

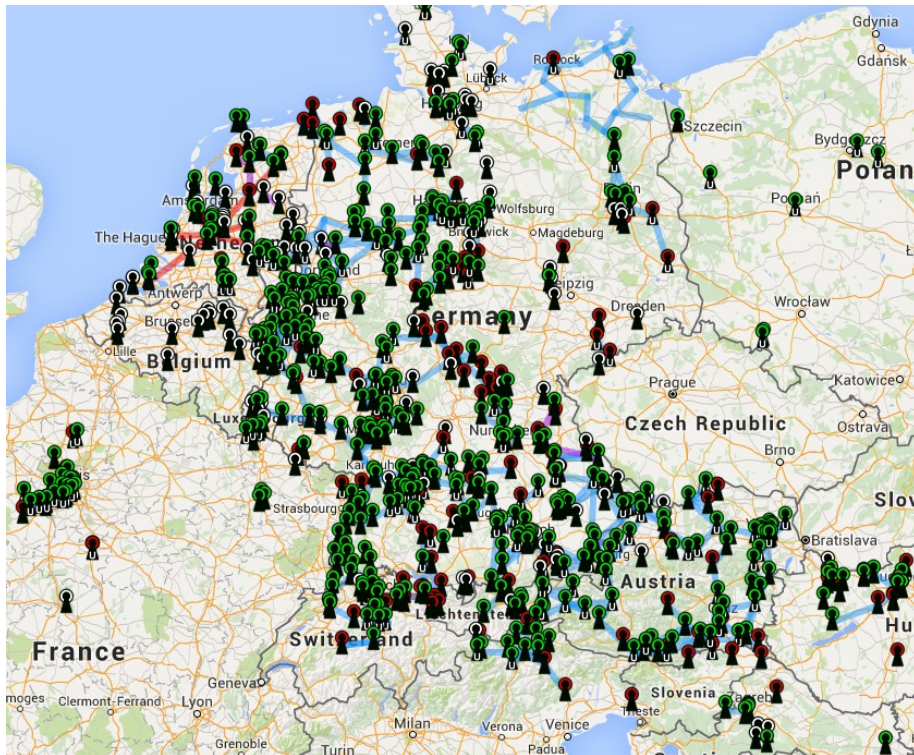
# The HAMNET

Mikrotik's role in the world of Amateur Radio

Jann Traschewski, DG8NGN

German Amateur Radio Club (DARC e.V.)

[dg8ngn@darc.de](mailto:dg8ngn@darc.de)



User access

Interlinks

<http://hamnetdb.net> → Map

# Introduction – Jann, DG8NGN



Member of the German Amateur  
IP-Coordination Team

- Region South: Jann Traschewski, DG8NGN
- Region North-West: Egbert Zimmermann, DD9QP
- Region North-East: Thomas Osterried, DL9SAU



VHF/UHF/Microwave Manager DARC e.V.



Profession:

System Engineer for Spectrum Monitoring  
Systems (Rohde & Schwarz Munich)

# Facts about Amateur Radio

- Exams

  - Germany: Multiple-Choice Test

    - Class A (full license)
    - Class E (entry level license: less power, less frequency bands)

- License allows Amateur Radio Operation on Amateur Radio Frequencies

- Amateur Radio Operators have their own worldwide unique Callsign

  - e.g. Jann Traschewski = DG8NGN

- Amateur Radio Operators are everywhere around us (esp. in technical business)

  - ~2 million amateur radio operators worldwide (~70.000 in Germany)
  - growing numbers in the last few years

# Facts about Amateur Radio

- Amateur Radio has its own national laws (rights & duties)
  - Amateur radio homebrew: Due to the technical knowledge proven by the exams, amateurs are allowed to build and operate their homemade radios
  - No commercial usage: Amateurs may not use their radio frequencies to provide commercial services
  - No obscured messages: Amateurs may not obscure the content of their transmissions
  - Identification: Amateurs need to identify with their callsign regularly

# Amateur Radio Operation

- Space Communication
- Moonbounce



International Space Station  
Callsign: DP0ISS

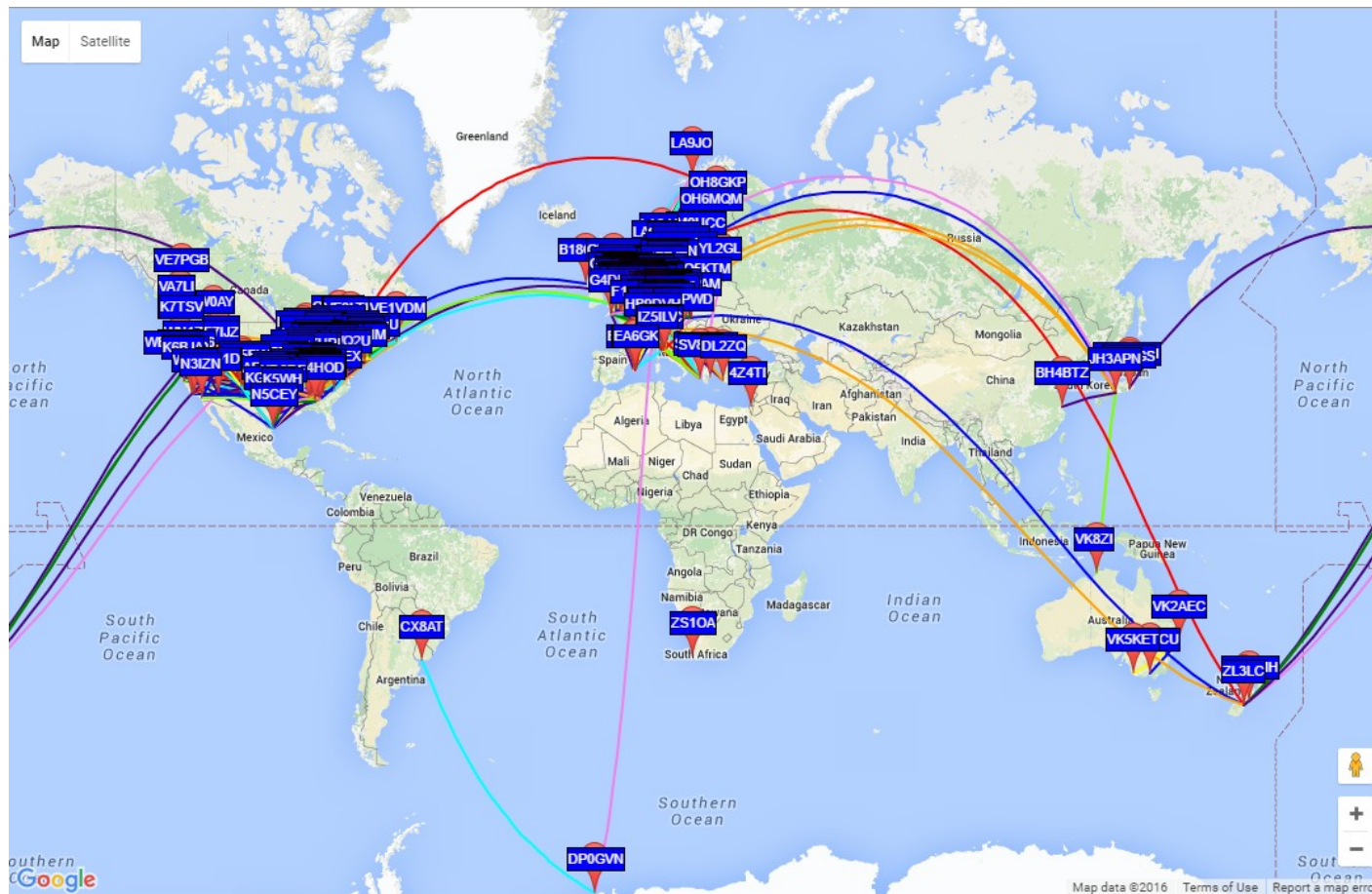


Moonbounce station from Joe, K5SO  
(<http://www.k5so.com>)

8.6m diameter Dish!!

# Amateur Radio Operation

- Weak Signal Propagation Reporter



- very low power (e.g. 20dBm)
- very low bandwidth
- very high range

WSPRnet propagation map 14 MHz (<http://wsprnet.org>)

# Amateur Radio Operation

- Repeater Operation

standalone vs. interconnected repeaters

Amateur Radio Interlinks vs. Internet based Links



Olympic Tower  
Munich



Telecommunication  
Tower  
Nuremberg

# Digital Radio Networks

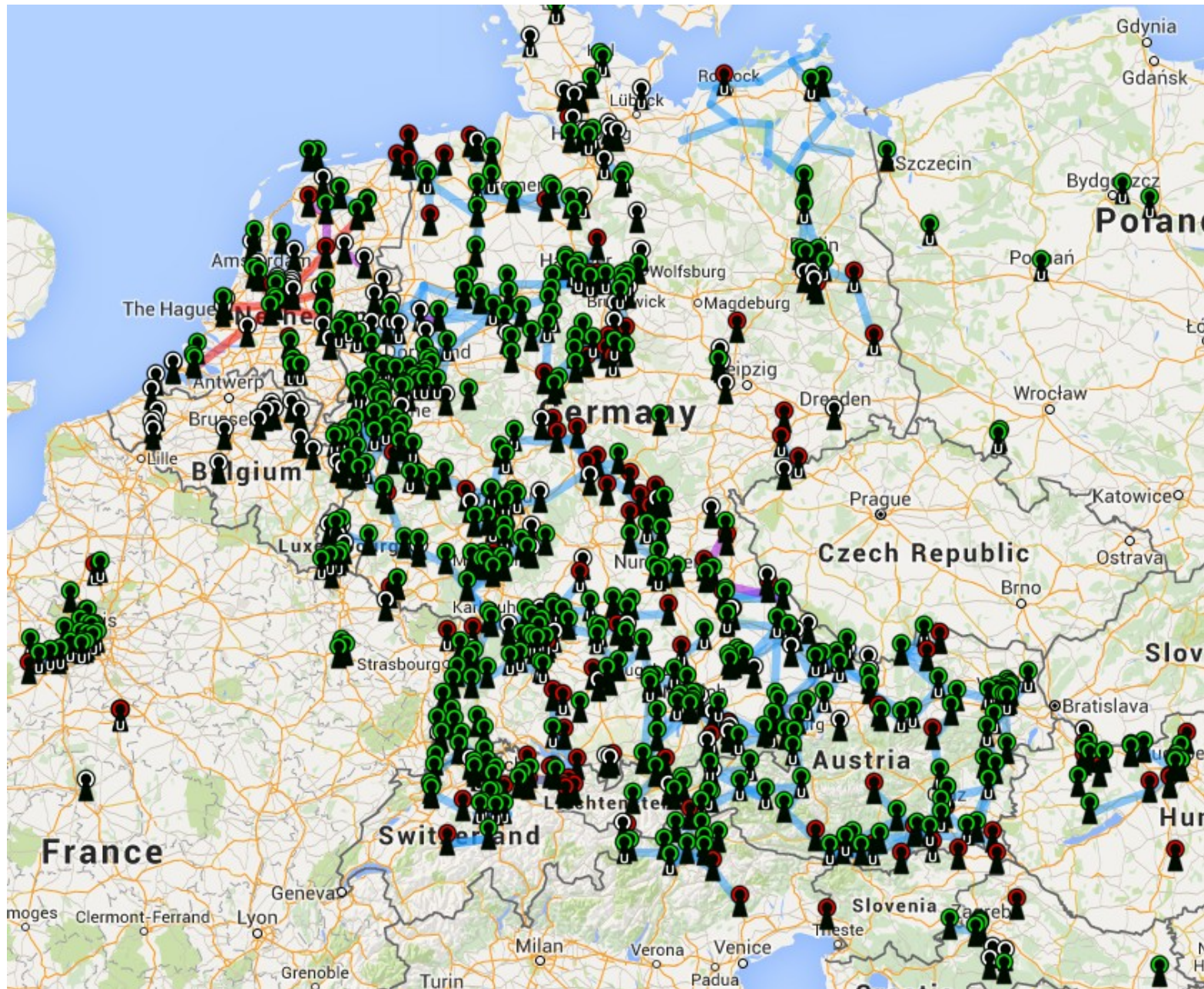
- Packet Radio Network
  - own protocol (AX.25)
  - own hardware (modems/radios)
  - „Peak“ Packet Radio ~ 1997
    - 2000 nodes (system designed for max. 600)
    - Interconnection speed typical 1,2 or 9,6 kbit/s
    - Large areas of Europe covered by Packet Radio
  - TCP/IP encapsulation in AX.25
    - Phil Karns, KA9Q, IP-stack implementation from 1985 evolved into the Linux kernel
    - Amateurs gathered the full IP address block 44.0.0.0/8 for worldwide usage in 1980



