
PW•SAT2

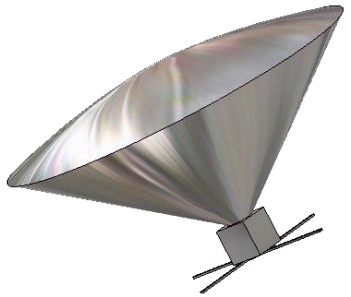
Deorbit Sail for PW-Sat2 satellite mission – low energy consumption and high efficiency system

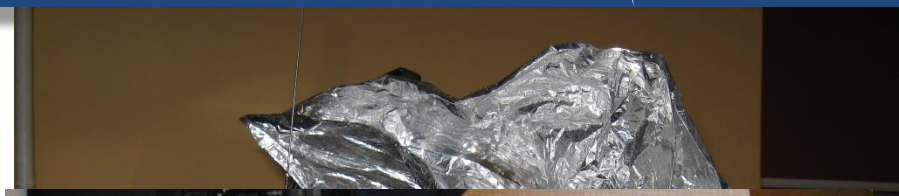
Inna Uwarowa

PW-Sat2 – Meet the team

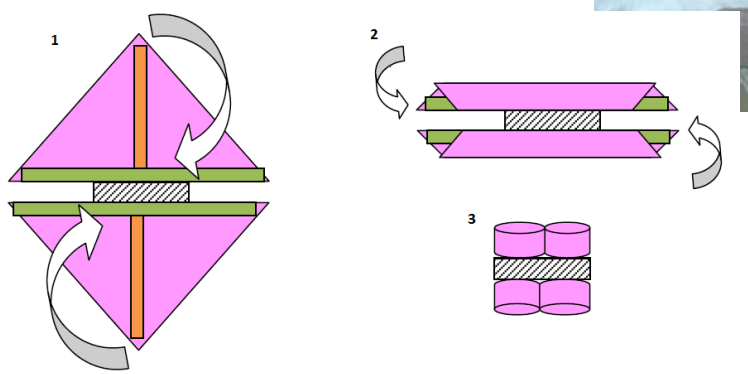
The brief history of the… concept

- PW-Sat(1) – started in 2004
  - Deorbit baloon
  - Deorbit sail (nitinol)

