The Application of Modern ICT in Increase of the Road Traffic Safety Level in Terms of Applicability of the Interdependence of Global Positioning System (Assisted GPS) and Dedicated Geographic Information System (GIS)

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***Abstract* – In order to promote traffic safety, and specifically in the prevention of accidents on the roads, modern standards and procedures require the construction, constant monitoring and updating the database of geospatial data of importance for the spatial and temporal distribution, an analysis of the traffic accidents causes and consequences and the creation of an appropriate response to the traffic risk arising from road's factor as a geospatial entity. One of the possibilities for meeting the said requirements is the use of GPS technology. Constant monitoring and topographic inventory of changes in the domain of exploitation and technical roads features on the digital geotopographic materials in some of the GIS environment is one of the requirements, standards and procedures for the traffic risk management, but also for creation of a part of the national infrastructure of geospatial data on the principle of interoperability. This paper presents the characteristics of GPS device GeoExplorer® 2008, produced by U.S. Company Trimble, which integrates GPS receiver and a portable computer with the Windows Mobile operating system, and thus represents a functional, light, portable and durable device for field work, with the range of applications for geospatial data mapping and updating in a various and primarily in mobile GIS applications. GIS is a set of software tools, which enable the analysis of different types of data associated with geographic maps. Data on current road conditions and technical traffic control collected by mentioned device shall form the basis for filling in a database in dedicated, stationary GIS applications as a support system part for the traffic safety management.**

***Keywords* – GPS Portable Computers, Geographic Information Systems, Prevention of Accidents on the Roads, Traffic Safety Management.**

1. Introduction

The Global Positioning System is currently the only fully functional Global Satellite Navigation System. The Positioning System was developed primarily from grown military requirements and form gained development level of satellite navigation and surveillance of units and ordnance. Satellites used by the Positioning system are high enough to overcome the problems typical for previous solutions, and they use technology that is precise enough to provide for positioning anywhere on the Earth, 24 hours a day. However, the original quality of the system is its potential.

With current technology of microprocessors and integrated circuits, positioning receivers have become small enough and cheap that anyone can have them and can be installed anywhere. The applications are almost limitless, because the Positioning system allows for each square meter of the Earth surface to receive its own unique address. That basically means that it is possible completely new way of life and work organization, because the Positioning system will give the world a new international standard for defining the location and distance, enabling countries and people to manage their natural resources more efficiently than ever before (Milojkovic, Marinkovic, 2007 : 42; Filipovic, Milojkovic, 2010:189). [3]

Modern Positioning systems include: the Global Positioning System (GPS - the real name is NAVSTAR - *Navigation System for Timing and Ranging*) developed by the Geodetic Service of the U.S. Department of Defense, operational since 1978, and the Global Navigation System (GLONASS) developed by the Geodetic Service of the Russian Ministry of Defense, operational since 1982. The Satellite Navigation System GALILEO, financed by the EU, is under construction and its use is planned from 2014. [9]

The Global Positioning System is definitely the best system available and free, proven and completely reliable, surely a promising system for

the future. It consists of three components, namely: the cosmic, control and user component.

Within the last years of the twentieth century there has been a remarkable improvement in the production of GPS equipment, which has become light, portable and easily available to users. Today there are more producers and hundreds of models of various GPS receivers (Trimble, Garmin, Magellan, Tom Tom, Lowrance, Mio, ViaMishelin etc.).

No matter how good and with no defects the system seems, still that system has several sources of errors, which to some extent can be eliminated by using the method of differential corrections. In many countries of the world, especially on the shores of the ocean, it was developed a network of differential GPS stations that continuously broadcast differential corrections for all users who are in their range. Where there is no such GPS infrastructure, the solution is setting up of temporary differential stations in the period when it is required by certain users. Presently, the predominant methods of GPS corrections distribution are GSM/GPRS and Internet. For the activities where correction is not needed immediately at the time of measurement, the data are recorded as "raw" and the correction is applied in post-processing.

The application of GPS technology is very widespread, and its capabilities can contribute to more effective traffic safety management. In fact, one of possible applications of GPS technology in the traffic safety is related to the function of collecting data on clearly resolved spatial positions that are related to the traffic and technical road elements data (spatial entity characteristics of roads database), for the implementation of tasks related records on public roads, that is for the construction of adequate Geographic Information System (GIS) as a decision support system part in the field of road traffic safety.

The U.S. Company Trimble Navigation Ltd. is a leading manufacturer of GPS equipment, which covers about 65% of the world market. Among the devices of mentioned company that are appropriate to the needs of traffic safety are: Trimble Juno in a standard mode of application (for massive data collection), Trimble Nomad in an advanced mode application (suitable for use in all weather conditions), and the world's first GPS field computer GeoExplorer® 2008 in a superb mode application in all geospatial and meteorological conditions.

