Multipath Exploitation Radar Data Collection Review

DARPA MER Industry Day

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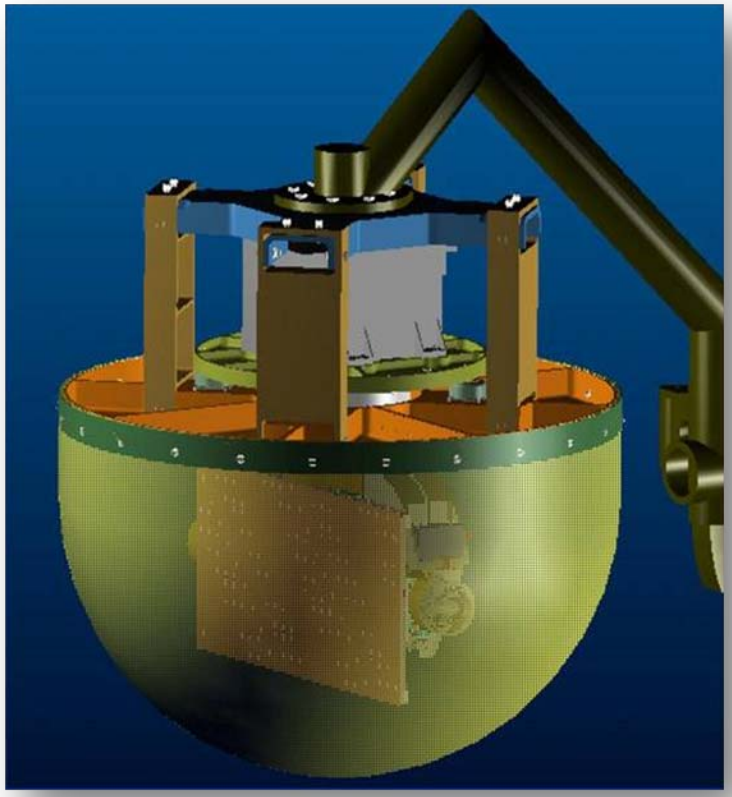
Distribution Statement “A” (Approved for Public Release, Distribution Unlimited)

Overview

- Hardware description
- Collection details
- Data types and formats
  - -radar, lidar, gps, aux
- Data access

NGTS Ku-band Radar



Two-channel monopulse GMTI radar

- frequency: 16.9 GHz
- bandwidth: 120 MHz
- PRF: 6800 pul/sec
- peak power: 300 Watts (P_{avg}= 12 W)
- polarization: HH

Rooftop Testing

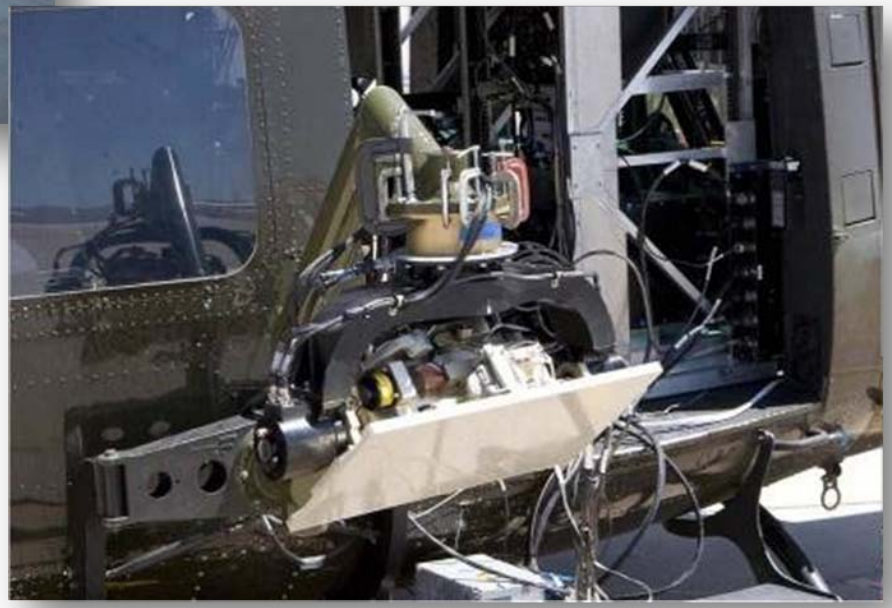
May/June 2008

- verified the radar system was operational and properly storing data

Platform Integration

June 2008

- fit the NGTS radar in an Army UH-1 helicopter from Yuma Proving Grounds
- verified mounting hardware and power requirements

