



Joint Navigation Warfare Center

GPS Frequency Clearances and Reliability Prediction Model



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Outline



Joint Navigation Warfare Center

- **Joint Navigation Warfare Center (JNWC) Introduction**
- **DoD Global Positioning System (GPS) Electronic Attack (EA) Frequency Clearance Request Process for GPS Peacetime Jamming**
- **Global Positioning System–Reliability Prediction Model (GPS-RPM)**
- **Conclusions**



JNWC Missions



Joint Navigation Warfare Center

- Advocate, plan, integrate, and coordinate Navwar activities and capabilities across the department
- Assess threat effects on critical information infrastructure
- Conduct Navwar testing and evaluation of fielded, operational systems and systems-of-systems
- Develop tactics, techniques and procedures (TTP) and mitigations
- Support warfighter exercises and joint experimentation
- Provide standards for analytical tools and methods
- Maintain central repository of Navwar information



JNWC Modeling and Simulation Mission



Joint Navigation Warfare Center

- **Manages DoD GPS EA frequency coordination process**
- **DoD Model Manager for the GPS-RPM software tool**
 - Supports GPS EA frequency coordination process
- **Coordinates with FAA on Navwar software M&S methods**
 - Address Navwar issues, identify requirements and assess capabilities as they apply to civil aviation
- **Develops and maintains Navwar M&S expertise for the DoD**



Ever Increasing GPS Applications



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New Jacket with Built-in GPS



A prototype jacket being shown at CeBIT features a built-in cell phone, MP3 player, headphones, microphone, and, more importantly, it also features "GPSoverIP," which is a type of indoor GPS. The jacket also has an emergency "call button," so if you're buried in an avalanche, you can press it to call for help. (Rescuers can start digging from the point where your GPS signal disappeared.)



EA Frequency Clearance Process



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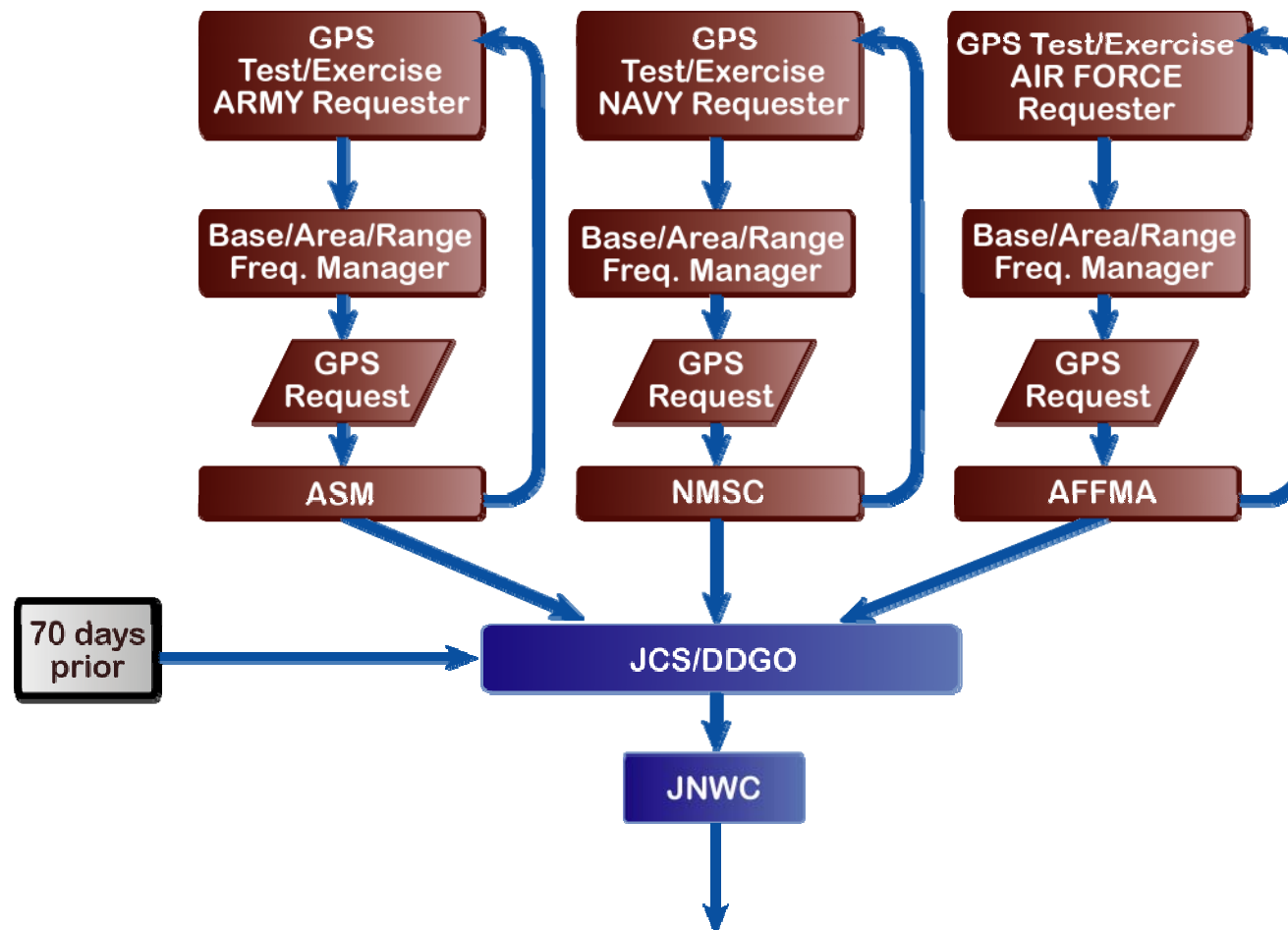
- **Requirements to test military GPS receiver equipment for interference vulnerabilities**
 - GPS Jamming
- **Spectrum governed by Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 3220.01B**
- **Clearance process outlined in CJCSM 3212.02B, “Performing Electronic Attack”**
- **Process exists to inform and protect civilian users**
 - Who may rely on GPS
 - Including emerging applications of GPS signals



