Low-Cost Centimeter-Accurate Mobile Positioning

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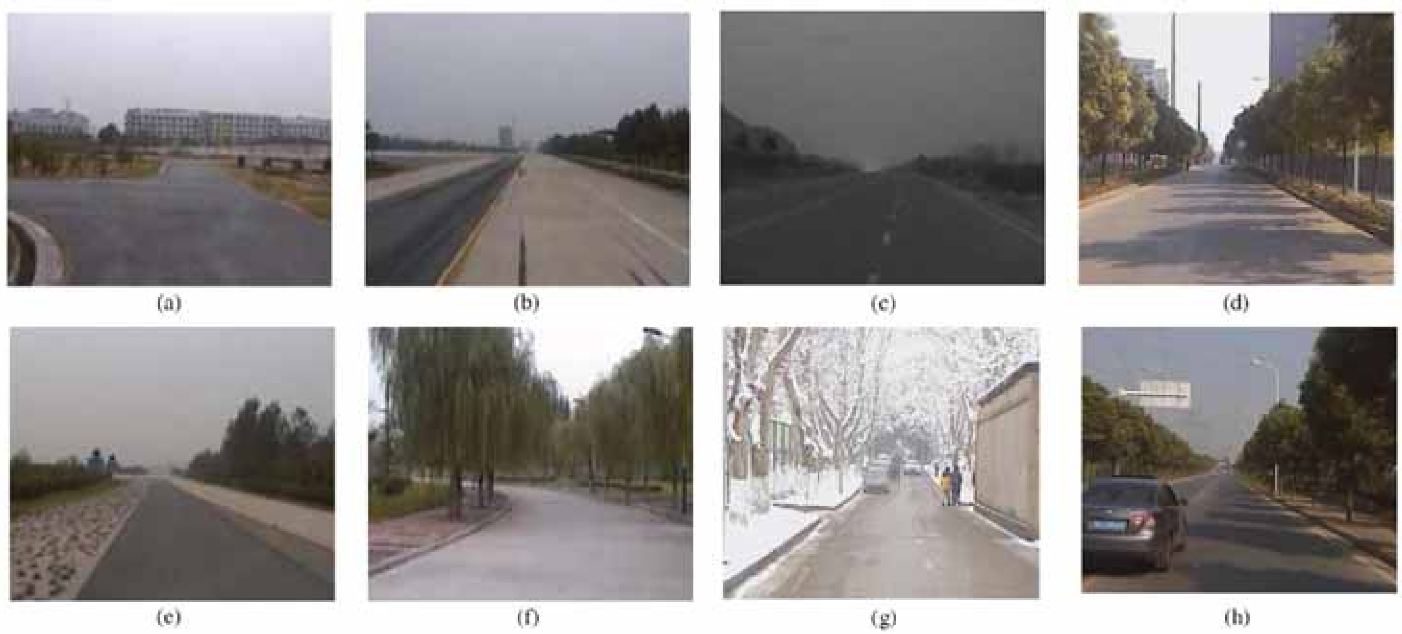
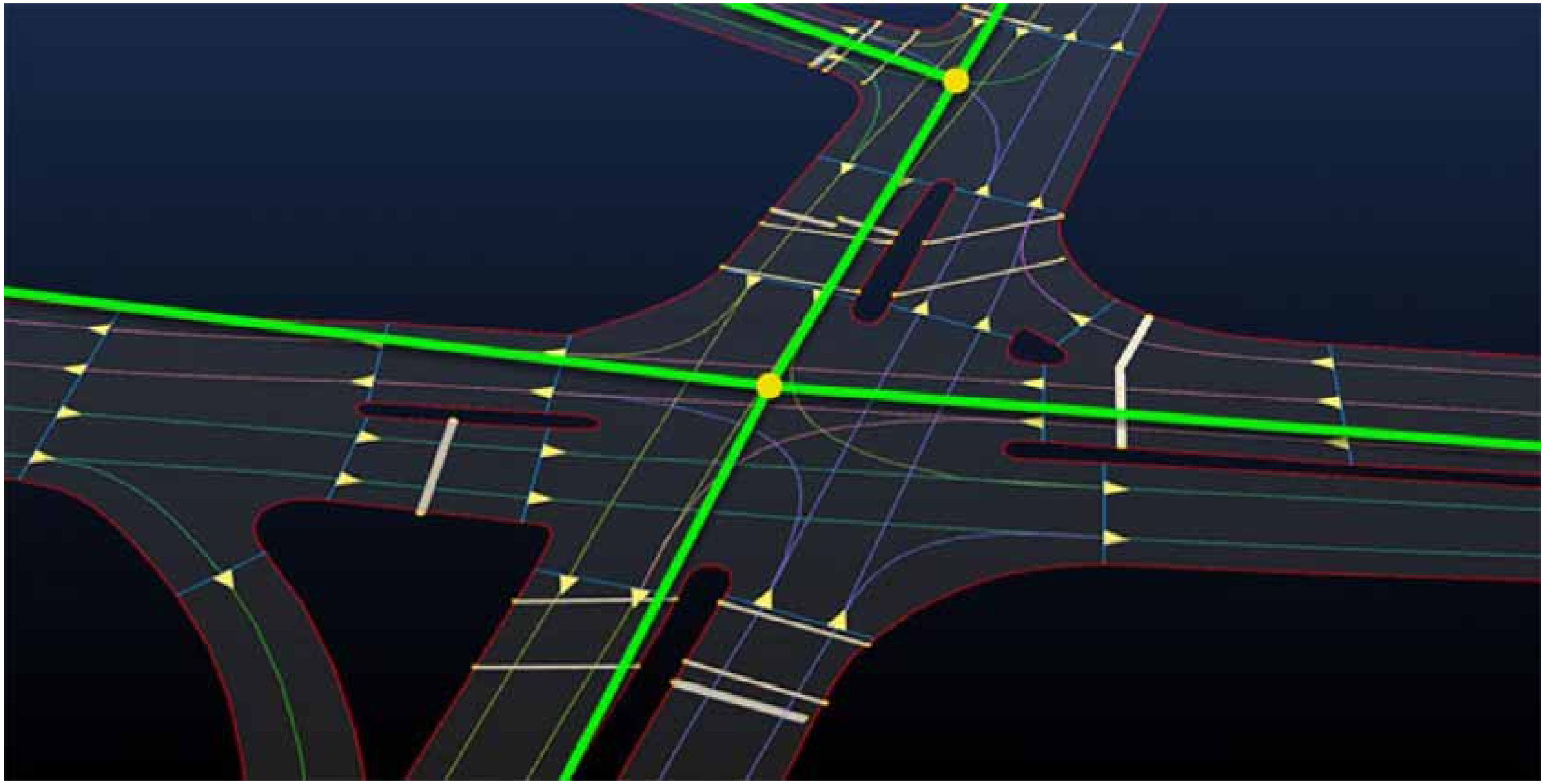
Better Streets | Oct. 26, 2015

