GA–C19570 (7/94)
(7/19/94)

PROGRAM STATUS
3rd QUARTER — FY 1994

CONFINEMENT SYSTEMS PROGRAMS

- DIII-D RESEARCH OPERATIONS
- INTERNATIONAL COOPERATION
- TOKAMAK PHYSICS EXPERIMENT
- FUSION PLASMA THEORY
- USER SERVICE CENTER
- ITER DESIGN ENGINEERING

Contract No. DE–AC03–89ER51114
General Atomics Projects 3466/3467/3470/3473/
3939/3940/3969/3990/3993

This Quarterly Report Under
DOE Contract DE–AC03–89ER51114
is Submitted in Compliance with Sections A and B
of the REPORTING REQUIREMENTS CHECK LIST

JULY 19, 1994

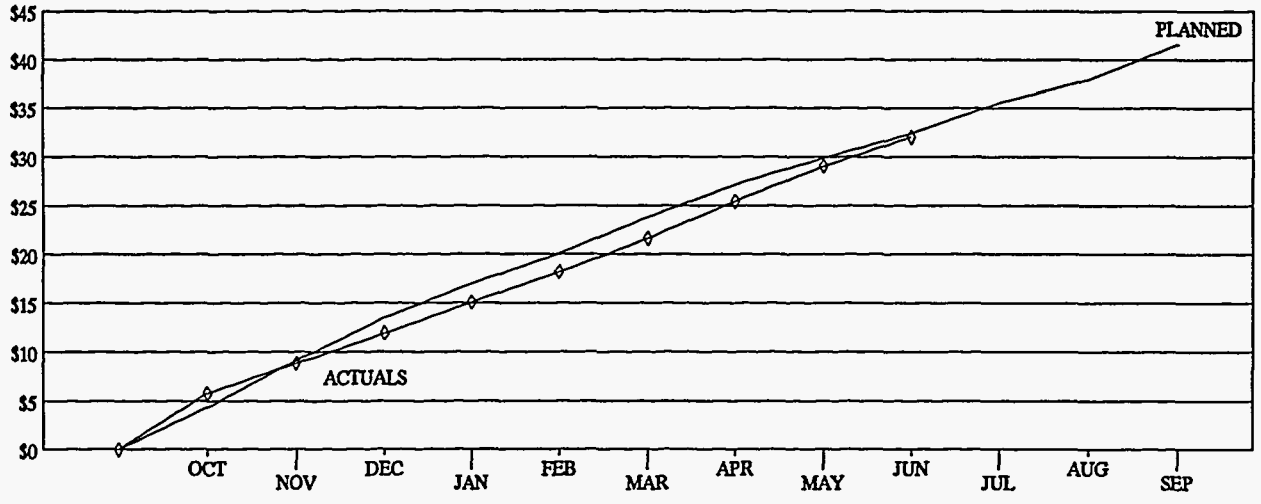
GENERAL ATOMICS

DIII–D RESEARCH OPERATIONS

Contract Management Summary Report

TITLE:	DIII-D RESEARCH OPERATIONS & RELATED RESEARCH	CONTRACT NO.:	DE-AC03-89ER51114
CONTRACTOR:	GENERAL ATOMICS P.O. BOX 85608 SAN DIEGO, CA. 92186-9784	COST & LABOR PLAN DATE: JULY 15, 1994	START DATE: SEPTEMBER 25, 1993 COMPLETION DATE: SEPTEMBER 30, 1994

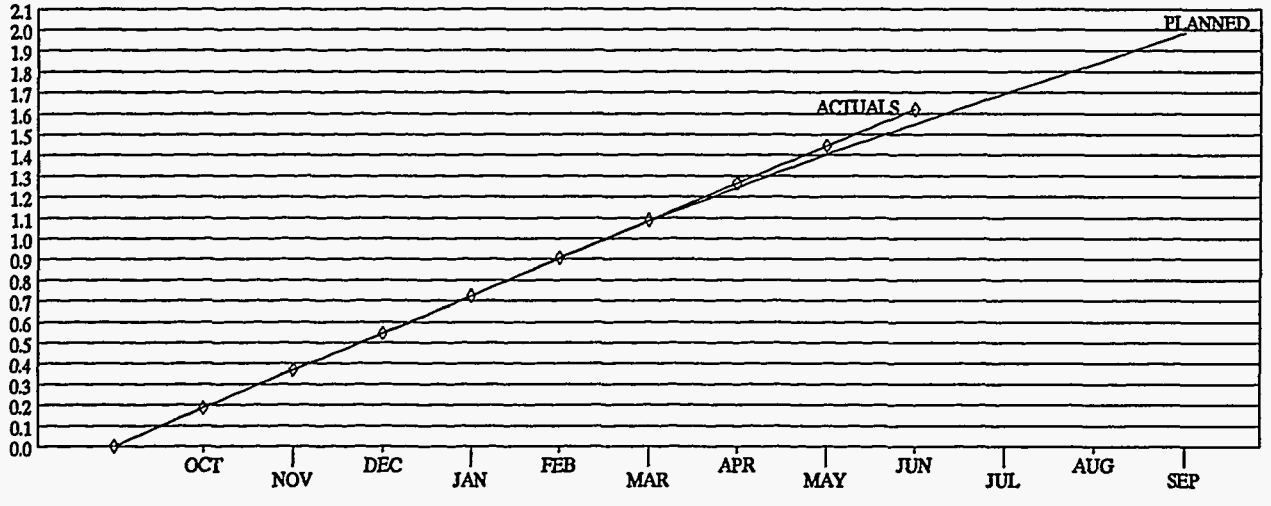
DOLLARS IN MILLIONS



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTALS
PLANNED	$4,317	$4,867	$4,262	$3,517	$3,138	$3,731	$3,312	$2,717	$2,471	$3,173	$2,423	$3,665	$41,593
ACTUAL	$5,773	$3,067	$3,064	$3,146	$3,123	$3,431	$3,832	$3,560	$2,997				$31,993
VARIANCE	($1,456)	$1,800	$1,198	$371	$15	$300	($520)	($843)	($526)				
CUM VAR	($1,456)	$344	$1,542	$1,913	$1,928	$2,228	$1,708	$865	$339				

(IN THOUSANDS)

PERSON – MONTHS (THOUSANDS)



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTALS
PLANNED	187.2	180.0	179.2	177.0	180.4	181.0	159.9	161.2	144.8	142.5	143.9	147.4	1984.5
ACTUAL	185.6	185.0	172.4	180.4	183.4	180.8	178.5	178.4	174.8				1619.3
VARIANCE	1.6	-5.0	6.8	-3.4	-3.0	0.2	-18.6	-17.2	-30.0				
CUM VAR	1.6	-3.4	3.4	-0.0	-3.0	-2.8	-21.4	-38.6	-68.6				

(PERSON-MONTHS)

SIGNATURE OF PARTICIPANT'S PROJECT MANAGER & DATE: _____

PROGRAM STATUS
3RD QUARTER — FY 1994

TASK: DIII-D RESEARCH OPERATIONS

B/R NOS: AT101014D (Operating)
35AT10020 (Capital)

CONTRACT NO.: DE-AC03-89ER51114

GA PRINCIPAL INVESTIGATOR: T. SIMONEN

OAK PROJECT MANAGER: M. FOSTER

OFE PROGRAM MANAGER: E. OKTAY

OPERATING

FY 94 FUNDING: $32,021K(1)

FY94 PLAN: $33,259K(2)

CAPITAL

FY 94 FUNDING: $6,355K(1)(2)

FY94 PLAN: $6,355K(2)(3)

	MILESTONE	LEVEL	APPROVED DATE	TARGET DATE	COMPLETION DATE
94.	Complete report on ITER R&D tasks	I	10/93	10/93	10/93
99.	Report on experiments to design the radiative divertor	I	1/94	1/94	11/93
96.	Checkout of the new FWCD transmitters	I	2/94	8/94	
83.	Complete installation of the multi-element antennas	I	3/94	3/94	4/94
95.	Report on preliminary radiative divertor design	I	6/94	6/94	6/94
70.	Inject pellets into H–mode plasma	I	8/94	8/94	

REMARKS:

(1) $38,376K anticipated total FY94 funding (Operating & Capital).

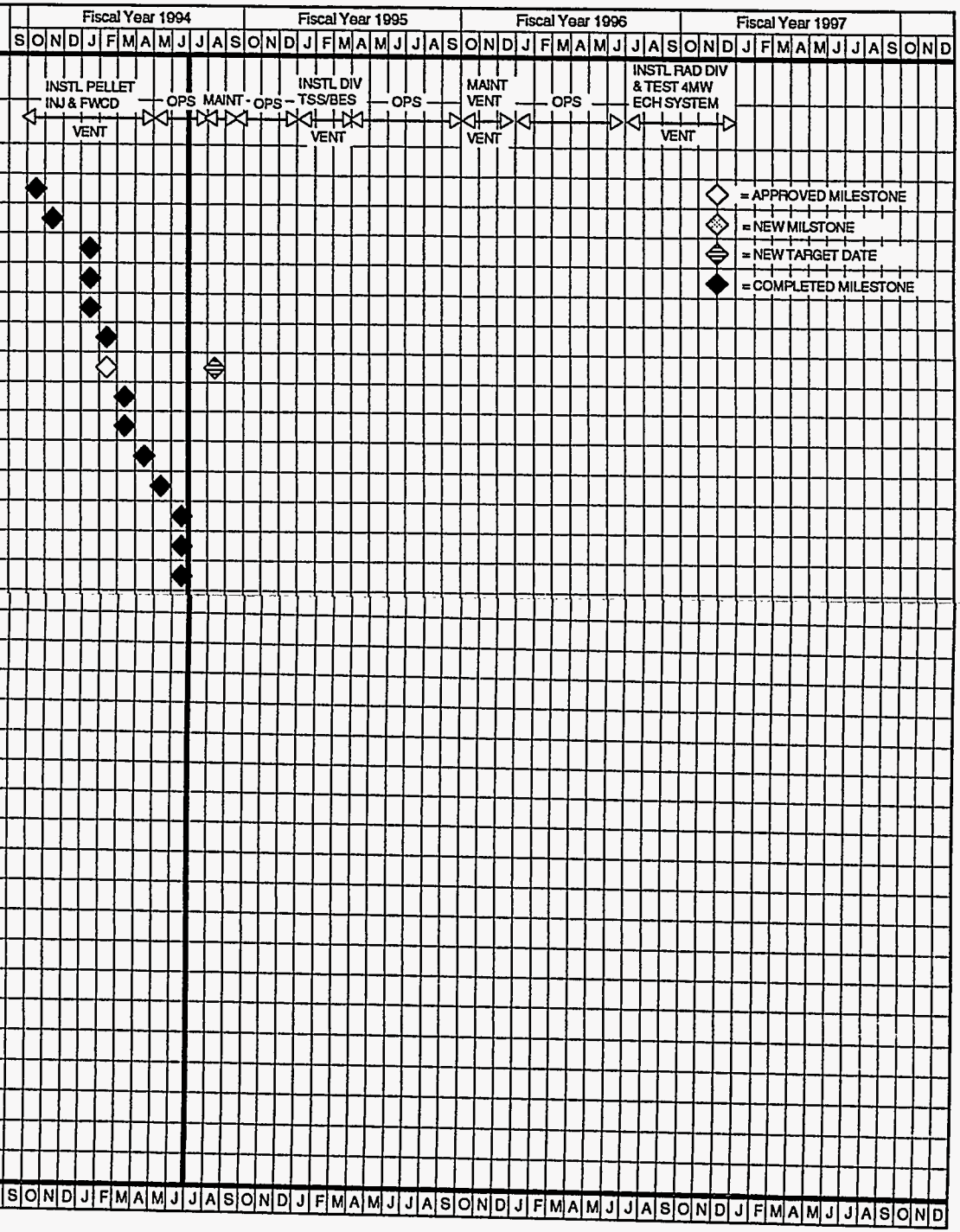
(2) Budget plan remains approximately $1.2M above anticipated FY94 funding levels. Tasks, personnel and procurement reductions are being made to bring expenditures in closer line with funding.

(3) Includes $0.8M commitment to 1 MW ECH Russian gyrotron.

Jun 29, 1994

DIII-D MILESTONE SCHEDULE

NO	MILESTONE DESCRIPTION	RESP
	MACHINE STATUS	
	MILESTONES	
94(GA)	COMPLETE REPT ON ITER R&D TASKS	LUXON
25(LLNL)	REPT ON THE DETAILED COLLABORATION PLAN FOR FY94	ALLEN
99(GA)	REPT ON EXPERIMENTS NEEDED TO DESIGN THE RADIATIVE DIVERTOR	STAMBAUGH
(ORNL)	DELIVER PELLET INJECTOR TO DIII-D	HILLIS
26(LLNL)	ISSUE REPT ON SUMMARY OF HEAT FLUX DISTRIBUTION	ALLEN
(ORNL)	DELIVER LONG PULSE FWCD ANTENNAS	HILLIS
96(GA)	COMPLETE CHECKOUT OF THE 2nd & 3rd FWCD TRANSMITTERS	FREEMAN
27(LLNL)	COMPLETE INSTALLATION OF VACUUM HDWR FOR THE EDGE MSE	ALLEN
83(GA)	INSTALL MULTI-ELEMENT ORNL FWCD ANTENNA	FREEMAN
28(LLNL)	REPT ON EXPTS & MEASUREMENTS DURING HIGH BETA POLOIDAL EXPTS	ALLEN
29(LLNL)	COMP INSTALLATION OF HDWR FOR THE DIV MW INTERFEROMETER	ALLEN
95(GA)	REPT ON THE PRELIMINARY RADIATIVE DIVERTOR DESIGN	STAMBAUGH
(ORNL)	PELLET INJECTOR READY TO OPERATE	HILLIS
(ORNL)	ASSESSMENT OF PARTICLE CONFINEMENT IN ELM FREE & ELMING H-MODE	HILLIS



PROGRAM STATUS
3rd QUARTER — FY 1994
DIII-D RESEARCH OPERATIONS

DIII-D PROGRAM
COMING ATTRACTIONS
4th QUARTER — FY 1994

- Continue experiments in July and September
- Begin FWCD experiments
- Operate C-coil
- 110 GHz ECH
  - — GYCOM and Varian gyrotron development
  - — Window testing
- Present results at Soft and IAEA meetings
- Prepare detailed budget and plans for FY95 based on OFE funding

PROGRAM STATUS
3rd QUARTER — FY 1994
DIII-D RESEARCH OPERATIONS

HIGHLIGHTS:

- Began experimental research operations
- Successfully passed Radiative Divertor Project review
- Presented papers at PSI, Diagnostics, and EPS meetings and prepared IAEA synopses
- New computer speeds up data acquisition
- Completed milestones
  - — Completed installation of FWCD antennas with Faraday shields (Milestone No. 83)
  - — Completed report of Radiative Divertor Preliminary design with review committee June 14–15 (Milestone No. 95)

INTRODUCTION AND PROGRAM PLANNING

The DIII–D tokamak has returned to routine operation following the recent major installation period. Vacuum conditions and over-all plasma characteristics were excellent by the end of the quarter. Considerable effort was expended during this quarter in completing the testing and calibration of various systems and diagnostics. Four sections of the new C–coil were completed, much of the new computer hardware needed to support the experimental effort was installed, and much of the installation of the new ICRF power systems was completed.

There were three weeks dedicated to experimental plasma operations this quarter. In addition ten shifts were spent on operations related calibration and testing activities.

Excellent progress has been made on the new ICRF systems. The first of the two systems will be ready for initial tests during the July experimental period. Accomplishing this has required considerable effort in working with late deliveries from the transmission line vendors to get critical parts. Considerable effort has also been required to get the power system for the first transmitter working. It is presently anticipated that the second system will be operational for the September run period although considerable concern remains over the delivery of transmission line parts for that system, and parts for the second power system have been used to make the first system operational.

The installation of new computer systems to support DIII–D operation is progressing rapidly and is already substantially improving response time during tokamak operations. The new data acquisition computer has been installed and much of the conversion to a UNIX operating system is complete. The time required to collect data between discharges has been reduced from 8 minutes to 3.5 minutes. The work station dedicated to analysis between shots has been installed and is operational. The size of the largest data set for a single shot has increased to 106 Mbytes.

Plans for the next quarter call for experiments in July and September. The main objectives during these run periods is to obtain plasma operations with the first of the new ICRF power systems, obtaining final results for inclusion in IAEA papers and achieving first operation of the pellet injector into plasma.

There will be no plasma operations over a six week interval beginning the first of August. This will allow the staff to take vacations which is necessary to reduce the manpower charges to the DIII–D program. During this time we plan to complete the installation of the second new ICRF system, and the last parts of the C–coil. The remainder of the new computers will also be integrated into the DIII–D data acquisition system.

We also anticipate considerable operation in the first quarter of the next fiscal year. Experiments are planned in October and additional experiments are planned in late November

and December. Considerable additional time will also be required for testing and calibration of experimental systems. Shortly after the first of the year, we anticipate venting the tokamak in order to install a new divertor Thomson scattering diagnostic, the BES system, and other diagnostics focused on increased understanding of the divertor. This activity is anticipated to take roughly two months, and following completion of the tasks we will return to routine experimental operation.

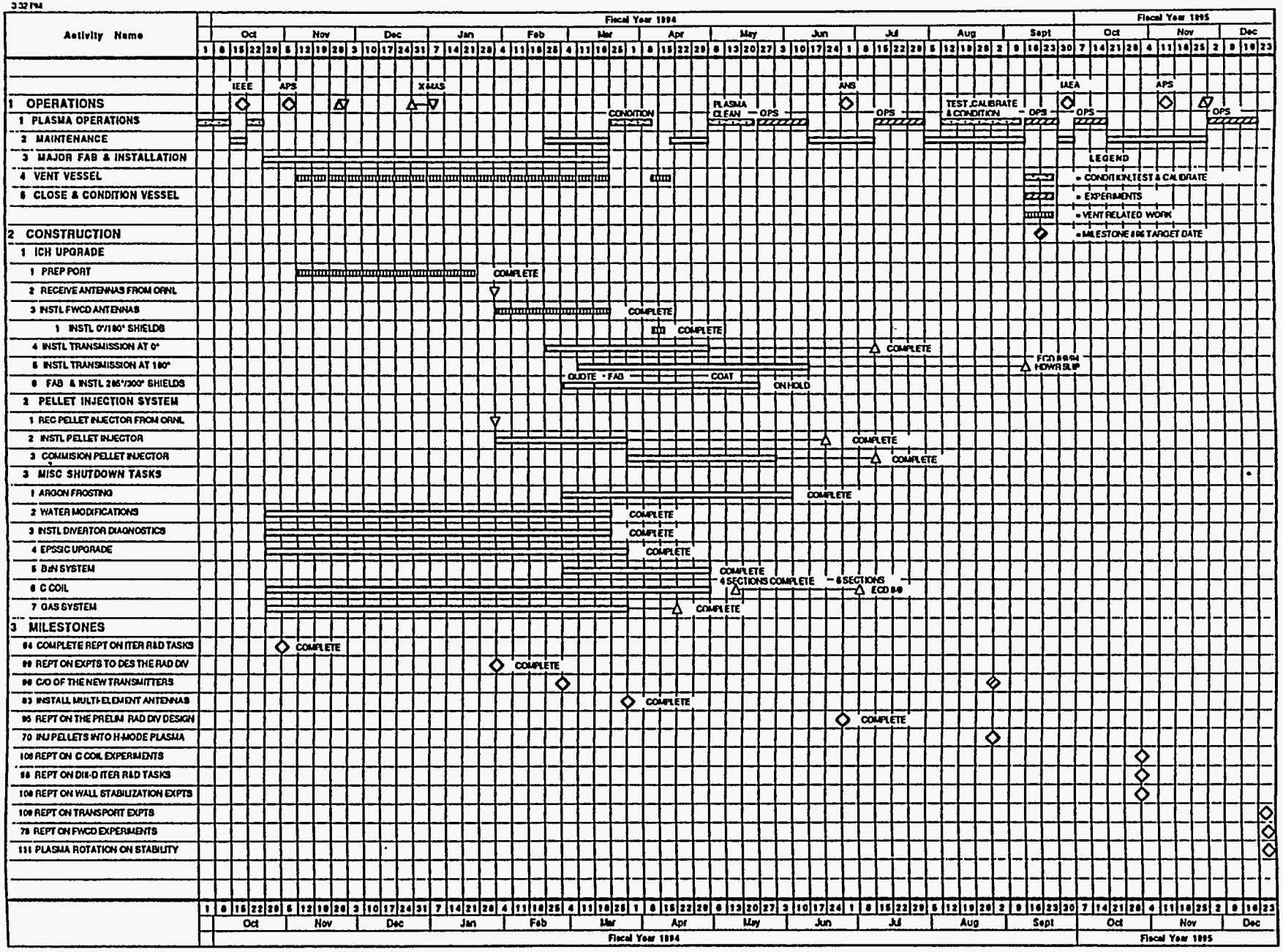
The upgrade projects have progressed well this past quarter. 1.) The Russians operated a short pulse prototype of our gyrotron at 1 MW (for 0.1 sec). They have now begun fabrication of the DIII–D long pulse gyrotron and expect it to be operating in November. 2.) Commissioning of the fast wave current drive upgrade has progressed in spite of delays in receiving certain transmission line components. We still anticipate first plasma experiments in July, as originally scheduled, but with only one of the two transmitters. The second transmitter should be available for experiments in September. The additional transmission line costs offset the transmitter procurement savings. 3.) An international committee of experts reviewed our radiative divertor project plans. Then endorsed the project.

On a longer term planning horizon we are begining to develop coordinated collaboration plans for FY95. The LLNL collaboration will largely continue as this year except their effort will be stressed by the installation of the divertor Thomson scattering in January for which they are responsible. This also requires support from GA. The ORNL collaboration is shifting from construction (FWCD antennas and pellet injector) to research operation and includes the addition of effort from ATF. We are working out details of the specific tasks and persons. The main concern has to do with the level of ORNL personnel on-site in San Diego. The new collaboration with PPPL is not yet well defined. General tasks areas have been agreed to but the funding level, individual assignments, and schedules have not been finalized. This needs to be completed before the end of August. Plans with SNL and the university collaborators are established contingent on their receiving the anticipated DOE funding.

The major budget concern centers around FY94 operating expenditures. GA plans to operate DIII–D in September. This results in an approximate $1M obligation for FY95. A second budget concern has to do with a short fall in capital in FY95. The congressional budget is $2.9M whereas $4.9M is needed. This requires trading operating funds for capital fundsin FY95.

Jul 15, 1994
3:32 PM

DIII-D OPERATION SCHEDULE



RESEARCH PROGRAM

BOUNDARY PHYSICS AND TECHNOLOGY

In the divertor area, work this quarter focussed on preparation of papers for the 11th International Conference on Plasma Surface Insteractions in Mito, Japan. Progress in experiments and code development were reported. Considerable work on diagnostics was done to prepare for the summer run period. A review of the Radiative Divertor Program was held.

In H–mode physics, VH–mode plasmas were obtained in an inner wall limiter configuration. Preparations for upcoming experiments, the upgrade of CER, and other diagnostics continued. A design review for the BES system was held.

DIVERTOR ENGINEERING

Advanced Divertor. Two days of biasing and pumping experiments were completed using the Advanced Divertor hardware. The hardware, both cryo pump and ring electrode, operated successfully during these experiments. Data was taken with the new bias ring IR TV.

Radiative Divertor. Design work continued on the modular Radiative Divertor hardware. Thermal and stress analysis on the structures proved feasibility of the concepts. Structural analysis of the inboard cryopump and supports were performed to support the design efforts for the new pump. Three different slot lengths are incorporated into the design along with variability in the slot width. Biasing is designed in as an add on system. Diagnostic access was carefully addressed for the three slot lengths under consideration. The 23 cm slot requires little modification of existing diagnostics as opposed to the 33 and 43 cm designs which require modification to view down into the slots. A international peer review board reviewed the engineering design with the most significant recommendation made that halo currents should be addressed in a slightly different manner.

IMPURITY STUDIES

ORNL He Transport and Exhaust Studies. Recent analysis has focused on helium transport data taken over the past few years and has shown that the helium particle diffusivity and the effective thermal diffusivity have nearly the same magnitude and profile shape in all conditions studied to date. Work in the area of helium transport studies over the past several years has culminated in two oral presentations and a paper submitted to Physical Review Letters. One oral presentation was given at the 11th Plasma Surface Interaction conference in Mito Japan. In addition an invited talk was given at the American Nuclear Society Topical meeting on Fusion Technology in New Orleans. As reported in these papers, the exhaust rate of He from these ELMing H–mode plasmas appears to be within the acceptable range for a fusion reactor, like ITER, based on a measured value of $\tau^*_{He}/\tau_E \approx 8$–12, which is a current measure of the "goodness" of a fusion reactor. Current reactor modeling codes indicate that this ratio τ^*_{He}/τ_E should be $\leq$ 7–15. A synopsis entitled "Helium Transport and Exhaust Studies in Enhanced Confinement Regimes on the DIII–D Tokamak" has also been accepted for presentation at the 15th International Conference on Plasma Physics and Controlled Nuclear Fusion Research.

In preparation for the upcoming DIII-D run period, the CER spectroscopy system and the H-alpha photo-diode array have been calibrated and the He penning gauge has been repaired.

Spectroscopy. The SPRED sprectrograph was operational during the vessel vent recovery. Early in the vent recovery phase, oxygen appeared to be limiting the burnthrough phase of the discharge. Also, monitoring of the spectra during initial clean-up operations showed a large influx of sulfur and bromine. However the sulfur and bromine levels rapidly decreased to levels similar to those observed last year.

The global air leak rate was reduced after several days of leak checking and in subsequent discharges there were no unusual impurity events to report. During the last operations period the spectrometer experienced a malfunction which caused the control hardware to deactivate during a tokamak shot. The malfunction is believed to be caused by a faulty relay and should be repaired in time for the next operations period.

Monte Carlo Impurity Transport Model (MCI). The MCI code was debugged and further improved. The ion and particle pushing routines were largely re-written, enforcing strict un-biased sampling of diffusion and ionization models. Expressions for the thermal gradient forces were corrected and generalized for arbitrary impurity species. A sheath potential model was incorporated in the boundary condition module. Errors in extrapolation of UEDGE background plasma data to the boundary defined by the DIII–D limiter were identified and a preliminary solution was adopted.

Several "gas bag" type limiter configurations, differing in aperture and shelf height, were developed in preparation for parametric studies of impurity retention for such configurations.

MIST and Transport Analysis. Analysis of core impurity behaviour during a power scan spanning many shots has shown that the C VI line radiation used for central impurity measurements can be affected by large gas puffing into the edge. Using MIST, the cause of this increase seems to stem from a change in the edge density and temperature profile, although this explanation is not totally convincing. A valid explanation of this behavior is needed in order to use the beam method (when the beams are not notched) to determine core impurity levels.

