INTRODUCTION

When analyzing traffic accidents, transportation engineers must have a clear understanding of the contributing factors. How would an analyst know if a sight distance restriction may have contributed to an accident? How would an analyst know if a traffic signal may improve the safety of an intersection? The answer: They wouldn’t if they are not seeing all possible influences with a particular pattern of traffic accidents.

But how can analysts see all the possible influences graphically on a collision diagram? The answer: Geographic Information Systems (GIS). Combining GIS and collision diagramming offers the ability for traffic engineers to understand all spatial implications with a particular area under investigation. Accident data can be analyzed with the true curvature of the roads, aerial photography, rights-of-way, edge-of-pavement, landscape and zoning information, and signage.

Until recently, Gwinnett County, Ga., like so many other counties and cities, did not have the capability to digitally integrate traffic analysis with GIS. The existing traffic diagramming system did not incorporate true spatial orientation of roads. Instead, it diagrammed accidents over what is termed a generic version of the roads, where roads are drawn as two perpendicular lines. Roads diagrammed in this fashion are less informative than a geographic system. The only purpose they serve is to identify the road names where the accidents are occurring. This would be OK, except accidents occur in the real world, where roads intersect at irregular angles and have curves. This is especially true in Gwinnett County, which has a complicated transportation infrastructure.

Additionally, the county had no way to plot midblock accidents. Midblock accidents are classified as all accidents that occur between intersections. One of the most frequent midblock accidents occur when someone pulls from a private driveway onto a busy street. The old method of diagramming mid-block accidents meant running database queries and drawing the diagrams by hand. This process could take hours, depending on how many accidents occurred at the specific location.

The county researched several off-the-shelf products but was unable to find a system that met the specific requirements. The main problem was that no application would work within the existing Oracle environment or within the existing GIS environment. Some systems claimed to be GIS, but they did not place and orient accident symbols geographically on a map. They mostly offered the ability to create accident density maps.

The county had an established GIS program and knew the potential of using a GIS to build better diagrams. To move forward, they contracted with Burns & McDonnell Engineering to develop a real-world solution for collision
diagramming using ArcGIS Desktop. Burns & McDonnell worked with the county and developed an ArcView extension known as CDARE, which Burns & McDonnell calls True Traffic. CDARE gives traffic engineers the ability to diagram both intersection and midblock accidents using the sophistication and power of GIS.

Gwinnett County Department of Transportation (GCDOT) captures crash data in an Oracle database. The county baseline map is available in GIS. For a given intersection or a road segment, CDARE queries collision information from the collision database (Oracle), matches each selected crash with a symbol taken from many stored in CDARE’s library, and plots one symbol per crash onto an appropriately zoomed-in intersection or road segment.

An overview of CDARE functionality:

1) For a given location and time period, select crash data from Oracle.
2) For each crash, using type of accident, vehicles road of travel, directions of travel and maneuvers, find a representative symbol from the “accident symbol file.”
3) On the GIS map, select the given location and zoom to an appropriate scale.
4) Place crash symbols on the map.
5) Prepare a table summarizing accident information, including the number and type of crashes, injuries and fatalities, if any. Place this summary below the collision diagram.
6) Prepare a separate, detailed report listing individual crashes.
7) Prepare an “Error Report” showing crashes that could not be diagrammed, including a reason (e.g., lack of necessary data).

The CDARE extension is a set of custom tools packaged in an extension for creating collision diagrams and reports within ArcView. CDARE interprets accident information stored in relational databases and produces graphical representations of the accidents. The graphical representation or symbol is placed on a GIS street centerline by geocoding the attribute information stored in the relational database. Multiple accidents for a given time period can be symbolized and placed on a layout to produce collision diagrams.

CDARE works by querying a county Oracle database for all accidents that occur at a selected intersection or midblock location. The data stored in Oracle contains all the characteristics of an accident, including accident type, vehicle direction of travel, roads traveled, vehicle maneuvers and others. CDARE analyzes each accident and places it in the appropriate location on the map. The map layout view in ArcView can include additional features that the analysts want to evaluate. These features might include edge of pavement, road centerlines, signs or aerial photos.

Simplified schematics are now only used when the intersection cannot be found on the centerline file. The county is already seeing benefits from the extension’s ability to build up its existing data into a more useful and reliable resource.

The system also flags potential inaccuracies in the traffic database data. In addition to better analysis, CDARE is improving the quality control of the accident data.