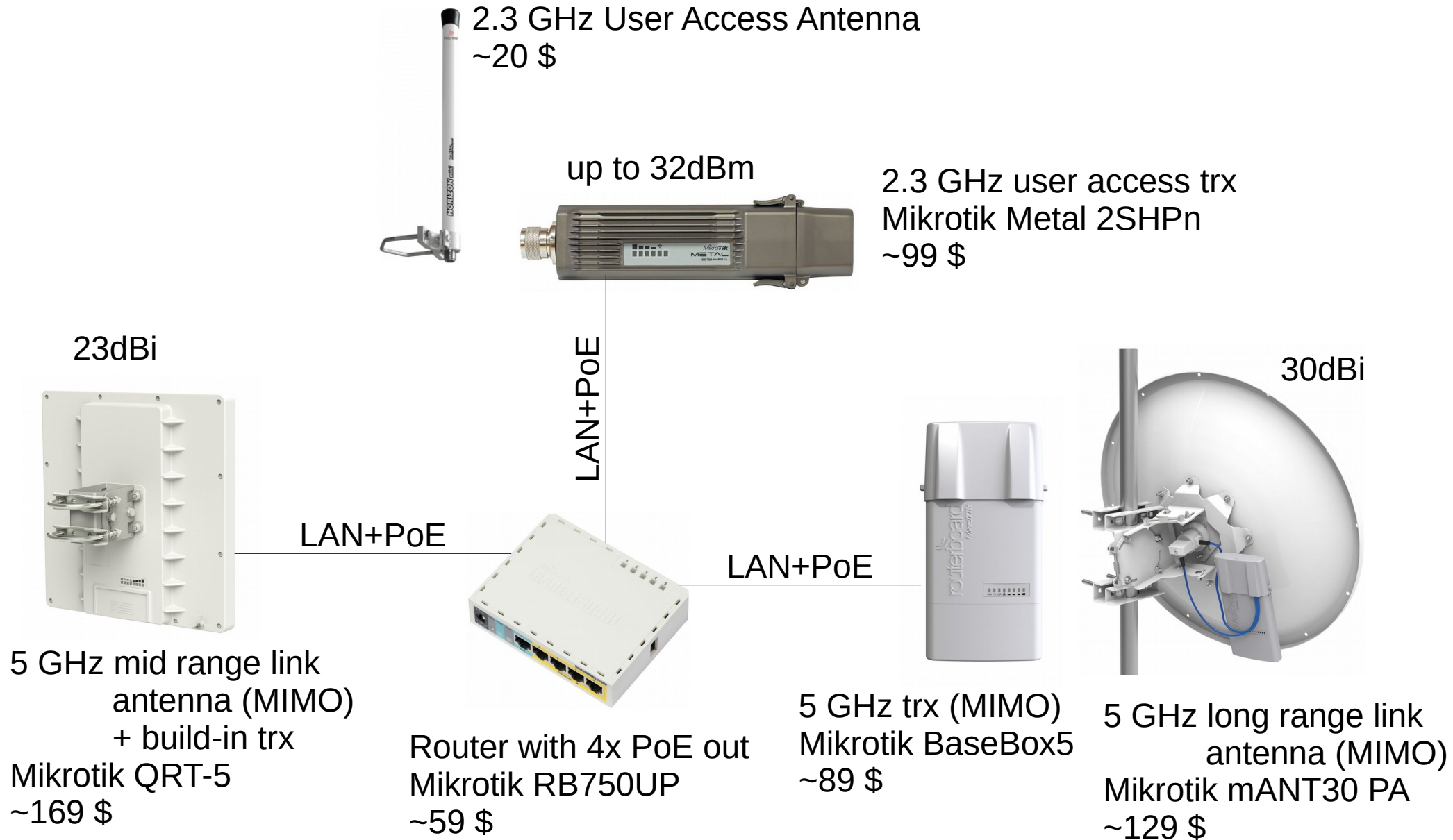
# The „HAMNET“

- **H**ighspeed **A**mateurradio **M**ultimedia **N**etwork
- From „TCP/IP over AX.25“ to „AX.25 over TCP/IP“
  - TCP/IP networks carry each kind of data
- Network is based on commercial wireless devices mainly used in the 6-cm amateur band (5650 MHz – 5850 MHz), Useraccess on 13-cm, 9-cm and 6-cm band
- Network covers mostly the Germany speaking region in Europe and growed already over the language border

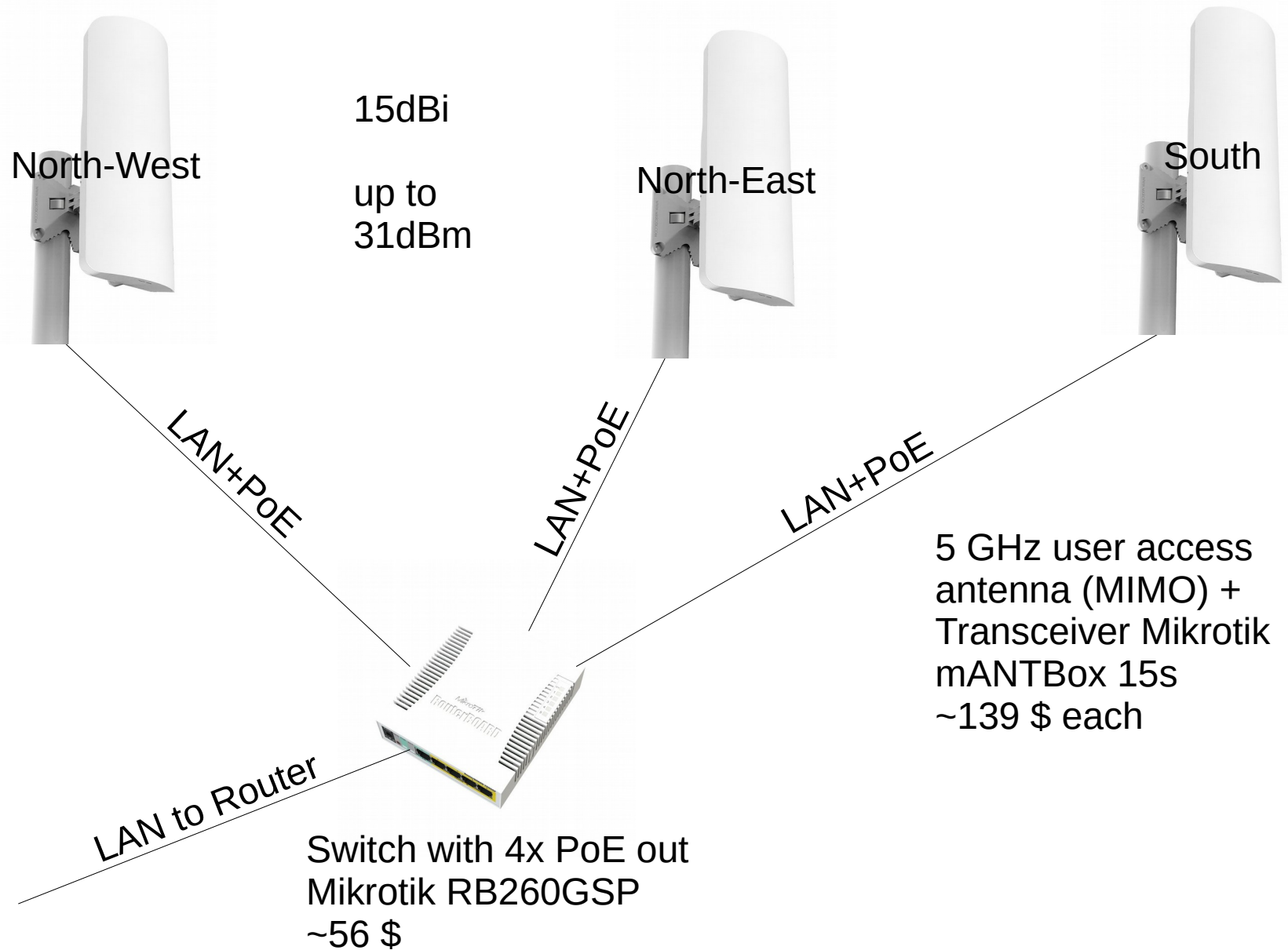
# The network



# Standard Deployment Example #1



# Standard Deployment Example #2



# Network Management – Principles & IP Allocations

- Keeping the experimental nature of amateur radio
  - Regional network management
  - Active regions will get enough resources (**IP-addresses, AS-numbers**)
  - Active regions will „speak“ **eBGP** to neighbors
- IP numbers for German regions will be provided by the German IP coordination team (cf. RIPE)

# Network Management – ASN allocations (16 bit)

- The HAMNET is using the private AS space as noted in RFC 1930 (AS64512 to AS65535)

[RFC 1930](#)

Guidelines for creation of an AS

March 1996

## 10. Reserved AS Numbers

The Internet Assigned Numbers Authority (IANA) has reserved the following block of AS numbers for private use (not to be advertised on the global Internet):

64512 through 65535

# Network Management – ASN allocations (16 bit)

- The allocation to different countries is not yet coordinated in a global way, thus we try to synchronize our wikis with recent changes:

DL: <http://www.de.ampr.org/dokumentation/as-nummern>

OE: [http://wiki.oevsv.at/index.php?title=Routing\\_-\\_AS-Nummern](http://wiki.oevsv.at/index.php?title=Routing_-_AS-Nummern)

This is the central documentation place for the allocation of AS numbers used within the AMPRNet.

Country	ASN Block	local documentation
OE Austria	64512-64599	<a href="#">Wiki</a>
I Italy	64600-64619	<a href="#">Wiki</a>
DL Germany	64620-64683	<a href="#">List</a> or <a href="#">WHOIS-Search</a>
LX Luxemburg	64684-64685	<a href="#">Wiki</a>
CR Croatia	64686-64690	<a href="#">Wiki</a>
PA Netherlands	64691-64694	<a href="#">Wiki</a>
S5 Slovenia	64695-64704	<a href="#">Wiki</a>
HA Hungary	64705-64707	<a href="#">Wiki</a>
EA Spain	64708-64719	<a href="#">Wiki</a>
HB Switzerland	64720-64739	<a href="#">Wiki</a>
HB0 Liechtenstein	64740-64741	<a href="#">Wiki</a>
F France	64742-64777	<a href="#">Wiki</a>
ON Belgium	64778-64788	<a href="#">Wiki</a>
TA Turkey	64789-64799	<a href="#">Wiki</a>
SP Poland	64800-64839	<a href="#">Wiki</a>
YO Romania	64840-64849	<a href="#">Wiki</a>
* Test and BGP-Confederations		65510-65534 <a href="#">Wiki</a>

# Network Management – ASN allocations (32 bit)

- RFC 6996 reflects the new 32-bit private AS number block 4200000000 to 4294967294
- Amateur usage:
  - 42 <3-digit country code ITU-T X.121> <5-digits free usage per country>

RFC 6996

Private Use AS Reservation

July 2013

## 5. IANA Considerations

IANA has reserved, for Private Use, a contiguous block of 1023 Autonomous System numbers from the "16-bit Autonomous System Numbers" registry, namely 64512 - 65534 inclusive.

