Federal Office
of Metrology and
Surveying

bev.gv.at

Amateur radio interference on APOS-stations 2017

EUPOS Council and Technical Meeting 2019, Budapest

Ernst Zahn
BEV – Federal Office of Metrology and Surveying
Budapest, 30th October 2018

1240 -1300 MHz Bandplan (Amateur Radio, Status 2016)

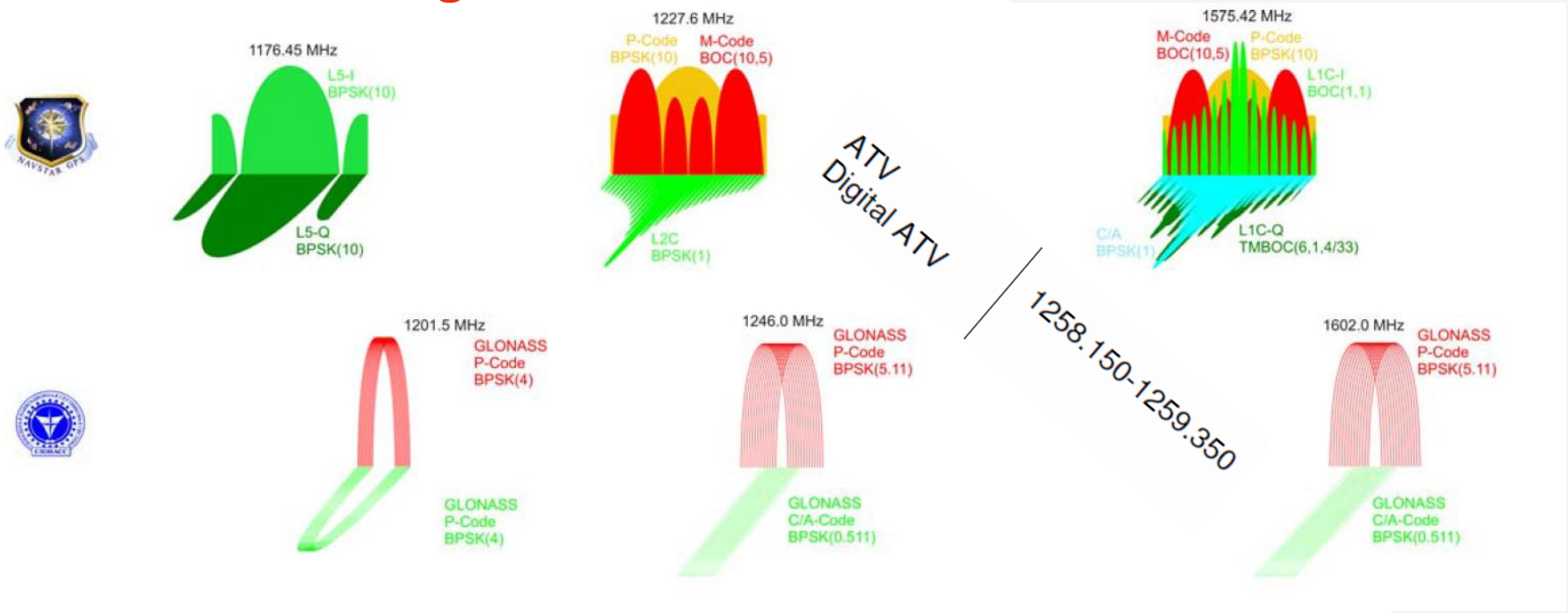
Frequency MHz	Maximum Bandwidth	MODE	USAGE	
1240.000 1240.500	2700 Hz	ALL MODE	(reserved for future)	
1240.500 1240.750	500Hz	Telegraphy MGM	Beacons (reserved for future)	
1240.750 1241.000	20kHz	FM Digital voice	(reserved for future)	
1241.000 1243.250	20kHz	ALL MODE	1240.000-1241.000 1242.025-1242.250 1242.275-1242.700 1242.725-1243.250	Digital communications Repeater output, ch. RS1 - RS10 Repeater output, ch. RS11 - RS28 Digital communications, ch. RS29 - RS50
1243.250 1260.000	(d)	ATV Digital ATV	1258.150-1259.350	Repeater output, ch. R20 - R68

