Title: ASAT. "Ad Solis, Ad Terram"

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☐ **Please keep our idea confidential if we were not selected as finalist/semi-finalist.**

Need

Unpredicted high solar activity could cause damages on Earth facilities and power lines. With better models, this damage could be mitigated. Accurate sun behaviour modelling can also provide deep and necessary insight in Earth global climate evolution. Sun influence on human's health is a growing issue and can be better understood by completing accurate measures.

Mission Objectives

1. Obtaining reliable scientific measurements on sun irradiance with a precision up to 1 PPM
2. Obtaining reliable scientific measurements on magnetic fields in exosphere up to 10 pT resolution.
3. Obtaining reliable scientific data on neutral gas, ion and electron measurements with high accuracy.
4. Doing all the above during a 3 years life mission, with option to extended lifetime.
5. Doing all the above features with a cost not superior to 10 M$ including launch.

Concept of Operations

GROUND SEGMENT - Due to the characteristics in orbit, only a ground station is needed for diary data download. Kiruna station from ESTRACK is this main station. E-USOC station adaptation is presented in order to obtain academic profits for researchers and aerospace engineering students interested in participate in real space operations.

Figure 1 - Kiruna Ground Station(left) and scientific facilities (right). E-USOC, Physics faculty at Complutense and ETSIA

Ground segment comprises scientific infrastructures where data from Kiruna can be analysed, too. These operations are expected to be located in University facilities.

SPACE SEGMENT - Space Segment will be comprised by a single spacecraft equipped with three instruments able to deliver all needed measurements.

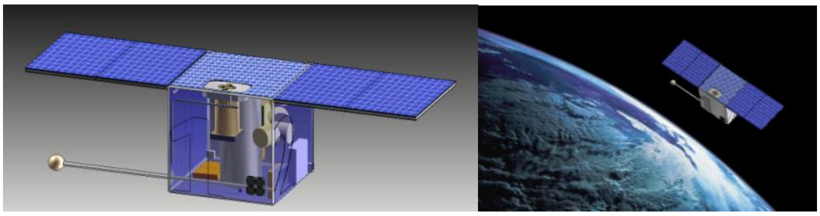


Figure 2 - Model of ASAT spacecraft and artistic representation in flight.

EPS		AOCS		Propulsion		Structure	
Element	**Weight (kg)**	**Element**	**Weight (kg)**	**Element**	**Weight (kg)**	**Element**	**Weight (kg)**
Panel	3,5	4x Reaction Wheels	3,8	Pressurizer tank	1,8	Main Structure	5,0
Batteries	2,1	2x star tracker	1,0	Hidrazine tank	4,4	Launching adapter	1,0
DC/DC Converter	1,0	3 x magnetorods	1,8	Valves	1,1	Mechanisms	2,0
Regulator	1,0	AOCS controller	0,2	Thruster	0,2		
Thermal knife	0,3	GPS	1,2				
Subtotal	**7,9**	**Subtotal**	**8,0**	**Subtotal**	**7,6**	**Subtotal**	**8,0**
Payload		COMM		DHCS		Thermal Control	
Element	**Weight (kg)**	**Element**	**Weight (kg)**	**Element**	**Weight (kg)**	**Element**	**Weight (kg)**
TIM	6,2	Antennas	0,4	Computer	0,1	Sensors and heaters	1,0
Magnetometer	1,4	Transceiver	0,6	SSR	0,1		
SSJ5	1,4						
Subtotal	**8,9**	**Subtotal**	**1,0**	**Subtotal**	**0,2**	**Subtotal**	**1,0**
		Total mass	**42,6**	**Margin**	**7,4**		

Figure 3 - Overall weights for spacecraft.

LAUNCH - Piggyback launching is the option chosen. SENTINEL 3 on a Vega launcher is the primary mission for launch in 2014.

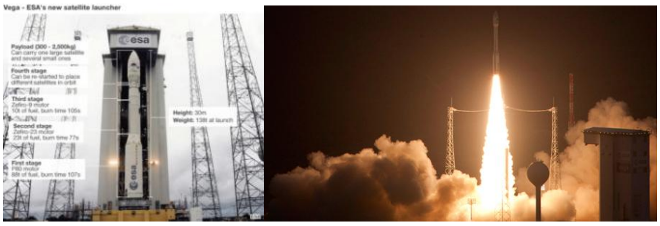


Figure 4 - Vega rocket launching from French Guiana.

