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Satellites for Communication and Science
Satelliten für Kommunikation und Wissenschaft

Es'hail-2 (P4-A) the first geostationary OSCAR from Qatar

Peter Gülzow, DB2OS
AMSAT-DL President

AMSAT Symposium Reno
2017

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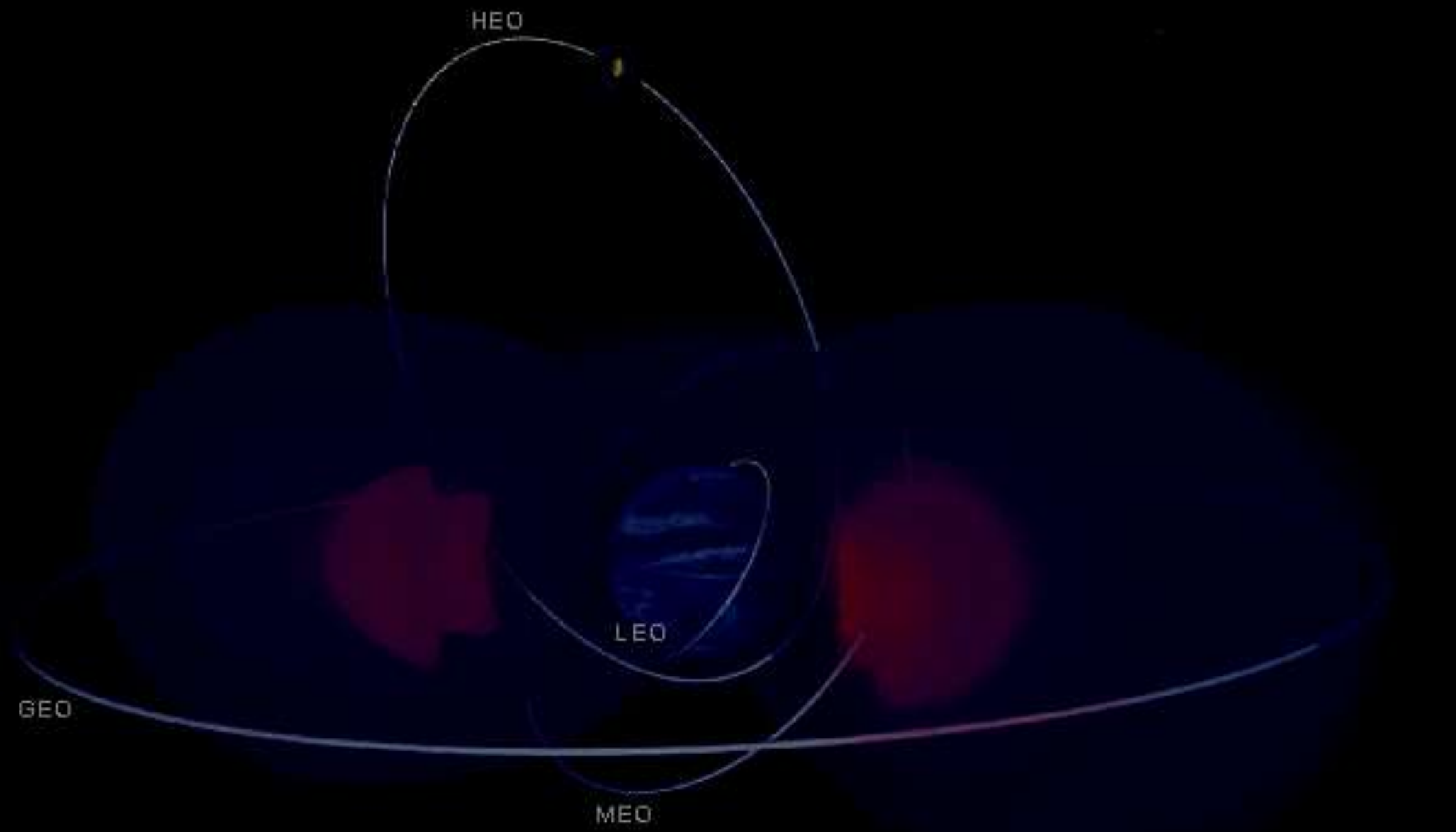
Satelliten für Kommunikation und Wissenschaft



AMSAT Phase 4

Hosted Amateur Radio Payload (AMSAT P4-A):

- S-Band uplink / X-Band downlink
- Linear transponder (all modes)
- 15 years lifetime

2012 QARS

.

2013 Es'hailSat

.

.

.

2016 MELCO Japan

.

2018 Launch with SpaceX

H E Abdullah bin Hamad Al Attiyah, Chairman of the Qatar Amateur Radio Society (QARS),

Falcon 9

Es'hail-2 status

Es'hail-2 successfully passed critical design review (CDR)

Environmental testing includes:

- Thermal vacuum
- Vibration
- …

- Launch is planned for
- 2018 with SpaceX
- (Falcon 9) from Cape
- Canaveral.

Executives from Qatar's Es'hailSat and Japan's Mitsubishi Electric Space Systems (MELCO) in Kamakura, outside of Tokyo, Japan, to observe the vacuum chamber test of Es'hail-2. Photograph courtesy of Es'hailSat, June 2016.

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The earth as seen by Es'hail-2

Es'hailSat سهيل سات
Qatar Satellite Company الشركة القطرية للأقمار الصناعية

AMSAT-DL

Q.A.R.S.
QATAR AMATEUR RADIO SOCIETY
الجمعية القطرية لهواة الاتصالات اللاسلكي

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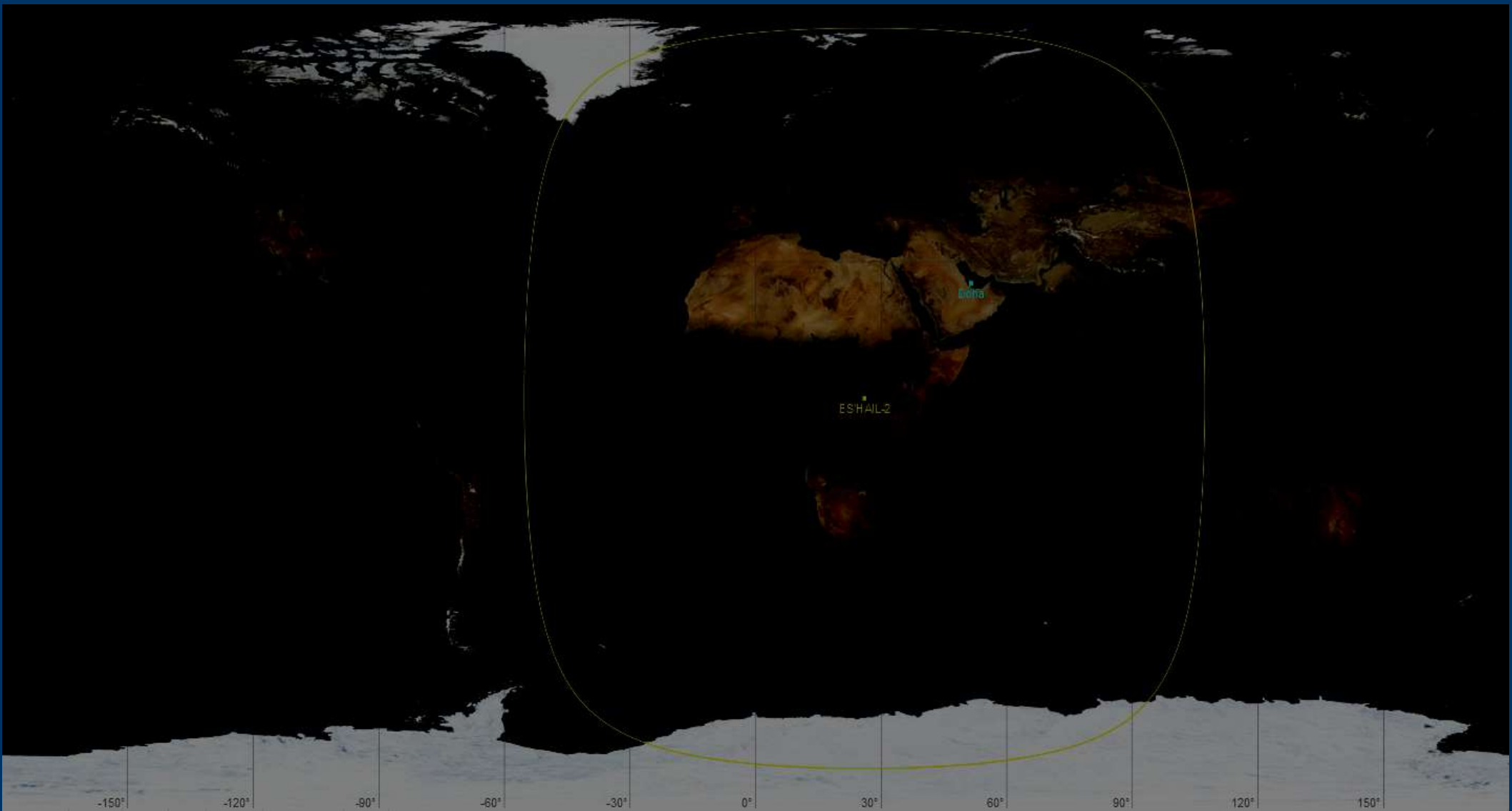
Earth Coverage Es'hail-2



