February 1989 SSC Monthly Report

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PROJECT SUMMARY

CENTRAL DESIGN GROUP (CDG)

Magnet Program

Phase I of the Magnet Industrialization Program was completed in February; the last of the three laboratory visits took place at FNAL on February 20–23. Many of the Phase I industrial participants expressed positive comments about the program. None expressed dissatisfaction, but a few seek still more information. They will be accommodated in a later two-day "Open House" at each laboratory, to be scheduled in April 1989.

Long magnet DD0016 was tested at FNAL and found to be mechanically sound. However, it displayed a serious problem with superconductor cable quality at one spot in the magnet (quench currents were limited to 5100 A). This cable problem will be carefully investigated during and after magnet DD0016 disassembly in March at BNL.

A workshop to study magnet coil insulation and cooling was held on February 15–16 at BNL. This event was helpful in evaluating the current design situation for these two important magnet topics. A second workshop on the developing superconductor wire and cable database was held at CDG on February 21–22, to begin familiarizing appropriate R&D Program individuals with the cable database. A regular Magnet Systems Integration Meeting was held at BNL on February 28–March 1.

Accelerator Physics

The Accelerator Physics Division met in Dallas to discuss various accelerator physics issues with the SSC leadership.

An experiment carried out at the CERN SPS last year is being examined in order to correlate its effect on the dynamic aperture criteria adopted for the SSC.

Considerable work was done on extending the software used for correction-elements working group simulations to allow for aperture and injection-energy studies.

Programs were developed to analytically calculate the smear caused by various multipole errors in dipole magnets.

Conventional Facilities

During January and February, the CDG Conventional Facilities Division became attached to the new URA SSC Laboratory Conventional Construction Division under Mr. Robert Robbins of the Sverdrup Corporation, an Architect/Engineer firm based in St. Louis. In developing its proposal to be the Management and Operating (M&O) contractor for the SSC Laboratory, URA entered into a subcontract arrangement with Sverdrup to supplement the conventional construction capabilities of URA.

Efforts of the Berkeley-based group continued to focus on characterization of the Texas site, on development of the tools and techniques for defining the collider "footprint" on the Texas site, and on modeling the surface complexes, collision halls, and the sequence in which various areas will be developed.

BROOKHAVEN NATIONAL LABORATORY (BNL)

Final assembly operations and warm measurements were completed on DD0018, and the magnet was shipped to FNAL the third week in February.

Preparations for constructing DD0019 were begun.

Interconnections and warm measurements for DDA010 were completed. The magnet was almost ready to be shipped to FNAL at the end of the month.

DSS16 and DSS17 were collared. DSS16 underwent final preparations for its vertical test at the end of the month.

FERMI NATIONAL ACCELERATOR LABORATORY (FNAL)

Tests on magnet DD0016 were completed. The magnet was removed from the test stand and returned to BNL. A series of quenches at about 5100 A suggested a stretch of defective cable. Magnet DD0017 was assembled, mounted and cooled down. The magnet will undergo thermal cycling in about mid-March. Magnet DD0018 was received from BNL at the end of February and assembly is expected to be complete by the end of March.

The Magnet Industrialization Program Phase I visitors were given lectures on the Fermilab/SSC magnet program and extensive tours of the Magnet Facility.

BNL's short magnet DSS12 has been reyoked with vertical split yokes. Strain gauge instrumentation will monitor the performance of vertical yoke during skinning, cooldown, and powering.

Long magnet tooling is in its final stages of assembly. Some practice cable has been received.

LAWRENCE BERKELEY LABORATORY (LBL)

The raised strand problem that occurred in the first outer-layer production cable made by Supercon has been investigated. The sources of the problem were identified as a tracer strand coated with Sn-1% Ag solder and slightly different processing conditions for some of the wire. The tracer strand is not required and will not be used in future SSC cables. The different processing conditions for different spools of wire were due to optimization studies performed only on this first production order.

A 2000-foot outer-layer practice cable was made from copper-nickel matrix wire left in the CBA inventory at BNL and sent to FNAL for practice winding and evaluation. However, the material selected from BNL inventory for the inner strand was found not to contain any niobium-titanium filaments and hence did not produce a cable that simulates the behavior of SSC cable. Investigation showed the material to have been mislabeled; other material has been located and (after verifying that it contains niobium-titanium filaments) it will be processed into practice inner cable in March.

Magnet D15C-1, the first of a new series having tapered (conical) ends, was tested this month. At 4.3 K, the first quench was at 6581 A in the straight section of the pole turn of the outer layer. Subsequent quenches were in the straight section of the pole turn of the inner layer, at 6800 ± 20 A.

D15C-2 coil assembly is complete, and collaring should begin soon. Tests measured pressure on the cable at the pole and midplane coils after assembly. In general, the results of these tests revealed some pressure concentrations along the inner-coil edges at the coil midplanes and good distribution (approximately uniform) from inner to outer edge at the poles. However, as expected, when the collar was allowed to deform the pole face of the outer coils was fully loaded only at every other collar plate. This lack of local support might adversely affect magnet performance.

Preliminary cross section design, field computation, and tooling design were completed on a 2-layer cos-θ dipole with a 5-cm bore and close-in iron for use in the Cable Test Facility.

QA1-R1, the reconstructed model of QA1 (originally tested 2 years ago), is awaiting recollaring; the collars will be fully supported in the yoke along their outside surface, as in several recent dipole models.

CDG REPORT

MAGNET PROGRAM

MSI Meeting

The MSI meeting was held at FNAL February 28–March 1. The opening report dealt with administrative, technical, and industrialization-related activities at the CDG. It was followed by reports from FNAL, LBL, and BNL.

FNAL reported that vendors had been selected to provide various cryostat subassemblies (support posts, anchor tie bars, insulation, vacuum vessels) with deliveries of ordered parts starting in early March.

LBL has constructed a short dipole (D15C-1) with flared ends. Its end fields meet SSC specifications.

Some cable problems (crossed, broken, and loose wires) were observed in cable supplied to BNL.

Results of the Dipole Coil Insulation and Cooling discussion group held at BNL on February 15–16 were summarized by E. Willen. R. Shutt and M. Rehak presented calculations on a transverse helium cooling flow method for the dipoles that indicate a large improvement in cooling over the present longitudinal cooling flow configuration. Adoption of this cooling method would alleviate concern about the temperature rise in the magnet conductor from synchrotron radiation heating and about the use of the mole during magnetic field measurements. The transverse cooling will be tried out on a long magnet to see how well it works. With the goal of improving the existing coil insulation, BNL tested various alumina-loaded Kapton films developed by industry and found some that have improved mechanical strength (punch-through resistance) over the present insulation. BNL's present bore-tube design will use a double-wall warm bore tube. The alternate design with helium cooling is too expensive and not needed if the transverse helium cooling method is adopted for magnets. Two copies of this design should be ready by May 1.

BNL presented test results of DSS13, DSS14, and DD0016. The short magnets DSS13 and DSS14, which have the design improvements incorporated into long magnets DD0016 and DD0017 (except for the latest iteration of the ramp splice upgrade, which only the long magnets have), both showed good training performance. The performance of DD0016 was disappointing; the magnet was apparently conductor limited at about 5100 amperes due to a bad section of cable. This conjecture will be investigated when the magnet is disassembled at BNL.

LBL reported that work is resuming on SSC quadrupole development.

The next MSI meeting is tentatively scheduled for April 18–19 at LBL.

Magnet Industrialization Program—Phase I

Fermilab presented the final Phase I Technology Orientation sessions February 20–23. Attendees were welcomed the first evening by Dr. Lederman at a reception hosted by the Fermilab Industrial Affiliates. Daily formal sessions presented by Fermilab technical staff included discussions of Tevatron magnets and various SSC magnet–related systems, including the cryostat suspension system, cryostat insulation, cryostat thermal shields, cryostat vacuum vessel, cryostat alignment, cryostat piping and interconnection, cryostat performance measurement, cryostat assembly, cold-mass production, and cold magnet testing. Several hours were spent demonstrating shop practices in the Industrial Area, including support post assembly procedures and automatic pipe welding. A tour of the QC area exhibited state-of-the-art dimensional analysis and spectrometric leak testing of large bellows assemblies. Microscopic examination of acid-etched superconductor filaments was also made possible.

Several general observations can be made about the Phase I Magnet Industrialization Program, now that all the laboratory sessions are complete. First, approximately 45–48 industrial participants attended each laboratory presentation; company representatives included vice-presidents, project managers, engineers, and quality assurance personnel. Second, putting the sessions together expedited the compilation of documentation such as drawing trees, procedures, and technical information, which together represent an up-to-date, complete resource of technical information on the design and construction of the present superconducting SSC R&D dipoles. Third, participants expressed interest in specific areas, such as Fermilab tooling, including drawings; variance in details between labs and between magnets (NC9 versus C358D, horizontal yoke split versus vertical split); all specific data such as drawings, specifications, and procedures; specification philosophy, such as build-to-print versus performance specification; and, in particular, keeping up the program momentum in the transition to Phase II.

Magnet Industrialization Program Phase II

Specific comments concerning the Draft Business Strategies Document for Phase II were received from the DOE and are being incorporated into a final version of the business plan. A draft of this plan was submitted originally by the CDG in November, 1988. The new comments render Phase II somewhat simpler contractually, with a single CPFF agreement with each vendor. The contract will cover the four stages of tooling and magnet development within Phase II: (1) development of coil tooling and prototype coil fabrication; (2) assembly of cold mass tooling and cold mass prototype production; (3) fabrication of one complete prototype magnet; and (4) a preproduction run of twenty complete magnets. In addition, the DOE suggested that it would not be possible to identify the extent and nature of foreign participation prior to requesting proposals; therefore, it is anticipated that all magnets will be acquired from domestic sources. It is recognized that if and when foreign participation is defined, appropriate changes will have to

be made. A *Commerce Business Daily* announcement will signal the official start of Phase II by soliciting proposals.

Magnet Testing—DD0016

Long magnet DD0016 was tested in February. Magnet DD0016 is the first of the "line-fit" design magnets in which the warm clearance between the collared coil assembly and iron yokes is nominally zero (hence a "line-fit" as indicated by drawings). (This design evolved from the successful tests in 1988 of magnets that had shims inserted between the collared coil assembly and the yokes to prevent axial motion.) The coil cross section in magnet DD0016 is the C358D design, which includes asymmetric wedges with modified sizes for improvement of field quality and coil fabrication. The coils were fabricated with improved tooling, which reduced the variation in (azimuthal) coil size and hence pre-stress by a factor of two compared with previous coils.

The strip-heater design and the ramp-splice treatment were both modified as a consequence of the results of magnet tests in 1988. In addition, the design of magnet DD0016 incorporates an improved alignment scheme for the yoke blocks (so-called "keyed yokes") that gives a more precise alignment of the vertical field.

