Collaborative Navigation using GPS Distributed Aperture Positioning

Joint Navigation Conference

Session B3: Collaborative Navigation Techniques

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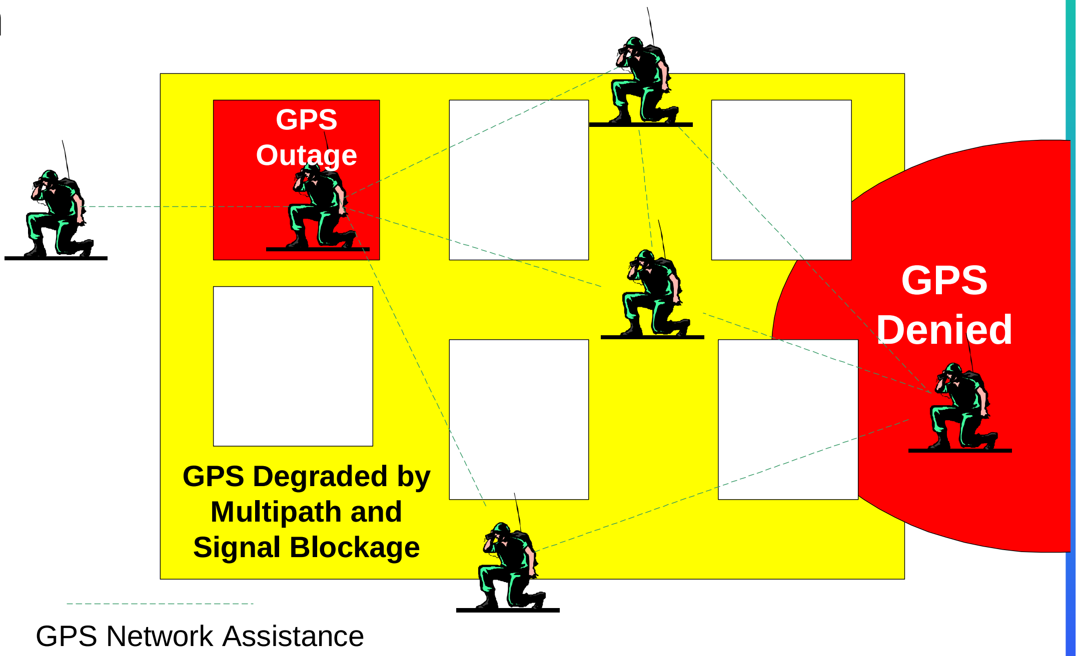
Alison Brown and Bruce Johnson
NAVSYS Corporation

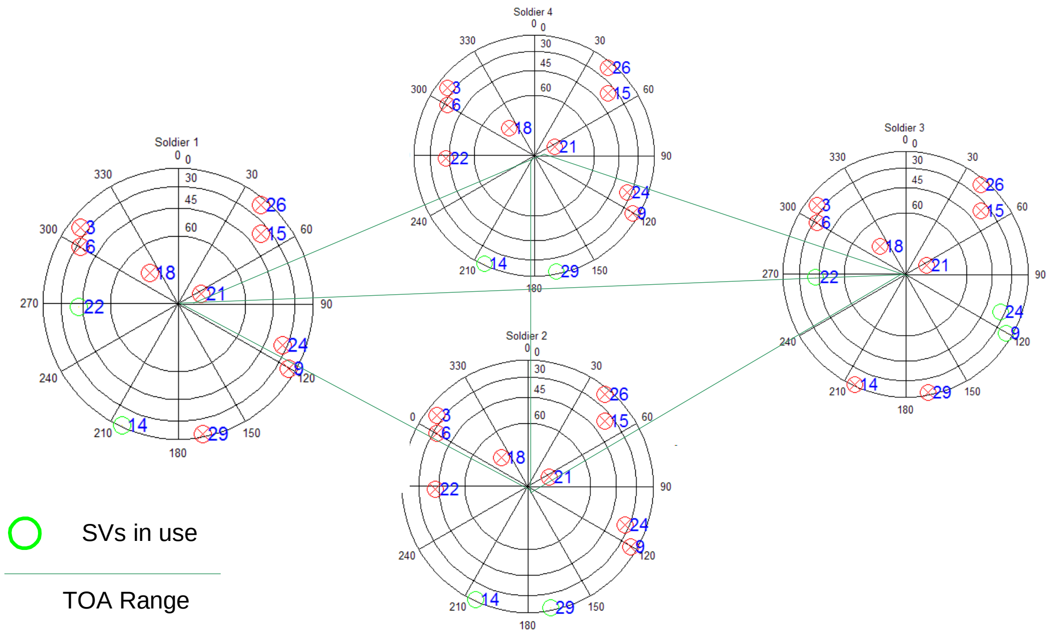
GPS Issues to be Overcome

- 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)

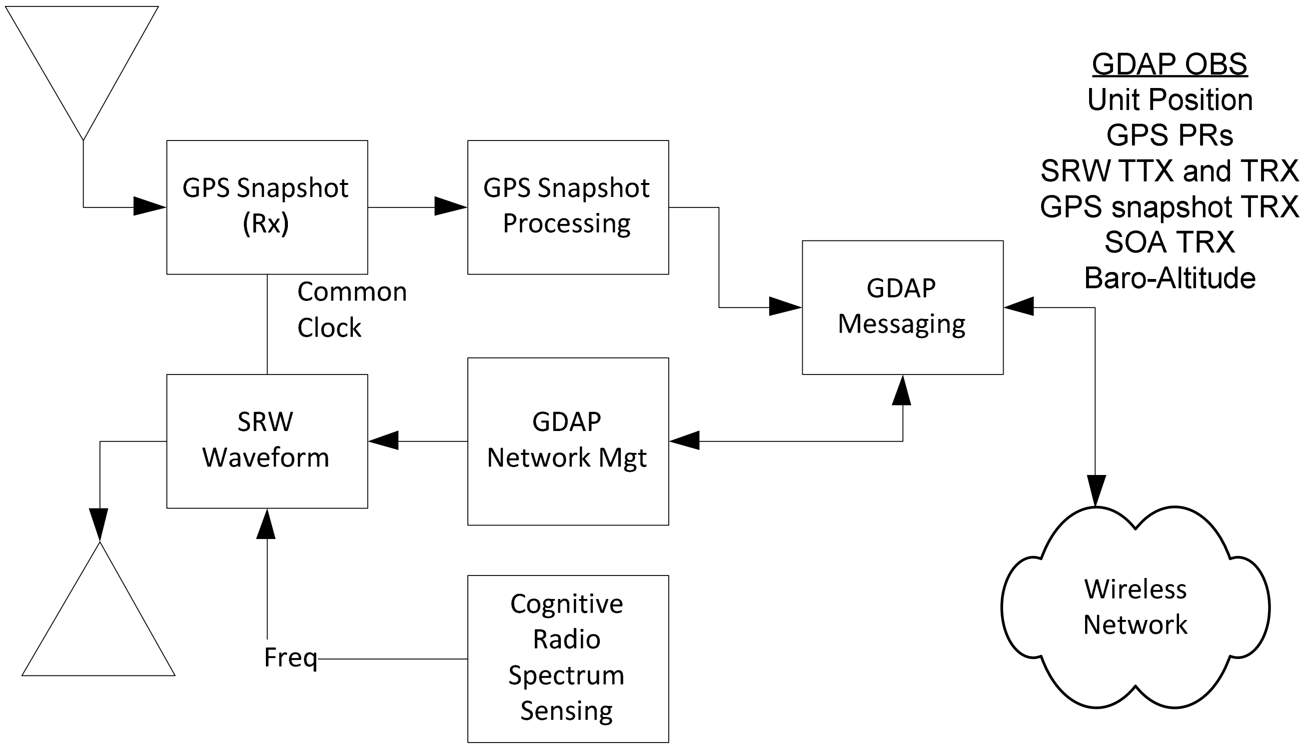


GPS Distributed Aperture Solution

- Combines individual GPS observations and intra-network ranges from a sparse network
- Calculates ensemble network location solution even when no locations can be "anchor points"

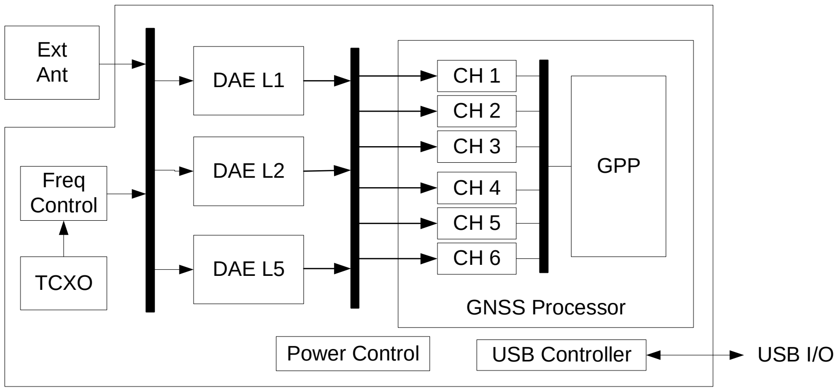


One Way GPS/TOA with SRW Ranging

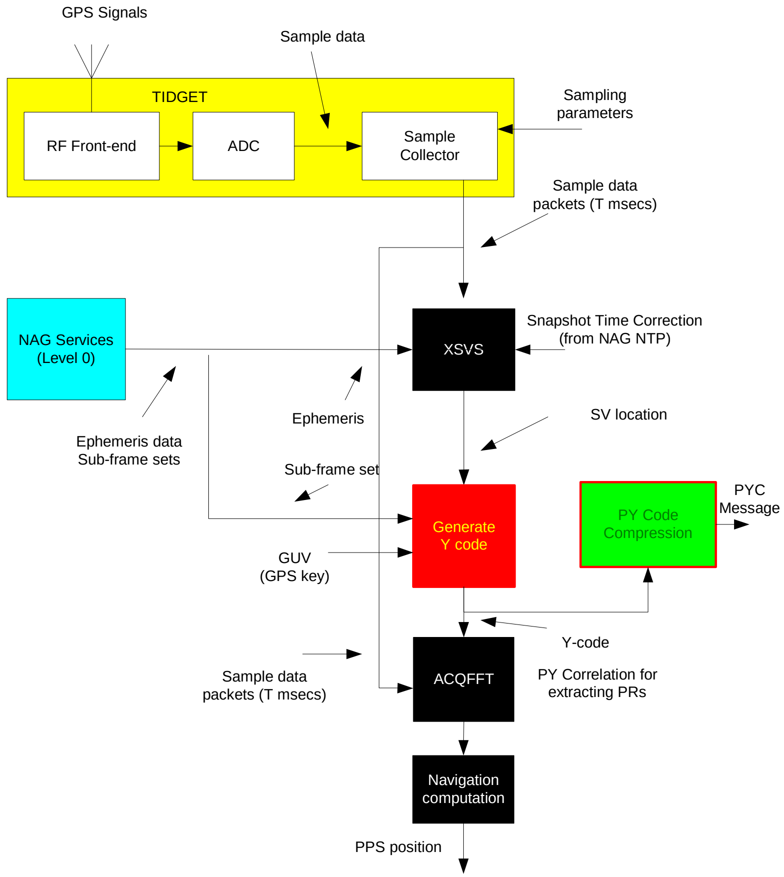


Use of common clock allows GPS time-stamping of SRW Tx signal frames for 1-way TOA ranging

