

The Modernization of a Trigonometric Coordinate List

(a dynamic web-based approach)

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By

Harry C. Martin

Department of Civil and Environmental Engineering and Geodetic Science

The Ohio State University

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Approved by

Dr. Bill Hazelton

Advisor

Geomatics Engineering

Abstract

This report provides a description of the design and implementation of a dynamic, web-based Trigonometric Coordinate List (Trig List) for the University Engineer's Office, The Ohio State University. Traditionally, a Trig List publishes pertinent monument data, such as Northings, Eastings, elevations and corresponding datums, along with text based point recovery information. This modernized Trig List, aside from publishing the traditional monument data, will also provide non-traditional data and detailed station recovery notes. Non-traditional data items include intervisibility between points and GPS availability if known. Station Recovery Notes will include site sketches, vicinity maps, and annotated digital photographs. Textural data input into the system and all data retrieval from the system will be accomplished through a web browser, versus the traditional database approach. This approach was selected due to its widespread availability and the small learning curve required of its users. By providing a user-friendly and well-known interface, it is anticipated that the Modernized Trig List will be utilized frequently, thus solidifying its own longevity. Through use, and subsequent refinement, the web-based system is proving to be an excellent platform for data distribution and maintenance. One positive unpredicted side effect is the ability to utilize the system as a management and planning tool for the maintenance and future densification of the Campus Control Network.

To my loving wife and children,
thank you for your patience and understanding.

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Introduction

The main focus of this project was to design, develop and implement an interactive, fully dynamic, web-based Trigonometric Coordinate List (Trig List), complete with up-to-date Station Recovery Notes, for the University Engineer's Office, The Ohio State University. This project was born out of necessity, as the previous Trig List was a hardcopy printout of a long since malfunctioning database system. This fact, coupled with years of handwritten notes and a countless number of disturbed or destroyed monuments (both known and unknown), has necessitated an overhaul/redesign of the existing system.

The web-based system is designed to accept not only new point data, but also revisions to existing point data, all from a single interface point. The system also has the capability to allow the user to remove point data from the active data tables when monuments become disturbed or destroyed. Once new or revised point data have been entered into the system, the corresponding feature pages are automatically updated through dynamic database links. Point data, or monument information, can be accessed from two different areas within the system. The first access point is a textual list categorized by type of point and installing agency (Figure 1). The second access point is through an interactive map of the Columbus Campus showing the layout and type of monumentation (Figure 2). Monument symbols on the interactive map are selectable features, and are hot-linked to their respective Station Recovery Notes (Figures A1 and A2, Appendix A).

Select Point to View Station Recovery Notes					
PK's		Iron Pins		"X" marks	
Point Name	Alias	Point Name	Alias	Point Name	Alias
PK001	PK97 MERSHN-5	IP001	IP25 COLINT17	X001	X51 BROWN-X2
PK002	PK16 HAML TR-1	IP002	IP52 SCENEBR	X002	X48 BROWN-X3
		IP003	IP44 ARPSHAL1	X003	X50 LORDHALX
		IP004	IP46 COLINT18	X004	X53 OVALMH-S
		IP005	IP26 COLINT19		
		IP006	IP43 MERSHON		
		IP007	IP107 MONORS-N		
		IP008	IP106 ENARGNES		
		IP010	IP119 COLINT12		
		IP011	IP62 UNIONLAW		
		IP012	IP83 SE-LAW		
		IP013	IP84 SW-LAW		
		IP014	IP75 HIGHLAND		
BM's		County Monuments			
Point Name	Alias	Point Name	Alias		
BM001	BM H20	ASTOR			
BM002	FH COLLEGE18TH	DEM 1991	CFMKNRD		
BM003	SA0843MH	CFMPARK			
BM004	SD0057CB	CONNOR			
		COROTA			
		CLASPOLE			
		LANE			
		LATSTONE			
		LINCOLN			
		MORRILL			
		MORRILL			
		MURPHY			

Figure 1. Layout and organization of the Station Recovery Notes access page. Monument ID's, in blue, are hot links.

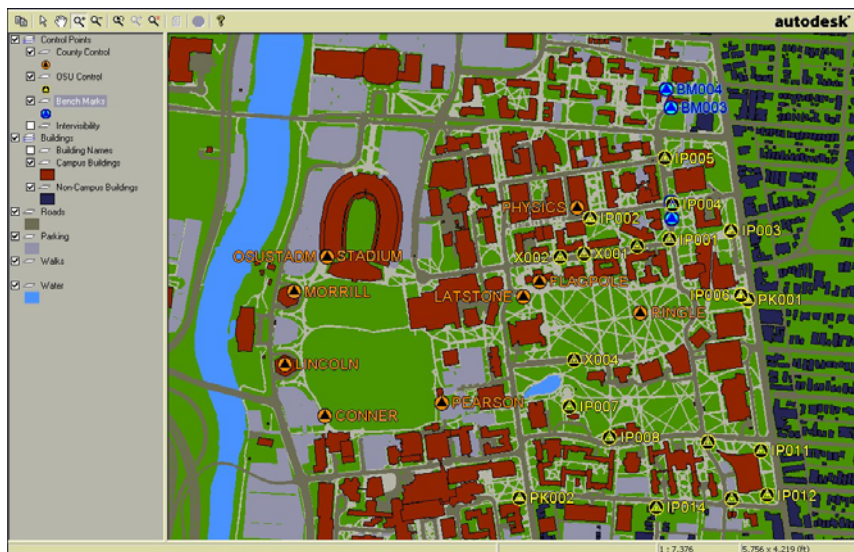


Figure 2. Image depicts a typical zoomed in section of the interactive control point map. Note the different types of symbols and monument ID's, each is hot linked to their respective Station Recovery Notes page.

