Useful spatial data and GIS applications on the Internet for transportation companies

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Abstract

The purpose of the thesis was to study theory of geographical information systems (GIS) and their application in transportation field as well as gathering useful spatial databases and services regarding the application. One of the main emphases was put on studying how the companies can utilize these services in transportation planning.

The research was mainly quantitative study of offered services on the Internet. The study consisted of products' description and review, test usage of several services to try performing simple tasks and feedback from users and the author regarding it. Test usage was applied from generic and transportation oriented point of view.

The result consisted of the fact, that open-source and free main services are sufficient for fulfilling tasks, applicable for small transportation companies, due to casual orientation of free services and poor amount of features applicable for transportation in open-source ones. On the other hand, proprietary services provide special toolboxes for transportation and able to be deployed in web environment, though the cost of that type of project is relatively large and can be profitable for big-scale companies.

The final part of the thesis was the analysis of data and features required for transportation operation, as well as round-up of reviewed products whether they hold up with that. Based on the fact gathered from research, recommendations were presented regarding using these products and sources.

Keywords/tags (subjects)
GIS, transportation, Web-services, digital maps,, open-source

Miscellaneous

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1. Introduction

1.1 Aim of the thesis

The aim of this thesis was to provide a detailed view of daily usage of GIS and spatial data and its possibility of implementation for utilization in a transportation company. In these latter days, geographical informational systems have become an irreplaceable tool in modern appliances including such regions as navigation, cadastre, databases etc. The thesis was commissioned by JAMK Logistics team.

1.2 Actuality of thesis topic

Alongside with development of cartography into Geographical Information Systems (GIS) and boost of calculation power of modern computers, another viable force was developed — the Internet. Recent products and solutions from GIS companies often involve and present as a feature the ability to use the global network in various ways: cloud storages, client- and server-side applications, web services and geoportals. Additionally, the GIS meta established is going out of lab doors or research institutions becoming more casual and easier to use for a regular person, open source community applying huge contribution in development of GIS. Finally, recent spread of portable devices such as smartphones and tablets with built-in access to Internet and most importantly navigation and geolocation, through GPS/GLONASS or special services, opens a huge market opportunity for portable clients of existing GIS and portals or even specially designed systems for mobile use.

Applications and services nowadays that are built with “online” style are remarkable for their free usage and can become a huge hit if designed as an intuitive and yet sufficient to fulfill user needs, as for example Google Maps did. Regarding transportation, the data that has to be retrieved from the system is now fully covered with such services, especially in places, where GIS community culture is developed. For example, such objects as road accidents, repairs or traffic jams cannot sometimes be monitored on company side, but can be submitted by regular people to a service database.

The actuality of the thesis topic is connected with spread of described activity in GIS and is defined in need for developing recommendations for refining usage in transportation area.

1.3 Goal of the thesis

The goal of the thesis was to analyze how GIS and spatial data in the Internet can help transportation companies in their operations. The goal was reached through these performed tasks:

- Beknowledge the GIS trivia via the history of its development and the structure behind every system
- Define the ways of GIS application in transportation field
- Find and analyze the existing products on the market and their applicability to the topic
- Review the existing examples of companies using GIS services on the Internet and benefits they gain.

1.4 Research methods and constraints

To analyze existing market and applications, the main method of research was a quantitative analysis of products reviews, websites and descriptions, user experience articles such as blogs and customer reviews, alongside with studying connected literature.

2. GIS

In order to gain full understanding of necessity in implementing GIS features into transportation workaround, trivia of GIS and spatial data should be described. The recent trends of scientific methods studying objects, processes and events of material world involve using approaches based on informatics, including real-life objects. Thus, the development of such phenomenon as GIS was imminent.

2.1 What is GIS?

Researchers give different explanations of the term, generalizing geoinformatics, geotechnologies and the systems under it. Yet, the main definition of GIS is a complex multi-functional information system, designed for collecting, processing, modelling and analysis of spatial data, its vizualisation using for solving computational problems and performing decision-making. Main purpose of GIS lies in forming knowledge base of Earth, its certain territories, landscape; and in timely delivery of sufficient and accurate geodata to GIS users to increase their working efficiency. ([Development and creating of GIS]).

2.2 GIS history

GIS development started in late 1960s by different research institutes of USA, Canada and USSR independently following different goals. Initial systems were just as they are called, providing pure geographical information, the base model assisting a user in operating the databases.

Early implementations of GIS were using cellular structures of data. The data representation consisted of variously shaped and sized cells placed on plane, sphere or ellipsoid for optimal solution of theoretical and technical due to computing power resources of that time and insufficient development of vector manipulation algorithms. Thus, first generation systems following this data organization were lacking functionality and showed primitiveness in cartographical visualization and documentation.

This was until one of the pioneers of GIS played a changing role in technology development – United States Census Bureau. In 1967, USCB started experimenting with computerized cartography. The programmers faced a problem of ineffectiveness and redundancy during map conversion from paper to digital format. Due to United States cities often having grid-like street system, when roads and ways form a grid of streets and avenues, every crossing had to be inserted into digital format 8 times as they represent corners or borders of different cells. This problem caused a heavy consideration that resulted into formulating principles of topology suggested by Bureau's mathematician, James Corbett. The principles realize a scheme where different objects have relations with each other, and describes which objects are bordered, which consist of smaller elements, following with identification of cells and knot points. George Farnsworth then calls this innovation DIME (Dual Independent Map Encoding) in 1967. In Census, knots were assigned as streets crossings and cells as blocks, in such way these principles can be applied for conversion. Applied scheme proved immediate effectiveness as they increased digitizing speed and reduced amount of errors in process, thus it became a standard of census cartography under the file format called GBF-DIME (Geographic Base File, Dual Independent Map Encoding). During the 70s, formatted maps were created for all cities of USA, and, under further transformation to TIGER (Topologically Integrated Geographic Encoding and Referencing), are used in modern GIS.

GBF-DIME success was followed by other US federal institutions for own purposes. One of the most important usages was the necessity of tax collection in every State. These systems were using a relatively large raster seed of nearly 0.16 km2, nevertheless proved useful. Many universities were developing these systems either with cooperation of city-planning centers or independently. In 1966-1968, Harvard computer graphics laboratory was a spring of various ideas, building a basis of current GIS, in particular a SYMAP program, first of its kind in map referencing.

Concurrently in 1969, two GIS pioneering companies start their ways. ESRI, founded by Jack and Laura Dangermond, was focusing on fundamental ideas development and commercial projects implementation and then started to develop and distribute own GIS products for end-user operation. The first product, ARC/INFO, was released in 1981, followed by a user conference, organized by ESRI. As new operating systems and new hardware were being developed, ARC/INFO was coming to newer platforms.

Former Huntsville IBM employees who were responsible for missile navigation programs creation founded the other company, founded the other company, Intergraph (Interactive graphics). The organization was initially consulting federal institutions about using computing technologies. The solutions of first customers' needs formed style in creating company's cartographical systems. In 1974, first commercial program - Interactive Graphics Design System – was sold to Nashville County administration.

Other countries were developing their systems as well for own usage by various research institutes and scientific teams throughout the world. For example, Canadian collective under management of R. Tomlinson developed a universal Canadian GIS – CGIS. This standard is used nowadays for city planning, topographic cartography, navigation, road planning, forest management etc.

In USSR, digital maps were initially developed for military purposes – navigating ICBMs and regular missiles, resulted in creation of digital map of USSR and standard in coding and classification of cartographic information, which was used for all countries of Warsaw pact. Similar researches were performed by NATO with creation of DIGEST standard.

As systems proved useful for initial purposes, the development continued on adapting concepts, ideas and methods to other fields. Due to stability of some geographical information and by-design flexibility of input data, GIS projects began to rise in various areas.

Another breakthrough in GIS development was optimization of vector algorithms to be able to use vector structure in cartography. In 1992, Defense mapping agency in cooperation with ESRI, partners from Canada, UK and Australia, developed a brand new cartography product – DCW (Digital Chart of the World). DCW was the first vector-based map of the world with scale of 1 : 1 000 000. It was the most detailed on that time database of spatial info with volume of 2 Gb, designed to be used for marketed PCs. Technologies used in creating DCW were idea continuation of ESRI products, TIGER format and optimization of problems with system computing power.

Burst of GIS aims and vector algorithms made kick-started various implementations, merging with other existing software and navigation technology alongside with standardization and regulation. In 1980s, the field experiences creating additional sources of spatial data, GPS and remote sensing adaptation, focus on integration with other commercial products and systems. Globalization caused international cooperation on creating catalogs of unified information by ISO regulation – Environmental data coding specification.

1990s were a start of worldwide Internet usage and significant increase of computing power, which required products to be cross-platform and oriented towards client-server architecture, complex networks of databases and programs with ability of joint analysis. In addition, first 3D models were introduced and expanded task range to even more appliances, coming out of military and federal usage to citizen life. A trend of universal usage created project on developing Open GIS, supported by simultaneous growth of Linux family operating systems.

In latter days, GIS are oriented on user models for desired purposes. XXI century opened even more visualization features, computer animation, and digital photography among rapid increase of computing power from year to year. Every aspect of GIS is being simplified and optimized, with researches of Artificial Intelligence solutions, event forecasting and even further unification in data presentation and referencing (adapted from Zhurkin I, Shaitura S, Geographic Information systems, 2009).

2.3 GIS recent trends

In Arcwatch (e-Magazine for GIS News, published by ESRI), issue February 2011, Michael Goodchild, a British-American geographer responsible for huge contribution of GIS development, and considered as a leading expert in the field and “father of GIS science”, wrote 5 thoughts of possible further development of GIS.

According to Michael Goodchild, the navigation will go further in indoors, navigating in buildings, however the main problem is to perform such accurate navigation, as GPS works poorly inside; objects will be described in various forms and in a way any of these forms will be understandable and transferable; usage of technologies additional to GPS, such as RFIDs and QR tags with spatial data stored (which can be found to be used now, for example in hospitals as RFID armlets for patients with stored info and possible ability to track them within walls of hospital). And yet the most interesting and innovative would be the real-time GIS updated by itself automatically through a system of sensor reacting with environment and requiring minimal operation from human in creating and managing spatial data.

3. Spatial data

Geographic or spatial data is the data that represents things that have a location. The data represents real objects as roads, rivers, cities, postboxes etc. or events and phenomena like police or emergency calls, rainfall rates and weather patterns (Diamond L, Introduction to geographic data formats). One of the features of spatial data is the ability to content not only the location of described object, but also its characteristics, attributes and nuances, for example a color of a post box or population of the city. Spatial data is used in two GIS subsystems: analysis and visualization, usually combining both. With many ways and formats created, spatial data is divided in two types: vector data and raster data (Figure 1). Both data is described briefly yet informative in QGIS tutorial e-book (Sutton, Dassau, Sutton, A Gentle Introduction to GIS, 2009).

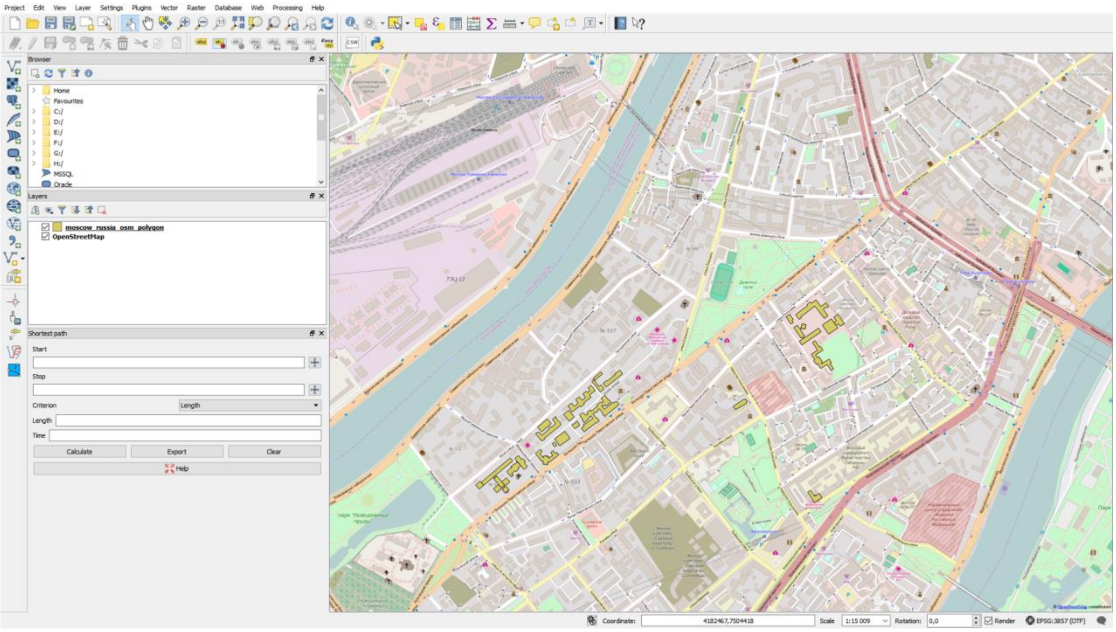

Figure 1: Vector polygons (yellow) on raster map layout (OSM) in QGIS.

