



GNSS signal interference by radio amateurs

(based on information from APOS / E. Zahn)

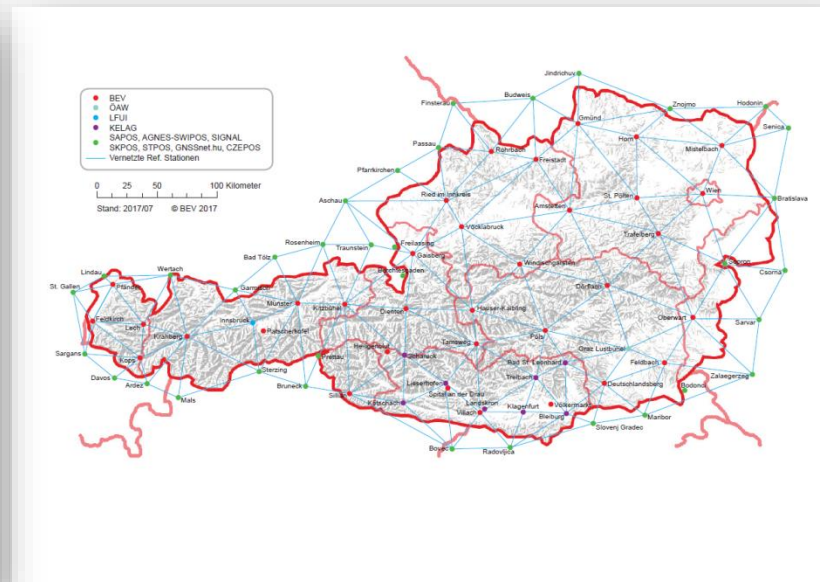
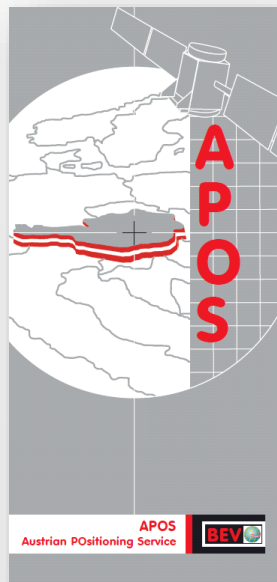
Ernst Zahn, Branislav Droščák

