Telemetriedaten empfangen
und dekodieren

DK3WN – Mike Rupprecht

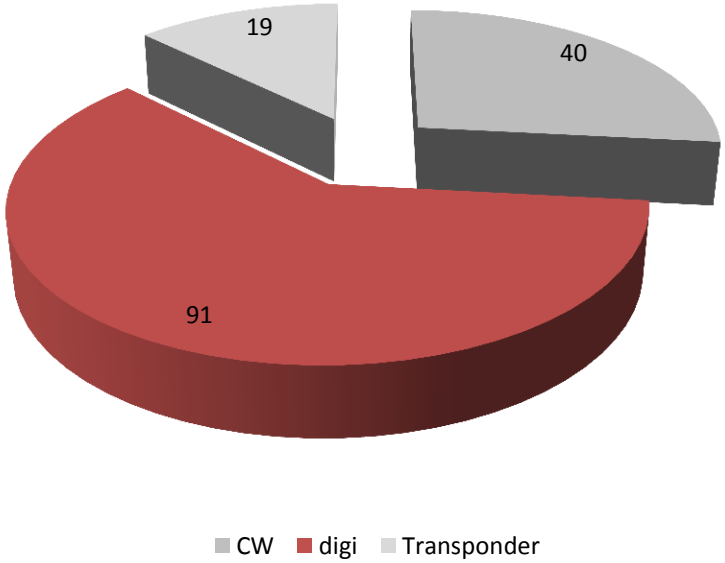
Amateurfunkdienst über Satellit «Mission Control bei sich zu Hause»

AMSAT-DL

International Satellites for
Communication, Science and Education

Dekodierung digitaler Telemetrie

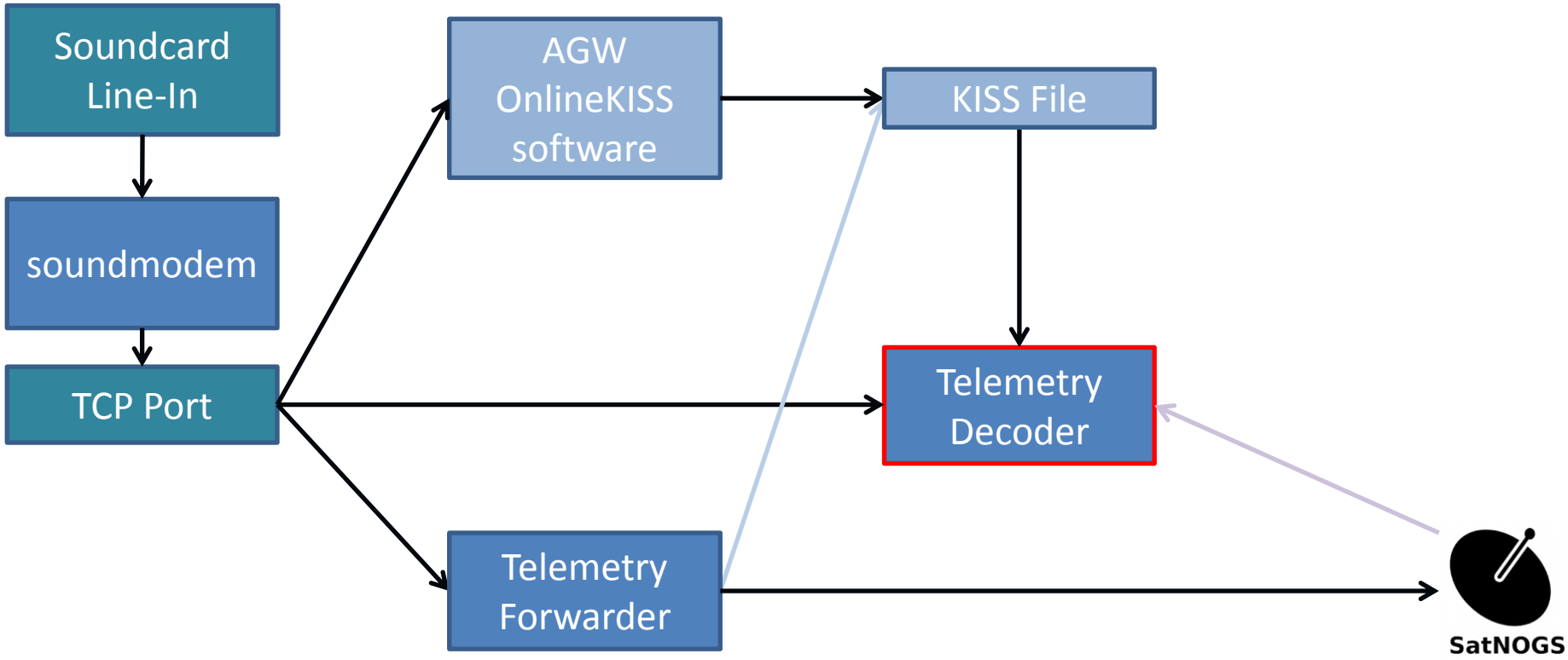
- OS: Windows / Linux
- Dekoder: Software / Soundkarte
  Hardware (TNC)
- Modulationsarten
- Anwendungen (Telemetrie, WOD, wissenschaftliche Daten, Bilder)
- Visualisierung Telemetrie
- Datenbanken



AALTO-1 * BEEAGLESAT * CAS-3G * CAS3-I * CAS-4A * CAS-4B * CHUBUSAT-2 * CHUBUSAT-3 * DUCHIFAT * HAVELSAT * HORYU-2 * SPROUT * SUCHAI * VZLUSAT-1 * XW-2A * XW-2B * XW-2C * XW-2D * XW-2F * AAUSAT-4 * AAUSAT-II * AENEAS * AIST-2D * ALSAT-1N * ATLANTIS * BEESAT-2 * BEESAT-4 * BEESAT-4 * BISONSAT * BUGSAT-1 * CHALLENGER * COLUMBIA * CUBEBUG-1 * CUBEBUG-2 * CUTE1.7+APDII * DELFI-C3 * D-SAT * DX-1 * E1P-U2 * E-ST@R-II * EX-ALTA1 * FIREBIRD-II FU3 * FIREBIRD-II FU4 * FOX-1A * FUNCUBE-1 * FUNCUBE-2 (ON UKUBE-1) * GOMX-1 * GRIFEX * HOOPOE * INSPIRE-2 * ISS * LAPAN-A2/ORARI * LAPAN-A3 * LILACSAT-1 * LILACSAT-2 * LINK * LITUANICASAT-2 * MCUBED-1 * MCUBED-2 * MINXSS-1 * NAYIF-1 * NIUSAT * NJFA-1 (TW1-C) * NJUST-1 * NSIGHT-1 * NUDTSAT * NUSAT-1 * NUSAT-2 * O/OREOS * PARKINSONSAT * PCSAT (NO-44) * PEGASUS * PHOENIX * ROBUSTA-1B * SHANGKEDA-2 (TW1A) * SKCUBE * STRAND-1 * SWISSCUBE-1 * TANUSHA-1 (RS-6S) * TECHNOSAT * TIGRISAT * UCLSAT * UNISAT-6 * UNSW-EC0 * UOSAT-2 UO-11 * URSA MAIOR * UWE-3 * X-CUBESAT * ZA-AEROSAT * ZACUBE-1

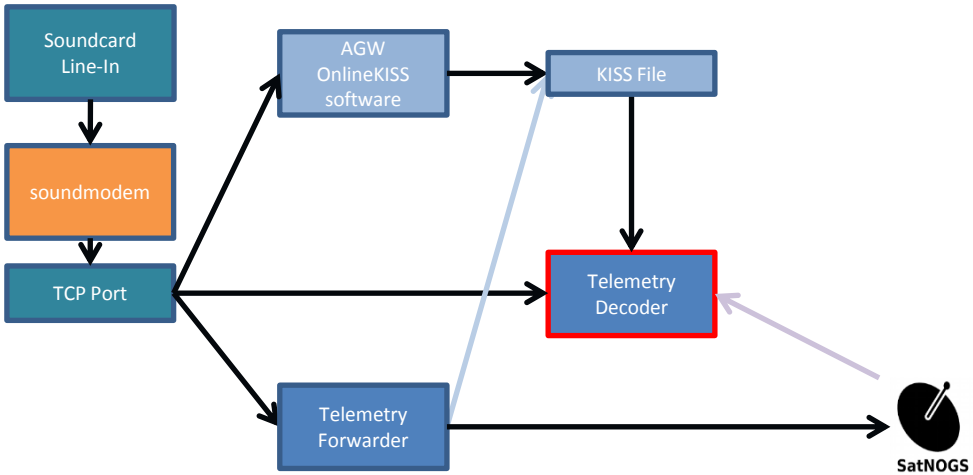
Dekodierung unter Windows

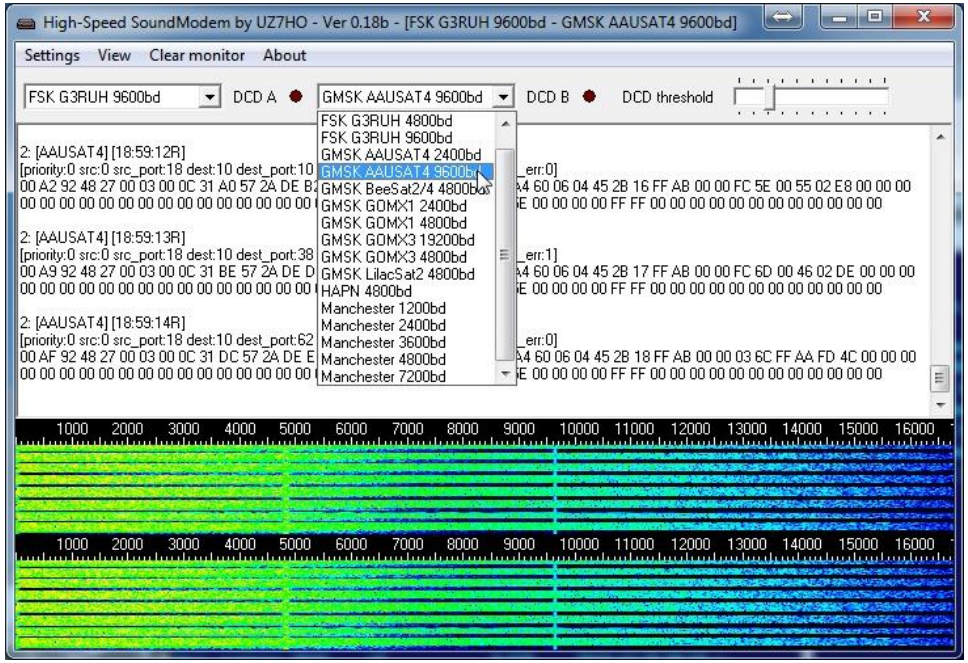
soundmodem Software UZ7HO http://uz7.ho.ua/packetradio.htm
Telemetriedekoder Software DK3WN http://www.dk3wn.info/p/?page_id=75524



UZ7HO's soundmodem

Andrey Kopanchuk, UZ7HO



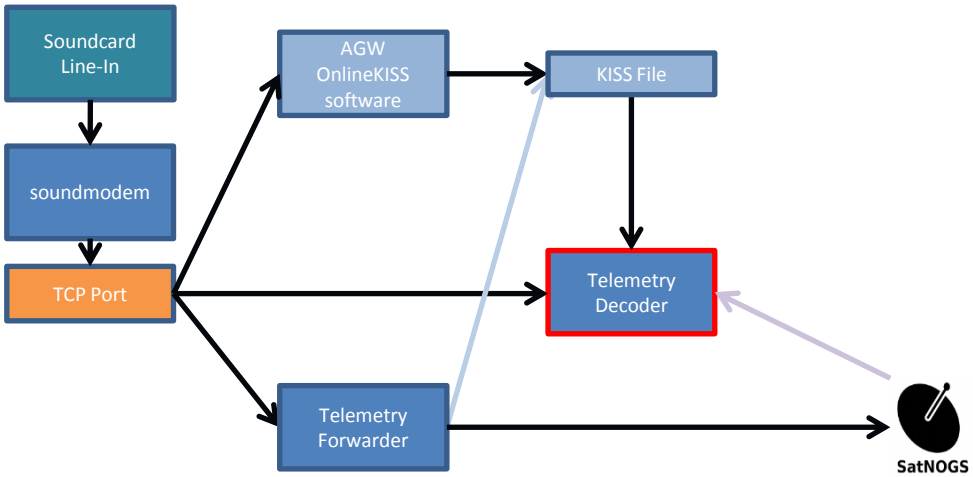


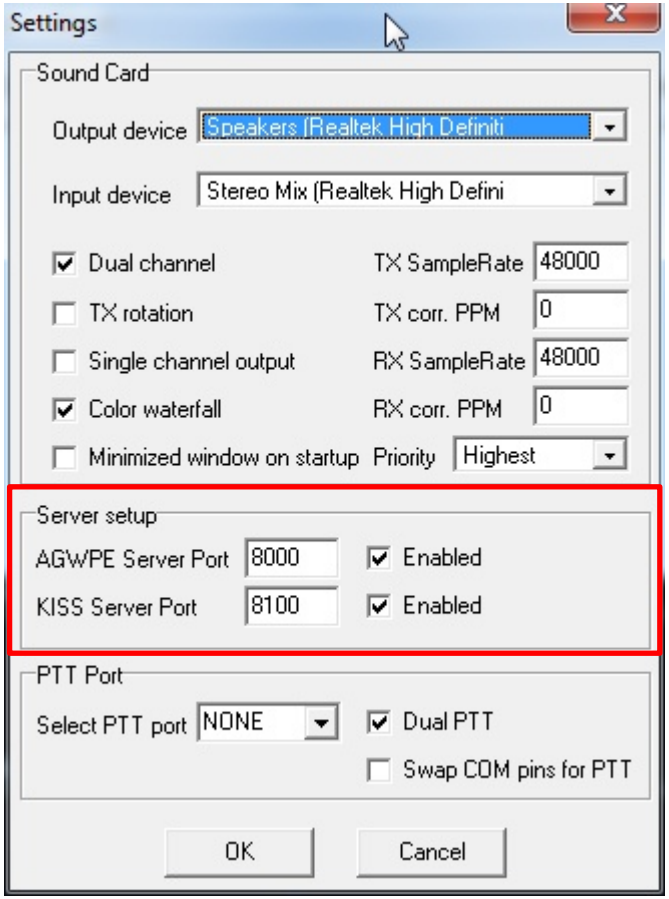
Modulationsarten

Soundmodem soundmodem97.zip (08 Oct 2017)
AFSK 300, 600, 1200, 2400 baud
(D)BPSK 300, 600, 1200, 2400 baud
(D)QPSK 2400, 3600, 4800 baud

