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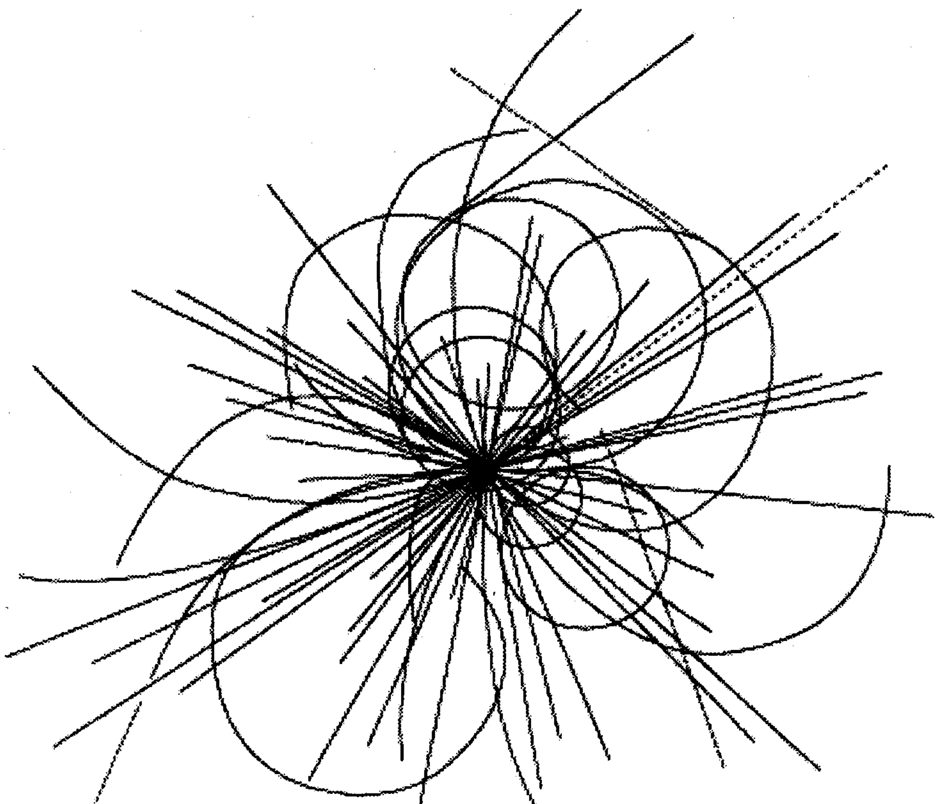

Superconducting Super Collider Laboratory

SSCL-SR-1231

Development of the Conventional Facilities of the Superconducting Super Collider

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1.0 OVERVIEW OF CONVENTIONAL FACILITIES DEVELOPMENT

The design of the conventional facilities for the SSC evolved with the evolution of the design of the technical systems, beginning with the >2 TeV pbar-p **Fermilab Dedicated Collider**[1a,b] in 1983, where a change was made from the prevailing central refrigerator concept to distributed independent refrigerator stations and the cryogenic distribution lines were incorporated into the magnet cryostat in lieu of separate transfer lines. The **Cornell Workshop**[2] in the Spring of 1983 developed considerations of tunnel design based on magnet size and installation concepts and also developed the basic concepts for radiation shielding requirements for the 20 TeV scale. The **Reference Designs Study**[3a–e] (RDS) of 1984 emphasized a plausible cost estimate for the facilities; the main design developments beyond Cornell were concepts for collision halls and related experimental facilities, and development of space requirements and architectural concepts for campus and support facilities for the projected population of the facility. In the RDS report the conventional facilities portions, which were prepared by PBQD, the A-E firm engaged to support the Study, are presented in an **Appendix**[3c] and a **Technical Appendix**[3d] to that appendix. The report of the RDS was used to derive **Siting Parameters**[4] and an **action plan**[5] for environmental and exploratory activities required to evaluate sites.

For the **Conceptual Design Report**[6a,b] (CDR) in 1986 the primary emphasis for construction was on designs and costs for the Collider tunnel, the major cost driver for the conventional facilities. Conventional systems considerations weighed heavily in the radical rearrangement of the major facilities from a distribution around the entire periphery in the RDS to the clustered arrangement of the CDR. In the CDR the design of the conventional facilities is contained in Attachment C, SSC-SR-2020C. In order to adequately parametrize the costs for these facilities in the CDR, three model sites were developed by RTK, the A-E firm supporting the URA/Central Design Group activities. These model sites spanned the range of variation of depth and rock/soils anticipated for suitable sites. The models were used, *inter alia*, to develop a tunneling cost model to be used for intersite cost evaluations. In the period following publication of the CDR, **time-phased computer graphic modeling techniques**[7a,b] were developed and implemented to parameterize the underground spaces. These studies led to an increase in tunnel diameter from 10 feet to 12 feet to accommodate installation requirements, as well as transport during operations. They also led to a change in shaft concept from single, multifunctional shafts to multiple, single-function shafts, and to a design concept for the large experimental halls which accommodated construction, operation and maintenance of the detectors. The design development accomplished by the Central Design Group between the publication of CDR and the phasing-out of the CDG were gathered into 5 **supplementary volumes**[7c] in December, 1988 and formally transmitted to the new Project organization. Volume IV, and Volume V(1–6) pertain especially to developments in the area of conventional facilities.