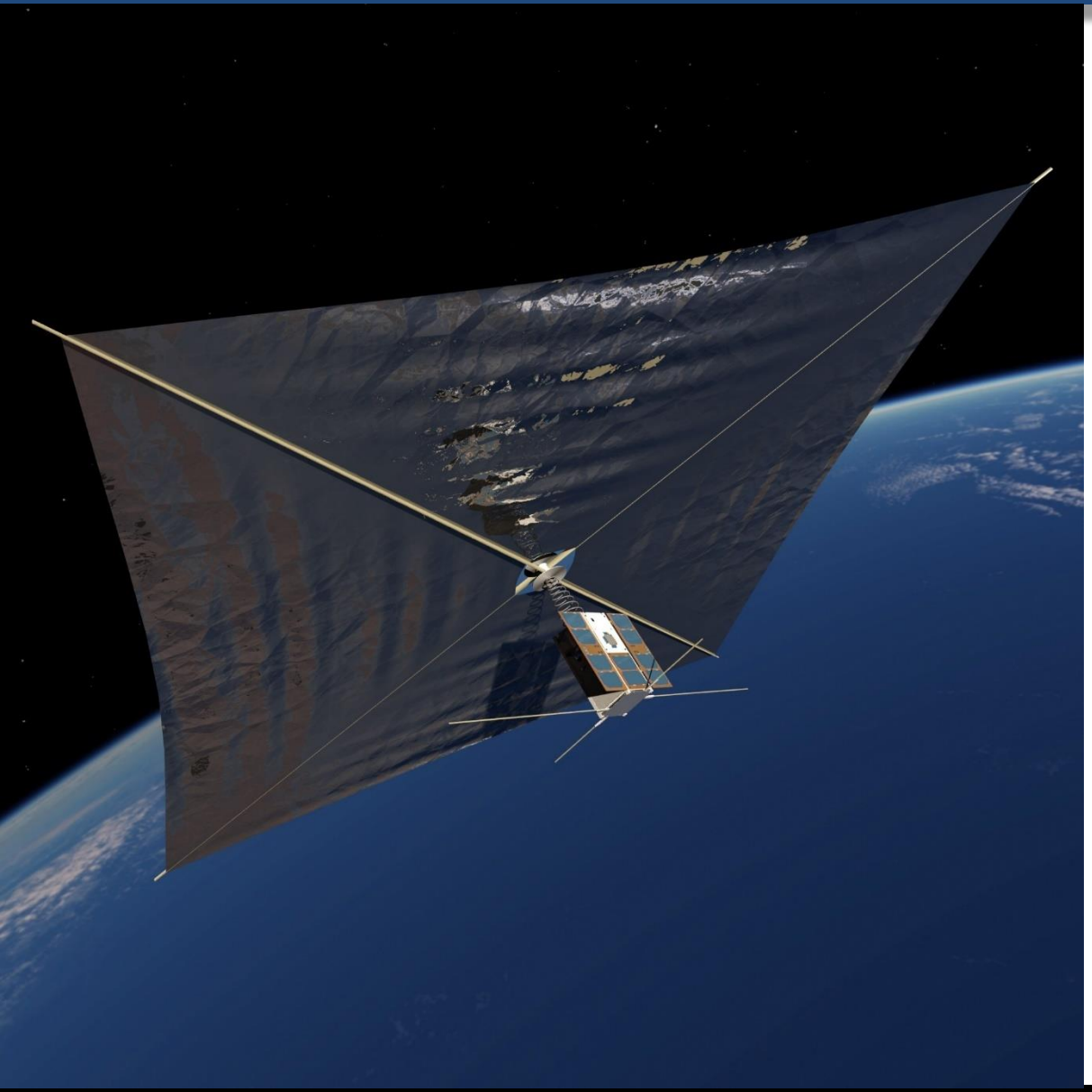




- PW-Sat2
  - Various sail options
  - More than 20 prototypes



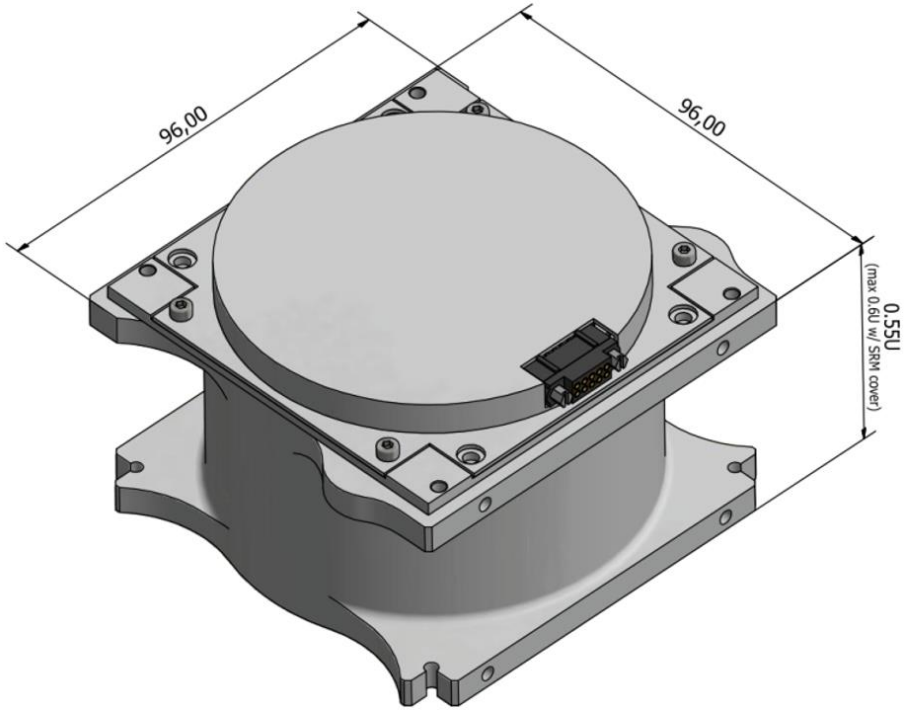
Final sail design

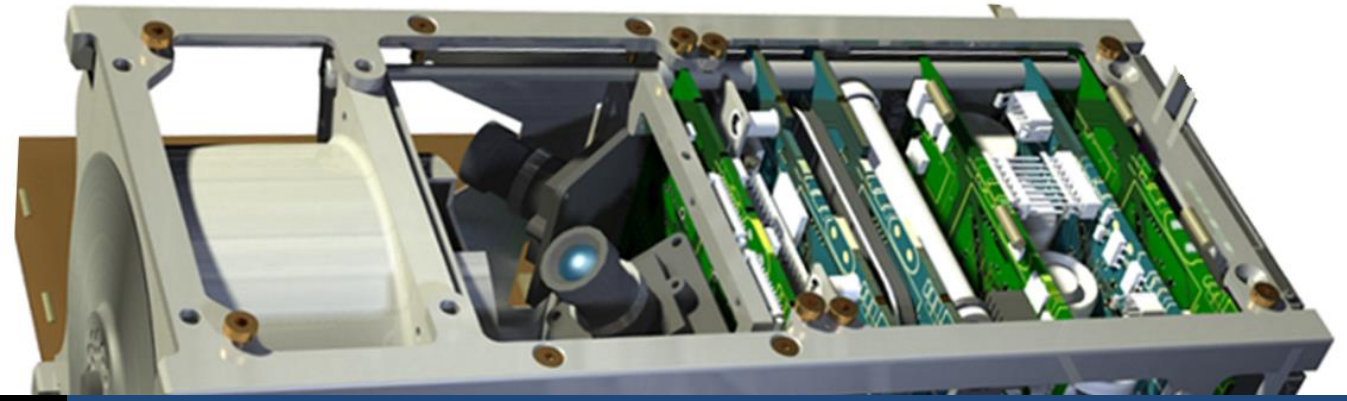


- $4m^2$ sail
- Flat springs
- Conical spring
- Mylar 6 µm
  - Aluminized double side
  - Material along the springs
- Sail Release Mechanism SRM
  - Dyneema wire (150°C)

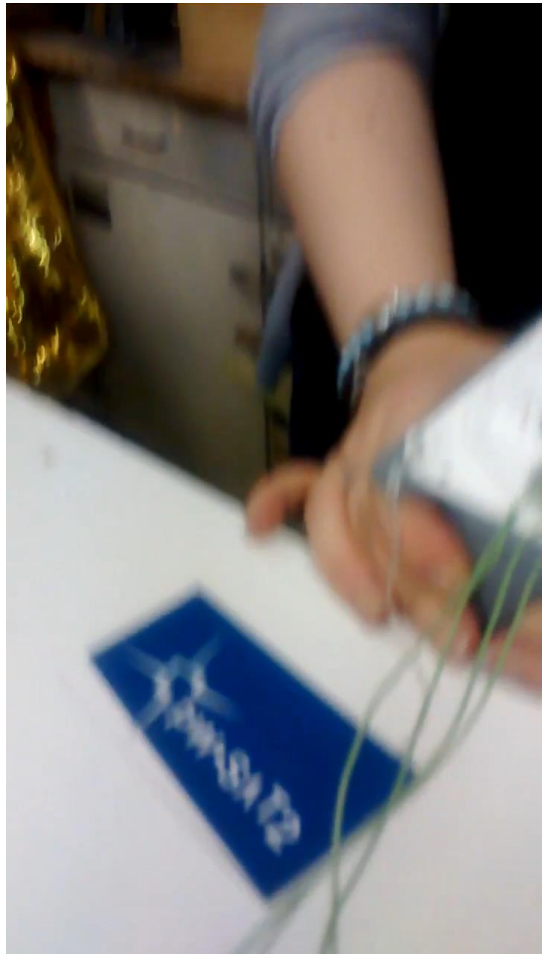
