Clutter Measurement Research at 3500 MHz

Chriss Hammerschmidt & Bob Johnk

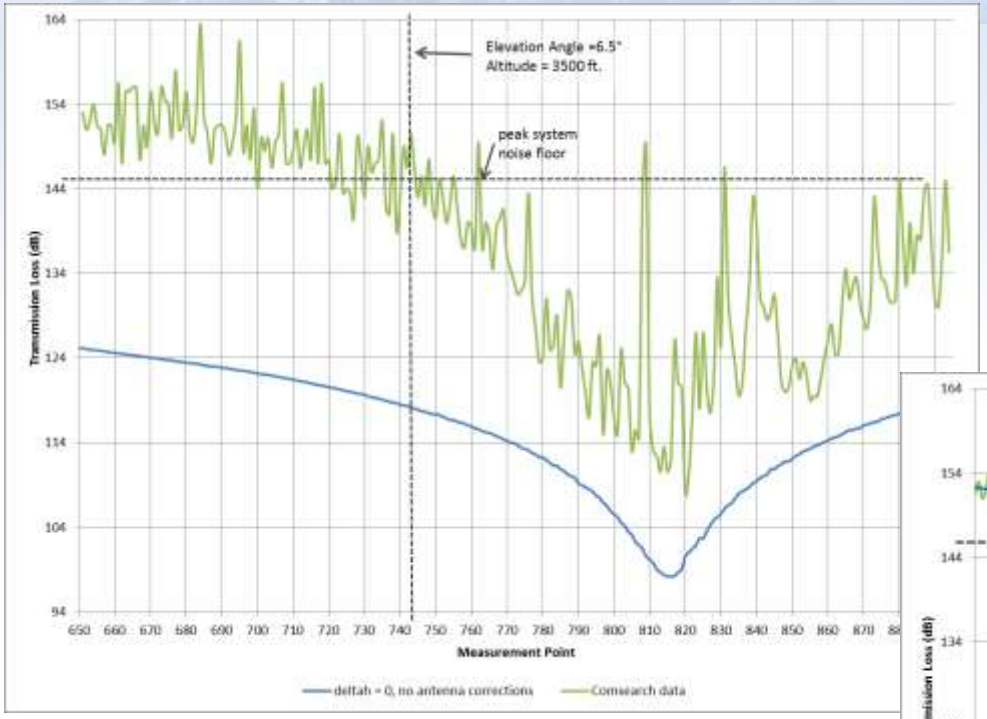
ITS

Outline

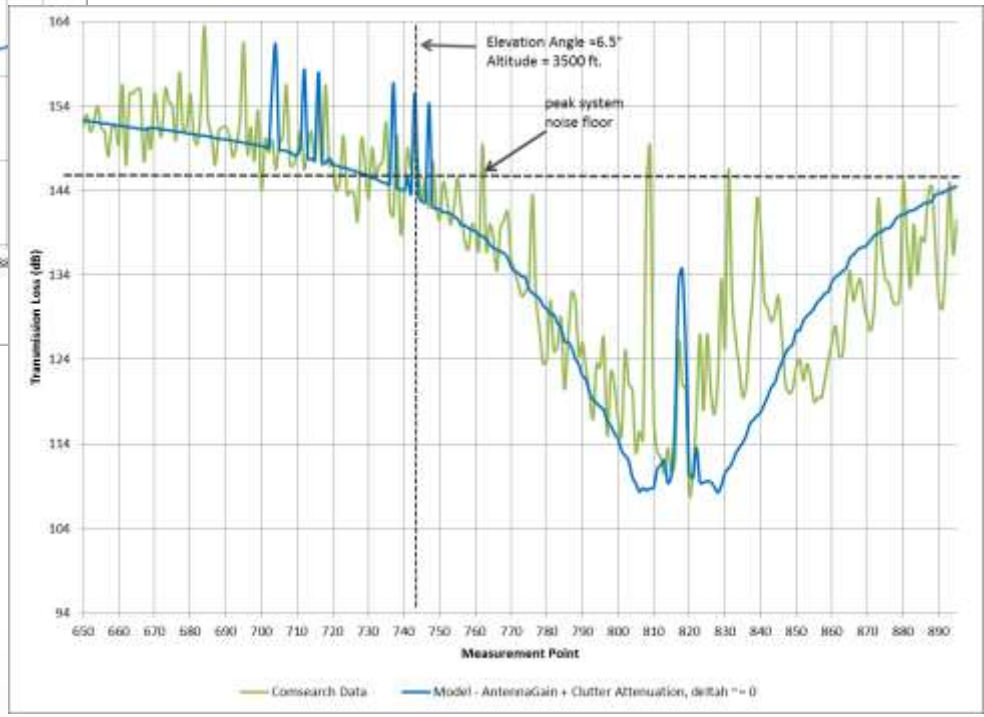
- Motivation (Post-CSMAC Analysis)
- Measurement Data at 3500 MHz
- Component Characterization & Sensitivity Analysis
- Clutter Modeling
- Measurement System
- Post Processing Information

