Raytheon

TUCSON TEST FACILITY PRESENTATION

Outline of Presentation

- Purpose
- Background
- Relevant Frequencies
- Technical Specifications
- Conclusion

Background

- Explain use of discrete frequencies and two frequency bands from 2-39 GHz at Raytheon Missile Systems (RMS) Tucson Test Facility (TTF) under the existing experimental license, KA2XAG.
- The purpose of the experimentation is to use radio signals to look at objects.
- RMS experimental license for this facility, KA2XAG, has been around for more than 20 yrs.
- Continuous spectrum is essential.
- Interference plots show no likely interference, and signals should stay on range.

KA2XAG and Navy Frequency Assignments Needed

- This question was the subject of discussion in meetings with the FCC and the Navy in 2008, 2009, and 2011. Both an FCC experimental license and a Navy Frequency Assignment are needed.

- Some of the testing at this range is conducted as independent research and development work – requiring Raytheon Missile Systems to hold an experimental license – KA2XAG

- Some of the testing at this range is conducted under a contract with the Navy, and that testing needs to be conducted under the auspices of a frequency assignment from the Navy – the plant is operated by the Air Force, but it is under the command of a Navy Captain.

- To comply with these requirements, we must renew both the FCC license and the Navy frequency assignments. This presentation is submitted in support of the FCC renewal application.

Required Spectrum

Navy Frequency Assignments:

155 MHz

815 MHz

1300 MHz

2000 – 4000 MHz

4000 – 8000 MHz

8000 – 12000 MHz

12000 – 18000 MHz

32000 – 39000 MHz

KA2XAG:

155 MHz

815 MHz

1300 MHz

2000 - 4000 MHz

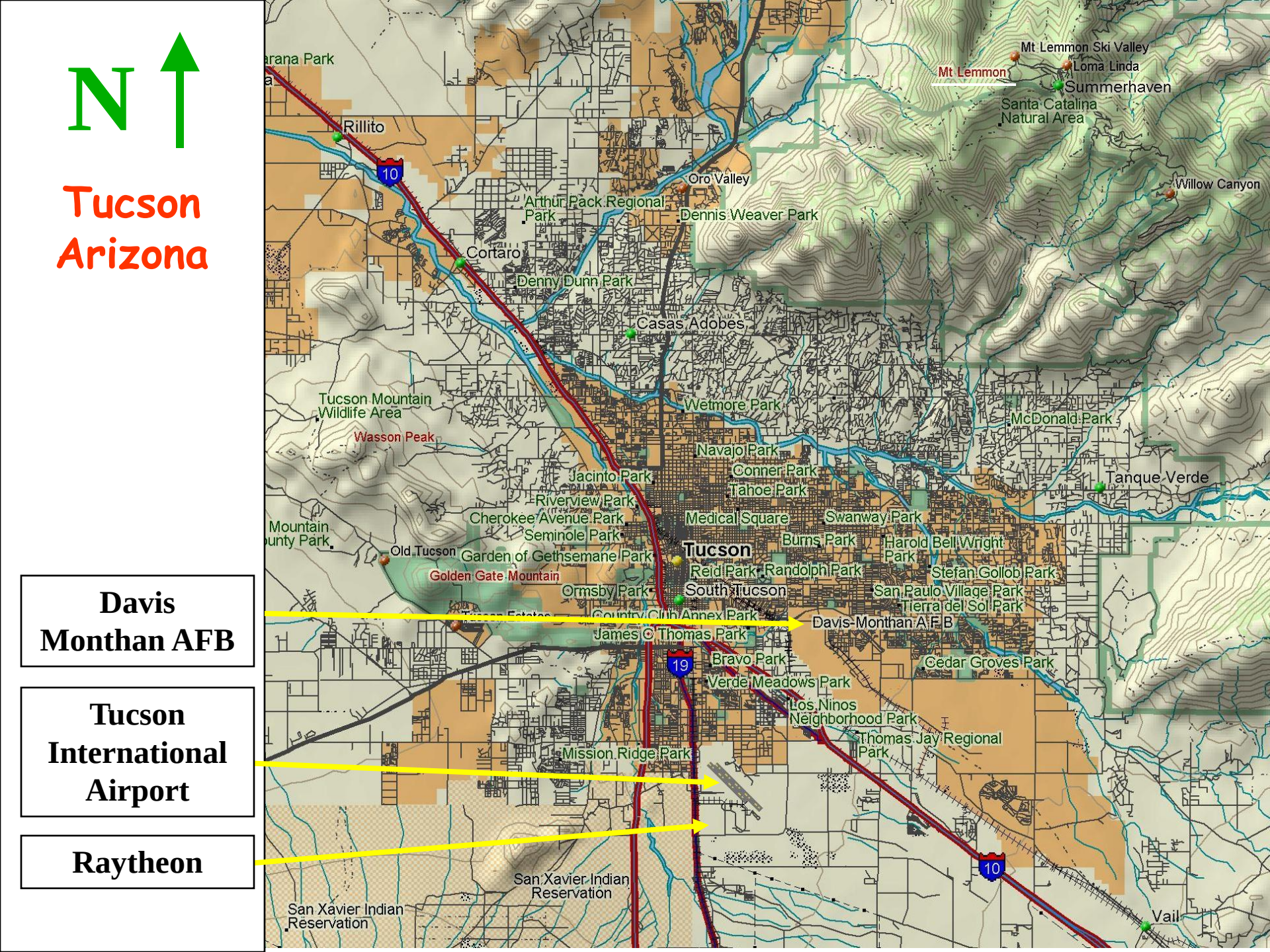
4000 - 8000 MHz

8000 - 12000 MHz

12000 - 18000 MHz

32000 - 39000 MHz

Required Spectrum is the same for both.


N
Tucson
Arizona
Davis
Monthan AFB
Tucson
International
Airport
Raytheon
Rillito
Oro Valley
Arthur Pack Regional Park
Dennis Weaver Park
Cortaro
Denny Dunn Park
Casas Adobes
Tucson Mountain Wildlife Area
Wasson Peak
Wetmore Park
McDonald Park
Navajo Park
Conner Park
Tahoe Park
Jacinto Park
Riverview Park
Cherokee Avenue Park
Seminole Park
Medical Square
Swanway Park
Burns Park
Harold Bell Wright Park
Old Tucson
Garden of Gethsemane Park
Golden Gate Mountain
Tucson
Reid Park
Randolph Park
Stefan Gollob Park
Ormsby Park
South Tucson
San Paulo Village Park
Tierra del Sol Park
Country Club Annex Park
Davis-Monthan A.F.B.
James O. Thomas Park
Bravo Park
Cedar Groves Park
Verde Meadows Park
Los Ninos Neighborhood Park
Thomas Jay Regional Park
Mission Ridge Park
San Xavier Indian Reservation
San Xavier Indian Reservation
Tanque Verde
Vail
Mt Lemmon Ski Valley
Loma Linda
Mt Lemmon
Summerhaven
Santa Catalina Natural Area
Willow Canyon
10
19
10

Air Force Plant 44

Technical Specifications

Tucson Test Facility (TTF)

- RCS Measurement Capabilities
  - Full-up Vehicle and Component Acceptance Testing
  - Research and Development
- RCS Measurement Specification
  - Type: Outdoor 520-foot Ground Bounce Range
  - Radar: élan 98, Pulsed, Coherent
  - Low Duty Cycle: <0.007%
  - Frequency: VHF/UHF – Discrete; L - Ku Band & Ka - Stepped
  - Step size: 10 MHz steps, minimum
  - Pulse Width 70 nanoseconds
  - Polarization: Linear Orthogonal Pulse-to-Pulse
  - Test time per freq 387 milliseconds maximum per day
  - Sweeps per test 128
  - Angles tested 3600 (0.1 degree angles)
  - Antenna azimuth 237 degrees, narrow (pencil) beamwidth

Tucson Test Facility Test Time

Test Time (RF on per freq)		Total Test Time	
3600	Angles	0.00000007	seconds per pulse
128	sweeps per angle	2300	frequencies
460,800	numbers of sweeps per pattern	0.000161	seconds per sweep
7E-08	70 ns per pulse	128	sweeps
0.032256	Time for one pattern per freq	0.020608	seconds per 128 sweeps
6	patterns	3600	angles
0.193536	6 patterns per day	74.1888	seconds per 3600 angles
2	polarizations	2	polarizations
0.387072	seconds per freq	148.3776	seconds for both polarizations
890.2656	Total test time per day	6	patterns
		890.2656	Total test time per day seconds
		14.83776	Total test time per day minutes

