Wind Turbine Results

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US Army Electronic Proving Ground

AGENDA

- Recommendations
- Tasks
- Summary
  - Timeline/Test Locations
  - Nordic Annual Power Production
  - Measurements
  - RF Models Reviewed
- Questions

RECOMMENDATIONS

- Recommend creation of a comprehensive Electromagnetic (EM) strategy requiring characterization of alternate energy systems prior to installation on Army facilities.
  - Provide scientific method to minimize EM effects of alternative energy systems on Army Installation-specific missions
    - Requires creation of a data-base for Army Installations defining mission in terms of systems and use of the EM spectrum
  - Electromagnetic strategy should require Vendors to provide System RF characterization
    - Inverter type
    - Measured RF emissions (DC – highest frequency used at facility)
    - Grounding configuration
    - Structure composition
  - Similar to the comprehensive environmental framework provided by National Environmental Policy Act (NEPA) for decision makers

RECOMMENDATIONS

- Recommend enhance Georgia Technical Research Institute (GTRI) ASPEN (Adaptive Sensor Prototyping Environment) Model
- ASPEN Model will provide a means to minimize / mitigate of Wind Turbine fields on RF system on Army Installations
  - Includes Doppler and amplitude modulation effects
  - Optimize turbine model selection
    - Tower height, Blade length, etc.
  - Include Small / Single Turbines
  - Determine standoff range
  - Mitigation
    - ASPEN current capability provides predictive algorithms to remove wind turbine effects from radar systems
  - Estimated cost for modification $450K (9 – 12 months)

RECOMMENDATIONS

- Recommend conducting structured study on the effects wind turbines specific to GPS signals
  - Observations during testing raise concern with GPS signal reception
    - Macho Springs Wind Farm, New Mexico
      - Loss of GPS
      - Loss of All Satellite Tracks
    - San Gorgonio Wind Farm, California
      - No loss of GPS Location
      - Loss of Satellite Track
    - No Effects Fort Huachuca, Arizona

TASKS

- Task 1: Record Electromagnetic (EM) Baseline measurements. Determine impact of several grounding and bonding schemes.
  - EM baseline is documented in final report.
  - Grounding & Bonding limited to single turbine (Ft. Huachuca).
- Task 2: Write a fully coordinated T & E Plan.
  - Distributed 30 Sep 2010
- Task 3: EPG will begin conducting T & E once the turbine is accepted by the government.
  - Completed, see timeline in slide 6

TASKS (cont.)

- Task 4: Invite other units on Ft. Huachuca to participate in testing.

Performed coordination with:

- US Army Construction Engineering Research Lab (CERL)
  - Cold Regions Research & Engineering Lab
- Ft. Huachuca Garrison
  - Libby Army Air Field
- US Army Intelligence Center of Excellence
- US Army Corps of Engineers
- Joint Interoperability Test Command (JITC)
- DoD Siting Clearinghouse
- Idaho National Lab
- Sandia National Lab
- US Dept. of Commerce
- US Air Force Tethered Aerostat Radar System (TARS)
- Eglin Air Force Base
- Edwards Air Force Base
  - Air Force Flight Test Center
- Naval Air Warfare Center – Pt.Mugu
- Naval Facility (NAVFAC) Engineering Service Center
- Westslope
- ComTech

TASKS (cont.)

- Task 5/6: Provide best suitable commercially available model to simulate commercial scale wind turbine effects on C4ISR and networks.
  - Research performed on four models, see recommendations.
- Task 7: Publish an intermediate report 90 days after the completion of Subtest 2.7.
  - Provided data on 22 Sep 2011, included in final report.
- Task 8: Publish the final report 90 days after completion of all EPG testing on the wind turbine, to include a suitable model to use in making recommendations on placement of commercial scale wind turbines on Army installations.
  - Final published Feb 2013, see timeline and recommendations.
- Task 9: Publish an update report for the second year of operation based on need dictated by the ACSIM and adequate funds provided.
  - All funds have been expended.

