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ICC 2019 SPECIAL ISSUE

Finland to have the most innovative and the safest geospatial ecosystem in the world

GEOPORTTI – HIGH-PERFORMANCE GEOCOMPUTING FOR RESEARCHERS

BENEFITS OF USING GEOSPATIAL DATA IN FINLAND – ALMOST 80% STILL TO BE REALIZED

Finland took a long bold leap

PHOTO: JULIA HAUTOJÄRVI

Spatial data is typically a requirement for different service products, rarely a service product in itself, such as a navigation service. By combining spatial data with other data, it is possible to produce a broad range of new services, such as Mobility as a Service (MaaS) and virtual reality services, to build a pollution spread model or to analyse optimal locations for social and healthcare services using population and public transport data.

The development of spatial data needs to be seen as part of customer- and service-driven societal development. In Finland, Prime Minister **Juha Sipilä**'s government programme of 2015 selected the digital public service as one of its leading projects. The goal was to produce cross-governmental electronic services by changing operating processes using new technologies and, if required, lighter regulations. Having digital services requires much more than converting them into electronic format. The Geospatial Platform Project is a development project aimed to build a shared geospatial platform for public organisations, providing shared specifications and services for data producers in the public sector, shared and harmonised data for all users and shared user services. The Geospatial Platform Project is based on material provided by different data producers. It is part of the spatial data ecosystem of the future. The first phase of the project will be completed in 2019.

The development of spatial data requires a shared view of the future. Even though there is no single correct overview, we need certain guidelines. The report on spatial data policy was also kickstarted by Prime Minister Juha Sipilä's Government Programme. Never before have parliamentary guidelines on the future of spatial data been made in Finland. Parliament unanimously accepted the report presented by the Government at the end of November 2018. According to the report's vision, Finland will have the most innovative and the safest spatial data ecosystem in the world. To make this vision come true, we need to take a number of actions to ensure the better availability of our address data, to build a shared geospatial platform for the security sector and to amend our legislation to safeguard development. The report steers development beyond the terms of government office holders.

The quality of data has always been a key requirement in terms of spatial data – be it the integrity of data, or its accuracy or coverage. Even though more spatial data is continuously being created, we already have massive amounts of still relevant data in our registers. We need to be concerned over the quality and usability of this data, since replacing this data with new data is not financially or functionally feasible. Let's stay reasonable.

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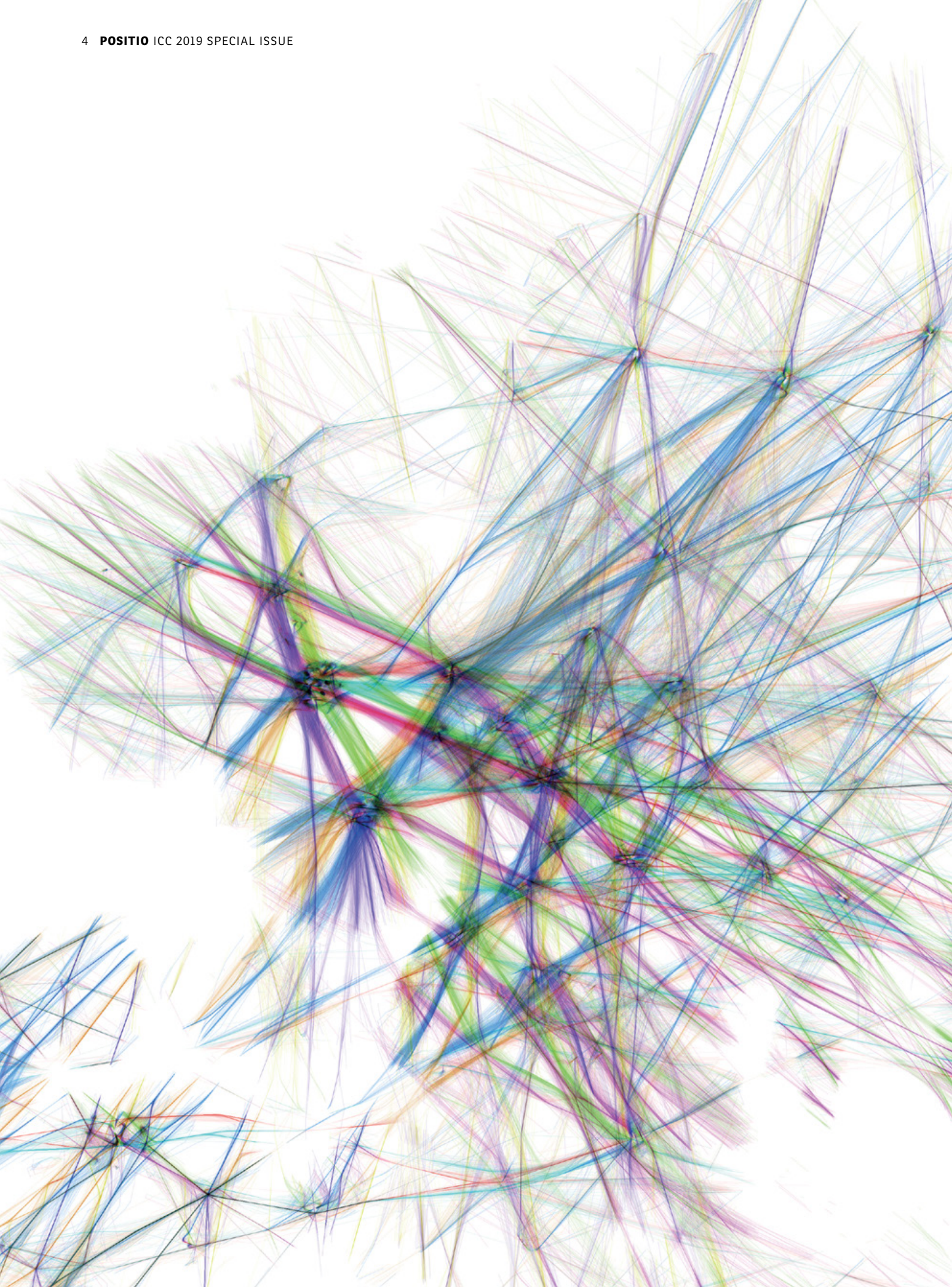


Geoportti brings refined geodata and high-performance geocomputing within reach of researchers

Geoportti's goal is to expand the use of geospatial data to different fields of research.

JUHA OKSANEN & LAURA PURANEN

Research that makes use of geospatial data and develops methods of geographical information science is in a state of constant flux. The amount of open spatial data has increased exponentially, while material collected by means of crowdsourcing, sensor data collected using various platforms and completely new kind of data, such as geotagged social media contents, have arisen alongside officially collected geospatial data. What is more, the availability and usability of data have improved significantly because of the developed spatial data infrastructures (SDIs). Commercial software solutions are now accompanied by high-quality and free open source geospatial tools. Even though the general situation in the field is good in this respect, scientists continuously voice how research could gain more benefits from geospatial data and geoinformatics methods and how they could be used in more effective and usable ways.

These needs were fulfilled in spring 2019 when the Geoportti.fi site was opened for all researchers in Finland who use geospatial data. The site brings together value-added material available in the national SDI, key tools for processing geospatial data and a group of instructions and training material users can find suitable for their geospatial data processing needs. The site will also include instructions on how geospatial data included in the Taito supercomputing environment of CSC – IT Centre for Science Ltd can be processed using tools already installed in the environment. The Geoportti.fi website has been built by the Open Geospatial Information Infrastructure for Research (oGIIR) project. Its participants include research institutions and universities.

The goal of the oGIIR project is to build a structure based on user-friendliness and open access to support the Finnish research community and to boost research in the geospatial sector. Its target group consists not only of researchers of geoinformatics, as the goal is to expand the use of geospatial data to different fields of research. What makes the project highly significant is that it works beyond university- and educational institution-specific boundaries. As part of the ground-breaking project, CSC's computing resources were made available for the research institutions that belong to the oGIIR consortium. Universities have already had access to these resources before. In 2017, the Ministry of Education and Culture, together with research and innovation parties, confirmed the 2017–2021 development project for research infrastructures for data management and computing (DL2021). This opened access to CSC's computing resources for all research institutions and has

increased the significance of oGIIR in providing seamless national geospatial data and analytical tools in a high-performance computing environment. As a result of the DL2021 programme, the opportunities of oGIIR will improve even further as, for example, CSC's supercluster will be updated in 2019–2020. After the update it will be the most powerful system in the Nordic countries, with a theoretical peak performance of 11 PFLOPS (1 PFLOP = 1,000 billion floating point operations per second) and a storage capacity of 12 PB (1 petabyte PB = 1,024 terabytes).

In addition to the Geoportti.fi site, key products and services of the oGIIR project by the end of 2019 include the material of the Paituli service of CSC mirrored in the Taito supercomputing environment and a group of seamless country-wide geospatial data, such as the 2013–2015 national forest inventory of the Natural Resources Institute Finland (Luke), all open access data of the Finnish Environment Institute (SYKE) and the National Land Survey's LIDAR point clouds, elevation models defined as virtual rasters and the monthly updated topographic database that is grouped according to themes. The Taito supercomputing environment also includes a group of regular pre-installed processing tools for geospatial data, such as GDAL/OGR, GRASS GIS, PDAL, Proj. 4, QGIS, SagaGIS, SNAP, TauDEM and Zonation, as well as R and Python with general geospatial libraries.

In the project, the Finnish Geospatial Research Institute has also developed the GeoCubes Finland, which pilots the management, analysis and visualisation of spatial data by means of data cubes. It contains a number of technically harmonized multi-resolution country-wide geospatial datasets, as well as application and service demonstrations for the use of data cubes. In addition to CSC's supercluster, the infrastructure provides access to the cPouta cloud service, which enables setting up of complete computing environments and online services to be built for research purposes. With regard to training, oGIIR offers ready-to-use lecture material, documents of best practices and tools for the evaluation of geospatial expertise. ESRI has provided full ArcGIS licence packages for members of the consortium. In addition to geodata, geocomputing and training services, oGIIR will offer UEF Drone Labs services, headed by the drone mapping unit of the University of Eastern Finland. The content of the service will be specified during 2019.

The oGIIR project is funded by the Academy of Finland and the members of the consortium. The Academy of Finland offers specific funding for research infrastructures which can be applied for in order to establish nationally significant research infrastructures or to strengthen and expand already existing infrastructure services. The oGIIR project has been on the Academy of Finland's FIRI roadmap since 2014, under the status of a potential infrastructure. The Geoportti services are intended for free use within the scientific community. The only condition, in addition to the licence required for the CSC environment, is that the oGIIR project is mentioned in conjunction with scientific results (e.g. "We made use of geospatial data/computing resources provided by the Open Geospatial Information Infrastructure for Research (oGIIR, urn:nbn:fi:research-infras-2016072513)").

GEOPORTTI.FI

Geoportti.fi is a new portal for oGIIR research infrastructure services. It helps researchers access to data and metadata services of the national spatial data infrastructure, to CSC's high-performance geocomputing services and to lecture and other training material created in the oGIIR project.

geo portti | Finnish Geospatial Research and Education Hub

Open Geospatial Information Infrastructure for Research (oGIIR) is a research infrastructure project for which the Academy of Finland has provided FIRI funding. Members of the consortium are professor Juha Oksanen (coordinator, Finnish Geospatial Research Institute in the National Land Survey of Finland), professor Risto Kalliola (deputy coordinator, University of Turku), Pekka Lehtovuori (CSC – IT Centre for Science Ltd), professor Kirsi Virrantaus (Aalto University), professor Alfred Colpaert (University of Eastern Finland), Sirpa Thessler (Natural Resources Institute Finland), Saku Anttila (Finnish Environment Institute), and research professor Vesa Nykänen (Geological Survey of Finland). Until December 2018, the consortium's coordinator was professor Tapani Sarjakoski (Finnish Geospatial Research Institute). Research infrastructures are large systems that consist of tools, equipment, data networks, databases and other material, as well as support services built around these.