The Challenge of Autonomous Perception



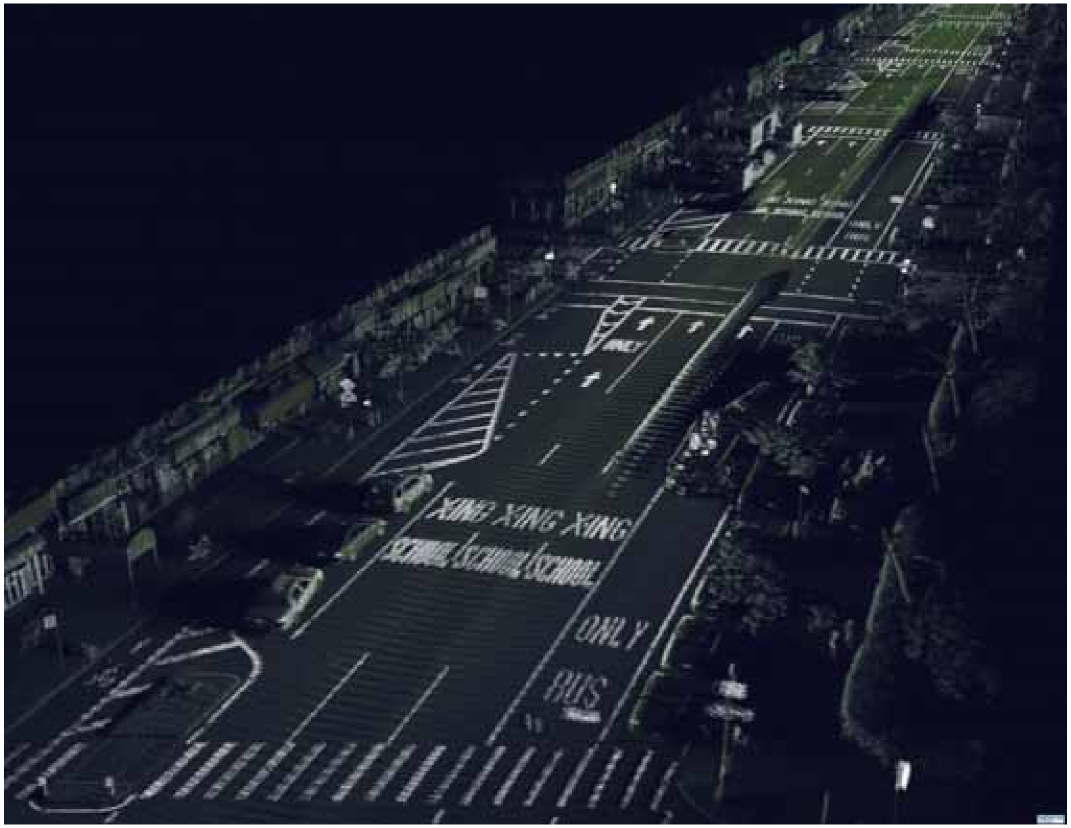
From Li, Qingquan, et al. "A sensor-fusion drivable-region and lane-detection system for autonomous vehicle navigation in challenging road scenarios." *Vehicular Technology, IEEE Transactions on* 63.2 (2014): 540-555.

