



Multi Protocol Digital Networks

Introduction, Overview and further
development

Agenda

- ▶ 1. digital modes: differences and commonalities
- ▶ 2. digital modes: infrastructure
 - ▶ 2.1 vendor specific
 - ▶ 2.1.1 DPLUS
 - ▶ 2.1.2 WIRES-X
 - ▶ 2.2 vendor independent
 - ▶ 2.2.1 Connect Plus Overview
 - ▶ 2.2.2 Why CCS7?
 - ▶ 2.2.3 Structure of the CCS7 number
 - ▶ 2.2.4 How CCS numbers are assigned
 - ▶ 2.2.5 CCS7 databases

Agenda

- ▶ 2.2.6 Reflector systems
 - ▶ 2.2.6.1 DCS
 - ▶ 2.2.6.2 DMR Plus
 - ▶ 2.2.6.3 dPMR
 - ▶ 2.2.6.4 C4FM (Fusion)
 - ▶ 2.2.6.5 APCO P25
- ▶ 2.3 bridging
- ▶ 3. Hardware
 - ▶ 3.1 hardware optimized for multiprotocol networks
 - ▶ 3.1.1 DVRPTR 1–3
 - ▶ 3.1.2 DV4mini
 - ▶ 3.1.3 DV4home
 - ▶ 3.1.4 DV4mobile: all digital protocol mobile transceiver for 144/222/440MHz
 - ▶ 3.1.4 more multiprotocol devices
- ▶ 4. Questions and Discussion

1. Digital Modes: differences and commonalities

Amateur Digital Voice Systems

Format Feature	P25 Phase II	DMR	DSTAR	FUSION	NXDN/IDAS
Operating Band	VHF, UHF, 700/800	70cm primary, 2m, 33cm,	2m, 70cm, 33cm	2m, 70cm	70cm primary, 2m, 33cm
Dual Band	Yes	No	Yes	Yes	No
Battery Life	40% longer	40% longer	Normal	Normal	20% longer
Dual Time Slot	Yes	Yes	No	No	N/A
Range	20-25% over wideband analog	20-25% over wideband analog	20-25% over wideband analog	20-25% over wideband analog	20-25% over wideband analog
Manufacturer specific	No	No	Yes, ICOM	Yes, Yaesu	Yes, Kenwood, Ritron/ICOM
Number of Manufacturers	>6	25+	1	1	2/1



1. Digital Modes: differences and commonalities

Amateur Digital Voice Systems

Format Feature	P25 Phase II	DMR	DSTAR	FUSION	NXDN/IDAS
Protocol	TDMA (Phase I was FDMA)	TDMA/4FSK	GMSK	FDMA/C4FM	FDMA
Vocoder	AMBE+2 Vocoder	AMBE+2 Vocoder	AMBE Vocoder	AMBE+2 Vocoder	AMBE+2 Vocoder
Forward Error Correction	Yes	Yes	No	No	Yes/Yes
Spatial Efficiency	12.5khz (dual 6.25khz slots)	12.5khz (dual 6.25khz slots)	6.25khz	12.5khz	6.25khz/12.5khz
Adopted Worldwide Standard	Yes, Public Safety	Yes, Commercial and Amateur	Yes, Amateur only	No, Amateur Use Only	No
No of Amateur Repeaters in the US	170	623	1100	219	52

DMR
DIGITAL MOBILE RADIO ASSOCIATION

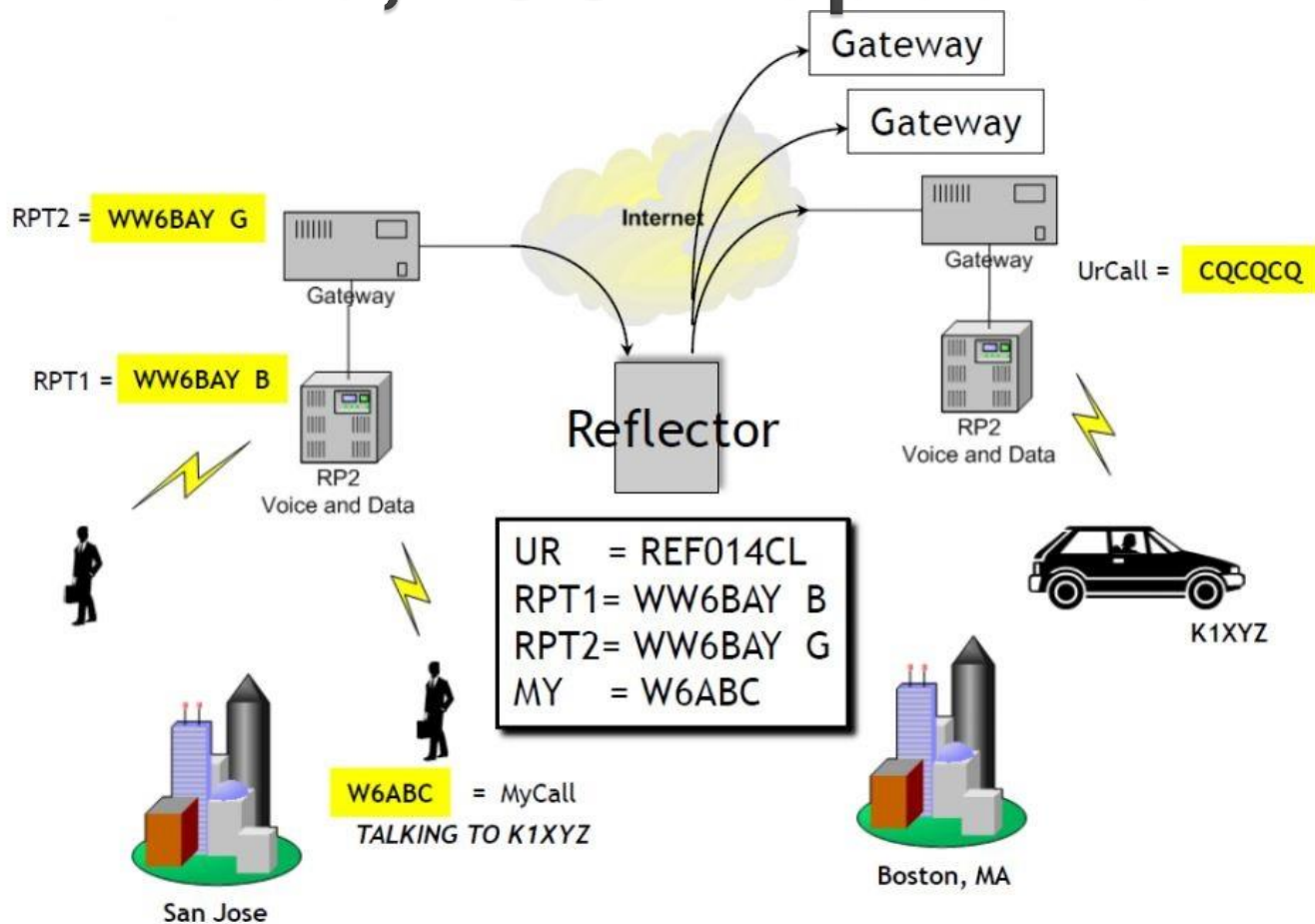
2.Digital modes:

