Saimaa University of Applied Sciences
Civil Engineering
Double Degree Programme

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Open data in civil engineering

Bachelor’s Thesis 2015

Abstract
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Open data in civil engineering, 39 pages, 4 appendixes
Saimaa University of Applied Sciences
Civil Engineering
Double Degree Programme
Thesis 2015
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Open data is information that anyone is free to use and distribute. Only one requirement is valid: to indicate the source of data and distribute it under the same conditions as the original. Open data, in particular the open government data is still a huge untapped resource. This thesis explains what the open data is, compares different systems of topographic survey and discusses the possibility of using open dataset as an additional source of information about any building. Moreover, it is offered the independent creation of a database for subsequent use in student training purposes.

The another goal of this thesis is to compare different kinds of the land survey works and to figure out how the open data and modern technologies in the laser scanning process can work as the one single system, which aims to simplify, speed up and improve the current approach to data collection process. The use of open data sources in this case can be successfully applied to the building or construction processes.

The added value of this diploma was to show that open data is already in use globally and it allows everyone, to one degree or another, to look at the world differently, to see the Earth (for what it is in reality) on a computer monitor, examine it and use this information for their own purposes. And just to prove that the open data really is the powerful tool towards the freedom of information.

Finally, work on this thesis gave me not only the possibility to understand the system of open data and its application, but also to know how I can use the existing open data resources in my profession of civil and construction engineer, where to look for data and how to use it correctly to simplify the design process.

Keywords: Open data, dataset, open source, topographic survey, mapping, cartography, student training, transparency, innovation, Pulsa.

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1 Introduction

The current state of development of the society and the economy in the information society operation and development democracy highlights up the issue of openness and accessibility of information. In this regard, there was such a thing as open data, which is widely used by both politicians and the general people.

Open spatial data is in turn the information that is accessible to everyone, usable and available for free. For example, Finland has plenty of open spatial data sets and services. Open spatial data sets are collected to Avoindata.fi service from Geographic Information Directory. State ICT center VALTORTA is responsible for Avoindata.fi service.

The main purpose of this work is to prove that open data is the powerful tool toward the way to the freedom of information and to demonstrate how it can be used in positive way on an example of building project.

This work is planned to study the history of open data, background, main ideas and goals of the system, as well to identify the existing problems and how open data can help in solving them. It is necessary to examine and compare the statistics from different countries, to find the most popular and demanded portals. This will help to understand in which direction the development of the system goes.

In addition, it is planned to consider the example of the use of open laser scanning data in the construction industry, namely on the example of the Pulsa-project. This specific example could help to describe the whole process: how to download the required data, which software to use for doing the project and how this system can simplify the work.

1 Open data

2.1 The concept and the background

Open data is the concept that reflects the idea that all tax-paid data should be free and accessible to everyone without such limitations as copyright, patent and other control mechanisms. Open data is often focused on non-textual material such as maps, genomes, chemical compounds, mathematical and scientific formulae, medical data and practice, bioscience and biodiversity. Access to data as well as their subsequent use is controlled by public and private organizations. The main requirement for open data placement is the free and chargeless use for everyone, including right to spread, copy, publish and combine with other information.

In principle, open data is not a new phenomenon, it has long existed in various forms. Open source and free licenses were not five, not ten years ago, but much earlier. The first steps towards the public available data were made in the 50s of the last century. Since July 1, 1957 to December 31, 1958, the geophysical observations and studies of a single method were conducted around the globe - this event is conventionally called the International Geophysical Year (IGY). Then the World Data Centre for storing data (resulting from activities carried out in the framework of the International Geophysical Year) was formed by International Council for Science. In 1958, NASA's legislature project was designed to ensure the broad dissemination of information. NASA has a long history of storing huge amounts of scientific data which is laid out in the public domain on the Internet, it is necessary to emphasize that the Agency has accumulated a huge amount of scientific data. But everything went not from the officials and the state, but from people who engaged this much earlier. Gradually, it has acquired such a mass character, that it was no matter if state opens data or not – somehow, it has already been learned to extract. In the United States before the appearance of data.gov, the Sunlight Labs and Knights Foundation were existed, it extracted data from the reports of Congress, converted into PDF-files or excel-files, excel-file is loaded into the database, and then was converted in the .CSV.

At its best, open data creates a culture of cooperative approach to work, which is enabled by the social and technological development of the Internet. In addition it would force us to think about how we are going to live in the middle of the web era in the future, and how to utilize the data we produced together. Three ideas of open data are shown in Figure 1.

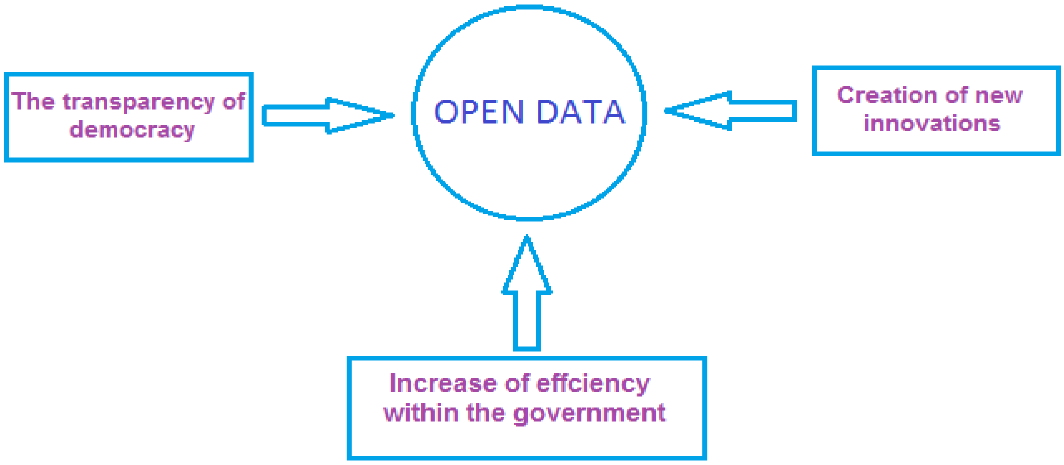

Figure 1. Three ideas of open data

2.2 Open data as a way to the “freedom” of information

The concept of open data means to increase the transparency of authorities, the formation of market for new applications and services, improving investment climate. Over the last decade, the issue about implementation of the open data idea, its development, benefits, use and distribution has been widely discussed on the international forums and conferences in Europe. As a result, there were three different goals set to aim: the transparency of democracy and administration, creation of new innovation and the increase of efficiency within the government [1-4].

Open data has long been used in almost all existing areas of business, medicine, education, politics, free transport, finance, statistics, geography, federal agencies, meteorology and science.

Let's start with transparency. Through projects such as the Finnish "tax tree" or the British "what are my money," you will know how the government spends your taxes. For example, thanks to open data in Canada it became possible to manage to stop fraud, tax breaks for charity a sum of 3.2 billion dollars. Danish “husetsweb.dk” site help to improve the energy efficiency of your home, perform financial planning and to find builders to do the job. It uses inventory information and information about government subsidies, as well as local companies register. Developers of “Google Translate” improve the quality of service, teaching translation algorithms on a huge volume of documents of the European Union, which are available in all European languages.

Opening the data begins with evaluating the organization’s own information resources. This is not a fast process, depending on the size and nature of the organization. However, not everything has to be done immediately. The opening process could proceed step by step, starting from the easier data and gradually moving on to more complex data sets. During the data analysis, organizations may come across data that they had no knowledge about or did not know how to use [5-7]. The organization can decide on their own how to utilize the information they have. To make it easier to use, after the inventory, all data should be converted into machine-readable format. Nowadays, more and more often, data is applied to the Internet and mobile applications. These applications allow users to access certain information without browsing the Internet. Of course, that way offers extra value.

What is important, organizations, which are offering their own data to be distributed, support the emergence of a truly useful service. Therefore, opening data is not a goal, instead it is a means of achieving the aim, and producing services is what is needed to accomplish by opening data. The most common wish is that the process would bring modern, creative and interesting uses of data, services that are usable and satisfy the needs of the public. When creating public data, it is quite essential to make the data as accessible and understandable as possible and to reach the users interested in that particular data. Accessibility can be technically improved by linked data, optimizing the results of search engines and adding the data to the largest data catalogues known to programmers [8,9].