Software GPS Solution enables precise timing on

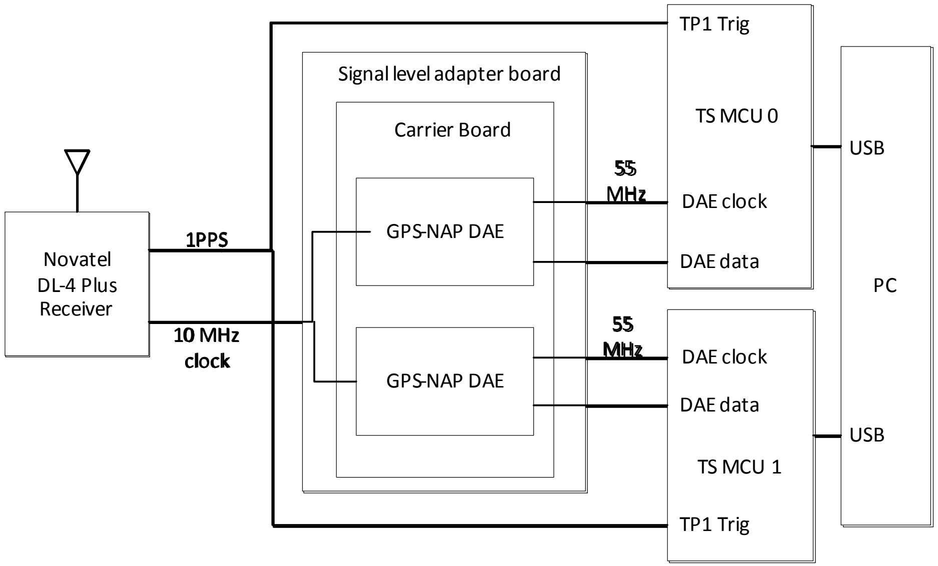


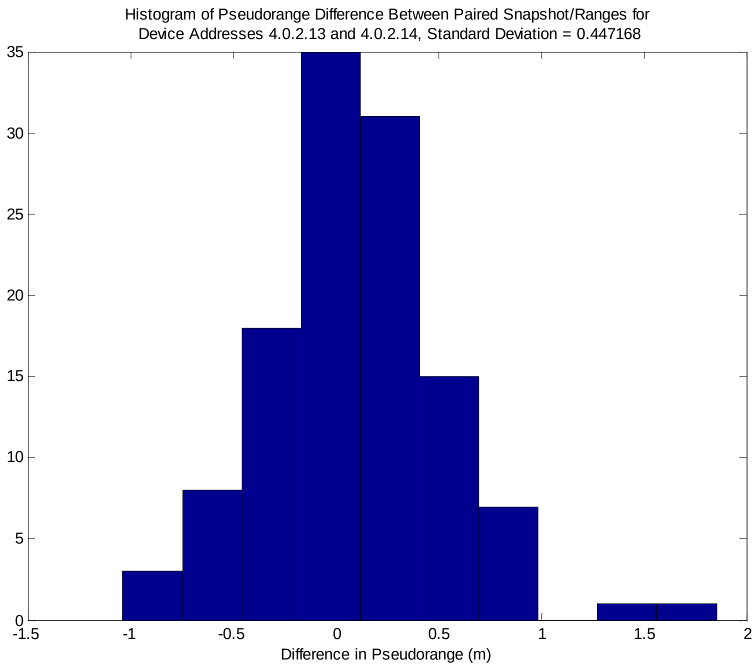
GNSSμSDR system architecture



GPS-Lite Snapshot Solution

GPS Snapshot Timing Testing



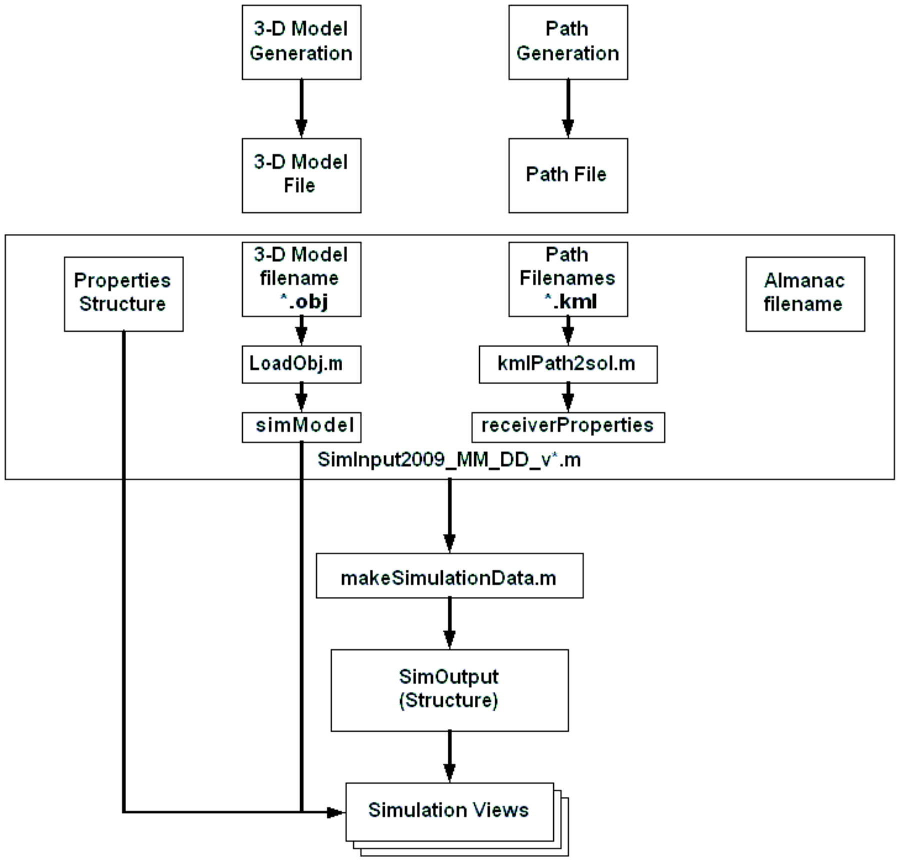


Timing Test-Bed captured snapshots from two different receivers using a common timemark

Time Differences were accurate to within 0.44m or 1.5 nsec (1-sigma)

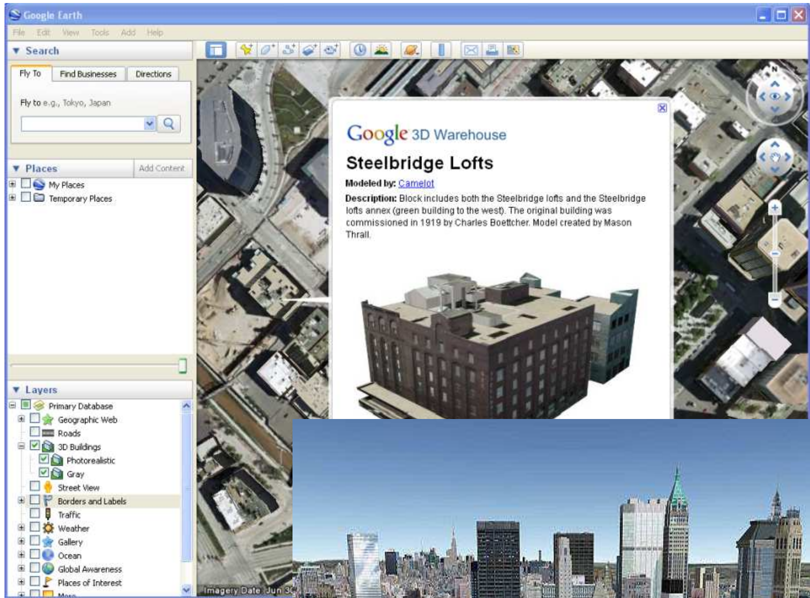
GDAP Simulation Tool

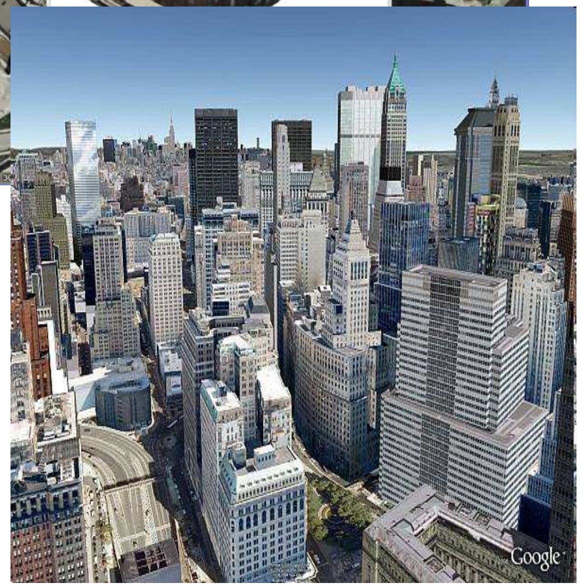
- Calculates ray paths from transmitters to receivers
  - TOA between units
  - Jammers
  - SoA
- Calculates ray path passing through buildings
- Models signal loss from RF propagation and dB/meter propagation loss in Building



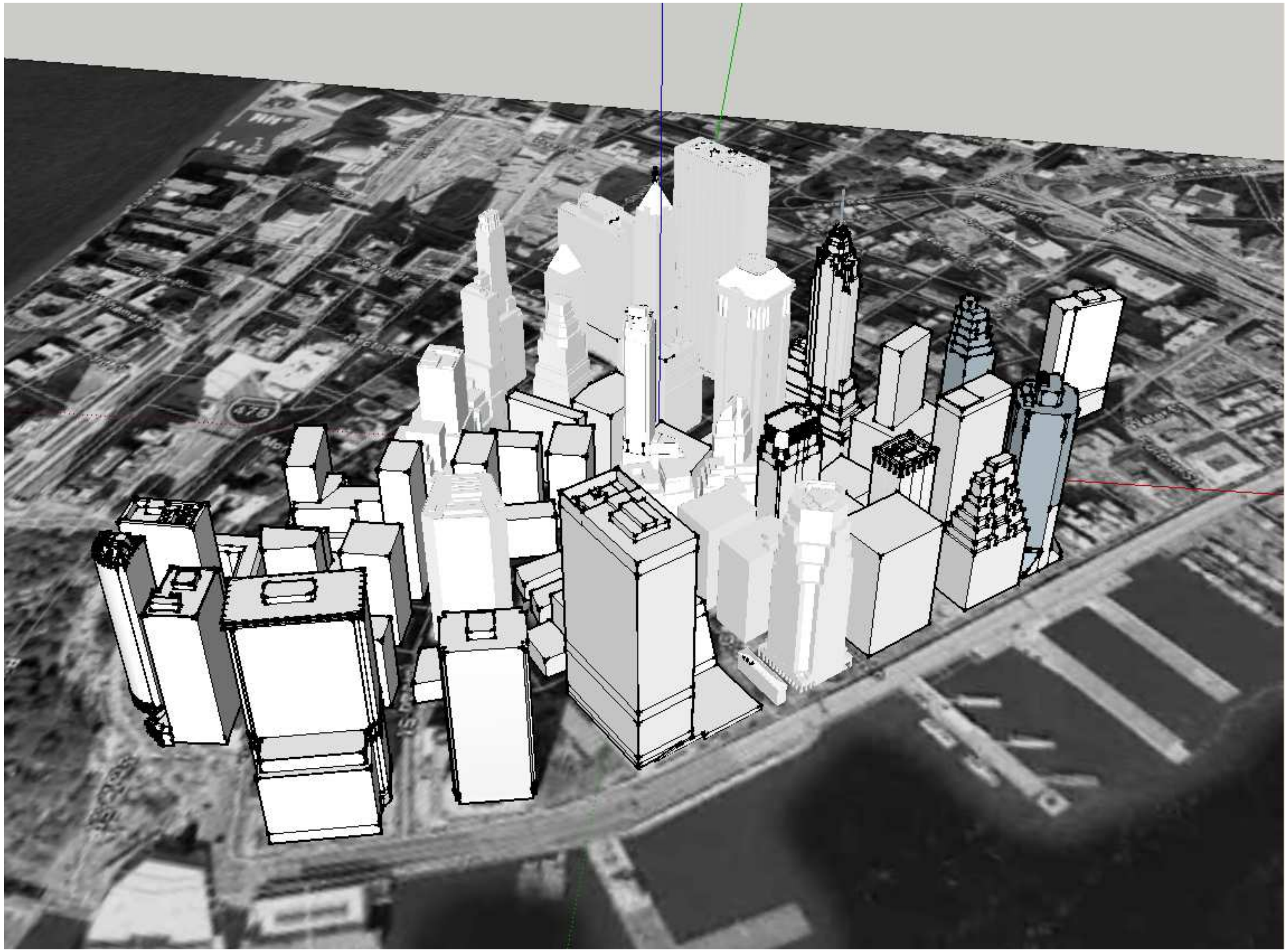
GDAP 3D Models

- GDAP simulates urban environment using Google 3D model
- Building a GDAP Google Earth 3D Model:
  - 3D Warehouse includes downloadable city models
  - Sketch-Up exports into 3D model file
  - Matlab reads as shape file for GDAP simulation
  - GDAP user paths entered in using Google Earth