Post-CSMAC Airborne Analysis

ITS Analysis w/antenna corrections, deltah ≠ 0, clutter corrections

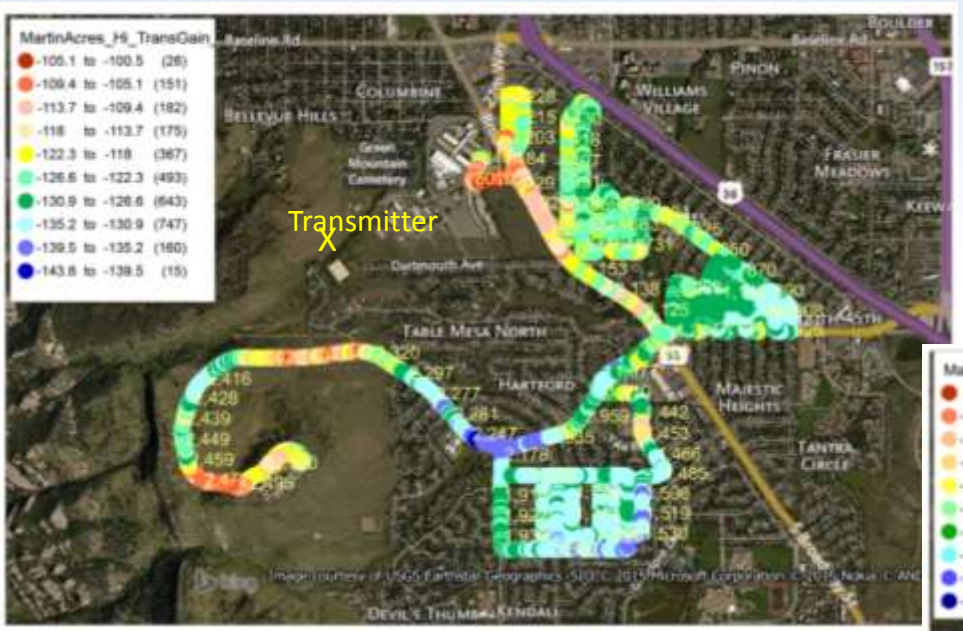


CSMAC Analysis

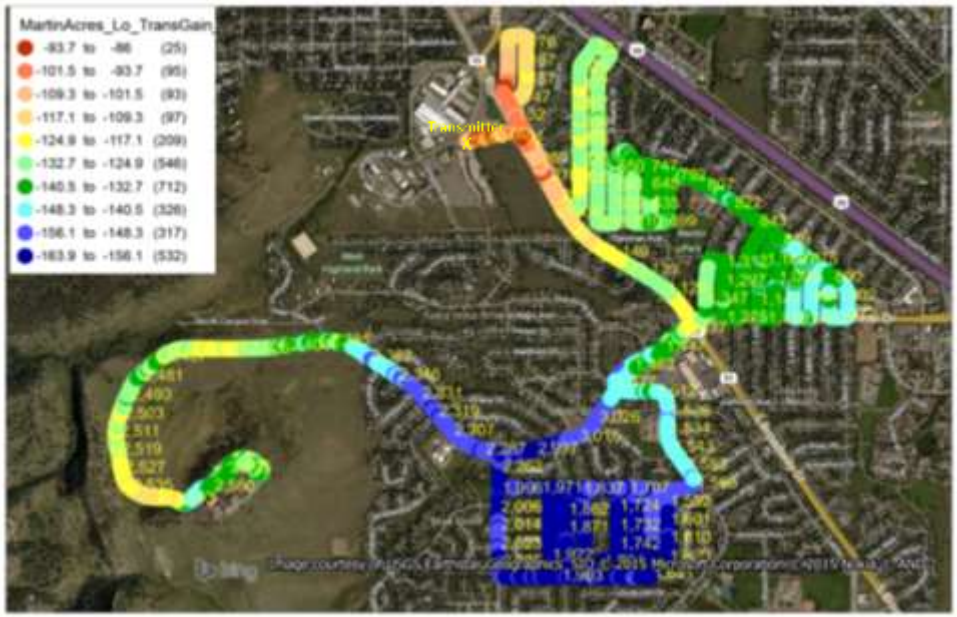


Transmission Gain

Transmitting Antenna on Green Mountain

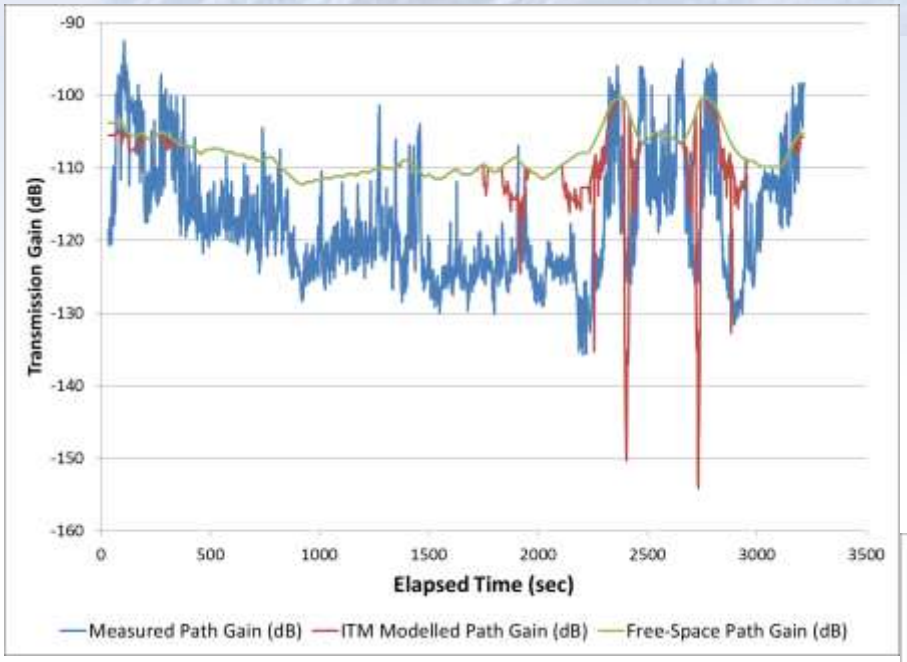


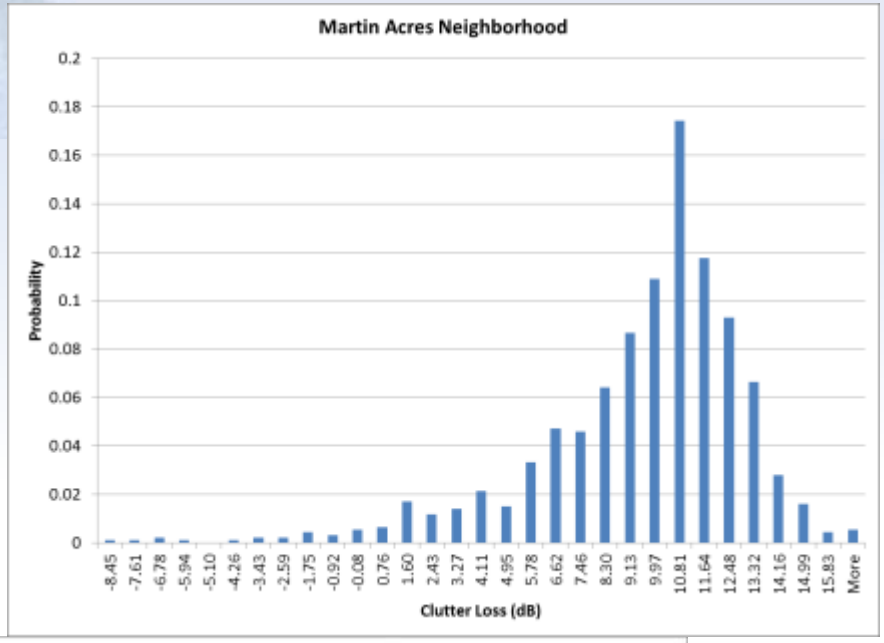
Transmitting Antenna on building 1 rooftop

