SIGNAL PRIORITY AN ARCVIEW APPLICATION SOFTWARE

Department of Civil and Environmental Engineering

By Paul Hom
December 8, 1998

COLLEGE OF
ENGINEERING AND TECHNOLOGY
BRIGHAM YOUNG UNIVERSITY
PROVO, UTAH
SIGNAL PRIORITY AN ARCVIEW APPLICATION SOFTWARE

A PROJECT PRESENTED TO THE DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING BRIGHAM YOUNG UNIVERSITY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE MASTER OF SCIENCE

PAUL JOHN HOM IV

DECEMBER 2, 1999
This project, by Paul John Hom IV, is accepted in its present form by the Department of Civil and Environmental engineering of Brigham Young University as satisfying the project requirements for the degree of Master of Science.

Mitsuru Saito, Committee Chair

Jim Nelson, Committee Member

Glen S. Thurgood, Committee Member

T. Leslie Youd, Department Head

Date
INTRODUCTION

In the City of Vacaville, California the process of prioritizing traffic signals installation has long been a debated and time-consuming process. Throughout this process traffic engineers are faced with numerous problems from special interest groups to political leaders. Often these groups struggle to understand the engineering aspects. With limited funds available and the high cost of signalizing an intersection, Vacaville can only signalize 3-4 intersections each year.

The problem in Vacaville comes down to what and who decides which intersection gets signalized given limited funds. To aid in this decision, Vacaville has adopted a method to show warrants and rank the priority of signalizing intersections. However, if more than 4 intersections that were budgeted for warrant the signal, the decision can become political. After carefully analyzing the proposed intersections a traffic engineer has a picture of which intersections need signalization the most. Unfortunately, this analysis is time consuming to do as is later shown in the section titled “Signal Priority Practice of Vacaville”, and even more difficult to clearly present the results of the analysis. Further exacerbating the problem is the dilemma an engineer faces trying to convince the city council if they see the need elsewhere.

In Vacaville a council member with an agenda to signalize an intersection from their neighborhood or from a constituent will not be held up long at overturning the engineer’s decision and convincing the other council members that their idea would be the best decision. But what is the council members’ criterion for signalizing the intersection? Often, the criterion is a result best described by the
squeaky wheel theory. The constituent or supporter who makes the most noise often gets their agenda pushed, rather than a decision made that is founded on sound engineering analysis. The traffic engineer of Vacaville needs a tool to explain to such council persons why particular intersections should have higher priority for signalization over other intersections.

Like many other cities, Vacaville, California has a method of ranking to prioritize signalization. They adopted their method from the City of San Buenaventura, California (I). Due to frequent turnover at their technicians level it is difficult to retrain new employees on this process. Currently, it requires several tables and pages of information and a map with push pins.

Traffic engineers have a need for new and innovative ways to manage and present data to the public and political leaders in a form that is simple and easy to understand. A Geographic Information System or “GIS” is one of the latest tools available that allows an engineer to manage infrastructure data and present it clearly.

Unfortunately, GIS software is cumbersome and difficult to learn for typical city traffic engineers, and technicians. This paper presents an application software that decreases the complexity of using a typical GIS for traffic signalization analysis. The application software customizes ArcView and creates a professional report displaying the intersections most in need of signalization, given the input of Average Daily Traffic (ADT) counts, an accident database, and other limited information from the user. This application software is meant to decrease the amount of time required for data reduction and improve the quality of the presentation so that decisions by city councils can be based on sound engineering practice rather than political agendas.
This report consists of eight sections. First it will give background as to what ArcView is. Then it will discuss the current signalization priority practice of Vacaville, the goals and objectives of the study, the structure of application “Signal Priority” software, how it works, its application to Vacaville, and finally presents a summary and conclusions.
ArcView is a GIS software used to build and manage geographic data.

Geographic refers to "the real world; the spatial realities; the geography" (2).

Information relates to "data and information; their meaning and use" and systems relates to "the computer technology and support infrastructure" (2). This software can be manipulated and its capabilities extended using its programming language

"Avenue."

Avenue is "the programming language and development environment that's part of ArcView... with it [the user] can: (1) customize the ArcView looks, (2) modify ArcView's standard tools, (3) create new tools, (4) integrate ArcView with other applications (5) develop and distribute custom applications on top of ArcView" (3). It is a programming language that allows the user to customize its interface, scripts, dialogue box, tool, and buttons.

**ArcView Project**

"Signal Priority" is an ArcView project. The project is the equivalent of a word processing document. A project is simply a shell within ArcView that allows the user to import spatial data. Changes to ArcView's interface, including customizations, can be saved as an ArcView project. Figure 1 shows a screen shot of an ArcView project.
Figure 1. ArcView project.
CURRENT SIGNALIZATION PRIORITY PRACTICE OF VACAVILLE

Each year the traffic division of public works in Vacaville prioritizes approximately 100 unsignalized intersections in their city limits. Currently this process is time consuming to do. The City Traffic engineer and his staff choose these intersections based on the following data:

- ADT (24 hour counts)
- Peak Hour volumes – Percent the minor volume is of the total
- The number of right-angle accidents