2. The Main Features and Possibilities of Using GPS Receiver Geoexplorer® 2008 for the Traffic Safety Needs

U.S. Company Trimble was the first that applied the concept of integration of PDA computer and GPS receiver back in 2002 to the series GeoExplorer CE. By combination of GPS receiver and computer with the Windows Mobile operating system it was obtained a lightweight, portable and extremely powerful and durable device for field work. Besides the ability in positioning and orientation, displaying the current time and date, GeoExplorer® 2008 is ideal for mapping and geospatial data updating in various, primarily mobile GIS applications. The system supports an indirect measurements (calculation of an inaccessible position based on taking the range with laser rangefinder) as well as synchronized log data from various external sensors. That means that the fields of application primarily involve mapping of natural resources, environmental studies, and creation and work with database of the state government, big companies, public utilities, and so on. In addition, the GPS receiver registers positional data while user enters attribute data according to pre-defined structure of the user system (Milojkovic, 2009:223).[5]. GeoExplorer® 2008 receiver is also the most appropriate to the traffic safety needs. GeoExplorer®_2008 is a standard Windows Mobile computer whose specifications are given in Table 1. The computer is ergonomically designed, no cables, and all electronic components are stored in a robust and waterproof case and they are electrostatically protected. Also, all communication ports are hermetically sealed, which means that the receiver meets climatic and mechanical resistance by the high military standards (IP 65).

The receiver has a keyboard with 11 keys and a color TFT touch screen (touch screen). Options can be selected with dedicated stylus or just using a finger. The receiver’s screen has a special anti-reflective coating, which makes the image extremely clear even in direct sunlight, changeable protective film and the possibility of display contrast adjusting. Also, the screen has a backlight for night work, which is automatically activated by clicking on the screen, and it has an integrated microphone and speaker. [8]

Due to the large memory and processor power, the device effortlessly displays scanned maps, air and satellite images which present an adequate basis for a variety of GIS projects. Additional slot for SD memory cards allows required memory expansion. GPS navigation is extremely simple, and GPS survey results are immediately visible on the screen.

General features	
Accuracy	0.10 – 3 m
H-Star Technology	Yes
EVEREST Reflection reduction	yes
Operating system	Windows Mobile 6
Processor	520 MHz X scale processor
Memory (RAM+Flash Disc)	128 MB + 1 GB
Screen size	8.9 cm
Screen type	Color TFT screen, Touch screen_
Bluetooth – wireless connection	Yes
Wireless LAN 802.11	Yes
Wight	780 gr.
Fallresistance from a height	0.9 m
Robustness – military standard	IP 65 standard
Working temperature	-20ºC do +60ºS
Battery duration	10.5 h

Table 1. Technical features of the Trimble GPS receiver brands GeoExplorer® 2008

The screen is similar to a desktop computer (icons, Start button and Taskbar range). There are installed the following standard programs: Windows Explorer Mobile, Internet Explorer Mobile, Inbox, Text Editor, Calculator, Sound Recorder, ActiveSync, Word, Excel, and PowerPoint Mobile, Windows Media Player, Connect to Remote Desktop and Networking. There are also a crucial purpose programs: GPS Controller to adjust the integrated GPS receiver and measurements planning and GPS Connector for connection of integrated GPS receiver with external communication ports.

In addition to standard software, GeoExplorer® 2008 can use application software for the collection and updating of GIS data (Trimble TerraSync, ESRI ArcPad), as well as different commercial applications for auto-navigation with detailed city maps (i-GO, TomTom, Garmin, etc.). . Moreover, it is possible to develop user applications for various purposes using Microsoft programming tools (Microsoft Embedded Visual C ++, Microsoft Embedded Visual Basic, Microsoft Visual Studio Net).

GeoExplorer® 2008 use Windows Mobile 6 operating system. It is a Microsoft operating system for PDA computers. It may also install and use the software to support field applications. Namely, the operating system supports a wide range of communication options, so that it provides access to databases, internet and email even on the field, when needed.

If GeoExplorer® 2008 is to be connected to the Internet via a mobile phone it can call the GIS server directly from the field and download topographic maps for the ground on which the intervention is to be taken. Direct connection to the GIS Server is allowed by Trimble TerraSync software, dedicated application for navigate, and GIS data collection and updating. The direct connection to the GIS server does not only mean showing the map in the background, or downloading parts of the GIS database, but it also means updating of those databases directly in the field. The process of information updating on the site includes the following options: choice and navigation to the existing point, verification and change of positional and attribute data of existing facilities (if required) and registration of new or missed facilities.

