disposal of retired nuclear weapons. General Bratton, as head of the Division of Military Application, is responsible for managing the program.

ERDA is responsible for the design, development, test, production, stockpile maintenance, and retirement of nuclear weapons; for conducting a vigorous weapons technology exploratory and advanced development effort; for production of special nuclear materials for weapons; for surveillance and certification of the technical quality of the stockpile; for provisioning of limited life components; and for reviewing jointly with DOD the safety of operating and handling procedures for weapons.

Briefly, the weapons funding requested for fiscal year 1978 will support the weapons requirements contained in the DOD guidance and the stockpile memorandum. The requested level will permit us to accommodate design efforts, including associated tests, at a minimum level for insuring delivery of future weapons systems into the nuclear stockpile and to continue producing those warheads required by the Department of Defense for supporting the Nation's nuclear deterrent posture.

LASER FUSION PROGRAM

Let me also comment briefly on the laser fusion program. The laser fusion program is conducted primarily at our three weapons laboratories—the Lawrence Livermore Laboratory, the Los Alamos Scientific Laboratory, and Sandia Laboratories. Other major program participants are KMS Fusion, Inc., a private corporation, and the University of Rochester. The objective of the program is to demonstrate scientific feasibility and utilize lasers, electron beams, or ion

beams to initiate inertial confinement fusion in solving national security and domestic energy problems. The near-term contributions are expected to benefit nuclear weapons technology applications, while the longer-term goal is commercial power production applications.

Unless you have questions, I will now ask General Bratton to proceed by discussing the fiscal year 1978 funding requirements for the weapons program. In addition, he will cover the \$1 million authorization request for the nuclear explosive applications program.

I might say he has actually prepared two separate presentations. One of those is 30 minutes long, and goes into additional detail; one is 20 minutes long. He can give either of the two that you would prefer to have.

Chairman STENNIS. You mean on the screen?

Mr. STARBIRD. On the screen.

Chairman STENNIS. As far as I am concerned, I have all the time that could be needed. I don't know what the situation is with the other members here. If you want to make the 20-minute demonstration and then have questions, gentlemen. You are the only additional witness with a statement?

General BRATTON. In the weapons program; yes, sir.

Mr. STARBIRD. Dr. Stickley has 5 minutes.

Senator JACKSON. I am somewhat, of course, familiar with the program. I defer to Senator Anderson.

Senator ANDERSON. Whatever you want to do.

Senator JACKSON. I would think 20 minutes, and that will activate questions. If you are ready with it now, proceed.

Chairman STENNIS. The only reason we are moving along is that Senators have appointments, and this is the only time available for a meeting this week.

Let's proceed with your statement.

STATEMENT OF MAJ. GEN. JOSEPH K. BRATTON, DIRECTOR OF ERDA'S DIVISION OF MILITARY APPLICATION

NUCLEAR WEAPONS PROGRAM

General BRATTON. The first part of my statement will discuss how we are set up and how we do business—very briefly. Most of the statement is directed to the fiscal year 1978 budget.

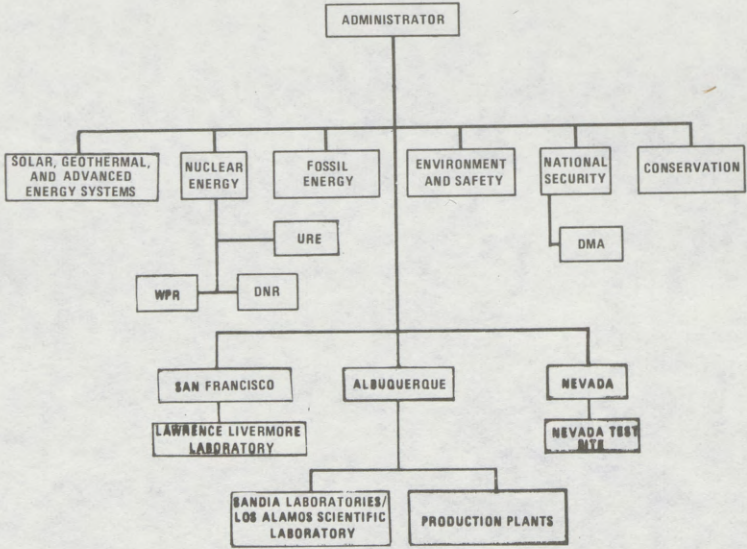
Chairman STENNIS. You are going to illustrate with viewgraphs?

General BRATTON. That is right.

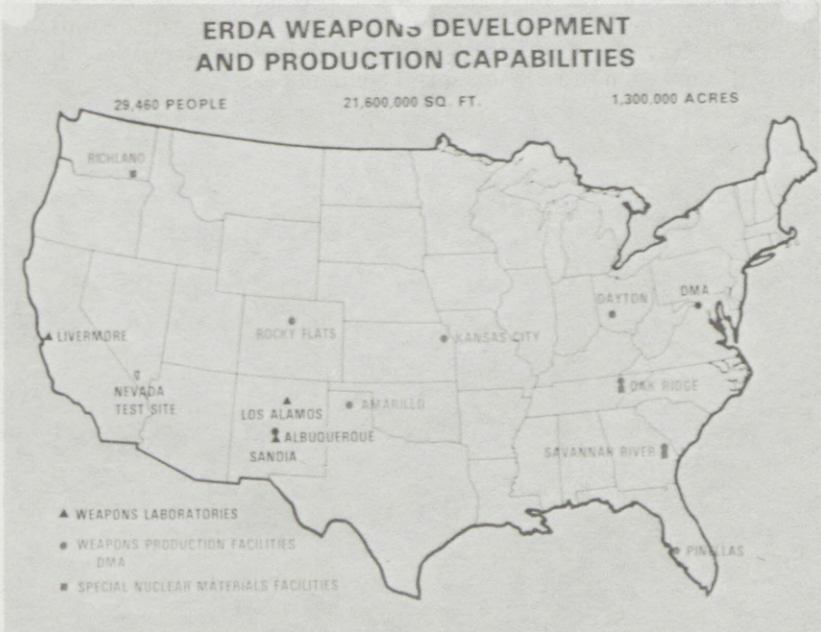
Regarding our organization and operation, my division, the Division of Military Application, which is directly under General Starbird, Assistant Administrator for ERDA for National Security, is responsible for the R. & D., the testing and production of nuclear weapons. We execute these responsibilities under authorization given to the Atomic Energy Commission by the Atomic Energy Act and subsequently transferred to ERDA.



ENERGY RESEARCH & DEVELOPMENT ADMINISTRATION (ERDA)



DMA directs the weapons program primarily through the ERDA Albuquerque, Nevada, and San Francisco Operations Offices. In addition, the Oak Ridge Operations Office in Tennessee and the Savannah



River Operations Office in South Carolina provide contract-management services.

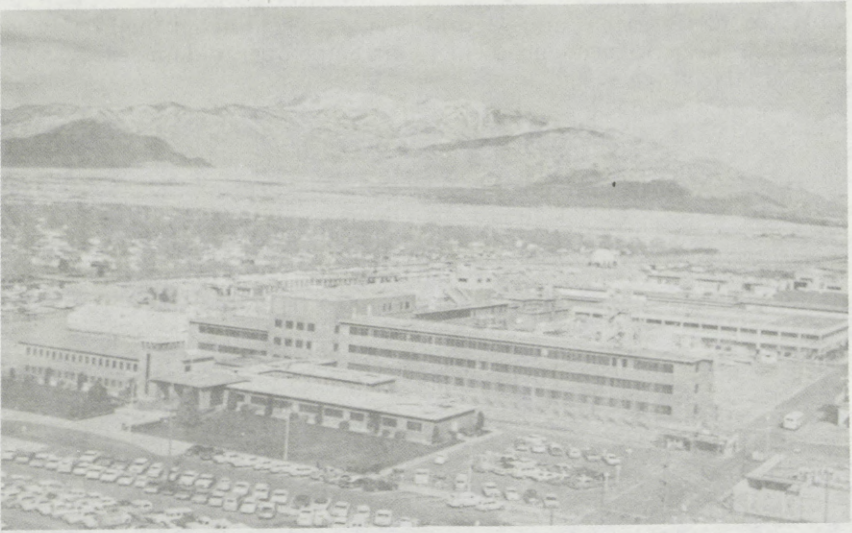


The ERDA weapons complex is an entity in which success depends on continuous interactions and close coordination among its major components—the laboratories at Los Alamos, Albuquerque, and Livermore; the Nevada test site; and the production facilities. I shall briefly discuss each of these essential elements.

Weapons research and development is conducted primarily at ERDA's three Government-owned contractor-operated nuclear weapon design laboratories:

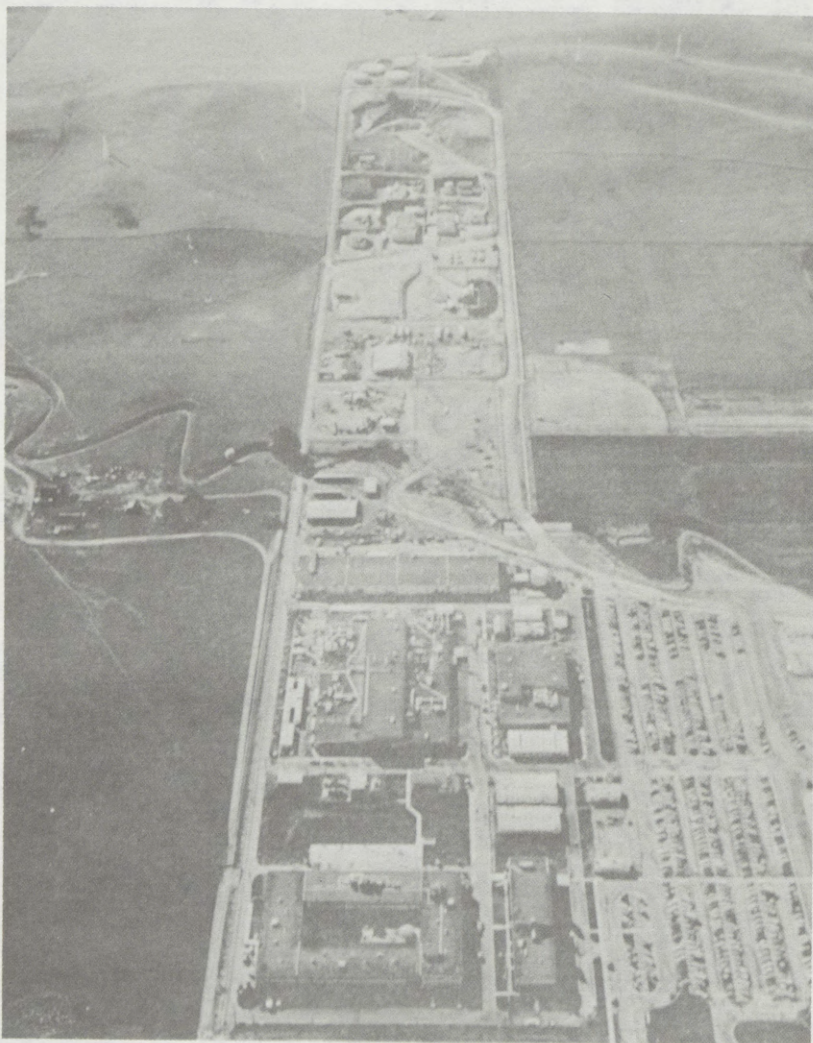


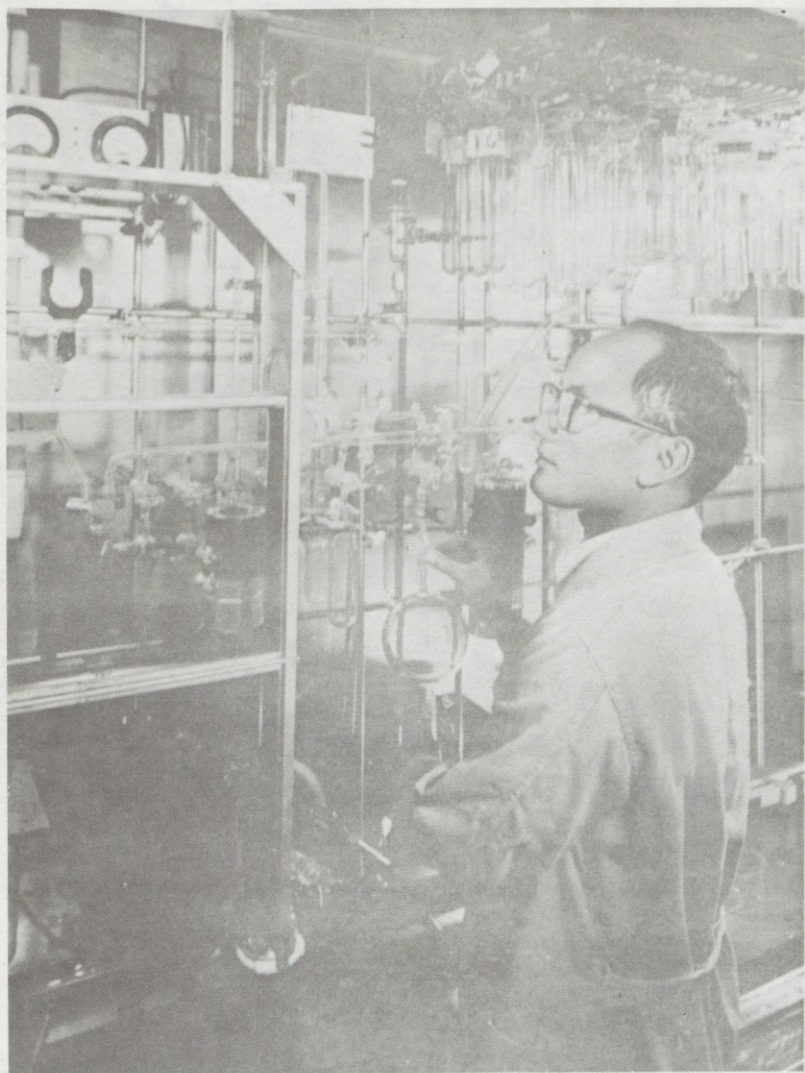
The Lawrence Livermore Laboratory (LLL), which is located in Livermore, Calif., about 40 miles east of San Francisco.



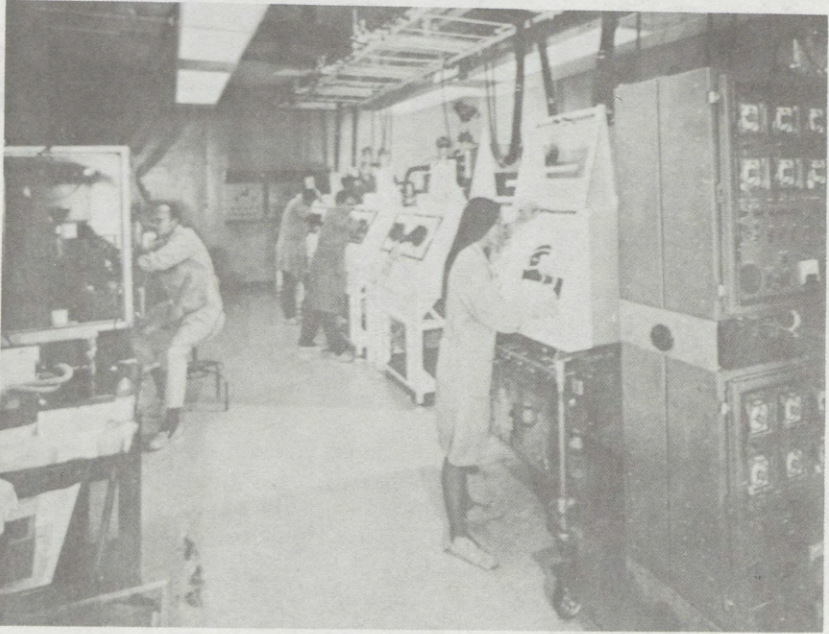
The Los Alamos Scientific Laboratory (LASL), Los Alamos, N. Mex.

The Sandia Laboratories with facilities in Albuquerque, N. Mex., and in Livermore, Calif. (SLL).





These laboratories employ over 21,000 people, with nearly 11,000 being funded by the weapons program. The remaining 10,000 are engaged in nuclear and nonnuclear energy research and development, biomedical research and development, and related work for other agencies. The primary task of the laboratories is to pursue supporting research and exploratory development of new or improved nuclear weapon concepts, to develop and test selected weapons designs in response to national security objectives, to monitor production of nuclear weapons, and to assure stockpile quality and reliability. However, all are broad-based, multiprogram laboratories. At LLL and



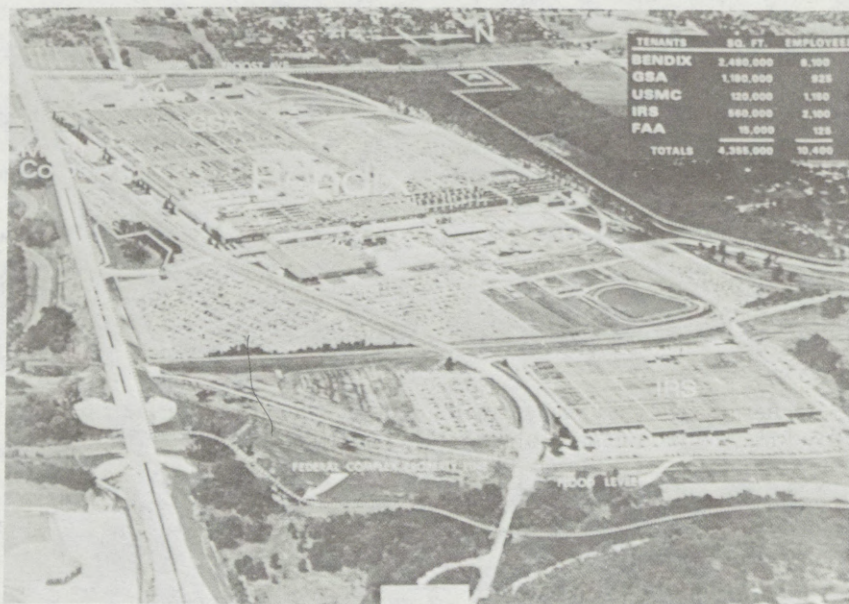
LASL the physical sciences are dominant, while at Sandia the emphasis is on engineering. LLL and LASL are the nuclear design laboratories. LASL was established under the Manhattan project during World War II. It is responsible for the nuclear-device aspects of weapons research and development. LLL was established in 1952, has similar responsibilities and, like LASL, is operated under contract with the University of California.

Sandia Laboratories was established in 1949 and is responsible for the nonnuclear aspects of weapons. Its operating contract is with the Western Electric Co.

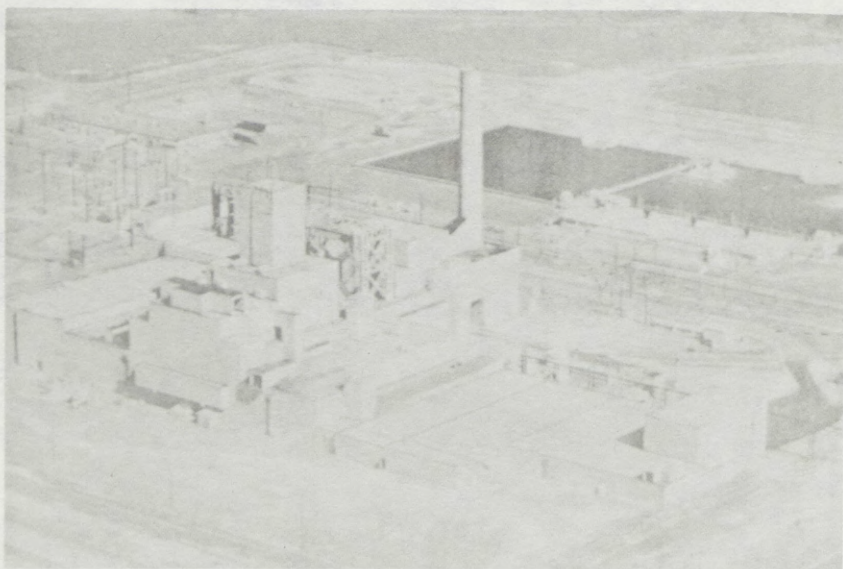


The Nevada test site, involving about 3,700 contractor personnel, is an extension of the three weapon laboratories and is currently this country's only active test area for underground nuclear experiments. The Nevada test site is managed by the ERDA Nevada Operations Office.

Weapons production is conducted at seven Government-owned, contractor-operated plants. These specialized installations employ approximately 22,000 people, 14,500 of whom are involved in weapon-related activities. These "integrated contractors" are:



Bendix Corp., which operates the Kansas City Plant, Kansas City, Mo.; this is our largest plant, and it is engaged in work on electrical, mechanical, and plastic components.



E. I. du Pont de Nemours & Co., Savannah River Plant, S.C.:
this facility supplies plutonium and tritium.



General Electric Corp., Pinellas Plant, Clearwater, Fla., this plant
produces neutron generators and other small components.



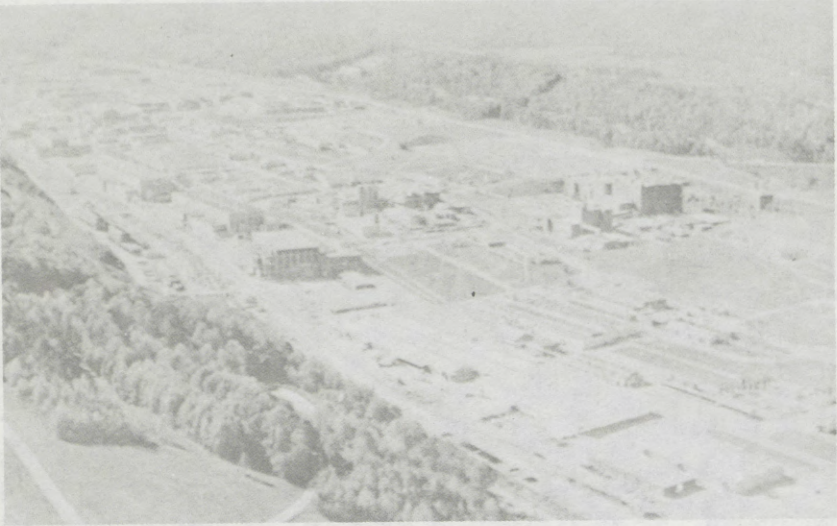
Mason and Hanger-Silas Mason, Pantex Plant, Amarillo, Tex.; this is our final assembly plant for all weapons.



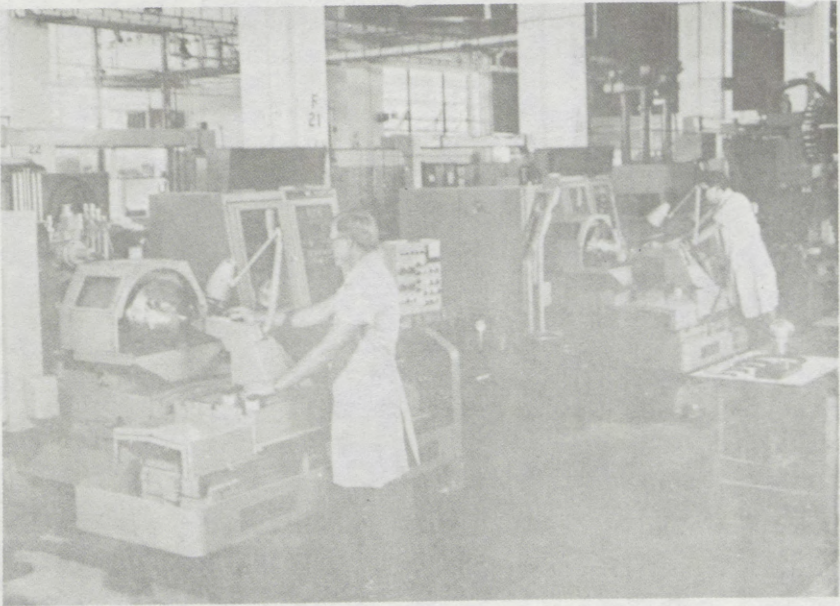
Monsanto Research Corp., Mound Laboratory, Dayton, Ohio; we produce detonators and other small components here.



Rockwell International, Rocky Flats, Golden, Colo.; here we have the facilities for plutonium recovery and fabrication.



Union Carbide Corp., Y-12 plant, Oak Ridge, Tenn., where our uranium fabrication and other work is carried out.



The production plants have a wide range of manufacturing skills and special capabilities needed to manufacture nuclear weapons, including the ability to produce components from uranium, plutonium, and rare elements and their compounds. The attained levels of precision, quality, reliability, and process controls are, in the most part, not found in private industry.

To illustrate the interdependency and complexity of the production complex, here is a drawing of the new W-76 Trident warhead [Chart deleted.] Note the involvement in its manufacture of all the plants and the large number of component parts and subcontractors. This involves many thousands of employees of many suppliers outside our own complex.

INTERAGENCY RELATIONSHIPS

Regarding interaction relationship, the longer statement which I will have in the record will elaborate on how we work directly with the Department of Defense. For the sake of time I will not present that portion of the statement but I will include it in the record.

We do work very closely with the DOD and coordinate our nuclear weapons production with their systems production.



FY 1978 ERDA WEAPONS PROGRAM

OPERATING FUNDS

- Research and Development
- Testing
- Special Test Detection
- Production and Surveillance

CAPITAL FUNDS

- Equipment (Other Than Plant)
- Construction

FISCAL YEAR 1978 BUDGET REQUEST

I shall now present to you our fiscal year 1978 budget in the several categories shown on this chart. I will begin with an overall summary and then address in sequence each of the areas listed.

FY 1978 ERDA WEAPONS PROGRAM

FUNDING REQUEST

(\$ Millions)

	<u>Budget Authority</u>	<u>Budget Outlays</u>
<u>OPERATING</u>		
Research & Development	\$ 368	\$ 356
Testing of Atomic Weapons	229	225
Special Test Detection	18	17
Production & Surveillance	566	519
Total Operating	<u>1,181</u>	<u>1,117</u>
<u>EQUIPMENT</u>	81	75
<u>CONSTRUCTION</u>	<u>204</u>	<u>124</u>
Grand Total	\$1,466	\$1,316

The fiscal year 1978 funding authorization request for the weapons program totals \$1,466,100,000 in new obligational authority. As in the budget before you, I show here the budget authority (B/A) and budget outlay (B/O) for the program. In subsequent sections, I will address the operating categories in terms of outlays, or costs, because we manage our subprogram activities on a cost-performance basis.

WEAPONS OPERATING PROGRAM

The weapons operating program proposed level includes \$356 million for research and development, \$225 million for testing of atomic weapons, \$17 million for special test detection activities, and \$519 million for the production of new weapons approved by the President

and maintenance of the stockpile of existing weapons to assure their readiness as required for our national security. I shall comment on each of these four categories.

RESEARCH AND DEVELOPMENT

FY 1978 ERDA WEAPONS PROGRAM

RESEARCH AND DEVELOPMENT

(\$ Millions)

	<u>FY</u> <u>1976</u>	<u>FY</u> <u>1977</u>	<u>FY</u> <u>1978</u>
Current Weapons	\$126	\$153	\$150
Advanced Development	45	52	68
Development Capability	98	101	119
Special Projects	<u>13</u>	<u>18</u>	<u>19</u>
Total	\$282	\$324	\$356

The budget request of \$356 million for research and development proposes an increase of \$32 million, or about 10 percent, over fiscal year 1977. It provides the resources—manpower, materials, and services—needed to support the efforts of ERDA's weapons laboratories in

research, development, and engineering of nuclear weapons, including current weaponization of DOD-required nuclear weapons for stockpile; advanced development for future weapons applications; and advancement of development capabilities in the science and technologies necessary to weapons development.

FY 1978 ERDA WEAPONS PROGRAM

RESEARCH AND DEVELOPMENT WORKLOAD (IOC)

CURRENT WEAPONS

W70 Mod 3 LANCE Warhead (Deleted)
 B61 Bomb Mods 3 (Deleted) and 4 (Deleted)
 W76 TRIDENT Warhead
 W79 (Deleted)
 W80 Cruise Missile
 W78 MK 12A Warhead for MINUTEMAN III (Deleted)
 B77 FUF0 Bomb (Deleted)

POSSIBLE CANDIDATES

Standard Missile Warhead
 PERSHING II Warhead
 M-X Warhead
 HARPOON Warhead
 155mm Nuclear Projectile

ADVANCED DEVELOPMENT

MRR Tactical Bomb
 Tactical Earth Penetrator Warhead
 Modular Guided Weapon System
 Improved Nuclear Torpedo
 Other Advanced Concepts and Technologies

{ Deleted }

Current weapons development, or weaponization, the focal point of the weapons R. & D. effort, is guided by current national needs for providing new strategic options; for modernization of tactical and theater weapons; and for monitoring and maintaining the reliability of weapons now in stockpile.

Weaponization will continue at about the fiscal year 1977 level with seven systems in engineering development. Depending on system complexity and scheduling, the weapons program budget request can accommodate from six to nine systems in fiscal year 1978. Systems now under development include the B-61 Bomb Mods 3 and 4, the W-70 Mod 3 Lance enhanced radiation warhead, the W-76 Trident warhead, the B-77 FUF0 Bomb, the W-78 warhead for the Minuteman III, the W-79 8" artillery fired atomic projectile, and the W-80 cruise missile warhead. In addition, it is expected that development engineering will be requested by the DOD for one or more of the following systems prior to the end of fiscal year 1978:

A nuclear warhead for the Standard missile, which is to be used in the Terrier and Aegis systems as a fleet defense against nuclear armed air and surface launched cruise missile threats;

A replacement warhead for the Pershing tactical missile which will employ a new terminal guidance system to achieve improved accuracy using a significantly lower yield warhead to achieve a substantial reduction in collateral damage;

A warhead for the M-X system;

A warhead that can be converted from conventional high explosive to nuclear for the Harpoon and antiship missile; and

An improved replacement for the existing W-48 155-millimeter artillery shell.

Most of the balance of the requested research and development funding will be directed to the laboratories' efforts in the areas of advanced development and development capability. Illustrative advanced development efforts are indicated on the chart.

FY 1978 ERDA WEAPONS PROGRAM

RESEARCH AND DEVELOPMENT

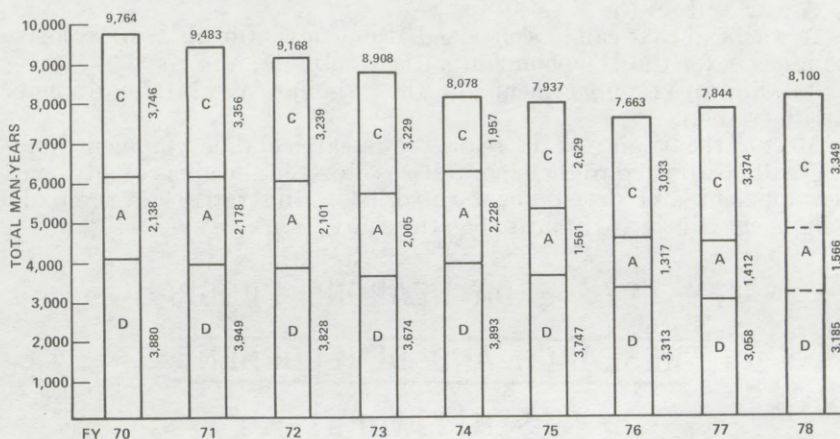
(\$ Millions)

	<u>FY</u> <u>1976</u>	<u>FY</u> <u>1977</u>	<u>FY</u> <u>1978</u>
Current Weapons	\$126	\$153	\$150
Advanced Development	45	52	68
Development Capability	98	101	119
Special Projects	<u>13</u>	<u>18</u>	<u>19</u>
Total	\$282	\$324	\$356

Returning to a previous chart, you will note that the requested funding increase for research and development is to augment our advanced development and development capability efforts. Advanced develop-

ment is the essential source of new concepts needed to maintain the quality of the U.S. nuclear weapons deterrent. Advanced development efforts involve the evaluation of the feasibility of weaponizing new concepts for specific weapons applications.

ERDA WEAPONS R&D MANPOWER



- C - CURRENT WEAPONS (PHASE 3 DEVELOPMENT ENGINEERING AND PRE-PHASE 3 EFFORTS)
 A - ADVANCED DEVELOPMENT (ADVANCED CONCEPTS AND PHASE 1 AND 2 STUDIES)
 D - DEVELOPMENT CAPABILITY (SUPPORTING RESEARCH, MATERIALS TECHNOLOGY, NUCLEAR/NON-NUCLEAR DESIGN TECHNOLOGY, FACILITY TECHNOLOGY, TEST TECHNOLOGY, SPECIAL PROJECTS AND OTHERS)

For several years prior to fiscal year 1977, our resources to conduct advanced development were eroded by the demands of current weapons development and the effects of inflation on a relatively fixed amount for our total research and development budget. Although the erosion, or decline, was reversed during the fiscal year 1976 transition period, the fiscal year 1977 effort in this category remains about 70 percent of the fiscal year 1973 level. The budget resquest for fiscal year 1978 will restore manpower in this category to approximately 78 percent of the fiscal year 1973 level.

TESTING OF ATOMIC WEAPONS

FY 1978 ERDA WEAPONS PROGRAM

TESTING

(\$ Millions)

	FY 1976	FY 1977	FY 1978
On-Continent Tests	\$151	\$154	\$156
Off-Continent Test Readiness	4	1	0
Laboratory Participation-Common	53	66	69
Total	\$208	\$221	\$225

The ERDA budget request for fiscal year 1978 for testing is \$225 million, an increase of \$4 million, or 2 percent, over fiscal year 1977. If inflation is considered, this represents a decrease of 6 percent in testing effort. This subprogram includes the underground testing program shown here in the budget category entitled on-continent tests, which represents a vital extension of the laboratories' research and development efforts on nuclear weapons and associated technology advancements.



The ERDA nuclear weapons full-scale underground test program is structured by ERDA, approved by the President, and accomplished at the Nevada test site under the operational management of the ERDA Nevada Operations Office. Technical direction for each individual test and testing operation is provided by the weapons design laboratories. The Nevada Operations Office provides the required Government-owned facilities plus engineering, construction, and logistical support through prime contractors.

Underground nuclear testing is an important part of the weapons research and development effort. Maintenance of an adequate level of testing is essential to improvement of nuclear designs and important to the general advancement of nuclear weapons technology, and to assurance of a capable technology base and a reliable weapons stockpile over the long term.

