Space Technology

The Alphasat propagation experiment

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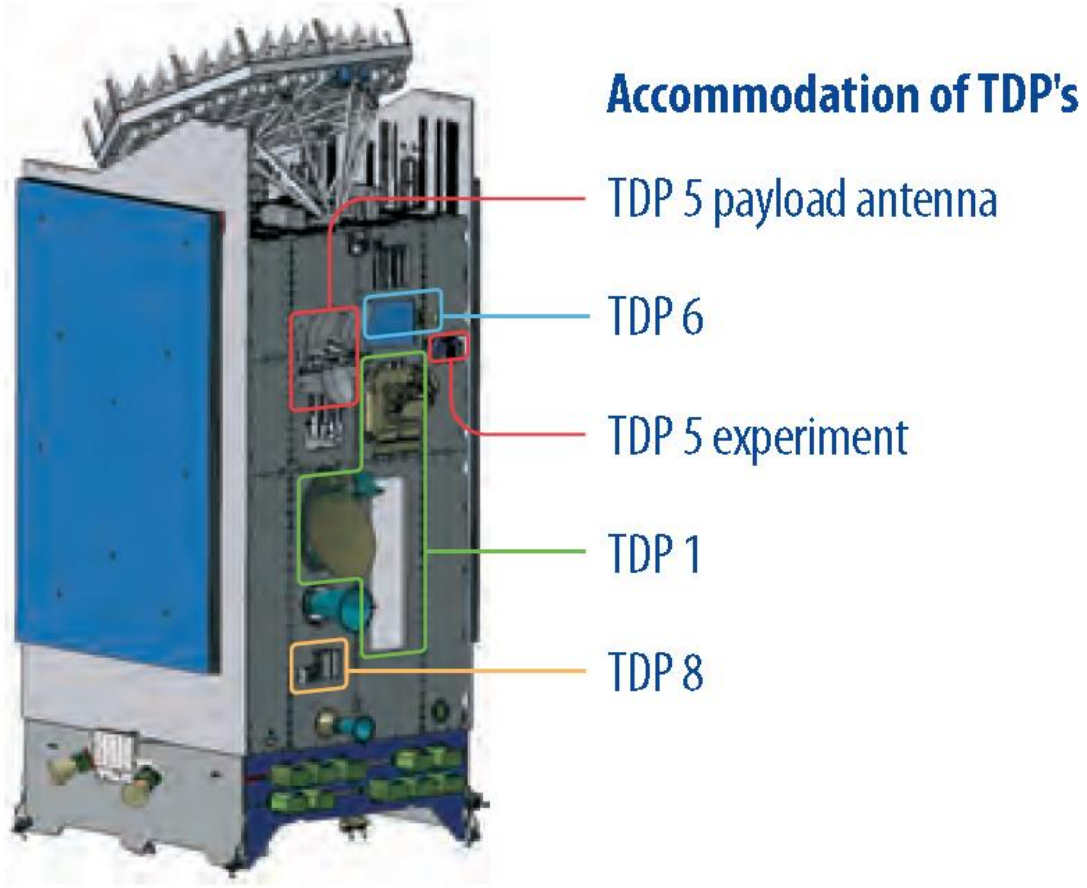
The Alphasat spacecraft 1.

- Launch: 25th July 2013
- Lifetime: 15 years
- Owner: Inmarsat
- Payload: BGAN service
- Developers: Astrium/ESA
- Orbit: geosynchronous
- Location: 25° E longitude
- 11 m diameter deployable reflector
- Total launch mass: > 6 tons
- Total electrical power: 12 kW

The Alphasat spacecraft 2.

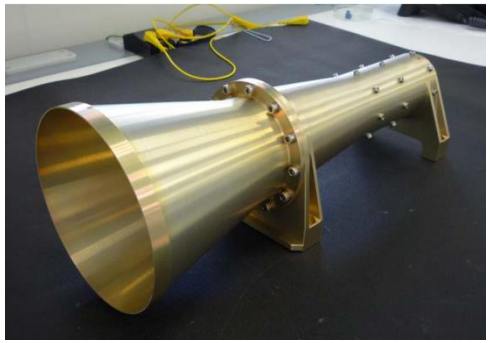
Technology Demonstration Payloads

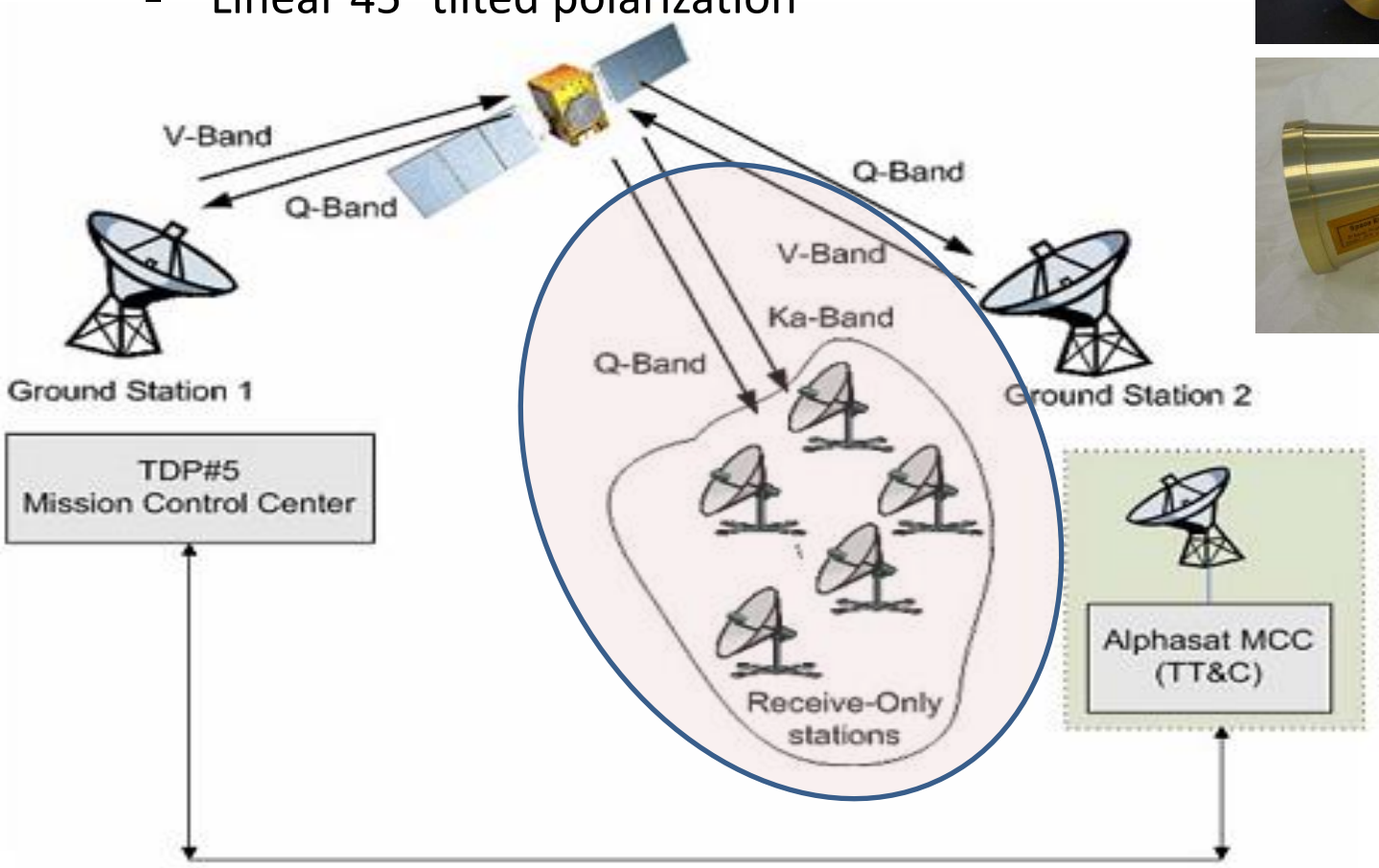
- An advanced laser communication terminal to demonstrate GEO to LEO communication links at 1064 nm (TDP 1)
- A Q/V -Band propagation and communications experiment to assess the feasibility of these bands for future commercial applications (TDP 5)
- An advanced star tracker with active pixel sensor (TDP 6)
- An environment effects facility to monitor the GEO radiation environment and its effects on electronic components and sensors (TDP 8)



