A *Flexible* Tactical SAR DMR Repeater

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For Loudoun Amateur Radio Group

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Overview

- The SAR DMR Repeater System featured herein serves & supports the Mid-Atlantic Region SAR Community.

- The technology can also be readily applied to domains, such as Amateur Radio, Civil Air Patrol, Public Safety, etc...

- What's a "repeater", how does it work, and why is it so important? (Review)

- *What can we do when we need to rapidly deploy to almost anywhere at anytime, and reliably operate??*

- SAR (and other deployable) organizations can be authorized multiple frequencies for outputs and inputs…

- Thus we need a *highly flexible* tactical repeater system that provides functional capabilities with *high agility*

- *BUT we had to build one, because there were NO suitable systems available!*

- Therefore, the *Flexible Tactical SAR DMR* Repeater System!

Basic Radio Network

"DIRECT" or "SIMPLEX" MultiPoint Network.
All Users & Groups can talk <u>directly</u>.
BUT <u>must</u> be in <u>radio range</u> (often <u>short</u>).

A Quick Review for New Folk...
(Commo Geeks! Be patient! ;-)
Everybody Please Stay Tuned??
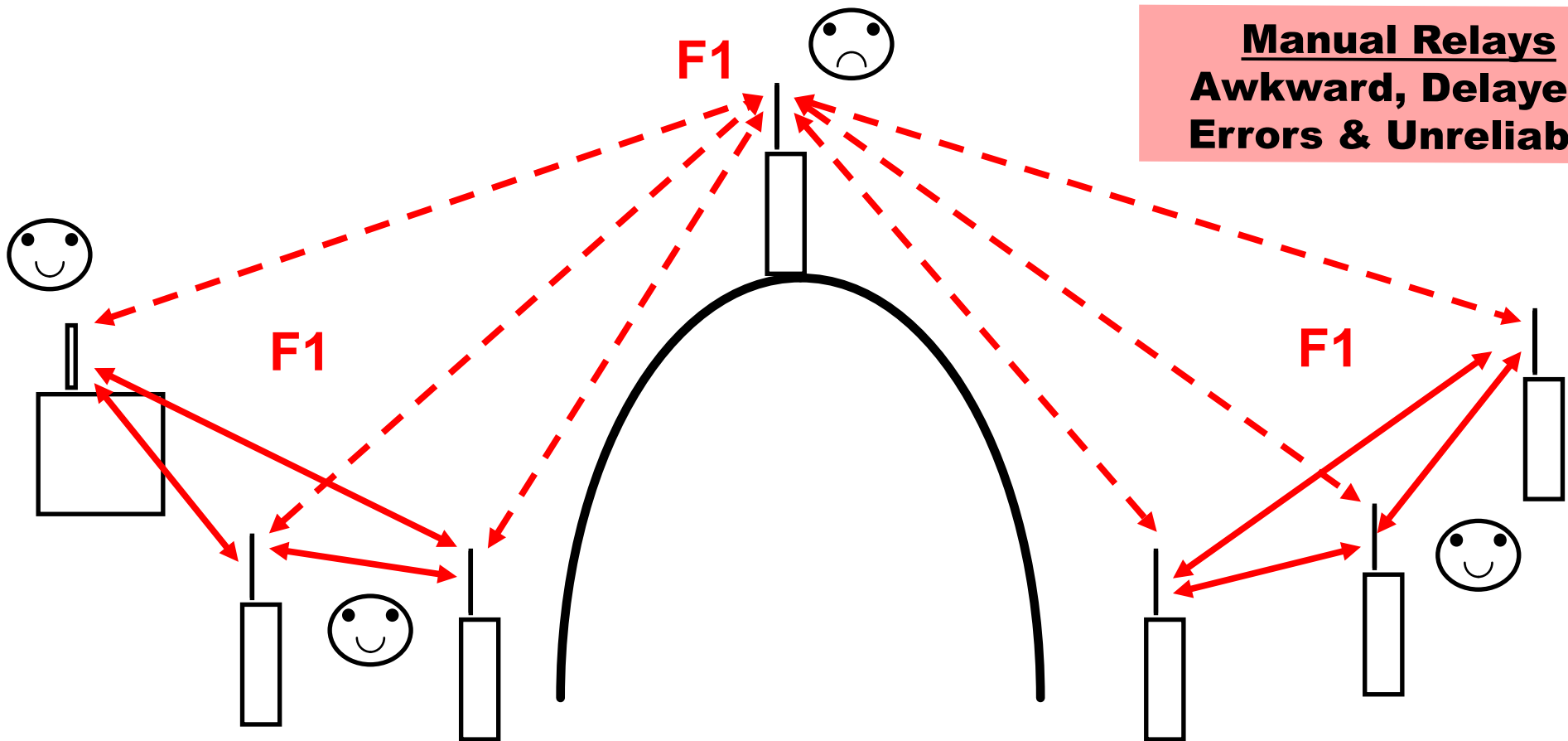
F1

F1

F1
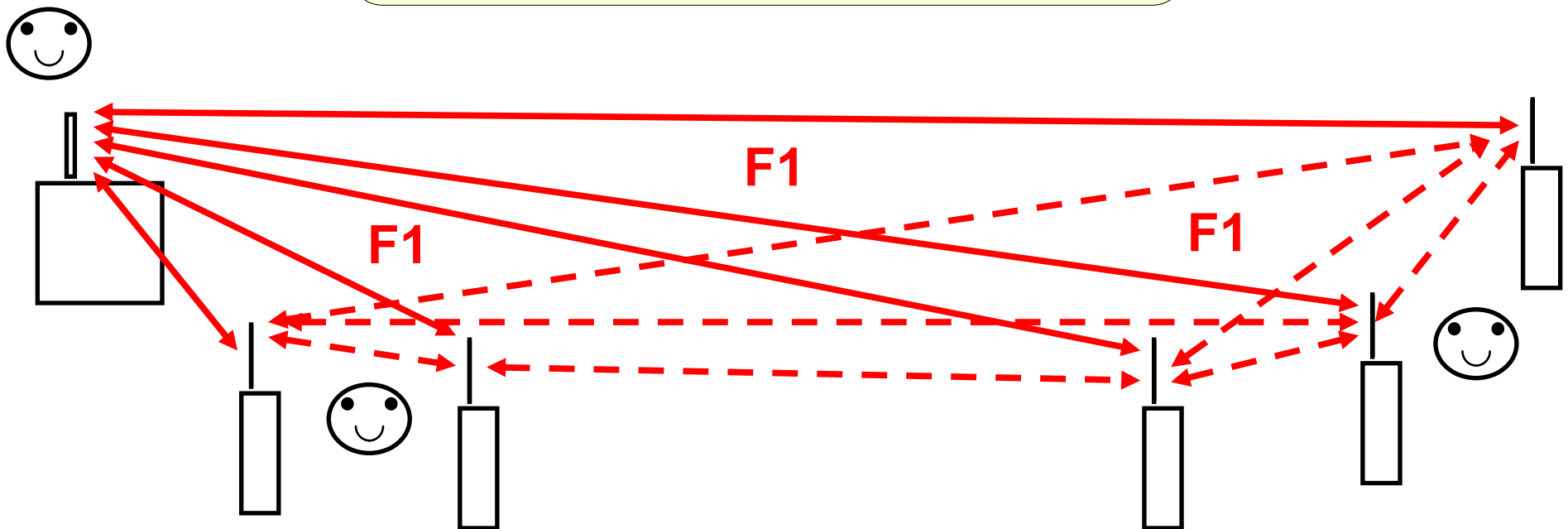
Isolated Direct Nets!

"DIRECT" or "SIMPLEX" Groups
can talk <u>directly</u> to Self,
BUT <u>separated</u> (blocked) Groups <u>cannot</u> talk!

F1

F1
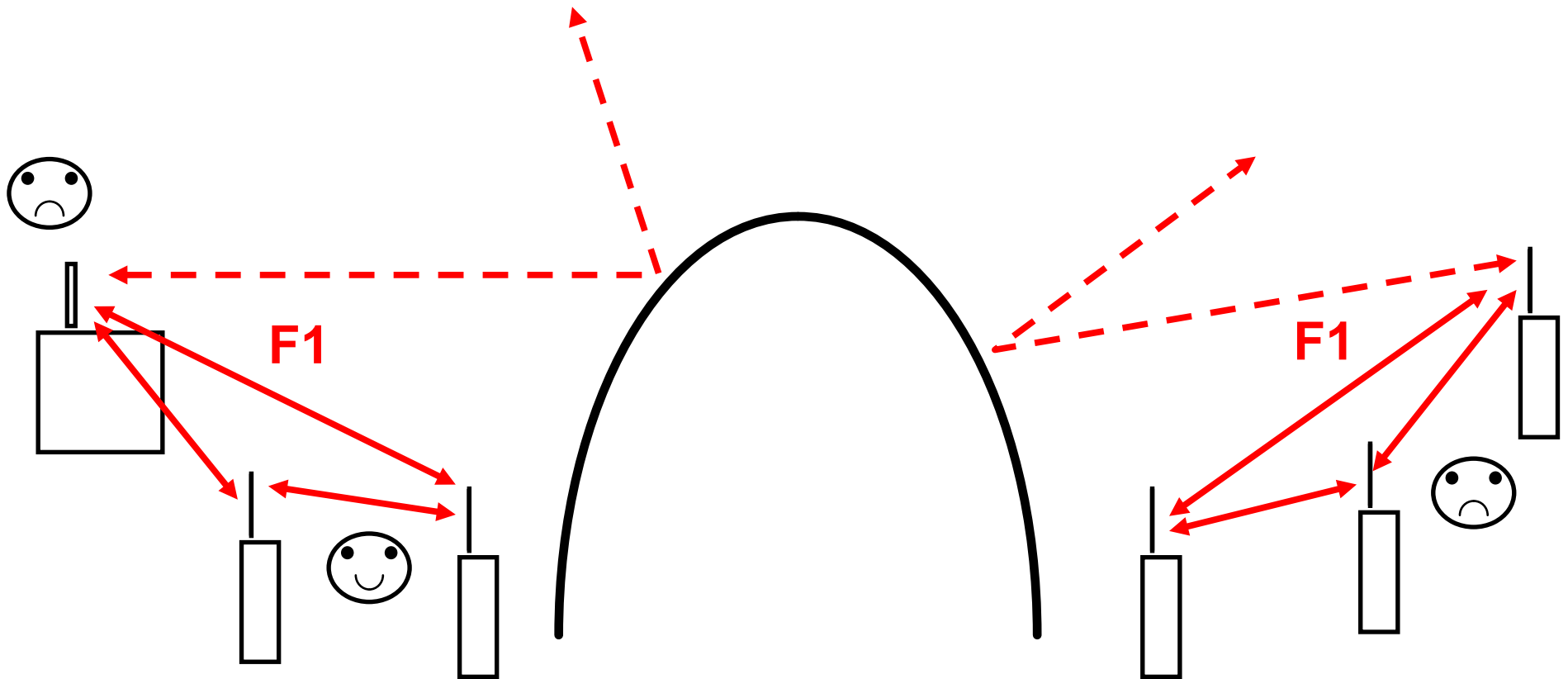
Manual Voice "Relay"

Local Groups still talk to Self <u>directly</u>.
BUT need a <u>Person</u> at a <u>mutual high location</u> to
Listen & Repeat messages <u>indirectly</u>.

F1

F1

F1

Manual Relays
Awkward, Delayed,
**Errors & Unreliable**

Automatic "Repeater"

Everybody talks <u>indirectly</u> (on a "Repeater" channel).
Local Groups can still talk <u>directly</u>,
<u>without</u> the Repeater (IF on a "Direct" channel).
All Repeater Users hear exactly the <u>same</u> messages.

F2 → **F1**

Automatic Repeaters
Instant, Accurate
& Reliable

MAGIC REPEATER BOX!

