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GIS/FIS Development for the SSC*

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GIS/FIS DEVELOPMENT FOR THE SSC

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INTRODUCTION

Throughout all phases of the Superconducting Super Collider Laboratory (SSCL) project life decisions will be made on how to manage complex interactions of components, systems, and people with each other and with their environment at both micro and macro scales. The SSC has a distinct advantage compared to other large projects constructed and operated in the past, for even in the early phases scientists and engineers can use computer technology to provide faster computation and better modeling capability to resolve conflict and to make design, construction, and installation decisions. Computer systems today let us go beyond just making pictures of the components and objects under consideration. Not only can we know what objects look like, but we can visualize what and where they are, how they fit together to make networks, and how the networks relate to other types of objects and networks. Two such computer-based systems that relate object position and attributes to one another are Geographic Information Systems (GIS) and Facility Information Systems (FIS).

The SSC GIS is a computer-based system that provides a development, management, and analysis environment for geographically referenced (mapped) features and associated descriptive information (attributes). GIS is typically associated with features and networks at the macro-scale, depicting information about the local geographic surface and sub-surface environment. The mapped information is not stored in the conventional CADD sense; instead a GIS stores the data from which one can create the desired map or view, drawn to suit a particular purpose.

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The House Appropriations Committee Report adopted June 13, 1990, identified GIS as a means of achieving desired coordination between various public and private entities involved in the planning, construction, and operation of the SSC. The Committee recognized that GIS is not simply a computer system for making maps, although it can create maps with colorful cartographic tools at different scales and in different projections. GIS is an analysis tool by which spatial relationships between various map features are identified, then used to resolve conflict, evaluate environmental impact, and help manage interactions between man and project resources.

The SSC FIS is a global, computer-based repository for both physical and attribute information related to the facility's vital technical and conventional components. FIS provides a development, management, and analysis environment for the components and systems required by all divisions of the SSCL for effective laboratory management throughout the SSC's life. Similar to GIS but at the micro-scale, the component intelligence of FIS resides within a relational data model in both graphic and text forms to support the development of various applications throughout the project life cycle.

GEOGRAPHIC INFORMATION SYSTEM (GIS)

GIS stores information about a particular geographic area as a series of coverages or layers, with each coverage representing a different theme or topic of information. Coverages consists of both graphic and descriptive information. There are two distinct data models used for graphic representation—vector and raster. Within the vector model, data can be stored in an unstructured "spaghetti" form or in a topologically structured "intelligent" form. A topologically structured coverage consists of points, lines, or areas that represent features to which descriptive information can be tied. Graphic information stored in a raster model includes images generated by satellite and airborne remote sensing systems, thematic grid cell models, scanned images of documents, drawings or photographs, and video frames. Using GIS, the two basic forms of graphic data can be brought together and combined to produce new information. Figure 1 illustrates the combination of GIS vector and raster data as output on the computer screen. The graphic and descriptive information present in each original coverage can be integrated so that users of the GIS can develop applications and perform spatial queries.

The PB/MK Design Division—Geodetic Survey and GIS Department began developing the SSC GIS in July 1991. The following objectives have been adopted for GIS development and implementation: 1) Integrate both existing-conditions data through the survey and mapping program and design data through the CADD system with other federal, state, and local data resources; 2) Create and maintain topologically structured maps and geo-referenced imagery suitable for planning, engineering, geodetic survey, construction management, facility and emergency management, public relations, and environmental applications; 3) Define attribute categories and input data into the relational database associated with the map information; and 4) Provide an efficient database query and cartographic system interface for end users of the GIS.

Much of the GIS discussion presented here is taken from the comprehensive GIS Plan that summarizes work performed to date and describes the computer system, data sources, accuracy, applications, production, maintenance, budget, and project-wide coordination necessary to meet contractual requirements and deliverables according to three project phases: I–Development; II–Implementation; and III–Operation and Maintenance.