GeoExplorer® 2008 device is manufactured in three models (GeoXM, GeoXT and GeoXN) that vary in the accuracy level of the internal GPS receiver.

All models support a differential correction in real-time as well as a post-differential correction (code and phase data) for which PC software for post-processing is necessary (Trimble Pathfinder Office).

GeoXT and GeoXN models provide high accuracy because they use EVEREST technology to eliminate rejected GPS signal. All models support the reception of differential corrections in real time from AGROS GPS network. Those corrections are received via the regular phone connected with Bluetooth wireless connection to the GPS receiver (GPRS communication) [10].

3. Application of GPS Device Geoexplorer ® 2008 for GIS Production in Terms of the Traffic Safety on Roads

GeoExplorer® 2008 GPS device has the ability to work with the TerraSync software, which is designed to collect new or update existing geospatial data directly in the field. The mentioned software is universal software for all Trimble GIS receivers. The software is localized into Serbian, which further facilitates the work. In addition, the software offers a wide range of functions that allow the user to perform data processing and verification even in the data collection phase. At the same time, it integrates different technologies such as mobile computers technology, modern operating systems, databases, mapping, GIS, GPS and mobile communication technology [4].

Within Trimble TerraSync software there is a module for planning of GPS survey. By this module it is possible to determine which satellites will be visible in a desired period of time and even track their animated movements. It is also possible to adjust GPS receiver parameters that affect the quality of the position (elevation mask, PDOP factor, the acceptable quality level of satellite signals). This provides a high quality level of position, when necessary.

Besides the simple mapping, Trimble TerraSync allows the transfer of GIS database to GPS computer. Thanks to this, it is possible to navigate to any facility in the database and to make updates of associated attributes right in the field (Figure 1).

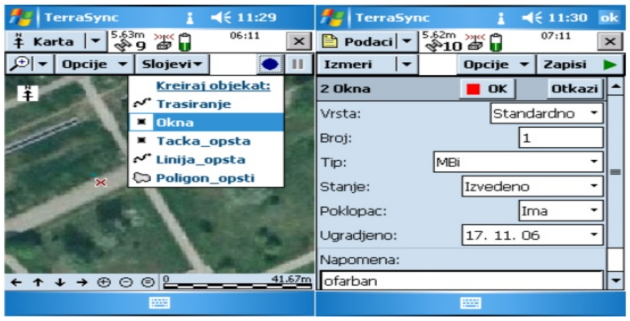

Figure 1. Data Collection and updating by Trimble TerraSync software

TerraSunc, as the most of this type of software, supports different data types and formats in raster (.jpg, .sid, .bmp and .tif) and vector formats (.cor, .imp, .phs and .ssf file format). However, the software has built-in functions for two-way communication ESRI shapefile, and just this possibility was used for presented thematic work, as it was used software package ArcGIS Desktop applications for the purpose of GIS production in the field of traffic safety [8].

For the construction needs of GIS pilot model in the field of traffic safety aiming to prevent the traffic accidents, it was used application of GPS device for mapping and data collection on the current state of some elements of the public road. This primarily refers to the position information: some road facilities, some facilities for road needs and traffic signs elements (primarily km marking). Pilot database includes much larger volume of data on a public road and traffic, which are spatially defined by fixed positions in GIS pilot model [1].

Data collection procedure implied the office preparation which has included software parameters setup (selection of coordinating system, selection of working units and GPS parameters definition), creation of new directory assistance and codes development of geometric and attributive data collection on quantitative and qualitative indicators of individual parts of the public roads pilot database. With readymade device, it was performed field collection of the necessary data for GIS pilot model. During data mapping on the dotted entities (kilometer markings, intersections, road damages, etc.), it is necessary to take pause for a period of one to two seconds, and then to perform position registration and entry of the necessary attributive data. Also, it is possible to record a voice message or record a detail on the road by digital camera or by a camera that can be with "bluetooth" connection delivered to a dedicated position of recorded facility or that can be add when processing in desk GIS application. The data can be collected by foot or by vehicles, with an obligation to stop for a period of one to two seconds prior to the registration point. [2] After completion of the field work, GeoExplorer® 2008 is placed on the substrate which is a USB device or a device connected with a serial line to a desktop computer. Microsoft AcitivSync software is used for undisturbed operation of files transferring. Collected data are exported in the shapefile form (.shp) and then are further imported into the GIS project.

