

# ***Collaborative Navigation using GPS Distributed Aperture Positioning***

Joint Navigation Conference

Session B3: Collaborative Navigation Techniques

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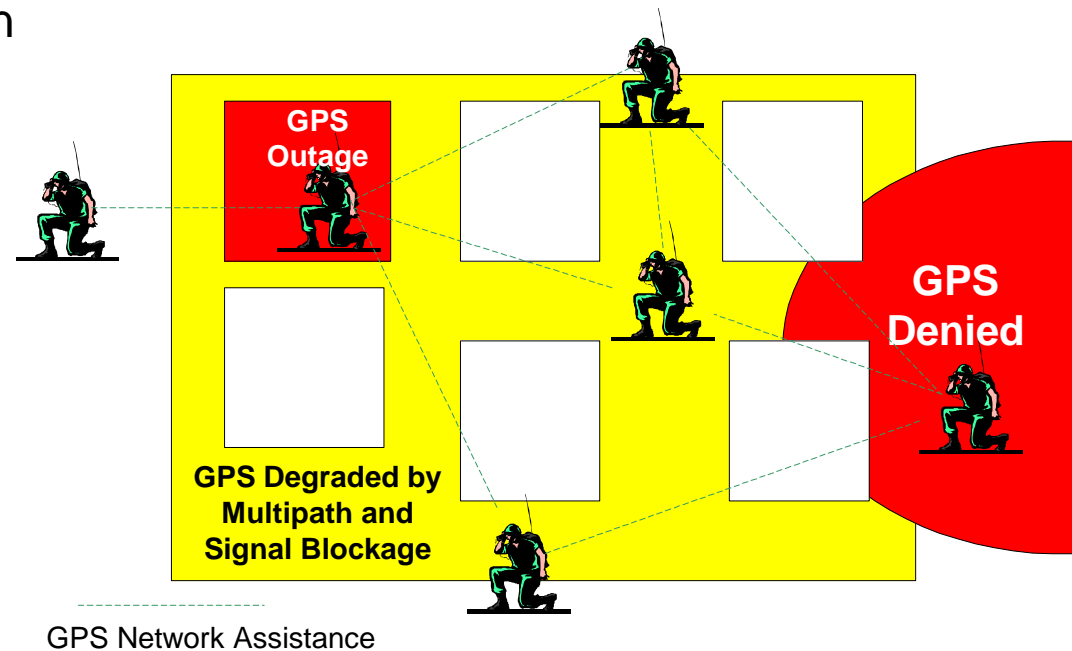
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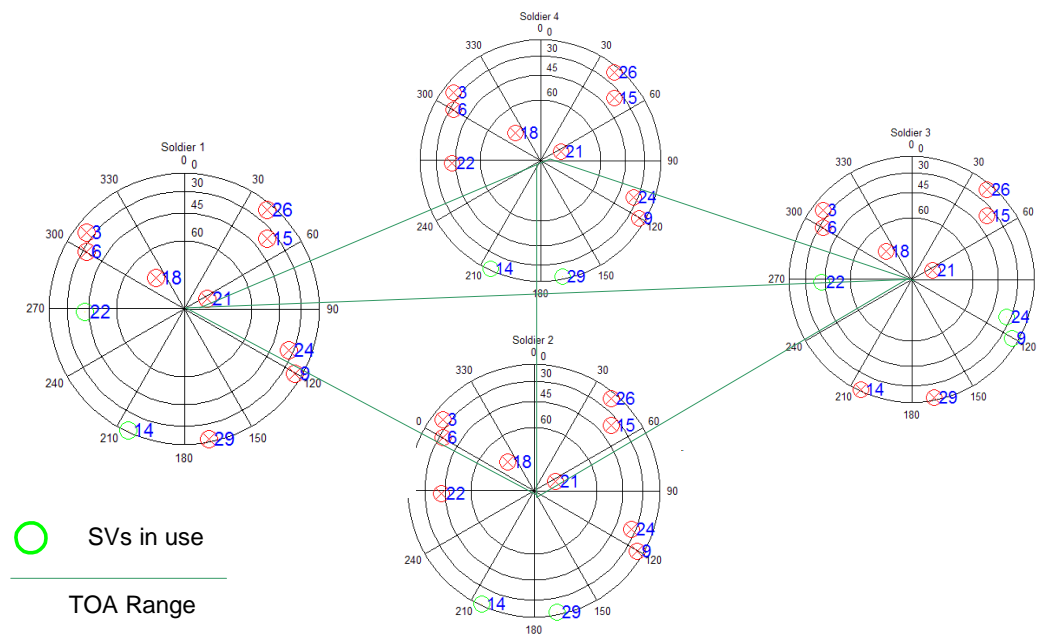
# GPS Issues to be Overcome

- 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)

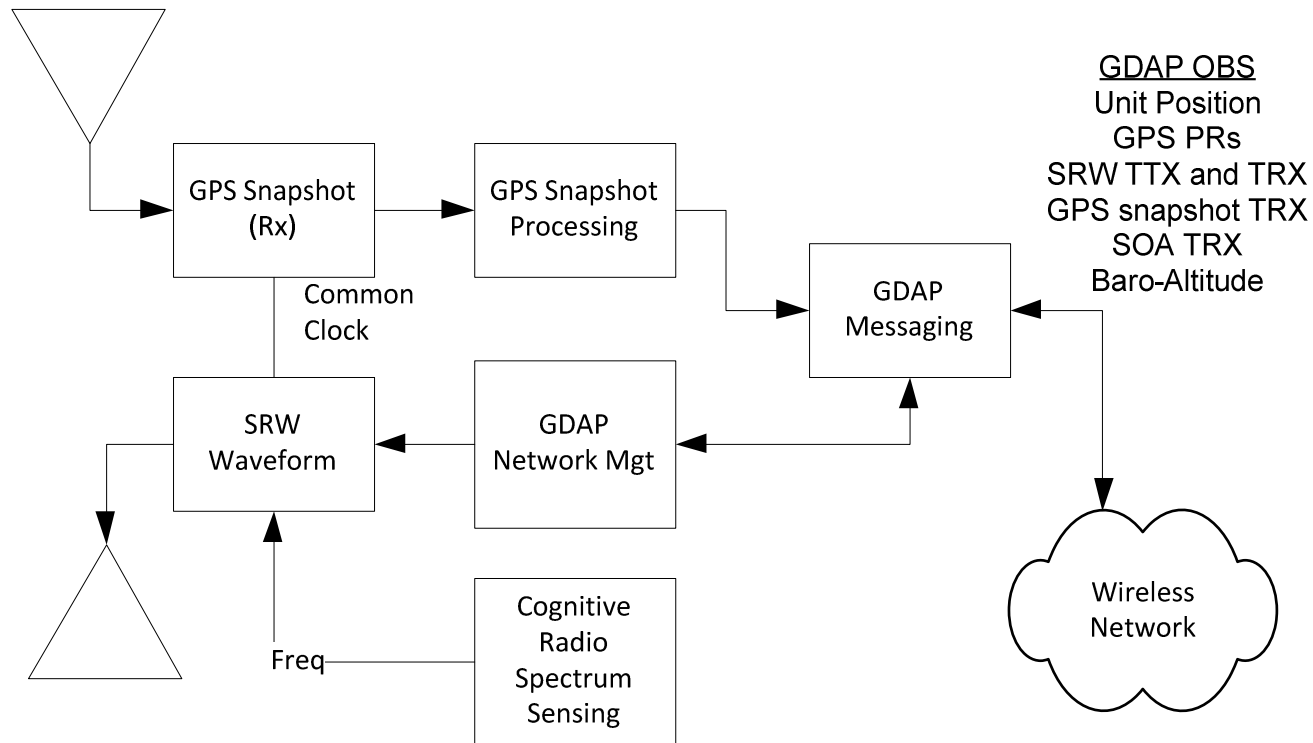


# GPS Distributed Aperture Solution

- 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”

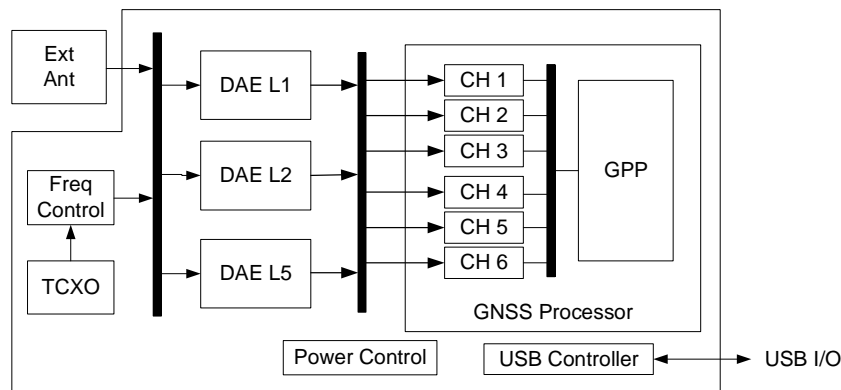


# One Way GPS/TOA with SRW Ranging

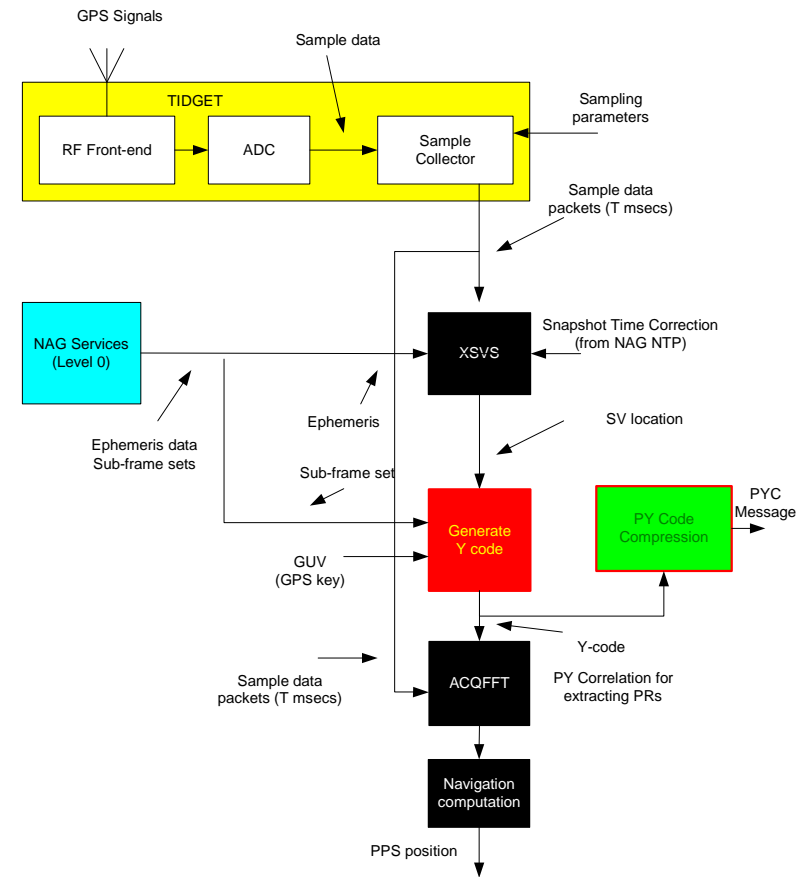


Use of common clock allows GPS time-stamping of SRW Tx signal frames for 1-way TOA ranging