TIMELINE/TEST LOCATIONS

2010 2011 2012 2013

Initial Effort
- SOW and MIPR rec'd
- 15 Sep 2009

Warren Air Force Base, WY
- Happy Jack Wind Farm
- Initial EMI Measurements
- 17 – 18 Feb 2010

Test Plan Delivered
- 30 Sep 2010

Research & Coordination
- Started 15 Oct 2009

IPR
- 19 May 2010

Construction
- Started 14 Jan 2011
- Completed 19 Jan 2011

IPR
- 23 Feb 2011

Interim Report Delivered
- 22 Sep 2011

IPR
- 29 Nov 2011

Turbine Operational
- 17 Jan 2012

Macho Springs, NM
- GPS Degradation Measured
- 9 – 11 Apr 2012

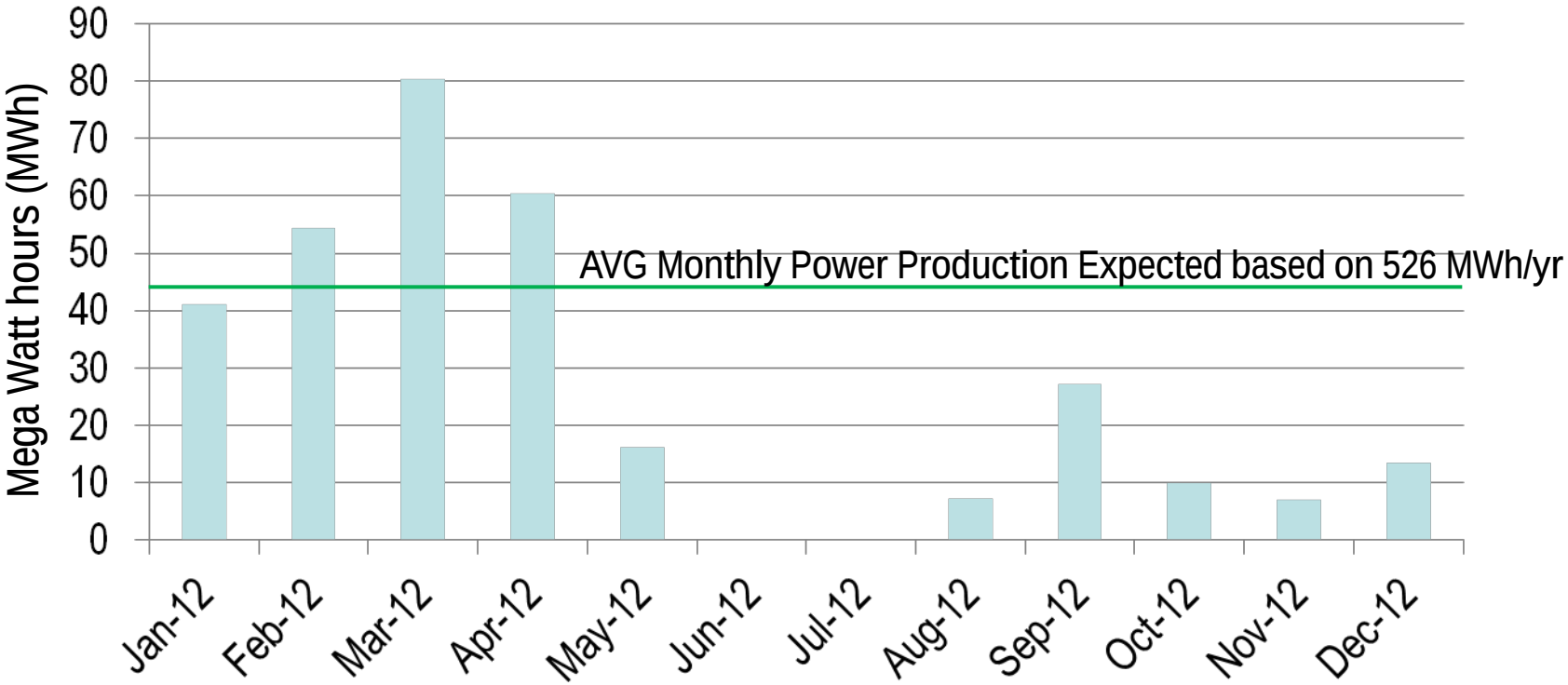
Coordination
- Completed 6 Sep 2012

IPR
- 2 Aug 2012

San Gorgonio, CA
- BER Measurements
- 20 – 22 Aug 2012

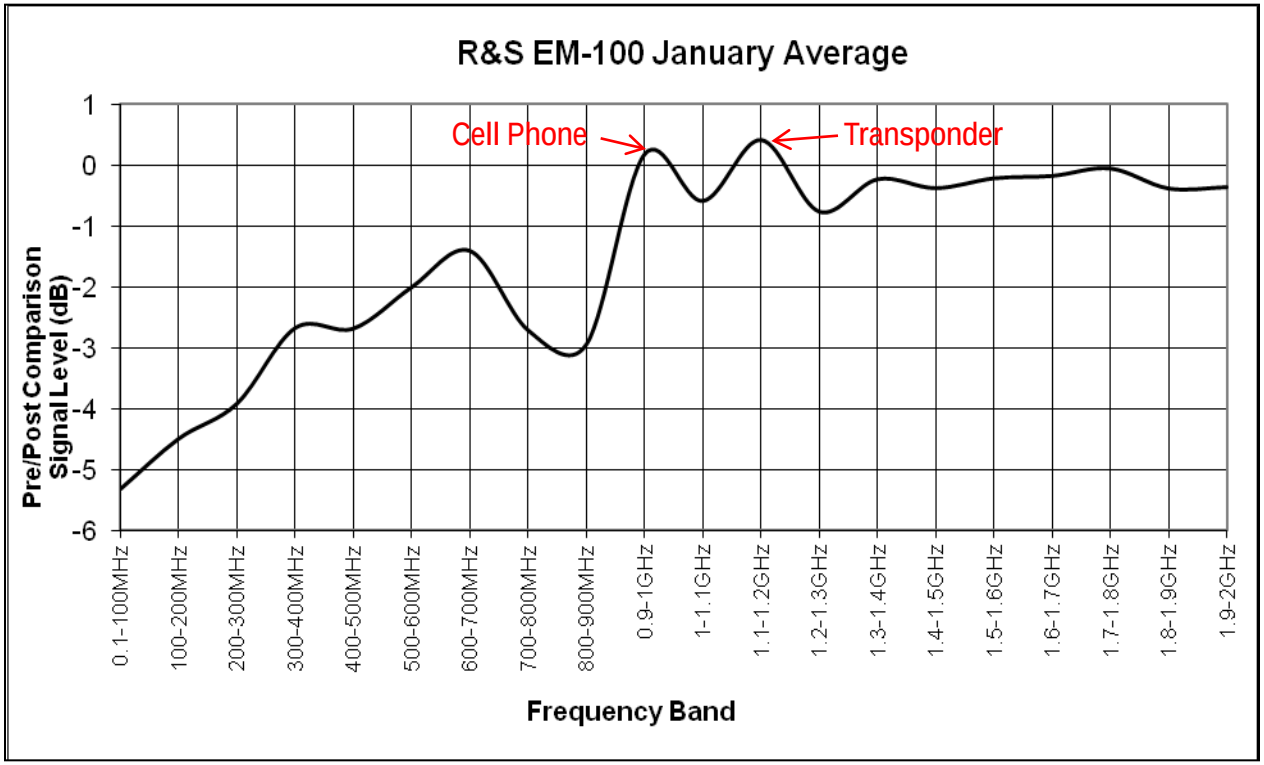
Deliver Final Report
- 12 Feb 2013

NORDIC ANNUAL POWER PRODUCTION



MEASUREMENTS

- Broad band RF signal attenuation up to 5 dB was measured shortly after the turbine was erected and prior to it being operational.



Signal Strength

0 dB	1
-1 dB	0.8
-2 dB	0.64
-3 dB	0.51
-4 dB	0.41
-5 dB	0.33

Comparison between ambient signal level – pre and post construction, averaged signal levels using scans from the R&S EM-100 receiver.

RADAR LOCATIONS

Distances from Wind Turbine	(km)
Tethered Aerostat Radar System:	3.0
Meteorological Radar:	8.1
Air Traffic Control Surveillance Radar:	10.0

Air Traffic Control Surveillance Radar

Specifications

- frequency: 2.7 and 2.9 GHz
- peak power: 25 Kilowatts
- average power: 2.1 Kilowatt
- displayed range: 60 nautical miles
- range resolution: 926 m (0.5 NM)
- beam width: 1.41°
- antenna rotation: 12 RPM

No interference was observed by the ATC Radar (ASR-11) at Libby Army Air Field on Ft. Huachuca.