Of course, the development of open data is gaining momentum also in the area of construction engineering.

2.3 Open data in civil and construction engineering

2.3.1 Main idea

It is well-known, that construction is the largest industrial sector in the production and economic activity of the state. It includes not only all the organizational, survey, design, construction, installation and commissioning work associated with the creation, alteration or demolition of the object, but also the interaction with the competent authorities in the issue of production of such works. That is why the existence of open data is so important to resolve production issues and processes. Conventionally, all data associated with the building in general can be divided into three parts (Figure 2). Open data in construction process includes information about such inalienable parts as permit, design, investment, stages of building, etc. Construction technology involves data about building or construction equipment, use of new technologies, implementing research data, information about building materials and resources. Influencing factors include everything which connected with weather patterns, meteorology and such natural factors as: hydrology, lay of land, atmospheric temperature, rainfall and water vapor, wind speed and airflow direction, ice, soil conditions and others [10-13].

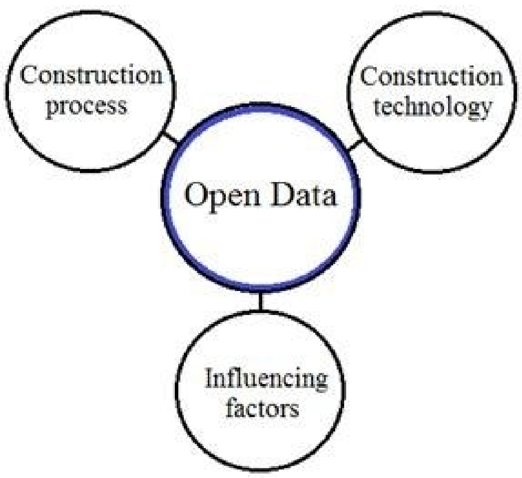

Figure 2. Three parts of open data in civil engineering

The issue of open data in the construction industry causes a lively interest in the whole world. According to the global ranking, prepared by the Open Knowledge Foundation to the summit of "Group of Eight" (G8) in Northern Ireland, which took place June 17, 2013, the first line is occupied by the United States and United Kingdom. Active development in this direction of Finland and Germany.

The most popular and common data associated with the construction are the following types of data:

- Hydrology, ecology
- Geodesy and topography
- Certificates and licenses
- Permits and orders for the construction
- Information about the builder and contractor

2.3.2 What is important to note about confidentiality

Nowadays, there are special building and construction commissions which develop and regulate the building industry. One of the main parts of their activities is the development of such policies of providing of open data which would provide complete and accurate information and at the same time does not violate the laws of confidentiality. At the moment, the free information in that area includes:

- a register of licensees and building certifiers
- a register of owner builder permits issued
- a register of Authorized Nominating Authorities and adjudicators, and the results of adjudication decisions

The information and data that may violate privacy laws on commercial confidentiality, integrity and security:

- insurance policy number
- the owner's name
- the builder's name and license number
- the site address
- the type of work insured

- the value of work and the policy commencement and expiry date

Therefore, the release of such data requires careful preparation, processing and compliance with the law [14].

2.3.3 Open data in Architecture industry

In recent years, many serious projects are related with the movement for open data in the field of architecture: more and more professionals want to share their data and technologies and enable people to transform their own buildings. In 2011, the editor of The Domus and curator Joseph Grima asked the staff of the architectural bureau Carlo Ratti associates to create an opensource-architecture manifesto. Instead, they wrote an article the Open Source Architecture, in Wikipedia, so that everyone could supplement it. In autumn 2012 the paper was turned into an opensource-movement architecture manifesto: at the exhibition in the framework of Istanbul, Design Biennial robot wrote an article on the gallery wall, showing how it changes in the course of revisions made by Internet users.

Another example is the open data in the field of interior design. That kind of open sources allow designers to share their experiences with other professionals (for example, place in the Internet free fonts or patterns). With the power of digital production, many designers make the open access to their projects documentation which allows people, for example, create a home furniture using these finished drawings. In addition, the new method of production - 3D-printing - allows place the 3D-models in the public domain.

3 The situation in different countries

3.1 Open data in Finland

Over the past few years, the pace of development and implementation of open data in Finland increased significantly. This is connected not only with the active use of Internet and multimedia resources, but also with understanding the need of creating new and innovative solutions to the many social and economic problems. For example, The Ministry of Education and Culture has launched the Open

Science and Research Initiative, for the promotion of information availability and open science for years 2014–2017. The Initiative will promote the reliability, openness and societal impact of science and research. The aim is to provide researchers with practical knowledge in how they as individuals can implement open data. The goal is that by 2017, Finland will become a leading country in the openness of science and research.

It is well known, that the good statistical office has always been in Helsinki, and now the city has reached a new level - all the data was published in the open access. Helsinki attracted neighboring towns to the collection and publication of data, as well as set a new competition format for developers. If somebody is interested in some information about Helsinki, the capital of Finland, it is likely, it will not be difficult to find. For more than a century, the city has been collecting data about population, employment, construction, and other things related to the urban environment. Today, thanks to the organization of City of Helsinki Urban Facts, the information is stored online and is available free for everyone. However, there was one problem - Helsinki is the largest city in Finland, but not the only one. Helsinki is the part of so-called metropolitan area, which consists of more than a dozen cities with a total population of almost 1,5 million residents. Therefore, if we have data only about Helsinki, we only have a part of the picture.

To solve this problem, Helsinki merged with three neighboring towns. The initiative is called Helsinki Region Infoshare and aims to become a hub of all these nearby towns. But that is not all. At the same time as data has become regional, they has become truly "open." In The site Helsinki Region Infoshare all the data is published in formats with which developers, researchers and journalists could work conveniently, analyze them and create useful applications on the basis of that information .

For four years of working of that initiative, more than 1000 machine-readable data sets have been published from noise road traffic map and snow plows movement in real-time to a database of corporate taxes.

Helsinki became the leader among open cities. The concept is the fact that many good things can come from the collection, standardization and free publication of urban data, brought in the European Commission's prize for innovation in public administration. In addition to creating the transparency in government, the initiative fueled many developers who create applications based on the data.

For example, the city council uses a database of decisions of city council Ahjo, which recently became open. The city has created a Web-based interface that lets you view all the executive decisions of the city, and one developer who did not even live in Helsinki, has created a mobile app for that - now anyone who is interested in urban solutions, can easily recognize them.

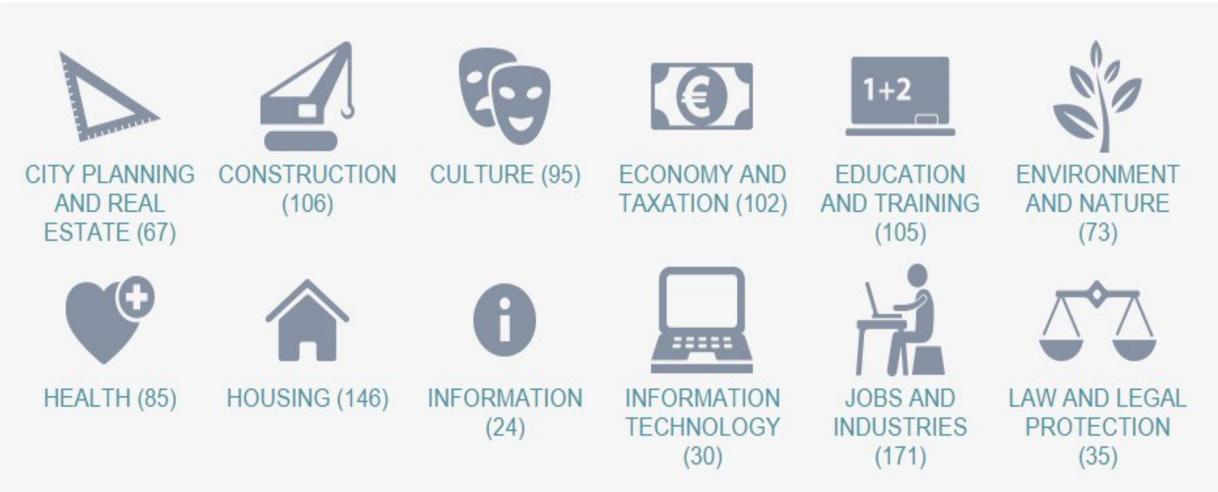

Figure 3. The interface of Helsinki Regional Infoshare portal

Another example is the mobile application BlindSquarea, which helps blind people to navigate the city. The application developer took the city information about public transport and services, combined with data from the application Foursquare, as well as mapping tools, GPS and voice capabilities of new smartphones. Now, the application is working in different countries and in different languages. Portal is indeed a very convenient and intuitive, and most importantly, useful. All helpful information from city planning till culture and education can be found there. Some data can be easily downloaded from the site for example, http://www.hri.fi/en/ (Figure. 3).

