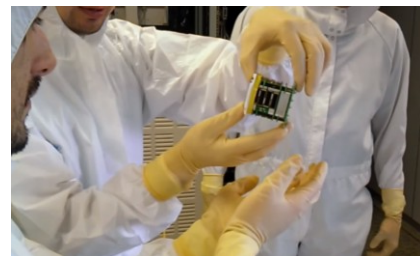
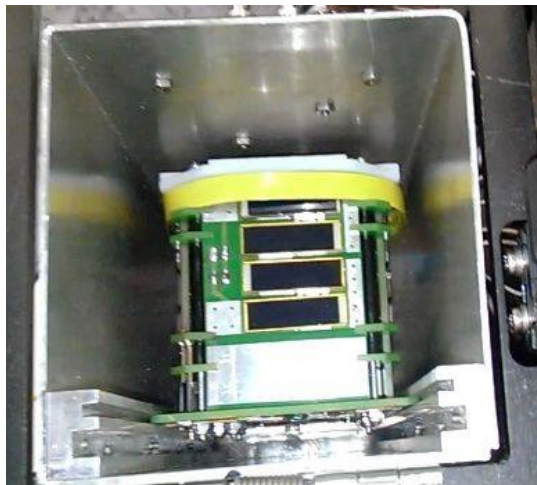
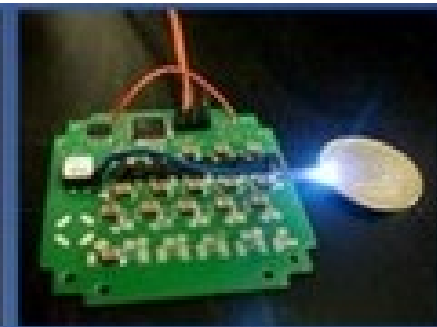


The role of freely available and open-source software in our daily space operations

Sacha Tholl
Hannah Walther





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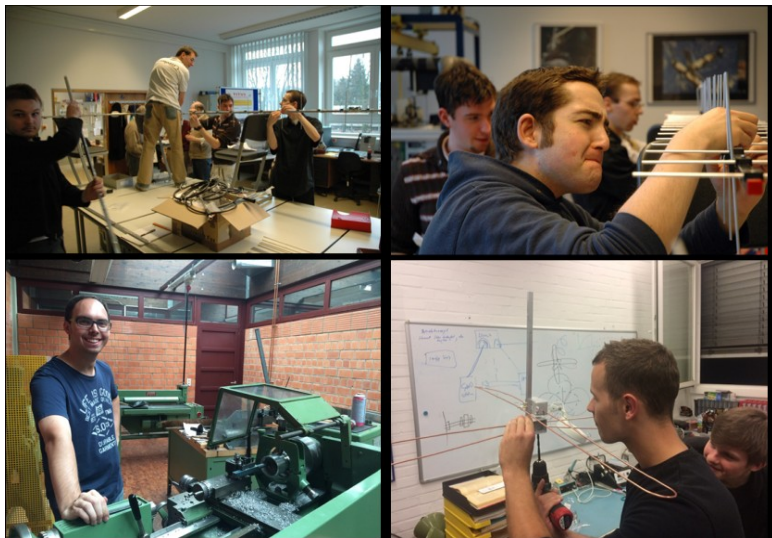
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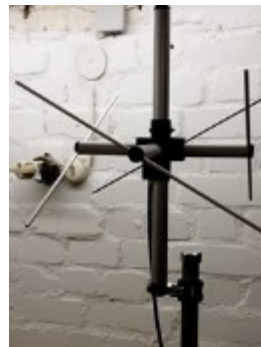
Hohenstaufenallee

- 70cm: 4 clockwise polarized 18 elements crossed-Yagi array; gain: 25dBi
- 2m: 2 clockwise polarized 8 elements crossed-Yagi array; gain: 20dBi
- 2-m helix antenna; gain: 3dBi



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Teleport Eupener Straße

- 70 cm circular polarized Yagi: 6.8dBi
- LogPer feed (0.8-7GHz)
- 3m parabolic dish
- RTL-SDR
- Rhode & Schwarz EM100 digital (SDR)



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- RTLSDR; HackRF
- Rohde & Schwarz EM100 (SDR receiver)
- ICOM 820
- ICOM 910h
- New ICOM 9700 just arrived last week



- HLV-770-LPD-LAN (430-440 MHz) RF Power Amplifier (low drive) will arrive soon ☺

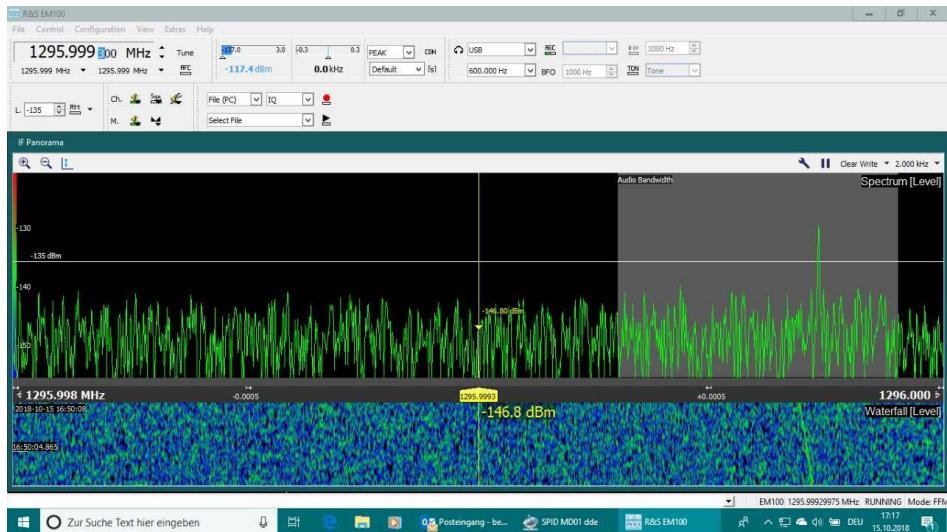


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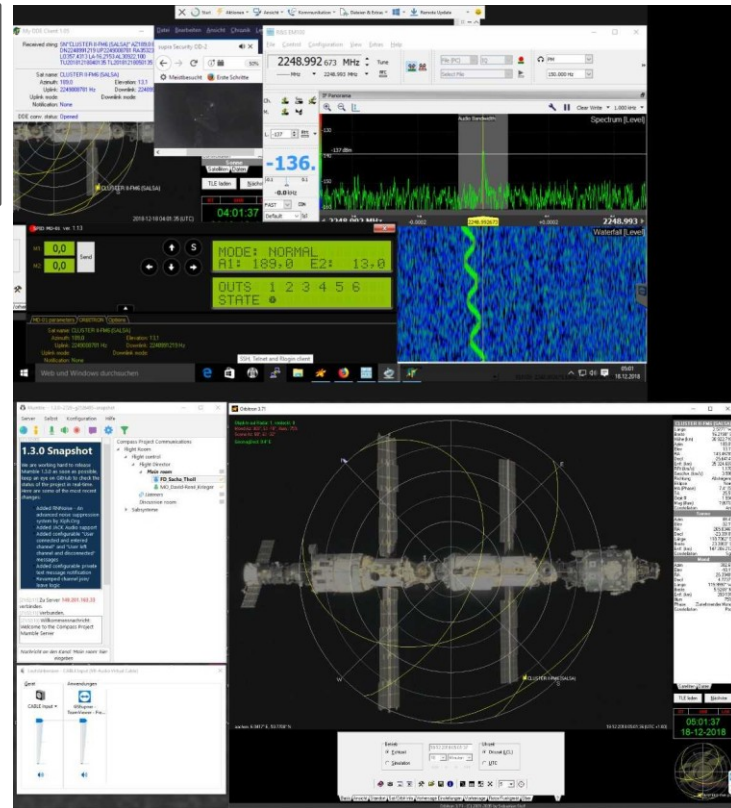


Moon reflection ON0EME (Belgium) - Moon - FHASOF over a total distance of 802.000km (15.10.2018). Peak at almost 1296 MHz). Elevation:12.5°

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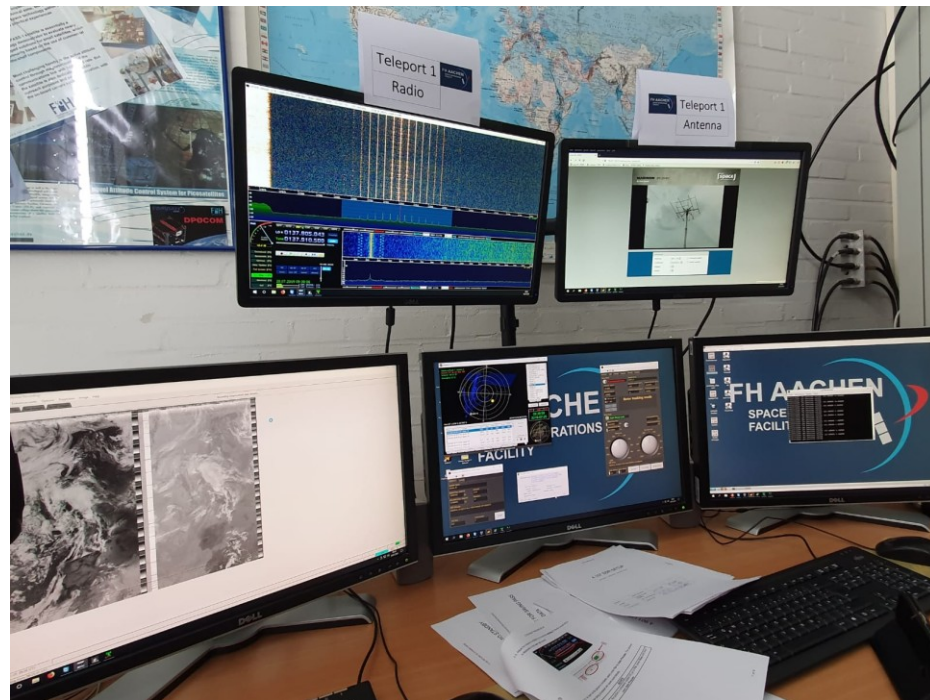
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Two examples what can be done with our EM100 // 3m Dish



