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**Country Reports**

# National Report - Finland*

* **Prepared by the National Land Survey, Finland**

# National Report
# National Land Survey, Finland

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## SUMMARY

The National Land Survey of Finland started the production of a new nationwide elevation model in 2008. The new elevation model has been calculated to a frame size of two metres, and its elevation precision is 30 centimetres. This is a significant improvement compared with elevation models previously produced by the National Land Survey. The old elevation models have been produced for the most part photogrammetrically and calculated to a frame size of 25 or 10 metres.

There are several globally initiated efforts to address climate change caused by deforestation and forest degradation by compensating developing countries for greenhouse gas emission reductions. In the first place before moving to compensations there are several steps to be taken, in one of them the governments are be required to develop a strategy to protect their forests. For that there need to be information of the existing forest. Among some donor countries Finland has agreed to contribute the UN-REDD programme.

Finland has during recent years carried out inspection of its international boundaries with Norway and Sweden and the inspection with Russia is going on at the moment. In Europe EuroGeogarphics has launched a project to create a data bank of European international boundaries. Similar activities to clarify international boundaries are also on the other continents. African Union has an ambitious goal to clarify all the African international boundaries, and in Asia for example countries in Far East have been active in the demarcation and reaffirmation of their boundaries.

**New Finnish nationwide elevation model incorporating laser scanning**

By Heli Laaksonen

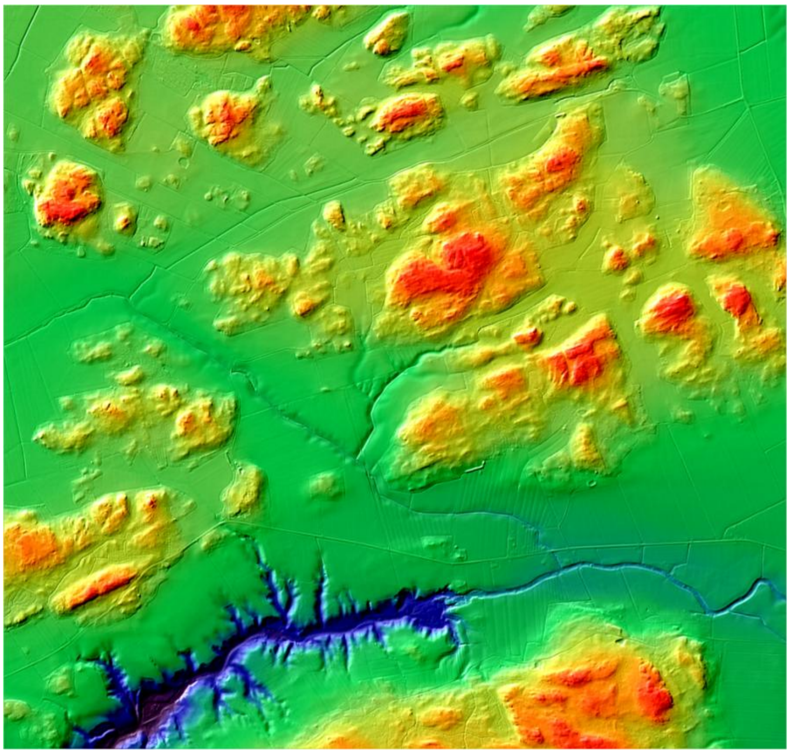
The National Land Survey of Finland started the production of a new nationwide elevation model in 2008. The new elevation model has been calculated to a frame size of two metres, and its elevation precision is 30 centimetres. This is a significant improvement compared with elevation models previously produced by the National Land Survey. The old elevation models have been produced for the most part photogrammetrically and calculated to a frame size of 25 or 10 metres. Currently, elevation information is obtained by means of laser scanning technology.

The advantage of laser scanning is its ability to generate reliable earth surface elevation data also over forested and shadowy areas beneath the trees and other vegetation. The best scanning period from the perspective of elevation model production is, however, early spring or late autumn, when the leaves of trees and brushwood do not cause elevation errors.

Nevertheless, the amount of light and minor defects in the weather conditions do not limit scanning: rather, the work can also be performed in the dark. This is a significant benefit at Finland’s lines of latitude in acquiring elevation and surveying information. The new generation laser scanners enable an increasingly higher flying altitude, when surveying work embracing the entire nation can be carried out in a cost-effective manner.