Another grate portal that has to be mentioned is the «Paikkatietoikkuna». Web address is http://www.paikkatietoikkuna.fi/web/fi. It is a public and free geoportal that contains geographic information about Finland and the rest of the world.

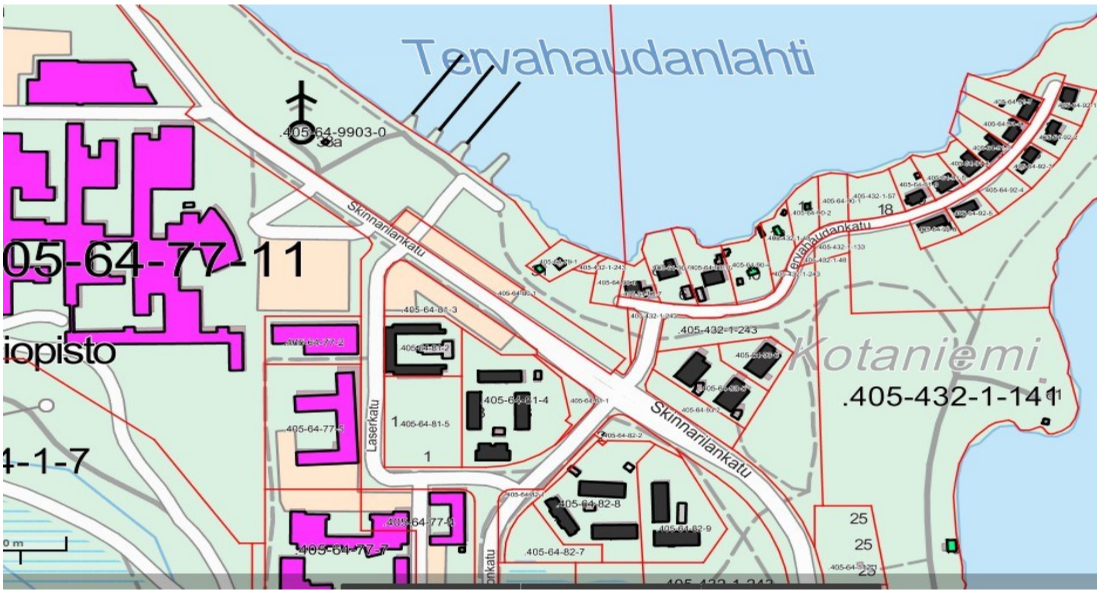

Figure 4. Paikkatietoikkuna map interface

Firstly, the map could be shown in three different styles: topographic, ortophotos and background map. The point is that the interactive map is divided into levels and layers (Figure 4). The Paikkatietoikkuna maps have hundreds items and elements which can be enabled or disabled. Therefore, it is possible to create your own map with information that will be useful and convenient for the particular user. The Paikkatietoikkuna stores data about such different areas as: buildings, administrative units, hydrography, traffic, transport networks, government services, human health and safety, population, surveying, natural risk zones and many others.

The list of the Finnish open data websites is in the Appendix A.

3.2 Other countries

3.2.1 Open data in Europe

European open data portals aims to improve access to and increase the importance of open data, and will be responsible for the entire chain from data collection to the conditions and opportunities for their future use.

Nowadays, the first line in Europe is occupied by the United Kingdom. Finland and Germany have active development in this direction too.

The European Union is interested in creating a truly digital single market will reduce entry barriers to the industry of big data, allowing everyone to easily create versatile solutions for the European Union in the field of information and communication technologies. The European portal for open data was recently launched (https://open-data.europa.eu/en/data/). The goal of the portal is show the benefits of open data which the government agencies are providing and facilitate its continued use. European Data Portal developed by the European Commission with the support of Capgemini, INTRASOFT International, Fraunhofer Fokus, Con Terra, Sogeti, Institute of open data, Time.Lex and the University of Southampton.

Next chapters tell about most popular and good examples of open data portals all around the world. Following countries are the leaders in the field of open data.

3.2.2 Canada

Another example of the graphical representation of the open data in other countries is, for example, an interactive map of the Canadian city of Edmond (Figure.5). On the map there are special boxes by clicking on that it is easy to find out information about road construction in a particular place. For clarity, in the third figure it is possible to see how it works in general. In the pop-up window appear such data as: start year, project location, project limits, construction type, construction supervisor, project status and also phone numbers and some information about construction ward.

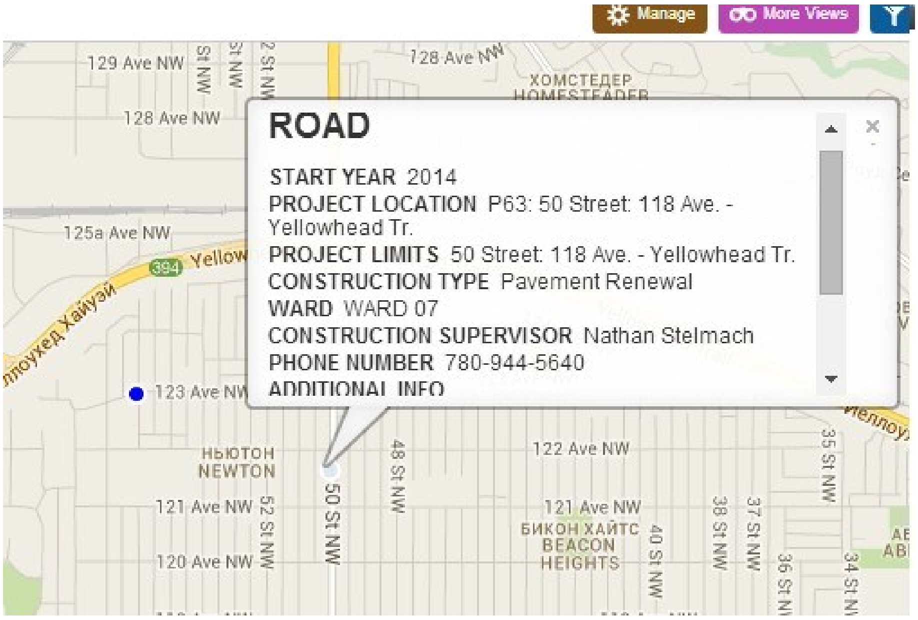

Figure 5. Interactive map of Edmond

3.2.3 United Kingdom

The most frequently used open data portal in UK is the Data.gov.uk (Opennig up Government). Website address is https://data.gov.uk/ . Open Data portal of the United Kingdom was launched in private beta in September, 2009. The official launch of the portal was held in January 2010. Many different kinds of data can be found there. For example, environment, mapping, health etc. Many leading agencies and offices are involved in the process of providing information for placing it in the website. Now there are more than 9 thousands data sets.

Data.gov.uk project success is connected with a direct interest of the highest governing circles in disclosure and re-use of public data.

In June 2012 the Cabinet of Ministers and the Commission on transparency presented Open Data White Paper - it's a great document, which describes the current situation with the development of open data, organizational moments and future plans. The main idea is to create an infrastructure of access, establish the trust relationship with the community to use the data for the benefit of everyone. The first projects that are based on open data in the United Kingdom:

- Planning Alerts - an application that sends alerts if something is constructed or subjected to redevelopment in the area of residence. The UK is now closed, but it works in Australia. In Britain, a new project on the openness of municipalities is launched - OpenlyLocal
- FillThatHole – “plug this hole”, the application and the site to collect complaints about potholes on the UK roads

3.2.4 United States of America

The main USA data portal is Data.gov (http://www.data.gov/). This portal was launched in 2009 at the initiative of the Barak Obama administration for the collection and publication of data of various state departments to further use in projects of physical and legal entities. Then President Obama said that the opening of government data is able to spur the development of new start-ups. Currently Data.gov offers more than 70 thousands datasets provided by 174 government departments and agencies. The interface is shown in a Figure 6.