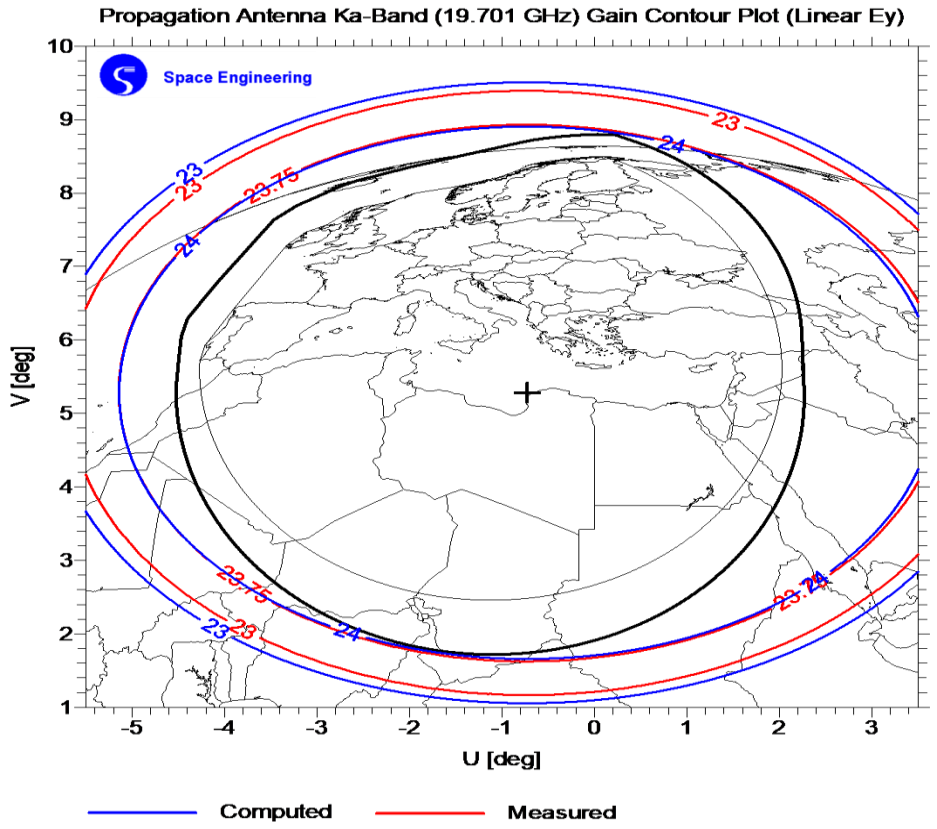
The structure of the propagation experiment

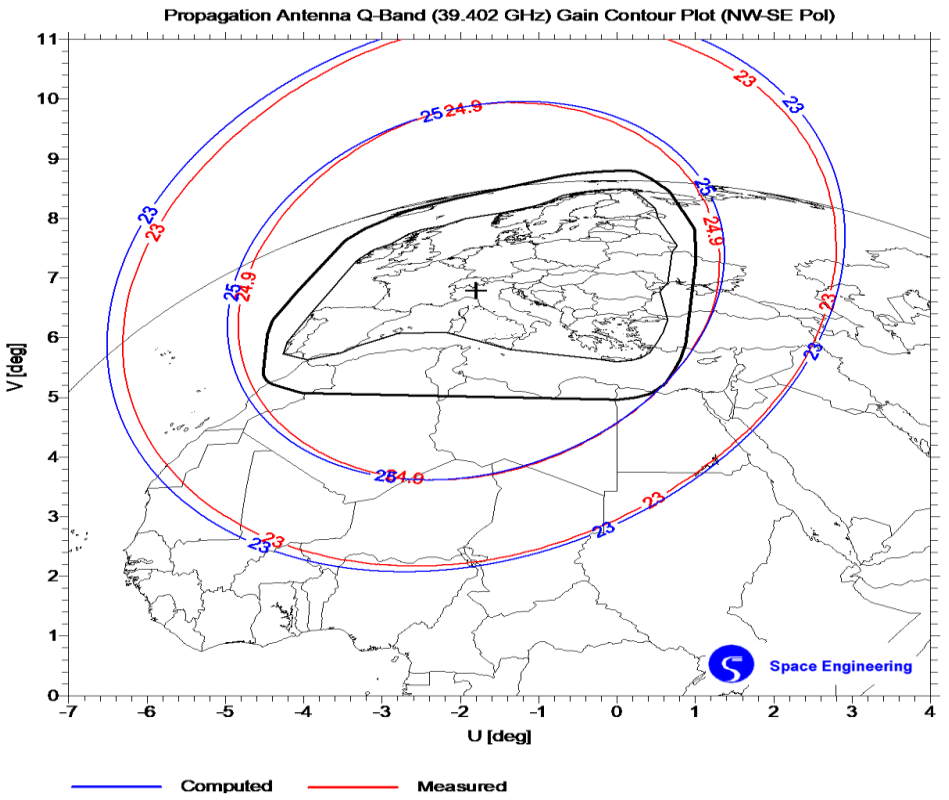
- Two separated beacon transmitters
  - Ka-band: 19.701 GHz / 19.5dBW EIRP
    - Linear V polarization
  - Q-band: 39.402 GHz / 26.5dBW EIRP
    - Linear 45° tilted polarization





