The HAMNET

Mikrotik's role in the world of Amateur Radio

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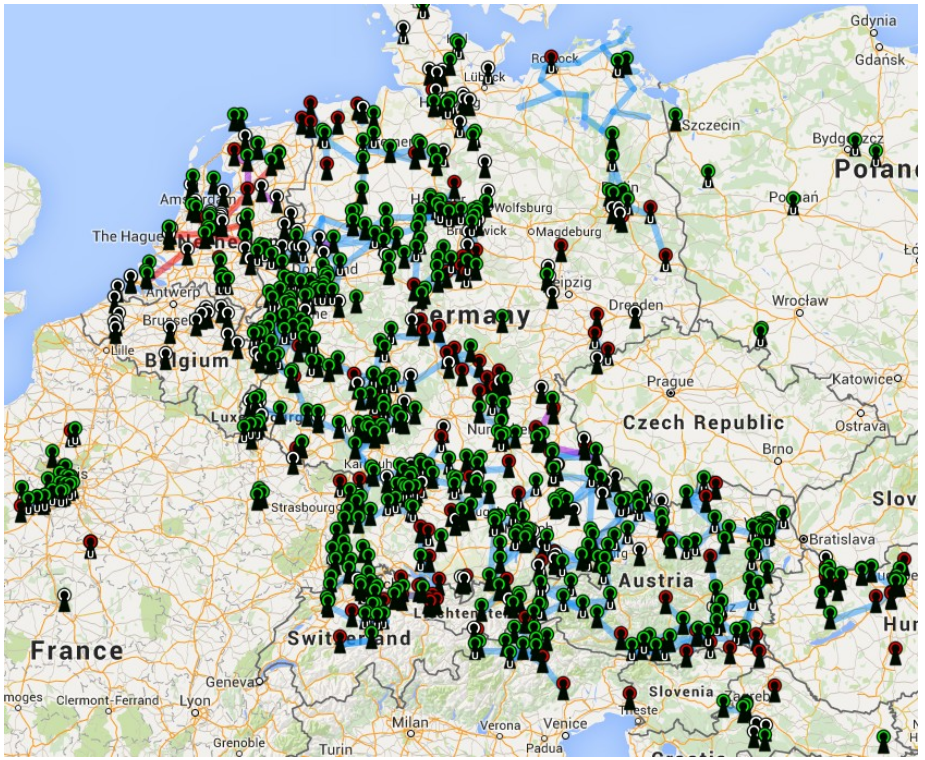


http://hamnetdb.net → Map

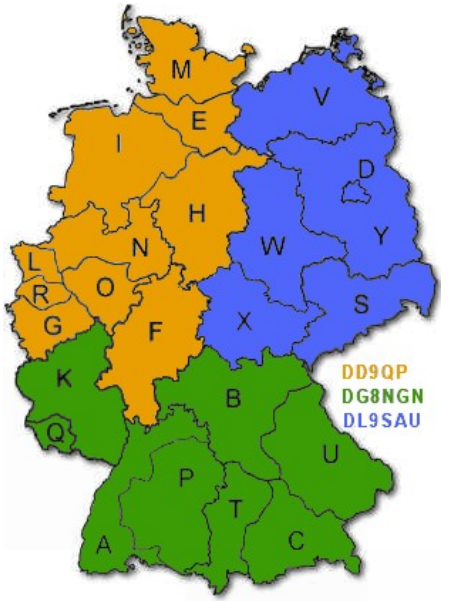
User access

Interlinks

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

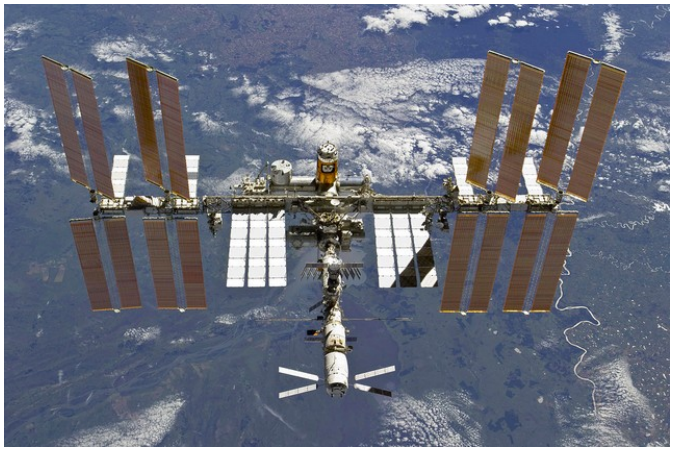
  e.g. Jann Traschewski = DG8NGN
- Amateur Radio Operators are everywhere around us (esp. in technical business)
  - ~2 million amateur radio operators worldwide (~70.000 in Germany)
  - growing numbers in the last few years

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 obsurced messages: Amateurs may not obscure the content of their transmissions
  - Identification: Amateurs need to identfiy with their callsign regularly

Amateur Radio Operation

- Space Communication



International Space Station
Callsign: DP0ISS

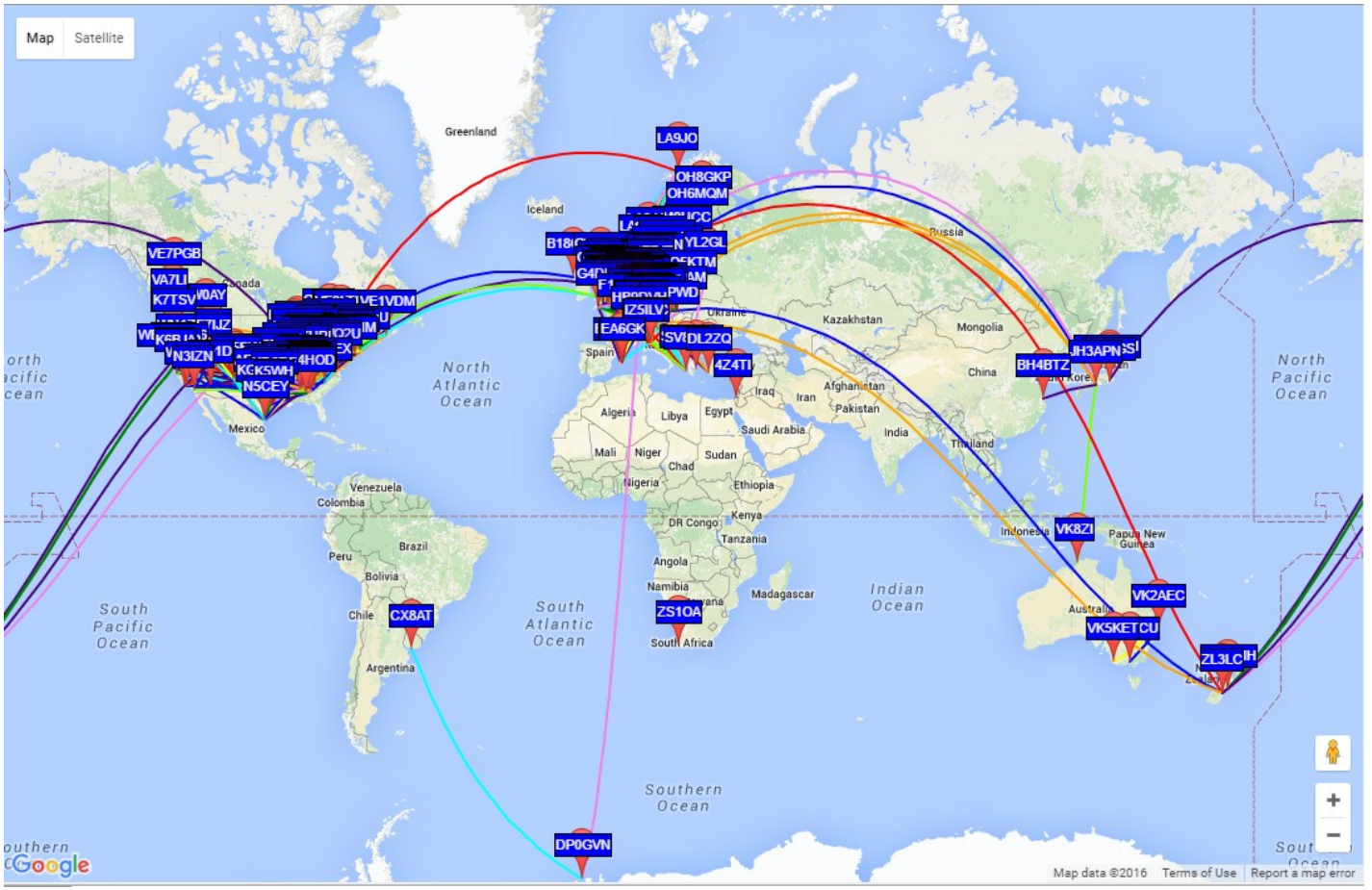
- Moonbounce

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 progagation 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

