

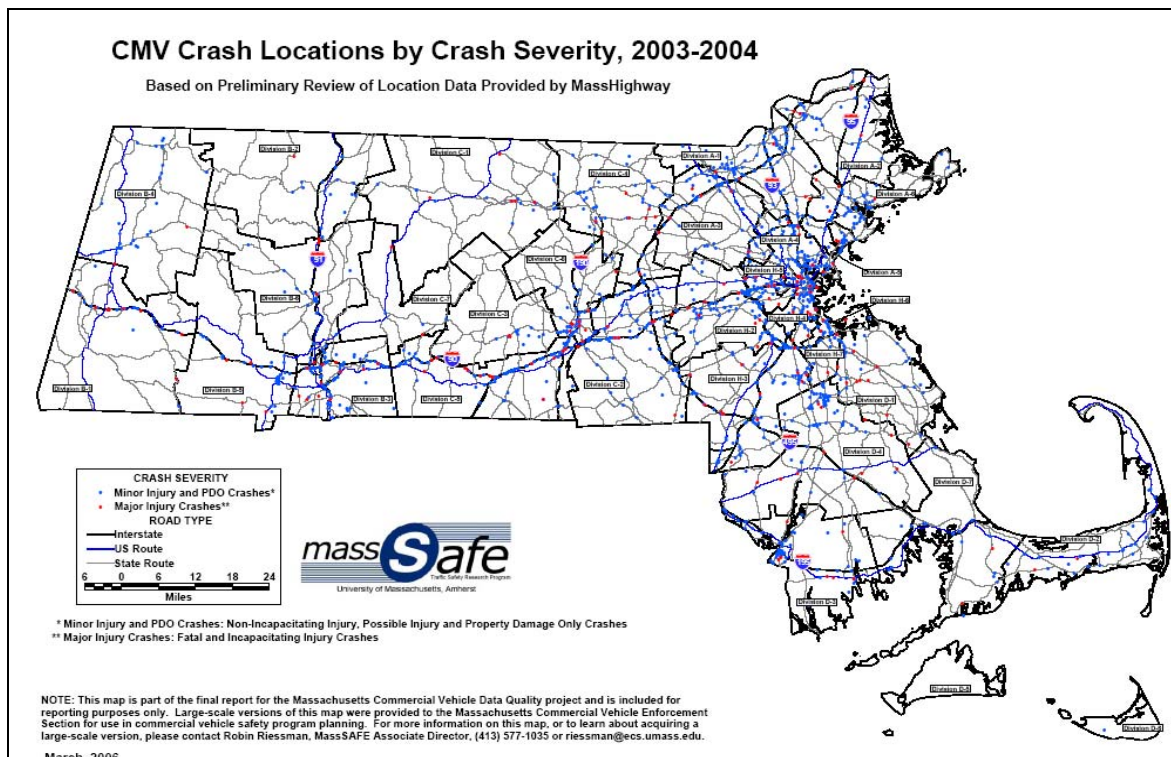
## Commercial Motor Vehicle Crash Location Mapping Tool Final Report

### Introduction

During the previous Massachusetts Commercial Vehicle Data (CMV) Quality project, a map pinpointing crash locations throughout the state was created for the Massachusetts State Police (MSP) using a traditional GIS platform (TransCAD). The benefits of being able to view CMV crashes in this map format prompted the MSP to request additional information on the potential for providing more detailed map-based tools for viewing and understanding CMV crashes. As part of a subsequent CMV proposal, the University of Massachusetts Traffic Safety Research Program (UMassSafe) included a feasibility study to examine the potential for tools that would provide crash details along with the crash location in a map format. The following are the results of this feasibility study.

### Background

As part of the previous Massachusetts Commercial Vehicle Data Quality project, commercial vehicle crash locations were mapped using location information obtained through GIS analysis. Figure 1 shows one of the maps produced for the project; this particular map illustrates CMV crash locations color coded by crash severity.



**Figure 1 CMV Crash Location by Crash Severity, 2003-2004.**

The process of identifying crash locations and providing them in a map format has proven valuable in two ways. First, the MSP Commercial Vehicle Enforcement Section (CVES) has already used the maps to identify crash “hot spots” and identify statewide enforcement needs, facilitating the allocation of enforcement to high-crash corridors. Second, the process of validating, mapping, and analyzing crash location data provided insight on data quality issues concerning location information. At the time this initial CMV mapping work was completed, crash location coordinates obtained by MassHighway geo-location technology were still preliminary. UMassSafe conducted a validation by hand locating a random sample of CMV crashes and comparing the results of the hand-location to those provided by MassHighway. In addition, geo-location processes were able to find only 75 percent of crash; therefore, the remaining reports were also located by hand. These findings were presented to the CMV Advisory Board where members—especially MSP CVES—expressed enthusiasm for computer-based access to CMV crash location information and the capability to access corresponding crash information.

As a result of the response to preliminary CMV crash location work, this study was designed to assess the feasibility of creating a mapping tool that will allow officers to access crash information (location as well as crash details) through a computer-based system. This study included an assessment of any available existing software, its compatibility with Massachusetts systems and needs, and determination of whether or not said software could meet these needs. This assessment was to result in a plan for implementation of a computer-based system for viewing CMV crash locations and related crash report information.

## Methodology

Crash locations were identified through a XX step process. First, the data points were generated from a linkage between the SafetyNet, which contains CMV crash records, and the Registry of Motor Vehicles (RMV) Crash Data System (CDS) database. CDS data are updated quarterly and this database includes spatial coordinates obtained from MassHighway geo-location processes that pinpoint the crash (precise within meters). For the years currently on the map, 2005-2006, almost 99% (1,761 of 1785) of the records from SafetyNet linked to a corresponding geo-located crash in the CDS database. One thousand four hundred and forty one of those crashes are geo-located (80.7% of all crashes, 81.8% of linked crashes)

After reviewing existing software tools, Google Maps was selected as the most effective tool. It is a user interface that many people are already familiar; many other researchers and systems specialists have worked to develop the finer points of Google Maps; and its widely used nature makes it ideal for a project like this and will allow for continued development. Upon determination that the development of a web based interactive CMV crash map tool was feasible, UMassSafe expanded the scope of the grant project to include initial development of the tool. The CMV crash-mapping tool was developed using the Google Maps Application Programming Interface (API). Correspondingly, anything available in Google Maps (such as high zoom levels and satellite imagery) is available in the map. Users can search for specific crashes by carrier name, USDOT number, or crash report number to locate and display information about a crash. Users can also zoom in to particular addresses, intersections, or towns.