Wall Conditioning. The anode voltage for glow discharge conditioning is now routinely above 700V, the highest voltage yet obtained since helium glow between discharges was implemented in 1988. Past studies have shown that recycling is reduced as anode voltage increases, so better conditioned walls should be possible with this advance. Several technical and operational problems were solved in order to operate at this high voltage. Now both anodes operate at approximately the same voltage.

DiMES. The DiMES sample insertion mechanism was removed from DIII–D to repair a leak between its secondary and primary vacuums. Repair of the DiMES mechanism is proceeding smoothly. The misalignment in the top flange of the mechanism was fixed and then carefully documented by QA. Re-installation on DIII–D is scheduled for the first week in July in order to be ready for the July operations period.

A new colorimetry diagnostic is being installed on DIII–D. The schedule is to use this diagnostic to measure film thickness during the next boronization July 9. Preliminary data will also be obtained during July to test the equipment and the procedures during tokamak operations. The colorimetry technique uses visible light reflected from a film at different wavelengths (red, green, blue) to infer the thickness of that film. Both DiMES samples and the graphite tiles surrounding DIMES can be viewed with this diagnostic and divertor erosion and deposition can be determined.

Preliminary laboratory work is in progress. The colorimetry camera and the filter wheel have been installed on an optical bench. The light source and the lens which will later be used at DIII–D to illuminate DIMES are now used to illuminate a precoated graphite tile. The camera is connected to the same VCR in the control room which will later be used to record the pictures of DIMES. First pictures of the test sample through three (red, green and blue) filters have been recorded. The brightness of the blue picture is very low, so to avoid possible problems an additional broadband filter with a center wavelength of 750 nm has being considered.

DIVERTOR MODELING

During the past quarter the boundary plasma modeling effort was focused on two events; presentations at the 11th International Conference on Plasma Surface Interactions in Controlled Fusion Devices, held in Mito City, Japan; and plasma modeling for the design of the DIII–D radiative divertor program. In support of these two foci, we have significantly enhanced the capability of the plasma fluid model of the scrape-off-layer (SOL), our ability to analyze neutral transport in a variety of baffle configurations, and the edge database.

Progress in the development of the 2–D plasma fluid code, UEDGE, has come in improving the numerical methods for a more robust code, adding additional physics capability, and running the code for a wide variety of DIII–D discharges, and plasma design configurations. The primary improvement in the physics capability of the code has been the recent addition of the ability to use non-orthogonal grids, and the inclusion of impurity transport equations for both an average ion model, and multi-species impurity model. The ability to model with non-orthogonal grids enables us to analyze the plasma with a more realistic divertor plate configuration.

We have improved our ability to analyze neutral transport in a variety of baffle configurations by developing the RECLUSE code. This code permits the rapid development of a grid which extends the flux-surface based grid used in the UEDGE code to a realistic vacuum wall and divertor plate geometry. The extension of this UEDGE grid then permits analysis of the neutral particle flow using the Monte Carlo code DEGAS. We have used this capability to determine the core ionization rates expected from a variety of baffle configurations for the DIII–D radiative divertor program.

Combined UEDGE and DEGAS simulation of the radiative divertor configuration indicate that a properly shaped baffle can reduce the core ionization rate arising from neutral recycling at the divertor by a factor of 10 over that expected for an open divertor. This reduction is sensitive to at least two factors; the distance from the separatrix to the nose of the baffle, and recycling from the horizontal surface of the baffle at the outer radial region of the SOL.

We have used the UEDGE code to analyze several DIII-D discharges. Most of our effort has been focused on H–mode discharges, although we have examined one low power L–mode shot. The results of our modeling efforts were recently presented at the PSI meeting in Mito city, Japan. We also gave a review talk on Divertor Bias Experiments throughout the world.

DIVERTOR PHYSICS

Work this quarter focused on data analysis for the bi-annual 11th Int. Conf. on Plasma Surface Interactions in Mito, Japan, and on preparation for the start of physics operations. Four papers from the Boundary Physics Group were presented at the PSI meeting, covering the subjects of power balance, toroidal asymmetries, enhanced SOL plasmas in double-null discharges, and the

effect of divertor pumping on the divertor plasma. Some highlights from these papers are: 1) power balance for ELMing H–modes has been improved to about 85% total accountability on average, 2) toroidal asymmetries are only observed on a small subset of single-null discharges, but on a much larger fraction of double-null shots, 3) enhanced scrape-off layers (higher density further from the separatrix) have been observed on L–, H–, and VH–mode discharges and may be related to the triangularity, δ, and 4) reducing $\bar{n}_e$ by divertor pumping allows the inboard divertor leg to reattach to the target plate, which increases the heat load there. These analysis results are being used to guide planning for future experiments.

In preparation for plasma operations, we worked to get all divertor diagnostics operating again following repairs and upgrades during the vent. A new divertor interferometer was installed and testing was starting during the first plasma operations. A new IR TV camera viewing the face of the bias ring and the throat of the divertor pump was installed and started taking data. An image intensifier for the tangential X–point TV was tested (this will help in imaging impurity line emission from the divertor region). The bolometers had new sensor blocks installed to reduce noise and the old array was moved to accommodate the new edge MSE system. The divertor probe electronics were repaired after it was found that a number of amplifiers were damaged during the last run period. And, some of the neutral pressure gauges were repaired. All of these diagnostics should now be available for the divertor experiments scheduled for this summer.

Members of the divertor group also worked on the diagnostic plan for the Radiative Divertor Project. We made more detailed assessments of the diagnostic modifications required when the new divertor hardware is installed and worked on a preliminary cost estimate and schedule for these modifications. We are now preparing a report on this plan.

H–MODE PHYSICS

Inner wall marginally limited VH–mode discharges were obtained for the first time during an experimental run on June 3. A characteristic of these discharges is that the separatrix flux surface nearly touches the inside wall (inner wall gap ≈ 0). The confinement enhancement was a factor of 2 above DIII–D/JET scaling. The heat deposition profile measured by the IR camera was similar to double-null VH–mode discharges. A toroidal spin-up, characteristic of DND VH–mode discharges, was clearly observed.

The highest priority miniproposal from the L to H Transition Working Group was approved. The goal of this experiment is to make a detailed investigation of the time history of the electric field and edge turbulence across the L to H transition. The fast stroke Langmuir probe has demonstrated 10 microsecond resolution in initial proof of principle experiments. If the results of

these two preliminary shots hold up, we will be able to conclude that the radial electric field starts to change 1–2 ms prior to the transition.

A miniproposal on the "Effect of NBI on Core Correlation Lengths," by T.L. Rhodes *et al.*, was written and approved (MP 315). This is the highest priority miniproposal from the Core Fluctuations Working Group.

Two miniproposals for counter neutral beam injection experiments have been written and were approved by the Research Planning Committee. These are high priority experiments from the VH-mode Working Group.

CER spatial and intensity calibration were completed during the vent in April, 1994. The in-vessel mirror at 315 R–2 was replaced; this increased the signal by about 20%.

The code that controls the CER system has been modified to take advantage of the multiple timing groups that are now allowed by the new hardware. We can now acquire data in four separate groups, each with its own start time integration time and number of timeslices. In addition, to exploit this timing flexibility, we have doubled the amount of data acquired to 8 Mbyte per shot. Improvements in the data acquisition cycle coding have kept the total acquisition time the same. These changes have forced changes in the output file formats (especially the header files) which, in turn, affect the analysis codes. In order to ease the load on the DIII–D computers, we are implementing local archiving of the CER data during an experimental day. The data will be gathered into the main shot data files after hours.Analysis of the computer coding required to maintain and extend the CER system analysis codes indicates the recent changes in the system will require 2–3 months of programming; since no programming support is available, effort that should be going into data analysis will be used for this work. This effort began in May; we are about one half done.

A workshop was held on June 20, 1994 on the status and plans for the deuterium BES diagnostic on DIII–D. It covered both the technical basis for the diagnostic and plans for experiments where BES could make a unique contribution.

The conceptual design review for the deuterium BES system was held on June 21, 1994. Minor technical concerns were identified by the participants, which will be addressed in the detailed design. Detailed design and fabrication will begin in FY95. The goal is to install the port interface during the vent of DIII–D in January, 1995. R. Durst and R. Fonck of the University of Wisconsin will be providing the detectors and data acquisition system. The goal is initial operation of a 16 channel system in March, 1995 with an upgrade to a 32 channel system in FY1996. This goal may be impacted by the extended operation of TFTR. K. Burrell met with R. Blanken, R. Dagazian and R. McKnight of DOE to discuss the deuterium BES system on DIII–D. The results of the workshop and the design review were summarized. Blanken stated that funding for the Wisconsin portion of the the project would be available.

The UCLA profile measurement reflectometer system was made operated during the last run period. In particular, profiles were obtained at a series of FW power levels for antenna loading calculations during the "nude" FW antenna operation experiment. The data obtained seems to be of high quality and shows profile modifications at low FW power levels—analysis is continuing.

Significant support was given to the ORNL reflectometry team in helping to make their system operational and ensure that they were able to take data during the "nude" FW antenna experiment. By operating both the UCLA and ORNL systems, reflectometer density profiles were obtained at two different toroidal locations for this run day.

We have cured the vibration problem for the phase contrast imaging (PCI) system that was produced by firing the fast stroke Langmuir probe by constructing a simple new support structure for one of the PCI mirrors. The support was tested both visually and by acquiring data during plasma operations, with fully successful results: no vibrations were observed when the Langmuir probe was fired.

D. Thomas presented an invited talk at the 10th High Temperature Plasma Diagnostics Conference on the results from the DIII-D lithium beam diagnostic. S. Coda (MIT), W.A. Peebles (UCLA), T.L. Rhodes (UCLA), C.L. Rettig (UCLA) and K.W. Kim (UCLA) presented posters at the same meeting.

CORE PHYSICS

CONFINEMENT

Two confinement related experiments were performed in our first experimental run period this year. An experiment to measure the change in volume averaged triple product $\langle nT \rangle \tau$ due to an increase in plasma elongation was performed. The motivation for the experiment came from the need for ITER to ascertain whether there may be a cost savings by reducing the overall size of the device with no deleterious effect on, and perhaps a modest gain in, ignition margin. The plasma elongation was varied from 1.7 to 1.9 by reducing the minor radius at fixed plasma height, $\beta_N = 1.8$, $q_{95} = 3.8$, $\langle ne \rangle = 4 \times 10^{19}$ m^{-3}, and $P_{NBI} = 6$ MW. Several H-mode energy confinement scaling expressions predict that elongating the plasma in this manner would lead to an increase in $\langle nT \rangle \tau$. Detailed EFIT and profile analysis indicates a substantial 50% increase in volume averaged ion temperature was obtained while only a modest 20% increase in volume averaged electron temperature was observed. Increases in T_e and T_i were observed over most of the profile. Confinement time remained about constant. Thus an increase in elongation obtained by reducing minor radius resulted in an estimated 40% increase in $\langle nT \rangle \tau$ predominantly due to an increase in ion temperature. Transport analysis indicates that the single fluid diffusivity profiles of the low and high elongation discharges were similar. The improvement in

performance in the high elongation case was correlated with a peaking of the heating profile. Similar analysis comparing a pair of low and high elongation discharges at higher density <ne> = 6.5×10^{19} m^{-3} resulted in a similar trend in ion and electron temperature improvements but much smaller improvements of 16% and 8% respectively were obtained. This results were presented at an ITER science meeting at the San Diego JCT site.

Another confinement experiment was devoted to studying the dependence of thermal diffuivity on density and temperature in 1 MA H–mode discharges. A factor of 2 difference in density was obtained at constant temperature by employing the cryopump and varying NBI power to hold the temperature fixed. Detailed energy transport analysis that concentrates on the dependence of thermal diffusivity on density at fixed temperature, plasma current, and beam depostion profile will be possible with this dataset.

Formation of ITER expert groups in seven different areas took place this quarter. Six DIII–D staff members participated in the first meeting of U.S. members held at Germantown, Maryland. Discussions focused on the role to be played by the various expert groups and modes of interaction between these groups and other U.S. and international groups.

Plasma Rotation and Wall Stabilization of High Beta Discharges

Analysis of high β_N discharges with low internal inductance has clearly shown the importance of the rotation and the rotation profile in maintaining stability with a resistive wall. Discharges were operated in full sized double null divertro configuration with low internal inductance, ℓ_i, in order to maximaize the coupling to the vacuum vessel wall. One discharge (80111) with $q(0) > 1$ was analyzed in detail, and normalized beta, $\beta_N = \beta/(I/aB)$, in this discharge reached $\beta_N = 3.8$ and remained near this value for many resistive wall times. To evaluate the stability limit in the absence of the wall, experimental equilibria from earlier in the discharge evolution at lower values of beta were analyzed. These equilibria were reconstructed using the measured pressure profile and q profile determined from the motional Stark effect diagnostic. Using these equilibria, the maximum value stable to n = 1 modes with no wall stabilization is $\beta_N = \beta/(I/aB) = 2.8$.

The good confinement phase of discharge 80111 is terminated by an m/n = 3/1 instability which has some of the characteristics expected of an ideal-plasma, resistive-wall mode stabilized by plasma rotation. The instability has a growth time of about 5 ms, comparable to the wall penetration time, and is stationary with respect to the wall from its onset. Although the discharge dwells near the maximum beta value for about 50 ms, the rotation velocity profile is evolving during this time. The rotation of the $q = 2$ surface is slowing but remains greater than 5 kHz, sufficient to provide stabilization of the m/n = 2/1 mode. However, the plasma rotation velocity at the $q = 3$ surface, as determined from charge exchange recombination (CER) spectroscopy,

decreases to zero shortly before the onset of the instability. This is consistent with the hypothesis that the 3/1 mode is Doppler-shifted by the plasma rotation, becoming unstable only when the rotation ceases and the stabilizing influence becomes that of a resistive wall rather than an ideal wall.

We speculate that toroidicity-induced Alfvén eigenmodes (TAE modes) may contribute to the loss of wall stabilization of the 3/1 mode. The downturn in the rotation rate coincides with the onset of large-amplitude TAE activity, leading to the loss of nearly half of the neutral beam ions as estimated from the D–D neutron rate. The reduction of angular momentum input as the fast ions are lost may be the reason for the slowing of the rotation.

Motional Stark Effect (MSE) Diagnostic Upgrade

The operation of the upgraded 16 channel MSE system during the first plasma operations period was very successful. High quality data were obtained on nearly all discharges. Offset angle calibrations performed for toroidal field values of –1.5 to –2.1 T look quite good. As in the past, we continue to have greater uncertainty in the calibration data at low-field (~1 T). An insertable in-vacuum polarizer on the edge MSE system has allowed us to accurately measure the small Faraday rotation effect in the optics. The EFIT/MSE equilibrium reconstruction codes have been updated for the 16 channel system, and are now used routinely. Although analysis of the first set of plasma experiments is still ongoing, some of the initial MSE highlights include:

1. Comparison of central and edge systems: the central and edge MSE systems have one common chord at R = 198 cm. Because the two instruments have completely separate viewing geometries and collection optics, this common measurement point is a useful check for systematic errors. Currently there is a ~3% systematic difference between the two measurements, which is quite good. We are making efforts to further improve this.
2. q_0 measurements: although sawtooth studies were not a significant part of the initial plasma operations period, there are some discharges with small amplitude sawteeth and a small inversion radius. We now have twice the chord density near the magnetic axis (every 5 cm) which helps constrain the uncertainty in q_0 to less than 0.05. In these early experiments, sawtoothing discharges had q_0 of almost exactly one. Before drawing conclusions on q_0 during sawteeth, we need to obtain discharges that have larger amplitude sawteeth with a larger inversion radius.
3. Edge current during L–H or L–VH–mode transition: the radial resolution of MSE measurements near the edge at R~228 cm has been improved from 12 cm to 2 cm. With this enhanced resolution, we are beginning to see more structure in the edge current density. In particular, there appears to be a significant edge current (perturbation in edge

poloidal field) that develops right at the L–H or L–VH transition time and is located near the region of steep pressure gradient very close to the separatrix.

Equilibria Reconstruction Including Measured Toroidal Rotation

The equilibria reconstruction code EFIT has been modified to include toroidal rotation. Testing of the code using DIII–D experimental data is under way. A rotational equilibrium of a VH–mode discharge has been reconstructed using a full set of magnetic, MSE, kinetic, and rotational profile data. Initial results indicate that the most distinctive feature of this rotational equilibrium is the displacement of the pressure surface from the magnetic surface in the region where there is strong toroidal flow. Further analysis of DIII–D discharges is in progress. A numerical scheme to implement the higher order non--linear response in the reconstruction of rotational equilibria has been developed and implemented into EFIT. Comparisons to the reconstruction results using only the low order response terms is in progress.

Progress on Plasma Control

The programmable anti-aliasing filters for the control system input signals have arrived and are being installed. Code for C coil control was written by Tim Scoville and is being tested. Code for reverse I_p operation was written by Al Hyatt and will be tested during counter injection experiments. Some changes were made in the software to be more immune to hardware failures.

H–mode and VH–mode Confinement in Marginally Limited Discharges

An experiment to evaluate the confinement in discharges limited on the inside wall has been completed. VH–mode with $\tau_E/\tau_{ITER89P} = H > 3$, was obtained in limiter discharges with the X–point outside the vessel. These VH–mode discharges were marginally limited, meaning that the separatrix flux surface is outside the limiter defined flux surface, but close by: the distance of closest approach between the limiter defined flux surface and the separatix defined flux surface, SEPLIM, is 1–2 mm. In discharges that were more limited, with SEPLIM approximately 5 mm, good ELMing H–moses were obtained with confinement equal to that predicted by JET/DIII–D ELM-free H–mode scaling. Low impurity content, low Z_{eff}, was obtained in these discharges.

RF PHYSICS AND TECHNOLOGY

RF PHYSICS

The existing Fast Wave Current Drive antenna was operated into plasma discharges without a Faraday shield for four piggyback days and one dedicated run day. The maximum long pulse power achieved was 0.82 MW, with short pulses as high as 1.24 MW. By comparison, long pulse power of 1.6 MW was achieved last year with a Faraday shield. However, there is possible

evidence that the limit was not the antenna, and the power limit will again be tested during the July run period.

During the no shield run day, extensive data on edge density profiles were obtained from microwave reflectometers and the recriprocating Langmuir probe. Changes in the scrape off layer and antenna loading were correlated with rf power. The data will be used to compare the actual antenna loading with theory. A key diagnostic for this experiment is the newly commissioned reflectometer from ORNL.

One of the two new FWCD antennas has not yet been connected to the transmission line and the straps can be easily accessed electrically externally. This allowed the antenna straps to be connected in the mode of the so-called combline antenna for low power measurements during plasma operations. The initial tests were promising but a great deal more testing is required to determine the coupling and directivity of the combline. The combline is a novel antenna for future FWCD systems.

The experimental FWCD dataset from 1993 was extensively compared to theoretical calculations from the CURRAY ray-tracing code. Good agreement was found between the model and experiment if a fixed edge loss in CURRAY of 3–4% per pass of the wave was included.

Two papers were prepared and presented at the meeting of the European Physical Society. The first summarized results from the 1993 FWCD campaign and the second describes the determination of the non-inductive current profile through a calculation of the electric field profile by differentiation of successive experimental equilibria.

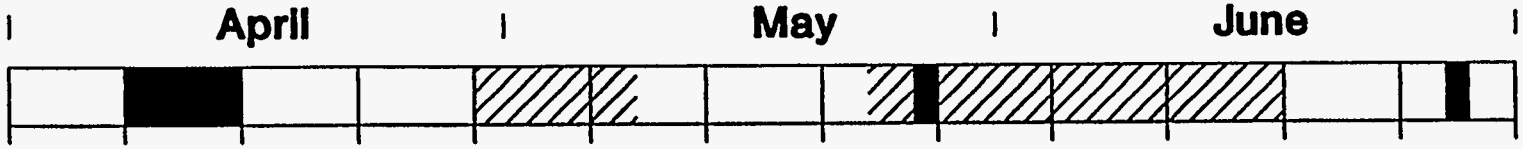
An extended synopsis on transport issues (dimensionally similar discharges and the heat pinch effect) for the 1994 IAEA meeting was accepted by the US selection committee.

OPERATIONS

TOKAMAK OPERATIONS

Experimental operations resumed in the third quarter following an intensive period of post vent systems checkout and vessel conditioning. A chronological summary of the operational activity for the quarter is shown in Fig. 1. After the vessel closure in mid-March and two weeks of power testing, leak checking, and baking, the vessel was vented on April 6 for one week to complete the in-vessel work. Major tasks accomplished included installation of the two B_4C coated Faraday shields, installation of the graphite tiles surrounding the antennae and the bumper limiter tiles, resolution of the high voltage breakdown on the ADP ring, repair of the in-vessel boronization gas lines, installation of the boronization sample array, calibration of the neutron, MSE, and CER diagnostics, and numerous other small tasks. All tasks were successfully completed and the vessel was pumped down on April 15.

DIII-D FY94 Third Quarter Operations



- NB conditioning
- Power systems checkout
- Vent to install Faraday shield
- First plasma
- H-mode achieved
- Diagnostic checkout
- Ops delayed for leak checking
- Vent to repair bolometer shutter
- VH mode achieved
- Disruption experiment
- Boronization
- Vent to repair ASDEX pressure gauge
- Successful operation of C-coil

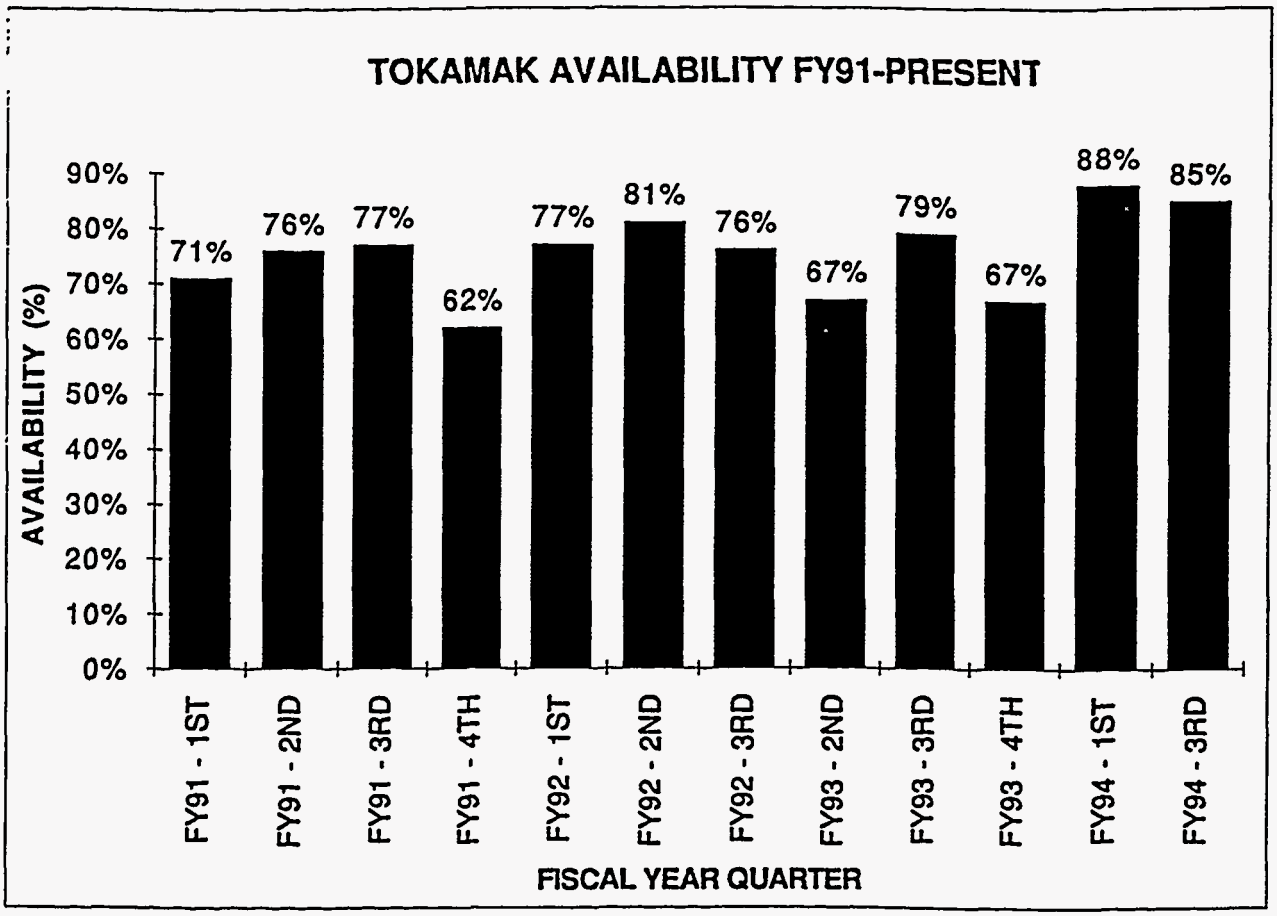
= Maintenance
= Operations
= Vent

Prior to the beginning of physics experiments in May, six days of plasma operation were performed for the purpose of conditioning the plasma facing components and the neutral beam drift ducts. Initial operation indicated that the vessel conditioning had rapidly reached a plateau that was below the level of cleanliness typically required for successful experiments. This was characterized by excessive radiation due to oxygen, high radiated power, and an inability to operate at either high current or low density. A possible explanation was that the small remaining vacuum leaks were contaminating the vessel. As a result, plasma operation was delayed for approximately one week in order to perform further leak checking of the vessel. During this time, four leaks were identified and the two dominant leaks were repaired. This reduced the measured leak/outgassing rate from 1×10^{-4} Torr-liter/sec to 2×10^{-5} Torr-liter/sec, a value that is typical for successful operation. Subsequent operation showed continual improvement and VH–mode operation was obtained on the last day of the conditioning period.

During the quarter, the tokamak was operated for 12 days for physics experiments with an availability of 85%. Analysis of the downtime is shown in Fig. 2. The major source of downtime was associated with the repair of the D2 field shaping supply. In addition to experimental operations, considerable time was dedicated to operating various tokamak systems for diagnostic calibration and power supply testing. Successful calibrations were performed on the Thomson scattering system, ASDEX pressure gauges, piezo valve flow sensors, lithium beam and the MSE diagnostic. Five additional operational shifts were dedicated for testing of the new C-coil power supplies, modification of the ohmic heating power supply for improved performance, and for plasma feedback system control matrix measurements.

During the quarter, there were a number of short clean vents to repair diagnostic systems considered critical for upcoming physics experiments. The vessel was vented on Friday May 20 to repair a broken shutter on the bolometer system and following a ten hour bake to 350°C, plasma operations with VH–mode were obtained on Monday. The vessel was also vented twice in June for the removal and reinstallation of the fast pressure gauge. Following the June vents, the tokamak was baked and the leak/outgassing rate rapidly recovered.