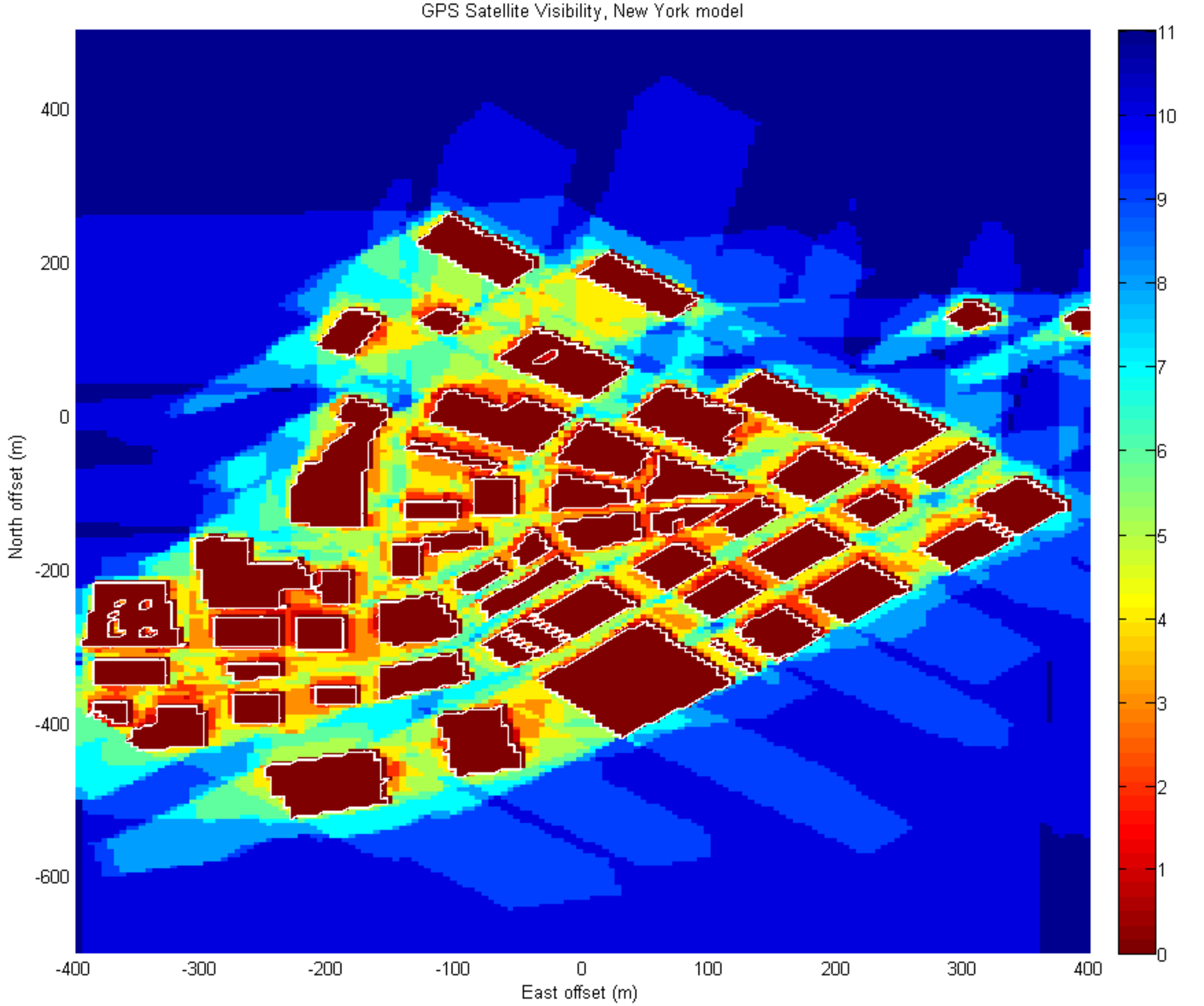




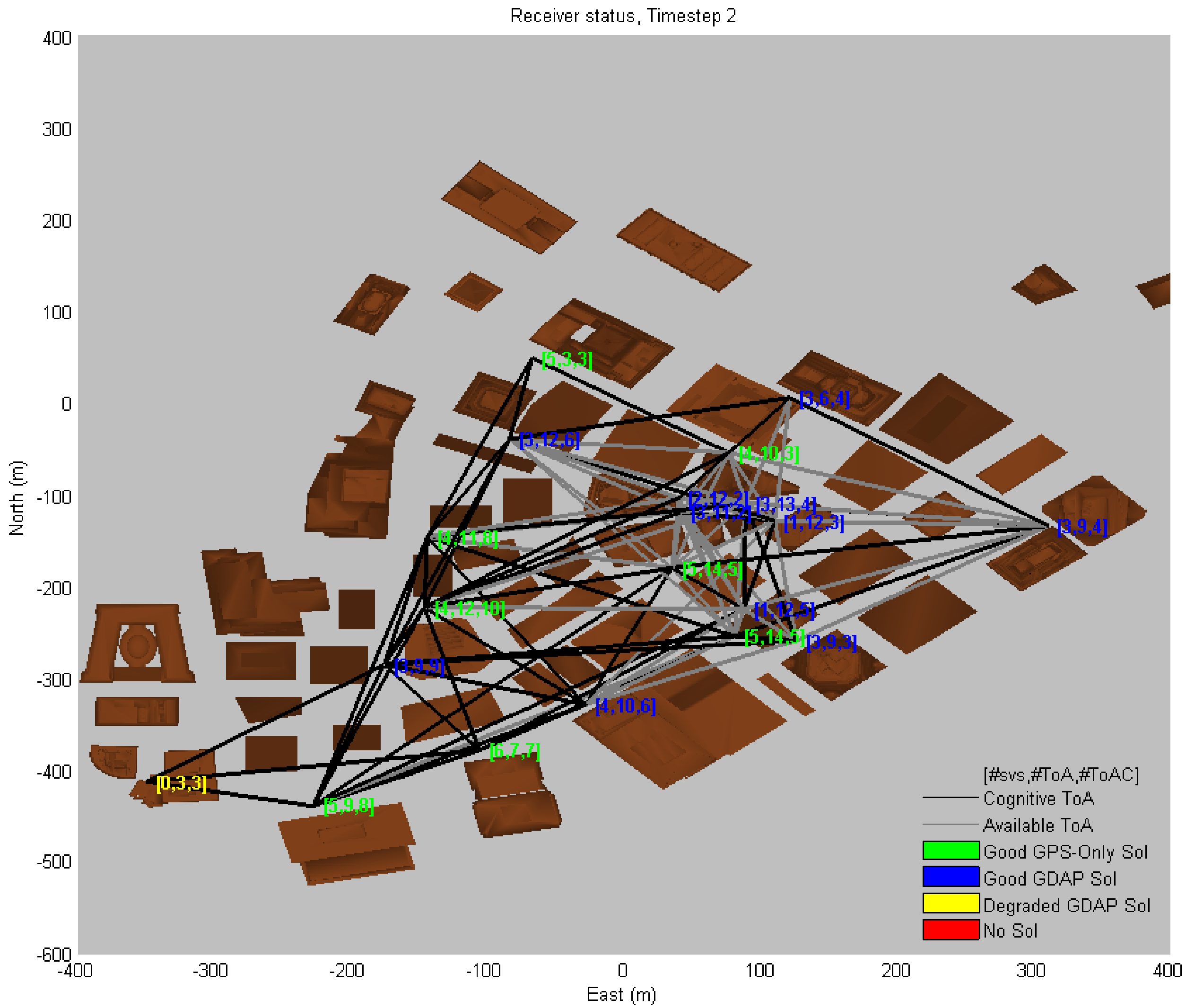
NY 3-D Model



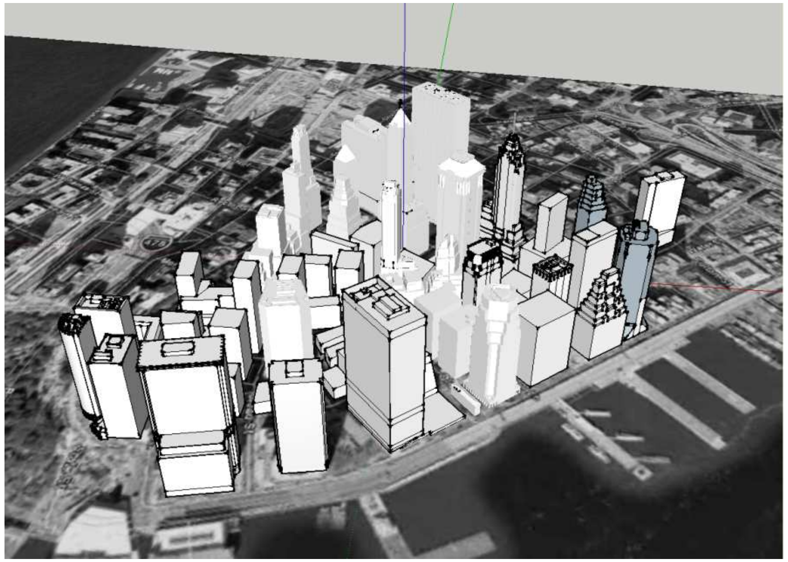
New York Satellite Visibility

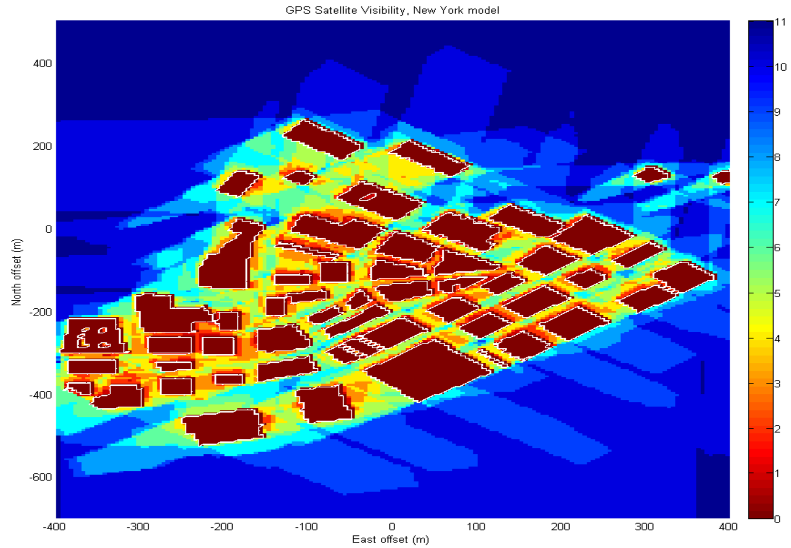


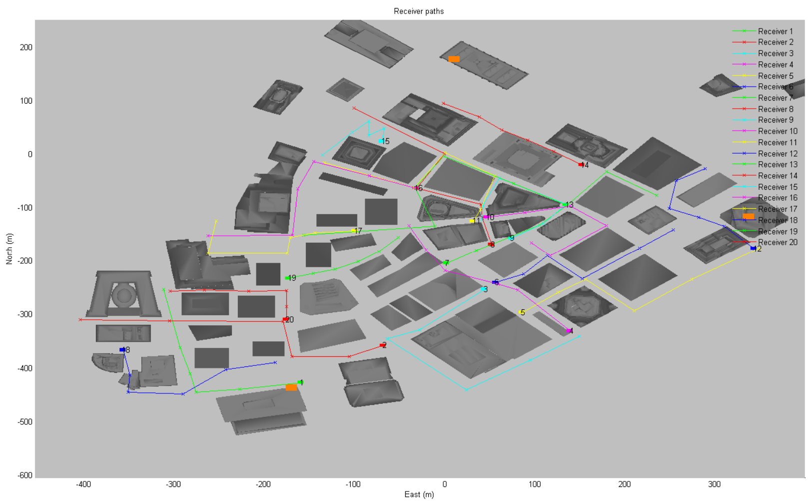
NY GDAP Results

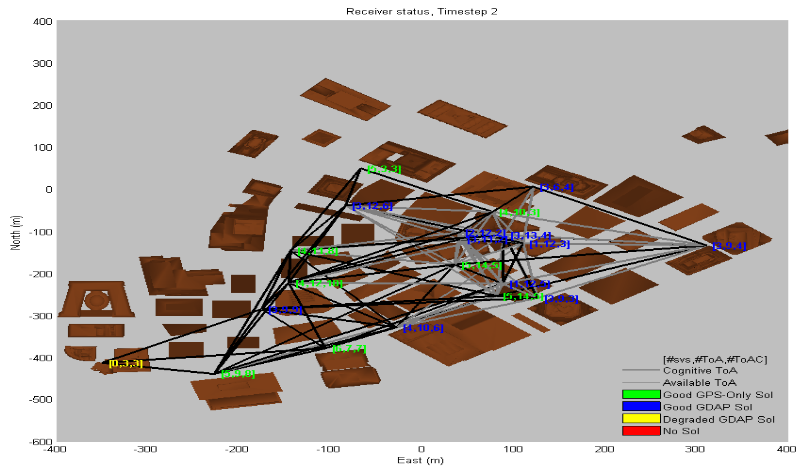


