DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
OFFICE OF ENERGY RESEARCH

OVERVIEW

MAGNETIC FUSION ENERGY

Fusion is the process by which the sun and other stars produce energy. The task of the Magnetic Fusion Energy program has been to develop theory and conduct experiments to determine how fusion reactions can be controlled and used to produce energy. While this has proven to be a very difficult task, substantial technical progress has been made in both the U.S. and throughout the world.

A 1989 National Academy of Science study concluded, "A prudent long-term energy strategy for the United States requires that alternative electric energy supply technologies be researched, developed, and demonstrated. A diversified array of alternatives is needed as insurance against the vulnerability of existing alternatives such as coal and nuclear fission".

At this point in its development, there appear to be a number of potential advantages to fusion. First, the fuel is inexpensive and easily obtained. Second, it has the potential to provide energy with minimum impact on the environment and to substantially reduce or eliminate any high-level long term radioactive waste problem. Third, the amount of fuel contained in a fusion reactor would be relatively small, thus enhancing the safety attractiveness of fusion. The fuel cycle for fusion is simpler than for fission and no fissile materials are produced that could be diverted to the production of nuclear weapons. Finally, while cost estimates for the production of fusion power must be based on a number of assumptions, economics of the fusion option appear to be acceptable compared to the alternative sources.

The path to the successful development of magnetic fusion energy requires the achievement of significant energy gain within the reacting plasma and development of the necessary technology. The program is currently trying to enhance its understanding of energy confinement in order to clarify the requirements for significant energy gain. In addition, science and technology research and development is required to assess the potential economics of fusion. Finally, an integrated world-wide program is appropriate to establish the science and technology base for fusion and create opportunities for the U.S. to benefit from collaboration on major facilities such as the proposed International Thermonuclear Experimental Reactor (ITER).

The science of fusion, plasma physics, is complex and rich in non-linear phenomena. The technology is challenging, pushing the state-of-the-art in a number of areas. In spite of the difficulties of achieving the magnetic fusion goal, significant progress has been made. This progress has yielded a solid basis for understanding the behavior of a plasma. This understanding has led to broad consensus on how magnetic confinement of fusion plasma is to be achieved. To date, the most effective way to confine the plasma is in a toroidal or doughnut shaped device. The leading toroidal confinement concept is the tokamak. The tokamak uses a toroidal magnetic field and an internal plasma current to confine the plasma. Tokamak performance has improved more than seven orders of magnitude over the past 20 years. Based on recent results from the Tokamak Fusion Test Reactor (TFTR) and Doublet III-D (both in the U.S.) and Joint European Tokamak (JET; in the EC), fusion continues to look promising.

The program is organized around four key technical issues. The first is understanding how the plasma behaves once fusion reactions are producing sufficient heat to maintain reacting or burning conditions. The second is determining the best confinement configuration by studying potentially improved devices or fuels. The third issue involves research on materials to see which ones provide the best safety margin and the lowest levels of induced radioactivity when introduced to a fusion reactor environment. The fourth issue requires the development of the nuclear technology to effectively and safely convert fusion energy to electricity. The emphasis in the program is currently on the first two issues. The technology elements are a modest portion of the program with ITER providing a valuable current focus and an essential future test environment.

The program is presently focussing on developing a predictive understanding of the mechanisms governing confinement of energy within the tokamak. Experimental data suggests improved confinement will be required for the next generation of devices. This improved confinement has now been observed in a number of tokamaks. The program is working on developing the understanding necessary to apply these observed improvements to future devices. Once the necessary degree of confidence is obtained, the next major step will be to explore the regime of self-heated, sustained plasmas.

The Magnetic Fusion Energy budget is organized into 5 major categories; Confinement Systems, Applied Plasma Physics, Development & Technology, Planning & Projects, and Program Direction.

The first budget category, Confinement Systems, provides the support necessary to operate the larger experimental devices and to analyze the data in order to improve our understanding of plasma behavior and to learn how to obtain and control the physical conditions necessary for the production of fusion energy.

The Tokamak Fusion Test Reactor, at the Princeton Plasma Physics Laboratory (PPPL), is the largest U.S. tokamak with a long term objective of operation using deuterium-tritium fuel at reactor-relevant plasma densities and temperatures. The Princeton Beta Experiment-M at PPPL is a highly shaped tokamak with a major focus on attaining higher plasma pressure operation. The Alcator C-Mod is under construction at the

Massachusetts Institute of Technology (MIT) and will begin operation in 1991 to study plasma performance with a compact high field, high-density design using improved plasma edge controls. The Advanced Toroidal Facility at Oak Ridge National Laboratory (ORNL) is a flexible stellarator which will contribute to the understanding of toroidal confinement. Doublet III-D, operated by General Atomics is the second largest tokamak in the U.S. and is the focal point for a variety of experiments on plasma transport. The Microwave Tokamak Experiment at the Lawrence Livermore National Laboratory (LLNL) is a compact, high field tokamak and will be used to test an advanced heating source of high frequency waves produced by a powerful free electron laser. Support for international collaborative efforts on foreign tokamaks, with unique features not available in the U.S., is also provided. Finally, R&D, prototype, and development and design support is provided for the Compact Ignition Tokamak. The objective of this device will be to study the physics of a self-heated plasma.

The second category, Applied Plasma Physics, provides for the study of potentially attractive advanced confinement configurations, as well as the physics and computing support for the rest of the program. Two advanced configurations being studied, because of their potential for more efficient use of magnetic fields than tokamaks, are the Reversed Field Pinch (RFP) and the Compact Toroids. The Confinement Physics Research Facility is under construction at Los Alamos National Laboratory (LANL) to improve our understanding of RFP's. For Compact Toroids, the Field Reversed Experiment-C (FRX-C) device at LANL is operated and construction of the Field Reversed Configuration Physics Experiment facility will be completed at Spectra Technologies in FY 1990. There are also several smaller university experiments in this area. Physics support includes the conduct of the more basic physics studies to understand the fundamentals of plasma behavior and to develop innovative plasma control techniques and to interpret experimental results from the major experiments. Activities include development of diagnostics for transport studies on the TEXT tokamaks and theory support to provide a predictive understanding of plasma behavior. The final element of the Applied Plasma Physics category is computing support. In cooperation with all Energy Research programs, advanced computing capability is provided for theoretical predictions, interpretation of the experiments, and design of experimental devices.

The third category, Development and Technology, provides support for development of plasma and fusion technologies and systems design work necessary to provide the technology needed for the fusion program to advance. Support of design and validating R&D of an International Thermonuclear Experimental Reactor is also provided in these areas. In plasma technology, large high field steady-state pulsed magnets are developed. In addition, plasma heating and fueling technologies are developed. In fusion technology, low activation and radiation resistant structural materials are developed that have acceptable characteristics for the fusion reaction environment. Also included is development of materials that can resist high heat flux and plasma erosion and fusion nuclear components to produce and process tritium and convert fusion energy into useful forms. The systems design work is targeted at developing improved reactor designs and performing the International Thermonuclear Engineering Reactor design.

The fourth category, Planning and Projects, provides support of major construction projects and miscellaneous items such as the Small Business Innovative Research (SBIR) program and landlord responsibilities at ORNL.

The fifth category, Program Direction, provides for the costs associated with carrying out the management responsibilities of the Magnetic Fusion Energy program.

An independent high level policy review of fusion is scheduled to be conducted in FY 1990. The FY 1991 budget request for Magnetic Fusion Energy provides funding which does not in any way presume the eventual conclusions of the review. This budget provides for continuing the program as much as possible as it was in FY 1989 and FY 1990 with a focus on confinement physics. Although there are some reductions, there will be no major changes in the program balance until the Secretary's review of the program is completed. Once it is completed, budget estimates will be revised as necessary. The allocation depicted in this budget document is not intended to signal any change in policy regarding fusion.

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
OFFICE OF ENERGY RESEARCH
(dollars in thousands)

LEAD TABLE

Magnetic Fusion Energy

Activity	FY 1989 Actual		FY 1990 Estimate		FY 1990 Base		FY 1991 Request		Program Change Request vs Base: Dollar	Program Change Request vs Base: Percent
Operating Expenses										
Confinement Systems..........	$172,650		$160,170		$160,170		$163,050		$+ 2,880	+ 2
Applied Plasma Physics.......	81,155		71,609		71,609		70,880		- 729	- 1
Development and Technology...	54,145		47,419		47,419		48,060		+ 641	+ 1
Planning and Projects........	1,122		4,206		4,206		4,250		+ 44	+ 1
Program Direction............	4,600		4,930		4,930		5,650		+ 720	+15
Subtotal Operating Expenses..	313,672		288,334		288,334		291,890		+ 3,556	+ 1
Capital Equipment............	18,835		13,330		13,330		14,310		+ 980	+ 7
Construction.................	12,152		18,595		18,595		19,100		+ 505	+ 3
Total........................	344,659	a/b/	320,259	b/c/	320,259	b/c/	325,300	b/	$+ 5,041	+ 2
Operating Expenses............	(313,672)		(288,334)		(288,334)		(291,890)		+ 3,556	+ 1
Capital Equipment............	(18,835)		(13,330)		(13,330)		(14,310)		+ 980	+ 7
Construction.................	(12,152)		(18,595)		(18,595)		(19,100)		+ 505	+ 3
Staffing (FTEs)..............	60		64		64		64			

Authorization: Section 209, P.L. 95-91

a/ Total has been reduced by $3,877,500 which has been transferred to the SBIR program.
b/ $2,152,000 in FY 1989, $2,759,000 in FY 1990, and $3,287,000 in FY 1991 has been transferred to the Environmental Restoration/Waste Management Program.
c/ FY 1990 reflects final Gramm-Rudman-Hollings sequester adjustments.