The major new design considerations for the **Site-specific Conceptual Design Report**[8a,b] (SCDR) in 1990 were an increase in the energy of the HEB from 1 TeV to 2 TeV, an approximately 10-fold increase in the volume of the large detectors, and adaptation of the design to the geography and geology of the Texas site. The change in the HEB approximately doubled the circumference of its tunnel and increased fourfold the impacted land area, and the increase in detector sizes correspondingly increased the size of the collision halls to house them.

2.0 OVERVIEW OF CONSTRUCTION RESPONSIBILITIES

Execution of the conventional construction of the SSC Laboratory, including underground facilities, buildings and infrastructure, is the responsibility of the Laboratory Associate Director for Conventional Construction, who is the Head of the Conventional Construction Division (CCD). The URA staff of CCD is supplemented by specialized support from the Sverdrup Corporation, a designated subcontractor to URA in the Management and Operations team. The Associate Director exercises his responsibilities through a subcontracted Architect-Engineer/Construction Manager (A-E/CM) firm, The PB/MK Team joint venture, who prepare the designs and manage the construction contracts.

In order to accomplish the construction, PB/MK subdivides the project into Construction Contract Units, CCU's, which are logical units of work. The configuration of the CCU's takes into account the functional completeness of a unit, geological boundaries, and costs relative to available obligational authority and to bonding capability of potential contractors.

A given CCU may involve several related categories in the project Work Breakdown Structure (WBS) (and, conversely, a given WBS category, like infrastructure, may be involved in a whole range of CCU's.) The relationships between WBS categories and CCU's is defined in a **Project Management Baseline (PMB) crosswalk document**.

3.0 OVERVIEW OF CONSTRUCTION DOCUMENTATION

For each CCU the design requirements are established by the Conventional Construction Division working with cognizant technical divisions. A **Design Requirements Document** (DRD), approved by the Laboratory is transmitted to the A-E/CM for execution of the design. The design process involves formal review documents at the **Title I** (30%), **60%**, and **Title II** (90%) levels. This process leads to an **Invitation for Bid**, which is the basis for award of a **contract** on a competitive lump sum basis. After award the contract may be modified by **Design Change Notices** (DCN). Progress in design is reported in a **Weekly Design Project Milestone Report**, while progress in construction is reported in **Weekly** and **Monthly Construction Status Reports**. Upon completion of the contract, a set of **As-Built** drawings and related documentation, **Title III**, are provided to the Laboratory by the A-E/CM.

The documents indicated in bold-face constitute the technical documentation of the design and construction process. Relevant documentation is cataloged under the appropriate CCU#. The documents are cross-referenced, in a Filemaker Pro database, to WBS, PB/MK Pkg. numbers, and SSCL Document Control numbers. The status of the documents for each CCU is also included in the database.

In addition to the facility-specific CCU's, there are a number of project-wide CCU's, such as the precision survey grid and the geotechnical characterization of the site, which have separate documentation.

Design concepts, specialized studies, Underground Technology Advisory Panel (UTAP) reports,[9] and site characterization activities predating the initiation of construction are documented outside of the CCU framework, as are publications in the technical literature and presentations made to professional groups. These reports and publications are referenced *passim* in this report and included in the reference listing below.

4.0 MAJOR PROJECT ELEMENTS & STATUS

The major elements of the Project, which constitute the first level of subdivision for construction purposes, are the Collider, the Injector, and the East and West Complexes. The Collider is made up of the North and South Arcs and the East and West Clusters; the Injector includes the Linac, LEB, MEB and HEB; the West Complex includes the West Experimental Areas, IR1 and IR2, the N15 area, the common infrastructure, and the Campus, while the East Complex includes the East Experimental Areas, IR5 and IR8, and the common infrastructure. The status of the conventional construction has been reviewed periodically in **conference reports**[10a,b] and **technical publications.**[11] The detailed status and documentation are discussed below.

5.0 SITE-WIDE ACTIVITIES

5.1 Siting

Siting of the SSC is complete with the exception of some ongoing litigation by the TNRLC with respect to fair value for lands taken by eminent domain. Siting of the SSC facility involved an iterative process including the designers, the DOE, and the State of Texas. The major features of the facility, i.e., the clustering of machine elements and interaction points on either side of the ring and the radius of the arcs connecting the clusters, were fixed in the **Conceptual Design Report**[6a] (CDR) published by the URA Central Design Group (CDG) in March 1986 and **reviewed by the DOE**[6b] in May 1986. The CDR was the basis of a **Siting Parameters Document**[12] which provided the technical basis for an **Invitation for Site Proposals**[13] (ISP) issued by the DOE in April 1987. Thirty-five responsive site proposals were submitted and were evaluated by a committee of the National Research Council. From a **Best Qualified List**[14a,b,c] (BQL) of 8 sites provided by the committee, then Secretary of Energy John Herrington selected the site near Waxahachie, TX, in January, 1989, for construction of the facility. Adaptation of the modified design to the site involved overlaying on USGS quad maps a template of the facility requirements, including buffer zones for radiation avoidance, to minimize interference with existing surface and environmental features. With the exception of an increase in the fee simple land area to contain the enlarged HEB and minor modifications to accommodate revisions to the Collider lattice, the SSC footprint was essentially set in the **proposal from the State of Texas for the Dallas-Ft. Worth site.**[15a,b,c]

