Kartlegging av underjordiske ledningsnett i Finland

Matti Arponen

Matti Arponen: Mapping of underground utilities in Finland

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This presentation delivers an overview of utility (pipes and cables) mapping and utility information services in Finland.

The roles of various participants, pipe and cable owners or operators, software vendors and mapping- and IT consultants as well as municipality land survey departments are described. Current and planned legislation concerning utility mapping and infrastructure management is explained. Utility mapping and GI standards and cooperative interface developments in Finland are reviewed. Detailed examples are provided from the utility mapping systems of the Helsinki metropolitan area.

Effective solutions for comprehensive utility mapping and data service for the whole country are difficult to attain because of differences between small municipalities and rural areas in comparison with denser city areas. Some 120 of Finland's 330 municipalities may be capable of organizing an all-inclusive geospatial system for their territory, including utility maps and similar infrastructure information. State authorities seem to be more enthusiastic about developing centralized eService solutions.

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Matti Arponen, Msc. (Surveying), Manager of Cartographic Office, City of Helsinki, Koivikkotie 12 as 5, FI-00630 Helsinki. E-mail: mkarpone9@gmail.com

1. Background regarding utilities and utility maps

Utility networks serve permanently settled houses and administrative, service or production buildings throughout Finland. In the beginning of 2012, they reached 57 233 apartment buildings with 1'808 475 inhabitants, 77 060 row houses with 701 698 inhabitants, 1'111 378 one family houses with 2'690 082 inhabitants and 214 034 business, service, administrative or production houses. There are some 3,1 million residential flats and business and other premises comprising the total number of houses. There are some isolated houses «off grid» in the islands and shores of the numerous lakes and Baltic Sea. Most of the 493 000 summer cottages are intentionally left without connections, but many are equipped similarly to city buildings. The yearly construction of apartments in new buildings was 34 065 in 2011; including 17562 units in 559 apartment houses, 4352 in 819 row houses and 11 497 in one family houses. The number of new administrative, production or service buildings was 3540 in 2011, and the number of new summer houses was 3600.

New utility pipes and cables are mainly built to serve new buildings.

Utility maps can be divided in two categories: 1) utility location maps with exact location of pipes and cables and 2) network maps with information that is more descriptive and includes attributes. Municipality land survey departments usually have and maintain accurate utility location maps, which are a central part of the municipality geographic information system (GIS). Utility companies have and maintain utility network maps also, as part of their assets management documentation systems or operational systems. Today many network maps are produced with sufficient location accuracy, too. The difference between utility location maps and utility network maps has to some extent disappeared.

Most of the actual mapping on sites is done by private mapping consultants. The utility operators have outsourced this part of the construction project. In Helsinki the Land Survey Department performs only the field surveys of central heating and cooling pipes, as a consultant. Utility pipe and cable

field surveys in Espoo and Vantaa are also mostly carried out by private consultants. Land Survey departments have about a 30% share of utility map field surveys.

In general, cities and rural municipalities need to be aware of their essential infrastructure. Unfortunately, the smallest cities and rural municipalities don't have utility location maps or a geographic information system at all. The current municipality division renewal campaign of the Finnish government (from 334 municipalities toward some 100 new municipalities) will result in stronger local government units. These new municipalities need and are capable of having continuously maintained GIS and utility maps of their territory.

Like the small municipalities, many small utility companies or cooperatives lack digital utility map systems and their maps are still in paper form.

To get a general picture of magnitude of the utility networks in Finland, we can compare them to the road and street networks. There are some 78 000 km of state roads with 5 200 km pedestrian and bicycle roads, 28 000 km of municipality streets with 12 700 km pedestrian and bicycle roads and 350 000 km private roads, including some 100 000 km of private roads providing permanent housing access for 1 million people. Most of the citizens live next to the municipality street network. The access road network to all continuously used houses is then in all about 206 000 kilometers.

A simple theoretical utility network to all permanent houses could be some 220 000 km long.

Most utility networks are located under the street surface or along roadsides, providing close connection between the utility network management and the road and street management during the planning, building or maintenance of utility networks.