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY RESEARCH AND DEVELOPMENT
(dollars in thousands)

SUMMARY OF CHANGES

Magnetic Fusion Energy

FY 1990 Appropriation	$ 320,259
Adjustments	--
FY 1991 Base	$ 320,259
Magnetic Fusion Energy Program	+ 5,041

- This represents an increase of about 2% and provides for continuing the program as much as possible as it was in FY 1989 and FY 1990 with a focus on confinement physics. Although there are some reductions in the level of effort there will be no major changes in the program balance, and international commitments will be honored, for the most part until the Secretary's review of the program is completed. Once it is completed, budget estimates will be revised as necessary. The allocation depecited in this budget document is not intended to signal any change in policy regarding fusion.

FY 1991 Congressional Budget Request	$ 325,300

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
ENERGY SUPPLY, RESEARCH AND DEVELOPMENT
(dollars in thousands)

KEY ACTIVITY SUMMARY

MAGNETIC FUSION ENERGY

I. Preface: Confinement Systems

The Confinement Systems subprogram addresses two of the four key technical issues for magnetic fusion - improving magnetic confinement systems and understanding the properties of burning plasmas. These issues are investigated through experimental research on controlling and heating the plasmas required for a magnetic fusion energy source. This research is conducted primarily on toroidal configurations, which have been proven most effective in providing the necessary plasma parameters. This research involves developing the data base needed to understand the behavior of a burning plasma and to identify an optimum confinement system. The approach is to use theory, modeling, and previous experimental results to determine how to extend the present data base using existing devices and to design and fabricate new devices when additional information is needed to complete the data base. The primary scientific issues being addressed by this research are energy confinement, heating, plasma stability, current drive, edge physics, and particle control. Energy confinement is a major critical issue affecting the size and cost of any future fusion device. In a reactor, the plasma must be heated to a high temperature to initiate the fusion reaction, and, at this high temperature, the plasma thermal energy must be sufficiently well contained that the heating power from the fusion reactions sustains the plasma. The research on this topic involves using and understanding auxiliary heating methods, such as neutral beam heating and radiofrequency (rf) wave heating, to heat a plasma to high temperatures and then using sophisticated diagnostics to characterize, understand, and reduce energy transport in a high temperature plasma. A major redirection of the Confinement Systems program in FY 1989 focused resources on the topic of energy confinement. This concentration on confinement will continue in FY 1990 and FY 1991. This work is carried out in close cooperation with experimental groups and theory groups in the Applied Plasma Physics subprogram.

In a practical fusion power reactor, the temperature and density of the plasma (the plasma pressure) must be quite large. The ratio of plasma pressure to the confining magnetic field pressure is referred to as beta. Since achievable magnetic fields are limited, research on plasma stability concentrates on alternate plasma shapes and operating modes that theory predicts can maximize the plamsa pressure supported for a given magnetic field. This work includes attempts at obtaining a predicted second regime of stability with even higher beta.

The current drive issue addresses operation of devices in a steady state mode as opposed to a pulsed mode. The primary advantage of steady state operation in a reactor is that it will reduce component fatigue problems. Planned experiments will attempt to drive continuous currents in tokamaks with radio- frequency heating.

The final technical issue is edge physics and particle control. Impurities can dilute the deuterium/tritium fuel, cool the plasma, and/or cause the plasma to contract and become unstable. Thus, impurities must be controlled throughout the period of operation. A major source of these impurities is particles dislodged from the vessel walls due to chemical and physical erosion. Studies are being conducted to ensure that the plasma is kept as clean as possible by reducing the generation of impurities and by isolating the impurities that are generated. Another particle control issue concerns methods of fueling to replenish the fuel ions. Current experiments are testing fueling by injection of frozen pellets. Finally, it is now recognized that edge physics and particle control can have a significant effect on the energy confinement time.

Research is being conducted on several toroidal devices to investigate the above mentioned physics issues and to prepare for performing the burning plasma physics experiments on the Compact Ignition Tokamak (CIT). The confinement of high temperature plasmas will be studied in the

TFTR device at Princeton Plasma Physics Laboratory (PPPL). Experiments on the confinement, beta, and current drive issues will be carried out on the Doublet-III-D device at General Atomics (GA). The objective of the Alcator C-Modification facility at the Massachusetts Institute of Technology (MIT) is to study rf heating energy confinement, and current ramp-up in a high field, high density plasma. The former Alcator-C tokamak has been moved to Lawrence Livermore National Laboratory (LLNL) and renamed the Microwave Tokamak Experiment (MTX). This provides LLNL with the unique target plasma capability to conduct initial experiment on the applicapability of pulsed high power microwaves as a heating technique in tokamak devices. International collaboration will be relied on to carry out research on a number of related plasma issues in foreign facilities including TEXTOR and ASDEX in West Germany, TORE SUPRA in France, Joint European Torus (JET) in England, and JFT-2M and JT-60 in Japan.

A concentrated U.S. analysis effort has been underway to establish the physics basis for achieving ignition and burn using the experimental data base from these U.S. and foreign experiments. Achievement of ignition has always been an essential objective of magnetic fusion research. The successful operation of an ignition divice like the Compact Ignition Tokamak (CIT) would demonstrate the fundamental feasibility of magnetic fusion, provide key support to the initiative to conduct a joint International Thermonuclear Experimental Reactor (ITER) program, and maintain the scientific progress in the U.S. fusion program. This budget continues the design effort to build such an ignition device to replace TFTR. It is the essential next step in the U.S. Fusion Program.

Work on identifying an optimum toroidal confinement system will be continued. The Princeton Beta Experiment (PBX-M) device at PPPL will resume its program of confinement and beta research with new hardware to provide pressure profile and current profile control. The Advanced Toroidal Facility (ATF) will continue study of confinement on beta in a configuration with helical field coils and no plasma current.

Upgrades and modifications to existing devices are accomplished by major device fabrication (MDF) projects. These projects increase the inherent capability of the devices in a cost effective way as progress is made towards understanding the relevant physics issues. The only remaining MDF project, the Alcator C-MOD at MIT, will be completed in FY 1991. Activities in the mirror program will be terminated in FY 1990 as close-out costs on MFTF-B are completed. The following table summarizes the operating expense funding for the Confinement Systems subprogram:

II. A. Summary Table: Confinement Systems

Program Activity	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change
Tokamak Fusion Test Reactor....................	$ 66,634	$ 60,465	$ 57,850	- 4
Base Toroidal..................................	60,802	59,800	64,810	+ 8
Advanced Toroidal..............................	22,998	16,695	23,250	+ 39
Major Device Fabrication.......................	4,900	3,410	390	- 89
Compact Ignition Tokamak.......................	14,967	17,300	16,750	- 3
Tandem Mirror Operations.......................	2,349	2,500	0	-100
Total, Confinement Systems	$ 172,650	$ 160,170	$ 163,050	+ 2

II. B. Major Laboratory and Facility Funding

General Atomics	$ 31,720	$ 30,422	$ 29,950	- 2
Lawrence Livermore National Laboratory	$ 15,720	$ 13,677	$ 10,800	- 21
Massachusetts Institute of Technology	$ 16,372	$ 16,191	$ 17,026	+ 5
Oak Ridge National Laboratory	$ 19,134	$ 17,426	$ 18,019	+ 3
Princeton Plasma Physics Laboratory	$ 84,873	$ 77,697	$ 80,504	+ 4

III. Activity Descriptions: (New BA in thousands of dollars)

Program Activity	FY 1989	FY 1990	FY 1991
Confinement Systems			
Tokamak Fusion Test Reactor	Following a redirection of the TFTR program early in the year, TFTR began a 3-year program to study the physics of plasma transport at reactor-like plasma parameters. In particular, TFTR attempted to establish the physics basis of peaked density profiles for a more attractive reactor concept. The D-T experiments were delayed 3 years.	An initial set of transport diagnostics will be added to characterize local transport, compare the transport with fluctuations, and compare the measured transport and fluctuations with various theories. Neutral beam and ICRF heating systems will be used at their full power capability of 30MW and 7MW respectively to optimize plasma performance and prepare for equivalent breakeven experiments in deuterium. The graphite limiter will be up-graded with carbon-carbon composite tiles, which can handle higher heat loads. Work will begin on an additions to the ICRF heating system.	A second set of transport diagnostics will be used to complete the transport studies and to demonstrate improved understanding of transport in deuterium plasmas. Work will continue on increasing the ICRF system power from 7 to 10 MW. The rf limiters will be upgraded so that they can handle more power. Finally, D-T preparation activities will be continued at a low level.
	$ 66,634	$ 60,465	$ 57,850
Base Toroidal	Carried out experiments on DIII-D to gain a detailed understanding of energy confinement time and beta as functions of plasma shape, current profile, and edge plasma conditions in both diverted and limiter discharges with an emphasis on pressure and current profile control with RF, neutral beam injection. Began implementation of 2MW 110GHz electron cyclotron heating systems and an Advanced Divertor Program to aid these experiments. Enhanced diagnostics capabilities for transport studies.	D-III-D continues energy confinement and high beta programs with optimized profile/ shape control. Initiate fast wave current drive Ion Cyclotron Radio Frequency experiments. Begin installation of 110GHz ECH system, fast wave current drive system and the advanced divertor baffle system for density control and edge modification.	D-III-D continues energy confinement and high beta program and begins divertor pumping and biasing experiments; complete installation of 2MW 110GHz ECH and evaluate initial results on fast wave current drive. Test non-inductive current drive at moderate beta.