The detailed configuration of the required land was driven largely by **radiation considerations**[16] and existing property boundary lines. Using **bedrock geology**[17a,b,c] from the site geotechnical characterization program, a **precise system of survey monuments,**[18] and a program of aerial survey and mapping, the strike and dip of the Collider ring were varied to minimize the amount of tunnel in the soft Eagle Ford Shale and maximize the amount in Austin Chalk, while maintaining the specified minimum cover of 50 feet everywhere around the circumference. A **Footprint Characterization Document**[19] was prepared by the SSC Laboratory and approved by DOE specifying the land requirements for construction and operation of the facility. This document was transmitted by DOE to the Texas National Research Laboratory Commission (TNRLC) as the formal specification by DOE for land acquisition by the State. The Footprint Characterization Document was supplemented by a **digital, 3-dimensional characterization**[20] of the required land volumes and areas in hard copy and magnetic formats.

5.2 Site Selection & Environmental Impact

In planning for the site selection process the DOE determined that a full environmental impact statement (EIS) would be a prerequisite to the decision on the site for the SSC. In practice, this was interpreted by DOE to mean that an EIS must be done for <u>all</u> of the finalist sites. The DOE contracted with Argonne National Laboratory (ANL) to prepare the EIS, making use of RTK, the A-E subcontractor to the URA Central Design Group, for technical support. Documentation relative to **radiation**[21] and **operational safety**[22a,b] considerations was prepared by URA/CDG to supplement the Conceptual Design Report of March 1986, which was the definitive basis for evaluation of the environment impact of the SSC. A **Draft EIS**[23] (DEIS) was issued in August 1988 encompassing all 8 of the BQL sites. Following a public comment period and public hearings at each of the sites a **Final EIS**[24] (FEIS) was issued in December 1988, and a Record of Decision (ROD) selecting the Texas site was issued in January 1989. The ROD included a requirement for a Supplemental EIS (SEIS) to treat the detailed adjustment of the facility to the Texas site. An **implementation plan for the SEIS**[25] was issued in July 1990. Following an additional comment period and public hearings the **SEIS**[26] was issued by DOE in December 1990, with the ROD in February 1991.

5.2.1 Geotechnical Exploration

An initial geotechnical exploration program involving 38 borings was carried out by the State of Texas and reported in the Texas site proposal. Following selection of the Texas site, an extensive program of approximately 120 borings was carried out for the Laboratory by RTK to characterize the geology of the site for optimization of the placement of the tunnel, halls and shafts. The data from the RTK program are contained in a **gINT database**[27] as well as an extensive series of borehole and summary **SSC-GR** reports listed in Appendix 2. A detailed program of project-specific borings has been carried out by PB/MK. These data form the basis of the **Geotechnical Design Summary Reports** (GDSR) which are provided in the design package for each of the underground contract CCUs.

5.2.2 Survey and Monumentation

As noted above, the gross siting of the Collider made use of templates overlaid on USGS quad maps for the area, initially by the State of Texas for inclusion in the Texas Site Proposal and later by the SSC Laboratory for the modified lattice. For detailed specification of the land for acquisition by the State, the Global Positioning Satellite (GPS) system was used to establish a network of master (Order B) and primary (First Order) monuments for horizontal survey control. A precision (First Order Level) network of vertical survey monuments was established by redundant precision levelling across the diameter and around the circumference of the Collider ring.[17] This high-precision network was later augmented with a view to the installation of the technical components in the tunnel.[28a,b]

5.2.3 Master Planning

CCD participated through their A-E[29] and A-E/CM[30] in several Laboratory master planning efforts. The master planning effort is described in the Site Development Plan elsewhere in this document.

5.3 West Complex, the N15 Area

The earliest site-specific design activity for the project involved use of the N15 area at the Northwest corner of the West Complex for initial magnet testing activity,[31] with a view to early installation and testing of a full refrigeration system and a string of magnets in the Collider tunnel at that location.[32] This drove early construction of the N15 Magnet Delivery Shaft, CCU #A602, and the magnet-related structures in the N15 area, *i.e.*, the Magnet Development Laboratory (MDL), CCUs #D102, D103, D107, the Magnet Test Laboratory (MTL), CCUs #C201, C202, C203, the Accelerator Systems String Test (ASST) facility, CCU #A625, and a package sewage plant, CCU #D108, along with their infrastructure. These facilities are complete and have been turned over to the Laboratory for operation.