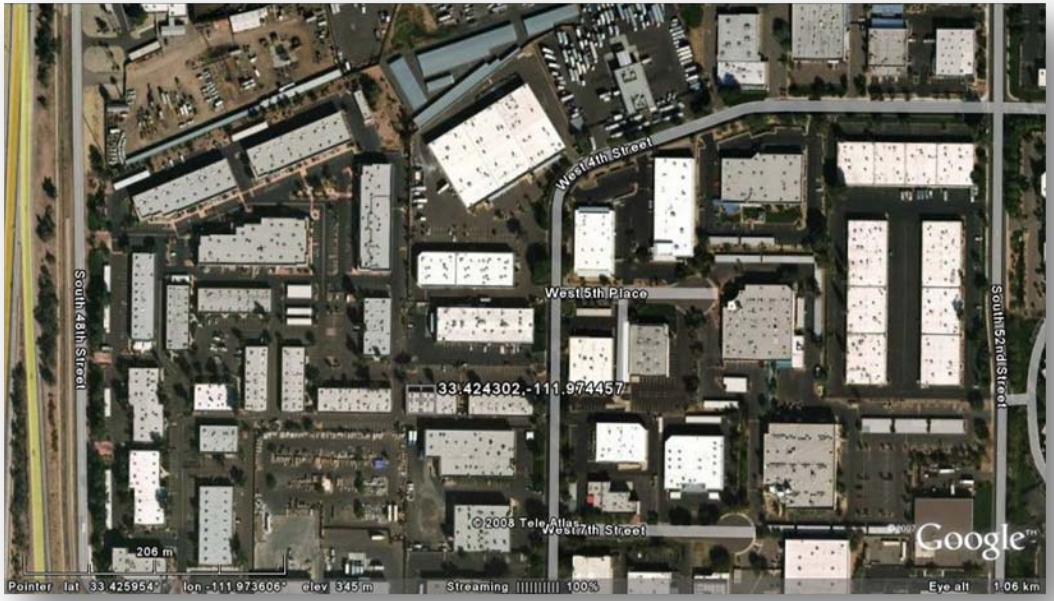


Site Selection

June 2008

Collection site requirements:

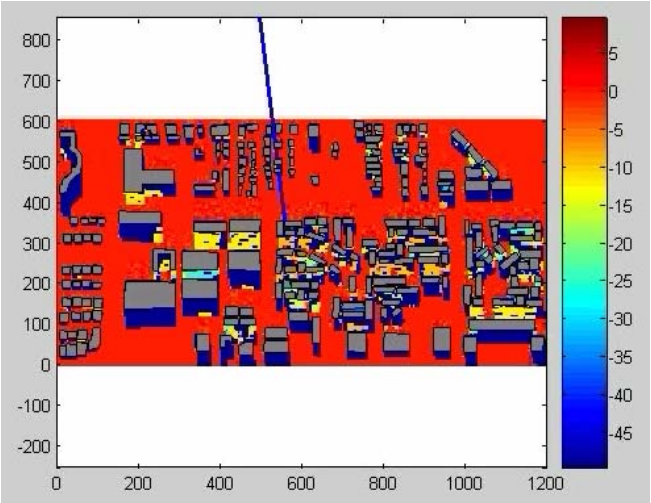
- urban landscape similar to Baghdad
- potential for strong multipath components
- intermittent LOS, non-LOS propagation
- offer various combinations of direct path, multipath (one and two bounce), and no-signal target tracking
- proximity to contractor



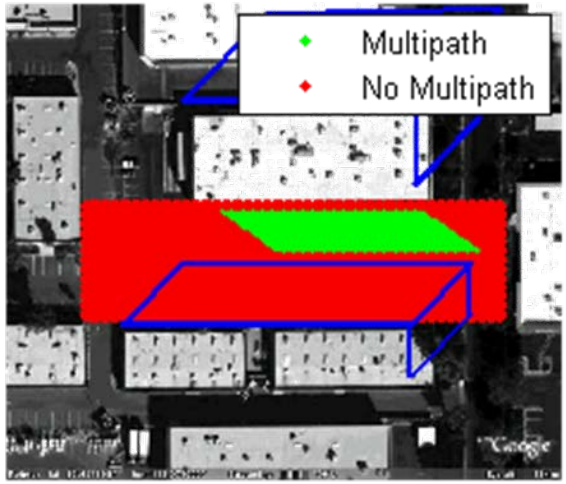
Collection Design
Multipath Analysis

Summer 2008

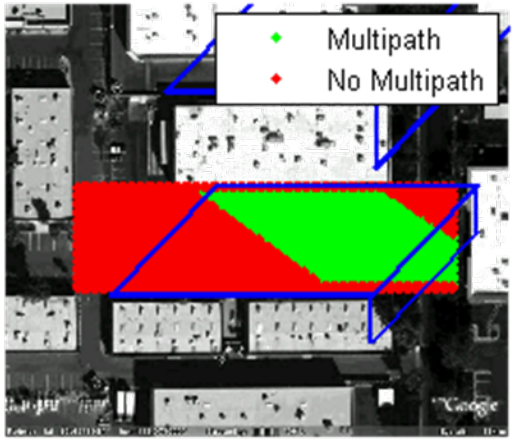
geometrical analysis example



Az = 224 to 226 ,El = 14 to 15 degrees



Az = 224 to 226 ,El = 7 to 8 degrees



- Variation of elevation angles to determine best collection geometry
- Propagation conditions present between buildings
  - LOS and multipath
  - multipath only

