Title	Small satellite solutions for land transport monitoring.
Author(s)	Aapaoja, Aki; Praks, Jaan; Hautala, Raine; Kostiainen, Juho; Kinnunen, Tuomo K; Höyhtyä, Marko
Citation	12th European Congress and Exhibition on Intelligent Transport Systems and Services, ITS European Congress 2017, 19 - 22 June 2017, Strasbourg, France. ERTICO.
Rights	This article may be downloaded for personal use only.

12th ITS EUROPEAN CONGRESS
ITS BEYOND BORDERS
Strasbourg, France | 19-22 June 2017

Organised by:

ERTICO ITS EUROPE

Hosted by:

Strasbourg.eu eurometropole

Supported by:

Agence Attractivité Alsace

ITS FRANCE

STRASBOURG CONVENTION + EXHIBITION CENTRE

Cluster Pôle Véhicule du Futur
Solutions for future vehicles & mobility

EURODISTRICT Strasbourg - Ortenau

Small satellite solutions for land transport monitoring

Dr. Aki Aapaoja

VTT Technical Research Centre of Finland Ltd.

Co-authors:

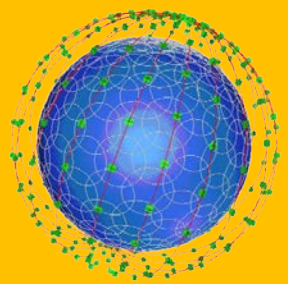
Jaan Praks, Aalto University, Finland

Raine Hautala, Juho Kostiainen, Tuomo K Kinnunen & Marko Höyhtyä, VTT, Finland

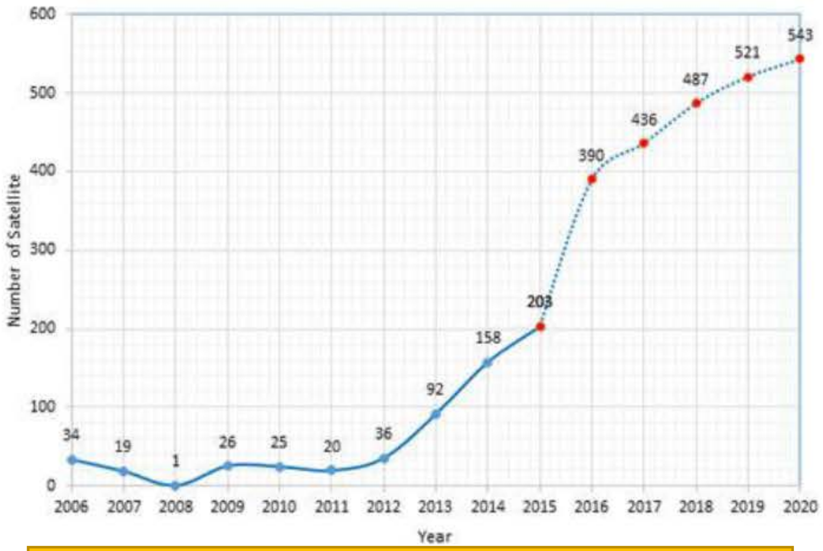
12th ITS EUROPEAN CONGRESS
ITS BEYOND BORDERS
Strasbourg, France | 19-22 June 2017

Motivation towards satellite observation

- Small satellite (<500 kg) technology spreads quickly
- Real time imaging is soon possible
- Satellite images are (and become) freely available
- Satellite is always a global solution



- Annual costs of
  - extreme weather events 13-18 billion € in Europe, 50 B$ in the USA
  - land infrastructure maintenance and asset management costs in OECD countries are over 130 billion