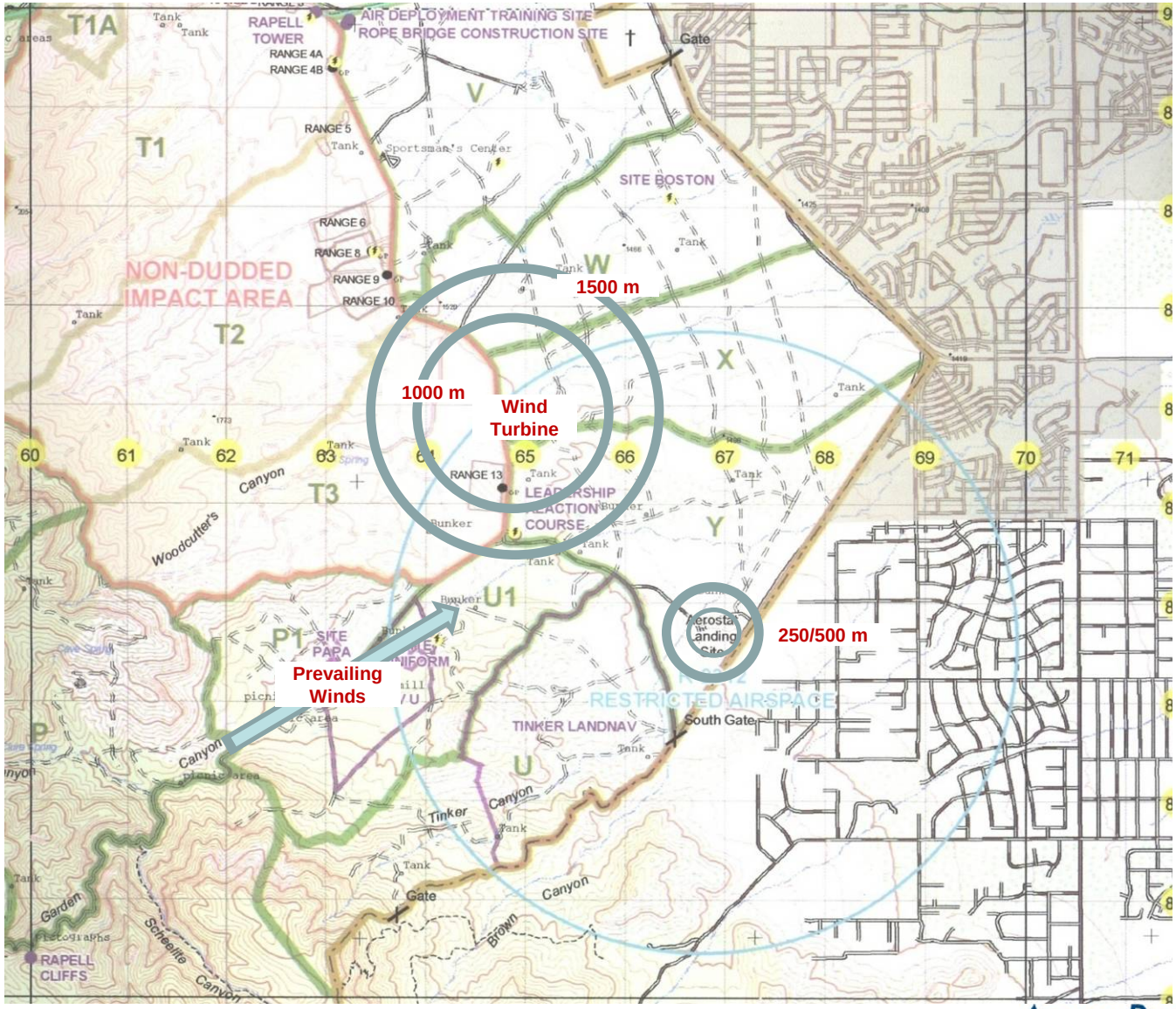
Weather Radar Antenna

Antenna

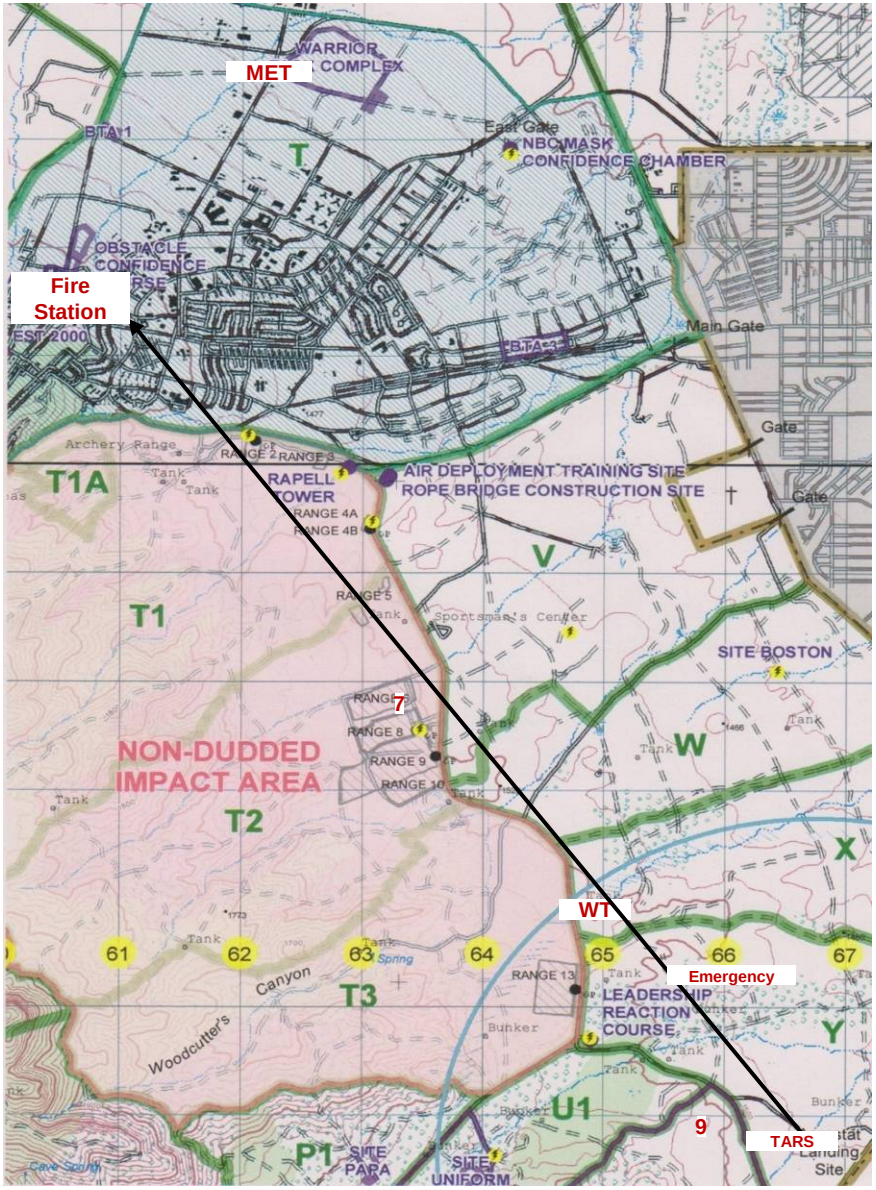
WEATHER RADAR	
LOCATED ON BASE, BUT 6.8 MILES OFF SITE	
LATITUDE	31º 34’30”N
LONGITUDE	110º 20’38”N
WEATHER MODE	5441.4812 (5441.4) MHz
TURBULENCE MODE	5439.9975 (5440.0) MHz

No interference was observed by the MET Weather Radar, or with the communication link to the meteorological station on the South Range of Ft. Huachuca.

Tethered Aerostat Radar System (TARS) Concern



TARS Concern



During measurements and investigations on Ft. Huachuca a signal generated at the TARS facility traversing the wind turbine site was identified. No interference has been observed on this signal - Fire Alarm link since the turbine became operational in Jan 2012.

MEASUREMENTS

- EM Spectrum monitoring before, during, and after construction revealed that the turbine structure creates a multipath and possible RF sink phenomenon.