Due to the need to expedite fabrication and accelerate the test program, most of the detailed diagnostic instrumentation was omitted from magnet DD0016: a small complement of voltage taps and only one collar gauge pack were used.

Initial cooldown began on January 28 but was halted when a blockage was detected in one of the helium return lines. The magnet was warmed and it was necessary to open the welded "single phase" bellows at the return end of the magnet to remove the obstruction. Following re-welding of the return-end bellows, the magnet was retested for high-voltage breakdown, and it failed at 1250 V (the desired voltage was 1500 V) in 4-A warm helium gas; it had passed this test prior to cooldown. Varying the gas pressure showed the breakdown to be a gas-dependent phenomenon (not a direct ground path, such as a carbon track). It was decided to proceed with cooldown.

After cooldown the magnet passed a 1500-V breakdown test in 4.35-K, 4-A helium, and the normal test procedure was followed, with appropriate attention to indications of ground current, breakdown, and so forth. No anomalies were observed.

The first spontaneous quench occurred at a current of 5129 A, nearly 1700 A below the expected short-sample current. (Although the measured current is 1700 A below the short-sample limit, the actual loss in current-carrying capacity is even greater, since the magnetic field is reduced relative to the field corresponding to the short-sample current value.) The second spontaneous quench occurred at almost the same current, 5109 A. A third quench also occurred at an anomalously low value of 5090 A. These first data gave limited information on the origins

of the quenches, due to a failure in the voltage-tap readout electronics that was subsequently corrected.

From the observed quench currents—three quenches separated by less than 40 amperes—it was hypothesized that the behavior was conductor dominated. A mechanical instability, it was thought, would not manifest itself in such a narrow range of currents, exhibiting no training behavior. The fact that the observed rise to quench was much faster than expected also indicated conductor origin for the quench behavior. To test this hypothesis, the helium temperature was varied, and quenches were taken at each of the temperature excursions. The results displayed a clear correlation with temperature: the rate of change with temperature is about one-half that of normal cable, indicative of the loss of about one-half the current-carrying capacity.

All quenches originated in the lower inner coil. Analysis of the uncorrupted voltage tap data revealed the origin to be roughly 30 inches from the return end on turn 16 (the pole turn), which is in the highest field region. Following testing the magnet was warmed to approximately 11 K, and a resistance measurement was made of the quarter coils. There was no significant difference in resistance between the lower inner coil (where all the quenches occurred) and the upper inner coil.

Magnet Testing—DD0017

Following the abbreviated DD0016 test schedule, the preparations for the test of magnet DD0017 were accelerated. Installation and checkout were advanced, and warm checkout of the magnet began late in February. DD0017 will be ready for cold tests early in March.

Mathematical Analysis

Results of recent finite-element analyses were presented at the International Industrial Symposium on the Super Collider (IISSC) in a paper entitled "Finite-Element Analysis of SSC Dipoles" by M. Chapman and B. Wands. The presentation included results from both the NC9 and C358D ANSYS models for various loadings (e.g., assembly, insertion into yoke, welding of skin, cooldown, energization).

Calculations using the C358D ANSYS model have produced some interesting results on the welding and cooldown processes. The calculated loss in coil prestress during cooldown varies considerably depending on the collar/yoke/skin interaction. Specifically, if the collars are unsupported by the yoke, the calculated stress loss is about 1500 psi for either the inner or outer coils. If the collars are supported by the yoke, however, the coil stress increases by 2000 psi due to welding the skin, provided that the midplane gap between yoke halves remains open during this procedure. If, in addition, the midplane gap remains open after cooldown, the stress loss due to cooldown is 650 psi for the inner coil and approximately zero for the outer coil. In contrast, if the yoke midplane gap closes during cooldown, the cooldown stress loss can be as large as 3500 psi for either coil. Clearly, the interaction between the yoke and collars has

significant effects on the change in stress due to welding and cooldown. Ongoing work is concentrating on relating these results to experimental magnet results and on optimizing the collar/yoke interaction to minimize stress loss while maintaining desirable yoke closure for magnetic reasons.

Refinements of the gauge-pack collar finite-element model have been made; results from the refined model indicate that the gauge-pack collars are about 20 percent less stiff than the regular collars under Lorentz loading. The unloading of the inner coil is slightly greater for the gauge-pack collars and significantly less for the outer coil. These results agree qualitatively with previous analyses.

An internal note examined in detail the time history for mechanical quantities over the complete test life of long magnet DD0012.

Magnet and Cable Database

The part of the database specification that deals with information up to and including the production of cable is essentially final; the part involving coil and magnet assembly is still preliminary.

To familiarize individuals associated with the development of the cable/magnet database with the software tools available on SYBASE, a workshop was held at the CDG February 21–22. A significant part of the first day was devoted to discussions of SYBASE and of several competing data management systems. However, the meeting was primarily to allow new users to interact with local experts and to obtain hands-on experience with SYBASE. Scientists from BNL, FNAL, LBL, and the CDG attended the workshop. After demonstrations of some of the SYBASE features and capabilities, participants working at VT100 terminals and SUN workstations produced reports and forms, which should prove to be useful in the eventual implementation of the cable/magnet database.

Work continued on the cable database, concentrating on input forms and screen development. The new (beta test) version of SYBASE, compatible with Sun OS 4.0, was installed on the 4/280 server.

Data Analysis and Software Development

Revisions to ancillary software, resulting from modified formats for the cryogenic data, continued in February. Several diagnostic routines were modified to accommodate these changes, including STRAIN_DUMP, a program used to examine the individual strain gauge resistances in detailed checks of calibration and performance.

Small changes in the strain-gauge data from recent short magnet tests at BNL required minor modifications to existing routines, which were completed at the end of February. Data from short magnet DSS14 were analyzed.

Work continued with the Sun 4/280 server and clients, the Magnet Division data management and analysis workstation network. Specific effort was directed at implementing an interface between the SDS data format (and tools developed to manipulate data in this format on the Sun) and the graphic output routines used with existing analysis routines on the Vax cluster.

Cable-Measuring Machine

The assembly of the first of three units continued. At the end of the month they were approximately 80 percent complete. Essentially all the mechanical work has been finished, and the electrical wiring of the unit has been started. The pneumatically powered hydraulic intensifier arrived and was installed on the first unit. A decision was made to increase the number of hydraulic rams on the measuring head from two to three. This will reduce the shop air pressure requirements from 90 psig to 60 psig. The drawing documentation is about 95 percent complete. Final assembly of the unit is expected to be completed by the end of March, and testing will start in April.

Cable-Insulating Machine

Evaluation of the three industrial proposals for the design, fabrication, and assembly of a prototype cable-wrapping machine continued. Separate discussions were held with all three vendors to clarify certain points in their proposals. Arrangements were made to visit two of the vendors to better evaluate their capabilities for designing and fabricating the unit. These visits will occur in early March; selection of the successful vendor is scheduled for late March.

Industrialization Program Phase II Drawings

Preparation of the dipole magnet coil drawings package for Part One of Phase II was completed. As stated in the January Report, the basis for the coil design is magnet DD0016. Drawings for Part Two of Phase II were started at the end of the month. Additional personnel were added to the design staff to help produce these drawings.

ACCELERATOR PHYSICS

Texas Accelerator Physics Meeting

A meeting was held February 28–March 1 at the SSC office in Dallas to discuss the various accelerator physics issues facing the SSC in the coming months. Attending the meeting were accelerator physicists from the CDG and the new SSC, as well as experts from outside. The wide range of issues discussed include lattice and footprint choices, magnet aperture, injection-energy choice, and software and hardware concerns. The discussions allowed views to be

exchanged, issues to be identified, and the next tasks to be defined. On the lattice and footprint issue, for example, bypass configurations were identified as requiring attention. Possible detailed lattice improvements were suggested and discussed. The status and most recent studies of the effects of a larger aperture and higher injection energy, as well as of long-term effects, were reviewed. It was decided that the upcoming E778 review meeting scheduled for March 16-17 at Fermilab would be expanded into an aperture workshop. A list of action items for the workshop by the CDG and by Fermilab was made. In general, it was reemphasized that much of the aperture demand can be relaxed by enlarging the magnet coil size and/or by raising the injection energy, and that a balance between these advantages and the increased cost they could entail should be dealt with in the coming months.

Dynamic Aperture Simulations

An experiment carried out at the CERN SPS last year is being examined in order to correlate its effect on the dynamic aperture criteria adopted for the SSC. The SPS experiment was similar to the E778 series of experiments carried out by the CDG at the Tevatron during the past several years. Eight sextupoles in the SPS were powered to very high excitation to introduce a deliberate and well-controlled nonlinearity. A "pencil" beam was then kicked and its subsequent behavior was observed. The smear and tune shift were measured as a function of amplitude and analyzed with short-term tracking simulations. A troublesome feature observed was that the beam diffused in size at an unacceptably high rate even when the smear and tune shift were well within the operating criteria for the LHC. It is necessary to understand the source of this diffusion effect and to evaluate whether it has an impact on the aperture criteria presently adopted for the SSC.

To examine this problem, long-term tracking simulations (well over a million turns) must be performed. A quick and/or inexpensive understanding of this behavior cannot be attempted. Furthermore, the precise cause of the beam blow-up is not known. An attempt is under way at the CDG to understand it qualitatively. The assumption made is that the cause of the beam blow-up was modulation of the quadrupole strengths due to power-supply ripple. Single-particle tracking simulations are being carried out to look specifically for signals of chaotic behavior, which is assumed to be equivalent to beam blow-up for multiparticle tracking. By changing the working point, the sextupole polarities, and the strength and frequency of the ripple, a correlation may be found between smear, tune shift, and beam blow-up rate.

Accelerator Physics Simulations

Scripts for automating correction-elements working group simulations have been extended for aperture and injection-energy studies. Another set of scripts has been written for automating tracking studies, such as investigating smear as a function of the magnitude of the error in different multipole components.

The other major thrust of software support work has been the redesign of the graphic interfaces to the modeling and operational simulation programs. Our experience with the InterViews graphics toolkit based on C++ has been quite positive. We have developed object-oriented classes for making data plots that support different styles of plotting and zooming, selecting points of interest, fitting curves to data points, and creating menus for other operations. These classes have been used to implement chromaticity plotting and correction, interactive decoupling, and various tracking data plots (phase space, smear, and turn-by-turn). Beta, eta, closed-orbit, and FFT plots will soon be forthcoming. The use of class libraries as opposed to subroutine libraries has proven a boon to creating readily extendible packages. With classes one can develop a new concept (for example, an interactive decoupling plot) by taking an existing concept (generic data plot supporting zooming, etc.) and specifying only the differences between the two.