III. Confinement Systems (Cont'd):

Program Activity	FY 1989	FY 1990	FY 1991
Base Toroidal (Cont'd)	Initiated installation of major components, diagnostic upgrades, and data acquisition systems to support initial operation of Alcator C-MOD in 1991. Continued development of advanced diagnostics, ECH, and advanced operating modes for C-MOD.	Continue installation of the major components, diagnostics, data acquisition systems, and control systems of Alcator C-MOD.	Finish installation of major components and begin operation of Alcator C-Mod, a high field, shaped, and diverted tokamak. Conduct experiments with ohmic and pellet fueled plasmas. Begin ICRF heating experiments at the 2MW level and finish ICRF installation required to achieve 4MW in 1992. Continue development of advanced diagnostics, and advanced toroidal modes of operation for C-MOD.
	Began initial ohmic operation of MTX and relate it to previous Alcator C operation. Initiated single pulse 140GHz Free Electron Laser (FEL) pulses into the plasma.	Install a pellet injector and a 140 GHz gyrotron for ECH heating studies of high density plasmas. Begin installation of a new wiggler in the FEL for burst mode operation.	Begin burst mode operation of the FEL using the new wiggler and conduct experiments on microwave absorption, heating, and confinement in high density plasmas.
	The Japanese collaborated on MTX by providing diagnostics and visiting scientists.	Continue collaboration with Japan on MTX.	Continue collaboration with Japan on MTX.
	Under collaborative programs with the several European countries, the DOE (1) continued the edge physics and particle control experiments on TEXTOR jointly with West Germany and Japan; (2) Completed hardware fabrication and prepare for experiments on particle control, pellet fueling, and ICRF heating, pending repair of Tore Supra coil; (3) Continued pellet fueling experiments on JET; and (4) Continued a collaborative research program on poloidal divertor and confinement experiments of ASDEX.	Using international collaboration, continue joint experiments on fueling, edge physics and particle control, heating, and energy confinement on TEXTOR, ASDEX, JET, and Tore Supra, and JFT-2M; Complete LH current drive experiments in ASDEX and initiate experiments on ASDEX-Upgrade; take part in high speed pellet fueling experiments on JET and participate in size scaling and divertor pumping experiments on JET. Complete divertor biasing experiments on JFT-2M.	Continue collaborative experiments on edge physics, particle control, fueling, heating, current drive, and confinement experiments on TEXTOR, ASDEX-U, JET, and Tore Supra.
	$ 60,802	$ 59,800	$ 64,810

III. Confinement Systems (Cont'd):

Program Activity	FY 1989	FY 1990	FY 1991
Advanced Toroidal	Investigation of high beta (second stability regime), transport, and plasma material interactions and particle control continued. Pellet fueling studies, an assessment of different methods of impurity control on ATF, and stellarator configuration studies were made.	Continue investigation of confinement characterization and improvement - low collisionality transport (bootstrap current and trapped electron modes) and edge fluctuation induced transport.	With additional heating power, diagnostics, and field error control, investigations of fluctuation induced transport, low collisionality transport, high beta and particle control will be conducted at ATF.
	PBX-M began using ion bernstein wave (IBW) heating and lower hybrid (LH) current drive in their efforts to increase beta.	The PBX-M experimental operation will be halted for the year. PBX-M will have 2MW lower hybrid current drive and 3MW ion bernstein wave heating equipment installed to produce highly indented high beta plasmas.	Experimental program will resume employing lower hybrid current drive and ion bernstein wave heating to investigate high beta 2nd stability; transport studies and divertor operation will be conducted using unique plasma shaping capability of PBX-M.
	$ 22,998	$ 16,695	$ 23,250
Major Device Fabrication	Finished fabrication and began installation of Alcator C-MOD at MIT.	Installation of all major systems for Alcator C-MOD at MIT is finished.	Final testing of all major systems of Alcator C-Mod will be carried out and initial operation will begin in mid FY 1991.
	$ 4,900	$ 3,410	$ 390
Compact Ignition Tokamak	Continued design optimization of CIT tokamak and accomplished technology R&D related to the magnetic coil systems.	Continue preliminary design and produce detailed designs and manufacturing procedures for major prototypes. Contract placement activities will be initiated for fabrication of prototype components in FY 1991 or subsequent years.	Continue preliminary design to improve device performance and conduce technology R&D in support of prototypes.
	$ 14,967	$ 17,300	$ 16,750

III. Confinement Systems (Cont'd):

Program Activity	FY 1989	FY 1990	FY 1991
Tandem Mirror Operations	Continued close-out of MFTF-B contracts and maintained the system components for other uses in a safe and secure way.	The mirror program will be completed with the final close-out of MFTF-B.	
	$ 2,349	$ 2,500	$ 0
Confinement Systems	$ 172,650	$ 160,170	$ 163,050

KEY ACTIVITY SUMMARY

MAGNETIC FUSION ENERGY

I. Preface: Applied Plasma Physics

The Applied Plasma Physics subprogram develops physics understanding and innovative techniques to allow for improved confinement concepts and achievement of program goals in ignition and reactor design. Applied Plasma Physics conducts research on basic magnetic confinement physics, including non-tokamak configurations, and supports and supplements research performed in the Confinement Systems subprogram by developing and implementing new diagnostics and by developing plasma heating and control concepts and basic data necessary to design and conduct larger scale fusion experiments. Activities include: theoretical and experimental physics support, research on advanced fusion concepts, and large-scale computing.

In Advanced Fusion Concepts, the scientific understanding of magnetically confined plasmas is being pursued through experiments with varying magnetic configurations. The technical objective is to conduct experimental tests of critical physics issues on potentially attractive reactor concepts that are alternatives to tokamaks and to understand fundamental plasma behavior so that reactor relevant improvements are possible in any magnetic configuration. Configurations currently being evaluated are categorized by the names Reversed Field Pinch (RFPs), Field Reversed Configurations (FRCs), and Spheromaks. These configurations offer particular technological advantages in reactor embodiments. They all offer high beta plasmas, that is, high power density within the plasma, and consequent efficient use of the applied magnetic fields. RFP's should not require auxiliary heating. FRC's and spheromaks have simple magnet systems but different stability properties. Each of these configurations provide a different physical environment in which magnetically confined plasma obeys the same overall physical laws governing plasma stability and transport of energy and particles within the plasma. Thus the study of these different configurations provides unique insights valuable to the understanding and mathematical approximation of physical laws governing the behavior of all magnetically confined plasma. During FY 1991 a new FRC device called LSX will be operated to test specific stability questions at Spectra Technologies, Inc. in Seattle, with university and international participation. Reversed field pinch development will be supported by experiments at the University of Wisconsin and at LANL with participation in start up of the RFX device in Italy and preparations for the new ZT-H device at LANL.

Plasma processes that determine the success of magnetic confinement are complex. The Fusion Plasma Theory and Experimental Plasma Research branches supply basic tools for understanding these plasma processes and in FY 1991 emphasis will be continued on applying these tools to current tokamaks.

Theory is responsible for the development of concepts and models that describe and predict the behavior of magnetically confined plasma. In FY 1991 specific emphasis will be given to modelling and understanding of processes controlling transport of energy and particles in toroidal plasma. Activities will also include modelling to predict and interpret plasma heating by ion cylotron waves (ICRF), electron cyclotron waves (ECH) and fast alpha particles generated by fusion reactions. In addition, general models of plasma behavior will be developed from physics features common to different confinement geometries. Predictive capability will be developed for parameter ranges not yet explored. This work uses both analytical and numerical techniques and is located at universities, national laboratories and industrial contractors.

The Experimental Plasma Research activity provides experimental techniques, basic data, and fundamental physics information required to operate and interpret present major confinement experiments. In FY 1991, at selected tokamaks, recently installed diagnostics will be applied that can measure properties associated with energy and particle transport. Also, new diagnostic techniques required for measuring plasma properties will be developed and tested. The TEXT tokamak at University of Texas, Austin will be operated with new electron cyclotron heating and divertors in order to compare transport of particles and energy in various tokamak operation modes. Atomic data necessary for understanding plasma behavior will be obtained and compiled. New ideas currently receiving first tests are directed toward improved heating and current drive, better particle and energy control, and plasma stability at higher betas. Most of this work is at universities, with some national laboratories and industrial activity as well.

The Energy Sciences computing network provides access to state-of-the-art computational hardware (CRAY 1 and CRAY 2 computers). The network facilities provide support for the development of models and codes of plasma theory, for management and interpretation of experimental results, and for design of large scale fusion experiments. The network consists of the computers at LLNL and five user service centers at LLNL, LANL, General Atomics, PPPL, and ORNL, together with international data links and telephone line access by smaller users. In FY 1991 computer capability will be improved with faster network access between major sites and the computer center and by adding local computing work stations that can manipulate output from the cray computers as well as carry out extended calculations locally. The following table summarizes the operating funding for the Applied Plasma Physics subprogram.