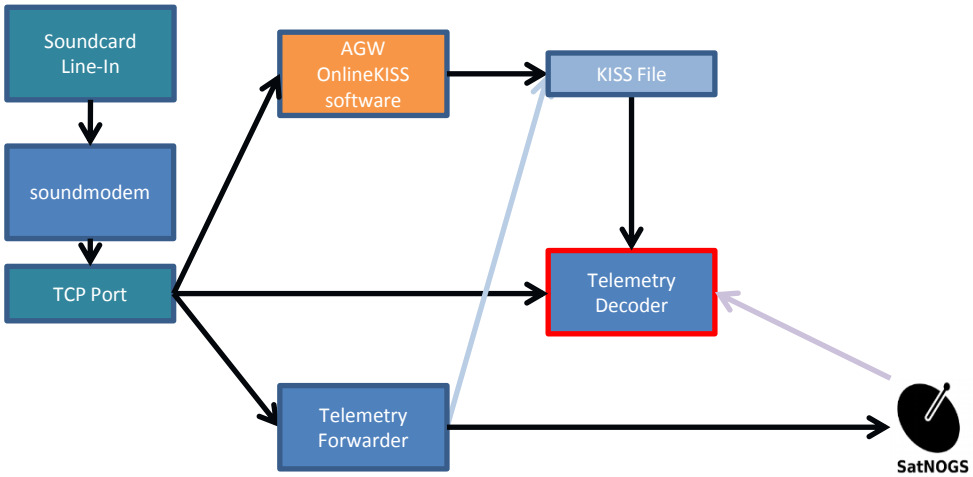
High-Speed Soundmodem hs_soundmodem19.zip (08 Oct 2017)
G3RUH 4800, 9600, 19200 baud
Manchester 1200, 2400, 3600, 7200 baud
GOMX-1/3, Mobitex-NX (BeeSAT-2/4), AAUSAT-4, LilacSat-2 decoders

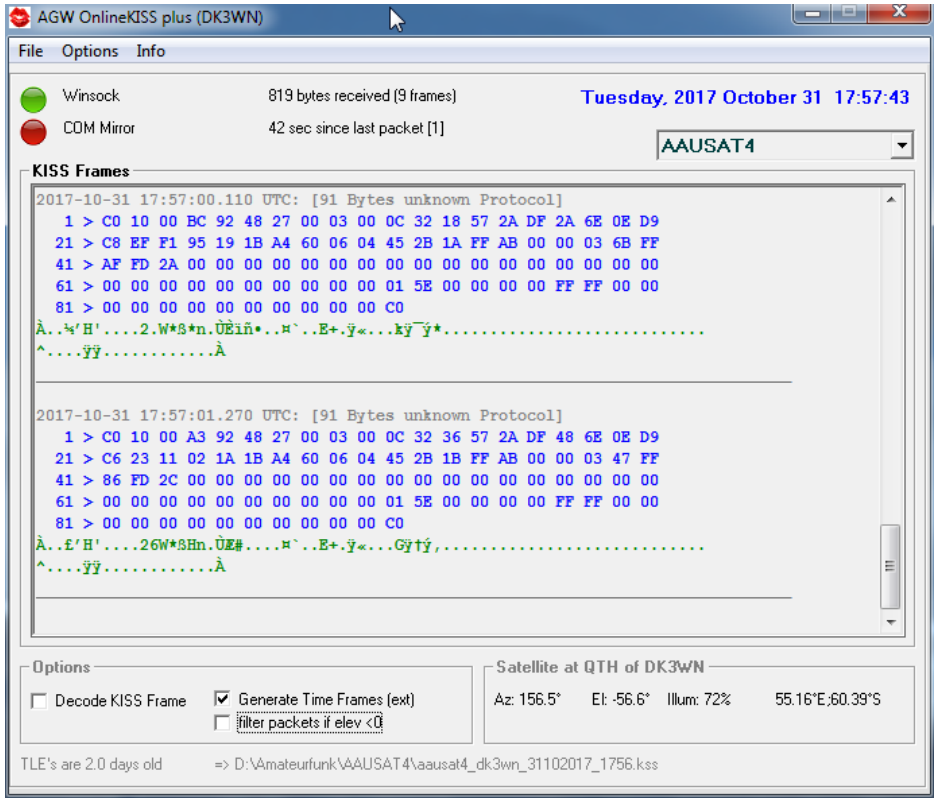
Soundmodem - TCP Port





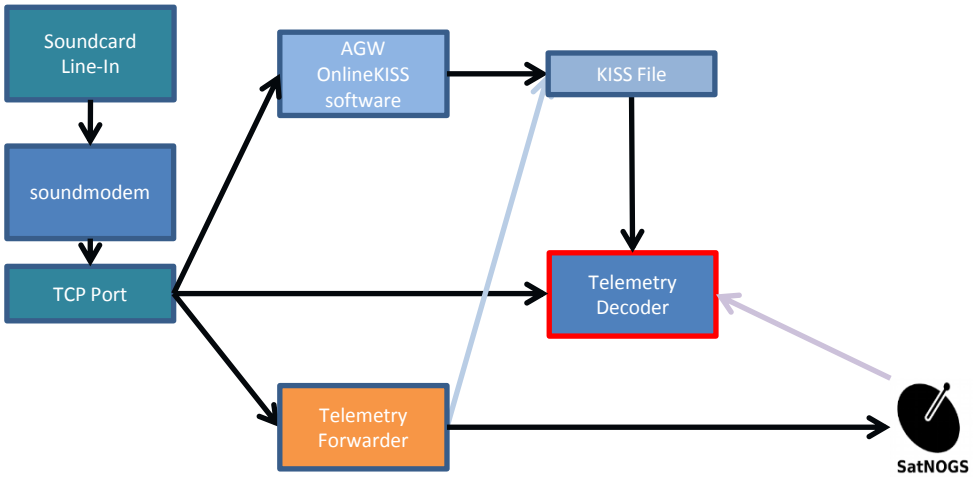
AGWOnlineKISS

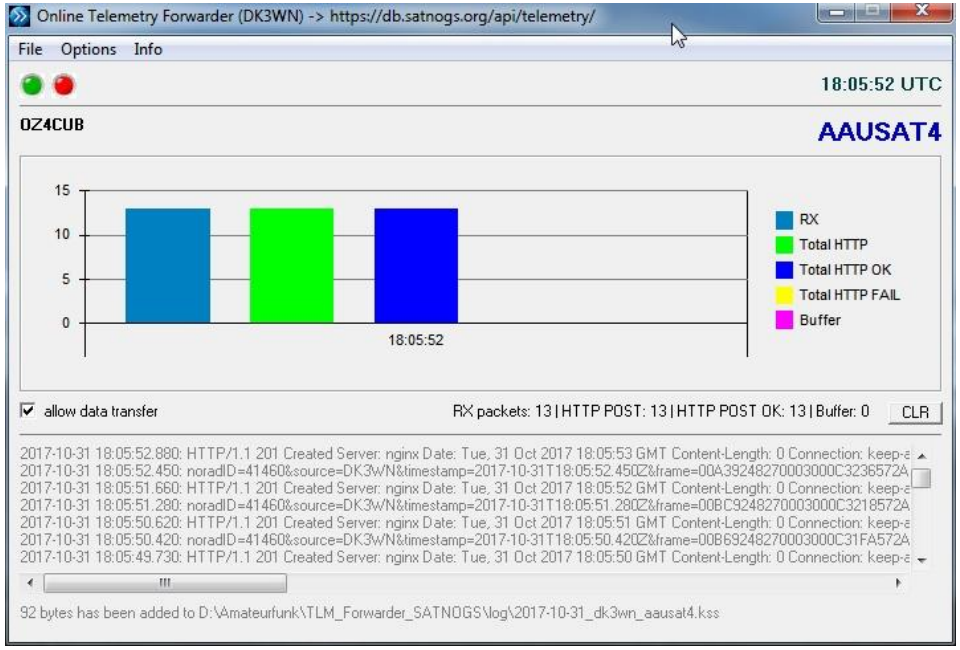





```
PORT = 127.0.0.1:8000
#
MIRROR_COM_PORT = 7
MIRROR_COM_SETTINGS = 9600,N,8,1
#
FILE_PATH = D:\Amateurfunk
#
TIMEFRAMES = YES
LOGFILE = NO
PAYLOADFILE = NO
#
CALLSIGN = DK3WN
#
# use QTH height in km
#
QTH_LAT = 49.73145
QTH_LONG = 8.95564
QTH_HEIGHT = 0.28
#
TLEFILE = D:\Amateurfunk\Orbitron\TLE\amateur.txt
```

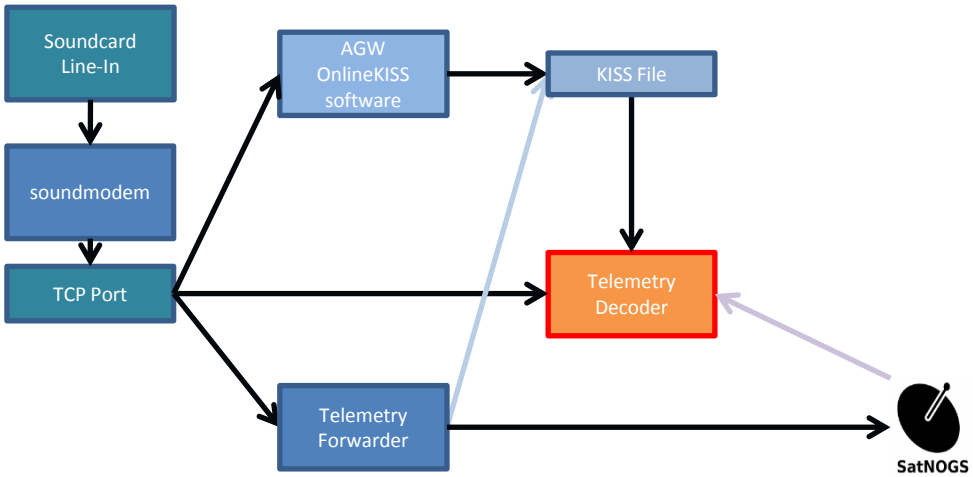
Telemetry Forwarder

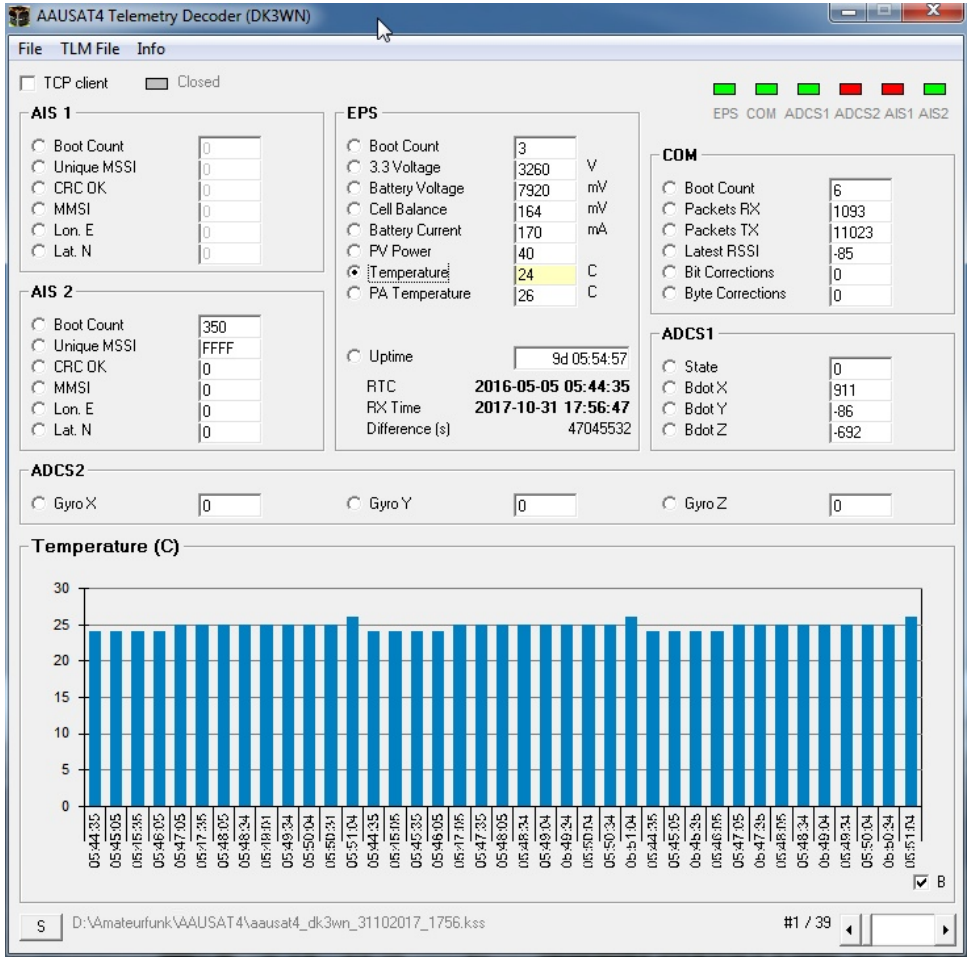





```
PORT = 127.0.0.1:8000

#kiss port e.g. soundmodem port 8002/8102
#if you on't use a second soundmodem please comment the port out by #
#
#PORT2 = 127.0.0.1:8002

#SATNOGS database
SERVER = https://db.satnogs.org/api/telemetry/

#
MYCALL = DK3WN
QTH_LAT = 49.73N
QTH_LONG = 8.95E
#

LEFT = 1
TOP = 1
```

