Voice Communications in Rural Areas

Voting Scan

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Today we will be talking about:

- Brief History of Two Way Radio in Caltrans
- Basic Operation of a Two Way Radio
- **Voting Scan Systems in Caltrans**
  - Caltrans Maintenance Operations
  - **Typical Voting Scan System Design Process**
- Operation hands-on with portable radios
- Demonstration (Optional)

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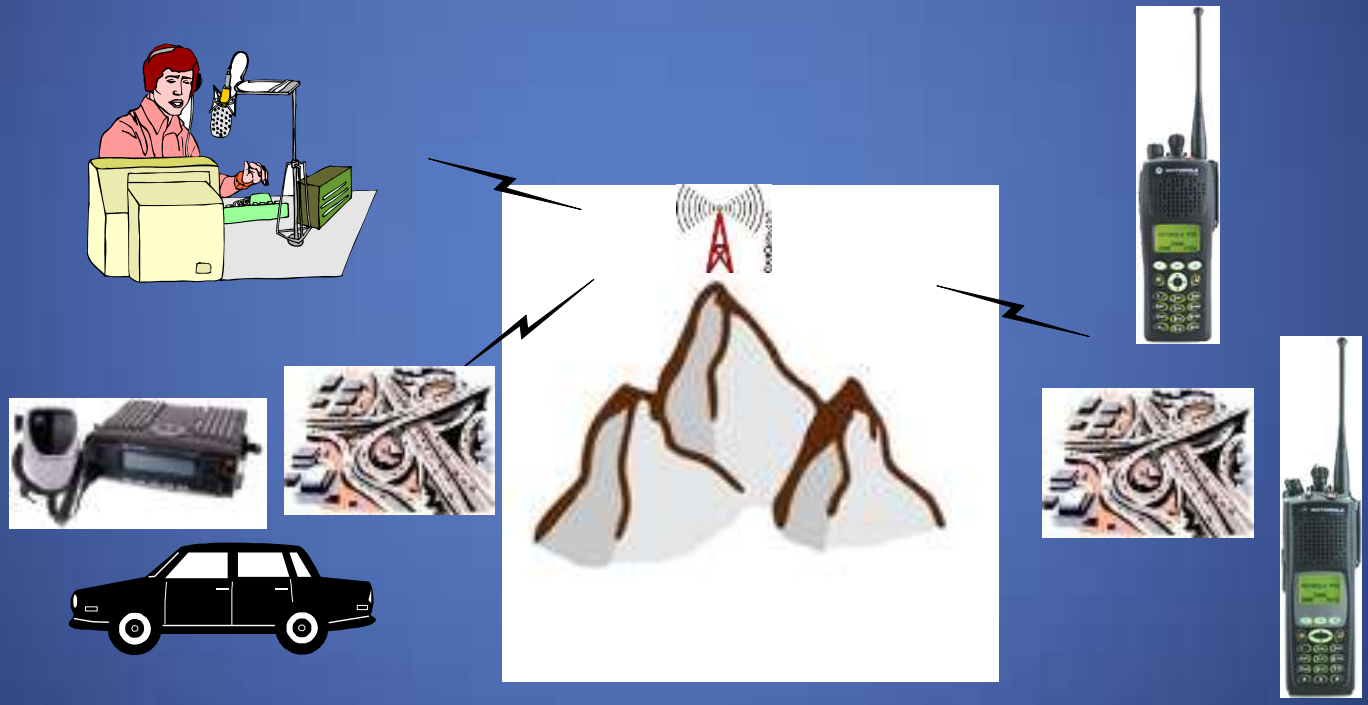
Brief history of voice Communications in Caltrans:

- Caltrans has used two way radios since its beginnings.
- Caltrans developed what is now the Public Safety Microwave System in California- Largest Public Microwave System in the world at the time.
- Caltrans operated voice radio systems in the Low Band 47 MHz frequencies till the 1980s when it started implementing the new 800MHz system.
- The systems were designed to meet the unique requirements of each District. Caltrans has 12 Districts: There are 12 unique two way Radio Systems in Caltrans independent from each other.
- Currently there are conventional Low Band Systems, Conventional 800 MHz Systems, 800MHz Trunked Systems, & now 800MHz Voting Scan Conventional Systems.

Basic two–way radio operation

Mode of Operation



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User Equipment

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- **Simplex Low Band System, Tx = Rx :**

  Pros:

  - **It projects a large area of coverage from a single site: line of site not needed**
  - **Simplicity of operation – one or 2 channels per district**
  - **Inexpensive. Simple low tech solution**
  - **Interfacing with CHP is possible because they use the same band**

Low Band System - Simplex - Tx = Rx :

Cons:

- **It does not work as a repeater (half duplex)**
- **It is limited to a Car-to-Car or Car-to-Dispatch Operation**
- **Radio Traffic Congestion**
- **Transmissions need to be relayed from dispatchers**
- **Skip – or the ability of the transmission wave to bounce off the ionosphere, it makes it prone to interference**
- **Portables are unreliable: Sometimes they are not able to reach the Base Station**
- **Mayor manufacturers do not make mobiles or portables : Phased out Technology**
- **Not APCO 25 Compliant**
- **Interference with other Caltrans Equipment**
- **RF Radiation Exposure.**

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➢800 MHz Conventional - Half-Duplex –: Tx&Rx

Pros:

- ▪Repeater systems: Information does not need to be relayed via a dispatcher
- • Multi-frequency of operation, up to 159 different channel combinations
- •It is not prone to skip - interference
- •Multiple Manufacturers
- •Portable Radios are as reliable as Mobile Radios
- •New technologies are developed for this band
- •APCO 25 Compliant

Cons:

- •It requires line-of-sight - limits area of coverage requiring more sites to cover the same area as low-band
- •Increased difficulty of operation
- •Increased Cost
- •Difficult to implement in rugged terrain
- •Attenuated by foliage and snow significantly

Voting Scan on 800 MHz

Conventional 800 MHz deployment stopped in the late 1980s, leaving D1, D2, D5 & D10 on the antiquated Low-band System. Reason not to implement 800 MHz in these Districts

- Ruggedness of the terrain
- Many more Radio sites will need to be developed to cover the road
- Usefulness of such a complex system was not clear.
- Funding was a mayor road block

In 1998 ORC started a research project to analyze the 800 MHz systems to find a viable solution for implementing them in areas not previously considered viable.

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What is Voting scan?

•Is a conventional Two Way Radio system consisting of multiple radio sites which cover a large area.

•All the sites are associated with one radio channel.

•All sites are received in the same frequency. They get VOTED at a central location. The best receive signal is then repeated to all locations in different or alternative frequencies to deal with coverage overlapping.

•The user radio VOTES again the best repeated signal and receive the message.

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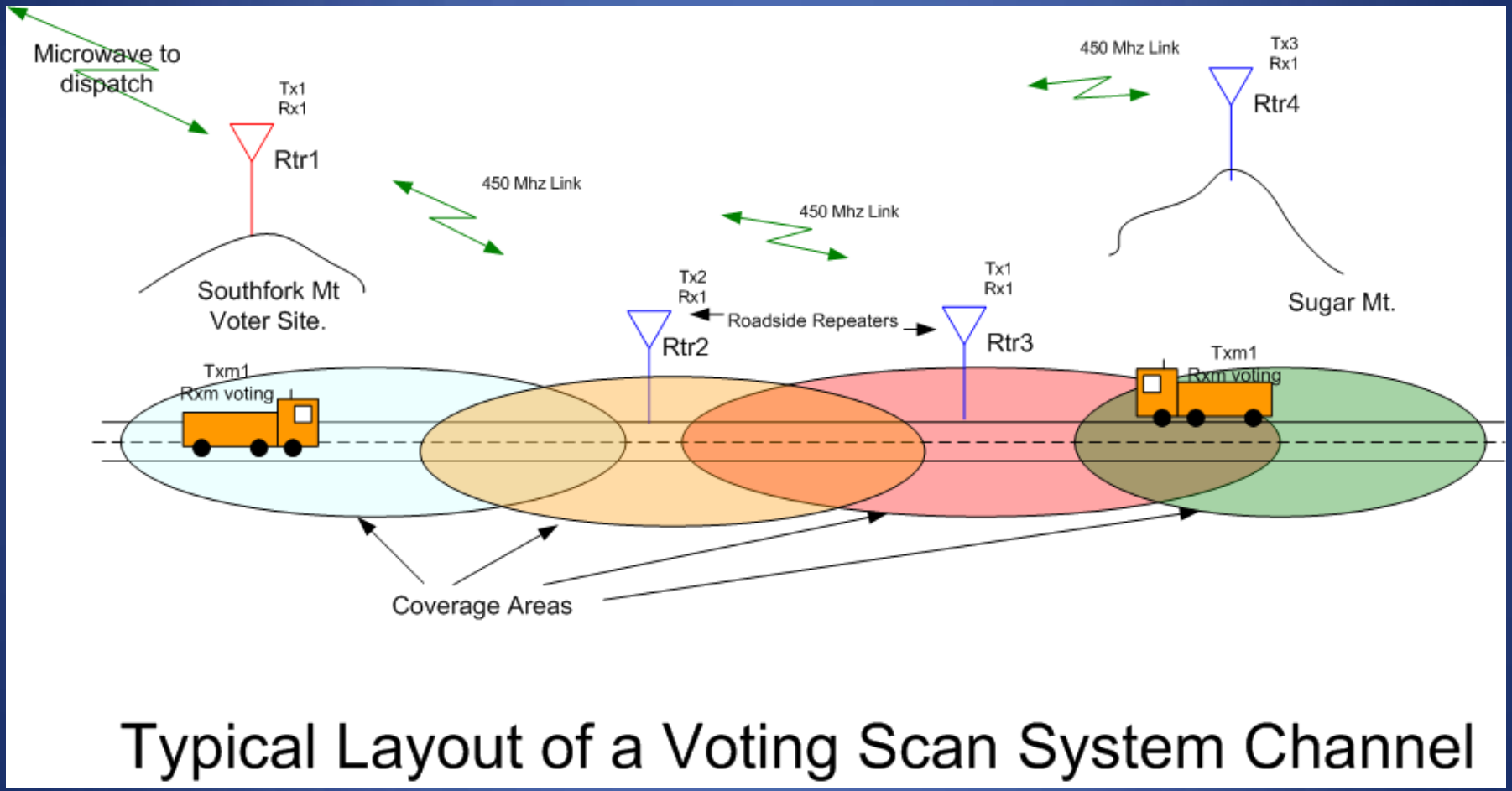