GPS EA Request Process



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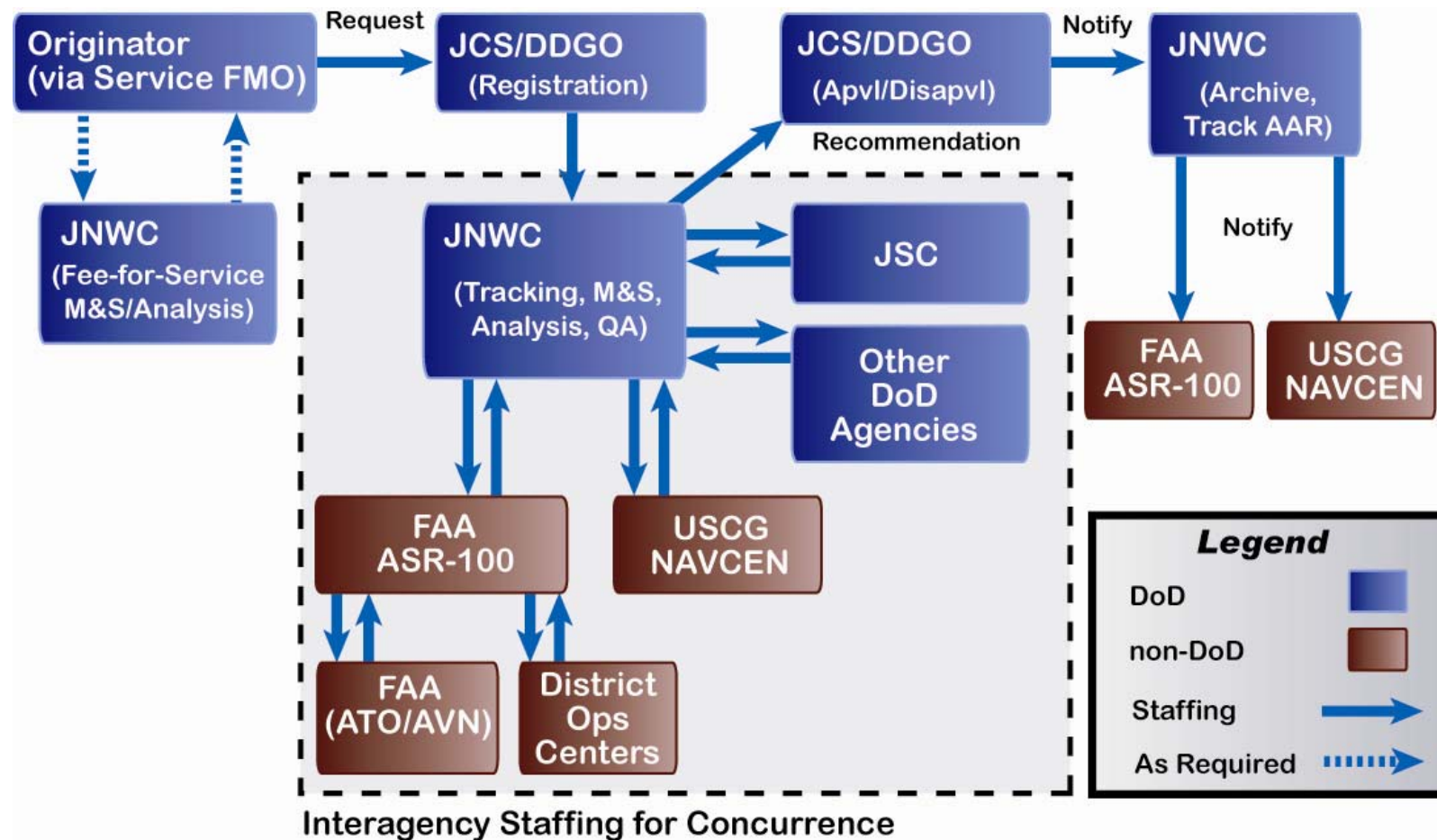