Key elements considered in the creation and applications of the web-based system were: maintainability of the data, data integrity, security of the data, and deliverables. Each element was required to adhere to the University Engineer's Office protocol for data dissemination. The caveat to the system was that it had to operate within the existing framework of software currently licensed and operating within the University Engineer's Office.

Another element of the project was to provide meaningful and up-to-date Station Recovery Notes (Figure A1, Appendix A). The recovery notes were designed to provide both traditional and non-traditional information. Traditional information included three plus point resection notes and detailed site drawings that enable a user to locate the monument based on directions and distances. Non-traditional information includes digital photos of each point and the surrounding area for orientation purposes, as-well-as information about the use of the point. Usage information encompasses the availability of GPS signals at the point and intervisibility to other monuments. Combining all of this information into a single document provides the user with all pertinent point data from a single source; in-turn, minimizing the amount of time spent researching monument data.

Literature Review

Since this is a web-based project, the best place to begin looking for information and similar projects was on the Internet. In fact, the Internet was the primary source of existing documentation, as no hardcopy text of any use could be found. Various attempts with different search strings eventually yielded several sites that contained control point information. Several sites were found to contain station recovery notes, interactive maps and other information relative to this project. Upon further review, these sites provided insight into the types of information being published, as well as publication methods (static vs. dynamic).

The first area to be studied was how station recovery notes for individual monuments were searched for, and what type of information was contained in the notes. Generally a map was used to indicate monument locations and the symbols were used to access the recovery notes. A few sites enabled the user to access recovery notes by typing in the name of the monument. Once the recovery notes were accessed, the information displayed was generally the same for each site. Typical recovery note information included latitude and longitude, elevation, a brief description of the monument, and location and reference points to the monument. The main differences between sites was related to layout and readability issues. Only a handful of sites provided a sketch of the monument and its reference marks. The sketches ranged from being a scanned freehand drawing to an actual CAD drawing of the area. An even smaller number of sites provided pictures of the point and/or a picture of the point and the surrounding area.

When accessing recovery notes, they were typically provided in the form of a PDF file, scanned document (raster/bitmap) or hard-coded directly onto the web page. The PDF's

were generally the best looking and took less time to load. The PDF's also allowed the user to save or print the sheets. The bitmap files were a little large and took some time to load, and in the end they did not provide the same professional look as the PDF's. The sites where the notes were shown adjacent to the map provided a nice visual appearance, but they were difficult to print as the web page was not designed with constraints aimed at printing. Overall, a number of good ideas were gleaned from these websites and incorporated into this project.

The second area of study focused on the maps that depicted monument locations. The most basic map used was a JPEG image showing the overall area, which contained monument symbols that were hot-linked to the respective recovery notes pages. Consequently, both the map and the recovery notes were comprised of static data. As the maps became more advanced, the user was able to zoom in on an area and select a point to view its station recovery notes. The most advanced sites provided interactive maps. These sites were generally published by a County and were tied directly into their respective GIS. These maps enabled the user to not only view the monuments, but various other features as well through the use of layers. For this project, the interactive maps proved to be the most useful resource in determining what types of information to display and how.

The final area of study focused on how information is added and/or updated. Not surprisingly, none of the sites that were visited gave any indication of the editing capabilities, if they existed. Most of the sites seemed to provide only static data. This meant if a change needed to be made, the entire sheet would have to be manually changed and loaded back into the system. This is a far more labor-intensive process than one built around a dynamic data structure. Some sites were known to contain static data due to the presence of scanned images, while other sites were only presumed to contain static data. The presumption of static data came from viewing the source codes

and looking at the address lines to see if any variables were being passed from page-to-page.

After searching a number of websites containing station recovery notes, a list of pros and cons was made. This list was centered on the three main areas of interest as previously discussed, and provided the basic guidelines for what to include in this system. The preliminary study laid the groundwork for how the data were to be accessed and published (static vs. dynamic), and was a major factor in determining how to publish a monument ID/location map.

Theoretical Planning and Development

As stated previously, all programming and database structures were required to adhere to the existing software framework currently utilized by the University Engineer's Office (UEO). The main software programs of note are: Macromedia Dreamweaver, Oracle, AutoCAD, AutoDesk MapGuide, TOAD, and Adobe Photoshop Elements. These programs comprise the basic software pallet for the web-based Trigonometric Coordinate List (Trig List). Another requirement, this time self-imposed, is that the data and its outputs be compatible with other enterprises currently operating in or being developed for UEO. Utilizing the aforementioned programs helps to ensure seamless compatibility with existing data and program structures.

Realizing from the outset the important role survey data, and consequently survey monumentation, plays in a Geographic Information System (GIS), it was decided to integrate the web-based Trig List into the GIS currently being developed by UEO. Utilizing Oracle as the database engine, layout and design for the data tables could begin. Data table content was initially based upon other published Trig Lists, such as the one published by the Franklin County Engineer's Office. In addition, other pertinent local data were to be stored for the convenience of the personnel within the Mapping and Surveying Office. Local data consisted of: GPS availability, intervisibility between points, and Campus Quad numbers where monuments are located.