Finland to have the most innovative and the safest geospatial ecosystem in the world

ARVO KOKKONEN

A recent Finnish Report on spatial data policy aims to steer governmental activities so that Finland would have the best-functioning geospatial data infrastructure in the world. The quality of Finland's spatial data functions is high on an international level. However, this does not mean that we can rest on our laurels. We have a lot of work ahead of us in order to fulfil the vision drawn in the heading of this article.

The starting point of the report is that data material, services and processes should be developed so that we could know how to use and understand why to use spatial data in Finland in the most innovative, effective and safest way in the world.

Making maps continue to be an important means of using spatial data. However, focus has shifted towards exploitation of the spatial data. Spatial data is mainly needed by parties who process it further. Users ask for processed spatial data analyses, services and products. It has been said that users do not need to know what data and analyses have been used to produce the analysis results they are using. It is sufficient that users can rely on the results or products being reliable and correctly made.

Then again, it is easy to make incorrect analyses using data, and possibly even easier using spatial data. Perhaps it would be better to know after all!

Key material from discussions with stakeholders

The vision and proposed actions of the Report on spatial data policy have been shaped as a result of discussions with a large group of stakeholders. These discussions were mainly carried out as face-to-face interviews, meetings, workshops and seminars primed by brief introductions. Four sub-reports were prepared for the report (http://mmm.fi/paikkatietoselonteko/osaselvitykset, available in Finnish only). Some 300 people participated in both interviews and workshops.

The sub-reports aimed to find answers from representatives of three target groups to the question of how the best possible system of spatial data functions can be built considering Finnish society. Another goal was to obtain an overview of roles and responsibilities in the public sector. Furthermore, the sub-reports aimed to identify any challenges and problems related to spatial data functions and to seek solutions, as well as proven practices and methods.

The target groups of the sub-reports were the business sector, the public sector, education and research. The fourth sub-report sought answers to the question of what are the effects of technological development on spatial data functions in Finland.

CONCEPTS USED IN THE REPOT ON SPATIAL DATA POLICY

- "Spatial data" covers all data that carries location as an attribute.
- "Spatial data ecosystem" means a system of spatial data and services that is developed and maintained in multi-disciplinary cooperation and that has pre-defined financial responsibilities.

Exploitation of spatial data through development actions

The Report on spatial data policy provides the Government with information about how spatial data can be used to develop the functioning and safety of society and the operating conditions of companies.

Development actions are key parts of the report. They help to pave the way for new and innovative business based on the use of spatial data, to make citizens day-to-day activities easier and to improve the efficiency of the public sector.

The preparation of these development actions will start at the beginning

of 2019 in cooperation with stakeholders. However, actual development cannot start until after the 2019 parliamentary elections when the new Government has been appointed.

Six parliamentary committees were exceptionally unanimous in supporting the guidelines and actions of the report. The committees obtained a total of 100 expert statements to support their work. The Report on spatial data policy was approved without any remarks in a plenary session on 29 November 2018.

Security more important than before

The increasing importance of internal and external security and the protection of personal data in the increasingly digital world have been addressed in the Report on spatial data policy. This applies to spatial data, in particular, because it is easy to combine together to make data combinations that put the protection of personal data or the general security at risk. In addition, different devices can be used to collect data from areas of which it is illegal to collect data. All data-related development actions need to pay more attention to the comprehensive security of the society and the protection of personal data.

In January 2017, the Ministry of Agriculture and Forestry established a project to prepare the Report on spatial data policy for setting guidelines for the development of spatial data functions in the public sector.

The Report on spatial data policy is available in English, Finnish and Swedish at mmm.fi/paikkatietoselonteko.

DEVELOPING THE SPATIAL DATA ECOSYSTEM

ENSURING HIGH-QUALITY ADDRESS DATA

National address data need to be corrected quickly in cooperation with different parties. The maintenance process for address data needs to be corrected in order to reduce the number of new errors. Any special needs of the security authorities need to be addressed.

ACCESS TO ACCURATE POSITIONING FOR ALL

The national FinnRef positioning correction service that enhances satellite positioning must be offered to be openly available for future positioning and logistics services. This is vital considering the development of autonomous transport. The comprehensive security of society needs to be addressed when providing the open access service.

BUILDING A COMMON SPATIAL DATA PLATFORM FOR ALL SECURITY AUTHORITIES

The security authorities have a number of common special needs related to spatial data sets and products. We need to build a common spatial data platform to fulfil these needs. For example, common-to-all and up-to-date spatial data products are needed to build an overview for the security authorities.

DEVELOPING A COMMON SPATIAL DATA ECOSYSTEM

We need to accelerate cooperation between different parties, both in the private and the public sector, for networking spatial data functions into a shared data and service system. Cooperation between different sectors will increase as a result of digitalisation. This forms the basis of the ecosystem and supports the improved efficiency of functions, harmonised data and the development of services and business operations.

MORE EFFICIENT COOPERATION VIA A NEW COOPERATION BODY

The efficiency of extensive cooperation between different sectors needs to be improved by developing an existing organisation or by establishing a new organisation. Its purpose will be to promote the use of spatial data, to develop business activities and related opportunities, and to increase knowledge and awareness of the potential of spatial data.

ENHANCING KNOWLEDGE AND EXPERTISE ON SPATIAL DATA

The efficient use of spatial data is slowed down by the lack of expertise and awareness regarding its potential. To fix this situation, spreading of information and activities that highlight spatial data and the benefits of its use will be encouraged at all levels of education and in all types of organisations.

LEGISLATIVE REFORMS TO ENSURE DEVELOPMENT

The legislation needs to be amended, for example, by defining key spatial data resources considering society and by defining roles and responsibilities related to the spatial data functions of public organisations. Furthermore, we need to obligate all authorities to produce and distribute key spatial data in an interoperable format, . Security aspects related to spatial data need to be specified, including information security, holistic security of society and the protection of personal data.

Beer and maps

Charity without any commitment, game-like activities and meeting like-minded people – there are many motives for voluntary mapping.

KATRI ISOTALO

I have walked with old people outdoors, but I'm not familiar with doing mapping for charity. Well, I'm not familiar with mapping in general. However, I boldly step inside a pub in Helsinki with my laptop where a HOT Beer and Maps event is about to start. It doesn't mean that they serve hot beer – HOT stands for Humanitarian OpenStreetMap Team.

About a dozen map professionals or students and a couple of newcomers like me are present. One of the new faces is a Nepalese student of environmental engineering and the other is an active user of OpenStreetMap (OSM) data.

First, I log in to OSM (openstreetmap.org), the Wikipedia of maps. Next, I'm instructed to go back to tasks.hotosm.org. It offers areas from different parts of the world for which maps are needed. The Tasking Manager tool makes sure that only one person is mapping one area at a time.

Our group selects an area close to Can Tho, a town in Vietnam. It is not a disaster area, but it needs to prepare for the flooding Mekong river. Eduardo Gonzales, who recently returned from Vietnam where he led a forest information project of the Ministry for Foreign Affairs, speaks about the area.

I select one easy-looking grid from the target area on my screen, after which I can access a Bing satellite image. It shows only a few buildings and

irrigation ducts. Someone has already mapped a larger channel that travels across the grid. Towns with their many buildings, as well as special terrains, should be left for more experienced users.

There are various editors to use. I decide to use iD. It is intended for beginners, but I still manage to make a big error: the irrigation duct which I'm mapping is shown as a dashed line, not as a continuous network. Luckily, **Vuokko Heikinheimo**, who is sitting next to me, sees this, and helps me to correct my error. Properties must also be defined for mapped areas. It is easy to select a classification for an irrigation duct from the menus. However, I've heard that the classification of African roads, for example, is not easy for Finnish users.

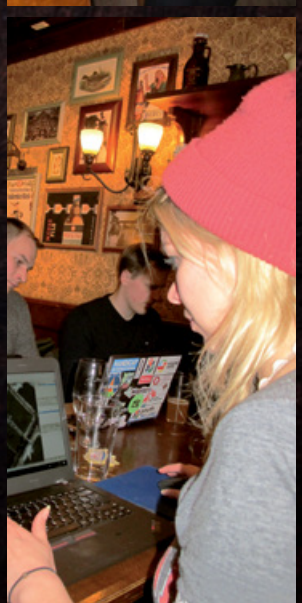
Routes for vaccination campaigns and landings sites for helicopters

Around the world, HOT events among OSM users started some ten years ago. Voluntary mapping became a busy activity in 2010 when volunteers aimed to help rescuers after an earthquake in Haiti. The mapping needs of voluntary associations are coordinated, for example, through the Missing Maps project. HOT is one of its founding members.

In Finland, general interest towards humanitarian mapping increased after an earthquake in Nepal in 2015, and regular HOT events have been held in Helsinki since autumn 2015. When the name of voluntary Mapathon meetings was changed from OSM coffee events to OSM beer events, the number of participants increased directly. In addition to voluntary meetings on Thursdays, the HOTOSM group has held larger and more organised Mapathons with the Red Cross, among others.

When a real disaster strikes, volunteers from all over the world map the area in just a few hours. This is why HOT events, held in Helsinki every two weeks, focus on less urgent areas.

In principle, anyone can propose an area to be mapped using the Tasking Manager tool. However, these areas are often proposed by the Red Cross, Doctors without Borders or any other local humanitarian organisation. The mapping request indicates what areas should particularly be mapped. If there is a flood, data is needed about rivers and inhabited areas, whereas roads and villages need to be mapped for vaccination campaigns. In disaster areas, data about suitable landing sites for helicopters is also valuable.



Crowdsourcing is a productive source

In one hour, I'm able to map two irrigation ducts and two buildings. What I learned is that the laptop mouse is not a good tool. However, mapping does not require any special equipment or a gaming computer. But what if mapped areas are classified incorrectly? What if a garden shed is classified as a residential building, or vice versa?

To my relief, I'm told that a local or at least a more experienced cartographer always validates the work of remote users. Grids to be mapped have been colour-coded to indicate whether the particular area is unmapped, mapped and/or validated.

Even though a couple of irrigation ducts seem like a modest result, Vuokko Heikinheimo consoles me by saying that now it's done and no-one else needs to do it. She says that she started by spending 20 hours mapping roads and inhabited areas in Mozambique for a cholera vaccination campaign. She realised that 20 people would have been able to do the same work in one hour!

An alternative for facebook

Everyone can do this at home. However, the participants in the HOT event agree that it's more fun working together. You can always ask for help from the person sitting next to you, and you can get to know other like-minded people.

"This is a good way to be useful without being overly committed", says **Pauliina Jalonen**, describing her hobby.

"Most importantly, this makes me feel better than spending a couple of hours on Facebook", Vuokko Heikinheimo continues.

Erno Mäkinen also believes in the power of competition. The statistics of each mapped area shows how many grids or square kilometres each user has mapped. The Missing Maps site even includes a leaderboard that lists the most active users. However, just mapping simple field areas isn't enough; the content of each grid also matters.

If the available space doesn't limit the number of participants, HOT events are open to all, in Finland and everywhere else. Events in Helsinki are advertised on Facebook. (www.facebook.com/groups/hotosmfi/)

The HOTOSM group encourages everyone to launch mapping events in other parts of Finland and helps everyone interested to get started.

QGIS raises interest among cities

QGIS challenges established software in management of municipal spatial data

SANNA JOKELA

Currently, open source software produces a large part of digital services in the public sector. In terms of spatial data, QGIS is the most advanced and globally the most widely used desktop GIS software. Currently rising numbers of Finnish cities and towns have added QGIS to their personnel's toolkits. How has this been done how do organisations use and maintain the QGIS software?

