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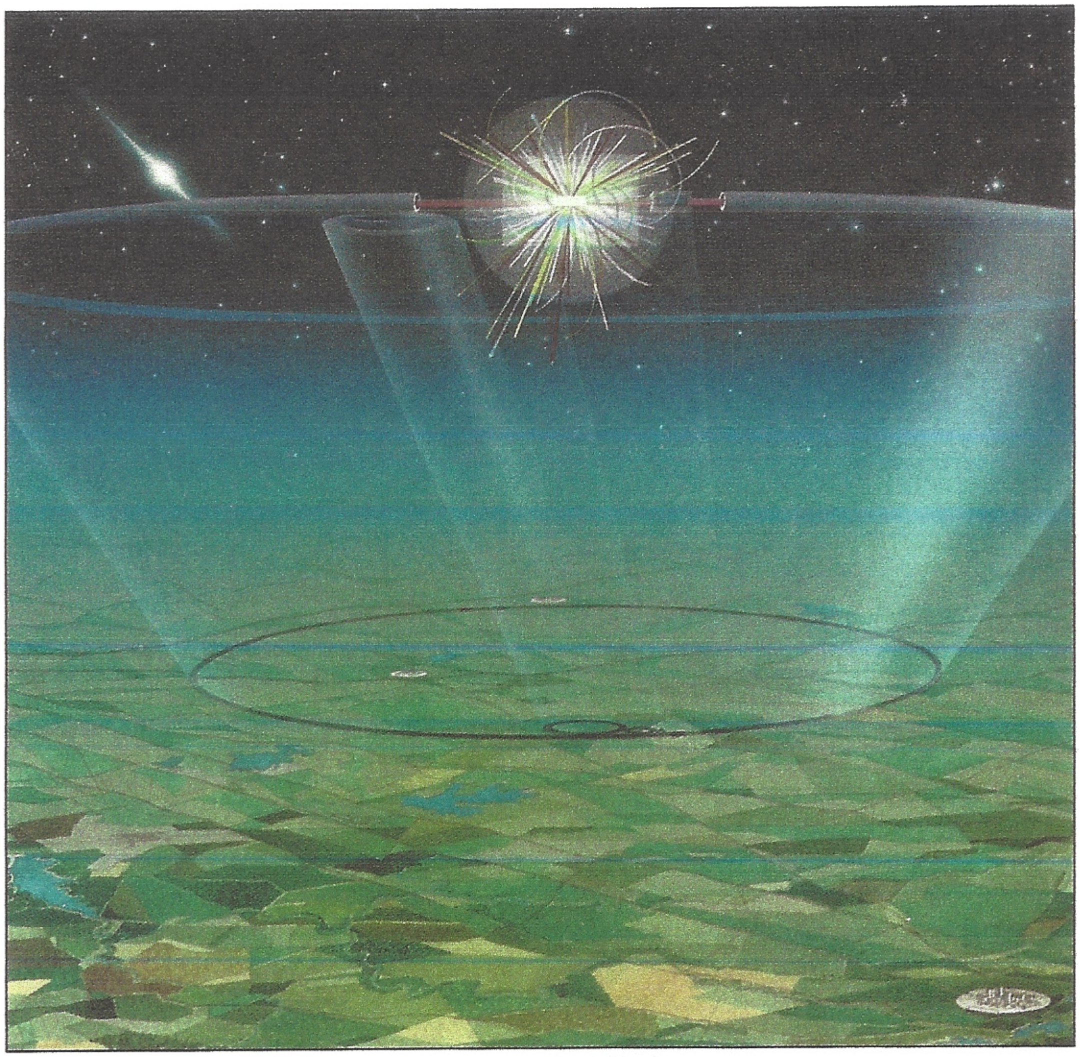

SHOWCASE PROJECT
THE SUPER CONDUCTING SUPERCOLLIDER

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Planning and Management of the Superconducting Super Collider

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INTRODUCTION

Sponsored by the U.S. Department of Energy and the state of Texas, the Superconducting Super Collider (SSC) Project is one of the largest, most visible scientific projects in America. With an estimated cost of approximately eight billion dollars and a nine-to-ten year construction schedule, the project will employ thousands of people and dozens of companies and organizations. The SSC will be one of the largest, most powerful scientific instruments ever built. At several times the energy of any existing particle accelerator, the SSC will allow high energy physicists from around the world the ability to explore and perhaps answer some of the most fundamental questions of mankind. What is matter composed of? What are the smallest particles? How did the universe begin?

While research, feasibility studies and conceptual design activities related to the SSC have proceeded since 1983, the decision to begin construction was only made by the U.S. Government in late 1988. The contract to design and build the SSC and the SSC Laboratory was awarded in January 1989 to Universities Research Association (URA), a consortium of American universities. In January 1989, URA with two partnering companies, EG&G Inc. and the Sverdrup Corporation, began transitioning to the site in Texas. Those three firms have since been joined by Lockheed, Inc., systems engineering contractor, and Parsons Brinkerhoff/ Morrison Knudsen, the AE/CM contractor, and are planning and implementing project management systems, and proceeding with planning, designing and constructing the SSC.

The challenges are immense. Some required technologies are yet to be developed. Funding is limited. But most of all, hundreds of different organizations, companies and participants from different environments, backgrounds and perspectives, must be integrated into a project team. Project management systems, methods and tools must be implemented. And planning of the project must proceed.

Admiral James D. Watkins
U. S. Secretary of Energy

The Superconducting Super Collider is one of the largest scientific projects ever undertaken. It is a Presidential initiative and one of the highest priorities of this Administration. The magnitude, complexity and cost of the SSC represent a substantial undertaking and a management challenge for the Department of Energy requiring a streamlined approach and a clear process for review, control and decision making. The Department of Energy is committed to managing the project effectively to ensure that its scientific objectives will be achieved and that the SSC will be completed within cost and on schedule.

THE SUPERCONDUCTING SUPER COLLIDER

The Superconducting Super Collider will be the world's largest particle accelerator; in effect, a microscope of unparalleled power. It will accelerate two tiny counter-rotating beams of protons to an energy of twenty trillion electron volts each, and bring them into head-on collision in large underground experimental halls. Computer controlled electronic detectors will catch the evanescent particles created in the collisions.

THE HISTORY

Although the scientific motivation for studying collisions of the fundamental constituents of matter at high energies emerged more than a decade ago, developing a technically reliable and cost efficient design has required the skill, hard work, and imagination of many people in the intervening years. The result of this dedicated effort is the SSC.

The International Committee on Future Accelerators sponsored workshops in 1978 at Fermilab and in 1979 at CERN to explore possibilities for very-high-energy accelerators. A number of approaches were considered, including multi-TeV hadron-hadron colliders. Encouraged by the successful domestication of superconducting accelerator magnet technology for the Fermilab Tevatron, the idea of a Superconducting Super Collider was conceived at the 1982 Summer Study on Elementary Particle Physics and Future Facilities organized by the Division of Particles and Fields of the American Physical Society. Studies of various accelerator and detector issues at Cornell University and at Lawrence Berkeley Laboratory the following year confirmed the viability of the SSC concept.