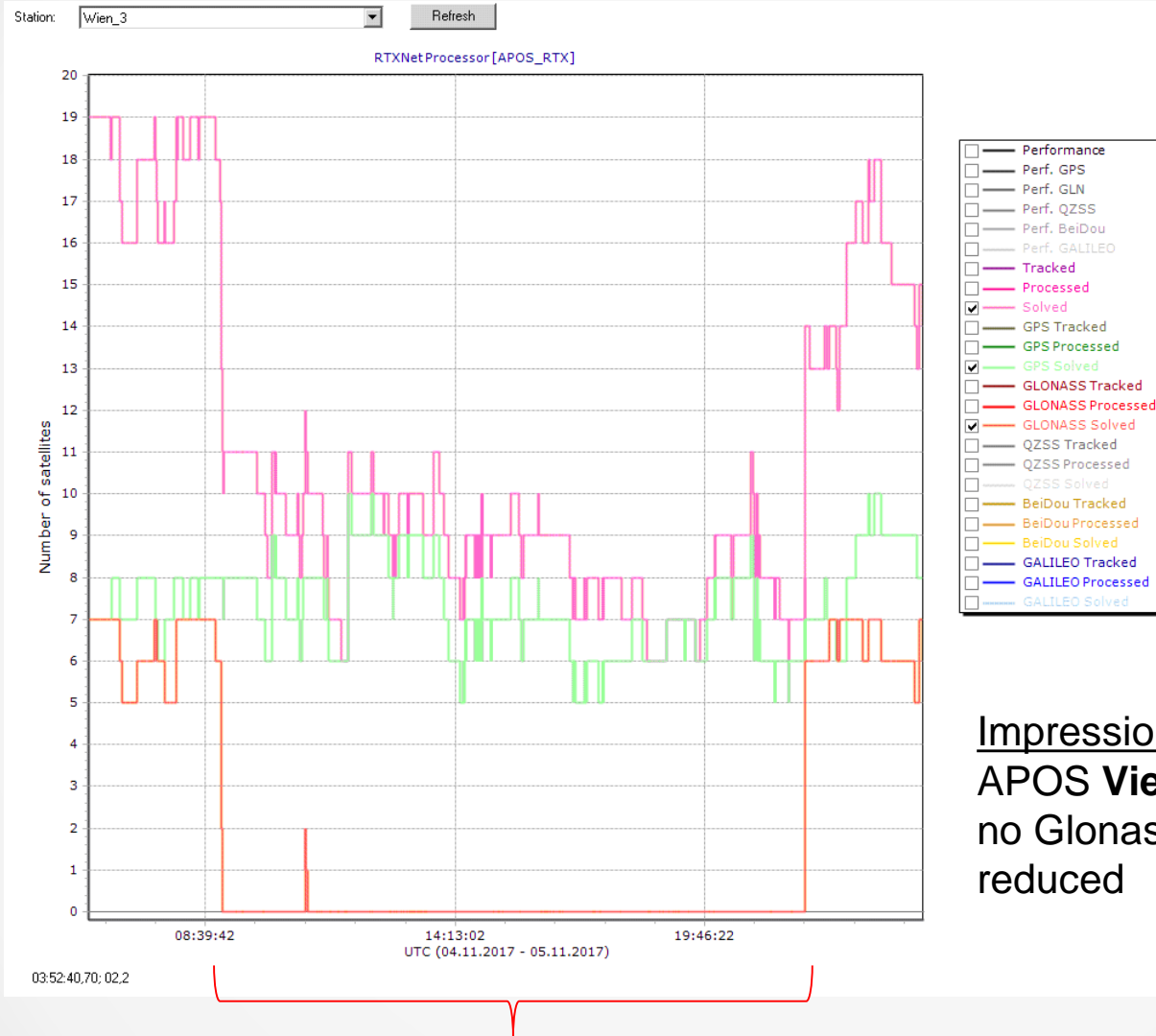


5th EUPOS® Council and Technical Meeting
November 14-15, 2018. Tallinn, Estonia

Motivation

- Mr. Zahn (APOS network Austria) orally presented on the 4th EUPOS technical meeting in Bratislava recognized GNSS signal interference on WIEN (Vienna) APOS station caused by radio amateurs





Impression 4th Nov. 2017
APOS Vienna (Wien_3), Leica GR30,
 no Glonass solving / GPS tracking
 reduced

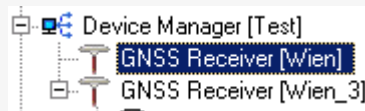
Satellite Tracking	Skyplot	Receiving Info	Multipath	Raw Data Analysis						
Sat	/	EI [°]	Az [°]	SNR (CA/P1/E1/B1)	SNR (L2/L2C/L2CA)	SNR (L5/E5/E5A/E5B)	SNR (E6/B3)	CA/P1/E1/B1	L2/L2C/L2CA	L5/E5/E5A/E5B
C02		4	107	-	-	-	-	-	-	-
C05		19	130	-	-	-	-	-	-	-
C07		15	70	-	-	-	-	-	-	-
C09		18	61	-	-	-	-	-	-	-
C10		14	93	-	-	-	-	-	-	-
E01		1	5	-	-	-	-	-	-	-
E03		52	249	-	-	-	-	-	-	-
E05		71	57	-	-	-	-	-	-	-
E08		2	246	-	-	-	-	-	-	-
E09		18	54	-	-	-	-	-	-	-
E14		31	242	-	-	-	-	-	-	-
E22		50	203	-	-	-	-	-	-	-
E24		10	102	-	-	-	-	-	-	-
G01		51	154	-	-	-	-	-	-	-
G03		80	353	-	-	-	-	-	-	-
G06		12	313	-	-	-	-	-	-	-
G09		22	221	-	-	-	-	-	-	-
G11		26	172	-	-	-	-	-	-	-
G12		0	348	-	-	-	-	-	-	-
G14		14	48	-	-	-	-	-	-	-
G17		34	271	-	-	-	-	-	-	-
G19		30	297	-	-	-	-	-	-	-
G22		65	80	-	-	-	-	-	-	-
G23		53	212	-	-	-	-	-	-	-
G31		30	66	-	-	-	-	-	-	-
J02		8	40	-	-	-	-	-	-	-
R04		20	60	-	-	-	-	-	-	-
R05		66	21	-	-	-	-	-	-	-
R06		40	268	-	-	-	-	-	-	-
R13		7	7	-	-	-	-	-	-	-
R14		45	207	-	-	-	-	-	-	-
R15		18	100	-	-	-	-	-	-	-
R20		44	203	-	-	-	-	-	-	-
R21		52	296	-	-	-	-	-	-	-