For ten years already, City of Tampere has been building a spatial data management system that is compatible with the national spatial data infrastructure. In addition to being able to transmit geospatial datasets via interfaces inside and outside its organisation, Tampere has integrated user management into an Oskari based map service (Oskari is also open source software originally created by the National Land Survey of Finland). According to **Marko Kauppi**, former leading senior planning officer in the City of Tampere who is currently working at Ubigu Ltd, a role-based approach makes it possible to allocate organisation-specific material to the right people and to build user-specific views. As data volumes are high, unnecessary work should be avoided and finding the correct data should be easy. Tampere's goal is that users only need to save data once and that all centralised data is available to all processes for different needs.

Tampere deployed the QGIS desktop software because of cost savings and its versatility. The aim was to distribute the management of spatial data reserves throughout the organisation. In this respect, QGIS has proven to be the best tool. QGIS supports the use of OGC compatible GIS interfaces and enables the easy management of data through database connections. It is also possible to produce visualisations for to the GeoServer map service engine using QGIS.

"Previously, we just hoped that it wouldn't crash. Now, it's a ready-made product. During the past two years, QGIS has taken huge leaps forward", says Marko Kauppi from the City of Tampere.

In Tampere, it is now easier to produce data, as users can directly maintain databases using QGIS. In addition, the volume of data made public has increased significantly. In this decentralised model, the skills of the users have an impact on the quality of data.

"An incorrectly modelled data structure is a challenge that causes problems in service interfaces. We need to have detailed instructions and trained users, and our organisational

IMAGE: TOPI TJUKANOV, GISPO LTD.

culture must support our operations. Of course, it's always possible that we forget something, regardless of training", Marko Kauppi says.

Unknown software without any licence problems

In Helsinki, the story of QGIS started three years ago when users wanted to use the software. After some mental briefing, the city officials decided that this unknown software would be a good addition. Licence policies used to cause headaches every year, which at worst meant that not everyone was even able to use spatial data software.

"Using free and open source software, no licences are needed. On the basis of the feedback, it seems that the use of QGIS has started nicely. Training is of course needed. Starting to use QGIS has been easy for new employees", says **Outi Hermans**, special planner in the City of Helsinki.

Kauppi and Hermans both mentioned city planners as one user group that has special needs due to the complex visualisation of geospatial datasets.

"Here, city planners, in particular, have enjoyed the diverse visualisation options of QGIS", Kauppi says.

"If we could effectively add data to databases and top it all with diverse visualisation features, QGIS would be a pretty good tool for planners. Often, it is not about available software, but about processes. Changing the working culture is the key factor", Hermans says.

For example, the database model of the Tampere land use plans has been developed during the past 12 months in this way – by addressing planning processes and working methods. By slightly configuring QGIS workspace, suitable tools and visualisation features can be built for planners.

QGIS as a ready-to-use package for employees

Instructions have been set up for packaging the software for organisations. For example, the municipality of Frederikssund in Denmark has published packaging instructions in its GitHub. In Helsinki and Tampere, a service provider packages the software for employees, with the assistance of specialists.

Helsinki favours the organisation versions of QGIS. These are long-term releases that only need to be updated roughly once a year.

"We have packaged the latest LTR version 2.18. A good Finnish translation of the software is a long-awaited improvement", Hermans says. The next major update will be expected as a result of QGIS 3.

In both cities, Tieto Corporation takes care of the QGIS packaging. Using packages, IT support can easily make the software available to all users via desktop distribution. In Tampere, every user always has access to the most recent software version.

"We are not using any organisation versions", Marko Kauppi says. "Users can always select the most recent version. The current version is a good one, and there's no reason to go back. What is particularly useful is that all employees have direct access to the software, even at schools."

The software packages can also be customised. In Helsinki, it would be handy to automatically add the OpenStreetMap tool to QGIS, as the Helsinki service map has been built on OSM. In Tampere, database and interface connections should be included in a single package, so that they do not need to be defined separately.

Compatibility and open interfaces are important.

What would you do if you could start with a clean slate?

What would you offer to municipalities, cities or other organisations that are planning to develop or change their geospatial infrastructure? What kind of a system would you build?

Marko Kauppi has straight answers to these questions: "QGIS with PostGIS, an extension of PostgreSQL, would be the best combination. When it comes to database software, PostGIS is in a league of its own. QGIS offers versatility."

Hermans calls for openness and compatibility in terms of data interfaces:

"I have tried to be device-neutral and support processes using good tools. The key is to separate databases and interfaces from a software and to step away from systems where data cannot be transferred between different software. Compatibility and open interfaces are important, no matter what software is used."

IN A NUTSHELL

- QGIS is open source desktop software for the processing, management and visualisation of geospatial data.
- Its development started in 2002.
- It is developed actively and new versions are released frequently. The latest version is QGIS 3.4 Madeira.
- The municipality of Frederikssund has published packaging instructions in GitHub.
- Instructions are also available at the Gis.stackexchange site.

Data modelling and spatial data join forces in building projects

A closer link between data modelling and spatial data offers an excellent growth medium for built environment projects and digital asset management solutions. This offers significant opportunities to reduce building costs and to improve quality.

ILKKA TIEAHO & ANSSI SAVISALO

The boundary between BIM and GIS methodologies is quickly becoming obsolete as compatibility between software, standards and data material is increasing. Conventionally, building information modelling (BIM) is made of CAD-based vector and attribute data which has largely arisen from the needs of building design and projects. Instead, geographic information systems (GIS) have originated from map measurements and the vector-based data management of large geographic areas.

These methodologies greet each other in the building wall surface where measurable room spaces and outdoor areas meet detailed attribute data about the walls and other building elements. Data about the building is supplemented by modelled data about the built infrastructure (outdoor areas and networks) which also serves project management and machine control during the building process.

Harmonised data about the characteristics and geometry of the planned and built environment forms an excellent base for project-specific data management as well as different service applications and simulations that use environmental data. These can, for example, support lighting design, the design of 5G networks, the management of IoT sensor data, air quality monitoring and wind analyses, as well as transport and mobility solutions. The primary starting point is the production and transmission of all environmental data using standard machine-readable formats, in which case data can be read by different systems automatically and dynamically, with as little manual work as possible.

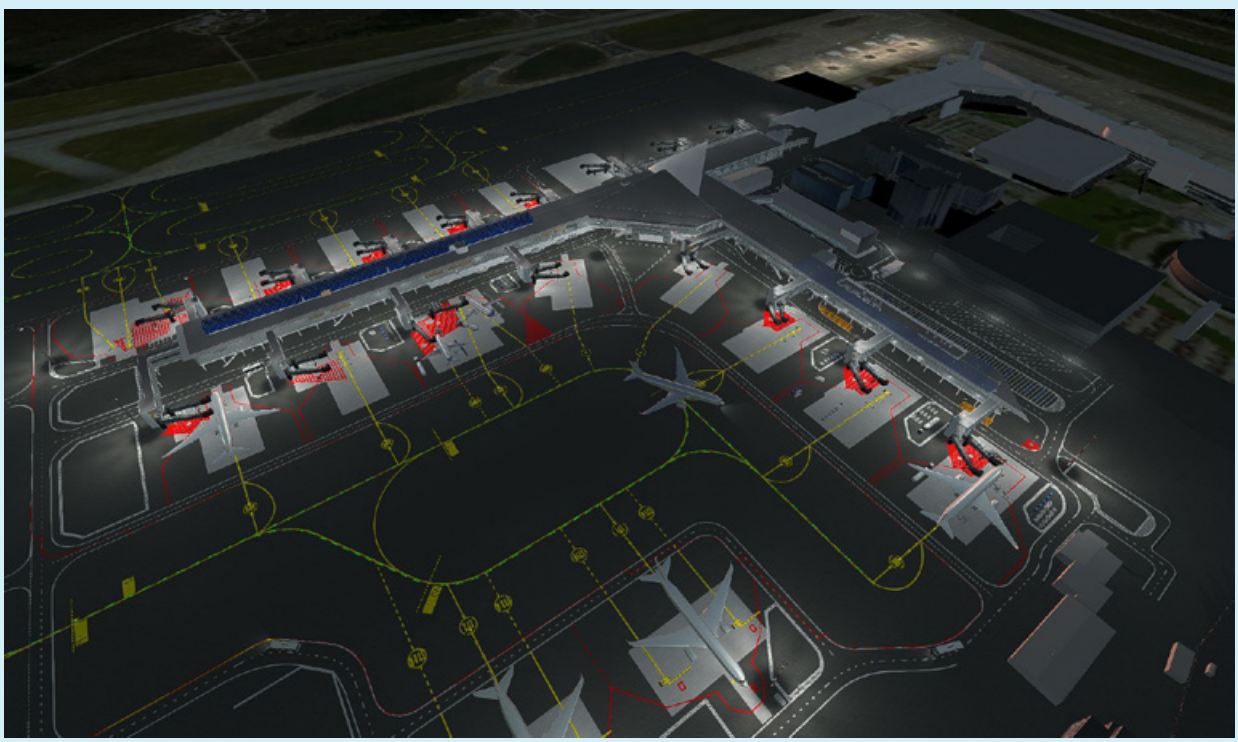
A seamless merger of building and infrastructure data models with measured spatial data enables versatile use of data throughout the construction projects, from the designer's desk into the excavator's cabin. Furthermore, this data produced during the design and construction stages can be used extensively when working with different stakeholders. With the help of the data and virtual models, the end users can easily be included in the assessment of the future environment.

BIM and GIS in the Helsinki-Vantaa Airport expansion project

Helsinki-Vantaa Airport is a significant air traffic hub between Europe and Asia. The airport is currently witnessing the largest expansion project in its history. During the project, significant changes and expansions will be made in terminal areas and the apron (taxiways and aircraft parking).

Sitowise has acted as the head designer of infrastructure in the project. In addition, we have been strongly involved in preparing and implementing the project's BIM strategy and in producing a virtual models of the project area. Infrastructure and building projects have worked closely together at all stages. The needs of both projects were addressed to reach the best possible results. By combining infrastructure and building projects and BIM models, it was possible to form a true powerhouse where OpenBIM and GIS data was used in various ways on all fronts.

Before the project to expand the airport infrastructure started, challenging goals were set: the project's design, building and interaction



Top: Case Finavia. By combining infrastructure and building projects and BIM models, it was possible to form a true powerhouse where OpenBIM and GIS data was used in various ways on all fronts. **Below:** In the airport expansion project, BIM design data and spatial data were also used in promoting interaction and cooperation during the project. An illustrative virtual model was prepared on the basis of design data, using the Unity game engine technology.

processes were to be built around a BIM methodology and models. Design was to be based on BIM data models, the building process was to be digital and interaction was to emphasise the opportunities of virtual models and digitalization. In this way, it was ensured that all design and building parties saw eye to eye.

A smart InfraBIM operating model is already built at the beginning of the design stage

Data modelling produces significant benefits in building projects, as all designs related to a specific area can be imported into a single 3D view. This allows the agile, accurate and visual coordination of designs and quality assurance. Any errors and conflicts can be eliminated early before the building stage by using more visual ways to view the plans.

In Finavia's development programme at the airport, the BIM operating model helped to transfer data dynamically between different software and databases and to ensure that identical data is always available in different software.

Starting points of the BIM operating model were the use of open data transfer formats (IFC, Inframodel) and the transfer of data to the worksite using digital cloud-based solutions. In addition, it was important to use 3D machine control and automation systems at the worksite to ensure that building processes follow plans to the point.

Build as planned!

Modern excavators and other heavy-duty machines are highly automated and operators are assisted by 3D machine control systems and monitors. Previously, building processes followed printed design drawings and yardsticks were placed all over the worksite. Now, modern 3D designs can be downloaded from the cloud directly to machine systems.

In Finavia's development programme, machine control data was transmitted, for example, using the Infrakit cloud service. It helped to agilely transfer data from the designer's desktop inside an excavator's cabin onto the operator's screen and into the machine control system. The accuracy of spatial data and data models for buildings and the infrastructure was a key success factor, also during the building process.