The signal ranking process requires two basic steps. The first is the data reduction. Each year after traffic counts were taken at various intersections, the data reduction begins. This process requires the use of two spreadsheets to store traffic data, one database manages collision data, and a priority point calculation method. To determine the ranking points Vacaville uses this method adopted from San Buenaventura. This process requires the engineer to toggle back and forth between two spreadsheets to get pertinent data, then use a calculator to obtain the necessary values pertaining to the priority of the intersection (see Figure 13 for San Buenaventura’s ranking value nomograph). A final query is done of the accident database to find all the right-angle accidents. (These right-angle accidents are the type of accidents that can be reduced by installing a traffic signal.) Once these values are obtained, they are placed into a nomograph and a ranking value is obtained then
assigned to the intersection. This process of manual data reduction requires between 5-10 minutes for each intersection. With the time required for each intersection and the large number of intersections the process becomes time consuming.

The second step in Vacaville’s current ranking process requires the engineer to examine each possible intersection relative to each other and the existing signals. This is done by placing pushpins into a map and using hard copies of the data to decide which intersection needs signalizing the most. The engineer must visualize spatially how signals would affect the overall system. Frequently, the decision to signalize an intersection is made if it adds to an existing network with other signals and will improve the overall efficiency of the road system. If this is so it requires the engineer to physically place another pushpin to represent the signals on the map. The criteria that the engineer uses to decide which intersection to signalize includes:

- The ranking of the intersection
- Traffic volumes
- Accident history

These three values combined with the location of the intersection and the engineers experience all help the engineer in deciding whether or not to signalize the intersection.
GOALS AND OBJECTIVES OF THE STUDY

The objective of this project is to create applications with ArcView that will help a traffic engineer or technician manage the data input and create professional layouts to present results. By using a GIS, this project will simplify the prioritization process, the preparation of spatial data, and help the traffic engineer make a rational decision.

Data Management

ArcView has features that allow the engineer to visually display the data. However, as explained previous it can be difficult to learn and use. Fortunately, ArcView allows the user to create “projects” or “extensions” that can automate the prioritization process. Using Avenues, ArcView can be customized to do simple calculations and data reduction. “Signal Priority”, the project developed for this study, is a customization of ArcView that automates many of the steps of the current signalization priority practice used by Vacaville. This project will incorporate the use of Avenue scripts and dialog boxes to manage the data reduction process. It will include the creation of various dialog boxes, which will gather such data as: the names of the roads intersecting, the ADT for each street, the

Figure 2. Add Intersection dialog box.
peak hour volumes. A typical dialog box that will be used is portrayed in Figure 2. Another dialog box will ask for the names of the output database to store the information and the name of the accident database to query. Several scripts are used to launch the dialog boxes, and store the values. Included in these scripts are computations that carry out much of the work, thus eliminating the need for a calculator.

The main goal of data management was to eliminate as much work for the user as possible. With the Signal Priority project all the computations and queries are embedded into the program. The engineer simply specifies the accident database for the program to query and the output table for storage of all the information. The specific values for each intersection are input by the engineer and the remainder of the computations and queries are automated. Two other important features include a tool to geocode (geocoding is the process of creating a map to correspond with various information) the new output table and a new menu that allows the user to add or remove various types of information to or from the map. The menu addition is useful in allowing the engineer to examine all the data at once or as different pieces by turning on and off various “themes”. (A theme is a coverage or piece of spatial data.)

**Data Presentation**

This portion of the Signal Priority project will assist engineers in clearly explaining pertinent information on decision-making to non-technical people. A tool was developed which allows the engineer to choose which intersection to show. It presents the intersections by ranking and allows the engineer to choose from all the
ranking intersections. A picture of the dialog box is shown in Figure 3. The presentation displays two views of the intersection, as shown in Figure 4. One view is zoomed in tight to display the intersection and shows nearby streets. The other view displays the intersection with respect to the entire city. The latter view represents the largest amount of space on the layout and has many significant details. This (as well as the other view) can be made to display all the existing signals in the city. This application allows the engineer to look at the proposed intersection with respect to other signals. He can best decide which intersection could be added to an existing signal network to maximize its benefit to the existing system using ranking values other traffic volumes, and accident data.

Accident data can also be displayed on the intersection. In the analysis, right-angle accidents are used; this includes injury, non-injury, and fatalities. Different types of accidents can be displayed such as rear-end collisions vs. right-angled accidents. These can be turned on and off easily by activating the view and going to the “Signal Priority” menu and choosing the desired option. Lastly, the layout displays the ADT, accident rate (rate per million entering vehicles – rmev), number of injury accidents, and the number of fatal accidents. All four pieces of information are important to engineering analysis.
Figure 4. Layout of Ranking Priority #1 from City of Vacaville.
STRUCTURE OF "SIGNAL PRIORITY" APPLICATION

The "Signal Priority" application consists of two tailored menus and three special function buttons. These application options appear in the Main menu section of ArcView and in its standard toolbar section. Figure 5 shows the "Theme On/Off" menu. This option allows the user to toggle various themes on and off. Figure 6 shows the startup file. The first button "Add Intersection shown in Figure 7, launches a task sequence to add an intersection into the database. This sequence requires seven scripts and three dialog boxes. The second button shown in Figure 8 launches the task sequence for the Geocode button as outlined in Figure 8. The third button "layout creator" and its task sequence are shown in Figure 9. These sequences and outlines are further discussed in the following section "How 'Signal Priority' Application Works."