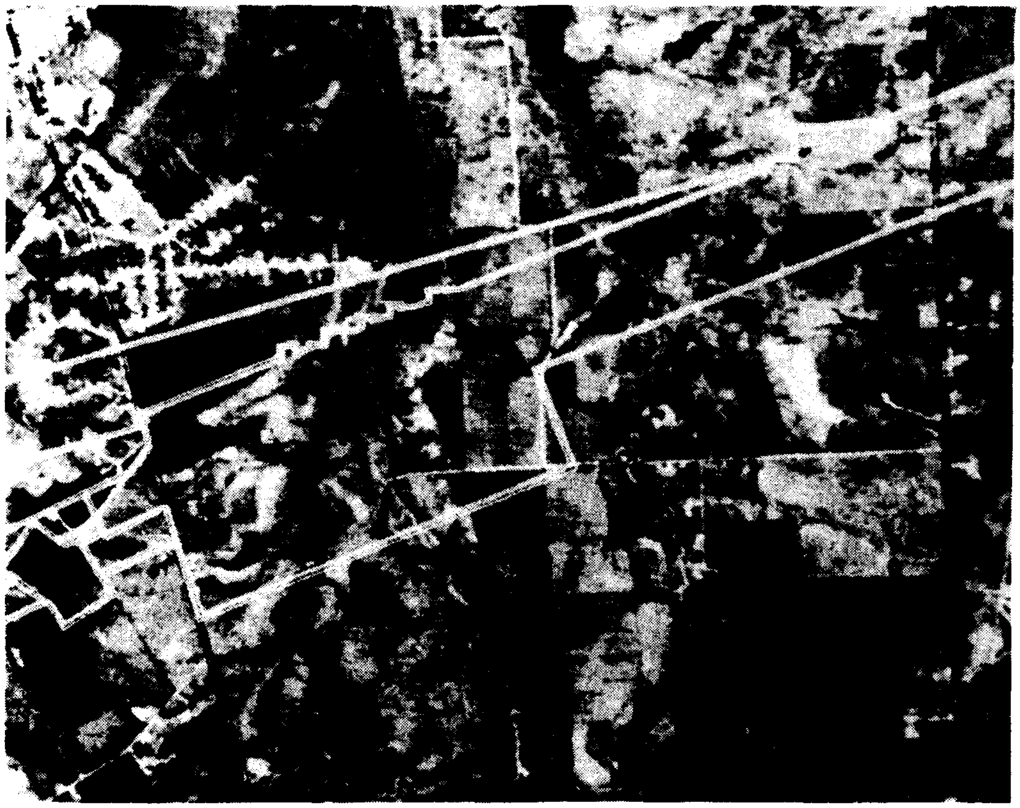

Figure 1. Combination of a 1991 Spot satellite image registered to project control and vector information from the LIS.

Phase I–GIS Development

GIS and image-processing software have been installed on UNIX-based workstations that interface through Ether networks with the Intergraph CADD system being used for SSC facility design and drawing production. Intergraph, Arc/Info, and ERDAS software are being used to develop two forms of spatial data: the vector form that represents map features as topologically structured points, lines, or boundaries, and the raster image form that represents information as pixels (picture elements) or grid cells. Attribute or descriptive data is maintained in a relational database with ties to the graphic information.

Regional (1:100,000 or 1:250,000), Planning (1:24,000 or 1" = 2000'), Vicinity (1:4800 or 1" = 400'), Engineering (1:480 or 1" = 40'), and Land Information System (LIS) base maps are being developed so that attribute and other map information can be managed at various levels of accuracy. Figure 2 depicts the extremes of geographic base maps being developed from the regional North Central Texas base to the project-specific LIS.