5.4 West Complex, the Injector

5.4.1 Overall Status and Generic Activities

The generic activities for the Injector complex include **an optimization study of the elevation of the Injectors,**[33] a program of geotechnical exploration to characterize the subsurface, a survey program to locate the facilities, the Infrastructure, and a cooling pond for rejecting the waste heat from the Injector. Except for the HEB portion, these generic activities for the Injector are complete. The relevant geotechnical reports, SGR-x, are referenced in the **Geotechnical Design Summary Reports (GDSR)** which are included in the Invitation for Bid for each CCU.

The overall status for the Injector construction is depicted in Figure 1, below.

5.4.2 Linac

The Linac package, CCU #A200, includes approximately 800 linear feet of underground machine enclosure, an 800 foot long equipment gallery, and 300 feet of transfer tunnel to the LEB. All of the conventional construction for the Linac has been completed with the exception of the small LCW Room, CCU #A201, on the south side of the Gallery Building. The opening in the Gallery wall for the LCW room will be closed with existing siding material. The Linac has been turned over to the SSCL for installation of technical systems.

5.4.3 LEB

The LEB package, CCU #A300, includes approximately 1900 linear feet of underground machine enclosure and associated surface buildings, 300 linear feet of transfer tunnels, and 600 feet of the cut-and-cover portion of the MEB tunnel adjacent to the LEB. The package is under contract and construction was well under way at termination. The LEB tunnel shell is approximately 90% complete with all but three of the floor slabs completed. The backfill of the tunnel to grade is 20% completed. The LEB to MEB Transfer Tunnel has been completed and backfilled to grade and 20% of the shielding berm over the Transfer Tunnel is in place. The 575 feet of MEB tunnel included in the LEB contract has been completed and 20% of the shielding berm above the tunnel is in place.

5.4.4 MEB

The MEB package, CCU #A400, includes approximately 20,000 linear feet of tunnel of which 7200 linear feet consists of transfer and test beam tunnels, 14 shafts and associated buildings, the portion of the Test Beams from WP0 to WP8, and the Injector cooling pond. This package is under contract and construction was under way at termination. Clearing and grubbing for the cooling pond has been completed, and excavation of the remaining cut-and-cover portion of the accelerator tunnel from the LEB tie-in is 90% complete. None of the Test Beam construction has been carried out. The design package for the remainder of the Test Beams facility, CCU #420 WP8-WP12, is complete and the package was ready for bid at the time of termination.

5.4.5 HEB

The HEB package, CCU #A500, includes approximately 40,000 linear feet of tunnel of which 5600 linear feet consists of transfer tunnels, with 11 shafts and associated surface buildings. The package is in a very early design stage; approximately 21% of the design is complete.

5.5 Collider

5.5.1 Generic Activities

The generic activities for the Collider include studies parameterizing **the cost of bored tunnels as a function of diameter,**[34a,b] **the encroachment of Eagle Ford Shale into the tunnel horizon as a function of tunnel elevation and tilt,**[35a,b] and **tunnel cooling efficiency and cost as a function of heat rejection media.**[36a,b] Other generic activities are the construction of access roads, extension/densification of the survey grid, and supplemental geotechnical exploration. Documentation for these is included under the related CCU's. The tunnel ventilation and cooling systems constitute CCUs #917 and #918, respectively, which were ready for bid at the termination of the project.

5.5.2 North Arc

The North Arc of the Collider extends approximately 22 miles, from N15 on the West to N55 on the East. The tunnel from N15 to near N25 is in shale and requires installation of a precast liner immediately behind the tunnel boring machine (TBM). The remainder of the North Arc is in competent Austin Chalk, which does not require a liner. Design and construction of the tunnels and related conventional facilities were divided into two phases, basic and finish. The basic package involved excavation of the basic tunnel, including shafts, adits, niches and alcoves, and installation of liner and other supports; the finish package included the invert, lights, ventilation, electrical systems, surface buildings and associated infrastructure. More than 76,000 ft. of basic tunnel and 14 of a total of 17 shafts had been excavated on the North Arc at the time of termination. See

Figure 2, below. Excavation of the basic tunnel and shafts is covered by CCUs #A602 N15 Magnet Delivery Shaft (MDS) basic, #A610 N15-N20 basic, #A611 N20-N25 basic, #A650 N25-N40 basic, and #A670 N40-N55 basic. All of the North Arc basic tunnel was under contract: the basic tunnel contracts from N15 to N25 have been completed except for the niches, which were to be contracted separately under CCU #A622. The niche design for N15 to N40 was completed and the contract was under negotiation at the time of termination. Construction of all of the shafts for CCU #A650, N25-N40, and the portion of tunnel from N25 to N35 were completed. Except for the 3 shafts at N55, all of the shafts for CCU #A670, N40-N55, were completed as well as the portion of tunnel from N40 to approximately 5000 ft. beyond N45. The shafts at N55 were partially excavated. The finish phase of the North Arc was included in two packages, CCU #A620 N15-N25, and CCU #A690 N25-N55. The design packages for both of these CCUs were completed and put on the shelf. An additional CCU, #A711, was prepared to provide stabilization where the chalk tunnel is deteriorating due to the presence of the bentonite marker bed in the tunnel horizon. DOE decided against implementing this CCU in the interest of minimizing termination costs.