Digital Maps: An Indispensable Additional Sensor



HERE 360 Blog

Nokia HERE: Mapping and Location Intelligence



Google's Autonomous Car Strategy: Also Map-Based

GNSS Has Been Marginalized as Sensor for Autonomous Cars

"... GPS has limited resolution ... the difficulty remains as the GPS is unavailable in many places." -- Li, Qingquan, et al.

Organizers of the China Future Challenge 2010 (like DARPA Grand Challenge) forbade the use of GPS/GNSS

The first 8 finishers in the China Future Challenge 2014 all depended crucially on Velodyne's 3D Lidar sensor

Google's autonomous cars also use Velodyne sensors, along with cameras. They use nothing more than standard SPS L1 C/A GPS (a ublox unit) with 1-3 meter accuracy

Question to Daimler autonomy team rep. at ION GNSS+ 2015:

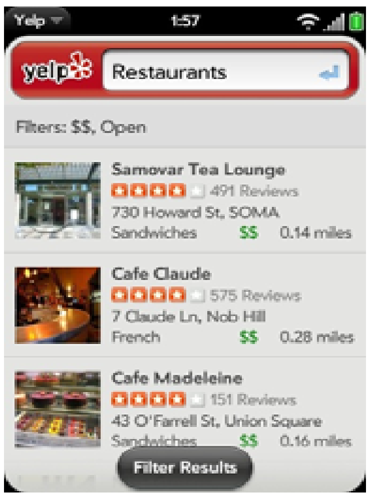
Q: “With such an emphasis on vision sensors for lane keeping, how will your cars react to snow-covered roads and heavy rain?”

A: “Our autonomy strategy does not cover these cases; the car will instruct the driver to take over.”

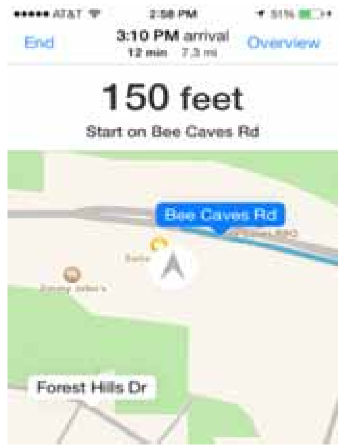

CAUTION
HEAVY
FOG

Sub-decimeter-accurate (1-sigma), low-cost GNSS positioning is key to improving the reliability and percent availability of autonomous driving

GNSS Positioning Today



Location-based Searches



Driving Directions

Location Sharing

Fitness Tracking

Where it’s Going

Virtual Reality

Augmented Reality

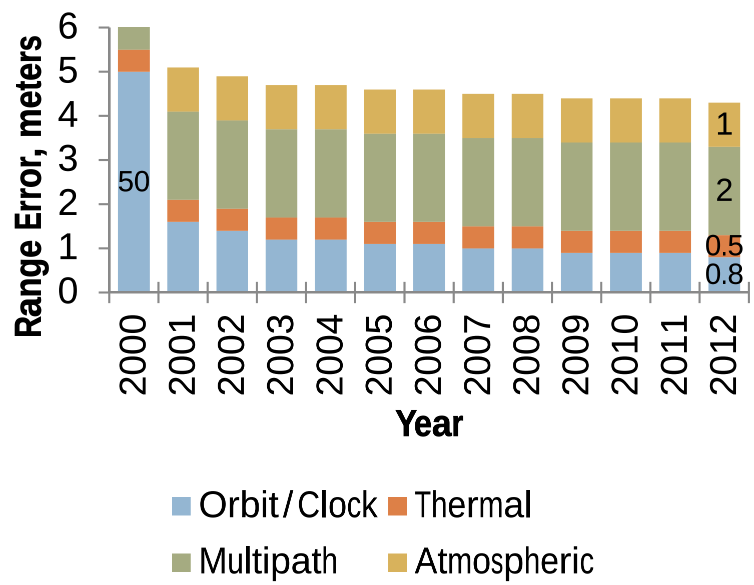
Large-scale Mapping

Autonomous Driving

SPS GNSS Accuracy Gains Have Stalled

- Prior to 2000
  - Intentional degradation
  - 50+ meter errors
- May 2, 2000
  - Degradation turned off
- Since 2000
  - Steady Improvements
  - Leveling off
  - Meter-level precision