Telemetrie Dekoder

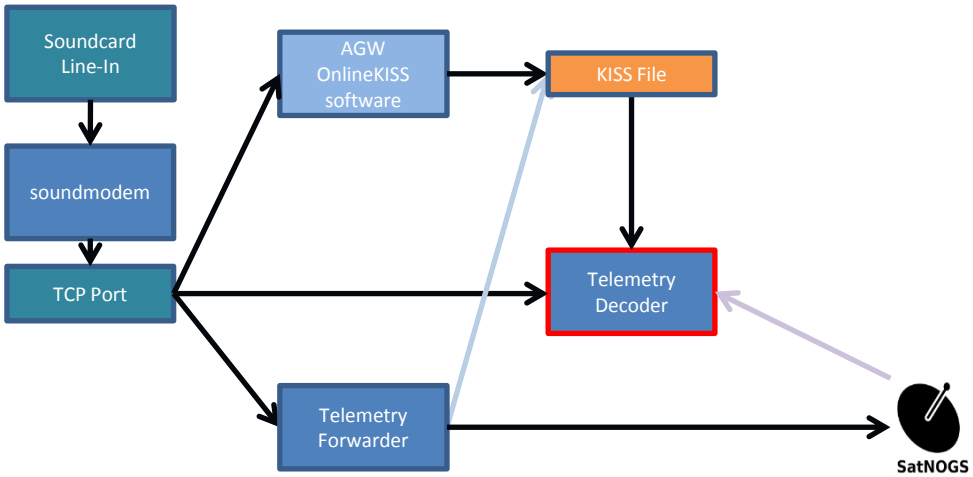


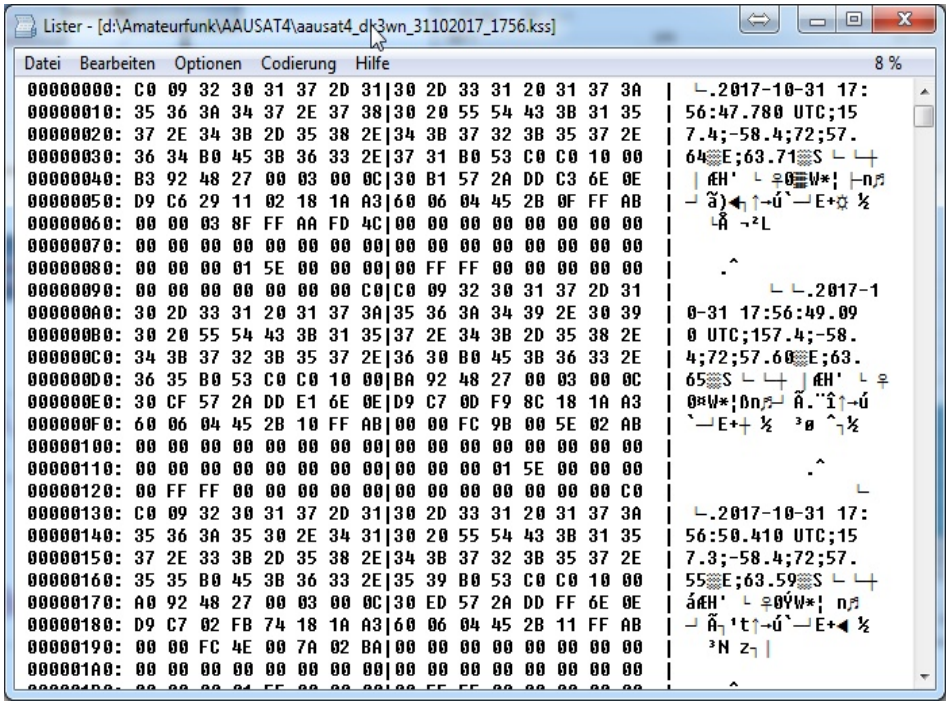


- Import: KISS, Text, Serverlog
- Export: CSV, Text

- TCP Client
- Screenshot Button

KISS File





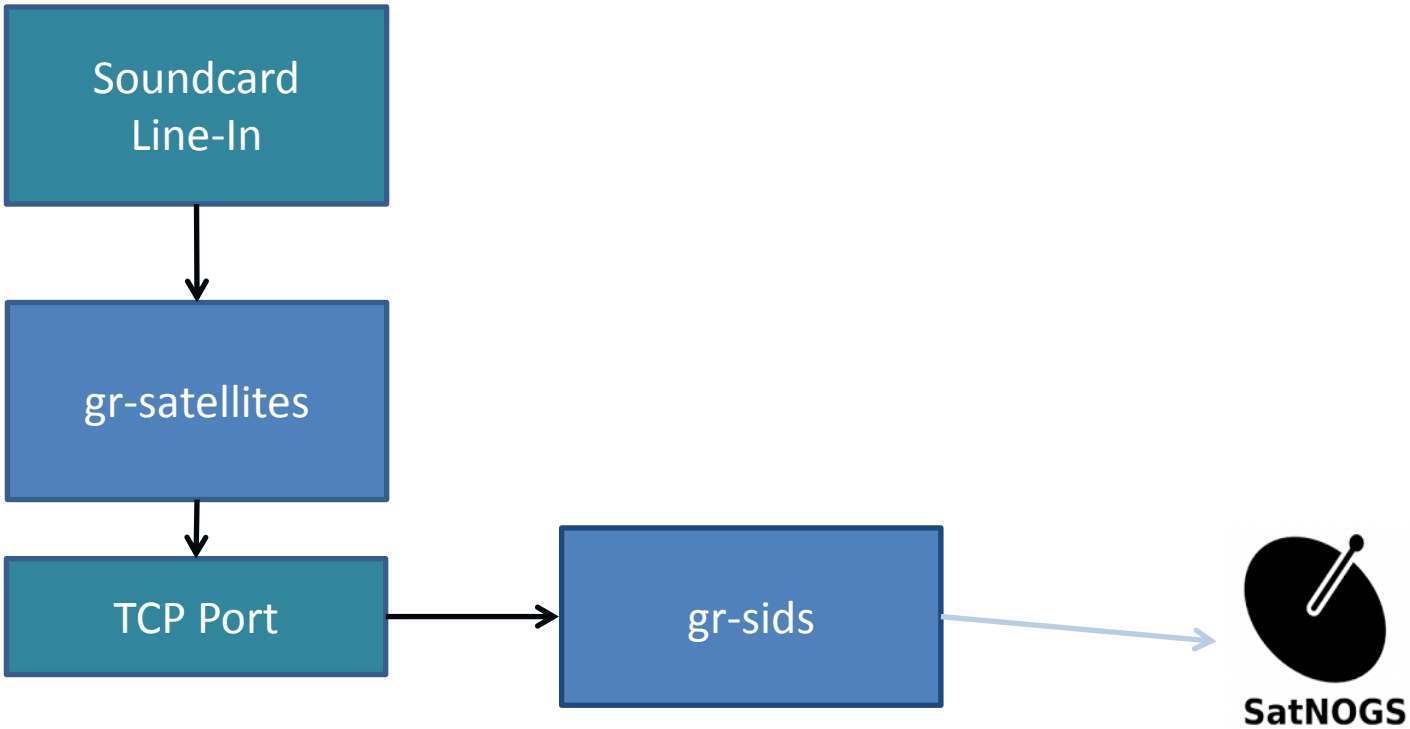
- KISS File = binäre Datei

- Timestamp
- AZ / EL / Illumination (AGWOnlineKISS)

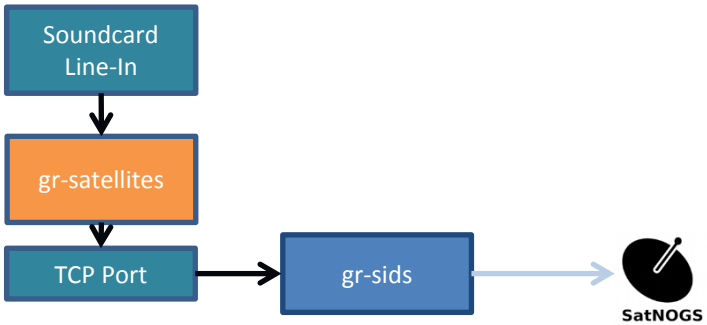
Dekodierung unter Linux

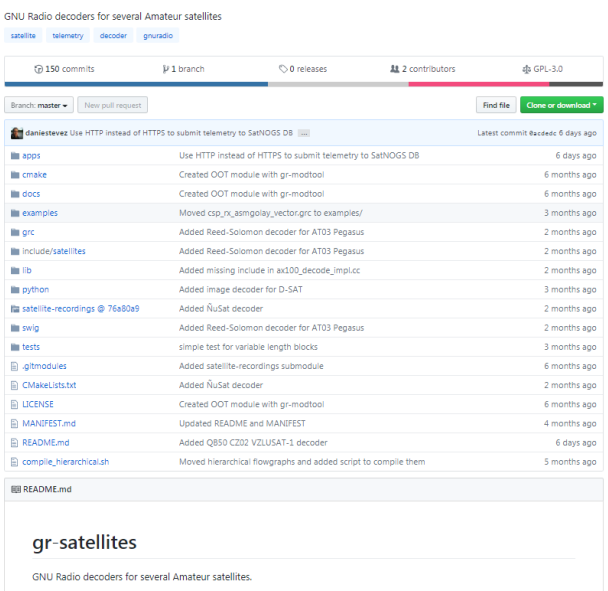
GNURadio

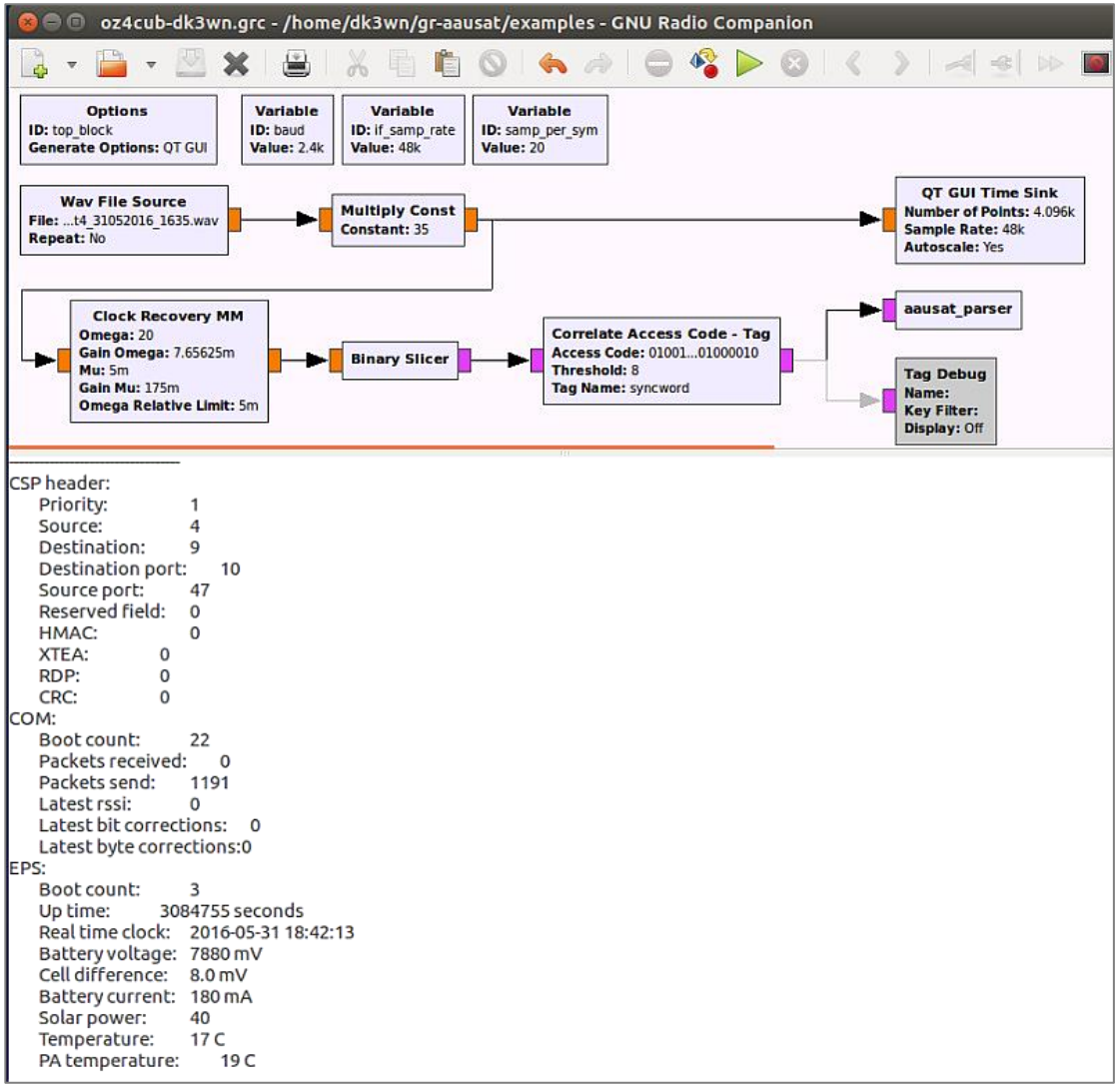
gr-satellite	EA4GPZ	https://github.com/daniestevez/gr-satellites
gr-sids	EA4GPZ	https://github.com/daniestevez/gr-sids



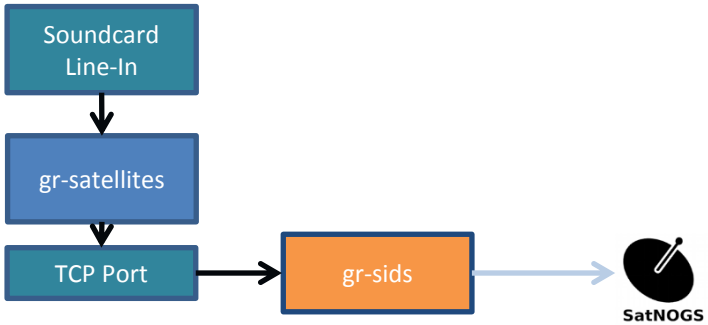
gr-satellites

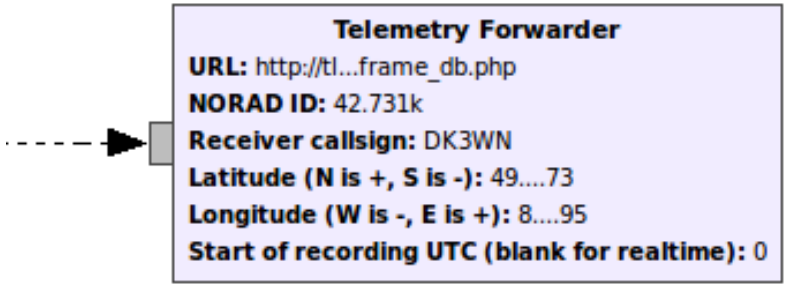






gr-sids





gr-sids is a set of GNUradio blocks designed to submit telemetry to a server using the Simple Downlink Share Convention (SiDS) protocol. This is the same protocol that it is used by the DK3WN Telemetry Forwarder

GNUradio telemetry forwarder using the Simple Downlink Share Convention (SiDS) protocol

12 commits | 1 branch | 0 releases | 1 contributor | Unlicense

Branch: master | New pull request | Find file | Clone or download

daniestevez Added deprecated note in README — Latest commit 4a0b4f3 on 13 May

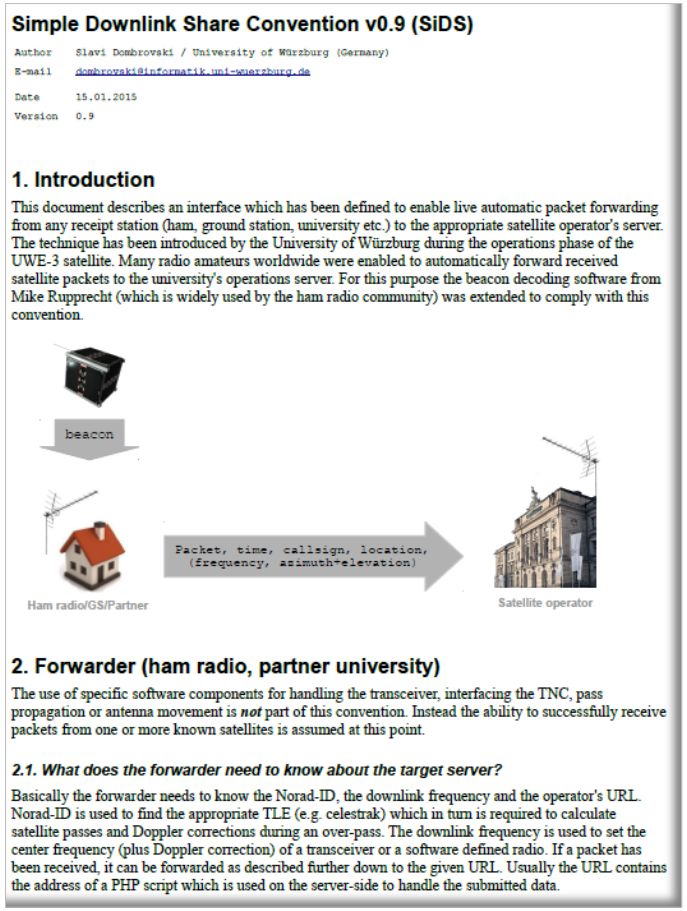
apps	New OOT module	a year ago
cmake	New OOT module	a year ago
docs	New OOT module	a year ago
examples	New OOT module	a year ago
grc	Corrected bug in default format of "Print timestamp"	9 months ago
include/sids	New OOT module	a year ago
lib	New OOT module	a year ago
python	Added "Print timestamp" block	9 months ago
swig	New OOT module	a year ago
CMakeLists.txt	New OOT module	a year ago
LICENSE	Initial commit	a year ago
MANIFEST.md	Updated MANIFEST and README	a year ago

Simple Downlink Share Convention

2015: SiDS Standard mit Universität Würzburg (UWE-3)

Field	*Type*	*Required*	*Description*	*Example*
noradID	Integer	yes	Norad ID of the spacecraft	39446
source	String	yes	e.g. Callsign of the receiver	DK3WN
timestamp	String	yes	UTC timestamp (*see ISO 8601*)	2014-05-01T10:21:33.560Z
frame	HEXString	yes	Received binary data as hexadecimal string. Whitespaces are *optional*	88 88 60 AA...
locator	String	yes	Type of the given receiver's location. Currently only 'longLat' is supported which defines the *WGS84* standard	longLat
longitude	String	yes	Longitude of the receiver's location (*WGS84*)	8.95564E
latitude	String	yes	Latitude of the receiver's location (*WGS84*)	49.73145N
tncPort	Integer	no	Port at which the packet was received (e.g. the defined Channel in the KISS packet)	0
azimuth	Float	no	Azimuth degree of a directional antenna (if available)	10.5
elevation	Float	no	Elevation degree of a directional antenna (if available)	85.0
fDown	Integer	no	Frequency of the transceiver's downlink channel during the receive (with doppler!)	436399000

Table 1: Required fields for the forwarding



Simple Downlink Share Convention v0.9 (SiDS)

Author Slavi Dombrovski / University of Würzburg (Germany)
E-mail dombrovski@informatik.uni-wuerzburg.de
Date 15.01.2015
Version 0.9

1. Introduction

This document describes an interface which has been defined to enable live automatic packet forwarding from any receipt station (ham, ground station, university etc.) to the appropriate satellite operator's server. The technique has been introduced by the University of Würzburg during the operations phase of the UWE-3 satellite. Many radio amateurs worldwide were enabled to automatically forward received satellite packets to the university's operations server. For this purpose the beacon decoding software from Mike Rupprecht (which is widely used by the ham radio community) was extended to comply with this convention.