Analysis and Coordination



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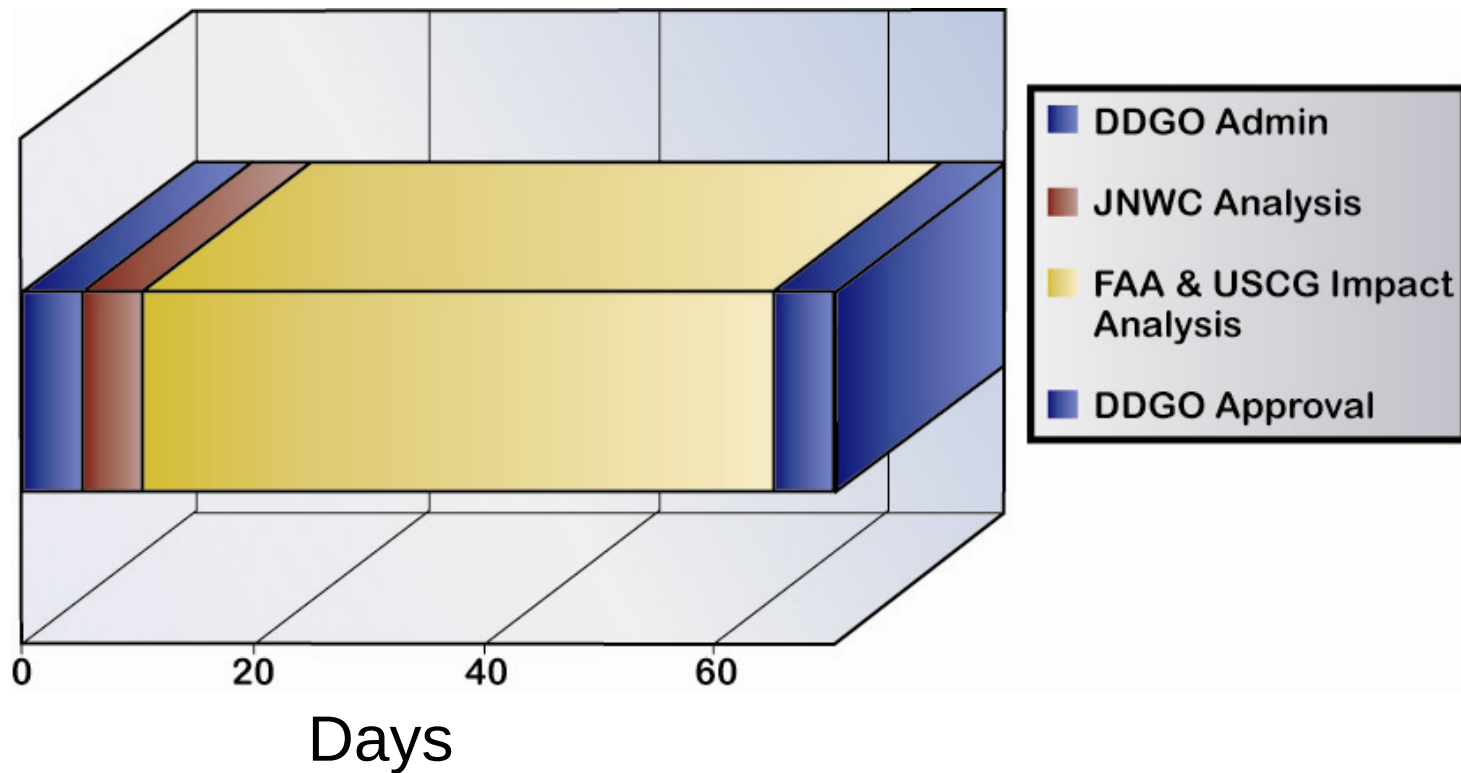




EA Frequency Request Timeline



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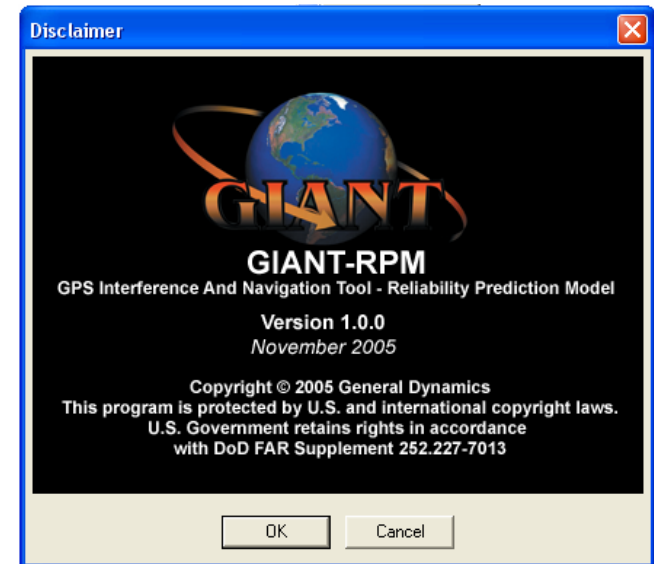


GPS-RPM



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- **GPS-RPM Features**
 - Configurable jammers Interference contours
 - Incorporates terrain analysis on RF signal
 - Calculates jamming power levels
- **GPS-RPM models**
 - Static jammers
 - Static environments