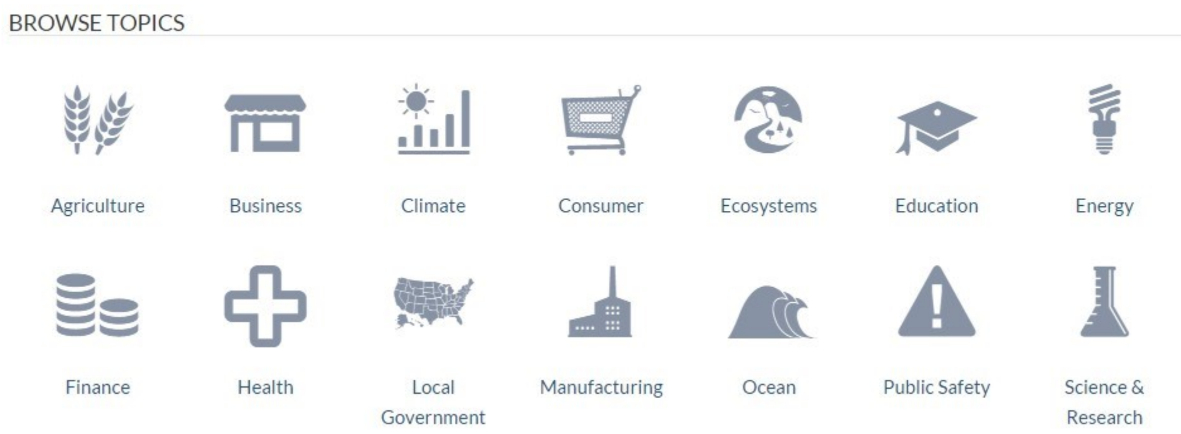

Figure 6. The interface of the Data.gov

USA also has great data portal “Geoplatform” (http://www.geoplatform.gov/) which provides a large amount of useful information about climate, geology and at the same time has an interactive maps. Also, the National Geospatial-Intelligence Agency published the information (including maps) about infrastructure and geographical features of the area, including bridges, roads, railway tunnels, canals and rivers.

The list of open data portals in different countries is in the Appendix B.

4 Technology of Laser Scanning Data

4.1 What is the LSD?

One of the most interesting open portals in Finland is National Land Survey of Finland (NLF). It is necessary to pay attention to one great innovation. It is called *Laser Scanning Data*. Laser scanning is a technology based on laser pulses transmitted by an active sensor, or a laser scanner, and on accurate location information.

The emergence of GNSS- technologies that allow for a few minutes to get the exact coordinates of the location of points (mode RTK), as well as reflectorless total stations which have an ability to operate without the use of special reflectors, was an important technological breakthrough in the field of geodetic measurements. However, the use of satellite geodetic receivers and reflectorless total station is not allowed to describe the subject and build a complete digital model – the coordinate data was accurate, but too sparse. The construction of three-dimensional digital models, for example, of building facades, requires considerable time resources and also became time-consuming and costly. With the advent of new technology - *laser scanning* - the task of building the 3D digital models was simplified greatly. These airborne laser scanning, and RS are the array (a "cloud of points") containing the spatial coordinates of points (X, Y, Z) and the laser reflection intensity values. The array includes the identifiers of points (GPS-time), and coordinates of the first and last reflection (the latter belongs to the earth's surface reflection). The NLS employs the point cloud to automatically classify the ground surface, meaning that the points representing the ground are separated from the point cloud. The data is further interpreted using aerial photographs, whereby the classification of ground points is visually checked and the laser pulse hits showing water areas and bridges are separated into specific point categories.

Firstly, this system helps to solve the following tasks:

- the creation of topographic design base and survey works
- geometric engineering structures measurement
- updated maps
- construction of digital elevation models (raster model, TIN, GRID),
- construction of mathematical models using the intensity of the reflected laser pulse
- interpretation of terrain objects,
- creation of orthophotos based on classified points on the earth surface.

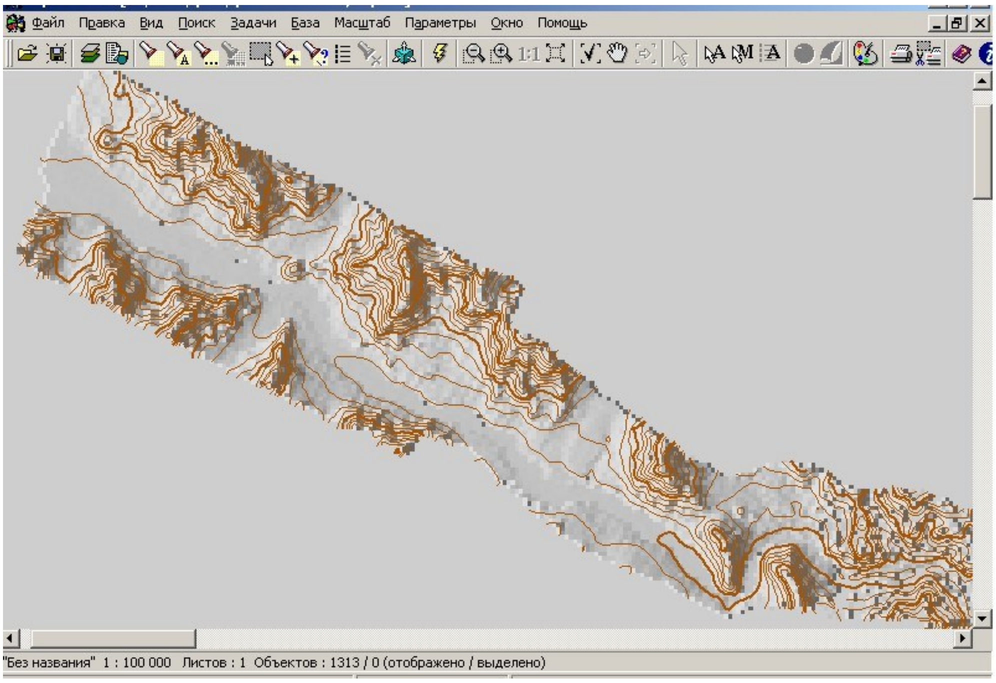

Figure 7. 3D model with terrain contours copied from [15]

Flat and three-dimensional mapping of the point model gives a clear idea of the nature of the relief, buildings and infrastructure. Digital irregular point model (MTD-model) allows to estimate the range of heights (Statistics surface) of a given site area, to get relief shading in the form of a raster (RSW). Using the MTD-model can generate 3D-metric defined objects, as well as perform automatic creation of terrain contours (Figure 7).

Digital irregular point model is used in constructing and displaying three-dimensional model of the site area. Three-dimensional model allows us to perform a visual evaluation of the chosen site topography and objects placed on it (Figure 8).

An aerial photograph is an uninterpreted photo of the terrain. Map production starts with aerial photography, on the basis of which the terrain and the changes therein are interpreted. Aerial photos of various kinds are suitable for different interpretations. Black-and-white aerial photos are most suitable for showing changes in a built environment, whereas colour and infrared photos allow us to interpret the quality of the tree stand and the terrain. Orthophotographs are produced according to a sheet line system and their terrain resolution, or pixel size, is generally 50 cm.