## Mapping Tool Capabilities

The Massachusetts Commercial Motor Vehicle Crash Map is an interactive tool that allows users to identify trends and pinpoint CMV crash information across the state. A colored marker representing each CMV crash can be clicked on to display detailed information on the crash, the vehicle, and the quality of the data for that particular case. Table 1 lists all the fields available for each crash in this mapping tool along with their description and the database containing the information.

CRASH INFORMATION		
<i>FIELD</i>	<i>DESCRIPTION</i>	<i>DATABASE</i>
Crash Report Number	Unique ID assigned to report	CDS
Crash Date	Date when crash occurred	SafetyNet
Crash Day	Day of the week when crash occurred	SafetyNet
Crash Time	Time of the day when crash occurred	SafetyNet
Crash Town	Town where crash occurred	CDS
Police Type	Type of police department reporting crash	CDS
Reporting Agency	Name of police department reporting crash	SafetyNet
Light Condition	Lighting conditions when the crash occurred	SafetyNet
Weather	Weather conditions when the crash occurred	SafetyNet
Road Surface	Condition of the road surface when the crash occurred	SafetyNet
Crash Severity	Most serious injury suffered by anyone in the crash	CDS
Traffic way	Characteristics of the roadway (one-way, divided, etc) where the crash occurred	SafetyNet
Citation Issued	Whether any citation was issued at the time of the crash	SafetyNet
Tow away	Whether any vehicle in the crash needed to be towed	SafetyNet
Officer Badge Number	Badge number of the officer filling out the crash report	SafetyNet
Number of Vehicles	Number of vehicles involved in the crash	SafetyNet
Number of CMVs	Number of commercial vehicles involved in the crash	SafetyNet
Number of Injuries	Number of injury people involved in the crash	SafetyNet
Number of Fatalities	Number of fatally injury people involved in the crash	SafetyNet
VEHICLE INFORMATION		
<i>FIELD</i>	<i>DESCRIPTION</i>	<i>DATABASE</i>
License Number	The license number of the vehicle	SafetyNet
License State	The State issuing the license of the vehicle	SafetyNet
VIN	The Vehicle Identification Number (VIN)	SafetyNet
Body Type	The type of CMV vehicle as recorded in SafetyNet	SafetyNet
Bus Use	Whether the CMV was a bus or not	SafetyNet
Configuration	The type of CMV vehicle	SafetyNet
Carrier Name	The name of the carrier	SafetyNet
Carrier Address	The address of the carrier	SafetyNet
Interstate Carrier	Whether the carrier was interstate or intrastate	SafetyNet
US DOT Number	US DOT Identification number	SafetyNet
Census Number	Census identification number in MCMIS	SafetyNet
Census State	State where the carrier is listed in MCMIS census	SafetyNet
DATA QUALITY		
<i>FIELD</i>	<i>DESCRIPTION</i>	<i>DATABASE</i>
Days to MCMIS	Number of days between crash occurred and crash reported to MCMIS	SafetyNet
Missing US DOT	Whether the US DOT number was recorded	SafetyNet
Missing VIN	Whether the VIN number was recorded	SafetyNet

Figures 2, 3, and 4 are screenshots of the Massachusetts Commercial Motor Vehicle Crash Map tool that show the display of a CMV crash using the satellite image option of Google Maps with all the information available for crash (Figure 2), vehicle (Figure 3), and data quality (Figure 4).

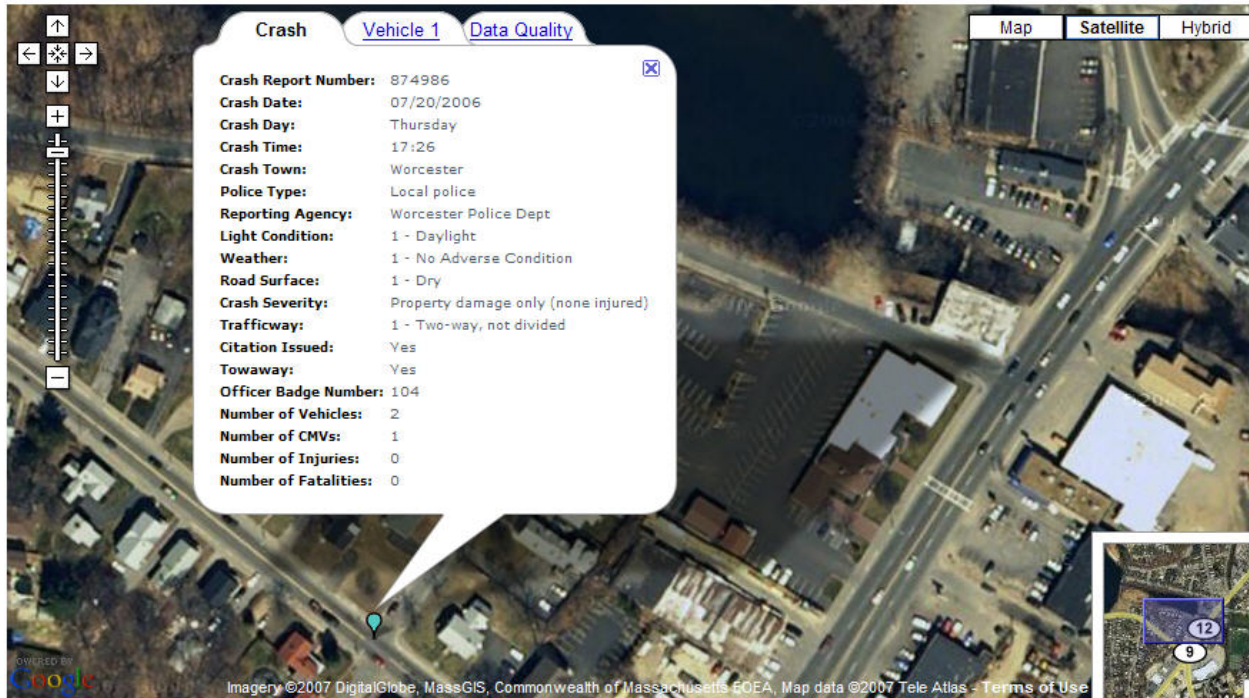


Figure 2 Map display of CMV with crash information.