Prior to generating data tables and fields, a data standard needed to be identified. Again, being a facet of the UEO departmental GIS, the only true recourse was to utilize the same standards. Therefore, The Spatial Data Standards for Facilities, Infrastructure, and Environment (SDSFIE) were used. SDSFIE are standards for graphic and non-graphic

GIS implementations within the Department of Defense. The reason SDSFIE was chosen as the data standard is that it is the only "nonproprietary" GIS data content standard designed for use with the predominant commercially available off-the-shelf GIS, CADD and relational database software. SDSFIE is more compatible with the University environment because it provides structure in areas that other commercially available standards do not. These areas include survey monumentation and extended utility distribution systems, both of which are vital to University infrastructure management. In this manner, SDSFIE provides a far more robust and flexible data standards solution.

SDSFIE, however, does not include guidelines for photo storage and archival measures; therefore, a secondary standard was created to address this need. Each monument was to receive a photo, sketch and vicinity map, each stored as individual JPEG's. A single standard was created and applied to archive files for each monument. In an effort to keep file naming simple, a prefix of p_, s_, and v_ were added to the monument ID; standing for photo, sketch and vicinity map, respectively. The original files are archived in separate folders based on point ID, while working copies of the originals are stored in a single folder for use on the web server.

The creation of electronic drawings to include layering, line types, and text is governed by existing office standards. The only deviation from these standards came in the form of file naming and storage guidelines. These deviations are necessary as the data and file usage are not compatible with the intent of the original standards. The guidelines for these deviations mimic those created for photo storage.

With the areas of data creation, file naming, storage, and archival procedures now covered by standards and procedures, the last main category of interest is security. Effective security is quite possibly the most challenging portion of any web-based documentation. Initially, the security is set up to allow only specific I.P. addresses to

access the system. A user must be accessing the system from one of three specific addresses within the University Engineer's Office subnet. This security allows access for both viewing and editing purposes. Since data editing itself is restricted to three individuals within the office, the safest measure was to limit this type of access to their specific workstations.

Beyond editing access, the security measures allow view only access to specified personnel. As of the writing of this report, the administration has limited data access to individuals within the University Engineer's Office, and certain others within the Department of Physical Facilities. Again, front line access is granted based on I.P. address, which must be within the specified subnet range stored in the security data table. After passing the initial security protocol, individuals must provide a user name and password to gain viewing access to the data. Since web security is an ever-changing environment, modifications to the security measures will be reviewed frequently and changed accordingly as required. As a consequence, a 'hard-and-fast' rule/standard for security management cannot be implemented.

Experimental Details and Results

With the initial concepts for layout and design of the data structure in place, creating the initial version of the dynamic web pages was the next step. The approach was to generate an html page that would show the required information in the order and format needed. Once this was accomplished, and the page was functioning properly, the page could then be edited for aesthetics.

Initial problems in generating html pages came in the form of screen resolution. Creating a page that gave the desired layout and appearance on one monitor did not produce the same results on another. Since practicality precluded a design for all possibilities of monitors and resolution settings, it was determined that the design should fit those stations, operating within the department, which comprised the primary access points. Therefore, a common size was established, based on the three editing workstations, to provide the best overall appearance on those monitors, while still maintaining an acceptable overall appearance elsewhere.

Entering data via a web interface to populate data fields is a straightforward process. The only caveat to this statement is capitalization of text. Data is entered into the database exactly as the user types it in. As was discovered in testing, inconsistent capitalization can manifest itself into a number of problems. Since database protocols do not consider capital and lowercase representations of the same character as the same entity, null values are returned from search strings on existing data. To counteract this problem, a character manipulation function was added to the insert statement. This function automatically capitalizes text in all data input fields, except for descriptions

and narratives, prior to storing the entries in the data tables. Therefore, text is always stored and reported in the same manner, regardless of entry method, eliminating potential searching or linking problems in the future.

Another aspect of data representation that caused problems was printing. Screen resolutions allowed more data to be displayed on the screen than could be printed on a single page. Two solutions to the problem were developed; 1) – write the appropriate code that would change the layout and size of the information to fit on standard letter size paper when the print option was selected, and 2) – reformat the entire page based on print size rather than screen resolution. It was decided to use the second method, but restrict its use to specific pages. Reformatting was applied to only those pages that are intended for printing (i.e., station recovery notes), so that the printed representations yielded the desired results.

Photographic guidelines on taking, storing, and publishing digital photos required a considerable amount of trial and error. Photos of each point are taken at each of the four cardinal directions. However, in some instances, photos are taken at other directions depending on field conditions and field crew preference. The driving force behind photo direction is orientation and information. That is to say a determination is made, on a case-by-case basis, as to which photo direction will best orientate the user to the site by providing the most useful information, in an effort to facilitate station recovery. In reality, this decision is one of personal preference and opinion. However, every effort has been made to remain consistent throughout the photo selection process.

Preliminary test photos also indicated the need for annotation. Unless the user has intimate knowledge of the Campus environment, small photos would be too ambiguous and of little use. To correct for this, monuments are identified in the photos with arrows, while roads and prominent buildings are annotated with text (Figure 3). Other photo



Figure 3. Annotations on a typical Station Recovery Notes photograph.

annotations include date of photo (month and year) and the direction the photo was taken. The amount and size of annotations are kept to a minimum, so as not to obscure the scene. To further aid the user, a photo symbol is added to the recovery notes sketch indicating the approximate position and direction of the camera (Figure 4).

