

# COLLABORATIVE METHODS FOR INFRASTRUCTURE-FREE POSITIONING



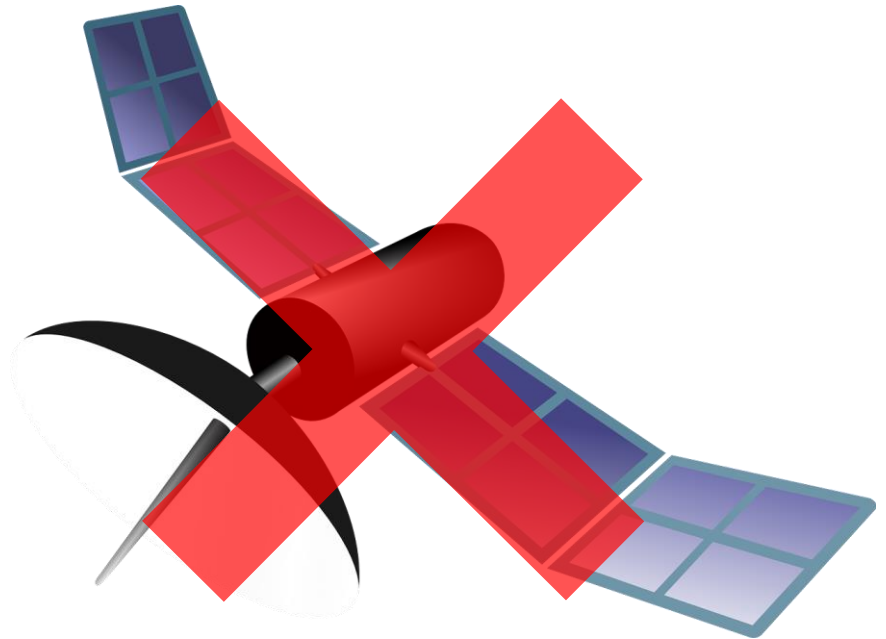
Imagine to be a firefighter in this situation...

Video: Varsinais-Suomen pelastuslaitos

<https://www.youtube.com/watch?v=7SABjHFEjbQ>

# INFRASTRUCTURE-FREE NAVIGATION

- Needed when satellite navigation, WiFi-positioning etc. are not available
  - Indoor space, jamming, spoofing, power outage...
  - Tactical and first response operations
- Based on wearable sensors
  - Inertial, barometer, sonar, camera, UWB



# INFRASTRUCTURE-FREE COOPERATIVE POSITIONING

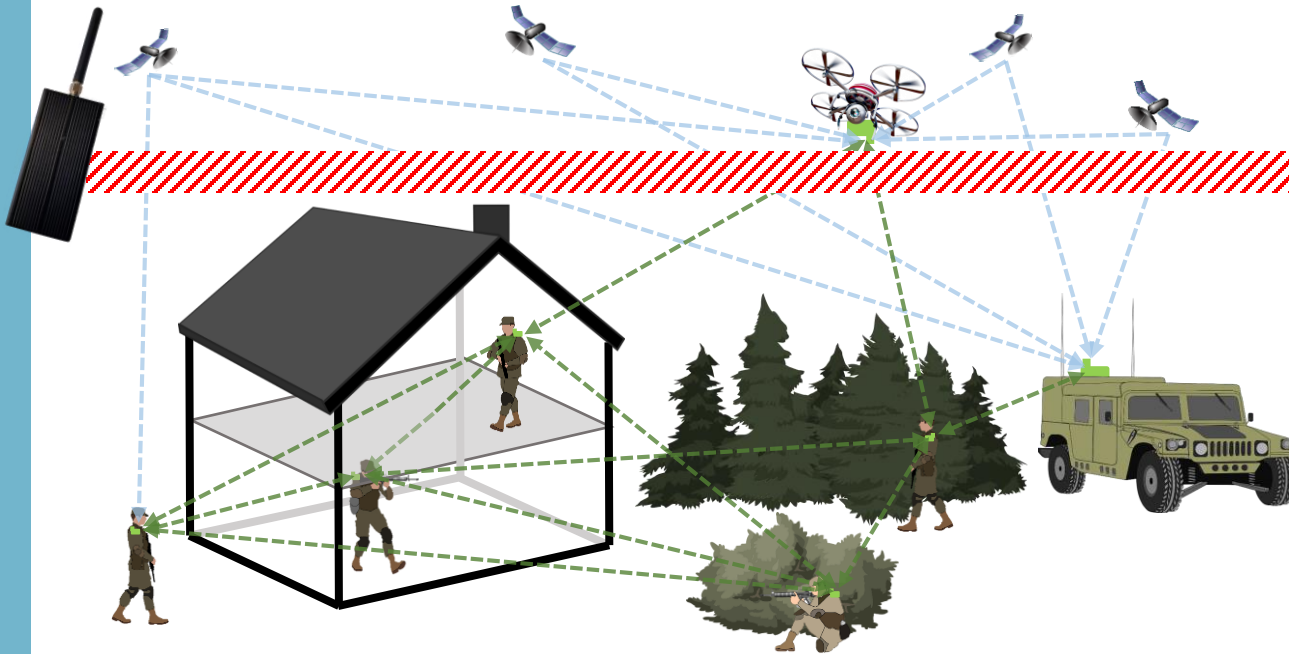
Terrestrial Ranging and  
Exchange of Information



