DISTRIBUTED GIS TO DISSEMINATE VIA INTERNET INFORMATION ON ROAD ACCIDENTS, TRAFFIC COUNTS AND SURFACE CONDITION OF HIGHWAYS

N. Villegas & A. Mendoza
Mexican Transportation Institute, Querétaro, México
villegas@imt.mx, mendoza@imt.mx

ABSTRACT

The aim of this work is to have a Geographic Information System (GIS) Distributed for disseminating information of road accidents, traffic counts and surface condition of Highways segmented every 500 m through the Internet. First, the automated procedures of dynamic segmentation were applied to georeferenced information from the Federal Highway Network, in order to generate the segments of 500 m with numerical keys of the entire road network. Then programming algorithms were developed to link the information of road accidents, traffic counts and surface condition of the road with segments of 500 m. Later, geographical representation was developed using tools that implement standards for geospatial data dissemination via the Internet, like Google Maps that facilitates the visualization of the environment of the road network highway and of the segments represented with different colors, according to the number of road accidents occurred in the segment, the registered traffic counts or the surface Condition; the information is displayed in a box by clicking on any segment. In this way the results generated by the system are shown for some major Mexican highways.

1. APPLICATION OF DYNAMIC SEGMENTATION IN GEOSPATIAL INFORMATION

Dynamic segmentation procedures applied to georeferenced information from the Federal Highway Network [1], were done using commercial software ArcInfo Workstation, developed by ESRI (Environmental Systems Research Institute) to automate, manipulate, analyze and display data space in digital form.

Dynamic segmentation is the process of transforming linearly referenced data (also known as events) that have been stored in a table like features that can be deployed and tested on a map. Each event in an events table must include a unique identifier and position across the line. And each line must have a unique identifier and size [2].

Dynamic segmentation procedures made possible the division and numerical classification of a wide network of road segments of a given length, in this case of 500 m. Subsequently, the programming algorithms link the information contained in databases with segments of 500 m through numerical keys. This facilitated the visualization of geographic data and its characterization via the Internet. Here are dynamic segmentation procedures applied to linear elements.

1.1. Creation of "coverage" and topology fixes

Initially, georeferenced information of the highway network was classified as road sections with a numerical identifier (id_unico) formed by two digits for the state, five for the road and two for the number of section, which was stored in files "shape” (data storage format of ArcView software) by State. At this stage, the file "shape" of the state (e.g. Querétaro in this case) was selected to implement dynamic segmentation procedures, each line in the file represents a section of road with their corresponding id_unico.

As the first step, the command “shapearc” was applied to the “shape” to create a “coverage”, which it means, a logically organized place of geographical similar elements and his descriptive information associated in ArcInfo, the parameters of the command are the file “fqro.shp” and the name of the “coverage” that also is named “fqro”, later the command “build” was applied to the “coverage” to construct its topology. It was necessary to edit the “coverage” in the module ArcEdit to fixes manually the errors or “dangles”, that is to say the cases in which an end of the arc is not connected to another arc, in order to give him continuity to the network. The commands used to perform the above were:

Arc: shapearc fqro fqro
Arc: build fqro
Ae: nodecolor dangle 3
Ae: de node dangle

1.2. Creation of route network and dynamic segmentation

As a next step, the routes of the State (e. g. Querétaro in this case) were created in ArcInfo using the command "arcroute" which takes as parameter the "coverage", the name of the system of routes (tramos) and id_unico of every each road section. In addition, the possible errors in the routes were corrected manually through ArcEdit commands.

Arc: arcroute fqro tramos id_unico id_unico
Ae: de route.tramos measureerrors
Ae: de route.tramos routeerrors

Subsequently, the real kilometers were reassigned on all routes, using a file AML (Arc Macro Language) ArcInfo programming language, this file contains the edition of the characteristics of routes using the command "ef", and for each routes, the selection of the numerical identifier of the route as well as the command "remeasure" for the assignment of initial and final kilometer (km) of it.