Sail ICD

- Dimensions
  - 96x96x65mm
- Mass
  - 600g
- Connector
  - Harwin M-80 series
- Price
  - 2550€





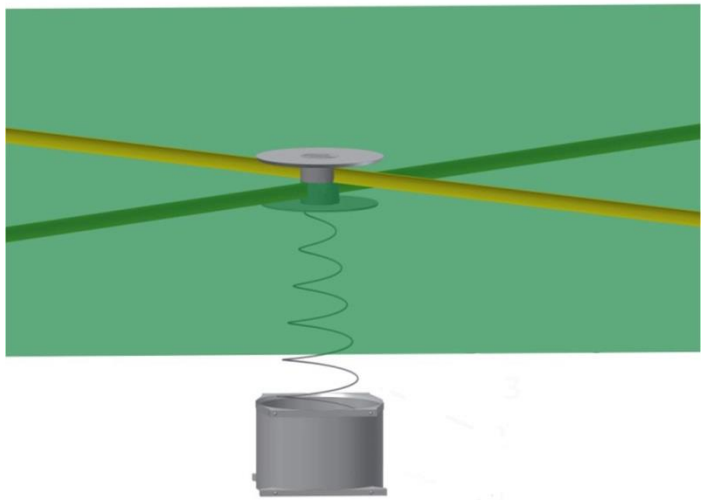
SRM design

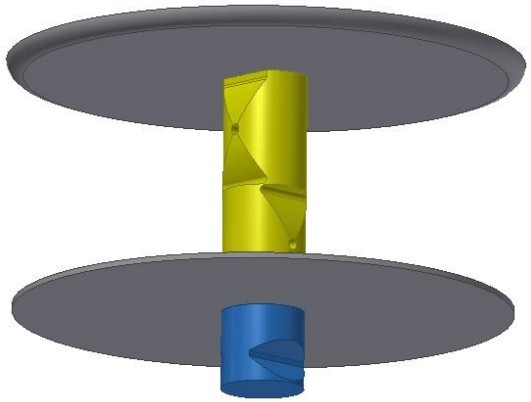


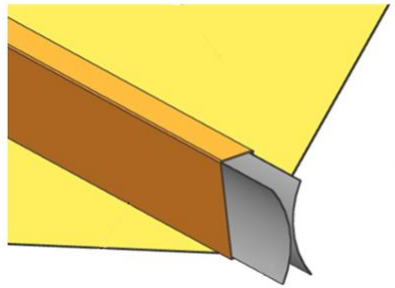
- Dyneema wire
  - 2W for 10s< t <1min
  - Redundant thermal knives
  - Simple electrical interface
  - Deploy indicator
  - Space heritage

