

# UC Riverside

## Other Recent Work

### Title

Navigation with cellular CDMA signals

### Permalink

<https://escholarship.org/uc/item/4dq3h3hc>

### Authors

Kassas, Zaher M, Ph.D.

Khalife, Joe

Shamaei, Kimia

### Publication Date

2016-04-22

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## MOTIVATION

Global navigation satellite system (GNSS) is at the heart of autonomous vehicles navigation systems. However, GNSS signals are unreliable due to:

- Severe attenuation in deep urban canyons
- Intentional and/or unintentional jamming
- Spoofing!

## APPROACH: EXPLOIT SOPs

Ambient signals of opportunity (SOPs) may enhance and assist conventional navigation techniques.



## CHALLENGES

- Unavailability of SOP models for navigation purposes
- Unavailability of receiver architectures for navigation observables extraction
- Unknown SOP emitters' states (position and clock)
- Less stable clocks than GNSS satellite vehicles

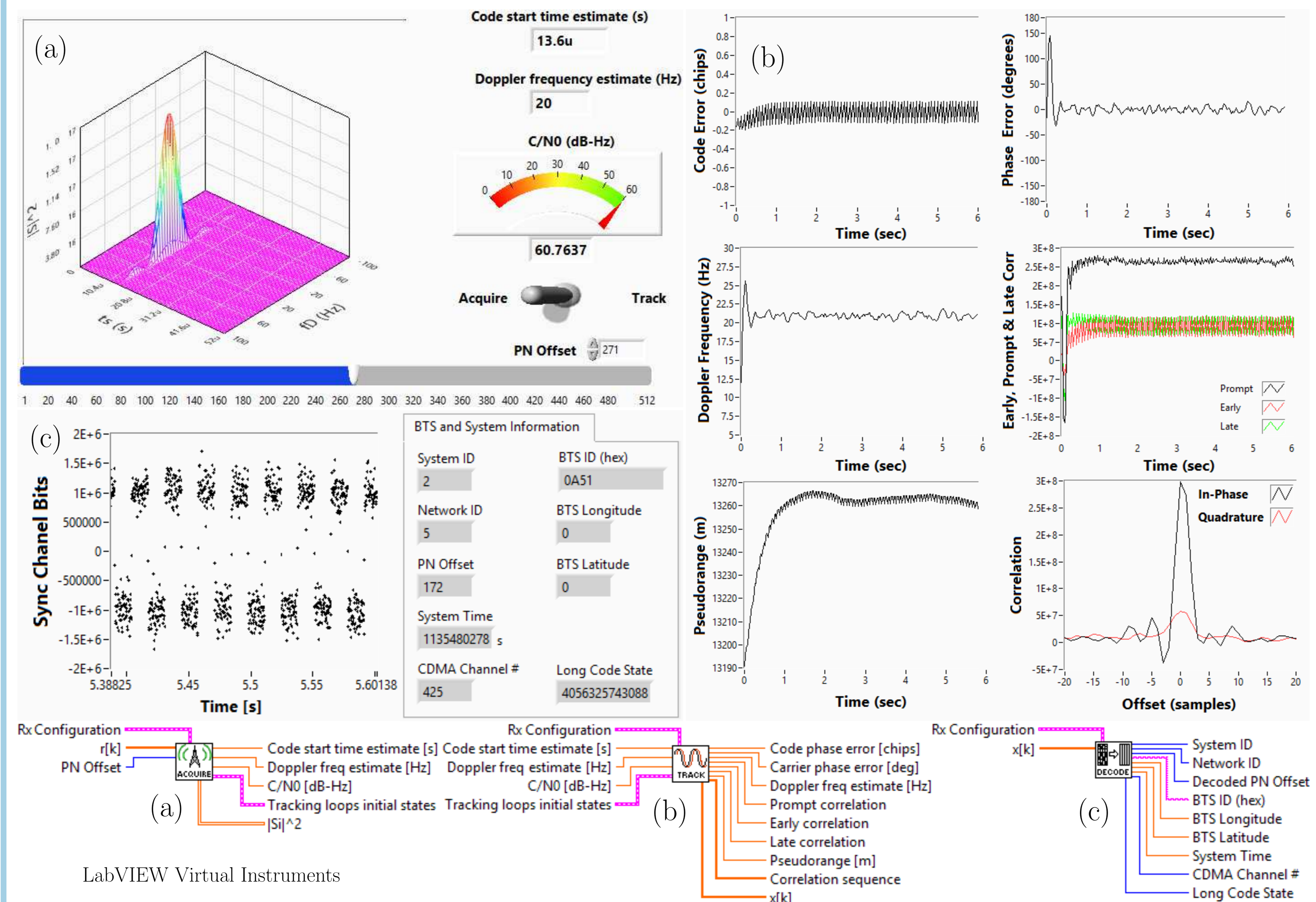
## CELLULAR CDMA AS SOPs

- Uses code division multiple access (CDMA), which is suitable for ranging
- Abundant and free to use
- Higher received power and bandwidth than GNSS

## CELLULAR CDMA NAVIGATION SOFTWARE-DEFINED RECEIVER

We implemented a cellular CDMA software-defined radio in LabVIEW to optimally extract relevant timing and positioning information. Although these signals were intended for communications, we were able to model them in terms of navigation observables. The receiver has three stages:

- Acquisition:** Signals from different BTSs are identified and a coarse estimate of their corresponding code delay and Doppler frequency is obtained.
- Tracking:** These estimates are maintained and refined via tracking loops.
- Decoding:** The message transmitted by the BTS is decoded and relevant information is extracted.