In 1984, after a Reference Designs Study (sponsored by the United States Department of Energy and the directors of the high-energy physics laboratories in the United States) had set forth three technically feasible approaches to achieving 10^8 collisions per second in a collider with 20 TeV (trillion electron volts) proton beams, SSC research and development was formally begun. The Department of Energy contracted with

**Joe Cipriano, Project Director
U. S. Department of Energy**

Being the project director for the SSC has got to be the best job in the world most days. Not only are you working to build the largest research facility in the world with truly awesome research potential, but you get to do it with the brightest and best of the world's science and engineering community. The program management challenges are extraordinary.

Resources for the project come from the international community, the State of Texas, and the federal government. How much or even what and when, is a continual negotiation. In addition, there is the delightful frustration of working with such talented technical staff and they can always have a better idea tomorrow. It is very difficult to decide when to freeze pieces of the design so construction schedules can be maintained, while at the same time ensuring that the creativity that has been so carefully assembled to craft the design is fully exploited. The ease with which extraordinarily difficult technical issues are resolved by these people almost makes you forget to be impressed.

My job is simply to take whatever actions are necessary to ensure that a fully capable SSC is completed on time and on budget. The hard part is to figure out what these are every day. I am often asked how you control costs with a non-profit contractor who essentially has no competition. The answer is you can't unless that contractor's staff is the future user and every dollar wasted detracts from the ultimate use and every day's delay translates into a postponement in the start of experiments. Such is the case with the SSC.

the Universities Research Association, Inc. (a consortium of leading research universities in the United States and Canada that had been organized to build and operate Fermi National Accelerator Laboratory) to oversee the conceptual design of the SSC for a site to be chosen later. University Research Association (URA) established the SSC Central Design Group and appointed Professor Maury Tigner of Cornell University as director. He assembled a group of experts from universities and laboratories around the world, and, as guests of the Lawrence Berkeley Laboratory, the team began their task, with the assistance of Brookhaven National Laboratory, Fermi National Accelerator Laboratory (Fermilab), Lawrence Berkeley Laboratory, Texas Accelerator Center and American industry.

In March 1986, a Conceptual Design Report was completed. That summer the Department of Energy and independent experts validated the design's feasibility. In January 1987 President Reagan declared the SSC an important national goal.

The Department of Energy initiated the SSC site selection process in April 1987 and asked the National Academies of Sciences and Engineering to review the proposals to identify several they considered best qualified. In December 1987, the DOE began a detailed evaluation of the recommended sites. As a result of this evaluation process, the Ellis County, Texas, site (near Dallas/Fort Worth), was designated the preferred site for construction of the SSC.

THE SSC LABORATORY

In January 1989, the Department of Energy announced the selection of the URA with two industrial partners, EG&G Intertech and Sverdrup Corporation, to manage the design, construction, and research program of the SSC Laboratory. URA then appointed Professor Roy Schwitters of Harvard University as director of the SSC Laboratory.

Office space was rented in Dallas, and work began near the site in March 1989. The immediate goals were to provide a conceptual design of the SSC precisely suited to the features of the Texas site, to begin defining the research program, and to rapidly build up the SSC Laboratory staff in order to accomplish detailed design and construction planning of the SSC components. In September 1989, the United States Congress appropriated $225 million for beginning construction of the SSC.

Upon award of the contract to design and build the SSC, employees of URA and EG&G began the transition to the designated site in Texas. Officially, the project had begun. Offices were located, hiring began and the project planning process was initiated in earnest.

Organizing the project team was a challenge from the beginning. Participants were joining the project office from universities, national laboratories, different companies and government, from locations around the United States. While a good deal of preliminary design and planning had occurred prior to 1989, everything now had to be tailored to the site in Texas. An Environmental Impact Statement had to be prepared, the SSC Footprint finalized, geological analysis completed and various local organizations had to be involved. Most importantly, the conceptual design of the collider, injectors, magnets and other SSC systems and components had to be updated. Associated with an updated conceptual design would be a new cost estimate and a schedule.

From January through October 1989, the primary emphasis was on staffing and organizing the SSC Project Team and on implementing management systems. While those processes were continuing, in late summer of 1989, the focus shifted to the revised conceptual design and associated cost estimate. By November 1989, it was apparent that the original $5.9 billion cost estimate would be inadequate to build a 20 TeV SSC, detectors and laboratory. After much design activity, analysis and hard work, a site-specific conceptual design was presented to DOE in January 1990 with a corresponding cost estimate of approximately $8 billion.

From the beginning of the project an SSC "Laboratory" orientation was established in Texas. The emphasis is on high energy physics research. High