The National Land Survey of Finland orders laser scanning services from subcontractors. Laser scanning is performed at an elevation of approximately 2000 metres. Point density is, at minimum, half a point per square metre. The calculated distance of the points from each other on the earth surface is, in this case, 1.4 metres. In targeting unambiguous surfaces such as asphalt, 15 centimetres with respect to the specified elevation is the elevation precision requirement, and it is 60 centimetres at level.

With reference to the first production years, the precision requirements can be regarded as having been well-realized. Automatic earth surface classification is performed for the laser scanning data, i.e. for the point cloud, in which the points representing the earth surface are classified in their own point class. Success in the classification of these points is visually inspected by means of aerial stereo photographs prior to the calculation of the general elevation model.



*A conceptual image of a calculated elevation model applied to the new two-metre frame size. The elevation models are calculated for map sheet distribution. The area of the map sheet in the image covers nine square kilometres. The area is situated in Southwest Finland. How even the small riverbeds and ditches can be distinguished in smooth terrain as well can be seen by means of the new elevation mode*

**Benefits to many from the new elevation model**

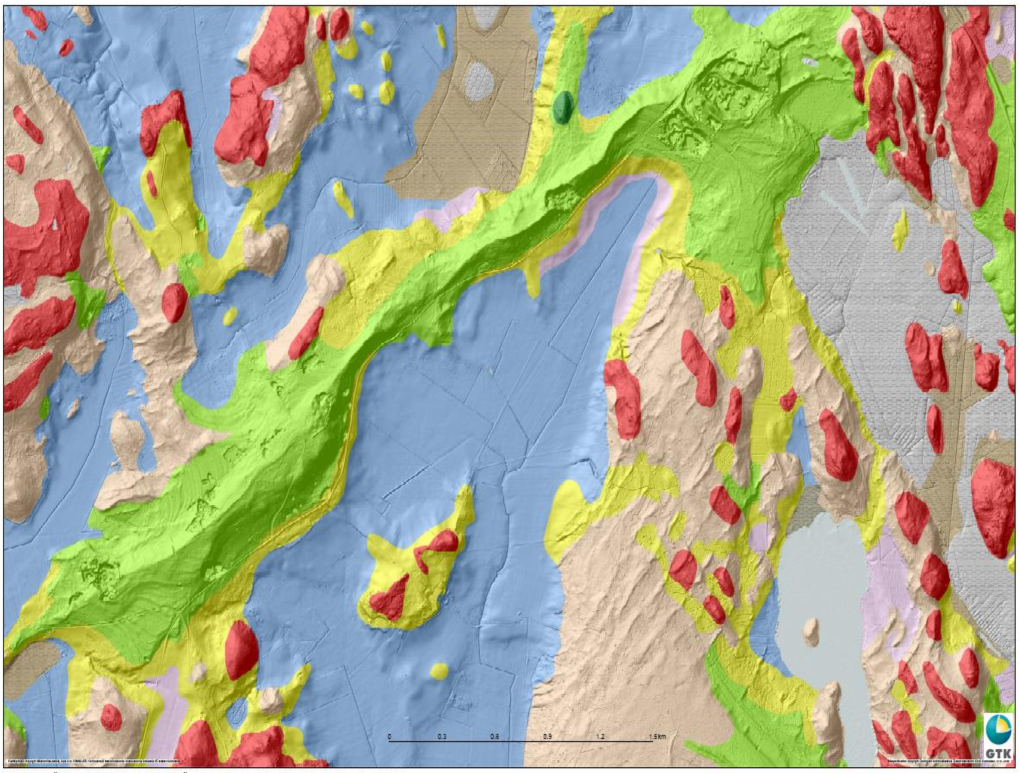
A more precise nationwide elevation model is required in the planning of many varied functions in the community as well as preparing for exceptional conditions. During the first years, elevation model production has given particular emphasis to areas susceptible to floods. In the spring of 2008, laser scanning areas totalled approximately 25,000 square kilometres, and in 2009 the total surface area of the areas came close to 30,000 square kilometres. The largest part of these production areas is located within the vicinity of the coast and the largest rivers.