- ▶ Network Infrastructure

2.1 vendor specific

- ▶ D-Plus
- ▶ WIRES-X

2.1.1 D-Plus, ICOM specific



Slide courtesy George Zafiropoulos KJ6VU

2.1.2 WIRES-X, YAESU specific

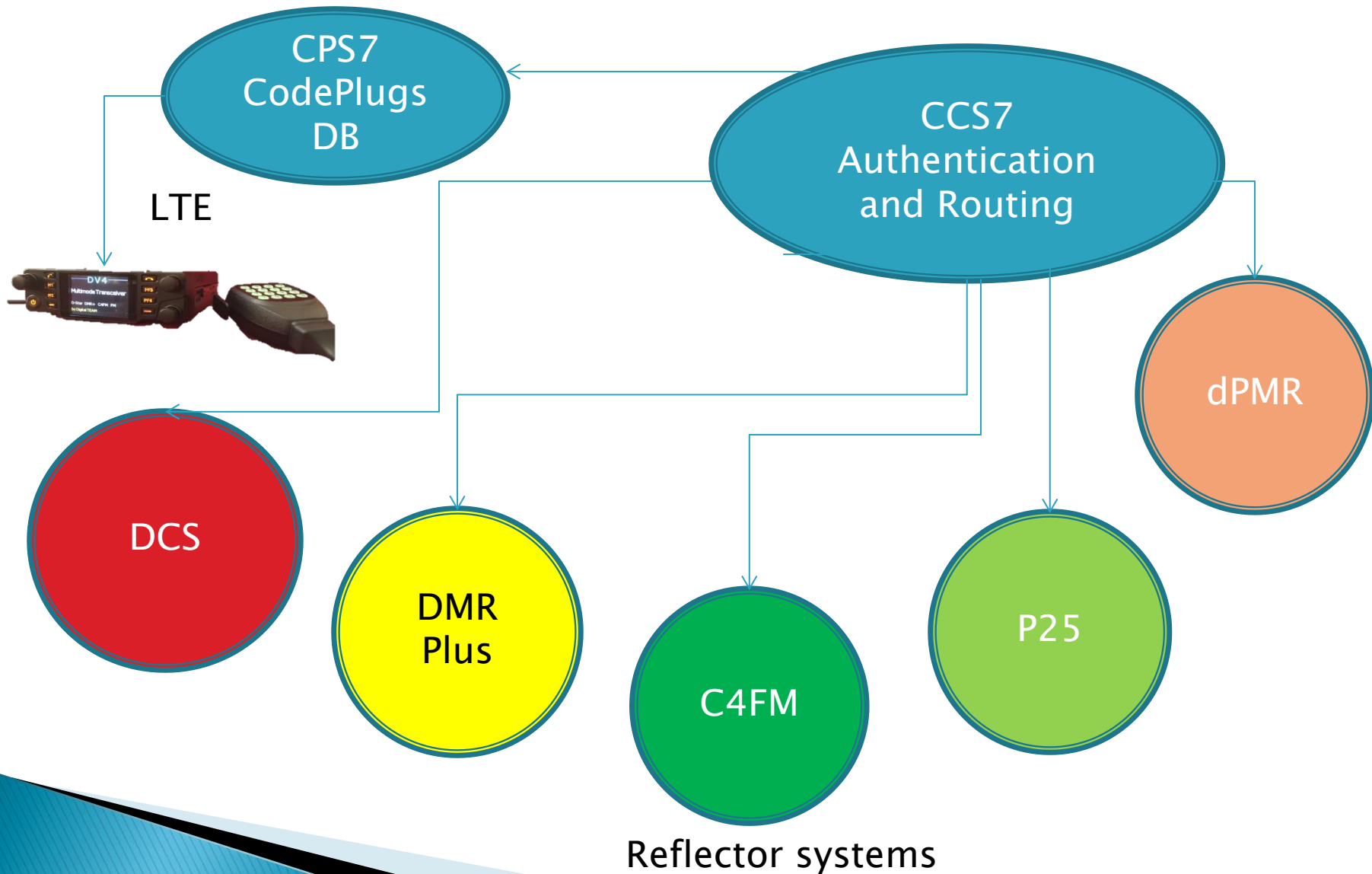
Every node PC is a reflector
Needs external radio and PC
Many Japanese Stations



2.2 vendor independent

- ▶ XREFLECTOR
- ▶ CONNECT Plus
 - DCS Plus
 - DMR Plus
 - dPMR Plus
 - P25 Plus
 - C4FM Plus

2.2.1 Connect Plus Overview



2.2.2 why CCS7?

- ▶ Other than D-Star all other digital systems do not work with call signs!

The DMR-Header has 3 bytes in the air interface as an address space

00 00 00 bis FF FF FF,

This represents a decimal number range between 0 bis 16 777 215 or, without special coding, (in ASCII) 3 characters.

A public data base correlates the call signs with these numbers

Based on „MCC“ Standard / [ITU-T Recommendation E.212](#)

(MCC = „Mobile Country Code“)
(http://en.wikipedia.org/wiki/Mobile_country_code)

2.2.3 Structure of the CCS7 number

- ▶ Hierarchically structured numbering system:

- 1: Test Networks
- 2: Europe
- 3: North–America
- 4: Asia
- 5: Australia, New Zealand, Philippines etc.
- 6: Africa
- 7: South Amerika
- 9: World Wide

2.2.3 Structure of the CCS7 number

- ▶ Hierarchically structured numbering system:

- ▶ Examples:

- ▶ 310–317 USA
- ▶ 204: Netherlands
- ▶ 228: Switzerland
- ▶ 232: Austria
- ▶ 234/235: United Kingdom
- ▶ 238: Denmark
- ▶ 262: Germany

- ▶ 311 2528 = Uli, AG0X


262 7506 = Uli, DH6SAB

2.2.4 How are CCS7 numbers assigned?









- ▶ To provide a common “phonebook” the DMR-MARC server assigns the numbers which are then synchronized with the D-Connect CCS7 servers:

DMR-MARC Network x

dmr-marc.net/cgi-bin/trbo-database/register.cgi



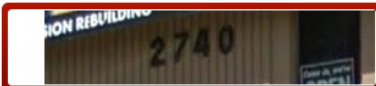
Motorola Amateur Radio Club Worldwide Network

Translations:        

Home Database Repeaters About Us Innovators Contact Us

ADD DMR USER

Country	Select Country
DMR ID	Will be emailed to you by the ID Team
Callsign	required
Full Name (First Last)	required
Nickname	Optional
City	required
State/Prov	Select Country First
Radio Type	Select Radio Type
Email Address	required
Comment	Tell us something about yourself