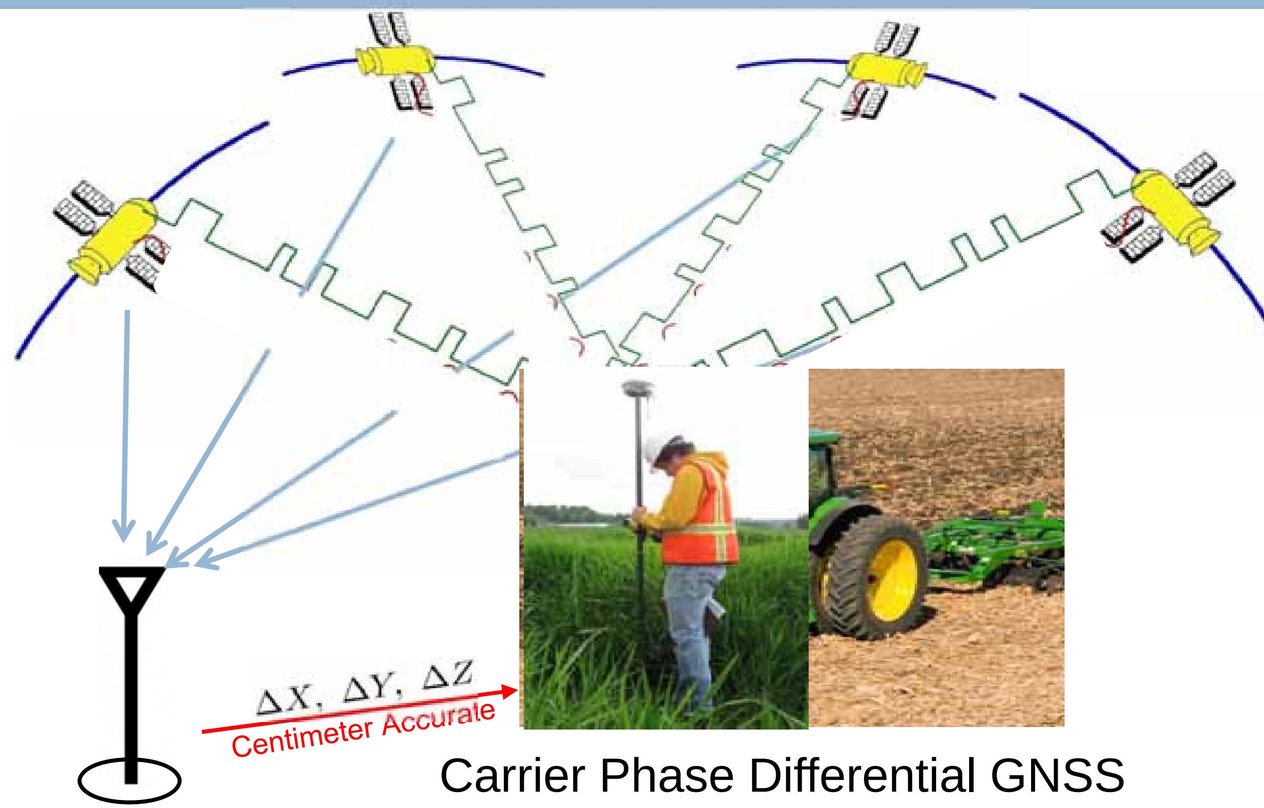
Average Civilian GPS Positioning Errors



Source: NOAA National Geodetic Survey

A Dramatic Increase in Accuracy

Carrier Phase Positioning



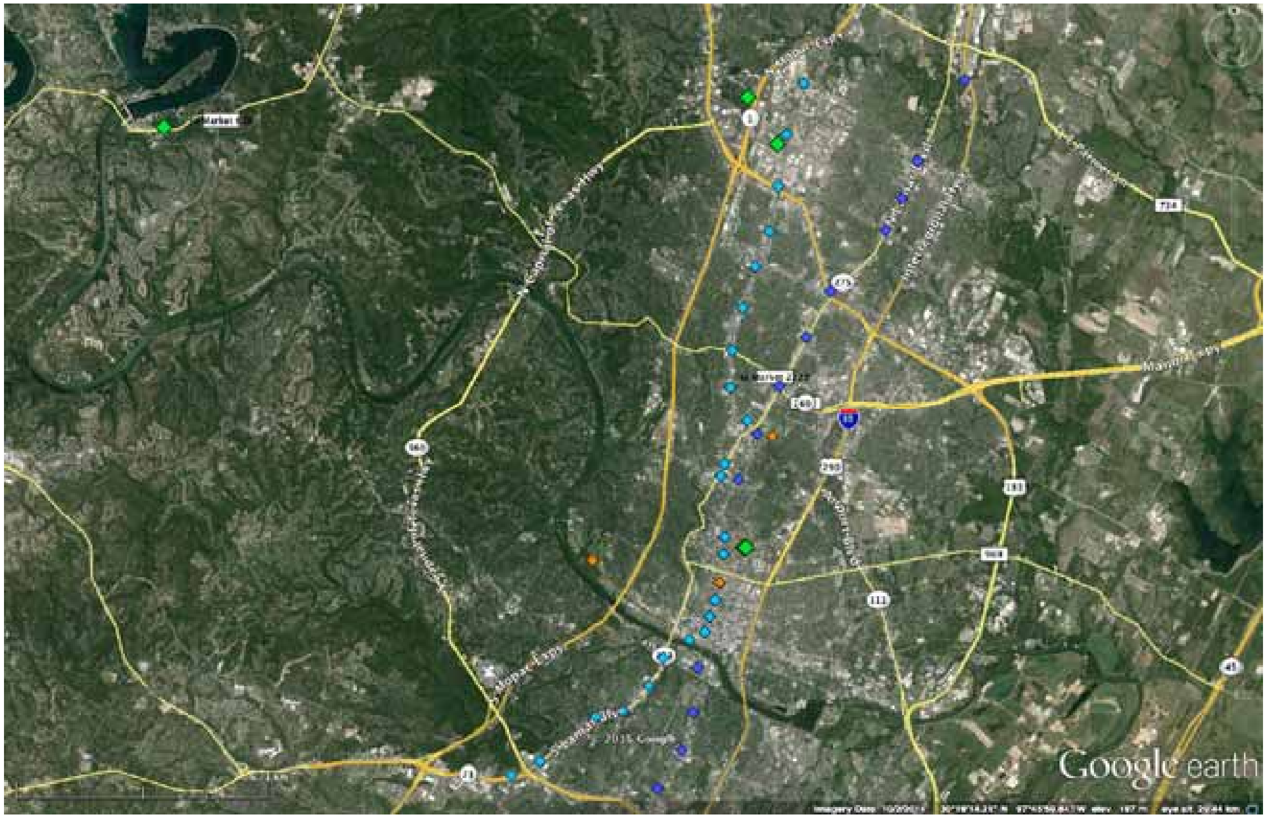
Carrier Phase Differential GNSS
(CDGNSS)