CDARE runs on numerous workstations throughout the county and allows Gwinnett County to address the safety concerns of citizens by giving engineers and non-engineers a clearer picture of where accidents happen and what contributing factors might be.
OVERVIEW OF THE PREVIOUS APPLICATION

CDARE replaced an AutoCAD based collision diagramming system. The previous application could not draw collision diagrams for road segments (collisions). Such accidents make up about 40% of the total crashes in the county. Hence the application could only draw intersection accidents (or 60% of the county’s total crashes).

The AutoCAD-based application drew every collision diagram on a “generic” intersection layout that was stored in the application’s memory. This layout showed a four-legged intersection with all approaches at 90 degrees to each other, with one of the roads running perfectly north/south and the other true east/west. The application used a Microsoft Access-based interface to query the collision database (Oracle), and was not Oracle compliant.
In Gwinnett County, few roads run true north/south/east/west. Most of the roads are oriented close to 45 degrees from true north. Additionally, it is typical for a road in the county to run in the general north/south direction for a certain length before changing direction to fall more along an east/west axis.

This meant diagrams drawn by the system were simplistic in nature. When interpreting these diagrams, the traffic engineering staff had to consult the county map to see the actual intersection layout. Also, when shared with outside agencies and consultants, risk existed for the diagrams to be misunderstood.

In addition to lacking full functionality (as well as intersection-type collisions), the application faced technical limitations. It was a homegrown application developed on a PC running the Windows NT operating system. When the application was under development, Windows NT was foreseen to be the operating system of choice. Various technical issues, developments and subsequent IT department decisions made Windows NT obsolete.

In view of it running on a non-standard operating system, the application needed transporting to other PCs. Unfortunately, all such efforts failed. The difference in operating systems was significant and the application itself was complex. The problem was compounded by the fact that the engineer who developed the application had left the county, leaving technical documentation incomplete. Consequently the PC holding this application became the only computer to house this critical application for the department. Over time, this PC became old and slow. The application crashed often. The department felt it has placed all eggs in one basket (and not a strong one).
To make the matters worse, the county’s IT department decided to disallow Microsoft Access-based interfaces into the Oracle database. While this addressed certain security concerns for other county departments, GCDOT was left holding the bag. The search for a new application was already on.

SEARCH FOR A NEW APPLICATION

At first, GCDOT attempted to purchase an off-the-shelf solution. The products reviewed were:

- Intersection Magic (www.pdmagic.com) (cost: approximately $7,500)
- AIMS (http://www.jmwengineering.com/aims_gis_software.htm) (cost: $6,000-10,000)
- Crossroads Software (www.crossroadssoftware.com) (cost: $28,000-32,000)

None of the products — at the time of our search — met GCDOT’s functional and the IT Department’s technical requirements. For example, “Intersection Magic” drew collisions on a generic diagram, similar to the previous application. It also could not draw diagrams nor it was Oracle compatible. AIMS stood in the same line.

Crossroads Software offered a GIS-based product that came close to meeting GCDOT’s needs. However, it was not Oracle compatible, was Microsoft Access-based, and required an interface into the collision database. The county’s IT department, having recently turned off an MS Access interface, was not anxious to have a similar product on its support portfolio.

The vendor did offer to convert the application to Oracle at an additional cost. Given that the vendor was a relatively small company and that they were very busy with projects at the time, the county did not pursue this option.

Instead, GCDOT, with support from the IT department, decided to hire a consulting firm. Burns & McDonnell was selected through the open bidding process.

CREATING A DIAGRAM AND REPORT

The county interacts with CDARE through a custom toolbar with seven buttons. Diagrams can be created by clicking on the Find, Intersection, or Midblock buttons. The buttons were designed to provide efficiency and give the county flexibility when starting the diagramming process.

Diagrams can also be created by selecting roads on the map. After the selection is made, the Intersection or Midblock buttons can be clicked to generate diagrams. See below for specific descriptions of the functionality of each button.

Generate an Intersection Diagram Using the Find Window

The first option for creating a diagram is to use an interactive lookup window that allows the county to find an intersection. This is the most common method because it is easy for a traffic engineer to quickly type in two known road names. The Find window is shown below.
After entering two roads, the user clicks on the Find Address button. CDARE then uses a geocoding service to return all the possible intersection matches for both roads. There are two possible scenarios at this point.

1. **No matches found by the geocoding service**
   If the geocoding service cannot find an intersection for the roads, the user can choose to create a generic diagram. Please refer to the Generate Generic Diagram section below for more information. Generic diagram functionality was included because it was known that there would be cases where the geocoding service could be outdated or contain errors.