3.1 Vector data

Vector data is a representation of real-life objects in GIS. Anything that is necessary as roads, buildings, cities, postboxes etc. can be described as an object and put into GIS database.

A vector object is defined in system by geometry, an array of connected vertexes with X,Y and Z (if needed) coordinates; location, a bond between an object and its position on the map, and attribute data, describing properties of an object. By the number of the vertexes vector data is divided as (Sutton, Dassau, 2009):

- Point feature, if an object is described by one vertex. Point is the most basic feature defining a selected place or single object on Earth.

- Polyline feature, if 2+ vertexes describe an object. Polyline usually represents objects that have scalable length and same attribute from one point to other. As an example, roads, water pipes or electricity cables.

- Polygon feature, if 4+ vertexes describe an object, and the first and the last vertexes are equal. Polygons are used for areal objects with same properties, such as cities, houses or landscape territories.

Depending on the scale, different types of vector data can define the same object. For example, on large scale, a city can be defined as a point, but in close, city is defined by a polygon or set of polygons for more informative representation (Sutton, Dassau, Sutton, 2009).

A set of vector objects with same feature and attribute data can be combined into a layer. The layers are convenient datasets to process and store. GIS with GUI usually possess a feature of switching and filtering layers for extended usage.

One of the main defining part of vector data is attribute data - information, describing different characteristics and parameters of objects in topographic dataset. Attribute data is that non-geographical piece and presented usually as an array or table of info with rows being objects and columns being needed categories. The values of the cells represent the attributes of each object in selected category.

Vector data is the best way to define spatial info, thanks to attribute data and relation of geometry designed in it. However, describing every single object as a vector is time consuming and sometimes impossible due to insufficient resources and uselessness, as there exists alternative data representation.

The most popular vector formats are:

- Shapefiles – initially used only in ESRI GIS products, this format became convenient and popular and stated to be a standard for geoinformational applications. Shapefiles is represented as a set of three files, representing one array of data, usually a layer: .shp for geometry of vector objects, .dbf as attribute data and .shx as supportive indexing information.

- GML – a specification created by OGC as a XML dictionary for describing spatial data featuring interaction with other XMLs. This format has a set of primitives, such as attributes, geometry, time, layer data, measuring units etc. used for creating XML Schemas.

- KML (Keyhole Markup Language) – this spatial data markup language is add-on to GML. KML was popularized by Google Earth, as being for some time the most accessible tool for working with spatial data, thus KML files received wide spread in the Internet and GIS services. Due to GML only describing spatial data rather than visualizing it (though visualization can also be tweaked without KML in some cases), KML is used for that reason, carrying GML data inside.

- GPX – text format, also based on XML. GPX involves active use of GPS traces and used for exporting data from trackers.

- GeoJSON – text format based on convenient JavaScript, effective in interactive cartography.

The shapefiles are usually used in Desktop systems, and GeoJSON and KML in web maps.

3.2 Raster data

Raster data is defined as matrix of cells called pixels each containing attribute data of area respective to it. Each pixel is a square with a size preselected when created, thus a single pixel can cover from tiny to huge area. Pixels also contain information about coloring, called bands. Bands are layers of necessary range of colors that are necessary in particular visualization. Bands can cover full spectre, as RGB or CMYK, or black-white or pseudo-colored images with gray-shading. In addition, raster attribute data is also contained in the pixels.

Raster in GIS is used for representing unchangable geospatial info and when using vector data would be complex and uneffective. In modern applications, rasters are used as visualizing background of a digital map for vector objects in purpose of user orientation.The main problem of raster is the higher detailization of an object is required, the more the amount of pixels is used, thus storage size increases (Sutton, Dassau, Sutton, 2009).

Raster data formats are usually commonly used image formats, as JPEG and TIFF.

3.3 Table data

Spatial data can also be stored in tables, like CSV or XLS, with rows representing each object and columns as the attributes of the objects. Table data can be geocoded (i.e. put on the digital map) as a vector layer (Figure 2). Usually, table data describes point features.

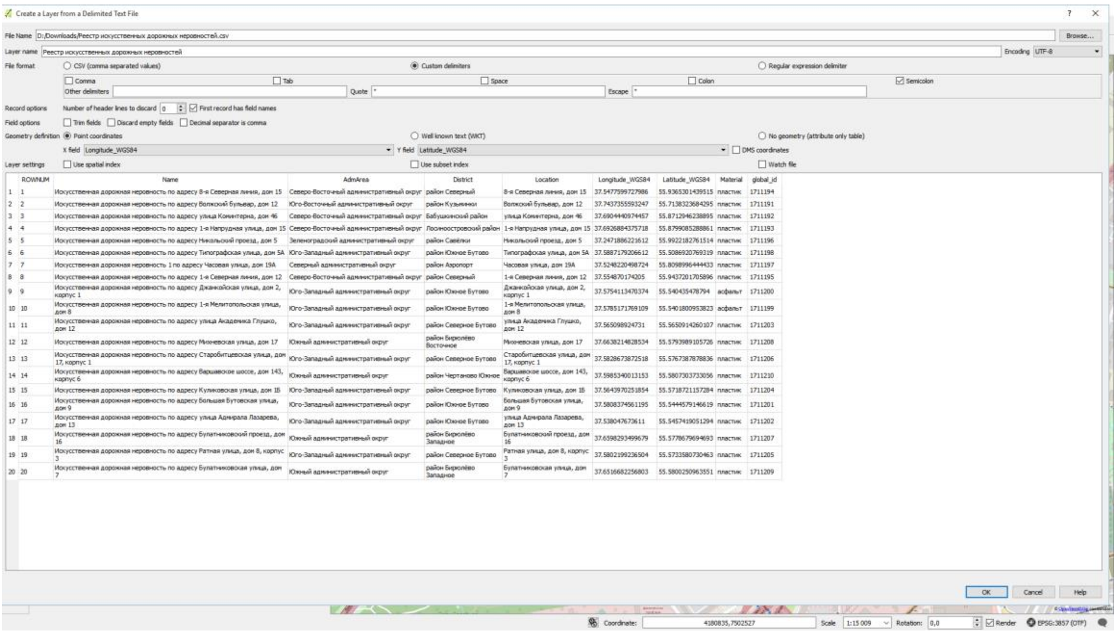

Figure 2: Geocoding CSV file into a layer in QGIS. Point coordinates are recognized using attributes in the table.

4. GIS structure

Looking deeper into GIS definition as a complex system, GIS can be defined by its capabilities — subsystems responsible for special set of similar functions. Marble and Pequet define four main GIS capabilities of subsystem interaction with spatial data: data input, data processing, data analysis and data output. (Schmandt M, GIS Commons: An Introductory Textbook on Geographic Information Systems).

4.1 Subsystem 1: Data Input

Data Input is a capability of receiving different types of data inside the system. The first phase consists of database designing, to assign and code necessary parameters of data to be stored. Database design is based on needs and resources of the system considering database characteristics:

- Key features of the system
- System resources, covered region, focus
- Required attribute data for key features
- Coding of database
- Map referencing features
- Projection parameters

The second step of data input is data acquisition process. Data acquisition process is major step and bottleneck not only in data input, but also in whole GIS application process, costing 80%+ of total project costs and time spent, with collecting, evaluating and converting data (UNIT 7 - DATA INPUT).

Data acquisition methods vary and usually selected by most suitable for particular system. The main sources of spatial information are existing databases and organizations in GIS industry, however a GIS project company can perform remote sensing, geodesic photography or environment monitoring if necessary.

Collected data is organized dependent on each other type and behavior. The complex of data organization principles is called a data model. Data models differ by methods of relations between different data. For example, Frank Aldrich's data model (Figure 3) suggests organization based on acquired data source alongside with its observability.

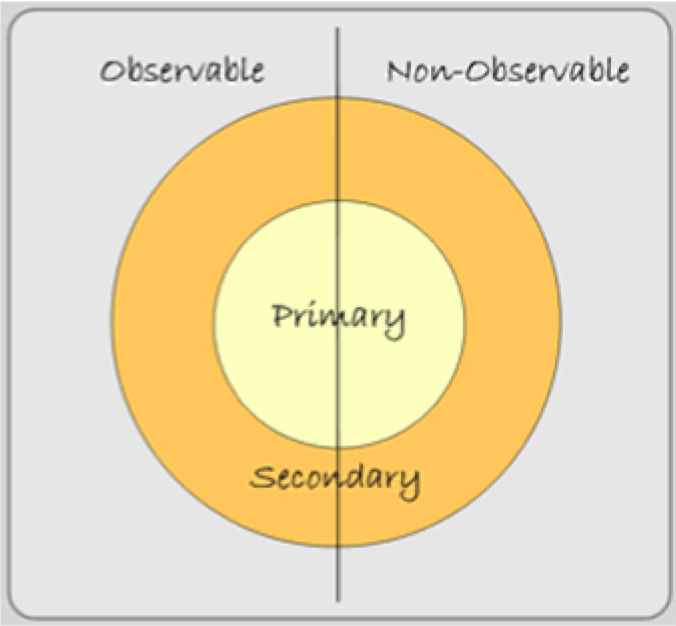

Figure 3. Aldrich data model (http://giscommons.org/chapter-2-input/)

Data to be collected is classified as primary - collected by GIS company personally, secondary - collected by second and third party companies), as well as observable and non-observable, based on whether the data can be seen by the collector.

After data collected, it needs somehow to be converted in suitable format, to insert it into the created database. This is called data capture process. Some acquisition methods already have features to present the information in applicable format, however, non-digital data, as maps, geodesic images, ledgers, and unsupported digital data require hard labor work on digitizing and converting it or developing algorithms to ease and speed up the process.

When data is captured, the GIS database needs to be tested if the concept works with base created. Thus, a small test project, called pilot project, is created to observe data flow in the systems, make evaluation, apply tweaks and modify the system.

4.2 Subsystem 2: Data processing

As described in spatial data chapter, captured data is transformed into its vector or raster representations as files with decided formats. Uploaded and stored, data has to be verified, where attribute data is connected to spatial info, evaluated on errors and coded to be used in GIS features and analysis. The information is stored in layers of vector and raster data, where each layer represents one spatial info type or thematic purpose of the area as seen below (figure 4):

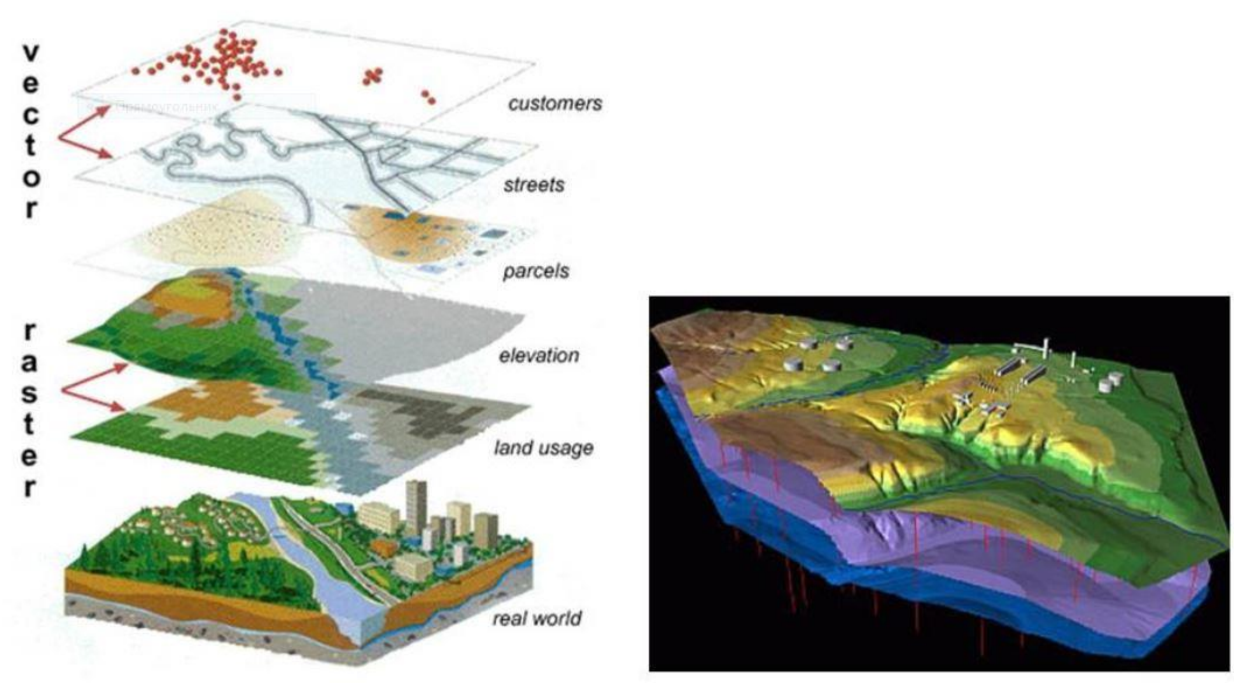

Figure 4: Layer representation of the area. Vector and raster types of data are seen (Adapted from “GIS Spatial Data”, http://www.lib.sfu.ca/research-data-library/gis-spatialdata).