Figure 5. Theme On/Off menu.
Figure 6. Startup file.

Figure 7. Task sequence of the Add Intersection button.
Figure 8. Task sequence of the Geocode button.

Figure 9. Task sequence of the Layout Creator button.
HOW “SIGNAL PRIORITY” APPLICATION WORKS

Each year the city of Vacaville conducts 24 hr ADT counts approximately 100 intersections to prioritize for signalization. Automating the process using ArcView will decrease the number of necessary databases and files to be managed and will thus simplify the process. The use of a visual database will be helpful in the visualization of where to place the signal. It will speed up and simplify the data reduction process. To simplify the organization, programming was divided into two segments: Module 1 – Data Reduction, and Module 2 – Data Presentation and are discussed in the section below. The entire ArcView project includes the addition of one new menu item, four dialog boxes, and twenty-eight scripts.

Module 1 – Data Reduction

This module of the “Signal Priority” project consists of a new menu, data reduction scripts, and the use of San Buenaventuras nomograph. The term “project” is used to mean an ArcView project in so far as it is used in this section.

Signal Prioritization Menu

At the top of the screen a new menu is provided as is shown later in Figure 14. It is labeled “On/Off Theme”. This menu has three items that allow the user to turn on and off various themes on the view. The first item allows the user to either show or hide the “streets” theme. This is done with the use of the script a.On/OffTheme. This script has a series of three “if then” statements. These statements check to see
which item is calling the script, and then change the theme to active or inactive. One of the needs of this program was that it would place certain themes on top of one another. There is a certain order of display due to the nature of the themes. For example, when displayed, the accidents or signals theme should be on top of the streets theme. If not, then the view of the signal is obscured by all the other data. Therefore, a sub program that shuffles the necessary themes was added to the main script. This script checks to see which themes are already active and always places the “street” theme on the bottom.

**Discussion of Scripts**

**a.Startup**

First it must be explained that the term “a.Startup” is simply the name of the script. The “a.” in front of the name allows the script to be found easily by the programmer when tying it to a button or menu. a.Startup is the script that is tied to the “Project Properties” under the “File” menu. It is a simple program that is launched at the opening of the “Signal Prioritization” project. It simply opens a message box that is tied to the GIF image shown in Figure 10.

**Signal Priority**

*By Paul Hom*

Figure 10: GIF image tied to a.Startup script.
a. ChooseTable

This script launches the dialog box "ad.ChooseTable" which asks the user to choose the output table, and the accident table that is used to query accident data. A picture of this dialog box is shown in Figure 11. In order for the user to choose a database it is necessary to use a combo-box. A combo-box "provides an interface for selecting an object from a list of related objects. A combo-box consists of a set of rows, each of which is associated with a single object of any kind"(4). From this the names of the selected tables are saved as global variables to be used later. A.ChooseTable's update button is attached to a script that launches the "ad.AddInt" dialog box. This dialog box is associated with the output table chosen by "ad.ChooseTable".

The "ad.AddInt" dialog box found in Figure 2 (see page 8) has three text-lines. The first text line asks the user to input the name of the intersection. This is stored as a global variable to be used to query the accident database. One problem that arises from this would be the order in which the accidents are kept in the database. As long as there is consistency in the order, all of the accidents will be queried. It is recommended that the intersections be entered alphabetically. For example, the user maintaining the accident database (as shown in Figure 12) should enter "Alamo & Peabody" rather than "Peabody & Alamo". A problem arises when both of the above values are entered in the intersection field. When the user queries
"Alamo & Peabody", and half of the values are "Alamo & Peabody", and the other half of the accidents are recorded as "Peabody & Alamo", the query will be inaccurate. In order to avoid problems, a consistent data entry system must be made, such as placing the streets in alphabetical order.

**a.AddInt**

The remainder of the input is the major and the minor street volumes. (The major and minor streets are assigned to the streets depending on their volumes).

These values are defined in the output table. The script "a.AddInt" is tied to the attributes of the "Add Intersection" button and is responsible for going to the dialog box "ad.AddInt" and performing all the things explained above. It also does pertinent calculations and enters them into the table. Some of these calculations
include summing the total volume and finding the percent the minor volume is of the total. Both of which are essential pieces of data to use the nomograph from San Buenventura. This script launches two programs "a.AccQue", and "a.RetNomino".

a.AccQue

"a.AccQue" is the name of the script that queries the accident database. This script performs several queries. First, it takes the global variable associated with the street name and queries the total number of accidents at that intersection. From this, accidents are calculated for one million entering vehicles (\(a_{RMEV}\)). This value is not directly used for the signal ranking with the nomograph (see Figure 13 on page 13). However, it is commonly used to analyze patterns in traffic data and will be displayed on the layout (5). The script then performs a second query to determine the number of right-angled accidents taking place at the intersection. This value is used on the nomograph to determine the resulting points (I). Another query is done to determine the total, right-angle, and severity of accidents, and stores these values for future use. Signalizing an intersection usually decreases the number of right-angle accidents. However, it may increase the number of rear-end accidents. For this reason, both of these values are included in the query and recorded in the output table.