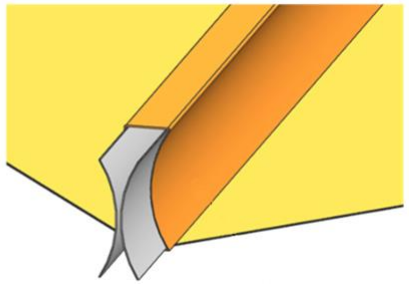
Sail structure

- Conical spring
  - Stabilized by net system
  - 200mm away from the satellite
- Reel
- Flat springs
  - X-shape
- Can be scaled
  - Springs
  - Container



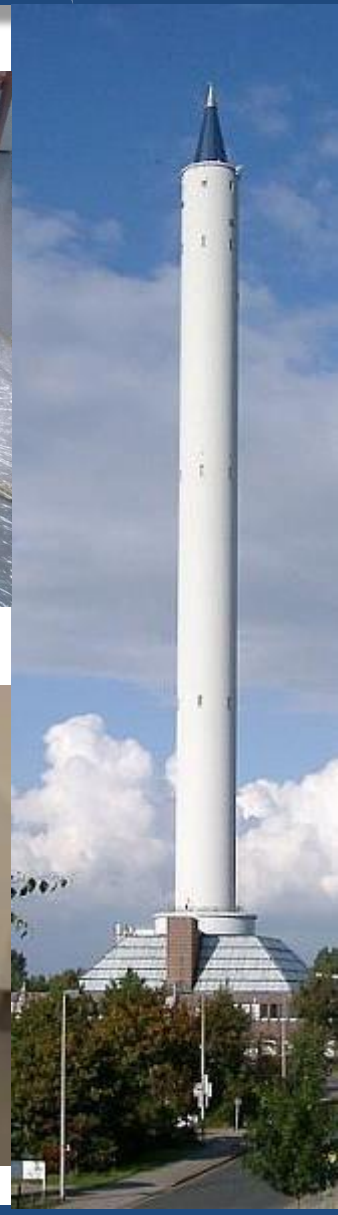






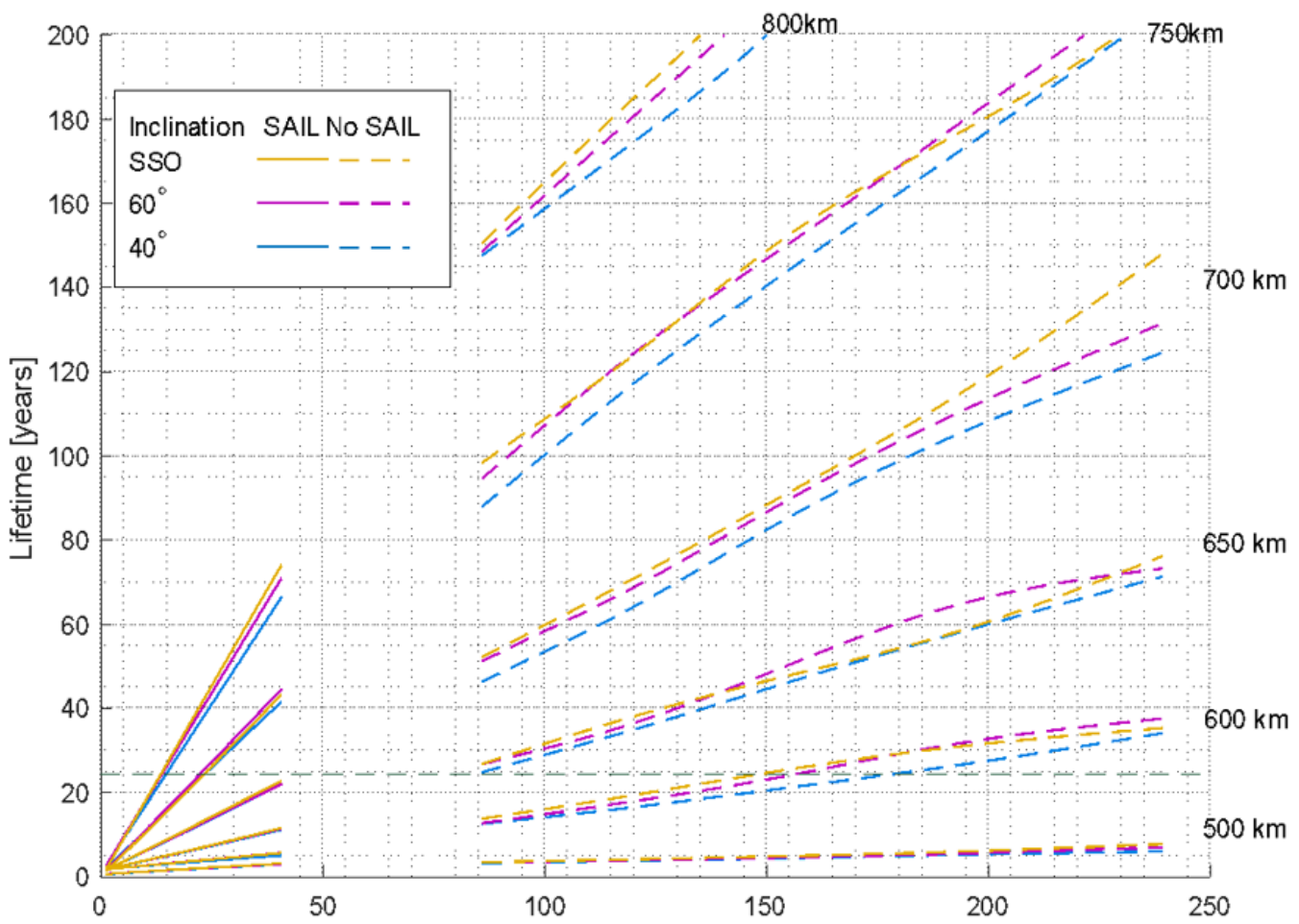
Test campaign

- Sail deployment
  - Low - friction surface test
  - Hanging test
  - Drop tower
- Container deployment
  - Vibration
  - Vacuum test



Deorbitation analysis

- System applicable:
  - Up to 12U
  - Up to 800km
- Low cumulated collision probability
- Analysis for 0.226m^2
  - Up to 700km



	Sail							No Sail						
