LAUSUNTO HUOMIOTAVAKSI SATELLIITTINAVIGOINTIJÄRJESTELMIEN TEHOKKAASTA HYÖDYNTÄMISESTÄ SUOMESSA -TOIMENPIDEOHJELMA 2017-2020

Diaari: LVM/1737/02/2017

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Saate:

Seuraava tutkimusraportin katkelma pyydetään huomioimaan toimenpideohjelmassa etenkin koskien (pien)satelliittien hyödyntämispotentiaalia (navigaatio, kaukokartoitus jne.) ja sovellusalueita liikenteessä - erityisesti maan- ja rautatieliikenne) kolmessa eri osa-alueessa:

1) Liikennejärjestelmän toimivuus kaikissa olosuhteissa ml. poikkeustilanteet; esim. huonot sää- ja keliolosuhteet, talvihoito, liikenteen jonoutuminen ym. häiriöt.
2) Liikenneinfran kunnossapito ja väyläomaisuuden hallinta; esim. pintakelirikot ym. pintavauriot.
3) Liikenteen ja liikenneinfran digitalisaatio ja automaatio; erityisesti automaattiajamisen edellyttämät ajantasaiset ja tarkat kartat.

Alla olevaan tektsiin viitaten toimenpideohjelmassa olisi syytä huomioida kehittyvä satelliittitekniikka monitoroinnin (esim. kaukokartoitus) näkökulmasta eikä pelkästään navigaation näkökulmassa. Satelliittien, erityisesti yleistyvien piensatelliittien, myötä on oletettavaa niiden pystyvän tulevaisuudessa tarjoamaan kustannustehokkaita keinoja infran monitorointiin ja liikenteenhallintaan. Havaintoaineisto yhdistettynä tarkkoihin paikannusratkaisuihin ja navigaatiojärjestelmiin takaa useita eri hyötyjä (esim. parempi turvallisuus, tehokkaampi liikenteenohjaus, ennakointi) kuten alla olevasta tekstistä käy ilmi.

Impact of extreme weather event on transport systems

Our mobility system serves multiple critical functions of our society. The movement of people and goods needs to be ensured not only under normal circumstances but also in harsher and more exceptional conditions, including rural and sparsely populated areas. Weather and infrastructure availability go hand in hand; different weather phenomena impact the transport environment and infrastructure in terms of safety, reliability, resilience and accessibility. Research findings show that the impacts of weather are significant (see e.g. Leviäkangas et al., 2013; Molarius et al., 2013); especially in the Northern Hemisphere, winter poses radical challenges to mobility and transport.

Shortfall in investments on maintenance and asset management generates increased risks of accidents, problems of congestion, increased disruptions and a reduced service to society. The value of the road network in the European Union is over 8000 billion euros, and the annual maintenance budget is close to 80 billion euros (European Union Road Federation, 2009). Also, the annual cost of extreme weather

events (storms, floods, blizzards) on transportation in Europe is 13-18 billion Euros (Nokkala et al. 2012). Currently, large transport related infrastructures are mostly monitored from the ground, but shortly new disruptive technologies can change the field by finding both more cost-effective – presently annual maintenance and asset management cost in OECD countries are over 130 billion US dollars (ITF 2017) – and sustainable solutions for transport system management.

Spaceborne technologies are one of the most promising fields in enabling competitive solutions for intelligent transport systems (ITS). However, the revisit time (i.e., temporal coverage) of current Earth Observation (EO) satellites is not frequent enough for effective operational (i.e., near real-time) applications. This will change with emerging small satellite constellations which can provide frequent observations with relatively affordable price. Innovative exploitation of small satellite technology unlocks new application areas with a compelling value proposition of great benefit to countries like Finland that have a large land mass with a substantial road network and rural communities in remote areas.

This memo lists the potential uses cases for small satellite (mass <500kg) monitoring in the context of transport and mobility

Application and research areas of small satellites in transport

Transport systems' operability and reliability in all conditions

Land transport infrastructures must be kept in usable condition. For example, in winter, snow must be removed and ice melted or treated, and road users, travelers and transport operators must be made aware of the condition and availability of their route and modal options. In other words, a transport system must have an ability to hold the desired course in an increasingly turbulent world where the unexpected is taking place. To ensure the operability and reliability of transport infrastructure, collecting up-to-date (i.e., near real-time) and accurate road weather and condition data are essential since weather is the most important factor that influences traffic and road safety. However, observing large areas and extensive infrastructures by traditional means and sensors (road weather stations, patrolling etc.) is incredibly challenging and expensive. Small satellites could be a supplementary and cost-effective solution providing current traffic situation through unprecedented observation frequency and coverage. Table 1 presents the desired use cases and research areas of small satellites to ensure the land transport systems operability, as identified in the workshop and interviews.