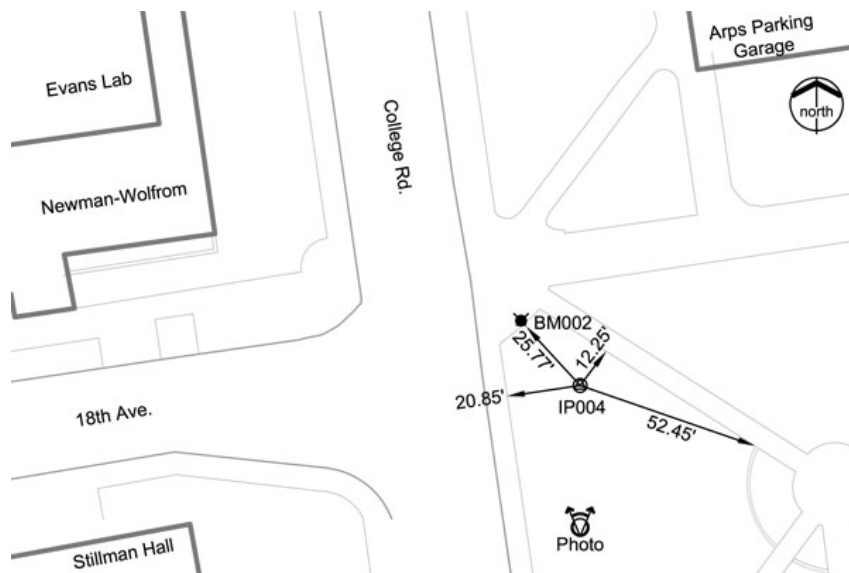


Figure 4. Typical Station Recovery Notes sketch. Note the photo symbol near the bottom right, indicating the approximate position and orientation of the camera.

Another aspect of digital photography is resolution. Again, through a trial and error process, a method for resolution was established. Resolution differs between the taking and storing of a photo and its html representation. Photos are taken and stored at a resolution of 300 dpi to capture as many details as possible for inventory and archival purposes. From these photos, one is selected for web display and stored at 100 dpi. This exceeds the standard 72 dpi normally used in web applications. However, an even factor of 100 allows for easier computations when determining sizes, as photos are required to fit into specific-sized windows on the reporting screens for printing purposes.

With the data creation/insertion problems resolved, it now came time to test the editing portion of the site. Initially the system ran smoothly, until it was realized that the possibility existed to associate existing data to points/monuments that were not present in the database. This was most evident when working with intervisibility. Due to the database structure, it was possible to enter intervisibility between an existing point and an imaginary point not in the system. This problem was solved with a data constraint that requires a search on existing point names, to validate intervisibility end points, as a prerequisite to committing updates to the database.

The final portion of the system is the interactive map (Figure A2, Appendix A). This project utilizes AutoDesk MapGuide as the interface to link database entries to the electronic map. This dynamic linking process is what produces the interactive map. In general, the application is a straightforward process. However, MapGuide requires symbol locations to be read in as Lat/Long values, and the existing database stores location values as Northings and Eastings (feet). In an effort to circumvent this problem, a method of obtaining and storing Latitude and Longitude had to be found. Keeping in mind that an underlying premise of the system is automation, manually calculating Latitudes and Longitudes was out of the question.

The solution was to write a conversion/transformation routine. This routine was written as a Cold Fusion trigger and embedded into the code that populates the data tables. The trigger is activated whenever a point is inserted or updated in the data tables. The trigger automatically calculates the Lat/Long of a point and stores the corresponding values in the appropriate cells. The calculated Latitude and Longitude are not published formally; they are only used as insertion points in MapGuide. This automated process allows the premise of a single point interface to remain intact, while providing the interactive map with the required data.

The interactive map has presented one problem that has yet to be fully resolved at this time. The map viewer is a plug-in that uses ActiveX controls and is easily downloaded from the AutoDesk website. The system automatically prompts the user to download the viewer if it is not currently installed. The problem is that popup blockers on some workstations prevent the user from doing this. If the user has full administrative rights to the workstation, this problem can be overcome with minimal effort. However, if the user does not have full admin rights the problem will persist. At this point in time, a single fix solution is not evident. This is mainly due to the different operating systems available and compounded with the different 'patches', which may or may not be installed on individual workstations.

Discussion

The two main goals of designing and implementing this web-based Trigonometric Coordinate List were: 1) – provide the user with all pertinent/relevant monument data, and a means of locating the monument in the field; and 2) – make the system easy to use, provide the most up-to-date information as possible, and ensure the longevity of the system.

Keeping these goals in mind, the decision was made to make the system dynamic and to automate as many processes as possible. Making the data dynamic solves two problems: 1) – it eliminates the need to create static pages of information that would require updating in the future as the Campus evolves; and 2) – the dynamic structure ensures that only the most up-to-date information available is being accessed. The automation of various processes allows the user to enter data from a single point source, and reduces data entry time and errors. Automation also helps ensure that steps and procedures within the data entry process are not overlooked.