- Annual market growth +20%
- From 900 Million USD to 2.50 Billion USD by 2020

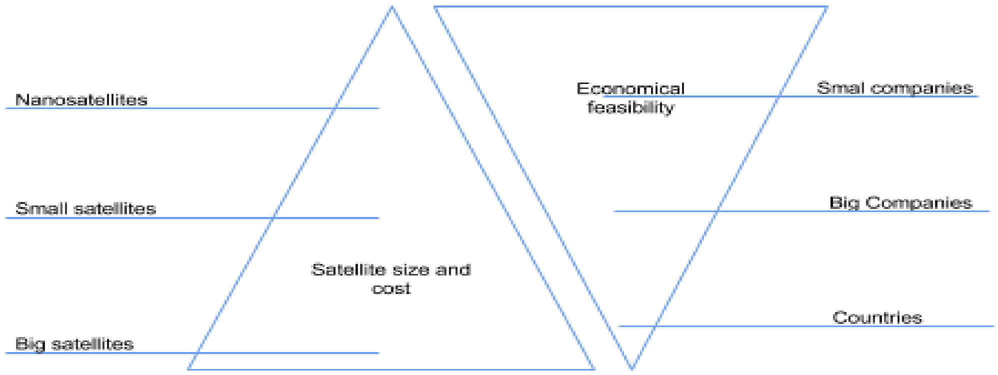
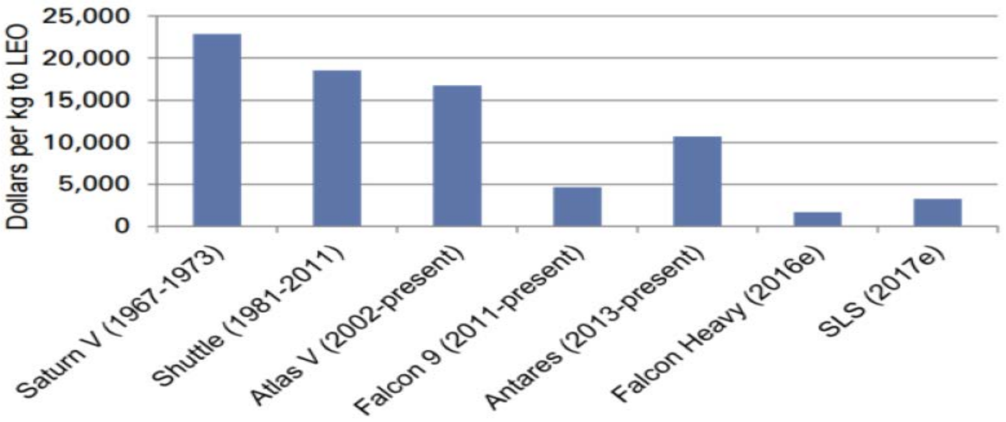


Exhibit 5: Falling launch costs open opportunity for new missions
Launch costs per payload kg fall over time, especially recently

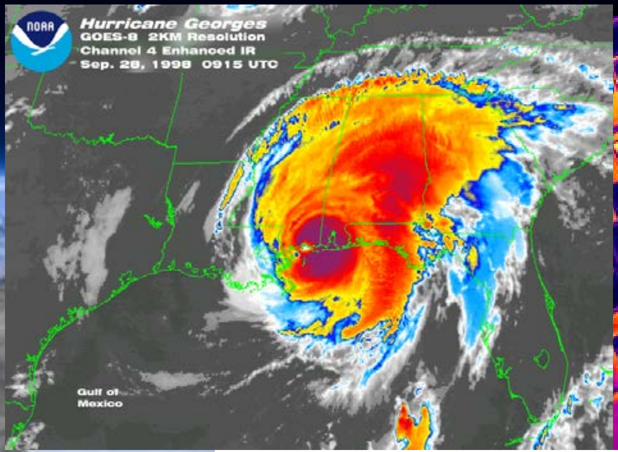


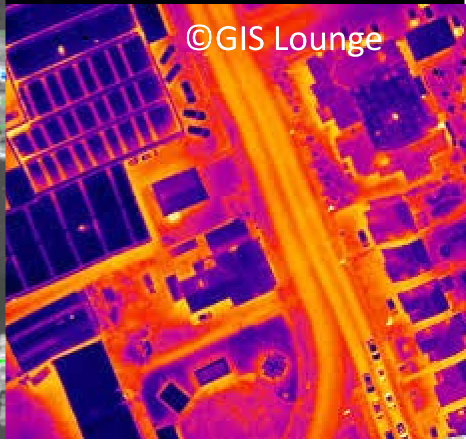
Small satellites’ promises and obstacles

