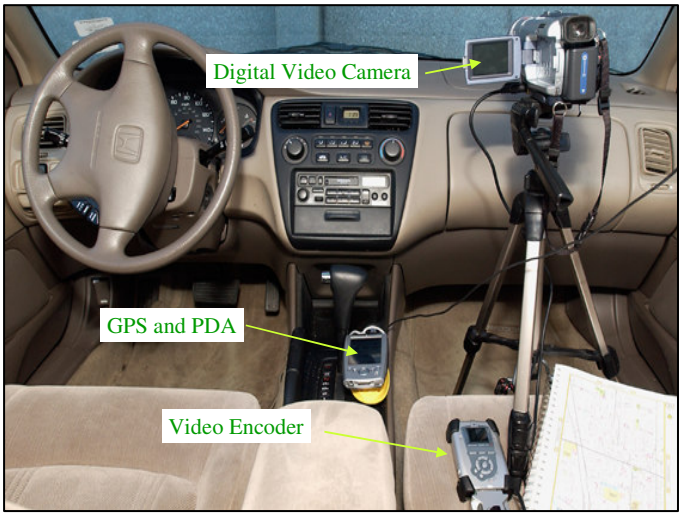
# 3. Methodology

## 3.1 Mapping and Travel Time Data

The 2010 Travel Speed Study included enhancements to the data collection, data management, and analytical methods. First, the roadways were mapped to verify the system attributes that were collected in 2006 on routes included in both studies, document changes since 2006, establish centerlines for new routes and record relevant roadway features using the newly developed Jacobs LRS Assessment field software. This data was used to update the CCMPO Geographic Information System (GIS) database developed by Jacobs as part of the 2003 and 2006 studies. The Jacobs GIS utilizes a linear reference system (LRS) as the basis of all roadway and travel speed data. Features and data within an LRS use position along a route instead of an x,y coordinate system. The route features contain measures or distance along the route. After mapping all routes, the travel time runs were collected. The 2010 Study used both GPS equipment and digital video for a thorough analysis. The roadway segments were videotaped during the mapping runs in order to provide a reference of operational conditions for possible mitigation. The digital videos were later linked to the GIS results for future reference. This provides a video log of most primary roadways within Nueces and San Patricio County.

The photograph on the right shows the typical setup for the field vehicle.




The roadways were broken down into 1079 directional segments in GIS for analyzing the travel time data at a segment level. The segments are defined by controlled intersection locations, in general. This helps to better identify areas of localized congestion.

After the field mapping was completed, travel runs were conducted using the floating car method. The floating car method is described in detail in the *Manual of Traffic Engineering Studies* published by the Institute of Transportation Engineers. The test vehicle travels within the flow of traffic, passing as many vehicles as pass the test vehicle. In this way, the test vehicle is representing the average vehicle. During the travel time runs, the Haicom BT GPS equipment recorded position and time at one-second intervals into a Dell Personal Digital Assistant (PDA) using Bluetooth technology. The data is saved through a customized travel speed program developed by Jacobs. The driver of the test vehicle drove the speed limit if no other cars were present and at the school zone speed limit if a school zone speed limit was in effect at the time of the travel time run.

For the 2010 Travel Speed Study, travel run data was collected during the months of August, September and October 2010. The data was collected on Tuesdays, Wednesdays, and Thursdays, during the morning and afternoon peak periods on all the routes and during the Mid-day period on selected routes. The study time periods were as follows:

- Morning Peak Period: 7:00 AM to 9:00 AM – 3 runs in each direction
- Mid-day Peak Period: 11:00 AM to 1:00 PM – 2 runs in each direction
- Afternoon Peak Period: 4:00 PM to 6:00 PM – 3 runs in each direction

After the travel runs completed, the data was analyzed with the help of the LRS. The data analysis included various levels of review, including automated QA/QC, and manual QA/QC. The primary steps taken to process the large amounts of data are shown below.

- Assign segments for aggregation purposes
  - intersection segment
  - speed limit
  - school zone speed (if applicable)
- Calculate travel time
- Calculate average Space Mean Speed and Time Mean Speed.
- Calculate frequency of stops within each segment
- Calculate the stop delay as the count of one second GPS points where the speed <=3 MPH
- Calculate the segment delay as the difference between travel time and free flow travel time
- Calculate free flow travel time
- Average by intersection segment

Because data was recorded every one second using GPS equipment, the intersection approach delay calculation was made feasible for all signalized intersections within the study area. Delay calculations were provided for through vehicles only. No analyses were conducted for turning movements. The delay in seconds was then compared with the HCM criteria for level of service for approaches to signalized intersections. These criteria categorize vehicle delay into levels of service ranging from LOS A, meaning less than or equal to 10 seconds delay, to LOS F, meaning more than 80 seconds of delay. The intersections with poor levels of service (i.e. long delay) were marked in GIS.