GPS L2 - mitigation

No Glonass L2

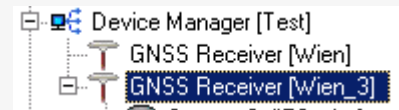
GPS L2 - mitigation

No Glonass L2



Septentrio POLARX5
(Auto Notch filter activated)

Impression 30th Oct. 2017
Vienna-Testbed (Wien/Wien3):
simultaneous GNSS-tracking with/without
filtering



Leica GR 30 (No filter)

Satellite Tracking	Skyplot	Receiving Info	Multipath	Raw Data Analysis						
Sat		EI [°]	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 / 17636	17634
G03		80	354	52	47 / 48	55	-	12628	12605 / 12747	12628
G06		13	313	40	36 / 40	44	-	1750	1750 / 1765	1770
G09		22	221	47	36 / 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	-	-
G23		53	212	50	40	-	-	7006	7006	-
G25		0	21	21	-	-	-	-	-	-
G31		30	66	48	37 / 41	-	-	8136	8129 / 8119	-
J02		8	40	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

GPS/Glonass L2 OK

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



Login: admin



4197 MB

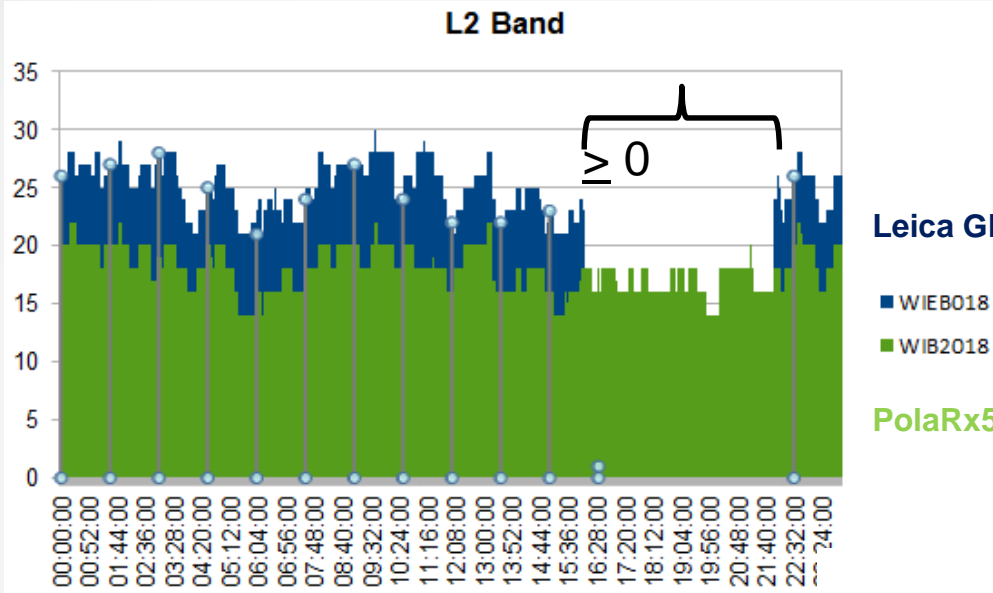


30.09.2017 14:53:41 [UTC Time]

Leica GR30

Leica GRX1200+GNSS)