4.3 Subsystem 3: Data analysis

The main interest and usage of GIS system are usually tools of analysis such as:

- Decision-making methods
- Knowledge base and expertise systems creation
- 3D-modelling

The most popular and effective analysis way in GIS is object-oriented approach, as it expands greatly range of applied tasks solution. Depending on field of application and their specialties, GIS is designed to be capable of dynamic modelling with variety of analyzing and visualization tools.

The main feature of spatial data is its relative stability and consistency, which allows using it as one of standard measurements like time. Analysis is usually designed to be capable of answering following general questions:

- What is located in …? (location definition)
- Where is the object located? (spatial analysis)
- What has changed since time …? (detect changes occurred in this particular area)
- What spatial structures exist?
- What, if…? (modelling and simulating a possible scenario)

The ways of analysis design and performance differ depending on database structure and representation method. As mentioned, vector data is flexible and can be used in various methods, while raster data requires scanning (image processing) to vector or special tools that require only images for analysis.

4.4 Subsystem 4: Data output

Visualization - the process of converting (transfer) the information encoded in the GIS database, into the human mind. The information transmitted to the end user in the form of cartographic products, should transmit the impression about the reality, and not about the database itself. Correct perception depends on the proper functioning of previous capabilities but the main thing is the subjective perception of the user. Some people do not have the skills of map reading; the other can handle the most complex and rich image information, but quickly lose interest and look for alternative sources. Visualization is to use a variant of detail required specific categories of users, from the general overview to a detailed understanding.

Effective visualization requires a good understanding of map symbols. Ideally, a set of map symbols is entirely clear to anyone, without the dual interpretations of the meaning of characters, character set can be expanded and modernized. Classes map symbols correspond exactly to feature classes:

Three-dimensional images are the most "spectacular" elements in the visual possibilities of GIS. Most of the systems can only work with the contour three-dimensional images in the form of rectangular (DEM-model) or triangular (TIN-model) network of intersecting lines. Modern GIS can be equipped with special modules to prepare for the publication of such three-dimensional images, equipped with anti-aliasing features and pouring relief. Angular contour model is smoothed set of spline functions for giving "realism", then the intercostal spaces are filled with a colored background (rendering) of a particular algorithm. The fill color can be determined by the position of the point on the altitude, orientation relative to the light source (the sun), or any other qualitative or quantitative characteristics. Sometimes obtained terrain model can be superimposed two-dimensional maps for visual analysis or three-dimensional symbols.

Appearance of cartographic documents produced with the help of GIS, is ultimately determined by the technical characteristics of available peripheral devices: monitors, printers and plotters. Monitors and printers display information using arrays of color or black and white dots - pixels (pixels). The pixel size determines the smallest size of the symbol, positioning accuracy and spatial resolution. It is of great importance and a set of colors available for the GIS, which provides a specific device. (cadaster.ua, [Information Output in GIS])

4.5 GIS as a technical system

In addition, the capabilities of GIS are inapplicable if not supported by material counterparts (Zhurkin, Shaitura, 2009):

- Hardware. A computer or network of computers forming the system and series of equipment supplying GIS operation.

- Software. A system contains utility and applied functions and tools required for data storage, analysis and visualization. Key components of software are tools for data input and operating, database administration systems, queries support systems and GUI. The capabilities of GIS are inapplicable if not supported by material counterparts:

- Data. The main source of GIS operation.

- GIS management. People working with software and developing usage algorithms. GIS users are tech specialists that create and modify the systems, and end-users who use it for problem solving. GIS efficiency is greatly dependent on planned terms of service adapted according to task specialty and organization activity.

5. GIS Market

GIS industry is a broad and competitive field of solutions designed to fulfill needs in working with spatial information. From enthusiasts' projects to serious enterprise workarounds, the products find innovative and neat usage of methods defining GIS capabilities.

5.1 2 styles of GIS Software development

Geoinformatics is starting to leave the lab doors into the society. Nowadays, thousands of people are involved in developing the systems and services. As in every IT field, GIS has divided into proprietary and open-source communities, fortunately interacting with each other. This gave the customers a huge variety of products, in which he/she can find a flexible solution the problem.

The proprietary systems do not cover commercial products alone. Many GIS services are presented as SaaS or PaaS free, though keeping and maintaining it by themselves or giving limited preferences to the customer and then offering extended features for payment. As a result, it is easier for such companies to manage the focus of their product and market share they are aimed. Additionally, companies provide customer support and eager to help integrating and tweaking their product.

Open-source is presented on philosophy of community-created products. OGC and OSGeo, which mission is to popularize and support open GIS, present the GIS in open-source. On their behalf, there was created several systems and services, standards and platforms that find usage in modern field. Additionally, open trend is popular nowadays by governments of countries or research institutes that are interested in creating open systems and support their development. (Dubinin, Rykov, 2010, [Open Desktop GIS, review of current situation], pp. 34-44).

Open-source structure of systems are remarkable for creation APIs for user plugin creation, rather than specially designed features, allowing creating necessary toolbox for specified field of application and sharing it with the community, which can help with improvements. As a drawback, unskilled or unfamiliar customer will struggle with lack of features in open systems and necessity of additional implementation.

5.2 Product types

Existing GIS applications can be divided in 3 categories: Desktop GIS, Web Services and adjacent products. These categories are tightly connected with each other, as GIS solutions usually offer a complex of products for different needs. Additionally multi-platforming is useful for optimization and compatibility features, as well as portability of incoming services.

5.3 Web Services

Simplicity and convenience of data representation in the Internet nowadays is obvious. The development of broadband connection and calculation capacity of computers made Web services possible, and with that trend, OGC has developed protocols to regulate and standardize those, similar to W3C with general global network optimization.

First step was the development of GML (Geography Markup Language) — another XML language designed for describing spatial data. Additionally, OGC suggested three types of GIS web services (OGC Standards):

- WMS (Web Map Service) is a service that defines request parameters and visualization of spatial data in form of image or set of objects. WMS describes conditions of receiving and presenting map contents information (i.e. attributes of an object in specified location on the map), as well as information about server capabilities.

- WFS (Web Feature Service) defines requests of receiving and updating spatial data from client-side application using GML and is responsible for UI and manipulation of spatial objects using HTTP protocol.

- WCS (Web Coverage Service) expands WMS capabilities by presenting additional raster data, generating image opposed to pre-loaded WMS image.

In other words, by using these specifications, most part of web services is created, with WMS dealing mainly with raster data, WFS with vector, and WCS as additional features to WMS. Mainly, Web services are presented by web mapping services and portals with digital maps and databases (refer to page 25 for further information).

The first type of web services is digital map services. These are casual services, offering raster overlay of satellite images or designed streets network with vector objects on it, using which a user has the ability to view the location of objects, calculate routes or view additional info. The notable examples of the services:

- Google Maps is by no doubt the leader of GIS web services. In fact, Google was the pioneer developer of such services and initiated creation of similar products throughout the world. The key of Google Maps is its usage of KML files and API allowing many features such as inserting any map from Google Maps on external website and creating mark-ups and additional info there via JavaScript. The API supports native names of spatial objects, which resulted in rapid international acclaim and support, though blame initially by governmental security services for publishing satellite images in public access. New features are constantly implemented, for example Street View, allowing view of detailed areas in the maps (Figure 5).

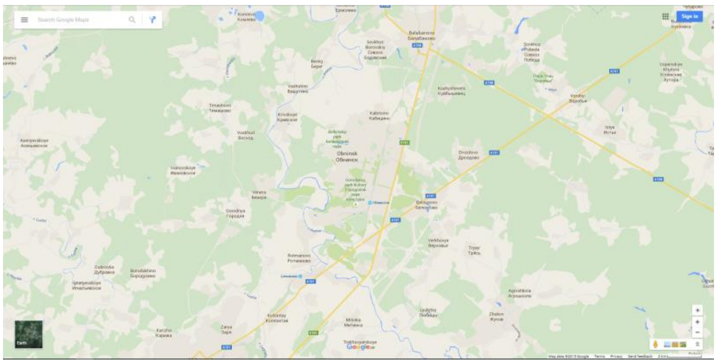

Figure 5: Google Maps.

- Yandex.Maps is the main Russian analogue of Google Maps, popular in Russian Federation. Yandex maps represent a compatible service in the region, as Russian users cannot evade using it – as functionality is broad and comfortable. Yandex Maps provide all the features Google Maps provides, though some of them are only for Russian Federation and CIS countries, but especially designed for usage in this area, creating intuitive and native software (Figure 6).

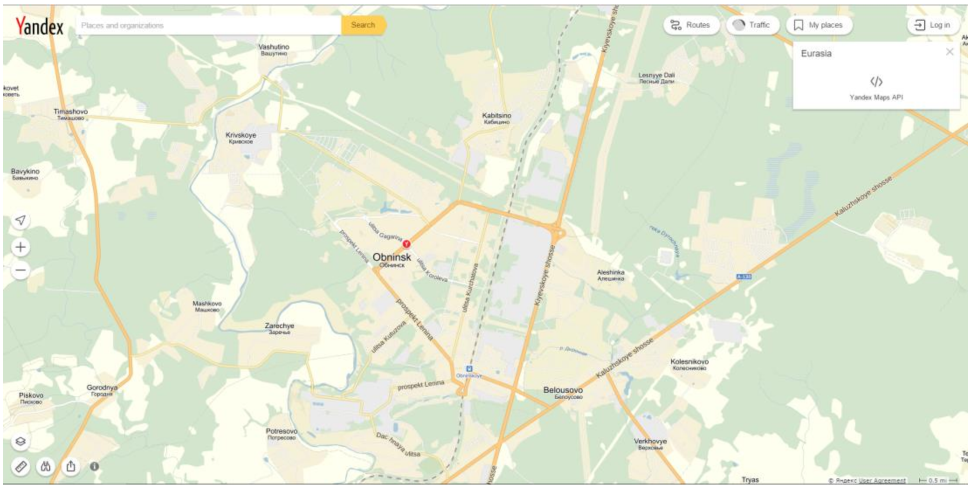

Figure 6: Yandex.Maps.

- Here Maps (formerly Ovi Maps and Nokia Maps, http://www.here.com/) is a mapping services provided by Nokia. Here has a good market share in navigation services with great features of map quality and traffic info, that ESRI uses their traffic info in ArcGIS. Recently, Nokia Here was sold to Daimler, BMW and Audi, as they were previously using Here in cars for navigation (Figure 7). (Nokia confirmed)

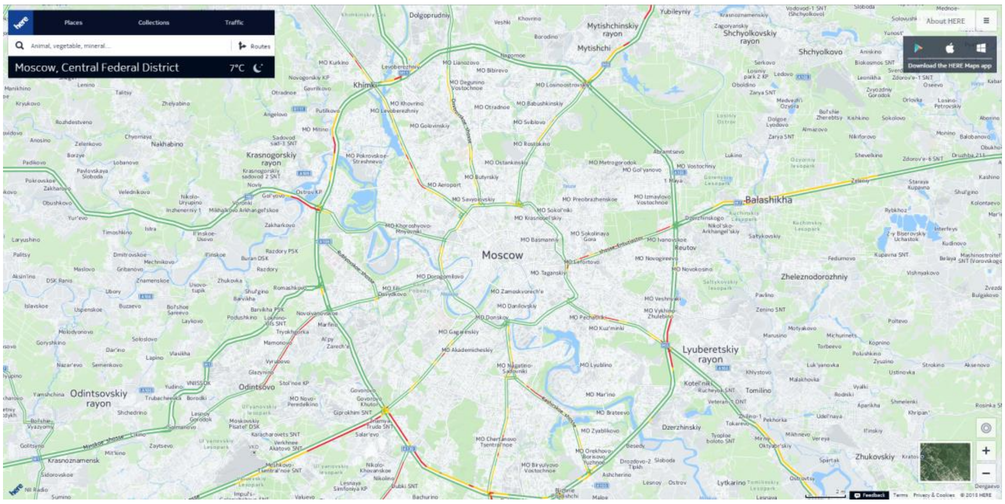

Figure 7: HERE Maps.