2. Forwarder (ham radio, partner university)

The use of specific software components for handling the transceiver, interfacing the TNC, pass propagation or antenna movement is ***not*** part of this convention. Instead the ability to successfully receive packets from one or more known satellites is assumed at this point.

2.1. What does the forwarder need to know about the target server?

Basically the forwarder needs to know the Norad-ID, the downlink frequency and the operator's URL. Norad-ID is used to find the appropriate TLE (e.g. celestrak) which in turn is required to calculate satellite passes and Doppler corrections during an over-pass. The downlink frequency is used to set the center frequency (plus Doppler correction) of a transceiver or a software defined radio. If a packet has been received, it can be forwarded as described further down to the given URL. Usually the URL contains the address of a PHP script which is used on the server-side to handle the submitted data.

```
http://robotik.informatik.uni-wuerzburg.de/uwe/report_frame.php?
2017-09-27 18:35:10.520: noradID=42702&source=DK3WN&timestamp=2017-09-27T18:35:10.520Z&frame=86A2404040406096887086 94A8E103F0FAF321
0800DE0080215EAB8EA1B12E62410609B50ABC0A890ABA0AB0B00000030073A0A4&locator=longLat&longitude=8.95E&latitude=49.73N&version=1.0.3
```

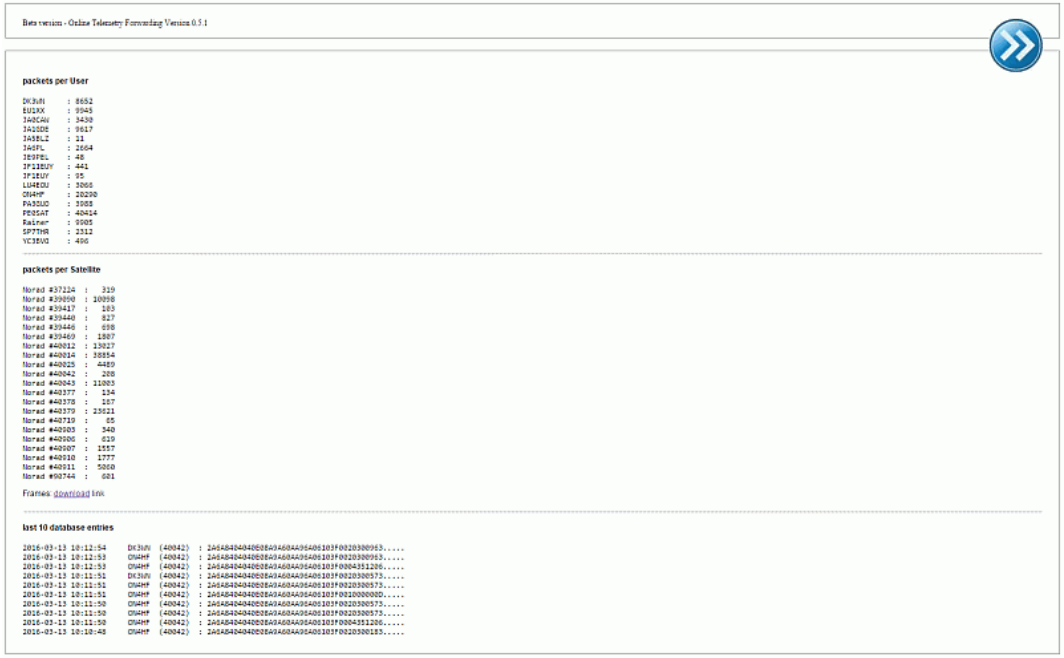
Datenbank PE0SAT

- tlm.pe0sat.nl/tlmdb/

- SQL Datenbank
- PHP/HTML Frontend

- Start: 03. April 2016
- Ende: 28.09.2017

- ca. 5.8 Mio Telemetriepakete
- Migration in SatNOGS DB

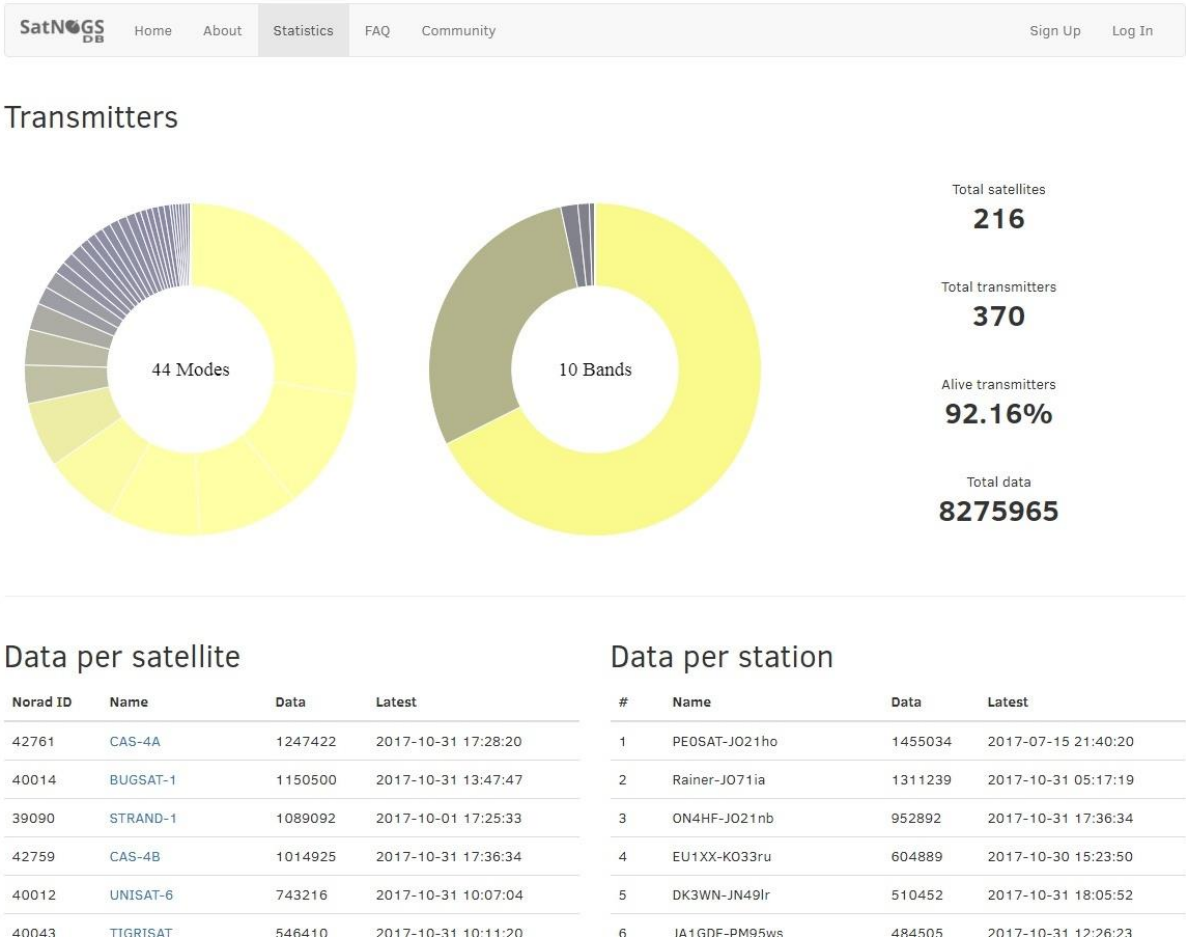


Datenbank SatNOGS

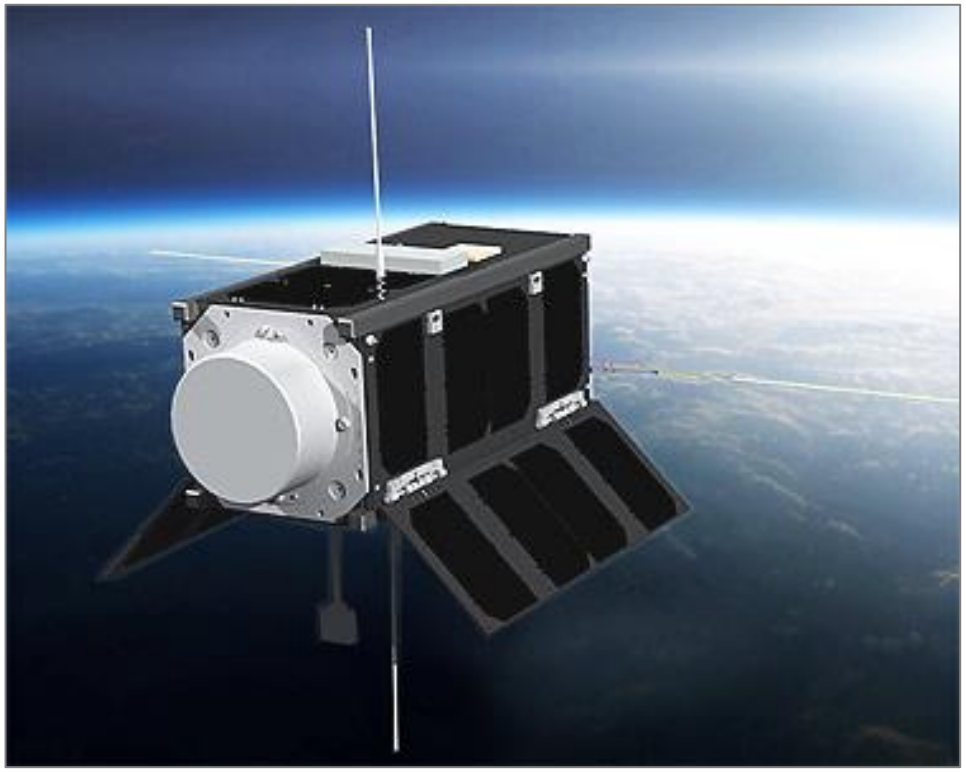
Satellite Networked Open Ground Station

- https://db.satnogs.org/stats/

- SQL Datenbank
- ca. 8.5 Mio Telemetriepakete



Telemetrie Dekodierung – z.B. LINK



Korea Advanced Institute of Science and Technology
LINK (ON01KR) QB50 project

Start :	18. Mai 2017
NORAD:	#42714
Modulation:	9k6 BPSK
Datenformat:	AX.25*, HDLC
Frequenz:	436.030 MHz
AX.25 Source:	ON01KR
AX.25 Destination:	D80LW
Beacon intervall:	30 s