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Satellites for Communication and Science
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Bochum

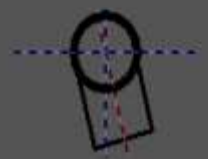
Your location:

Latitude:
51.48° N (51° 28' 47")

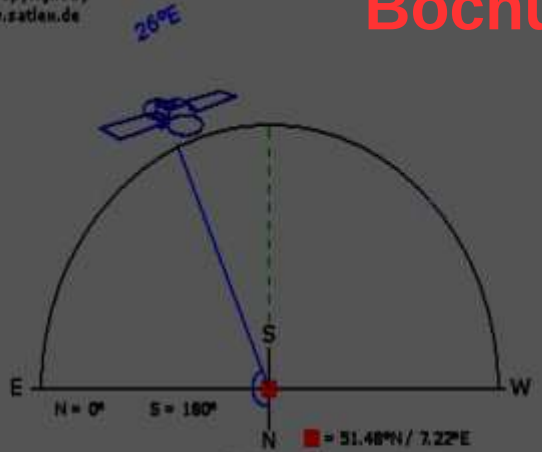
Longitude:
7.22° E (7° 13' 11")

City:
Bochum

Country:
Germany



LNB tilt (Skew)



Azimuth angle

Following values have been calculated for your location:

Azimuth angle:
156.51° *(True North)*

Elevation angle:
28.55°

LNB tilt (Skew):
-14.37°

Offset angle:
20.36°

Distance to satellite:
38747.37 Km

Signal delay:
258.32 ms *(Uplink + Downlink)*

Declination angle:
-7.34°

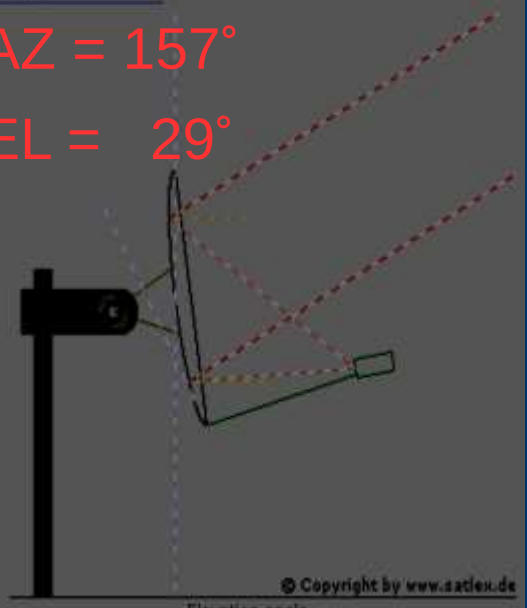
Polarmount hour angle:
159.33°

Angle setting on motor:
20.67° East

Satellite:
Badr 4/5/6 (26° E = 334° W)

AZ = 157°

EL = 29°



Elevation angle

Doha

Your location:

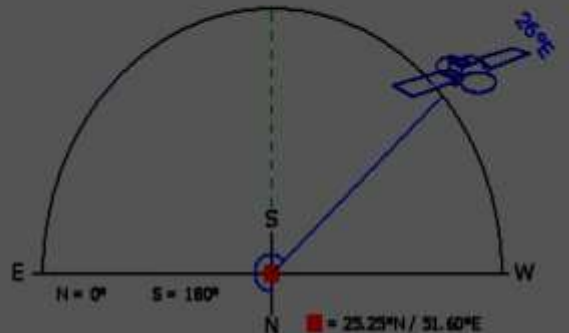
Latitude:
25.25° N (25° 15' 0")

Longitude:
51.60° E (51° 36' 0")

City:
Doha

Country:
Qatar

LNB tilt (Skew)



Azimuth angle

Following values have been calculated for your location:

Azimuth angle:
228.32° *(True North)*

Elevation angle:
48.98°

LNB tilt (Skew):
42.49°

Offset angle:
20.36°

Distance to satellite:
37145.43 Km

Signal delay:
247.64 ms *(Uplink + Downlink)*

Declination angle:
-4.18°

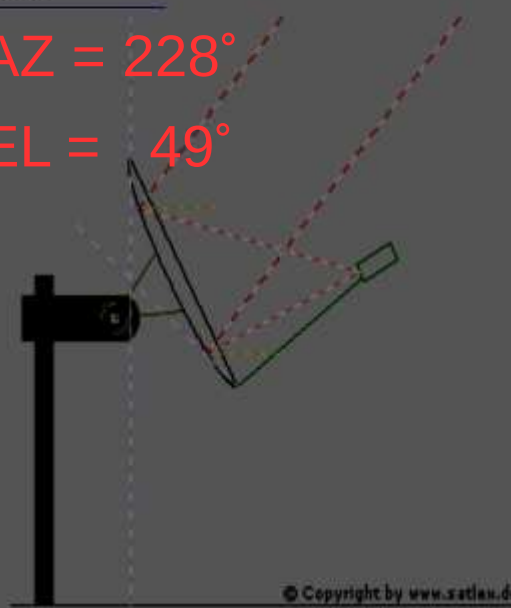
Polarmount hour angle:
209.44°

Angle setting on motor:
29.44° West

Satellite:
Badr 4/5/6 (26° E = 334° W)

AZ = 228°

EL = 49°



Elevation angle

Rio de Janeiro

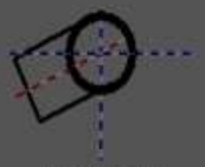
Your location:

Latitude:
-22.90° N (22° 53' 59")

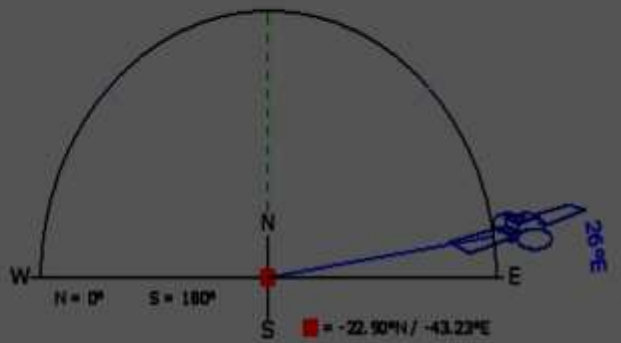
Longitude:
-43.23° E (43° 13' 47")

City:
Rio De Janeiro

Country:
Brazil



LNB tilt (Skew)



Azimuth angle

Following values have been calculated for your location:

Azimuth angle:
81.60° *(True North)*

AZ = 82°

Elevation angle:
10.61°

EL = 11°

LNB tilt (Skew):
65.69°

Offset angle:
20.36°

Distance to satellite:
40531.41 Km

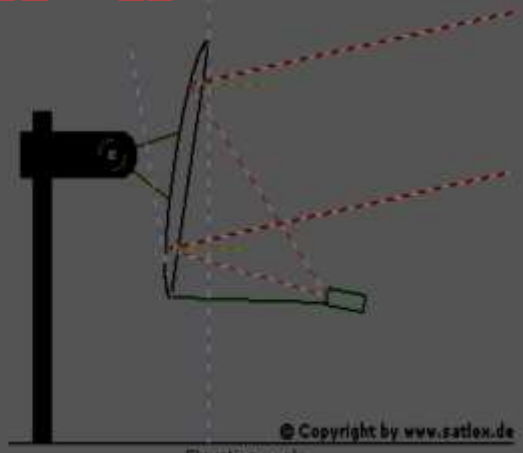
Signal delay:
270.21 ms *(Uplink + Downlink)*

Declination angle:
3.48°

Polarmount hour angle:
76.94°

Angle setting on motor:
103.06° East

Satellite:
Badr 4/5/6 (26° E = 334° W)



