Analysis of the Impact of Deployable Structures on LitSat-1 Passive Attitude Control

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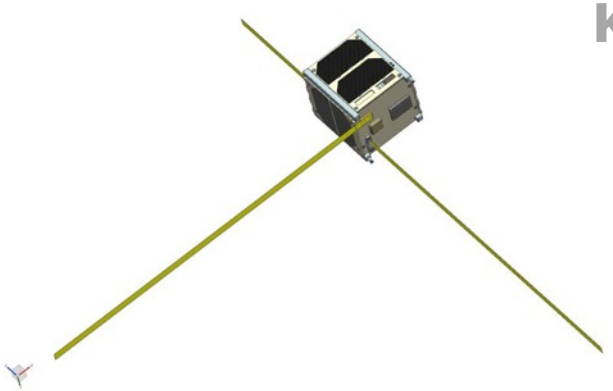
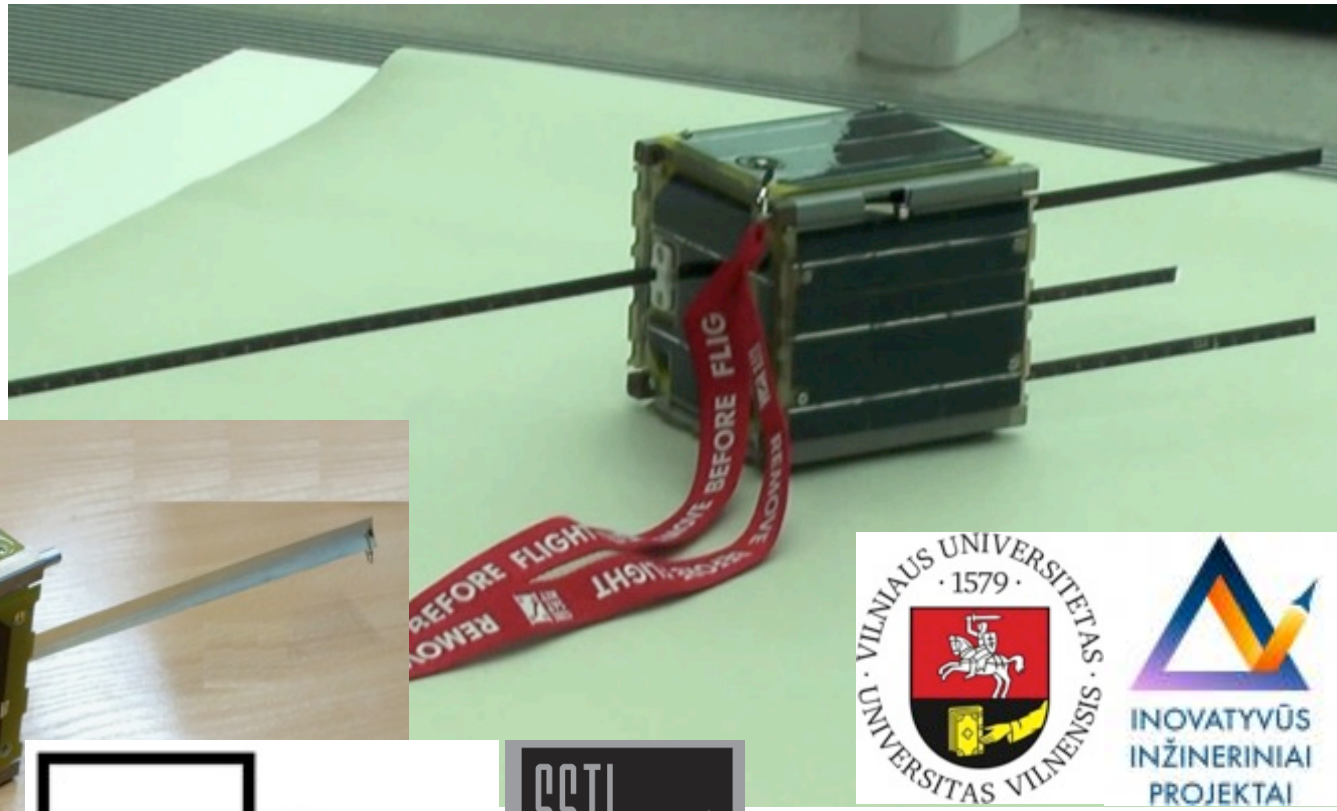
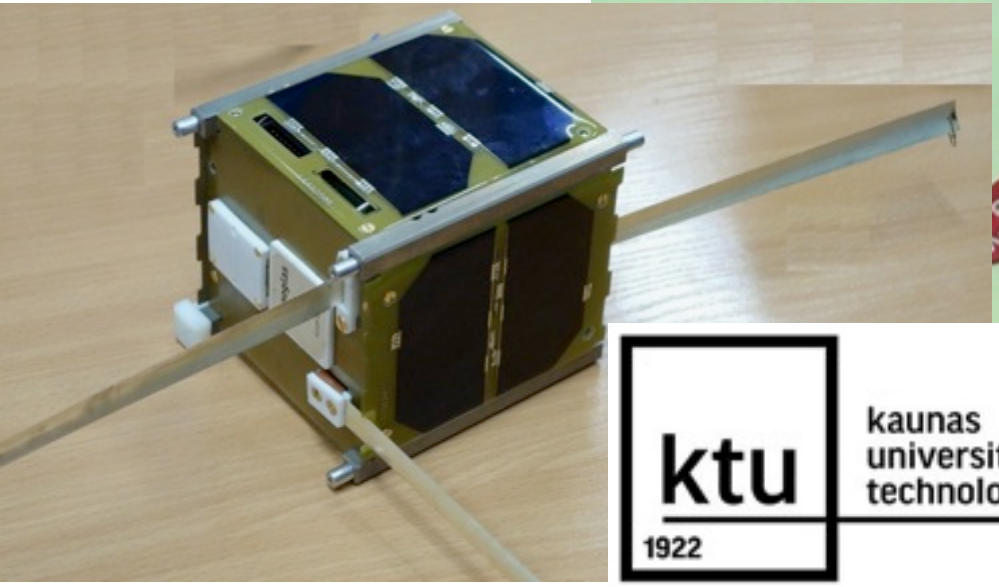
Tartu, 23th of September 2014



LituanicaSat 1 and Litsat1





Main Components

Litsat-1

- **V/U** Linear transponder
- Space qualified GPS receiver
- GaAs and LT Silicon Solar panels
- Solar sensors
- **V/U** Comm board He-100

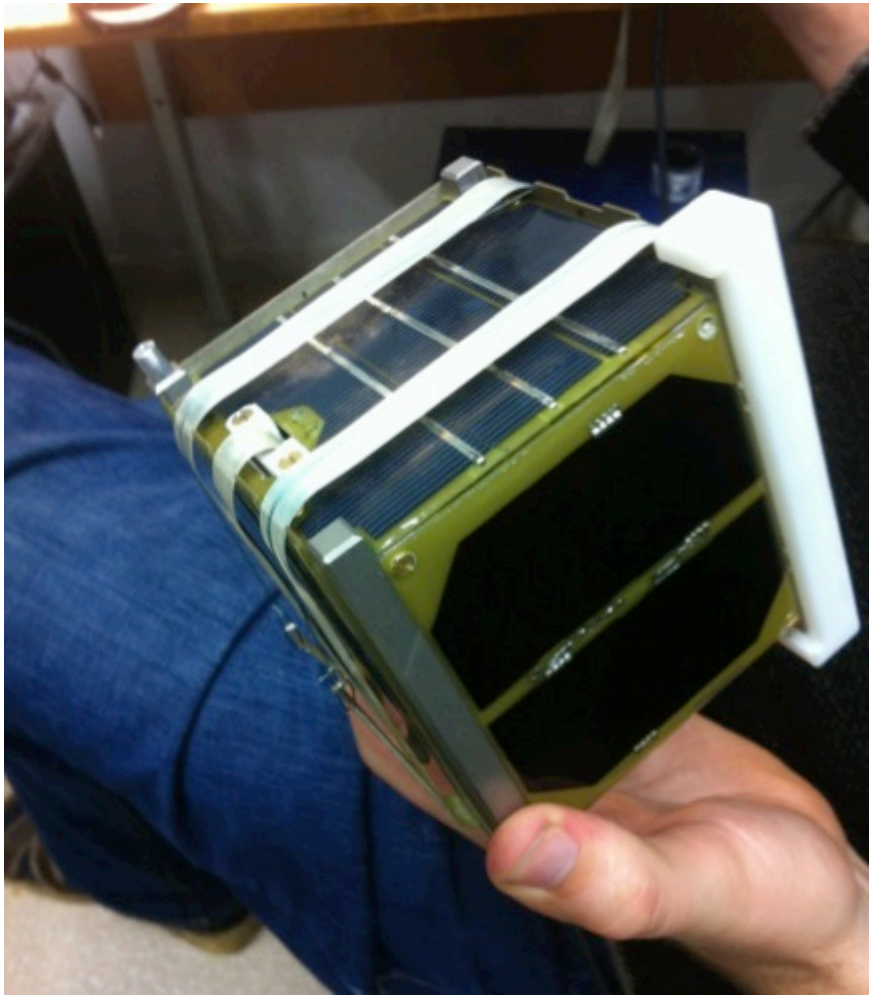
LituanicaSat-1

- **U/V** FM repeater
- Arduino board with Camera
- Radio beacon
- LT Silicon Solar panels
- **U/V** Comm board He-100

