REPORT TO THE CONGRESS

Problems In Developing The Atomic Energy Commission's Fast Flux Test Facility

B-164105

BY THE COMPTROLLER GENERAL OF THE UNITED STATES

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

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To the President of the Senate and the
Speaker of the House of Representatives

This is our report on problems in developing the Atomic Energy Commission's Fast Flux Test Facility. Our review was made pursuant to the Budget and Accounting Act, 1921 (31 U.S.C. 53), and the Accounting and Auditing Act of 1950 (31 U.S.C. 67).

Copies of this report are also being sent to the Director, Office of Management and Budget, and to the Chairman, Atomic Energy Commission.

Comptroller General
of the United States

Contents

ABBREVIATIONS

AEC	Atomic Energy Commission
FFTF	Fast Flux Test Facility
GAO	General Accounting Office
LMFBR	Liquid Metal Fast Breeder Reactor
RDT	Division of Reactor Development and Technology

COMPTROLLER GENERAL'S REPORT TO THE CONGRESS

PROBLEMS IN DEVELOPING THE ATOMIC ENERGY COMMISSION'S FAST FLUX TEST FACILITY B-164105

D I G E S T

WHY THE REVIEW WAS MADE

The Fast Flux Test Facility is the highest priority project in the Atomic Energy Commission's (AEC) civilian power reactor program. The Congress authorized $87.5 million for the design and construction of the Test Facility. The authorizing legislation provided that the estimated project cost prior to beginning of construction not exceed the $87.5 million by more than 25 percent. AEC's current estimate of the construction cost is $102.8 million which is within the limitation.

The Fast Flux Test Facility is being designed to provide for radiation exposure of fuels and materials under conditions similar to those expected to be encountered in liquid metal breeder reactors. Also, it will provide an engineering focal point for the Liquid Metal Fast Breeder Reactor program. This program is expected to lead to the use by the utility industry of breeder reactors (which produce more fuel than they consume) for producing electricity beginning in the early 1980's. (See p. 4.)

Responsibility for developing the Test Facility was vested in AEC's contractor-operated Pacific Northwest Laboratory at Richland, Washington. On January 30, 1970, AEC and the Laboratory announced that certain aspects of the Laboratory's work on reactor development--including the Test Facility--were to be transferred to a new contractor. This report covers the administration and management of the project prior to the transfer. (See p. 10.)

The General Accounting Office (GAO) reviewed the development of the Test Facility to determine why the design of the project was being delayed.

FINDINGS AND CONCLUSIONS

Problems

The conceptual design of the Test Facility--the first step in the design cycle--was delayed and thereby caused compressed schedules on the remaining phases of the work. Because major milestones have not been met, the contingency time available in the final design, construction, and plant check-out schedules has been reduced, and, therefore, there is greater emphasis, with its inherent risks, on completing the work within the remaining scheduled time. AEC's current estimate is that the Test Facility

will be completed in June 1974, about 1 year later than initially scheduled.

GAO believes that delays were caused by management problems. Specifically:

--the Laboratory did not establish an engineering-oriented organization with sufficient management and technical capabilities to develop such a complex project and

--AEC (with its various levels and dispersion of management) did not effectively bring about changes in organization and design approaches that had been identified and apparently agreed upon by the Laboratory. (See p. 13.)

Also, the technological base for developing the project was not as advanced as was initially believed. (See p. 13.)

Capabilities of the Laboratory

AEC emphasized that developing the Facility would be a very complex and difficult undertaking and would require the best talents and resources available from AEC and industry. When AEC designated the Laboratory as project manager in January 1966, it noted that the Laboratory's capabilities would need to be significantly augmented with those of engineers and scientists from other AEC facilities and industrial organizations. At that time AEC did not believe that the Laboratory had enough experienced manpower to act as a systems manager but thought that the Laboratory could develop the capability. (See p. 25.)

The Laboratory attributed the delays and problems in part to the various AEC organizational components it had to deal with. The Laboratory told GAO that AEC's Division of Reactor Development and Technology overmanaged the project and the Laboratory overresponded and that the lack of specific contractual assignment of both authority and responsibility inevitably strained working relations. (See p. 28.)

Recent developments

The change in project managers (effective in July 1970) was because of a request from the contractor operating the Laboratory that the Test Facility and closely related activities be excluded from its contract because of possible changes in the contractor's tax status as a public organization resulting from the tax law enacted in December 1969.

Also, to improve the progress of the project, AEC has taken a number of actions which include:

--Establishing the Office of Assistant Director for Pacific Northwest Programs at Richland, Washington, which is responsible for

(1) implementing technical direction of the reactor programs and
(2) administering the contract for development of the Test Facility.

--Selecting a task force in October 1969 to review and evaluate the project design effort.

The task force completed its work in February 1970. Agreement was reached between AEC and the Laboratory on a design that would meet the objectives of scope and cost as stated in the approved congressional authorization and within the 25-percent cost limitation.

RECOMMENDATIONS OR SUGGESTIONS

GAO suggested that AEC review the reactor development and technology organization and all levels of contractor and Laboratory management involved with the project to streamline the organization, to strengthen the communication and technical review channels, and to provide some assurance that management and staff would provide maximum contribution to this high-priority project.

AGENCY ACTIONS AND UNRESOLVED ISSUES

AEC told GAO that the new contractor was expected to review the current project position and its plans for development of the conceptual design, scope, cost, and schedule for the Test Facility, recognizing the annual budgetary limitations. Also, AEC has said that the actions that have been taken or are being taken are intended to establish clear lines of responsibility and unequivocal authority.

If the stated actions are taken and properly implemented, the project's management should be greatly improved.

Since an evaluation of the effect of the actions cannot be made until they are complete, AEC has agreed to keep GAO apprised of the progress and status of the project.

MATTERS FOR CONSIDERATION BY THE CONGRESS

This report contains no recommendations or suggestions requiring action by the Congress. GAO is reporting this matter to the Congress because of its expressed interest in the civilian power reactor development program and because of the top priority designation assigned to the related Fast Flux Test Facility.

CHAPTER 1

INTRODUCTION

The General Accounting Office has reviewed the Atomic Energy Commission's administration and direction of project management for the development of the Fast Flux Test Facility (FFTF) which is to be constructed at Richland, Washington. The scope of our review is described in chapter 3.

It is estimated that, because of the continued growth in the U.S. population and in the per capita consumption of electrical power, the national demand for electricity is nearly doubling every 10 years. The annual electric generating capacity in the United States in 1967 was about 250 million kilowatts. It is expected that the generating capacity by 1980 will have increased to about 520 million kilowatts and will have risen to more than 1-1/2 billion kilowatts by the year 2000. AEC has estimated that 23 to 30 percent of the electrical generating capacity will be nuclear in 1980 and about 50 percent in the year 2000. The extent to which nuclear power will be used by the utility industry in the post-1980 period will depend, largely, on the development of the breeder reactors because of the potential economic efficiency and the conservation of fuel resources by these reactors. The breeder reactor is designed to "breed" more fuel than it consumes.

The primary objective of the civilian power reactor development program in the United States is widespread use of nuclear energy for the production of electricity. AEC expects that the Liquid Metal Fast Breeder Reactor (LMFBR) program will assist in meeting this objective by providing an efficient means of exploiting the energy available in uranium which should reduce fuel costs.

The following schedule shows the spending levels from the AEC operating fund appropriation for the LMFBR program for the past 3 fiscal years.

	1968 (actual)	1969 (actual)	1970 (estimate)
	(000 omitted)		
LMFBR program:			
Fuel development	$11,279	$12,824	$11,392
Physics development	17,492	15,758	11,041
Component development	11,710	12,699	21,254
Systems and plant development	4,665	7,552	7,828
Experimental Breeder Reactor No. 2	11,044	15,471	13,580
Sodium Reactor Experiment	431	50	30
Fast Flux Test Facility	11,730	15,719	17,575
Total	$68,351	$80,073	$82,700

FFTF is identified in the schedule above as a significant part of the LMFBR program dollars and also is strongly dependent on other development work under the LMFBR program. The FFTF role in the LMFBR program follows:

Role of FFTF in LMFBR Program

FFTF provides to LMFBR program	LMFBR program provides to FFTF
Fast flux irradiation of LMFBR fuels and materials	First priority on FFTF problems
Experience in design, construction, operation, and maintenance of liquid-metal-cooled fast reactor	Same proven components and equipment
Statistically significant experimental data	Coordination of LMFBR development requirements with FFTF requirements
Verification of design	Results of basic technology programs
Verification of analytical procedures	Facilities for FFTF support
Identification of needs for codes and standards	Results of LMFBR codes and standards program
Training ground for personnel from industrial organizations and national laboratories	Broad industrial base
	Analytical procedures
	Technical personnel from organizations of LMFBR program participants to augment FFTF technical staff

AEC has developed an LMFBR program plan which includes the FFTF and three or more demonstration reactors having a rating in the range of 300-500 megawatts of electricity. FFTF, which has been assigned the highest priority in the LMFBR program, will have testing capability to provide development technology principally for fast reactor programs. AEC expects to initiate work on the first demonstration reactor before the FFTF is completed in 1974. The LMFBR program plan contemplates construction of three demonstration plants which are scheduled for completion in fiscal years 1978, 1980, and 1982. The LMFBR program is to provide the technology for designing 1,000-megawatt-range commercial reactors to be used in utility systems.

In AEC's February 1967 supplement to its 1962 report to the President on civilian nuclear power, the importance of FFTF to the LMFBR program was explained in the following manner.

> "The construction of the FFTF and its subsequent operation are necessary to provide adequate and flexible testing space for the many LMFBR fuels and materials which will be developed for the demonstration and commercial fast breeders. Its power level of about 400 MWt [megawatts thermal] will provide a fast neutron flux temperature and coolant environment similar to that of a commercial breeder. The successful achievement of high fuel burnup required for economic operation of the fast breeders will, in a large measure, be dependent on the FFTF."

The need for a fast flux test reactor has been recognized by AEC since the late 1950's. Studies were made during the early 1960's of existing facilities to determine whether such facilities could be used. Although it was determined that some use could be made of certain facilities, studies showed that a new facility was needed. In April 1965, AEC authorized the Pacific Northwest Laboratory to develop a conceptual design and cost study of the FFTF. The Laboratory developed a preliminary conceptual design and issued a report in August 1965, which was one of several documents used in preparing the congressional authorization request.