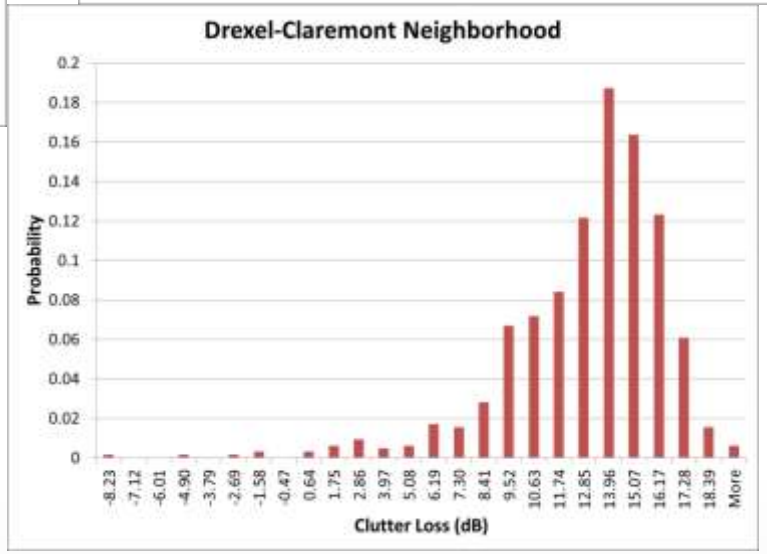


ITS

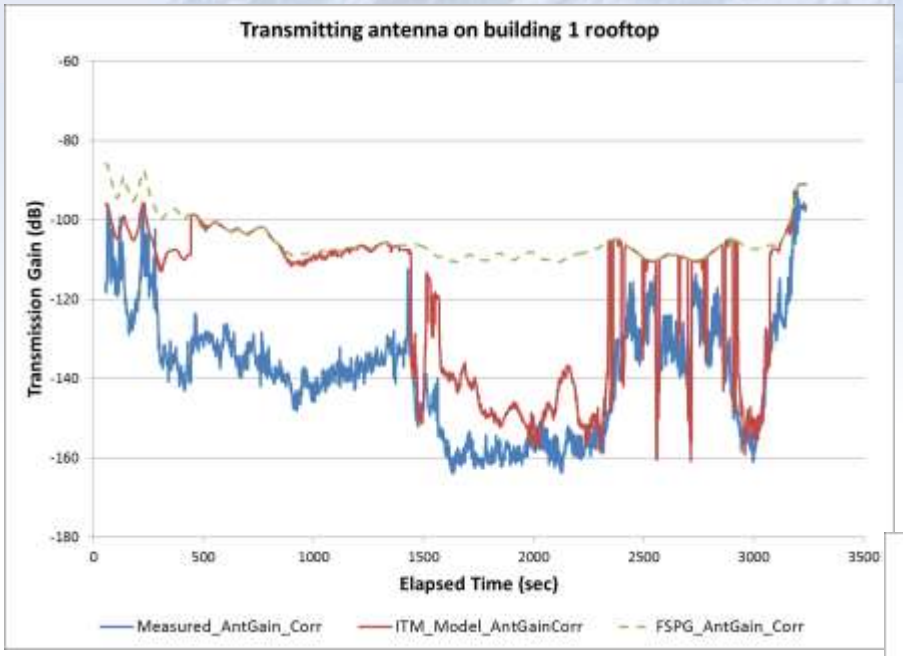
Transmitting Antenna on Green Mountain

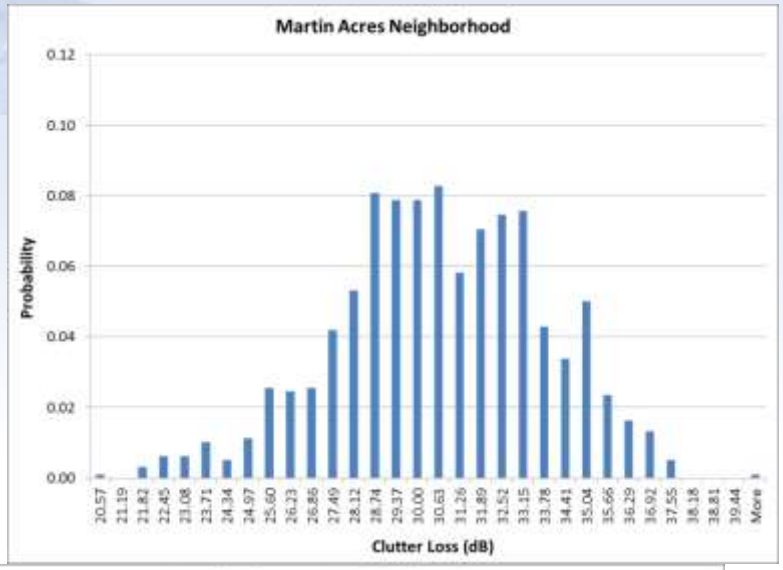


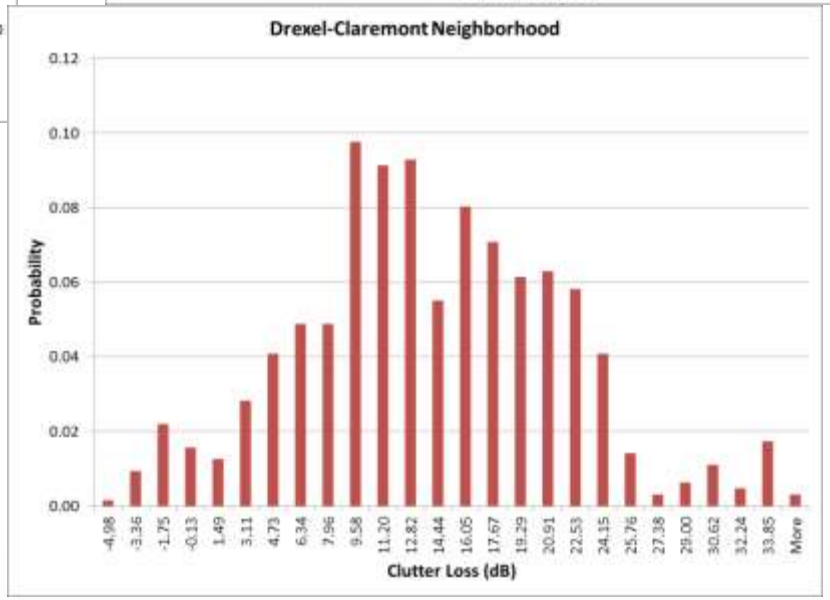




Transmitting antenna on building 1 rooftop



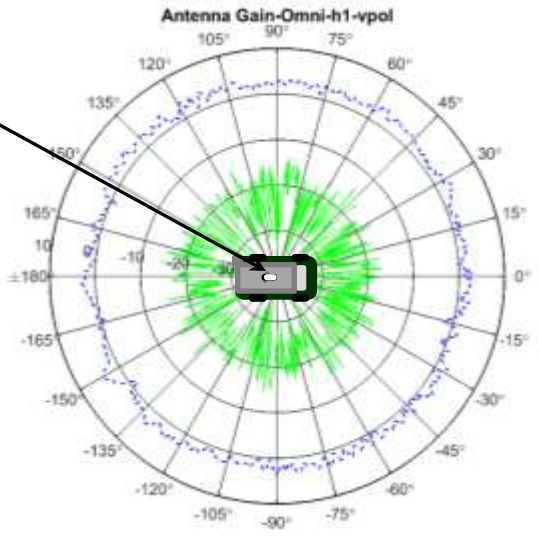




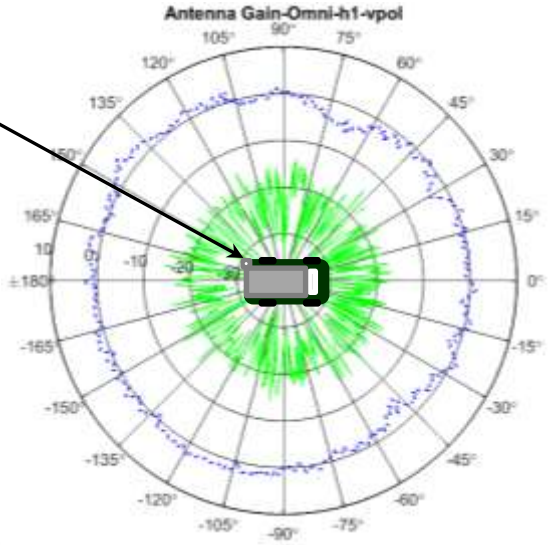
Antenna Pattern Measurements

- Antenna Pattern Measurements
  - Measured omni antenna on receiving van at various elevation angles.
  - Measured elevation and azimuthal patterns for transmitting antennas.

antenna in center of van



antenna on mast



ITS

Screening Experiments

Screening experiments are designed under the assumption that real-world processes are driven by only a few relevant factors.