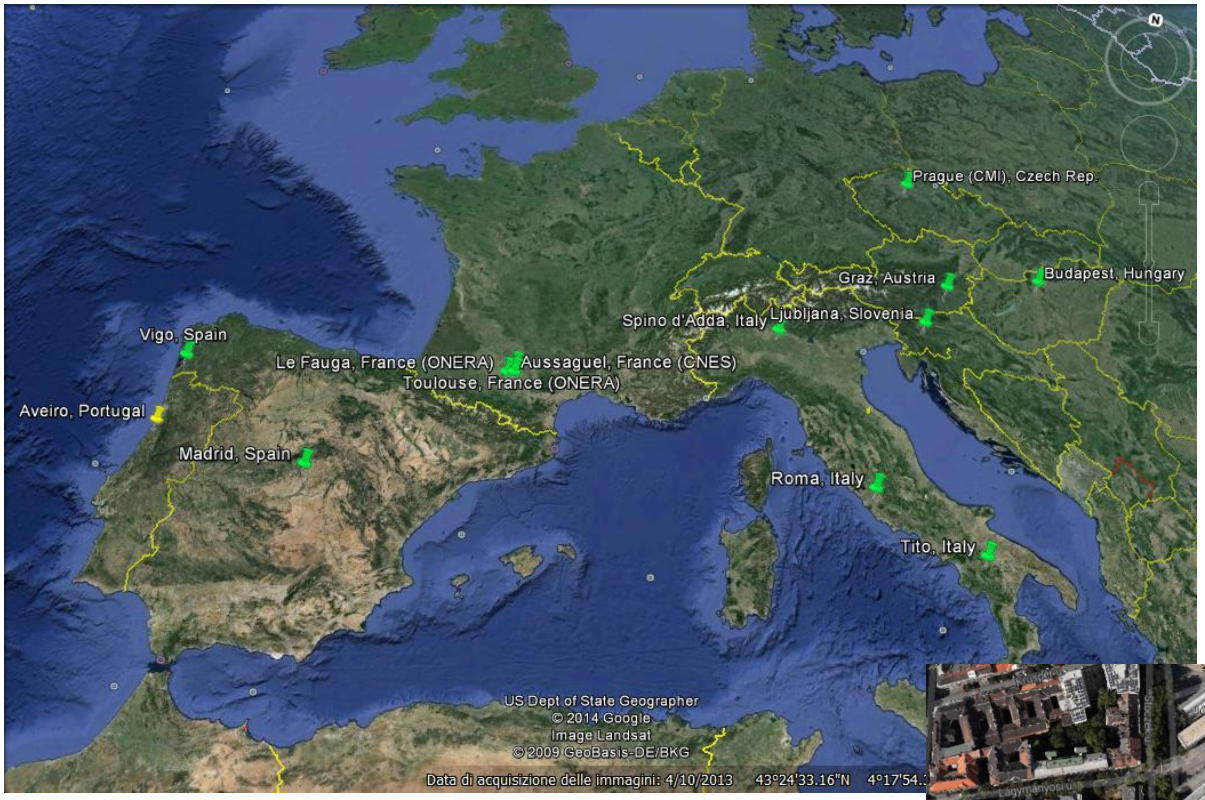
Coverage maps



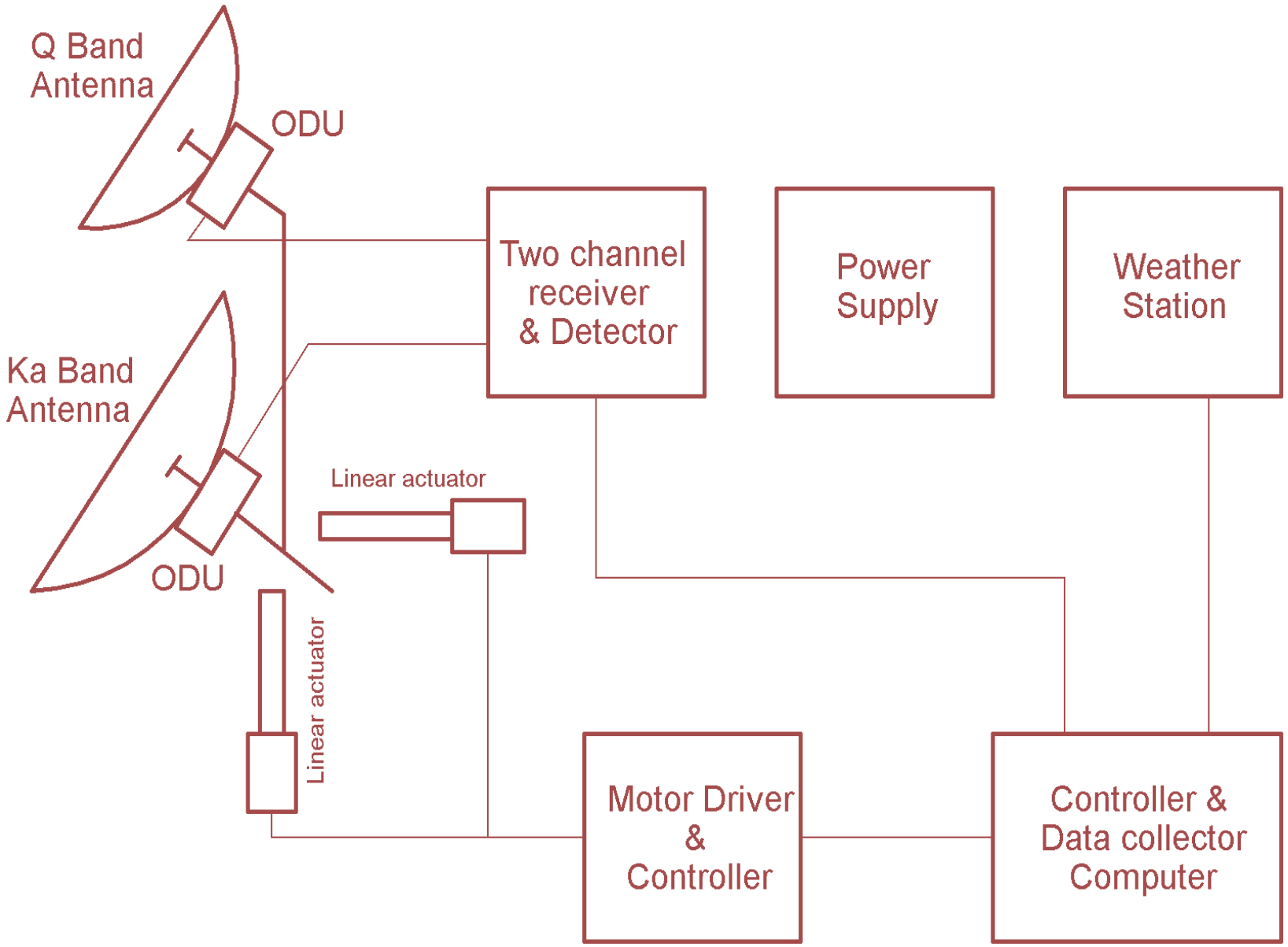


Coverage area of the Ka-band (left) and Q-band (right) beacon

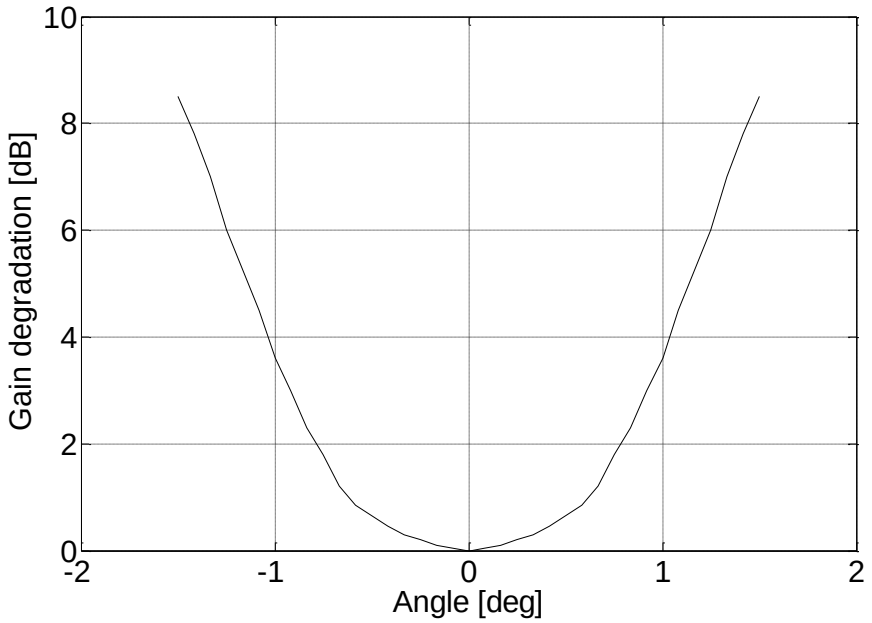
Receiver locations – Europe/Hungary



BME receiver block diagram



Receiver antennas

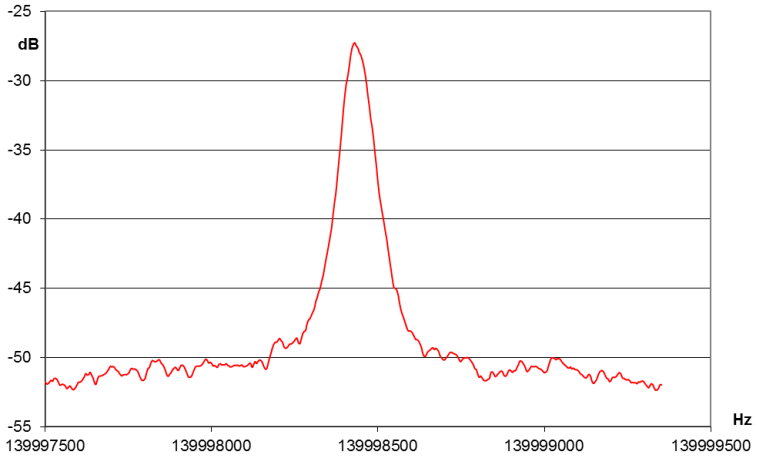


	Ka-band	**Q-band**
Type (Cassegrain)	HPA 0.6 S 180230 FR	HPA 0.3 S 380 SR
Frequency range	17.7-23.6GHz	37-39.5GHz
Diameter	0.6m	0.3m
Mid band gain	39.5dBi	39.2dBi
Polarization	Linear simplex (V/ H)	Linear simplex (V/H)
Half-power beamwidth	1.6°	1.7°

