HAM RADIO on 927 MHz FM

K5TRA

Why 900 MHz ?

- 900 MHz is a new frontier for FM operation
- It is very much like 70 cm was 35 years ago
  - *Radios are modified commercial gear:*
    mostly Motorola or Kenwood
  - *Propagation is more challenging than lower frequency bands (2M – 70CM)*
  - *Technical interest*
  - *Weak signal compatible*

Some History

- *August 2007 I visited friends in W. Texas*
- *We talked about 900 MHz and plans for 902-HUB*
- *I returned to Portland 'stoked' to get on 900 MHz*
- *Began 1st repeater in October. It was operational by Christmas*
- *The 2nd machine was on the air in March 2008*
- *Repeater moved to Larch Mtn (WA) in June 2008*

Five Years Later

- *902 HUB was formed in 2008*
- *Austin based 927 TECH now carries the linking load*
- *927 TECH was formed in 2012 and has grown:*

  W.Texas (11), N.Arizona (3), S.California (2), N.California (11), Washington (1), Oregon (3), Idaho (2), Kansas (1), Austin (4), Georgia (1), Pennsylvania (1) ***~ AS MANY AS 40 REPEATERS ! (all 900 MHz)***
- *Two K5TRA repeaters remain in Portland linked to HUB*
  - *Downtown (100W 927.1875)*
  - *Larch Mountain, WA (100W 927.1375)*
- *Four repeaters operational in Austin and linked to HUB*
  - *K5TRA LagoVista (100W 927.1150)*
  - *K5TRA Southwest (100W 927.1250)*
  - *K5TRA North (100W 927.1375)*
  - *WA6UFQ South (15W 927.1625)*
  - *K5TRA portable repeater available for special events (10W)*

What's 900 MHz Like?

- Similar to 70 CM with
  - *Faster mobile flutter*
  - *More multipath*
  - *Greater building penetration due to reflections*
  - *A bit more path loss*
- A good antenna is extremely important
- 12W to 15W is adequate
- 30W radios are available
- Feed line losses are higher (use low loss coax)

900 MHz Mobile Radios

KENWOOD TK-981

MOTOROLA MCS-2000

GOOD CHOICES

KENWOOD TK-931

MOTOROLA SPECTRA

POOR CHOICES

KENWOOD TK-941

MOTOROLA MAXTRAC

MOTOROLA GTX

900 MHz Portables

GOOD CHOICES

POOR CHOICES

MOTOROLA
MTS-2000

KENWOOD
TK-481

MOTOROLA
MTX-9250

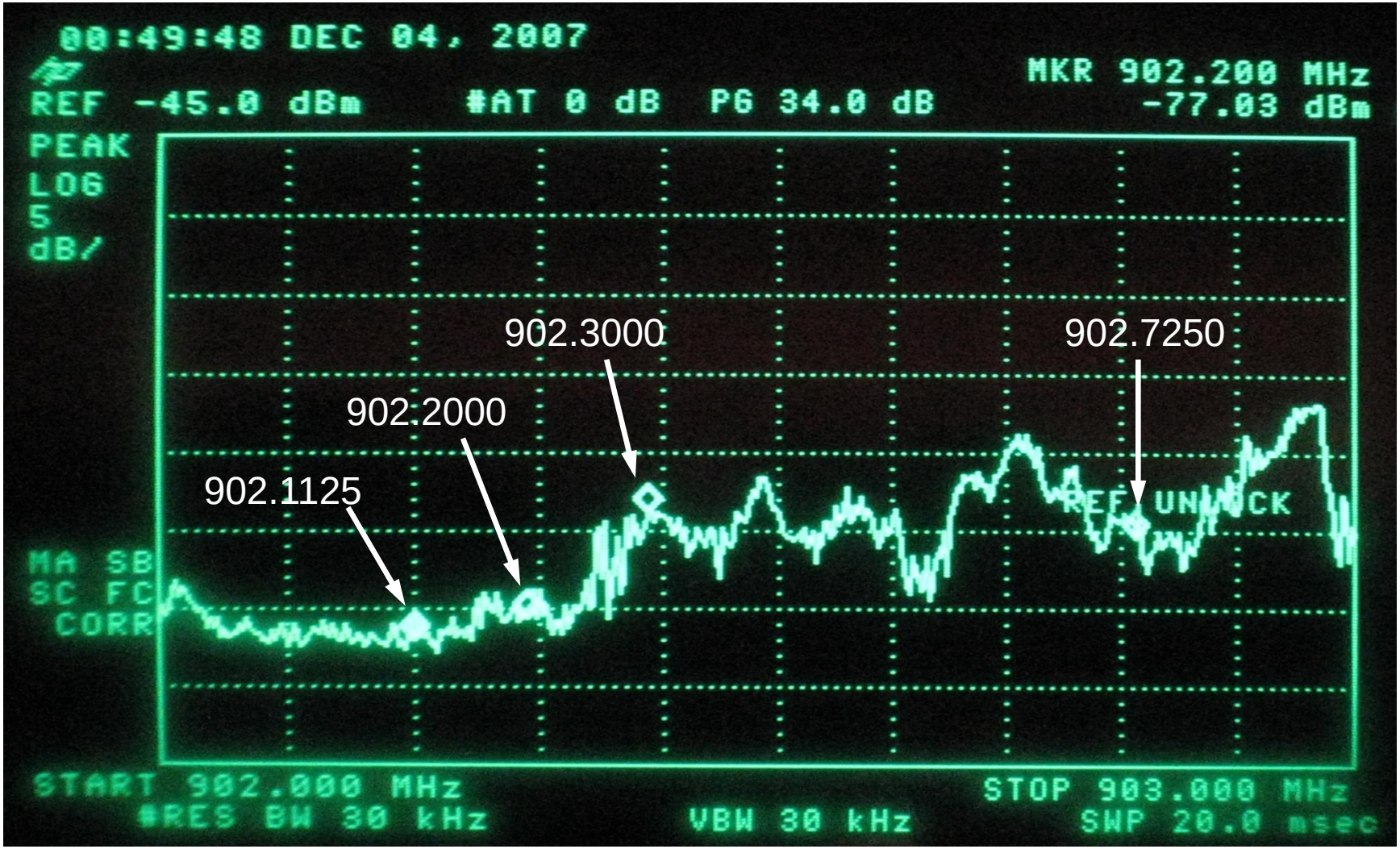
MOTOROLA
GTX

KENWOOD
TK-431

Current US 900 MHz Band Utilization

- In 1985 ARRL's band plan: 12 MHz split for FM repeaters
  - Not used due to available equipment limitations
  - Nearly 300 repeaters are 927 MHz – 902 MHz (25 MHz split)
- Weak signal SSB/CW and FM share the band very well
  - Both groups are populated by "Techies"
  - In many areas weak signal hams also run FM
  - High power repeater outputs are at 927 MHz
- Repeater inputs are in the 902 - 903 MHz
  - Some areas begin FM at 927.1125 (1st channel above 902.1)
  - Some share the lower 100 KHz
  - Noise floor often degrades above 902.2 MHz due to interference from spread spectrum transmitters that share the band