Finally, the script finds the total number of accidents and selects from it the number of injury accidents and the number of fatal accidents. These values will be included in the layout for public presentation. This program returns control to the a.AddInt program which inputs the values into the database.
a.RetNomo

The a.RetNomo program is launched from the a.AddInt program after it has input the values into the table. It is responsible for accessing values from the database to be used in the nomograph. The user must take the values shown on the dialog box and use them with the nomograph and to determine the resulting value. The value from the nomograph is then entered into the dialog.

San Buenventura's nomograph

An example case is presented here to better illustrate the nomograph process used by Vacaville. This process is done manually, as the following is not part of the program (project). Suppose the Average 24-Hour Count (ADT) is 12,000, the percent the minor street volume is of the total is 13%, and there were 8 accidents this year. In

Figure 13: San Buenventura nomograph. (I)
step A the engineer would begin using the 12,000 ADT value and look for that input at the top of the chart. Step B is the percentage the minor peak volume is of the total peak. This percentage is represented by curved lines. The user would follow the 12,000 down to the 13%. From this, the number of accidents, eight is represented by a diagonal value. In step C the user goes horizontally from the point along the 13% over to the eight accidents. In the final step the engineer goes vertically down, resulting in a value of 23 points (I). The computer then prompts the user to input this value, and it is stored in the output table. At the conclusion of this script Avenue runs a final script which is attached to the dialog box ad.Repeat. This script and dialog allow the user to repeat the process of inputting another intersection. If the user selects “yes” then the dialog box runs a.AddInt again. If the user selects “no” it runs the script to shut the dialog box. (For a better understanding of the process the Westernite July-August article presenting this process is included in the appendix on pages 1-4.)

**Recommended Enhancements**

Currently, a problem exists in the “Signal Priority” menu item “Show Streets”. The script is written so that when the user selects the “Show Streets” menu item the computer brings the streets theme back into the view. However, the problem arises in the case where Vacaville’s streets theme has only three fields in the database. It has an ETAK ID, which normally has to be joined manually with an accompanying database called “strdata”. This table contains all the street data and other information used for geocoding. This problem is unique to the city of Vacaville; therefore, the script will be customized to their needs. The customization will take
place either inside of the *a.On/OffTheme* script or outside with another script. If it is
done outside the script, an additional dialog box can be created which will allow the
user to select the field and table to join. If it is done inside the script the name of the
joined table and field will be hard-wired into the program. This process will be
included in a later version of this project.

### Module 2 – Data Presentation

This segment of the project allows for the presentation of all data. This
segment geocodes the output database and creates a presentation. There are two
buttons associated with this segment: the Geocode button and the Layout Creator
button, which are shown in Figure 14.

![ArcView GIS Version 3.1](image)

**Figure 14: Add Intersection, Geocode and Layout Creator buttons.**

Relating to a blown up image of the two new buttons in Figure 14, the button
on the left brings up the geocode option, which allows the user to create a map of the
desired output table. The button on the right asks the user which ranking of
intersection to create a layout. Previous to this the intersections have been assigned a
ranking from one being the highest down to the last number being the lowest. The
following discussion describes the scripts included in Module 2, and the resulting
presentation.
Discussion of Scripts

a.Layout

The script a.Layout is used in the process shown in Figure 9. However, this script is preceded by a dialog launch and sorting script named a.Sort. The dialog script accesses the database, and retrieves all the values from the rank field. Immediately after acquiring the ranking values the a.Sort script is run which places the values into a list and sorts them in ascending order. This list fills the values of the combo box. A combo box allows the user to choose from a list of options in a dialog box. The user selects the appropriate ranking and selects the button “Draw”. This launches the a.Layout, the main script responsible for creating the layout. First the script takes the chosen ranking and selects the record; it retrieves the data from various fields for later placement on the layout. Next, it sets up the page parameters. The default page is 8.5” X 11” but it can be adjusted to 11” X 17” simply by changing the values in the script.

The Presentation

There are two views on the layout as shown in Figure 15. One view is a zoomed-in view of the intersection, which has street names on it (the right half of the layout). This view helps the engineer spatially identify where the proposed street is located in relation to the rest of the city. The script automatically zooms to the selected record, thus showing the intersection in the center of the layout. One of the options that was initially included was a script that automatically labeled the surrounding streets. Unfortunately, the labeling of all the streets looked too cluttered.
Therefore the user will simply have to access the view in the layout, and select which roads should be labeled and where to place the label. The second view is shown in the left half of the layout. It includes the street network, the signals, the ranked intersections, and the option to show the accidents or not. This view is intended to show the intersection in respect to the city network as a whole. From this view the engineer can view the proposed intersection with respect to other signalized intersections. This helps the engineer to relate it to other signals in a network. It also allows the user to look at the other ranked intersections in relation to this intersection. The engineer might choose to signalize two intersections that are not the highest

Figure 15: Layout of Ranking Priority #1 from City of Vacaville.
ranking but include them in this selection because they are related to one another and will improve traffic overall. The accident summary is another important option of this layout. This is due to the fact that the types of accidents that take place would change after the intersection is signalized. Once signalized it would be estimated that the number of rear end accidents would increase but the number of right-angle accidents would decrease. This could be viewed in the layout and would be useful in making the decision of which intersections to signalize. If the number of rear-end collisions is large, or larger than the number of right-angled collisions, the engineer should visit the site to see if there is a sight distance related problem.