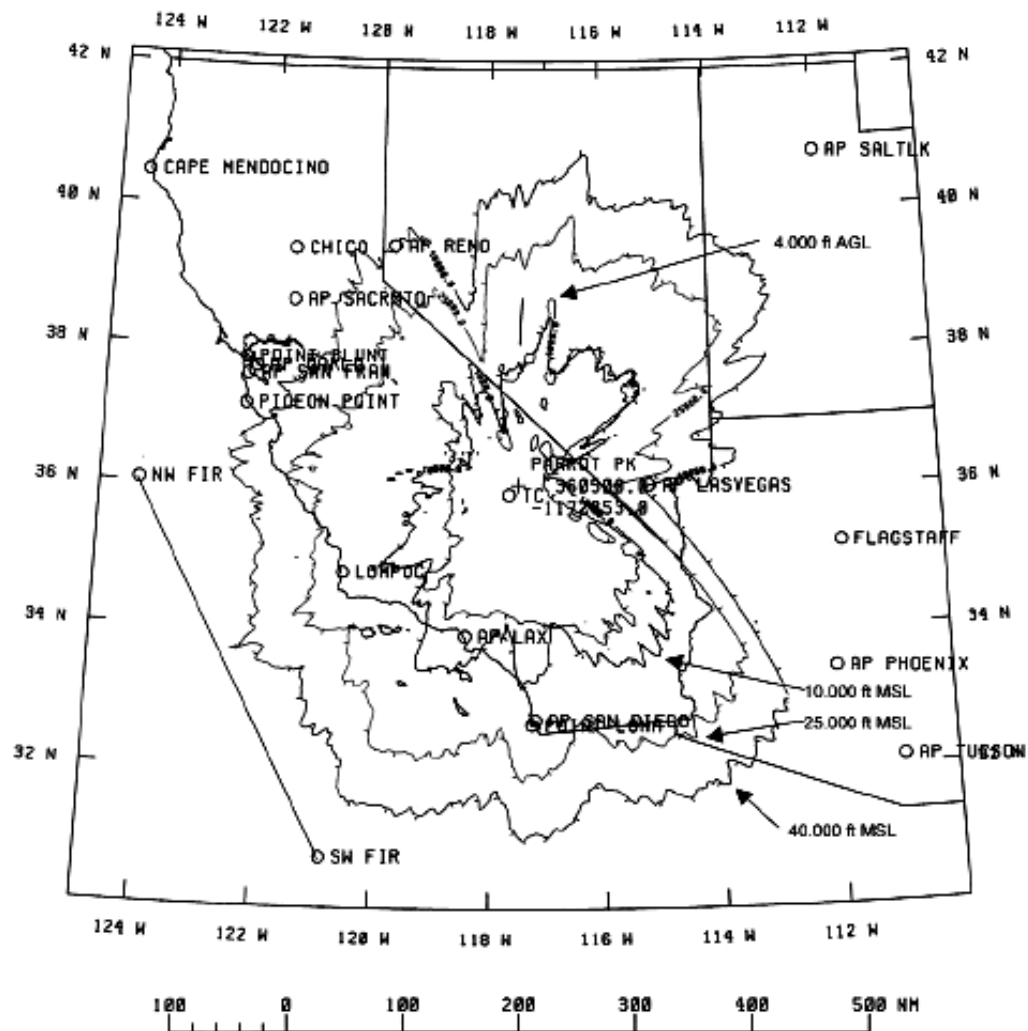


GPS-RPM History



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- Replacement for GPS Integrated Topographic Analysis System (ITAS)
 - ITAS was created by the Joint Spectrum Center
 - Only operating system supported was Windows 95
 - ITAS ran slowly