900 MHz Noise Floor

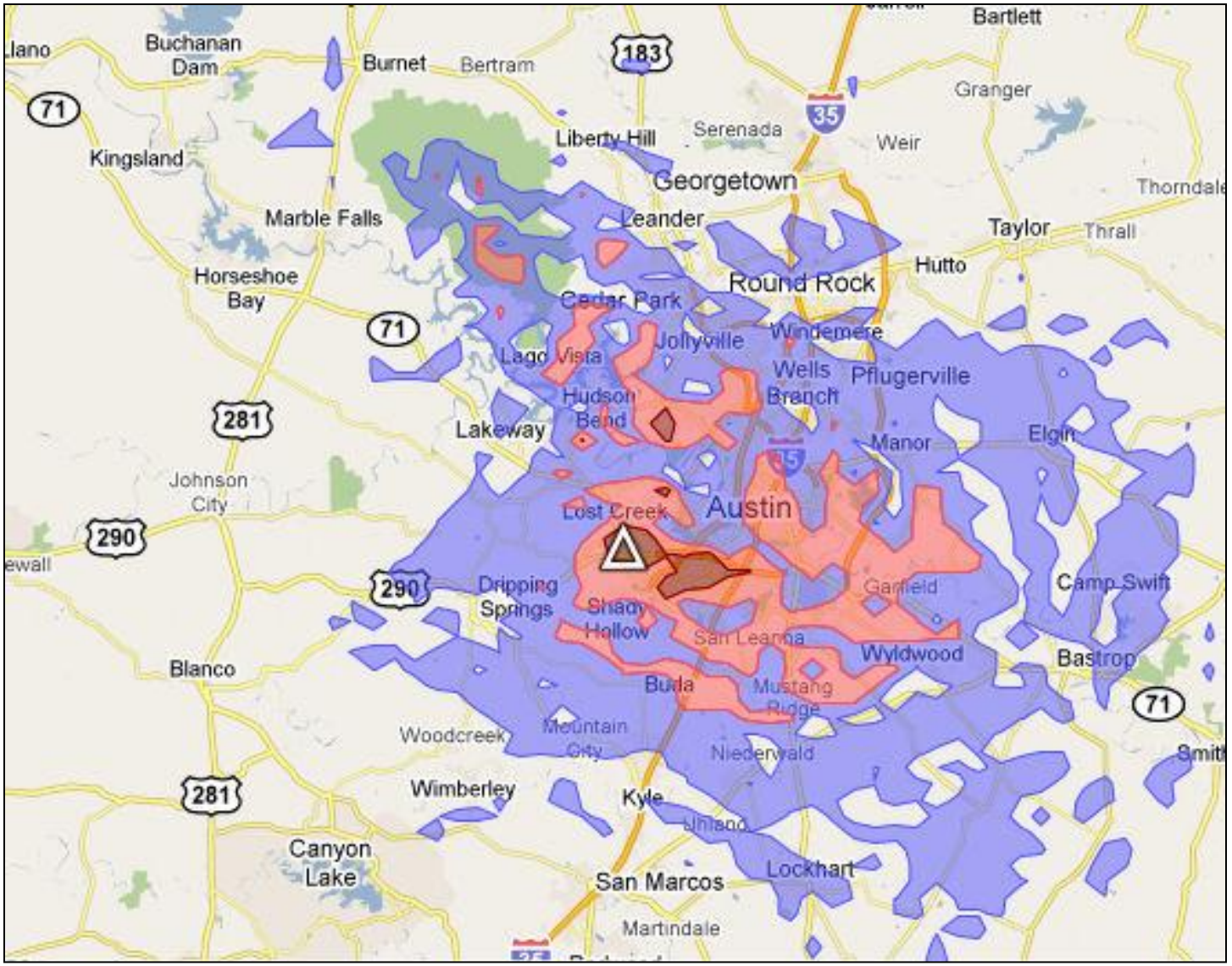


ORRC 33 CM Band Plan

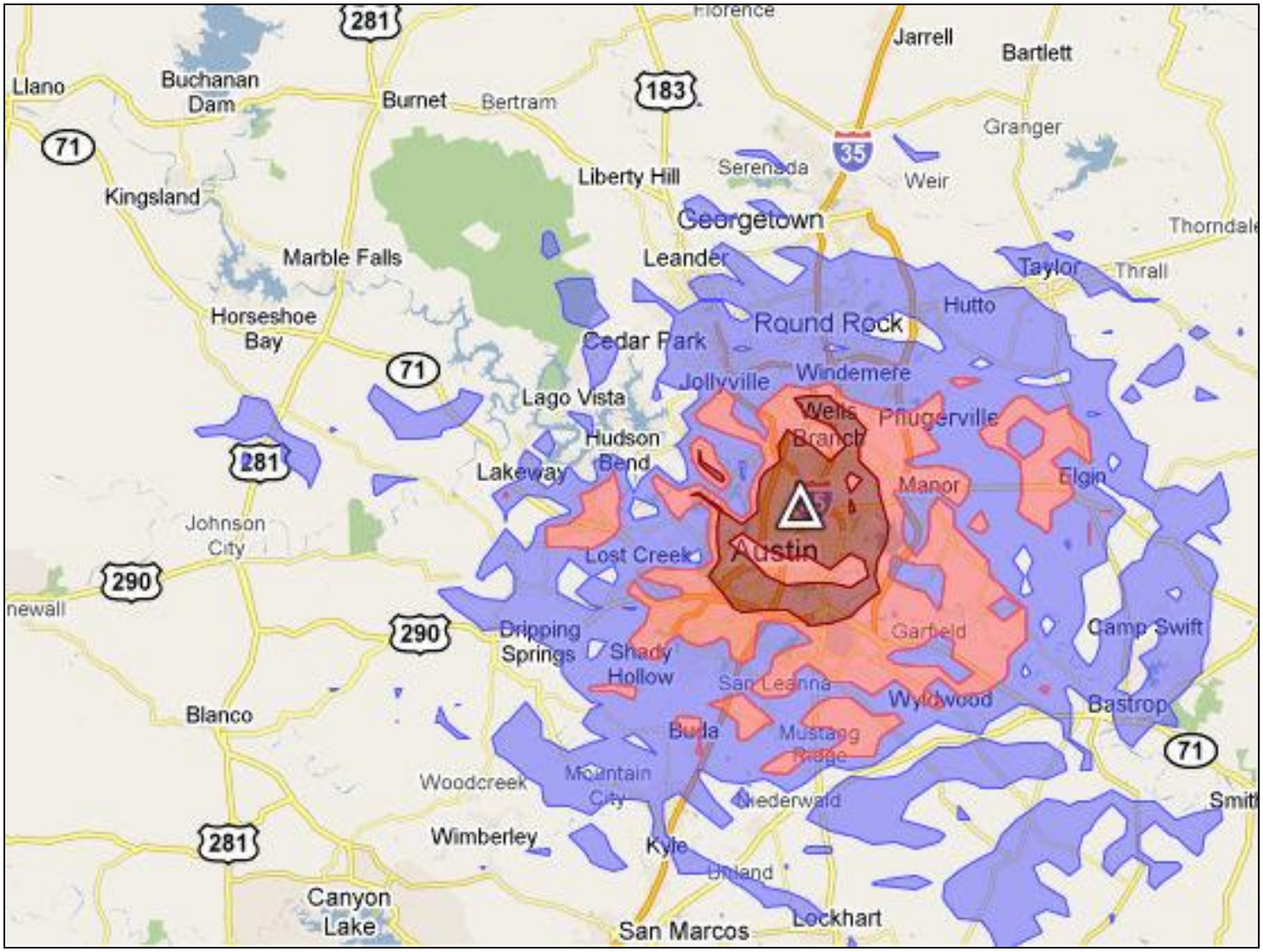
- UPDATED JUNE 2008 -

Frequency *From*	Range *To*	Allocated *KHz*	Usage	Comments
902.0000	902.1000	100.0	Weak Signal	EME, Weak Signal, Experimental. No FM
902.1125	902.4875	375.0	Repearer Inputs	12.5 KHz spacing for Repeater Inputs +25 MHz Offset
902.5000	902.6875	187.5	Control Stations	12.5 KHz spacing for Control Frequencies
902.7000	902.8875	187.5	Repearer Inputs	12.5 KHz spacing for Repeater Inputs +25 MHz Offset
902.9000	902.9375	37.5	Repearer Inputs	Analog Voice Repeater Inputs SNI/Test Pairs +25 MHz Offset
902.9500	902.9875	37.5	Repearer Inputs	Digital Voice Repeater Inputs SNI/Test Pairs +25 MHz Offset
903.0000	904.0000	1000.0	Weak Signal	EME, Weak Signal, Experimental. No FM
904.0000	916.0000	12000.0	ATV	ATV Simplex or Repeater (input or output) AM or FM permissible
916.0250	916.3750	350.0	Linking	12.5 KHz spacing for Link Inputs +10 MHz Offset
916.4000	926.0000	9600.0	Experimental	Experimental, Digital, New Modes, Wide Bandwidth Permissible
926.0250	926.3750	350.0	Linking	12.5 KHz spacing for Link Outputs -10 MHz Offset
926.4000	927.1000	700.0	Experimental	Experimental, Digital, New Modes, Narrow Bandwidth ONLY
927.1125	927.4875	375.0	Repeater Outputs	12.5 KHz spacing for Repeater Outputs -25 MHz Offset
927.5000	927.6875	187.5	Simplex	12.5 KHz spacing. National Simplex: 927.5000
927.7000	927.8875	187.5	Repeater Outputs	12.5 KHz spacing for Repeater Inputs -25 MHz Offset
927.9000	927.9375	37.5	Repeater Outputs	Analog Voice Repeater Outputs SNI/Test Pairs -25 MHz Offset
927.9500	927.9875	37.5	Repeater Outputs	Digital Voice Repeater Outputs SNI/Test Pairs -25 MHz Offset