There was considerable progress made in bringing up systems to monitor vessel heat loads on critical components, in particular, the Fast Wave Current Drive antennas and Faraday shields and the new outer wall bumper limiter tiles. A 3–element germanium lens system and IR camera have been installed for viewing the 180° antenna and shield. This IR camera utilizes a moveable mirror to allow viewing of either the antenna or the ADP ring and is presently producing clear images. An IR camera has also been installed for viewing the 0° antenna and shield and visible light camera views are available for both the 0° antenna and the old FWCD antenna at 300°. Observations using these camera views in conjunction with thermocouple readings from the outer wall bumper limiter tiles at 95°, 220°, and 310° have been used to develop an


TOKAMAK AVAILABILITY FY91-PRESENT
AVAILABILITY (%)
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
71%
76%
77%
62%
77%
81%
76%
67%
79%
67%
88%
85%
FY91 - 1ST
FY91 - 2ND
FY91 - 3RD
FY91 - 4TH
FY92 - 1ST
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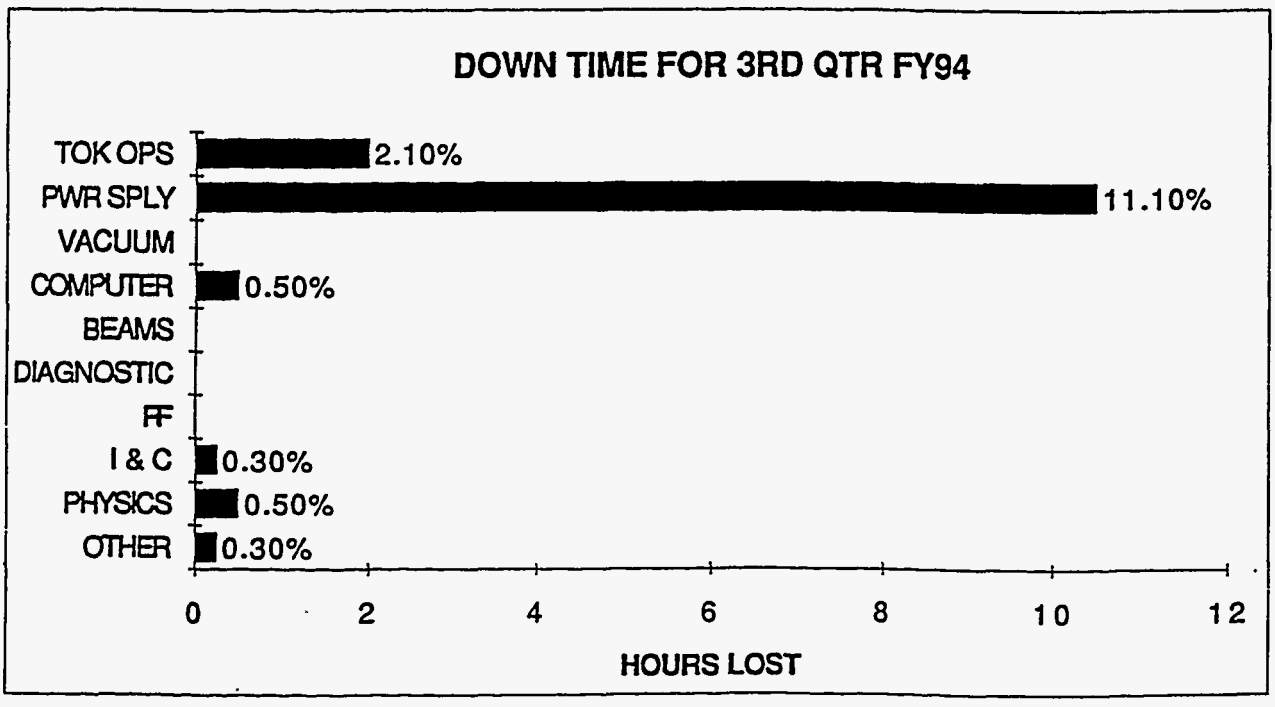
FY93 - 3RD
FY93 - 4TH
FY94 - 1ST
FY94 - 3RD
FISCAL YEAR QUARTER


DOWN TIME FOR 3RD QTR FY94
TOK OPS
PWR SPLY
VACUUM
COMPUTER
BEAMS
DIAGNOSTIC
RF
I & C
PHYSICS
OTHER
2.10%
11.10%
0.50%
0.30%
0.50%
0.30%
0
2
4
6
8
10
12
HOURS LOST

understanding of the factors affecting the heat loads on these components. Based on this data, a set of operating guidelines have been developed for the minimum gap spacing permitted between the plasma and the outer bumper limiter as a function of injected power and pulse length. These guidelines should limit the surface and bulk temperature of the outer bumper tiles to safe levels and simultaneously limit excess interaction of the plasma with the Faraday shields.

Following the installation of the first four sections of the C–coil, a set of electrical tests of the structure were performed to verify proper construction. These included a successful high voltage test to 5 kV of the entire system including support struts, isolated bolts, insulated connections, and cables. A single point ground was also verified for each part of the structure. The coil resistances, hard ground connections (for personnel safety) and soft ground connections (for ground reference during operation) were all verified. Prior to the testing of the coil with the new C–coil power supplies, additional instrumentation was also installed. These included two Rogowskis for measuring the coil currents, two temporary TV cameras for viewing any structural motion during the testing, and fiber optic temperature sensors for the coil. All tests of the structure and power supplies have now been completed and the entire system is ready for use in the upcoming experimental period.

DISRUPTION STUDIES

A study of the proper boundary conditions for use with the DINA halo model has been completed. The new simulations will allow the halo to expand to maintain constant halo edge flux from the time of wall contact to the end of the simulation. In addition, a sensitivity study has demonstrated that force, plasma trajectory, and poloidal halo current evolution are insensitive to halo width evolutions which provide significantly wider halos than those resulting from the flux conserving assumption (virtually out to the vessel wall).

During his visit to GA, V. Lukash from the TRINITI lab in Russia has performed a scoping study of major disruptions in ITER using the DINA code. A presentation was made to the ITER San Diego Joint Work Site personnel which will included the present status of the DINA code for disruption and control simulation as well as the results of the two ITER scoping studies performed to date.

The first dedicated disruption experiment was performed this quarter. Disruptions were successfully induced using argon puffs and the timing of the disruptions were reproducible to within a few milliseconds. Analysis of the data is now in progress. Preliminary analysis of the current profile shows a rapid and severe current flattening at the time of the thermal quench. This analysis has been significantly enhanced by using the data from the MSE diagnostic including data from the newly installed edge MSE system. In addition, very large amplitude fluctuations have been observed at the disruption time with frequencies in the range of 600 kHz. Data on

temperature and density profiles, heat deposition patterns, and radiated power were also obtained.

Work began on implementing a neural network technique for the analysis of DIII–D disruptions. The best programming tool seems to be the Matlab software with its extensive neural network package and an excellent signal processing and signal identification package. We have obtained a trial version of the new neural network tool box to augment the existing computational tools. A graphical user interface (GUI) is being built between the DIII–D data base and the Matlab package. This allows easy access to shot data for plotting and data analysis using the wide range of signal processing tools available in the Matlab.

Work continued on the use of TEQ to generate plasma response objects for DIII–D control. A study of rigid versus nonrigid instability growth rates was completed. The results were consistent with previous studies of highly elongated plasmas as well as general theoretical predictions: rigid current-conserving growth rates were found to be lower than nonrigid ideal MHD growth rates. The difference between rigid and nonrigid growth rates ranged from 20% to 50% for a $\kappa = 1.8$ LSND equilibrium, depending on choice of stabilizing conductors. This is of interest to ITER since several studies of axisymmetric instability growth rates have indicated the opposite ordering for the EDA baseline design.

RADIATION MANAGEMENT

Radiation Health Physics

The total neutron radiation at the site boundary in the 3rd quarter was 1.5 millirem, the total gamma radiation was 0.5 millirem, giving a total for the quarter of 2.0 millirem. The California annual limit is 100 millirem.

Radiation monitoring for in-vessel vent work and for pit work continued. A total of 87 people received doses from work in the vessel or near the machine his quarter and the highest accumulated dose was 48 mrem.

The radiation monitoring system was readied for plasma operations and the two part check out procedure, before and during first plasmas, was successfully performed and logged.

The holes in the North and South pit wall for RF lines and in the East wall for the pellet injector cryo line have been temporarily filled with poly shielding for plasma operations. All pit wall penetrations made during the vent period were shielded for plasma operations.

The annual audit by Health Physics was held on May 25 by R. Tadesse. One minor action item (posting a WA) was generated.

A radiation training class for previously untrained individuals was held on May 26 and attended by 15 people.

The 29 digital dosimeters passed their semiannual calibration check. Two dosimeters, however, had malfunctioning alarm circuits and have been sent out for repair.

The dose near the ramp to the north end of the building (opposite the pit run door) was measured during the recent run period to verify that the building remodeling has not changed the dose at this location. The dose is consistent with the previous measurements.

Work has started on the DIII–D work authorization (WA) renewal which expires in September. The new WA will raise the site boundary guideline from 20 to 40 millirem per year and the DIII–D worker exposure limits from 300 to 400 millirem per quarter (1200 to 1600 millirem per year). The radiation control procedures and exposure control logic is being reworked to be consistent with these increases.

The grit blaster was decontaminated and declared clean in preparation for disassembly and relocation of the unit.

Fusion Product Physics

The second neutron calibration session for the plasma neutron detectors was performed using the californium source in the vessel to determine the absolute calibration of the most sensitive channels.

The new compact horizontal charge exchange system installation was completed and functioned very successfully during neutron generating plasma operations. Even in VH–mode, the neutron noise is a small fraction of the signal, a large improvement over the old analyzer which was unusable during neutron generating deuterium beam injection. A conceptual design for installation of more compact charge exchange detectors on other horizontal and vertical ports has been initiated.

The 15 MeV proton probe was re-installed with the C–coil in place; its new vacuum system awaits installation. The 14 MeV neutron detector is not working properly; a new diode was ordered to replace the radiation damaged detector.

A UC Irvine undergraduate research project was summarized in a short paper entitled "The nonlinear saturation of beam-driven instabilities: Irregular bursting in the DIII-D tokamak." The objective was to determine why the burst cycle of beam-driven instabilities is periodic in many cases, but irregular in many other cases. It was found that, for fishbone bursts in DIII–D, irregularity correlates with the appearance of additional MHD activity. The explanation for this correlation is that the additional MHD perturbs the mode damping and particle transport of the fishbones. Using simple predator-prey model equations it was shown that irregular cycles are expected in the presence of perturbations.

An experiment on the effect of Alfvén instabilities on neutral beam current drive was performed. Initial data analysis suggests that: lots of MHD was created, including BAE modes;

that the MHD correlates with a degradation in fast-ion confinement; and that degraded fast-ion confinement correlates with increases in loop voltage, indicating reduced current drive efficiency.

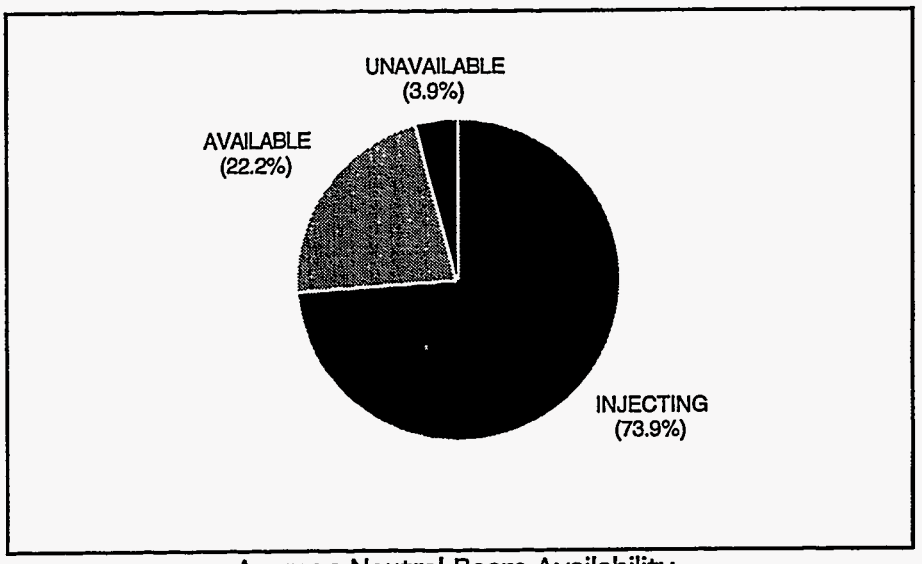
NEUTRAL BEAM OPERATIONS

Operational Summary. Major efforts were put into conditioning all eight ion sources and checking out beam systems in April. In May, neutral beams were injected into the tokamak for beamline drift duct cleaning and vessel conditioning, and for physics diagnostic system (CER and MSE) calibrations. Eight beam systems were then operated to support 11 days of physics experiments in this quarter, three days in May and eight days in June.

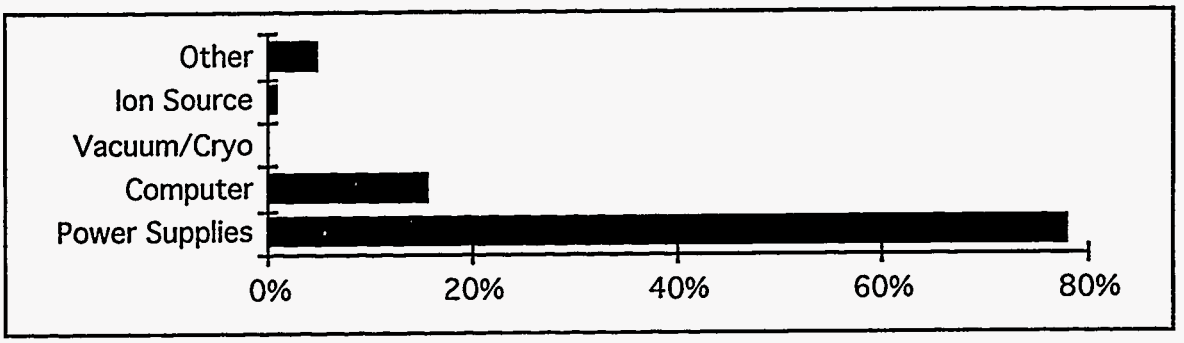
The 30° right source not only still has a beam blocking problem (2–3 beam blocks for a 1–second pulse), it also has a high reading of the gradient grid current and low beam perveance, indicating that the optics was disturbed when the accelerator of the ion source was disassembled in an attempt to fix the beam blocking problem.

The 150° right ion source developed a water leak internal to the source, which was detected on April 26, during a routine weekly pressure rate-of-rise measurement. This ion source was then removed from the beamline and the spare source was installed on the 150° beamline. The water leak has been localized to a bellows (or bellows braze) in the plasma grid rail holder. Since DIII–D has no capability of performing the required repair, we are developing a cost effective plan to repair this ion source and to refurbish the 30° right ion source, and have contacted Burle Industries (the ion source maunfacturer) to get an estimate of comparative costs of various repair strategies.

System Availability. Overall availability was good at 96.1%, with 73.9% of the time all requested beams were injected into the plasma, and 22.2% of the time beams were available but were not used for injection, for the 11 days of physics operations supported during the quarter.



Average Neutral Beam Availability
for DIII-D shots 81140 through 81551
April 1, 1994 through June 30, 1994



Causes of the 3.9% Unavailability

Maintenance and Inspections. The vacuum valves, which isolate the beamline drift duct vacuum from an ion gauge (measuring drift duct pressure during beam injection into the tokamak) of three beamlines, were damaged during the vent period and were replaced with newer model units. We do not know the cause of damage, since there was heavy traffic in the drift duct areas during the vent period while performing various kinds of tasks.

Water leaks developed on the 150° and 210° beamlines due to corrosive copper gaskets used in the conflat flanges of the calorimeter water cooling lines. The leaks were so large that even cold liquid nitrogen panel could not pump 210° beamline down to a pressure lower than 10^{-4} Torr. These copper gaskets on all four beamlines have been replaced in two maintenance periods of this quarter.

Limit switches of the four neutral beam TIVs (Torus Isolation Valve) required inspection and re-adjustment after these TIVs were maintained and repaired during the DIII-D vent period. With the cycling of these valves, all limit switches were re-adjusted and signals indicating the TIV position were checked out prior to neutral beam injection into the tokamak vessel.

Scheduled preventive maintenance and inspections were performed in June on four ion sources mounted on 150° and 210° beamlines. This task includes external visual inspection, measuring resistance between the plates of the arc chamber, checking filament resistance with low current, and leak-checking of the cooling water channels internal to the source. No problems were found.

A scheme for assessing neutralizer gas pulse PLC relay reliability in the DIII–D magnetic fields was devised and incorporated in the 30° and 210° CI stations. So far, no operational failure has been detected. Fluctuations in the gas flow signals during DIII–D pulsing are being examined to determine if the Sierra gas flow controllers are, in fact, being affected by stray magnetic fields.

Noise was measured on the 30° and 150° pyrometers during the initial beam injection into the tokamak for vessel conditioning. The noise in the 30° pyrometer was large enough to prevent beam injection. Removal of a ground loop between the pyrometer support frame and the tokamak box beam successfully cleared the noise in the 30° pyrometer. Insulation of the water manifold in the bolometer cooling system, which was moved to and mounted on the 150° beamline support frame during the vent period, cleared the 16 KΩ fault.

Screen shields were installed on the neutral beam console cabinets, which house the Grinnell monitors in the control room, to protect personnel from the electrical hazard of the high voltage tube while performing work on the other equipment inside the cabinets.

Activities. The neutralizer gas flow system upgrade was completed for all eight beam systems, and was tested during the beam injection into the tokamak plasma with very good results. This upgrade is intended to prevent neutralizer gas shut-off during beam injection into the plasma when the tokamak is pulsing in certain operation modes.

Beam power transmission and beam power deposit on the accelerator grids were measured during the source operation period to compare with the data of last year, and to confirm the calculations of injected beam power.

The Doppler shifted spectroscopy system measured beam species and beam divergence during beam operation period to compare with data of last year. The species measurement also helped to detect the 150° right source water leak. The beam divergence measurement on the ion sources, which have been disassembled for repair, was especially useful in determining the accelerator grid alignment after the re-assembly.

The portable RGA/leak-checker has been built and checked out with excellent base pressure of 6×10^{-8} Torr after the system was baked. This system was also successfully used to sample and verify a deuterium gas bottle.

The argon frost system, recently installed on the 210° beamline for helium gas pumping, has been successfully tested to pump 5–second helium gas pulse from two ion sources

simultaneously. Four 4–second helium beams can be provided for physics experiments when installation of an identical system on 150° beamline is completed (90% has been completed).

The neutral beam personnel have also supported non-beam related tasks and are responsible for coordinating with ORNL staff for the installation of the pellet injector on DIII–D. The pellet injector has successfully produced pellets with temporary liquid helium supply, and has also achieved injecting pellets into the torus isolation valve in synchrony with the DIII–D power supply testing shots. Commissioning of the pellet injector with its cryogenic system will start in the first week of July, and pellets will be injected into the plasma during the July experimental run.

ECH OPERATIONS

110 GHz ECH OPERATIONS

There was no activity on this system this quarter due to personnel limitations and a higher priority placed on getting the first of the new ICH transmitters operational for the July run period.

ICH OPERATIONS

The ICH effort concentrated on the upgrade project described later. Extensive vacuum conditioning was done in preparation for the one day of physics operations this quarter. RF voltage breakdown was encountered in the power splitter at powers of approximately 1 MW. It is not known at this time if this was caused by operating the antennas without the Faraday shield or if it was the sole cause for limiting the power. We will attempt to pressurize this section of transmission line to increase the voltage holdoff capability for the next run period.

COMPUTER DATA SYSTEMS

Startup, operations and calibration all were supported by computer systems during this period. Over 843 shots were taken, and 44.1 Gbytes of data was collected. A new record shot size of 106.2 Mbytes was recorded.

The UNIX real-time systems were used during this operations period. Approximately 16 Mbytes of data was collected in approximately 1 1/2 minutes on the new system.

Software was completed and tested so that new modules could be moved to the new system during the long non-operations period this quarter. Many digitizers, clock, amplifiers and other modules were moved to give a total of 46 Mbytes now on the new system. This data can be collected in 3 1/2 minutes. Additional work was done to rearrange the CAMAC highways remaining on the old data acquisition system, and one of those three computers was turned off. About 11 Mbytes of data remains on the old system, and only half of this is routinely collected.

The total time to collect this data should now be reduced from approximately 8 minutes to 3 1/2 minutes. The upgrade board for the new UNIX system (to go from a Motorola 88100 to a 88110) was installed and tested. This was a large change since the operating system revision, CAMAC driver, FORTRAN compiler, and shared-memory driver all are different. However, all software is operating with the new board.

The AUSPEX, the GA corporate nfs server, was made available to fusion by the Information Resources Division. Although the AUSPEX has not been released for production, one 3GB disk drive was configured as scratch space and mounted on several workstations and a VAX. This was heavily used during the last two days of the last run period, allowing the EFIT output files to be viewed by all interested parties.

An HP 9000 735–125 has been installed in the control room. This very fast system will be used to support between shot analysis and data examination. It should help the general user see the data results more quickly, and also should help keep network traffic localized during operations. Printers were set up and remote disks mounted on this workstation, including the Auspex file server. All support software, such as a VAX-like editor, IDL, and the DISPLA graphics software library along with several system administration packages have been installed on this machine. Key codes are in the process of being ported to this machine. REVIEW is the first which is targeted. Also, the PLOT10 library is being ported. This system should be helping the operations personnel during July.

MECHANICAL ENGINEERING

FLUID SYSTEMS

Water

To optimize EIMAC tube operation in the neutral beam, Transrex Mod/Regs, the manufacturer's piping was removed and replaced with larger diameter piping. During these modifications, the flowrate, pressure and interlock instrumentation were simplified and upgraded. All work has been completed. The four Mod/Regs were successfully checked-out and placed back into operation.

The Armstrong 125 hp cooling water circulation pump was received and installed in the Low Pressure Cooling Water System. This makes a total of four pumps in this system with a capacity of over 5000 gpm; sufficient for supplying cooling to the NB Mod/Regs, MFTF power supply and the three ICH transmitters.

The review of the tokamak's bottle gas purity requirements, suppliers' purity testing procedures, specification and certification and methods to verify certified purity at DIII–D is

continuing. It is anticipated that the review will be completed in early July and a recommended plan of action, including the role required by Fusion's QA Department, will follow shortly.

A purchase requisition was initiated for a second "plate & frame" heat exchanger for the DIII–D deionized cooling water system. This exchanger will replace the two remaining original units which are showing signs of deterioration.

During the June maintenance period, a new float system was installed on the sump pump which is located in the lower access pit of the machine building. This sump, water level detection system is extremely important in that it not only activates the sump pump but initiates a signal that notifies Emergency Services of water accumulation in the pit for further action by ES and DIII–D personnel.

A disparity has been observed in the thermocouple readings on the vessel's inner wall during baking operations. As part of the investigation into this apparent irregularity, it is planned to collect data over the next few vessel bakings and determine if the temperatures are valid and if so what may be possible causes for the dissimilarities.

New 6" PVC water lines were routed to the newly installed ICH Dummy Load. Interface connections on the Dummy Load were modified to mate with standard ANSI flanges. Cooling water connections and the installation of instrumentation were completed.

The 125 hp motor in the AWCS compressor, C–2, developed a ground fault. The motor was removed, repaired and replaced. Initial effort to align the motor and compressor shafts to within manufacturer's specification proved fruitless. The alignment was finally accomplished but only after a one week delay and the expense to obtain a new motor side, flexible shaft coupling. This alignment problem was undoubtedly missed several years before when the original motor required replacement due to bearing failure.

Modifications to the ECH, F–75 chiller were completed. These changes included a new, larger water surge tank and stronger flanged end-caps on the 8" piping that serve as the chiller barrel. The chiller manufacturer serviced the refrigeration unit under warranty.

Cryogenics

The entire cryogenic system including the helium liquefier was shut down on May 17 to conserve electrical power. The system will be brought back on line just prior to the July operations period.

The Pellet Injector flexible liquid helium transfer line was received and installed. Completion of fabrication, installation and testing of the entire cryogenic system for the Pellet Injector is scheduled for early July.

The Pellet Injector propellant system has been installed and is awaiting control system installation and testing.

The Pellet Injector was successfully tested by ORNL personnel using a temporary cryogenic supply and propellant system.

Corrective maintenance was performed on the two 400 hp Sullair helium compressors to rectify cooling problems. Copious amounts of calcium and silicate precipitates were removed from the compressors' oil/water heat exchangers. Additional methods to prevent buildup of precipitates in this cooling water system are being investigated.

The Advanced Divertor Cryopump was successfully operated during this reporting period.

Greg Laughon delivered a paper on "Two Phase Liquid Helium Flow Testing to Simulate the Operation of a Cryocondensation Pump in the DIII–D Tokamak" at the 15th International Cryogenic Engineering Conference at Genoa, Italy.

Vacuum

A dedicated RGA test station was built from existing DIII–D hardware. This test station will be used to evaluate and adjust spare RGA's after they have been repaired and before installation on DIII–D. It is intended that this station will support other projects such as the recently identified gas purity analysis task.

Adjustments and repairs were made to the DIII–D gas injection system. Several component failures were isolated to electrical shorts in cables. Efforts to improve the cabling have begun. Gradually the bugs in the gas system are being isolated and eliminated one by one. As the reliability of the gas system increases, more time will be given towards increasing the number of spare components.

Two air leaks into the tokamak were found and temporarily repaired with secondary vacuum cans. The location and (size) of each leak are 0°R0 voltage probes (2.5×10^{-5} helium atm cc/sec) and 30°V–1 wave guide window o-ring seals (5×10^{-5} helium atm cc/sec). With the cans installed, the DIII–D global leak rate dropped from 1.2×10^{-4} Torr-liters/second to 1.9×10^{-5} Torr-liters/second. Two smaller leaks were also found but they do not significantly affect plasma operations. These two leaks will be fixed at a later date. The location (and size) of each leak is 75°R0 SXR bellows (1.2×10^{-6} to 1.5×10^{-5} helium atm cc/sec) and 135°R–2 ADP feedthrough conflat seal (7×10^{-7} helium atm cc/sec).

The following vessel vacuum leaks were found and repaired prior to pumping down the vessel after a scheduled one week vent: 0°R0 helicoflex seal, 0°R0 thermocouple braze joint, 0°R0 2–3/4 inch conflat seal, 0°180V–2 thermocouple braze joint (installed a secondary vacuum can), 270°R0 gate valve paddle seal, and two piezo valve seats at 0°V–1.

The Varian TMP6000 turbomolecular pump shutdown due to another false indication from the oil level switch. The switch has been taken out of service until it can be replaced. The turbopump is currently in operation.

The five piezo valves and electronic controllers were removed from the vessel for a second round of repairs and modifications. The work was done in the newly dedicated lab set up for piezo hardware. The five valves and controllers have been reinstalled on the vessel and checked-out is continuing.