ESTIMATED COST FOR FFTF PROJECT

In May 1966 the Congress authorized $7.5 million for architect-engineer services to perform design necessary to define the project scope and to establish a detailed cost estimate. Approximately 1 year later--in July 1967--the Congress authorized an additional $80 million for construction of FFTF, which made the total authorized cost of design and construction for the project $87.5 million. Details of the cost estimate which AEC presented to the Congress are as follows:

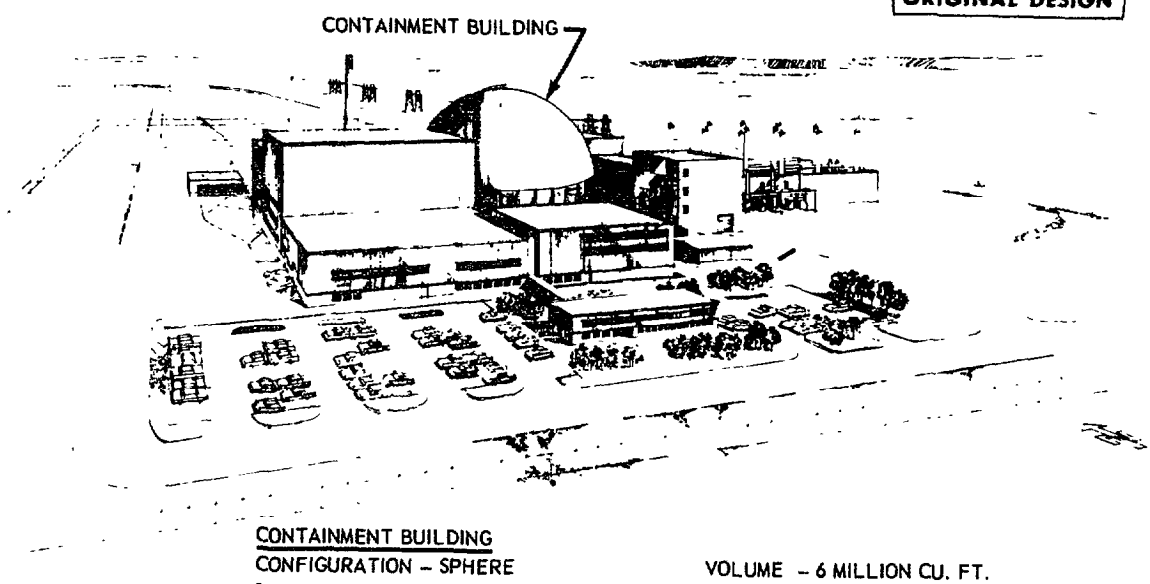
Engineering, design, and inspection		$11,000,000
Construction:		
Reactor system	$22,500,000	
Closed test loops	7,700,000	
Fuel handling and storage	3,200,000	
Buildings, structures, cranes, electric, and miscellaneous	11,300,000	
Interim fuel examination facility	5,200,000	
Containment	3,200,000	
Nuclear proof test facility	1,300,000	
Maintenance facility	1,800,000	56,200,000
Contingency		20,300,000
Total project cost		$87,500,000

The FFTF project, as discussed during the congressional authorization hearings in March 1967 and as depicted by the Division of Reactor Development and Technology (RDT) in February 1970, is illustrated in drawings obtained from AEC, which are shown on the following page. A comparison of the drawings shows the difference in the outer structures of FFTF. Some of the significant changes that occurred during development of the design are discussed on page 21.

On complex projects such as the FFTF, AEC authorizing legislation provides that, at the start of construction, the current estimates of the project be within the start-of-project limitation which is the estimated cost--$87.5 million for FFTF--plus a stated percentage. The authorizing act for FFTF allows the total cost of construction

ILLUSTRATION OF FFTF DESIGN PRIOR AND SUBSEQUENT TO DESIGN EFFORT BY TASK FORCE COMPLETED IN FEBRUARY 1970

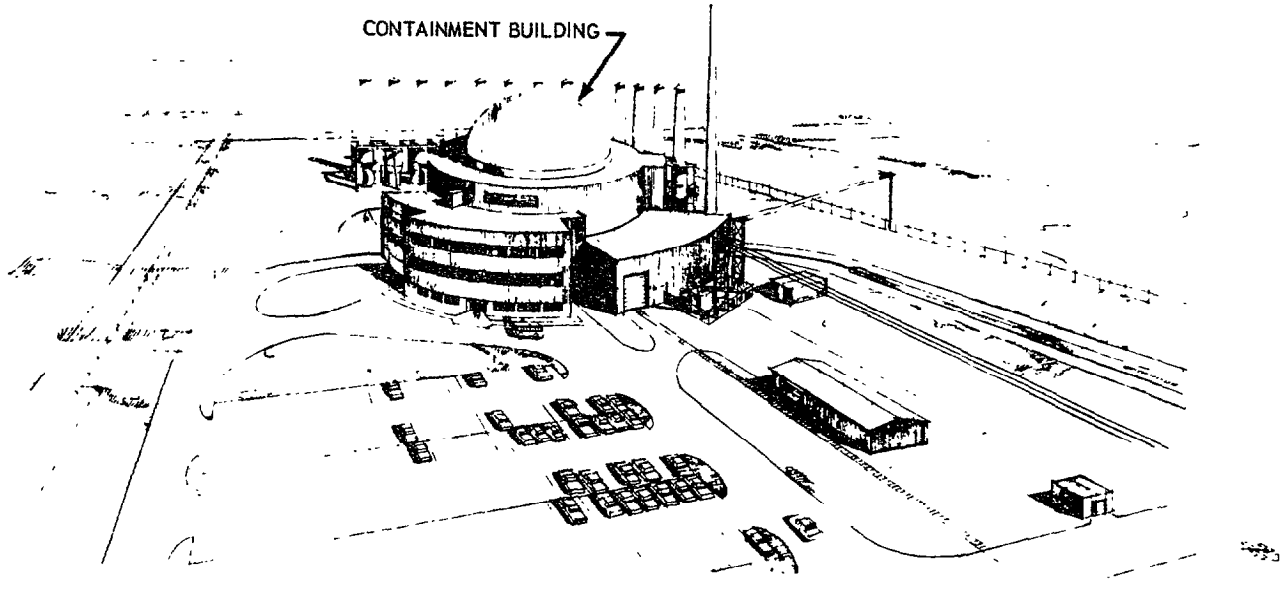
ORIGINAL DESIGN



CONTAINMENT BUILDING
CONFIGURATION – SPHERE
DIAMETER – 225 FEET

VOLUME – 6 MILLION CU. FT.
CONCRETE – 68,860 CU. YDS.

TASK FORCE DESIGN



CONTAINMENT BUILDING
CONFIGURATION – CYLINDRICAL
DIAMETER – 135 FEET

VOLUME – 2.7 MILLION CU. FT.
CONCRETE – 25,950 CU. YDS.

estimated prior to the start of construction to be as much as 25 percent over the $87.5 million authorized.

As of June 26, 1970, RDT estimated the total project cost on FFTF to be $102.8 million on the basis of a definitive conceptual design completed in early 1970. This will result in a total cost of about $6 million less than the start-of-project limitation provided for in the authorizing legislation.

As of June 30, 1970, $59.7 million of the $87.5 million authorized for the design and construction of FFTF had been appropriated. At May 31, 1970, funds amounting to $11.5 million had been obligated for the FFTF project, of which $833,000 had been expended.

In addition to the capital construction costs, there are costs incurred for research and development directly related to FFTF. The current estimate of these costs includes $126.8 million which AEC has identified as being for research and development directly associated with the design and construction of FFTF. The balance of the costs consists of estimated costs for fuel loadings ($10.5 million) and reactor operations ($13.4 million), which will be incurred before the reactor begins operating; however, costs for these activities will be incurred throughout the operating lifetime of FFTF.

The following schedule shows the research and development costs for FFTF from the beginning of the project as projected through the period of initial criticality. The schedule shows the costs estimated at the time the project was totally authorized in fiscal year 1968 compared with AEC's current cost estimates.

	Fiscal year									Cumulative costs
	(actual) 1966	1967	1968	1969	1970	1971	1972	1973	1974	
	(millions)									
Original estimate	$4.0	$7.2	$9.0	$10.0	$10.5	$10.5	$10.5	$10.5		$ 72.2
Current estimate				39.6[a]	17.6	20.5	25.0	24.0	$24.0	150.7

[a]Cumulative actual costs.

Total research and development costs incurred in connection with FFTF through March 31, 1970, have amounted to $53.1 million.

The cost of other capital facilities and equipment needed for development of FFTF through completion of construction is currently estimated to be about $5.4 million. AEC expects that operating costs to be incurred when the FFTF project is completed, exclusive of fuel costs, will be about $7 million annually.

In January 1966, AEC assigned to the Pacific Northwest Laboratory project management responsibilities for FFTF and for developing industrial capabilities to the maximum extent to achieve the AEC objectives of the LMFBR program. This assignment was made so that work on the FFTF project, in addition to providing the testing capabilities, would make a maximum contribution to the overall LMFBR program. In carrying out its assignment, the Laboratory entered into subcontracts with (1) an architect-engineer and construction manager in June 1968 and (2) a reactor plant designer in December 1968. The reactor plant designer initiated work in May 1968 under an existing contract with AEC.

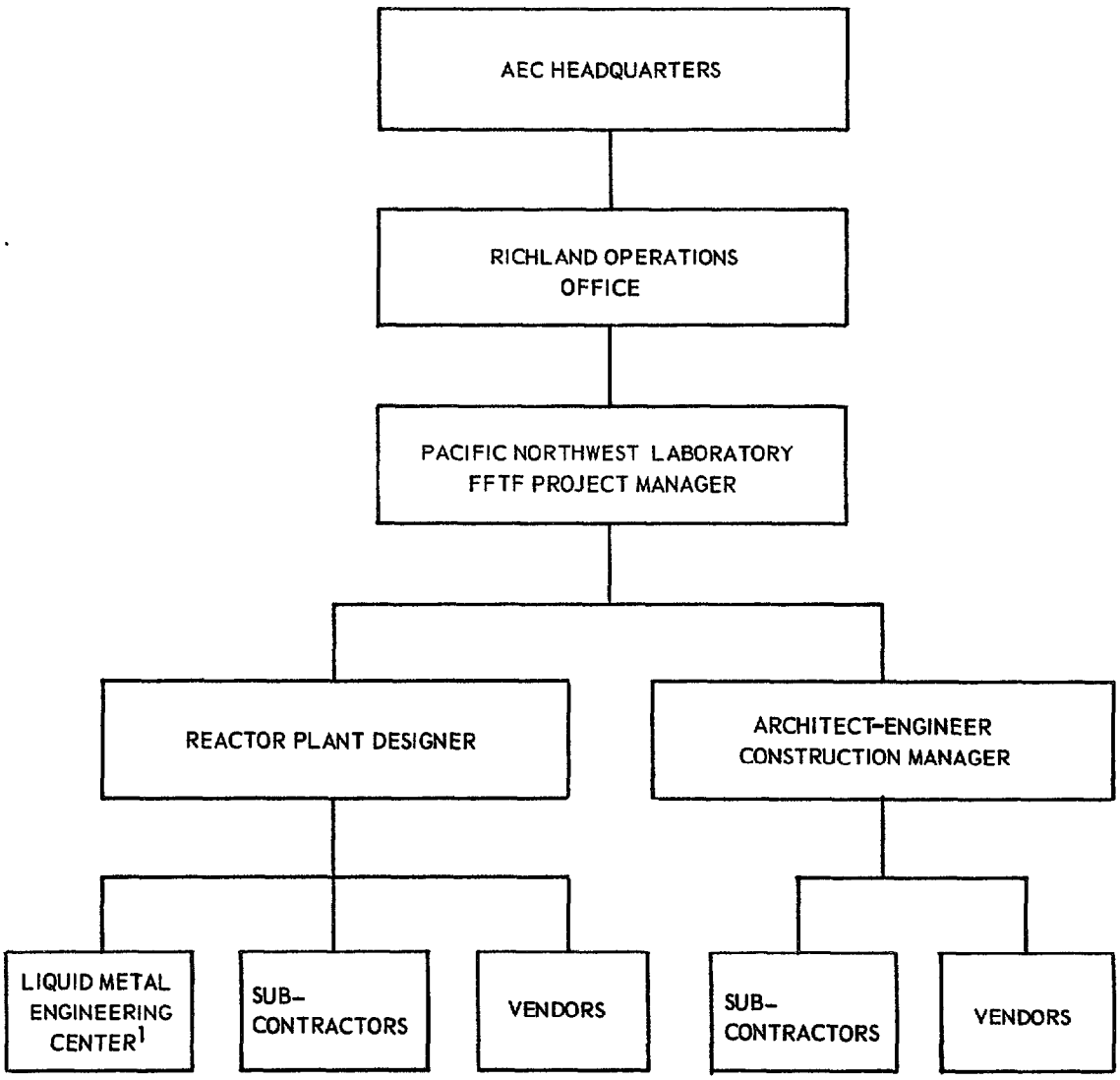
In January 1967, AEC announced the selection of Richland, Washington, as the site for FFTF. By letter dated January 20, 1970, Battelle Memorial Institute, the contractor operating the Pacific Northwest Laboratory, requested AEC to exclude FFTF and closely related activities from its forthcoming contract extension because of possible changes in its tax status as a public organization resulting from the tax law enacted in December 1969.