Fade margin calculations: the link budget

	Q-band	Ka-band	
Frequency	39.4	19.7	GHz
Guaranteed EIRP (EoC EoL)	26.5	19.5	dBW
Earth–Satellite distance	35756.0	35756.0	Km
Free-space attenuation	215.4	209.4	dB
Aggregate non-rain attenuation	2.0	2.0	dB
Receiving antenna gain	39.2	39.5	dB
Antenna efficiency	55.0	55.0	%
Receiver Noise Figure	3.0	3.0	dB
Antenna Noise Temperature	25.0	25.0	K
Receiver Noise Temperature	288.6	288.6	K
Receiver System G/T	14.2	14.5	dB/K
Received carrier power	-121.7	-122.4	dBm
Noise power density	-198.0	-198.0	dBW/Hz
Receiver bandwidth	100.0	100.0	Hz
Noise power	-178.0	-178.0	dBW/Hz
C/N	26.3	25.6	dB
C/Nmin (approximated)	3.5	3.5	dB
Rain margin	22.8	22.1	dB

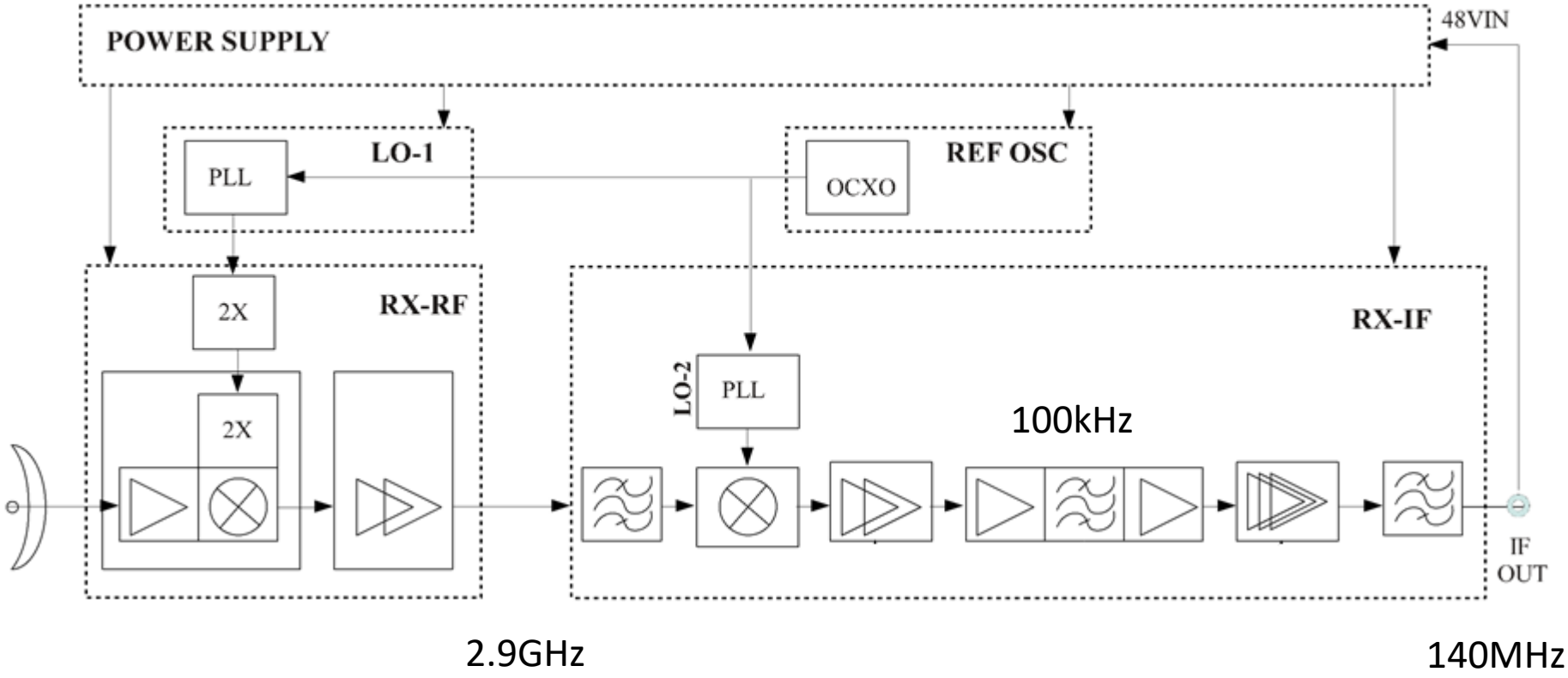
IF spectrum (140MHz)



The outdoor unit (ODU) 1.

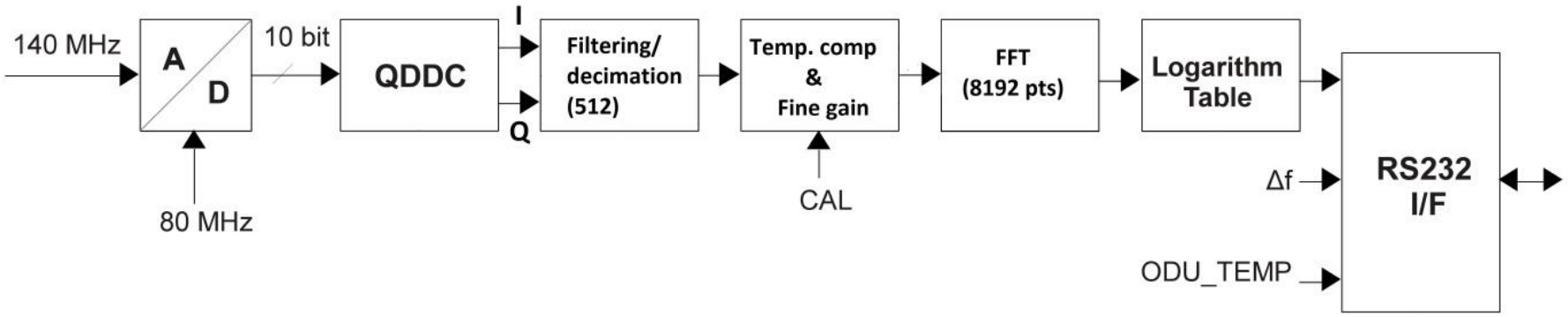
- LNA: amplifies the weak satellite signal
- Downconverting the satellite frequency to IF band
- Performs further amplification on IF band

The outdoor unit (ODU) 2.



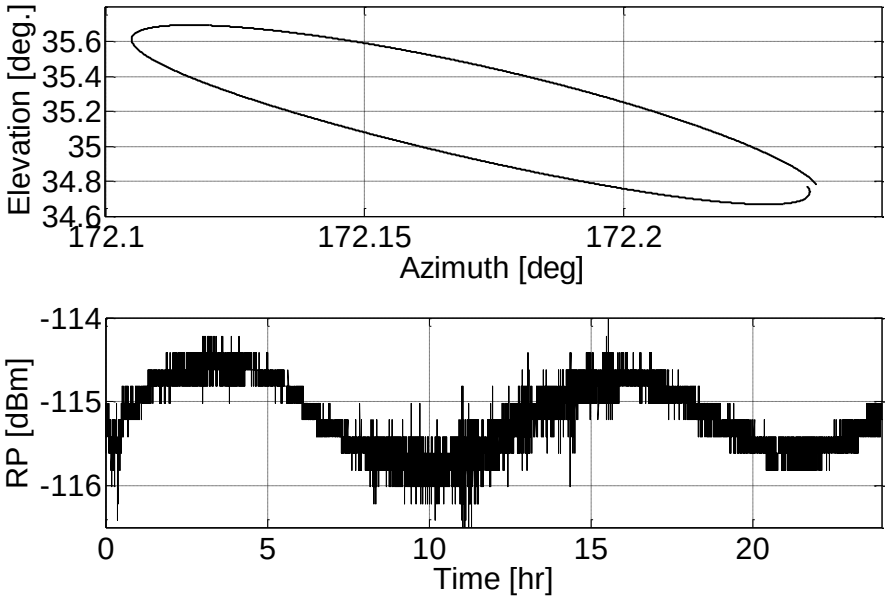
- Cable between ODU/IDU
  - Powering the ODU
  - Connect IF signal to IDU

The indoor unit (IDU)



„Geo” orbits and their specialities

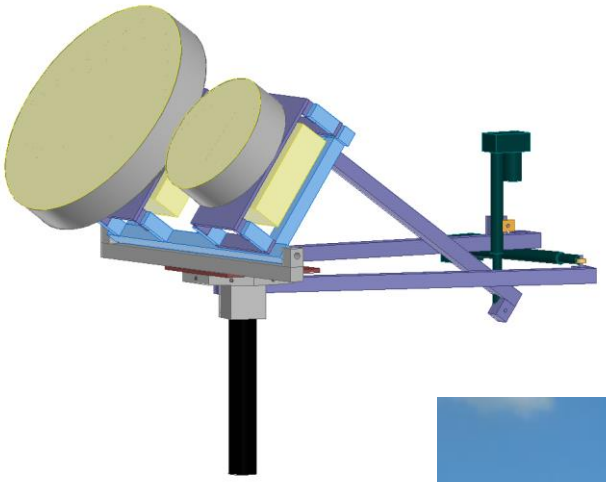
- Communications satellites, broadcasting: geostacionary/geosynchronous orbits



Daily movement of a geosynchronous satellite (16/08/2014)

- Cause of movements
- Position detection and correction
- Doppler effects

Tracking system 1.