Type the text

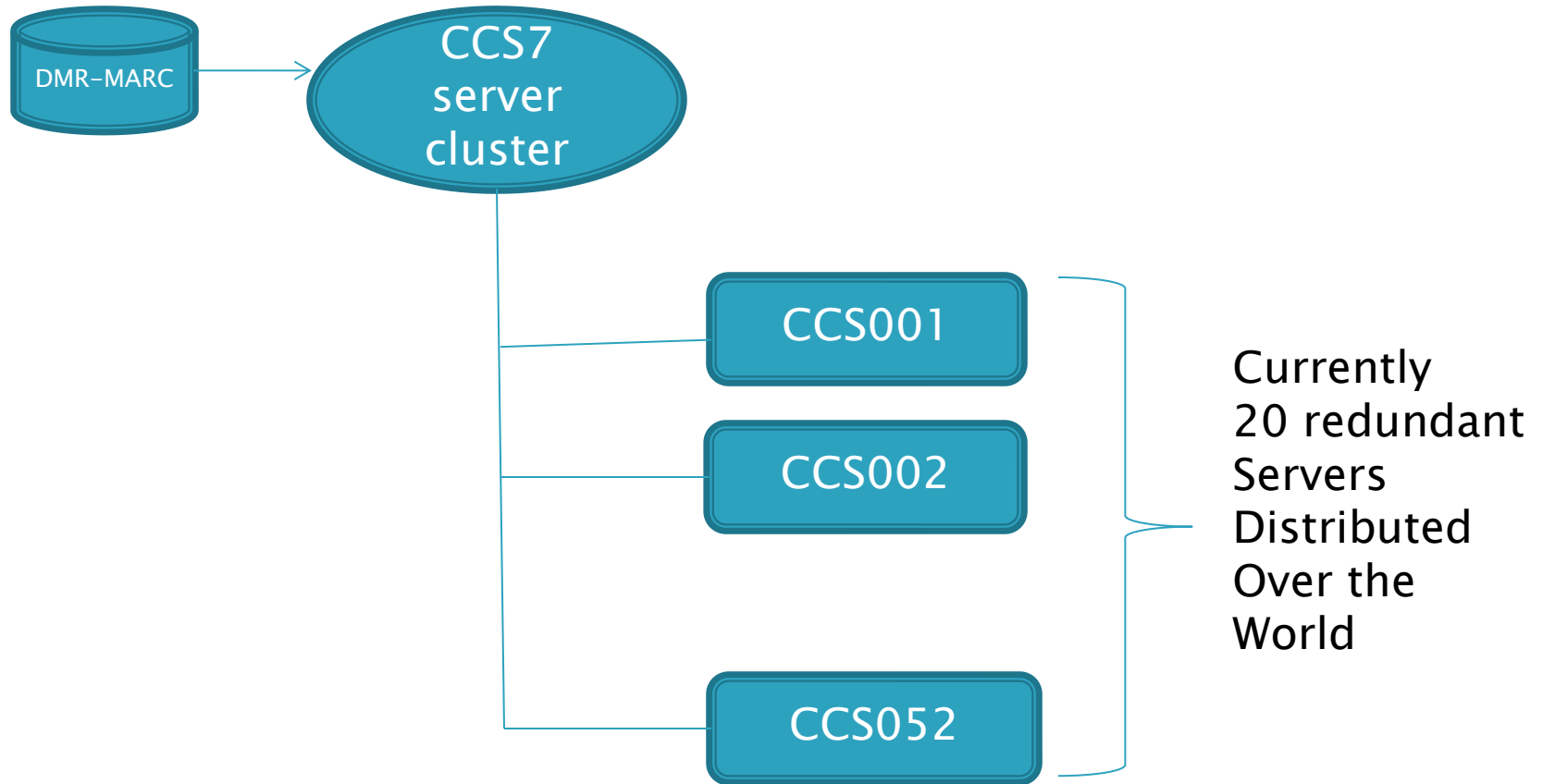
Privacy & Terms

reCAPTCHA

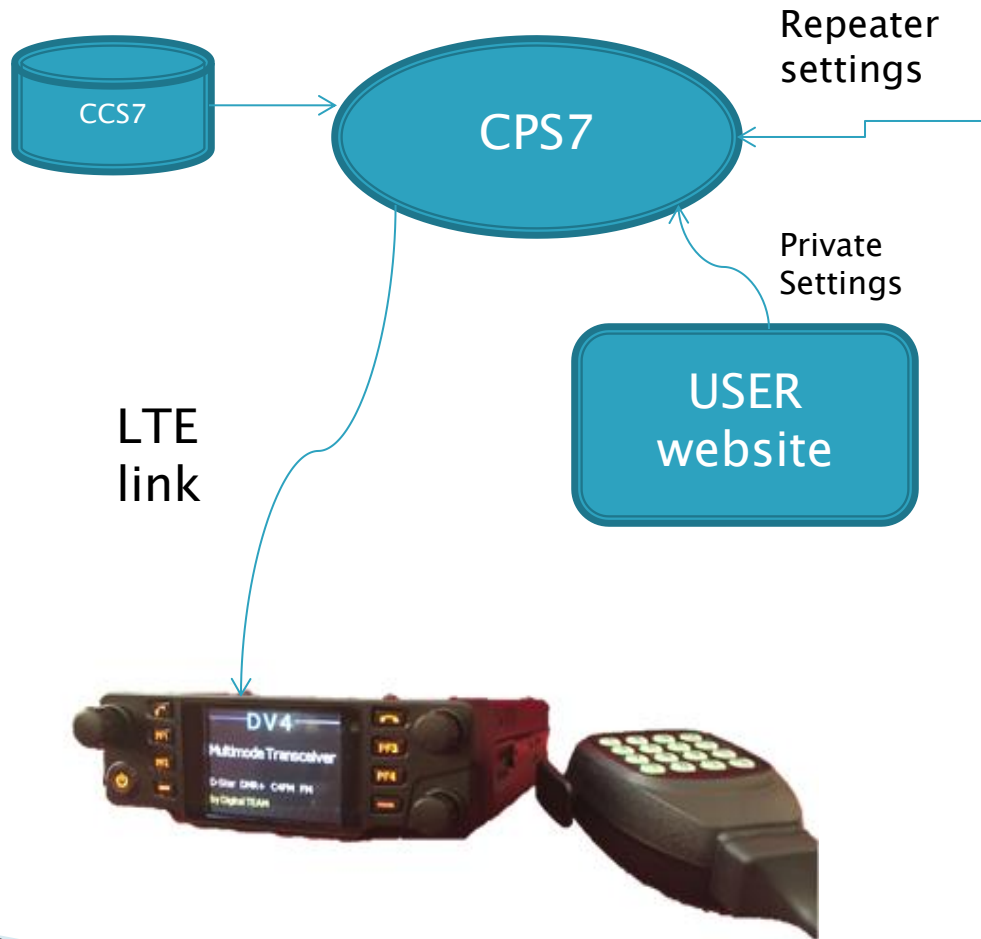
The correct reCAPTCHA phrase includes all letters or numbers on the white background and those in the image next to it.

Register

2.2.5 CCS7 data bases



2.2.5.1 CPS7 data base



Digital Amateur Radio Registration System

Sysop-Page

[Home](#) [SysopArea](#) [Change password](#) [You are logged in](#) [Log-out \(AG0X\)](#)

DMR Repeater Registration

Repeater ID:	311256
Repeater Call/SID:	AB4NP
Repeater Callsign:	AB4NP
Licensee Call:	
Admin Callsign:	AG0X
Admin First Name:	Uli
Admin Surname:	Aitvater
Email Address:	uli@aitvater.com
Country:	United States
Repeater location:	Naples
Zip code:	
Latitude (+ North/ - South):	decimal 26.126234 - or -
Longitude (+ East/ - West):	decimal -81.727877 - or -
Transmit Frequency in MHz:	449.87500
+/- Repeater offset in MHz:	-5.000
Antenna height Above Ground Level (m):	100
Antenna gain (dBi):	2
Losses (dB):	2
TX power (W):	50
Mixed Mode analogue/digital:	off / on
Color-code / systemcode:	1
DMRplus-Features:	off / on

Only supported by Hytera repeaters and DMRplus-ABridge!