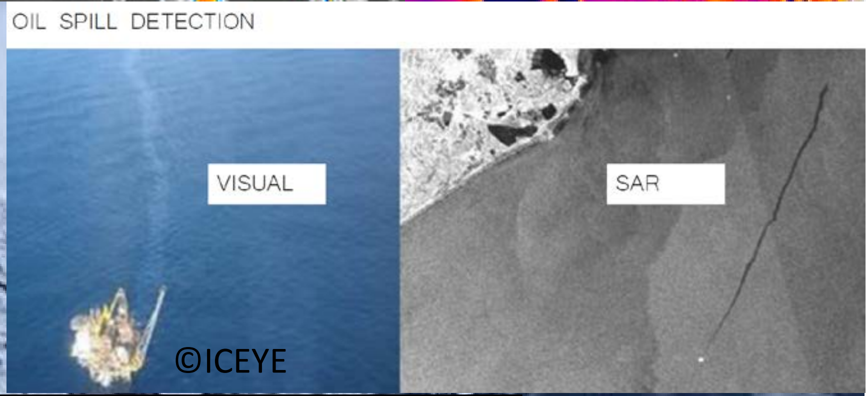
Key promises	Obstacles
Rapidly decreasing cost of a single satellite enables large satellite constellations	Space debris is a growing risk and launching a large number of satellites is controversial
Large number of satellites enables global coverage with a short revisit time	Frequency coordination according to current practices is too slow
Decreasing expenses allow entry of new providers to the field	Small satellite reliability (e.g., miniaturized technology) is not yet on par with requirements
New constellations enable new application areas and open new markets	Small size of the satellite limits the performance (size of payload, energy, monitoring capability) of the single satellite
Decreased maintenance and asset management costs	
New business opportunities	
Various applicable technologies (Visual imager, Hyperspectral imager, Radars)	

Use case: operability and usability in all conditions

- **Collecting near real-time and accurate road weather and condition data is crucial**
- **Observing large areas by traditional means (e.g, RWIS) is challenging, expensive and spatial**
- **Small satellites**
  - **Supplementary solution**
  - **Cost-effective**