Typical Layout of a Voting Scan System Channel

New Radio System design Criteria:

District Requirements:

- Design should follow Maintenance Operational Procedures
- One Channel per Maintenance Crew area of operation (Cost Center)
- Cover 90% of each Cost Center
- Easy to operate like the low band – One Channel per Cost Center
- Channels should be accessible from adjacent maintenance stations

Technical Requirements:

- 800 MHz conventional
- Design for Mobile receiver
- Receiver sensitivity to -100 dBm

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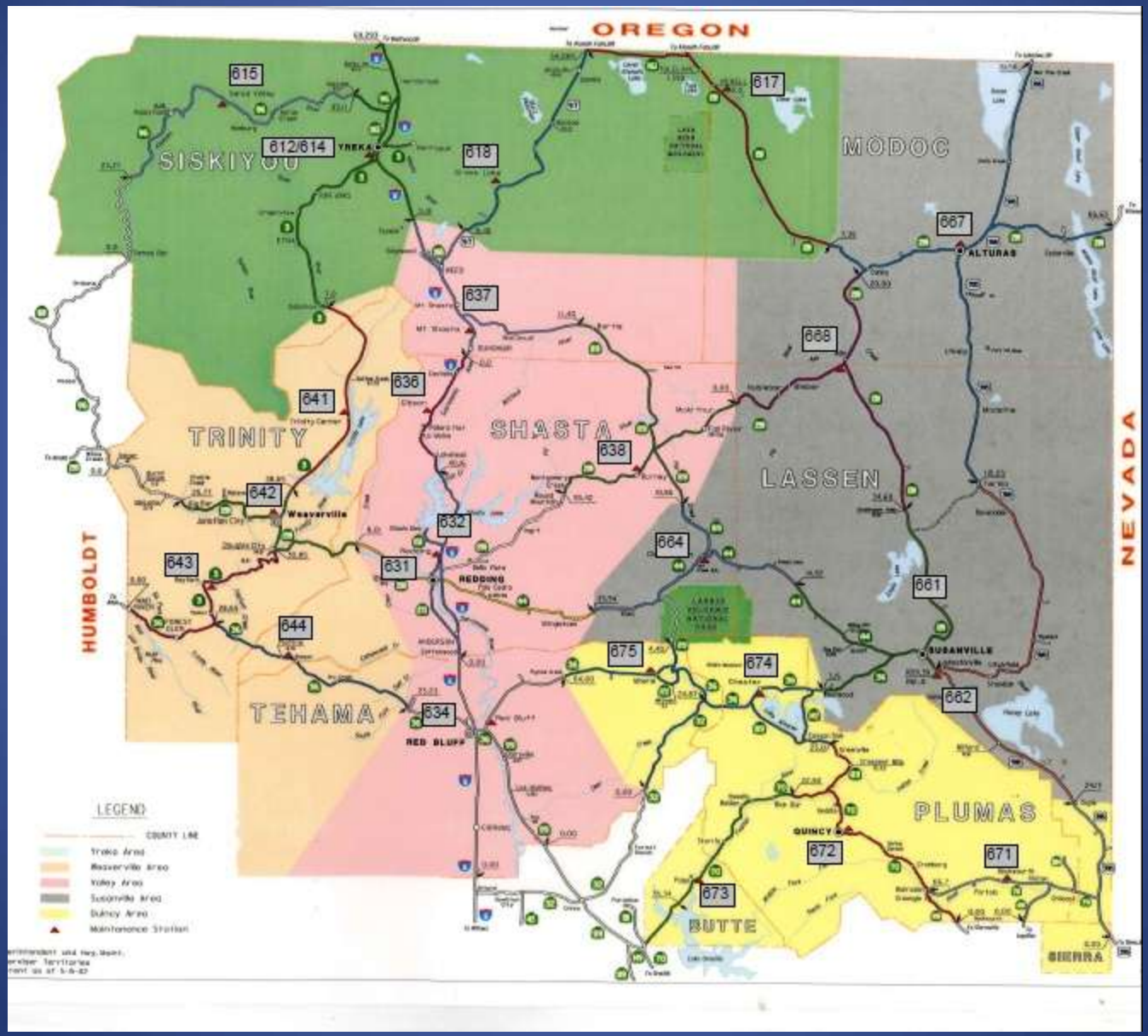
DISTRICT 2



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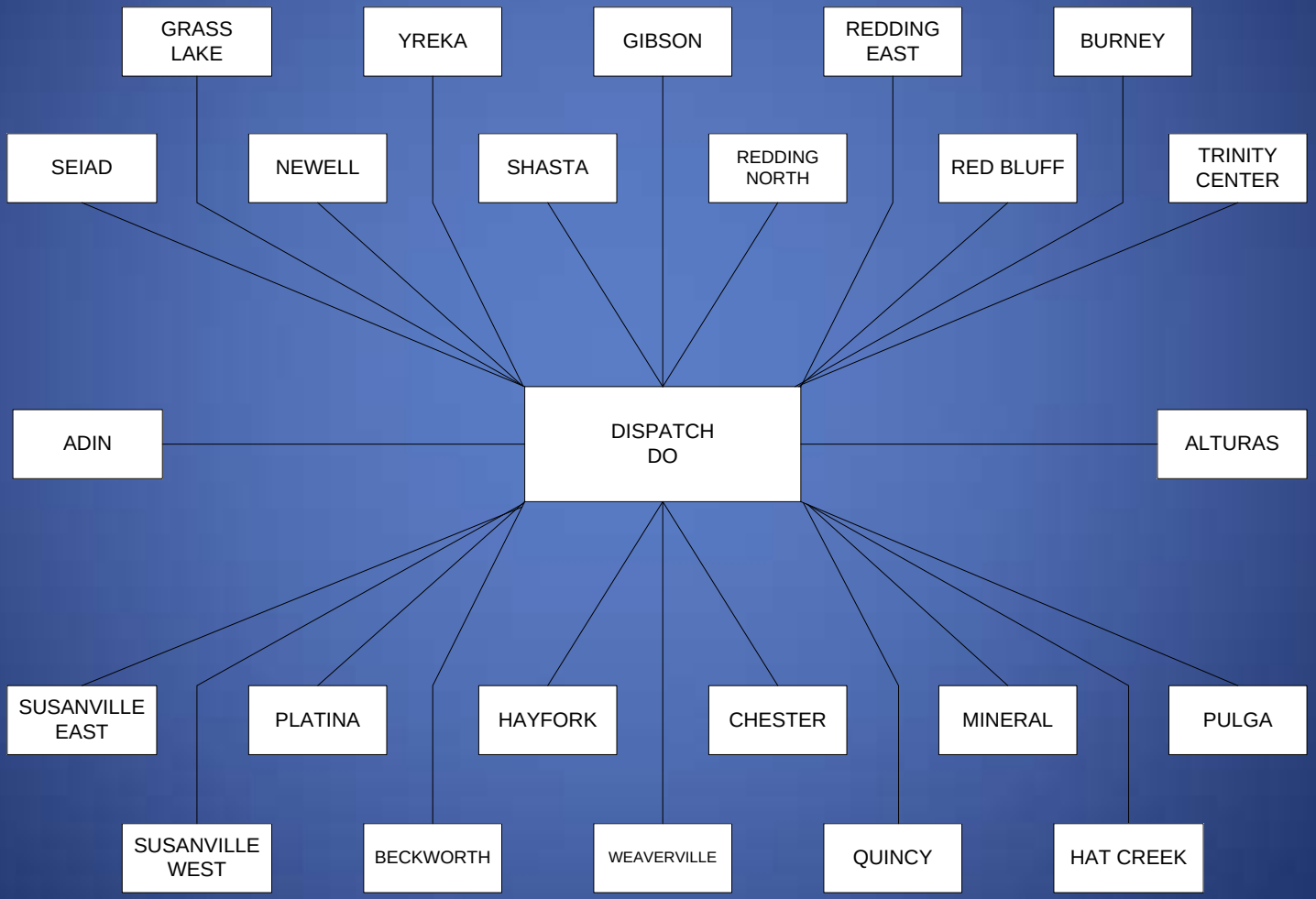
District 2 System



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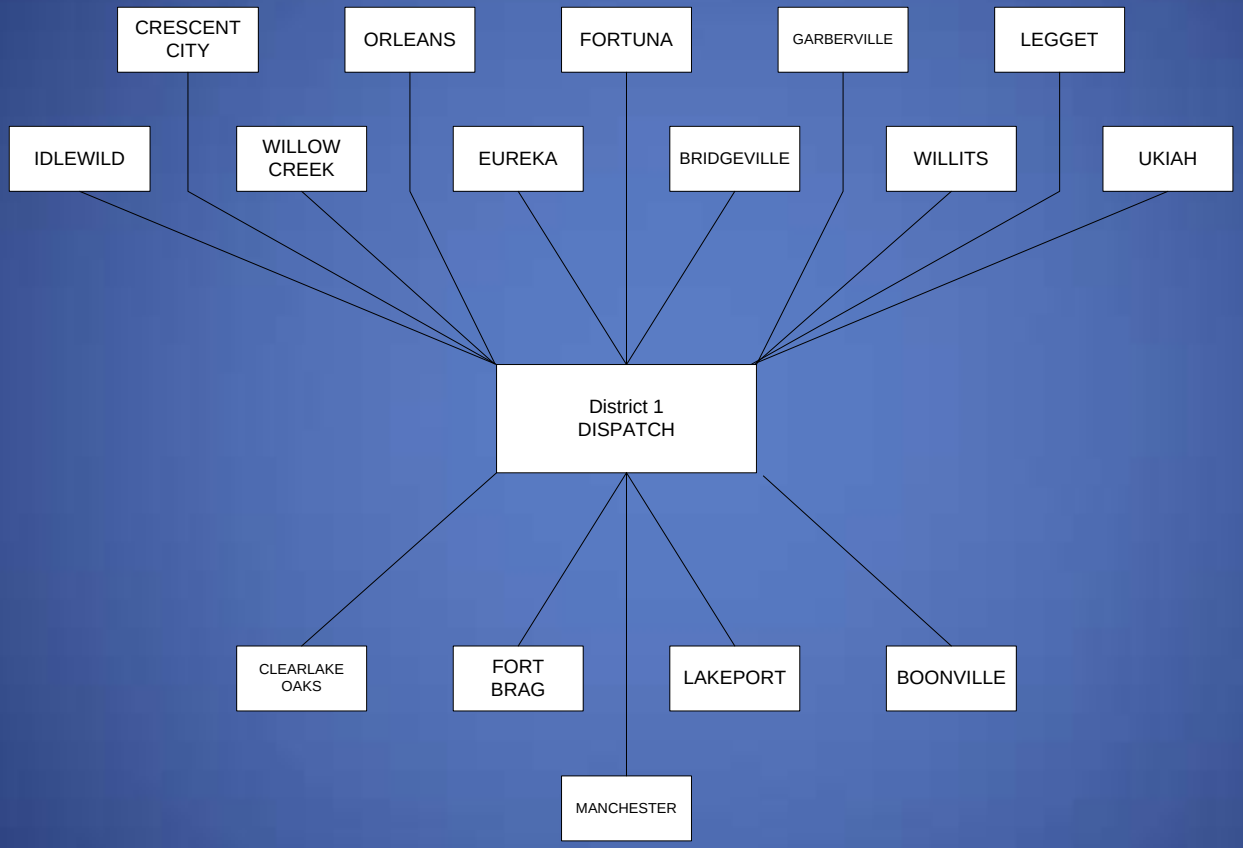
District 1 System