Improved positioning  
accuracy and situational  
awareness in  
challenging conditions!



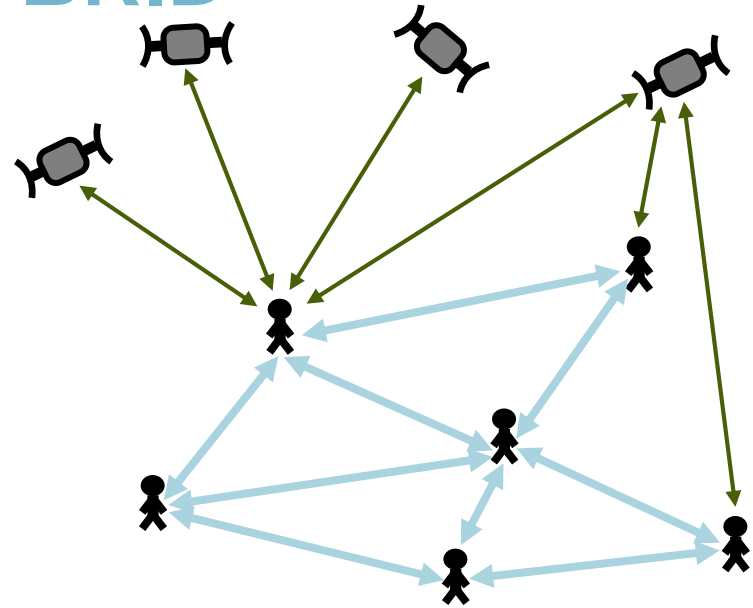
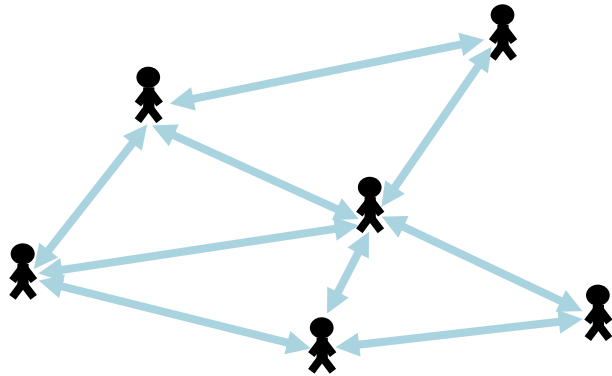
# INFRASTRUCTURE-FREE NAVIGATION RESEARCH AT FGI



