Finland's public precise positioning service based on nationwide GNSS network

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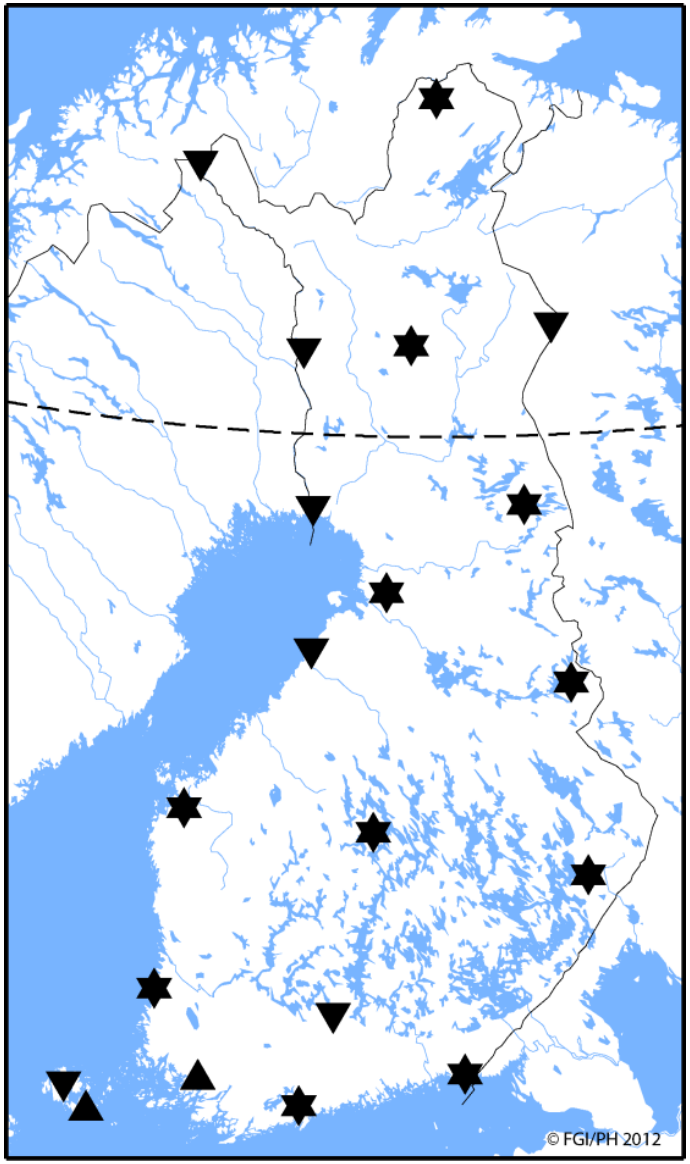
Finnish Geospatial Research Institute

- Governmental research institute for geospatial information science and technology
- Four research departments
  - Geodesy and Geodynamics
  - Geoinformatics and Cartography
  - Remote Sensing and Photogrammetry
  - Navigation and Positioning
- Current staff: about 100

FinnRef

- National network of permanent GNSS stations
  - Operated by the Finnish Geospatial Research Institute
- Some stations belong to
  - International GNSS Service (IGS)
  - European Permanent Netwok (EPN)
- Renewal process 2012-2013
- Fully operational since 2014
- Open data policy



Equipment

Javad Delta-G3T

Javad Choke Ring antenna

Antennas are individually calibrated

Masts are on a stable bedrock

GNSS	Signals
GPS	L1, L2, L2C, L5
Glonass	L1, L2, L3
Galileo	E1, E5a, E5b, AltBOC
SBAS	EGNOS, WAAS, MSAT
Beidou	B1, B2