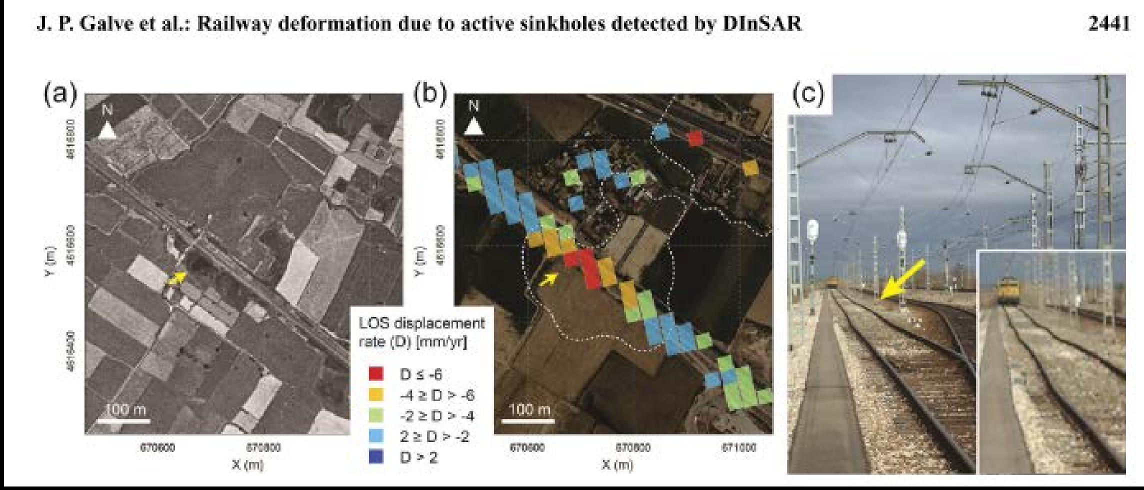




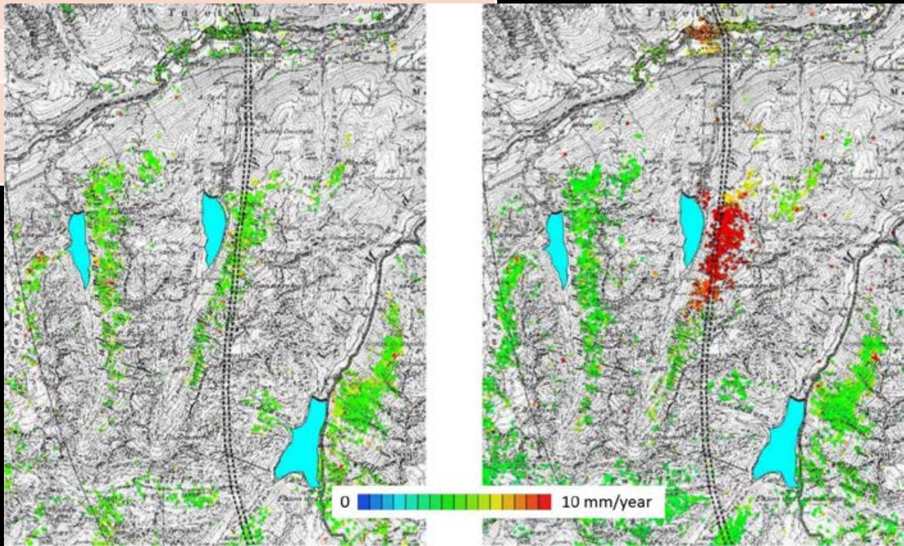
Desirable use cases	
Snow and frozen ground maps	Frost heave and bearing capacity
Sudden extreme weather events (floods, snow/sand storms/blizzards, downpour…)	On-road/-rail condition detection (snow, slush, packed snow)
Traffic census (congestions, incidents)	Thermal mapping (friction, surface temperature)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

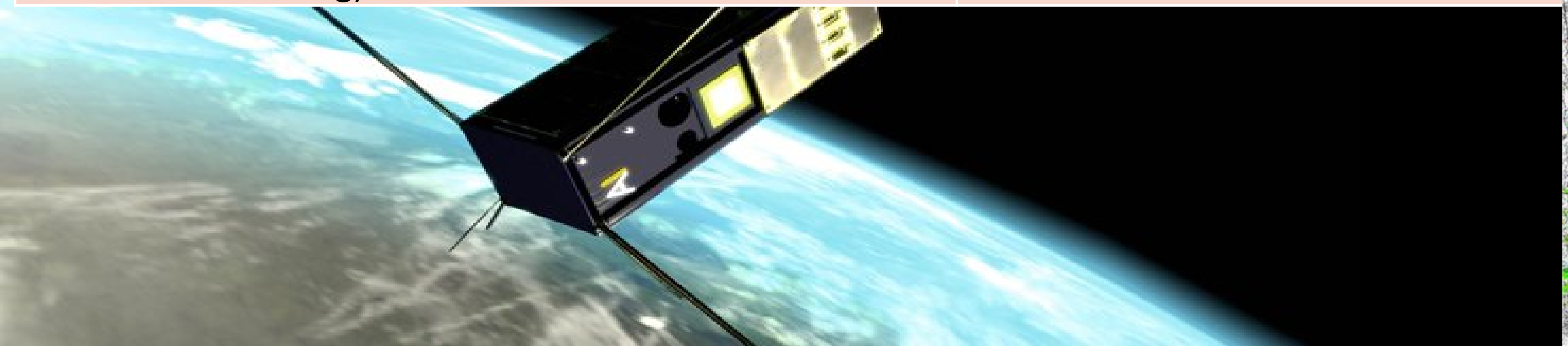
Use case: long-term asset management and evaluation

- Optimizing infrastructure life-cycle
- Enhancing resilience
  - Preparation
  - Adaptability



