Distributed Network Opportunistic Positioning (DiNO)

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Session B7: Collaborative Navigation Techniques

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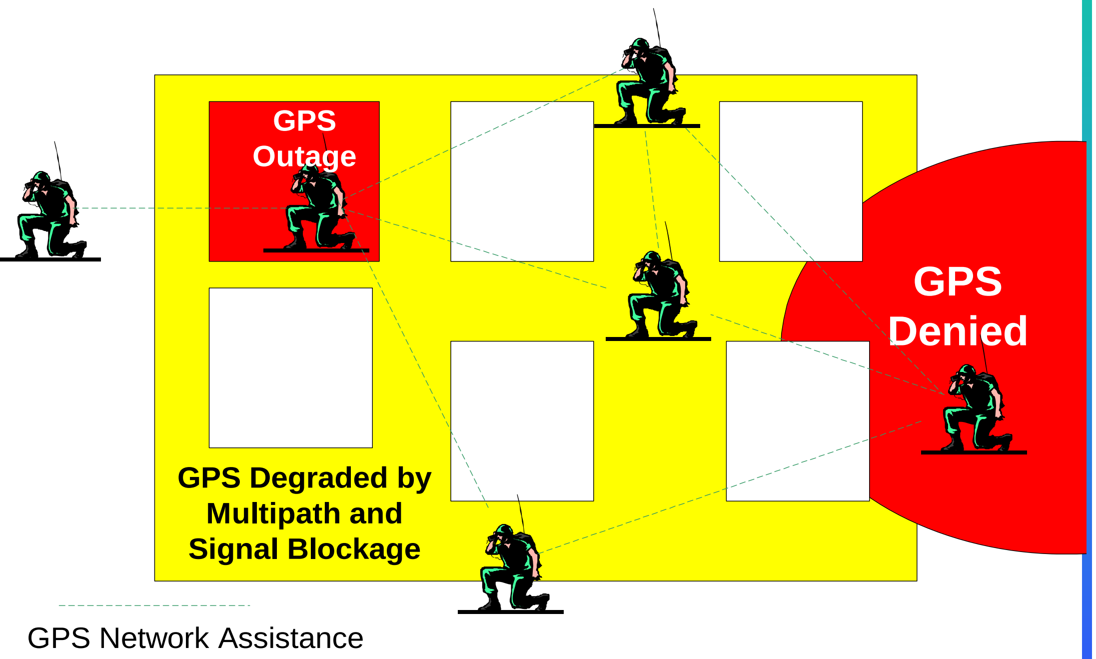
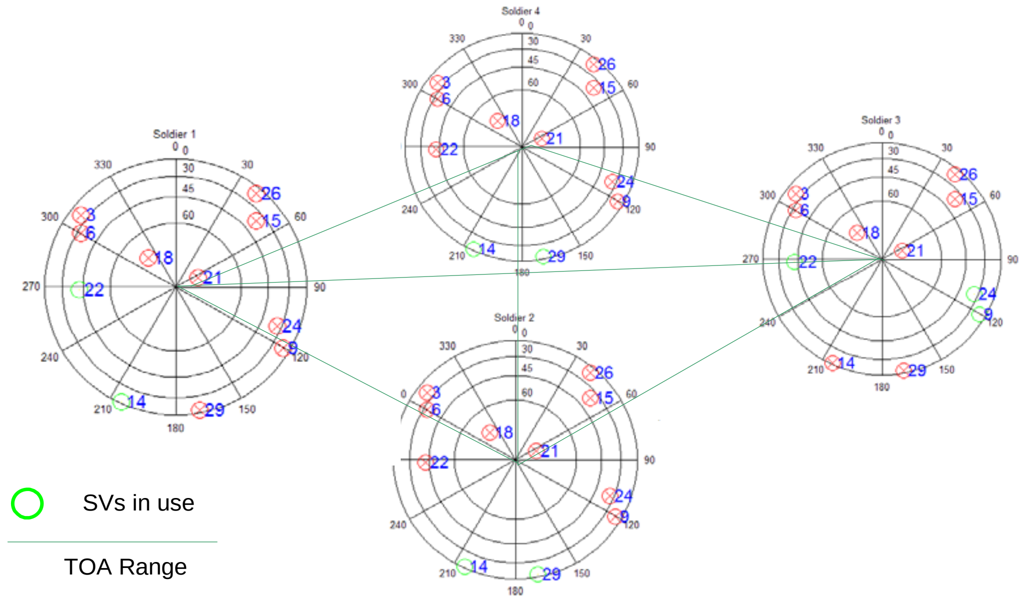
GPS Issues to be Overcome

- GPS signals may be attenuated when operating under foliage, in an urban canyon, or inside a building to the extent that they cannot be detected by a conventional GPS receiver.
- GPS signals can be denied when in close proximity to a GPS jammer or interference source
- The GPS signals can be corrupted with multipath when operating in urban canyons
- GPS navigation is not possible without sufficient satellites to provide good geometry (PDOP)