FY 1978 ERDA WEAPONS PROGRAM

TEST SUMMARY

(Device Tests)

	<u>FY</u> <u>1970</u>	<u>FY</u> <u>1972</u>	<u>FY</u> <u>1975</u>	<u>FY</u> <u>1976</u>	<u>FY</u> <u>1977</u>	<u>FY</u> <u>1978</u>
Current Weapons		(DELETED)				
Advanced Development		(DELETED)				
Development Capability		(DELETED)				
Total		(DELETED)				

The fiscal year 1978 budget for testing will provide for a program of approximately [deleted] device tests in support of ongoing current and advanced development programs.

We are seeking to achieve a program of testing properly balanced between current weapons and advanced development for future weapons. Of the [deleted] tests planned, [deleted] are for current weapons development programs and [deleted] are for tests in the advanced development category.

FY 1978 ERDA WEAPONS PROGRAM

TESTING

(\$ Millions)

	<u>FY</u> <u>1976</u>	<u>FY</u> <u>1977</u>	<u>FY</u> <u>1978</u>
On-Continent Tests	\$151	\$154	\$156
Off-Continent Test Readiness	4	1	0
Laboratory Participation-Common	<u>53</u>	<u>66</u>	<u>69</u>
Total	\$208	\$221	\$225

You will note in our budget that within the testing subprogram there is also a category identified as laboratory participation-common. This category and the associated funding distinguished laboratory manpower costs for scientific support from those required for test devices and the operation of the Nevada test site.

No funds are included within the weapons testing subprogram for maintaining a capability to resume nuclear testing in the atmosphere. The termination of this category was initiated with the fiscal year 1977 budget.

SPECIAL TEST DETECTION

FY 1978 ERDA WEAPONS PROGRAM

SPECIAL TEST DETECTION

(\$ Millions)

	<u>FY</u> <u>1976</u>	<u>FY</u> <u>1977</u>	<u>FY</u> <u>1978</u>
Underground Detection	\$1.0	\$ 1.2	\$ 1.6
Surface and High Altitude Detection	6.5	8.3	9.5
PNE Verification	<u>1.5</u>	<u>5.5</u>	<u>5.8</u>
Total	\$9.0	\$15.0	\$16.9

The fiscal year 1978 request of \$17 million for special test detection activities provides for the continued development of improved nuclear test detection methods and capabilities applicable to monitoring compliance with the terms of the Limited Test Ban Treaty, the Threshold Test Ban Treaty, and the Peaceful Nuclear Explosions Treaty.

The program includes three categories: The underground nuclear detection program; the surface and high altitude detection program related to atmospheric and space nuclear detonations; and the peaceful

nuclear explosions verification program related to verifying Soviet compliance with the provisions of the Peaceful Nuclear Explosions Treaty.

PRODUCTION AND SURVEILLANCE

FY 1978 ERDA WEAPONS PROGRAM

PRODUCTION AND SURVEILLANCE

(\$ Millions)

	<u>FY</u> <u>1976</u>	<u>FY</u> <u>1977</u>	<u>FY</u> <u>1978</u>
War Reserve New Production	\$187	\$197	\$305
Stockpile Maintenance	42	60	56
Stockpile Reliability	52	60	60
Process Development	33	37	43
Other Costs	43	47	54
Cost of Work for Others	74	109	115
Gross P&S	<u>431</u>	<u>510</u>	<u>633</u>
Receipts from Work for Others	<u>-82</u>	<u>-104</u>	<u>-114</u>
Net P&S	\$349	\$406	\$519

Our largest operating category is for production of nuclear weapons as approved by the President and surveillance of the weapons stockpile to assure its readiness and reliability. Production of nuclear weapons is conducted at our integrated complex of seven production plants.

The request for fiscal year 1978 is for \$519 million. The increase of \$113 million, or 28 percent, over fiscal year 1977 is almost entirely to provide for production of new war reserve weapons, as indicated on the first line of the chart. I shall discuss this subprogram further using additional charts.

FY 1978 ERDA WEAPONS PROGRAM

WAR RESERVE NEW PRODUCTION

(\$ Millions)

	<u>FY</u> <u>1976</u>	<u>FY</u> <u>1977</u>	<u>FY</u> <u>1978</u>	<u>IOC</u>
B61-2 Bomb				
B61-3 Bomb				
B61-4 Bomb	[DELETED]	[DELETED]	[DELETED]	[DELETED]
B61-5 Bomb	[DELETED]	[DELETED]	[DELETED]	[DELETED]
W62 MINUTEMAN III (MK 12)	[DELETED]	[DELETED]	[DELETED]	[DELETED]
W69 SRAM				
W70-2 LANCE	[DELETED]	[DELETED]	[DELETED]	[DELETED]
W70-3 LANCE ER				
W76 TRIDENT (MK 4)				
B77 Bomb (FUFO)				
W78 MINUTEMAN III (MK 12A)				
W79 AFAP				
W80 Cruise Missile				
Standard Missile (SM-2)				
Total				

War reserve new production, which accounts for about 60 percent of the weapons production category, is for procurement, fabrication, and assembly of material, piece-parts, and components needed to manufacture weapons to be delivered to the Department of Defense for the nuclear weapons stockpile. This chart shows these deliveries for the period fiscal year 1976-78 by specific bomb and warhead, and indicates in the right-hand column the date of initial operational capability.

I will show another chart in a moment on the actual production of weapons.

FY 1978 ERDA WEAPONS PROGRAM

STOCKPILE MAINTENANCE

(\$ Millions)

	<u>FY 1976</u>	<u>FY 1977</u>	<u>FY 1978</u>
Modification, Repairs, and Other Stockpile Support	\$12	\$11	\$12
Replacement of Limited Life Components	26	43	37
Retirements	<u>4</u>	<u>6</u>	<u>7</u>
Total	\$42	\$60	\$56

Maintenance of weapons and components in or to be delivered to the stockpile; this includes modification and repairs, replacement of limited life components, and disposal of retired weapons.

FY 1978 ERDA WEAPONS PROGRAM

STOCKPILE RELIABILITY

(\$ Millions)

	<u>FY 1976</u>	<u>FY 1977</u>	<u>FY 1978</u>
Quality Assurance	\$ 4	\$ 4	\$ 4
New Materials/Stockpile Lab Tests	24	26	28
New Materials/Stockpile Flight Tests	19	24	22
Surveillance	<u>5</u>	<u>6</u>	<u>6</u>
Total	\$52	\$60	\$60

Stockpile reliability, which encompasses activities required to assure the quality and reliability of weapons and components in or to be delivered to the stockpile; and

FY 1978 ERDA WEAPONS PROGRAM

PROCESS DEVELOPMENT

(\$ Millions)

	FY <u>1976</u>	FY <u>1977</u>	FY <u>1978</u>
Process Development	\$33	\$37	\$43

Process development, which includes development of materials, processes, and manufacturing techniques required to fabricate nuclear and nonnuclear weapon components.

FY 1978 ERDA WEAPONS PROGRAM

OTHER PRODUCTION COSTS

(\$ Millions)

	FY <u>1976</u>	FY <u>1977</u>	FY <u>1978</u>
Nuclear Material Recycle and Recovery (Pu, T, Oralloy)	\$28	\$29	\$33
Field Engineering and Training Manuals	2	2	2
Transportation and Security Shipments	9	11	12
Miscellaneous	<u>4</u>	<u>5</u>	<u>7</u>
Total	\$43	\$47	\$54

There are also other costs for recovering and recycling material from fabrication and assembly operations, limited life components, and

retirements of weapons and components; field engineering and training manuals; and transportation of weapons, subassemblies, and nuclear materials.

FY 1978 ERDA WEAPONS PROGRAM

WEAPONS DELIVERY AND RETIREMENT SCHEDULE

	<u>FY</u> <u>1976</u>	<u>FY</u> <u>1977</u>	<u>FY</u> <u>1978</u>	<u>FY</u> <u>1979</u>	<u>FY</u> <u>1980</u>	<u>FY</u> <u>1981</u>
B61-2 Bomb						
B61-3 Bomb						
B61-4 Bomb	[DELETED]	[DELETED]	[DELETED]	[DELETED]	[DELETED]	[DELETED]
B61-5 Bomb						
W62 MINUTEMAN III (MK 12)						
W69 SRAM						
W70-2 LANCE	[DELETED]	[DELETED]	[DELETED]	[DELETED]	[DELETED]	[DELETED]
W70-3 LANCE ER						
W71 SPARTAN						
W76 TRIDENT (MK 4)						
B77 Bomb (FUFO)						
W78 MINUTEMAN III (MK 12A)						
W79 AFAP (Deleted)						
W80 Cruise Missile Standard Missile (SM-2)						

Total

Retirements

The planned production for new bombs and warheads, which establishes the principal funding requirement in the general category of production and surveillance, is summarized here for the period fiscal year 1976 through fiscal year 1981. The annual stockpile memorandum we receive from the President is operative at the present time through fiscal year 1981.

Our deliveries to the DOD are shown by weapon type and by year; the last line shows planned retirements. You will note, in particular, [deleted].

A significant amount of the funding requested for fiscal year 1978 is to prepare in time for these increases by procuring long-lead items of tooling, hardware, and components, and for some expansion of the trained work force on a properly phased and orderly schedule.

I will depart from my prepared statement here to mention, sir, that this chart reflects in the case of the W-76 Trident and the W-78 Minuteman, the IOC schedule and the bills which were effective when the budget was submitted and indeed which were effective up until this very week. We have now received a change from the Department of Defense which will tend to slip just a little bit some of these deliveries. I will state that formally and give you the impact in a formal communication within a week to your committee.

Chairman STENNIS. Within what?
 General BRATTON. Within a week.
 Chairman STENNIS. All right.

WEAPONS CAPITAL EQUIPMENT

General BRATTON. I would like to turn now to weapons capital equipment.

FY 1978 ERDA WEAPONS PROGRAM

EQUIPMENT

(\$ Millions)

	<u>FY</u> <u>1976</u>	<u>FY</u> <u>1977</u>	<u>FY</u> <u>1978</u>
Research & Development	\$24	\$27	\$36
Testing	11	13	17
Production & Surveillance	19	25	19
Other Capital Equipment	<u>6</u>	<u>7</u>	<u>9</u>
Total	\$60	\$72	\$81
Computers (Included Above)	\$ 8	\$10	\$ 8

The fiscal year 1978 budget authority requested for capital equipment not related to construction totals \$81 million. Included are \$73

million for basic equipment and \$8 million for major computer acquisitions.



Because of limited funding in recent years, it has been necessary to defer the upgrading and replacement of equipment at the three weapons laboratories, the Nevada test site, and the seven production plants. A significant portion of equipment at these facilities has exceeded life standards. For example, equipment at our weapons laboratories is 68 percent depreciated as compared to an accepted norm of 50 percent. Current efficiency and effectiveness is, therefore, being significantly impaired. The equipment funding levels have been adversely impacted by the decrease in buying power caused by inflation, the additional costs due to the growing complexity of required equipment, and the necessity to accommodate increased requirements for nonprogrammatic needs such as those involving health, safety, safeguards, and security.

Included in the request is \$6 million for purchase of safeguards and security equipment—primarily for ATMX railcars for transporting nuclear weapons and for escort rail coaches.



The fiscal year 1978 request does not provide for the purchase of a major computer; it does provide for the upgrade of existing systems. As may be noted in our operating budget, we are requesting funds for continued lease of two major systems and for the lease of three new major computers. Large, modern, scientific computers are absolutely

essential to nuclear weapons design, and there is now a deficiency of computer capability at the nuclear design laboratories. Future major computer acquisitions will be necessary.

WEAPONS CONSTRUCTION PROJECTS

FY 1978 ERDA WEAPONS PROGRAM

CONSTRUCTION BUDGET

(\$ Millions)

	FY 1978	
	Requested New Authorization	Requested New Obligational Authority
General Plant Projects	\$ 24	\$ 24
New Projects (12)	161	116
Continuing Projects (5)	<u>49</u>	<u>64</u>
Total	\$234	\$204

Turning now to the weapons construction budget, the amount requested for authorization is \$234 million, while associated appropriations (or new obligational authority) total \$204 million. This includes \$24 million for general plant projects, \$116 million for new construction projects, and \$64 million for continuing construction projects.

FY 1978 ERDA WEAPONS PROGRAM

CONSTRUCTION

(\$ Millions)

	Total Estimated Cost	FY 1978	
		New Author.	New Ob. Auth.
1. Cruise Missile production facilities, various locations	\$ 18.1	\$ 18.1	\$ 18.1
2. Full fuzing option (FUF0) bomb production facilities, various locations	43.0	43.0	23.5
3. High explosive flash radiography facility, Lawrence Livermore Laboratory, Calif. ...	10.9	10.9	10.9
4. Weapons safeguards, various locations	28.0	28.0	17.0
5. New weapons production installations, various locations	5.0	5.0	5.0
6. Replace 10-inch water main, Bendix Plant, Kansas City, Missouri	2.0	2.0	2.0
7. Radioactive liquid waste improvement, Los Alamos Scientific Laboratory, New Mexico	12.5	12.5	6.8
8. Tonopah Test Range upgrade, Sandia Laboratories, Albuquerque, New Mexico ..	4.0	4.0	4.0
9. Production component warehouse, Pantex Plant, Amarillo, Texas	4.0	4.0	4.0
10. Surface water control system, Rocky Flats, Colorado	2.8	2.8	2.8

In the interest of time, I will not discuss in my prepared statement the 18 separate requested construction items. I am prepared to respond to any questions that you may have concerning any of them.

2

(\$ Millions)

	Total Estimated Cost	FY 1978	
		New Author.	New Ob. Auth.
11. Core facilities office building utilities, and roads, Lawrence Livermore Laboratory, California	\$ 12.3	\$ 12.3	\$ 12.3
12. Steam plant improvements, Y-12 Plant, Oak Ridge, Tennessee	18.5	18.5	10.0
13. General plant projects	24.0	24.0	24.0
14. Safeguards and research and development laboratory facility, Sandia Laboratories, Albuquerque, New Mexico	8.3	0	4.3
15. Safeguards and site security improvements, various locations	13.5	0	7.8
16. 8" Artillery fired atomic projectile production facilities, various locations	22.6	2.1	12.6
17. Laboratory support complex, Los Alamos Scientific Laboratory, New Mexico (A-E only)	*	0	2.0
18. Fire, safety, and adequacy of operating conditions projects, various locations .	287.0	<u>47.0</u>	<u>37.0</u>
Total		\$234.2	\$204.1

* To Be Determined.

The last five projects shown on this chart are continuing projects.

We are also requesting \$47 million in additional authorization for completion of the new plutonium recovery facility at the Rocky Flats plant. This and a similar but smaller facility at Los Alamos are the final projects being constructed under Project 71-9, fire, safety and adequacy of operating conditions at various locations. The high priority attached to the several projects conducted under this project was based upon urgent safety considerations in providing proper, modern

plutonium-handling facilities throughout the weapons complex. The total estimated cost of this project is \$287 million; \$240 million has already been authorized. The total cost of the Rocky Flats facility is estimated at \$187 million.

NUCLEAR EXPLOSIVE APPLICATIONS PROGRAM

FY 1978

NUCLEAR EXPLOSIVE APPLICATIONS PROGRAM

(\$ Millions)

	FY <u>1977</u>	FY <u>1978</u>
OPERATING		
Storage Application Development	\$.4	\$.4
Technology Support	.6	.6
Total	<u>\$1.0</u>	<u>\$1.0</u>

Just a moment in closing, sir, to mention our nuclear explosive applications program. Our request this year is for \$1 million, the same as it was last year. This level of support is low, and will not permit field experiments. It will provide for scientific personnel to maintain a technological base in the phenomenology associated with peaceful nuclear explosives and thereby partially offset the technology asymmetry developing between the United States and the USSR in this area.

The fiscal year 1978 program will permit conducting theoretical and experimental laboratory development of application concepts of mutual interest to the United States and the international community. For example, it will permit us to continue the modest effort begun in fiscal year 1977 to investigate the technical feasibility of utilizing very deep underground cavities for hydrocarbon storage and permanent disposal of radioactive wastes by encapsulation.

Mr. Chairman, that completes my prepared statement.

ERDA BUDGET

Chairman STENNIS. As I understand it, that concludes your presentation here, and we will have questions. But first, you have budget approval of all these items you are asking for, Dr. Fri, is that right?

Mr. FRI. From the President? Budget approval from the President?

Chairman STENNIS. Yes, from the President.

Mr. FRI. Yes, we do.

Chairman STENNIS. Do you have authorization for any of it, I mean congressional authorization?

Mr. FRI. I don't believe any congressional authorization has passed.

Chairman STENNIS. This is an authorization hearing on related matters that have been considered by the Joint Atomic Energy Committee. These matters are not all represented here, but those you do

bring to this committee were formerly reviewed by the Joint Atomic Energy Committee.

Mr. FRI. That is correct.

Chairman STENNIS. And some of your matters are in the public works appropriation bill?

Mr. FRI. That is correct.

Chairman STENNIS. Gentlemen of the committee, this is the first time that this committee has had the authorization matter with reference to this weaponry. It has been in the Joint Atomic Energy Committee where it was originally placed in 1947, as I recall, when it was, I won't call it an infant program, but it was certainly a new program. There it gradually grew over the years and runs now into the billions of dollars.

Your request here today is somewhere close to \$2.5 billion.

Now, as I have said, some of the items the Joint Committee handled, went through the Appropriations Committee, Public Works Subcommittee, I imagine, but do not know, that the creation of the new Energy Department may cause changes in the reference of many of the matters that apply to that Department.

But, for this year, we are considering this material. Frankly, I favor that we retain it, because as an original proposition it belonged here all the time. When the Joint Atomic Energy Committee was created, one of the ideas was to keep these matters separate from everything else, and there were some good reasons for that. But it should have been here for a good while, since it became a large part of the military budget.

I didn't make any special reference this year, because of the uncertainty of just what turn things were going to take with reference to first the Joint Committee, and then with reference to the creation of a department, to cover the whole energy matter. So if we consider it next year, we expect to refer it to the proper subcommittee to go into this in depth. This year there is not a chance timewise to get into it in depth.

How long have you had budget approval for this program anyway? It took time to get that, I am sure. You say you changed it a little bit even last week?

Mr. FRI. The President Ford-approved budget in January. President Carter reviewed the budget in February and very minor, if any, changes were made to the weapons program.

Chairman STENNIS. Do you have any other witness here? Admiral Rickover was listed as a witness here this morning.

Mr. STARBIRD. We have Dr. Martin Stickley.

Mr. FRI. There are three additional programs that have not been covered. One is the laser fusion program, which Dr. Stickley operates, the production of materials for weapons program. Mr. Cunningham, I understand, is outside.

Chairman STENNIS. All right.

Mr. FRI. And Admiral Rickover's program.

Chairman STENNIS. We want to get all of this out on the table today. There won't be a chance to finish it up. But let's call Dr. Stickley on laser fusion, and Admiral Rickover, and Mr. Cunningham too.

Senator HART. Mr. Chairman, when would be an appropriate time to ask questions of the witnesses who have already testified?

Chairman STENNIS. Well, we are going to try to get in some questioning right away.

Senator HART. After they have made statements?

Chairman STENNIS. It won't take but a few minutes. Let's let them make their statements if that is all right.

STATEMENT OF DR. C. MARTIN STICKLEY, DIRECTOR, DIVISION OF LASER FUSION ON THE INERTIAL CONFINEMENT FUSION PROGRAM

LASER FUSION PROGRAM

Dr. STICKLEY. Mr. Chairman.

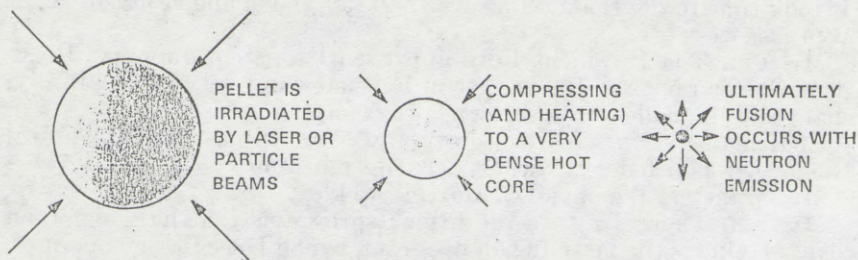
Chairman STENNIS. You have only a brief statement? I am not crowding you for time. We can't go into it at all if it is not brief.

Dr. STICKLEY. It is brief.

Mr. Chairman and members of the committee, I appreciate the opportunity to appear before this committee to discuss ERDA's inertial confinement fusion program. With your permission I would like to read a brief overview of my longer statement which I will submit for the record.

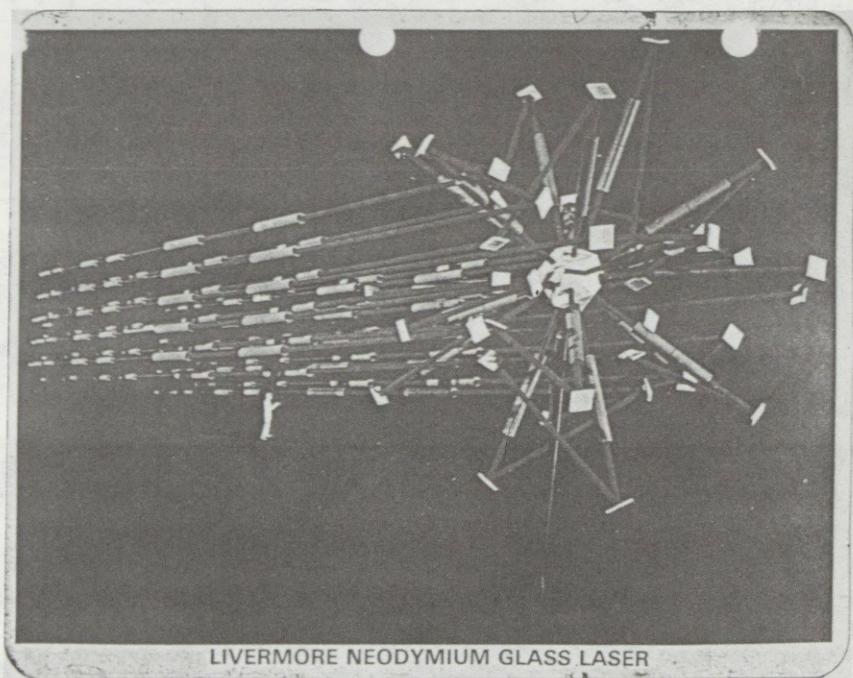
The inertial confinement program is based on the concept that fusion energy can be released from tiny pellets of deuterium-tritium fuel, if the pellets can be compressed to densities greater than that of a solid and at the same time heated to the extremely high temperatures characteristic of thermonuclear reactions.

INERTIAL FUSION CONCEPT



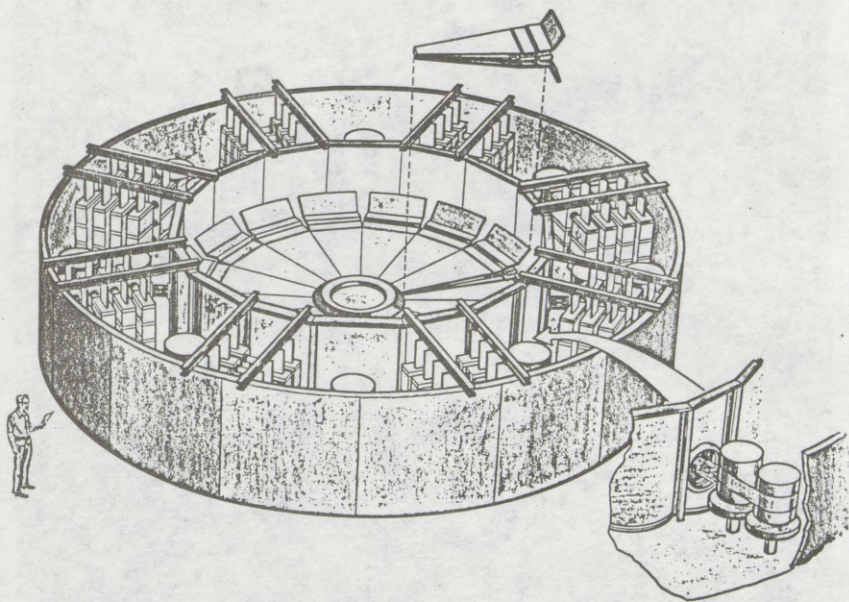
Because the compression, heating, and reaction must occur before the heated pellet flies apart, the concept is often referred to as inertial confinement; that is to say, the thermonuclear reaction time must be shorter than the time required to overcome the inertia of the fuel mass. To provide the required compression and heating, an energy source,

often referred to as a driver, is needed that can deliver a pulse of many thousands of joules of energy to a tiny pellet of material in a fraction of a billionth of a second.



An experimental laser fusion system consists of the beam formation and amplification elements, represented in this figure as blue elements in the path of the laser beams, which are shown in red; the beam steering and focusing optics, shown in white, and the target chamber, also shown in white as a dodecahedron, to illustrate one focusing pattern of a 20-beam system. This is a model of the SHIVA laser now nearing completion at Lawrence Livermore Laboratory. Each of the beams is a laser chain of proven performance, so that we can estimate the beam energy that will strike a target positioned in the target chamber at the focal point of the optics. Complex computer codes are used to design an appropriate fuel pellet that will make the most of

this available power. In addition, highly sensitive diagnostic equipment is mounted in a target chamber to collect data from experiments for analysis and feedback into the codes, which must be constantly improved.



Particle beam generators such as this one developed at Sandia Laboratories are a very different approach to the driver problem, but much of the physics is common. In the CO_2 laser development program at Los Alamos, a series of increasingly higher power lasers is

being developed which promise to be much more efficient than Nd:glass lasers and can provide the high repetition rate that would be needed in a power reactor.

APPLICATIONS FOR FUSION ENERGY

WEAPONS TECHNOLOGY

- HIGH TEMPERATURE & PRESSURE MATERIALS STUDIES
- DATA APPLICABLE TO WEAPONS TECHNOLOGY
- IMPLOSION DYNAMICS
- WEAPONS PHYSICS EXPERIMENTS
- WEAPONS EFFECTS SIMULATION

ENERGY AND POWER APPLICATIONS

- CENTRAL STATION ELECTRICAL POWER GENERATION
- BREEDING OF FISSILE FUELS
- SYNTHETIC FUELS PRODUCTION
- PROCESS HEAT

The inertial confinement concept is an outgrowth of weapons technology developed in the early 1960's and has near-term applications to nuclear weapons design. Experiments using this technology are already contributing important data to weapons development, complementing that available from underground testing. In the longer term, inertial confinement fusion may be used for civilian power production. Major areas of potential commercial use of inertial confinement fusion include central station electrical power generation, fissile fuel produc-

tion, and perhaps synthetic fuels. Only the naval reactor program among current ERDA programs shares with laser fusion the potential for significant contributions to both the national security and the civilian energy development missions of ERDA.

LASER FUSION PROGRAM BUDGET

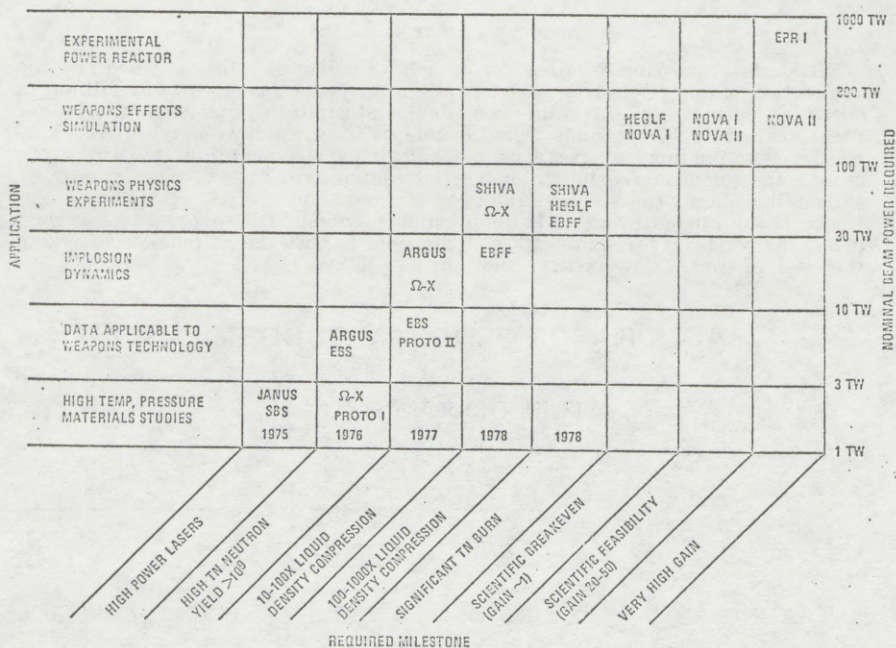
(\$ IN MILLIONS)

	FY 1977		FY 1978	
	B/A	B/O	B/A	B/O
OPERATING	\$ 80.0	\$ 75.8	\$ 101.0	\$ 94.0
CAPITAL EQUIPMENT	12.8	8.2	13.2	10.4
CONSTRUCTION				
NOVA	0	0	3.0	2.5
HEGLF	9.7	3.2	2.9	7.0
EBFA	9.1	1.5	1.9	2.5
SHIVA	0	9.2	0	3.6
TOTAL CONSTRUCTION	18.8	13.9	7.8	15.6
TOTAL PROGRAM	\$ 111.6	\$ 97.9	\$ 122.0	\$ 120.0

The fiscal year 1978 budget request for this program—the application of laser, electron and ion beams to pellet fusion—is \$94 million in operating outlays and \$21 million for plant and capital equipment

authority. These funds would enable us to continue research directed toward nuclear weapons technology development and toward determining the scientific feasibility of inertial confinement fusion.

REQUIREMENTS FOR ICF APPLICATIONS



This last figure is included to indicate the linkages between facilities, milestones in the program, and applications. On the left side can be seen the applications of inertial confinement fusion technology. Plotted along the horizontal are the major program milestones. The names of the facilities available or planned for the program are shown above the major program milestones they are expected to attain and opposite the specific applications that will be possible with each facility. The requirements for these applications are progressively more difficult as you move up the chart toward the first actual power generation test. Thus, weapons physics applications will be possible before we can confidently construct an experimental power reactor. The second milestone, high thermonuclear neutron yield, has been met using the Argus laser. This plus other target experiment results give us confidence we can meet the future milestones shown here for the program. Accomplishment of the major program milestones will provide immediate benefits in weapons technology development, near-term future benefits in weapons effects simulation, and lay the groundwork of potential long-term benefits in civilian power technology development.

I appreciate having had this opportunity to appear before you today to describe ERDA's inertial confinement fusion program. I will be happy to answer any questions the committee members may have.

[The prepared statement of Dr. C. Martin Stickley follows:]

PREPARED STATEMENT OF DR. C. MARTIN STICKLEY, DIRECTOR, DIVISION OF LASER FUSION ON THE INERTIAL CONFINEMENT FUSION PROGRAM

Mr. Chairman and members of the committee: I appreciate the opportunity to appear before this committee to discuss ERDA's inertial confinement fusion program and the related budget requests for fiscal year 1978.

BUDGET REQUEST SUMMARY

ERDA is requesting funding for inertial confinement fusion research—the application of laser, electron and ion beams to pellet fusion—of \$94 million in operating outlays and \$21 million for plant and capital equipment authority for fiscal year 1978. These funds would enable us to continue research directed toward impacting nuclear weapons technology development and toward determining the scientific feasibility of inertial confinement fusion as a virtually inexhaustible energy source for civilian power production.

The Laser Fusion Program is unique among current ERDA programs because it has the potential for significant contributions to both the national security and the civilian energy development missions of ERDA.

LASER FUSION PROGRAM BUDGET

(\$ IN THOUSANDS)

	FY 1977		FY 1978	
	B/A	B/O	B/A	B/O
OPERATING	\$ 80,000	\$ 75,800	\$101,000	\$ 94,000
CAPITAL EQUIPMENT	12,800	8,200	13,200	10,400
CONSTRUCTION				
NOVA	0	0	3,000	2,500
HEGLF	9,700	3,200	2,900	7,000
EBFA	9,100	1,500	1,900	2,500
SHIVA	0	9,270	0	3,670
TOTAL CONSTRUCTION	18,800	13,970	7,800	15,670
TOTAL PROGRAM	\$ 111,600	\$97,970	\$122,000	\$120,070

CHART 1

High power lasers have been under development since the early 1960's and have demonstrated their ability to generate thermonuclear neutrons in pellet implosion experiments since the early 1970's. Hence, the program is called Laser Fusion although it really encompasses all high power sources which can initiate inertial confinement pellet implosions. The overall program is directed by the Division of Laser Fusion, which was established during 1976 within the Office of the Assistant Administrator for National Security in ERDA. In the following presentation, the concept of inertial confinement pellet fusion and the applicability of lasers as well as electron beams and ion beams will be described in some detail.

In the President's Budget, there appear two distinct subprograms—Laser-Induced Implosion Fusion and Electron Beam-Induced Implosion Fusion. These are described at length in the accompanying justification of subprograms. In my presentation, I will concentrate on several specific aspects of the overall program effort—laser development, particle beam source development, target experimentation, and systems and advanced technology—as they relate to the near-term and long-term program objectives.

INERTIAL CONFINEMENT FUSION

1. Basic concepts

An early outgrowth of nuclear weapons development was a research program into the use of magnetic fields to contain thermonuclear fusion reactions. This program is based on the observation that a suitable gaseous plasma fuel at moderate densities and the high temperatures required for fusion might be contained by magnetic fields for seconds or minutes—long enough to produce net energy that could be converted to electricity or some other usable form of 14 MeV neutrons.

A later outgrowth of weapons technology, developed in the early 1960's, is based on a quite different concept: that a fusion energy release can be caused to occur from very small amounts of fuel that, if suddenly compressed to densities greater than that of a solid and heated to high temperatures by means of laser beams would, under proper conditions, yield more fusion energy than the input laser energy before the physical processes occurring in the fuel mass caused it to blow apart.

The term inertial confinement is used for this latter concept, since the reaction time would be shorter than the time required to overcome the inertia of the fuel mass.

