CENTRUM BADAŃ KOSMICZNYCH
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Systemy astronomicznego satelity UVSat

(Base systems of astronomical satellite UVSat)

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UVSat mission concept

UVSat mission concept assumes observation and study of objects at shorter wavelengths than currently implemented on the BRITE satellites. The UVSat satellites would be complementary to BRITE and extend their capabilities in following aspects:

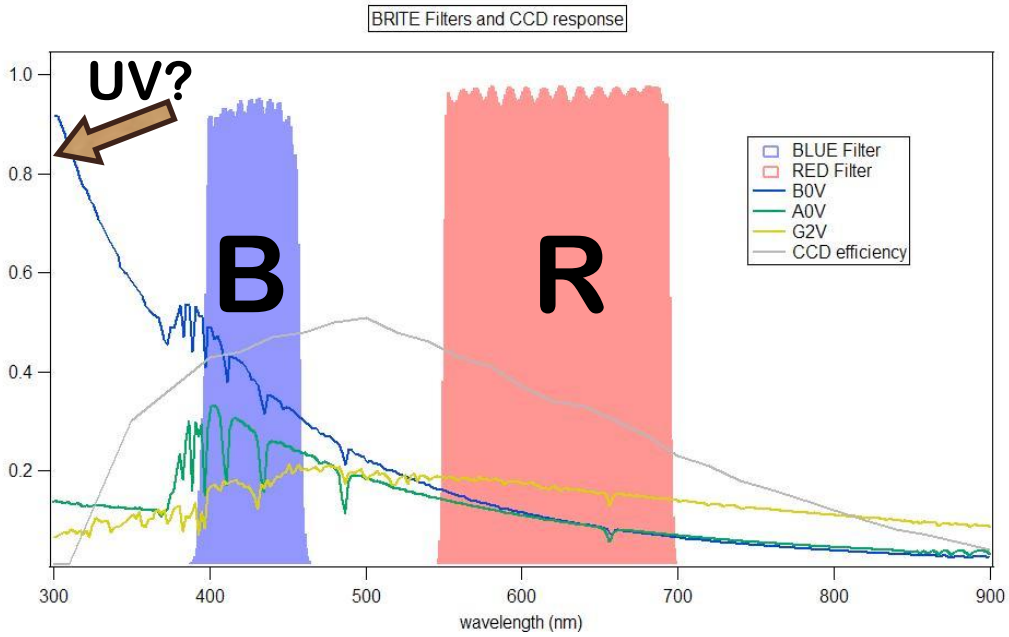
- Continuation of BRITE observations objectives (in photometric variant),
- Continuation of BRITE observations methodology (in photometric variant),
- Adding new band (UV) for observation and investigation,
- Extension of objects list and scientific problems available for investigation,
- Increase of performance and precision in relation to BRITE measurements,
- Search for a niche to be filled in a perspective of the next decade.

Astronomical tasks of UVSat

/ UV Photometry /

Wavelengths:

It is considered to study photometric variability of astronomical objects in ultraviolet (UV) and visual (Vis) bands. For UV 200-300nm band is in our main scope of interest.



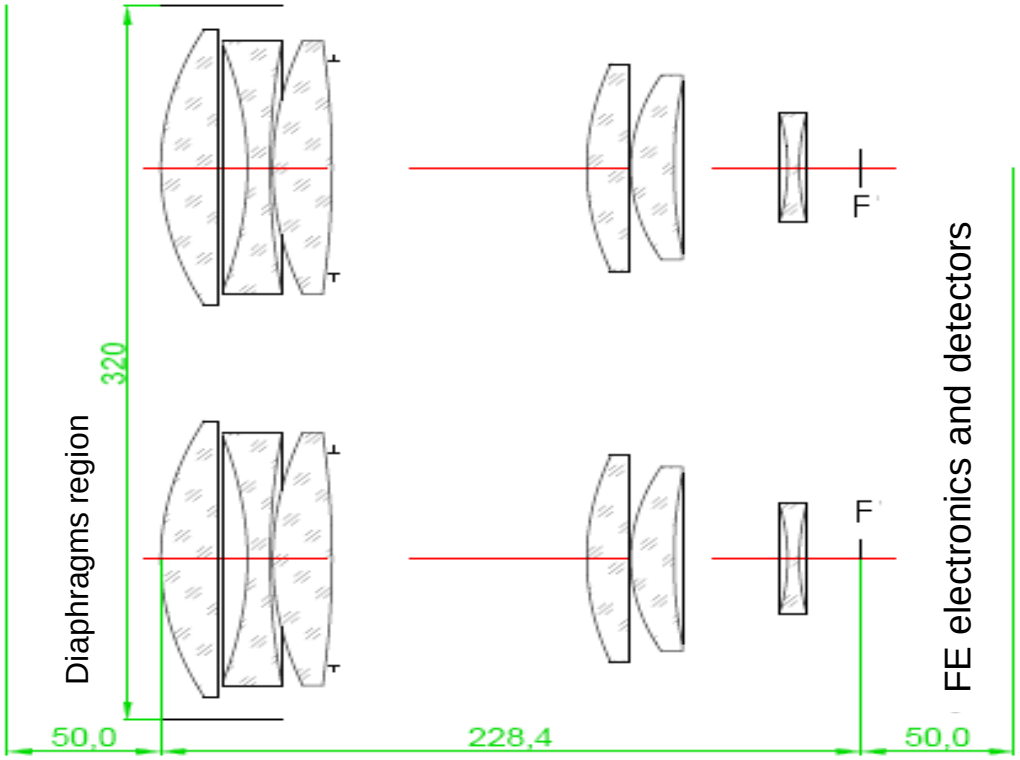
Main investigation subjects:

Hot main-sequence pulsating stars; The most massive stars: O-type stars, Wolf-Rayet stars, Luminous Blue Variables, early-type supergiants (α Cyg-type stars); Massive bina-ries: O-Type binaries, High-Mass X-ray Binaries (including Be/X-ray systems); Double Periodic Variables; Shock breakout flares in supernovae (esp. in superluminous SNe); Pulsating pre-white dwarfs, white dwarfs and subdwarfs; Variability of AGNs; Other objects and phenommena;

UVSat - payload ver.1: photometer

Concept:

The satellite hosts two telescopes with aperture of ~10cm, able to assure observation precision (per orbit) in UV band should be better than 1 mmag (S/N ≈ 1100) for an object of magnitude 11 mag in UV band and 12 mag in the Vis band.



Payload parameters:

Optics:

f=148,9 mm, Φ=100 , f/ 1,5

Payload size including detectors, electronics and baffles:

330 x 320 x 160 mm

Mass estimation: 8 kg,

Power estimation: 8W.

Astronomical tasks of UVSat

/ UV Spectroscopy /

Wavelengths:

Two bands for spectroscopy are considered: NUV 200-320nm and FUV 115–200nm.

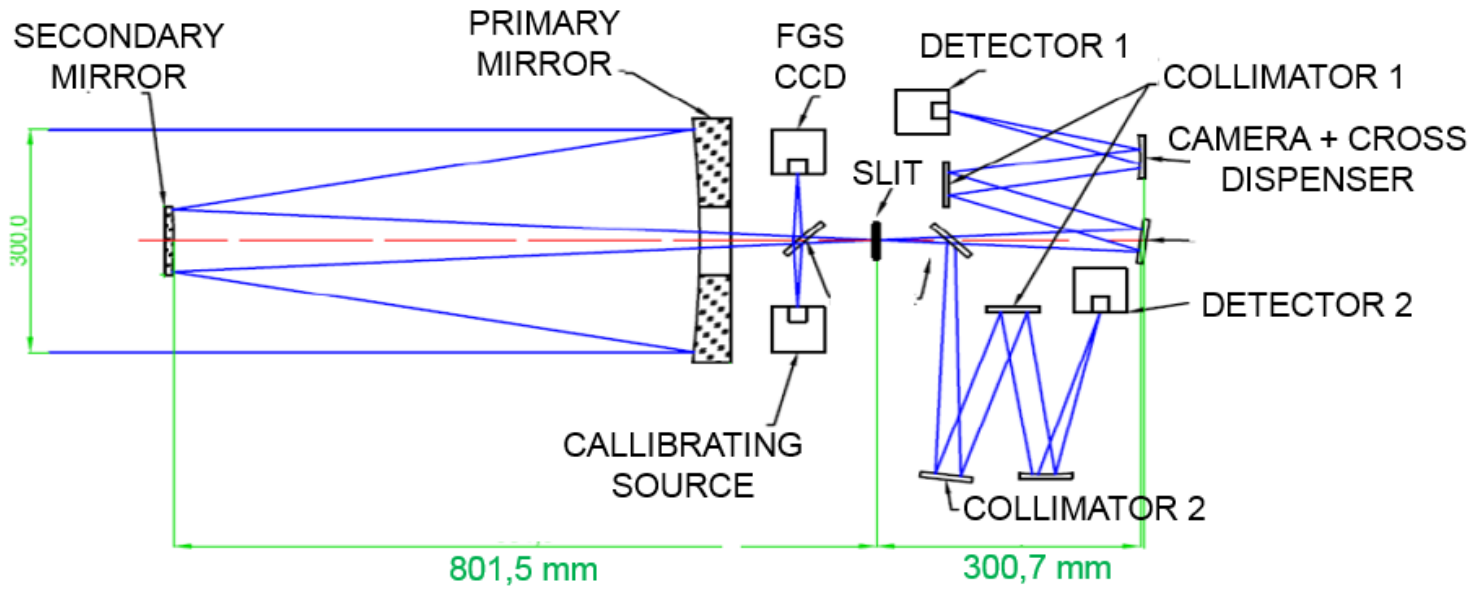
Main investigation subjects:

- Massive hot stars: winds and disks, asteroseismology;
- Double stars: hot components, mass flows, black holes, coalescence of stars;
- AGN's and comets;
- Spectroscopy of lines of active galactic nuclei: CIV λ 154.9 nm;
- Spectroscopy of emission lines and bands of comets: H, CO, OH etc.: 121.6 nm, 135-175 nm, 193 nm, 199 nm, 206 nm, 216 nm, 309 nm;
- Absorption spectra of interstellar lines: Mg I, Mg II (~ 280 nm), CO;
- Winds and flows in a wide range of objects in the lines: O VI λ 103 nm, Lyα λ 121.6 nm, CIV λ 154.9 nm, He λ 164.0 nm;

UVSat - payload ver.2: spectrometer

Concept:

30…50cm telescope aperture able to observe 7th magnitude object, at R ~ 30,000 in the NUV (200-320nm). At low resolution, R ~ 2000, objects 2 magnitudes fainter can be observed. In the FUV (115-200nm), the limits are one magnitude brighter. FoV: 20 arcmin. Spatial resolution: 1..2 arc sec, beam diameter in the spectroscope: 25 mm, optical efficiensy of optics: 0,8 and spectrograph: 0,7.



UVSat – selected properties

- LEO satellite
- Mission lifetime >3 years.
- Expected min. data rate 3GB/day,
- Availabiliy to store 10 days of acquired data (downlink capability: 4GB/day),
- At least 20% of each orbit available for observation,
- At least two observation fields per orbit,
- Orientaion stability during observation: 10 arc sec RMS for photometer and 1 arc sec RMS for spectrometer,
- Utilization of CID detectors (CID820, Thermo Fisher) for NUV (200-300nm), and Image Intensifier coupled with image sensor for FUV.

UVSat – AOCS concept

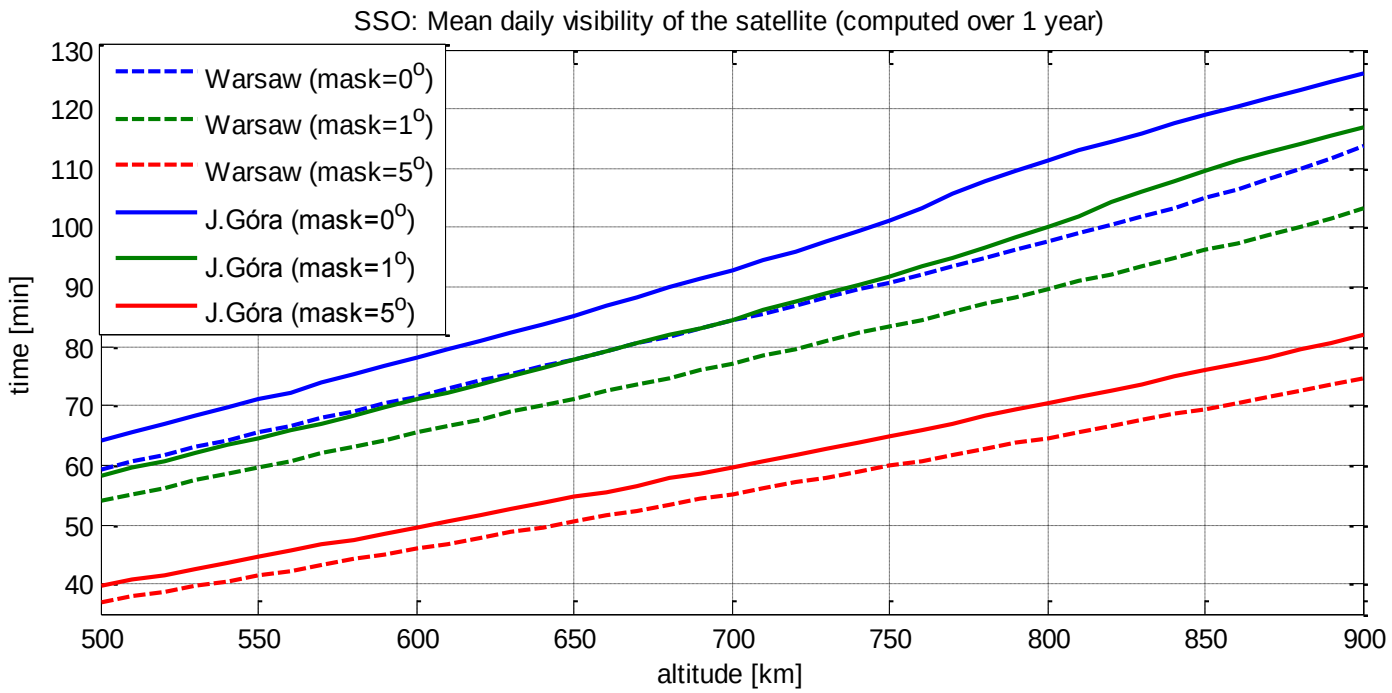
1. In photometer case precission of stabilization on level of 10 arc sec RMS can be achieved by using system similar to BRITE.
2. Precission of stabilization on level of 1 arc sec for spectrometer can be achieved if following conditions are met:
   - Error of orientation determination < 1 arcsec.
   - Time needed for determination of orientation < 1 sec.
   - Reaction wheels should be controlled with gradation <= $1e^{-6}$ Nm.
   - Compact, cubic-like shape should be imlemented to minimize impact of atmospheric drag and gravitational gradient.
   - Flexible components and large deployments shall be avoided. ‚Unknown' disturbance can be compensated if are limited its variations are less than $0.1e^{-6}$ Nm/sek.
   - Optical axis shall be paralel to one of main axes of the moment of inertia.