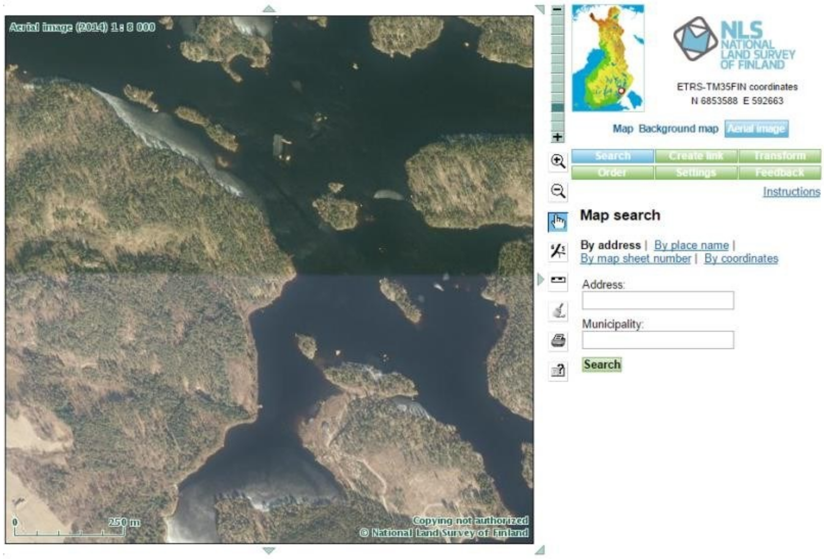

Figure. 8. The visualized 3D model of terrain screenshot [16]

Since 2009 a digital aerial camera is used in aerial photography. During one flight, the camera simultaneously takes photographs in black-and-white, colour and infrared. These flights are carried out at an altitude of 5 000 m and the topographic resolution of the photographs is 50 cm.

Digital aerial photographs have been used to make orthophotos covering nearly all parts of Finland. The orthophoto update index (in Finnish) shows the annual production of orthophotographs.

4.2 How the Laser Scanning works

4.2.1 Terrestrial laser scanning

In recent years, we can observe the increasing use of the technology of terrestrial laser scanning. Many modern problems of design and construction, maintenance of buildings and structures require the presentation of spatial data, which could accurately and completely describe the relief situation, the relative position of parts of buildings and structures. Using traditional surveying techniques and tools can solve most problems, but there are limitations associated with the severe conditions of visibility, rate of collection of obtained data.

Terrestrial laser scanning is the most rapid and high performance means of obtaining of most accurate and complete information about spatial objects: a monument of architecture, industrial buildings and industrial sites, the mounted process equipment. The essence of the scanning technology is to determine the spatial coordinates of the object points. The process is realized by measuring the distances to all the points determined by the phase or pulse reflectorless EDM.

Measurements are made with a very high rate - thousands, hundreds of thousands and sometimes millions of measurements per second. On the way to the object, the pulses of the rangefinder scanner laser pass through the system consisting of a movable mirror, which is responsible for the vertical displacement of the beam. The horizontal displacement of the laser beam is produced by rotating the top of the scanner relative to the lower rigidly attached to a tripod. The mirror and the upper part of the scanner are controlled by precision servomotors. In the end, they provide the accuracy of direction of the laser beam on the subject. Knowing the rotation angle of the mirror and the top of the scanner at the time of observation and the measured distance, the processor calculates the coordinates of each point.

The total control of the device is carried out from a laptop computer with a set of programs or from the control panel, built in scanner. These coordinates of points from the scanner are transmitted to a computer and stored in the database of the computer or the scanner, creating a so-called cloud of points.

The scanning is often carried out in several sessions because of the shape of the object, when all the surface is simply not visible from one vantage point. The simplest example is the four walls of the building. Obtained from each point of standing scans are coinciding with each other in a common space in a special software module.

Terrestrial laser scanning is significantly different from other methods of collecting spatial information:

- technology fully implemented the principle of remote sensing, which allows to collect information about the object, at a distance from it, and the subject is not necessary to install any additional devices and appliances (brands, reflectors, etc.);
- density and accuracy of the determined object points on the surface can be calculated in fractions of a millimeter;
- laser scanning has unmatched speed - up to several hundreds of thousands measurements per second

4.2.2 Airborne laser scanning

Airborne laser scanning is often the most rapid, reliable, and sometimes the only one method for collecting data on the real surface, including remote areas and areas covered with forests.
Airborne laser scanning is carried out from a height of 500-1500 m. The height of the recording depends on its accuracy. High precision of laser scanning in the air is 15 cm height, maximum up to 5 cm.

The result of airborne laser scanning is a 3D array of laser reflection points, classified on the basis of "land / no land", density up to several tens of dots per 1 square meter and the accuracy of determining the coordinates of at least 5 cm. In fact, it is a true digital model of the relief of high density and precision, the basis for orthophotos, digital topographical plans scale 1: 500 and smaller, three-dimensional terrain models and objects.

4.2.3 Unmanned Aerial Vehicle

Basically, UAV (Unmanned Aerial Vehicle) is the aircraft without a crew on board. UAV is created for air shooting and real-time monitoring of ground objects. UAVs can be remote controlled or can fly autonomously based on pre-programmed flight plans or more complex dynamic automation systems. The simplified scheme of getting data is in Figure 9.

There are unmanned aerial vehicles:

- Unmanned free;
- Unmanned automatic;
- Unmanned remotely piloted vehicles (RPV).

UAVs can be divided by the interrelated parameters such as mass, time, distance and height of flight. There are the following classes of devices:

- Micro - weighing up to 10 kg, the flight time of about 1 hour and altitude of 1 kilometer;
- Mini - weighing up to 50 kg, the time of flight of a few hours up to 3-5 km;
- Medium - up to 1000 kg, the time of 10-12 hours , height of 9-10 km;
- Heavy - with altitude up to 20 kilometers and 24 hours of flight time or more
- Impact UAV

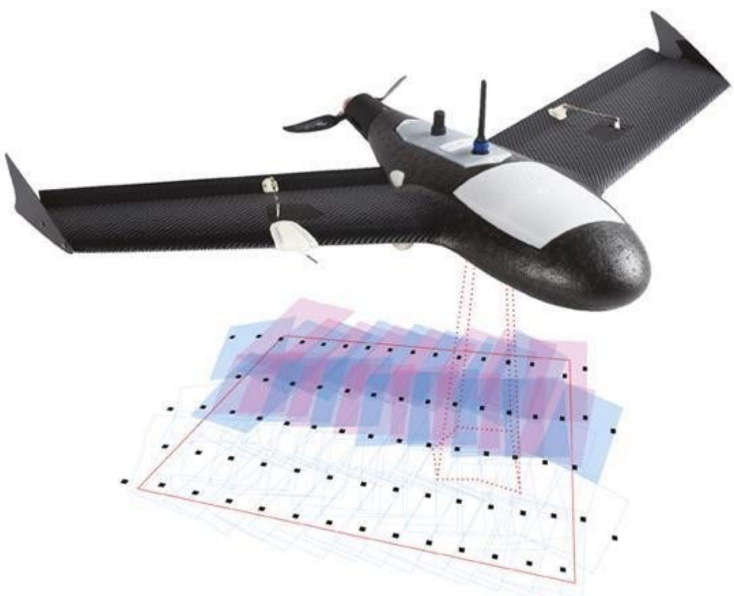

Figure 9. The simplified scheme of getting data. Reprinted from www.ru.all.biz [17]

The UAV system is becoming useful and popular to solve problems in many fields and branches of science, for example military and civil industry, aviation and large scale mapping.

The use of drones in cartography and aerial photography to create topographic maps significantly reduced the acquisition cost of manned aircraft to create maps and terrain models. UAV aerial operates

flights on a given area automatically and semi-automatically, gets high-quality geo-referenced images, which allows to use them for the creation of topographic maps of high accuracy. Photo and video data after processing in the specialized software provides the foundation for figurative and iconic models of space in the form of flat, textured and three-dimensional maps and globes. UAVs allow experts to create as soon as possible UAV orthophoto, DEM terrain and individual objects. Mapping requires the most accurate data and high-quality images that drones get due to improved payload on an electromagnetic suspension with secured stable camera position, regardless of wind gusts and other influencing factors.

Advantages and uniqueness of this technology for surveying production are obvious: Aerial UAV is used to create and update digital maps and plans of the territories for which there is no practical possibility and economic feasibility of a detailed study of the terrain and numerical description of satellite images or materials of traditional aerial photography, for example in the areas of:

- Covered with shadows and clouds in space or traditional aerial photographs;
- Changing terrain predominantly linearly extended objects changed;
- Changes in areas with point construction in the settlements;
- Changes in areas that require operational analysis and decision-making (seasonal changes in areas such as river floods flooded areas).