16000 MHz	2 to 18 GHz	7000 MHz	32 GHz to 39 GHz

Average Power Calculation

100	Peak Watts
0.000434783	Pulse width over Pulse repetition Frequency
0.043478261	Avg power watts

Transmission Characteristics for Required Spectrum

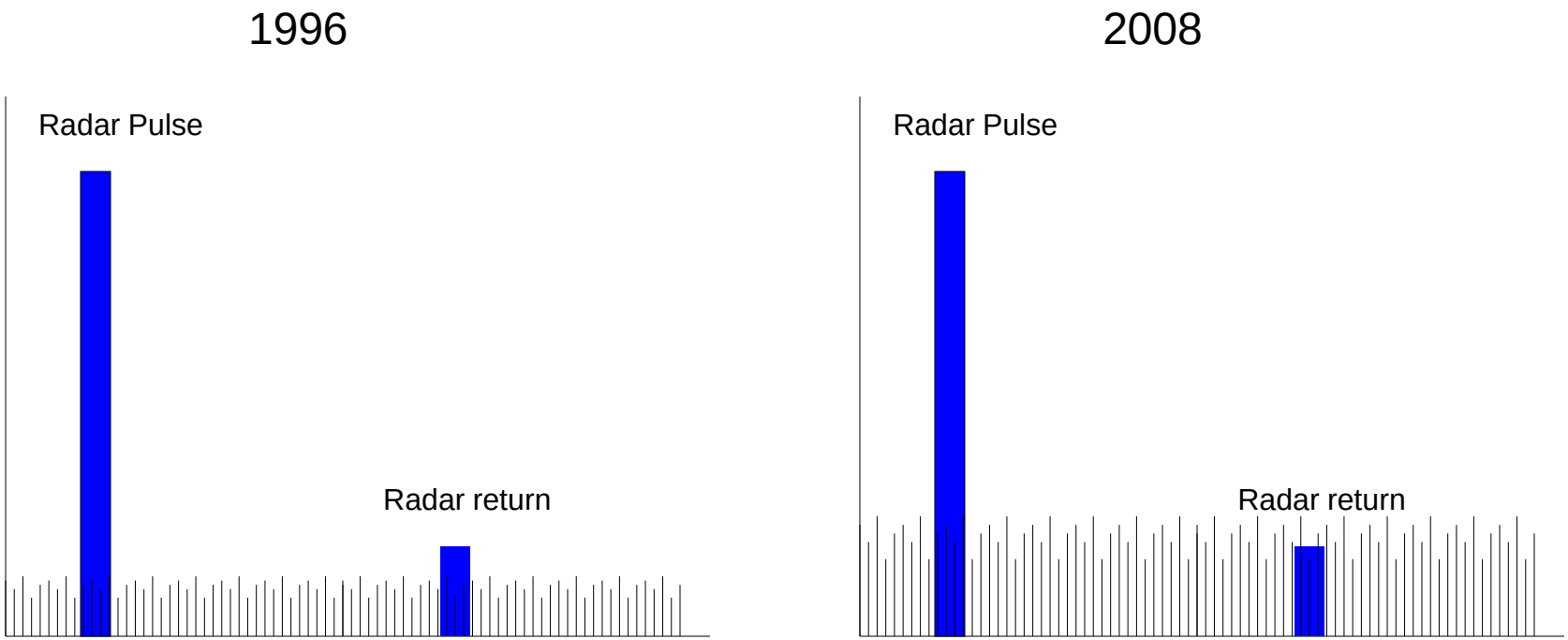
Frequency (GHz)	Power Level (Watts)	Coax Loss (db)	Antenna Gain (dBi)	ERP (Watts)	Main Beam Width (degrees)	Backlobe Antenna Gain (dBi)
0.155	10	3.49	12	43	2.3	-22
0.815	100	7.83	24	2.495	3	-22
1.3	100	1.31	28	28,119	2.3	-18
2.0-4.0	100	1.59	32	66,222	3.5	-18
4.0-8.0	100	2.19	30	36,392	5.5	-18
8.0-12.0	100	3.1	33	58,884	3.2	-20
12.0-18.0	100	3.84	34	62,517	3	-18.5
32.0-39.0	10	10.2	37	2,884	2.5	-19

This is peak power, average power is much lower
All Antennas pitched down toward the ground at 0.5 degrees, azimuth 237

Required Power Level

- The power levels that are currently in use under KA2XAG are required for the range to accomplish its work: 100 W of power at the transmitter, but *only 10 W for 155 MHz and 32-39 GHz.*
- Lower power operations will not allow the range to accomplish its goals
- The power levels proposed has not caused any harmful interference
- The next slide shows the increase in the noise floor between 1996 and 2008. It was in 2008 that Raytheon Missile Systems sought and received approval for operations at 100 W for most of the frequencies.
- There have been no complaints of harmful interference since 2008, when operations have been at the powers listed on the slide above.