Strategy

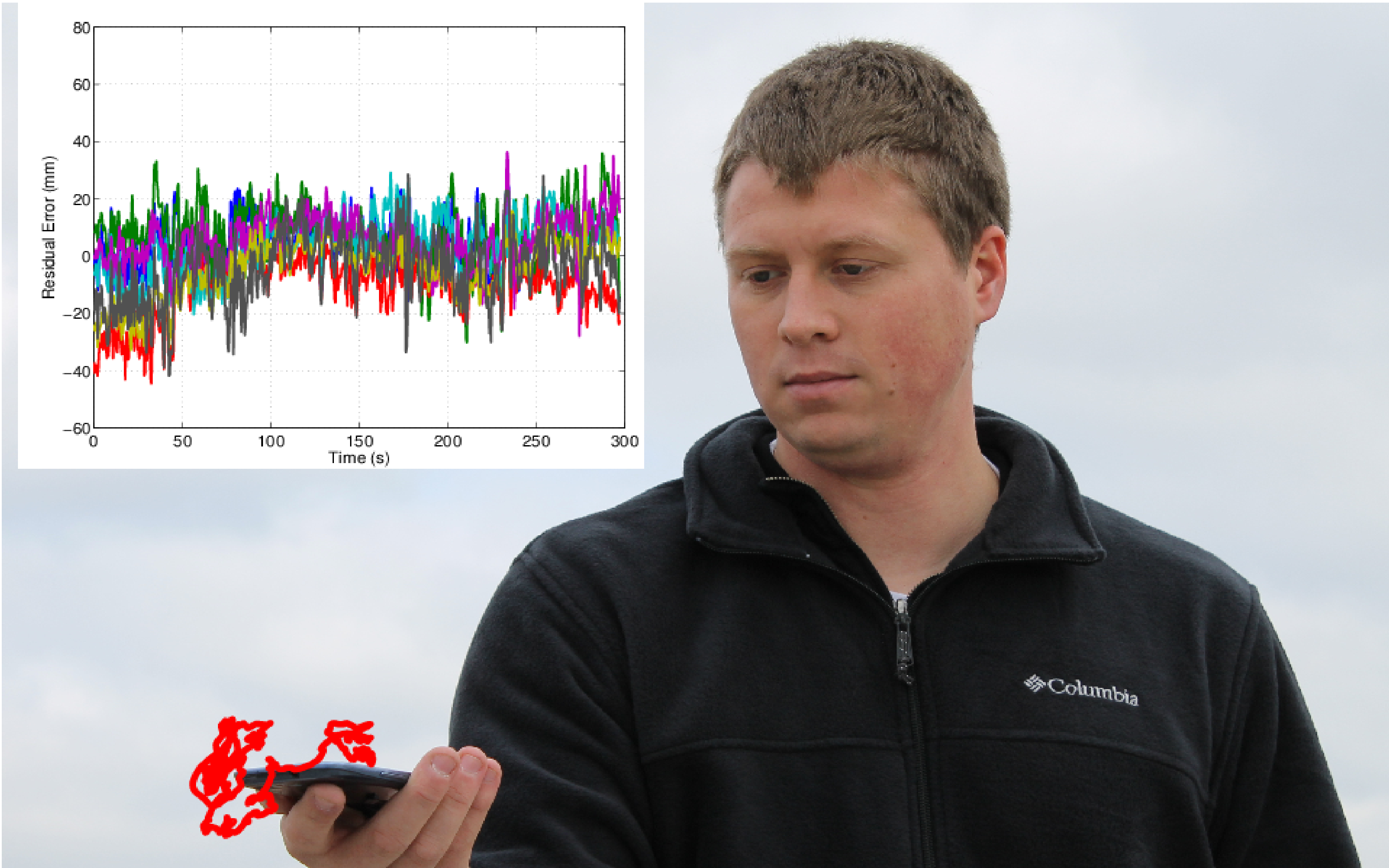
Two critical factors for mainstream cm-accurate GNSS users will be *__time to fix and cost.__* Keeping these tolerably low will require network RTK or PPP-RTK with a dense network:

1. As compared to traditional PPP (sparse reference network), network RTK and PPP-RTK have faster convergence times
2. As the number of users increases, it makes sense to shift costs from the user devices to the network: *if having a 15-km spaced reference network (dense) enables <$50 precise positioning for millions of users, it makes economic sense*