AEC and the contractor announced on January 30, 1970, that certain aspects of the work at the Laboratory relating to the reactor development program, including FFTF, were being transferred to a new contractor. On May 22, 1970, AEC executed an agreement with the new contractor, which was made effective retroactively to February 1, 1970, to assume responsibility for AEC's reactor development program including FFTF. AEC told us that the transfer of these new responsibilities from the Laboratory to the new contractor should be completed about July 1, 1970. This report covers

the administration and management of the FFTF project prior to the transfer to the new contractor.

The organizational relationship for management of development of FFTF during the period when the Laboratory was project manager is shown on the following page.

ORGANIZATIONAL RELATIONSHIP OF THE MANAGEMENT OF THE DEVELOPMENT OF THE FFTF



[1] CONTRACTUAL DIRECTION PROVIDED BY SAN FRANCISCO OPERATIONS OFFICE

CHAPTER 2

DELAYS IN DEVELOPMENT OF THE FAST FLUX TEST FACILITY

Considerable time has been lost in attaining the capability required to design and develop the FFTF project. Because major milestones have not been met, the contingency time available in the final design, construction, and plant checkout schedules has been reduced, and, therefore, there is greater emphasis, with its inherent risks, on completing the work within the remaining scheduled time.

AEC considers FFTF to be by far the most important facility to which it is committed in the breeder reactor program and has stated that FFTF is essential to the success of the LMFBR program. AEC's cost benefit studies show that benefits from earlier introduction of the breeders are materially greater than those associated with the later introduction of breeders because of the potential savings in fuel costs. AEC, therefore, has placed reliance on the success of FFTF and its completion on time in order that it may be utilized in developing LMFBR demonstration plants and other fast reactor projects.

We found that major objectives of FFTF development had not been met as scheduled. Important among these objectives were the conceptual design, preliminary design, start of construction, award of fabrication contracts, and proof testing. Meeting each of these major milestones had been delayed about a year or more.

With respect to the problems and concern that had been evidenced, our examination into the AEC and Laboratory management of the design and development of the FFTF project showed that (1) the Laboratory had not met its objectives in terms of establishing an engineering-oriented organization with sufficient management and technical capabilities to develop such a complex engineering project as the FFTF, (2) AEC, with its various levels and dispersal of management, had not effectively executed its responsibilities to bring about the changes that had been identified and apparently agreed upon as being essential, and (3) the technological base was not as sufficiently developed as initially represented.

PROJECT SCHEDULE DELAYS

AEC's early schedules for completion of conceptual design, for initiation of preliminary design and construction, and for completion of the project were substantially underestimated. AEC attributes these delays in meeting the important milestones primarily to the failure of the Laboratory to develop the managerial and technical capability needed to meet the program objectives.

AEC advised us that it had overestimated the capability of the Laboratory to manage the development of a complex project of the magnitude of FFTF. Also, the technological base was not as sufficiently developed at the time the project was initiated as was believed by AEC and the Laboratory.

In February 1966, AEC advised the Joint Committee on Atomic Energy that the completion date for the conceptual design of the various FFTF systems would be July 1966; however, the first system was not approved until October 1967 and a firm conceptual design of the entire project except for one system was not completed and approved by AEC until February 1970, about 3-1/2 years later. In March 1967, AEC advised the Joint Committee that construction of FFTF would commence in about June 1968 and would be completed in about April 1973. The conceptual design was completed only after a task force was established at the request of AEC to firm up the design. Although preliminary design work was initiated on a key system beginning in January 1969, most of the preliminary design work was not started until February 1970, about 2-1/2 years later than the target date provided the Joint Committee in March 1967 and about 5 years after the Laboratory had initiated work on the conceptual design.

Because of the delay in completing an FFTF conceptual design and the corresponding delay in completing preliminary design work, construction work had not been initiated as of May 1970. AEC therefore revised its estimated completion date to about June 1974--about 7 years after the project was authorized by the Congress.

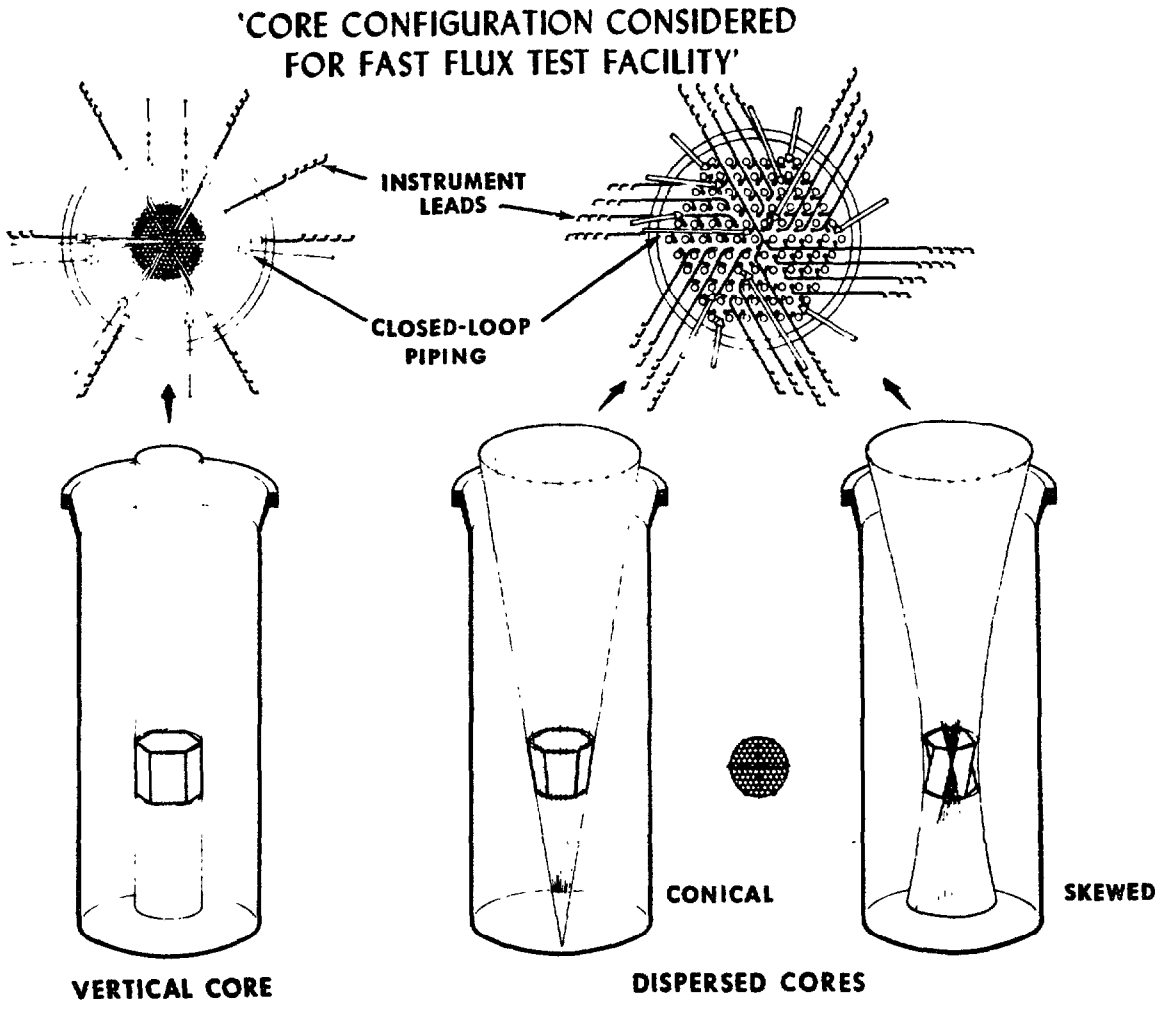
AEC recognized that its initial estimates of time for developing a design for FFTF had been understated, and, at

the request of the Joint Committee, it prepared revised estimates for inclusion in the 1968 authorization hearings. During succeeding authorization hearings, AEC kept the Joint Committee advised of the status of the project.

Details showing schedular slippages that have occurred on certain key systems of FFTF are included as appendix II. The following information on one of these systems--the reactor core--illustrates the managerial and technical difficulties encountered during the efforts to develop an FFTF conceptual design.

An example of a major component of the reactor which was delayed is the conceptual design on the reactor core. Delays were encountered in developing the reactor core concept because of several changes in the configuration to be used as the reference design for FFTF. In August 1965 the Pacific Northwest Laboratory issued a report on conceptual design studies wherein the reactor core assembly was described as being arranged in a skewed array. Further reviews were performed by the Laboratory and its subcontractors during 1966 on various core concepts, such as those shown on the following page. In March 1967 the Laboratory recommended and AEC concurred with the selection of the split conical core as the reference FFTF core arrangement and a vertical core as a backup arrangement.

Reevaluations of the split conical core and reviews of other core concepts were made by the reactor industry and the Laboratory and its subcontractors during the period December 1967 through October 1968. During the period July to December 1968, AEC, the Laboratory, and the reactor plant designer and its principal subcontractor concentrated on a design effort to evolve an improved core concept. In December 1968, AEC approved the current vertical core concept. The principal factors influencing this selection were that the split conical concept (1) would not provide as high a fast neutron flux, (2) presented unique structural problems, and (3) was not considered to be prototypic of LMFBR plants. The conceptual design system for the reactor core was approved by AEC in August 1969 and was reapproved in February 1970 along with all other systems except for the plant fire protection system which required further work.