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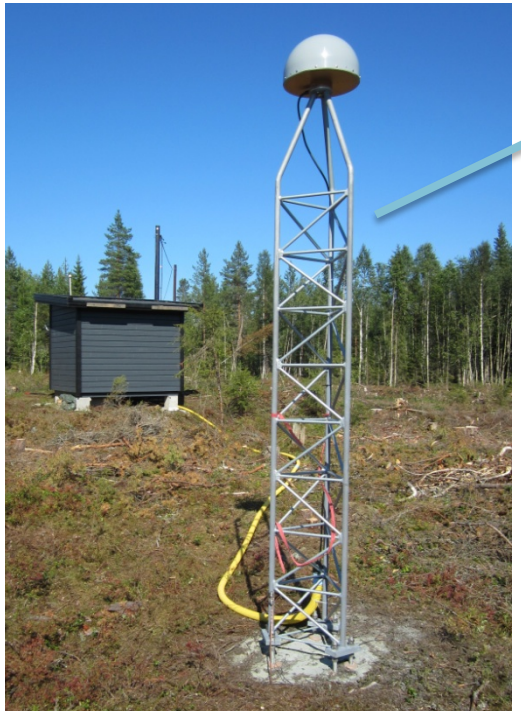
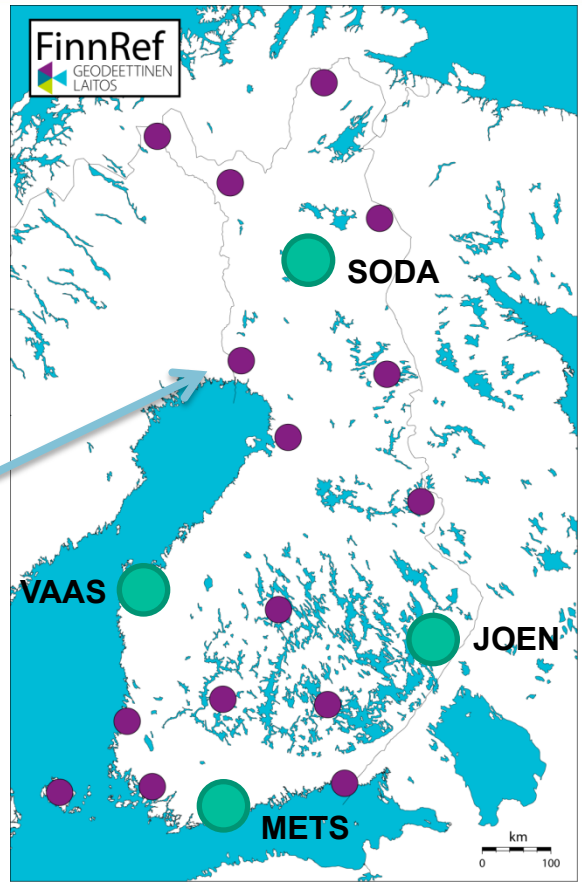
FinnRef

- Open data policy 2014
- Real time data streams
- Positioning service
  - GNSMART by Geo++
    - DGNSS service (free)
    - Network RTK service (pilot)
    - Rinex data (free)





More information:
http://euref-fin.fgi.fi/fgi/en

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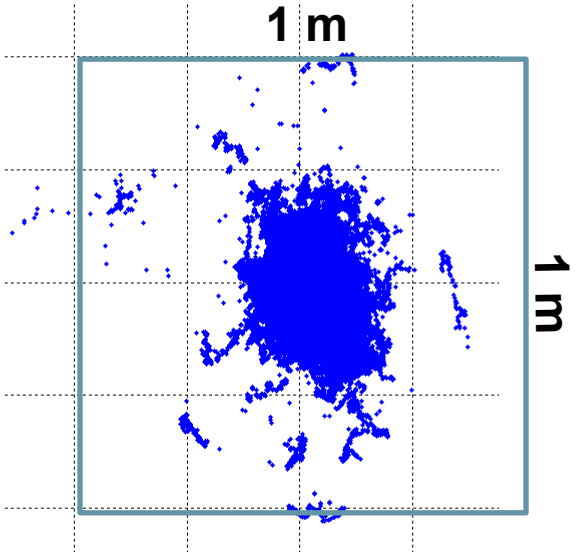
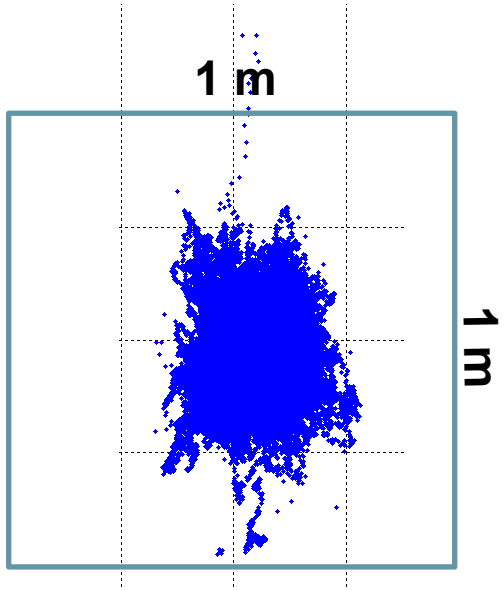
Accuracy: DGNSS and DGPS

