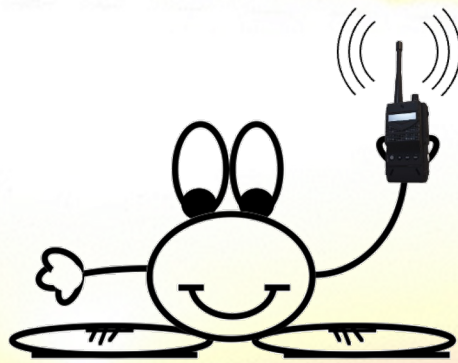


D-Star Simplified



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Joe Touch / AK6MB



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Stuff I use...

- Shack

- ICOM IC-705 
- Hardrock-50 amp w/tuner
- Ultimax 100 66' HF 80-6m
 - Horizontal 10-20' up, 5' over solar
- Diamond X300A UHF/VHF
- Astron 20A
- WPSD simplex hotspot
- WPSD duplex hotspot

- POTA

- ICOM IC-705
- Mini Buddipole
- ICOM AH-705 tuner
- NanoVNA-H4 analyzer

- Software (Apple)

- SDR-Control (FT8, SDR)
- Ham-Toolbox logbook (QRZ)

- Mobile

- ICOM ID-52a Plus HT
- Baofeng, Quansheng
- Car window mount U/V 19"

Overview

- Background
 - What it is, how it's different
- What D-Star does for you
 - From a user's viewpoint – we're not building radios here
- How to GOTA with D-Star
 - Register, setup, and go!
- Hotspots
 - A personal digital repeater
- Things I'm still learning
 - And plenty that you can help with too

D-Star background

- Digital mode
 - Open specification
 - Proprietary voice compression algorithm (because an open one did not exist at the time)
 - Digital message with each transmission
 - Supports location tracking (like APRS)
- For hams, by hams
 - Requested by gov't of Japan in 1998
 - Designed by Japan Amateur Radio League
 - First standard approved 2001
 - ICOM registered the name “D-Star” (as protection?)

Who supports D-Star?



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D-Star is expensive

Brand	Model	Price	Power	Type
ICOM	ID-50a	\$400	5W	HT/D-Star
Kenwood	TH-DX75	\$640	5W	HT/D-Star
Yaesu	FT-70DR	\$190	5W	HT/C4FM
Anytone	ATD168UV	\$200	6W	HT/DMR
Baofeng	DM-1701	\$35	5W	HT/DMR

D-Star advantages

- Efficient digital encoding
 - GMSK: Gaussian minimum shift encoding (variant of FSK)
 - Modulation index of 0.5 (the smallest possible)
 - Low 6.25 kHz bandwidth
 - Similar to GSM phone, Bluetooth
 - “Constant envelope”: fade, interference, noise resistant
- Supports all bands
 - 2m (144 MHz), 70cm (440 MHz), 23cm (1.2 GHz)
 - 1.25m (220 MHz) US Kenwood, not ICOM (not in Japan)
 - HF on ICOM IC-705, IC-7100, IC-9100, Flex

Some details

- 4,800 bits/sec
 - 3,600 bits/sec voice, proprietary CODEC
 - Other bits are data and error correction
- Runs internally on a private network
 - Users assigned 10.x.x.x address blocks
 - Callsigns mapped to IP addresses

Ham mode comparisons

Mode	Examples	Edge	Repeater connect	Operator access	Repeater
Phone	SSB, FM, AM, CW	Analog RF	None	RF	Analog RF
Internet ham radio	Echolink, Allstar	Analog RF	Internet	Internet	Analog RF “nodes” ClearNode, SHARI
Digital voice	D-Star, C4FM, DMR, P25	Digital RF	Internet	RF*	Digital RF, “hotspots” ZumSpot, MMDVM
Packet	FT8, FT4, WSPR	Digital RF	None	RF	N/A
Other digital	RTTY, SSTV, APRS, etc.	Digital RF	None	RF	N/A

**Shark M1KE, phone/pc apps collapse the RF side*

Digital mode comparisons

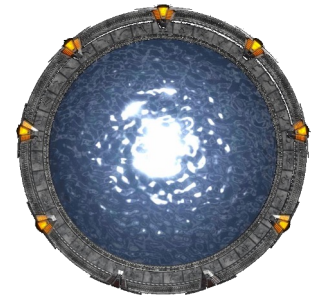
	Open Std	Voice rate	Code	Types of info.	BW	Band
D-Star	JARL	3.6 kbps^	GMSK	Data, message, location, image, video	6.25 kHz	Any
C4FM (Fusion)	Yaesu	4.4 kbps	FSK	Data, message, location, image	12.5 kHz	UHF/VHF
DMR	ETSI	2.45 kbps	FSK	Message, location	12.5 kHz	UHF/VHF
P25	TIA	4.4 kbps	FSK	Packet IP, location	12.5 kHz	UHF
NXDN	IC/KW	4.8 kbps	FSK	Message, location	12.5 kHz (2x 6.25 kHz)	UHF/VHF
POTS*	Bell	56 kbps	PCM, PAM	Data, message, image	56 kbps	n/a

^Equivalent to 7.2 kbps in a 12.5 kHz channel

*"Plain Old Telephone Service" shown for contrast

What D-Star does for you

- It's a system of gateways (like Stargates)
 - Enter at your local stargate
 - Pop out at any other stargate!
 - Even find someone at *any* stargate!
- Stargates connect via the Internet @
 - SOME hams consider that “cheating”
 - To others (me), it's just a different way of linking repeaters (vs. cables, microwave links)