The new elevation model enables more exact modelling of flood conditions as well as visualisation on a map foundation. The production of flood maps also represents preparation for the evidently increasing prevalence of floods as a result of climate change and the potential future rise in the sea level. By means of flood maps, it is possible to issue guidelines for construction in safe areas and formulate rescue plans that must be made against the potential threat of floods.

Elevation information can also be beneficially utilised in many other functions aimed at environmental protection, such as the modelling of overland flow. Rain waters rinse accompanying damaging chemicals from the fields into nearby waterways. Harmful agents from a capsized transporting vehicle result in a threat to the purity of the groundwater. By modelling the flow of waters, it is possible to target anticipatory measures correctly.

In addition to the elevation of the terrain, it is feasible by means of laser scanning and the elevation model to examine various small earth surface forms. Laser scanning data as well as the new elevation model can be utilized in many types of applications studying the ground and land surface.

Exact elevation information on the terrain is also important in designing various structures. For example, having the correct elevation data for high buildings and masts in close proximity to airports is crucial in planning flight routes. In landscaping projects for dumpsites and designing noise barriers for large motorways, earth surface elevation information in addition to the structures interpreted from laser scanning data facilitate and accelerate the planning work.




MAAPERÄKARTTA YHDISTETTYNÄ LASERKEILAUSAINEISTOON 1 : 5 000

*Image: a map made by the Geological Survey of Finland in which the laser scanning data generated by the National Land Survey of Finland have been combined with a land map. The gravel pits in the esker can be located and measured, and the small terrain forms can, by means of the laser scanning materials, be delineated better than before – also in wooded and otherwise covered areas.*

The three-dimensional point cloud generated with laser scanning technology is also beneficially exploited in, for instance, the forest industry and forest research, route formulation connected with various gas pipes and cables, the determination of terrain-based navigability and visibility in the defence forces, and in the planning of various recreational areas such as golf courses.

The new nationwide elevation model production lines will remain similar in 2010 as well. The regional prioritisation of elevation model production is being steered by the cooperation group led by the Ministry of Agriculture and Forestry, whose comprehensive social representation enables the consideration of many varied needs and points of view in planning the continuation of elevation model work.

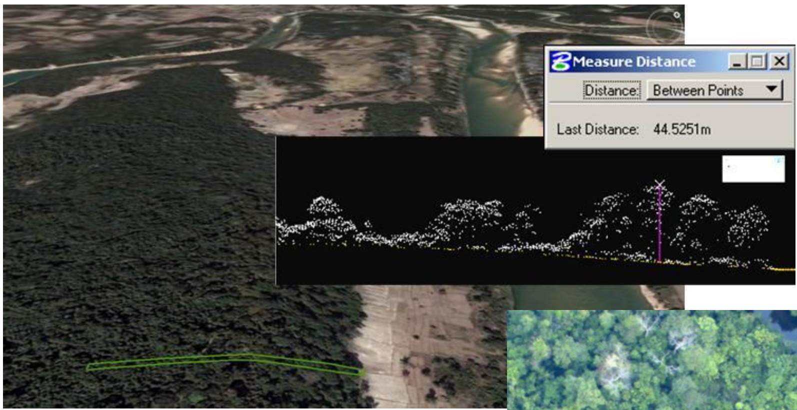
## REDD, Energy and Spatial Data Infrastructure