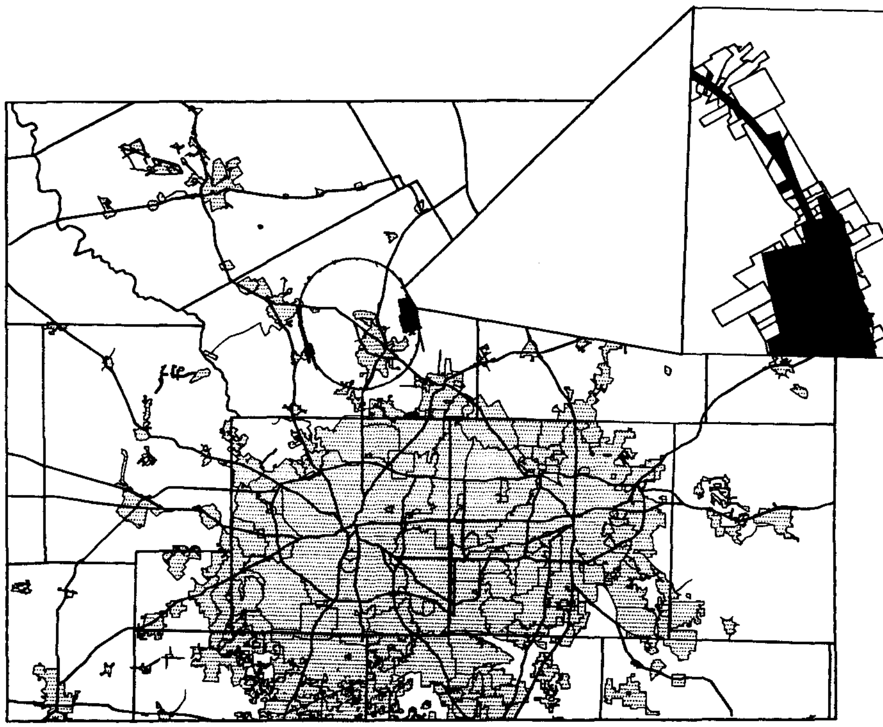

Figure 2. Layers of base map development from the regional level showing surrounding counties to the LIS parcel base map.

Base mapping and coverage development has begun on all levels, satellite imagery is on-line, and the digital orthophoto coverage is planned to be available by summer of 1992. Table 1 lists coverages identified for SSC GIS implementation. Coverages are in various stages of development. The initial engineering base map will soon be complete. LIS land parcels have been transmitted from the Texas National Research Laboratory Commission (TNRLC), and ownership and access agreement information is being associated with each parcel. Several attribute categories have been identified and are being associated with appropriate map information. Other attribute information will be identified through a User Needs Assessment conducted by the PB/MK GIS Department with SSCL coordination. GIS is an evolving computer-based system; as particular coverages and applications come on-line, others will be in development. Maps, GIS analysis, and electronic data can be transmitted as information progresses from development through QA/QC. The implementation date listed in Table 1 is the estimated date by which the coverage will have been edited and topologically structured. At this point coverages are ready for additional attribute assignment and application programming.

Table 1. GIS coverages identified for development and implementation.

Coverage Description	Data Source	Attributes	Implement Date
Land Information System (LIS)			
Geodetic Network-Monumentation	PB/MK, RTK & USGS	LSCS & NAD83 ST PL (x,y,z)	7/92
SSC Lattice	SSCL, PB/MK	to be determined	6/92
Fee Simple & Stratified Fee Land	TNRLC	to be determined	1/92
Land Parcels	TNRLC	access, ownership, env. data	1/92
Utility Easements & R.O.W.	TNRLC, PB/MK	classification, ownership	7/92
Surveyed footprints	PB/MK	structure description	7/92
Engineering base map (1" = 40')			
Planimetric	PB/MK	fences, roads, structures, trees, water	4/92
Topography	PB/MK	5' index & 1' intermed. contour	4/92
Digital Elevation Model (DEM)	PB/MK	spot elevations–TIN	4/92
Land Management	PB/MK	existing & planned practices	7/93
Geotech Borings	PB/MK, RTK	sample properties & profile	10/92
Vicinity base map (1" = 400')			
Digital Orthophotography	PB/MK	NAD83 ST PL coord. (2' pixel)	7/92
Street Network	PB/MK	name, class, restrictions, add. range	9/92
Bordering Land Parcels	ECAD, PB/MK	parcel ID	1/93
Rural Residences	Ellis Co. 911, PB/MK	name, address, phone number	2/93
Env. Baseline Radiological	SSCL ES&H, PB/MK	Monit. station ID, data type, prop.	7/93
Hydrology–Wetlands	PB/MK, JJR	class, name, quality, hydraulics	7/93
Land Use–Land Cover	PB/MK, JJR	Anderson Classification System*	1/93
Archaeological	SSCL, SMU, JJR	to be determined	7/93

Table 1. GIS coverages identified for development and implementation (Continued).