Key Performance Parameters

- Irradiance monitoring instrument: TIM (5).
- Magnetic field monitoring instrument: fluxgate magnetometer (6).
- Ion and neutral gas data instrument: SSJ/5 (4).
- Low weight and low cost concept

Sun behaviour and its interaction with Earth has not been fully approached under a low cost mission focus yet. Continuous and multiple irradiance sun measures are needed in order to have data on magnetic fields interaction, and ion and neutral gas readings in exosphere. ASAT provides a low cost model focused on obtaining reliable scientific data to support existent missions and provide redundancy on this important matter.

Space Segment Description

Every subsystem has been sized according to mission requirements.

AOCS - TIM requires ±10 arc min Sun pointing, while SSJ/5 requires zenith to be contained in the sensor field of view. Consequently, a 3 axis stabilization using reaction wheels will be implemented. Reaction wheels unloading will be performed with magnetic torquers. GPS-based attitude determination will be used for coarse data, and it will be improved with star-tracker measurements. Up to 13 operating modes have been defined so as to appropiate control of satellite.

PROPULSION - Propulsion system has to provide a total impulse of ΔV= 191 m/s, for two manoeuvres: a Hohmann transfer at the first part of the mission and de-orbit at the end of life. A monopropulsion liquid system based on hydrazine and helium as pressurizer has been chosen. A thruster of 10 Newton, valves and conductions complete the system.

STRUCTURE - The satellite has a cubic shaped external structure with a cylinder inside. Cylinder has been designed to withstand launch loads. The selected material is Al-7075.

THERMAL CONTROL - In order to reduce weight and power a passive system has been selected. Thermo optical properties of satellite faces and the use of heaters can accomplish our requirements.

POWER - A 110 W maximum consumption has been designed based in solar photovoltaic. Different consumptions have been studied in every operating mode to assure optimizing performance in subsystem, allowing flexibility during lifetime.

COMM - Four S-band patch antennas in nadir face provide 4 Mbps downlink and 1kbps uplink with a proven, low weight, low power transceiver. Passive pointing strategy and antenna switching provide reliable links with ground segment.

CDHS -It is based on a centralized architecture and is able to storage and compress 1 GB of diary data. System can provide redundancy over peripheral systems controllers in case of failure.

SYSTEMS /Operating modes		Nominal Mode (W)	Hibernation (W)	COMM/CONFIG (W)	DESATURATION (W)	...	FAILSAFE (W)
PAYLOAD	TIM	14	0	0	0	...	0
	SSJ5	1,4	0	5	0	...	0
	Magnetometer	3	3	3	3	...	0
AOCS	Reaction wheels	10,5	0	10,5	10,5	...	10,5
	Magnetorods	0	0	0	4,5	...	0
	Sensors	6,5	0	5,5	5,5	...	5,5
EPS	Control	5	2	5	5	...	5
	Aconditioning	5	1	5	5	...	5
STRUCTURE		0	0	0	0	...	0
THERMAL	Sensors	1	1	1	1	...	1
	Heaters	15	15	15	15	...	15
COMM	Uplink Receiver	1	0	1	0	...	1
	Donwlink Transmitter	30	0	30	0	...	30
CDHS	Computer	10	10	10	10	...	10
PROPULSION	Sensors	0	0	0	0	...	0
	Valves	0	0	0	0	...	0
	Others	0	0	0	0	...	0
PEAK POWER (W)		**102,4**	**32**	**91**	**59,5**	**...**	**83**

Figure 5 - Example of operating modes defined.

Orbit Description

Because of on board instruments requirements, it has been considered that the optimum orbit is a repeating ground track sun-synchronous orbit, which repeats its ground track 14 times and completes 14 orbits daily. This orbit has the following orbit parameters:

- a = 7272 km
- i = 98,9 º
- e = 0
- Local time of the ascending node: 09:30

So, as the mission will be launched with Vega from Kourou, the satellite will have the following ground track:

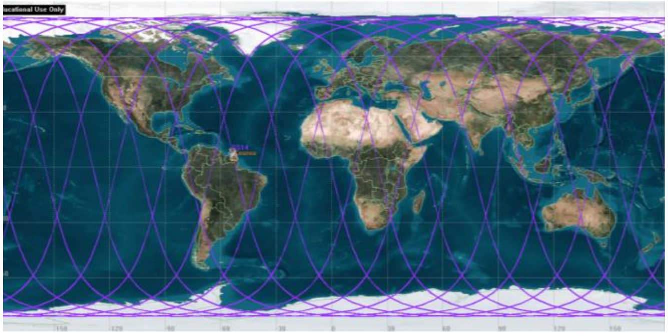


Figure 6 - Orbit traces.