'CORE CONFIGURATION CONSIDERED
FOR FAST FLUX TEST FACILITY'
INSTRUMENT
LEADS
CLOSED-LOOP
PIPING
CONICAL
SKEWED
VERTICAL CORE
DISPERSED CORES

Indications are that the decision to proceed with the vertical core concept was delayed for about 1 year because of a disagreement between AEC and the Laboratory regarding the dispersed concepts. AEC stated that the vertical concept permitted more conventional mechanical design and attainment of an adequately high fast flux, whereas the Laboratory believed that the skewed concept had certain other technical advantages. We were advised by RDT that, although it believed that the skewed core had certain advantages:

> "*** the technology for the skewed core had not been developed and was certainly a more difficult and risky undertaking; furthermore, the concept was unlike any considered for commercial reactors."

Combined efforts by RDT, the Laboratory, and other AEC contractors proved the feasibility and advantages of the vertical concept.

Effect of schedule delays on completion date

Construction of FFTF was originally estimated to be completed in June 1973 by AEC as shown in the congressional data sheet prepared in September 1966. At that time, about a 7-year period was apparently considered to be adequate for development of the project management capability as well as for complete development of the project. As various milestones were missed due to delays, the remaining time available to develop and complete the FFTF facility was correspondingly reduced. As difficulties remained unresolved and delays occurred, AEC had to decide whether (1) to compress the remaining schedule by bypassing management problems and development issues or (2) to slip the completion date by increasing its efforts to strengthen the Laboratory and resolve the problem areas.

In regard to completion of the FFTF, the Director, RDT, during AEC's 1968 authorization hearings, advised the Joint Committee on Atomic Energy that:

> "*** Certainly I feel a lot of pressure on the date when the FFTF will be ready; I want it to be early, too. However, right now I don't know when

the FFTF will be ready. I hope that it will be ready in 1973 to test fuel. But we are all more willing to have the FFTF ready in 1974 to really test fuel than to start it up in 1973 and then have it shut down in 1974 and then find ourselves rebuilding it in 1975, and perhaps in 1976. This is the type of philosophy we are proceeding on for the design of the FFTF, because we have no choice since we really need the FFTF to test fuel. ***"

In the fiscal year 1970 report authorizing appropriations for AEC, the Joint Committee on Atomic Energy stated that:

"During previous authorization hearings considerable emphasis has been placed on the relationship between the FFTF and other LMFBR program activities. Consistent with the discussions in the committee's authorization report for fiscal year 1969, the committee believes that the Commission has applied extensive efforts to utilize the FFTF program as a focal point for the program and an instrumentality for achieving the maximum industrial contribution toward solving the LMFBR technical problems and for broadening the base of industrial capability in both technical and management areas. As an outgrowth, the Pacific Northwest Laboratory (PNL) has developed into the AEC's principal engineering laboratory for the LMFBR program, complemented by several other Commission laboratories and industrial facilities. The Commission is taking steps to strengthen PNL in this capacity, both in organizational and management structure, and also by investing in new facilities and effectively utilizing existing facilities, both at PNL and other locations. In a like manner, during the past fiscal year the Liquid Metal Engineering Center at Santa Susana, Calif.--a large complex of liquid sodium test facilities--has been expanded to include the technical management of AEC-sponsored R.&D. contracts in all major sodium component development areas."

Expressing concern over apparent delays in the development of the LMFBR program, the Chairman, Joint Committee on Atomic Energy, stated in a speech on December 3, 1969, that he intended to propose the establishment of a "blue ribbon ad hoc committee" to find out why development of the breeder was lagging and why and how it could be developed faster. With respect to the nuclear industry, the Chairman stated that:

> "We can be diverted and divided from constructive cooperation. We can, if we choose, tilt our lances at windmills with the same ineffective results that Don Quixote had. Or we can unite in our efforts to achieve the breeder reactor and extract the maximum amount of energy from our nuclear fuels, thereby bequeathing to our progeny an almost unlimited supply of electrical energy."

Referring to his earlier speech, Chairman Holifield was quoted in a technical publication dated December 18, 1968, that:

> "In my comment concerning the breeder program I cautioned everyone not to block the quarterback. Anyone going through the record of our hearing and the comments in our authorization reports will see that we subscribe to the program laid out for the breeder reactor. Fundamentally we are disappointed with the speed at which work is progressing. I want to look into the program to find out why we can't move faster. One area I want to look into particularly concerns the part our national laboratories are playing in this effort. As I said before the Forum on December 3, the laboratories must concentrate efforts on our priority commitments.
>
> "I feel a responsibility to assure we achieve the goals we have set. My objective is to carry out this responsibility."

During AEC's fiscal year 1971 authorization hearings, Chairman Holifield discussed with AEC the selection of a new contractor to take over project management of FFTF from the old contractor, which is divesting itself of major project-management-type activity to ensure its public status under the 1969 tax reform legislation.

The Chairman stated his satisfaction in the shifting of project management responsibility for the development of FFTF to a new contractor. The Chairman indicated that, because of its experience in the naval reactor program as well as in the civilian reactor program, the new contractor was well qualified for the FFTF management role. Also, the Chairman indicated that he hoped for management changes designed to strengthen the LMFBR work at other laboratories.

CURRENT STATUS

Although conceptual design of FFTF has been under way at the Pacific Northwest Laboratory since April 1965, it was not finalized until February 1970 after a concerted effort by a task force composed of key officials from the Laboratory, the reactor plant designer, and the architect-engineer and construction manager. The task force which was established in October 1969 completed its design effort on all but one FFTF system by February 20, 1970.

We were advised by an AEC official that one of the major design changes as a result of the task force efforts was a reduction in the physical size of the containment building of FFTF. The diameter of this building was reduced from a sphere of about 225 feet in diameter to a cylinder of about 135 feet in diameter. Drawings provided by AEC showing the conceptual design of FFTF prior and subsequent to the task force study illustrate these changes and are shown on page 8.

Although these illustrations show a significant scaling down of FFTF not only in the containment building but also in the support area in order to stay within the cost limitations of the authorization, we found no indication at the time of our review that FFTF would not perform those capabilities that were originally justified to the Congress except for the physics experiments which had been planned to be performed in the nuclear proof-test facility that had been indefinitely deferred. These experiments are currently being performed in AEC's zero power reactor facilities in Idaho and Illinois.

During the fiscal year 1971 authorization hearings before the Joint Committee in March 1970, the Director, RDT, provided information on cost and time schedules on FFTF, as follows:

"Representative Hosmer. *** Now, with regard to the FFTF, that was authorized at $87.5 million——

"Mr. Shaw. That is correct, sir.

"Representative Hosmer. That was a pretty plush design to begin with. It had to be scaled down considerably, or are you going to have to come in for more money?"

* * * * *

"Mr. Shaw. As I indicated earlier, when we came forth with the FFTF authorization, we recognized there were a number of possibilities with regard to what it would cost and what it would do for us.

"Representative Hosmer. You knocked some of the things out, but I wonder if there are 'holes' where everything required is not there, and if after awhile you will be coming around for alterations?

"Mr. Shaw. As things are today, Mr. Hosmer, we have a design that incorporates every facility, every part of that concept we intended to incorporate when we began, with one exception: we were going to put in a nuclear proof-test facility, which was estimated at about $1 million, or in that order. This was a physics facility to be used to run critical experiments. We have since deferred that part of the FFTF because we are using our zero power reactors for that type of work as of now. However, we would still like to have the nuclear proof-test facility.

"Besides that, we have had to scale back some of our ideas, not in the sense of the authorization, but in the sense of limiting their scope while being able to live within the financial limits. But the FFTF will accomplish those things we had identified in the authorization.

"I submit we could do these things better if we had a little more money. But the significant escalation along with the delays have hurt us. We are going to build good facilities. We are going to build an FFTF that does the job we intended to do.

"This is the chart *** I used in 1967 to show that the design studies we would conduct could get you an FFTF costing anywhere up to $120 million or down to roughly $65 million if you did not want to put certain things in it. I think this is almost still the case today, with the exception of the heavy escalation."

* * * * *

"Representative Hosmer. When do you expect to get the design finalized and start to work on it?

"Mr. Shaw. We are just about through with the design concept work. It is being wound up; we have complete agreement; it is being documented now, and it is going through the approval chain.

"We had expected to wrap it up by the first of April, but this major management change at PNL may cause some slight delay, but nothing significant.

"Representative Hosmer. When will you break ground?

"Mr. Shaw. We will break ground probably late in the spring or early in the summer. But we do have, as I indicated before, the pressure vessel and the head on order now with Combustion Engineering. Official construction will probably begin, we hope, about April 1, although groundbreaking may be adjusted to accommodate a possible ceremony."

USE OF IN-HOUSE AEC LABORATORY TO MANAGE DEVELOPMENT OF THE PROJECT

In February 1965, AEC discussed with the Joint Committee the role of its Government laboratories in the reactor development program and stated an inclination "toward using the in-house laboratories to provide a strong technical base to an important industry." In accordance with this approach, AEC selected the Pacific Northwest Laboratory as its project manager for FFTF. The Laboratory was given the responsibility to develop an FFTF conceptual design and was encouraged to develop a strong technical organization capable of managing such a complex engineering undertaking.

During the 1967 authorization hearings, AEC discussed with the Joint Committee its plan to utilize its laboratories as extensions of RDT to achieve improved planning and technical management and to ensure the maximum development and use of competitive industrial capability. The Director, RDT, stated:

> "I believe we have a tremendous competence in our national laboratories. We have a big investment in people, facilities, as well as in the technologies, in those laboratories. It is of great concern to us sometimes when we have a specific problem that we may not be bringing this competence immediately to bear on the specific problems. They are part of the Commission's assets that should be working on our most important problems.
>
> "It is in this area that we have been working in an attempt to get these laboratory resources aligned more specifically to our high priority commitments. At the same time we must be careful, not to stifle the basic and applied research, the applied development, and the exploratory development that are necessary and can be carried forward most effectively in these laboratories."

Also, during the 1967 authorization hearings, AEC advised the Joint Committee that it had substantially

strengthened the RDT staff with the addition of new personnel. The Director, RDT, stated that:

> "In discussing my organization plan *** I felt that the most important single job I had to accomplish was to strengthen significantly and obtain a more disciplined technical activity at Headquarters in order to more effectively aline and utilize the collective resources we have in the field offices, laboratories and industry to obtain a better alinement between the collective resources and RDT commitments and their priorities, such as to make sure that we don't overstaff low priority jobs compared to understaffing high priority jobs."

During the authorization hearings in succeeding years, AEC reemphasized the importance and desirability of utilizing its laboratories and continued to advise the Joint Committee of actions being taken to improve the capability of the laboratories for work on the reactor programs.