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



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

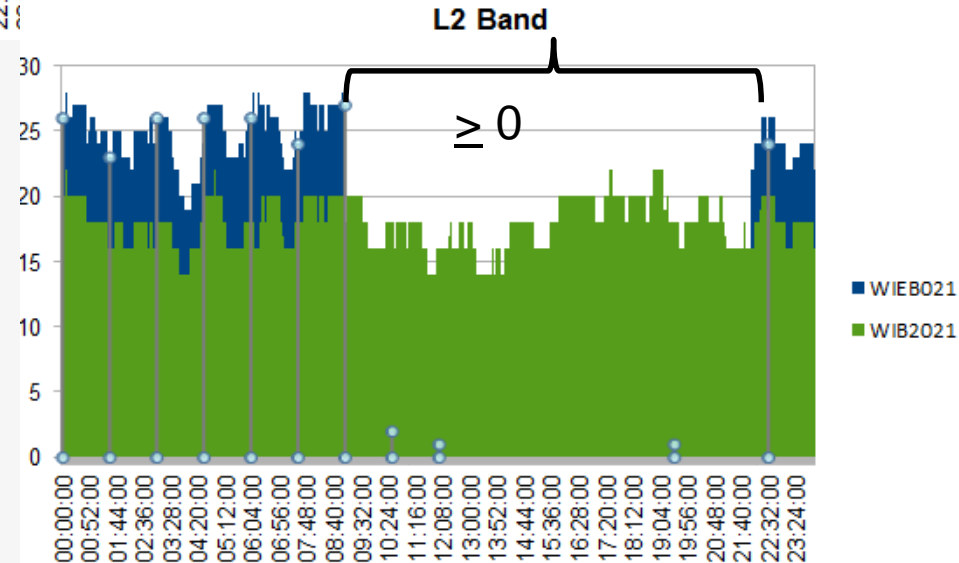
Leica GR30

DOY 018 / 2017
(Wednesday)

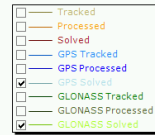
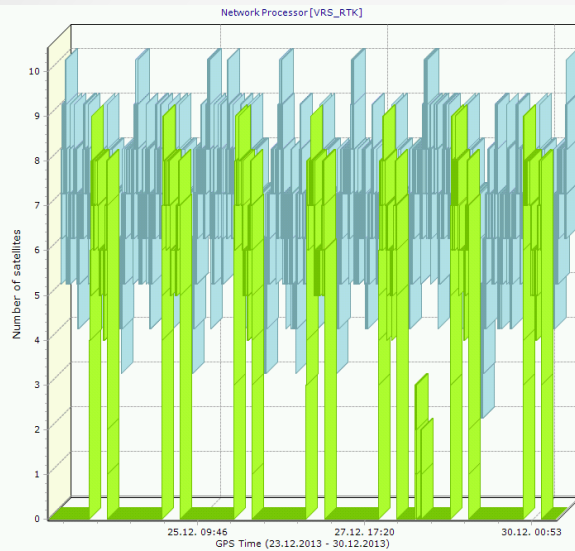
DOY 021 / 2017
(Saturday)

Leica GR30

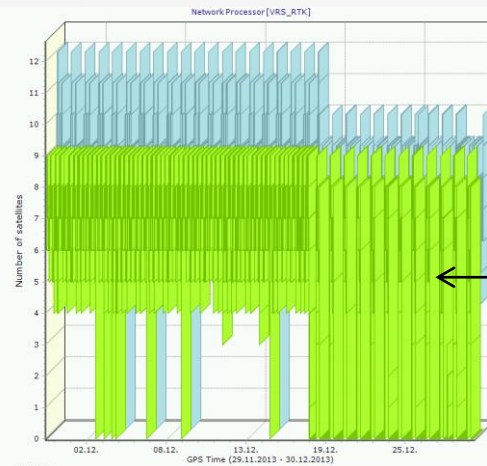
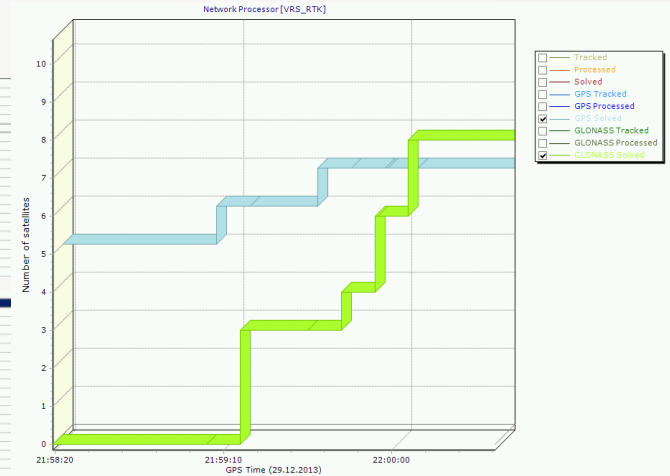
PolaRx5



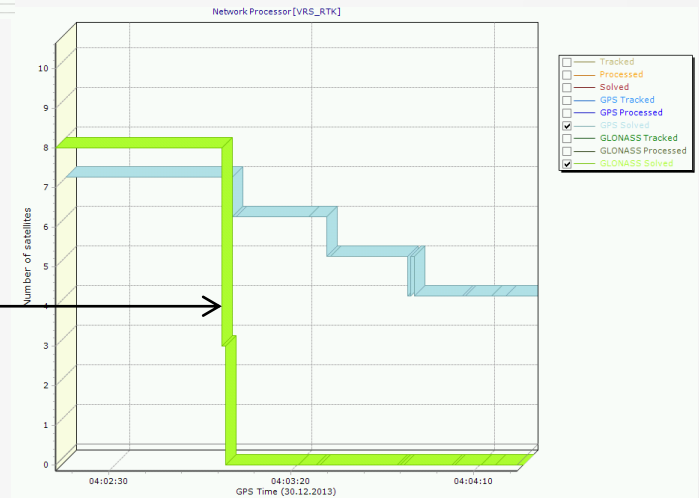
Impressions of Station **Krahberg/Tyrol** (12/2013): Leica GRX 1200+GNSS without filtering / alternate radio amateur activities