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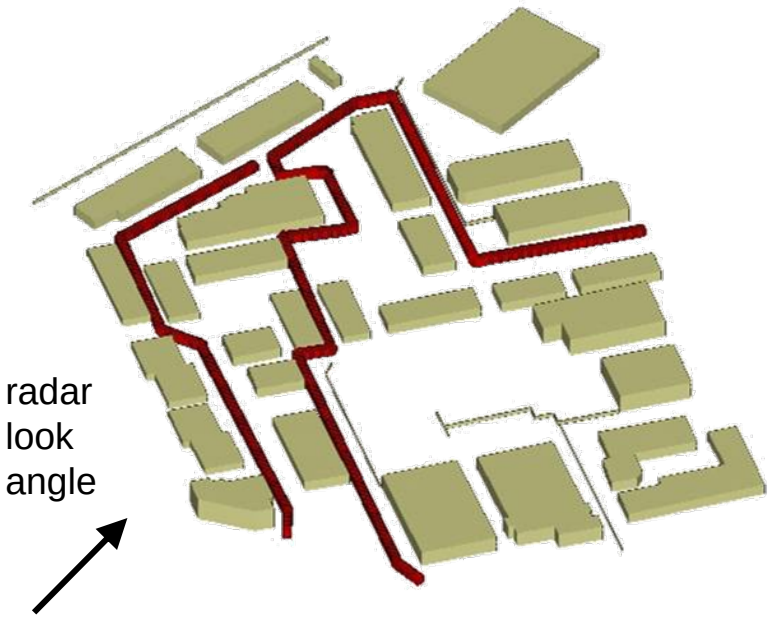
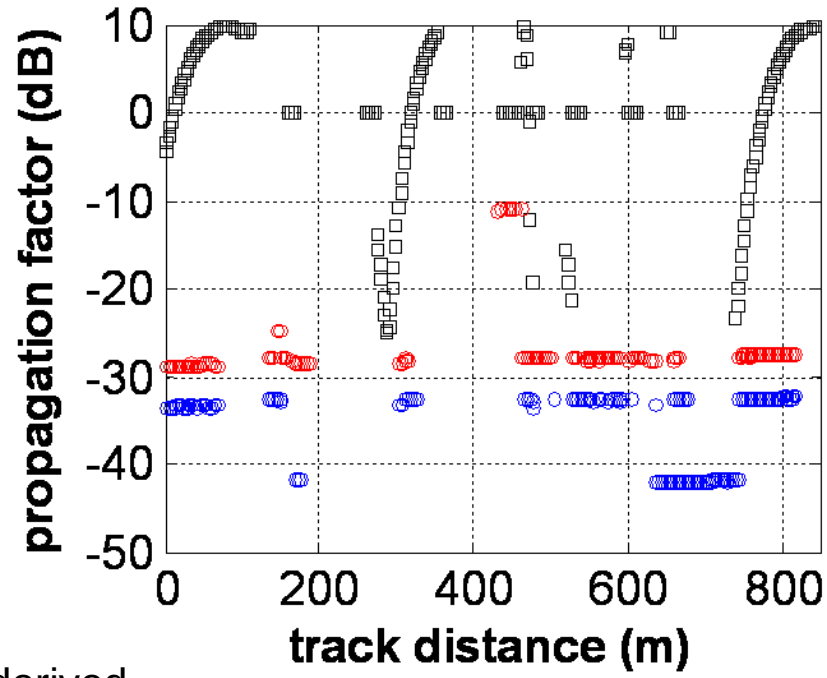
Collection Design
Multipath Analysis

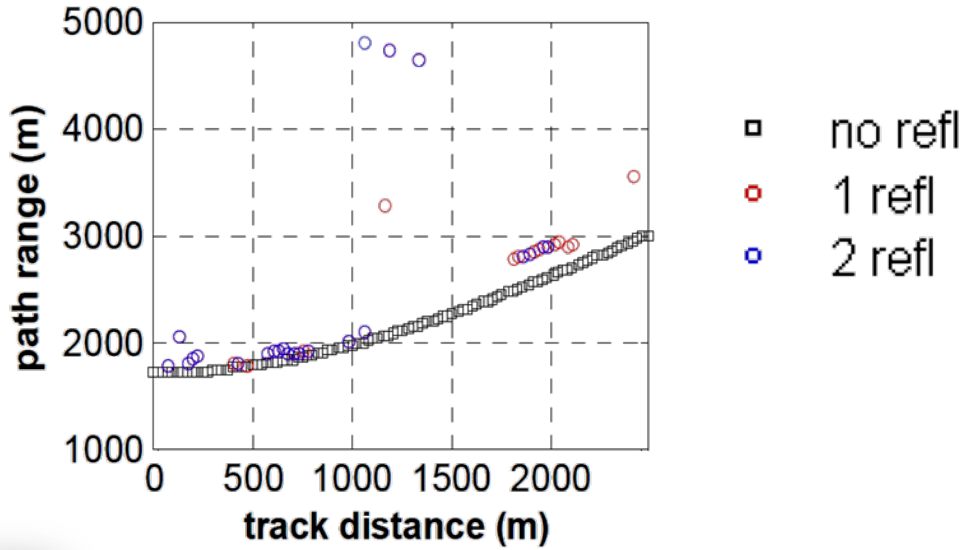


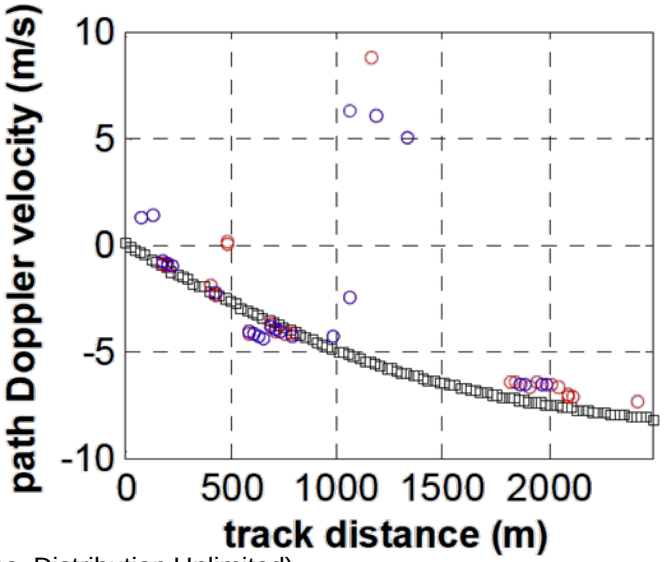


- Building layout and target routes derived from area imagery
- InSite simulation parameters
  - SBR propagation, with ray spacing = 0.01 degrees
  - only reflection EM interactions allowed (maximum 4 per propagation path)
- Carports, trees, and any other objects (e.g. crates and trucks seen in Google Earth image) are not modeled