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Modulation Schemes

- Uplink: CW, RTTY; in AX.25 or raw: AFSK, FSK, PSK Manchester, HBPN up to 9600baud
- Downlink: CW, AFSK, FSK, GMSK, PSK, RTTY, Manchester, HBPN, and more:
- CCSDS being implemented

Tracking Data Formats

- Two-line elements (Space track; Celestrack; JSPOC)
- Topocentric horizon RAZEL & Doppler shift
- Ephemeris types: CCSDS-OEM

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Serviced Missions / Heritage

- Compass-1 (2008-12, primary ground station, mission completed)
- Compass-2 ON04DL (2017 primary ground station, mission failure)
- PocketQube Wren DP0WRE (2013, primary ground station, mission completed)
- Stars-C (2017, secondary GS, mission completed)
- Stars-ME (2018 – today, secondary GS, still ongoing)
- Stars-AO (2018 – today, secondary GS, still ongoing)
- ESA Ops-Sat (ESA operated CubeSat on which we run experiments, shadow tracking)

Workforce Structure

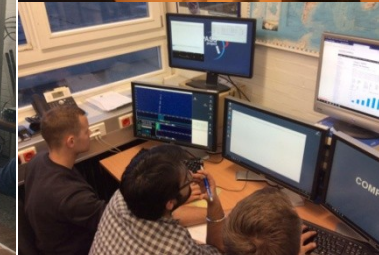
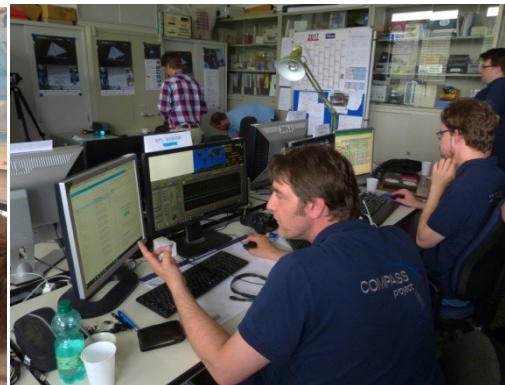
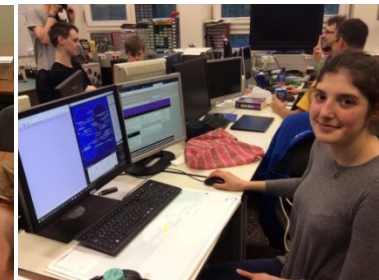
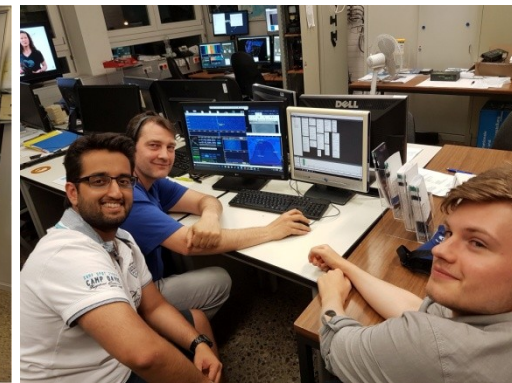
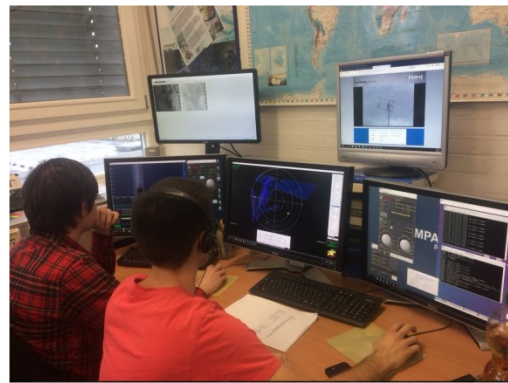
- 21 active student members
 - 18 Bachelor students
 - 2 master
- 6 active working groups:
 - Management
 - Operators
 - Flight Dynamics
 - Documentation
 - Maintenance
 - PR & Open-reach
- Project direction
Prof. Dr.-Ing. Bernd Dachwald
- Lead & flight director
Dipl.-Ing. Sacha Tholl
- Supervising engineer
Dipl.-Ing. Engelbert Plescher

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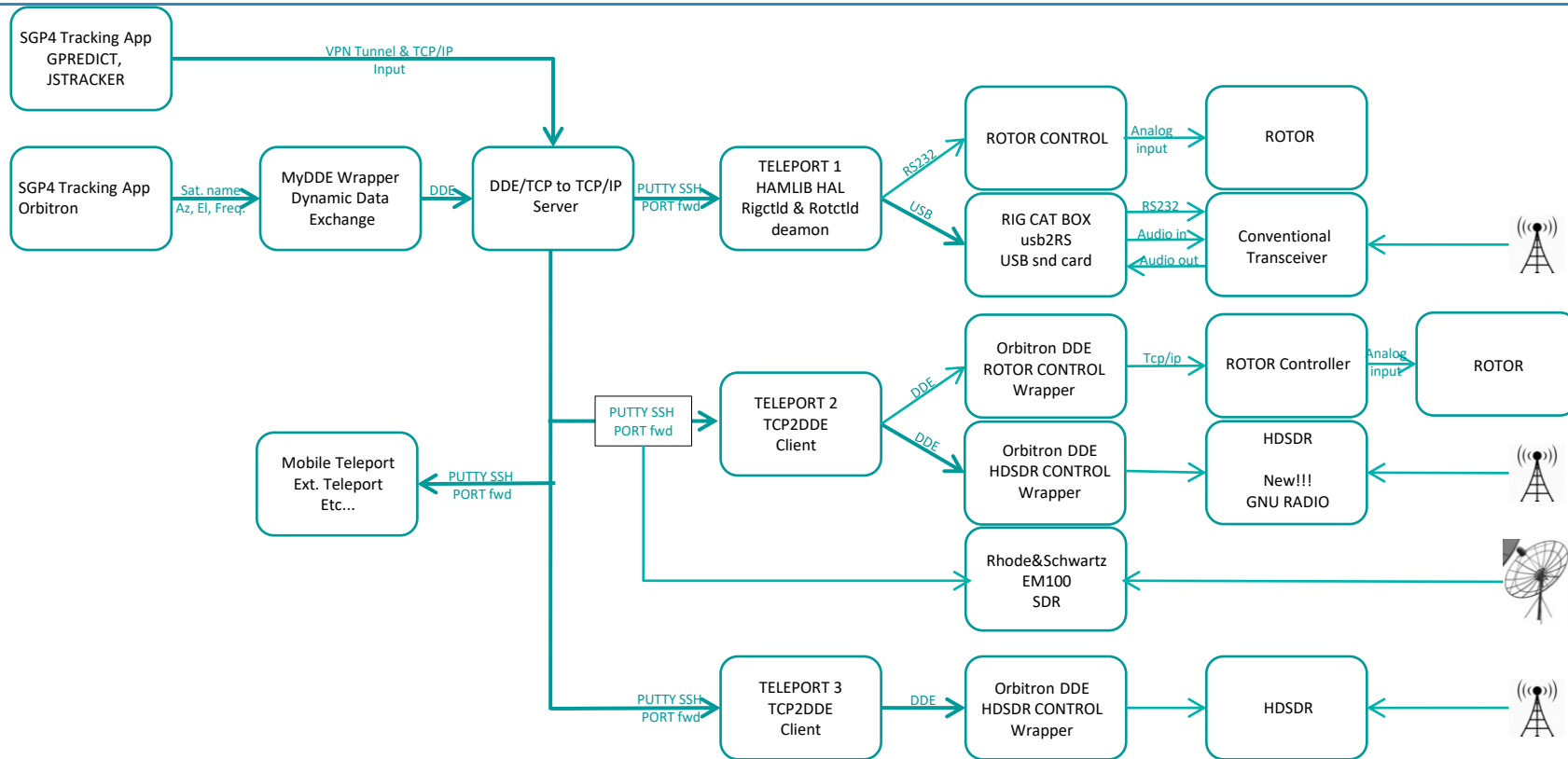
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FHASOF groundstation 3 teleports setup





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0) Propagator evaluates:

- Frequency shift due to Doppler - FX
- Az/El at any given time

1) MyDDE

2) DDE2TCP/IP

**Specially for SDR
DDE to TCP/IP**

HamLib server over TCP/IP

3) Radios

4) Rotors

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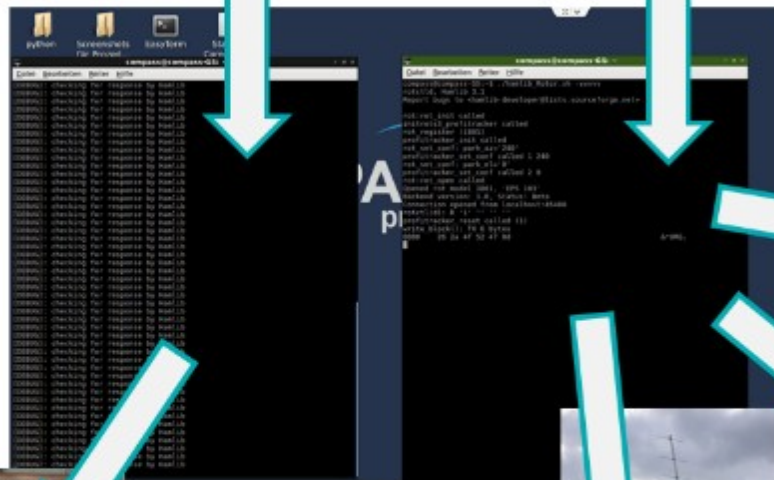
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HAM Lib using rigctld cmd