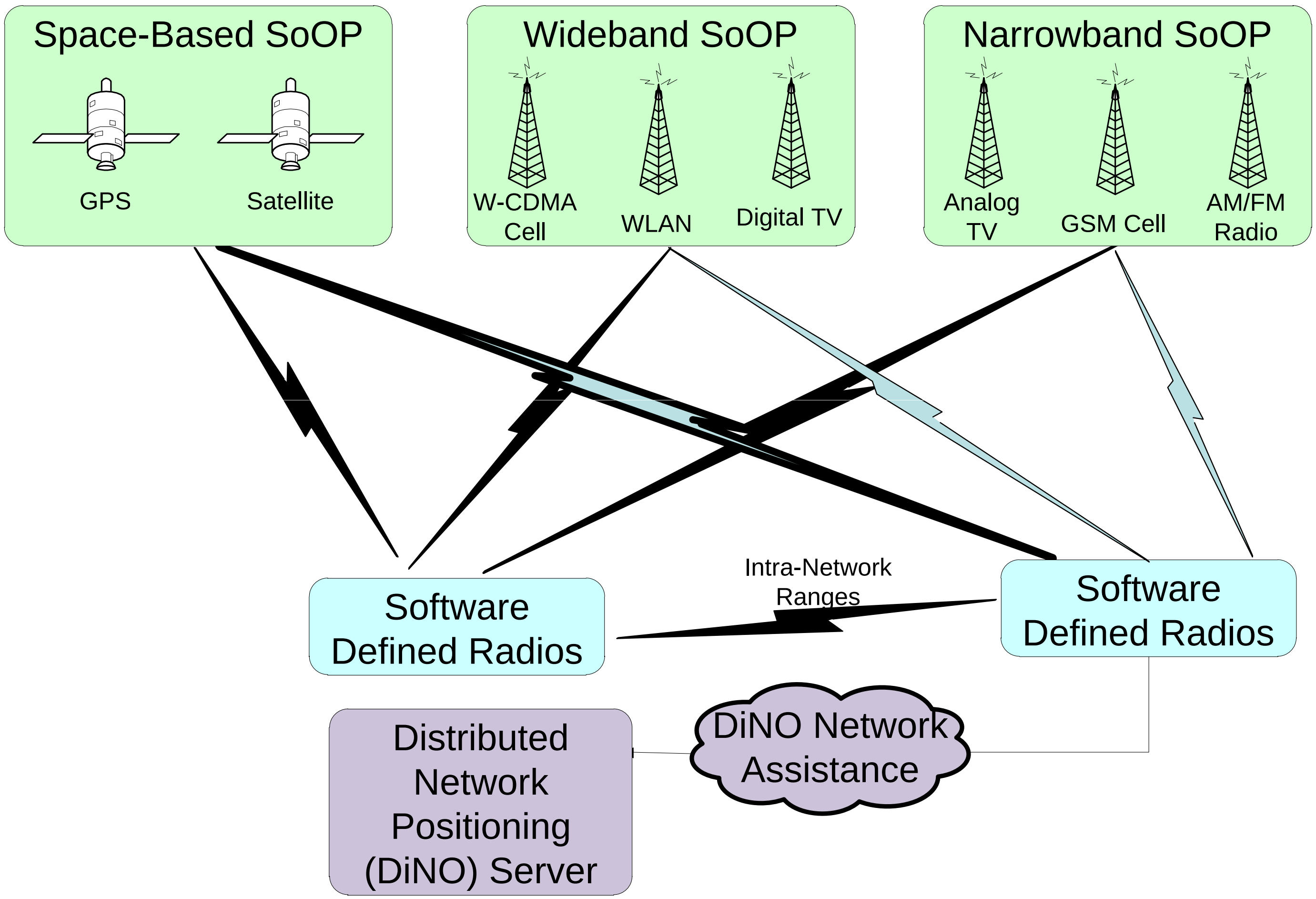


GPS + Cross-link Ranging Distributed Network Solution

- Combines GPS observations and intra-network ranges from a sparse network
- Calculates ensemble network location solution even when no units have complete GPS observability