GD01	25	276 47	24	3407	889
GD02	55	172 50	26	15002	10751
GD03	37	152 49	26	18891	15254
GD04	50	248 50	25	1688	7249
GD05	30	198 49	24	1207	1029
GD06	7	182 47	-	39813	-
GD07	10	90 42	-	10255	8110
GD08	87	275 50	26	12507	10751
GD09	43	90 49	24	15044	11258
GD10	40	160 50	22	17176	14081
GD11	16	322 48	22	3173	24
GD12	33	212 49	23	3448	887
PD04	2	35 43	-	16623	-
PD05	15	44 50	-	11807	-
PD06	43	163 50	-	8075	-
PD07	13	203 43	-	1496	-
PD12	8	362 47	-	113	-
PD13	9	361 47	-	3485	-
PD18	3	127 42	-	23995	-
PD20	52	116 48	-	10258	-
PD21	70	340 49	-	3463	-
PD22	21	393 47	-	2787	-

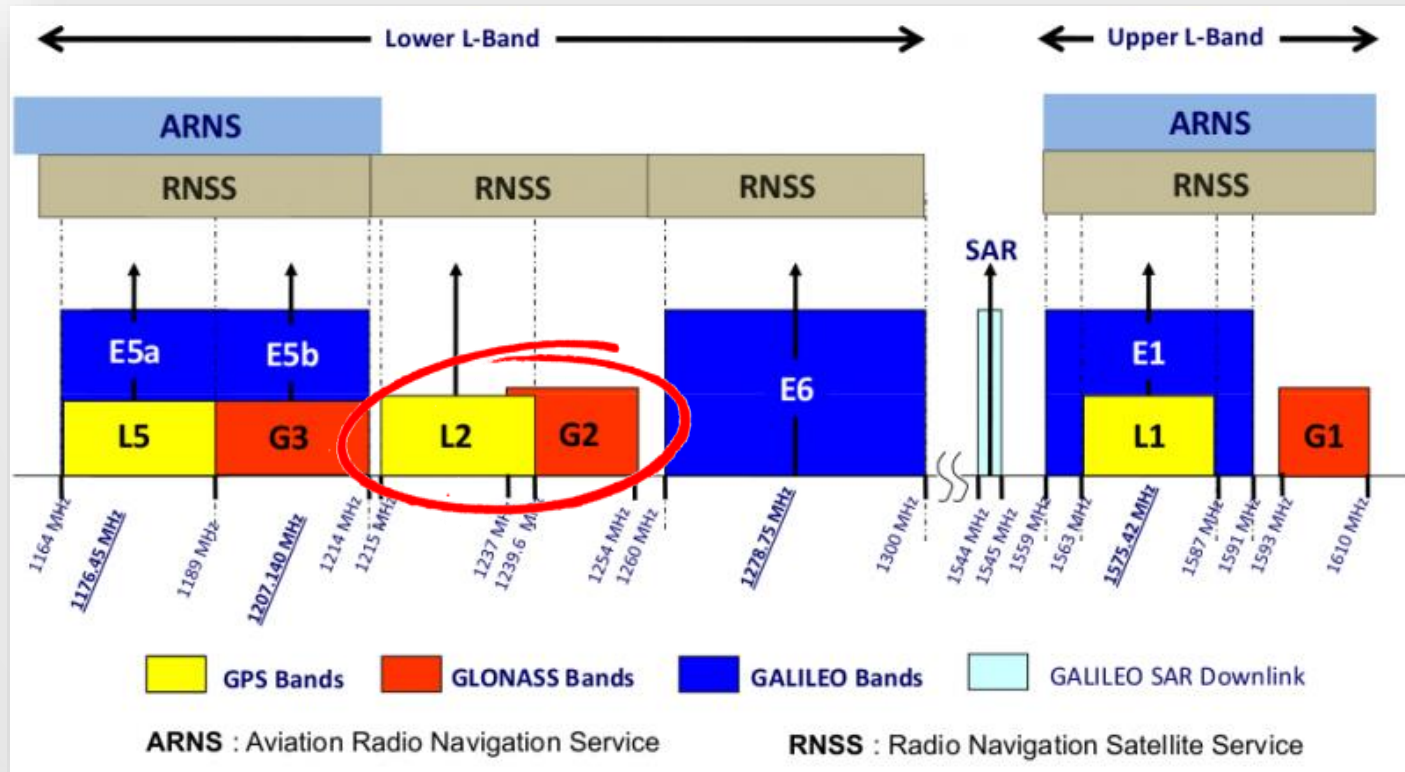


Glomass



GPS and GLONASS L2 frequency

- **GLO L2 Band:** 1242.9375 MHz to 1248.625 MHz
- **GPS L2 Band:** 1227.6 MHz with a bandwidth of 11 MHz