# Software GPS Solution enables precise timing on

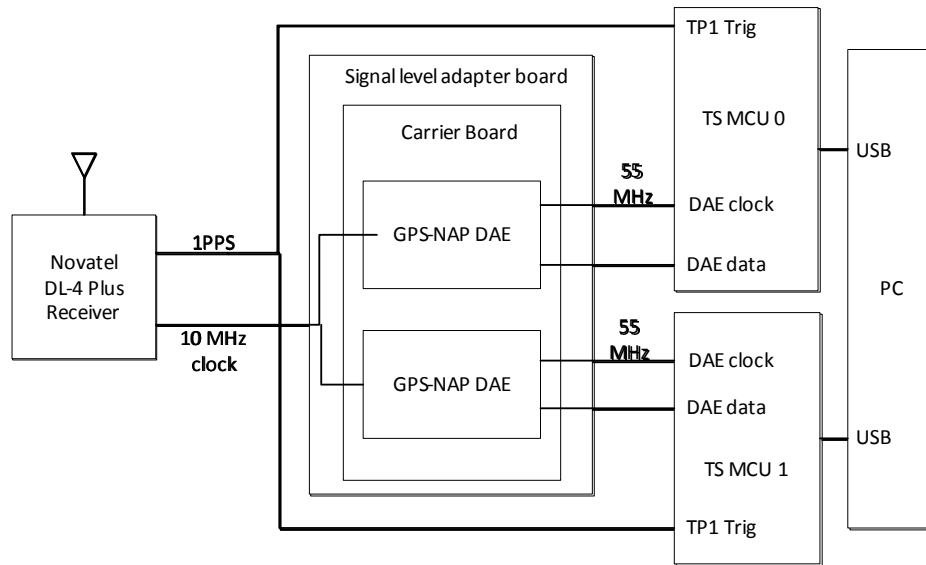


GNSSμSDR system architecture

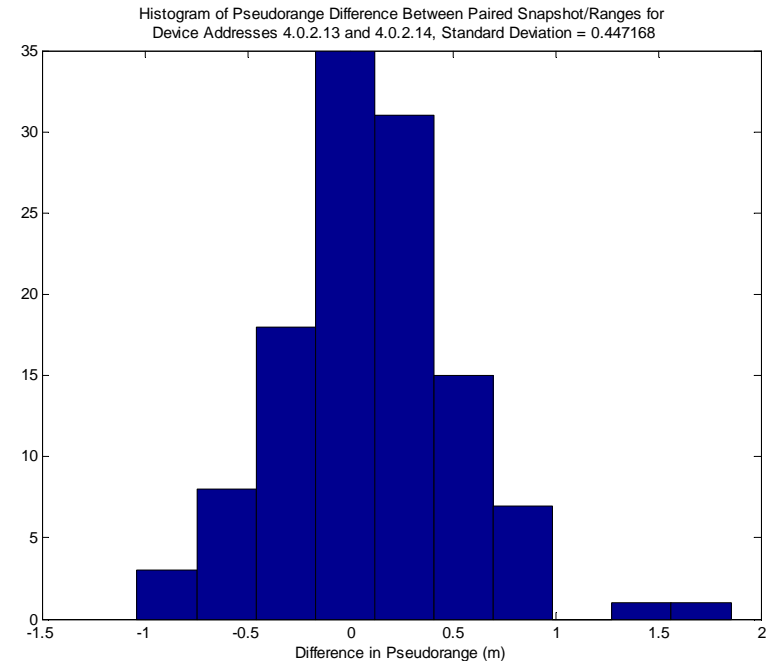


GPS-Lite Snapshot Solution

# GPS Snapshot Timing Testing



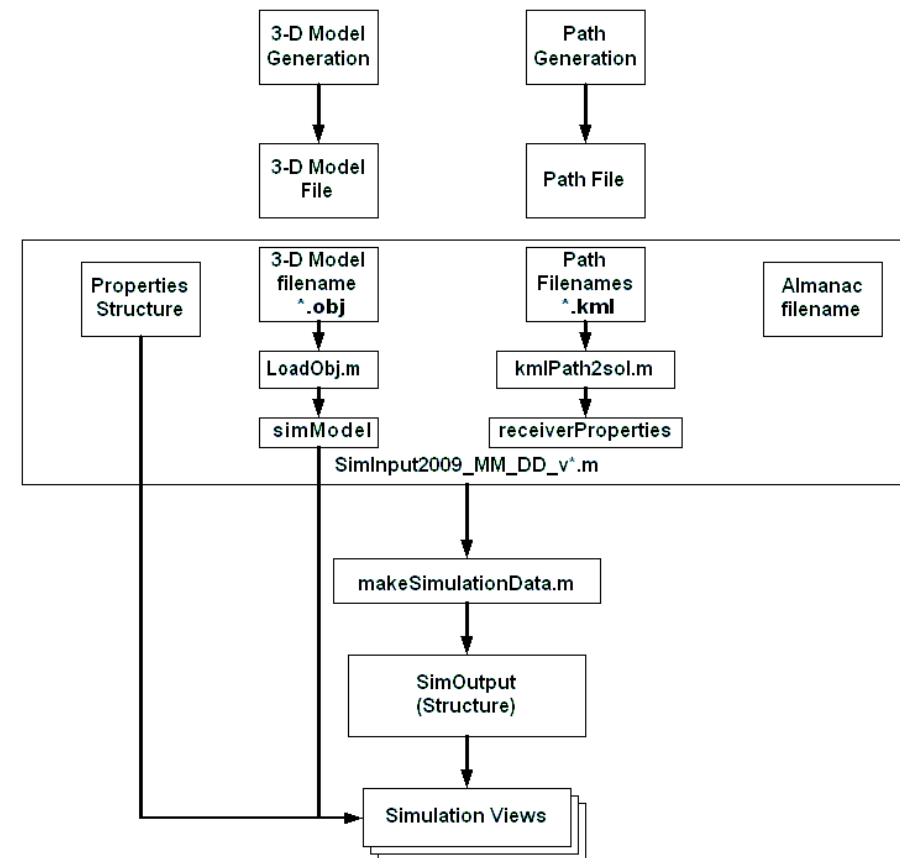
Timing Test-Bed captured snapshots from two different receivers using a common timemark