4.2.4 Construction of UAV

Determining the origin of the Earth and the speed of modern UAVs, the satellite navigation receivers (GPS and GLONASS) are usually used. The angles of orientation and overload are determined using gyroscopes and accelerometers.

As a control equipment, typical specialized calculators are based on digital signal processors or computers PC / 104, MicroPC running real-time operating systems (QNX, VME, VxWorks, XOberon). Software is usually written in high level languages such as C, C ++, Modula-2, Oberon SA or Ada95.
To transfer to the control of video data received from the onboard sensors, there is a part of the UAV which has a transmitter that provides a radio receiving equipment. Depending on the format of the image and the degree of compression capacity digital radio links data-unit may be hundreds of Mbit/s. In addition, the composition of the board should include UAV radio receiver control commands and a transmitter service data. Modern UAV is shown in Figure 10.

Figure 10. Example of Modern UAV printed from dronedesign.blogspot.com [18]

Aerial UAV has the following advantages over the traditional and space shooting:

- low-altitude (allows shooting at altitudes from 100 to 1000 m);
- high resolution terrain (see the fine details of relief and even a centimeter-size objects);
- the ability to shoot at an angle to the horizon (perspective mode), which is impossible for space photography and quite difficult with conventional aerial photography;
- the ability to create panoramic images (satellite and traditional Aerial do not have this capability);

- possible detailed survey of small objects; Aerial UAV technology allows aerial photography of small objects and small areas where other species make it unprofitable to aerial photography, and in some cases it is technically impossible;
- a choice of weather conditions and time of day for aerial photography;
- efficiency (the entire cycle from the exit to the shooting until the final results take several hours in one day);
- low cost (much cheaper than traditional methods of aerial photography);
- environmental safety (for using an electric motor that provides virtually silent and ecological purity of flights).

4.2.5 Technological scheme of creation of digital topographical plans

There is a detailed scheme that describes steps and stages of creation of digital topographical plans (Figure 11). Basically, the whole process can be divided into 4 steps: preparatory work, air work, creation of orthophoto and digital plans and report.

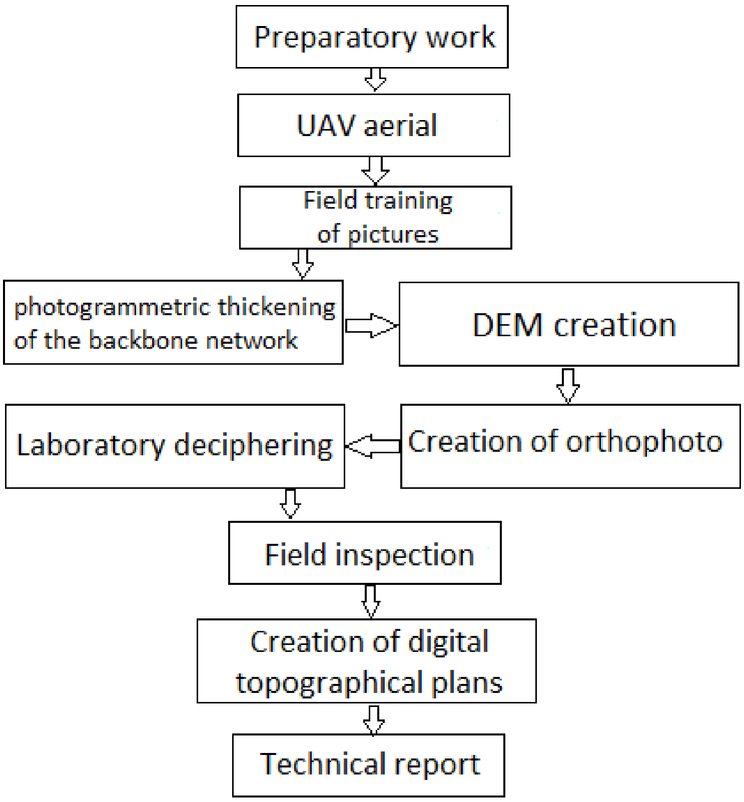

Figure 11. Detailed scheme of creation of digital topographical plans

4.2.6 The GIS techniques and technology

Geographic Information Systems (GIS) has emerged as a powerful tool for solving complex problems due to its capabilities to integrate, visualize, and analyze geographic data across domains and disciplines. The concept of an information system is also used in a narrower sense - as a tool (software) that allows users to search, analyze, and edit as a digital terrain map and additional information about the objects. In the domain of information modeling, the municipal (urban GIS), mining, geological and environmental are highlighted. Among them, the land information systems received a special name.

Typical questions that can respond to geographic information system:

- "What is in the ...?" (Defining place).
- "Where is it?" (Spatial analysis).
- "What has changed since ...?" (To determine the temporal changes in a certain area).
- "What spatial patterns exist?"
- "What if ...?" (Simulation of what would happen if you add a new road).

4.2.7 Mobile laser scanning

Nowadays, mobile laser scanning (MLS) is one of the most advanced survey methods. MLS is a lot like the terrestrial laser scanning (NLS), which is quite widely used, but unlike the NLS, mobile scanning is performed while the scanner is installed on the vehicle. At the same time, the shooting speed matches the speed of the vehicle, and this is tens of kilometers per hour. A mobile scanning system can be mounted on cars, ships, wagons and other vehicles. The scanning is performed along the trajectory, at a distance of several hundred meters in all directions.

MLS should be done with geodetic surveys and monitoring the state of roads and railways, assessment of technical conditions of tunnels, three-dimensional modeling of urban infrastructure and other facilities along the transport routes.Only aerial photography and airborne laser scanning exceeds MLS data collection in speed, but far inferior in accuracy and detail (dot density).

The principle of operation of the mobile laser scanning is simple enough. The system consists of two main units: the measuring unit and the navigation unit. The measuring unit scans objects and the positioning system carries out the "snapping" of motion path of the scanner. High-speed laser rangefinder or a deflection mirror is mounted on a rotating basis (usually called "laser head").

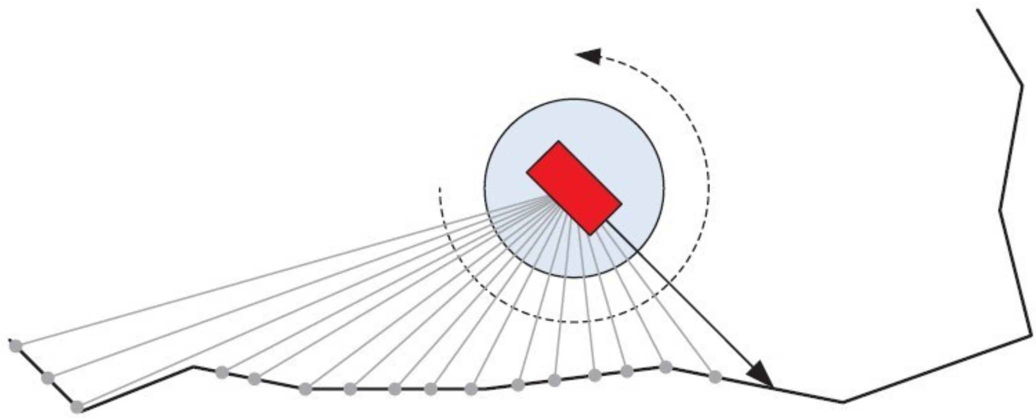

Figure 12. The principle of operation of the mobile laser scanning copied [19]

During one turn of the head, the rangefinder makes thousands of measurements that make the "cut" of the surrounding space in the same plane (Figure 12). To calculate the coordinates of individual points of laser scanners it is necessary to know the exact position and orientation of the head in space at the time of each measurement. It uses inertial navigation system (INS), combined with GPS.