BIM and GIS also support interaction processes and engagement

In addition to design and building processes, it is important to understand that BIM and spatial data can produce significant added value in a number of other applications. In the airport expansion project, BIM design data and spatial data were also used in promoting interaction and cooperation during the project.

For these purposes, an illustrative virtual model was prepared on the basis of design data, using the Unity game engine technology. The customer used this model in decision-making processes and in offering induction to different stakeholders, such as the airport staff, the authorities and pilots. In this way, it was possible to ensure that the area is built according to the wishes of all parties concerned and, for example, that different weather and lighting conditions are addressed.

Standard data and harmonised operating methods boost the building industry

The most important added value brought by digitalisation is the elimination of manual data processing stages and the reuse of once-produced data in various processes throughout the lifecycle of the built environment. In order to make this possible, special attention needs to be paid to the machine-readability of data and the traceability of its accuracy.

Harmonised operating methods in the industry, combined with standard international data storage and transfer formats, are cornerstones for the development of the industry, along with shared content requirements for data modelling, concepts and conceptual models.

Harmonised operating models and concepts are developed in various joint projects in the public and private sectors, led by ministries and building SMART Finland, which coordinates standardisation processes in the Finnish building industry. All industrial parties are welcome to join these projects and to have an impact on the future of their industry!

How to design a visually working map mashup?

JARI KORPI

A map mashup is a typical modern map in which thematic data is displayed on top of the background map. This thematic data can be material of the owner of the mashup, whereas the background map often comes from another party. It can be a commercial party, such as Google, or a community, such as OpenStreetMap. This type of a map offers a relatively easy way to visualise geographic information, as the background map is readily available, and all that needs to be done is to visualise the thematic layer.

However, not everyone focuses on the visual design of thematic layers. This leads to clumsy maps, even though the data and technical implementation were otherwise impeccable. By putting a little more into it, a significant leap could be taken in terms of usability. This would ensure that information reaches its user and the map offers a good user experience.

I focused on challenges in the design of thematic layers in my last year's dissertation in which I studied design problems from the viewpoints of graphic design and human perception. My strategy was to apply the visualisation principles of conventional cartography, cognitive ergonomics, perception psychology and computer science to map mashups. In practice, I tested hypotheses derived from previous research using user tests. The results hinted at simple solutions to improve the usability of map mashups. Map mashups can be used for various purposes. Different design challenges are typical when designing different kinds of maps.

Three of these challenges are briefly described below: symbol design, congestion control and the visualisation of highlighted objects.

Symbol design has an impact on the information content of a single symbol.

If the number of objects on a map is limited and the map does not include many functions, symbol design is the most important factor that affects the usability of map mashups. General quality factors applied to symbols define their functionality in all operating environments. As map symbols are small, they need to be simple and stand out from the background map. Symbols should also form a coherent set, while individual symbols should be easily distinguishable from one another.

Map symbols can be roughly divided into abstract and pictographic symbols. Abstract symbols are geometric shapes, in which case map users need to use the legend to interpret them. Pictographic symbols try to resemble the object they represent, in which case their meaning can be deduced. Therefore, pictographic symbols can represent objects more intuitively, while they have much more design challenges than abstract symbols.

When using pictographic symbols, focus should be placed not only on factors that define the appearance of the symbols, but also on semantic factors that define how easily each symbol can be interpreted correctly. In addition to effectiveness, aesthetic factors determine how highly users regard the symbols and the entire map.

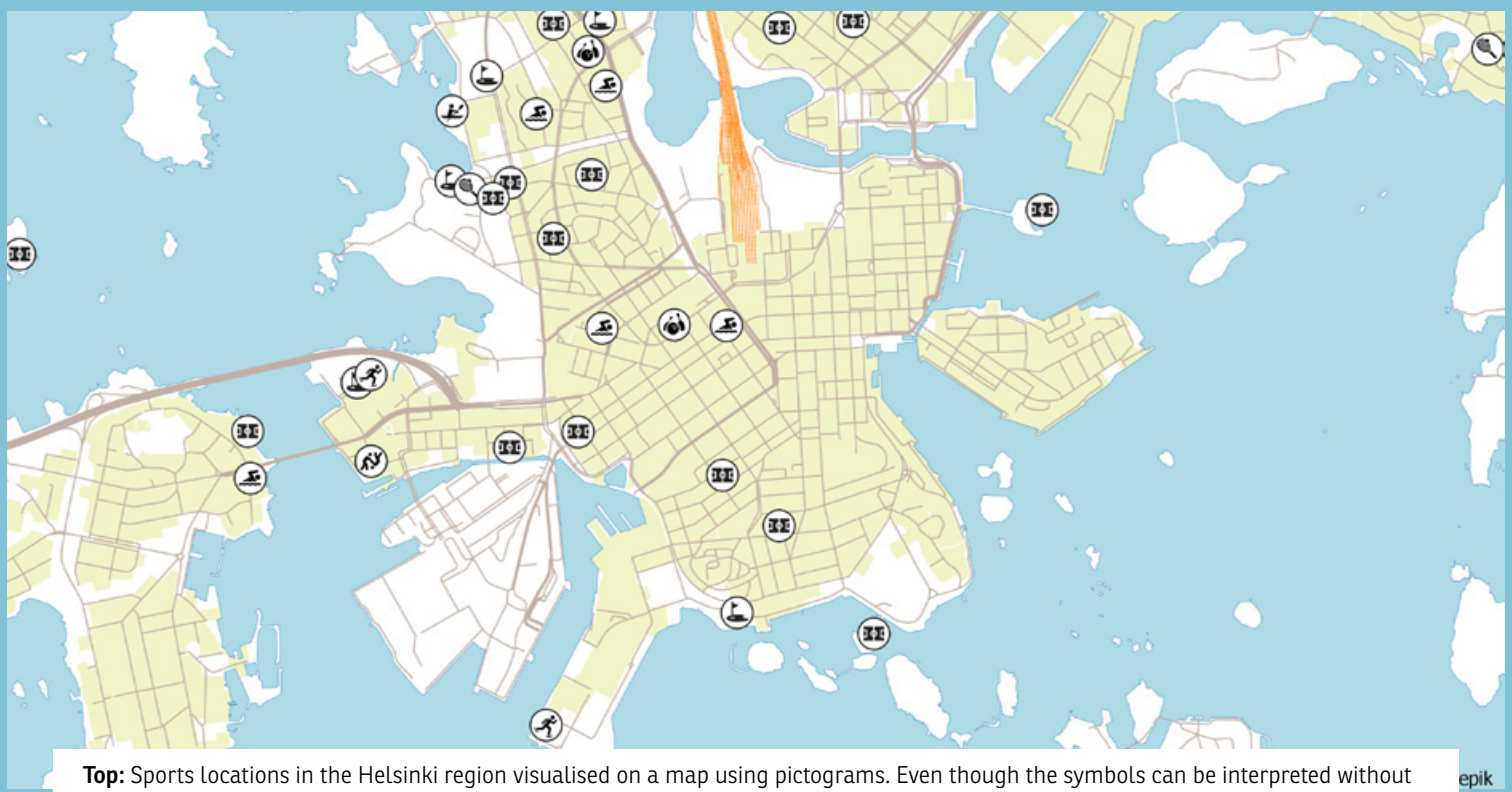
In addition to general quality factors, the intended users need to be taken into consideration, as the interpretation of pictographic symbols, in particular, depends highly on the culture, and people with different cultural backgrounds may interpret individual symbols in different ways. Multicultural environments, such as international crisis management operations where participants come from highly different backgrounds, present another challenge.

Congestion control is essential when data volumes are high

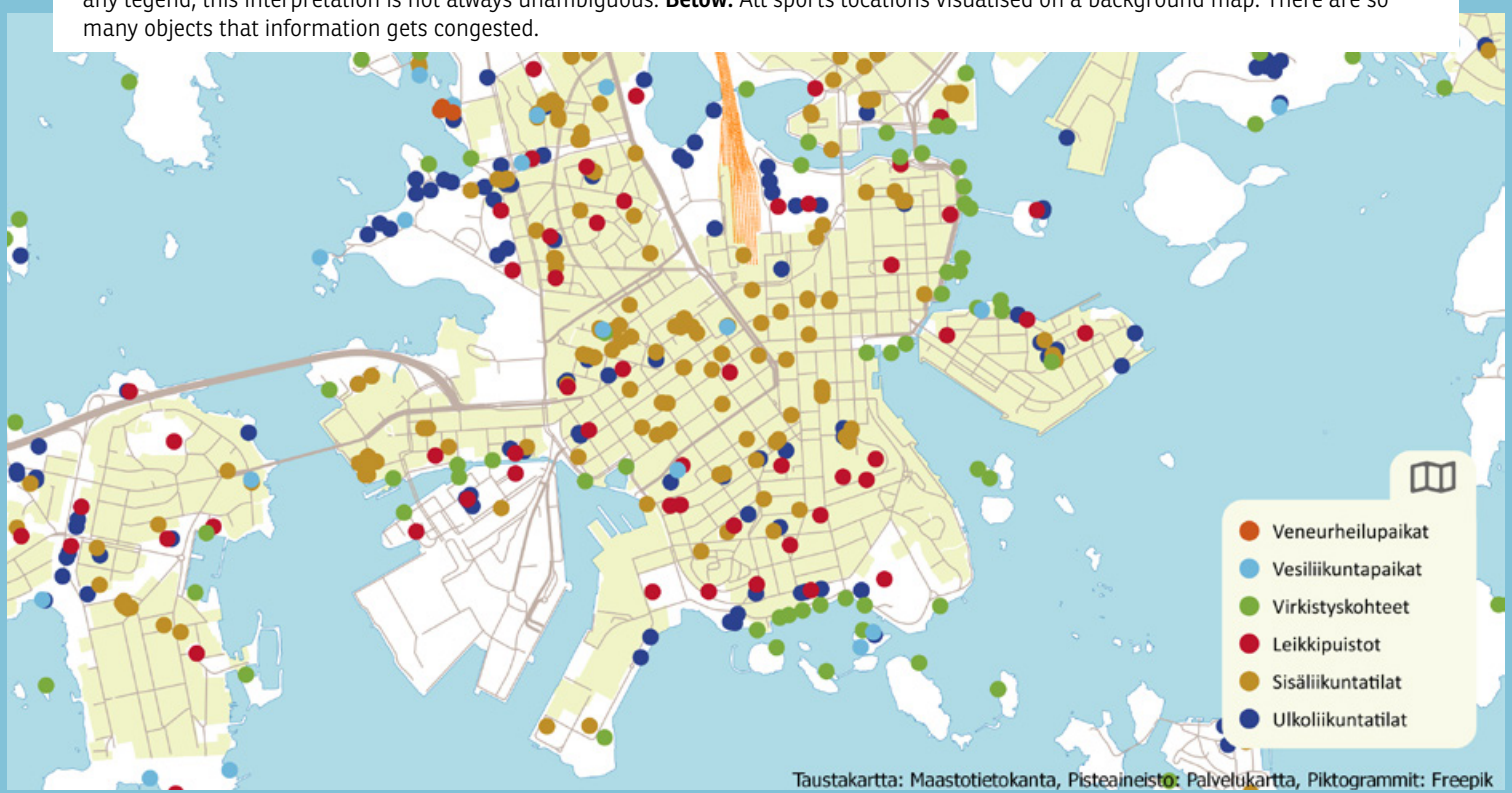
When a map includes many objects, the map easily gets congested and symbol design loses its significance, unless congestion is under control. On a normal digital map, the data volume and the presentation method are controlled when the scale changes using automated generalisation operators that remove, transfer, simplify and aggregate objects. In this way, users can always view an understandable map.