NY Simulation Example

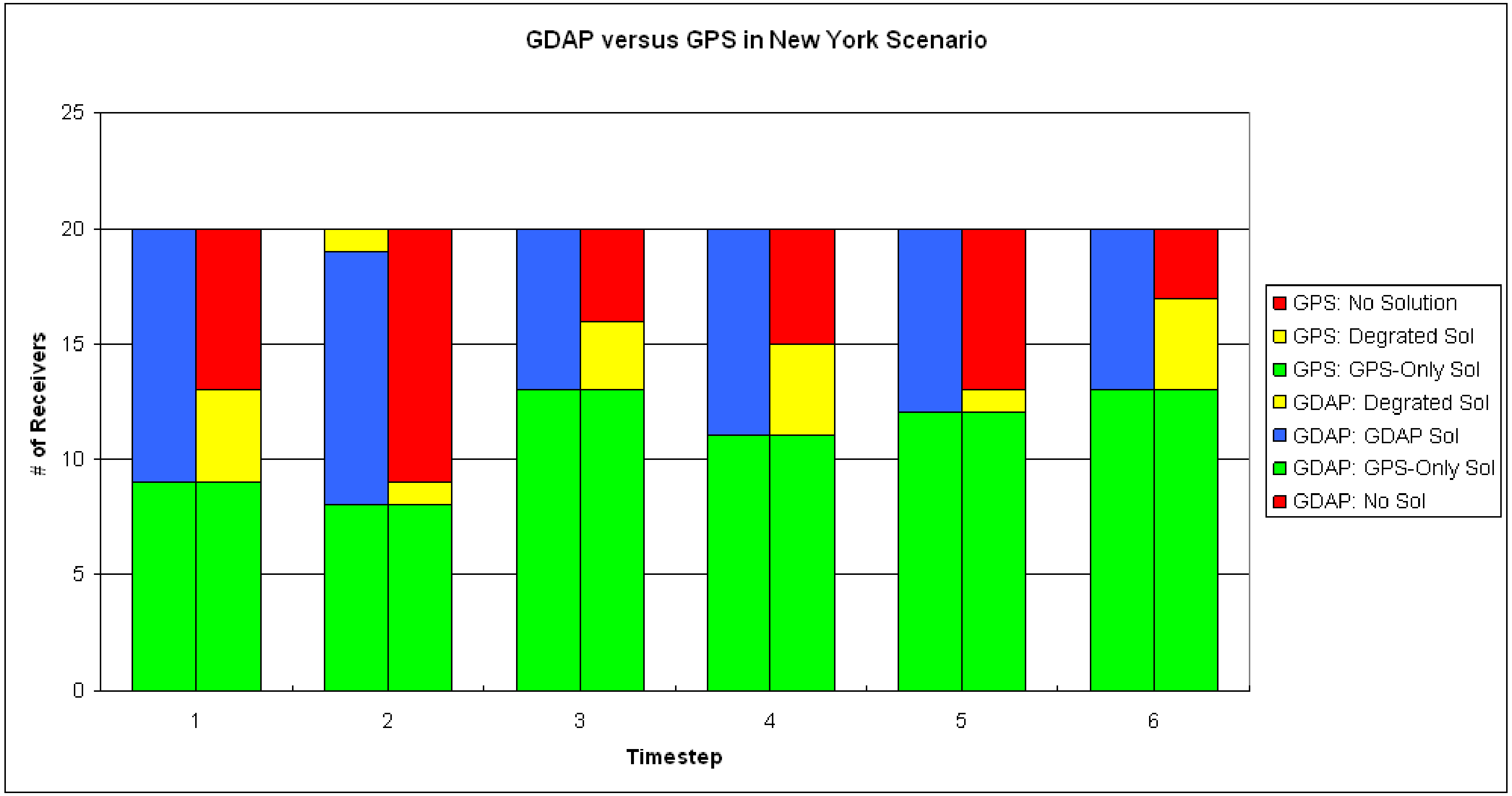






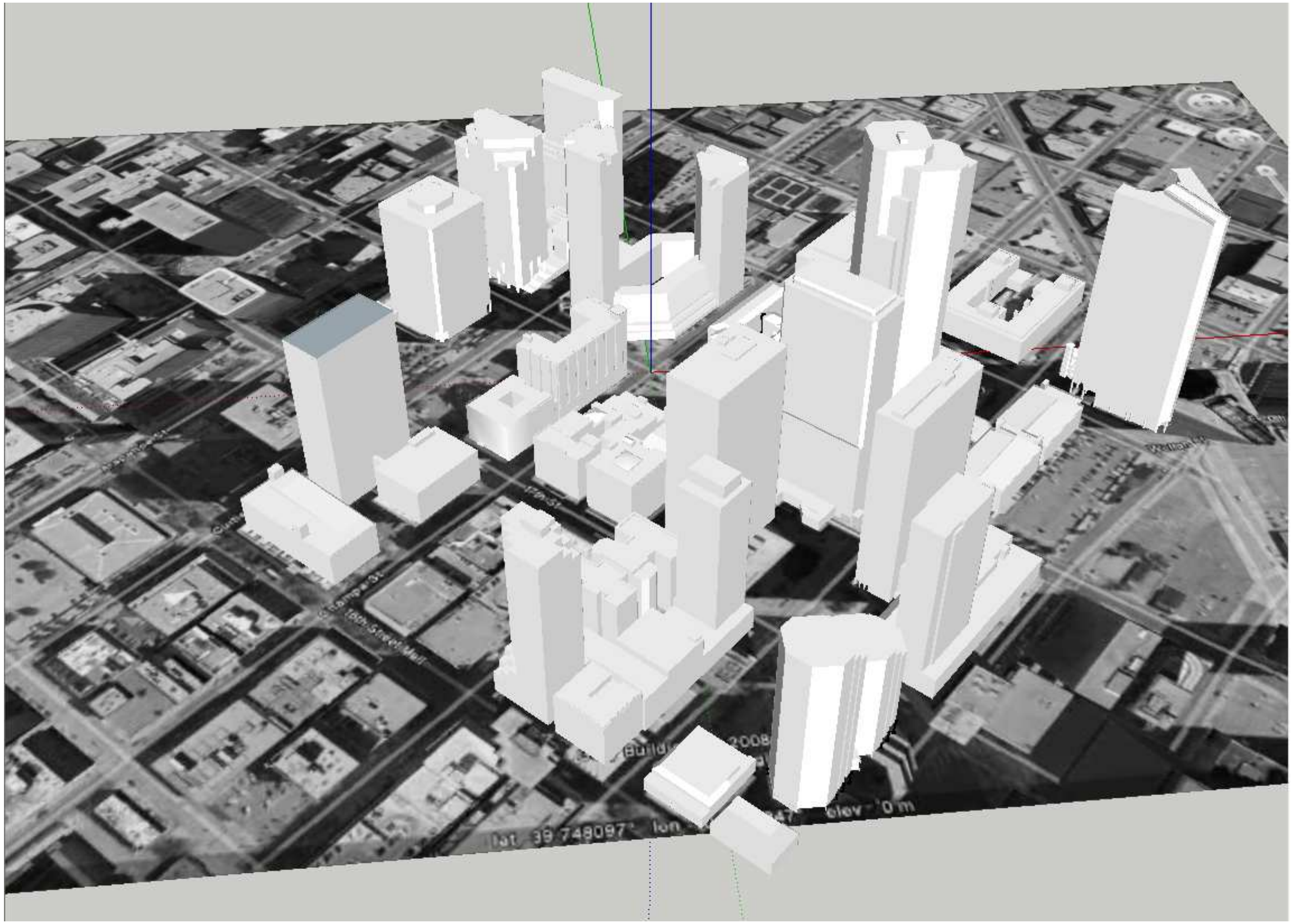


NY Performance

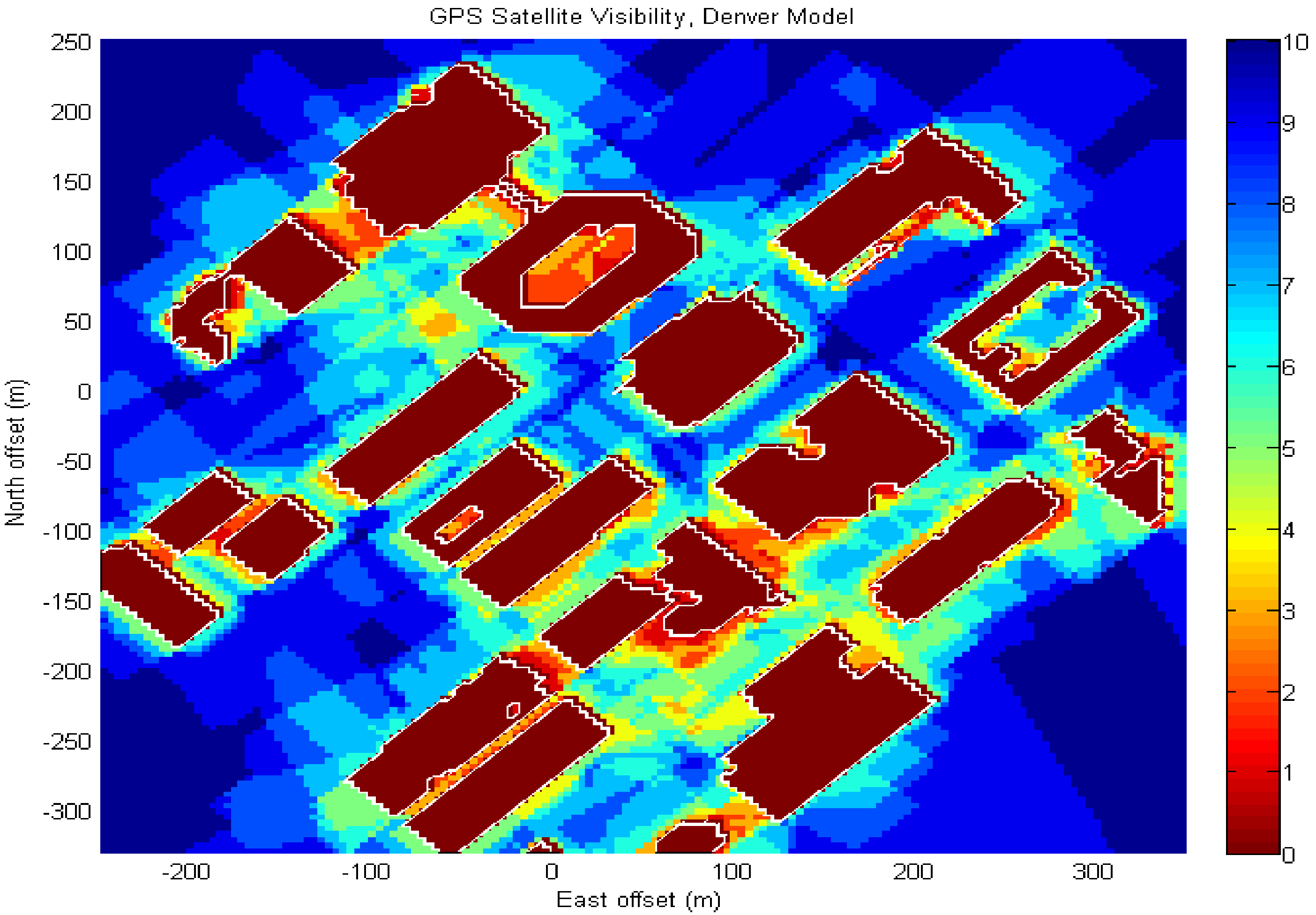


- For each time step, GDAP on left, GPS only on right
- Compare GDAP green/blue with GPS green
- No jammers