Along these lines, work has begun on a set of classes representing models of the accelerator. So far, classes representing tracking data have been developed and a rudimentary class encapsulating the general functionality of the modeling programs (such as compute tune and get/set multipole strength) is under way. The former has been used to develop a program to compute smear and the graphical interface for exploring turn-by-turn data; the latter will shortly replace explicit calls to TEAPOT routines in simulation programs. Once all simulations are written in terms of the modeling program class, we will be able to transparently plug the entire simulation into different modeling programs and, ultimately, directly into the actual accelerator.

Analytical Calculation of Smear

Using the analytical approach developed by E. Forest (SSC–95), an attempt was made to calculate the contribution to smear by the different multipoles. A program has been developed to do the analytical manipulations, using the computer algebra system MACSYMA.

The program is now being used to obtain FORTRAN functions for the calculation of the different contributions due to random multipole errors. The result is the average smear and the sigma for different random seeds. The results will be checked with tracking.

The idea is to extend this approach to include the contribution from systematic multipoles and orbit errors. The only complication here is that the orbit has to be calculated analytically. A recipe for this has been worked out. These results can then be used to resolve the different sources of the contributions to the smear.

ACCELERATOR SYSTEMS

Correction Magnet Prototype Program

Fabrication for the prototype correction-coil winding machine was 90 percent completed. The design for the first prototype coil (dipole trim coil) was completed and fabrication of parts was started. It is planned to fabricate 9 dipole prototypes with various materials and construction techniques and to evaluate their performance. The bench for coil fabrication was also designed and fabrication of parts began.

CONVENTIONAL FACILITIES

Texas Site Characterization

On January 18 the Secretary of Energy confirmed that the site in Ellis County, Texas, was the definitive site of the SSC Laboratory. This gave the URA team access to the Texas proposal documents and opened the way to focusing all the siting work on the Texas site. This also opened the way to establishing a working relationship with the Texas Commission and to obtaining additional data.

On January 27 a meeting was held at the Texas National Research Laboratory Commission (TNRLC) offices in De Soto, Texas, to plan for the assimilation of existing data and the establishment of a program to acquire supplementary data to characterize the collider footprint. In addition to TNRLC personnel, representatives from the CDG, Sverdrup, RTK, and Earth Technology Corporation (the geotechnical subcontractor to RTK) participated. Questions about the depth and tilt of the ring were discussed, and a general discussion was held of requirements and responsibilities for characterizing the footprint.

Follow-up meetings were held in Dallas on February 15 and in Oakland on February 17: Participants formed into working groups on monumentation, geotechnical characterization, footprint construction, and physical modeling of the site. An orientation was conducted at FNAL on February 20 for Sverdrup members of the SSC conventional construction team and TNRLC personnel.

Programs were developed for supplemental geological studies and surveying to locate the study loci. These programs essentially follow the program evolved with TETC in the period after selection of the BQL sites. The survey program, using satellite techniques, is designed to support the geotechnical program. Field work is expected to begin in mid-March.

Tunneling Technology

The U.S. National Committee on Tunneling Technology met at the National Academy on February 1–2 to prepare the final draft of a study on contracting practices in underground construction. This DOE study focuses on the large amount of underground construction involved in the SSC project. R. Matyas represented the SSC Laboratory at the meeting.

Data Exchange

Exchange of graphics files between the RTK Intergraph system and the TNRLC AutoCAD system was successfully accomplished during February. This exchange will allow the large amount of updated map data accumulated by TNRLC to be assimilated into the SSC Laboratory CAD files. It will also allow a digitized collider footprint to be given directly to TNRLC for use in land acquisition.

Experimental Area Concept Development

A substantial effort during January and February was devoted to development of experimental hall concepts expressly for the Texas site. Sample detectors and representative collision halls were modeled last year. The physical dimensions of the sample detectors permitted a realistic assessment of the structural requirements for the collision halls in the Austin chalk, Eagle Ford shale, or Taylor marl present at various collision hall locations. A workshop on the results is planned for late March. This work has been mainly directed by M. Marx, who has been helping the cause on his sabbatical from SUNY.

Injector and Test Beam Layout Studies

J. Bensinger, on sabbatical from Brandeis University, has been investigating how to fit an injector into the collider layout on the Texas site. Issues include the relative elevations of the various injector rings, shielding for beam lines, the impact of topography on placement of the rings, and environmental questions. Bensinger is also developing, in consultation with many potential users, the desirable parameters for the test beam areas at the SSC.

AE/CM Selection Activities

Support was given to URA management in the selection of an AE/CM contractor. Studies initiated by the CDG over the past year in anticipation of a fast-paced AE/CM selection process, based on DOE presolicitation of Standard Forms 254 and 255 from interested companies and joint ventures, proved useful.

BNL REPORT

MODEL MAGNETS

Long Magnets

Interconnections, assembly, and warm measurements were completed on DD0018, and the magnet was shipped to FNAL on February 21.

Cable is being insulated for the next long magnet, DD0019, and other preparations for its construction were begun.

Interconnections for DDA010 were completed, and warm measurements were made.

Short Magnets

Short magnet work focused on collaring DSS16 and DSS17 and on installing voltage taps on DSS18. At the end of February, DSS16 was being attached and wired to the top hat in preparation for vertical tests.

Trim Coils

Several 1.8-m trim coils were produced to be used to test the anticipated assembly procedure for the long (10-m) trim coil of DD0019.

0.013-inch-diameter wire was received. It will be used in trim coils for next (fiscal) year's magnets. Most of the prints for the long trim coil test equipment were released to the central shop.

Beam Tubes

The first draws of the bore tube material were successfully completed. Assembly of optimized tooling in the tunnel facility has started. Completed beam-tube plating samples are being inspected.

Insulation R&D

Samples of Kapton high in Al_2O_3 were successfully wrapped onto cable. Polyimide-coated samples of this Kapton are undergoing preliminary examination.

TOOLING AND FACILITIES

Coils

A design for new laminated 1.8-m formblocks was begun.

Collars

Design drawings for the tapered-key insertion device of the preproduction collaring press were finished and are being checked. Some necessary design changes have been identified.

Shell

Drawings of various components of the longitudinal shell-welding fixture—including the cable-pulling device and a modified coil compression gauge with a traveling cart—were released to the shops.

Cold Mass Insertion Fixture

The fixture is about half complete. Stands are being set up on the floor. Assembly tables are expected shortly from the outside vendor.

Horizontal Test Facility

Work continued on feed cans, end cans, and their support system for Bays A and B.

Test Equipment

All components for mole D are finished and being assembled. Design studies continued of new versions of the mole, including a mole designed for use without a warm bore tube.

FNAL REPORT

DIPOLE CRYOSTAT

Measurement of the 300 to 80 K performance of the design B insulation continued. The Heat Leak Test Facility is operating with liquid nitrogen. The instrumentation calibration has been verified, and data taking began.

A trailer identical to the BNL SSC cold mass transport unit for over-the-road magnet cryostat response measurements is expected to be delivered in three months. Magnet-cryostat-to-trailer interfaces are being developed.

Work on Vertical Plane Probe Transporters has been deferred.

Magnet Industrialization Program Phase 1 has been completed.

Work continues on the design C cryostat. Plans for completion of the preliminary design by June 1989 remain in effect.

Work on the SSC Interconnection Tunnel Mockup has been deferred.

Work resumed on SSC cryostat alignment with an SSCL consultant as the leader. The consultant will visit Fermilab to observe the alignment of magnet DD0018.

Work has began on cryostat axial restraints for shipping magnet DDA010 to Brookhaven. The concept, developed by the SSCL alignment consultant, involves a hydraulic axial restraint. It will be installed on both DDA010 and DSHIP.

Since the transport of DDA010 to BNL affords the opportunity of evaluating the possible stress relaxation of the vacuum vessel due to transportation-associated vibration, the vacuum vessel will be surveyed at Fermilab after the insertion of the internal assembly. After transit, the vacuum vessel will be resurveyed at BNL, and possible changes of the shape will be evaluated.

MAGNETIC MEASUREMENTS

DD0016 was cooled down and quench-tested. All quenches appear to be in the same area of the inner coil at approximately 5100 A. It appeared that the quenches are occurring at short sample, suggesting a local defect in the cable. Measurements of the coil resistance at 11 K show no asymmetry between upper and lower inner coils, although the outer coils do show such an asymmetry. The magnet is being warmed to room temperature for removal and shipment to Brookhaven, where the conductor will be examined.

Magnet DD0017 was mounted on the stand. The beam tube has been fully connected on DD0017 to allow magnetic measurements. Cooldown began in late February.

LONG MAGNET FABRICATION

Progress on Cold Mass Pilot Production Factory Setup: Laminated Tooling

Assembly of the inner curing mold is continuing after additional notching was added to laminations for temperature sensing.

The inner winding mandrel is completely stacked.

The outer winding mandrel laminations are still at the vendor for shaving to allow liner installation. Proof laminations for inspection are due the week of March 13.

Stacking of lower collaring mold laminations is 50 percent complete.

Presses

The assembly of curing and collaring presses is still progressing at a steady rate. Some delays were encountered because of out-of-specification return spring for the 15-ton cylinder on the curing press.

Winding Table

The debugging of the winding table is 95 percent complete. Completion is expected the week of March 20.

Cryostat Assembly

DSHIP:	A pre-shipping survey of the vacuum vessel was completed on February 6.
DD0018:	DD0018 arrived from BNL on February 23. Five sets of precision skins were returned on the same truck. The long magnet is expected to be completed March 21.
DD0016	DD0016 is expected to arrive from MTF on March 1 for disassembly.
DD0015	Teardown of DD0015 is complete. It will be stored in Industrial Center Building until a decision about its disposition is made.

MAGNET DEVELOPMENT

The original yoke laminations have been removed from DSS012. Horizontally split line-fit yoke laminations of the standard BNL design were installed, and the shims at the yoke-collar interface were removed. (It was discovered that the shims were present only on the top half of the

magnet.) Strain gauges measuring coil stress and end force, azimuthal skin stress, and beam pipe vertical deflections were monitored throughout disassembly and will be monitored during reassembly. New skins have been machined to length. Strain gauges will be mounted on one of the new half-skins to measure azimuthal and longitudinal stresses at the position of the collar gauge pack. Cold offsets will be measured for these gauges before the skins are welded onto the magnet, allowing the stress state of the skin to be determined throughout all phases of assembly and testing.

Strain-gauge modules have been procured from MTF to allow measurement of all gauges on DSS012. The required cables are being made. Installation of isolation amplifiers, LeCroy Data Loggers, and the required cables has also begun in preparation for testing F5. The system currently being assembled will be able to read up to 60 voltage taps, but can be expanded to read more than 120.

Test laminations were punched with the die for vertically split yoke laminations and have passed inspection. Enough laminations for the second re-yoking of DSS012 were ordered.

F Series Model Program

Magnet F4 was collared on February 16. The collared coil is being potted and sectioned. Cookies are also being made through the strain-gauge pack.