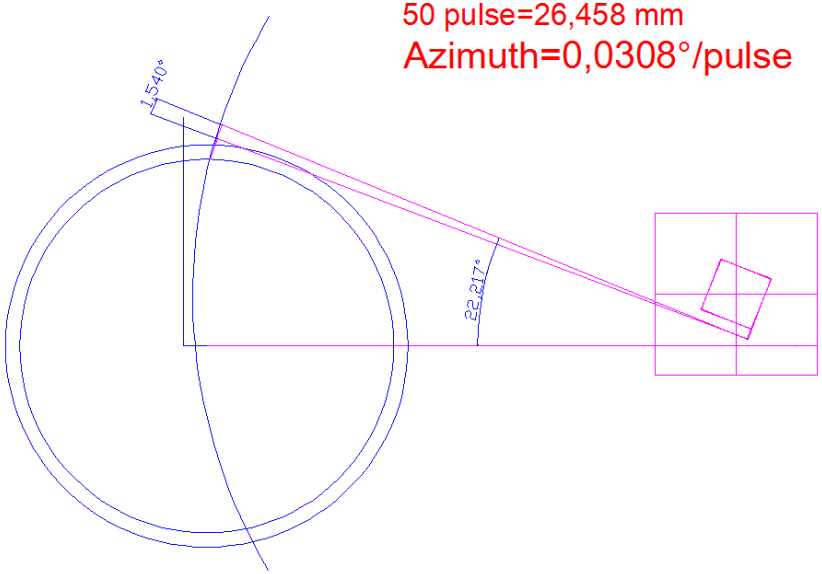
- Only ±3°correction required
- High precision is needed
- Narrow beam antenna characteristics

Tracking system 2.

Linear motors:

- Temperature range: -30° C to +50° C
- Static Load capability: 450 kg
- Dynamic Load capability: 250 kg
- Stroke length: 305 mm (12”)
- Input voltage: max. 36VDC
- Speed: 5,6mm/sec
- Reed sensor: ~2 pulses/mm (48 pulses/inch)

0,52917 mm/pulse
50 pulse=26,458 mm
Azimuth=0,0308°/pulse



0,52917 mm/pulse
50 pulse=26,458 mm
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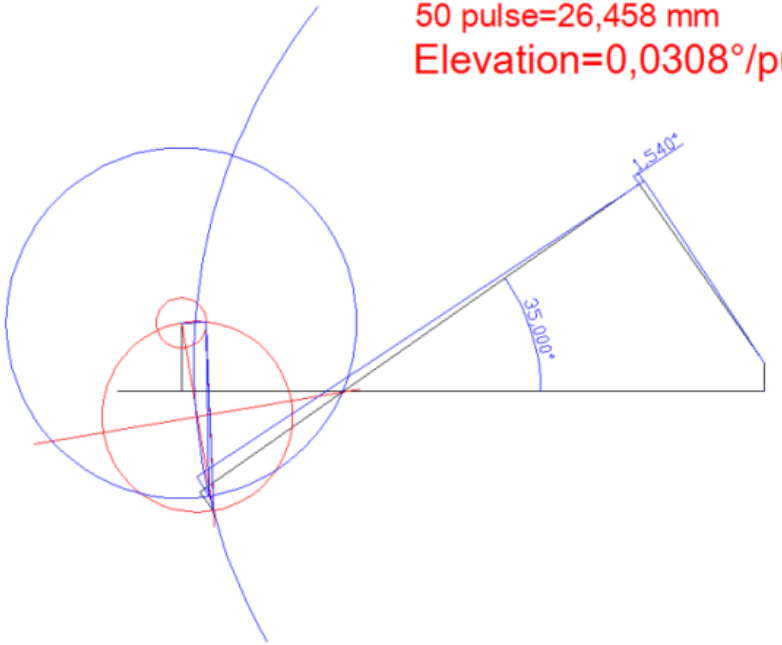
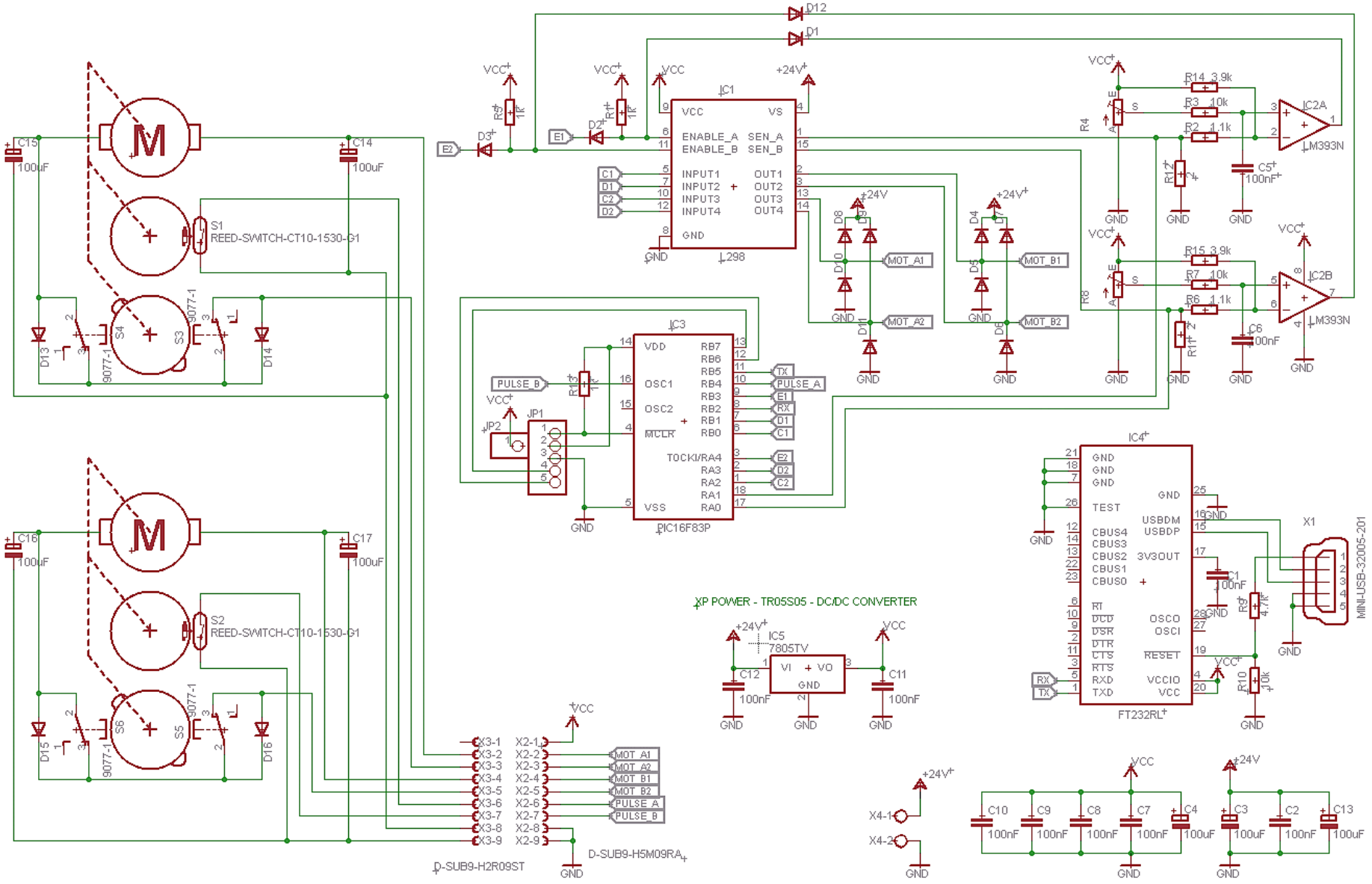
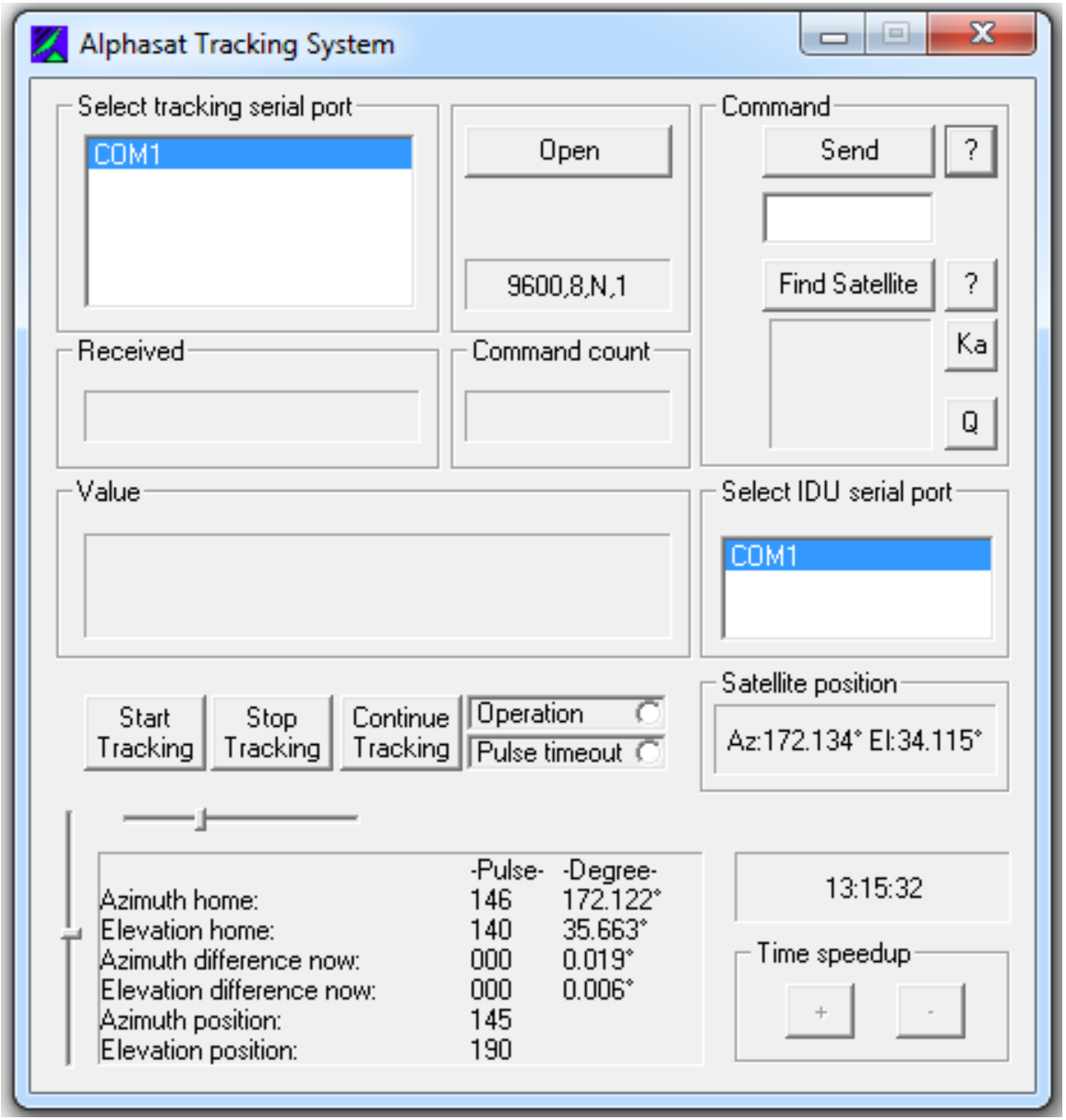