INTERNATIONAL AMATEUR RADIO UNION REGION 1

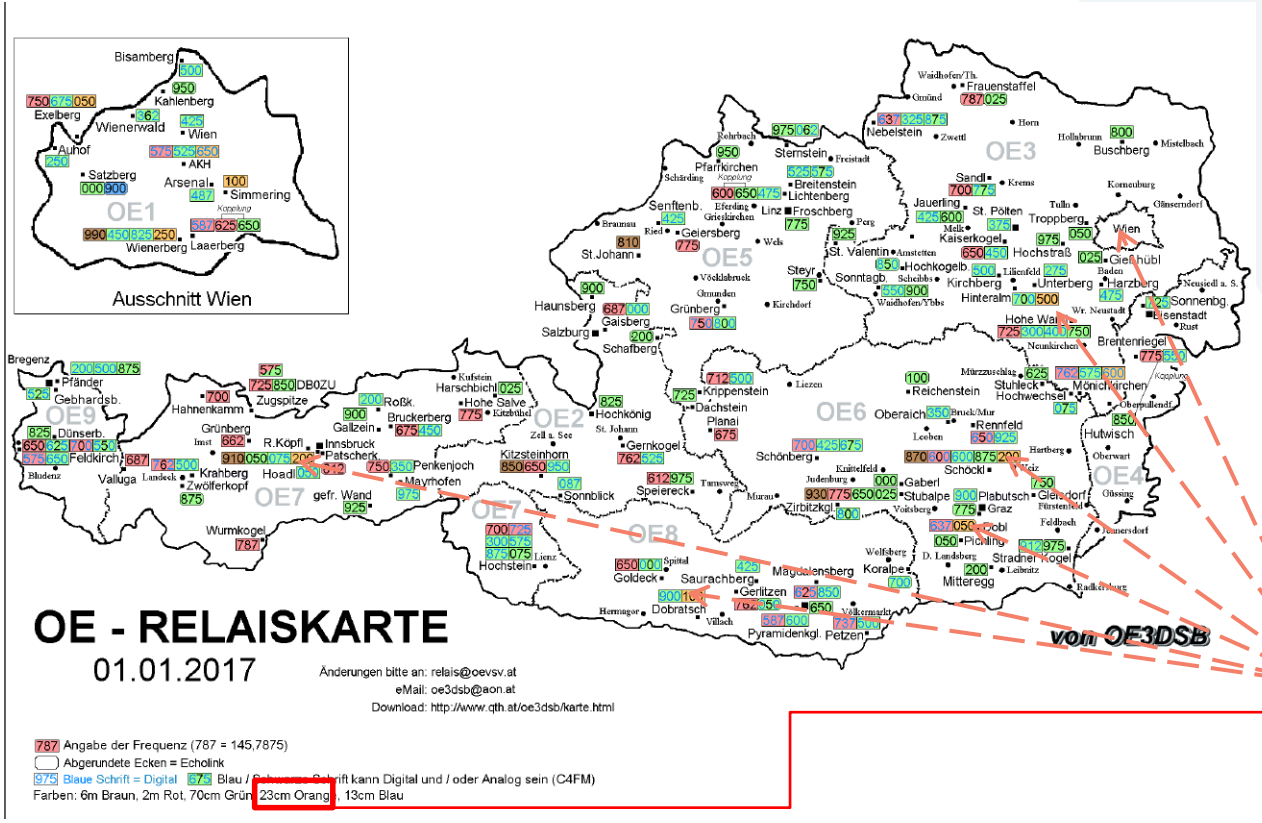
VHF MANAGERS HANDBOOK

(Maybe switch to 430-440 MHz)

GPS & GLONASS Signals



Relais Map of the Austrian test transmitter association (ATV)



23 cm (orange)

Chronology APOS <> ATV (Part I)

2010

- Contact with the „Austrian Supreme Radiocommunications Authority“ (SRA) in terms of ATV-problems

- Primary/Secundary users: ATV and other radio amateurs are secundary users and will be forced to switch to another band mid-term. SRA admitts that GLONASS because of its disastrous situation several years ago was not really in their focus. The BEV is the first to appear, describes the current situation and „ thus forces the SRA to take action“.

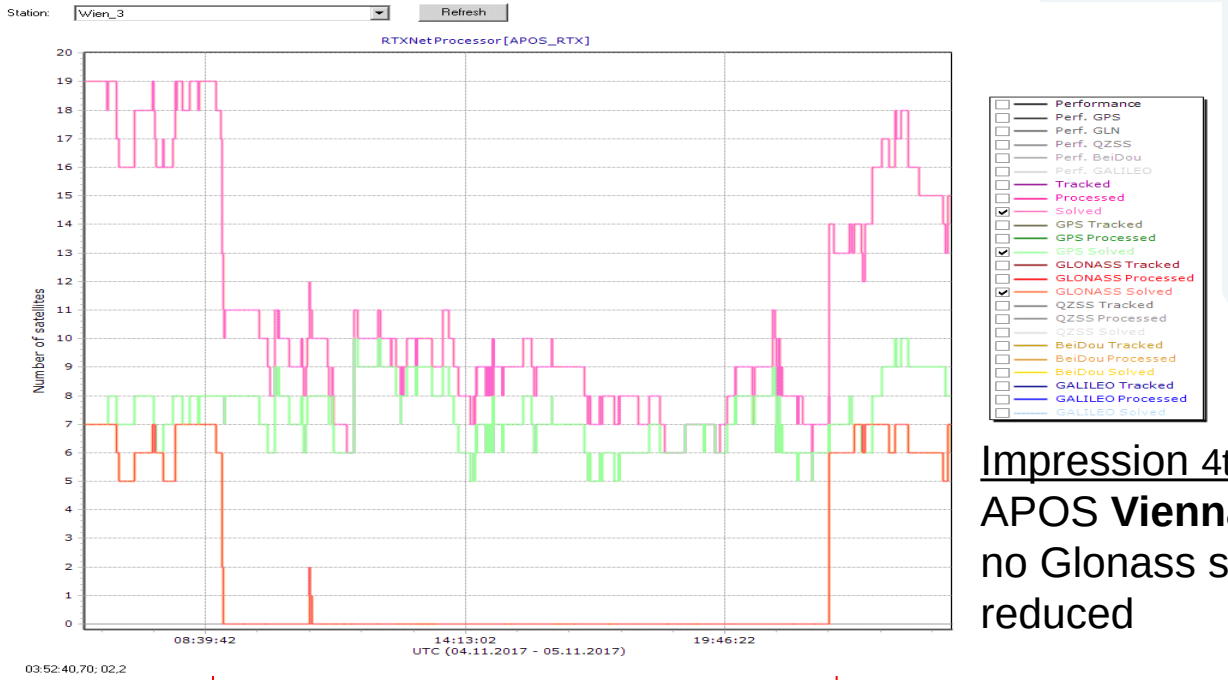
Chronology APOS <> ATV (Part II)

