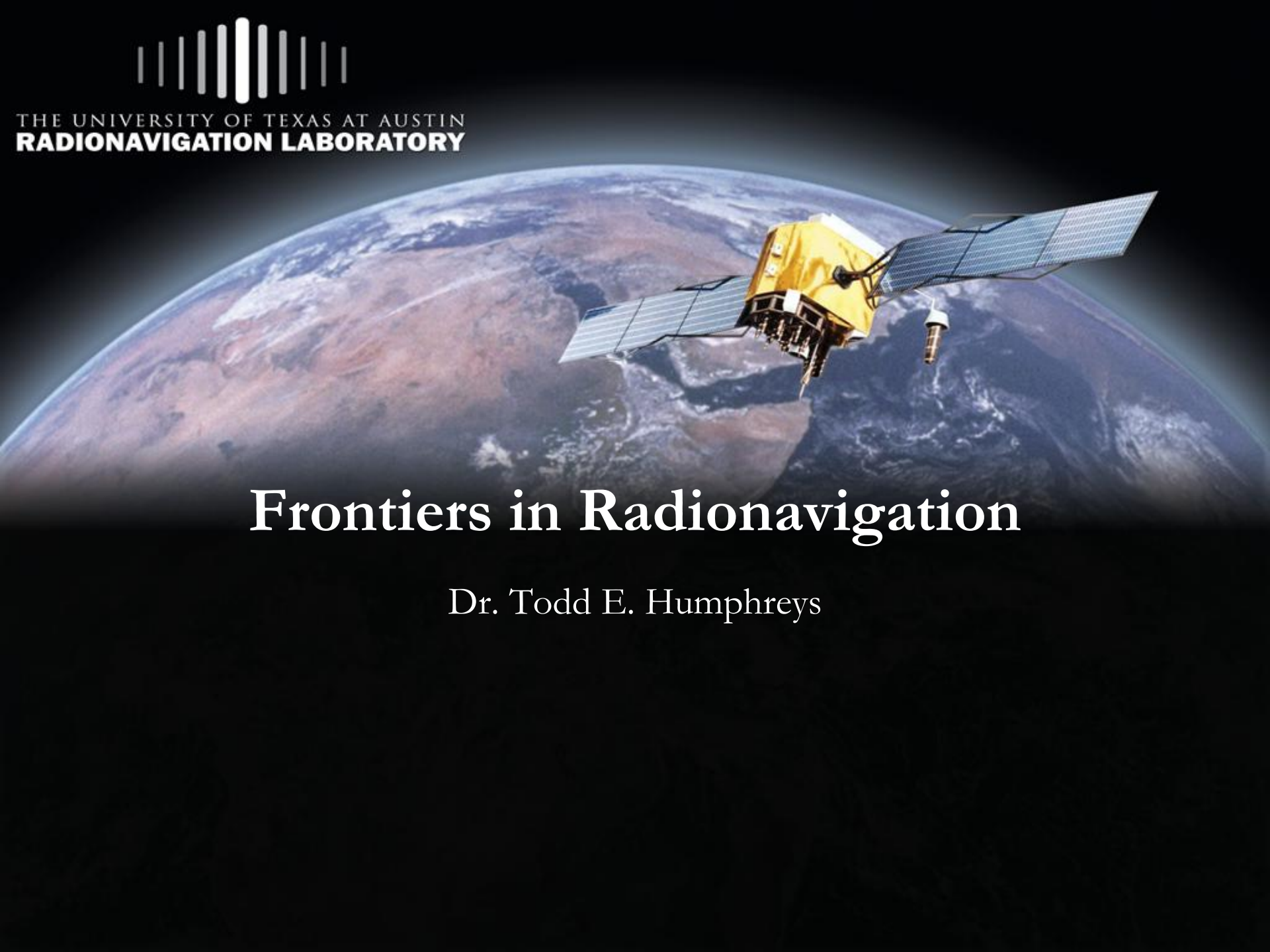
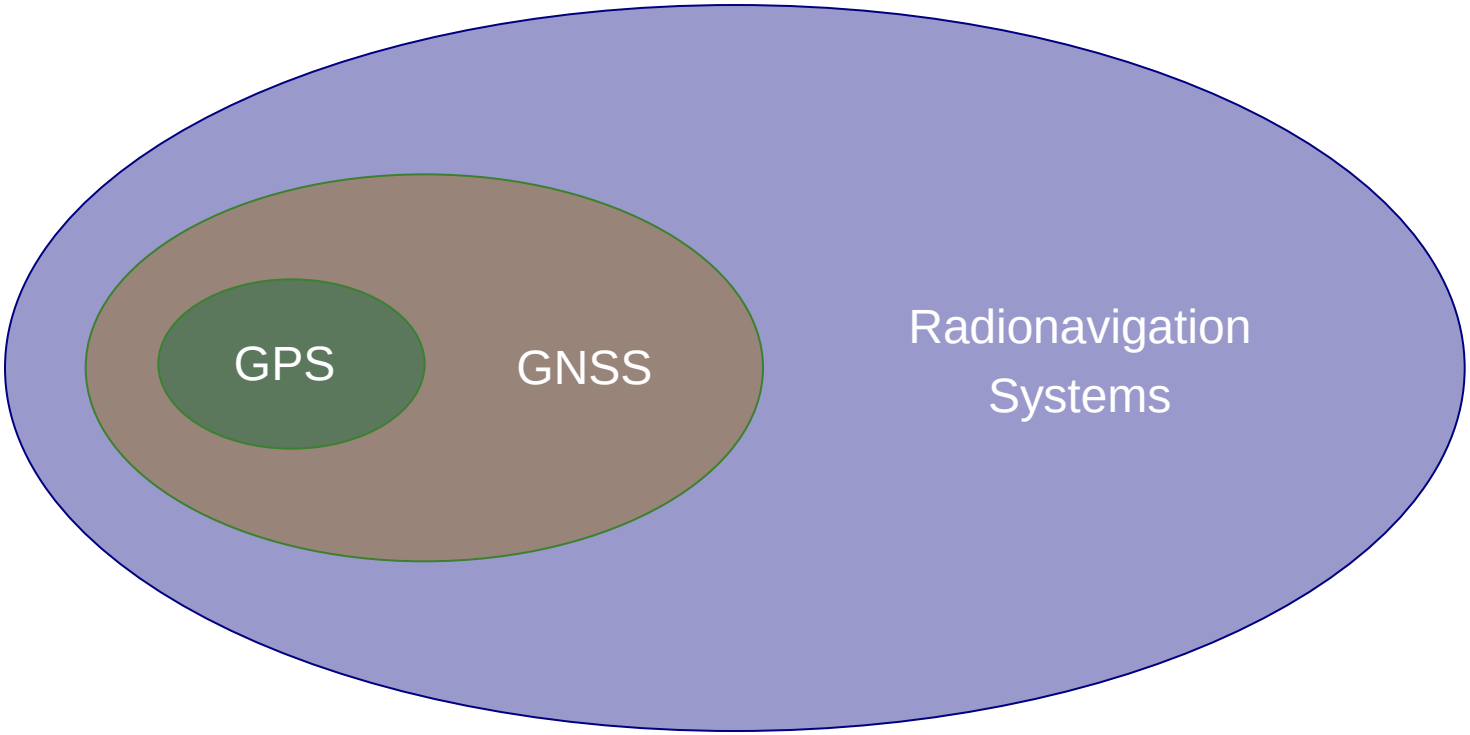