INERTIAL FUSION CONCEPT

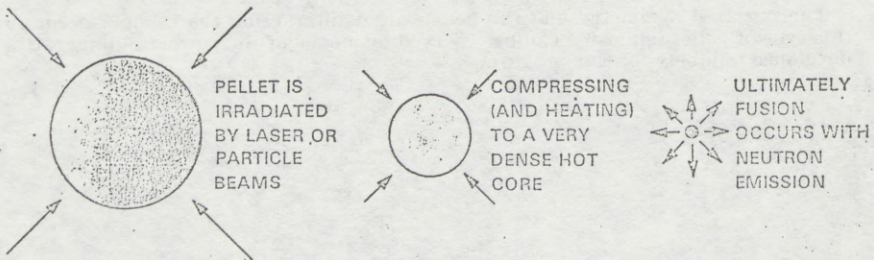


CHART 2

If the energy yield from the pellet exceeds twenty times that of the input power energy, we call this the demonstration of scientific feasibility, since the achievement of high energy yield from pellets will entail settling the basic physics questions remaining in the program.

Laser technology has progressed to the point where fusion reactions can be routinely induced in very small deuterium and tritium filled fuel pellets imploded by laser beams.

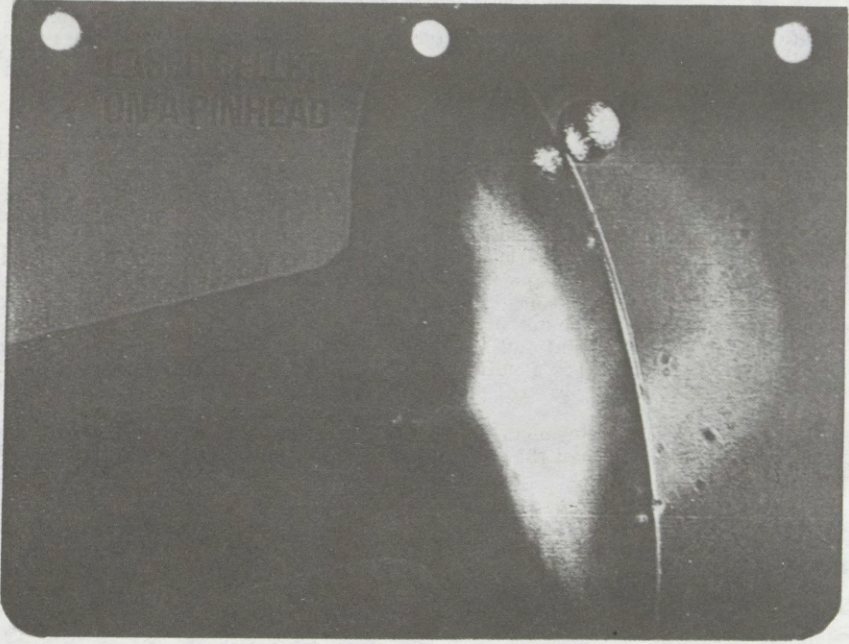


CHART 3

The required symmetry and the beam-target interaction that should occur in this type of pellet implosion can be observed by means of the powerful diagnostics developed uniquely for this program.

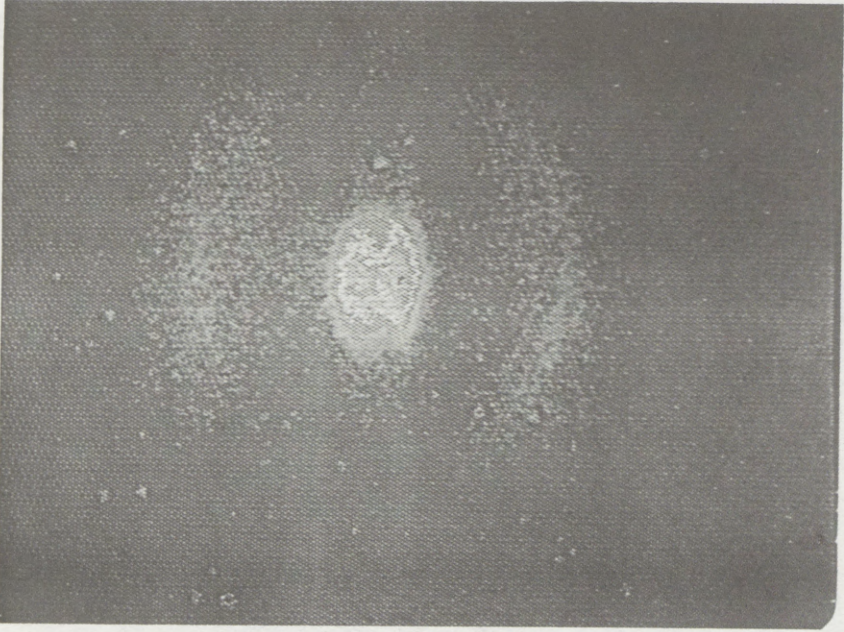


CHART 4

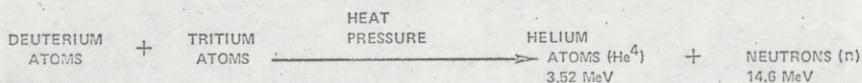
Very powerful lasers, careful control of the beam-target interactions, and precision design of the pellet will be required eventually to achieve conditions in the imploded pellets such that enough fusion energy is released to more than account for the energy needed to power the laser driver.

Another possible method of imploding the pellet is through the use of particles. Beams of electrons or ions appear to have some superior properties, such as their energy deposition in pellets, as compared with laser beams. The technology for particle beam production is relatively efficient and well developed compared to lasers, but particle beams are more difficult to focus on a target than with lasers. The complementary features of the two general approaches to inertial confinement have led to the inclusion of particle beam fusion research in the program. Since some of the target physics is common to both approaches, we expect that

the feasibility of inertial confinement fusion can be demonstrated without developing all the different driver concepts to fusion reactor power levels. This should lead to economies in the total program.

Both the magnetic and inertial confinement fusion concepts will initially employ a mixture of deuterium and tritium—the heavy isotopes of hydrogen—as their fuel.

NUCLEAR FUSION REACTION



MORE DIFFICULT REACTIONS

(REQUIRE MUCH HIGHER TEMPERATURES)

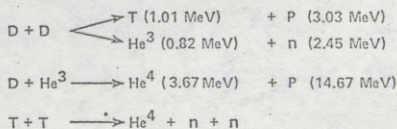


CHART 5

The major part of the energy from this reaction appears in the form of fast-moving neutrons that must be captured in a suitable blanket material, most probably a lithium compound since this material would breed additional tritium as well as give off heat to a thermal electric conversion system. Eventually, more difficult reactions may be possible such as the deuterium-deuterium reaction, which would not require radioactive tritium.

2. Applications and environmental advantages

Magnetic and inertial confinement differ fundamentally in that inertial confinement has near-term military applications.

APPLICATIONS TO THE NUCLEAR WEAPONS PROGRAM

- PROVIDES SUPPORT FOR UNDERGROUND TESTS
- POTENTIAL FOR LARGE-SCALE WEAPON EFFECTS SIMULATION
- ALLOWS MODELING OF ATMOSPHERIC NUCLEAR EXPLOSIONS
- PROVIDES UNIQUE CAPABILITY FOR MODELING OF NUCLEAR WEAPON PHYSICS INCLUDING:
 - NORMALIZATION OF DESIGN CODES
 - STUDIES OF IMPLOSION PHYSICS
 - MEASUREMENTS OF CRITICAL MATERIALS PROPERTIES

An inertial confinement fusion device would reproduce on a laboratory scale much of the fundamental physics and, if sufficiently large, many of the radiation effects of nuclear weapons. Laser and particle beam target experiments can pro-

CHART 6

vide data for weapons technology development; for example, late-time effects that cannot be measured in an underground test because of its destructive effects on diagnostic equipment can be analyzed on the basis of laboratory data. The early particle beam machines used in the program were developed for weapon effects studies rather than fusion research. Lasers developed for fusion research have recently reached the power levels and control of beam-target interactions needed to produce data that assist weapons design activities.

Preliminary application studies have been completed that show a great potential for the commercial application of inertially confined fusion.

ENERGY TECHNOLOGY APPLICATIONS

- ⊙ ELECTRICAL POWER GENERATION
- ⊙ FISSION-FUSION HYBRIDS
 - POWER
 - FUEL BREEDING
- ⊙ RADIOLYTIC GENERATION OF SYNTHETIC FUELS AND CHEMICAL FEED STOCKS
- ⊙ PROCESS HEAT

CHART 7

The broad categories of application include electric power, fissile fuel breeding, radiolysis of synthetic fuels, and process heat. The lithium fuel supply, using the D-T reaction, is adequate for at least 1,000 years. Fissile fuel breeding in a laser fusion system is more cost effective than other breeding schemes, allowing eight light water reactors to be fueled by one fusion-fission hybrid of the same size. There are no physical constraints now known that force laser fusion systems to be prohibitively large. This size advantage may permit the consideration of small, on-site laser fusion systems providing process heat, thereby avoiding intermediate energy forms and distribution networks. It is possible to use the energetic neutrons directly from the fusion reaction to produce chemicals or fuels from inexhaustible feed stocks such as water. Studies of these and other applications will continue.

Conceptual power plant designs permit some tentative projections of safety and environmental factors related to fusion energy feasibility.

SAFETY AND ENVIRONMENTAL ADVANTAGES

- NO POSSIBILITY OF NUCLEAR RUNAWAY
- NO AFTERHEAT COOLING PROBLEM WITH LOSS OF COOLANT WITH PURE FUSION
- NO CHEMICAL COMBUSTION PRODUCTS
- LOWER BIOLOGICAL HAZARD POTENTIAL THAN FISSION POWER

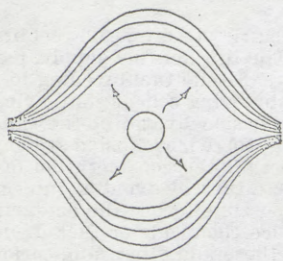
CHART 8

Tritium is hazardous, but it is thought to be containable below levels set by the Nuclear Regulatory Commission with small effect on power cost. Furthermore, the required inventories of tritium at fusion power plants would be relatively small. The disadvantages of tritium handling would be far exceeded by the advantages over fission plants—no risk of a runaway reaction or loss of coolant problem, little radioactive waste disposal problem, and significantly lower biological hazard potential.

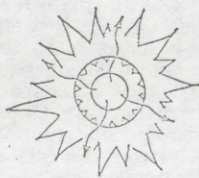
3. Magnetic and inertial fusion contrasted

In contrast with inertial confinement, magnetic confinement has already begun to address some areas of reactor technology development.

TWO APPROACHES TO FUSION



MAGNETIC CONFINEMENT



INERTIAL CONFINEMENT

- BOTH HAVE POTENTIAL AS SAFE, CLEAN, VIRTUALLY INEXHAUSTIBLE ENERGY SOURCE IN NEXT CENTURY
- DEVELOPING STEADY-STATE SYSTEMS APPROACHING REACTOR CONDITIONS
- DEVELOPING REACTOR TECHNOLOGY
- DEVELOPING SINGLE-PULSE SYSTEMS TO DEMONSTRATE HIGH GAIN IMPLSIONS
- INVESTIGATING DRIVERS WHICH COULD BE REPETITIVELY PULSED FOR COMMERCIAL USES
- NEAR-TERM WEAPONS DESIGN AND TEST APPLICATIONS EVEN AS SINGLE-PULSE ENERGY SOURCE

CHART 9

Since the two programs take fundamentally different approaches to the fusion problem, there is little synergism between the two programs other than in reactor technology and system studies. With the possible exception of reactor materials

issues, breakthroughs or obstacles encountered in one program are not likely to have much impact on the other in the near term. These are best viewed as distinct long-term energy programs, along with the fission breeder and solar electric technologies.

PROGRAM STRUCTURE AND GOALS

1. Influence of weapons development experience

Experience with nuclear weapons development provided much of the impetus to inertial confinement fusion research and has contributed to the advanced pellet designs that appear at this time to have the best chance of attaining high energy gain implosions.

EVOLUTION OF LF PROGRAM

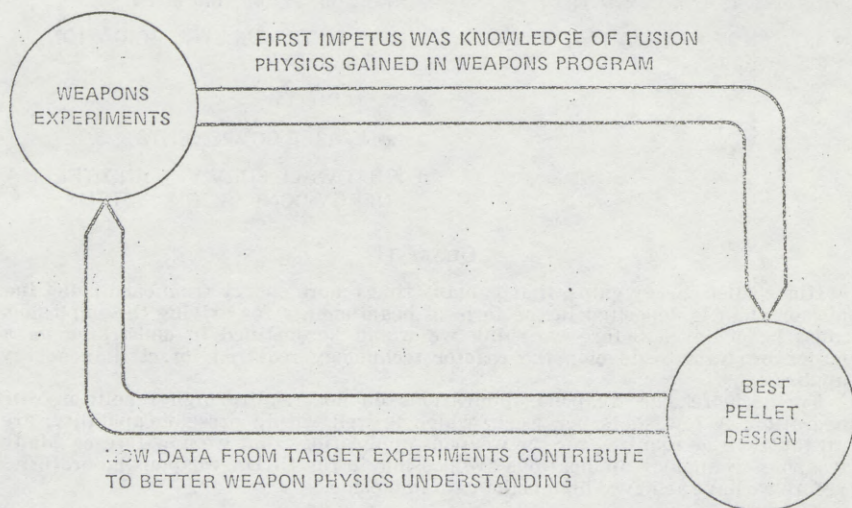


CHART 10

In return, actual experimental results have begun to contribute to weapons technology development. This contribution is expected to grow to be a very significant one as we attain higher and higher thermonuclear yields from pellet implosion experiments.

The reinforcing relationship between weapons development experience and inertial confinement fusion pellet experimentation speeds the development of both the weapons and fusion programs. Advanced pellet design uses complex computer codes to model experiments and subsequently bring about, on the basis of experimental results, improvements in the physics codes. A relatively low-cost program to continue experimentation with unclassified pellet concepts appears to be warranted because of the eventual need to develop very low-cost pellets for use in civilian inertial confinement fusion reactors.

2. Differing military and civilian applications requirements

ICF APPLICATIONS REQUIREMENTS

WEAPONS DESIGN & TESTING

- o LOW ENERGY YIELDS FOR WEAPONS DESIGN DATA
- o HIGH ENERGY YIELDS FOR EFFECTS SIMULATION
- o SINGLE-PULSE OPERATION
- o LOW SHOT RATE (A FEW SHOTS PER WEEK)

LONG-TERM ENERGY OPTION

- o VERY HIGH ENERGY GAIN PER PELLET IMPLOSION
- o REPETITIVE OPERATION (10-50 PULSES PER SECOND)
- o EFFICIENCY (MINIMUM 1%)
- o HIGH RATE PELLET FABRICATION AND INJECTION
- o RELIABILITY
- o LONG-LIFE COMPONENTS
- o FIRST WALL SURVIVAL AND THERMA ENERGY CONVERSION SYSTEM

CHART 11

High pellet energy gains, that is many times more energy from each pellet implosion than is deposited in the form of beam energy for driving the implosion, must be achieved before we think we would be justified in embarking on a major program to develop the reactor technology required for civilian energy applications.

Furthermore, the weapons applications do not require high repetition rate operation. A few shots per week, which is well within present capability, are all that will be required for the weapons applications that we now foresee. Many weapons technology applications are possible in the ERDA weapons laboratories before we have achieved high pellet gain implosions.

3. Roles of program participants

The program is now structured so that our major effort is directed simultaneously toward first, achieving high energy pellet gain, and second, making possible immediate weapons technology applications.

ICF PROGRAM STRUCTURE

- o MAJORITY OF BASE PROGRAM IS IN THE WEAPONS LABORATORIES WHERE WEAPONS TECHNOLOGY CAN BE APPLIED TO FUSION RESEARCH WHILE NUCLEAR WEAPONS CONCEPTS ARE PROTECTED
- o OTHER RESEARCH ORGANIZATIONS PARTICIPATE IN AREAS OF SUPPORTING TECHNOLOGY DEVELOPMENT AND BASIC RESEARCH
- o ROLE FOR MAJOR INDUSTRY WILL OCCUR AFTER SUCCESS IN THE CORE PROGRAM DEMONSTRATES THE FEASIBILITY OF ICF

CHART 12

This effort is the core program, which is supported by smaller-scale experiments, technology development, and training activities. Other research efforts

are directed toward meeting the long-term energy technology goals of inertial confinement fusion. These latter efforts are relatively small because the energy goals are more distant ones and are contingent on our ability to demonstrate in the near term the scientific feasibility of high energy yield from pellet implosions.

The development of the full inertial confinement fusion technology capable of meeting near-term program goals requires the construction and operation of large driver systems, the use of classified pellet design concepts, and the use of high-speed computer facilities and diagnostics, all in the iterative process of pellet design and experimentation. These capabilities are uniquely available at the ERDA weapons laboratories. Furthermore, the weapons laboratories facilitate the use and safeguarding of classified data. Also, large investments in facilities are more appropriate at government installations having broad and deep research and development programs and capabilities, thus enabling the application of these resources to a broad range of technical efforts of national importance.

Supporting research and technology development are performed by other government laboratories, industry and universities, or by the ERDA laboratories on a competitive basis.

The current effort in reactor technology development is limited but is contracted to the best qualified organizations, some of which are also participants in related areas of the magnetic fusion energy program. In the near term, this area of the inertial confinement fusion program may benefit significantly from work that is sponsored by the magnetic confinement fusion program in areas of common interest such as reactor energy systems, materials, and economic and environmental analyses.

A role for major industry will occur after the research phase of the program; that is, the demonstration of scientific feasibility. However, several industrial and utility companies are already participants in the program through the National Laser Fusion Users Facility at the University of Rochester.

In summary, based on the pertinence of the background experience of the ERDA weapons laboratories to inertial confinement fusion and the relevance of the early phases of this research to weapons technology design questions, the following program objectives have been established:

Near term:

- Demonstrate single-pulse inertial confinement fusion; and
- Assist nuclear weapon development and testing.

Long term:

- Develop the technology for energy and power plant (multiple-pulse) applications.

PROGRAM FUNDING SUMMARY, PARTICIPANTS, AND GOALS

1. Summary of program funding

ERDA is requesting \$94 million in operating outlays for the program in fiscal year 1978.

SUMMARY OF PROGRAM FUNDING

(\$ IN THOUSANDS)

	<u>FY 1977</u>	<u>FY 1978</u>
OPERATING FUND OUTLAYS		
CATEGORY I		
SINGLE-PULSE ICF & WEAPONS DESIGN APPLICATIONS		
LASER DEVELOPMENT	23,730	19,500
PARTICLE BEAM SOURCE DEVELOPMENT	8,150	9,300
FUSION THEORY & EXPERIMENTS	32,490	50,050
CATEGORY II		
POWER PLANT TECHNOLOGY	11,430	15,150
PLANT AND CAPITAL EQUIPMENT AUTHORITY	31,600	21,000
o All plant funds go to Category I		
o ~ 8% of capital equipment funds go to Category II		

CHART 13

About 84 percent of the total would go to support laser and particle beam machine development and fusion experiments leading to high-gain, single-pulse operation of experimental devices that will be almost entirely applicable to both nuclear weapons technology development and eventual use in civilian power systems. The total amount of \$8 million in funding for construction projects, and about 92 percent of the \$13 million in funding for capital equipment other than construction, would support the development of single-pulse inertial confinement fusion.

Some 16 percent of operating outlays, and about 8 percent of the equipment funding, would support program efforts that are directed primarily toward power plant technology development, which will require high repetition rate operation of a complete driver, pellet, and energy conversion system.

2. Program participants

Each of the ERDA weapons laboratories is a leading participant for a major approach to inertial confinement fusion.

LARGEST PROGRAM PARTICIPANTS, ROLES, AND MILESTONES

LAWRENCE LIVERMORE LABORATORY; LIVERMORE, CALIFORNIA

- GLASS LASERS AND TARGETS
- DEMONSTRATE HIGH PELLET GAIN (NOVA)
- UNDERSTAND IMPLSION DYNAMICS

KMS FUSION; ANN ARBOR, MICHIGAN

- SMALL GLASS LASERS AND TARGETS
- DEVELOP PELLET FABRICATION TECHNIQUES

UNIVERSITY OF ROCHESTER; ROCHESTER, NEW YORK

- MEDIUM GLASS LASER
- NATIONAL USERS FACILITY

LOS ALAMOS SCIENTIFIC LABORATORY; LOS ALAMOS, NEW MEXICO

- CO₂ GAS LASERS AND TARGETS
- EVALUATE CO₂ LASER APPROACH
- DEMONSTRATE UNITY PELLET GAIN (HEGLF)

SANDIA LABORATORY; ALBUQUERQUE, NEW MEXICO

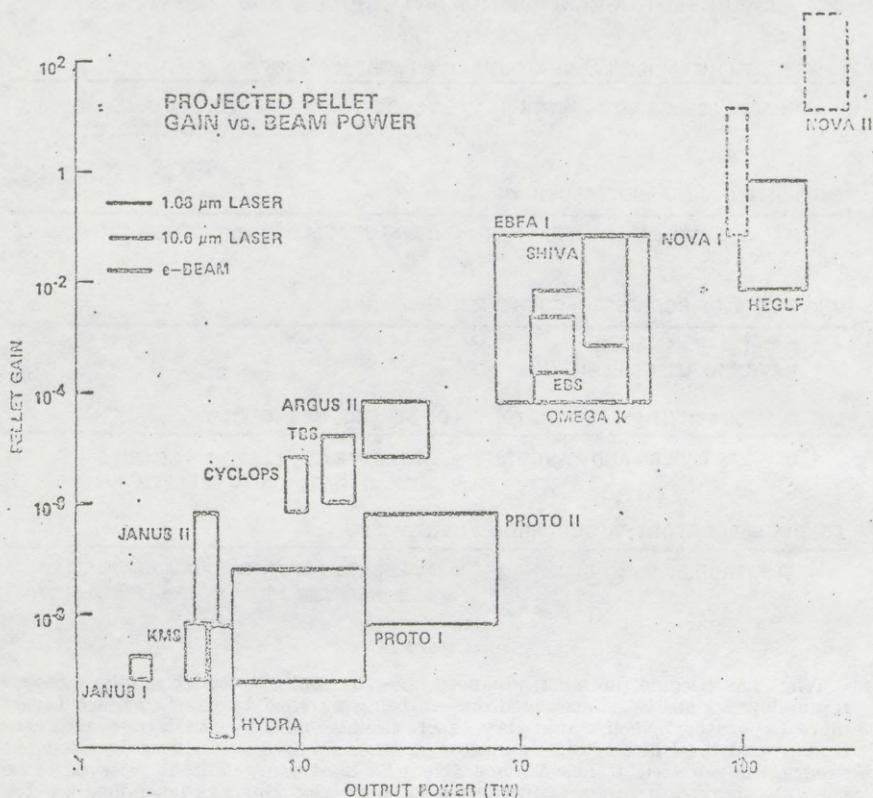
- ELECTRON BEAM SOURCE
- EVALUATE ELECTRON BEAM APPROACH
- DEMONSTRATE PELLET GAIN OF 0.01 (EBFA)

CHART 14

What has become the most advanced laser technology—which employs neodymium-doped glass as a laser medium—is being pursued by the Lawrence Livermore Laboratory. Neodymium glass lasers are also used by smaller research centers around the United States and abroad. The carbon dioxide laser development program is centered at Los Alamos Scientific Laboratory. This is believed to be the only significant program in the world to develop this gas laser medium for fusion applications aside from a newer and still small effort in Canada. Particle beam development for fusion is centered at Sandia Laboratories. Albuquerque, based upon pulsed power technology originally developed at Sandia for weapon effects research. The only other particle beam fusion program—and a much larger one—is in the Soviet Union. The University of Rochester is developing, with Federal, State, and industrial participation, a center for laser fusion research that is to be available for users from other institutions. The Naval Research Laboratory conducts laser-target interaction experiments as an ERDA contractor. KMS Fusion, Inc., conducts research in pellet fabrication and laser-target interactions with funding from ERDA.

3. Program facilities

The base program consists of the development of experimental systems—laser and particle beam machines—as well as the pellet design and fabrication and diagnostic capabilities, required to meet the major program milestones.



The SHIVA laser facility at Lawrence Livermore Laboratory, and the Electron Beam Fusion Facility at Sandia Laboratories, Albuquerque, are designed to produce significant thermonuclear burn in fuel pellets. The High Energy Gas Laser Facility (HEGLF) at Los Alamos is designed to operate in the region of scientific breakeven—the point beyond significant thermonuclear burn at which the energy out of the pellet equals the energy of the laser beam. The Nova project at Livermore, an upgrade of the SHIVA facility, would be designed to achieve still more fusion burn to produce pellet energy gains on the order of 10 to 100 and perhaps higher.

To attain these milestones for pellet gain requires the simultaneous development of successively larger drivers and continual improvement in our ability to understand and control beam-target interactions. The program as currently funded permits ongoing target experimentation on machines now available, as well as relatively low-risk design and development efforts leading to the more powerful machines and more advanced pellets required to meet future milestones. Our projected fiscal year 1978 program emphasizes fusion theory and target experimentation activities that will use the existing devices more intensively, while slowing down the introduction of some new facilities that have been planned previously in the program.

USES OF ICF PROGRAM OPERATING FUNDS - FY 1978

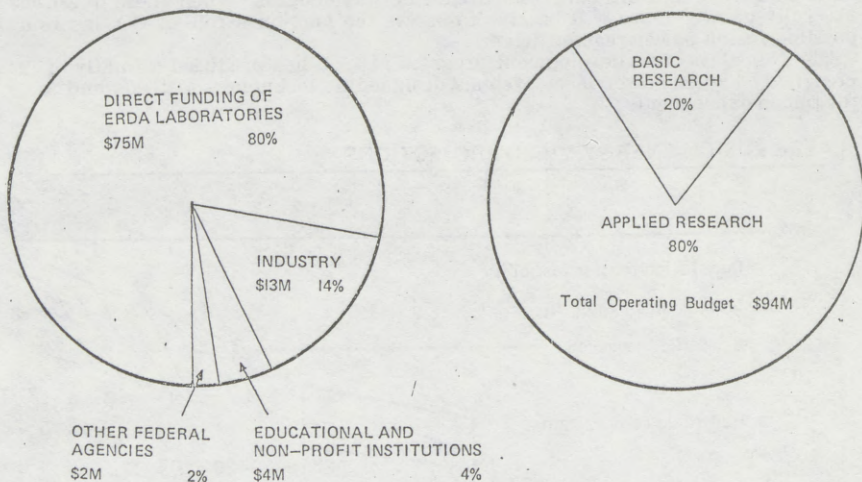


CHART 16

4. Reactor technology

A relatively small but crucial part of the program funding requested for fiscal year 1978 would support program goals in the area of powerplant technology. These efforts emphasize the development of efficient, high repetition rate driver technologies such as one would need for a fusion reactor. These are to develop by 1981 a 1000 Joule new laser with potential capability for the required repetition rate, and to perform studies leading to a future determination of how to best pursue the heavy ion fusion approach. In addition, we must perform some detailed analyses of commercial systems in order to identify critical technologies required to develop a fusion reactor based on inertial confinement.

In fiscal year 1978 the program is not funded to undertake some of the long-term tasks that are already identified: materials, automated pellet manufacturing, repetition-rate technology, reactor design, and the fuel cycle.

DETAILED PROGRAM ACCOMPLISHMENTS, MILESTONES, AND FUNDING

1. Laser development

The Division of Laser Fusion is supporting an ongoing program of laser research and development to meet program needs in the near term for single pulse experiments and for weapons applications.

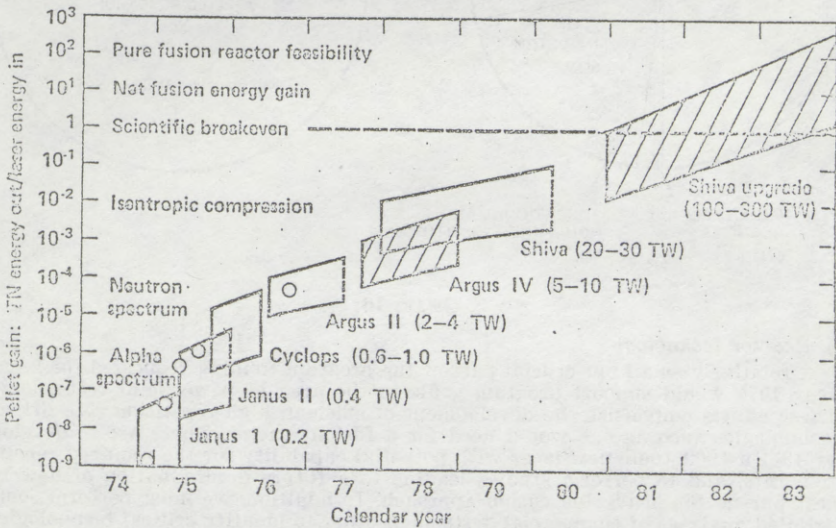
The laser development program consists of two principal efforts: Neodymium: glass (Nd: glass) laser development and carbon dioxide (CO_2) laser development. Nd: glass lasers are, at present, the most highly developed laser technology for fusion experimentation and, therefore, represent the lowest risk approach to achieving the near term objective of demonstrating the scientific feasibility of inertial confinement fusion. The Nd: glass laser development effort is centered at the Lawrence Livermore Laboratory, Livermore, Calif.

The development of CO_2 lasers for fusion purposes is less advanced than Nd: glass laser development. However, CO_2 is an inherently more efficient medium than Nd: glass and can be cooled rapidly because CO_2 is a gas. Because of these basic advantages and because of a large existing technology base for CO_2 lasers, research in this area offers a potential major advantage to the program as a high repetition rate fusion reactor driver. The CO_2 laser program is centered at the Los Alamos Scientific Laboratory, Los Alamos, N.M.

At present we are resolving several questions about the differences between laser-initiated implosions performed at the 10 micron wavelength of the CO_2 laser and those performed at much shorter wavelengths. When these questions are fully answered we will be able to assess the long-term role of CO_2 lasers as possible fusion power reactor drivers.

The Nd: glass laser development program at LLL has produced a family of increasingly higher power laser systems designed as technology testbeds and tools for fusion experiments:

LASER FUSION ENERGY YIELD PROJECTIONS



12/75

CHART 17

The Janus laser operated in 1974 at a power of 0.4 terawatt (TW); the Cyclops laser operated in 1975 at the 1 TW level, and most recently the Argus laser which is currently operational. The Argus laser, designed as a 2 TW, 2-beam

device, has exceeded design goals and has operated at a power level in excess of 4 TW on target, making it the most advanced fusion laser in the world.

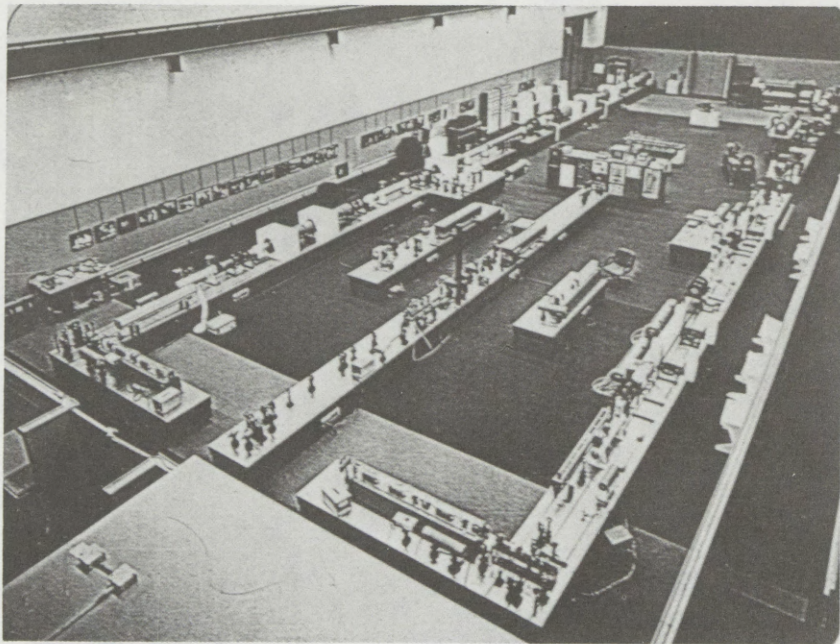


CHART 18

Laser design improvements made at LLL and demonstrated on Argus appear to control what is termed beam breakup, a nonlinear optical interaction between the propagating laser pulse and the transparent optical materials through which it propagates. This interaction has, in the past, presented severe limitations on the focusable power of Nd:glass lasers. The performance of Argus above design levels now permits us to project with confidence to still larger laser systems that represent the lowest-risk approach to the attainment of our major program milestones.

The first in the next generation of Nd:glass lasers will be the Shiva laser now nearing completion at LLL.

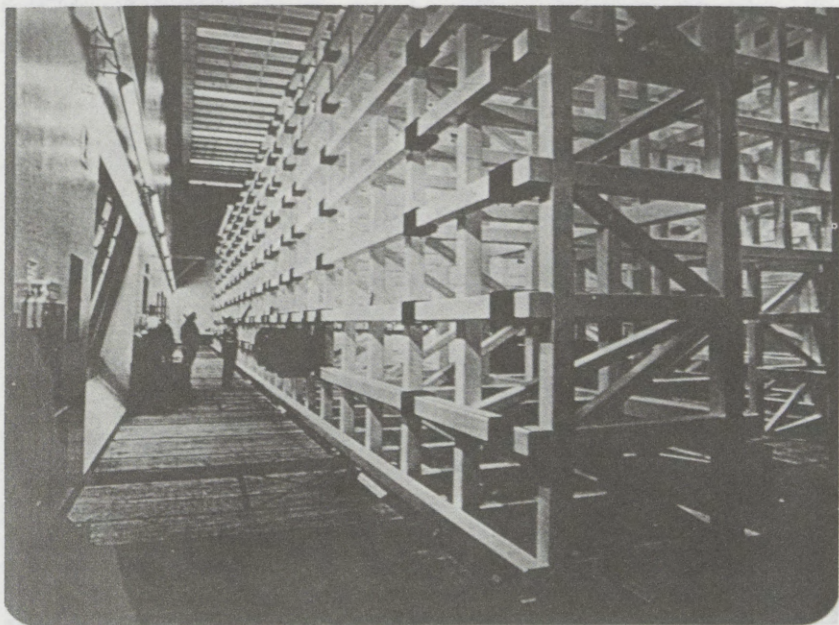


CHART 19

This 20-beam laser system, based largely on the proven Argus system, will generate laser pulses with powers of 20-30 TW. In a long pulse mode (~ 1 nano-second= 10^{-9} seconds) this laser will generate pulses of 10-15 kilojoules. The Shiva laser will be operational in the first quarter of fiscal year 1978 and during the first year of operation is expected to achieve target gains of 0.01 to 0.1. The upper limit on its capabilities will probably be determined by advances in target design.

