

Smart solutions for seamless navigation

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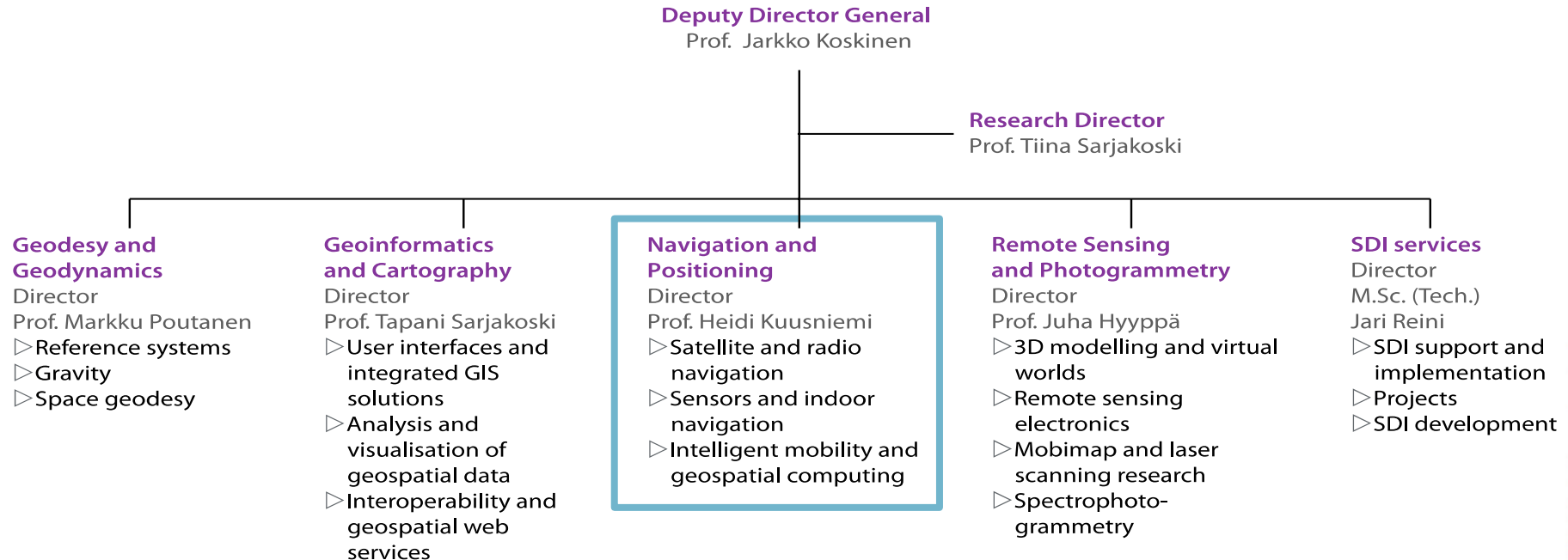
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***“Navigation for the future” seminar, Aalto University, Design Factory
31st May, 2016***



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Satellite navigation

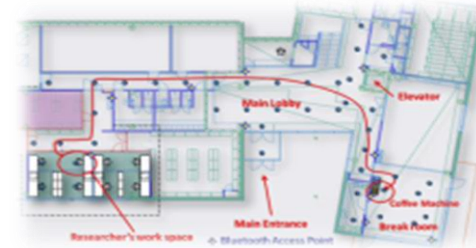
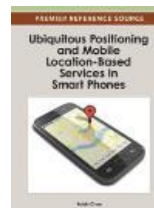
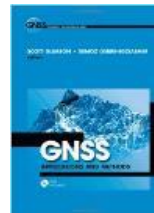
- GPS, GLONASS, BeiDou, Galileo, IRNSS
- SBAS systems, especially EGNOS
- Interference detection and mitigation
- Receiver techniques
- Software-defined GNSS receivers
- Carrier-phase based positioning for precise navigation

Expertise areas of the Dept. of Navigation and Positioning



Intelligent mobility

- Mobile location based services (mLBS)
- Positioning in intelligent transportation
- Positioning for maritime safety and situational awareness



Indoor navigation

- Sensor integration
- Indoor positioning
- Visual and DTV positioning
- Optical sensors e.g hyperspectral 3D measurements