F2 F1

F2 F1
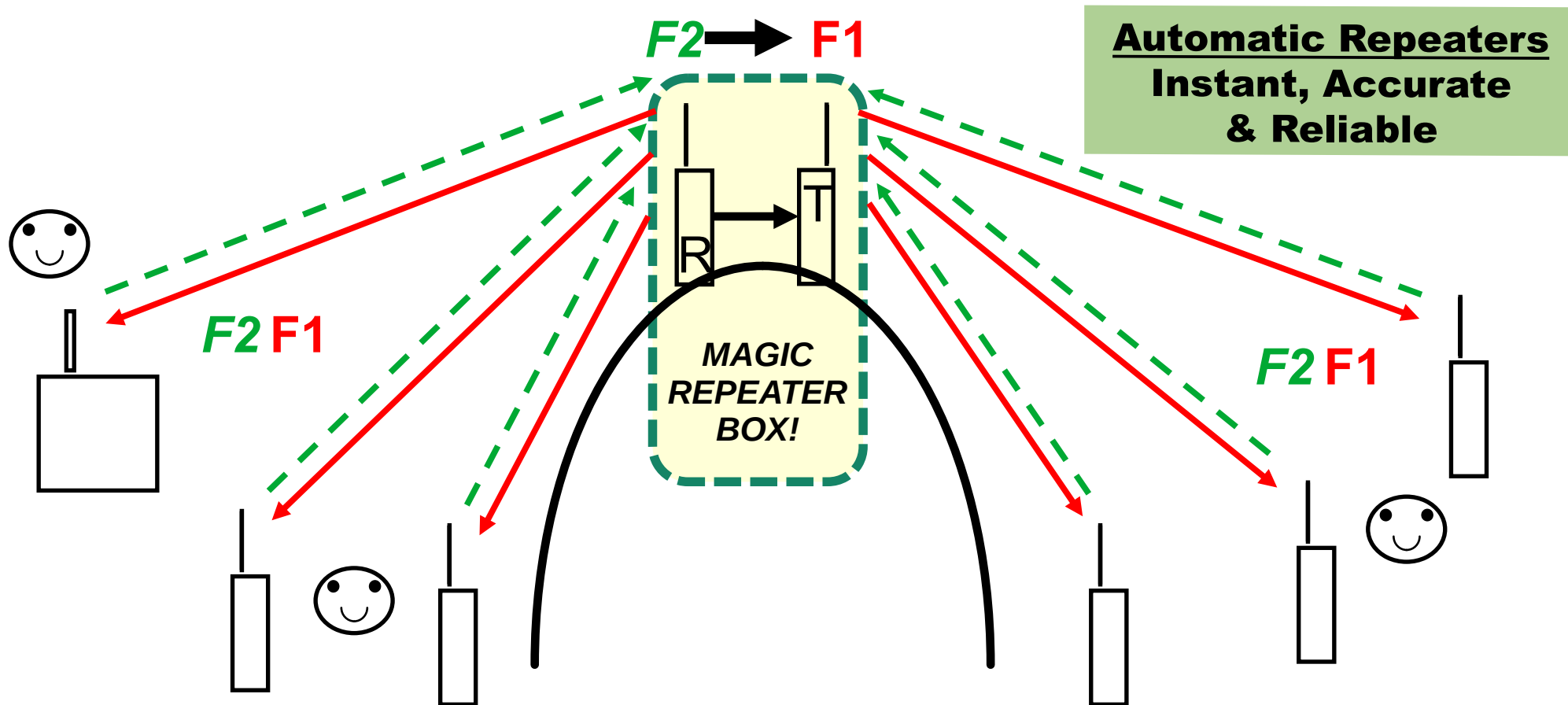
Repeater Deployment

Repeater placed on site with best available <u>radio coverage</u> for all Users (& reasonable access!). Usually a hilltop or knoll near trail head, etc.

Antenna

F2 → **F1**
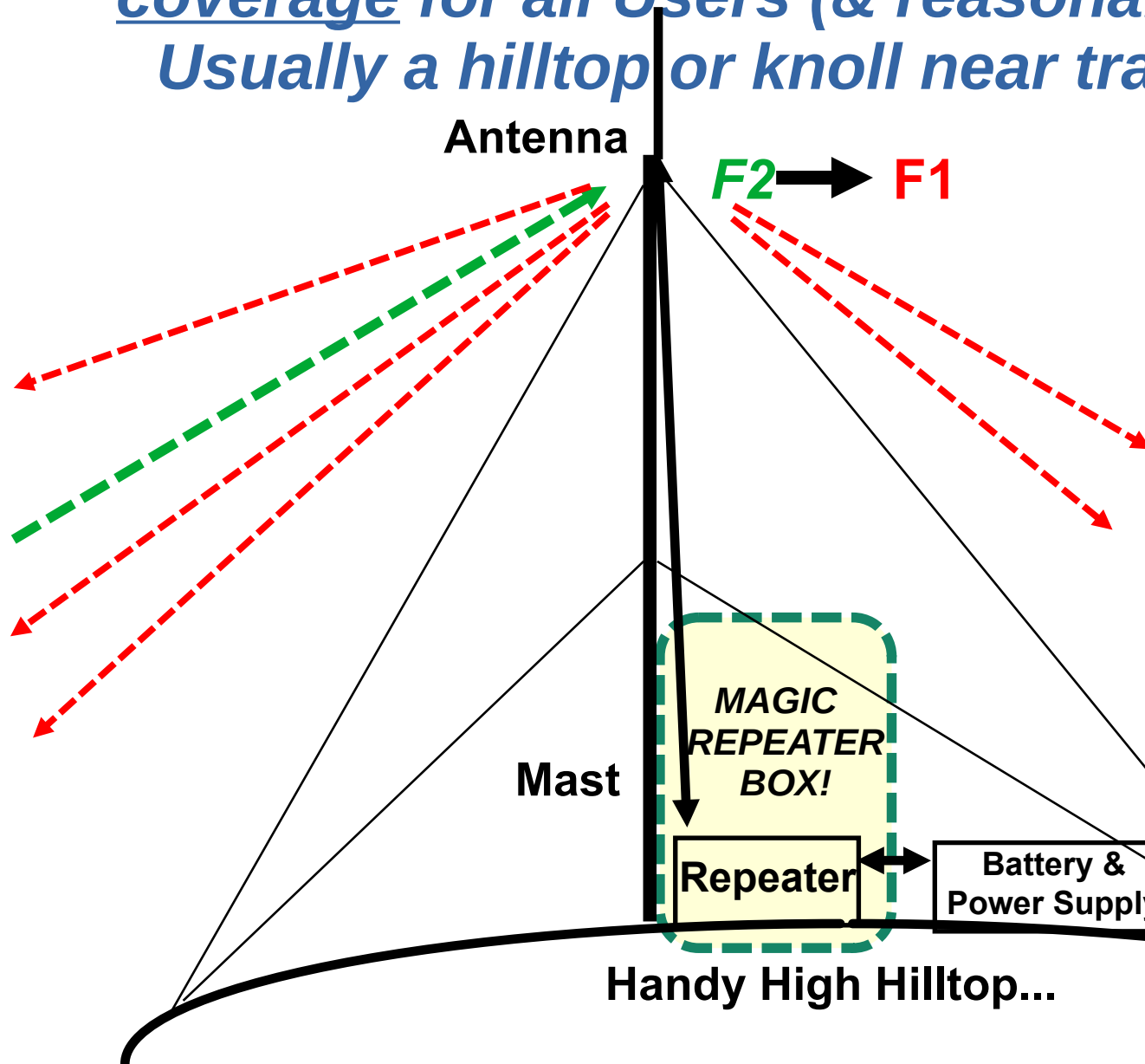
Automatic Repeaters
Instant, Accurate & Reliable

IF Users can <u>hear</u> the Repeater, they can <u>usually</u> talk to <u>everybody else</u> who can also hear it!

MAGIC REPEATER BOX!

Mast

Repeater ↔ **Battery & Power Supply**

Handy High Hilltop...

Tactical Repeater Examples

**THERE ARE _ZERO_ PRODUCTS IN THE LMR MARKET
THAT SUFFICIENTLY SATISFY OUR
CRITICAL OPERATIONAL MISSION REQUIREMENTS!!**

**ISSUES & DEFICIENCIES:
> Very few available (Motorola, TAIT…)
> Public Safety, Govt & Military require <u>P25</u>.
> Primary Customers have Unlimited Funds,
> _Thus costs are unachievable for Us!_
> _Almost NO Transportable <u>DMR</u> offerings._**

Fixed Repeater Examples

**THERE ARE _ZERO_ PRODUCTS IN THE LMR MARKET
THAT SUFFICIENTLY SATISFY OUR
CRITICAL OPERATIONAL MISSION REQUIREMENTS!!**

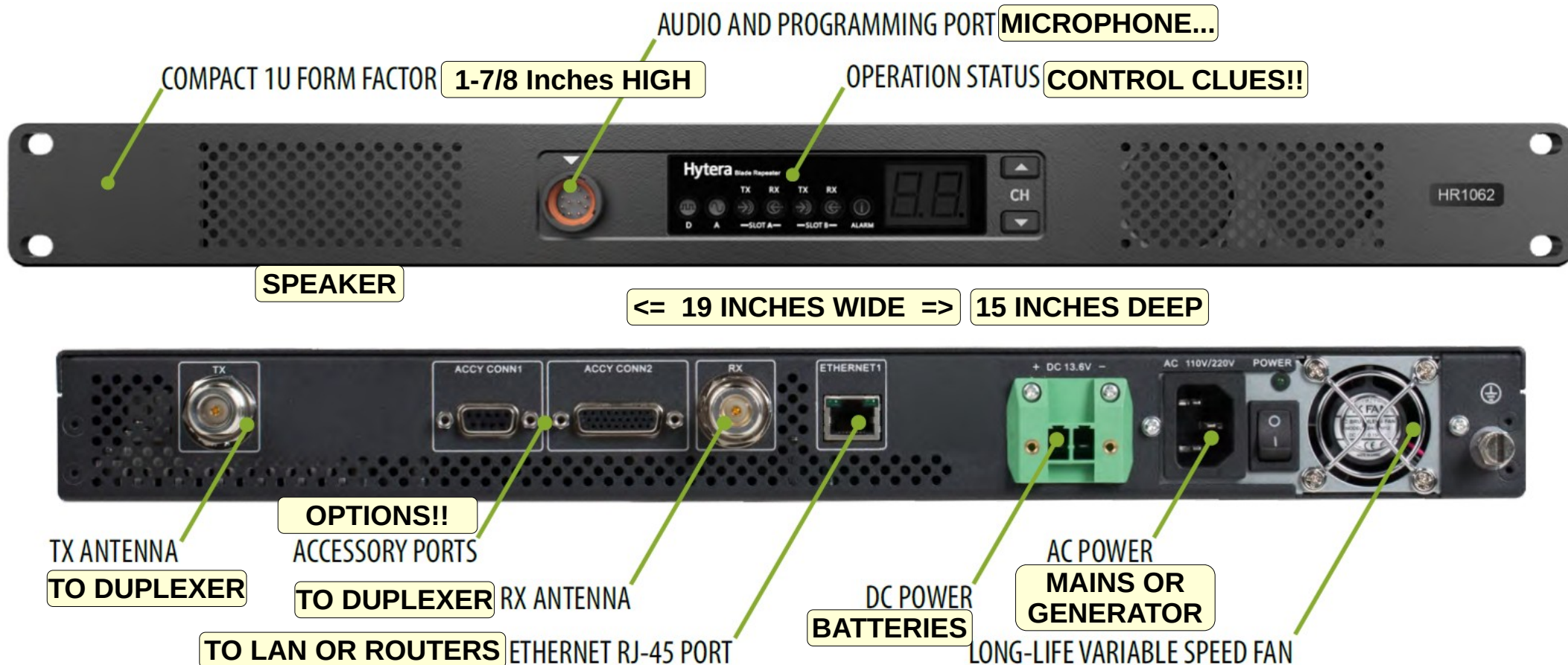**ISSUES & DEFICIENCIES:**
> Yes, some provide essential functions...
> DMR & Analog FM & vital Mixed Mode.
> More capable than transportable units.
> Modest size, weight, power, costs.
> _BUT require repackaging for field use._

Hytera HR1062 Repeater

THE BRAINS IN THE MAGIC BOX!!
A Commercial Grade Communications System
With Excellent RF & DMR Capabilities,
Kidnapped, Repurposed & Stuffed into a
Highly Deployable Tactical Transport System!

AUDIO AND PROGRAMMING PORT   MICROPHONE...

COMPACT 1U FORM FACTOR   1-7/8 Inches HIGH   OPERATION STATUS   CONTROL CLUES!!

Hytera Blade Repeater   HR1062

TX   RX   TX   RX

D   A   —SLOT A—   —SLOT B—   ALARM

CH

SPEAKER

<= 19 INCHES WIDE => | 15 INCHES DEEP

TX   ACCY CONN1   ACCY CONN2   RX   ETHERNET1   + DC 13.6V −   AC 110V/220V   POWER

OPTIONS!!