Tracking system 3.

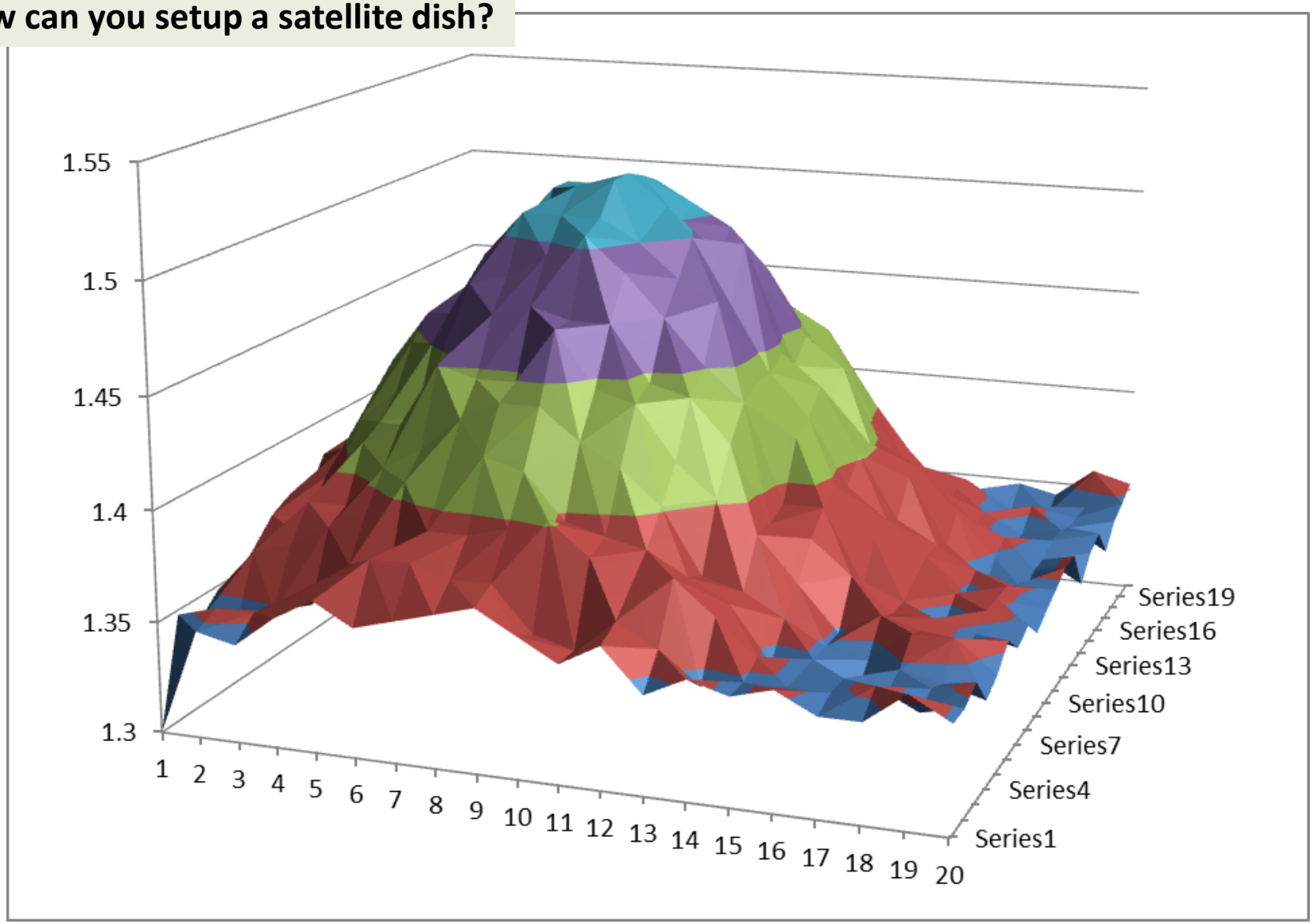


Tracking system 4.