Inner/outer cable for magnet F5 has been reinsulated with 47.5 percent overlap Kapton instead of the 52.5 percent that was used on F4.

Winding of magnet F5 is beginning.

Most end parts for magnet F7 were released to manufacturers. Some have been completed and are being inspected.

Fermilab technicians have been sent to BNL to be trained in applying voltage taps. The BNL scheme will be used on Fermilab's short models.

Design of a cold calibration fixture for strain gauges is beginning.

Design of the rework required to adapt the SSC collaring tooling to produce C358D collared coils is under way.

Glass tape is being ordered with significantly lower percentages of B-stage epoxy than that now being used on SSC magnets. It will be used on some SSC short models.

LBL REPORT

SUPERCONDUCTOR AND CABLE

The raised strand problem in the first outer-layer production cable made by Supercon was due primarily to a tracer strand coated with Sn-1% Ag solder and, secondarily, to slightly atypical processing conditions for some of the wire. The tracer strand is not required and will not be used in any future SSC cables. The atypical processing conditions were due to optimization studies performed on this first production order. They will not occur in subsequent cables.

Practice cable has been made from copper-niobium matrix wire left in the CBA inventory at BNL. Two thousand feet of outer-layer cable was sent to FNAL for practice winding and evaluation. The material selected from BNL inventory for the inner strand was found not to contain any niobium-titanium filaments and hence did not simulate the behavior of SSC cable. Investigation showed the material in BNL inventory to be mislabeled; other material has been located, and (after verifying that it contains niobium-titanium filaments) it will be processed into practice inner cable in March.

If the practice winding tests are satisfactory, 100,000 feet of outer cable and 90,000 feet of inner cable will be made for use in practice coils.

MAGNET MODELS

Dipole Models

Dipole D15C-1. Magnet D15C-1 is the first of a new series of dipoles with tapered (conical) ends. The aluminum collar structure is also stiffened by having the iron return yoke bore directly on the outside of the collars. Initial cryogenic testing took place February 8–17. After ten days at room temperature, the magnet was again cooled to 4.3 K, this time with a UCLA experiment installed to test an NMR magnetic field measurement system under the direction of Professor G. Clark. Memory tests of training will be performed at 4.3 K on March 1.

Dipole D15C-2. Coils for model D15C-2, a second flared-end dipole model similar to D15C-1, have been wound and molded. Coil assembly is complete, and coils are ready to be collared. Target coil prestress after collaring is in the 8000 to 9000 psi range. The collared coil will be fully clamped in the yoke, as was D15C-1. A gap will exist at the yoke midplane before and after cooldown. Aluminum clamps and 1-inch-diameter stainless steel screws will be used to clamp the yoke halves together.

The molded coils for this model were tested to determine the distribution of pressure at the pole and midplane faces of the coils after assembly. The coils were insulated with the standard

coil caps and ground plane insulation and placed into a lower collar pack. The coil midplanes were loaded with known force using a pusher that could either constrain the midplanes to be horizontal (as in a completed model assembly) or allow it to rotate. Fuji pressure-sensitive film was placed at the pole and midplane coil faces. The collar pack was either supported along its entire outside edge (essentially eliminating collar deflection) or by its keyways, permitting the collars to deform as they do in an actual collared assembly.

These tests revealed some pressure concentrations along the inner coil edges at the coil midplanes and good distribution (approximately uniform) from inner to outer edge at the poles. The most significant result was that, when the collar was allowed to deform, the pole face of the outer coils was fully loaded only at every other collar plate. Elastic deformation of the collar plates causes alternate plates to move in opposite directions at the outer coil pole faces. This alternate plate motion was expected, based on finite-element models of the collars and on observation of the way the collar plates are loaded and the appearance of the outside surface of collar packs on collared coils. There are now definitive measurements showing that the slight movement of the back collar plate away from the coil face (relative to the front collar face) results in less support of the cable strands at these locations. Since the plate thickness is about three times the strand diameter, this lack of local support may adversely affect magnet performance.

This effect may also contribute to the observed tendency for aluminum-collared coils (LBL models) to train at the pole turn of the outer coil. The collar packs for model D15C-2 have accordingly been modified to allow use of a 0.06-inch-thick stainless steel bar at the pole of the outer coils. This bar will span the recessed back collar and provide support to the outer cable strands at these locations.

Dipole D15C-3. Coils for model D15C-3 were completed.

50-mm-Bore Dipoles. Preliminary cross section designs, field computations, and tooling designs were completed on a two-layer cos-θ dipole with a 5 cm bore and close-in iron for short-sample measurements of 1-m long cable samples. This magnet will be used in the Cable Test Facility. A new cable design has been made with 28 inner and 36 outer strands; Turk's-head rollers are being ground to produce this cable.

Quadrupole Models

QA1-1R1. This reconstructed model of QA1, originally tested two years ago, is awaiting recollaring. The gauges were recalibrated, and pole shims were remade to increase the coil prestress slightly. The collars will be fully supported in the yoke along their outside surface, as in recent LBL dipole models.

QB. Detailed design studies continued on QB, a new design having greater margin and lower gradient.

PROJECT COST DATA

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TABLE C-1
CENTRAL DESIGN GROUP
FEBRUARY

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
1.1	ADMINISTRATION	148.5	172.6	95.1	416.2	1663.1	6246.0
1.2	PROGRAM PLANNING & MANAGEMENT	40.0	13.3	25.5	78.9	274.8	1190.0
1.3	ACCELERATOR R & D	268.1	224.4	114.1	606.6	2614.6	17004.0
1.4	CONVENTIONAL SYSTEMS DEVELOPMENT	25.2	37.1	32.5	94.8	303.7	1740.0
	PROGRAM COSTS	481.8	447.4	267.1	1196.4	4856.2	26180.0
1.41	RTK COSTS	0.0	66.8	0.0	66.8	293.9	750.0
	CDG/RTK COSTS	481.8	514.2	267.1	1263.1	5150.1	26930.0
	COMMITMENTS					2075.5	
	DELTA COMMITMENTS					363.5	

TABLE C-2
BROOKHAVEN NATIONAL LABORATORY
FEBRUARY

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
2.1	MAGNET DESIGN	56.8	41.1	38.7	136.6	678.8	3348.0
2.2	17-M COLD MASS FABRICATION	170.3	191.5	143.2	505.0	2101.5	4134.0
2.3	TOOLING & FIXTURES	9.5	55.8	25.8	91.1	889.7	640.0
2.4	BEAM TUBE DEVELOPMENT	9.5	42.5	20.6	72.5	328.2	633.0
2.5	1.8-M DIPOLE FABRICIATION	18.9	0.0	7.5	26.4	136.4	538.0
2.6	TRIM COIL DEVELOPMENT	18.9	14.0	13.0	45.9	194.7	752.0
2.7	MAGNET MEASUREMENT	94.6	47.6	56.3	198.6	1051.0	3341.0
2.8	INDUSTRIALIZATION	9.5	5.9	6.1	21.4	118.0	316.0
	MAGNET TOTALS	387.8	398.4	311.2	1097.5	5498.3	13702.0
2.9	ACCELERATED LIFE TESTS	23.6	12.5	14.3	50.4	229.6	898.0
	BNL R & D TOTALS	411.4	410.9	325.5	1147.9	5727.9	14600.0
	COMMITMENTS					1790.0	
	DELTA COMMITMENTS					-234.0	
	EQUIPMENT COSTS	0.0	93.3	0.0	93.3	238.3	2947.0
	EQUIPMENT OPEN COMMITMENTS					131.0	

TABLE C-3
FERMI NATIONAL ACCELERATOR LABORATORY
FEBRUARY

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
3.1	GENERAL	1.3	48.8	19.4	69.5	122.5	222.0
3.2	LONG MAGNET FABRICATION	48.9	-111.5	209.2	146.6	811.7	1891.0
3.3	MAGNETIC MEASUREMENTS	72.5	28.8	101.3	202.6	464.3	2168.0
3.4	COLD MASS FABRICATION	87.0	-32.9	184.0	238.1	848.5	3845.0
3.5	INDUSTRIALIZATION	25.3	-13.3	21.3	33.3	103.4	417.0
3.6	CELL TESTS	0.0	0.0	0.0	0.0	0.0	0.0
3.7	ACCELERATOR STUDIES	7.4	-3.4	6.7	10.7	31.5	71.0
3.8	HALF-CELL TESTS SUP. (REE)	2.5	6.0	1.5	10.0	14.3	466.0
3.9	CRYOGENIC R & D (RAC)	34.3	-45.0	59.6	48.9	247.8	1009.0
3.10	GENERAL MAGNET R & D (RAE)	13.4	5.3	22.7	41.4	100.2	1384.0
3.11	MTF MODIFICATION (RAI)	2.5	-9.5	13.1	6.1	50.0	278.0
3.12	DIPOLE TOOLING R & D (RAJ)	87.3	-150.6	85.1	21.8	384.5	417.0
	PROGRAM COSTS	382.4	-277.3	723.9	829.0	3178.7	12168.0
	COMMITMENTS					734.1	
	DELTA COMMITMENTS					102.7	
	EQUIPMENT COSTS	0.8	124.2	0.0	125.0	361.7	1640.0
	EQUIPMENT OPEN COMMITMENTS					526.0	

TABLE C-4
LAWRENCE BERKELEY LABORATORY
FEBRUARY

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
4.1	GENERAL	6.5	34.1	19.3	59.9	103.3	350.0
4.2	SUPERCONDUCTOR & CABLE	7.1	5.4	5.9	18.4	210.3	1340.0
4.3	CABLE SHORT SAMPLE TEST FACILITY	10.5	0.0	5.0	15.5	89.3	50.0
4.4	DIPOLE MAGNET DEVELOPMENT	73.6	8.7	38.8	121.1	645.5	760.0
4.5	QUADRUPOLE MAGNETS	10.6	0.0	5.1	15.7	16.8	260.0
4.6	COIL PROPERTIES	2.3	0.0	1.1	3.4	6.0	200.0
4.7	TECHNOLOGY TRANSFER TO INDUSTRY	0.0	0.0	0.0	0.1	51.2	50.0
	MAGNET R & D TOTALS	110.6	48.3	75.1	234.0	1122.4	3010.0
4.8	ACCELERATOR THEORY SUPPORT	25.2	1.4	12.7	39.3	160.3	410.0
	R & D COST TOTAL	135.7	49.7	87.8	273.2	1282.7	3420.0
	COMMITMENTS					365.0	
	DELTA COMMITMENTS					104.0	