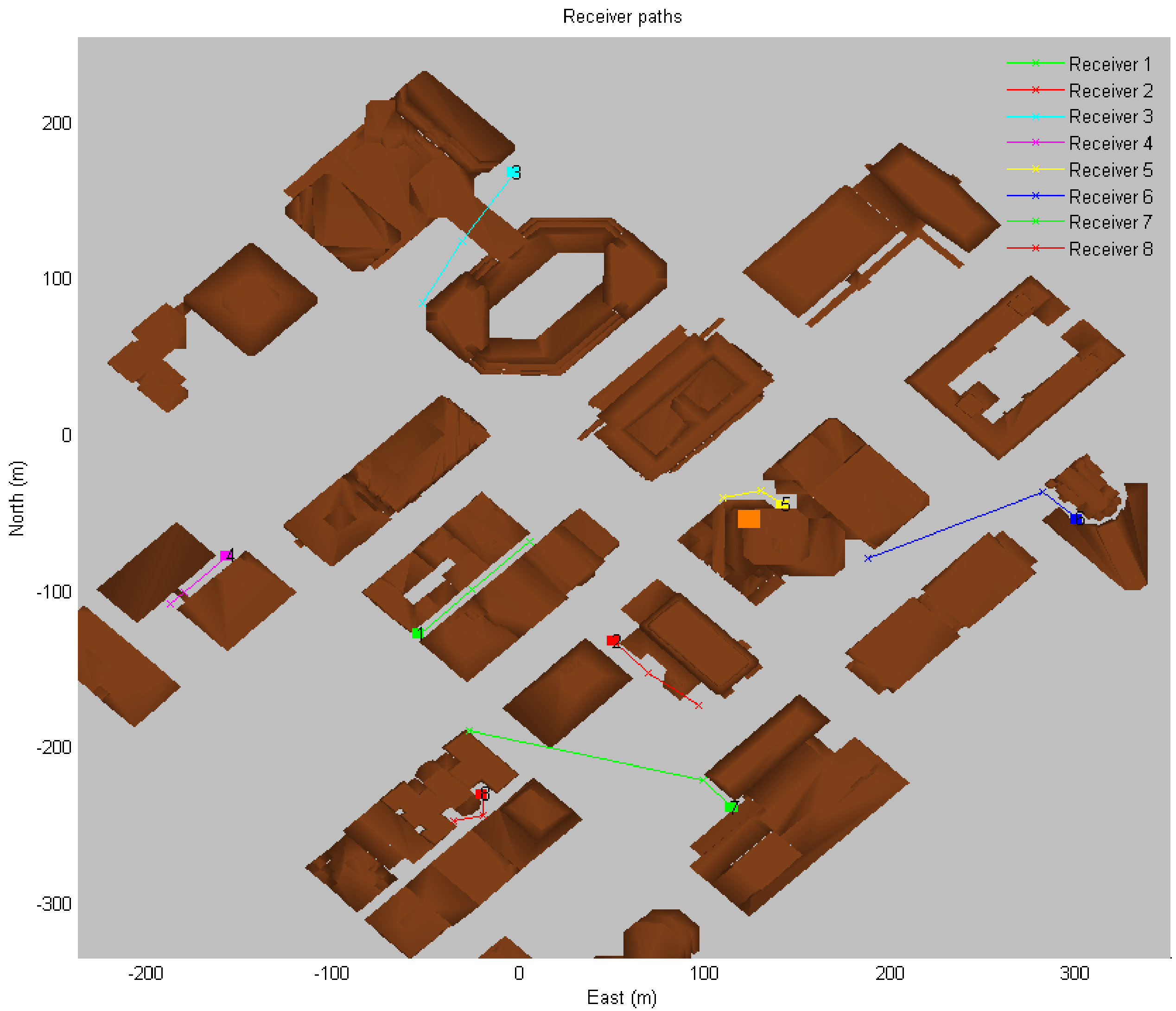
Denver 3-D Model



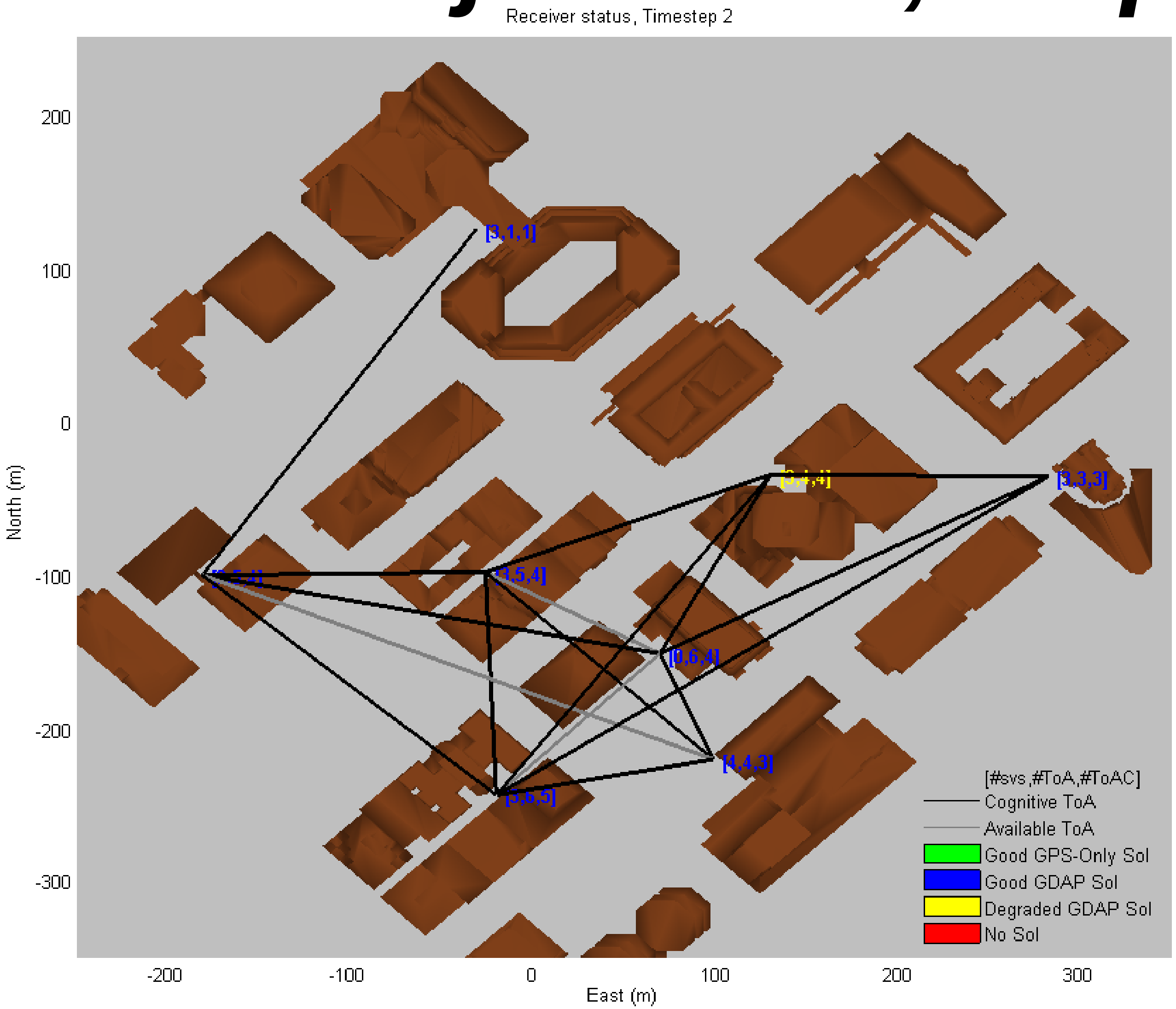
Denver GPS Visibility



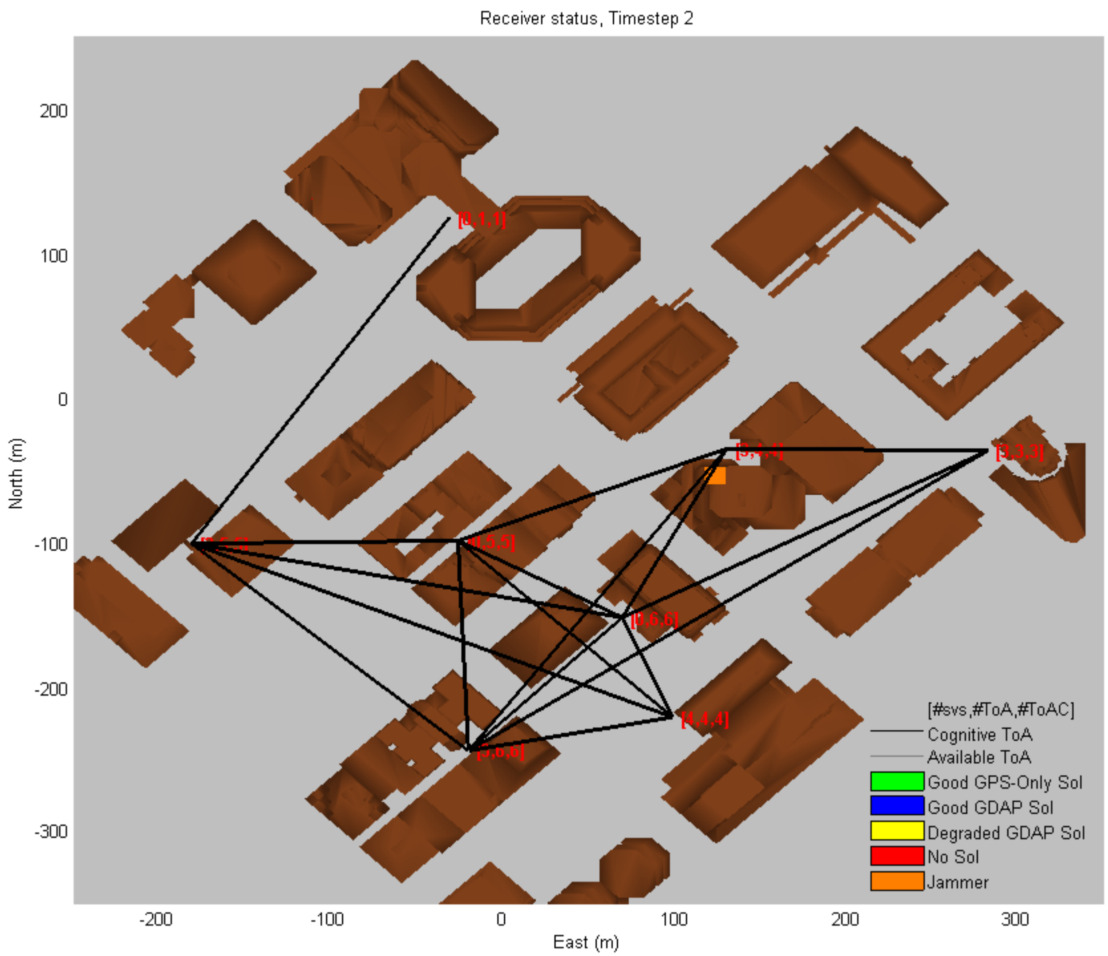
Denver Receiver Paths



Denver: no jammers, step 2

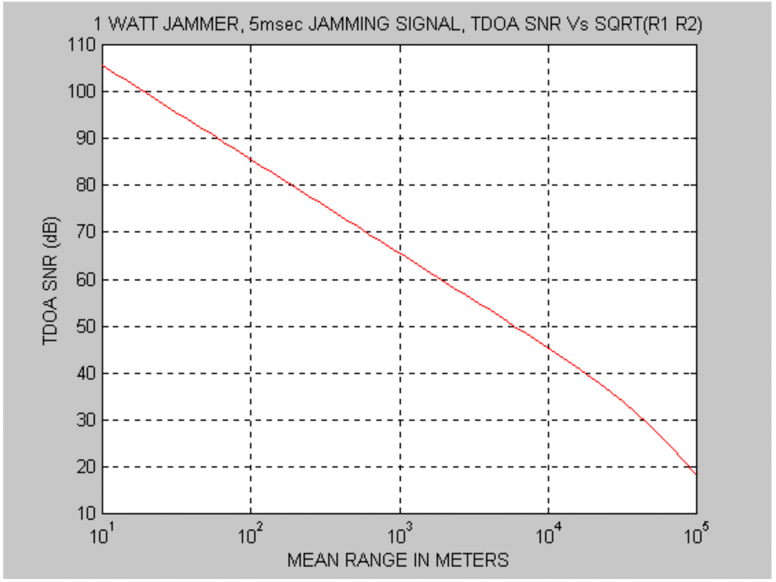