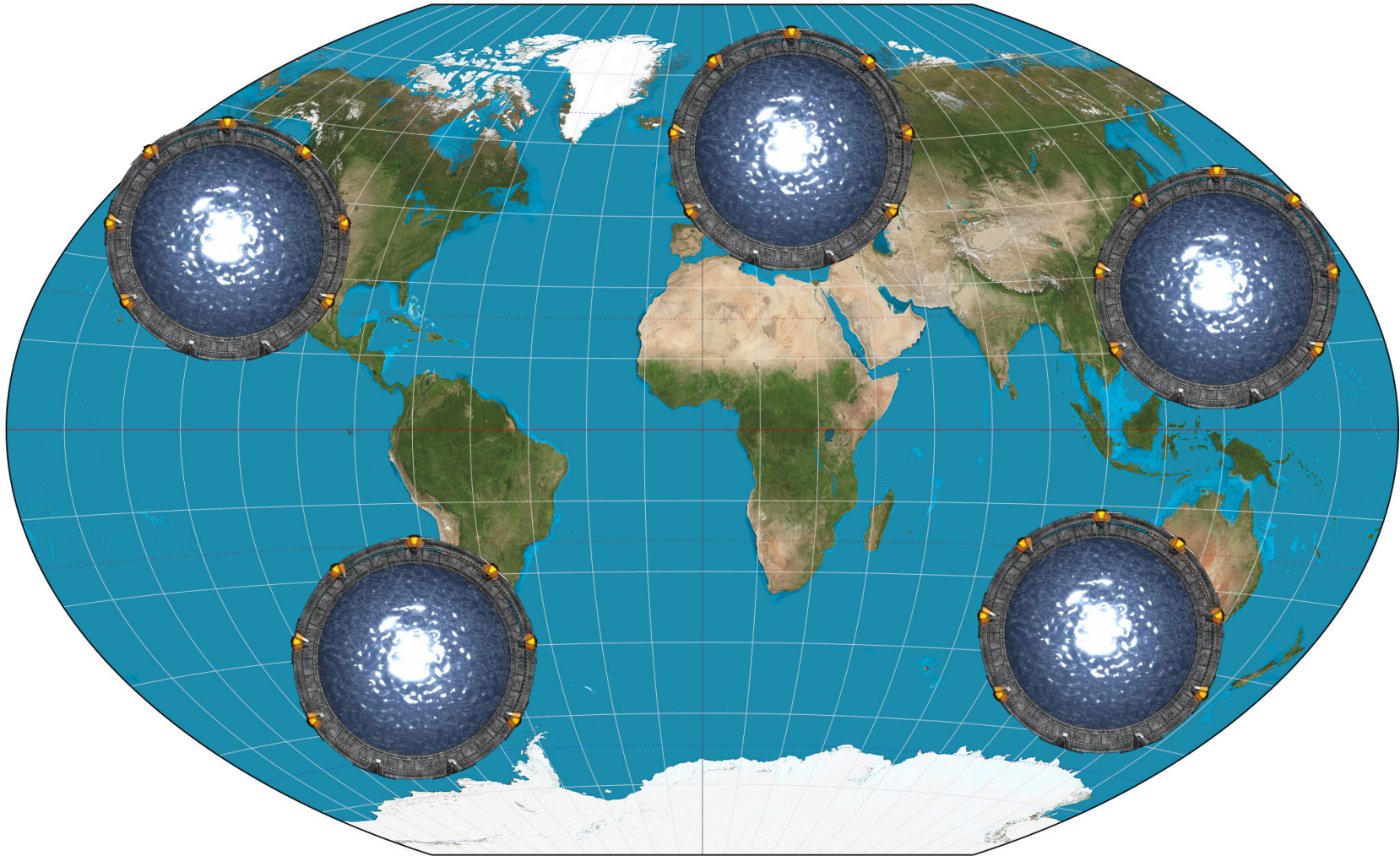


The D-Star Stargate model

- Each D-Star is like a Stargate
 - You exchange signals on a “port”
 - A,B,C are RF
 - G is the gateway (Internet)
- Where can you go?
 - Exit that stargate via a different “port”
 - Exit a different stargate at a specific “port”
 - Exit the stargate/port pair of a specific callsign
 - Exit a group of linked stargates



D-Star repeaters everywhere

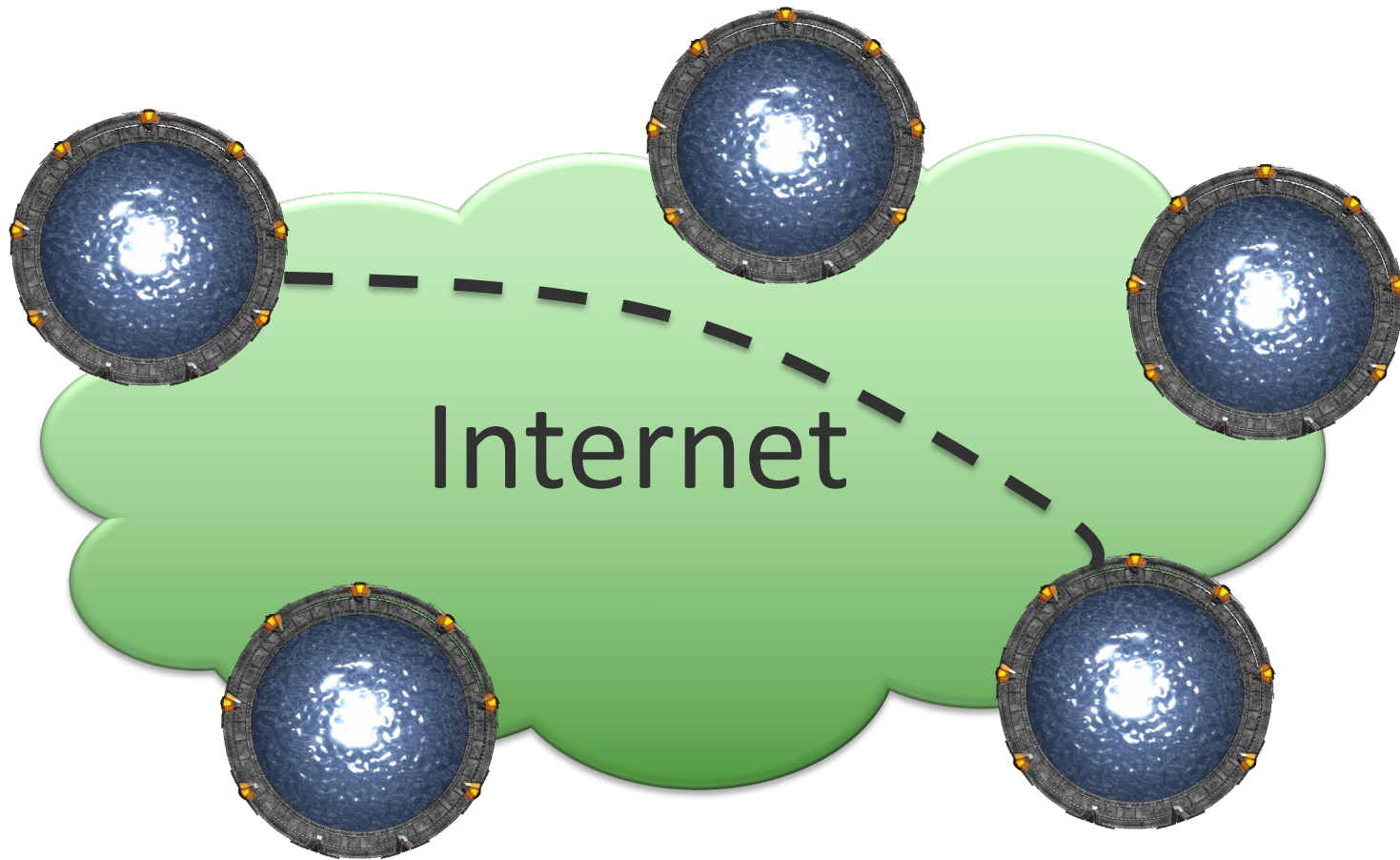


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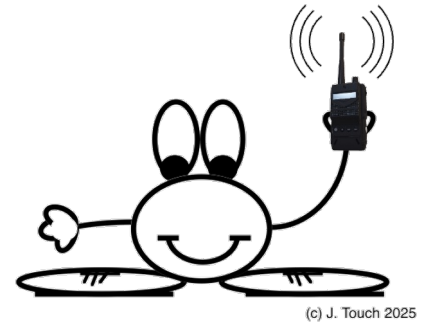
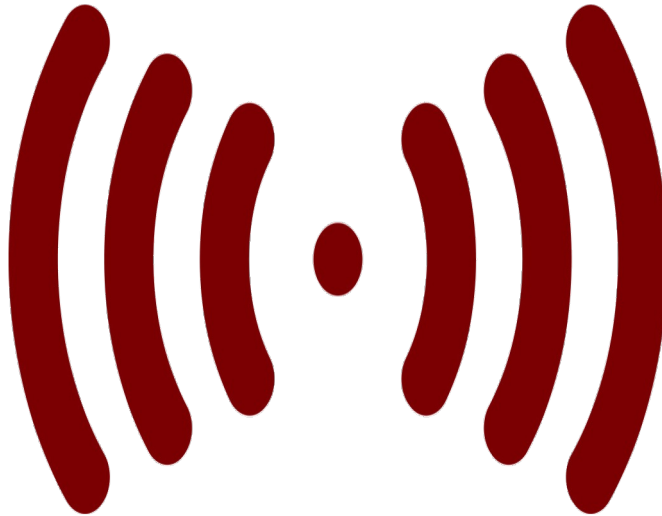
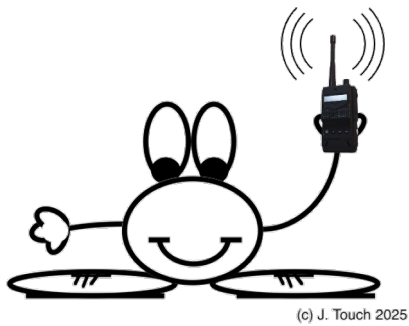
13