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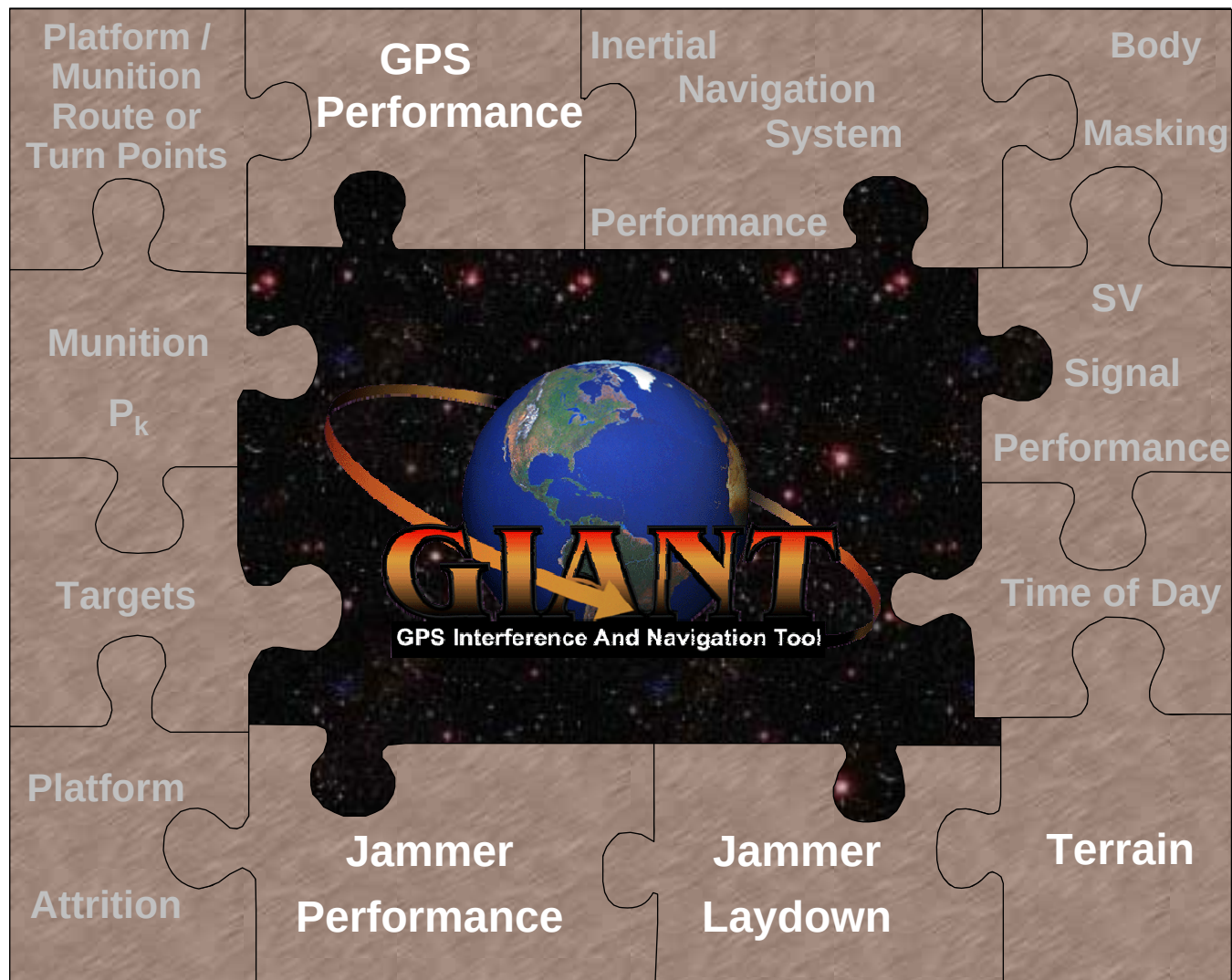




Inputs & Modules



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Free Space Loss



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- The Friis Equation is the simple foundation of the GPS-RPM model
- P_j = jammer power
- G_j = jammer antenna gain
- G_{Gps} = receiver antenna gain
- L_p = loss factor
- J_j = Jammer power at distance R

$$J_j = \frac{(P_j)(G_j)(G_{GPS})(\lambda_j)^2}{(4\pi R)^2 L_p}$$



Transmitter GUI



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- Easily select antennas and signal types
 - Standard list
 - Create a new set
- Transmitter sites open in separate windows
 - Allows access to multiple transmitter files simultaneously

A screenshot of a software window titled "Transmitter Site: Jammer1.txst". The window has a menu bar with "File" and a toolbar with icons for file operations. Below the toolbar are two tabs: "General" (selected) and "Properties". The "General" tab contains several input fields and buttons. The "Antenna" field is a dropdown menu showing "omni 1dBi gain" with an "Edit..." button. The "Signal" field is a dropdown menu showing "2_MHz_L1" with an "Edit..." button. The "Transmit Power" field is a text box with "1" and a "Watts" dropdown. The "Duty Factor" field is a text box with "1" and an "Edit" button, with a note "(Time on/Total time) (scalar)". The "Site classification" field is a dropdown menu showing "U". The "Location" section has "Latitude" (N 36° 49' 00.0000" degrees (+N/-S)), "Longitude" (W 115° 37' 00.000 degrees (+E/-W)), and "Altitude" (6 feet AGL). The "Orientation" section has "Heading" (0 degrees (From True North)) and "Pitch" (0 degrees (+Up/-Down)).



Antenna GUI



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- Three built-in ways to design antennas
- Use $\sin^2(x)/x^2$ ($\text{sinc}^2(x)$) to model horn antennas
- Use square pattern if side lobe parameters are known
- Create a table for maximum accuracy or custom resolution

Antenna Type: omni_1 dBi_gain.ant

File

General Properties

☐ $(\sin^2 x)/x^2$ Pattern

3dB Beamwidth-Azimuth: 0 degrees

3dB Beamwidth-Elevation: 0 degrees

Backlobe GAIN: 0 dBi

☐ Square Pattern

	Main Beam	1st Side Lobe	Elsewhere
Azimuth	0	0	degrees
Elevation	0	0	degrees
Gain	0	0	0 dBi

☒ Table

Table Filename: omni_1dBi_gain Edit...



Signal Type GUI



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- Create specific signal properties
- Select bandwidth
- Select modulation type
- Choose between L1 and L2 carrier frequencies

A screenshot of a software window titled "Signal Type: 2_MHz_L1.sig". The window has a "File" menu and icons for file operations. It contains two tabs: "General" and "Properties". Under the "General" tab, there are fields for "Channel", "Carrier Frequency" (set to 1575420000 Hz), "Modulation" (set to BB), and "Bandwidth" (set to 2000000 Hz).