HAM Lib using rotctld cmd

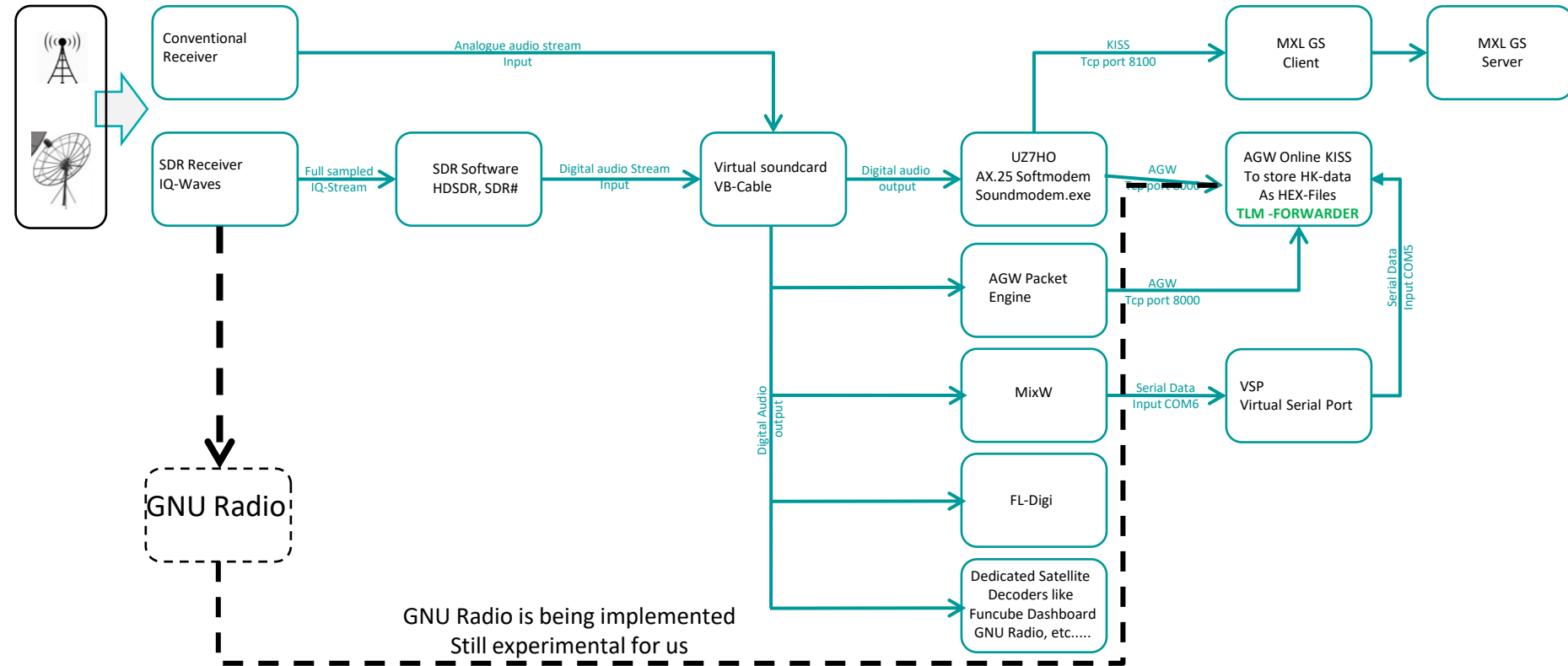


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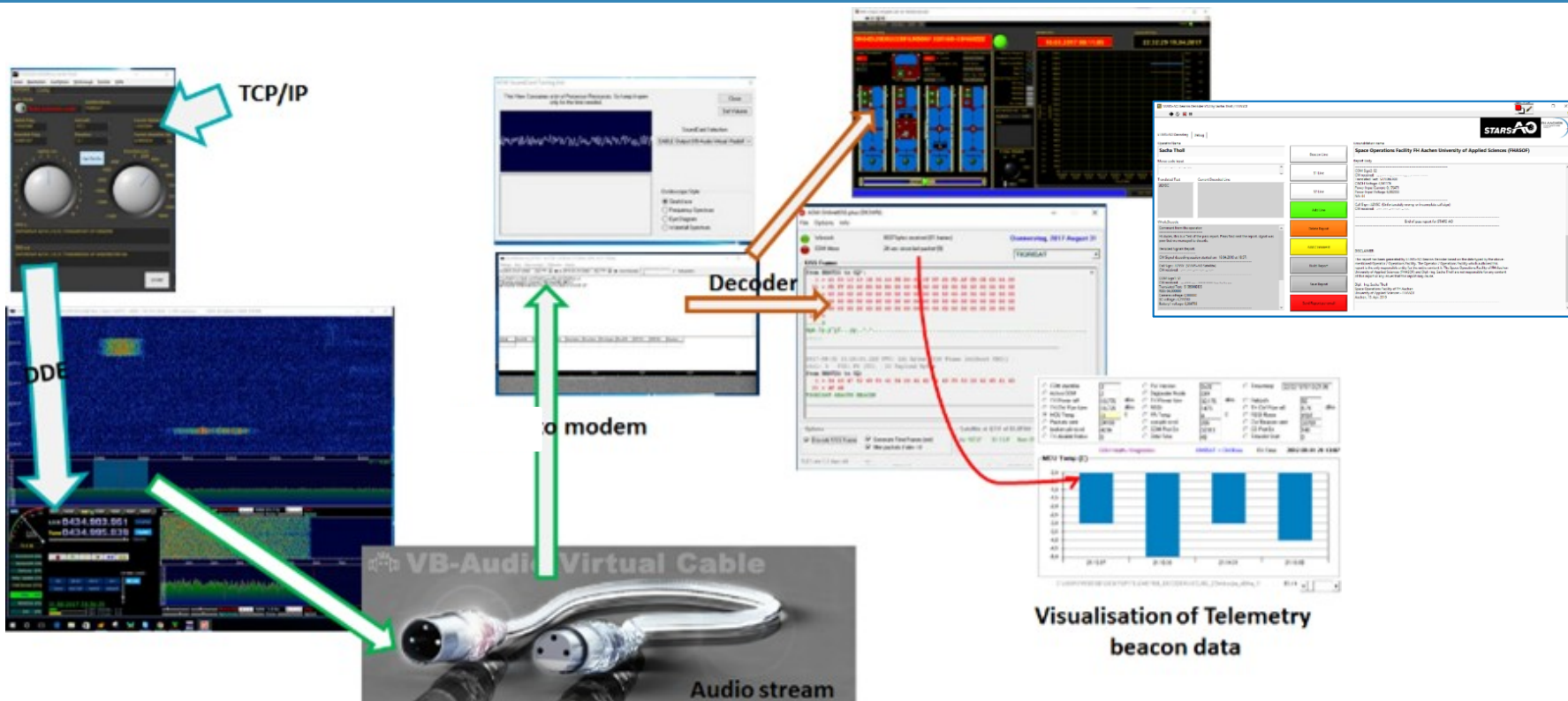


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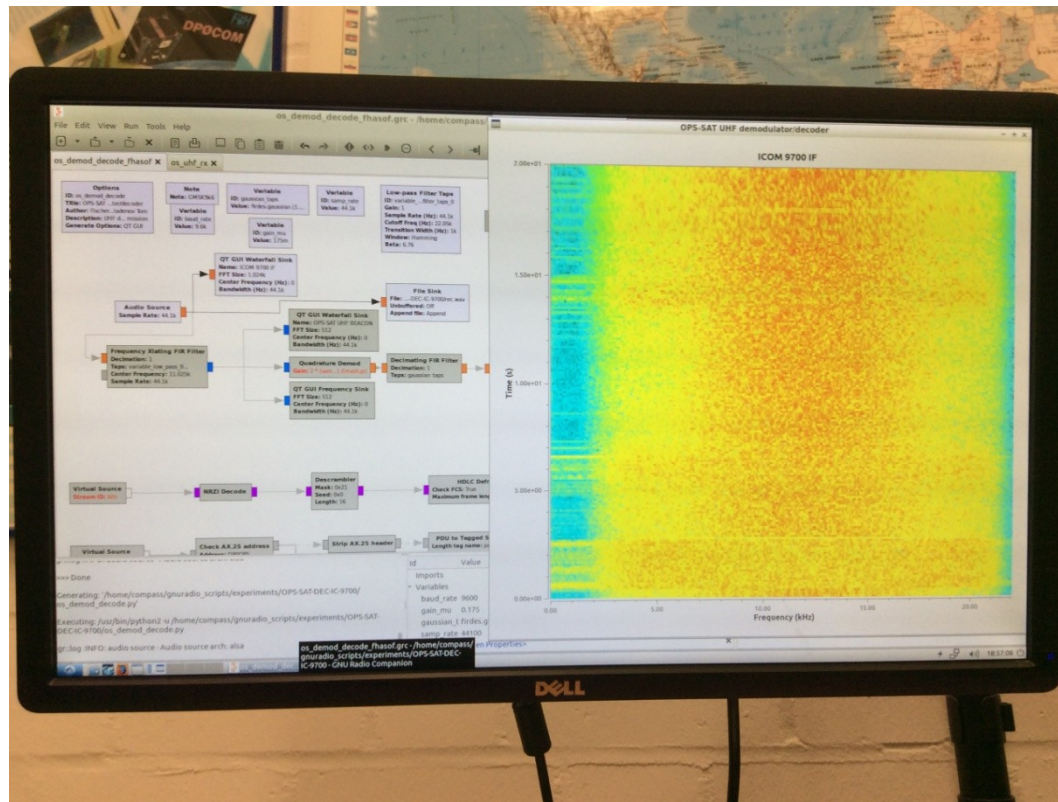


