From Control Points to VRS – The Development of Using GPS in National Land Survey of Finland

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Key words: Cadastral Survey, GPS, Virtual Reference Station (VRS) Network, Real Time Kinematic (RTK) Measurements

SUMMARY

In Finland the government organisation National Land Survey of Finland (later NLS) is responsible of land survey, cadastral survey and national mapping. Hereby NLS has a long history in using different methods of measurements in all sectors of surveying. However, the use of GPS was not extensively implemented until the year 2000. Before 2000 GPS was used mainly in geodetic survey. Since then the development of using GPS has been rapid.

In 1999 launched a project to invest and make operations models for land and cadastral surveys. The project also made proposals of quality requirements, program of device acquisition, training programme of surveying skills and arrangements for general development and support of surveying activities. The project proposed that NLS should implement the use of GPS in stages.

At first every District Survey Office (13 in all) supplied at least one GPS-equipment with cm-level accuracy. The aim was primarily to assist other measurements by making control points for cadastral surveys. So the external accuracy of cadastral surveys improved significantly. A GPS-team was formed in every District Survey Office. These teams made all the GPS-measurements in an area of a District Survey Office. Needed measurements ordered by all surveyors who make cadastral surveys. So the operations model was an internal client–producer –model. In the year 2000 basic GPS courses was held in 11 District Survey Offices. In that year was also the first nationwide user´s meeting, which has taken place annually since then.

Until now the number of GPS-equipments has risen quickly. In March 2004 there were app. 110 pairs of GPS device (reference and rover) in use in NLS. GPS devices are all capable to RTK-measurements of cm-level accuracy.

During the year 2003 NLS tested GPS measurements with the Virtual Reference Station (VRS) network, which is built and maintained by a private company named Geotrim. In co-operation with Geotrim, the VRS-network is now expanding north to the level of Oulu in 2004, and to the whole country in 2005.

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1. NATIONAL LAND SURVEY OF FINLAND

In Finland the government organisation National Land Survey of Finland (later NLS) is responsible of land survey, cadastral survey and national mapping. Hereby NLS has a long history in using different methods of measurements in all sectors of surveying. However, the use of GPS was not extensively implemented until the year 2000. Before 2000 GPS was used mainly in geodetic survey. Since then the development of using GPS has been rapid.

2. CADASTRAL SURVEYS

The NLS carries out legal surveys outside city plan areas. Three quarters of legal surveys concern parcelling. Parcelling is a cadastral survey in which an unseparated area that is a transfer of part from an existing real estate unit is made into a new independent unit. Legal surveys are carried out by District Survey Offices.

2.1 Measurement Classes

Cadastral surveys in Finland are divided in 5 classes according to the requirements of accuracy of measurements. The measurement classes and requirements of accuracy are as follows:

Measurement class 1: Built-up areas with high value of land. City plan areas.	**Requirements of accuracy**: 120 mm compared with control points.
Measurement class 2: Built-up areas with mainly detached houses. City plan areas.	180 mm compared with control points.
Measurement class 3: Areas of plans with only minor construction rights, usually shore plan areas (summer cottage areas).	250 mm compared with control points or 0,02 * SQR(L) m, where L is the distance of measured points and SQR is square root.
Measurement class 4: Sparsely populated land, mainly agricultural land.	0,05 * SQR(L) m.
Measurement class 5: Sparsely populated land, mainly forest areas.	0,08 * SQR(L) m.

The requirements are easily achieved with RTK-GPS-measurements in measurement classes 3-5, where NLS mainly operates. So the main method of measurement in cadastral surveys is now RTK-GPS.

2.2 RSK

When measuring boundary marks, we consider also the positional accuracy as an attribute of the boundary information in the database. Positional accuracy is called RSK (value in meters). RSK is an estimated mean error of measurements at that boundary mark. RSK is calculated with following formula:

$$RSK\ (m) = SQR(\ i_r^2 + i_m^2 + L_m^2\ ),$$

where i is the uncertainty of identification, both measured (m) and reference (r) points, and L is the accuracy of measured point.