- Distance to nearest station 10 km





DGNSS

Mean of errors: 19 cm

95 %: 40 cm

DGPS

Mean of errors: 22 cm

95 %: 43 cm

~24h data/ 1s interval

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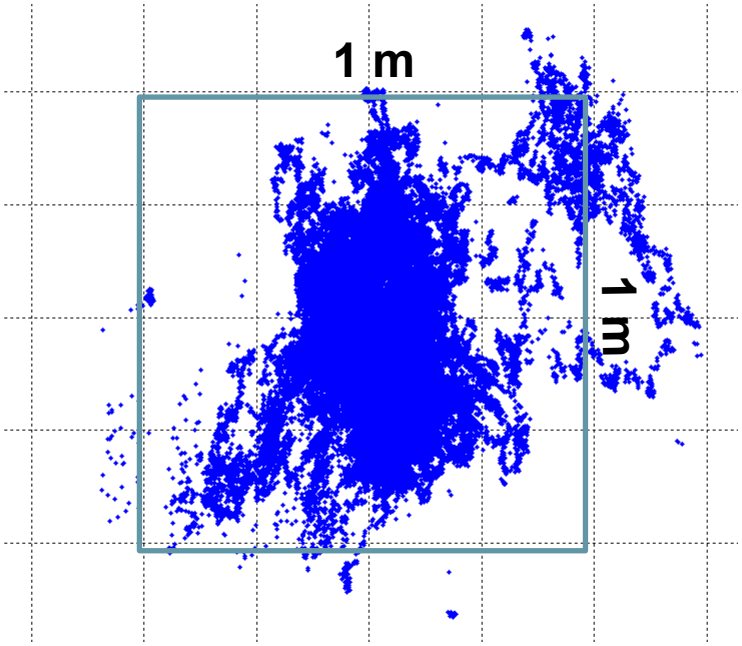
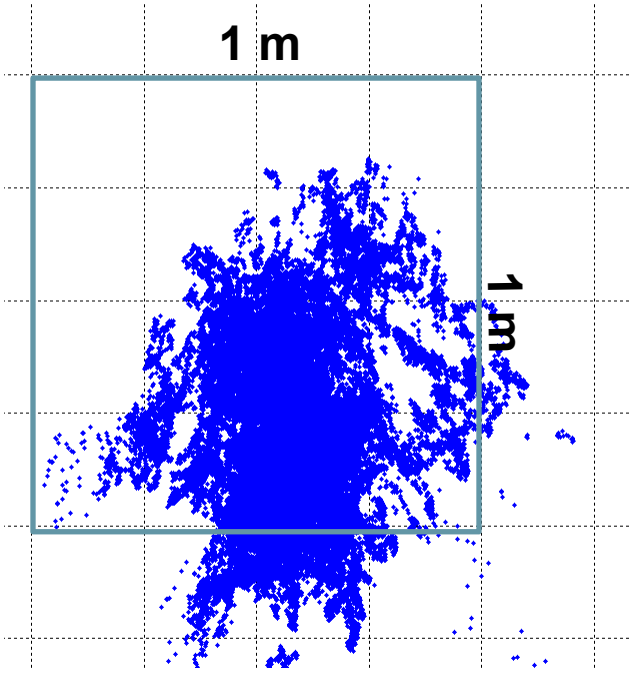
Extrapolation