- OpenStreetMap (OSM, https://www.openstreetmap.org/) – is a non-commercial open source project of creating open map of the world. For creating the map contributors, that must be noted in every OSM mention. Use data from GPS-trackers, topography, street panorams etc, for creation. The contributors are mainly enthusiasts, though some governmental mapping agencies also take part, for example Finnish National Land Survey of Finland's Topographic Database (Figure 8). (https://www.openstreetmap.org/copyright/en)

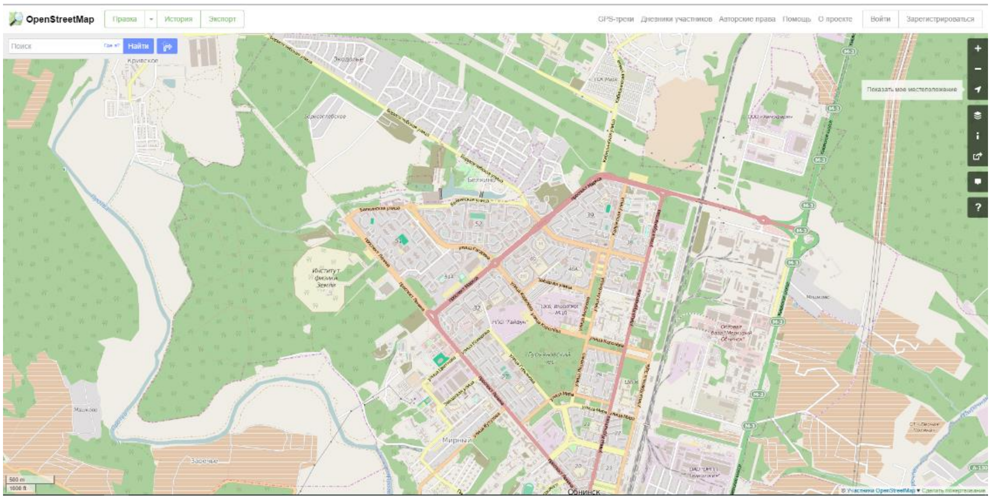

Figure 8: OpenStreetMap

- ArcGIS Online (https://www.arcgis.com/home/) falls from casual service category, as it provides full compatibility with ArcGIS products. Using ArcGIS online, a user can also import files as vector layers, or add layers and overlays from ESRI Atlas, a huge database of different default or user-created maps. However, ArcGIS Online is unavailable without having an ESRI account, which is free only for 60 day trial (Figure 9).

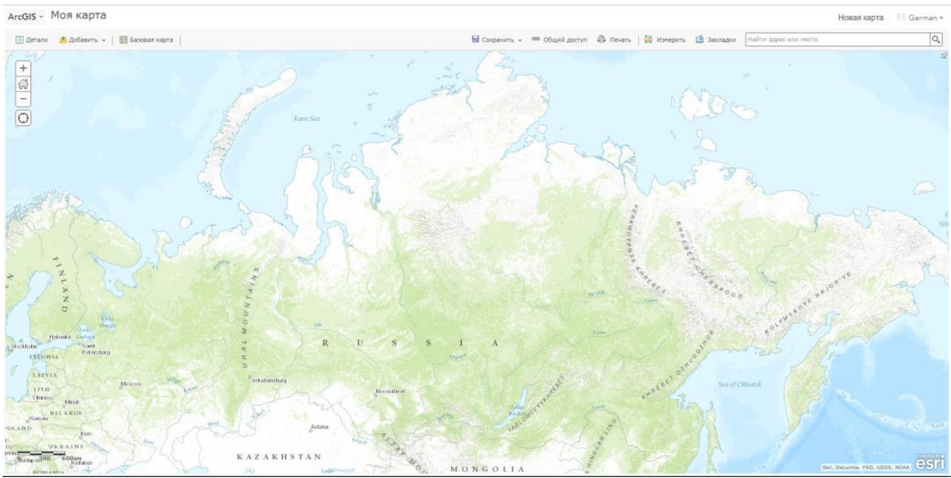

Figure 9: ArcGIS online digital map.

Another important part of GIS Web services are databases of spatial data. Open databases containing different types of data are called portals. Portals are the fascinating phenomenon of free information sharing. Created mainly by government departments, research institutions and enthusiasts, these portals contain loads of useful data for any user to view and take. This data can sometimes can be impossible or costly to retrieve otherwise, due to lack of other source or inaccuracy of attempted data collection, thus portals are very important. Two main features of portals are the ability to view selected data on digital map in browser online; usually OSM or Google.Maps overlay, and export it to GIS in JSON or CSV format. There are various portals on the Internet, for example:

- INSPIRE Geoportal (http://inspire-geoportal.ec.europa.eu/) – Inspire directive is EU directive on creating database portal of spatial data (Figure 10).

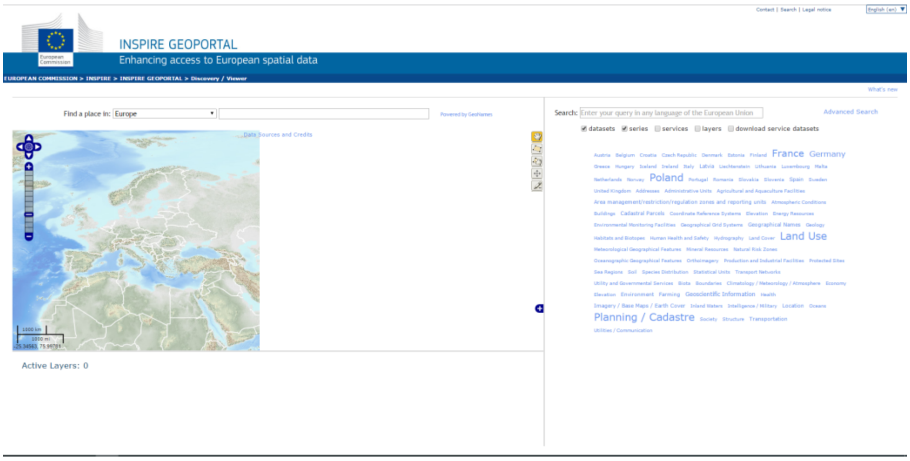

Figure 10: INSPIRE Geoportal Main page.

- Open Data of Moscow City Government (http://data.mos.ru) – Portal containing various spatial info of Moscow, categorized and user-friendly oriented. Unfortunately, English version has mainly data regarding tourist info (Figure 11).

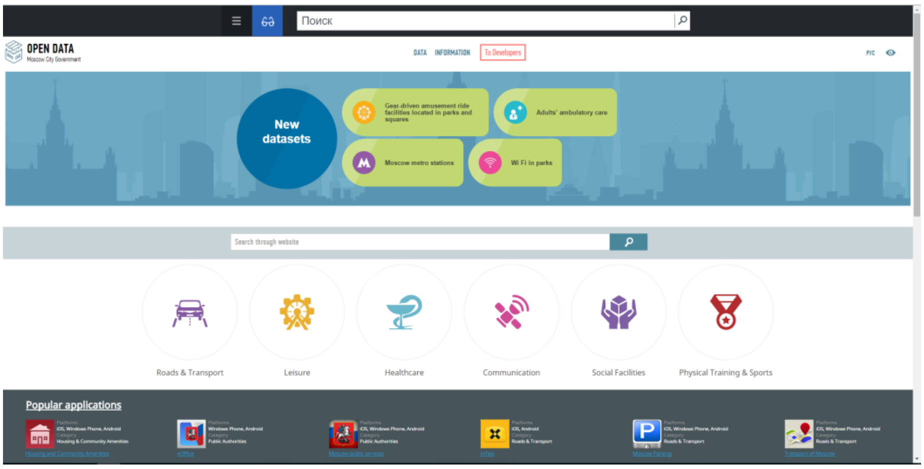

Figure 11: Moscow Open Data Portal.

5.5 Desktop GIS

In meantime of Web services and spatial databases have filled the firm niche in GIS field, desktop system are still actively searching theirs. Desktop GIS is a cartographic software that can be installed and launched on PC. Some features of desktop GIS have been replaced with web services with development of the Internet, however the need of analysis, computational problem solving and local work with data is the main reason they are necessary and actively developed.

In commercial field, as of 2015 there are three main GIS Products. As they offer great flexibility of their solutions, they also contain services in other branches of GIS market, such as Web services or adjacent services:

- Esri ArcGIS (http://www.esri.com/) – the largest competitor on GIS market. ArcGIS is a system for creating of GIS at any level, as it gives the ability easily to create spatial data, maps, models using desktop software and then use it in Server, Web, Mobile or Desktop products. ArcGIS gives all necessary tools for developers in creating own applications. In addition, the system has the flexibility based on product orientation, allowing to select necessary features or bundles needed for user operation.

- MapInfo (http://www.pitneybowes.com/us) – is a competitor of ArcGIS, that offers variety of different software as toolkits, development and visualization of spatial data. Flexible pricing plans of MapInfo resulted to be one of the most spread systems for GIS education and use in business.

- Intergraph Geomedia (http://www.hexagongeospatial.com/products/producer-suite/geomedia) - is a comprehensive GIS product line that enables realization of the maximum value of your geospatial resources, integrating them to present clear, actionable information. It provides simultaneous access to geospatial data in almost any form, uniting them in a single map view for efficient processing, analysis, presentation, and sharing. GeoMedia's intuitive, dynamic analysis functionality enables concatenation of analysis processes so the results of one operation feed directly into the next process, as well as automatic updating of results in response to data changes. It delivers high-productivity tools that speed the implementation of geospatial databases by improving the efficiency of common workflows. GeoMedia provides flexibility, interoperability, open architecture, and adherence to industry standards such as OGC and ISO standards. (Product Features and Comparisons, 2015, slide 2).

The most popular open source GIS are:

- Geographic Resources Analysis Support System (GRASS) GRASS GIS is a system with access to over 300 modules for working with 2D and 3D raster and vector data and has similar amount of features as ESRI ArcGIS ArcInfo. However, lack of convenient GUI affects GRASS spreadability thus it is still mainly used by research institutes and universities.

- Quantum GIS (QGIS) The development of QGIS began in 2002 by a group of enthusiasts, later continued by OGC patronage. Their aim was to create a simple and fast viewer of spatial data for Linux family. With growth of popularity, QGIS was then designed to act as a GUI for GRASS receiving its analytical and other features. Using QT toolkit, QGIS is available for most today platforms as Windows, Mac OS X, Linux and beta version of Android. The features can be expanded by creating plug-ins using C++ or Python. Moreover, QGIS has one of the most developed communities, having convenient system structure and good documentation as a result.

- User-Friendly Desktop Internet GIS (uDig) The purpose of creating uDig was the development of software, capable of viewing and editing data stored in databases directly or via the Internet. System is written using Java with Eclipse Platform and was mainly designed operating vector data. Eclipse platform allows uDig to act as plug-in of another Eclipse created application or vice versa, however the user interface of the system looks like SDK itself, thus may confuse end-user.

- Generalitat Valenciana, Sistema d'Informacio Geografica (gvSIG) On behalf of department of transport of Valencia (Spain), gvSIG is one of the biggest, in terms of funding, open projects of open GIS. The research began with decision of regional authorities to migrate all computers to Linux system. Written on Java, gvSIG supports operation with vector and raster data, and main mission of fullfilling the feature set of ArcView was accomplished and even succedeed in performance in some components. However, system is dependent on over C++ and Java libraries which may affect suing the system.

- System for Automated Geoscientific Analysis (SAGA) Developed by Hottinghem University (Germany), SAGA GIS was developed for operating raster data. Main feature of the system is landscape analysis, soil cartography and vizualisation problems solving.

5.6 Adjacent Products

In addition to GIS products, some companies develop services that utilize usage of spatial data, but don't act as GIS in its common meaning. Mainly, these solutions are pointed towards tweaks and optimizations of either existing GIS and data, or act as cross-platform and cloud storage services.

There are various products, from which those should be noted:

- CartoDB (https://cartodb.com/) is an online service for geodata operation, representing as a hosting with a feature of vizualisation and sharing personal spatial info. CartoDB has a convenient interface, allowing any user with different level of competence to be acknowledged with the service. Additionally, CartoDB has a website «The Map Academy», where it publishes examples and tutorials for the service.