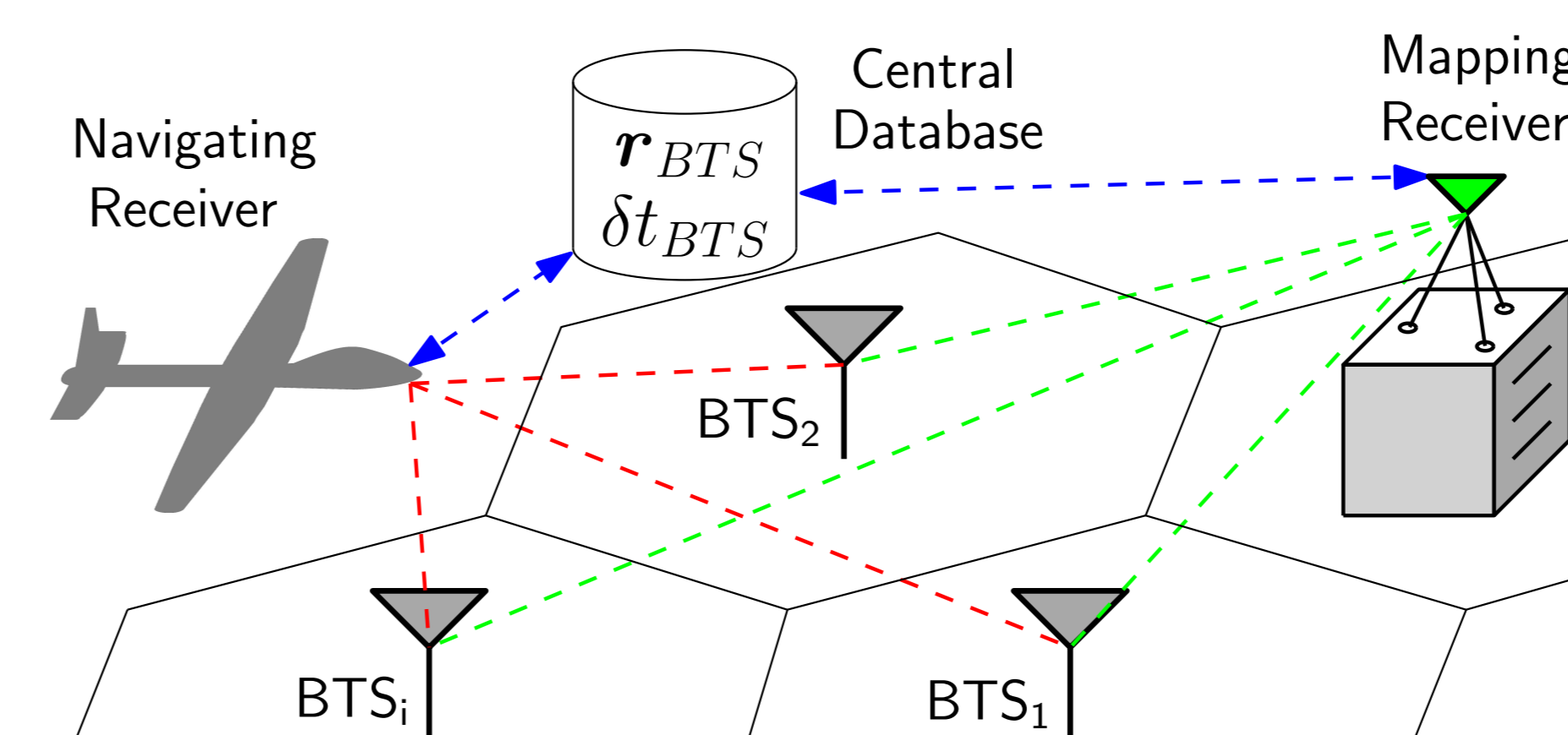


## NAVIGATION FRAMEWORK