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

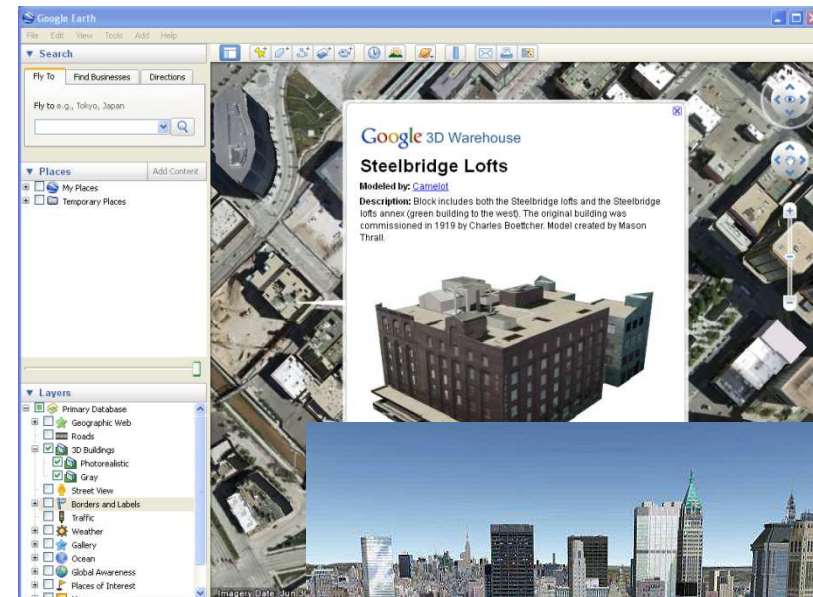
# GDAP Simulation Tool

- 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



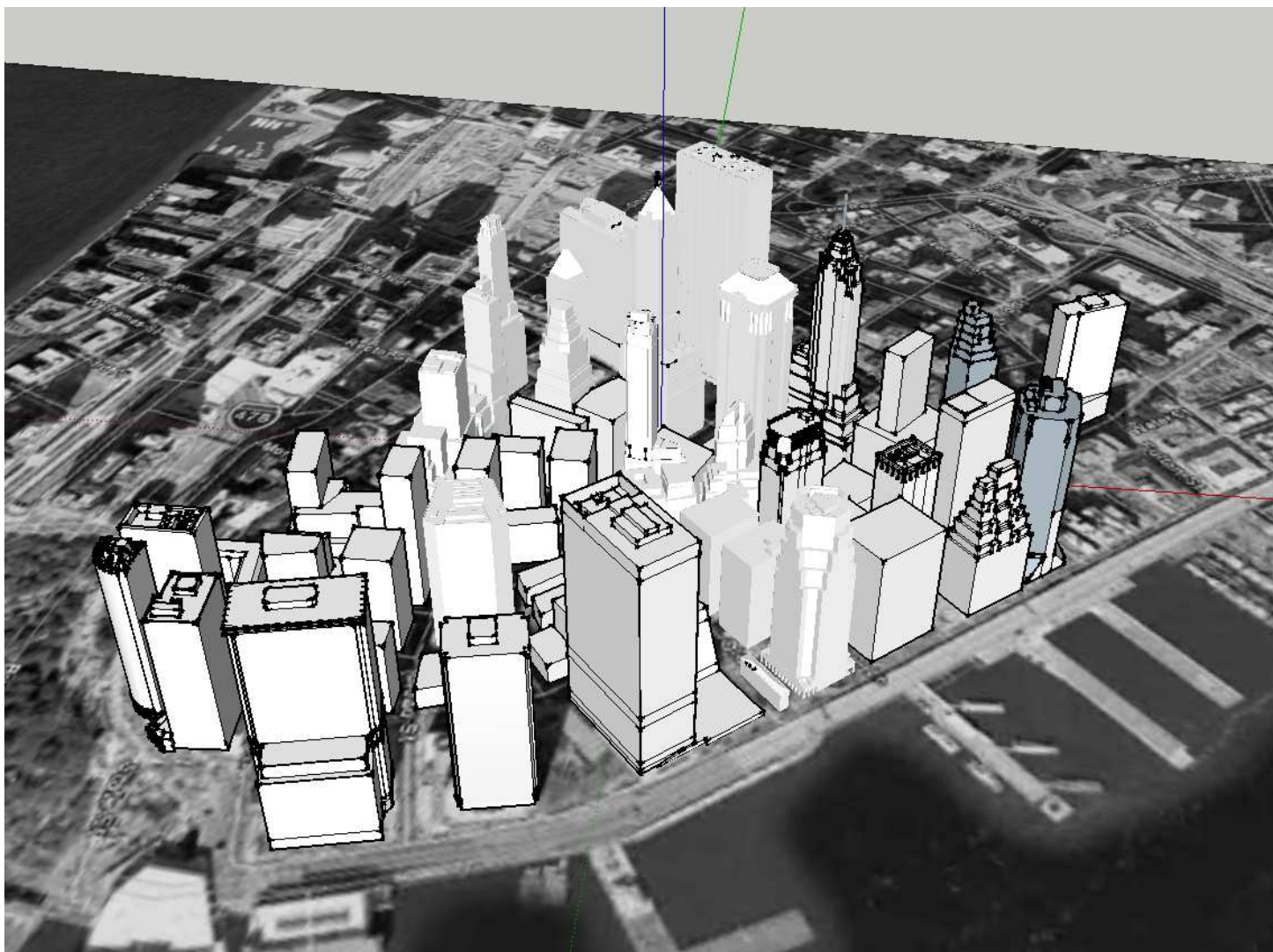
# GDAP 3D Models

- 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



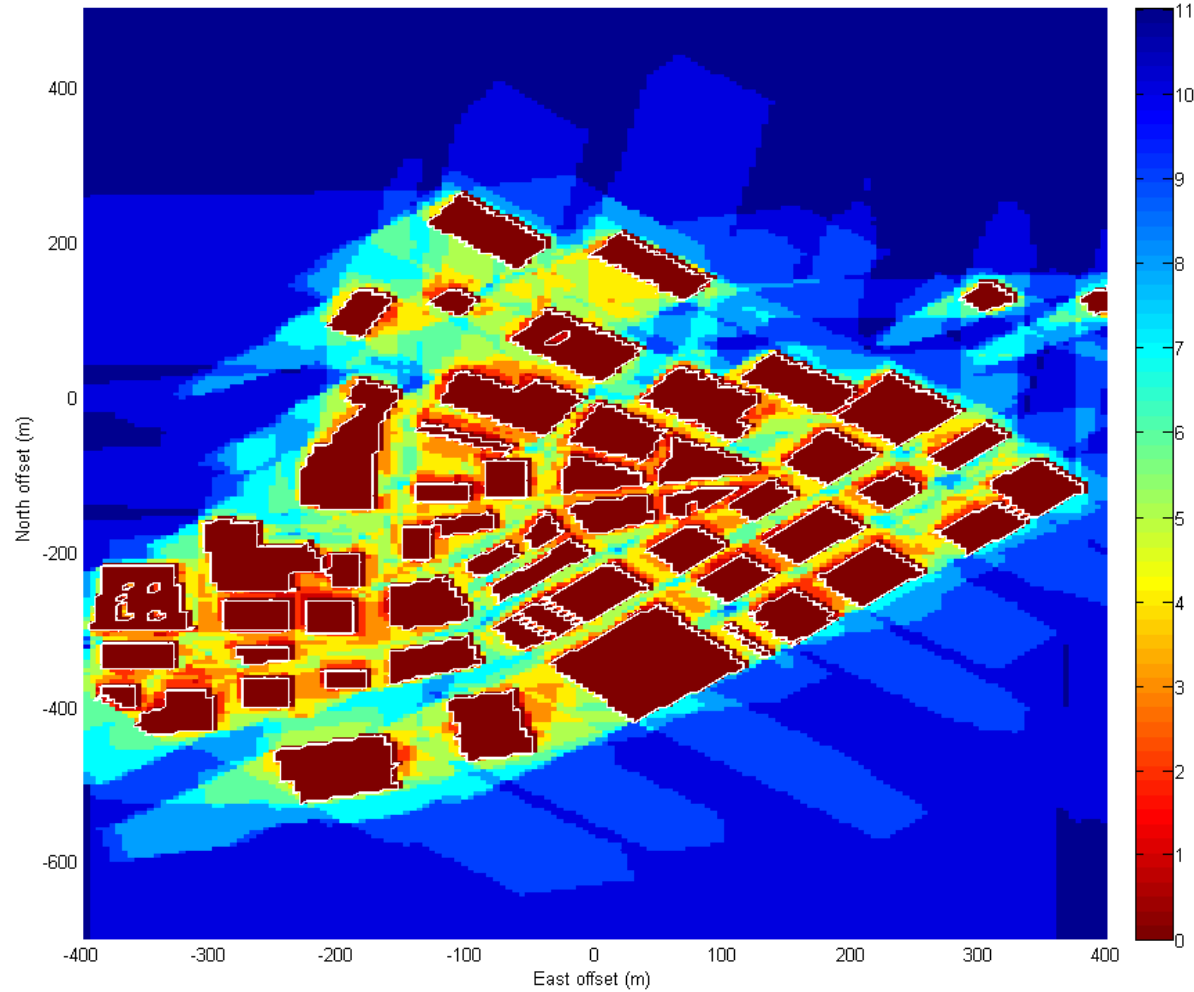


# *NY 3-D Model*

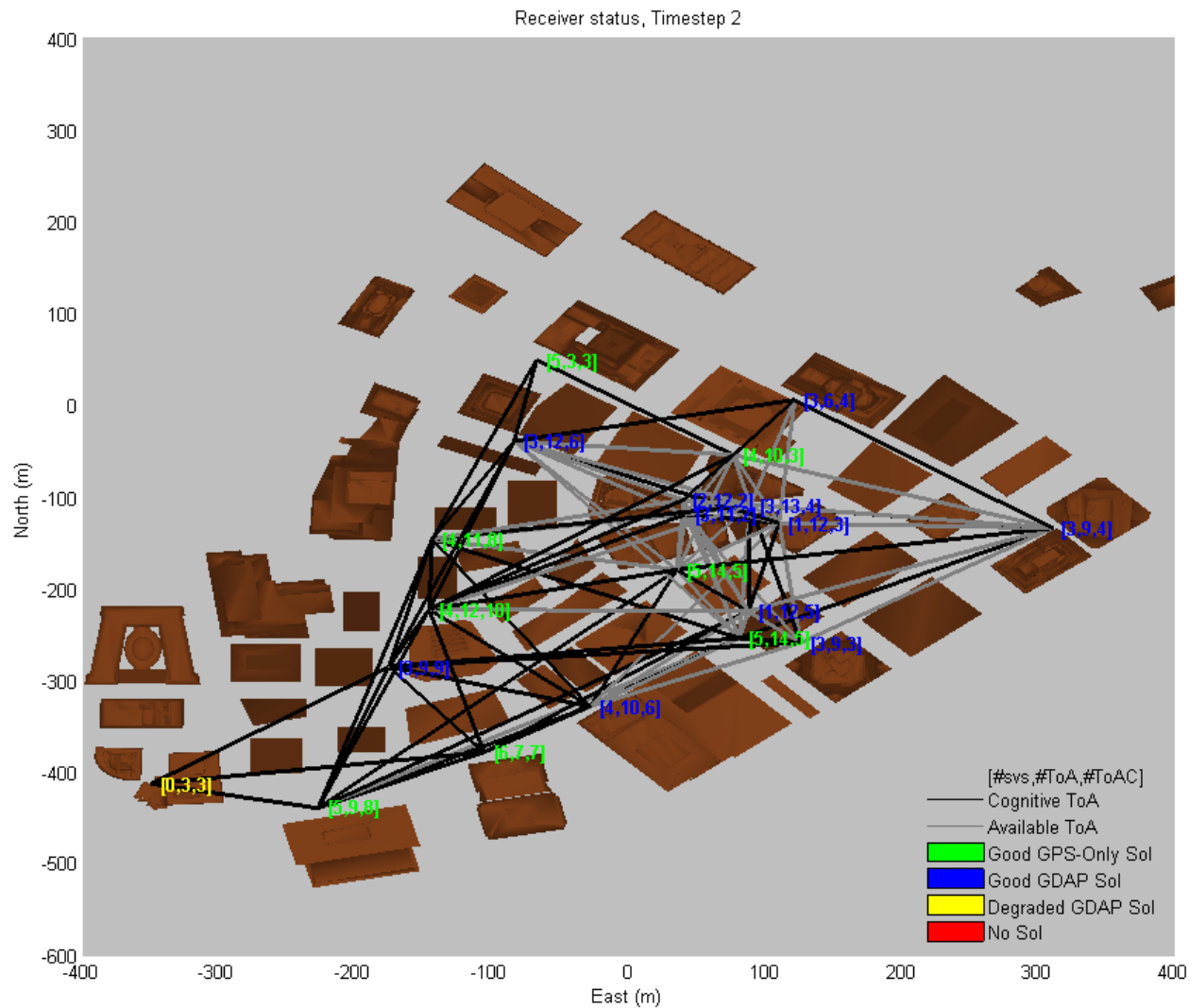


# New York Satellite Visibility

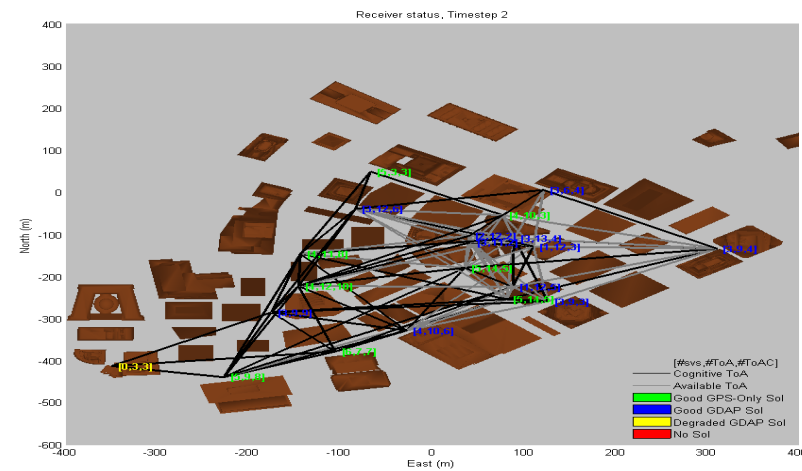
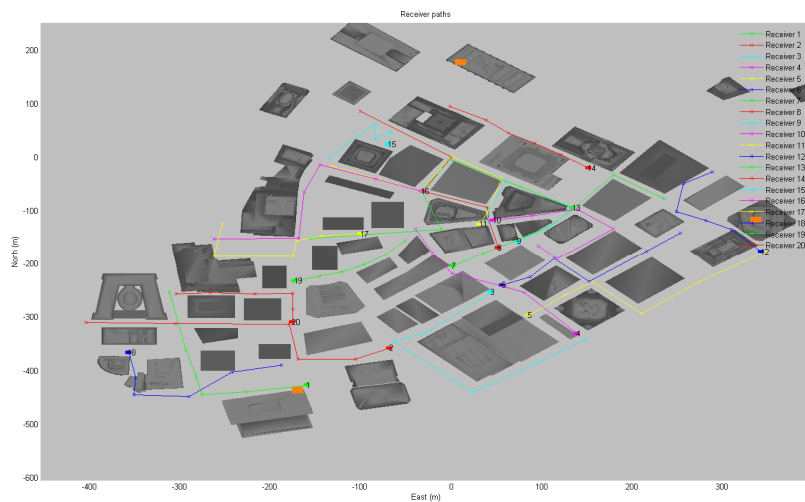
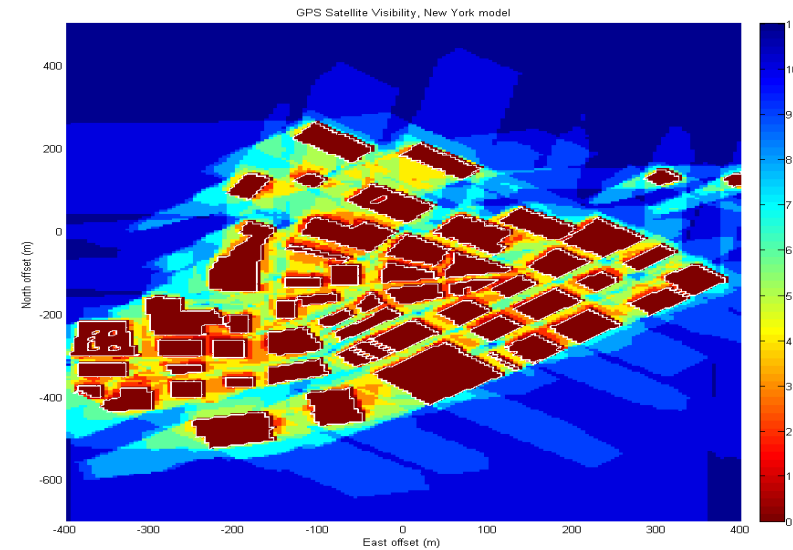
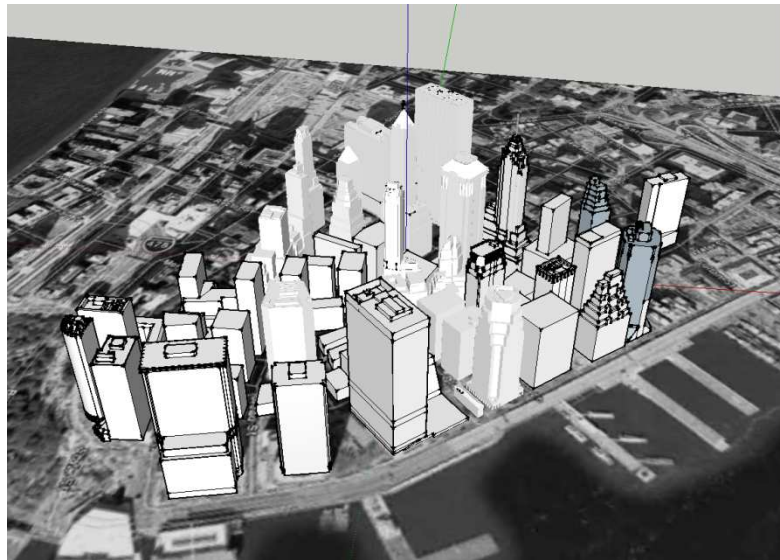
GPS Satellite Visibility, New York model



