Civil Systems Aspects of the SSC *

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The Reference Designs Study (RDS) of the Superconducting Super Collider (SSC) came to a conclusion in May, 1984. During the course of the study, the design team had shown the feasibility of designing and constructing an SSC. An important element in the overall project concerned the physical plant for the new research laboratory. About 1/3 of the approximately $3 billion cost estimate was devoted to the construction of the tunnels, buildings and conventional facilities for the project. The SSC is planned to be constructed in less than six years following the development phase, currently estimated to end in October, 1987.

This paper will briefly review the civil systems that were developed during the course of the RDS. The technical features of the SSC led to a consideration of the siting needs and criteria. The criteria that have been suggested to DOE will be briefly described. Finally, the study and design work to be undertaken in the next couple years is outlined including a brief exploration of issues and problems.

The RDS from the standpoint of the conventional facilities is divided into five parts: site, campus area, injector, collider ring, and the experimental areas. In order to initiate the RDS work, a generic site was invented. This provided and essential mechanism for proceeding to outline the design objectives, and for entering into technical discussions with the architectural/engineering firm, Parsons, Brinckerhoff, Quade, and Douglas. Lead by the project manager, Ahmet Gursoy, the A/E design team outlined a composite site, called the "median site". It contained features representative of the sites suggested in the first edition of the Site Atlas (ref 1). This approach allowed for a consideration of the real problems that may be encountered with geological conditions on sites large enough for the SSC. As will be seen, it also facilitated a cost estimate that was based upon a variety of approaches to tunnel construction. The vast scale of the site is illustrated in Fig. 1 where the site covers several counties. An outline of the collider ring as it disappears in the distance provides a feeling of scale for the project.

In the foreground of Fig. 1 can be seen the Campus of the SSC. In the RDS it was convenient to gather together in this area a number of the technical facilities, as well as some of the support services for the laboratory. The focus of the Campus is the Central Laboratory Building containing office and laboratory space for administrative and technical personnel. It would also include control rooms, an auditorium, computing facilities, a main cafeteria, and a series of conference rooms, to name some of its prominent features. Industrial and service buildings complete the Campus layout, as can be seen in Fig. 2.

Adjacent to the Campus is the injector complex consisting of a cascade of accelerators. In the model of the RDS, there are three separate accelerators: a linac, a low energy booster (LEB), and a high energy booster (HEB). The arrangement is shown in Fig. 3 along with the large collider ring. From the linac, 1 GeV protons are injected into the LEB where they are accelerated to 70 GeV. From there they go into the HEB for the final acceleration to 1 TeV. The HEB has to do double duty, since beams must be provided to both rings of magnets in the Collider.

At the Collider the two beams of protons are injected into separate rings of superconducting magnets. While moving in a counter-rotating manner, they are each accelerated to 20 TeV. Fig. 4 is an illustration from the RDS of a possible tunnel cross-section showing people standing adjacent to a cryogenic vessel that contains both magnets. At six locations around the circumference of the SSC, the proton beams are brought into collision at interaction regions. The two beams are directed to collide almost head-on in the heart of particle detectors, which surround the beams at these points. The detectors are contained in under ground experimental halls that are accessible through shielded passageways to the data collection facilities located above ground. Fig. 5 is a cut-away view of how such an experimental facility might look.

Using the RDS as described above, it was possible in the fall of 1984 to initiate work on evaluating the site requirements for the SSC. The first step consisted of re-examining the RDS from a different perspective. The task was to "understand" the design elements for the purpose of developing site criteria. Immediately, the problem of what collider ring circumference to use was encountered. The ring circumference is determined by the strength of the magnetic field, and by January, the magnet group had reduced the magnetic fields being considered from three to two, namely 3 and 6 Tesla. These fields imply circumferences of approximately 100 or 60 miles, respectively. The parameters and systems corresponding to these two configurations are shown in Table I. It should be pointed out that these are just representative of how the SSC might be designed, having been based upon the RDS.