- LOS
- 1 REFL
- 2 REFL

Collection Design
Multipath Analysis





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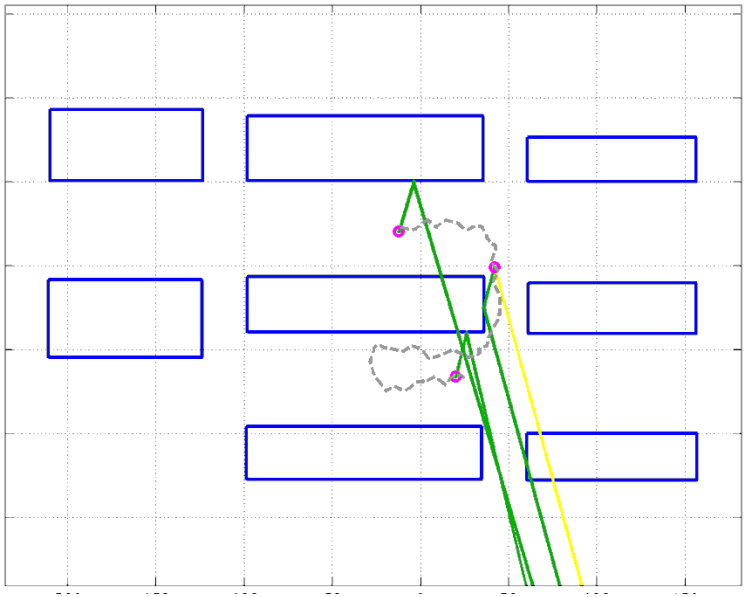
Flight Checkout Tests

December 2008

The radar system was remounted in the UH-1 and performed:

- vibration and shock inspection
- power availability test
- beam pattern analysis
- air/ground communication tests