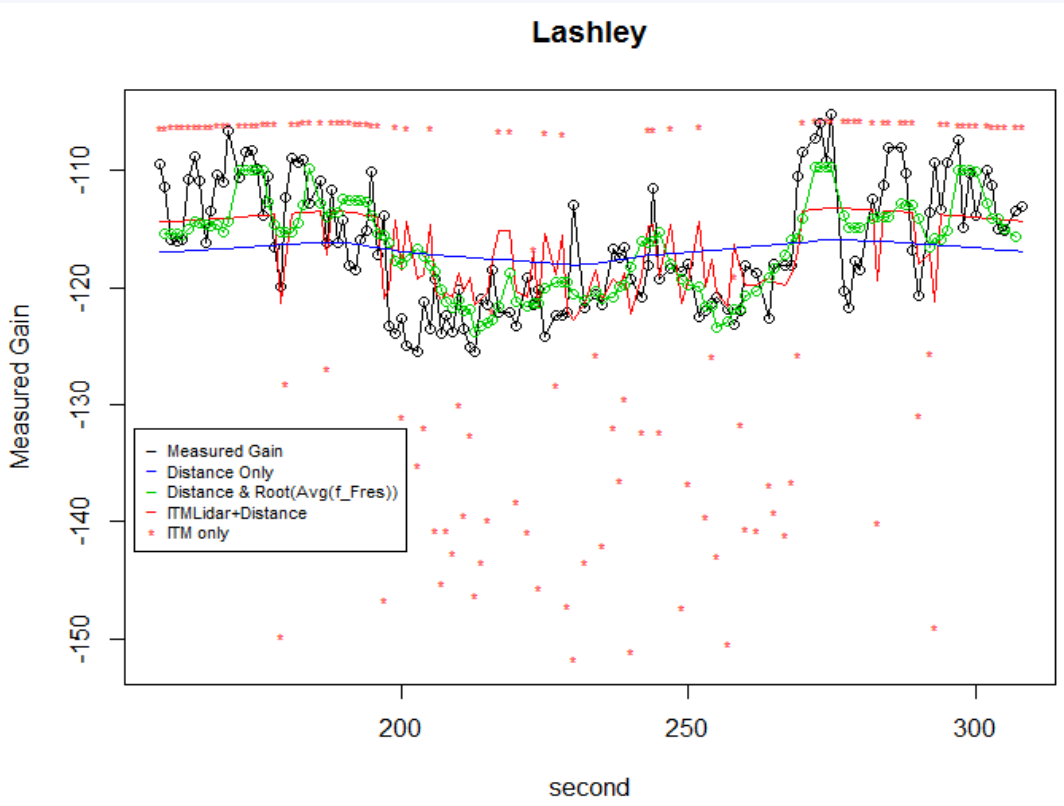
GOAL: determine the sensitivity of six variables on the criterion measure (e.g. path loss or "clutter") [Kirk, 2013]:

- Elevation Angle
- Frequency
- Local Traffic
- Clutter
- Power
- Speed

and all two-way interactions via the mean square error measure :

	Elev. Angle – Hi	Frequency – Hi	Traffic – Hi	Clutter – Hi	Power – Hi	Speed – Hi
Elev. Angle – Lo	+	+	+	+	+	–
Frequency – Lo	+	+	–	+	+	–
Traffic – Lo	–	–	+	–	–	–
Clutter – Lo	+	+	–	+	+	+
Power – Lo	+	+	+		+	–
Speed – Lo	–	–	+	+	–	–

Clutter Modeling based on LiDar data

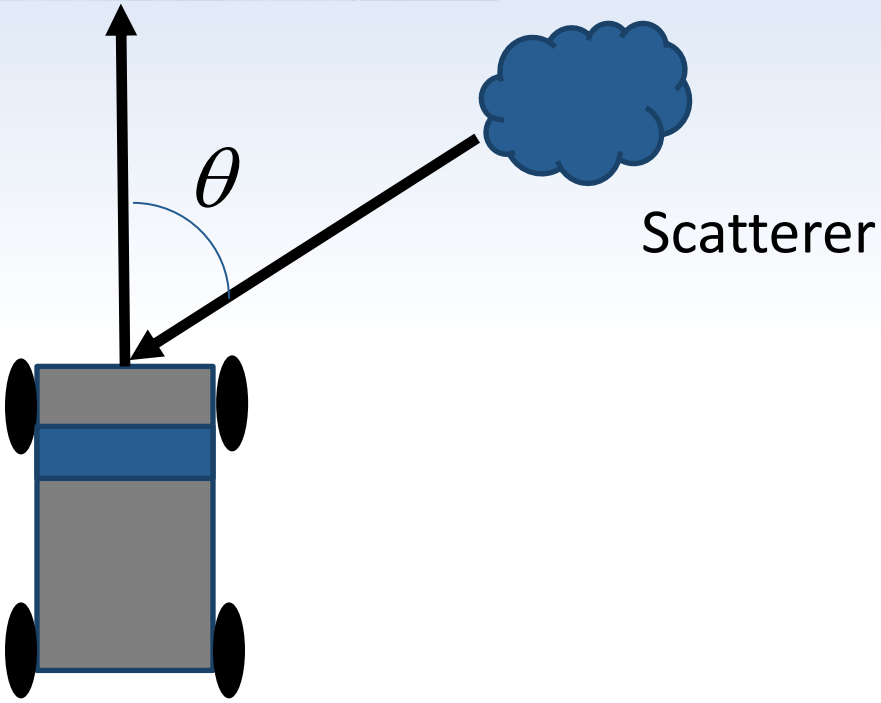


Additional Measurement System Capabilities:
Power Spectral Analysis

Power Spectral Analysis

- Baseband I-Q data acquisition with precise frequency references on transmitter & receiver
- De-trend received signal to isolate the fast-fading portion of the waveform
- Perform power spectral analysis in complex I-Q series
- The result of this is a baseband Doppler Spectrum
- Doppler shift: F_d = (carrier freq) x (speed) x $cos(\theta)$