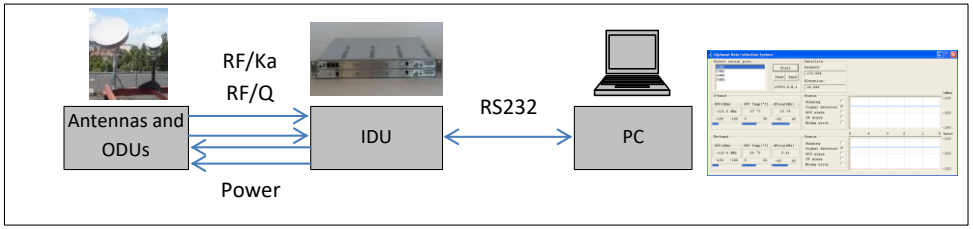


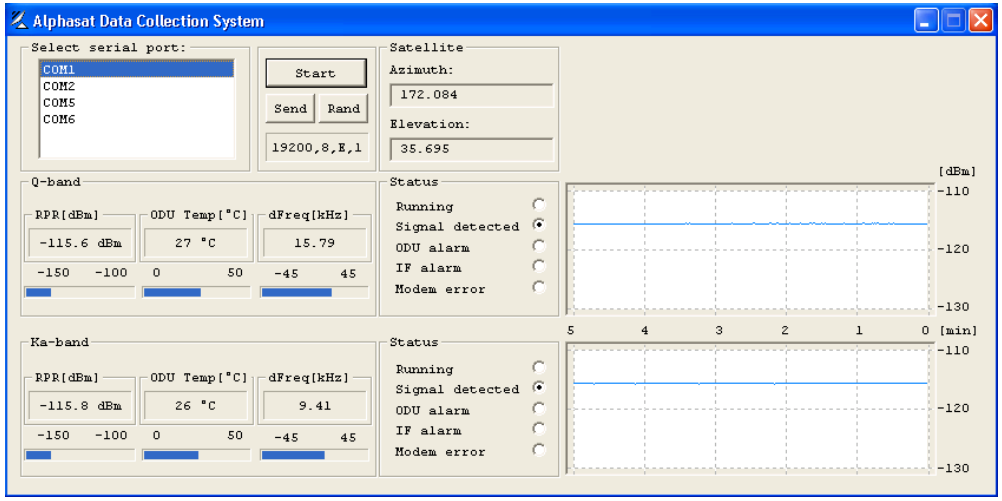
System calibration

How can you setup a satellite dish?



The receiver system



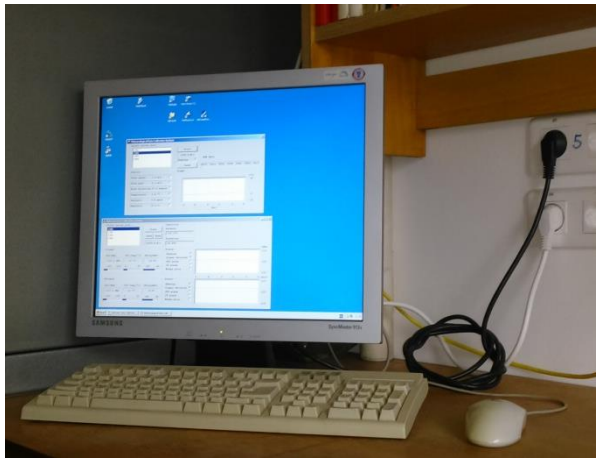


Ka and Q band receivers

Data collection system

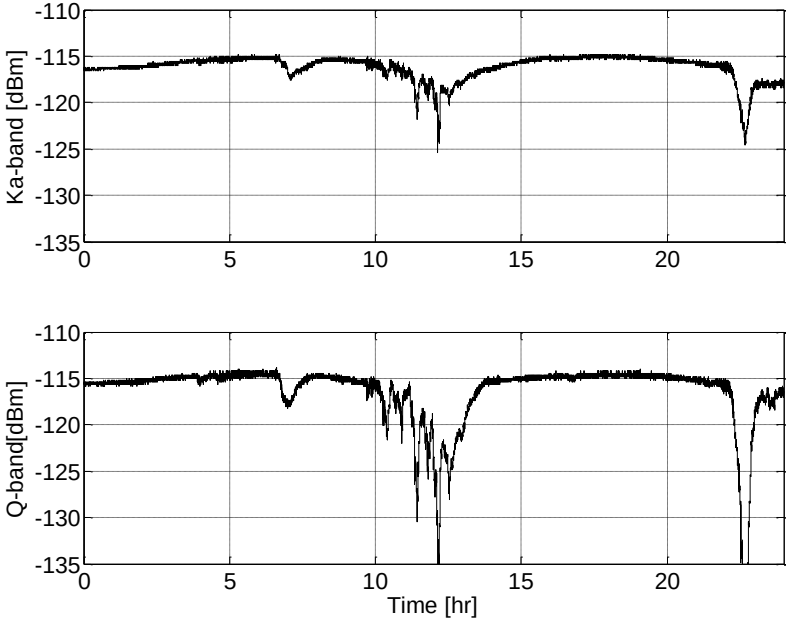
Tasks of the receiver system

- Periodically (1sec) polls the IF boards and requests for status and measurement data
- Displays the actual data in text and graphical mode
- Creates a daily data file that contains the RAW measurement data
- Maintains the system clock by periodically synchronizing to a time server
- Daily downloads the satellite orbital parameters (TLE file), calculates and stores the satellite position for each seconds of the measurement time
- Daily updates the online measurement data graph on the BME-HVT's Alphasat server

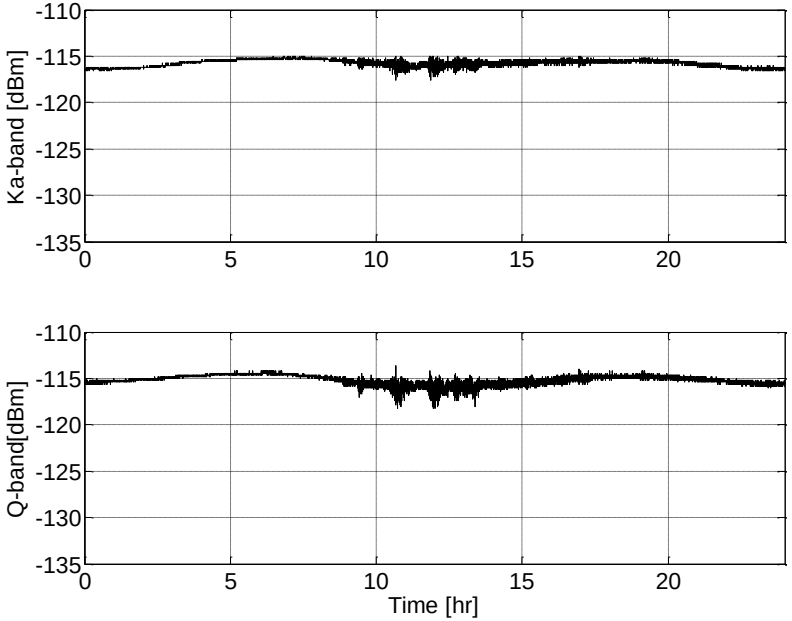


Received power time series (Alphasat, BME)