# NY GDAP Results

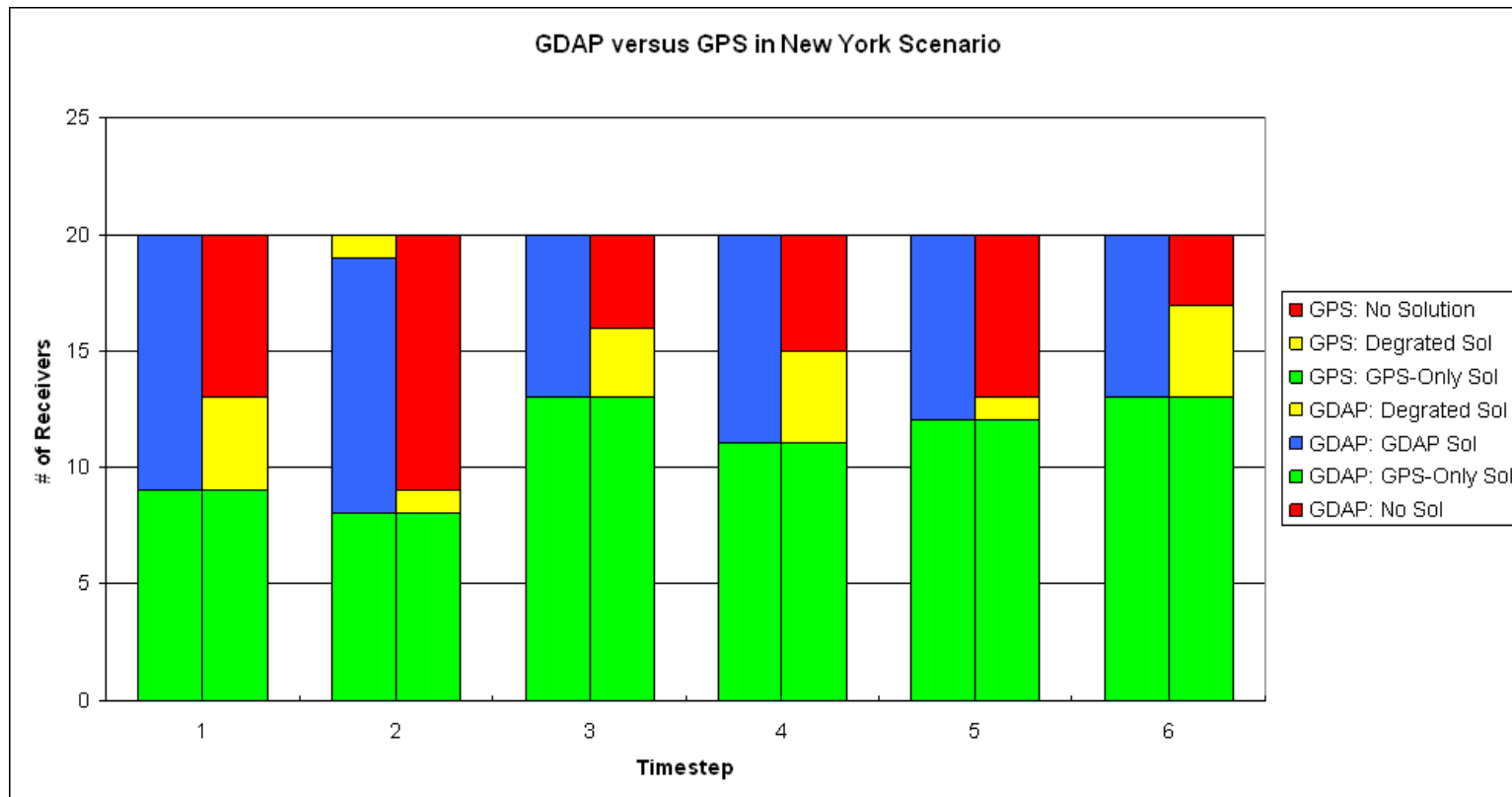


# NY Simulation Example



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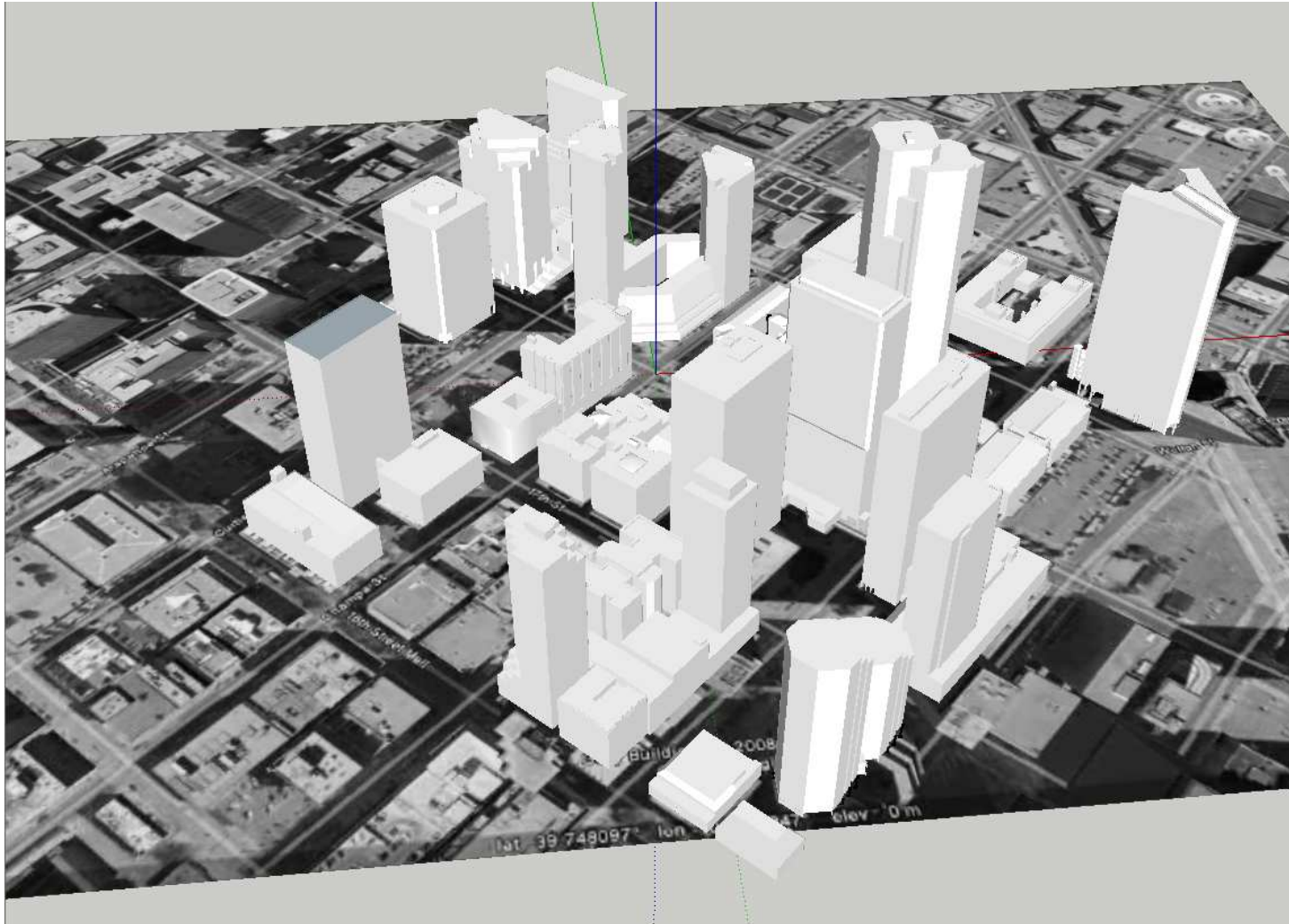
# NY Performance