Elevation angle

Penang

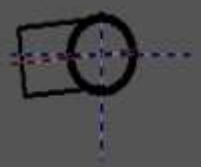
Your location:

Latitude:
5.50° N (5° 30' 0")

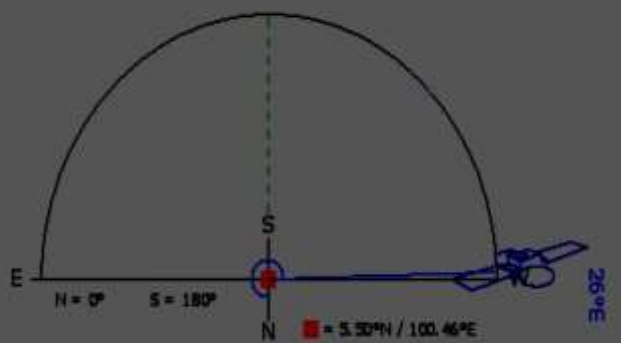
Longitude:
100.46° E (100° 27' 35")

City:
Pinang

Country:
Malaysia



LNB tilt (Skew)



Azimuth angle

Following values have been calculated for your location:

Azimuth angle:
268.47° *(True North)*

AZ = 268°

Elevation angle:
6.95°

EL = 7°

LNB tilt (Skew):
84.29°

Offset angle:
20.36°

Distance to satellite:
40927.52 Km

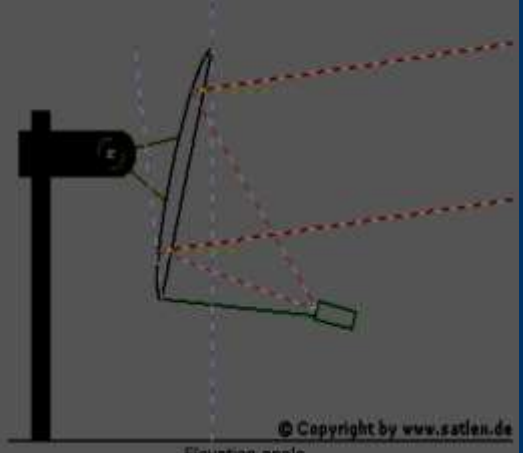
Signal delay:
272.85 ms *(Uplink + Downlink)*

Declination angle:
-0.85°

Polarmount hour angle:
262.93°

Angle setting on motor:
82.93° West

Satellite:
Badr 4/5/6 (26° E = 334° W)



Elevation angle

“NB” Transponder (narrow band)

Linear Transponder for low power narrow bandwidth voice, morse and digital communication

- preferred modes: narrow band modes like SSB and CW, PSK

- 250 kHz allocated bandwidth

- non-inverting bent-pipe transponder

- Assumes 50 simultaneous 2-way carriers to serve 100 Users

- X-Band Downlink (SAT-TV dish):
  - 90 cm dishes in rainy areas at EOC like Brazil or Thailand
  - 60 cm around around coverage peak
  - 75 cm dishes at peak -2dB

- Downlink Polarisation on X-Band is Vertical !

- Uplink Polarisation on S-Band is RHCP
- Uplink transmitter 5-10W PEP (22.5 dBi antenna gain, 75cm dish)

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“WB” Transponder (wide band)

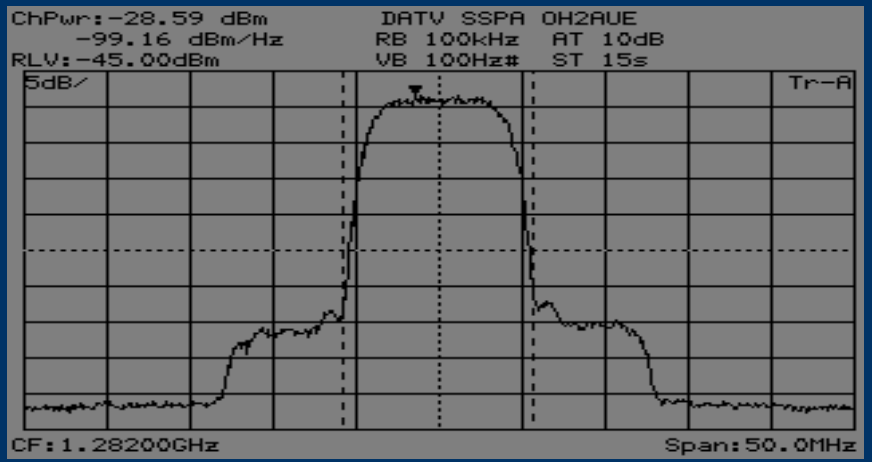
Linear Transponder for Digital Amateur Television (DATV) and other highspeed data transmissions.

- **First DATV transponder in space!!**

- with 8 MHz bandwidth one or two DVB-S2 carrier in HD quality will be possible
- in SD or lower quality more channels possible

- Assumes S-Band Uplink peak EIRP of 53 dBW (100W PEP into 2.4m dish)

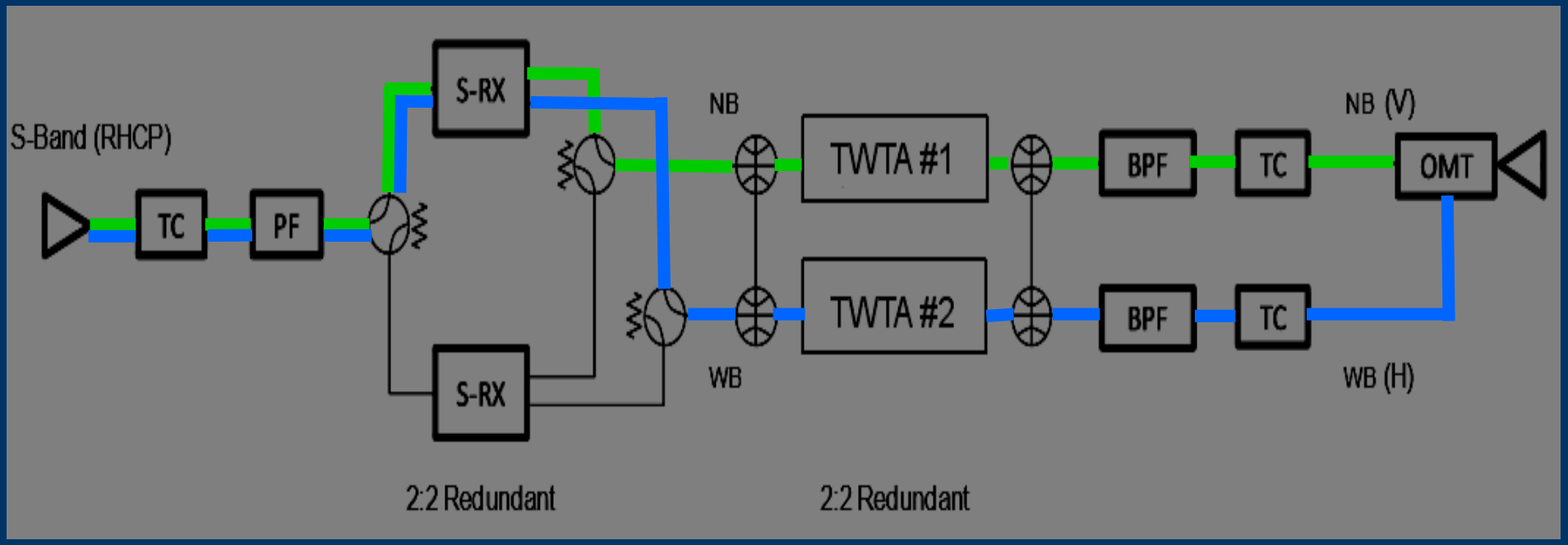
- X-Band Downlink (SAT-TV dish):
  - 90 cm dishes in rainy areas at EOC like Brazil or Thailand
  - 60 cm around around coverage peak
  - 75 cm dishes at peak -2dB