2010

- Agreement with ATV: Temporary leaving of the 23cm band during night time though problems for stations and users possibly can occur
- SRA shall find out further jammers in cooperation with the ATV and externals
- 1st step: closing of the relaisstation Bisamberg/Vienna a.s.a.p.

2011 or later: with the help of ATV-Austria we solved a similar problem in Marburg …

2017: Final APOS - tests and closing of ATV activities in the L2-Band



<u>Impression 4th Nov. 2017</u>

APOS **Vienna** (Wien_3), Leica GR30, no Glonass solving / GPS tracking reduced

Impression 30th Oct. 2017

Vienna-Testbed (Wien/Wien3): simultaneous GNSS-tracking with/without filtering

Satellite Tracking | Skyplot | Receiving Info | Multipath | Raw Data Analysis

Sat	El [°]	Az [°]	SNR (CA/P1/E1/B1)	SNR (L2/L2C/L2CA)	SNR (L5/E5/E5A/E5B)	SNR (E6/B3)	CA/P1/E1/B1	L2/L2C/L2CA	L5/E5/E5A/E5B
C02	4	107	-	-	- / - / - / 41	-	-	-	- / - / - / 3046
C05	19	130	- / - / - / 42	-	- / - / - / 43	-	- / - / - / 20989	-	- / - / - / 20989
C07	15	70	- / - / - / 42	-	- / - / - / 43	-	- / - / - / 4749	-	- / - / - / 4995
C09	18	61	- / - / - / 42	-	- / - / - / 43	-	- / - / - / 31341	-	- / - / - / 31341
C10	14	93	- / - / - / 42	-	- / - / - / 42	-	- / - / - / 3904	-	- / - / - / 3969
E01	1	5	- / - / 43	-	- / 44 / 42 / 42	-	- / - / 6834	-	- / 6833 / 6762 / 6692
E03	52	249	- / - / 51	-	- / 52 / 51 / 51	-	- / - / 8989	-	- / 9352 / 9045 / 9361
E05	71	57	- / - / 51	-	- / 52 / 52 / 52	-	- / - / 16985	-	- / 16983 / 16983 / 168
E08	2	246	- / - / 42	-	- / 44 / 42 / 42	-	- / - / 159	-	- / 157 / 157 / 157
E09	18	64	- / - / 47	-	- / 49 / 47 / 47	-	- / - / 23200	-	- / 23197 / 23199 / 231
E14	31	242		-	-	-	-	-	-
E22	50	203	- / - / 51	-	- / 52 / 51 / 51	-	- / - / 19402	-	- / 19401 / 19401 / 194
E24	10	102	- / - / 46	-	- / 47 / 45 / 45	-	- / - / 2071	-	- / 2070 / 2070 / 2070
G01	51	154	51	30 / 34	-	-	17592	15428 / 11421	-
G03	80	353	52	33 / 36	-	-	12720	11393 / 8201	-
G06	12	313	44	18	-	-	1392	339	-
G09	22	221	48	26	-	-	3102	1795	-
G11	26	172	46	16	-	-	19062	16630	-
G12	0	348	46	17	-	-	330	1	-
G14	14	48	45	15	-	-	16872	231	-
G17	34	271	50	24 / 30	-	-	9528	8152 / 765	-
G19	30	297	47	24	-	-	6342	-	-
G22	65	80	50	30	-	-	16157	-	-
G23	53	212	50	28	-	-	7169	-	-
G31	30	66	50	22 / 28	-	-	8118	-	-
J02	8	40		-	-	-	-	-	-
R04	20	60	48	-	-	-	18098	-	-
R05	66	21	47	-	-	-	12636	-	-
R06	40	268	48	-	-	-	5904	-	-
R13	7	7	40	-	-	-	7448	-	-
R14	45	207		-	-	-	-	-	-
R15	18	100	47	-	-	-	2764	-	-
R20	44	203	48	-	-	-	13696	-	-
R21	52	296	50	-	-	-	7194	-	-

GPS L2 - mitigation

No Glonass L2

Login: admin

Device Manager [Test]
- GNSS Receiver [Wien]
- GNSS Receiver [Wien_3]

Septentrio POLARX5
(Auto Notch filter aktivated)