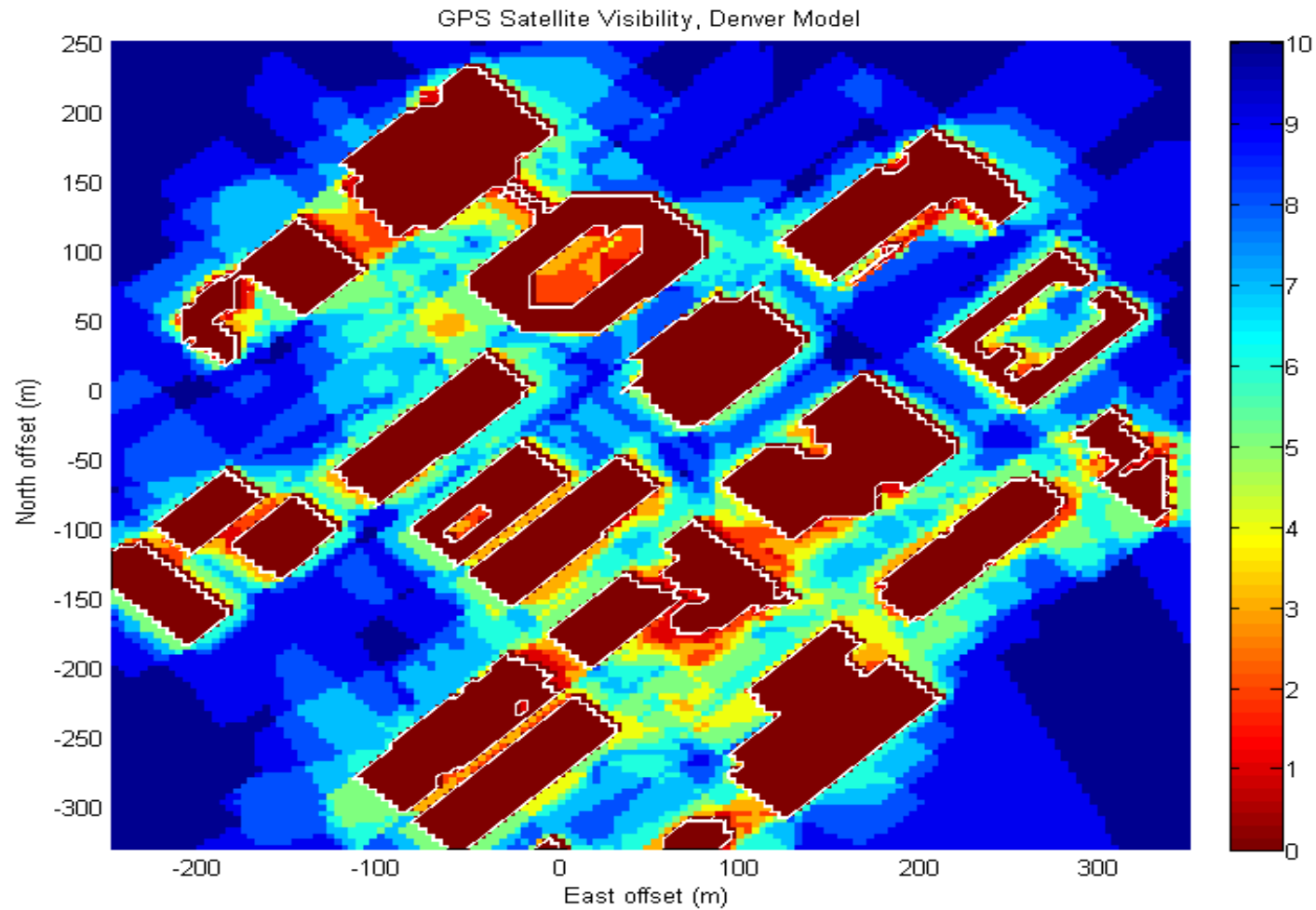
- For each time step, GDAP on left, GPS only on right
- Compare GDAP green/blue with GPS green
- No jammers

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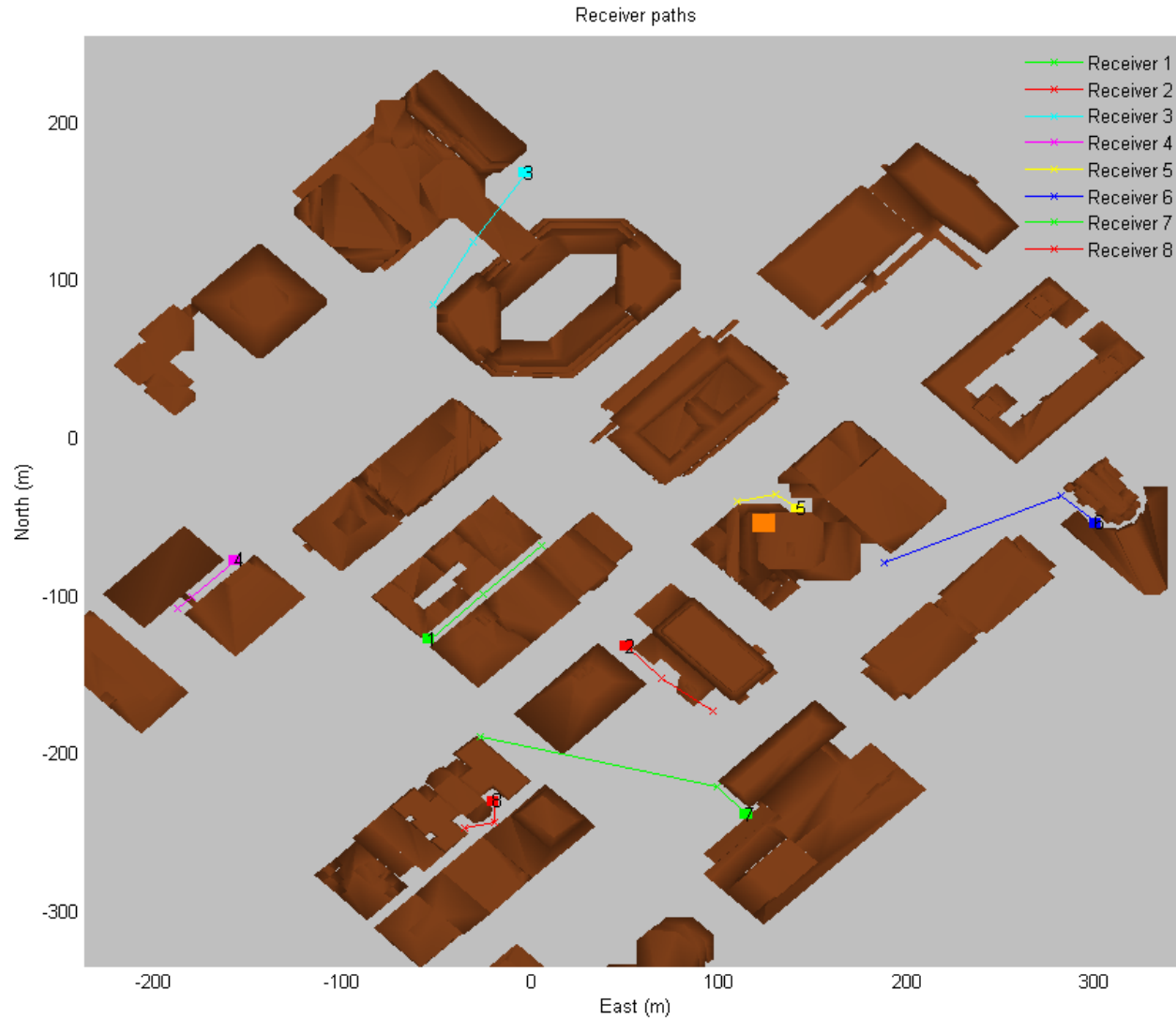
# *Denver 3-D Model*