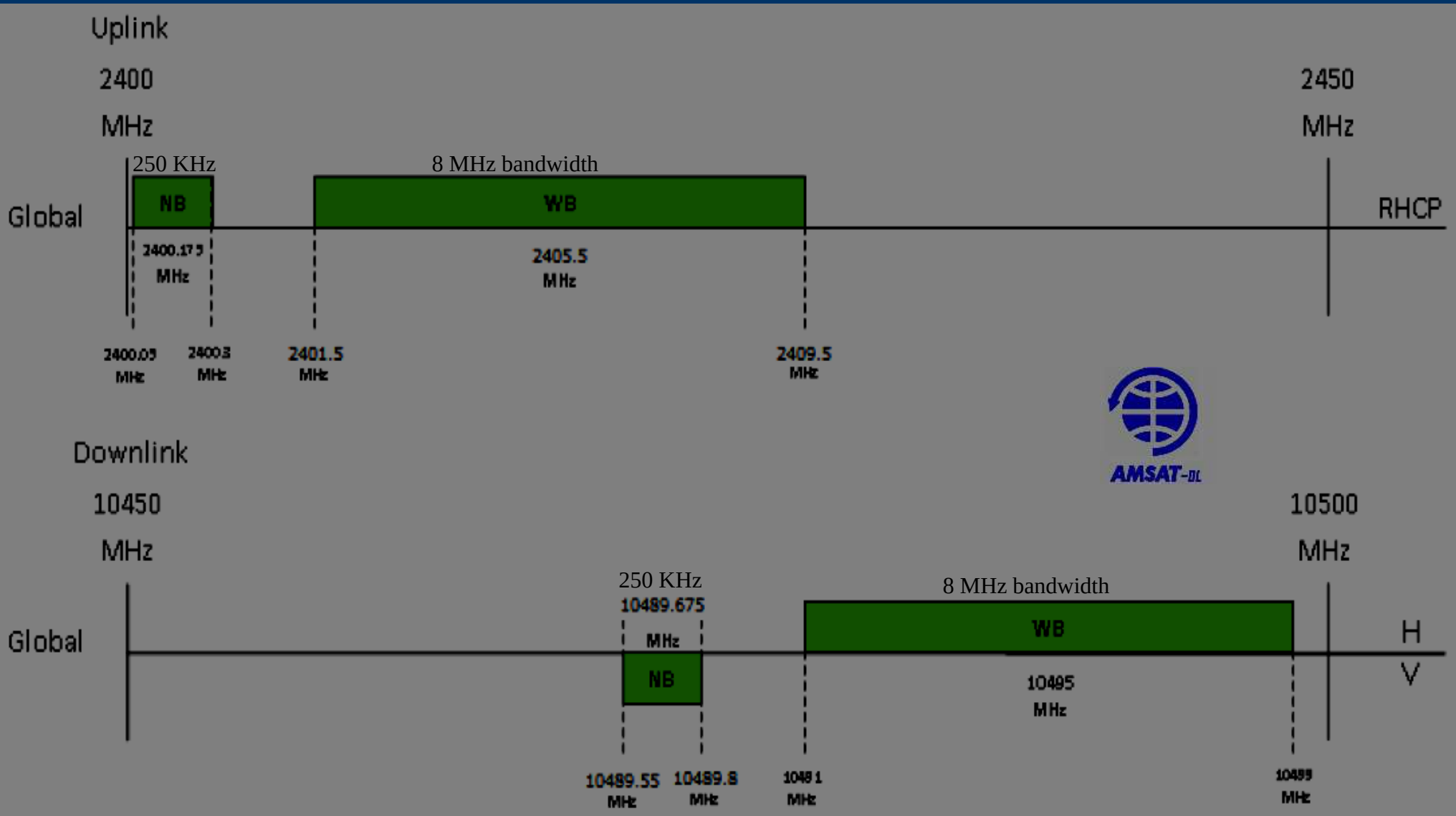


- Uplink Polarisation on S-Band is RHCP
- Downlink Polarisation on X-Band is Horizontal !

- DVB-S2 “beacon” from Qatar is planned with Live WebCam and promotional videos for Ham radio activities

AMSAT Payload Block Diagram





Xpdr	U/L FREQUENCY (MHz)				D/L FREQUENCY (MHz)				LO	BW
No	Pol	Begin	Center	End	Pol	Begin	Center	End	(MHz)	(MHz)
NB	RHCP	2400.05	2400.175	2400.3	V	10489.55	10489.675	10489.8	8089.5	0.25
WB	RHCP	2401.5	2405.5	2409.5	H	10491	10495	10499	8089.5	8

Es'hailSat Satellite Control Center

AMSAT-DL HQ Bochum

- 3m antenna for 2.4 GHz Uplink with VE4MA septum feed
- 2.5m antenna for 10 GHz Downlink

AMSAT Ground Segment

- Located at the Es'hailSat Satellite Control Center (SCC) near Doha in 'shelter' close to main Es'
- unattended operations, but remote access to tweak LEILA-2 parameters shall be possible.
- 2.4 Meter dedicated Uplink antenna for AMSAT on S-Band
- In-Orbit-Verification and Monitoring of the AMSAT transponder with FFT passband (NB+WB) dis
- LEILA-2 (LEIstungs Limit Anzeige) will analyse passband of NB transponder and send Marker t
- LEILA-2 will generate pseudobeacon(s) and add them to the uplink signal (400 Bit/s PSK Telem
- Hamradio shack equipped with SSB equipment for Voice and with DVB-S equipment for DATV t
- Backup station for LEILA will be located in Bochum at AMSAT-DL HQ

Pseudobeacon

- A beacon signal to enable users a signal reference (frequency and level) to orient themself
- A beacon generated on ground, not inside spacecraft
- Same flight-proven Phase 3 format, 400 bit/s BPSK telemetry with FEC
- Pseudobeacons at both ends of the Passband
- (transmissions outside are not permitted)

LEILA

- LEILA is an german acronym for "LEIstungs Limit Anzeige", which means: Power Limit Indicator.

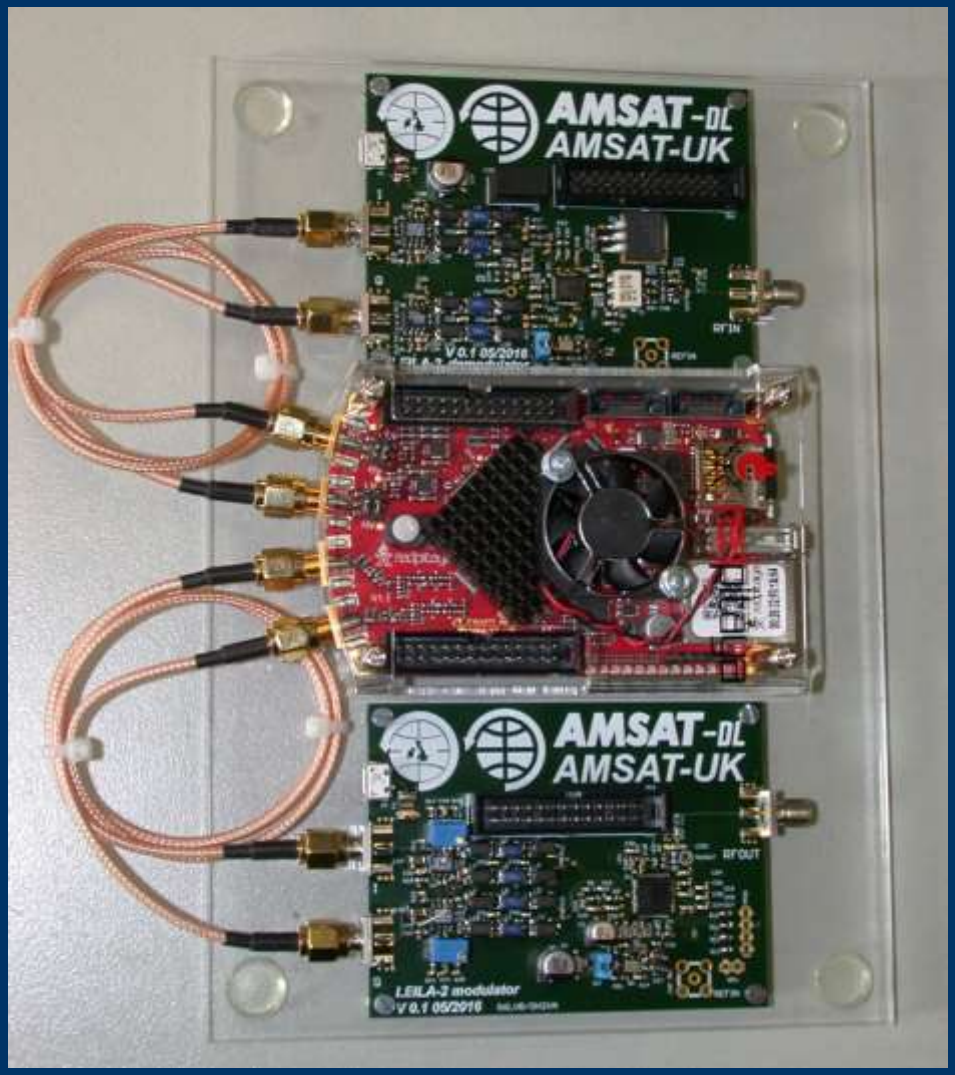
- The original concept of an hybrid analog/digital LEILA on AO-40 was developed by Dr. Karl Meinzer DJ4ZC and Dr. Matjaz Vidmar S53MV. It was the first time that such a system was used as part of an transponder with ***uncoordinated multiple access***.