5.5.3 South Arc

The South Arc extends from S15 on the East to S55 on the West, a mirror image of the North Arc. The eight-mile portion from S40 to S55 is in Austin Chalk and is designed as an unlined tunnel, while the remaining 13 miles from S40 to S15 is in Taylor Marl and lined. All of the basic tunnels for the South Arc have been designed and are included in CCUs #A701 S10-S25, #A720 S25-S40, and #A740 S40-S55. The portions from S40-S55 and S25-S40 are under contract; 600 ft. of tunnel and excavation has been completed on 3 with partial excavation of 3 additional shafts. See Figure 3, below. The designs for the finish contracts for the South Arc, CCUs #A703, S25-S10 Finish, and #A730, S25-S55 Finish, are incomplete at a level short of Title II.

5.5.4 East Cluster

The East Cluster extends approximately 6.5 miles, from N55 on the North Arc to S15 on the South Arc and includes, on the North, the beam crossing points at IR8 and IR5 and, on the South, the East Utility Straight Section. The basic tunnel excavation for the utility straight section is the same as an arc tunnel and is included in CCU #701, S25-S10 basic, whose design is complete through issuance of the IFB. The IFB was later cancelled. The tunnel finish for the utility straight section is included in CCU #A703, S25-S10 finish, whose design is at the Title I level. The basic tunnel through the IR regions is contained in CCU #702, S10-N55 basic. This design was completed through Title II and archived. The tunnel finish for the IR region is contained in CCU #A704, S10-N55 finish, whose design was never initiated.

5.5.5 West Cluster

The West Cluster extends approximately 6.5 miles from S55 on the South Arc to N15 on the North Arc and includes, on the South, the beam crossing points at IR4 and IR1 and, on the North, the West Utility Straight Section. The West Utility Straight Section is the most complicated underground structure in the Project, involving crossing injection tunnels from the HEB in the vertical plane, intersecting tunnels for the North and South beam absorber channels in the horizontal plane, enlargements for the radio-frequency (RF) cavities and waveguides, and various specialized shafts and galleries. Although the South portion of the Cluster is in competent Austin Chalk, the complicated West Utility Region is in weak Eagle Ford Shale requiring careful excavation and substantial support. Excavation for the basic tunnel through the IR region, which had been contained in CCU #A760, was to be combined with CCU #A780, West Utility Straight Section basic, to take advantage of the longer, potentially more cost-effective tunnel drive from N15 through this region, if the contractor had the option of driving a uniform cross-section tunnel. The Design Requirements Document for the West Cluster was completed, but the design did not proceed beyond that stage.

5.6 Experimental Areas

5.6.1 Generic Activities

Since the collision halls were a major element in defining the construction program for the facility, it was necessary to scope the configuration and potential size of the halls even in the absence of a defined experimental program. It was also necessary to understand the potential limitations on the size of the halls imposed by geotechnical considerations. To explore the range of potential requirements for the collision halls **a generic study**[37] was conducted using model detectors from **the Berkeley summer study of 1987.**[38] The study made use of advanced CAD/E modeling techniques and project scheduling software to explore construction, maintenance and operation spatial and schedule requirements for construction, maintenance and operation of each of the models. In addition, a **Workshop on Detector Hall Limitations**[39] was held at the CDG including geotechnical experts, experienced detector builders, heavy rigging experts, and experienced experimental facilities engineers from US and foreign high energy physics laboratories. Following selection of the Texas site, which narrowed the range of potential depths and excavation procedures, a **Site-Specific Study**[40] was carried out for the facilities for four generic detector designs

5.6.2 West IR's

An Exploratory Shaft, CCU #E101, was constructed at IR1 as the first element of construction in order to examine the *in situ* properties of the Eagle Ford Shale. This shaft was completed and was instrumented for study of long term behavior of the shale.

Up until the termination of the project no decisions had been made about experiments for the small West experimental areas, IR4 and IR1, so they remain undefined except for their locations, which are determined by crossing points of the Collider lattice. These locations also serve as reference locations for Master Planning purposes, especially for the Safdie campus plan. The cooling ponds to supply heat rejection for these facilities are an integral element of the plan. An Exploratory Shaft, CCU #E101, was constructed at IR1 as the first element of construction in order to examine the properties of the Eagle Ford Shale *in situ*. This was completed and was instrumented for study of long term behavior.

5.6.3 East IR's

Initially, the two major detectors were sited on the West Complex to facilitate communication among experimenters, accelerator staff, and support personnel by focusing the population into the same geographic region. When the geotechnical exploration program indicated that the base of the collision halls would lie in the Eagle Ford Shale, **a detailed, time-phased design study**[41] was carried out for the assembly halls, including considerations of the required stability of the supporting foundations during assembly and operation. In the light of these studies and the properties of the Eagle Ford Shale a decision was taken to move the large detectors to the East Complex, to IR5 and IR8. At these locations the detectors would be supported on the Austin Chalk underlying the Taylor Marl which would form the walls of the enclosures. The SDC detector was sited at IR8, on the North, while the GEM detector was sited at IR5 on the South construction of the underground halls was divided into basic and finish packages. The basic packages are CCU #E305, IR8 Underground Shell, and CCU #E405, IR5 Underground Shell; the finish packages are CCU #E306, IR8 Underground Finish, and CCU #E406, IR5 Underground Finish. The shells were under contract and some site grading had been accomplished at termination. The Title I designs for both finish packages are complete. These experimental areas required extensive Infrastructure preparation, described below, as well as extensive site preparation and wetlands mitigation. The site preparation for the East IRs, CCU #S445, was completed. However, the extensive wetlands mitigation required by these activities was to be provided in CCU #S499, which was not put under contract before termination of the project.