- Mapbox (https://www.mapbox.com/) is a service for storing cloud spatial data and publishing it on various platforms. In comparison to CartoDB, MapBox services, such as TileMill, provide additional features of customizing the map and objects it contains, using CartoCSS, a special CSS for digital maps. The customization is performed layer-to-layer, and created map can be exported as static image or cloud storage with different payment plans.

- APIs of popular Web services contain plenty of useful components of their digital maps. If studied properly, one can create custom maps or use capacities of these services for their own cause. However, privacy policy and license of APIs must be considered, as it may regulate free usage of the component. For example, using Geocoder of Yandex.Maps API is limited to 50000 uses per day for free. Further usage must be discussed and partnered with Yandex otherwise website using API can be blocked. This regulation is made due to high load to the servers, if geocoder is used with such frequency. Moreover, with use of open-source APIs and source codes available there can be forks developed to expand usability of parent service.

5.7 GIS-ish

There is also category of software that takes its niche in GIS market, however not being or seeming as GIS. Due to the geoinformatics still being relatively unfamiliar to public, the marketing suggests naming and positioning the products under different names and purposes. As an example, many companies are dealing with so-called tracking software. As the customer only wants to have features of having monitoring of his child during the day, or path of its recent cycle trip, he does not need to study or fall in GIS itself, rather to have the system worked, the less complex description the better. Thus, such services as GPS-Trace Orange or Wialon for example exist.

When looking on the products websites at first glance, there are no mention of term GIS or related whatsoever unless went deeper, though they technically are or use GIS:

- Wialon (http://gurtam.com/en/gps_tracking.html) – Wialon is a software platform with WEB Interface usable for transport satellite monitoring, offering toolkits in fleet management and logistic features. Using SaaS model and external maps support, Wialon is a powerful tool in transportation field.

- GPS-Trace Orange (http://gps-trace.com/) – is an open tracking system, based on Wialon and provides Casual services using smartphones as trackers. "GPS-Trace Orange has rich functionality that helps to solve numerous tasks. Creating one account, you can connect up to 5 units you want to be tracked. Keep calm and stop worrying — GPS-Trace Orange will inform you about anything." – written on Orange about page. (About GPS-Trace Orange).

6. Application of GIS for Transportation Company

Having reviewed the development and technology basis of GIS system, there can be defined its application to transportation field. Harvey J. Miller and Shih-Lung Shaw (Geographic information systems for transportation, principles and applications, pp. 245-246) suggest transportation planning, intelligent transportation systems, hazardous and environment conditioned transportation and logistics as main fields of application. As for regular transportation company, transportation planning and hazardous transportation are the main applications of using GIS.

6.1 Transportation Planning

The objective of transportation planning is to guide development of transportation system to achieve beneficial economic, social and environmental outcomes. Thus, GIS-T is reviewed firstly as an investment to the company in order to obtain those benefits, and this investment has to be discussed from various point of views, for example fleet size, area of operation and types of goods delivered (Miller, Shaw, pp. 247-294).

Huge amount of delivery workers and fleet for a company manager is very problematic in terms of planning. Without a designed system, various problems may occur: traffic jams, human error of operator guiding a driver to wrong address, road accidents, either paralyzing traffic or involving the delivery vehicle itself, driving with an urgent order. For a customer any delay of estimated time is considered and taken on bad side, affecting reputation of a company, every failed delivery can cause a loss of customer. Additionally, drivers may be dishonest, making «unregulated» jobs or diverging the process, like stealing fuel from the vehicle ([Delivery, solving optimization problems and uncover “diversions”], 2013).

Thus for companies, that operate in-city transportation, planning is crucial. The usage of IT-solutions makes all the problems clear and obsolete. The automatization is required for:

- Courier services no matter the size
- e-commerce with big distribution and fleet — 50 is already a heavy manageable load
- Transportation companies — also with considerable fleet
- Companies that deliver «by a phone call», for example pizza delivery
- Companies that deliver batches of goods with low expiry date (i.e. food) and resupply in JIT model and also need to optimize routes of delivers to the stores,
- Companies delivering valuable or hazardous goods

6.2 System requirements and benefits

The system must take into account various factors of road condition in order to calculate right path and schedule for timed delivery. Every city has a network of roads with extra attributes such as one-way only or speed limit, zones with regulations regarding type of vehicle and maximum load it can carry on the road, prohibiting driving through this zone. In bigger cities, traffic jams is a huge problem, that interferes route forecasts and long-term planning due to its relative unpredictability, thus require operative updated information of road conditions, crashes and blocks. Additionally, the company wishes the system to be automotive with minimal possible involvement of human entering the data. Extra sources of info are preferably to be exported to the system in a designed way, rather manually inserted and transformed ([Delivery, solving optimization problems and uncover “diversions”], 2013).

If the system fulfills requirements of the company, TC receives huge benefits such as:

- Work time and fleet economy. Optimal routing can decrease delivery time and fleet involved creating complex paths and modelled schedule. Additionally, decrease of fleet and drive time leads to decreasing of fuel and maintenance costs.
- Decrease of load, especially in peak days.
- Decrease of level of expired or non-conditional products (expired goods, warm meat, cold pizza etc.)
- Decrease of the human error factor.
- Decrease of amount of conflict situations with customer regarding condition and delivery time, thus additionally leading to lowering loss of customer base and even its further expansion.
- Company can offer additional features to clients, for example real-time tracking, delivery guarantees, expanded level of deliveries (i.e. it was impossible to deliver certain goods due to inability to calculate optimal route in the past). In addition, well-developed transportation can carry features of hazardous transportation, mentioned earlier.

6.3 Implementation of the system

To implement IT-tools into the TC, two systems are required: TMS (transportation management system) and GIS-T. TMS is the system that is responsible for gathering and operating information regarding transportation, giving optimal graph of routes. Information is collected from data sources connected, such as fleet availability, address database, and then operated to create optimal solution and schedule for each delivery vehicle. TMS manages to solve complex and untypical tasks to optimize the costs of transportation, estimated time or involving the minimal fleet, with additional factors such as urgency, hazardous material etc. TMS analysis and calculation is built around complex algorithms of «Travelling Salesman Problem». Depending of scale of fleet, amount of warehouses and delivery points, with correlation of additional factors the problem can mostly be solved through brute-force (an exhaustive search of all the solutions with choosing the optimal one), which requires huge computing power, thus additionally the proper hardware is required. An example of TMS capable of such complex solving could be for example Oracle Transportation Management, which has an important feature of importing data from external sources.

GIS-T is used as a support of the TMS. Without data regarding speed limits, traffic organization or traffic jams, TMS won't be able to define optimal graph without spatial data especially transportation related, or give false routes, not taking into account road conditioning or speed limit, resulting a failure. As mentioned earlier, GIS-T must give fresh and constantly updated info especially regarding traffic jams, so TMS can design alternative route in short period, not delaying the delivery.

6.4 Additional features

Moreover, an important task is monitoring and maintaining deliveries. Every courier or delivery vehicle has to be equipped with GPS tracker or navigator to visualize in real-time the position and register the condition of delivery. For special treatment goods, additional sensors, for example temperature sensor, may be required with same feature of exporting into the system. TC can use it to make decisions in unexpected events and provide features to the customers, that may be interested in additional safety and monitoring access. Drivers can be equipped with special mobile terminals to receive tasks online or report crucial alerts to the company, however this requires for developing intuitive interface understandable for unqualified person, such as driver.

TCs are also interested in analytics and forecasting. For example, where exist risks leading to bad event or delivery delay, where it is more applicable to send lighter vehicle or just a courier rather than a truck, Such situation modelling can also be achieved with usage of TMS and GIS-T, as some TMS may be tuned to have reactions on different triggers and act accordingly, i.e. sending an SMS to a customer or alternative route design, estimated time recalculation etc. One of the most complex and interesting applications of such modelling finding a new solution of transportation. For example, a vehicle is involved in road accident, and TMS has to find nearby unloaded vehicle to pick up the load and deliver it to destination, not affecting its regular schedule, with following alerting of all members of delivery chain on possible delays, changes in route and vehicle and so on. These scenarios can drastically improve the efficiency of TC and its position in the business.

7. Using the Products

7.1 GIS as a project

In the book "Thinking of GIS", Roger Tomlinson describes methods of implementing GIS into a generic company from manager, rather than GIS specialist point of view. Implementing such systems as GIS must be considered as a project with studying company resources, expected economic value and reasons of using GIS, as the payback of such implementation differs from company to company. Proprietary systems capable of various features cost a lot of money and may be expensive for smaller companies. Additionally, small companies may not require such power due to size of the city and fleet and be able to develop the routes manually. Moreover, GIS as technical subsystem is also hardware, GIS personnel and data, which can increase the load and complexity of implementation. Thus, GIS project must firstly be thought through and considered under different points of view.

7.2 Using Proprietary products

One of the examples of fulfilling transportation needs is ArcGIS for Transportation Analytics (ArcGIS for Transportation Analytics website). This bundle contains core desktop and server ArcGIS Advanced software for regular ArcGIS operation, and transportation-based software as Network analyst that solves routing problems, looks for closest facilities and creates services areas; NAVTEQ or HERE powered real-time traffic optional add-on, and StreetMap Premium Advanced, an enhanced, ready-to-use street dataset that provides geocoding, routing, and high-quality cartographic display, and includes attributes needs to support truck legal routing such as weight, and height limit (ArcGIS for Transportation Analytics Website).

In addition, this bundle includes subscription to ArcGIS Online (Figure 12), allowing usage of Internet web services for data import and browser use of

Transportation Analytics Suite. The demonstration of the service can be seen on ESRI Video (http://video.esri.com/watch/1671/arcgis-for-transportation-analytics).

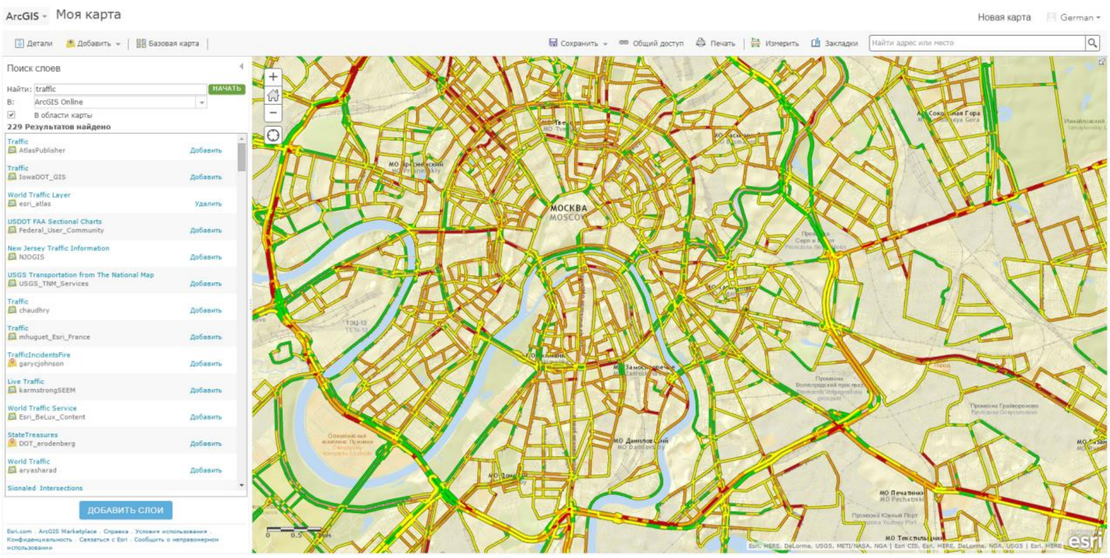

Figure 12: ArcGIS Online digital map with real-time traffic info layer, powered by HERE. Map is updated every 5 minutes.

Another good solution could be Wialon. The platform provides features such as:

- Relative low price of implementation and tech support due to SaaS model.
- Multi-lingual web interface in 49 languages.
- Support of Web maps, such as Yandex, Google, OSM, Bing and Yahoo maps, though default are own Gurtam Maps.
- Gurtam Maps is a server featuring geocoding and routing and exporting user-created maps.
- Support of market of existing GPS and GLONASS trackers.

Based on Wialon, customer can deploy a suitable Web-oriented workaround, and usage of ActiveX based SDK can expand the working environment. All the features are well presented and described in software documentation (Wialon Hosting documentation).