Frontiers in Radionavigation

Dr. Todd E. Humphreys

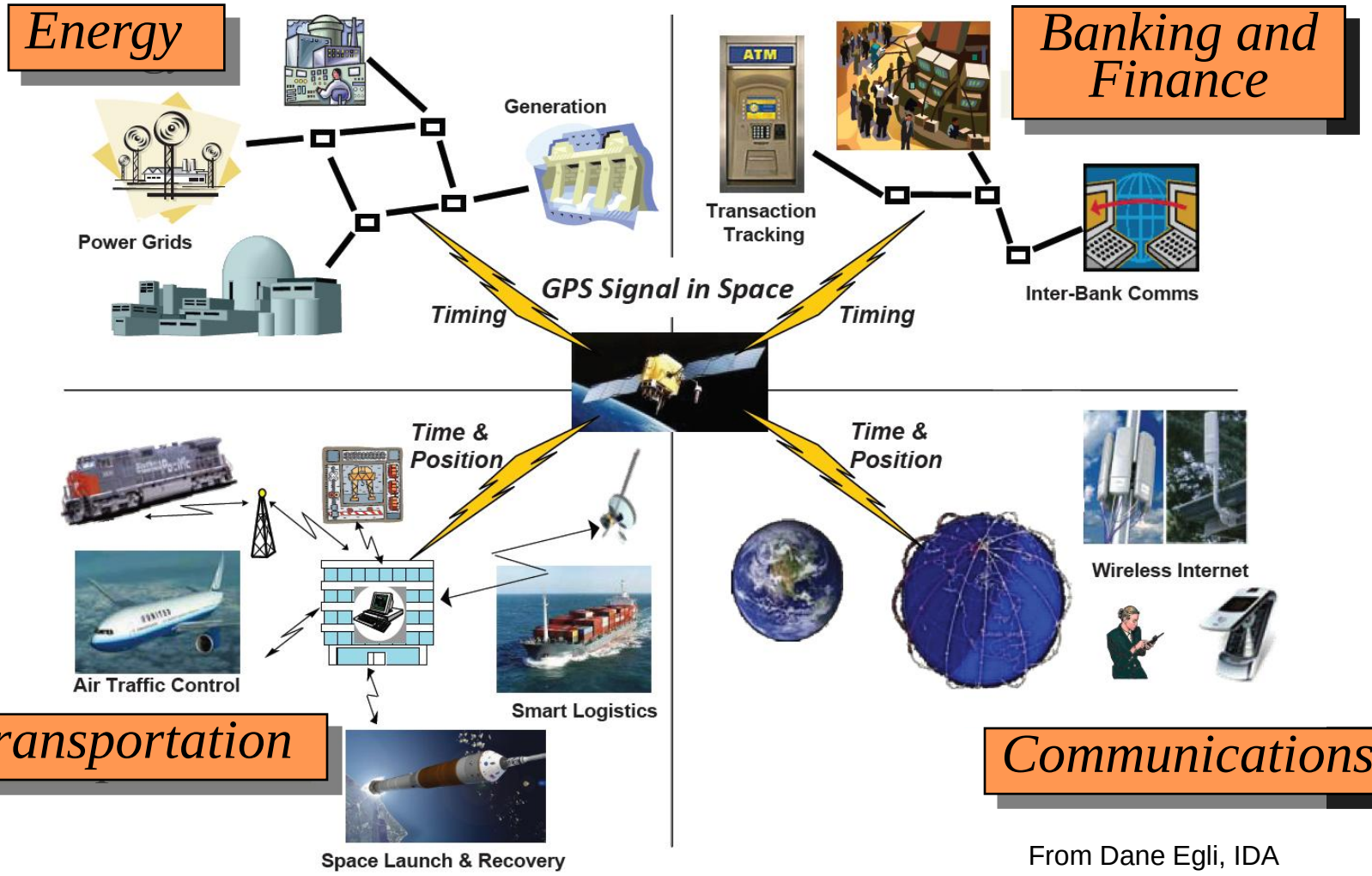
Radionavigation



GPS: The Big Issues

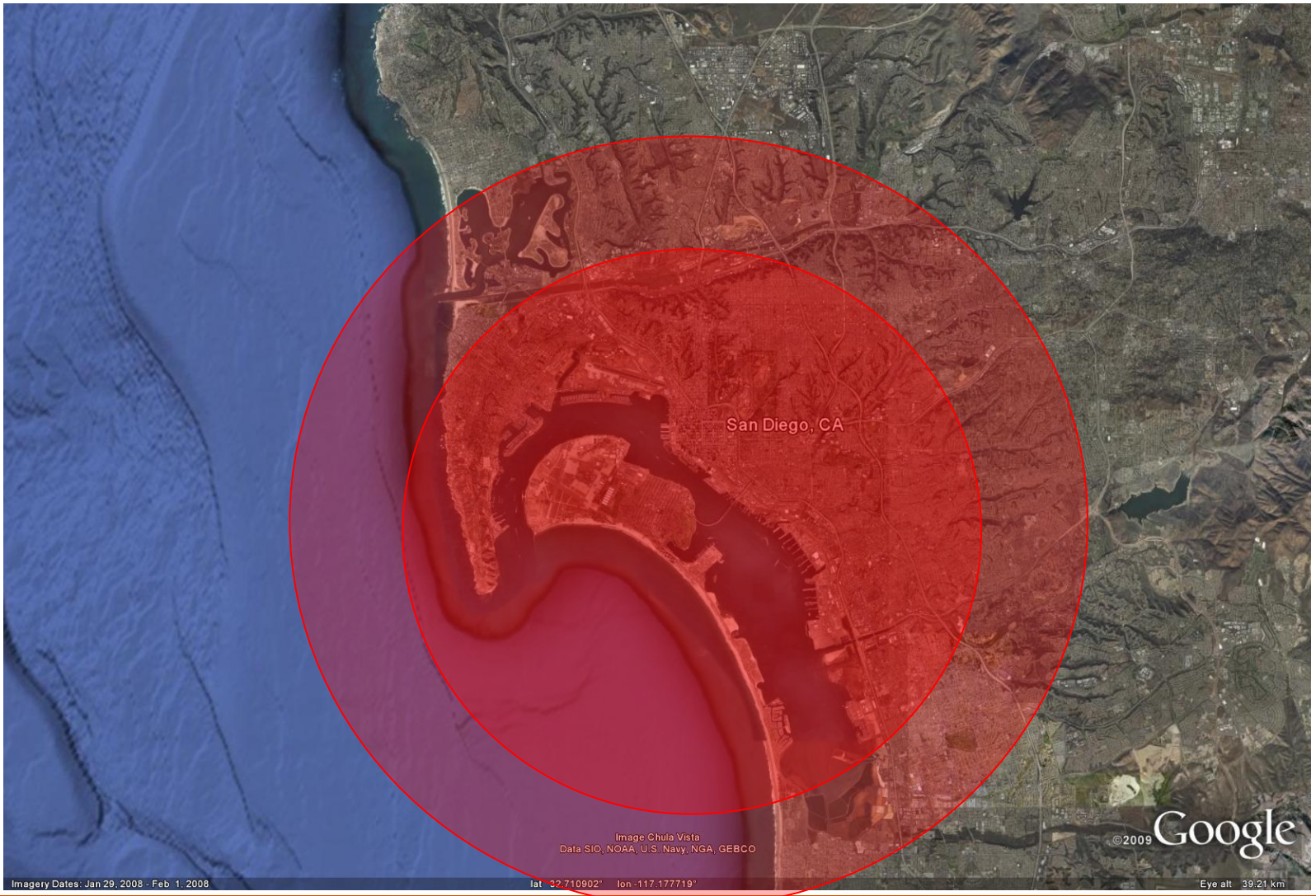
- **Weak GPS Signals**
  - Like a 30-Watt lightbulb held 4000 km away
  - GPS does not penetrate well indoors
  - GPS is easy target for jamming
  - GPS is vulnerable to natural interference (e.g., solar radio bursts and ionospheric scintillation)
- **Unauthenticated Civil GPS Signals**
  - Civil GPS broadcast “in the clear”
  - Makes civil GPS vulnerable to spoofing