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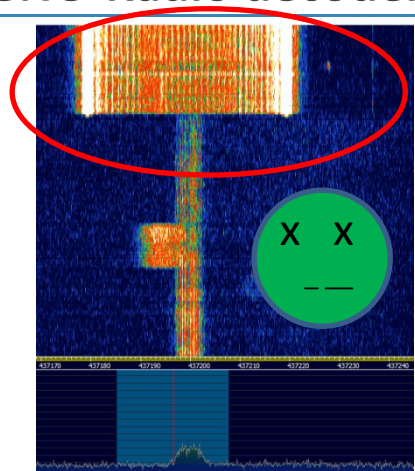
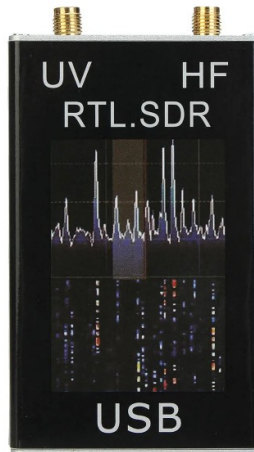
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- Soundmodem (UZ7HO)
- AGW-Online Kiss (DK3WN)
- TLM Forwarder (DK3WN)
- Telemetry interpretation application for OPSSAT

The screenshot displays a typical software setup for satellite operations. Key components include:

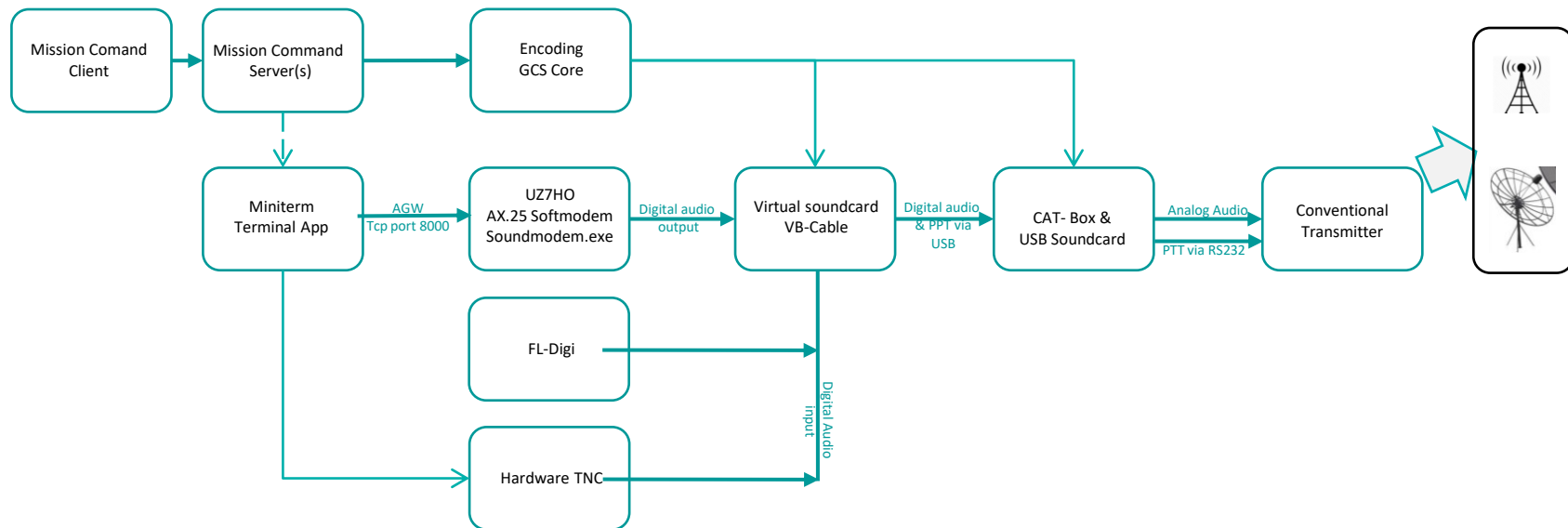
- Telemetry Forwarder (DK3WN):** Shows a bar chart for 'DPOPS -> DL0ESA' with metrics for RX, Total HTTP, Total HTTP OK, Total HTTP FAIL, and Buffer. Below the chart is a log of received packets.
- Audacity:** An audio player showing a waveform of the received signal, with a project rate of 44100 Hz.
- SPACE OPS:** The logo for the Space Operations Facility.
- KISS Frames:** A window displaying received KISS frames, including packet details like '2020-01-26 18:17:39.470 UTC: [78 Bytes KISS Frame (without CRC)]' and the raw data bytes.
- High-Speed SoundModem by UZ7HO:** A window showing the modem's settings and a hex dump of the received data, such as '1 > 80 DC A1 CA 15 01 2F 7F 96 02 AB 00 09 56 1D 00 00 01 A4'.

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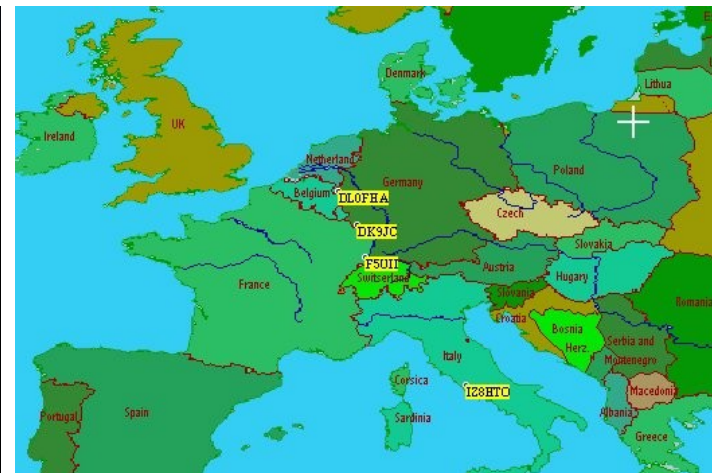
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The image shows two overlapping software windows. The top window is 'EasyTerm by UZ7HO - Ver 0.38b - Terminal: DL0FHA'. It has a menu bar (File, Settings, View, Stations, About) and a toolbar with icons for Connect, Disconnect, Beacon, YAPP, MHeard, and Mailbox. The main area shows terminal output: '1:Fm DL0FHA To JI2YPL <UI C Pid=F0 Len=11> [01:37:09T] CPNMS0331F', '1:Fm DL0FHA To JI2YPL <UI C Pid=F0 Len=11> [01:37:15T] CPNMS0331F', and '1:Fm DL0FHA To JI2YPL <UI C Pid=F0 Len=11> [01:37:18T] CPNMS0331F'. Below the terminal is a status bar with 'TALK', 'Not connected', 'Buffer: 0', and 'TNC Active'. The bottom window is 'SoundModem by UZ7HO - V...97b - [AFSK AX.25 1200bd]'. It has a menu bar (Settings, View, Clear monitor, Calibration, About) and a toolbar with a dropdown menu set to 'AFSK AX.25 1200bd', a '1700' value, and a 'DCD threshold' slider. The main area shows the same terminal output as EasyTerm. Below the terminal is a table with columns: MyCall, DestCall, Status, Sent pkts, Sent bytes, Rcvd pkts, Rcvd bytes, Rcvd. The table is currently empty. At the bottom of the window is a frequency scale from 1000 to 2000 kHz with a marker at 1288.0 kHz.



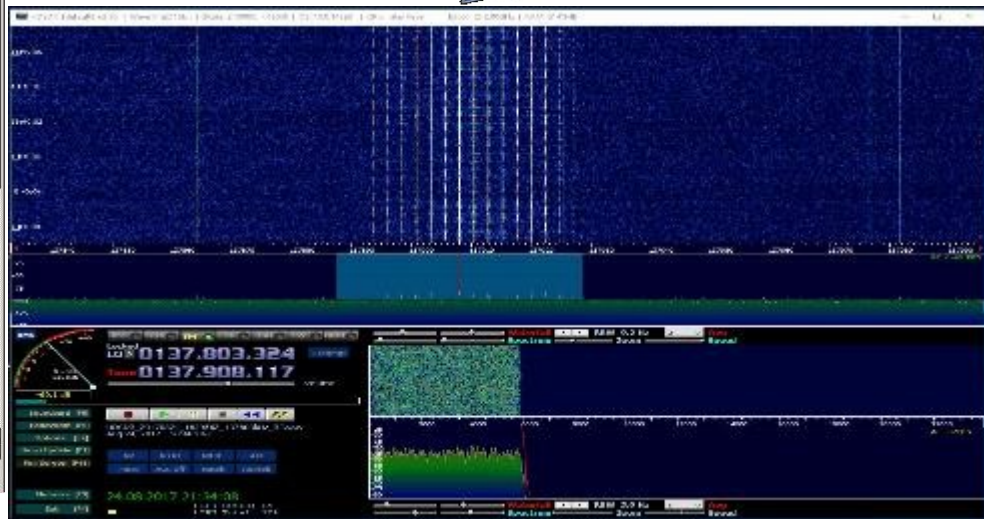
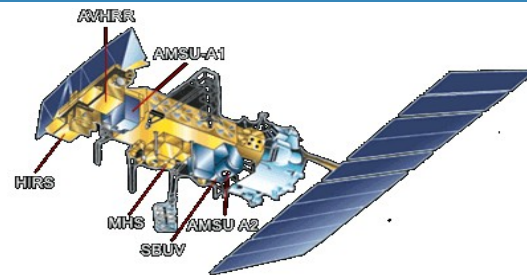
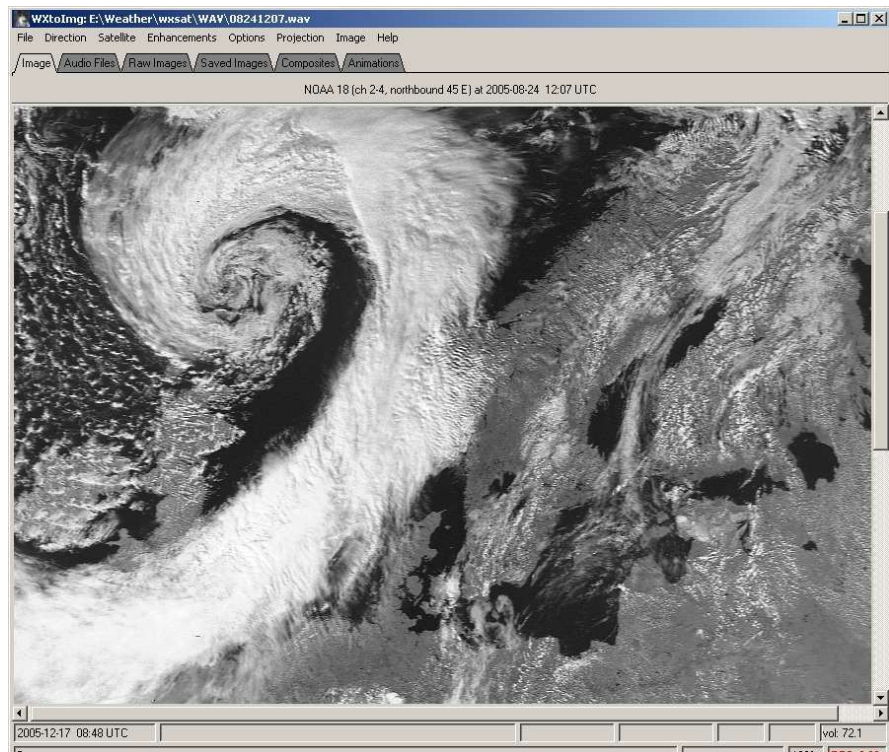
```
00:00:13:37 : DL0FHA]CQ, RSOISS*, qAR, MB7UEI-6:=5046.15N/00602.30E`73`
00:00:14:14 : G7HCE-71APK004.RSOISS*. qAR. MB7UEI-6::PDORLX :Hi from I
```