7.3 Using free products

As mentioned, in the beginning GIS was a narrow and specified field in IT industry, with a small community of enthusiasts and researches. With development of the Internet, computing power, popular cartographic services and mobile devices and apps, every person nowadays can perform tasks that were complex before. IT companies such as Google, Yahoo, Microsoft, Nokia and Yandex made everything to simplify the way of interacting with GIS and using it in its way. Small companies unaware of other GIS that can be used, are eager to use such services. Author took two interviews with managers of small companies in Finland and Russian Federation respectively.

Kuljetusliike J.Jokinen Ky is a small company in Petäjävesi, 32 km west from Jyvaskyla. Company's representative denied announcing its clients but named that their fleet size is 5 trucks. The company was not familiar with term GIS, and after brief explanation, a representative told about their experience.

Kuljetusliike J.Jokinen Ky uses Google maps for their route planning. According to Niklas (representative's name), Google maps has all the features they require for their operations, completely free and require no installation, everything can be used in the Internet. In addition, Android powered smartphones fully support Google maps features and can import information about the routes to the navigation system. Thus, built-in navigators in smartphones or basic navigators are used in trucks for the delivery.

Company "Usadba" is located in Obninsk, Kaluga region. One of companies activities delivering labor workers and building materials to various location in the city, and off-limits. Though Usadba's main involvement is not transportation, it provides transportation services related to building material deliveries and supplies themselves with them. Their scale is similar to Kuljetusliike J.Jokinen Ky, with fleet of 4 trucks and a bus for workers' transit to company customers. The company is also responsible for building cottages and repairing flats, therefore the customers are delivery addressees. "Usadba" has to deliver several building materials to different addresses from one warehouse in one working day and needs transportation costs to be minimum.

The company is familiar with GIS, and uses Yandex Maps. The head of the company responds, that this system is the most fitting for transportation activity: it is free to use, can be used online through portal or offline through a PC with tools of route planning to different locations right to the entrance door. Additionally, system supports all mobile operating systems and can be install on smartphone with same features as PC version and system's database fully covers necessary regions.

These two interviews show that on a small-scale a coordinator with help of a convenient service and «pen and paper» can define and give routes to drivers for the day. As described in GIS-ish part, the casual customer does not need to go deep in GIS, rather be able to find easily information and services capable of the job. Thus, such WMS as Google Maps or HERE Maps, tracking services as Orange or OpenGTS, portals as INSPIRE or data.mos.ru come to help.

Author chose Google Maps and Yandex.Maps as tools of capabilities demonstration. The demo consists of selecting three routes on these two systems using the iPad versions of the applications (Yandex.Navi and Google Maps): in-city, from city to city, and international. Due to Yandex.Maps field of operations limit and remarkable for the demo road condition in Moscow, the routes are:

- Calculating a route from Nahimovsky pr. Moscow, to Kremlin. The in-city route involves passing Garden Ring — a circular avenue with length of 15,6 km and width of 60-70 m. This avenue is remarkable for its hard road condition especially in daytime.

- Calculating a route between Moscow and Obninsk. The city mentioned by the interviewee is located within the Kievan Highway (main part of European route E101), a federal road connecting Moscow through south-west of the country to the Ukrainian border. In addition, between Moscow and Obninsk various factories are located and connected with the road. Combining these factors, Kiev highway is infamous for its exceptionally unpredictable road condition with high traffic level and car accidents involving trucks and paralyzing highway segments.

- Calculating a route from Moscow to Jyvaskyla, Finland. A simple case of international transportation.

Google Maps showcase:

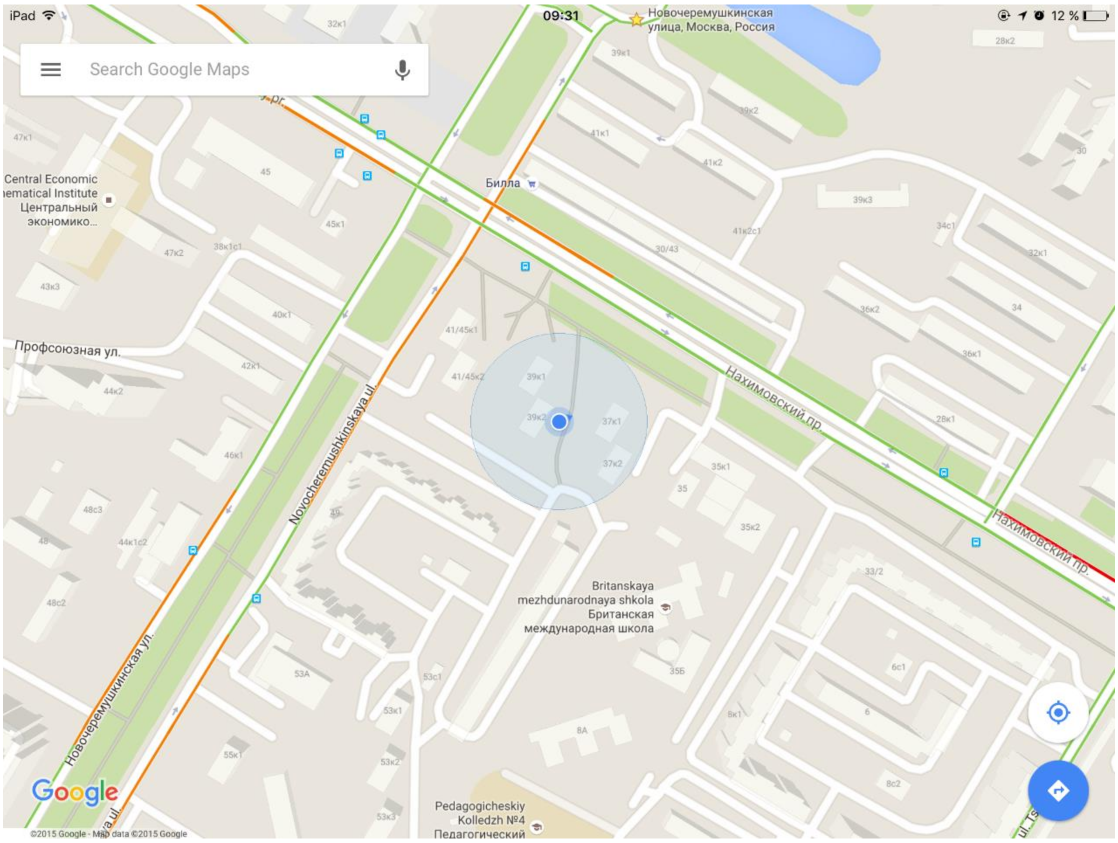

Figure 12.1: Geolocation using Google Maps: road condition is highlighted with gradient form green as least to red as most loaded, road direction is shown. Different objects such as schools and supermarket can be seen.

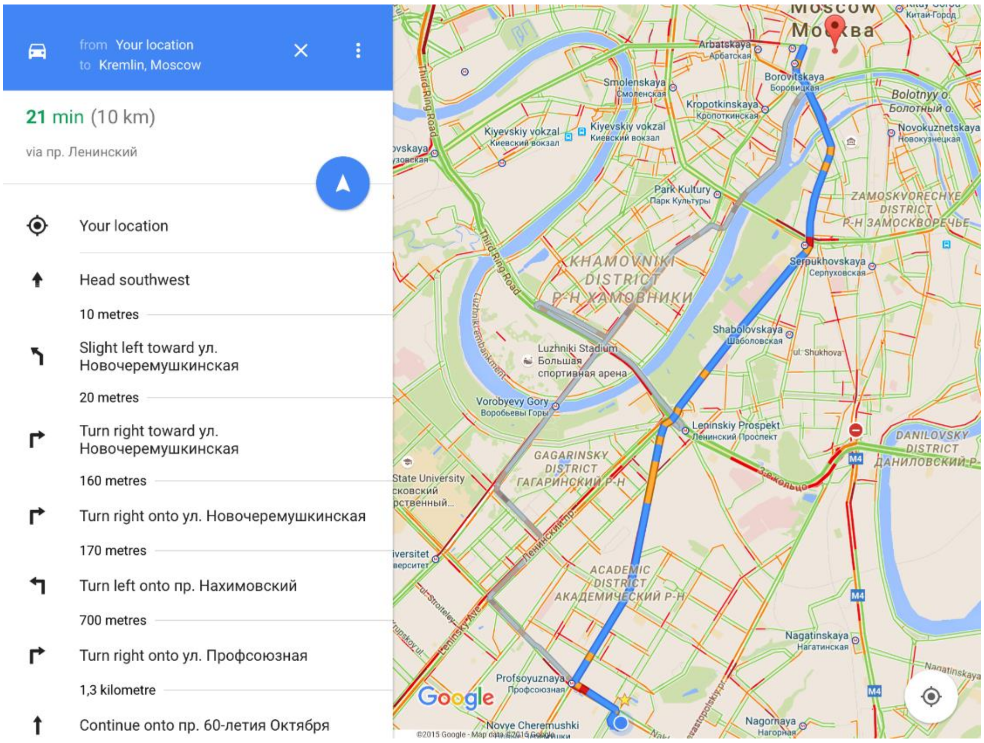

Figure 12.2: Route 1 calculated. Blue path has yellow and red segments showing complicated parts of the route.

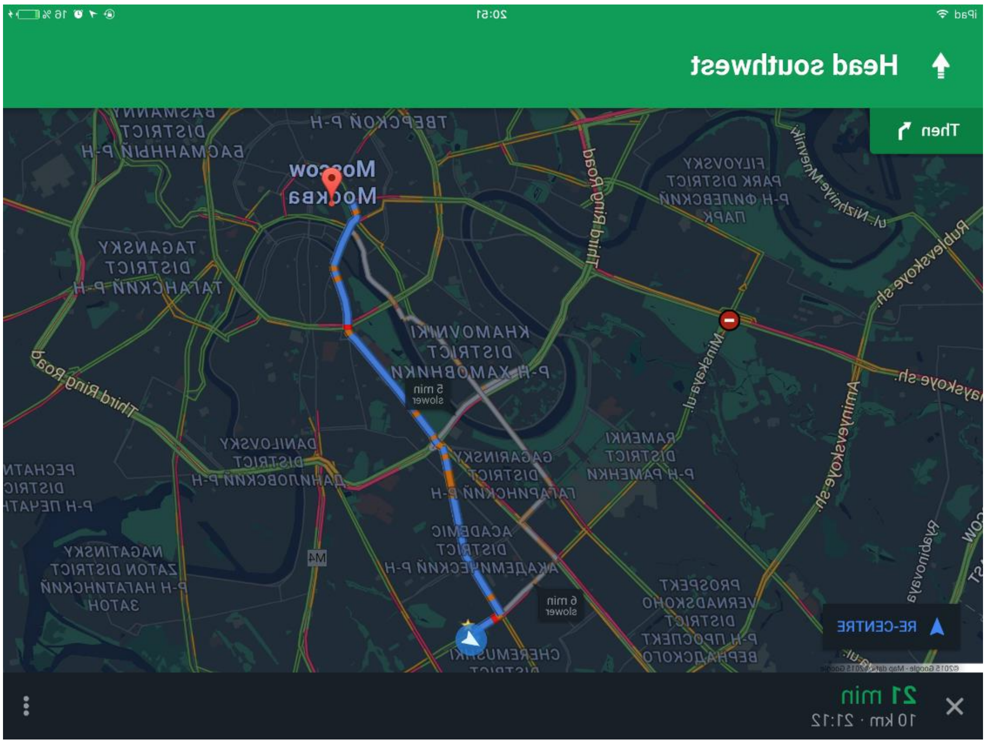

Figure 12.3: Google Maps in navigation mode. ETA and distance is shown, guidance can be performed by voice-over in minimized mode or on-screen orders.