TABLE C-5
PROGRAM SUMMARY - SUPERCOLLIDER
FEBRUARY

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
1.	CDG PROGRAM	481.8	447.4	267.1	1196.4	4856.2	26180.0
1.41	RTK PROGRAM	0.0	66.8	0.0	66.8	293.9	750.0
2.	BNL SSC PROGRAM	411.4	410.9	325.5	1147.8	5727.9	14600.0
3.	FNAL SSC PROGRAM	382.4	-277.3	723.9	829.0	3178.7	12168.0
4.	LBL SSC PROGRAM	135.7	49.7	87.8	273.2	1282.7	3420.0
	TOTAL SSC PROGRAM COSTS	1411.3	697.5	1404.3	3513.1	15339.4	57118.0
	COMMITMENTS					4964.6	
	DELTA COMMITMENTS					336.2	
	EQUIPMENT COSTS					600.0	4587.0
	EQUIPMENT OPEN COMMITMENTS					657.0	

TABLE C-6

MONTHLY AND CUMULATIVE SUMMARY
OF PLANNED AND ACTUAL COSTS AND COMMITMENTS

1.0 CENTRAL DESIGN GROUP - SUPERCOLLIDER

MONTH	MONTHLY PLANNED COSTS	FY PLANNED CUMULAT	MONTHLY ACTUAL COSTS	FY ACTUALS CUMULAT	MO ACT+ DELTA COMMITS	CUM ACT + COMMITS	CURRENT COMMITS	DELTA COMMITS
OCT	1158.0	1158.0	236.1	236.1	1027.3	2035.9	1799.8	791.2
NOV	1238.8	2396.8	1365.0	1601.1	1473.9	3509.8	1908.7	108.9
DEC	1319.6	3716.3	1105.8	2706.9	943.5	4453.3	1746.4	-162.3
JAN	1400.4	5116.7	1180.3	3886.9	1145.9	5598.9	1712.0	-34.4
FEB	1588.9	6705.6	1263.2	5149.8	1626.7	7225.3	2075.5	363.5
MAR	1831.2	8536.8						
APR	2154.4	10691.2						
MAY	2477.6	13168.8						
JUN	2827.7	15996.4						
JUL	3177.7	19174.2						
AUG	3608.6	22782.8						
SEP	4147.2	26930.0						

2.0 BROOKHAVEN NAT'L LAB - SUPERCOLLIDER

MONTH	MONTHLY PLANNED COSTS	FY PLANNED CUMULAT	MONTHLY ACTUAL COSTS	FY ACTUALS CUMULAT	MO ACT+ DELTA COMMITS	CUM ACT + COMMITS	CURRENT COMMITS	DELTA COMMITS
OCT	1216.7	1216.7	1033.8	1033.8	3502.9	3502.9	2469.1	2469.1
NOV	1216.7	2433.3	1017.1	2050.9	557.0	4059.9	2009.0	-460.1
DEC	1216.7	3650.0	1173.8	3224.7	1227.8	5287.7	2063.0	54.0
JAN	1216.7	4866.7	1355.4	4580.1	1316.4	6604.1	2024.0	-39.0
FEB	1216.7	6083.3	1147.9	5728.0	913.9	7518.0	1790.0	-234.0
MAR	1216.7	7300.0						
APR	1216.7	8516.7						
MAY	1216.7	9733.3						
JUN	1216.7	10950.0						
JUL	1216.7	12166.7						
AUG	1216.7	13383.3						
SEP	1216.7	14600.0						

3.0 FERMI NAT'L ACCEL LAB - SUPERCOLLIDER

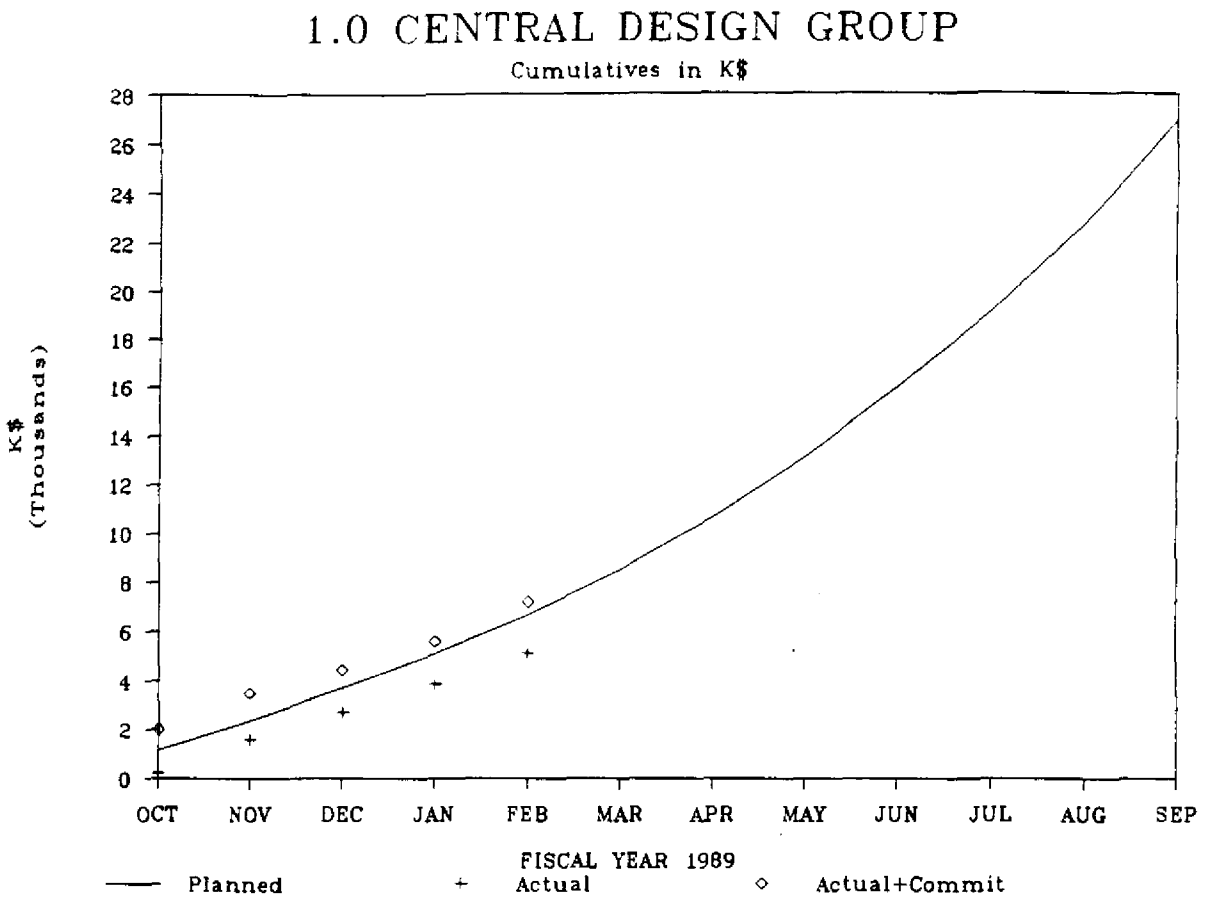
MONTH	MONTHLY PLANNED COSTS	FY PLANNED CUMULAT	MONTHLY ACTUAL COSTS	FY ACTUALS CUMULAT	MO ACT+ DELTA COMMITS	CUM ACT + COMMITS	CURRENT COMMITS	DELTA COMMITS
OCT	1014.0	1014.0	366.1	366.1	1178.9	1178.9	812.8	812.8
NOV	1014.0	2028.0	670.2	1036.3	488.4	1667.3	631.0	-181.8
DEC	1014.0	3042.0	613.1	1649.4	593.5	2260.8	611.4	-19.6
JAN	1014.0	4056.0	787.2	2436.6	807.2	3068.2	631.4	20.0
FEB	1014.0	5070.0	829.0	3266.0	931.7	4000.1	734.1	102.7
MAR	1014.0	6084.0						
APR	1014.0	7098.0						
MAY	1014.0	8112.0						
JUN	1014.0	9126.0						
JUL	1014.0	10140.0						
AUG	1014.0	11154.0						
SEP	1014.0	12168.0						

4.0 LAWRENCE BERKELEY LAB - SUPERCOLLIDER

MONTH	MONTHLY PLANNED COSTS	FY PLANNED CUMULAT	MONTHLY ACTUAL COSTS	FY ACTUALS CUMULAT	MO ACT+ DELTA COMMITS	CUM ACT + COMMITS	CURRENT COMMITS	DELTA COMMITS
OCT	285.0	285.0	244.6	244.6	-5.4	339.6	95.0	-250.0
NOV	285.0	570.0	212.2	456.8	215.2	554.8	98.0	3.0
DEC	285.0	855.0	208.8	665.6	206.8	761.6	96.0	-2.0
JAN	285.0	1140.0	343.9	1008.4	508.9	1269.4	261.0	165.0
FEB	285.0	1425.0	273.2	1280.5	377.2	1645.5	365.0	104.0
MAR	285.0	1710.0						
APR	285.0	1995.0						
MAY	285.0	2280.0						
JUN	285.0	2565.0						
JUL	285.0	2850.0						
AUG	285.0	3135.0						
SEP	285.0	3420.0						

