Leibniz Universität Hannover

GNSS in Urban Areas – Benefits and Limits of Collaborative Positioning

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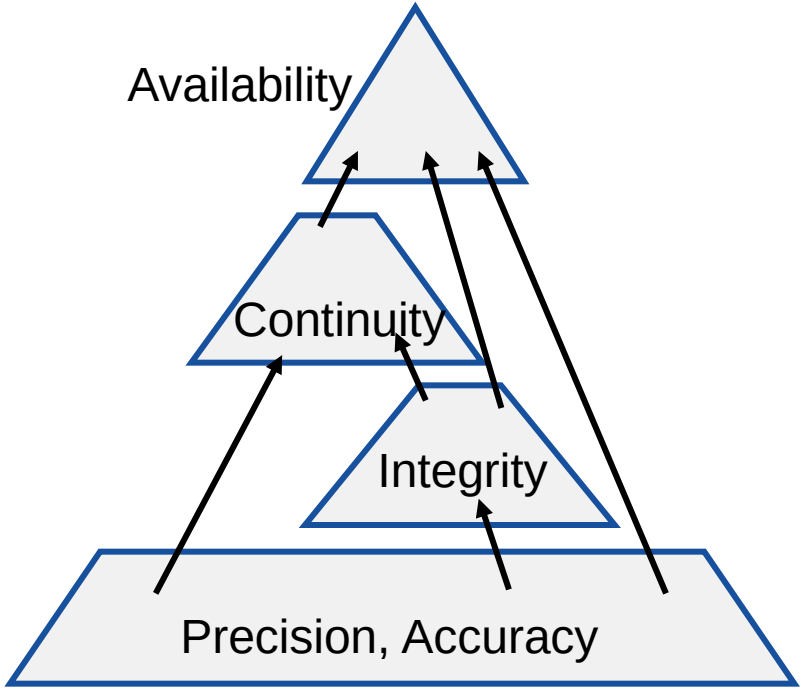
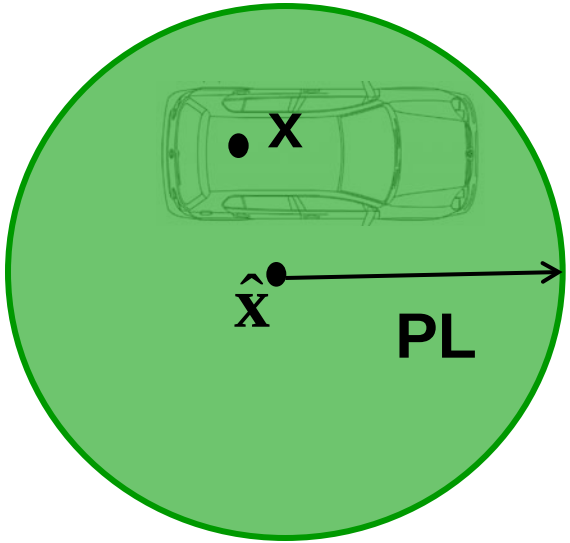
Demanding Navigation Applications