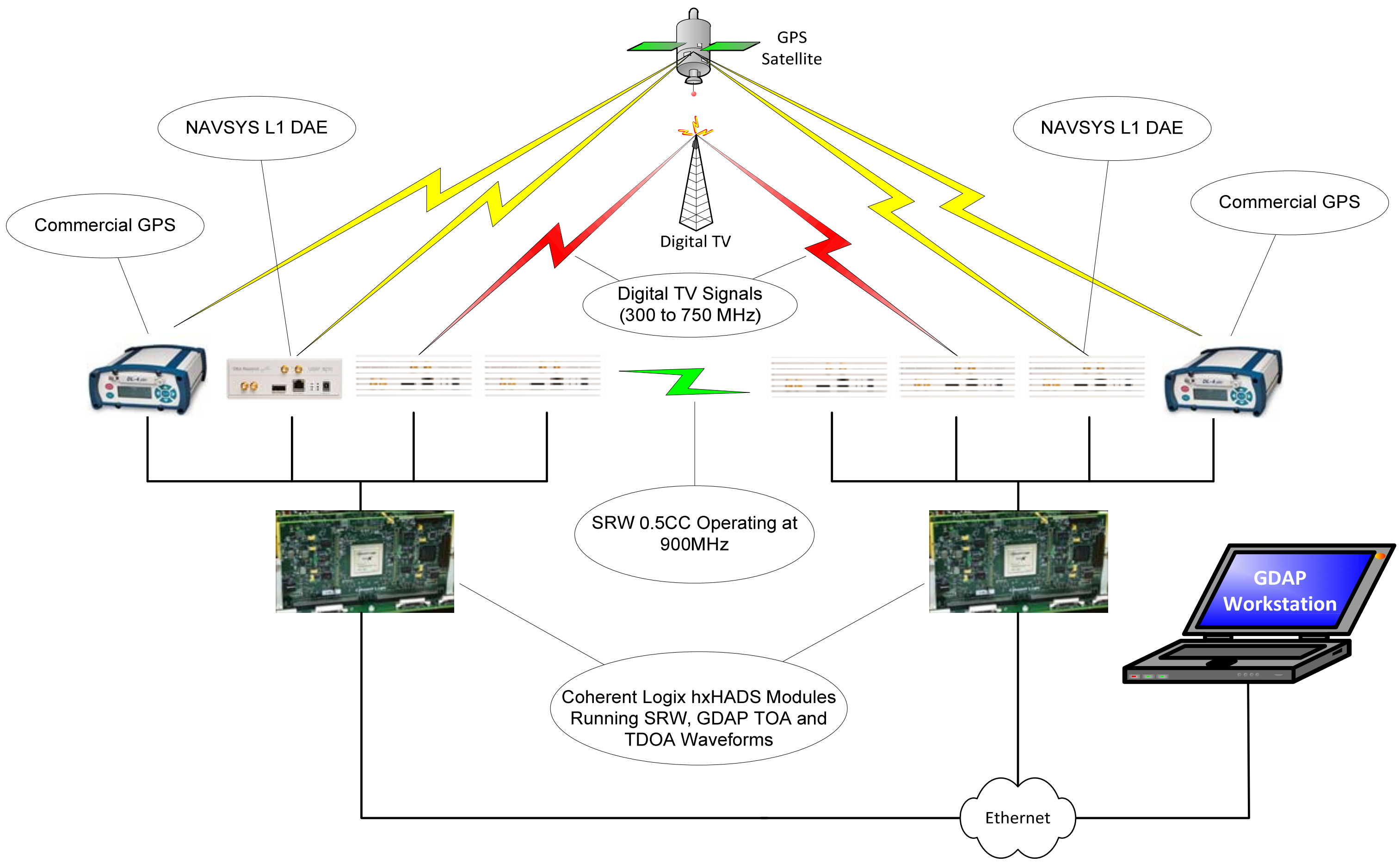
DiNO Positioning with Signals of Opportunity (SoOP)



SDR Enabling Capabilities for collecting DiNO observations

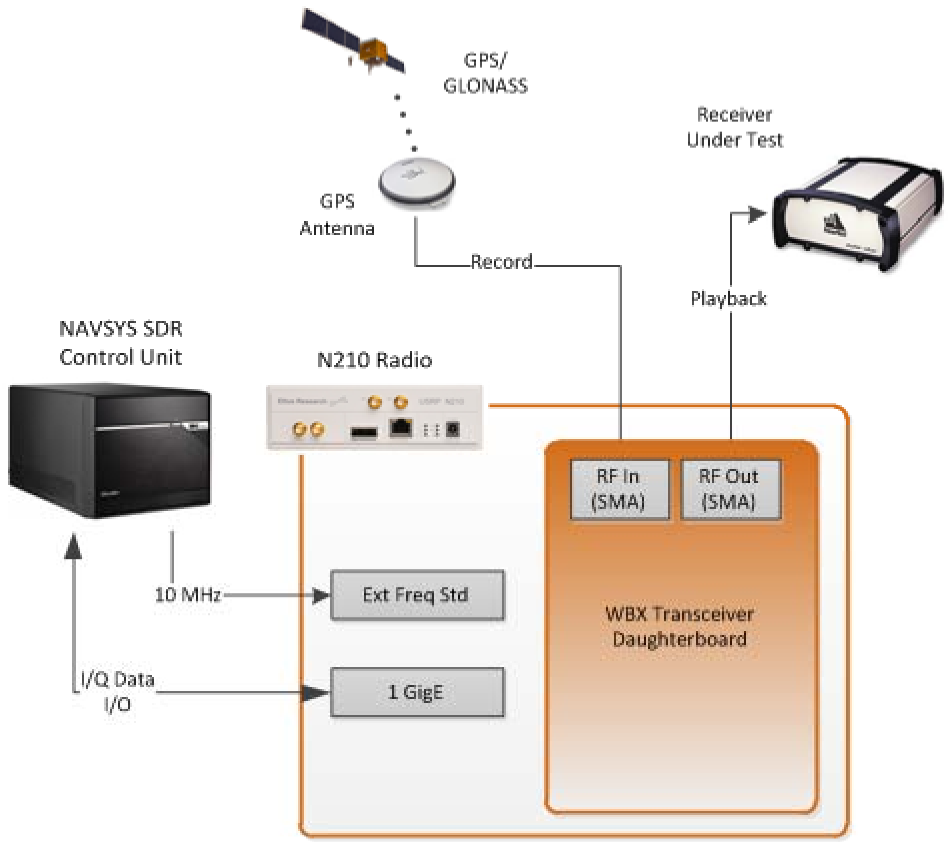
- Multi-band operation
  - Channels can be tuned to scan for SoOP and collect signal samples for DiNO processing
- Common channel reference clock
  - Common clock for GPS and SoOP channels reduce to DiNO solution solving for common Bu offset for each unit (4-states per unit)
- Network communications
  - Can be used for messaging and intra-channel ranging