In the fiscal year 1978 budget, we are requesting an initial \$3 million authorization for engineering design of an advanced Nd:glass laser system, Nova, which is being planned as an upgrade of the SHIVA laser system.

SHIVA NOVA LASER SYSTEM

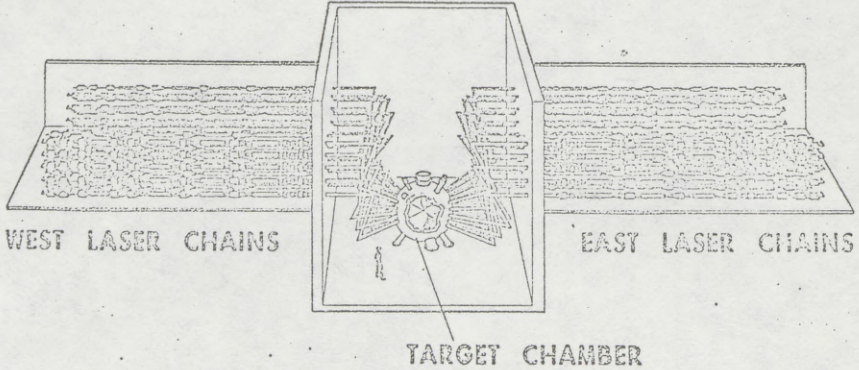


CHART 20a

The Nova system is being designed to generate laser pulses in the 150-300 TW range with energies of 100-300kJ. This system should be capable of demonstrating high energy, high gain pellet implosions and thereby demonstrate the scientific feasibility of inertial confinement fusion. Phase I, scheduled for completion in fiscal year 1982, should attain gains of 20. Phase II, which would be completed in 1984-85, should attain much higher pellet gains.

We are also requesting in fiscal year 1978 continued funding of the laser equipment for a national laser fusion users' facility at the University of Rochester in Rochester, N.Y.



CHART 21

This facility, which is planned to include a large Nd : glass laser system (Omega Ten), is being designed and constructed by the University with funds provided by ERDA, the State of New York and the General Electric Co. Northeast Utilities, and EXXON Corp. During 1976 a prototype laser system was constructed and operated, and detailed plans were developed for the full 24-beam system. At present we are seeking to define the next phase of the project which will be the construction of the facility at an intermediate power level.

In the CO₂ laser development program at Los Alamos, a series of increasingly higher power lasers is being developed both to advance the technology and for fusion experimentation.

CO₂ FUSION LASERS

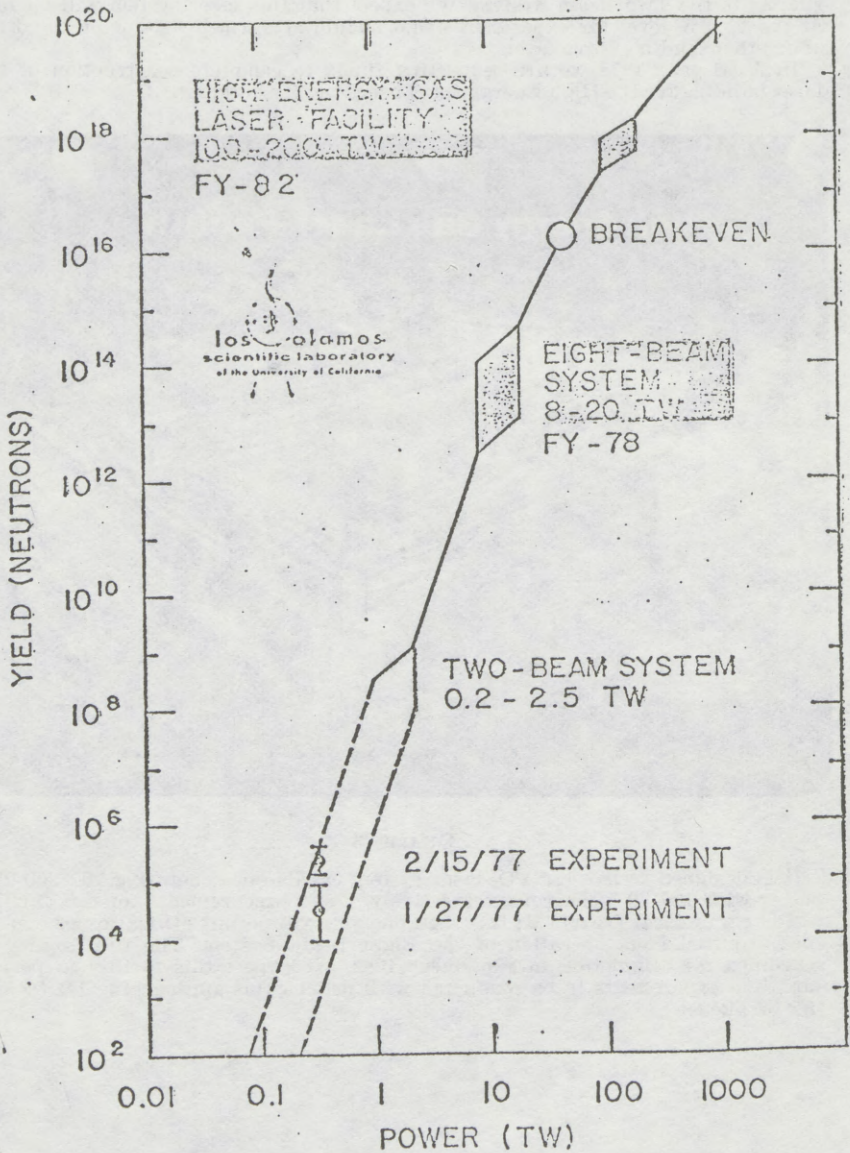


CHART 22

The Two Beam System has recently operated at the 0.8 TW level. With further development we expect that this system will be capable of achieving in excess of 2 TW on target. The Two Beam System will serve to test techniques for multiline, short-pulse energy extraction and target isolation which will be essential in the development and use of higher power CO₂ laser systems.

The Eight Beam System, which is now under construction and projected to begin operation in early 1978, will consist of four modules, each of which is similar to the Two Beam System. We expect that this laser system will operate at the 10 TW level for experiments that should attain pellet gains on the order of one-thousandth of breakeven.

In fiscal year 1978 we are requesting funds to complete construction of the laser building for the High Energy Gas Laser Facility building.

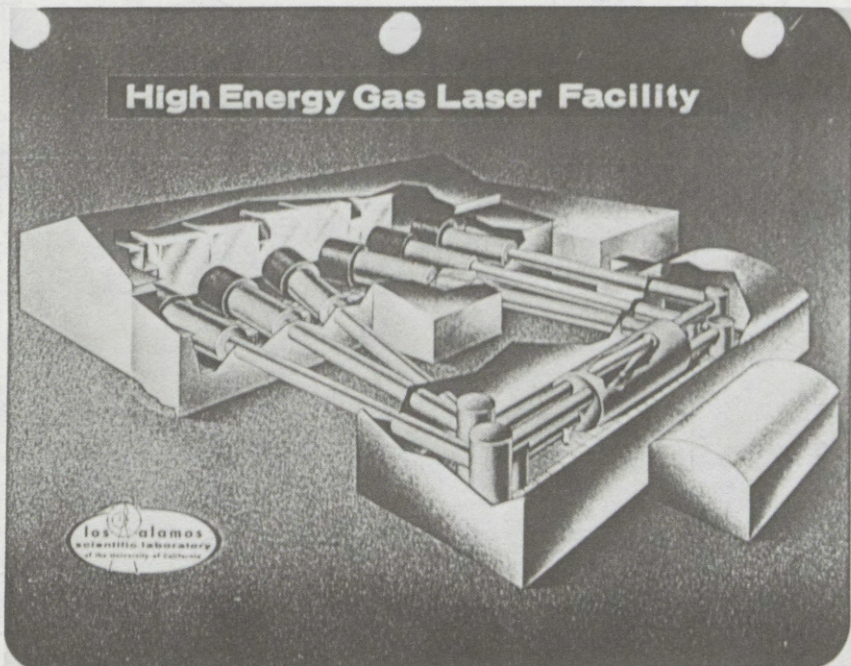


CHART 23

It is designed to house a CO₂ laser system capable of generating 100-200 TW pulses with 100-50 kJ energies respectively. Laser procurements for this facility will begin in fiscal year 1979; this time phasing will permit utilization of experience acquired from operation of the Eight Beam System. The full facility is scheduled for completion in September 1982. We expect this facility to permit implosion experiments to be conducted with pellet gains approaching 1.0 (scientific breakeven).

2. Particle beam source development

The particle beam source development program, centered at Sandia Laboratories, has grown out of earlier Sandia work in pulsed power generators for weapon effects research. These accelerators promise to be relatively inexpensive, efficient and simple generators of intense beams of electrons or ions, which could initiate repetitive inertial confinement fusion microexplosions in an eventual power reactor. A series of accelerators of increasing power is being built to evaluate the physics of particle beams and their interaction with fusion targets, and to arrive at a design for an optimized prototype particle fusion reactor in the 1980's.

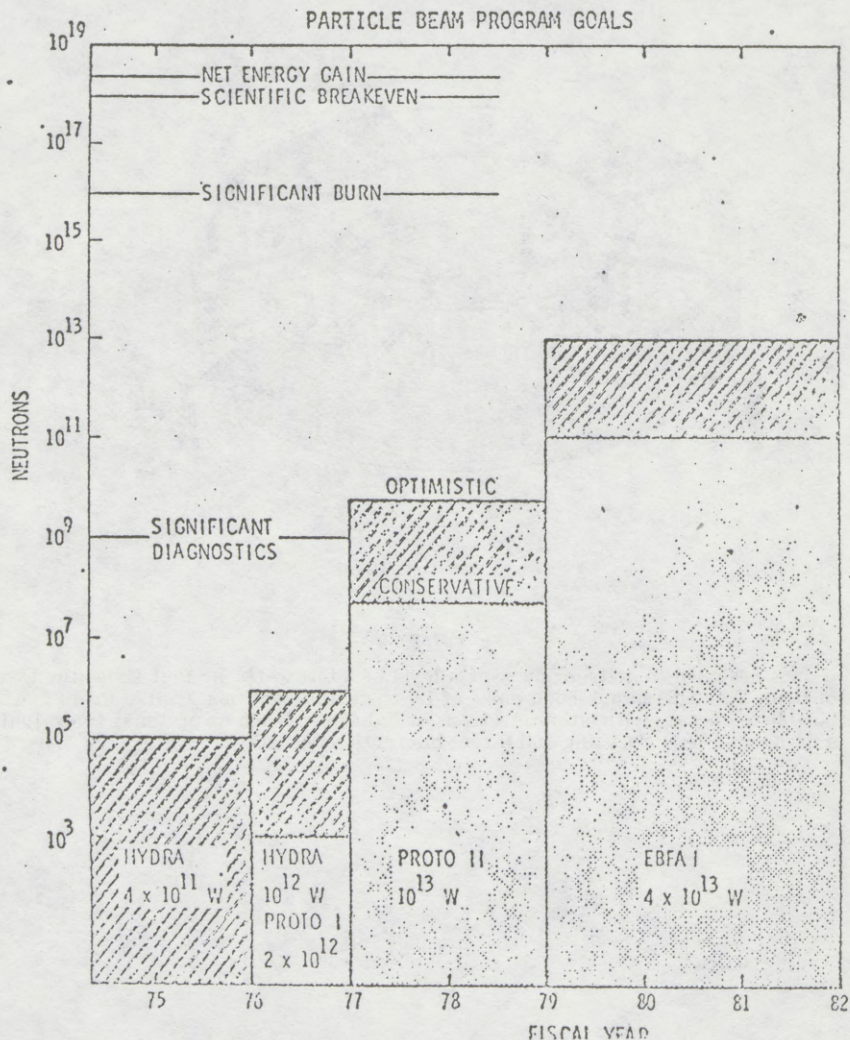


CHART 24

Proto I became operational in 1975. It has been used to test a number of fundamental technological concepts and has delivered two electron beams to a single target with faster pulse risetimes and significantly higher peak power than previously possible. This oil-insulated accelerator, designed to deliver about 2

terawatts of 3 megavolt electrons in a 24 nanosecond pulse has already shown, in critical experiments carried out during the past year, that beams can be focused from large-area diodes with such short-duration pulses. Fusion target experiments, which produce measurable numbers of thermonuclear neutrons, are now underway on Proto I.

Operation started in early 1977 on Proto II, the prototype water-insulated accelerator.

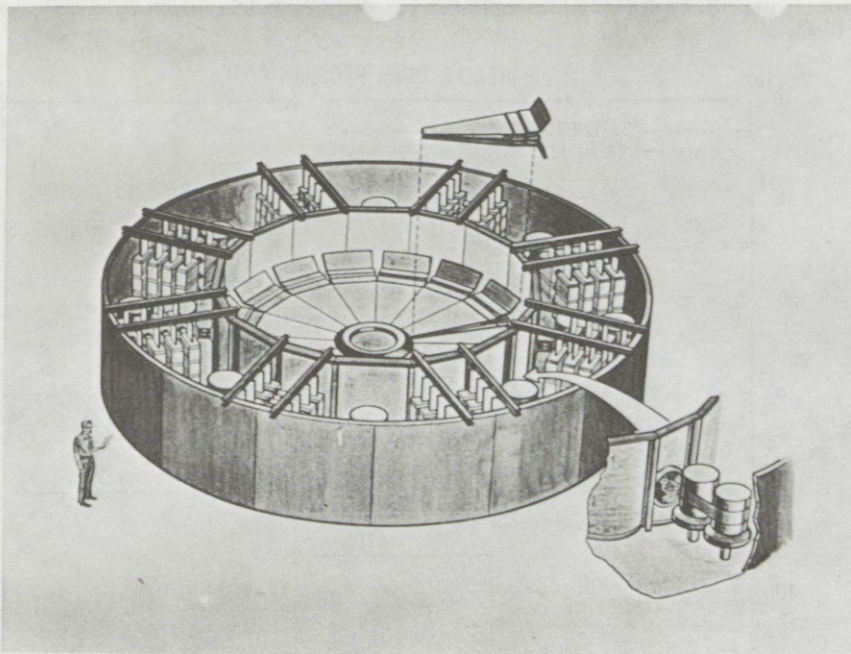


CHART 25

It is designed to deliver power at a level of 8 terawatts, or four times the level of Proto I, in a 24 nanosecond pulse of 1.5 megavolt electrons. It, like Proto I, will be able to operate with either electrons or light ions (such as protons) to evaluate a number of beam focusing and target interaction options.

In early 1977 construction was initiated on the Electron Beam Fusion Facility.

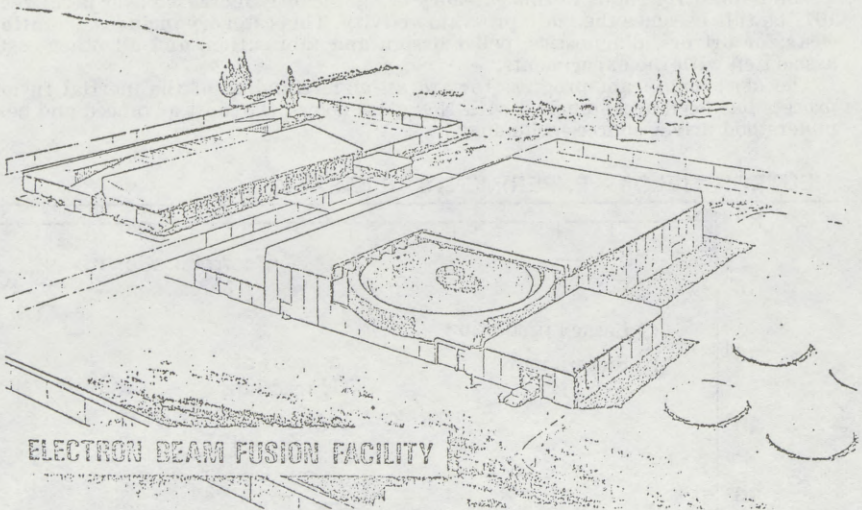


CHART 26

It will house a water-insulated accelerator EBFA-I, which will be operational early in 1980. This generator will be similar in design to Proto II, but some five times more powerful. At the 40 terawatt level, EBFA-I should be able to perform definitive experiments regarding particle and target parameters.

It should be noted that a vigorous Soviet electron beam fusion program recently has been announced at the Kurchatov Institute in Moscow. It will use a different approach to concentrating the electron beam energy in a small target, and is being pursued on the same timetable but on a much larger scale than our efforts.

A cooperative R. & D. effort is being formulated involving the Division of Laser Fusion and the Defense Nuclear Agency (DNA). It will utilize their considerable experience in pulsed power technology for the inertial confinement fusion program and for other projects of mutual interest.

3. Fusion experiments and theory

The request for funds in this category is significantly increased over fiscal year 1977 as this becomes the main program activity. This category includes operating costs for drivers, diagnostics, pellet design and fabrication, and all other costs associated with the experiments.

The most significant progress toward an understanding of the inertial fusion process has been accomplished with Nd: glass lasers, the most advanced and best understood driver source technology.

NEUTRON YIELDS - EXPERIMENTS VS LASNEX

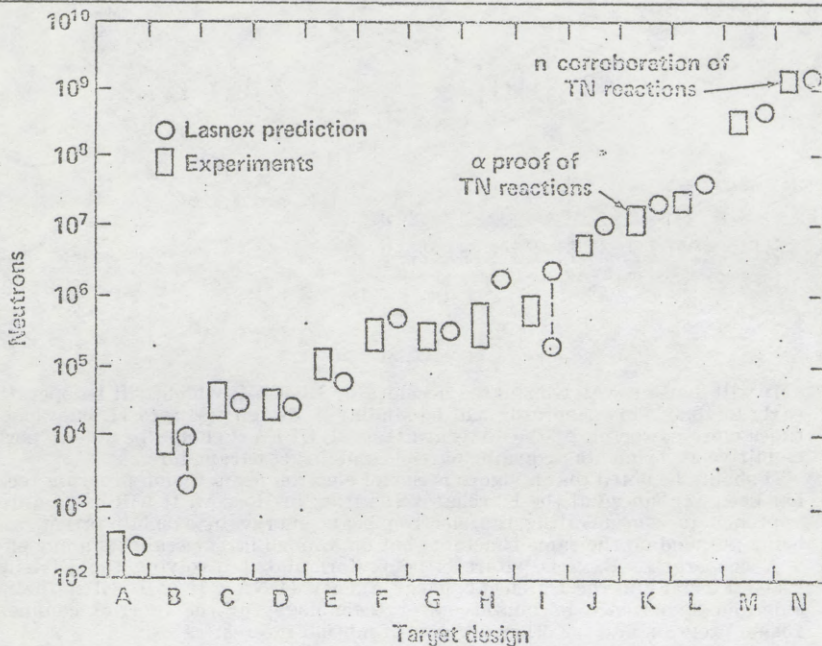


CHART 27

Through target experimentation with these lasers we have predicted and measured neutron yields over a range of 10^7 . This gives us great confidence that

we can achieve the forthcoming program milestones with the Shiva and Nova systems.

TARGET EXPERIMENT ACCOMPLISHMENTS

- NEUTRON YIELD FROM TARGET IMPLOSIONS HAVE RISEN FROM 10^5 AT THE BEGINNING OF 1976 TO 10^9 IN RECENT EXPERIMENTS
- FUSION ION TEMPERATURES AND NEUTRON YIELDS APPROACH THOSE NEEDED FOR FUSION REACTOR; EQUAL THOSE OF ANY EXPERIMENTS IN THE INERTIAL OR MAGNETIC CONFINEMENT PROGRAMS
- COMPUTER CODES PREDICT RESULTS TO BETTER THAN A FACTOR OF TWO OVER AN OBSERVED NEUTRON RANGE OF 10 MILLION
- ACHIEVED FIRST SIGNIFICANT FUEL COMPRESSION - 10 X LIQUID DENSITY
- BASIC INTERACTION OF CO_2 LASER LIGHT WITH TARGETS IS ENCOURAGING
- FIRST NEUTRON YIELDS FROM E-BEAM TARGET IMPLOSIONS

CHART 28a

A particularly important milestone was accomplished in September 1976 when a pellet implosion was produced using an advanced target design on the multi-terawatt ARGUS laser system.

This experiment produced fusion ion temperatures of 8 keV (90 million degrees centigrade) and a thermonuclear neutron yield of 1.5×10^9 neutrons (a factor of 100 increase over 1975 results). These results approach as close to the conditions needed for a fusion reactor as any attained so far in the magnetic confinement program, corresponding to a DT fusion gain (i.e., fusion energy out as a fraction of plasma thermal energy of 1 percent.)

FOR FUSION, ALL PLASMAS MUST

- BE CONFINED LONG ENOUGH TO BURN (LAWSON CRITERIA):

$$n \tau \gtrsim 10^{14} \frac{\text{sec}}{\text{cm}^3}$$

- BE HOT ENOUGH:

$$T \gtrsim 10 \text{ keV}$$

THE GAIN OF A DT PLASMA IS:

$$G = \left(\frac{\text{FUSION ENERGY RELEASED}}{\text{PLASMA ENERGY}} \right) \propto \frac{n \tau}{T}$$

CHART 29a

One measure of the progress of all fusion devices toward reactor-like conditions is the quality of confinement or "Lawson number," which is the product of the fusion plasma density and the confinement time of the plasma.

The various magnetic confinement experiments which have been performed or are planned are shown on the accompanying graph in terms of their Lawson number and their plasma temperature.

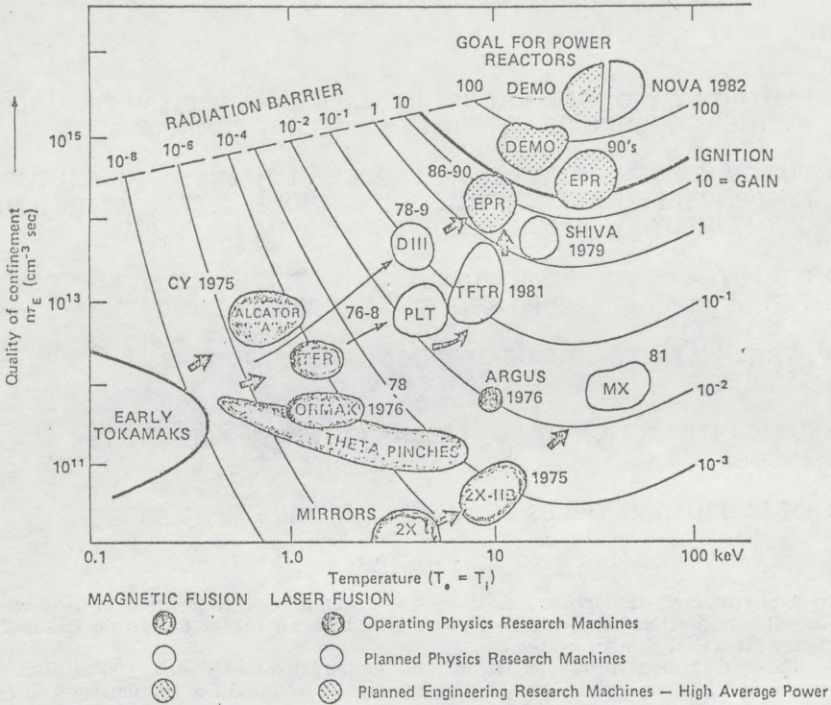


CHART 30

Also shown are the Nd: glass laser fusion experiments in the Lawrence Livermore Laboratory program. The main observation is that the ARGUS experiment is about a factor of ten closer to ignition conditions than any other fusion experiment to date. It should be noted, however, that the inefficiencies of the implosion process itself are such that an ICF reactor would probably have to operate at about ten times the gain of a Tokamak-like reactor. This is shown on the graph by the position of the laser fusion DEMO at gains of the order of 200, as compared to the magnetic confinement DEMO which is projected to run in the gain 10 to 100 region.

The other major caveat is that a plot such as this is a very inadequate representation of progress toward commercial fusion reactors. It omits such factors as duty cycle, efficiency and cost which ultimately will be crucial. A unique feature of the inertial confinement approach to fusion power, however, is the ability to separate many of the scientific issues which can be addressed in single-pulse experiments, such as are presently in progress, from those problems that relate to the high repetition rate, high average power conditions of a reactor.

- LASER FUSION HAS ACHIEVED GAINS OF 10^{-2} .
- AN ICF REACTOR MUST REACH GAINS OF 200; NOVA WILL DO THIS.
- MICROEXPLOSIONS ALL HAVE $\tau \approx 2 \times 10^{-11}$ SEC. TO REACH HIGH GAINS, WE MUST CONCENTRATE ON INCREASING DENSITIES TO 1,000-10,000 TIMES LIQUID.

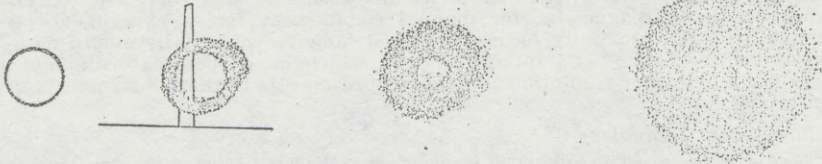
CHART 31

Furthermore, it is possible to explore the tradeoffs between confinement times and temperatures by varying pellet designs. Magnetic confinement concepts do not afford this degree of flexibility.

A second major step forward was the determination of ion temperatures of several keV deduced from neutron time-of-flight measurements taken during a separate pellet implosion experiment on Argus. This measurement confirmed the thermonuclear origin of the neutrons and added to a self-consistent model we have developed for the pellet implosion fusion process. All of these experiments have demonstrated the effectiveness of our highly sophisticated computer codes which are being used to model these and future inertial fusion experiments. The codes are capable of predicting important experimentally measurable parameters such as ion temperature and neutron yield to better than a factor of two over an observed neutron range of 10 million. We regard this as a major achievement given the complexity of the phenomena, and it gives us considerable confidence in our extrapolations to future reactor level experiments.

Another extremely significant milestone was recently achieved with the first demonstration of compression of DT gas to high densities. In this case it was to 10 times liquid density and was accomplished as a pellet implosion experiment on the Janus laser system at LLL. The achievement of even higher density compressions is critical for the achievement of net fusion gain (i.e., greater than 100 percent as defined above) and will occupy an increasing share of our attention over the next few years.

Exploding Pusher



Isentropic Implosion

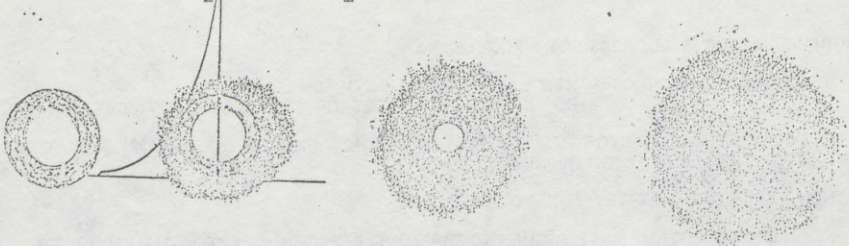


CHART 32

Very high density compressions are difficult to accomplish, since they require a more powerful, more carefully tailored laser pulse as well as a more elaborate target than the "exploding pusher" target experiments performed up to now. This latter class of experiments has been very useful in confirming our basic models of the implosion process by producing high temperatures and resulting high neutron yields, but experiments of this kind cannot be extended to reactor conditions.

Also during the past year, the first multi-beam experiments were conducted at LASL on the absorption of CO₂ laser light by targets. Considerable effort has been devoted to the experimental and theoretical understanding of the different

effects of long wavelength (10.6 micrometer) CO₂ laser radiation and the shorter (1.06 micrometer) Nd: glass laser light. Our present understanding of these effects on inertial confinement fusion experiments is quite encouraging. Laser energy appears to be effectively absorbed, and the production of potentially deleterious energetic electrons does not appear to be much worse for CO₂ laser illumination than for the more extensively studied Nd: glass laser fusion experiments. Modifications of the best available computer code to include more accurately the effects of the laser light pressure on the plasma have helped clarify why these long wavelength effects are less serious than had been expected. Furthermore, recent CO₂ laser-target experiments have generated neutrons in the range of 10⁴ to 10⁶ per experiment.

Experimental and theoretical work also has been progressing rapidly in the area of particle beam initiated implosions. The most important achievement has been the experimental and theoretical observation of enhanced electron beam energy deposition in thin shells over what had been predicted from simple models. This order-of-magnitude enhancement reduces the requirements on the design of targets and generators for e-beam fusion.

New target designs have been developed to take advantage of the properties of intense electron and ion beams from existing machines. Experiments with some of those targets are yielding preliminary evidence of thermonuclear neutron production. These encouraging experiments will be extended during 1977 and 1978 to the multi-terawatt Proto I and Proto II electron beam machines.

In support of all these fusion experiments, a wide range of new diagnostic equipment has been developed. Among the more important accomplishments of the past year have been the first spatially resolved time history of an implosion experiment using a streaked X-ray pinhole camera, and the development of neutron and alpha particle diagnostics to give information concerning the temperature, density, and spatial extent of the fusion plasma core. The extreme requirements on diagnostics for inertial confinement fusion experiments are typified by X-ray proximity focused streaked cameras we have developed with 3 picosecond resolution, and interferometers which have operated with 5 picosecond, 2 micrometer resolution. Further improvements in these instruments are continuing.

4. Powerplant technology

Advanced laser.—The advanced laser effort is directed toward the development of a laser capable of driving a fusion reactor.

POWER PLANT TECHNOLOGY

CURRENT EFFORTS ADDRESS SOME PROBLEMS . . .

- o DRIVER EFFICIENCY — NEW LASERS AND HEAVY ION BEAMS
— CO₂ LASERS AND ELECTRON BEAMS ALSO APPLICABLE HERE
- o CONCEPTUAL REACTOR DESIGN: SYSTEM STUDIES PROVIDE ROUGH APPROXIMATIONS TO FEASIBLE REACTOR DESIGNS

OTHER TASKS ARE NOT YET FUNDED . . .

- o HIGH REPETITION RATE DRIVER OPERATION: A FUSION REACTOR MAY HAVE TO OPERATE AT A RATE OF 10-50 PER SECOND
- o LOW COST, AUTOMATED PELLET FABRICATION: NEEDED BOTH TO LOWER UNIT COSTS AND TO MEET REPETITION RATE OF REACTOR
- o MATERIALS: REACTOR MATERIALS MAY BE MOST IMPORTANT TECHNICAL OBSTACLE. MAGNETIC FUSION PROGRAM HAS SOME EFFORTS UNDERWAY THAT WILL BE RELEVANT TO INERTIAL FUSION REACTOR DESIGN AS WELL

The requirements we project for such a laser are an energy of 10^5 to 10^6 Joules, a pulse duration of ~ 1 nanosecond, wavelength between 300nm and 2000nm, a minimum efficiency of 1 percent, and a repetition rate of ~ 10 Hz. A near term goal of the program is to develop by 1981 a 1 kJ laser which has the potential to be scaled to meet the above criteria.

A number of promising advanced laser media have been identified. The leading candidates are two of the metastable atoms, sulfur and selenium, and two metal vapor combinations, CdHg and Hg₂.

The main lines of approach are to select a metastable atom laser medium, examine the scaling of pumping sources and design a 1 kJ system, and to examine the stability and scaling of metal vapor media and, if results are favorable, build a 100 J amplifier.

Heavy ion fusion.—The use of intense, short bursts of high-energy heavy ions to ignite ICF pellets is an attractive new concept. A recent study involving over 50 specialists in plasma physics, pellet design, high energy physics and accelerator technology has concluded that there is great potential for the application of heavy ion beam driven inertial fusion to powerplant uses. The pulse rates, reliability, efficiency, component life and stored energy capabilities of current accelerator technology that appear appropriate to the requirements of ICF reactor designs are available in various existing machines. Target requirements can be extrapolated from experience with laser target design. The concept of heavy ion fusion will be pursued in a concerted R&D effort by the accelerator and target communities and has been initiated in fiscal year 1977 with the cooperation of the Division of Physical Research of ERDA.

Automated pellets.—Low cost, mass production of ICF targets will be an essential element of the commercial application of this concept. An ICF electric powerplant might consume in the vicinity of a billion pellets annually. Current ICF target pellets are prepared in a very time consuming manual process. A development similar to that experienced in automated micro-miniature component production will be required for fusion pellets. The hybrid integrated circuit industry has outstanding abilities in the inexpensive production of micro-miniature components. However, these components are only two-dimensional in character. Exploratory efforts will be initiated to adapt technology similar to that gained in this two-dimensional regime to the three-dimensional regime of ICF pellet designs. Studies will be conducted to examine the trade offs in pellet design that can be made to allow low cost fabrication.

Reactor design and applications.—Commercial energy applications of ICF have been studied to identify areas of economic potential and related technology needs. Major areas of potential commercial use of ICF include electric power generation process heat, synthetic fuel, and fissile fuel and tritium production. Conceptual system studies have been completed for ICF electrical power plants and fusion-fission hybrids.