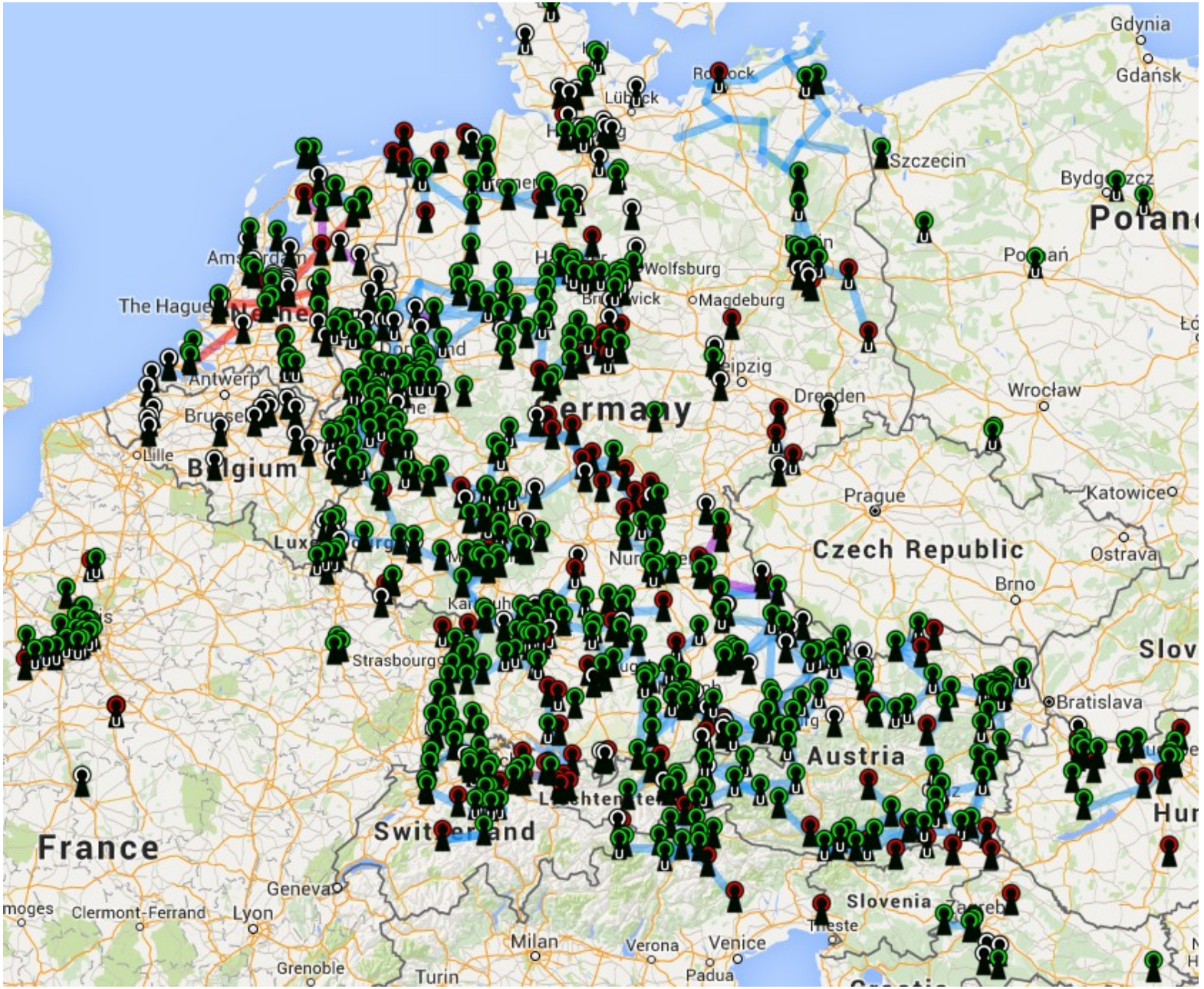
Digital Radio Networks

- 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 encapsulaton in AX.25
    - Phil Karns, KA9Q, IP-stack implementation from 1985 envolved 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 **Net**work
- 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


Gdynia
Gdańsk
Szczecin
Wolfsburg
Magdeburg
Dresden
Wrocław
Prague
Katowice
Ostrava
Brno
Czech Republic
Austria
Bratislava
Slovenia
Switzerland
France
Belgium
Lille
Antwerp
Strasbourg
Geneva
Lyon
Clermont-Ferrand
Grenoble
Turin
Milan
Verona
Venice
Padua
Trieste