Device Manager [Test]
- GNSS Receiver [Wien]
- GNSS Receiver [Wien_3]

Leica GR 30 (No filter)

Satellite Tracking | Skyplot | Receiving Info | Multipath | Raw Data Analysis

Sat	El [°]	Az [°]	SNR (CA/P1/E1/B1)	SNR (L2/L2C/L2CA)	SNR (L5/E5/E5A/E5B)	SNR (E6/B3)	CA/P1/E1/B1	L2/L2C/L2CA	L5/E5/E5A/E5B
C09	18	61	- / - / - / 44	-	- / - / - / 44	-	- / - / - / 31427	-	- / - / - / 31427
C10	14	93	- / - / - / 43	-	- / - / - / 41	-	- / - / - / 3977	-	- / - / - / 3977
E01	1	5	- / - / 38	-	- / 42 / 39 / 39	-	- / - / 6959	-	- / 6959 / 6959 / 6959
E03	52	249	- / - / 48	-	- / 54 / 50 / 51	-	- / - / 9414	-	- / 9397 / 9398 / 9408
E05	70	57	- / - / 49	-	- / 55 / 52 / 52	-	- / - / 17024	-	- / 17029 / 17029 / 170
E08	2	246	- / - / 36	-	- / 40 / 37 / 37	-	- / - / 227	-	- / 224 / 227 / 227
E09	18	64	- / - / 44	-	- / 47 / 44 / 45	-	- / - / 23280	-	- / 23258 / 23260 / 232
E14	30	242		-	-	-	-	-	-
E22	49	203	- / - / 48	-	- / 54 / 50 / 51	-	- / - / 19432	-	- / 19431 / 19433 / 194
E24	10	102	- / - / 43	-	- / 45 / 42 / 42	-	- / - / 2139	-	- / 2139 / 2141 / 2141
G01	50	154	50	43 / 46	52	-	17628	17619 / 17626	17634
G03	80	354	52	47 / 48	55	-	12828	12805 / 12747	12828
G06	13	313	40	26 / 40	44	-	1770	1758 / 1765	1770
G09	22	221	47	35 / 42	46	-	3151	3135 / 3153	3186
G11	26	172	43	29	-	-	19092	19069	-
G12	0	348	42	21 / 32	-	-	472	408 / 25472	-
G14	14	48	42	25	-	-	16908	16885	-
G17	34	271	49	37 / 41	-	-	9552	9536 / 9530	-
G19	30	296	46	36	-	-	6193	6193	-
G22	65	80	48	42	-	-	15871	15871	-
G23	53	212	50	40	-	-	7006	7006	-
G25	0	21		-	-	-	-	-	-
G31	30	66	48	37 / 41	-	-	8136	8129 / 8119	-
J02	8	40		-	-	-	-	-	-
R04	19	60	50 / 49	44 / - / 44	-	-	18135 / 18127	18098 / - / 18125	-
R05	66	22	47 / 47	41 / - / 42	-	-	12672 / 12669	12195 / - / 12660	-
R06	40	268	48 / 48	42 / - / 42	-	-	5941 / 5936	5739 / - / 5875	-
R13	7	7	39 / 38	33 / - / 32	-	-	7464 / 7469	7432 / - / 7433	-
R14	45	207		-	-	-	-	-	-
R15	18	100	47 / 46	35 / - / 35	-	-	2480 / 2588	1771 / - / 1759	-
R20	44	203	47 / 47	48 / - / 47	-	-	13743 / 13725	13725 / - / 13725	-
R21	52	296	52 / 52	49 / - / 49	-	-	7225 / 7218	7205 / - / 7205	-
R22	9	337	44 / 44	41 / - / 42	-	-	1061 / 1061	1060 / - / 1110	-

GPS/Glonass L2 OK

Login: admin | 4197 MB | 30.09.2017 14:53:08 [UTC Time]

Status | History | Ionosphere | Residuals | Station Performance | Code Bias Calibration Status

Epoch [GPS Time]: 30.09.2017 14:53:58 Time since last initialization: 2d 23:04:38 Network performance 24h / 1h [%]: 88.13 89.44

Date of DCB files: 30.09.2017 [Trimble]