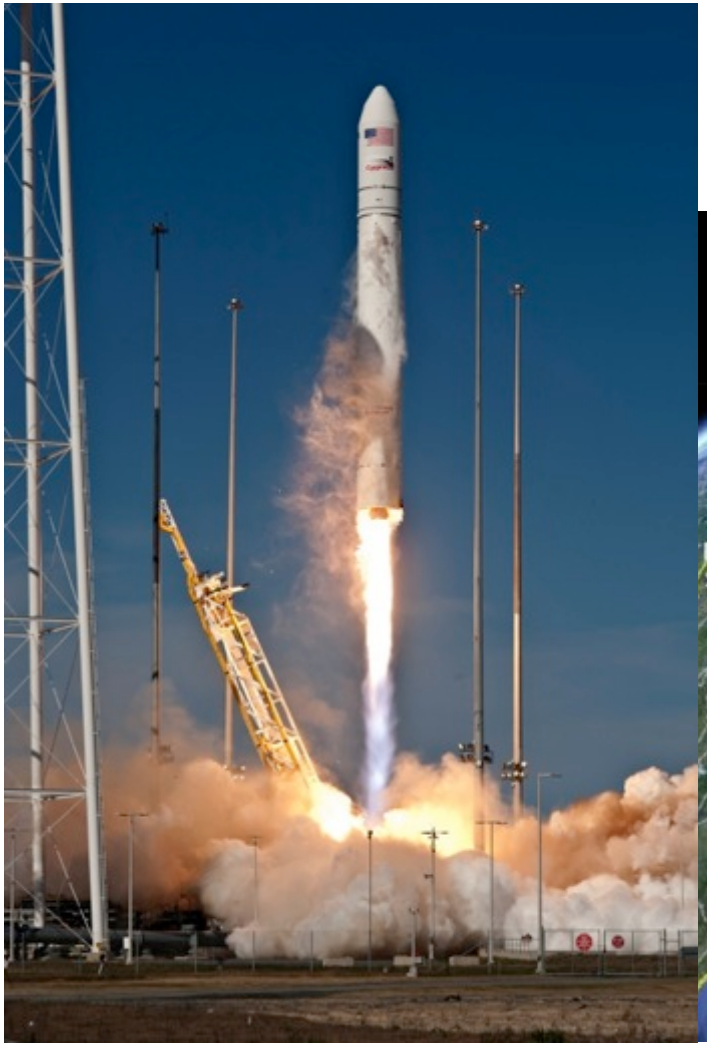
1U CUBESAT Platform (common)

- ARM 7 Cortex M4 On board processor
- 3x Gyro, 3x Accel., 3xMagnetom.
- Gomspace Power Supply
- System board