Ae: ef routes.tramos
Ae: sel id_unico=220042301
Ae: remeasure 0 104.7

In some cases it was necessary to change the direction of the routes using the ArcEdit command "flip", so that the start of the chains were in the right place. Subsequently, the events file for all roads was generated in dBASE format, and the command "dbaseinfo" from ArcInfo was used with events file. In the events file ("qro_seg" in the case of Querétaro) each record corresponds to a segment of 500 m, therefore the number of records or road events depend on the length of it, and the main fields containing are id_unico, the segment identifier (id_seg), the initial km (seg_de) and final km (seg_a), among others. The example of Table 1 shows only a few records from the archive, where the first record or segment of 500 m of the entity 22, road 00411, corresponds from kilometer 145+800 to 146+300.

Table 1 - Some records of the events file

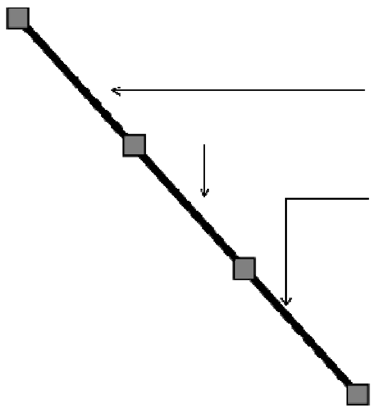
Id_unico	Id_tramo	Nom_tramo	Id_seg	Seg_de	Seg_a	L_inf	L_sup
220041109	09	LIM. EDOS. MEX./QRO. - CASETA "PALMILLAS"	220041109001	145.80	146.30	411145800	411146300
220041109	09	LIM. EDOS. MEX./QRO. - CASETA "PALMILLAS"	220041109002	146.30	146.80	411146300	411146800
220041109	09	LIM. EDOS. MEX./QRO. - CASETA "PALMILLAS"	220041109003	146.80	147.30	411146800	411147300
220041109	09	LIM. EDOS. MEX./QRO. - CASETA "PALMILLAS"	220041109004	147.30	147.80	411147300	411147800
220041109	09	LIM. EDOS. MEX./QRO. - CASETA "PALMILLAS"	220041109005	147.80	148.30	411147800	411148300

Arc: dbaseinfo qro_seg qro_seg

Then, it was necessary to establish in ArcInfo file containing the events or segments of 500 m that made each route, using the command "eventsource”. Finally, the segmentation of routes to every 500 m was performed using the command "eventarc”.

Arc: eventsource add_linear qro_seg qro_seg info ordered id_unico id_unico seg_de seg_a
Arc: eventarc fqro tramos qro_seg qro_seg500

In the “coverage” generated with the command “eventarc”, which was named “qro_seg500”, the number of arcs is equal to the number of records in the events table. The Figure 1 is an example of the relation of the events table with every segment of 500 m, in this case the identifier of segment (id_seg) is formed by two digits for the Federative Entity (22), five for the highway (00411), two for the number of road section (10) and three for the number of segment (001 … 003).



Eventos (segmentos 500 m)

idseg	seg_de	seg_a	nomtramo
220041110001	148,5	149	T.Izq. Toluca-T.Der.Ote. San Juan del Río
220041110002	149	149,5	T.Izq. Toluca-T.Der.Ote. San Juan del Río
220041110003	149,5	150	T.Izq. Toluca-T.Der.Ote. San Juan del Río

Figure 1 - Representation of events in linear elements

2. LINKING OF SEGMENTS AND SECTIONS WITH DATABASES

In this stage, the road accidents Database was linked to the segments of 500 m, also, the information of traffic counts and surface condition was integrated to the sections of the Network Federal Highway. The previous thing was carried out by programming algorithms in the software Microsoft Visual FoxPro. The algorithms link the information with the segment identifier or road section. Below, the procedures to link the road accidents, traffic counts and surface condition are described briefly.

2.1. Integration of road accidents Database with segments of 500 m

The Federal Police of the Secretary of Public Security provide the reports of the road accidents registered in the Network Federal Highway. The accidents were linked to the segments by assigning a segment identifier to each record in the road accidents Database, this process was carried out by the programming algorithm “asigna_id_segmento.prg”. This algorithm assigns each accident record of accident its identifier of corresponding segment of 500 m, in accordance with the identifier of road (idcarr) and the kilometer exact where the incident happened. The Figure 2 shows in tabular form the link of the records of road accidents with the events table or segments of 500 m. The Figure 3 shows in graphic form the same relation.

