SLAC MicroStation Geographics Study

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Background

The Stanford Linear Accelerator Center (SLAC) is a laboratory devoted to the study of particle physics and related fields. SLAC was established in 1962 and is located at Stanford University in California. The mission of SLAC is to design, construct and operate electron accelerators and related experimental facilities for use in synchrotron radiation research (photon science) and high-energy physics (particle physics). A Geographic Information System (GIS) has been proposed to organize survey measurements supporting this research.

SLAC is currently changing focus from particle physics research to photon science. The goal is to search for answers to the question of the fundamental structure of matter. Traditional particle accelerators are used to speed electrons and positrons through a tube or beamline to nearly the speed of light and study their collisions. Photon science focuses more on the structure of matter at the atomic and molecular scale using special x-ray radiation known as synchrotron light. This is intense focused radiation and is well suited for studies in biology, chemistry, biomedical and environmental science. SLAC's most recent photon science project, currently under construction, is known as the Linac Coherent Light Source (LCLS). It will be the world's first x-ray laser able to actually observe molecular and atomic interactions as they occur.

The Alignment Engineering Group (AEG) is responsible for a wide range of alignment and positioning activities at SLAC. Positioning of accelerator components using specialized equipment and data adjustment techniques is the core task of the group. Additionally, geodetic concerns related to the placement of larger structures are also a major task of the AEG. The scale and accuracy of these projects range from micrometer measurements of accelerator components to centimeter-level site wide positioning of new and existing structures. Large amounts of existing data and continuous generation of new data make the organization and retrieval of this information a challenging endeavor. To accomplish this in an efficient and accessible manner, a GIS has been considered.

A GIS for the Alignment Engineering Group requires high drawing accuracy. Since the scale of SLAC alignment tasks have such a wide range, the need to store survey data that is accurate to at least one micrometer while still allowing site-wide representation is paramount. The system chosen for these goals is a GIS platform based on a CAD system with a fine resolution.

After investigating various options for a GIS, the high resolution package known as MicroStation Geographics was considered. It is based on the MicroStation CAD platform with which SLAC is familiar. Members of the AEG visited a large organization that had successfully implemented this specific system. The Port of Long Beach in California maintains a large array of data including port buildings, utilities, cargo and more. The visit demonstrated the abilities of the GIS for accurately maintaining this large and diverse set of data. As SLAC holds full licenses for the program and it is compatible with existing SLAC drawings, a decision was made to go forward with a study of this GIS for a limited region of SLAC.

Project Description

The GIS for the AEG (known as AEGis) is initially focused on establishing a limited region base map. The base map is an accurate 2D representation of the site depicting buildings, roads, parking lots, landscape, select utilities and survey monuments. As the base map continues to be more fully established, accurate representations of actual beamline components or similar entities will be added.

As this base map serves as the point of reference for subsequent information, it is crucial that it has the highest level of accuracy. By simply tracing buildings and other features from orthophotos, the integrity of the base map would suffer. (Scale corrections due to geometric projections can be the most significant source of error.) It was thus decided to have only newly surveyed measurements serve as coordinate data for the base map since they are more accurate than tracing. The use of orthophoto tracings was minimal and restricted to drawing entities that are spatially non-critical such as certain landscape features.

Special GPS surveys known as RTK (Real-Time Kinematic) are combined with total station observations and are used for most outdoor structures. (Total stations are survey instruments that measure angles and distances) Indoor data is obtained from other equipment including laser trackers and laser scanners (laser-based survey instruments), as well as total stations, survey levels and more. Based on the CAD data, geographic features are built into the Geographics GIS system. These features are linked using associated database tables which have attributes specific to each object. The emphasis again is for highly accurate survey data to be used in this base map.

GIS Structures

The steps below summarize how the study of MicroStation Geographics for the SLAC loop road area (see Figure 1 and 2) has progressed so far. These steps eventually lead to a prototype GIS that is currently able to perform basic analysis including thematic mapping and topology analysis.