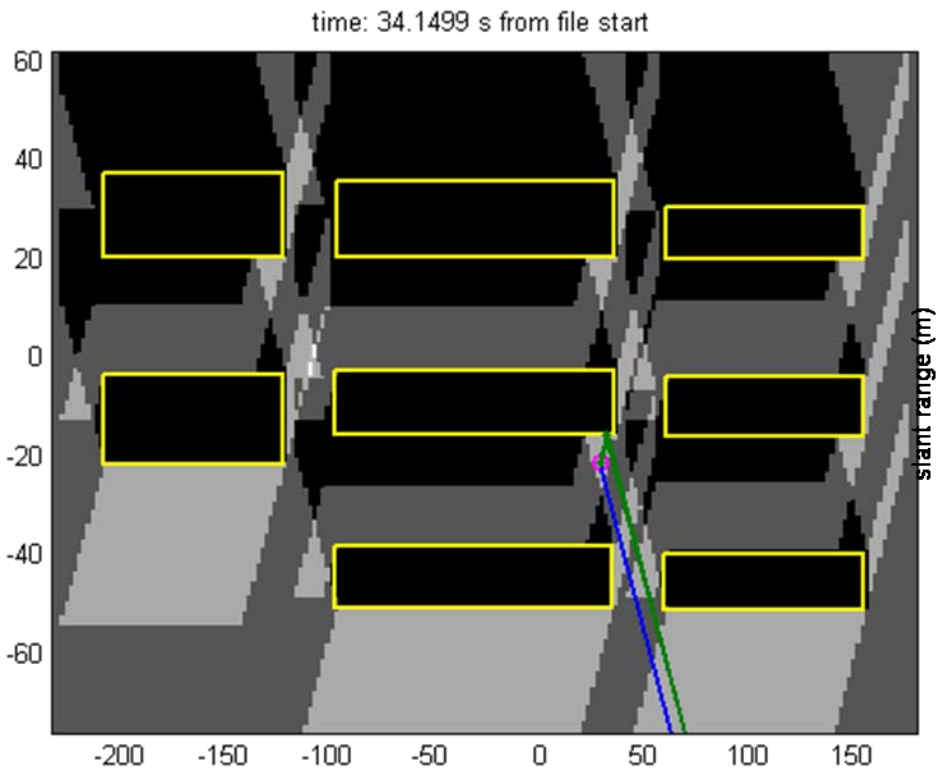


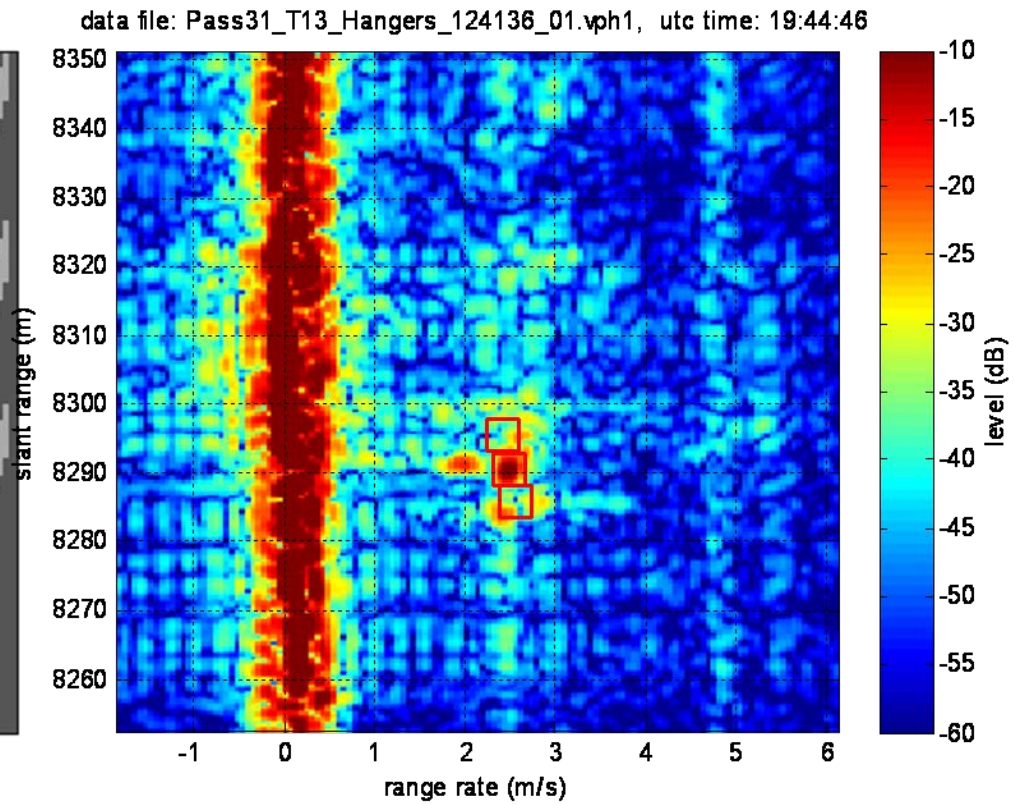
LOS

multipath

Flight Checkout Tests Preliminary Results

LOS and single-bounce multipath example





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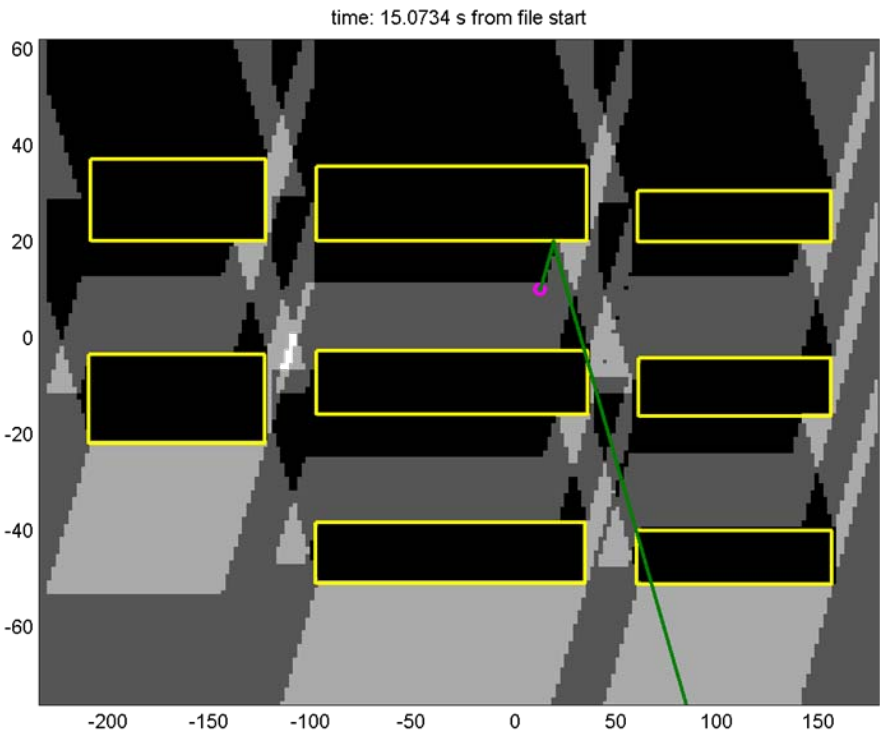
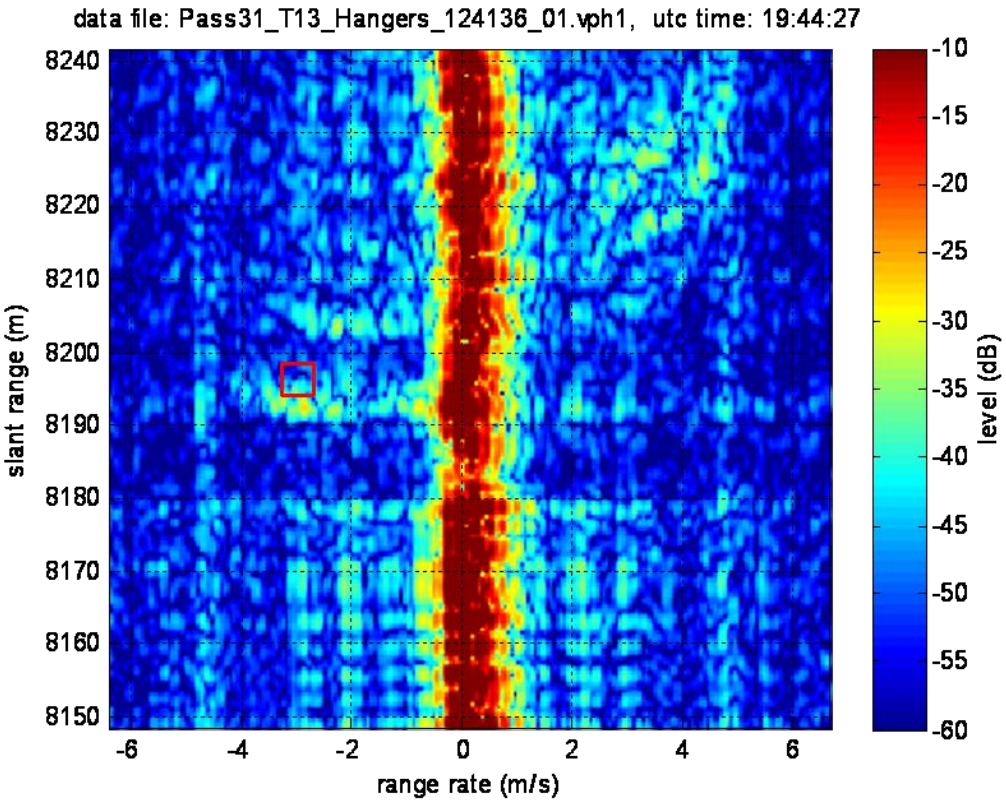
Flight Checkout Tests Preliminary Results