DiNO SDR Test Bed

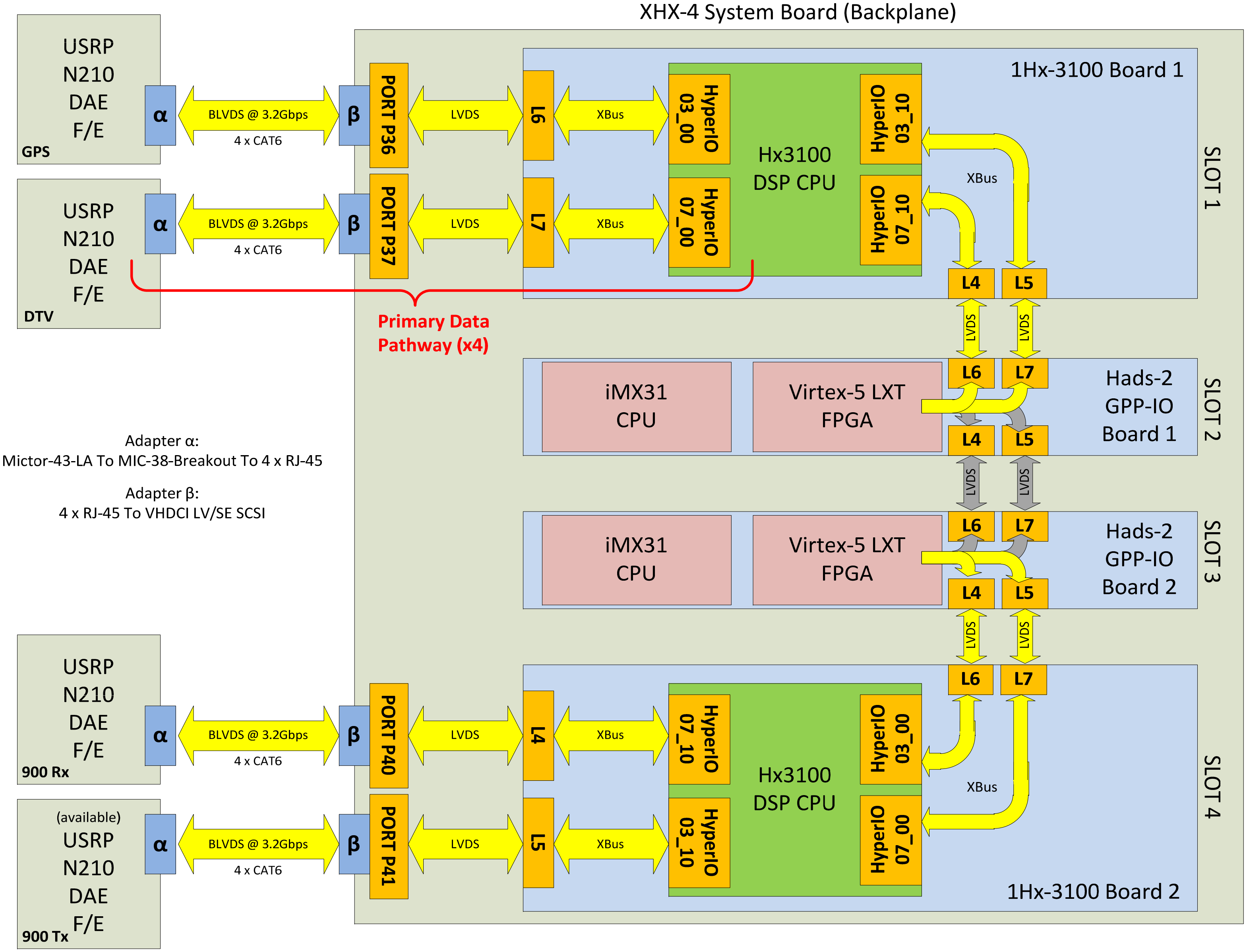


Ettus Universal Software Radio Peripheral (USRP)

- USRP Software
  - Open source GNU Radio
  - GNU Radio Companion
- N210 Radio
  - Spartan-3A 3400 DSP
  - Transceiver daughterboards
- USRP WBX transceiver daughterboard
  - Full-duplex
  - 50 MHz to 2.2 GHz
  - 14 bits A/D