Fabrication has begun on two water traps for the boronization system main vacuum pump and RGA vacuum pump. These traps will be connected to the vacuum pump exhaust and have been designed to trap liquid water that might otherwise be sucked out of the water bubblers and into the vacuum pumps.

Fabrication of a new replacement thermal decomposer for the boronization system has begun. Repairs to the boronization rotary vane pump were completed and the pump reinstalled. Maintenance and repair work on the entire boronization system was completed.

Purchase of a new heavy duty motor assembly to repair one of two spare Balzers TMP5000 turbomolecular pumps has been delayed until late August due to budget constraints. The second spare turbomolecular pump requires a bearing overhaul. This work will be accomplished as technicians become available.

A leaking bonnet seal in the 210° neutral beam torus isolation valve was repaired.

Pressure changes in each neutral beam line during several pump downs of the vessel were negligible indicating that the recent repairs to the neutral beam TIVs are holding up.

The ion gauge strip chart recorder has been returned to service. A tune-up of the vessel ion gauge system was completed with the goal of increasing its reliability until a new system can be purchased and installed.

TOKAMAK ENGINEERING

Vent Coordination

The vessel was vented from April 6 through April 15. The following tasks were completed; installation of the faraday shields and the adjacent tiles, installation of new bumper limiter tiles, and repair of earlier ADP ring hi-pot problems (165 degrees).

Error Field Correction Coil (C–Coil)

Installation of the first four coil sections (final installation consists of six sections) with the conductor cables was successfully completed in May. All four sections were successfully hipotted to 5 kV and power supply testing with the coils has been initiated. Installation of the fifth section (49°–109°) was completed in June. Installation of the sixth and final coil section (229°–289°) is 25% complete and will be finished during the August maintenance period. The first four coil sections are planned for use during the July plasma operations period.

FWCD Antenna Installation

Boron carbide coating of the Faraday shields for both antennas has been completed by a French company with very good results. These shields were installed on the antennas in the vessel during a vent in early April. A total of five thermocouples have been affixed to various locations on the shields for future monitoring of thermal performance. This work completes the installation of these two antennas. A series of eight current probes and sixteen voltage probes has also been installed on these two antennas. Connection into the DIII–D data acquisition system remains to be completed.

Glow Discharge Electrode Redesign

A locking mechanism to prevent the electrode from being inadvertently inserted into the plasma was installed during the vent in April. This completes this task.

DIII–D Gas System

The DIII–D gas delivery system installation and testing has been completed and the gas system is being used for operations. A self test procedure is being developed to detect system leaks. This procedure will then be programmed and executed automatically by the PLC.

Diagnostic Support and Miscellaneous Mechanical Engineering Tasks

It has been observed that the MIT interferometer mirror support box for the first and last mirrors in the system is heavily affected by operation of a nearby diagnostic. Images transmitted by the mirrors are indistinct due to vibrations transmitted into the support structure. A new mirror support structure has been designed, fabricated, and installed to provide a more rigid load bearing path for these primary input and output mirrors. These supports have been relocated from the 6' 8" floor support structure to the concrete pit floor to eliminate vibration effects caused by operation of a nearby diagnostic. This task is complete.

The conceptual design review for the beam emission spectroscopy (BES) diagnostic was completed on June 21, 1994. The proposed design for the port modification at 105° R-0 was approved. Detail design and fabrication of parts is expected to commence after October 1, 1994.

The Tokamak Operations Group initiated a requirement for 20 silicon and graphite samples to be installed in the ports of DIII–D for the purpose of measuring the coating uniformity obtained during boronization. A sample holder design was developed and parts were fabricated and installed during the April vent. Plans are to release as-built design documentation at a later date when designers become available.

A calibration light source is being designed for the CER system. Preliminary meetings and a design review were held during this month. All of the parts have been machined from computer sketches completed without designer time. This calibration source will be installed before the

next run period. All of the required parts have been ordered and most of the machining is complete.

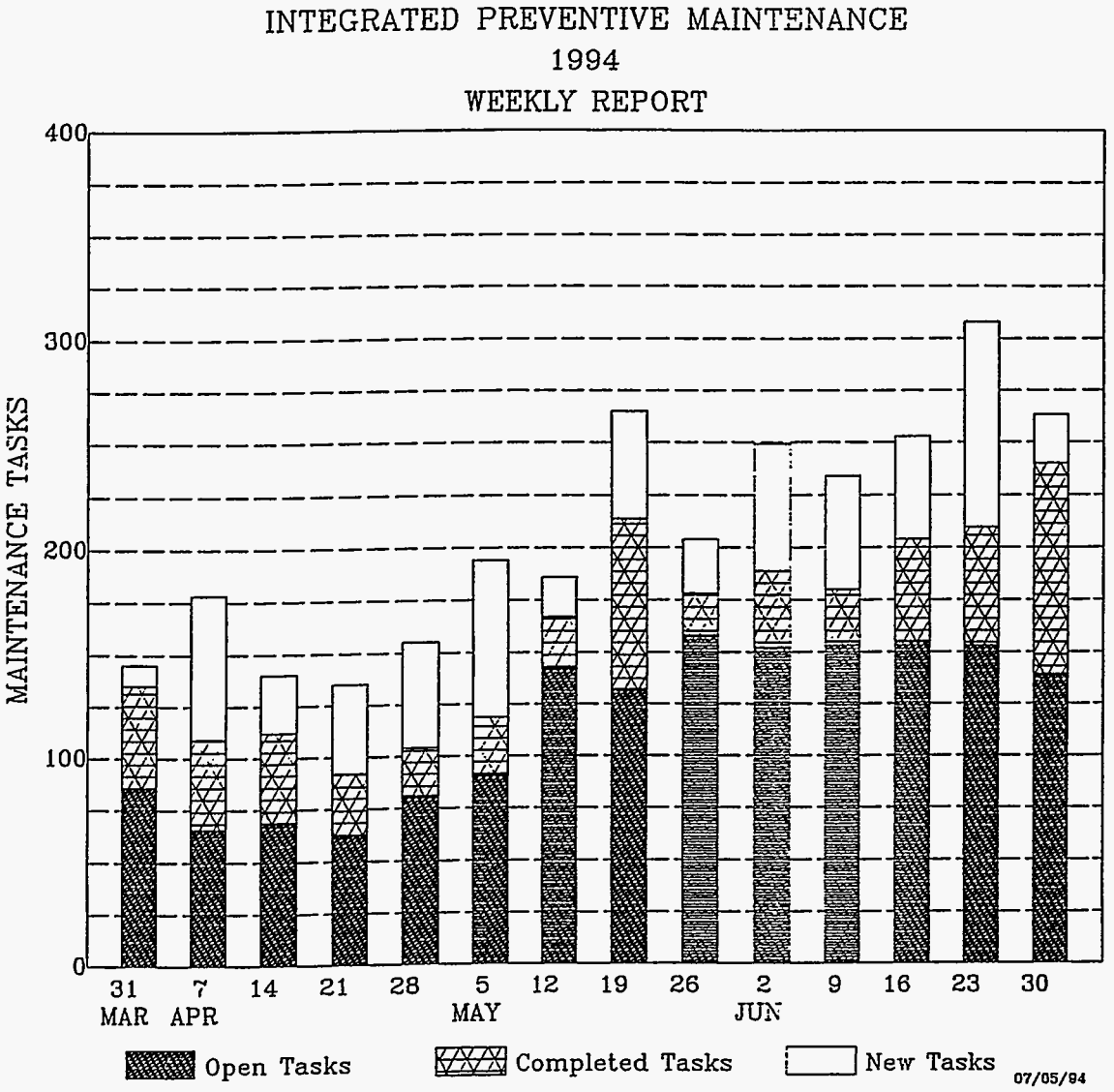
Operational problems with the ASDEX gauges installed at 120° V-1, and 240° R–1 were investigated. An inspection of the gauges showed that; loose and poor fitting hardware, coating of the ceramic insulators, and moisture absorbed by the MgO signal cables (outside of the vacuum) were the probable causes of the high resistance shorts in the gauges. The 120° V–1 gauge head was reworked and the MgO cables were replaced with Teflon insulated coax cables. Also, the ceramic feedthrus for the gauge head were replaced, one of which was found damaged during the inspection. The current plan is to reinstall the 120° V–1 gauge on the vessel after testing in the lab.

Design and fabrication of X–ray shielding plates and detector mounting adapters was completed for Dr. Cho of Japan as part of the toroidal x-ray system JAERI collaboration.

INTEGRATED PREVENTIVE MAINTENANCE PROGRAM (IPMP)

There were 701 maintenance tasks identified during this quarterly report period for an average of 234 tasks per month. Of this number 502 PM and 58 CM tasks were completed with an average turnaround time of 19 days and 6 days respectively. There remain 115 PM and 24 CM outstanding tasks. Of the outstanding tasks, there are 13 priority "1" tasks (affects machine operation), and 70 priority "2" tasks (may affect machine operation). The remaining 56 outstanding tasks are priority "3" which do not have any affect on machine operation. There are currently 1267 components entered in the IPMP. This represents an increase of 35 components over the previous quarter.

The following plot shows the number of completed and new maintenance tasks per week ending on each of the dates shown. The open (outstanding) tasks is the total number of maintenance tasks up to each of the dates shown.



ELECTRICAL ENGINEERING

Electrical systems support of DIII–D operations was resumed this quarter after initial testing and calibration of the electrical systems were completed. Startup of the electrical systems went very well, with only minor adjustments needed to the new E power supply control loop. The first two C–coil power supplies were also commissioned during this quarter, and are now operational. A patch panel setup error caused damage to one of the chopper power supplies (X12) when reverse current was allowed to flow through it during discharge cleaning operation. The new EPSSIC, gas delivery system, and CER VME computer are working well.

Electrical Preventive Maintenance

A total of 217 preventive maintenance tasks were closed in this quarter; 68 tasks were open as of 6/23/94.

Power Systems

Most of the effort this quarter was devoted to preventative maintenance of the electrical systems in preparation for the startup of operation after the extended shutdown period.

Time was also allocated to testing of the many upgrades which were made to the power supplies during the last quarter. These upgrades were; new 15 kV vacuum interrupters and new gate drive circuit assemblies for the B power supply, new PLC for the E power supply, new EPSSIC protection system, new PLC for the F–system CAMAC interface, and new PLC's for the new C–coil power supplies. These improvements have already produced improvements in performance, operational flexibility, and ease of troubleshooting of the coil power systems. Problems with the E power supply vacuum circuit breakers which were not upgraded were again experienced, and these are now scheduled to be replaced in the fall. Overall, the startup was considered very smooth, considering the extensive modifications that were made during the shutdown period.

Signs of arcing were found in the 12.47 kV switchgear busswork in one of the neutral beam power systems as part of the routine maintenance inspections, and repairs were made.

INSTRUMENTATION AND CONTROL

The most noteworthy I&C accomplishment during this quarter was the timely completion of the EPSSIC protection system for the DIII–D tokamak. This system has already provided greatly enhanced operational flexibility in terms of system status reporting and troubleshooting support.

Work continues on the noise interference attenuation task for the data acquisition and control systems. In parallel with this work, active filters have been installed for the analog signals used for the plasma control system. Work also continued on model validation tests to characterize the coil and vessel coupling as part of the control system development effort.

A new very accurate Thomson beam alignment system has been completed and is operational. The CER VME computer was also brought on line this quarter.

UPGRADE PROJECTS

110 GHZ ECH UPGRADE PROJECT

Varian has reached 500 kW, 1 msec with the new internal mode converter gyrotron. Some unexpected oscillation were observed in the launch section of the tube. This additional power loss may limit the power operation, but it seems that >200 kW cw can be achieved (ITER goal). However, Varian was only able to achieve about 50 kW average power. This power level was limited by arcing in the dummy load. Arcing was believed caused by a high content of a non-guassian mode exiting the window. The plan is to rebuild the tube with a new launcher configuration to improve the mode purity of the output and to eliminate the post cavity oscillations that have been observed. Before ending testing Varian was able to test GA's distributed window aluminum mockup, and at 50 kW a throughput level 96% or better throughput was observed with little or no observable affect on the operating conditions of the gyrotron. This result is consistent with our expectations.

On June 20, the tube was cut open at various seal ring joints; at the gun seal, the beam tunnel/cavity seal, the cavity/launcher seal, and the body/collector seal. Extensive damage was observed in the upper beam tunnel. All the lossy rings in the upper beam tunnel area were coated with copper. The entry to the cavity was also damaged. All these damages appeared to be due to electron beam interception. The true cause of it is still under investigation. A likely scenario is that the damage occurred after a change over or magnet quench.

For the rebuild of the gyrotron, the beam tunnel and cavity are being rebuilt. The launcher and the first two mirrors have been designed. Cold test parts are being fabricated. The final two mirrors are being designed by the University of Wisconsin and will incorporate a flat output profile to lower the thermal stress on the output window and thus increase the power throughput.

GYCOM has completed testing of their short pulse prototype gryrotron and has achieved 1 MW pulses 50–100 msec in duration. The efficiency of the tube at the 1 MW output level was 36 ± 2%. No other mode was observed, either at the same or different frequency. The performance of the tube is such that no changes to the rf design is now anticipated and the only changes that is planned for the long pulse tube is a slight change in the gun. The plans are to build the long pulse tube, which is expected to go into test in November.

FAST WAVE CURRENT DRIVE 6 MW UPGRADE PROJECT

Effort this quarter focussed upon doing everything possible to maintain the schedule of having first plasma operation of one of the two new systems during the July experimental period.

The Faraday shields for both new modular antennas from ORNL were successfully installed during the DIII–D vent completed this period. The antennas were then carefully positioned relative to the outer DIII–D tiles, and new close fitting tiles were installed to immediately surround the antennas. These antennas have modular Faraday shields coated by a French vendor with boron carbide, using a process developed by the Tore Supra laboratory. This coating functioned well during the original DIII–D run period in June, although there have been no RF operations with the antennas yet. Formerly, we have had problems from neutral beam damage of a boron carbide coating which was too thick.

The rf feedthroughs for the antenna straps and the current and voltage diagnostics were installed for both antennas. The water cooling system was connected to the main DIII–D vessel system and has functioned without incident during the initial operating period.

The transmission and tuning system for the 0 degree antenna has been completely installed. Late delivery of components by RFT, the vendor for the phase shifters and stub tuners, has delayed the installation of the 180 degree system. The schedule calls for finalizing this installation in August, to be ready for operation in September. The two dummy loads were installed and have been used in bringing up the power on the new transmitters.

GA has gone to extraordinary effort to work with RFT to achieve the earliest possible delivery of the needed components. RFT is behind due to a combination of poor planning on their part and a cash flow crisis (RFT is a small company). On numerous occasions GA sent representatives to RFT to accept completed units at their site so that payment could be wired to them, rather than have them wait for the better part of a week for truck shipment to GA. Some of the RFT equipment has had problems in the mechanical elements, but RFT has corrected the problems, sending a technician to GA for several days on one occasion. The rf properties of the equipment have proven acceptable.

Problems with the rf side of the ABB transmitters were resolved, while problems with the power supplies for these units are still being worked on. The lead ABB transmitter design engineer from Switzerland spent three weeks at GA correcting control problems with the transmitters. At that time it became clear that there was a significant voltage regulation problem with the power supplies, manufactured by NWL under subcontract to ABB. An engineer from NWL came to GA to work on this problem. In the course of testing, a damaging arc occured in a high voltage transformer on one of the two power supplies, which required sending the transformer back to NWL where it is being repaired. With concurrence by NWL, we moved the transformer from ABB unit #2 to replace the damaged one on ABB unit #1, and continued to bring up unit #1. The voltage regulation problem must still be fixed, and an engineer from NWL will come to GA the first week in July to continue this effort.

OPERATIONS SUPPORT

PLANNING

Services including storekeeping, materials handling, quality assurance, plant engineering, inspection, safety monitoring and control, scheduling, cost control, procurement control, status reporting, and engineering services such as document control, design integration, space allocation and CAD support were provided to DIII-D under "Operations Support."

Anticipated FY94 funding levels are indicated in the following table.

Table 2

FY94 Funding

	Initial FY94 Financial Plan 9/2/93	Obligated Funding	Anticipated FY94 Funding Level
Research Operations	31,800	32,021	32,021
Capital	6,496	6,220	6,355(1)
Intnl Cooperation	1,045	1,003	1,003
Theory (from AP&T)	500	565	565
User Service Center (from AP&T)	237	240	240
Tokamak Physics Exp.	—	64	64
ITER Design Engineering (from I&T)	1,395	1,395	1,395
	41, 373	41,508	41,643(2)

(1) Includes $135K ORNL antenna hardware payback anticipated.

(2) $14K reduction in FY94 funding from that anticipated in 2nd quarter.

A minor adjustment of $14K (reduction) was made to the FY94 funding level. This follows the ≈$1.1M funding increase that was provided in the 2nd quarter to increase operations. It is anticipated the FY94 funding level indicated in Table 2 will be the "final" funding picture.

FY94 funding levels significantly lower (≈$2M) than those expected prior to the start of the year, less than optimum mix of operating $/capital $, and the need to provide machine operations, maintenance & associated staff at the end of FY94 and in FY95 will likely result in FY94 expenditures of ≈$1.2M above FY94 funding. We have taken actions during the 3rd quarter to reduce/move tasks, procurements, staff in order to minimize this difference.

FACILITIES

Modification and rearrangements to the DIII-D facility funded by General Atomics have been completed. These were made in order to allow ICRF and diagnostic equipment to be located closer to the machine.

These modifications/rearrangements include:

— ICRF mezzanne
— Vacuum lab relocation
— Diagnostic lab expansion
— QA/Hipot lab relocation
— Machine shop relocation
— Additional office construction to accomodate collaborators/visitors.

SAFETY

TRAINING

Quarterly CPR training was conducted for all Emergency Response Team members and individuals working on electrical equipment. The training was presented to 43 employees.

Two ergonomics training classes were conducted with 58 employees attending.

Two Lockout\Tagout (Control of Hazardous Energy Sources) training classes were held with 82 individuals attending.

A special DIII–D Crane Training class was conducted with 18 employees attending.

A lunch time presentation was held showing a video on EMF that was previously given by an individual from SDG&E. This session was attended by 15 employees.

A special Emergency Response Team training session for fifteen members was conducted consisting of training on the ADT System that is used to monitor and annunciate emergencies.

Twelve individuals received a visitor/new employee safety indoctrination this quarter.

INSPECTIONS/REVIEWS

Three regular internal safety inspections of the DIII–D site were conducted by representatives from GA Safety, Fusion Safety, Fusion Management, Fusion Facilities and Collaborators with 65 discrepancies noted. Discrepancy lists were issued and corrective action is in progress.

An outside electrical inspector was contracted to inspect the DIII–D facility for electrical discrepancies. There were 38 items that were found and correction is already in progress.

The San Diego fire department's Combustible, Explosive and Dangerous Materials (CEDMAT) team inspected the DIII–D facility this quarter. The inspector was impressed with our control and handling of hazardous materials. A report indicating his few comments will be sent in the near future.

The quarterly sling and shackle inspection was completed by D&R Crane.

ACCIDENTS/INCIDENTS

There were three incidents this quarter. One involved a person who strained his right shoulder trying to unstick a cryo piston. A second incident involved a person who fell through the TREX bi-deck roof and the third incident was when the Glow Discharge power supply was turned on by a computer while an individual was working on the probe. Of most concern was the application of high voltage to the cables for the glow discharge electrode system while personnel were working on the system. Although the high voltage was turned off before anyone was hurt, the incident has prompted a number of reviews of this and similar systems. A set of recommendations to better safeguard the glow system have been prepared and will be implemented in the August maintenance period. In the interim, administrative procedures have been modified to prevent any operation of the system unless the machine hall is closed and under the control of the chief operator. In addition, there was a training class on the proper lockout/tagout procedures for energized equipment. Finally, a complete review of the location of all high voltage in use in the machine area is underway.

There was two accidents this quarter. One occurred when an individual cut his finger while using a band saw. The individual received thirteen stitches but lost no work time. The second accident involved a strained back by an individual working on the C–coil. This resulted in lost work time. This was the first DIII–D lost time accident in 845 days.

There was a dump of the CO_2 in MG #2. The problem was traced to a faulty heat detector and the fact that they were not wired on a cross zone configuration. The detectors have been re-wired and the CO_2 cylinders are now full again.

There was a fire in chopper X12. An incorrect power supply hookup resulted in the overheating of and subsequent fire in a chopper power supply during a recent inductive bake of the DIII–D vessel. Although all normal and established procedures were followed, these procedures were not sufficient to protect the chopper because of an unusual power supply configuration used on a previous operating day. Our procedures for setting up the power supply configurations prior to baking have now been modified. All fire protection systems functioned properly and all personnel followed the proper procedures so that there was no injury to any personnel and there was no damage to any equipment around the affected chopper. The fire was extinguished by both the GA and San Diego Fire Departments.

MEETINGS—INTERNAL

The Fusion Safety Committee met six times this quarter to discuss various safety issues, reviewed accidents and incidents, and approved Hazardous Work Authorizations (HWA's) including:

Pellet Injector Operation
CO_2 Interferometer Operation Renewal
Pressure Testing of ECH Wave Guides
Operating and Maintaining the DIII–D Cryogenic System
CO_2 Phase Contrast Imaging
Reviewed the possible introduction of Beryllium using the DIMES Probe in DIII–D

MEETINGS—EXTERNAL

The Fusion Safety Officer attended an Occupational Safety and Health Worker Protection Pilot Model Program on Electrical Safety. This class is sponsored by the DOE.

The DIII–D safety assistant attended a two hour seminar at SDSU regarding employee ivolvement in company safety programs.

DIII–D ENVIRONMENTAL ASSESSMENT

The DIII–D environmental assessment required as part of the contract renewal was submitted. It is being revised following a July 7th meeting to discuss DOE/OAK comments and the final version will be submitted in July.

MISCELLANEOUS

All the oxygen and combustible detectors were replaced in the pit and with a plan to accomplish this on a yearly basis. This should provide greater reliability to the monitoring system. They are still scheduled to be calibrated quarterly.

The installation of the new oxygen and combustible monitors for the gas bottle room and two other labs is now complete. The monitors were tested and are now connected to the main building monitoring and alarm system.

Fifty seven safety manuals were updated with four updated procedures and one new procedure.

COLLABORATIVE EFFORTS

LLNL — The LLNL collaboration is focused in the areas of divertor physics and advanced tokamak physics. During the third quarter of FY 1994, we completed milestones in each of these areas: 1) completion of a detailed report about the high β_p experiments (April), and

2) installation of the internal hardware for the divertor microwave interferometer (May). These milestones were completed on schedule.

A major area of LLNL effort with GA and the other DIII–D collaborators this quarter was the successful completion of an external DOE review of the Radiative Divertor Program in June. The review committee indicated that the detailed engineering design of the Radiative Divertor should proceed.

Experiments, diagnostics, and modeling were performed to guide the design of the new divertor for DIII–D. One day of argon and neon gas puffing experiments was performed in June. In the July run period, we are planning experiments with gas puffing and pumping to explore particle removal with detached plasmas. A key diagnostic in these experiments is the bias-ring IR TV, installed during the vent, which allows measurement of the divertor heat flux when the strike point is in the optimum pumping location (under the ring). A summer student is involved with modifying the IR analysis routines to include calculation of heat flux on the boron-nitride tiles near the bias ring. A divertor microwave interferometer was installed during the vent, and the installation of the electronics and the debug of this diagnostic has progressed during the last quarter. Further tests will take place during the operations period in July. We have also been increasing the sensitivity of the camera for the tangential TV system so that impurity emissions (using a visible filter) can be measured during gas puffing experiments.

Substantial progress has been made in the area of modeling and computations for the divertor. The RECLUSE code (a computational grid generator) was upgraded for use with the DEGAS (Monte-Carlo neutrals transport) code to examine various configurations of the Radiative Divertor. RECLUSE generates the computational grid outside the UEDGE (fluid-code) plasma, and thereby couples the plasma grid to the overall DEGAS grid. This has allowed us to efficiently change the grid for each radiative divertor test design. The UEDGE-DEGAS modeling has indicated that the most recent slot for the radiative divertor is too narrow, and should be widened to reduce recycling off of the divertor structures. It is noteworthy that the code calculations are guiding the divertor design.

In the Advanced Tokamak area, we have obtained successful operation of the new upgraded 16 channel MSE system (installed during the vent in the second quarter of FY 1994). The EFIT–MSE equilibrium reconstruction codes have been updated for the 16 channel system, and are now used routinely. An insertable in-vacuum polarizer on the edge MSE system has allowed us to accurately measure the small Faraday rotation effect in the optics. Initial analysis of the data has shown: 1) A common viewing chord is shared between the edge and central systems. Currently there is a ~3% systematic difference between the two measurements, and we are making efforts to further improve the agreement. 2) On-axis safety factor q_0 measurements have been improved because of the increased number of viewing chords at the plasma axis, and the

uncertainty in q_0 is less than 0.05. 3) The increased radial resolution at the edge has allowed us to observe changes in the edge current density with the transition to H or VH–mode. We plan detailed analysis of these trends during the next quarter.

Work has continued on the analysis of the high β_p experiments, including the fast ion losses. We are also expanding the analysis of fast ion losses to other types of discharges. Papers have been presented at the European Physical Society meeting, and will be presented at the upcoming IAEA and APS meetings on this analysis.

LLNL has continued to provide technician support for diagnostics. We have focused on our new diagnostic installations (MSE, divertor interferometer, and bolometers), but have provided general diagnostic support, including work on the Russian soft X–ray system, Thomson Scattering, and the Charge Exchange Recombination system. We plan increased work on the divertor Thomson Scattering system in the next quarter, with an anticipated installation in January of 1995.

We have also worked on several computer tasks, including, modifications to several software routines that are used for acquisition and archiving of DIII–D data. These modifications allow for more efficient operation using multiple files for a single DIII–D shot. These changes have been installed and are presently in use during this operations period. In addition, we have installed LLNL's interprocess communications software on several DIII–D computers to provide synchronization for these distributed file operations.

ORNL

The ORNL collaboration includes work in the areas of the Advanced Divertor Program, boundary physics, FWCD, RF physics, pellet injection, and plasma shaping studies. Much of the effort during this quarter has been in preparation for the 11th International Conference on Plasma Surface Interactions in Controlled Fusion Devices, held in Mito, Japan (May 23–27, 1994). Four papers from ORNL were presented at this meeting. An invited paper on helium transport by Mickey Wade was also presented at the 11th American Nuclear Society Meeting on the Technology of Fusion Energy in New Orleans (June 19–23, 1994.) Other ORNL activities have focused on RF experiments and preparations of the pellet injector system for upcoming experiments.