Coverage Description	Data Source	Attributes	Implement Date
Planning base map (1" = 2000')			
Ellis Co. Street Network	TNRLC,ECPW, PB/MK	name, class, restrictions, add. range	4/92
Bridges	TNRLC, ECPW	class, load limits, restrictions	5/92
Util.(elec, gas, product, water, phone)	TNRLC	class, owner	3/92
Surf. Hydro-Watersheds-Flood Pl.	USGS, PB/MK, FEMA	class, name, quality, hydraulics	5/93
Ground Water	BEG, TWC	name, quality, hydraulics	10/92
Water Wells	BEG, TWC	ID, quality, depth, class, owner	3/92
Oil & Gas Wells	TRRC	ID, class, status	10/92
Surface Geology	BEG	name, properties	8/92
Sub-surface Geology	BEG	name, properties	7/93
Soils	TNRLC, SCS, JJR	name, properties	10/92
Political Boundaries - E911	TNRLC, Ellis Co. 911	name, characteristics	1/93
Public Service & Emer. Facilities	Ellis Co.NCTCOG,JJR	name, phone no.	7/93
Extended Rural Residences	Ellis Co. 911, PB/MK	name	7/93
Env. Baseline - Air	TACB, EPA, FAA	to be determined	12/93
Pt. Discharges Water Intake	EPA, TWC, NCTCOG	name, class	12/93
Extended Land Use - Land Cover	PB/MK, NCTCOG, JJR	Anderson Classification System	8/93
Comprehensive Cty Plan- Zoning	JJR, Ellis Co.	class, restrictions, status	4/93
Rare & Endangered Sp.	TP&WL, JJR	name, status	4/93
Regional (1:100,000 & 250,000)			
Regional Street Network	USGS, NCTCOG,Tiger	name, class	4/92
Traffic Survey Zones	NCTCOG	traffic model	10/92
Political Boundaries - E911	NCTCOG, JJR	name	1/93
School Districts	NCTCOG, JJR	name	10/92
Census Tracts	NCTCOG, UTD	Tract ID, demographics	4/92
Zip Codes	NCTCOG	ID	4/92
Regional Land Use	NCTCOG, UNT, JJR	Anderson Classification System	10/92
Surf. Hydro. - Watersheds	USGS, NCTCOG, JJR	name, class	1/93
Ground Water	BEG, JJR	name, quality	10/92
Digital Elevation Model (DEM)	USGS	elevation - TIN	10/92
Surface	BEG, JJR	name, properties	8/92
Sub-surface Geology	BEG	name, properties	8/92
General Soils	SCS, JJR	name, properties	10/92

Phase II–GIS Implementation

Implementation represents an intermediate phase in SSC–GIS evolution, when priority GIS applications become operational at the same time new applications are in development. Database design becomes critical during this phase, and SSCL coordination is extremely important as the Functional User Requirements, System Specifications, and Data Dictionary documents are written. Database query, cartographic system interface, and menu options will be developed during this phase so that efficient links to other technical systems are provided for SSC facility management.

Priority GIS tasks include the implementation of: 1) the LIS, which defines land parcels, SSC real property requirements, right of way, and existing utilities easements so that access agreements, permits, and ownership information can be tied to appropriate land parcels; 2) thematic maps such as updated topological street network for Ellis County, road and bridge restrictions, potential construction access routes, geotech and soil information, hydrology, land use, political boundaries, utilities, rural residences, and environmental resource data for planning and construction applications; and 3) GIS to CADD and FIS interface standards.