TX ANTENNA   ACCESSORY PORTS   RX ANTENNA   DC POWER   AC POWER   MAINS OR GENERATOR
TO DUPLEXER   TO DUPLEXER   BATTERIES
TO LAN OR ROUTERS   ETHERNET RJ-45 PORT   LONG-LIFE VARIABLE SPEED FAN
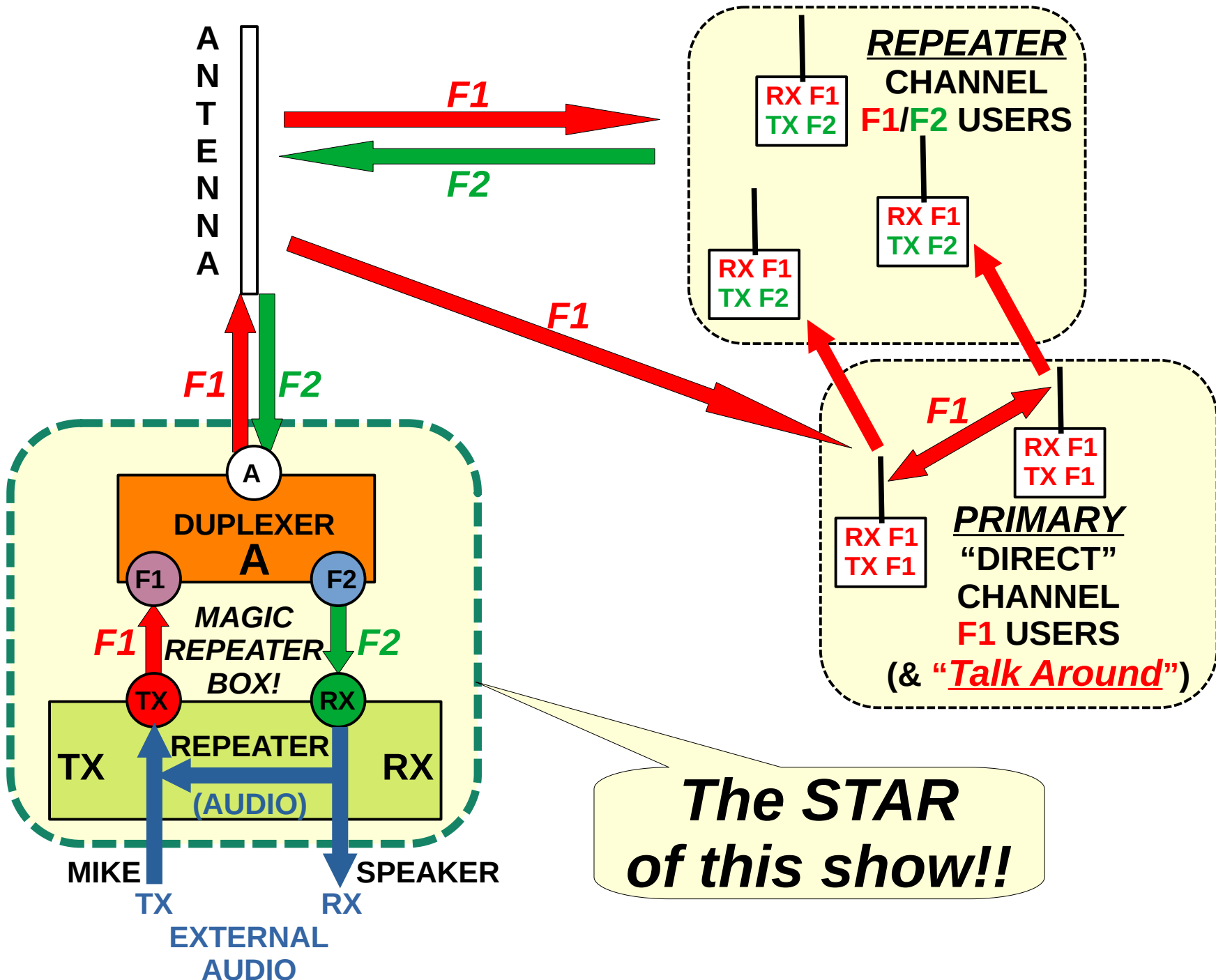
Hytera HR1062 Repeater

- Meets or exceeds essentially *all* our unique ***SAR*** requirements!

- VHF-High band for *SAR & Support*

- FCC Part 90 with Full 136-174 MHz coverage

- Analog Narrow Band FM, Plus *DMR Tier 2*,

- Plus Automatic *Mixed Mode!*

- Capacity 64 channels, essential frequency flexibility
  - (BUT due to a manufacturer FW error, Mixed Mode is only available on 16 of 64 channels, but feasible anyway...)

- Adjustable 5-50 Watts RF output.

- Powered from both 120 VAC & 12 VDC,

- With AutoFailover.

Hytera HR1062 Repeater

- Relatively <u>light</u> weight & <u>compact</u>.

- Can be controlled by <u>local</u> Operator with mike & speaker.

- Can be managed <u>remotely</u>, via <u>internet</u> type connections.

- (Future) ability to <u>interface</u> to other repeaters, link radios, PSTN & VoIP/SIP phones, via IP Connect and IP based transport, such as the internet or our own deployed systems.

- <u>Modern</u> technology, <u>modestly</u> rugged, suitable for <u>transport</u> packaging and field <u>deployments</u>.

TRADITIONAL (1 PAIR) REPEATER SYSTEM

ANTENNA

F1 →

← **F2**

F1

F1 ↑ **F2** ↓

A

DUPLEXER A

F1   F2

MAGIC REPEATER BOX!

F1   **F2**

TX   **RX**

TX   **REPEATER**   **RX**

(AUDIO)

MIKE   SPEAKER

TX   **RX**

EXTERNAL AUDIO

REPEATER CHANNEL **F1**/**F2** USERS

RX F1
TX F2

RX F1
TX F2

RX F1
TX F2

F1

F1

RX F1
TX F1

RX F1
TX F1

PRIMARY "DIRECT" CHANNEL **F1** USERS (& "*Talk Around*")

The STAR of this show!!

VHF High Band Duplexer

THE _OTHER_ MAGIC BOX!!
A Special Radio Frequency Filter,
that enables a _Powerful_ Transmitter
and a _Sensitive_ Receiver,
to Share the _Same_ Antenna,
Without Killing Each Other!!
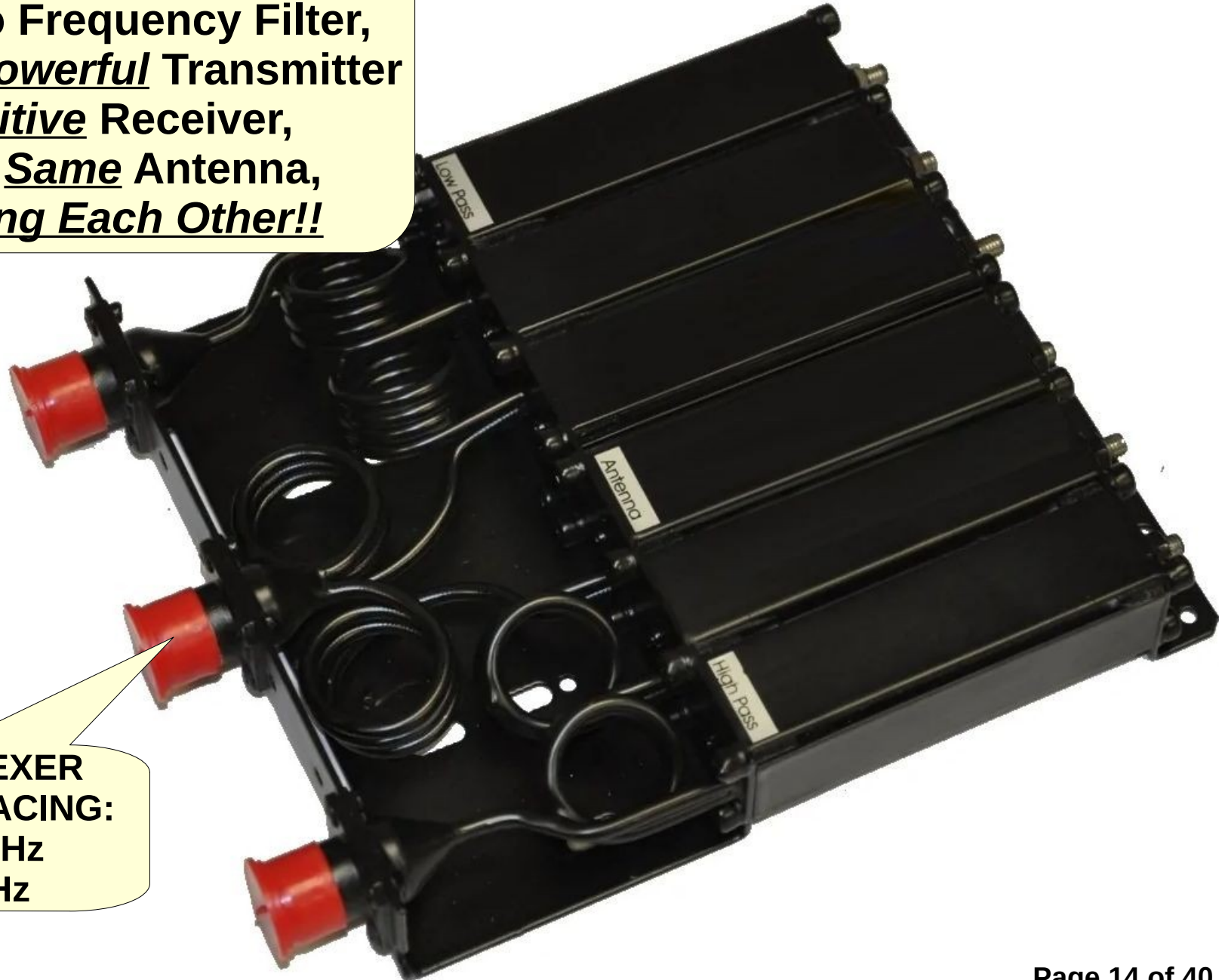
MOBILE DUPLEXER
FREQUENCY SPACING:
VHF >> 4.5 MHz
UHF >> 5 MHz

Spectral Agility => _Channels_

- Traditional repeaters use their <u>single</u> pair of frequencies, as a <u>single</u> radio channel, but we need _many_ frequencies!

- As we deploy across our wide operational area, we need to <u>intercommunicate</u> with many other SAR, PS and Support organizations, while also <u>avoid interference</u> with existing local frequency users….!