Boundary Physics and Particle Control

The major activities during this quarter were the preparation and presentation of four papers at the 11th International Conference on Plasma Surface Interactions in Controlled Fusion Devices in Mito, Japan (May 23-27, 1994). The papers presented at this meeting were:

1. R. Maingi et al, "Effects of Particle Exhaust on Edge and Divertor Plasma Parameters."

2. P.K. Mioduszewski *et al.*, "Experiments on Steady State Particle Control in Tore Supra and DIII–D."
3. M.R. Wade *et al.*, "Helium Exhaust Studies in ELMing H–mode Plasmas in DIII–D."
4. L.W. Owen *et al.*, "Transport Modeling of Divertor D_α Radiation and Core Fueling in DIII–D."

ORNL Fast Wave Current Drive and RF Physics Program

The installation of the 0° and 180° antennas in the vacuum vessel was completed in April with the installation of the boron carbide coated Faraday shields. The transmission line installation and transmitter commissioning are not yet complete so these antennas were not operated during the May–June operating period. The 0° antenna will be operational for the July operating period, and the 180° will be available in September.

The Faraday shield of the 285°–300° antenna was removed during the shutdown. New carbon limiter tiles extending 2 cm above the vessel surface were installed. Experiments in this configuration were conducted in order to determine the power limit for antenna operation without a Faraday shield and to obtain edge density data with the new microwave reflectometer mounted in the antenna port. The maximum power coupled during these experiments was about 1.2 MW, not significantly higher than during the Faraday shieldless operation in 1992. The cause of the power limit has not as yet been unambiguously determined. Density profiles (from microwave reflectometers adjacent to and away from the antenna) and RF loading measurements have been taken as a function of RF power, separatrix position, and phasing between straps. We observed a significant change in loading as a function of RF power in the 10–50 kW range, correlated with a change in the density profile. The measurements are compared with theoretical calculations.

The solid state super-heterodyne electron cyclotron emission (ECE) radiometer used on ATF has been installed on DIII–D. The instrument has been operating routinely since May 19, 1994. The radiometer can measure ECE in the frequency range 83–114 GHz (32 channels, each with a 3 dB bandwidth of 1 GHz), corresponding to R = 248–181 cm at B = 2.16 T. Under typical operating conditions, most of the outboard side of the electron temperature profile is covered, with a spatial resolution of about 2 cm. 32 channels of ECE data from DIII–D plasmas have been obtained and the signals compare well with the Michelson interferometer data. The ORNL radiometer has not yet been independently calibrated. The radiometer will complement the existing Michelson interferometer used to measure ECE by providing electron temperature data on a time scale smaller than that obtainable (8–15 ms) by the Michelson. Direct comparison with the Michelson will allow determination of the electron temperature extracted from the ECE.

The ORNL-built amplitude-modulation (AM) reflectometer previously used on PBX–M has been installed on DIII–D and is now operational. The microwave reflectometer launcher is located next to an ICRF antenna, and access to this launcher is shared with the UCLA reflectometer. The AM reflectometer operates from 32.5–50 GHz with 200 MHz sinusoidal amplitude modulation. Presently, a Backward Wave Oscillator (BWO) microwave source is being used to generate the swept 8.125–12.5 GHz signal which is multiplied up to the desired output frequencies. This source is capable of sweeping at rates as low as 0.5 ms but is presently being swept at 10 ms. Data with this AM reflectometer was taken in conjunction with the UCLA FM reflectometer during the RF experiments with no Faraday shield on June 7th. The data analysis programs used to analyze the AM reflectometer data have been successfully implemented on the GA computers and the analysis of the data has begun. Preliminary results indicate that this reflectometer can measure the edge profile all the way out to the bumper tile. Modification of the edge profile with the application of ICRF power is observed in the small amount of data processed to date. The initial results show that the 200 MHz modulation frequency presently used on this reflectometer is too large and should be reduced by a factor of approximately two.

Other activities in the RF physics area include RANT3D modeling of spectra for the old and new DIII–D antennas and exploration of Advanced Tokamak scenarios including ITER-relevant low-frequency current drive scenarios. These results will be discussed with the GA RF group during the forthcoming visit by D. Batchelor and M. Murakami.

Pellet Injector Program

General Atomics has continued installation of the liquid helium system and the DIII–D/Pellet Injector interlock and control interface. When the cryo system is complete, ORNL personnel will return to GA to complete commissioning of the injector. T. Jernigan will be at GA during the month of July to continue preparations of the pellet injector.

A checkout operation of the pellet injector on DIII–D was recently completed. A series of multiple pellets were made under the control of the DIII–D timing system. Pellet injector diagnostics and control systems were successfully tested. These tests were performed by firing pellets into the target plate with no plasma present. It is expected that pellets will be injected into DIII–D during the July run period.

JAERI — S. Konoshima is investigating the physics of the VH–mode in DIII–D. N. Isei visited DIII–D again for one week to study disruptions on DIII–D and to discuss with D. Humphreys, P. Taylor and A. Kellman. His main interest was whether the current decay time at the density-limit disruption can be expressed by a simple L/R time using measured quantities such as electron

temperature. He found that existing DIII–D data indicated a faster decay time than that of JT–60U and consistent with his picture at least qualitatively .

UCLA — A new three year UCLA Grant proposal was submitted to the DOE at the end of April. The proposal is for the continuation and expansion of the current UCLA diagnostic development program on DIII–D. The range of activities covered includes topics such as reflectometer density profile measurements, inside launch reflectometry, divertor reflectometry and correlation reflectometer development. Presentations are being prepared for an on-site review of the proposal to be held in UCLA on July 14.

The new (upgraded) inside launch reflectometer system is almost complete. The in-vessel components were installed during the vent in March, and the external microwave circuit is now ready for installation on the machine.

An ORNL reflectometer system has been brought to DIII-D from PBX under an agreement between UCLA, ORNL and GA. This system will be used as part of an ongoing UCLA program to test and compare different reflectometer profile measurement techniques, including FM, AM and pulsed radar techniques. This comparison has commenced, and UCLA provided support in getting the ORNL system operational on DIII-D.

The UCLA and ORNL reflectometer systems have been used in tandem to perform high resolution edge density profile measurements at two toroidal locations during RF operation at a series of RF power levels. The profile data will be utilized for loading calculations at ORNL, and the calculations compared with experimental loading measurements. The edge density profile is observed to change at low RF power levels (10's of KW), the loading also changing at the same power levels.

A second, upgraded RF wave monitor reflectometer system is ready for installation on DIII–D in July.

UCLA/UCSD— The Fast Probe Collaboration has been transferred from UCLA to UCSD. Following several weeks of maintenance work and improvements to the midplane fast reciprocating probe system in preparation for plasma operations in 1994, the probe was operated in support of five experiments during the first operations period:

- Bias assisted particle exhaust
- Replace HeGWC with pumping
- Alfvén instabilities and NBCD
- RF operation without Faraday shield
- Investigation of gases for radiative divertor experiments

John Cuthbertson is developing a gridded energy analyzer for ion temperature measurements in the PISCES-Upgrade device. This GEA is currently being tested in PISCES–A. The experience gained from this development work will be used to develop a similar GEA device for mounting on the X–point and midplane fast reciprocating Langmuir probe drives at DIII–D in 1995 or 1996. Design of a GEA for DIII–D was also discussed with Guy Matthews of JET during his visit to GA (as a member of the RDP Review Panel). Dr. Matthews is designing a similar device to mount on a reciprocating drive at JET.

SANDIA–SNL— Work continued with the divertor and edge probes.

UNIVERSITY OF MARYLAND — Work continued on ECE.

MIT — Work continued on the phase contrast imaging.

UC BERKELEY — Work continued on helium transport and other topics.

UC IRVINE — Active charge exchange measurements during deuterium beam injection were obtained for the first time on DIII-D with a compact electrostatic analyzer. Installation of three additional analyzers is planned. This diagnostic system will be used to measure the beam-ion profile in Advanced Tokamak configurations, to detect the damping of fast waves on ions, and to measure the edge neutral density in divertor studies.

An experimental day devoted to "The effect of Alfven instabilities on neutral beam current drive" was very successful. Preliminary analysis indicates that degraded fast-ion confinement in the presence of Alfvén instabilities correlates with increases in loop voltage, indicating reduced current drive efficiency.

DIII–D POSSESSORY INTEREST AND SALES TAX ACTIVITY

POSSESSORY INTEREST TAX

The Department of Justice (DOJ) Solicitor General approved the appeal to the U.S. 9th Circuit Court during the second quarter of FY94. The court will be asked to address the following issues:

— Is DIII–D a fixture?

— Is there a taxable interest?

— If taxable interest, it's calculated wrong.

— Previous court decisions have discriminated against GA because no one else taxed on "acquired expertise."

All briefs have been filed and the parties are awaiting a court date. This should be within 4–6 months. A decision would then follow within a year of the arguements.

It is anticipated the loser will petition the U.S. Supreme Court to hear the case. If granted, a ruling could be expected in approximately 1 year. If denied, it's over.

SALES TAX

No response has been received from a request made (April 19, 1994) of DOE OAK for approval to pay interest of $29,293 resulting from the sales tax audit for the period 4/1/89 to 6/30/92.

DIII-D RESEARCH OPERATION OPERATING

	FY94 BUDGET FTE's	FY94 BUDGET TOTAL $000	FY94 ACTUALS FTE's	FY94 ACTUALS TOTAL $000
BASE OPERATIONS	45.2	9,814	45.7	7,453
PHYSICS	39.9	8,315	41.9	6,396
DATA SYSTEMS	9.9	2,318	9.3	1,620
DIAGNOSTICS	8.8	1,732	10.1	1,326
HEATING				
NBI HEATING	12.5	2,489	11.7	1,513
RF HEATING	8.6	1,671	8.4	1,396
OPERATIONS SUPPORT	23.0	4,440	24.4	3,552
COLLABORATION	2.8	1,388	3.2	1,055
SPECIAL TASKS				
ADVANCED DIVERTOR	0.2	96	0.7	137
RADIATIVE DIVERTOR	3.4	558	3.3	376
PELLET INJECTOR	1.4	292	0.7	174
ORNL ANTENNA	0.1	146	0.3	183
BUDGET ADJUSTMENT	(9.0)	(1,238)[1]		
TOTAL	146.8	32,021	159.7	25,181

CAPITAL

	FY94 BUDGET FTE's	FY94 BUDGET TOTAL $000	FY94 ACTUALS FTE's	FY94 ACTUALS TOTAL $000	OPEN COMMIT.
BASE OPERATIONS	—	230	—	228	—
PHYSICS	—	—	—	—	—
DATA SYSTEMS	—	430	—	166	263
DIAGNOSTICS	—	230	—	228	—
RF HEATING	—	15	—	14	—
OPERATIONS SUPPORT	—	11	—	11	—
CAPITAL PROJECTS					
110 GHz ECH	0.8	858	0.1	69	860
ICRF 4 MW UPGRADE	4.9	4,581	7.3	3,853	737
TOTAL	5.7	6,355[2]	7.4	4,564	1,860

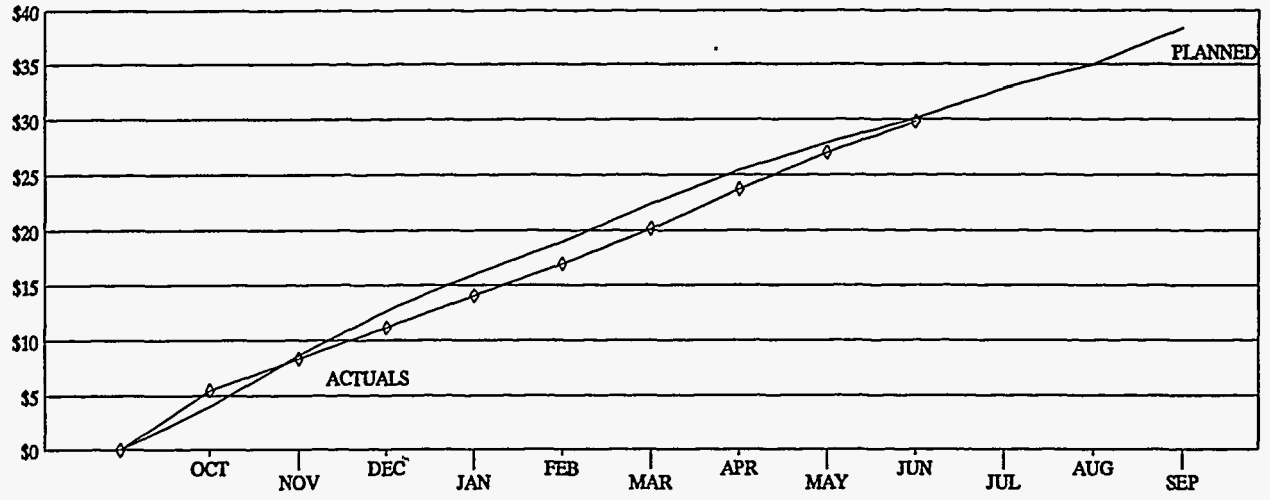
[1] Task, procurements & staff reductions/moves are being pursued to minimize the year end difference between funding & expenditures.

[2] Includes $0.8M commitment to 1 MW 110 GHz Russian gyrotron.

Contract Management Summary Report

TITLE:	DIII-D RESEARCH OPERATIONS & CAPITAL			CONTRACT NO.:	DE-AC03-89ER51114
CONTRACTOR:	GENERAL ATOMICS P.O. BOX 85608 SAN DIEGO, CA. 92186-9784	COST & LABOR PLAN DATE:	JULY 15, 1994	START DATE: COMPLETION DATE:	SEPTEMBER 25, 1993 SEPTEMBER 30, 1994

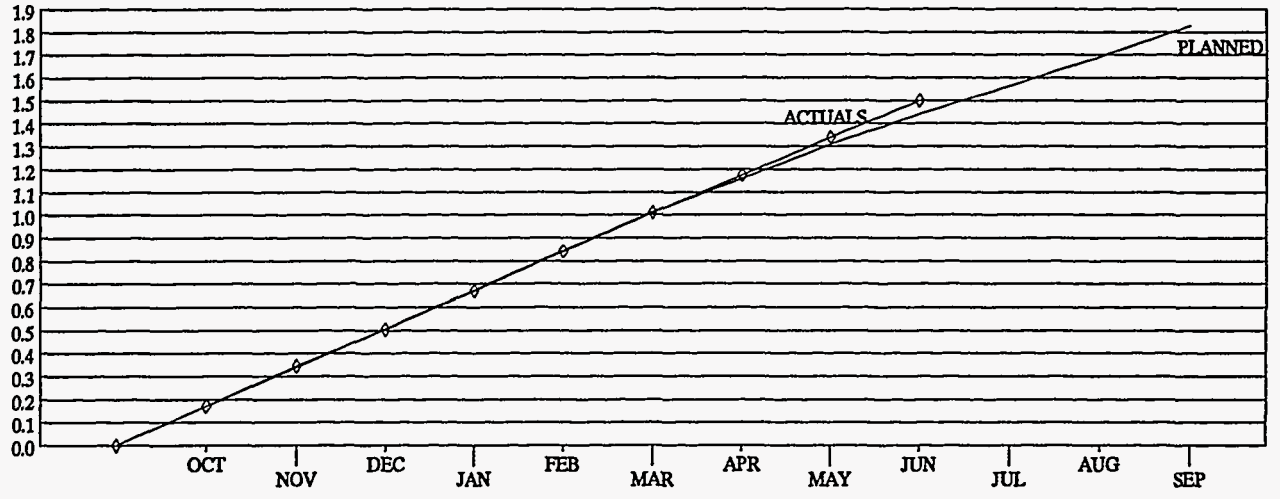
DOLLARS IN MILLIONS



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTALS
PLANNED	$3,973	$4,674	$4,054	$3,300	$2,897	$3,481	$2,992	$2,489	$2,213	$2,779	$2,173	$3,351	$38,376
ACTUAL	$5,464	$2,856	$2,834	$2,885	$2,891	$3,203	$3,552	$3,337	$2,728				$29,750
VARIANCE	($1,491)	$1,818	$1,220	$415	$6	$278	($560)	($848)	($515)				
CUM VAR	($1,491)	$327	$1,547	$1,962	$1,968	$2,246	$1,686	$838	$323				

(IN THOUSANDS)

PERSON – MONTHS (THOUSANDS)



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTALS
PLANNED	171.8	168.2	167.8	165.8	169.3	169.2	147.3	150.5	130.1	124.3	129.2	132.6	1826.1
ACTUAL	172.4	171.3	159.7	167.0	170.7	167.5	166.1	165.7	159.2				1499.6
VARIANCE	-0.6	-3.1	8.1	-1.2	-1.4	1.7	-18.8	-15.2	-29.1				
CUM VAR	-0.6	-3.7	4.4	3.2	1.8	3.5	-15.3	-30.5	-59.6				

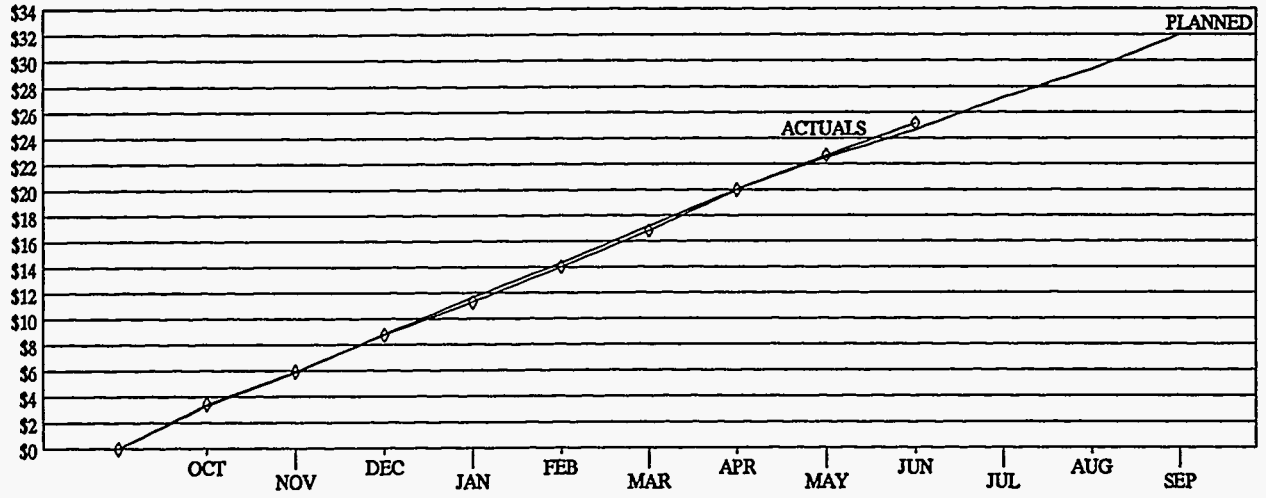
(PERSON-MONTHS)

SIGNATURE OF PARTICIPANT'S PROJECT MANAGER & DATE: _____

Contract Management Summary Report

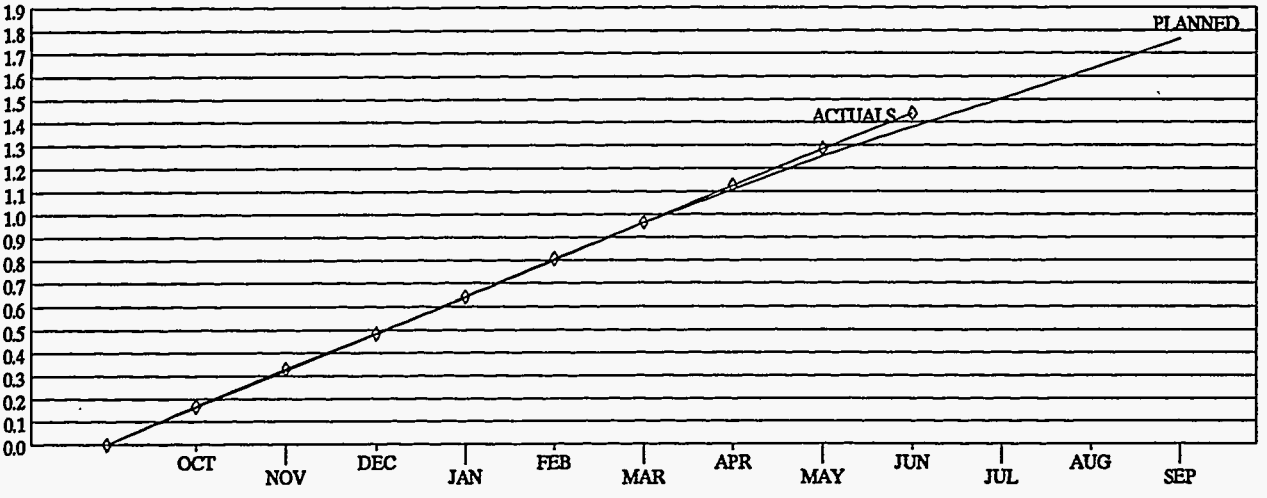
TITLE:	DIII-D RESEARCH OPERATIONS B\R NO: AT101014D	**CONTRACT NO.:**	DE-AC03-89ER51114
CONTRACTOR:	GENERAL ATOMICS P.O. BOX 85608 SAN DIEGO, CA. 92186-9784	**COST & LABOR PLAN DATE:** JULY 15, 1994	**START DATE:** SEPTEMBER 25, 1993 **COMPLETION DATE:** SEPTEMBER 30, 1994

DOLLARS IN MILLIONS



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTALS
PLANNED	$3,347	$2,509	$2,979	$2,839	$2,655	$2,818	$2,932	$2,422	$2,163	$2,517	$2,159	$2,681	$32,021
ACTUAL	$3,441	$2,502	$2,813	$2,545	$2,717	$2,792	$3,221	$2,641	$2,509				$25,181
VARIANCE	($94)	$7	$166	$294	($62)	$26	($289)	($219)	($346)				
CUM VAR	($94)	($87)	$79	$373	$311	$337	$48	($171)	($517)				*(IN THOUSANDS)*

PERSON – MONTHS (THOUSANDS)



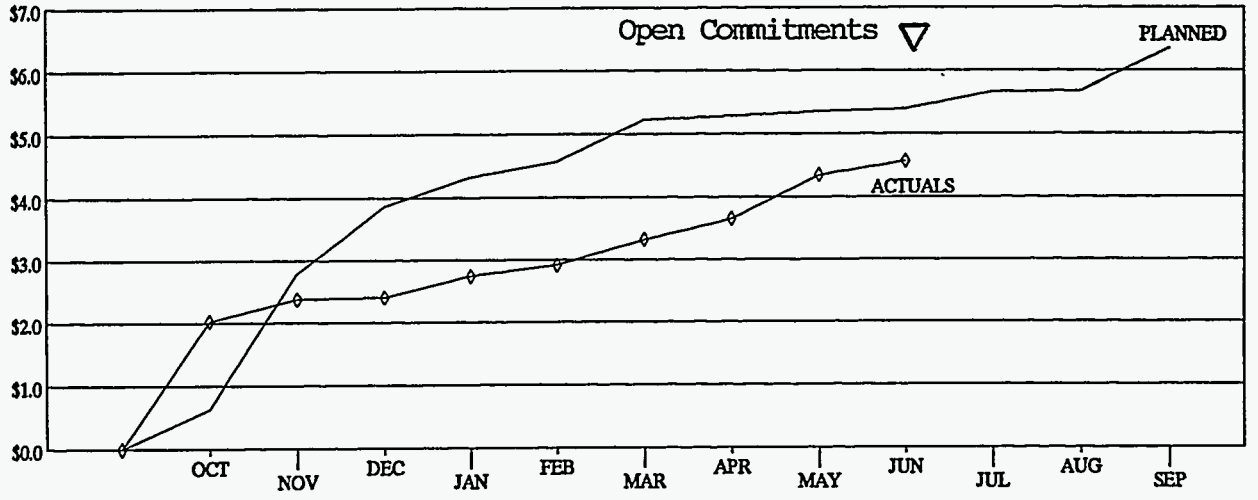
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTALS
PLANNED	161.6	159.4	160.7	158.6	159.7	163.6	144.2	145.3	126.0	123.6	128.0	131.4	1762.1
ACTUAL	167.1	162.6	154.1	158.9	163.3	158.5	160.6	159.2	154.2				1438.5
VARIANCE	-5.5	-3.2	6.6	-0.3	-3.6	5.1	-16.4	-13.9	-28.2				
CUM VAR	-5.5	-8.7	-2.1	-2.4	-6.0	-0.9	-17.3	-31.2	-59.4				*(PERSON-MONTHS)*

SIGNATURE OF PARTICIPANT'S PROJECT MANAGER & DATE: _____

Contract Management Summary Report

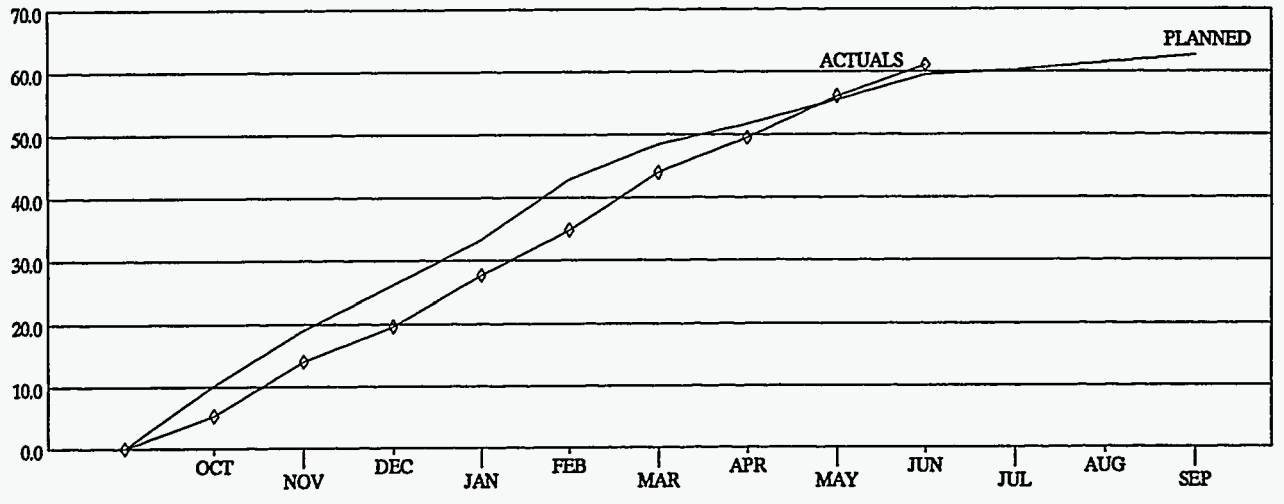
TITLE:	DIII-D CAPITAL SUMMARY B\R NO: AT1010140	CONTRACT NO.:	DE-AC03-89ER51114
CONTRACTOR:	GENERAL ATOMICS P.O. BOX 85608 SAN DIEGO, CA. 92186-9784	COST & LABOR PLAN DATE:	JULY 15, 1994
START DATE:	SEPTEMBER 25, 1993	COMPLETION DATE:	SEPTEMBER 30, 1994