Project Steps

Determined:

1. The study area boundary
    - SLAC site's boundary
2. Coordinate system
    - Datum: NAD83
    - Projection: CCS83 Zone 3
    - Unit: Meter
3. Required Map layers
    - 6 types (buildings, parking lots, survey monuments, utilities, landscape, and hardscape)
4. Required data accuracy
    - buildings ~5cm, survey monuments ~1µm
5. Required features
    - real objects in layers on a map
6. Required database attributes
    - database table links and describe features
7. Data availability (CAD data, GeoTIFF, database attributes, etc.)
    - existing maps, orthophotos and attribute data which can be used for the project
8. The amount of spatial data that needs to be surveyed with GPS or total station and built from the survey data
    - critical features which are required with accuracy such as monuments, beamlines, and magnets
9. The amount of spatial data that needs to be digitized from orthophotos and hand-measured
    - features which may or may not be linked to database tables such as trees, planting beds, and pathways

After that, combined all data and built a base map (see **Base Map** section), cleaned topology, and imported into GIS for part of the project area. Also, created database attribute tables (see **Attributes** section).

Analyses Performed in GIS:

Thematic mapping (see **Thematic Mapping** section)
- categorizes feature types by colors

Topology analysis (see **Topology Analysis** section)
- examines relationships of features

Base Map

The base map was drawn from GPS, total station, hand-measured survey data and orthophotos (see Figures 1, 2 and 3). The map shows six layers for part of the SLAC site: buildings, parking, monuments, hardscape, landscape, and utilities. Further areas of SLAC will be included as part of the base map depending on the survey needs.

These layers have their own database attribute tables (see **Attributes** section). Some features were linked using associated database table rows, and more features will be linked in the future.

