

Georeferencing Road Accidents with Google Earth: Transforming Information into Knowledge for Decision Support

Jorge Ricardo Ferreira

e-Geo Centro de Estudos de Geografia e Planeamento Regional – Faculdade de Ciências Sociais e Humanas – Universidade Nova de Lisboa, Lisboa, Portugal.

jr.ferreira@fcsh.unl.pt

João Carlos Ferreira

Geopoint

amadora@portugalmail.pt

Abstract: Over the last fifty years mobility practices have changed dramatically, improving the way travel takes place, the time it takes but also on matters like road safety and prevention. High mortality caused by high accident levels has reached untenable levels. But the research into road mortality stayed limited to comparative statistical exercises which go no further than defining accident types.

In terms of sharing information and mapping accidents, little progress has been made, aside from the normal publication of figures, either through simplistic tables or web pages. With considerable technological advances on geographical information technologies, research and development stayed rather static with only a few good examples on dynamic mapping. The use of Global Positioning System (GPS) devices as normal equipments on automobile industry resulted in a more dynamic mobility patterns but also with higher degrees of uncertainty on road traffic. This paper describes a road accident georeferencing project for the Lisbon District involving fatalities and serious injuries during 2007. In the initial phase, individual information summaries were compiled giving information on accidents and its major characteristics, collected by the security forces: the Public Safety Police Force (Polícia de Segurança Pública - PSP) and the National Guard (Guarda Nacional Republicana - GNR). The Google Earth platform was used to georeference the information in order to inform the public and the authorities of the accident locations, the nature of the location, and the causes and consequences of the accidents. This paper also gives future insights about augmented reality technologies, considered crucial to advances to road safety and prevention studies.

At the end, this exercise could be considered a success because of numerous consequences, as for stakeholders who decide what to do but also for the public awareness to the problem of road mortality

Keywords: Road Accidents, Geobrowser, GoogleEarth, GIS (Geographical Information System), Augmented reality.

1. Introduction

Over the last fifty years we've watched tremendous changes in mobility habits. Culture, economy and technology built a new society based on new pattern of accessibility, integration of networks, faster and more efficient transportation and these resulted in changes in the way we live and move.

In the beginning automobile was a luxury object but suddenly it became an essential asset of modern societies. This rapid change had consequences over society but mortality caused by traffic accidents was probably the worst. Mortality rates reached unbelievable numbers for modern societies and in this context a lot of studies, projects, initiatives and campaigns have been carried out in order to minimize the problems and maximize solutions.

In Portugal, the local authority with responsibilities on traffic accidents, safety and prevention (Lisbon Civil Government) has developed a project for mapping and georeferencing all the accidents within the limits of Lisbon District, area of its territorial authority. What began as an academic exercise, ended up with a tremendous amount of success within the sphere of local security and road prevention' authorities. The data gathered and analysed referred to the year of 2007 and considered only the accidents that involved death and serious injured people. This methodology was used because one of the first objectives of the project was to accentuate places and locations where

accidents had dangerous consequences to people, revealing at the same time its real causes (human failure, mechanical failure or technical/construction error).

Using geographical information systems (GIS) with georeferencing tools and associating it with statistical data can be tremendously useful. Complex data models can be obtained and results can be interesting but also very complex to deal and to understand without the usual mathematical algorithms. Examples like UNETRANS (available on <URL> <http://www.ncgia.ucsb.edu/vital/unetrans>) and others like transport integration models for planning (Huang 2003) are considerably complex (available on <URL> http://www.itc.nl/library/Papers_2003/phd_theses/zhengdong_huang.pdf).

But sometimes to create models and achieve the best results it is also crucial to analyse them visually and interactively, but also disseminate results in a truly global way. With a geobrowser like Google Earth that became possible and the results were obvious. The public awareness seemed better accomplished and it became possible to create better road safety measures, adjust prevention campaigns to regional and local necessities and model future sceneries. And these appeared to be done with less complexity in a way that models can be understood by territorial managers, road safety technicians, public safety agents or police.