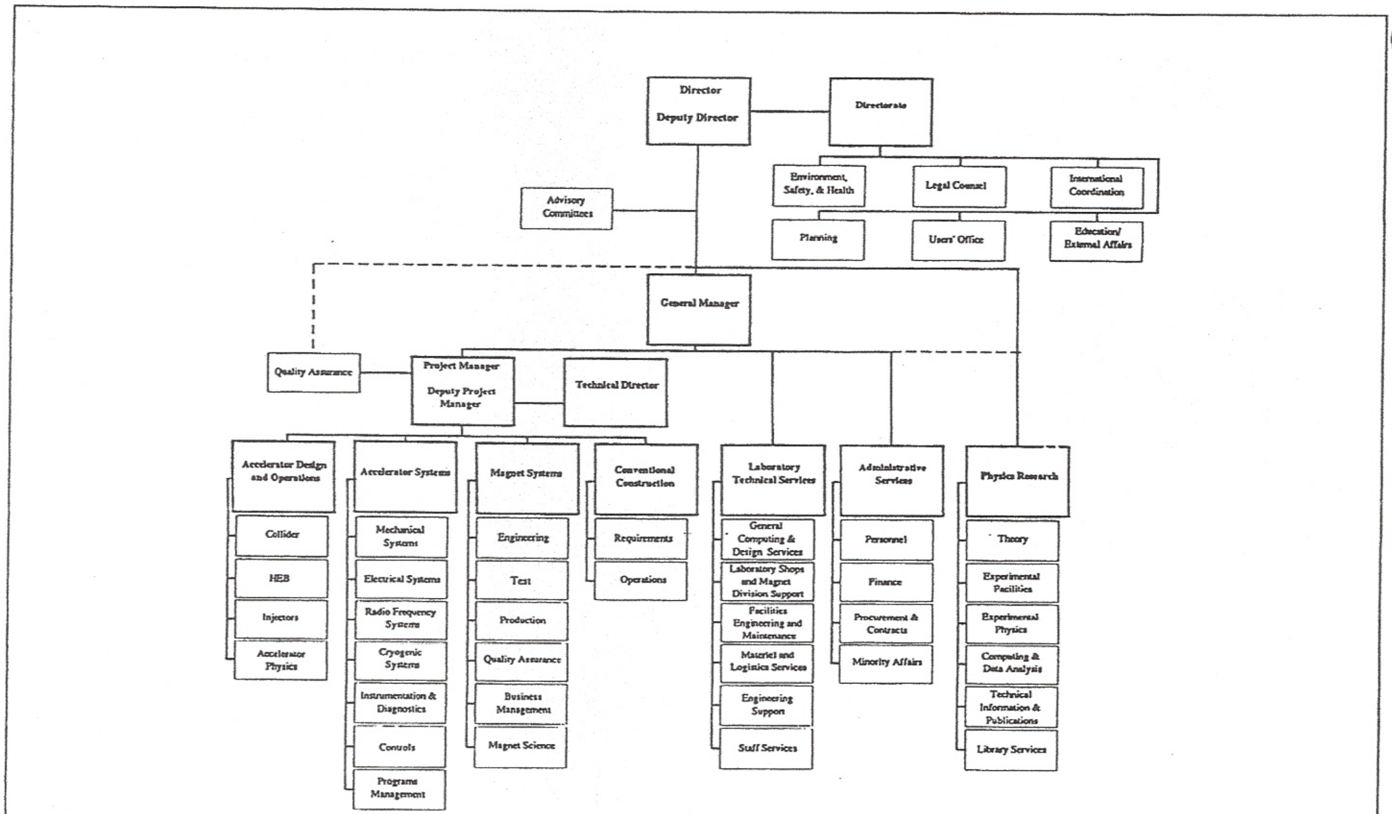

Figure 9. SSC Laboratory Organization Chart

energy physicists will design the equipment and machinery to be used at the SSC, as well as the experiments to be conducted.

An SSC Laboratory (SSCL) organization was established (see Figure 9) and the organizational infrastructure to support an operating physics laboratory is being developed. Rather than a nine-to-ten year construction project, current activity is rather viewed as the current phase of a much larger process—building and operating the SSCL.

Major participating organizations and personnel are being integrated into a single SSCL organization, with SSCL managers often employed by different companies. The emphasis is on integration and teamwork

THE CHALLENGES

Any mega-project of the size and complexity of the SSC will present a multitude of challenges to project management. A pioneering project like the SSC with its many participants from a wide spectrum of environments and backgrounds magnify those challenges and offers new ones.

Technical Challenges

At a little over fifty miles around, the SSC will be the world's biggest accelerator as well as the most powerful. Tremendously large, complex and powerful systems and equipment will be required to satisfy these requirements.

For instance, the particle detectors which must be designed and built for the SSC will be more complex and expensive than any previously assembled. There will be more wires, more cells, more microchips, more electronics. The components will be faster and more sophisticated. In terms of sheer size, speed, precision and computing power, the SSC detectors will be built on a scale never seen before in high-energy physics. SSC detector electronics will have to be capable of making thousands of times more decisions than today's state-of-the-art detectors, and thousands of times faster. With so many more components they will also have to be smaller and use less power to avoid generating excessive heat. The computing power required for triggering and data analysis will be equivalent to hundreds of supercomputers, or hundreds of thousands of smaller computers. But raw power will not be enough. The software will need to be easy to use and easy to change, so that it can be readily modified in response to new ideas and discoveries.

The challenges to SSC scientists and engineers are tremendous. Superconducting Magnet technology has never been demonstrated on the scale required at the SSC. Computing capacity will be challenged. Much needed equipment has never been built. SSC project management must manage R&D activities, design, development, procurement, installation and integration of components and systems, and construction of tunnels and facilities to house the machinery.

Organizational Challenges

Organizing, directing, and managing the many participants on the SSC project will require significant skill and knowledge. Many of the people are from vastly different backgrounds, representing a broad spectrum of fields, professions and disciplines. What's more, while many of the new

Table 1. Current SSC Project Participants

CORPORATIONS
Universities Research Association
EG&G, Inc.
The Sverdrup Corp.
Lockheed Corp.
PB/MK
General Dynamics
Westinghouse
Koch Process Systems, Inc.
(Over 300 other firms)

GOVERNMENT
U.S. Deparment of Energy
President's Science Advisory Office
Congressional Subcommittees
Texas State Organizations
U.S. Senators and Congressmen
State and Local Officials

NATIONAL LABORATORIES
Fermi National Accelerator Lab
Lawrence Berkeley Lab
Brookhaven National Lab
Battelle National Lab

UNIVERSITIES
Over 70 leading universities in the United States and other countries.

managers at the SSCL are among the world's technical experts, some have not had much formal training in project management techniques and processes.

Due to the complexity and many integration issues, teamwork and communication are critical. Since many project participants have never before worked together, special attention must be focussed on organizational efficiency, communication processes and individual interfaces.

Table 1 displays the set of current project participants at the SSC Laboratory in Texas. Over sixty North American universities are currently a party to the decisions made at the SSCL, primarily through URA. In addition, interest in experiments at the SSCL have been expressed by hundreds of American and foreign schools and scientists. As the SSC project moves into the design of experiments and experimental systems, participation by European, Japanese, Soviet and other foreign laboratories and scientists will increase. They bring tremendous pressures to the SSC project management office for effective communication, systems, and team-building strategies and methods. The need for common goals, objectives and understanding is clear and paramount.

Management Systems Challenges

The SSC Project can be described as a "green field" project. The project team has had to define and establish all information systems to be used on the project and at the new SSC Laboratory.

Due to the urgent need for accounting, procurement and personnel systems, interim information systems were implemented during 1989. Based on preliminary needs analysis and systems requirements, off-the-shelf software was procured for short-term solutions. A project management software package was procured and implemented and a variety of personal computer-based software/systems used for various information processing.

Now, however, the SSC project and laboratory must plan for the design, procurement and implementation of long-range management information systems (MIS). An important requirement will be the compatibility and integration of various technical and management information. It is a challenge appreciated by the managers and scientists in the project management office, who realize the paramount need to exchange information quickly and efficiently.

The Planning Challenge

Perhaps the greatest challenge of all is planning itself. Planning all aspects of a complex mega-project like the SSC requires formal structure, systems and discipline. Some scientists and engineers from laboratory and university environments are not accustomed to rigorous project planning requirements and procedures. In nearly every aspect of the project, R&D is still involved. In some cases a great deal of research is required, making planning more difficult. Organizing the project team and producing the plans demanded by the U.S. DOE has required a tremendous effort by SSC project and laboratory management.

ACTION

CRITICAL PLANNING REQUIREMENTS

DOE Requirements

For projects of the size and complexity of the SSC, the U.S. Department of Energy has recognized the need for disciplined project management and especially project planning. The primary governing requirement is DOE Order 4700.1, Project Management System, which is imposed on all large DOE projects. DOE Order 4700.1 requires comprehensive project planning, disciplined project control and reporting, and adequate safety, environmental protection, quality, configuration management and construction management. DOE Order 4700.1 specifically calls for a project charter, a project plan, a project management plan, contractor management plans, advance acquisition or assistance (procurement) plans, systems engineering management plans, test and evaluation plans, configuration management plans, project transition plans, and construction management plans.