GPS: Dependency Begets Vulnerability

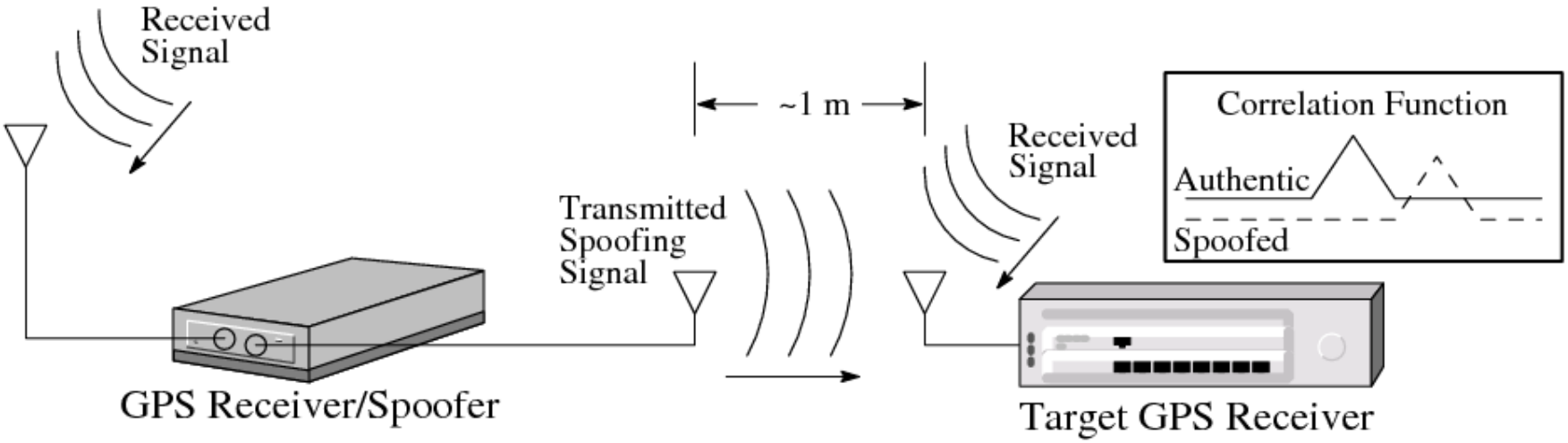


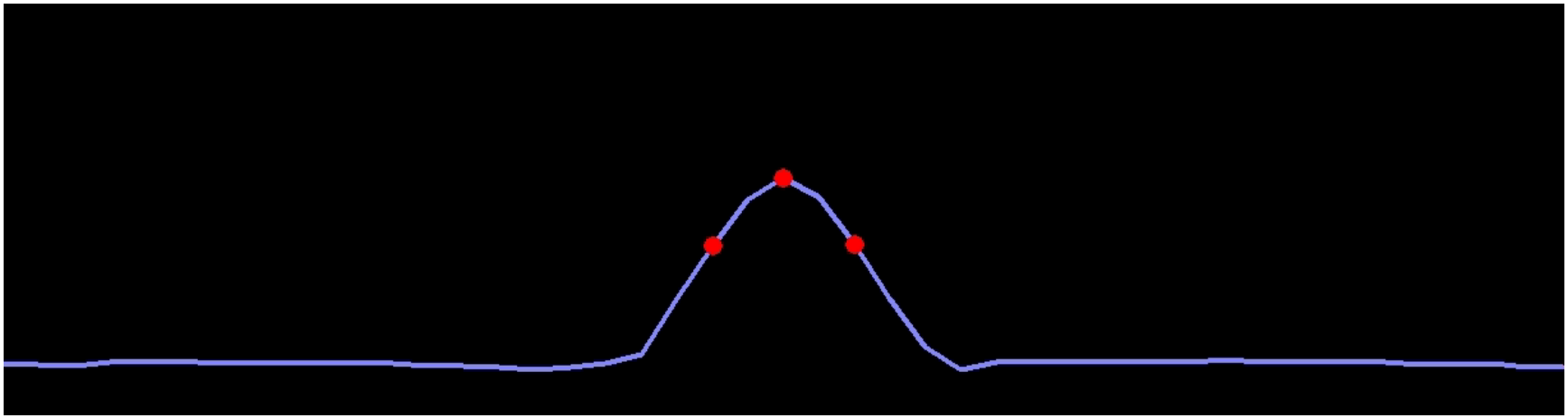
From Dane Egli, IDA

Civil GPS Jamming Event