Typical RSK-values in RTK-measurements are 0,1 – 0,2 m in our cadastral survey areas.

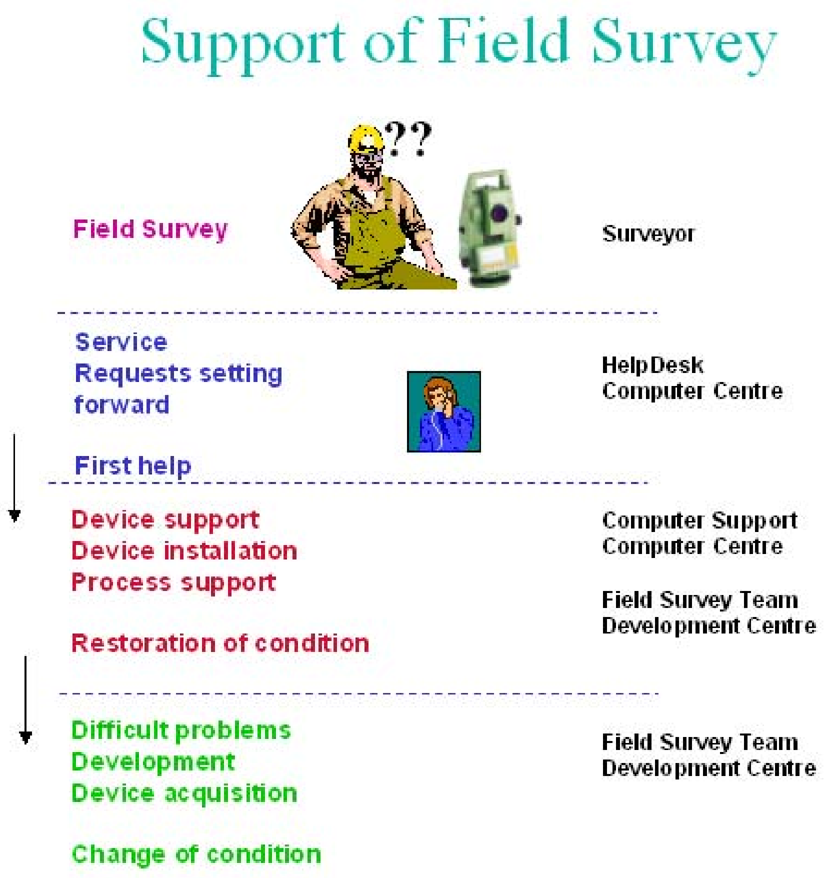
3. GPS DEVELOPMENT PROJECTS IN 1999 - 2000

In 1999 launched a project to invest and make operations models for land and cadastral surveys. The project also made proposals of quality requirements, program of device acquisition, training programme of surveying skills and arrangements for general development and support of surveying activities. The project proposed that NLS should implement the use of GPS in stages.

At first every District Survey Office (13 in all) supplied at least one GPS-equipment with cm-level accuracy. The aim was primarily to assist other measurements by making control points for cadastral surveys. So the external accuracy of cadastral surveys improved significantly. A GPS-team was formed in every District Survey Office. These teams made all the GPS-measurements in an area of a District Survey Office. Needed measurements ordered by all surveyors who make cadastral surveys. So the operations model was an internal client–producer –model. In the year 2000 basic GPS courses was held in 11 District Survey Offices. In that year was held also the first nationwide users meeting, which has taken place annually since then.

4. SUPPORT OF FIELD SURVEY

In 2001 formed a nationwide team called Field Survey Team. The 9 members of the team are representing wide range of production and service units and District Survey Offices. The team takes care of development, maintenance and support of all field survey activities in NLS. Support is organized within the HelpDesk-service, which is used also in other information systems of NLS, such as the main cadastral and topographic database system called JAKO. Other tasks of the team are to take care of device acquisition, maintenance and logistics in co-operation with Computer Centre and the District Survey Offices. Field Survey Team is also updating instructions and recommendations of field surveying thus ensuring the quality and consistency of surveying in NLS.