UVSat – AOCS concept

Component	Important parameter	Remarks
Reaction Wheels for maneuvers 10SP (SSTL) RW3-1.0 (Sinclair Interplanetary)	Max. Angular momentum 0.42 Nms 1.0 Nms	3 pcs.
Accurate RWs RW-0.01 (Sinclair Interplanetary)	Max. Angular momentum 0.01 Nms	4 pcs.
Magnetic torquers MTR-5 (SSTL) własnej produkcji (cewka bezrdzeniowa)	Max. Magnetic dipole 6.2Am^2 7Am^2	3 pcs. (coreless version preferred)
Startracker ST-16RT2 (Sinclair Interplanetary)	Accuracy 5 arcsec	Initial positionning
Fine guidance sensor system incorporated in optical path of telescope (dedicated CCD)	Accuracy < 1 arcsec	
Sun sensors SS-411 (Sinclair Interplanetary) Nano-SSOC-D60 (CubeSat Shop)	Accuracy 0.1 st 0.5 st	6 pcs.
Magnetometer NSS (CubeSat Shop) RM3100 (PNI Corp.)	Sensitivity level 6.5nT 26nT	Mounted on a boom outside the spacecraft.
Giroscope STIM210XYZ (Sensonor)	Offset stability 0.5deg/h	As a sensor to suport stabilization of orientation

UVSat – Communication

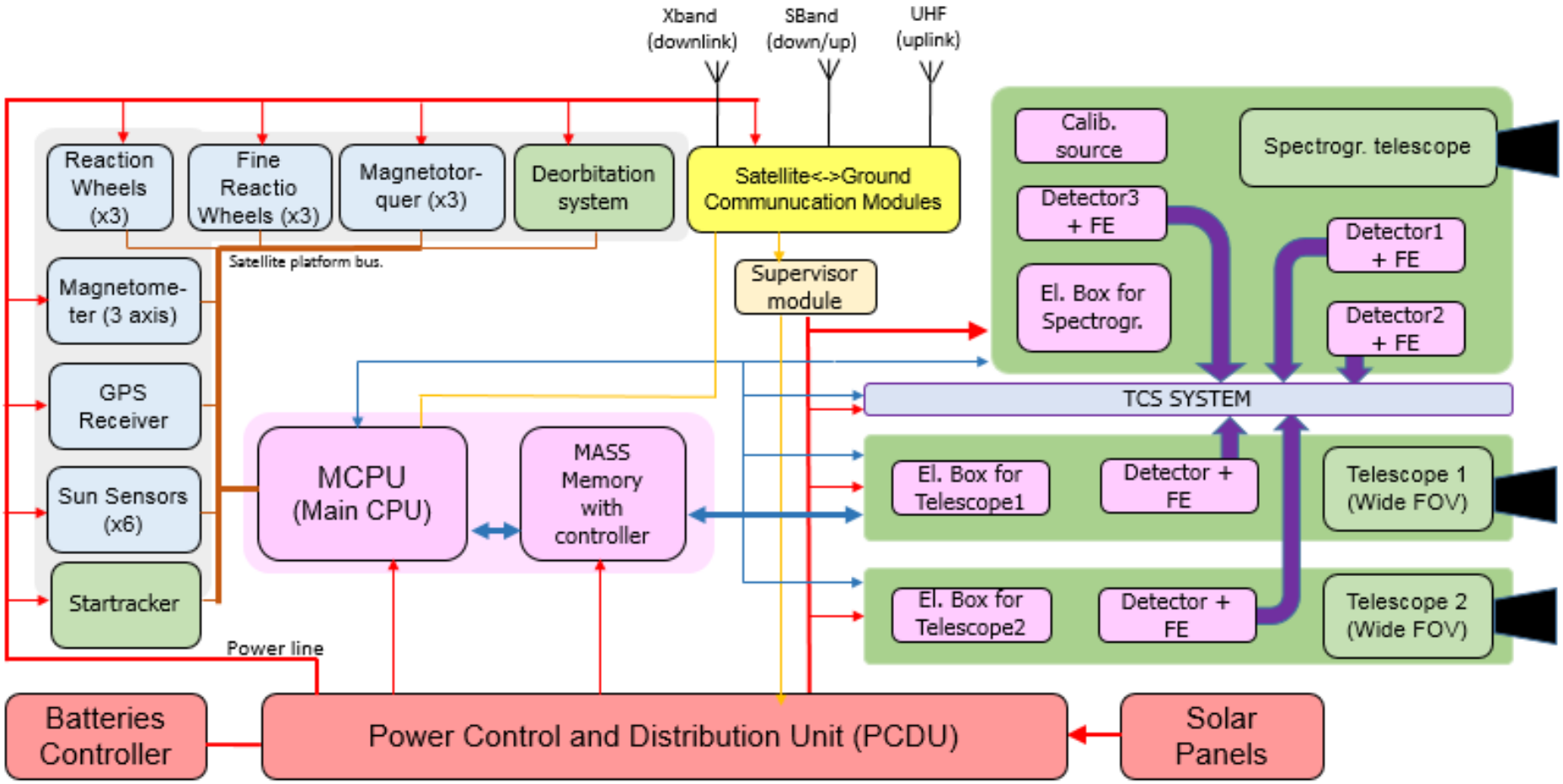
Expected rate of data generation by UVSat is ~4GB/day.