2. Information and statistics on utility networks and infrastructure

A short description and some statistics and other information on the various utility networks in Finland are given in following sections.

Electricity

85 network companies operate electricity networks in Finland. The length of the electricity network consists of

- 14 000 km high voltage lines (110–400 kV) which are mostly in the air
- 137 000 km medium voltage lines (1–70 kV), 11 % buried
- low voltage lines 233 000 km (less than 1 kV), 35 % underground (year 2009).

In Helsinki 30 % of the 200 km of 110 kV cables are underground, 99.5 % of the 1600 km of 10–20 kV lines are underground and 96.5 % of the 4500 km of low voltage lines are underground.

Some electricity network operators are small, operating in one municipality and have fewer than 1000 customers. According to new legislation, energy production and distribution must be under separate organizations. After this restructuring, most of the street light cable networks were also transferred to the ownership of municipality engineers' offices, as were the traffic lights networks. Those networks may be estimated to be more than 40 000 km. State road administration may have some 10 000 km of road light network, too.

Pure water and waste water (+storm water)

In Finland, the ownership and maintenance of water utilities is divided among numerous small organizations. There are some 1500 water operators or co-operatives. Most municipalities have a water utility department or separate water works unit, which operates mainly in the city plan area of the municipality. Many small co-operative water networks operate in rural areas. The total length of the water pipes is estimated to be 100 000 km, sewerage water pipes + storm water networks are estimated to be 50 000 km, house owner pipes on site 10 000 km. The yearly addition was 1600 km of water pipes and 950 km of sewerage pipes in 2009.

Telecommunications

In 2010 the Ministry of Transportation and Communications appointed a work group to

develop the location data management of telecommunications cables along roads and railroads. The work group estimated that the telecommunications network cable length in Finland may be 370 000 km, where 70 000 km is fiber optic. The biggest players in telecommunications business are TeliaSonera, Elisa, and DNA, which are also the leading telephone and mobile operators. Other significant companies are TDC and Corenet as well as Finnet Group, which is a cooperative of smaller local telephone operators. New investments in telecommunications networks are mostly aimed at expanding fiber optic networks. A massive effort «broadband to all» is ongoing in Finland, supported by the government and the EU. Under this umbrella program, new fiber optics network are built into rural areas. At the same time, the big operators are building competitive fiber optic networks to cities. On rural areas old copper lines are mostly stripped away.

Central heating and cooling

Central heating networks are 12500 km long and are mostly located under municipality streets and sidewalks. Central heating networks serve some 2,6 million people and 90 % of the apartment buildings of Finland are connected to some central heating network. Central cooling networks are developing fast in the few largest cities with a network length of about 100 km (year 2012). Central heating and cooling networks expand some 500–1000 km annually. The central heating network in Helsinki is about 1230 km long and is expanding some 20 km annually.

Gas

Gasum Oy provides Russian natural gas and local bio gas through its network of 1310 km high pressure pipes and 539 km delivery pipes. The gas is mainly for industrial purposes or electricity and heat production (mostly CPH = combined heat and power). The annual expansion of gas network is 120 km. The daughter company Kaupunkikaasu Oy serves gas to older parts of Helsinki city center and residential areas.

Other utilities

Finland has many smaller utility networks.

The railroad network (5919 km) has its cable networks along the track sides. They handle administration of permissions for other utility networks to use railroad area or cross the railroad area separately.

State road administration has its networks for road lights and some traffic lights. They have a centralized service in Tampere, Center for Economic Development, Transport and the Environment (Pirkanmaan ELY-keskus) that grants permission for other pipes and cable to use or cross the road area.

State waterways and canals administration, which is part of the Finnish Transport Agency, has quite a long underwater network serving some of the 33 000 maritime aids on the Baltic sea and lakes with shipping or boating fairways. Most of the other under water cables and pipes are also included in their Finnish Nautical Chart database.

The city tramway in Helsinki and traffic light administration in all cities have underground networks and are also included in the city utility location map.

Some industrial plants are located in areas in which pipe and cable connections between different sites need to go through street areas. Some housing companies also connect different sites.