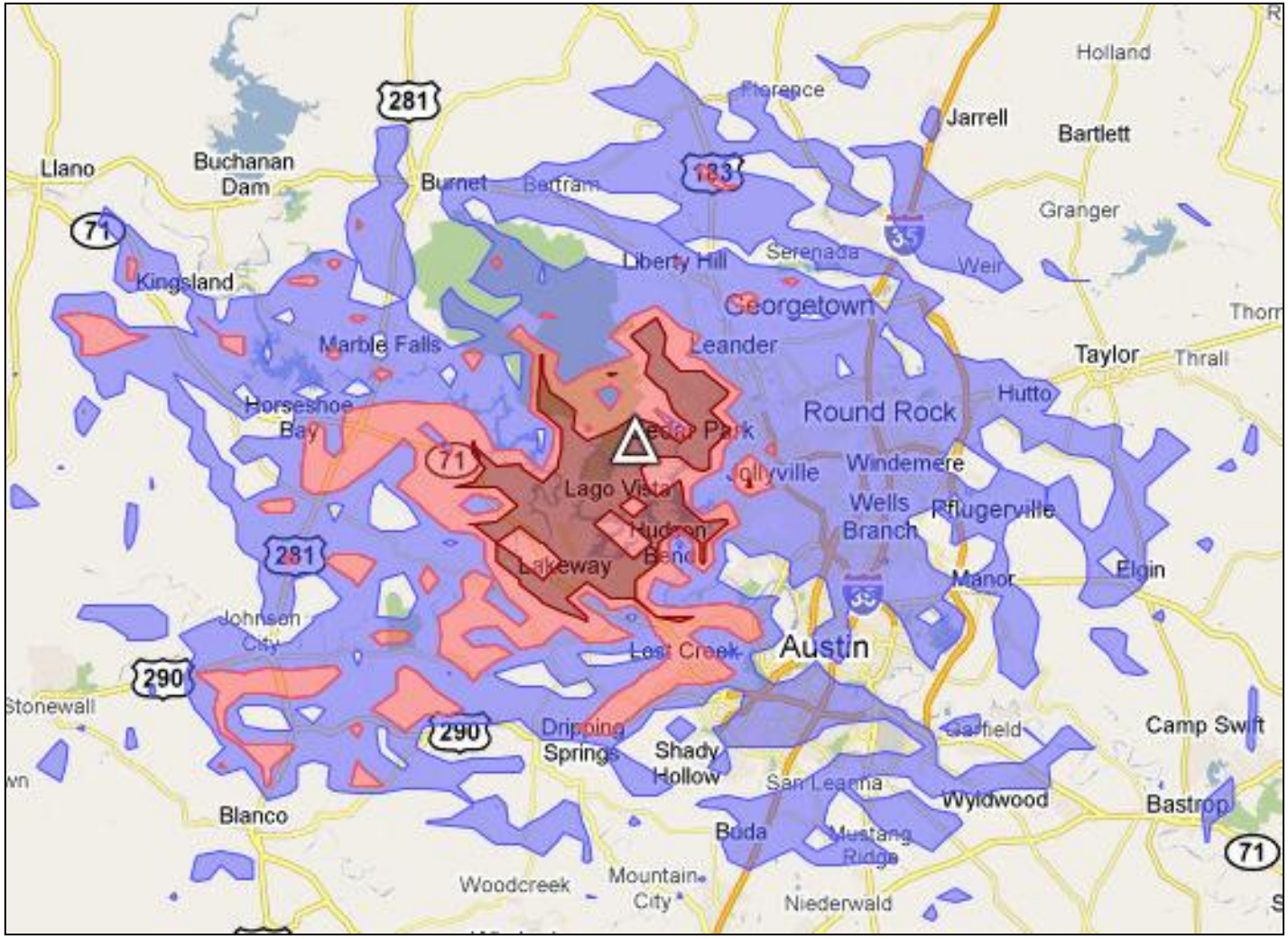
Southwest Repeater 927.1250 MHz



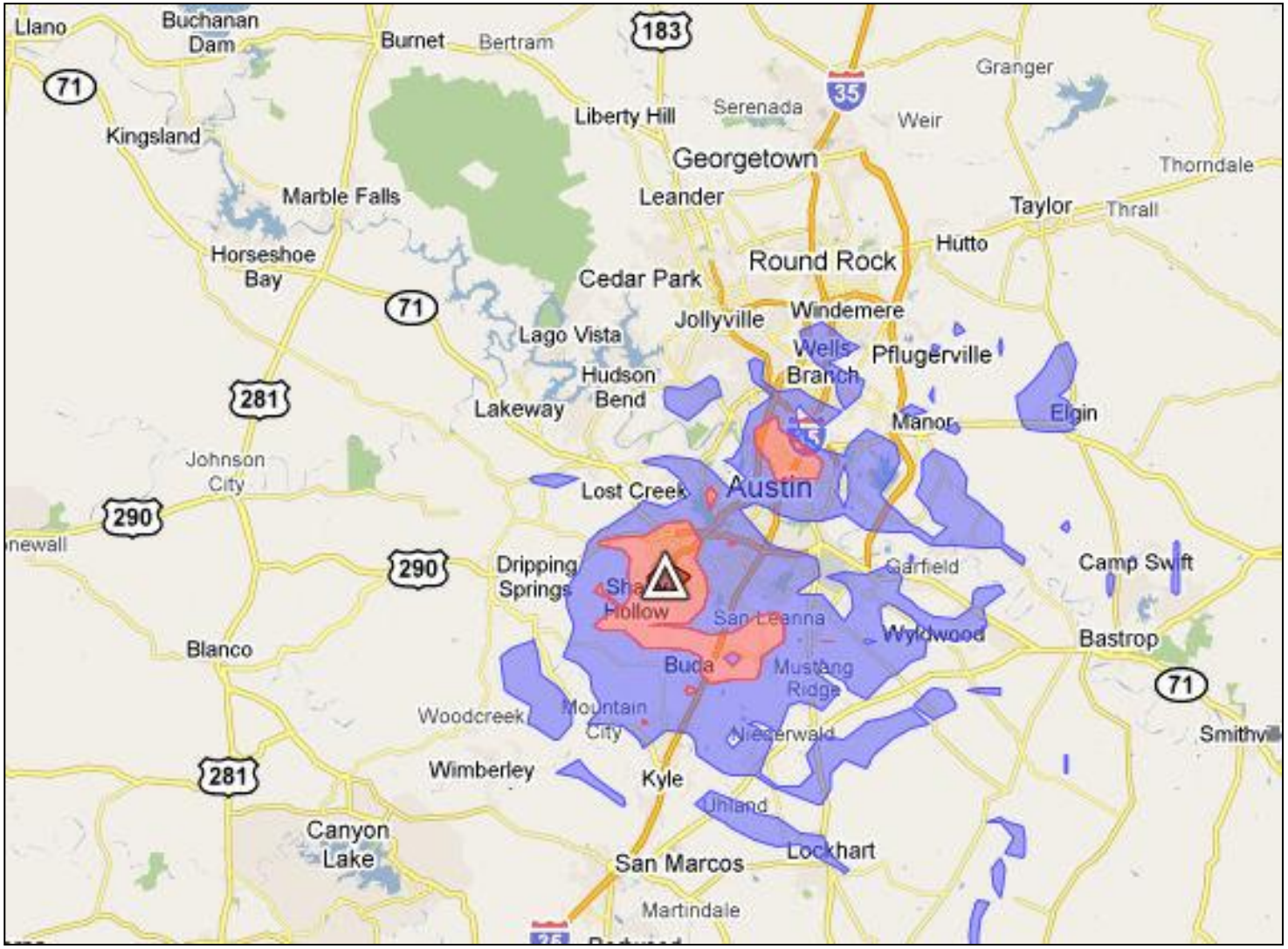
North Central Repeater 927.1375 MHz



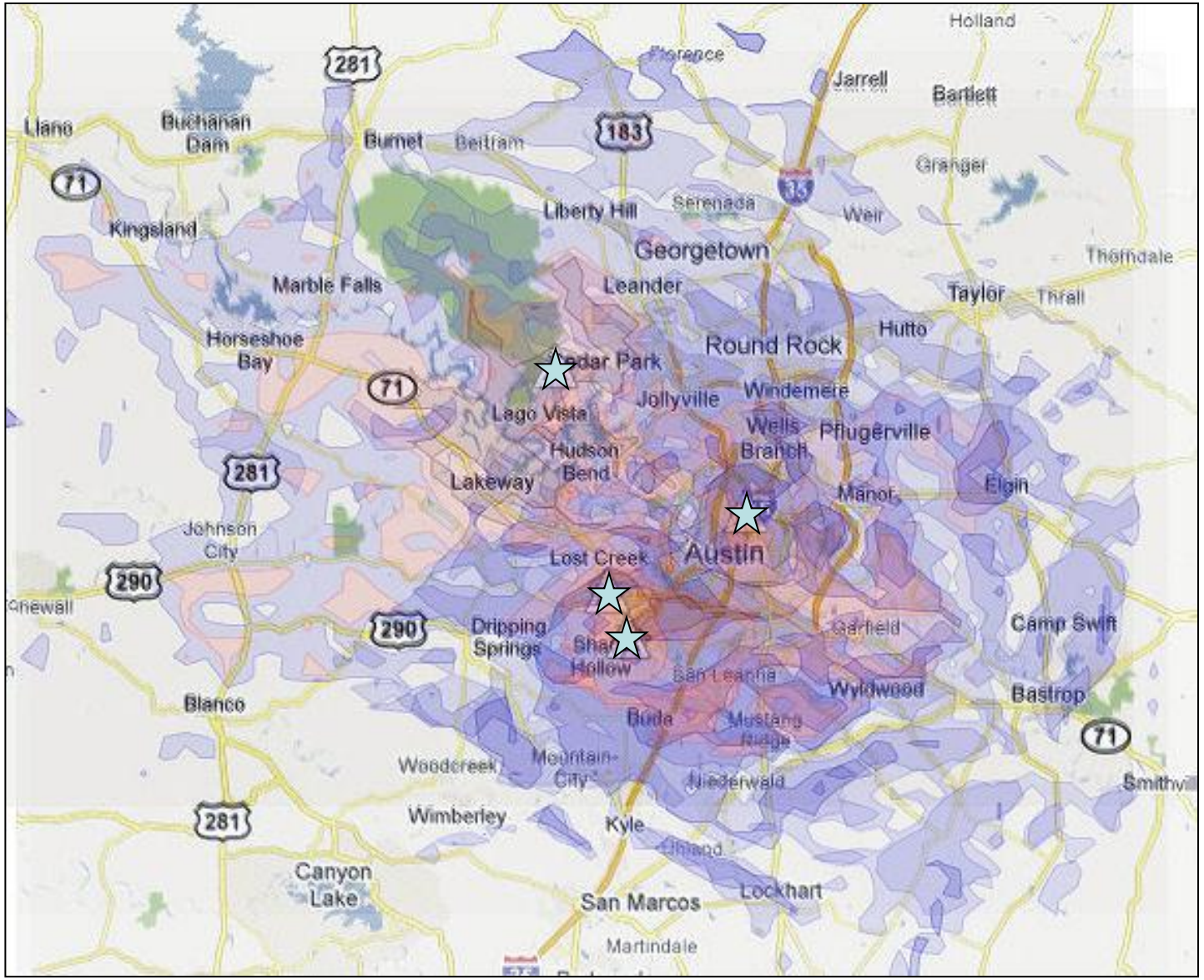
Lago Vista Repeater ***927.1125 MHz***



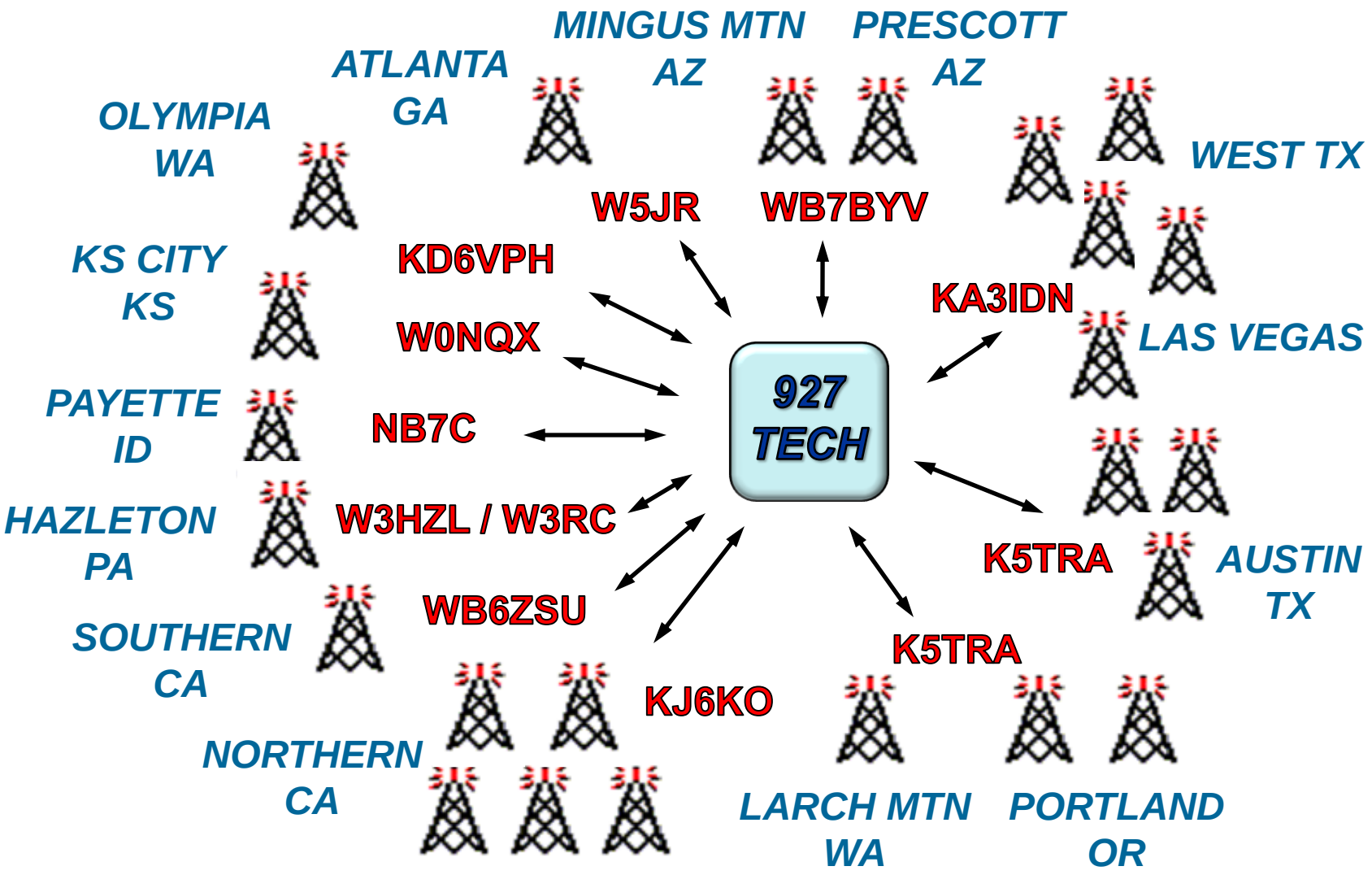
South Side Repeater 927.1625 MHz



Austin Linked Repeater Coverage



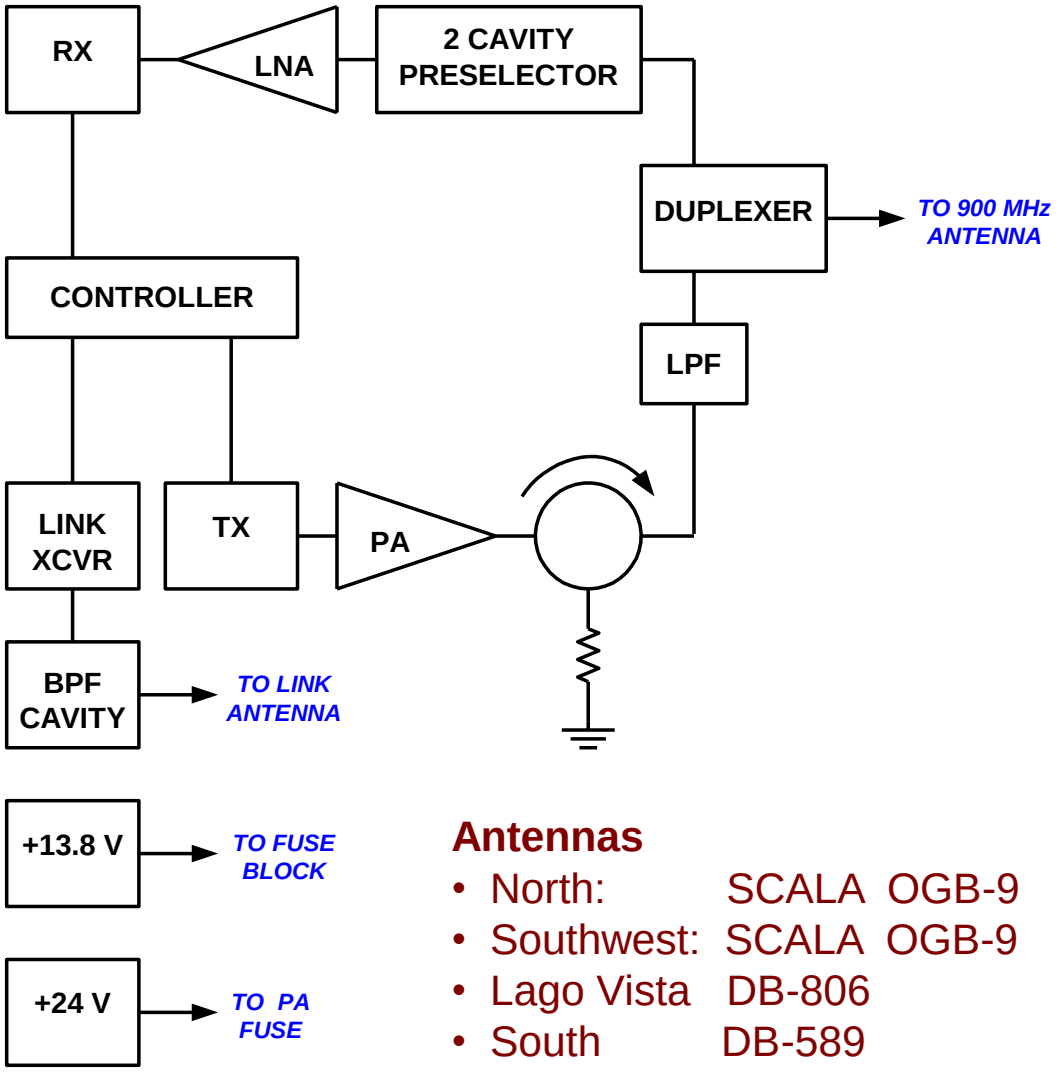
900 MHz Linked Repeaters



SHORT HAUL RF LINKS TO INTERNET BACK-BONE