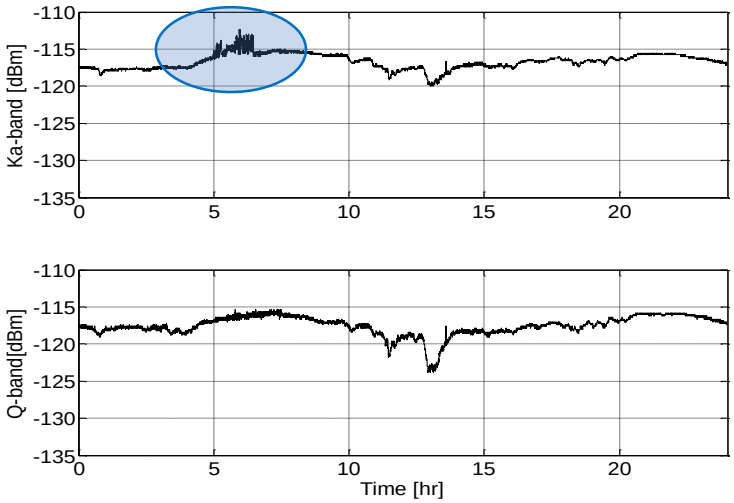
Rain; 8th July 2014



Scintillation; 7th July 2014



Increase of signal level 2th December 2014



Received data format

Daily files:

236_AlphaSat_Mon_Aug_25_2014_K.txt
236_AlphaSat_Mon_Aug_25_2014_Q.txt

065;008;044;138;004;001;172.1369;35.9136;1
065;008;044;138;004;001;172.1369;35.9136;2
.
.
065;003;043;138;004;001;172.1256;35.9129;86399
065;003;043;138;004;001;172.1256;35.9129;86400

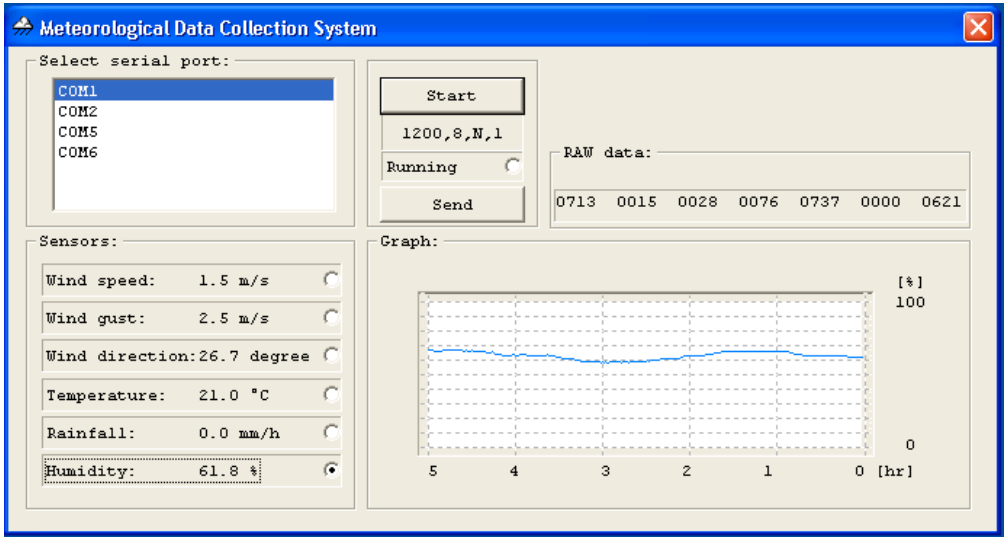
Data1: IDU status byte
Data2: ODU temperature
Data3: frequency deviation
Data4: received level
Data5: IDU firmware version
Data6: IDU number
Data7: satellite azimuth
Data8: satellite elevation
Data9: second of the day

Weather station 1.

Aanderaa Instruments Automatic Weather Station AWS 2700

Wind Speed Sensor (2740)
Wind Direction Sensor (3590)
Air Temp. Sensor (3455)
Rainfall Sensor (3064)
Relative Air Humidity Sensor (3445)

Sensor Scaning Unit (3010)



Weather station 2.

Daily data files:

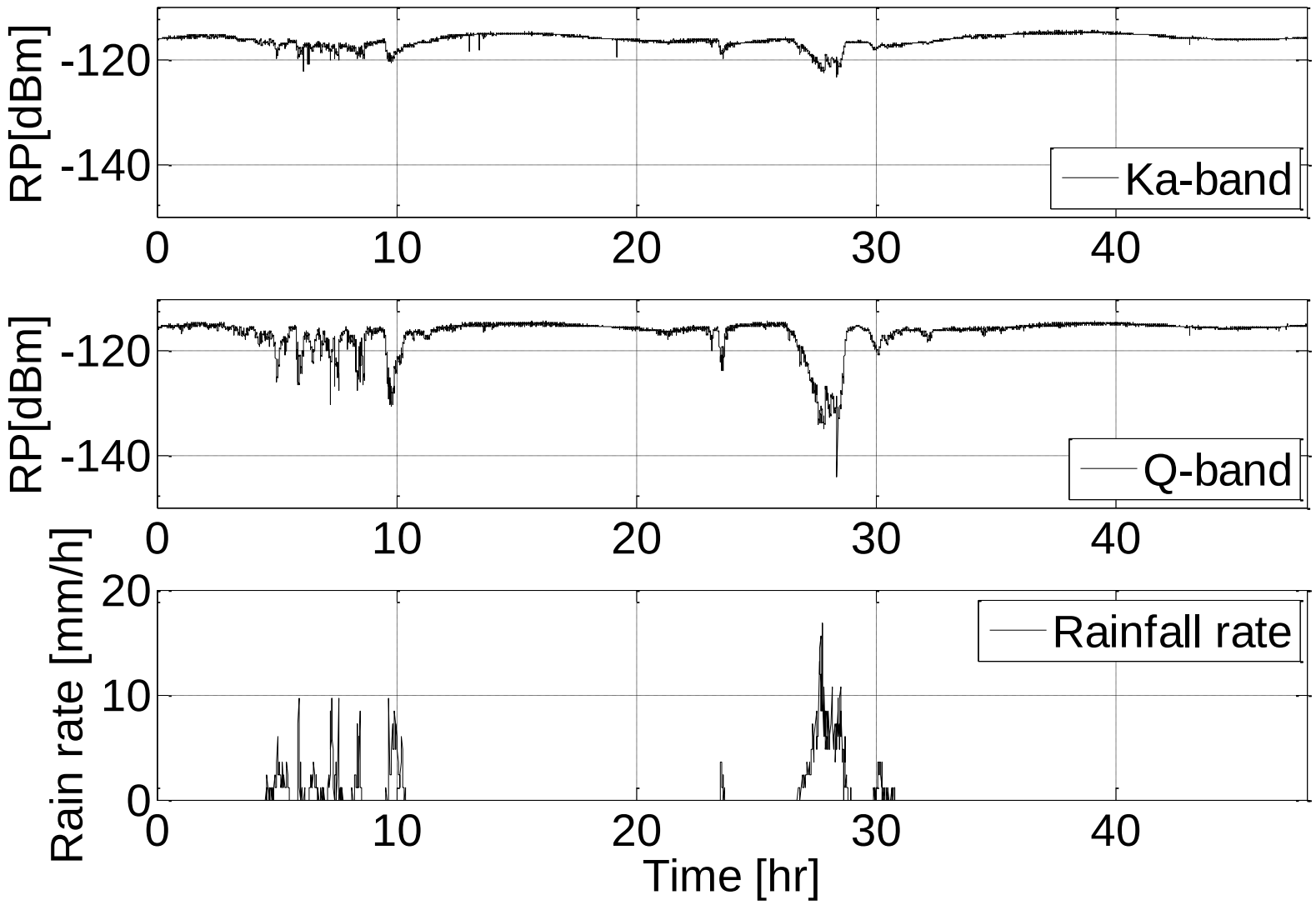
062_Meteorology_Thu_Mar_03_2016.txt

1 measurement/min

ID 6* sensor data timestamp

0713;0009;0024;0308;0567;0000;0743;1
0713;0009;0020;0243;0567;0000;0741;2
0713;0012;0020;0249;0566;0000;0741;3
.
.
.
0713;0022;0036;1005;0579;0000;0845;1438
0713;0018;0040;1022;0579;0000;0845;1439
0713;0022;0036;0020;0579;0000;0844;1440

Received power during a rainy period (20-21 August, 2014.)



Main topics / questions

- The goal of the Alphasat propagation experiment
- What is a beacon signal?
- What is the fade margin of a receiver system?
- Which meteorological parameters are usually recorded for propagation experiments?