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Challenges designing a Cost Center Radio System

1. Ruggedness of terrain: they can not be covered entirely from one high level Radio Site.
2. Power or Telco are assumed not to be accessible or reliable in remote areas.
3. Filling in coverage gaps in canyon areas, (highly prone to accidents) where there are no com sites available.
4. Agreements with third party site owners may not be attainable.
5. Simplicity of operation
6. Environmental impact

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Solutions to the challenges

1. Ruggedness :Repeaters can work together-linked to cover wide area (Voting Scan)
2. Power and Telco :
   - Low power consumption equipment: use of Solar, wind generators and fuel Cells
   - Use of FCC license 450 MHz wireless links
3. Coverage gaps – Use of Road site Repeaters (voting Scan).
4. Agreements with third party providers – Provide multiple alternatives to the solution.
5. Simplicity of Operation - Voting Scan works like Low –Band : One channel per Cost Center
6. Environmental : No construction in sensitive areas.

Cost Center Design and Implementation Process:

1. Search For Potential sites in the state database and FCC database
2. Computer simulated Coverage
3. Perform actual Survey with Equipment and GPS aid coverage logging system (we use SIT logger)
4. Look for potential Road Side Repeaters to fill in coverage holes and perform a survey from that point.
5. System Design
6. Agreement Process
7. Installation
8. Implementation

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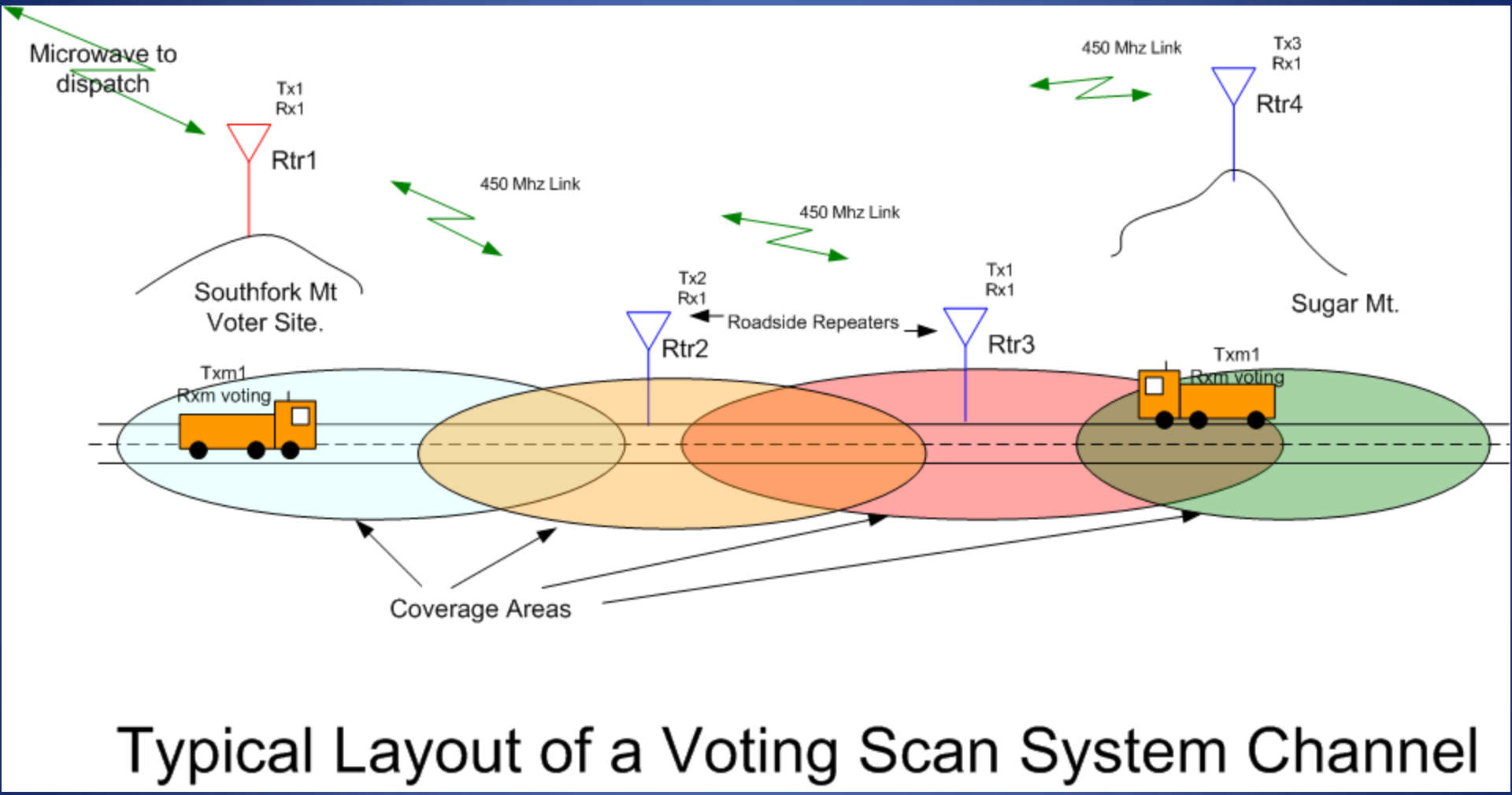

Typical Layout of a Voting Scan System Channel

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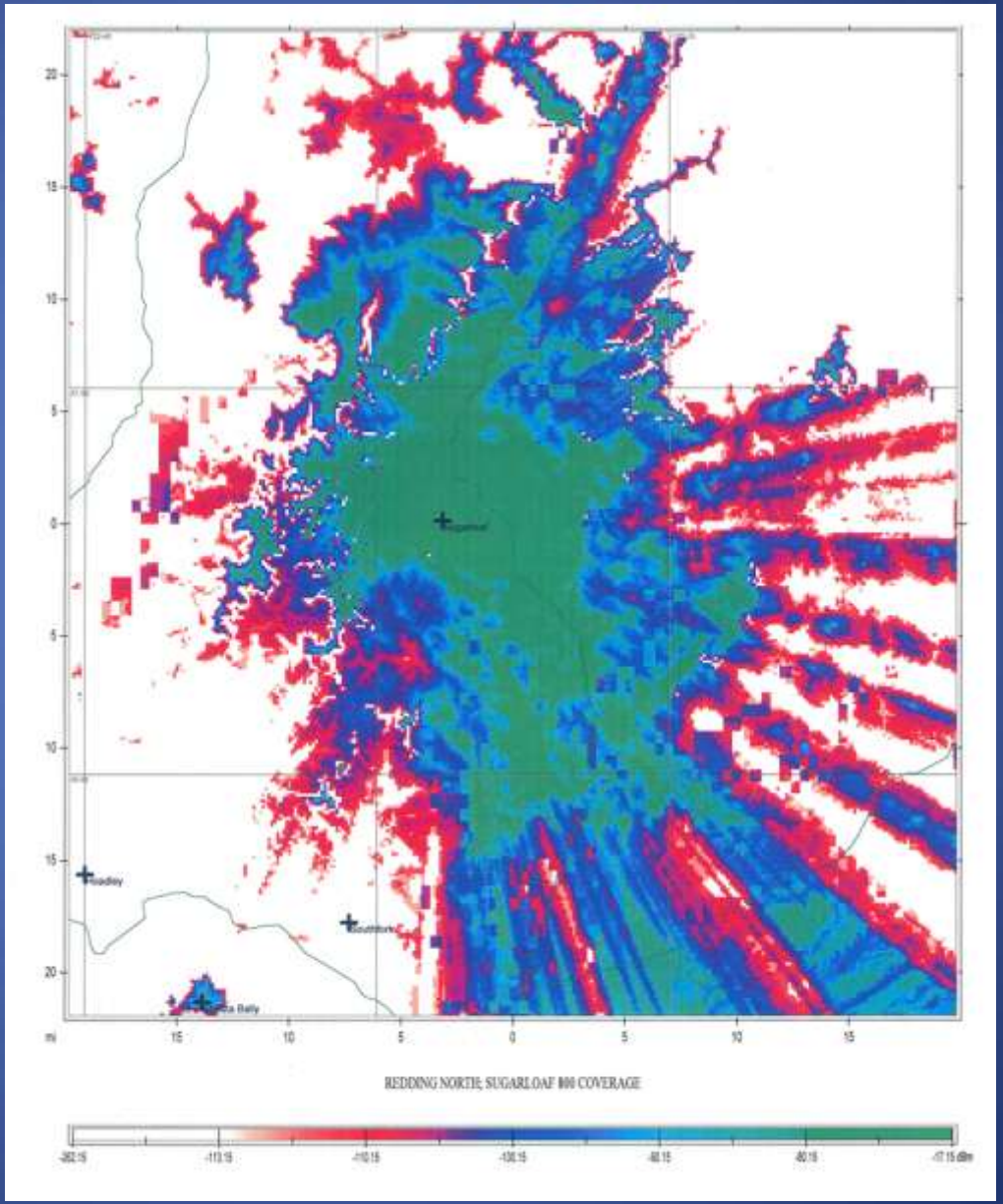
Computer Simulated Coverage Map for Sugarloaf Mt.



