uNavChip: *Ultimate Navigation Chip*

Chip-Scale Personal Navigation System Integrating Deterministic Localization and Probabilistic Signals of Opportunity

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Accelerating Technology to Improve first responder communications and operations

ABSTRACT

This project addresses the location based services intended to localize emergency responders, assets and equipment, and other people (e.g., patients and trapped persons) indoors and in covered outdoor environments, where GPS signals are unusable.

Our technical approach is based on simultaneous integration of Deterministic, Probabilistic, and Cooperative Localization.

Our overall technical objective is to design, build, and demonstrate a miniaturized Personal Navigation System achieving the localization accuracy on the level of 1 meter in GPS-denied environment for hours of operation.

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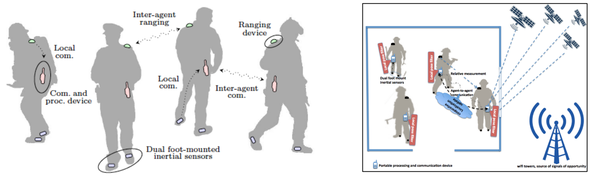
INTRODUCTION

Localization, together with communication, are key capabilities to achieve effective situation awareness, coordination, and support.



Agents are preferably localizing themselves w/o any infrastructure.

The enabling technologies include foot-mounted miniaturized inertial sensors, ranging devices, and a communication (com.) and processing (proc.) devices.

APPROACH

Inertial navigation, with foot-mounted sensors and motion models providing zero-velocity updates, constitute a unique, robust and high accuracy dead reckoning capability.

Signals of Opportunity (i.e., cellular signals) can be turned into our own "dedicated pseudolites" for position fixing and augmentation.

Cooperative Localization for a team of mobile agents, with comm. and comp. capabilities; jointly processing a relative measurement between any two agents increases localization accuracy.

Deterministic + Probabilistic + Cooperative

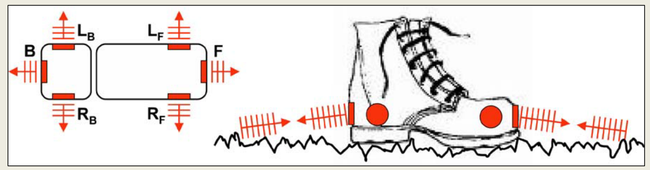


Figure 1. Inertial Navigation, Foot-to-Foot Ranging, and ZUPTing

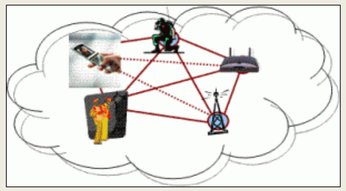


Figure 2. Cloud of SOP

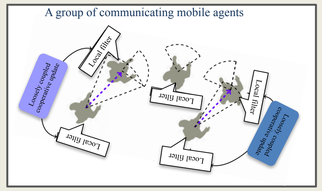
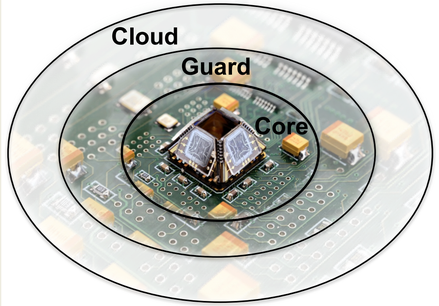


Figure 3. Cooperative Localization

IMPLEMENTATION

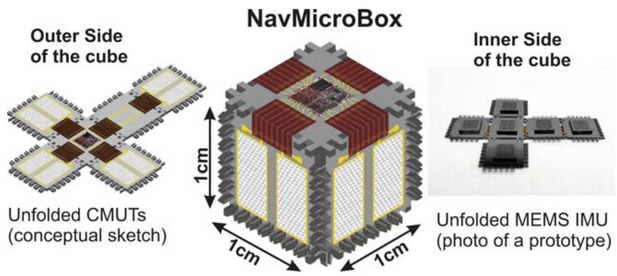
Ultimate Navigation Chip (uNavChip)



- **Core**
  Inertial Measurement Unit, Clock, Altimeter, Proximity
- **Guard**
  Authenticate external signals of opportunity
- **Cloud**
  Detect external signals of opportunity

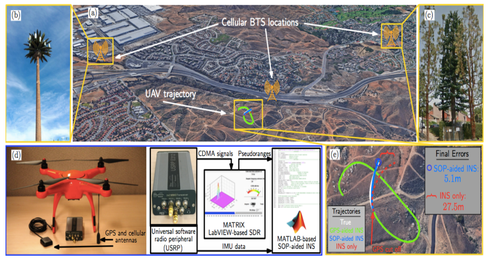
Provide maximum autonomy, security, precision

NavMicroBox



Personal Navigation System (PNS) Integrating IMU and CMUT

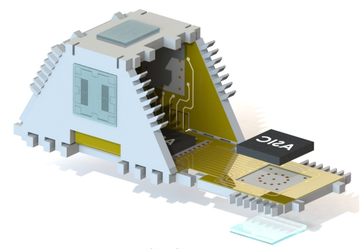
On-Board Detection of Signals of Opportunity

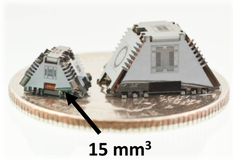


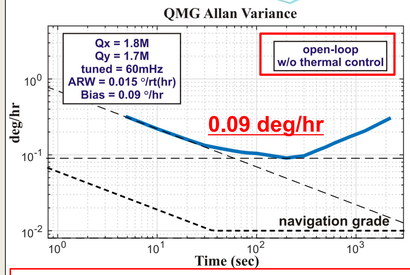
- Radio SLAM with signals of opportunity (SOPs)
- Indoor and covered outdoor cellular SOP reception stochastic modeling and analysis
- SOP-aided INS and synthetic aperture navigation

ENABLING TECHNOLOGY

Micro-Electro-Mechanical Systems





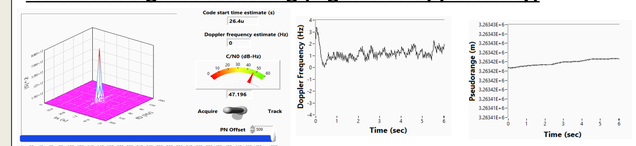


Recent lab test	
ARW	0.015 deg/rt-hr
Bias	0.09 deg/hr

Government test	
ARW	0.0562 deg/rt-hr
Bias	0.2 deg/hr

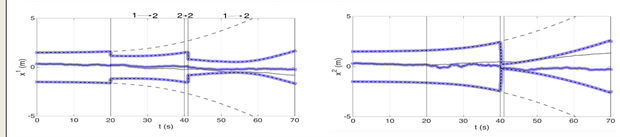
Demonstrated near-Navigation grade in-run ARW and bias floor, [1]

Advanced Signal Processing (Signals of Opportunity)



Demonstrated SOP-aided INS with 5.1m CEP after 30 sec, [2]

Optimal Estimation Theory (Cooperative Localization)



Predicted over 70% improvements due to coop. localization, [3]

REFERENCES

[1] Shkel, A. M. (2013). Expert Advice: The Chip-Scale Combinatorial Atomic Navigator. GPS World.
[2] Kassas Z., et al (2017) I hear, therefore I know where I am: Compensating for GNSS limitations with cellular signals, IEEE Signal Processing Magazine
[3] J. Zhu and S. S. Kia, (2017), "Consistent loosely coupled decentralized cooperative navigation for team of mobile agents," in ION's Int. Tech Meeting