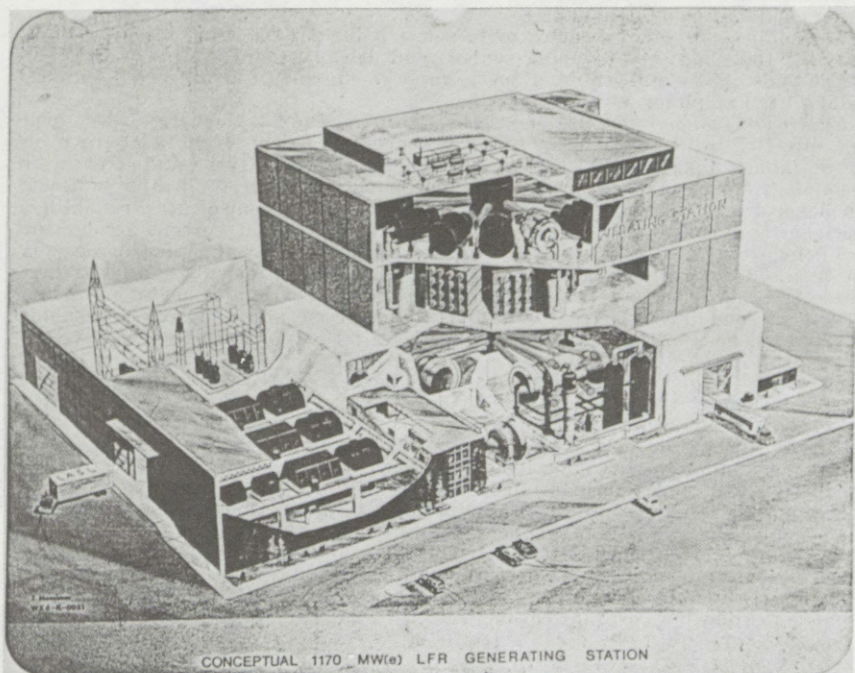


CHART 34

These studies show an attractive potential for ICF in both applications. The results of these studies have shown that internal ICF reactor conditions are not severe, and that ICF reactors can be made relatively small and will be of simple geometry. Current studies will explore the advantage of small reactor size in applications for process heat. The search will continue for improved radio chemistry to allow the radiolysis of synthetic fuels directly from the ICF pellet output. Improved pellet designs will be used to match pellet outputs and reactor designs to solve first wall, last mirror and component life limits of current designs.

THE OUTLOOK FOR INERTIAL CONFINEMENT FUSION

The program is modular, in that the task of scientific feasibility demonstration, for both significant military and for civilian power applications, can be addressed separately from the applications engineering tasks. These would follow up a decision to proceed with one or both of the areas of application. While there is as yet no discernible critical path to this major decision point, we believe that the program as now structured represents an orderly, moderate risk approach to feasibility demonstration. Sufficient options are maintained that the basic physics understanding and a preliminary engineering evaluation of alternative driver technologies should be available by the mid-1980's.

The major facilities that will be available in the early to mid-1980's—the EBFA, HEGLF, and NOVA facilities—will represent a significant weapons design and test capability at each of the weapons design laboratories. They will also serve as a basis for the conceptual design of the materials testing and experi-

mental power facilities that would be the next major steps in a civilian power program. The program is not now funded to undertake work on the long lead-time design and engineering.

We are confident that we now have sufficient understanding of driver and pellet technology to achieve single-pulse, high energy gain pellet implosions.

REQUIREMENTS FOR ICF APPLICATIONS

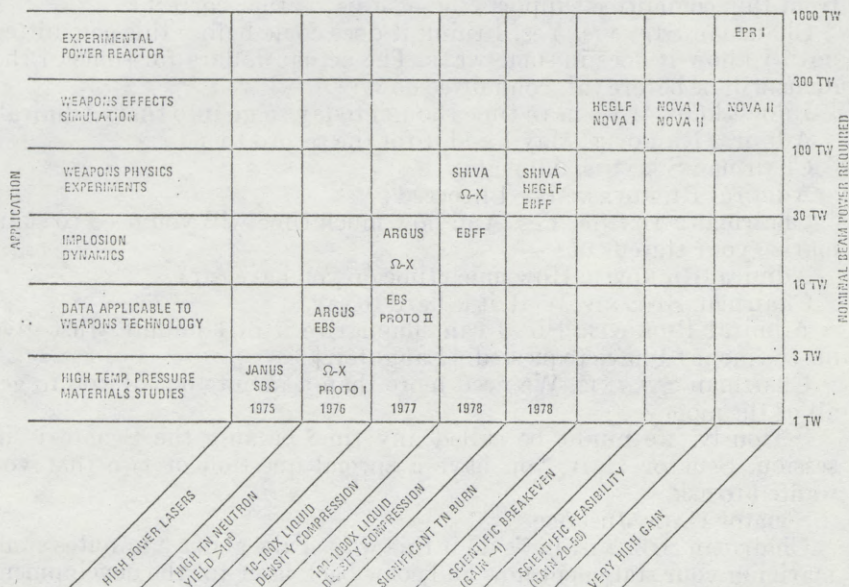


CHART 35

Taking pellet gain as the measure of feasibility of each application, we can fit the experimental systems available, under construction, and now in the design stage of the requirements for the applications. Accomplishment of the major program milestones will provide immediate benefits in weapons technology development, near-term future benefits in weapons effects simulation, and lay the groundwork for potential long-term benefits in civilian power technology development.

I appreciate having had this opportunity to appear before you today to describe our plans and recommendations for the fiscal year 1978 Inertial Confinement Fusion Program.

Chairman STENNIS. Thank you very much.

Gentlemen, I don't know how much time we are going to have. The Senate is already in session. I want to save some time for questions.

Admiral Rickover, we are glad to have you here this morning. We have heard you many times.

You were over in appropriations this week, or Friday of last week.

Of course, you are familiar with this subject and have had a major part in it.

I understand you do not have a prepared statement. If you do have one, let's take it now.

**STATEMENT OF ADM. HYMAN RICKOVER, DIRECTOR, DIVISION OF
NAVAL REACTORS, ERDA**

Admiral RICKOVER. Yes, sir, I have a brief statement I would like to make. I know your time is limited though, so please interrupt me at any time.

Also I understand that you have some interest in a brief comparison of nuclear carriers versus conventional ones, since part of the money from this committee supports these ships; is that correct?

Chairman STENNIS. Yes, I think it does come before this committee now. I know it does in some ways. The actual dollars for some of the items will be before this committee now.

I don't know if we have time though today to go into that, Admiral.

Admiral RICKOVER. May I add it for the record then?

Chairman STENNIS. All right.

Admiral RICKOVER. May I proceed?

Chairman STENNIS. Yes. And how much time will you need to summarize your statement?

Admiral RICKOVER. How much time do you have, sir?

Chairman STENNIS. Well, it is hard to say.

Admiral RICKOVER. Sir, I can summarize it in 1 minute. Just give me the money I have requested. [Laughter.]

Chairman STENNIS. We need more than a minute out of you to get all of the money.

Seriously, we might be called any time because the Senate is in session. Senator Hart, you have a special question or two that you wanted to ask.

Senator HART. Just one.

Chairman STENNIS. Let's do it this way. Take about 5 minutes summarizing your statement now and come back later for the development of any thoughts.

Admiral RICKOVER. That's fine, sir; I can come back whenever you'd like.

Chairman STENNIS. That is right.

Senator THURMOND. Could I say a word? I am on the Ethics Committee and must leave any minute. I will stay as long as I can. I have some questions they could answer for the record. If I leave I wanted you to understand it is not because of my lack of interest. I am strong for nuclear power. I am strong for nuclear ships, and submarines, and I think it is the best hope for power at a reasonably early date, and I think that in the long run nuclear ships are the kind we should build.

Admiral RICKOVER. Thank you, Senator, I have always appreciated your strong support. If I could take about 4 minutes I will try to summarize my statement for the members of this committee who are compelled to leave for other reasons.

Chairman STENNIS. Without objection, your complete statement will be placed in the hearing record at this point.

[The prepared statement of Admiral Rickover follows:]

PREPARED STATEMENT OF ADMIRAL RICKOVER

Mr. Chairman: Since the Public Works Subcommittee of the Appropriations Committee handles the appropriation of the ERDA funds and you are the Chairman of that Subcommittee, I know that you are personally familiar with the

work on naval nuclear propulsion development done by ERDA and its predecessor the Atomic Energy Commission. Since the inception of the naval nuclear propulsion development program, that work has been authorized by the Joint Committee on Atomic Energy.

Over the years the Joint Committee has played a key role in the development and application of naval nuclear propulsion. In fact, it was the Joint Committee which authorized the appropriation of funds in the Atomic Energy Commission Budget to procure the nuclear propulsion plants for our first two nuclear submarines, the *Nautilus* and the *Sea Wolf*, because the Department of Defense would not support the application of nuclear propulsion to submarines.

Of course, the members of the Armed Services Committee are very familiar with the reluctance of the systems analysts in the Office of Management and Budget and Department of Defense to accept the application of nuclear propulsion to any naval ship. A few days ago when I was testifying to the Public Works Subcommittee, I recalled that in 1968 the systems analysts succeeded in persuading Secretary of Defense McNamara to approve halting all submarine construction after 1970. They even went so far as to recommend that consideration be given to sinking 10 of our Polaris submarines as a cost-saving measure, but that particular plan was not approved.

Senator Stennis called for an investigation of the nuclear submarine program by the Preparedness Investigating Subcommittee which he chaired.

He assigned two experienced investigators to go into the matter thoroughly. Their investigation was followed by hearings and a Subcommittee report. This investigation and subsequent investigation by the Joint Committee on Atomic Energy and the House Armed Services Committee ultimately led to overturning the Department of Defense proposed termination of the nuclear submarine building program and led to the authorization of a new class of high speed nuclear attack submarines called the SSN 688, or *Los Angeles* Class.

At that time the development of the nuclear propulsion plant for this class of submarine had been underway for four years in the Atomic Energy Commission program. This is the same budget category you are considering this morning.

Thirty-one submarines of this class have now been authorized. The first ship of the class, the *Los Angeles*, was commissioned four months ago and the second ship, the *Philadelphia*, has completed her initial sea trials. Five more have been launched.

I am sure it will interest you to know that the *Los Angeles* has recently completed her first fleet exercise and that the initial review of the exercise data indicates that she has demonstrated technical capabilities far greater than those of all earlier classes of nuclear attack submarines. Throughout this exercise in which she participated with one of our best *Sturgeon* Class submarines, the higher speed of the *Los Angeles* greatly improved her ability to identify, locate, and attack submarines assigned to attacking forces.

I will give you for the record a classified summary of this exercise.

(See p. 89 for summary of *USS Los Angeles* exercise.)

Mr. Chairman, the decision of Congress to overturn the recommendations of the Department of Defense and insist on the development and construction of the SSN 688 Class submarines has been totally vindicated and will go down in naval history as a significant example of the wisdom of our forefathers in assigning to Congress the power "To provide and maintain a Navy." The American people owe a debt of gratitude to you and to your colleagues on the Senate Armed Services Committee for the action you took in bringing about the *Los Angeles* Class submarines.

The Joint Committee on Atomic Energy also had a major role in bringing about the *Nimitz* Class nuclear carriers. When Secretary of Defense McNamara, based on the advice of his systems analysts, refused to provide nuclear propulsion in the *John F. Kennedy*, the Joint Committee held extensive hearings on the subject of nuclear propulsion for surface warships. That was in 1963. By early 1964 the Joint Committee got Secretary McNamara's agreement to proceed with the development of the two-reactor nuclear propulsion plant now installed in the *Nimitz*. An examination of the relative strengths of the Soviet Navy and the United States Navy quickly reveals that the only category of combatant ship in which the United States is clearly superior in numbers and individual ship combat capability is the aircraft carrier. The *Nimitz* Class carriers are by far the most powerful of all, since in addition to nuclear propulsion they carry 50 percent more ammunition and about twice as much aircraft fuel as the largest conventional carrier.

As you know the Congress decided last month to go along with the Department of Defense recommendations to build two smaller, conventional carriers in fiscal year 1979 and 1981 in lieu of proceeding with the fourth *Nimitz* Class carrier in fiscal year 1978. In recent testimony I pointed out that the *Nimitz* Class carriers carry a 50 percent larger air wing, almost three times the aircraft ammunition, and more than four times the aircraft fuel, have better seakeeping capabilities, and are [deleted] knots faster than the conventional carrier currently being studied for authorization next year. That conventional ship has a combat load displacement of 60,000 tons. If an even smaller carrier is to be built, as some have suggested, its combat capabilities would be degraded further.

There are two basic, and separable, issues involved here. The first is what size aircraft carrier is needed for our first line naval strike forces. The second is the need for nuclear propulsion independent of the size of the carrier.

Last year's study by the Navy of alternate size carriers concluded that the air wing which could be accommodated on a carrier of the smaller size now being considered would be "marginally capable of operation in the force projection role in low threat areas and incapable in high threat areas due to limited numbers of aircraft available for essential functions combined with the inability to generate required sortie rates." The study also concluded that a carrier of this size "could not serve effectively in the multi-purpose sea-control role, again because too few aircraft could be accommodated."

It is often said that the advantage of two smaller carriers in lieu of one larger one is that one carrier can't be in two places at once. But what good is it to have two carriers in two places if neither one carries an air wing large enough to take care of itself against the projected threat?

It is also said that we should not build a \$2 billion carrier because it is too vulnerable. But this argument ignores the fact that the vulnerability of the smaller, conventional carrier is far greater.

The aviation community predicts that the combat aircraft of the future will be a Vertical Short Take Off and Landing (V/STOL) type aircraft. Predictions of when high performance combat aircraft of this type will be developed range from the late 1980's to the turn of the century. Of course, much of the new technology could also be used to improve the performance of catapult launched aircraft.

Some people seem to think that the development of V/STOL aircraft will eliminate the need to build large-deck carriers for our first line naval strike forces. This appears to me to be a *non-sequitur*. Even though the Navy may be able to develop high performance V/STOL aircraft over the next 15 years, I do not see what that has to do with the size of the aircraft carrier.

I have seen nothing predicted about V/STOL technology that will make the aircraft smaller or reduce the number needed in an air wing. There is nothing about the V/STOL concept that will reduce ammunition and aircraft fuel requirements. There is nothing in the V/STOL concept that will reduce the maintenance shops, spare parts, and personnel needed in a carrier. There is nothing about V/STOL that will make a smaller carrier more seaworthy.

The take off space required for a fully loaded combat V/STOL aircraft is expected to be about the same as that now required for catapults. It is true that the need for arresting wires will be eliminated by V/STOL. However, our present carriers already utilize the landing area for parking aircraft during air wing launch operations. Thus, a V/STOL air wing with the same number of aircraft will probably require essentially as much flight deck space as is required for catapult launched aircraft.

Therefore, it appears to me that it will require just as large a carrier to support an adequate air wing of V/STOL aircraft as is required to support an adequate air wing of catapult aircraft. Navy studies show that a nuclear carrier the size of the proposed smaller conventional carrier can be built, but that a *Nimitz* size carrier provides more than twice the combat capability of the smaller carrier. The total cost of two of the smaller, conventional carriers would be far more than the total cost of one *Nimitz* Class carrier.

Mr. Chairman, I have also testified this year at some length on the reasons I believe nuclear propulsion is needed in *Aegis* ships and the significant increase in military capability of the strike cruiser recommended by the Chief of Naval Operations compared to the weapons systems planned for the non-nuclear DDG-47. I note that Congressman Bob Wilson inserted some of my comments in the Congressional Record for March 24, 1976 at page E1787.

[The results of the *U.S.S. Los Angeles* exercise follows:]

RESULTS OF "U.S.S. LOS ANGELES" EXERCISE

From March 2, 1977 to March 10, 1977 the *U.S.S. Los Angeles* (SSN 688), the lead ship of the newest class of attack submarines, participated in the first of a series of fleet exercises to test this class of submarine. The purpose of this exercise was to evaluate the ability of *Los Angeles* to protect a task force from submarine attack during a high speed transit of the Atlantic Ocean. For comparison *U.S.S. Sea Devil* (SSN 664), a 637 class submarine with significant previous operating experience, also provided protection to the task force under identical conditions.

While the results have not been thoroughly analyzed it is clear that the performance of the SSN 688 class submarine was markedly superior to that of the SSN 637 class submarine. In the exercise, a simulated task force transited 3500 nautical miles at speeds of advance from 12 to [deleted] knots during which 2600 miles were transited at speeds of [deleted] knots or greater.

During the exercise *Los Angeles* detected and attacked [deleted] of 24 targets which entered her patrol area while the SSN 637 class submarine detected [deleted] and attacked [deleted] 24 targets which entered her patrol area. *Los Angeles* detected targets at [deleted] the average initial detection range and attacked at [deleted] the range from the patrol area rear boundary than the SSN 637 class submarine. *Los Angeles'* detection and attack performance exceeded that of the SSN 637 class submarine at all exercise speeds, particularly at high speeds of advance. At higher speeds of advance, *Los Angeles'* high speed capability allowed her to maintain a search position [deleted]. This allowed detections to be made at greater ranges from the center of the task force formation, earlier warning to the task force commander of a potential threat, and attacks of longer range with more geographic flexibility. Of particular importance was the ability demonstrated by the SSN-688 Class to maintain a high level of performance over an extended period at high speeds of advance.

Admiral RICKOVER. May I add any remarks that would contribute to the statement as a result of the discussion?

Chairman STENNIS. Yes, all discussions automatically go in the record, Admiral. If you have something else you want to present we will be glad to have it.

Admiral RICKOVER. The first thing I want to do is emphasize the great success we have had with the new SSN-688 class nuclear powered submarines. Were there time I would read from my statement what Senator Stennis contributed as chairman of the committee by appointing his investigators to find out if the Navy needed that submarine. It was a result of the investigation and hearings he held and under his personal actions that this class of submarines was authorized.

The SSN-688 has performed remarkably well, better than any other submarine we have ever had. It can make high speed and is better from an antisubmarine warfare standpoint, and from a military standpoint. Furthermore, it has shown that it can act as an escort ship for a surface task force. This was the original idea behind building such a class of submarines. In addition to everything else this submarine can do, it can take the place of some surface escort vessels. The Navy is far more satisfied with this submarine than they ever expected to be.

I would like to mention that, and again express my thanks to the Chairman and other members of the committee who backed the program.

I will not take up time by going into detail.

Chairman STENNIS. Admiral, you are the father of that program, and it was a good one.

We are going to give you unlimited time at a later date, but we don't have it now.

Admiral RICKOVER. Yes, sir; that was the import of the first part of my prepared statement.

The other thing I would like to touch on now is to make a brief comparison of the capabilities of the *Nimitz* class nuclear carriers compared to conventional carriers. In my opinion, the recommendation from the Defense Department to substitute conventional carriers for nuclear carriers is a ploy.

I think the real issue that should be faced and argued out is not whether aircraft carriers should be nuclear or conventional, but whether the Navy should build new aircraft carriers. I think there is a ploy going on.

I believe that the Office of Management and Budget believes that the Navy should not build new aircraft carriers. I think there are elements in the Defense Department that believe that, as well, particularly the system analysts. The issue is being disguised by whether carriers should be nuclear or conventionally powered.

In my opinion there is no real intention on the part of the Defense Department to build any more carriers. I think that issue should be faced by this committee. That is the basic issue. Should we or should we not build new aircraft carriers? The decision should be made on that basis and not on the basis that one is more expensive than the other. Actually, the analyses that have been made indicate very clearly that over the lifetime of a nuclear carrier task force, a conventional carrier task force costs about the same. There is no discernible difference.

Then the other factor I think you should consider is the one that faced Hannibal when he reached the Alps with his army and their elephants. He probably thought, "If I have to take elephants across the Alps I should at least be allowed to choose my own elephants."

I think there is something to that. The Department of Defense and Office of Management and Budget should not be telling the Navy what kind of a particular ship they could have.

Now I will read briefly this comparison of carriers.

Last year's study by the Navy of alternate size carriers concluded that the air wing which could be accommodated on a carrier of the smaller size now being considered would be—

marginally capable of operation in the force projection role in low threat areas and incapable in high threat areas due to limited numbers of aircraft available for essential functions combined with the inability to generate required sortie rates.

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could not serve effectively in the multipurpose sea-control role, again because too few aircraft could be accommodated.

It is often said that the advantage of two smaller carriers in lieu of one larger one is that one carrier can't be in two places at once. But what good is it to have two carriers in two places if neither one carries an air wing large enough to take care of itself against the projected threat?

It is also said that we should not build a \$2 billion carrier because it is too vulnerable. But this argument ignores the fact that the vulnerability of the smaller, conventional carrier is far greater.

The aviation community predicts that the combat aircraft of the future will be a vertical or short take off and landing (V/STOL)-type aircraft. Predictions of when high performance combat aircraft of this type will be developed range from the late 1980's to the turn of the century. Of course, much of the new technology could also be used to improve the performance of catapult launched aircraft.

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Now, I would like to briefly say something about the light-water breeder reactor. You are very much interested in that program because it may affect our future energy position.

For members of the committee not familiar with this program we expect to have a small light-water breeder reactor in operation later this year. The LWBR core will be operated in the ERDA-owned reactor at Shippingport, Pa. Manufacture of the core is complete and it is now being installed in the nuclear central station reactor at Shippingport. It will generate at least 50,000 kilowatts of net electrical

power. This is about the same electricity generation rate as the first Shippingport core. As you may know, I was assigned the responsibility, because of my experience with naval plants to design and build the first central station atomic power plant in the United States. This is the Shippingport plant.

For the light water breeder core, we did not have to build an entirely new plant. This was one of the objectives of the program, to confirm that a light water breeder could be installed in an existing light water reactor plant. The LWBR core will operate for 3 or 4 years before refueling. We estimate that the ratio of fissile fuel content at the end of life compared to the beginning of life will be about 1.01. This means that the core will be breeding more nuclear fuel from fertile material than it burns to generate electricity. Once a reactor is operating on this self-sustaining breeding cycle there would be no need for make-up uranium-235. Thus, it would not be necessary to mine or enrich additional uranium to support that increment of generating capacity, only make-up thorium would be required. It will take many years to get a reactor on the self-sustaining breeding cycle, but from then on the reactor would use thorium instead of uranium.

My remarks about the LWBR do not mean that ERDA should stop working on the liquid metal breeder. My opinion is that ERDA should continue development of the liquid metal breeder because of its potential for furnishing more new fissionable material. When you consider the whole energy situation in the United States, the amount of money that will be spent on the liquid metal breeder doesn't mean much. Energy is going to be the most valuable raw material we have. As I see it, the United States is not realistically facing up to the energy situation. Everybody seems to act as if the amount of energy now available to each individual will continue. The only people who appear to realize the situation are the Saudi Arabians. They are planning on not having any more oil about 35 years from now, and they are building up an industrial complex which they think will carry them along.

I think the United States, probably more than any other major nation, does not really understand the vast dislocations that will occur in our entire way of living that ultimately will be forced on many of us when energy supplies are depleted.

These remarks have been extemporaneous. I am just trying to tell you my convictions. As far as our budget is concerned, it has been approved heretofore. I suggest that in order to save time we will answer questions along that line in the record, if that is satisfactory, Mr. Chairman.

Chairman STENNIS. Yes; we will certainly have some questions for you, Admiral, and we want you to come back to repeat some of this as you see fit.

I believe now we are likely to be called to a vote from the hearing. Let's use what time we have left to ask a few questions, and I am going to yield my part to Senator Jackson. Senator Hart has been waiting. Do you have a question?

Senator HART. One question of Admiral Rickover.

Senator JACKSON. I will defer for the question. I only have one question. I want to know how come the Admiral is the only one at the table who can read when he does not wear glasses?

Admiral RICKOVER. I can answer that, sir.

I would offer as a suggestion good clean living, sir. [Laughter.]

Senator JACKSON. It has been said my problem has been I am too righteous to be interesting.

Admiral RICKOVER. Also I exercise. I walk fast, 4 miles every morning, and do 88 toe bends every morning in the year.

Senator ANDERSON. Why 88?

Admiral RICKOVER. Because I am always 10 or 11 ahead of my age, sir.

Senator JACKSON. He picked good ancestors, I think.

Admiral RICKOVER. That is a help. I hope all of you here have picked good ancestors. I wish you as much life as you wish to have. How is that, sir?

Senator JACKSON. Thank you.

Chairman STENNIS. Senator Hart.

Senator HART. Admiral, what correlation can we draw between nuclear power and the size of the surface of a vessel; that is to say, is it possible to draw a line from the tonnage, or what, where the nuclear power does not make any difference?

Admiral RICKOVER. That was considered by the House Armed Services Committee when Carl Vinson, a friend of all of you, was chairman. He made a decision in the early 1960's that about 8,000 tons was as small a surface warship as it would be reasonable to provide with the advantages of nuclear propulsion. I think today with the increased weapons suite the ships should carry, that is probably too low. I would say something a little above that would start to pay off. The rationale was that since nuclear propulsion is more expensive than an oil-fired propulsion plant, it should be applied to our first line warships that carry our best weapons and sensors so the ships can take advantage of being nuclear powered. The nuclear cruiser U.S.S. *Bainbridge* displaces about 8,500 tons, sir.

I mentioned before that the issue is not really nuclear versus conventional propulsion. For aircraft carriers the issue is should the Navy build new aircraft carriers?

I am not the one to settle that issue, sir.

Getting back to nuclear power. Looking at what this country faces, people are starting to realize what the energy situation is. For example, the initial fuel installed in a nuclear aircraft carrier is the equivalent of 11 million barrels of fuel oil. At today's prices it would cost over \$300 million to buy, store, and deliver this much fuel oil to an oil-fired aircraft carrier. The initial nuclear fuel is included in the cost of the nuclear ship. This is one reason the Navy studies show that ultimately there is no discernible difference between lifetime cost of a nuclear carrier task force and a conventional carrier task force.

But is the oil going to remain at the same price it is today? Can anyone here imagine that?

Probably by the time these ships are in the middle of their life, oil will be three times as expensive. But that is not the real issue here, because when the Navy gets into a war, it won't matter what it costs. World War II cost about \$300 million a day toward the end of the war. At today's prices that would be over \$1 billion a day.

The real issue is can you get the oil to the warships and can you de-

pend on tankers? Are tankers going to survive in high-threat areas to supply fuel oil to oil-fired warships?

These things are easily forgotten. I am shocked because the people in the Defense Department who should know better are simplifying everything down to cost alone.

There is a man up at MIT who is a systems analyst and who has just written a book pointing out that the systems analysts are using their mathematics in an improper way. And they are. When the analysts get an idea that they like something or they don't like something then they prove their conclusions with their own mathematical formulas. They rationalize the answer. An ordinary person could see the problem of supplying propulsion fuel to a warship in a high-threat area, but the systems analyst can't.

I don't think it requires any mathematical brainpower to figure that it will be difficult for the Navy, if not impossible, to get the oil where they need it to fight in time of war. Wouldn't it be better to use nuclear power and give our sailors a better chance to win? I don't see where that is a very difficult issue for any Defense Department people to understand. They insist, though, on putting everything on a mathematical basis, and they have been proven wrong over and over again.

You may remember, that in 1968 and 1969, the systems analysts advocated sinking 10 of our 41 Polaris submarines as a cost-saving measure and not to build any more submarines after 1970. They fought against building the SSN-688 class submarines, which are the best submarines we have today.

I cannot find a single thing that the system analysts have recommended that has ever been correct.

Senator HART. That is a sweeping statement. The answer to my question—

Admiral RICKOVER. That is a sweeping statement, sir, but one I believe to be true.

Chairman STENNIS. Gentlemen, we are going to have to conclude in just a few minutes.

Senator HART. The answer to my question is about 10,000 tons?

Admiral RICKOVER. The House Armed Services Committee came out at 8,000 tons. The *Virginia* class cruisers are about 11,000 tons.

Senator HART. What is your judgment?

Admiral RICKOVER. Somewhere in that order, I think. On a *Virginia* class cruiser, I think the plant weighs about [deleted]. The issue is not so much ship displacement as it is the initial cost. Since the nuclear propulsion plant costs more, it is not worthwhile unless the ship carries the best weapons and sensors available. This will force the ship to be at least 8,000 tons. But when these issues are decided on cost, the advantages you get from a military standpoint of having an essentially unlimited high-speed cruising radius is ignored. That could mean the difference between winning and losing a battle. The *Nimitz* class aircraft carriers operating now are expected to be able to steam for 13 years without being refueled. Just think of the value to the United States—particularly where oil supplies can be cut off in high threat areas, of having ships that can operate for 13 years, without concern for propulsion fuel. Today we are designing cores to last longer than that.

Chairman STENNIS. The Senate is debating that bill now, and I think we will have to conclude.

SPECIAL MATERIALS PRODUCTION

Mr. Cunningham, we want to especially thank you for being here. We thank you for that 10-minute statement you are going to propose to put in the record, and we will invite you to come back if we feel the need to make a special comment on it later and have questions directed to you.

[The prepared statement of Dr. George W. Cunningham follows:]

PREPARED STATEMENT OF GEORGE W. CUNNINGHAM, ACTING DEPUTY ASSISTANT ADMINISTRATOR FOR NUCLEAR ENERGY, ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

Mr. Chairman and Members of the Committee: I am pleased to have the opportunity to appear before this Committee to discuss the Energy Research and Development Administration's (ERDA) Special Materials Production, Naval Reactors and Space Applications Programs for fiscal year 1978. In accordance with the Committee's request, most of my programmatic comments will be directed toward the Special Materials Production Program. The budget requests for the Naval Reactors and Space Applications Programs will be covered briefly.

SPECIAL MATERIALS PRODUCTION

ERDA produces plutonium, tritium, and other nuclear materials to meet the weapon requirements of the Department of Defense and certain energy research, development and demonstration needs of ERDA. To do this, we operate three heavy-water-moderated reactors at Savannah River, South Carolina, the N-Reactor at Richland, Washington, and related chemical processing and waste management facilities at each site.

In support of these production facilities, ERDA operates feed material manufacturing facilities at Fernald and Ashtabula, Ohio. These plants provide target elements made from depleted uranium metal for the Savannah River reactors, and large metallic billets made from slightly enriched uranium for fueling the N-Reactor at Richland. At Savannah River and Richland, reactor fuel elements are finished and clad for supply to the reactors. The Fernald plant also provides depleted uranium metal for fabrication into weapons parts at Y-12 at Oak Ridge. In addition, the Y-12 plant fabricates enriched lithium components and produces deuterium for weapon components.

Nuclear materials produced for the national security program are required to support weapons production, research and development, quality assurance, process development, and weapons testing programs. Since the requirements for these materials strongly influence the activities included in the Special Materials Production program budget, I would like to briefly review for the committee the process by which they are derived.

The Atomic Energy Act of 1954 stipulates that the President will give annual consent and direction for the nuclear weapons stockpile. The U.S. Energy Research and Development Administration and the Department of Defense (DOD) jointly produce an annual Memorandum for the President covering nuclear weapons stockpile planning. The draft of the memorandum is prepared by the staffs of the Military Liaison Committee (MLC) within the DOD and the Division of Military Application (DMA) within ERDA. The specific annual weapon requirements are derived from a process beginning with the issuance of a Planning and Programming Guidance Memorandum. This document provides the basis for the publication of the Joint Chiefs of Staff's (JCS) Joint Forces Memorandum (JFM). The JCS and Service departments' annual submissions, along with the decisions of the Secretary of Defense on the annual budget, provide the basis for preparation of the DOD nuclear weapons requirements in the Stockpile Memorandum submitted to the President in May of each year. The basic data contained in the Stockpile Memorandum are then incorporated by ERDA in the development of a comprehensive Materials Planning Estimate.

The total budget request for the Special Materials Production Program is \$671.4 million in authority and \$597.1 million in costs. In terms of budget authority, our requested increase of \$121 million represents a 22 percent increase in this program over the 1977 appropriations level.

SPECIAL MATERIALS PRODUCTION

[In millions of dollars]

	Fiscal year 1977		Fiscal year 1978		Increase	
	Budget authority	Budget outlay	Budget authority	Budget outlay	Budget authority	Budget outlay
Operating expenses.....	358.9	336.7	416.4	394.6	57.5	57.9
Capital equipment.....	29.7	23.2	36.7	28.5	7.0	5.3
Construction projects.....	161.8	82.1	218.3	174.0	56.5	91.9
Total.....	550.4	442.0	671.4	597.1	121.0	155.1

The following chart summarizes the operating request for fiscal year 1978.

FISCAL YEAR 1978 BUDGET ESTIMATES—OPERATING BUDGET AUTHORITY SPECIAL MATERIALS PRODUCTION

[In thousands of dollars]

Operating summary	Estimate fiscal year 1977	Estimate fiscal year 1978
Production.....	243,736	288,900
Process development.....	15,915	11,800
Waste management (ERDA):		
Interim.....	63,062	63,576
Long term.....	36,153	52,124
Subtotal waste management (ERDA).....	99,215	115,700
Total.....	358,866	416,400

Line item construction projects proposed for fiscal year 1978 as well as equipment obligations required to support the program are shown in Figure I. Figure II details the funds required in fiscal year 1978 for those phase-funded projects authorized in prior years.

I will now describe in some detail, the activities which are supported by this request.

Production reactor operation

At Richland, the N-Reactor produces both plutonium and by-product steam. The steam is utilized by the Washington Public Power Supply System (WPPSS) in its power generating station located adjacent to the reactor. The present contract between ERDA and WPPSS, terminating in June 1978, calls for ERDA to provide WPPSS annually with steam availability up to an equivalent of 4.5 billion Kw-hr. The fiscal year 1978 budget provides for operating of N-Reactor in fiscal year 1978, and is based on extension of the operation through June 1983. In fiscal year 1977, the Government will realize steam revenues from the operation of the N-Reactor in the amount of about \$22.5 million.

Contract negotiations with WPPSS for extending the steam availability arrangements through June 1983, are nearing completion. Contract extension is anticipated this month.

At Savannah River, fuel and target elements are irradiated in the reactors to produce tritium and weapon-grade plutonium. Each Savannah River reactor has the capability to produce weapon-grade plutonium or tritium or various combinations of each. Other products such as plutonium-238 and transplutonium isotopes (i.e., Pu-242) are produced to meet requirements, primarily for non-weapons use such as in space applications and in the field of medicine.

The principal use of plutonium and tritium produced at Savannah River is for the production of nuclear weapons, but smaller quantities are used for other weapons-related activities such as research and development and process development for weapons tests. ERDA works closely with the DOD in establishing projected nuclear weapons stockpiles and the materials required to support them.

Consistent with their projected requirements in fiscal year 1978, reactor operations at Richland and Savannah River are scheduled to continue at essentially the same level as in fiscal year 1977. The increase in funding requested for fiscal year 1978 reactor operations is primarily due to escalation.

Chemical processing

The fiscal year 1978 budget provides for continued chemical reprocessing of fuel irradiated in the Savannah River reactors as well as resumption of chemical reprocessing in the Purex plant at Richland, Washington. Processing of nuclear materials will continue at Savannah River in fiscal year 1978 at about the same level as in fiscal year 1977. Additional operating funds of \$10.5 million are requested for the hot operation of the Purex plant at Richland. The Purex plant at Richland, Washington, has been in standby status since 1972, but is to be reactivated in fiscal year 1978 in order to begin the reprocessing of a several-year accumulation of fuel from the N-Reactor.