0.0 PROGRAM SUMMARY - SUPERCOLLIDER

MONTH	MONTHLY PLANNED COSTS	FY PLANNED CUMULAT	MONTHLY ACTUAL COSTS	FY ACTUALS CUMULAT	MO ACT+ DELTA COMMITS	CUM ACT + COMMITS	CURRENT COMMITS	DELTA COMMITS
OCT	3673.7	3673.7	1880.6	1880.6	5703.7	7057.3	5176.7	3823.1
NOV	3754.4	7428.1	3264.5	5145.1	2734.5	9791.8	4646.7	-530.0
DEC	3835.2	11263.3	3101.5	8246.6	2971.6	12763.4	4516.8	-129.9
JAN	3916.0	15179.4	3666.8	11912.2	3778.4	16540.6	4628.4	111.6
FEB	4104.5	19283.9	3513.3	15424.3	3849.5	20388.9	4964.6	336.2
MAR	4346.9	23630.8						
APR	4670.1	28300.9						
MAY	4993.2	33294.1						
JUN	5343.3	38637.4						
JUL	5693.4	44330.8						
AUG	6124.3	50455.1						
SEP	6662.9	57118.0						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K$ (Thousands)
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4
6
8
10
12
14
16
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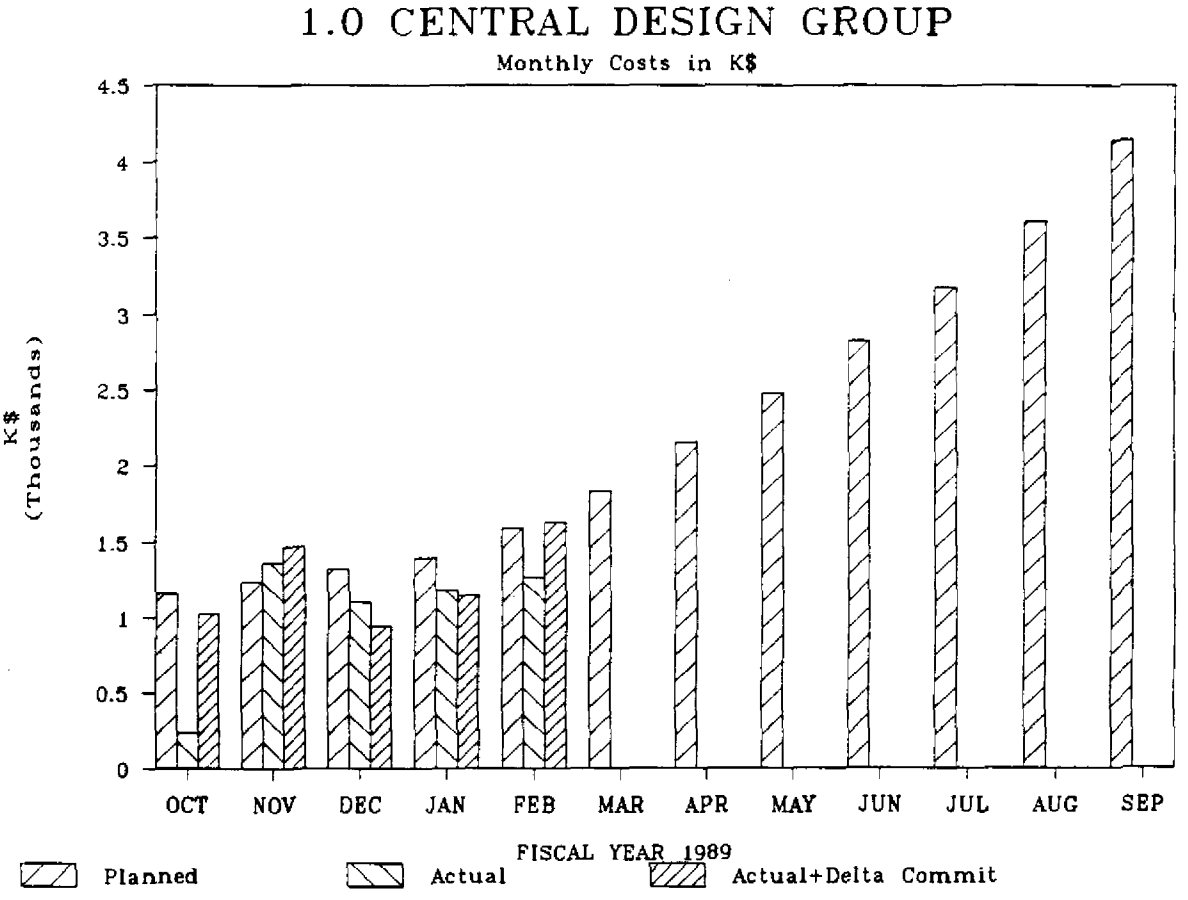
20
22
24
26
28
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Commit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Monthly Costs in K$
K$ (Thousands)
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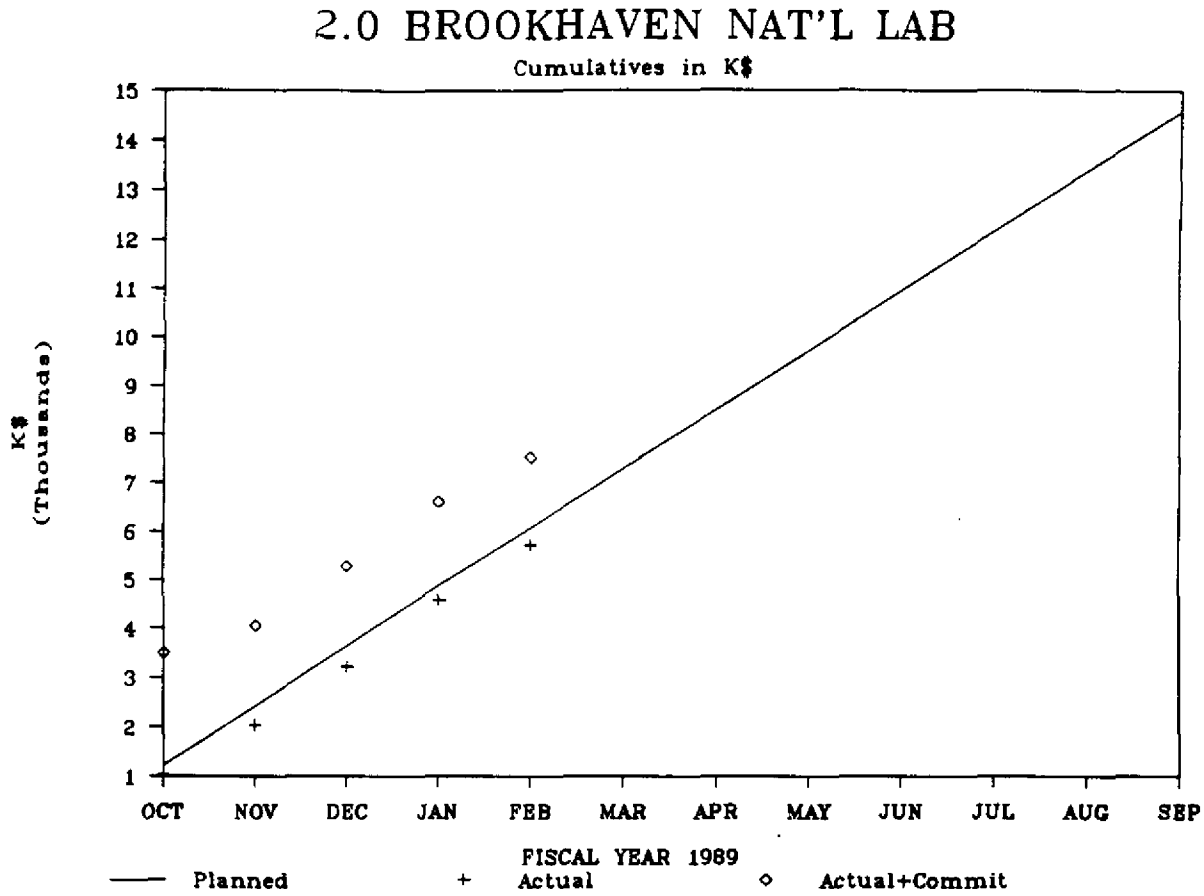
0.5
1
1.5
2
2.5
3
3.5
4
4.5
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Delta Commit

Figure 1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Cumulatives in K$
K$ (Thousands)
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13
12
11
10
9
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7
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4
3
2
1
OCT
NOV
DEC
JAN
FEB
MAR
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MAY
JUN
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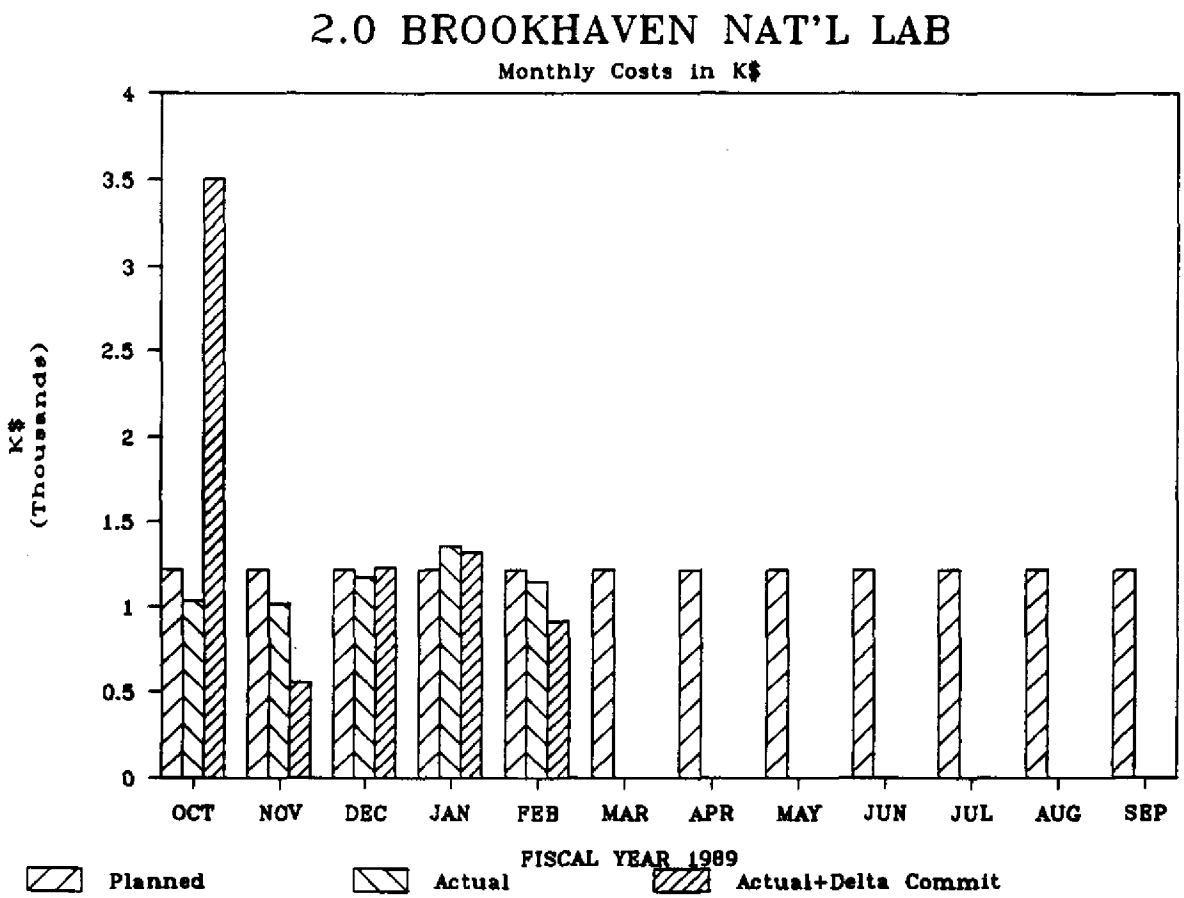
AUG
SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Commit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Monthly Costs in K$
K$ (Thousands)
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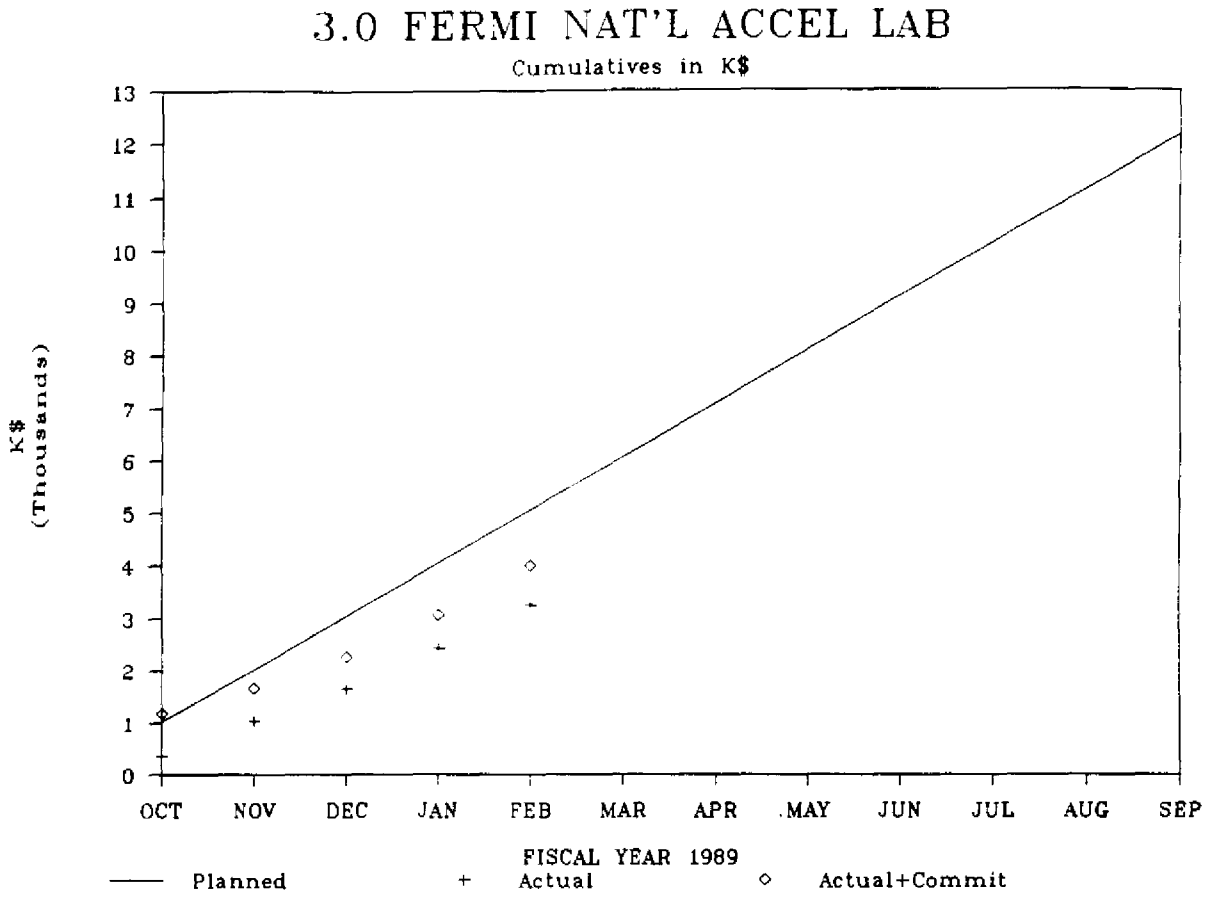
3.5
3
2.5
2
1.5
1
0.5
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Delta Commit