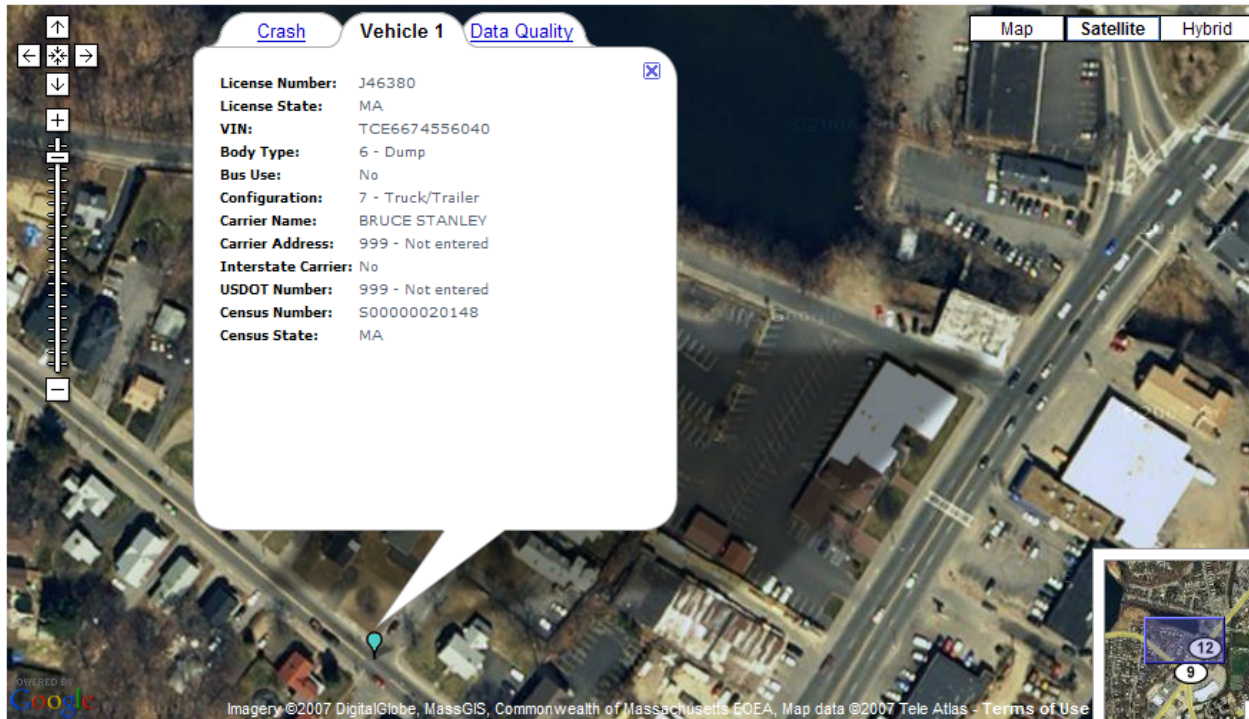
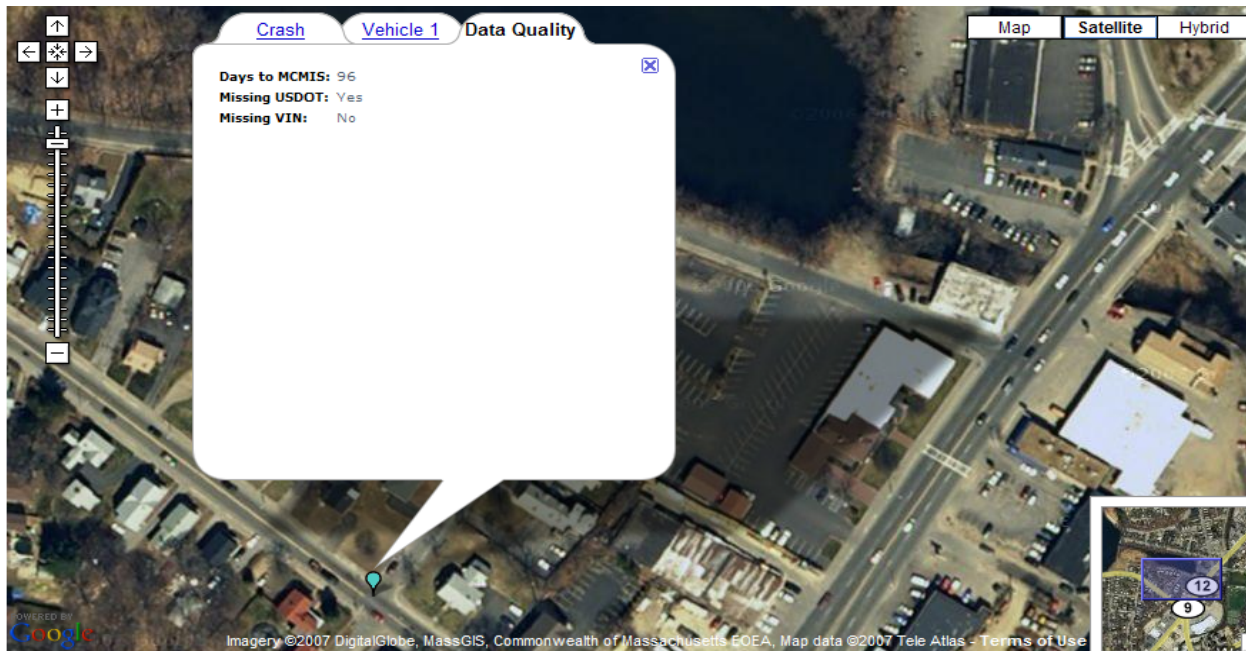
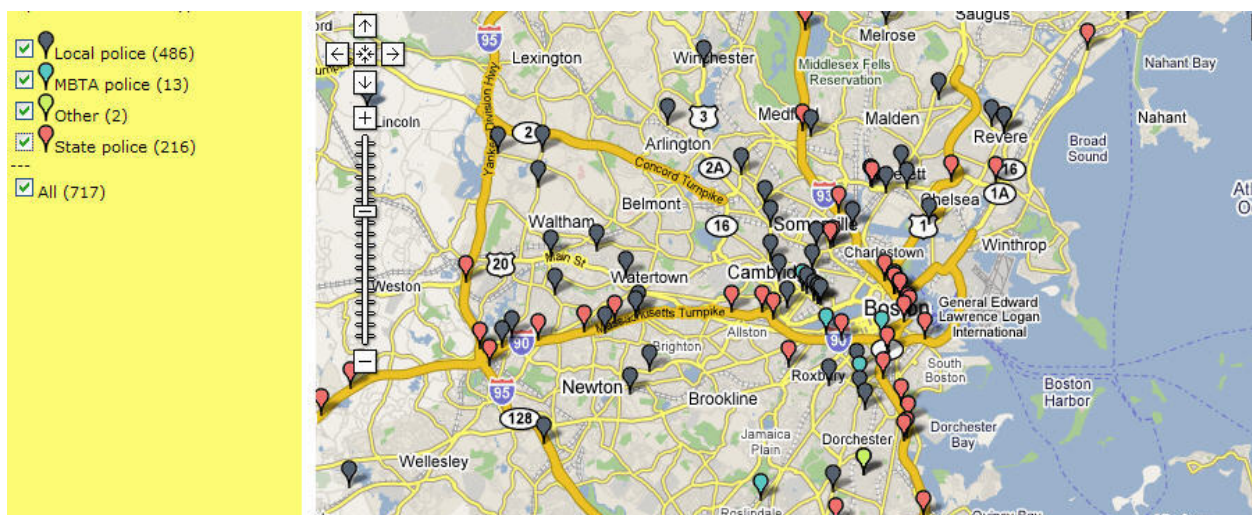


Figure 3 Map display of CMV crash with vehicle information.