Table 2. Partial List of DOE Orders Applied to SSC

DOE ORDER NO	TITLE
1360.1	Acquisition and Management of Automatic Data Processing Equipment and Resources
2200.1	Accounting Policies and Practices
2250.1C	Cost and Schedule Control Systems Criteria
4700.1	Project Management System
5480.1A	Environmental Protection, Safety and Health Protection Program for DOE Operations
5700.2C	Cost Estimating, Analysis and Standardization
5700.6A	Quality Assurance
6430.1	General Design Criteria

DOE has also imposed DOE Order 2250.1C, Cost and Schedule Control Systems Criteria (C/SCSC), on the SSC. DOE Order 2250.1C requires disciplined, systematic, detailed planning, control and reporting of project costs and schedule status. Earned value must be utilized and performance measurement reporting and analysis are included.

While DOE Order 4700.1 is the overriding project management requirement, and 2250.1C addresses cost and schedule, additional orders and requirements are also levied upon the SSC (and other similar large government projects). Table 2 displays a partial list of DOE Orders with which the SSC must comply.

Figure 10 displays a document tree of plans resulting from DOE Order 4700.1.

The central planning document, the Project Management Plan (PMP), includes objectives, WBS, cost estimate, schedule, logic, management systems descriptions, and references to other plans, documents and procedures. A PMP is prepared for the entire project, and for each of the major project participants.

Baseline Planning Requirements

The primary baseline planning issues are scope, schedule and cost. Technical criteria (Quality) and WBS are included in scope definition. For the SSC, the major baseline planning requirements include the following:

- Work Breakdown Structure and Dictionary
- Site-Specific Conceptual Design Report (SCDR)
- Cost Estimate
- Schedule

SSC organizational and contracting issues could be finalized upon completion of the cost estimate, when resource requirements are better known.

Management Systems Planning Requirements

A comprehensive approach to management systems for the SSC project is being adapted. Systems, including information processing, are required for the following:

- Finance/Accounting
- Procurement
- Cost/Schedule Control (C/SCSC)
- Human Resources
- Document Control
- Configuration Management
- Travel Administration
- Property Management
- Physics Research
- ES&H Management
- Total Quality Management
- Engineering Standards
- CAD/CAE
- Communications
- Geotechnical
- Construction Management

Due to the early stage of management systems development, the requirement has been established to maximize compatibility of software/hardware, and to integrate systems for communication purposes. Long-Range issues dictate the need for software and databases which can handle great volumes of data and multiple users, and provide ease of use and transfer of data to other databases/software. All SSC information systems will be integrated into an overall SSCL Management Information System (MIS).

THE APPROACH

Program Objective

The overall program objective is to build a world-class accelerator and associated laboratory infrastructure to meet the needs of the national and international high energy physics program by the start of the twenty-first century.

"The Superconducting Super Collider will be an accelerator complex, unique in the world, providing access to particle collision energies an order of magnitude greater than are available at existing facilities today."

SSC Directors/ Project Management Leadership

The Laboratory Director, the Laboratory Deputy Director, and the Laboratory General Manager provide the overview in formulating program requirements. Physics Research and Experimental Facilities are directed by the Associate Director for Physics Research. He is responsible for direction and requirements for construction of the experimental facilities, as well as planning the initial complement of experiments. Additionally, reporting directly to the Laboratory General Manager are the Associate Director for Technical Services, the Associate Director for Administrative Services, and the SSC Project Management Office.

In the project management office are the Project Manager, the Deputy Project Manager and the Technical Director. Their responsibilities include full-time management of the

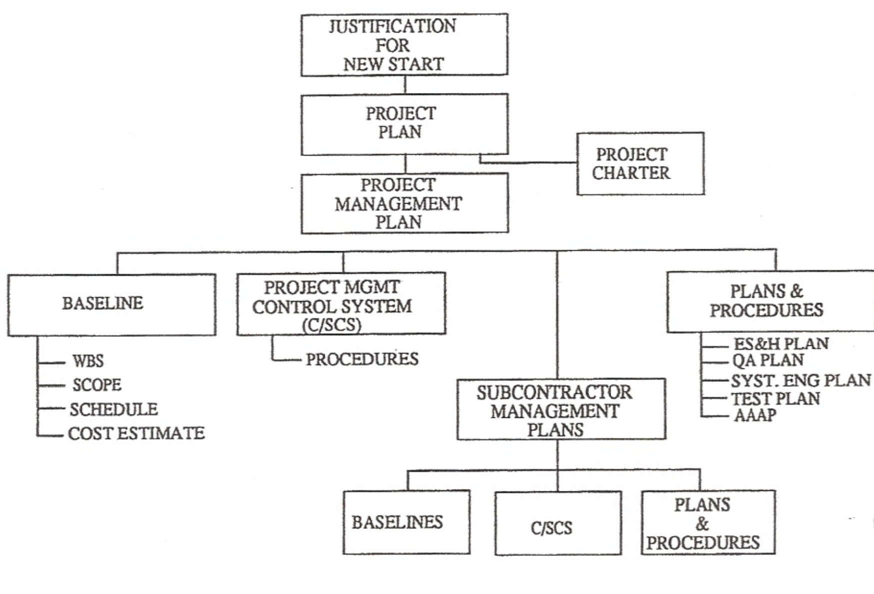

Figure 10. Document Tree of DOE Order 4700.1 Plans

SSC Project. The office is responsible for the overall planning, engineering, and construction of the project, within guidance provided by the Department of Energy. The project management office is also responsible both for constructing special conventional facilities and for providing project coordination and liaison with R&D programs in support of the SSC Project.

Reporting to the project management office are the associate directors for accelerator systems, magnet systems, conventional construction, and accelerator design and operations. These associate directors ensure that the design of the systems delegated to them will meet SSC technical objectives within prescribed cost and schedule. Responsibility for R&D, design, construction, installation, and acceptance test details for individual systems are assigned to individual project group leaders reporting to the appropriate associate director.

The SSC Research Complex

The SSC Laboratory is committed to providing an accelerator that will reliably deliver both colliding beams and external beams (for test and calibration of apparatus) on time, soon after the initial commissioning of the accelerators. The laboratory is also dedicated to providing the opportunity for researchers from around the world to carry out experiments addressing all aspects of the physics potential at the SSC as early as possible. The SSC conceptual design is a timely, cost-effective approach to providing an accelerator and experimental complex that will meet these goals, while maintaining the flexibility to respond to new directions in particle physics.

Procedures to Establish the Experimental Program

The SSC Laboratory will follow the usual procedures of the world's existing high-energy physics laboratories in determining its experimental program. Experiments will be initiated by expressions of interest (similar to letters of intent) or proposals submitted to the laboratory. These will be reviewed in detail by a Program Advisory Committee (PAC) for physics merit and technical feasibility and by laboratory staff members for impact on laboratory resources. Recommendations from these groups will then be presented to the director.