Radar Pulses



Background noise increased during those 12 years

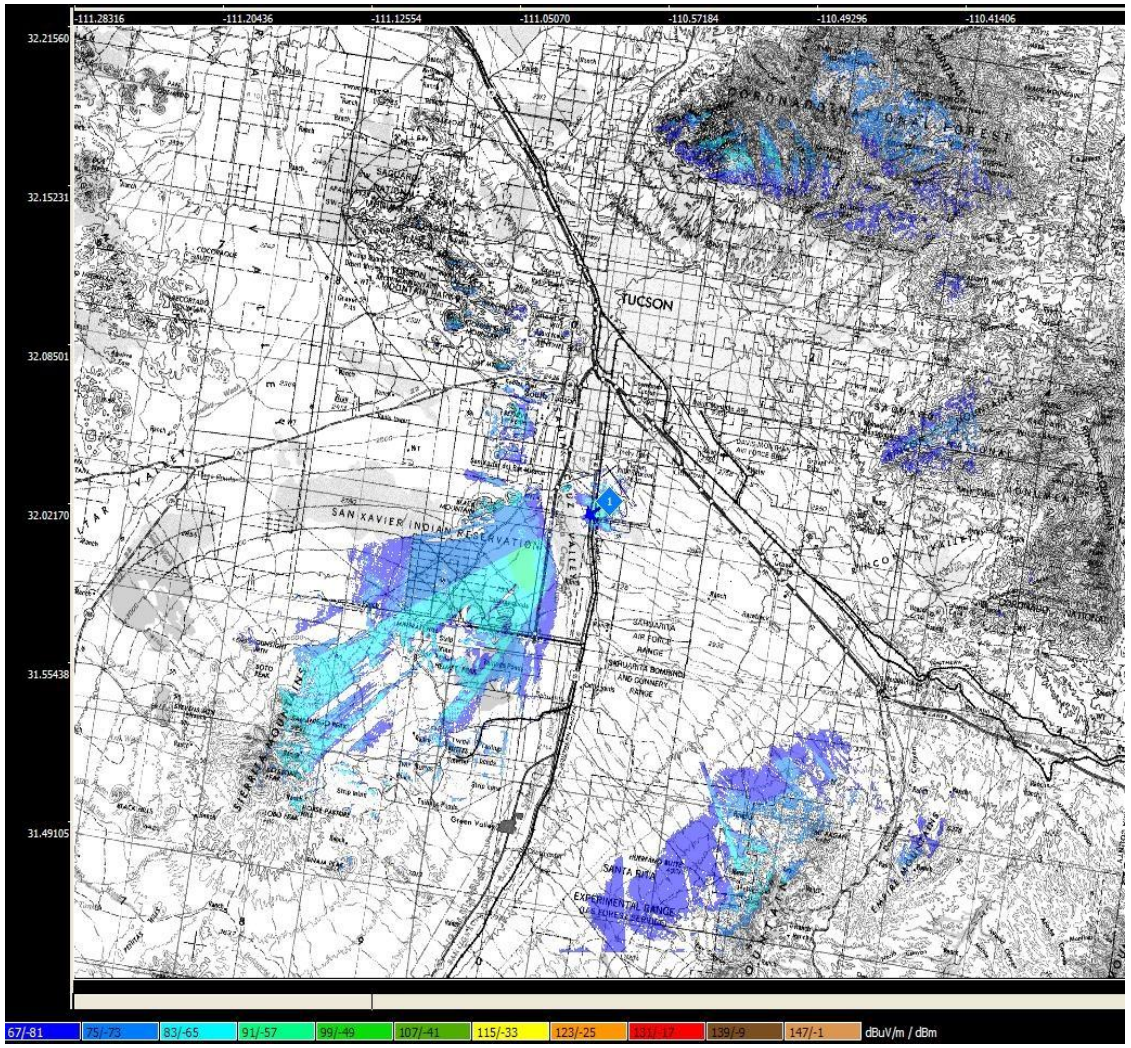
Power increase was needed to see radar return; 2008 levels are still required for effective operations.

Spectrum plots

- To analyze the potential for interference, RMS ran spectrum plots using Hertz Warfare software.
- We ran plots for each of the relevant frequency bands
- The plots ***do not*** take into account the attenuating effect of buildings, there are buildings shielding the backlobes of the antennas and around the range.
- The pages that follow show that the highest predicted signal level off the Raytheon facility is very low. In most cases, less than -60 dBm.