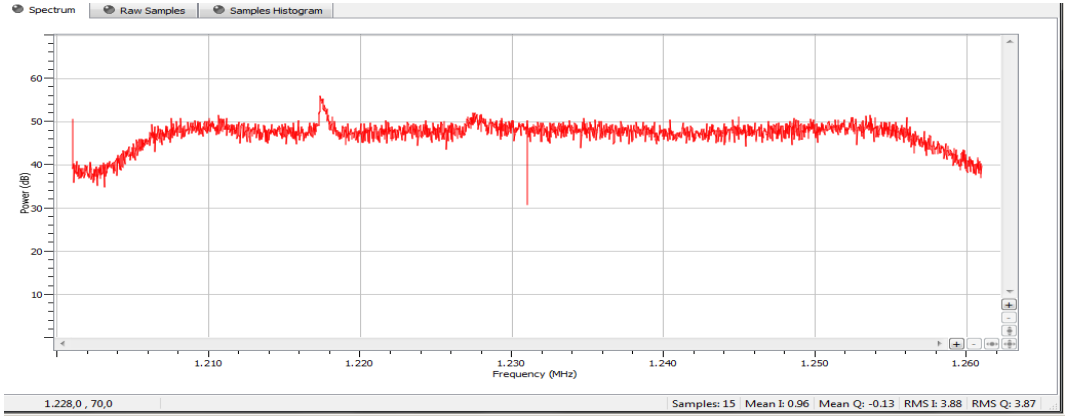
Station	Station Name	Station	Tra	Pro	Solved	GPS Solved	GLN Sol	GAL Processed	GAL Solved	BDS Processe	BDS Solve	24h Perfo	1h Perform	Not Solv
99	Wien_3	WIE3	15	15	9	8	0	0	0	3	1	83.65	81.85	G06[N] G
157	Dienten	DIEN	16	16	13	8	5	0	0	0	0	86.46	93.05	G06[N] G
185	Sillian	SIA2	15	15	14	9	5	0	0	0	0	90.72	93.76	R15[N]
123	Trafiberg	TRF2	16	16	14	9	5	0	0	0	0	87.23	93.52	G06[N] R
196	Kops	KOP2	16	16	14	9	5	0	0	0	0	86.96	90.71	G06[N] R
183	Muenster	MUEN	16	16	14	9	5	0	0	0	0	87.19	88.72	G09[N] R
546	Ceske_Budejovice	CBUD	18	18	14	9	5	0	0	0	0	87.78	87.41	G06[N] G
301	Koetschach	KOE2	16	16	14	9	5	0	0	0	0	85.32	88.00	G06[N] R
530	Finsterau	FNST	17	17	14	9	5	0	0	0	0	88.18	90.37	G06[N] R
529	Passau	PASU	18	17	14	9	5	0	0	0	0	88.65	91.79	G06[N] G
605	Bodonci	BODO	18	17	14	9	5	0	0	0	0	83.79	85.58	G06[N] G
601	Bovec	BOV1	16	16	14	9	5	0	0	0	0	88.04	90.97	G09[N] R
603	Sloveni_Gradec	SLOG	17	17	14	9	5	0	0	0	0	85.35	93.04	G06[N] G
150	Voecklabruck	VKLB	19	18	15	10	5	0	0	0	0	88.03	89.80	G06[N] R
158	Tamsweg	TAM2	18	17	15	10	5	0	0	0	0	86.90	90.36	G06[N] R
195	Lech	LECH	18	18	15	10	5	0	0	0	0	88.63	89.89	G06[N] R
106	Mistelbach	MSTB	18	18	15	9	6	0	0	0	0	89.25	91.12	G06[N] G
146	Ried im Innkreis	RIED	19	18	15	10	5	0	0	0	0	87.06	88.75	G06[N] R
794	Pfaender	PFA3	19	18	15	10	5	0	0	0	0	87.96	87.22	G06[N] R
149	Windischgarsten	WING	18	18	15	10	5	0	0	0	0	86.88	89.82	G06[N] R
182	Kitzbuehel	KTZ2	18	18	15	10	5	0	0	0	0	88.13	90.80	G06[N] R
147	Rohrbach	ROHR	19	18	15	10	5	0	0	0	0	88.30	89.39	G06[N] R
160	Doerflach	DOER	17	17	15	10	5	0	0	0	0	87.61	93.85	G06[N] R
193	Feldkirch	FLDK	19	18	15	10	5	0	0	0	0	88.07	87.23	G06[N] R
107	Gmuend	GMUE	19	18	15	9	6	0	0	0	0	87.66	90.20	G06[N] G
167	Hauser_Kaibling	HKBL	19	18	15	10	5	0	0	0	0	87.26	86.45	G06[N] R
187	Krahberg	KRBG	19	18	15	10	5	0	0	0	0	87.98	87.45	G06[N] R
188	Patscherkofel	PAT2	19	18	15	10	5	0	0	0	0	88.80	89.99	G06[N] R
547	Jindrichuv_Hradec	CJHR	19	18	15	10	5	0	0	0	0	87.89	88.02	G06[N] R
303	Klagenfurt	KLA2	19	17	15	10	5	0	0	0	0	87.36	85.85	G06[N] R

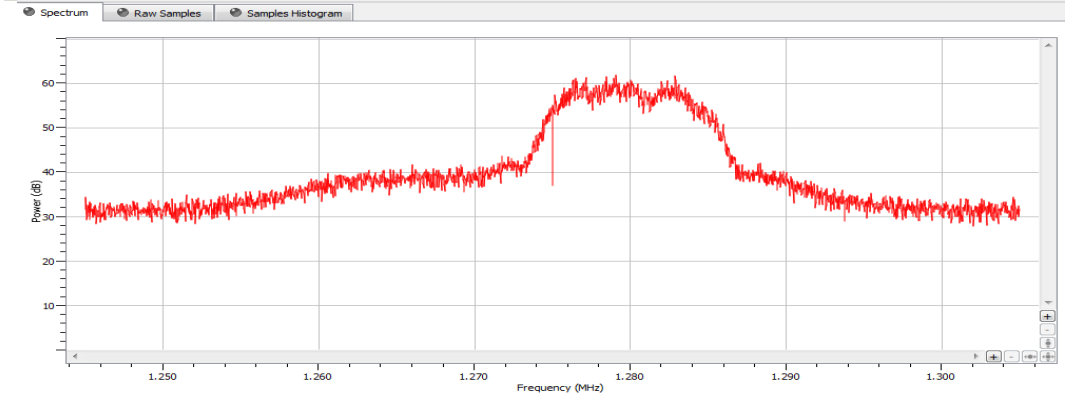
Login: admin | 4197 MB | 30.09.2017 14:53:41 [UTC Time