- LEILA on P4-A is ***ground-based !!***
- Notch filter not possible
- Siren marker (sufficient if operators work full duplex)

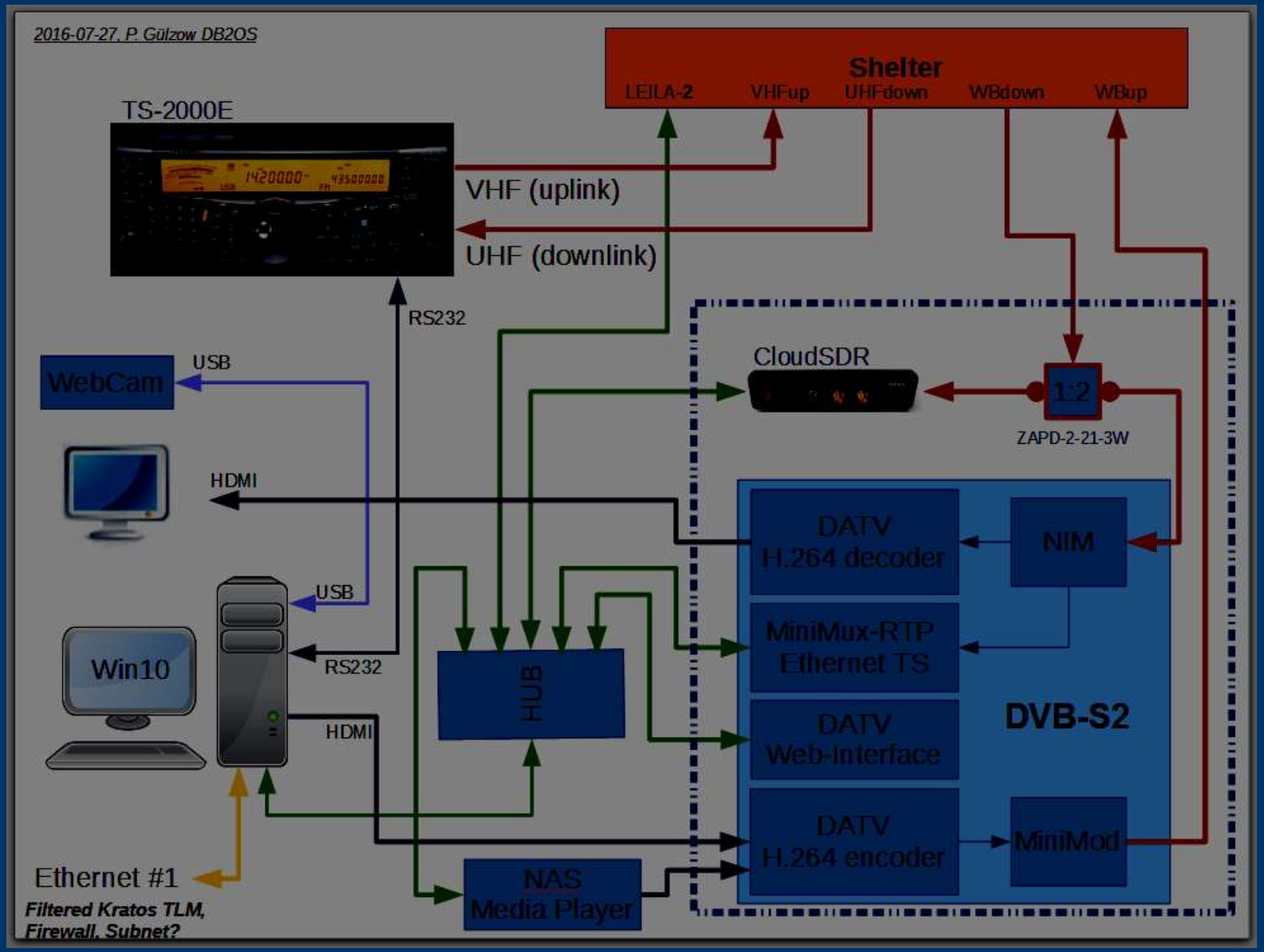
LEILA-2

redpitaya

- Analyzing the passband (FFT) and generating siren markers
- Encoding (FEC) and generation of pseudobeacon(s)
- Accessible via ethernet to tune settings and provide TLM data
- Up-/downconversion boards developed by AMSAT-DL/UK (DH2VA/G6LVB)



Radio Shack


2016-07-27, P. Gülzow DB2OS
Shelter
LEILA-2
VHFup
UHFdown
WBdown
WBup
TS-2000E
VHF (uplink)
UHF (downlink)
RS232
WebCam
USB
CloudSDR
1:2
ZAPD-2-21-3W
HDMI
DATV
H.264 decoder
NIM
USB
MiniMux-RTP
Ethernet TS
Win10
RS232
HUB
DVB-S2
HDMI
DATV
Web-Interface
DATV
H.264 encoder
MiniMod
Ethernet #1
Filtered Kratos TLM,
Firewall, Subnet?
NAS
Media Player

Advantech Wireless

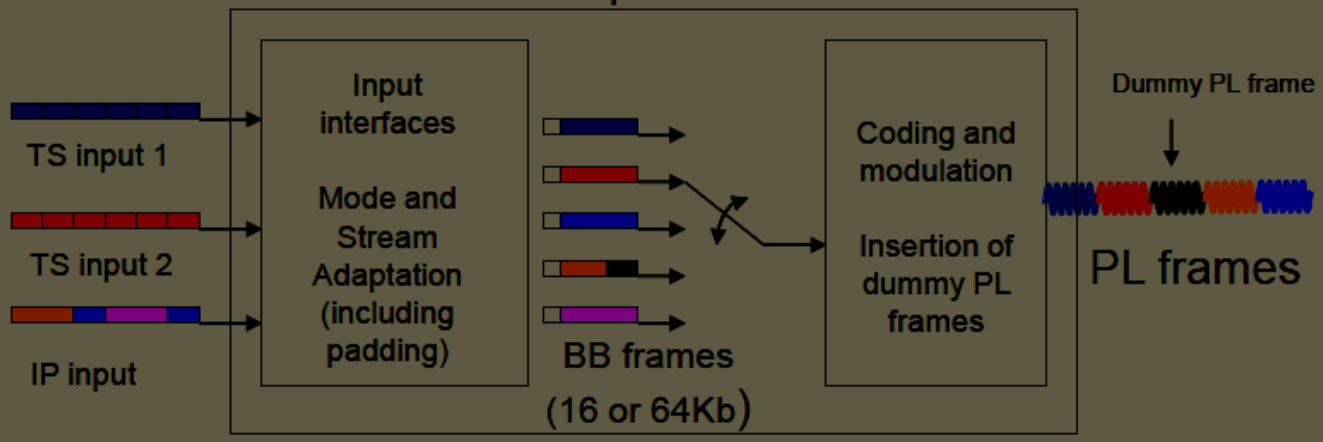
What is DVB-S2 ?

- **New DVB standard for digitial satellite communications**
- **Meant to replace DVB-S & DVB-DSNG**
- **Much better spectral efficiency**
  - –Up to 30% bandwidth saving
  - –Up to 2.5 dB margin gain
- New features such as
  - –Variable and Adaptive Coding and Modulation
  - –Generic Mode (no transport stream overhead)
  - –Support of multiple streams on a single carrier
- So close to the Shannon limit that it could be the last DVB-S standard!