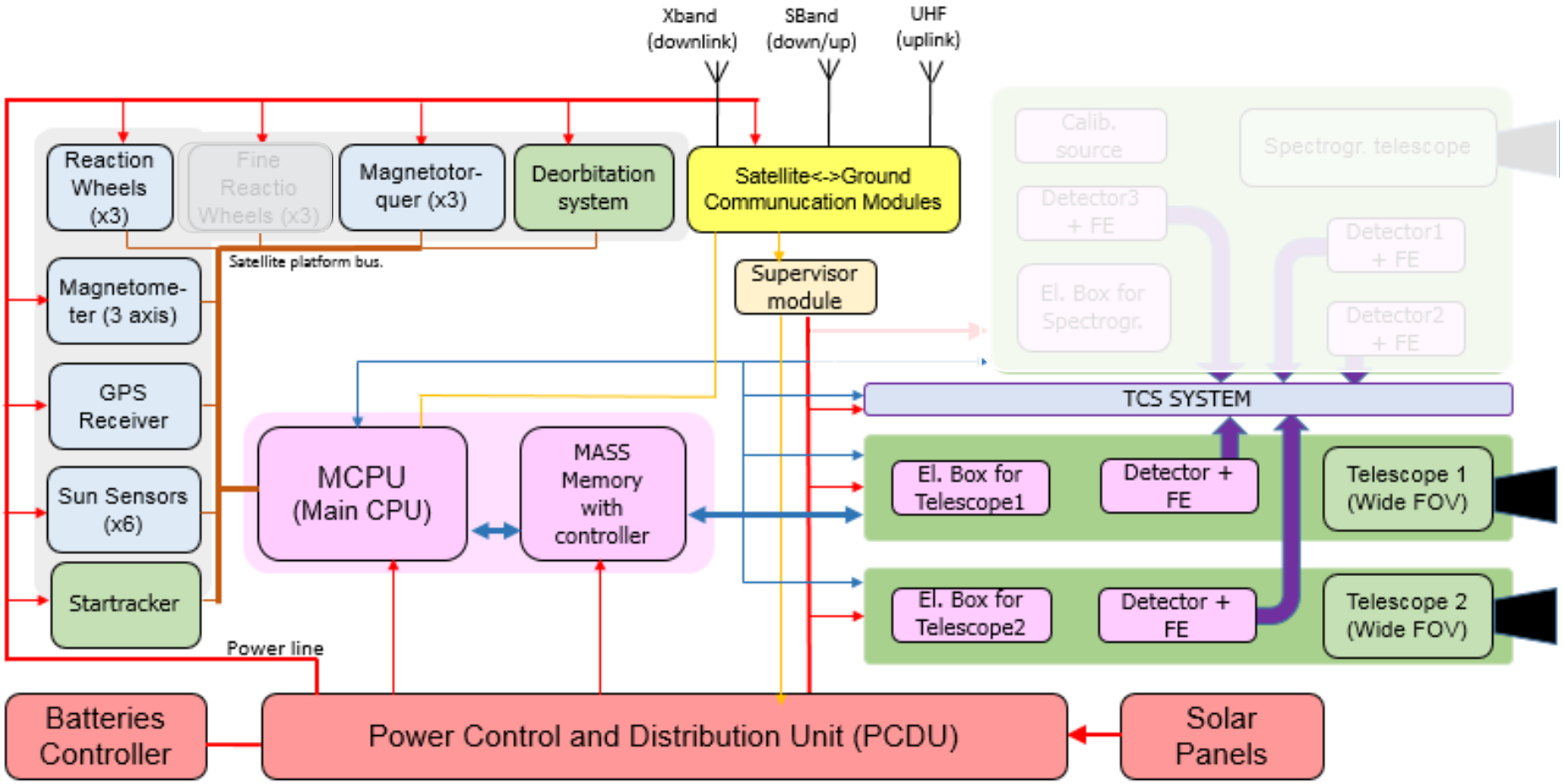
Mean summary daily time of satellite visibility in a case of SSO orbit for selected location of ground station.