The International PAC, which advises the director, first met in February 1990 to determine the procedures and schedule for evaluation of the first round of SSC experiments. Expressions of interest represent the first formal step in defining the experimental program. Longer than traditional letters of intent but less detailed than proposals, they will be used to determine support for large experiments whose design and construction must begin now if they are to be ready when the accelerator is. More detailed

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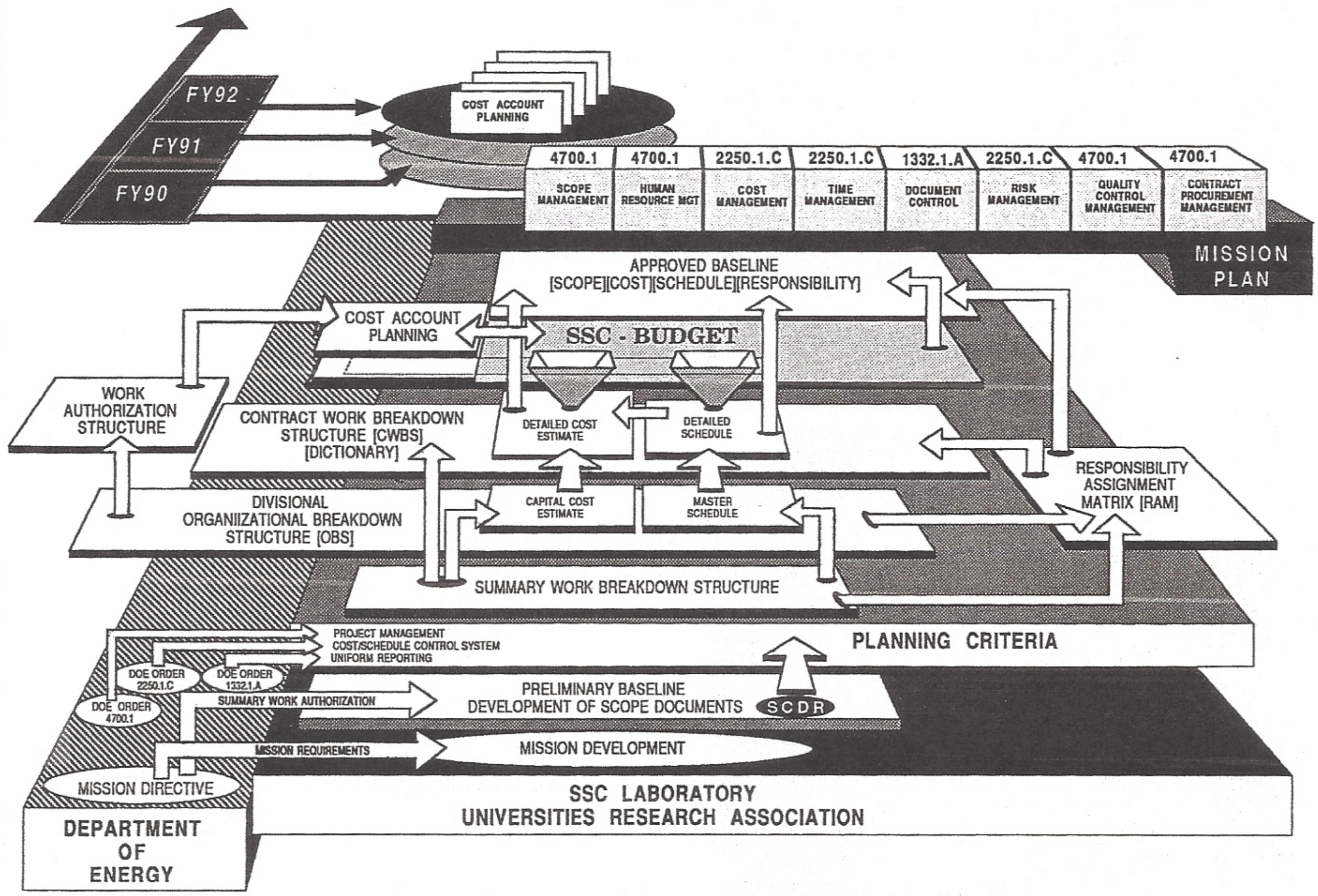

Figure 11. SSC Project Baseline Development Process

proposals based on this preliminary work can then emerge by the end of 1991.

Project Baseline Planning

The project baseline plan is being prepared at the same time management systems for the SSC project are being established. All SSC managers are involved in developing the design criteria, cost estimate and schedule for their areas of the project. For SSC project management systems, the designated system (functional) managers, working with the MIS department, are responsible for designing and implementing individual systems (i.e., the finance manager is responsible for accounting system).

Development of the SSC project baseline, represented by the WBS, SCDR, cost estimate, and schedule, will be an iterative process involving many individuals and managers. The WBS will play a pivotal role for baseline integration. Coordination and communication among those involved in planning, however, will be the key to successful baseline development.

Figure 11 displays a summary representation of the baseline development process on the SSC. The paragraphs that follow describe the approaches employed for completion of the WBS, SCDR, Cost Estimate and Schedule.

WBS

The basic project Work Breakdown Structure has been in place since July 1982. Figure 12 displays the current project summary WBS. This WBS is being updated to reflect current scope and approach in the construction, magnet and accelerator legs.

The SSC WBS is being maintained by the Cost Estimating Group, in conjunction with completion of the baseline cost estimate. It has been reviewed by each SSCL division. As the various managers complete the SCDR and proceed with development and design activities, they can propose changes to the WBS. Following acceptance of the baseline by DOE, any changes to the WBS will be managed in accordance with formal change control procedures.

The WBS Dictionary, a document which describes the work content of each WBS element, is also being developed in conjunction with the cost estimate. The contents of the WBS Dictionary are based on the latest draft SCDR.

Site-Specific Conceptual Design Report (SCDR)

The Conceptual Design Report (CDR) contains the technical specifications, requirements and parameters for the various technical systems, subsystems and components of the project. It contains preliminary and conceptual design characteristics, including drawings and functional specifications, of the magnet systems, injector systems, collider ring, experimental systems and facilities.

An initial CDR was prepared in 1986 by the Central Design Group at Lawrence Berkeley Laboratory in California. That report was updated to the SCDR in the fall of 1989.

The completion of the SCDR was a major step in the project. The design report and supporting documentation present a complete conceptual design and related cost and schedule estimates for all aspects of the SSC. The land required for the accelerators and the experiments has been established, and the process of acquiring it has begun. All major accelerator parameters have been fixed, and detailed design leading to construction of the accelerator components is beginning.