- For <u>SAR</u> per FCC licenses (155 & 150 MHz)
  - <u>8</u> Primary (Simplex) & Repeater <u>Outputs</u> (ALPHA...)
  - <u>3</u> Repeater <u>Inputs</u> (ROMEO...)
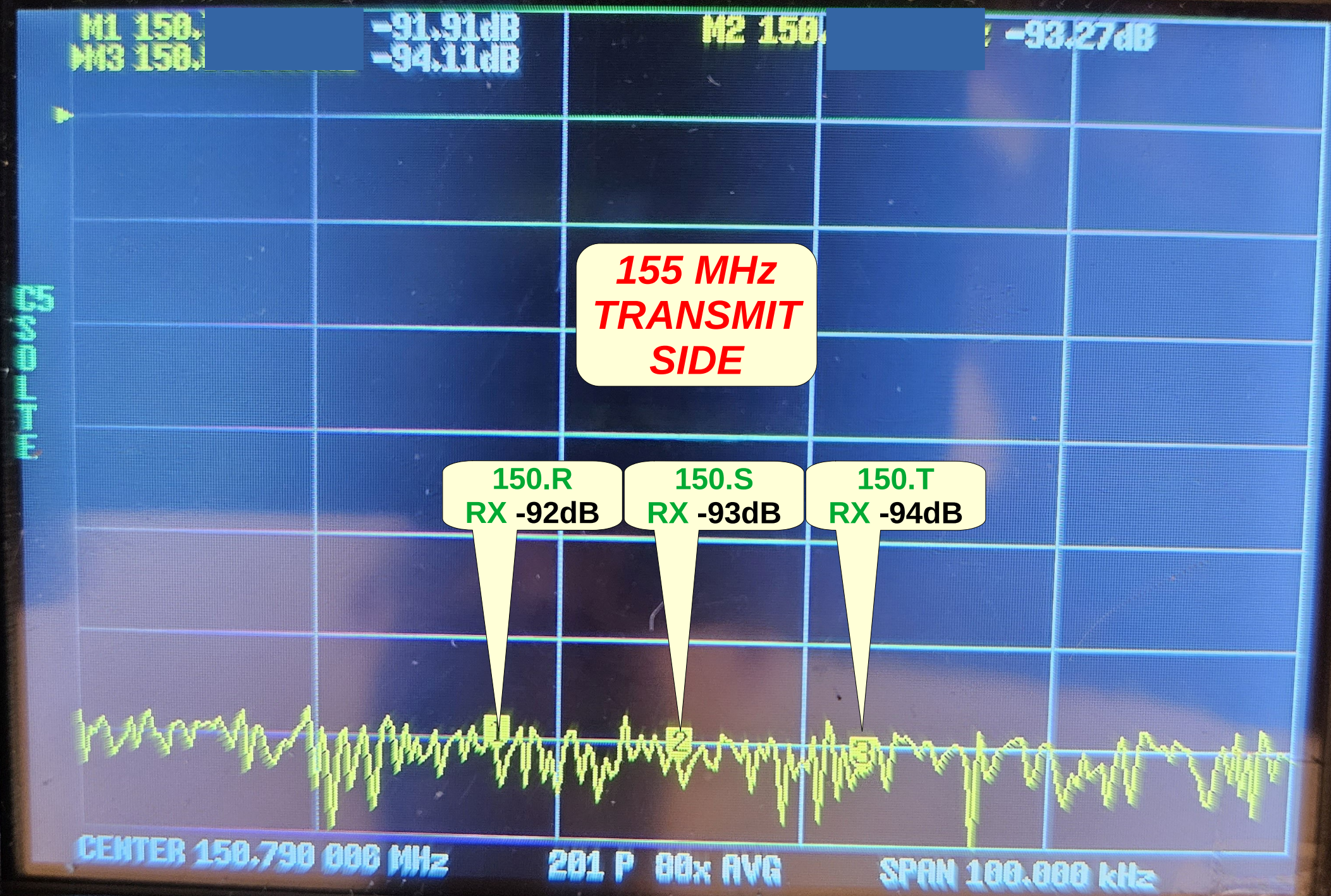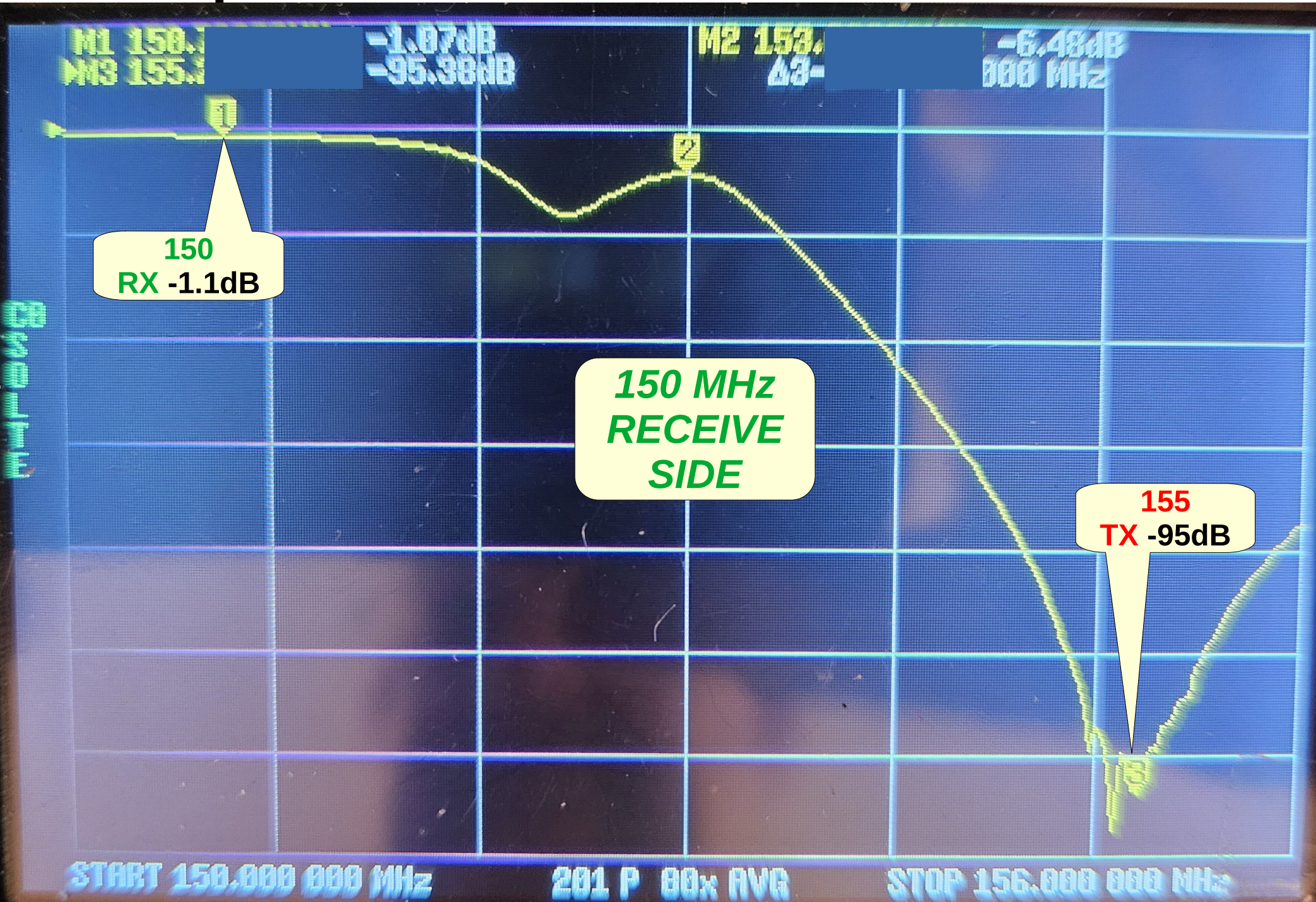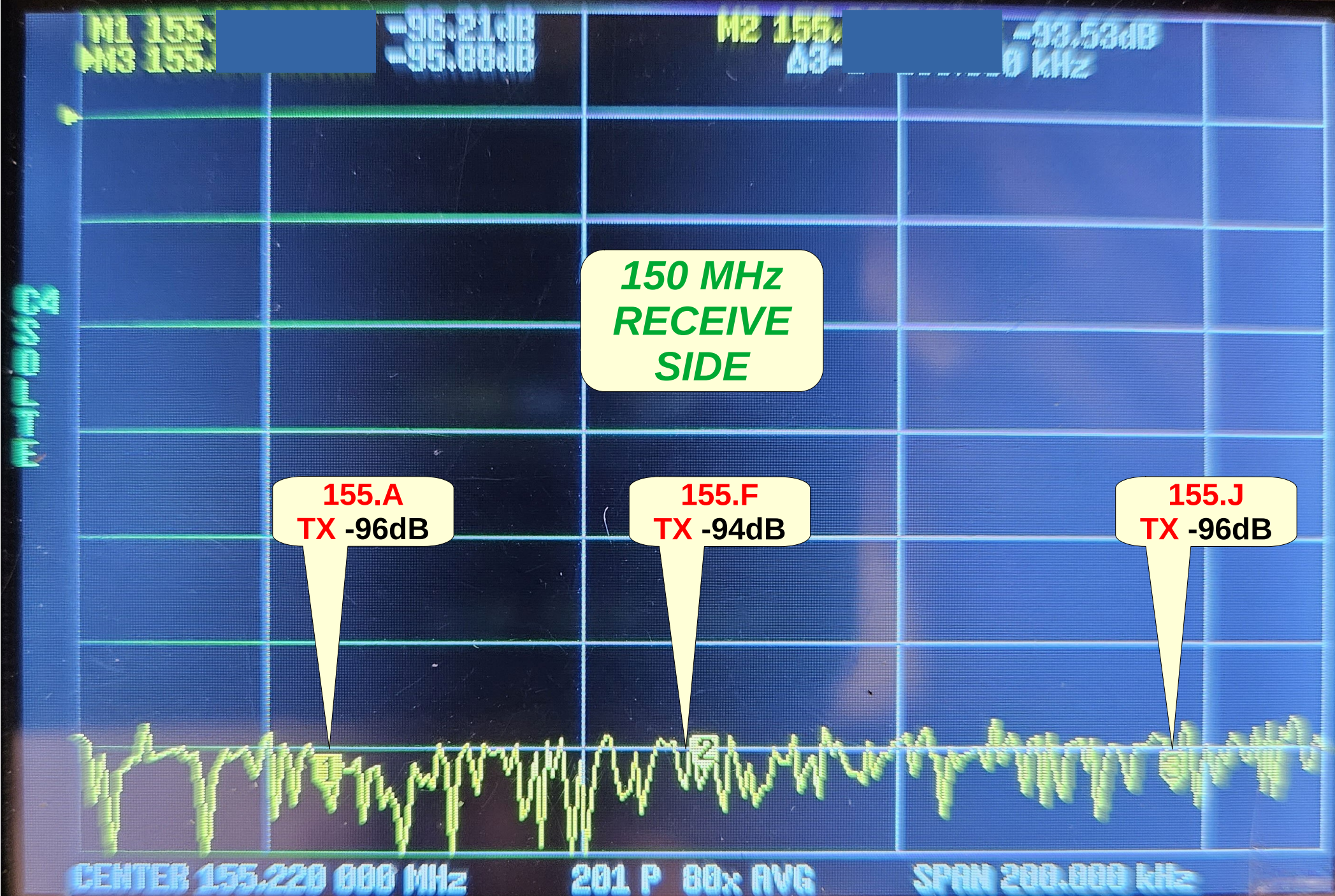 - **Thus <u>24</u> combinations (& channels!)**

Duplexer – **150** Notch -93dB

Duplexer – **155** Notch -95dB

Spectral Agility => *Duplexers*

- Plus, for <u>Support</u>, per FCC licenses (151 & 158 MHz)
  - 7 (repeater usable) frequencies (LIMA1…)
  - Organized as 5 out x 2 in = 10, x 2 ways...
  - **Thus <u>20</u> combinations (& channels!)**

- ***Thus we need to accommodate at least <u>44</u> repeater channels!***

- As a critical design requirement, to support both SAR and Support groups of frequencies, ***we need <u>two</u> separate duplexers***. They can be switched by cable swaps during initial mission setups.

- *As a Bonus, we can <u>bypass</u> duplexers, reprogram a channel, and use <u>split antennas</u> to support almost any pair of frequencies in <u>entire VHF-High band</u>!*