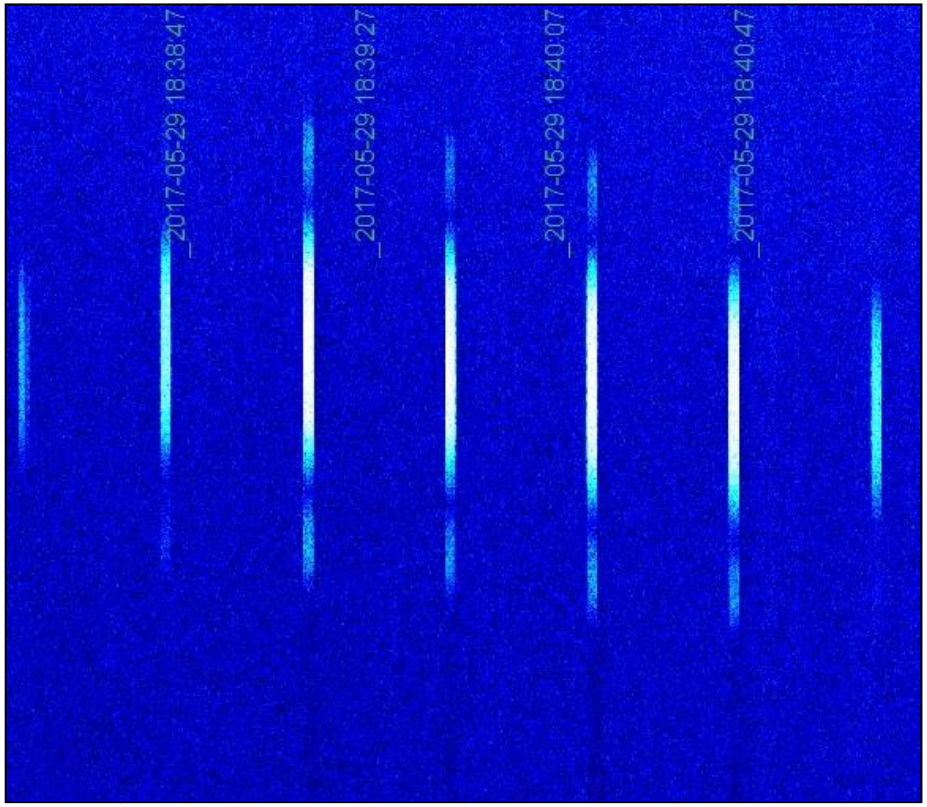
- gr-satellites
- soundmodem

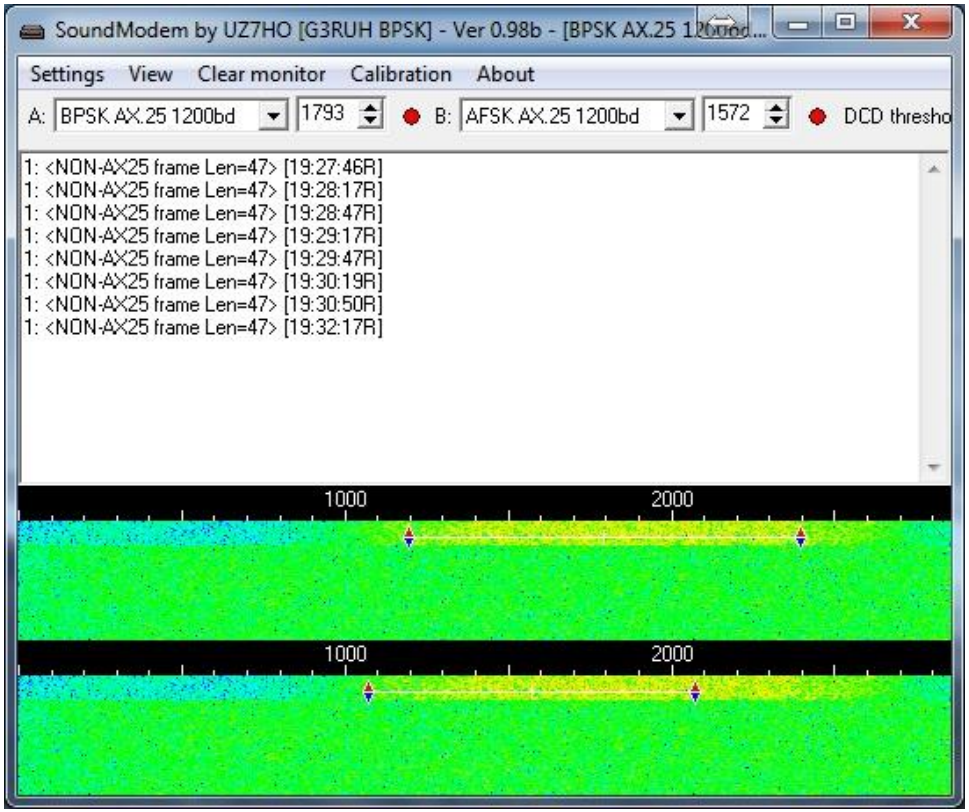
KAIST

LINK
LITTLE INTELLIGENT NANOSATELLITE OF KAIST

LINK

HF Spektrum (SpectraVue)
Beacon Intervall 30 Sekunden





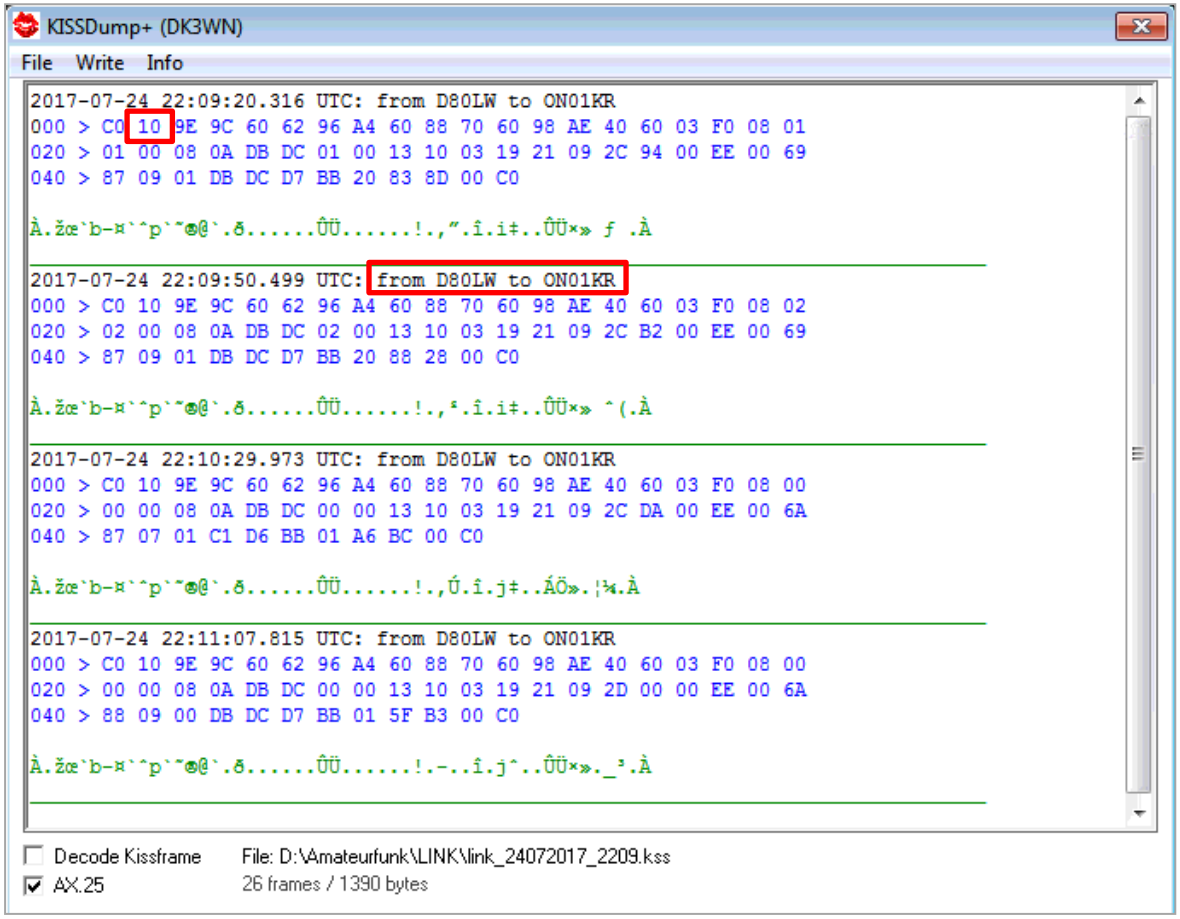
KISS

keep it simple, stupid

- entwickelt von Mike Chepponis K3MC und Phil Karn KA9Q
- Amateurfunk Protokoll für die Kommunikation mit einem TNC
- AX.25 Layer 2
- Auf korrekte Implementierung achten !

Packet format [edit]

Begin	Command	Data0..DataN	End
FEND	High nibble – Port Index Low nibble – Command	Data	FEND

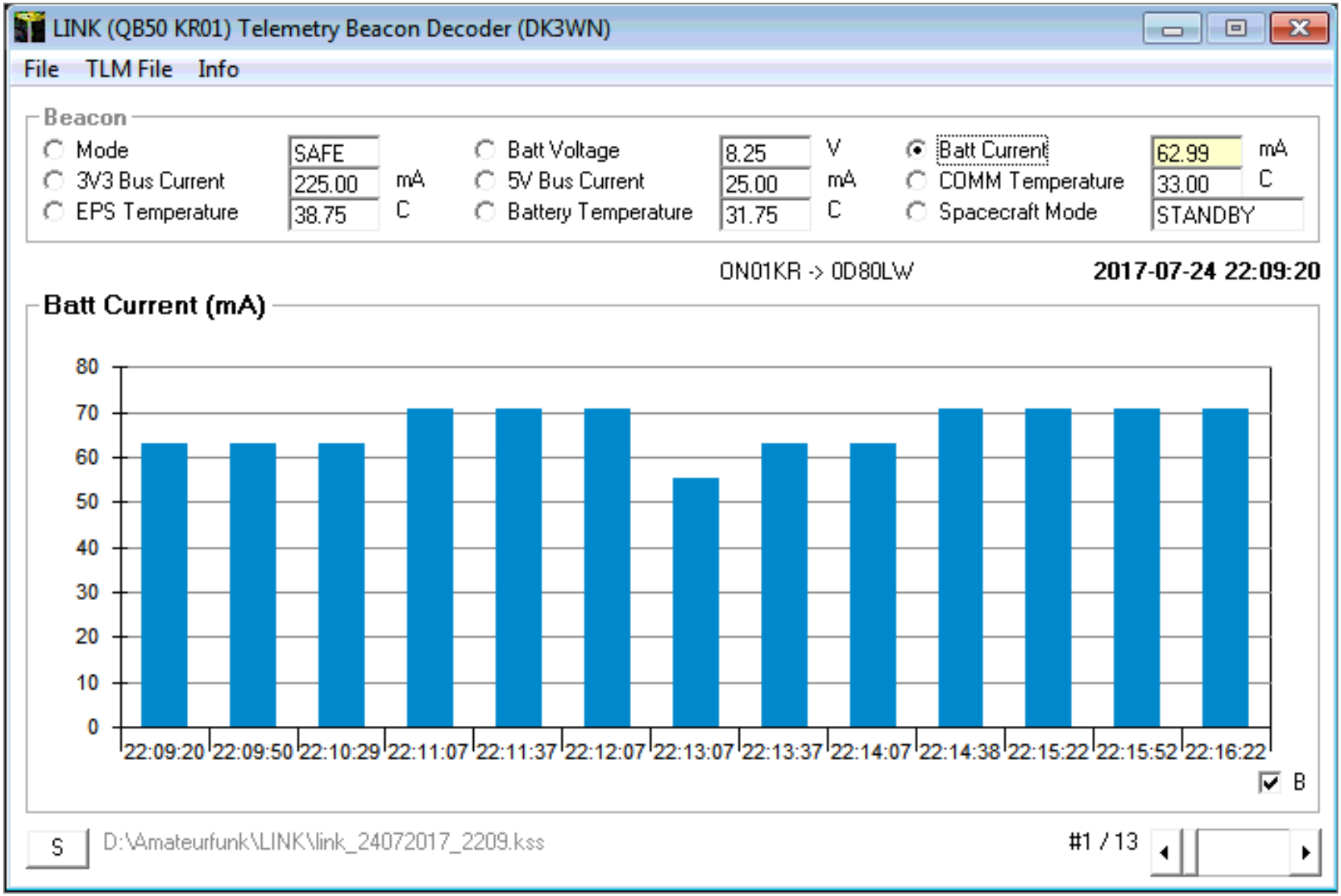


Telemetrie Paket

```
000 > C0 10 9E 9C 60 62 96 A4 60 88 70 60 98 AE 40 60 03 F0 08 01

020 > 01 00 08 0A DB DC 01 00 13 10 03 19 21 09 2C 94 00 EE 00 69

040 > 87 09 01 DB DC D7 BB 20 83 8D 00 C0
```

bit	Description	Unit	Conversion
8	0xEE		
7	spare bits		
1	Mode		1: MISSION MODE, 0: SAFE
8	Battery Voltage	V	Val= X/20 + 3
8	Battery Current	mA	Val = (X/127 - 1) *1000
8	3V3 Bus Current	mA	Val = (X/40) *1000
8	5V Bus Current	mA	Val = (X/40) * 1000
8	Temp COM	°C	Val = X/4 – 15
8	Temp EPS	°C	Val = X/4 – 15
8	Temp Battery	°C	Val = X/4 – 15
8	SC Mode		0: GND_DEBUG, 1: INITIAL, 2: COMMISSIONING, 3: MISSION, 4: COMM, 17: POWERSAFE, 18: DETUMBLE, 19: DEBUG, 32: STANDBY

0x69 = 105	105/20+3 = 8.25
0x87 = 135	1000*(135/127-1) = 62.99
0x09 = 9	9/40*1000 = 225
0xDBDC = 0xC0 = 192	192/40-15=33


LINK (QB50 KR01) Telemetry Beacon Decoder (DK3WN)
File
TLM File
Info
Beacon
Mode
SAFE
3V3 Bus Current
225.00
mA
EPS Temperature
38.75
C
Batt Voltage
8.25
V
5V Bus Current
25.00
mA
Battery Temperature
31.75
C
Batt Current
62.99
mA
COMM Temperature
33.00
C
Spacecraft Mode
STANDBY
ON01KR -> 0D80LW
2017-07-24 22:09:20
Batt Current (mA)
80
70
60
50
40
30
20
10
0
22:09:20
22:09:50
22:10:29
22:11:07
22:11:37
22:12:07
22:13:07
22:13:37
22:14:07
22:14:38
22:15:22
22:15:52
22:16:22
B
S
D:\Amateurfunk\LINK\link_24072017_2209.kss
#1 / 13

LINK
Margono
YC3BVG
LINK
Vladimir
EV1XX
LINK
JA6PL
Horacio
CX8AF
Kasei san
JA1GDE
Tetsu San
JA0CAW
Daniel
EA4GPZ
Albert
PD0OXW
Jan
PE0SAT
Scott
K4KDR
Mike
DK3WN
ASCL
KAIST
Korea Advanced Institute of Science and Technology
Department of Aerospace Engineering

Anwendungsbeispiele wissenschaftliche Daten Telemetrie SSTV

GOMX-3, LilacSat-1, Ursa Maior, FUNcube, Bugsat, ESTCube-1

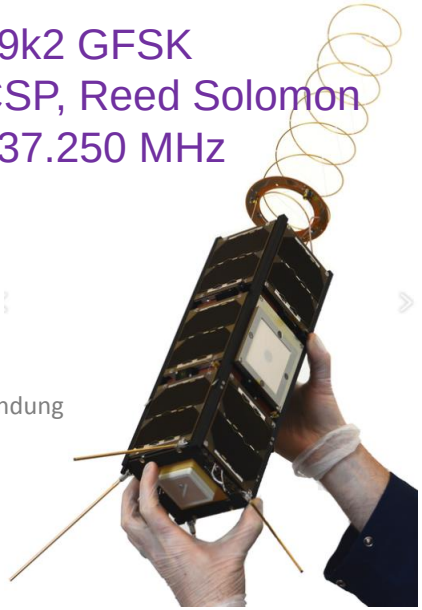
GOMX-3

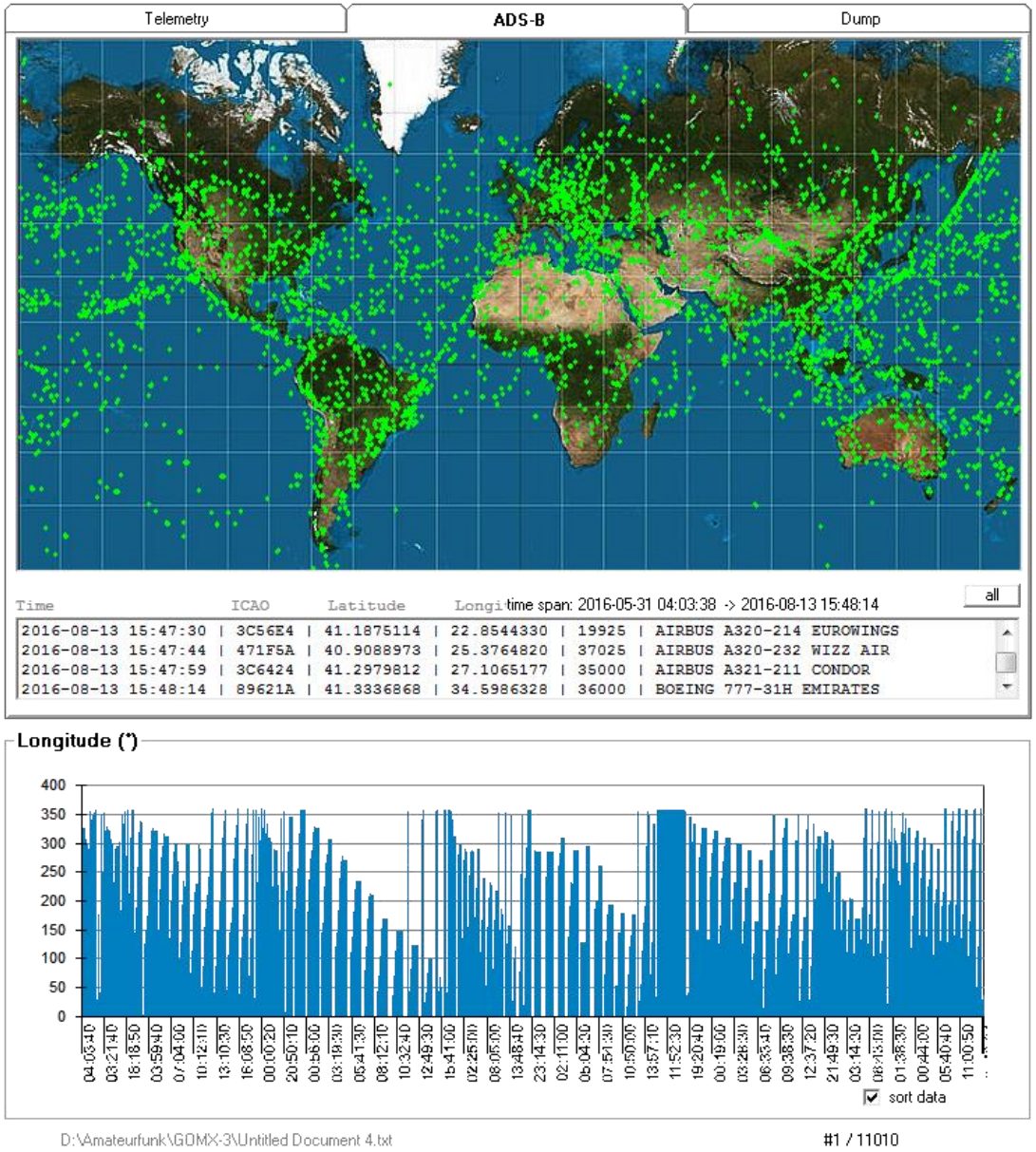
GomSpace Dänemark
3U Cubesat ADS-B Empfänger*