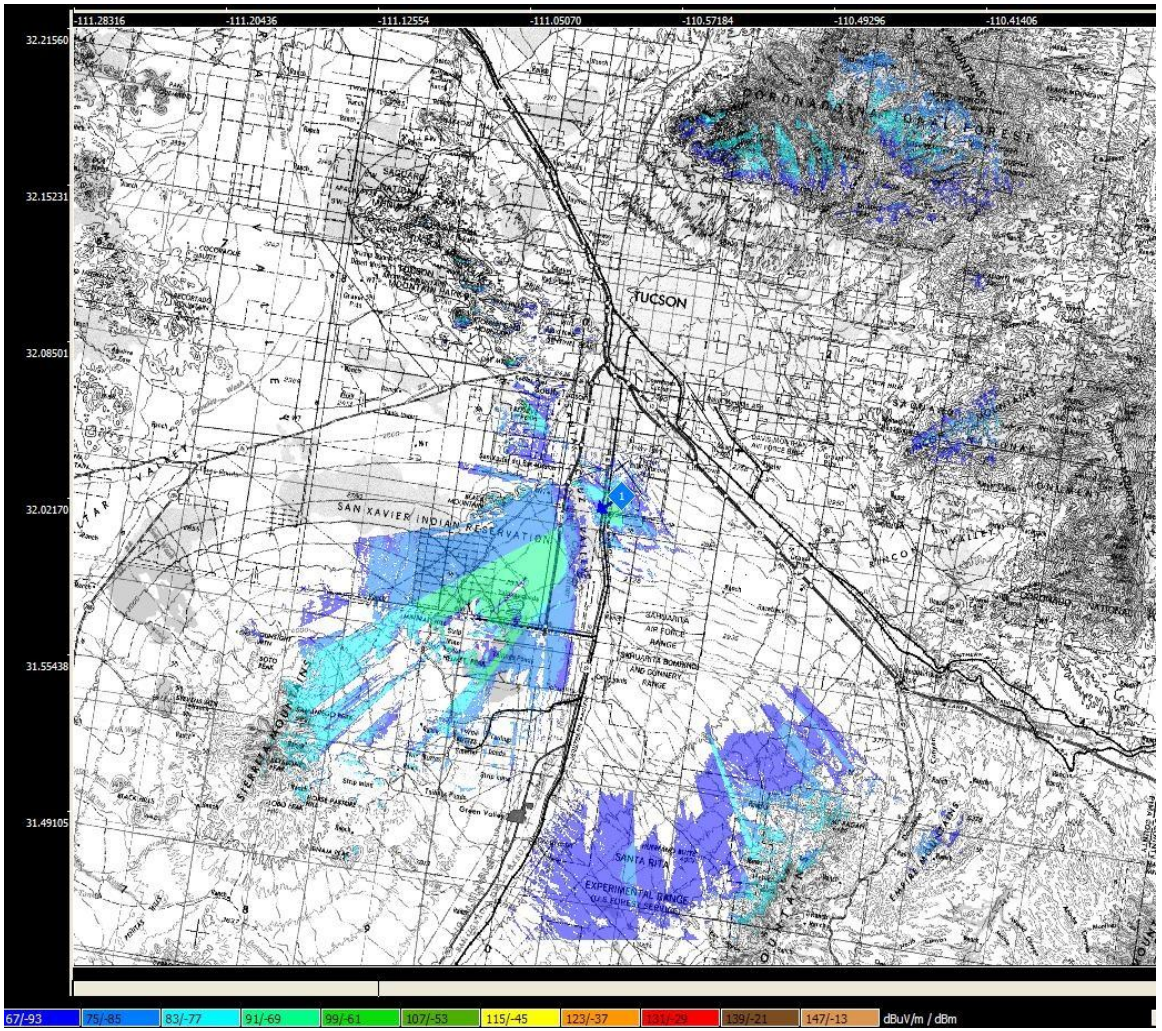
RF Analysis – 3700 MHz

- 3700 MHz
- Narrow beam width
- Worst- case propagation analysis
- No consideration given to shielding effects of buildings
- Low RF levels
- Very little backlobe radiation



RF Analysis – 14.200 GHz

- 14.2 GHz
- Narrow beam width
- Worst- case propagation analysis
- No consideration given to shielding effects of buildings
- Low RF levels
- Very little backlobe radiation



Conclusion

- The purpose of the experimentation is to determine how the test objects reflect radio signals.
- Continuous spectrum is essential to test the objects
- Each Frequency is in use only 387 milliseconds per day
- That time of use is spread over 8 hours
- Pulse width is only 70 nanoseconds
- Power level must be high enough to find the return signal above the noise floor
- Antenna azimuth is 237 degrees, focused, narrow beamwidth
- The signals are pulsed, with a very low duty cycle
- Maximum average power is less than 400 mW
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