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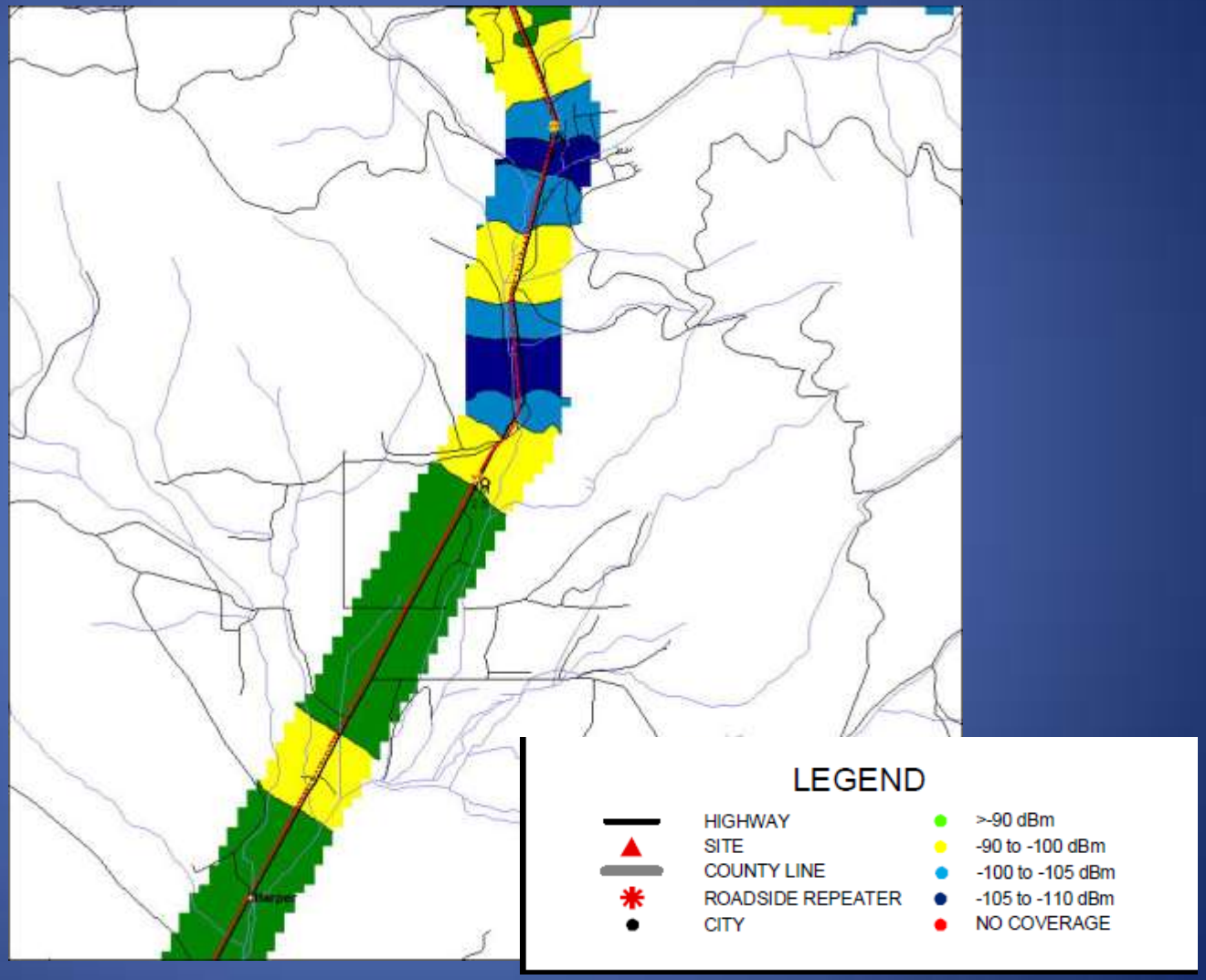
Collected Survey Data from Sugarloaf



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Cost Center – Redding North

Collected Survey Data

LEGEND

HIGHWAY		>-90 dBm
SITE		-90 to -100 dBm
COUNTY LINE		-100 to -105 dBm
ROADSIDE REPEATER		-105 to -110 dBm
CITY		NO COVERAGE

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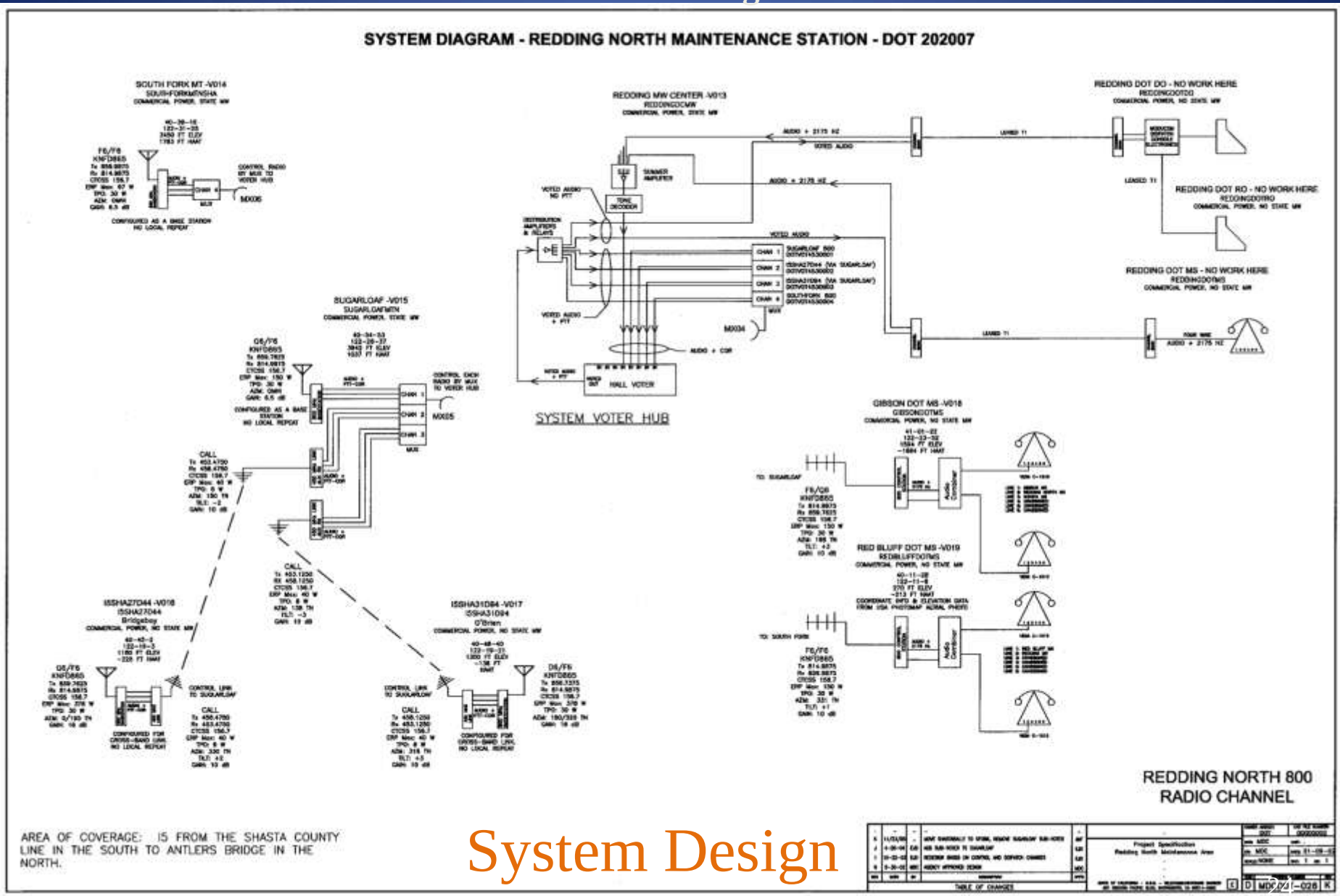

System Design

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Voter Equipment

DOUG HALL VOTER
SPECIFICATIONS

	4RV Four Channel Voter
Voting Method:	Signal-to-Noise.
Hysteresis:	Approximately 10% Factory set. See options section.
Capacity:	Four channels expandable to 32, 4 channels per card.
Voting Criteria:	Approximately 2db difference in signal-to-noise. (measured with low input noise levels)
Voting Time:	Continuous, fast voting - no delay or sampling, Four independent circuits working simultaneously.
Calibration:	Built-in audio level calibrator. Test points provided.
Indicators:	5 LED's (4 on slave cards.) 4 Bicolor Voted (green) and Receiving / Active (red)
Audio in:	100mv - 10v p-p into approximately 10K input impedance.
COR:	Ground is the active state (unsquelched) 12v sourced opto-isolated input with > ~2mA to ground active.
Mixer:	Audio mixer input available for external input.
Output Section:	
Audio:	1v p-p adjustable with a master level pot into approximately a 5K load.
Distortion:	< 0.5% at rated output.
Frequency Response:	Ref. Figure in following pages.
PTT:	Ground is the active state (unsquelched). Open collector NPN output to ground and will sink at not more than 50v or 100mA.
Disable Inputs:	Low disabled (grounded) high enabled (open) - Same as COR inputs.
Voted Indicator Outputs:	+12V "VOTED" (sourced up to ~100 mA) outputs.
Vote-Lock time:	1 second + or - 0.3 secounds.
Vote-Lock Enable:	Ground active.
Test Points:	(4) Audio level calibration points - 1 per receiver on edge connector and front panel. (1) Calibration bus on edge connector. (1) Audio output test jack on front panel.
Power Requirements:	+11v to +15v regulated at < 500mA per 4 channels.
Dimensions:	4.5"H x 6.8"L x 1/2"W (4.5" x 6.5") Card only.
Connections:	44 pin edge connector (22 per side) gold plated fingers - 0.156" spacing - similar to Vector R644. (not included)
Circuit Board:	Fiberglass epoxy, double sided, tinned and gold plated contacts.
Service:	Spare (loaner) cards available.