IANA has also reserved, for Private Use, a contiguous block of 94,967,295 Autonomous System numbers from the "32-bit Autonomous System Numbers" registry, namely 4200000000 - 4294967294 inclusive.

These reservations have been documented in the IANA "Autonomous System (AS) Numbers" registry [[IANA.AS](#)].



# Routing within a region

- Each region is free to use its favorite routing protocol (e.g. OLSR, B.A.T.M.A.N., OSPF, internal BGP)
- Internal BGP is often used
  - Full Mesh: Each node needs to talk to each other node (more traffic, does not scale →  $n(n-1)/2$  BGP links necessary)
  - Route Reflector: Each node needs to talk to the route reflector (Single point of failure)
  - BGP Confederation (preferred): ASN block 65510 to 65534 is used as internal AS numbers

# Deployment - Sites

- Get in touch with anybody on this site:  
<http://hamnetdb.net/?m=util&func=maintainer>

## Maintainers with write-access in this database:

Callsign	Full Name	Comment	Edited
db1hdn	Dennis	Admin DB0ROW, DB0RTN	364d dh6bb
db5jl	Detlev	C21	536d dg8ngn
db7mj	Peter	Sysop DB0ESS	477d dl8mbt
db7yi	Michael	Sysop DB0PM	595d dg8ngn
db8zp	Peter	Sysop DB0TAN	403d dg8ngn
dc1dmr	Matti		92d dh3wr
dc1nf	Dieter	Sysop DB0ADS	303d dg8ngn
dc1paa	Michael	Sysop DB0ALU	557d dg8ngn
dc1rd	Rainer	Sysop DB0SL	423d dg8ngn
dc2ve	Frank	Verwaltung AS64650	538d dg8ngn
dc4ah	Andreas	Sysop DB0DLX	293d dk2ern

- They can create an account for you to edit the database
- Or ask me ([dg8ngn@darcd.de](mailto:dg8ngn@darcd.de)) to get you an account

# Deployment - Sites

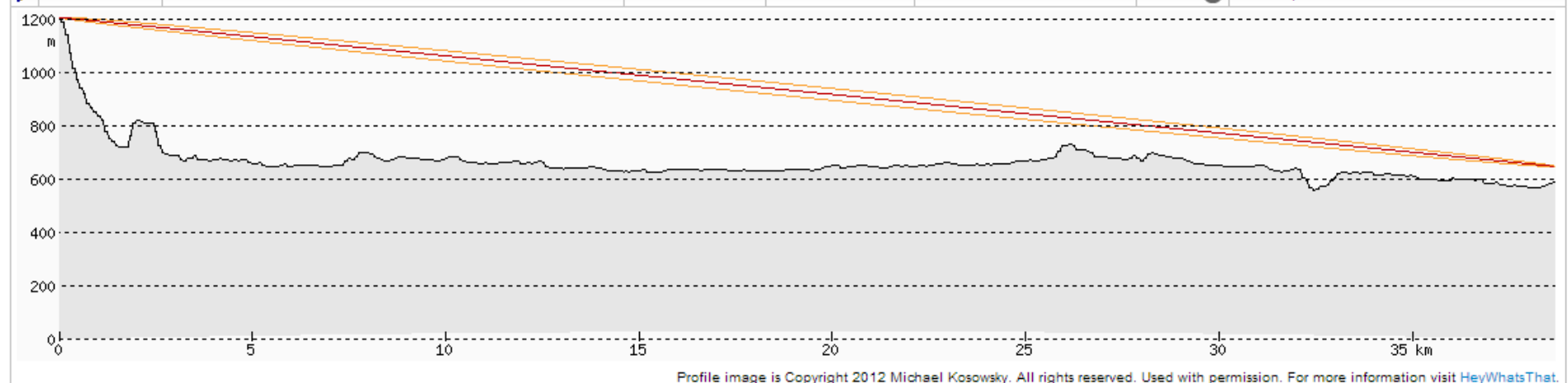
- Login to <http://hamnetdb.net>
- Click on „Sites“
- Press „New Site“
- Fill the following data into the form:
  - Call sign
  - Descriptive Name
  - Latitude, Longitude and meters above **ground**
  - Comma separated list of maintainers

# Deployment - Sites

- Click onto your site and scroll down the list
- Have a look for nearby sites and check the link profile by clicking „Profile“

## Other sites near db0isw:

Site	Name	Distance	Direction	Above ground	Edge	
No Call	Herzogstand	19.6 km	223.6°	20 m		<a href="#">Profile</a>   <a href="#">Show in linktool</a>
db0pme	Hintereck / Gmund am Tegernsee	21.2 km	84.5°	5 m	+	<a href="#">Profile</a>   <a href="#">Show in linktool</a>
db0pm	Brenten / Hausham	26.7 km	85.2°	9 m	+	<a href="#">Profile</a>   <a href="#">Show in linktool</a>
db0abx	Laber	33.9 km	240.8°	5 m		<a href="#">Profile</a>   <a href="#">Show in linktool</a>
No Call	Raisting EMC-Turm	34.3 km	304.3°	35 m		<a href="#">Profile</a>   <a href="#">Show in linktool</a>
dl0igi	Hohenpeissenberg	36.1 km	281.9°	50 m		<a href="#">Profile</a>   <a href="#">Show in linktool</a>
dm0gap	Wank / Garmisch-Partenkirchen	36.6 km	226.7°	8 m	+	<a href="#">Profile</a>   <a href="#">Show in linktool</a>
db0ona	Hohenpeissenberg	36.8 km	281.5°	4 m	+	<a href="#">Profile</a>   <a href="#">Show in linktool</a>
db0dba	München DEBA-Hochhaus	38.6 km	0.6°	61 m	+	<a href="#">Profile</a>   <a href="#">Show in linktool</a>



- Check for line of sight (5 GHz) and get in touch with the operator

# Deployment – Link Budget

- You might want to calculate your link budget to estimate the data rate you could achieve
- Check your data sheet of your TRX (e.g. Mikrotik QRT 5)
  - Gain is 23 +/- 1dBi

	TX power / RX sensitivity
TX/RX at MCS0	30dBm / -96dBm
TX/RX at MCS7	24dBm / -78dBm
TX/RX at 6Mbit	30dBm / -96dBm
TX/RX at 54Mbit	27dBm / -80dBm
Frequency range	4900-5920MHz

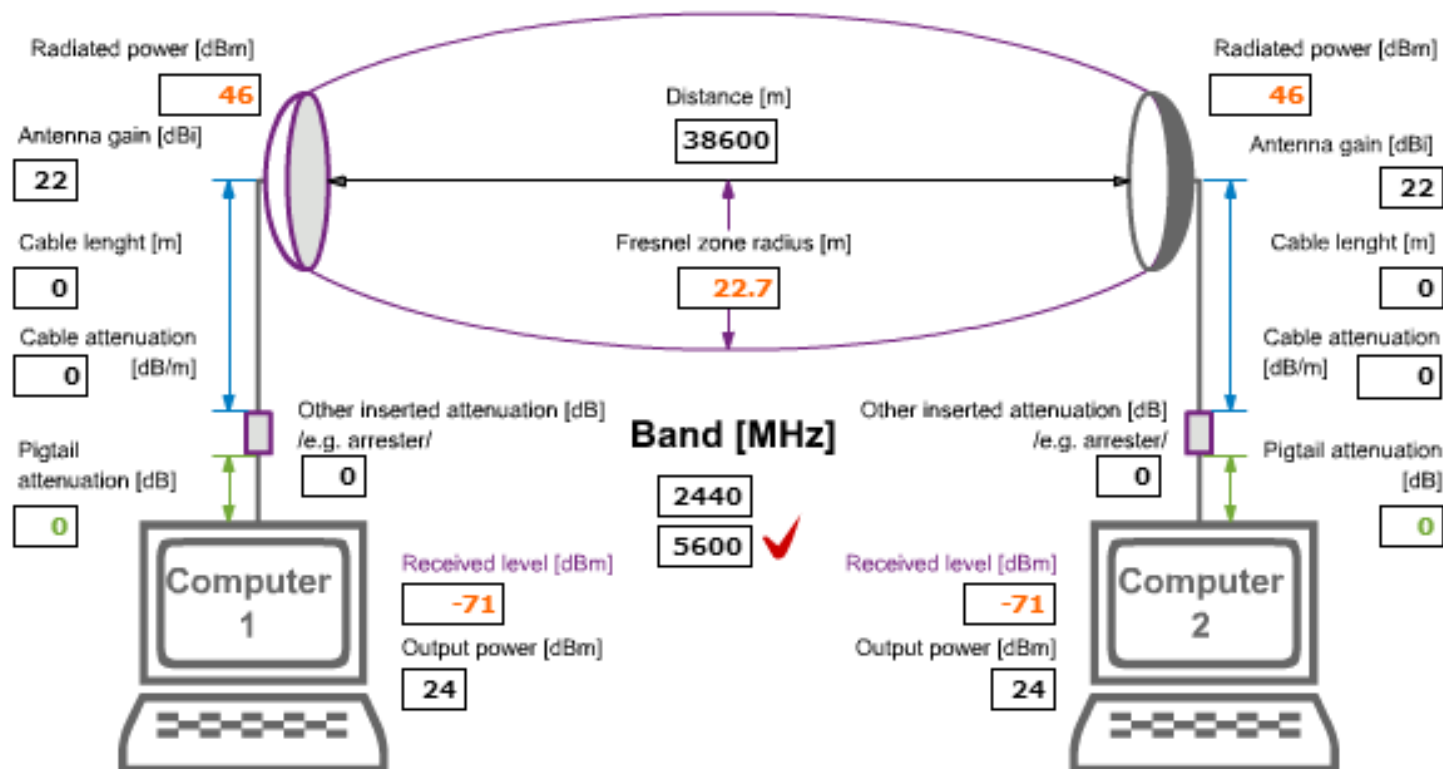
- TX level at MCS7 (Modulation and Coding Scheme: 64-QAM with Coding rate 5/6) will be 24dBm
  - RX at MCS7 needs -78dBm of receiving power level
- Check additional losses of antenna gain by looking into chart „gain vs. frequency“ (if provided by manufacturer)

# Deployment – Link Budget

- There are many link budget calculation tools on the web
- Pick one and put the worst case values in (e.g. <http://en.jirous.com/calculation-wifi>):

## Fresnel zone

Fresnel zone is an area where most of the power between antennas is transmitted, it is cigar shaped. If there is a barrier in this area, the transmission attenuation increases. Calculated radius is in the middle of the link and at the end it decreases.



# Deployment – Link Budget

- Estimated receiving level is -71dBm, so we have 7dB left for inaccuracy (e.g. unknown frequency/gain behavior)
- Keep in mind that changing bandwidth from 20 MHz down to 10 MHz will give you 3dB more gain (respectively 6dB by narrowing down to 5 MHz) but the throughput will suffer from the same factor (divided by 2 respectively 4)
- Running 2 spatial streams (horizontal and vertical polarization) at the same time will give us 130 Mbit/s:

MCS index	Spatial streams	Modulation type	Coding rate	Data rate (Mbit/s)			
				20 MHz channel		40 MHz channel	
				800 ns GI	400 ns GI	800 ns GI	400 ns GI
7	1	64-QAM	5/6	65.00	72.20	135.00	150.00
15	2	64-QAM	5/6	130.00	144.40	270.00	300.00

# Deployment – Spectrum Regulatory

- Before deploying a radio link for an automatic radio station you need to check the rules which apply for your country
- Germany
  - Automatic radio stations need a special license (they get a special call sign e.g. „db0xyz“) from the regulation authority „BNetzA“ (200,- € per call sign)
  - Different rules will apply per band or even frequency ranges (e.g. 10 MHz bandwidth maximum in Germany) by law
  - Each desired frequency usage needs to be applied at the regulation authority
  - Frequencies will be granted/denied after ~4-5 month



# Deployment - Identification

- Radio amateurs need to identify in regular intervals
  - ESSID (e.g. HAMNET-DB0ABC-DB0XYZ)
    - But is a transmission coming from DB0ABC or DB0XYZ?
      - Only valid with fixed convention (e.g. AP-Mode = first call sign and Station-Mode = second call sign)
      - How to handle Point-to-Multipoint Links?