Satellite Design

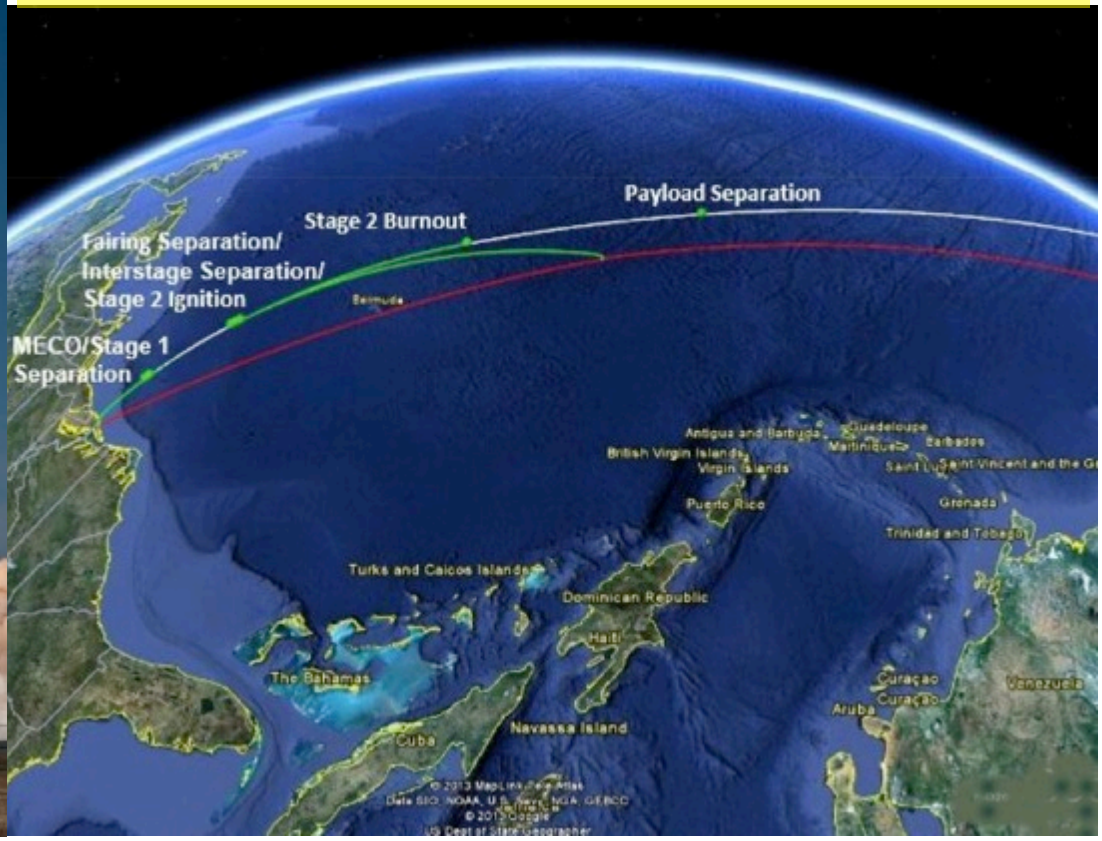


Start of the Journey

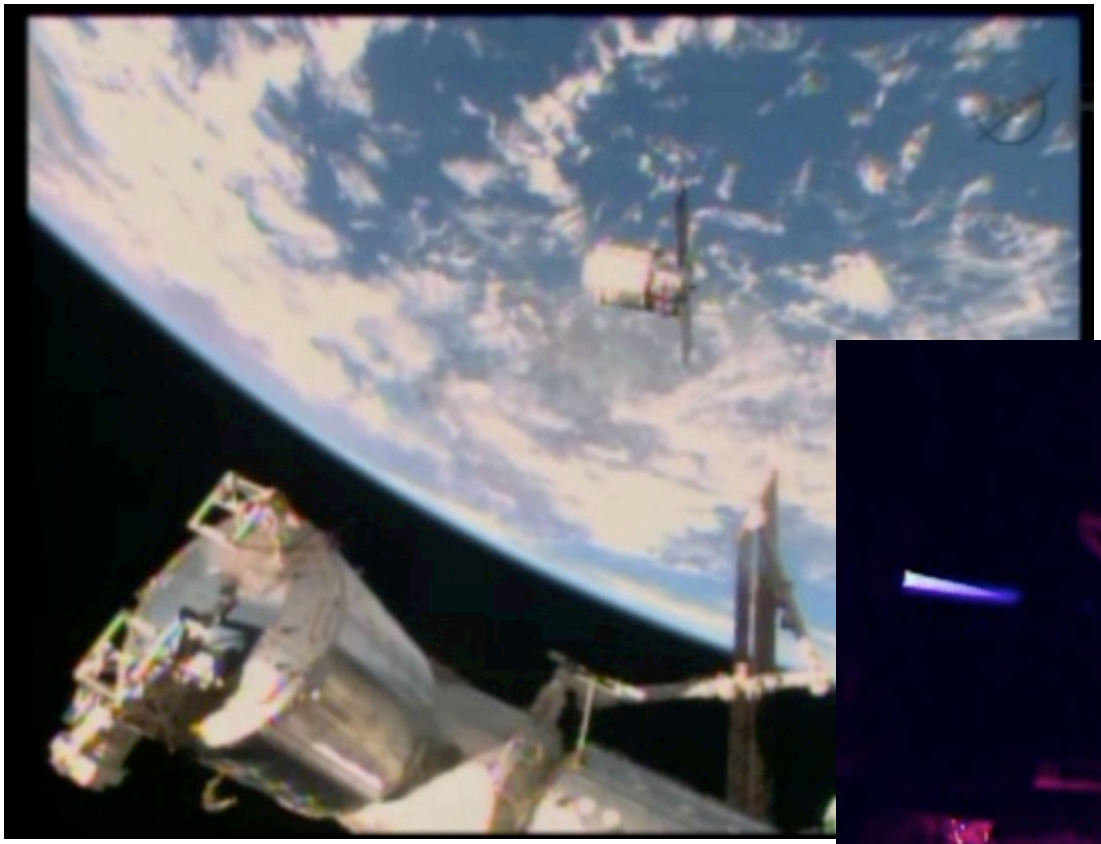


Launch from: NASA Flight Facility
Wallops Island, VA, USA

At Jan 9 2014 8:30 pm Lithuanian time



Docking on the Space Station
12-th of Jan 2014



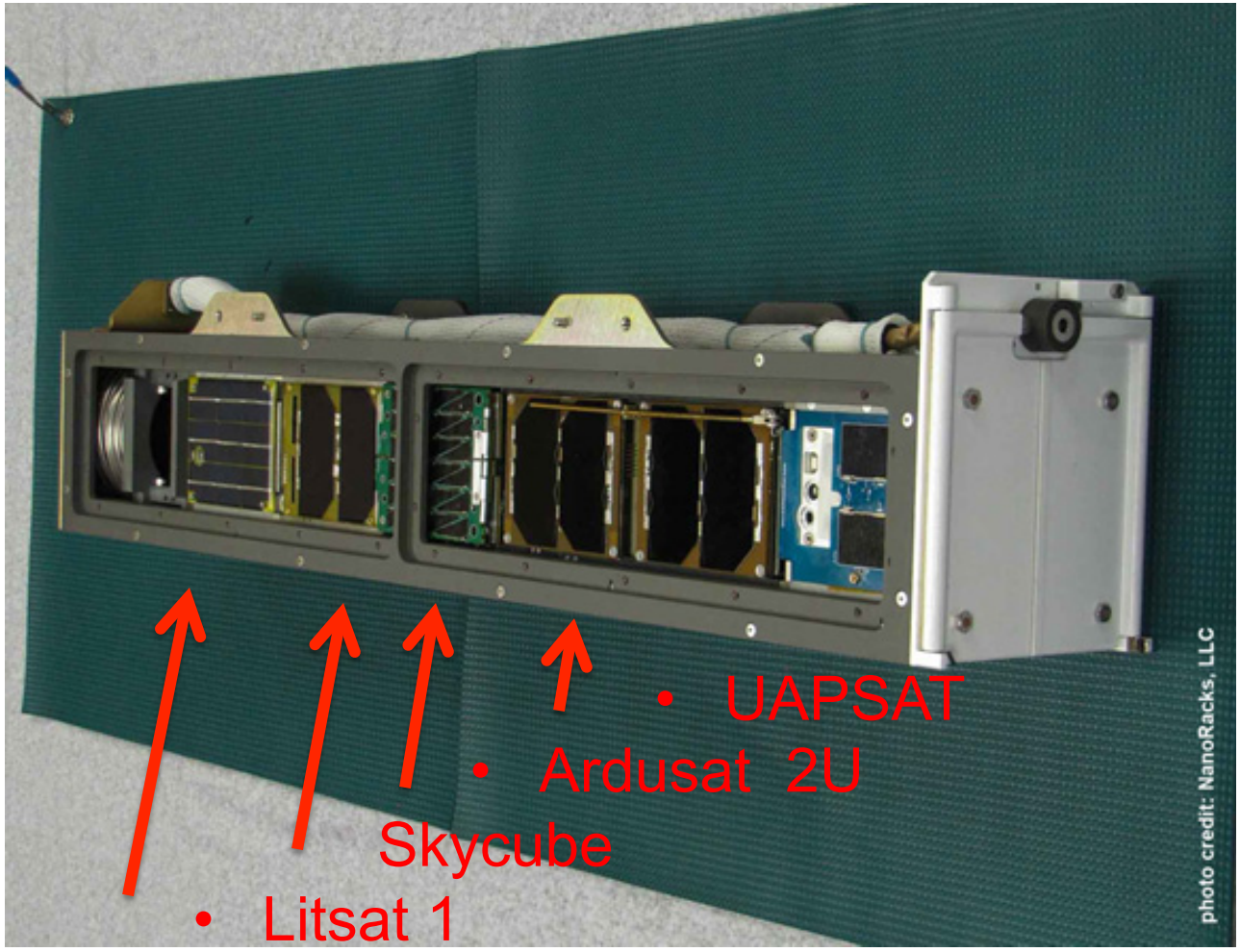
Launching into the Orbit

Launch into the orbit from Japanese Kibo module at 28-th of February 2014

Astronaut Koichi Wakata, JAXA

Ground Control Station in Liepiskes and Kaunas TU

Launcher Bay of Nanoracks LLC

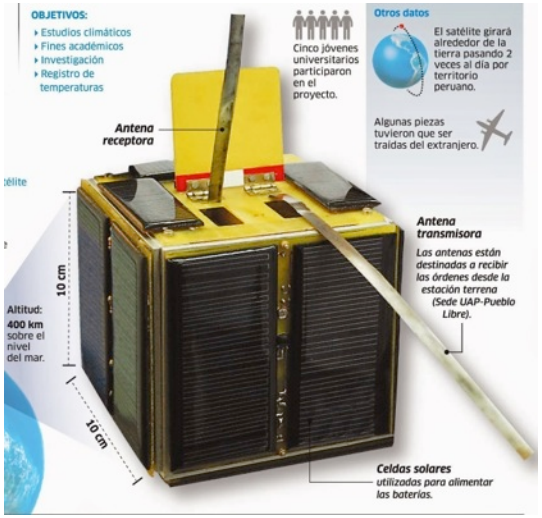


- LituanicaSat 1

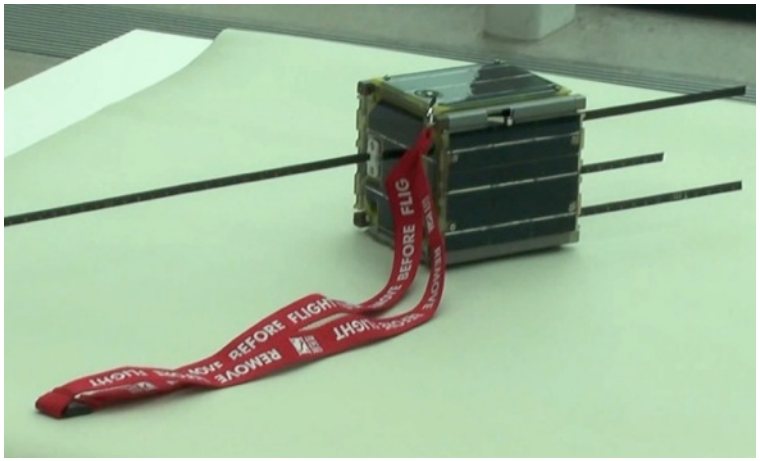
Actual Decays

- UAPSAT – Decay May 21
- Litsat 1– Decay May 23
- Ardusat 2 – Decay Jul 1
- LituanicaSat 1 – Decay Jul 28
- Skycube – Sep 22 – still at 330 km altitude