Motivation for multi-technology approach to navigation

Reliable positioning is needed despite the situation

- Dense forests, urban and indoor environments



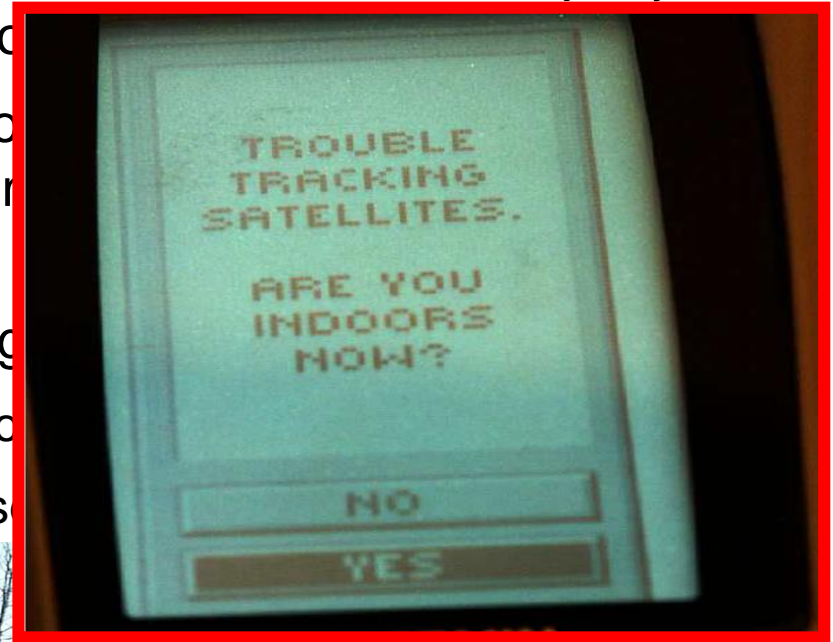
- While exposed to jamming or spoofing

→ **Multi-sensor and multi-system positioning**



Positioning technologies (1)

- GNSS functions mainly in open sky environments but the majority of users are in urban and indoor conditions
- With rapid advances in sensor technology and communications, various positioning methods have been developed
 - determining the locations of moving objects
 - typically satellite-based positioning of stationary objects
 - typically WLAN and self-contained sensors



Positioning technologies (2)

NON-RF SYSTEMS

<i>Technology</i>	<i>Pros</i>	<i>Cons</i>
Inertial	Precise with expensive sensors Works in a variety of environments	Unusable without frequent corrections from external reference
Vision	High precision Works when instrumented	Limited range Extensive instrumentation
Ultrasound	Very inexpensive emitters and sensors High-precision	Limited range Very sensitive to surrounding noise
Infrared	Very inexpensive emitters and sensors High-precision	Limited range Very sensitive to surrounding noise