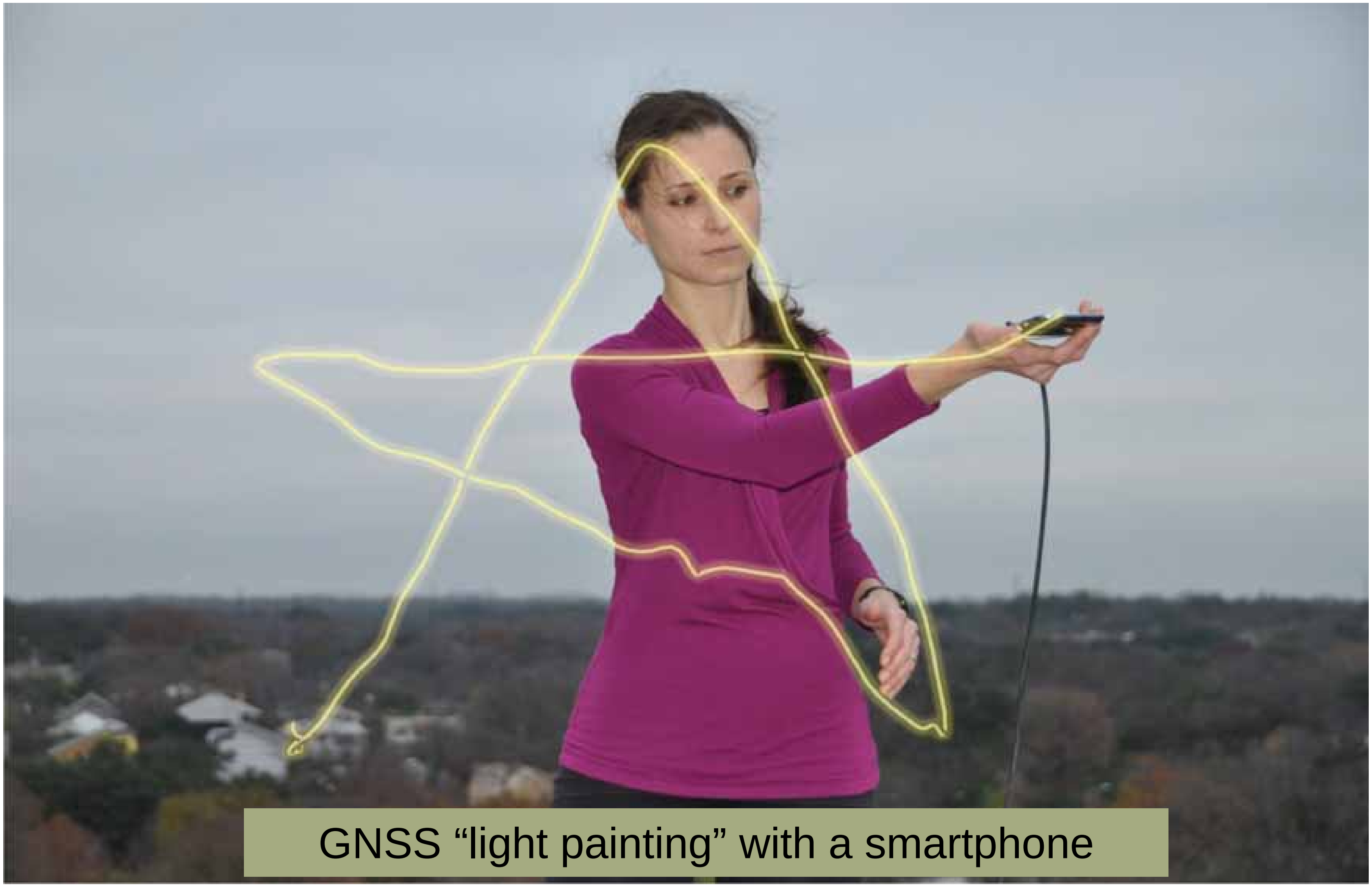
Envisioned Dense RTK Network in Austin