MLS. Types of finished products:

- Topographic mapping of linear features (roads, railways, bridges, tunnels);
- Creation of 3D models of objects;
- Creation of longitudinal and transverse profiles of the road;
- Longitudinal and transverse slopes of carriageway;
- The digital terrain model and digital model of pavement;
- Creation of road passports;

- Evaluation of rutting and defining of longitudinal roughness of coverage using the international roughness index (IRI);
- Zones visibility evaluation;
- Making of statements of traffic signs, guardrails, information and advertising boards, etc. with the application of photographic materials

The benefits of mobile technology laser scanning:

- significant cost savings compared to traditional surveying methods.
- high precision and detail of the data - the relative accuracy - 8 mm, the absolute - the first centimeters, detail - about 3000 points on 1 m at 60 km/h;
- Increased safety when geodesic work on dangerous objects (high-voltage power plants, railways, chemical production).
- very high performance data collection - up to 300 linear kilometers per day;
- high mobility (the system can be installed on any vehicle)

Topographic survey is something that involves all aspects and elements that are continuously developing at that moment: engineering, technology, science, and even creativity. The development of one of these areas is instantly reflected in the sphere of creation of topographic maps and plans, increasing accuracy, reliability, speed and reducing the cost.

5 Practical examples

5.1 Pulsa – project

5.1.1 General information

Let us review the process of collecting data using the example of Pulsa – project. The purpose of telling about Pulsa-project is to show how the modern software in combination with open data sources can be used to visualize the particular area. This chapter tells about the whole process of making the complete project from beginning with measurements till the end. The main idea is to describe the process of formation of single 3D-model of terrain with all objects on it.

The Saimaa University of Applied Sciences got the task from the owner of the old train station Pulsa to collect data, make measurements and create the 3D models of every separate building and the whole area altogether. Basically, Pulsa is the old railway station near Lappeenranta which was built around 1867 – 1870 (Figure 13). Subsequently, the station has been changed several times. Last time the main building has been overhauled was in 1997. Nowadays, the Pulsa area is privately owned by Lasse and Petra Karjalainen, who started renovation.

Figure 13. Pulsa main station (photo: Anu Kainulainen)

Today, the Pulsa railway station is working as the guest house, cafe and summer theater. The whole area includes several small houses, walking place, café and parking places.

5.1.2 Measurements

A group of summer school students of Saimaa University of Applied Sciences started the project of creating a database of Pulsa area in summer 2015. The main idea was to collect as much information as possible and create finally the single database including drawings, schemes, plans and 3D models.

Everything was started with simple measurements. Students decided to use only rulers, tape-lines and pencils because at the moment there was a huge amount of different furniture and other things which were creating problems to use digital equipment. The main railway station building is full of old style architecture elements on facades. Every detail has been measured by hand. There are many separate buildings, and every house was measured this way. For example, houses Junanlahettajantalo (Figure. 14) and Peratalo (Figure 15).

Figure. 14. Junanlahettajantalo (photo: Anu Kainulainen) [20]

Figure. 15. Peratalo (photo: Anu Kainulainen) [20]

First of all, the 3D models of the main building and other houses had to be created. The example of 3D model of the main building is attached in Appendix A. The next task was to make layouts of every floor of Pulsa main station building and another modeled buildings. Students made measurements inside the house and drafted detailed plans and cross-sections.

Examples are in Appendix C.

Also, much work has been done to find old drawings, information about the history and previous owners. As a result, all presented in a big folder, which has access to the electronic version.

5.1.3 The process of making the 3D model of the whole area

One of the most important parts of the Pulsa-project is the visualization of the entire area in a one 3D model. It should include the topography, natural features, all the houses and roads. The main option is that the topography plan was taken from open data source Maanmittauslaitos (NLS) where it is possible to download the 3D model of relief and then use it in different 3D modeling softwares [22].

The software was used in creating the 3D terrain model:

- Terra-solid (This is program which allows to upload and edit image data from airborne and mobile laser scanning systems)
- Bentley MicroStation (This program allows to create and work with renderings and vizualizations)
- 3D – Win (Conversion program)

First, the point database from NLS was uploaded to Terra-Solid program. In this case it is easier to edit the surface, points, delete unusable sectors and in general modify the file into convenient form [23]. The interface of Terra-solid is in the Figure 16.

Terra-solid also was used to make the triangulation of surface using general points. Then the finished model was uploaded to 3D-win program to convert it into the convenient format.

The final step was to make the 3D surface model based on the map gotten from 3D-win. Also, 3D models of houses were placed in right positions as well as they situated in reality [24].

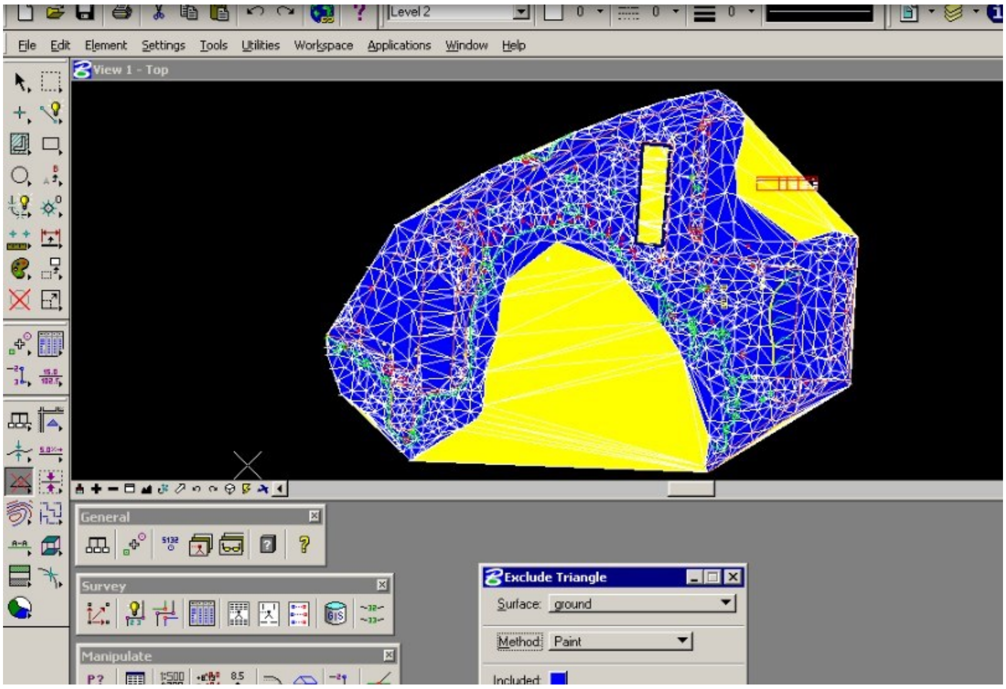

Figure 16. The interface of Terra-solid screenshot [21]

In this way, the Pulsa database includes:

- History data
- Separate 3D models
- 3D model of the whole area
- Plans and drawings

This database can be used by its owners in so many different ways.

Collecting of data is quite long but very interesting process. The accuracy and clarity make the results even more useful in the application, allowing to create a complete picture of the object of research.

6 Conclusion

The advent of open data has allowed to simplify the solution of some problems related to varying human activities. Regardless of industry, the concept of open data has become one of the most rapidly developing and widely discussed in Europe and in the whole world over the past few years. In this issue, there are still so many niches for research discussions, and most importantly, for the development.

This thesis tried to cover as much information as possible about the development of open data in Europe and in the world, about the importance of the implementation of this global project, also about plans and prospects. Some options of open data usage were considered in the thesis. The example of the laser scanning technology confirmed that open data of this kind allows ordinary people to see the earth on which they live on the monitor in all details.

This work was carried out the main task to tell about the way of collection, storage and use of open data in a practical example. In addition, it was demonstrated how open data can be useful in the construction industry: how to use ready data and software to create the project much faster (for example, to import point cloud directly into the information modeling software). It means, that in the future, the system of open data (which is continuously improving) could help me do my work better, faster and more precisely. It can give me the great possibility to share my experience with other engineers, thereby learning and developing much faster and easier than it was before.

The idea of open data, together with the modern technologies opens a big gate on the way to the Freedom of Information, and this is something what 100 years ago no one could dream of, and it is available to everyone now.