The GIS Functional User Requirements Document will be delivered upon completion of the users' needs assessment. System Specifications and Data Dictionary documents will be prepared in coordination with the SSCL. Phase II–GIS Implementation is planned to begin in FY 1992 for the priority GIS applications listed above, while other GIS operations are in development. GIS implementation is projected to continue through FY 1995, when most of the identified coverages and applications will have undergone quality assurance and control testing.

Phase III–GIS Operation and Maintenance

The PB/MK Geodetic Survey and GIS Department will provide effective transfer of GIS services in a timely manner to end users of the SSC–GIS. Quality Assurance and Quality Control programs are planned to ensure data integrity and correct operation and use of the GIS. The PB/MK GIS staff will assist the SSCL staff in operation and maintenance of the GIS during the transfer stage. Operation and maintenance procedures for GIS applications, base maps, thematic maps, and attribute data begin when QA/QC programs are in place for any particular GIS function. GIS Operation and Maintenance could begin as early as FY 1993 for critical applications such as construction management, base map updating, and CADD interface functions. Operation and maintenance tasks will be performed by the PB/MK GIS group until the SSCL is prepared to take over operation. GIS hardware, software, and database will be delivered in its entirety to the SSCL upon project completion.

The SSC–GIS is an evolving computer-based system that will interface with other technical application systems at PB/MK and the SSCL. However, GIS differs from many computer development projects in that as geographic information comes on-line, users can access the data in reference to other mapped features and can immediately perform spatial analysis. With planned implementation and end-user coordination, GIS can be used effectively during the early design and construction phases as well as in the installation, operation, and decommissioning phases of the SSC.

FACILITY INFORMATION SYSTEM (FIS)

The SSC FIS is an integrated repository for the vital component intelligence of the SSCL. The repository consists of information and related applications accumulated during five major lab life cycle phases by each division working independently in its own arena of responsibility. The information will be coordinated and integrated globally, supporting each participating division's access directly to its own subset of information, and indirectly to all other pertinent information lab-wide. Each participating division throughout all phases of the lab life cycle are able to update, use, and maintain the information for which it has responsibility.

As both conventional and technical systems components are designed, the information regarding each component is collected and stored electronically. The evolution represents a process of information collection and use that began during design of both conventional and technical systems and progresses through the phases of construction, installation, operation, and maintenance. At each phase, the "deliverable" is envisioned to be an electronic base of data resident on Intergraph hardware with other UNIX-based hardware support, accessible to participating groups and divisions through the use of Intergraph and other application software, and made available to the SSCL via Ethernet network and Intergraph workstations as well as PCs and Macintoshes.

Within the FIS database each component is guaranteed uniqueness so that pertinent information is uniquely retrievable for each component. An SSC working group is defining global identification of components. Every technical and conventional vital component will be assigned a global component identifier that will remain a part of the component for its duration of service to the Laboratory.

Figure 3 represents a sampling of applications identified as requirements for facility management. DESIGN DATA consists of all of the design information relevant to the selection and/or fabrication of the component. COMPONENT GEOMETRIC DEFINITIONS comprises the geometry of each component for a 3-D graphical display of its image on any CADD or graphical display system. OPERATIONAL CHARACTERISTICS is a set of significant information related to the operation of each functional component or system. This information could be used to determine the steady-state operating condition of any component compared to an abnormality or emergency condition. PROCUREMENT contains information and documentation relative to the procurement trail of events for each component. VENDOR SELECTION AND PERFORMANCE documents the selection trail for service and/or supply vendors. It is also a log of all vendors' performance history and comparison ratings for future selection criteria for each component. WAREHOUSING contains status information regarding the maintenance, repair, and storage of each component that is out of commission and/or in a storage redundancy state. When a magnet is removed and replaced by another, the removed magnet may be shipped for repair, at which time a new location set of coordinates would be assigned. Later, when warehoused, a ready state and new location would be assigned to the magnet. INSTALLATION SCHEDULING reflects any necessary data pertinent to installation procedures, problems, practices, and precautions for any component. A HAZARDOUS MATERIAL CLASSIFICATION is issued for each pertinent component containing hazardous material or having a potential of environmental contamination. The classification would be a secondary key that connects the GIS base of information for emergency response and environmental impact studies. MAINTENANCE SCHEDULING represents information relevant to the history of a component's maintenance, its maintenance records, and maintenance scheduling data necessary for scheduling and budgeting future preventive maintenance activities. It also would assist in coordinating routine preventive maintenance of different components in a congested area. OPERATING HISTORY contains information relative to the operational track record for each component and its expectations under various conditions. COMPONENT GEOGRAPHIC COORDINATES is a link to the GIS base of data and uniquely identifies each component and system with a global coordinate system location. Two coordinate systems currently exist for objects that are located either above or below the surface. DRAWINGS, DOCUMENTS, SPECIFICATIONS constitutes our lab-wide technical document control. Each component appears on one or more technical drawings and/or documents, or is referenced in specifications. The document control number for each reference to the component becomes an attribute of the component in the document control fields of the database.