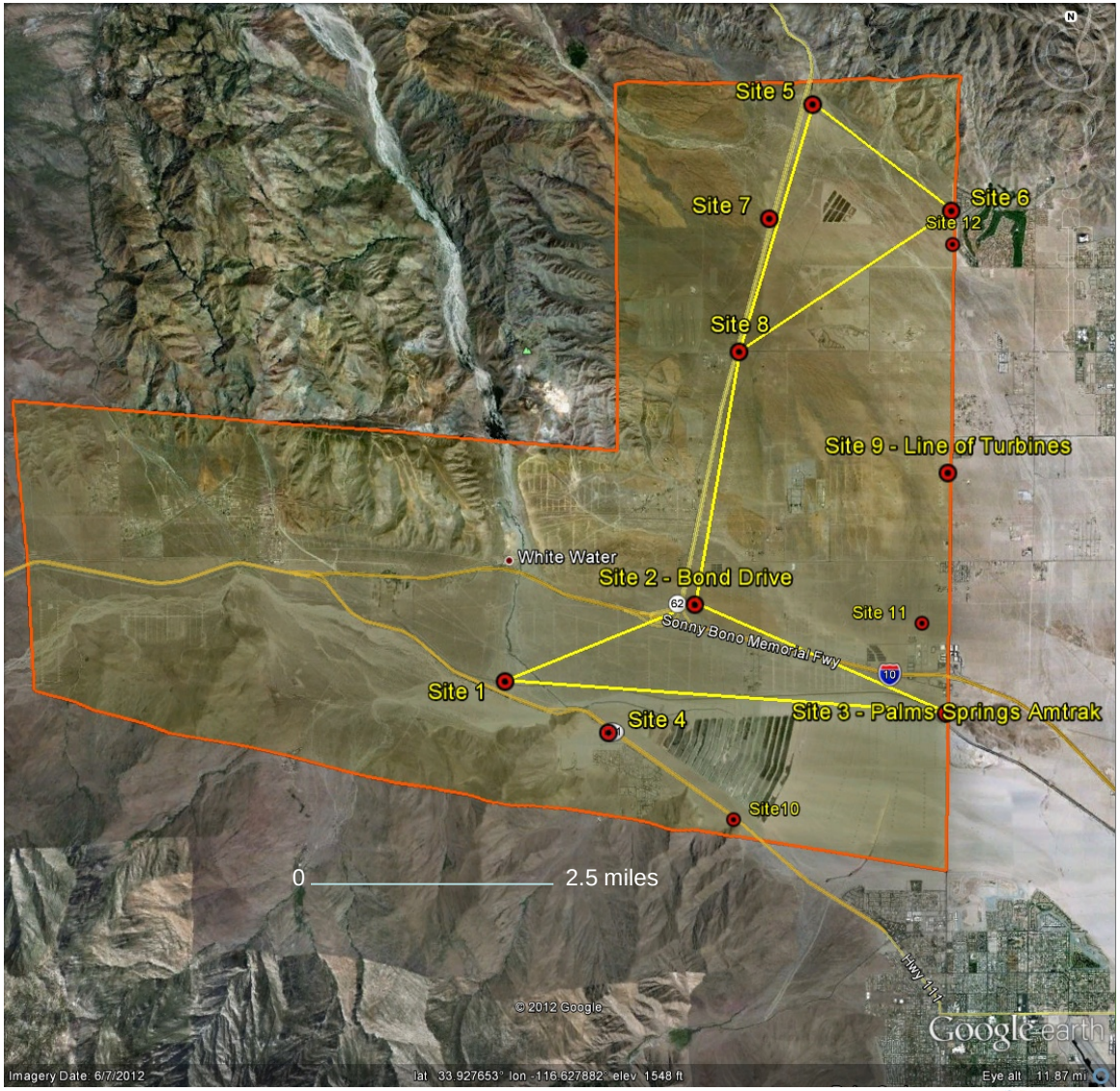
(Play Multipath Video Clip in loop mode)

MEASUREMENTS (cont.)

There was substantial multipath interference that impacted tactical communications. Additionally, the SINCGARS and AN/PRC-117 were tested with limited approved frequency coverage. Interference was observed due to multipath phenomenon as demonstrated by significantly increased BIT Error Rates.