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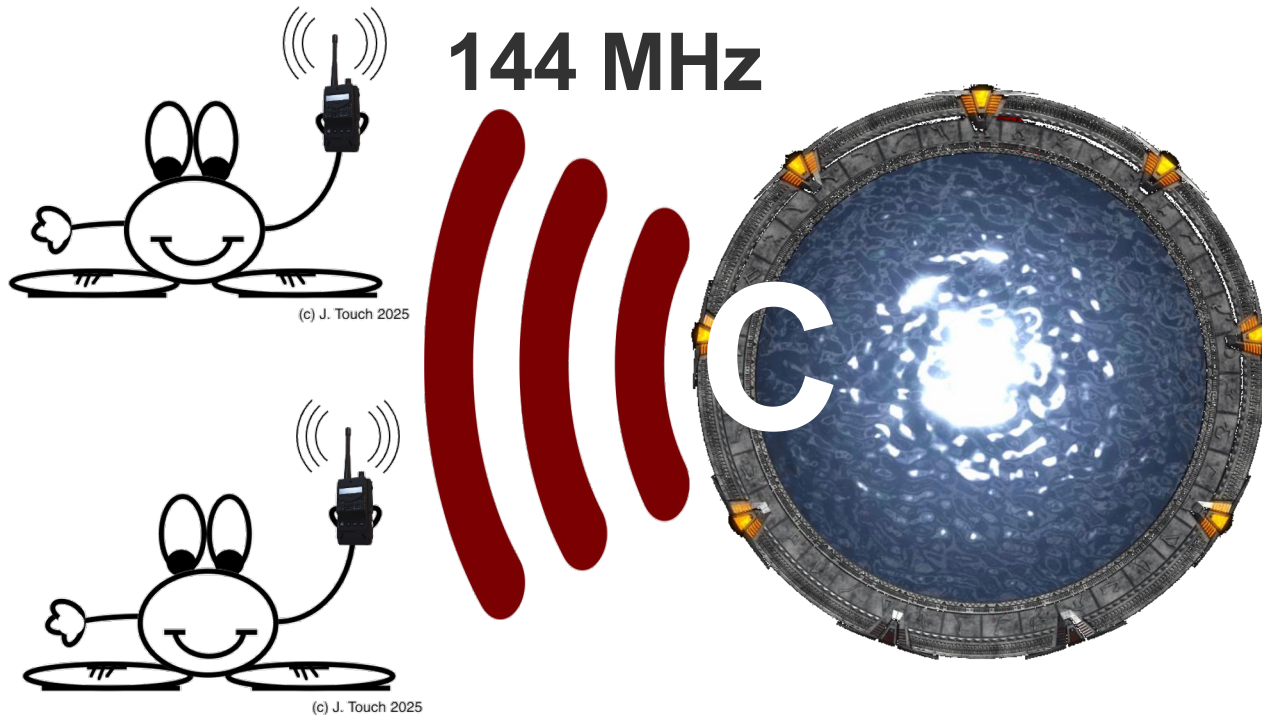
Up to one hop interconnect