Advantech Wireless

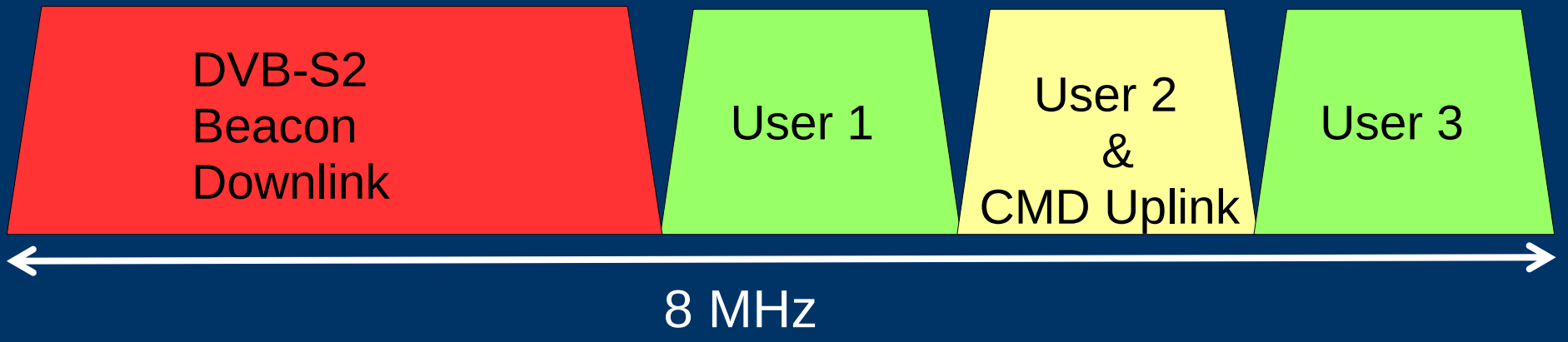
Multiple streams on single carrier (CCM-VCM-ACM)

- A DVB-S2 modulator can have several physical or logical inputs:



- The data of each each input is processed in separated Base Band frames.
- The BB frames are time-multiplexed at the Physical Layer on the same carrier (no TS multiplexing)
- When no data is present the modulator can pad incomplete BB frames or insert dummy PL frames
- Demodulators can receive and decode individual streams independently from the other streams

DATV Bandplan (draft)

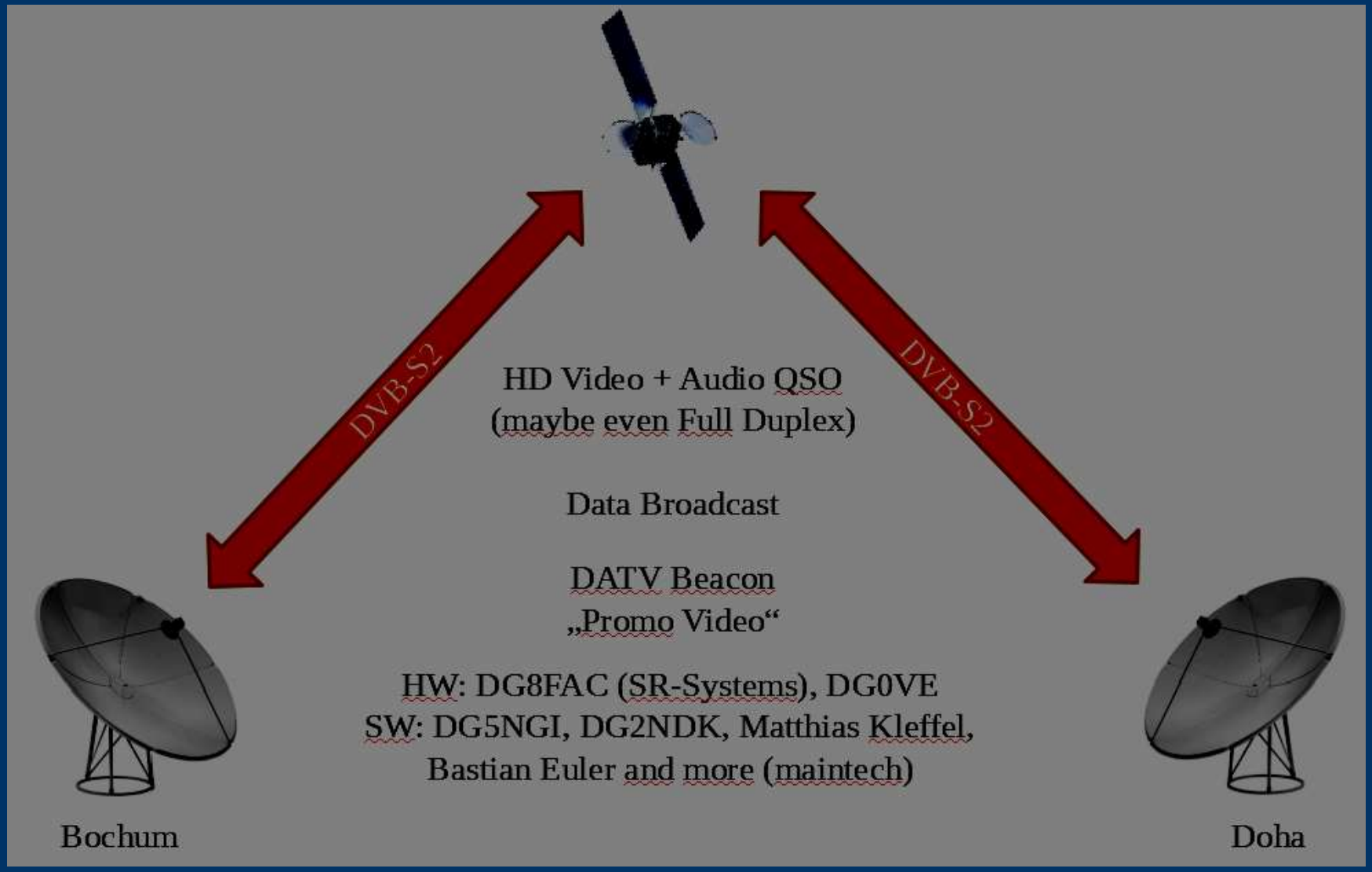


Beacon: 2403,000 MHz, 2.4 Msym (BW=3 MHz, DVB-S2)
User 1: 2405,350 MHz, 1.2 Msym (DVB-S2 or DVB-S)
User 2: 2407,000 MHz (see User 1 and Command Uplink)
User 3: 2408,700 MHz (see User 1)

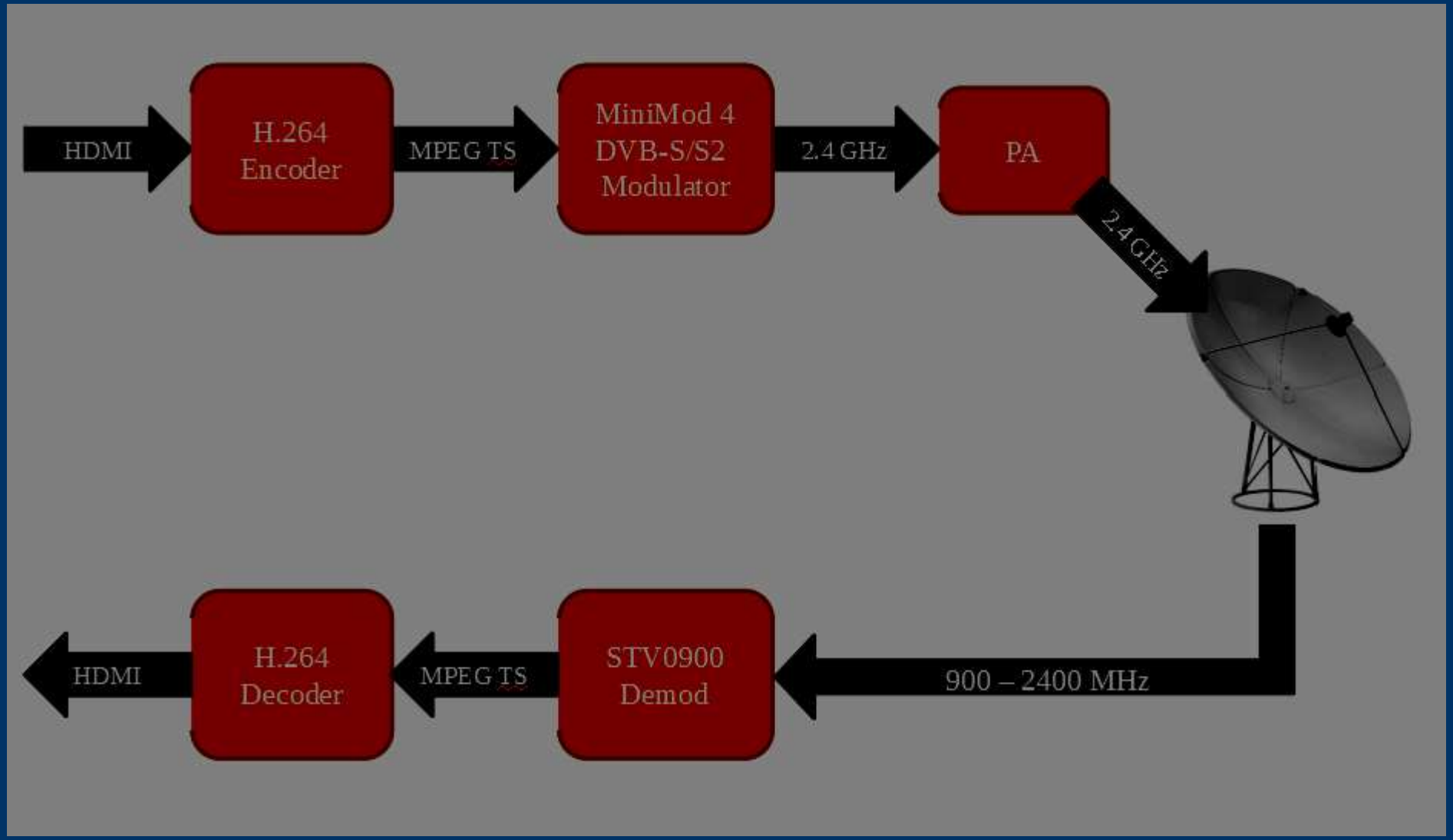
User DVB-S2: 8PSK with 2/3 FEC, BW = 1.5 MHz
User DVB-S: QPSK with 7/8 FEC, BW = 1.62 MHz