Figure 1 - Base Map

Figure 2 – Close-Up SLAC Loop Road

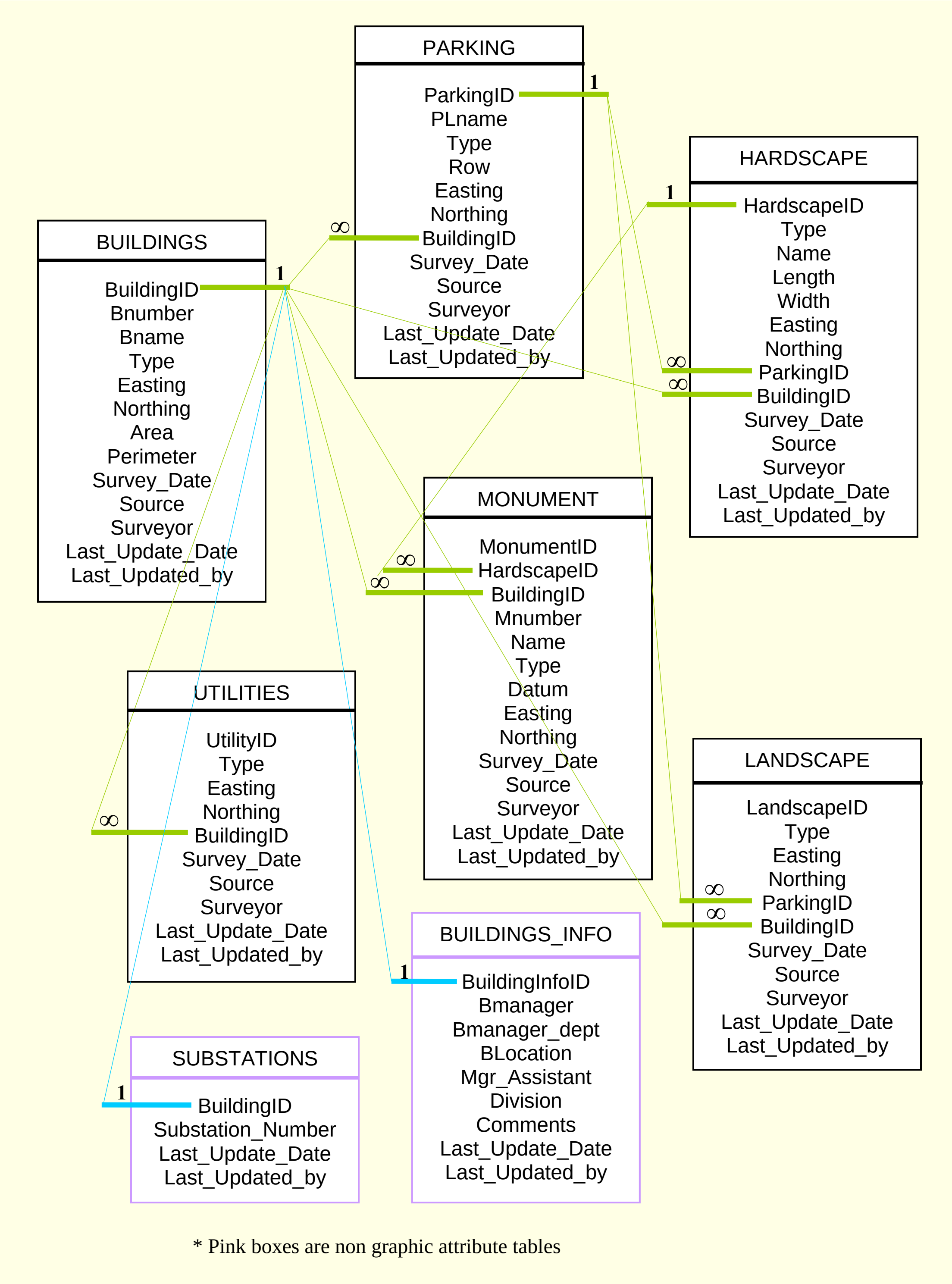
Figure 3 – Set of Orthophotos in 2001

* *This is a set of orthophotos covering the loop road at SLAC. The area is from 1848768 to 1849377 meters Easting and 603200 to 603657 meters Northing.*

Attributes

The project area's database has six attribute tables: BUILDINGS, HARDSCAPE, MONUMENTS, PARKING, LANDSCAPE, and UTILITIES. Figure 4 shows relationships of the database attribute tables.

Figure 4 - Entity Diagram



* Pink boxes are non graphic attribute tables

Figures 5, 6, and 7 show column descriptions for BUILDINGS, PARKING, and MONUMENTS attribute tables.

Figure 5 – Database Elements for BUILDINGS Table

Column Name	**Description**
BuildingID	Used to assign a unique ID number to every entry
Bnumber	SLAC building numbers
Bname	SLAC building names
Type	Buildings usages (office, laboratory, etc…)
Easting	X coordinate of SLAC buildings
Northing	Y coordinate of SLAC buildings
Area	Area of SLAC buildings
Perimeter	Perimeter of SLAC buildings
Survey_Date	Dates of survey
Source	GPS, Total Station, CAD, or Orthophotos
Surveyor	Person who made survey measurements
Last_Updated_Date	Latest spatial data updated dates (footprints)
Last_Updated_by	Latest person who did the update (footprint or others)

Figure 6 - Data Base Elements for PARKING Table

Column Name	**Description**
ParkingID	Used to assign a unique ID number to every entry
PLname	Parking lots’ names or numbers
Type	Parking spots’ usages (general, handicapped, etc…)
Row	Parking lot rows’ zoning
Easting	X coordinate of each parking spot
Northing	Y coordinate of each parking spot
Survey_Date	Dates of survey
Source	GPS, Total Station, CAD, or Orthophotos
Surveyor	Person who made survey measurements
Last_Updated_Date	Latest spatial data updated dates (footprints)
Last_Updated_by	Latest person who did the update (footprint or others)

Figure 7 - Data Base Elements for MONUMENTS Table

Column Name	**Description**
MonumentID	Used to assign a unique ID number to every entry
Mnumber	Control points' names or numbers
Type	Indicates temporary or permanent control points
Datum	Indicates control points' datums
Easting	X coordinate of each parking spot
Northing	Y coordinate of each parking spot
Elevation	Indicates control points' elevations
Survey_Date	Dates of survey
Source	GPS, Total Station, CAD, or Orthophotos
Surveyor	Person who made survey measurements
Last_Updated_Date	Latest spatial data updated dates (footprints)
Last_Updated_by	Latest person who did the update (footprint or others)

Figure 8 provides examples of BUILDINGS and PARKING attribute tables.