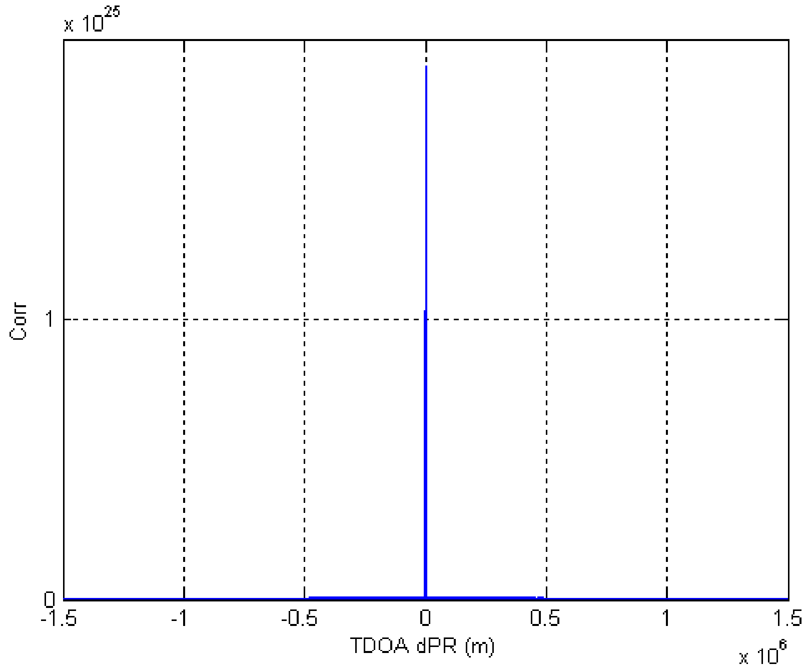
USRP DAE to HyperX

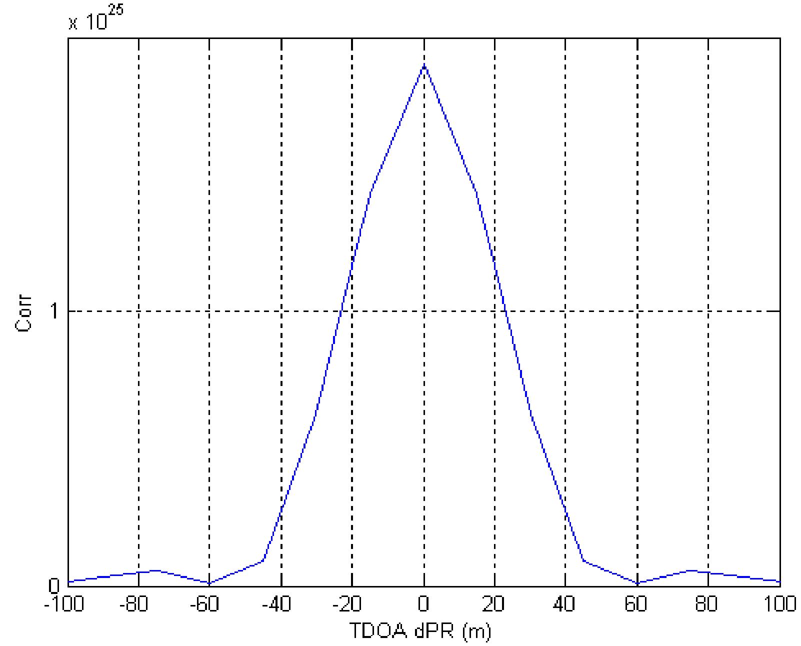


DiNO Signals of Opportunity

- Desired Features
  - Broadband modulation
  - Frequency separation
  - Strong received signal
- DiNO Processing
  - Geolocates SoOP using TDOA observations (note does not require detailed knowledge of signal structure)
  - Uses TDOA dPR obs to augment network positioning
- DTV
  - 300-750 Mz
  - 6 MHz BW, >1000 kW
- PCS
  - 1930-1990 MHz
  - 1.23 MHz BW, 100-500W
- WiMax
  - 2.3, 2.5, 3.6 GHz
  - 3.5 -20 MHz BW, 100 W