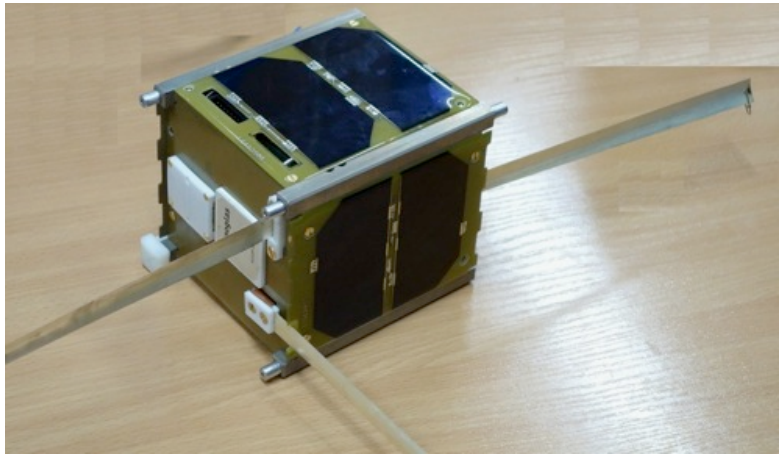
Configuration 1U



UAPSAT

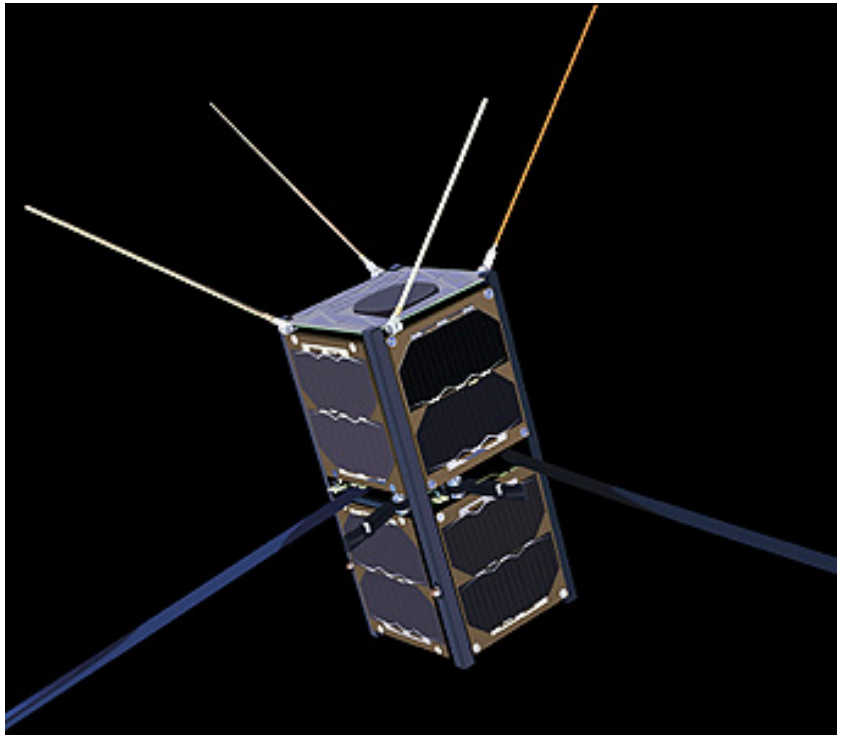


LituanicaSat 1

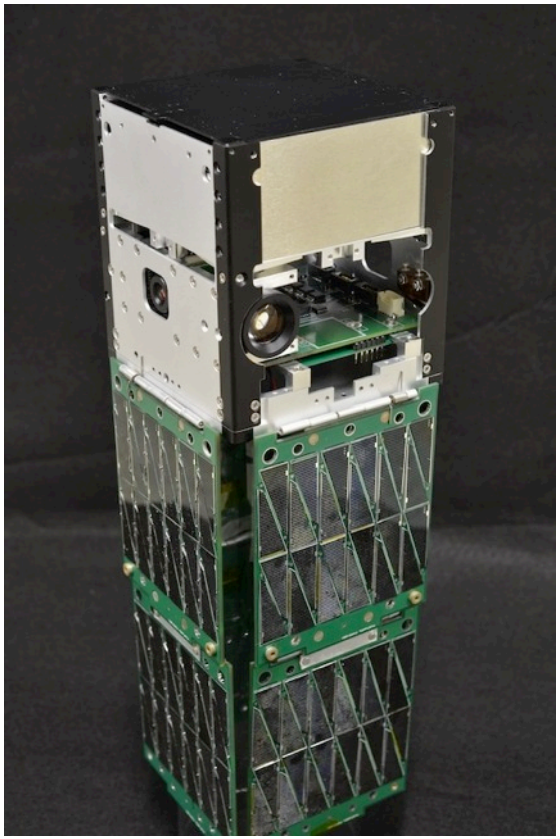


Litsat 1

Configuration 2U

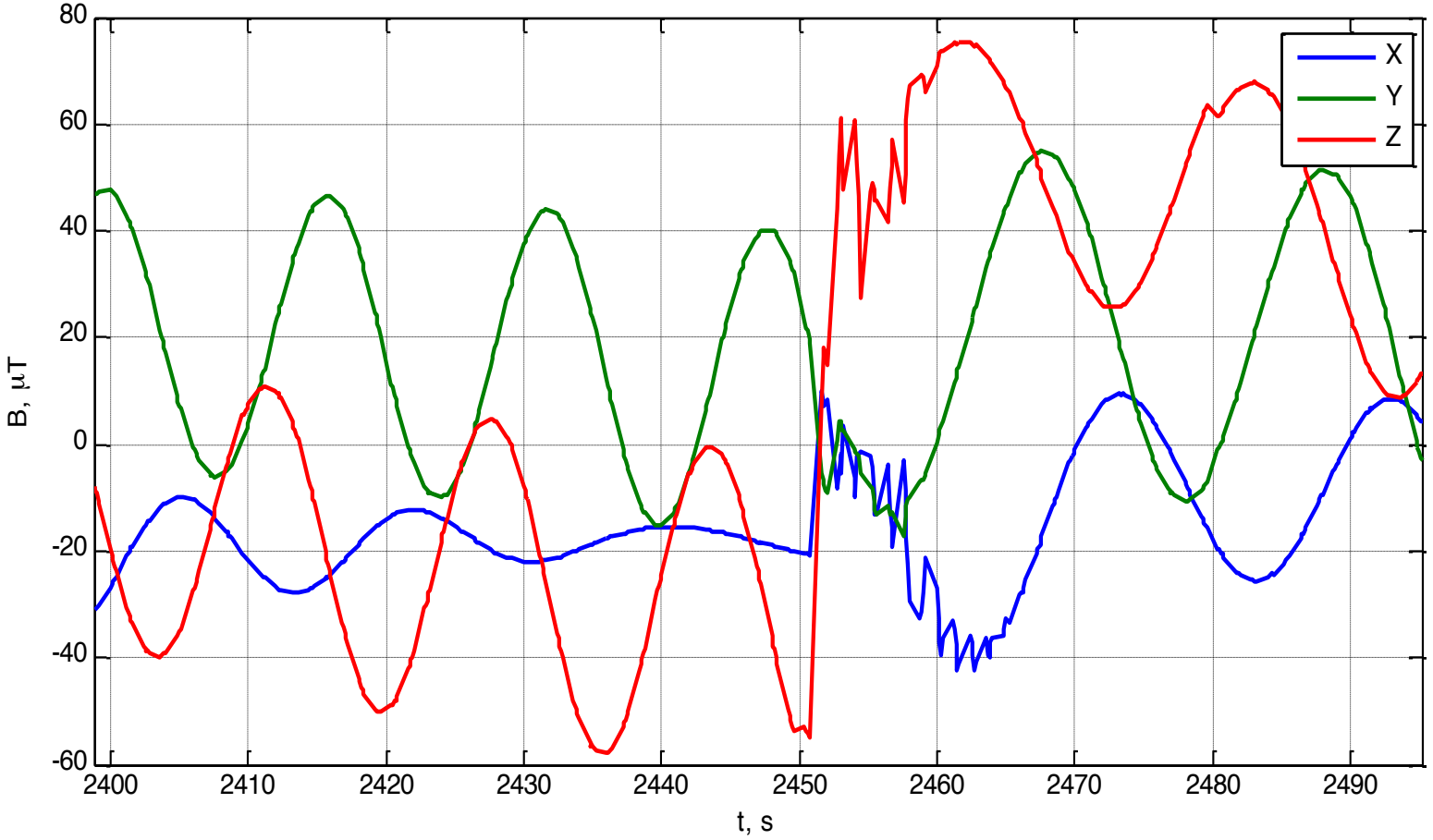


Ardusat



Skycube

Magnetic sensor Data



Magnetometer signals (X,Y,Z) during antenna deployment (~2450 s)

Photo sensor data

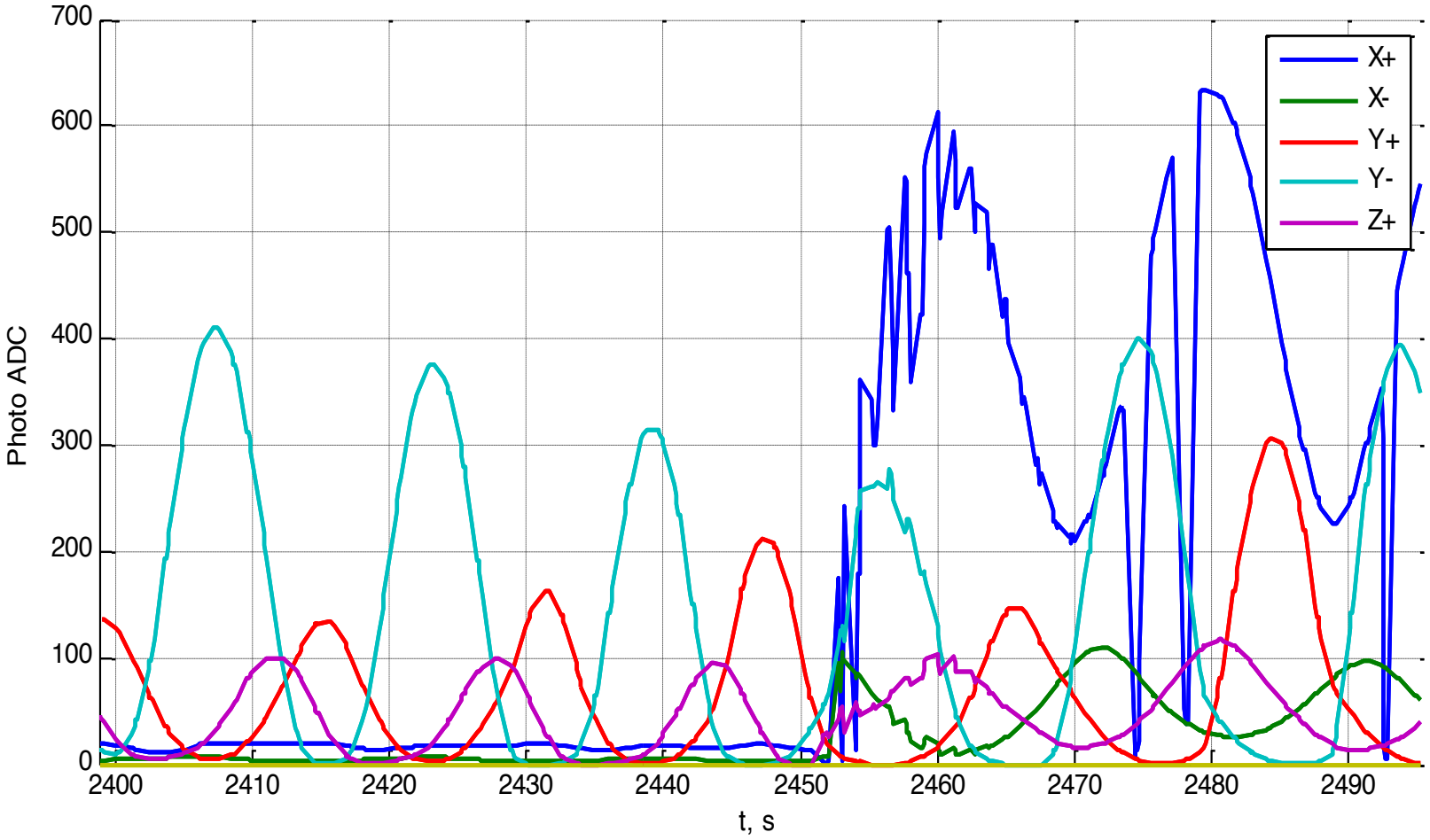
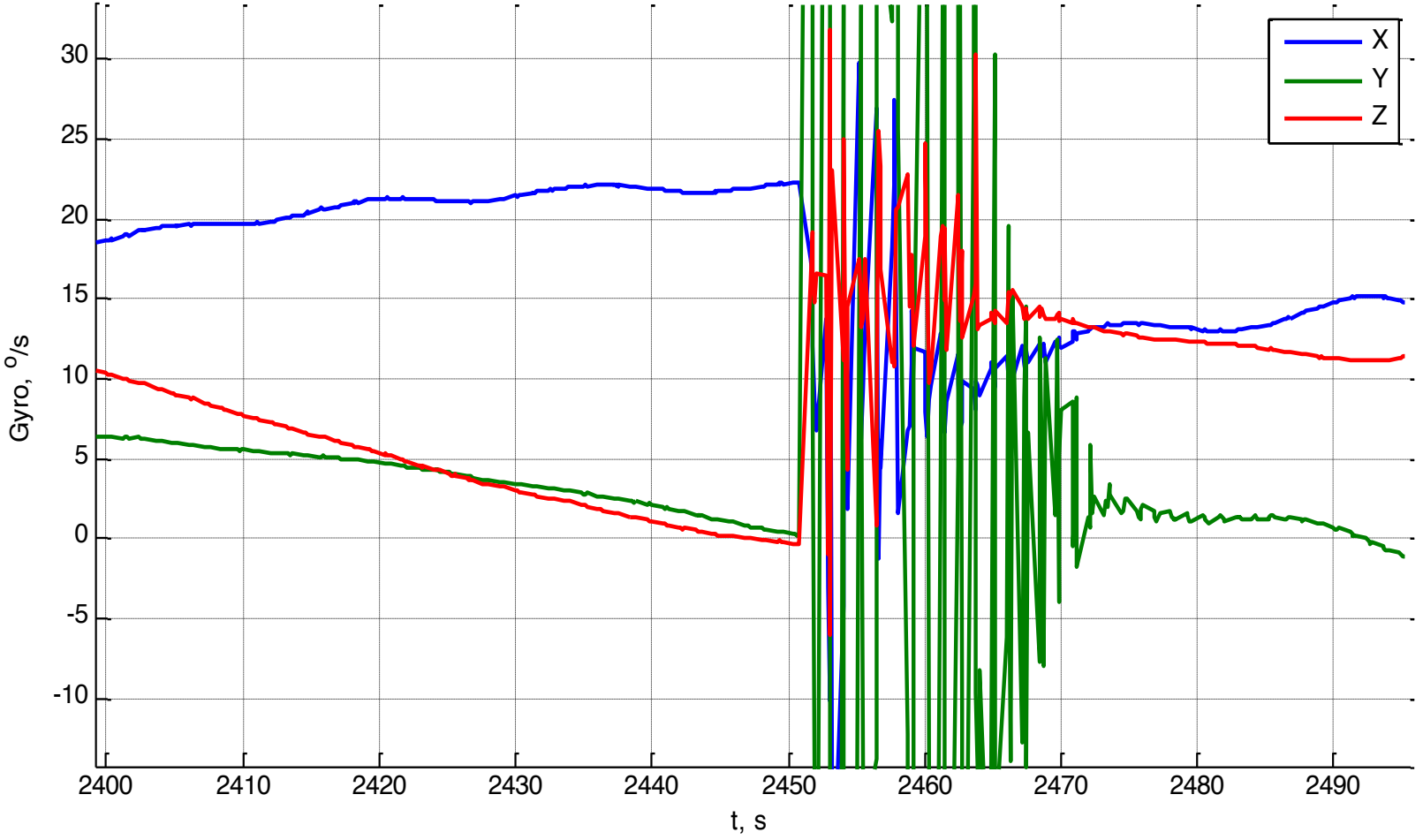