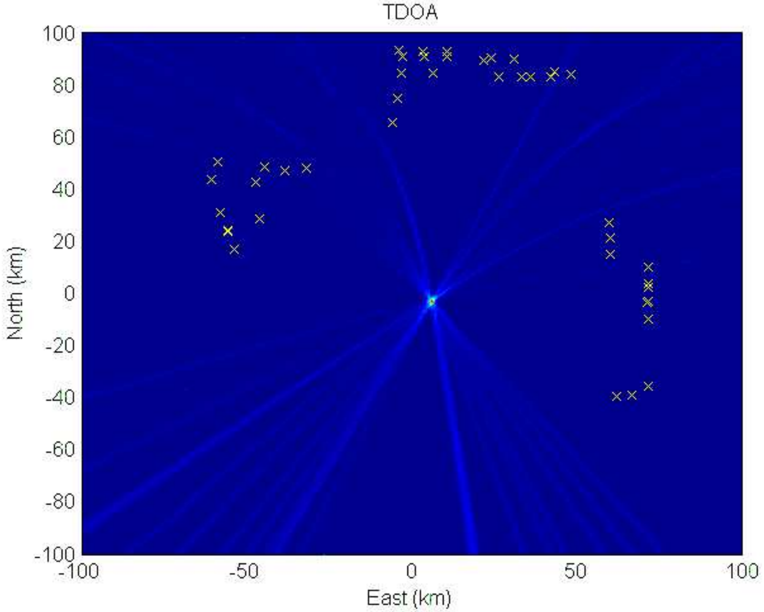
Denver with Jammer, step 2



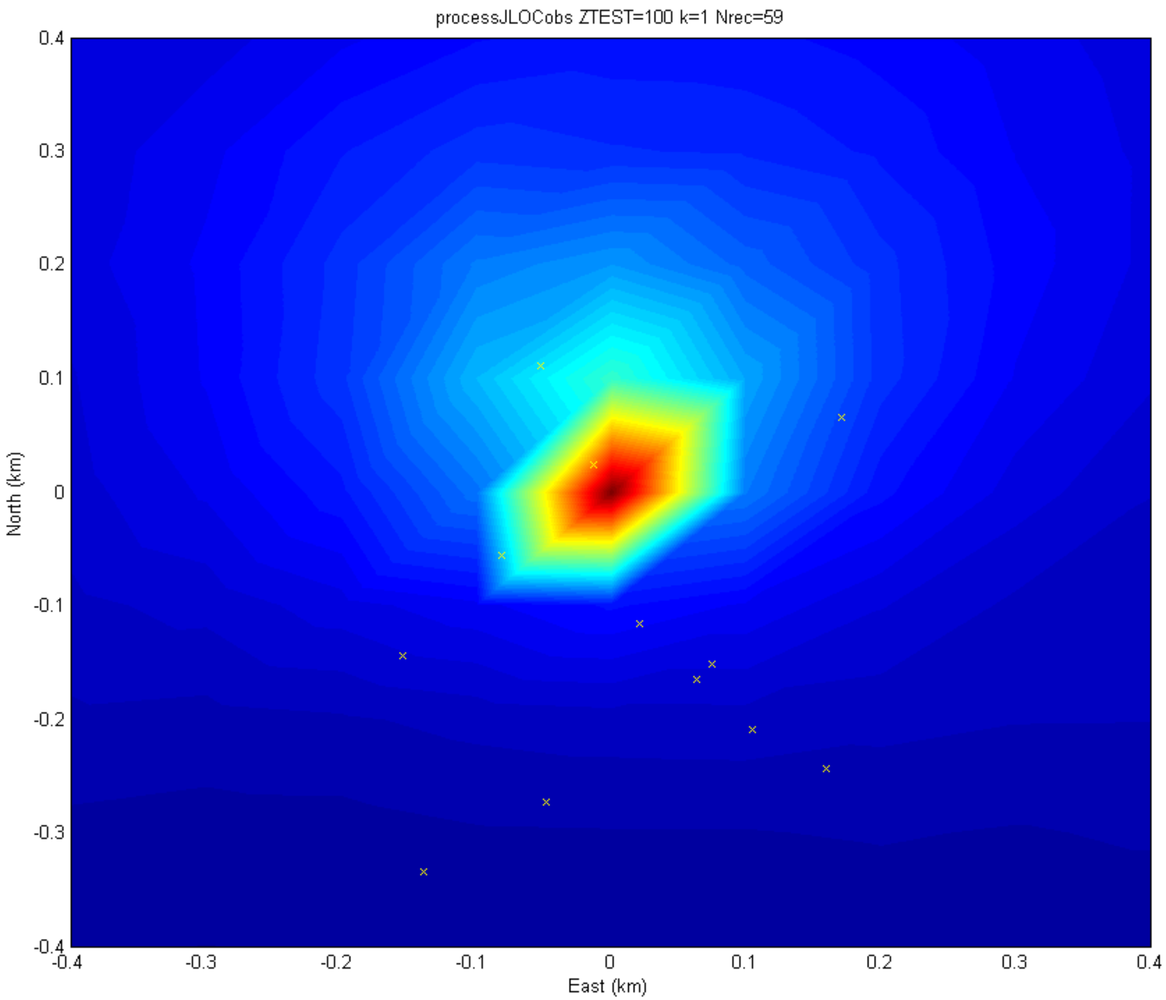
Other Ranging Signal (SoA)

- GPS Jammers: Time Difference of Arrival (TDOA) + Jammer Location (LOC)
- Television: TDOA + TV transmitter location database