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RX-SSTV v.2.0.1 ©ON6MU (SSTVENG.DLL v.1.06)

File Edit View Tools Setup Help

RX History 77/80 2020-01-31_16.50.19.jpg

Signal

1200 1500 1900 2300

RX options

Robot 36 *Modea* RX ReSync

Martin 1 Martin 2 Slant

Scottie 1 Scottie 2

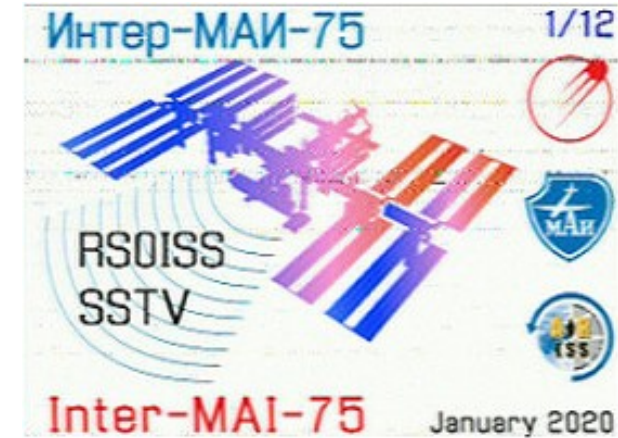
Robot 36

DSP

AFC LMS BPF

Exit

RX-SSTV de ON6MU



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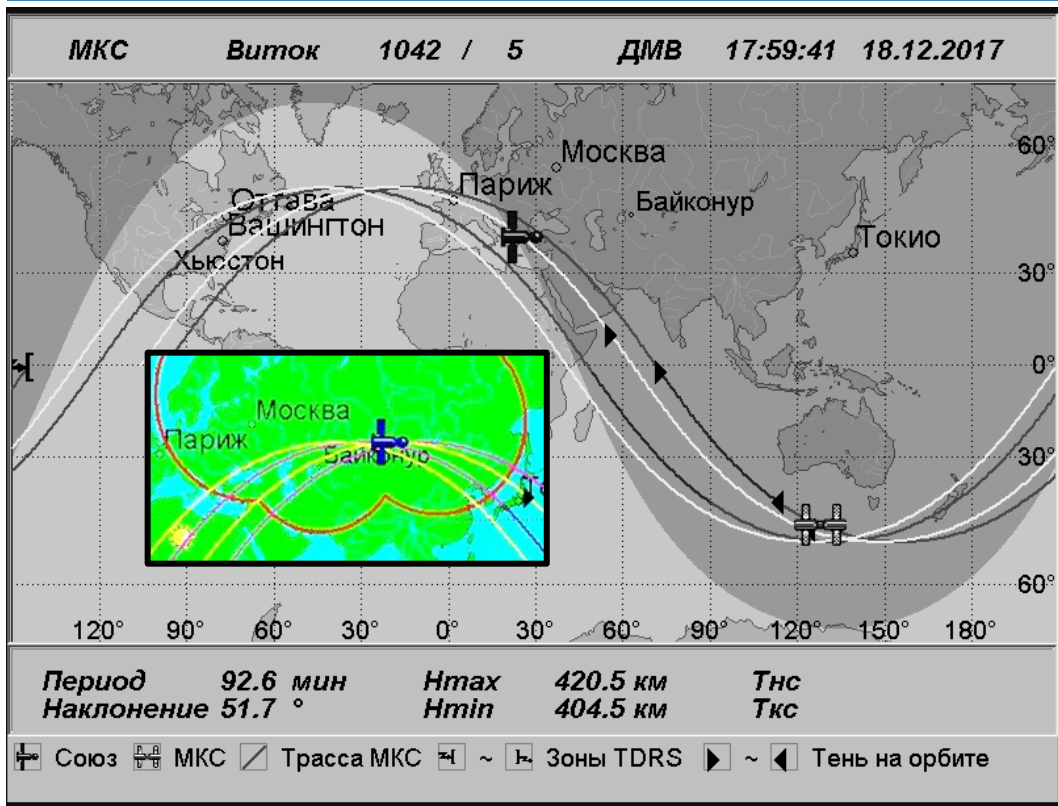
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Tracking the Soyuz

FH Aachen Space Operations Facility

Hohenstaufenallee 6 | 52064 Aachen | Germany | DL0FHA

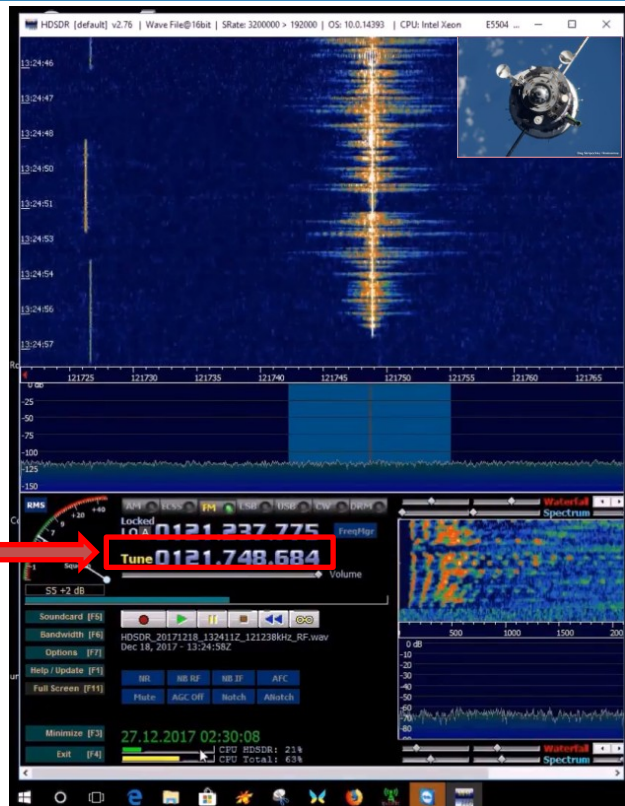
+49 241 600 952 830



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Something special with DSLWP-B



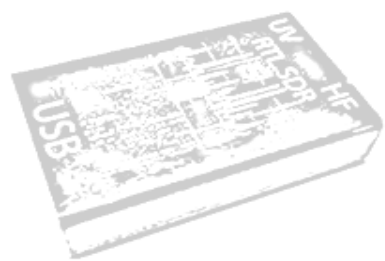
Astropellen Teleport 3

Eupener Teleport 2

Radio Control 5
Rundfunk Schmalband GP2 Receiver
IC 920 (fbd)