# Deployment - Identification

- Using locally administered MAC-addresses
  - Encoding of call sign into the free bits in a MAC-address

```
Byte 6   Byte 5   Byte 4   Byte 3   Byte 2   Byte 1
RRRRRRXX RRRRRRNN RRRRRRSS RRRRRRSS RRRRRRSS RRRRRRSS
8 Bit   1 8 Bit   1 8 Bit   1 8 Bit   1 8 Bit   1 8 Bit   1
```

R = Bits for coding the call sign

S = Bits for the station identifier (SSID)

N = reserved for future applications

X = Standardbits according to IEEE 802

Bit 1: 0 = unicast / 1 = multicast

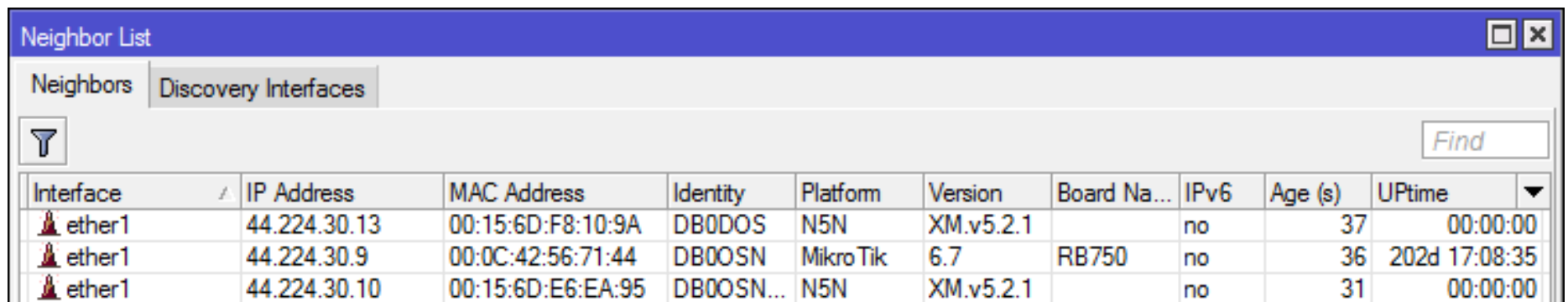
Bit 2: 0 = globally unique / 1 = locally administered

Details and Tools/Scripts available (in German) on:

<http://db0fhn.efi.fh-nuernberg.de/doku.php?id=projects:wlan:proposal>

# Deployment - Identification

- Neighbor Discovery Protocols
  - There are plenty of neighbor discovery protocols in the wild (CDP, LLDP, MNDP, ...)
  - Just set the „Identity“ to your call sign and you're fine



The screenshot shows a window titled "Neighbor List" with two tabs: "Neighbors" and "Discovery Interfaces". Below the tabs is a search bar with a filter icon and a "Find" button. The main content is a table with the following columns: Interface, IP Address, MAC Address, Identity, Platform, Version, Board Na..., IPv6, Age (s), and Uptime. There are three rows of data, all for the "ether1" interface.

Interface	IP Address	MAC Address	Identity	Platform	Version	Board Na...	IPv6	Age (s)	Uptime
ether1	44.224.30.13	00:15:6D:F8:10:9A	DB0DOS	N5N	XM.v5.2.1		no	37	00:00:00
ether1	44.224.30.9	00:0C:42:56:71:44	DB0OSN	MikroTik	6.7	RB750	no	36	202d 17:08:35
ether1	44.224.30.10	00:15:6D:E6:EA:95	DB0OSN...	N5N	XM.v5.2.1		no	31	00:00:00

Neighbor List of HAMNET Station „DB0DOS“  
(Mikrotik and Ubiquiti Devices)

# Deployment – AS/IP-Subnet-Allocation

- Regions need to get an AS- and IP-Allocation
  - The German IP Coordination is taking care

```
# -----  
# HAMNET-DL  
# -----  
# AS-      AS-      NETWORKS      NETWORKS      NETWORKS  
# NO      NAME      BACKBONE      USER/SERVICES  PACKET-RADIO  
  
*                               44.225.254.0/23 # Anycast  
64625     DISTRIKT-C-625-AS  44.224.10.0/23  44.225.20.0/22  44.130.56.0/24  
64626     DISTRIKT-B-626-AS  44.224.12.0/23  44.225.24.0/22  44.130.60.0/24  
                                                44.130.99.0/24  
  
64627     DISTRIKT-L-627-AS  44.224.14.0/23  44.225.28.0/22  44.130.146.0/24  
64628     DISTRIKT-S-628-AS  44.224.16.0/23  44.225.32.0/22  
64629     DISTRIKT-D-629-AS  44.224.18.0/23  44.225.36.0/22  
64630     DISTRIKT-U-630-AS  44.224.20.0/23  44.225.40.0/22  44.130.59.0/24  
64631     DISTRIKT-T-631-AS  44.224.22.0/23  44.225.44.0/22  44.130.53.0/24  
                                                44.130.61.0/24
```

# Deployment – AS-Allocation

- Information is reflected in the HAMNETDB

**The Hamnet-Database** Show: [Map](#) [Fullscreen Map](#)  OSM

	AS	Name	Maintainer	Comment	Edited
	<a href="#">AS64625</a>	DISTRIKT-C-625-AS	dl3mbg,dg8ngn	Oberbayern	567d dl8mbt
	<a href="#">AS64626</a>	DISTRIKT-B-626-AS	dg8ngn	Franken	598d dg8ngn
	<a href="#">AS64627</a>	DISTRIKT-L-627-AS	dd9qp	Niederrhein - WES, KLE	162d dd9qp
	<a href="#">AS64628</a>	DISTRIKT-S-628-AS	dg1cpa	Distrikt Sachsen	510d dd9qp
	<a href="#">AS64629</a>	DISTRIKT-D-629-AS	dl7uaz	Berlin	594d dg8ngn
	<a href="#">AS64630</a>	DISTRIKT-U-630-AS	dl8rds,dg8ngn	Ostbayern	594d dg8ngn
	<a href="#">AS64631</a>	DISTRIKT-T-631-AS	dg8ngn	Schwaben	595d dg8ngn

<http://hamnetdb.net/?m=as>

# Deployment – IP-Subnet-Allocation

- Information is reflected in the HAMNETDB

	Subnet-IP	Type	Own AS	Parent	Radio parameters / Comment	Edited
/	<a href="#">44.130.53.0/24</a>	AS-Packet-Radio	-	<a href="#">AS64631</a>		393d dg8ngn
/	<a href="#">44.130.56.0/24</a>	AS-Packet-Radio	-	<a href="#">AS64625</a>		393d dg8ngn
/	<a href="#">44.130.59.0/24</a>	AS-Packet-Radio	-	<a href="#">AS64630</a>		393d dg8ngn
/	<a href="#">44.130.60.0/24</a>	AS-Packet-Radio	-	<a href="#">AS64626</a>		399d dg8ngn
/	<a href="#">44.130.61.0/24</a>	AS-Packet-Radio	-	<a href="#">AS64631</a>		393d dg8ngn
/	<a href="#">44.130.99.0/24</a>	AS-Packet-Radio	-	<a href="#">AS64626</a>		186d dg8ngn
/	<a href="#">44.130.146.0/24</a>	AS-Packet-Radio	-	<a href="#">AS64627</a>	Distrikt-L Packet-Radio Netz	162d dd9qp
/	<a href="#">44.224.10.0/23</a>	AS-Backbone	-	<a href="#">AS64625</a>		665d dg8ngn
/	<a href="#">44.224.12.0/23</a>	AS-Backbone	-	<a href="#">AS64626</a>		594d dg8ngn
/	<a href="#">44.224.14.0/23</a>	AS-Backbone	-	<a href="#">AS64627</a>	Distrikt-L Backbone Netz	579d dg8ngn
/	<a href="#">44.224.16.0/23</a>	AS-Backbone	-	<a href="#">AS64628</a>		594d dg8ngn
/	<a href="#">44.224.18.0/23</a>	AS-Backbone	-	<a href="#">AS64629</a>	Berlin Backbone Netz	585d dl7uaz
/	<a href="#">44.224.20.0/23</a>	AS-Backbone	-	<a href="#">AS64630</a>		594d dg8ngn
/	<a href="#">44.224.22.0/23</a>	AS-Backbone	-	<a href="#">AS64631</a>		594d dg8ngn
/	<a href="#">44.225.20.0/22</a>	AS-User/Services	-	<a href="#">AS64625</a>		689d dl8mbt
/	<a href="#">44.225.24.0/22</a>	AS-User/Services	-	<a href="#">AS64626</a>		594d dg8ngn
/	<a href="#">44.225.28.0/22</a>	AS-User/Services	-	<a href="#">AS64627</a>	Distrikt-L User/Services Netz	579d dd9qp
/	<a href="#">44.225.32.0/22</a>	AS-User/Services	-	<a href="#">AS64628</a>		594d dg8ngn
/	<a href="#">44.225.36.0/22</a>	AS-User/Services	-	<a href="#">AS64629</a>	Berlin User-Service Netz	458d dl9sau
/	<a href="#">44.225.40.0/22</a>	AS-User/Services	-	<a href="#">AS64630</a>		688d dl8mbt
/	<a href="#">44.225.44.0/22</a>	AS-User/Services	-	<a href="#">AS64631</a>		688d dl8mbt

<http://hamnetdb.net/?m=subnet>

# Deployment – „IP-Subnetting“

- Each region gets a /23 for the backbone (transfernetworks) and a /24 for user-/services (sitenetworks)
- Best practice:
  - Each site has a single router
  - Each site gets a /27 network from the maintainer (leave the next /27 free in case a network needs to be increased)
  - The sitenetwork will be announced by the router to the network
  - The sitenetwork can be splitted „internally“ at the site into several networks (e.g. /28 for users and /28 for services) → easy firewalling
  - Each site uses a /29 transfer network to interconnect to another site

# Deployment – Network Documentation

- The HAMNETDB provides network management capabilities
- Data structure (AS, Hosts, Subnets, Sites):
  - Hosts belong to sites (user defined)
  - Hosts belong to subnets (by nature)
  - Subnets belong to AS (user defined)
- The HAMNETDB is able to visualize data



# Deployment – Network Documentation Example

## Site db0zm (München-Freimann Studentenstadt)

Show: [Map](#) [Fullscreen Map](#)  OSM

Coordinates: 48.184086,11.611249 - 48°11.05' N 11°36.67' E - 48°11'02" N 11°36'40" E  
Elevation: 65 m above ground

Maintainer: **dl8rds,dg8ngn,dl8mbt,dd5ki**

Am Standort ist auch

- 2m FM Relais DB0ZM 145.750
- 70cm FM-Relais DB0NJ 438.775
- 70cm DMR-Relais DB0NJ 439.4375
- 2 Kameras von <http://www.foto-webcam.eu>