Austin Repeater Configuration

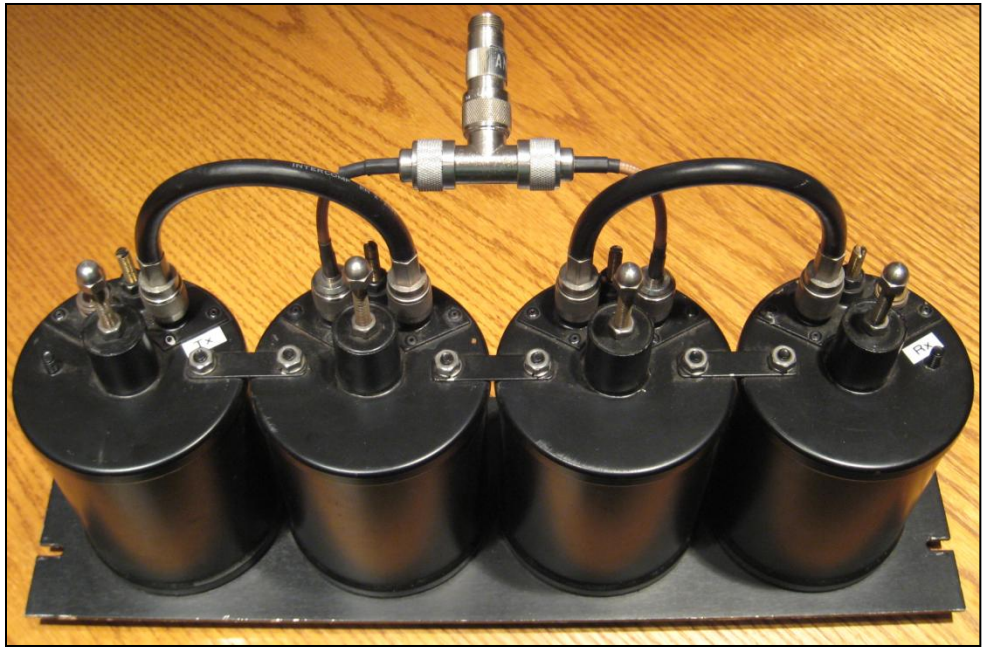
- **Duplexer:** Cellular base station
  - dual combline
- **Preselector:** Wacom cavities
- **LNA choices**
  - Angle Linear
  - *Minicircuits*
  - ARR
- **TX and RX**: TK-941
- **Link Transceiver:** TK-840
- **Controller:** ICS Linker II
- **PA:** Motorola cellular 150W
  - Requires +24V
- **Isolator & load:** Celwave
- **Power Supplies (switching)**
  - Meanwell (SE-600-12)
  - Meanwell (SE-600-24)