By Veikko Jantunen

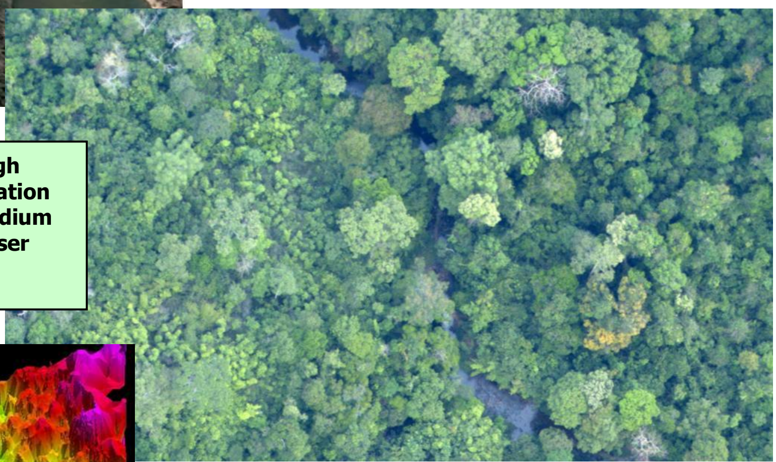
There are several globally initiated efforts to address climate change caused by deforestation and forest degradation by compensating developing countries for greenhouse gas emission reductions. In the first place before moving to compensations there are several steps to be taken, in one of them the governments are be required to develop a strategy to protect their forests. For that there need to be information of the existing forest. Among some donor countries **Finland** has agreed to contribute money to the facility in REDD (*The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries*) and is also active in energy sector.

### REDD

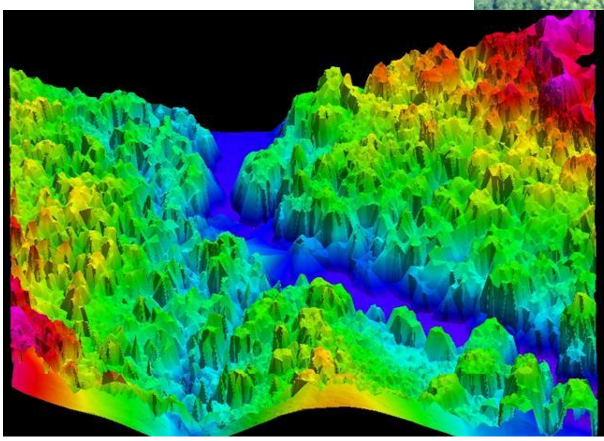
As a result there has been a pilot project to establish the volume of biomass within a selected area in Laos. Comparison to previously established field surveys is going on, but it is clear that airborne laser scanning with precise positioning facility (GPS & IMU) will be the future way to establish biomass volume. The data is recorded in national coordinate system attachable to national spatial data infrastructure. Along with the laser scanning it is possible to obtain REAL high resolution digital images contributing to the forest development strategy that is needed prior to sound carbon initiatives.




**Crosscut of natural forest on a single flight line of an aircraft with Lidar laser camera in Southern Laos**



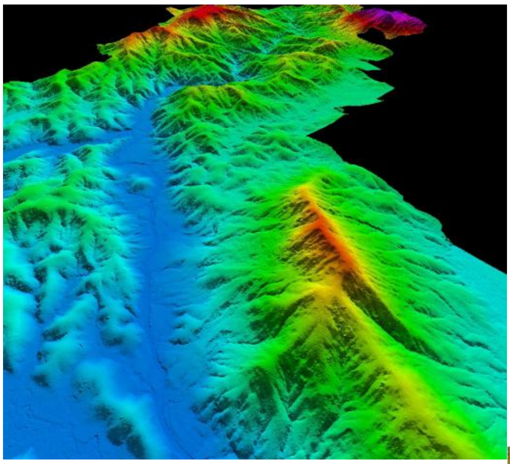
**Orthophoto mosaic compiled of *REAL high resolution digital images, with flight elevation 1200m, using RCD-105, 39 Megapixel medium size digital camera attached with Lidar laser scanner over tropical forest in Cambodia**



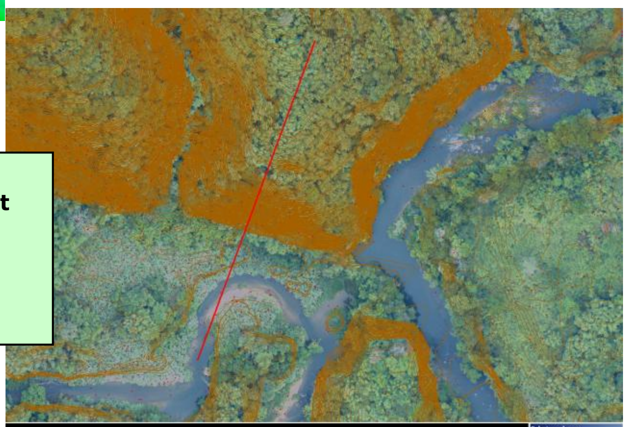
**River valley tropical forest in biomass estimation process processed after Lidar laser scanner flight in Cambodia**