PROJECT STAFF

Since 1965, AEC has sought to establish a strong technical base at the Laboratory for FFTF, as part of the overall LMFBR program, but has not been as successful in this endeavor as planned. When AEC designated the Laboratory as the project manager in 1966, it noted that the Laboratory's research-oriented capabilities would need to be significantly augmented with the capabilities of engineers and scientists from other laboratories and industrial organizations. At that time, AEC considered the Laboratory to have little experience as a systems manager and advised it of the need to strengthen its capability necessary to undertake an engineering project of the magnitude of and as difficult as FFTF. In correspondence and meetings with AEC, the Laboratory acknowledged the need to develop such a capability and advised AEC of its plans to do so.

AEC has continuously stated its concern that the Laboratory has not developed an adequate engineering-oriented staff to manage the project. AEC has held meetings, written memorandums, and visited the Laboratory to discuss the

problems in progress on the FFTF project since 1965. On numerous occasions the Laboratory was advised that the project had repeatedly been subjected to delays and difficulties because the Laboratory did not have the required number of highly qualified people. Also, meetings were held between RDT and the Laboratory in early 1967 to discuss FFTF project reorganization at the Laboratory, and in June 1967 changes were made to organize the Laboratory's staff along project lines.

In June 1967 the Director, RDT, advised the AEC General Manager that it was essential that AEC continue to direct top-management attention to the FFTF project staff to ensure the effective performance by the Laboratory of the project management functions. In a number of other meetings, and through correspondence, AEC officials expressed their concern to the Laboratory that it was not making enough progress in high-level staffing for FFTF.

According to AEC there was not an awareness at the Laboratory as to the personnel and organizational requirements for the successful completion of a development and design project as large and as difficult as FFTF. AEC stated that FFTF would be a "tough, uncertain project for the strongest reactor development organization which could be put together" and that the Laboratory lacked the experienced managerial and technical skills required for such a development project in a field in which so few sound technical bases existed.

ROLE OF PACIFIC NORTHWEST LABORATORY

The Laboratory stated that it had been given additional tasks which AEC desired primarily for the overall LMFBR program and which the Laboratory believed had only limited benefits expected for FFTF. The Laboratory stated also that about half of the total effort on such tasks contributed to FFTF and that the use of the Laboratory staff and resources on such tasks would therefore affect the timely completion of work required for FFTF.

Areas cited by the Laboratory as examples of additional work being required to benefit the overall LMFBR program rather than specifically the FFTF project were in the development and procurement of fuel and pumps. The Laboratory stated

that it was required by AEC to help develop the capabilities of vendors to provide fuel and pumps when commercial sources of such items already existed and that the additional sources of supply were desired for the long-range LMFBR program and were not necessary for FFTF. We were told that these efforts took considerable time of the Laboratory's top-technical personnel and, therefore, prevented the use of their services on other work more pertinent to FFTF.

AEC stated that it did not believe that work had been required which was not related to FFTF and that the Laboratory had requested and accepted AEC program direction and funds on the basis that the work was related. AEC told us that the Pacific Northwest Laboratory, as an AEC laboratory, was expected to perform other work as required but that its efforts in the LMFBR area were related to development of the FFTF. Regarding pump procurements, AEC told us that there were firms with some capability which could probably have developed the pumps but that substantial effort would have been required by AEC and the Laboratory to ensure that the procured items were adequate.

AEC advised us that qualified vendors for the FFTF and LMFBR fuels were not available and that a program was under way to qualify vendors.

Also, we were told that AEC did not want to get in a position where FFTF was dependent on a sole-source vendor for such items, particularly for fuel, since FFTF is expected to have annual fuel requirements costing several million dollars.

Although agreement had been reached, there were obvious misunderstandings concerning the execution of the plan to the extent that major milestones and schedules were not met. The fact that such basic differences in operating and management philosophy existed for several years and the fact that the differences were not properly resolved emphasized the management problem that contributed to the delays.

MANAGEMENT SYSTEM

The Laboratory attributed the delays and problems on the FFTF work at least in part to the various AEC organizational components it had to deal with. The contractor advised us on March 30, 1970, that RDT overmanaged the FFTF project and that the Laboratory management overresponded. The contractor advised us further that, during a 1-year period (July 1968 to June 1969), 457 formal directives were received by the Laboratory from RDT and 94 formal meetings were held between AEC and the Laboratory staff. The contractor stated that the lack of specific contractual assignment of both authority and responsibility to the Laboratory inevitably strained working relations. The contractor stated that, although many responsibilities were assigned to it by various letters and communications from RDT with respect to FFTF including program management, the authority commensurate with these assigned responsibilities was never given to the Laboratory by AEC.

The AEC cost-plus-fixed-fee contract for operating the Laboratory provides that the contractor manage, operate, and maintain the Laboratory facilities and perform research and development. This contract which was effective for a 5-year period beginning January 4, 1965, required work to be performed as in other AEC-owned, contractor-operated facilities with directions and instructions which AEC may deem necessary.

An RDT memorandum of January 28, 1966, provided the Laboratory with program direction for the FFTF conceptual design and evaluation efforts and authorized it to use selected organizations to assist in preparing the conceptual design.

As part of RDT's charter direction, the Laboratory was expected to and agreed to help develop industrial

suppliers and to perform work which would be required for the FFTF project in support of the LMFBR program.

As project manager of FFTF, the Laboratory was authorized to utilize the services of other AEC laboratories and contractors. Such work was in areas related to physics, nuclear safety, and fuels and materials at Argonne National Laboratory and component testing at the Liquid Metal Engineering Center. AEC records indicated that the Laboratory had experienced difficulty in managing the work at these sites and that coordination with subcontractors had not been satisfactory.

Although there was some question concerning the Laboratory's understanding of its increasing role and responsibilities with respect to the LMFBR program, RDT initially provided it with a broad charter and subsequently provided significant detail direction. The differences in understanding with respect to the Laboratory's role and the FFTF cost schedule and performance were the subject of many communications between the Laboratory and AEC organizations.

The Laboratory advised us that there was a lack of agreement, written or otherwise, as to the completion date and ultimate costs for the FFTF and that there was the absence of specific identification or assignment of responsibility as to who should make the final decisions necessary to meet program objectives.

With respect to the schedule slippages, the Laboratory advised us that, although it preferred to work with a clearly defined schedule, "such a situation was not possible." The Laboratory stated that its authority to carry out assigned responsibilities for major FFTF accomplishments was nonexistent and that its actions generally required RDT approval. Further, the Laboratory stated that:

> "In fiscal years 1967, 1968, and 1969, [RDT] testimony before the JCAE provided such 'guidance' as existed for the FFTF. This obviously was not a clearcut schedule. ***"

"From time to time we pointed out to [RDT] that the absence of specific decisions negated elements of the originally proposed time table. However, unreinforced persuasion is--at best--rather ineffective and we ultimately deferred to their decisions to allow the schedule to slip."

RDT advised us that its working arrangements with the Laboratory and related procedures were similar to those used in other reactor programs. The Laboratory was provided with direction with regard to its scope, schedule, and funding at the time of its assignment as FFTF project manager. Its initial direction was adjusted annually in program letters acting on the Laboratory's research and development assessments and recommendations. AEC procedures require that significant direction be provided in writing. In addition, as required to assist in the orderly development of the FFTF project, meetings and further written direction were given to the Laboratory on the basis of a review of results of research, design, and development work performed at AEC laboratories and by other contractors.

Although RDT has responsibility for both funding and program direction for the development of FFTF, the contracting responsibility for the development of this project is vested in the Richland Operations Office.

The organizational relationships, as shown in the AEC organization chart in appendix III, between RDT and the AEC operations offices, including Richland, are significantly different from the relationships in the other two divisions within the Assistant General Manager for Reactors' area of responsibility. These two headquarters divisions have the respective AEC field offices reporting directly to them.

Contract performance appraisals

The AEC Richland Operations Office has contract administration responsibility for the Laboratory contract, and RDT maintains technical responsibility for the FFTF-LMFBR work that the Laboratory performed under its contract with Richland. Each year the Richland contract administrator made an appraisal of contract performance pursuant to

AEC regulations. Richland's appraisal of the Laboratory's activities for the period July 1967 through June 1968 included performance of the FFTF project in the areas of "contract performance, management performance and relationships with others." The performance was summarized as being "satisfactory and meets AEC standards." The appraisal report stated that no major deficiencies were noted and that minor weaknesses disclosed were expected to be corrected. Minor weaknesses were said to exist but were expected to be resolved as the project progressed. The report stated that:

> "Many of these problems have been encountered because of the new system of [the Laboratory and RDT] procedures being employed on the FFTF project."

The report was qualified as follows: "The technical appraisal of the FFTF Project is not considered in this report." The technical appraisal was to be performed by RDT. We were told by RDT that, although it did not prepare a formal technical appraisal of the Laboratory's FFTF work as such, it considered the many communications with the Laboratory and meetings held to discuss RDT's assessment of work to be an adequate advisement of performance.

Contract performance appraisals similar to those in the 1968 report were made by Richland for each year, and the summary evaluations exclusive of the RDT technical work was indicated to be generally satisfactory, as follows:

Period	Appraisal
Calendar years 1965 and 1966	Satisfactory and meets or exceeds AEC standards in all respects.
Calendar year 1967	Satisfactory and meets or exceeds AEC standards.
July 1967 to June 1968	" " " AEC standards.
" 1968 to " 1969	Acceptable and meets AEC standards. The conclusion section of this report stated that the Laboratory's performance in general had been "satisfactory to excellent and the FFTF programs have been conducted in an efficient and professional manner, considering the complexity of the project, state-of-the-art, and AEC requirements imposed." (Underlining supplied.)

Although Richland's project management appraisal report for fiscal year 1969 stated that the Laboratory's performance overall was satisfactory to excellent, it stated also that submittal of documents and correspondence requiring AEC review and approval were sometimes lacking in necessary content and required information. Richland recommended that the Laboratory "strengthen its Quality and Reliability Assurance area to avoid slippage and rescheduling of documentation required by the AEC" and that it "insure that its submittals to the AEC (RL and RDT) are complete when AEC review is required, thus eliminating unnecessary requests for additional documentation to [the Laboratory] enabling faster approval."

Each annual contract appraisal report stated that performance was satisfactory and met AEC standards. At the same time the Laboratory received RDT's comments on technical submittals and attended management conferences with RDT pertaining to technical performance which, according to RDT, indicated the need to strengthen its engineering and technical capabilities with highly qualified people who could adequately function in the laboratory-industrial arena. For instance, on June 10, 1968, notwithstanding the fiscal year 1968 contract performance appraisal of satisfactory, the Richland Manager formally advised the Laboratory of AEC Headquarters management's concern with the status of FFTF key staffing and requested a comprehensive status report on this problem.

Although the functions of the Richland Operations Office and RDT with respect to the FFTF project were significantly different, a better coordination in appraisals would undoubtedly have strengthened the AEC position and possibly would have avoided some of the confusion the Laboratory was faced with in dealing with various organizations within AEC.