An aggressive program of collider dipole magnet development will lead

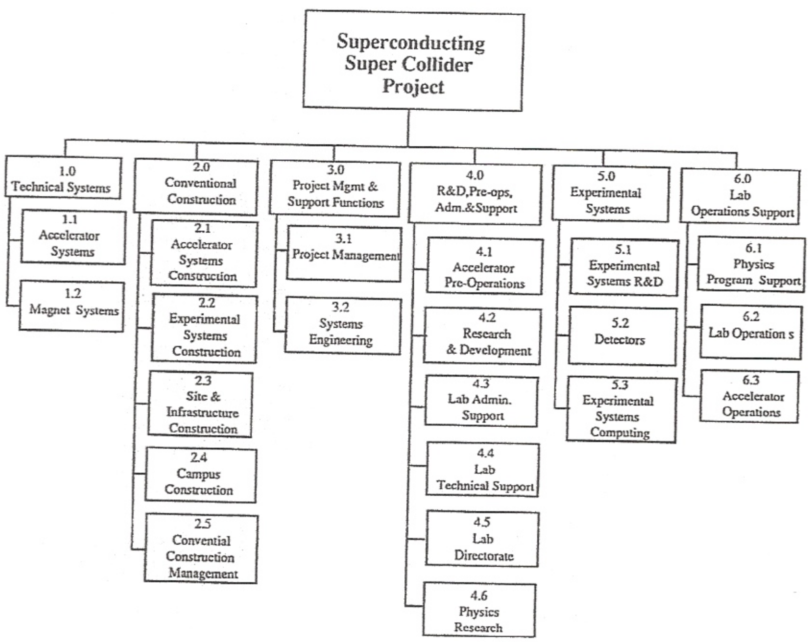

Figure 12. SSC Project Summary WBS

to production of the first collider dipoles in collaboration with industry and to a test of a string of dipoles under conditions similar to SSC operation by the end of fiscal year 1992. Conceptual plans for civil construction associated with the accelerators and the experiments now exist and have been documented in the SCDR. In the summer of 1990, the AE/CM consortium of Parsons Brinkerhoff/Morrison Knudsen began work with the laboratory staff to turn the conceptual designs into reality. Procedures to initiate the experimental program at the SSC have been established, and the expressions of interest in SSC experiments were reviewed in the summer of 1990.

Cost Estimate

The baseline cost estimate is being prepared and maintained by a group of professional capital cost estimators, working out of the SSC Project Management Office (PMO). Working with technical managers in the various SSCL divisions, who are responsible for systems, subsystems, design, construction and support, the estimators are developing a database of detailed resource requirements for every WBS element. For the cost estimate, the WBS has been extended as low as level eight in some areas. Labor rates are applied to labor resource estimates to develop estimated costs in both escalated and current year dollars. Cost estimates are being prepared for the entire nine-year schedule, based on completion in September 1998. The cost estimate will be applied to the total project schedule when networking and scheduling activities near completion.

The baseline cost estimate will be used for funding projections and will also provide the basis for establishing the performance measurement baseline for C/SCSC reporting to DOE.

Schedule

A set of milestones for the project has been developed and negotiated with DOE. Key milestones are categorized as level one, two or three, corresponding to impact on program and level of authority for approving changes. Approximately nineteen level one milestones require the approval of the DOE SSC program manager in Washington, D.C. Approximately one hundred level two milestones require the approval of the DOE SSC on-site project office manager. Level three milestones include key events controlled by SSCL (URA), with DOE needing only to be informed. SSC milestone dates will be formally established upon completion of the project schedule and approval of the project baseline by DOE.

The SSC project schedule will be developed by a team of schedulers, both in the central PMO and in the SSCL divisions, working with the various technical, system, and line managers. Critical path networks are being developed, by systems, within the divisions by division schedulers. Division system networks are then given to the central PMO schedulers for integration into the master schedule and into the overall project schedule database. Network information is transferred on both hard copies and floppy disks. All network and schedule information has corresponding WBS numbers identified.

Figure 13 displays the project schedule development process on the SSC.

As logic for various WBS legs is completed and integrated, that information is summarized and reviewed. Based on milestone constraints, schedules can be developed. Resource and cost estimates are then tied to the schedules by WBS account, and time-phased cost profiles developed. This process will continue until all areas of the project are planned in detail. Schedules, cost estimates and corresponding Scope (and technical specs) will then be systematically reviewed within the SSCL and by DOE.

The Critical Path Network will have two distinct legs; first, all those elements, systems and components which are required to interface in order to achieve one 20 TeV Collider, and secondly all those elements and processes required to completely build out the SSC Laboratory. The SSC program schedule will provide visibility for all activities associated with the project. A multi-tiered schedule will be implemented by all laboratory