EP1603781B1; Google, telematics magazine, P.Birnes Pexels, E.Rames, Pexels

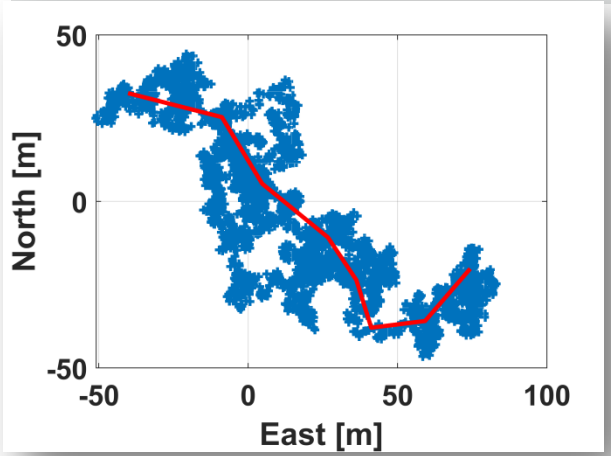
Navigation Performance Parameters



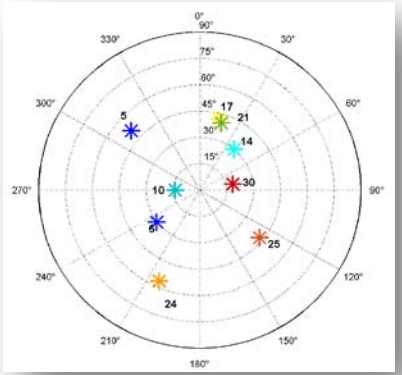


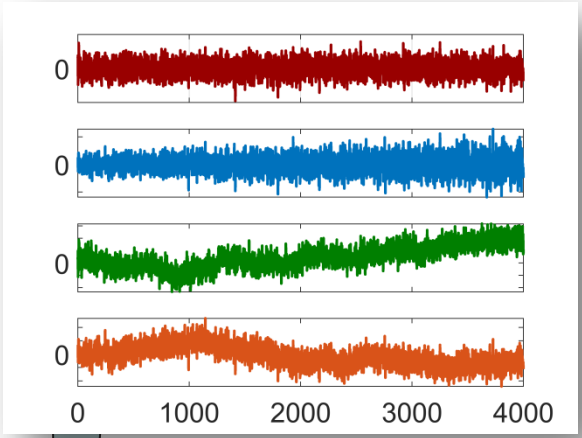
Need to trust the navigation solution

Quality of Positioning



Quality of positioning



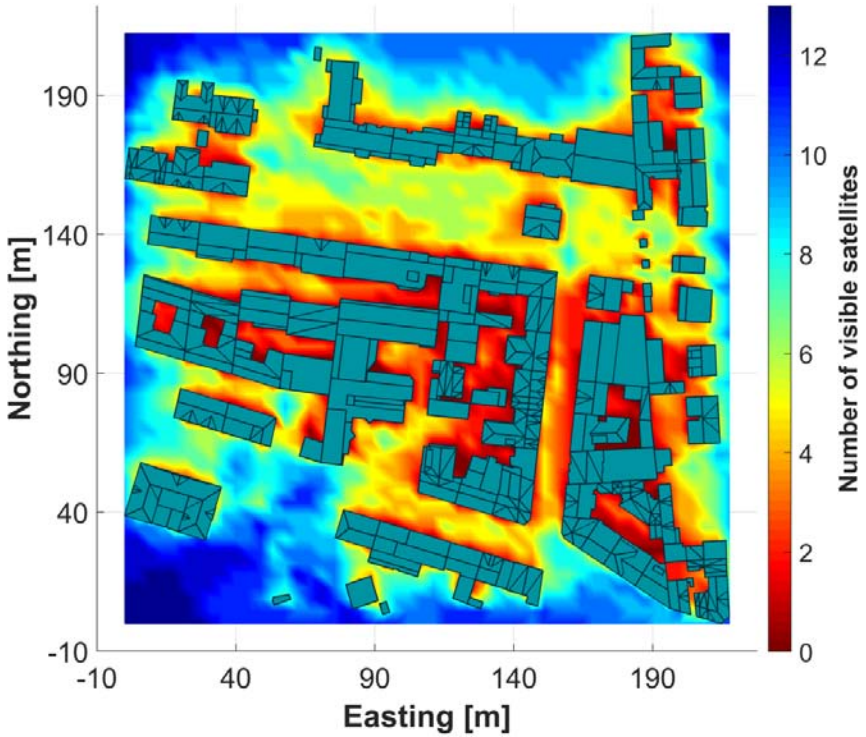


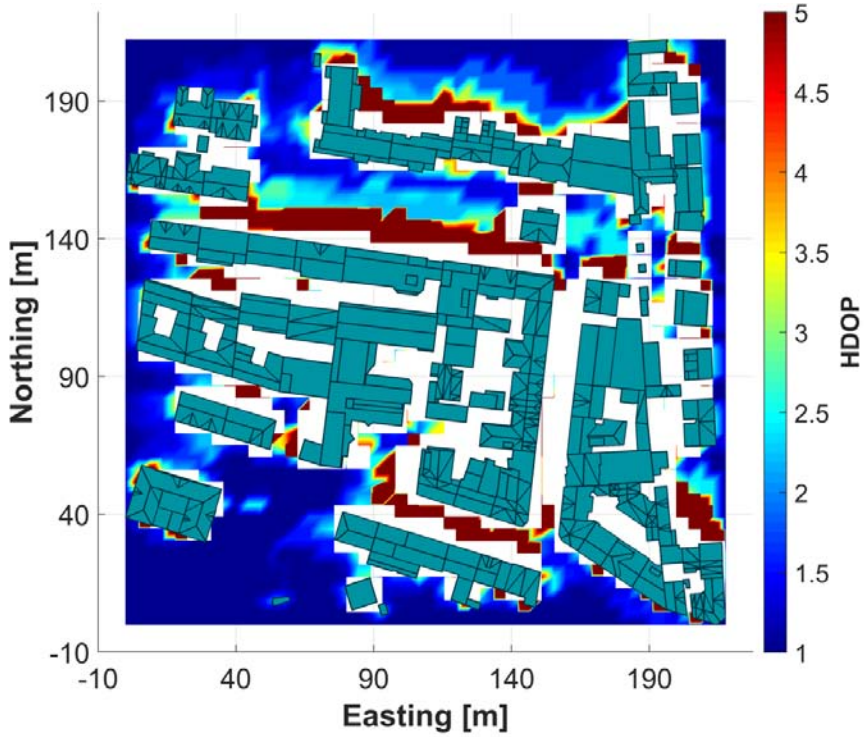
Quality of observations

Navigation Geometry (DOP)

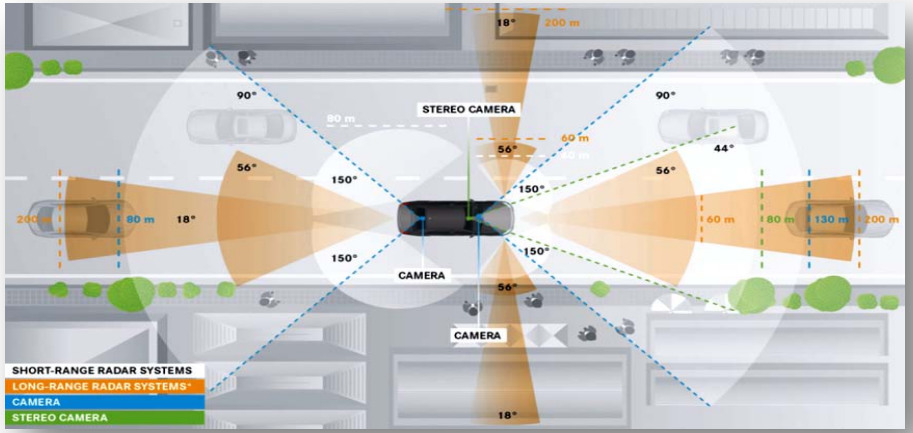
Urban Area: Example Hannover

GNSS in Urban Areas



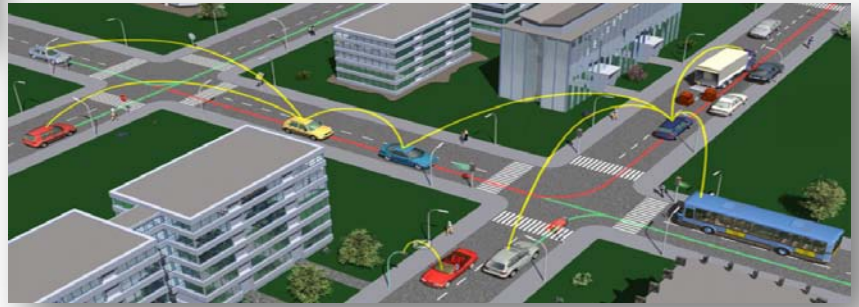


Collaboration – A Solution ?



Fusion of various nodes into one dynamic network solution

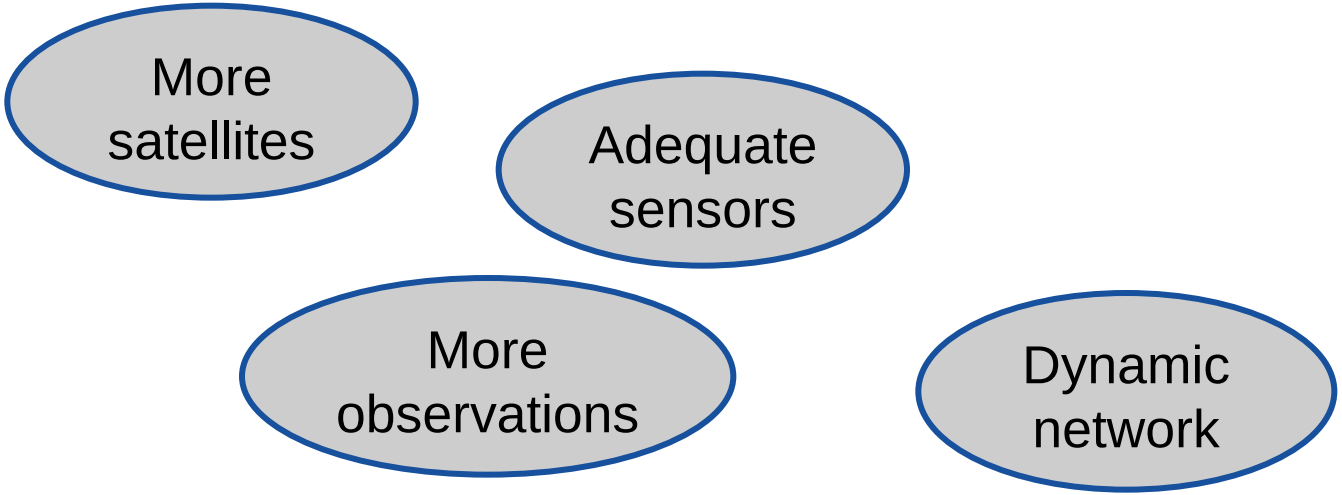
Combination of various sensors at one platform



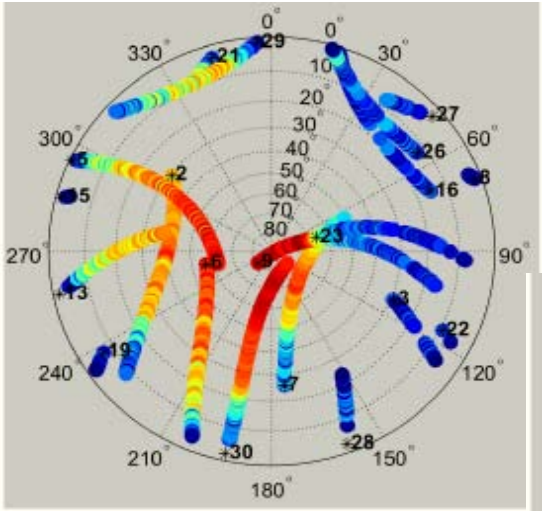
IEEE Intelligent Transportation Systems Magazine, Vol. 6, No. 2, pp. 8-20, 2014; www.car-2-car.org

Possibilities of Improvement

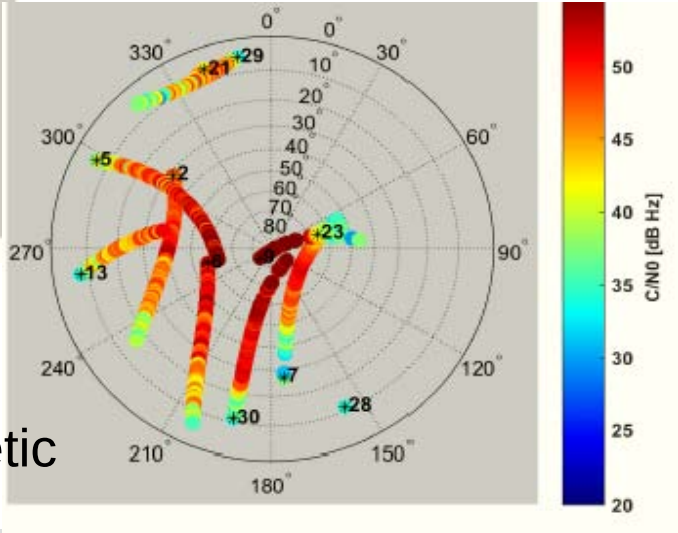
- Strengthening the geometry of navigation
- Reducing systematic errors (Integrity, outlier detection)



