Interreg Sudoe

EUROPEAN UNION

NANOSTAR

European Regional Development Fund

Research and innovation

# Attitude and Orbit Control System (AOCS) software for nanosatellites

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NANOSTAR consortium

Cooperation depends on you
www.interreg-sudoe.eu
http://nanostarproject.eu

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Project funded by the Interreg Sudoe Programme through the European Regional Development Fund (ERDF)

## INTRODUCTION AND MOTIVATION

Since the year 2000's more and more nanosatellites are launched. Thanks to the miniaturization in electronics and the development of the CubeSat standards, space became accessible first to university for educative and research projects and now days to a wide range of agencies and businesses.

According to a Spaceworks 9th market forecast, the number of small satellites (1 – 50kg) launched could reach over 750 in 2023.

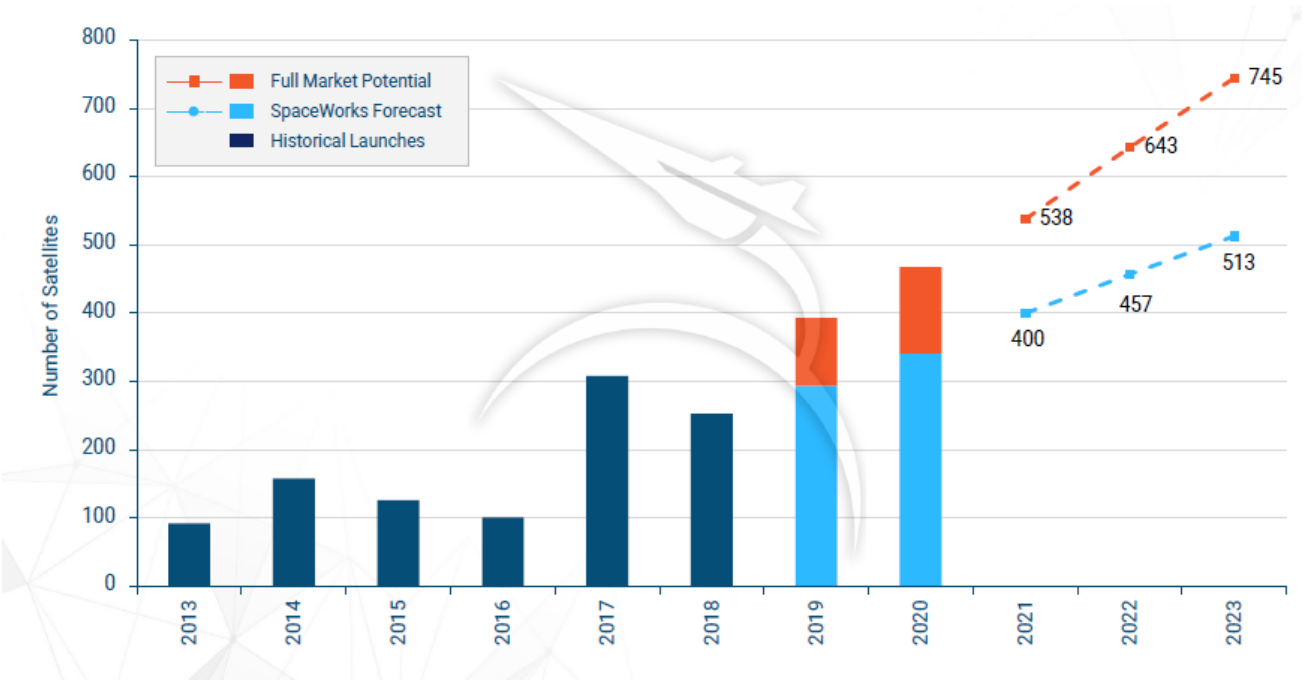


FIGURE 1: SPACEWORK MARKET FORCAST

A number of these missions may fly outside LEO orbits or require VLEO orbits. For higher than LEO; in the absence of magnetic field they would need propulsion for attitude control. Satellite in VLEO would need propulsion to maintain a reasonable life time.