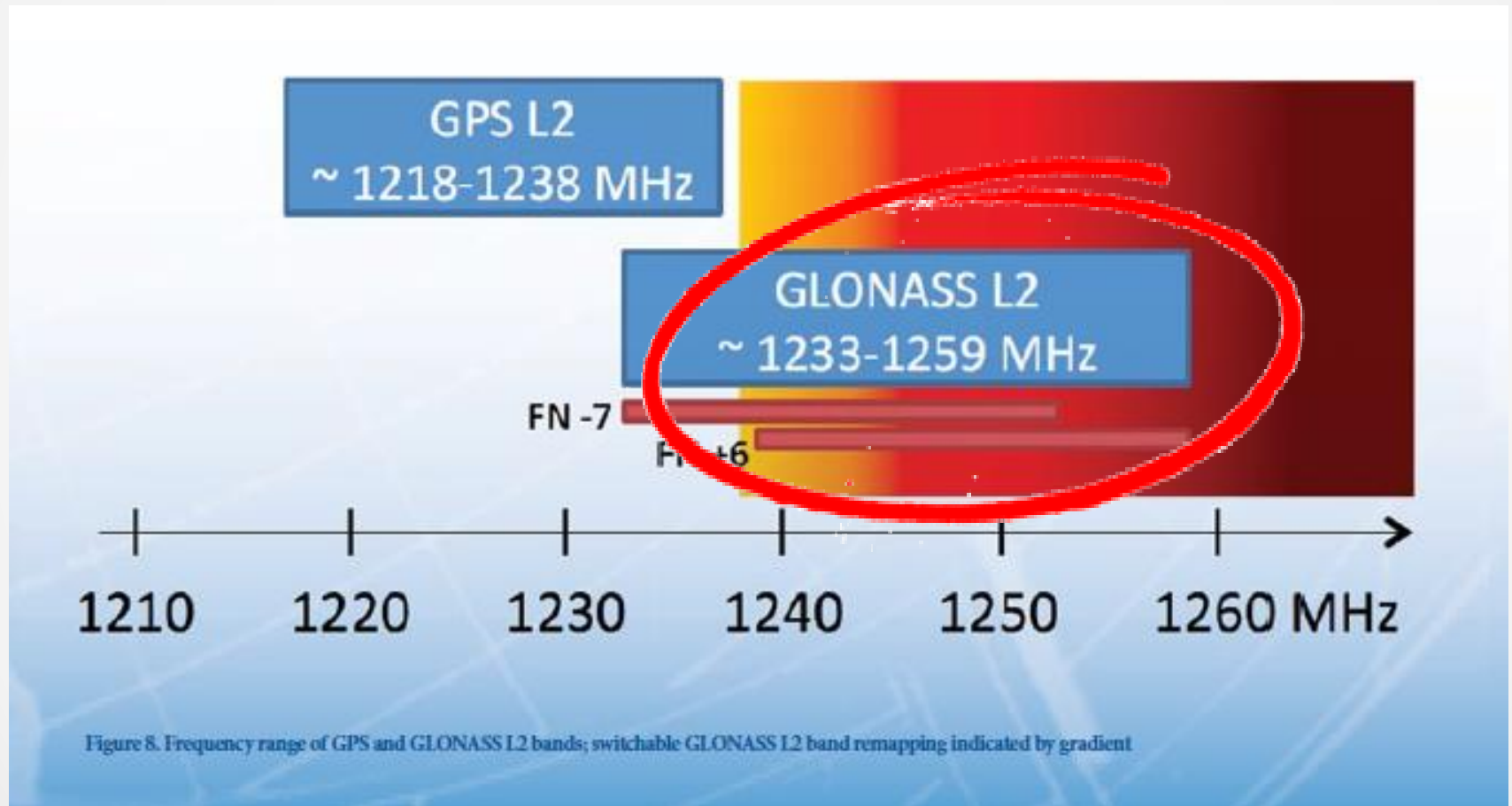


Radio amateur UHF (23cm) frequency

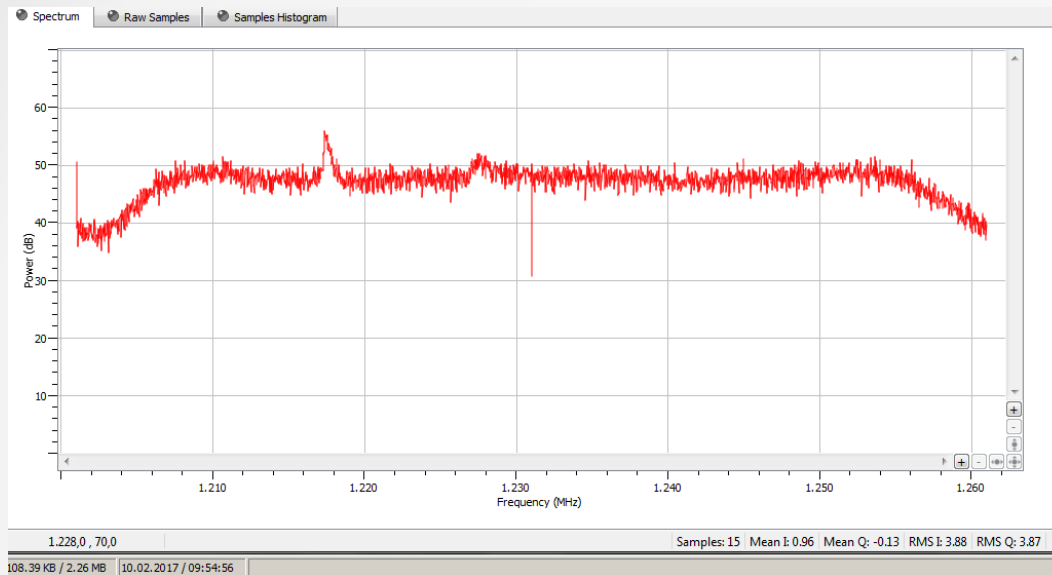


- The **23 centimeter, 1200 MHz or 1.2 GHz** band is a portion of the [UHF](#) ([microwave](#)) radio spectrum internationally allocated to [amateur radio](#) and [amateur satellite](#) use on a secondary basis. **The amateur radio band is between 1240 MHz and 1300 MHz.