Figure 2


3.0 FERMI NAT'L ACCEL LAB
Cumulatives in K$
K$ (Thousands)
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1
2
3
4
5
6
7
8
9
10
11
12
13
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Commit

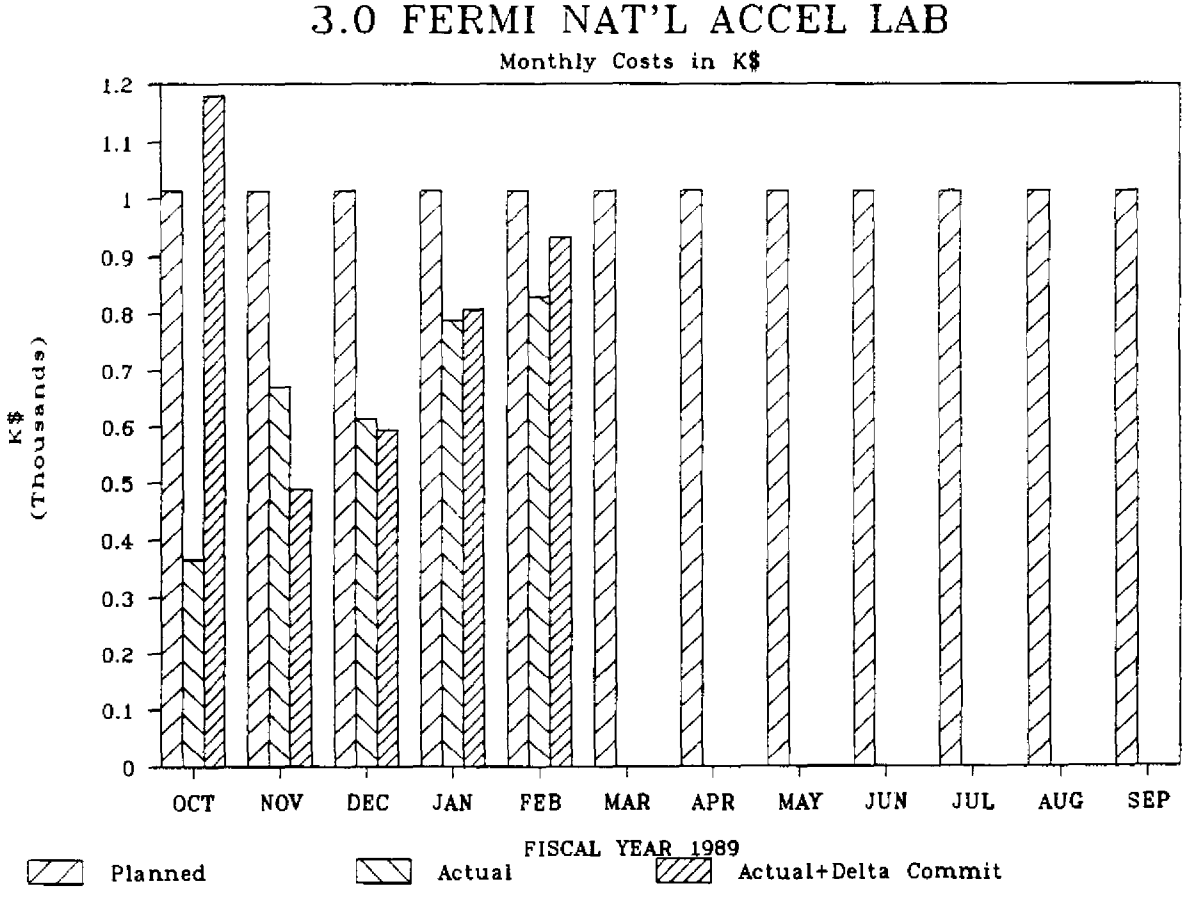
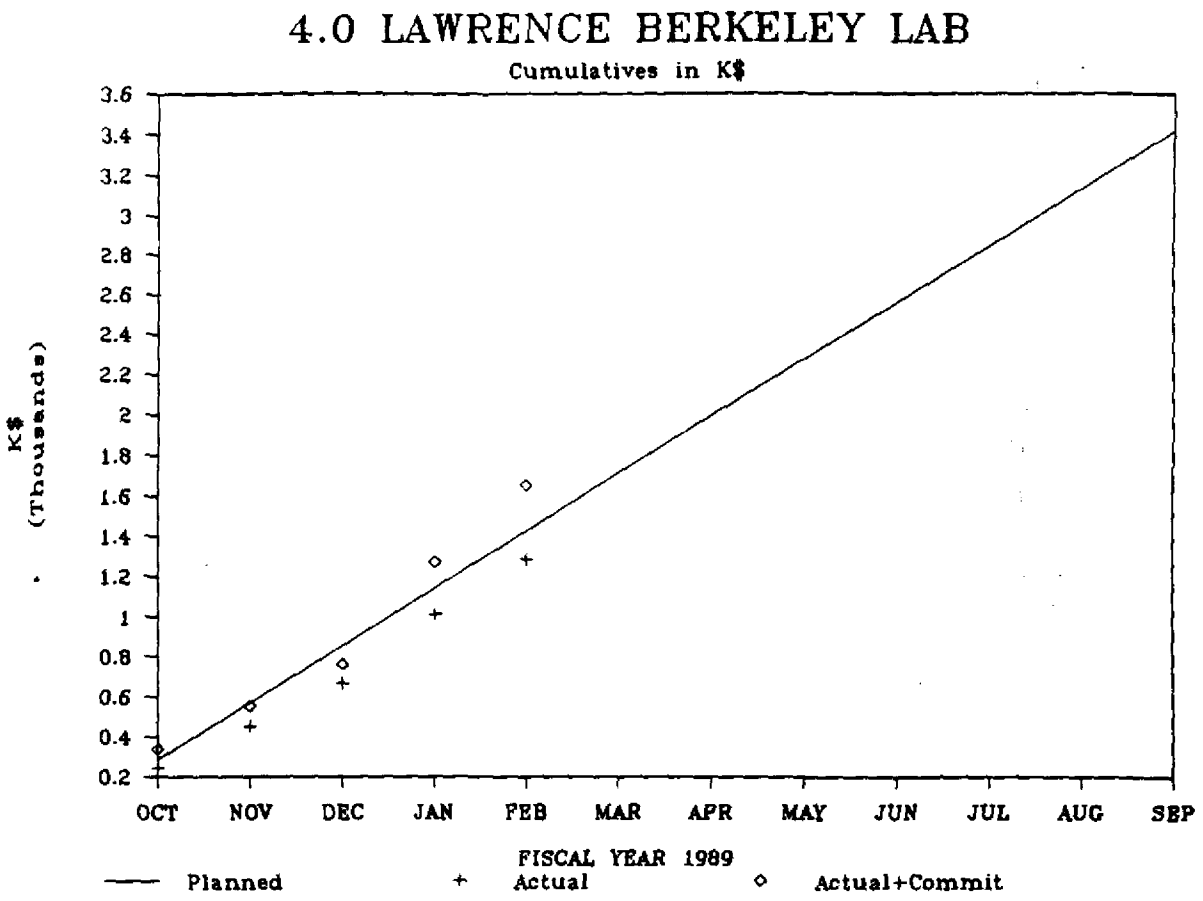

3.0 FERMI NAT'L ACCEL LAB
Monthly Costs in K$
K$ (Thousands)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Delta Commit