The web pages are deemed dynamic because none of the point specific data resides in the html code. Rather, a Cold Fusion code either recalls or inserts data into the database. This event occurs each time a page is accessed or refreshed. An example of a dynamic page is the Station Recovery Notes page (Figure A1, Appendix A). The basic form and layout of the page appear in the html code, as well as the headings (bold text), because they are the same for every point. Point specific data (regular text and photos) reside in the code as variables, and are read in directly from the database. Because of this

dynamic structure, only one page is required to be built and maintained. This approach saves programming time and valuable server space, and also provides the user with the most up-to-date data possible.

The automation of processes occurs when the Cold Fusion code performs tasks in the background, without the expressed knowledge of, or input from the user. One example of this is the file naming and path generation for the JPEG's used in the Station Recovery Notes. Three JPEG's are created for each point; photo, sketch and vicinity map. When entering data, all that is required of the user is to input a valid monument name/ID. During the processing of the data, the Cold Fusion code automatically creates a filename and generates a path, then stores the data in the correct fields in the data tables (Figure 5). This automated process alleviates the need for the user to remember and type file paths and generate new file names, thus eliminating user errors.

MONUMNT_PATH	SKETCH_PATH	VICINITY_PATH	PHOTO_PATH
IP001	CONTROL/S_IP001.jpg	CONTROL/V_IP001.jpg	CONTROL/P_IP001.jpg
IP002	CONTROL/S_IP002.jpg	CONTROL/V_IP002.jpg	CONTROL/P_IP002.jpg
IP003	CONTROL/S_IP003.jpg	CONTROL/V_IP003.jpg	CONTROL/P_IP003.jpg
IP004	CONTROL/S_IP004.jpg	CONTROL/V_IP004.jpg	CONTROL/P_IP004.jpg
IP005	CONTROL/S_IP005.jpg	CONTROL/V_IP005.jpg	CONTROL/P_IP005.jpg
IP006	CONTROL/S_IP006.jpg	CONTROL/V_IP006.jpg	CONTROL/P_IP006.jpg
IP007	CONTROL/S_IP007.jpg	CONTROL/V_IP007.jpg	CONTROL/P_IP007.jpg
IP008	CONTROL/S_IP008.jpg	CONTROL/V_IP008.jpg	CONTROL/P_IP008.jpg
IP010	CONTROL/S_IP010.jpg	CONTROL/V_IP010.jpg	CONTROL/P_IP010.jpg
IP011	CONTROL/S_IP011.jpg	CONTROL/V_IP011.jpg	CONTROL/P_IP011.jpg
IP012	CONTROL/S_IP012.jpg	CONTROL/V_IP012.jpg	CONTROL/P_IP012.jpg
IP013	CONTROL/S_IP013.jpg	CONTROL/V_IP013.jpg	CONTROL/P_IP013.jpg
IP014	CONTROL/S_IP014.jpg	CONTROL/V_IP014.jpg	CONTROL/P_IP014.jpg
LANE	CONTROL/S_LANE.jpg	CONTROL/V_LANE.jpg	CONTROL/P_LANE.jpg
LATSTONE	CONTROL/S_LATSTONE.jpg	CONTROL/V_LATSTONE.jpg	CONTROL/P_LATSTONE.jpg
LINCOLN	CONTROL/S_LINCOLN.jpg	CONTROL/V_LINCOLN.jpg	CONTROL/P_LINCOLN.jpg
MORRILL	CONTROL/S_MORRILL.jpg	CONTROL/V_MORRILL.jpg	CONTROL/P_MORRILL.jpg

Figure 5. A partial view of the data tables showing the file names and paths of images used in the system. Monument ID is based on user input; all other fields are automatically generated by the Cold Fusion code.

Working with dynamic data and automated processes requires special consideration be given to how the data will be accessed and stored. In this system each record is keyed on, or linked by, its monument ID. The monument ID was chosen because it is common to all data tables, and it is the one piece of information about a point that will never change or be duplicated. When data is inserted or recalled from fields in the database, the monument ID is the key that determines in which cells the action will take place. The monument ID is also the variable that gets passed from one html page to the next so that viewing and editing options for a particular point are displayed properly (Figure A3, Appendix A). This singular key field identifier aids in data integrity and is an essential component in data organization.

Another key ingredient in ensuring data integrity and organization is the introduction of and adherence to a robust standard. Implementing a data standard not only accomplishes these tasks, but also allows for a more seamless transfer when exporting data to other sources. The standard for this project was borrowed from the Spatial Data Standards for Facilities, Infrastructure, and Environment (SDSFIE). SDSFIE are Department of Defense standards for graphic and non-graphic GIS implementations. The proven track record of these standards in government organizations, public utilities, and private industry make them the best fit for the University environment.

The implementation of a project such as this must also take other factors into account, aside from those required to generate the data. The economic and sustainability factors notwithstanding, one must also consider the ethical and social/political factors involved. The economic factors involved are not limited to the upfront costs of creating and maintaining a project such as this, but should also consider the potential cost savings that the system will provide. Upfront costs should include any hardware and software upgrades required, plus the programming costs involved. This project was completed using available software and hardware, so the only upfront costs are related to hours spent developing the system. With the initial costs calculated, an estimate on cost

savings must be made to complete the overall economic picture. One consideration is the potential costs of station recovery on ill-represented notes vs. accurately detailed notes, photos, and maps. Another consideration is duplication of effort. Since the data is dynamic, the most up-to-date information is always available, not sitting unused until the next publication date. When potential savings on lost time are considered, initial costs can quickly be amortized, and a project of this nature can quickly pay for itself.