Leica GR30

Leica GRX1200+GNSS)

30th Sept. 2017, Vienna-Testbed (Wien3, Leica GR30): GNSS-tracking without filtering





Septentrio POLARX5 Spectrum-view

(Testing on 10th Feb, 2017 at APOS Station **Vienna** simultaneously with interfered Leica GR30)

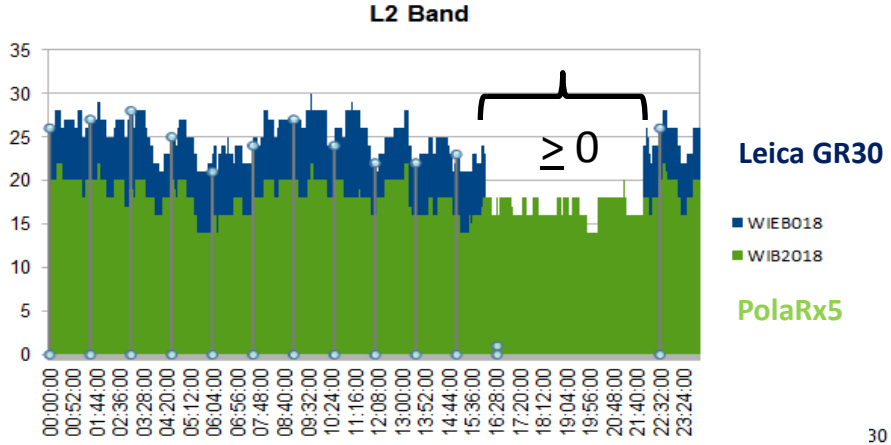
Main freq. 1.230 GHz

Main freq. 1.275 GHz

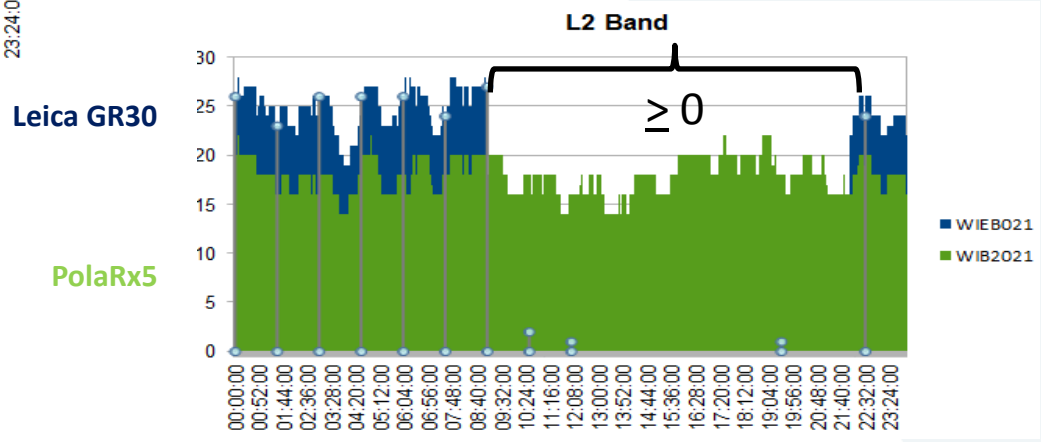
(detection of amateur radio before interference mitigation; interferes obviously the Glonass L2 - spectrum)

# of Sat. during Amateur radio activity (APOS Station **Vienna**)

DOY 018 / 2017
(Wednesday)