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MOTOROLA SPECTRA RADIO SPECIFICATIONS

PERFORMANCE SPECIFICATIONS FOR 800 MHz MODELS

GENERAL						
Frequency Range				Rx : 851–869 MHz; Tx : 806 – 824 MHz & 851–869 MHz (talkaround)		
FCC Designation				ABZ89FT5712		
Channel Spacing				25 kHz, 12.5 kHz from 809 – 869 MHz		
RF Power Output				15 W		
POWER SUPPLY						
		AC CURRENT DRAIN (MAX.) (110 VAC/220 VAC)		DC CURRENT DRAIN (MAX.) @13.8 VDC		
RF OUTPUT	DUTY CYCLE	RECEIVE	TRANSMIT	STANDBY	RECEIVE	TRANSMIT
15 W	100%	0.82A/0.47A	1.24A/0.62A	1.5A	3.5A	7A
TRANSMITTER						
Spurious and Harmonic Emissions				-70 dBc		
Frequency Stability				±0.00015% of assigned center frequency from -30°C to +60°C ambient (+25°C reference)		
Modulation				20K0F1E, 16K0F3E, 16K0F1D, 15K0F2D		
Maximum Frequency Separation				18 MHz within each of two groups: 806–824 & 851–869 MHz		
FM Hum and Noise: EIA Method				-35 dB		
RECEIVER						
Sensitivity: 20 dB Quieting EIA SINAD				(per EIA spec. RS204C) 0.40 µV 0.30 µV		
Selectivity: EIA SINAD				-80 dB @ ±25 kHz		
Spurious & Image Rejection				90 dB		
Intermodulation: EIA SINAD				-80 dB @ ±25 kHz		
Maximum Frequency Separation				18 MHz		
Frequency Stability				±0.00015% of assigned center frequency from -30°C to +60°C ambient (+25°C reference)		
FM Hum and Noise : EIA Method				-45 dB		

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE

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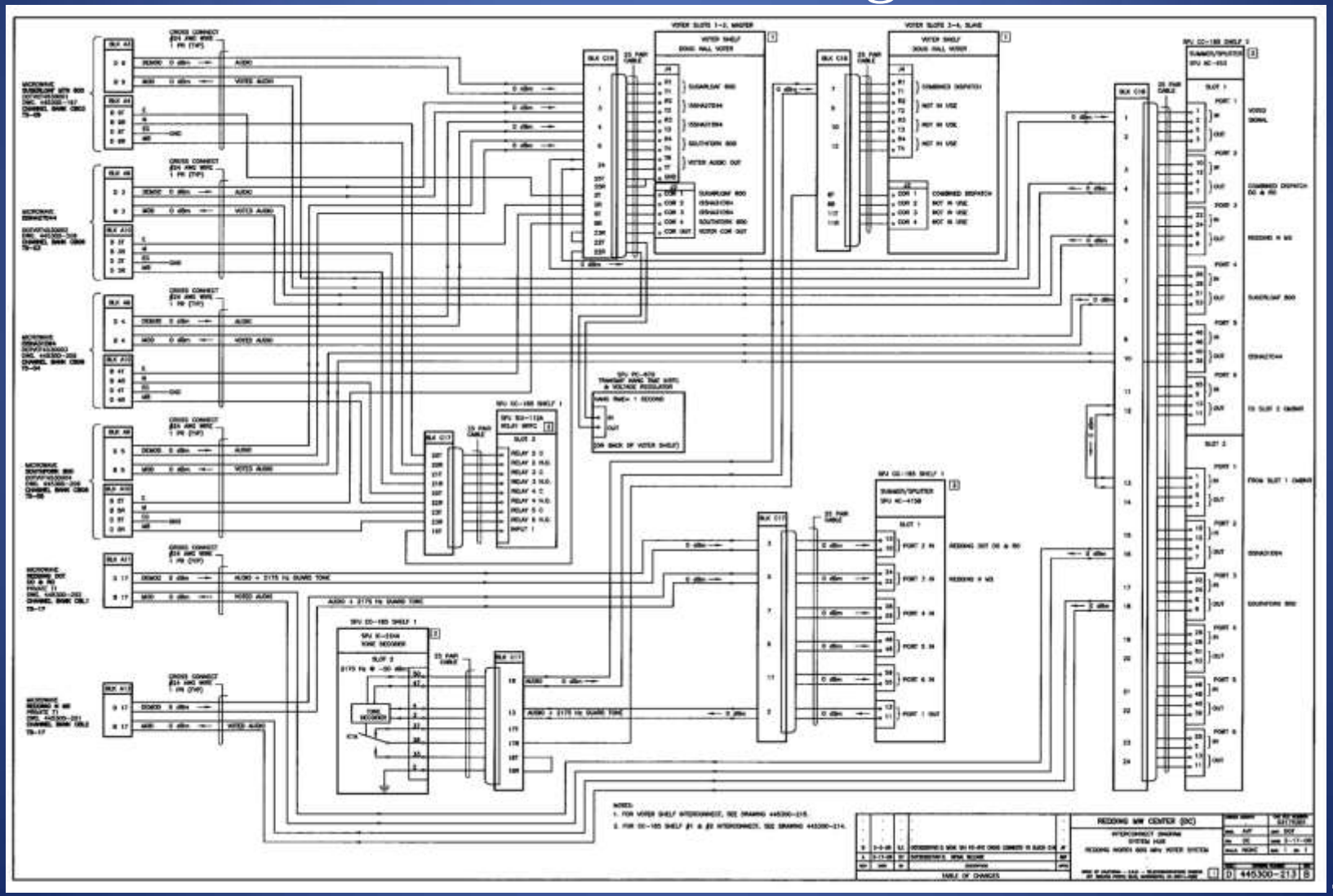
Voter Interconnect Diagram



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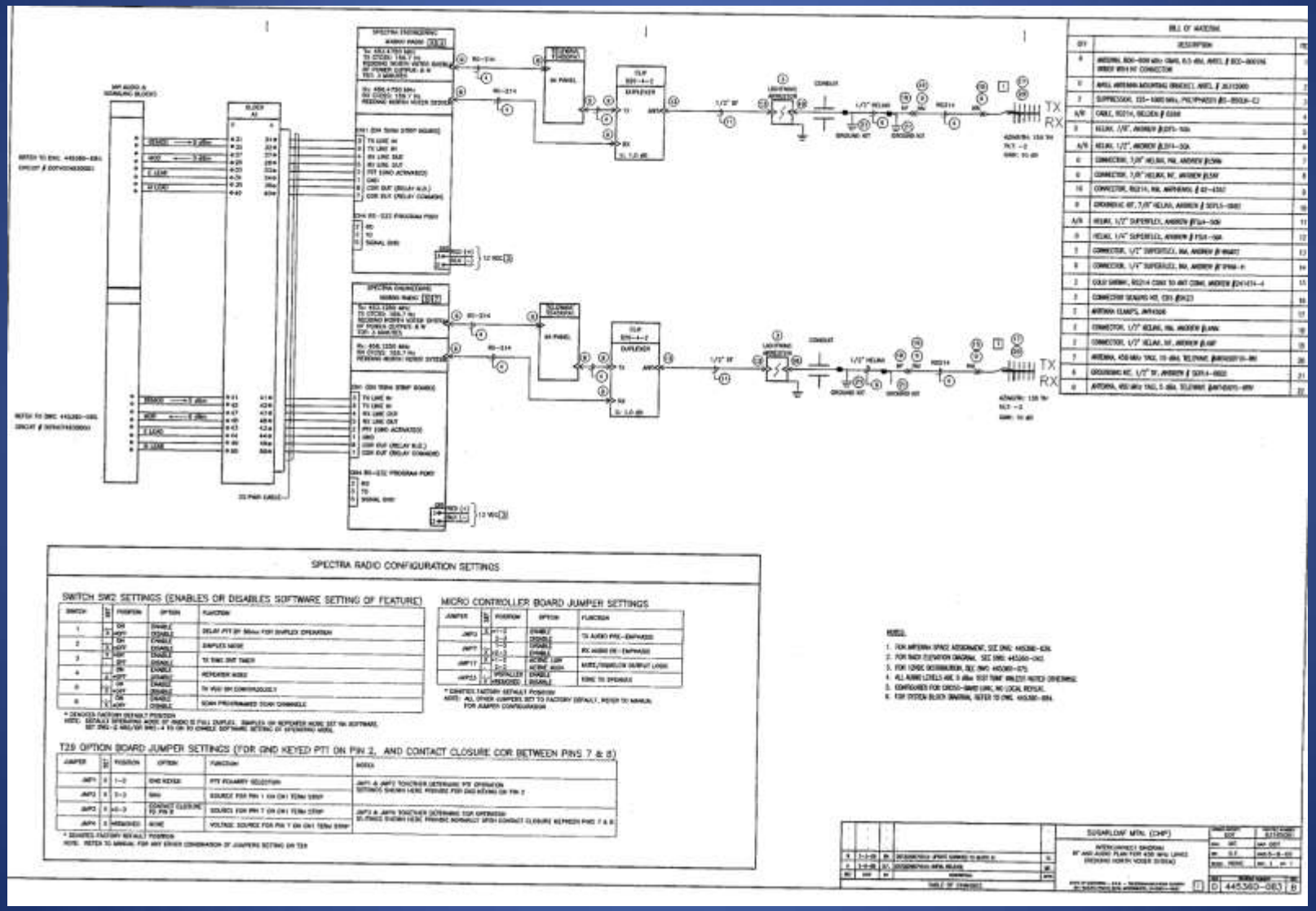