This paper show the results of a project based upon the Road Accident Statistical Bulletin (Boletim Estatístico de Acidentes Rodoviários – BEAV). This simple form is filled “on site” by the two Local Police Authorities, Public Safety Police (Polícia de Segurança Pública - PSP), local police within the city limits and Republican National Guard (Guarda Nacional Republicana – GNR), the police authority outside the city limits. The difficulties remain on its correct fulfilling. The geographical component was taken into account, although its statistical treatment was sometimes impossible due to inappropriate bulletin fulfilling.

This research emphasizes the geographical aspects of information dissemination, showing the precise location of the accidents. To achieve a more user-friendly interface it was developed a KML file to visualize the accidents through the georeferencing Google Earth geobrowser. To create this KML we programmed over HTML language. The final result was an individual page for each “accident point” with a complete set of information, vital to the perception and knowledge of each situation. This information is accessible worldwide in compatible files for all GPS devices. The data can be visualized over a geographical perspective resulting as an instrument for road safety.

The future of this system would be the upload of accidents to the system by the security forces onsite. This scenario would permit a constant up to date of information resulting in dynamic patterns of mobility avoiding traffic congestion caused by the accidents. At the end, this would provide a support system to achieve a higher degree of safety and prevention to the driver.

2. Road Accidents, Geographical Information and Safety

In the last few decades, road safety has become a high priority in many governments’ policy-making, and is now a critical item on the political agenda. Road mortality rates are very high around the world and its economic and social cost is a barrier to social development. In fact, road accidents are one of the main causes of death. On the developing countries the problem is even greater due to the growing number of cars, the poor quality of road projects and the lack of legislation related to driving and safety.

In 2000, there were over 40.000 road deaths in Europe and almost 2 million injuries resulting from nearly 1.5 million reported accidents, carrying an estimated cost in insurance losses of almost 2% of GDP, around EUR 160 billion a year (www.erscharter.eu). These figures can be confirmed on the “Innovative concepts for smart road restraint systems to provide greater safety for vulnerable road users - SMART RRS” Project available on the European Commission CORDIS web page (available on <URL> http://cordis.europa.eu/fetch?CALLER=FP7_TRANSPORT_PROJ_EN&ACTION=D&DOC=6&CAT=PROJ&QUERY=0122c3567887:627e:0ceb1f58&RCN=90093).

Portugal ranked second lowest in 2000 among the EU-15 countries for accidents, with 184 deaths per million population, which is much higher than the European average of 108 deaths. By 2006, after a drive to reduce the number of victims, Portugal gradually managed to reach 13th place in the European ranking, with 91 deaths per million habitants.

Road traffic accidents are complex to analyse as it crosses the boundaries of engineering, geography and human behaviour (Mahmud 2010). And the majority of GIS road accidents studies are focused on particular data or subject like for example the management of ambulances on emergency scenarios (Derekenaris 2000). There are also a lot of Chinese and Japanese studies on road accidents supported by GIS technologies. High populated Asian cities have a lot of traffic and these research themes are very popular. Hundreds of published and unpublished works dating from 2000 to 2005, like theses and working papers, explore different approaches to the phenomena. A very interesting GIS system for Dalian city in China (Sun 2003) or for example the Sendai city GIS model for road traffic assignment (Yasunori 2000), are just two of the numerous examples available on digital repositories.

A few years ago the Faculty of Science and Technology from the University of Coimbra collaborated with the City of Lisbon District and the National Laboratory of Civil Engineering (LNEC) on a study about the urban road network of Lisbon. This work analysed areas with high mortality rates. The objectives were: (i) reduce the number of claims; (ii) set priorities for action on road safety; (iii) identify areas of accumulation of accidents in the urban area; (iv) define a method of diagnose for the security problems on these particular areas; (v) select the best mitigating measures; (vi) establish procedures to assess the effect of these measures on road safety through benchmarking procedures.

The research protocol also provided the development of joint projects on Research & Development, including various ones on demonstration and transfer of technology and specialized training of technical teams. This project on road safety has evolved to the actual "Safer roads in urban areas". It's now being co-funded by the Foundation for Science and Technology (Fundação para a Ciência e Tecnologia) under the Operational Programme for Science and Innovation 2010 (available on <URL> http://www.fct.mctes.pt/projectos/pub/2004/painel_result/vglobal_projecto.asp?idProjecto=58259&idEmConcurso=41).