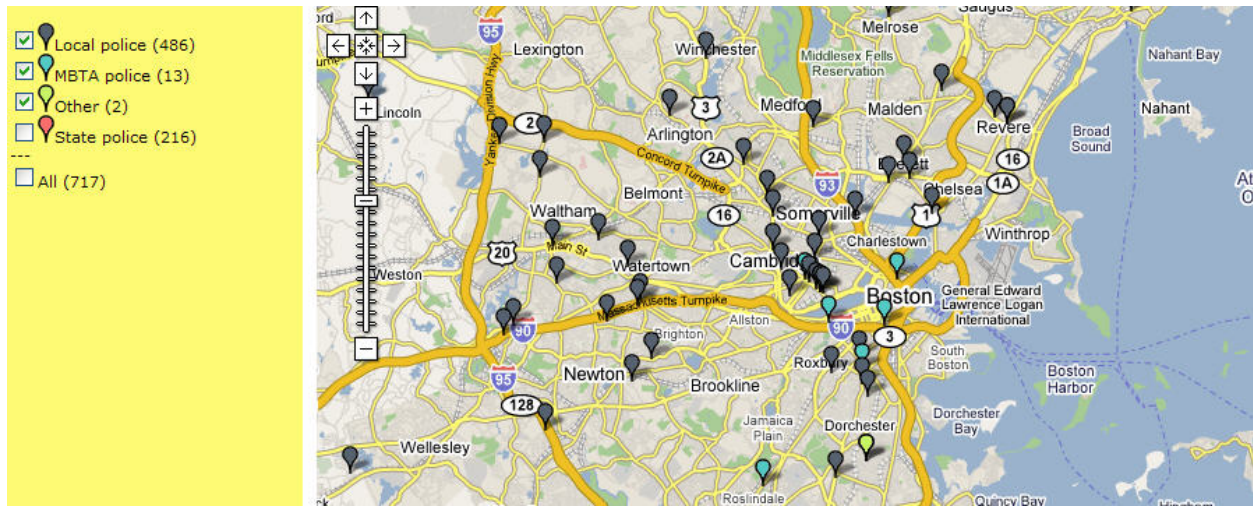


**Figure 4 Map display of CMV crash with data quality information.**

In addition to viewing all crashes individually with their particular attributes, users can aggregate characteristics and to better understand trends and common characteristics of CMV crashes. By selecting a specific crash characteristic, the appearance of the map changes, providing a color-coded system for viewing crashes for each of the values associated with the characteristic selected. For example, when the 'Police Type' field is selected, each crash is colored red (for state police), blue-grey (for local police), aqua (for MBTA police), or yellow (for unknown). A legend appears on the left side of the screen with the different values for the characteristic chosen. By selecting and deselecting the check boxes next to each characteristic in the legend, the user can show and hide each type of crash in the map. Figure 4 shows this color-coding feature when police type is selected. Figure 5 shows how one category (in this case State Police) can be hidden in the map.



**Figure 4 Sample map of CMV crashes by police type.**



**Figure 5 Sample map of CMV crashes by police type with State Police reported crashes hidden.**

The Massachusetts Commercial Motor Vehicle Crash Map tool also provides aggregate data for each state police barracks. Accordingly, the number of crashes for each barracks can be shown, along with a breakdown based on a selected crash characteristic. As an example, Figure 6 shows that Barrack B-1 had 11 CMV crashes in 2006, two of which were reported by local police, with the other nine reported by State Police. When some of data quality attributes are selected, barracks are colored based on their performance in that particular area. As an example, Figure 7 shows when the ‘Days to MCMIS’ attribute is selected, barracks are colored red, yellow, or green based the percentage of crashes they reported to MCMIS in fewer than 90 days during the selected timeframe. The map also provides this aggregated crash information for each town in Massachusetts.



**Figure 6 Map display of State Police barracks: data for Barrack B-1.**



Figure 7 Sample map of State Police barracks by 'Days to MCMIS'.

### Massachusetts CMV Crash Map Instructions

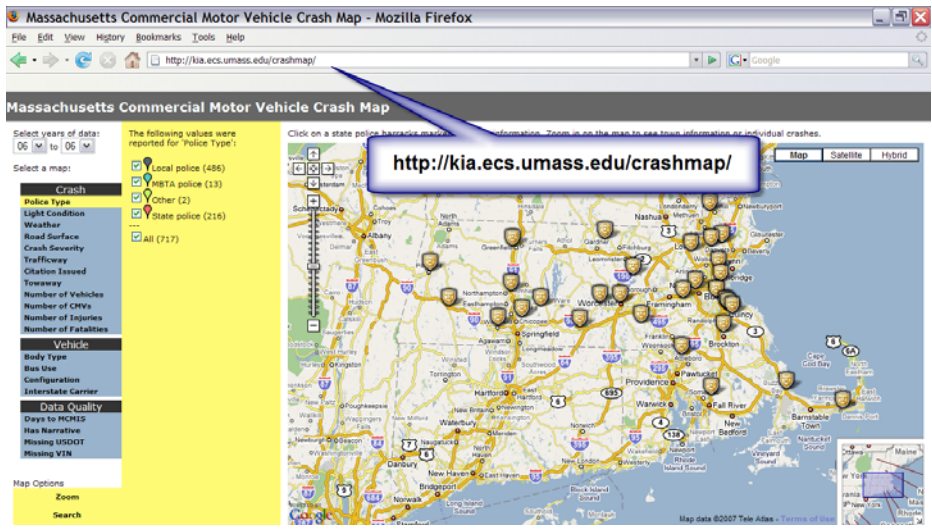
To help users maximize the maps' full potential, detailed step-by-step instructions and examples of how this tool can be used are provided in this section. This is intended to be used as a tutorial to help users learn how to navigate the crash map tool and all features available.