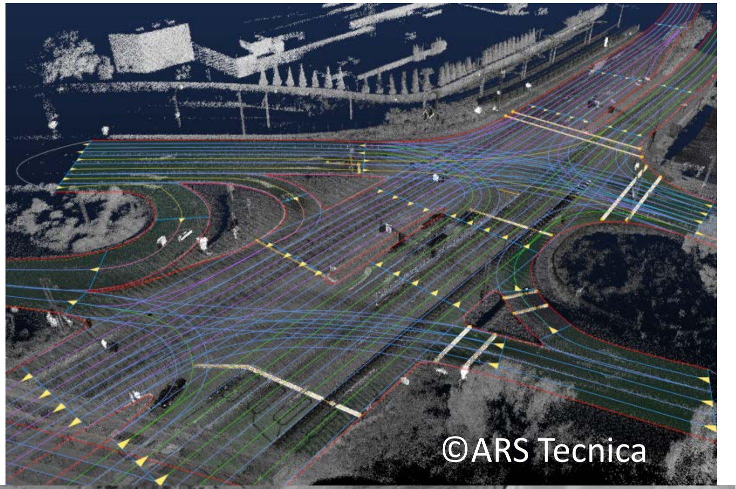
Desirable use cases	
Surface damages (e.g., frost damages, rutting, cracking)	Road and rail infrastructure monitoring (bridges, tunnels, culverts, subways, embankments)
Landslide warnings (movement of ground)	Wildfires
Floods	Earthquakes
Vegetation height measuring (e.g., trees next to rails cause risks of falling)	

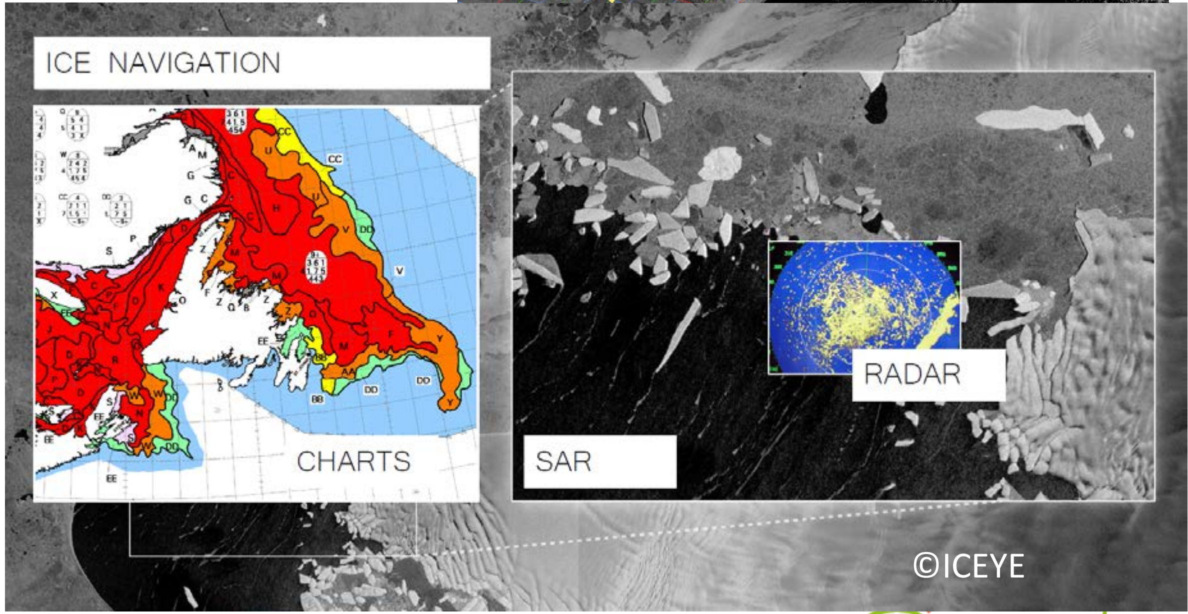




Digitalization of transport and mobility

- **Automated vehicles call for a comprehensive situational picture and connectivity**
  - **Combined data from LIDARs, cameras, radars…**
- **Communication through satellites in sparsely populated areas**
  - **Fast and reliable (5G)**
  - **Low latency**