** The amateur satellite band is between 1260 MHz and 1270 MHz, and its use by satellite operations is only for up-links on a non-interference basis to other radio users

Collision GPS/GLONASS L2 frequency and UHF 23cm frequency



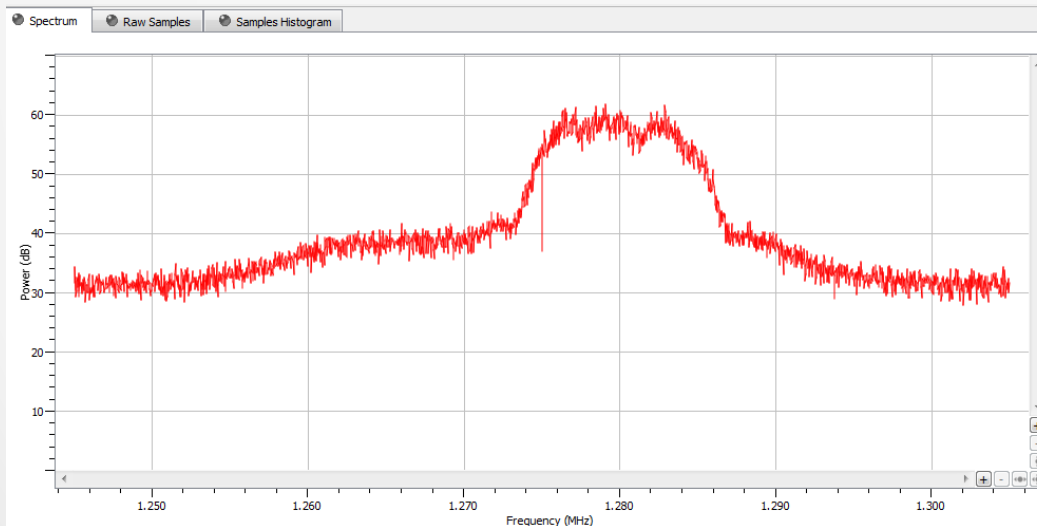
- Source: http://mensuro.cz/mac-pro/uploads/2018/01/Septentrio-AIM_GNSS_Interference.pdf