Sustainability issues flow directly from the economics of the project. The system must remain viable over time to make the investment a worthwhile process. The ease of use of this system, coupled with the way in which the data is presented, will help to ensure its longevity by providing a commonly used interface with a minimal learning curve. Other sustainability issues include the format in which the data is presented and the software that created the data. Being web-based is an advantage for this system as more and more programs and data sources are moving in that direction, a trend that is projected to continue well into the future. Another positive sustainability aspect is the software that was used in the creation of the system. Each individual software component comes from an industry standard/leader. For this application the backbone programs were Oracle and AutoDesk, both of which enjoy large market shares in their respective disciplines and are not likely to be phased out or become unsupported in the foreseeable future. Therefore, based on its design and use, this project should enjoy a long and productive lifespan.

When presenting data, either web-based or hardcopy, ethical questions always arise. Is this data correct? Are we providing an honest representation of the data? Who is using the data and for what purposes? These are the types of questions that must be considered when providing others with geographically-referenced data, either formally or informally. This system answers these questions by timeliness of delivery and by access to the data. A direct result of designing a dynamic system allows access to the most accurate and up-to-date data possible at all times. The security imposed on

accessing the data ensures that only those individuals/institutions cleared to view the data have access. Controlling access to the system helps to ensure that the data is being used in a manner consistent with its design and intent.

While functioning mainly as an in-house product for the University Engineer's Office, this system has benefits outside of its predominant user group. It can be used as a marketing tool with other departments and institutions due the ease in which data can be viewed and shared across 'political' boundaries. Being a part of a larger GIS, the system is a good public relations tool, showing the functionality and capabilities of its owners to potential users, clients and investors.

Conclusions and Recommendations

Being born out of necessity, this modernized Trigonometric Coordinate List had two main objectives: to provide the user with all pertinent/relevant monument data, and a means of recovering monuments; make the system easy to use, and provide the most up-to-date information as possible. Based on these criteria alone, the system is proving to be quite beneficial. It is providing all pertinent monument data in a straightforward and accurate manner from a single point source, thereby proving to be an excellent platform for this task.

Aside from achieving the main goals, the system has provided some beneficial side effects. With the addition of the interactive map, the system has the unanticipated capability of being used as a management and planning tool. The interactive map shows monument locations and intervisibility through the use of layer tools. By simply analyzing these two layers, two things can be readily accomplished: 1) – plan for the layout and integration of future utility and topographic surveys, based on existing monumentation; and 2) – conceptualize the placement of new monuments for the densification of the control network, based on maximizing usability of any given point through intervisibility relationships. This aspect provides the field survey crew the ability to be more proactive in monument placement and potentially reduces the number of control surveys needed to perform daily surveying tasks.

After subsequent use and refinement of the system, two main areas of recommendations can be made on ActiveX controls and platforms. This system utilizes MapGuide to publish an interactive map. MapGuide requires an ActiveX plug-in that can cause problems on workstations where full administrative rights are not available to the user.

There are other choices in software that can be made; however, those that do not employ ActiveX controls are not as robust. If the reduced functionality is not an issue in an application, this certainly may be an avenue worth pursuing.

Deciding on which platform to design a web-based system must be given careful consideration. This system was designed for use with Internet Explorer (IE) exclusively. This decision was made based primarily on the widespread use and availability of IE throughout the department where it is being used. Due to time constraints, and programming resources at hand, it was not feasible to design a system capable of crossing platforms. To accomplish this would have restricted the functionality of the code and hampered the efforts to publish an aesthetically pleasing page. However, if a cross platform system is needed, it most certainly can be accomplished.