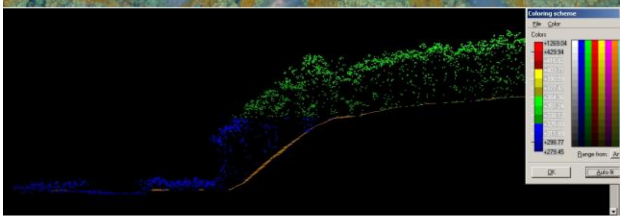
**ENERGY**

Finland is also participating in Energy Planning Development within the Mekong Region. A recent laser scanning project in Cambodia shows digital terrain model and REAL high resolution aerial images. The scanning provided 20cm elevation contours of the hydro reservoir helping to establish the water volume and the flight over the area digital images with 11cm resolution for an orthophoto that can be used to map the planimetric details, such as waterways, roads, villages and most importantly cultivated fields and orchards that are sparse and therefore important for the livelihood in mountainous terrain and may need to be compensated along the hydro planning process.



**Digital terrain model of a mountainous river valley planned for hydro power development**





**Cross-section shows the ground level and the height of the tropical vegetation above the ground level. Brown lines are 20cm contours**

**SPATIAL ENABLEMENT**

In the aerial survey projects for biomass determination and for the hydro power reservoir the survey flights were done using GPS and inertial measurement unit (IMU) integrated with an aerial camera and/or Lidar laser scanner. This method reduces the numbers of ground control points and makes the geo-referencing of imagery more direct and fast. It also makes the compilation of orthophoto mosaic faster. Therefore all the works and end results will be in coordinate system compatible with other spatial data.

## Towards technically sustainable approach in REDD and detailed design as part of SDI

The pictures of the recent projects show how to obtain volume of biomass, how to provide tools for sustainable forest management and to reduce forest degradation based on detailed information for planning and how to have detailed elevation models for better planning of hydro power, flood control and livable settlements. These methods can be applied in climate change monitoring.

There seems to be an understanding that participation in ***carbon trading*** requires established data of the volume of biomass. The mechanism is still being developed, but at this stage after pilot studies of FINNMAP[1] in ***Laos and Cambodia***, it can be said that laser scanning / digital images is highly recommendable method for that. It can reliably establish the volume of biomass and is very useful for forest management and provides a detailed digital elevation model of the terrain with useful information of access in difficult terrain.

Laser scanner goes normally with *REAL* high resolution digital camera (39 Megapixel or more). The images and the first step of the mapping product (after processing the data) – an orthophoto mosaic- seems to be most useful. All this data will contribute to the topographical mapping, forest inventory, cadastral indexing, land use planning, hydro project design, and naturally to the ***Spatial Data Infrastructure***.

**FINALLY**

Knowing the limitations of small scale images in providing enough horizontal resolution and especially vertical accuracy which is often crucial, aero controlled laser scanning and digital aerial photography will provide feasible solution.

We can confidently look into future with well improved information that can support not only carbon trading initiatives but also designs of hydro power facilities, flood control and management and land use planning within the best practises.

Today Lidar laser scanner is the only device that can identify forest degradation and changes in land use.

INSPECTION OF THE FINNISH INTERNATIONAL BOUNDARIES
By Pekka Tätilä

According to the international Law, the sovereignty of a state includes three basic elements: 1) a permanent population, 2) a defined territory and 3) an own government and a legislation. The defined territory means agreed and recognized international boundaries with neighbouring countries.

The birth of a boundary is normally based on an agreement between two countries. The boundary has to be delimitated after the agreement. The final phase in the boundary making is the demarcation in which the boundary is marked on the field.

In many cases the demarcation has been carried out a long time ago and conditions on the boundary have changed since. Therefore it is needed to carry out a boundary inspection – a reaffirmation – from time to time, in which two neighbouring countries check their boundaries and update the boundary documentation.

Finland has a mechanism to make a boundary inspection every 25th year with Norway and Sweden and latest inspections have been carried out in the year 2000 and 2006. There is going on a comprehensive technical boundary inspection with Russia at the moment, and it will be finalised in the year 2011.