Options:

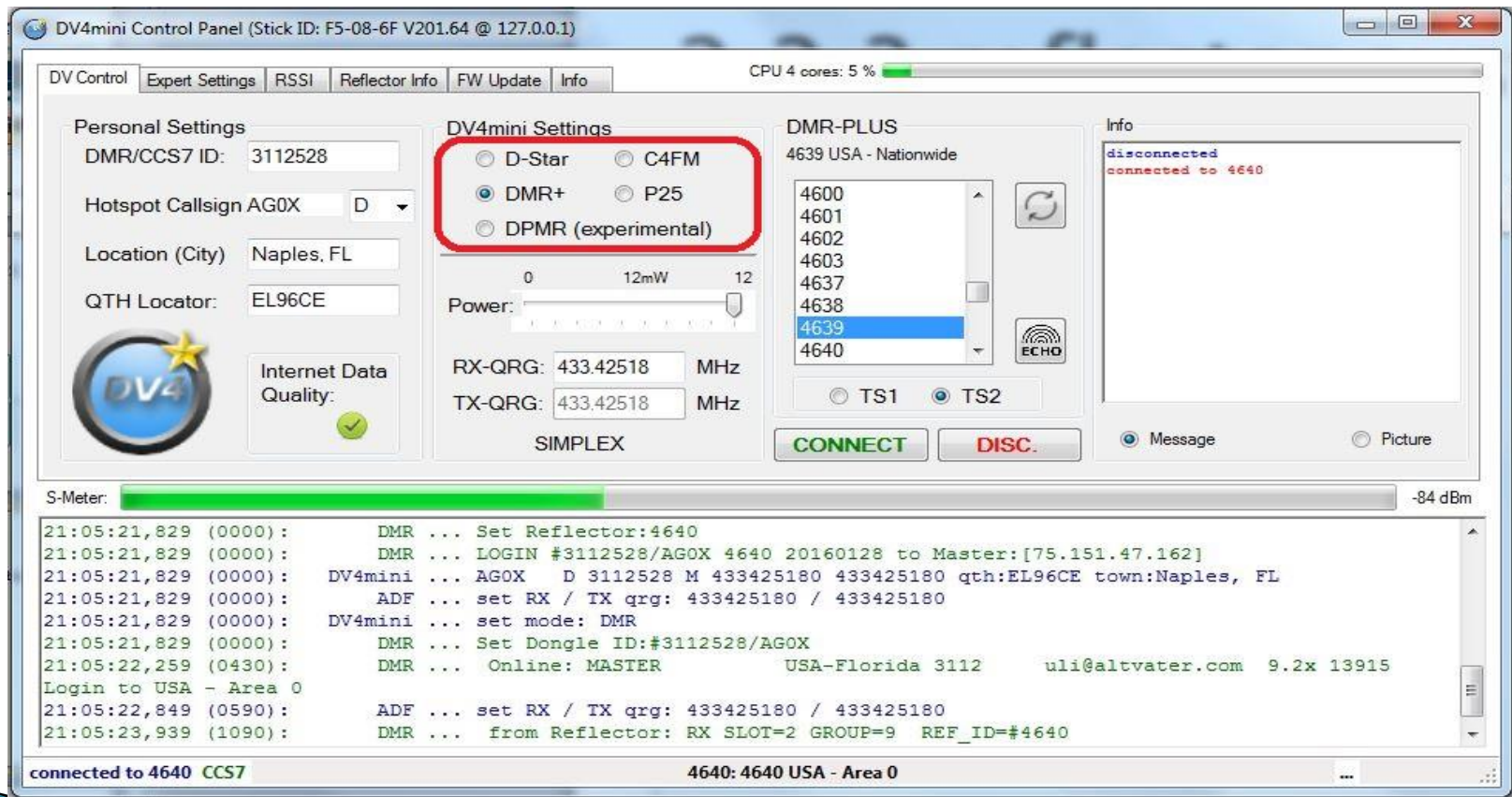
TS1 Group1	311	(default: 311 = Own Country)
TS1 Group2	1	(default: 1 = Worldwide)
TS1 Group3	262	(default: Language Region)
TS1 Group4	0	
TS1 Group5	0	
TS2 Start Reflector	4639 USA - Nationwide	
TS2 Reflector Relink Time	60	
TS2 Link control by users	off / on	

[Save changes](#) / [Check changes](#) / [Return without changes](#)

Distributed
Over the
World

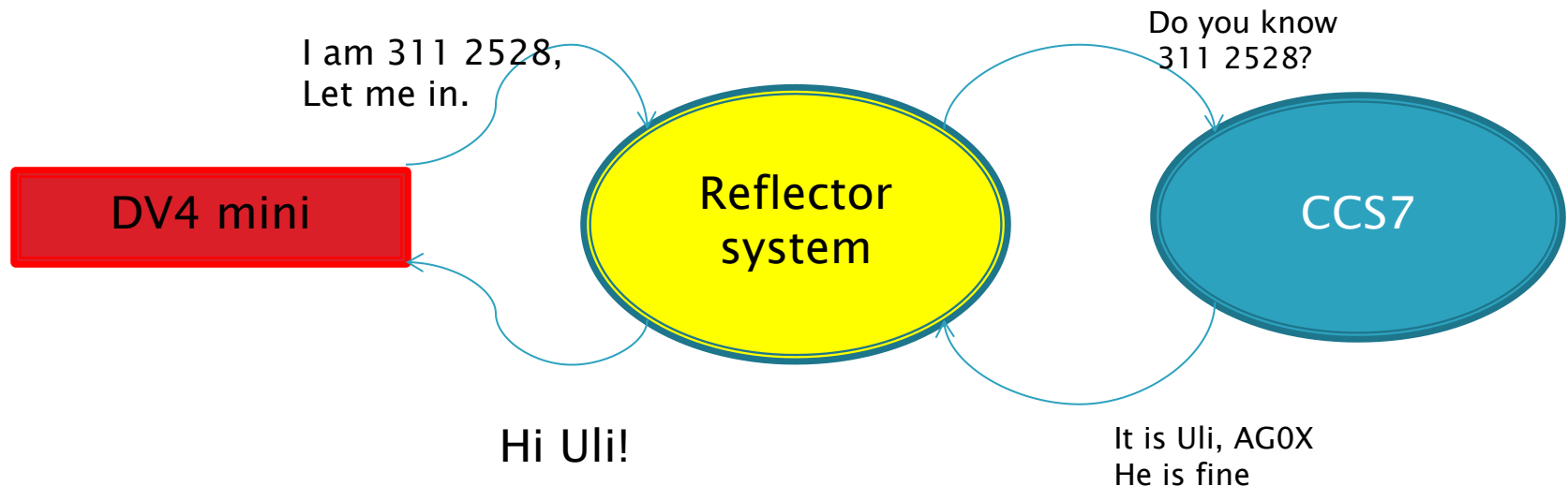
2.2.6 reflector systems

- ▶ What happens when I push these buttons?



2.2.6 reflector systems

- ▶ What happens when I push these buttons?