FLEXIBLE TACTICAL REPEATER SYSTEM
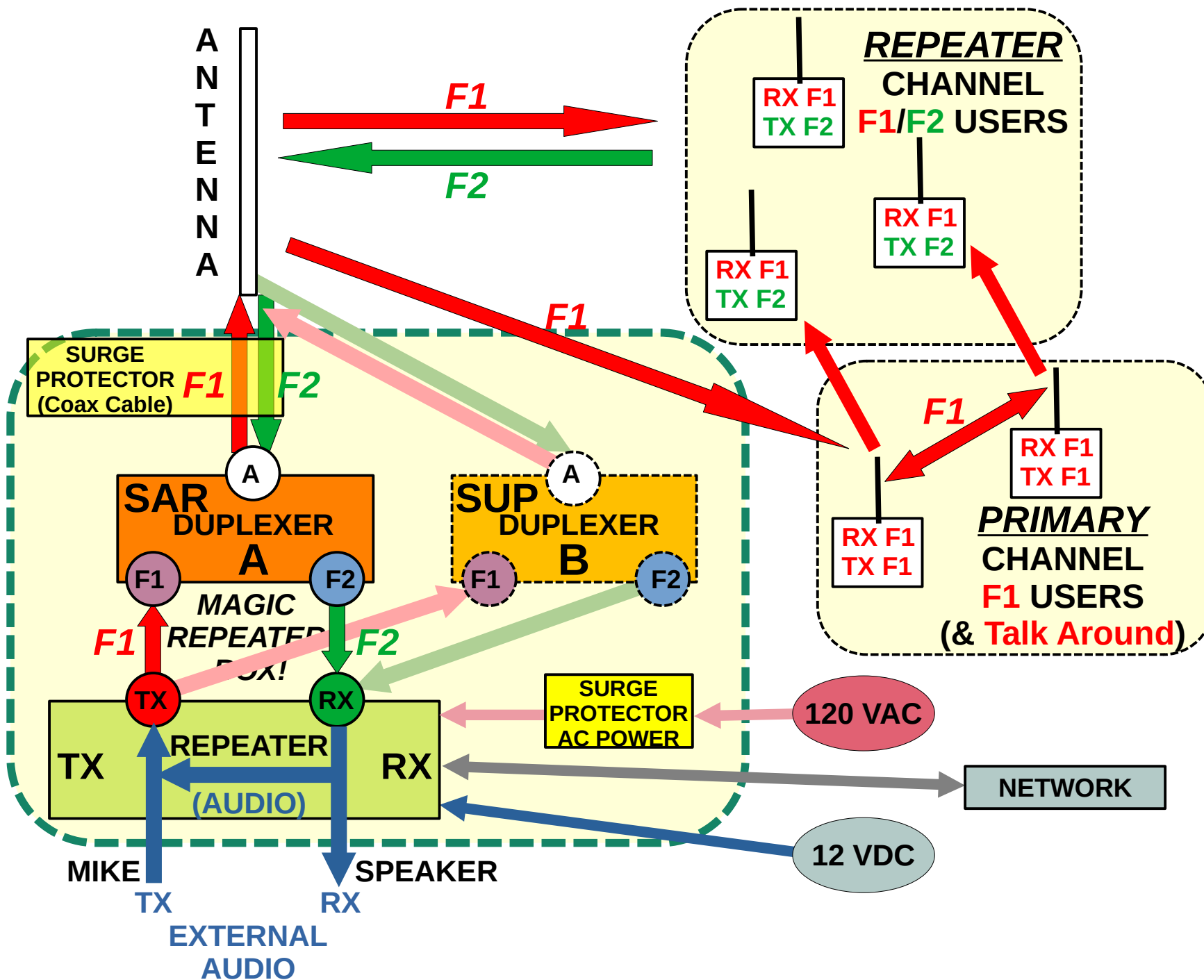
Dual VHF Duplexers
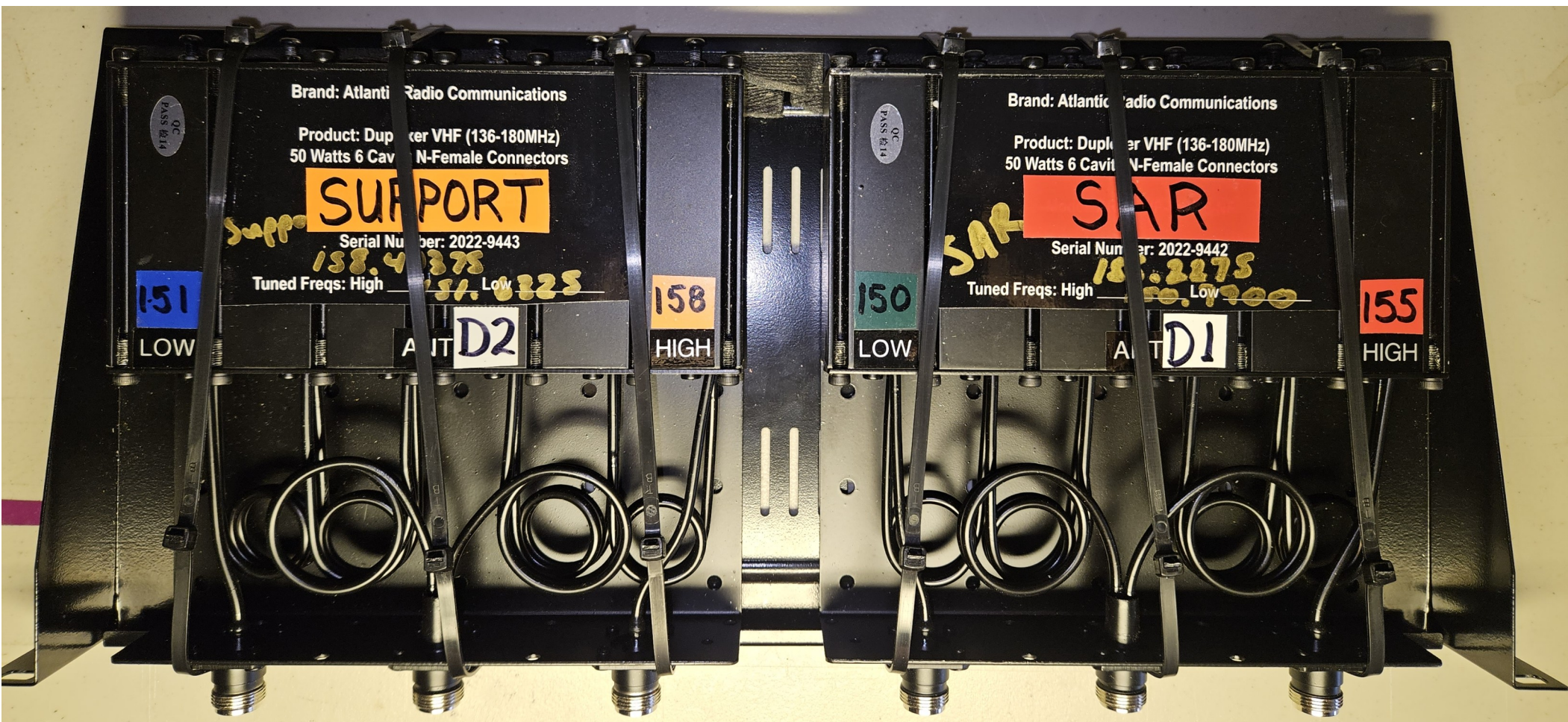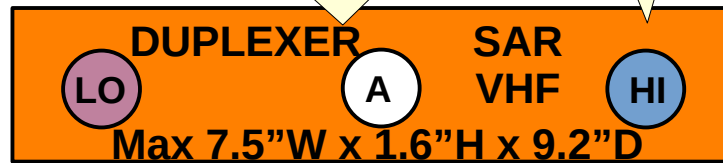
THE FEATURED CAST OF CHARACTERS

REAR VIEW

DUPLEXERS:
Enables use of <u>Single</u> Antenna
& achieve identical coverages
for both Input F2 & Output F1

SAR DUPLEXER:
Enables National Standard
SAR Channels (150 & 155)

SUPPORT DUPLEXER:
Enables Support
Channels (151 & 158)

DUPLEXER   SAR
LO   A   VHF   HI
Max 7.5"W x 1.6"H x 9.2"D

DUPLEXER   SUPPORT
LO   A   VHF   HI
Max 7.5"W x 1.6"H x 9.2"D
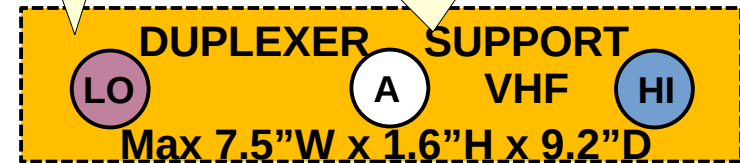
REPEATER - VHF
TX   RX
19"W x 1.74"H x 14.5"D

PAIRED CHANNELS:
User radios need *both* the
Primary F1 <u>Direct</u> channel, plus an
Alternate F1/F2 <u>Repeater</u> channel.
Both can hear everything on F1.

REPEATER:
Automatically relays signals
from Any Users on Input F2
to All Users on Output F1

OPERATIONAL ADVANTAGES:
Users can also talk directly (Simplex) to each other on F1
(a.k.a. "Talk Around") while also monitoring
(or sending) messages through the repeater

TACTICAL REPEATER *CHANNEL LIST* - VHF

V2.0 - 29 DEC 202_ (cut off)

(Callout labels: CHANNEL NUMBER, CHANNEL NAMES, DUPLEXER CHOICE — these overlay portions of the NAME–ASRC and COMMENTS columns.)

#	MIX	NOT	CH	NAME – ASRC	SVC	DPX	MODE	COMMENTS
01	1		01	ALP…O M	SAR	SAR	MIXED	SAR D…
02	1		02	ALP…RA M	SAR	SAR	MIXED	SAR D
03	1		03	ALP…O M	SAR	SAR	MIXED	SAR D
04	1		04	CHA…EO M	SAR	SAR	MIXED	SAR D
05	1		05	CHA…RA M	SAR	SAR	MIXED	SAR D
06	1		06	CHA…GO M	SAR	SAR	MIXED	SAR D
07	1		07	EC…O M	SAR	SAR	MIXED	SAR D
08	1		08	EC…A M	SAR	SAR	MIXED	SAR D
09	1		09	EC…D M	SAR	SAR	MIXED	SAR D
10		1	10	FOXT…EO A	SAR	SAR	Analog	SAR D
11		1	11	FOXT…EO D	SAR	SAR	DMR	SAR D
12	1		12	FOXT…RA M	SAR	SAR	MIXED	SAR D
13		1	13	FOXT…GO A	SAR	SAR	Analog	SAR D
14		1	14	FOXT…GO D	SAR	SAR	DMR	SAR D
15		1	15	GO…D A	SAR	SAR	Analog	SAR D
16		1	16	GO…D D	SAR	SAR	DMR	SAR D
17	1		17	GO…A M	SAR	SAR	MIXED	SAR D
18		1	18	GO…D A	SAR	SAR	Analog	SAR D
19		1	19	GO…D D	SAR	SAR	DMR	SAR D
20		1	20	HOT…O A	SAR	SAR	Analog	SAR D
21		1	21	HOT…O D	SAR	SAR	DMR	SAR D
22		1	22	HOT…RA A	SAR	SAR	Analog	SAR D
23		1	23	HOT…RA D	SAR	SAR	DMR	SAR D
24		1	24	HOT…O A	SAR	SAR	Analog	SAR D
25		1	25	HOT…O D	SAR	SAR	DMR	SAR D
26		1	26	IND…O A	SAR	SAR	Analog	SAR D
27		1	27	IND…O D	SAR	SAR	DMR	SAR D
28	1		28	IND…A M	SAR	SAR	MIXED	SAR D
29		1	29	IND…O A	SAR	SAR	Analog	SAR D
30		1	30	IND…O D	SAR	SAR	DMR	SAR D
31		1	31	JUL…EO A	SAR	SAR	Analog	SAR D
32		1	32	JUL…EO D	SAR	SAR	DMR	SAR D
33		1	33	JUL…RA A	SAR	SAR	Analog	SAR D
34		1	34	JUL…RA D	SAR	SAR	DMR	SAR D
35		1	35	JUL…O A	SAR	SAR	Analog	SAR D
36		1	36	JULIET TANGO D	SAR	SAR	DMR	SAR D…DUPLEXER

#	MIX	NOT	CH	NAME – ASRC	SVC	DPX	MODE	COMMENTS
37	1		37	L…	SUP	SUP	MIXED	SUP D
38	1		38	L…	SUP	SUP	MIXED	SUP D
39		1	39	L…	SUP	SUP	Analog	SUP D
40		1	40	L…	SUP	SUP	DMR	SUP D
41		1	41	L…	SUP	SUP	Analog	SUP D
42		1	42	L…	SUP	SUP	DMR	SUP D
43		1	43	L…	SUP	SUP	Analog	SUP D
44		1	44	L…	SUP	SUP	DMR	SUP D
45		1	45	L…	SUP	SUP	Analog	SUP D
46		1	46	L…	SUP	SUP	DMR	SUP D
47	1		47	L…	SUP	SUP	MIXED	SUP D
48	1		48	L…	SUP	SUP	MIXED	SUP D
49		1	49	L…	SUP	SUP	Analog	SUP D
50		1	50	L…	SUP	SUP	DMR	SUP D
51		1	51	L…	SUP	SUP	Analog	SUP D
52		1	52	L…	SUP	SUP	DMR	SUP D
53		1	53	L…	SUP	SUP-R	Analog	REVE…
54		1	54	L…	SUP	SUP-R	Analog	REVE
55		1	55	L…	SUP	SUP-R	Analog	REVE
56		1	56	L…	SUP	SUP-R	Analog	REVE
57		1	57	L…	SUP	SUP-R	Analog	REVE
58		1	58	L…	SUP	SUP-R	Analog	REVE
59		1	59	L…	SUP	SUP-R	Analog	REVE
60		1	60	L…	SUP	SUP-R	Analog	REVE
61		1	61	L…	SUP	SUP-R	Analog	REVE
62		1	62	L…	SUP	SUP-R	Analog	REVE
63		1	63	V…	NIFOG	(NONE)	Analog	TW…
64		1	64	HAM …A	TEST	(NONE)	Analog	TW…