High Sensitivity GPS in Urban Areas



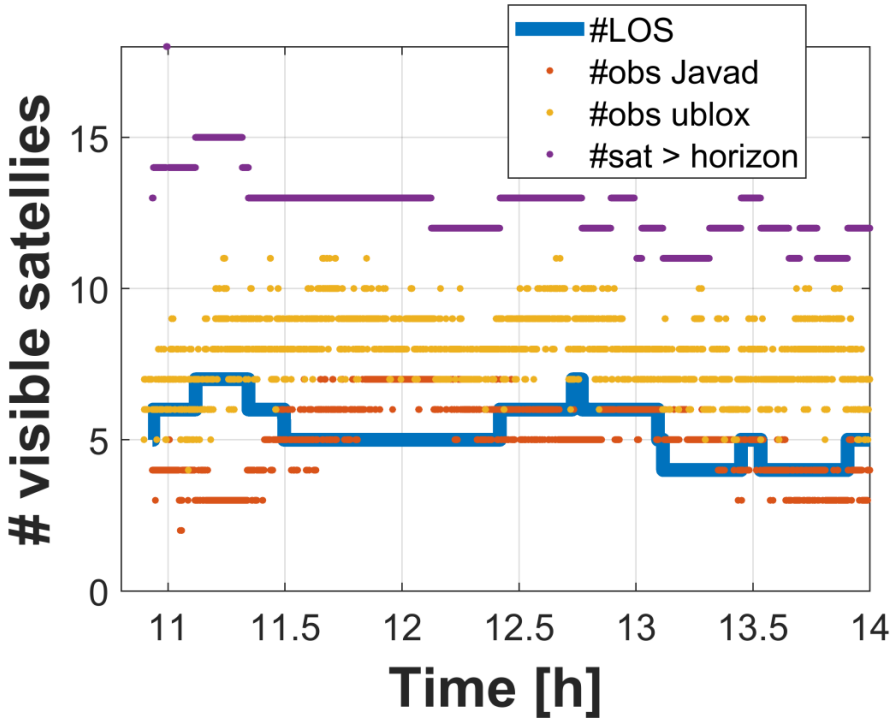
High sensitivity

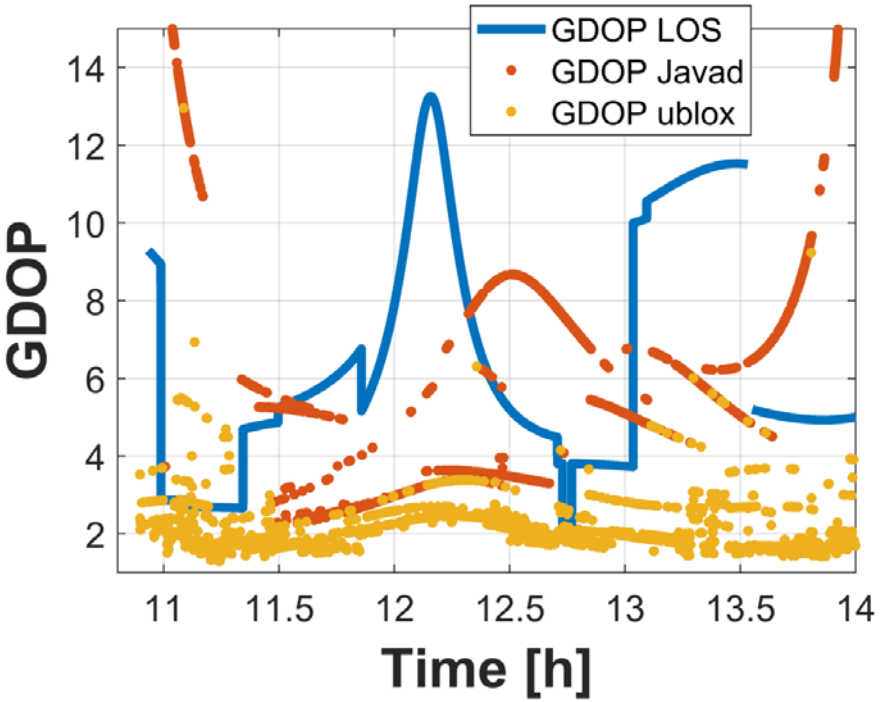


Geodetic

BA J. Hartmann
Orthophoto Stadt Hannover

High Sensitivity GPS in Urban Areas

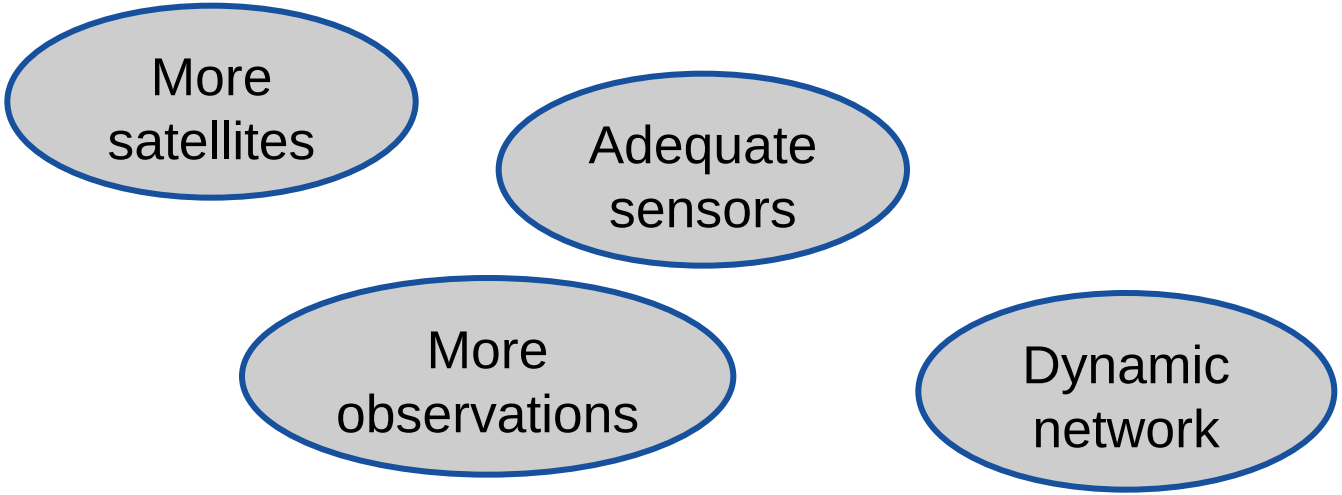




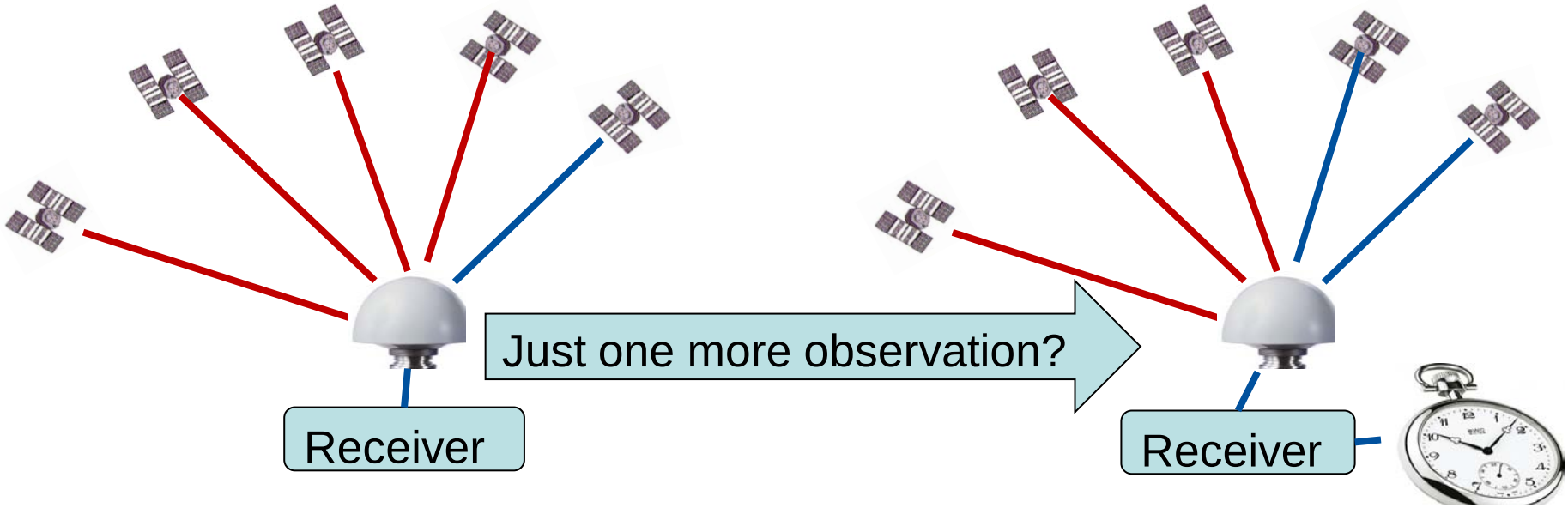
Signals available but biased

Possibilities of Improvement

- Strengthening the geometry of navigation
- Reducing systematic errors (Integrity, outlier detection)

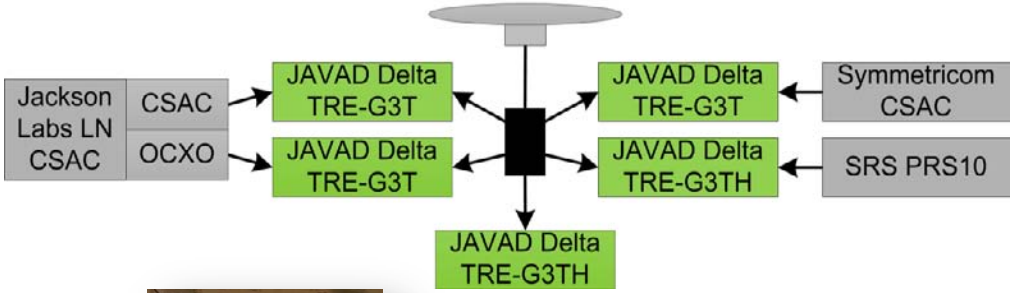


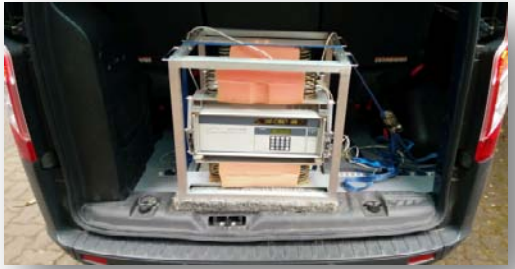