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[22] Anu Kainulainen interview, Saimaa University of Applies Sciences

[23] Mikko Lonka interview, Saimaa University of Applies Sciences

[24] Riku Bjorkholm statement, Saimaa University of Applies Sciences

Appendix A

The list of Finnish open data websites

https://www.avoindata.fi/

http://www.hri.fi/

https://en.ilmatieteenlaitos.fi/open-data

http://tilastokeskus.fi/org/avoindata/index_en.html

http://www.maanmittauslaitos.fi/en/opendata (National Land Survey)

http://www.ldf.fi/

http://databusiness.fi/2015/11/25/finnish-open-data-business/

Appendix B

The list of open data portals in other countries

USA:

https://www.data.gov/

http://www.a2gov.org/services/data/Pages/default.aspx

http://www.geoplatform.gov/

United Kingdom:

https://data.gov.uk

http://theodi.org/roadmap-uk-2015

https://www.gov.uk/government/publications/open-data-charter

Canada:

http://open.canada.ca/en

https://data.edmonton.ca/

http://datalibre.ca/links-resources/

http://www.opengovpartnership.org/

Germany:

https://www.govdata.de/

http://opendata.esri-de.opendata.arcgis.com/

https://offenedaten.de/

Australia:

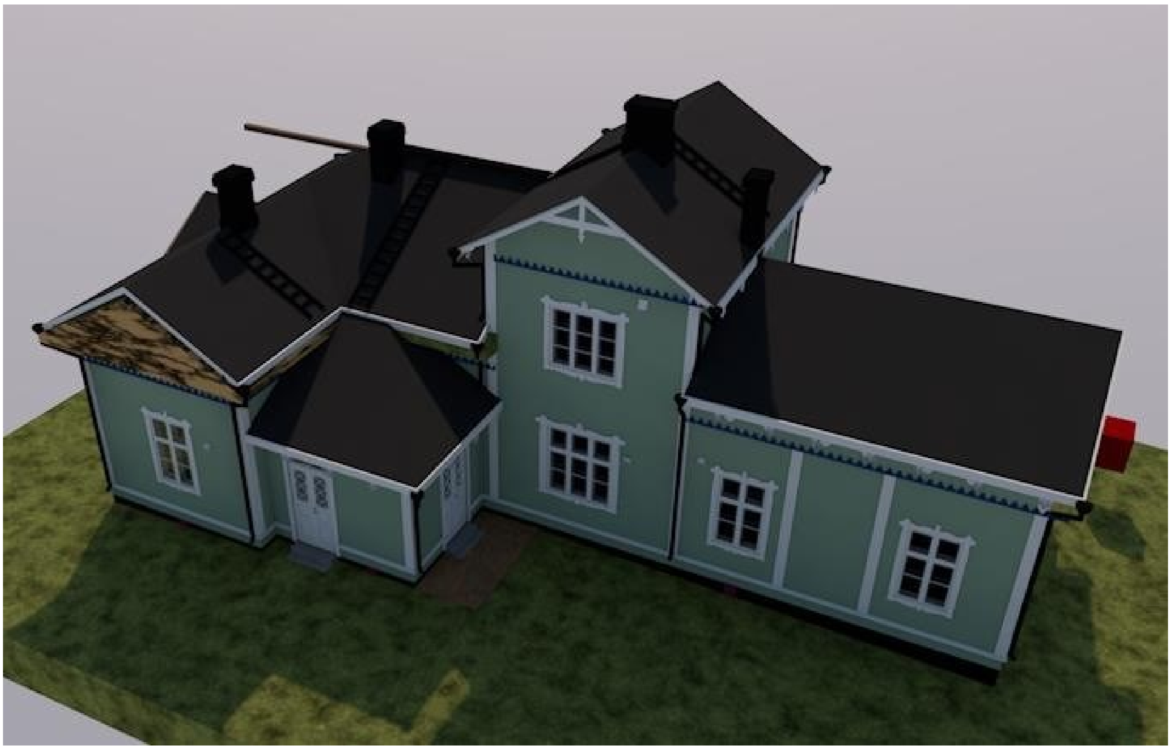
http://data.gov.au/

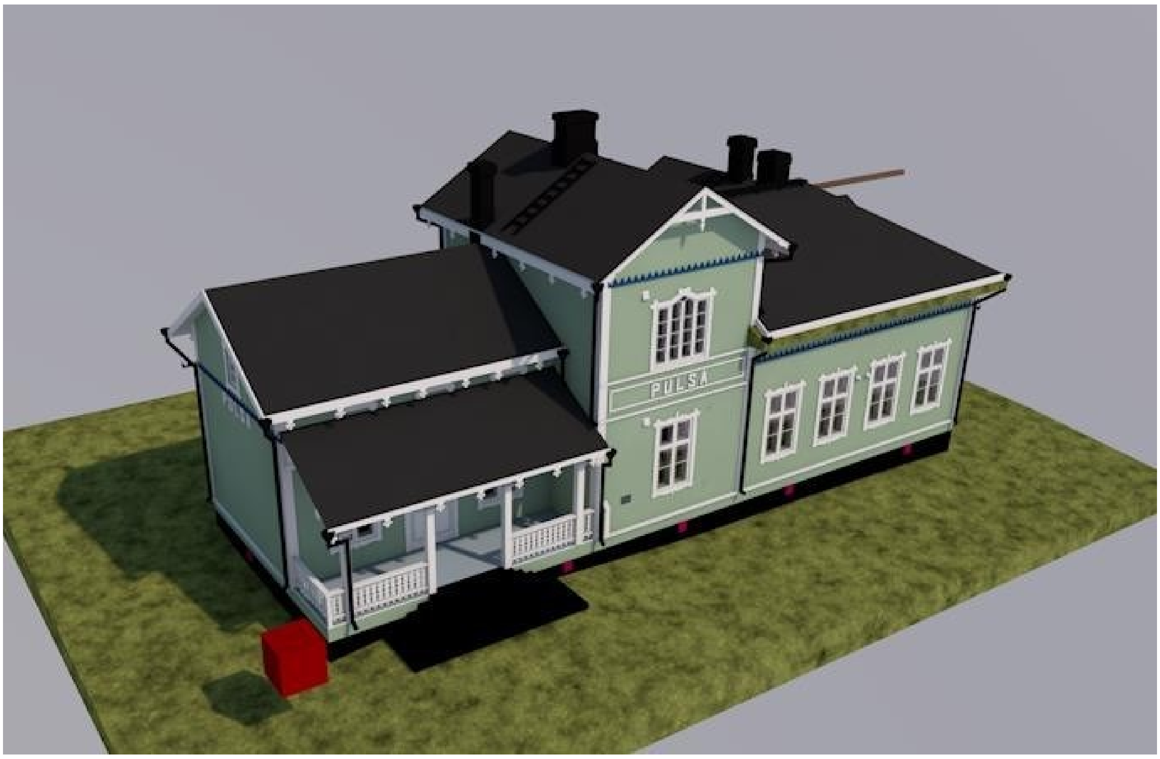
http://www.opendata500.com/au/

http://data.wa.gov.au/

Appendix C

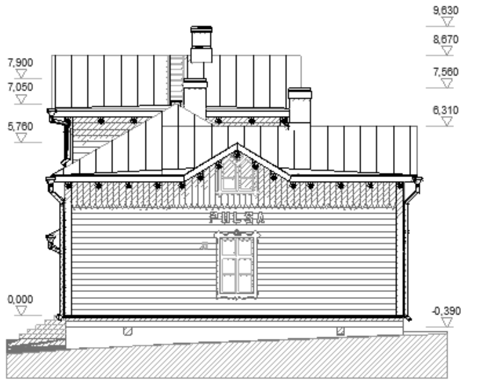
3D model of Pulsa station main building (model: Topi Huhtanen)





Appendix D

Cross-sections and plans (made by Topi Huhtanen)



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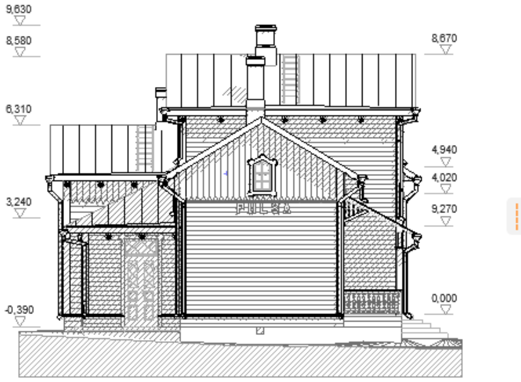

JULKISIVU LÄNTEEN 1:100