**ALL 24 *SAR* CHANNEL COMBINATIONS.
ALL 20 *SUPPORT* COMBINATIONS.**
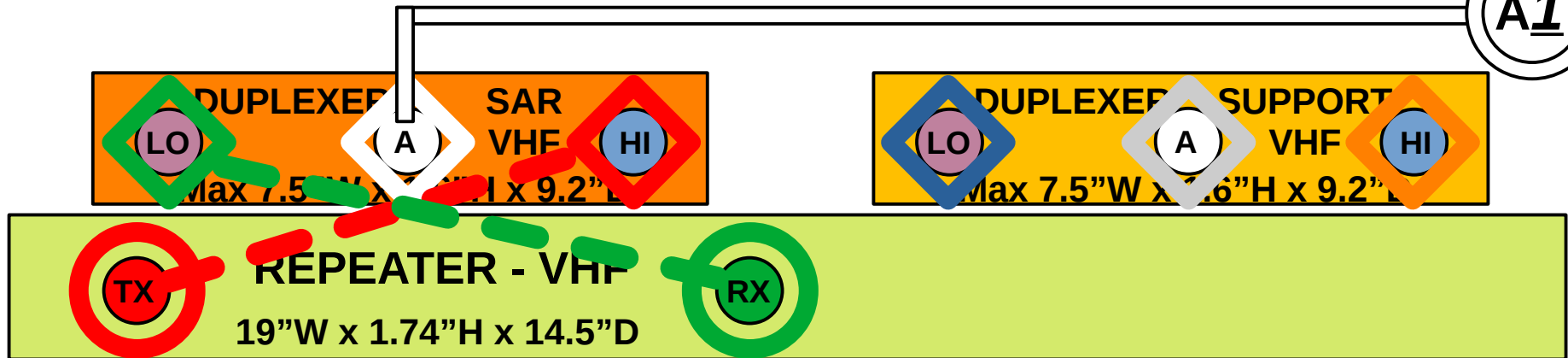
SAR CHANNELS = 1-36

SAR CHANNELS 1-36
TX RED – Duplexer RED
RX GREEN – Duplexer GREEN
ANT WHITE – Duplexer WHITE

REAR VIEW

SURGE PROTECTED   A*1*

DUPLEXER SAR
(LO)   (A)   VHF   (HI)
Max 7.5"W x 7.6"H x 9.2"L

DUPLEXER - SUPPORT
(LO)   (A)   VHF   (HI)
Max 7.5"W x 7.6"H x 9.2"L

(TX) REPEATER - VHF (RX)
19"W x 1.74"H x 14.5"D

REPEATER   *DUPLEXER*   *ANTENNA*

TRANSMITTER   **SAR HI**
TX (RED) = = = = = = = (RED)

ANTENNA   ANTENNA
(WHITE) = = = = = =   *A1* (WHITE)

RECEIVER   **SAR LO**
RX (GREEN) = = = = = (GREEN)

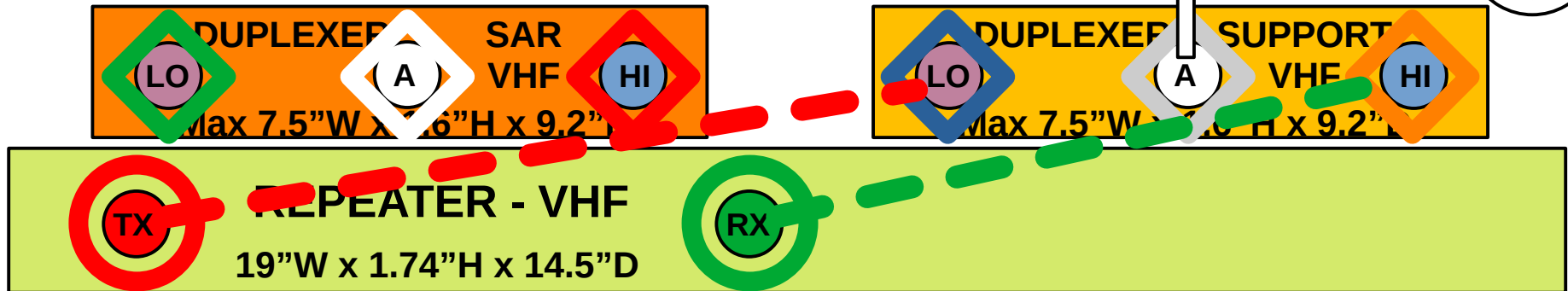# SUPPORT CHANNELS = 37-52

SUPPORT (A) 37-52
TX RED – Duplexer BLUE
RX GREEN – Duplexer ORANGE
ANT WHITE – Duplexer GRAY`

REAR VIEW

SURGE PROTECTED **A1**

DUPLEXER SAR VHF
(LO) (A) (HI)
Max 7.5"W x 6"H x 9.2"

DUPLEXER SUPPORT VHF
(LO) (A) (HI)
Max 7.5"W x 10"H x 9.2"

(TX) REPEATER - VHF
19"W x 1.74"H x 14.5"D
(RX)

REPEATER   DUPLEXER   ANTENNA

**TRANSMITTER
TX (RED)** = = = = = = **SUPPORT LO
(BLUE)**

**ANTENNA
(GRAY)** = = = = = = **A1 (WHITE)**

**RECEIVER
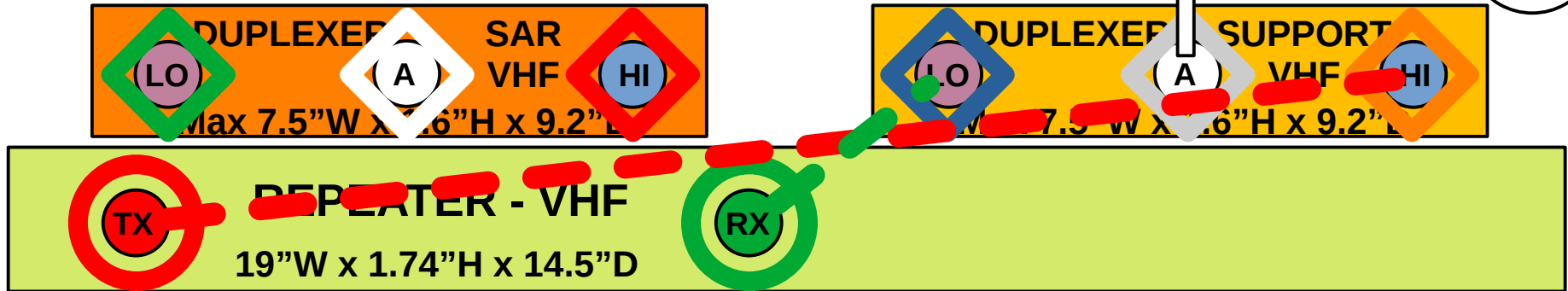RX (GREEN)** = = = = = **SUPPORT HI
(ORANGE)**

SUPPORT CHANNELS = 53-62

SUPPORT (B) 53-62
TX RED – Duplexer ORANGE
RX GREEN – Duplexer BLUE
ANT WHITE – Duplexer GRAY`

REAR VIEW

SURGE PROTECTED A**1**

DUPLEXER SAR
(LO) (A) VHF (HI)
Max 7.5"W x 1.6"H x 9.2"D

DUPLEXER SUPPORT
(LO) (A) VHF (HI)
W x 7.5"W x 1.6"H x 9.2"D

(TX) REPEATER - VHF (RX)
19"W x 1.74"H x 14.5"D

REPEATER *DUPLEXER* *ANTENNA*

TRANSMITTER
TX (RED) = = = = = =

SUPPORT HI
(ORANGE)

ANTENNA
(GRAY) = = = = = =

ANTENNA
A**1** (WHITE)

RECEIVER
RX (GREEN) = = = = = =

SUPPORT LO
(BLUE)

SPECIAL CHANNELS = 63-64

SPLIT ANTENNAS
TX RED – ANTENNA A**2**
RX GREEN – ANTENNA A**1**

REAR VIEW

DUPLEXER — SAR VHF
LO   A   HI
Max 7.5"W x .6"H x 9.2"D

DUPLEXER — SUPPORT VHF
LO   A   HI
Max 7.5"W x .6"H x 9.2"D

REPEATER - VHF
TX   19"W x 1.74"H x 14.5"D   RX

A**1**

SURGE PROTECTED

A**2**
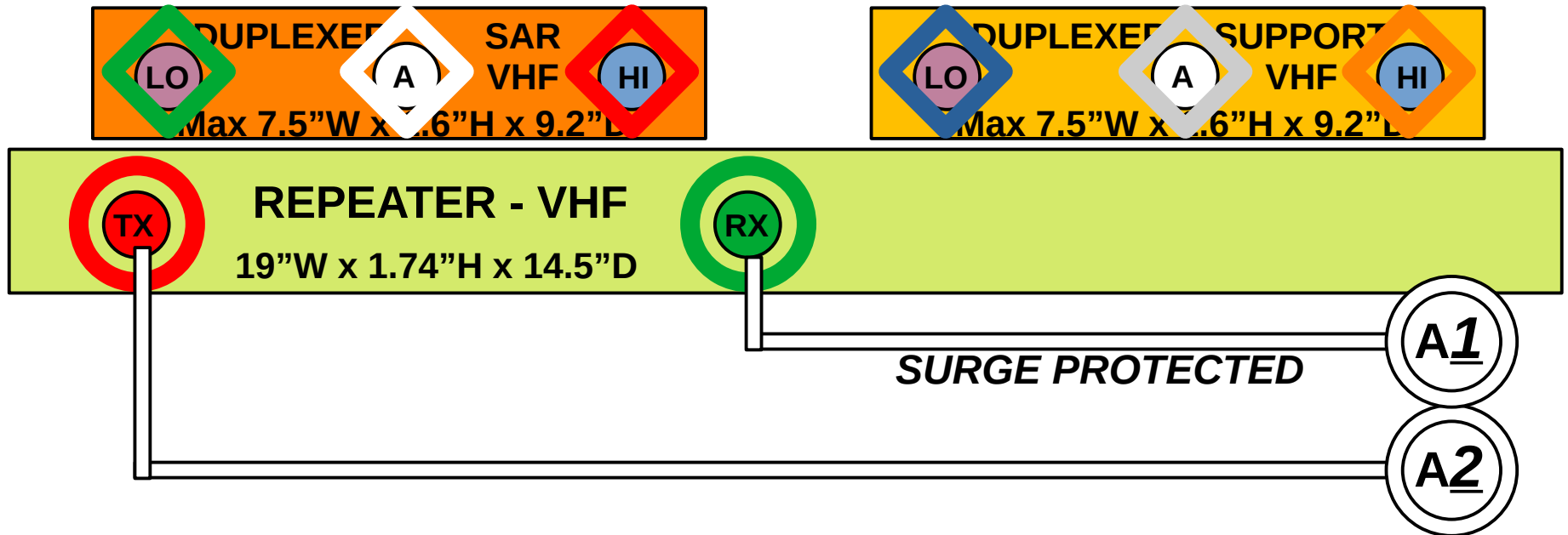
REPEATER   ~~DUPLEXER~~   ANTENNA

TRANSMITTER   **ANTENNA**
TX (RED) = = = = = = = = = = = = = = = = = = A**2** **(WHITE)**

RECEIVER   **ANTENNA**
RX (GREEN) = = = = = = = = = = = = = = = = = A**1** **(WHITE)**

REPEATER _TEST MODES_ & _PROTECTION_

TEST MODES

TX RED – ATTENUTORS
RX GREEN – AS NEEDED

REAR VIEW

DUPLEXER SAR VHF
LO A HI
Max 7.5"W x 4.6"H x 9.2"D

DUPLEXER SUPPORT VHF
LO A HI
Max 7.5"W x 4.6"H x 9.2"D

REPEATER - VHF
19"W x 1.74"H x 14.5"D

TX   RX

TBD as NEEDED   _TBD as NEEDED_

A1

SURGE PROTECTED

TBD as NEEDED

A2

DUMMY LOAD-1 (Attenuator 10dB)

DUMMY LOAD-2 (Attenuator 15dB)

OPTIONAL SMALL LOCAL ANTENNA!