During March and April 2004 Field Survey Team launched a training program "GPS Basics", which was aimed at new GPS users. The training includes an Internet training kit with 8 modules and one-day course with the devices. There were 180 participants in all just recently.

5. USING GPS IN FINLAND

GPS measurements in Finland face some obstacles, which are not so common in other parts of the world.

First, Finland is situated between northern latitudes of 60° and 70°. Since the inclination of GPS satellites' orbits to the equator is 55°, most satellites' altitude is relatively low in the sky most of the time. So the satellite configuration means a lot, and has notable impact in planning measurements.

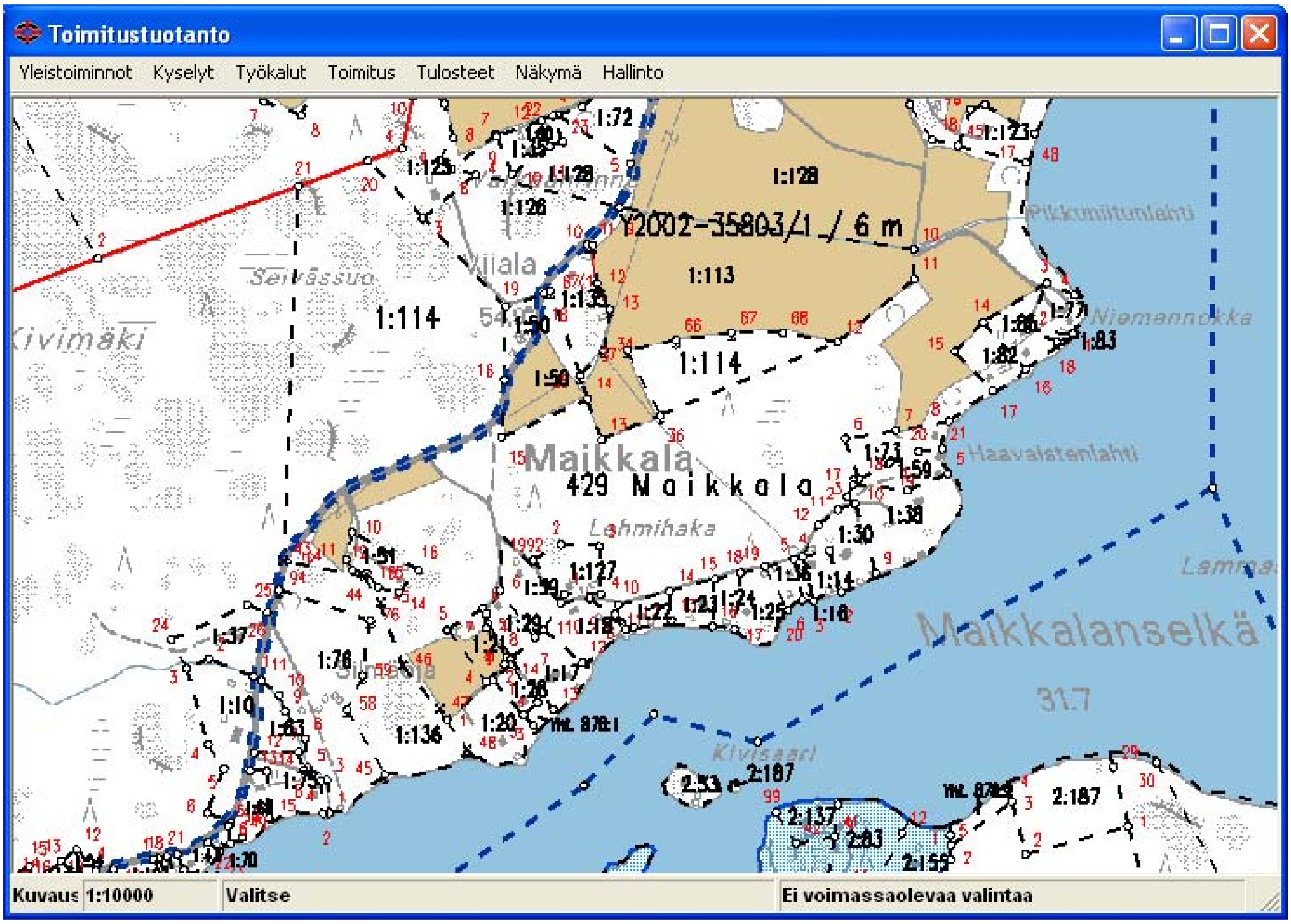
Other obstacles are forest canopy and winter weather, as described below.