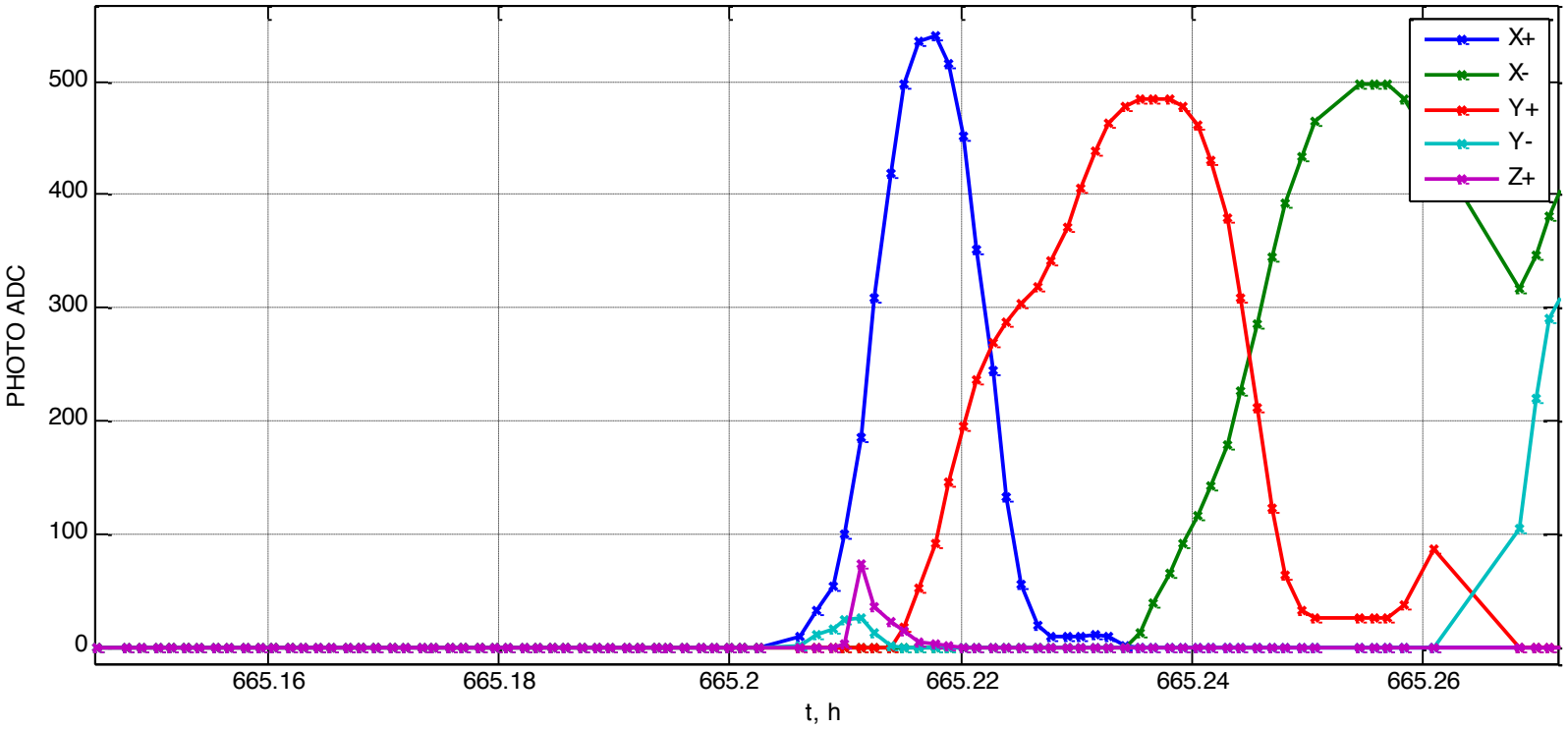
Photo sensor data (X,Y,Z) during antenna deployment (~2450 s)