Assuming ~40min/day of average communication time (550km altitude orbit, GS in Warsaw, elevation mask 5deg.) required mean transmission is: (3*1024*8)/(40*60)=14Mbps. Taking into account BRITE-PL based experience communication link capable to reach 40Mbps shall be used.

UVSat – satellite system diagram

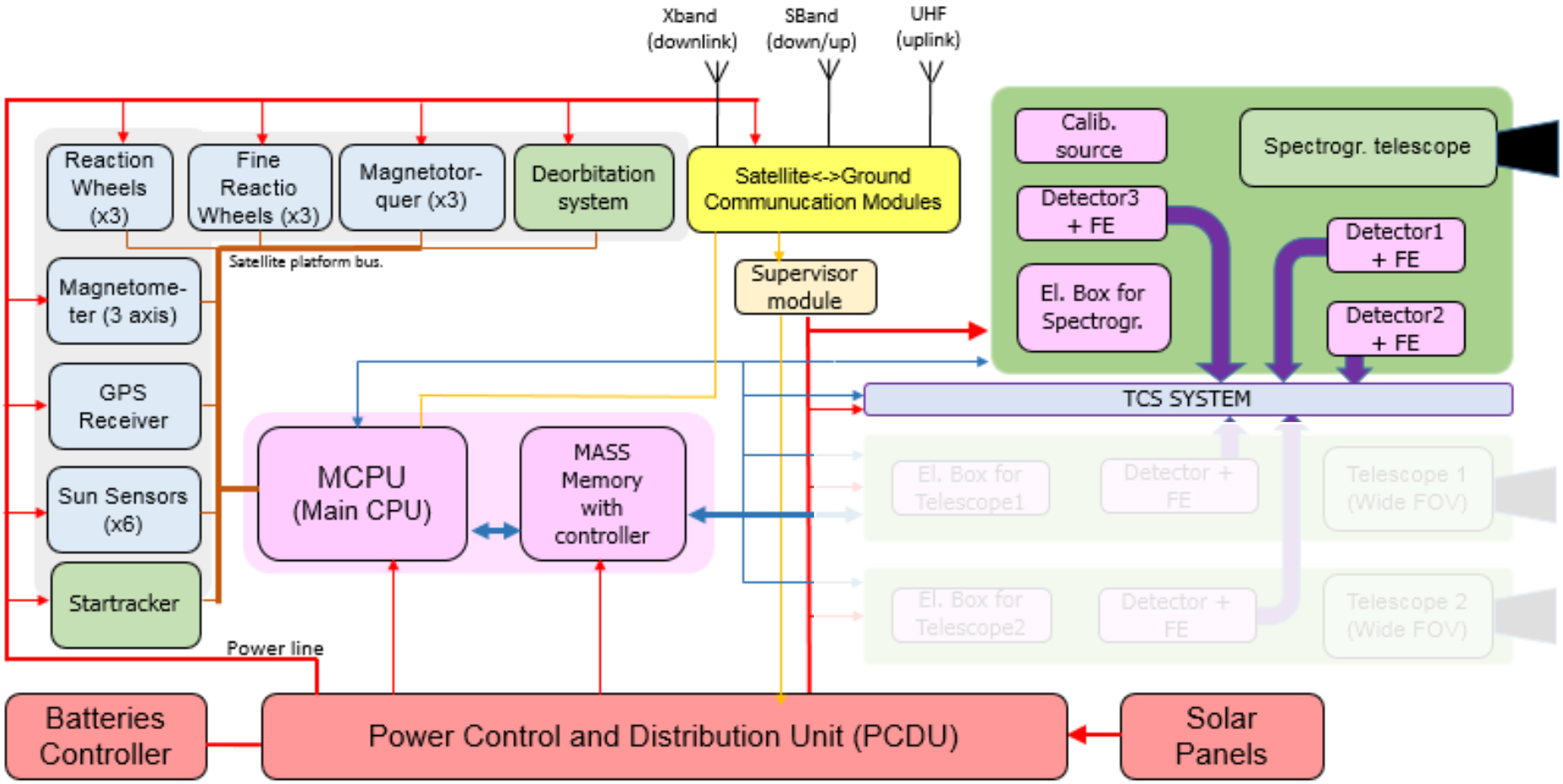


UVSat – satellite system diagram



Photometer

UVSat – satellite system diagram



Spectrometer

UVSat – photometer version

Podsystem		Element podsystemu	Masa [kg]	Moc [W]
Dla satelity fotometrycznego	Ładunek	**Podsumowanie**	**10,6**	**25**
	System komputera pokładowego	Komputer pokładowy	0,5	4
		Pamięć masowa + kontroler	2	2
		Podsumowanie - Komp. Pokł.	**2,5**	**6**
	System kontroli orientacji	Koła zamachowe manewrowe 3szt. (system z dwoma zestawami kół - TBD)	3	6
		Magnetorquers (x3)	0,5	0,5
		Magnetometer (x1)	0,1	0,5
		Sun Sensors (x6)	0,15	0,5
		Startracker	0,3	2
		GPS+antena	0,3	1
		system napędowy/deorbitujący	3	0
		Podsumowanie AOCS	**7,35**	**10,5**