The solid waste collection system is a new underground pipeline service. Two networks are under construction in Helsinki.

The communication networks of the Finnish defense forces have many locations underground and in water.

Private real estate owners have many buried cables and pipes, which cannot be found in any map.

Underground tunnels and equipment are mapped on the utility location map in Helsinki. One popular new utility in the utility location map is heat pump bore holes. In Helsinki the number of bore holes is now about 1300.

3. Cooperative bodies and interest groups in utility network mapping

The following organizations are important players in the discussion of rules and regula-

tions as well as cooperative measures concerning utility network mapping in Finland.

- Finnish Energy Industries http://www.energia.fi/en
- FICOM (http://www.ficom.fi/inbrief/index.html) Finnish Federation for Communications and Teleinformatics, is a co-operation organisation for the ICT (information and communications technology) industry in Finland
- Finnish Water Utilities Association (FIWA) (http://www.vvy.fi/in_english) is the co-operative association of the Finnish water and waste water utilities with 300 members.
- The Association of Finnish Municipalities and Regional Authorities (336 municipalities) <http://www.localfinland.fi/en/Pages/default.aspx>
- Three Ministries: Ministry of Environment, Ministry of Traffic andCommunications, Ministry of Employment and Economy

4. Software for location map, network map and infrastructure management , documentation of infrastructure assets and operations management

The municipal utility location map 1:500 is part of the municipality's geospatial information system. It is mostly used together with the municipality base map 1:500. The complete location map has layers for each utility found in a municipality or city.

Municipality GIS software vendors such as Tekla, Bentley Finland, Airix, Basepoint, Logica, Karttakeskus, Keypro, Sito and Vianova Systems also have an application for the utility location map using the standards described in chapter 5. International brands such as Microstation, Autocad, ArcGIS, MapInfo, Intergraph and Oracle are used in most of those software programmes.

All of the large utility companies or larger municipality departments that own and operate some utility network use network map software. Today, network map applications are part of quite complicated operational and/or asset management systems. These are supplied by some of the vendors mentioned above, as well as other vendors such as ABB, Tieto, Smallworld, etc.

In municipal GIS, new developments integrate GIS and mapping applications more tightly to web services and operational eService applications.

5. Standards and ISO 19100 interfaces

Utility location maps and map databases should preferably be made according to commonly accepted standards.

The SFS 3161 (SFS = Finnish Standards Association) underground utility map standard was created some 25 years ago, during the first digitization of utility maps. It has description and drawing instructions for each utility object type and printing instructions. Helsinki city's combined utility map 1:500 was created during the years 1984–1993 and follows this standard. The next step was to utilize the Municipality Classification of Terrain Information (Kuntaliitto: Maastotiedon luokitus (MTL)), which was made by the Association of Finnish Municipalities and Regional Authorities (Kuntaliitto = Kommunforbundet). Many other cities and municipalities created utility maps according to these standards in a similar way.

In the beginning of 21st century, the GI cooperative work group of The Association of Finnish Municipalities and Regional Authorities started to develop standardization of municipality maps and the geospatial branch through the OGC and ISO 19100 family of standards. The work group (Kunnan paikkatiedon yhteistyöryhmä) consists of members of municipality survey departments, universities, National Land Survey and Ministry of the Environment, as well as the private companies serving GIS software for municipalities and mapping consultant companies.

In the KuntaGML project (KuntaGML = MunicipalityGML), the Municipality GI data transfer standard for municipality basemap 1:500 and city plan was created first. This development was based on the ISO19000 and OGC definitions. The basemap schema includes most pipe and cable objects in use, in municipal combined utility maps 1:500.