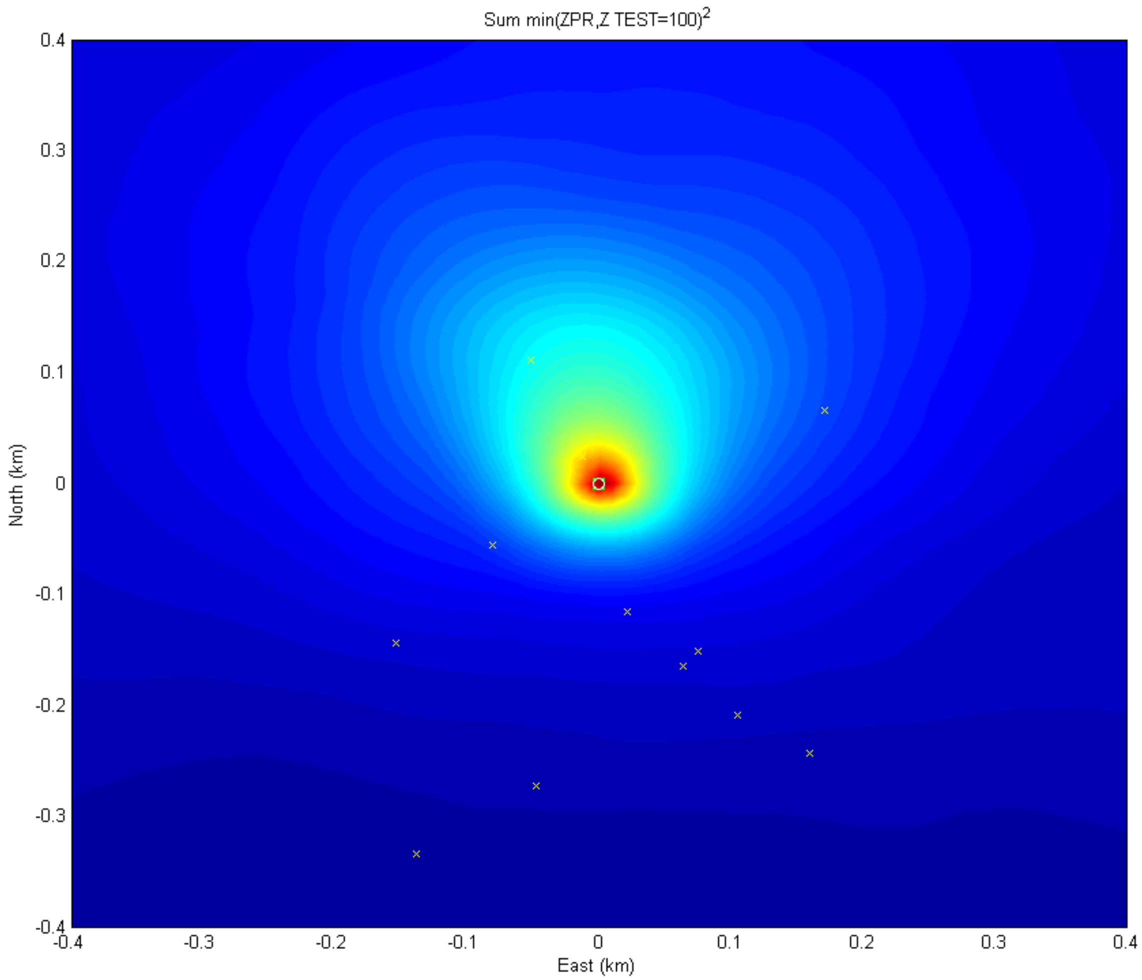




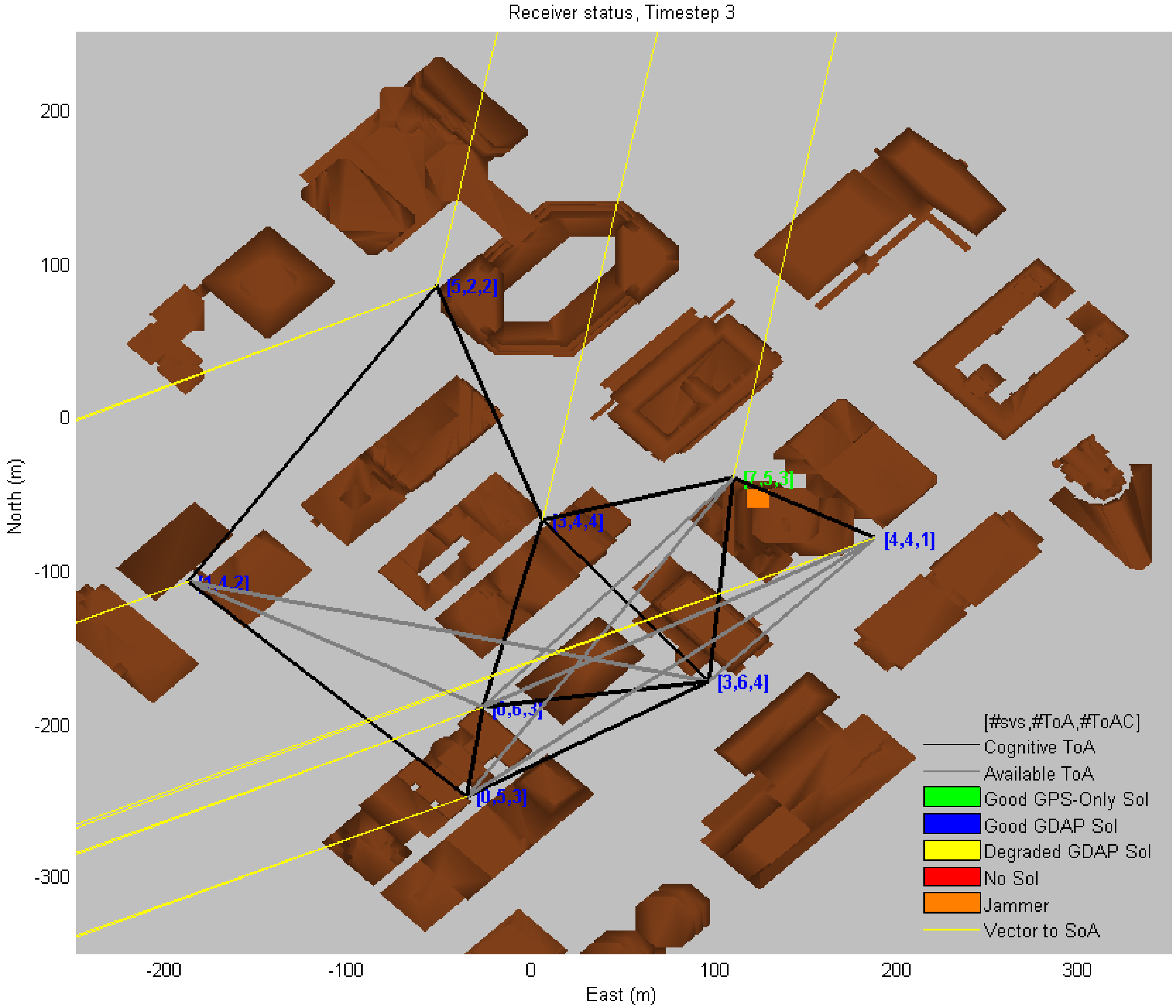
JLOC Processing Run



JLOC Processing Run with additional time steps

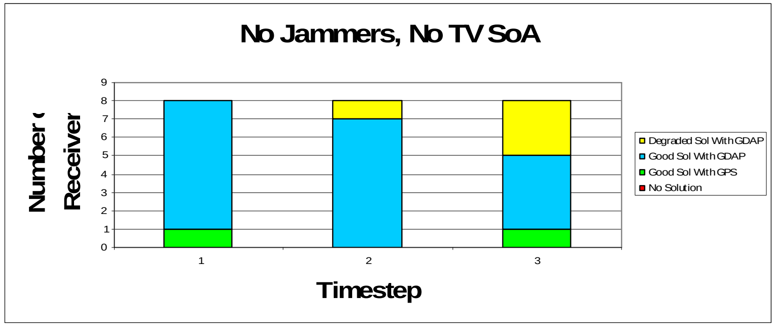


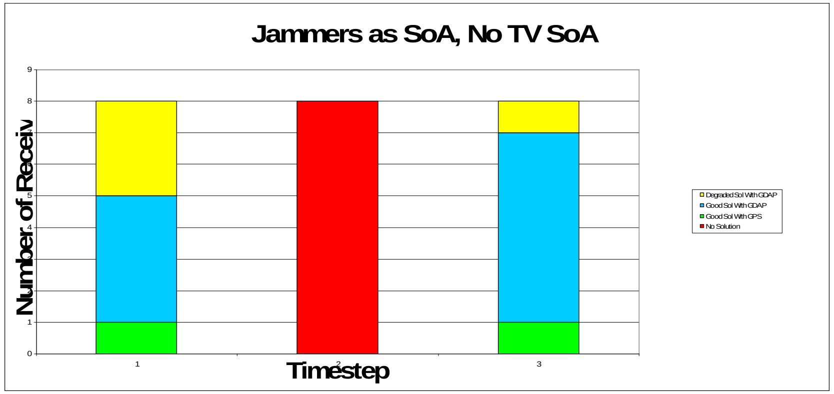
Denver with Jammer and TV SOA, step 3

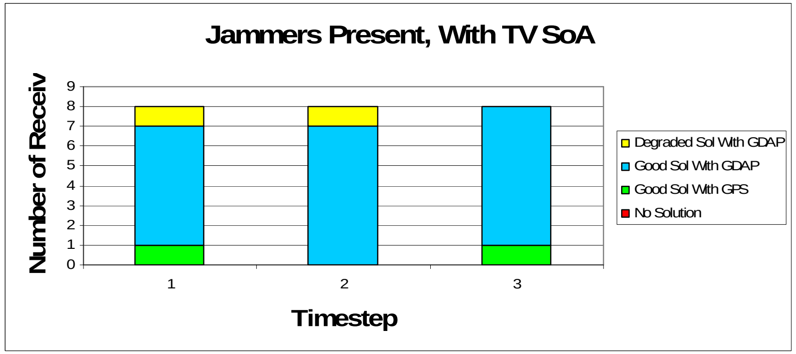


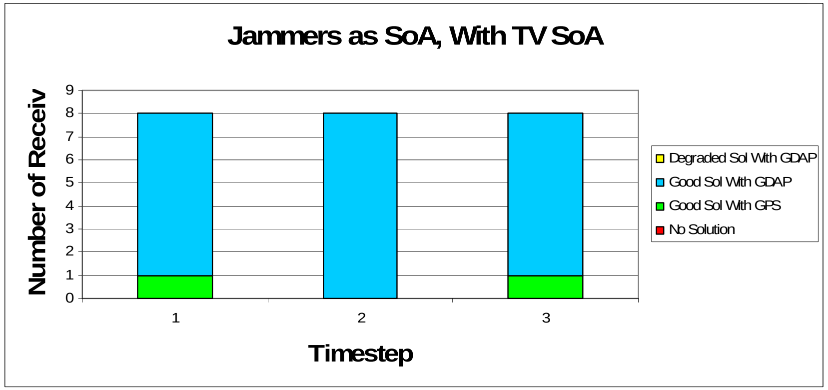
Denver Performance

• Compare GDAP (Green/Blue) with GPS only (Green)