Coordination of management direction

During a meeting in October 1966, RDT and the Laboratory personnel discussed problems in communications between their technical staffs. At the meeting RDT indicated that there should be more direct channels of communication between engineering and scientific personnel.

During the approximately 3-year period October 1966 and August 1969, direct contacts were being made between the Laboratory and RDT staff personnel. With respect to formal communication, apparently there were no changes in the procedures which required technical information being submitted by the Laboratory to RDT to be routed through the Laboratory's FFTF project manager and through the Richland Operations Office and an Assistant Director in RDT prior to being sent to the addressee.

In December 1968 the Laboratory registered a complaint to the RDT site representative that it was receiving directions informally on construction projects from a variety of sources and that, in some cases, the directions apparently did not reflect RDT program requirements or policy and resulted in false starts and much wasted effort. The Laboratory also complained about uncoordinated informal AEC requests for "bits and pieces of information" required to provide additional support for projects. AEC stated that the Laboratory was not expected to answer informal requests and that it had been made aware of this procedure.

In April 1969 the Laboratory expressed concern with the large amount of time being spent in various review meetings with members of RDT, the repetitive meetings with various members of RDT covering essentially the same subject, and the increasing informality and lack of notification for such meetings. The Laboratory stated that the cost in both time and money for such meetings was increasing because most meetings required participation by a number of contractors. The Director, RDT, advised the Laboratory in June 1969 that he had taken action to ensure that RDT's written instructions for meetings were being followed and urged that it do likewise. The Director also advised us that, although the lack of notification for such meetings occurred infrequently, he attached considerable importance to technical meetings as a tool for effective management and coordination.

AEC recognized the difficulty in communicating with the Laboratory and took actions designed to resolve this problem. One such action was to establish an RDT Office of Assistant Director for Pacific Northwest Programs on

August 10, 1969. The Office is located at Richland, Washington, and is responsible for implementing technical direction of RDT's programs. In October 1969 this Assistant Director was delegated responsibility to act as contract administrator on the Laboratory's contract for the Richland Manager. Both AEC and the Laboratory advised us that this management change should assist both organizations in avoiding some of the problems experienced previously.

After the establishment of the position of Assistant Director for Pacific Northwest Programs in August 1969, the functions of contract administration and of implementing RDT's technical direction were established within one office. There remained, however, a myriad of other organizational relationships that the Laboratory had to deal with at both RDT and other AEC laboratories even though communications were to funnel through a single channel at Richland, Washington. For example, there were several RDT Assistant Directors with respective subgroups involved in the LMFBR program, which is indicative of the many individuals and organizations, that would be telephoning and, where authorized, writing letters to the Laboratory.

Completion of conceptual design by task force

The conceptual design for the plant and the major components of FFTF continued to lag behind schedule in 1968 and 1969 which was beyond the period that actual construction was to begin. The organizations within RDT were each bringing pressures to bear to have their respective part of the FFTF project completed in accordance with the program plans. Even with the heavy and continuing attention and effort exerted to expedite the plant design and related development work, the project had not reached the degree of success hoped for by the end of fiscal year 1969.

AEC selected several task forces from time to time to perform development work in critical problem areas with respect to developing the conceptual design. AEC advised that follow-through of these efforts was difficult to achieve. Specifically, a task force was selected in October 1969 to complete the conceptual design work and to review and evaluate the FFTF design effort. This task force

which was composed of individuals from several organizations was free from all organizational restraints and duties. It was to remain in force until the conceptual design was completed.

The task force completed its work on 28 of the 29 FFTF systems in February 1970. We were advised by AEC officials that, as a result of the task force work, agreement was reached on a conceptual design for the FFTF that would meet the objectives of scope and cost for a test facility to support the LMFBR program as stated in the approved congressional authorization and within the 25-percent limitation provision.

BATTELLE MEMORIAL INSTITUTE COMMENTS

On March 30, 1970, Battelle Memorial Institute furnished us its comments as operator of the Pacific Northwest Laboratory and specifically as project manager for the design and development of the FFTF project. The complete comments are included as appendix I.

Pertinent parts of the comments have been included in the respective sections of the report where deemed applicable. The Laboratory has undoubtedly made significant technical accomplishments in developing certain aspects of the FFTF project. (See app. I.) In recognition of these technical accomplishments and the complex engineering task undertaken, it is understandable that other technical problems existed. It is axiomatic in almost every research project that all problems and solutions are not known at the inception of each project.

Also, Battelle stated its concern over the problems indicated in dealing with the many AEC organizations in obtaining rigorous project directions, assessments, schedules, and goals and in obtaining authority commensurate with assigned responsibility. AEC has advised us that these concerns reflect inexperience in complex and developmental engineering undertakings and that the procedures employed with the Laboratory are similar to those that have worked successfully in other reactor programs.

In consideration of the Laboratory's accomplishments and the many problems it had to deal with in managing the design and development of the FFTF project, of remaining and paramount importance is the fact that Battelle was unable to meet its agreed-upon objectives in terms of establishing an organization with sufficient management and technical capabilities to design and develop the FFTF project on a schedule that would allow for construction to be completed within the cost and time estimates approved by the Congress. Major milestones were missed, schedules slipped, and the conceptual design had not been completed and cost estimates had not been established until a task force was appointed in late 1969.

We agree with Battelle that there is little to be gained at this point in an exercise of sorting out and attempting to assign specific responsibility for identifiable deficiencies. On the other hand, we believe that, for the benefit of the new contractor and for the good of the expeditious development of the FFTF project, it is important to remedy those management problems and differences in operating philosophy that have been contributing factors to delaying the successful design and development of the FFTF project.

CONCLUSIONS

The FFTF project is an important part of the LMFBR program and is a complex engineering development. As important as the FFTF project is and as necessary as its vital testing function will be to the development of economical nuclear electrical power in large plants, the project has been plagued with design and development delays that have caused considerable time to be lost and schedules to be compressed. We attribute the underlying cause of these delays and schedule slippages to the management problems that have existed thus far. Also, the technological base was not as sufficiently developed as initially represented. In our opinion, AEC and the Laboratory did not establish a constructive working relationship at the top-management level that could effectively communicate and reach meaningful agreements where needed on the conduct of the project and the capabilities needed to perform the assignment.

The change in the management of the FFTF project is important provided that appropriate and definitive steps are taken to establish an organization, lines of communications, and a positive unequivocal understanding concerning the respective responsibilities and to establish cost, schedule, and performance milestones that can be vigorously adhered to. Such an organization and agreements are needed on the part of AEC and the new contractor in order to accomplish the established task which has been increased because of the compressed schedule.

AEC stated that the problems associated with the development of FFTF had been discussed on a number of occasions

with the legislative and appropriations committees and that distinct efforts had been made to disclose fully the specific circumstances as well as the strengthening actions that were to be taken. The Director, RDT, in testimony before the Joint Committee on Atomic Energy in March 1970 stated that the following actions are those that should be taken with respect to the contractor that is assuming responsibility for the construction of the FFTF:

> "1. Restructuring existing research laboratory-oriented patterns in order to separate, functionally and administratively, reactor engineering development programs and key supporting activities, thus providing mission-oriented focus and direction.
>
> "2. Providing clear lines of responsibility, authority, and accountability by placing the separate organizations under the control of highly qualified and experienced full-time managers.
>
> "3. Adopting and applying, in a wholehearted, constructive manner, systematic, disciplined engineering techniques, with strong quality assurance programs intimately coupled to all the reactor development work of the laboratories.
>
> "4. Recruiting a significant number of senior reactor engineering personnel experienced in the successful management of design, construction, and operation of large power reactor projects, and assigning these individuals to positions of unequivocal responsibility.
>
> "5. Improving communication and coordination with the industrial organizations which must ultimately use the technology developed by the laboratories.
>
> "6. Improving business methods, including planning, programming, budgeting, cost control, and procurement."

The Director stated further that the new contractor, "because of its experience and long-terms commitment in the power reactor business, their staff of experienced reactor people, and use of what I call a disciplined engineering approach, has the potential for coming in to the FFTF and invoking each of these strengthening actions without too much difficulty."

AEC also has advised us that, upon completion of the transition of responsibility for the FFTF project to the new contractor, the new contractor is expected to review the current project position and its plans for development of the conceptual design, scope, cost, and schedule for FFTF, recognizing the annual budgetary limitations that affect the FFTF support activities as well as the LMFBR base program. In addition, AEC has advised us that the actions which have been taken or are being taken with respect to the FFTF are intended to establish clear lines of responsibility and unequivocal authority.

We are not making any recommendations in light of actions taken or being taken by (1) AEC to strengthen the management of the FFTF project, (2) contract administration by establishing an RDT Office of Assistant Director for Pacific Northwest Programs with responsibility delegated from Richland for administration of the FFTF project, and (3) RDT to periodically evaluate its organization and make such changes as may be needed from time to time to strengthen program direction on the FFTF project to effectively expedite its completion.

Because of the problems encountered on the FFTF project thus far and because of the importance of the FFTF to the development of economical electrical power, we believe that the need for the actions taken by AEC to strengthen program management are of extreme importance. We recognize, however, that an evaluation of the effect of such actions cannot be made until the actions are complete, and, therefore, AEC has agreed to keep us apprised of the progress and status of the management and development of the FFTF project.

CHAPTER 3

SCOPE OF REVIEW

Our review was performed at AEC Headquarters in Germantown, Maryland; at the AEC Richland Operations Office and the Pacific Northwest Laboratory in Richland, Washington; and at the Liquid Metal Engineering Center in Santa Susana, California. The work was completed in June 1970.

We reviewed the applicable legislative history and pertinent records and documents relating to the civilian nuclear reactor program and, specifically, the Fast Flux Test Facility. In addition, we obtained the views of various AEC and contractor personnel responsible for the development of the project.

APPENDIXES

Battelle Memorial Institute

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March 30, 1970

Mr. Dean K. Crowther
Assistant Director
U. S. General Accounting Office
Civil Division
Washington, D. C. 20548

Dear Mr. Crowther:

We greatly appreciate the chance to participate in a review of your study of the management of the development of the Fast Flux Test Facility (FFTF) Project. By way of background, I believe it will be useful to describe the kind of organization Battelle is and to describe the circumstances under which Battelle came to be associated with the FFTF Project. Additionally, I would like to review briefly the five-year Battelle/FFTF accomplishments.

Battelle Background

Battelle is a not-for-profit organization devoted largely to research, development, and educational activities. Most of Battelle's research and development work is performed under the sponsorship of a large number of industrial sponsors and essentially all Government agencies having research and development interests. Unlike many of the contractors who operate AEC facilities, Battelle has no commercial interests and sells no products in the market place.

In 1964 the AEC was in the process of segmenting the AEC contract covering all of the AEC's operations at Hanford. Under this contract, the General Electric Company operated all aspects of the Hanford Project. There had been cutbacks in production facilities at Hanford creating the desire on the part of the AEC to diversify the means by which its operations were carried out, and to bring in several different entities with the possibility of expanding the economic base of the area.