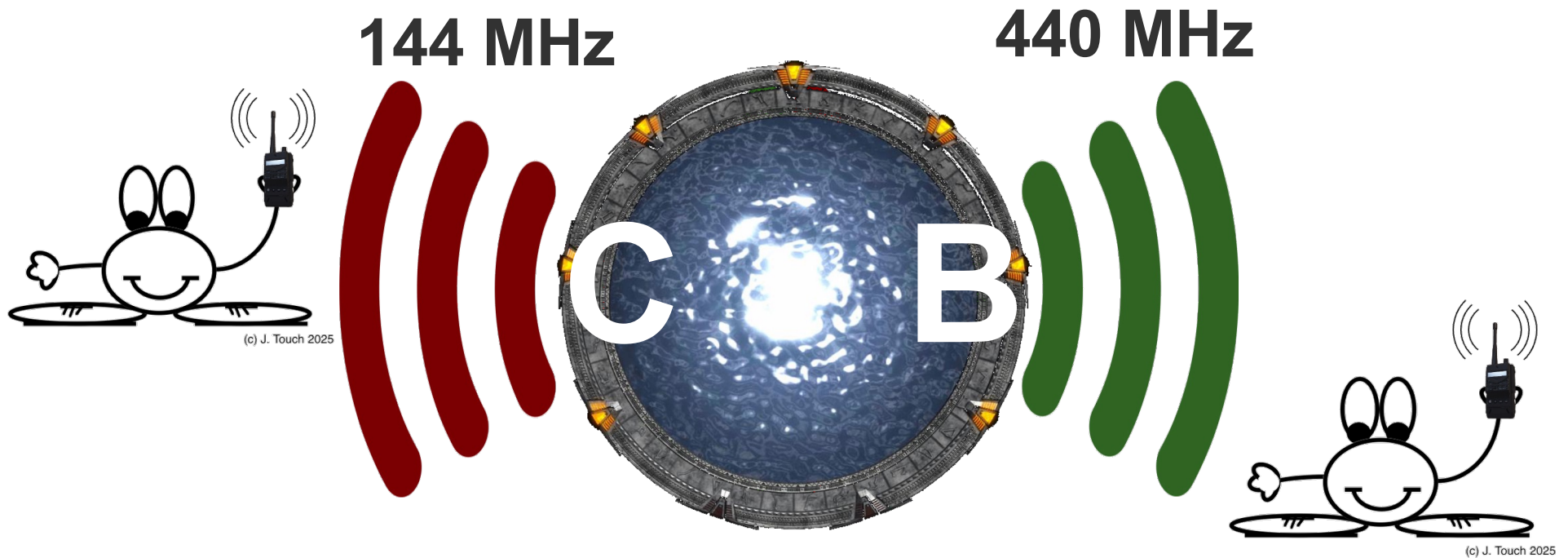
Direct



Local repeater



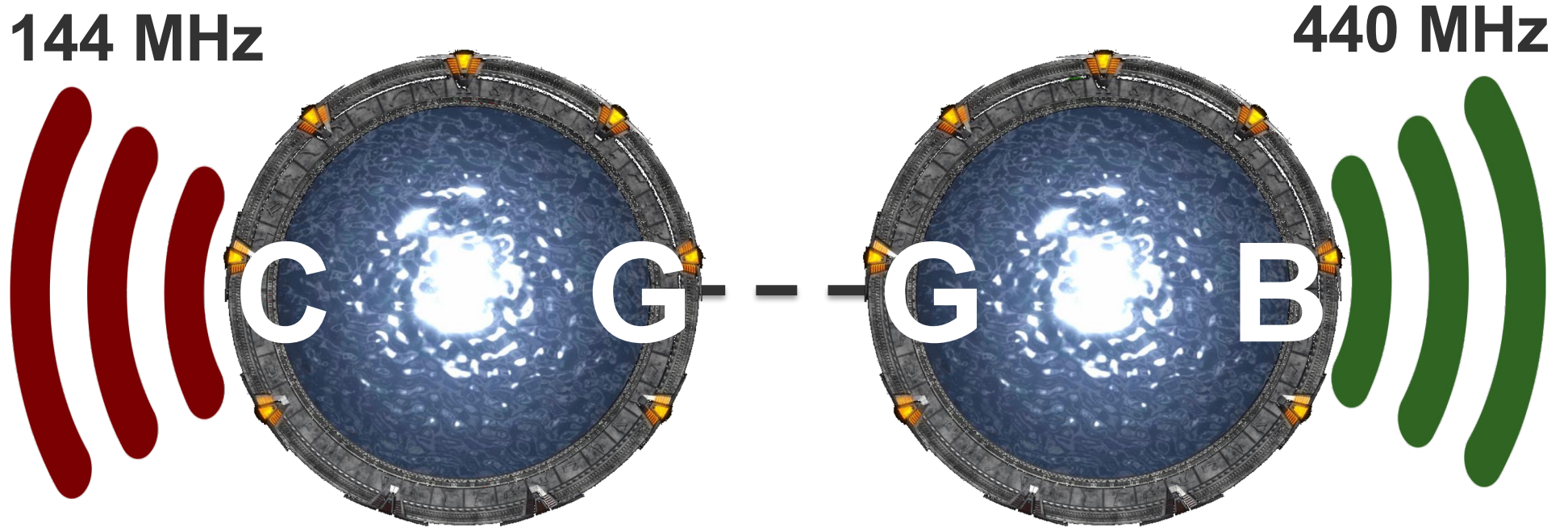
Local repeater as translator



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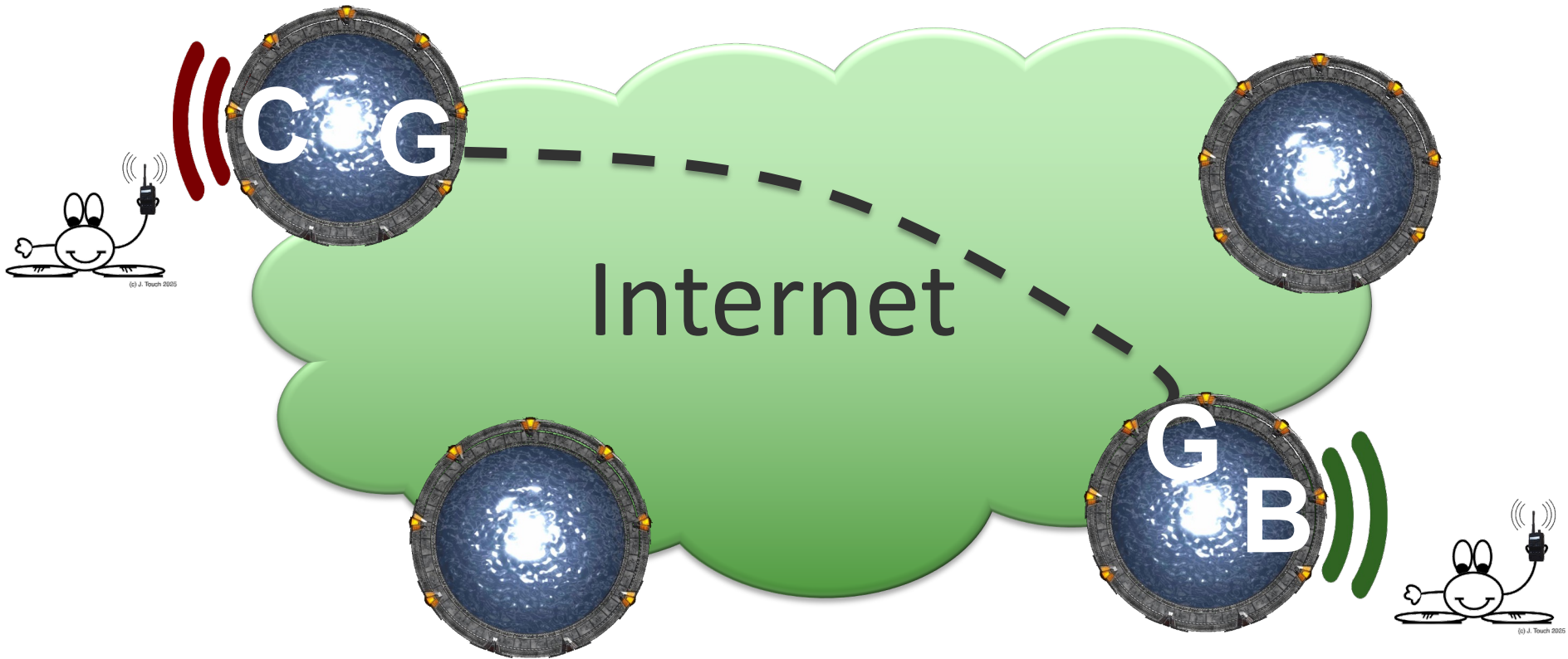
Repeater pair as translators



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Connect to a remote port

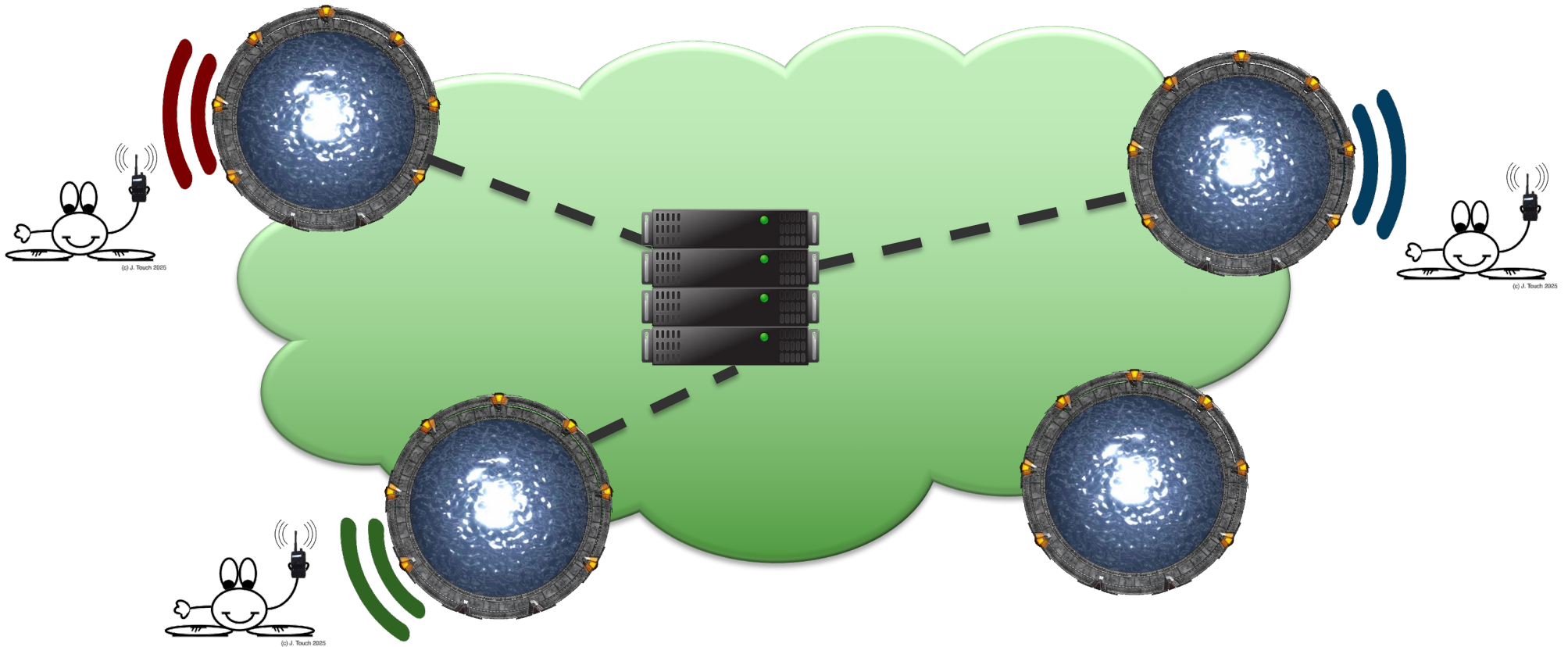


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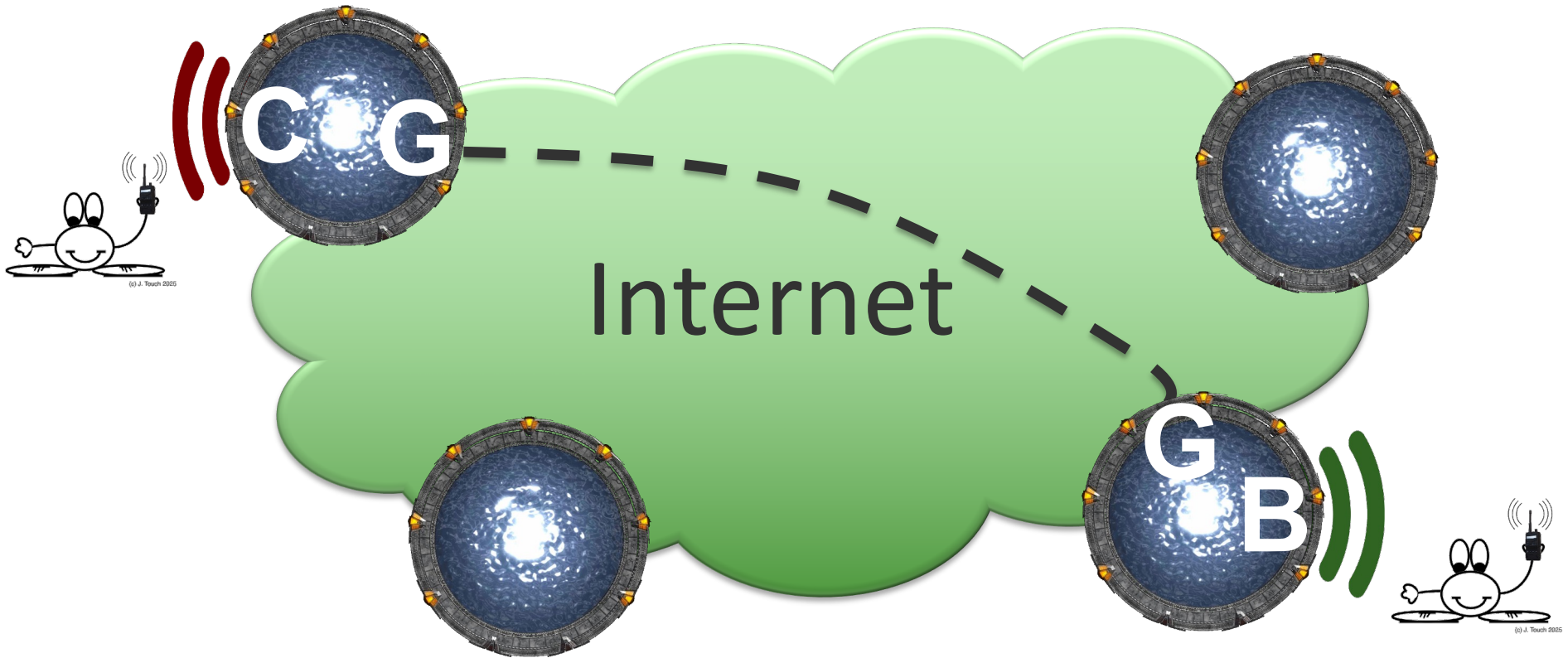
Join a D-Star reflector – REF