Signal Type: 2_MHz_L1.sig

File

General Properties

Channel

Carrier Frequency: 1575420000 Hz

Modulation

Modulation Type: BB

Bandwidth: 2000000 Hz

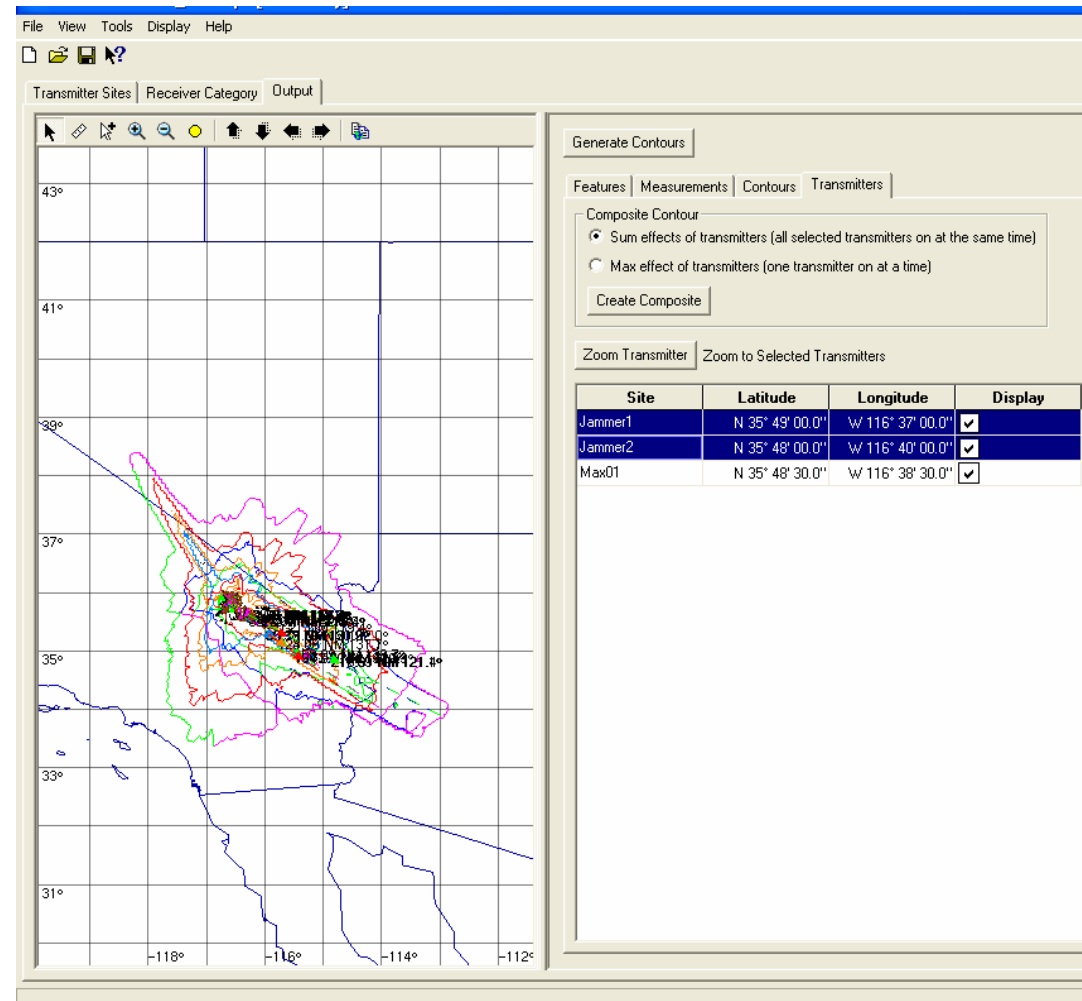


Multiple Transmitter Operations



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- Sum creates an all-on composite plot (sums transmitter outputs)
- Max creates a one-at-a-time-on composite plot (sums contours)





FAA Interference Thresholds



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GIANT-RPM: Test ITEA.rpm[Read-Only]

File View Tools Display Help

Transmitter Sites Receiver Category Output

Frequency: 1575.42 MHz

Receiver Characteristics

GPS Receiver Category	Frequency (MHz)	Representative Type	Antenna Height (Ft)	Height Reference	Antenna Gain (dBi)	Interference Threshold (dBm)
Surface	1575.42	Handheld	6	AGL	0	-105.5
Surface	1575.42	DGPS/WAAS	50	AGL	0	-120
Surface	1575.42	Timing	200	AGL	0	-105.5
Airborne	1575.42	Airborne	4000	AGL	-4.5	-120
Airborne	1575.42	Airborne	10000	MSL	-4.5	-120
Airborne	1575.42	Airborne	15000	MSL	-4.5	-120
Airborne	1575.42	Airborne	25000	MSL	-4.5	-120
Airborne	1575.42	Airborne	40000	MSL	-4.5	-120