Standard Deployment Example #1

2.3 GHz User Access Antenna
~20 $

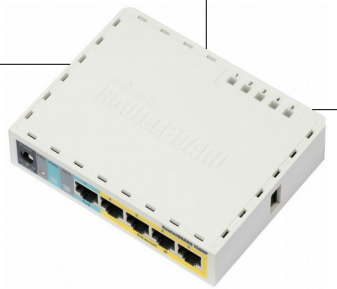
up to 32dBm

2.3 GHz user access trx
Mikrotik Metal 2SHPn
~99 $

23dBi

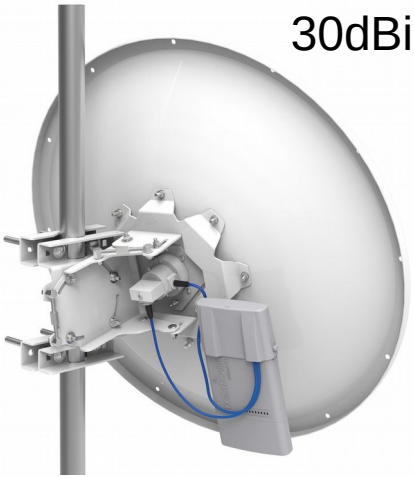
LAN+PoE

LAN+PoE



LAN+PoE

30dBi



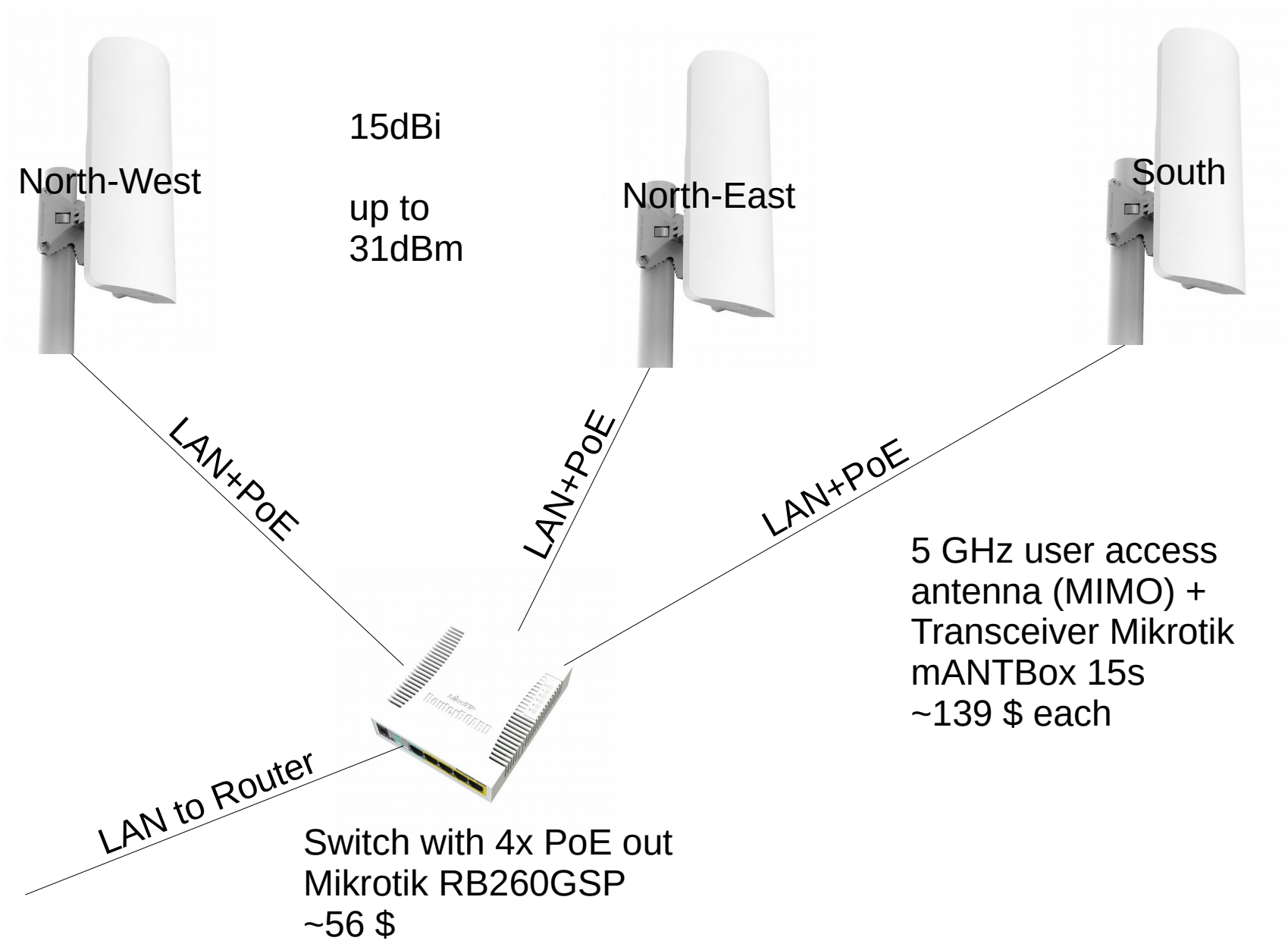
5 GHz mid range link
antenna (MIMO)
+ build-in trx
Mikrotik QRT-5
~169 $

Router with 4x PoE out
Mikrotik RB750UP
~59 $

5 GHz trx (MIMO)
Mikrotik BaseBox5
~89 $

5 GHz long range link
antenna (MIMO)
Mikrotik mANT30 PA
~129 $

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

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	Wiki
I	Italy	64600-64619	Wiki
DL	Germany	64620-64683	List or WHOIS-Search
LX	Luxemburg	64684-64685	Wiki
CR	Croatia	64686-64690	Wiki
PA	Netherlands	64691-64694	Wiki
S5	Slovenia	64695-64704	Wiki
HA	Hungary	64705-64707	Wiki
EA	Spain	64708-64719	Wiki
HB	Switzerland	64720-64739	Wiki
HB0	Liechtenstein	64740-64741	Wiki
F	France	64742-64777	Wiki
ON	Belgium	64778-64788	Wiki
TA	Turkey	64789-64799	Wiki
SP	Poland	64800-64839	Wiki
YO	Romania	64840-64849	Wiki

* Test and BGP-Confederations 65510-65534 Wiki

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 (prefered): 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
dc4ab	Andreas	Sysop DB0DLX	293d dk2crn

- They can create an account for you to edit the database
- Or ask me (dg8ngn@darc.de) to get you an account

Deployment - Sites

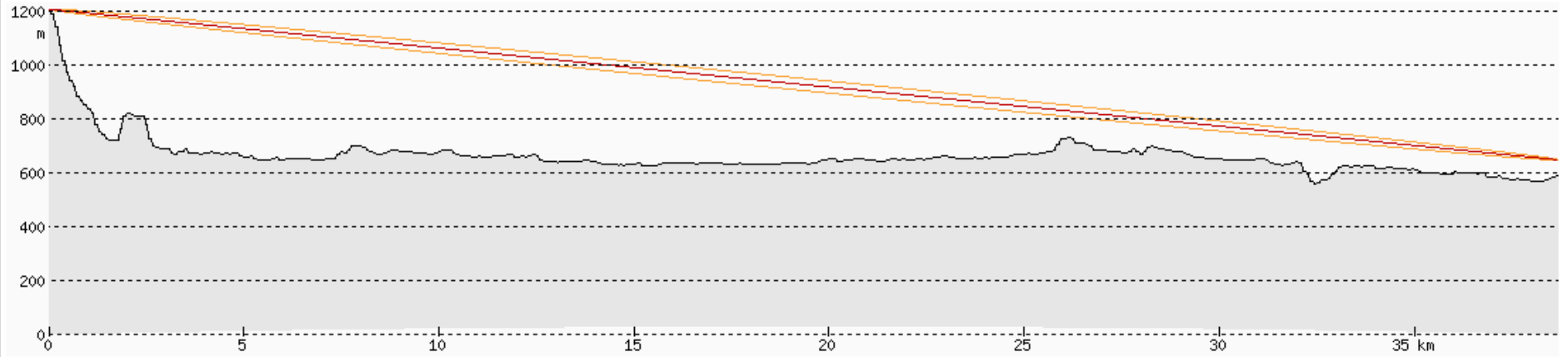
- Login to http://hamnetdb.net
- Click on „Sites“
- Press „New Site“
- Fill the following data into the form:
  - Call sign
  - Descriptive Name
  - Latitude, Longitude and meters above **ground**
  - Comma separated list of maintainers

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		Profile | Show in linktool
	db0pme	Hintereck / Gmund am Tegernsee	21.2 km	84.5°	5 m	⊕	Profile | Show in linktool
	db0pm	Brenten / Hausham	26.7 km	85.2°	9 m	⊕	Profile | Show in linktool
	db0abx	Laber	33.9 km	240.8°	5 m		Profile | Show in linktool
	No Call	Raisting EMC-Turm	34.3 km	304.3°	35 m		Profile | Show in linktool
	dl0igi	Hohenpeissenberg	36.1 km	281.9°	50 m		Profile | Show in linktool
	dm0gap	Wank / Garmisch-Partenkirchen	36.6 km	226.7°	8 m	⊕	Profile | Show in linktool
	db0ona	Hohenpeissenberg	36.8 km	281.5°	4 m	⊕	Profile | Show in linktool
	db0dba	München DEBA-Hochhaus	38.6 km	0.6°	61 m	⊕	Profile | Show in linktool