Following this, the script creates a legend that is associated with the larger view, and describes what each symbol means. “Neatlines” are then drawn around the perimeter of the views and the legend. “Neatlines” are the term describing a line surrounding the perimeter of an object. Beneath the larger view of the city a small table was included. This table shows the Average Daily Traffic (ADT), the accident rate per million entering vehicles ($a_{REV}$), the total number of injury accidents, and the total number of fatal accidents.

**Recommended Enhancements**

The first recommended improvement to the project in module 2 would be to allow the engineer to choose between two types of layouts on the *ad.Layout* dialog box to meet his or her presentation needs. The first will provide a presentation geared towards the interests of an engineer. This layout will include a table with the number of right-angle accidents and rear-end accidents. It will also have a chart comparing it to other intersections in its class. The second layout will be more of a presentation
for city councils and public officials. It will show total numbers of accidents, injury accidents, and fatal accidents by type. A chart will also be included to show these accidents in relation to other intersections of its class.

Another possible improvement may include two “radio” buttons allowing the user to create a new layout or replace an old one. A “radio” button allows the user to choose between two options. The script will need to be altered so that the name of the layout is associated with the ranking it received. This will help the user to be able to access old layouts and know beforehand which ranking they are associated with.
APPLICATION TO VACAVILLE

This portion presents how the current prioritization process presented in a previous section would be automated with the use of “Signal Priority” software.

**Signal Ranking with “Signal Priority”**

The signal ranking with “Signal Priority” consists of the following five steps in the order listed.

- Step 1: Preparation
- Step 2: Adding an Intersection
- Step 3: Using the Nomograph
- Step 4: Geocoding
- Step 5: Creating a Layout

These five steps to using “Signal Priority” are discussed below.

**Step 1: Preparation**

In preparation to using “Signal Priority”, the engineer must first import a theme coverage including street names. The user needs to create a new table for the output and storage of all the data. Twenty-four-hour counts of potential intersections and an accident database containing types of accidents by intersection are all necessary for this process. The “On/Off Theme” menu can be used to toggle on and off various themes in view ports. This menu item is useful in both the data reduction phase of signal ranking and in the presentation phase. As the user is preparing the
data, frequently the amount of data displayed on the view can be too busy – too busy in the fact that the information displayed overwhelms the user and is not useful. In this case it is recommended that the user choose the “On/Off Theme” option and decrease the amount of information displayed. This can also be used for the same reasons when displaying the information in the layout.

**Step 2: Adding an Intersection**

A list of the required information to add an intersection includes:

1. ADT (24 hour counts)
2. Peak Hour volumes – Percent the minor volume is of the total
3. The number of right-angle accidents

With the ADT counts in hand, the engineer is ready for the next step. The engineer selects the “Add Intersection” button and is asked to identify the output table and the accident table. These two tables, as explained previously, are essential for data reduction. The output table is used to store the ADT values and other queried information regarding specific intersections. The accident table is used to query the total, the right-angle, injury, and fatal accidents at specific intersections.

After giving this information the engineer selects “update” and another dialog box is presented. This dialog box prompts the engineer to input the potential intersection, major, and minor volumes. After providing this information the engineer selects update. Once the update button is selected the computer queries the tables and finds the relevant information, and does the necessary calculations.
Step 3: Using the Nomograph

When completed the pertinent values are displayed for the user to apply them to the nomograph (there was no way to automate the nomograph process) and find the points to issue the intersection. As was demonstrated in the section “San Buenventura’s nomograph on page 20, the user applies the ADT, the percentage of cross street volume, and the number of accidents to the nomograph. From this the engineer finds the assigned point value to this intersection and inputs it in the dialog box. Once updated the information is stored into the output table. The computer runs a script that ranks all of the existing intersections in the table.

Step 4: Geocoding

The fourth step includes the use of the “geocode” button (see Figure 8). The geocode option allows the engineer to visually display the information on the view. Figure 16 shows an image of the geocode dialog box. The first piece of information the engineer enters is the reference

Figure 16. Geocode dialog box.
theme. The reference theme, refers to the theme with the street names. It is essential that the engineer specify the address table. The address table is the table to be geocoded, or rather placed visually in the view. The engineer also specifies the address field. This tells the computer which field to look for on the map. The engineer chooses the name and location to save the geocoded theme to, and selects “Batch Match.” The computer will then place each item from the specified address table in the address field.

**Step 5: Creating a Layout**

The final step in using “Signal Priority” is to create a layout. To begin the engineer selects the “layout creator” button (see Figure 9). The engineer specifies which ranking of the intersection he or she desires to make a layout. Once selected the user presses “Draw”, and the computer creates a layout of the desired intersection. Three important aspects of displaying the layout include: (1) GIS display of signals, (2) GIS display of intersections, and (3) intersections with “graduated colors” that corresponds to Figure 19 on page 34.
Figure 17: Picture of Signal Priority project showing signals.