As part of its road safety responsibilities and in partnership with the eGeo, Research Centre for Geography and Regional Planning (available on <URL> <http://e-geo.fcsh.unl.pt>) a research unit within the Faculty of Social and Human Sciences of Universidade Nova de Lisboa, the Civil Government of Lisbon has developed an accident georeferencing project (for fatalities and serious injuries) for 2007. Thus, greater emphasis has been placed on accidents with more serious implications for human life. This approach was considered a priority within the Civil Government that made possible the conclusion of the 2007 data project and assured the financial support and the physical structure to continue with the project.

3. Geographical Information Systems (GIS) for Road Accident Analysis

This project involved the presentation of a report with all accidents georeferenced, providing all the information available on each accident, to which a photographic component has been added. This information has also been made available to the general public on the organization's official website, but with fewer specifics about the accidents, since certain information may be deemed confidential. The objective was to provide this report to the Coordinating Council for District Road Safety (C.C.S.R.D.) (Conselho Coordenador de Segurança Rodoviária Distrital) bodies, which make policy for the different sectors and manage the roads to simplify decision-making and improve road infrastructures, thereby preventing new tragedies from occurring. The geographical information is a valuable asset but its usefulness can only be achieved when data is gathered and analysed on a georeferenced perspective. But when the output is available to all on a worldwide interface like Google Earth, that's when the true meaning of information comes to light and becomes knowledge.

In Portugal, road accidents are now recorded in an information system developed by the General Transportation Department (DGV) (Direcção Geral de Viação) using Road Accident Statistical Reports (B.E.A.V.), under the coordination of the National Road Safety Authority (A.N.S.R.). The authorities, the police force (PSP) and the GNR's National Transport Unit fill out the B.E.A.V. reports for each accident. The report already has a geographic component built in, but the geographic data fields are normally left blank. In the near future all the georeferencing gaps will be surpassed once the authorities became aware of the true benefits of the geographical data accuracy.

The georeferencing process starts with the A.N.S.R. uploading information from the B.E.A.V. reports into the database. This Excel database organizes general information on the accidents, vehicles, drivers, passengers, and pedestrians, but the data requires processing to make the text uniform.

On the initial stage of information analyses and although a B.E.A.V identification number existed, a new ID was created over the main table (from 1 to 497) to identify every accident in a more easily way. This permits the connection between tables in a geographical information system. To facilitate the Excel search the PROCV function was used to find corresponding values in other sheets. With this procedure it was possible to create a correct and single ID to every register in all the sheets.

To start the accident georeferencing process, a Geodatabase was created using ArcGis's ArcCatalog software, named "Sinistralidade07" in which three dataset features were added defined in the Datum 73 Hayford Gauss coordinate system (a coordinate system is a system which uses a set of [numbers](#), or coordinates, to uniquely determine the position of a [point](#) or other geometric element), as this system is specified for the orthophotomaps used as a working standard.

Georeferencing took place using the Attribute Selection tool which allowed the great majority of locations to be identified and, along with Portuguese Geographic Institute's (IGP) (Instituto Geográfico Português) orthophotomaps, Google Earth and Virtual Earth, enabled observation of the locations and adjustment of the coordinates to the exact site. For those places which could not be identified in that way, street searches were carried out using door numbers (or road kilometer markers).

Once the georeferencing was complete for all accidents, with the shapefile determining the accident ID, the B.E.A.V. ID, and the nature of the accident (using three general categories – Vehicle Collision, Departure from Roadway and Pedestrian Collision), it was possible to add more information into the General table using ArcGIS's Join tool. The accidents' common ID information allowed the georeferenced points in the Geographical Information System (SIG) to be linked to the table.