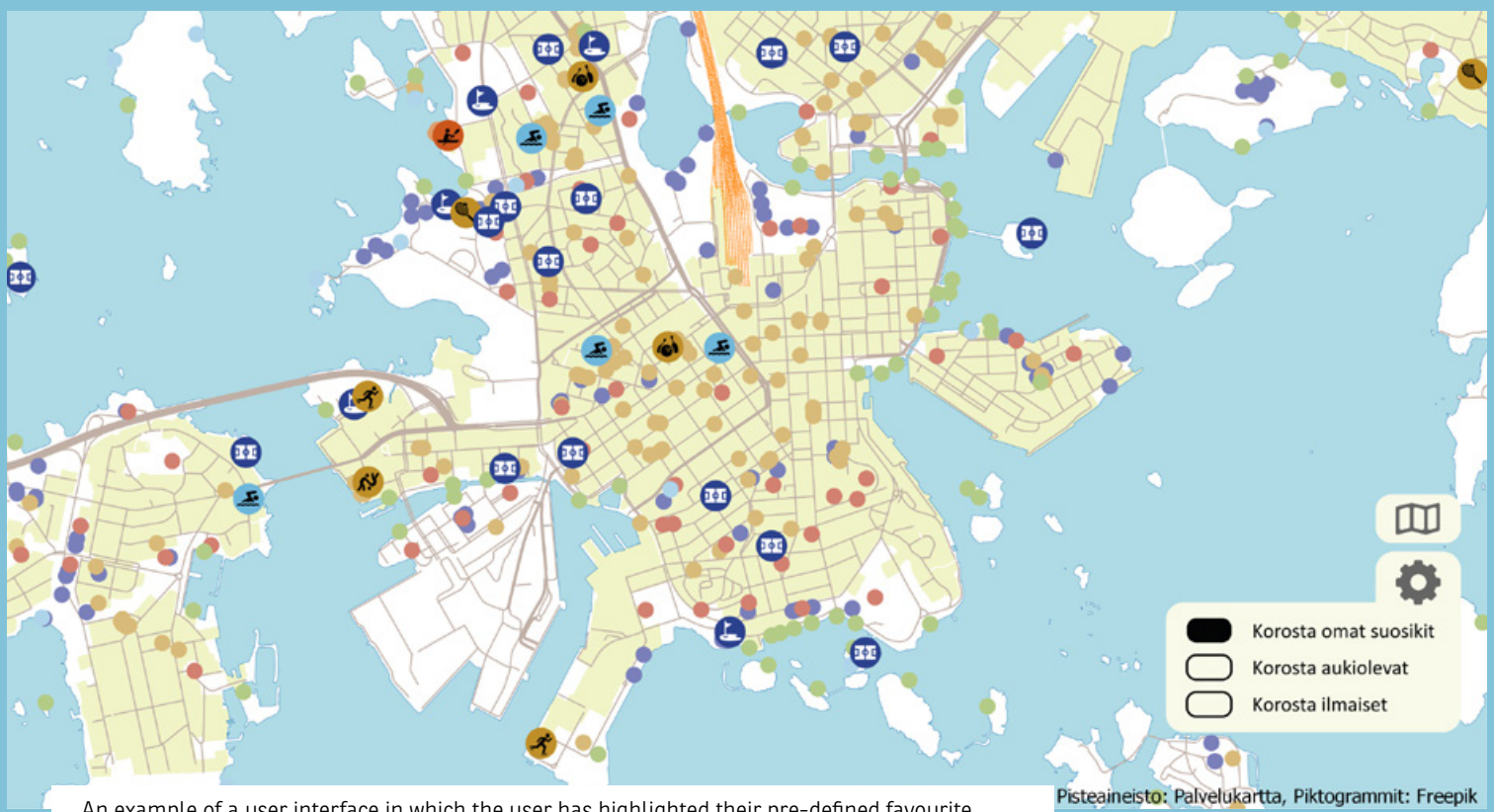
In general information visualisation domain information is largely visualised using the same methods as those used in cartography. However, information visualisation applications provide users with interactive tools, using which they can freely edit different views. In addition, objects can be animated or the background map can be stretched so that the most congested areas are enlarged. As a map mashup is both a map and an information visualisation app, both of these congestion control approaches are feasible.

Congestion control is always a compromise, and different methods have their pros and cons.



Top: Sports locations in the Helsinki region visualised on a map using pictograms. Even though the symbols can be interpreted without any legend, this interpretation is not always unambiguous. **Below:** All sports locations visualised on a background map. There are so many objects that information gets congested.





An example of a user interface in which the user has highlighted their pre-defined favourite locations. The highlighting method used has a significant impact on the usability of maps.

For example, high congestion cannot be resolved simply by displacing symbols, and some data can be lost by aggregating different objects. This means that no single method is considered better than another. The correct solution must be identified in each individual situation.

Visualisation of highlighted symbols is essential in terms of usability

Highlighting symbols in different views is a key feature in interactive user interfaces. When an object or a group of objects is selected in a one view, similar objects will also be highlighted in other views. In interactive map interfaces, highlighting can be used to visualise a selection of objects. For example, a user may be allowed to highlight service stations that sell fuel below a user-defined price on a map. This is not a big thing to design but, if a little effort is put into it, it makes the interactive map easier to use.

From the viewpoint of perception, the purpose of highlighting objects is to help to distinguish them from other objects and to guide attention towards them. This can be done by increasing the visual value of highlighted objects, by decreasing the visual value of other objects, or by adding a visual element that visually groups highlighted objects.

Not even good data results in a high-quality map if the visuals aren't right.

An optimal difference between the visual values of highlighted and other objects is a key factor in terms of the effectiveness of highlighting. This can be done by editing attention-guiding visual variables, such as the symbol size or colour brightness. Of course, the appearance of symbols has an impact on what method to select. For example, if symbols are already visually powerful, dimming other objects is a better solution than increasing the visual value of highlighted symbols even further.

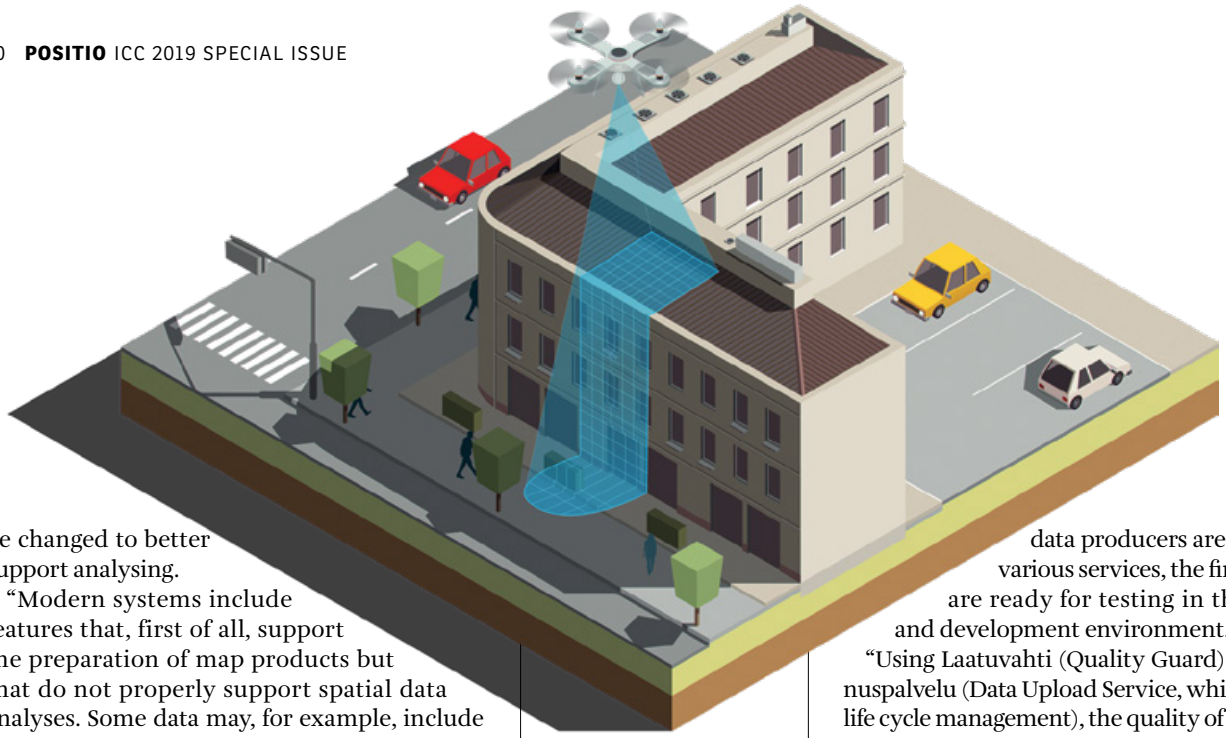
The topographic database of the future is being built right now

ANNIINA LUNDVALL

The National Topographic Database is an extensive cooperation project led by the National Land Survey of Finland. It aims to harmonise Finland's key spatial data and transfer it into a single database. There is much work to be done, requiring thoroughness, as the data reserve is a valuable national property. The work that is done right now extends far into the future.

The National Topographic Database brings together building, transport network and land cover data, as well as hydrographic data, and later also infrastructure networks and geographical names.

"Aerial photos, elevation models and laser scanning data are also saved in the National Topographic Database. Data is produced in a shared data ecosystem. Its goal is to eliminate any overlapping work and ensure interoperability", says **Risto Ilves**, leader of the National Topographic Database programme. Data modelling will also



be changed to better support analysing.

"Modern systems include features that, first of all, support the preparation of map products but that do not properly support spatial data analyses. Some data may, for example, include "data spaghetti." This means vector data without any topologies or property data, in which case it is impossible to analyse spatial data", Ilves says.

Towards a harmonised data ecosystem

The data ecosystem is made on pieces, the management and coordination present a challenge. In addition to the National Land Survey, members of the network of data producers include Finnish municipalities, the Finnish Transport Infrastructure Agency (former Finnish Transport Agency), the Finnish Environment Institute, the Finnish Food Authority and the Finnish Forest Centre. And, yes, you guessed it – each of these use their own systems and technologies and have their own ways to produce and share data. The harmonisation process started by defining standard conceptual models.

"It is absolutely essential that every party produces data in the same way and that we apply a shared set of rules to the management and maintenance of data. We will define national basic products and services, on top of which municipalities and companies, among others, can build value added services", says Ilves.

The parties have already defined 2.5D and 3D conceptual models for buildings and structures, and conceptual models for terrains, addresses, hydrography, and transport are nearly complete.

The world is changing – data remains permanent

In addition to having harmonised conceptual models, it is important that data is not lost at any stage.

"We will provide objects with a permanent ID, so they can be monitored starting from their creation. Even if a building disappears from the cityscape, its data will remain in the National Topographic Database, indicating what happened to it", Ilves says. Municipalities and other data producers are assisted by various services, the first of which are ready for testing in the training and development environment.

"Using Laatuvahti (Quality Guard) and Tallennuspalvelu (Data Upload Service, which includes life cycle management), the quality of spatial data and its storage in the National Topographic Database can be tested. We are currently developing new data products and services, together with data producers, and we will offer these to customers to ensure the best possible service", says Ilves. As the interfaces to be built are based on international standards, they can easily be connected to the data systems of customers.

Eyes set far into the future

Future technologies will be deployed during the project, for example, in Laser scanning software. The project parties will keep a close eye on international development and work closely with the Nordic and Baltic countries. Special attention will be paid to data protection and opportunities to merge data.

"The National Topographic Database has long-term goals, for example, regarding 3D data. Starting from 2020, the national laser scanning programme will produce point cloud data of the whole country more densely, quickly and effectively. Ilves says. The National Land Survey will produce 3D models of buildings over the whole of Finland using laser scanning data

"This is a significant investment in increasing the effective use of spatial data in society."

KMTK.PAIKKATIETOALUSTA.FI

The development of the National Topographic Database can be monitored at kmtk.paikkatietoalusta.fi. Services of data producers are available at beta.paikkatietoalusta.fi. Currently, all services are available in Finnish only.