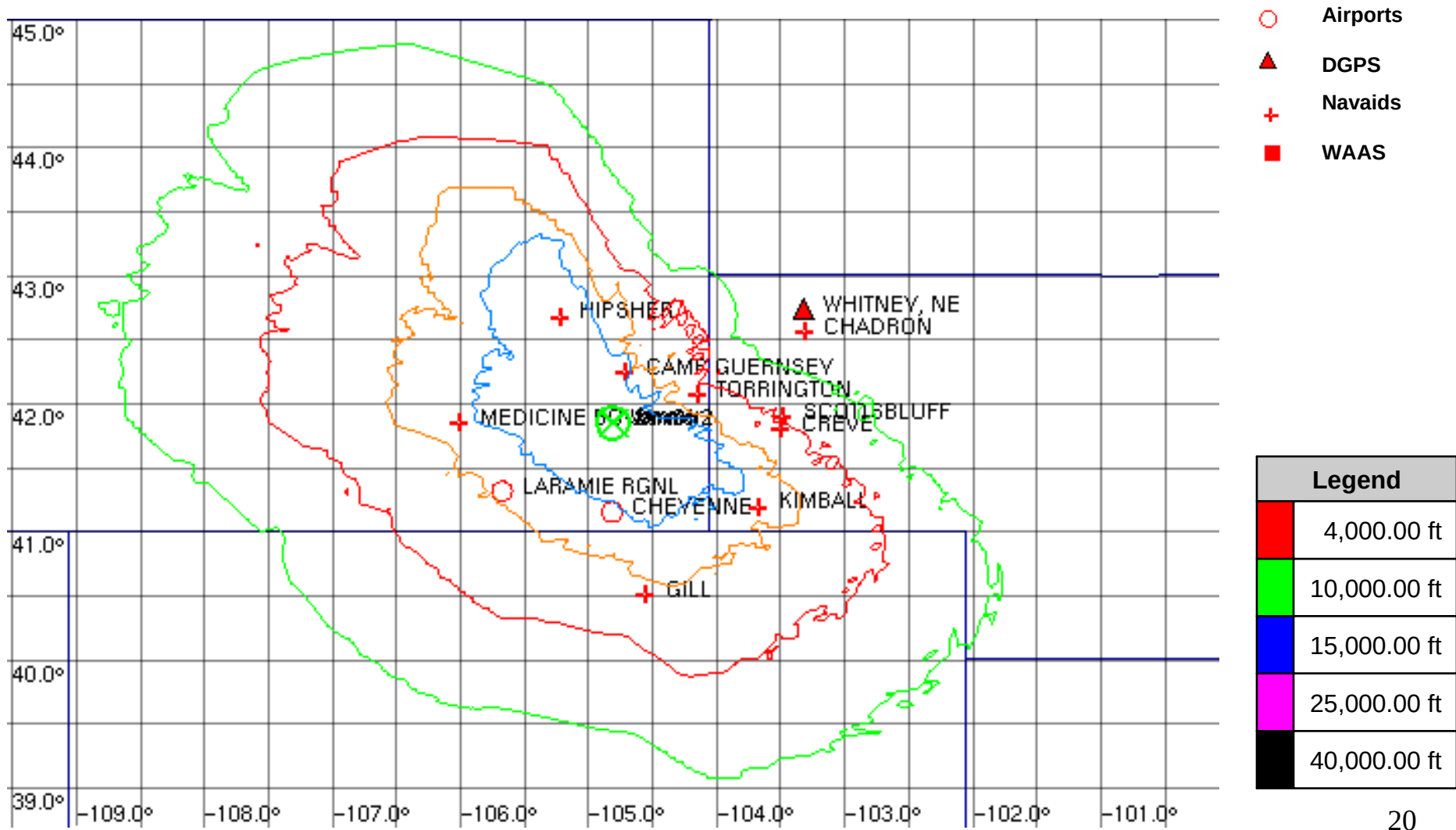


Sample Output Contour



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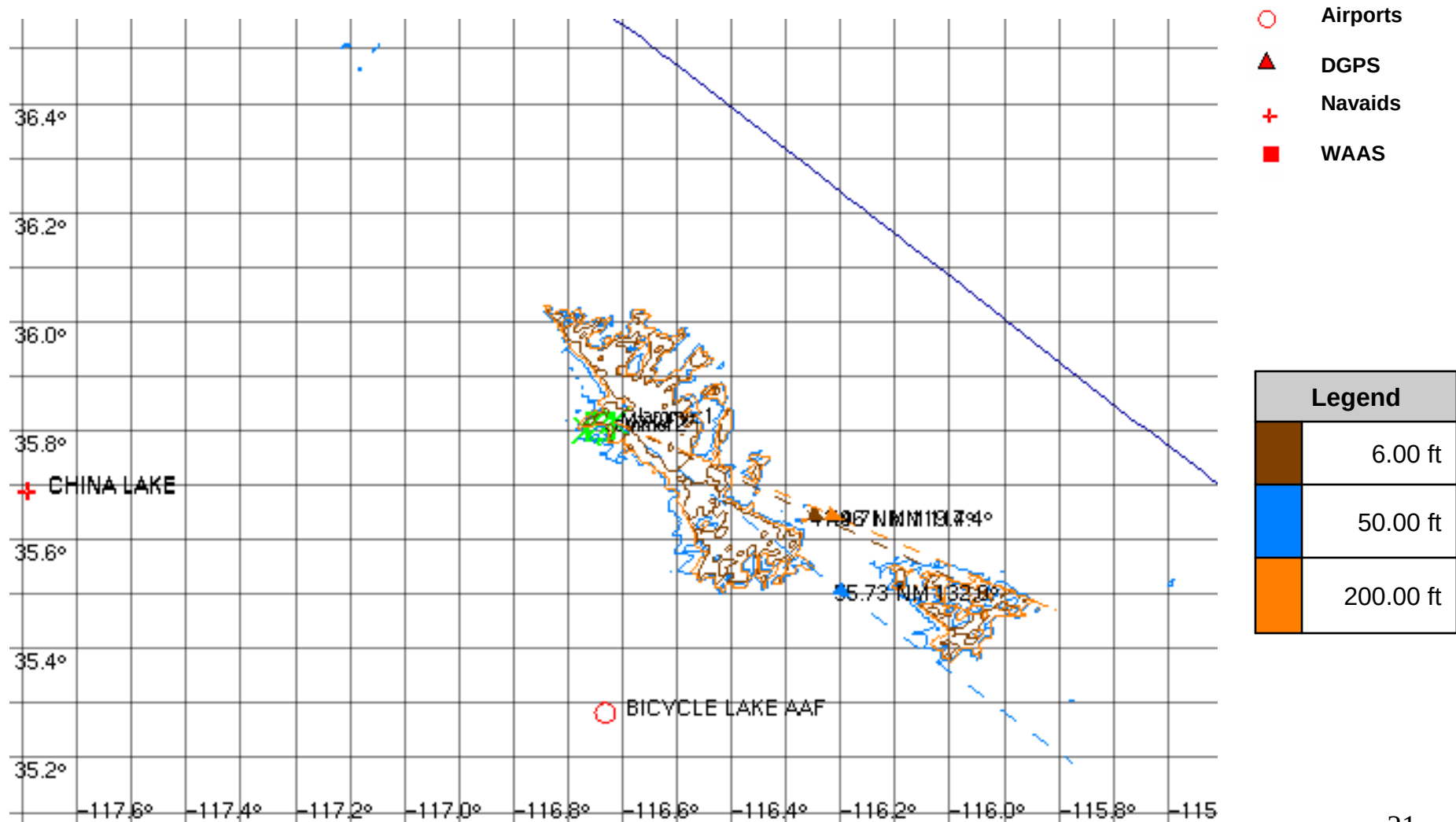
Jammer1: Airborne Receivers





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Jammer1: Surface Receivers





Sample Output Values



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Ranges to Predicted Interference Contours

From	To	Range	Bearing
Jammer1	6.00 ft Contour	31.59 NM	-175.0°
Jammer1	50.00 ft Contour	32.74 NM	-173.4°
Jammer1	200.00 ft Contour	33.71 NM	-174.5°
Jammer1	4,000.00 ft Contour	40.82 NM	-8.8°
Jammer1	10,000.00 ft Contour	44.22 NM	-137.7°
Jammer1	15,000.00 ft Contour	68.10 NM	-138.9°
Jammer1	25,000.00 ft Contour	105.89 NM	-139.2°
Jammer1	40,000.00 ft Contour	152.07 NM	-138.7°



Digital Terrain Elevation Data (DTED)



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- **DTED Level 0**
 - Elevation post spacing is 30 arc second
 - 900 meters between points
- **DTED Level 1**
 - Terrain elevation values with post spacing every 3 arc seconds (approximately 100 meters)
 - 1:250,000 scale resolution
- **DTED Level 2**
 - Basic high-resolution elevation data source
 - Terrain elevation values with post spacing of one arc second (approximately 30 meters)
 - 1:50,000 scale resolution



Dynamic Modeling with a Static Model



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Test Requirement

1. 10dB directional antenna 0–255° azimuth 0° elevation
2. Mobile jammer(s) operating anywhere within in a 10-mile square