2. **Matches found by the geocoding service**
   The geocoding service returned one or more possible matches for the roads entered. At this point, the user can use the tools in the Find Window to zoom to the intersection to verify that the correct intersection was returned. This verification is optional and dependent upon the analysts’ knowledge of the centerline data. Once the particular roads are identified, the user clicks on the Diagram Intersection button to create an intersection diagram.

**Generate an Intersection Diagram Using the Map**

The second option for creating an intersection diagram is to select roads on the map. There are several methods to identify a road or an intersection. The most popular way is to locate an intersection by panning and zooming through the map. Use the Zoom In, Zoom Out, and Pan default ArcGIS tools find the desired intersection. The user can also set spatial bookmarks for frequently visited areas.

If the county selects an intersection from the map, CDARE will instantly create a collision diagram based on the parameters set by the user. Numerous parameters allow the system to create custom diagrams based on dates, user preferences, colors, fonts, etc. For more information on parameters, see the Parameters section.
Generate Generic Diagram

If an intersection cannot be located in the street centerline dataset, the user can create a generic diagram. The user types in the road names using the Find Address window. To create a generic diagram, the user specifies the road directions via the Generic Diagram window as illustrated below since the road directions are required to correctly position accidents.

![Generic Diagram: Assign Road Names to Intersection](image)

After the user fills out all the information, the diagram can be created.

Generate a Mid-block Diagram Using the Find Window

Similar to creating intersection diagrams, County users can create midblock diagrams using the Find window or the map. When using the find window the user selects Midblock as the diagram type. When this selection is made, the system loads a “Midblock Starting Intersection” and “Midblock Ending Intersection.” This allows the user to use the geocoding service to find both the starting and ending intersections. After the user identifies the two intersections, the user can diagram the midblock. The system will automatically connect the two intersections to create an entire midblock segment.
Generate a Midblock Diagram Using the Map

The county can also create a midblock diagram using the map by selecting an entire midblock segment between two intersections. The midblock segment can span multiple intersections. This has the advantage of allowing the user to select a road without having to specify starting and ending intersections.
CDARE can produce any size printout of the diagram. The typical sizes used are 8.5 by 11 and 11 by 17. CDARE comes with standard diagram templates, or users can create custom map templates for specific diagramming needs. Below is an example of several diagrams.

Diagrams

**Intersection**

![Intersection Diagram](image_url)

<table>
<thead>
<tr>
<th>YEAR</th>
<th>ACC</th>
<th>INJ</th>
<th>FAT</th>
<th>ARG</th>
<th>HO</th>
<th>RE</th>
<th>SSS</th>
<th>SSQ</th>
<th>OTH</th>
</tr>
</thead>
<tbody>
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<td>3</td>
<td>10</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>15</td>
<td>3</td>
<td>10</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>13</td>
<td>11</td>
<td>5</td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>13</td>
<td>6</td>
<td>5</td>
<td>0</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
Summary Table

Within the diagram a summary table displays the statistics for the diagram. The table summarizes the accidents by year and includes the number of accidents for the following categories:

<table>
<thead>
<tr>
<th>YEAR</th>
<th>ACC</th>
<th>INJ</th>
<th>FAT</th>
<th>ARG</th>
<th>HO</th>
<th>RE</th>
<th>SSS</th>
<th>SSO</th>
<th>OTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>17</td>
<td>10</td>
<td>0</td>
<td>10</td>
<td>1</td>
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<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2002</td>
<td>15</td>
<td>3</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
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</tr>
<tr>
<td>2003</td>
<td>13</td>
<td>11</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2004</td>
<td>13</td>
<td>6</td>
<td>0</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

- Injuries
- Fatalities
- Angle
- Head On
- Rear End
- Sideswipe Same Direction
- Sideswipe Opposite Direction
- Other Types

The summary table can be customized to view all of the summarized data for the entire report or for just those accidents diagrammed on the current report page.
Detailed Report

The county has the option to print a report that provides more detail than the summary table. The detailed report includes information about each accident. Some information included in this report includes accident number, date, day, time, type of crash, number of fatalities, number of injuries, vehicle maneuvers, vehicle directions, weather conditions, surface conditions and light conditions.
PARAMETERS

County officials have the ability to adjust several parameters to customize how CDARE creates diagrams. A summary of these parameters are provided below. The user can obviously specify a date range for querying accidents.