Table 1 – Industry needs to ensure operability in all conditions

Desirable use cases	
Snow and frozen ground maps	Frost heave and bearing capacity
Sudden extreme weather events (floods, snow/sand storms/blizzards, downpour…)	On-road/-rail condition detection (snow, slush, packed snow)
Traffic census (congestions, incidents)	Thermal mapping (friction, surface temperature)

Detection of on-road/-rail obstacles	Sky and atmospheric condition observations for weather forecast

Proactive long-term transport systems' asset management

Damages caused by extreme weather and climate change have gained much attention recently. Both aspects require actions especially considering the life-cycle of any transport infrastructure and system asset. The more durable and resilient a system is built and maintained, the fewer resources are needed to keep it in good condition. Combined with traffic management and operable transport systems, asset management forms the resilience of a transport system. Efficient use of satellite data may improve the resilience of critical infrastructures.

Even though up-to-date traffic management and long-term asset management are partially overlapping as well as supporting themes,certain aspects for both of those can be separated. Transport system asset management, in general, is mostly based on long-term monitoring and evaluation rather than rapid response and decision-making. Hence, asset management is not as time-dependent as traffic management. Table 2 summarizes desired use cases for transport asset management.

Table 2 – Industry needs for effective asset management

Desirable use cases	
Surface damages (e.g., frost damages, rutting, cracking)	Road and rail infrastructure monitoring (bridges, tunnels, culverts, subways, embankments)
Landslide warnings (movement of ground)	Wildfires (not in Finland)
Floods	Earthquakes (not in Finland)
Vegetation height measuring (e.g., trees next to rails cause risks of falling)	

Digitalization of transport and mobility

One of the biggest changes in future transportation is realized through digitalization through for example automated vehicles as well as shared and demand responsive transport services (that may also be automated) that require a comprehensive situational picture and connectivity for optimization. Human drivers can adapt their driving based on the prevailing road weather and conditions. In order to do the same, automated vehicles must have an ability to obtain and process data and then interpret it to ensure they are driving safely. For this, communication and positioning methods are crucial for connected and automated vehicles to small satellites can be used to provide related services. Automated vehicles will have to rely not only on their own sensors but also those of other vehicles as well as remote sensing data. An increasing amount of information has to reach its destination with very low latency. These requirements for the future communication system are so high that both

terrestrial and satellite components are needed. Small satellites could be used in the near future to provide decent data connection speeds in sparsely populated areas where the building of dense mobile cellular networks is too costly. Table 3 summarize the finding of workshop related to the digitalization of transport and mobility.

Table 3 – Industry needs for digitalization of transport and mobility

Desirable features and needs	
Detection of on-road obstacles and incidents	Positioning
Traffic census and decentralization/balancing	Communication, especially in rural areas (e.g., combined satellite and terrestrial 5G network)
High-definition up-to-date maps	

Next steps

Even though some technological areas such as satellite data is starting to be relatively mature, especially small satellite technologies and concepts are not yet developed enough for commercial use and hence they still require research to enable large-scale market penetration. Some emerging research areas for small satellites are presented in table 6.

Table 6 – Emerging research areas

Research topics	**Subtopics**
Data fusion and analytics	Integration of multisource data (satellites and terrestrial) Analytics of remote sensing data and added value information
Standardization and legislation	Communication formats and interfaces Satellite structure and modularity International legislation and coordination
Remote sensing technologies and data resolution	Radio, radar and optical imaging capability and application areas
Communication technologies	Miniaturized radio technologies Integration of satellite and terrestrial systems Inter-satellite communications
Technological validation and socio-economic assessment	Pilots and proof-of-concepts, Technological and economic validation and assessments

Another challenge is finding appropriate and plausible actors (firms, authorities, research institutes etc.) to form business ecosystems that can develop, demonstrate and exploit the possibilities of emerging technologies. Attracting and convincing especially private companies mostly requires a clear demonstration of business opportunities which can often be a challeng for emerging technologies and services. Hence to create new business opportunities for companies, societies' proactive support for and investments in emerging themes, technologies and research is required in order to reveal the

breakthrough applications and expertise areas before others do it. Since emerging technologies can create room for new kinds of competencies and services, ecosystems must be kept open for new actors too.

References

1. European Union Road Federation (2013) Keeping Europe Moving. http://www.irfnet.eu/images/stories/Road_Asset_Management/Screen-ERF.pdf
2. International Transport Forum (2017) Transport infrastructure investment and maintenance spending. https://stats.oecd.org/Index.aspx?DataSetCode=ITF_INV-MTN_DATA
3. Leviäkangas, P., Molarius, R., Könönen, V., Hietajärvi, A. -M., & Zulkarnain (2013). Devising and Demonstrating an Extreme Weather Risk Indicator for Transportation System. Transportation Research Record, Journal of the Transportation Research Board, 2329, 45-53. http://dx.doi.org/10.3141/2329-06
4. Molarius, R., Könönen, V., Leviäkangas, P., Zulkarnain, & Rönty, J. (2013). The Extreme Weather Risk Indicators (EWRI) for European transport system. Natural Hazards. Springer. http://dx.doi.org/10.1007/s11069-013-0650-x
5. Nokkala M, Leviäkangas P, Oiva K (eds) Hietajärvi A-M, Schweighofer J, Siedl N, Vajda A, Athanasatos S, Michaelides S, Papadakis M, Kreuz M, Mühlhausen T, Ludvigsen J & Klæboe R (2012) The costs of extreme weather for the European transport system – EWENT Project D4. VTT TECHNOLOGY 36, Espoo, Finland.