# Denver GPS Visibility



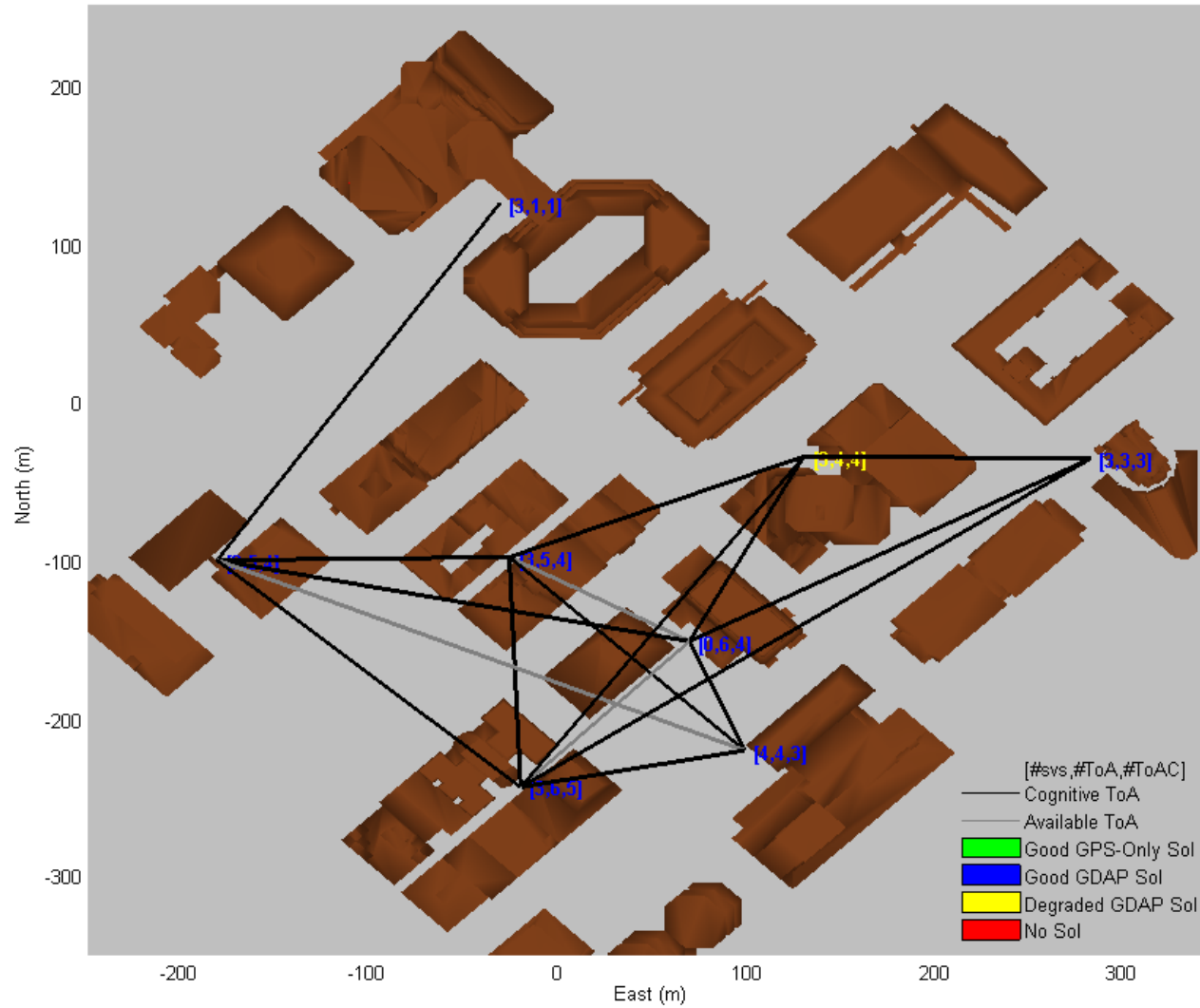
# Denver Receiver Paths



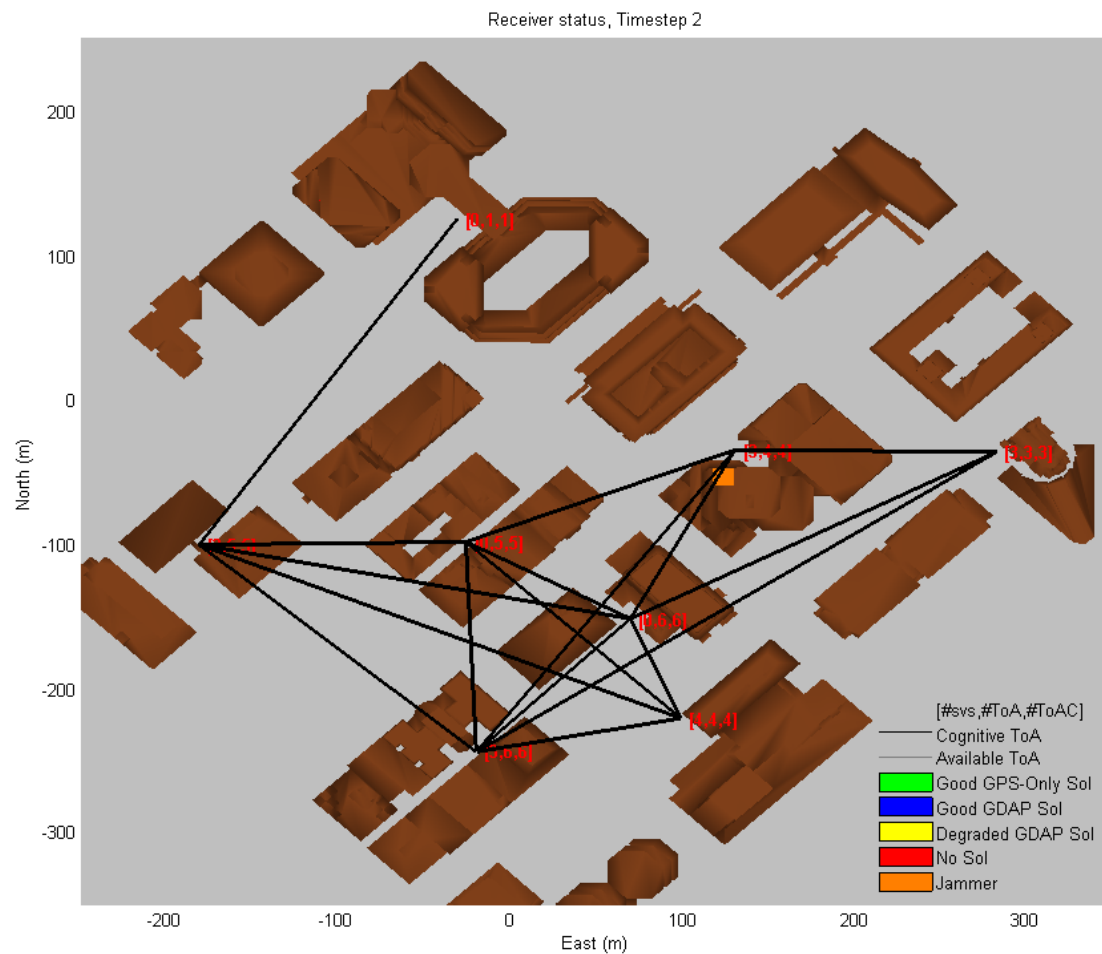


# Denver: no jammers, step 2

Receiver status, Timestep 2

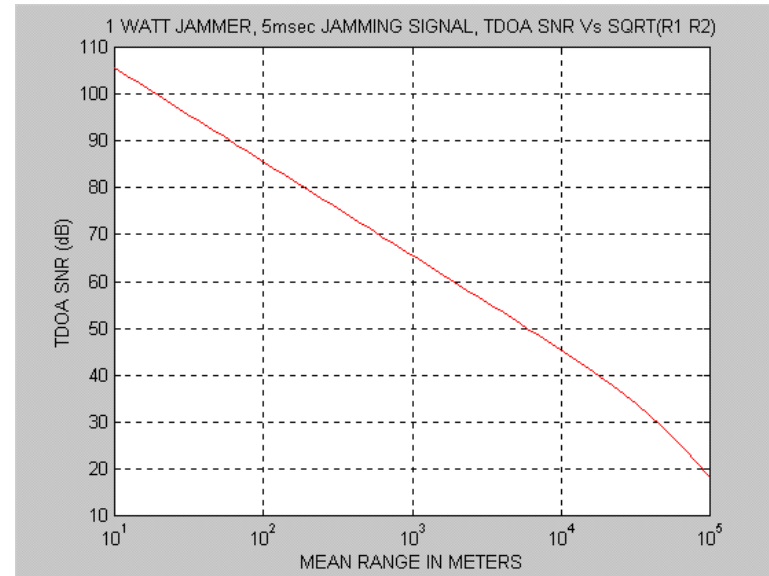
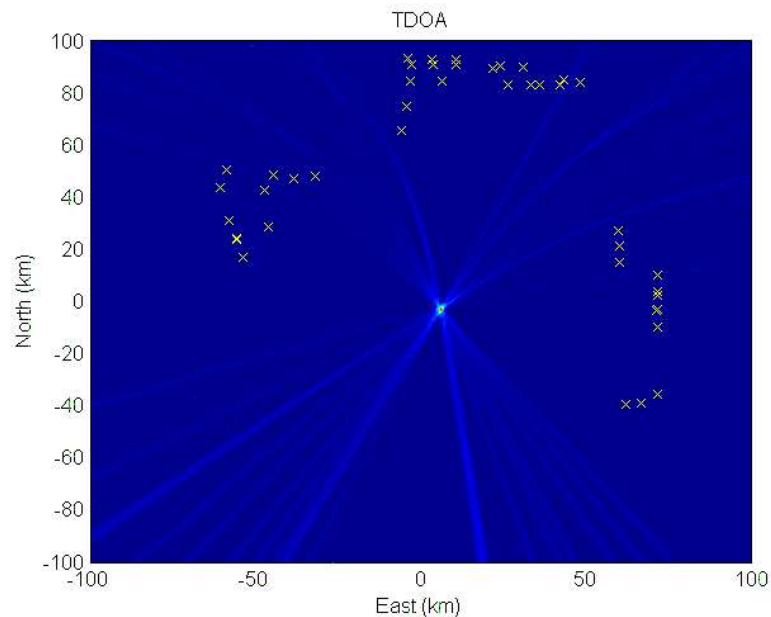