Some fieldwork was needed to confirm whether the accident locations were correctly marked before entering them into the Google Earth platform. In parallel with the georeferencing work, site visits were required at the locations to take photographs. The support material consisted of a GPS to verify the accident location information. All points that had already been georeferenced were put into the GPS in the following way:

1. The WGS84 decimal coordinates were added to the ArcMap points (tool used: Add XY Coordinates);
2. A predefined Excel table was used with the coordinates and accident record number fields filled out;
3. The "POI (Points of Interest) Converter" application was used for the Excel software, saving the data as an "OV2" file for the TomTom brand GPS;
4. The two files were imported into the GPS device.

In order to present the Lisbon district accident georeferencing project to the C.C.S.R.D., a report was submitted containing the 497 summaries of the accidents that met the original criteria, with the B.E.A.V. details for each one (including photographs taken during the site visits and an orthophotomap which shows the location in context). During this process, a vast amount of information was generated, some of which was irrelevant for an understanding of events. Thus, the following selection criteria were used (Table 1).

To present the descriptive summary texts, the Excel text table provided by A.N.S.R. needed to be edited: correction of the abbreviations, street names and additional text in the table. Then, the titles for each field were defined with columns created in the table for each attribute being presented. Finally, a Word file was created with all the information set out for each row in the table.

Table 1: Relevant criteria used for the report

1	Vehicles:	<ul style="list-style-type: none">• Fatalities and/or serious injuries are involved• There are anomalies in the state of the vehicle• Invalid car insurance• Invalid vehicle inspection certificate
2	Drivers:	<ul style="list-style-type: none">• A fatality and/or serious injury• Undertook risky maneuvers• Has alcohol in the blood• Invalid driver's license
3	Passengers and Pedestrians:	<ul style="list-style-type: none">• A fatality and/or serious injury

To facilitate accident identification for each data set, the accident's ID a number from 1 to 497 was added beforehand. After the information was organized, it was added into the descriptive summary report, selecting only those meeting the defining criteria.

The report presents a map with the exact location of each accident. This is generated individually for each place after marking each point in ArcGis. For this, the colour of all the points is removed, and only when the intended point is chosen does it become visible on the map. The map scale is defined at 1:10,000.

The photos also required some processing in order to be of a manageable size (approximately 50 kb) and have the final measurements to fit easily in the document. "ACDSee Photo Manager" software was used to process and manipulate the images, using the Batch Resize Images tool (Figure 1).

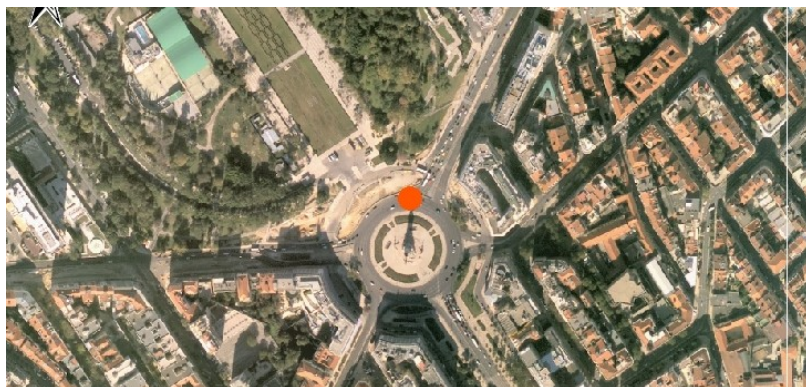


Figure 1: Image after software processing

After processing the information, it was inserted into the descriptive summary report. It is important to make clear that these three processes were taking place while the accidents were being georeferenced and the locations photographed, and that this was the aim of a trial-and-error process until a final result was reached.

4. Use of the Google Earth Platform in Sharing Geographical Information: Road Accidents

One of the deliverables is a KMZ file (a set of points of interest viewable through Google Earth) whose objectives are:

1. To easily identify the accidents by type (Vehicle Collisions, Departure from the Roadway and Passenger Collisions);
2. To disclose data on each accident (with only certain data from the General Table selected for inclusion to avoid publishing personal information, for ethical reasons);
3. To publish the photographs taken on site.