Fusing GNSS with Chip Scaled Atomic Clocks



Different geometry,
Different temporal parameter resolution feasible

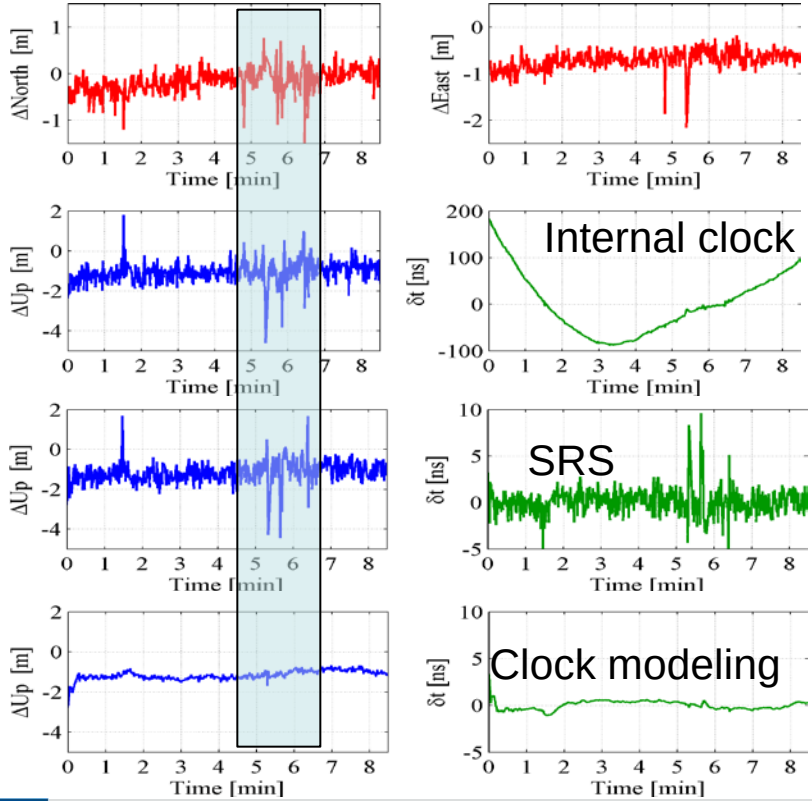
Collaboration GPS + Atomic Clock

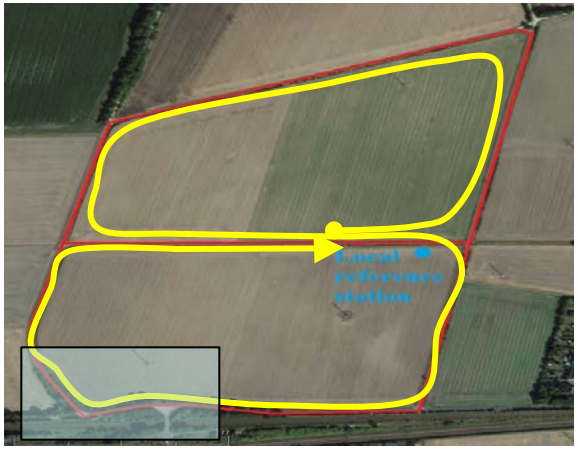




Krawinkel/Schön (2014,2016) ION GNSS
Krawinkel/Schön (2016) GPS Sol
Krawinkel/Schön (2016) GPS World
Krawinkel/Schön (2018) ION GNSS
Krawinkel/Schön (2018) ESA Navitec
Krawinkel (2018) PhD Dissertation

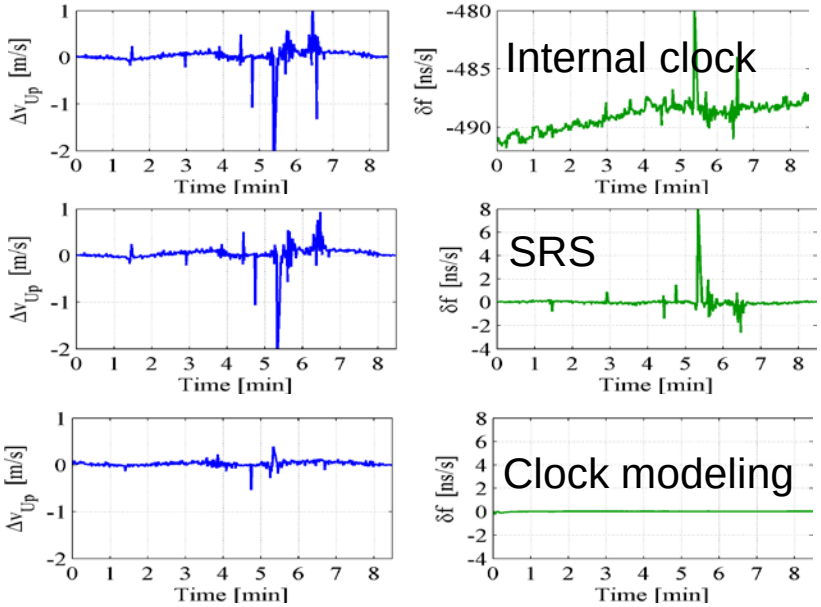
Collaboration GPS + Atomic Clock: Position