DOLLARS IN MILLIONS



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTALS
PLANNED	$626	$2,165	$1,075	$461	$242	$663	$60	$67	$50	$262	$14	$670	$6,355
ACTUAL	$2,023	$354	$21	$338	$176	$409	$329	$698	$221				$4,569
VARIANCE	($1,397)	$1,811	$1,054	$123	$66	$254	($269)	($631)	($171)				
CUM VAR	($1,397)	$414	$1,468	$1,591	$1,657	$1,911	$1,642	$1,011	$840				*(IN THOUSANDS)*

PERSON-MONTHS



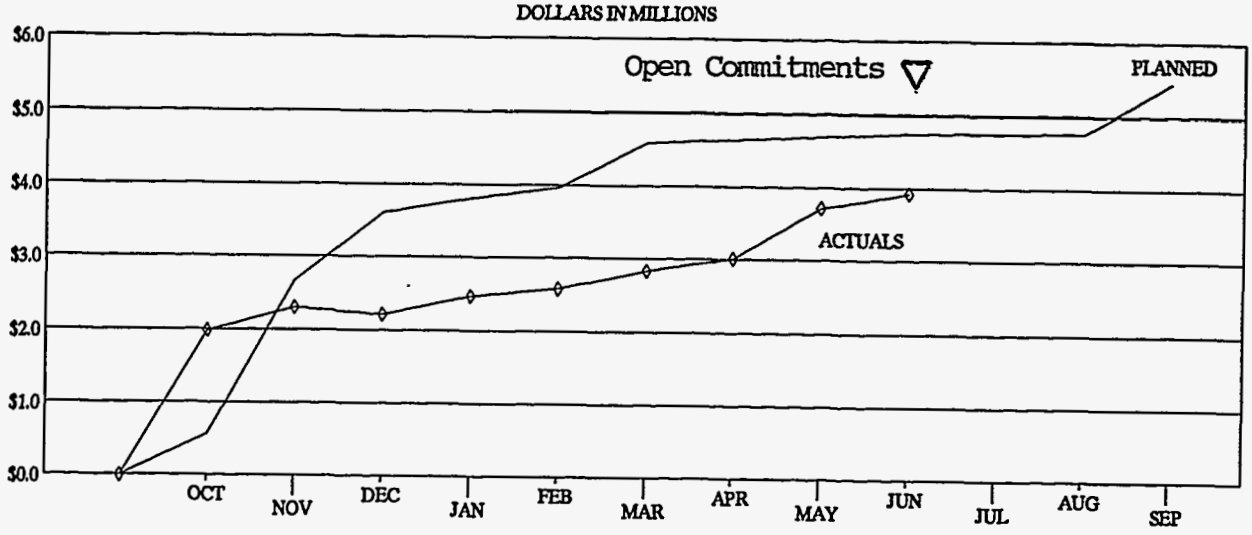
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTALS
PLANNED	10.2	8.8	7.1	7.2	9.6	5.6	3.1	3.8	4.1	0.7	1.2	1.2	62.6
ACTUAL	5.3	8.7	5.6	8.1	7.1	9.2	5.5	6.5	5.0				61.0
VARIANCE	4.9	0.1	1.5	-0.9	2.5	-3.6	-2.4	-2.7	-0.9				
CUM VAR	4.9	5.0	6.5	5.6	8.1	4.5	2.1	-0.6	-1.5				

SIGNATURE OF PARTICIPANT'S PROJECT MANAGER & DATE: _____

Contract Management Summary Report

TITLE:	DIII-D CAPITAL PROJECTS B\R NO: AT1010140	**CONTRACT NO.:**	DE-AC03-89ER51114
CONTRACTOR:	GENERAL ATOMICS P.O. BOX 85608 SAN DIEGO, CA. 92186-9784	**COST & LABOR PLAN DATE:**	JULY 15, 1994
		START DATE:	SEPTEMBER 25, 1993
		COMPLETION DATE:	SEPTEMBER 30, 1994

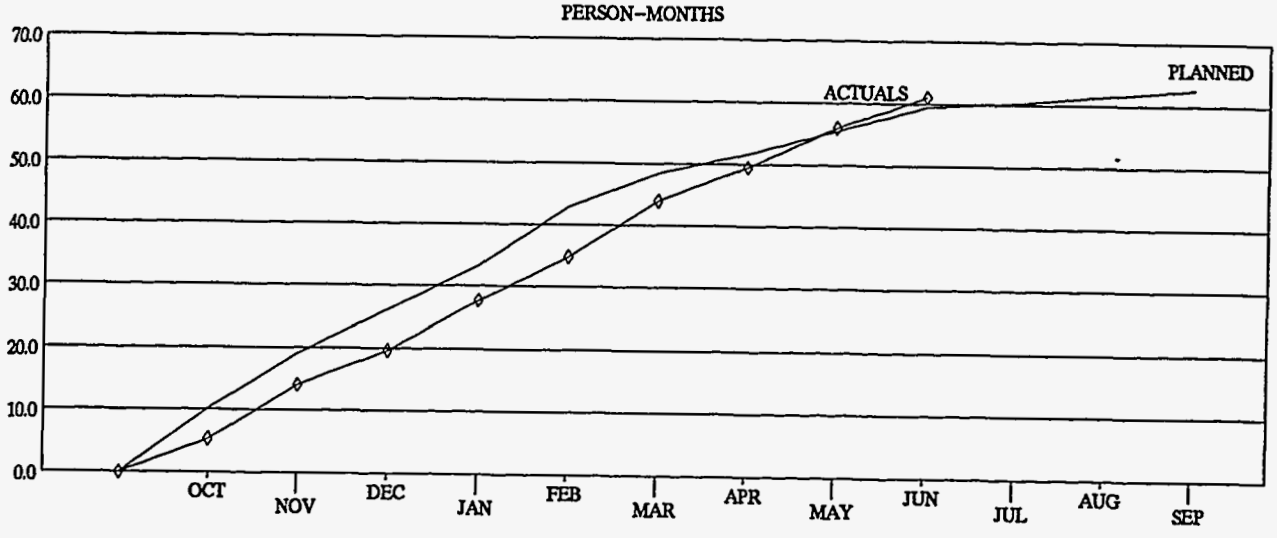
DOLLARS IN MILLIONS



													TOTALS
PLANNED	$561	$2,100	$935	$211	$155	$629	$52	$52	$50	$10	$14	$670	$5,439
ACTUAL	$1,981	$316	($88)	$256	$110	$247	$193	$695	$212				$3,922
VARIANCE	($1,420)	$1,784	$1,023	($45)	$45	$382	($141)	($643)	($162)				
CUM VAR	($1,420)	$364	$1,387	$1,342	$1,387	$1,769	$1,628	$985	$823				

(IN THOUSANDS)

PERSON-MONTHS



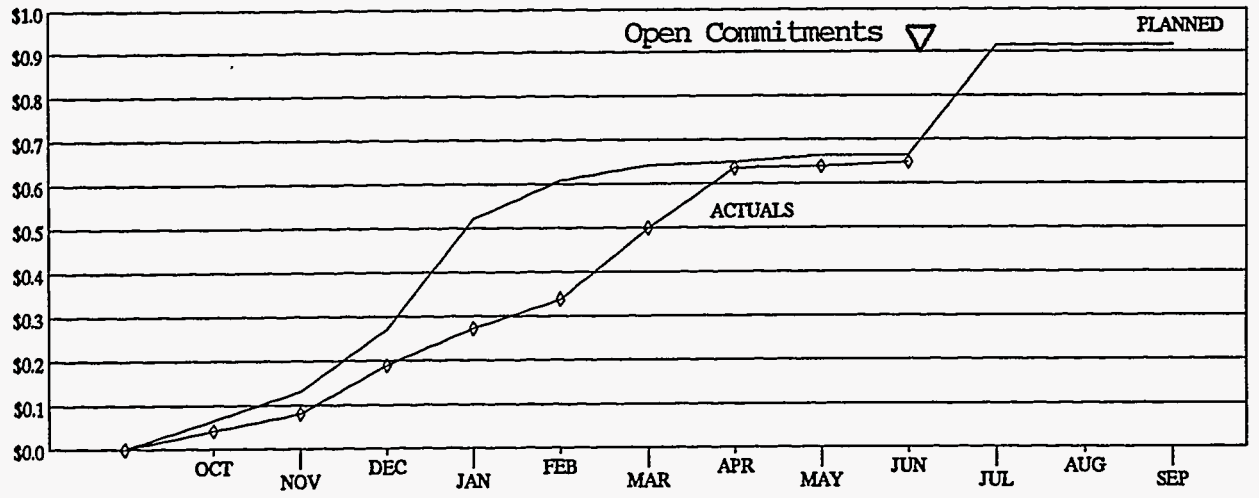
													TOTALS
PLANNED	10.2	8.8	7.1	7.2	9.6	5.6	3.1	3.8	4.1	0.7	1.2	1.2	62.6
ACTUAL	5.3	8.7	5.6	8.1	7.1	9.2	5.5	6.5	5.0				61.0
VARIANCE	4.9	0.1	1.5	-0.9	2.5	-3.6	-2.4	-2.7	-0.9				
CUM VAR	4.9	5.0	6.5	5.6	8.1	4.5	2.1	-0.6	-1.5				

SIGNATURE OF PARTICIPANT'S PROJECT MANAGER & DATE: _____

Contract Management Summary Report

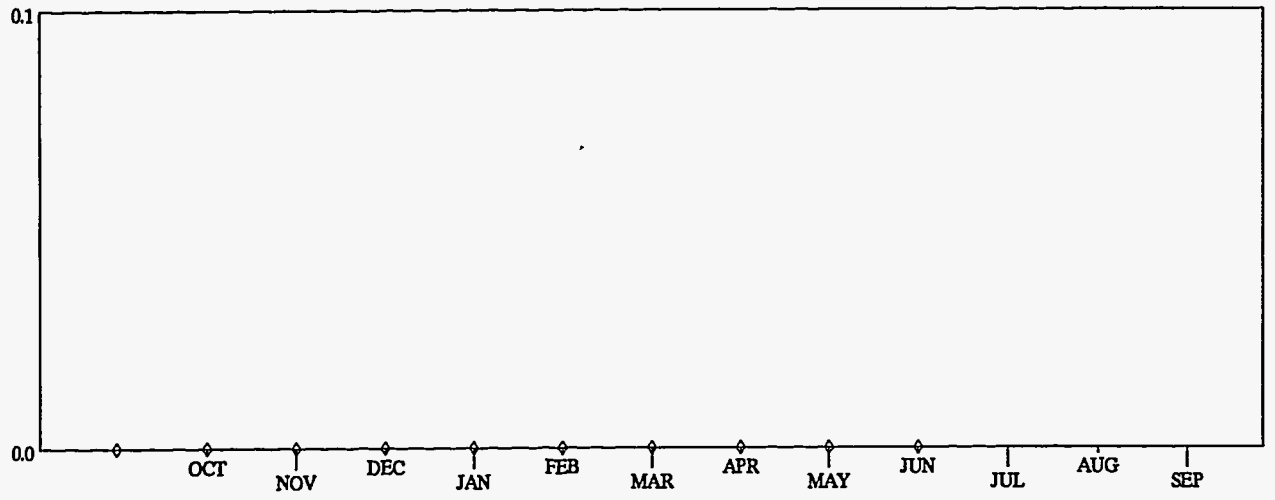
TITLE:	DIII-D CAPITAL EQUIPMENT B\R NO: AT1010140	**CONTRACT NO.:**	DE-AC03-89ER51114
CONTRACTOR:	GENERAL ATOMICS P.O. BOX 85608 SAN DIEGO, CA. 92186-9784	**COST & LABOR PLAN DATE:** JULY 15, 1994	**START DATE:** SEPTEMBER 25, 1993 **COMPLETION DATE:** SEPTEMBER 30, 1994

DOLLARS IN MILLIONS



													TOTALS
PLANNED	$65	$65	$140	$250	$87	$34	$8	$15	$0	$252	$0	$0	$916
ACTUAL	$42	$38	$109	$82	$66	$162	$136	$3	$9				$647
VARIANCE	$23	$27	$31	$168	$21	($128)	($128)	$12	($9)				
CUM VAR	$23	$50	$81	$249	$270	$142	$14	$26	$17				*(IN THOUSANDS)*

PERSON-MONTHS



													TOTALS
PLANNED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ACTUAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VARIANCE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CUM VAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

SIGNATURE OF PARTICIPANT'S PROJECT MANAGER & DATE: _____

RON BROWN X-3266
RELEASED 1/5/94.REVISED 3/25/94
STATUSED 6/24/94
ISSUE 3. FILE MAST-94

DIII-D FY 1994 MASTER SCHEDULE

LEGEND
EVENT PROGRESS = IXXX—I
COMPLETED MILESTONE = ▲
SCHEDULED PAD =- - - -:

FY 1994

OCT 1 8 15 22 29 | NOV 5 12 19 26 | DEC 3 10 17 24 31 | JAN 7 14 21 28 | FEB 4 11 18 25 | MAR 4 11 18 25 | APR 1 8 15 22 29 | MAY 6 13 20 27 | JUN 3 10 17 24 | JUL 1 8 15 22 29 | AUG 5 12 19 26 | SEP 2 9 16 23 30

ITEM	DESCRIPTION	T LEADER
	11 WEEK OPERATION PLAN	
	VESSEL VENTS	
	SCHEDULED MAINTENANCE	
	CONFERENCES	
	MILESTONES	
94	COMPLETE REPORT ON ITER R & D TASKS	LUXON
99	REPT ON EXPERIMENTS TO DESIGN THE RADIATIVE DIVERTOR	STAMBAUGH
96	CHECKOUT OF THE NEW FWCD TRANSMITTERS	FREEMAN
83	COMPLETE INSTALLATION OF THE MULTI-ELEMENT ANTENNAS	FREEMAN
95	REPT ON THE CONCEPTUAL RADIATIVE DIVERTOR DESIGN	STAMBAUGH
70	INJECT PELLETS INTO H-MODE PLASMA	LUXON
	CONSTRUCTION PROGRAMS	
1	RADIATIVE DIVERTOR	SEVIER
1	DIVERTOR	SMITH
2	CRYOPUMP	SMITH
3	DESIGN	SMITH
2	ICRH FWCD 4 MW UPGRADE	CALLIS
1	ABB TRANSMITTERS	CARY
2	FACILITY MODIFICATIONS	CARY
3	TRANSMISSION SYSTEM	O'NEILL
4	DUMMY LOAD	FERGUSON
5	EXCITER,INSTRUMENTATION & TEST EQUIP	FERGUSON
6	ORNL ANTENNA CONSTRUCTION(2EA)	CALLIS
7	MODIFY 180° PORT	O'NEILL
4	VESSEL TILE	SEVIER
1	ICH PORT TILE	HOLLERBACH
2	BUMPER TILE	HOLLERBACH
5	PELLET INJECTOR SYSTEM	PHILLIPS

OPS | OPS TEST | CONDITION | PLASMA CLN | OPS | TEST | OPS | OPS
VENT | VENT
MAINT. | MAINT. | MAINT | MAINT | MAINT
IEEE | APS | ANS
10/93 ▲COMPLETED
1/94 ▲COMPLETED
2/94 ECD 8/94
3/94 ▲COMPLETE
6/94 ▲COMPLETE
8/94
CONCEPTUAL DESIGN | RDP REVIEW | 6/14/94 COMPLETE
CONCEPTUAL DESIGN | RDP REVIEW | 6/14/94 COMPLETE
DESIGN
INSTALLATION | BEGIN C/O
MEZZANINE CONSTRUCTION | COMPLETE
PROCURE | INSTALLATION | 0°SYST | 180°SYSTEM | 0° COMPLETE,180° ECD 9/9/94
PROCURE | INSTL | COMPLETE
PROCURE & INSTALL | 0° COMPLETE.180° ECD 9/9/94
ORNL CONSTRUCTION | INSTALLATION | COMPLETE
COMPLETE
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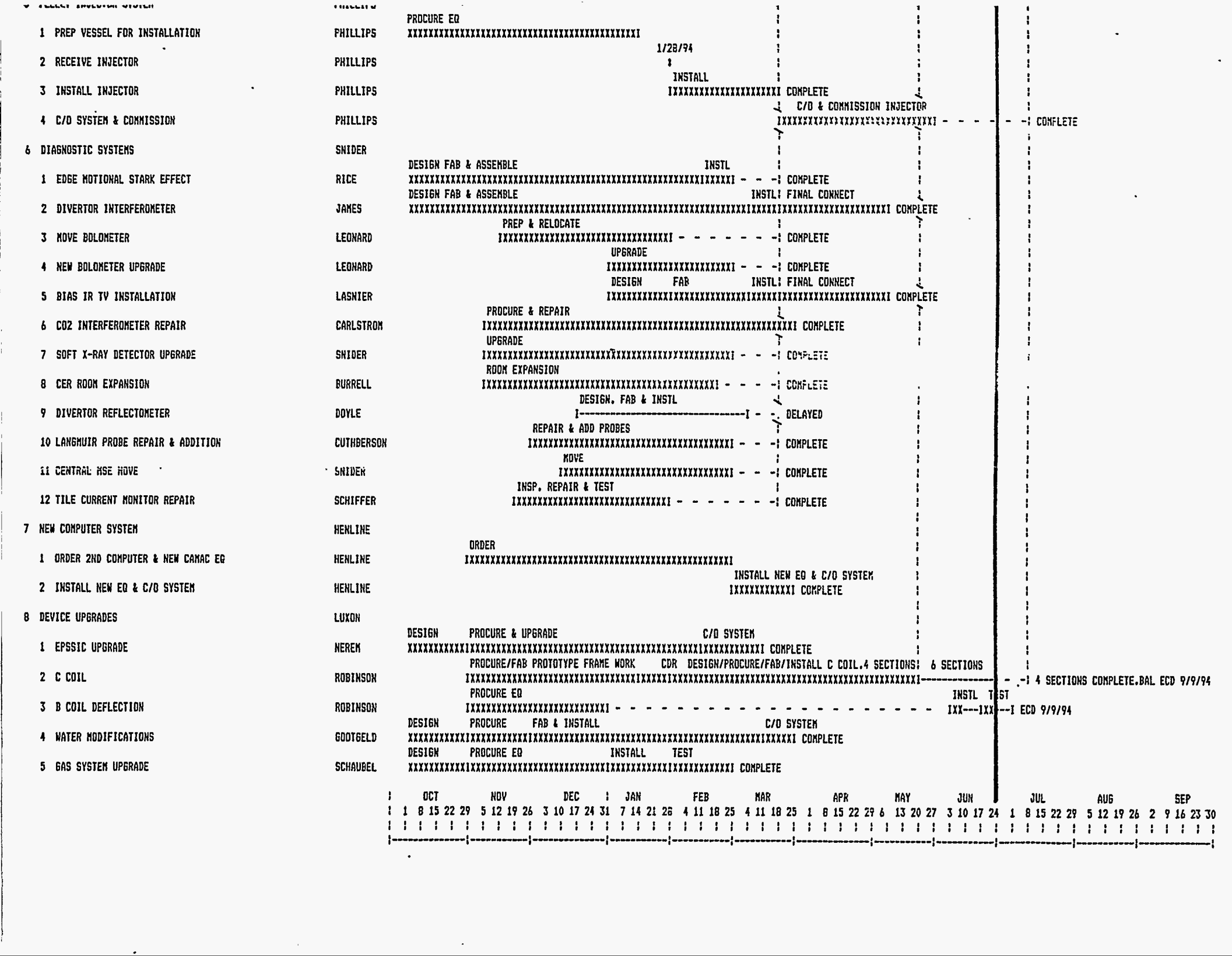
PROCURE EQ
1 PREP VESSEL FOR INSTALLATION PHILLIPS
1/28/94
2 RECEIVE INJECTOR PHILLIPS
INSTALL
3 INSTALL INJECTOR PHILLIPS
COMPLETE
C/O & COMMISSION INJECTOR
4 C/O SYSTEM & COMMISSION PHILLIPS
COMPLETE
6 DIAGNOSTIC SYSTEMS SNIDER
DESIGN FAB & ASSEMBLE
INSTL
1 EDGE MOTIONAL STARK EFFECT RICE
COMPLETE
DESIGN FAB & ASSEMBLE
INSTL
FINAL CONNECT
2 DIVERTOR INTERFEROMETER JAMES
COMPLETE
PREP & RELOCATE
3 MOVE BOLOMETER LEONARD
COMPLETE
UPGRADE
4 NEW BOLOMETER UPGRADE LEONARD
COMPLETE
DESIGN FAB INSTL
FINAL CONNECT
5 BIAS IR TV INSTALLATION LASNIER
COMPLETE
PROCURE & REPAIR
6 CO2 INTERFEROMETER REPAIR CARLSTROM
COMPLETE
UPGRADE
7 SOFT X-RAY DETECTOR UPGRADE SNIDER
COMPLETE
ROOM EXPANSION
8 CER ROOM EXPANSION BURRELL
COMPLETE
DESIGN, FAB & INSTL
9 DIVERTOR REFLECTOMETER DOYLE
DELAYED
REPAIR & ADD PROBES
10 LANGMUIR PROBE REPAIR & ADDITION CUTHBERSON
COMPLETE
MOVE
11 CENTRAL HSE MOVE SNIDER
COMPLETE
INSP, REPAIR & TEST
12 TILE CURRENT MONITOR REPAIR SCHIFFER
COMPLETE
7 NEW COMPUTER SYSTEM HENLINE
ORDER
1 ORDER 2ND COMPUTER & NEW CAMAC EQ HENLINE
INSTALL NEW EQ & C/O SYSTEM
2 INSTALL NEW EQ & C/O SYSTEM HENLINE
COMPLETE
8 DEVICE UPGRADES LUXON
DESIGN PROCURE & UPGRADE
C/O SYSTEM
1 EPSSIC UPGRADE NEREM
COMPLETE
PROCURE/FAB PROTOTYPE FRAME WORK
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6 SECTIONS
2 C COIL ROBINSON
4 SECTIONS COMPLETE.BAL ECD 9/9/94
PROCURE EQ
INSTL TEST
3 B COIL DEFLECTION ROBINSON
ECD 9/9/94
DESIGN PROCURE FAB & INSTALL
C/O SYSTEM
4 WATER MODIFICATIONS GOOTGELD
COMPLETE
DESIGN PROCURE EQ
INSTALL TEST
5 GAS SYSTEM UPGRADE SCHAUBEL
COMPLETE
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
1 8 15 22 29 5 12 19 26 3 10 17 24 31 7 14 21 28 4 11 18 25 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 30

INTERNATIONAL COOPERATION

PROGRAM STATUS
3RD QUARTER — FY 1994

TASK: INTERNATIONAL COOPERATION **FY94 FUNDING:** $1003 K

B/R NO: AT101014Z **FY94 PLAN:** $ 953 K(1)

CONTRACT NO.: DE-AC03-89ER51114

GA PRINCIPAL INVESTIGATOR: D. BAKER

OAK PROJECT MANAGER: M. FOSTER

OFE PROGRAM MANAGER: E. OKTAY

The budget and plan for international cooperation are included later in this section. Because we had initially planned not to operate DIII–D in the summer, most of the exchanges were scheduled for the summer quarter as indicated by the plan. Approximately eight scientists are on international assignments during this period.

JET (England)

Ted Strait has just started a two month exchange with JET on the subject of high beta plasmas in tokamaks. Subjects to be addressed are; how to exceed the 'Troyon limit' and the effects of high beta on confinement. Mike Schaffer has begun a multimonth exchange to work with the JET divertor physics group.

ASDEX/WS 7a (Germany)

Tim Luce is participating in ECH experiments on the WS 7a stellarator. The experimental plans are complete and have been presented to the physics group for on- and off-axis ECH comparisons with and without plasma current. The goal is to test if the free energy in the poloidal magnetic field or the applied parallel electric field is the source of profile consistency in tokamaks. Target discharges have been successfully made, and the capability of generating stellarator equilibria with current has also been developed.

Phil West will begin a 5 month exchange working with the ASDEX divertor group.

REMARKS:
(1) Adjustment for FY93 over expenditure.

TEXTOR (Germany)

Felix Weschenfelder from TEXTOR is at GA for one year to perform colorimetry measurments with the DIMES experiment. Colorimetry was developed at TEXTOR as a technique to observe the carbon erosion and redeposition on extended limiter areas. It measures the interference color of a transparent co-deposit of carbon, boron and hydrogen to determine the thickness of the layer. With the observation of a changing color pattern on a limiter the erosion or deposition rate or even an erosion contour over an extended area can be measured. With the colorimetry on DIII–D the erosion rates on a precoated DIMES sample will be measured. A DIMES sample will be coated during a boronization. After the boronization the DIMES sample will be exposed during tokamak discharges. By measuring the change in the color of the deposit on DIMES between discharges, erosion rates will be determined.

TORE SUPRA (France)

There are three GA scientists at Tore Supra. John Ferron and Cary Forest are working the measurment and control of the current profile in a variety of plasmas. Parallel electric field profiles have been determined for lower hybrid enhanced performance (LHEP) mode plasmas. These plasmas are characterized by a broadening of the current profile and enhanced central confinement. Work has also begun on evaluating the capability to use the lower hybrid facility to do feedback control of q(0). Ali Mahdavi is participating in experiments on pumped limiters, to compare the performance of the pumped limiter in Tore Supra with the pumped divertor in DIII–D.

JAERI (JAPAN)

On JT60–U, Craig Petty was involved with several experiments to vary the current density profile by the use of Lower Hybrid Current Drive. It was found that by varying $n_{||}$ it was possible to generate either broad or narrow current profiles. In general, the higher the $n_{||}$, the broader the current profile. Compound spectra, with more than one $n_{||}$ were also used to broaden the profile. An experiment proposed by Dr. Petty was run to test the cold accessability criteria. The idea is to see if it is possible to broaden the current profile even under conditions where the wave is not accessible to the plasma center. A compound spectra was used. The high $n_{||}$ is used to heat the edge electrons so that the low $n_{||}$ absorption is enhanced thus reducing impurity generation problems. The experimental results seemed to verify this concept.

Some discussions were held concerning the possibility of using the GA designed combline ICRF antenna on JFT–2M. There is interest in this experiment by JFT–2M scientists however some modifications to the experimetal hardware will have to be made.

TRINITI (RUSSIA)

Scientists from TRINITI Institute are at GA to participate in DIII–D experiments. Victor Lukash worked on the DINA code for modeling plasma disruptions. Sergey Tugarinov made measurements with the Russian spectrometers which are installed on DIII–D. Oleg Buzhinskij worked with Phil West on a paper on the materials tests which were done on DIII–D and also at TRINITI.

T–10(RUSSIA)

John Lohr and Jared Squire went to Moscow for a several week exchange on T–10. The microwave Michelson Interferometer brought from GA is functioning and has been used to measure the spectrum of the Russian gyrotrons. These measurements showed a 5 GHz frequency shift during the first 25 ms of the pulse. High power ECCD experiments are presently in progress.