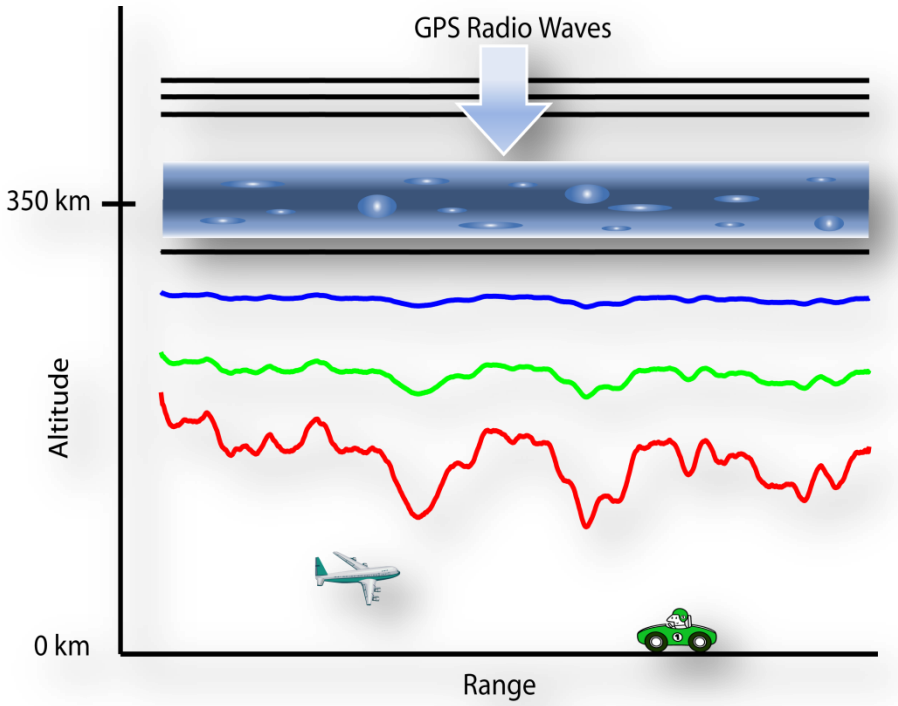
Civil GPS Spoofing

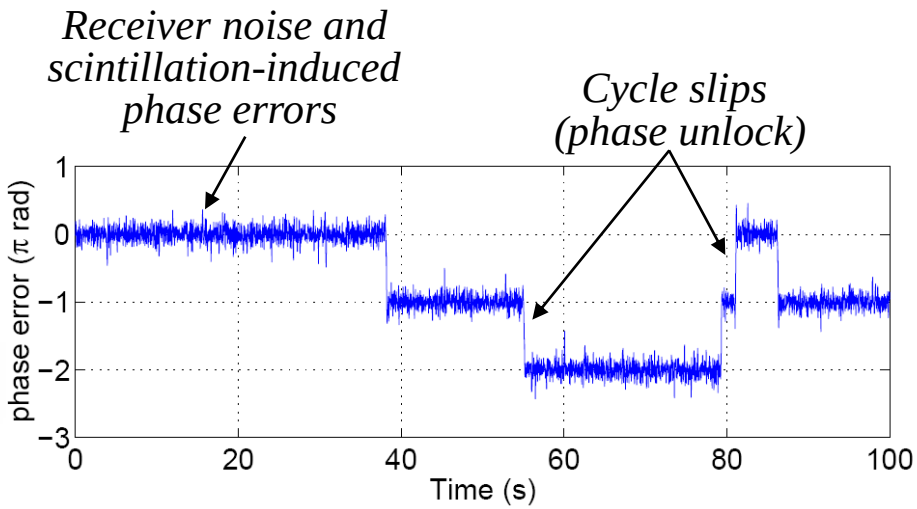


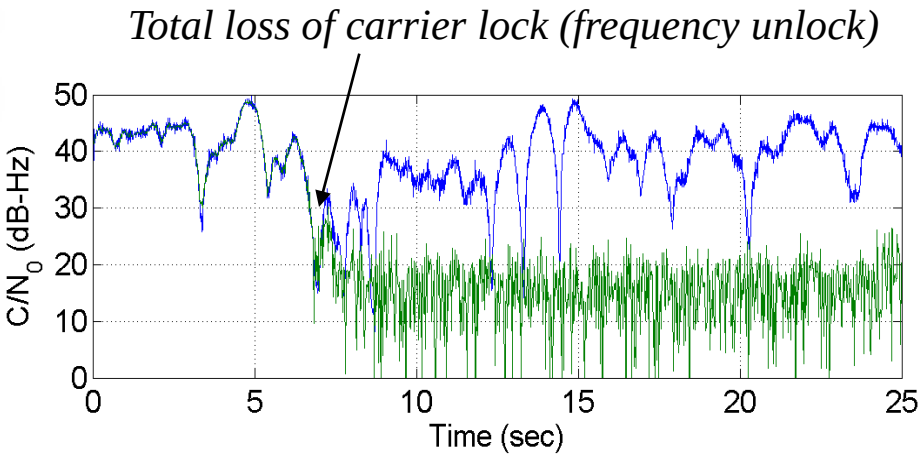


Civil GPS Spoofing (cont'd)