Reflectors copy the data stream



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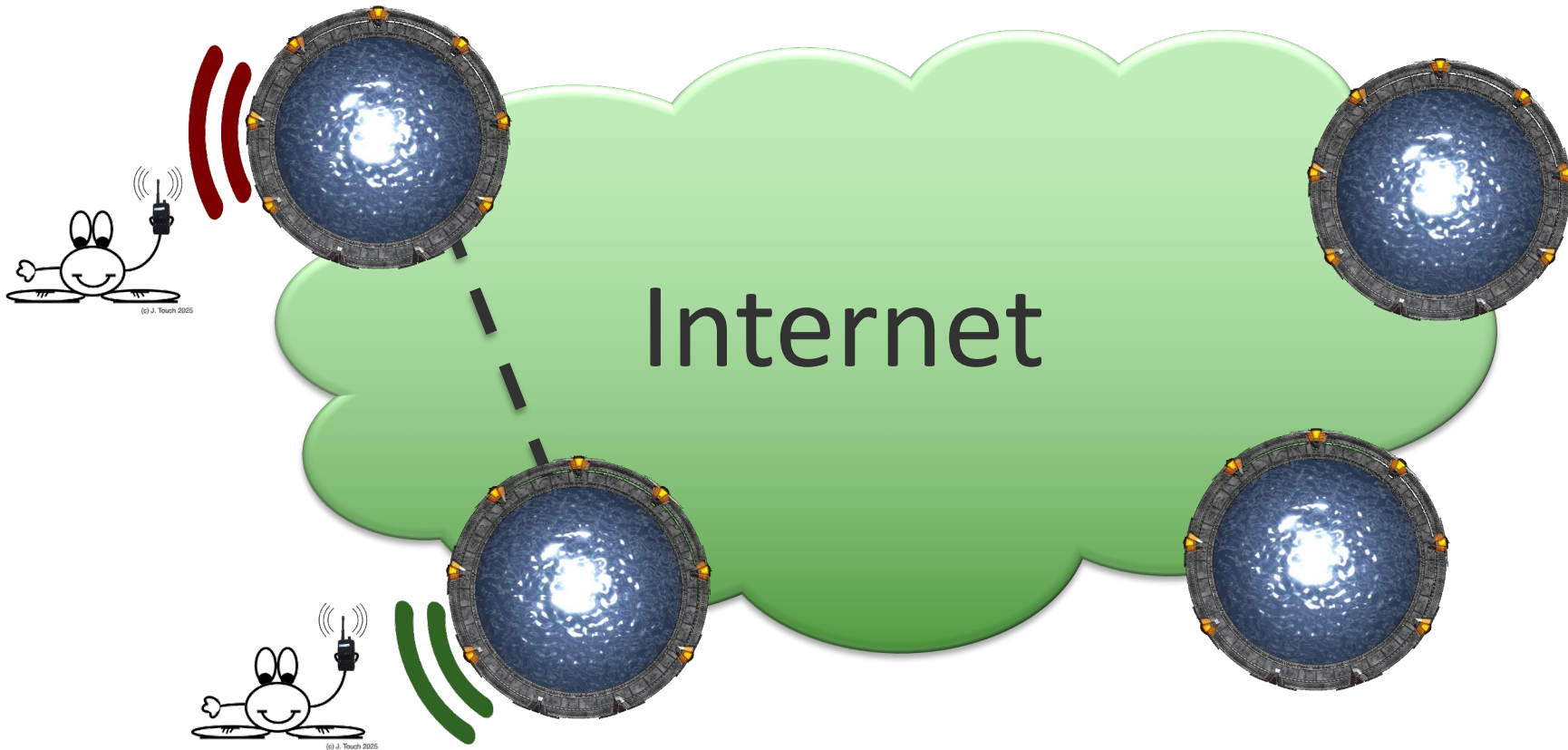
Find a callsign



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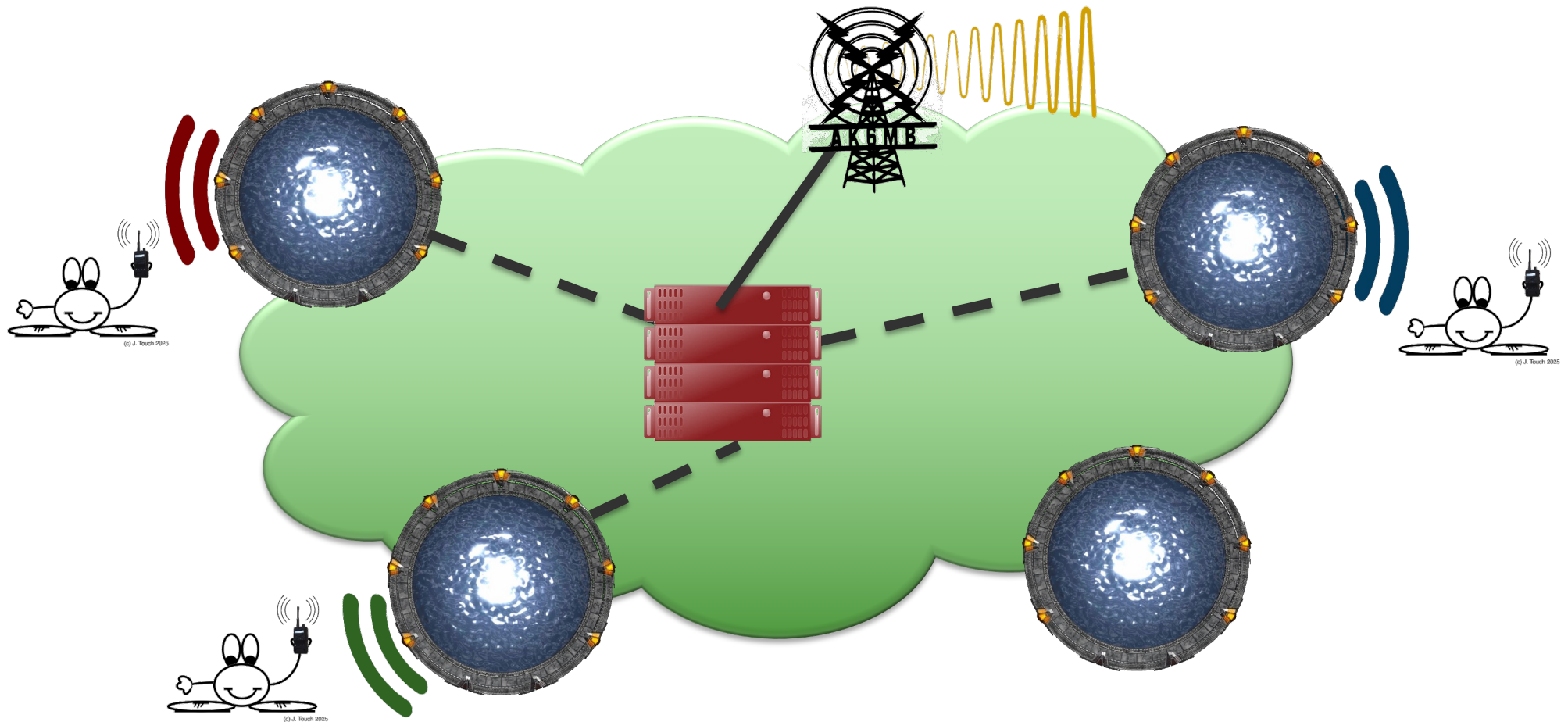
Find a callsign