Cmd Uplink: 1.2 Msym / 3.6 Msym, ~ 9,3 Mbit Data

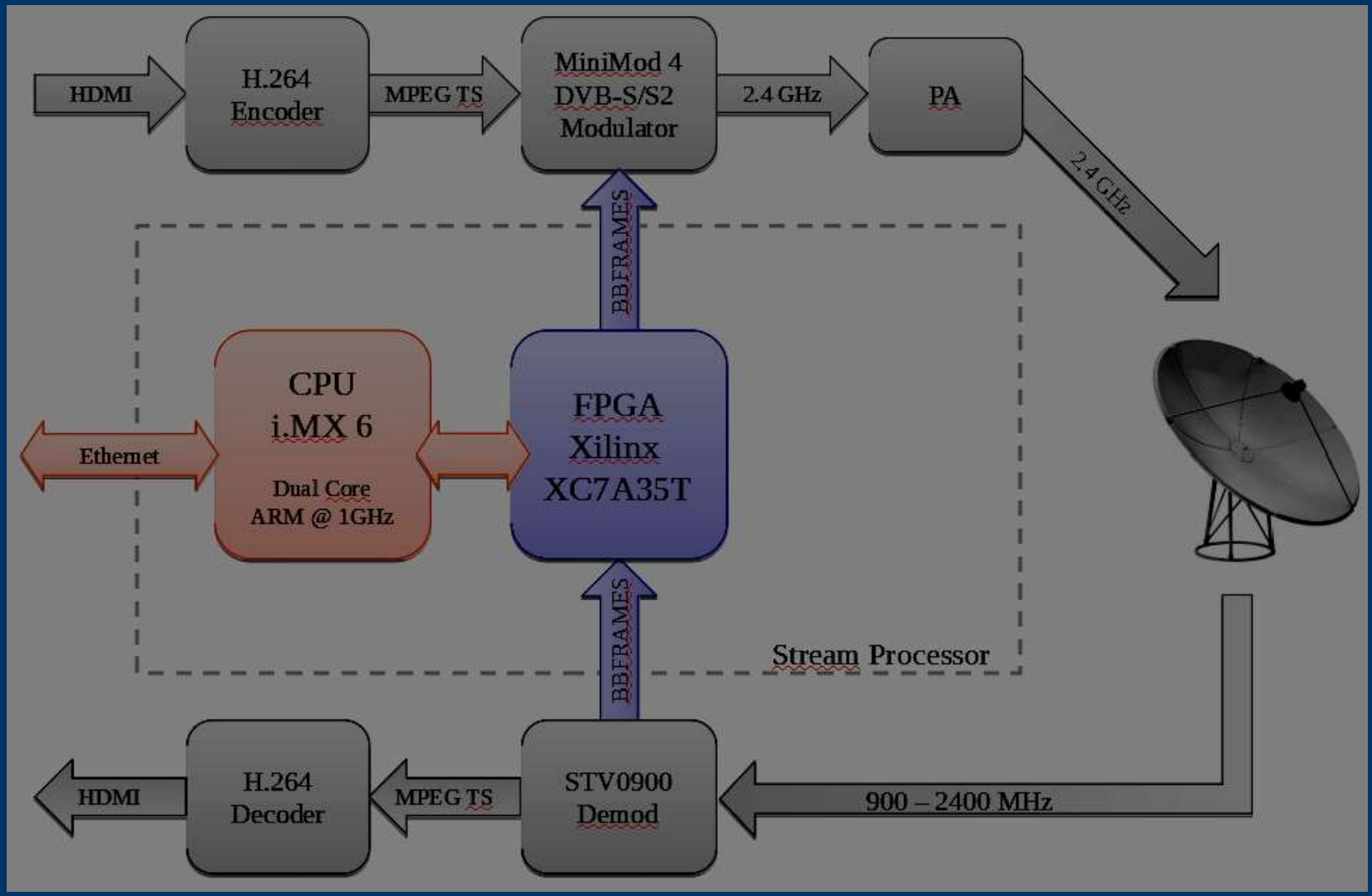
DATV


DVB-S2
DVB-S2
HD Video + Audio QSO
(maybe even Full Duplex)
Data Broadcast
DATV Beacon
„Promo Video“
HW: DG8FAC (SR-Systems), DG0VE
SW: DG5NGI, DG2NDK, Matthias Kleffel,
Bastian Euler and more (maintech)
Bochum
Doha

DATV - Video


HDMI
H.264 Encoder
MPEG TS
MiniMod 4 DVB-S/S2 Modulator
2.4 GHz
PA
2.4 GHz
900 – 2400 MHz
STV0900 Demod
MPEG TS
H.264 Decoder
HDMI

DATV - Data


HDMI
H.264 Encoder
MPEG TS
MiniMod 4 DVB-S/S2 Modulator
2.4 GHz
PA
2.4 GHz
BBFRAMES
CPU i.MX 6
Dual Core ARM @ 1GHz
Ethernet
FPGA Xilinx XC7A35T
BBFRAMES
Stream Processor
HDMI
H.264 Decoder
MPEG TS
STV0900 Demod
900 – 2400 MHz

DATV - Requirements

- Send and receive Video + Audio

The Ground Station will be used for QSOs between Doha and Bochum.

- Easy to use

DVB-S2, H.264 and bandwidth allocation will result in >25 parameters which need to be set correctly. To make this work, we need presets.

- Send „beacon“ aka. Video Loop

Semi-automatic operation should be possible to implement a beacon mode.

- Updatable

Frequency allocation and operation modes will be subject to change even after GS is deployed

- Platform for Advanced DVB-S2 Experiments

This is not really a requirement – but it was wanted by the developers

- Fit into 19“ 2HE
- Modularity

Reduce cost and allow ham radio amateurs to build (parts of) the GS themselves.