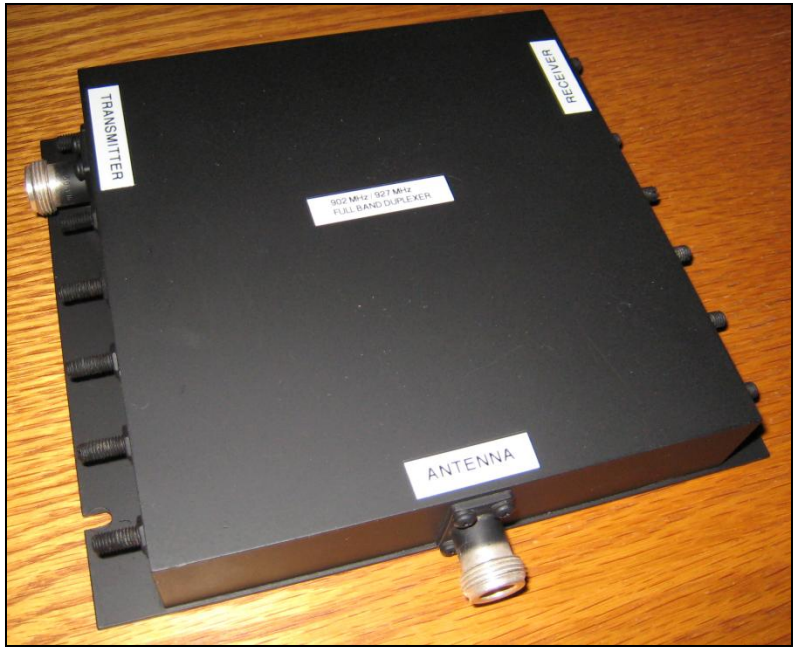


Antennas

- North: SCALA OGB-9
- Southwest: SCALA OGB-9
- Lago Vista DB-806
- South DB-589

902 MHz / 927 MHz Duplexers





PASS - REJECT CAVITY DUPLEXER

USED IN LARCH MOUNTAIN (WA)
927.1375 MACHINE

COMBLINE DUPLEXER
from CELLULAR BASE STATION

USED IN PORTLAND (OR)
927.1875 MACHINE

902 MHz / 927 MHz Duplexer

COMBLINE DUPLEXER
from CELLULAR BASE STATION

USED IN AUSTIN 927.1120, 927.1250 and 927.1375 MACHINES

902 MHz LNA Preselector Filters

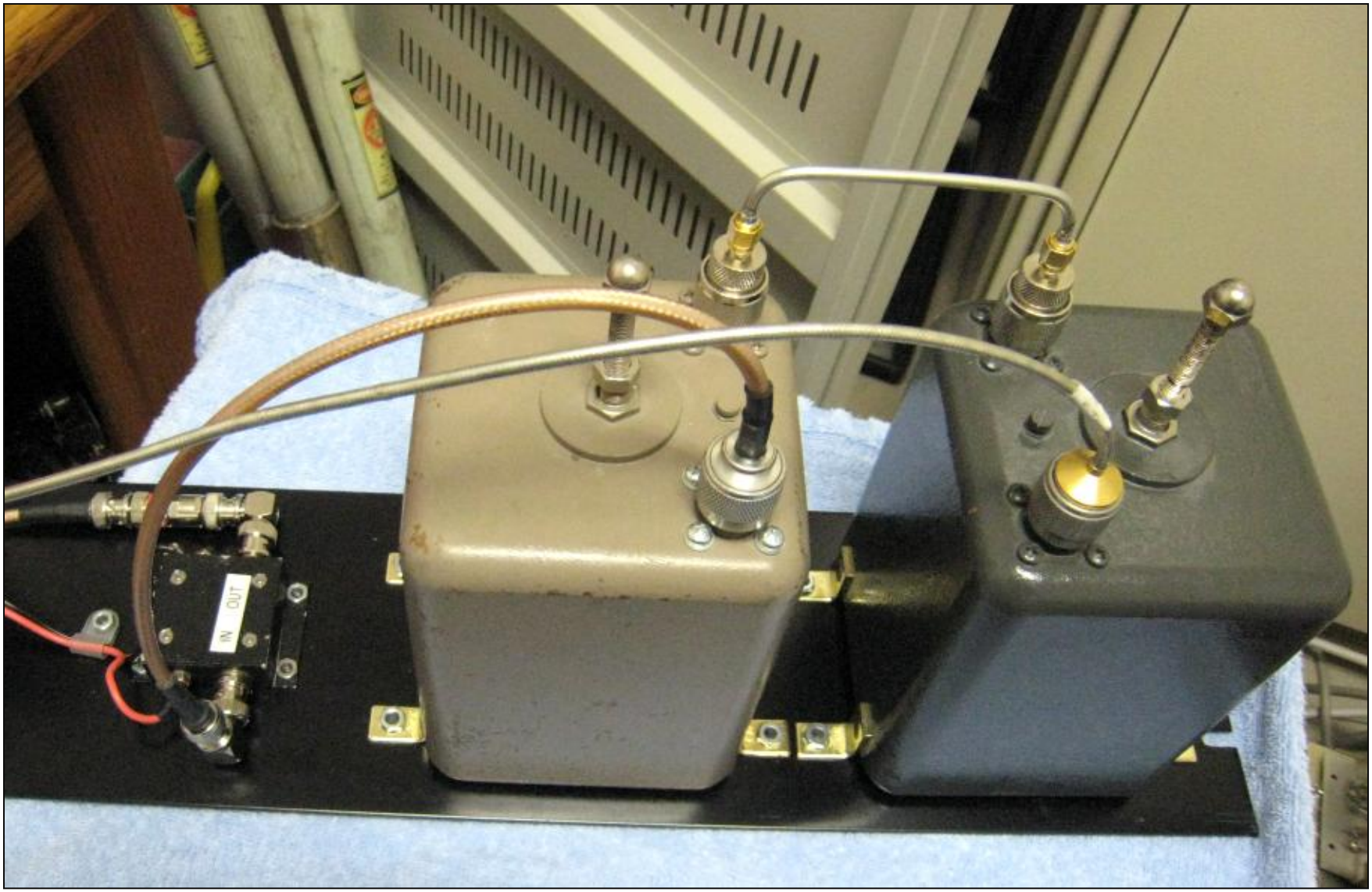
COMBLINE FILTER

MULTI-CAVITY FILTER

TWO CAVITIES and LNA

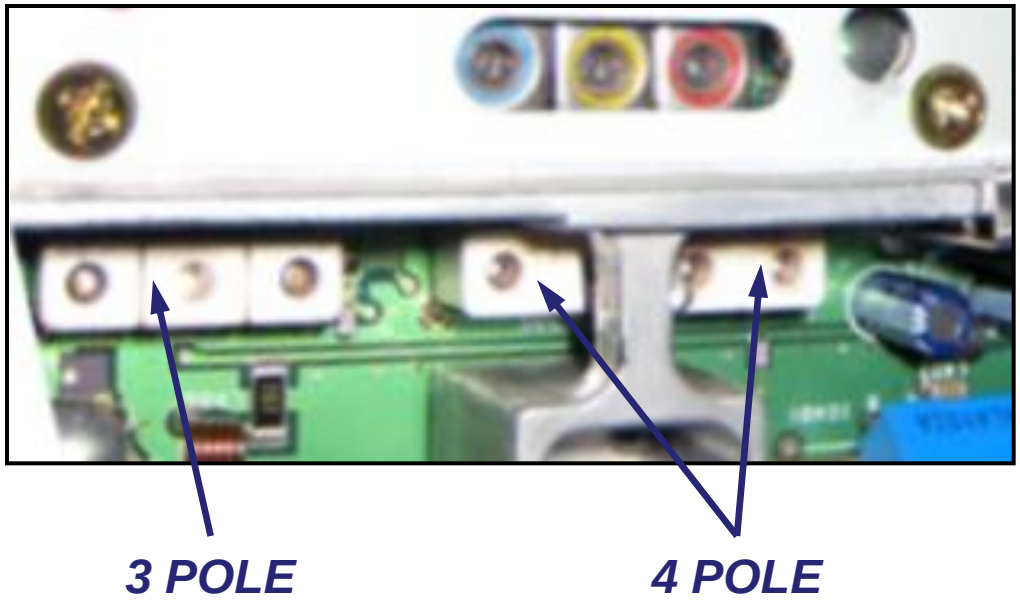
EXAMPLES OF RX FILTERING BETWEEN DUPLEXER & LNA

Celwave Cavities with ARR LNA



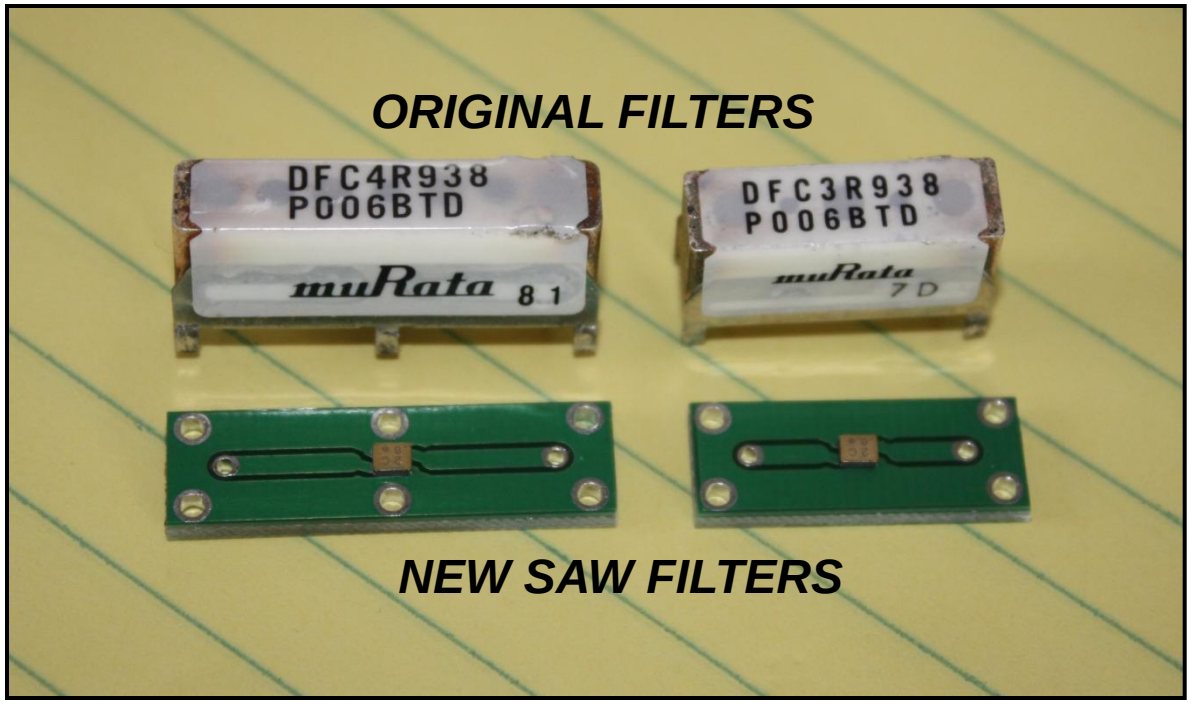
Receiver COS Interface

Receiver Ceramic Filter Change



- Replace original front-end filters
- Provides good response at both 902 MHz and 927 MHz
- Construct 4 pole filter from pair of 2 pole filters