Doppler Shift

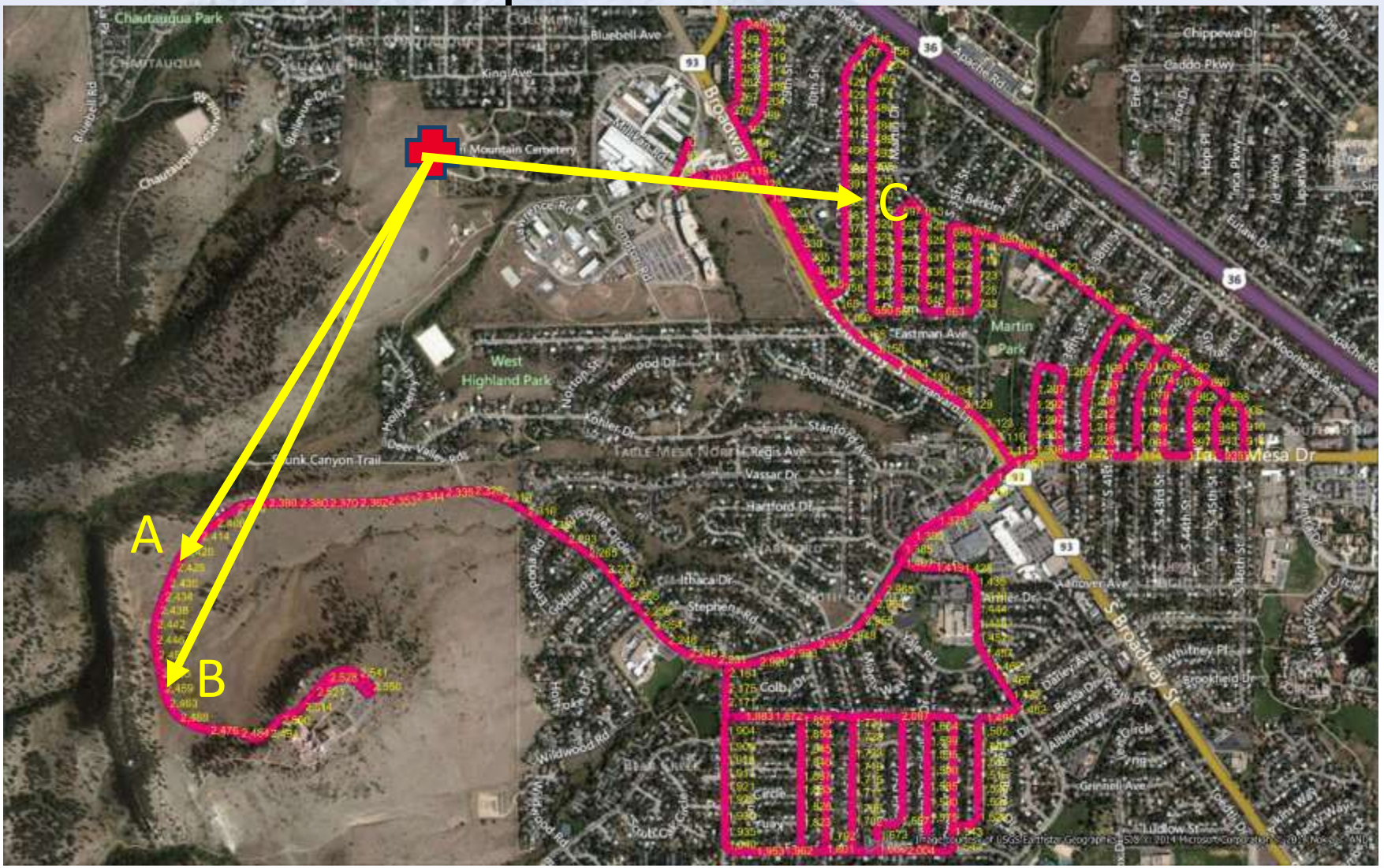


- Fd = (carrier freq/) x (speed)/c x $cos(\theta)$

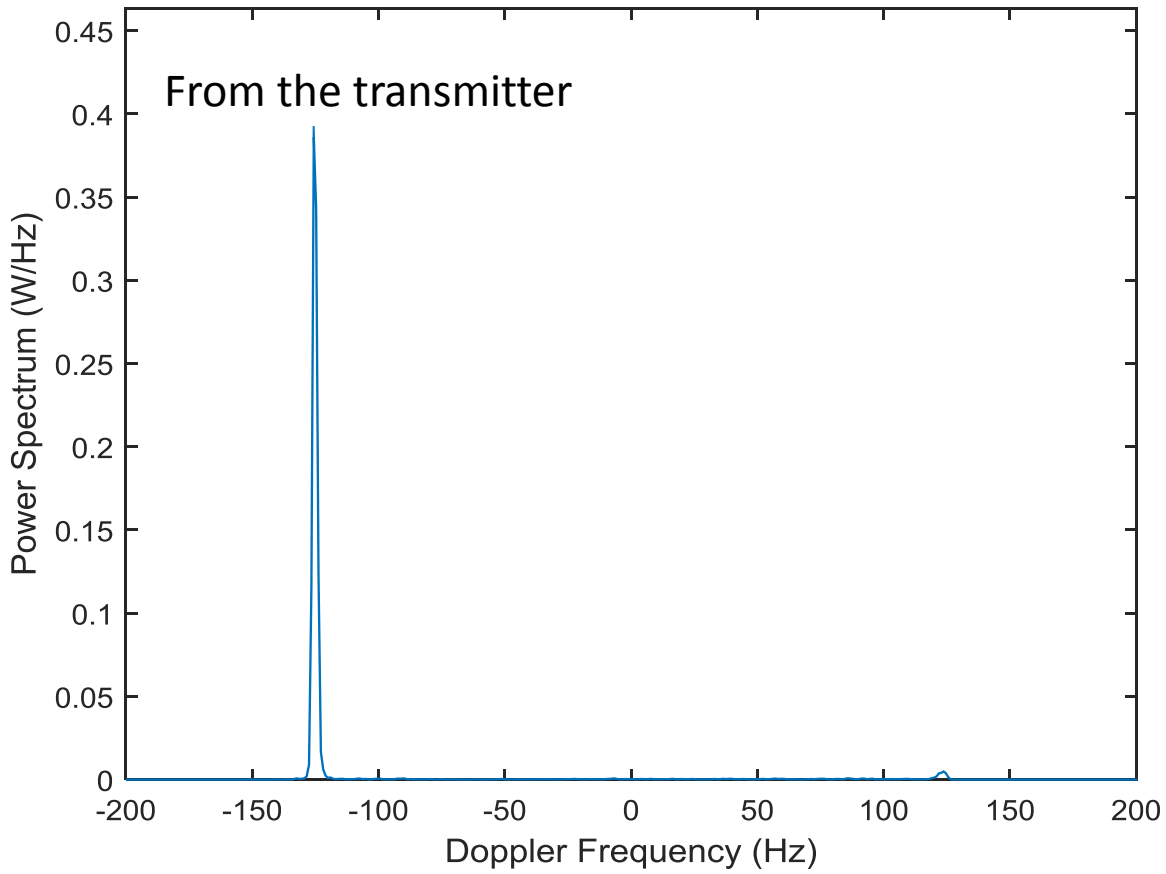
Observations

- The Doppler frequency is related to the direction of a radio wave relative to the direction of travel of the mobile measurement system
- The “radio wave” could either be directly from the transmitter or a scattered component
- Insight into the scattering environment
- Powerful enhancement!