II. A. Summary Table: Applied Plasma Physics

Program Activity	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change
Advanced Fusion Concepts........................	$ 21,618	$ 12,140	$ 12,000	- 1
Fusion Plasma Theory............................	20,520	19,412	19,600	+ 1
Experimental Plamsa Research....................	20,890	24,677	23,680	- 4
MFE Computing...................................	18,127	15,380	15,600	+ 1
Total, Applied Plasma Physics	$ 81,155	$ 71,609	$ 70,880	- 1

III. Activity Descriptions: (New BA in thousands of dollars)

Program Activity	FY 1989	FY 1990	FY 1991
Applied Plasma Physics			
Advanced Fusion Concepts	Continued the Confinement Physics Research Facility (CPRF) MDF project. About 50% of the funding has been committed.	Continue support of the CPRF construction project under the construction account including development of research diagnostics.	Continue support of the CPRF construction project under the construction account including development of research diagnostics.
	Operated Madison Symmetric Tokamak to understand confinement.	Use new equilibrium control on MST, and improve confinement.	Employ improved diagnostics on MST and correlate fluctuations with RFP confinement. Optimize density for improved confinement.
	Delayed LSX MDF project at Spectra Technology by 8 months. Revised cost and schedule completed. Project is on schedule (revised).	Complete LSX MFD in July.	Operate LSX to test stability theory.
	Modified Maryland Spheromak to increase temperature as part of the energy confinement study. Continue heating of LANL FRC device, and studied transport. Use ZT-40 program at LANL to prepare for RFP experiments.	Continue Maryland Spheromak heating experiments. Obtain record high temperatures in FRC at LANL. Study compression heating and transport.	Conduct high power rf heating experiments of Spheromak at the University of California at Berkeley. Conduct high field ohmic heating of Spheromak at the University of Maryland.
		Support LSX diagnostic development at universities.	Studies of rotation or the internal tilt mode will be carried out. Enhancement of formation time will be dermined.
	$ 21,618	$ 12,140	$ 12,000
Fusion Plasma Theory	Continued to apply theory to understand plasma confinement experiments.	Continue to emphasize theory that seeks understanding of transport processes controlling plasma confinement.	Increase emphasis on developing improved understanding of transport and confinement in toroidal devices. Develop new techniques for experimental data evaluation and analysis.

III. Applied Plasma Physics (Cont'd):

Program Activity	FY 1989	FY 1990	FY 1991
Fusion Plasma Theory (Cont'd)	Continued theory on ignition physics, both by providing increased theory support for confinement experiments that are directly related to CIT and by developing new codes and models. Expanded efforts in alpha-particle theory and studies of transport and support for diagnostics in these areas.	Continue theory related to CIT with emphasis on plasma heating by RF waves (ICRF and ECH) and by fast alphas generated within reacting plasma.	Continue theory development in support of CIT and ITER. Special emphasis will be placed on resistive MHD (current ramp-up), RF heating (ECH and ICRF), alpha particle theory, and modeling of alpha particle detection techniques.
	Continued to carry out theoretical analysis of alternate concept experiments.	Provide predictions of behavior for new FRC plasmas and refine RFP theory to support Wisconsin experiment and future RFP device at LANL.	Emphasize theories and models for advanced toroidal concepts including non-inductive current drive, auxiliary heating, particle control and edge effects. Continue theoretical analysis of transport and confinement properties of alternate concept devices and apply insights gained from alternate concept theory to tokamak devices.
	$ 20,520	$ 19,412	$ 19,600
Experimental Plamsa Research	Conducted tests of innovative current drive schemes. Continued basic experiments on high frequency RF effects in plasma.	Evaluate experiments on helicity injection current drive. Develop concepts for current profile control in tokamaks.	Evaluate effects of increased current on helicity injection experiments in low aspect ratio system. Investigate physics of compact toroid injection into medium sized tokamak.
	Increased operating time and heating capability of TEXT to extend results of earlier experiments to higher temperature plasmas. Constructed new coils and vacuum chamber for TEXT to study edge configuration effects on transport.	Install new coils, vacuum chamber, additional diagnostics, and additional ECH power at TEXT and initiate transport studies with various edge configurations.	Study correlation between edge electric field, fluctuations and transitions between various confinement modes using beam probe and related diagnostics on TEXT.
	Tested alpha diagnostic approaches.	Develop proof-of-principle alpha diagnostic for installation on major tokamak.	Install proof-of-principle alpha particle diagnostic system on a major machine for evaluation.

III. Applied Plasma Physics (Cont'd):

Program Activity	FY 1989	FY 1990	FY 1991
Experimental Plamsa Research (Cont'd)	Conducted basic physics experiments in small stellarators and tokamaks with emphasis on plasma wave coupling to assist design of RF heating for major experiments.	Continue basic physic experiments in small stellarators and tokamaks with emphasis on understanding confinement.	Continue basic physic experiments in small stellarators and tokamaks with emphasis on understanding confinement.
	Installed and applied diagnostic devices to measure transport-related properties at major tokamaks.	Study effect of fluctuations on transport in major tokamaks. Develop combined spectroscopy with neutral beam for transport diangostics.	Carry out edge physics and fluctuation measurements related to transport on major tokamaks.
	Began publication of recommended atomic data for fusion in international collaboration through IAEA.	Compile and recommend atomic data for application to plasma edge issues with IAEA.	Begin excitation measurements for multiply charged ions using energy loss system. Continue electron-ion collision studies.
	$ 20,890	$ 24,677	$ 23,680
MFE Computing	Continued supporting large-scale computing and data analysis for the fusion program, through operation of the MFE network. Provided funds to initiate an upgrade of the User Service Center at General Atomics to improve support of DIII-D experiment. Continued supporting large-scale computing and data analysis for the fusion program, through operation of the MFE network. Provided funds to initiate an upgrade of the User Service Center at General Atomics to improve support of DIII-D experiment.	Participate with Energy Sciences Advanced Computation in operation of MFE Computer Center which operates two Cray 2's and one Cray XM-P 22 as well as the nationwide ESNET computer network, providing access to supercomputers and facilities at fusion laboratories. In addition, this activity provides partial support for local computing at major fusion sites. Begin installing local computing and upgrade network.	In cooperation with ESAC program operate the National MFE Computer Center with one Cray X-MP, one Cray 2, and one Class VII computer. Release newest Cray 2 at beginning of fiscal year but retain Serial 1 Cray 2 with smaller memory. Participate in Energy Sciences Network for connectivity to MFECC from other fusion sites and local computing work stations.
		Implementation plans for the Energy Sciences Network project, identified in the Applied Mathematical Sciences subprogram of the Basic Energy Sciences program, will proceed. The Magnetic Fusion Energy programs share for the implementation of ESNET is $493,000.	Upgrades of ESNET to conform to the national research and education network standards will continue to be pursued and will be shared among ER programs that benefit from ESNET.
	$ 18,127	$ 15,380	$ 15,600

III. Applied Plasma Physics (Cont'd):

Program Activity	FY 1989	FY 1990	FY 1991
Applied Plasma Physics	$ 81,155	$ 71,609	$ 70,880

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KEY ACTIVITY SUMMARY

MAGNETIC FUSION ENERGY

I. Preface: Development and Technology

The Development and Technology subprogram provides for the development of the technologies needed for present and future fusion experiments and for design and analysis of fusion systems. The work is divided into three main areas: Plasma Technologies, Fusion Technologies, and Fusion Systems Analysis.

The Plasma Technologies activity develops the technologies needed to form, contain, heat and sustain a reacting fusion plasma. These technologies include magnetic systems, plasma heating systems, and plasma fueling systems. The principal activity in the magnetic systems program is to develop reliable high field pulsed and steady state superconducting magnets that provide the magnetic field conditions required to confine the plasma. The heating program focuses on developing the technologies required to heat the plasma ions and electrons to reactive conditions and to sustain a steady state plasma current needed for long term confinement of the plasma. It encompasses negative ion neutral beams and the electromagnetic wave heating approaches using electron cyclotron heating (ECH) and ion cyclotron resonance frequency (ICRF) techniques. The plasma fueling program develops high speed deuterium and tritium pellet injectors to not only maintain the proper amount of plasma fuel, but to tailor the plasma density profiles for optimum performances. Use of the developed heating and fueling systems directly supports the key technical issues of improving magnetic confinement and burning plasma systems and has enabled the production of record plasma conditions in fusion devices. This U.S. technology is in high demand internationally and provides the basis for many existing and future international collaborative programs. Projected experiments in higher density and higher temperature plasmas will necessitate continued development of higher power, longer pulse length, and higher frequency electromagnetic wave sources, transmission components, and improved fueling devices. The ITER magnets require a significant development and demonstration of the technology of very large, high field superconducting magnets.