Gyro data

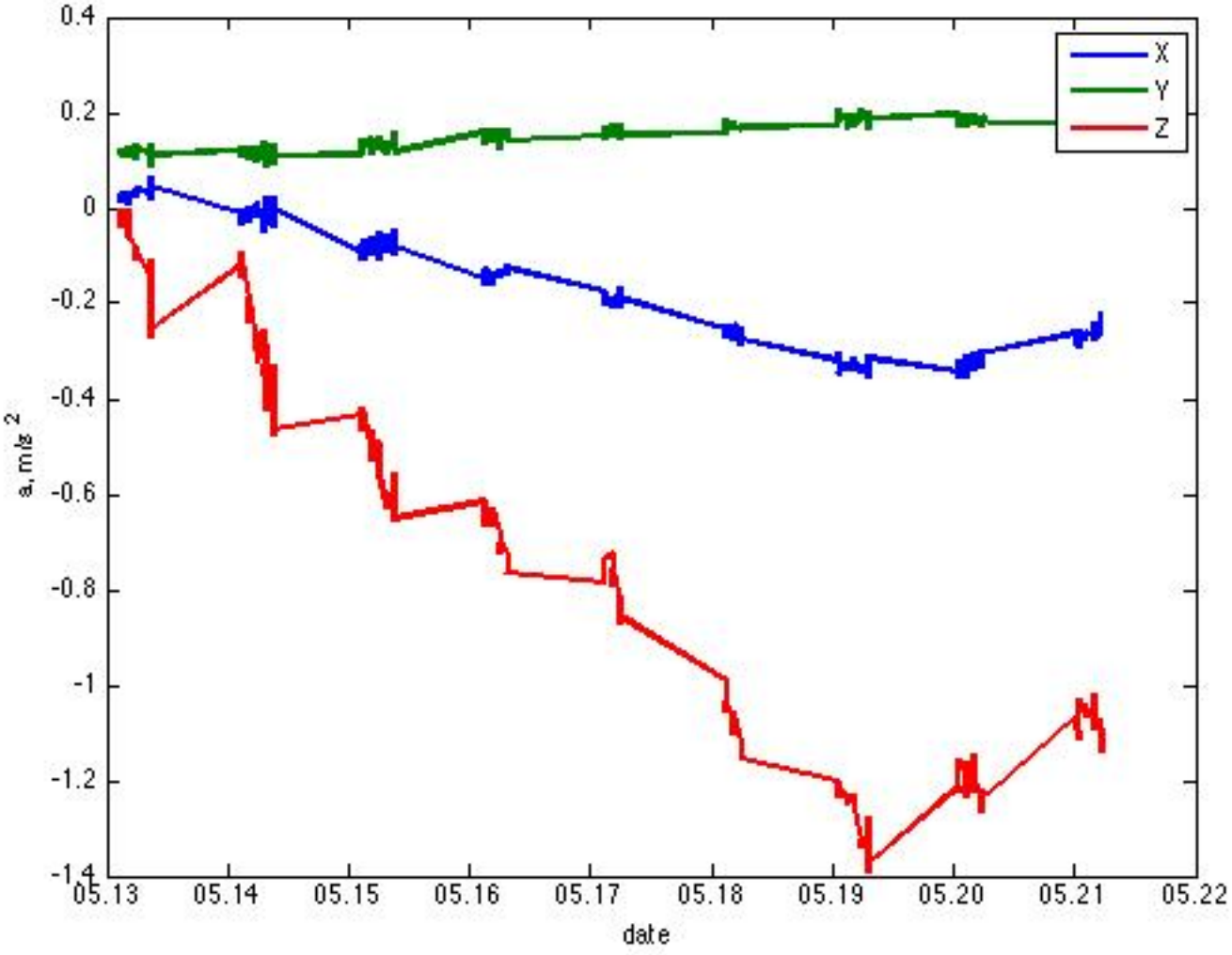


Gyro data (X,Y,Z) during antenna deployment (~2450 s)

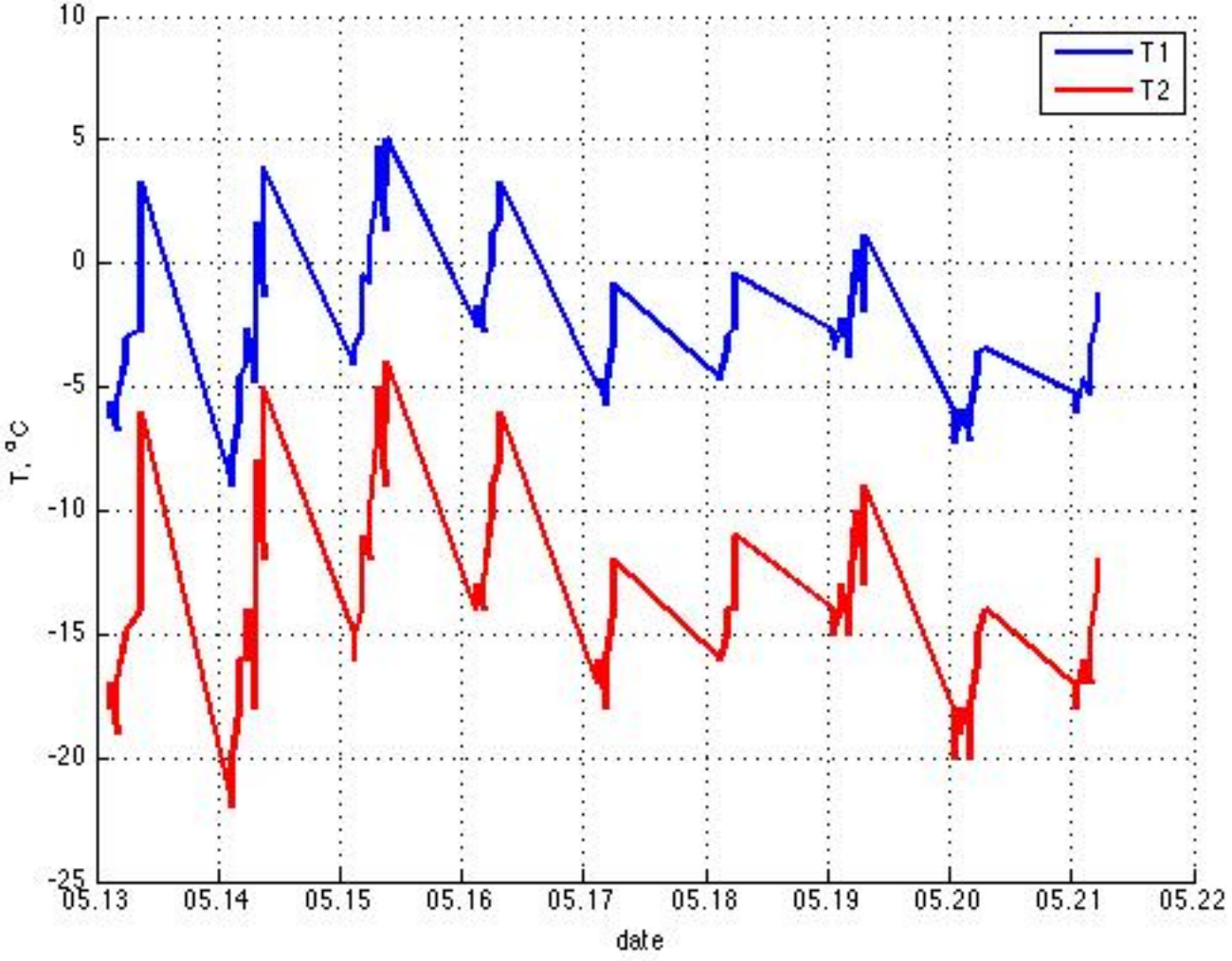
Photo sensor data (Sunrise)