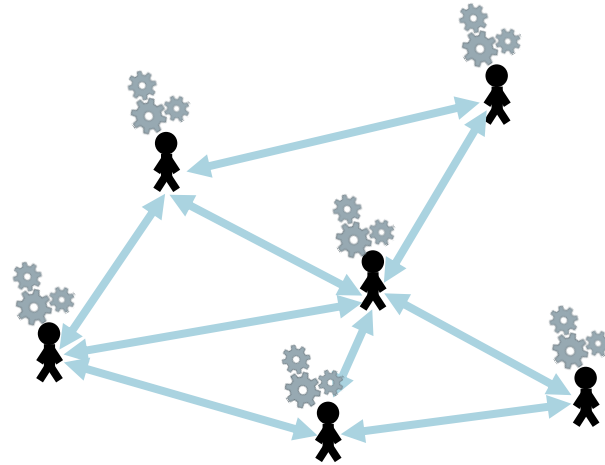
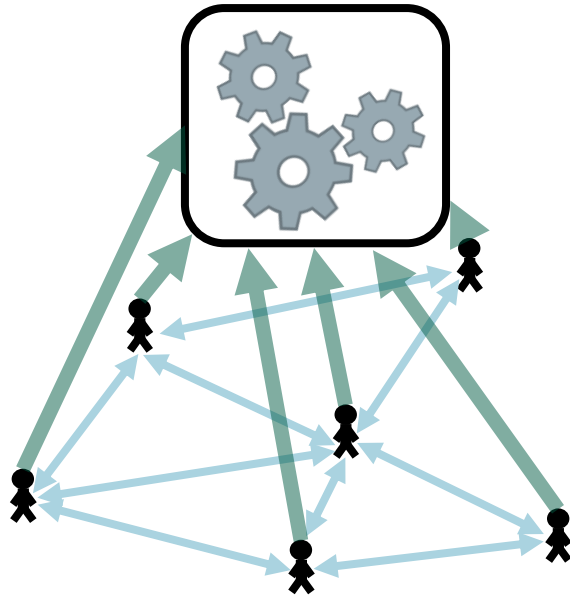
## Projects:

- **INTACT 2015-2017**
  - Funded by Scientific Advisory Board for Defence (MATINE)
- **CANDO 2018-2019**
  - Funded by NATO Science for Peace and Security programme

# COOPERATIVE POSITIONING: GNSS-FREE OR HYBRID



# COOPERATIVE POSITION ESTIMATION: CENTRALIZED OR DECENTRALIZED





4.11.2019

# Sensors in infrastructure-free pedestrian navigation



# PEDESTRIAN DEAD RECKONING

- Inertial sensor placed on foot
- During each step foot is momentarily stationary
  - When this is detected, system makes a *Zero-Velocity Update (ZUPT)*
- Limits error growth in the inertial navigation algorithm

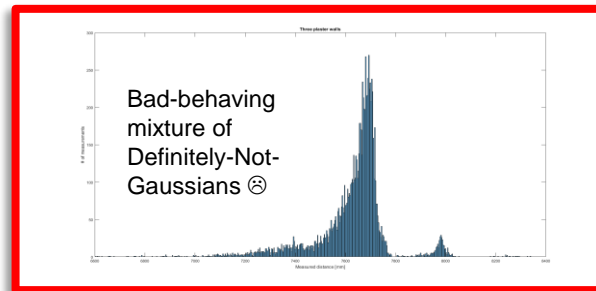
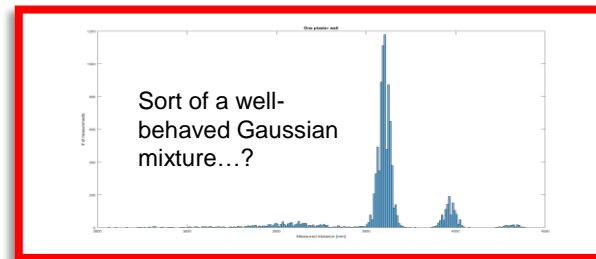
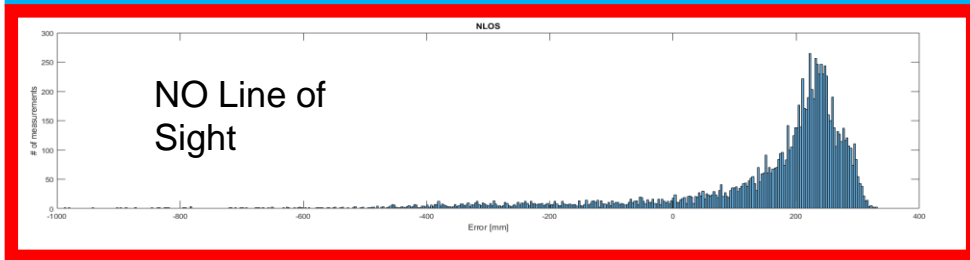
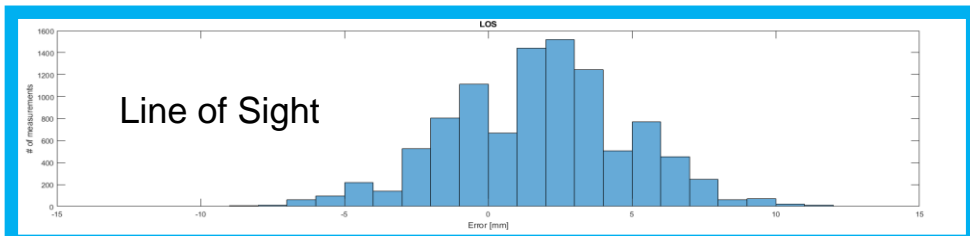
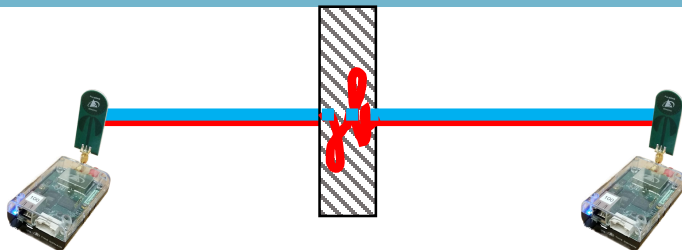