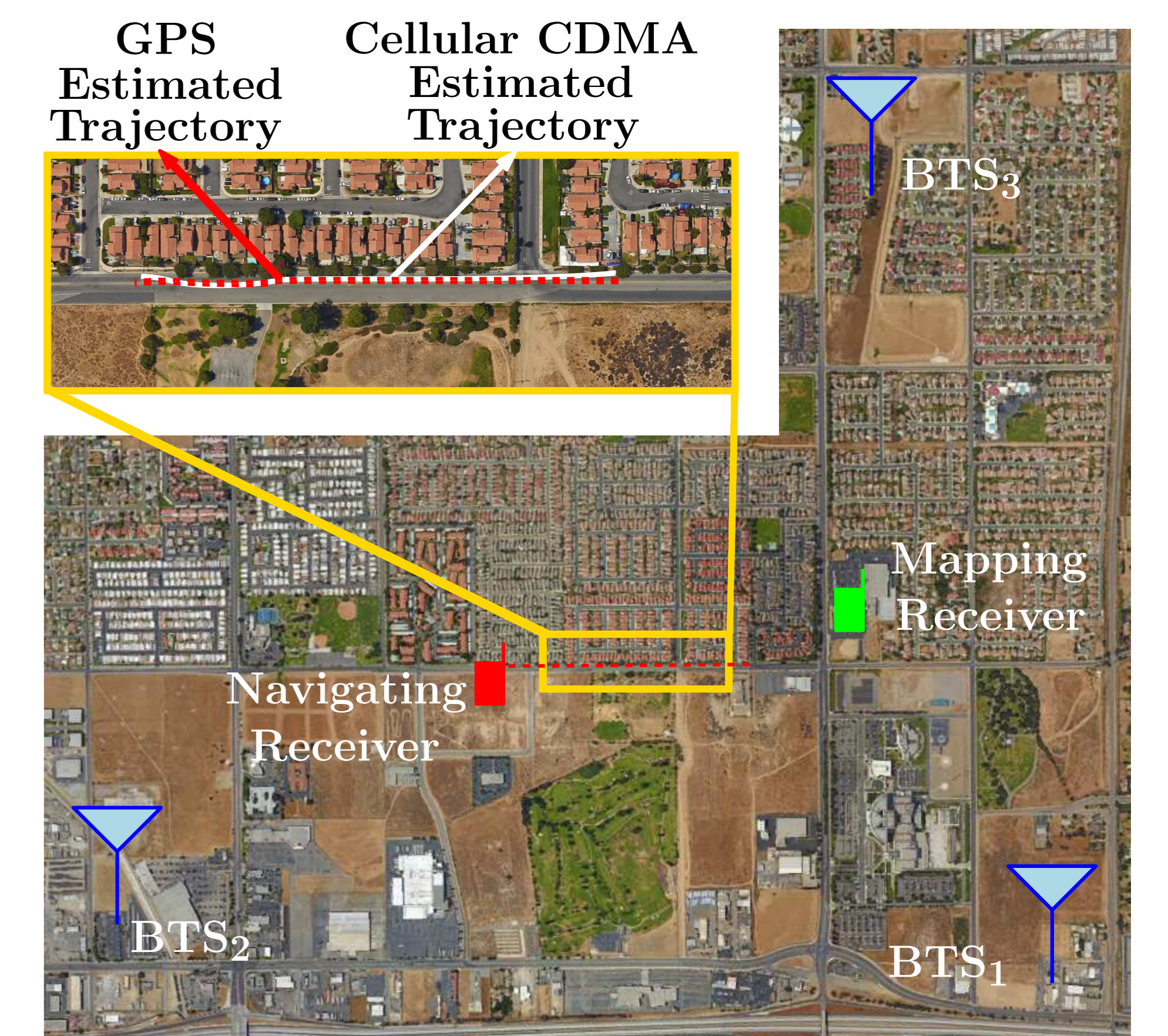
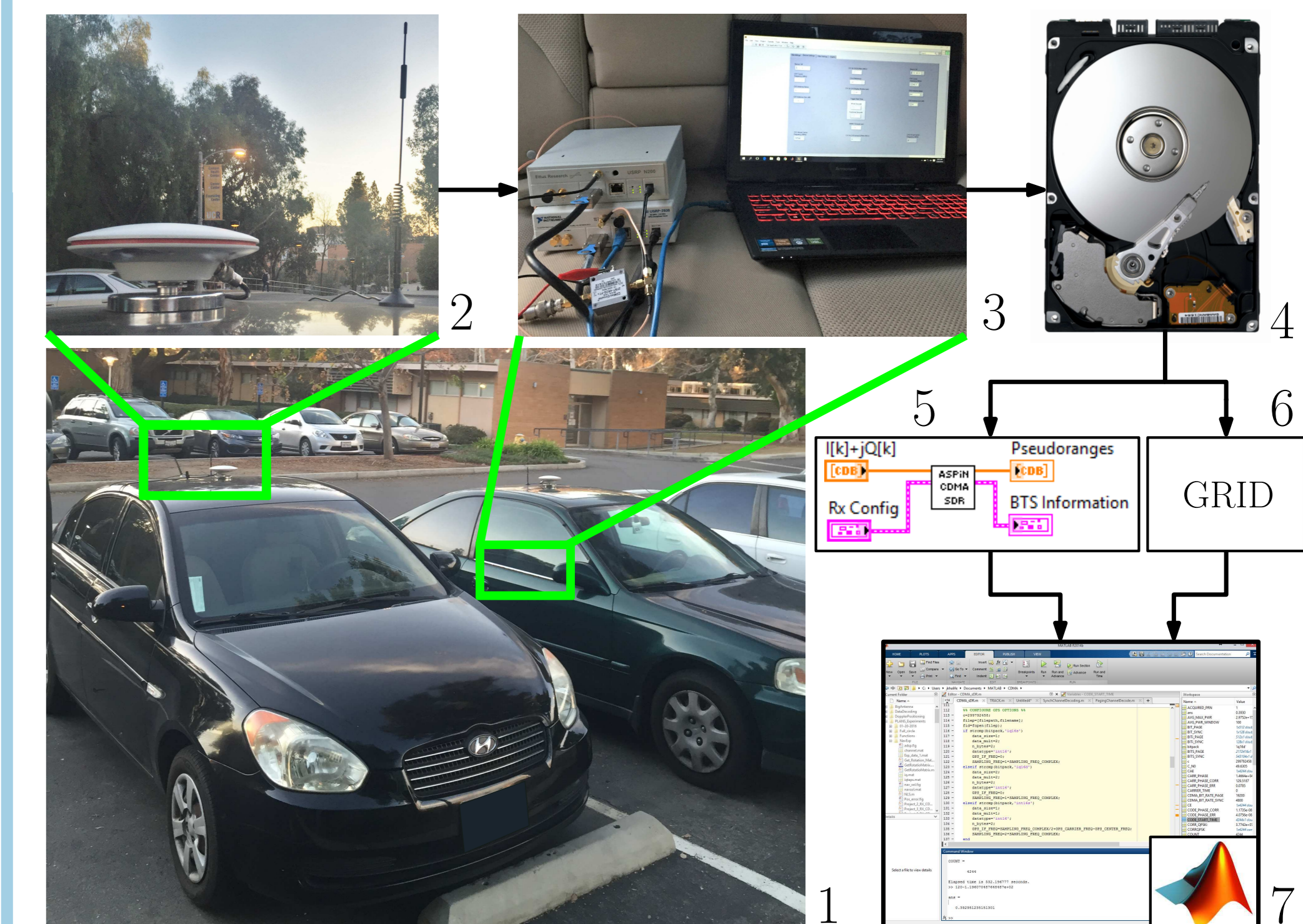
The pseudorange measurement  $\rho$  is given by