# Denver with Jammer, step 2

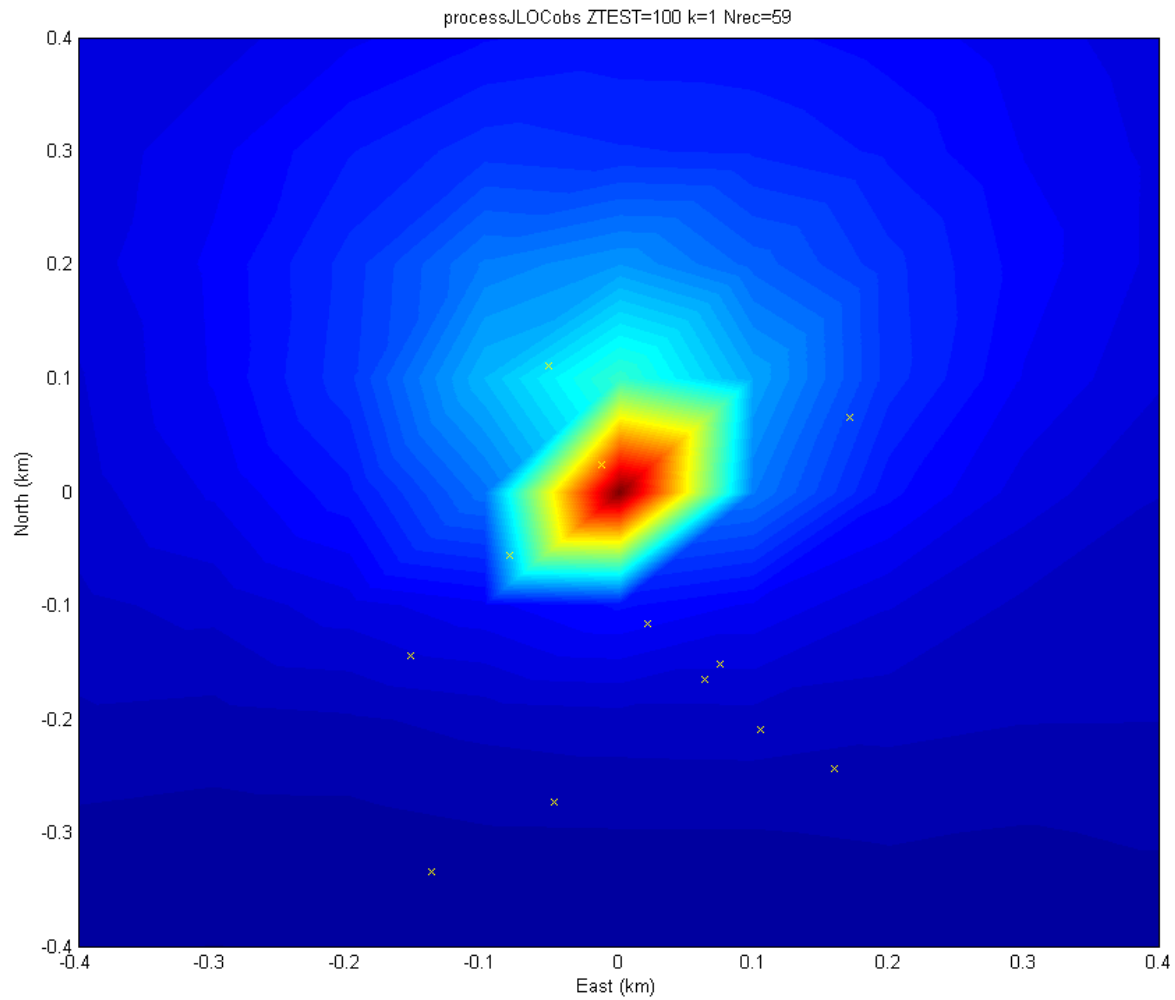


# Other Ranging Signal (SoA)

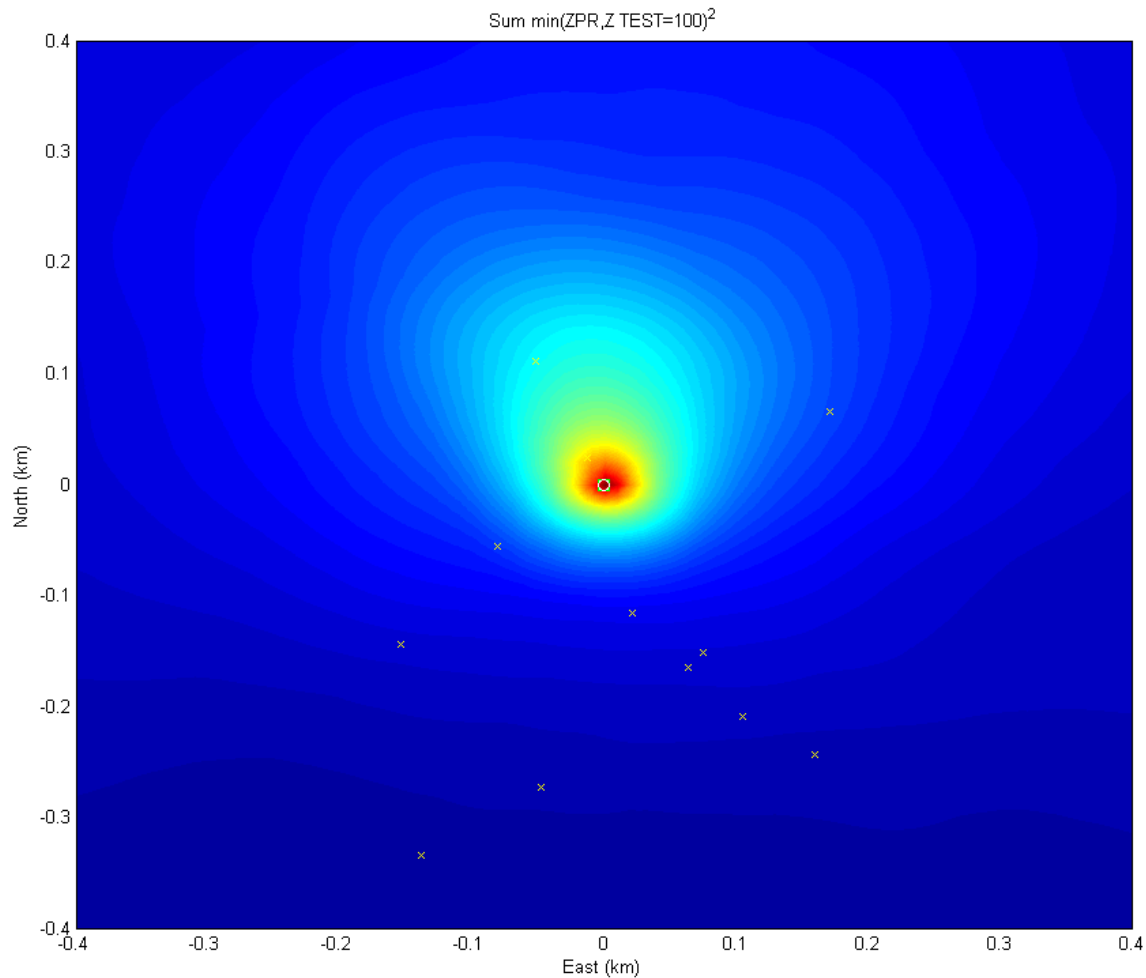
- GPS Jammers: Time Difference of Arrival (TDOA) + Jammer Location (LOC)
- Television: TDOA + TV transmitter location database



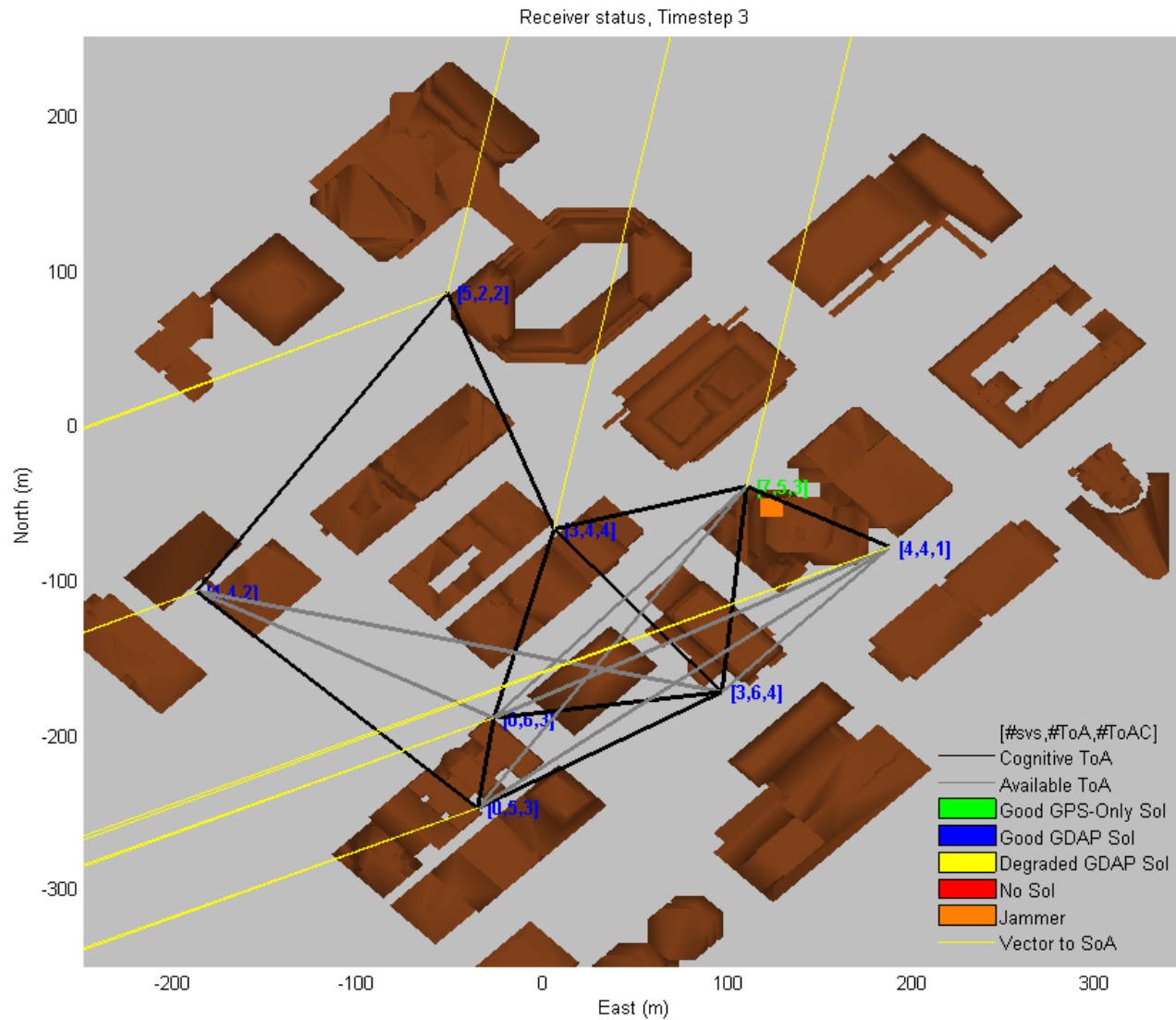
# JLOC Processing Run



# *JLOC Processing Run with additional time steps*

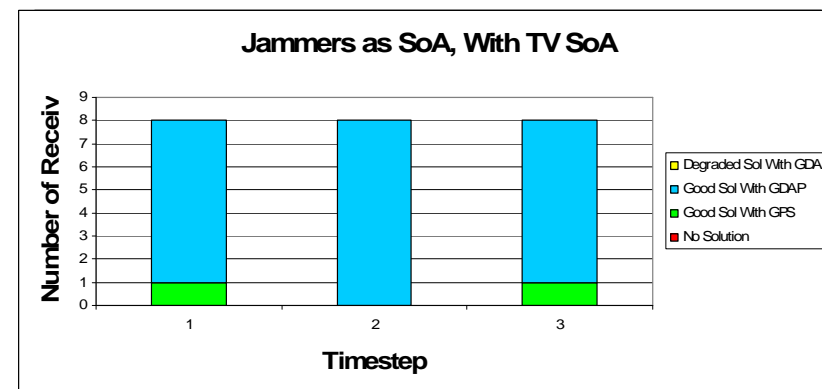
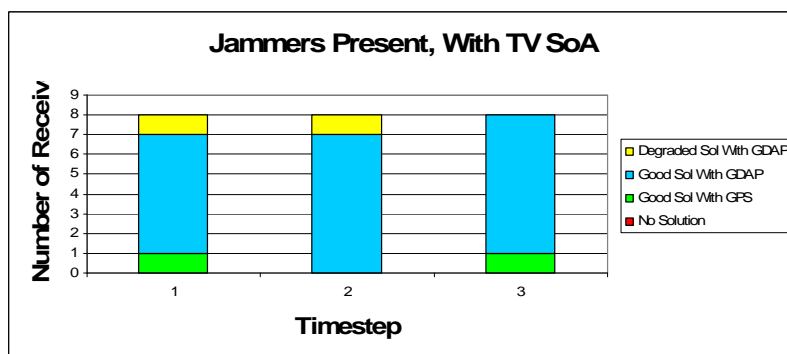
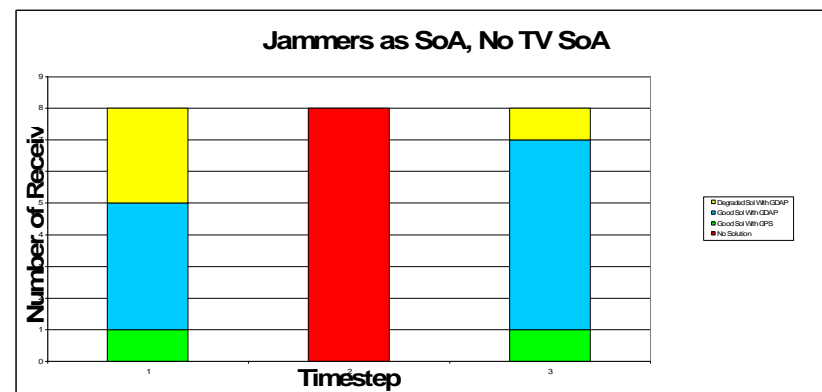
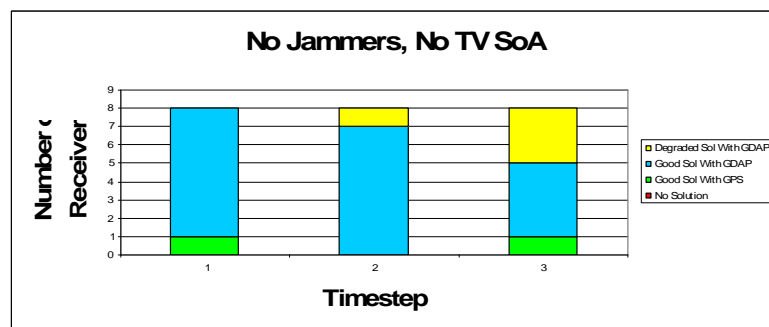