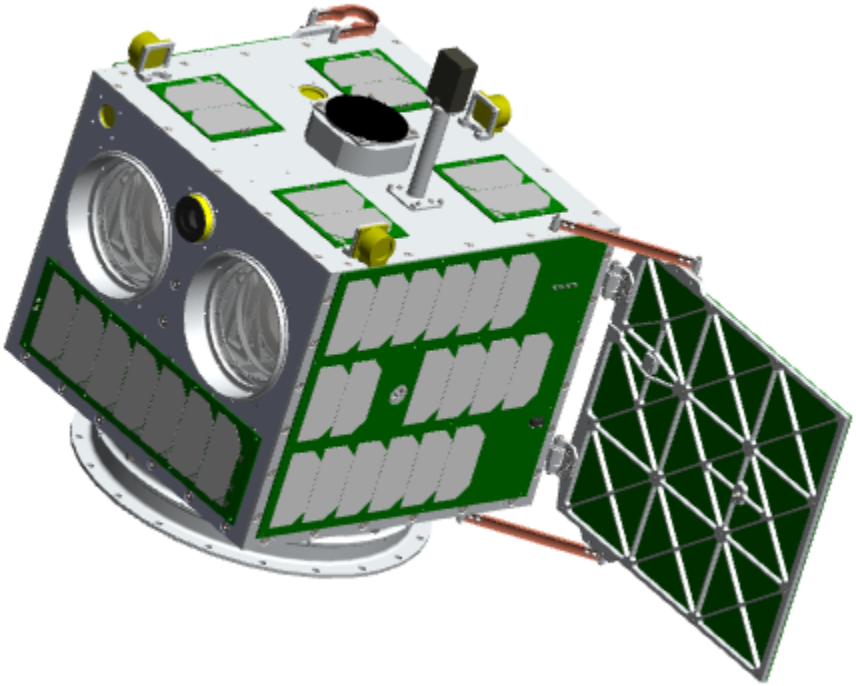
UVSat – photometer version

Podsystem		Element podsystemu	Masa [kg]	Moc [W]
Dla satelity fotometrycznego	System komunikacji	UHF Rx	0,2	1
		S-band Rx	0,3	0,5
		S-band Tx	0,4	1
		X-band Tx	0,4	1
		Podsumowanie - komunikacja	**1,3**	**3,5**
	System zasilania	BCDR	0,3	0,5
		Power Distribution	0,5	2
		Akumulatory	1	0
		ogniwa słoneczne	0,5	0
		Podsumowanie - zasilanie	**2,3**	**2,5**
	Struktura tylko fotometr	**Struktura mechaniczna**	**10**	
	podsumowanie (sat+Bus)		**32**	**45**

UVSat – photometer version

Main parameters of UVSat in photometer option.

Mass	Size	Power	Cost
32kg	40x45x45cm	45W	9.69 mln. EUR



Project of HyperSat platform, under development by Creotech company, with accomodated UVSat photometer.

UVSat – spectrometer version

Podsystem		Element podsystemu	Masa [kg]	Moc [W]
Dla satelity Spektrometrycznego	Ład. spektrometryczny	**Podsumowanie**	**64,3**	**43**
	System komputera pokładowego	Komputer pokładowy	0,5	4
		Pamięć masowa + kontroler	2	2
		Podsumowanie - Komp. Pokł.	**2,5**	**6**
	System kontroli orientacji	Koła zamach. manewrowe (3szt., duży moment)	3	6
		Koła zamach. stabilizujące (4 szt. Mały moment)	0,8	0,4
		Magnetorquers (x3)	0,5	0,5
		Magnetometer (x1)	0,1	0,5
		Sun Sensors (x6)	0,15	0,5
		Startracker	0,3	2
		GPS+antena	0,3	1
		system napędowy/deorbitujący	5	0
		Podsumowanie AOCS	**10,15**	**10,9**
	System komunikacji	UHF Rx	0,2	1
		S-band Rx	0,3	0,5
		S-band Tx	0,4	1
		X-band Tx	0,4	1
		Podsumowanie - komunikacja	**1,3**	**3,5**