DTV DPR Observations

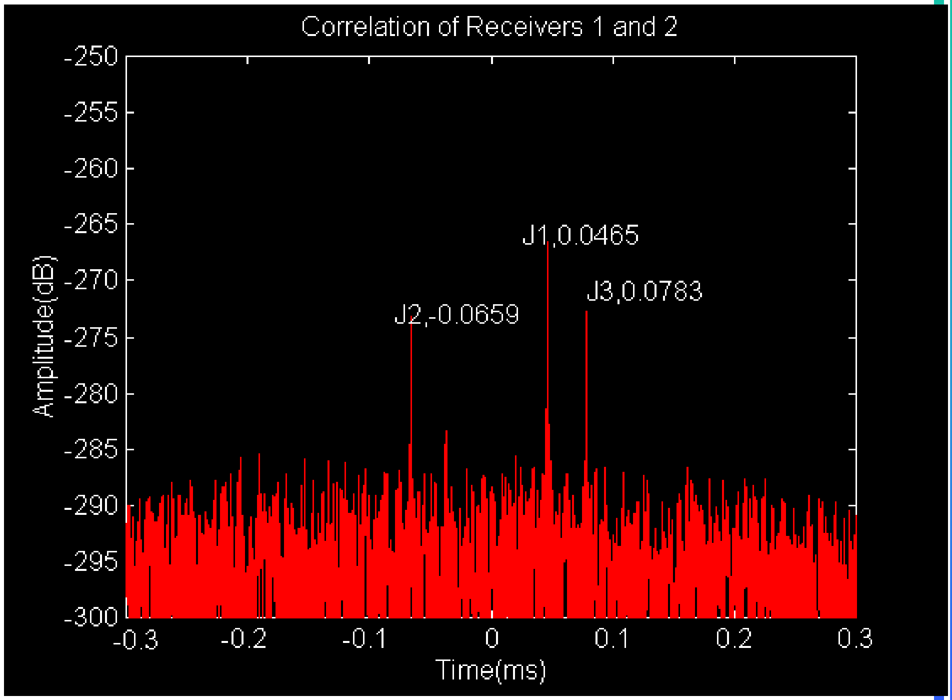




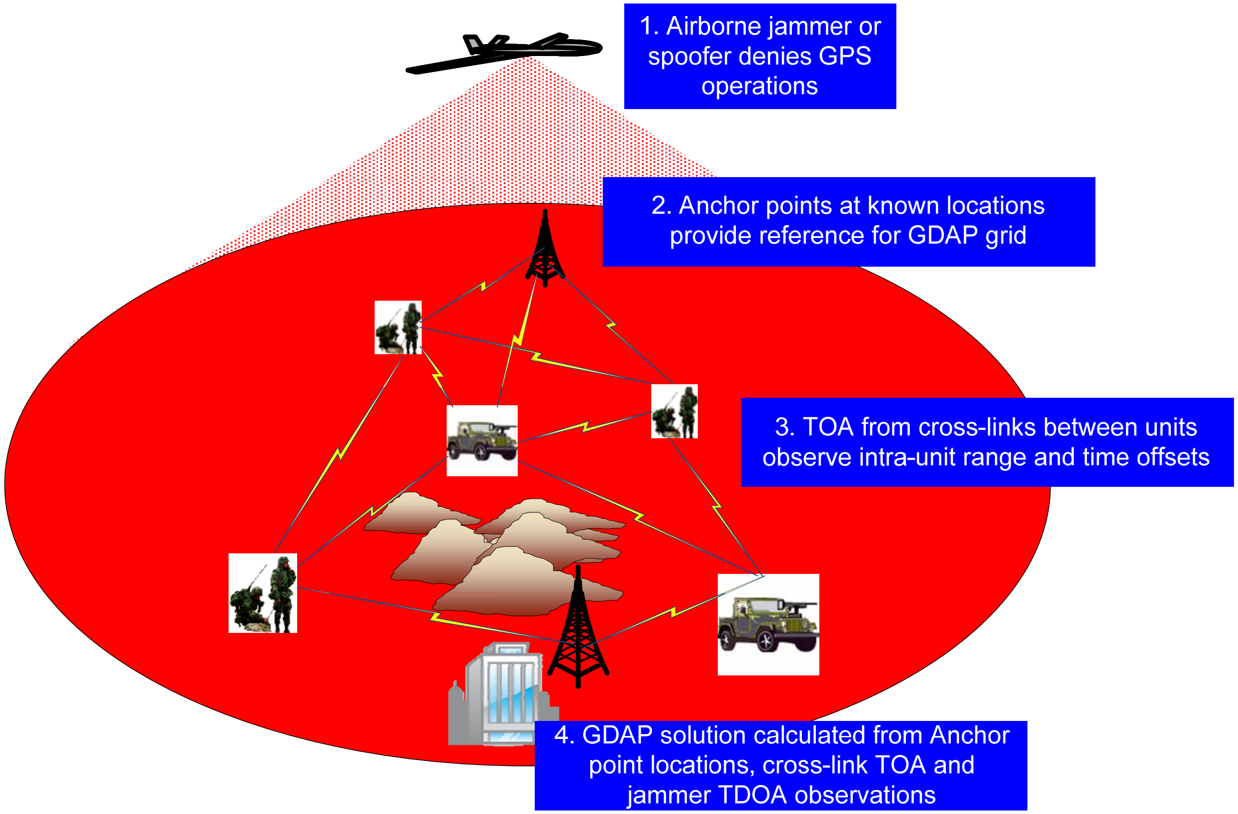
Cross-correlation of two samples in DTV band provides D-PR observations

GPS Jammers as SoOP

- Example jammer signals collected at WSMR
- TDOA cross-correlation provides dPR observations
- DiNO algorithm associates dPR with each jammer node and solves for location