type	2U	3U	6U	12U	24U	48U	100	2U	3U	6U	12U	24U	48U	100
BC	97.61	85.85	116.8	152.6	192.0	238.3	120.0	1.29	1.94	3.86	7.39	14.6	29.02	40.96
800 km	3.1	3.7	6.0	12.4	26.3	49.6	70.7	160.6	148.2	179.9	193.3	199.2	199.7	177.1
750 km	2.7	3.0	4.1	6.6	14.9	31.1	43.3	104.0	93.0	118.9	149.1	173.8	189.8	121.9
700 km	2.3	2.5	3.1	4.0	6.9	16.7	22.4	58.6	49.7	64.2	90.5	108.4	134.8	65.7
650 km	1.9	2.2	2.6	3.2	4.2	7.4	12.2	30.2	26.4	35.3	48.2	60.1	73.5	35.7
600 km	1.4	1.7	2.2	2.6	3.1	4.3	5.3	14.7	13.4	17.7	23.2	30.1	35.6	17.6
500 km	0.2	0.3	0.7	1.3	2.0	2.4	2.7	3.7	3.6	4.1	4.7	5.6	7.1	4.1

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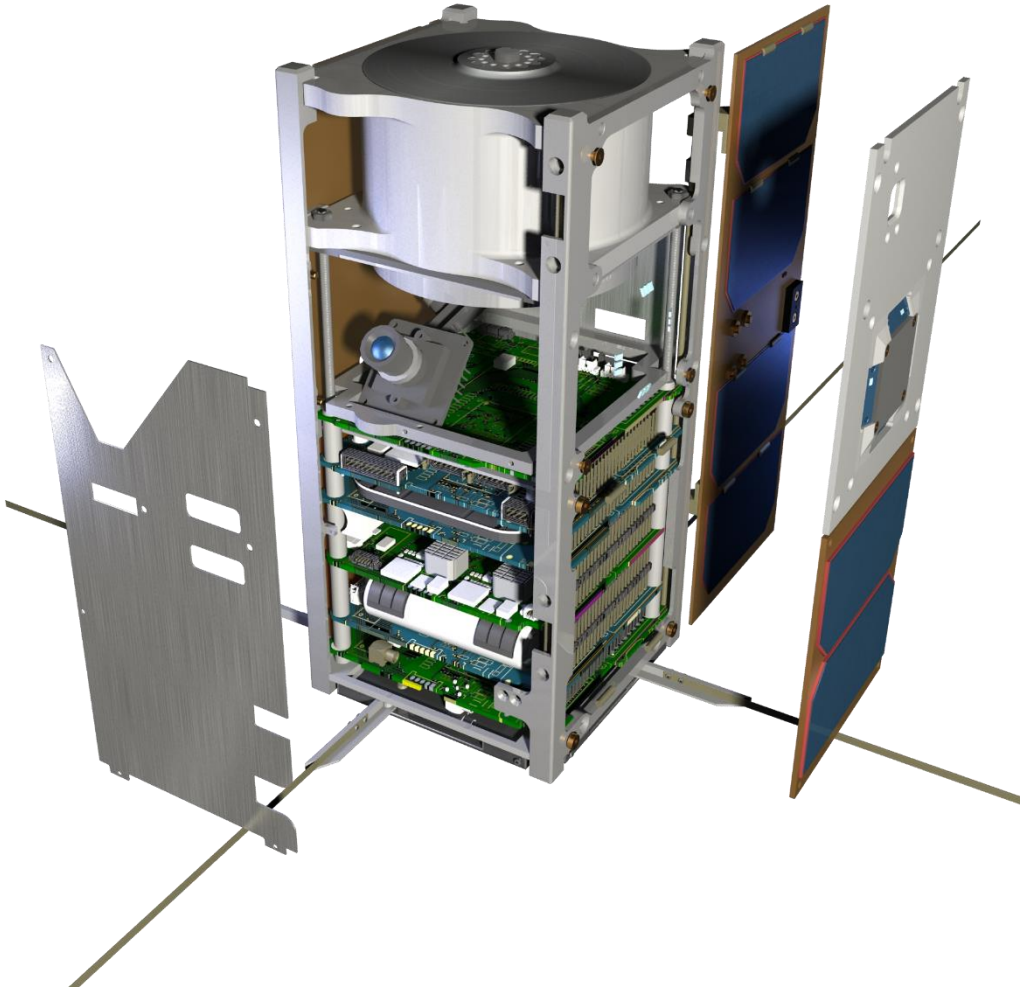