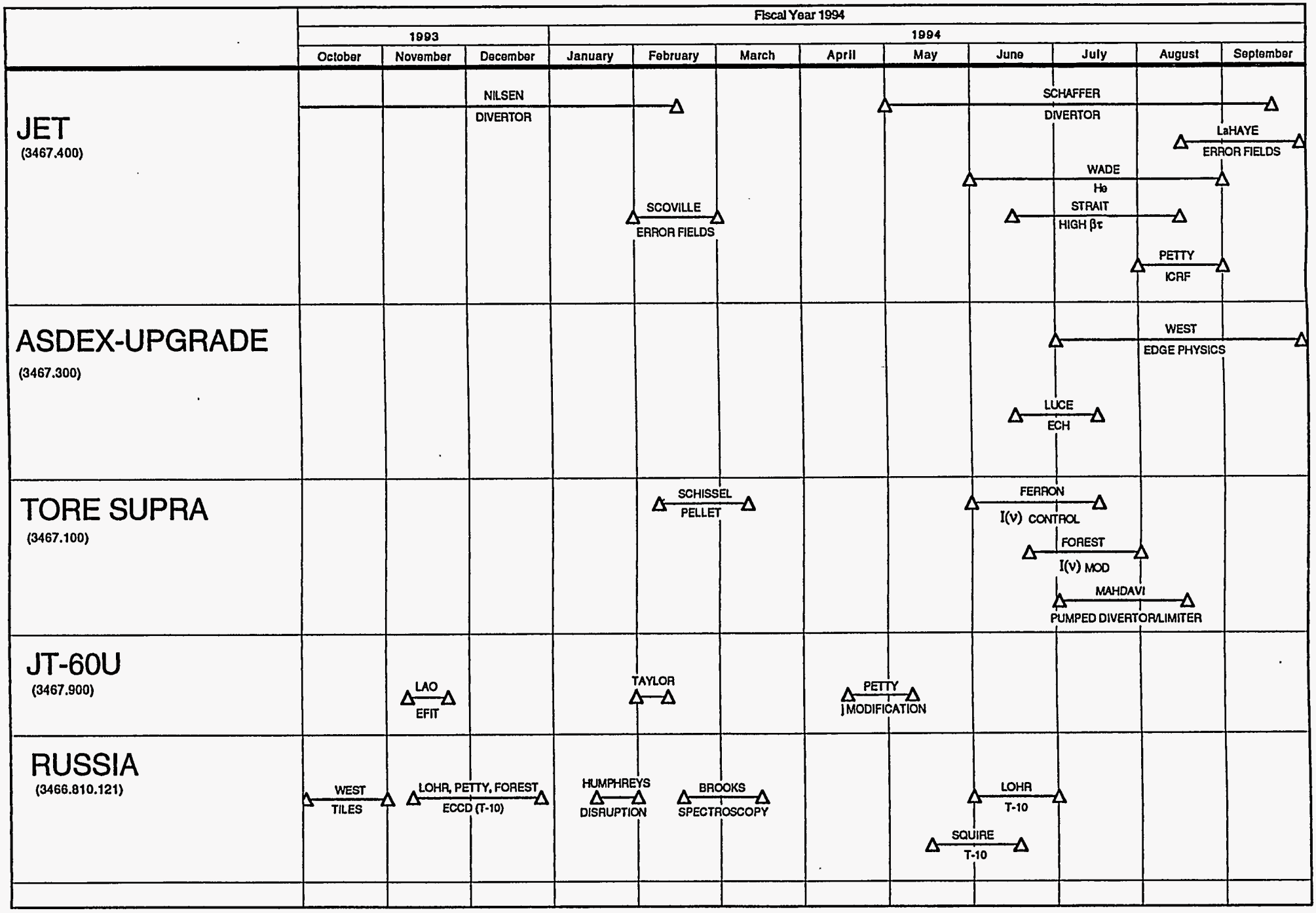
ARIES (PULSAR) SUPPORT

During this quarter disruption analyses of the PULSAR–I and PULSAR–II designs were completed and documented.

INTERNATIONAL COOPERATION

	FY94 BUDGET		FY94 ACTUALS	
	FTE's	TOTAL $000	FTE's	TOTAL $000
JET	1.4	306	0.8	122
ASDEX	0.5	148	0.1	25
TORE SUPRA	0.5	162	0.4	66
JT–60U/JFT–2M	0.3	126	0.2	42
RUSSIAN SUB–CONTRACT	–	161	0.1	131
ARIES SUPPORT	0.2	50	0.3	43
TOTAL	2.9	953	1.9	429

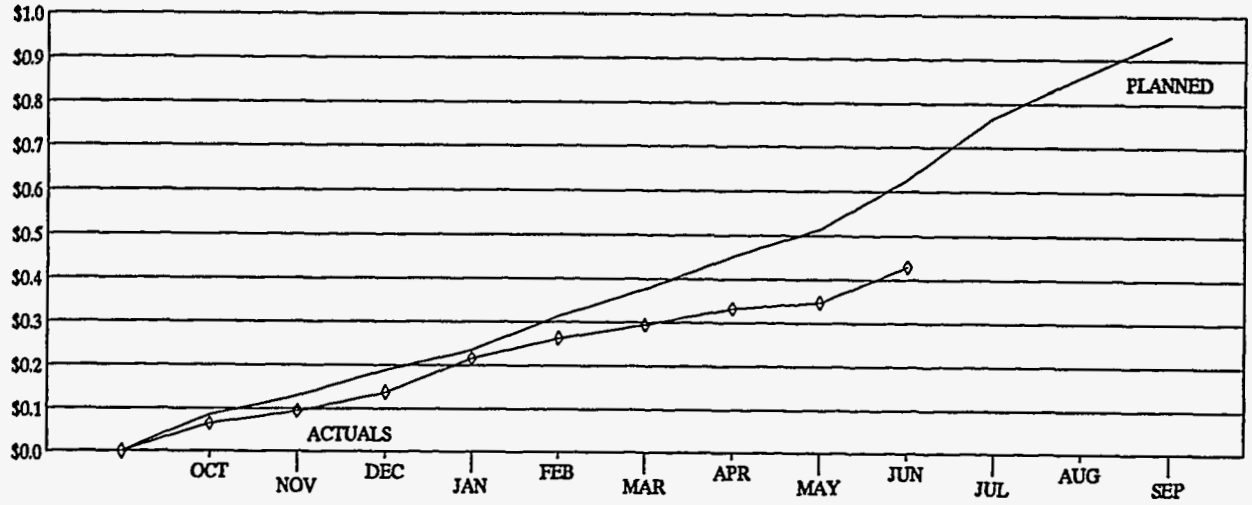
DIII-D INTERNATIONAL COOPERATION TRAVEL
- FY 94 -



Contract Management Summary Report

TITLE:	INTERNATIONAL COOPERATION B/R NO: AT101014Z	CONTRACT NO.:	DE-AC03-89ER51114
CONTRACTOR:	GENERAL ATOMICS P.O. BOX 85608 SAN DIEGO, CA. 92186-9784	COST & LABOR PLAN DATE:	JANUARY 17, 1994
START DATE:	SEPTEMBER 25, 1993	COMPLETION DATE:	SEPTEMBER 30, 1994

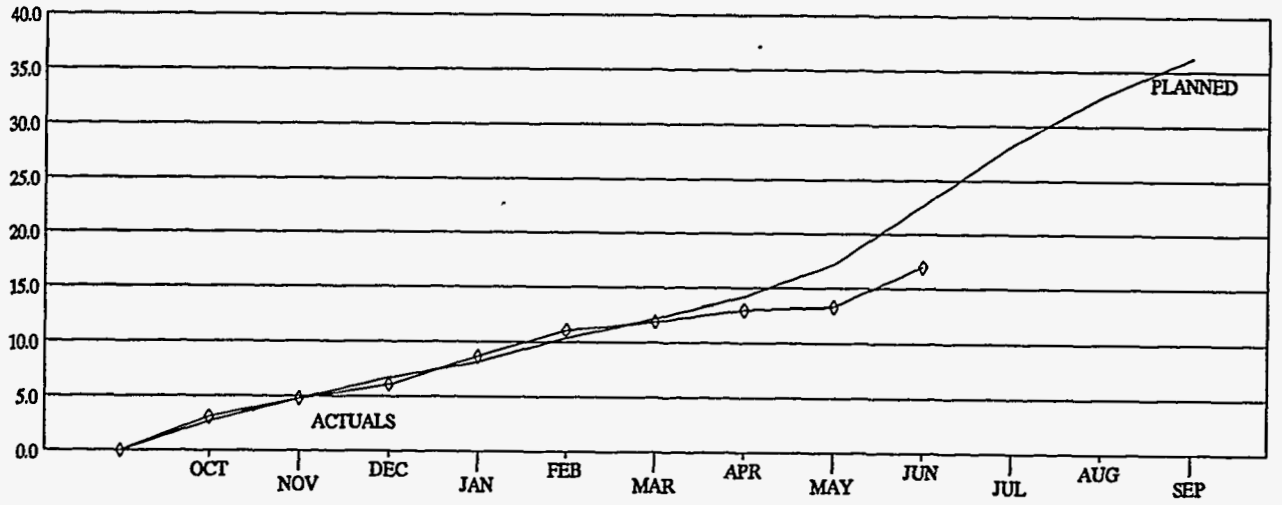
DOLLARS IN MILLIONS



													TOTALS
PLANNED	$85	$44	$59	$46	$79	$63	$75	$64	$111	$144	$91	$92	$953
ACTUAL	$64	$29	$44	$79	$46	$32	$38	$15	$82				$429
VARIANCE	$21	$15	$15	($33)	$33	$31	$37	$49	$29				
CUM VAR	$21	$36	$51	$18	$51	$82	$119	$168	$197				

(IN THOUSANDS)

PERSON-MONTHS



													TOTALS
PLANNED	2.7	2.1	1.9	1.5	2.2	1.8	2.0	3.0	5.5	5.5	4.5	3.5	36.2
ACTUAL	3.1	1.7	1.3	2.6	2.4	0.8	1.1	0.3	3.7				17.0
VARIANCE	-0.4	0.4	0.6	-1.1	-0.2	1.0	0.9	2.7	1.8				
CUM VAR	-0.4	0.0	0.6	-0.5	-0.7	0.3	1.2	3.9	5.7				

SIGNATURE OF PARTICIPANT'S PROJECT MANAGER & DATE: _____

TOKAMAK PHYSICS EXPERIMENT

PROGRAM STATUS
3RD QUARTER — FY 1994

TASK: TOKAMAK PHYSICS EXPERIMENT **FY94 FUNDING:** $64 K(1)

B/R NO: AT1010190 **FY94 PLAN:** $64 K

CONTRACT NO.: DE-AC03-89ER51114

GA PRINCIPAL INVESTIGATOR: P. POLITZER

OAK PROJECT MANAGER: M. FOSTER

OFE PROGRAM MANAGER: E. OKTAY

HIGHLIGHTS:

- A draft TPX experimental plan has been developed in conjunction with the TPX Program Advisory Committee.

The work in support of the development of a plan for TPX experimental goals and milestones continued. In conjunction with the working group on this topic established by the TPX Program Advisory Committee, we have developed a detailed draft plan listing major goals and milestones, as well as secondary milestones. This covers the three principal TPX research areas of Plasma Control, Advanced Tokamak Operating Regimes, and Steady State Divertor. This plan is intended to provide a credible basis for estimating the needs for manpower, operating time, and upgrade hardware needed to accomplish the TPX mission.

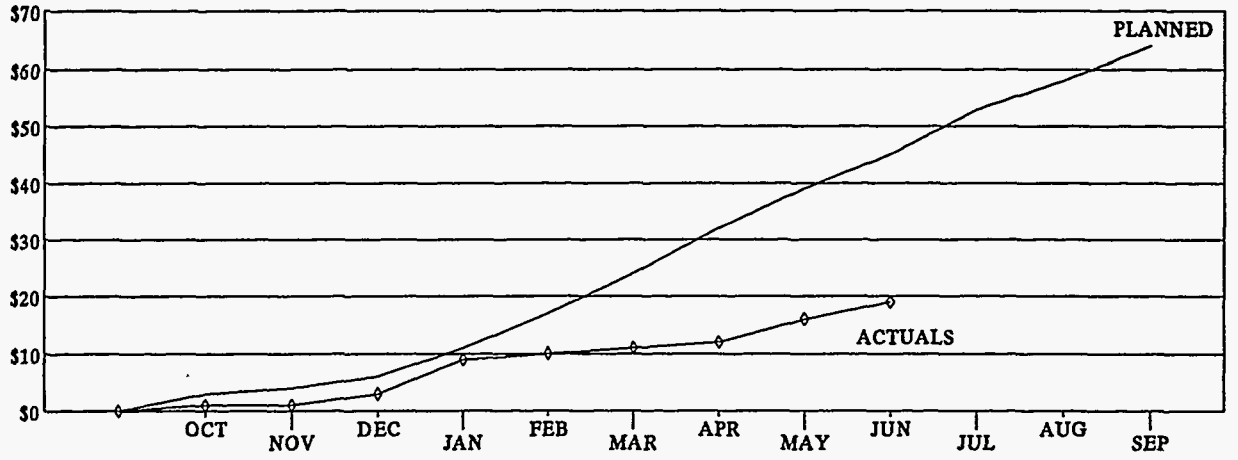
REMARKS:

(1)$2K funding reduction in latest Financial Plan.

Contract Management Summary Report

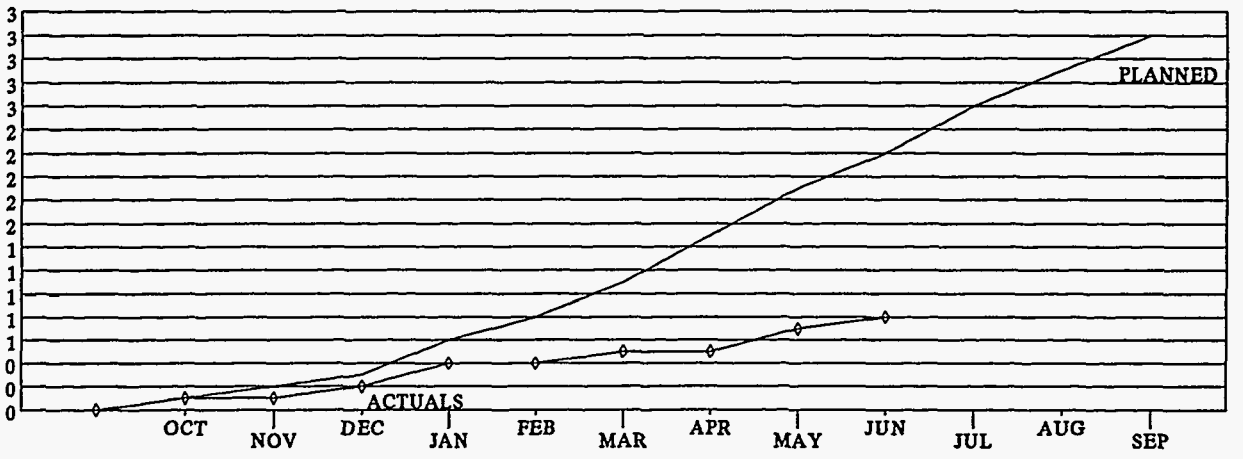
TITLE:	TOKAMAK PHYSICS EXPERIMENT B&R NO: AT101090	CONTRACT NO.:	DE-AC03-89ER51114
CONTRACTOR:	GENERAL ATOMICS P.O. BOX 85608 SAN DIEGO, CA. 92186-9784	COST & LABOR PLAN DATE: JULY 8, 1994	START DATE: SEPTEMBER 25, 1993 COMPLETION DATE: SEPTEMBER 30, 1994

DOLLARS IN THOUSANDS



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTALS
PLANNED	$3	$1	$2	$5	$6	$7	$8	$7	$6	$8	$5	$6	$64
ACTUAL	$1	$0	$2	$6	$1	$1	$1	$4	$3				$19
VARIANCE	$2	$1	$0	($1)	$5	$6	$7	$3	$3				
CUM VAR	$2	$3	$3	$2	$7	$13	$20	$23	$26				

PERSON-MONTHS



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTALS
PLANNED	0.1	0.1	0.1	0.3	0.2	0.3	0.4	0.4	0.3	0.4	0.3	0.3	3.2
ACTUAL	0.1	0.0	0.1	0.2	0.0	0.1	0.0	0.2	0.1				0.8
VARIANCE	0.0	0.1	0.0	0.1	0.2	0.2	0.4	0.2	0.2				
CUM VAR	0.0	0.1	0.1	0.2	0.4	0.6	1.0	1.2	1.4				

SIGNATURE OF PARTICIPANT'S PROJECT MANAGER & DATE: _____

FUSION PLASMA THEORY

PROGRAM STATUS
3RD QUARTER — FY 1994

TASK: FUSION PLASMA THEORY **FY 94 FUNDING:** $565 K

B/R NO: AT0520210 **FY94 PLAN:** $565 K

CONTRACT NO.: DE-AC03-89ER51114

GA PRINCIPAL INVESTIGATOR: V. CHAN/R. WALTZ

OAK PROJECT MANAGER: M. FOSTER

OFE PROGRAM MANAGER: W. SADOWSKI

HIGHLIGHTS:

- An invited review talk on all tokamak divertor bias experiments was given by Gary Staebler at the 11th International Conference on Plasma Surface Interactions in Controlled Fusion Devices, Tokyo, Japan, May 23–27, 1994. This will be published in a special issue of Journal of Nuclear Materials.
- A high degree of participation and cooperation has been achieved in the GA/Russian Theory Collaboration. A contract covering October 1993 through January 1995 has been signed and payment has been made on the basis of six of seven February and four June milestone reports. As an example of long distance collaboration, Alexander Smirnov electronically delivered the GENRAY ray tracing code to a GA local SGI workstation and debugged it on the workstation from Moscow.
- Simulations of turbulent diffusion of toroidal momentum demonstrate the possibility of a momentum transport bifurcation which may be important in understanding the transition to the VH mode. The core plasma has nearly pure toroidal rotation. Toroidal rotation projects to a stabilizing $\mathbf{E} \times \mathbf{B}$ rotational shear and a destabilizing parallel velocity shear. At sufficiently high current (low Rq/r), the $\mathbf{E} \times \mathbf{B}$ shear begins to stabilize the turbulence and hence the turbulent toroidal viscosity decreases to a low level. As a result the plasma spins up to a higher state of rotation where parallel shear may start to drive instability but nevertheless a lower state of heat transport can be obtained.
- A proposal for a new 3-year APT Theory Grant starting October 1994 has been submitted to DOE.

Fusion Theory efforts at GA are funded via Grant ($1150K–FY94) and DIII–D Contract ($565K–FY94). The workscope and progress reported reflect the total theory program funded from both sources.

STATEMENT OF WORK

1. Improve on existing models and codes leading to improved understanding of experiments.
2. Conduct theoretical physics development of advanced concepts with application to present and future experiments.

The object of the theoretical plasma physics research at GA is to support the DIII–D and other tokamak experiments and to significantly advance our ability to design a commercially-attractive fusion reactor. We categorize our efforts in three areas: magnetohydrodynamic (MHD) equilibria and stability, plasma transport with emphasis on H–mode, divertor and boundary physics, and radio frequency (RF) heating current drive.

PROGRESS

Rotation in tokamaks is believed to be necessary to avoid MHD kink instabilities and locked modes. Sheared rotation is believed to be desirable for suppressing turbulence and allowing access to improved confinement regimes. Toroidal rotation in present tokamaks occurs mainly because of neutral beam injection, which might not be used in a reactor. Some other means of producing toroidal rotation would be needed, in the absence of neutral beams. Two other approaches to obtaining rotation are being pursued: alpha particle drive and RF drive.

The birth of alpha particles produces a radial current because of the orbital motion of the alphas away from the radius where they were born, and because the birth profile is non uniform in radius. Because the plasma dielectric constant is very large, a nearly equal but oppositely directed current must flow in the plasma, and this return current causes a torque on the plasma. This current is non zero only during about one alpha slowing down time; after the alpha particle distribution function reaches a steady state, the birth current is zero.There is also a toroidal alpha particle flow because of their orbital motion and non uniform birth profile. The toroidal momentum of the alphas is transferred to the plasma by collisions, resulting in a torque on the plasma. This momentum transfer also produces a radial current, which causes a torque on the plasma. We find, surprisingly, that these two torques cancel. Thus, for times longer than about one slowing down time after the beginning of alpha production, there is no net torque produced by the birth and slowing down of alpha particles. However if alpha particles are born on loss orbits, then a radial current must flow in the plasma in response to the alpha loss current, and this produces a torque on the plasma. The loss of alphas results in a non-isotropic alpha distribution function, so that the alphas have a non zero toroidal momentum. This momentum is transferred to the plasma by collisions, which produces a torque on the plasma.These two torques do not

cancel, in general. The steady-state toroidal rotation velocity has been estimated, by balancing this torque with the empirical rate of toroidal angular momentum transport.The resulting toroidal rotation velocity is fairly large. It has been suggested that these alpha currents could also drive a large poloidal rotation which would be more favorable to the suppression of turbulence. However by balancing the poloidal torque with the poloidal rotation damping by friction between trapped and untrapped ions, the driven poloidal rotation is estimated to be smaller.

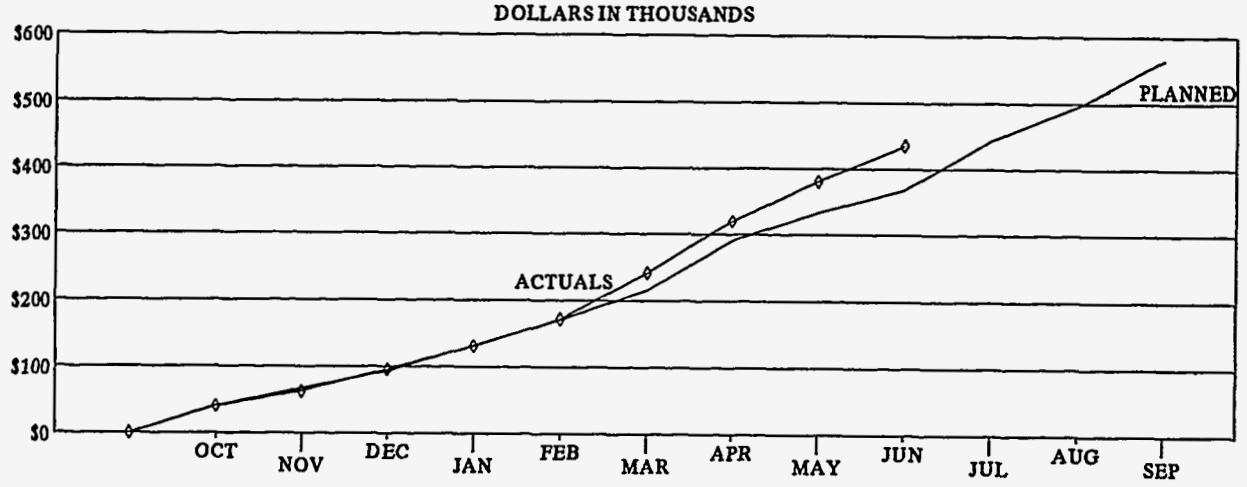
Resonant and nonresonant rotational forces due to RF wave power were calculated and compared with those due to neutral beam power. It is found that in reactor regimes, the RF force may be of the same order of magnitude as the neutral beam force. This results from the high ratio of energy to momentum in the beam required to penetrate an ignition device (essentially the beam velocity) compared to the that of the wave (essentially the phase velocity). While resonant wave-particle interaction is the mechanism predominantly used in the past, nonresonant interaction has the conceptual advantage of a weak dependence of efficiency to density. The Vlasov equation has been used to solve for a sheared slab in a small gyroradius expansion. The averaged resonant and nonresonant parallel forces are calculated from a general quasi-linear expression. Past calculations have restricted to frequencies much lower than the cyclotron frequency. This restriction is eliminated in the present calculation and magnetic shear is included.

The gyrokinetic stability (GKS) code is being used to model the VH–mode magnetic breaking experiments establishing that rotational shear has a beneficial effect on confinement. The DIII–D experiment shows that when the n=1 coil is energized to produce drag (braking) on the plasma rotation, the rotational shear decreases and the temperature gradient which can be supported at fixed power flow markedly decreases. The GKS code models the complete physics of high-n ballooning microinstabilities in real geometry. Using the experimental rotational shear rates and plasma conditions we use the GKS code to compute the linear growth rates with and without the magnetic braking. Our working hypothesis gained from nonlinear simulations that the heat diffusion is roughly proportional to the microinstability growth rate minus the $\mathbf{E} \times \mathbf{B}$ rotational shear rate seems to be consistant with the experiment. We find that the computed growth rates are comparable to the shear rates hence it is not surprizing that a larger temperature gradient with larger growth rate can be supported when the shear rate is higher.