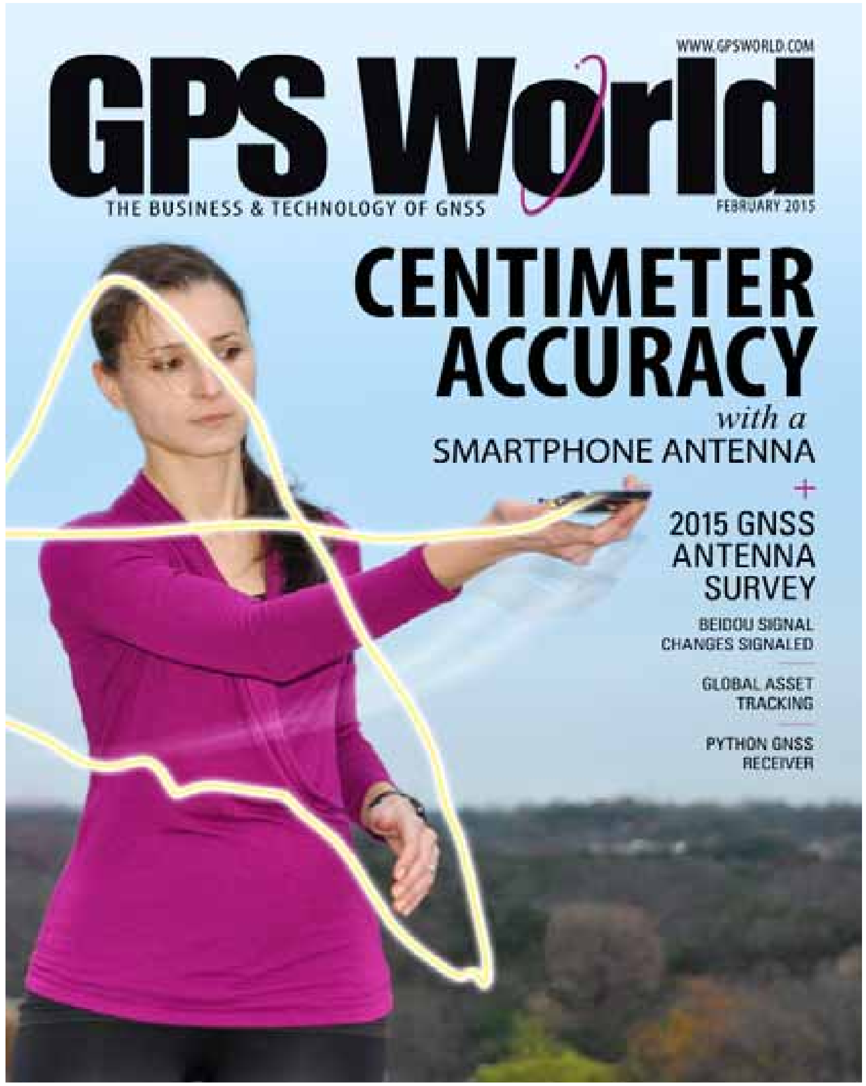
December 2014: Successful RTK positioning solution with a smartphone