Forest covers nearly 2/3 of Finland's total land area. One main forest type is pine forest, as seen on the left. Although pine forest is not very dense in foliage, it has surprisingly great effect causing multipath reflections in GPS signal.

The other main forest type is spruce forest (left). Spruce trees have dense foliage (not so dense in the picture), and getting GPS signals through is nearly impossible in such forests. Both pine and spruce trees are evergreen, and winter gives no help to this problem.

Finland is snow-covered nearly half of the year. Cold weather in itself is not an obstacle in GPS measurements, but the boundary marks and other measurable objects are under the snow and so difficult to find.

Besides these obstacles we have also many advantages in cadastral surveys in Finland. The cadastral database called JAKO comprises all country and is continuously up-to-date. The database con-tains information of real estates, boundaries and boundary marks. The topographical database has also the same JAKO software basis, and the two databases are compatible. This gives us gain as we combine information, for instance, of real estate boundaries and shorelines, when the boundary line is determined to shoreline.



Cadastral database JAKO with information of real estates and boundaries.

Cadastral information is available also in the topographic data system JAKO/TDS.

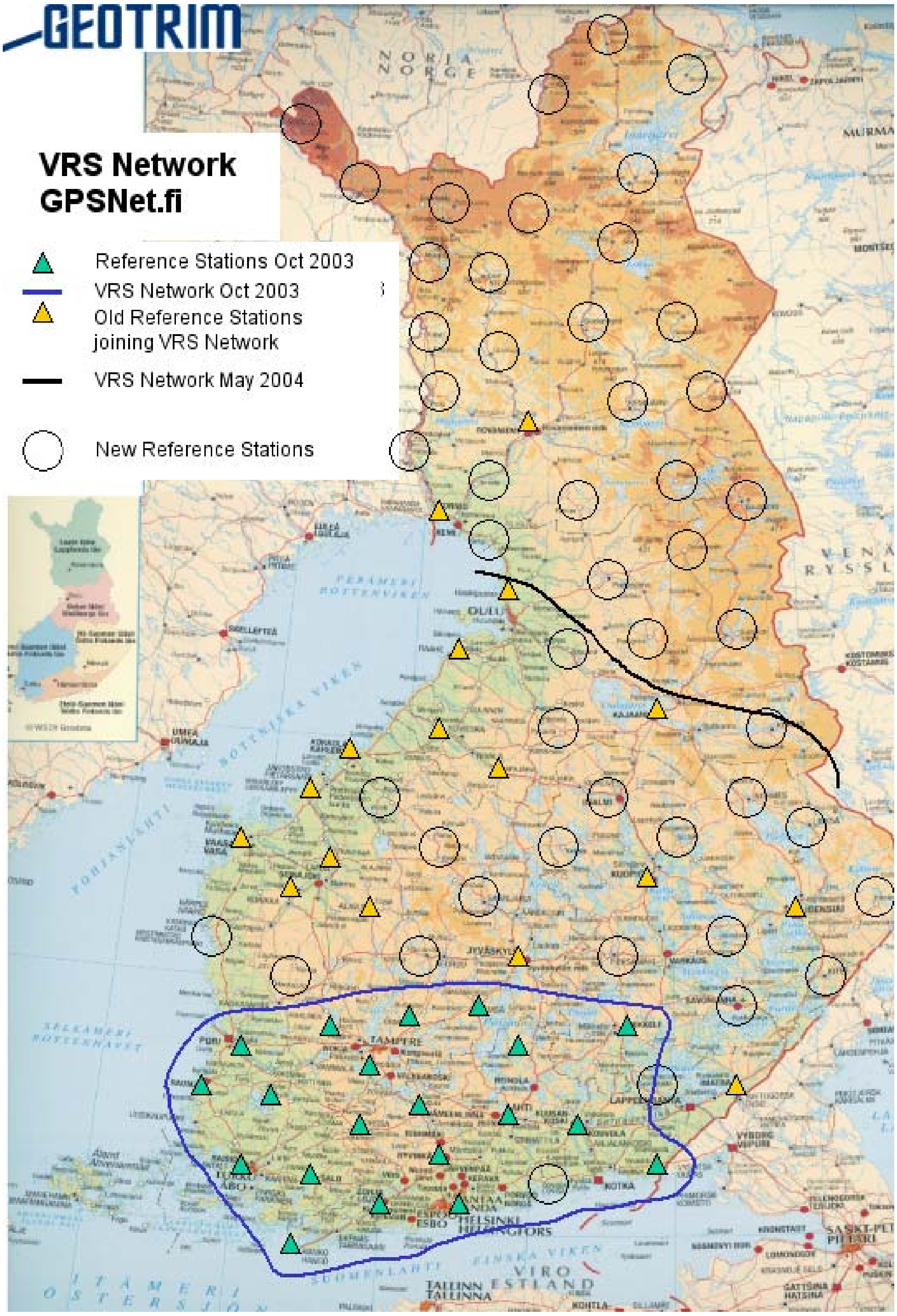
JAKO/TDS has a lot of geographic information covering almost all the country, except the northernmost tip of Finland.