2.2.6.1 DCS (D-Star)

DCS

33 reflector
Systems
With
26 rooms
each

DMRplus DCS006 CCS7 Security Mode ON | Reflector System 7 Status and Control

DCS006 Reflector System


Group	User on GROUP	Repeater on GROUP	Online 34
World Wide	User	Repeater	
USA Preferred channel	User	Repeater	14
USA Alternate channel	User	Repeater	
USA Fusion test	User	Repeater	
USA DMR test	User	Repeater	
Available	User	Repeater	
Dv-Mega	User	Repeater	
Dstar Contest 1	User	Repeater	
Dstar Contest 2	User	Repeater	
Dstar Contest 3	User	Repeater	
USA California	User	Repeater	
USA Texas	User	Repeater	
USA New York	User	Repeater	
USA Florida	User	Repeater	
Available	User	Repeater	
Available	User	Repeater	
Quadnet	User	Repeater	2
USA Colorado	User	Repeater	11
Minnesota	User	Repeater	1
Available	User	Repeater	
USA Iowa	User	Repeater	
USA Iowa	User	Repeater	1
Ragchew channel	User	Repeater	1
USA Bilingual EN/SP	User	Repeater	4
Emergency Comm	User	Repeater	
Echo USA	User	Repeater	

 **Germany**
DCS001

[User](#)

[Repeater](#)

[Group Info](#)

 **World Wide**
DCS002

[User](#)

[Repeater](#)


[Group Info](#)

 **Switzerland**
DCS003

[User](#)

[Repeater](#)

[Group Info](#)

 **Denmark**
DCS004

[User](#)

[Repeater](#)

[Group Info](#)

 **Great Britain**
DCS005

[User](#)

[Repeater](#)

[Group Info](#)

 **United States of America**
DCS006

[User](#)

[Repeater](#)


[Group Info](#)

 **Netherlands**
DCS007

[User](#)

[Repeater](#)

[Group Info](#)

 **Italy**
DCS008

[User](#)

[Repeater](#)

v1.7 | DCS Server v12.7_64Bit

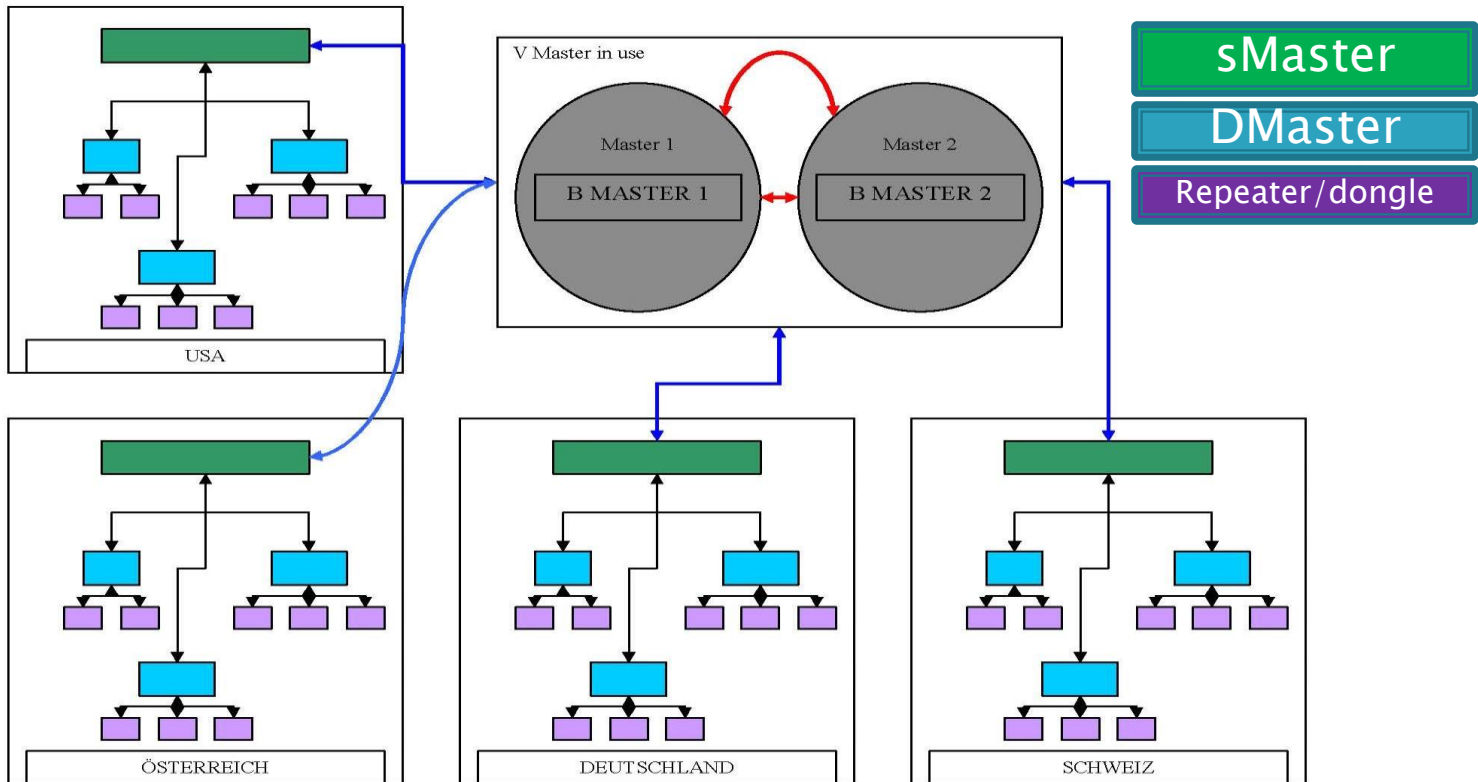
URCALL

DCS006AL
DCS006BL
DCS006CL
DCS006DL
DCS006EL
DCS006FL
DCS006GL
DCS006HL
DCS006IL
DCS006JL
DCS006KL
DCS006LL
DCS006ML
DCS006NL
DCS006OL
DCS006PL
DCS006QL
DCS006RL
DCS006SL
DCS006TL
DCS006UL
DCS006VL
DCS006WL
DCS006XL
DCS006YL
DCS006ZL

Z

D626

2.2.6.2 DMR Plus



2.2.6.3 dPMR

► Experimental System

x-NET LCD001 Dashboard | Reflector Status and Control

dPMR Reflector System by DG1HT/DJ0ABR

Status System v0.1 | LCS Server v0.1_64Bit

HOME	Nr.	CALL	Last Heard	Name	Group
USER	1	PA3DPS	1 h 32 m 13 s	ECHO	99
	2	M1DAZ	1 h 59 m 24 s	ECHO	99
	3	DG6FAX	6 h 15 m 5 s	in use	09
INFO	4	DF4UD	12 h 12 m 40 s	ECHO	99
	5	K4IGZ	22 h 26 m 16 s	ECHO	99
	6	DO2STA	1 d 3 h 46 m 14 s	in use	09
	7	DO2JZ	1 d 6 h 13 m 46 s	in use	09
	8	N4VBR	1 d 8 h 14 m 1 s	ECHO	99
	9	DL3MX	1 d 15 h 57 m 20 s	in use	09
	10	EA7IYR	2 d 14 h 56 s	ECHO	99
	11	DO7WO	3 d 5 h 32 m 17 s	in use	09
	12	DM1ER	3 d 9 h 32 m 13 s	in use	09
	13	OK1MSU	3 d 16 h 4 m 14 s	ECHO	99
	14	K4LKL	4 d 2 h 12 m 34 s	ECHO	99
	15	DF2OO	6 d 3 h 9 m 56 s	ECHO	99
	16	M6LSJ	6 d 6 h 6 m 52 s	in use	09
	17	M0RDC	7 d 34 m 32 s	in use	09
	18	DG2DAD	8 d 12 h 11 m 47 s	Deutschland	01
	19	DB0KX	9 d 4 h 59 m 30 s	in use	09
	20	IU5AVW	10 d 23 h 24 m 59 s	ECHO	99
	21	DG1FBA	11 d 15 h 27 m 22 s	ECHO	99
	22	PD0ADC	13 d 4 h 30 m 23 s	ECHO	99
	23	DH0PAT	18 d 14 h 4 m 51 s	in use	06
	24	OE1KBC	19 d 5 h 2 m 37 s	ECHO	99
	25	DO1PBH	19 d 5 h 40 m 12 s	in use	09
	26	DD1KJ	22 d 23 h 26 m 14 s	in use	05
	27	N3NJI	24 d 1 h 4 m 38 s	in use	06
	28	DJ3OW	24 d 7 h 38 m 54 s	ECHO	99
	29	VA3DRM	24 d 17 h 15 m 53 s	ECHO	99
	30	W1RZO	25 d 2 h 14 m 52 s	Deutschland	01
	31	M3OPW	25 d 7 h 33 m 38 s	ECHO	99
	32	M0VTM	26 d 2 h 11 m 43 s	ECHO	99
	33	PD0BEL	28 d 13 h 6 m 16 s	Repeater	00
	34	IW8ELN	30 d 47 m	in use	05
	35	M1BCB	30 d 1 h 51 m 14 s	ECHO	99
	36	OZ3HLF	31 d 8 h 6 m 12 s	Deutschland	01
	37	DB0ZAV	31 d 9 h 1 m 57 s	in use	87