Start :	10. August 2015
ISS Deployment:	05. Oktober 2015
Ende:	04. November 2016
NORAD:	#40949
Modulation:	19k2 GFSK
Datenformat:	CSP, Reed Solomon
Frequenz:	437.250 MHz

- gr-satellites
- soundmodem

- ADS-B ist keine Amateurfunkanwendung



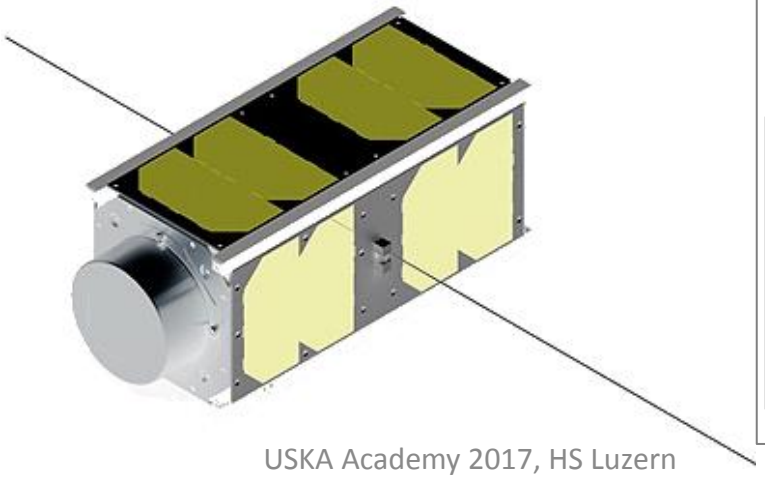


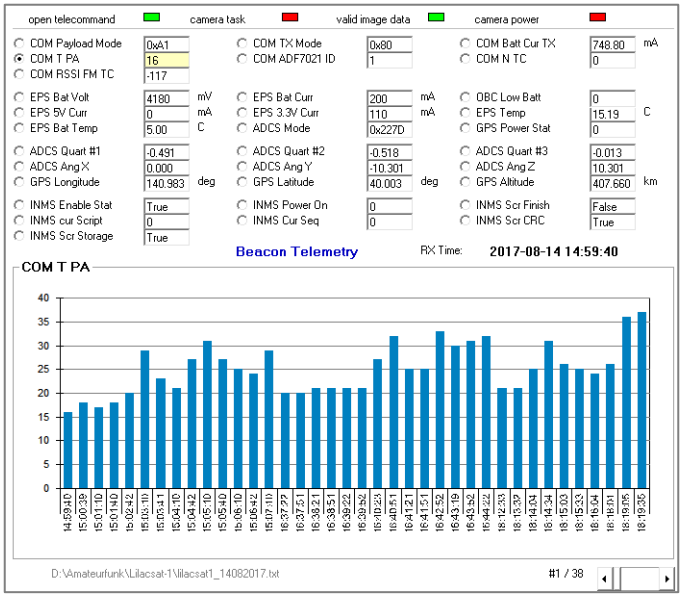
LilacSat-1

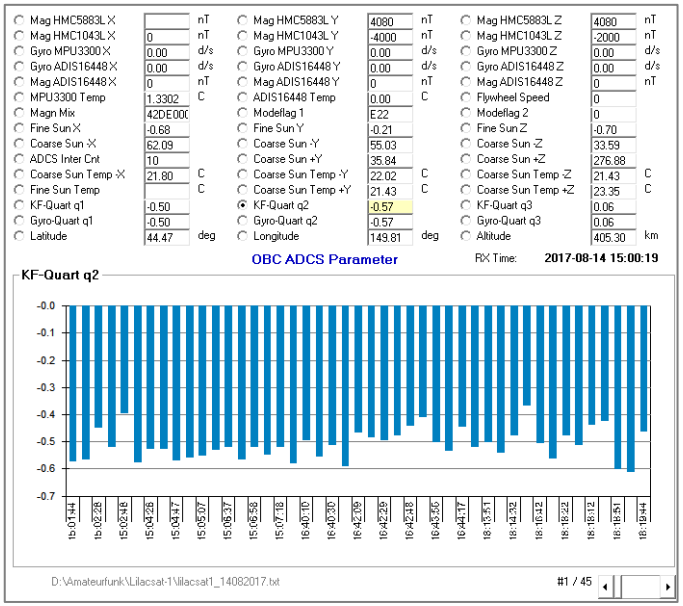
Harbin Institute of Technology China
FM/USB dig. Transponder, Kamera
LILACSAT-1 (ON02CN) QB50 project

Start :	18. April 2017
ISS Deployment:	25. Mai 2017
NORAD:	#40949
Modulation:	9k6 BFSK
Datenformat:	Convolutional Code r=1/2, k=7, Codec2
Frequenz:	436.510 MHz

- gr-satellites



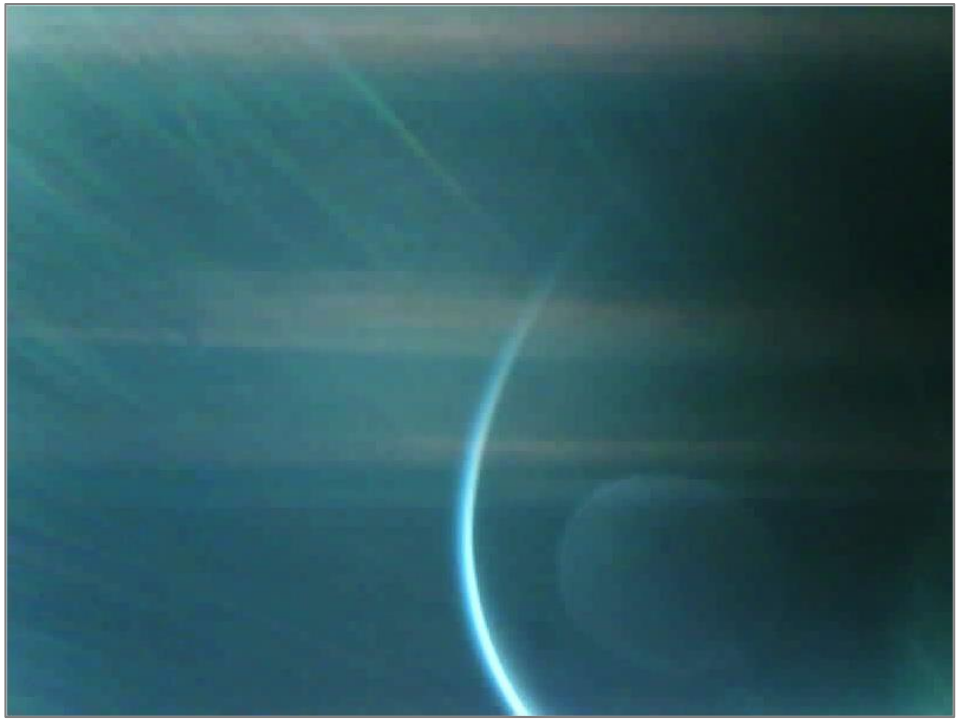


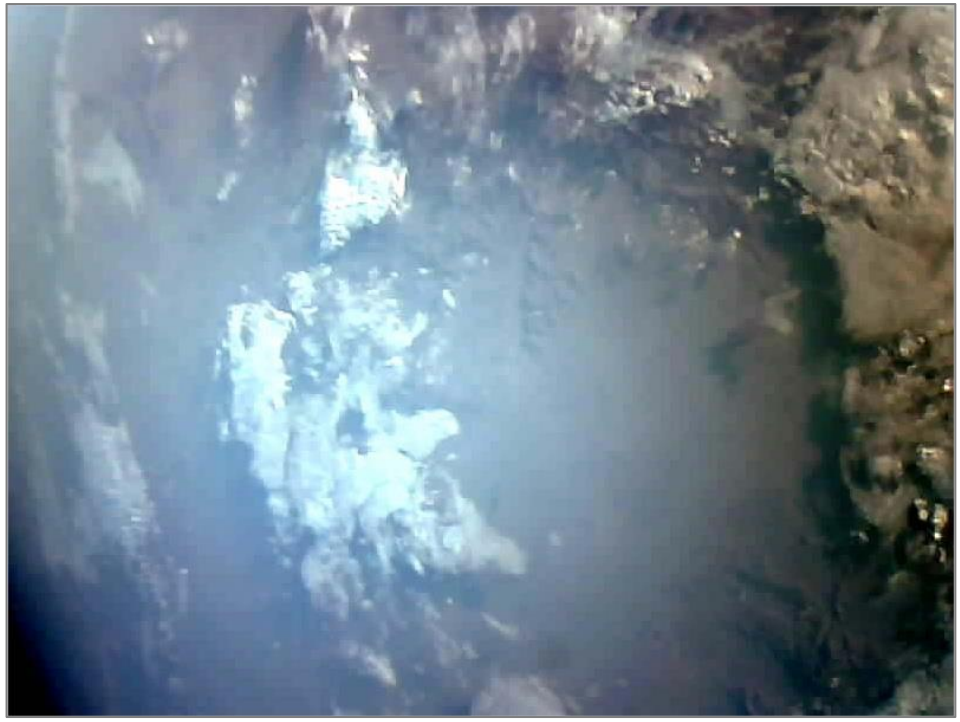


LilacSat-1

- Thermal IR Camera
- JPEG, 800x600 pixel, 64 byte Chunks
- Command 0x00 - take picture / 1k0 FM-AFSK 1000Hz/1833.33Hz, AX.25

```
0000: b8 64 2e 00 06 00 00 00 00 96 79 00 00 00 00 ff
0010: d8 ff e0 00 10 4a 46 49 46 00 01 01 01 00 00 00
0020: 00 00 00 ff db 00 43 00 08 06 06 07 06 05 08 07
0030: 07 07 09 09 08 0a 0c 14 0d 0c 0b 0b 0c 19 12 13
0040: 0f 14 1d 1a 1f 1e 1d 1a 1c 1c 20 24 2e 27 20 5b
0050: 06 00 00 2d cf 94 4d
```

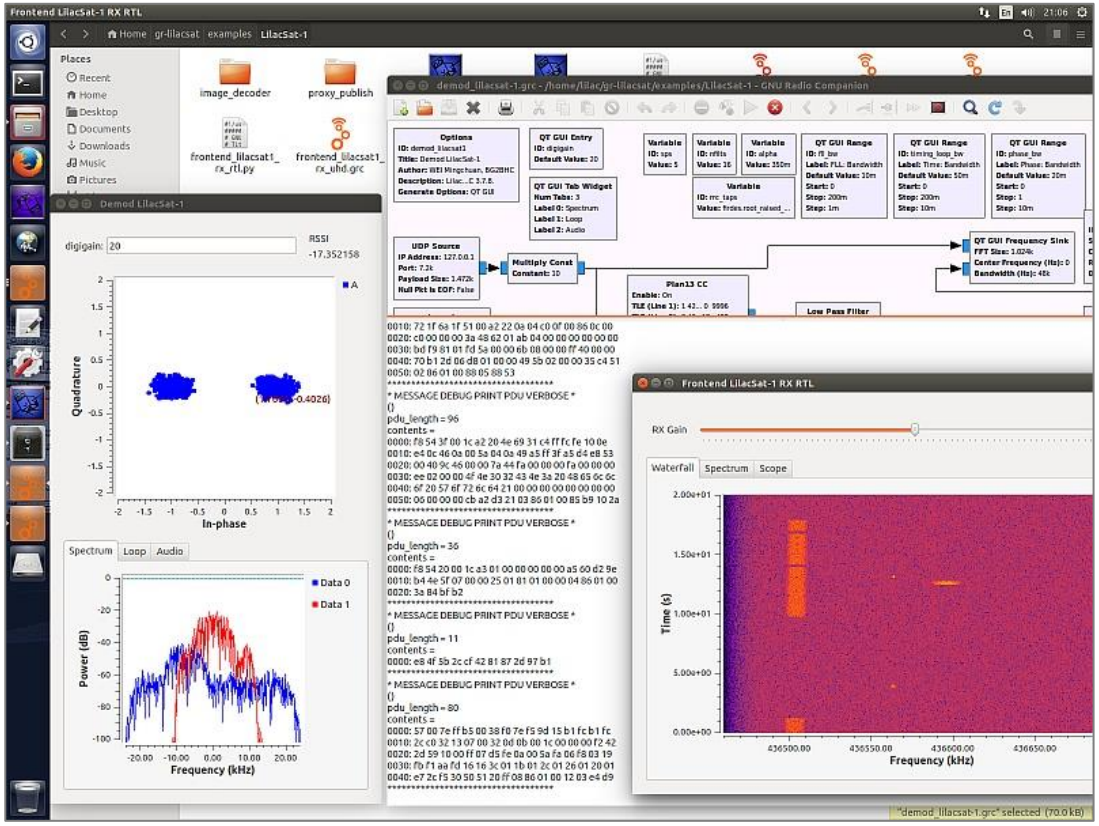


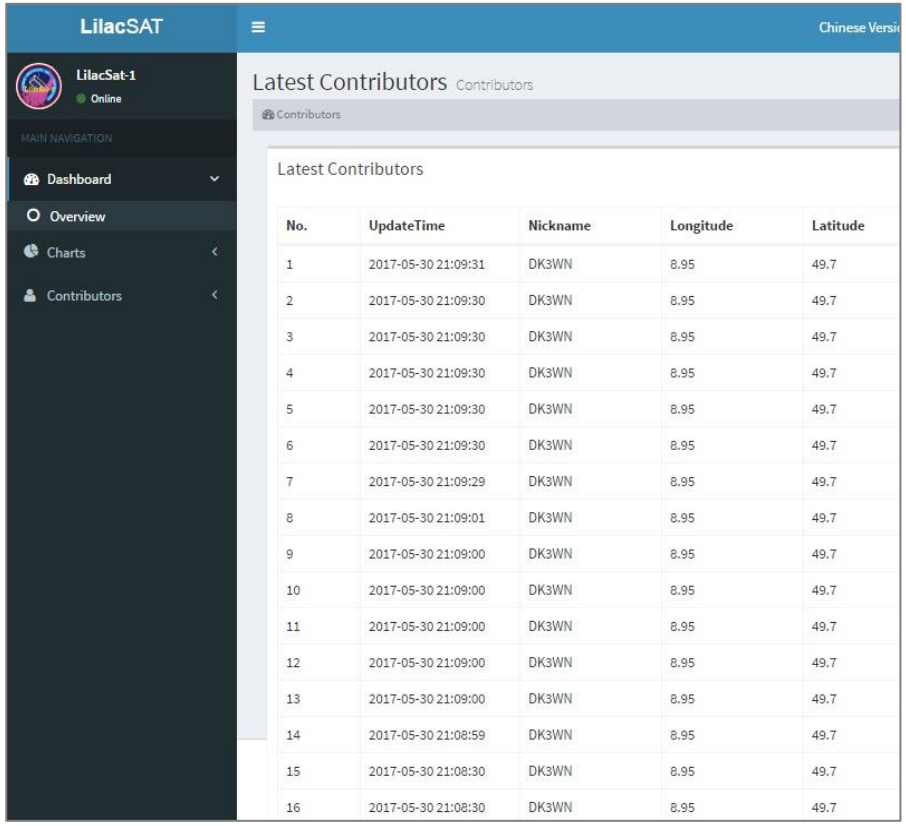


LilacSat-1

GNURadio
THE FREE & OPEN SOFTWARE RADIO ECOSYSTEM

- gr-satellites — Daniel Estevez, EA4GPZ
- proxy_publish — Wei Mingchuan, BG2BHC
- web frontend — Harbin Institute http://lilacsat.hit.edu.cn