The Fusion Technologies activity focuses on elements of fusion devices related to long term waste issues, safety features, environmental considerations, device reliability, tritium breeding, processing and retention, and power extraction. These elements are important for both the future fusion power reactors and for the ongoing fusion experiments. The tasks that address these elements are blanket and nuclear data, materials irradiation, plasma material interaction, and environment and safety. Ongoing tasks under blankets and nuclear data includes examination of different blankets designs for ITER, and cooperative IEA and US/Japan work on blanket engineering and Tritium Systems Test Assembly (TSTA) experimental tritium processing research. Materials irradiation supports examinations of ITER structural materials and divertor materials. In addition, there is an ongoing search for better future fusion structural materials in cooperation with Japan. Under Plasma Materials Interaction (PMI), research is ongoing for materials that provide the capability to withstand higher heat flux and plasma erosion for the first wall and divertor. PMI research focuses on examining erosion and redeposition on present tokamaks, as well as tritium retention and bake out. Environment and safety is concerned with the coupling of all the components in a safe and environmentally acceptable way. Emphasis today is being placed on studying the hazards associated with fusion radioactive products.

Fusion Systems Analysis conducts studies using analytical and computational tools as well as data from the ongoing fusion program to model future fusion systems to identify issues and to provide future directions. In late FY 1990, the ICF reactor design study will be initiated. In FY 1991, the ITER conceptual design activity and the ARIES study will be completed.

Some of the significant facilities utilized in the Development and Technology subprogram include the FENIX Test Facility at the Lawrence Livermore National Laboratory (LLNL) for testing of superconducting magnets; the Plasma Materials Test Facility at Sandia National Laboratories; the RF Test Facility at ORNL; the neutral beam test facilities at Lawrence Berkeley Laboratory (LBL); and a megawatt gyrotron test facility at Varian. The Tritium Systems Test Assembly (TSTA) at Los Alamos National Laboratory and the fusion material, work in the High Flux Irradiation Facility (HFIR) at ORNL and in the Fast Flux Test Facility (FFTF) at Richland are also supported under collaborative agreements with Japan.

The following table summarizes the operating expense funding for the Development and Technology subprogram.

II. A. Summary Table: Development and Technology

Program Activity	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change
Plasma Technologies				
Magnetic Systems..............................	$ 6,966	$ 5,423	$ 5,000	- 8
Heating and Fueling...........................	13,239	9,117	9,900	+ 9
Subtotal, Plasma Technologies	$ 20,205	$ 14,540	$ 14,900	+ 2
Fusion Technologies				
Fusion Nuclear Technology.....................	$ 6,460	$ 5,515	$ 5,600	+ 2
Environmental & Safety........................	2,100	2,055	2,060	0
Fission Materials.............................	14,721	13,274	13,500	+ 2
Subtotal, Fusion Technologies	$ 23,281	$ 20,844	$ 21,160	+ 2
Fusion Systems Analysis.......................	10,659	12,035	12,000	0
Total, Development and Technology	$ 54,145	$ 47,419	$ 48,060	+ 1

II. B. Major Laboratory and Facility Funding

	FY 1989	FY 1990	FY 1991	% Change
Argonne National Laboratory..................	$ 4,273	$ 3,258	$ 3,435	+ 5
University of California at Los Angeles......	3,100	2,800	2,765	- 1
Lawrence Livermore National Laboratory.......	11,311	9,970	9,860	- 1
Los Alamos National Laboratory...............	2,785	2,520	2,555	+ 1
Massachusetts Institute of Technology........	3,400	2,700	2,490	- 8
Oak Ridge National Laboratory................	12,923	8,332	9,290	+ 11
Pacific Northwest Laboratory.................	3,525	3,297	3,125	- 5
Sandia National Laboratory...................	4,160	2,700	3,950	+ 2

III. Activity Descriptions: (New BA in thousands of dollars)

Program Activity	FY 1989	FY 1990	FY 1991
Development and Technology			
Plasma Technologies	A focused development program in high field, steady state and pulsed superconducting magnets for ITER was maintained with international cooperation.	Technology for superconducting high field radiation tolerant magnets for ITER continued. U.S. demonstration of poloidal coil tests begun in Japan.	U.S. demonstration tests of polodial coil completed in Japan. Base technology program maintained to develop superconductors and struc- -l materials data at cryogenic temperatures for ITER. FENIX high field test facility available for international collaborations.
	ICRF development was maintained to develop and test a system for C-Mod and CIT. Efforts were continued to be applied to ECH and negative ion neutral beam development to access improved techniques for heating, current drive and plasma control for near term machines and ITER.	High power CIT prototype ICRF antenna under construction for C-Mod for testing. Some Fusion Materials Irradiation Test Facility (FMIT) power unit development modifications completed for CIT. Increased emphasis on 1 MW gyrotron ECH source development for DIII-D. Fast wave current drive antenna completed for DIII-D.	C-Mod antenna completed and shipped to MIT. Small scale negative ion source for ITER tested. Complete 1 MW gyrotron test facility and test 1 MW steady state gyrotron.
	Development efforts on higher performance pellet injectors is empahsized because of the need to fuel higher temperature and higher density plasmas in CIT and ITER.	Higher speed pellet injector approaches assessed and narrowed to one or two.	Development efforts maintained on higher speed fueling devices for CIT and ITER.
	$ 20,205	$ 14,540	$ 14,900
Fusion Technologies	In the plasma/materials interaction/high heat flux area, ITER, TFTR, and CIT support was continued, as was support for international collaborations on TEXTOR, ASDEX, and TORE SUPRA. Innovative impurity control techniques were pursued. Carbon-based, beryllium and high Z materials were investigated.	In the plamsa/materials interaction/high heat flux area, ITER, TFTR, and CIT support will continue, as will support for international collaborations on TEXTOR, ASDEX, and TORE SUPRA. Innovative impurity control techniques will be pursued. Carbon-based, beryllium and high Z materials will be investigated. The Tritium Systems Test Facility will be upgraded to densities which are ITER-relevant. Work on low Z materials, which are regeneratable	In the plamsa/materials interaction/high heat flux area, ITER, TFTR, and CIT support will continue, as will support for international collaborations on TEXTOR, ASDEX, and TORE SUPRA. Innovative impurity control techniques will be pursued. Carbon-based, beryllium and high Z materials will be investigated. Work on low Z materials, which are regeneratable through plasma spraying, will be increased. Work on high Z materials for the divertor throat for

III. Development and Technology (Cont'd):

Program Activity	FY 1989	FY 1990	FY 1991
Fusion Technologies (Cont'd)		through plasma spraying, will be increased.	ITER will be increased.
	In the neutron interactive materials area, continued research and devlopment on reduced activation materials. Continued irradiation testing in the FFTF/MOTA. Participated in IEA irradiation facility studies.	In the neutron interactive materials area, continue irradiation testing in HFIR and FFTF in cooperation with Japan and with IEA partners. Continue R&D in support of ITER and CIT including low activation steel, fracture behavior, and special purpose ceramics and diagnostic system materials.	In the neutron interactive materials area, continue testing in HFIR and FFTF in support of CIT and ITER, as well as future reactors.
	In the nuclear analysis area, blanket and shield technology area, conducted research on blanket system technologies with emphasis on ITER applications.	In the nuclear analysis area, blanket and shield technology area, continue research on reactor relevant blanket issues with the particular objective of design of ITER blanket modules.	In the nuclear analysis area, blanket and shield technology area, continue international cooperation in blanket research including design of next step tests. Maintain ITER blanket support.
	In the tritium processing technology area, continued joint operation of Tritium Systems Test Assembly (TSTA).	In the tritium processing area, continue joint operation of TSTA and install Japanese Atomic Energy Research Institute (JAERI's) Fuel Cleanup System into TSTA loop.	In the tritium processing area, continue joint opreation of TSTA and initiate tritium testing of JAERI's Fuel Cleanup System.
	In the environment and safety program, experimental efforts were continued in the tritium, activation products, blankets, and magnet areas, along with the supporting analytical efforts. Initiated effort to develop and incorporate ESECOM computer models into fusion systems code.	In the environment and safety program, continue with experimental and analytical efforts in tritium, activation products, blankets, and magnet areas and complete ESECOM report. Initiate operation of small tritium laboratory at INEL.	In the environment and safety program, continue with experimental and analytical efforts in tritium, activation products, blankets, and magnet areas, focusing on key ITER safety issues.
	$ 23,281	$ 20,844	$ 21,160
Fusion Systems Analysis	Maintained the ITER and the ARIES effort with completion in FY 1991.	Continue ITER conceptual design study. Continue the ARIES effort as planned with effort planned for completion in FY 1991. Initiate unclassified conceptual design of ICF reactors.	Complete the conceptual design of the ITER. A follow-on to ARIES will be started. Continue conceptual design study of an ICF reactor with completion in FY 1992.

III. Development and Technology (Cont'd):

Program Activity	FY 1989	FY 1990	FY 1991
Fusion Systems Analysis (Cont'd)	$ 10,659	$ 12,035	$ 12,000
Development and Technology	$ 54,145	$ 47,419	$ 48,060

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KEY ACTIVITY SUMMARY

MAGNETIC FUSION ENERGY

I. Preface: Planning and Projects

II. A. Summary Table: Planning and Projects

Program Activity	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change
Planning and Projects	$ 1,122	$ 4,206	$ 4,250	+ 1
Total, Planning and Projects	$ 1,122	$ 4,206	$ 4,250	+ 1

III. Activity Descriptions: (New BA in thousands of dollars)

Program Activity	FY 1989	FY 1990	FY 1991
Planning and Projects	Continued the program's legal obligation to support the SBIR program; continue support for non-fusion landlord responsibilities.	Continue the program's legal obligation to support the SBIR program; continue support for non-fusion landlord responsibilities.	Continue the program's legal obligation to support the SBIR program; continue support for non-fusion landlord responsibilities.
	$ 1,122	$ 4,206	$ 4,250
Planning and Projects	$ 1,122	$ 4,206	$ 4,250

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KEY ACTIVITY SUMMARY

MAGNETIC FUSION ENERGY

I. Preface: Program Direction

This subprogram provides the Federal staffing resources and associated funding needed to plan, direct, manage, and administer the highly scientific and technical research and development program in fusion energy. This program supports the national goal to provide an adequate supply of environmentally safe energy at reasonable cost and uses international collaboration as a major resource and to avoid needless duplication.