The first activity in the Hanford area to be offered for bidding was the operation of the AEC's research and development laboratories. It was a prime objective of the AEC in its invitation for proposals that the bidder

would stimulate the Tri-Cities area economy through the use of the Hanford laboratory for research and development for private organizations and other Government agencies. An important consideration in the selection of the contractor was his willingness to invest private capital and fees earned under the contract in privately owned research and development facilities in the Pacific Northwest.

Battelle's proposal to undertake operation of the Hanford Laboratory (subsequently renamed the Pacific Northwest Laboratory) resulted in AEC Contract No. AT(45-1)-1830 (Operating Contract). The Operating Contract calls for Battelle to manage, operate, and maintain the Laboratory facilities, and to perform research and development. This contract was entered into December 30, 1964, effective January 4, 1965, for a five-year period. It is worth noting that Battelle is not considered as an independent contractor in any provisions of this contract. On the contrary, Battelle is required to perform the work in accordance with directions and instructions not inconsistent with the contract which the Commission may deem necessary or give to Battelle from time to time. Although seemingly a minor point, the directions and instructions from the Commission need not be in writing.

Battelle and the FFTF

Battelle's contract for operating the Pacific Northwest Laboratory facilities and performing research and development does not mention the FFTF. Battelle's first authorization to perform work in connection with the FFTF came from the AEC after the initiation of the contract. As the legislative history of the FFTF shows, the AEC requested a half million dollars for FY-1965 and one and one-half million for FY-1966. Considering the total job of Battelle under the Operating Contract, the volume of the FFTF work was relatively small during the first two years.

As the funding for research and development on the FFTF and LMFBR increased, Battelle was assigned more and more research and development work under AEC approved programs. The record substantiates the valuable technical contributions to the FFTF and LMFBR resulting from Battelle's work. Some of these accomplishments are discussed later.

During Battelle's 40-year history as a successful contract research organization, Battelle adopted those policies which resulted in the most efficient and useful administration and performance of research work for others. One of these policies is based on the fact that the relationship between a researcher and his sponsor is a professional relationship which cannot be conducted on an arms-length basis and which must have elements

of mutual trust on both sides. Battelle entered into its research and development relationship with the AEC on this basis and feels that such a relationship indeed continues to prevail.

In light of the foregoing therefore, contrary to the kind of reaction that might have been expected from a commercial manufacturer, it was perfectly natural for Battelle to wish to respond to the AEC's directions and instructions fully and without hesitation. It is completely inconsistent with Battelle's tradition and the essence of its character to dispute its principal or to deal with its principal on an arms-length basis.

We understood that this responsiveness was what the Commission wished from us in connection with the FFTF Project. We felt that this was a reasonable approach for the FFTF Project inasmuch as the AEC's DRD&T is well staffed with highly competent technical experts. There were occasions when we felt a matter was of such significance that we brought it to the attention of the DRD&T, but in all cases we ultimately accepted the disposition of the matter by DRD&T.

It is well known that the AEC's operating contractors are subject to extensive direction and control by the AEC. You no doubt are familiar with Harold Orlans' study entitled "Contracting for Atoms". The AEC's own recent "Reynolds Committee Report" recognizes that DRD&T of the AEC controls its contractor procurement activities very closely and that much of this control is informal. The Joint Committee recognizes the technical supervision provided by AEC to its contractors, e.g., see page 839 of FY 1969 Hearings.

So long as research and development work was the principal job at hand, Battelle felt that it was performing satisfactorily by turning out good research and development work on the programs directed by the AEC and by staying within the limitations of the financial plans as authorized by the AEC. Every penny spent under the operating contract and particulary DRD&T programs is covered by a program plan and a financial plan issued by AEC.

As the time to begin the design and construction of the plant itself came nearer, we felt that it would be in the best interests of the Commission in terms of its responsibilities under the authorizing legislation for the FFTF Project, to set up some specific arrangements under which the scope of the project and the basis for the costs and schedule would be agreed upon. In other words, we felt that the research and development method would not be as successful for the Commission as the more normal contract relationship used where a specific result is desired.

We made these views known to the AEC and were in the process of discussing organizational and contractual arrangements for implementing the design and construction phase of this important project when a completely unanticipated event occurred. This was a last-minute change in the Tax Reform Act of 1969 which defined the requirement of diverse support for classification as a public organization. This was not known until the end of 1969. Briefly speaking, under Section 509(a) (2) Battelle could be disqualified as a public organization if it received too much of its total support from the AEC in any year such that the test for broadly-based support specified in the Act could not be met.

Battelle's request, then, to be relieved of the future work on the FFTF was not in any way a criticism of the AEC but due solely to the vital interest of Battelle to assure its continuation as a public organization. The question might arise as to why, of all of the AEC programs being performed by Battelle, Battelle recommended that the FFTF Project be assigned to another contractor. The answer to this was given in my letter to the AEC of January 20, 1970, a copy of which you have. As noted therein, of all of the major programs being done by Battelle for the AEC, the design and construction of the FFTF, although definitely a developmental facility in itself, is less related to Battelle's research and development mission than its other AEC projects. Further, no work for any other single sponsor approached the magnitude of Battelle's research and development effort for the AEC.

The FFTF Project: 1965-1970

Little purpose would be served by an unequivocal statement that the nearly five years of Battelle performance/management on the FFTF were without incident or shortcoming. Nor would it be cogent or realistic to attempt to assign specific responsibility for any readily identified fault or deficiency.

There is, in our overview, a burden of evidence that says DRD&T overmanaged and Battelle (PNL) management over-responded -- predictably -- to these requests. To illustrate the over-supervision of DRD&T, for example, in a one-year period (July 1968-June 1969) 457 formal directives were received from DRD&T by PNL. In addition, 94 formal meetings were held between AEC and the PNL staff. All of these directives, etc., were accepted by PNL in fact, if not in spirit.

Accompanying this willingness to respond, however, was the attempt by PNL to implement its designated role as "project manager" in fact as well as in fiction. The lack of specific contractual assignment of both authority and responsibility to PNL inevitably strained working relations

between both principals. Table I is a listing of major FFTF responsibilities assigned to Battelle by various letters and communications from DRD&T. It is important to note, however, that the authority commensurate with these assigned responsibilities was never given to Battelle.

The above point illustrates only a PNL view of a problem area. Undoubtedly DRD&T/AEC staff can with equally good intent exemplify situations which focus on their explantion of the strained relations.

More important, however, than finding fault is to note that the record of achievement for the first five years of FFTF project activity is -- by any standards -- outstanding. What Battelle requested to be transferred to another contractor is a going, successful, well-staffed (and managed) operation that not only can -- but will succeed.

The AEC itself has emphasized that the FFTF would be a very complex and difficult undertaking which would require the best talents and resources available from AEC and industry. Examples of FFTF Project accomplishment are noted in the paragraphs which follow.

1. Personnel - The projected DRD&T plan for staffing of FFTF was to build to 350 by 1970. The record:

Mid-1966	80
Mid-1967	125
Mid-1968	230
Mid-1969	360

To implement the AEC desire to utilize the best available resources, it should be noted that only two of the key FFTF Project managers were recruited from within PNL. The others have come from outside. Employees of the project have been recruited from APDA, AGN, AI, ORNL, GE, Westinghouse, LASL, DUN and others.

2. Subcontractors - PNL/FFTF subcontractors include or have included AGN, Bechtel, Westinghouse (the designed PNL successor), General Electric and Atomics International. It is not possible to suggest that the nuclear industry is not represented in the FFTF team. The requirement to integrate industrial organizations into the effort, however, added a complicating dimension to an undertaking already complex.

3. Technical Accomplishments - The FFTF Project has been credited by the USAEC with major technical accomplishments. Some accomplishments which Battelle management believes are significant are given in Table 2.

Table 1. Major FFTF Responsibilities Assigned to Battelle as of December 31, 1969

(1) Provide over-all management for the FFTF program.
(2) Provide the conceptual design for the FFTF Project.
(3) Prepare a capital cost estimate and schedule for the FFTF Project.
(4) Negotiate and administer contracts for design and construction of the FFTF Project.
(5) Utilize the FFTF program to make a maximum contribution to the over-all LMFBR Program.
(6) Develop the capabilities of industrial firms to contribute to the LMFBR Program.
(7) Control allocation and expenditure of FFTF operating and PACE funds.
(8) Define, plan, obtain, and utilize supporting test facilities.
(9) Define over-all FFTF development and testing program.
(10) Perform or direct development and testing in support of FFTF, as assigned by AEC.
(11) Utilize ongoing LMFBR development programs to support FFTF, including involvement of LMEC to technically direct component development programs.
(12) Maintain and control project schedules.
(13) Establish nuclear safety of the facility and obtain required AEC approvals and authorizations.
(14) Perform procurement planning and conduct or direct procurements for the program.
(15) Prepare RDT standards and quality assurance requirements for LMFBR components and familiarize industry with the use of these new standards and QA requirements.
(16) Develop qualified fuel vendors and procure first cores.
(17) Plan and direct facility activation including acceptance tests, operations personnel staffing and training, test practices, fuel management, and all aspects of plant operation.
(18) Operate the completed facility.

Table 2. Summary of Significant Technical Accomplishments

Accomplishment	Program Impact
1. FFTF conceptual design established	Permits project to proceed on a firm technical basis.
2. Reactor design established	Highly prototypic of LMFBR
3. Fuel selected	Common fuel type and development program for FFTF and first LMFBR.
4. FTR critical experiment on cores with test regions.	Definition of effect of test control rods and Ni reflector.
5. Full-scale FTR critical experiment accomplished	Analytical computer codes verified. 1000 liter critical experiment completed.
6. Ex-reactor heated pin bundle test completed	Multiple pin bundle tests of electrically heated ex-reactor specimens in sodium. Precise data obtained for dynamic thermal hydraulics.
7. Irradiated materials damage assessed	Swelling and creep behavior of irradiated stainless steel characterized.
8. Fuel pin mechanical behavior assessed	Rational analytical model developed to predict in-reactor fuel pin behavior.
9. Reactor hazards assessed	Improved analytical data and methods have significantly reduced estimates of maximum accident probability and consequences.
10. Integral HTS emergency cooling capability established.	Separate emergency cooling system is not necessary.
11. Momentum in fuel development program.	Accelerated industrial involvement in support of FFTF-LMFBR requirements.