2.2.6.4 C4FM (YAESU Fusion)

- ▶ 2 reflector systems with 100 room each:
- ▶ FCS001 / FCS002

DMRplus FCS002 Dashboard Reflector Status and Control			
Fusion Reflector System by DQ1HT		Status System v0.1 FCS Server v0.1_64Bit	
HOME	Group	Group Nr	DTMF
USER	TALK USA1	00	A200
INFO	TALK USA2	01	A201
	Alabama	02	A202
	Alaska	03	A203
	Arizona	04	A204
	Arkansas	05	A205
	California	06	A206
	Colorado	07	A207
	Connecticut	08	A208
	Delaware	09	A209
	Florida	10	A210
	Georgia	11	A211
	Hawaii	12	A212
	Idaho	13	A213
	Illinois	14	A214
	Indiana	15	A215
	Iowa	16	A216
	Kansas	17	A217
	Louisiana	18	A218
	Maine	19	A219
	Maryland	20	A220
	Massachusetts	21	A221
	Michigan	22	A222
	Minnesota	23	A223
	Mississippi	24	A224
	Missouri	25	A225
	Montana	26	A226
	Nebraska	27	A227
	Nevada	28	A228
	New Hampshire	29	A229
	New Jersey	30	A230
	New Mexico	31	A231
	New York	32	A232
	North Carolina	33	A233
	North Dakota	34	A234
	Ohio	35	A235
	Oklahoma	36	A236

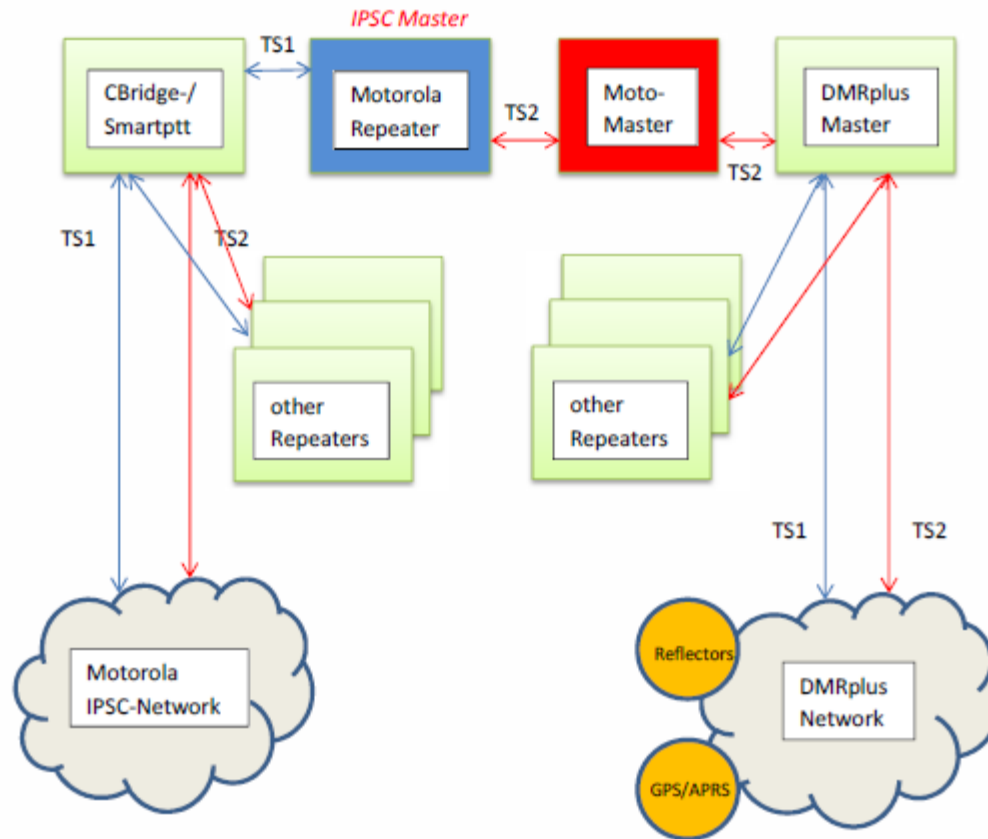
2.2.6.5 APCO25 (P25)

- ▶ 1 reflector system with a second one in Los Angeles currently being installed.

x-NET PCS001 Dashboard Reflector Status and Control					
P25 Reflector System by DG1HT/DJ0ABR				Status System v0.1 PCS Server v0.1_64Bit	
HOME	Nr.	CALL	Last Heard	Name	Group
USER	1	G4TUZ	16 s	in use	06
	2	NC5P	45 s	in use	06
	3	N8GY	1 m 57 s	in use	06
INFO	4	WY8E	4 m 29 s	in use	06
	5	G0UZJ	7 m 47 s	in use	06
	6	N2UFQ	8 m 41 s	in use	06
	7	KH2PM	31 m 50 s	in use	06
	8	G0YNM	35 m 2 s	in use	06
	9	DO3DL	56 m 27 s	Repeater	00
	10	DL5DAE	1 h 11 m 27 s	Repeater	00
	11	DF1VB	2 h 13 m 39 s	in use	06
	12	DL1BH	3 h 26 m 37 s	Repeater	00
	13	WH6FM	5 h 18 m 56 s	in use	06
	14	G8VBJ	10 h 21 m 4 s	in use	06
	15	VE6EN	12 h 5 m 47 s	in use	06
	16	DL2FDL	12 h 59 m 15 s	Repeater	00
	17	W8RW	18 h 28 m 15 s	in use	40
	18	VK4TUX	18 h 39 m 56 s	in use	06
	19	G7EPL	1 d 11 h 43 m 31 s	in use	06
	20	K8ARW	1 d 17 h 41 m 49 s	in use	40
	21	NF9K	1 d 19 h 46 m 25 s	in use	06
	22	N6VYT	1 d 21 h 56 m 22 s	in use	06
	23	NS2B	1 d 23 h 6 m 11 s	in use	06
	24	W1MSG	2 d 59 s	in use	06
	25	N2LBT	2 d 2 h 41 m 32 s	in use	06
	26	DG4LX	2 d 5 h 33 m 34 s	in use	50
	27	KN5UPS	2 d 6 h 29 m 46 s	in use	05
	28	K8UH	2 d 7 h 50 m 49 s	in use	06
	29	K1LNX	2 d 10 h 42 m 49 s	in use	69
	30	WB4JGI	2 d 19 h 43 m 41 s	in use	69
	31	KC7NP	3 d 2 h 1 m 11 s	Repeater	00
	32	KJ4SHL	3 d 2 h 28 m 45 s	in use	06
	33	KG5EEL	3 d 4 h 42 m 9 s	in use	06
	34	W1KFR	3 d 6 h 49 m 56 s	ECHO	99
	35	DL2OAM	3 d 7 h 18 m 41 s	Deutschland	01
	36	HB9EMQ	3 d 12 h 39 m 30 s	in use	06
	37	AK4EG	3 d 12 h 43 m 34 s	Deutschland	01