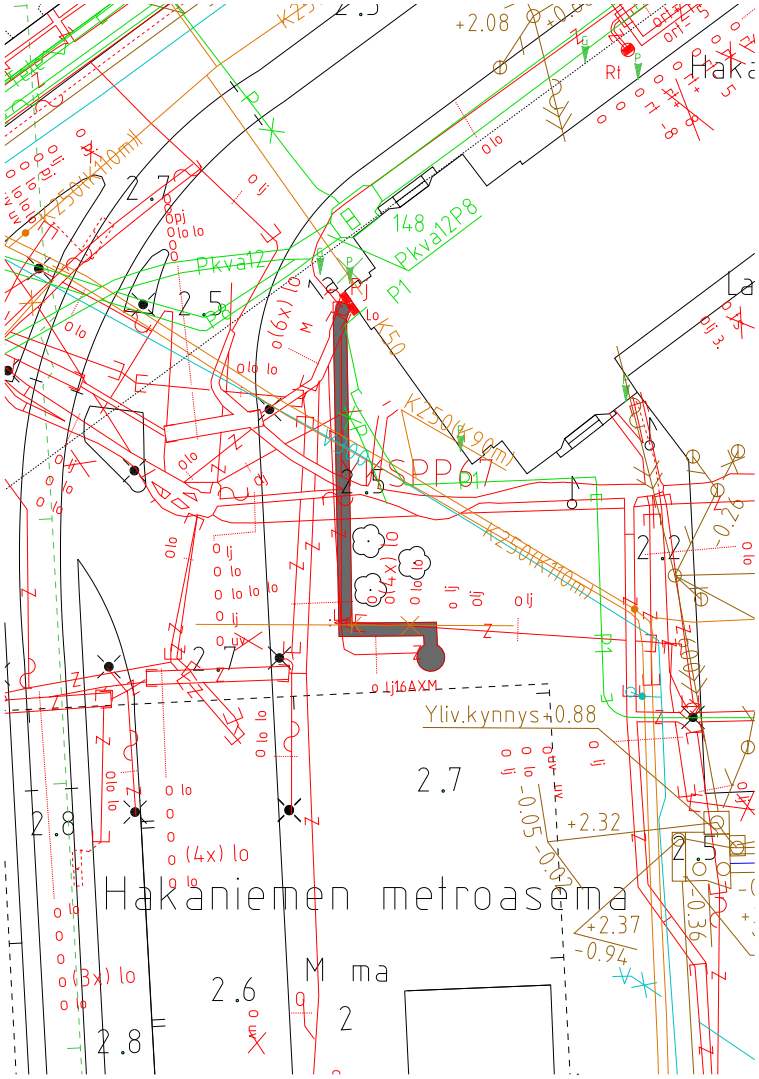

Figure 1. The utility location map (Winkki) in 1:500, showing the electricity connection for a new project. The project is to build an advertisement pylon. The area is our second market square in Hakaniemi, Helsinki.

All municipality GIS vendors have realized KuntaGML.

Before that there was a definition project called VerkkoGML (verkkoGML = networkGML), This was the first network map in GML standard, in which municipalities and central associations of network owners tried to create a cooperative and common standard for utility GIS. Tensions between the municipality sector and the utility associations prevented the development of the standard on the part of municipalities. Municipalities created a similar schema inside of the basemap schema.This is in use in Helsinki metropolitan area municipalities and in some other cities. The largest network companies use the VerkkoGML standard in data transfer cooperation with Johtotieto Oy. Johtotieto Oy is a state owned company that provides utility network information and utility maps for projects in large areas of Finland outside the Helsinki Metropolitan area. In the Helsinki Metropolitan Area the services are provided by municipality land survey departments.

KuntaGML development has continued until 2011 in the KRYSP project (KRYSP = Municipality Built Environment eServices).

There more data transfer interfaces were defined as schemes and realized in many GIS packages used in Finnish Municipalities. The following data transfer interfaces exist today:

- basemap
- city plan
- building permission and building information
- many environmental permissions
- address data
- guide map
- municipality services (basic info)
- street network topology
- exceptions in building permits and city plans
- contaminated lands
- permission to use soil materials
- nature objects
- environment monitoring

All these standards can be found at www.paikkatietopalvelu.fi

The KRYSP project elaborated also a municipality cooperative WMS/WFS service (kokoava tietopalvelu KTP), using the above mentioned standards. Each participating municipality has its own WMS/WFS service, and KTP collects data from different municipalities according to the interest area and type defined by user. This service is currently in experimental use.