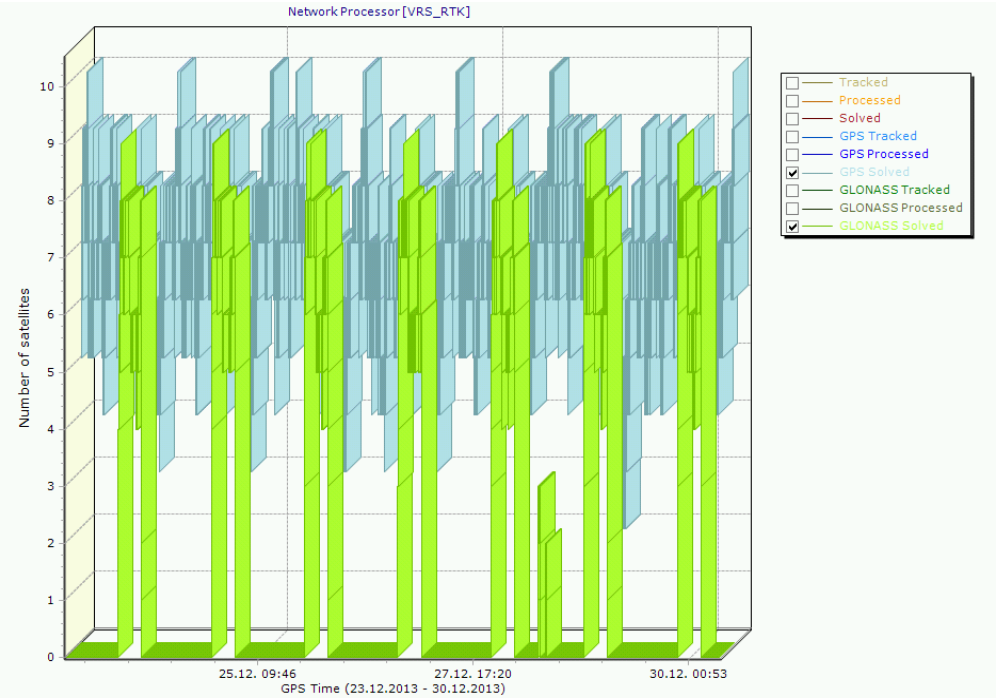


DOY 021 / 2017
(Saturday)



Impressions of Station **Krahberg/Tyrol** (12/2013):

Leica GRX 1200+GNSS without filtering / alternate radio amateur activities

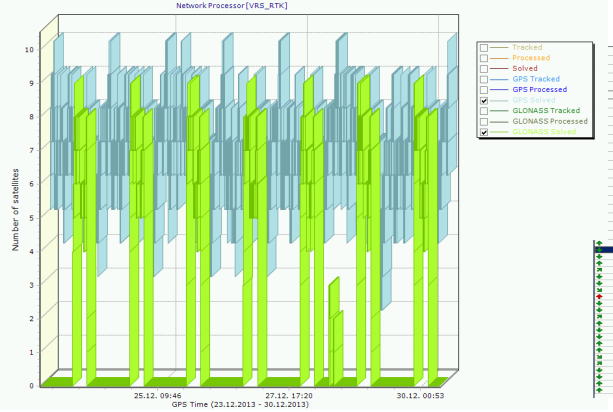


	G01	29	278	47	24	3407	889
	G03	55	172	50	26	15932	10751
	G06	37	152	49	26	18591	15254
	G11	50	288	50	25	6608	2168
	G14	32	106	48	24	5397	1029
	G16	3	189	42	-	20619	-
	G18	10	50	42	-	18255	-
	G19	81	235	50	30	12267	8110
	G22	43	58	49	24	15044	11258
	G27	48	151	50	27	17175	14361
	G28	16	322	46	22	3173	24
	G32	33	212	48	23	3448	867
	R04	2	31	43	-	15633	-
	R05	51	44	50	-	11687	-
	R06	63	183	50	-	6875	-
	R07	13	203	43	-	1496	-
	R12	8	302	41	-	113	-
	R13	9	351	41	-	2655	-
	R19	3	127	42	-	23159	-
	R20	52	115	46	-	15236	-
	R21	70	340	49	-	9463	-
	R22	21	315	47	-	2787	-

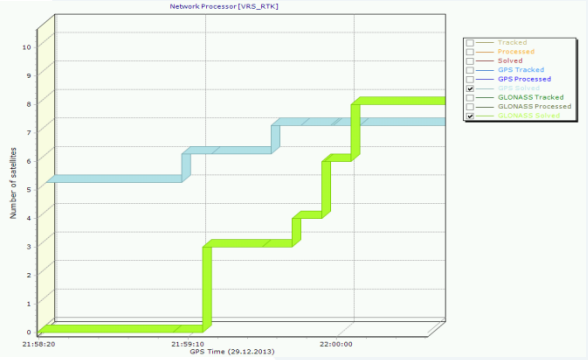
	G01	31	279	47	44	3623	1105
	G03	53	172	50	47	16148	10967
	G06	35	152	48	44	18807	15470
	G11	51	289	50	46	6824	2384
	G14	33	105	49	41	5613	1245
	G16	1	189	40	29	20835	28
	G18	9	50	42	35	18471	28
	G19	81	223	50	50	12483	8326
	G20	2	227	-	-	-	-
	G22	41	58	50	45	15260	11474
	G27	46	152	50	48	17391	14577
	G28	17	320	47	35	3389	28
	G32	34	212	49	44	3664	1083
	R04	0	31	42	35	15849	21
	R05	49	43	50	47	11903	21
	R06	65	183	49	48	7091	25
	R07	15	204	43	39	1712	23
	R12	7	300	40	37	91	23
	R13	9	350	40	40	2871	23
	R19	2	128	28	-	23375	-
	R20	51	117	46	47	15452	23
	R21	72	342	48	43	9679	23
	R22	23	316	48	43	3003	23