Once the georeferencing in ArcGis of all accidents in the Lisbon district was complete, the two attribute tables were added – in ArcGis and Excel – through the common ID field. The final result was exported to a new shapefile, after removal of the table’s irrelevant fields, thus making it possible to start building the KMZ \file. The process started with the conversion of the “Sinistros07” coordinates system shapefile, which is in the Datum 73 Hayford Gauss IPCC, to the WGS84 geographical coordinates system. Next, the file was divided into three parts and attributes were selected, first choosing Departures from the Roadway locations, then Vehicle Collisions, and finally Passenger Collisions (Figure 2).

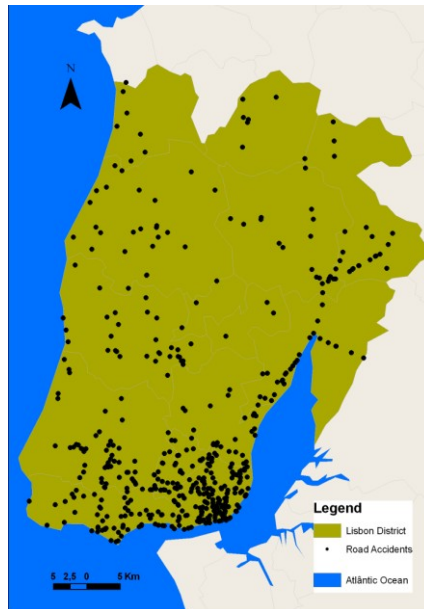


Figure 2: ArcGis map with road accidents

The data was thus ready for the shapefiles to be converted into individual KML files with specific icons, in which information could be added and later inserted into a KMZ file. A new ArcGis tool was used for this process, called “Export to KML”, which uses HTML to create a page for presentation in Google Earth when the point is chosen. The Export to KML tool allowed information to be added from the table linked to the shapefile, and allowed HTML programming for images and hyperlinks to be added to web pages (Figure 3).

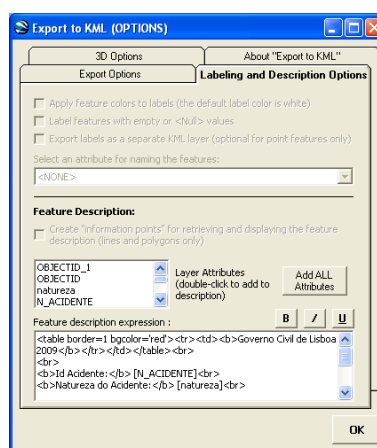


Figure 3: ArcGis Export to KML Tool

The file needed to be processed for the image with four photos to appear as shown in the next figure and ACDSee Photo Manager’s “Batch Resize Images” was used at 50% to prevent the Google Earth image from being oversized. Once ready, the images were stored on the Civil Government of Lisbon server using a total of 18 MB for the set of 497 individual files. A column named “Link” was added to

the ArcGis points table, with the right address for each set of photos, so that those images were linked correctly to each georeferenced location (Figure 4).



Figure 4: Final layout of each Google Earth Point Of Interest (POI).

As one of the objectives of this deliverable was to show photographs of the location along with the rest of the information in Google Earth, and because KML's export tool offers HTML programming, a better context for the desired text could be provided, presenting it together with a customized image using four photos from each location on the page of each POI in Google Earth. Thus, to place the HTML code in the "Labelling and Description Options" section of the Export to KML tool, the following format was used:

```
<table border=1 bgcolor="red"><tr><td><b>Civil Government of Lisbon </b></td></tr></table><br>
<br>
<b>Accident ID:</b> [ID_ACIDENT]<br>
<b>Accident Type:</b> [Natureza_1]<br>
<b>Location:</b> [Localização]<br>
<b>Date:</b> [Data]<br>
<b>Time:</b> [Hora]<br>
<b>Municipality:</b> [Concelho]<br>
<b>Parish:</b> [Freguesia]<br>
<b>Area:</b> [Cod_Via], [N_Arr]<br>
<b>Km:</b> [Km]<br>
<b>Fatalities:</b> [M]<br>
<b>Serious Injuries:</b> [FG]<br>
<b>Slight Injuries:</b> [FL]<br>
<b>Severity Indicator:</b>
[Indicador_]<br><br>

```

Opening the KML file in Google Earth allows the 497 accidents to be viewed and easily identifiable by type (Vehicle Collisions, Departures from the Roadway and Passenger Collisions), since different icons were used. Clicking on each point automatically opens the corresponding page for each accident (Figure 5).