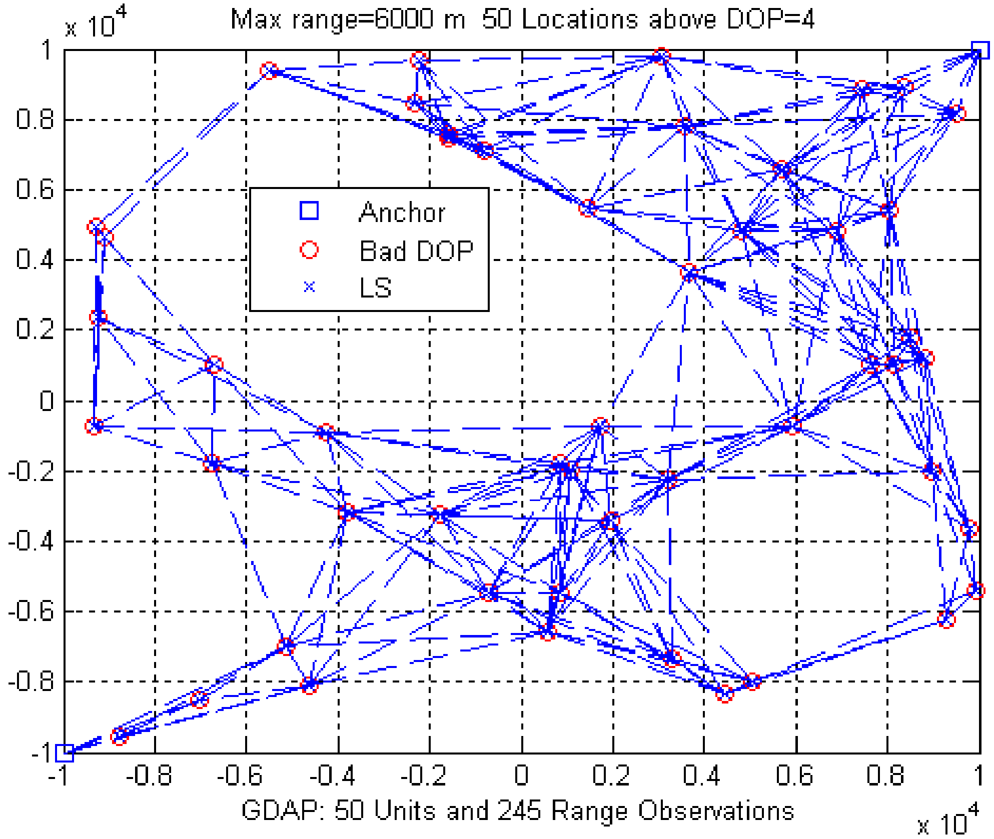
Jammer-Assisted Collaborative Navigation Solution



DiNO Navigation Example

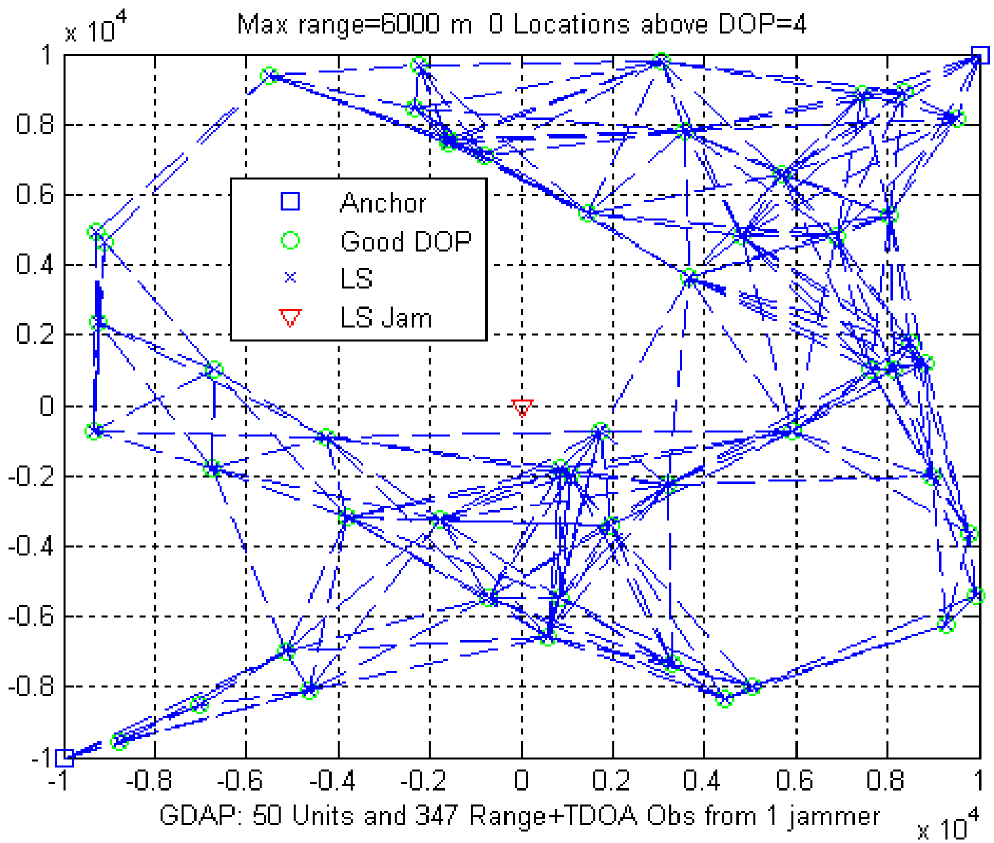
- Interior units have intra-network ranges (e.g. SRW)
- DiNO App captures snapshots from selected SoOP on all units (e.g. DTV and/or GPS jammer)
- DiNO network service calculates <u>all</u> distributed networked units' locations and also locations of SoOP
- Solution can be calculated with <u>no</u> GPS observations through addition of two "anchor" units at known location with precise local clock