REPEATER   _DUPLEXER_   _ANTENNA_
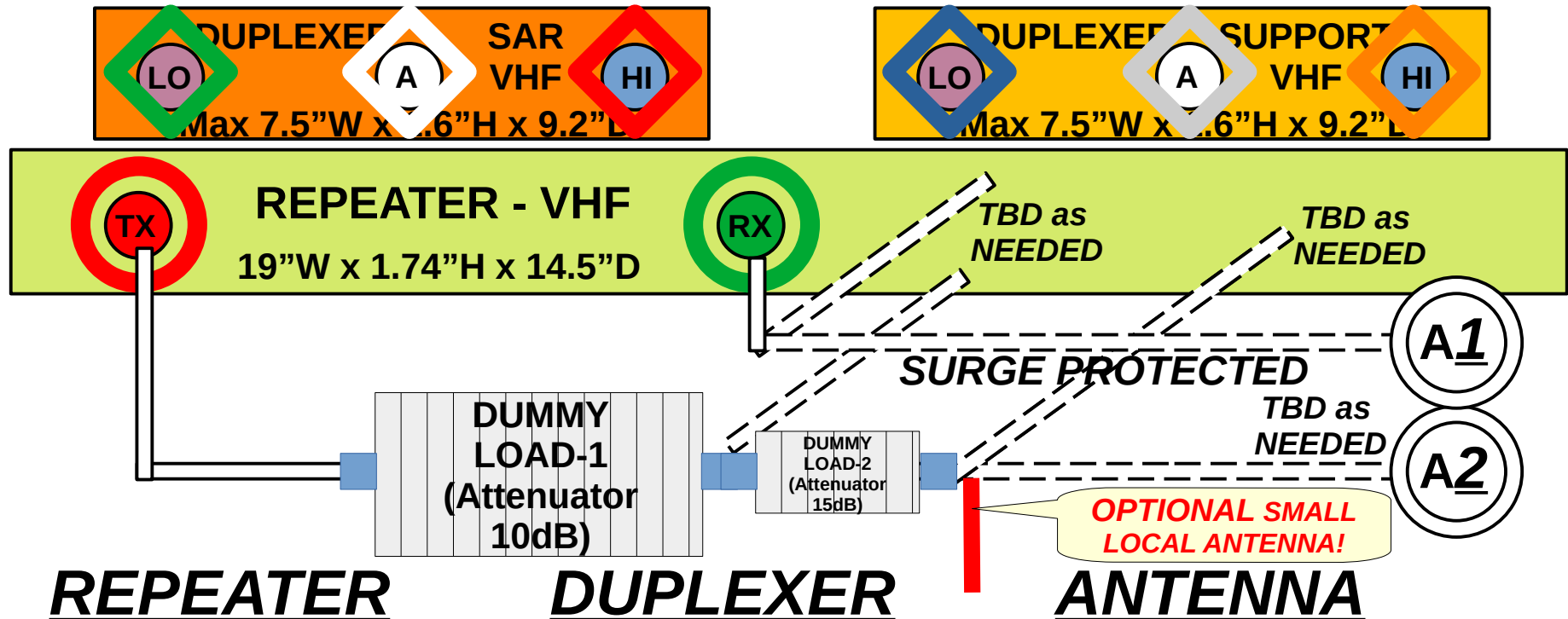
TRANSMITTER
TX (RED) = = = = ATTENUATOR(S)
        then Optional OPEN or
            DUPLEXER or ANTENNA A2 (WHITE)

RECEIVER
RX (GREEN) = = = = = [DUPLEXERS or ANTENNA A1]

"TEST MODE" & Protection

BIG DUMMY LOAD (10x or -10 dB ATTENUATOR)

Little Dummy Load (31x or -15 dB ATTENUATOR)

ADD OPTIONAL LITTLE LOCAL ANTENNA??

SIGNAL FROM TX ENTERS ON LEFT (UP TO *50 W*)

-10dB TX SIGNAL AVAILABLE IN MIDDLE (UP TO *5 W*)

-25dB TX SIGNAL ARRIVES ON RIGHT (UP TO *160 mW*)

TX HERE..

BIG Attenuator 10dB

Little One 15dB

50W 10dB DC-3GHz RF Attenuator

10W 15dB DC-3GHz
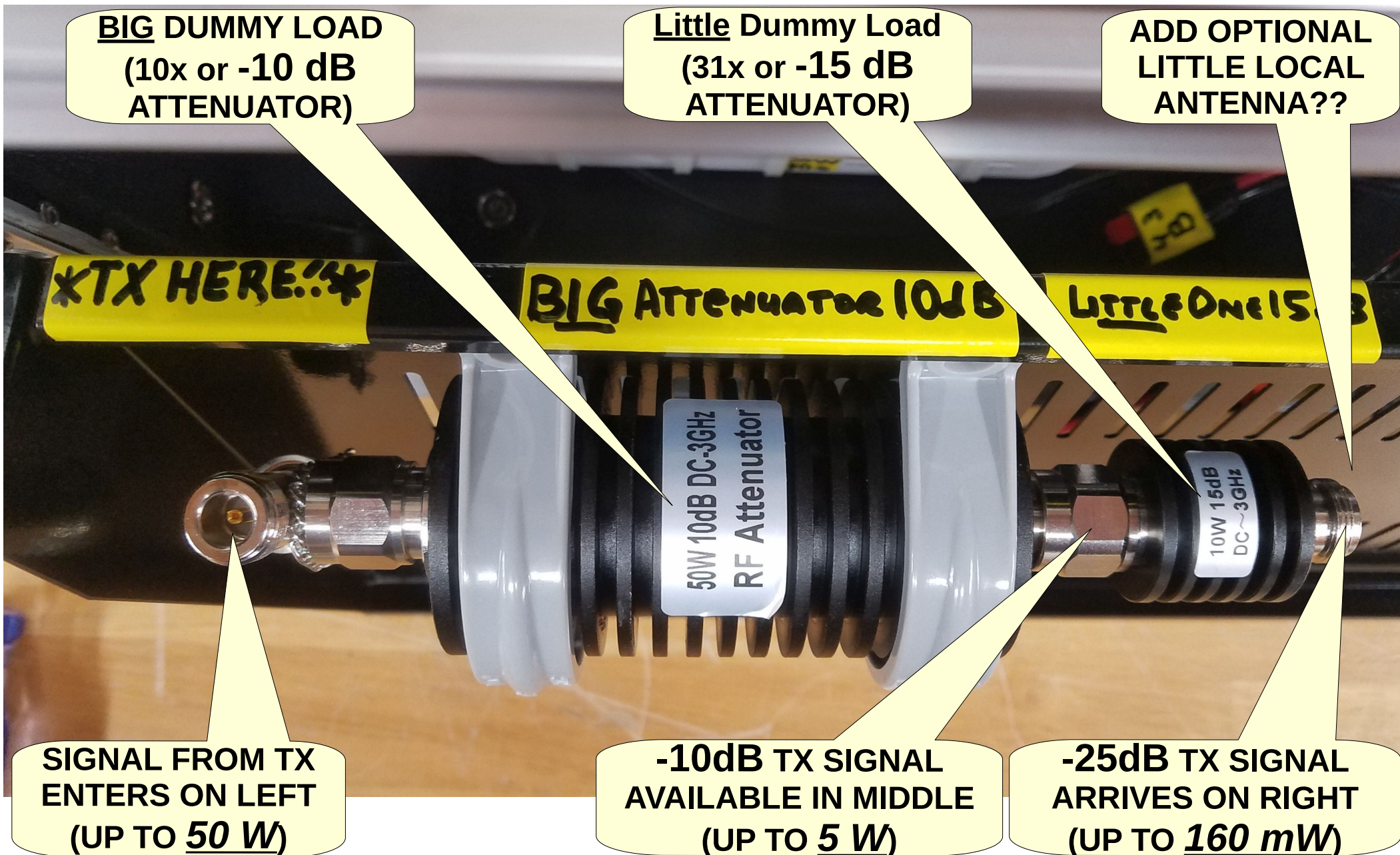
Transport Package

- Based on modest yet rugged transportable cases, with internal rack mounts, commonly used by Military, FEMA, Red Cross...

- Fits industry standard 19 inch wide equipment, ~12-24in deep.

- Capacity is measured by rack height, in "U" (units) = 1-7/8 inches.

- The exterior dimensions are a few inches more.

- *Overall Right Sized "4U" = 7" High*

- **Repeater System weight under 50 pounds...**

- ***A "Rolling Case" for <u>smooth & flat</u> surfaces (floors & roads)***

- ***BUT do NOT drag it on a trail or drive over rough surfaces!!***

- ***Normally use 2-person carry, or lash & carry with evac litter!!***

- *Note – For majority of events, the Repeater will be inside a SAR Trailer, or an ICP building, or other shelter, and rarely in the Wild.*

Gator Rolling Rack Case

REPEATER – EXTERNAL VIEW

RADIO CONNECTIONS

POWER METER

DATA & CONTROL CONNECTIONS

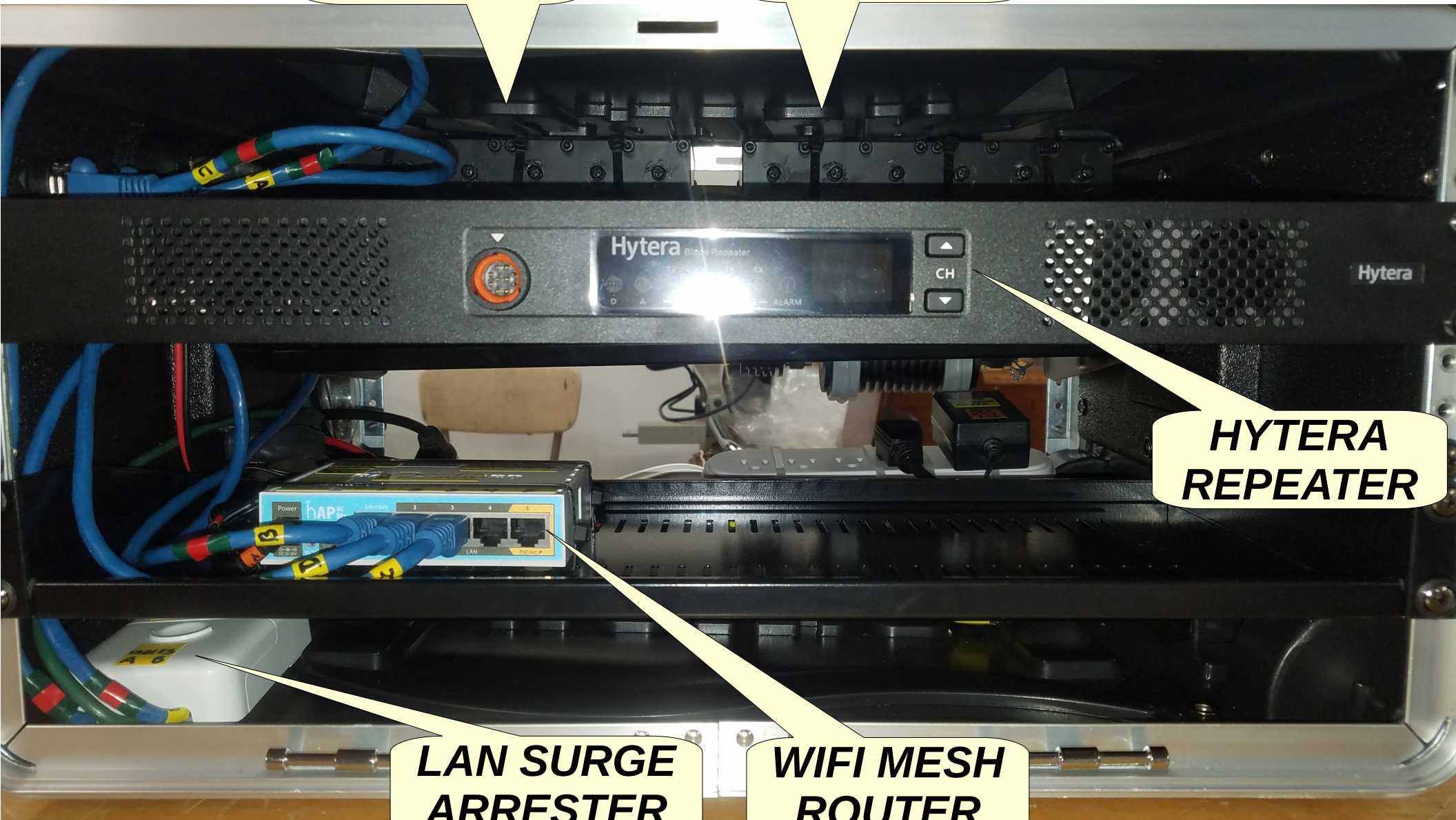ALTERNATE ACCESS

POWER CONNECTIONS

REPEATER – FRONT VIEW

SUPPORT DUPLEXER

SAR DUPLEXER

HYTERA REPEATER

LAN SURGE ARRESTER

WIFI MESH ROUTER

REPEATER – REAR VIEW

SAR DUPLEXER:
Enables National Standard
SAR Channels (150 & 155)