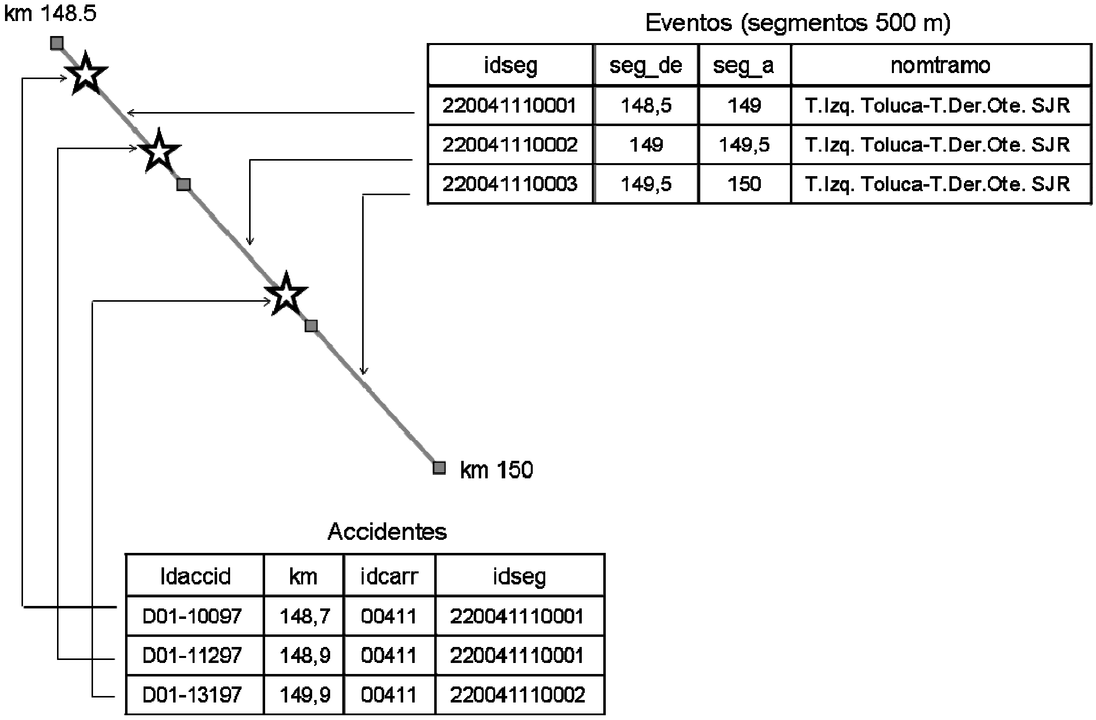
Accidentes

Idaccid	km	idcarr	idseg
D01-10097	148,7	00411	220041110001
D01-11297	148,9	00411	220041110001
D01-13197	149,9	00411	220041110003

Eventos (segmentos 500 m)

idseg	seg_de	seg_a	nomtramo
220041110001	148,5	149	T.Izq. Toluca-T.Der.Ote. SJR
220041110002	149	149,5	T.Izq. Toluca-T.Der.Ote. SJR
220041110003	149,5	150	T.Izq. Toluca-T.Der.Ote. SJR

Figure 2 - Relation of records of road accidents with the segments



Eventos (segmentos 500 m)

idseg	seg_de	seg_a	nomtramo
220041110001	148,5	149	T.Izq. Toluca-T.Der.Ote. SJR
220041110002	149	149,5	T.Izq. Toluca-T.Der.Ote. SJR
220041110003	149,5	150	T.Izq. Toluca-T.Der.Ote. SJR

Accidentes

Idaccid	km	idcarr	idseg
D01-10097	148,7	00411	220041110001
D01-11297	148,9	00411	220041110001
D01-13197	149,9	00411	220041110002

Figure 3 - Relation between the accidents and the segments

2.2. Integration of traffic counts Database with road sections

The General Direction of Technical Services (DGST, according to its initials in Spanish) of the Secretary of Communications and Transports provides the traffic counts Database. At this stage requires two databases, one road sections Database with id_unico, and the other traffic counts Database. The information of the last one is assigned to road sections using procedures described below.