Ionospheric Scintillation



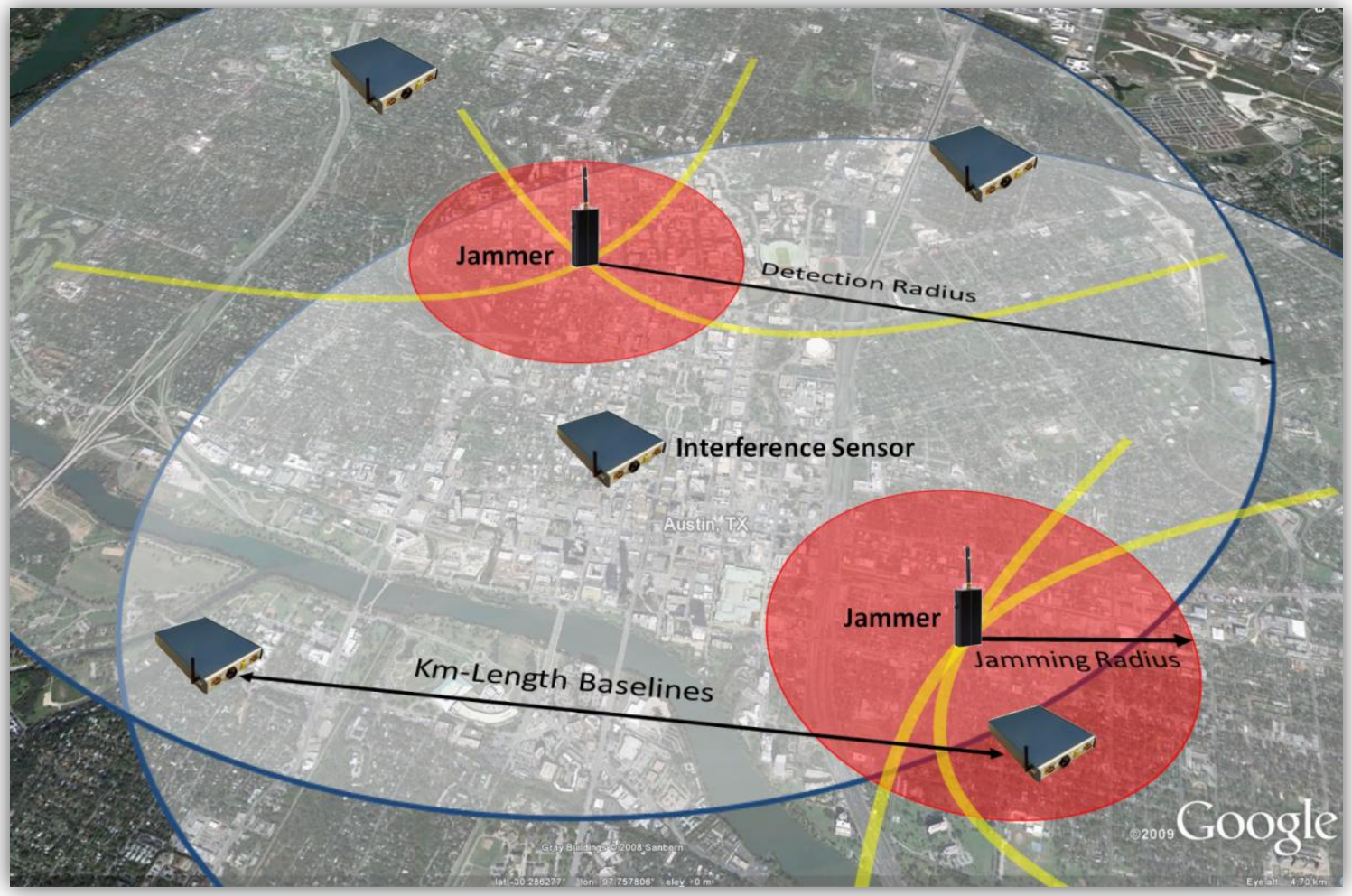




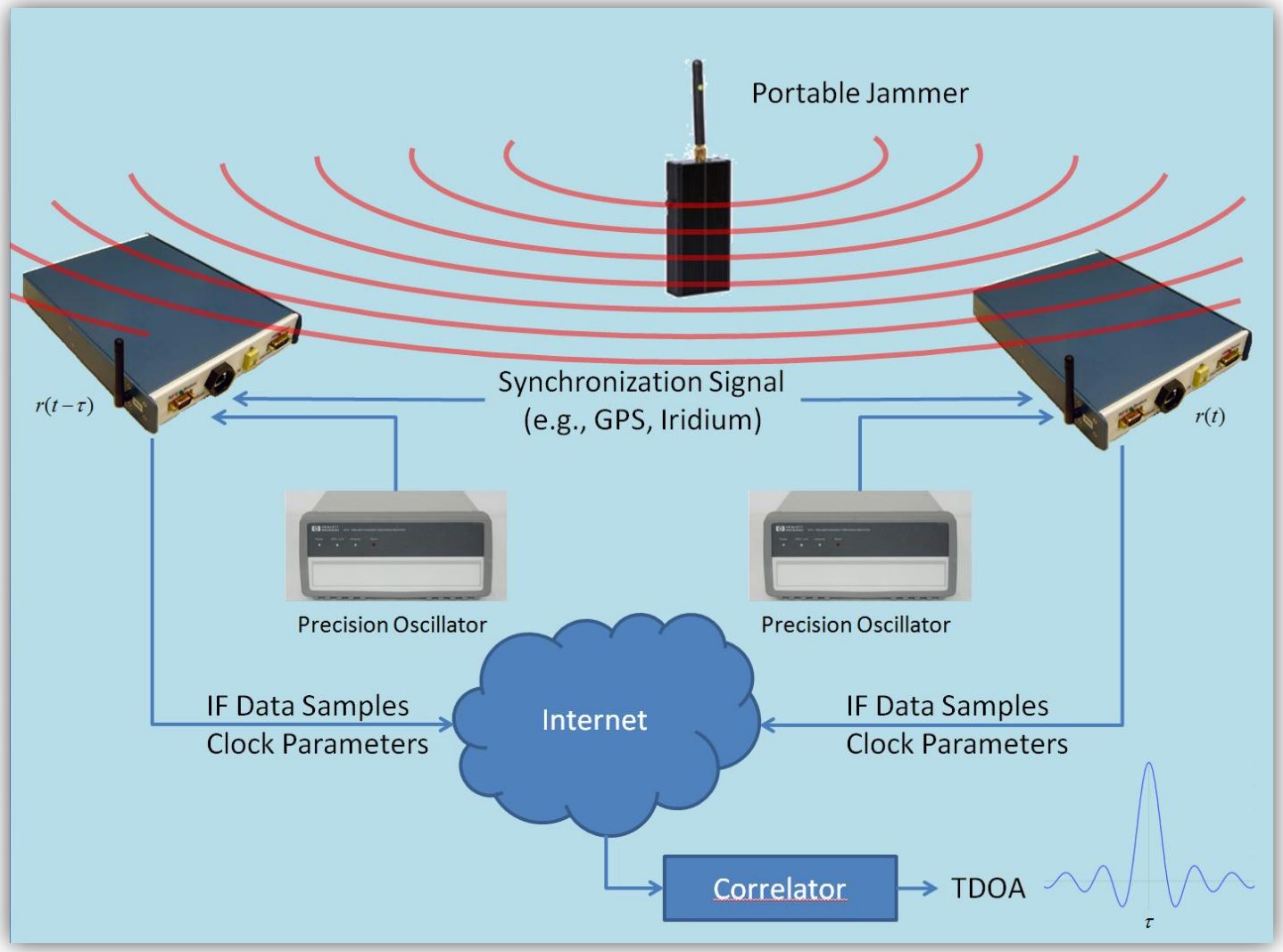
Research Agenda

- **GPS Jamming**
  - Develop augmentation-based defenses
  - Locate jamming sources by combining data from a network of receivers
- **GNSS Spoofing**
  - Characterize spoofing signatures
  - Develop receiver-autonomous defenses
  - Develop augmentation-based defenses
- **Natural GNSS Interference**
  - Improve tracking loop robustness to scintillation