II. A. Summary Table: Program Direction

Program Activity	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change
Salaries and Expenses...........................	$ 3,967	$ 4,670	$ 5,390	+ 15
Other..	633	260	260	0
Total, Program Direction	$ 4,600	$ 4,930	$ 5,650	+ 15

III. Activity Descriptions: (New BA in thousands of dollars)

Program Activity	FY 1989	FY 1990	FY 1991
Program Direction			
Salaries and Expenses	Provided funds for salaries, benefits, and travel for 60 full-time equivalents (FTE's) in the Office of Fusion Energy and related program and management support staff. Staff activities include: policy development; preparation of technical research and development plans; assessment of scientific needs and priorities; development and defense of budgets; review, evaluation, and funding of research proposals; monitoring, evaluation, and direction of laboratory work and allocation of resources; oversight of implementation of university and industrial research programs; oversight of construction and operation of scientific R&D facilities; control of interagency and international liaison and negotiation; and related program and management support activities. Focused on the program management and key technical issues required for an ignition project including R&D prototypes for several critical components and extensive use of international collaboration to advance the program in a timely way, especially through joint projects, such as R&D and conducting the conceptual design for the ITER.	Provide funds for salaries, benefits, and travel related to 62 FTE's included in the FY 1990 budget, including normal increased personnel costs. A revised request for two additional FTE's above that level will provide enhanced oversight of environment, safety, and health (ES&H) activities related to nuclear safety, health physics, occupational safety and industrial hygiene, environmental protection, hazardous waste management, safeguards and security, emergency preparedness, and quality assurance. Perform safety appraisals and environmental compliance audits to ensure compliance with ES&H directives and regulations at fusion energy facilities.	Provide funds for salaries, benefits, and travel related to 64 FTE's. The increased funding will provide for two additional FTE's above the FY 1990 budget level, as discussed in FY 1990, and for the normal increased personnel costs resulting, for example, from within-grade and merit increases and the impact of the FY 1990 general and executive pay raises. Continue to support the increased ES&H responsibilities discussed in FY 1990. Continue to participate in international collaboration to advance the program in a timely way.
	$ 3,967	$ 4,670	$ 5,390

III. Program Direction (Cont'd):

Program Activity	FY 1989	FY 1990	FY 1991
Other	Provided funds for a variety of program support services such as printing and editing, supplies, and materials. Also included contractual support, for example, to assist with the environment, safety and health workload required by current regulations and directives and for timesharing on various information systems and communications networks.	Continue the variety of program support required in FY 1989.	Continue the variety and level of program support required in FY 1990.
	$ 633	$ 260	$ 260
Program Direction	$ 4,600	$ 4,930	$ 5,650

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KEY ACTIVITY SUMMARY

MAGNETIC FUSION ENERGY

I. Preface: Capital Equipment

The capital equipment request for FY 1991 of $14,310,000 supports the procurement of essential hardware to facilitate the conduct of the experimental program. This permits the effective utilization of devices and people. In addition, general purpose equipment needs at ORNL as part of the program's landlord responsibilities at the ORNL. Much of this equipment is used to support the operation of the fusion experimental devices or to make measurements and gather technical data. Some of this equipment replaces existing obsolete equipment while other items of equipment are new items of equipment required to allow the science to advance. Listed below is a summary of the specific capital equipment needs by program area.

II. A. Summary Table: Capital Equipment

Program Activity	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change
Confinement Systems............................	$ 8,435	$ 6,635	$ 6,650	0
Applied Plasma Physics..........................	2,445	536	1,720	+221
Development and Technology.....................	4,155	2,938	2,840	- 3
Planning and Projects..........................	3,800	3,221	3,100	- 4
Total, Capital Equipment	$ 18,835	$ 13,330	$ 14,310	+ 7

III. Activity Descriptions: (New BA in thousands of dollars)

Program Activity	FY 1989	FY 1990	FY 1991
Capital Equipment			
Confinement Systems	Continued maintenance and modest upgrades to data acquisition systems by replacing/upgrading output devices, analog to digital convertors, mass storage systems, etc., as needed. Purchased necessary power supplies, oscilloscopes, vacuum hardware, spectrum analyzers, amplifiers, detectors, RF test equipment, and safety equipment to carry out experimental programs on D-III-D, ATF, PBX, MTX, and TFTR. Initiated purchase of main thyristor power supplies for Alcator C-MOD.	Complete purchase of main thyristor power supplies for Alcator C-MOD.	Equipment support provided to support experimental operations of existing devices. Continue maintenance and modest upgrades to data acquisition systems by replacing/ upgrading output devices, analog to digital convertors, mass storage systems, etc., as needed for DIII-D, PBX and TFTR.
	$ 8,435	$ 6,635	$ 6,650
Applied Plasma Physics	Continued acquisition of power system for CPRF. Provided general laboratory equipment for experimental research at national laboratories including plasma control and diagnostic equipment and equipment for alpha diagnostic devices.	Provide general laboratory equipment for experimental research at national laboratories including plasma control and diagnostic equipment and equipment for alpha diagnostic devices.	Provide general laboratory equipment for experimental research at national laboratories including diagnostic equipment for the Confinement Physics Research Facility.
	$ 2,445	$ 536	$ 1,720
Development and Technology	Special and general purpose equipment was purchased to increase the efficiency and productivity of the research and development efforts and technology test facilities.	Special and general purpose equipment is purchased to increase the efficiency and productivity of the research and development efforts and technology test facilities.	Special and general purpose equipment is purchased to increase the efficiency and productivity of the research and development efforts and technology test facilities.
	$ 4,155	$ 2,938	$ 2,840

III. Capital Equipment (Cont'd):

Program Activity	FY 1989	FY 1990	FY 1991
Planning and Projects	Purchased general purpose equipment to support non-fusion-specific landlord responsibilities at ORNL to replace obsolete and worn equipment and to provide new state-of-the-art equipment.	Purchase general purpose equipment to support non-fusion specific landlord responsibilities at ORNL to replace obsolete and worn equipment and to provide new state-of-the-art equipment.	Purchase general purpose equipment to support non-fusion specific landlord responsibilities at ORNL to replace obsolete and worn equipment and to provide new state-of-the-art equipment slightly below the FY 1990 level.
	$ 3,800	$ 3,221	$ 3,100
Capital Equipment	$ 18,835	$ 13,330	$ 14,310

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KEY ACTIVITY SUMMARY

MAGNETIC FUSION ENERGY

I. Preface: Construction

II. A. Summary Table: Construction

Program Activity	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change
Compact Ignition Tokamak........................	$ 3,500	$ 0	$ 0	0
General Plant Projects..........................	8,652	7,680	8,000	+ 4
Confinement Physics Research Facility...........	0	10,915	11,100	+ 2
Total, Construction	$ 12,152	$ 18,595	$ 19,100	+ 3

III. Activity Descriptions: (New BA in thousands of dollars)

Program Activity	FY 1989	FY 1990	FY 1991
Construction			
Compact Ignition Tokamak	Effort provided for continuation of detailed design of CIT device components and systems.	No activity.	No activity.
	$ 3,500	$ 0	$ 0
General Plant Projects	Supported projects to meet health, safety, and programmatic requirements and to provide miscellaneous modifications, additions, alterations, and non-major new construction items to meet programmatic goals.	Support projects to meet health, safety, and programmatic requirements and to provide miscellaneous modifications, additions, alterations, and non-major new construction items to meet programmatic goals.	Support projects to meet health, safety, and programmatic requirements and to provide miscellaneous modifications, additions, alterations, and non-major new construction items to meet programmatic goals.
	$ 8,652	$ 7,680	$ 8,000
Confinement Physics Research Facility	Supported as an operating expense funded project.	Proceed with fabrication of the coils and vessel/shell.	Complete fabrication of coils and vessel/shell and begin installation of these components. Complete generator start-up tests.
	$ 0	$ 10,915	$ 11,100
Construction	$ 12,152	$ 18,595	$ 19,100

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KEY ACTIVITY SUMMARY

CONSTRUCTION PROJECTS

Magnetic Fusion Energy

IV. A. Construction Project Summary

Project No.	Project Title	Total Prior Year Obligations	FY 1990 Appropriated	FY 1991 Request	Unappropriated Balance	TEC
89-R-800	Confinement Physics Research Facility	41,584	10,915	11,100	12,001	75,600 a/
GP-E-900	General Plant Projects	0	0	8,000	0	8,000
88-R-901	General Plant Projects	0	7,680	0	0	7,680
Subtotal, MFE Construction		$ 41,584	$ 18,595	$ 19,100	$ 12,001	
Operating Funded						
-	Alcator C-Modification	13,800	3,410	390	0	17,600
Subtotal, OE Funded		$ 13,800	$ 3,410	$ 390	$ 0	
Total, MFE		$ 55,384	$ 22,005	$ 19,490	$ 12,001	

a/ CPRF proposed as a line item construction project in FY 1990. This project was authorized and appropriated as an operating expense funded project through FY 1989. Recent reductions in the appropriation and from the sequestration to the FY 1990 level for this project have led to the need to defer work into subsequent years. The impact on the total estimated cost and schedule from this action are under review.