Site configuration: <https://www.dropbox.com/s/0sd219kow4lb23f/DB0ZM.gif>

Last edited 2013-12-07 by **dl8mbt**

**db0zm** (München-Freimann Studentenstadt)  
bb-db0tvm.db0zm  
[44.224.10.49](#)  
Station WDS (NStreme)  
000c423a644c

Backbone-Network  
[44.224.10.48/29](#)  
5685MHz, 10Mhz, horizontal

**db0tvm** (München Olympiaturm)  
bb-db0zm.db0tvm  
[44.224.10.54](#)  
AP Bridge (NStreme)  
000b6b234bca  
4.4km - 256.2° - [Show in Linktool](#)

**db0zm** (München-Freimann Studentenstadt)  
bb-db0wai.db0zm  
[44.224.10.46](#)  
Station WDS (NStreme)  
000c4260e61f

Backbone-Network  
[44.224.10.40/29](#)  
5825MHz, 10Mhz, horizontal


**db0wai** (München Thalkirchen)  
bb-db0zm.db0wai  
[44.224.10.41](#)  
AP Bridge (NStreme)  
000c4260f560  
8.6km - 207.5° - [Show in Linktool](#)

































**db0zm** (München-Freimann Studentenstadt)  
bb-db0ebe.db0zm  
[44.224.10.73](#)  
Station WDS (NStreme)  
000c436fb3f2

Backbone-Network  
[44.224.10.72/29](#)  
5795MHz, 10Mhz, vertikal

**db0ebe** (Ebersberg Aussichtsturm)  
bb-db0zm.db0ebe  
[44.224.10.78](#)  
AP Bridge (NStreme), 23dBi  
000c426fb3f2  
28.0km - 111.8° - [Show in Linktool](#)

# Deployment – Network Documentation Example







Contains the following hosts :

	Host-IP	M	Hostname	Type	Site	Radio parameters / Comment	Edited
	44.224.10.46		bb-db0wai.db0zm	Routing-Radio	db0zm	Station WDS (NStreme)	584d dg8ngn
	44.224.10.49		bb-db0tvm.db0zm	Routing-Radio	db0zm	Station WDS (NStreme)	584d dg8ngn
	44.224.10.73		bb-db0ebe.db0zm	Routing-Radio	db0zm	Station WDS (NStreme)	378d dg8ngn
	44.224.10.74		Ink-db0ebe.db0zm	Service	db0zm		584d dg8ngn
	44.225.20.193		router.db0zm	Service	db0zm	Routerboard RB433AH (WAI, TVM)	584d dg8ngn
	44.225.20.194		allstarlink.db0zm	Service	db0zm	2m FM-Relais DB0ZM	667d dg8ngn
	44.225.20.195		eoip.db0zm	Service	db0zm	Routerboard RB411AH (EBE)	667d dg8ngn
	44.225.20.196		hamnetdb.db0zm	Service	db0zm	Raspberry PI mit Debian - ProxyPa..	506d dl8mbt
	44.225.20.197		webcam-nord.db0zm	Service	db0zm	Kamerarechner WL500GP OpenWRT - h..	589d dl8mbt
	44.225.20.198		webcam-sued.db0zm	Service	db0zm	Kamerarechner WL500GP OpenWRT - h..	589d dl8mbt
	44.225.20.199		dmr.db0zm	Service	db0zm	db0nj 439.4375 MHz, Motorola DR30..	269d dl8mbt
	44.225.20.200		proxmox.db0zm	Service	db0zm	Server for Virtual Machines	7m dg8ngn
	44.225.20.201		ipmi.db0zm	Service	db0zm	Remote Console	7m dg8ngn
	44.225.20.202		winxp.db0zm	Service	db0zm	Windows VM	6m dg8ngn
	44.225.20.203		dhcp-44-225-20-203.db0zm	DHCP-Range	db0zm	assigned dynamically	0s system
	44.225.20.204		dhcp-44-225-20-204.db0zm	DHCP-Range	db0zm	assigned dynamically	0s system
	44.225.20.205		wetter.db0zm	Service	db0zm	Wetterstation Davis Vantage Vue -..	102d dl8mbt
	44.225.20.206		netio.db0zm	Service	db0zm	Schaltsteckdose - 1: DMR-Relais D..	269d dl8mbt

18 entries.


# Deployment – Network Documentation Example

## Surrounding subnets +:

	Subnet-IP	Type	Own AS	Parent	Radio parameters / Comment	Edited
	<a href="#">44.224.10.0/23</a>	AS-Backbone	-	<a href="#">AS64625</a>		665d dg8ngn
	<a href="#">44.224.10.40/29</a>	Backbone-Network	-	<a href="#">AS64625</a>	<a href="#">db0zm</a> , <a href="#">db0wai</a> - 5825MHz, 10MHz, horizontal	691d dl8mbt
	<a href="#">44.224.10.48/29</a>	Backbone-Network	-	<a href="#">AS64625</a>	<a href="#">db0tvm</a> , <a href="#">db0zm</a> - 5685MHz, 10MHz, horizontal	691d dl8mbt
	<a href="#">44.224.10.72/29</a>	Backbone-Network	-	<a href="#">AS64625</a>	<a href="#">db0zm</a> , <a href="#">db0ebe</a> - 5795MHz, 10MHz, vertikal	691d dl8mbt
	<a href="#">44.225.20.0/22</a>	AS-User/Services	-	<a href="#">AS64625</a>		689d dl8mbt
	<a href="#">44.225.20.192/28</a>	Site-Network	AS65530	<a href="#">AS64625</a>	<a href="#">db0zm</a>	264d dg8ngn



6 entries.

## Surrounding AS:

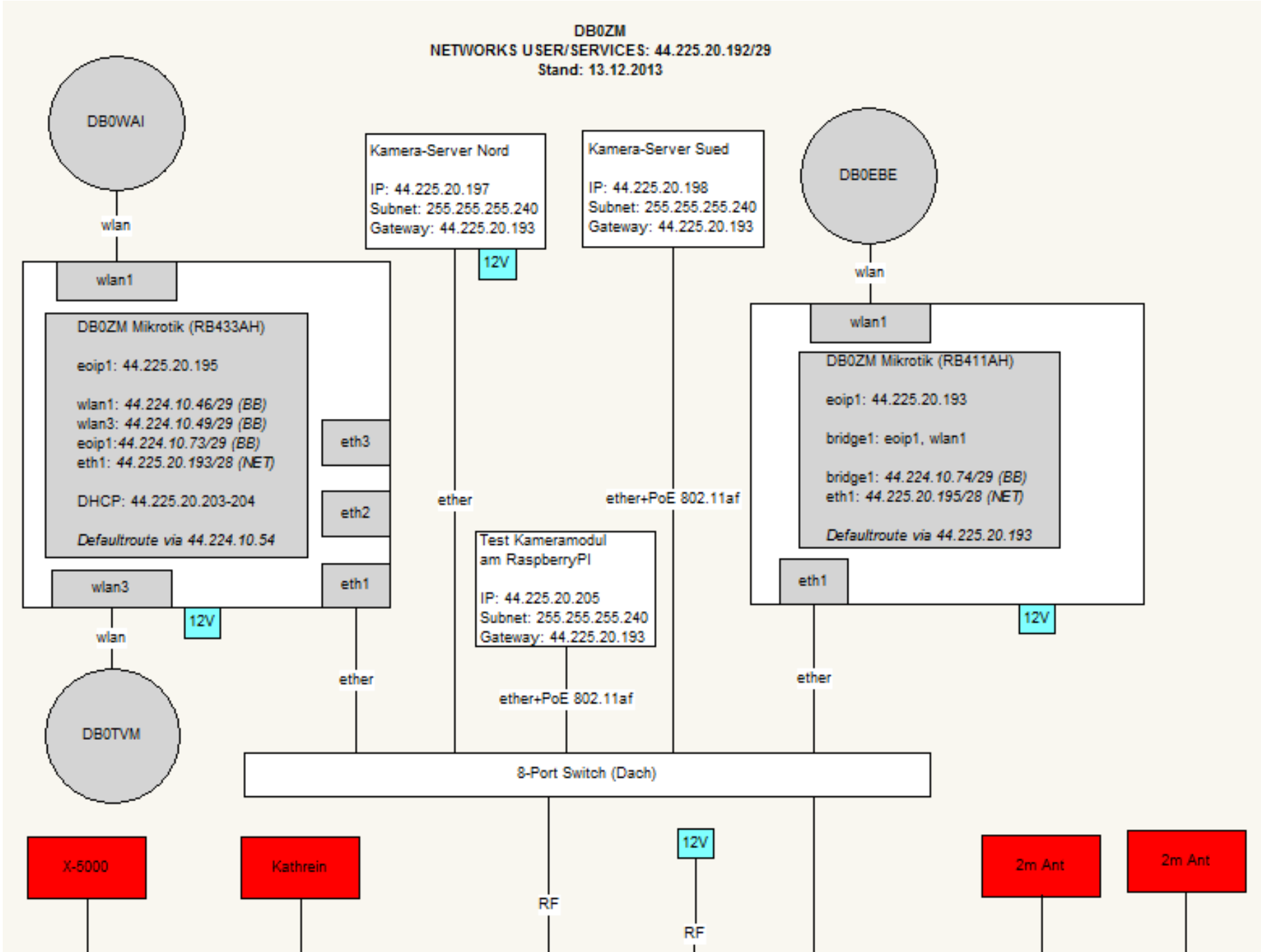
	AS	Name	Maintainer	Comment	Edited
	<a href="#">AS64625</a>	DISTRIKT-C-625-AS	dl3mbg, dg8ngn	Oberbayern	567d dl8mbt

1 entry.

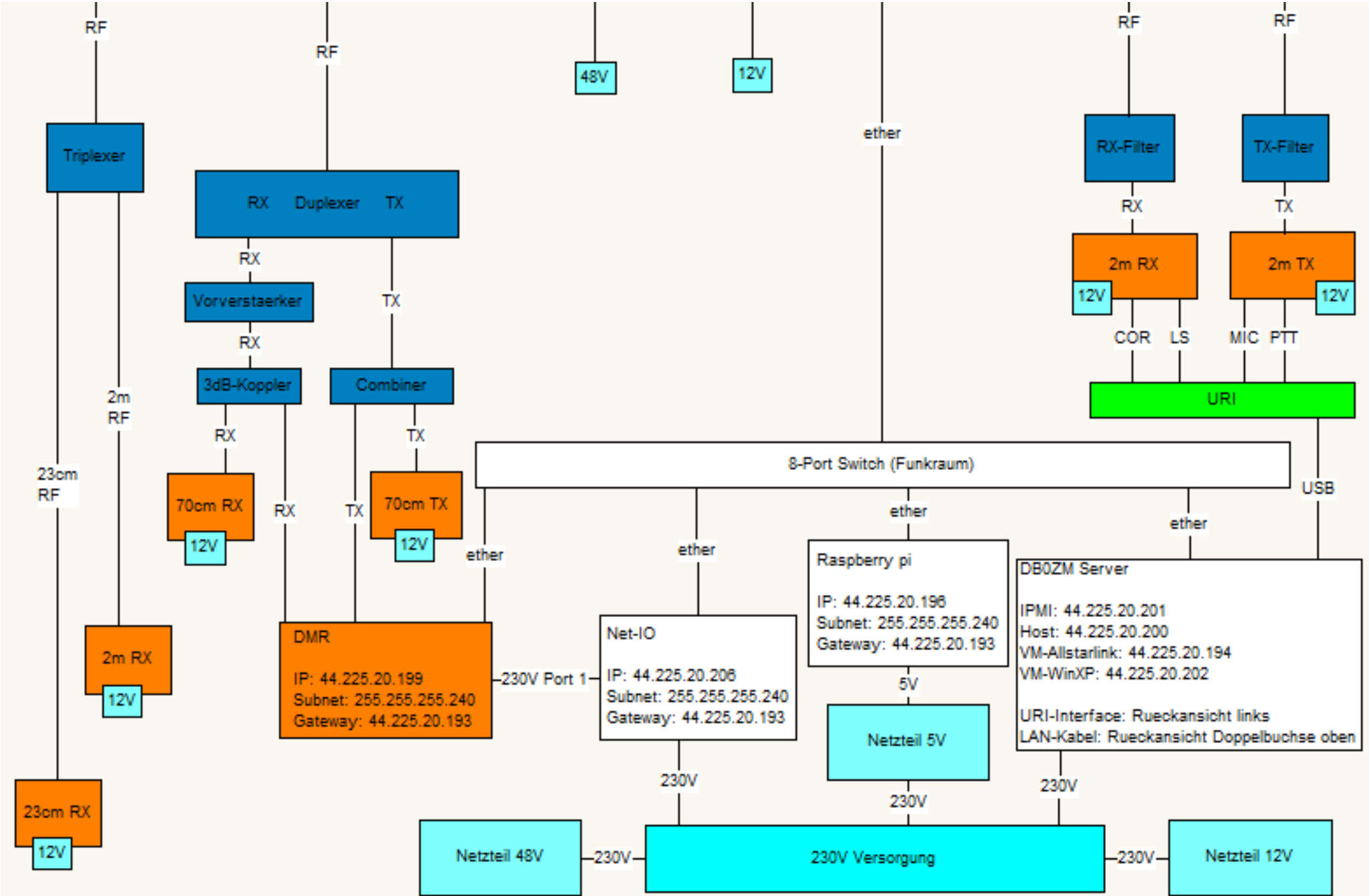
## Other sites near db0zm:

	Site	Name	Distance	Direction	Above ground	Edge	
	<a href="#">db0tvm</a>	München Olympiaturm	4.4 km	256.2°	200 m		<a href="#">Profile</a>   <a href="#">Show in linktool</a>
	<a href="#">dl0muc</a>	Clubstation Chaos Computer C..	5.0 km	228.0°	30 m		<a href="#">Profile</a>   <a href="#">Show in linktool</a>

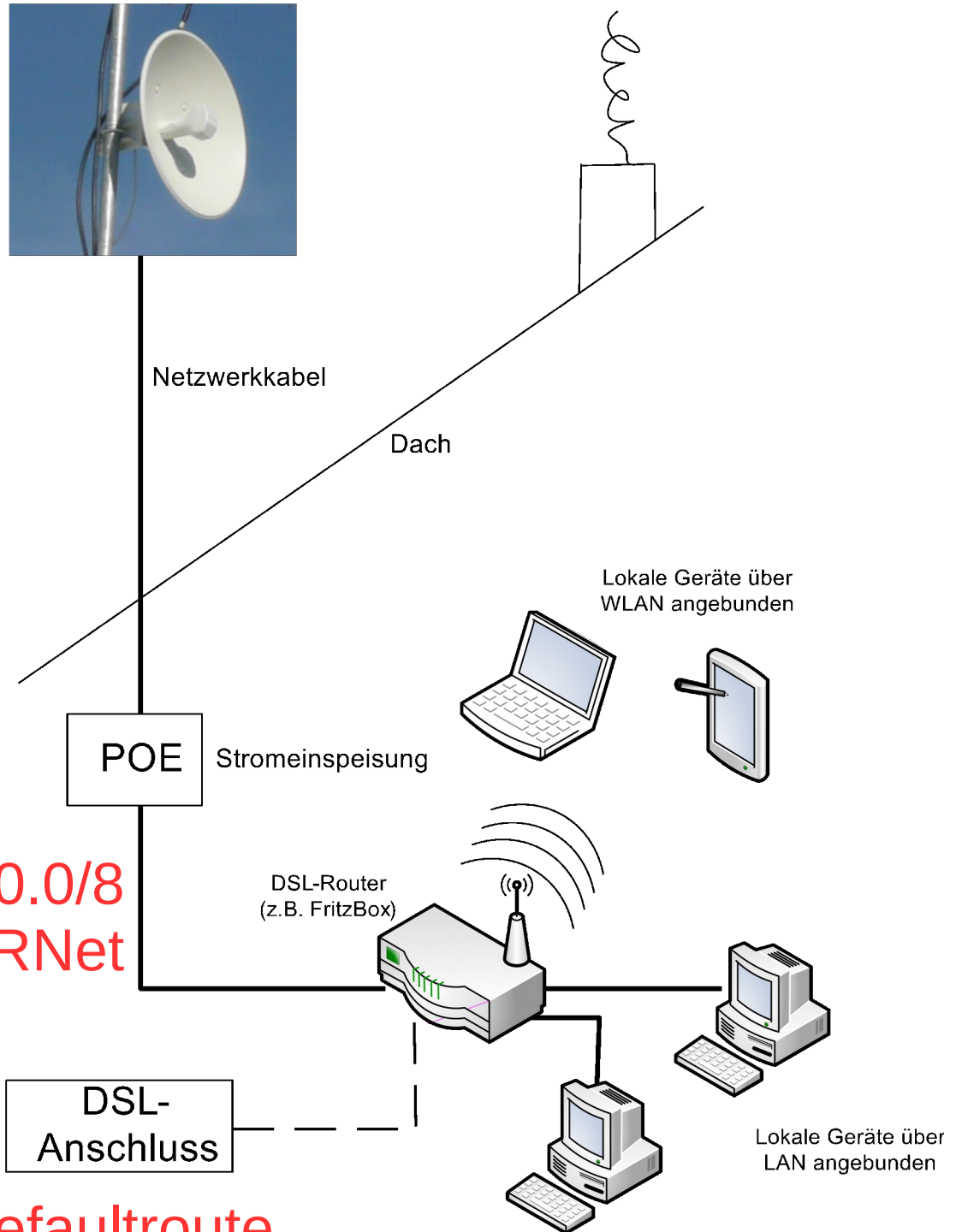
# Deployment – Network Documentation Example



# Deployment – Network Documentation Example



# Deployment - Typical User Setup



Keep 44.0.0.0/8 for radio amateurs only !

# Motivation – Intranet for Radio Amateurs

- Trusted “Intranet” for radio amateurs
  - Packets from net44 are supposed to come from an amateur radio operator
  - Providing gateways from the Intranet to Radio is OK without further authentication of the individual amateur (e.g. access to shared Remote Transceivers, ...)
- End-to-End communication
  - NAT is evil...
  - No need to struggle around with portforwarding
  - No Firewall issues (cf. central DPI firewalls at universities...)

# Motivation – Building a RF backbone

- Backbone for services (cf. Packet Radio Network – BBS, Convers, ...)

Transport of:

- DATV, VoIP (DMR, D-Star, Echolink, Asterisk), APRS, Packet Radio
- whatever you can transport on TCP/IP...
- Build an independent network for emergency communication (where the funding could come from...)
- Connecting public non-commercial webcams to the Internet

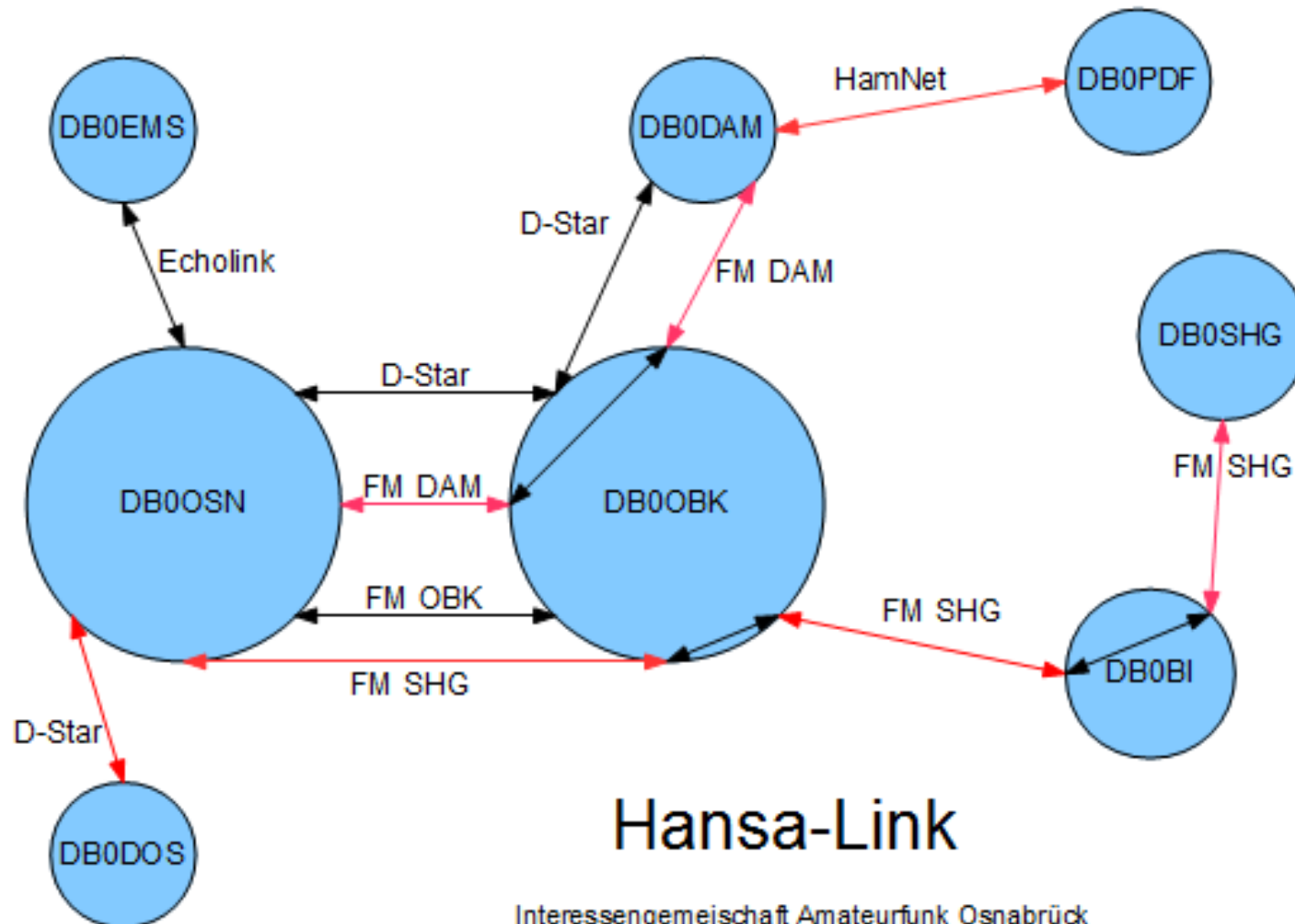


# Motivation – Learning & Experimentation

- Building your own Internet
  - Technology you usually don't get in touch with (Routing protocols, Server-to-Server VPNs, DNS-Hosting, ...)
  - Large testbed to improve things
- Building your own backhaul
  - GHz wave propagation
  - System Integration of backhaul technology