In Figure 17 a theme has been created using an existing database of signals. To do this a spreadsheet file of all the existing signals is used. This file is imported into the example project and geocoded. With this view of the existing signals many conclusions can be drawn. The addition of this theme increases the users understanding of the city as a whole. The signal networks can be viewed spatially with their relationship to one another. This alone could simplify the process of helping the user choose an intersection to signalize with relation to existing signals.
GIS Display of Intersections

Figure 18 displays the geocoded database previously entered in by the user (step 4). By geocoding this database the user can now see the relationship and compare potential signalized intersections to the others.

Figure 18: Picture of signals and potential signals.
**Intersections with Graduated Color**

The display of graduated colors in Figure 19 allows the user now to draw additional information and relationships of potential signalized intersections to one another. From the combination of all three aspects, several conclusions can be drawn. One such example would be in the case where the engineer decides to signalize an intersection that may not be the highest ranking or priority, but because it fits in with the network of other signals-again, one of the warrants.

---

Figure 19: Picture showing graduated colors of potential signals.
Figure 20. Image of ten intersections studied.

The following is a hypothetical example to better explain the use of Signal Priority. Assume that ten specific intersections were studied to evaluate the need for signalization in a certain year. Due to budget constraints, only two intersections out of the ten intersections can be signalized. Before the study councilwoman A approached the engineer. Councilwoman A is familiar with an intersection that she feels requires a traffic signal. After speaking with councilwoman A, the engineer substitutes the said intersection to the list of ten.

After completing the counts the engineer uses “Signal Priority” to input all of the information into the city’s GIS using the Add Intersection and Geocode buttons.
see section steps one through four shown above. The resulting image is shown in Figure 20. Notice the graduated color scheme in the legend showing the ten intersections studied in figure 20. The red dot (referred here after as intersection 1) shown in the upper left corner represents the intersections with the greatest need for signalizing. It is the intersection of both Ulatis Dr. (runs East/West) and Burton Dr (runs North/South). The two green dots, one on the upper right corner and the other in the lower left corner represent the intersections with the second greatest need for

![City of Vacaville Signal Priorization Ranking Priority #1](image)

Figure 21. Image of hypothetical #1 rank.

signalization (referred here after as intersections 2 and 3). Intersection 2 is between Ulatis Dr (runs East/West) and Leisure Town Rd (runs North/South). Intersection 3 is Beelard Rd (runs North/South) and Marshall Rd (runs East/West). The intersection studied for councilwoman A is shown in the lower right corner. It is the intersection of Marshall Rd (runs East/West) and Leisure Town Rd (runs North/South) shown by
the light gray dot (referred hereafter as Intersection 10). Out of all the intersections studied, intersection 10 ranked the lowest in need signalization.

In Figure 21, the blue flags shown in the legend represent signals. Notice that intersection 1 has the potential to network with two signals on the road shown horizontally. Based on this fact alone, intersection one represents a good candidate for signalizing. Compared with other the ten intersections studied, it has the highest ADT, the largest number of accident, and the most fatalities. For these reasons Intersection 1- Ulatis and Burton is the prime candidate for signalizing.

![City of Vacaville Signal Priorization Ranking Priority # 2](image)

Figure 22. Image of hypothetical #2 rank.

Intersection 2 (shown in Figure 22) is the intersection of Leisure Town and Ulatis. Ulatis currently has four signals on it. The addition of intersection two will add to the efficiency of the overall network. Intersection 2 had an ADT of 17,000
vehicles per day. During the year studied it had an accident rate of 28 amev, 13 injury accidents and one fatality. Due to its high number of injury accidents and its fatality, intersection 2 represents a good applicant for signalization.

Figure 23. Image of hypothetical #3 rank.

From the image shown in Figure 23, Intersection 3 has a signal to the east of it. Not shown in this image are two other signals that intersection 3 could network with. Intersection 3 would fit into the existing signal network and improve the networks efficiency. The ADT count resulted in 20,000 vehicles per day. This result was greater than Intersection 2. It was ranked below intersection 2 because of its lower accident rate. With the high number of vehicles per day, and the amount of traffic at other nearby intersections, Intersection 3 could be improved with signalization.
Figure 24. Image of hypothetical #10 rank.

Intersection 10 shown in Figure 24, lies in the bottom right corner of the map. It is a three-legged intersection with a small amount of traffic on one leg. Due to the small amount of traffic and lack of accidents it is ranked low. The fact that it intersects two important streets would mean that Intersection 10 could be improved with signalization. However, Intersection 10 does not represent the same risk as Intersections 1, 2, and 3, and proves to be the most important intersection for signalization.
SUMMARY AND CONCLUSIONS

Due to limited funds and political pressure in Vacaville, selection of intersections for signalization is becoming increasingly difficult, and prioritization of such intersections is time consuming. With the use of ArcView (a GIS software), the management and displaying of spatial data and can be used to display traffic data in an attractive and informative manner. “Signal Priority”, an extension to ArcView provides an option for engineers to manage and display their signal prioritization data. It is valuable in that it saves the traffic engineer time learning the details of ArcView and allows him or her to produce quality professional presentations. Data reduction and storage become less cumbersome and confusing. In summary, “Signal Priority” lessens the tedious amount of data reduction, analysis, and presentation work of the current signalization ranking process.