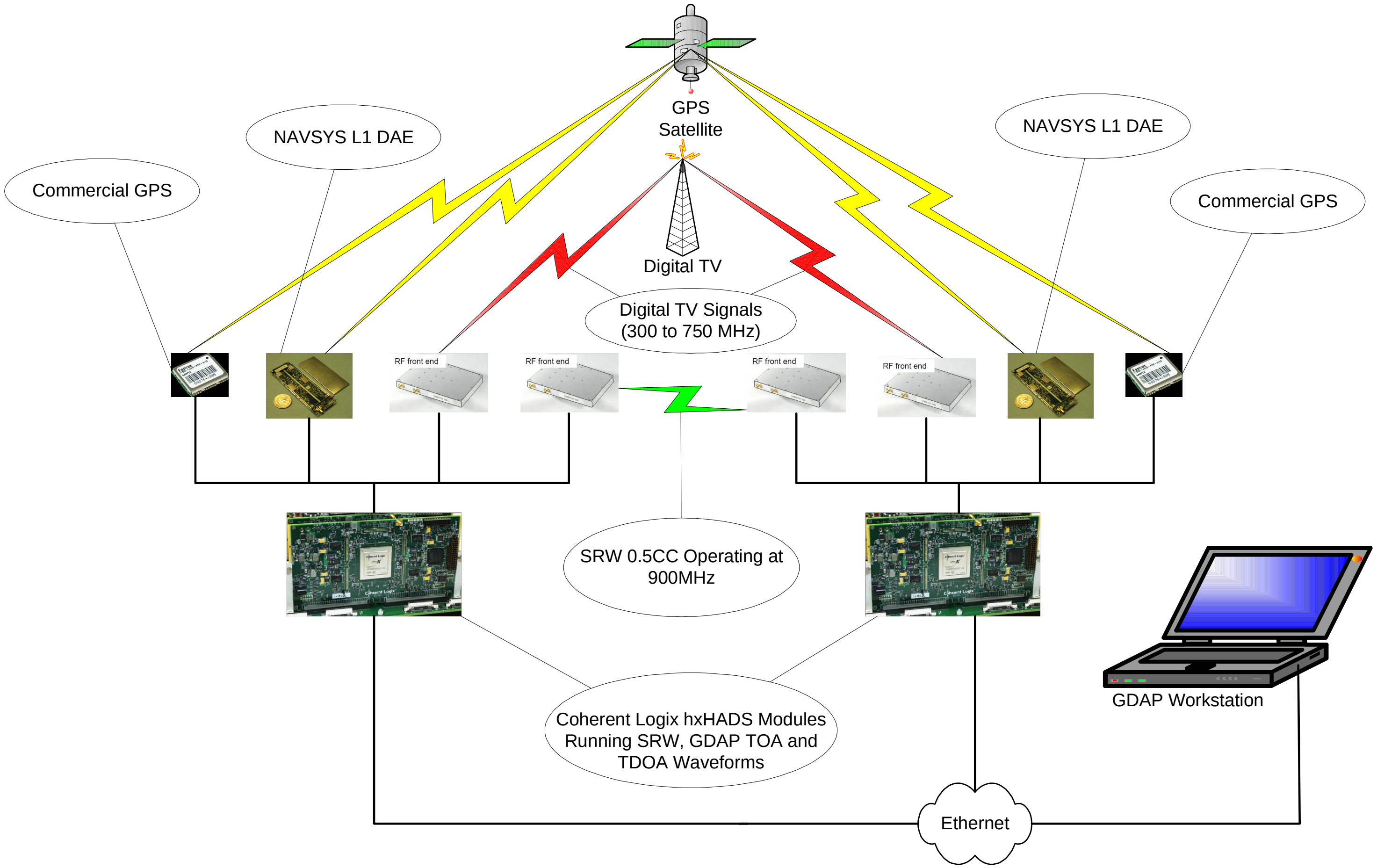








GDAP Test Bed



Conclusion

- GPS Distributed Aperture Positioning provides robust collaborative positioning in an urban environment where GPS satellite visibility is occluded
- GDAP leverages GPS + RF Ranging Network assistance to allow positioning of users in an environment where GPS is completely obstructed or denied
- GDAP urban simulation tool can be used to generate simulated scenarios in a complicated urban environment.
- Lab and field testing planned with GDAP test bed under US Army contract with DARPA SBIR funding

Back-Up

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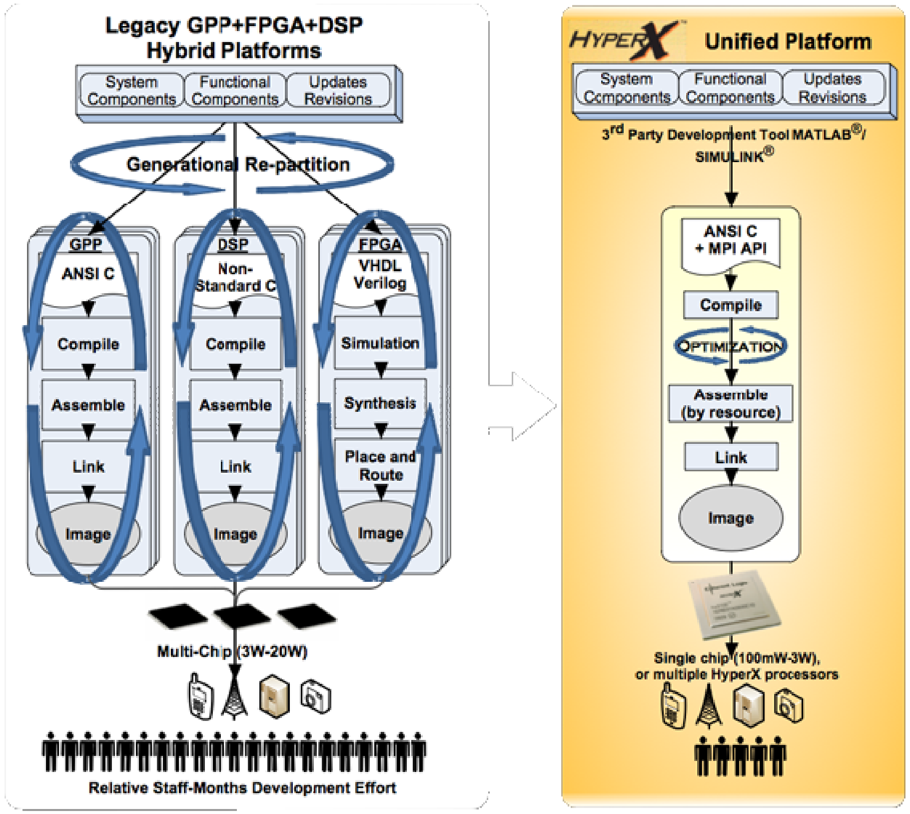
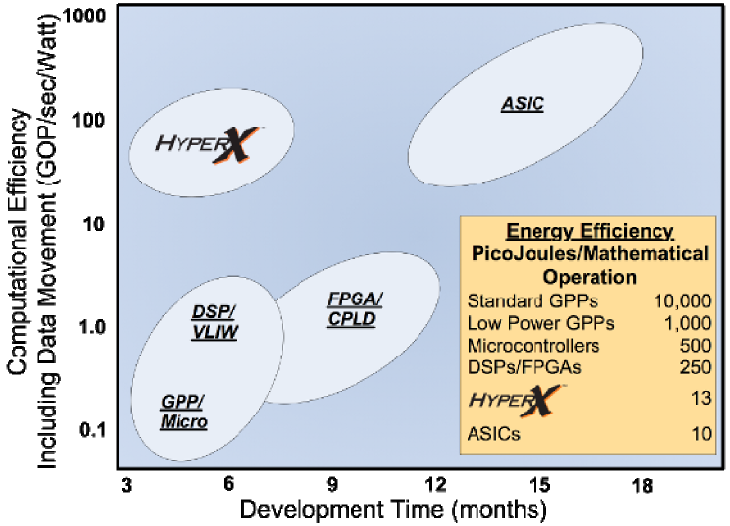
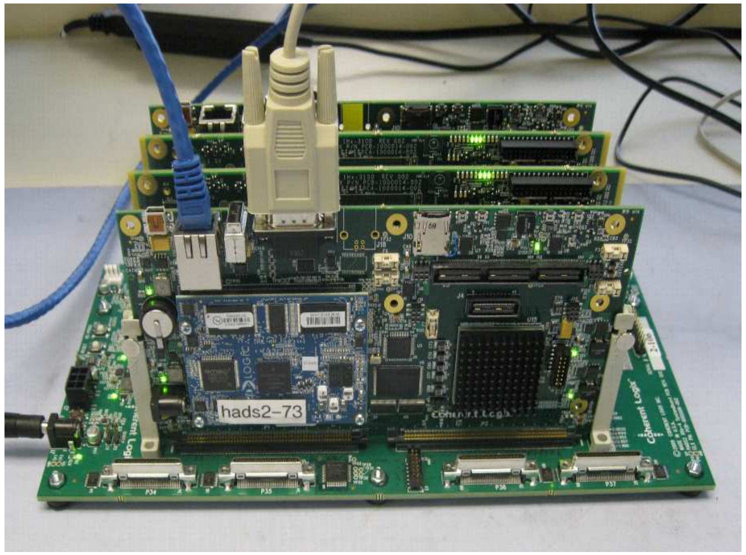
HyperX

Simplification of System Partition and Implementation

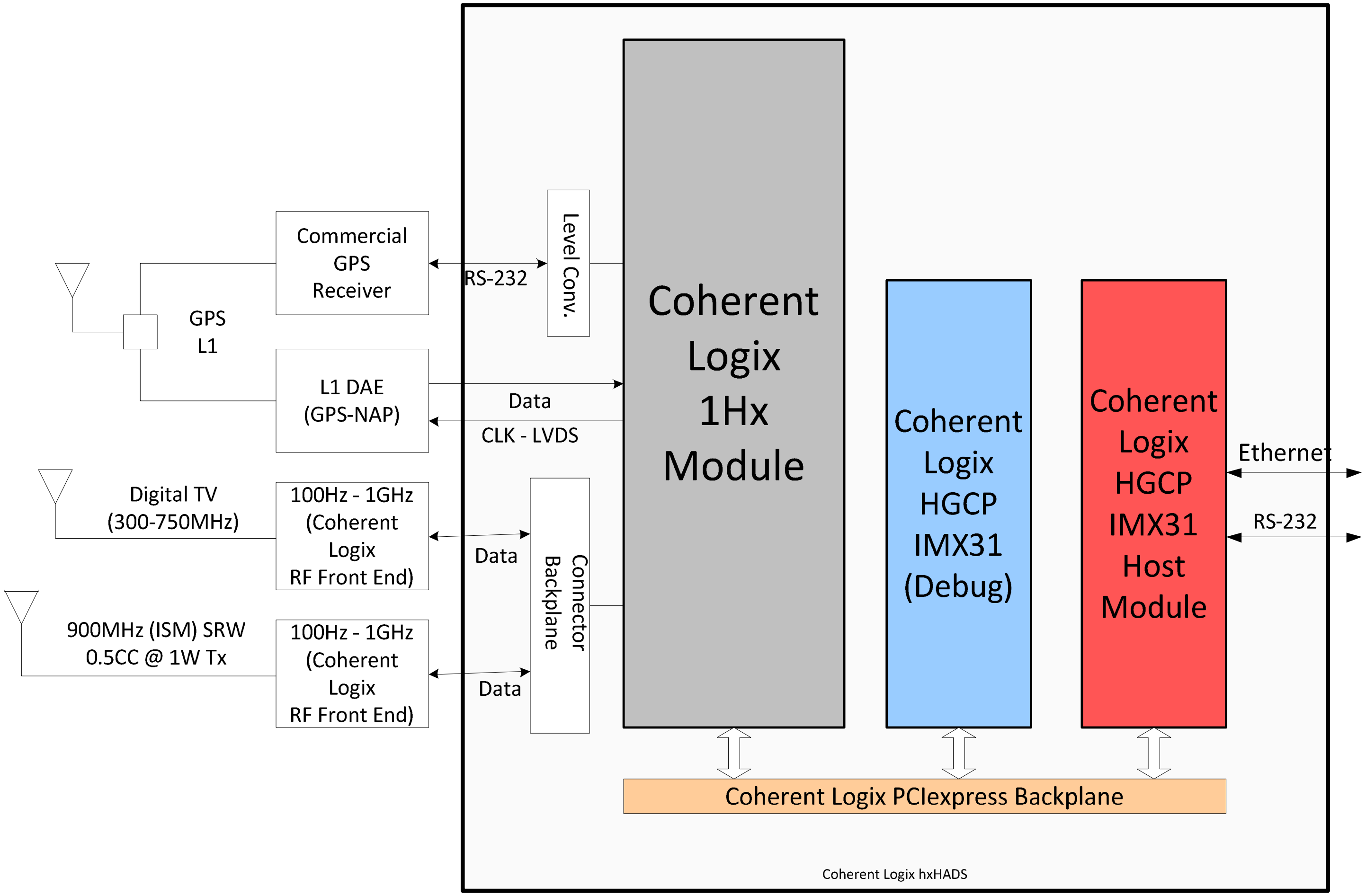


Computational Efficiency vs. Development Time





GDAP Test Bed Hardware



GDAP System Architecture