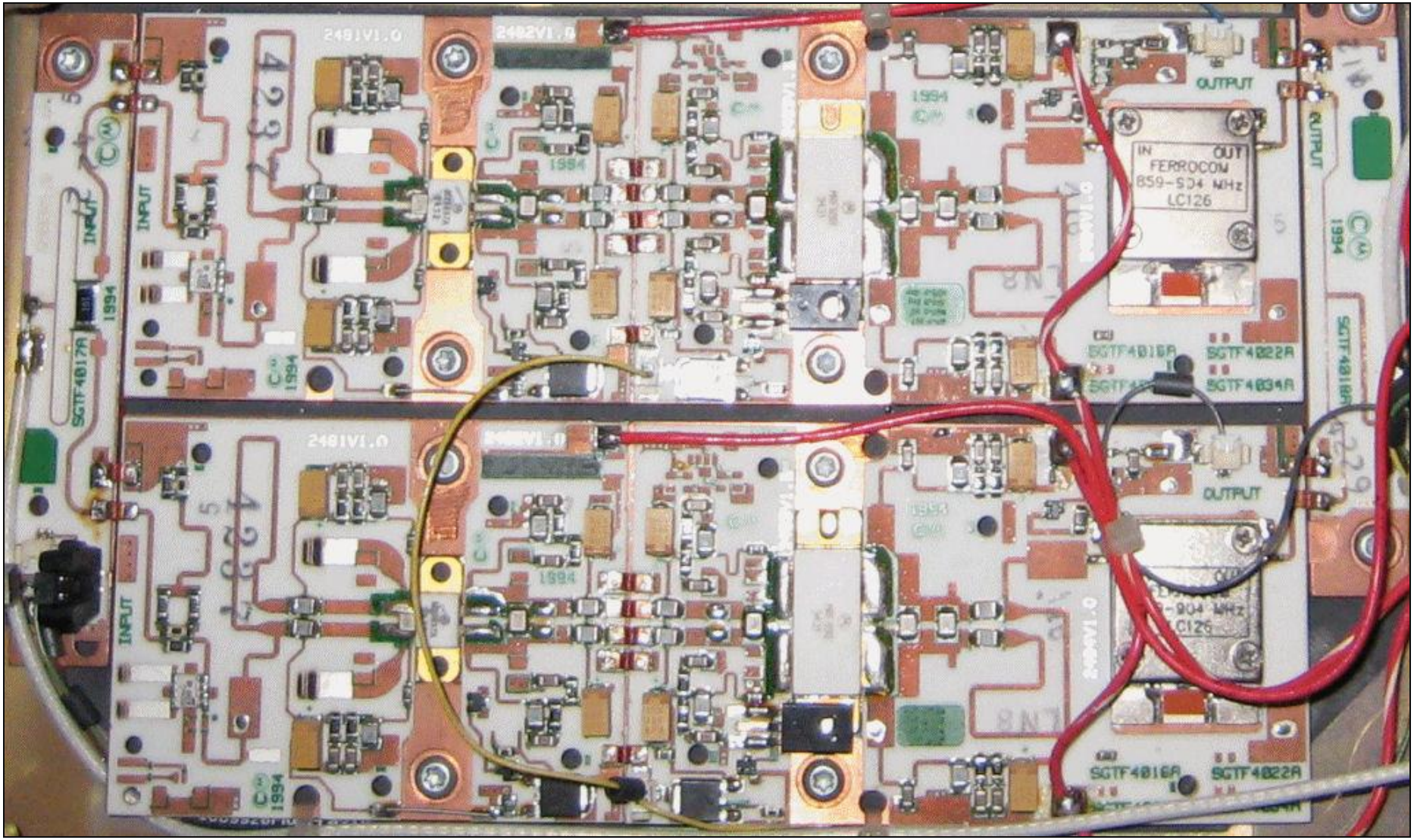
SAW Replacement for Ceramic Filters



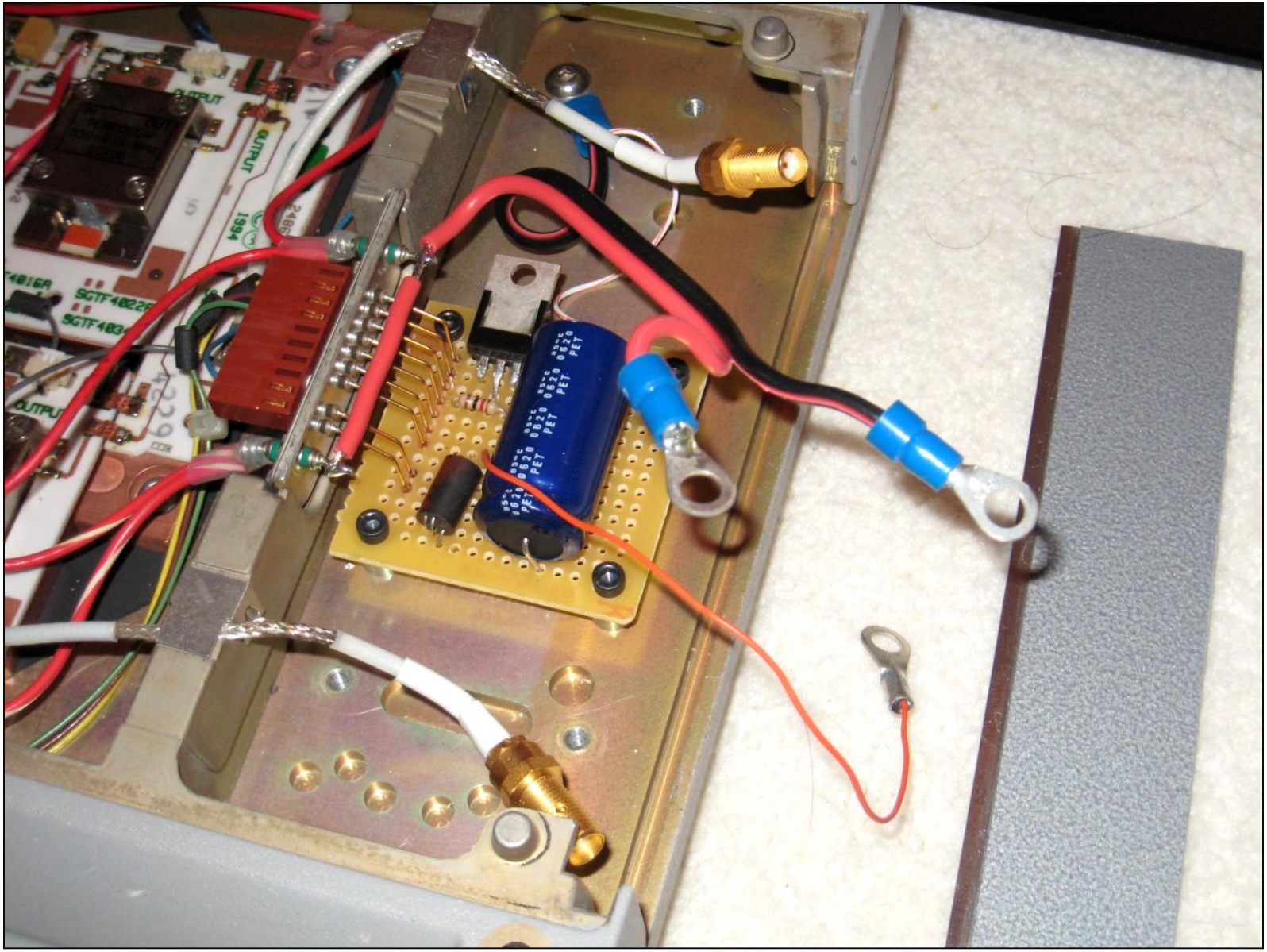
- Replace original front-end filters
- SAW filters attached to interface PC boards
- Footprint matched to original ceramic filters