(Play Tactical Comms Video Clip in loop mode**)**

SAN GORGONIO



TACTICAL COMMS RESULTS

		Inside the Wind Farm (Aug 22nd)											
		Link A				Link B				Link C			
		Site 1 to 2		Site 2 to 1		Site 1 to 3		Site 3 to 1		Site 2 to 3		Site 3 to 2	
Frequency	Waveform	BER	RSL	BER	RSL	BER	RSL	BER	RSL	BER	RSL	BER	RSL
30.050 MHz	SINCGARS	-	-109	10.50%	-79.6	-	-83.45	18.50%	-84.9	6.19%	-78.76	-	-108
34.650 MHz	SINCGARS	7.46%	-107	13.40%	-105.7	9.56%	-83.16	0.67%	-84.2	5.11%	-77.01	13.50%	-106
36.900 MHz	SINCGARS	9.06%	-110	9.10%	-109.3	3.99%	-78.24	0.14%	-78.54	0.27%	-79.04	8.21%	-113
38.375 MHz	SINCGARS	9.46%	-107	9.35%	-114.7	1.08%	-92.29	0.23%	-93.25	0.59%	-79.57	12.10%	-109
49.825 MHz	SINCGARS	7.65%	-114	7.57%	-114.2	-	-79.81	0.88%	-79.31	0.03%	-75.15	-	-106
235.275 MHz	VULOS	11.40%	-114	0.71%	-83.81	0.04%	-96.48	0.71%	-95.34	0.74%	-84.56	0.75%	-81
237.175 MHz	VULOS	6.11%	-118	0.71%	-86.94	3.66%	-100.8	0.86%	-99.58	-	-89.37	-	-92
274.975 MHz	VULOS	1.12%	-114	1.09%	-82.22	-	-95.89	-	-93.7	0.88%	-76.06	0.74%	-71
305.375 MHz	VULOS	-	-80	1.36%	-80.83	-	-84.97	1.21%	-84.31	-	-79.06	0.87%	-76
378.725 MHz	VULOS	1.48%	-112	1.01%	-83.27	-	-89.72	-	-89.61	0.96%	-82.87	0.83%	-80

		Baseline Outside Wind Farm (Aug 23rd)											
		Link A				Link B				Link C			
		Site 5 to 6		Site 6 to 5		Site 5 to 8		Site 8 to 5		Site 6 to 8		Site 8 to 6	
Frequency	Waveform	BER	RSL	BER	RSL	BER	RSL	BER	RSL	BER	RSL	BER	RSL
30.050 MHz	SINCGARS	2.81%	-109	-	-79.6	-	-80.9	0%	-84.51	0.00%	-86.87	0.33%	-108
34.650 MHz	SINCGARS	0.00%	-107	0.00%	-105	0.00%	-78.8	0.00%	-84.6	0.00%	-83.46	0.02%	-106
36.900 MHz	SINCGARS	0.05%	-110	0.22%	-109.9	0.00%	-79.9	0.00%	-79.69	0.00%	-83.97	7.20%	-113
38.375 MHz	SINCGARS	0.00%	-107	2.79%	-114	4.64%	-78.42	-		2.11%	-84.57	8.32%	-109
49.825 MHz	SINCGARS	0.01%	-114	2.68%	-114.6	0.00%	-82.59	0.00%	-82.05	0.00%	-84.64	0.01%	-106
235.275 MHz	VULOS	0.04%	-114	0.76%	-98.41	0.00%	-91.08	0.08%	-95	3.90%	-104.3	7.04%	-100
237.175 MHz	VULOS	0.00%	-115	0.80%	-105.6	3.33%	-92.99	2.17%	-99.1	-	-104.4	-	-100
274.975 MHz	VULOS	0.39%	-114	0.91%	-84.72	-	-103.4	-	-100.4	0.97%	-105.3	5.79%	-103
305.375 MHz	VULOS	0.02%	-80	0.91%	-80.35	0.00%	-88.89	1.02%	-94.11	-	-94.69	6.90%	-91
378.725 MHz	VULOS	2.38%	-112	0.92%	-84.2	1.53%	-90.19	4.05%	-89.91	0.92%	-99.86	0.82%	-98

RF MODELS REVIEWED

Model	Spinning Blades	Radar	Comms
ATDI (Electronic Warfare)	R	G	G
QinetiQ (Stealth Technology)	G	G	R
AGI (Satellites)	G	G	R
GTRI (Academia)	G	G	R

R No Capability

G Adequate

QUESTIONS?