Other irradiated reactor fuel elements not associated with production of nuclear materials are also processed to recover the residual uranium at the Idaho Chemical Processing Plant (ICPP). These fuels are mostly from research reactors, test reactors and Naval propulsion reactors. They contain uranium highly enriched in U-235. The recovered highly enriched uranium is used as fuel in the Savannah River reactors. During fiscal year 1978, the most significant activity at ICPP will be the reprocessing of about 2,800 kg of Rover nuclear rocket fuel. Also to be processed are over 400 kg of EBR-II fuel. Budget increases reflect the greater amount of fuel to be processed with the campaign increasing from 165 days in fiscal year 1977 to 315 days in fiscal year 1978.

The fiscal year 1978 budget authorization for chemical reprocessing activities at Idaho include an additional \$5.0 million for continuation of A-E services and long-lead procurement related to the Fluorinel project (head-end fuel dissolution process and receiving basin). The project is required to receive and process future government fuels assigned to the ICPP and will be fully integrated with the existing facility.

Management of defense waste

Operations and development programs associated with ERDA radioactive process wastes are conducted at three sites: Idaho, Richland and Savannah River. These waste management activities are characterized as interim storage and long term disposal.

Interim high-level waste storage

The basic objectives of ERDA's interim waste management program are to control the waste in a manner that will protect the health and safety of employees and the public, and protect man's environment. Since the 1960s, a major effort has been directed toward solidifying the backlog of liquid waste and newly generated waste at the three sites. The liquid waste is being solidified into immobile salt-like cakes to reduce the need for additional waste storage tanks and to remove liquid wastes from tanks that have leaked. This program provides for the construction of new, double-shell storage tanks, a tank within a tank concept, to store liquid waste awaiting solidification. The fiscal year 1978 budget request costs total \$62.4 million in operating costs for defense and non-defense reactor wastes and process development work.

Continual progress is being made at the production sites to reduce waste volume inventories by solidification. ERDA's total high-level waste inventory (liquid plus solid) decreased by 1.5 million gallons during calendar year 1976, even though new waste generation from reprocessing activities amounted to about 3 million gallons. During the year, the total liquid inventory decreased by about 2.2 million gallons, or 6 percent.

At the Idaho Chemical Processing Plant, radioactive high-level waste is generated from the reprocessing of irradiated research and Navy fuels. The liquid waste is stored in underground tanks, fabricated of stainless steel, prior to solidification in a calcining facility. The calcining operation, using a fluidizing bed, converts the liquid acid waste under high temperature into a relatively immobile granular solid with a tenfold reduction in volume.

The fiscal year 1978 budget includes an additional appropriation request of \$18.5 million for a New Waste Calcining Facility (NWCF). Construction of this facility began in October 1976, with completion scheduled in fiscal year 1980. The fiscal year 1978 budget also includes a request for construction of the fifth set of calcined solids storage bins to be used in conjunction with the New Waste Cal-

During calendar year 1976 at Richland there was a decrease in the volume of liquid waste stored in the waste tanks as a result of the satisfactory operation of the large-scale evaporator-crystallizer. The liquid waste volume decreased by 2.7 million gallons and the volume of the resulting wet salt cake increased by 0.6 million gallons. Without the evaporators, the larger waste inventory to date would have required 67 additional one million gallon tanks.

In the waste salt cake at Richland, a final residue of liquid waste will remain which cannot be suitably solidified by the existing evaporators and must be stored for future solidification by some other method. Research and development is continuing on several promising methods to immobilize the residual liquid waste, but until the methods are proven, this residual waste will require safe storage. The fiscal year 1977 budget request provided funding for six additional double-shell tanks to store residual waste and for improved storage of salt cakes resulting from the continuing evaporator operations. Construction has begun on these tanks. A recent examination of requirements for tanks at Richland indicates that another four tanks are required and these are included in the fiscal year 1978 budget request. The TEC of this project is \$27 million with a request for obligations of \$18 million in the fiscal year 1978 budget. Progress in the construction of three double-shell tanks and another large-scale vacuum-crystallizer authorized in fiscal year 1974 was delayed by a 25-week strike of the local plumbers' union. These facilities are now scheduled to be completed this spring. The strike did not delay construction of the six tanks authorized in fiscal year 1976, however, since it occurred during the excavation and foundation period of that construction.

The evaporator operations at Savannah River continued to solidify the liquid waste to reduce its mobility as well as to minimize tank requirements for storage of the waste. During calendar year 1976 the evaporators recovered about 1.9 million gallons of tank space, which was equivalent to about 90 percent of the new waste receipts during the year. Thus, the inventory of waste at Savannah River remained at about the same level throughout 1976.

A total of 30 large underground tanks have been constructed at Savannah River. Eight of the tanks are of single-shell design built from 1957 to 1962; low-heat waste is stored in seven of these tanks. Sixteen tanks have secondary liners of the 5-foot height and are over 20 years old; eight of these tanks have incurred hairline cracks in the primary tank's wall due to stress-corrosion cracking.

ERDA's planning calls for removal of the waste from both types of these tanks for storage in new highly engineered double-shell tanks. Six tanks of the double-shell design are in service. The primary tanks of the new storage tanks are stress-relieved to prevent the stress-corrosion cracking which occurred in the earlier tanks. The new storage tanks have complete secondary steel liners.

Progress is continuing on construction of the tanks authorized in fiscal years 1974, 1975, 1976, and 1977. The tanks authorized in the fiscal year 1974 budget will be completed in late fiscal year 1977. The fiscal year 1978 budget request includes a project for an additional four tanks and associated facilities to continue with ERDA's plans to replace the aging tanks; the TEC is \$42 million, with a request for obligations of \$16 million in fiscal year 1978 for the project. Surveillance and monitoring of the stored waste and maintenance of the associated equipment at Savannah River was continued throughout calendar year 1976. No leaks from waste storage tanks were experienced during calendar year 1976.

Long-term high-level waste disposal

This program is designed to determine and implement an acceptable alternative for final disposal of the high-level wastes at Savannah River, Richland and Idaho. Basic to this objective is the development effort required to provide the technology leading to a decision on the feasible alternatives for ultimate disposition of these wastes. Defense Waste Documents (DWD's) will be prepared discussing the feasible technical alternatives and their associated costs and risks. Public comment on the DWD's will be considered in preparation of the Environmental Impact Statements which will be an integral part of implementing the

long-term programs and which will further elicit public input into the decision-making process.

This development and support program has increased \$7.8 million over fiscal year 1977. In addition to the basic technology effort, the program includes an expanded fiscal year 1978 effort at Savannah River, Richland and Idaho to prepare draft environmental impact statements, as well as conceptual design efforts and engineering studies. These elements of the program apply to major alternatives being considered.

Solid low-level wastes

The program involves the handling of low-level solid waste from all ERDA sites, of which a major element relates to that solid waste contaminated with transuranic elements (TRU waste). Since 1970, TRU waste has been placed in 20-year retrievable storage, but a geologic repository is now planned to receive these TRU wastes for final disposal. Other solid low-level waste is disposed of in ERDA land burial sites.

Low-level transuranic wastes (TRU)

The major emphasis of the research and development program for transuranium (TRU) waste processing is to develop technology which provides the capability of processing TRU waste to a form acceptable for disposal in a geologic repository, as well as attendant volume-reduction benefits. More specifically, these efforts currently involve developing technology for incineration of combustible waste, decontamination and volume reduction of contaminated metal waste, immobilization of waste residue, and packaging of the waste in a manner acceptable for interim and terminal storage. In addition to the development of treatment technology, a major management effort is underway at each of the ERDA sites to reduce the generation of TRU-contaminated waste. Incinerators are currently being installed for developmental purposes at a number of ERDA sites, which will also benefit comparable development efforts which address treatment technology programs related to TRU wastes to be generated by the commercial nuclear industry.

A major increase over fiscal year 1977 is in support of the terminal storage program. Operating costs have increased by about \$4 million, and \$22 million in construction funds is being requested for A-E work, long lead time procurement and land acquisition for the Waste Isolation Pilot Plant (WIPP). This facility will provide the capability for the demonstration of waste isolation methodology and operation using ERDA transuranic-contaminated waste. Activities will continue to support the preparation and issuance of a final environmental impact statement and preliminary safety analysis report for the WIPP. Such activities include rock properties and mechanics studies, thermal and structural analysis, system analysis, nuclide migration, and transport studies. In addition, environmental baseline monitoring and development of special equipment, waste form and acceptance criteria and operations criteria will continue or be initiated to support the future operations of the WIPP. In conjunction with this project, we will continue to acquire the necessary land, oil, gas and mineral rights.

Low-level solid buried waste

There is a requested increase of \$4.8 million over fiscal year 1977 in the operational solid-low-level waste program. Improvements continue in the land burial of solid low-level radioactive waste. This ongoing program is consistent with the recommendations contained in the GAO Report B-164105 of January 12, 1976. Some of the improvements are installation of improved monitoring systems, better recordkeeping practices including startup of a prototype computerized inventory, continued upgrading of facilities and sealing of selected areas to minimize factors conducive to migration of radioactivity. A program has also been initiated to conduct an in-depth assessment of the adequacy of existing ERDA low-level burial facilities and operations, in light of current knowledge, which will be used to identify any deficiencies which require correction.

ERDA also has underway a program designed to develop improved site selection and operating practices for land burial. This program will be accelerated in fiscal year 1978 in recognition of the increased need to base future low-level radioactive waste burial on a sound technical understanding. Although formulated to develop needed technical input into ERDA's land burial activities, this program will also provide base technology of use in establishing burial sites for low-level waste from the nuclear industry.

I would now like to turn my attention to our Naval Reactor Development and Space Applications programs.

NAVAL REACTOR DEVELOPMENT PROGRAM

The Naval Reactor Development Program provides for the design and development of improved Naval nuclear propulsion plants and reactor cores having high reliability, maximum simplicity, and optimum fuel life. In fiscal year 1978, the budget request is for \$243 million in Budget Authority, \$212 million in operating and \$31 million in plant and capital equipment (figure III). Development will continue on improved reactor concepts, components and materials for application to submarines and surface warships, with particular emphasis placed on obtaining higher power long-life cores necessary for increased ship performance and size, simplifying operating and maintenance requirements, and increasing reliability and maintainability of reactor plant components.

SPACE AND TERRESTRIAL APPLICATIONS

The ERDA space and terrestrial applications activities are part of our Nuclear Research Applications program. Requests for space power sources require ERDA to develop, qualify, and fabricate power units and subsequently to supply production units on a reimbursable cost basis to DOD and NASA. Terrestrial applications of isotopic power systems included in the Technology Development and Special Projects area are also under development in response to DOD and other agency requirements. There is also a significant effort underway to investigate other potential beneficial uses of nuclear energy and nuclear-related technologies for energy supply and conservation.

As Figure IV shows, in 1978 the budget request for space and terrestrial activities is \$51 million in Budget Authority. The military-related portion of this is about \$12 million which includes a dynamic flight test in support of potential Global Positioning Satellite (GPS) deployment and development of a Sterling Isotopes Power System for the Navy.

Mr. Chairman, this concludes my prepared remarks. I will now be happy to answer any questions you or members of the Committee may have.

FIGURE I.—FISCAL YEAR 1978 BUDGET ESTIMATES SPECIAL MATERIALS PRODUCTION SUMMARY PLANT AND CAPITAL EQUIPMENT

(Dollar amounts in thousands)

Plant	Project number	Total estimated cost	Fiscal year 1978 obligations
OBLIGATIONS FOR CONSTRUCTION PROJECTS NEW FISCAL YEAR 1978 LINE ITEM PROJECTS			
1. High-level waste storage and waste management facilities, Richland, Wash.	78-18-a-----	\$27,000	\$18,000
2. High-level waste storage facilities, Savannah River, S.C.	78-18-b-----	42,000	16,000
3. 5th set of calcined solids storage bins, INEL, Idaho	78-18-c-----	12,500	12,500
4. New hydrofracture facility, ORNL, Tennessee	78-18-d-----	5,400	5,400
5. Environmental, safety and security improvements to waste management and materials processing facilities, Richland, Wash.	78-18-e-----	15,500	10,000
6. Powerhouse emission control improvements, Richland, Wash.	78-18-f-----	6,500	6,500
7. Fanhouse and increased fan capacity, H chemical separations area, Savannah River, S.C.	78-18-g-----	3,400	3,400
8. Plantwide fire protection, Savannah River, S.C.	78-18-h-----	6,300	6,300
9. Improved emergency coolant supply in reactor areas, Savannah River, S.C.	78-18-i-----	3,500	3,500
10. N-reactor environmental improvements, Richland, Wash.	78-18-j-----	7,500	7,500
General plant projects	78-21-----	12,000	12,000
Total plant			101,100
Capital equipment			36,700

FIGURE II.—FISCAL YEAR 1977 BUDGET ESTIMATES—PLANT AND CAPITAL EQUIPMENT
SPECIAL MATERIALS PRODUCTION
[Dollar amounts in thousands]

Additional fiscal year 1978 funding— Projects authorized in prior years	Project number	Total estimated cost	Fiscal year 1978 obligations
1. Flourinel dissolution process and fuel receiving improvements, Idaho Chemical Processing Plant, Idaho National Engineering Laboratory, Idaho (A-E and long lead procurement only).	77-13-a	\$15,000	\$5,000
2. High level waste storage and waste management facilities, Savannah River, S.C.	77-13-d	56,000	27,000
3. High level waste storage and handling facilities, Richland, Wash.	77-13-e	40,000	22,000
4. Waste isolation pilot plant Delaware Basin, southeast, New Mexico (A-E and long lead procurement only).	77-13-f	28,000	22,000
5. Safeguards and security upgrading, production facilities, multiple sites.	77-13-g	16,400	8,700
6. Additional facilities, high level waste storage, Savannah River, S.C.	76-8-a	68,000	10,000
7. Additional high level waste storage facilities, Richland, Wash.	76-8-b	35,000	4,000
8. New waste calcining facility, Idaho Chemical Processing Plant, Idaho National Engineering Laboratory, Idaho.	75-1-c	65,000	18,500
Total projects authorized in prior years.....			117,200

FIGURE III.—NAVAL REACTOR DEVELOPMENT PROGRAM BUDGET SUMMARY

[In millions of dollars]

	Estimate fiscal year 1977	Estimate fiscal year 1978
Budget authority:		
Operating.....	191.5	211.7
Capital equipment.....	6.0	15.2
Construction projects.....	2.6	15.8
Total.....	200.1	242.7
Budget outlays:		
Operating.....	202.6	220.0
Capital equipment.....	7.0	10.6
Construction projects.....	31.4	17.5
Total.....	241.0	248.1

FIGURE IV.—SPACE AND TERRESTRIAL NUCLEAR APPLICATIONS BUDGET SUMMARY

[In millions of dollars]

	Estimate fiscal year 1977	Estimate fiscal year 1978
Budget authority:		
Total program.....	35.5	51.2
Military related.....	8.6	12.2
Budget outlays:		
Total program.....	34.5	43.6
Military related.....	7.8	10.8

NUCLEAR WEAPON TESTING

Senator NUNN. I will direct my question to Mr. Fri.

To what extent is the nuclear program that you have outlined here dependent on continuing underground testing? What would be the effect of your programs of, say, a 6-month or 12-month nuclear test ban initiative either by treaty or by unilateral action?

Mr. Fri. The test program for both the strategic and tactical weapons that are presently scheduled for development will require a continuation of testing for about 2 years. In general the strategic weapons testing could be completed a little earlier than the tactical weapon testing.

If the test ban went into effect prior to the end of that 2-year period of time we could not reliably develop all of these weapons that are presently scheduled.

Senator NUNN. You say you couldn't reliably develop any of the weapons, that there would be some you couldn't develop?

Mr. Fri. Depending on the exact timing. We couldn't develop all of them. If it ran for about a year we pretty well could do the minimum testing of the weapons currently scheduled for production. As I recall, we could not complete testing of the systems yet to be committed to production. With 2 years we could complete testing to meet most currently projected requirements—which are primarily for modern tactical weapons. In any event it would have to be a somewhat accelerated program.

Senator NUNN. Would a 6 month delay jeopardize your program, or jeopardize national security?

Mr. Fri. Well, I am not exactly sure, Senator, what you mean by 6 months.

Senator NUNN. I am just—

Mr. Fri. If we cease testing today for 6 months and then resume, I think there would simply be a 6-month delay in the production of these weapons by and large.

Mr. STARBUCK. You have to break the weapons into two categories. Many of the weapons types General Bratton described are already developed. However, there are some critical ones that Defense has asked for and that the President has approved for production—President Ford, not President Carter—that were called for up here that would still need developing and testing. It will require, as Mr. Fri indicated to meet the more urgent needs of the early future, for the ones that are approved, about 2 years to complete all of that testing.

Now, if you stop testing, and if you resume in say 6 months, the impact would not be great on your ultimate ability to develop and test weapons. The delay would be slightly over 6 months.

On the other hand, if you terminated and didn't know whether you were ever going to go back and then you try and come back you would have a significant time delay before anything worthwhile could be accomplished. If you stopped testing and you don't go back for 5 or 10 years, then it will be an extended period of time, like a few years, before you could reassemble the testing team, reassemble the laboratory team, carry the developments to where they are ready to test and resume testing. If you went on for 20 years, all of your laboratory expertise would be gone. The laboratory people won't stay if they don't have a job to do.

You would also have had a change in the generation, people, and at the end of that 20 years you really won't be able to remake weapons and have as much, remake the same ones and use them again, and you wouldn't have the feeling of confidence in them because you didn't have the experts who knew the little things that are the differences that cause a problem in a weapon.

Senator NUNN. Thank you, sir.

Chairman STENNIS. Gentlemen, we have a fine capable group of witnesses here. This hearing gets the matters out on the table now, and identifies the various areas, and there will be another chance to get into this more.

NAVAL REACTORS PROGRAM

Senator ANDERSON. Admiral, I hesitate to ask the question, I don't know why a flashlight or a radio works. Why is it that nuclear power seems to be well accepted when it comes to submarines and so forth and yet when it comes to a nuclear powerplant back in our home States there are all sorts of controversy and such. Why is that? Are the fears that our people have back home for nuclear power plants justified? Back home they are going more to coal plants rather than nuclear. Briefly, could you comment on that?

Admiral RICKOVER. I can talk about the naval program. We have 139 reactors in operation, which is about twice as many as there are in the entire U.S. commercial program. The naval nuclear propulsion program has been in operation for a quarter of a century. We have never had a single nuclear accident during that time. Your next question might be how has this been done. The reason I believe we have been successful is that the normal military system of doing things has not been followed. Instead of having an officer as a manager who stays only briefly and then moves on to a new assignment, I have been in charge from the beginning. My organization is responsible for the design and construction of the nuclear plants, for how the reactors are operated, and for the training of personnel who operate these plants. I take my responsibility very seriously and have insisted on technical excellence.

You have a different situation in the commercial nuclear power program. Most of the people who run the utilities that operate the central nuclear stations are lawyers, or accountants. They are business people. They don't have detailed technical knowledge of the nuclear power plants. They also have a large group of people who have a vested interest in opposing nuclear power and they will use any means they can to point out it is unsafe.

For example, I am responsible for the design, and construction and operation of the first nuclear central station plant in this country, the Shippingport Atomic Power Station in Pennsylvania. That project was assigned to me because of our work in the naval program. Several years ago claims were made that there were increased instances of cancer in the area around the plant. The contention was completely unfounded and was based on twisted statistics. We have never had a nuclear accident there nor has there been any adverse impact on the environment.

We take great care in the design, operation, and the training of people. I think this is a critical aspect of our approach and one that has demonstrated nuclear power can be handled in a safe manner.

Senator ANDERSON. I have a daughter that would like to get involved in nuclear submarine work because she would like to be President. I would like to know how she would go about it.

Admiral RICKOVER. One of our submarines is the nuclear powered research submersible, NR-1. It carries five people, and it has only one primitive lavatory in it, and no privacy. I don't know whether you want your daughter there or not.

Senator ANDERSON. She is only 8 years old, Admiral.

Chairman STENNIS. Without objection, Senator Tower requests certain questions be inserted in the record for your attention, gentlemen, and answer.

I have additional questions here for the same purpose. Does anyone have questions?

Senator HART. I have some questions of the ERDA representatives.

Senator NUNN. I have a couple.

Senator JACKSON. Do we understand we will be having another session?

Chairman STENNIS. Yes; but don't assume all of these witnesses will be here. If you have some questions for the record present them now.

Senator HART. I have some oral questions.

Chairman STENNIS. This doesn't complete the hearing. We will get the issues identified here and we will have a further hearing.

Admiral RICKOVER. Senator Anderson, women do not presently serve on submarines but they do serve on my staff and as instructors at the Navy nuclear power school. If your daughter is qualified she can apply for these programs which will include my giving her an interview.

Chairman STENNIS. Without objection, the questions I have will be placed in the record, and we thank all of you very much.

The committee will recess subject to call of the Chair.

[Whereupon, at 12:50 p.m., the committee recessed, subject to call of the Chair.]

QUESTIONS SUBMITTED BY SENATOR JOHN C. STENNIS, CHAIRMAN, TO ADM. HYMAN RICKOVER, DIRECTOR, DIVISION OF NAVAL REACTORS, ERDA

Chairman STENNIS. Admiral Rickover, why is the NR-1, a small deep-diving submarine, being decommissioned?

Admiral RICKOVER. Although the Navy was considering decommissioning NR-1 earlier this year because of budget constraints, current Navy planning does not call for decommissioning the NR-1 in the foreseeable future.

Chairman STENNIS. What has the NR-1 done of use over the last few years, and what uses could you project for the next years if it were not decommissioned?

Admiral RICKOVER. The NR-1 is our only nuclear-powered deep-diving oceanographic research submarine. Since her completion in August, 1969, she has completed a wide variety of missions for the Navy. These have included extended periods making direct visual observations and sonar recordings of the features of several ocean floor canyons and investigations of other significant geological features on the ocean floor. NR-1 has also assisted in erecting underwater sonar transmitting and receiving equipment in the Azores for acoustics research, and has been used extensively for inspecting and burying underwater cables.

Last summer, NR-1 located and recovered the Phoenix missile and assisted in salvage of the F-14 aircraft lost from the aircraft carrier *Kennedy* in about 1,900 feet of water. The combination of high sea states on the surface at the time of

this recovery and the presence of significant amounts of debris on the ocean floor in the area made locating and recovering the missile by any other means virtually impossible.

With her proven capabilities and sophisticated oceanographic equipment she can be even more extensively used in the future for further study of the ocean floor, for new Navy support missions and for such new projects as prospecting for undersea mineral deposits. She is an asset which can be used if new needs such as the Phoenix missile recovery emerge.

Chairman STENNIS. How much additional funding would be required if we did not decommission the NR-1?

Admiral RICKOVER. The funding for NR-1 is being provided within existing Navy resources.

Chairman STENNIS. As I understand it, your work on the submarine advanced nuclear propulsion plant includes developments which could permit the installation of high-powered reactors in relatively smaller submarine hulls. Does this mean that we may be able eventually to build a smaller SSBN than the Trident without sacrificing power or quietness in the propulsion plant?

Admiral RICKOVER. The size of the Trident submarine hull was not set by the propulsion plant. In developing the present Trident submarine design, the Navy also considered building small ballistic missile submarines. However the smaller submarines were not considered cost-effective in terms of their missile performance capabilities.

Chairman STENNIS. You are requesting \$23.1 million for Destroyer Type Dual Nuclear Propulsion Plant effort. Your justification states in part "the research and development efforts necessary to uprate the propulsion power of the D1G plant with the D2W core for use in the CSGN will continue, and support will be provided for procurement of CSGN components." How much of the fiscal year 1978 request is to support efforts on the nuclear strike cruiser?

Admiral RICKOVER. Continued research and development efforts directed toward application of the D2W core and the D1G reactor plant to the new class of CSGN strike cruiser are provided for in fiscal year 1978 ERDA budget request. While a specific project has not been separately identified for this work, it is estimated that less than a million dollars will be spent in fiscal year 1978 for uprating the propulsion power of the D1G plant with the D2W core for use in the CSGN.

QUESTIONS BY SENATOR STENNIS FOR MR. FRI, GENERAL STARBIRD,
GENERAL BRATTON, AND DR. STICKLEY

Question. What are the primary reasons why the Administration believes that the weapons program should remain with ERDA rather than being transferred to the DoD?

Answer. The Energy Reorganization Act of 1974 called for a study of the desirability and feasibility of transferring to the DoD ERDA's military application and Restricted Data functions. The study, conducted by ERDA in collaboration with the DoD, resulted in a report that was transmitted to the President in January 1976. The conclusion, agreed to by both the DoD and ERDA, was that ERDA retain its current responsibilities regarding nuclear weapons; naval, space, and other military reactors; and control of Restricted Data.

The reasoning, behind the 1976 recommendation is still applicable today:

Retain intact a national resource which for over a quarter century has fulfilled the Nation's nuclear weapons needs and ensured that the design and availability of the stockpile are kept current.

Assure retention of important characteristics of the weapon complex and interagency relationships that have proven to be well-founded, and an environment where weapon and energy research and development programs can mutually share the benefit of their individual advances.

Avoid unnecessary disruption of a currently healthy organization.

Avoid potential serious risks inherent in divided ERDA/DoD management responsibility.

Continue to have the advantage of both ERDA and DoD involvement in judgments on such important matters as nuclear weapon safety, security, control, and performance features.

Question. As I recall, one of the original objectives in establishing ERDA's predecessor, the Atomic Energy Commission, was to ensure that nuclear weapons and atomic energy matters were clearly under civilian direction. What are the principal ways in which civilian control over these activities is currently ensured? Was your conclusion to preserve the weapons development activities in ERDA based on this idea of civilian control?

Answer. Your recollection is accurate. Whether atomic energy development should be under civilian control or placed in charge of the military establishment was one of the principal issues during the formative stages of the Atomic Energy Act of 1946. Civilian control was decided upon, but coupled with a specially prescribed system of relationship with the military agencies and also with the President in regard to matters pertaining to the common defense and security. This system has remained essentially unchanged during the past three decades. It has been working very well.

The concept of civilian control over all atomic energy matters, which the 1954 Atomic Energy Act left in place and the Energy Reorganization Act of 1974 continued, is effectuated within ERDA in the following manner:

The Assistant Administrator for National Security (ANS), one of the six categories of functions specified in the 1974 Act creating ERDA, is directly responsible to the Administrator of ERDA for the Administration and direction of the weapons program and complex, as well as certain other security related activities. Under the control of the ANS, the weapons program, to the degree necessary and practical, is conducted apart from the integrated or coordinated administration of ERDA's civilian energy functions.

Where the special capabilities or facilities of the weapons complex can contribute to ERDA's civilian nuclear or nonnuclear energy missions, in the judgment of any of ERDA's programmatic managers, such supportive energy work may be carried out by the weapons complex if it does not interfere significantly with the complex's primary weapon role. Similarly, the weapons complex can also support non-ERDA work in the material interest to the extent concurred in by the Assistant Administrator for National Security.

In the ultimate sense, civilian control over all atomic energy matters is ensured by the statutory direction and the implementing procedural observance that the Administrator head the agency and be responsible for all of its activities. The Administrator makes all the final key agency judgments, including those pertaining to nuclear weapons or other security-related matters.

Effective civilian control is facilitated by the organizational and substantive elements prescribed in the Atomic Energy Act since 1946. These include the General Advisory Committee, the Division of Military Application within ERDA, the Military Liaison Committee which functions as a communications bridge between ERDA and the DoD, and the role of the President in making certain important decisions involving the common defense and security.

ERDA's judgment that the nuclear weapons program should remain in ERDA was not substantially based on the concept of civilian control, but rather on the considerations mentioned at the end of our answer to the first question.

Question. In the proposed reorganization of energy-related activities in the Executive Branch, will there be a statutory position of Assistant Secretary who will have the responsibility for ERDA's national security activities? Why (why not)?

Answer. The materials provided to the Congress along with the President's proposed legislation indicated that there will be in the DOE an Assistant Secretary for Defense Programs. It is my understanding that the intention of this designation is to ensure that the functions now exercised by ERDA in the area of national security will be exercised in the Department by an Assistant Secretary for Defense Programs.

Among these functions are the:

1. Nuclear weapons program, including design, development, test, production, maintenance, and retirement;
2. Classification and declassification of Restricted Data;
3. Safeguards and security aspects of the weapons program as well as safeguards and security aspects of our nuclear research and development functions;
4. ERDA's intelligence functions;
5. ERDA's relationship to the Military Liaison Committee; and
6. Other weapons-related research and development programs.

At the present time, many of the functions exercised by ERDA in these fields are specified by statute. Thus, the Energy Reorganization Act specifically provides for an ERDA Assistant Administrator for National Security, for a Division of Military Application to be directed by a Military Service General/Flag Officer on active duty, and for ERDA's relationship to the MLC. The legislation which has been proposed does not specifically retain these organizational units presently established by statute, and provides that these functions will be organized as determined by the Secretary of Energy.

As indicated earlier, however, the intention of the proposed legislation appears to be that these functions will be exercised by the Assistant Secretary for Defense Programs.

Question. If there were no Assistant Secretary for national security matters in the new Department, is there any danger that the laboratories on which we currently depend for our weapons technology and design might be redirected to civilian activities and that we might thereby lose this military asset?

Answer. In the event of no provision for an Assistant Secretary for national security matters in the proposed new DOE, I suppose one could say that the laboratories on which we currently depend for our weapons technology and design could be redirected to civilian activities.

I think it is important to point out that our existing weapons complex, consisting of three design laboratories, the Nevada Test Site, and the seven production plants, is currently engaged in complementary non-weapon programs of various types, sizes, and durations. In fiscal year 1978, the weapons laboratories' expenditures in support of non-weapon activities will comprise approximately 32 percent of their total operating budget.

To adequately support our national security objectives, I feel we cannot dilute the capabilities of our weapons complex—and this can be best assured by having an Assistant Secretary responsible for national security matters, who reports directly to the Secretary, and who has responsibility for maintaining an overview of the weapons complex and weapons program, and reporting to the Secretary any assignment to the complex of civilian activities which may unacceptably degrade the weapons capability. There also should be a Director and a Division of Military Application who devote themselves completely to directing the nuclear weapons activities of the weapons complex, and assuring retention in the complex of an adequate weapons capability and to meet the DOE's responsibilities for research, design, development, test, production, retirement, and stockpile surveillance of all U.S. nuclear bombs and warheads.

Question. As ERDA and the DoD jointly produce their annual planning paper for nuclear weapons planning, what has been the pattern of practical decision-making? Are the weapons development issues in practice decided more by the DoD or by ERDA? Is there any pattern of differences regarding priorities, and if so, how have these differences typically been resolved?

Answer. Annually, the DoD and ERDA jointly prepare and send a memorandum to the President which includes recommendations regarding the composition of our nuclear stockpile. This memorandum was implemented last year by a National Security Decision Memorandum (NSDM) which approved the stockpile for the next three years and noted the stockpile planning for two additional years. This NSDM also requested that the period covered by the planning years be extended from two to five years in the memorandum submitted in 1977. The pattern of practical decision-making regarding the composition of the national stockpile can be explained by stating that the DoD expresses its requirements and ERDA modifies them if they exceed ERDA's capabilities to develop and produce warheads. In practice, issues are decided by careful independent and joint study and evaluation by both the DoD and ERDA. The process begins with Weapons Conception (Phase 1) and proceeds through Program Study (Phase 2), which includes a Joint Feasibility Study and an ERDA Impact and Capabilities (I&C) study to evaluate various warhead candidates. Upon request from the DoD and agreement by ERDA, ERDA then proceeds into Development Engineering (Phase 3), Production Engineering (Phase 4), First Production (Phase 5), and Quantity Production and Stockpile (Phase 6). In practice, decisions regarding requirements are considered generally under the purview of the DoD and those regarding nuclear design, testing, and production are the responsibility of ERDA. In practice, there is extremely close coordination between the two organizations at the staff and project office levels as well as the management level. Detailed coordination and decisions are made at the DoD/ERDA Project Officer Group level, which includes qualified representatives from the DoD and ERDA staffs and laboratories. Final coordination proceeds through the ERDA and DoD staffs and management and culminates in a recommended stockpile to the President from the Secretary of Defense and the ERDA Administrator.

Question. If there were a comprehensive test ban treaty, what would be the financial reductions that would be produced from a cessation of our testing program?

Answer. The fiscal year 1978 weapons test program budget request is for \$225 million, most of which is associated with the Nevada Test Site (NTS). Assuming safeguards were established to assure the capability to resume testing should future events so dictate and to preserve a nuclear weapon design capability in the U.S. laboratories, the NTS would have to be maintained in a functioning condition, including the sophisticated data collection and processing equipment. In the laboratories, greater emphasis would be placed on experimental simulation and computer modeling. Depending on the extent of this effort, little savings may be available initially.

Question. What would be the effects of a comprehensive test ban on the development of new nuclear weapons?

Answer. Only tested designs, or minor variants to tested designs, would be available for new weapon applications. Even then, greater uncertainty in design yield would result. No major technological advances would be possible.

Question.—On the modification of current weapon designs?

Answer. In the short term, minor modifications to current weapon designs should be possible with little or no effect on design yield uncertainty. This is because an experienced professional staff of engineers and scientists would be on hand to evaluate such modifications. In time, however, the level of competence will degrade as the experienced staff leaves or retires and is replaced by others inexperienced in weapons development, and the extent of our confidence in performance will decrease. This will apply not only to weapons that are modifications to existing designs, but also to "duplicates" that might be produced at some future time when the present stockpile may be replaced.

Question.—On our confidence in the operational reliability of current weapons in the forces?

Answer. Stockpile reliability applies to every aspect of the arming, fuzing, and firing of the nuclear weapon leading to a specified nuclear yield. Because there is an active test program, most yields are certified to [deleted] percent of the design yield. Without testing, the certified yield uncertainty for weapons in the stockpile may increase. In addition, our confidence in the performance of the stockpiled weapons will decrease. The U.S. has no appreciable stockpile experience beyond about twenty years, and no experience in maintaining stockpile reliability under conditions of a comprehensive test ban. However, after about 20 years, we believe that our confidence in the performance of stockpiled weapons will be seriously degraded.

Question. Given your understanding of Soviet nuclear weapons technology, would the Soviets or would we be more severely limited by a comprehensive test ban, assuming that both sides complied?