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KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Magnetic Fusion Energy

IV. B. Plant Funded Construction Project

1. Project title and location: 89-R-800 Confinement Physics Research Facility
Los Alamos National Laboratory

Project TEC: $75,600[1/]
Start Date: 1st Qtr. FY 1986
Completion Date: 4th Qtr. FY 1993[1/]

2. Financial schedule:

Fiscal Year	Appropriated	Obligations	Costs
1986	$ 7,711	$ 7,711	$ 3,599
1987	11,850	11,850	7,692
1988	11,293	11,293	13,812
1989	10,730	10,730	13,792
1990	10,915	10,915	10,915
1991	11,100	11,100	11,100
1992	10,139	10,139	10,700
1993	1,862	1,862	3,990

3. Narrative:

(a) The presently operating reversed field pinch (RFP) devices have achieved outstanding experimental results which surpass design specifications. It is now important to extend the plasma current capability in order to test energy confinement. As a result, a device having a 1.7 MA capability will be fabricated. This new facility will bring to the fusion program an experimental capability to explore, in a multikilovolt collisionless regime, the physics properties of a toroidal confinement concept that has the theoretical potential (in a future device) of ohmic heating to ignition with low magnetic fields at the magnet coils.

1/ Recent reductions in the FY 1990 level for this project have led to the need to defer work into subsequent years. The impact on the total estimated cost and schedule from this action are under review.

(b) The CPRF includes an existing test cell and space in an adjacent building and will consist of magnetic field coils, vacuum system, control system, structural support, and power supply system.

(c) Certain key features of the CPRF will be sized with an ultimate capability of 4 MA, thereby facilitating a cost effective upgrade to the 4 MA operating level in the future, if warranted.

4. Total Project Funding (BA):

	Prior Years	FY 1989	FY 1990	FY 1991	To Complete
Construction............	$30,854	$11,230	$11,404	$11,500	$ 14,499
Capital Equipment.......	0	0	0	0	0
Operating Expenses......	0	0	0	0	0

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KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Magnetic Fusion Energy

IV. B. Plant Funded Construction Project

1. Project title and location: GP-E-900 General Plant Projects
Various locations

Project TEC: $ 8,000
Start Date: 1st Qtr. FY 1991
Completion Date: 4th Qtr. FY 1992

2. Financial schedule:

Fiscal Year	Appropriated	Obligations	Costs
1991	$ 8,000	$ 8,000	$ 2,640
After 1991	0	0	5,360

3. Narrative:

(a) This project supports many small alterations, additions, modifications, replacements, and non-major new construction items required annually to provide continuity of operation, improvement in economy, road and structure improvements, elimination of health and safety hazards, minor changes in operating methods, and protection of the Government's significant investment in facilities. Currently the estimated distribution for FY 1991 by laboratory is as follows:

Los Alamos National Laboratory	$ 400,000
Princeton Plasma Physics Laboratory	1,500,000
Oak Ridge National Laboratory	6,100,000
	$ 8,000,000

4. Total Project Funding (BA):

	Prior Years	FY 1989	FY 1990	FY 1991 Request	To Complete
Construction	$ 0	$ 8,652	$ 7,680	$ 8,000	$ 0
Capital Equipment	0	0	0	0	0
Operating Expenses	0	0	0	0	0

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KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Magnetic Fusion Energy

IV. C. Operating Expense Funded Construction Project

1. Project title and location: Alcator C-Modification
Massachusetts Institute of Technology
Cambridge, Massachusetts

Project TEC: $17,600
Start Date: 1st Qtr. FY 1987
Completion Date: 3rd Qtr. FY 1991

2. Financial schedule (Construction cost, capital equipment and operating expenses (BA))

	Prior Year	FY 1989 Actual	FY 1990 Appropriated	FY 1991 Request	To Complete
Construction......	$ 8,900	$ 4,900	$ 3,410	$ 390	$ 0
Capital Equipment.	500	3,500	700	0	0
Operating Expenses	7,260	3,235	1,505	0	0

3. Narrative:

(a) The Alcator C-Mod. project will provide a unique device, using existing support facilities, to conduct a test of recent improvements in tokamak physics design of the Compact Ignition Tokamak (CIT). Alcator C-Modification will allow us to develop operational techniques and control methods to produce high temperature, high density, well confined plasmas. Specific areas of physics investigation include ion cyclotron radiofrequency heating, plasma edge control, pellet fueling, impurity control, and current ramp-up.

(b) The major objective of Alcator C-Mod. is to provide unique and valuable information on transport in high density plasmas with intense ion cyclotron resonant frequency heating.

(c) Alcator C-Mod is finished and operation of the tokamak begins in late 1990. 4-5MW of ICRF heating system will be installed for later operation.

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEET
ENERGY SUPPLY RESEARCH AND DEVELOPMENT - PLANT AND CAPITAL EQUIPMENT
MAGNETIC FUSION

(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: Confinement physics research facility (CPRF)
Los Alamos National Laboratory (LANL)

2. Project No. 89-R-800

3. Date A-E work initiated: 1st Qtr. FY 1986

3a. Date physical construction starts: 2nd Qtr. FY 1987

4. Date construction ends: 4th Qtr. FY 1993[1/]

5. Previous cost estimate: $75,600
Date: January 1989

6. Current cost estimate: $75,600[1/]
Date: December 1989

7. Financial Schedule:

Fiscal Year	Appropriation	Obligations	Cost
1986	7,711	7,711	3,599
1987	11,850	11,850	7,692
1988	11,293	11,293	13,812
1989	10,730	10,730	13,792
1990	10,915	10,915	10,915
1991	11,100	11,100	11,100
1992	10,139	10,139	10,700
1993	1,862	1,862	3,990

8. Brief Physical Description of Project

The CPRF includes an existing test cell and some space in an adjacent building. In addition, CPRF includes power, vacuum, control and data acquisition systems. The reversed field pinch (RFP) device within CPRF, called ZT-H, includes a vacuum vessel, shell, coils and associated structure. Also included are buildings for the power system and necessary modifications in the test cell and adjacent building.

1/ Recent reductions in the appropriation and from the sequestration to the FY 1990 level for this project have led to the need to defer work into subsequent years. The impact on the total estimated cost and schedule from this action are under review.

CONSTRUCTION PROJECT DATA SHEET

1. Title and Location of Project: Confinement physics research facility (CPRF) Los Alamos National Laboratory (LANL)

2. Project No. 89-R-800

9. Purpose, Justification of Need for, and Scope of Project

The purpose of CPRF is to provide a magnetic fusion research facility that is capable of exploring, in a multikilovolt-temperature, collisionless regime, the physics properties of a toroidal confinement concept that has the theoretical potential, in future devices, of ohmic heating to ignition with low magnetic fields. These physics properties include particle and energy transport and MHD activity in a high-beta, high-shear, low-q regime, including relaxation phenomena and the associated potential for steady-state current drive.

Presently operating reversed field pinch devices have achieved outstanding experimental results which surpass their design specifications. For example, in the ZT-40M device, experiment duration has reached 35 milliseconds exceeding the design goal of 2 milliseconds. The Magnetic Fusion Advisory Committee recommended proceeding with the physics exploration of the reversed field pinch concept. The importance of extending the plasma current capability to values in the megampere range in order to test energy confinement was emphasized.

The initial research device that is to be installed in CPRF, and is included herein as part of the CPRF, will be capable of a 1.7 MA plasma current operating level. Certain key features of the CPRF will be sized with an ultimate capability of 4 MA, thereby facilitating a cost effective upgrade to the 4 MA operating level in the future, if warranted.

10. Details of Cost Estimate

	Item Cost	Total Cost
a. Engineering and design..............................		$15,000
b. Construction related costs..........................		57,500
(1) Procurement/fabrication..........................	$27,500	
(2) Assembly/installation............................	10,700	
(3) Construction.....................................	5,300	
(4) Test/other.......................................	11,200	
(5) R&D Activities...................................	2,800	
Subtotal...		72,500
c. Contingency at about 4% of above costs...............		3,100
Total Estimated Cost (TEC)............................		$75,600

Escalation is included at 5% per annum.

CONSTRUCTION PROJECT DATA SHEET

1. Title and Location of Project: Confinement physics research facility (CPRF) Los Alamos National Laboratory (LANL)

2. Project No. 89-R-800

11. Method of Performance

The design, engineering, R&D, installation and test will be carried out by LANL. Responsibility for construction and procurement will also reside with LANL. The use of fixed-price contracts will be emphasized during all stages of the construction effort.