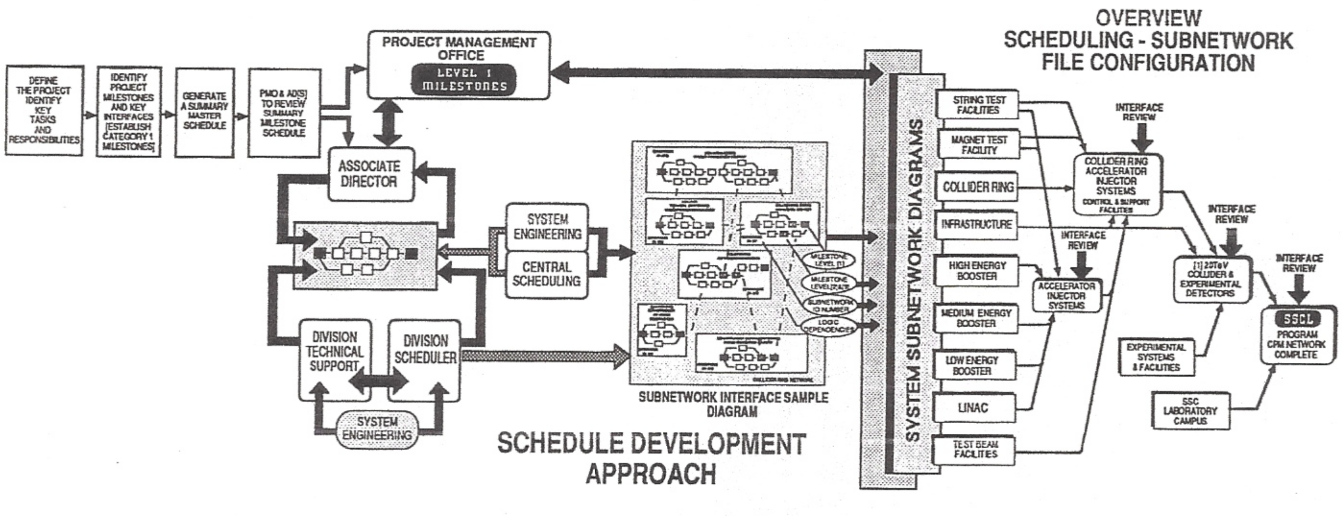

Figure 13. SSC Project Schedule Development Process

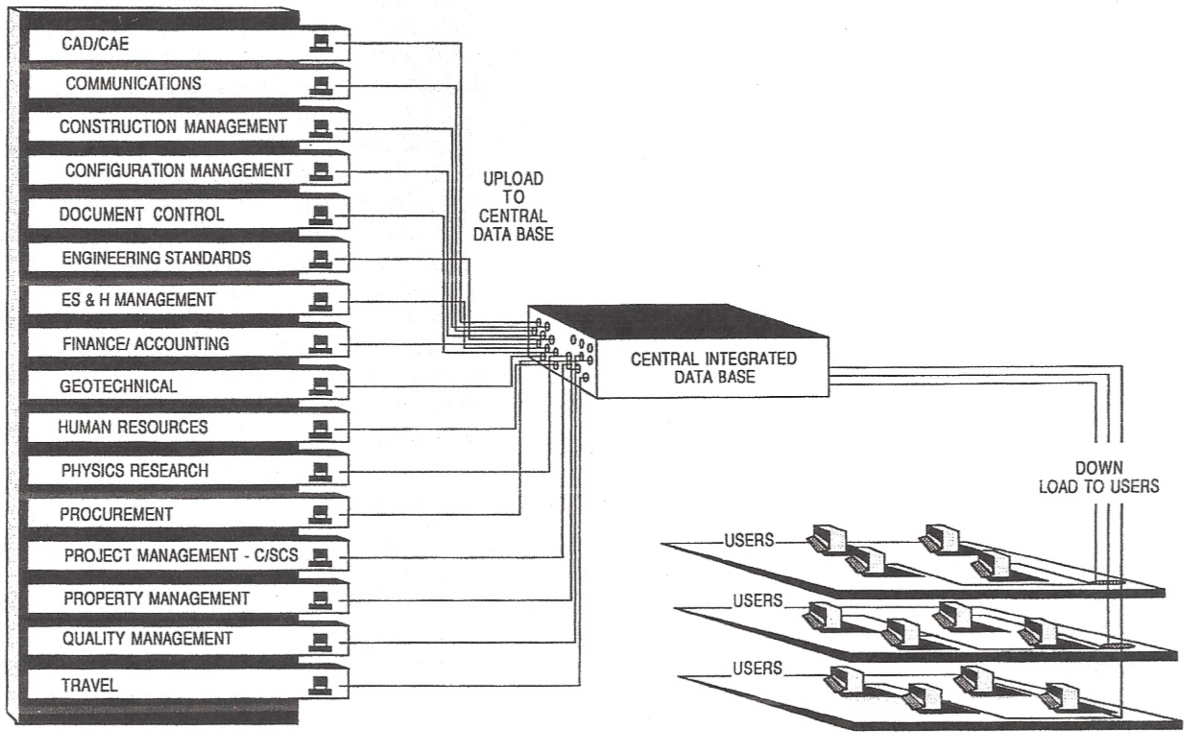

Figure 14. Planned SSCL MIS Configuration

divisions. Individual division schedules will be combined, linked and analyzed in order to provide a fully detailed network of project activities, using precedence diagramming (PDM). Uniform coding of the lowest level activities will be implemented to guarantee upward summarization to intermediate and top-level (Program Master Schedule) schedules.

Project Management Systems Planning

The approach to management systems implementation on the SSC Project is one of shared responsibility. Functional systems managers define the objectives, performance requirements, procedures and application responsibilities. The laboratory MIS department defines hardware, database, communication and system operating requirements. Working together, teams from the MIS department and functional (project) groups establish design criteria, evaluate and select software, and install, test and operate the systems.

Figure 14 displays a possible configuration of management information systems for the SSC project and laboratory.

Since several of the systems were needed immediately—during project start up—interim solutions were procured and implemented. The overall management systems implementation process now includes interim MIS and long-range MIS implementation projects. Long-range MIS will be based on detailed system requirements analysis, and will consider all configuration, compatibility, communication and operating objectives during design. Interim systems may or may not emerge in the long-range MIS.

EXPERIENCE TO DATE

The SSCL is moving forward at a tremendous pace. Approximately forty people are added to the SSCL staff each month, with a projected population of 2,200 in 1992. Funding for the project was $225 million and in 1990 will grow to approximately $300 million in 1991, and approximately $700 million in 1992. (These are the federal contributions.) To complete the SSC by the year 2000, annual funding will reach a peak of over $1 billion in 1995.

Project Planning

The updated SCDR and associated cost estimate were presented to DOE in January 1990. Based on acceptance of that design and direction to proceed by DOE, the SSCL PMO is now working on a total project baseline plan. That plan includes a WBS and WBS dictionary (work scope). Final cost estimate planning is proceeding with active participation by all SSCL managers. Directed by the PMO, the baseline planning effort will result in a plan against which SSC project performance and status will be compared and reported.

Because of the size and importance of the SSC project, DOE requires compliance with its Cost and Schedule Control Systems Criteria (C/SCSC). These criteria require that all near-term work be planned in detailed cost accounts and work packages. On the SSC, all FY1990 work has been planned in cost accounts, with detailed planning of FY1991 activity currently in process.

Systems and procedures are in place to support these important planning processes. While the PMO directs and integrates planning activities and information, individual organizations and managers are responsible for doing the detailed planning. That information is given to PMO staff for integration, summarization and review.

Standard Method For Management Plans Fosters Better Planning, Communication and Teamwork

Initiated by the Laboratory Technical Services Division, a Standard Method for Management Plans has been developed to facilitate planning at the SSC laboratory. Based on DOE guidelines for developing Project Management Plans, and on some fundamentals of project management, the Standard Method provides a standard outline for developing management plans for any organization or project at the SSCL.

Each management plan must address the following ten standard elements:

1. Charter (Mission)
2. Introduction (Purpose, Objectives and Background)
3. Workscope (Tasks, Requirements, Approach)
4. Work Breakdown Structure
5. Logic, Milestones and Schedule
6. Resources, Cost Estimates and Budgets
7. Organization (Structure, Responsibilities and Interfaces)
8. Management Control and Reporting
9. Total Quality Plan
10. Environmental, Safety and Health Protection

Dozens of Management Plans have been prepared or are in development at the SSCL. By addressing the ten elements, managers are developing more comprehensive plans for their projects and organizations. Where unknowns exist, the standard method forces managers to seek answers, communicate with other managers, make estimates and document "a plan".

The management plans provide an excellent means for introducing outsiders, upper management or other organizations to a given project or organization. The management plans indeed are fostering teamwork as managers see where the interfaces are, when various resources are needed for what tasks, and who is responsible for what. The Standard Method is another important technique being employed to promote sound management on the Super Collider.

Management Systems Implementation

Interim systems are in place for project cost/schedule planning, control and reporting; for project financial management; for procurement tracking and management; for property management; and for human resource management. Systems for document control, configuration management and total quality management are in the planning stage. Upgrades or replacement of these existing systems are being addressed in long-range MIS planning currently in process.

Technical Information Systems, including CAD/CAE, geological databases, environmental protection and compliance, magnet design, physics research and others have also been implemented and will be integrated into the overall SSCL MIS. In every case, detailed implementation plans are required to ensure that systems are developed and installed effectively and efficiently.

Overall Project Status

Design work on injector systems components and the collider ring have begun. Since superconducting magnet development and mass production are critical to SSC completion, magnet systems planning and procurement activity are being emphasized. The collider dipole magnets will represent close to $1 billion of procurement activity, so magnet design and production capabilities are being transferred to private industry from DOE's national laboratories under a "Magnet Industrialization" program. Development and testing of prototype magnets are now being conducted at several national laboratories.