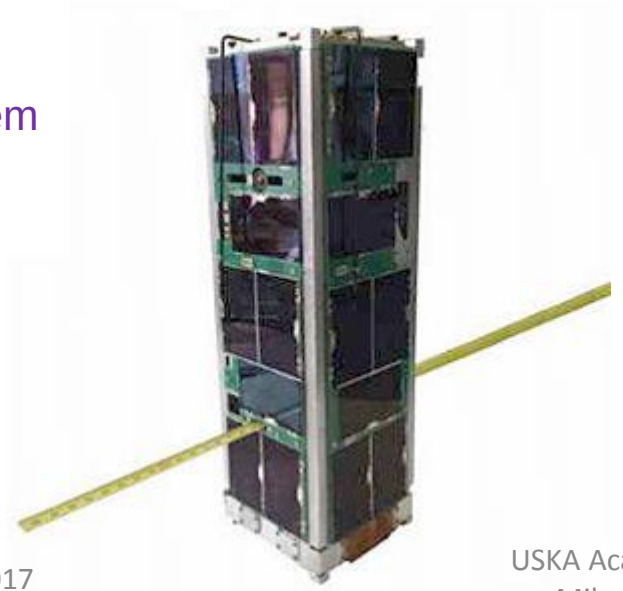


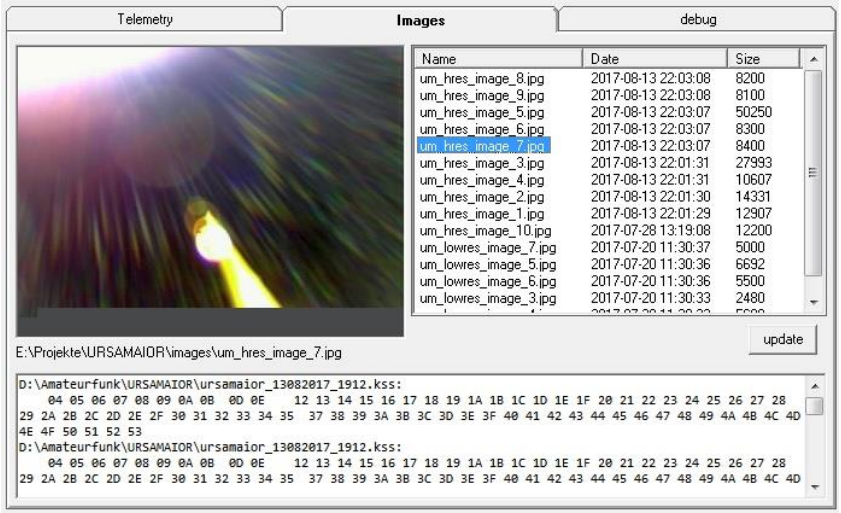
Ursa Maior

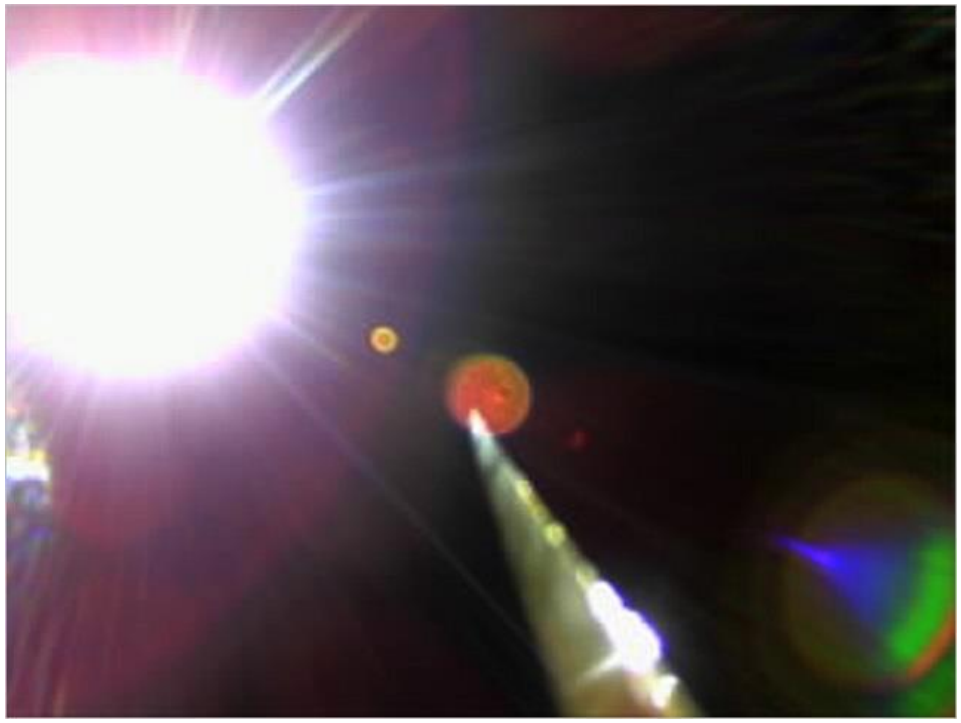
University of Rome la Sapienza Italien
Cameras, MEMS, Multineedle Langmuir Probe
URSA MAIOR (ON02IT) QB50 project

Start :	23. Juni 2017
NORAD:	#42776
Modulation:	9k6 FSK
Datenformat:	AX.25, HDLC NRZI encoding
Frequenz:	435.950 MHz

- gr-satellites
- soundmodem





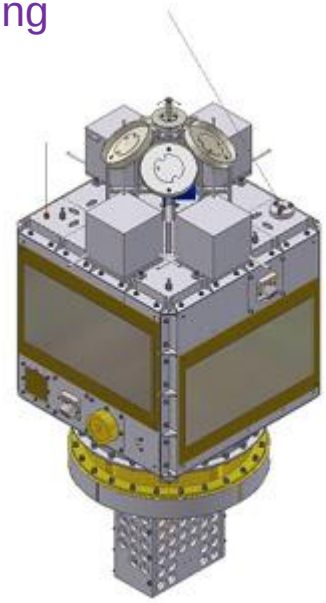


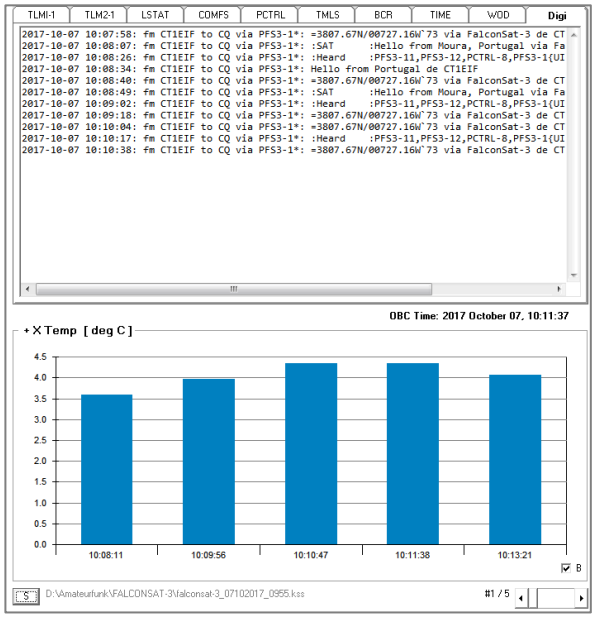
FalconSAT-3

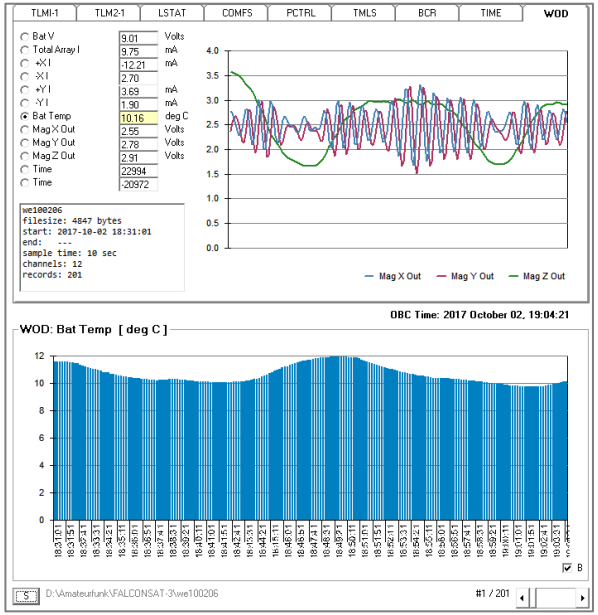
Space Systems Research Center at the US Air Force Academy in Colorado Springs
Gradient Boom, Thruster, BBS

Start :	09. März 2007
NORAD:	#30776
Modulation:	9k6 FSK
Datenformat:	AX.25, HDLC NRZI encoding
Frequenz:	145.840 / 435.103 MHz
Output:	1W, continuously

- soundmodem
- offen für Amateurfunk seit September 2017
- BBS Management: WISP (Windows)
  PacSatTools (Linux)
  PB/PG (Linux)
- Digipeater







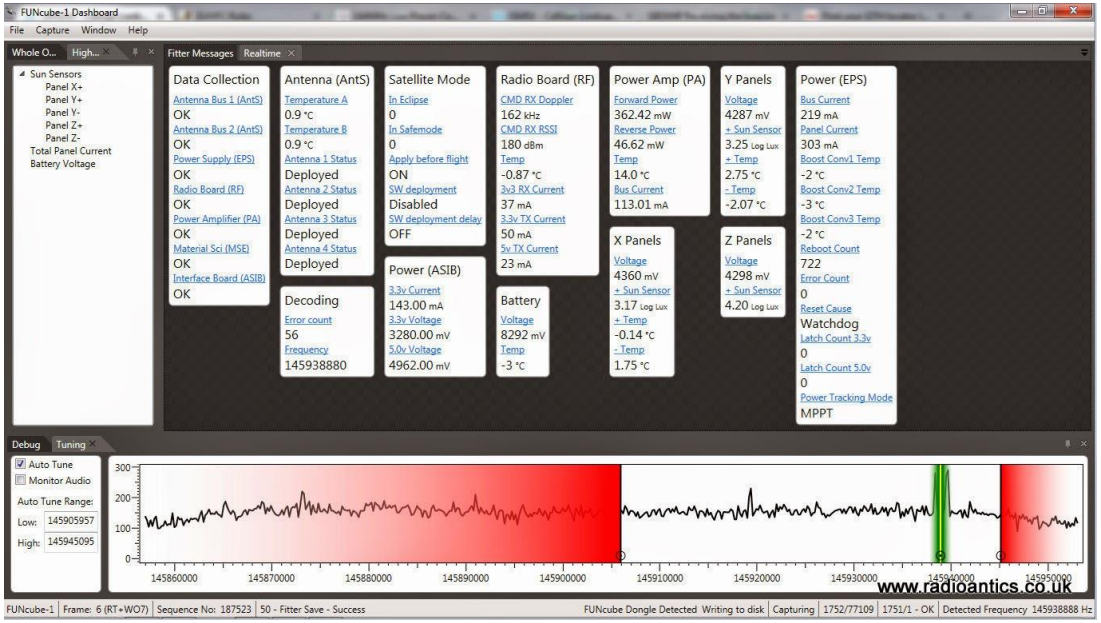
FUNcube-1 (AO-73)

AMSAT UK, ISIS
Mode UV inv. 300mW transponder
Material Experiment, Fitter

Start :	21. November 2013
NORAD:	#39444
Modulation:	1k2 BFSK
Datenformat:	HDLC, FEC
Frequenz:	145.935 MHz
Transponder:	435.140 / 145.960 MHz