- Distance to nearest station 163 km





Network DGPS

Mean of errors: 40 cm

95 %: 106 cm

DGPS

Mean of errors: 65 cm

95 %: 119 cm

~24h data/ 1s interval

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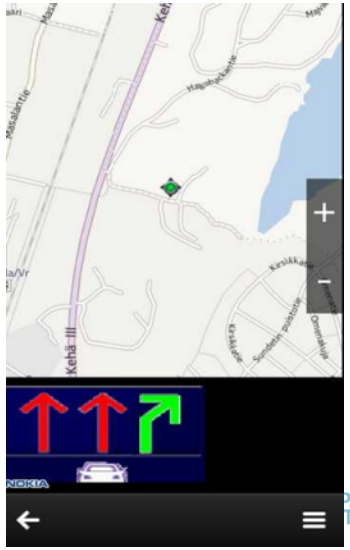
Background – Next Generation ITS 1/2

- Road-level navigation
  - GNSS + map-matching => NO PROBLEMS
- Lane-level navigation
  - better than 0.5 m positioning accuracy is needed
  - achieved with a high-cost dual frequency receiver
  - price of the GNSS receiver (> 1000 Euros) is not acceptable for mass market applications



Background – Next Generation ITS 2/2

- Safety Applications, position accuracy 0.5-1.0 m
  - Warnings for: Intersection and Forward Collision, Lane Change, Blind Spot
- Position based charging, e.g. parking
- Road maintenance, e.g. snow plowing, sanding

Intelligent transportation systems

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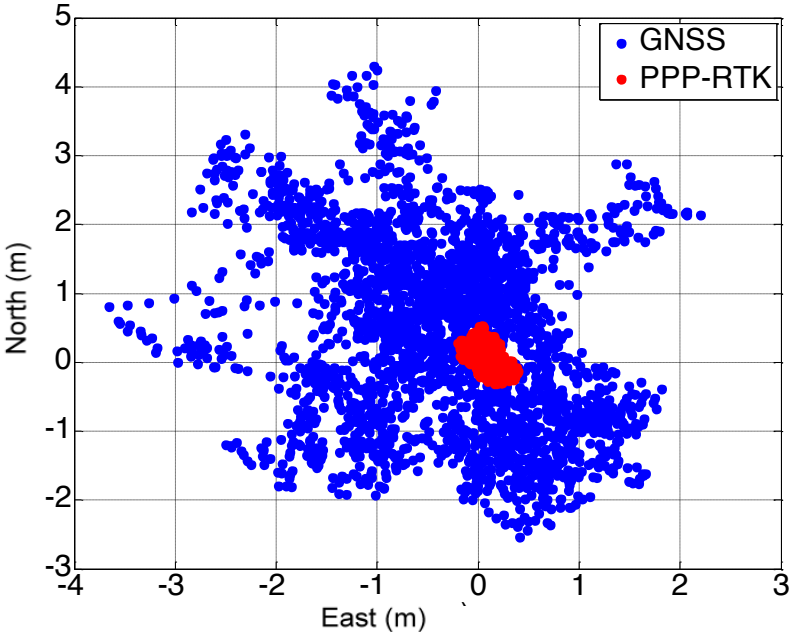
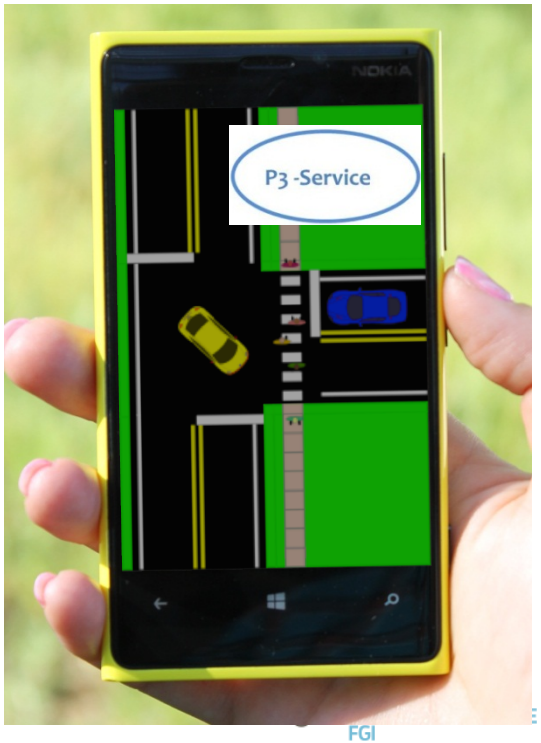
Mobile Precise Positioning with FinnRef