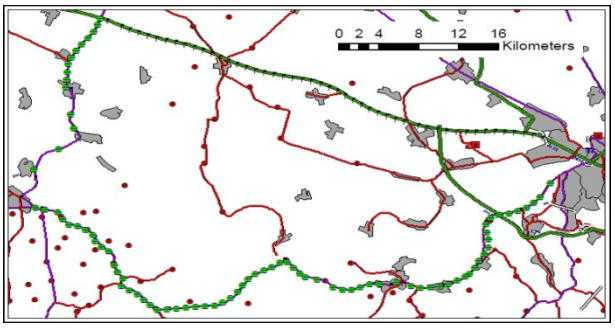

Figure 2. Appearance of GIS window of mapping territory by GPS device GeoExplorer® 2008

Figure 2 shows graphical visualization in the form of thematic map with presented geospace which formed a sample of mapping objects indicating on geometric and attributive data of kilometric markings (current position, type and condition), intersection, and damage on the road and so on, on explored part of the road network [8].

Namely, GPS device GeoExplorer® 2008 allows roads mapping with many features, such as the intersections with crossing manner (at grade, beyond the level, with other communications, with lower category road - lower significance road etc.) and traffic regulation manner (with traffic lights, traffic signs or traffic rules), pedestrian crossings, bridges, underpasses, overpasses, culverts, elements of road structure, embankments, cuts and notches, protective and retaining walls, slides, etc., [8] For mentioned geometric k-ke points, in addition to the above, it can be also collected the following attributive data: road mark, number of lanes, lane and pavement width, sidewalks with a width, formation width, substrate type, road importance, the type and characteristics of the damage on the road, as well as a large number of text with observations that can be recorded by voice and by a digital camera.

Figure 3 gives an example of one attributive table for an intersection on the main road M-19 with kilometer mark in the immediate vicinity, which is in the form of a metal pole in an upright condition.

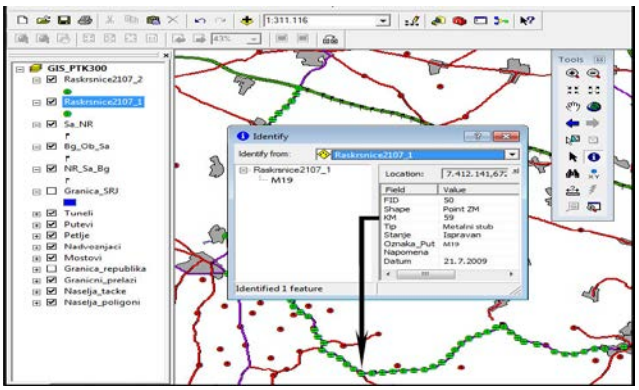

Figure 3. Attributive table of one part of the importance for the traffic safety

It is recognized the possibility of the application also to the other tools applications in the traffic safety, such as for example the traffic safety control, as there can be recorded multimedia data (in voice and image) on recognized risks causes such as: reduced visibility at the intersection due to leaved trees on the inside of the curve, dirt presence on the road inflicted with agricultural machines from the earth (dirt) road and so on.

When a database is established, it is easy to get reports on specific queries that are common in working with databases. Users of this database can be all those involved in the prevention of accidents on the roads, but special interest is showed by the road managers and scientific and research organizations. The road manager acquires a basis for decision making in the management process based on the actual situation while the scientific and research organizations have the opportunity to develop new management models and to provide high efficiency in the use of funds allocated for the traffic safety improvement.

There are several examples of implemented applications of collected data, using the above or similar GPS devices, for creation a basis for the databases development in the traffic safety. Researches were conducted in 2010 and 2011 at the Police Academies and relevant Criminal Services in order to create a database of traffic accidents in the countries of former Yugoslavia, aiming to apply modern methods of identification of hazardous locations and sections on the roads and streets, and definition of remedial measures for identified hazardous locations. Organized database of traffic accidents and their consequences provided a process for identifying the hazardous locations and sections using ArcGIS software package, based on the latest identification models of spatial risk accumulation in the traffic [6].

4. Conclusion

The traffic safety management is a systematic process that helps a state to reduce the number of traffic accidents through design for improvement of the traffic safety. Modern approach to traffic safety problem solution involves the application of modern methods that allow high efficiency in operation. However, the application of modern methods is

caused by the application of modern devices, especially when it is about GIS and software applications that support it. Therefore, it is very important to consider the possibilities of modern GPS devices, especially those that integrate multiple functions in one package to enable the collection of a large number of information important for decision-making in preventing of the traffic safety. Their use enables the creation and completion of GIS database on traffic accidents and roads, then also the use a database in the management procedure and the use of special tools to reduce risk on the roads.

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