Answer. Although a properly drawn CTB agreement would impose the same legal constraints on both the United States and the Soviets, the subsequent responses of the two nations might be different, leading to asymmetries where none may now exist. For example, the Soviet technology base might not decline as rapidly as the U.S. technology base because Soviet scientists and engineers might be more readily retained in the weapons program than U.S. scientists and engineers. From the broader standpoint, if both sides decline equally, then the relative value of conventional weapons will increase and asymmetries in conventional weapons will become more important than they are already.

Question. How do you determine what is an adequate level of personnel in our ERDA laboratories? On what criteria?

Answer. Two factors, the ability to support service-requested weapon programs and the need to maintain a balance between near-term requirements for specific weapons and long-term benefits from research and development, determine the nature and level of personnel in the ERDA laboratories. In general, approximately the same numbers of personnel are normally assigned to the three budget areas: current weapons, advanced development, and development capability. When the demand for current weapons work increases, as it did during the last three years, shifts are made from advanced development to current weapons, but not without an adverse effect on future opportunities and capabilities. Fiscal year 1978 increases in laboratory personnel levels reflect an effort at restoring a proper balance to the laboratory programs commensurate with current and projected weapons program workloads.

Question. What has been the effect on your program of the lack of an authorization bill for fiscal year 1977?

Answer. ERDA's not having an authorization for fiscal year 1977 has had, to this point, no major programmatic impact upon the weapons research and development, testing, or production activities. It has resulted, however, in overall delays in initiating new program efforts and new construction project starts. Due to the provisos contained in ERDA's fiscal year 1977 appropriation acts which made availability of funding subject to passage of an authorization act and the subsequent passage of the Continuing Resolution suspending these provisos until March 31, 1977, OMB delayed apportioning funds pending settlement of legal questions on ERDA's authority to obligate fully fiscal year 1977 appropriations. These questions and concerns were resolved with the enactment of Public Law 95-3 on February 16, 1977. Because of the need to restrict allotment of funds through the first half of fiscal year 1977, some programmatic imbalance may result which we can ill-afford at this time, partially resulting from not having complete planning direction based upon a Congressional authorization.

Our fiscal year 1978 budget request anticipated fiscal year 1977 authorization at certain levels for several construction projects. As a result of our not having this authorization, these projects are only partially authorized. If the balance of the authorization is not provided in fiscal year 1978, we will be in a position of having to stop some partially completed projects.

There are general provisions and limitations related to ERDA's total operations that are contained in the annual authorization bill. For example—GPP Limitations/Exceptions; Advanced AE Authority; Transfer Authority; Retention of Revenues; and the Reprogramming Authority.

The lack of new authorization impacts the weapons program in these areas as well as the balance of ERDA operations.

Question. Of the tactical nuclear weapons currently in the NATO theater, which, if any, are militarily obsolescent?

Answer. The DoD, not ERDA, determines military obsolescence and the requirement for new weapons systems. ERDA continues to develop and improve its nuclear technology and produce nuclear warheads to meet the DoD requirements and improve the safety and security of these warheads.

However, the following systems are being retired: the Honest John rocket (W31) and Sergeant missile (W52) warheads in NATO are currently being replaced by the Lance missile (W70 warheads). The older tactical B28 and B43 bombs are also being replaced by the B61 Mod 2 bombs. Near-future plans are to replace the old W33 8-inch AFAP with the W79 AFAP beginning in [deleted] and to continue to replace B28 and B43 bombs with improved versions of the B61 bomb (Mods 3, 4, and 5). Other tactical nuclear weapons that are candidates for replacement by modern weapons include the PERSING missile (W50) warhead and the 155mm AFAP (W48). In each case, this modernization is proposed to eliminate current limitations of the older weapons and replace them with weapons which incorporate modern technology—weapons which provide: (1) enhanced safety, (2) improved command and control, (3) better security and disablement features, (4) effects that are tailored to the increased ranges and accuracies of improved delivery systems, and (5) compatibility with the increased environmental stresses encountered in new long-range howitzers.

Question. What percentage of these tactical nuclear weapons in the NATO theater lack even the first generation of devices to ensure the integrity of the command process, their easy disablement, and enhance handling safety?

Answer. None. All weapons currently in NATO are protected by a Permissive Action Link (PAL) device of some type which insures integrity of the command process. Distribution of PAL devices in NATO weapons is shown in the table below. The only weapons in NATO which have an inertial command disable capability are the W70 LANCE warhead and the B61-2 bomb [deleted]; however, the equipment and trained personnel are present with every nuclear weapon in NATO to perform emergency weapon destruction if and when required. All nuclear weapons in NATO have environmental sensing devices, PAL devices, and other devices or procedures which enhance handling safety.

PAL devices in NATO weapons

<i>Type</i>	<i>Percentage</i>
1. Combination lock-----	[deleted]
2. Coded Switch—4 digit (ground operated)-----	[deleted]
3. Coded Switch—4 digit (airplane operated)-----	[deleted]
4. Coded Switch—4 digit (limited try [deleted])-----	[deleted]
5. Coded Switch—6 digit (limited try [deleted])-----	[deleted]
6. Multiple code coded switch—6 digit (limited try [deleted])-----	[deleted]

The DoD and ERDA have underway a modernization program to improve the PAL's and other security features of NATO nuclear weapons.

Question. Of the deployed tactical nuclear stocks in the NATO theatre, what plans do you have over the next five years to recycle the critical nuclear materials for other weapons developments?

Answer. Nuclear materials from NATO tactical weapons which are retired will be used in new production weapons for systems in production as the materials become available. Once the material from retired weapons has been recovered and processed to be used in new builds, it is difficult to differentiate it from virgin production. Over the next five years, the materials reclaimed from NATO's retired weapons will be used along with other retirements to support the new weapons produced for use in NATO as well as other commands.

Question. Since much of the increase in your funding request for weapons activities is due to the production of several new weapons, we are naturally interested in the timing of those programs. For example, since the MK-12A warhead for the Minuteman III's IOC has slipped, was there any revision downward of your request for fiscal year 1978 from last year's projected level?

Answer. During our testimony before your Committee on March 25, 1977, we advised you that there have been certain changes in DoD requirements, schedules, weapon design features, and refinement of ERDA estimates since the President submitted his budget request in January. I have detailed these changes to you in my letter of April 4, 1977. One of those changes is your referenced [deleted] IOC slip in the W78 MK-12A warhead for the Minuteman III's. There is a \$6,500,000 estimated reduction from our last year's projected level related to this slip.

However, in addition to the W78 change, other major changes have occurred which tend to balance within the President's fiscal year 1978 weapons program funding request. Those major changes are tabulated below:

Weapon system and brief reason for change :	Millions
W68 Poseidon—Retrofit-----	\$2.0
W70-3 Lance—Schedule change-----	-2.4
W76 Trident—Material price changes-----	8.9
W76 Trident—Schedule change-----	-4.1
B77 FUFO—Change in component qualification schedule and requirements for additional testers related to enhanced integrated circuitry-----	3.5
W78 Minuteman III—[deleted] slip of initial operational capability---	-6.5
W79 8" AFAP—Reduction in long lead procurement and reduced design effort in the Joint Flight Test Program-----	-2.3
W80 Cruise missile—Additional design requirements such as: Cat D PAL, nonviolent command disable, [deleted] et cetera-----	3.6
Balance of Changes-----	+2.7

Realizing that the design of the newer weapons are not yet firm and that current development engineering and process development effort should provide cost trade-off options, we feel that any current projected increment/decrement potential is within our management purview and recommend no change in the weapons program funding requested in the President's budget. Significant changes will of course be reported to your Committee as they are identified.

Question. If the IOC for the Land Attack (Tomahawk) Cruise Missile were slipped and the IOC for the Air Launched Cruise Missile (ALCM) were not accelerated [deleted] would there be a reduction in your required funds for the development of the W80 common warhead?

Answer. There would be some reduction in the production funds required in fiscal year 1978 if the Tomahawk IOC were slipped and the ALCM were not accelerated. However, total costs for development of the W80 warhead will not be affected appreciably by minor changes in development schedules. Major changes could lead to increased costs due to inefficiencies of scale. In order to insure that development goals are met in a timely and logically progressive manner, development schedules are laid out many months in advance of planned actions. Such schedules include planned dates for completing certain design actions, fabrication of hardware in accordance with the designs, and testing of this hardware. Implicit in these development schedules is a rate of expenditure of funds for manpower and for materials. Funds are committed to procure materials well in advance of a scheduled test date in order to insure that hardware can be fabricated in time to be available for testing. In order to prevent abrupt changes in the manpower levels at our nuclear laboratories, a degree of flexibility is maintained for moving personnel from one development program to another or from

a technology improvement program to a development program. Hence, halting or slowing the pace of a particular development effort does not necessarily save the cost of manpower previously charged to that effort since personnel would likely be assigned elsewhere within the laboratory. All of these factors combine to offset monetary savings which might otherwise result from slowing or halting a development effort. Such is the case with the development program for the W80 common warhead.

Question. What would be the possible benefits of upgrading the Minuteman II warhead? What would be the approximate cost?

Answer. The W56-1/MK 11 for the Minuteman II (MM II) entered the stockpile in 1963. Since that time, it has been modified, hardened, and upgraded to its present state, the W56-4/MK 11C. Basically, the W56 utilized technologies of the late 1950's and early 1960's. [Deleted].

ERDA is developing cost estimates associated with replacing the W56/MK 11C [deleted] would more than warrant the cost involved in developing and producing the new MM II warhead.

Question. Would you explain to the Committee in as nontechnical language as possible the practical near-term and long-term military applications of the laser fusion activity program?

Answer. There are two aspects to the use of Inertial Confinement Fusion (ICF) in the weapons program. The first is to use the radiation output of fusion pellets to simulate the effects of the enemy's nuclear weapon radiation on our military systems. The inertial confinement fusion process is versatile because the target output—high energy neutrons, alpha rays, gamma rays, X-rays—can be varied by varying the target design. When very large ICF experimental devices become available, we expect to be able to provide full-scale simulation of weapons effects on materials and actual weapon systems. Some of the effects that can be studied now only by underground testing can be simulated eventually in the laboratory using large inertial confinement fusion systems.

The other aspects of the use of ICF experiments is to model various aspects of the design of our nuclear weapons. Certain of the phenomena that occur in a laser- or particle-beam irradiated target are similar to those which occur in a [deleted] weapon. Nuclear weapons physics has been largely an empirical development, obtained by testing devices. On a laboratory scale, data that can contribute to enhanced weapon physics understanding can be obtained by irradiating target materials with laser or particle beams. Increasing beam powers from successively larger machines provides an increasing weapon physics capability.

QUESTIONS BY SENATOR STROM THURMOND FOR DR. C. MARTIN STICKLEY, DIRECTOR,
DIVISION OF LASER FUSION, ERDA

Question. Dr. Stickley, what cuts were imposed on the laser fusion account in the budget amendments?

Answer. The budget reductions in the Laser Fusion Program amounted to a total of \$20 million. The major components of this reduction are:

\$2.5 million reduction in the Electron Beam Fusion Facility at Sandia.

\$12.0 million reduction in the High Energy Gas Laser Facility at Los Alamos.

\$8.0 million reduction in the High Energy Laser Facility (NOVA) at Livermore.

\$2.5 million increase in operating funds to achieve a proper balance between operating and construction programs in light of the current construction program reductions.

Question. How will the budget cut of the Los Alamos Gas Laser Facility delay that program?

Answer. The budget reduction in the Los Alamos High Energy Gas Laser Facility (HEGLF) from \$14.9 million to \$2.9 million will delay the completion of this project by one year to September 1982.

Question. When was this construction project begun and was it on schedule up until this point?

Answer. Architect-engineering effort was begun on this project in fiscal year 1976. Due to delays in A-E effort and budget constraints, the previous completion date of September 1980 was revised to September 1981. This project is currently on a schedule toward meeting that completion date which will now be slipped to September 1982.

Question. Does the budget action mean termination of any major contracts?

Answer. The budget cut will be absorbed by the delay of construction and fabrication tasks within the project so that no contract terminations will be necessary.

Question. What programs could be most adversely affected by the delay in this facility's capability to provide weapons effects simulation in the laboratory?

Answer. At this time, there is no specific dependence of any of the weapons programs on the ability of HEGLF to provide weapons effects simulation. Applications are now underway to more specifically define the weapons design and simulation uses of the HEGLF and other inertial confinement fusion devices.

QUESTIONS SUBMITTED BY SENATOR STROM THURMOND TO ADMIRAL
HYMAN RICKOVER, DIVISION OF NAVAL REACTORS, ERDA

Senator THURMOND. Admiral Rickover, current policy set by Congress calls for nuclear power for all of the Navy's major combatants. What tonnage guidelines are being used to determine the size of a ship classified as a major combatant?

Admiral RICKOVER. Senator Thurmond, Title VIII of Public Law 93-365, to which you refer, specifically defines "major combatant vessels for the strike forces of the United States Navy" as:

- (1) Combatant submarines for strategic or tactical missions or both;
- (2) Combatant vessels intended to operate in combat in aircraft carrier task groups (that is, aircraft carriers and the cruisers, frigates, and destroyers which accompany aircraft carriers); and
- (3) Those types of combatant vessels referred to in clauses (1) and (2) above designed for independent combat missions where essentially unlimited high speed endurance will be of significant military value.

Accordingly, there is no specific tonnage guideline. There are many support force and convoy type ships that could be bigger than our smaller nuclear ships. Nuclear surface ships range in size all the way from the *Nimitz* Class carriers with a combat load displacement of about 95,000 tons to the U.S.S. *Bainbridge*, a guided missile cruiser with a displacement of about 8,500 tons.

As you can see, nuclear propulsion plants can be built for any reasonable size ship. However, since nuclear propulsion plants are expensive to construct and operate, nuclear propulsion is not worthwhile except for the Navy's best ships—our major combatant vessels.

Mr. Vinson, when he was chairman of the House Armed Services Committee, set a limit of 8,000 tons and established the policy that any warship over 8,000 tons should be nuclear. That is still a practical guide for surface warships because by the time suitable anti-air warfare, anti-surface and anti-submarine warfare weapons, with the necessary sensors, are accommodated in the ship design, I feel sure the ships would be at least 8,000 tons displacement.

Senator THURMOND. Is that likely to change in the years ahead?

Admiral RICKOVER. Senator, I do not think it is likely to change very much.

Senator THURMOND. Would the proposed "smaller" aircraft carriers be nuclear propelled?

Admiral RICKOVER. Senator, the Department of Defense and Office of Management and Budget have taken the stand that the smaller aircraft carriers which they propose, designated "CVV's," are not to be nuclear powered.

As you know, it is not my business to determine whether or not the Navy needs aircraft carriers or how many the Navy needs. However, I have been recommending for over 20 years that any aircraft carriers built for the Navy be nuclear powered.

Whatever carrier is built should be nuclear for the same reasons that the *Nimitz* Class were made nuclear in the first place. It makes no sense to build strike force ships that are supposed to take on the best the enemy throws against us that are dependent on a vulnerable tanker force for propulsion fuel in time of war. The tankers will be the first targets for enemy submarine and air attacks, as they were our first priority targets in the Pacific in World War II. What good are oil-fired strike force ships that are short of propulsion fuel. We must build our strike force ships to be able to fight and win in war. If we believe that there will never be a war, why build the ships at all?

Senator THURMOND. Does DOD evaluate the nuclear programs based on life-time costs?

Admiral RICKOVER. Senator Thurmond, I do not know the basis used by the Department of Defense to decide not to build the CVN 71.

My statement to the House Appropriations Committee yesterday explained why I believe the CVN 71 should be built. That statement, of course, cites the lifetime costs of nuclear carrier task forces versus conventionally powered carrier task forces which show that over their lifetime nuclear carrier task forces really do not cost much more. I explained why I do not believe the successful development of V/STOL aircraft has anything to do with whether or not the CVN 71 should be built.

Senator THURMOND. What weight is given to the fact that the larger ships carry much more in the way of weapon systems?

Admiral RICKOVER. The only way I can figure it, the analysts must not have considered the fighting capability of the ship when they reached their decision, because if they did, I don't see why they would recommend against building the CVN 71.

Senator THURMOND. Admiral, why do the systems analysts seem to often come down on the side of conventionally powered ships?

Admiral RICKOVER. You really should ask the systems analysts to come over here and testify to your Committee and ask them that question, I simply don't know.

Senator THURMOND. Is there any likelihood of smaller nuclear powered attack submarines? Is such a prospect desirable?

Admiral RICKOVER. The Navy currently has no plans for constructing smaller nuclear powered attack submarines. Although it would be desirable to decrease the size of attack submarines, I do not believe this prospect is likely. Over the past twenty years, the trend has been just the opposite—increasing not decreasing size. This has been caused by requirements for improved military characteristics such as speed, quietness, depth, sonar, and communications. There have been many studies of smaller attack submarines, but in each case a reduction in size is achieved only by assuming unacceptable reductions in reliability maintainability, safety, or military characteristics. None of these studies or industry proposals have been accepted by the Navy for further effort.

Senator THURMOND. What evaluation is made in weighing the availability or non-availability of oil for conventional ships in high threat areas?

Admiral RICKOVER. Again, Senator, the analysts apparently give no weight to the vulnerability of tankers in high threat areas. All the cost studies I have ever seen from the systems analysts have assumed that propulsion fuel oil can be provided to the combatants in high threat areas, wherever and whenever needed. The one study that was done in the middle 1960's which analyzed the threat to the replenishment forces found that the conventional powered task forces capability in the high threat areas was much less due to the greater amount of logistic support required for the conventional warships.

Even in this study the assumption was made that whenever a logistic support ship was lost to enemy action, a replacement ship would leave port immediately to replace it.

Now, Senator, you know that assumption is unrealistic. The systems analysts simply refuse to face the world as it really is.

Senator THURMOND. How is the speed of a ship when moving from Point A to Point B evaluated in making a determination as to the advisability of nuclear or conventional power?

Admiral RICKOVER. The analysts say they give consideration to the speed of a ship when moving from one place to another; however, even this consideration is often superficial. For example, in the Report to Congress on U.S. Strategy and Naval Forces Requirements dated 15 January 1977, on page 60, there is a paragraph on the relative advantages of nuclear power for transiting long distances. The paragraph concludes:

"In contrast, however, if the transit distance is only on the order of 4,000 nm (e.g., East Coast of U.S. to Eastern Mediterranean), the nuclear and oil-fired carrier can arrive at about the same time."

Now, there was a real world parallel to this statement during the Jordanian crisis in 1970.

The oil-fired aircraft carrier *John F. Kennedy*, CVA 67, was sent from the Second Fleet to reinforce the Sixth Fleet in the Mediterranean. She transited about 4,000 miles from Roosevelt Roads near Puerto Rico at a speed of advance of about 23 knots. This low speed of advance was necessary to conserve fuel so that a reasonable reserve would be aboard upon arrival. She refueled from the tanker *Truckee* west of the Strait of Sicily.

Had a higher speed been necessary for the transit it would have been necessary to refuel at Gibraltar as she does not carry sufficient black oil for a high speed transit of that distance without refueling. The *Kennedy* burns nearly twice as much fuel per mile steamed at 30 knots as she does at 23 knots.

A nuclear carrier could have made the transit at high speed and arrived two days earlier without concern for refueling. Now, remember, the analysts, in their 15 January 1977 Report to Congress said they would arrive at about the same time.

In a real war situation the two days could have been decisive in battle and the tanker would have been a vulnerable target and might well have already been sunk when the *Kennedy* arrived. This is another example of the need for nuclear propulsion in our first line surface warships.

I will furnish for your record the statement concerning the carrier issue I gave yesterday to the House Appropriations Committee.

[The following statement was provided for the record:]

AIRCRAFT CARRIERS

An examination of the relative strengths of the Soviet Navy and the United States Navy quickly reveals that the only category of combatant ship in which the United States is clearly superior in numbers and individual ship combat capability is the aircraft carrier.

For the foreseeable future, the aircraft carrier will be the principal offensive striking arm of our Navy in a non-nuclear war. No other weapon system under development can replace the long range, sustained, concentrated firepower of the carrier air wing. Torpedo firing nuclear submarines, cruise missile firing nuclear submarines, nuclear cruisers with anti-air, anti-surface, and anti-submarine capabilities—all are needed to supplement and augment the capabilities of the nuclear carrier. But without the tactical air power provided by carriers all of our other surface forces would have greatly increased vulnerability. If an opponent is successful in developing weapons that can sink large numbers of our carriers, and we are not successful in developing adequate counter weapons—or if we simply do not build a sufficient modern carrier force to protect our sea lanes—the United States will have to change its national objectives to be consistent with our inability to conduct overseas military operations.

How many carriers the Navy must have I am, of course, not qualified to determine. However, I note that the number of overseas air bases available to us continues to decline, and there is no known alternative to carriers for providing significant tactical air power beyond the range of provisioned and protected land bases. Since the capabilities of the Soviets to attack us at sea with land-based aircraft, nuclear submarines, and surface ships continue to increase, our need for numbers of carriers capable of penetrating this threat appears to me to be increasing rather than decreasing. I have observed over the past 25 years that the carrier force level projected by the Secretary of Defense for future years often showed a decline to around 12, but that each year as defense officials faced current realities they decided on a force level for that year of at least 14. But since only four new carriers have been authorized for construction since 1963, a lower force level has now been dictated by the necessity to retire over-age ships that are rapidly wearing out. Further, we no longer have the flexibility of rapidly increasing the carrier force level by reactivating Reserve Fleet carriers, as we did in the Korean War when we reactivated relatively new *Essex* Class ships which were mothballed after World War II.

Long-lead Funds for the Fourth *Nimitz* Class Carrier, CVN 71

The Navy originally proposed that a fourth *Nimitz* Class carrier, the CVN 71, be built for delivery in October 1984—four years after the contract delivery date of the nuclear aircraft carrier *Carl Vinson*, CVN 70. To achieve this delivery, the carrier would have to have been authorized in fiscal year 1978 or 1979 with a minimum of \$350 million in fiscal year 1977 and a minimum of an additional \$410 million in fiscal 1978 for procurement of long leadtime items. President Ford's fiscal year 1977 budget authorization request submitted to Congress in January 1975 requested the first increment of advance procurement funds. However, the President's amended fiscal year 1977 budget authorization request submitted to Congress in January 1976 deferred the advance procurement funds to fiscal year 1978. In May 1976 President Ford further amended his fiscal year 1977 budget request

to restore the request for \$350 million in fiscal year 1977 for the CVN 71. Secretary of Defense Rumsfeld testified that the on-going National Security Council review of naval forces had proceeded to the point that it was clear that the fourth *Nimitz* Class carrier is needed. The Congress authorized and appropriated the funds.

In January 1977 President Ford notified Congress that he had decided to cancel the CVN 71 and requested that the \$350 million for CVN 71 be rescinded. President Ford proposed that two smaller, conventional carriers, to be authorized in fiscal year 1979 and 1981, be built in lieu of the CVN 71. In his letter to the Speaker of the House of January 19, 1977 justifying this change in the carrier program he did not give any comparison of the capabilities of the proposed conventional carriers and the *Nimitz* Class ship. The letter merely states:

"After reviewing the missions and force levels of the Naval strike forces in the past year, I have also concluded that it is in the national interest to begin procurement of a conventionally powered aircraft carrier sized for Vertical/Short Take-off and Landing (V/STOL) aircraft.

"While our recent aircraft carriers have been nuclear powered, the reduced size of the V/STOL carrier raises serious questions regarding the benefits to be derived from nuclear power. The fiscal year authorization request for the Department of Defense includes \$1,250 million for the first ship of the new class of aircraft carriers."

The President's letter indicated that the cost of the fourth *Nimitz* Class carrier, CVN 71, would be \$2.11 billion. However, the table attached to the President's letter showed that this pricing was based on providing only \$130 million in fiscal year 1978 which would stretch out the delivery of the ship to fiscal year 1986 and increase its cost over \$100 million compared to the funding plan proposed by the Navy. The National Security Council study listed the cost of the CVN 71 as \$2.3 billion.

In February the new Administration endorsed President Ford's proposal to plan on substituting two smaller, conventional carriers for the fourth *Nimitz* Class carrier. The Administration proposed that contracts amounting to \$268.4 million for nuclear propulsion plant components that had already been placed not be cancelled, since the components could be used as shore-based spares for the three *Nimitz* Class carriers already authorized. Early this month the Congress approved the Carter Administration's request to rescind the remaining \$81.6 million originally appropriated in fiscal year 1977 for the CVN 71.

Just to set the record straight I would like to point out that the Navy's end-cost estimate for the CVN 71 was \$1.984 billion provided the \$350 million appropriated in fiscal year 1977 had been released to procure long lead equipment and at least an additional \$410 million had been appropriated in fiscal year 1978 as the Navy had recommended.

Since \$81.6 million of the fiscal year 1977 advance procurement funds has now been rescissioned and no fiscal year 1978 advance procurement funds are planned, if the fourth *Nimitz* Class carrier is authorized at some future date, its delivery will be delayed and its cost, of course, will be significantly increased.

AIRCRAFT CARRIER SIZE

There are many who would push the Navy in the direction of constructing carriers much smaller than the *Nimitz*, without nuclear propulsion, and with the fighting capability selected based on a predetermined ship size or cost. The systems analysts have mounted a concerted effort to do this for the past several years. Unfortunately, as H. L. Menchen said, "For every difficult and complex problem, there is an obvious solution that is simple, easy, and wrong."

There are two basic, and separable, issues involved here. The first is what size aircraft carrier is needed for our first line naval strike forces. The second is the need for nuclear propulsion independent of the size of the carrier.

Over the past half century I have followed with great interest the evolution of the aircraft carrier into the Navy's principal offensive weapon system for non-nuclear war. When I graduated from the Naval Academy in 1922, the Navy's first carrier, the *U.S.S. Langley*, CV-1, a converted collier, had just been completed. This was the same year the United States ratified "A Treaty Between the United States of America, the British Empire, France, Italy, and Japan Limiting Naval Armament." The treaty, which resulted from the Washington Naval Conference of 1921, set forth limitations on naval armament in two major categories: capital ships and aircraft carriers. The term "capital ship" was defined in the

treaty as a vessel of war, not an aircraft carrier, whose displacement exceeds 10,000 tons or which carries a gun with a caliber exceeding 8 inches. The United States was allowed to retain 18 existing capital ships, all of which were battleships, for a total tonnage of 500,650 tons. Capital ships could be replaced when they reached 20 years of age except no new capital ships were to be laid down for 10 years after November 12, 1921, with certain minor exceptions specified in the treaty. The total capital ship replacement tonnage of the United States was agreed not to exceed 525,000 tons. It was also provided that no capital ship exceeding 35,000 tons standard displacement would be acquired or constructed by any of the powers. Standard displacement was defined in the treaty as:

"The displacement of the ship complete, fully manned, engined, and equipped ready for sea, including all armament and ammunition, equipment, outfit, provisions and fresh water for crew, miscellaneous stores and implements of every description that are intended to be carried in war, but without fuel or reserve feed water on board."

The treaty stipulated that all existing aircraft carrier tonnage should be considered experimental and therefore aircraft carriers could be replaced without regard for age. The powers also agreed that the total tonnage for aircraft carriers for the United States would not exceed 135,000 tons in standard displacement. An aircraft carrier was defined as a vessel of war with a displacement exceeding 10,000 tons and designed for the specific and exclusive purpose of carrying, launching and landing aircraft.

It was also provided that no more than two aircraft carriers exceeding 27,000 tons standard displacement would be acquired by or constructed by any of the powers. Two carriers could be of a tonnage of not more than 33,000 tons standard displacement and had to be accounted for within the total tonnage allowances for aircraft carriers. For economy these two carriers could be converted from any two ships whether constructed or in the course of construction which would otherwise be scrapped under the provisions of the treaty. The United States utilized this provision to convert the battle cruisers *Lexington* and *Saratoga* which were under construction to aircraft carriers; otherwise they would have been scrapped.

A little arithmetic will show that the total aircraft carrier tonnage allotted to the United States under the term of the treaty could have provided as few as four or as many as 13 aircraft carriers depending on their displacement, in addition to the 18 battleships. Under the terms of the treaty, the *Langley* was considered experimental and did not count against the aircraft carrier tonnage allotment. The United States actually used its allotment of 135,000 tons to build six aircraft carriers *Lexington*, *Saratoga*, *Ranger*, *Yorktown*, *Enterprise*, and *Wasp*, which were all completed or under construction before the treaty was terminated on December 31, 1936.

In view of the current great interest in disarmament talks, I think it would be worthwhile if more people read the Senate report on the 1921 disarmament conference. (Senate Report on Conference on the Limitation of Armament, February 3 (calendar day, February 10), 1922, Document No. 126 67-2).

On December 7, 1941, when the Japanese attacked Pearl Harbor, the United States had in commission 17 battleships and seven aircraft carriers in addition to one escort carrier, the *Long Island*, which had been converted from a C-3 type cargo ship. In addition eight battleships and the first five aircraft carriers of the *Essex* Class had been laid down. The *Essex* Class carriers, all of which are now retired, had a standard displacement of about 33,000 tons and a combat load displacement of about 43,000 tons.

During World War II the aircraft carrier came into its own as the heart of our naval strike forces. The need for increasing the size of carriers in order to provide adequate combat capabilities of individual units became evident. Before the war was over, construction started on the three carriers of the *Midway* Class with a combat load displacement over 60,000 tons each.

Based on the lessons learned during the war and the evolution of higher performance aircraft, the need for even larger carriers became evident. In order to accommodate an air wing with sufficient variety and numbers of aircraft to handle the missions of a first line carrier, and to provide sufficient ammunition, aircraft fuel, maintenance shops, spare parts, and personnel accommodations, the large-deck carriers of the *Forrestal* Class were developed in the decade following World War II. Eight were built between 1955 and 1968, the *Forrestal*, *Saratoga*, *Ranger*, *Independence*, *Kitty Hawk*, *Constellation*, *America*, and *John F. Kennedy*. These 80,000 ton ships and the nuclear carriers *Enterprise* and

Nimitz are the backbone of our present Navy for non-nuclear war. The *Midway*, *Franklin D. Roosevelt*, and *Coral Sea* are also still in commission, but are all over 30 years old.

The *Nimitz* Class carriers are slightly larger than the large-deck non-nuclear carriers, but since they carry much more aircraft fuel and ammunition they have about a ten percent greater displacement.

Over the past 10 years the total number of carriers in the Fleet has been reduced from 23 to 13 as the older and smaller *Essex* Class carriers have been retired. The anti-submarine warfare functions previously assigned to our smaller carriers have now been added to the attack missions assigned to our large-deck carriers. As the Soviet naval threat has expanded, the need for a large, versatile air wing on each carrier has increased. The increase in the variety of aircraft on an individual carrier needed to carry out multiple missions has increased the space required for maintenance shops, spare parts, and specialized personnel associated with each type of aircraft.

Throughout this half century the performance of individual aircraft has increased markedly. However, the demands placed on them have also increased as the threat which they must penetrate has become more sophisticated. The aviation community predicts that the combat aircraft of the future will be a Vertical Short Take Off and Landing (V/STOL) type aircraft. Predictions of when high performance combat aircraft of this type will be developed range from the late 1980's to the turn of the century. Of course, much of the new technology could also be used to improve the performance of catapult launched aircraft.

Some people seem to think that the development of V/STOL aircraft will eliminate the need to build large-deck carriers for our first line naval strike forces. This appears to me to be a *non-sequitur*. Even though the Navy may be able to develop high performance V/STOL aircraft over the next 15 years, I do not see what that has to do with the size of the aircraft carrier.

I have seen nothing predicted about V/STOL technology that will make the aircraft smaller or reduce the number needed in an air wing. There is nothing about the V/STOL concept that will reduce ammunition and aircraft fuel requirements. There is nothing in the V/STOL concept that will reduce the maintenance shops, spare parts, and personnel needed in a carrier. There is nothing about V/STOL that will make a smaller carrier more seaworthy.

The take off space required for a fully loaded combat V/STOL aircraft is expected to be about the same as that now required for catapults. It is true that the need for arresting wires will be eliminated by V/STOL. However, our present carriers already utilize the landing area for parking aircraft during air wing launch operations. Thus, a V/STOL air wing with the same number of aircraft will probably require essentially as much flight deck space as is required for catapult launched aircraft.

Therefore, it appears to me that it will require just as large a carrier to support an adequate air wing of V/STOL aircraft as is required to support an adequate air wing of catapult aircraft.

How large an aircraft carrier should be has been studied many times over the past 15 years. The construction of the last conventional carrier, the *John F. Kennedy*, was held up for over a year while the Navy studied this issue in response to the request of Carl Vinson when he was Chairman of the House Armed Services Committee. When Admiral McDonald became Chief of Naval Operations in 1963, one of the first things he did was have the Navy make a new study of how big an attack carrier should be. He had commanded the smaller carrier *Coral Sea*, and only became convinced after extensive studies that construction of large-deck carriers should be continued.

In 1964, Secretary of Defense McNamara accepted the policy recommended by the Navy that all aircraft carriers to be authorized in the future would be nuclear powered. But it was only after additional studies of alternative size carriers that he agreed that the *Nimitz* Class carriers would be larger than the *Kennedy*; he had thought they should be about *Midway* size. Over the next decade the *Nimitz*, *Dwight D. Eisenhower*, and *Carl Vinson* were authorized.

In a memorandum to Secretary of the Navy Warner dated 21 September 1972, Deputy Secretary of Defense Rush disapproved the Navy recommendation to plan on authorization of a fourth *Nimitz* Class carrier in fiscal year 1978 and directed that the next carrier be designed to cost not more than \$550 million in fiscal year 1973 dollars. Leonard Sullivan, when he was Assistant Secretary of Defense for Program Analysis and Evaluation, the senior systems analyst in

the Pentagon, later told me that this cost restraint was selected to force the Navy into designing carriers smaller than the *Forrestal* Class and without nuclear propulsion. This ship was given the designation CVX. The Navy spent over \$2 million and over two years developing a tentative conceptual baseline for this ship. The design has acquired the acronym TCBL.

Although the Navy was unable to get the design of this ship down to a specified cost of \$550 million in fiscal year 1973 dollars, the TCBL design represents the minimum conventional carrier the Navy was willing to build. The Navy presently estimates it would cost \$1.25 billion to build this ship in the fiscal year 1979 shipbuilding program. This ship design is being considered for the carrier now planned in the fiscal year 1979 program.

A *Nimitz* Class carrier would have the following substantially superior military characteristics compared to the tentative baseline characteristics of the cost constrained CVX conceptual design:

(a) All the advantages of nuclear propulsion, including nuclear cores capable of providing 13 years of normal operation. In this regard, it should be noted that these cores contain the equivalent of 11 million barrels of oil. At today's prices it would cost about \$330 million to buy and deliver this much oil to the conventional carrier.