Summarizing the results purely by average speed may indicate slow speeds when in reality, traffic may be traveling according to a low posted speed limit. In order to differentiate between congested roadways and roadways with low speed limits, a method for illustrating the data that was introduced in 2003 and used in 2006 was once again used in the 2010 Travel Speed Study. This method uses a ratio of actual travel speed to posted speed limit called the Congestion Index (CI). A CI of 1.0 or greater indicates free flow speed, where traffic is traveling at the speed limit or higher. Municipalities can define levels of CI to indicate free flow, average flow, and congested flow. This information can be used in the planning process to better appropriate funds for needed improvements.

Congestion Index = Actual Average Speed / Weighted Average Posted Speed Limit

Actual Average Speed = Average speed of all runs on a segment in a peak period
Weighted Average Posted Speed Limit = Average of all posted speed limits on the segment weighted by length

According to the CCMPO criteria established with the 2003 study, a CI less than 0.75, indicates a congested section. For example, this would be traveling less than 30 mph when the posted speed limit is 40 mph. A CI of 0.75 to 0.99, or approximately 30 mph to 39 mph, indicates a section of stable flow. And a CI greater than 0.99, or 40 mph or higher, indicates free flow conditions. Table 1 defines the congestion index criteria.

The travel speeds on congested segments are slower than drivers typically want to drive, and there may be less opportunity for lane changing and maneuvering. Stable sections are accommodating volumes less than capacity. Travel speeds are somewhat slower than the speed limit, but generally acceptable to drivers. Lane changing and maneuvering is less difficult than in congested segments. Free-flow sections are operating well below capacity. Travel speeds that equal or exceed the speed limit indicate that traffic can maneuver without interference.

**Table 1 – Congestion Index Criteria**

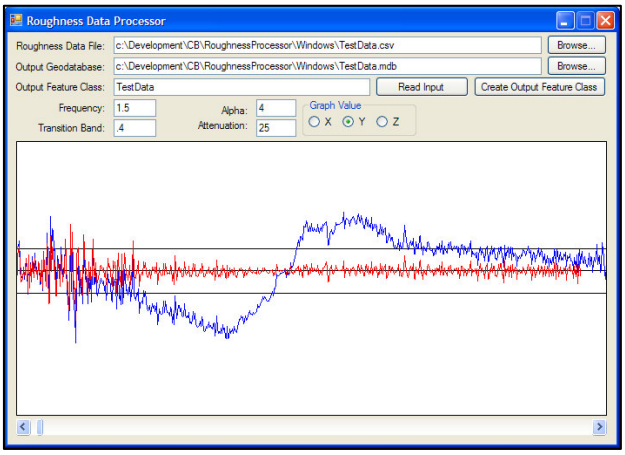
| Congestion Index (CI) | | |
|---|---|---|
| Congestion | Stable Flow | Free Flow |
| < 0.75 | 0.75 to 0.99 | > 0.99 |

## 3.2 Pavement Roughness

Pavement roughness was evaluated for the first time in Fall 2010 and presented in GIS. This was included to assist the CCMPO staff to objectively evaluate pavement condition along corridors.

Each route was driven in one direction. The data was collected and processed as described below.

1. GPS unit records a position, time and speed every second.
2. A 3D-accelerometer was mounted to the vehicles' axle. It captures the 3-axis acceleration of the axle 20 times per second (Hz) and the position is interpolated based on speed and time of the last GPS reading.
3. As shown in the illustration, the 20 Hz acceleration data are filtered using a high pass digital filter that removes the lower frequency components (less than 1.5 Hz) of the raw vertical acceleration values (blue



line). A common source of these low frequency components are centrifugal forces around curves. The filtered data (red line) are visually inspected and compared to the original, unfiltered data to ensure proper performance of the filter.

4. The area under the red acceleration curve represents the relative pavement roughness and is calculated by multiplying the distance traversed by the vertical accelerometer value.

5. Each acceleration value is then grouped into a 0.1 mile segment and the total area under the curve per foot and percent above each standard deviation is summarized for each 1/10$^{th}$ of a mile segment.

## 4. The CCMPO Linear Referencing System

The traffic elements that were captured during mapping including intersection control, speed limits school zones limits, number of lanes, median type, bike lanes and construction areas are shown in the following figures. Other elements that were coded in GIS using data provided by the MPO included: jurisdictional boundaries, model area type, and model facility type. This information was used to determine the segment lengths and theoretical travel times, and to provide better insight into the resulting travel time runs and improvement recommendations.