As a first step, a numerical key “carrtram” was assigned to each record in the traffic counts Database, formed by the identifier of road and a number of consecutive road section, which initiates in one, it increases and finishes with the whole of road sections that form every road. Later, the Transit Daily Average Annual (TDPA) in sections with the same name and two-way traffic 1 and 2 is added. For the rest of the TDPA the quantity goes TDPA equal to a new field.

On the other hand, in every record of the road sections Database with numerical identifier an origin and a destination was assigned, that is to say, the numerical key “carrtram” both origin and destination that corresponds to it according to the section name and the initial and final kilometer, in order to link the information. At the same time, the sense of circulation was verified before assigning the above mentioned key, this because the information of traffic counts initializes the majority of the routes with an initial kilometer equal to zero, while the road sections Database considers the real kilometer of beginning and end of each section.

Finally, the programming algorithm “vincula_aforos.prg” links key origin and destination of the road sections Database with the field “carrtram” of traffic counts Database and calculates averages for vehicle type.

2.3. Integration of surface condition Database with road sections

The General Direction of Conservation of Highways (DGCC, according to its initials in Spanish) provides the surface condition Database, which contains measurements of the International Roughness Index (IRI, according to its initials in English) for kilometer for the Federal Free Highways. The integration of information of surface condition to the road sections Database, needs from the programming algorithm “vincula_iri.prg”. It is necessary to assign previously a numerical identifier of road to the surface conditions Database, to link and to assign averages in the road sections Database in accordance with the identifier of road and the initial and final kilometer of every section.

3. REPRESENTATION OF GEOSPATIAL INFORMATION VIA INTERNET

Today Geographic Information Systems (GIS) are being studied for countless articles and research issues, firstly because of the possibility of having access to maps and information databases on the Internet, and secondly to advantages of using and managing the information generated by the same. Since the emergence of free software, specifications for implementation of distributed GIS standards and the availability of conventional tools to access Databases, it is possible to have a tool to display geographic information highway, and its characterization in a Web browser.

Distributed GIS is simply GIS technology that has been built and deployed using the standars and software of the Internet [3].

At present, the services of SIG in Internet facilitate the use of geospatial information from its origin, without the need to have locally all the information. The advances in the technologies of the information, standards of open systems, networks of communication with major speed and the access to Internet, offer major advantages of use and distribution of the geographical information, as well as also limitations in the exchange of information.

On-line data access allows GIS users who have stand-alone GIS software installed on their local machine to access and transmit GIS data across the Internet. This method of use of the Internet is efficient for data access, but the user’s ability to view and analyze the data is limited by his or her desktop GIS software. The ability to access to GIS analysis functions and to conduct GIS analysis anywhere over the Internet is the next important step. The major framework of on-lined GIS processing is still under development and will be available very soon to provide a true Internet GIS or distributed GIService [4].

Under the above, this work represents an initial effort to have a Distributed GIS, which for the time being is provided with capacity of dissemination of geospatial information via Internet, and that takes as a base the automated procedures of dynamic segmentation that make possible the punctual identification and manipulation of spatial information of segments of 500 m of a wide network of highways, also, the programming algorithms to automate the link of the above mentioned segments with information of road accidents, traffic counts and surface condition, whose content changes year with year.

The representation of geospatial information was carried out by two procedures, the first one by the commercial tool SVGMapper, available in Internet, and the second one across Google Maps, free map viewer. With both tools the representation is prepared by road sections in order that the process of visualization of information in the Internet navigator could be more rapid. Next both procedures are detailed.

3.1. Representation of geospatial information via the Internet by SVGMapper

The geographical representation of linear elements initiates from the content of a file “shape” in the software ArcView, with which a file HTML is generated by the extension SVGMapper, which contains the map with the linear information and attributes of the Federal Highways, as well as the reference to a series of files with code XML, SVG and JavaScript. The file “shape” is generated by the process of dynamic segmentation described previously.

As soon as the file HTML was generated, the user visualizes in the map, across an Internet navigator, those arcs that have a minor or major number of accidents, for example the Figure 4 shows, in this case for the Federal Highways in the environment of the City of Monterrey in the State of New León, that the big majority the arcs are represented by the blue color, which indicates the occurrence from 1 to 3 accidents in the above mentioned arcs, on the other hand, in an interval from 4 to 6 in green color and finally, in major quantity, the arcs that presented from 7 to 9 accidents in red color. In addition to that the user can do a 'zoom' or approach to the elements of the map, as well as select a certain segment and visualize in a box the arc attributes, such as section name to which there corresponds the segment of 500 m, initial km, final km, segment identifier, number of accidents, between others.