- Smoother height coordinates (50% improvement)
- Reduction of outliers
- Remaining offsets due to orbit, ionosphere

Velocity

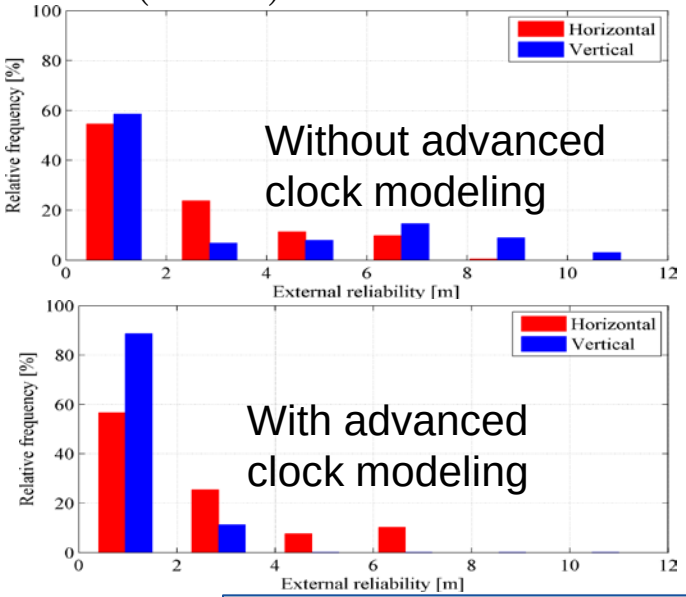


Improved velocity
(up to 60% in RMS, 60% in std)

Reliability

Impact of gross errors on parameters

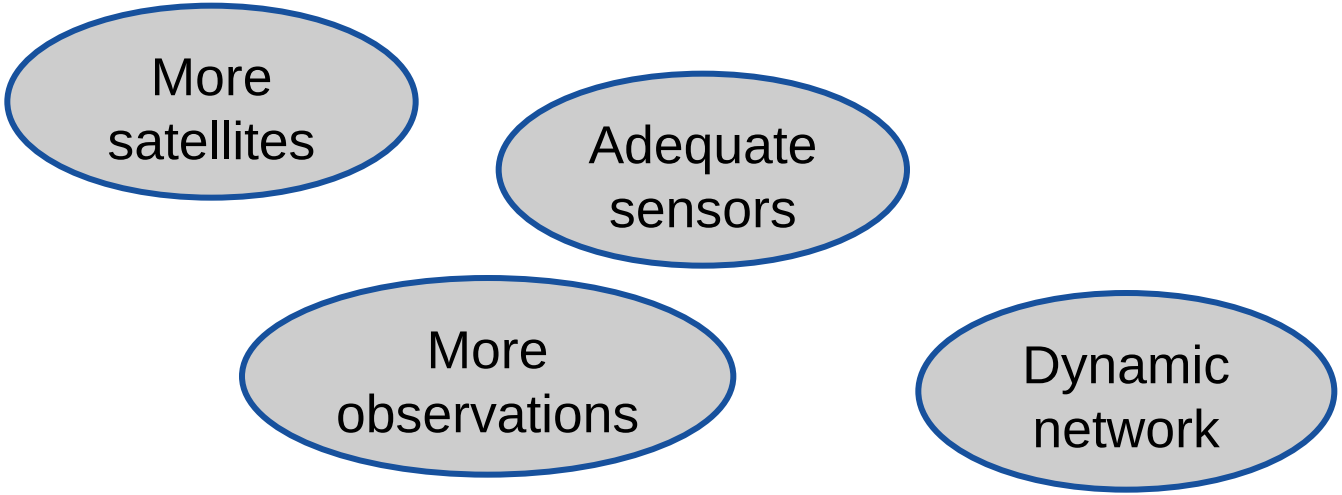
$$\nabla \mathbf{x}_i = \left(\mathbf{A}^T\mathbf{P}\mathbf{A}\right)^{-1}\mathbf{A}^T\mathbf{P}\cdot\nabla\mathbf{y}_i = \mathbf{K}\cdot\nabla\mathbf{y}_i$$



Results more robust

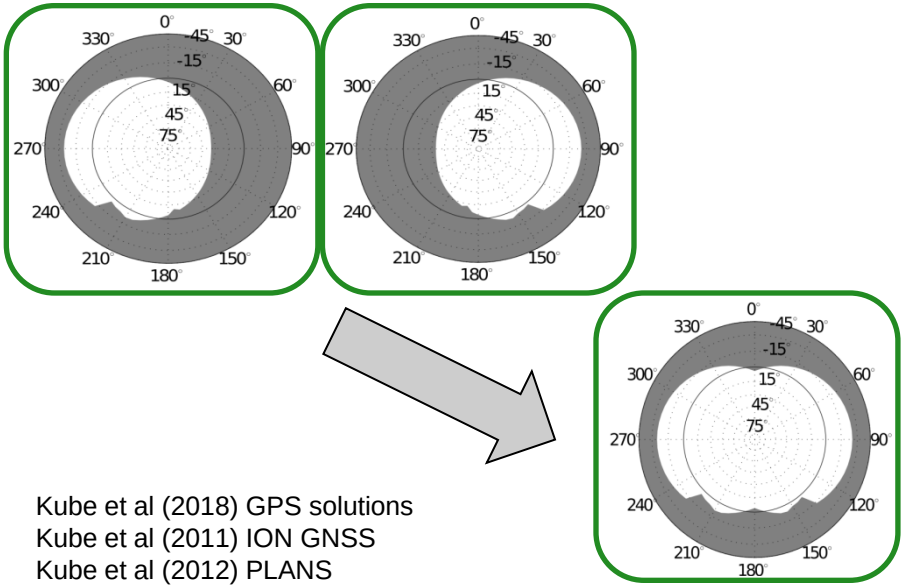
Possibilities of Improvement

- Strengthening the geometry of navigation
- Reducing systematic errors (Integrity, outlier detection)



Fusing Multiple GPS Antennas: Virtual Receiver

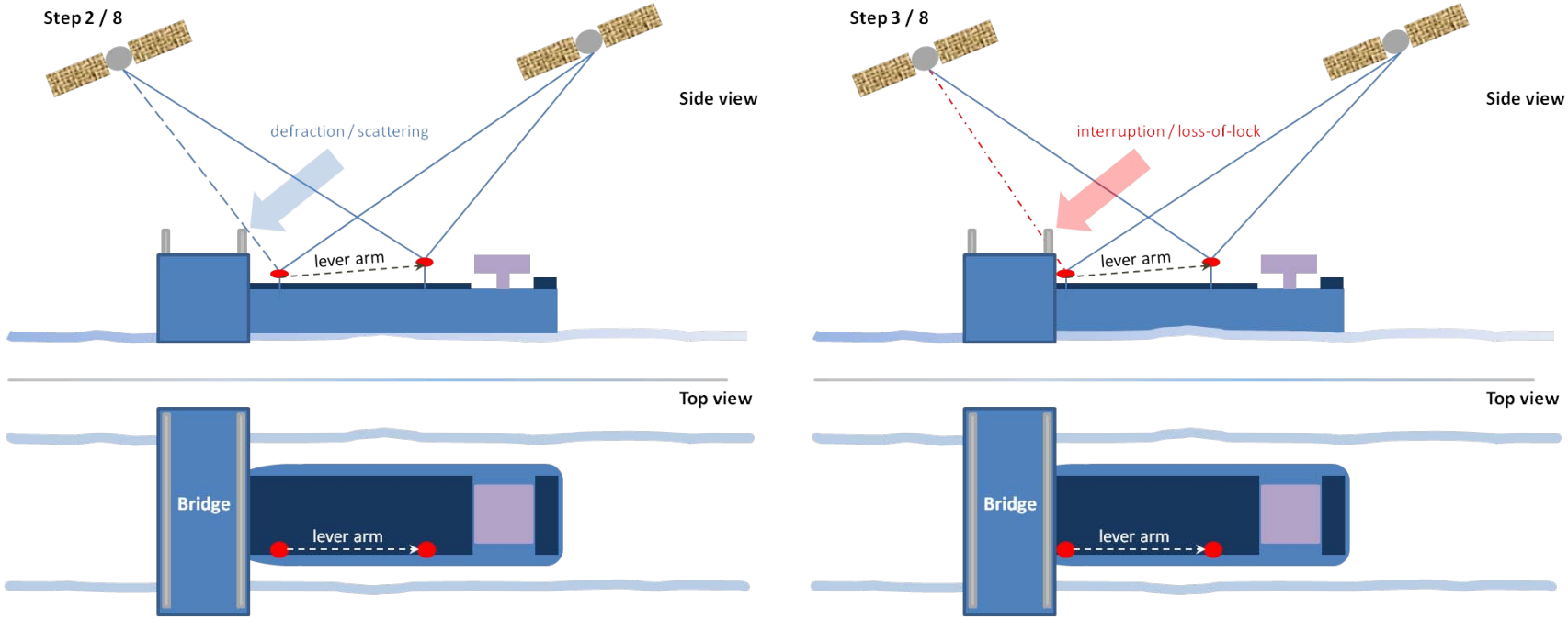
- Combining observations from optimally installed antennas in one platform solution