- **Network-Centric Navigation**
  - Establish theory for time stability transfer
  - Pursue opportunistic and collaborative navigation

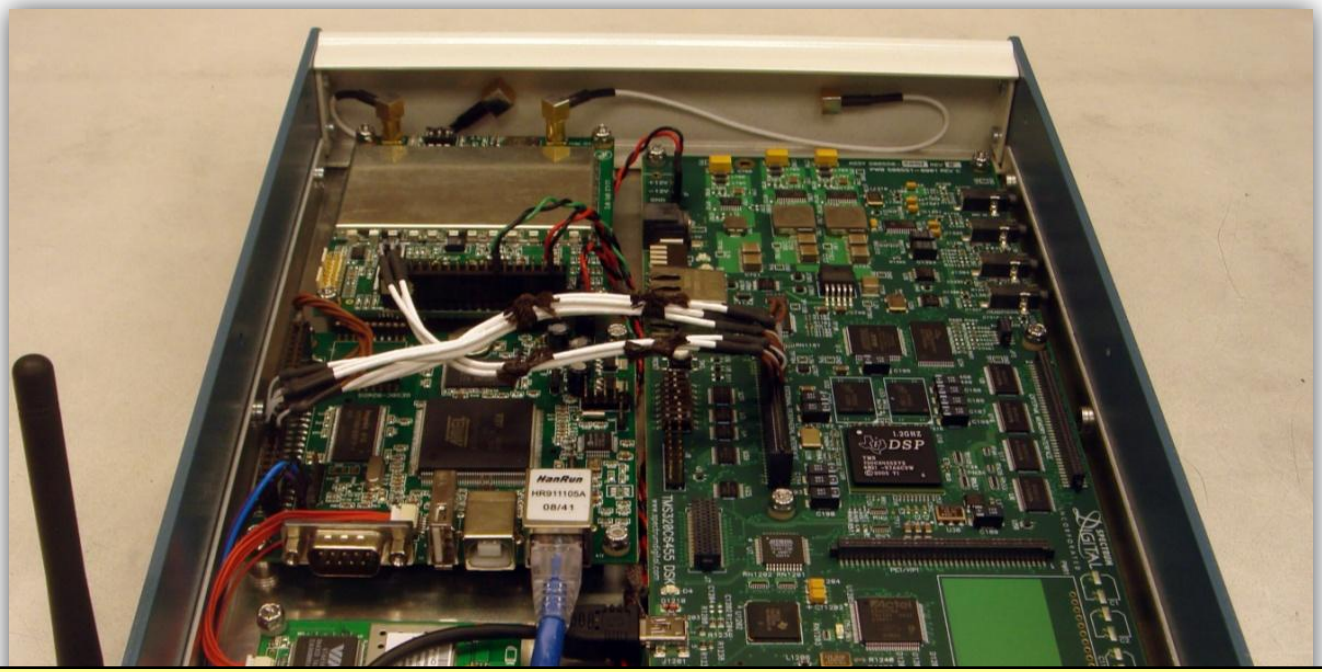
INTERLOC:
Network-based Interference Location



INTERLOC Functional Diagram

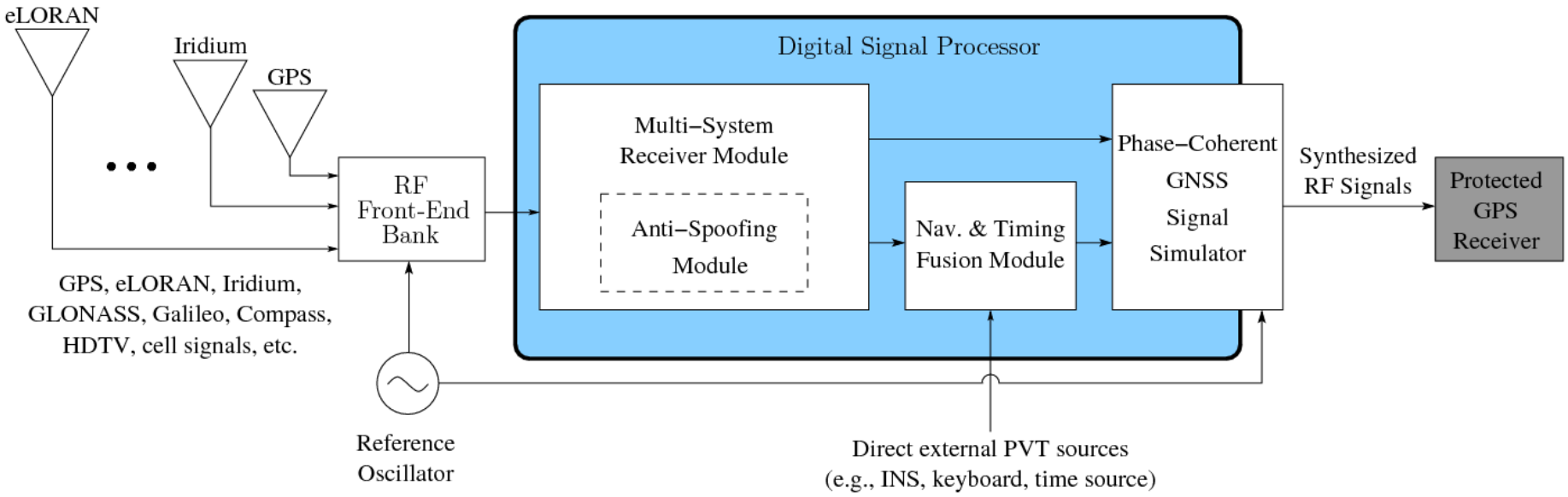


GRID Software-Defined Radio



Flexible software-defined radio platform enables:
GPS Assimilator
Spoofing characterization
GPS-based scientific research
Collaborative navigation research