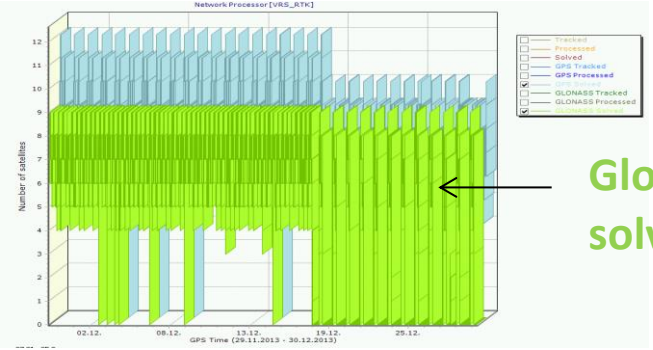
Impressions of Station **Krahberg/Tyrol** (12/2013):

Leica GRX 1200+GNSS without filtering / alternate radio amateur activities

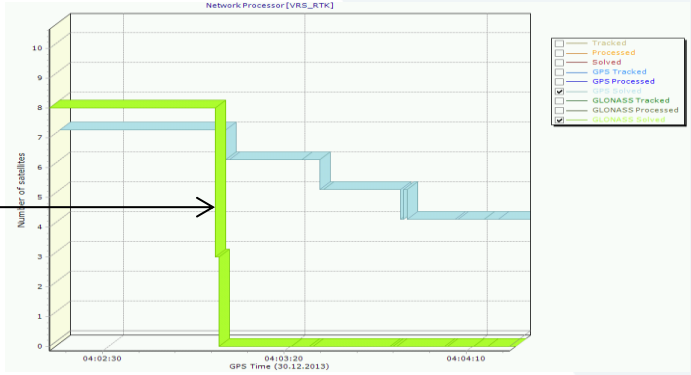


G01	29	278 47	24	3497	889
G03	55	172 50	26	19932	10751
G06	37	152 49	26	18591	15254
G11	50	288 50	25	6608	2168
G14	32	106 48	24	5397	1029
G16	3	189 42	-	20619	-
G18	10	93 42	-	16255	-
G19	81	235 50	30	12267	8110
G22	43	58 49	24	19344	11258
G27	46	151 50	27	17175	14361
G28	16	322 46	22	3173	24
G32	33	212 48	23	3448	867
R04	2	31 43	-	15633	-
R05	51	44 50	-	11687	-
R06	63	183 50	-	6875	-
R07	13	203 43	-	1486	-
R12	8	302 41	-	113	-
R13	9	351 41	-	3895	-
R19	3	127 42	-	23159	-
R20	52	115 46	-	15236	-
R21	70	340 49	-	5463	-
R22	21	315 47	-	2767	-
G05	31	279 47	44	3620	1195
G07	58	152 50	44	18749	10452
G08	56	153 49	41	18697	10470
G11	51	289 50	46	6824	2394
G14	32	106 49	41	5613	1245
G16	1	189 40	29	20835	28
G19	9	93 42	35	19471	28
G19	81	223 50	50	12493	8326
G20	2	227 -	-	-	-
G22	41	98 50	45	15250	11474
G27	46	152 50	48	17291	14077
G28	17	320 47	35	3369	28
G32	34	212 49	44	3664	1093
R04	0	31 42	35	15649	21
R05	49	43 50	47	11903	21
R06	65	183 49	48	7091	29
R07	15	204 43	39	1712	23
R12	7	300 40	37	91	23
R13	9	350 40	40	2871	23
R19	2	126 28	-	23375	-
R20	51	117 46	47	15452	23
R21	72	342 48	43	5679	23
R22	23	316 49	43	3003	23





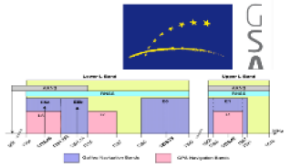
Glonass solved



Conclusion

- ✓ Problems with Radio Amateurs (ATV) in Austria are obviously solved (since 2017)
- ✓ Most of the CORS brands today have optional filter technologies
- ➢ Question(s): how can GNSS-users be protected against jamming/spoofing?
  - Upcoming „LowCost“ GNSS-Chips for mass market seem to be more vulnerable …
  - e.g. GALILEO is in preparation for special services
    - HAS (encryption for access) for all
    - PRS (encryption, broadband signal spectrum, etc.) > restricted to government-authorised users, for sensitive applications that require a high level of service continuity etc.
    - ….
- ❖ How can we deal with such szenarios in the future, resp. partizipate?

Galileo and EGNOS differentiators enable innovative applications. Examples



- Dual frequency, with E5 as second frequency
  - E5 especially effective in urban areas, bringing new levels of accuracy (sub-meter level) and robustness. Now available in smartphones (see Xiaomi Mi8) and automotive

- Authentication
  - Data level: Open Service Navigation Message Authentication (OSNMA)

    Integrated in the E1-B band for OS. Aimed at mass market users and offered for free. Already prototyped and under testing.

  - Range level: Signal Authentication

    Based on the E6-C Spreading Code Encryption to protect against more sophisticated attacks.

- High Accuracy Service (HAS)
  - Provision of PPP corrections via E6B (and terrestrial link tbc), offering high accuracy (decimeter level) for mass market and profesional users
  - FREE provision of service

Thank You for Your Attention!

Ernst Zahn
BEV – Federal Office of Metrology and Surveying
ernst.zahn@bev.gv.at