# RANGING BETWEEN COLLABORATORS

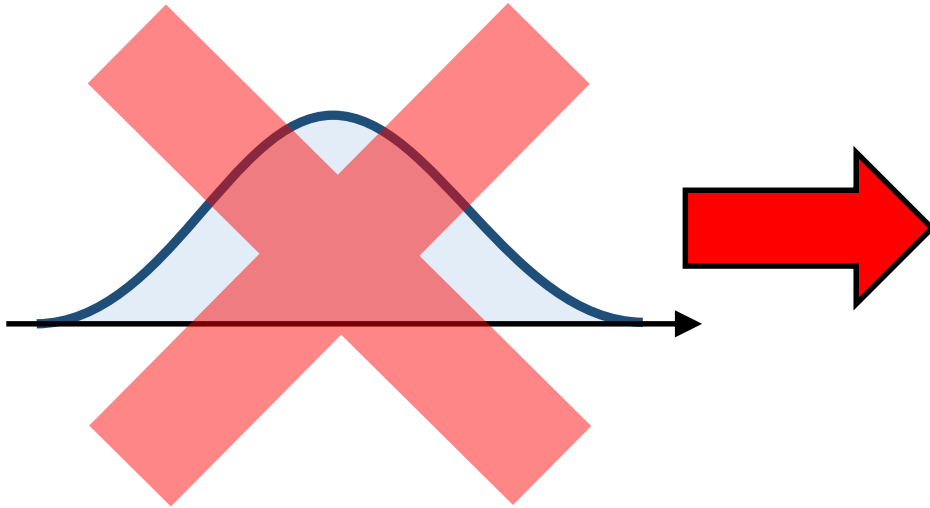
- Key element in collaborative navigation
- Ultra Wideband signal is a good choice
  - Not sensitive to reflections
  - Penetrates walls (to some extent)



# UWB RANGE MEASUREMENTS

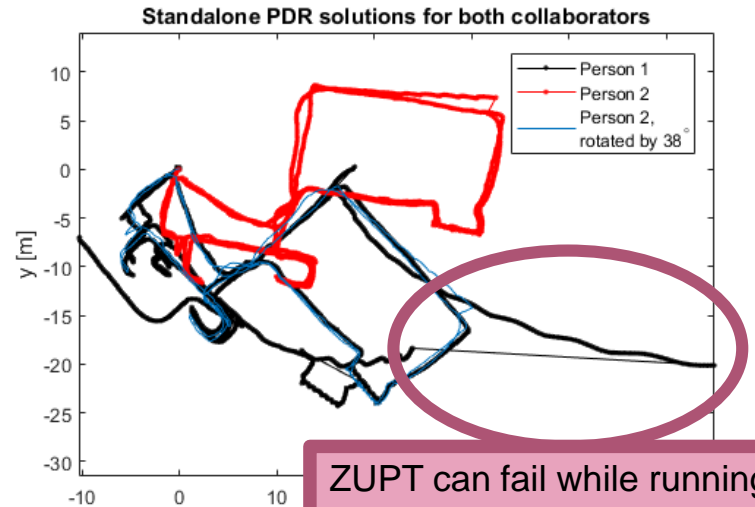
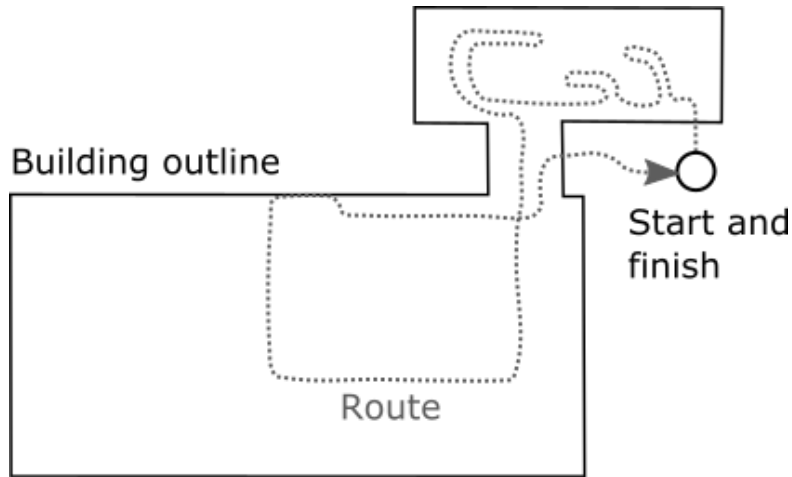