- Improved coverage
- But full attitude needed

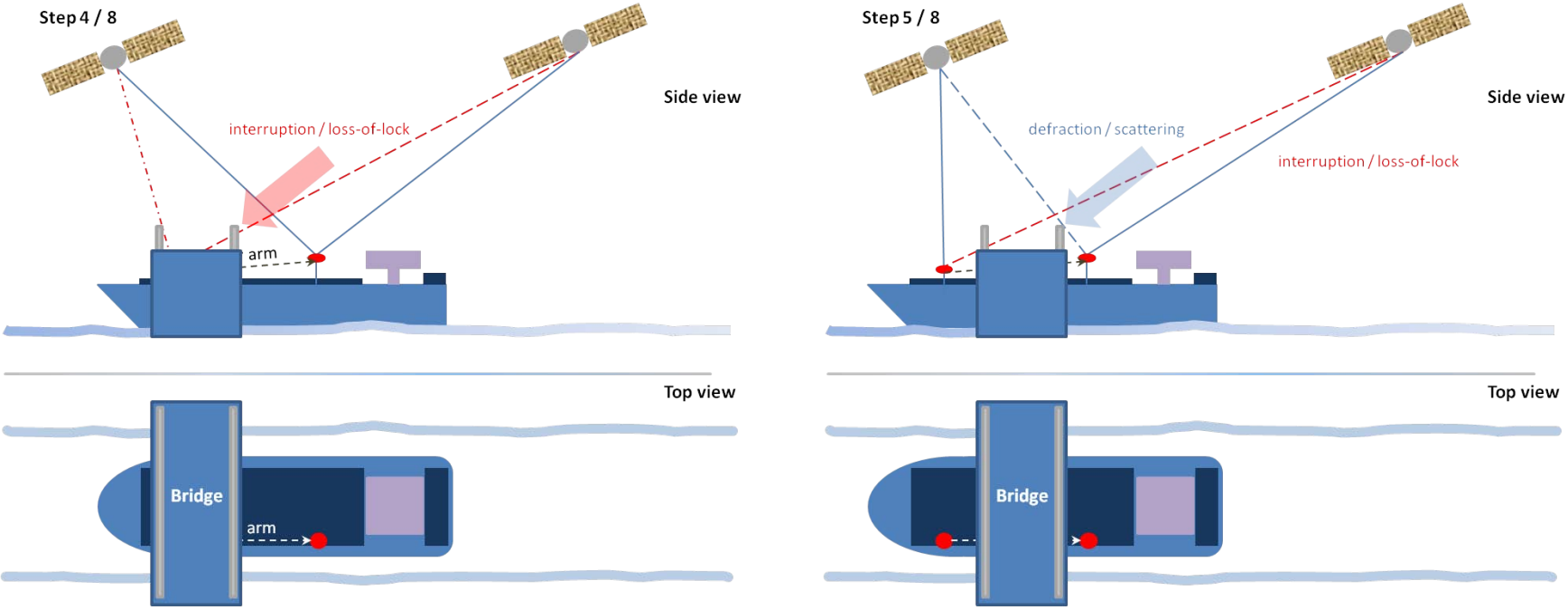
Kube et al (2018) GPS solutions
Kube et al (2011) ION GNSS
Kube et al (2012) PLANS

Virtual Receiver: Bridge Crossing



Kersten et al (2018) DGON PosNav
Kersten et al (2018) ESA Navitec

Virtual Receiver: Bridge Crossing



Kersten et al (2018) DGON PosNav
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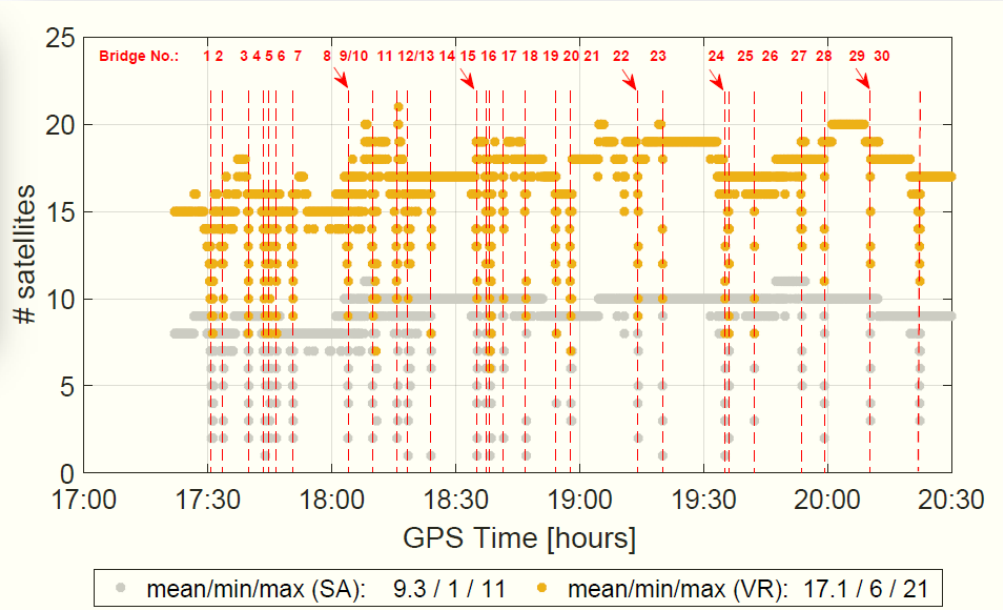
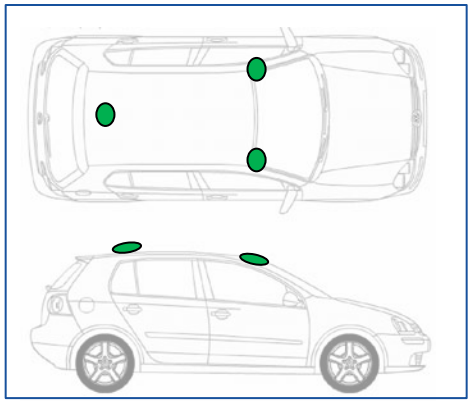
Virtual Receiver: Bridge Crossing

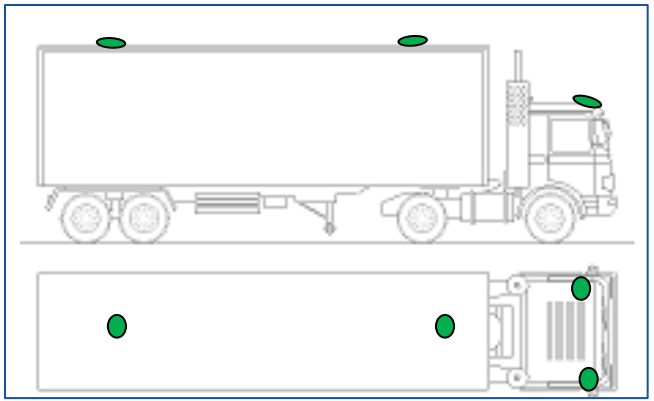


Kersten et al (2018) DGON PosNav
Kersten et al (2018) ESA Navitec

Virtual receiver in urban areas ?