In this way the user views an interactive map with details of the location of the accident, which facilitates the identification of state of those segments with a high rate of road accidents.

3.2. Representation of geospatial information via the Internet using Google Maps

Geographical representation through Google Maps was made from a file "shape". First, the width and line type of "shape" are defined by the free MapWindow GIS software, and with the "shape2earth" is converted to KML format. Then in Google Maps is generated a map with KML file. Finally, the link of the map is inserted into an HTML file in order to display it on a Web page through a Web browser. Figure 5 illustrates the geographical representation of a section of the highway Mexico-Toluca.

Google Maps facilitates the visualization of the Highways environment, as well as segments of 500 m represented with four different colors, according to the number of accidents in the segment, red being those with the highest number of road accidents, information of number of accidents is shown in a box by clicking on any segment. The maps are made by road sections, so the web browser performs the display process data without problems. As it increases the quantity of geoespacial information the process of visualization of information is slower.

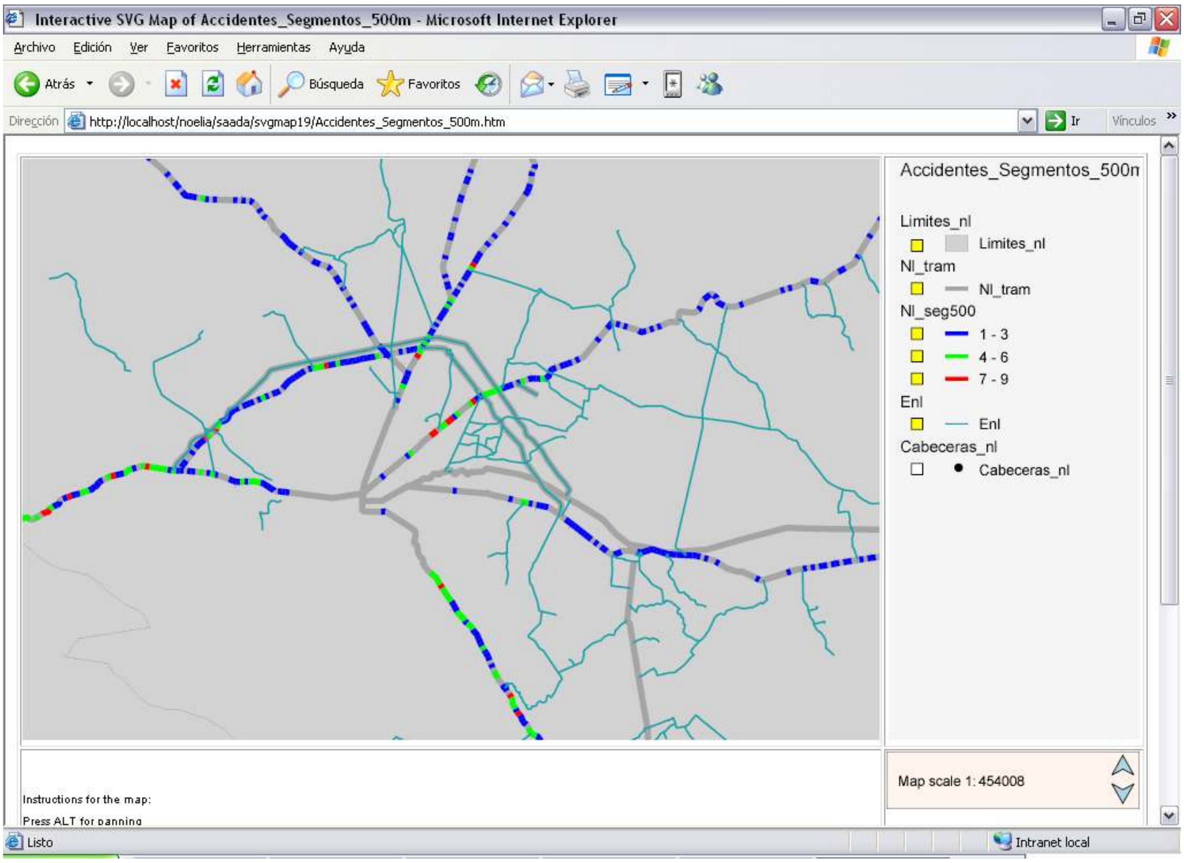


Figure 4 - Geographical representation of accidents on roads in the vicinity of the City of Monterrey by SVGMapper