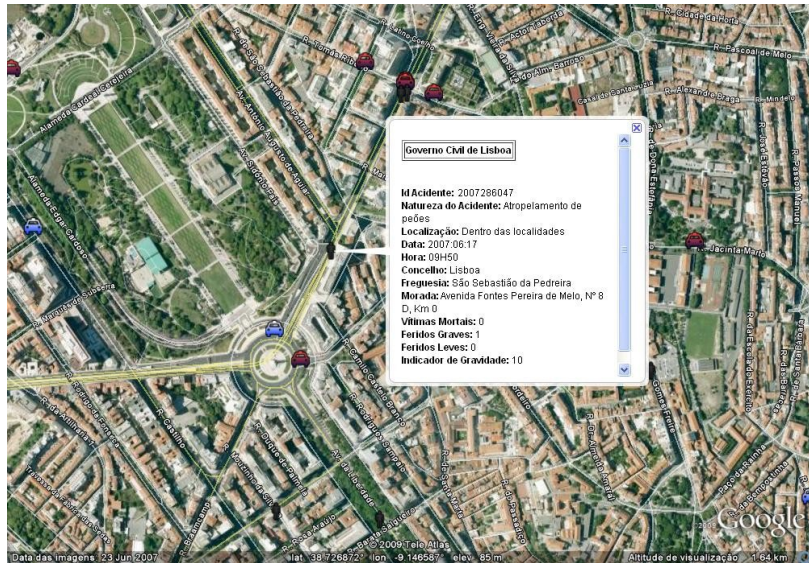


Figure 5: Google Earth with the accidents information

After the georeferencing was complete and the files were converted into KML format for the Google Earth platform (Figure 6). The files were hosted on the Civil Government of Lisbon website, with only the KML file accessible by the general public (available on <URL> <http://www.gov-civil-lisboa.pt/inicio/areas-actuacao/prevencao-seguranca-rodoviaria>).

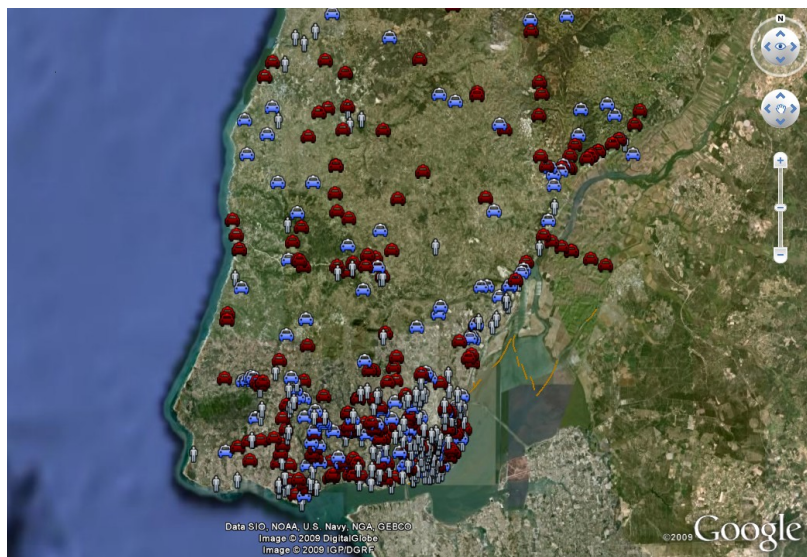


Figure 6: Final Google Earth image showing all the registered accidents

Visualization is widely regarded as a process that involves developing and using visual representations of data to generate ideas and knowledge about phenomena. Geographic sciences have a long tradition of using graphical data to help insights and to explain phenomena that vary spatially. The 'art and science' of cartography provides a knowledge base that has been used to help those in the geosciences with their visualization. This has been developed through experience, preference, empirical evaluation and a deep understanding of the nature of geographic phenomena. It has lead to a number of established approaches and conventions.