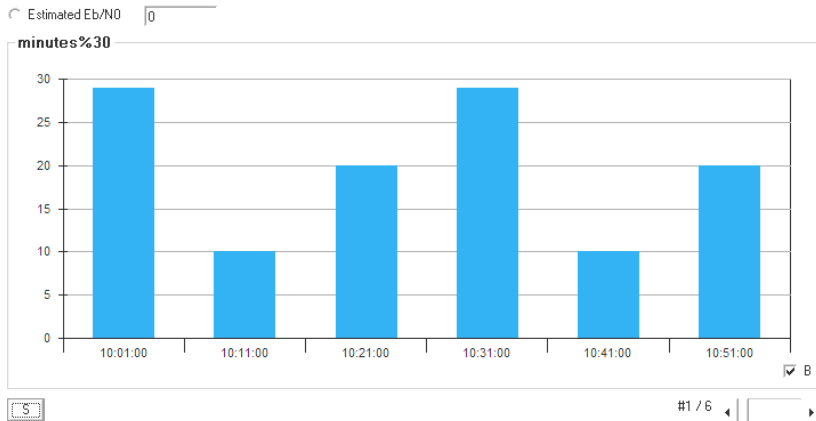
Haupt Mission
Haupt Mission

Gernwarte Aachen: Teleport 2

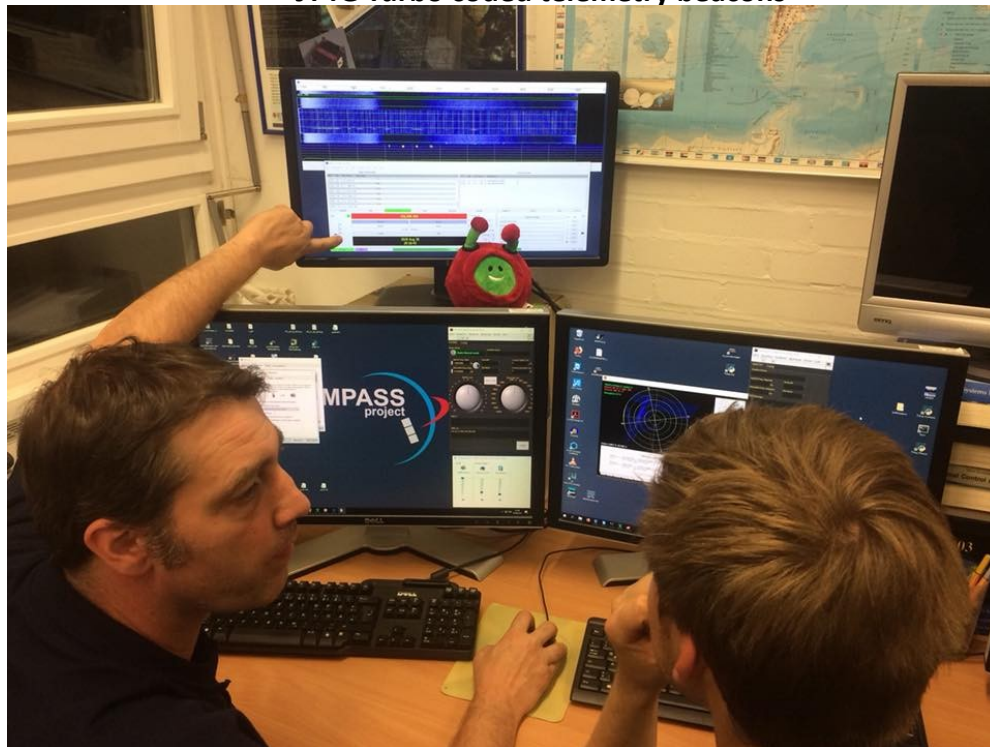


DSLWP WDD #1						DSLWP WDD #2						W/U Transceiver 1		JT4G beacon	
100100	4	-15	1.4	-61	11 *	B11SNJ8661PDT		1	0	B					
101100	5	-14	1.4	-72	11 *	B11SNJ8691PDA		1	0	B					
102100	5	-15	1.4	-92	13 *	B11SNJ86A1PDK		1	0	A					
103100	9	-11	1.4	-133	13 *	B11SNJ86A1PDT		1	0	B					
104100	5	-14	1.4	-177	11 *	B11SNJ8671PDA		1	0	A					
105100	6	-13	1.4	-217	11 *	B11SNJ8671PDK		1	0	A					
110100	0	-20	4.3	718	4 *	NO-Signal									

<input type="checkbox"/> BIN	<input type="text" value="19"/>	<input type="checkbox"/> tx gain	<input type="text" value="8"/>	<input type="checkbox"/> snr_threshold	<input type="text" value="1"/>
<input type="checkbox"/> rssi_channel	<input type="text" value="-129"/> dBm	<input type="checkbox"/> n_rf_tx	<input type="text" value="1"/>	<input type="checkbox"/> t_pa	<input type="text" value="35"/>
<input type="checkbox"/> i_bus_tx	<input type="text" value="325"/> mA	<input checked="" type="checkbox"/> minutes%30	<input type="text" value="29"/>	<input type="checkbox"/> precoder	<input type="text" value="1"/>
<input type="checkbox"/> turbo_rate	<input type="text" value="0"/>	<input type="checkbox"/> baud_rate	<input type="text" value="0"/>	<input type="checkbox"/> rx_freq	<input type="text" value="3"/>



JT4G Turbo coded telemetry beacons



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Signals from DSLWP-B using WebSDR

FH Aachen Space Operations Facility
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+49 241 600 952 830

G.A. Müller Radio Astronomy Station
"Topfeutebek your reference"

We have live signals from the 25 m dish in Dwingelo here. See the current tracking information below the dish picture to see whether we're tracking the moon and the Chinese DSLWP moon satellite.
The 2m and 6m streams are from small yagi antennas for meteor scatter reflections.

These antennas are operated by [CAMRAS](#)
Questions and comments can be sent to pub@camras.aachener-uni.de, and/or use the chatbox at the bottom of this page.

More WebSDR sessions for other bands can be found at <http://www.aachener-uni.de>

Your name or call sign:

View: all bands others slow one band blind Allow keyboard:

Waterfall: Java HTML5 Sound: Java HTML5

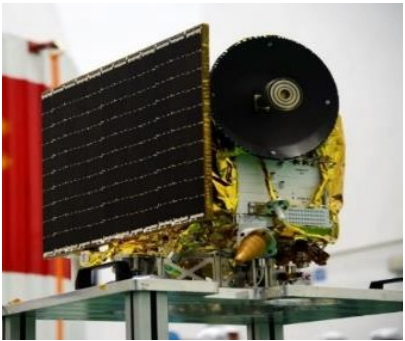
tracking: **Moon** 6.24° -0.30°
EL: **-25.417°** AZ: **19.825°**

Frequency: kHz
Bandwidth: kHz @ -6dB, 2.95 kHz @ -60dB
Band: 2m 6m
On line by clicking dragging radio buttons on the frequency scale.
Or drag the pointer edges on the frequency scale.

Waterfall view:
zoom out zoom in
FMS 2.0 FMS 1.0
On your wall select the frequency window
Speed:
Size:
View:
 Hide labels

Logbook:
Call of station that you hear:
Comments, if any:
Note: time, frequency, your name and DXCC information are added automatically.
View the [last 20 lines of the logbook](#), or the [single logbook](#) (not click the see sub-button).

Audio recording: 2779 KB
 Your browser does not seem to support it.



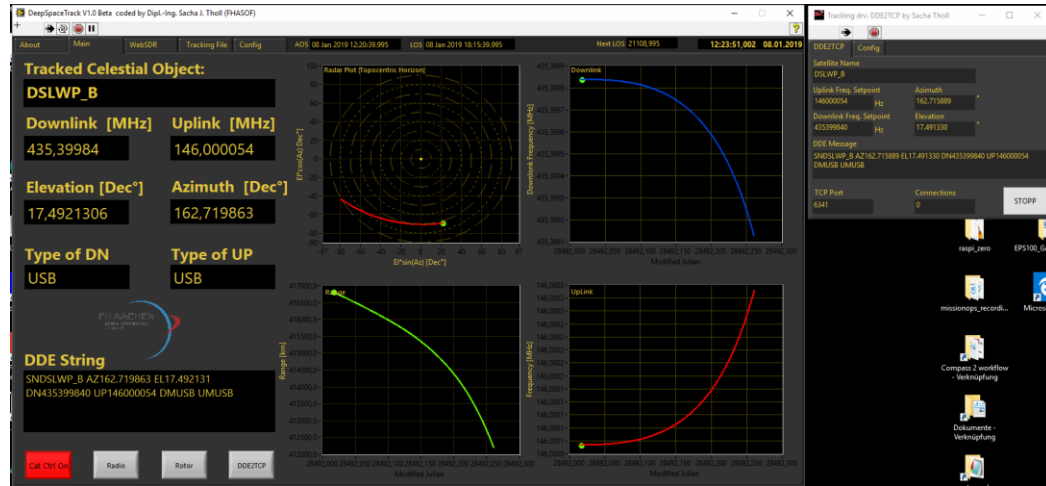
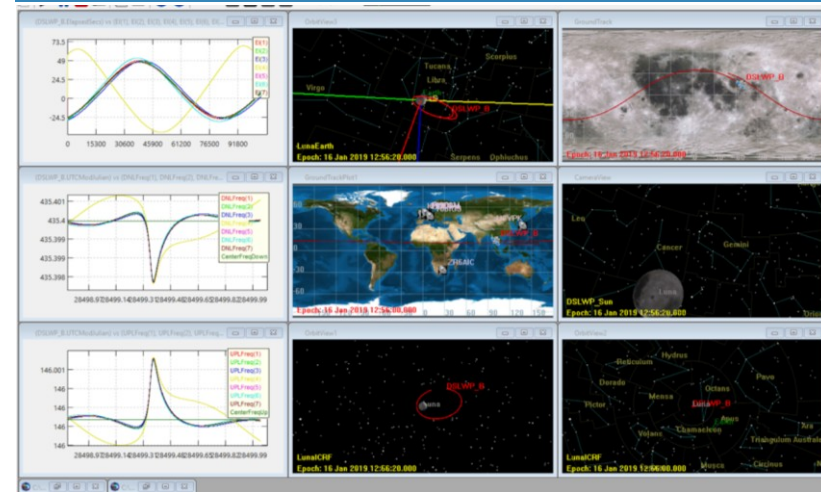
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An application for tracking non-earth orbiting and deep space celestial objects

GMAT for flight dynamics purpose and tracking non earth-orbiting celestial objects