Figure 8a

Example of BUILDINGS Table

BuildingID	Bnumber	Bname	Type	Easting	Northing	Area	Perimeter
57	040	Central Laboratory - WAA 16	Laboratory	1849124	603314	2419.152	276.2457
58	040S	Central Lab Substation	Utility	1849092	603307	58.33714	30.8513
59	041	Administrative and Engineering	Office	1848988	603399	2294.061	210.7919
60	042	Cafeteria	Service	1849146	603395	419.0593	102.2849
61	042A	Breezeway	Service	1849143	603421	117.0621	45.48487
62	043	Auditorium	Service	1849140	603442	587.6604	107.4412
63	043A	Visitor Center	Service	1849134	603425	99.65098	42.50666
64	044	Test Laboratory - WAA 8	Laboratory	1849027	603329	3483.227	344.0185

Survey_Date	Source	Surveyor	Last_Update_Date	Last_Updated_by
3/22/2006	TS/GPS	Banuelos	6/28/2006	Banuelos
3/22/2006	TS/GPS	Banuelos	6/28/2006	Banuelos
5/2/2006	TS/GPS	Banuelos	6/28/2006	Banuelos
5/1/2006	TS/GPS	Banuelos	6/28/2006	Banuelos
5/1/2006	TS/GPS	Banuelos	6/28/2006	Banuelos
5/1/2006	TS/GPS	Banuelos	6/28/2006	Banuelos
5/1/2006	TS/GPS	Banuelos	6/28/2006	Banuelos
5/2/2006	TS/GPS	Banuelos	6/28/2006	Banuelos

Figure 8b

Example of PARKING Table

ParkingID	PLname	Type	Row	Easting	Northing	Survey_Date
215	G	Bicycle	11	1848816	603314	4/4/2006
216	G	Cart	11	1848818	603321	4/4/2006
217	G	Handicap	11	1848821	603326	4/4/2006
218	G	Hcaccess	11	1848823	603332	4/4/2006
219	H	General	12	1848843	603345	4/4/2006
220	H	General	12	1848849	603346	4/4/2006
221	H	General	12	1848855	603347	4/4/2006
222	H	General	12	1848862	603348	4/4/2006

Source	Surveyor	Last_Update_Date	Last_Updated_by
GPS	Banuelos	5/2/2006	Matias
GPS	Banuelos	5/2/2006	Matias
GPS	Banuelos	5/2/2006	Matias
Count	Banuelos	5/2/2006	Matias
Combined	Banuelos	5/15/2006	Matias
Combined	Banuelos	5/15/2006	Matias
Combined	Banuelos	5/15/2006	Matias
Combined	Banuelos	5/15/2006	Matias

Thematic Mapping

Figures 9, 10 and 11 show a particular thematic mapping function with building and parking spot types categorized by colors. Thematic mapping will be used in the future for survey and alignment related studies. For example, magnet types and magnet fiducialization data will be incorporated into the GIS.