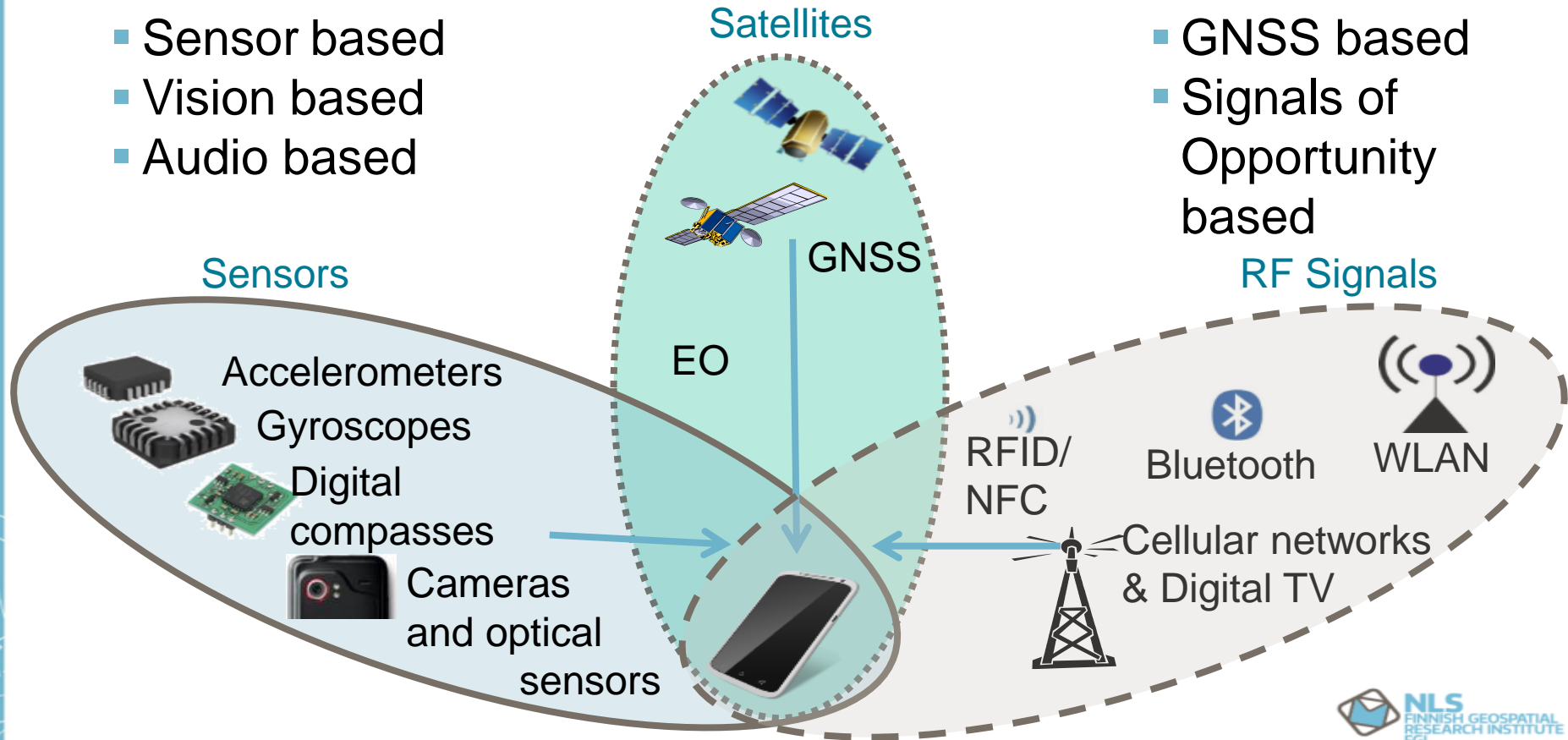
RF SYSTEMS

<i>Technology</i>	<i>Pros</i>	<i>Cons</i>
Cellular	Wide coverage	Precision < 150 m typically Some instrumentation needed
Local area networks (e.g.WLAN)	Access points widespread	Somewhat limited range Instrumentation needed
RFID	Low-cost	Limited range Extensive instrumentation needed
GNSS	Worldwide coverage Free to use	Accuracy 10 m unaided Limited indoor use

Seamless navigation and situational awareness

- Sensor based
- Vision based
- Audio based

- GNSS based
- Signals of Opportunity based



Novel methods for positioning

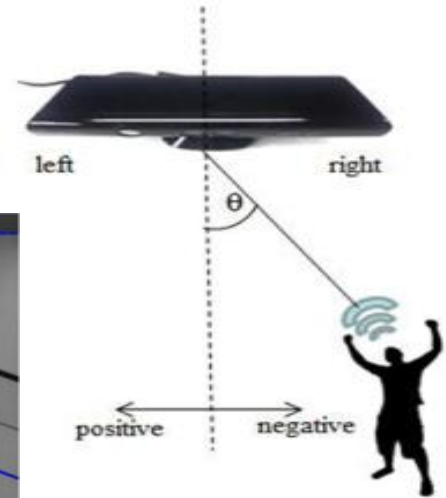
Continuously
exploring new
methods of robust
positioning



Signal of
opportunity
such as digital
TV signals



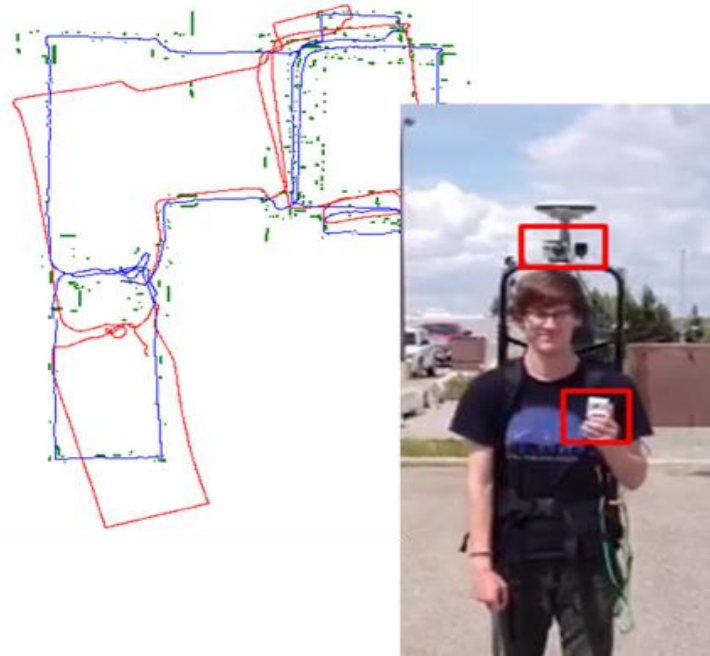
Visual positioning



Acoustic
positioning

Infrastructure-free situational awareness

- **Simultaneous Localization and Mapping (SLAM)**
- **Indoor positioning and context awareness using equipment carried by the user**



- **Multiple inertial sensors**
- **Camera**
- **Ranging equipment (ultrasound...)**

Thank you!

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