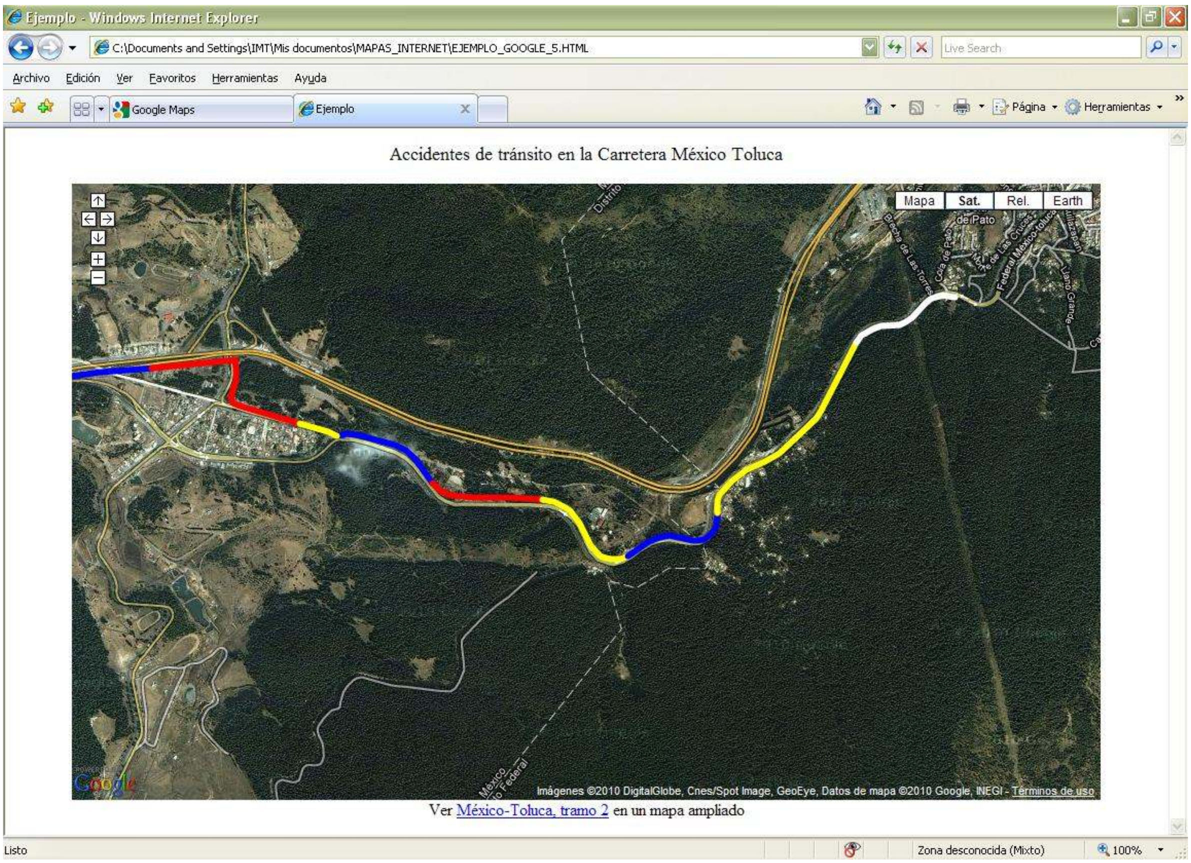


Figure 5 - Representation of accidents for a section of the Mexico-Toluca highway by Google Maps

Figure 6 illustrates the branch Cd. Hidalgo in the State of Chiapas, with segments of 500 m represented with three different colors, according to IRI recorded in the segment, the yellow being those with an IRI of less than 3, the blue with an IRI between 3 and 5, and red with an IRI greater than 5.