$$\rho = \|\mathbf{r}_r - \mathbf{r}_{BTS}\|_2 + c \cdot (\delta t_r - \delta t_{BTS}) + v,$$

- $\mathbf{r}_r$ : receiver position       $\mathbf{r}_{BTS}$ : BTS position  
 $\delta t_r$ : receiver clock bias       $\delta t_{BTS}$ : BTS clock bias  
 $v$ : measurement noise       $c$ : speed-of-light



## EXPERIMENTAL DEMO



Mean Error: 5.51 m    Standard Deviation: 4.01 m

## REFERENCES

- [1] K. Pesyna, Z. Kassas, J. Bhatti, and T. Humphreys, "Tightly-coupled opportunistic navigation for deep urban and indoor positioning," in *Proceedings of ION GNSS Conference*, September 2011, pp. 3605–3617.
- [2] Z. Kassas, J. Bhatti, and T. Humphreys, "A graphical approach to GPS software-defined receiver implementation," in *Proceedings of IEEE Global Conference on Signal and Information Processing*, December 2013, pp. 1226–1229.
- [3] Z. Kassas and T. Humphreys, "Observability analysis of collaborative opportunistic navigation with pseudorange measurements," *IEEE Transactions on Intelligent Transportation Systems*, vol. 15, no. 1, pp. 260–273, February 2014.
- [4] J. Khalife, K. Shamaei, and Z. Kassas, "A software-defined receiver architecture for cellular CDMA-based navigation," in *Proceedings of IEEE/ION Position, Location, Navigation Symposium*, April 2016, pp. 816–826.

## REFERENCES

- [1] K. Pesyna, Z. Kassas, J. Bhatti, and T. Humphreys, "Tightly-coupled opportunistic navigation for deep urban and indoor positioning," in *Proceedings of ION GNSS Conference*, September 2011, pp. 3605–3617.
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- [5] Z. Kassas, V. Ghadiok, and T. Humphreys, "Adaptive estimation of signals of opportunity," in *Proceedings of ION GNSS Conference*, September 2014, pp. 1679–1689.
- [6] J. Morales and Z. Kassas, "Optimal receiver placement for collaborative mapping of signals of opportunity," in *Proceedings of ION GNSS Conference*, September 2015, pp. 2362–2368.