IR-8

Assembly of the SDC detector, as determined by extensive modeling exercises,[38] would take place mostly underground in the collision hall, so extensive assembly space was not required on the surface. A surface Assembly Building, CCU #308, was under construction with the massive floor slab poured and the supporting steel partially erected at the time of termination. A number of other auxiliary buildings were included in CCUs #E312, #E313, #E315, and #E319. A final DRD is in hand for #E313, with only preliminary DRDs for the rest.

IR-5

The GEM detector anticipated major assemblies on the surface, including fabrication of the very large air core superconducting magnet. The design packages for two very large assembly buildings, CCU #E408 North and South Assembly Buildings, had been prepared and were shelved awaiting funding. A number of auxiliary buildings were combined into the underground finish package, CCU #E406. A preliminary DRD was in hand for CCU #E419 IR5 Gas Mixing Building.

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West Complex, The Injector

31. PB/MK Doc. #CPB-000544, Linac, LEB, and MEB Elevation Study, The PB/MK Team, May 1991.

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34b. Report of Independent Review Panel, Independent Review of PB/MK Tunnel Diameter. Study and Cost Estimates, April 13, 1991.

35a. SSCL Internal Report, Ring Raise Alternatives Study, P. P. Nelson, 12 September 1990.

35b. PB/MK Report CPB-00949, Collider Tunnel Elevation Study Report, The PB/MK Team, October 15, 1991.

36a. PB/MK Doc. No. CPB-100017, Collider Tunnel Arc Section HVAC Study, The PB/MK Team, 21 February 1992.

36b. PB/MK Doc. No. CPB-100045, Collider Tunnel Arc Section HVAC Study, Option 9M, The PB/MK Team, 27 February 1992.

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38. Donaldson, R., Gilchriese, M.G.D, Experiments, Detectors, and Experimental Areas for the Supercollider, Berkeley, CA, 1987, World Scientific.

39. SSC-SR-1028, Report of the Workshop on Collision Hall Limitations, URA/CDG, 1987.

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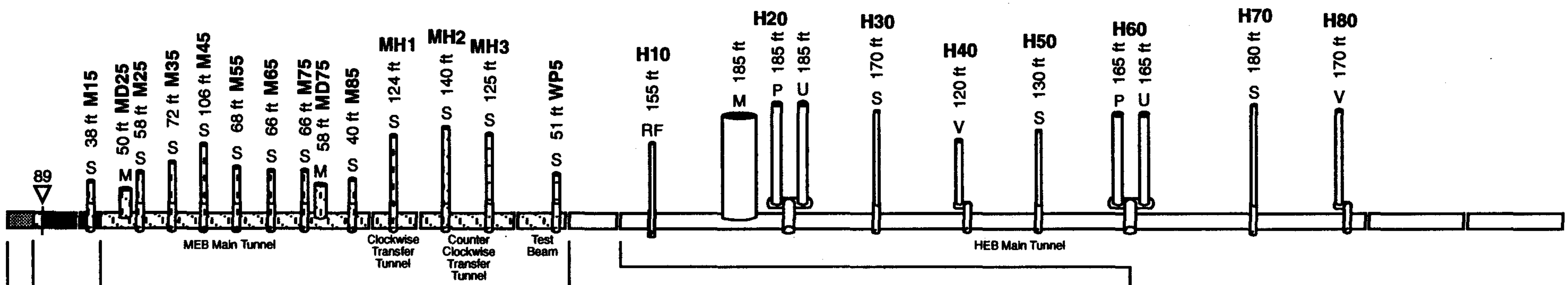
SSC Basic Injector Progress—Tunnel & Shafts

October 5, 1993



LEB CCU A300
Cajun Contractors
Value: 9.1M; NTP 12/92; FCD 9/94
Total 2,910 ft; Main Tunnel 1,870 ft; Other/ MEB Tunnel 1,040 ft 2581 ft (89%) Complete
Shafts: none
AC - Cut and Cover
Comments: Partial work suspension issued on 9/3/93.

MEB CCU A400
H.B. Zachry/Monterey
Value: 46.7M; NTP 6/93; FCD 3/95
Total 20,295 ft; Main Tunnel 12,414 ft; Other / Test Beam Tunnel 7,201 ft; Adits 620 ft; Niches 60 ft 0 ft (0%) Complete
Shafts: 2M, 8S, 3 Transfer Line, 1 Test Beam; Total 1682 ft 0 ft (0%) Complete
AC - Unlined & Cut and Cover Combination
Comments: Niches Included. "Limited Stop Work Order" issued on 9 Aug 93.
Completed Secant Piles Placed for Shaft M35, M85 & MH1, laid out Secant Piles for M25 & MD25, & started Cut & Cover Excav.