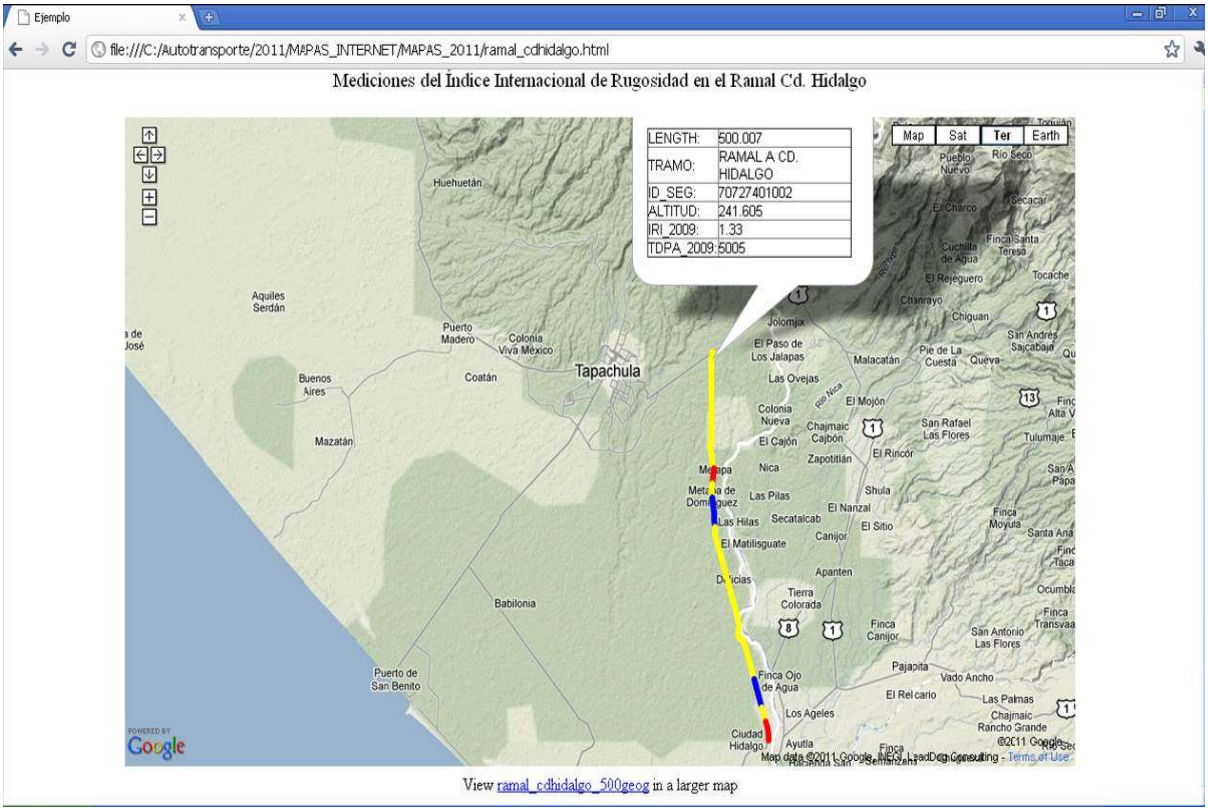


Figure 6 - Representation of IRI in Branch Cd. Hidalgo in the State of Chiapas

Finally, Figure 7 illustrates the México-Querétaro highway with segments of 500 m represented with three different colors, according to vehicle capacity presented by segment, red being those who reported a greater TDPA (more than 50000 vehicles).

Thus, the dissemination of geospatial information of highways via Internet is a useful tool when it shows both physical and operational characteristics of linear elements. The definition of dynamic segmentation procedures to the representation of georeferenced information in segments of 500 m, as well as the link with the Databases that contain specific information of road accidents, traffic counts and surface condition by programming algorithms, they contribute so that a System of Geographical Information provides the expected results, also, it makes the update of information possible year with year.

Additionally, an important advantage that comes from having a wide network of highways classified and segmented to every 500 m, focuses on the diversity of uses and applications in the field of transportation engineering: calculation of vehicle operating costs, obtaining accident statistics by segment, road sections and highway, among others.