Figure 3


4.0 LAWRENCE BERKELEY LAB
Cumulatives in K$
K$ (Thousands)
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Commit

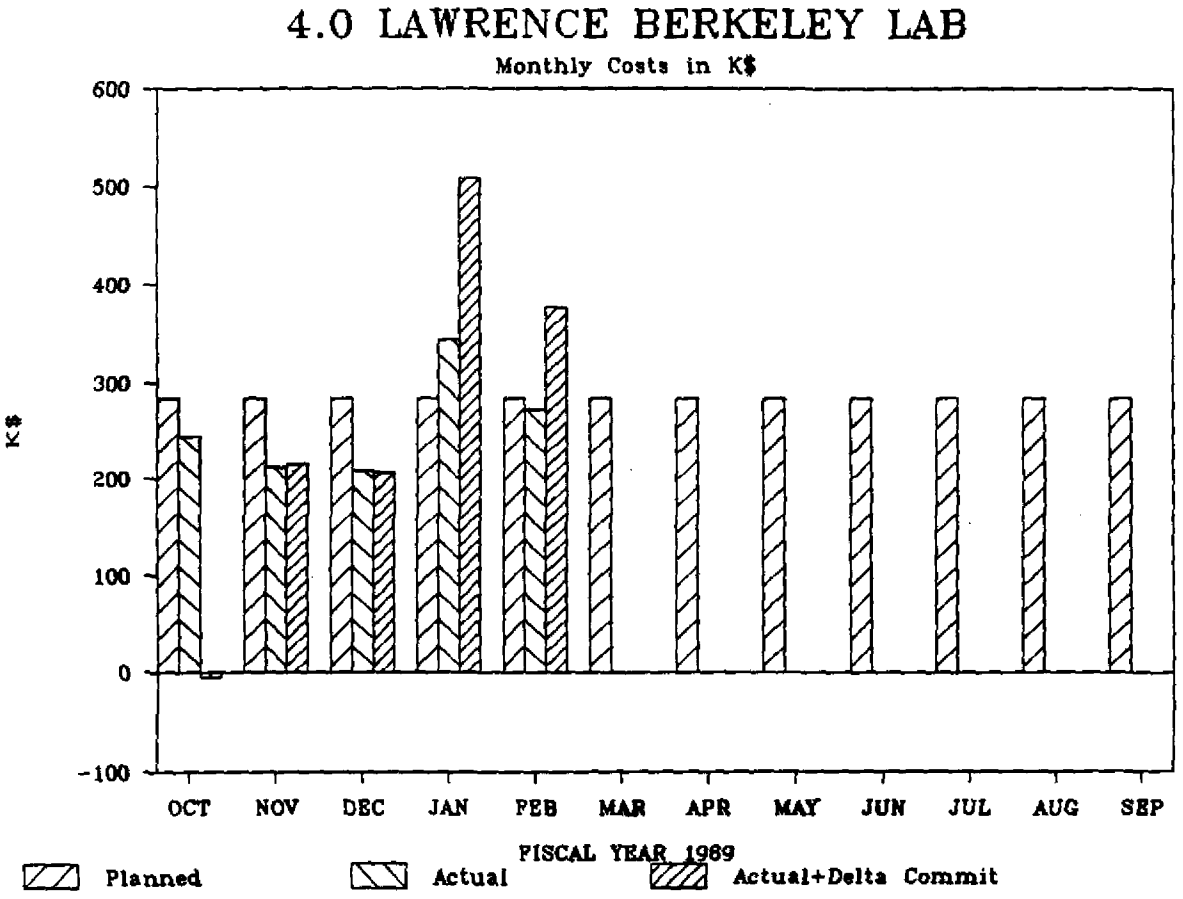
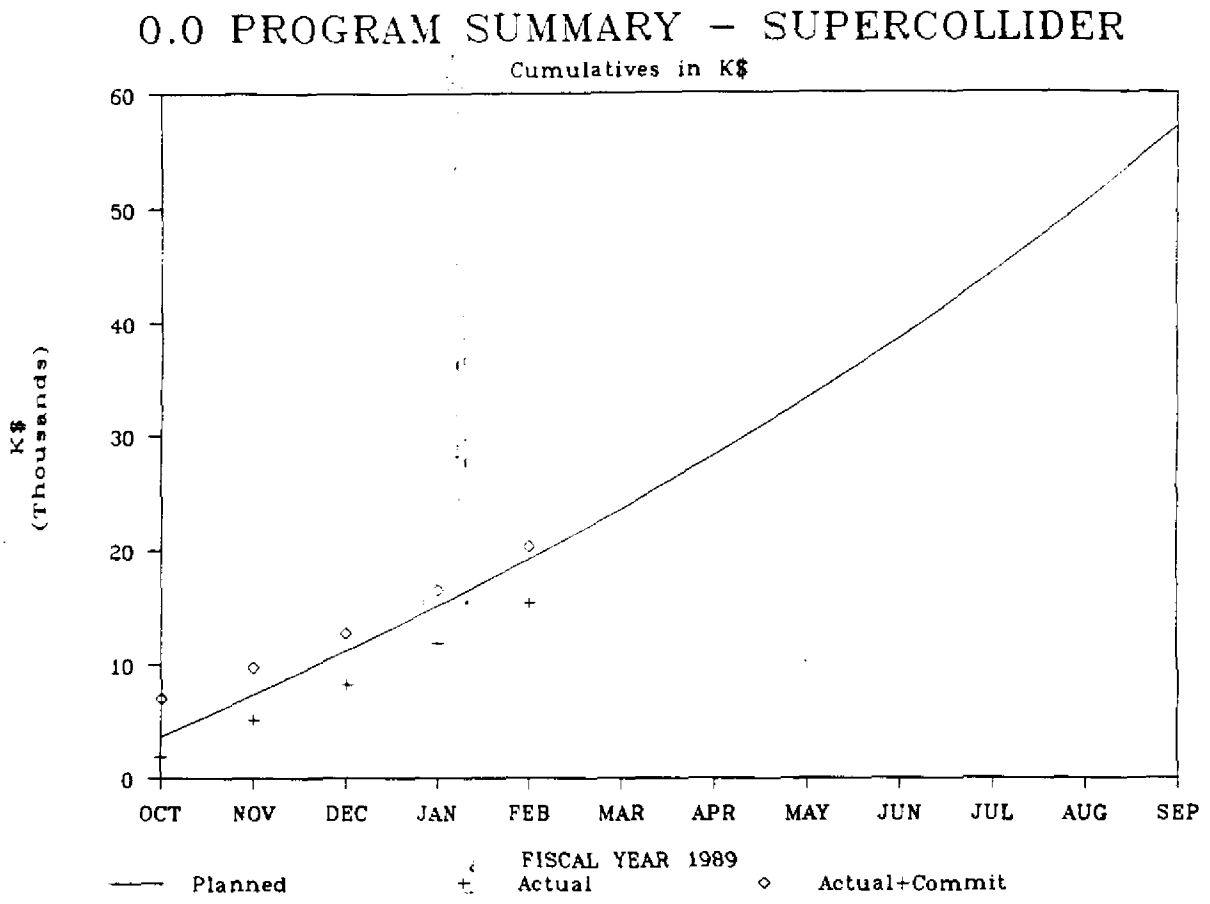

4.0 LAWRENCE BERKELEY LAB
Monthly Costs in K$
K$
600
500
400
300
200
100
0
-100
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Delta Commit

Figure 4


0.0 PROGRAM SUMMARY – SUPERCOLLIDER
Cumulatives in K$
K$ (Thousands)
60
50
40
30
20
10
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Commit

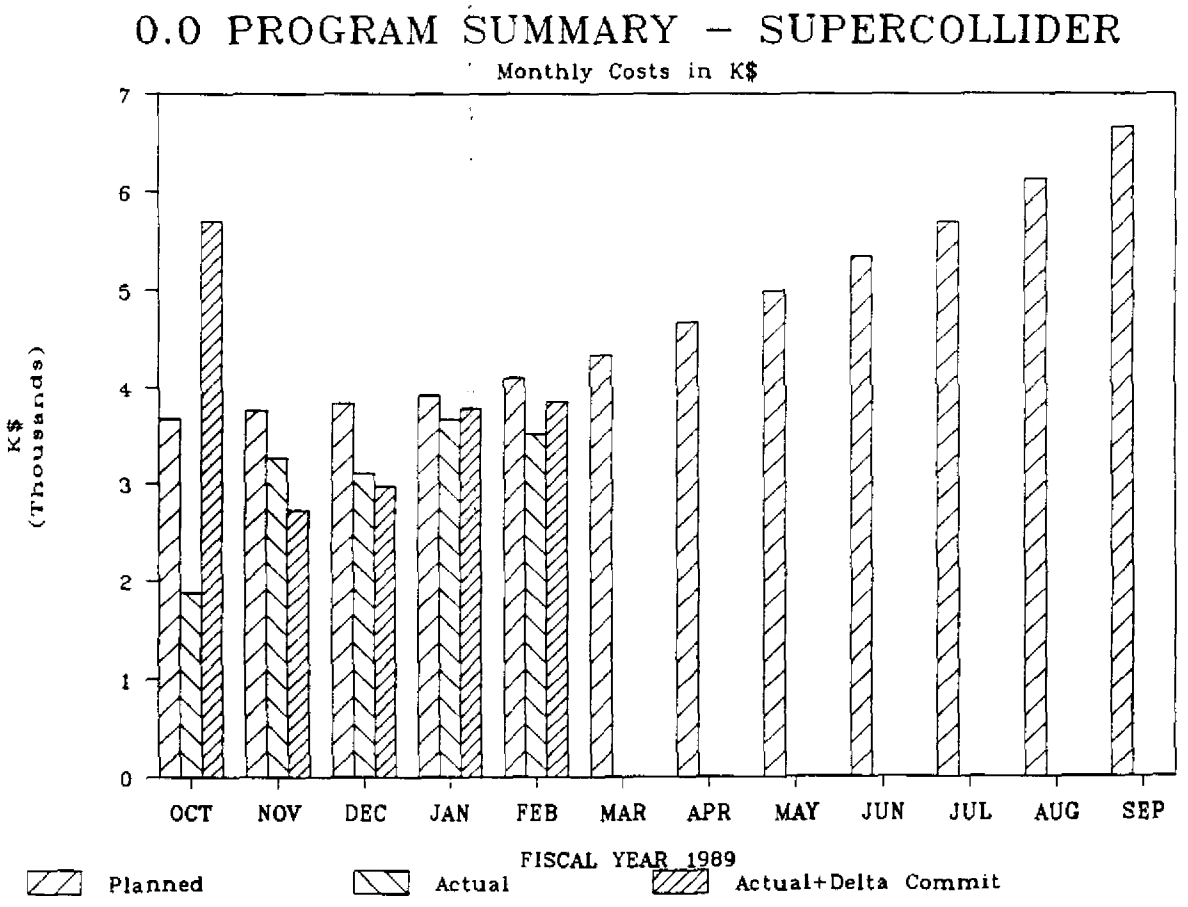

0.0 PROGRAM SUMMARY – SUPERCOLLIDER
Monthly Costs in K$
K$ (Thousands)
7
6
5
4
3
2
1
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1989
Planned
Actual
Actual+Delta Commit

Figure 5