PHOTOS: MARKO KALLIO

Clean water is often a socioeconomic or administrative question

MARKO KALLIO

Our entire society is based on the sufficient availability of clean water. Still, clean water cannot be taken for granted. Natural examples of this include arid deserts and steppes and, in particular, dry conflict areas in Syria and Yemen, among others. In these areas, sufficient amounts of water may not be physically available. However, clean water can also be a socioeconomic or administrative question.

Water poverty means a situation where a sufficient amount of clean water is not available in order to fulfil basic needs. It is a multifaceted problem which is reflected in the entire society and may result from social structures, any lack thereof or a permanent or temporary drought.

Southeast Asia has a tropical monsoon climate which divides the year into two extreme seasons: drought and heavy rainfall. In Laos, more than 90% of the annual rainfall (1,000–3,500 mm) takes place during the rainy season between May and November. The heavy rainfall causes floods, destroys roads and damages infrastructure. During the dry season, the problem is that sufficient amounts of water may not be available for all villages. This problem is emphasised at the end of the dry period when the last rains have passed months ago. At this time, temperatures also soar high, rising close to 40 °C.

However, the availability of water, the level of the infrastructure and the socioeconomic position of the population are not static or random factors; they vary according to the time and place following a well-known principle, the Tobler's First Law of Geography.

The water poverty index is an indicator of water and its management

In my thesis work (and later as part of my postgraduate studies), I examined the division of water poverty in Laos between geographic locations and sea-

sons. Laos is one of the poorest and least developed countries in Asia. Its government has set a goal of exiting the list of the least developed countries in the world by 2020. The key reason why the country still remains on this list is malnutrition, which afflicts as much as 30% of the non-adult population. Understanding the reasons for water poverty is particularly important for a country that depends on the cultivation of rice, i.e. the sufficient availability of water.

In my study, I calculated a multivariate water poverty index (WPI) for 8,215 villages located in different parts of Laos using openly available data. The WPI consists of five components: the amount of water, access to clean water, the capacity of water resources management, the use of water and the state of the (hydrological) environment. In principle, my data sources included census data and hydrological modelling results regarding the availability of water. I applied spatiotemporal data mining methods to the calculated index and its components.

The availability of water is not the main reason for the lack of safe water in Laos

In a geographic sense, the distribution of water poverty was as expected. The best situation is near Vientiane, the country's capital, and along the Mekong river on the border between Thailand and Laos. The situation near the capitals of each province is better than in more rural areas, and the most difficult in mountainous and sparsely populated regions next to Vietnam and China. This geographic distribution is fairly similar during both the dry and rainy season.

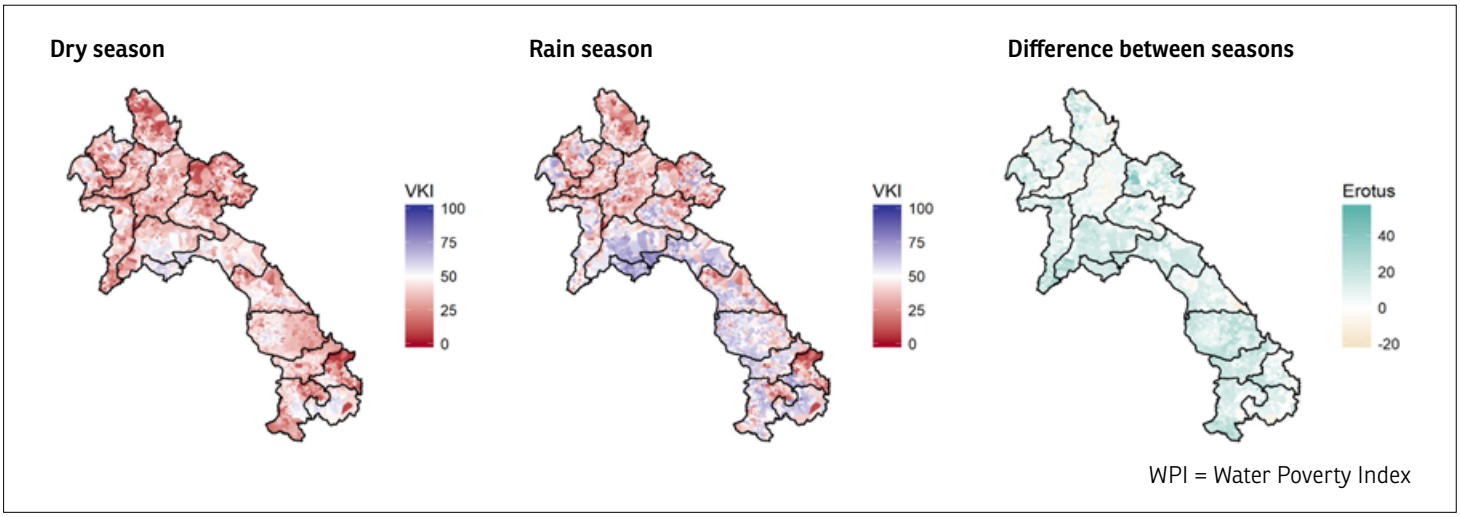
What was surprising was that the availability of water does not seem to be the determining factor in terms of water poverty in Laos. Instead, differences between regions can be explained by socioeconomic and infrastructure-based factors, such as poverty, the level of education, sources of tap water, irrigation systems and the distance between a village and the closest administrative capital. Therefore, the WPI of villages in the poorest position does not increase at all during the rainy season, whereas that of villages in a better position increases by as many as dozens of points. As the WPI is measured using a range from 0 to 100, this is a major improvement.

When reasons for water poverty are examined as processes, agricultural elements are emphasised. This is logical, considering that 70% of the population of Laos live in rural areas where agriculture is the primary source of income. In a geographically weighted regression analysis, eight out of ten key variables are related to agriculture. However, their importance varies so that reasons related to agriculture are more significant in sparsely populated areas and less significant near larger cities. In particular, the dependence of the income of village populations on agriculture is also a good indicator of water poverty. It seems that the agricultural population of Laos is in the weakest position in terms of water.

Spatial data in key role in understanding reasons for water poverty

The geographically weighted principle component analysis I have developed further during my postgraduate studies confirms the same conclusions: Socioeconomic factors are in a determining position across the entire country when examining water

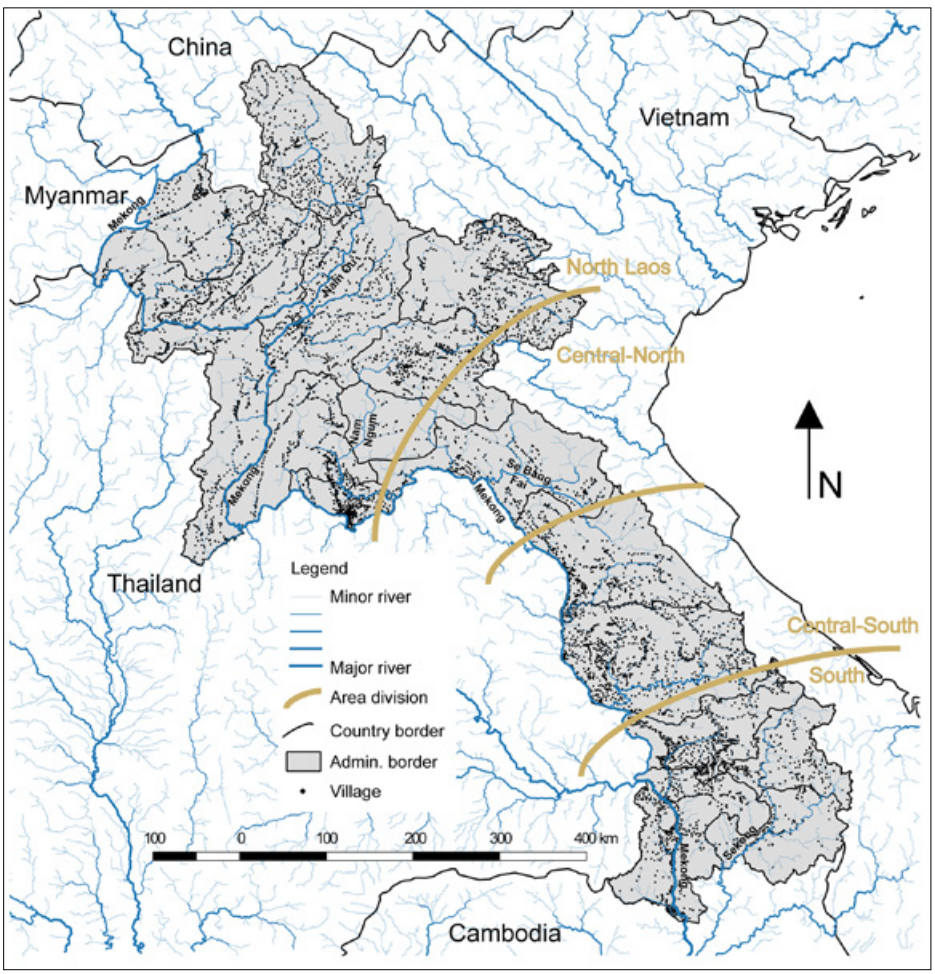
Boys doing laundry and playing in an irrigation channel in Cambodia's Battambang.



poverty. However, subsequent factors vary according to the time and place. Environmental factors and income from agriculture are emphasised in northern parts of Laos. In southern parts, it was not possible to sufficiently distinguish different processes from one another. This may mean that the variables used to calculate the WPI are not fit to examine the processes in the South. Therefore, an analysis based on spatial data is necessary in order to understand local differences related to water poverty. This analysis also showed that a single set of indicators cannot be applied to all parts of the country. This is not apparent, unless the analysis is location-specific.

My study shows that spatial data is closely linked with water-related problems, also aside the physical availability of water. This was the first study in which the WPI was calculated for a large number of villages. This was also the first time when the WPI and its components were studied by means of data mining. Spatial data turned out to be invaluable in examining water poverty, but also in understanding its underlying processes.

It should also be noted that, even though my study focused on one of the least developed countries in the world, it was fully conducted using openly sourced material. The tools used were also open source spatial data programs: QGIS and R. The extended study based on the thesis work was published in Social Indicators Research in December 2017. The data used in the study is available at:



DOI.ORG/10.1007/S11205-017-1819-6

Why are flood maps important?

Flood maps show how likely it is that an area remains under water when there is a flood. The modelling system is refined as the raw data becomes more detailed and information about the impact of climate change increases.

An Ivalo flood map of a flood returned once every 250 years would be a magnificent artwork on the wall.

KATRI ISOTALO, UPDATED BY **MIKKO HUOKUNA, MIKKO SANE** & **ANTTI PARJANNE**

The EU Floods Directive speeded up flood mapping in Finland. During the first six-year period, closed at the end of 2015, Centres for Economic Development, Transport and the Environment (ELY Centres) prepared flood hazard and floor risk maps for 21 significant risk areas. In addition to these, flood maps have been prepared for roughly 120 areas by the end of 2018. On the basis of flood maps, ELY Centres prepare management plans for flood risks. These flood maps are available in the flood map service maintained by the Finnish Environment Institute (SYKE).

The flood maps indicate what areas are at risk during floods of different magnitudes. The maps not only help to prevent flood damage and to improve communication, they also offer support in land use planning. For example, residential buildings should be located at least so high that an overflow of water can reach the area only once in a hundred years on average.

The lowest recommended building levels were updated in 2014. The previous recommendations dated back to 1998.

An elevation model offers key information

The flood maps prepared by ELY Centres are based on the National Land Survey's DEM2 elevation model and numerical flow models based on cross-sections of channels. Observations of water levels and flows have been used to calibrate the model. Flood models were calculated using this data and the probabilities of floods were determined on the basis of data material.