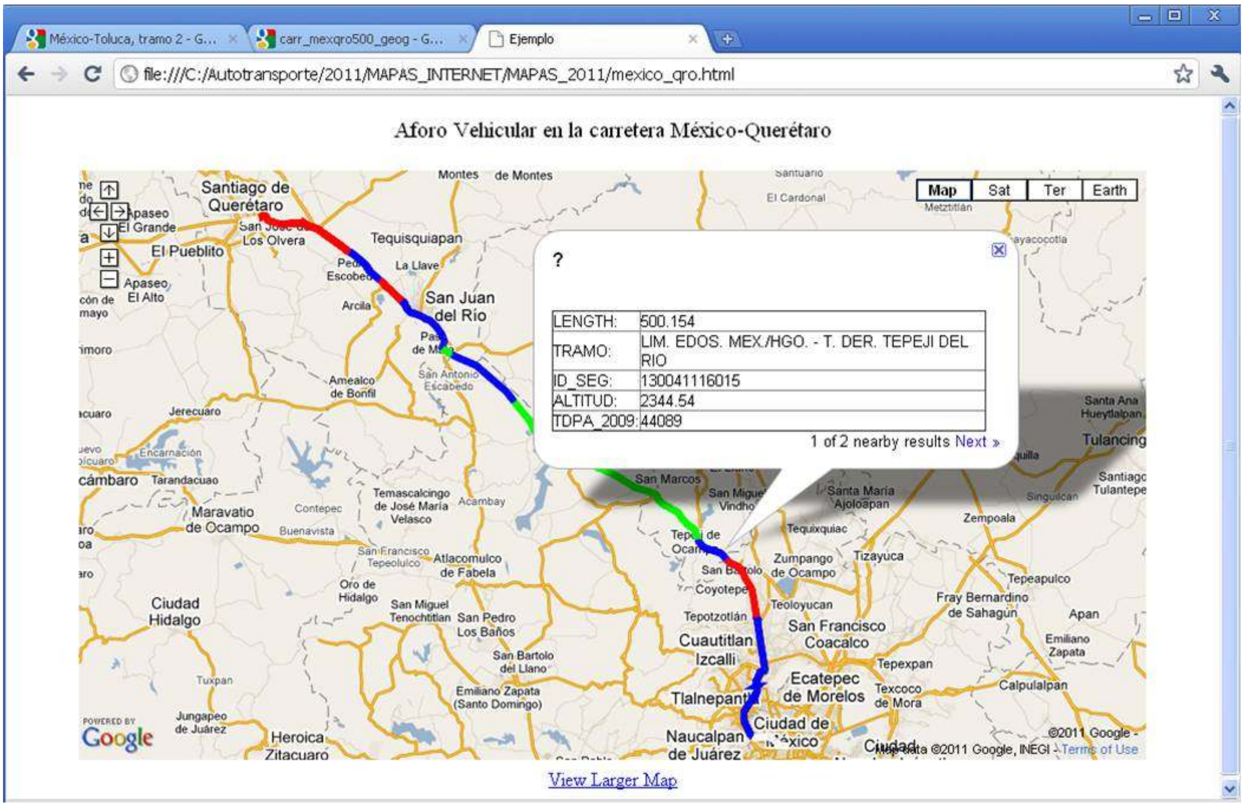


Figure 7 - Representation of traffic counts in the México-Querétaro highway

4. PROGRAMMING ALGORITHMS

The representation of geospatial information with the characteristics of road accidents, traffic counts and surface condition, was made possible by programming algorithms in Microsoft Visual FoxPro. The flowchart and code of the three main programming algorithms used (“asigna_id_segmento.prg”, “vincula_aforos.prg” and “vincula_iri.prg”), as well as other detailed information, are contained in a master’s thesis [5].

REFERENCIAS

1. IMT 1999. Mexican Transportation Institute. Geostatistics Information System for Transportation (SIGET), Queretaro, Mexico.
2. ESRI, 1995, Understanding GIS, The Arc/Info Method, version 7 for Unix and Open VMS.
3. Tait, Michael G., 2004, Implementing Geoportals: Applications of Distributed GIS, Elsevier, Computers, Environment and Urban Systems, p 35.
4. Zhong-Ren, Peng; Ming-Hsiang, Tsou, 2003, Internet GIS, United States of America, John Wiley & sons, INC, p 5.
5. Villegas, Noelia, 2011, Distributed GIS for Identification of High Accident Rate Areas on Federal Highways, Autonomous University of Queretaro, Mexico.