It was necessary to reduce the technical requirements for the SSC into manageable statements. The physical, electrical, civil, and mechanical needs were studied, and determined. This resulted in tables of conventional construction requirements based upon the two fields, and circumferences, as described earlier. The separate information has been combined in Table II for convenient comparisons. One notices how little the requirements differ for the two rings of such otherwise different sizes. This is due in part to several surprising

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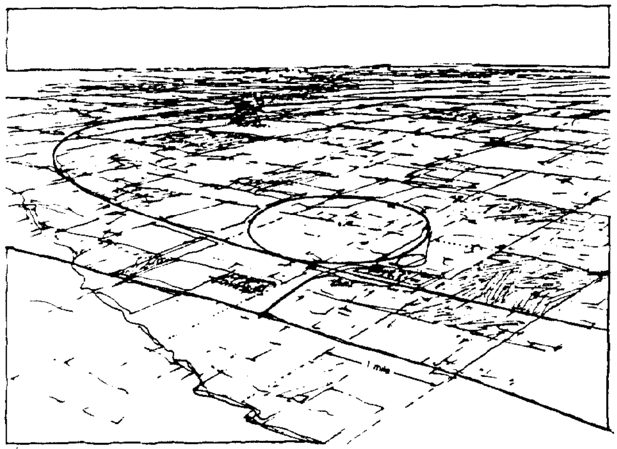

Figure 1

Aerial view of median site illustrating the scale (see 1-mile marking) of the SSC facility. The collider ring perimeter is only noticeable when the tunnel approaches the surface. The injector and campus area are visible in the center. Access roads to nearby population centers are clearly visible.

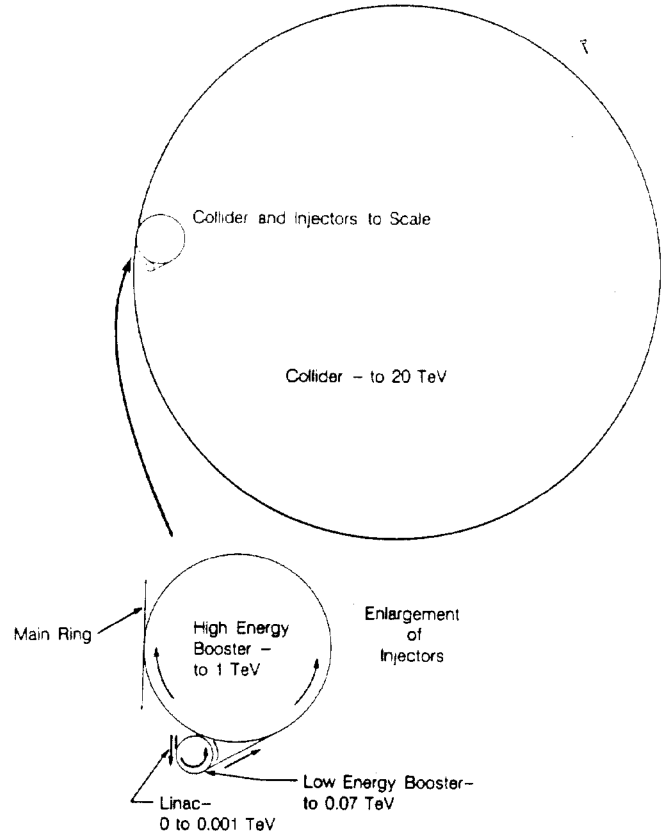

Figure 3

Layout of the SSC indicating the injector complex and the main ring where protons are accelerated to 20 TeV in counter-rotating bunches that collide at six points around the circumference.