Flood maps have been prepared for areas where inland flooding is more likely to occur. In 2017, SYKE and the Finnish Meteorological Institute (FMI) prepared a flood map for Finland's coastal areas. Finland's environmental administration is in charge of flood scenarios regarding rivers and FMI is responsible for those regarding sea areas.

Flood hazards are indicated by different probabilities of floods. Return period 1/5a means that the water level rises to the flood height once in five years on average. Flood maps have been prepared for floods occurring once in 5, 10, 20, 50, 100, 250 and 1,000 years.

"We were able to prepare flood maps fairly easily for more return periods than what is required in the Floods Directive", says **Mikko Huokuna** from SYKE.

Flood hazard maps present the coverage and depth of floods. In addition, flood risk maps present the number of people living in the flood area, roads remaining under water and special areas, such as treatment and educational institutions, waste processing sites and culturally and historically valuable sites. The number of people and buildings was evaluated using the building and apartment register, which has been supplemented using building data included in the National Topographic Database.

"When we compared different material, we discovered that the differences in the number of buildings located in flood areas between these two registers are smaller than we expected", Huokuna says.

The flood map service also includes maps of dam damage surveys and previous floods.

The flood map service has been built using Esri's ArcGIS Server technology. As the service must operate round the clock without any interruptions during a flood, there is a back-up system in place.

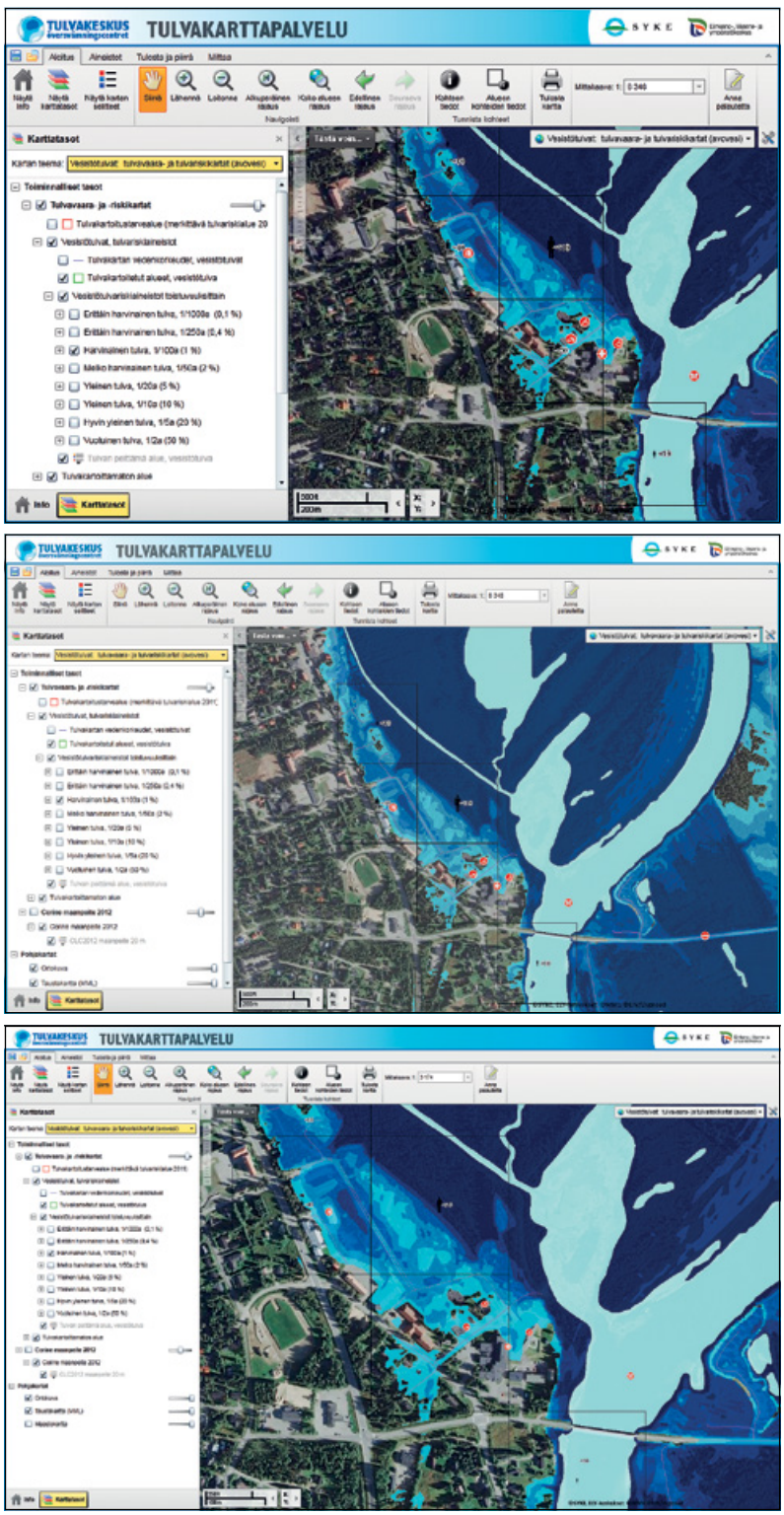
The flood map service's users mainly include government officials and some of the largest municipalities in coastal areas, but it has also been used by consultants and regular people.

The Flood Centre issues forecasts and warnings

Alongside the flood map service, SYKE and FMI established the Flood Centre at the beginning of 2014. It is a virtual centre that communicates acute floods to other authorities and maintains the hydrological information service. Data is openly available on its website to everyone. SYKE and FMI produce these services in cooperation with ELY Centres and the rescue authorities.

Flood forecasts and warnings are based on weather forecast models, water level and weather observations, sea models and the watershed simulation and forecasting system (WSFS). Forecasts prepared using WSFS are based on real-time hydrological data obtained from more than 200 water level and flow monitoring stations.

SYKE is in charge of flood forecasts and warnings regarding watercourse flooding. It is



The flood map service shows, for example, Kittilä in a situation where Ounasjoki floods as much as can be expected once in 100 years.

also responsible for ice jam forecasts and map services. FMI is in charge of weather forecasts, sea water level forecasts and warnings, as well as heavy rainfall warnings.

SYKE and FMI are also prepared to create flood maps during acute flooding. According to Huokuna's experience, a flood map can be created in a matter of hours using different geographic information material.

Changes in the sea water level in Finland's coastal areas are affected by the total water volume in the Baltic Sea, i.e. water flows via Danish straits, air pressure and wind conditions regarding short-term changes in weather, and the characteristic variation in the water level of the Baltic Sea.

"Where the aim is to identify future floods in sea areas, we also need to consider the post-glacial rebound in Finland's coastal areas, the rising of ocean levels as a result of global warming and its impact on the level of the Baltic Sea", says **Ulpu Leijala**, research scientist at FMI. "When we are talking about an intense sea water flood, it should be kept in mind that such a flood always results from the joint effects of multiple factors."

Closer cooperation between different authorities

The Flood Centre was established not only to offer better communication, but also to help different authorities to work closer together. However, SYKE and FMI continue to convey information and release notifications in their own services, particularly during acute flooding.

Cooperation with municipalities should also be closer. FMI issues warnings of stormwater floods, among others, while municipalities are in charge of planning related risk management activities.

"The impact of climate change, such as stormwater, is one significant development area in the future", Mikko Huokuna says.

In spring 2018, SYKE released a preliminary stormwater flood map for municipalities to help them to prepare initial assessments of stormwater flood risks. The preliminary stormwater flood map has been prepared for nearly all urban areas in Finland using a surface runoff model. Its initial information is mainly based on the National Land Survey's DEM2 elevation model. Transboundary cooperation has been carried out in the Tornionjoki area between the environmental administration, FMI, the Finnish-Swedish Transboundary River Commission, and the municipalities of Tornio and Haparanda.

A flood map can be created in a matter of hours.

Climate change calls for more attention

During this second six-year period for flood risk management, the aim is to address any needs to update flood risk areas. In addition to assessing the impact of climate change, development areas include at least identifying ice and hanging dam floods and increasing cooperation with municipalities.

"One challenge and the most significant uncertainty factor in forecasting the rising of ocean levels is the future behaviour of ice sheets. Knowledge of climate change is increasing and any uncertainties in calculations related to the rising of sea levels are decreasing, which means that we continuously need to update long-term water level scenarios and the lowest recommended construction levels", Ulpu Leijala says. Flood maps are available at http://www.ymparisto.fi/tulvakartat and the Flood Centre is available at http://www.tulvakeskus.fi. Flood map material is openly available as geographic information material at www.syke.fi/avointieto.

The publication of flood maps is reflected in house prices

According to a study published by FMI in autumn 2015, the publication of maps of flood risk areas has had an impact on the prices of properties located in these areas.

The FMI study analysed the development of the prices of residential properties in the Helsinki region, Pori and Rovaniemi before and after the publication of flood risk maps in 2006–2010.

The results show that the prices of houses located in flood risk areas increased less than those of houses in each location on average. At the same time, the prices of similar houses located outside direct risk areas increased more than the average level in each location. Therefore, house prices represent loss risks better than expected.

A database consisting of roughly 340,000 property transactions was built for the study. As a result of this large database, it was possible to distinguish the impact of flood risk maps from other impact using an econometric model.

The researchers **Athanasios Votsis** and **Adriaan Perrels** stated that markets can act as effective transmitters of climate change information, provided that this information is easily available.

Spatial data has potential

A little more than one fifth of all benefits enabled by spatial data has been realised so far. The built environment shows the highest potential.

JAANA MÄKELÄ

The Report on spatial data policy and the Geospatial Platform Project, which are part of the Government's Digitalisation of Public Services key projects, have made decision-makers at the highest level aware of spatial data and related benefits.

The economic impact of using spatial data was analysed in Spatineo's study conducted in summer 2018. The study mainly analysed the potential impact in four ecosystems: bioeconomy, the built environment, social services and healthcare and traffic. Spatineo's study is a meta-analysis of previous Finnish and international studies, the results of which were applied to Finnish conditions. One core requirement for using an existing study was that spatial data needed to be an integral part of a product, application or service, the use of which provides economically productive activities for public organisations, companies or citizens. The study also analysed the percentage of the benefits enabled by the Geospatial Platform of the total value.

According to the study, the annual potential benefits of using spatial data in Finland are up to EUR 13 billion, but only 22%, or EUR 3 billion, has been realised so far. When these analysed benefits are compared with Finland's GDP, which was EUR 223.5 billion in 2017, or with the percentage of public expenses from GDP, which was 55% in 2017, the potential benefits are notable particularly in improving the efficiency of operations, but also in the production of new products and services. The ecosystems analysed in the study play a significant part in Finland's economic growth. Bioeconomy made up EUR 60 billion (27%) of GDP, the built environment comprised EUR 34 billion (15%), healthcare and wellness services accounted for EUR 21 billion (9.4%), and transport covered EUR 22 billion (10%).

Only 14% of the potential of the built environment has been realised

The most significant benefits, EUR 5.9 billion in total, can be achieved in the ecosystem of the built environment. New technologies, such as LIDAR,

PHOTOS: JULIA HAUTOJÄRVI

enhanced GNSS, sensors, machine control, machine learning and augmented reality, enable the use of smart 3D models in the planning and construction of buildings and infrastructure. According to the Australian study (Economic value of spatial information in NSW, 2017), as much as 20% of planning and construction costs can be saved if 3D data models produced by companies and public organisations are combined. In Finland, this would mean annual savings of EUR 320 million in planning and EUR 3.5 billion in construction. Currently, only 14% of the potential benefits of the built environment have been realised.

The City of Espoo has estimated that it could save up to 30% of its infrastructure planning costs if the information required are available in the form of data models. Using laser scanning data and aerial photos, it is possible to inspect the building and dwelling registry and the status of illegal buildings. Based on the study conducted by FCG (https://yle.fi/uutiset/3-10348899), Finnish municipalities have buildings outside of property taxation at a value of EUR 200–300 million.