DiNO Simulation – TOA Obs



Insufficient TOA observation geometry to compute solution without any GPS obs

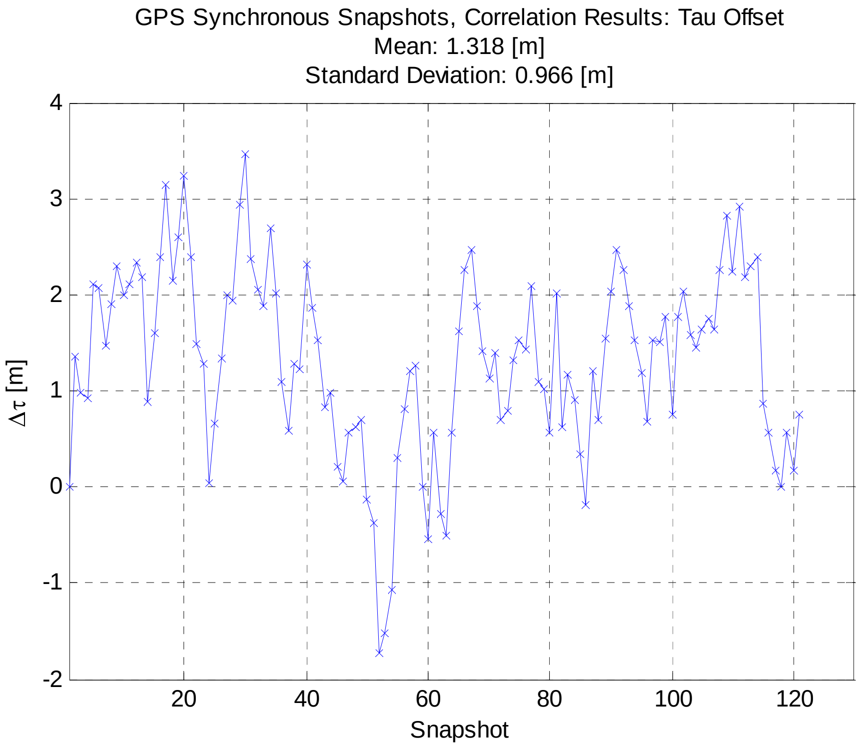
TOA + GPS Jammer Assistance



TOA + Jammer dPR obs relative to anchor units provides sufficient geometry for solving for jammer and network participant locations

GPS Timing Testing

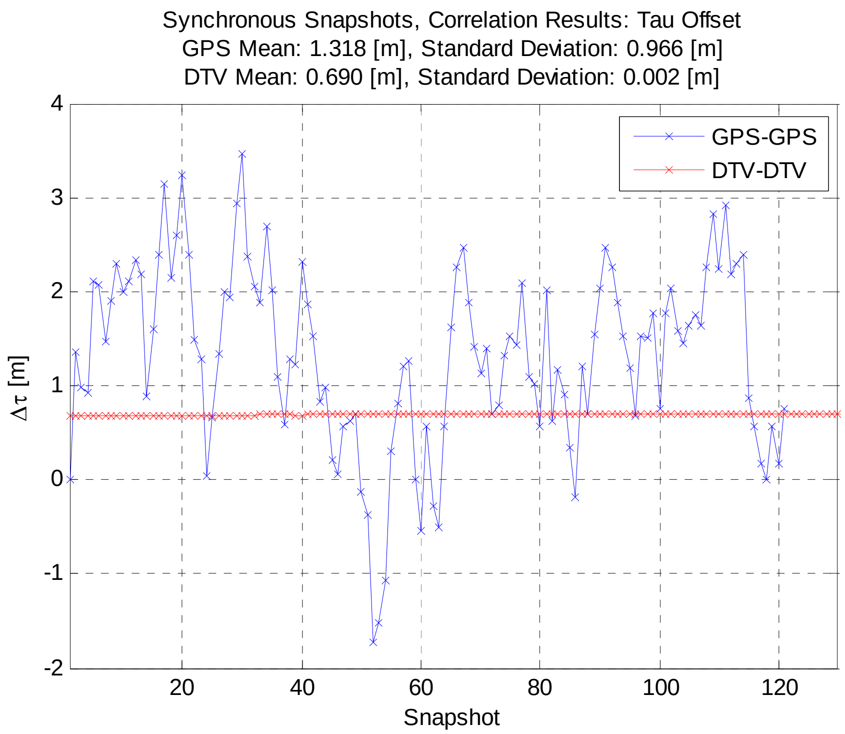
- GPS snapshot collected from two SDRs
- GPS time of transmission extracted to mark start time of samples
- Test data collected with common clock used to observe accuracy



Time Differences were accurate to within 1 m (1-sigma)

GPS/DTV Observation Accuracies

- GPS and DTV snapshots were collected using two channels on SDR
- SDR clock offset determined from GPS observations
- DTV dPR observation created using GPS corrected SDR clock offset



DTV dPR observations were accurate to within 2 mm (1-sigma)

Conclusion

- Distributed Network Opportunistic Positioning (DiNO) provides robust collaborative positioning in an urban environment where GPS satellite visibility is occluded
- DiNO leverages GPS + RF Ranging Network assistance to allow positioning of users in an environment where GPS is partially denied
- DiNO leverages RF Ranging + SoOP (including GPS Jammer Assistance) to allow positioning of users in an environment where GPS is completely denied
- DiNO provides back-up navigation capability to GPS as an embedded SDR and Network application
- Lab and field testing planned with GDAP test bed under US Army contract with DARPA SBIR funding