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Join a multimode reflector – XRFXLX

Copies the data to digital and FM



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Command types

Suffix	Command	Meaning
L	Link	Connect stargates via a reflector (REF) or stargate
O	Link (extra/exper)	Connect stargates via an X-reflector (XRF/XLX)
U	Unlink	Unlink from a reflector, X-reflector, or stargate
I	Info	Report current status and other information
E	Echo	Play back this (brief) recording

Basic commands are 8 characters

Callsign routing 

Always your local repeater 

This is where most errors occur: most of the power is in URCALL

	CSR	URCALL	RPT1	RPT2	Notes
simplex		(callsign)	(empty)	(empty)	Transmit to a receiver directly
local		CQCQCQ^^	AK6MB B	AK6MB B	(or RPT2 blank) Local repeater one band
Local x-band		CQCQCQ^^	AK6MB B	AK6MB A	Local repeater cross-band
Use repeater		CQCQCQ^^	AK6MB B	AK6MB G	Use the linked reflector (to anyone)
Link to REF		REF012AL	AK6MB B	AK6MB G	Link to a D-Star reflector
Link to XRF/XLX		XRF012AO	AK6MB B	AK6MB G	Link to a cross-mode reflector
Unlink		^^^^^^^U	AK6MB B	AK6MB G	Unlink the local repeater (if any)
Info		^^^^^^^I	AK6MB B	AK6MB G	Local repeater sends a report (content varies)
Echo		^^^^^^^E	AK6MB B	AK6MB G	Local repeater records and plays back a transmission
Call an individual	X	AA6AAA	AK6MB B	AK6MB G	Use remote repeater where last heard or registered
Call to the repeater	X	/AA6AAA	AK6MB B	AK6MB G	Route TO a repeater (/=repeater), presumably useful as remote LOUIE?
Link to exit a repeater	X	AA6AAApL	AK6MB B	AK6MB G	? (defined in the specs, but unclear what it does – this looks like L in LOUIE, but lacks the "/")
Call out a repeater port	X	/AA6AAAp	AK6MB B	AK6MB G	Route to <u>repeater's</u> specific node (/= repeater)

NOTE: "^" indicates a space character

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Digital mode comparisons

	To a group	To a person	Time slots^	To a repeater	To a repeater port	Echo test	Info / status
D-Star	Yes	Yes	No	Yes	Yes	Yes	Yes
C4FM	Yes	No	No	No	No	Yes	Yes
DMR	Yes	Yes*	2^	No	No	Yes	Yes
P25	Yes	Yes*	2^ ($\phi 2$)	No	No	No	Yes
NXDN	Yes	Yes*	No	No	No	No	Yes
Phone	No	No	No	No	No	No	No

*Only on the same repeater

Although a feature, not all amplifiers support the high-speed switching required

D-Star and duplex

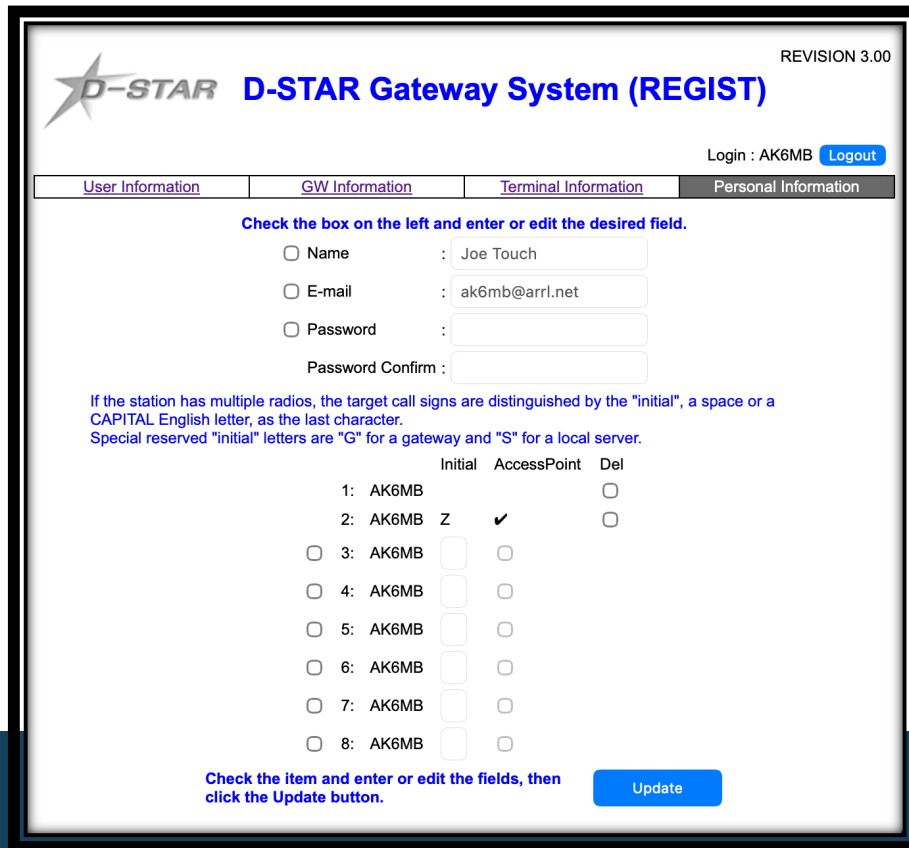
- D-Star has two modes
 - Repeater mode (where RPT1/RPT are filled in)
 - >> which is **ALWAYS DUPLEX**
 - Direct (where RPT1/RPT2 are empty)
 - >> which appears to be always SIMPLEX
- Using repeater mode on simplex is possible!
 - Useful for simplex (less expensive) hotspots
 - BUT: You MUST configure your rig to operate “duplex”
 - E.g., DUP+ or DUP- with offset = 0
 - Otherwise, D-Star won't operate at all (yeah, seems like an oversight to me too)

How to GOTA with D-Star

- Register
- Setup your radio
- Go!

Register

- Create a login and register on D-Star
 - On your local repeater if possible



The screenshot shows the 'D-STAR Gateway System (REGIST)' web interface. At the top, it says 'D-STAR' with a star logo and 'D-STAR Gateway System (REGIST)' in blue. The version 'REVISION 3.00' is in the top right. Below the title, there's a login field with 'AK6MB' and a 'Logout' button. A navigation bar has four tabs: 'User Information', 'GW Information', 'Terminal Information', and 'Personal Information'. The 'User Information' tab is active. It contains a form with fields for Name (Joe Touch), E-mail (ak6mb@arri.net), Password, and Password Confirm. Below the form, there's a table for radio information with columns 'Initial', 'AccessPoint', and 'Del'. The table has 8 rows, with the second row (AK6MB Z) checked. At the bottom, there's an 'Update' button and a note: 'Check the item and enter or edit the fields, then click the Update button.'

D-STAR D-STAR Gateway System (REGIST) REVISION 3.00

Login : AK6MB Logout

User Information GW Information Terminal Information Personal Information

Check the box on the left and enter or edit the desired field.

☐ Name : Joe Touch

☐ E-mail : ak6mb@arri.net

☐ Password :

Password Confirm :

If the station has multiple radios, the target call signs are distinguished by the "initial", a space or a CAPITAL English letter, as the last character.
Special reserved "initial" letters are "G" for a gateway and "S" for a local server.