Yet another line of development for data transfer standard is the InfraRYL project. In this project, the infrastructure construction industry, consultants and state railroad administration, state road administration as well as municipality civil engineering branch are developing parallel standards for data transfer using LandXML and Building Information Modeling (BIM) development as starting point. The land survey branch, which is more used to OGC and ISO19100 standards should work more to unite those two developments.

6. Utility network legislation

§45 of the Land Use and Building Decree (895/1999) give power to municipalities to prepare utility location maps. Utility companies must provide data to municipalities for utility maps free of charge. It is, however, voluntary for the municipality to prepare utility location maps or organize a co-operational underground utility data service. This paragraph in the Land Use and Building Decree was a result of long development process. As early as in 1987, the Ministry of the Environment set up a committee to prepare legislation concerning utility mapping and utility data services. In 1989, after receiving some 70 statements from interested parties, the committee wrote the final proposal which was to become utility map law. In the report the committee writes that some of the utility owners or their lobbying organizations mentioned that paragraph 4 was against this law. All other statements agreed to the law. The Ministry never gave this proposal to the Finnish parliament for processing for it to become law.

The Communications Market Act (393/2003), §111, orders all digging or excavation projects to investigate in advance whether any telecommunications cables exists in the work area. The purpose is to protect the cables. Same paragraph also includes requirements for telecommunications operators to provide information on cable locations free of charge. They are even ordered to mark the cables in the field free of charge.

The law proposed that cables should be placed primarily in street or road areas, in order to minimize harm to private land owners, but telecommunication cables can be located on private land. The companies must compensate for any harm incurred.

The Land Use and Building Act 132/1999) §161 grants rights to place municipality infrastructure on private land or -sites.

The Water Act (587/2011) Chapter 4 §8, states rules for locating water pipes on other owners' land, but no rules concerning mapping of pipes.

Easement rights for locating cables or pipes on other owners' land are covered by real estate legislation KML 554/1995 §154.

7. Municipal utility mapping and data service

The three cities Helsinki, Espoo and Vantaa have very functional organization of their utility mapping, map data bases and utility

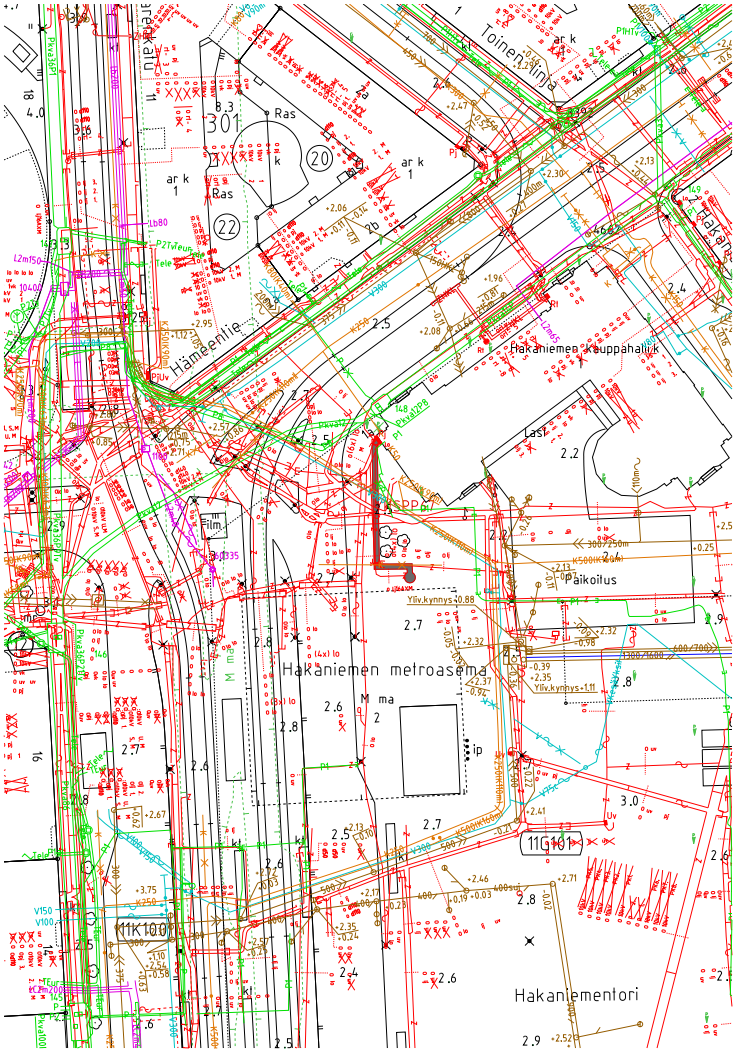

Figure 2. The same project as in Figure 1, showing a larger area of the Hakaniemi market square.