- P3-service project: a mobile public precise positioning
- FinnRef DGNSS accuracy on mobile low cost receivers > 1m
- Smartphone as the application platform
- Improved accuracy
  using carrier phase measurements

Positioning accuracy 0.5 m





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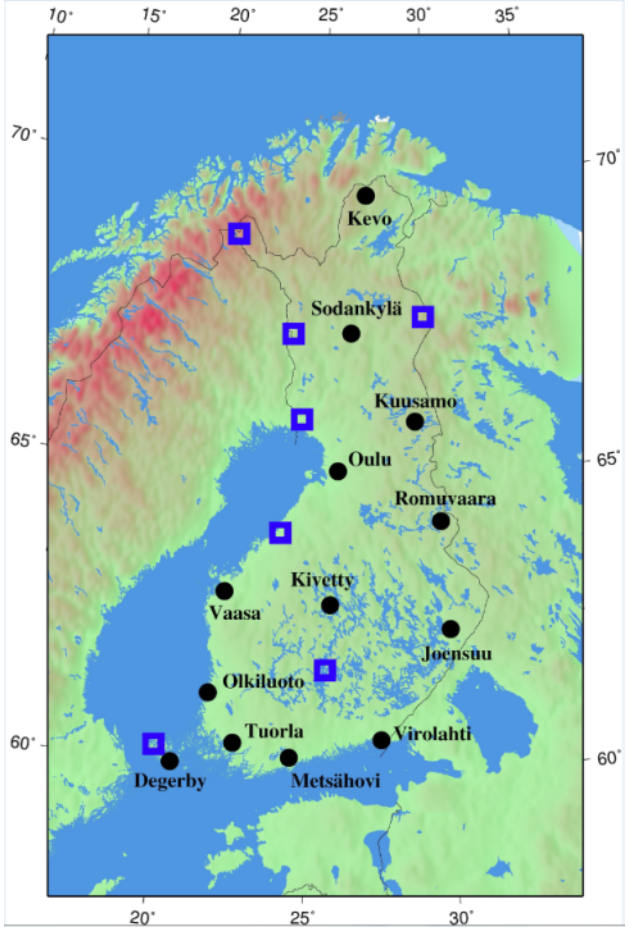
FinnRef in P3-Service

- Inter-station distances: 150 – 300 km, shortest client-to-reference distance: < 100 km.
- New algorithms are needed for achieving a 0.5 meter positioning accuracy with a very low cost receiver
  - Single frequency
  - Larger measurement noise
  - Larger residuals of the error models



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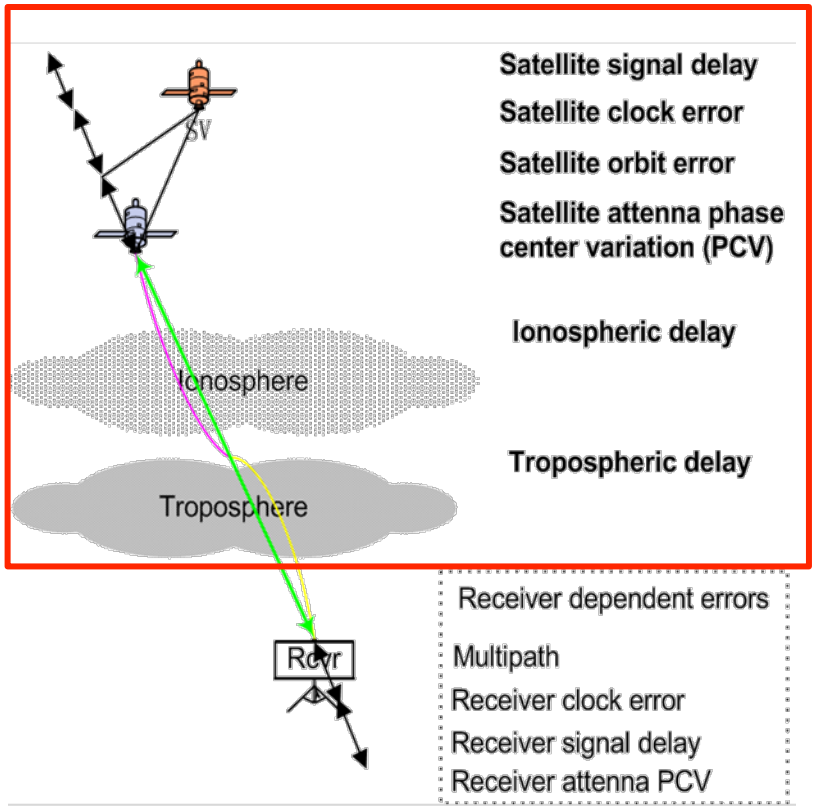
Precise Positioning using FinnRef Network