# NON-GAUSSIAN, SO WHAT?



- Increased computational complexity for robust position estimation
  - Larger power consumption
  - Increased latency
- Problematic when the power source needs to be wearable

# COOPERATIVE SENSOR FUSION: UTTI TESTS



- ZUPT can fail while running
- Can be fixed by recognizing motion mode and adapting algorithm threshold

# COOPERATIVE SENSOR FUSION: UTTI TESTS

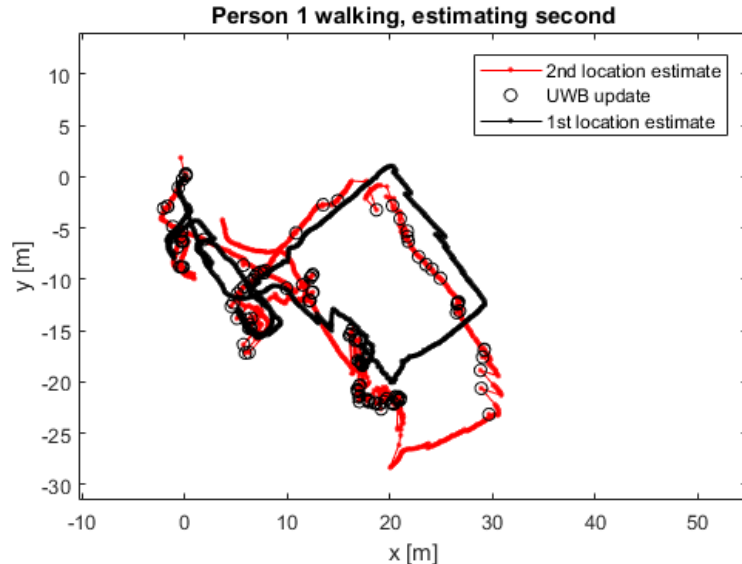


TABLE I  
RMS ERROR OF THE HEIGHT ESTIMATES, IN METERS.

	Estimate	Est. by collaborator	PDR
Person 1	1.53	1.54	3.81
Person 2	1.69	1.69	2.22

Barometer

M. Mäkelä, M. Kirkko-Jaakkola, J. Rantanen and L. Ruotsalainen, "Proof of Concept Tests on Cooperative Tactical Pedestrian Indoor Navigation," 2018 21st International Conference on Information Fusion (FUSION), Cambridge, 2018, pp. 1369-1376. DOI: 10.23919/ICIF.2018.8455380

4.11.2019

# NEXT STEPS IN RESEARCH

- Inclusion of magnetometer to sensor fusion for absolute heading estimation
- Machine learning methods for ranging error mitigation
  - Preliminary results show promise!



SEMINAR

**Friday 29 November, 2019**  
**9:00 – 16:00**

Scandic Park,  
Mannerheimintie 46, Helsinki, Finland



<https://intoseminar.com/>



# THANK YOU!

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# DEPARTMENT OF NAVIGATION AND POSITIONING

Current staff: 21, with 10 PhD, 8 nationalities

Two research groups:

[Satellite and Radio Navigation](#) (SaRaNa)

[Sensors and Indoor Navigation](#) (SiNa)

A navigation laboratory with state-of-the-art equipment (signal simulators, roof antennas, repeaters, receivers and sensors)