2.3 bridging

► MotoTrbo/Hytera



2.3 bridging

► MotoTrbo/Hytera

IPSC-Server-Control by DG1HT / DL5DI / OE1KBC - vers. 1.72

System	Master Repeater	Peer Repeater	Matrix TS1	Matrix TS2	Dongle	User	Info	new
Nr	Connection	Call	DMR_ID	TS1	TS2	TS2_TG	ONLINE	
1	INTERLINK	IPSClink	143859	MOT	ON		ONLINE	
2	INTERLINK	IPSClink	126201	MOT	ON		ONLINE	
3	INTERLINK	IPSClink	184553	MOT	ON		ONLINE	
4	MOT	OE7XTT	232703	MOT	ON	Refl. 4197	ONLINE	
5	MOT	OE7XBI	232702	MOT	ON	Refl. 4197	ONLINE	
6	MOT	OE7XLI	232709	MOT	ON	Refl. 4197	ONLINE	
7	MOT	OE3XDB	232101	MOT	ON	Refl. 4183	ONLINE	
8	MOT	OE3XKC	232304	MOT	ON	Refl. 4193	ONLINE	
9	MOT	OE4XUB	232401	MOT	ON	Refl. 4191	ONLINE	
10	MOT	OE7XZH	232701	MOT	ON	Refl. 4197	ONLINE	
11	MOT	OE8XKK	232108	MOT	ON	Refl. 4198	ONLINE	
12	CBRIDGE	OE8XIK	232893	MOT	OFF		ONLINE	
13	HYT	OE9XVJ	232991	HYT	ON	Refl. 4199	ONLINE	
14	HYT	OE6XIG	232606	HYT	ON	Refl. 4196	ONLINE	
15	HYT	OE5XGL	232502	HYT	ON	Refl. 4193	ONLINE	
16	HYT	OE3XTR	232391	HYT	ON	Refl. 4191	ONLINE	
17	HYT	OE6XCD	232605	HYT	ON	Refl. 4191	ONLINE	
18	HYT	OE6XBF	232604	HYT	ON	Refl. 4196	ONLINE	
19	HYT	OE7XLH	232708	HYT	ON	Refl. 4197	ONLINE	
20	HYT	HB9BO	228391	HYT	ON	Refl. 4060	ONLINE	
21	HYT	OE1XQU-2	232193	MOT	ON	Refl. 4191	ONLINE	
22	HYT	OE6XAG	232607	HYT	ON	Refl. 4196	OFFLINE	
23	HYT	OE1XAR-S	232197	OFF	ON	Refl. 4000	ONLINE	
24	HYT	OE1XQU-7	232192	HYT	ON	Refl. 4180	ONLINE	
25	HYT	DB0NG	262400	HYT	ON	Refl. 4006	ONLINE	
26	MOT	OE6XAR	232603	MOT	ON	Refl. 4196	ONLINE	
27	HYT	OE8KBC	232888	HYT	ON	Refl. 4000	ONLINE	
28	MOT	OE1DATA	232010	MOT	ON	Refl. 4000	ONLINE	

► MotoTrbo/Hytera

[illegible]

3. Hardware



3.1 hardware optimized for multiprotocol networks



Torsten, DG1HT

3.1.1 DVRPTR1-3



3.1.2 DV4 mini: first all mode dongle with 70cm transceiver



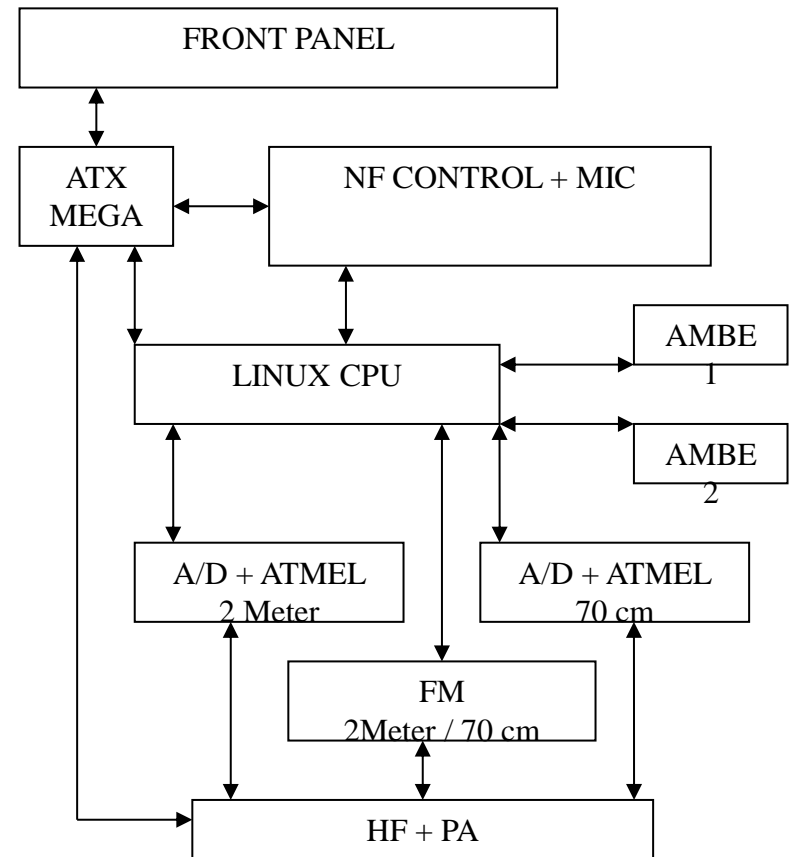
3.1.3 DV4 home: stand alone all mode with transcoding and wireless