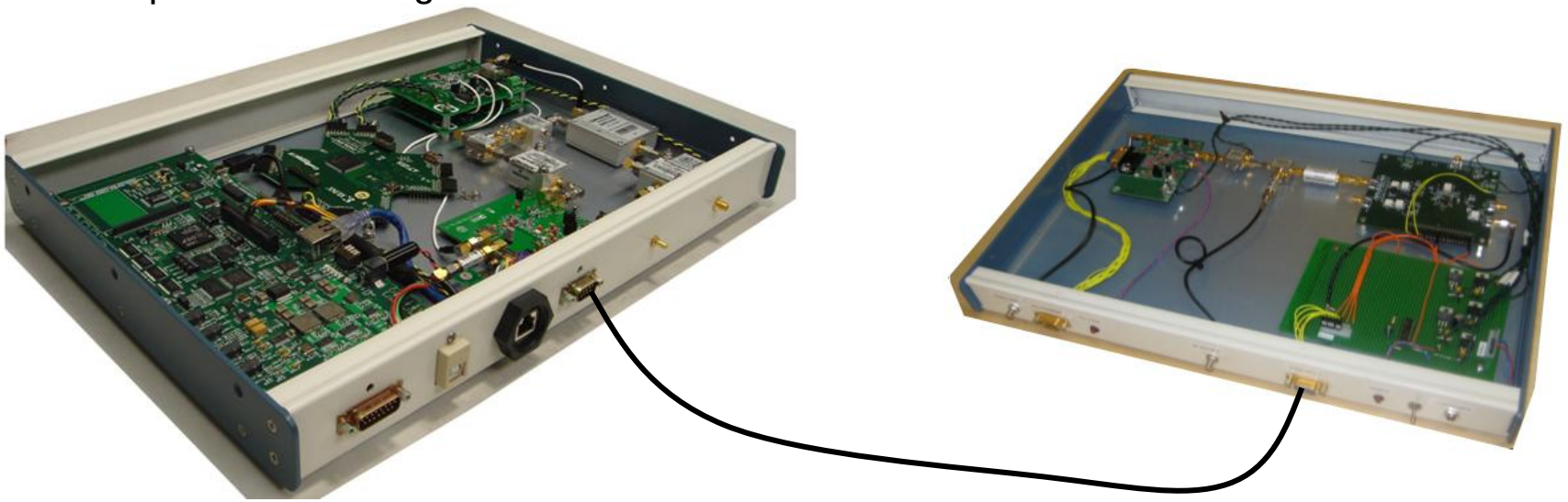
The GPS Assimilator



The GPS Assimilator modernizes and makes existing GPS equipment resistant to jamming and spoofing without requiring hardware or software changes to the equipment