Inna Uwarowa

Project Coordinator

iouvarova@gmail.com

Artur Łukasik

Vice coordinator

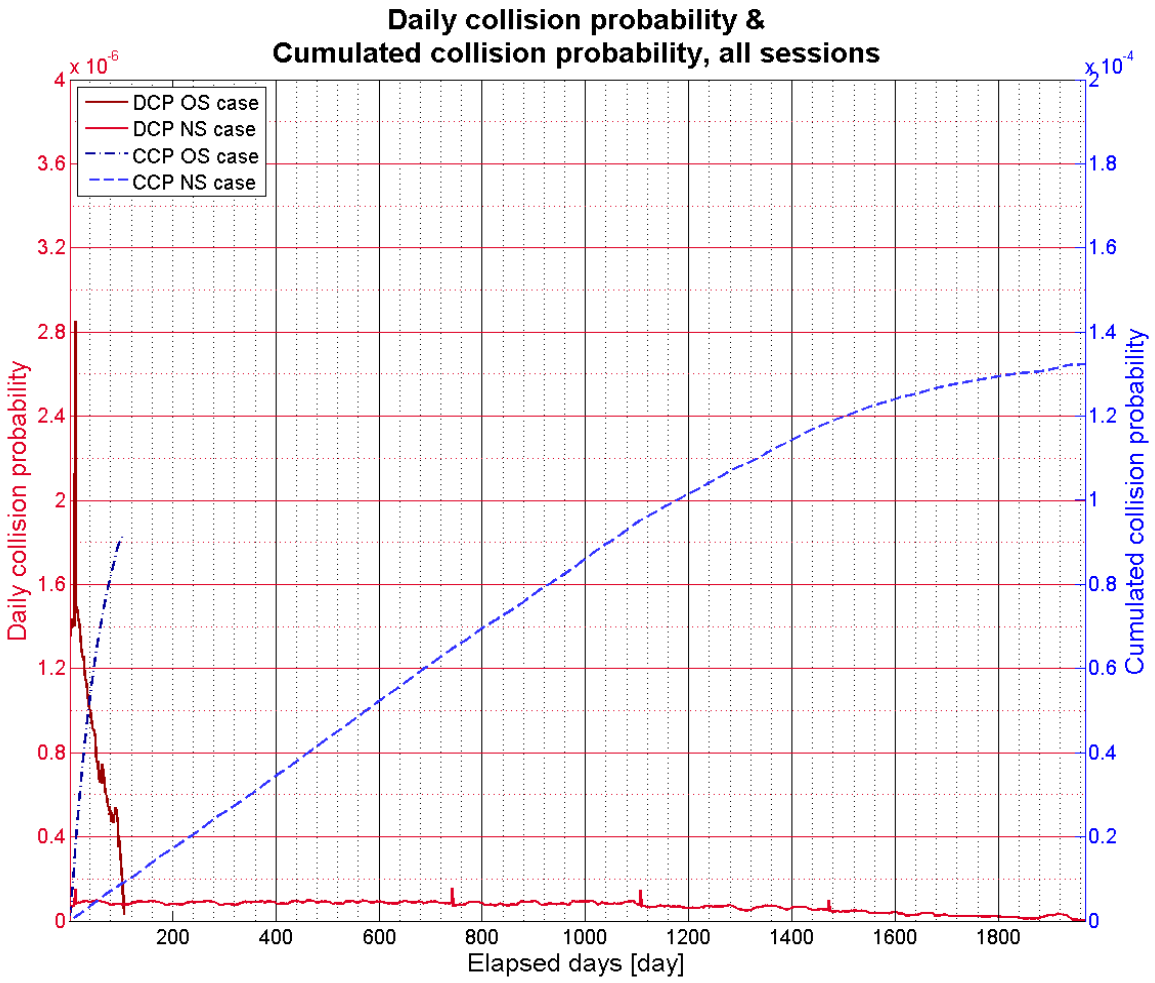
artur.mikolaj.lukasik@gmail.com

Dominik Roszkowski

PR and cooperation

dominik.roszkowski@gmail.com

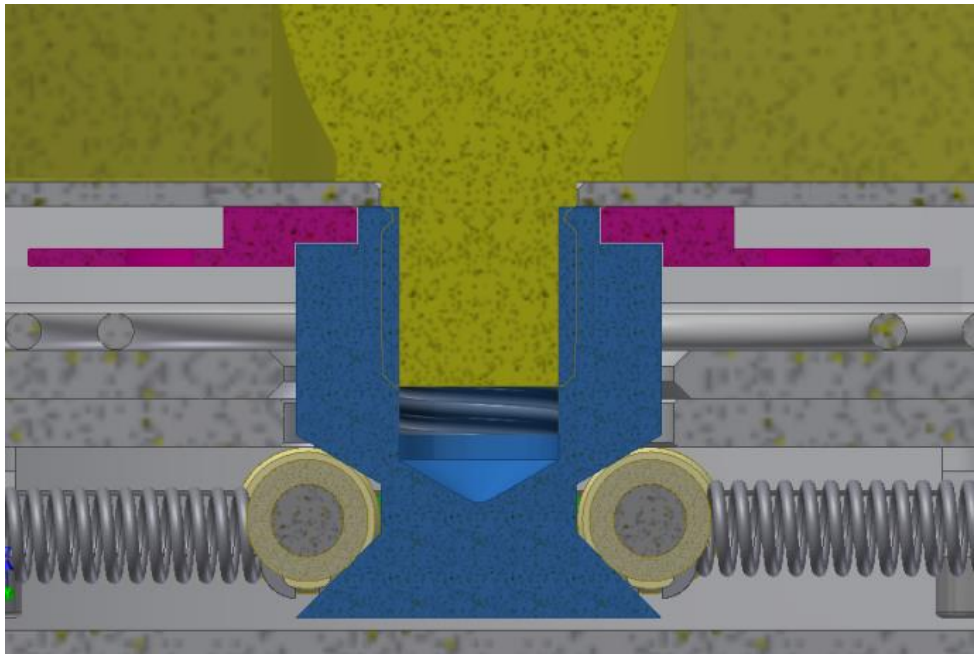
Colision risk probability

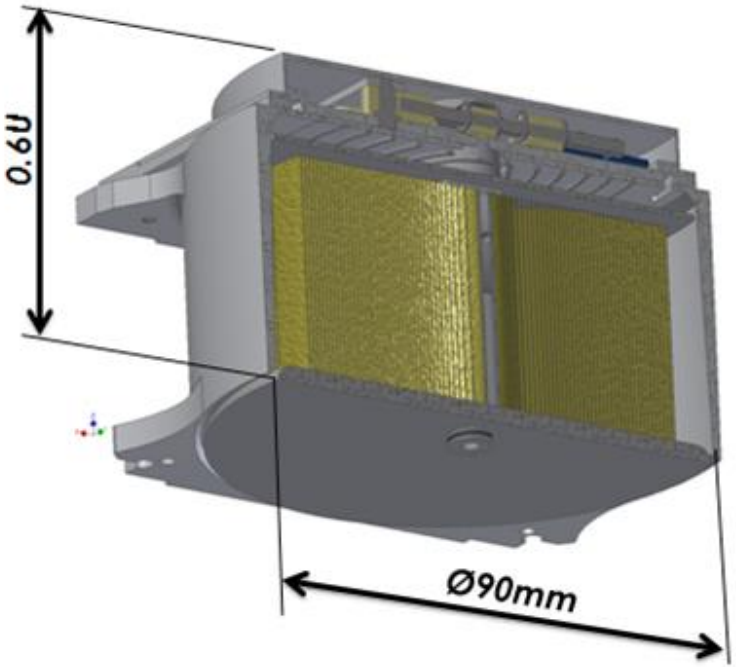


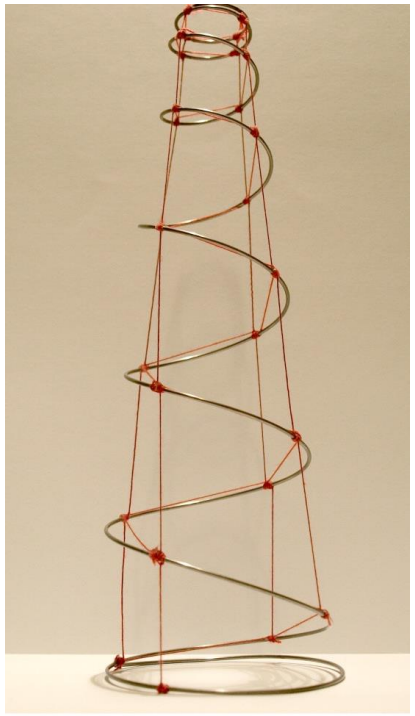
- DRAMA ARES Results. Daily Collision Probability (DCP) and Cumulated