- 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

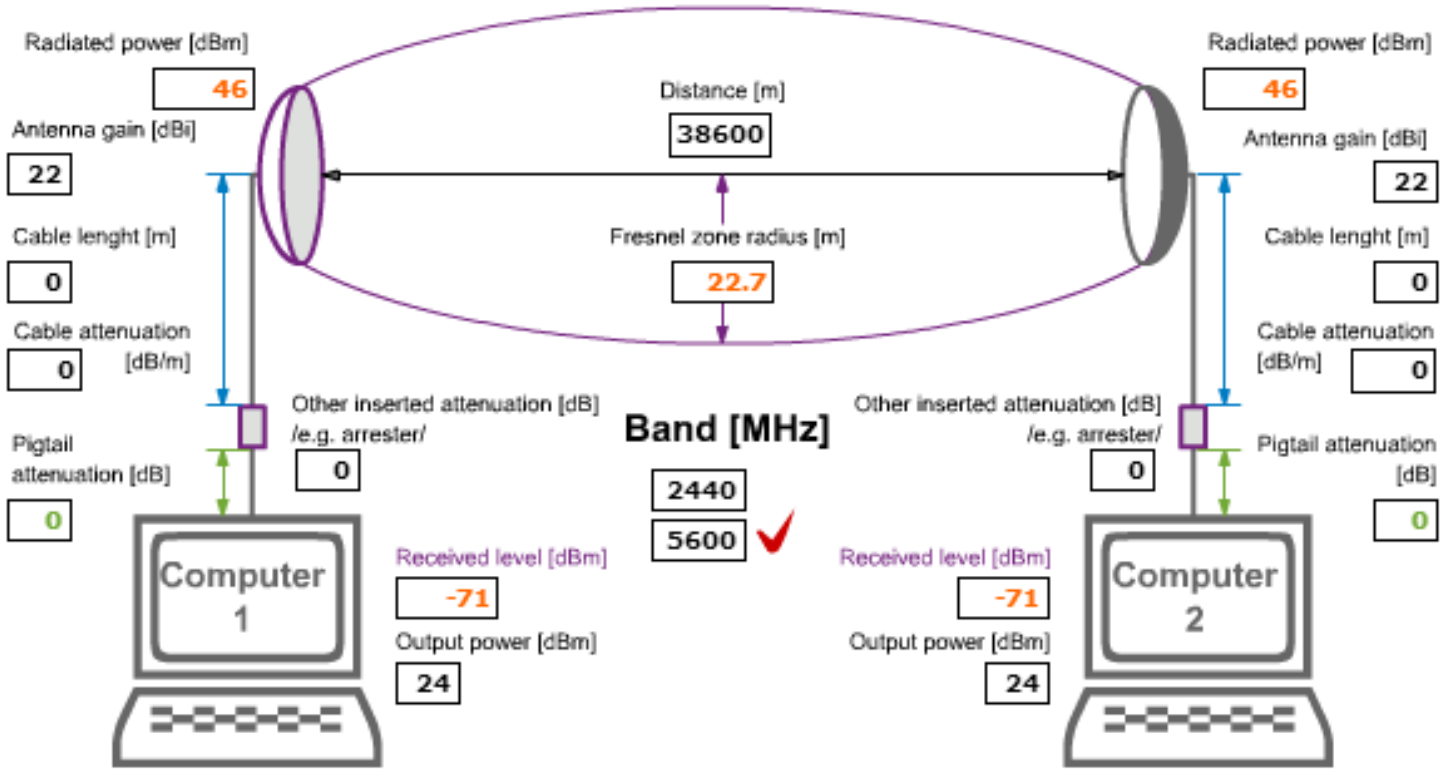
- Check additional losses of antenna gain by looking into chart „gain vs. frequency“ (if provided by manufacturer)

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

http://en.wikipedia.org/wiki/IEEE_802.11n-2009

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-Mulitpoint Links?

Deployment - Identification

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

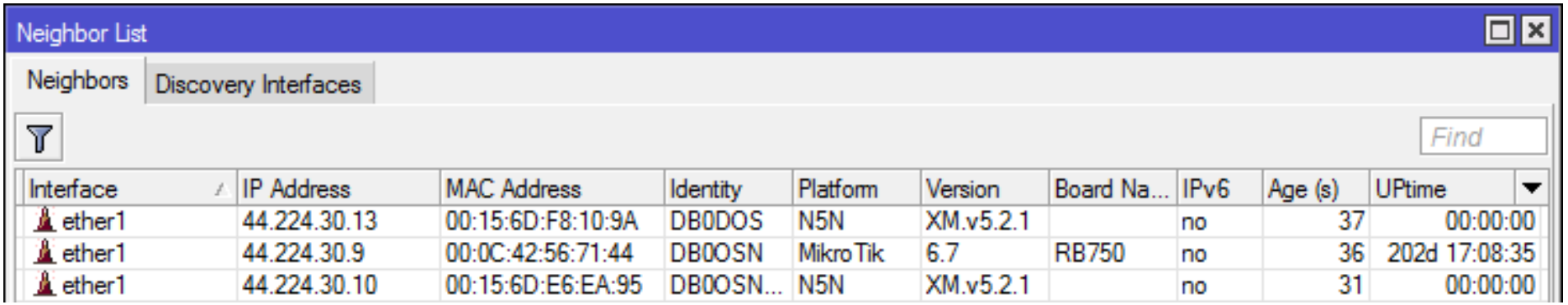
```
 Byte 6   Byte 5   Byte 4   Byte 3   Byte 2   Byte 1
RRRRRRXX RRRRRRNN RRRRRRSS RRRRRRSS RRRRRRSS RRRRRRSS
8 Bit  1 8 Bit  1 8 Bit  1 8 Bit  1 8 Bit  1 8 Bit  1

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



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
```

http://www.de.ampr.org/dokumentation/as-nummern/as-list-de

Deployment – AS-Allocation

- Information is reflected in the HAMNETDB

The Hamnet-Database Show: Map Fullscreen Map OSM

	AS	Name	Maintainer	Comment	Edited
	AS64625	DISTRIKT-C-625-AS	dl3mbg,dg8ngn	Oberbayern	567d dl8mbt
	AS64626	DISTRIKT-B-626-AS	dg8ngn	Franken	598d dg8ngn
	AS64627	DISTRIKT-L-627-AS	dd9qp	Niederrhein - WES, KLE	162d dd9qp
	AS64628	DISTRIKT-S-628-AS	dg1cpa	Distrikt Sachsen	510d dd9qp
	AS64629	DISTRIKT-D-629-AS	dl7uaz	Berlin	594d dg8ngn
	AS64630	DISTRIKT-U-630-AS	dl8rds,dg8ngn	Ostbayern	594d dg8ngn
	AS64631	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
	44.130.53.0/24	AS-Packet-Radio	-	AS64631		393d dg8ngn
	44.130.56.0/24	AS-Packet-Radio	-	AS64625		393d dg8ngn
	44.130.59.0/24	AS-Packet-Radio	-	AS64630		393d dg8ngn
	44.130.60.0/24	AS-Packet-Radio	-	AS64626		399d dg8ngn
	44.130.61.0/24	AS-Packet-Radio	-	AS64631		393d dg8ngn
	44.130.99.0/24	AS-Packet-Radio	-	AS64626		186d dg8ngn
	44.130.146.0/24	AS-Packet-Radio	-	AS64627	Distrikt-L Packet-Radio Netz	162d dd9qp
	44.224.10.0/23	AS-Backbone	-	AS64625		665d dg8ngn
	44.224.12.0/23	AS-Backbone	-	AS64626		594d dg8ngn
	44.224.14.0/23	AS-Backbone	-	AS64627	Distrikt-L Backbone Netz	579d dg8ngn
	44.224.16.0/23	AS-Backbone	-	AS64628		594d dg8ngn
	44.224.18.0/23	AS-Backbone	-	AS64629	Berlin Backbone Netz	585d dl7uaz
	44.224.20.0/23	AS-Backbone	-	AS64630		594d dg8ngn
	44.224.22.0/23	AS-Backbone	-	AS64631		594d dg8ngn
	44.225.20.0/22	AS-User/Services	-	AS64625		689d dl8mbt
	44.225.24.0/22	AS-User/Services	-	AS64626		594d dg8ngn
	44.225.28.0/22	AS-User/Services	-	AS64627	Distrikt-L User/Services Netz	579d dd9qp
	44.225.32.0/22	AS-User/Services	-	AS64628		594d dg8ngn
	44.225.36.0/22	AS-User/Services	-	AS64629	Berlin User-Service Netz	458d dl9sau
	44.225.40.0/22	AS-User/Services	-	AS64630		688d dl8mbt
	44.225.44.0/22	AS-User/Services	-	AS64631		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 sitenetwok 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		lnk-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
	44.224.10.0/23	**AS-Backbone**	-	AS64625		665d dg8ngn
	44.224.10.40/29	Backbone-Network	-	AS64625	*db0zm,db0wai* - 5825MHz,10MHz,horizontal	691d dl8mbt
	44.224.10.48/29	Backbone-Network	-	AS64625	*db0tvm,db0zm* - 5685MHz,10MHz,horizontal	691d dl8mbt
	44.224.10.72/29	Backbone-Network	-	AS64625	*db0zm,db0ebe* - 5795MHz,10MHz,vertikal	691d dl8mbt
	44.225.20.0/22	**AS-User/Services**	-	AS64625		689d dl8mbt
	44.225.20.192/28	Site-Network	AS65530	AS64625	*db0zm*	264d dg8ngn

6 entries.