	Initial	AccessPoint	Del
1:	AK6MB		☐
2:	AK6MB Z	✓	☐
☐ 3:	AK6MB	☐	
☐ 4:	AK6MB	☐	
☐ 5:	AK6MB	☐	
☐ 6:	AK6MB	☐	
☐ 7:	AK6MB	☐	
☐ 8:	AK6MB	☐	

Check the item and enter or edit the fields, then click the Update button. Update



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Setup your radio

- Digital

- Your call sign

Select
Name
Callsign

S
Joe
AK6MB



*This is the only
required part*

- My station

- My call sign

Select
Callsign
/

S
AK6MB
I705

- TX message

Select
Message

S
Manhattan Beach, CA

- GPS

- GPS Setting

- GPS TX

GPS TX Mode
Item, info

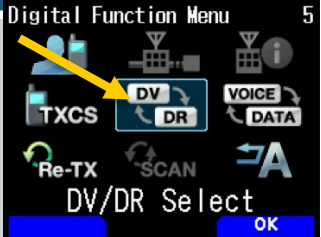
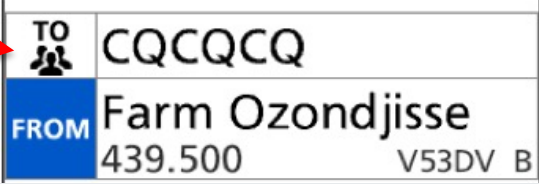
D-PRS

- DPRS info

Configure D-Star repeaters

- Most D-Star radios come pre-configured
 - Add any missing entries
 - NOTE: Only ONE entry per repeater callsign
 - Callsign (required), frequency, offset, direction
 - No PLL or other tones, codes, or groups

D-Star mode

	ICOM		Kenwood
Enter / exit D-Star mode	Hold [DR]	 	
Select command (URCALL) <i>[not really "to", in most cases]</i>	Select "TO"		
Select entering repeater (RPT1) <i>[not really "from"]</i>	Select "FROM"		

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Kerchunk away!

- On D-Star, kerchunk sends a message
 - Always sends your callsign
 - Optionally also:
 - Your name
 - A 4-character note (typically your radio model)
 - A text message
 - Your GPS location, with an object icon you select
- Kerchunk sends commands too
 - To link, unlink, get info, test echo

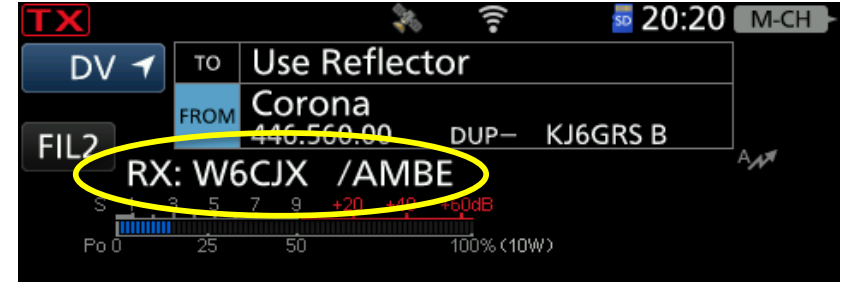
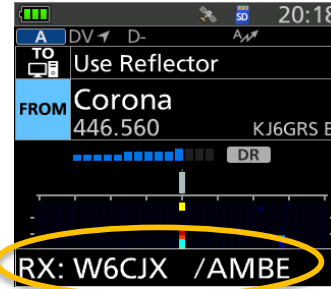
Examples...

- Introduce yourself

- Callsign, 4-character code (rig ID, e.g., I705)

AK6MB / I705

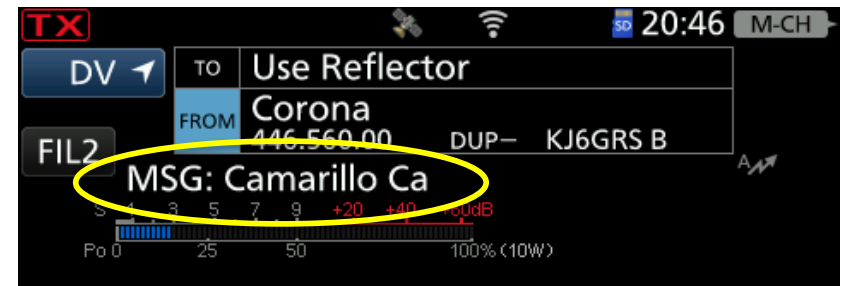
AK6MB / Joe



- 20 Character message (location, message)

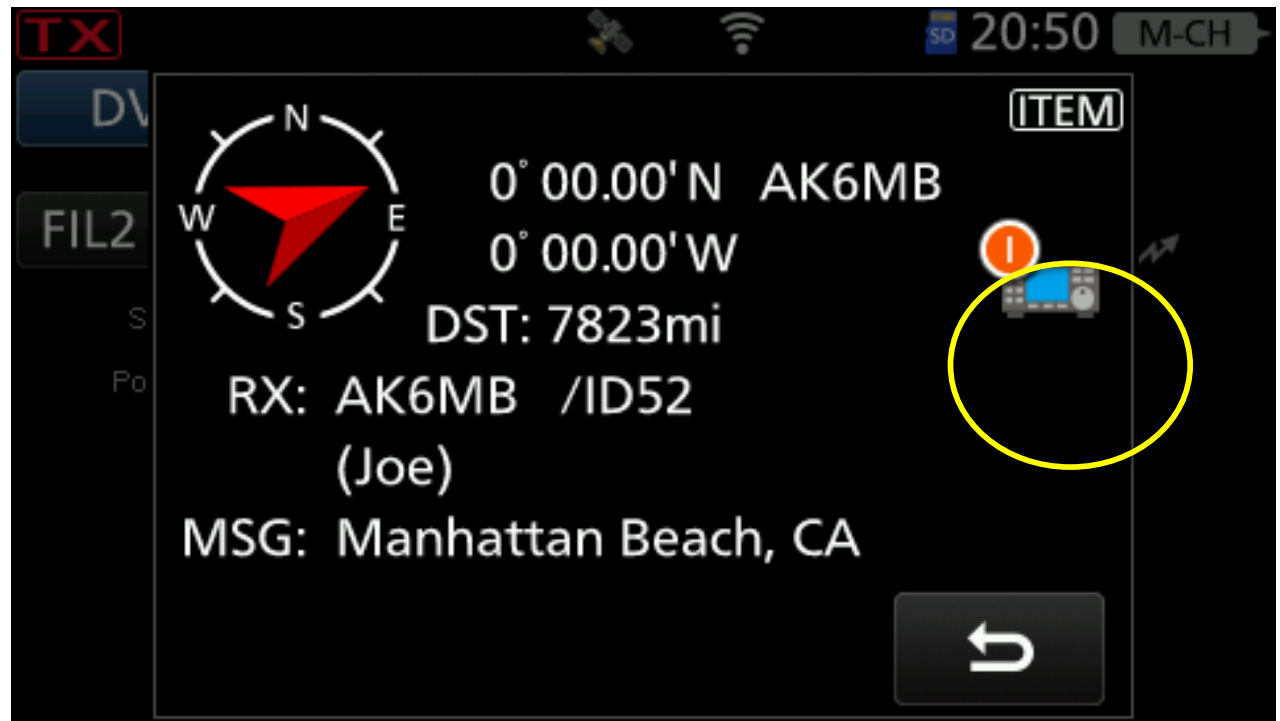
Manhattan Beach, CA

Surf's up, dude!



Provide your location and info

- Info:
 - Object
 - Item
 - Weather
- Sent **ONLY** when GPS is up!
 - Not sent if no GPS signal



Configure – DV

- This might already be done
 - Most D-Star rigs have an initial DV repeater list
- Add to DV list if needed
 - One entry for each port (band) per repeater (in DV, not MEM)
 - Each call/port pair can appear only ONCE
 - E.g., some PAPA DV repeaters are already in Icom list ... so change them rather than adding a new entry (as you would for FM repeater lists in regular memory)
- DV list has advantages
 - Search by 'nearest' in Icom radios (works for FM/SSB too)
 - Select local repeater,/port remote repeater/port, and command independently (vs. one entry per command in MEM list)

Configure – memory

- Add to memory list (with FM stations)
 - No limit on call/port duplicates
 - One entry per <local repeater/port, remote repeater/port, command> tuple
- No independent selection
 - Entire tuple in each memory slot
 - Usually use at least 3 slots each:
link, unlink, 'use repeater'

DV list vs. memory list

- Both can include FM and D-Star entries
- DV list is primarily for D-Star
 - Can be searched by GPS location in Icom radios
 - Allows DV entry with easily changing URCALL, RPT1, RPT1 parameters
- Memory list is similar to non-D-Star rigs
 - D-Star repeaters typically use one entry for each URCALL, RPT1, RPT2 parameter set, because changing those parameters is awkward from the rig

Call sign routing

- There...
 - Use callsign routing
 - URCALL = destination callsign padded to 8 chars
 - Last character can be per-destination, use, etc.
 - E.g., P for portable, E, F for two different uses?
 - RPT1 = local repeater RF port (B or C, typ.)
 - RPT2 = local repeater Internet port (G)
- And back again
 - Use “RX->CS” button to “callsign route back”
 - No need to know source callsign location

Why hotspots?