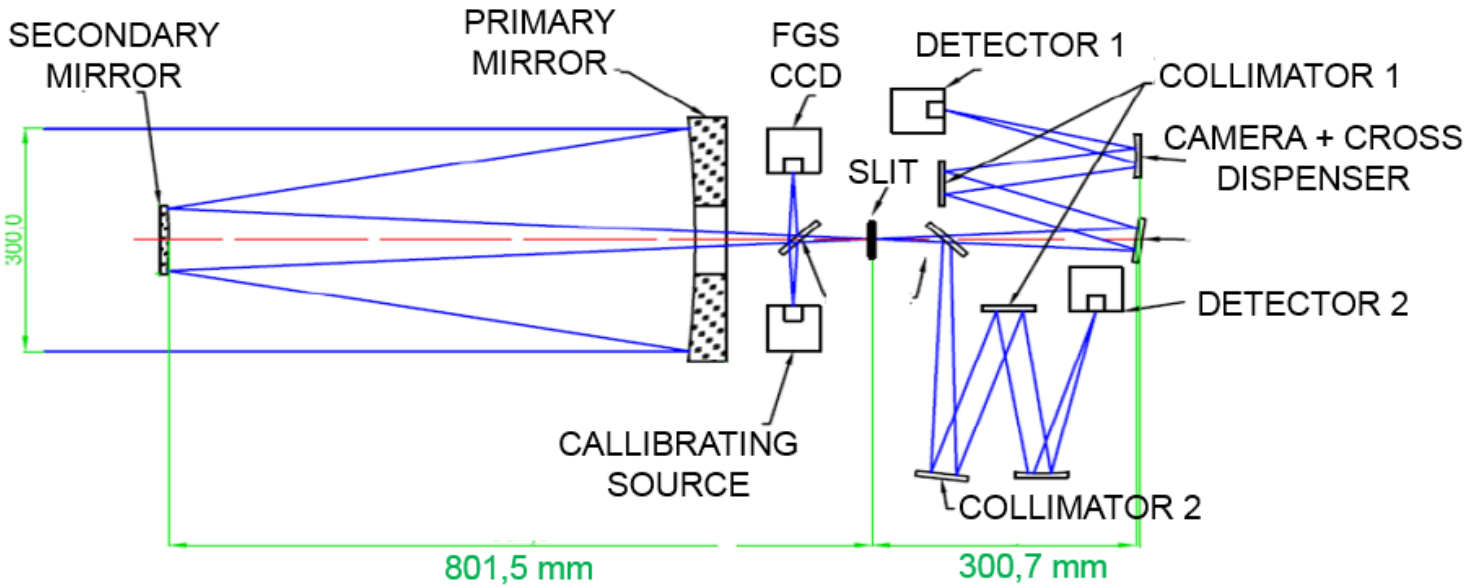
UVSat – spectrometer version

Podsystem		Element podsystemu	Masa [kg]	Moc [W]
Dla satelity Spektrometrycznego	System zasilania	BCDR	0,5	0,5
		Power Distribution	1	4
		Akumulatory	1,5	0
		ogniwa słoneczne	1	0
		Podsumowanie - zasilanie	**4**	**4,5**
	Struktura /tylko spektrometr	Struktura, mechanizmy oraz interfejs mechaniczny do rakiety	33	
	Struktura - spektrometr + fotometr	Struktura, mechanizmy oraz interfejs mechaniczny do rakiety	37	
	Podsum. /spektrometr		115	68

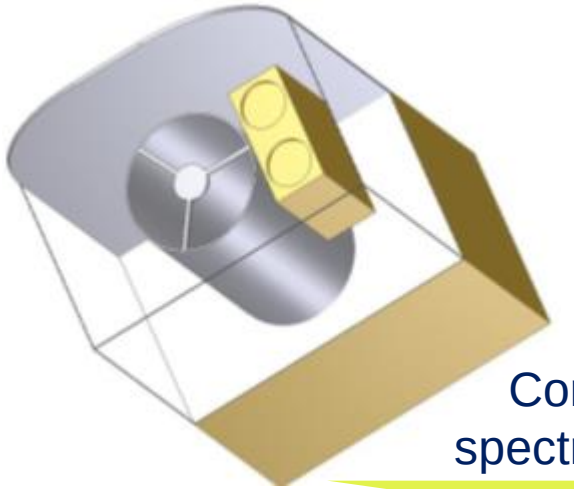
UVSat – spectrometer version

Main parameters of UVSat in spectrometer version.

Mass	Size	Power	Cost
115kg	120x80x50cm	68W	40 mln. EUR



UVSat – Mission Options



Parameters of UVSat in spectrometer + photometer variant.

Mass	Size	Power	Cost
130kg	120x80x50cm	93W	45 mln. EUR

Conceptual sketch of UVSat in spectrometer + photometer version.

One satellite with an onboard photometric (imaging) instrument;

One satellite with both instruments (photometer and spectrometer) on board.

One satellite with an onboard spectrometric instrument;

x N

Constellation ???

x K

Summary

- The concept of UV satellite has been proposed and is developing by effort of team which core derives from BRITE community in Poland.
- The UVSat concept has been analyzed already in a frame of Polish Space Agency grant (Phase 0) and its results are considered in following space-related activities dedicated for both subsystems and system level projects.
- It is still under investigation which configuration of satellite(s) would be the most suitable and feasible for realization.
- The UVSat concept has been submitted to Polish Roadmap for Research Infrastructure list.
- There are several projects, currently ongoing in Poland, which cover selected aspects of UVSat project or might be utilized in a frame of this initiative (e.g. satellite platform, OBC). Costs of these projects could be considered as a part of UVSat budgets.