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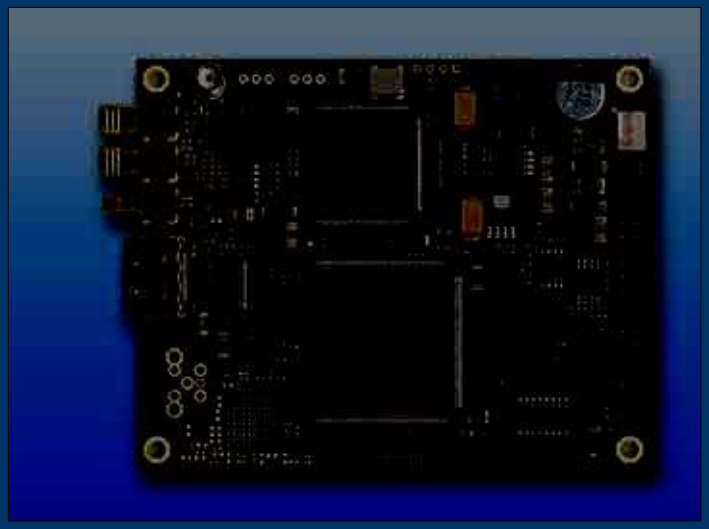
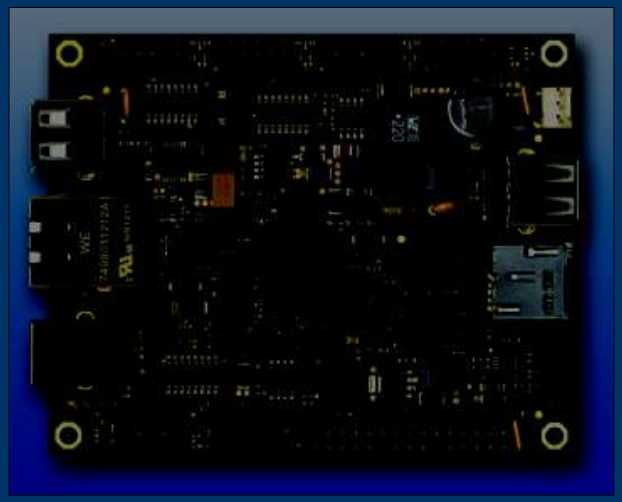
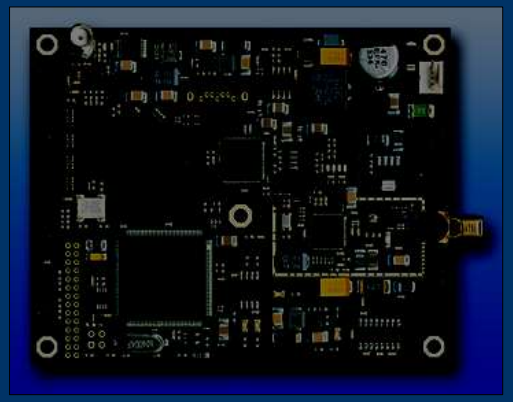
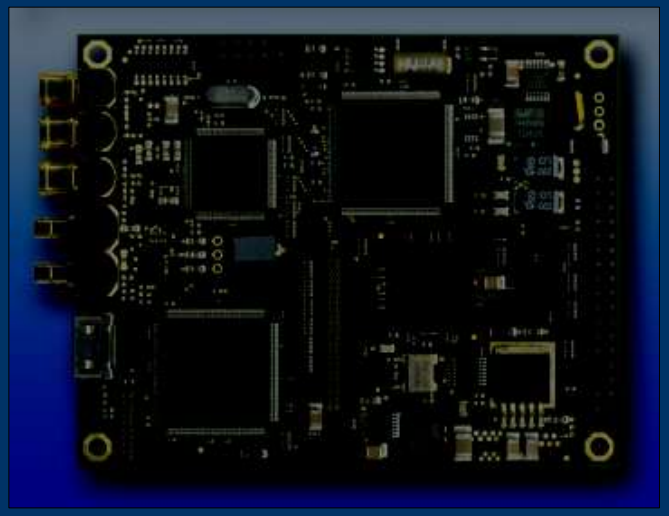
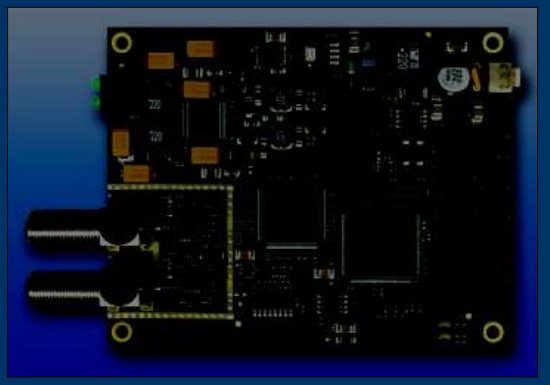
DATV - GS



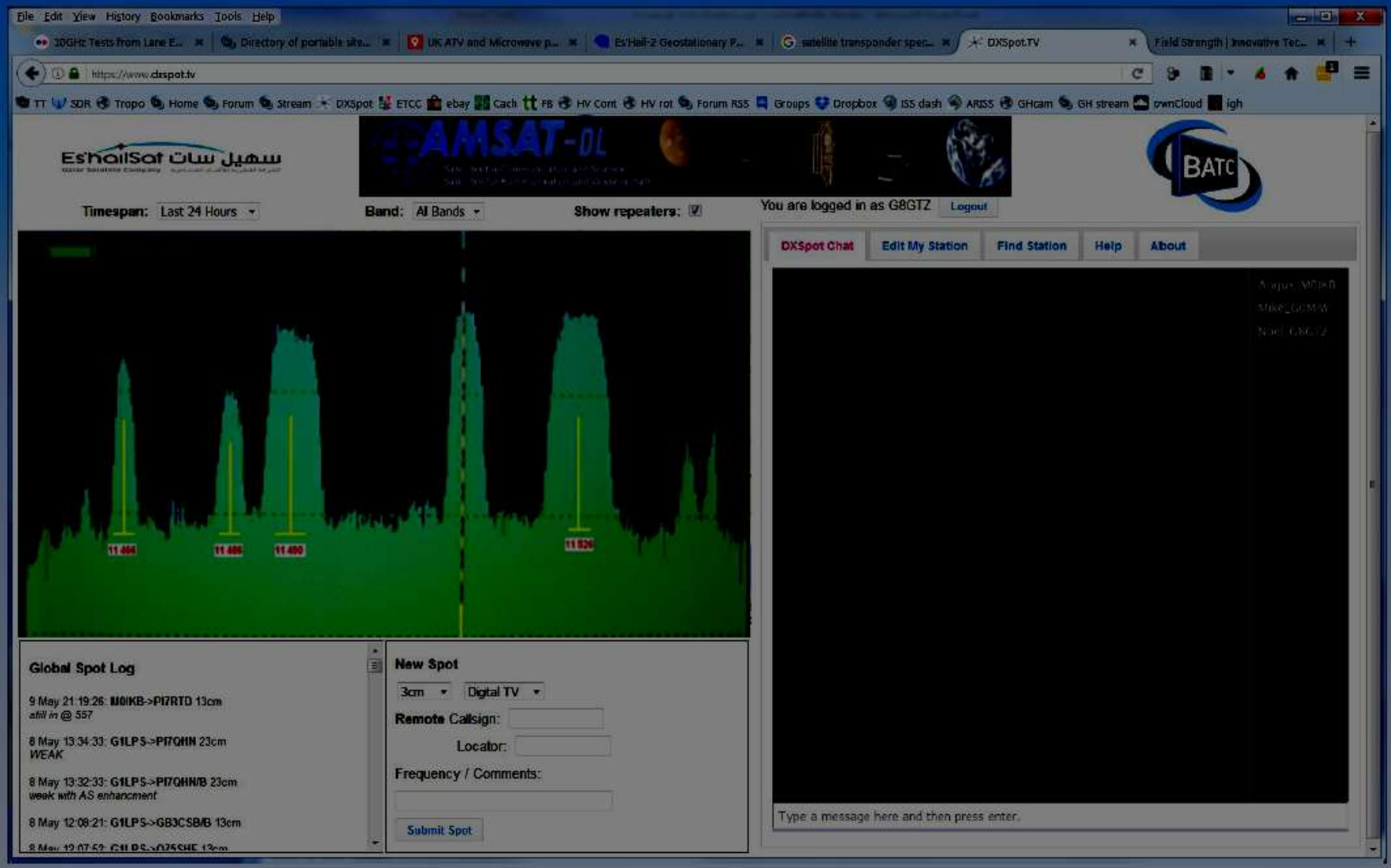








Real time monitoring



All-in-one solution (DB6NT)

OSCAR Phase 4 Down-Converter

X Low Noise down converter with feed horn
X 10.4 GHz -> 432 MHz
X No frequency drift due to TCXO
X mountable with standard LNB peg

All-in-one solution (DB6NT)

OSCAR Phase 4 UP-Converter

X 144 MHz -> 2.4 GHz
X 20 W output power
X stand-alone device
X fully remotely controllable
X numerous protection circuits

Partners

Es'hailSat سهيل سات
Qatar Satellite Company الشركة القطرية للأقمار الصناعية

AMSAT-DL

الجمعية القطرية لهواة اللاسلكي
Q.A.R.S.
QATAR AMATEUR RADIO SOCIETY

KENWOOD

JAMSAT

AMSAT-UK

BATC

AMSAT-OH

maintech GmbH

SR

Conclusion

- Es'hailsat, QARS and AMSAT-DL are working towards the first linear hamradio transponder in geostationary orbit (P4-A)

- Launch is planned for the year 2018
- Two transponders: 250 kHz narrowband, 8 MHz wideband
- Target RX station size: 60-90cm
- Target TX station size: 60-90cm, 10 W (narrowband)
  240cm, 100W (wideband)

- Leaftlet with key information is available:

•AMSAT-DL website and AMSAT-DL on Facebook.

•http://www.amsat-dl.org