- Extended field of view ?
- Variability w.r.t multipath (carrier phase)

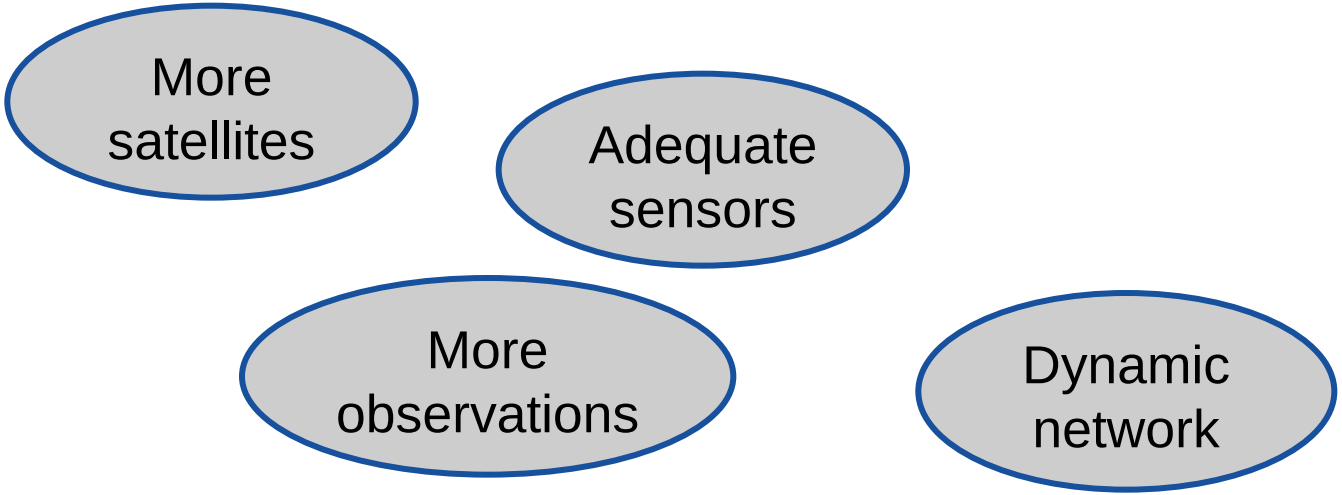




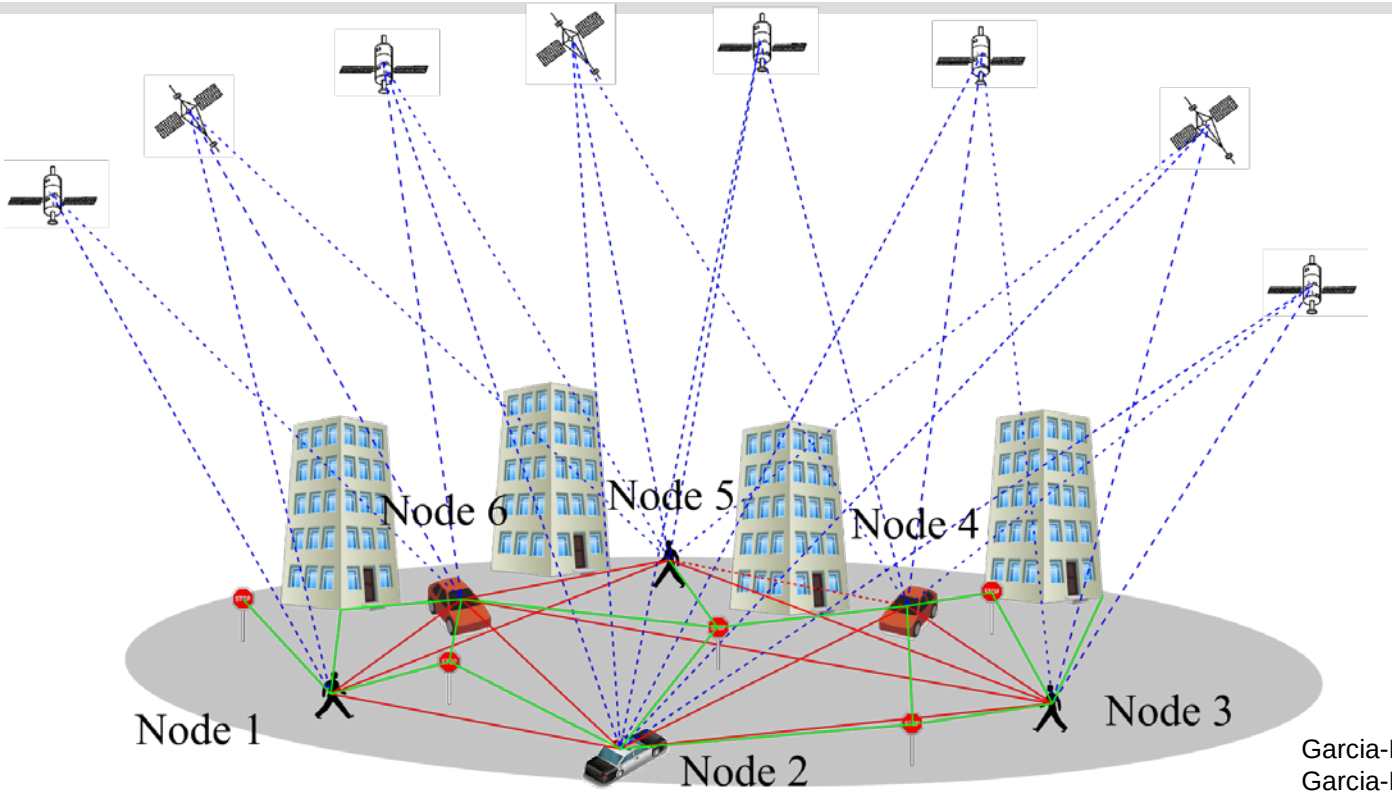
From theory: all navigation parameters are improved, except accurcay
Open question: strengthened geometry vs more biases

Possibilities of Improvement

- Strengthening the geometry of navigation
- Reducing systematic errors (Integrity, outlier detection)

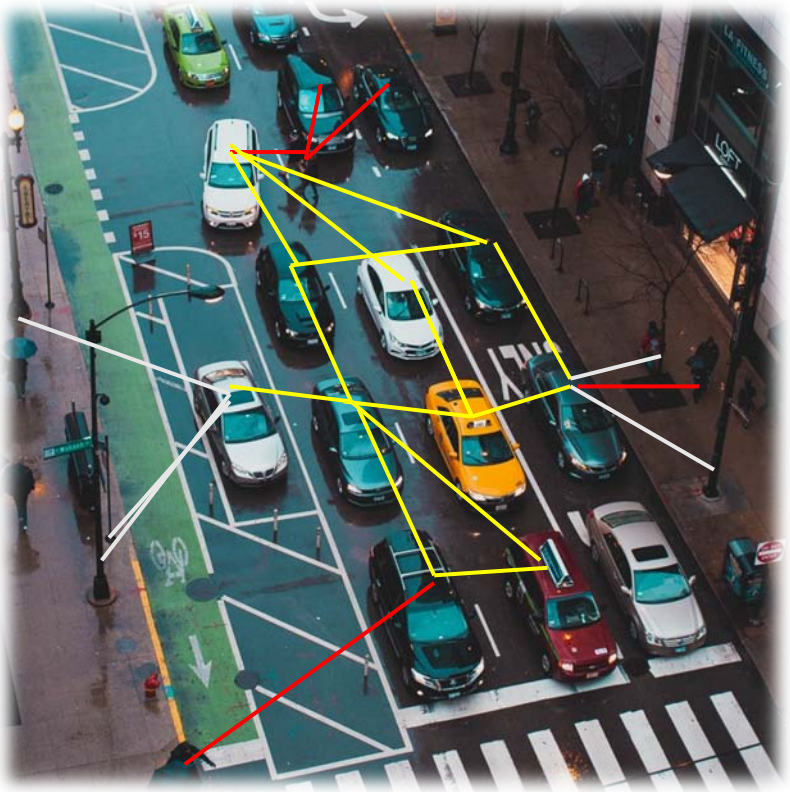


Collaboration in a Dynamic Network



Garcia-Fernandez/Schön (2017) WPNC
Garcia-Fernandez/Schön (2018) PLANS
Garcia-Fernandez/Schön (2019) ION