6. GPS EQUIPMENTS

The number of GPS-equipments has risen quickly since year 2000, when GPS equipments acquisition started in large scale. In March 2004 there were approximately 110 pairs of GPS device (reference and rover) in use in NLS. GPS devices are all capable to RTK-measurements of cm-level accuracy. As measurements in VRS network need only the rover device, many of the reference devices can be changed to rover devices. Thus the number of measuring GPS units will rise in the tens during the year 2004. Though some of the reference devices will be used to modernize the geodetic survey equipment.

7. VRS NETWORK STARTING

During the year 2003 NLS tested GPS measurements with the Virtual Reference Station (VRS) net-work, which is built and maintained by a private company named Geotrim. In co-operation with Geotrim, the VRS-network is now expanding north to the level of Oulu in 2004, and to the whole coun-try in 2005 (see picture below). In April 7th 2004 the network opened to NLS users, and there will be app. 80 licences in use in summer 2004.



VRS Network in Finland

In the VRS system RTK correction data is sent to rover by GSM-data transfer. GSM-network covers Finland quite well, and problems with receiving data are rather with satellite data than with GSM data. The GPRS-data transfer is planned to start later in the system.

The use of VRS network means a considerable development in use of GPS. The cm-accurate RTK-measurements are then available to all who do land surveys in NLS. Also easiness of the use of GPS in VRS network is an important factor to widen the use of GPS to an every-day tool of land surveyor. Time is saved and much inconvenience is avoided, as only the rover device is needed.

8. FUTURE DEVELOPMENT

GPS is used also in updating of the Topographic Database. The road network updates mainly by driving roads with DGPS-equipment in a car. Implementation of the National Street and Road Database Digiroad later in the year 2004 means new requirements for updating the road data. In future the DGPS-measurements are also planned to do with VRS-based correction data. This means more accurate DGPS-measurements. It means also that more objects of the Topographic Database can be updated by GPS-measurements. So the cycle of updating important data in Topographic Database will get shorter.

In years to come the modernisation of GPS and the new Galileo system will positively affect the use of GPS. In National Land Survey of Finland there will be still a lot more to do in the development of using GPS.

BIOGRAPHICAL NOTES

Author has been working in Development Centre in National Land Survey of Finland since 1990. He has worked with several projects of the Topographic Database System. Now his responsibilities includes mainly the support and development of field survey. From 2002 he has been a national representative of MAKLI, Finland to FIG commission 5.

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