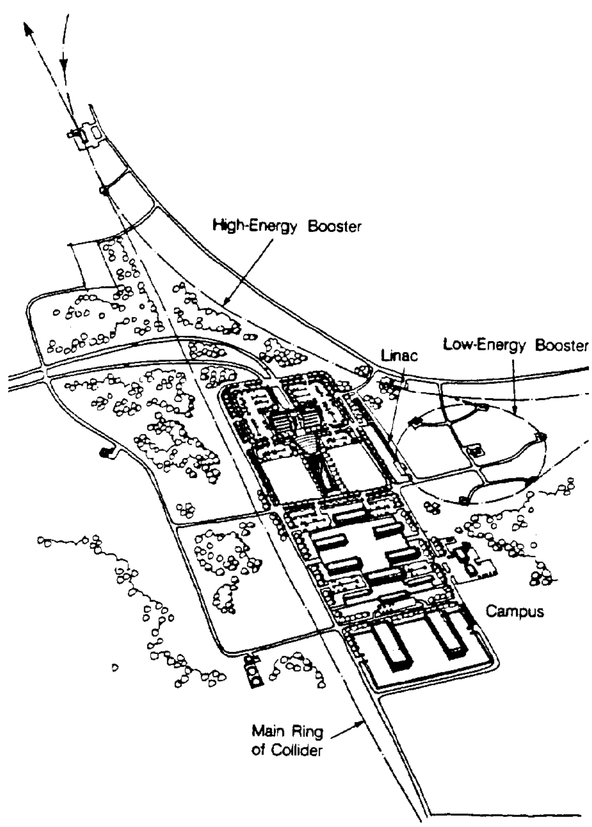

Figure 2

Aerial view of the campus revealing its compact arrangement and its proximity to the injector facility.

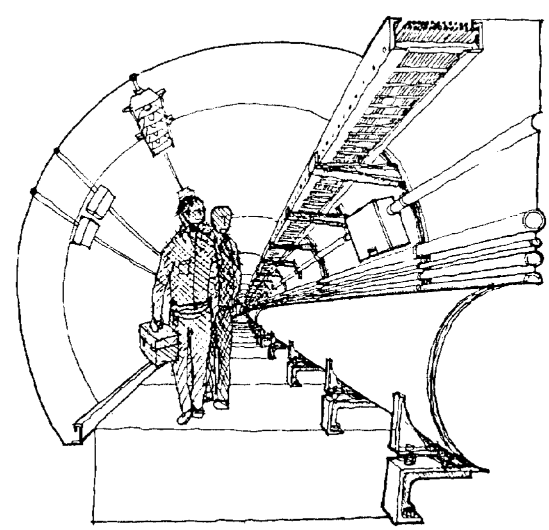

Figure 4

SSC tunnel with a 2-in-1 magnet cryostat.

Table I

The major features of the SSC RDS are as follows:

Injector

Linac	
Energy	1 GeV
Length	750 ft
Low-Energy Booster	
Energy	70 GeV
Circumference	0.7 mi
Conventional Magnet Peak Field	2 T
No. of Service Buildings	6
High-Energy Booster	
Energy	1 TeV
Circumference	4 mi
Superconducting Magnet Peak Field	5 T
No. of Power-Supply Service Buildings	6
No. of Helium Refrigerators	1
No. of RF System Service Buildings	1

Collider

Peak Bending Field	6 T	3 T
Beam Energy	20 TeV	20 TeV
Accelerator Circumference	60 mi	100 mi
No. of Counter Rotating Beams	2	2
No. of Power-Supply Service Buildings	12	24
No. of Helium Refrigerator Systems	12	24
No. of Nitrogen Liquefier Systems	2	4
No. of Injection Conjunctions	2	2
No. of RF Accelerating Systems	2	2
No. of Abort Systems	2	2

Experimental

No. of Interaction Regions (equally spaced, or clustered in two or three areas.)	6	6