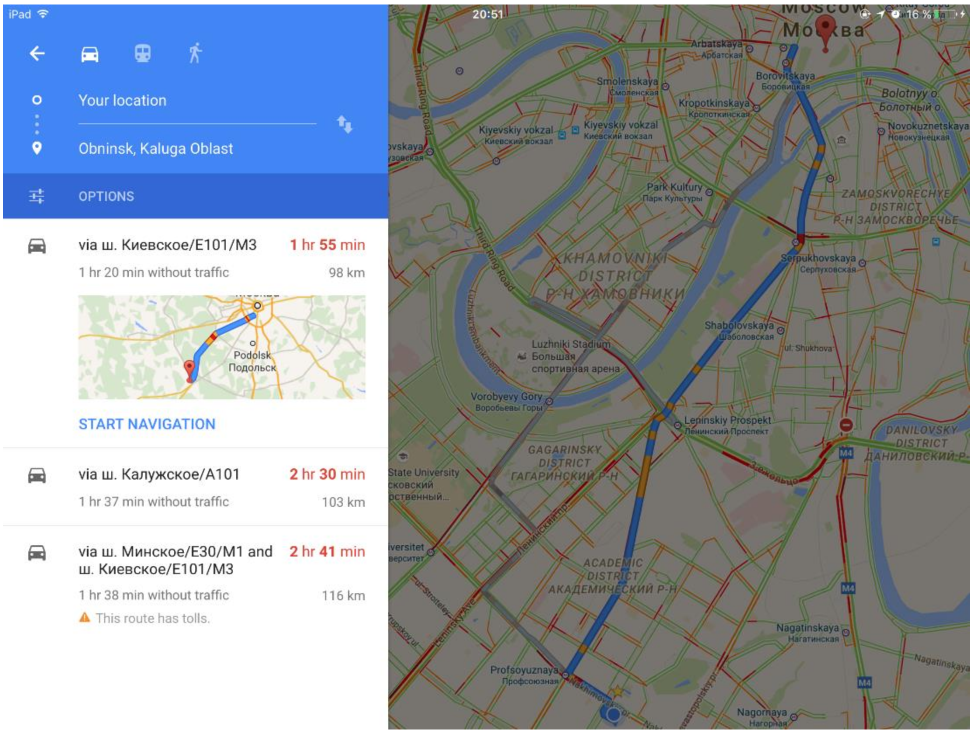

Figure 12.4: Route 2. Google maps app shows alternative routes with ETAs and notifies that third route has tolls.

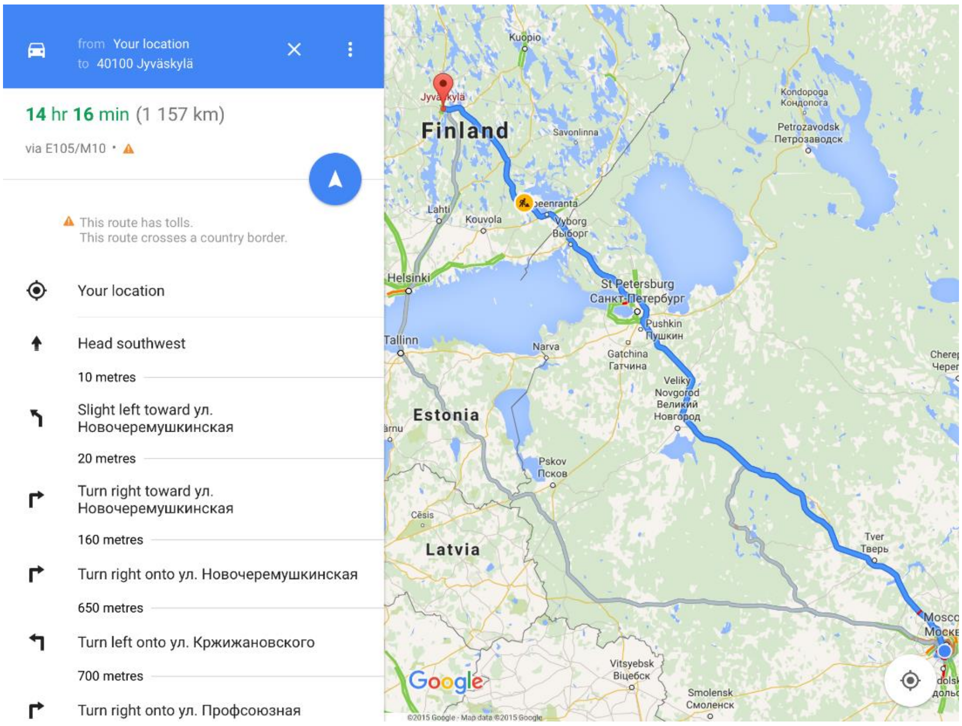

Figure 12.5: Route 3.

Yandex.Maps showcase:

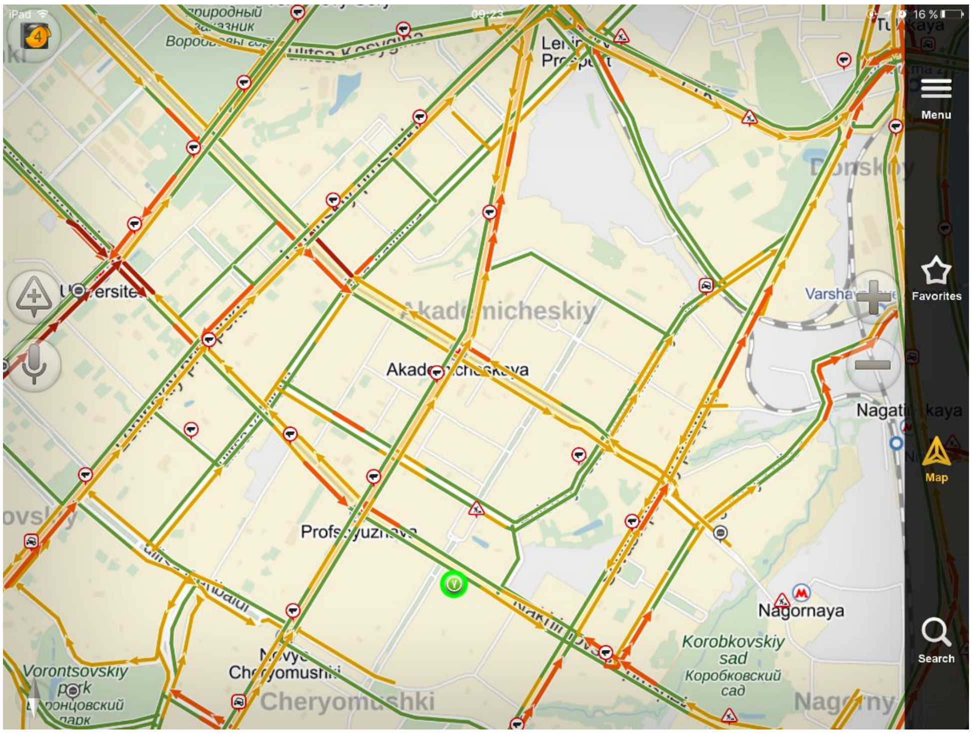

Figure 12.6: Geolocation with Yandex.Navi: Traffic light icon represents general road condition from scale 1-10, parts of traffic jam and direction are highlited, additional objects as speed cameras, road crashes and repairs are shown as pictograms.

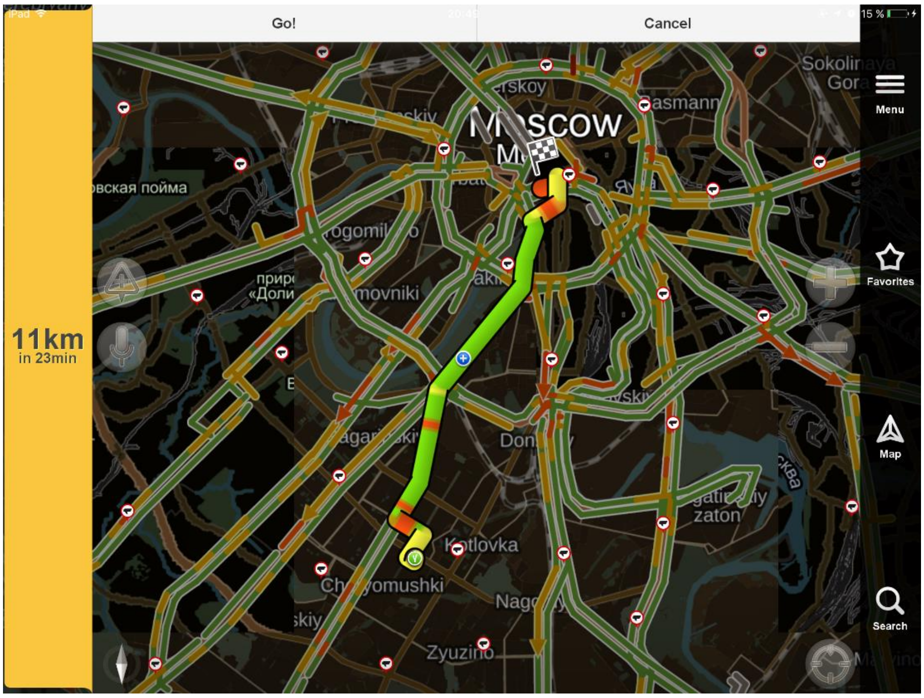

Figure 12.7: Route 1. Route is gradiented according to road condition.

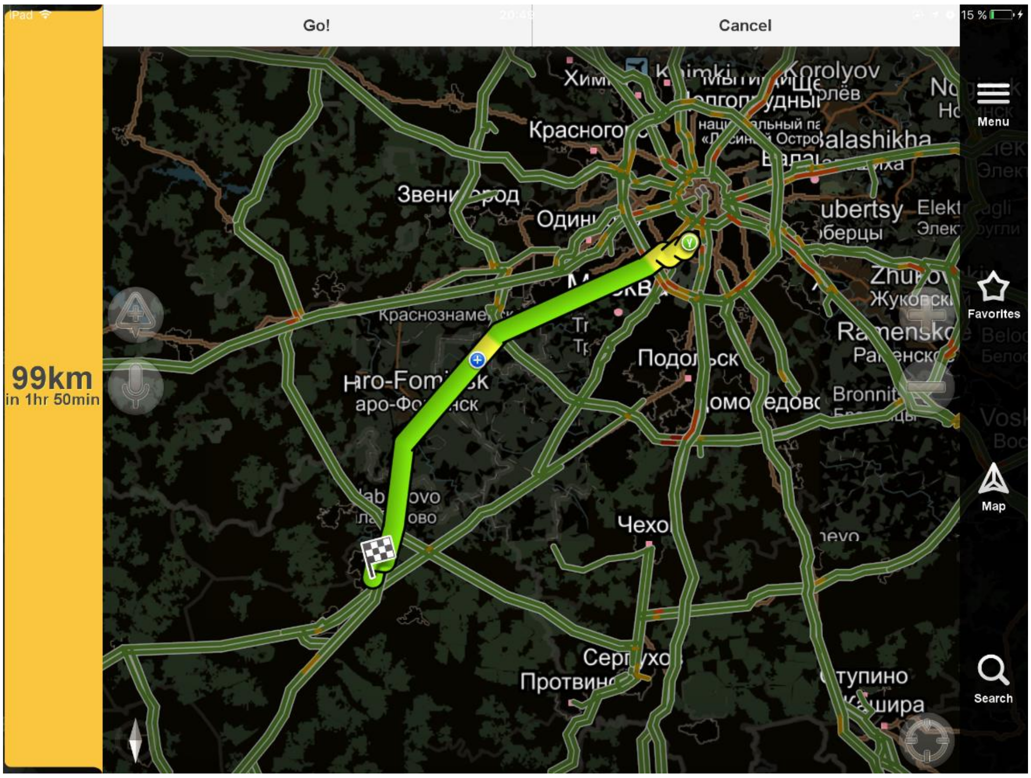

Figure 12.8: Route 2.

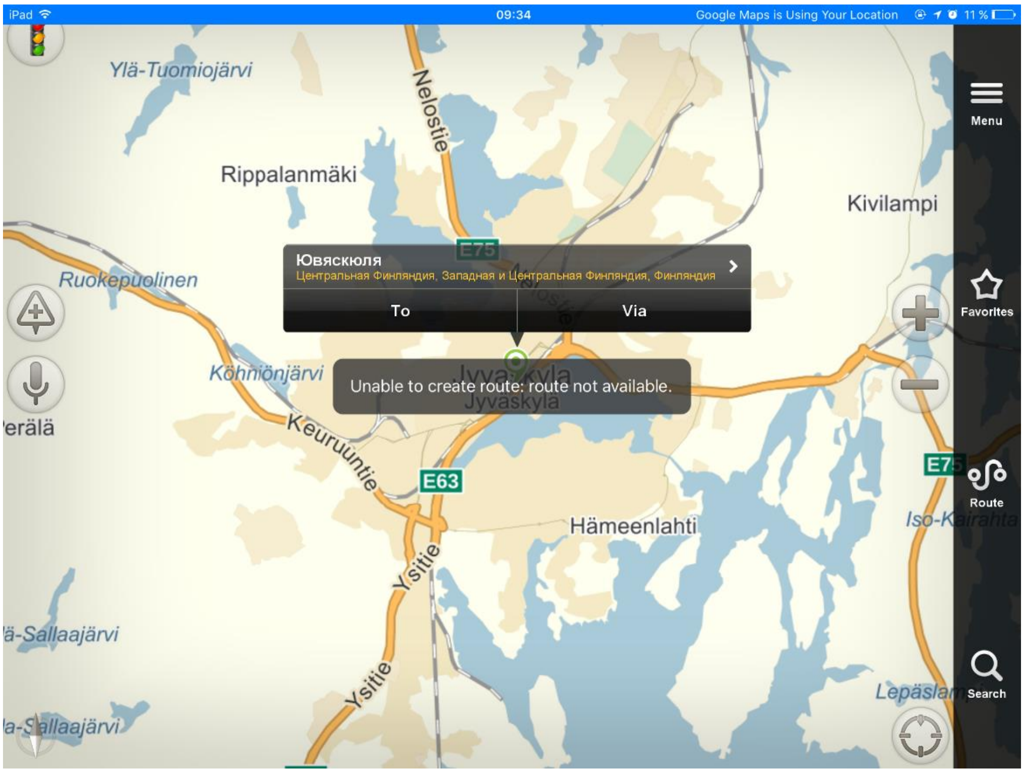

Figure 12.9: Yandex.Navi unable to calculate route 3.