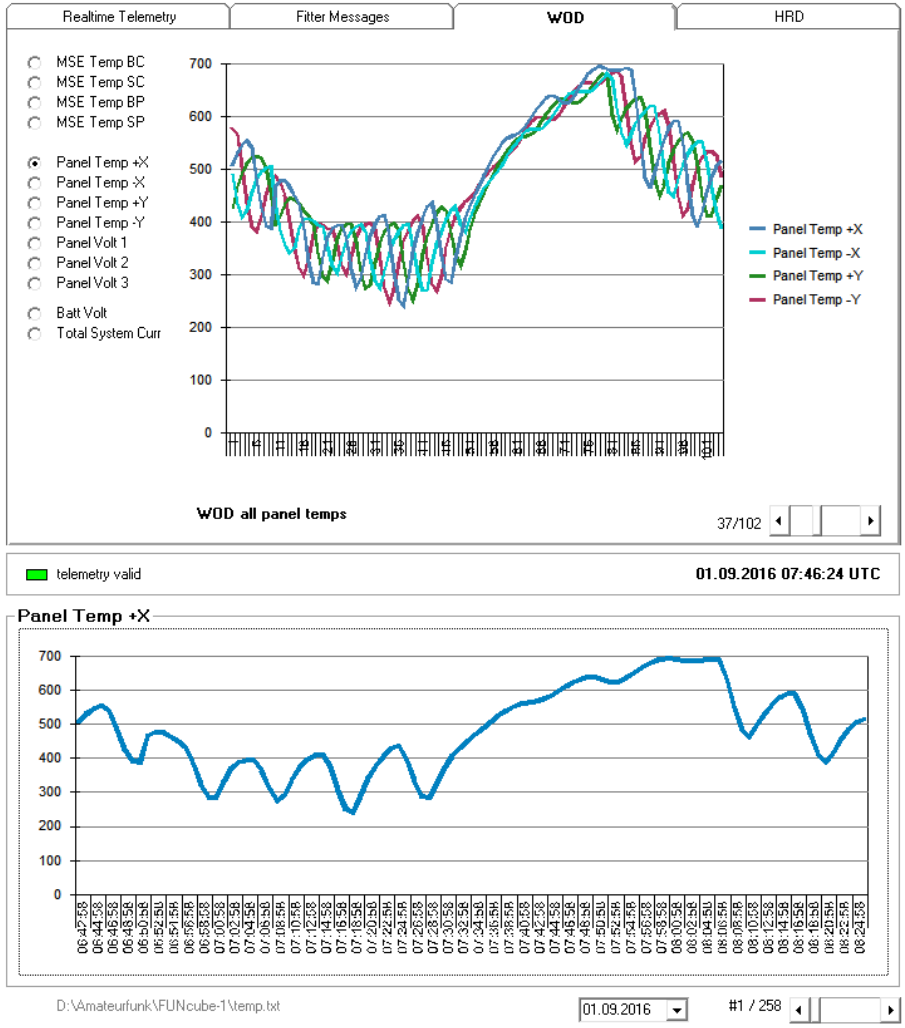
Data Warehouse

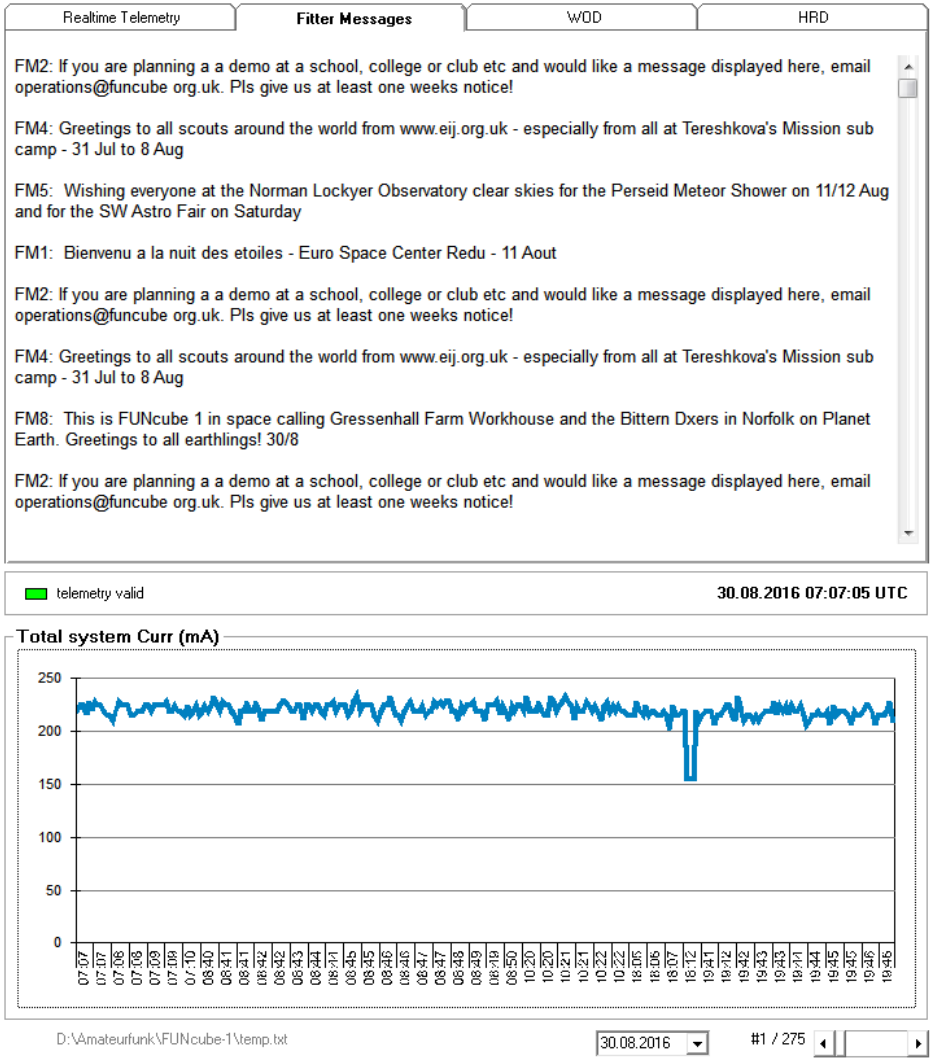
- Dashboard Software
- soundmodem
- gr-satellites



Dashboard Software

FUNcube-1, -2, -Nayif-1





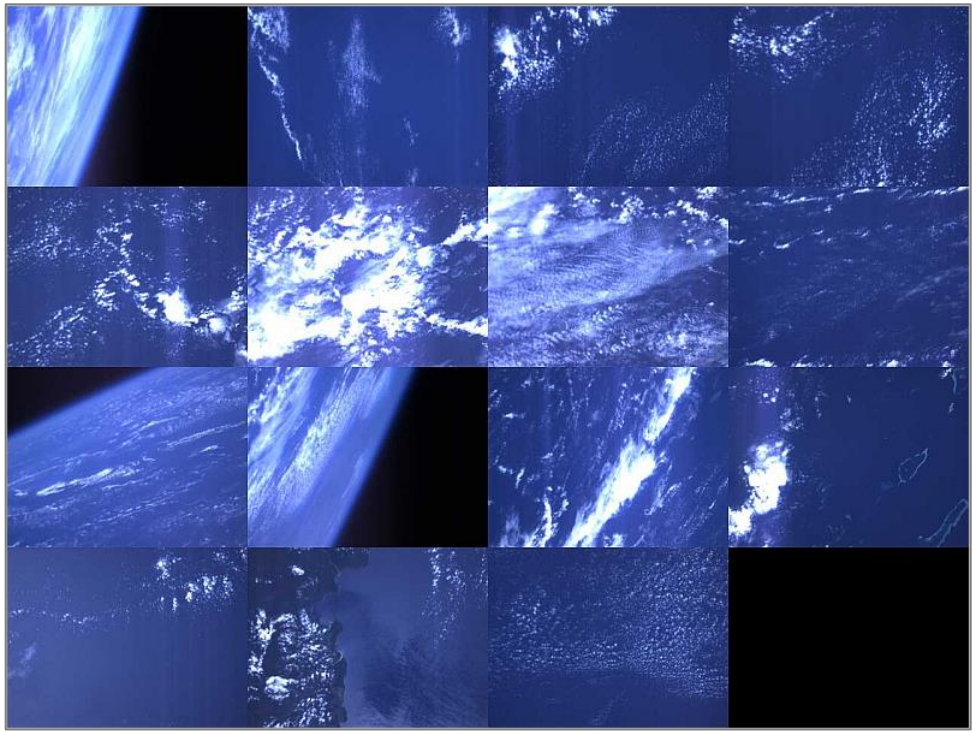
BugSat (Tita)

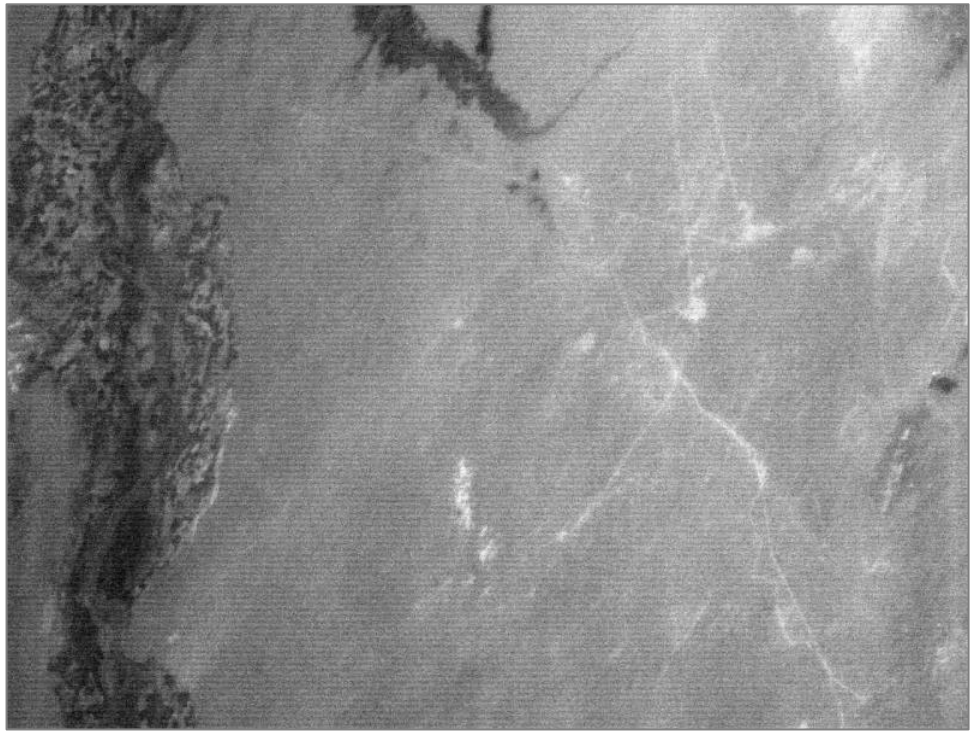
Satellogic Argentinien

Start : 19. Juni 2014
NORAD: #40014

Modulation: 9k6 FSK
Datenformat: AX.25, HDCL
Frequenz: 437.455 MHz

- soundmodem
- gr-satellites

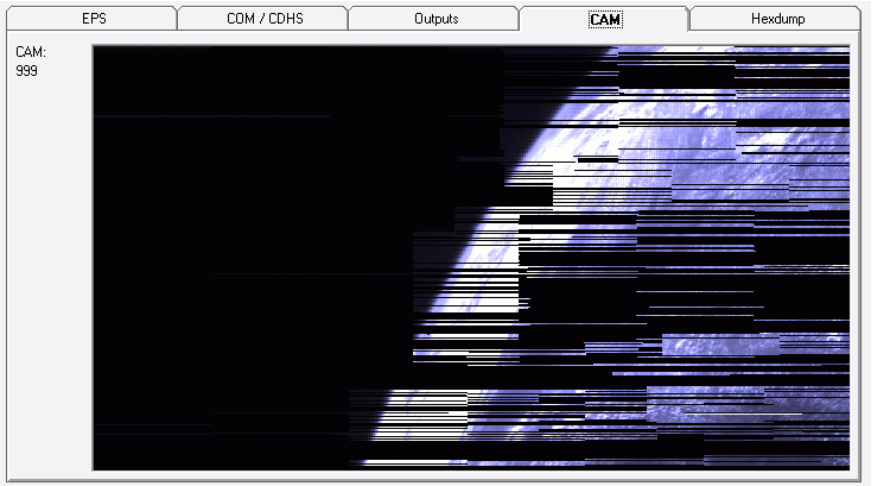


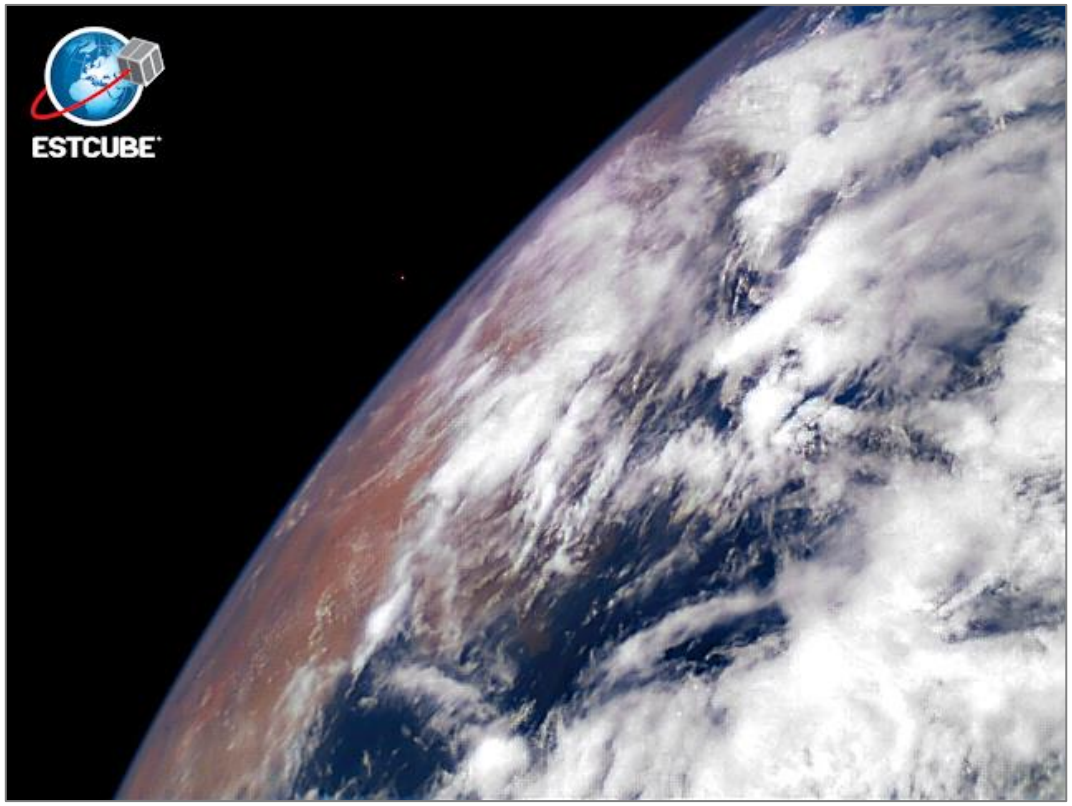


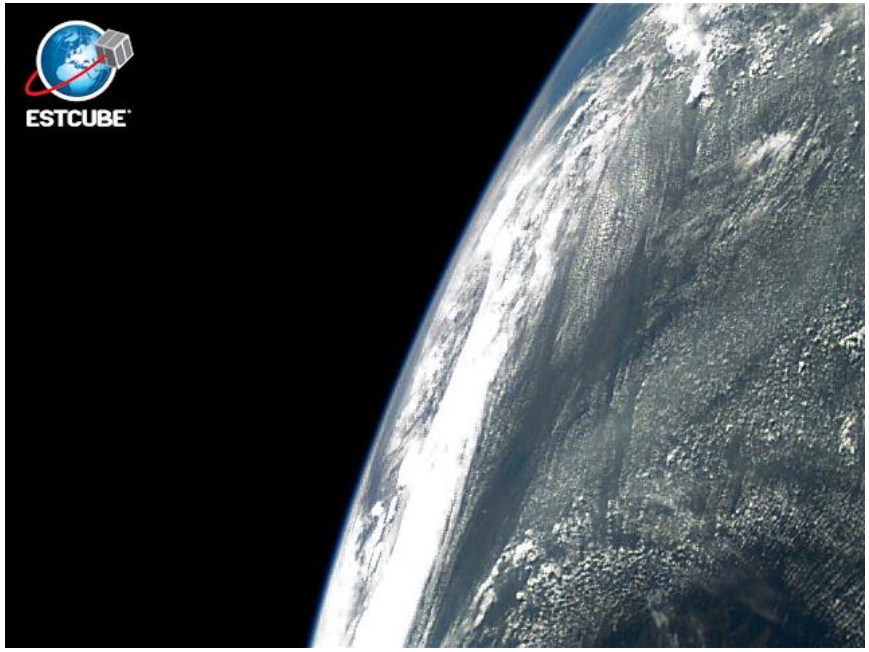
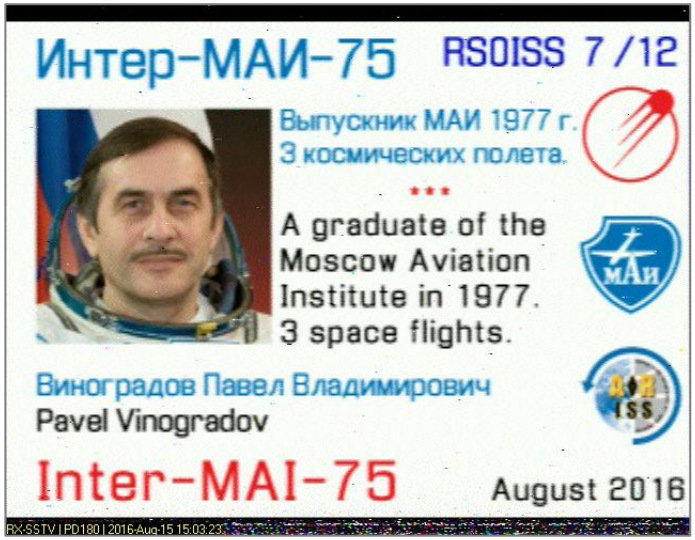
ESTCube-1

University of Tartu

Start : 17. Mai 2013
End of Mission: 17. Februar 2015
NORAD: #39161







SSTV *(ISS, ANTELSAT)*