- Precise positioning solution for free.
- Satellite and atmospheric related errors modelled
- Real-time processing in a Cloud service



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P3-Service Project 1/2

- Duration 9 / 2013 – 11 / 2015
- Research project funded by
  - Tekes - the Finnish Funding Agency for Innovation
  - Finnish Geospatial Research Institute
    - Department of Navigation and positioning
    - Department of Geodesy and Geodynamics
  - 9 Companies:
    - Microsoft => **custom made mobile phone providing carrier phase measurements**
    - Sonera : teleoperator
    - VR Track (Finnish Railways), Destia (Road maintenance), Indagon, Space Systems Finland, Semel, Hohto Labs, FastROI

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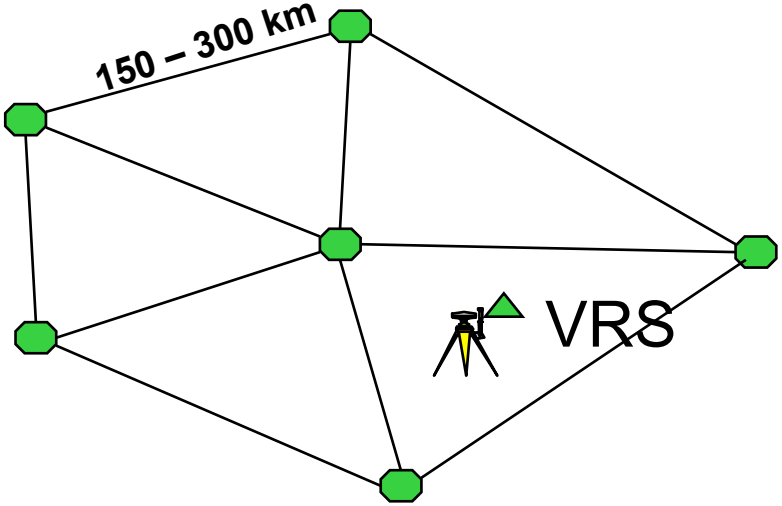
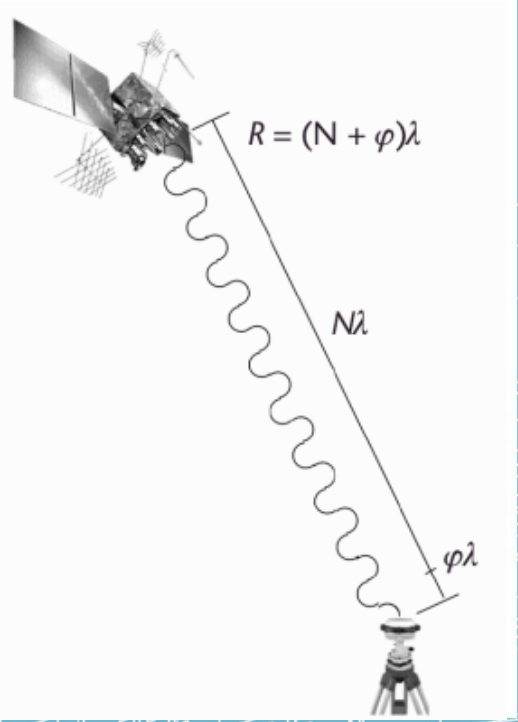
P3-Service Project 2/2