The following steps are included:

- STEP 1. Go to the website;
- STEP 2. How to sort characteristics by State Police barracks;
- STEP 3. How to change the years of data;
- STEP 4. How to get information about particular crashes;
- STEP 5. How to sort characteristic for a particular town;
- STEP 6. How to hide/show crashes with specific characteristics;
- STEP 7. How to zoom; and
- STEP 8. How to search.

#### STEP 1. Go to the website: <http://kia.ecs.umass.edu/crashmap/>

Please be patient and allow the map to load, it is completed when you see the police badge icons on a map of Massachusetts as shown below.



## STEP 2. How to sort characteristics by State police barracks.

Once on the web site, the map loads showing data aggregated by state police barracks. At the left side of the screen is a list of all possible crash, vehicle, and data quality characteristics by which crashes can be sorted. On top of this list, there are the years of data available. The message on top of the map should say 'Click on a state police barracks marker for more information. Zoom in on the map to see town information or individual crashes.' As this indicates, by clicking on a police badge you can see information about each particular police barrack.

Once the map is loaded, you will see 2006 CMV crashes by state police barracks broken down by the reporting police type, which is the first characteristic on the list. To select any other characteristic, click on top of it; the chosen characteristic will be highlighted in yellow, and the map will be updated.

For example, click on 'Body Type' under vehicle characteristics. The map will be updated. If you click on the police badge that corresponds to barracks B-1, a list of the crashes broken down by vehicle body type will appear as shown in the map below. In the yellow area, a legend shows every category of 'Body Type'. In parenthesis next to each category of 'Body Type', you can see the number of CMV crashes that occurred in Massachusetts for the year of data selected. Please note that the numbers of CMV crashes listed in parenthesis next to each category correspond to the whole state, not just to the area in the map.

The screenshot displays the web application interface. On the left, a sidebar contains filter categories: Crash, Vehicle, and Data Quality. The 'Body Type' filter is selected and highlighted in yellow. A legend in the center lists 11 categories of 'Body Type' with their respective counts for the selected year (2006):

- 1 - Bus (seats 9 - 15 people, including driver) (15)
- 10 - Grain, Chips, Gravel (22)
- 12 - Not Applicable (9)
- 2 - Bus (seats more than 15, including driver) (124)
- 3 - Van/Enclosed Box (154)
- 4 - Cargo Tank (31)
- 5 - Flatbed (32)
- 6 - Dump (43)
- 7 - Concrete Mixer (4)
- 8 - Auto Transporter (8)
- 9 - Garbage/Refuse (24)
- 98 - Other (9)
- 999 - Not entered (242)

At the top left, the 'Select years of data' section shows '06' selected for both the start and end years. A callout box on the map, titled 'Barracks: Division B-1', provides a breakdown of crashes for that specific area:

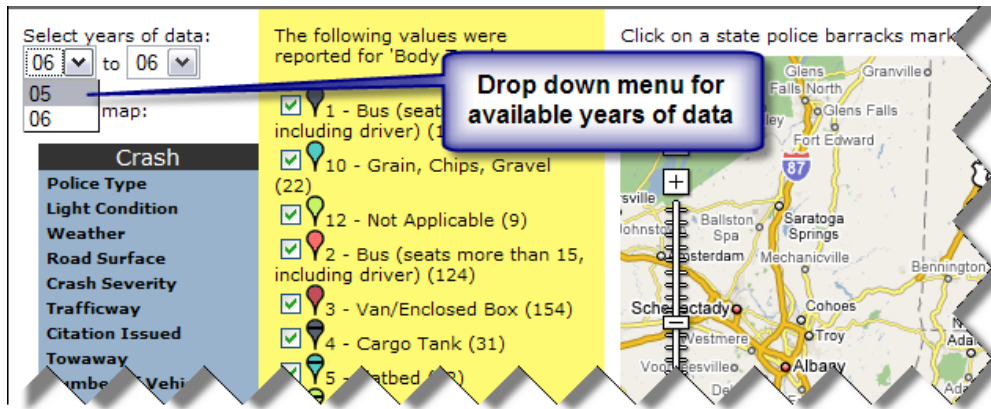
- Total crashes: 11
- Totals for 'Body Type':
  - 2 - Bus (seats more than 15, including driver): 1
  - 3 - Van/Enclosed Box: 4
  - 7 - Concrete Mixer: 1
  - 8 - Auto Transporter: 1
  - 9 - Garbage/Refuse: 1
  - 999 - Not entered: 3

A blue callout box points to the legend with the text 'Number of crashes by 'Body Type''. A yellow callout box points to the 'Body Type' filter with the text 'Select 'Body Type''.

## STEP 3. How to change the years of data.

You can change the years of data that are shown in the map. To do so, select the years of data using the drop down boxes at the top left corner of the screen as shown in figure below. The left box corresponds to the first year of data and the right box to the last year of data you would like to see on the map. To see only one year, choose the same year in both boxes.