Collision Probability (CCP) for opened sail (OS - dark red, dark blue), and no sail (NS - red, blue) cases

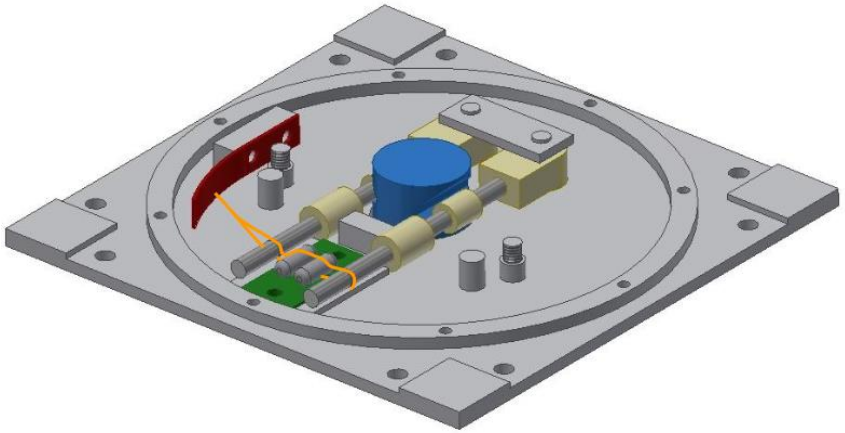
Worst case scenario

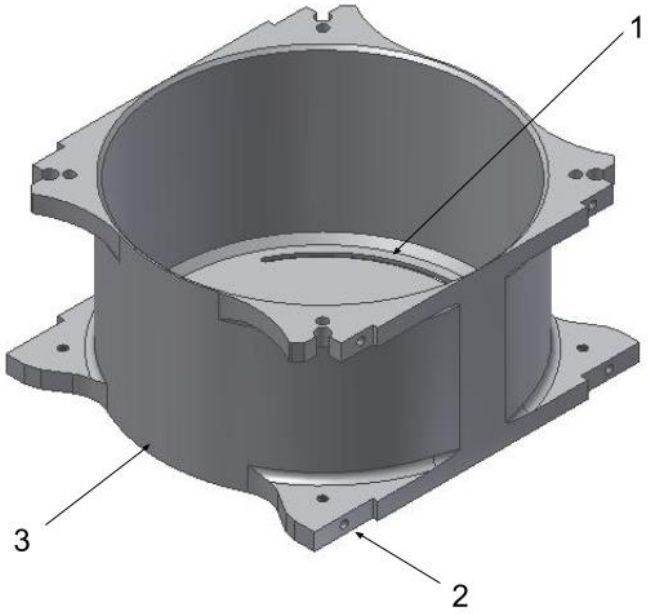
x [yrs.]	Worst case (effective drag area = 0.2266 m^2)						
	Probability of lifetime shorter than x						
	SSO 780 km	SSO 700 km	SSO 600 km	SSO 500 km	SSO 400 km	52˚ 600 km	65˚ 575 km
< 1	0 %	0 %	23 %	63 %	100 %	24 %	32 %
< 2	0 %	6 %	43 %	92 %	100 %	44 %	51 %
< 3	0 %	17 %	56 %	99 %	100 %	57 %	64 %
< 4	1 %	27 %	65 %	100 %	100 %	67 %	78 %
< 6	5 %	42 %	93 %	100 %	100 %	93 %	99 %
< 10	17 %	86 %	100 %	100 %	100 %	100 %	100 %
< 15	52 %	98 %	100 %	100 %	100 %	100 %	100 %
< 25	96 %	100 %	100 %	100 %	100 %	100 %	100 %
min; max; max/min lifetime [years]							
max	31.60	17.43	7.81	3.57	0.50	7.90	6.65
min	2.94	0.90	0.24	0.08	0.02	0.21	0.16




0.6U
Ø90mm



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