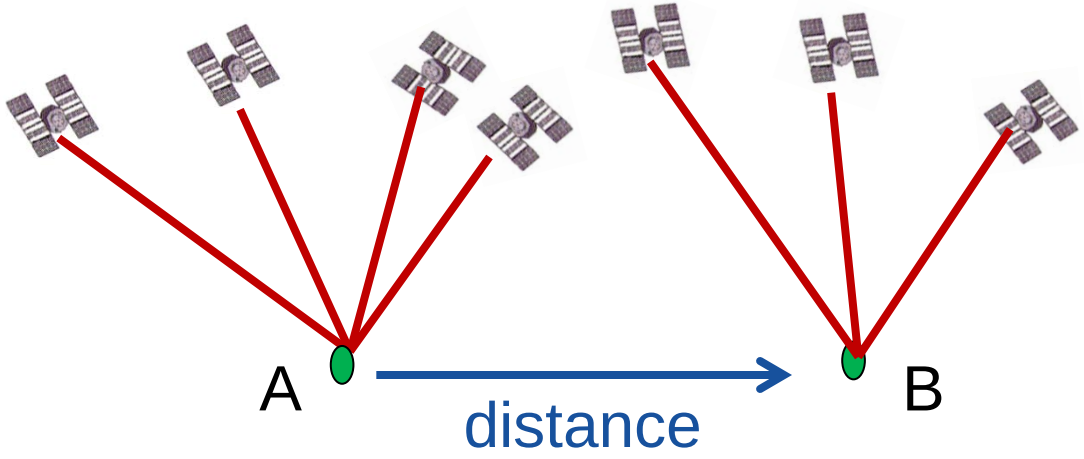
Collaboration in a Dynamic Network



- Dynamic network
- High redundancy
- Improved positioning

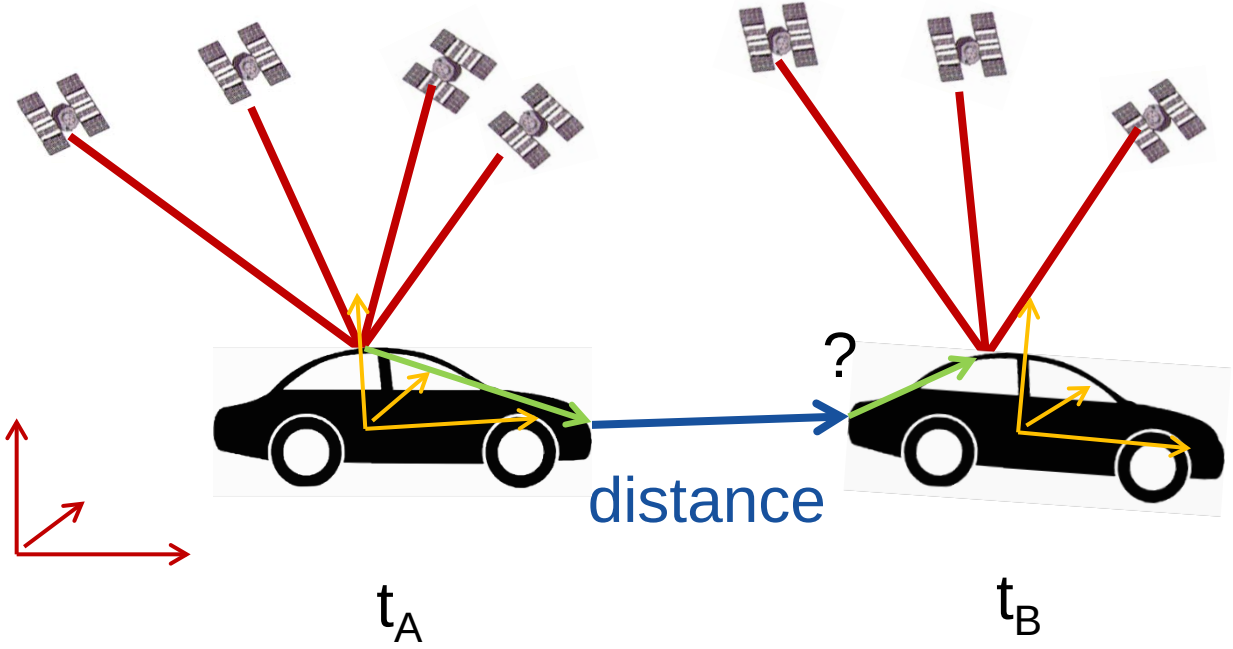
Collaboration in a Dynamic Network

- Urban Canyon



Collaboration in a Dynamic Network

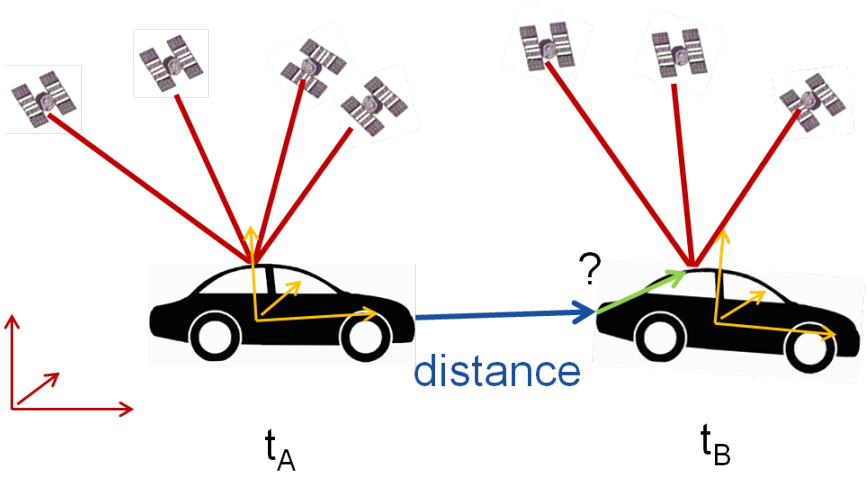
- Urban Canyon



Coenen (2018)

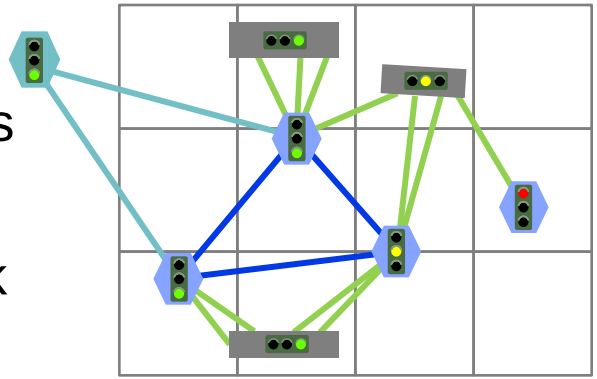
Collaboration in a Dynamic Network

- Access to a common frame
- 3D pose needed
- Identification of target point
- Link in body frame
- Common observation epoch ?
- …



Conclusions

- Collaboration is beneficial
- Virtual receiver and combination with atomic clocks are alternative concepts of collaboration
- Lever arms, attitude and time synchronisation play key role in multi-sensor multi node systems
- Adding integrity to such systems is a future task



Schön S, Brenner C et al. (2018) Integrity and Collaboration in Dynamic Sensor Networks. Sensors (Basel, Switzerland). 2018;18(7):2400. doi:10.3390/s18072400.

New openings: DFG RTG 2159:
www.icsens.uni-hannover.de/application.html?&L=1