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Appendix A

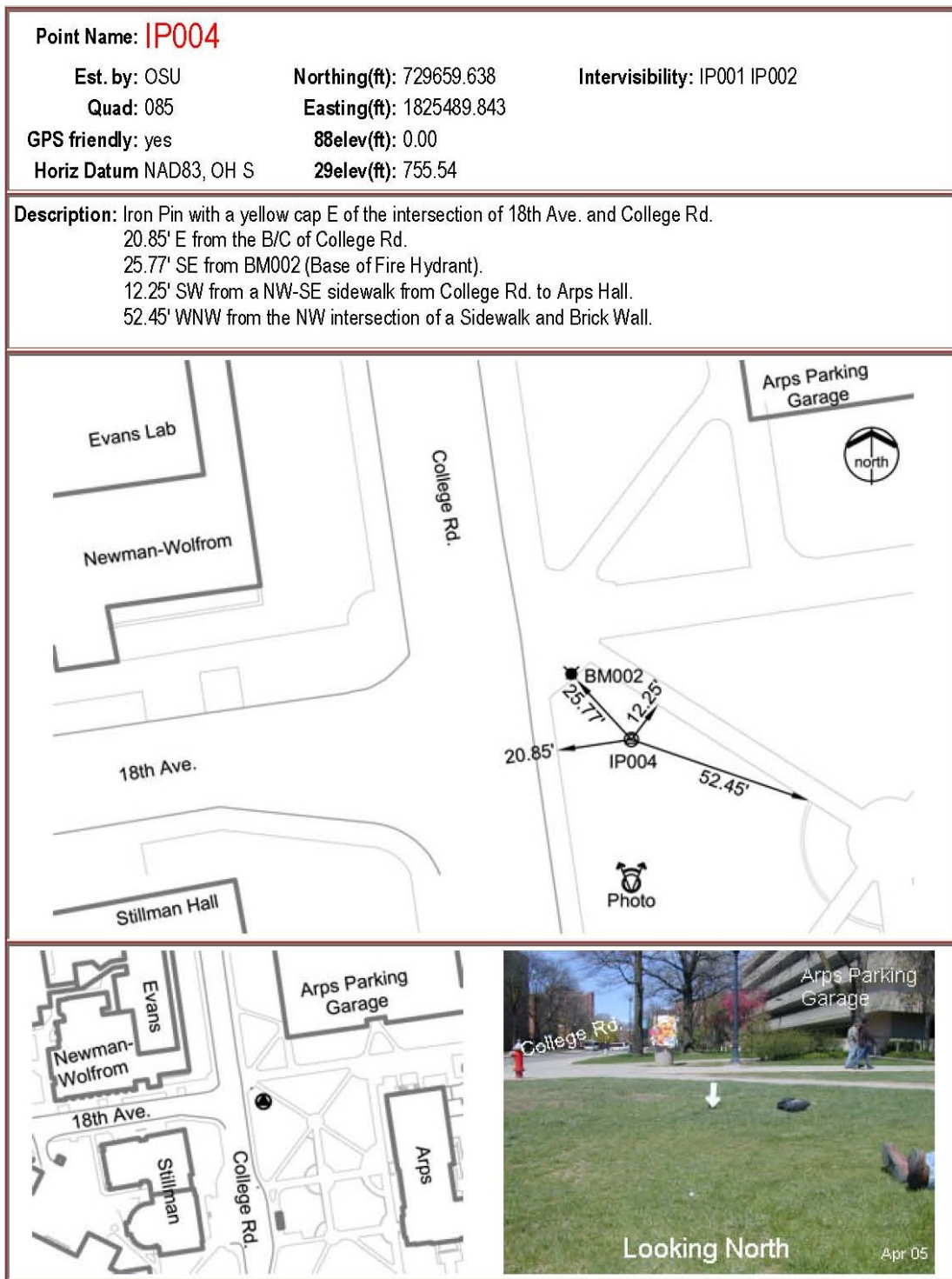


Figure A1. Typical Station Recovery Notes for a monument (shown in a reduced size). All information contained in the notes is stored in the data tables. Due to the dynamic nature of the system, each individual recovery notes page is assembled “on-the-fly”.