TEST BEAM CCU A420
Value: TBD; NTP 10/94; FCD 3/96
Total 4,387 ft; Beam Pipes 2,980 ft; Other 1,407 ft 0 ft (0%) Complete
Shafts: none
AC - Cut and Cover Combination
Comments: Design Complete 6/93.

HEB CCU A500
Value: TBD; NTP 11/94; FCD 6/96
Total 40,433 ft; Main Tunnel 33,630 ft; Other Tunnel 5,649 ft; Adits 494 ft; Niches 660 ft 0 ft (0%) Complete
Shafts: 1M, 2P, 1 RF, 3S, 2U, 2V; Total 1810 ft 0 ft (0%) Complete
AC - Unlined
Comments: Under Design. IFB 8/94.

LINAC CCU A200
Sedalco, Inc.
Value: 5.9M; NTP 5/92; FCD 8/93
Total 1,068 ft; Main Tunnel 792 ft 1068 ft (100%) Complete
Shafts: none
AC - Cut and Cover

SHAFTS	
M	Magnet Delivery
P	Personnel
RF	Radio Frequency
S	Service
U	Utility
V	Ventilation

LEGEND
■ Construction Complete
▨ Under Contract
▽ Tunnel Drive Percent Complete

ROCK FORMATIONS	
AC	Austin Chalk
EFS	Eagle Ford Shale
TM	Taylor Marl

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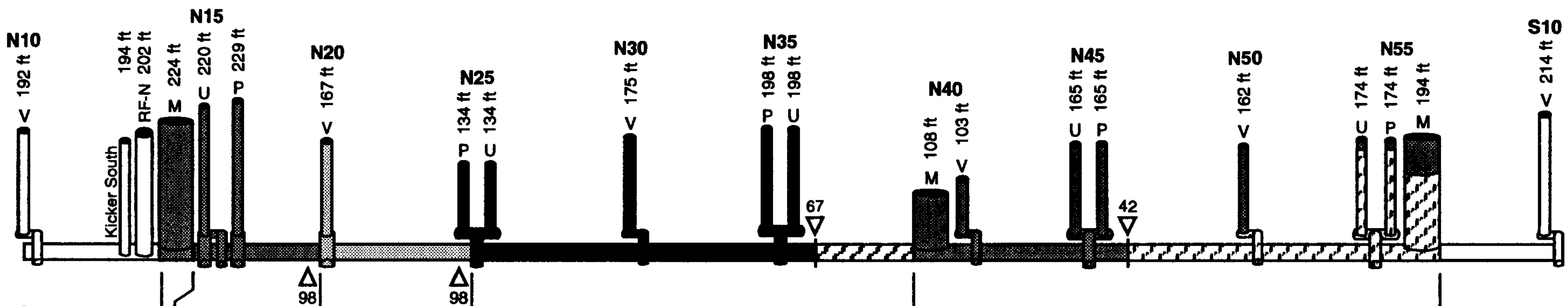
Figure 1

SSC Basic Collider Tunnel Progress—North Arc

October 5, 1993



	CCU A780	CCU A610	CCU A611	CCU A650	CCU A670	CCU A702
Contractor		Obayashi/ Dillingham	Traylor Bros/ Frontier Kemper	Gilbert/Shea	Gilbert/Shea	
Value		Value: $ 18.0M; NTP 2/92; FCD 9/93	Value: $ 17.3M; NTP 6/92; FCD 9/93	Value: $ 24.0M; NTP 7/92; FCD 9/94	Value: $ 27.1M; NTP 9/92; FCD 9/94	
Length	Total 16,173 ft; Main Tunnel 15,752 ft; Adits 129 ft; Niches 292 ft	Total 15,077 ft; Main Tunnel 14,486 ft; Adits 256 ft	Total 13,178 ft; Main Tunnel 12,710 ft; Adits 166 ft	Total 45,136 ft; Main Tunnel 43,673 ft; Adits 456 ft	Total 46,412 ft; Main Tunnel 44,691 ft; Adits 713 ft; Niches 1008 ft	Total 15,143 ft; Main Tunnel 14,600 ft; Adits 129 ft; Niches 414 ft
Progress	0 ft (0%) Complete	14,742 ft (98%) Complete	12,876 ft (98%) Complete	30,022 ft (67%) Complete	19,445 ft (42%) Complete	0 ft (0%) Comp
Shafts	Shafts: 1K, 1RF, 1V; 588 ft; 0% Comp	Shafts: 1V, 1P; 449 ft (100%) Comp	Shafts: 1V; 167 ft; 167 ft (100%) Comp	Shafts: 2P, 2U, 2V (includes 1V at S30); Total 1033 ft 1033 ft (100%) Complete	Shafts: 2M, 2P, 2U, 2V; Total 1245 ft 767 ft (62%) Complete	Shafts: 1V; Total 214 ft; 0% Comp
Rock	EFS - Lined	EFS - Lined	EFS - Lined to AC	AC - Unlined	AC - Unlined	TM - Lined
Comments:	Under Design. IFB - 12/93.	Niches in A622; Total 336 ft. Holed Thru 9/2/93.	Niches in A622; Total 302 ft. Holed Thru 8/12/93.	Niches in A622; Total 1008 ft. Completed top heading excavation at N35 chamber, adit and alcove. "Limited Stop Work Order" issued on 9 Aug 93.	Niches Included—Work was started on 6 Niches. "Limited Stop Work Order" issued on 9 Aug 93.	Under Design. IFB - 4/94.