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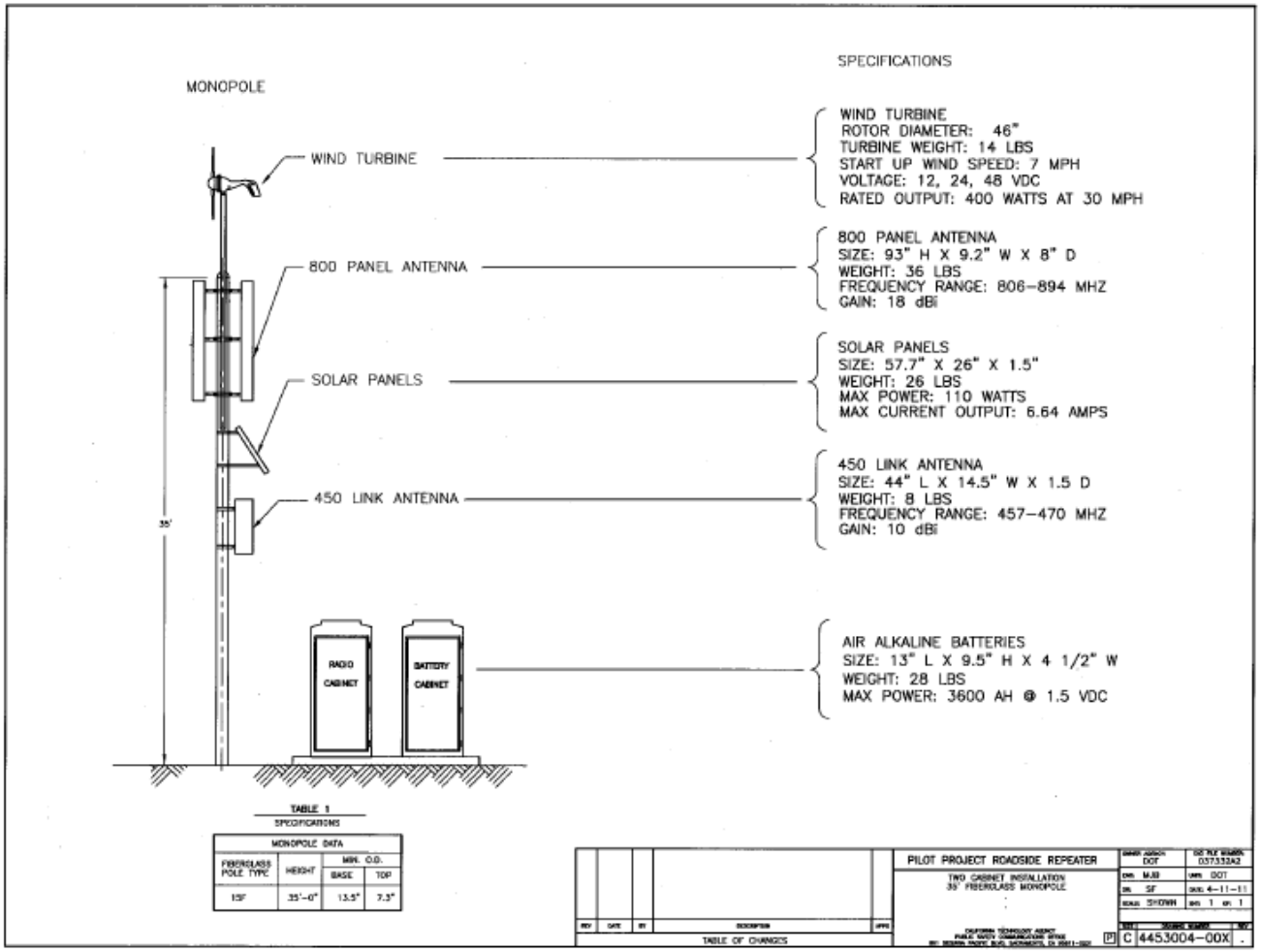

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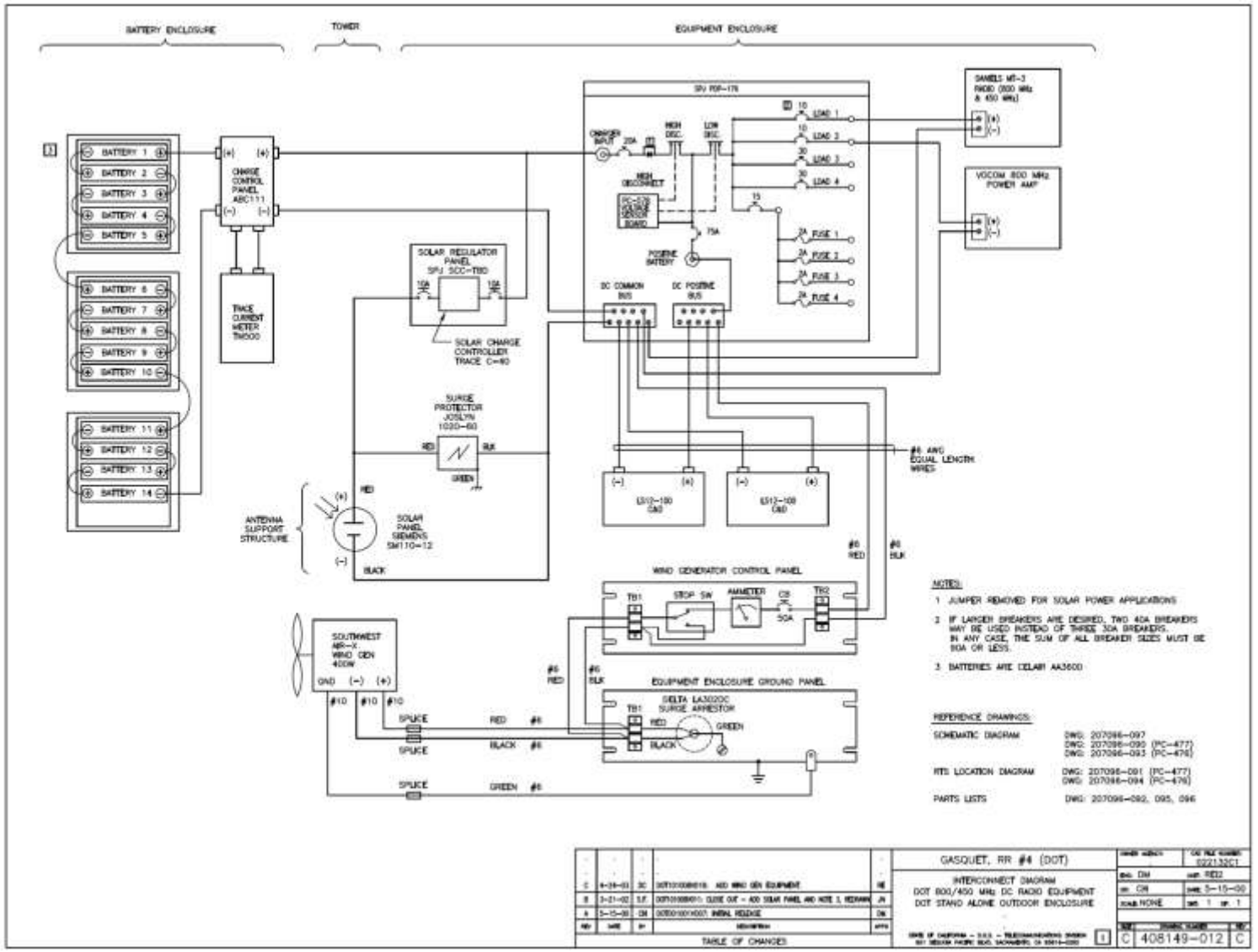

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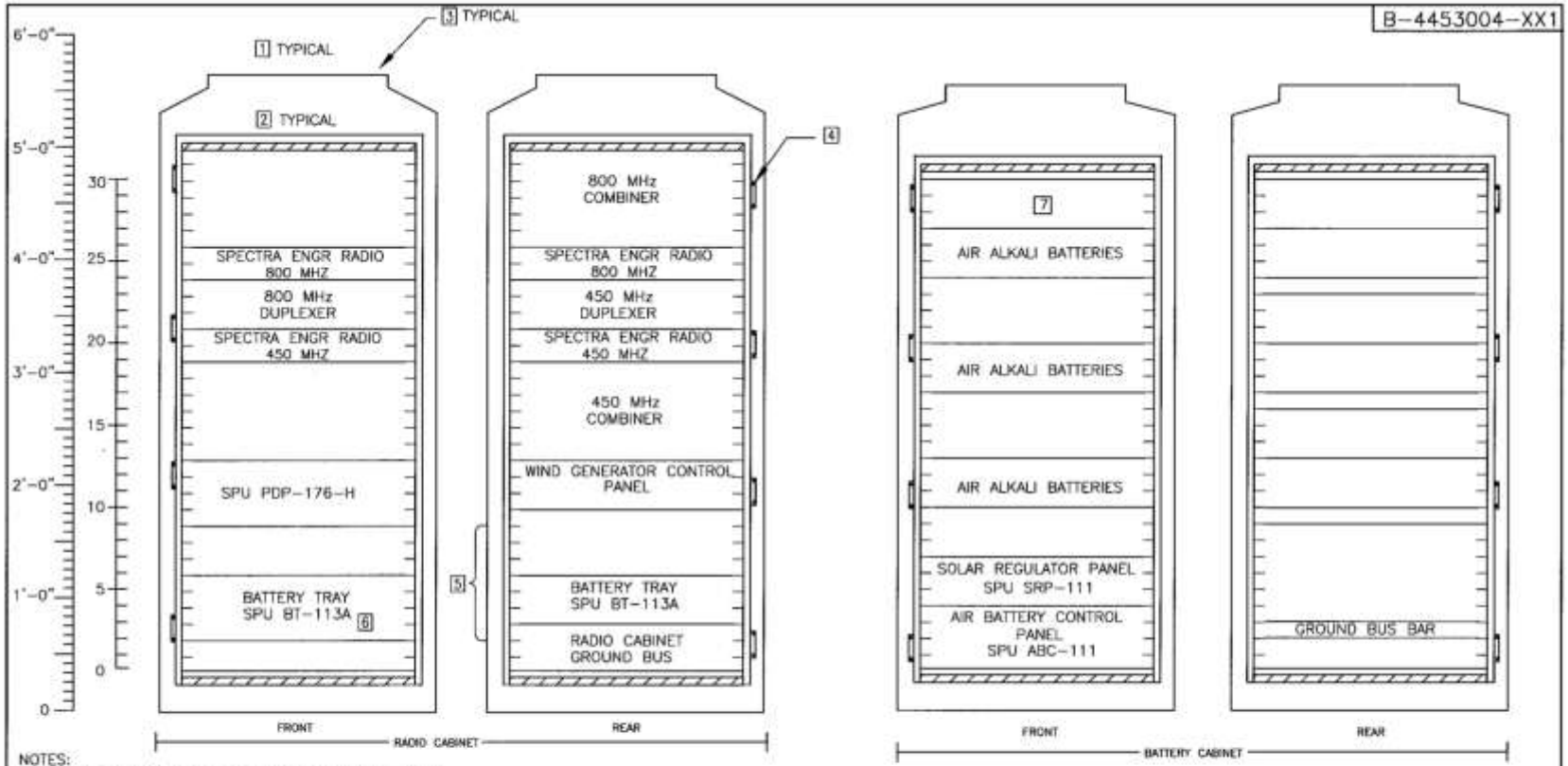

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Rack Mounted Radios:800 & 450

800 MHz Power Amplifier

Breaker Panel

Batteries

Road Side Repeater Equipment

Road Side Repeater

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Any Questions so far?