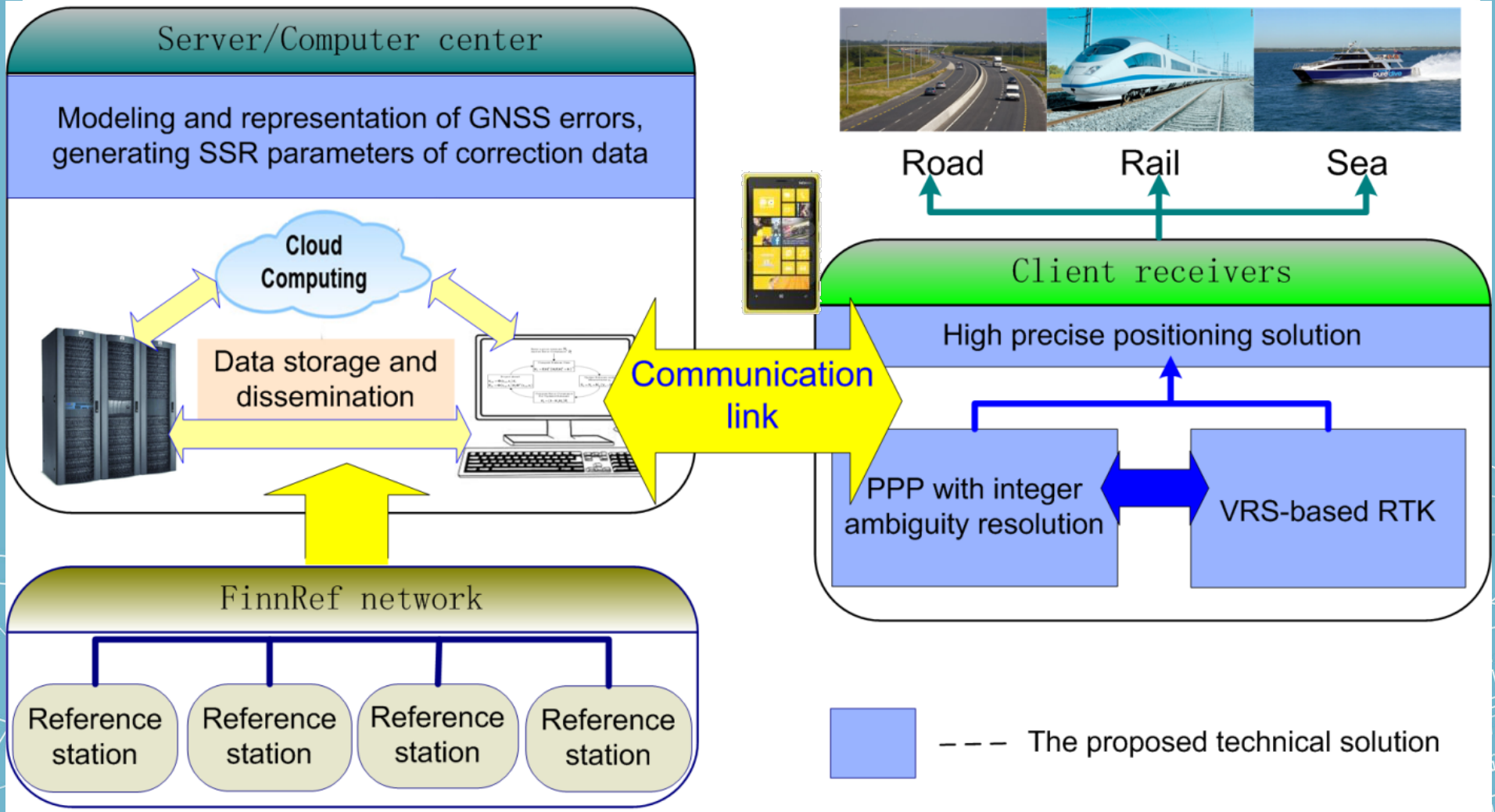
- Real-time GNSS Error Modelling
- Virtual Reference Station Generation
- Dual-Core Precise Point Positioning (PPP)- Real Time Kinematics (RTK) Algorithm
  - PPP initialized (and recovered) using RTK => reduced convergence time
  - PPP: no baseline limitation