double-bounce multipath example





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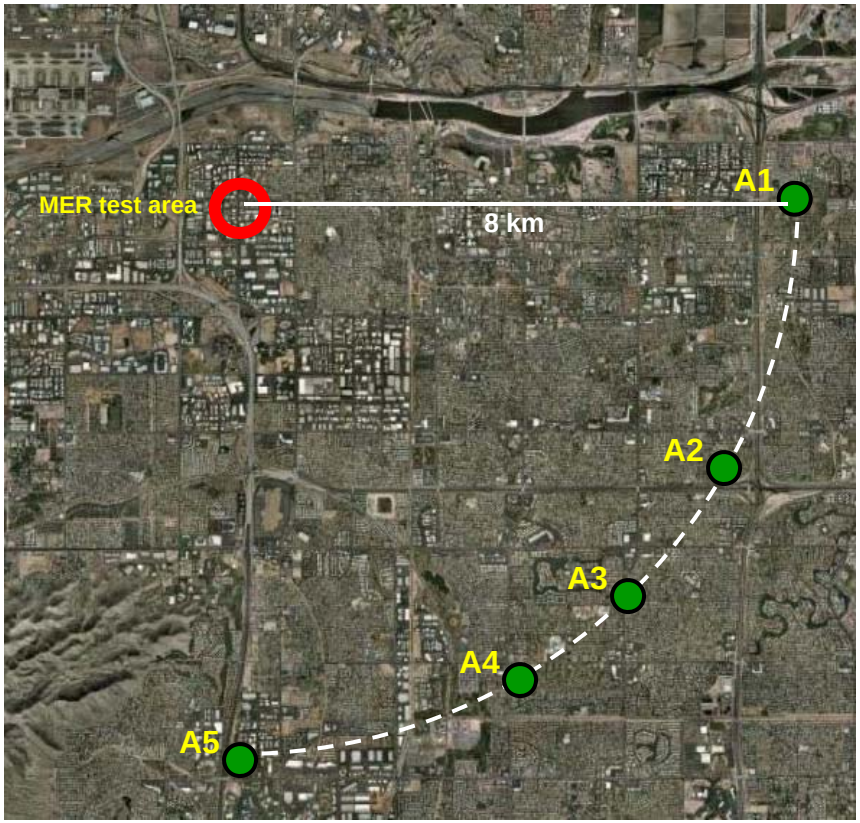
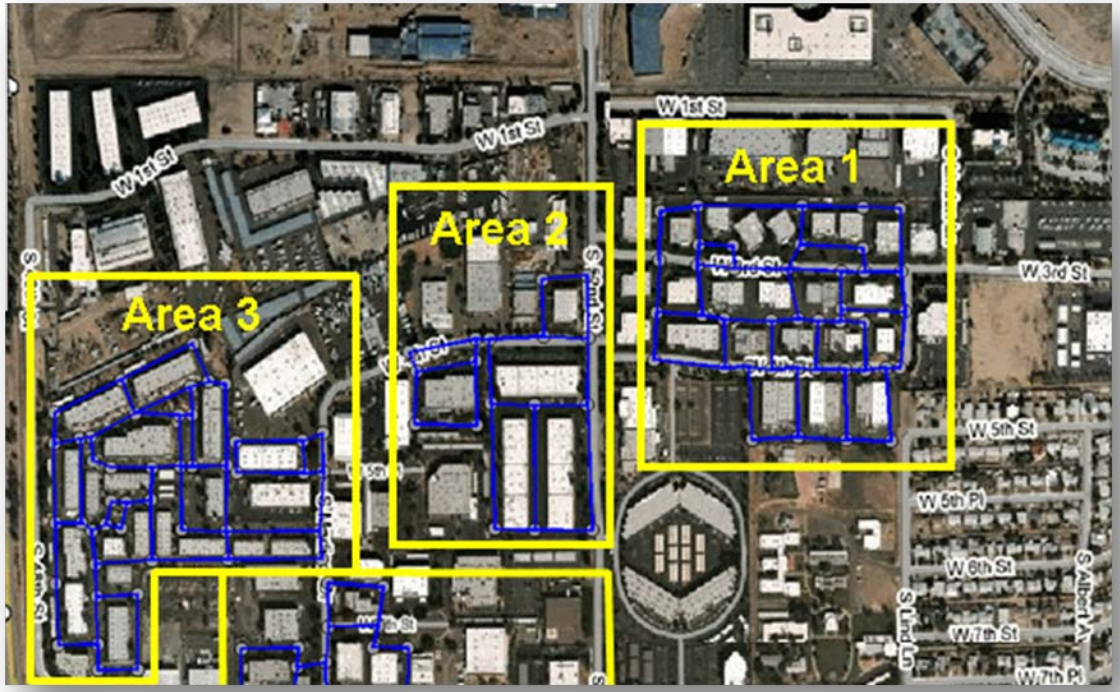
Experiment: Airborne Collection Positions



To acquire multipath radar returns with differing geometries of the same urban landscape, the platform varied position on an arc surrounding the collection site, and varied in altitude:

- four platform positions for the for the stationary collects (A1, A3, A4, A5)
- three platform positions for the moving collects (A3, A4, A5)
- two depression angles (~7º and ~10º)

Experiment: Ground Collection Areas



The ground scripts were performed in three areas at the collection site. Areas 1 and 3 provided random vehicle movement through the urban landscape. Area 2 provided an opportunity for thorough multipath phenomenology analysis at various aspect angles.