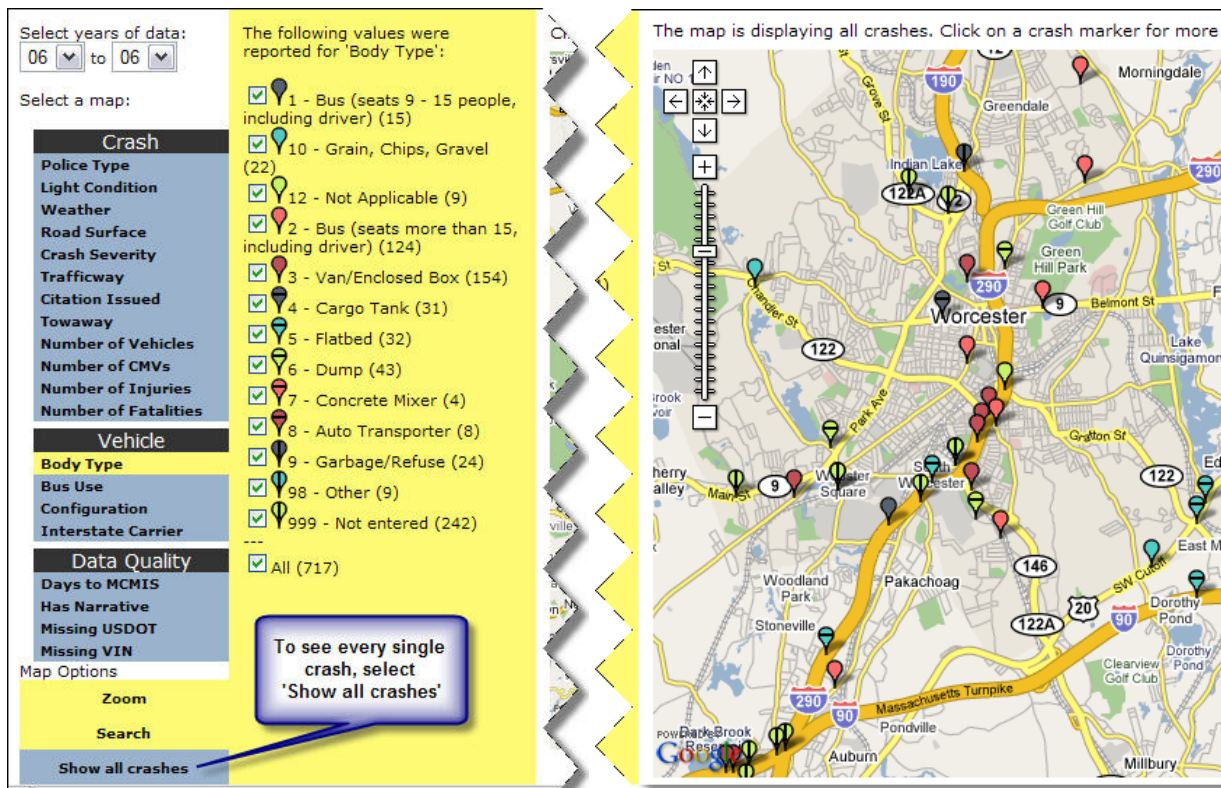




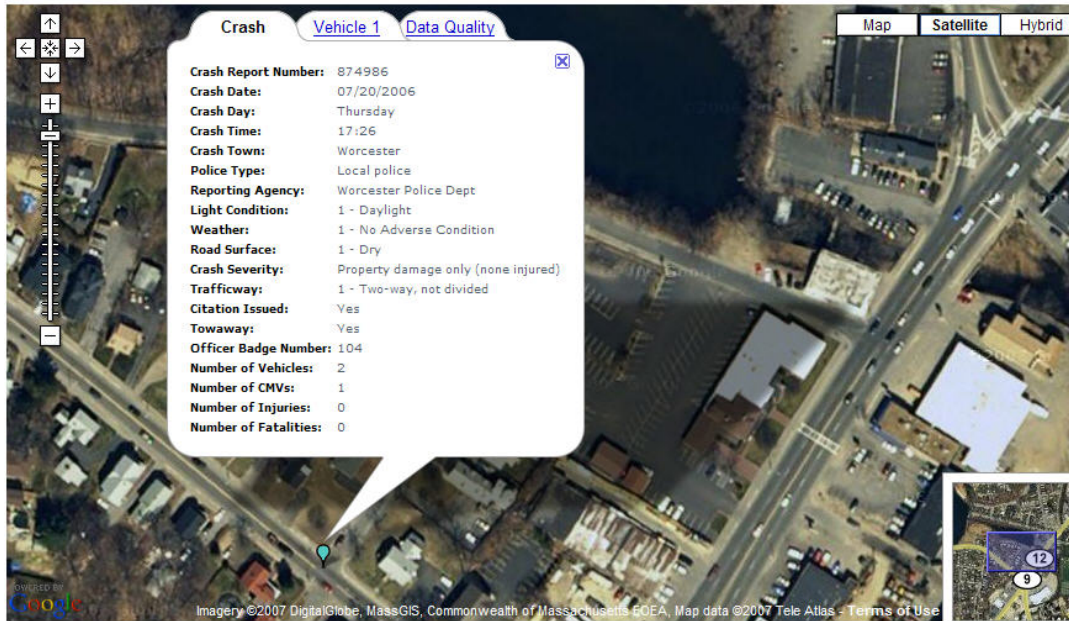
#### STEP 4. How to get information about particular crashes.

To see individual crashes on the map, instead of aggregated data, select 'Show all crashes' on the bottom left corner of the screen. The tool will update the image to show individual CMV crashes for the chosen period represented as a colored marker on the map. On top of the map, the following message will appear 'The map is displaying all crashes. Click on a crash marker for more information'; this verifies that the map shows all crashes.

In a similar way as in step 2, the crashes on the map can be sorted by the different crash, vehicle, and data quality characteristics listed on the left side of the screen. The example below shows 2006 CMV crashes in Worcester color-coded by 'Body Type'. Each different color/pattern of a crash marker in the map corresponds to a different vehicle 'Body Type'. The legend on the yellow area gives the color/pattern that represents each value for the characteristic chosen. Please note that the numbers of CMV crashes listed in parenthesis next to each category correspond to the whole state, not just to the area in the map.

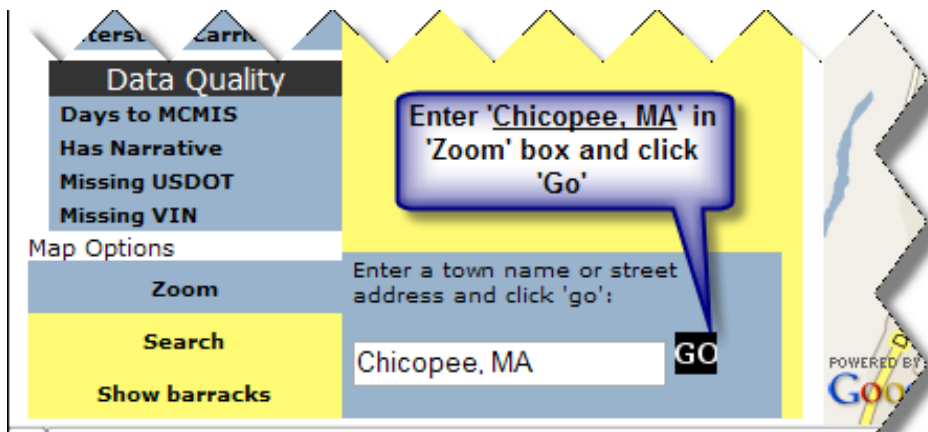


Click on a specific marker to see the characteristics of each particular crash. Notice that the pop-up window with the information has three tabs, corresponding to crash, vehicle and data quality characteristics as shown in the map below. In cases where the crash report was electronically submitted to the Registry of Motor Vehicles by the police department, the crash report narrative has been included as a fourth tab.