The P3-Services

SSR= state space representation

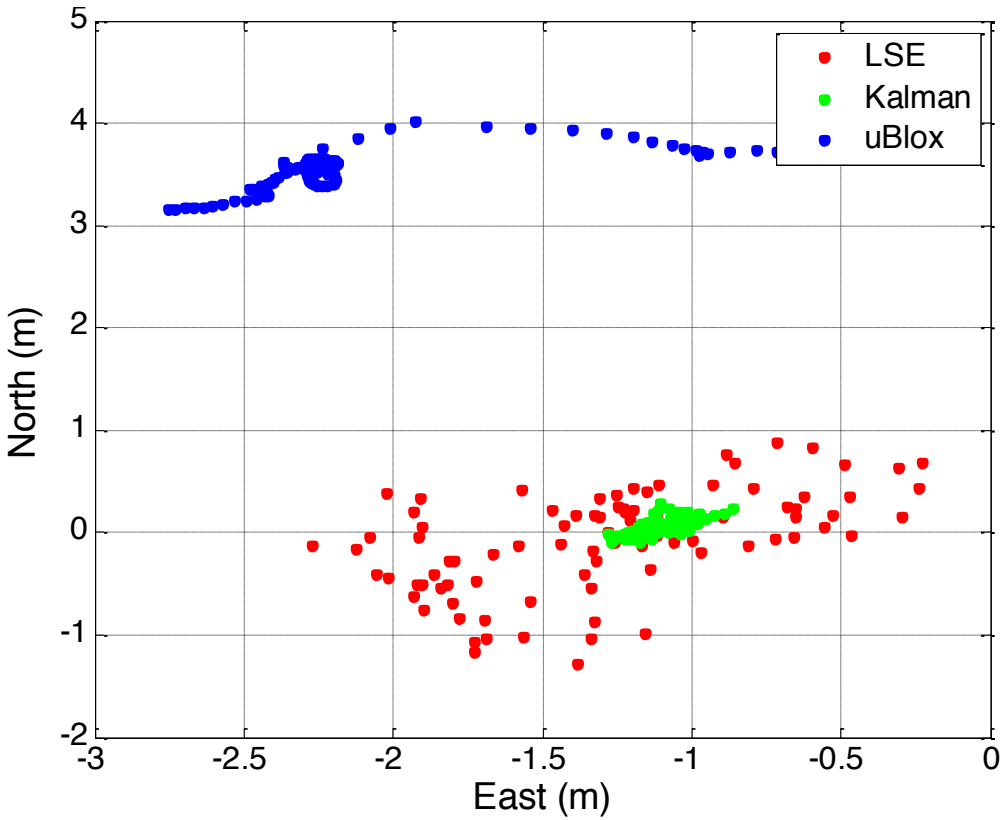


Dual-Core PPP-RTK

- RTK available for short periods => e.g. 1 minute enough to initialize PPP
- Traditional PPP uses only subset of GNSS corrections, P3 will
  - Use also ionosphere and troposphere corrections
  - Compute single-difference between two satellites
    - Initial phase in receiver removed
    - Integer ambiguity resolution improved
    - Initialization time reduced

Initial results using PPP-algorithm

- Measurements done using U-Blox EVK-6T
- Distance to nearest station 2.8 km
- Horizontal offset 1.12 m
- FinnRef still missing ionospheric corrections => results will improve



- RTK tested with good results
- Next steps
  - Dual-Core RTK-PPP
  - Smartphone implementation

ENC 2016

www.enc2016.eu

European Navigation Conference 2016

Helsinki, Finland, 30th May – 2nd June 2016

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IMPORTANT DEADLINES

Full-paper submission: (Scientific Track)	15th January, 2016
Abstract Submission: (Industry Track)	15th January, 2016
Acceptance Notification:	31th March, 2016
Early Registration:	15th April, 2016

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