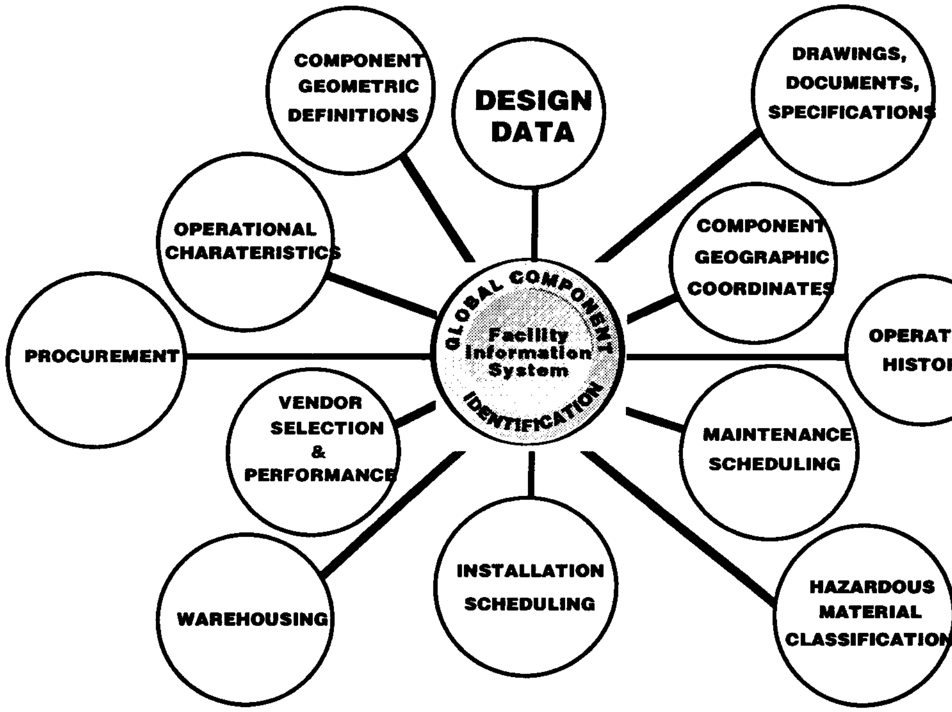

Figure 3. Required applications for Facility Management.

SUMMARY

Facility management for a project of the size and complexity of the SSCL is a challenging task. The Facility Information System/Geographic Information System (FIS/GIS) should provide an effective tool for the demanding work ahead. Both the FIS and GIS encompass information that many potential users across multiple disciplines will require for effective facility management. FIS will be integrated with the GIS for applications that involve duplicate needs of graphic and attribute data. In particular, infrastructure networks, environmental monitoring, emergency dispatching, and hazardous materials management have been identified as areas where the two systems will interface. In general, the GIS will manage graphic and attribute information outside the actual structure of the SSCL. The FIS will take over operation of components and networks within the SSCL facility. By providing a method for informed decision-making, implementation of the SSC FIS/GIS will facilitate the tasks involved in managing our Laboratory during all phases of its life.