3. One jammer that may be moved to several locations

Modeling Solution

1. Model as 10dB omni antenna any azimuth 0° elevation
2. Model 5 jammers; 1 at each corner and 1 at highest point a jammer could possibly occupy
3. Model all locations and take the maximum effect instead of the sum effect



Web Sites of Interest



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- USCG Web site with link to GPS Interference notices
 - <http://www.navcen.uscg.gov/gps/gpsnotices/default.htm>
- FAA NOTAM Web site
 - <https://www.notams.faa.gov/>
- U.S. Naval Observatory (USNO) GPS Operations - Timing
 - <http://tycho.usno.navy.mil/gps.html>
- GIANT Procurement Web site
 - <http://giant.gd-ais.com/>
- GPS Operations Center
 - <http://gps.afspc.af.mil/gpsoc/advisories.htm>



Conclusions



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- **GPS-RPM is a reliable, user friendly tool approved by the DOT(FAA) for modeling jamming effects**
- **GPS-RPM is the only model approved to support the DoD EA frequency request process**
- **Frequency request process requires 70 days after submission to JS/DDGO to complete**
- **Notices of GPS jamming can be found in the FAA “NOTAM” system, United States Coast Guard, and other service/availability Web sites.**
 - **Please inform everyone in our GPS community where to find notices to minimize adverse jamming effects to users expecting reliable GPS signals**



For More Information



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