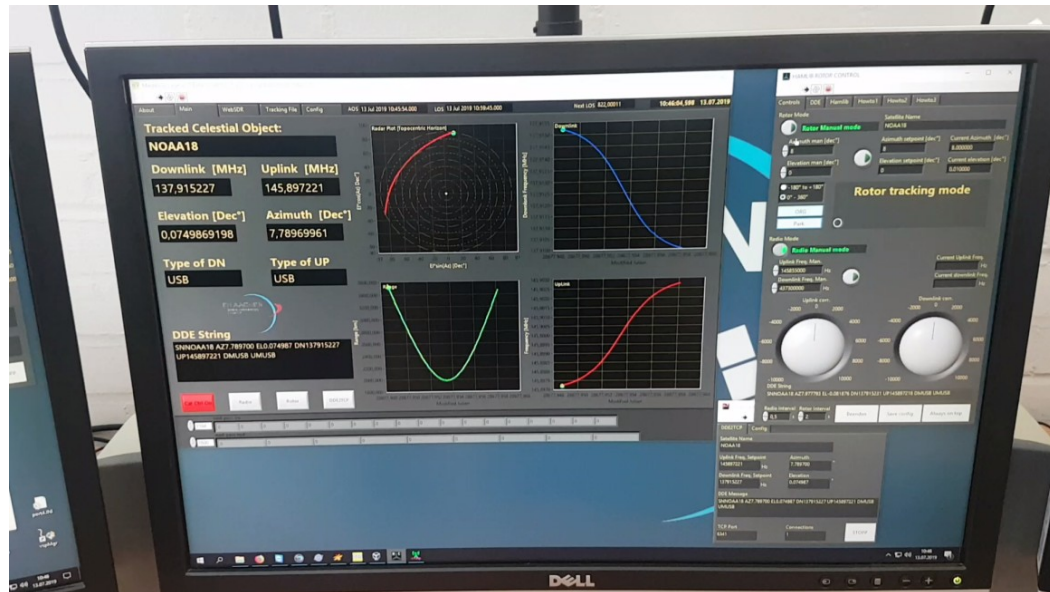
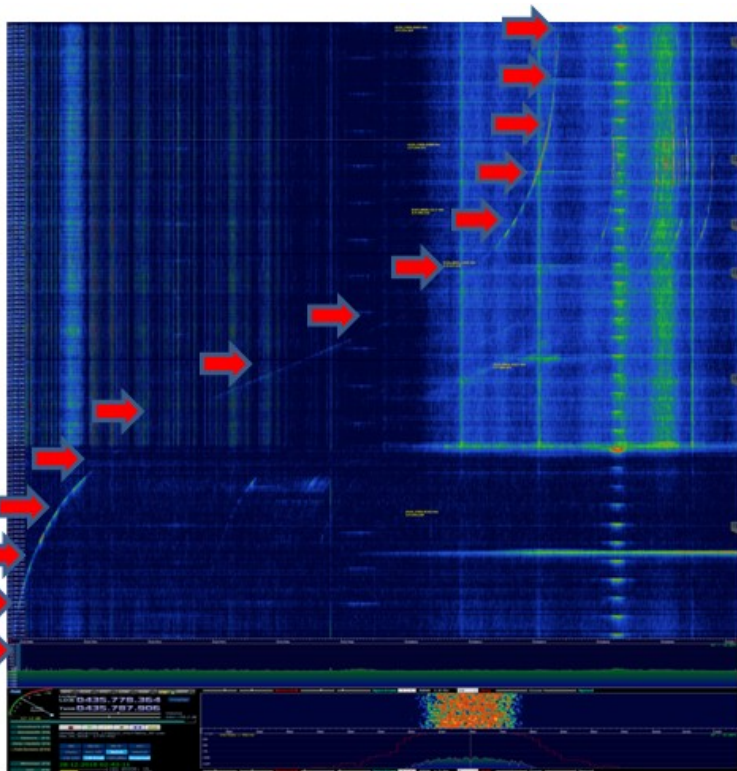
I got the idea when I saw this GMAT sheet from Daniel Estevez. I implemented David Vallado's RAZEL algorithm as a native GMAT function to get a file that would provide the exact pointing and doppler correction of DSLWP-B or any other celestial object. This propagator will be soon posted under GitHub. An announcement will be made on twitter.

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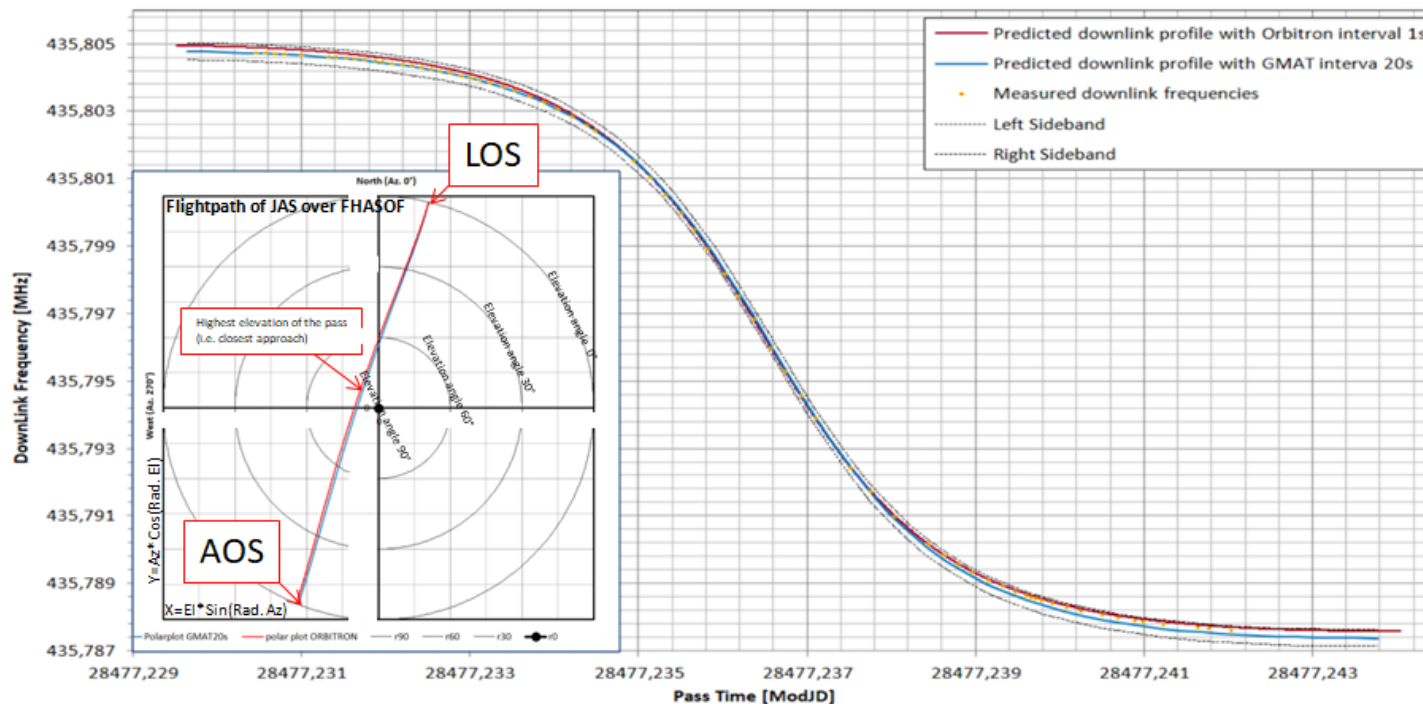
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Satellite JAS-2 FO29 pass over DL0FHA @ 17:30:30 utc 24.12.2018



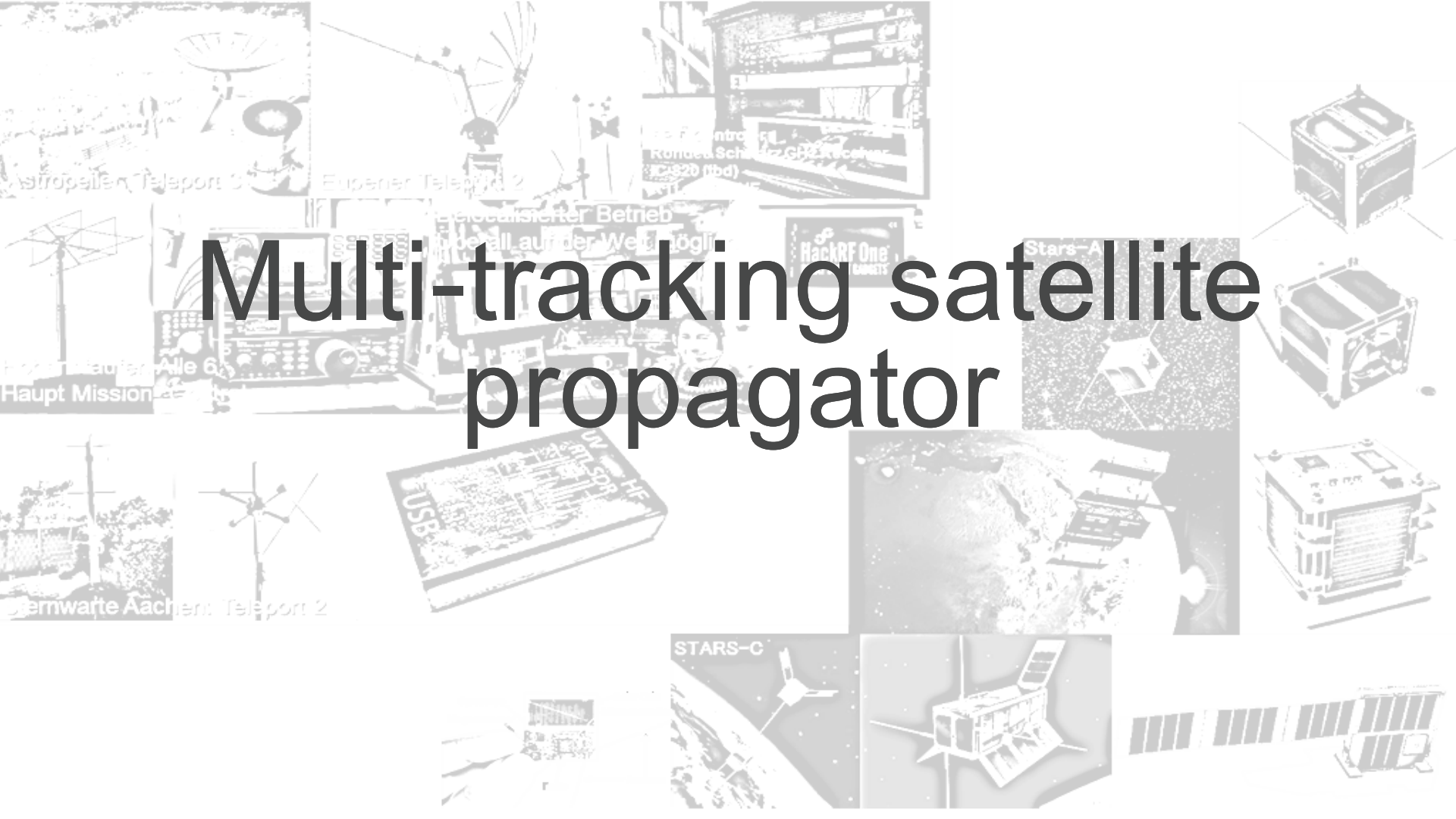
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Multi-tracking satellite propagator