Due to non-specified usage of these maps, special transportation features as, for example, viewing and avoiding roads, where trucks are allowed cannot be viewed and analyzed, thus manual extra data acquisition is required. The second useful feature could be forecasting traffic condition in specified time.

7.4 Open-source GIS

If using web services of casual GIS is insufficient and TC has some resources and interest in GIS field, company can consider choosing Open-source product. The benefits of using open-source is that software offers similar features as commercial GIS, but is free and has huge community built around. The community releases new features, patches glitches in the system, writes plug-ins and releases tutorials on making own projects with use of open GIS, for example QGIS.

The main problem of using open-source GIS for transportation is that open source alternative is still in development and not sufficient and competitive compared to commercial products. In addition, there is no feature to get a bundle designed especially for your needs; everything has to be tweaked manually, from plugin installation to system management, compared to ESRI Support, for example.

Author found some promising ways that open source alternative can be liable in future. There are two lacks in author's opinion that interfere creating of such workaround: lack of real-time traffic info and lack of analysis tools. ArcGIS for transport bundle is a bundle of core ArcGIS components alongside with NAVTEQ powered services and network analyst tool, thus if ArcGIS can be replaced with QGIS for instance, traffic info and network analysis can not. The only way is plugins or open sources. Creating such open system would strongly rely on creating such add-ons and historical and permanent data, such as speed and weight limits, can be retrieved from transportation portals, if those portals exist and provide such data in the first place. As for add-ons, AEquilibriAE (http://www.aequilibrae.com/) transportation modelling toolkits for QGIS and OpenTraffic (http://opentraffic.io/) platform can fulfill the job. Unfortunately, as of September 2015 they are still in development.

The following is an example of how these plug-ins and data from the Internet could be used for generic transportation tasks for in center of Moscow, using QGIS. In QGIS, plugins as CartoDB, OpenLayers Plugin, ad all OSM related should be downloaded, alongside with possible upcoming AEquilibriaE and OpenTraffic realization through OSM (Figure 13) ([Visualize it tutorial], 2015).

OpenLayers plugin provides raster overlay of Google, Bing, OSM or Apple Maps imported into GIS project.

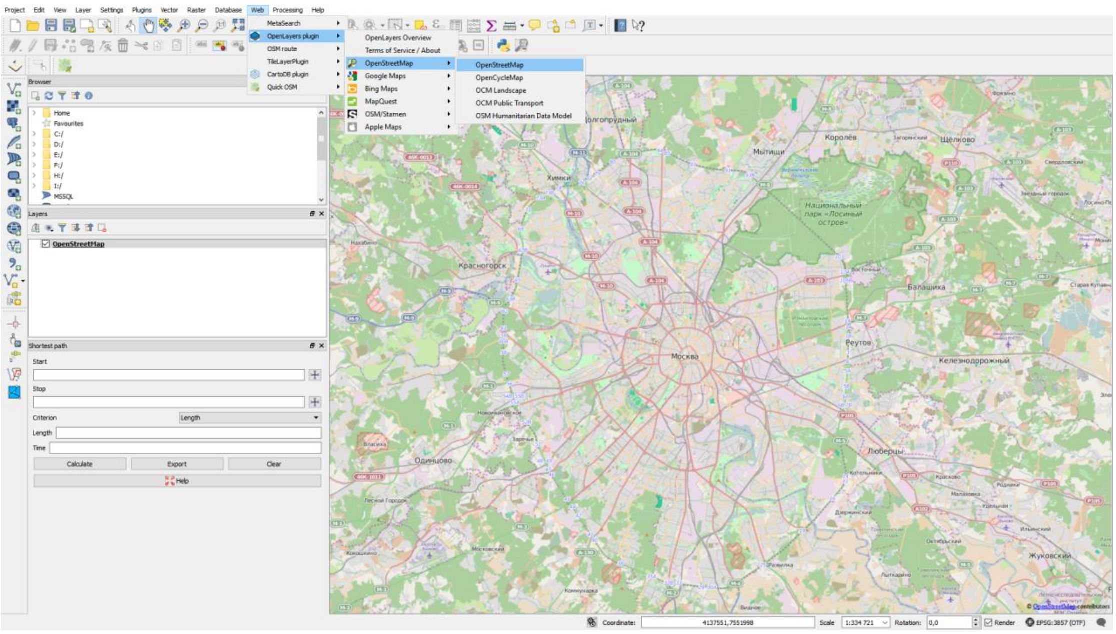

Figure 13: OSM raster layer using OpenLayers plug-in. QGIS.

Then permanent vector data should be required. Using GIS-Lab repository (http://beryllium.gis-lab.info/project/osmshp/) Figure 14, OSM vector object database, object regarding Moscow are downloaded. Line objects with attribute “roads” and polygon objects with attribute “buildings” are needed.

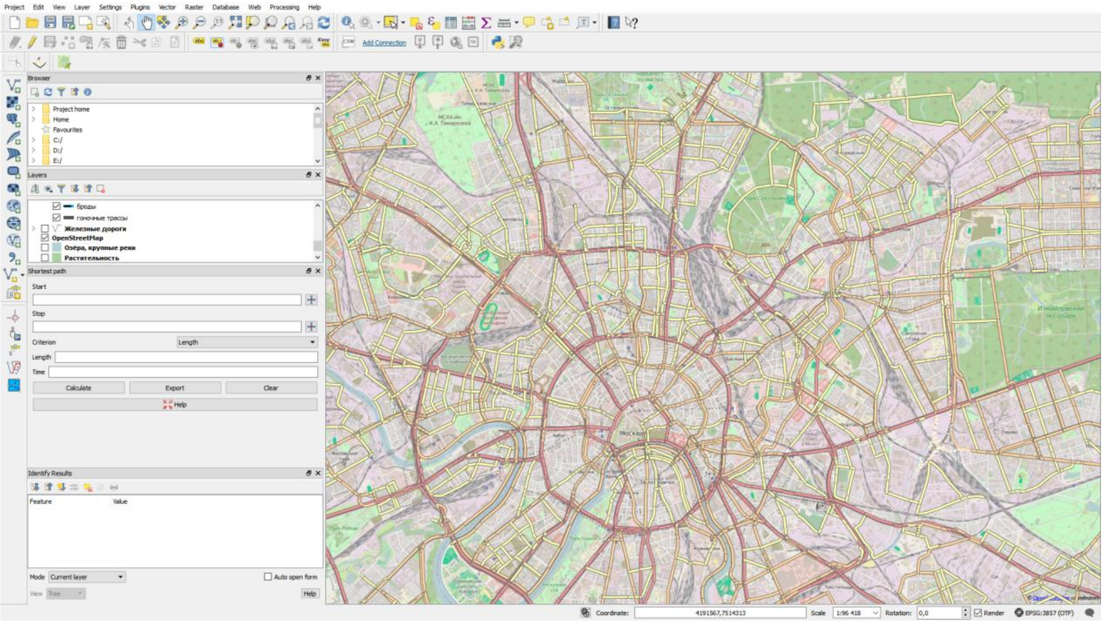

Figure 14: Added group of vector layers representing roads. Each type of road has different color.

Secondly, using Government of Moscow Open Data Portal (http://data.mos.ru) some traffic related info can be downloaded via CSV files, as an example road bumps location. As an example, data regarding speed bumps is downloaded and then the vertexes are customized as speed bump road signs using open SVG image (Figure 15).

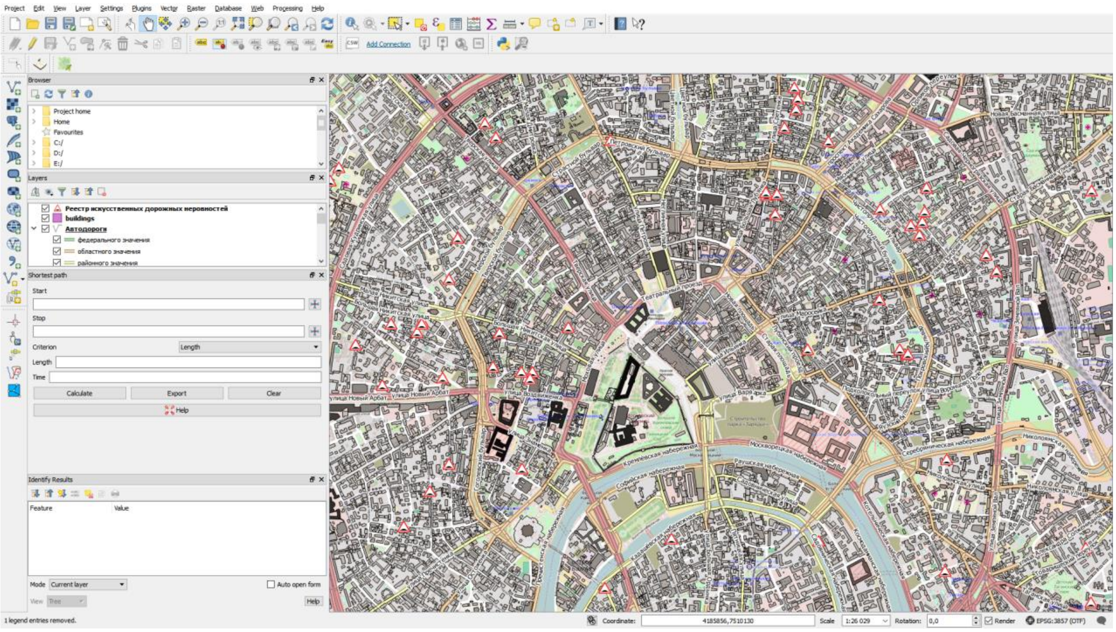

Figure 15: Added layers of buildings with black fill dependent on building size. Road bumps are added with road sign icons.

This is just the generic example of a layout of environment in QGIS in which further transportation tasks could be performed. The data can be added as import from open data portals and repositories or created manually using tools in QGIS. Traffic info could be added via OpenTraffic, additionally tracking info is also supported by OpenTraffic, and needed analysis using network analyst toolkit. Unfortunately, this yet remains to be only a concept.

8. Conclusion

The research of the thesis was to study the abilities of transportation companies to utilize GIS and spatial information on the Internet. Quantitate method allowed to gather info about large sector of GIS market, and, with understanding of GIS structure and its possible application in transportation field, showed the ways of using the products. Firstly, one must consider using GIS as a powerful tool, yet requiring company resources. Based on that, certain type can be chosen, either to use proprietary and transportation oriented platforms, or use casual and open source services for smaller scale. Portals of spatial data can be used as sources of necessary additional info and exported to selected GIS in preferred manner, as data stream or file format.

Usage of open source GIS is more complex, as it requires additional plugin development and info gathering, however the continuation of such projects similar to OpenTraffic will result possible competitiveness with commercial software.

Thus, as GIS industry goes more connected with the public, new services develop and trend of mobile platform continues, the main orientation is towards Internet and cloud storage, portability and mobile platform. As of 2015, main products developers are already positioning and prioritizing Web interfaces and services in their work. Portals of useful and quickly exportable data are essential part of GIS world are becoming the main sources of information. Constantly updated info, for example traffic, requires resources to be always correct, thus remaining closed or used in commercial agreement, although open-source alternative projects start to develop.

Regarding transportation, necessary info can be retrieved from the Internet, and Web or desktop interface allows performing transportation related tasks, with use of network analysis tools. Such bundles as ArcGIS for Transportation Analytics help Server-Client environment, in which user can operate complex transportation, with every calculation performed on distant server and data retrieved from web sources and trucks. This is almost ideal online transportation company management.

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Google Maps – http://maps.google.com

GPS-Trace Orange - http://gps-trace.com/

HERE Maps – http://here.com

INSPIRE - http://inspire-geoportal.ec.europa.eu/

MapBox – http://mapbox.com

MapInfo – http://www.pitneybowes.com/us

Open Data Portal – http://data.mos.ru

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