Contract Management Summary Report

TITLE:	THEORY B\R AT0520210	**CONTRACT NO.:**	DE-AC03-89ER51114
CONTRACTOR:	GENERAL ATOMICS P.O. BOX 85608 SAN DIEGO, CA. 92186-9784	**COST & LABOR PLAN DATE:** JULY 8, 1994	**START DATE:** SEPTEMBER 25, 1993 **COMPLETION DATE:** SEPTEMBER 30, 1994

DOLLARS IN THOUSANDS



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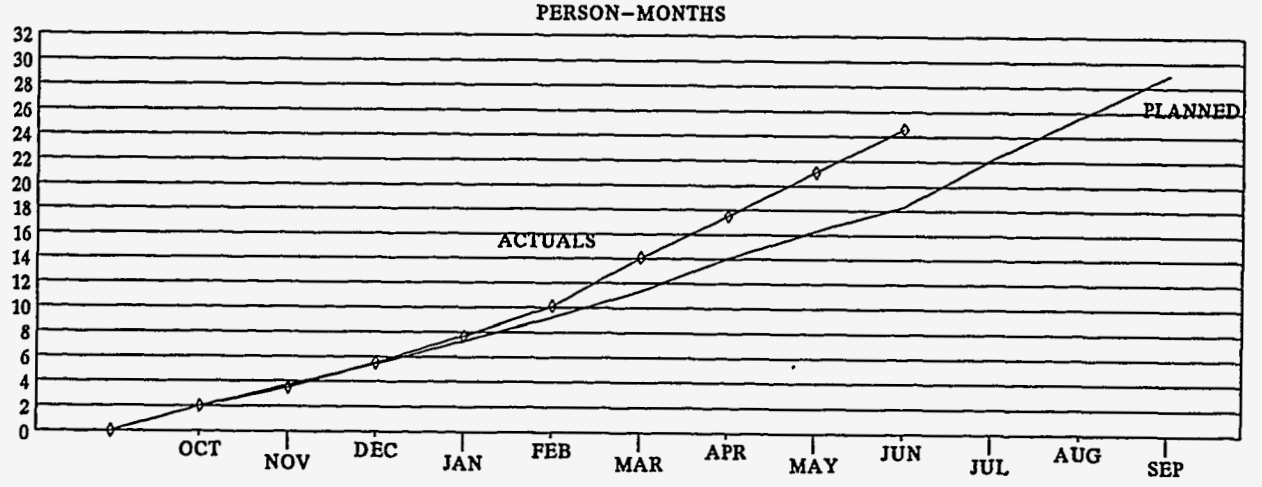
PLANNED	$41	$26	$26	$39	$39	$45	$74	$44	$34	$75	$53	$69	$565
ACTUAL	$40	$23	$33	$35	$41	$70	$78	$60	$55				$435
VARIANCE	$1	$3	($7)	$4	($2)	($25)	($4)	($16)	($21)				
CUM VAR	$1	$4	($3)	$1	($1)	($26)	($30)	($46)	($67)				

PERSON-MONTHS



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTALS
PLANNED	2.0	1.7	1.7	1.9	1.9	2.1	2.8	2.2	2.0	3.9	3.4	3.4	29.0
ACTUAL	2.0	1.5	2.0	2.2	2.4	4.0	3.4	3.6	3.5				24.6
VARIANCE	0.0	0.2	-0.3	-0.3	-0.5	-1.9	-0.6	-1.4	-1.5				
CUM VAR	0.0	0.2	-0.1	-0.4	-0.9	-2.8	-3.4	-4.8	-6.3				

SIGNATURE OF PARTICIPANT'S PROJECT MANAGER & DATE: _____

USER SERVICE CENTER

PROGRAM STATUS
3RD QUARTER — FY 1994

TASK: USER SERVICE CENTER **FY 94 FUNDING:** $240 K[1]

B/R NO: AT0540420 **FY94 PLAN:** $240 K

CONTRACT NO.: DE-AC03-89ER51114

GA PRINCIPAL INVESTIGATOR: K. KEITH

OAK PROJECT MANAGER: M. FOSTER

OFE PROGRAM MANAGER: M. SCOTT

	PLANNED ACTIVITIES/GOALS	ORIGNAL TARGET	CURRENT TARGET	COMPLETION DATE
1.	Operate and maintain the User Service Center.	←	ONGOING	→
2.	Provide archival and retrieval services for DIII–D data.	←	ONGOING	→
3.	Maintain ESnet communication.	←	ONGOING	→
4.	Provide local support for NERSC users.	←	ONGOING	→
5.	Maintain integration of USC VAX cluster with DIII–D computer systems.	←	ONGOING	→
6.	Continue UNIX/VMS integration; particularly as it relates to code portability.	←	ONGOING	→
7.	Install and integrate new cycle server into the USC environment	3rd Q FY94		
8.	Move general physics and systems codes to the cycle server.	4th Q FY94		
9.	Install and configure LAN monitors; continue monitoring LAN.	4th Q FY94		
10.	Provide additional computer support and resources for new collaborators.	←	ONGOING	→
11.	Modify Cray production codes for portability.	←	ONGOING	→

[1]Funding reduction to $230K anticipated and $10K added for video/audio telecommunications.

HIGHLIGHTS

- 18 Gigabytes of disks were purchased for exclusive fusion use on the GA corporate nfs server.
- A Hewlett-Packard 9000 Series 800 T500 computer was selected as the fusion compute server.
- The first VAX has been removed from the USC cluster.
- Security vunerability on HP VUE software was corrected.
- A cleanup script was developed for the NERSC Cray systems to help users minimize their disk usage.
- Assistance was provided to the DOE High Energy Physics Advisory Panel.

The GA corporate computer center procured an Auspex nfs server to provide file serving services to all GA. Consequently, fusion purchased 18 GB of disks for their exclusive use to be served by the Auspex. One disk drive on the AUSPEX was configured as scratch space and mounted on several workstations and one of the VAXes. It was made available to fusion during the last two days of the last run period of the quarter and was heavily used as a repository for between shot data analysis results. This allowed the EFIT output files to be viewed by all interested parties from almost any platform. Although this was a temporary arrangement, it was so successful it will be included in the final production configuration.

The selection process for the compute server that will replace two of the old VAXes in the USC has been completed. Purchase orders were placed for a Hewlett-Packard (HP) 9000 Series 800 T500 Compute Server (T500). The procurement included third party software already in use in fusion (IDL, IMSL, DISSPLA) and software to help VMS users cope with UNIX (nuTPU and DCL shell). Also included were two weeks of on-site consulting by a HP expert so as to optimize the installation and operation of the T500. A T500 transition team was formed and will be meeting weekly until the system is fully operational. The team will be responsible for the smooth integration of the T500 and Auspex file server into the fusion computing environment. The VAX 11/785 was shut down and removed from the USC VAXcluster. Maintenance on this machine was canceled.

We received notice from the DOE's Computer Incident Advisory Capability (CIAC) group of a security vulnerability in HP VUE, the HP screen management system. We obtained a patch and

have started installing the fix. A VUE-like package also runs on the Plasma Control computers and may have the same problem. CIAC is in contact with the vendor.

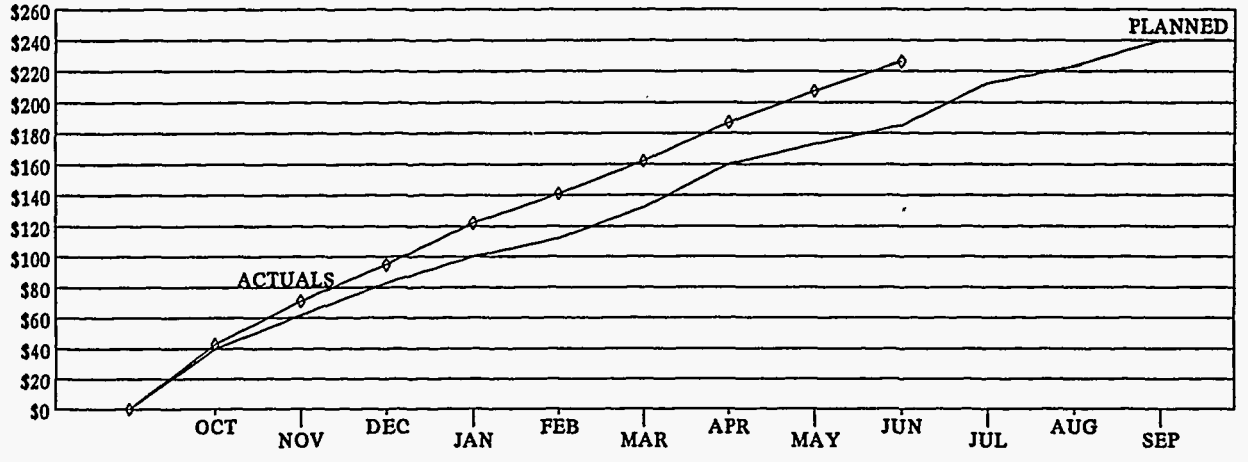
The CLEANUP file housekeeping system, developed in January in response to discussions which took place at the ERSUG (Energy Research Supercomputer Users Group) meeting regarding problems with insufficient disk space on the CRAYs, was made available to the users. CLEANUP has gained wide use among GA users, and has come to the attention of the NERSC staff. NERSC has requested a formal software submission for incorporation into the general CRAY environment. This system will be ported and implemented on the T500.

There was a meeting of the DOE High Energy Physics Advisory Panel (HEPAP) in San Diego in early April. We were requested to provide some sort of dial-in local access so that members of the panel could reach their home sites without the expense of long distance calls. In response, three of our dial-in lines to the Xyplex terminal server were made available for the duration of the meeting. There was no contention for these lines by fusion staff, and the lines have been returned to the general pool. The DOE High Energy Physics Division expressed their thanks.

Contract Management Summary Report

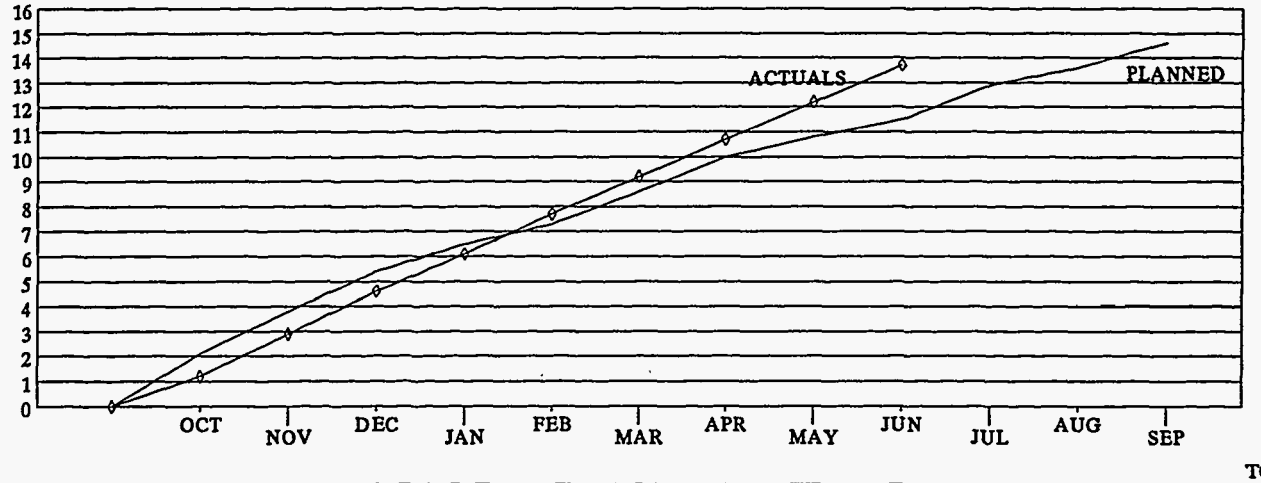
TITLE:	USER SERVICE CENTER B\R AT0540420	**CONTRACT NO.:**	DE-AC03-89ER51114
CONTRACTOR:	GENERAL ATOMICS P.O. BOX 85608 SAN DIEGO, CA. 92186-9784	**COST & LABOR PLAN DATE:** JULY 8, 1994	**START DATE:** SEPTEMBER 25, 1993 **COMPLETION DATE:** SEPTEMBER 30, 1994

DOLLARS IN THOUSANDS



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTALS
PLANNED	$40	$22	$21	$17	$12	$20	$28	$13	$12	$27	$11	$17	$240
ACTUAL	$43	$28	$24	$27	$19	$21	$25	$20	$19				$226
VARIANCE	($3)	($6)	($3)	($10)	($7)	($1)	$3	($7)	($7)				
CUM VAR	($3)	($9)	($12)	($22)	($29)	($30)	($27)	($34)	($41)				

PERSON-MONTHS



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTALS
PLANNED	2.1	1.7	1.6	1.1	0.8	1.3	1.4	0.8	0.7	1.4	0.7	1.0	14.6
ACTUAL	1.2	1.7	1.7	1.5	1.6	1.5	1.5	1.5	1.5				13.7
VARIANCE	0.9	0.0	-0.1	-0.4	-0.8	-0.2	-0.1	-0.7	-0.8				
CUM VAR	0.9	0.9	0.8	0.4	-0.4	-0.6	-0.7	-1.4	-2.2				

SIGNATURE OF PARTICIPANT'S PROJECT MANAGER & DATE: _____

ITER DESIGN ENGINEERING

PROGRAM STATUS
3RD QUARTER — FY 1994

TASK: ITER DESIGN ENGINEERING **FY 94 FUNDING:** $1395 K

B/R NO: AT150403A **FY94 PLAN:** $1395 K

CONTRACT NO.: DE-AC03-89ER51114

GA PRINCIPAL INVESTIGATOR: C. HAMILTON

OAK PROJECT MANAGER: M. FOSTER

OFE PROGRAM MANAGER: T. JAMES

PERSONNEL

- Current ITER secondees and their nominal assignments include:

San Diego Co–Center

John Wesley — Physics Analysis

Fred Puhn — Systems Integration

Peter Smith — Automation of Design Activities

Julie Van Fleet — External Relations

Garching Co–Center

Doug Remsen — Radio Frequency Heating Systems

Naka Co–Center

Bob Bourque — Cryogenic Systems

Randy Hager — Remote Handling (June, 1994)

PROBLEM/RESOLUTION

1. Problem: Foreign Travel – Contractual requirement to obtain DOE approval 30 days prior to travel which is dictated and controlled by JCT management.

   Resolution: Thomas James memo dated May 27, 1994; Martha Krebs memo dated May 27, 1994. New travel procedures for U.S. participants seconded to ITER effective July 1, 1994 are outlined. In summary the new procedures do the following: (1) delegate authority to Directors of Laboratories/Mangers of Operations Offices (as appropriate under existing authority) to approve foreign travel, including "Exceptions" for late requests. (2) exemption from the trip report submission requirement. (3) exemption of U.S. JCT staff attending international major conferences from inclusion in the approved DOE ceiling.

Department of Energy
Washington, DC 20585

May 27, 1994

To: U.S. Members of the Joint Central Team (JCT)

Dear Colleagues:

This letter is to inform you of new DOE travel procedures, effective for travel beginning on July 1, 1994, for U.S. members of the JCT seconded to the ITER Joint Work Sites in San Diego, CA, in Naka, Japan, and in Garching, Germany. The new procedures were developed for the majority of the U.S. ITER secondees, namely, those U.S. JCT staff supported by the Office of Fusion Energy (OFE) program funds. In addition, some administrative procedures related to Joint Fund travel were also developed.

We believe that these new travel procedures will streamline the administrative process so U.S. JCT staff can meet the needs of the ITER EDA. Your seconding institution has been formally notified of these travel procedures. Please contact your seconding institution in planning your foreign travel to be initiated on or after July 1, 1994, for further information.

As noted in the information sent to the seconding institutions, Debra Frame, OFE, is available to answer questions should they arise. Ms. Frame can be reached on 301-903-5771 or fax: 301-903-2791 or e-mail: debra.frame@mailgw.er.doe.gov.

Sincerely,

Thomas R. James, Director
ITER and Technology Division
Office of Fusion Energy
Office of Energy Research

cc:
U.S. ITER JWS Administrative Contacts
U.S. Institutional Contacts for ITER
J. Selles, LLNL

336/2

Department of Energy
Washington, DC 20585

MAY 24 1994

Mr. Terry Vaeth
Acting Manager
Oakland Operations Office
U.S. Department of Energy
1301 Clay Street
Room 700N
Oakland, California 94612

Dear Mr. Vaeth:

The purpose of this letter is to inform you of new travel procedures for U.S. participants seconded to the International Thermonuclear Experimental Reactor (ITER) Joint Work Sites (JWSs) in San Diego, California, in Garching, Germany, and in Naka, Japan.

The objective is to minimize unnecessary administrative travel requirements and simplify the approval process for U.S. members of the Joint Central Team (JCT) seconded to the ITER JWSs who are directly funded by the Department of Energy (DOE) Office of Fusion Energy (OFE), Office of Energy Research. This includes the majority of the U.S. secondees. For your information, there is an ITER Joint Fund, comprised of monies from the four ITER Parties, that supports travel conducted under ITER Council rules, rather than domestic rules. At this time, however, only senior ITER management personnel are covered by this Joint Fund, including a small number of U.S. secondees, whose travel is not covered by DOE rules. Therefore, action is needed now to relieve continuing problems within the travel system for the majority of the U.S. ITER secondees.

These new travel procedures were developed for U.S. JCT staff with the cooperation of the DOE Office of International Research and Development Policy, which manages the DOE Foreign Travel Management System. The procedures summarized in the enclosure are effective July 1, 1994. The Policy Office has requested my approval for three of these procedural changes. In response, with regard to foreign travel for U.S. JCT staff supported by OFE program funds, I am informing you that as of July 1, 1994, I am:

1) delegating authority to Directors of Laboratories/Managers of Operations Offices (as appropriate under existing authority) to approve foreign travel including "Exceptions" for late requests,

2) exempting those U.S. JCT staff from the trip report submission requirement, and

3) exempting those U.S. JCT staff attending international major conferences from inclusion in the approved DOE ceiling.

The new travel procedures identified in the enclosure will be incorporated in the final version of DOE Order 1500.3.A., "Foreign Travel Authorization."

If you have any questions concerning the implementation of these new procedures, you may contact those persons identified in the enclosure.

We would appreciate your taking the necessary steps to notify your JCT secondees of these new procedures and approve Energy Research foreign travel for JCT staff without interruption. We have streamlined the administrative process to approve JCT foreign travel and simplified travel reporting requirements so U.S. JCT staff can meet the needs of the ITER EDA Director. Your cooperation will be greatly appreciated.

Sincerely,

Martha Krebs

Martha A. Krebs
Director
Office of Energy Research

Enclosure

ENCLOSURE

TRAVEL PROCEDURES FOR U.S. PERSONNEL SECONDED TO ITER JOINT WORK SITES (JWSs)

(EFFECTIVE JULY 1, 1994)

During 1994, the first year of the operation of the Joint Fund for the ITER Engineering Design Activities (EDA), the travel costs of the majority of the Joint Central Team (JCT) staff will not be covered by the Joint Fund. Under this circumstance, the U.S., Japan, the Russian Federation, and the European Community will each fund travel for their seconded JCT participants. In subsequent years, it is expected that the number of seconded personnel covered by the Joint Fund will increase.

The new travel procedures below address both travel supported by program funds of the Office of Fusion Energy, Office of Energy Research, and some administrative procedures related to Joint Fund travel.

1. The ITER procedures do not pertain to the Department of Energy (DOE) employees. DOE employees must continue to adhere to standard approval procedures for official foreign travel, including required embassy clearances, particularly for travel to Russia.

2. For foreign travel by contractor and laboratory employees seconded to the different Co-Centers and not funded by the Joint Fund.

DOE'S RESPONSIBILITY

a. The Department's Office of International Research and Development Policy, within the Office of Policy, Planning and Program Evaluation, will provide prior approval for periods of one year for all foreign travel by U.S. personnel traveling on U.S. funds for ITER activities originating from the San Diego, Naka, or Garching JWSs.

RESPONSIBILITY OF THE SECONDEE AND THE SECONDING INSTITUTION

a. The seconding institution will obtain from the secondee sufficient information including name of traveler, estimated costs, sites visited, and purpose for entry of each trip into the Department's Foreign Travel Management System (FTMS).

b. Travel made within the European Union by U.S. JCT staff stationed at the Garching JWS shall not be considered foreign travel. Appropriate administrative documentation of European travel must be available from the traveler's seconding institution as with normal domestic U.S. travel.

c. To streamline the process for U.S. ITER travelers, the Policy Office has agreed that travel information can be entered into FTMS up to but not later than one month after the departure date.

3. Foreign travel by contractor and laboratory employees seconded to the different Co-centers and funded by the Joint Fund, which will be managed under ITER Council's Financial Rules, does not have to be entered into the FTMS. Nonetheless, because of current contractual requirements, the following procedures apply.

DOE'S RESPONSIBILITY

a. If the associated efforts (salary, fringe benefits, etc.) are ultimately being charged to a DOE appropriation and the purpose of the travel directly involves an ongoing DOE project (e.g., U.S. ITER participation), the DOE will have travel-related oversight responsibilities.

b. If deemed applicable, the Managers of the Operations Offices will grant prior approval for periods of one year for all foreign travel by U.S. personnel traveling on Joint Fund monies. This action will satisfy the current contractual requirements with the seconding institution. Travel funded by the Joint Fund is not required to be entered into the FTMS.

c. The DOE will communicate to the ITER Director the expectation that appropriate travel records for audit purposes will be available at the ITER JWSs.

RESPONSIBILITY OF SECONDEE AND SECONDING INSTITUTION

a. If prior notification of a trip is necessary to assure the traveler's insurance benefits, then arrangements should be made between the secondee and the seconding institution regarding this notification.

b. For foreign (intercontinental) travel, if required to satisfy the current contractual requirements, the secondee must notify the seconding institution of the travel. Arrangements will be made between the secondee and the seconding institution regarding this notification.

4. Individuals not seconded and not supported by the Joint Fund will continue to be required to complete DOE F1512.1 (Request for Approval of Official Foreign Travel) and to use the FTMS for approval. Non-Federal employees undertaking a long-term assignment, permanent assignment, or a permanent change of station are not exempted from the overall submission requirements outlined in paragraph 6(j)(3) of DOE Order 1500.3, dated November 10, 1986, and paragraph m(5) of Attachment 2 of draft DOE Order 1500.3A, dated January 29, 1993.

5. In view of the planned elimination of the Exception Process, currently outlined in paragraph 9f of Draft DOE Order 1500.3, and the implementation of field approval authority for sensitive travel, the Director of Energy Research delegates final approval authority to Designated Laboratory Directors/Managers of Operations Offices for travel relating directly to ITER JCT staff supported by the Office of Fusion Energy program funds.

6. The Director of Energy Research has granted an exemption from the trip report submission requirements for official travel by contractor employees for JCT staff seconded to the ITER Co-Centers. Their travel is under the management authority of the ITER EDA Director. The description of the purpose of the trip entered on the travel request form will be satisfactory to Energy Research and to the Policy Office.

7. The Director of Energy Research has granted an exemption for U.S. JCT staff attending international major conferences from inclusion in the approved DOE ceiling since they are under the management authority of the ITER EDA Director.

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CONTACTS:

Arthur Katz, DOE/OFE (ER-521) (301) 903-4932
(301) 903-2791 (fax)

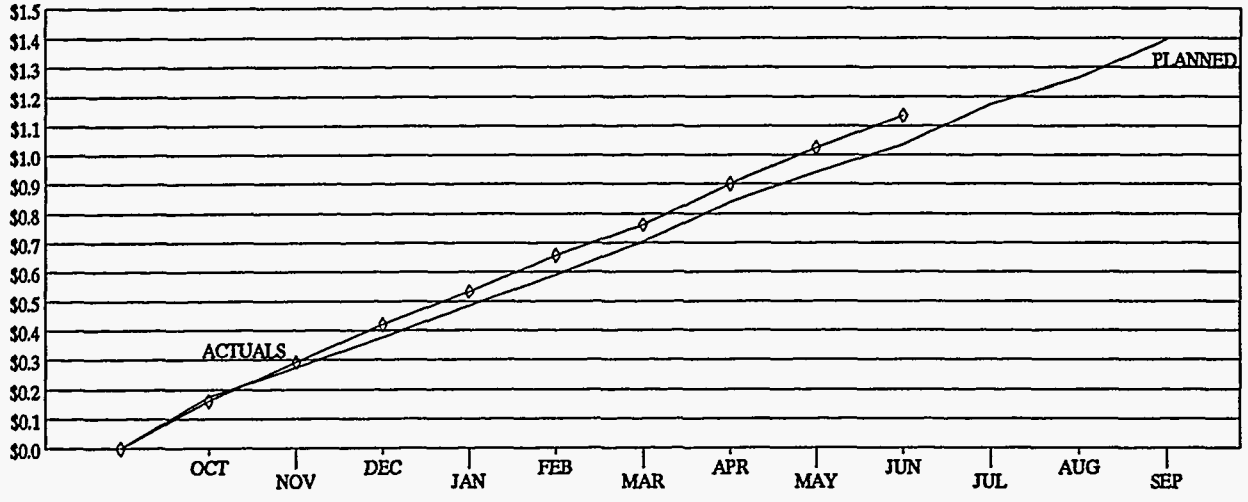
Debra Frame, DOE/OFE (ER-521) (301) 903-5771
(301) 903-2791 (fax)

George Person, DOE/PO (PO-70) (202) 586-9250
(202) 586-1180 (fax)

Contract Management Summary Report

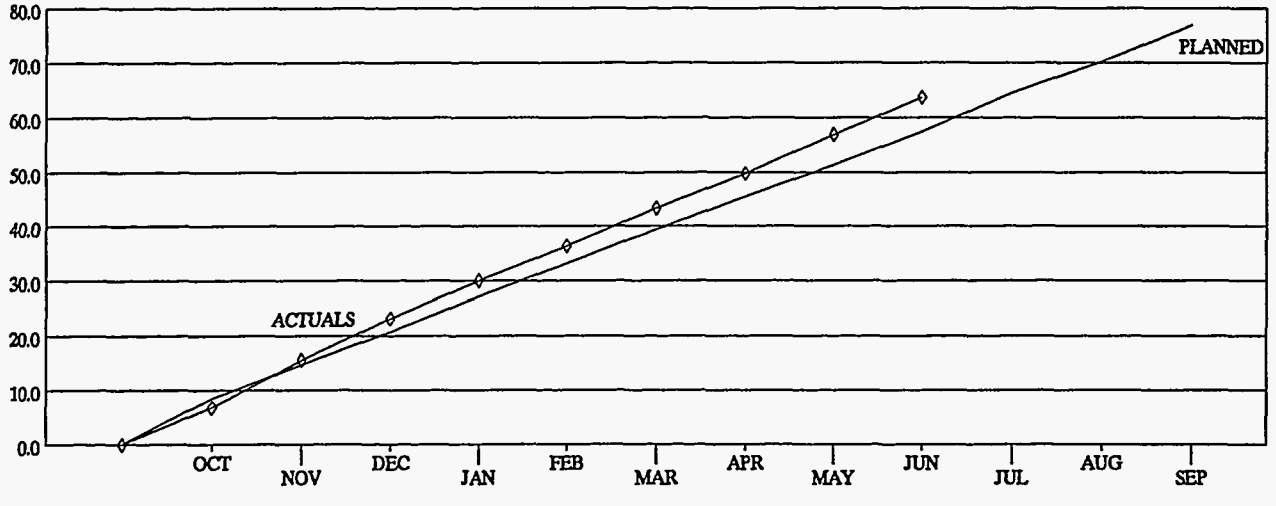
TITLE:	ITER JCT SECONDEES B/R NO: AT150403C	**CONTRACT NO.:**	DE-AC03-89ER51114
CONTRACTOR:	GENERAL ATOMICS P.O. BOX 85608 SAN DIEGO, CA. 92186-9784	**COST & LABOR PLAN DATE:** JANUARY 17, 1994	**START DATE:** SEPTEMBER 25, 1993 **COMPLETION DATE:** SEPTEMBER 30, 1994

DOLLARS IN MILLIONS



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTALS
PLANNED	$175	$100	$100	$110	$105	$115	$135	$100	$95	$140	$90	$130	$1,395
ACTUAL	$161	$131	$127	$114	$124	$105	$138	$124	$110				$1,134
VARIANCE	$14	($31)	($27)	($4)	($19)	$10	($3)	($24)	($15)				
CUM VAR	$14	($17)	($44)	($48)	($67)	($57)	($60)	($84)	($99)				*(IN THOUSANDS)*

PERSON-MONTHS



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTALS
PLANNED	8.5	6.2	6.1	6.4	6.0	6.3	6.0	5.7	6.2	7.0	5.8	6.6	76.8
ACTUAL	6.8	8.8	7.6	6.9	6.3	6.9	6.4	7.1	6.8				63.6
VARIANCE	1.7	-2.6	-1.5	-0.5	-0.3	-0.6	-0.4	-1.4	-0.6				
CUM VAR	1.7	-0.9	-2.4	-2.9	-3.2	-3.8	-4.2	-5.6	-6.2				

SIGNATURE OF PARTICIPANT'S PROJECT MANAGER & DATE: _____