Surrounding AS:

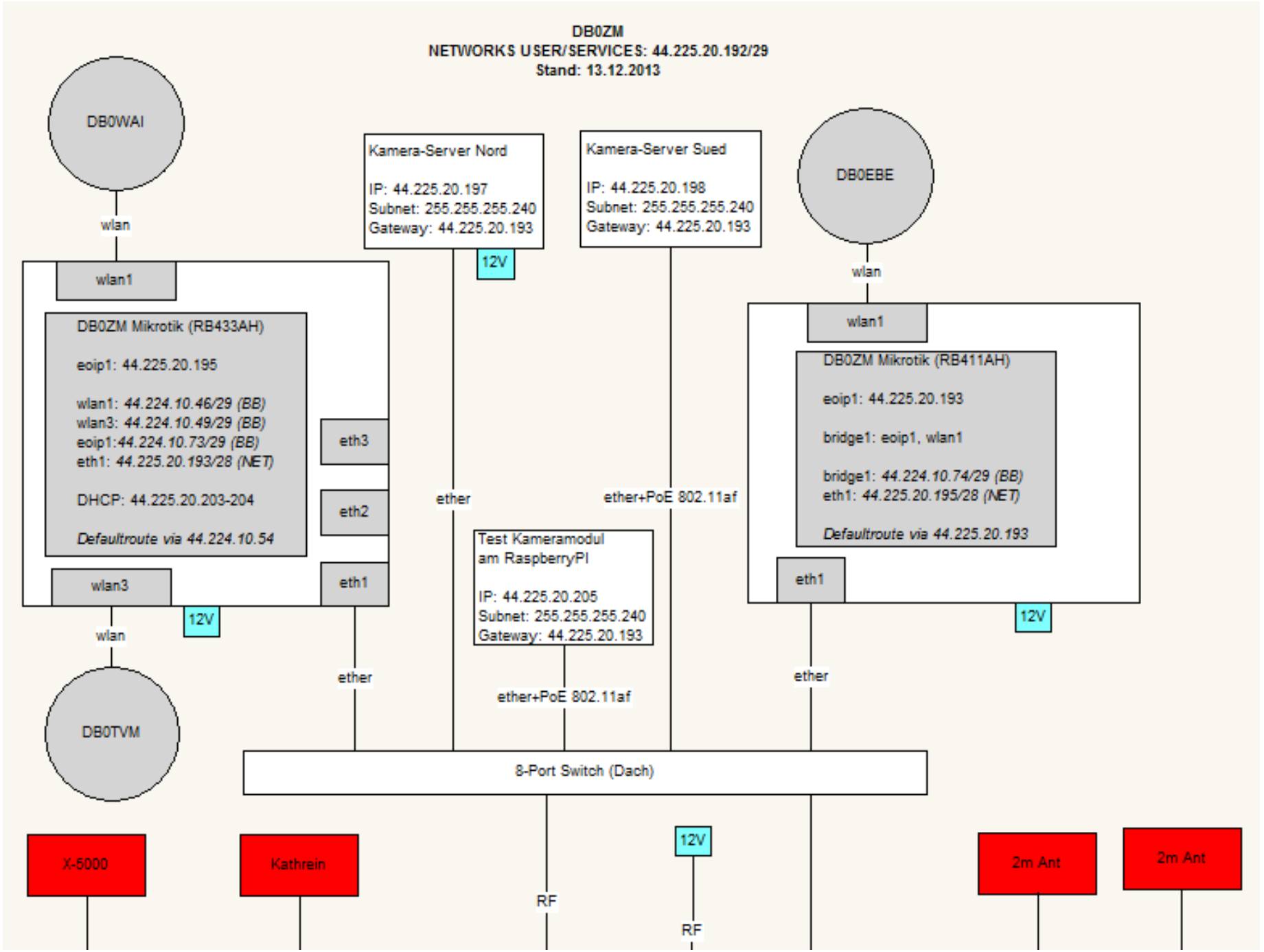
	AS	Name	Maintainer	Comment	Edited
	AS64625	DISTRIKT-C-625-AS	dl3mbg,dg8ngn	Oberbayern	567d dl8mbt

1 entry.

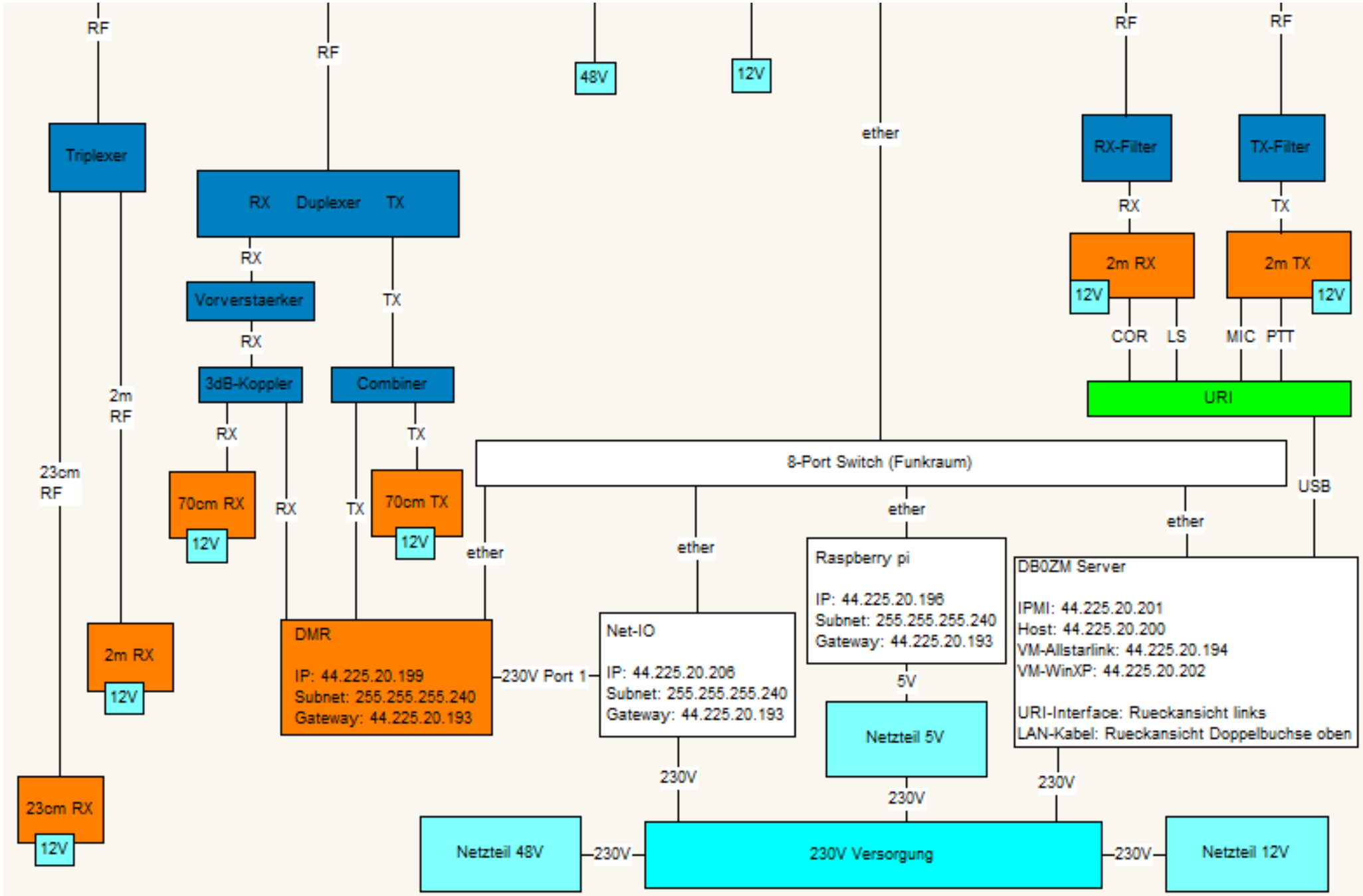
Other sites near db0zm:

	Site	Name	Distance	Direction	Above ground	Edge	
	db0tvm	München Olympiaturm	4.4 km	256.2°	200 m		Profile | Show in linktool
	dl0muc	Clubstation Chaos Computer C..	5.0 km	228.0°	30 m		Profile | Show in linktool

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:

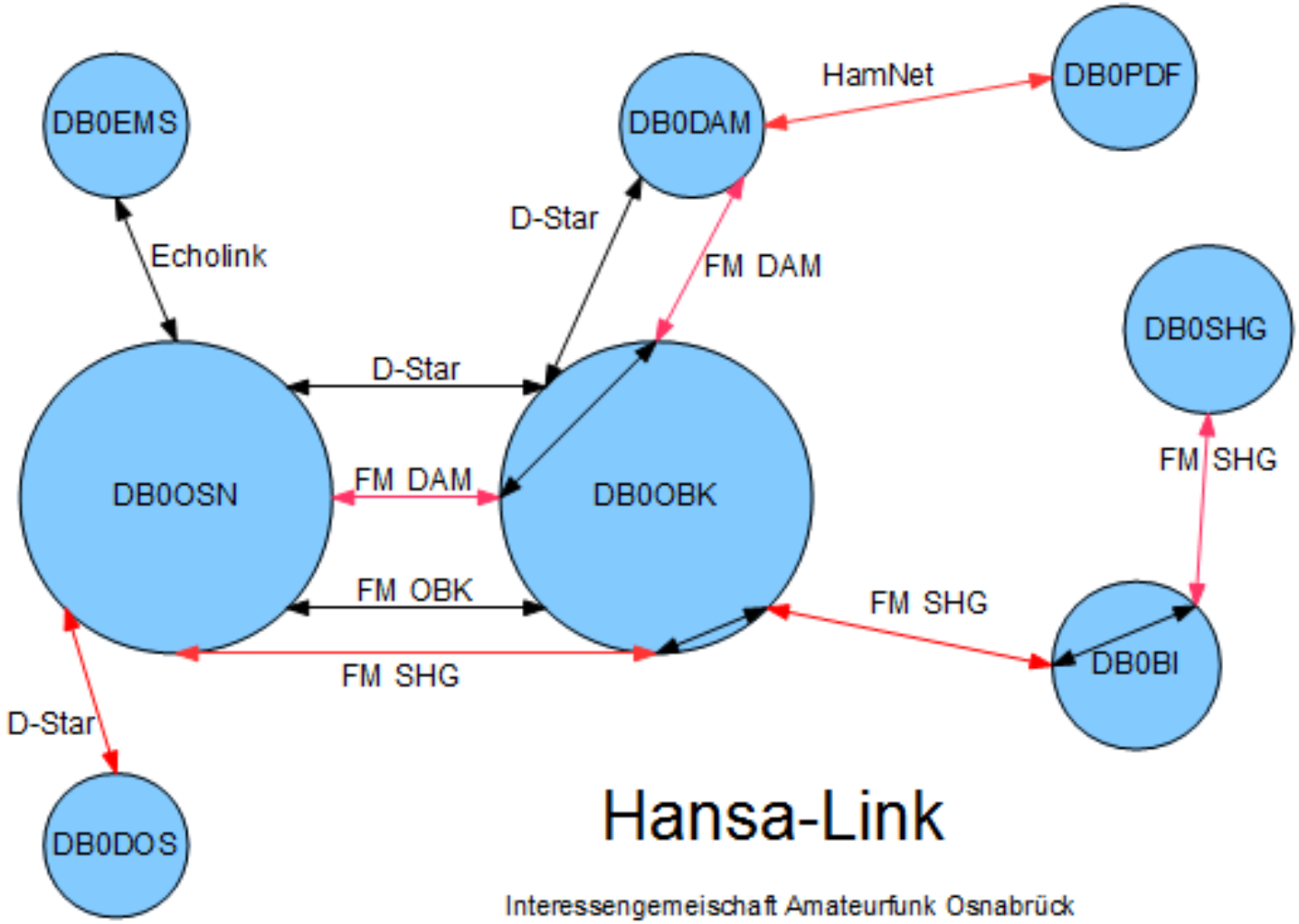
  - DATV, VoIP (DMR, D-Star, Echolink, Asterisk), APRS, Packet Radio
  - whatever you can transport on TCP/IP...
- Build an independent network for emergency communication (where the funding could come from…)
- Connecting public non-commercial webcams to the Internet

Motivation – Learning & Experimentation

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

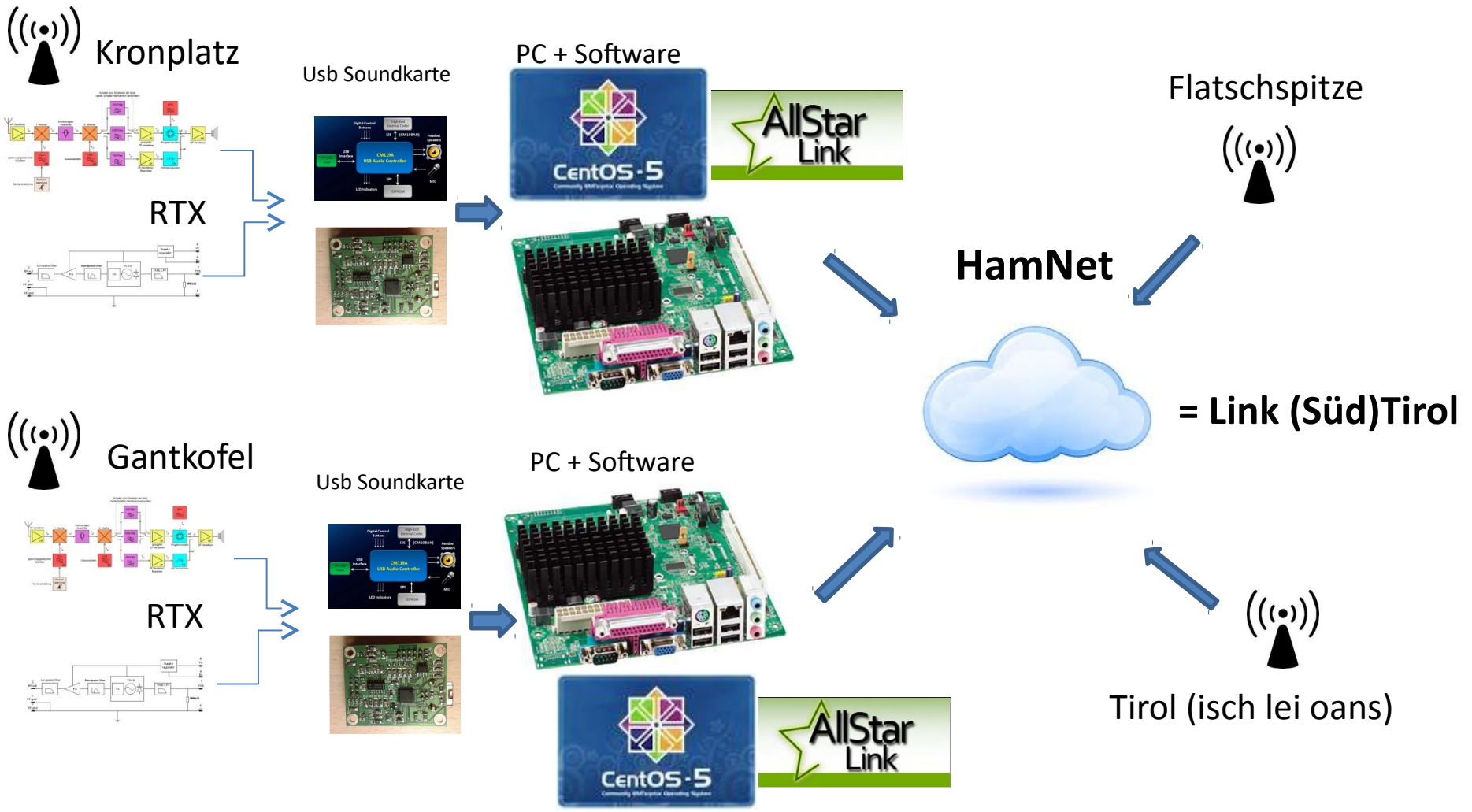
Application Examples - FM Repeater Group (SVXLink)

- Hansa-Link Network



Application Examples - FM Repeater Group (Allstarlink)

- Link (Süd) Tirol



Application Examples – ATV Livestreaming

Home Startseite | ATV Info rund ums Fernsehn | 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 Kontakt aufnehmen.