Receiver VCO Modification

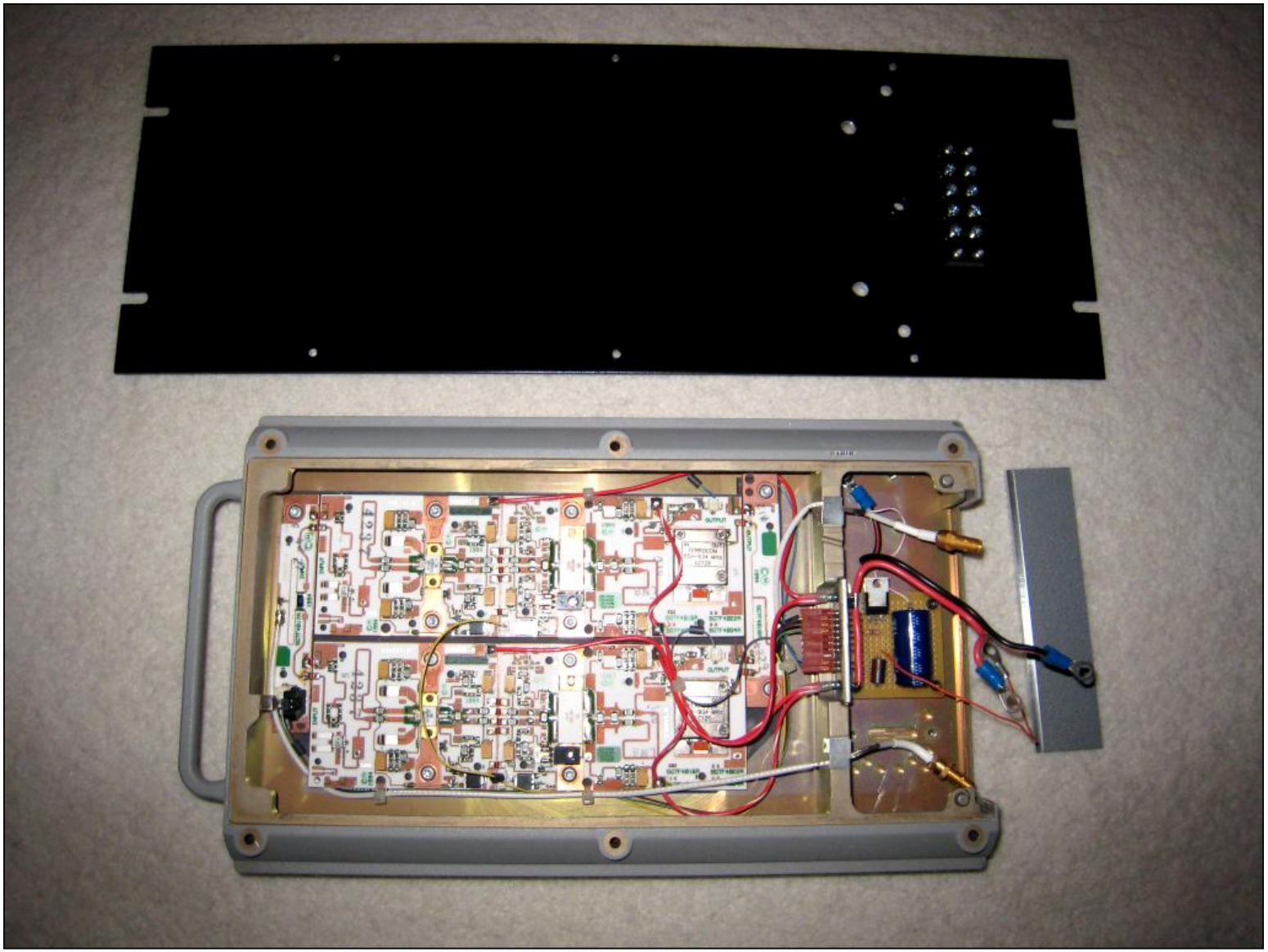
Power Amplifier Boards



PA Bias Board

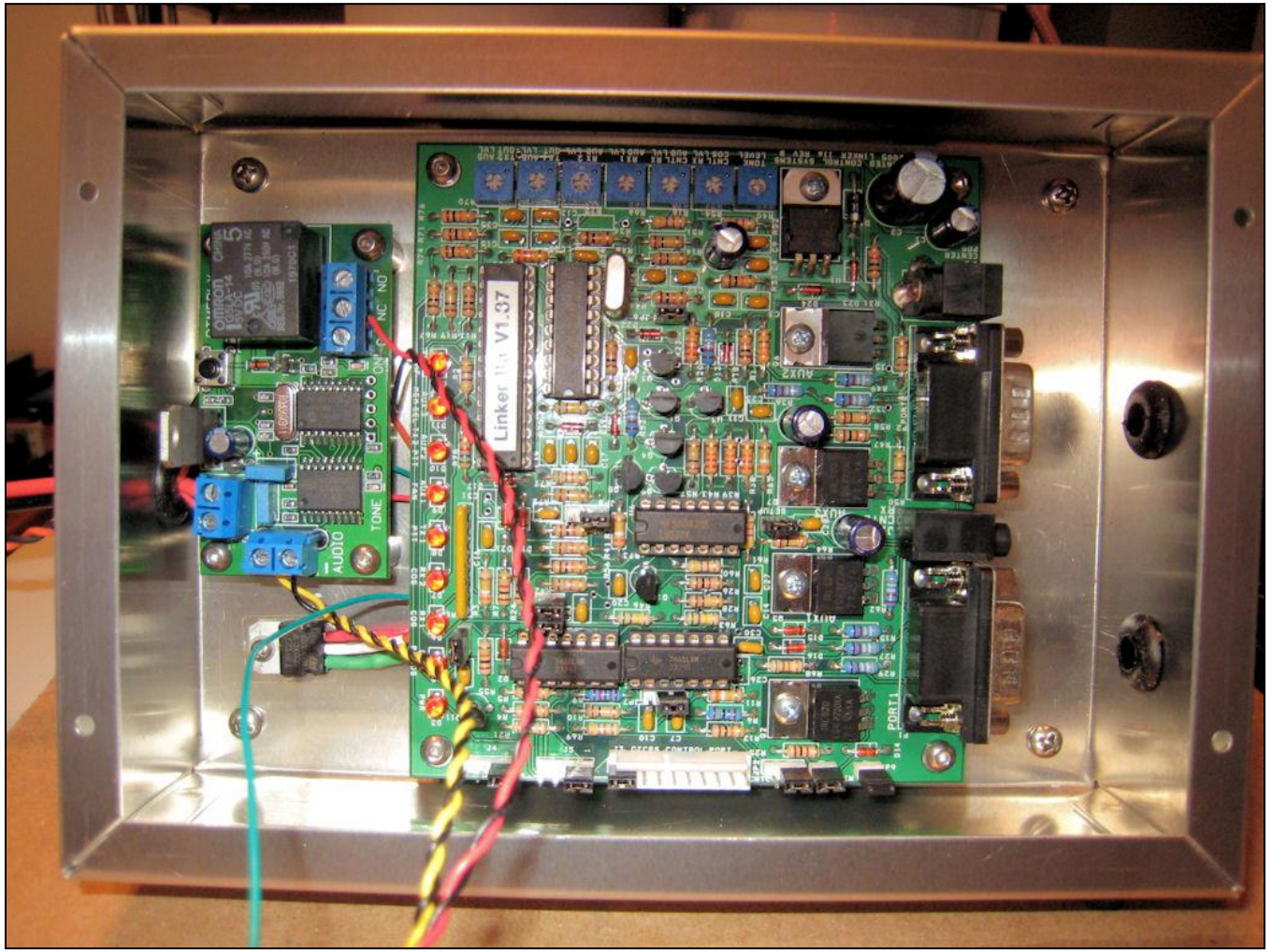


Modified PA and Panel

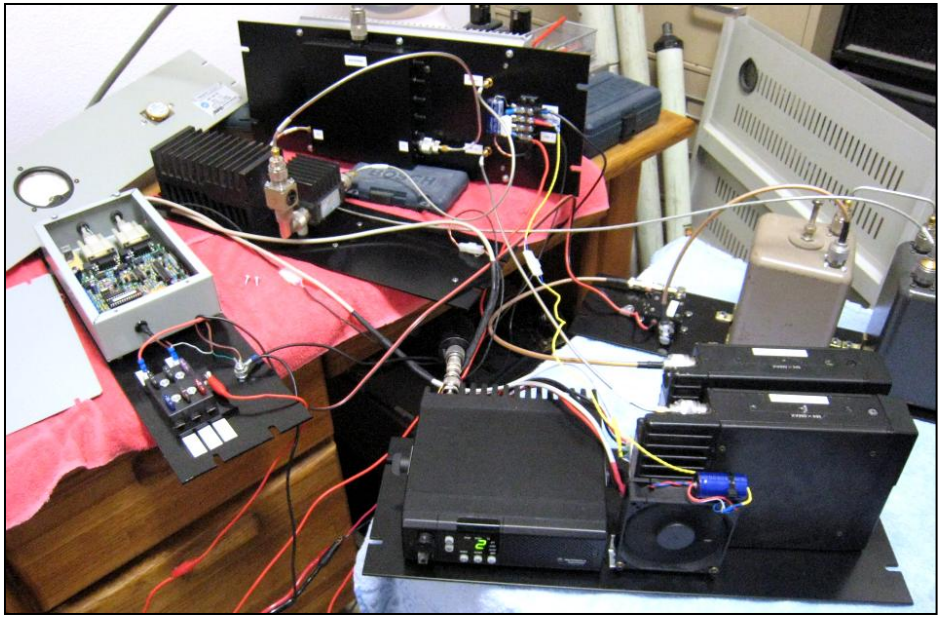


PA Mounted to Panel

Controller and DTMF Relay



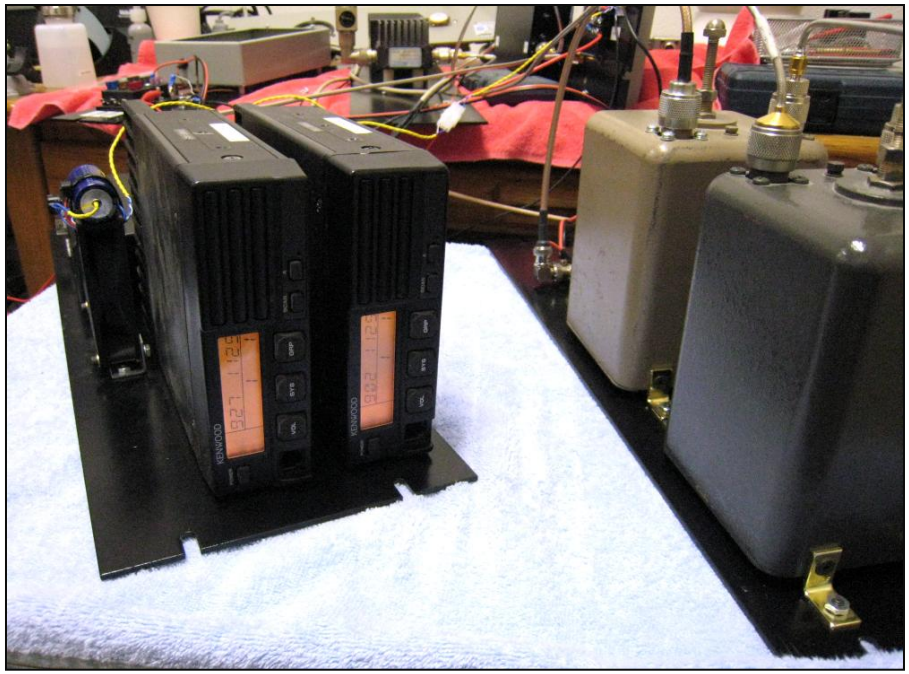
Bench Testing



Photos from Portland repeater

TX/RX Stacks

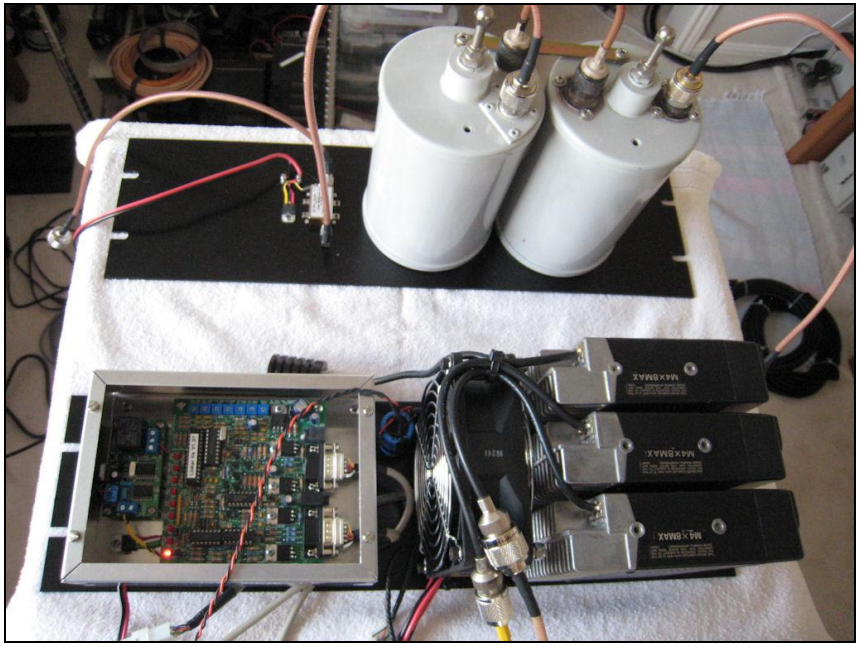
TK-941 panel



TK-931 panel

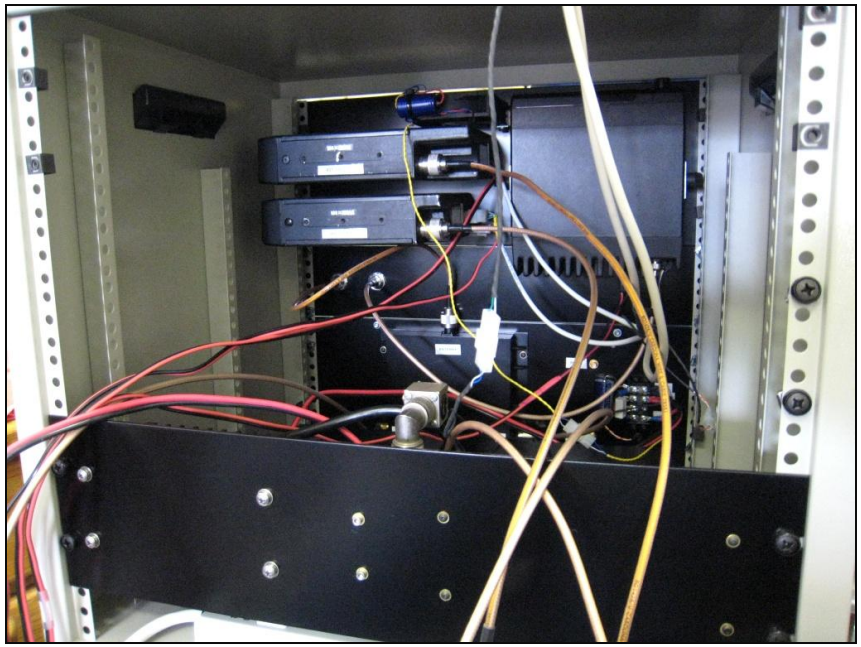
Radios, Controller, LNA & Preselector

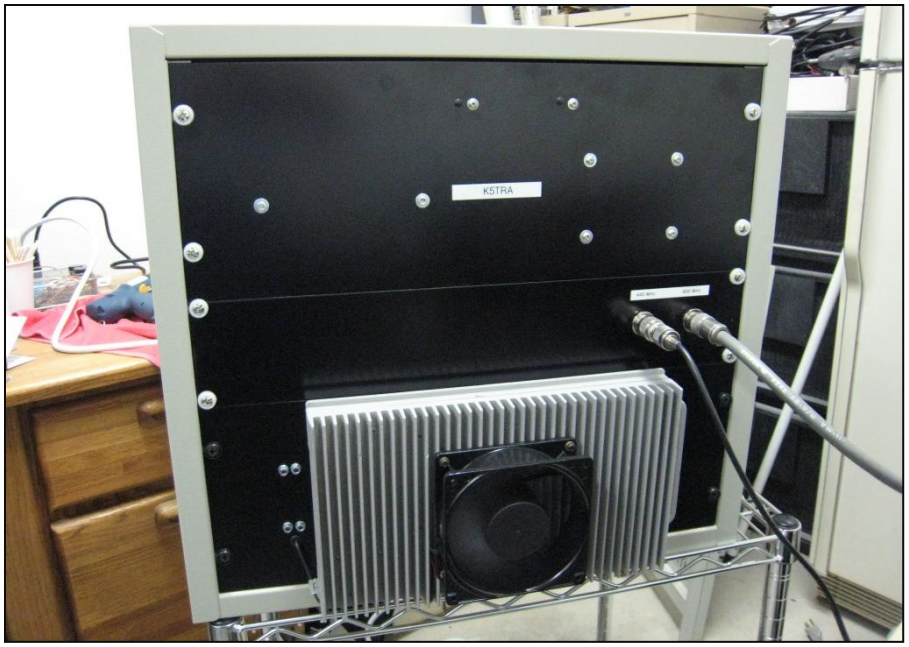
SW Austin repeater



LagoVista repeater

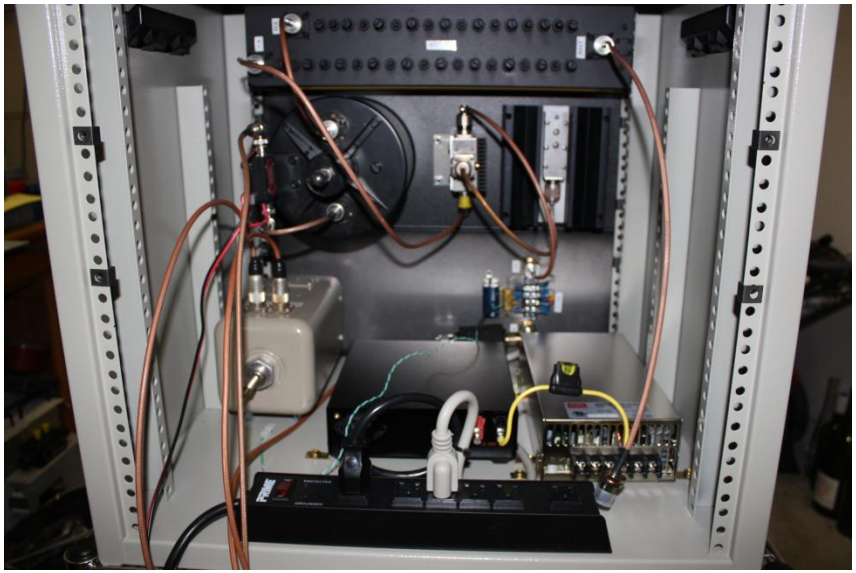
Portland Downtown Repeater

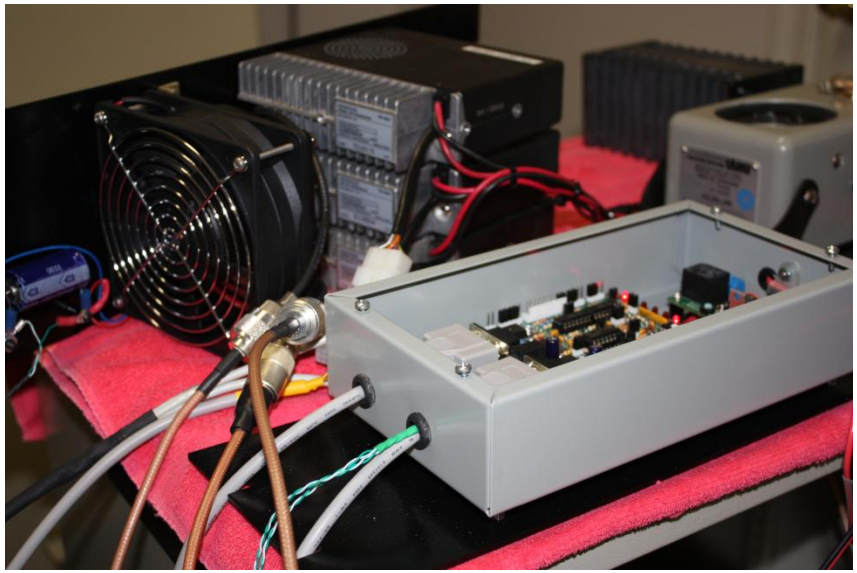




- TK-931 TX / RX and GM300 Link
- ARR LNA with Celwave preselector cavity
- Motorola “300W” cellular PA
- Celwave Isolator
- K&L cellular combline duplexer
- ICS Linker-IIa controller

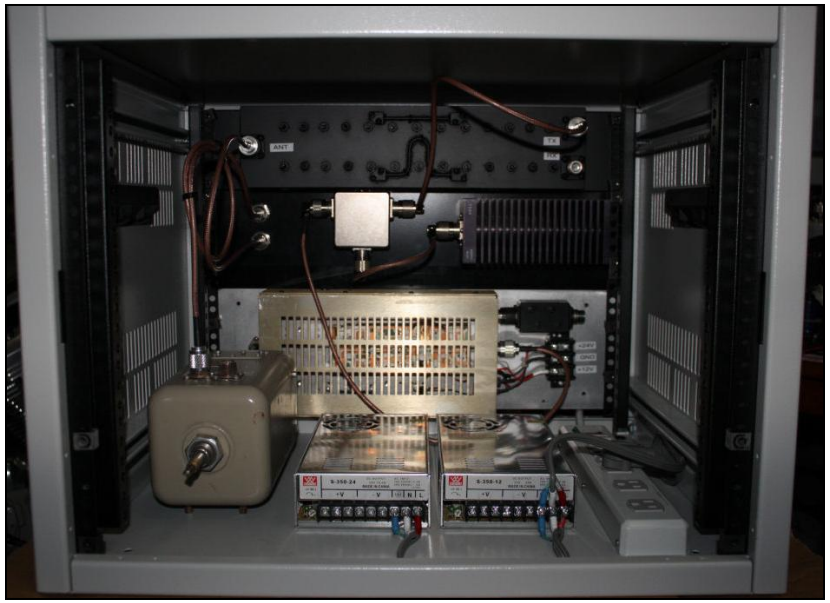
North Austin Repeater





- TK-941 TX / RX and TK-840 Link