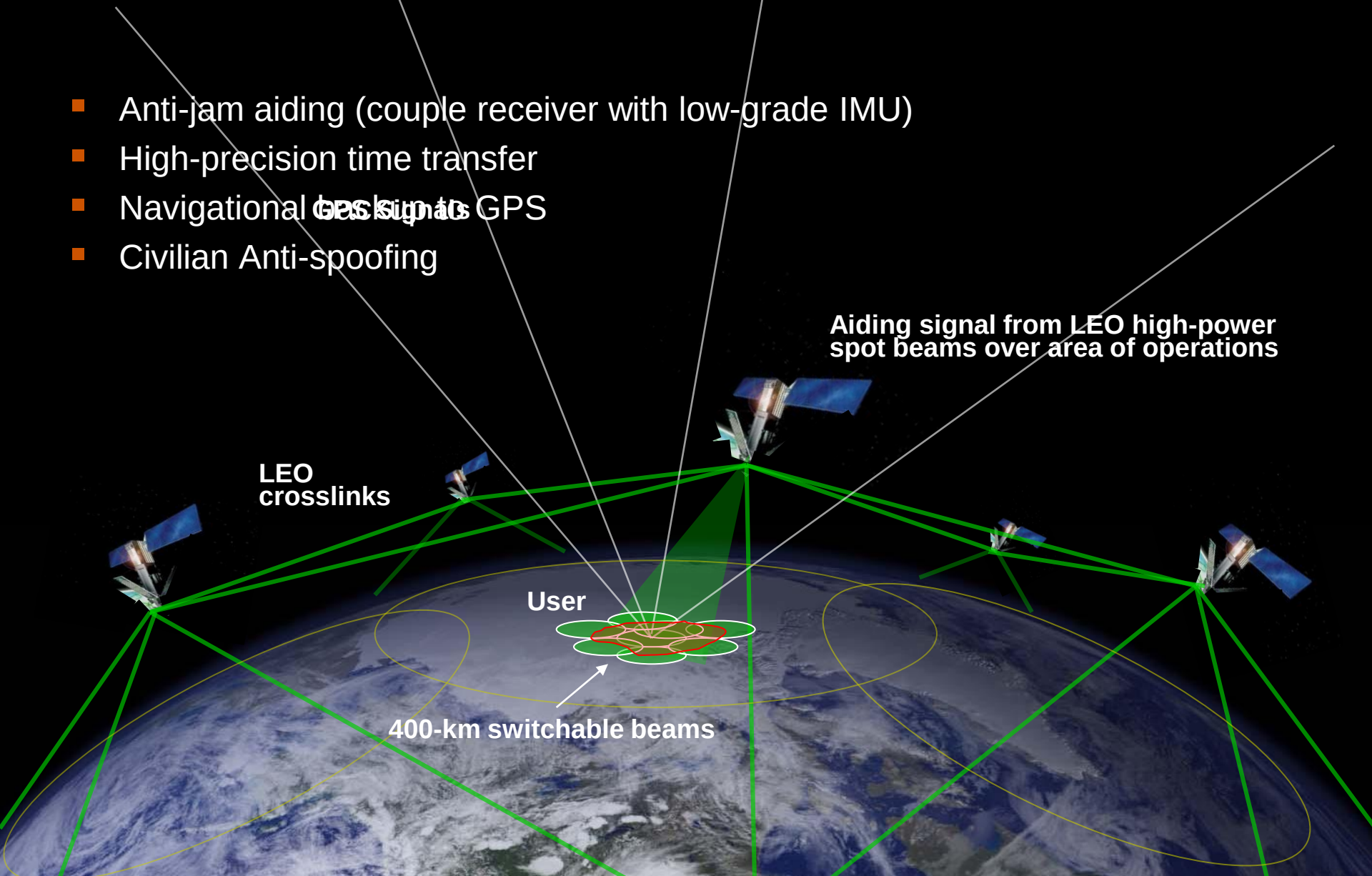
GPS Assimilator Prototype

- All digital signal processing implemented in C++ on a high-end DSP
- Marginal computational demands:
  - Tracking: ~1.2% of DSP per channel
  - Simulation: ~4% of DSP per channel
- Full capability:
  - 12 L1 C/A & 10 L2C tracking channels
  - 8 L1 C/A simulation channels
  - 1 Hz navigation solution
  - Acquisition in background



Iridium-Augmented GPS

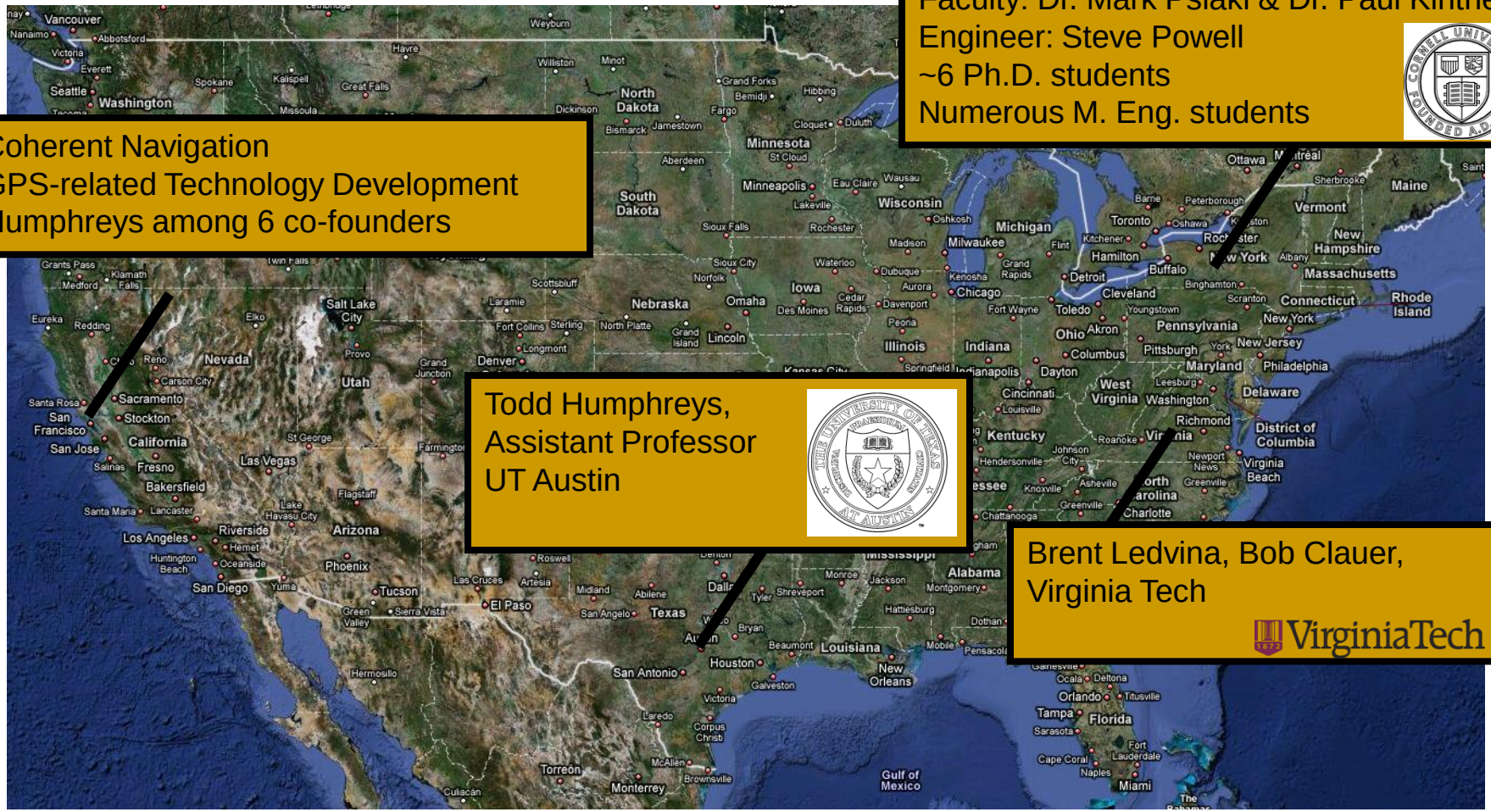
- Anti-jam aiding (couple receiver with low-grade IMU)
- High-precision time transfer
- Navigational backup to GPS
- Civilian Anti-spoofing



Radionavigation Lab

- Jahshan Bhatti
  - Ph.D.-track, AE
  - INTERLOC, spoofing defenses
- Muthukumar Pasupathy
  - Ph.D.-track, AE
  - Ionospheric effects on SatNav
- Kyle Wesson
  - Ph.D.-track, ECE
  - Collaborative navigation and time stability transfer
- Ken Pesyna
  - Ph.D.-track, ECE
  - Time stability transfer, cell-phone-based opportunistic navigation
- Zach Tschirhart
  - Undergraduate, AE
  - Lab manager/technician

Outside Collaboration



Who is Interested in our Work?

- Scintillation-robust software GPS receivers
  - ASTRA (Atmospheric and Space Technology Research Associates LLC)
  - National Science Foundation
- Spoofing characterization and defenses
  - Joint Research Centre, European Commission
  - Office of the Secretary of Defense
  - GPS Wing of the Air Force
- GPS Assimilator
  - DARPA
  - Department of Homeland Security
  - Coherent Navigation