map services for building and construction projects in street and park areas. These systems serve more than 10 000 projects annually in the three cities comprising a total of nearly 1 million inhabitants. Most construction projects on the streets are done by other utility owners, who expand or renew their network or make new networks for newly planned housing or industrial sites and areas.

Some 30 other municipalities are working with utility location maps. They are creating combined utility maps of all utilities in their area. The rest (300 municipalities) have not been very active in this important area of the municipal GIS. They have water utility maps under continuous maintenance, because many municipalities operate water and waste water networks and services.

8. Connections to municipality infrastructure management

Utility network management closely tracks or is part of the municipality infrastructure management, at least in city plan areas. In rural areas, where the intensity of land use is low, more lax procedures are possible.

In Helsinki the underground utility service is organized within the same information system as street management (Winkki sys-

tem). A more detailed description of the Helsinki region utility map system and of utility map customer service can be found in Swedish Land Survey magazine Aspect 6/2011, Arponen.

When new areas are built on, utilities are also built and mapped. Thus most utility network expansion tasks are follow ups of new city plan projects to realize the infrastructure for new housing and service- or industrial building sites. It is the duty of municipality administration to control and coordinate municipality development and infrastructure. According to the Street Maintenance Act 1978/669 and its amendments §14a and §14b, the municipality controls all tasks on the streets and can collect payments concerning the control and use of the street area.

Both small and large infrastructure development projects proceed the same way with a similar timetable structure. Often these new infrastructure development projects are related to new streets.

All projects proceed according to the following steps:

1. Preliminary planning and opening of the task or project (in the utility owner's operational system). During this phase, appropriate digital basemap and utility map data as well as other needed GIS data are collected to facilitate planning the task.
2. Negotiations to cooperate and integrate with other projects on the same street or site.
3. Decision to start the task and define the time frame for the task on site
4. Defining the exact project or task area
5. Clarification and guidance from the municipal utility map service regarding the utility location map and pipes and cables. Registration of the task in the municipal street management system (in Helsinki the system is Winkki). Guidance and possible orders for and timing of field markings of existing pipes or cables.
6. Location announcement or the city engineer's permission to locate pipes or cables in the street or park area in question.
7. Formulation of a traffic plan for the site.
8. Localization and marking of the location of the old pipes or cables on site
9. Actual construction on site
10. Mapping the new utilities (pipes or cables) on site
11. Payment for the permissions
12. Restoration of the street surface back to original condition
13. Updating of the municipal utility map
14. Closing the task or project in the municipal street management system (Winkki system in Helsinki)

9. Commercial utility map services

Earlier in this article Johtotieto Oy is mentioned. This company is now fully owned by State of Finland, providing utility information and map extracts for some 100 000 projects annually. They have agreements with and data from some 85 utility network owners. In most municipalities, Johtotieto Oy doesn't have full coverage of information from a municipality territory, so the customer must collect his data from many sources. or operate without proper knowledge project site.

Keypro Oy has started an Internet service www.kaivulupa.fi <http://www.kaivulupa.fi/> where they claim to provide proper utility information and utility map extracts for project sites. Keypro's service does not have all information of all utility networks existing in certain municipality territory similarly as Johtotieto Oy, but their situation is less favorable.

Some municipalities, such as Helsinki, have utility map services for digging projects that include full coverage of information of all existing utilities in the municipality.

My opinion is, that a municipality needs only one service with full coverage of information on all existing utilities in the municipality.