**Midblock Tab**

The user can adjust how accidents are spaced on midblock diagrams. Since accident symbols must be placed in true geographic space in the GIS, CDARE provides some ability to dictate how to correlate and space the accident symbols along the midblock roads. The correlation of accident symbols is critical for traffic pattern analysis. The default option is to allow CDARE to determine the best distance, either equidistance or minimum spacing. The equidistance option divides the midblock into perfect increments as close to the specified distance as possible. It takes into account the symbol placement to help eliminate overlapping symbols. The minimum spacing option uses the symbol sizes to find the smallest generalized distance that can be used for grouping symbols and placing them on a diagram. The application finds the best distance that fits into a midblock segment without leaving a long generalized distance for the last grouping of accidents placed. Each mid-block segment is treated uniquely if multiple segments are chosen. Users can also specify a specific distance along a road to place accidents.
The **Generic** tab allows the user to adjust how the generic diagrams will look. The user can adjust the text size and the location of labels.
Text Tab

This tab is used to modify what text is displayed with each symbol and how it is displayed. The user can choose up to three different text displays. Each text field corresponds to a database field or combination of fields for one line of text that is placed with the accident symbol. An example of the text is below, which identifies accidents by number, date, day, time, and injury and fatality occurrence.
The user can also adjust the rotation, color of text, and how text is emphasized for accidents with injuries or fatalities.

![Parameters](image)

<table>
<thead>
<tr>
<th>Text To Display</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1st Symbol Text Field</strong></td>
<td>ACC_NUM</td>
</tr>
<tr>
<td><strong>2nd Symbol Text Field</strong></td>
<td>DateTime Combined Text</td>
</tr>
<tr>
<td><strong>3rd Symbol Text Field</strong></td>
<td>Conditions Combined Text</td>
</tr>
</tbody>
</table>

- **Rotate Text with Accident Symbol**
- **Color Text same as Accident Symbol**
- Display Text with Injuries or Fatalities: **Bold**, **Italicize**, **Underline**
Graphics Tab

The Graphics tab allows the user to adjust the size of symbols and text. The user can also specify whether to use a color or black and white scheme.

Other Tabs

Two other tabs are advanced settings that users adjust during initial application setup. The Application and Data tabs specify key data parameters that are needed for the application to function properly. The Application tab also provides immense flexibility to the analyst in the placement, positioning and correlation of accident symbols, in order to identify the most significant traffic accident patterns.

LOG FILE MESSAGES

CDARE provides quality control by flagging invalid accidents that are missing crucial details or have incorrect spatially oriented values. The extension performs complex spatial algorithms against actual road directions and angles to ensure accidents are correctly entered into the database. For example, it reports an error when a driver was indicated as going north on a street that runs east and west at the accident location. When an error is discovered, a log file is created that allows users to correct the invalid values in the database. The log file also is capable of reporting on invalid road centerline data. An example of bad centerline data is dangling nodes.

CDARE provides quality checks on accident data by interpolating directional values stored in the database. The program intuitively checks and ensures the county’s data are correct. After using CDARE for less than a year, the county has corrected hundreds of accidents that were incorrectly entered or recorded. Without this capability the accidents would have gone unnoticed and incorrectly interpreted. However, with CDARE, the county has a level of accuracy that ensures accidents are being diagrammed correctly for highly accurate analysis by traffic engineers.
Below are common errors that are discovered and reported in the log file.

- Selected roads do not share common node or end-point
- Invalid road names in the centerline file
- Missing roads in the centerline file
- Missing or invalid accident data
- Data integrity issues with the database
- Data entry errors
- Inaccurate reported vehicle directions
- Distance reporting errors by officers when accidents are recorded

CONCLUSION

CDARE is a powerful application. It diagrams crashes on a GIS-based street centerline map that represents the actual intersection or the road segment. This is in sharp contrast with what most off-the-shelf diagramming applications offer: “generic collision diagrams” drawn upon hypothetical, textbook-style intersections showing four approaches, all at 90 degrees.

In the hands of a traffic safety engineer, collision diagrams are key to understanding crash patterns with a view towards the root cause of every crash pattern. A generic diagram — at best — only partially shows the true picture and — at worst — could be misleading.

Despite all the strengths, CDARE does have certain limitations. For example, it does not show the road topology. Hence any visibility or other issues caused by a sharp vertical grade remain unidentified. Hence the diagram does not eliminate the need for the engineering staff to pay a field visit.