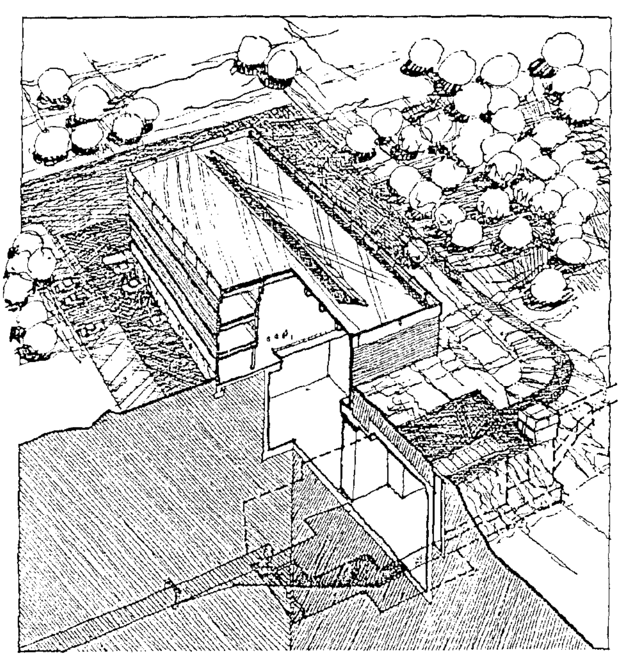

Figure 5

Cut-away view of an experimental area showing collision and assembly areas and counting rooms.

results. For example, the land needs of the larger ring are nearly the same as for the smaller ring, since the width of space reserved for shielding purposes is considerably reduced in the former case compared to the width of land needed for the smaller ring. Furthermore, the larger ring, using weaker magnetic fields, needs less helium coolant per unit distance leading to electrical power requirements almost equal to that of the smaller ring. These fortuitous circumstances facilitated the generation of the siting criteria.

The development of site criteria was initiated after a thorough reading and examination of the work done prior to the founding of NAL, now known as Fermilab. In the mid 60's, a design team at LBL prepared a reference design for a 200 GeV accelerator. It included site criteria developed in conjunction with DUSAF, the A/E firm that assisted LBL and later NAL. This material serves as a model since it lead to the successful establishment of the Fermi National Accelerator Laboratory nearly twenty years ago.

The process that was followed consisted of and extended consideration of the information that would be needed to evaluate a proposed site. Following discussions within the CDG and with the A/E personnel, the following topics emerged:

A. Setting
B. Environment
C. Geology and Tunneling
D. Community Resources
E. Utilities
F. Man-made Disturbances
G. Climate
H. Cost and Schedule

The criteria topics were selected with care, and arranged according to the priority given by the CDG. Some topics are quantitative including magnitudes, while others are of a "softer" nature leading to qualitative statements. A summary of the recommended criteria are displayed in Table III. The full criteria statements are contained in the Siting Parameters Document. The material in the Document is organized as follows:

I. SSC Project Description
II. Features of the SSC
III. SSC Siting Criteria
IV. Information Needed about Proposed Sites

Starting from a general description of the high energy facility, the case is made for the criteria leading up to a list of information that DOE is encouraged to seek from prospective site proposers. The Document was submitted to DOE on April 15, and it is hoped that it can be released soon.

Attention within the Construction Division of the CDG now turns to the considerable work that lies ahead. With the assistance of an A/E firm, it is intended that the design work done for the RDS be extended, and augmented. For the purpose of a proposal, minor design work will be attempted with the attention concentrated upon developing an overall project schedule integrated with the needs of the technical systems. Following that, a masterplan will be developed to guide the subsequent work. In this phase there will be an examination of the space and facility requirements of the accelerator and research groups, including university users. The next step will be a conceptual design where attention will be paid to a number of technical problems. The tunnel requirements will be studied in much more detail, including an examination of a number of safety considerations. The technical systems of the accelerator/collider will be further defined, and optimized solutions sought. Since the site will not have been chosen, generic studies will be undertaken in the area of environmental analysis, site infrastructure, utility systems distribution, etc. As before, attention will be paid to achieving an integrated schedule that will lead to efficient construction in a cost effective manner. This will be demonstrated by a detailed cost estimate, including the needs for annual funding.