“Signal Priority” is an initial step to automate the process. A few improvements could be made to make the program more flexible. The first improvement that should be made is a customization for the city of Vacaville. This would include the changes to the aOn/OffTheme script so that it joins the necessary tables and displays the legend for the “streets” theme. Another recommendation for this project would include the option to create a separate layout geared either to the public or to an engineer. This would significantly increase the flexibility of the project and increase its value. The final recommendation would result in increased organization for the project. By adding a radio button to allow the user to create a new layout or replace an old layout, the number of layouts in the project will
significantly be reduced. It will also enable the user to quickly identify the needed ranking and thus reducing the work in signal installation decision-making.
Route Determination for the Transportation of Hazardous Materials
Amelia Edwards (A), HDR Engineering

INTRODUCTION
In September of 1990, the U.S. House of Representatives Public Works and Transportation Committee approved a major revision to the hazardous materials transportation law. This revision calls for states to develop emergency response plans and training of response teams for dealing with the transportation of hazardous materials. One of the major provisions of this bill calls for a federal and state partnership in developing routing plans for transportation. The Department of Transportation will provide standards for developing acceptable highway routes for hazardous material transportation. Using these standards, the states must designate highways considered part of the hazardous material transportation routes.

To understand the need for such routing plans, it is necessary to understand what a hazardous material is. The Resource Conservation and Recovery Act legislation provides a definition of a hazardous material.

Hazardous Material – a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may (1) cause, or significantly contribute to, an increase in mortality or an increase in serious irreversible or incapacitating reversible illness or (2) pose a substantial present or potential hazard to human health or the environment when

Continued on page 5

New Signal Priority System

By Robert Yalda, Associate Transportation Engineer, City of San Buenaventura, CA and Bill Baranowski, City of Salt Lake City

BACKGROUND
The City of Ventura, California, population 99,000 is located on the Pacific Coast, 75 miles north of Los Angeles. The City is expected to experience slow to moderate growth until the year 2010, and is therefore facing increasing demands on its limited capital fund revenues. One such demand is the need to signalize intersections. The City currently controls 101 existing signals (see Figure 1). There are an additional 10 locations where signals need to be installed. The City's seven year capital program provides enough funding to install only two new signals per year at a cost of $150,000 each. However, there are many more locations that need signalization, and there is a need to prioritize these locations.

Some agencies prioritize signals on a chronological basis using the date the signal warrant is met. In other instances, the funding program and its restrictions may influence their installation date. For example, state funds may exist for installations on designated routes, whereas the local city has no funds. Or, a city capital improvement program (CIP) may have been approved that provides funds for specific locations and prohibits shifting of funds to other locations. A system was needed to develop priorities based on a defensible basis of need, taking into account the degree which warrants are satisfied. Such a system has now been developed and by using this system, the City will be able to focus its limited resources on the intersections with the greatest safety needs.

NEW PRIORITY SYSTEM DEVELOPMENT
The City contacted several transportation professionals in Southern California to study other methods of prioritizing signals. Criteria common to most signal priority ranking systems were identified using the Manual of Traffic Signal Design (1). Table 1 shows typical criteria found in most

Continued on next page

*Mr. Baranowski was an Assistant Transportation Engineer with the City of San Buenaventura at the time this article was written.
New Signal Priority System

Continued from page 1 column 2

priority systems. These criteria were combined with a method developed by Willdan Associates in 1987(2) to produce the form shown in Figure 2. These criteria are all related to signal warrants with only the number of points awarded for each criteria varying. The most important criteria have been allocated the highest number of points.

As shown in Figure 2, the following point system was then used to calculate the priority of each intersection where a signal needed to be installed.

1. Vehicular Volumes and Accident History (Up to 80 points)
The majority of points are awarded in this category (Up to 80) because of the greater importance given by the MUTCD(3) to peak hour volumes, average daily traffic, and number of right-angle accidents. These three values are entered into a nomograph shown in Figure 2 to determine the number of points to be assigned to each intersection.

2. Traffic Signal Progression (Up to 5 points)
Each intersection is allocated up to an additional 5 points depending on its ability to fit into an existing traffic signal progression system.

3. Pedestrian Demand and School Crossing Safety (Up to 5 points)
Up to an additional 5 points are allocated, depending on the new signal’s ability to serve pedestrians, especially near schools. The number of points depends on the level of pedestrian volumes.

4. Traffic Speeds, Sight Distance and Road Curvature (Up to 5 points)
This category accounts for the geometry and physical location of the intersection. If a serious sight distance problem exists which cannot be corrected by other measures, the intersection receives 5 points. If a severe vertical or horizontal curve exists, the intersection also receives 5 points. A lower number of points is awarded for locations where sharp curves exist but are not severe enough to cause significant safety problems.

5. The Severity of Accidents (Up to 5 points)
This category awards points based on the severity of accidents occurring within the last 3 years. A fatal accident correctable by installing a signal received 5 points. If a fatal accident occurs near the intersection, but is not totally correctable by a signal, it received up to 3 points. If no fatal accidents have occurred near the intersection, but the proportion of severe accidents is above the City-wide average, points are allocated based on overall accident severity.