# Denver with Jammer and TV SOA, step 3

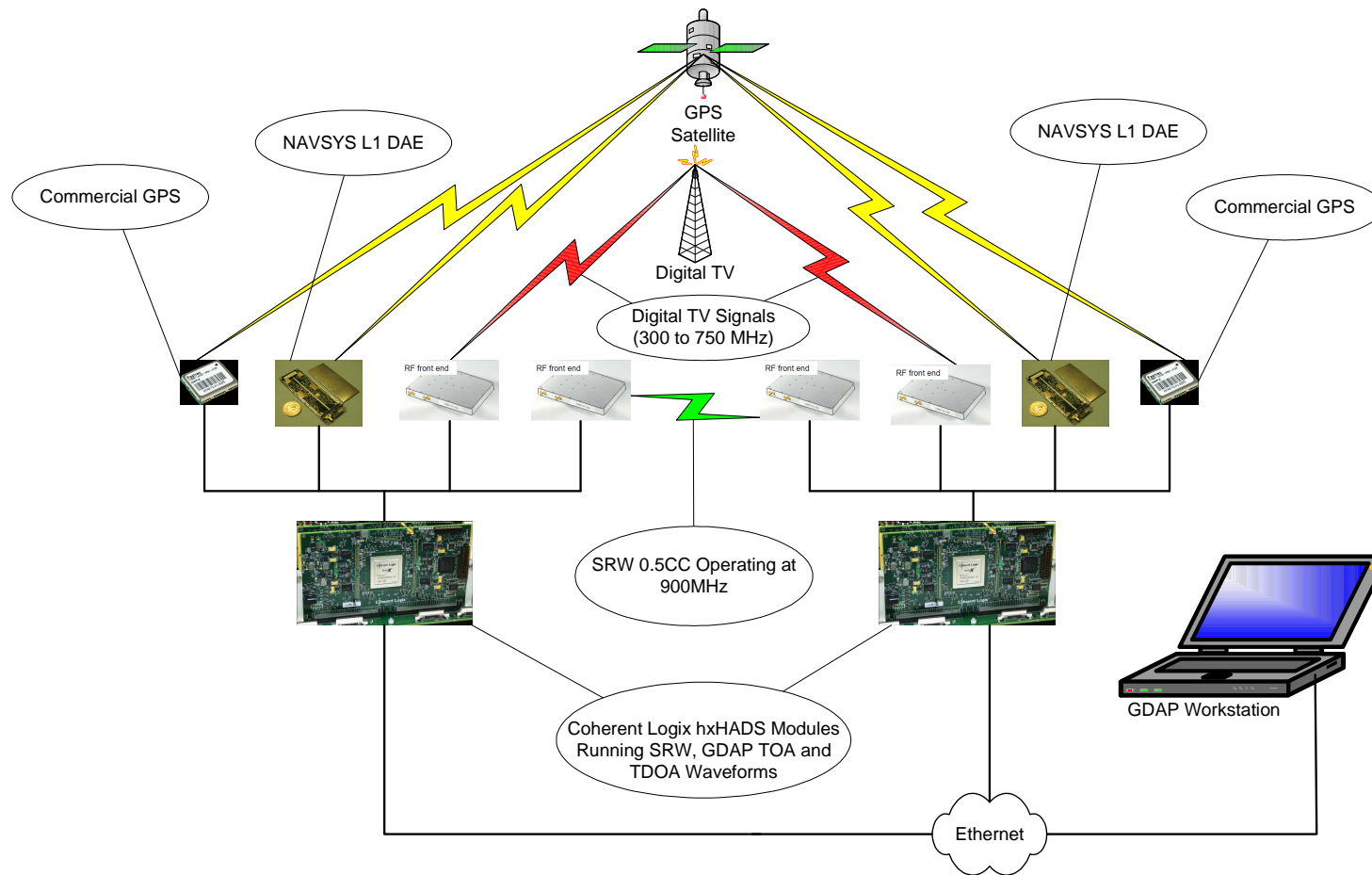


# Denver Performance

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



# GDAP Test Bed





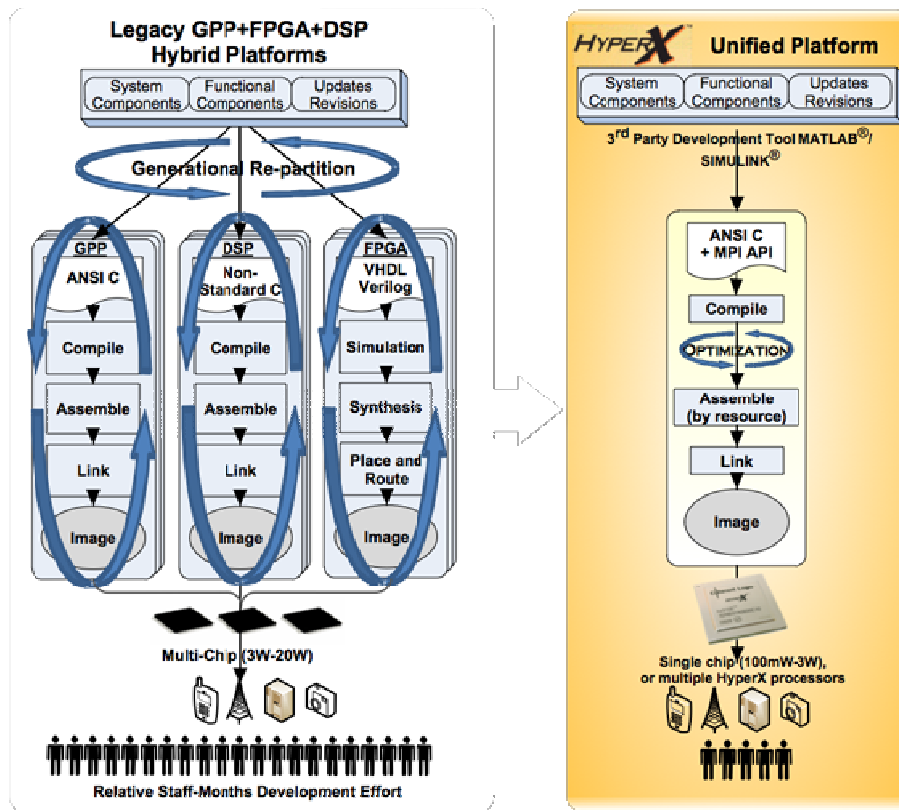
# Conclusion

- 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

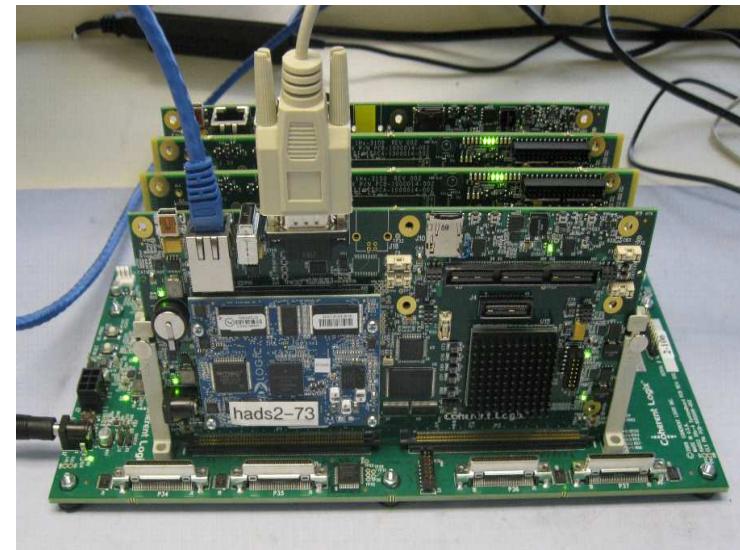
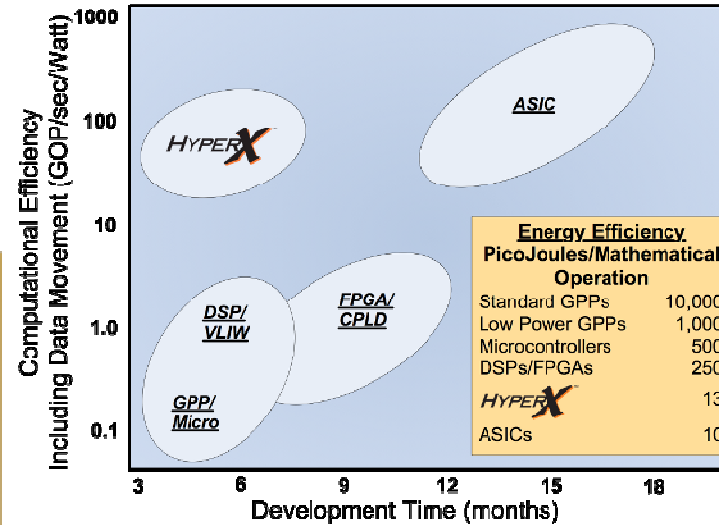
# ***Back-Up***

# HyperX

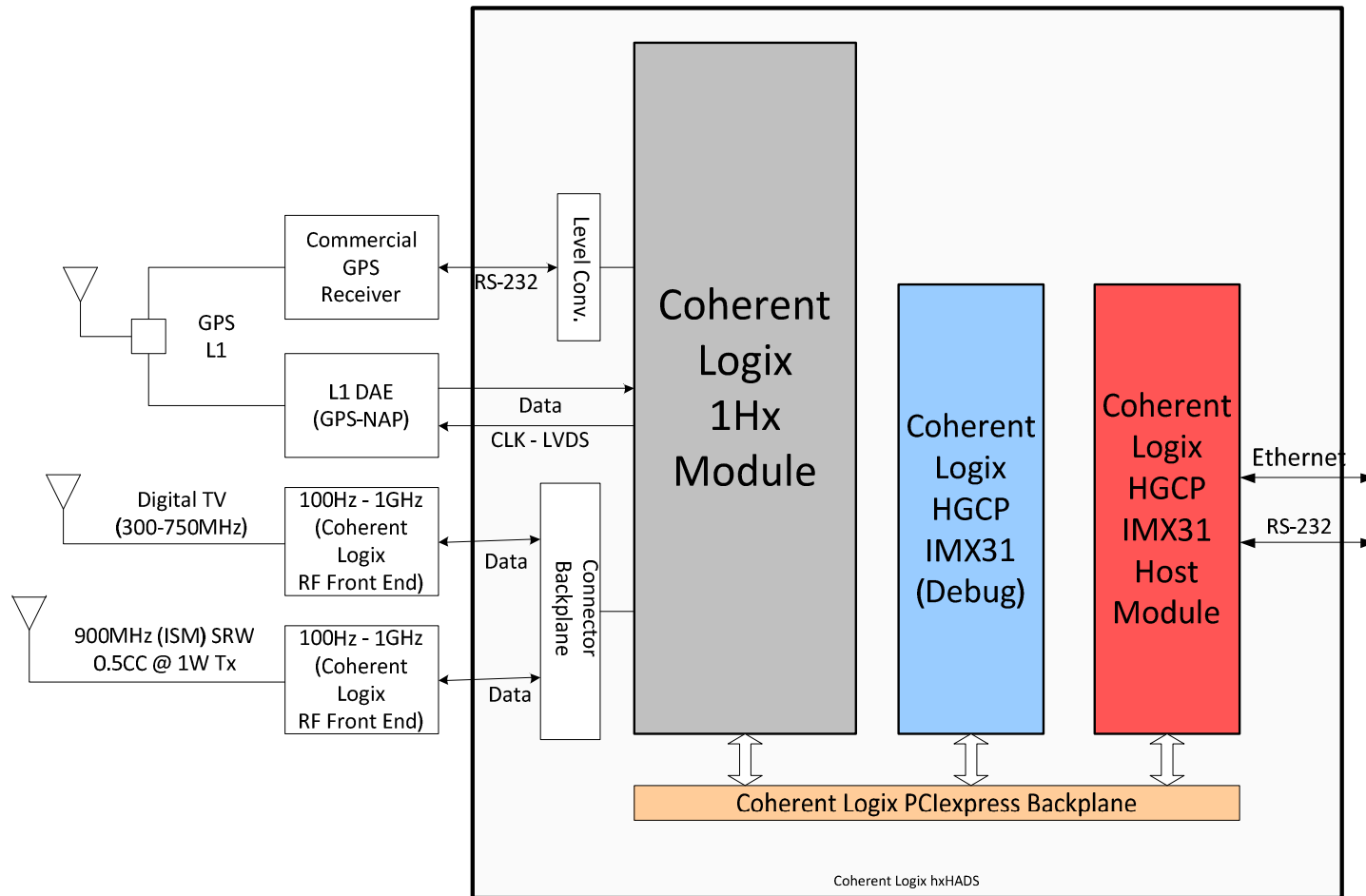
## Simplification of System Partition and Implementation



Computational Efficiency vs. Development Time



# GDAP Test Bed Hardware



# GDAP System Architecture