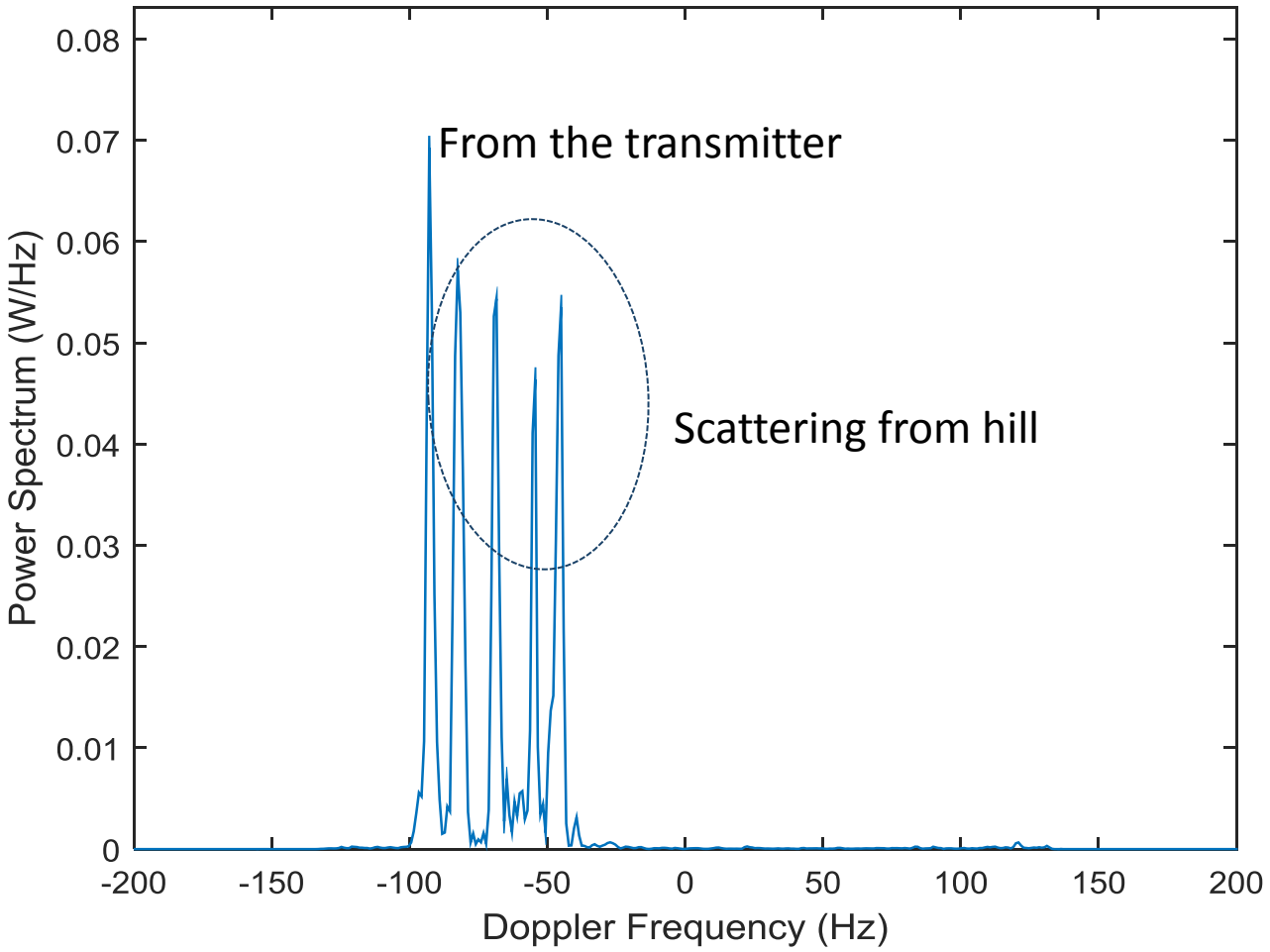
Example Test Drive Route



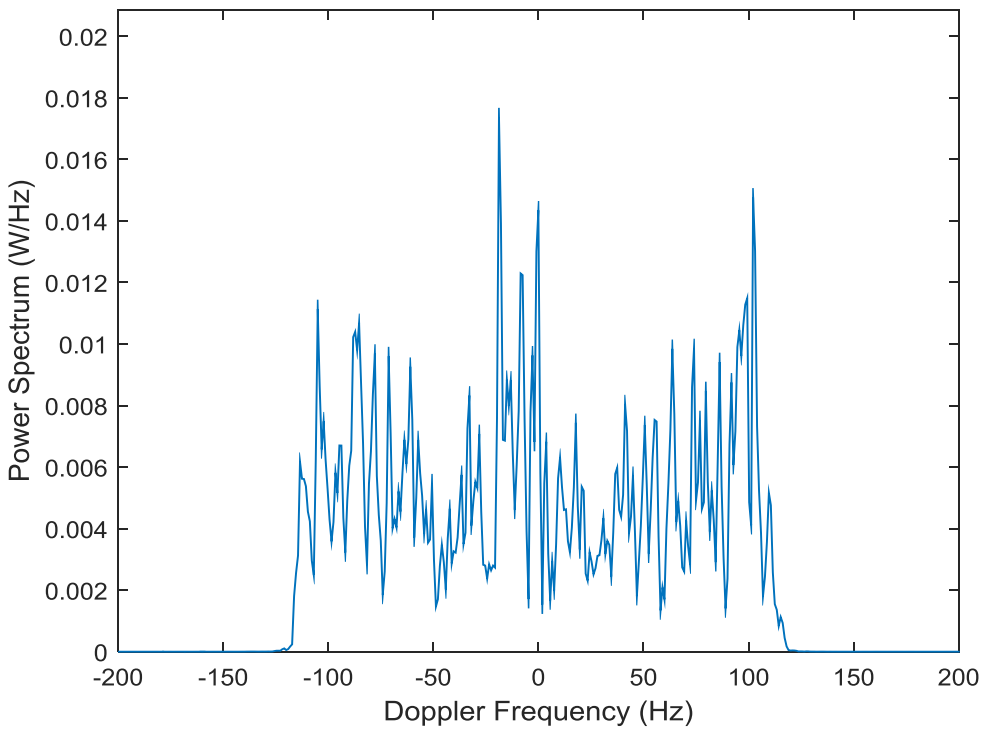
At point “A”-unobstructed



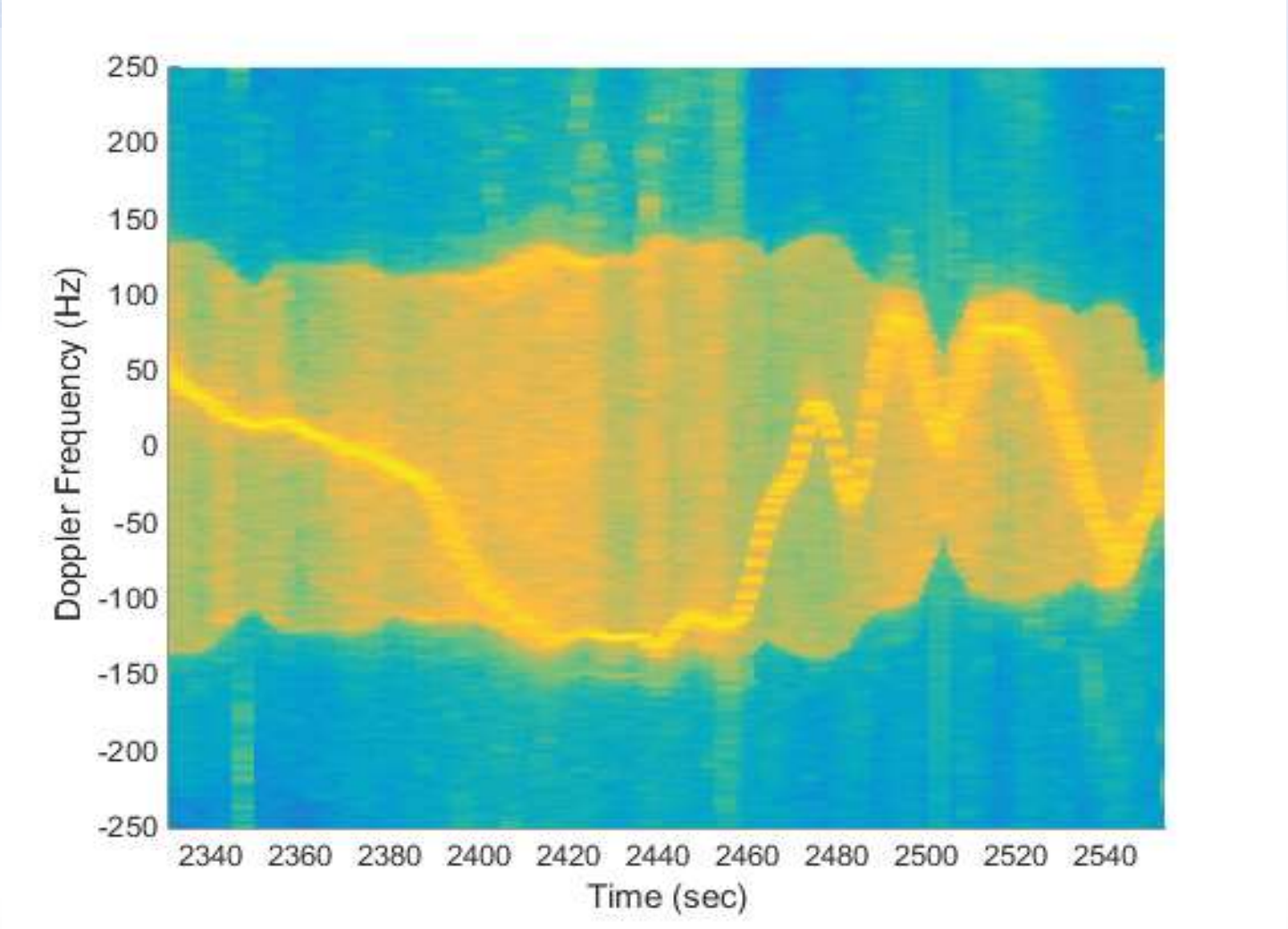
At Point “B” Reflections from hill



At Point “C”-Residential Area



Joint Time Power Spectrum Plot



Conclusions

- CW measurements combined with precise frequency references yields high performance measurement system
- Data can be processed at various levels to study path loss, power spectrum, and statistical analysis
- Practical system with high dynamic range & interference immunity
- Thank you ☺
- Questions???