## Early regular boundary inspections

Under a proclamation issued by states in 1847, the boundary between Finland and Norway should be demarcated every 25 years. The required boundary inspection has taken place in 1871, 1896-97, 1925, 1950, 1975-76, and in 2000. The agreement about ordinary inspections between Finland and Sweden has been made in the early 1900s and inspections have been carried out according to that in 1956, 1981 and 2006. The Finnish-Russian boundary has been inspected in the 1930s and partly demarcated in 1940. The boundary between Finland and Norway is 736 km long, between Finland and Sweden 614 km and between Finland and Russia 1340 km.

## The basis of the inspections

When the inspection begins, both countries appoint delegations to carry it out. Normally the members of the Finnish commission come from National Land Survey and from the Border Guard. Both countries' foreign ministries will issue similar instructions to their delegations. According to the instructions, the purpose of the inspection is to check, measure and document the line of the boundary in the terrain and to ensure that the boundary is marked and determined in an appropriate and explicit manner.

The instructions also state that the boundary going from a point to the next point should run according to the previous boundary documents.

Moreover, in the latest inspections countries have agreed that the coordinates of the boundary marks and other boundary signs should be determined in accordance with the pan-European EUREF89 coordinate system.

## Inspection proceedings

Within the latest inspections the most laborious work on the land boundary has been the measurement of the modern coordinates for all the boundary pillars totalling some 1800 in the boundaries with three neighbouring countries of Finland.

Because the Finnish-Swedish boundary is almost fully a river boundary and also one third of the Finnish-Norwegian boundary is on the river, the task is to find there the thalweg which the boundary follows.

As part of the inspection proceedings, orthophoto maps or maps based on an aerial photography of the boundary are produced. The maps covering the land boundary are at a scale of 1:50,000 on Finnish-Norwegian boundary, while the maps of the river boundary on Finnish-Swedish and Finnish-Norwegian boundary are at a scale of 1:20,000. The new Finnish-Russian boundary maps will be at a scale of 1:25000 according a modern international scale standard.

## Conclusion of the inspection proceedings

Normally at the end of inspection process the two delegations sign the boundary documents. The documents are 1) Boundary protocol; in Finnish, 2) Boundary protocol; in Norwegian, Swedish or Russian, 3) Boundary mark protocols and 4) Boundary maps. The documents are also stored into a CD in digital form.

The boundary protocol contains the minutes of the final meeting, boundary agreements, details of the previous inspections, and a comprehensive report of the actual inspection.

Each boundary mark protocol gives the coordinates of one mark and its distance to adjoining marks, a drawing of the symbols engraved in the stone on top of the boundary mark, a drawing showing the location of the auxiliary marks, and other information about the boundary mark.

Boundary maps show the line of the boundary, boundary marks and their numbers, and other boundary signs. The maps, which are based on aerial orthophotos, also show contours and the nomenclature.

## Approving the results

The proposal unanimously supported by both delegations is then approved by State organs in both countries - – in Finland by Parliament. After that the final agreement is validated by exchange of notes between the two countries. This means that the boundary arrangements between the two countries as agreed in the inspection proceedings will remain in effect until the next regular boundary inspection.

## EuroGeographics initiative

The organisation of the European Mapping Authorities - EuroGeogarphics - has launched a project to create a data bank of European international boundaries in the year 2005. The aim is to collect a comprehensive data set of agreed boundary points. The coordinates of all the points should be stored in common ETRS - European Terrestrial Reference System. The data model includes also many attributes, for example original Agreements and contact information of the organisation which is taking care of boundary in respective country.

To finalise the data for the whole Europe will take years because reaffirmation has to be done for many boundary sections. The present data has been collected a long time ago and is based only on old and small scale topographic maps in many cases. Therefore modern satellite measurements are needed and countries have to agree about this data mutually before storing it to the data bank of EuroGeographics.

There are similar activities to clarify international boundaries on the other continents beside Europe. African Union has an ambitious goal to clarify all African international boundaries before the year 2012, and for example countries in Far East have been very active in demarcation and reaffirmation of their international boundaries.