Figure 9 –Thematic Mapping

Building Types

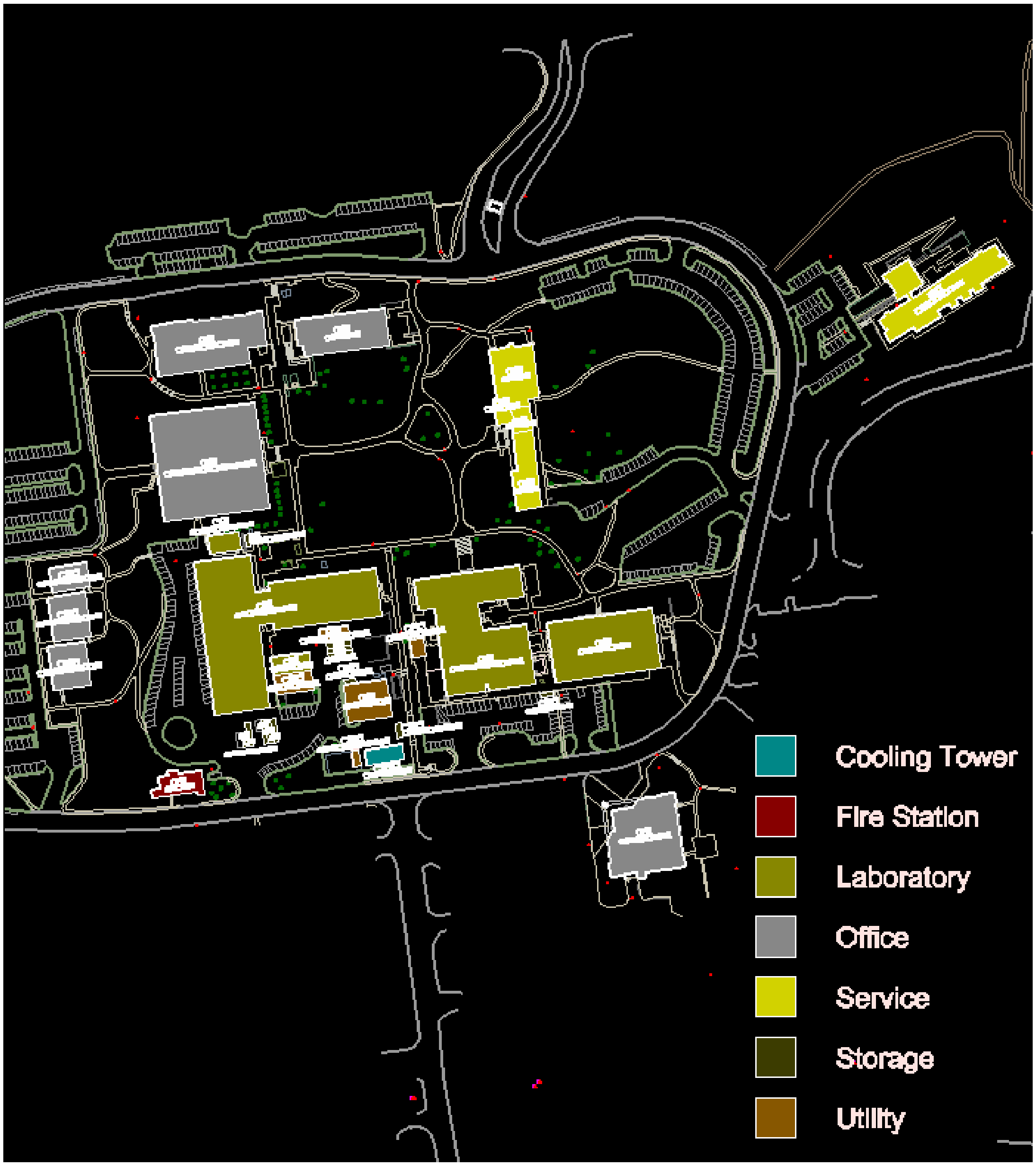
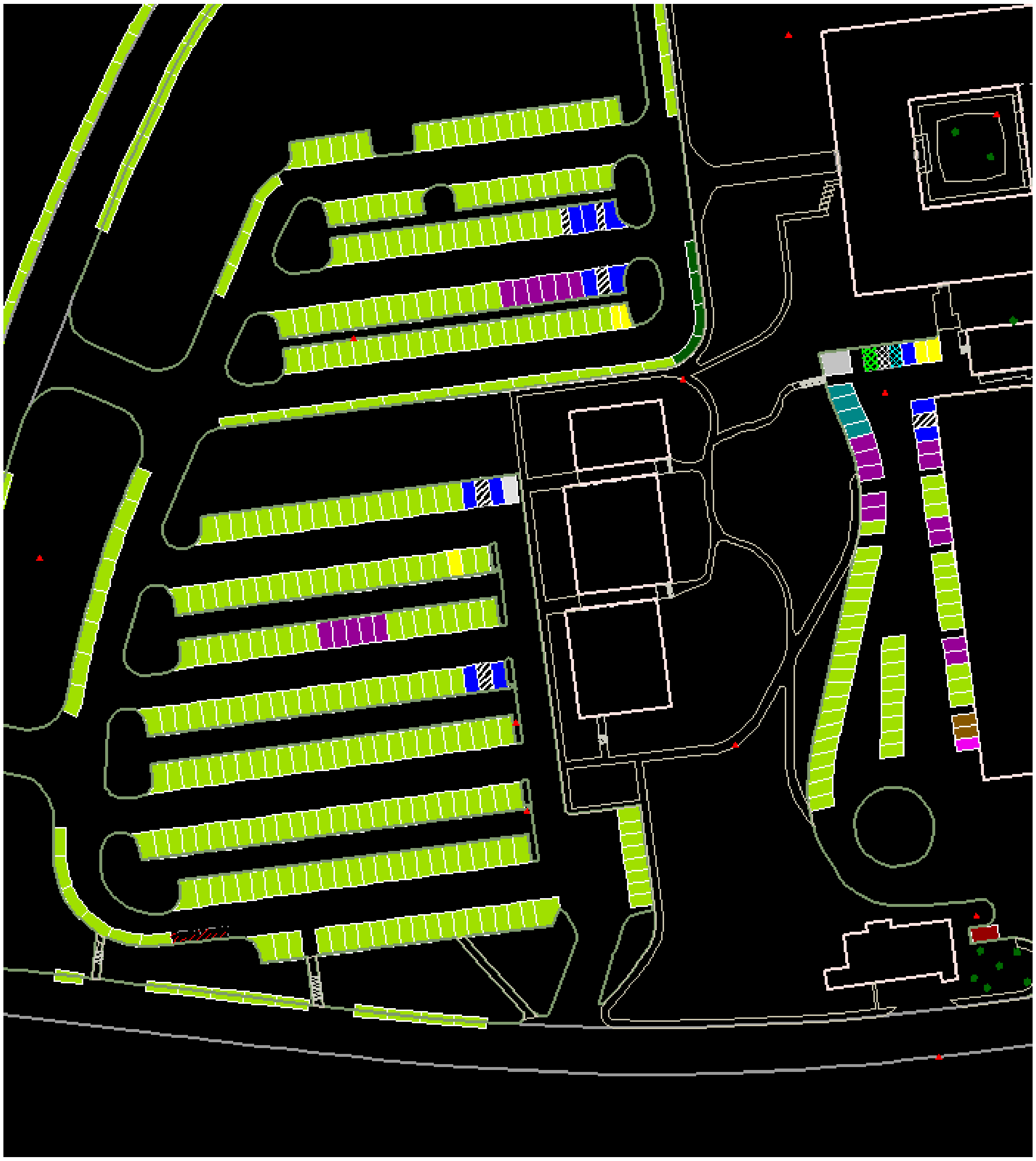


Figure 10 –Thematic Mapping

Parking Spot Types

Figure 11–Thematic Mapping

Parking Spot Types (Close Up)



Topology Analysis

This topology analysis function is an example performed to indicate nearest parking spots from a specified building or buildings. Figure 12 shows highlighted blue and white parking spots that are within 100m of the Auditorium, which is highlighted in yellow.

Topology layer functions will eventually be used for beamline queries. For example, topology functions could be used to determine all beamline components near a particular magnet and quickly generate a summary of all the survey data for each.

Figure 12 –Topology Analysis

** Blue and white parking spots are within 100m of the auditorium.*

Conclusion

This report provided some background and details on this first GIS feasibly study by the Alignment Engineering Group. It demonstrated a learning example of a GIS and is moving towards a specialized alignment-based GIS. Survey monument information is the first part of this transition while the largest transition will be the inclusion of beamline data into the final system.