12. Funding Schedule of Project and Other Related Funding Requirements

a. Total Project Funding

	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991	FY 1992	FY 1993	Total
(1) Total Estimated Cost of Facility	$ 3,599	$ 7,692	$13,812	$13,792	$10,915	$11,100	$10,700	$ 3,990	$75,600
(2) Other Project Funding									
(a) GPP Funds necessary to complete the CPRF	0	0	0	605	537	525	2,220	0	3,887
Total Project Cost	$ 3,599	$ 7,692	$13,812	$14,397	$11,452	$11,625	$12,920	$ 3,990	$79,487

b. Other Related Annual Costs

	Annual Estimate
(1) Facility preparation for operation, research diagnostics and operation costs	$ 17,500
Total Other Related Annual Costs	$ 17,500

13. Narrative Explanation of Project Funding and Other Related Funding Requirements

a. Total Project Funding

(1) Total Estimated Cost of CPRF - Description is provided in Sections 8 and 9.

1. Title and Location of Project: Confinement physics research facility (CPRF) Los Alamos National Laboratory (LANL) — 2. Project No. 89-R-800

13. Narrative Explanation of Project Funding and Other Related Funding Requirements (Continued)

(2) Related GPP Funds - These funds provide for various facility related tasks including weather protecting buildings for the power systems and miscellaneous modifications to the test cell and the adjacent building.

b. Other Related Annual Costs (FY 1993 dollars)

(1) Facility preparation for operation, research diagnostics and operation costs - The facility is estimated to operate at least for four years with the initial RFP research device installed. The funding needs begin prior to operation at a lower level and reach the level indicated in 1993 and remain approximately level thereafter. The funds are needed for preparation for operation and operations activities such as personnel costs, materials and services, maintenance, spare parts and utilities. Also included are costs for research diagnostics that are required in order to diagnose the plasma conditions within the RFP device.

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
ENERGY SUPPLY RESEARCH AND DEVELOPMENT - PLANT AND CAPITAL EQUIPMENT
MAGNETIC FUSION ENERGY

(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: General plant projects

2. Project No.: GPE-900

3. Date A-E work initiated: 1st Qtr. FY 1991

3a. Date physical construction starts: 2nd Qtr. FY 1991

4. Date construction ends: 4th Qtr. FY 1992

5. Previous cost estimate: None
Date:

6. Current cost estimate: $8,000
Date: December 1989

7. Financial Schedule:

Fiscal Year	Obligations	Costs FY 1989	Costs FY 1990	Costs FY 1991	Costs After FY 1991
Prior Year Projects	XXXXXXXX	$ 4,131	$ 4,015	$ 3,384	$ 0
FY 1989 Projects	$ 8,652	2,848	3,757	2,047	0
FY 1990 Projects	7,680	0	2,534	3,149	1,997
FY 1991 Projects	8,000	0	0	2,640	5,360
		$ 6,979	$ 10,306	$ 11,220	$ 7,357

8. Brief Physical Description of Project

These projects provide for the many miscellaneous alterations, additions, modifications, replacements, and non-major new construction items required annually to provide continuity of operation, improvement in economy, road and street improvements, elimination of health and safety hazards, minor changes in operating methods, and protection of the Government's significant investment in facilities at the present time. The continuing review of our requirements will result in some of the projects being changed in scope; it will also result in other projects being added to the list with the necessary postponements of some now-listed, all depending on conditions or situations not apparent at this time.

1. Title and location of project: General plant projects 2. Project No.: GPE-900

8. Brief Physical Description of Project (continued)

The current estimated distribution of FY 1991 funds by location is as follows:

1. Los Alamos National Laboratory	$ 400
2. Princeton Plasma Physics Laboratory	1,500
3. Oak Ridge National Laboratory	6,100
	$ 8,000

9. Purpose, Justification of Need for, and Scope of Project

The following are tentative examples of the major items to be performed at the various locations:

Los Alamos National Laboratory		$ 400
Lightning Protection	145	
Grading and Paving	255	
Princeton Plasma Physics Laboratory*		$ 1,500
Office Space - Material Control	215	
Roof Replacement and Structural Reinforcement	240	
Life Safety Code Compliance Modifications	145	
TFTR Experimental Area HVAC System	190	
Access and Circulation for Handicapped Facilities	245	
D Site Cooling Systems Modifications	160	
Miscellaneous small projects	305	

*These projects will be constructed at the Princeton Plasma Physics Laboratory which is non-Government owned property.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: General plant projects 2. Project No.: GPE-900

9. Purpose Justification of Need for, and Scope of Project (continued)

Oak Ridge National Laboratory...$ 6,100

These funds cover the Magnetic Fusion Energy program's responsibility to fund all of the generic general plant projects needs at this multipurpose laboratory.

Extend Main Entrance Drive..	225
Sentry Post Replacement - Gate 19B..	175
New Hydrofacture/Melton Valley Storage Tanks Stack Monitoring Improvements....	700
Housing for Semiconductor Physics Group.......................................	1,200
East Area Utilities Extension...	300
Hazardous Materials Analytical Laboratory Elevator............................	100
Mechanics Laboratory Upgrade - Fusion Energy Engineering Technology Building..	380
Advanced Technology Maintenance Facility......................................	1,150
Geosciences Research Laboratory Building......................................	1,000
Sewage Treatment Plant Modification...	800
Miscellaneous Small Projects..	70

10. Details of Cost Estimate

Not available at this time.

11. Method of Performance

Design and engineering will be on the basis of negotiated subcontracts and construction work under fixed price subcontracts awarded on the basis of competitive bidding.

12. Funding Schedule of Project Funding and Other Related Funding Requirements

This item does not apply to general plant projects.

Since needs and priorities may change, other projects may be substituted for those listed, and some of these may be located on non-Government owned property.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: General plant projects   2. Project No.: GPE-900

13. Narrative Explanation of Total Project Funding and Other Related Funding Requirements

This item does not apply to general plant projects.

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL REVIEW BUDGET
OPERATING EXPENSE FUNDED PROJECT DATA SHEET
ENERGY RESEARCH

Energy Supply Research and Development - Operating Expenses
Magnetic Fusion Energy

(Tabular dollars in thousands. Narrative material in whole dollars.)

Alcator C-Modification (C-MOD)
Massachusetts Institute of Technology

Total Estimated Cost: $17,600,000
(For Design and Construction)

Alcator C-Modification (C-MOD)
Massachusetts Institute of Technology*

Total Estimated Cost: $17,600,000

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1987 Actual		FY 1988 Actual		FY 1989 Actual		FY 1990 Estimate		FY 1991 Estimate		Total Project Costs
	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O	B/A
Fabrication											
Operating Expenses											
Design and Construction	$ 4,000	$ 4,000	$ 4,900	$ 4,900	$ 4,900	$ 4,900	$ 3,410	$ 3,410	$ 390	$ 390	$17,600
Subtotal	4,000	4,000	4,900	4,900	4,900	4,900	3,410	3,410	390	390	17,600
Related Funding Requirements											
Research Operations	2,760	2,760	4,500	4,500	3,235	3,235	1,505	1,505	0	0	12,000
Capital Equipment	0	0	500	382	3,500	3,500	700	818	0	0	4,700
	2,760	2,760	5,000	4,882	6,735	6,735	2,205	2,323	0	0	16,700
Total Project	$ 6,760	$ 6,760	$ 9,900	$ 9,782	$11,635	$11,635	$ 5,615	$ 5,733	$ 390	$ 390	$34,300

Description, Objective and Justification

The presently operating Alcator-C facility will be modified to Alcator C-MOD, a high-performance tokamak to optimize confinement in a high density, RF-heated plasma with the largest toroidal field operating range in the world. C-MOD will have a double-null divertor, and it will utilize 4-5 MW of ICRF power for auxiliary heating. $3.7M in capital equipment funds are to be used to replace power supplies transferred to LLNL for the Microwave Tokamak Experiment (MTX).

*This project will be constructed at the Massachusetts Institute of Technology which is non-Government property.

Alcator C-Modification (C-MOD)
Massachusetts Institute of Technology

Total Estimated Cost: $17,600,000

(Tabular dollars in thousands. Narrative material in whole dollars.)

Description, Objective and Justification (continued)

The major objective of Alcator C-MOD is to provide unique and valuable information on transport in high density plasmas with intense ICRF heating. With the high current capability of C-MOD, good confinement is expected. The improved access in C-MOD, together with most recent advances in divertor designs, will make it possible to investigate both the physics and engineering of high field tokamak operation.

During the initial phase of operation, the objective is to develop operational techniques and control methods to produce high-temperature, high-density, well confined plasmas using such tools as a baffled divertor and pellet fueling. Further in the area of particle control, C-Mod will develop operational techniques to improve confinement effects. C-Mod will address issues such as current ramp-up for discharge optimization.

(a) Schedule of Planned Activities

	Start	Complete
Design	1Q FY 1987	4Q FY 1987
Fabrication	3Q FY 1987	1Q FY 1990
Installation	1Q FY 1989	3Q FY 1990
Startup	4Q FY 1990	3Q FY 1991

(b) Management and Contracting

This project will be managed by the MIT Plasma Fusion Center under separate contract.

(c) Prior Year Achievements

Fabrication of major components complete. Owner fit up of site complete. Start of final tokamak assembly.

(d) Current Year Achievements

Finish component fabrication tokamak assembly. Begin machine check out

(e) Reasons for Increases or Decreases

N/A

(f) Cost Estimate

Engineering and Design	$ 2,700
Hardware Fabrication and Installation	12,600
Contingency	2,300
Total	$17,600

Escalation at 5% per year.