DB0KWE Livstream
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

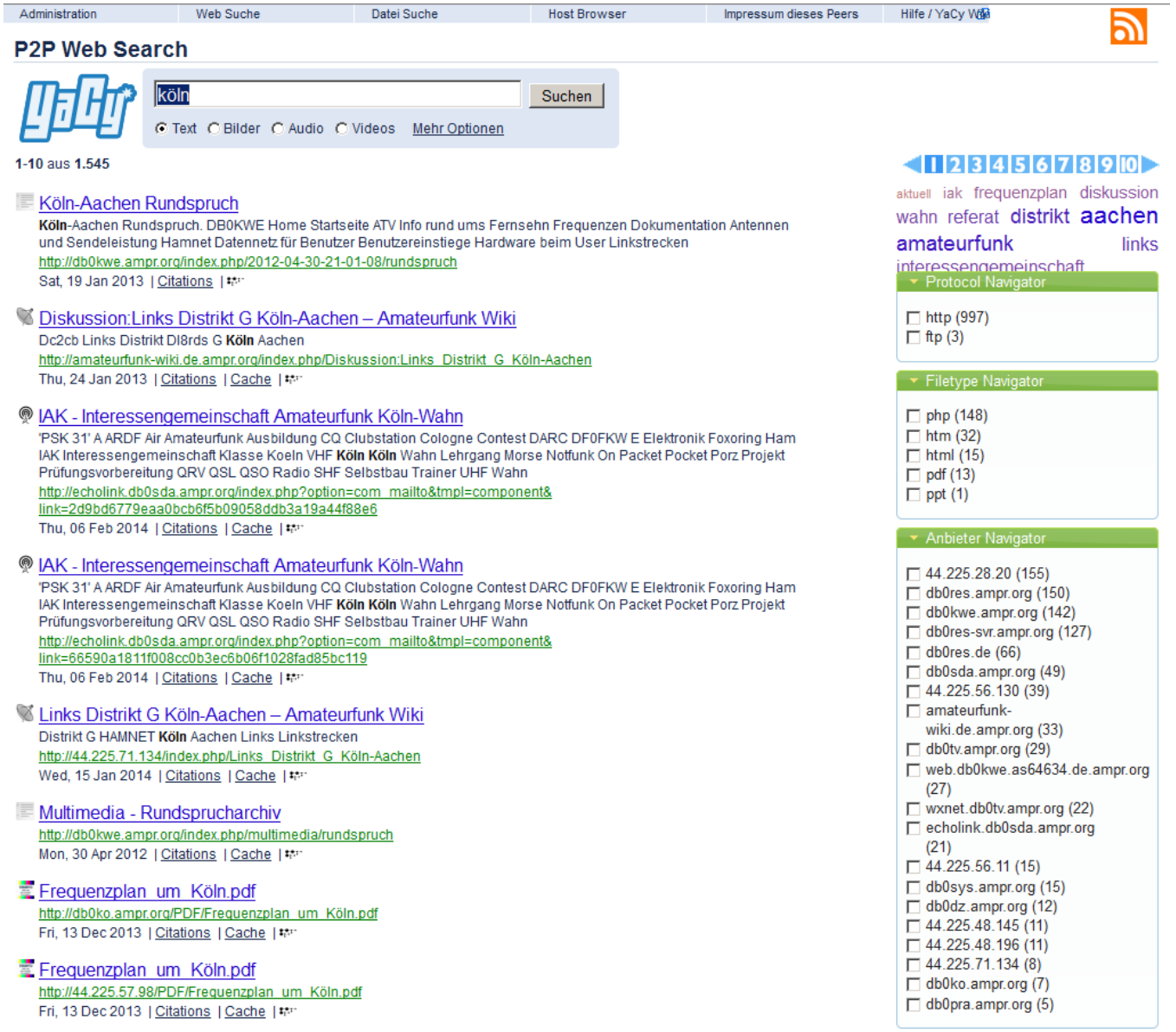

DF5KT Livestream
Bei Bedarf kann Norbert hier einen Videostream senden


DL2KBH Livestream
Bei Bedarf kann Dieter hier einen Videostream senden

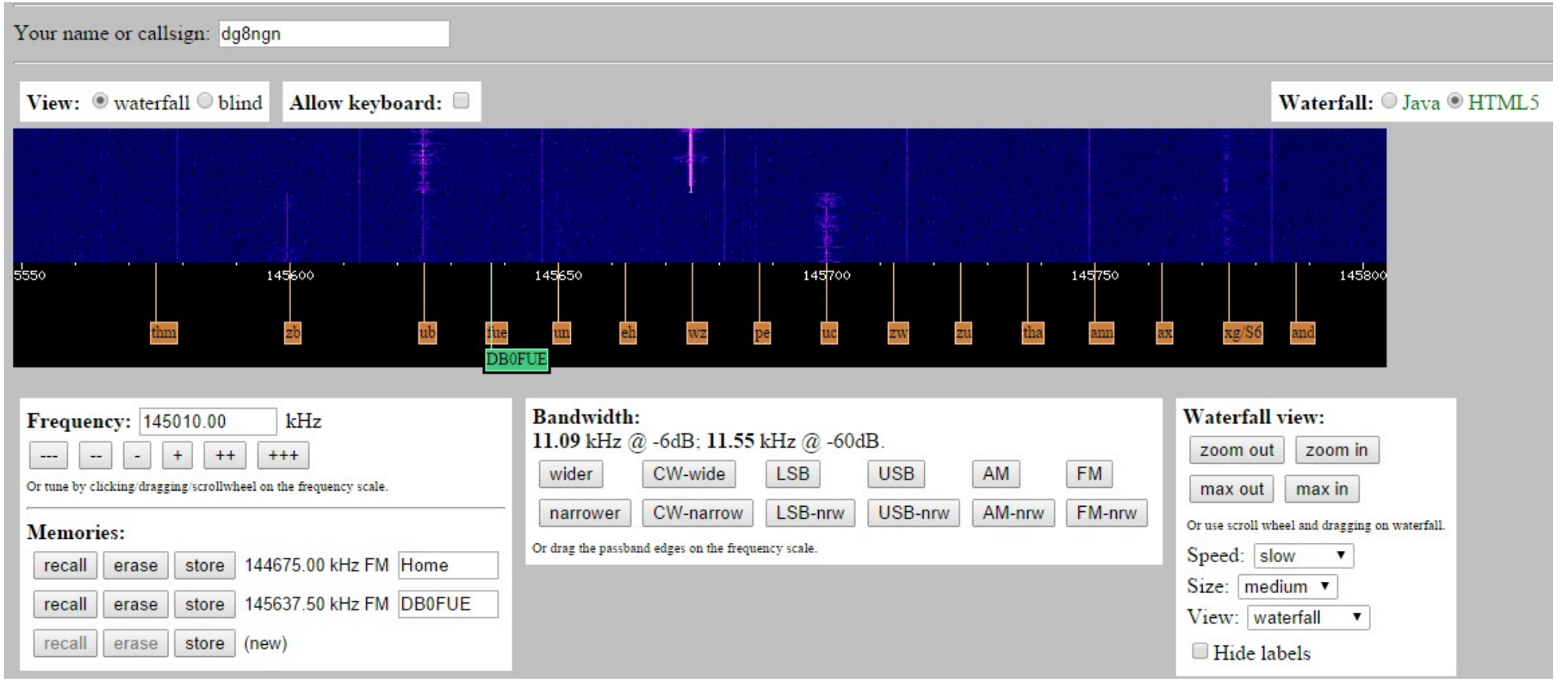
test Livestream
ATV-Livebild das im Moment in xxx ausgestrahlt wird