Septentrio POLARX5 Spectrumview

(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)

Interference caused by radio amateurs confirmed

- APOS colleagues contacted Trimble - the suspicion fell on radio amateurs
- Investigation confirmed assumption – unintentional L2 frequency interference caused by radio amateurs antenna directly oriented to WIEN station
- Solution – negotiation with radio amateurs
 - radio amateurs change used frequency and informed Slovenian (Maribor) colleagues as well to do it



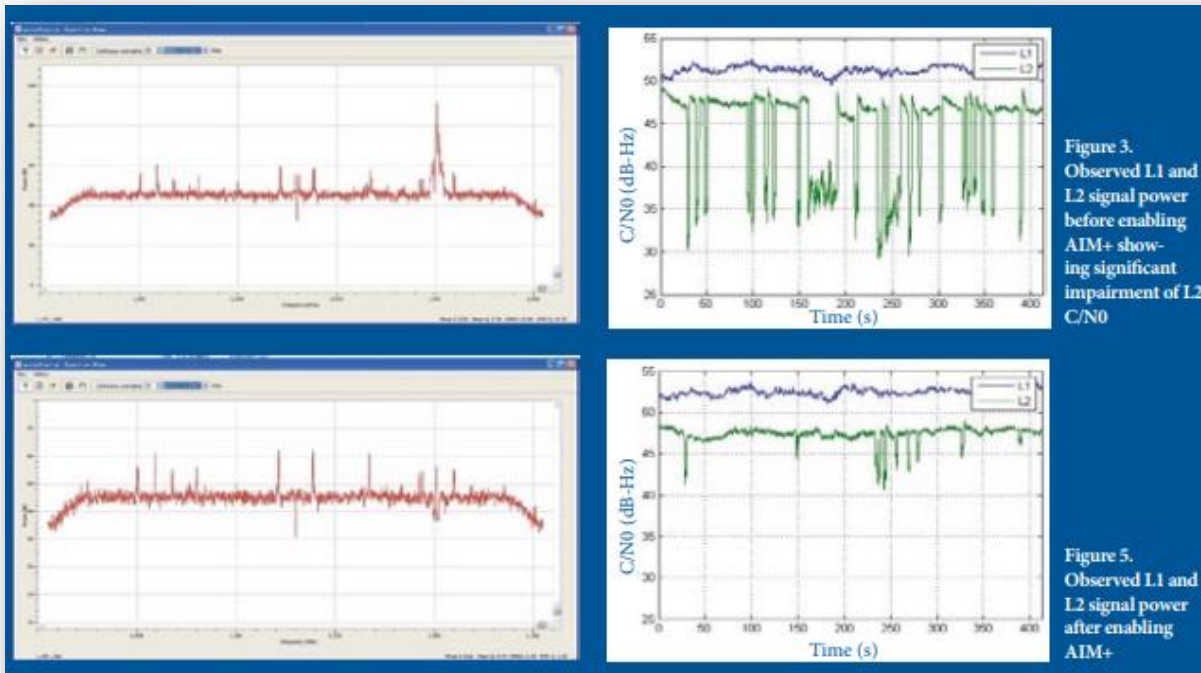
Symptoms of L2 frequency interference by radio amateurs

- according to ESA white paper (https://www.researchgate.net/...Invited_Lecture/.../An-introductio...)

Impact on GNSS receiver:	GNSS-user would notice:
<ul style="list-style-type: none">• Degradation of C/N0	<ul style="list-style-type: none">• Loss of tracking• Lower availability observables• Cycle Slips
<ul style="list-style-type: none">• Higher noise on code and phase observables	<ul style="list-style-type: none">• Degradation of accuracy
<ul style="list-style-type: none">• Longer Acquisition Time	<ul style="list-style-type: none">• Longer Time-To-First-Fix

Hint

- Septentrio receivers was not affected because they use special Adaptive Notch Filtering solution which helps to prevent interference or signal degradation



Summary

- In case of problem with L2 frequency (especially on GLONASS) check possible interference by radio amateurs transmission
- contact radio amateurs society and ask them for used frequency change

Thank you for your attention

Ernst Zahn, Branislav Droščák