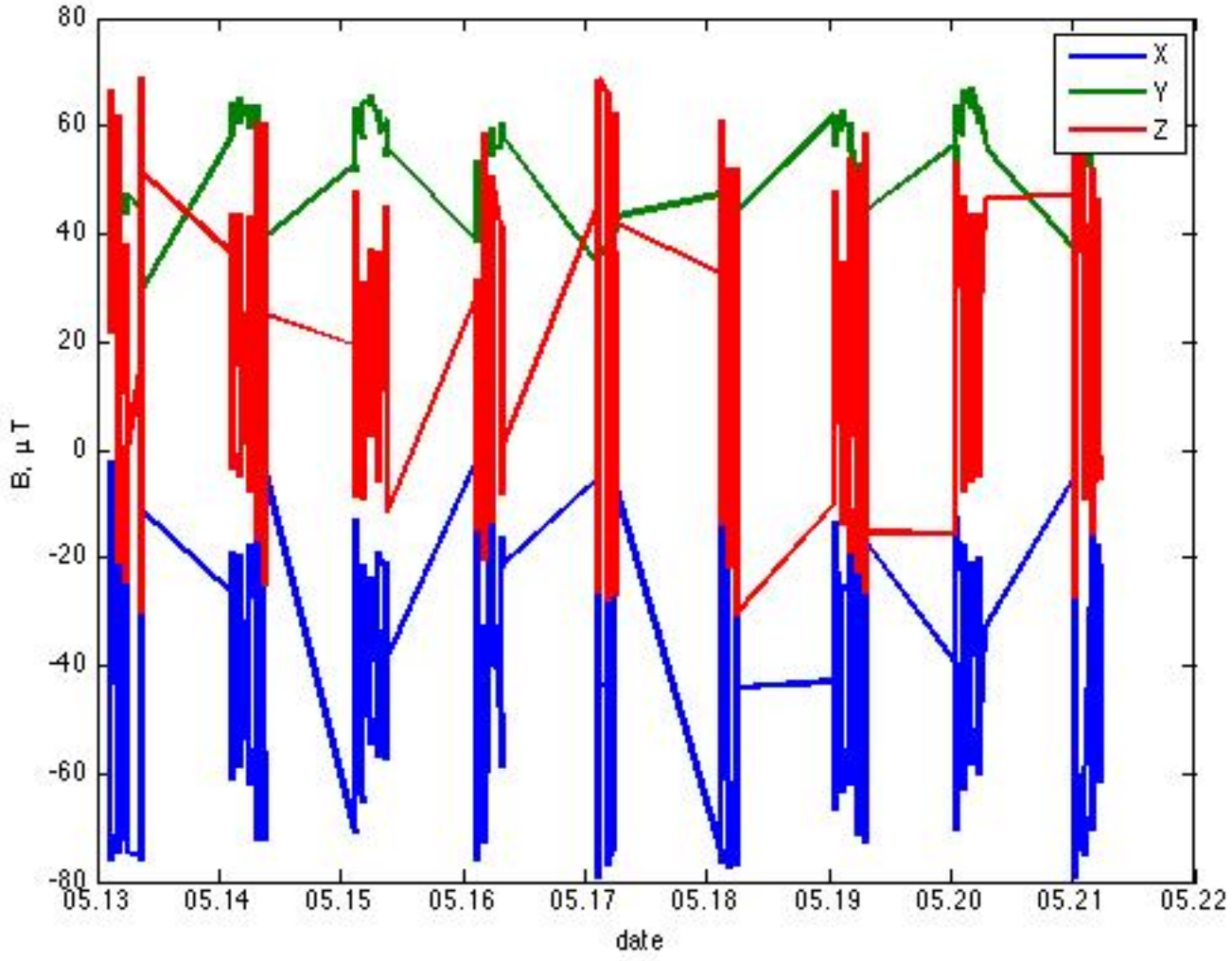
Accelerometer data May 13-22, 2014



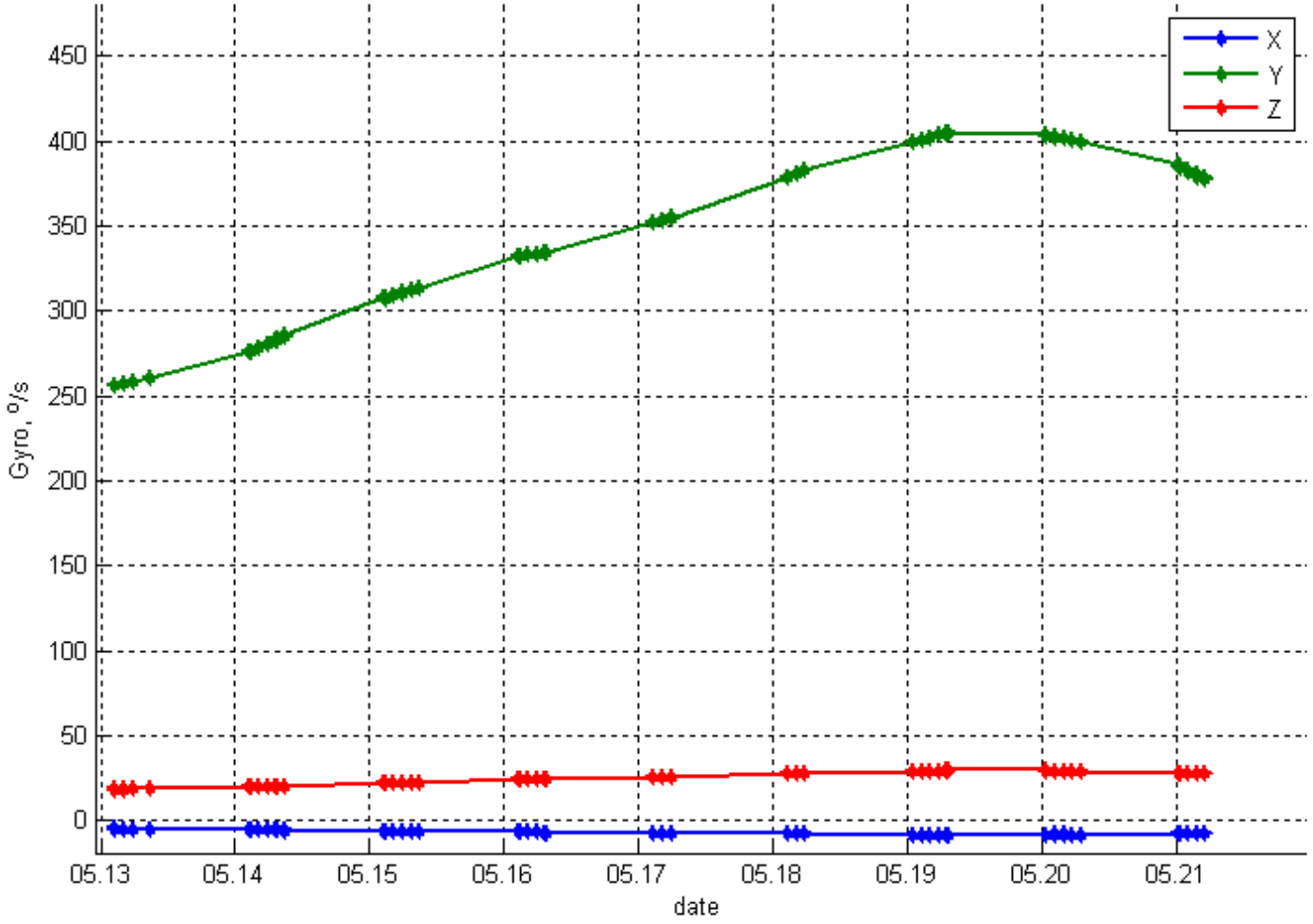
Temperature data
May 13-22, 2014



Magnetometer data
May 13-22, 2014



Gyro data
May 13-22, 2014

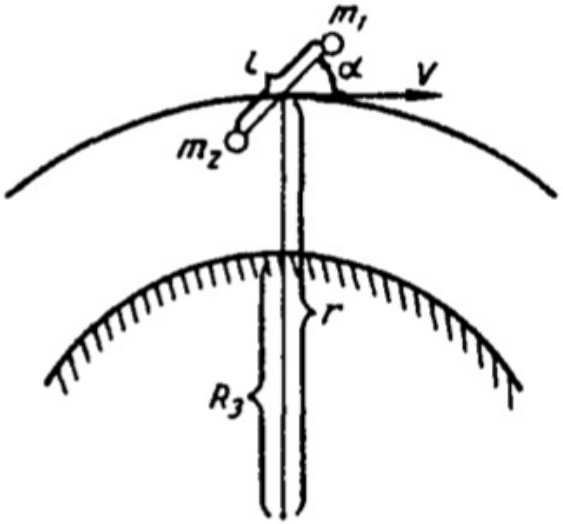


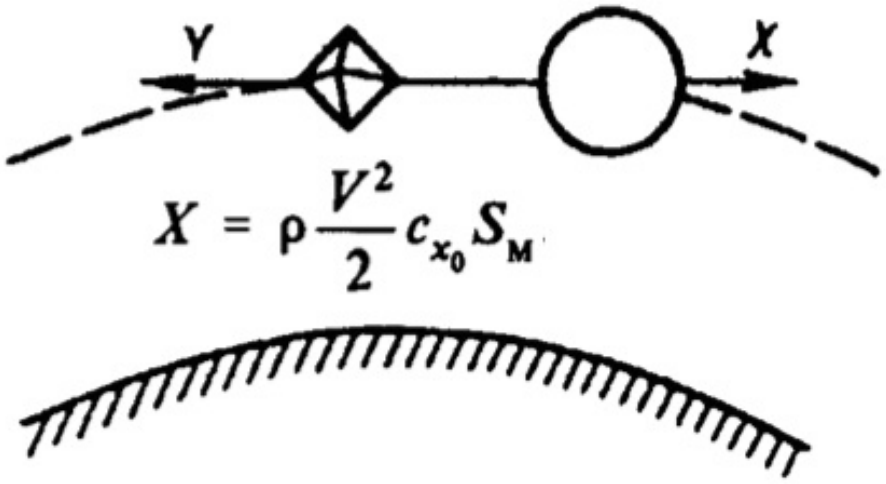
Orbital Perturbations

$$F = f\frac{mM}{(R+H)^2} - \frac{mV^2}{(R+H)} = 0$$

Estimation of:

- Delta V change caused by Aerodynamic drag
- Aerodynamic torque
- Gravitational torque