A number of new topics have emerged in the past year. In addition to the accelerator systems needs, attention must be given to the experimental purposes of the SSC. The matter of test beams must be considered, and clustered experimental areas addressed. These considerations must be prepared so that final design decisions can be made rapidly when a site is selected. The shape of individual experimental areas should be considered in light of future experiments. These studies will lead quite naturally into the evaluation of the experimental equipment needs, and the requirements for data handling and analysis. This topic will address earlier concerns, since this same information is needed in order to specify the configuration of the laboratory facilities, and the placement of buildings.

As in the past, there are numerous, interesting topics to be approached in the years ahead. I'd like to acknowledge the sustained help of Tim Toohig and Vish More, my colleagues at the CDG, in pursuing the design tasks. All of us hope that the accelerator and high energy physics community will be sufficiently intrigued with these challenging topics to help in their resolution.

Reference

[1] R. Slansky, Site Atlas for the Superconducting Super Collider (1983)

Table II

TABLE OF FACILITY PARAMETERS FOR THE SSC

This table summarizes the basic physical parameters of the SSC for the 6-T and 3-T peak bending field configurations. The requirements are derived from the RDS.

1. General			
Magnetic Field		6 T	3 T
Circumference of the Collider Ring		60 mi	100 mi
2. Area			
Campus		500	500 acres
Service Areas		400	800
Site Infrastructure		400	700
Injector		1,500	1,500
Collider		5,000	4,300
Experimental Areas		500	500
Total		8,300	8,300 acres
3. Above-Ground Buildings (gross area)			
Campus Buildings			
Central Laboratory Building	365,000 sq ft		
6 Assembly Buildings	168,000		
3 Shops Buildings	30,000		
2 Warehouses	80,000		
Other Buildings	24,000		
Subtotals		667,000	667,000 sq ft
Injector Service Buildings		56,000	56,000
Collider Service Buildings		112,000	169,000
Experimental Area Buildings		225,000	255,000
Total		1,060,000	1,117,000 sq ft
4. Below-Ground Enclosures			
Injector		28,000	28,000 ln ft
Collider (excluding experimental areas)		317,800	525,800
Experimental Areas		2,200	2,200
Total		348,000	556,000 ln ft
5. Utilities (average except as noted)			
Total Electric Power		106	117 MW
Total Electric Power (peak)		160	196 MW
Heat Rejection Load		306	303 MBtu/hr
Cooling-Tower Make-Up Water		780	775 gal/min
Potable Water		310	310 gal/min
Pond Make-Up Water		130	130 gal/min
Irrigation Water		300	300 gal/min
Fire-Protection Water Storage		2.8	2.8 Mgal
Sewage-Plant Effluent Discharge		91,000	91,000 gal/day
Solid-Waste Disposal		30,000	30,000 cu yd/yr
Heating Rate (coldest month)		55,000	55,000 MBtu/hr
Telecommunications		200	200 trunks

Table III

CRITERIA STATEMENTS

SETTING	space for ring circumference of 60-100 miles looking for a site for a planar machine flat (level) or with a tilt < 1° need up to 11,000 acres
ENVIRONMENT	SSC will comply with NEPA need baseline data
GEOLOGY AND TUNNELING	long, uniform material extensive characterization avoidance of active faults good soil stability avoid unconsolidated solids with ground water awareness of seismic activity
COMMUNITY	staff needs: housing, education, cultural reasonable commuting times major airport, all-weather roads adequate industrial/construction resources
UTILITIES	≤ 2000 gal/min of water ≤ 250 MV, separate feeds, outages < 2/yr
MAN-MADE DISTURBANCES	excessive noise--avoidance vibration ~3 Hz is bad
CLIMATE	desireable average temperature 35° - 80°F desireable average relative humidity 25%-70%
COST AND SCHEDULE	land costs, utility rates what's being offered