Another Example:

Pilot project : Hwy 199

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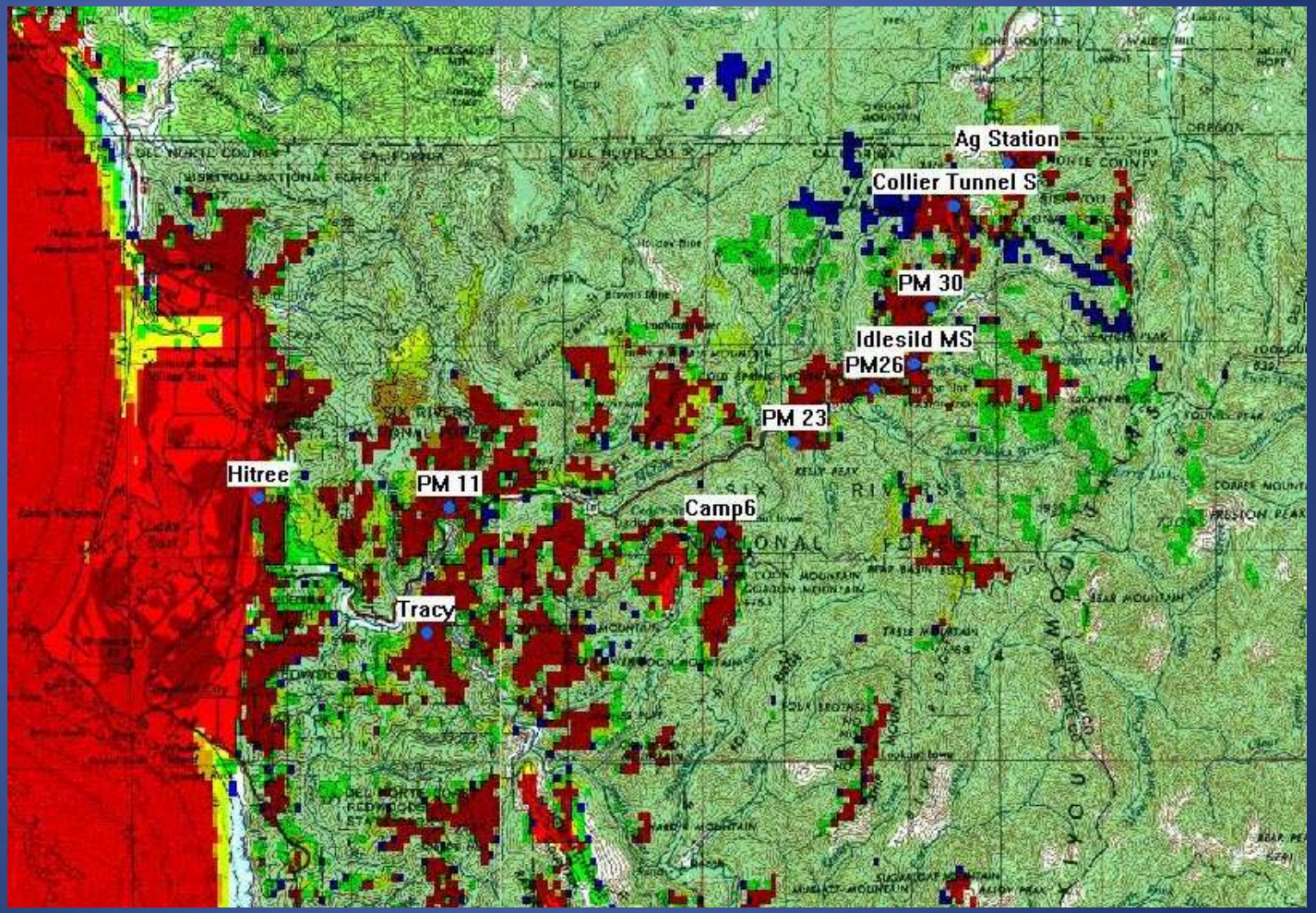
Surveys



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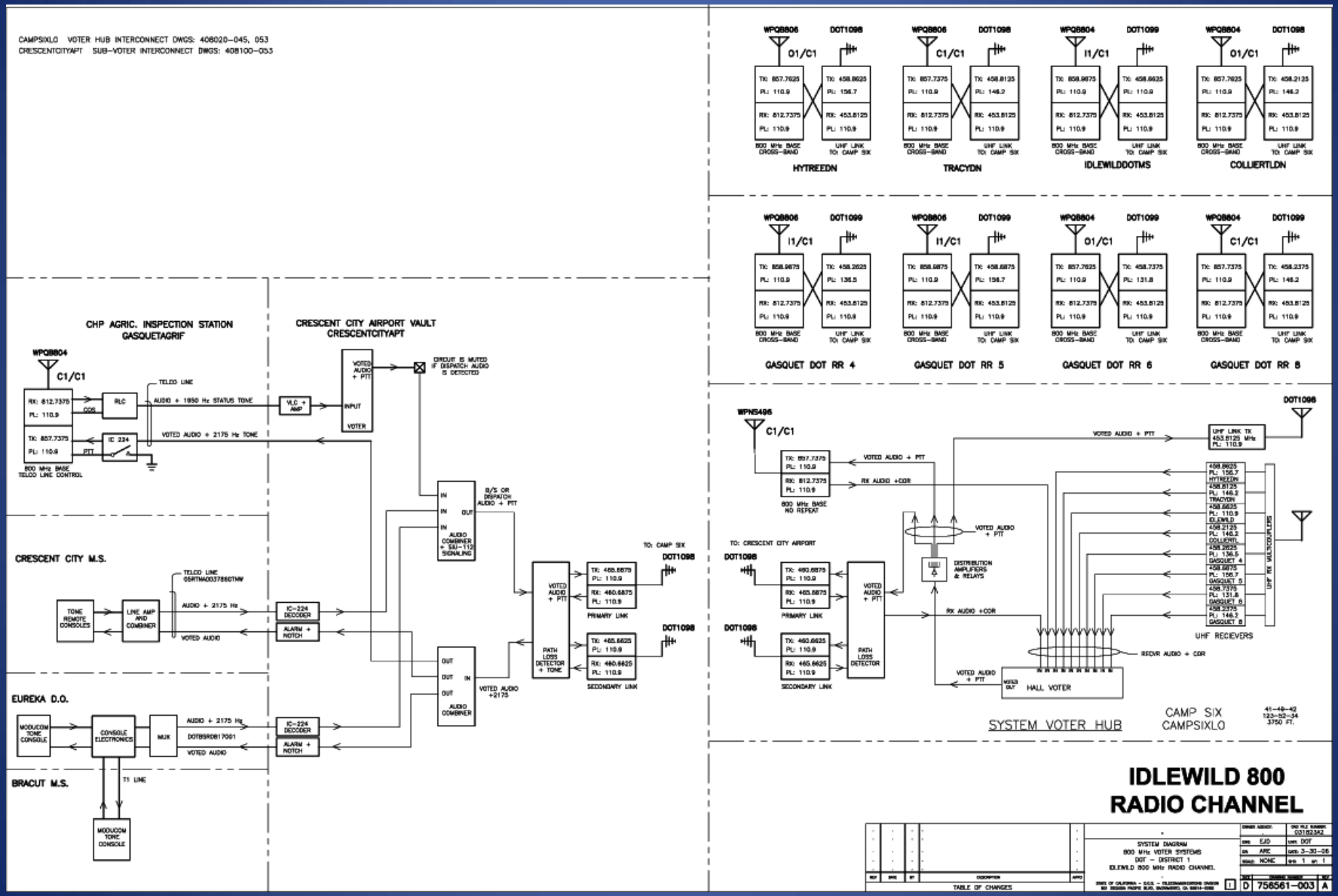

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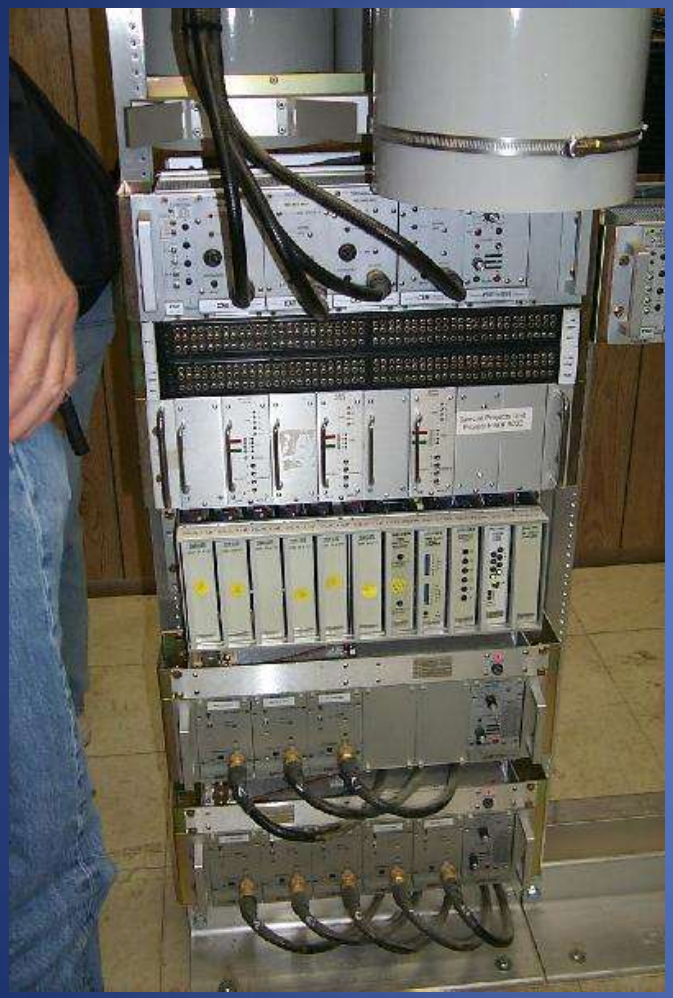

Voter Site Equipment

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Radio System in Hwy 199

Road Side Repeater and Camp 6 Voter Site

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Road Side Repeater Pole with power generation options