Satellite imagery services are also expected to improve the efficiency of planning and monitoring of the built environment. For example, the European Union's free Copernicus data is expected to produce the most benefits in agriculture and in the monitoring of the built environment.

Potential in social services and healthcare is difficult to estimate

In the field of social services and healthcare, the potential benefits of using spatial data in planning and implementation of services were estimated to be EUR 255–510 million.

The actual potential is difficult to estimate, as studies conducted in this area are not easily available. Aapeli Leminen's study (Positio 2/2017), which combined the potential of using health technology and spatial data, is an excellent example of the development of services in healthcare. By decreasing 50% of diabetes patients' follow-up visits to health centres for monitoring purposes by means of self-monitoring, combined with the optimised number and location of health centres through the analysis of spatial data, would produce savings of 60% in total monitoring costs and patient transport costs in the North Karelia region. At the national level, annual savings could be as high as EUR 35–40 million.

In the field of home care services, route optimisation can produce savings of more than 10% in working hours. These can in turn be invested directly in customer care. The value of time savings is EUR 13–25 million.

Transportation optimisation can still be improved

In public transport, the annual total benefit to citizens of the use of route planning is estimated at EUR 12–75 million. The use of navigation applications in private driving produces annual savings of EUR 24 million in fuel costs and savings of EUR 540 million in work-related travel.

Transport planning helps to produce savings of at least 10% from transport costs. This would result in savings of more than EUR 700 million in the industrial sector and in savings of more than EUR 600 million in trade sector. The currently estimated deployment rate is 30%, meaning that EUR 400 million of these benefits have been realised.

The Geospatial Platform will produce benefits of hundreds of millions of euros

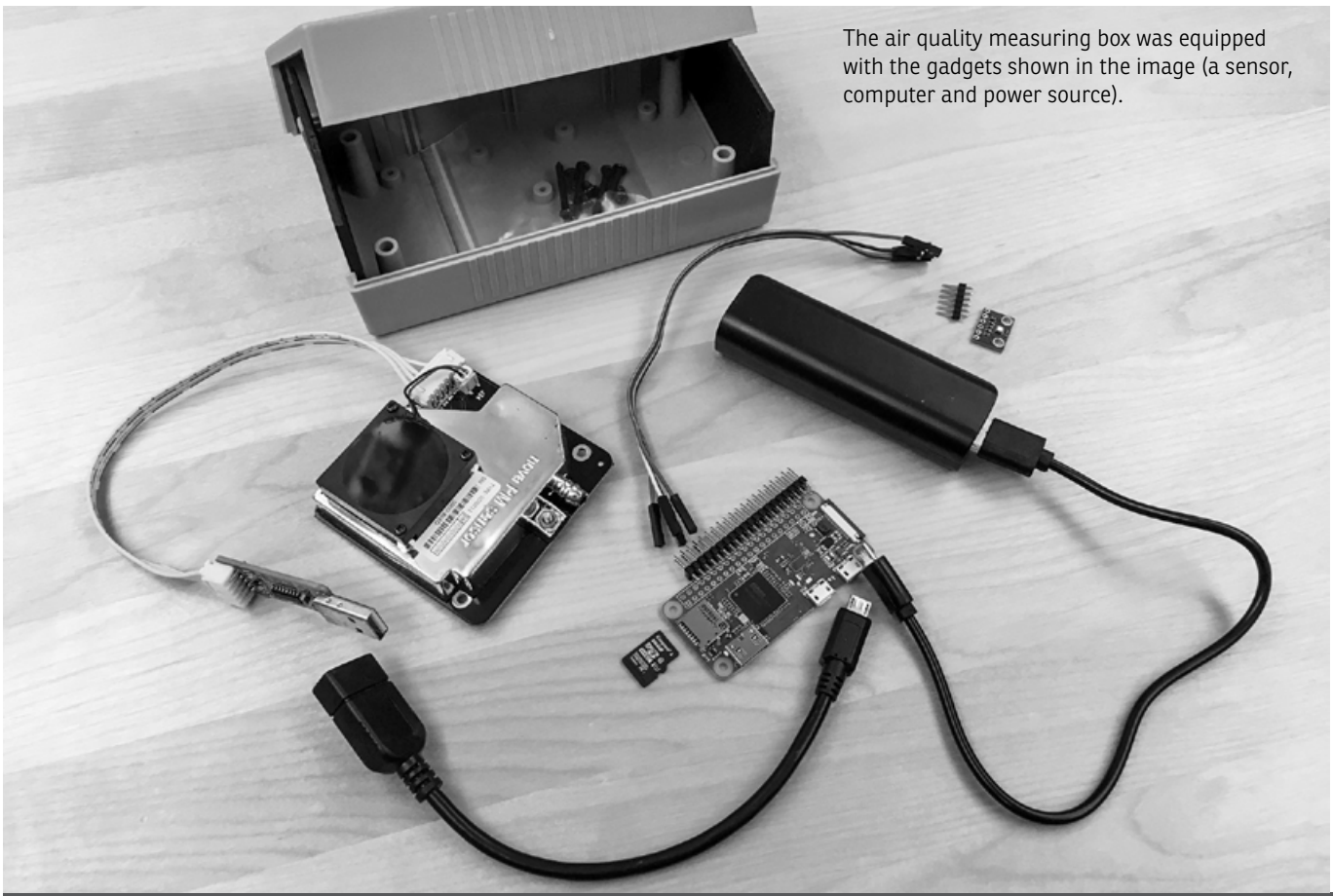
The economic benefits enabled by the Geospatial Platform and its services extend to all four ecosystems. In 2025, the direct economic benefits produced by the Geospatial Platform are estimated to be EUR 150 million and its indirect benefits are estimated at EUR 400 million per year. These estimates are based on cost-benefit calculations related to the Geospatial Platform and an assessment which spatial data and services of the Platform are needed in different ecosystems.

The direct economic benefits of the Address Information Service of the Geospatial Platform are estimated to be EUR 12 million per year. Based on Charles Prescott's study (Prescott 2015, What Is the Value of an Address?), it was estimated that the value of the Address Information Service in commercial services is more than EUR 100 million.

Potential cannot be realised without hard work

The economic benefits of the use of spatial data focus on cost savings through improved operational efficiency. However, this efficiency cannot be realised without innovative applications and services that are developed by Finnish companies as well.

The huge potential of the use of spatial data cannot be realised without a strong will and hard work. We need to have courage and enthusiasm to test and deploy new methods and develop operational processes. We also need to invest in research in order to utilize new technologies. In addition, stakeholders need to engage in close long-term cooperation in ecosystems.



The air quality measuring box was equipped with the gadgets shown in the image (a sensor, computer and power source).

Collecting data using inexpensive computers and bucket covers

Crowdsourcing means that members of the surrounding community are encouraged to collect data.

SARI PUTKONEN

The idea of Helsinki-based VekotinVerstas (Gadget Workshop) is to share data about sensors and sensor platforms and to build a community around the Internet of Things (IoT) using open source code.

"This idea came from my interest in sensors and that of **Aapo Rista**, one of the organisers of the workshop. We have for long collected data, for example, about water pipes that freeze easily. We have seen how technologies have advanced and how measuring has become relatively easy. In addition, the prices of sensors and sensor platforms, computers the size of a matchbox, have dropped to a fraction of what they were ten years ago", says **Henri Kotkanen**, who is involved in developing the activities of VekotinVerstas and who works in the IoT team of Forum Virium.

VekotinVerstas is only getting really started. So far, it has already installed sensors in an official's workspace to collect data about the quality of air for building management.

"One of our most fun projects has been an environmental artwork that would be built in Kalasatama to measure moisture in plants. It would then indicate when it's time to water the plants", Kotkanen says.

Data about the quality of air through crowdsourcing

The idea of crowdsourcing is to encourage other people to collect data. Its results are based on the success of campaign messages and the identification of the correct target group.

When VekotinVerstas held a sensor workshop at the end of October, it marketed it to everyone

who is interested in the IoT. Building boxes to measure air quality raised interest, and all eight positions were filled. During the workshop, the participants built boxes that they should carry around town to measure the quality of air. The results of the project will be available later.

"Official air quality measurements are carried out using equipment that costs hundreds of thousands of euros. In the VekotinVerstas project, the same measurements are conducted using simple inexpensive components", Kotkanen says.

The project studies what kind of data can be collected using inexpensive equipment and what kinds of measurement errors there are. Kotkanen hopes that data collected in this way could also be used in research in the future.

Collecting data about observations made in nature

The Finnish Environment Institute (SYKE) has a three-year Envibase project in progress. In one of its sub-projects, regular people are encouraged to make different observations in nature. In addition, a service to save and distribute data about observations made has been developed during the project.

"People are very active, as long as the correct target group can be found", says **Timo Pyhälahti**, senior expert at SYKE. "Birdwatchers make useful observations of birds. However, they may not be able to report, for example, observations of bats via their own services."

Crowdsourcing helps to collect data from where people are. This also means that there can be too much or too little data: no observations are made in some areas, while in some areas there are more observations than what are needed. Pyhälahti says that it would be useful if a service that brings all observations together encouraged people to make observations in new areas.

Crowdsourcing always involves the question whether the data material is reliable. JärviWiki and MeriWiki are the most long-standing observation services of SYKE. These are built and published in cooperation between the authorities and regular people. The data collected by regular people in JärviWiki has been studied, and its quality has been found to be as high as that of data collected by researchers.

Bucket covers and other measuring devices

People have used simple measuring devices to collect data in SYKE's project. One of these is the Secchi disk that can be made, for example, from a white bucket cover.

"The test identifies the depth at which the disk can no longer be seen. This gives us data about water clarity, and longer time series indicate any changes over time", Pyhälahti says. People were also able to test the iQwtr water quality indicator based on the Secchi3000 technology. Its price was less than EUR 20.

Catching data

When collecting data from regular people, the technologies used have room for improvement. People catch data, and it cannot be used easily.

"There is a broad range of devices to collect data, but not many cooperation platforms. Some services are open, while some are closed. Often, there are no ways to share data between systems", says Pyhälahti. There are also questions related to rights to use different material. In the SYKE project, data material is shared as open access data using the Creative Commons 0 (CC0) licence. This means that the licensed data can be freely used in every possible way. Data is anonymised and all personal data is removed.

Kotkanen dreams of a data warehouse of the future where people could save their data and define rights to access this data, so that public organisations would be able to use data for research purposes, while companies would only have access to this data in exchange of a fee.

Encourage and reward others

SYKE and VekotinVerstas return data collected by means of crowdsourcing to people as open access data. Results are also demonstrated using visual map material.

More innovative ways of rewarding data collectors have been considered. Kotkanen proposes that, for example, someone who gives the City of Helsinki access to their data for research purposes could be rewarded by using Helsinki coins that can be used to purchase, say, public transport tickets.

A 70 EURO AIR QUALITY METER

VekotinVerstas wanted to keep the costs of its air quality meters low. The simple box consists of air sensors (EUR 40), a Raspberry Pi 0 W computer (EUR 10), a power source and a box. A smartphone app is also needed to read the data sent from the box and to add information about the time and place to this data.

A dumb sensor measures data. A smart sensor platform sends data via a Bluetooth connection to a smartphone, from which data is sent to a cloud.

Voilà! One air quality meter has been built. It can be built by anyone. More detailed instructions are available from GitHub:

GITHUB.COM/VEKOTINVERSTAS/RPISENSORBOX

SUOMEN KARTOGRAFINEN SEURA

CARTOGRAPHIC SOCIETY OF FINLAND

The mission of the Cartographic Society of Finland, founded in January 26th 1957, is to promote the discipline and profession of cartography and geoinformatics.

The Cartographic Society of Finland is a member of the Federation of Finnish Learned Societies. The Society also represents Finnish cartographers as a national committee of the International Cartographic Association.

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