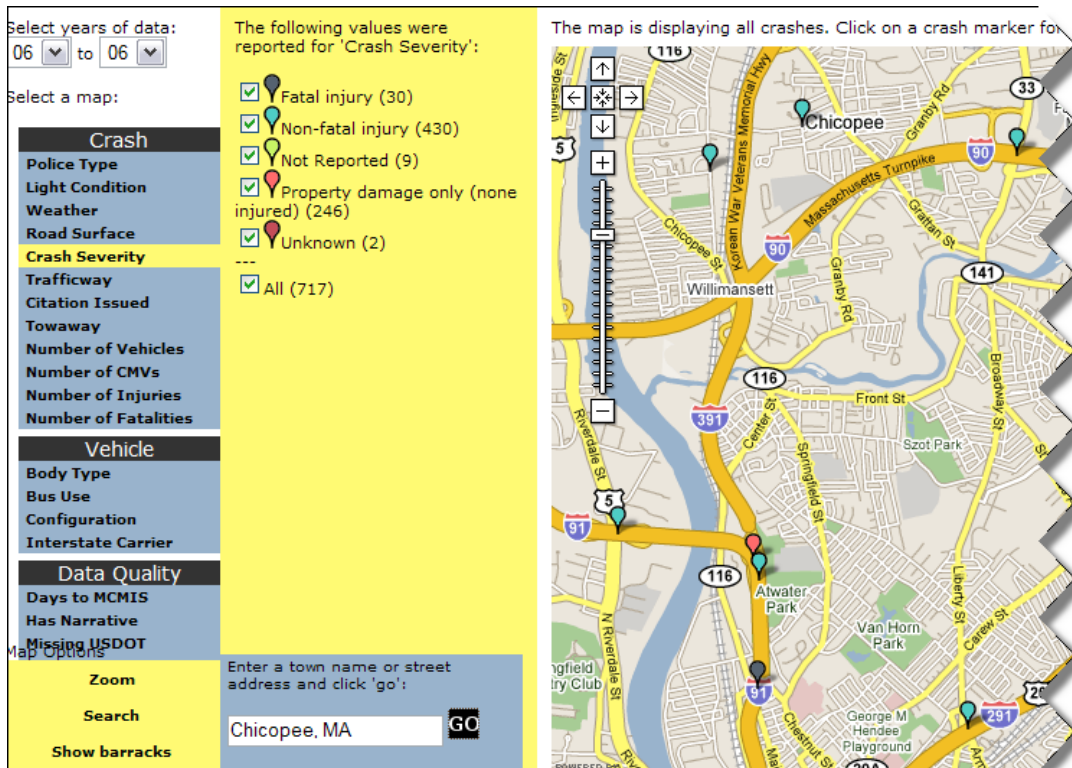


#### STEP 5. How to sort characteristic for a particular town.

To enlarge any particular area of the map, you can use the 'Zoom' button at the bottom left of the screen. You can use this 'Zoom' feature to see a map of any town in Massachusetts. Once the map loads the town chosen, you can select any of the characteristics and sort the crash markers by categories. As an example, type 'Chicopee, MA' in the 'Zoom' box and click go. The tool will reload the map showing the Chicopee area.



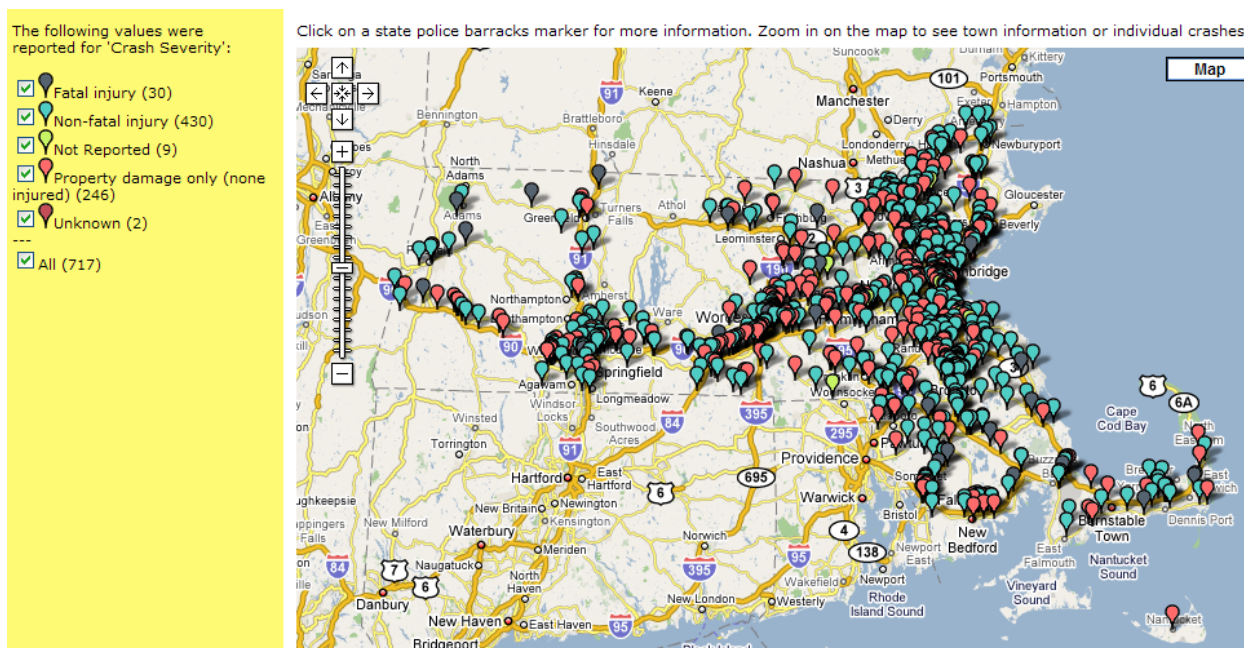
Once the map is loaded, you can select any particular characteristic from the left side list to sort the crashes in the town you have selected. As an example, select 'Crash Severity'. The color/pattern of the crash markers will update to show the different values of the characteristic chosen as shown below. Please note that the numbers of CMV crashes listed in parenthesis next to each crash severity correspond to the whole state, not just to the area selected.



**STEP 6. How to hide/show crashes with specific characteristics.**

CMV crashes with specific characteristics can be hidden in the map. By selecting and unselecting the check boxes next to each characteristic in the legend, you can hide types of crashes you are not interested in and show only the ones that are relevant to you.

As a simple example, zoom out to see the map of Massachusetts and select as a characteristic 'Crash Severity'. As shown in the next map, you will see five different color markers to show the categories of 'Crash Severity'. Unselect all categories but 'Fatal Injury'. Now the map will show only those CMV crashes that involved a fatality as shown below.