RADIATION - According to (1) up to 10 krad(Si) per year is expected in a high altitude polar orbit. Total dosing is a major concern in the mission and it's been tackled with several strategies like proper shielding, high level of redundancy and radiation tolerant components selection.

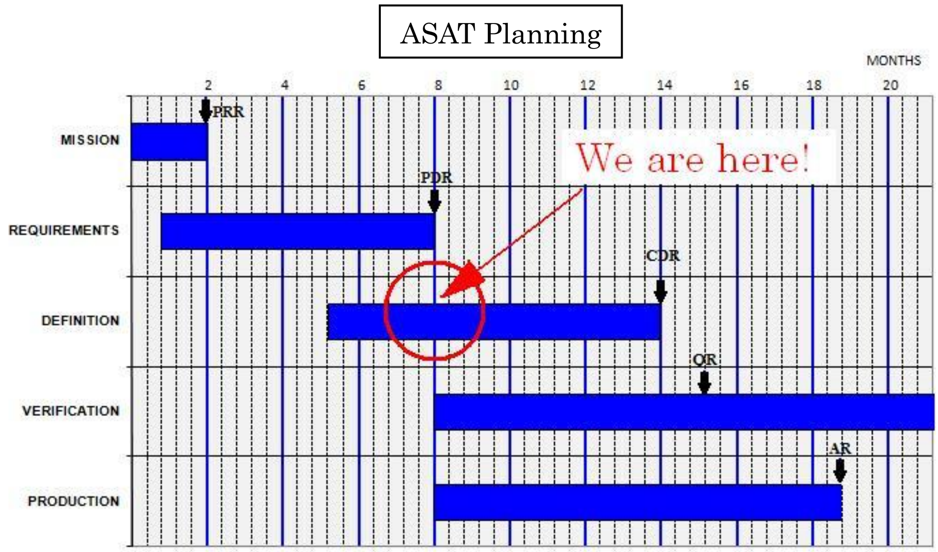
Implementation Plan

PLAYERS - Players are expected to be academic supporters and space related institutions interested in testing system and using scientific data obtained. ESA agreement is expected not only for launch but for ground segment economic use. E-USOC and universities will provide technical advice during manufacturing and validation of space segment system.

Figure 7- Expected players involved in ASAT development.

TOTAL LIFE CYCLE COST

M$	
DESIGN	0.1
DEVELOPMENT	0.1
SYSTEMS & ASSEMBLY	2.8
INTEGRATION	1
VERIFICATION	1.5
LAUNCH	1
OPERATION	1
MARGIN (20%)	1.5
TOTAL	9



AR: Acceptance review

CDR: Critical design review

PDR: Preliminary design review

PRR: Preliminary requirement review

QR: Qualification review

Figure 8 - Economic Budget and ASAT Planning for primary launcher.

Project Risks

- Component manufacturing and shipping in schedule. Also failures in integration and unexpected delays.
- Launching.
- Unexpected problems during orbit.
- Lack of economic support during lifetime or extended lifetime.
- A steady solar activity would not allow the scientific mission to operate.

References

1. **NASA.** *Space Radiation effects on electronic components in LEO.* s.l. : NASA, 1996.

2. **Vingut O., Pardo C., Hernando J., González G, Arnas D., Alonso J.** *Mission Analysis for JPN2 project.* s.l. : ETSIA, 2012B.

3. **Wertz James R., Larson Wiley J.** *Space Mission Analysis and Design .* s.l. : Kluwer Academic, 1999.

4. **NOAA/NGDC.** SSJ/4- Precipitating Electron and Ion Spectrometer. *SSJ/4- Precipitating Electron and Ion Spectrometer.* [Online] http://www.ngdc.noaa.gov/dmsp/sensors/ssj4.html.

5. **George M. Lawrence, Gary Rottman, G. Kopp, J. Harder and others.** *The Total Irradiance Monitor (TIM) for the EOS SORCE mission.* s.l. : SPIE Proc, 2002.

6. **Mission, CHAMP.** CHAMP Mission magnetometer data. *CHAMP Mission magnetometer data.* [Online] http://www-app2.gfz-potsdam.de/pb1/op/champ/systems/index_SYSTEMS.html.

7. **Vingut O., Pardo C., Hernando J., González G, Arnas D., Alonso J.** *Anteproyecto JPN2. ASAT.* Madrid : ETSIA, 2012.