- ARR LNA with Celwave preselector cavity
- Motorola “150W” cellular PA
- Celwave Isolator
- Narda cellular combline duplexer
- ICS Linker-IIa controller

Southwest Austin Repeater



- TK-941 TX / RX and TK-840 Link
- Angle Linear LNA with Wacom preselector cavities
- Motorola “150W” cellular PA (in TPL housing)
- Celwave Isolator
- Narda cellular combline duplexer
- ICS Linker-IIa controller

Lago Vista Repeater

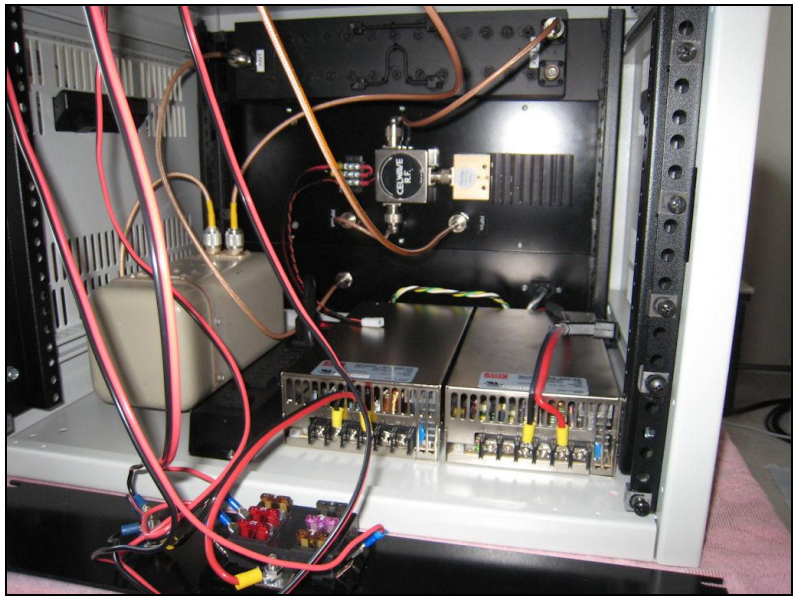
- TK-941 TX / RX and TK-840 Link
- Minicircuits LNA with Wacom preselector cavities
- Motorola “150W” cellular PA
- Celwave Isolator
- Narda cellular combline duplexer
- ICS Linker-IIa controller

100 W Output


WATTS
THRULINE
BIRD ELECTRONIC CORP
100W
400-1000 MHz
100E
CLEVELAND OHIO USA
DECIBEL
DR4303B
100 WATT LOAD

Lago Vista Crew

Lago Vista Repeater



Above the Clouds – Larch Mtn

Larch Mountain Site

Larch Mountain Site

Working on Larch Mtn Repeater

Looking to Portland & Salem from Larch Mtn WA

Portable 900 MHz Repeater