Handheld RTK result with some signals passing through Ken’s body



GNSS “light painting” with a smartphone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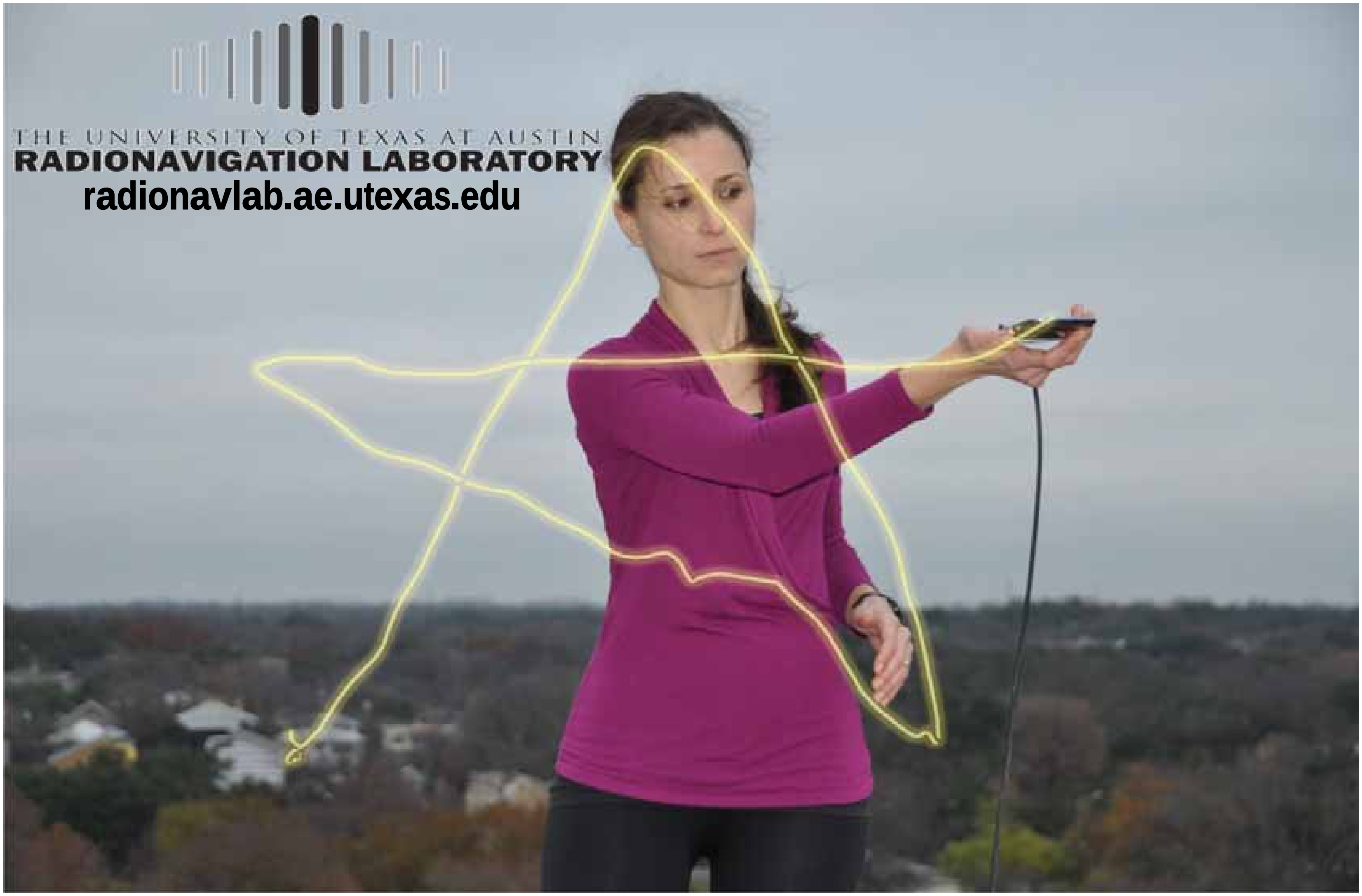
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