3.1.4 DV4mobile: all digital protocol mobile transceiver for 144/222/440MHz



- D-Star
- C4FM
- DMRplus
- dPMR
- P25
- LTE
- Code plug in the cloud



3.2.5 DV4 mobile at Ham Radio



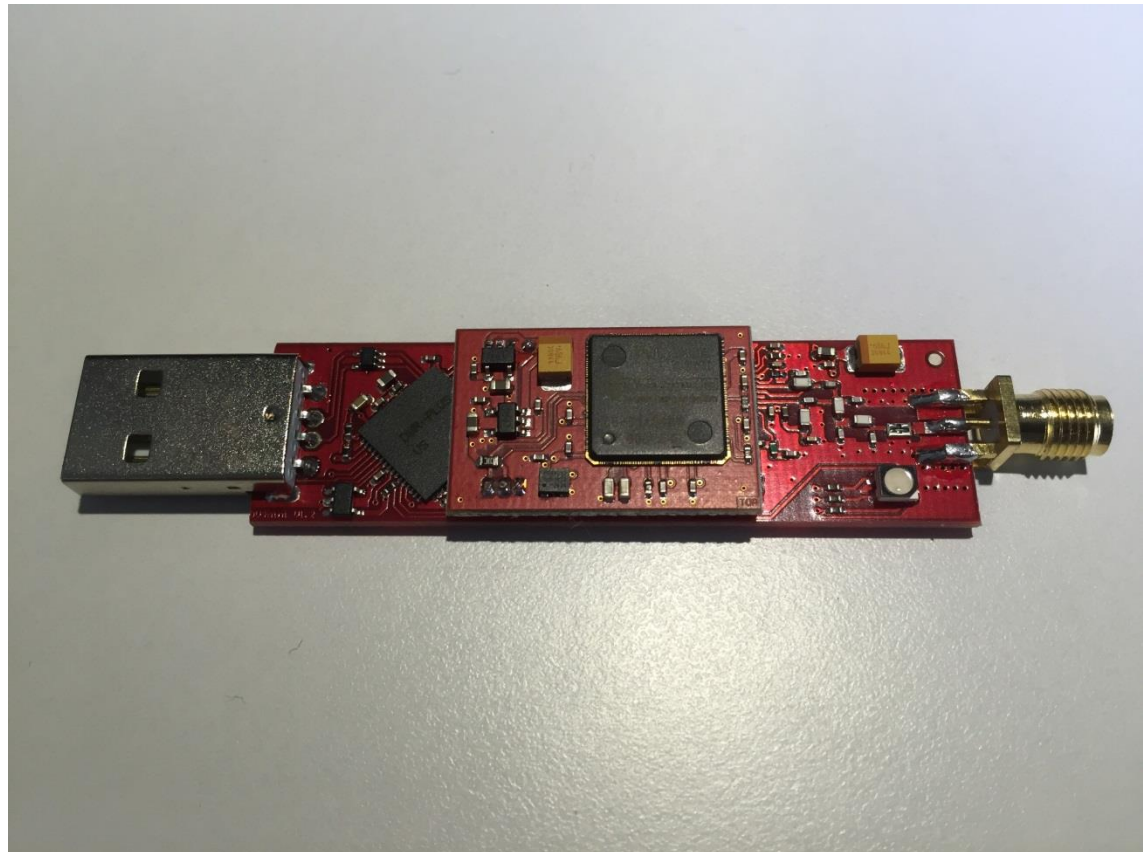
3.2.6 DV4 mobile at Ham Radio



3.2.7DV4mobile at Ham Radio



3.1.8 DV4 AMBE



3.3. IPSC2

The image shows a tall exhibition stand for the DMRplus IPSC 2 Link-Control software. At the top, there is a graphic of a globe with network lines. Below this, the title "DMRplus IPSC 2 Link-Control" is displayed in large, bold, blue letters. A descriptive paragraph in German states: "DMRplus IPSC 2 eine in C++ programmierte Software-Lösung welche HF-Repeater für DMR-Umsetzer verschiedener Hersteller zu einem Netzwerk zusammenfassen kann." To the left of the text is a circular logo with a network symbol. To the right is a diagram showing a network of repeaters connected by lines. Below the text, there are several bullet points in German describing the software's features: Repeater/Dongle registration, support for various protocols (HYTERA, MOTOROLA, MMDVM, DV4mini), interlink connections, management of connections, connection to LastHeard applications, and a dashboard. At the bottom of the stand, there is a screenshot of the software's interface, which includes a table of repeaters and a control panel. The table has columns for ID, Name, Type, and various status indicators. The control panel has buttons for "Repeater", "Group", and "Status". At the very bottom, the text "Design und Programmierung Torsten DG1HT, Hans-Jürgen DL5DI, Kurt OE1KBC" and the email "Informationen: ipcs2@ham-dmr.de" are printed. In the background, a Swiss flag is visible on the right, and a sign for "Amateurfunk - Fern" is visible on the left.

**DMRplus
IPSC 2
Link-Control**

DMRplus IPSC 2 eine in C++ programmierte Software-Lösung welche HF-Repeater für DMR-Umsetzer verschiedener Hersteller zu einem Netzwerk zusammenfassen kann.

- Repeater/Dongle Registrierung Master & Peer Connections
 - HYTERA
 - MOTOROLA
 - MMDVM
 - DV4mini Dongle
- Interlink Verbindungen um dezentrale eigenständige und hierarchische Verbindungsmodelle aufzubauen
 - CBridge, SmartPTT
 - IPSC 2 InterLink
- Verwaltung der Verbindungen
 - Nach Sprechgruppen oder Reflektoren
 - Sprechgruppen OnDemand
 - Repeater / Sprechgruppenmatrix
 - Matrixgesteuerte Haltezeit für TG
 - Interlinkmatrix
- Verbindung zu LastHeard Applikationen
- SYSOP IPSC-Control-Center
- SYSOP Audio Kontrolle ohne HF
- HTTP IPSC-Control-Pages (Dashboard)

IPSC-Server Created by DG1HT / DL5DI / OE1KBC - since 1.7.17

ID	Name	Type	Mode	Power	Frequency	Offset	Bandwidth	Mode	Power	Frequency	Offset	Bandwidth	Mode	Power	Frequency	Offset	Bandwidth
1	14-0001	1	14-0001	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
2	14-0002	2	14-0002	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
3	14-0003	3	14-0003	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
4	14-0004	4	14-0004	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
5	14-0005	5	14-0005	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
6	14-0006	6	14-0006	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
7	14-0007	7	14-0007	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
8	14-0008	8	14-0008	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
9	14-0009	9	14-0009	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
10	14-0010	10	14-0010	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
11	14-0011	11	14-0011	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
12	14-0012	12	14-0012	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
13	14-0013	13	14-0013	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
14	14-0014	14	14-0014	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
15	14-0015	15	14-0015	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
16	14-0016	16	14-0016	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
17	14-0017	17	14-0017	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
18	14-0018	18	14-0018	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
19	14-0019	19	14-0019	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
20	14-0020	20	14-0020	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
21	14-0021	21	14-0021	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
22	14-0022	22	14-0022	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
23	14-0023	23	14-0023	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
24	14-0024	24	14-0024	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
25	14-0025	25	14-0025	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
26	14-0026	26	14-0026	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
27	14-0027	27	14-0027	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
28	14-0028	28	14-0028	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
29	14-0029	29	14-0029	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
30	14-0030	30	14-0030	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
31	14-0031	31	14-0031	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
32	14-0032	32	14-0032	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
33	14-0033	33	14-0033	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
34	14-0034	34	14-0034	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
35	14-0035	35	14-0035	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
36	14-0036	36	14-0036	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
37	14-0037	37	14-0037	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
38	14-0038	38	14-0038	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
39	14-0039	39	14-0039	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
40	14-0040	40	14-0040	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
41	14-0041	41	14-0041	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
42	14-0042	42	14-0042	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
43	14-0043	43	14-0043	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
44	14-0044	44	14-0044	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
45	14-0045	45	14-0045	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
46	14-0046	46	14-0046	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
47	14-0047	47	14-0047	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
48	14-0048	48	14-0048	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
49	14-0049	49	14-0049	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
50	14-0050	50	14-0050	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
51	14-0051	51	14-0051	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
52	14-0052	52	14-0052	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
53	14-0053	53	14-0053	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
54	14-0054	54	14-0054	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
55	14-0055	55	14-0055	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
56	14-0056	56	14-0056	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
57	14-0057	57	14-0057	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
58	14-0058	58	14-0058	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
59	14-0059	59	14-0059	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
60	14-0060	60	14-0060	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
61	14-0061	61	14-0061	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
62	14-0062	62	14-0062	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
63	14-0063	63	14-0063	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
64	14-0064	64	14-0064	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
65	14-0065	65	14-0065	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
66	14-0066	66	14-0066	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
67	14-0067	67	14-0067	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
68	14-0068	68	14-0068	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
69	14-0069	69	14-0069	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
70	14-0070	70	14-0070	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5	DMR	100W	144.000	0	12.5
71	14-0071	7															

3.4 Horkheimer Award at Ham Radio Friedrichshafen



3.5 Horkheimer Award at Ham Radio Friedrichshafen



DG8FAC

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DG1SW

KF4DX

Questions?