SUPPORT DUPLEXER:
Enables Support
Channels (151 & 158)

HYTERA REPEATER

TEST LOAD

POWER STRIP, USB & SURGE ARRESTER

12VDC POWER STRIP

REPEATER – <u>SUPPORT</u> FULL POWER

SUPPORT DUPLEXER

PROTECTED ANTENNA <u>A1</u>
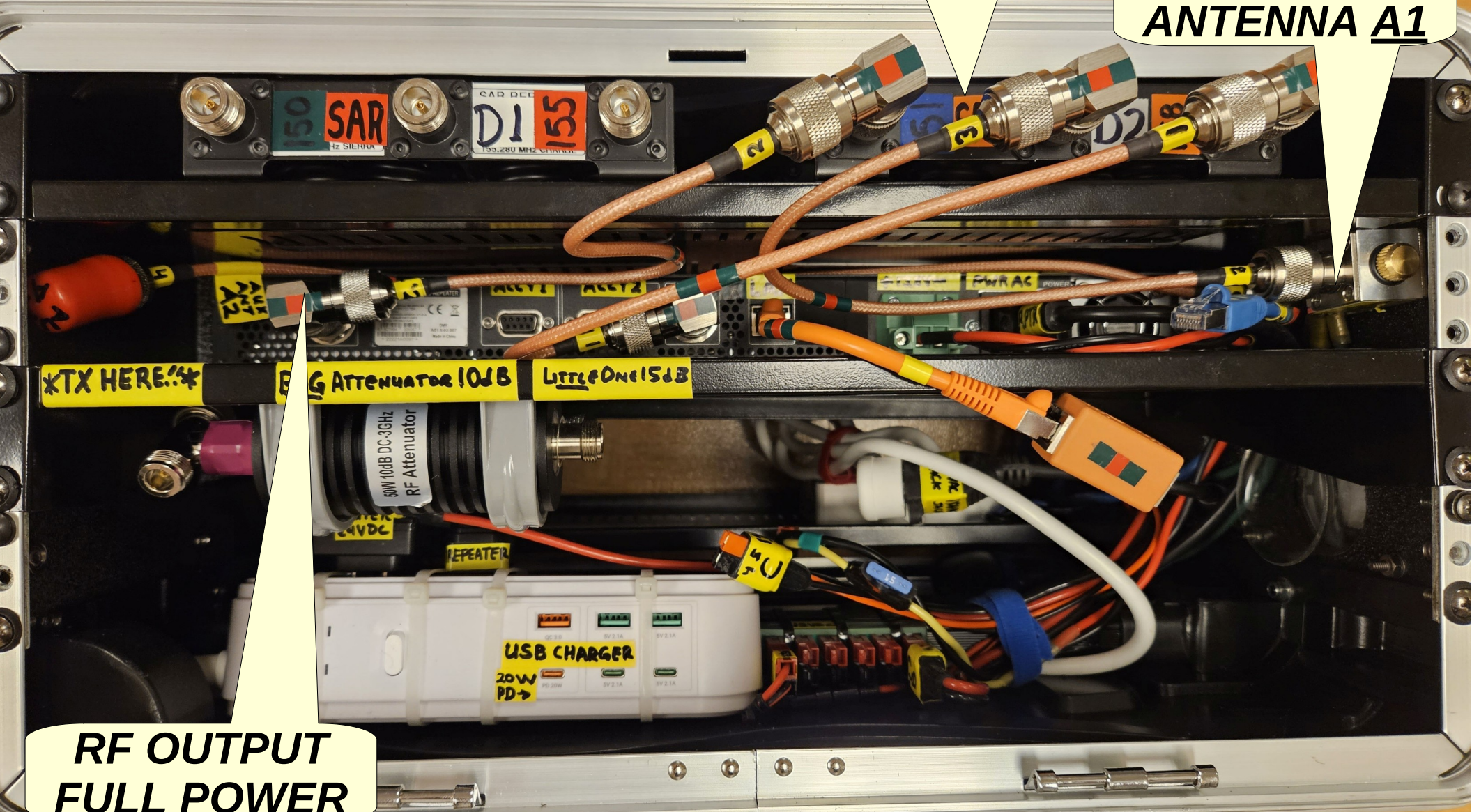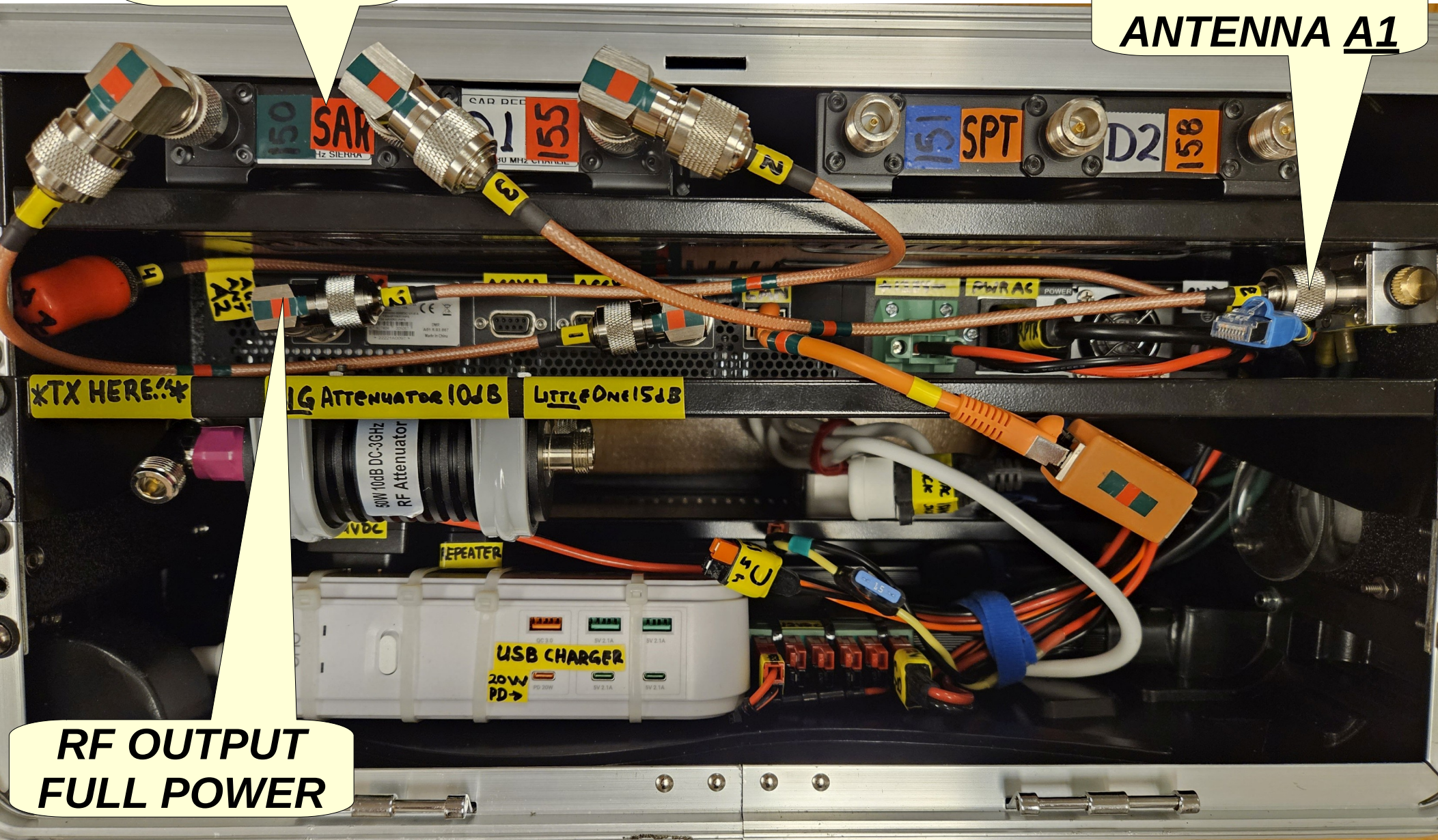
RF OUTPUT FULL POWER

REPEATER – <u>SAR</u> FULL POWER
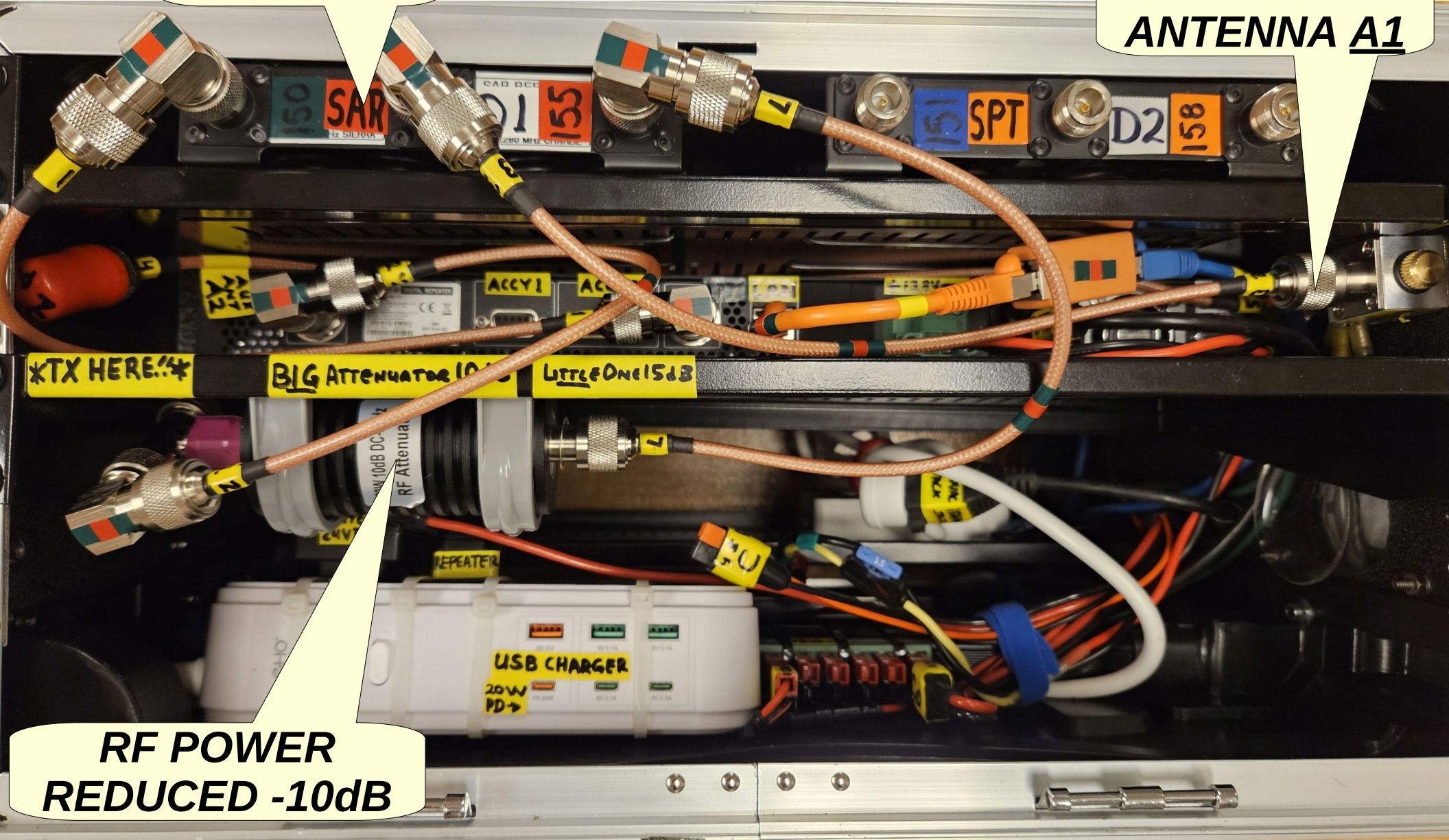

SAR DUPLEXER

PROTECTED ANTENNA <u>A1</u>

RF OUTPUT FULL POWER

SAR DUPLEXER

PROTECTED ANTENNA <u>A1</u>

RF POWER REDUCED -10dB

REPEATER – EXAMPLE USE

ANTENNA & MAST

CRAFTY COMMS CREW

REPEATER & BATTERY GOES HERE

TACTICAL TERRAIN ADAPTATION SUBSYSTEM

HIGH RADIO LOCATION

Questions?

Better Ideas?

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