Significant efforts are currently going in to the development of highly interactive interfaces. Researchers in computer science and the geographic sciences are participating in this effort. Much of the knowledge developed in cartography applies to the static domain, but some is relevant to visualization, particularly when visualization involves dynamic phenomena.

As data volumes in general increase georeferenced data are more widely collected and available. Spatial data that is centrally developed through a 'top-down' approach, such as that recorded by governments through formal means (for example via a census of population), is increasingly accessible online. Equally, users contribute with spatial data, whereby user communities informally generate content with georeferences in a 'bottom-up' manner, is increasing in volume. The development and popularity of 'geobrowsers' is not unrelated. These applications provide rich spatial data sets and sophisticated and intuitive interfaces through which users can browse geographic information. Road accidents viewed on Google Earth are an excellent example of how data can be managed and processed on a GIS and then visualized on a global scale.

5. Conclusion

The accident georeferencing project for 2007 data was considered an applied piece of research. This field is fundamental to understand a phenomenon that remains a national concern. The worst problems with this kind of research are still the "inconvenient" results. Because of that, similar research projects based on protocols between governmental departments and universities are kept almost "under secret" due to political or economical reasons.

Research works on geographical information systems for simulation costs (Partheeban 2009) and on space and time distribution (Yu *et al.* 2009) have been essential to develop good approach methodologies and strengthened the theoretical research on road accidents but it is always very difficult to quantify the benefits. The best output is the one that's used as an input on other process. That means the outcome of this research must be used to leverage more research. Probably the best way to continue the data-information-knowledge chain would be a spatial analysis path. The future is always uncertain but it's possible to foreseen a lot of basic applications related with immersive technologies and augmented reality.

The combined use of geographic analysis and referencing tools such as the Geographic Information System and the large online map platforms have been indispensable for sharing the data in a more global way, providing information about a reality that should concern all citizens. Its use also allows public safety policies for road safety to be created and justified. Geographical information technologies and specifically the geographical information systems, are an important tool for matters relating to road accidents, but also mobility, since they help optimize territorial management and planning, avoiding or correcting errors from the past.

Sharing all this information on a global and popular platform like Google Earth offers an enormous amount of added value. Analysing the last achievements on automobile safety systems, it's possible to glimpse the future of safety devices. Virtual embedded systems allow the driver to see what his eyes cannot reach. Information gathered and retrieved on a database can be redirected to that system when a danger situation is likely to occur. The example of an accident a few kilometres ahead or the road congestion related to a sudden car accident can be redirected to a driver on the same road. Electronic systems with the ability of decision are now a reality. Lights that go on, brakes that automatically activated or rings that awake a sleepyhead driver are now standard equipment.

This project for 2007 data received an excellent response from the population at large, as well as from governmental institutions, in particular the Ministry of Home Affairs in Portugal, the city councils of the District of Lisbon and the security forces (PSP and GNR). A second edition is now available for 2008, which is also on the Civil Government of Lisbon website. After this second edition, an arrangement was finalized in October 2009 between this entity and the security forces to deploy GPS equipment in order to help fill out the geographical coordinates correctly for all accidents that involve fatalities or serious injuries.

The project is now on a second stage of development. With the collaboration of the army, new approaches are being made in the fields of spatial analysis and modeling. Future works also consider human behavior, time analysis and weather but augmented reality is also being considered (for now, only on a theoretical perspective). But in the near future, more accurate platforms like the European Galileo geo-positioning system combined with 4G broadband technologies that permit higher transfer rates will support new applications. Furthermore, devices based on open-source technologies will allow drivers to be warned in advance of potentially dangerous locations alerting them to adapt more

defensive behaviours which are commensurate with the hazard levels of those places. Augmented reality (AR) for example is a growing area in virtual reality research. The world environment provides a wealth of information that is difficult to duplicate in a computer. An augmented reality system generates a composite view for the user. It is a combination of the real scene viewed by the user and a virtual scene generated by the computer that augments the landscape with additional information. For driving as for road safety AR is probably one of the unquestionable state of the art research fields.

To perceive space, Geography gives the substance and content. Technology gives the frameworks and the processes. Men give the significance.

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