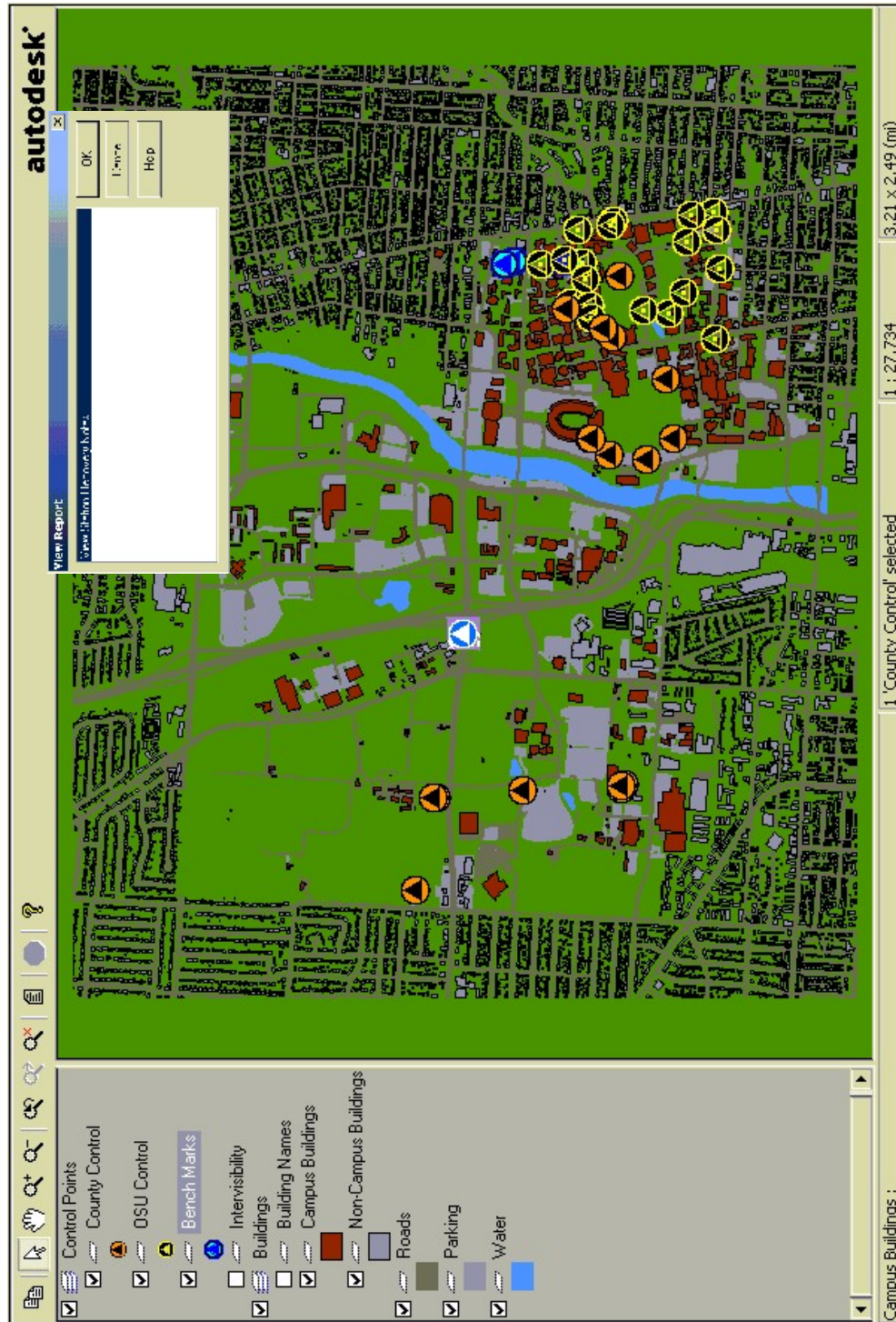


Figure A2. Interactive map representation. The layer table at left allows the user to customize the map by turning layers on or off. The view report dialog box, upper right, allows the user to view station recovery notes for a selected monument (in this case, the highlighted monument in the center).

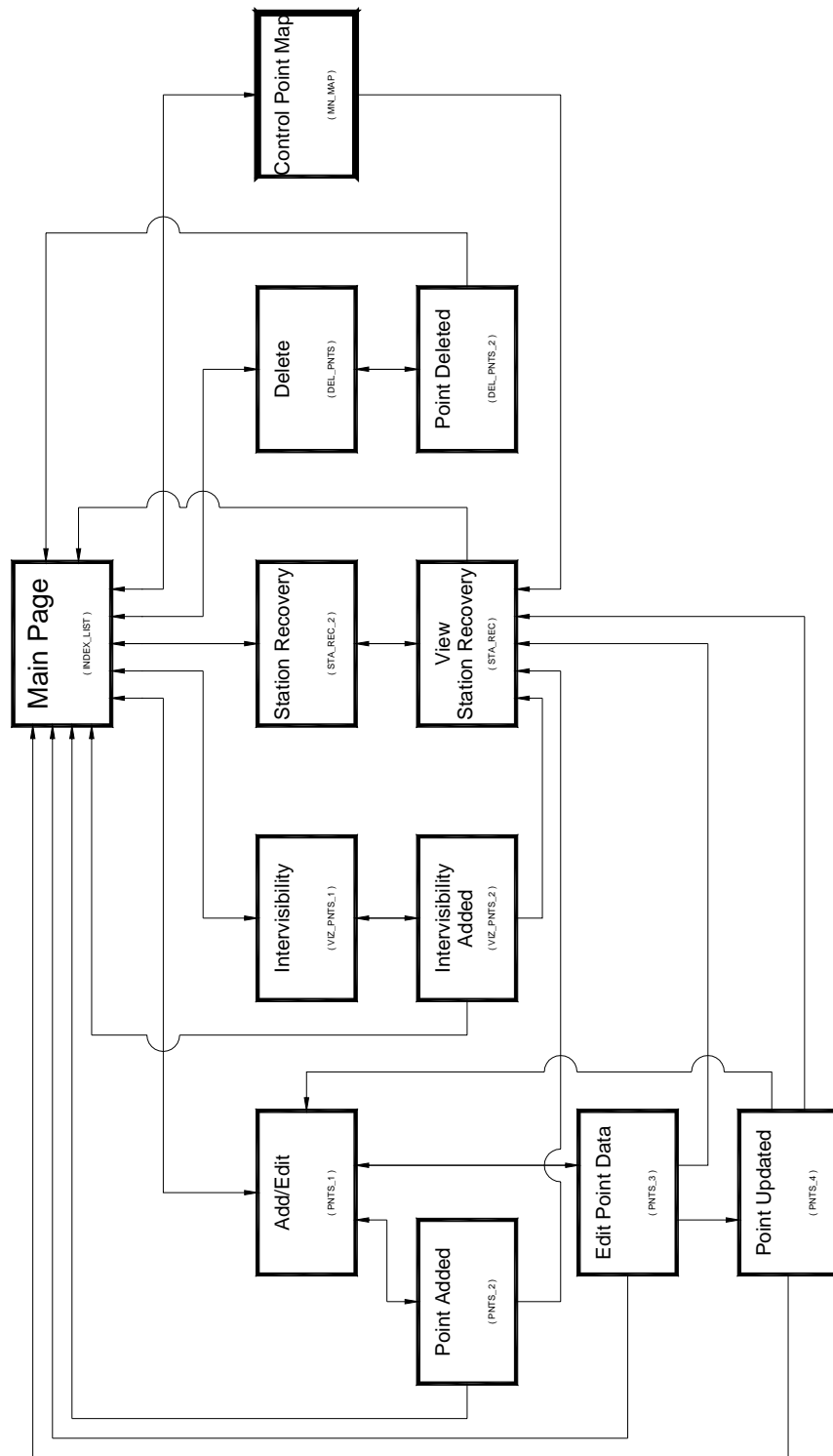


Figure A3. Schematic diagram showing layout and interconnectivity of the Trig List website. Where point specific data are required, the monument ID is the key identifier that determines which record(s) get displayed.