USING THE SYSTEM

Once the new priority system was developed, it was then tested by evaluating the 10 warranted signals awaiting installation shown in Figure 1. The results are summarized in Table 2. The points calculated for each location were checked to see if the locations were ranked in an order that was similar to expectations based on experience. Table 2 has been used by City of Ventura staff to recommend alternative solutions to particular intersection accident problems rather than installing a signal. For example, if an intersection meets the accident warrant and no other warrant, it has been recommended to the City Council to install access control islands to eliminate the accident problem rather than increasing the list of unfunded signals.
CONCLUSIONS
1. This new system has been found to be consistent in prioritizing signals because the majority of points are awarded according to measurable traffic data such as vehicular volumes and accidents. It also allows room for engineering judgment using the points assigned for progression, pedestrian volumes, location and accident severity. The system has been designed to be flexible enough to apply to the prioritization of unwanted signal locations that the City monitors every year to determine if these intersections meet warrants.
2. The signal prioritizing system described provides an easy and consistent method of allocating limited funding to the intersections with the highest need for signalization.
3. Table 2 has been effectively used to explain to citizens why the particular intersection where they are requesting a new signal cannot be signals immediately.
4. By using this new priority system, political and funding issues can be more effectively addressed and only the most justified signals will be installed under current funding restrictions.

RECOMMENDATIONS
1. Agencies should develop a system of prioritizing signals if their limited funding resources do not permit immediate signalization of all warranted intersections. The method outlined in this paper could be adopted by any agency that currently does not have an effective priority system.
2. When the priority of a newly warranted signal is compared to a previously warranted signal using the system described here, the method by which the points are assigned for progression, pedestrian volumes, location and accident severity should be consistently applied.
3. The priority of signal locations in Table 2 should be updated every year using current accident and volume data.

REFERENCES

Continued on page 5

| TABLE 1 |
| TYPICAL CRITERIA IN A SIGNAL PRIORITY RANKING SYSTEM |
| CRITERIA | POINTS AWARDED |
| Satisfaction of volume warrants | Additional points for higher volume. |
| Pedestrian volume | Additional points if intersection has a moderate to high pedestrian activity associated with it. |
| School crossing proximity | Additional points if intersection is a school crossing or is approximate to school crossing. |
| Satisfaction of warrants | Additional points for the number of hours a warrant is met. |
| Accidents | Additional points for correctable accidents over the warrant number. |
| Coordination | Additional points if signal fits into an arterial progression or grid system. Reduction in points if signal does not lend itself to coordination. |
| Intersection geometrics | Reduction in points for "L" intersections. Additional points for higher-speed locations, sight-distance restrictions, vertical or horizontal curvature conditions. |
| Area considerations | Points added or subtracted for CBD, urban or rural locations. |
| Public Demand | Points added based on intensity of public demand. |

| TABLE 2 |
| FUNDING STATUS AND INSTALLATION PRIORITY OF SIGNAL LOCATIONS |

<table>
<thead>
<tr>
<th>INTERSECTION #</th>
<th>PRIORITY RANKING CATEGORIES*</th>
<th>TOTAL</th>
<th>FUNDING SOURCE</th>
<th>FUNDING YEAR</th>
<th>COST ESTIMATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>31</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>21</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>19</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>29</td>
</tr>
<tr>
<td>6</td>
<td>16</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>16</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>17</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>15</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>14</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

* Ranking Categories
1 = Volume warrants and accident history 
2 = Arterial progression or grid system 
3 = School crossing or pedestrian activity 
4 = High speed location, sight distance and curvature condition 
5 = Severity of accidents

BB:12-132
The Traffic section is faced with a number of locations where a traffic signal is warranted. Available funds do not allow us to signalize all warranted locations. It is therefore necessary to decide the order in which installation should be scheduled.

The signal priority ranking system includes the following five categories:

1. **Vehicular volumes and accident history**

   **STEPS A, B, C**

   **Step A:**
   AVERAGE 24 HOUR Vehicular Volume
   Entering Intersection from all Approaches.
   (#'s in Thousands of Vehicles)
   ADT 12 Thousand

   **Step B:**
   PEAK HOUR VOLUME
   Highest One Hour Traffic Volume
   Entering Intersection From:
   - Major Street: 1,600
   - Minor Street: 240
   Total: 1,840
   % of Total from Minor Street: 13%

   **Step C:**
   ACCIDENTS
   Yr. No.
   - Number of 88 5
   - Right Angle 89 4
   - Accidents 90 6
   Total 3 15
   Yearly Avg. 5

2. **Add up to 5 points if signal fits into an arterial progression or grid system.**
3. **Add up to 5 points if intersection contains a school crossing; is near a school crossing, or if intersection has a moderate to high pedestrian activity associated with it.**
4. **Add up to 5 points for a high speed location, sight distance restriction, vertical or horizontal curvature condition.**
5. **Add up to 5 points for severity of accidents.**

**Category** | **Points**
--- | ---
1. Volume, Accidents | 14 /80
2. Progression | 1 /5
3. School or Peds | 2 /5
4. Location | 2 /5
5. Severity of Accidents | 3 /5
TOTAL / FTS. POSSIBLE | 25 /100
PRIORITY RANK | 10

**Figure 2**