- The following values were reported for 'Crash Severity':
- Fatal injury (30)
  - Non-fatal injury (430)
  - Not Reported (9)
  - Property damage only (none injured) (246)
  - Unknown (2)
  - All (717)

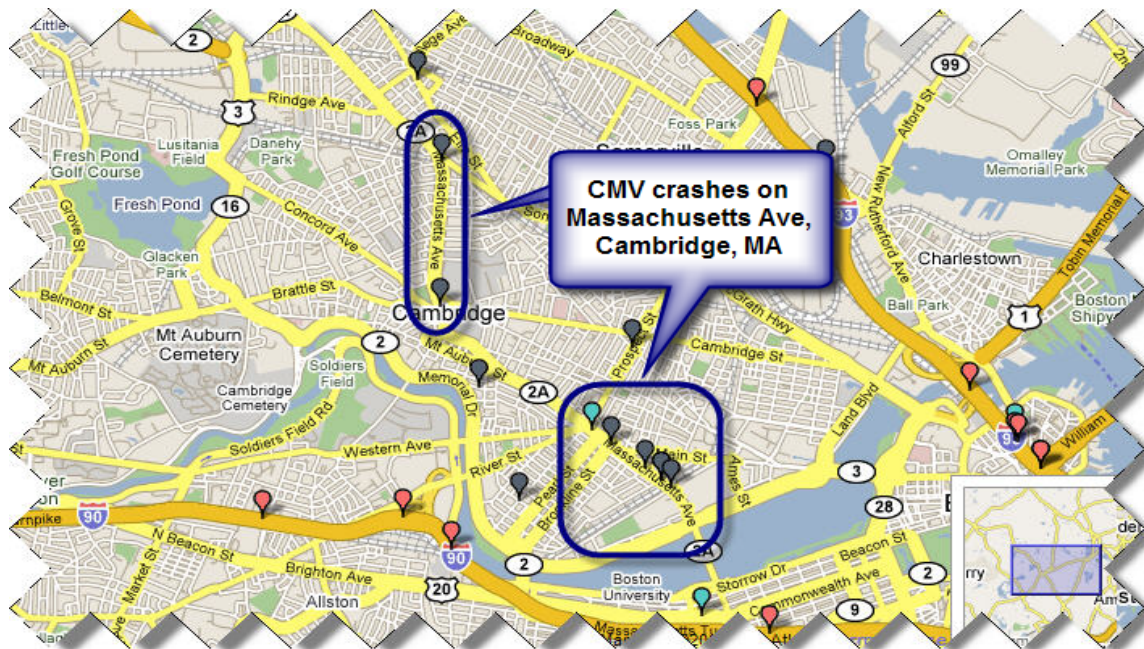
Click on a state police barracks marker for more information. Zoom in on the map to see town information or individual crashes.



### STEP 7. How to zoom.

To enlarge any particular area of the map, you can use the ruler on the map (+ to zoom in, - to zoom out) or you can use the 'Zoom' button at the bottom left of the screen. You can enter any address, roadway, or town you would like to zoom in to. As an example, enter 'Massachusetts Ave, Cambridge, Ma' in the 'Zoom' box and click 'Go'. The tool will reload the map to show the street entered.





### STEP 8. How to search.

The tool has an initial search capability, which is currently being tested and improved. To search for specific characteristics, you can use the 'Search' button at the bottom left of the screen. By typing any word as search criteria, you can find all crashes that contain that word entered in any data field. The advantage of this feature is that works as a filter so you get only those CMV crashes that met your criteria. As opposed to the show/hide feature (step 6) and the zoom feature (step 7) that still give you the numbers for the whole state, the search criteria pulls out the exact number of crashes meeting the criteria. For example, if 'Cambridge' is chosen, the tool searches in all fields for 'Cambridge' and gives you as a result all CMV crashes that happened in 'Cambridge'.

One current limitation of this search capability is that the system simply searches for a string of letters so in some cases could give misleading results. For example, if 'rain' is chosen, the tool searches every field in the crash attributes for the four consecutive letters in 'rain'. In this example, not just Weather='rain' would be found but also Body Type = 'grain, chips, and gravel' is selected because of the word 'grain'. In addition, currently the text entered in the search box is compared to all crash attributes. One future modification will be to allow a user to specify the fields they want to search on. For example, if they want to find the carriers that match 'Jones', but not drivers that match 'Jones', they will be able to specify this. UMassSafe will revise and improve this search feature in the future to prevent this.

## Next Steps

The development of the CMV Crash Map tool was designed to enable police officers to pinpoint locations with a high incidence of CMV crashes; this information can be used in targeted enforcement efforts. . The CMV map also provides information concerning data quality such as crash report timeliness and missing US DOT number. Being able to sort these types of data by police department allows the MSP CVES to identify police departments that struggle to submit reports on time or have a high number of missing US DOT numbers and help them improve their performance. This will grant MSP the ability to improve CMV crash data quality while targeting high-incidence CMV crash locations. Potential improvements to the web site and expansion of the CMV crash mapping capabilities include the following:

- Increase the tool's speed so that more years of data can be viewed at the same time.
- Expand the data linkage by hand reviewing and manually matching crashes that did not link using only unique identification from each database.
- Increase the number of located crashes on the map by individually analyzing the location data entered in each report for those crashes that did not successfully geo-locate and finding where the crash occurred using web based mapping tools such as Google Maps and MapQuest.
- Develop and post on the web site PDF files of basic crash maps for users that do not want to query the system.
- Expand the web site and create tool capability to post reports to illustrate data quality performance at the state level as well as at the state police barracks and town levels. These reports could be viewable in four ways:
  - Management emails could be sent to state police supervisors to identify barracks and towns with deficient data quality scores;
  - Individual emails could be sent to each police barracks or town police department to alert them that their performance is deficient;
  - Data quality statistics could be viewable on the internet, and could be shown in tabular or graphical format (illustrating increases or decreases in performance over time); and
  - A map showing data quality performances for barracks and towns could be made viewable on the internet. This map could also show individual crashes and their associated narratives.
- Identify and develop additional data quality metrics (these will partially be taken from federal crash report requirements) and add to the mapping system.

MSP CVES representatives expressed a strong need for additional training and tools for police to use in their efforts to understand CMV crashes. UMassSafe could expand the website beyond the crash map to include crash report form training and previous years' statistical analyses of CMV crash reporting data. Currently, MSP cannot access statistical data from the Records Management Systems (RMS), which hinders planning for safety improvements. MSP representatives have indicated that a website, which provides CMV crash reporting information, as well as training on how to fill out the truck and bus section of the form correctly, would be beneficial. The web site could be expanded to integrate all data quality elements. The site could include the items above, as well as online crash report training for state and local police.