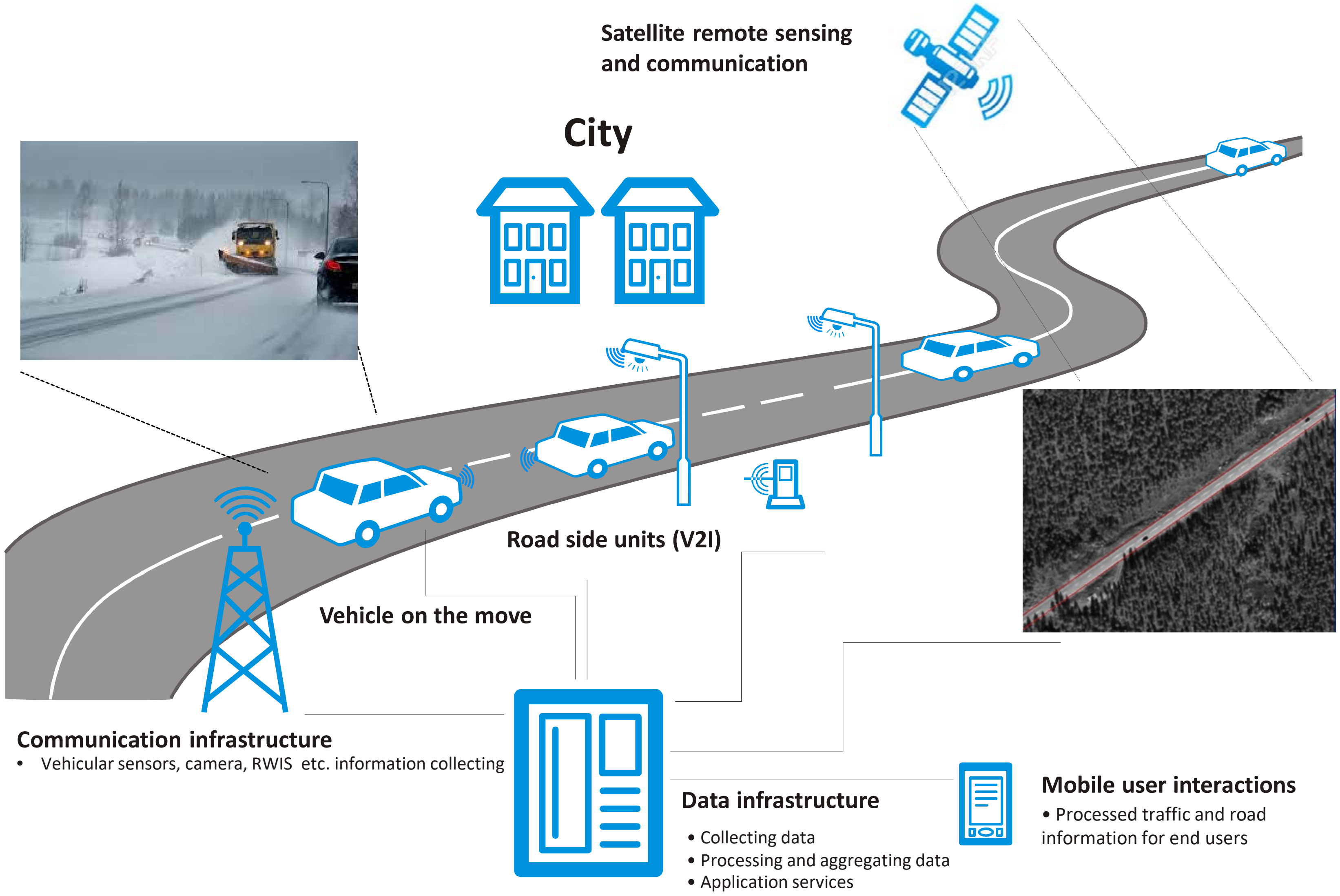


Desirable features and needs	
Detection of on-road obstacles and incidents	Positioning
Traffic census and decentralization/balancing	Communication, especially in rural areas
High-definition up-to-date maps	

Research opportunities

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

Future land transport monitoring supported by satellites and machine vision



New space – key promises and developments

- Rapidly **decreasing cost** enables **large number of satellites**
- **Decreasing investment** requirements enable **new investors and players**
- **Short revisit time** enables **new applications and new markets**
- **Constellations** enables **cheap and fast communication**
- **More** consumer **services will depend** on **space** segment
- Spaceborne **sensing** will approach **real time** and enable **new application areas**
- **New** level of **global collaboration** is inevitable

The CubeSat generation will have hands full of work!

AKI AAPAOJA
Research Scientist, D.Sc. (Tech.)
Intelligent Transport Systems

Tel. +358 20 722 2017
Mobile +358 40 7444 823
Email aki.aapaoja@vtt.fi

VTT TECHNICAL RESEARCH CENTRE OF FINLAND
Kaitoväylä 1, Oulu
P.O. Box 1100
FI-90571 Oulu, Finland
www.vtt.fi