Application Examples – Social Network

Application Examples - Searchengines



Application Examples - WebSDR



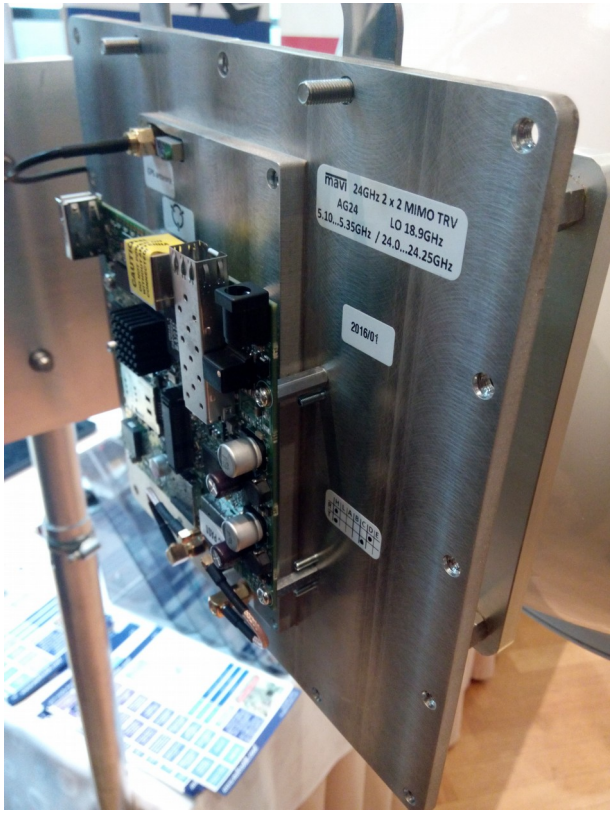
http://websdr.org

Application Examples - Webcams

http://www.foto-webcam.eu

Challenges – More bands

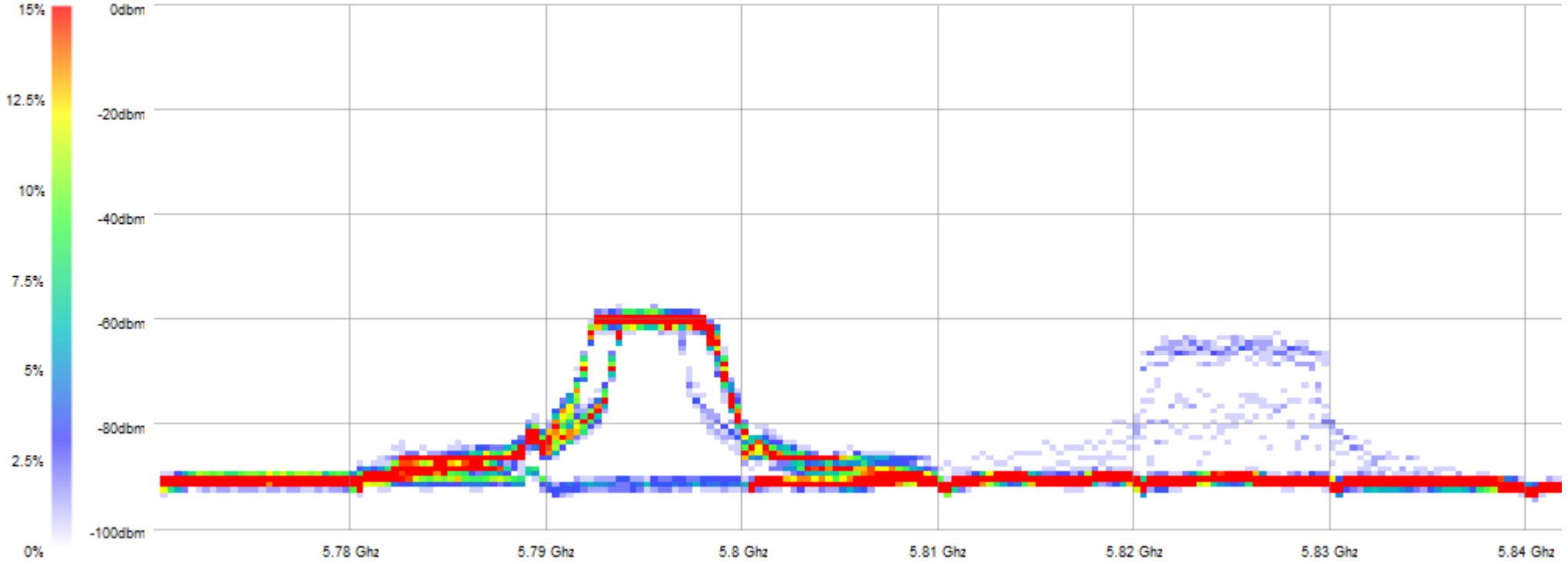
- 9cm – 3.4 GHz is available for amateur radio
  - more expensive compared to 6cm/13cm
- 3cm – 10 GHz: No Equipment from Mikrotik
- 24 GHz: Transverters
  - high price
- or even higher? 47 GHz, 76 GHz, ...
- Homebrew Up-/Downconverter?
  - Full duplex with Mikrotik NStreme Dual possible
    - One card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



24 GHz Transverter seen at MUM, Ljubljana, 2016

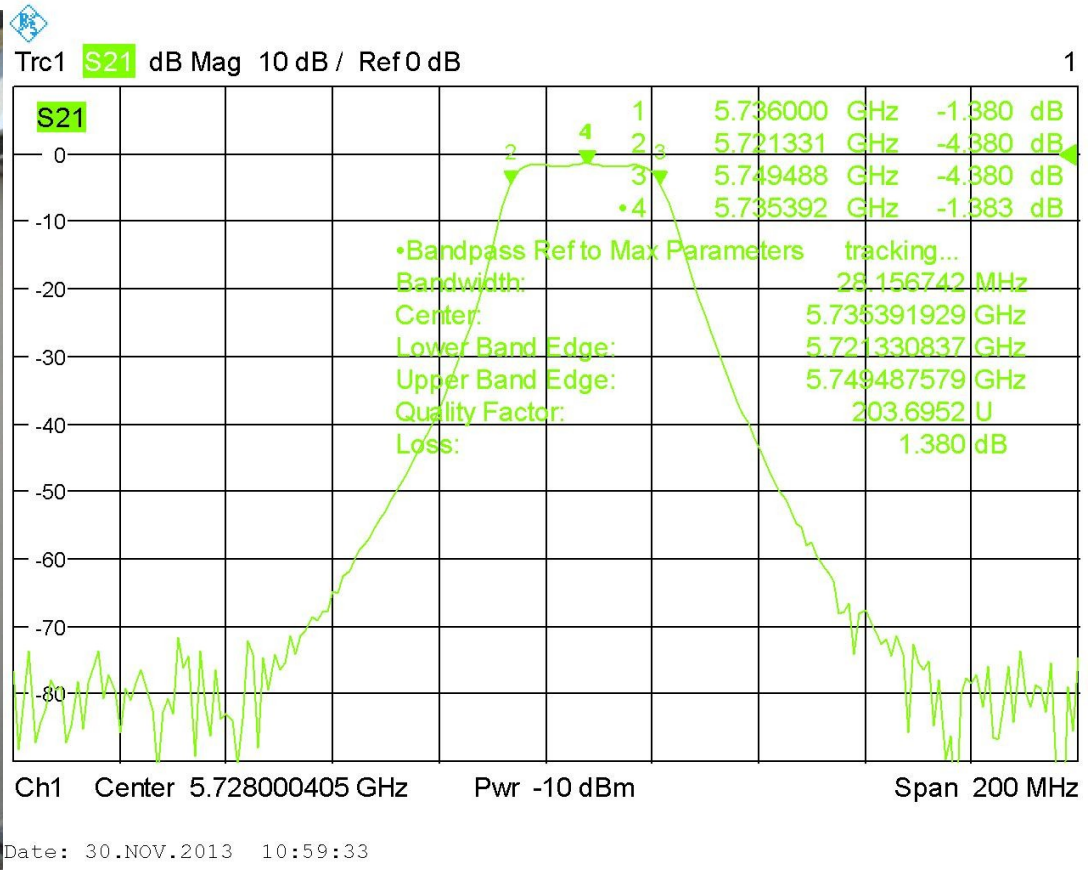
Challenges – Spurious emissions

- 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

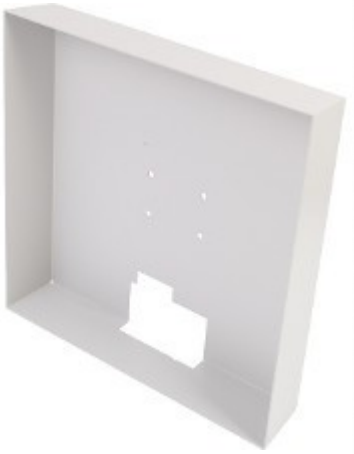
- Metal 5SPHn + Filters



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

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 troughput 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 perspectvie

- 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 manufactors

Impressions

Gefrorenen Wand, OE7XGR, 3255m

Observatorium Sonnblick, OE2XSR, 3106m