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Road Side Repeaters

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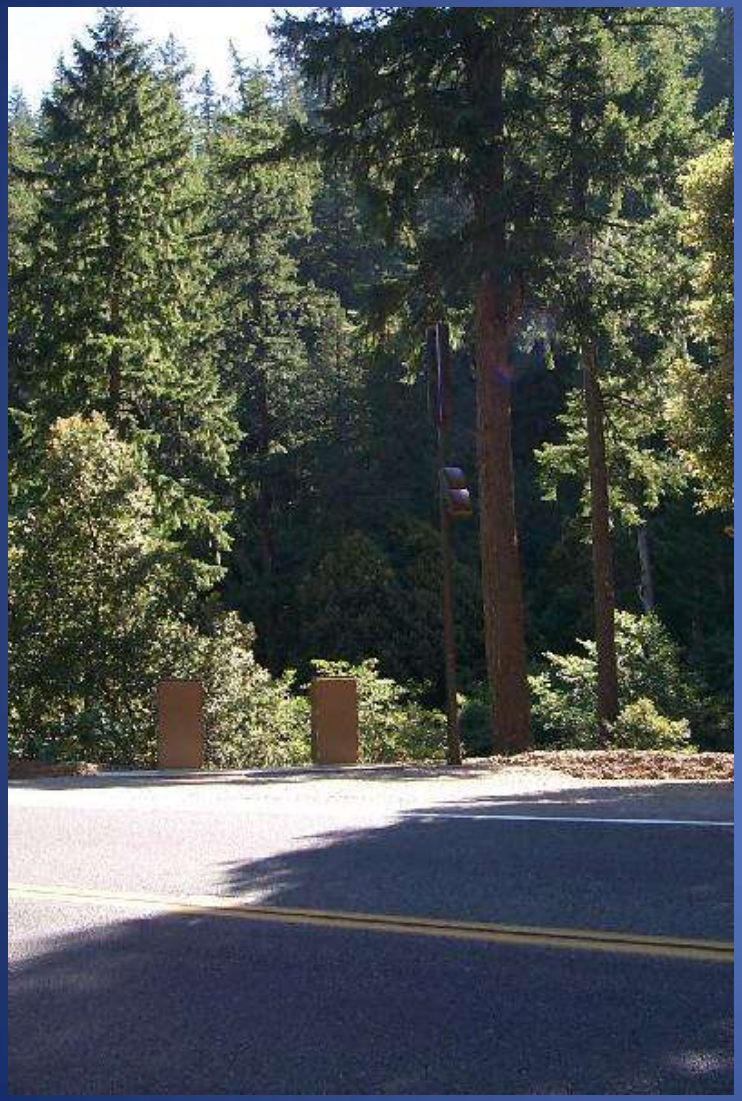

Road Side Repeaters

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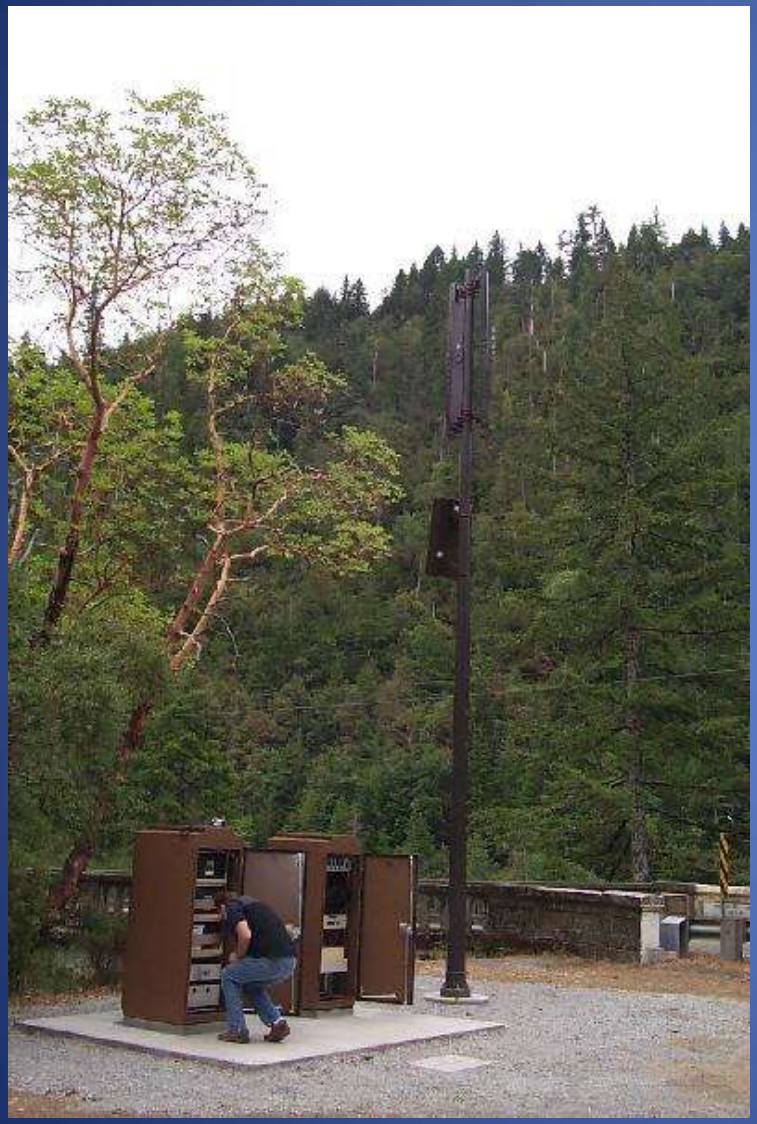

Road Side Repeaters

Operational Program Hands-on Demonstration

A number of portable radios will be available for people to look at and operate.

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Table 1 ZONE ALLOCATION FOR RADIO PROGRAM DISTRICT 1 & 2

ZONE	DESCRIPTION
1	District 1 - Channel Allocations
2	District 2 - Channel Allocations
3	District 3 – Channel Allocations
4	Tactical Frequencies – Interoperability safety Channels
5	State Wide Frequencies: A, BR1, BR2, C (1-6)
6	State Wide Frequencies: D, ER1,ER2, F (1-6)
7	State Wide Frequencies: G, H, I (1-6)
8	State Wide Frequencies: J (1-6), O1, P2,Q1,Q4,R1R1,R3R1,
9	OASIS trailers
10	Scan lists - Technician use only
11-16	Not assigned

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Zone: 1	(Conventional)							
Mode	Zone	Readout	Type	Mobile Transmit	Mobile Receive	TX/RX CTCSS	Notes	
1	D1	1 CAR-CAR	Cnv	856.9875	856.9875	110.9/CS	A1/CS	CS = Carrier Squelch
2	D1	2 CR-CR 2	Cnv	859.7375	859.7375	156.7	G6	
3	D1	3 IDLEWIL	Cnv	812.7375	857.7375	110.9	C1	
4	D1	4 CRCNT C	Cnv	811.7375	856.7375	146.2	D5	
5	D1	5 WLLOW C'	Cnv	811.9875	856.9875	136.5	A4	
6	D1	6 ORLEANS	Cnv	813.7625	858.7625	131.8	P3	
7	D1	7 EUREKA	Cnv	812.7375	857.7375	123.0	C2	
8	D1	8 BRGVILL	Cnv	811.9875	856.9875	156.7	A6	
9	D1	9 FORTUNA	Cnv	811.7375	856.7375	123.0	D2	
10	D1	10 GRBRVI	Cnv	813.9875	858.9875	146.2	I5	
11	D1	11 LEGGET	Cnv	814.1625	859.1625	131.8	RB3	
12	D1	12 WILITS	Cnv	814.7625	859.7625	136.5	Q4	
13	D1	13 UKIAH	Cnv	813.9875	858.9875	123.0	I2	
14	D1	14 LAKEPO	Cnv	812.0875	857.0875	110.9	RR1	
15	D1	15 BOONVI	Cnv	814.7375	859.7375	156.7	G6	
16	D1	16 MNCHSR	Cnv	814.1625	859.1625	136.5	RB4	
17	D1	17 CLROAK	Cnv	814.9875	859.9875	146.2	F5	
18	D1	18 FTBRAG	Cnv	813.7375	858.7375	110.9	H1	

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Zone: 2 (Conventional)

Mode	Zone	Readout	Type	Mobile Transmit	Mobile Receive	TX/RX CTCSS	Notes	
1	D2	1 CAR-CAR	Cnv	856.9875	856.9875	110.9/CS	A1/CS	CS=Carrier Squelsh
2	D2	2 CR-CR 2	Cnv	859.7375	859.7375	156.7	G6	
3	D2	3 SEIAD	Cnv	813.7625	858.7625	131.8	P3	
4	D2	4 GRASSLK	Cnv	812.9875	857.9875	110.9	J1	
5	D2	5 NEWELL	Cnv	812.7625	857.7625	156.7	O6	
6	D2	6 YREKA	Cnv	812.7625	857.7625	146.2	O5	
7	D2	7 SHASTA	Cnv	811.7625	856.7625	110.9	N1	
8	D2	8 GIBSON	Cnv	812.7375	857.7375	110.9	C1	
9	D2	9 REDDNGN	Cnv	814.9875	859.9875	156.7	F6	
10	D2	10REDDNGE	Cnv	814.7375	859.7375	146.2	G5	
11	D2	11 REDBLF	Cnv	811.9875	856.9875	156.7	A6	
12	D2	12 BURNEY	Cnv	811.9875	856.9875	136.5	A4	
13	D2	13 TRNTYC	Cnv	811.7625	856.7625	136.5	N4	
14	D2	14WEAVRVL	Cnv	811.7375	856.7375	156.7	D6	
15	D2	15HAYFORK	Cnv	814.7625	859.7625	110.9	Q1	
16	D2	16PLATINA	Cnv	813.7625	858.7625	123.0	P2	
17	D2	17MINERAL	Cnv	812.7375	857.7375	123.0	C2	
18	D2	18CHESTER	Cnv	812.7625	857.7625	131.8	O5	
19	D2	19QUINCY	Cnv	814.7625	859.7625	123.0	Q2	
20	D2	20 PULGA	Cnv	812.7375	857.7375	136.5	C4	
21	D2	21BCKWRTH	Cnv	813.9875	858.9875	146.2	I5	
22	D2	22 SUSNVW	Cnv	813.7375	858.7375	110.9	H1	
23	D2	23 SUSNVE	Cnv	811.9875	856.9875	110.9	A1	
24	D2	24 HATCRK	Cnv	814.9875	859.9875	123.0	F2	
25	D2	25 ADIN	Cnv	813.5125	858.5125	110.9	RE1	
26	D2	26ALTURAS	Cnv	813.9875	858.9875	156.7	I6	

Discussion

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Thank you