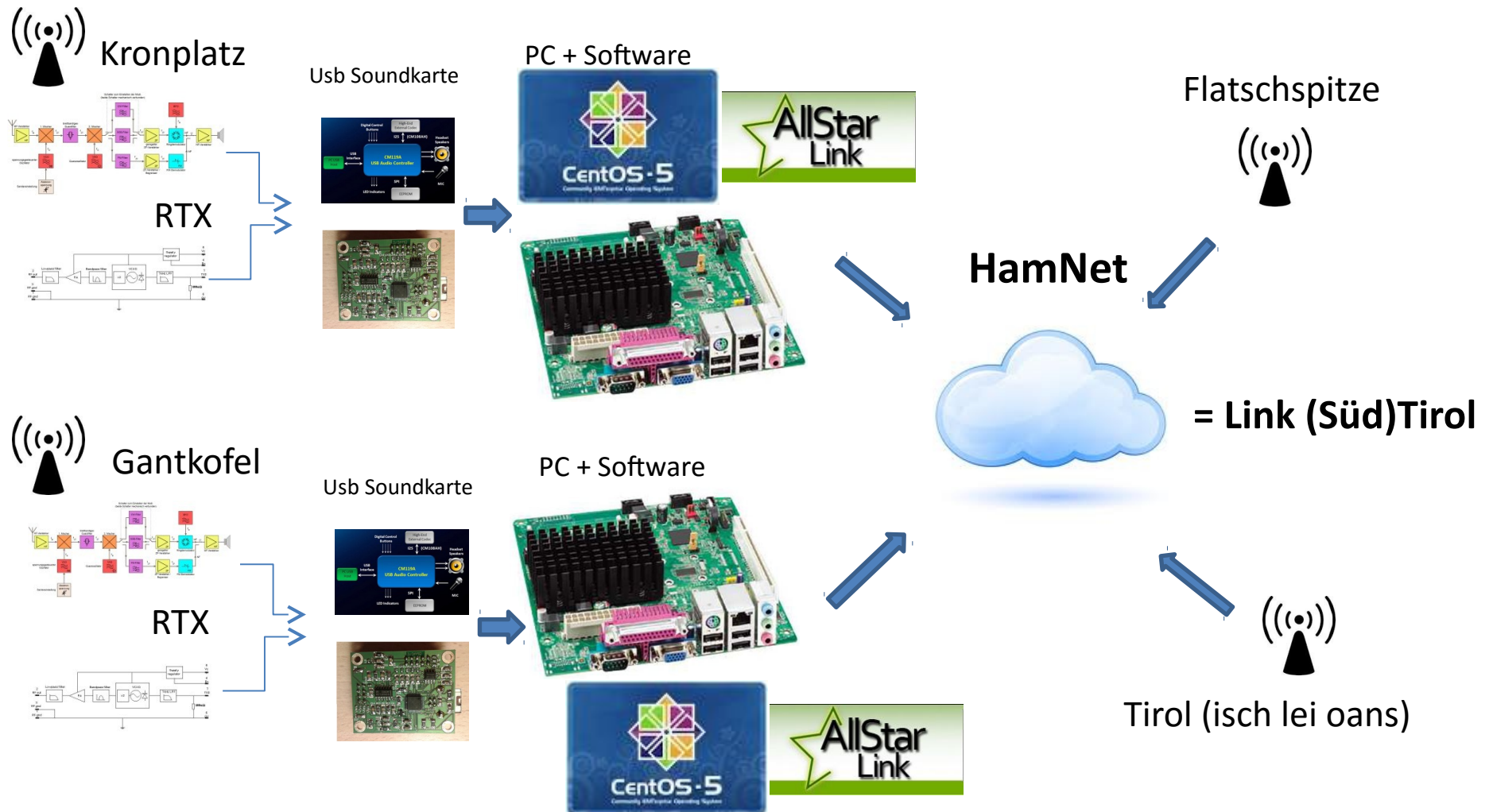
# Application Examples - FM Repeater Group (SVXLink)

- Hansa-Link Network





# Application Examples - FM Repeater Group (Allstarlink)

- Link (Süd) Tirol



# Application Examples – ATV Livestreaming



[Home](#) Startseite

[ATV](#) Info rund ums Fernsehen


[Hamnet](#) Datennetz für Benutzer

**Anwendungen** Was YL/OM machen kann...

[Multimedia](#) Bilder und Videos


Ortsverband Eschweiler

## Anwendung - Live-Streaming

**Details** | Kategorie: [Anwendungen](#) | Erstellt am 23. April 2012 | Veröffentlicht am 23. April 2012 | Geschrieben von Ralf DH3WR | 

Zugriffe: 3220

Hier wird in einem Flashplayer Live-Stream von Amateurfunkstationen angezeigt. Benutzer können hier ebenfalls ihren eigenen Kanal bekommen. Bitte mit [rwth-afu@online.de](mailto:rwth-afu@online.de) Kontakt aufnehmen.



00:00 | 00:00

**DB0KWE Livestream**  
ATV-Livebild das im Moment in Weisweiler ausgestrahlt wird

**DB0KO Livestream**  
ATV-Livebild das im Moment in Köln ausgestrahlt wird

**DL9KAR Livestream**  
Bei Bedarf kann Bernd hier einen Videostream senden

**DH3WR Livestream**  
Bei Bedarf kann Ralf hier einen Videostream senden

**DF5KT Livestream**  
Bei Bedarf kann Norbert hier einen Videostream senden

**DL2KBH Livestream**  
Bei Bedarf kann Dieter hier einen Videostream senden

**test Livestream**  
ATV-Livebild das im Moment in xxx ausgestrahlt wird

# Application Examples – Social Network

Status: online  Willkommen, DH3WR! [Abmelden](#)

# hambbook

- Startseite
- Freunde
- Nachrichten (2)
- Eigene Bilder

### Neue Statusnachricht

### Freundschaftsanfragen

1 Freundschaftsanfrage

19.01.2014, 21:31 [DF3AK](#) möchte Ihr Freund werden.  Annehmen  Ablehnen **Neu**

### Aktuelles

[DC1DMR](#) hat [DM3IKE](#) zu seinen Freunden hinzugefügt.  
05.02.2014, 16:23 **Neu**

| 0 0 |


[DC1DMR](#) hat [DF3AK](#) zu seinen Freunden hinzugefügt.  
26.01.2014, 10:17 **Neu**

| 0 0 |


[DM4KCS](#) hat [DH3WR](#) zu seinen Freunden hinzugefügt.  
07.01.2014, 10:06

| 0 0 |

# Application Examples - Searchengines

Administration   Web Suche   Datei Suche   Host Browser   Impressum dieses Peers   Hilfe / YaCy 

## P2P Web Search



Text    Bilder    Audio    Videos   [Mehr Optionen](#)

1-10 aus 1.545

- [Köln-Aachen Rundspruch](#)  
Köln-Aachen Rundspruch. DB0KWE Home Startseite ATV Info rund ums Fernsehen Frequenzen Dokumentation Antennen und Sendeleistung Hamnet Datennetz für Benutzer Benutzereinstiege Hardware beim User Linkstrecken  
<http://db0kwe.ampr.org/index.php/2012-04-30-21-01-08/rundspruch>  
Sat, 19 Jan 2013 | [Citations](#) | [\\*\\*](#)
- [Diskussion:Links Distrikt G Köln-Aachen – Amateurfunk Wiki](#)  
Dc2cb Links Distrikt DI8rds G **Köln** Aachen  
[http://amateurfunk-wiki.de.ampr.org/index.php/Diskussion:Links\\_Distrikt\\_G\\_Köln-Aachen](http://amateurfunk-wiki.de.ampr.org/index.php/Diskussion:Links_Distrikt_G_Köln-Aachen)  
Thu, 24 Jan 2013 | [Citations](#) | [Cache](#) | [\\*\\*](#)
- [IAK - Interessengemeinschaft Amateurfunk Köln-Wahn](#)  
"PSK 31" A ARDF Air Amateurfunk Ausbildung CQ Clubstation Cologne Contest DARC DF0FKW E Elektronik Foxoring Ham IAK Interessengemeinschaft Klasse Koeln VHF **Köln Köln** Wahn Lehrgang Morse Notfunk On Packet Pocket Porz Projekt Prüfungsvorbereitung QRV QSL QSO Radio SHF Selbstbau Trainer UHF Wahn  
[http://echolink.db0sda.ampr.org/index.php?option=com\\_mailto&tmpl=component&link=2d9bd6779eaa0bcb6f5b09058ddb3a19a44f88e6](http://echolink.db0sda.ampr.org/index.php?option=com_mailto&tmpl=component&link=2d9bd6779eaa0bcb6f5b09058ddb3a19a44f88e6)  
Thu, 06 Feb 2014 | [Citations](#) | [Cache](#) | [\\*\\*](#)
- [IAK - Interessengemeinschaft Amateurfunk Köln-Wahn](#)  
"PSK 31" A ARDF Air Amateurfunk Ausbildung CQ Clubstation Cologne Contest DARC DF0FKW E Elektronik Foxoring Ham IAK Interessengemeinschaft Klasse Koeln VHF **Köln Köln** Wahn Lehrgang Morse Notfunk On Packet Pocket Porz Projekt Prüfungsvorbereitung QRV QSL QSO Radio SHF Selbstbau Trainer UHF Wahn  
[http://echolink.db0sda.ampr.org/index.php?option=com\\_mailto&tmpl=component&link=66590a1811f008cc0b3ec6b06f1028fad85bc119](http://echolink.db0sda.ampr.org/index.php?option=com_mailto&tmpl=component&link=66590a1811f008cc0b3ec6b06f1028fad85bc119)  
Thu, 06 Feb 2014 | [Citations](#) | [Cache](#) | [\\*\\*](#)
- [Links Distrikt G Köln-Aachen – Amateurfunk Wiki](#)  
Distrikt G HAMNET **Köln** Aachen Links Linkstrecken  
[http://44.225.71.134/index.php/Links\\_Distrikt\\_G\\_Köln-Aachen](http://44.225.71.134/index.php/Links_Distrikt_G_Köln-Aachen)  
Wed, 15 Jan 2014 | [Citations](#) | [Cache](#) | [\\*\\*](#)
- [Multimedia - Rundsprucharchiv](#)  
<http://db0kwe.ampr.org/index.php/multimedia/rundspruch>  
Mon, 30 Apr 2012 | [Citations](#) | [Cache](#) | [\\*\\*](#)
- [Frequenzplan um Köln.pdf](#)  
[http://db0ko.ampr.org/PDF/Frequenzplan\\_um\\_Köln.pdf](http://db0ko.ampr.org/PDF/Frequenzplan_um_Köln.pdf)  
Fri, 13 Dec 2013 | [Citations](#) | [Cache](#) | [\\*\\*](#)
- [Frequenzplan um Köln.pdf](#)  
[http://44.225.57.98/PDF/Frequenzplan\\_um\\_Köln.pdf](http://44.225.57.98/PDF/Frequenzplan_um_Köln.pdf)  
Fri, 13 Dec 2013 | [Citations](#) | [Cache](#) | [\\*\\*](#)

**1 2 3 4 5 6 7 8 9 10**

aktuell iak frequenzplan diskussion  
wahn referat distrikt aachen  
amateurfunk links  
interessengemeinschaft

Protocol Navigator

- http (997)
- ftp (3)

Filetype Navigator

- php (148)
- htm (32)
- html (15)
- pdf (13)
- ppt (1)

Anbieter Navigator

- 44.225.28.20 (155)
- db0res.ampr.org (150)
- db0kwe.ampr.org (142)
- db0res-svr.ampr.org (127)
- db0res.de (66)
- db0sda.ampr.org (49)
- 44.225.56.130 (39)
- amateurfunk-wiki.de.ampr.org (33)
- db0tv.ampr.org (29)
- web.db0kwe.as64634.de.ampr.org (27)
- wxnet.db0tv.ampr.org (22)
- echolink.db0sda.ampr.org (21)
- 44.225.56.11 (15)
- db0sys.ampr.org (15)
- db0dz.ampr.org (12)
- 44.225.48.145 (11)
- 44.225.48.196 (11)
- 44.225.71.134 (8)
- db0ko.ampr.org (7)
- db0pra.ampr.org (5)

# Application Examples - WebSDR

Your name or callsign:

View:  waterfall  blind    Allow keyboard:

Waterfall:  Java  HTML5

5550 145600 145650 145700 145750 145800

thm zb ub iue tu eh wz pe uc zw zu tha ann ax xg/S6 and

**Frequency:**  kHz

--- -- - + ++ +++

Or tune by clicking/dragging/scrollwheel on the frequency scale.