Experiment: Ground Description

Multipath surfaces:

- two story buildings
- concrete
- few windows or wall other obstructions
- minimal surface roughness

Ground conditions:

- performed at night
- little vehicle or foot traffic
- most driving in parking lots

Experiment: Target Ground Vehicles

GPS instrumented targets for day 1 tests (stationary platform):

- 2 SUVs (moving)
- 1 Pick-up with a set of fixed corner reflectors in the bed (stationary or moving)

GPS instrumented targets for day 2 tests (stationary and moving platform):

- 1 SUV (moving)
- 1 Pick-up with unsecured corner reflectors in the bed (moving)

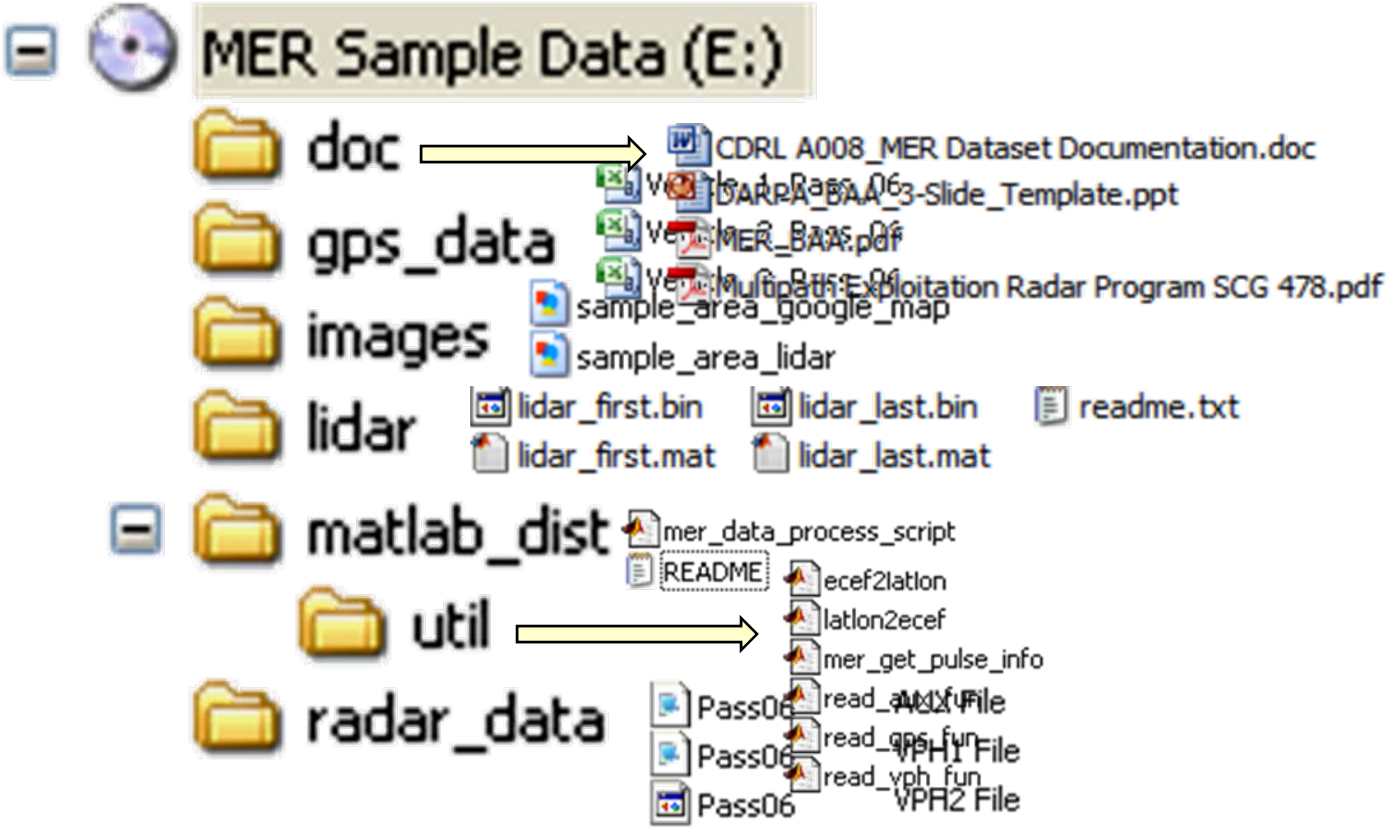
Experiment: Vehicle Ground Scripts

16 scripted collects with the platform stationary
13 scripted collects with the platform moving