Impact of delay to the Niche production (CCU A622) award is not yet shown in the Forecast Completion Dates & Values

CCU A602

TL James
Value: $ 3.8M
Shaft: 1M; 224 ft
224 ft (100%) Complete

Note: Impact of the SSCL directed Limited Stop Work Orders and other funding constraints are not yet reflected in the Forecast Completion Dates and Values

SHAFTS

- M Magnet Delivery
- P Personnel
- U Utility
- V Ventilation

LEGEND

- Construction Complete
- Under Contract
- ▽ Tunnel Drive Percent Complete

ROCK FORMATIONS

- AC Austin Chalk
- EFS Eagle Ford Shale
- TM Taylor Marl

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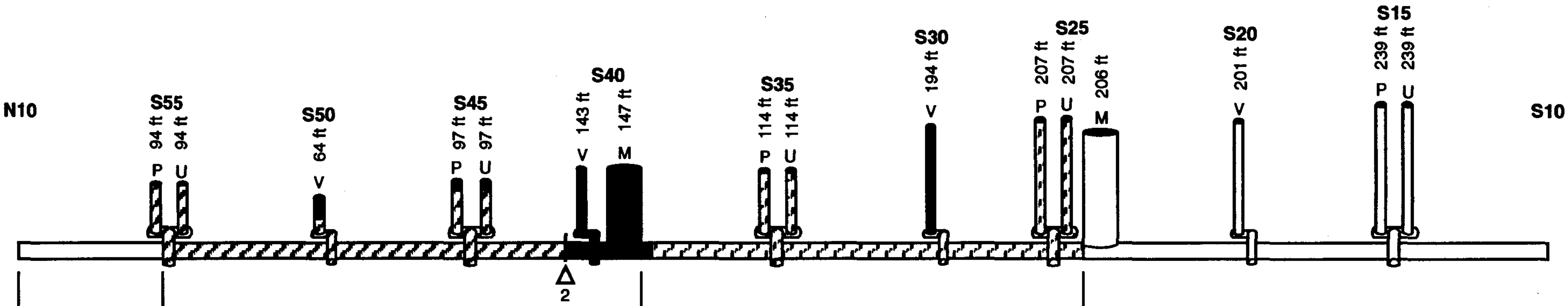
Figure 2

SSC Basic Collider Tunnel Progress—South Arc

October 5, 1993



CCU A760	CCU A740	CCU A720	CCU A701
	Traylor Bros/Frontier Kemper	SSC Tunnelers	
	Value: $ 24.2M; NTP 12/92; FCD 11/94	Value: $ 32.4M; NTP 6/93; FCD 4/95	
Total 18,133 ft; Main Tunnel 17,719 ft;	Total 43,134 ft; Main Tunnel 41,576 ft; Adits 584 ft; Niches 974 ft	Total 43,535 ft; Main Tunnel 42,224 ft; Adits 327 ft; Niches 984 ft	Total 42,659 ft; Main Tunnel 41,393 ft; Adits 292 ft; Niches 974 ft
Adits 0 ft	741 ft (2%) Complete	0 ft (0%) Complete	0 ft (0%) Complete
0 ft (0%) Complete			
Shafts: none	Shafts: 1M, 2P, 2U, 2V; Total 736 ft 340 ft (46%) Complete	Shafts: 2P, 2U; Total 642 ft 0 ft (0%) Complete	Shafts: 1M, 1P, 1U, 1V; Total 885 ft 0 ft (0%) Complete
AC - Unlined	AC - Unlined	TM - Lined	TM - Lined
Comments: Design Start 10/93. IFB - 8/94.	Comments: Niches Included. S40 V Shaft Adit Bench and Starter Tunnel Completed. "Limited Stop Work Order" issued on 9 Aug 93.	Comments: Niches Included. Site Work Continues at S35. "Limited Stop Work Order" issued on 9 Aug 93.	Comments: Niches Included. Design Complete; Receipt of Bids Suspended Due to Funding Uncertainty.

SHAFTS

- M Magnet Delivery
- P Personnel
- U Utility
- V Ventilation

LEGEND

- ■ Construction Complete
- ▨ Under Contract
- ▽ Tunnel Drive Percent Complete

ROCK FORMATIONS

- AC Austin Chalk
- EFS Eagle Ford Shale
- TM Taylor Marl

THE PB/MK TEAM 10/06/93 lms

Figure 3