**Memories:**

recall	erase	store	144675.00 kHz FM	Home
recall	erase	store	145637.50 kHz FM	DB0FUE
recall	erase	store	(new)	

**Bandwidth:**  
11.09 kHz @ -6dB; 11.55 kHz @ -60dB.

wider CW-wide LSB USB AM FM

narrower CW-narrow LSB-nrw USB-nrw AM-nrw FM-nrw

Or drag the passband edges on the frequency scale.

**Waterfall view:**

zoom out zoom in

max out max in

Or use scroll wheel and dragging on waterfall.

Speed:  ▼

Size:  ▼

View:  ▼

Hide labels

<http://websdr.org>

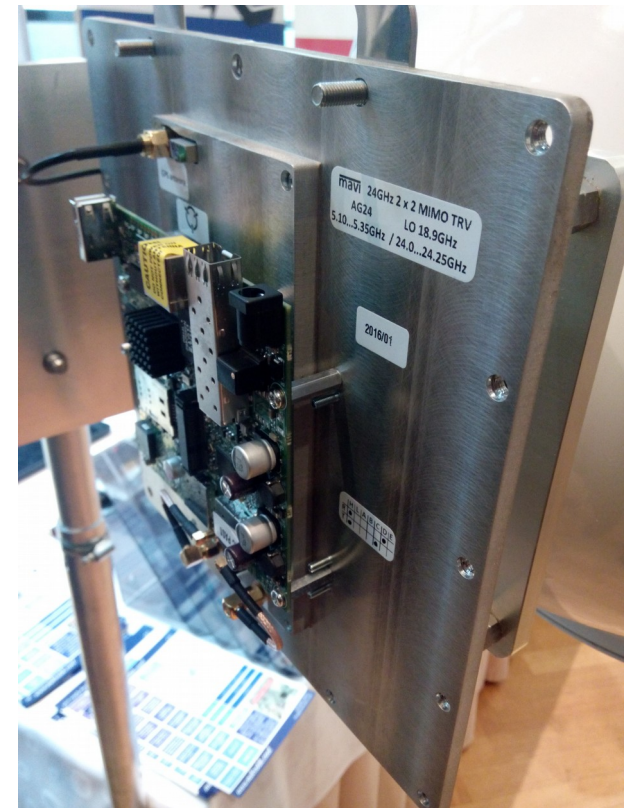
# Application Examples - Webcams





# Challenges – More bands

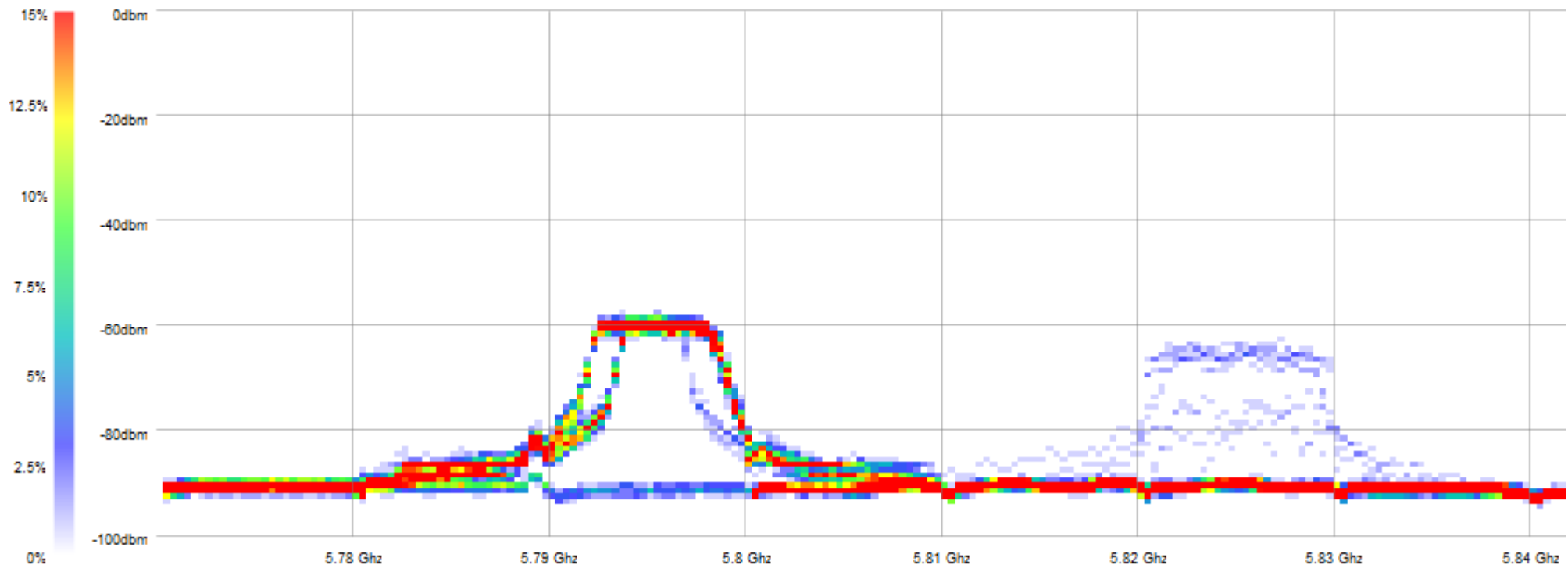
- 9cm – 3.4 GHz is available for amateur radio
  - more expensive compared to 6cm/13cm
- 3cm – 10 GHz: No Equipment from Mikrotik
- 24 GHz: Transverters
  - high price
- or even higher? 47 GHz, 76 GHz, ...
- Homebrew Up-/Downconverter?
  - Full duplex with Mikrotik NStreme Dual possible
    - One card in TX mode
    - One card in RX mode



24 GHz Transverter seen at MUM, Ljubljana, 2016

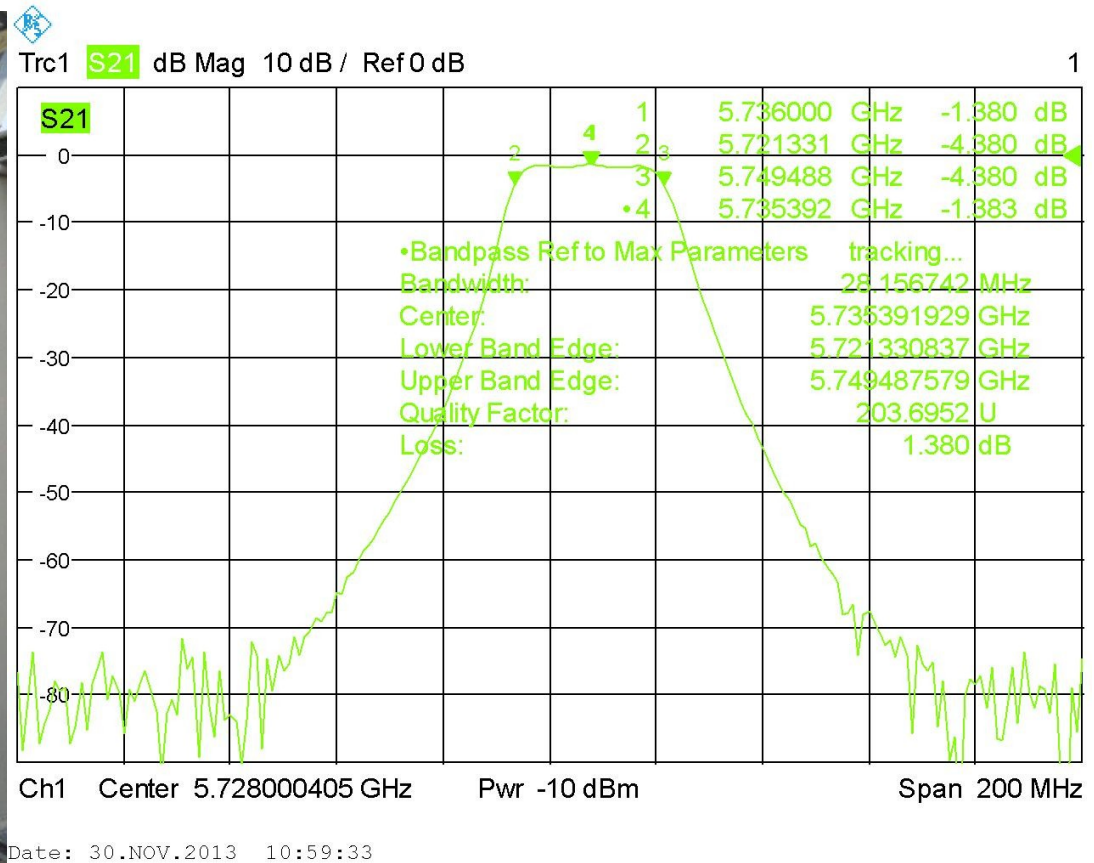
# Challenges – Spurious emissions

- 5 MHz bandwidth
  - +/- 20 MHz → own signal seen again (lower level)
  - +/- 40 MHz → own signal seen again (less lower level)
- 10 MHz bandwidth
  - +/- 40 MHz → own signal seen again (lower level)



# Spurious emissions suppressed

- Metal 5SPHn + Filters



Recommendation:

„Wireless - What you see is not always what you get?“ by Ron Touw (LinITX, United Kingdom)

[http://wiki.mikrotik.com/wiki/MUM\\_2015\\_CZ](http://wiki.mikrotik.com/wiki/MUM_2015_CZ)

# Challenges – EMC (electromagnetic compatibility)

- Don't interfere with other nearby radio users
- Don't interfere with your own amateur radio applications in other radio bands (e.g. 2-m-band)
- Unshielded wireless boards in plastic cases?!?
- Do shielding products work?
- Use Cat7 cables only!
- Ferrite rings might help...



# Challenges – User Access Technology

- Connectivity more important than speed
- Reduced bandwidth = less noise → longer range
- Lower band = better for non-line-of-sight requirements
- **Wishlist**
  - 70cm band 432 MHz: 2 MHz, 1 MHz, 500 kHz, **200 kHz**, 100 kHz
  - 23cm band 1296 MHz: 10 MHz, 5 MHz, 2 MHz, **1 MHz**, 500 kHz, 200 kHz (10 MHz / 5 MHz available from Doodlelabs)
- We run D-Star DD 128kbit/s User Access on 23cm
- SDR experiments (HackRF, USRP, ...)
- Internet of Things?

# Challenges – Routing Protocols

- Most routing protocols doesn't take changing conditions on a radio link into account
  - Packet loss (any kind of reason, e.g. Interference)
  - Changing throughput due to adaptive modulation and coding (AMC)
  - TX-ccq and RX-ccq (Client connection quality)
  - Flapping routes, unreliable connections...
- There are some protocols to test (B.A.T.M.A.N., OLSR, Mikrotik MME, Babel)
  - Protocols can be tested within a region, however sometimes communication between two stations might be better routed using a path through an external autonomous system...
- Requirement: KISS (Keep it simple, stupid)

# Possible Cooperations?

- Distributors
  - German Radio Club DARC e.V. invests in the digital backbone
  - See “challenges” to solve...
- Mikrotik
  - The HAMNET is a large testbed for e.g. a new layer 3 routing protocol taking radio qualities into account
- Wireless Internet Service Providers
  - Recently we took over an old WISP network and all the obligations to deconstruct the network

# Urgent topics from amateur radio perspective

- Popular Amateur Radio User Access frequencies are under threat (e.g. 2392 MHz or 2397 MHz) due to the „FCC / ETSI firmware lockdown“  
Special solution for authorized group of people (e.g. amateurs, military, government purpose, ...)  
needed
- New 802.11ac chipsets do not support 5 MHz and 10 MHz bandwidth  
Demand needs to be addressed to the chipset manufacturers



# Impressions



Gefrorenen Wand, OE7XGR, 3255m



Observatorium Sonnblick, OE2XSR, 3106m