Planning of physics research experiments and experimental systems has started, with participation by American and foreign universities and laboratories. A contractor for the $1 billion contract for Architectural Engineering and Construction Management (AE/CM) services contract was selected in May 1990. The AE/CM contract is now scheduled for award in November 1990. Detailed planning of tunnels and facilities at the SSC site is proceeding.

The "footprint" of the SSC tunnel and campus was approved by DOE and acquisition of land by the state of Texas began. A site-specific Environmental Impact Statement is nearing completion. In all areas, SSC project management is working in compliance with all DOE orders, requirements and regulations.

Organizational Effectiveness

Organizing and directing the growing SSC Laboratory and project office have been accomplished with a great deal of effort, but not without problems. There has been pressure to hire staff in order to accomplish the planning and technical tasks needed to get design and construction underway. With the different backgrounds of various participants, conflicts have occurred and reorganizations have been necessary. The SSCL PMO has recognized these pressures, which are not uncommon during start-ups of megaprojects. They have maintained teamwork by emphasizing technical integration and by focussing on the common vision—the future SSC Laboratory.

The U.S. DOE now has an on-site project office established in Dallas and is participating in SSCL planning and review activities. Communications have improved dramatically as the "customer's" representatives are more available for feedback and participation.

THE FUTURE

The future on the SSC project is exciting. Construction will begin in 1991, experiments will be planned and more international participation will occur. As management systems come on line many frustrations should be relieved, The SSC is the most fascinating project I've worked on in more than thirty years. Its scope and physical dimensions, its value and budget, its time frame, its ultimate mission – all represent outstanding scalar dimensions and managerial challenges. The conventional facilities for the SSC, about one billion dollars worth of enclosures (tunnels, buildings, experimental halls, etc.), services (water, power, gas, communications, etc.), and support facilities (fire protection and security, sewage treatment, water treatment, etc.) are our responsibility to design and construct on schedule and within the budgets provided by the SSC Laboratory.

Paul H. Gilbert, PE, Project Director
Parsons Brinkerhoff/Morrison Knudsen
SSC-Architect-Engineer/Construction Manager

As the project director for the architect-engineer/construction manager, the requirements here are in many ways very similar to any billion dollar, multi-year public works project. But here, and uniquely, we have a few very significant additional requirements to satisfy. The scientific instruments that are housed in our tunnels and supported by our services are truly state-of-the-art, and then some. Consequently, their requirements are, of necessity, subject to change as breakthroughs occur. Our conventional facilities role in this process is to provide all the latitude for change that the budget will allow, to provide experienced engineering and construction input to the development process, and to maintain schedule.

How do we do this? We employ systems engineering techniques for change control and configuration management. We do trending analyses and have a fine cost and scheduling control system in place. And all these and other tools play a role. But the real answer to the question lies in conscientious use of basic project management fundamentals. We employ the radical technique of clearly defined deliverables and assigned accountability for each deliverable. Good communication and good people, even in a complex scientific environment, remain the best answer to the management challenge. And we will be utilizing a lot of good people.

and, in fact, dramatic advances made in information processing and exchange, understanding and decision making.

Transition to Design and Construction

With the selection of an AE/CM contractor and the approval of the SSC footprint by DOE, construction planning is proceeding rapidly. Facilities planned for the SSCL campus are needed as soon as possible, including magnet testing and development laboratories.

Design is now proceeding on all SSC subsystems. For equipment and components, large procurements will be utilized. For more "conventional" systems and facilities, the AE/CM contractor will perform much of the engineering design activity, and will manage contractors selected for tunneling, construction, infrastructure and utilities work.

During this transition period, the SSCL organization will grow and expand to accommodate the new organizations and their people. Care will be taken to account for additional cultural influences and incorporation of new perspectives into the SSC Laboratory society.

Planning and Configuration Control

The emphasis on planning will continue. With the amount of R&D still involved in development of accelerator and detector components, changes will be frequent and welcomed. SSC project management philosophies, policies, systems and practices must support the ability to revise plans, designs and approaches. Change control and configuration management are recognized keys to project control over the coming years. These processes will receive more emphasis as project activity expands and documentation/information reach major proportions.

Emphasis on Team Building and Communication

At a minimum, the SSC will be a ten-year project. At its height, thousands of people will be working on the project at locations around the world. In order to achieve efficient and productive project performance, a great deal of emphasis will be placed on communication and teamwork. Again, technical and managerial systems integration will be keys to achieving coordinated and high quality results.

Planning for teamwork must be addressed. Personnel development activities such as training will be provided. Meetings, oriented toward communication and team building, will be established and conducted on a regular basis. Most importantly, a "common vision" will be maintained and promoted to keep the common cause clear to ali participants. Top management's role in that process has already been clearly demonstrated.

Integration and Efficiency

Only through effective integration and teamwork can systems and people produce efficient results on the SSC project. All technical components and subsystems must eventually work together with precision when the SSC comes on line in ten years. That integration will require the close coordination of hundreds of scientists and engineers over the life of the project.

Technical and management information must be communicated efficiently to most project participants. DOE and the state of Texas will require constant status information, of both a technical and administrative nature. True efficiency will be required to satisfy and involve the multitude of participating organizations, professionals and special interest groups. We are seeing that today. It will increase manyfold in the next few years.

CONCLUSION

The SSC project is a huge, complicated project, involving thousands of people and organizations from around the world. The challenges are immense, but so are the opportunities. The project management team at the SSCL in Dallas is addressing these challenges through emphasis on planning, integration and communication. The process is working. A project baseline has been presented to DOE. Meanwhile management systems are being developed, implemented and integrated into an overall MIS that will serve the SSCL for years to come.

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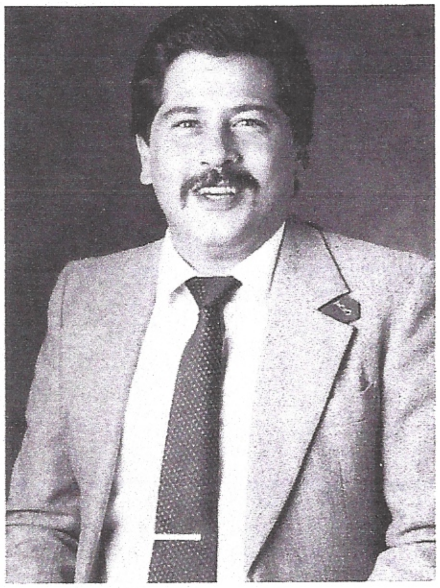

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As an expert witness, Mr. Aprile has been heavily involved in construction contract claims analysis and court room presentations in the construction industry

Mr. Aprile is now a team member of the central cost and schedule reporting group of the Superconducting Super Collider, currently implementing the project management systems for tracking the research and development, design, procurement, construction and eventual operation of the Superconducting Super Collider Laboratory.

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