- Too far away
 - No local D-Star repeater
- Practice
 - Learn how to link, unlink, connect
 - Reduce impact on shared resources

Hotspots

- Commercial

- ZUMspot 1.3 \$175
- ZUMspot 2.4 \$190
- OpenSPOT 4 Pro (batt) \$375



- Assembled

- Ebay elecdesign2015 \$75

Hotspots on the cheap - \$62

- DIY

- MMDVM modem + case

\$32

- Walmart MMDVM hotspot hat oled case

- Raspberry Pi Zero 2 W

\$25

- Amazon raspberry pi zero 2 w pre-soldered

- 8GB SDHC card

\$5

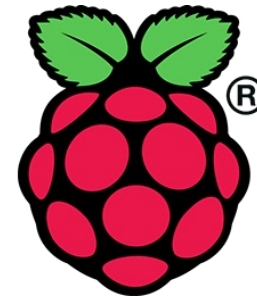


- Bigger display // Raspberry Pi 3/4 // Duplex

- Available, but increases the cost

DIY hotspot

- Assemble the parts
 - Watch out for static
 - Be patient and careful
- Program the SD card
 - Download wpsd (or pi-star) to your computer
 - Use Raspberry Pi Imager to load it
 - Unmount the SD card and remove it
 - Insert the SD card into your hotspot
- Configure your hotspot
 - Wait for it to boot (via its display) - a few minutes the first time
 - Join *its* WIFI net
 - Pull up its web page
 - Configure via that web page



My hotspots

- Simplex
 - 145.770 (-0)
 - MUST use DUP
(+ or -, set offset=0)
- Duplex
 - 449.4625 (-)
 - Requires send/rcv separate by 5 MHz
(2m band is only 4 MHz wide,
but 70cm is 30 MHz wide)



Hotspot website monitoring

Hostname: wpsd

WPSD Dashboard for AK6MB

WPSD Dashboard Ver.# b6806f215b

08:38:26 PM, Oct 7

ProfilesAppearanceLive CallerSimple ViewSysInfoAdmin

Radio Status	TX/RX Freq.	Radio Mode	Modem Port	Modem Speed	TCXO Freq.	Modem Type
TX: D-Star	145.770 MHz	Simplex	/dev/ttyAMA0	115,200 bps	14.7456 MHz	MMDVM_HS_Hat-v.1.6.1

Mode Status

D-Star	DMR
YSF	P25
NXDN	POCSAG
DMR X-Mode	YSF X-Mode

Network Status

D-Star Net	DMR Net
YSF Net	P25 Net
NXDN Net	POCSAG Net
DMR2NXDN	DMR2YSF
YSF2DMR	YSF2NXDN
YSF2P25	APRS Net

D-Star Status

RPT1	AK6MB	C
RPT2	AK6MB	G

D-Star Network

REF012 A (DPlus/Outgoing)

Current / Last Caller Details

Callsign	Country	Name	Location	Mode	Target	Src	Dur(s)
W6CJX/AMBE		Robert	Camarillo, California, USA	D-Star	CQCQCQ REF012 A	Net	TX 19+ sec

Gateway Activity

Caller Details: ☒ Hide Kerchunks: ☐

Time (PDT)	Callsign	Country	Mode	Target	Src	Dur(s)	Loss
08:38:06 PM Oct 7	W6CJX/AMBE		D-Star	CQCQCQ REF012 A	Net	TX	
08:38:01 PM Oct 7	KE6CZH/4100		D-Star	CQCQCQ	Net	0.5	0%
08:37:57 PM Oct 7	AK6MB/ID52		D-Star	REF012AL	RF	0.7	0%
08:05:50 PM Oct 7	AK6MB/INFO		D-Star	CQCQCQ	Net	2.6	0%

Local RF Activity

Time (PDT)	Callsign	Mode	Target	Dur(s)	BER	RSSI
08:37:57 PM Oct 7	AK6MB/ID52	D-Star	REF012AL	0.7s (28 secs ago)	---	S9+42dB (-51 dBm)

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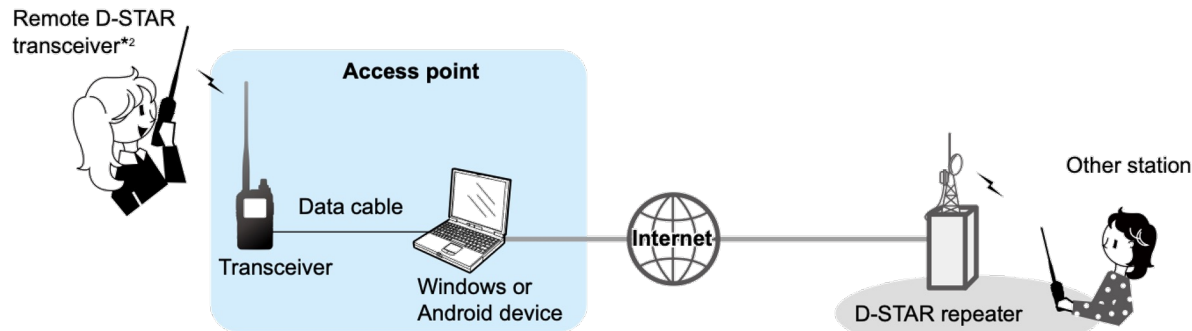
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D-Star Modes as Hotspots

- **Terminal mode – leave the hotspot home**
 - HT as a Gateway with a direct mic (like SharkRF M1KE)
 - Key up and packets go out USB/WIFI/BT over the Internet, to another Gateway
 - No need for a local repeater or hotspot



- **Access point mode – an expensive hotspot**
 - Similar to OpenSPOT, ZUMspot, etc.



D-Star Modes – why not?

- Both modes need real IPv4 addresses
 - Most home Internet IPv4 is NAT'd (translated)
 - Many home NATs can't open ports (CGNAT)
 - Fixed, real IPs can be expensive
 - AR/DC will give you "44-net" addresses, but requires VPN software (WireGuard)
- Access point mode is easier/cheaper with a hotspot
 - And hotspots can be full duplex (HTs cannot)
 - And access point mode needs TWO callsigns (hotspots don't)

PAPA D-Star

- AI6BX C is outlier – should be “????? B”?

Status	NAME	Site Link	Frequency	Callsign	Emergency Power	Last Update
Online	D01	Oat Mountain	447.835-	KI6JKA B	Yes	2020-05-23
Online	D03	Santiago	446.560-	KM6LVQ B	Yes	2021-08-27
Online	D04	Saddle Peak	445.855-	KD4PAP B		2020-05-23
Online	D06	Santa Ynez	447.840-	KK6GFX B	Yes	2020-05-23
Online	D09	San Marcos	447.190-	KJ6FCH B		2020-05-23
Online	D10	Palomar	RX: 147.570 TX: 145.015	KI6MGN C		2020-05-23
Online	D11	Otay	446.980-	KW6HRO B		2020-05-23
Off Network	D14	Blue Ridge	447.835-	KJ6LJZ B	Yes	2020-05-23
Online	D15	Woodson	447.845-	KI6KQU B	Yes	2020-05-23
Online	D16	Edom Hill	447.140-	W6THC B	Yes	2020-05-23
Online	D20	Redlands	446.580-	AI6BX B	Yes	2023-01-03
Online	D28	Needles Multimode	445.300-	AI6BX C		2021-08-30

Things I'm still figuring out...

- Transfers
 - Picture, video
- Functions
 - BK (break-in), EMR* (emergency broadcast*)
- D-Star registration
 - Use of other suffix letters
 - Whether 2+ hotspots can use one callsign
- Callsign routing
 - Safely, without tying up others' repeaters (see *)
- Exactly how reflectors pick sources
 - I think xmiters “capture” the reflector until it goes idle (seems true?)
 - Or do reflectors “sum” their inputs? (hard to tell – not heard yet)