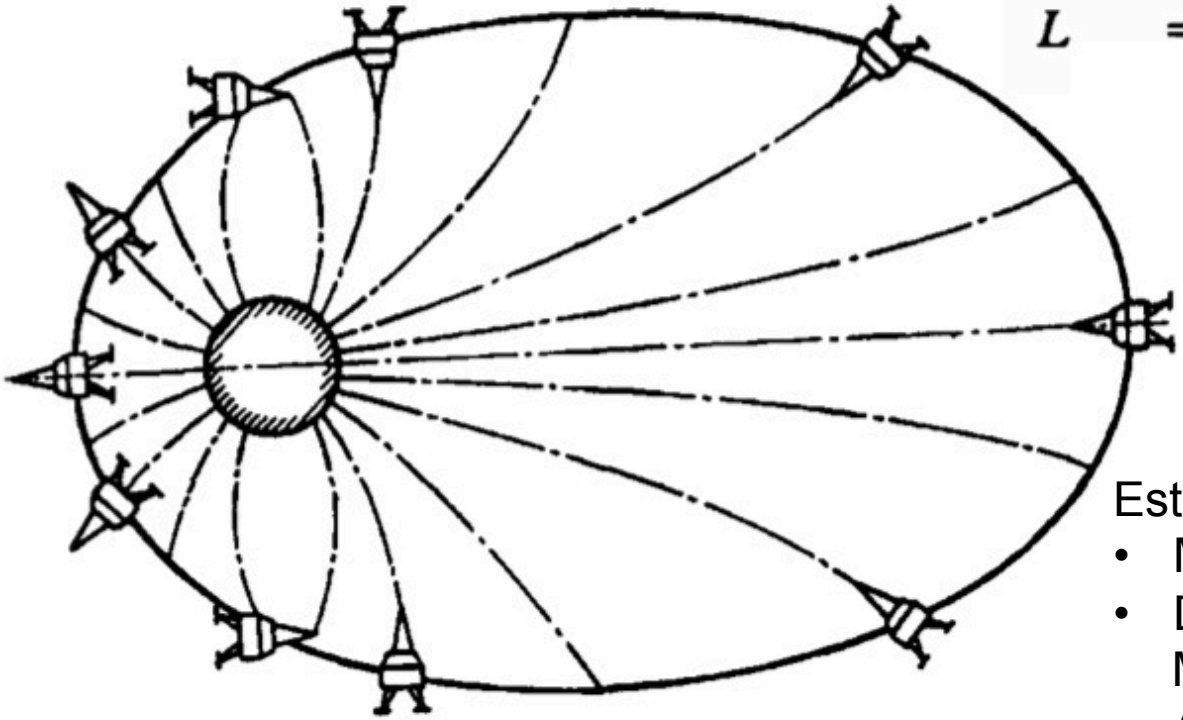




$$X = \rho\frac{V^2}{2}c_{x_0}S_M$$

$$\delta f = \pm\frac{m_1}{(R+H)^2}\left(2f\frac{M}{R+H} - V^2\right)\delta H$$

Orbital Perturbations



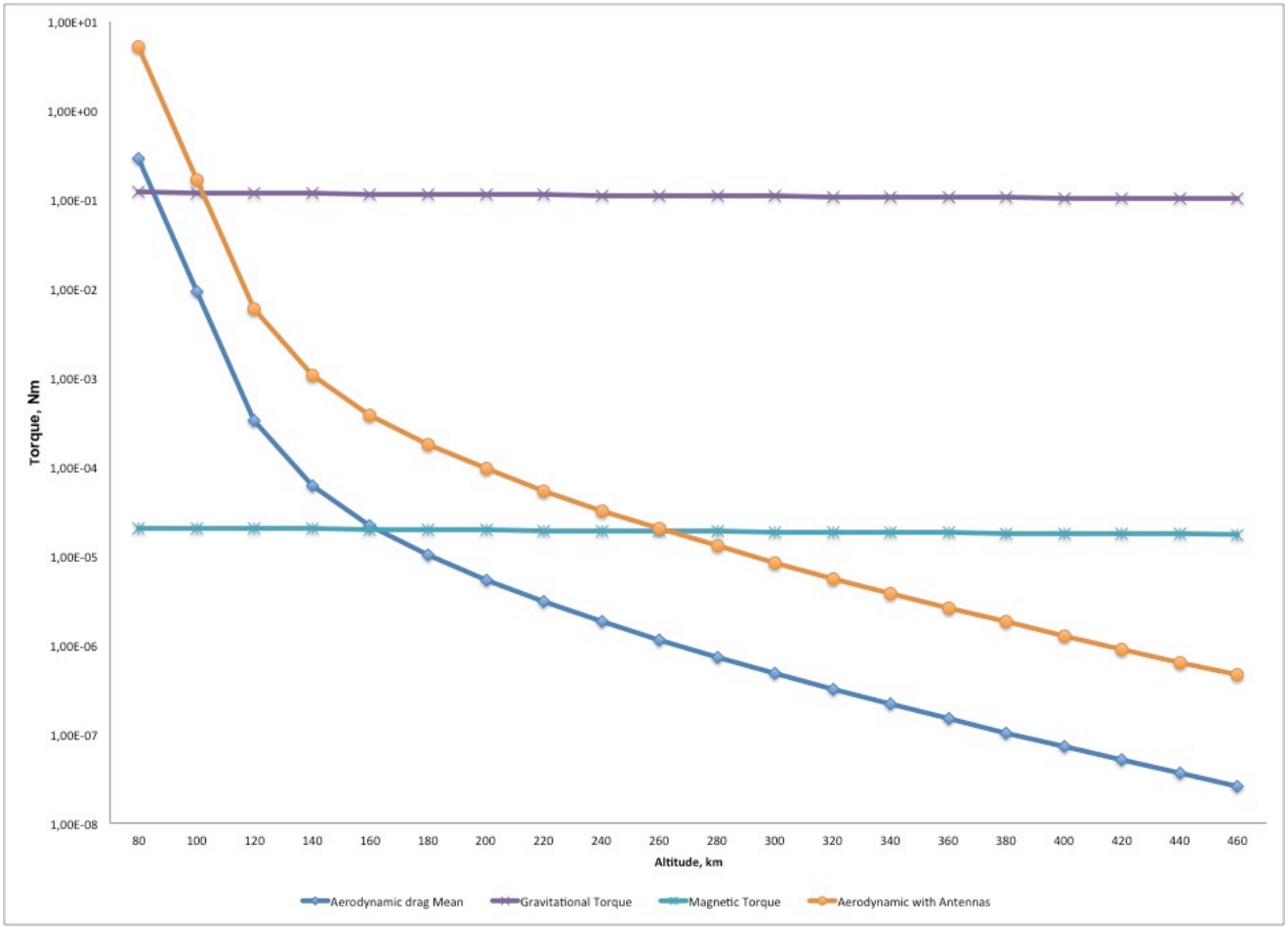
$$L = -H_E \mu \sin\sigma$$

$$\mu = VB$$

Estimation of:

- Magnetic torque
- Delta V change caused by Magnetic re-orientation of Aerodynamic and Gravitational torques and Energy dissipation on Magnetic Hysteresis

Estimation of Satellite Torques



Heuristic modeling of Balistics Coefficients

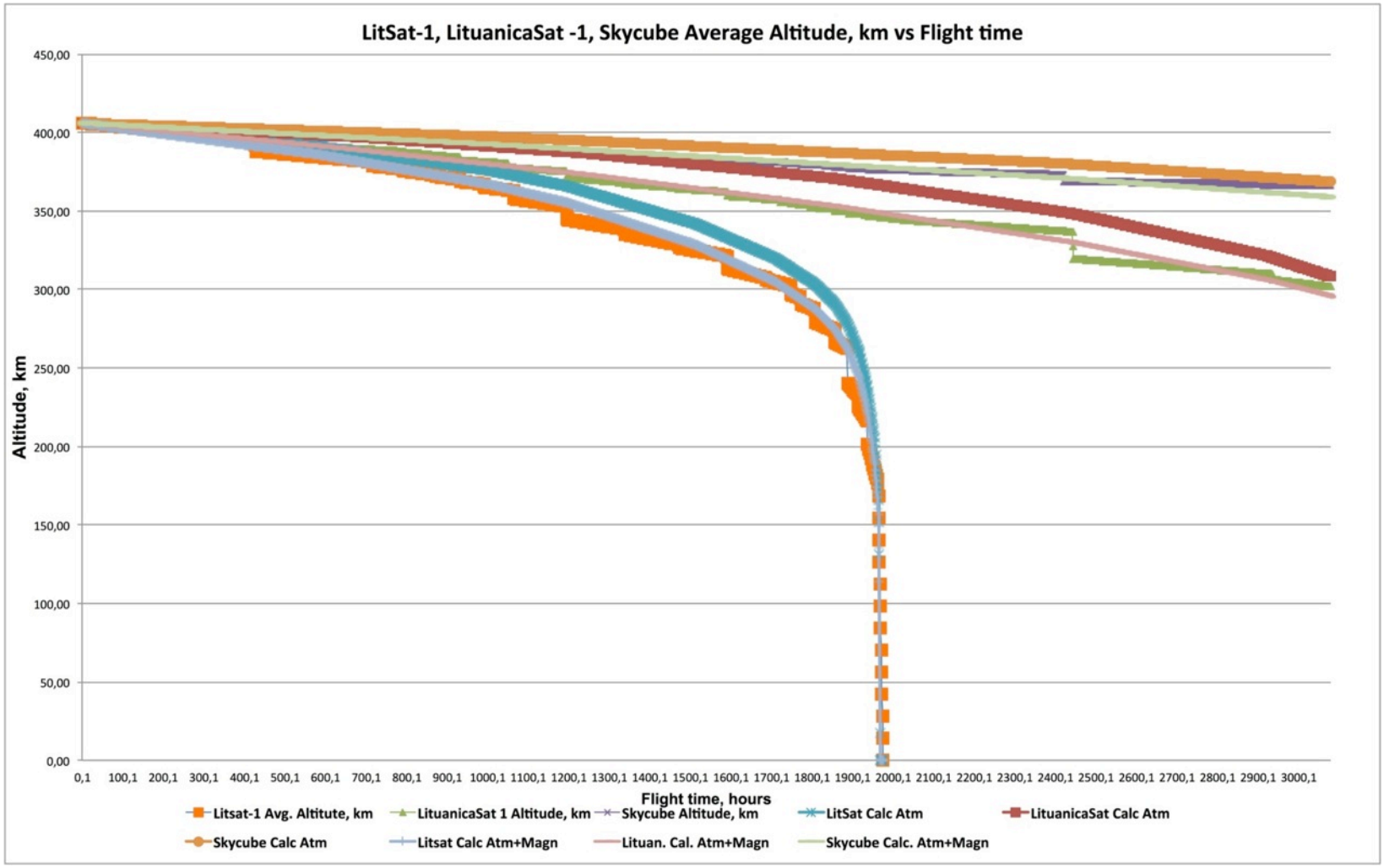
- UAPSAT – Decay May 21
- Litsat 1– Decay May 23
- Ardusat 2 – Decay Jul 1
- LituanicaSat 1 – Decay Jul 28
- Skycube – Sep 22 – still at 330 km altitude

1 Table. Calculation of Ballistic Coeeficient (Experimental Data)

BC=Cx*A(m2)/m(kg)

Decay		Cx	A, m2 (Area)	Cx+Magn	A, m2 (Area) +Magn	d, cm (Effect. Side Length)	m, kg	BC
May 22	UAPSAT	1,28	0,026	1,28	0,026	16,1	0,95	0,0350
May 23	Litsat -1	1,28	0,026	1,28	0,026	16,1	0,95	0,0350
Jul 1	Ardusat 2	1,28	0,048	1,1	0,010	21,9	2	0,0307
Jul 28	Lituanicasat-1	1,28	0,015	0,88	0,011	12,2	1,09	0,0176
> Sep 23	Skycube	1,28	0,012	0,6	0,010	11,0	1,3	0,0118

Orbital Decay



Conclusions

- Simple decay model does not fully fits the actual decay data;
- Additional of energy dissipation caused by remagneting hysteresis has been added to the model, producing much better results;
- Estimated additional decrease of orbital speed ΔV is by average 5×10^{-3} m/s per hour
- Nature of increasing rotation speed of the satellite is not fully known yet;
- Additional calculations and research should be performed in this field.

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THANK YOU FOR ATTENTION !