The current situation is confusing. If the project personnel use inadequate utility data it can have dangerous consequences at digging sites. Digging project personnel should collect the data or ask for information from all utility owners who may possibly operate in that municipality. The best solution is to create full coverage utility location maps for those municipalities which lack a utility location map. A utility location map should be

Figure 3. The same project as in Figure 1, showing the stripped base map with the project.

included in the municipal GIS. Local service for local projects seems also beneficial in comparison to centralized services. Open internet service may not be possible either, because infrastructure information is sensitive for common safety reasons. The state authorities seem to prefer one centralized service, which should be Johtotieto Oy.

10. New developments and ideas

There is quite a high level of variability in the utility map sector in Finland.

It seems to be difficult for the Ministries and state authorities to include municipalities in development projects as an organized group in GI related matters, as they prefer sporadic participation of some selected municipalities, if any. The municipalities don't have a strong GI expert base in the Association of Finnish Municipalities and Regions. Municipalities don't have their own «central government». The number of land survey and GI personnel in municipalities is about the same as the personnel in National Land Survey in Finland. This makes the situation difficult for municipalities, and we need to search for solutions.

If strengthening of local government is a common political goal, as it seems to be in Finland, local GI services should be strengthened. Comprehensive geospatial information on the municipal territory is one key tool to make municipal administrative work more effective and also more economical.

The work group of the Ministry of Transport and Communications (MTC) made in 2010 the following proposals to improve utility mapping in Finland. Their proposals are presented in the left side of the table.. The city of Helsinki made a counterstatement to those proposals, presented on the right side of the table.

MTC	Helsinki City Survey comments
1 The goal is a centralized service portal, where customer can get all utility location information, maintained by several utility owners or map providers	As in alternative 2, the goal is municipality- or regionally based service
2 A data transfer interface should be defined and created between this new service and current cable location systems	The current KuntaGML interface can be developed to serve this service
3 A more unified standard for the map data used in the display of cable data will be developed	The current SFS 3161 standard can be developed and united to KuntaGML family of standards
4 Network operators are obligated to connect and fit their utility network or location systems to the new service portal using a cooperative data transfer interface	Network operators are obligated to send utility map data already, according to the Land Use and Building Act §45, to the municipal or regional utility map database Those utility location maps must be created
5 Also future cable projects should be reported to the service portal	This can be done in municipal or regional project follow up systems such as Winkki in Helsinki
6 Cooperative construction of traffic investments and communications infrastructure and other infrastructure investments should be strengthened	A good idea which can be realized within a system like Winkki
7 The proposed new service portal will be offered to commercial service providers (without profit expectations)	Services can be realized in municipal or regional services as in Helsinki (without profit expectations)

In the following list I make some concluding remarks regarding the current situation and present ideas, proposals and suggestions for future improvement.

- All municipalities need to include full coverage of all utilities in their area in their GI services.
- Municipalities should strengthen local GI services with the support of the state authorities. This is very important when new, larger municipalities are created.
- The municipal land survey and civil engineering branches should develop common data transfer interface standards, rather than competing
- VerkkoGML and KuntaGML standards should be united, rather than competing. In other words, better cooperation between municipalities and utility operators should be created.
- A cooperative HankeGML (Hanke = task or construction project on the streets and parks) should be created
- Sensitive utility data should be provided freely on internet, but only to identified citizens from the neighborhood of the home or new building site. A citizen should be able to mandate his consultants to see all data needed in his projects. Frequent constructors could register themselves and get access to utility data and use utility project service themselves
- Utility pipes and cables should only be mapped from the open project hole, not scanned later through the pavement
- When the state develops GI-based services for municipalities, municipal participation should be negotiated with the GI development group in the Association of Municipalities and Regional Authorities, rather than haphazardly selecting the municipalities to participate. It would be better to grant development money to municipalities or to the municipality association.
- State authorities should implement all KuntaGML standard interfaces in their own systems, in cases in which data are needed and transferred from municipalities.

Sources:

This article is based mostly on information from the Internet and reports from the organizations mentioned in the article, as well as personal interviews of some persons working in those organizations. Some of the statistics are taken from the Internet pages of Statistics Finland.