Table 2 (continued)

12. LMFBR specifications developed for major sodium components	Permits major FFTF equipment procurement to begin using a preferred specification ultimately destined to become an industry standard.
13. Developed quality assurance requirements for FFTF Project	Used as a reference in developing AEC quality assurance standard F2-2T.
14. Designed, procured and constructed fuel process demonstration line	Permits development and demonstration of reference fabrication process. Provides fabrication support for irradiation test fuel pins.
15. Forty-three encapsulated fuel pins have been irradiated and 222 encapsulated fuel pins are under irradiation in EBR-II	No failures to date with exposures to 47,000 MWd/T. Provides increasing assurance the reference fuel will meet FTR performance requirements
16. Defined reactor mockup program, initiated construction of test facilities and performed the first successful thermal hydraulic tests of electrically-heated pin bundle (fuel simulation)	Tests have already produced new core hydraulic and thermal data for FTR and LMFBR. Other imminent mockup tests in both water and sodium will extend mechanical, thermal, and hydraulic development of reactor features.
17. Effective industrial development of fuel cladding	Capability of industrial production of fuel cladding of quality not previously available in the world has been established.
18. Sodium chemistry facilities established	Development of needed analytical chemistry technology. Provides information related to the transport and deposition of activated corrosion and fission products. Develop methods for analysis of cover gas.
19. Analytical chemistry program completed	Industrial capabilities improved and precision and accuracy of standard methods established for analysis of mixed oxide fuels.
20. Developed Westinghouse competence in fast reactor technology	Battelle-Northwest's fast reactor technology provided a high standard of competence to assist and assess Westinghouse performance during the early FTR design stages.
21. Initiated code development in support of FTR and LMFBR	Industry and ASME code attention has been focused on structural design criteria for LMFBR components.

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4. Dissemination of Information/Technology - Since 1965 approximately 525 reports and documents have been distributed by PNL to account for and describe FFTF technical work and progress. These reports were given either Standard AEC category distribution or LMFBR Program distribution. Additionally some 225 talks, papers and presentations have been made to and for the benefit of both the general technical and lay public. Almost without exception, the information has been UNCLASSIFIED assuring the broadest possible distribution and utilization.

Six patents have been issued to and an additional 14 patent applications have been filed on behalf of PNL staff members covering inventions made while working on the FFTF/LMFBR Programs.

5. Performance Evaluation - In both FY-1968 and -1969 the Richland Operations Office appraised "...the performance of the Pacific Northwest Laboratory (PNL), Battelle-Northwest (BNW) and Fast Flux Test Facility (FFTF) in the areas of contract performance, management performance and relations with others..."

In FY-1968 AEC/RL said, "The BNW FFTF Division performance has been satisfactory." The FY-1969 appraisal notes that, "In general, BNW's performance has been satisfactory to excellent and the FFTF programs have been conducted in an efficient and professional manner considering the complexity of the project, state-of-the-art, and AEC requirements imposed."

A high-water mark in FFTF Project staff satisfaction was achieved upon receipt of a copy of a letter dated October 17, 1969, to D. G. Williams (Manager, RLO) from Milton Shaw (Director, DRD&T). Two important points are made in this letter. The first, "Of particular significance for the future of the LMFBR program is the degree to which other divisions in PNL, other laboratories, and industry are now involved in and are contributing to the FFTF effort to develop a thorough technical understanding of the entire LMFBR mixed oxide stainless steel fuel system.

The second, "This progress demonstrates again that a staff of capable professionals, committed to a specific programmatic objective, using disciplined engineering methods, and given strong management leadership can overcome the difficulties associated with an undertaking as demanding and complex as the development of an entire fast reactor fuel system. In its successful prosecution of the FFTF fuel program, PNL is making major technical contributions not only toward the successful and economic operation of FFTF, but to the entire LMFBR program. Much remains to be done, but an excellent start has been made. The individuals involved, both in PNL and RL, are to be congratulated for their progress to this point."

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Additionally, to obtain an independent evaluation of the FFTF Project and its management, Battelle Memorial Institute engaged (in 1969) an outside organization to assess the operation. A principal in this outside organization has achieved national prominence for his outstanding management of large-scale projects while a senior officer in the U. S. defense establishment. Recently he was named to head President Nixon's "Advisory Council on Management Improvement."

The management consultant's report found the FFTF Project operation generally sound and satisfactory. It called attention, however, to a major potential problem area -- that of the lack of agreement, written or otherwise, on completion date, ultimate costs and who should make the final decisions necessary to meet program objectives.

6. Budget/Financial - The FFTF Project operated each year using approved AEC budgeting procedures for submission, review, and final approval of AEC Forms 189. Each program within the Project received the appropriate step-by-step review and approval in consonance with DRD&T. All costs were controlled in accordance with AEC-approved financial plans and utilizing the additional criteria of DRD&T for limiting cost-budget variances among approved 189's and individual tasks thereunder.

The ultimate cost of the FFTF has, of course, been a subject of concern to both the AEC and Battelle. You will recall that a joint AEC/PNL task force was established to study the subject of conceptual design, project schedule, and to make estimates of the cost for a realistic conceptual design.

From your report, I conclude DRD&T presently believes that the FFTF can be built within its approved congressional limitation including the 25 percent limitation provision. As noted above, our outside consultant believes that firm agreement on both the completion date and ultimate cost are important essentials to a successful contractor/AEC relationship. We commend this point to the Commission's attention in their arrangements with our successor.

7. Time/Schedule - With regard to schedule, we believe that a reading of almost any of the Joint Committee Hearings on this project during the past five years will show the AEC's viewpoint on scheduling. Essentially, their view is that the technical bugs must be worked out in advance and the design must be thoroughly understood before a plant is built. If there is a question of compromising technical understanding or design in order to meet a schedule, this will simply not be done.

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Although Battelle's FFTF Project management would have preferred to work with a clearly defined schedule, such a situation was not possible. While as noted earlier Battelle was assigned responsibilities for major FFTF accomplishments, its authority was non-existent and its (Battelle's) actions generally required DRD&T's approval. In fiscal years 1967, 1968 and 1969, DRD&T testimony before the JCAE provided such "guidance" as existed for the FFTF. This obviously was not a clearcut schedule. That these schedule goals were not firm can be seen from typical testimony -- quoted below -- from "AEC Authorizing Legislation Fiscal Year 1969, Part 2."

> "But I would like to alert the committee, as I did last year, that I plan to hold up when in doubt in order to focus attention on getting the beneficial occupancy date rather than on meeting commitments on a particular chart." p. 79
>
> "...I am guaranteeing you this, Mr. Hosmer: that we will not take any steps to shortcut the engineering approach to get this reactor on line. . ." p. 81
>
> ". . .Also, we know that the task ahead on the LMFBR program is certainly more difficult than it was on the water reactor plant program." p. 276

From time to time we pointed out to DRD&T that the absence of specific decisions negated elements of the originally proposed time table. However, unreinforced persuasion is -- at best -- rather ineffective and we ultimately deferred to their decisions to allow the schedule to slip.

Present Status and Actions

Hopefully, the foregoing material provides an additional dimension to your present study of the FFTF Project. We would, of course, like very much to have the opportunity to review any subsequent draft(s) of your findings. If further information or data are either required or desired, please let me know.

On the basis that you will utilize this letter either in your final report or as an Appendix to the report, you have our permission to use the Battelle name. After you have had an opportunity to review this letter, I stand ready to meet with you to discuss it, if you desire.

Mr. Dean K. Crowther March 30, 1970

Currently, we are working with USAEC and WADCO representatives to make a smooth, expedient and effective transfer of both staff and facilities on the FFTF/LMFBR program. Based on Battelle experience to date, we are recommending to the AEC and WADCO that the project responsibilities and authorities be carefully defined. Further, we feel it is most important that major project milestones and goals be rigorously established.

Very truly yours,

S. L. Fawcett
President

SLF:ljp

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SCHEDULE SLIPPAGES ON MAJOR MILESTONES,

SUPPORT FACILITIES, AND COMPONENT TESTING

A. DESIGN AND CONSTRUCTION

	Completion dates (Estimate) as of 2-66 (note a)	Completion dates (Actual) as of 3-70 (note b)	Delay in months
Conceptual design:			
Primary electrical power	7-66	12-67	18
Structures	7-66	6-69	36
Reactor containment	7-66	6-69	36
" core	7-66	8-69	38
" vessel and shielding	7-66	4-69	34
" heat transport	7-66	8-68	24
Control and data handling	7-66	2-70	43

	Starting dates (Estimate) as of 3-67 (note c)	Starting dates (Actual) as of 3-70	
Preliminary design:			
Primary electric power	6-67	2-69	20
Structures	6-67	2-70	32
Reactor containment	6-67	2-69	20
" core	6-67	2-70	32
" vessel and shielding	6-67	1-69	18
" heat transport	6-67	2-70	32
Control and data handling	6-67	2-69	20

	Estimate as of 3-67 (note c)	Estimate as of 3-70	
Construction:			
Initiation	6-68	4-70	22
Completion	4-73	6-74	14

SCHEDULE SLIPPAGES ON MAJOR MILESTONES,

SUPPORT FACILITIES, AND COMPONENT TESTING (continued)

B. FFTF SUPPORT FACILITIES

	Completion dates		Delay
	Original estimate	Present estimate	in months
Facility:			
Fuel fabrication demonstration pilot line	1-68	1-69 (actual)	12
Sodium Pump Test Facility	3-68	9-74[d]	77
Pump Bearing Test Facility	10-70	6-71[e]	8

C. COMPONENT PROOF TESTING

	Estimated starting dates				
	PNL schedule Apr. 1968	PNL schedule June 1969	LMEC(note f) schedule Oct. 1969	PNL schedule Jan. 1970	Total slippage
Component:					
Pumps	5-71	1-72	7-72	8-73	27 months
Valves	12-69	3-71	6-71	5-73	41 months
Dump heat exchanger	6-71	2-72	1-72	7-73	25 months
Intermediate heat exchanger	6-71	7-72	1-72	7-73	25 months
Control rod drive mechanism	7-70[e]	11-70	10-70	3-71	8 months
Oscillator	7-70[e]	7-71	6-71	N/A	12 months

[a]Based on schedular dates provided to Joint Committee when project was originally authorized in fiscal year 1967.

[b]Conceptual design on systems previously approved by RDT were approved again in February 1970 as a result of the task force study.

[c]Based on schedular dates provided to the Joint Committee when project was fully authorized in fiscal year 1968.

[d]Based on scheduled data used to support information provided to the Joint Committee during fiscal year 1971 authorization hearings. Facility being built in two phases. This date reflects completion of Phase II construction.

[e]These dates are from the Laboratory schedule dated March 15, 1968.

[f]Liquid Metal Engineering Center.

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AUGUST 1, 1970

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5/ under the supervision of the Assistant General Manager
6/ for advice and counsel on safeguards matters

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OF

THE ATOMIC ENERGY COMMISSION

RESPONSIBLE FOR ADMINISTRATION OF THE ACTIVITIES

DISCUSSED IN THIS REPORT

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ASSISTANT GENERAL MANAGER FOR REACTORS:		
G. M. Kavanagh	Jan. 1966	Present
J. A. Swartout	Dec. 1964	Dec. 1965
DIRECTOR, DIVISION OF REACTOR DEVELOPMENT AND TECHNOLOGY:		
Milton Shaw	Dec. 1964	Present
FIELD OFFICE MANAGERS:		
Richland Operations Office:		
D. G. Williams	July 1965	Present
J. E. Travis	Aug. 1955	July 1965

U.S. GAO Wash., D.C.