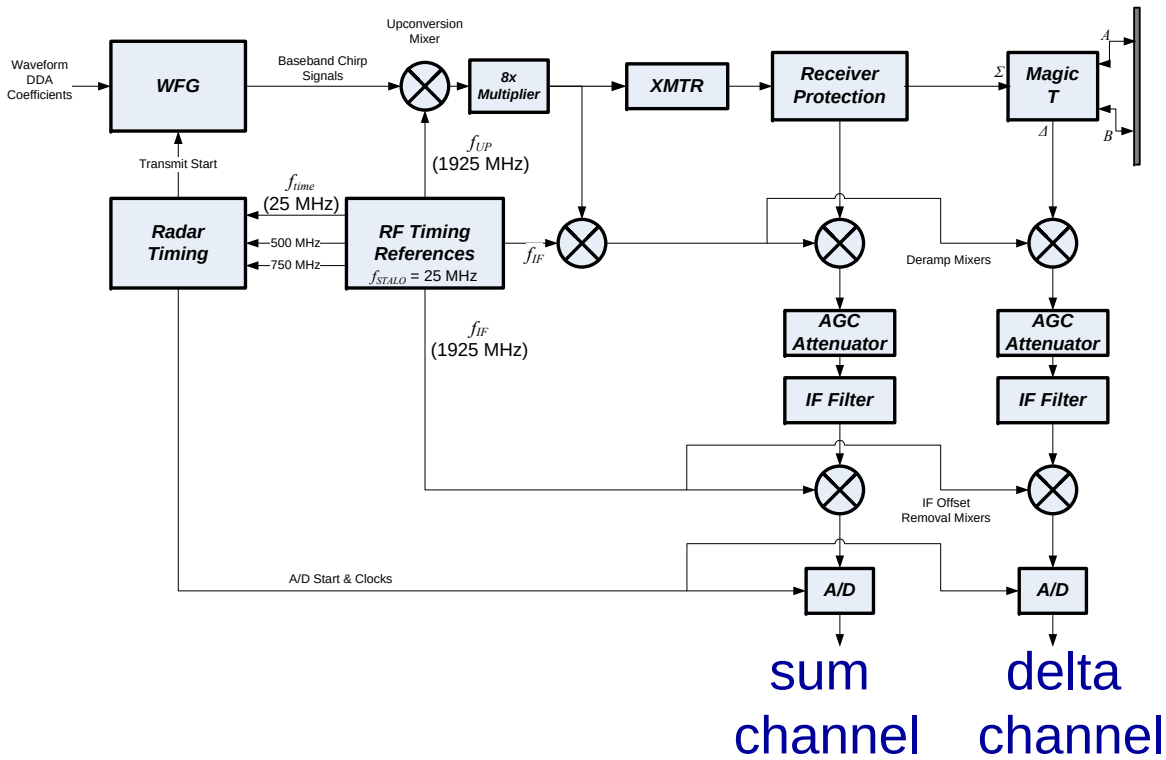
random vehicle traffic patterns

phenomenological analysis

Available Data
radar, lidar, gps, aux



Radar Data: Two-channel GMTI radar



sum channel

delta channel

*.vph1

*.vph2

The received signals are gated to the proper target range, mixed, and filtered providing monopulse vph data.

Fixed beam (not scanning)

Illumination ground area ~250mx500m

How do I read the vph data?

Included is a Matlab file called *mer_data_process_script.m* that calls the function *read_vph_fun.m* which reads *.vph binary-format data file and returns radar data and header information.

AUX Data

The Aux data file contains records of the system attributes corresponding to approximately every 26th pulse. The attributes are listed in Table 4 of *CDRL*.

Name	Description	Precision, Units, Limits
Record_Number	Index number of AUX record, beginning at 0 for the first record of the collection and incremented by 1 for each successive AUX record.	N/A
MSU_Lat	Latitude from motion sensing unit	WGS-84 coordinate system
MSU_Lon	longitude from motion sensing unit	WGS-84 coordinate system
MSU_Alt	altitude from motion sensing unit	WGS-84 coordinate system
MSU_North_Vel	Value of the velocity vector in the north direction from motion sensing unit	Meters per second
MSU_East_Vel	Value of the velocity vector in the east direction from motion sensing unit	Meters per second
MSU_Up_Vel	Value of the velocity vector in the up direction from motion sensing unit	Meters per second
CP1_Lat	Latitude of collection point 1	WGS-84 coordinate system
CP1_Lon	Longitude of collection point 1	WGS-84 coordinate system
CP1_Alt	Altitude of collection point 1	WGS-84 coordinate system
AC1_Lat	Aircraft latitude position 1	WGS-84 coordinate system
AC1_Lon	Aircraft longitude position 1	WGS-84 coordinate system

AUX Data

How do I read the aux data?

A function called *read_aux_fun.m* is included that reads the MER aux binary-format data file and returns the information as a structure into MATLAB. This function addresses all alignment and timing issues mentioned in the *readme* file.

GPS Data

How do I read the GPS data?

A function called "read_gps_fun.m" is included that reads GPS csv-format (ascii) data files and returns the GPS data as a structure into MATLAB.
The file format expected by this function is *not* the same as the GPS data format specified in LMCO's "Dataset Documentation", instead this function reads GPS data in the comma-separated-value (csv) ascii format of the AFRL-provided GPS data.

LIDAR Data

The LIDAR data is a subset of the full geo-tiff images.

The binary format files contain of a series of triplets of single-precision values representing latitude (decimal degrees N), longitude (decimal degrees W), and elevation (meters).

The ".mat" files can be loaded into MATLAB using the "load" command, and contains three variables, "lat" representing the latitude grid (decimal degrees N), "lon" with the longitude grid (decimal degrees W), and "limage" with elevation data (meters).

Data Requests

AFRL Sensor Data Management System (SDMS):

- Established by AFRL, OSD, and DARPA to solve the ‘classical’ data problems within the ATR/SF
- Provides centralized Data Management support to the sensor exploitation technology research and development community
- Supports numerous DARPA programs such as: MSTAR, DDB, MSET, AMSTE/MTFP, DTT, AT3, JIGSAW, POSSE, NetTrack, FOPEN, VIVID, and E3D
- Distributed more than 250 TB of data in the last 12 years

Data Requests

Specifics

- Go to secure webpage at: https://www.sdms.afrl.af.mil/
- Request MER data from webpage
- All data requests must be approved by DARPA before distribution