(b) Capacity to carry and support a 50 percent larger air wing.

(c) Capacity for almost three times the aircraft ammunition and more than four times the aircraft fuel.

(d) Four catapults and four elevators in lieu of two each for the CVX, which provides greater mission reliability and at least twice the aircraft launch rate. It should be noted that an FY 1979 aircraft carrier will operate with aircraft which require catapulting for a number of years, even if V/STOL aircraft eventually replace catapult launched aircraft for first line missions. In this regard, since much of the improved technology planned for V/STOL aircraft would also improve the performance of catapult launched aircraft, it will be very difficult to develop V/STOL aircraft which will match the performance of catapult launched aircraft of the same vintage.

(e) Better sea-keeping capabilities which reduces the likelihood that air operations will have to be suspended due to sea conditions. A study of alternative carrier designs done last year by the Office of the Chief of Naval Operations showed that a ship the size of the CVX would have to suspend air operations during winter in the North Atlantic twice as frequently as a *Nimitz* Class carrier. The CVX could also be expected to have twice the night-landing accident rate when weather permitted air operations.

(f) About [deleted] knots greater speed. The CVX could not keep up with nuclear carrier task forces and would thus be more vulnerable to submarine attack.

(g) Four propulsion shafts in lieu of two for the CVX, which provides greater propulsion reliability.

The CVX had a combat load displacement of 60,000 tons. If an even smaller carrier is to be built, as some have suggested, its combat capabilities would be degraded further. In this regard, it should be noted that last year's Navy carrier study concluded that a carrier with the air wing capabilities of the CVX could generate only half the number of sorties that could be generated by the air wing on the CVN 71. The study also concluded that the air wing which could be accommodated on a carrier the CVX size would be "marginally capable of operation in the force projection role in low threat areas and incapable in high threat areas due to limited numbers of aircraft available for essential functions combined with the inability to generate required sortie rates." The study also concluded that a carrier of this size "could not serve effectively in the multi-purpose sea-control role, again because too few aircraft could be accommodated."

It is often said that the advantage of two smaller carriers in lieu of one larger one is that one carrier can't be in two places at once. But what good is it to have two carriers in two places if neither one carries an air wing large enough to take care of itself against the projected threat?

It is also said that we should not build a \$2 billion carrier because it is too vulnerable. But this argument ignores that fact that the vulnerability of the smaller, conventional carrier is far greater.

Frankly, it does not make sense to me to set an arbitrary limit on the acquisition cost or displacement of an aircraft carrier, nuclear or conventional. The fighting capability of the air wing the carrier can support determines the offensive capability of the entire carrier task group. For the relatively small amount "saved" in carrier acquisition cost by forcing it to be smaller, major reductions

in combat capability of the air wing result. Such reductions do nothing to cut carrier task group support costs such as escort force costs. In fact, they increase logistic support costs because of the more frequent replenishment required by the reduced capacity of smaller carriers for combat consumables. These considerations will still apply even when high performance V/STOL aircraft become available sometime in the 1990's or later.

Navy studies show that a nuclear carrier the size of the proposed smaller conventional carrier can be built, but that a *Nimitz* size carrier provides more than twice the combat capability of the smaller carrier. The total cost of two of the smaller conventional carriers would be far more than the total cost of one *Nimitz* Class carrier.

The reduction in the total number of carriers in the Fleet requires each to be large in order to accommodate an adequate number of aircraft so that the minimum number of carriers need be used for any given assignment. Also, the increasing sophistication of the projected Soviet air threat argues against a decrease in the capabilities of the carrier air wing which would be forced by a significant reduction in carrier size.

The CVNX Characteristics Study Group Report published by the Navy last year concludes:

"Overall, it is more cost effective to procure modified design *Nimitz* Class carriers. The principal reasons are:

"Projected funding levels will support a force level of not more than 13 or 14 fully capable carriers.

"At force levels of 13 or 14 carriers, high individual carrier capability is required to meet tactical requirements.

"Carriers significantly smaller than the *Nimitz* Class cannot support the practical minimum number and types of aircraft required to perform missions alone in the presence of an air threat. *Nimitz* size carriers provide more than twice the combat capability of the smallest practical nuclear powered alternative.

"*Nimitz* size carriers have more flexibility to incorporate changes in characteristics that may be required during the life of the ship due to changes in the threat and new technological developments."

I concur in the conclusion of the Navy carrier study that we should continue building *Nimitz* Class carriers.

A substantial portion of the higher investment cost of a nuclear carrier is directly offset by the elimination of the cost of buying and delivering propulsion fuel oil; also, by the reduced cost of the logistic support forces needed due to less frequent replenishment of combat consumables because of the larger capacity of the CVN for aviation fuel and ammunition. Navy studies have shown that it takes the equivalent of an extra fleet oiler just to provide the peacetime propulsion fuel support for an oil-fired aircraft carrier. Of course, in wartime the oil-fired carrier's vulnerability is largely determined by its requirement for a continuous supply of propulsion fuel and the extreme vulnerability of oilers.

Naval authorities throughout the world said we made a grave mistake when the last oil-fired carrier, the *John F. Kennedy*, was built without nuclear propulsion. Are we now so shortsighted as to repeat that mistake?

QUESTIONS BY SENATOR THURMOND FOR MAJOR GENERAL BRATTON, DIRECTOR,
DIVISION OF MILITARY APPLICATION, ERDA

Question. General Bratton, as you know, President Carter has expressed a strong interest in a ban on underground tests. How would such a ban affect our current research and development capability?

Answer. Underground nuclear testing is an integral part of the research and development process, providing both experimental data and design evaluations. Without the support of a strong test program, development would, of necessity, be restricted to the adaptation of tested technology to both current and projected requirements. Within five or ten years, even that capability would probably be lost because the scientists and engineers capable of applying the technology would have, for the most part, moved on to other more active fields of endeavor. In my view, the long-term impact on the nuclear weapons R&D capability is the most far reaching consequence of the proposed test ban because it will affect not only our ability to develop weapons in response to future requirements but also our ability to correct deficiencies in those weapons that we have, should such deficiencies be uncovered at some future time.

Question. To what degree can simulation in labs replace the benefits of underground tests?

Answer. There is no simulation by itself that will enable us fully to design or evaluate a weapon. Calculations, modeling, simulation, and nonnuclear testing can be utilized in the design of many of the components of nuclear weapons. However, the performance of the nuclear materials in the heart of the weapon cannot be simulated in the laboratory but must be tested in the field. There are simulations that help us to determine weapon effects. Weapon effects simulations are, for the most part, limited to single (decoupled) effects; e.g., X-ray effects. Combined effects are very difficult to simulate and can only be evaluated in underground tests where full-scale hardware can be exposed to the true nuclear environment. Laboratory simulations help us prepare for these evaluations by detecting otherwise unsuspected design deficiencies and by screening the proposed solutions. The final proof, however, rests upon the results of actual exposure in a nuclear weapons effects test.

Question. How are current test restrictions impacting on our gaining knowledge necessary to maintain our technological base?

Answer. By agreement with the Soviet Union, the United States has not conducted any tests at yields above 150 kt since March 31, 1976. Prior to that date, beginning in July 1974, a high-yield test program was conducted to develop sufficient test data to support high-yield test requirements for those programs then in advanced development and in engineering development. In no sense were all of the desired data obtained; consequently, final designs, if stockpiled, will not be optimized and may have increased uncertainty as to actual yield. This may prove especially troublesome if design modifications are required to accommodate restrictions in the availability of special nuclear materials (enriched uranium, plutonium, and tritium) or physical constraints (weight, size, and shape).

Question. Does your current program include research on techniques to advance nuclear weapon technology in the absence of full-scale testing?

Answer. Yes. Our most important design tool is the computer, which employs models developed by our engineers and scientists from prior test experience as well as from first scientific principles to predict the performance of new designs. In the absence of full-scale testing, much more effort would have to go into improving computer techniques. It is not reasonable, however, to expect such efforts to lead to any major improvements in technology; rather, they would only let us make the best use we can of the technology that we already have.

Question. Does the current agreement with the Soviets in any way work to our disadvantage or favor the Soviets?

Answer. The current agreements which seriously affect our test program are:

1. The Limited Test Ban Treaty of 1963 which requires that we test underground; and
2. The Threshold Test Ban Treaty of 1974 which limits the yields that we can test to 150 kilotons.

Both these treaties apply equally to the U.S. and the U.S.S.R.

The Soviets could gain an advantage by testing at yields greater than 150 kilotons. We have no indication that they have conducted tests greater than the Threshold since March 1976.

Question. Would any ban permit the so-called "peaceful nuclear explosions"?

Answer. The Soviet Union has an active peaceful nuclear explosions (PNE) program. The Soviets have tabled a draft Comprehensive Test Ban Treaty at the current session of the Conference of the Committee on Disarmament in Geneva, and the draft proposes that peaceful nuclear explosion be excluded from the CTBT. However, such a PNE exception could permit substantial military benefits to accrue to the Soviet Union. This is possible not only because some of the most advanced nuclear explosive design and production techniques go into the making of a PNE device, but also because there still remains no known way to distinguish between the tests of a nuclear weapon design and a peaceful nuclear explosion. In the absence of a U.S. experimental program to develop applications of PNE's and in consideration of the Soviet Union's interest in pursuing a PNE program, the potential for the Soviets' obtaining weapons-related benefits while conducting PNE events, and the resulting technical asymmetry between the two nations, would pose a threat to national security. The ERDA view is that the U.S. should avoid an agreement containing a PNE accommodation.

Question. Assuming you lose the authority to test devices now in stockpile, how could you certify to Congress in the future that the stockpile is reliable?

Answer. During a nuclear test ban, we can test and evaluate the operation of all the components of a nuclear weapon except the nuclear assembly. For a weapon already in stockpile, the nuclear design will have been tested during its development phase. A new nuclear design could not be stockpiled without testing. In a prolonged test ban period, our confidence in the performance of the stockpile will decline. We anticipate that during such a period we would rapidly lose our experienced engineers and weapons designers. This would result, within about 10 years, in the loss of capability to design new weapons or to modify older designs for replacement or rebuild of older weapons. Although we could maintain a stockpile of old or rebuilt weapons, our confidence in the reliability of those weapons would be substantially reduced after about 20 years.

Question. How would any test ban impact on our ability to deploy MX warheads with the optional capability?

Answer. Primarily as a result of the higher yield tests conducted before the March 31, 1976, effective date of the Threshold Test Ban Treaty, ERDA has developed several high yield [deleted].

Question. What weapon systems now in sight would be affected by a ban this year?

Answer. Testing for the following systems under engineering development or advanced development has been completed:

[Deleted.]

Testing for the following systems also under engineering development or advanced development has not been completed:

[Deleted.]

Question. Do you have any role in monitoring Soviet tests?

Answer. The Department of Defense is responsible for maintaining a program to monitor foreign test activities. ERDA cooperates with the DoD in this program. For instance, ERDA provides instrumentation for satellite detection of atmospheric and space nuclear explosions. We also conduct research concerned primarily with theoretical and empirical analyses which is aimed at improving U.S. capability to estimate accurately the yield of underground nuclear explosions using seismic means.

Under the verification provisions of the Peaceful Nuclear Explosives Treaty we are training, and will field, verification teams and equipment for onsite activity at foreign sites (either inside or outside the U.S.S.R.) when the Soviet Union conducts a PNE operation with aggregate yield greater than 150 kt.

Question. Is there any question, from a technical standpoint, that the Soviets are in compliance with current agreements?

Answer. We do not question Soviet compliance with the Limited Test Ban Treaty of 1963. Pending ratification of the Threshold Test Ban Treaty, the Soviet Union and the United States have announced their intentions to abide by the 150 kt yield limitation. Within the uncertainties associated with teleseismic yield determination, there is no evidence that any Soviet tests have exceeded the limit over the past year.

Question. What capabilities are available to mask compliance with current or future agreements?

Answer. With respect to the yield limitation of the Threshold Test Ban Treaty, techniques exist to decouple the seismic shock of nuclear tests. Such techniques as the use of an underground decoupling cavity or a low-coupling medium are known and available to the Soviet Union. In addition, under the Peaceful Nuclear Explosives Treaty, it would be possible for the Soviet Union to conduct an unannounced weapon test simultaneously with a large-scale PNE event. With respect to future test agreements, such as one establishing a lower threshold or a comprehensive test ban, techniques such as hide-in-earthquake, earthquake simulation, and, assuming a PNE accommodation, substitution of a weapon for a PNE explosive are all possible. The R&D effort planned for fiscal year 1978 in the Peaceful Nuclear Explosives Verification subelement of Special Test Detection will explore more fully these and other techniques to evaluate their efficacy in clandestine nuclear weapons testing by the Soviet Union in violation of existing or future agreements. We are in the process of examining the establishment of unmanned seismic observatories and onsite inspections in the Soviet Union as a means of improving CTB verification capability. As verification and evasion techniques are well enough understood, the intent is to develop methods, techniques, and instrumentation to detect attempts by the Soviet Union to circumvent the terms of their agreements.

Question. General Bratton, while I would oppose any unilateral halt to testing, there are some who favor it as a unilateral initiative. In such an event, how quickly could we be damaged from a development or test standpoint if the Soviets continue tests and we halt them?

Answer. The impact of a unilateral halt in the U.S. nuclear weapons development program will depend, of course, on when that halt occurs and whether or not adequate time is provided in advance of such a halt to permit test schedule adjustments that might enable the design laboratories to complete some of the most important programs. If a halt were to occur today [deleted]. On the other hand, if a halt in testing were announced today, taking effect two years from now, schedule adjustments could be made so that all of our current weaponization programs could be completed, along with many of those now proposed for future weaponization. Even then, programs such as the [deleted] could not be sufficiently developed to enter production.

As for the damage to our development capability, a total cessation of testing will ultimately prove extremely serious because, as noted earlier, the weapons designers will shift to other endeavors and trained replacements will not be available. These effects will not be applicable to the Soviets if they continue to test, and a wide disparity in national capabilities would develop within a very few years. Our nuclear design capability in the laboratories would show substantial degradation beginning in a year or two, and could be largely lost in 5-10 years.

Question. General Bratton, in view of the Soviet military buildup, do you feel sufficient resources are being allocated for new nuclear weapons technology?

Answer. The fiscal year 1978 R&D, test, and production programs are at the minimum level sufficient to meet the requirements for national security. This is in consonance with the need to hold costs to the minimum. If schedules were to be accelerated in response to a new perception of the threat, or in anticipation of a projected halt to testing, then additional resources might be required.

Question. To what degree are the weapon applications of your program given priority over other programs?

Answer. My program within the Energy Research and Development Administration, the weapons program encompasses only those efforts associated with weapons applications—the development, testing, and production of nuclear weapons for meeting national defense needs. I am therefore, responsible only for priorities within the scope of these ERDA defense activities.

As may be noted in the President's budget, the ERDA budget specifically identifies funds for defense activities which include the special materials production and naval reactor development programs as well as the nuclear weapons program. The budget also includes levels for energy research and related efforts. Although a total budget is requested for the Energy Research and Development Administration, the ERDA Administrator separately prioritizes the various and potential means for meeting the nation's energy shortcomings and the funding requirements for ERDA's mission of meeting DoD's requirements for modernizing and maintaining the quality of the nation's nuclear weapons stockpile.

After Congressional action on the budget, ERDA applies weapons funding based upon Congressional intentions as contained in the ERDA appropriation. Similar priorities are also developed and applied within the scope of ERDA's energy activities.

Question. What is included in your fiscal year 1978 test program?

Answer. The fiscal year 1978 test program is expected to include a total of [deleted] projected as follows:

[Deleted.]

Question. The overall level of tests is down; to what is that attributed?

Answer. Every effort has been made by ERDA and the Department of Defense to hold testing to the absolute minimum commensurate with DoD requirements. In some cases, this has meant increasing the complexity of the test in order to maximize the amount of information obtained. In other cases, it has meant reducing the number of designs to be evaluated prior to selecting the design for weaponization, provided that design can meet the required performance criteria and the development risk is small. These efforts are reflected in the lower level of tests presently being conducted. Further reductions, however, do not appear feasible if development advances are to continue.

Question. If more funds are available, in what areas would you use them?

Answer. In the research, development, and testing activities, we would pursue certain promising advanced development work that is important to the future national security. These activities are not carried out currently because of the high priority work that must be done in the area of current weapons. Some examples of this advanced development effort follow:

[Deleted.]

Component development

The development of improved nonnuclear ordnance components, which will allow us to develop improved nuclear warheads in the future. Improvements include reduced sizes, safer and more secure systems, more survivable systems, longer life, and more command/control. Components include firing systems, [deleted] and neutron generators.

Improved diagnostics

Facility technology, materials and fabrication technology, computer codes and other applied research necessary to conduct nuclear weapons development.

Question. What are the long range plans for the Savannah River Plant?

Answer. We anticipate that operations at the Savannah River plant will remain at about the current level into the indefinite future.

Material from the production reactors at Savannah River is required to maintain an operational stockpile by replacing tritium decay and to continue modernization of the nuclear weapon stockpile. In addition, if current long range DoD plans for strategic systems are realized, present materials production capacity will have to be increased. The Savannah River plant is also needed to produce other products not directly related to the weapons program such as plutonium-238 for heat sources and californium-252 for medical purposes.

QUESTIONS BY SENATOR NUNN

Question. I noticed on one of your charts that ERDA is actively working on a new 8-inch howitzer shell, but not on a 155mm howitzer shell which was listed as a "possible candidate". Given the fact that the 155mm gun is much more numerous in U.S. and NATO inventories of artillery than the 8-inch gun, what is the rationale for concentrating work on the 8-inch and not the 155mm?

Answer. [Deleted.] The Department of Defense can make available additional information concerning deployment and employment of the 155mm AFAP; in this regard, the "Joint DoD/ERDA 155mm AFAP Modernization Analysis", forwarded on February 28, 1977, to the Senate Armed Services Committee, is a useful reference.

Question. In what ways would the new 8-inch shell be superior to the present shell?

Answer. The new W79 8-inch AFAP now in development is superior to the current W33 in many ways. The W33 entered the inventory in 1956. It employs the original [deleted].

Question. Have there been any guidelines established with respect to how far this country is prepared to go in lowering the yields of its smaller tactical nuclear weapons?

Answer. Because of NATO concerns with respect to collateral damage in the event of a nuclear exchange in Europe, we are including yield options of [deleted].

Question. From a technical standpoint, how far can yields be lowered?

Answer. There is a practical lower limit to fission weapon yields of current Pu and U designs at about [deleted].

Question (a). To what extent is continued development of nuclear weapons now in the program dependent upon underground testing?

Answer. Nuclear weapons now in engineering development or advanced development are:

[Deleted.]

Additional testing is needed for all of these programs except the [deleted] for which testing was completed in December 1976. With an accelerated test effort, many of these programs might be completed in two years, but some, such as the [deleted].

Question (b). Would a 6-month or 1-year ban on underground testing severely affect these programs?

Answer. At best, a test ban of short duration would delay these programs by only that duration. If the period of the ban is extended, then additional time would be required to reconstitute the program—men and material—before further progress could be made. Eventually, many, if not most, of the scientists and engineers will have moved to other areas and would no longer be available. In that event, it might no longer be possible to reinstitute the program, particularly where the effort represents an advancement in design technology.

QUESTIONS BY SENATOR TOWER

Question (a). What percentage of real growth does your fiscal year 1978 request have over what was appropriated last year?

Answer. In budget outlays, our fiscal year 1978 budget is projected to be \$1,316 million compared to \$1,146 million in fiscal year 1977, a 15 percent increase. Allowing for an average of 7 percent inflation, we would anticipate a real growth of 8 percent.

Question (b). For the past five years what budget growth in real terms have the weapons and laser fusion programs seen?

Answer. Operating costs in fiscal year 1977 dollars for the weapons and laser fusion programs are as follows:

[In millions of dollars]

Fiscal year:	Weapons program	Laser fusion
1977.....	966.3	75.8
1976.....	949.7	64.2
1975.....	1,032.0	55.7
1974.....	1,104.1	51.7
1973.....	1,301.5	36.5

The weapons program has experienced a budget reduction in real terms of \$335 million over the past five years. This is an average 5 percent per year decline in program funding.

The laser fusion program has experienced a budget growth in real terms of \$39.3 million over the past five years. This is an average of 21.5 percent per year growth in the program funding.

Question. In your judgment, are we ready to enter into a complete nuclear test ban treaty?

Answer. The United States recently conducted a high-yield test program to support development of an improved series of strategic warheads. Testing of lower yield designs, both strategic and tactical, was in large measure deferred until after March 31, 1976, when the restrictions of the Threshold Test Ban Treaty went into effect. An extensive test program is required to complete the weapons modernization program now under way. This program, if accelerated, will still require over two years to complete. A decision to halt the underground test program will have to weigh any advantages of that halt against the disadvantages of cutting off these developments important to United States security at a time when they may weigh heavily in other arms control negotiations with the Soviet Union.

Question. What are the limitations of limiting the yield of underground nuclear testing?

Answer. If a nuclear explosive concept is to be developed and eventually certified for the stockpile, it must undergo a series of nuclear experiments and tests. These tests first establish its feasibility and then insure that it will meet military requirements and operate under all foreseen conditions to detonate over the target with high reliability. This reliability cannot be assigned without testing. The limitation of limiting the underground test yields is significant if the desired warhead has a design yield greater than the yield threshold allowed.

[Deleted.]

New strategic weapons primarily are affected by reducing the yield thresholds. Since most strategic warheads, both currently stockpiled and planned in the future, have design yields greater than [deleted], we will be severely limited in maintaining these warheads over the long term and building new warheads to meet military strategic requirements. Any new warhead will be limited to only

those improvements or changes that can be made based on proven designs tested in the past or based on partial yield tests. In other words, the high yield portion of most new warheads will be fixed to past well established technologies. New high yield designs cannot be reliably calculated without testing; therefore, they will not be employed in the future stockpile.

If the threshold is reduced to lower yields, the impact becomes more serious unless the DoD wants to lessen the yield requirements or use existing warheads in future weapon delivery vehicles. The repackaging of existing designs into new weapon vehicles has seldom been possible in the past due to new military requirements associated with modernized or new DoD weapon systems.

In summary, testing thresholds cause us to design warheads based on proven, well established technology of the past. In a few cases, this may be adequate but designs employing improved safety and security, reduced sizes, optimum shapes, improved outputs, and more economical use of materials may be precluded. Therefore, any new warheads may impose certain system penalties and will constrain future defense options.

Question. In retrospect, what have the ramifications been of the atmospheric test ban treaty? Has our technology suffered as a result or do you think we have fallen behind the Soviet Union militarily?

Answer. Prior to the Limited Test Ban Treaty (LTBT), the Soviets carried out a series of high altitude tests that we believe were very effective and useful for their design of ABM systems. [Deleted.] Subsequent to the implementation of the LTBT, a strong underground nuclear test program has been developed. However, there are certain types of tests, including nuclear weapons effects tests, that cannot be conducted and studied by current laboratory or computer simulation methods.

Safeguard C to the LTBT has, in the past, and continues to address the potential requirements in understanding the phenomena associated with interaction of multiple bursts of nuclear weapons and the integrated effects on complex weapons systems. Annually, ERDA and DoD jointly develop a list to determine the types and priorities of tests necessary to accomplish test objectives that cannot be satisfied with underground testing, and incorporate this assessment into the Annual Status Report on the Safeguards to the LTBT. The readiness posture is currently limited in terms of funds, manpower, and equipment in response to recent Presidential direction regarding the Safeguard C requirements.

QUESTIONS BY SENATOR HART

Question. Your construction program this year is nearly \$250 million. Would you discuss your overall facility requirements?

Answer. The weapons program request for authorization in fiscal year 1978 is \$258.8 million. The fiscal year 1978 new obligatory authority necessary to prosecute the new projects and to complete five previously authorized projects is \$204.1 million.

The weapons program facility requirements can be categorized in three major categories: (1) nuclear weapons manufacturing facilities; (2) nuclear weapons research, development, and testing facilities; and (3) conventional plant facilities such as office buildings, power plants, utility services, etc. The weapons construction budget also includes projects needed to correct deficiencies in security, safeguards, environmental, health, and fire safety areas. In addition, weapons will budget for energy conservation and fuel conversion construction projects.

The facility requirements to support the weapons program are responsive to the needs of evolving technologies in weapons research, for new weapons production, and improvements driven by program growth, health, and safety of personnel and replacement due to age.

Question. What is your validated backlog of construction? What requests should we expect to see in future years?

Answer. Facility planning is initiated with the long-range plan which is updated annually and tabulates projected construction needs consistent with long-range planning guidance. Specific facility requirements are generally derived from site master planning at the field office level.

In the new weapons production area, we are working on advanced development of more than ten new weapons for future consideration. Specific weapon systems that are to be selected by the DoD for production are not identified specifically in long-range planning. However, new manufacturing facilities related to new weapons requirements in any particular year could be realistically projected at about \$50 million per year. New research facilities required for weapons research, development, and testing would require about \$20 to \$30 million per year.

Modifications to existing facilities, small buildings, and minor construction projects are funded under our general plant projects line item which requires a commitment of about \$25 million per year. The general plant project funds support a weapons complex valued at over \$10 billion replacement cost. Construction necessary to correct known safeguards and security deficiencies will probably require at least \$10 million per year for another two or three years. A backlog of environmental, health, and fire safety deficiencies has been steadily reduced during the past few years and will require funding of about \$15 million per year for the next two or three years for completion of known deficiencies. Environmental concerns are dynamic and can produce a significant impact on our environmental project projections if significant new Federal, State, or local requirements are imposed. Many of our existing plant facilities are old and in need of extensive repairs or replacement—as an example, the fiscal year 1978 Steam Plant Improvement Project at Oak Ridge, Y-12 Plant. Our long-range plan includes provisions for replacement of deteriorated and temporary buildings, upgrading plant utility systems, and restoration of process support facilities. The annual cost to keep abreast of the necessary replacement and upgrading is projected at about \$15 million.

An area that portends significant construction cost in the near future is in the energy field. Although our long-range planning in this area is only partially complete, it presently appears that over the next five years it will be necessary to spend, at minimum, \$200 million for energy conservation construction and replacement of oil- and gas-fired steam plants.

Question. Would you tell us a little bit about how you execute your construction program? Who does the design? Who is your construction agent? Who administers your construction contracts?

Answer. Conceptual designs are prepared in the field by operating contractors; in some instances, private architect-engineering firms aid in this effort. Conceptual designs are performed for each line item construction project for which Congressional authorization is planned. The fundamental purposes of conceptual design are to develop a project scope that will satisfy program needs, assure project feasibility, and develop cost estimates and schedules.

For complex construction projects, construction planning and design (CP&D) funds may be used when necessary to perform additional engineering and design (Titles I and II) work to assure feasibility, better define the scope and provide cost estimates and schedules based on sufficient study to be as reliable as possible prior to submission for Congressional authorization.

For each project included in the President's budget, field offices prepare plans for required architect-engineer selections; prepare design criteria for each project; and prepare a project management plan. The field office is responsible for executing the project and contracting for architect-engineering and construction services. When the project has been authorized and appropriated by Congress, funds are furnished to the field office, an architect-engineer firm is selected, and preliminary design is begun. Following ERDA approval of preliminary design (Title I), detailed design (Title II—preparation of drawings and specification for construction) is prepared by the outside architect-engineering firms. In some cases, designs for equipment layout, equipment procurement and installation may be accomplished by the ERDA CPFF operating contractor who will later operate the facility. The operating contractor also provides technical support to ERDA by performing technical review of the A-E's plans and specifications. Support facilities (i.e., office building, warehouse, utilities, etc.) are also designed by outside architect-engineering firms.

Upon completion of the detailed design (Title II), contracts are awarded to outside contractors for the construction of facilities. Inspection of construction (Title III) is conducted by the architect-engineer, the operating contractor, and the field office. On many projects, the process or production equipment is installed by the operating contractor who will operate the facility. These installation costs are included as part of the total construction project cost.

Contracts for architect-engineering services and construction of facilities are administered, in most cases, by the ERDA field offices. This also includes design, procurement, and construction activities related to line item construction projects conducted by the operating contractors.

Question. I note in your request that you don't begin design of a facility until it is authorized by Congress. Do you do concept studies in advance of authorization?

Answer. Yes. In preparing for developing the annual budget, field offices are authorized to perform conceptual design studies of construction project candidates to be considered for inclusion in the weapons budget. The engineering studies determine project feasibility and program objectives and give an estimate of cost and schedule.

The term conceptual design, as used in ERDA, consists basically of a site selection and development plan, floor plans, sections and elevations necessary to portray general layouts and space allocations, and single line diagrams for process systems and utilities. Emphasis is placed on preliminary trade-off studies needed to identify the most economical construction; to identify critical equipment types; and to identify criteria critical to operating efficiency, radiological safety, and other critical factors pertaining to the use and maintenance of the facility. The conceptual design results in a detailed description of the project; a clear definition of the project scope and performance requirements; a budget quality cost estimate based upon the project concept; the selected construction method; a completion schedule; and outline specification standards and criteria established for the project.

The cost of a conceptual design is approximately one-half to one percent of the total estimated project cost. Significant engineering begins after project authorization.

Question. Are all of your projects on government-owned installations?

Answer. Yes.

Question. In scanning your project justification documents, your design, overhead, and contingency costs appear extremely high—in some cases 50 percent of the total cost of a project. Why? (For DOD projects design is 6 percent, overhead is 5 percent, and contingency 5 percent for a total of 16 percent.)

Answer. ERDA engineering, design, and inspection (ED&I) costs shown in our budget submittals are not directly comparable to DOD's design costs. ERDA's estimated costs for ED&I shown on the construction project data sheet submittal include preliminary design (Title I), detailed design and preparation of specifications and bid documents (Title II), and construction inspection (Title III). DOD's engineering costs do not include all these activities. In addition, complex design and engineering analysis required to develop designs for a technological advanced project or to protect personnel and the public from radiological exposure cost far in excess of those for standard or repetitive projects.

With regard to contingencies ERDA, unlike DOD, submits the majority of line item construction projects based on the conceptual design effort as described in the answer to Question 3 above. At the completion of conceptual design, there are uncertainties in details and in item costs related to the total estimated cost of the project. These uncertainties may include design requirements; programmatic or production requirements; equipment development that is not the "state-of-the-art" or "off-the-shelf" items; and facilities requirements such as remote operations, radioactive shielding, ability to withstand tornado or seismic forces, sizing of utilities, etc., that are normally developed during preliminary design.

Question. I note in your statement that you are asking for \$28 million for improving the security of nuclear material. Would you discuss your effort in this regard to include what you are doing, how much it will cost, and timing?

Answer. The costs and relative priorities on a site-by-site basis are as follows:

	<i>Millions</i>
Pantex plant—Amarillo, Tex.-----	3.3
Perimeter Barriers and Warning System-----	2.0
Guard Towers and Lighting-----	0.9
Interior Alarms and Doorway Monitors-----	0.4
LASL—Los Alamos, N. Mex.-----	10.1
Intrusions Detection Alarm System-----	2.8
Upgrade Security Facilities—8 Tech. Areas-----	4.6
Perimeter Alarming Systems—8 Tech. Areas-----	2.6
SNM Assay Equipment-----	0.1

Rocky Flats plant—Golden, Colo.-----	9.5
Modify Plant Alarm System-----	1.0
Improve SNM Facility Security-----	2.5
Harden Plant Guard Station-----	0.5
SNM Control and Accounting Devices-----	1.1
Plant Perimeter Early Warning System-----	4.4
Mound Laboratory—Miamisburg, Ohio-----	2.1
Alarm and Monitoring Systems-----	1.2
Communication Center Upgrade-----	0.4
Pu Assay Verification Facility-----	0.4
Guard Equipment and Firing Range Facility-----	0.1
Sandia Laboratories—Albuquerque, N. Mex.-----	2.2
Operations Center Building-----	0.8
SNM Storage Vault-----	0.5
Early Warning System—Reactor Area-----	0.8
Fencing and Barriers-----	0.1
Y-12 plant—Oak Ridge, Tenn.-----	0.8
Transportation Operations Facility-----	0.8
Total costs-----	28.0

Architect-engineering work will be initiated in the first quarter of fiscal year 1978. Physical construction will start in the second quarter of fiscal year 1978, and construction will end in the fourth quarter of fiscal year 1980.

The biggest and most complicated tasks are at Los Alamos Scientific Laboratory and Rocky Flats. At Los Alamos Scientific Laboratory (LASL) we will be doing some preliminary work to prepare for a good start as soon as fiscal year 1978 funds are available. The LASL problem will depend to an extent on some ongoing research and development; the main problems are complexity of the circuitry and long distances between technical areas to be monitored at a central alarm station. The Rocky Flats work is similar in complexity; however, security work begun there under another project has solved many of the technical problems and the ground work for the fiscal year 1978 project construction will permit work to begin promptly. We expect to complete the LASL work and the Rocky Flats work about August 1980.

Security construction at Pantex has been in progress for about 1½ years under Projects 76-14 and 77-11-b. Work remaining to be completed at Pantex has been deferred to the fiscal year 1978 project while research and development efforts defined the best solutions to the safeguards problem. This work is now thoroughly planned, can start promptly on receipt of funding, and be completed probably before the fourth quarter of fiscal year 1980.

Safeguards and security construction planned for the Y-12 Plant is scheduled for completion in July 1979. Work at Mound and at Sandia is expected to conclude at about the same date.

Question. What is the threat as you see it to nuclear weapons or nuclear material?

Answer. Although there is no basis for assigning high credibility to any threat, ERDA, as a matter of prudence, assumes for purposes of system design a threat of violent attack by a small group of terrorists (with insider assistance) with the intent of theft of a nuclear explosive device or nuclear material to make a nuclear explosive device.

Question. I assume you use civilian guards at your facility. Is that correct?

Answer. Yes. ERDA employs civilian guards at all facilities.

Question. In addition to the physical measures you are taking, it would seem to me that you need a reaction force capable of countering the threat. Would you comment.

Answer. Reaction forces are a part of overall safeguards and security system design for each facility and such forces have been established at all facilities having significant quantities of special nuclear materials. Such forces are equipped with two-way communications and include not only the guard force of the facility but also the capabilities that exist in the surrounding local law enforcement agencies. Exercises and assessments are periodically conducted to evaluate and maintain a high state of readiness.



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