Astropellen Teleport 3

Eupener Teleport 2

Radio Control
Rundfunk-Sender GPR Receiver
C920 (fbd)

Freizeitbetrieb
Überall auf der Welt möglich

HackerRF One
GADGETS

Stars-A

Haupt Mission

USB
RTL-SDR
HF

STARS-C

Gernwarte Aachen: Teleport 2

Special tool for semi-automatic multi tracking (In-house development)

We not only perform single-track sessions, but also so-called multi-track sessions, where we try to listen to as many satellites as possible.

This application is a propagator that evaluates in real-time which satellite is at this very moment, the best one to track. It analyses if the satellite is still moving towards the station or if it is already flying away. It considers the actual pointing position of the antennas to evaluate the chances of a successful interception after the injection into orbit of a cluster launch (lots of satellites very close to each other, like a swarm).

It also evaluates the downlink quality (if the satellite radio specs are known) and makes then suggestions on which satellite would be the best satellite to track. If you acknowledge, it points the antenna to that satellite, taking into consideration the time the antenna takes to move toward the satellite, to intercept the satellite on the fly to maximize the reception time.

This application is still under construction, a first Alfa release will be online on Github in April this year.

Min. Tracking El: 10 Dec°

2017-036P

TX [MHz]: 145,883 **RX [MHz]: 437,305**

Time UTC: 01:42:21,0 29.06.2017 UnixTime: 1498690000 Orbital Ph [m256]: 63,138

Asimut [Dec°]: 199,175 Elevation [Dec°]: -50,664 Orbit Number: 82 Velocity [Km/h]: 27358,535

Longitude [Dec°]: 23,948 Latitude [Dec°]: -50,903 Altitude [km]: 524,488 Range [km]: 10484

RSET Map Show HSDSR HSDSR Wisp Rotor Cat Control On Optionen Download TLE Change Sat

COMPASS
Propagator project

Graphical Propagation Representation
Study DragSail/FH Aachen
By Dip.-Ing. Sacha Tholl

Shutdown

TRAPS

Satellite	Cat Nr.	Range [km]	El. [°]	Az. [°]	Lat. [°]	Long. [°]	Orbital	Vel. [km/h]	Alt. [km]	Uplink1 [MHz]	Uplink2 [MHz]	Downlink1 [MHz]	Downlink2 [MHz]	Bcn. 1 [MHz]	Bcn. 2 [MHz]	Modes	Callign	Status	AGS	LDS	Elmax [°]
2017-036P	42778	10530	-51,005	190,740	-51,644	23,640	62,597	27358	524	145,885	145,885	240300,000	437,300	437,300	437,300	AFSKAX25	ONM4DL	ACTIVE	29.06.2017 10:19	29.06.2017 10:20	14
2017-036N	42777	10696	-52,281	197,219	-54,383	22,651	61,457	27356	525	145,885	145,885	240300,000	437,300	437,300	437,300	AFSKAX25	ONM4DL	ACTIVE	29.06.2017 10:19	29.06.2017 10:20	14
2017-036F	42770	10864	-53,626	195,570	-57,263	21,447	57,617	27361	524	145,885	145,885	240300,000	437,300	437,300	437,300	AFSKAX25	ONM4DL	ACTIVE	29.06.2017 10:20	29.06.2017 10:30	14
2017-036M	42776	10974	-54,488	194,458	-59,141	20,544	61,013	27352	528	145,885	145,885	240300,000	437,300	437,300	437,300	AFSKAX25	ONM4DL	ACTIVE	29.06.2017 10:21	29.06.2017 10:31	14
2017-036L	42775	11016	-54,632	194,010	-59,805	20,180	60,614	27352	526	145,885	145,885	240300,000	437,300	437,300	437,300	AFSKAX25	ONM4DL	ACTIVE	29.06.2017 10:21	29.06.2017 10:31	14
2017-036E	42774	11145	-55,910	192,573	-62,214	18,859	58,256	27352	529	145,885	145,885	240300,000	437,300	437,300	437,300	AFSKAX25	ONM4DL	ACTIVE	29.06.2017 10:22	29.06.2017 10:32	15
2017-036J	42773	11176	-56,174	192,212	-62,785	18,470	57,802	27352	529	145,885	145,885	240300,000	437,300	437,300	437,300	AFSKAX25	ONM4DL	ACTIVE	29.06.2017 10:22	29.06.2017 10:32	15
2017-036H	42772	11227	-56,613	191,603	-63,736	17,838	57,203	27351	529	145,885	145,885	240300,000	437,300	437,300	437,300	AFSKAX25	ONM4DL	ACTIVE	29.06.2017 10:22	29.06.2017 10:32	15
2017-036G	42771	11289	-57,146	190,850	-64,889	17,009	55,818	27352	529	145,885	145,885	240300,000	437,300	437,300	437,300	AFSKAX25	ONM4DL	ACTIVE	29.06.2017 10:22	29.06.2017 10:32	15
2017-036E	42769	11302	-57,681	190,605	-66,097	15,947	54,768	27351	530	145,885	145,885	240300,000	437,300	437,300	437,300	AFSKAX25	ONM4DL	ACTIVE	29.06.2017 10:23	29.06.2017 10:33	15
2017-036D	42768	11464	-58,707	188,541	-68,266	14,082	52,317	27353	530	145,885	145,885	240300,000	437,300	437,300	437,300	AFSKAX25	ONM4DL	ACTIVE	29.06.2017 10:23	29.06.2017 10:33	15
2017-036B	42766	11544	-59,440	187,392	-69,852	12,361	53,608	27350	531	145,885	145,885	240300,000	437,300	437,300	437,300	AFSKAX25	ONM4DL	ACTIVE	29.06.2017 10:24	29.06.2017 10:34	15
2017-036A	42765	11545	-59,446	187,394	-69,864	12,351	53,632	27350	531	145,885	145,885	240300,000	437,300	437,300	437,300	AFSKAX25	ONM4DL	ACTIVE	29.06.2017 10:24	29.06.2017 10:34	15
2017-036C	42767	12475	-69,316	163,623	-79,742	259,960	50,914	27338	537	145,885	145,885	240300,000	437,300	437,300	437,300	AFSKAX25	ONM4DL	ACTIVE	29.06.2017 10:31	29.06.2017 10:42	18
2017-036C	42767	12487	-69,693	162,994	-79,389	257,953	50,554	27338	537	145,885	145,885	240300,000	437,300	437,300	437,300	AFSKAX25	ONM4DL	ACTIVE	29.06.2017 10:31	29.06.2017 10:42	18

TX Base [MHz]: 145,885

RX Base [MHz]: 437,300

TX Freq: [input type="text" value="145,885"] RX Freq: [input type="text" value="437,300"] Show: [input type="radio" checked="" value="All Sats"/> All Sats [input type="radio" value="Only incoming"/> Only incoming

Uplink1: [input type="radio" checked="" value="Downlink 1"/> Downlink 1 [input type="radio" value="Beacon1"/> Beacon1 [input type="radio" value="Beacon2"/> Beacon2

Uplink2: [input type="radio" value="Downlink 2"/> Downlink 2

Satellite Catalog Number: [input type="text" value="42778U"] Inclination [Dec°]: [input type="text" value="97,4512"] Mean Anomaly [Dec°]: [input type="text" value="138,628"] Revolution number [Revs]: [input type="text" value="75"] Peace of launch: [input type="text" value="P"]

JD [UTC] TLE Epoch: [input type="text" value="2457932,994444444"] Exentricity: [input type="text" value="0,0011818"] Mean Motion [Revs/day]: [input type="text" value="15,2033"] B⁰ Drag Term [1/ER]: [input type="text" value="4,523E-5"] Launch year: [input type="text" value="17"]

Peace Nr.: [input type="text" value="16"] RAAN [Dec°]: [input type="text" value="239,239"] 1st Derivative of Meam motion: [input type="text" value="9,15E-6"] Satellite Number: [input type="text" value="42778"]

TLE epoch (UTC): [input type="text" value="13:52:00,000 28.06.2017"] 2st Derivative of Meam motion: [input type="text" value="0"] Launch number of year: [input type="text" value="37"]

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Notice:

We are always eager to test new hard equipment and software applications. So if you have any space- operations related open-source applications that need to be (beta)-tested under real-world conditions, such as propagators, sdr-radio applications, sdr-hardware, ground-station applications, encoders/decoders, just send us an email:

Sacha Tholl: tholl@fh-aachen.de





Thank you for having
listened

We want to particularly thank all the developers of open-source software. Without your impressive work, our passion would be far more difficult to achieve!

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