In the meantime, there is also growing awareness about the problem caused by space debris. Satellite now need to de-orbit within 25years of the mission's end. Better, most constellation operators and universities tried to de-orbit as fast of possible. The addition of a propulsion sub-system is a plus, as it allows to speed up the orbit decay.

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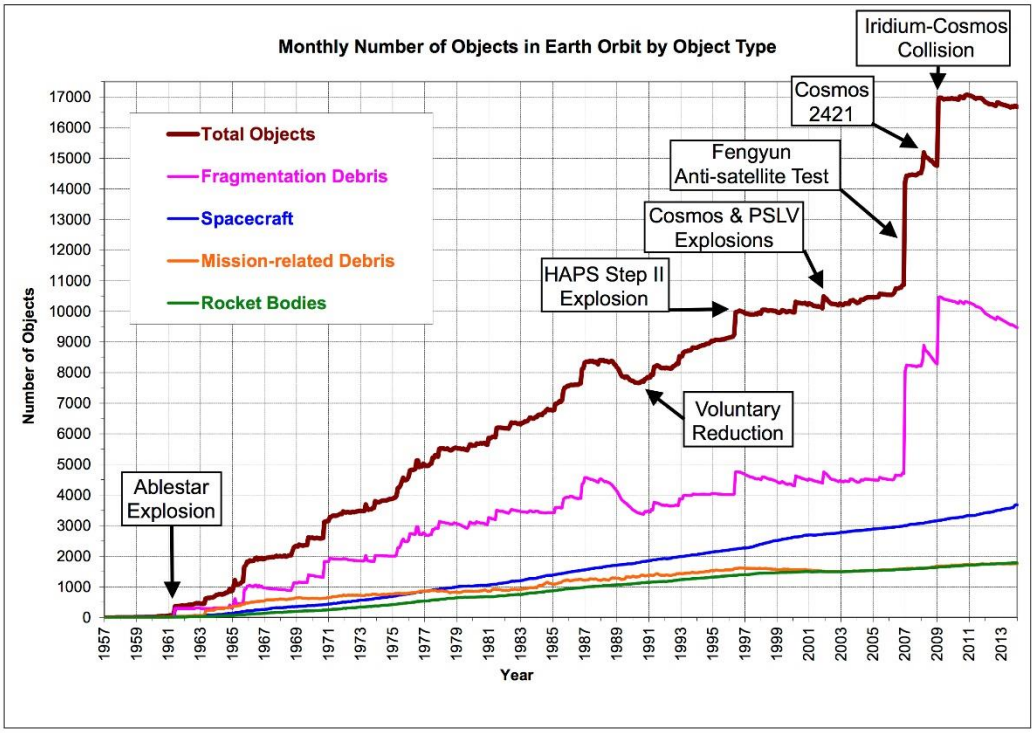



FIGURE 2 : NASA LEO OBJECT ESTIMATION

Finally, missions are getting more and more ambitious and CubeSats are becoming interplanetary. The most known CubeSats are maybe the MARCO from NASA's JPL who performed a Mars Fly-By in 2018. NASA, ESA and others have numerous plans for mission to the moon, asteroids and other planets.

In the absence of magnetic field outside LEO Orbit, such missions will require propulsion to control the satellite attitude.

## STATE-OF-THE-ART

This challenge aims at design an algorithm control for the Robusta-3A project which will take on board Thrust-Me's I2T5 thruster. This collaboration will help CSUM better understand propulsion, prepare future mission and compliances with the "25 year rules", in return Thrust Me will gain insight on how CSU's work and collect valuable data about the thruster behavior in space.

### *CENTRE SPATIAL UNIVERSITAIRE DE MONTPELLIER*

CSUM is an educational platform of Montpellier University for Science and Technology through nanosatellite engineering.

In France, the CSUM is one of the leader in the development of student nanosatellites. It is also a European center of reference devoted to bringing together equipment and skills for the development, production, testing and operation of nanosatellites. These projects involve student interns and encourage regional economic development.

To do this, the CSUM has facilities and equipment dedicated to nanosatellite engineering:

- A control center including a transceiver radio station and antennas in UHF and S-Band;
- A dedicated CIC room (concurrent engineering center);
- AIT facilities (Assembly, Integration and Testing) including a clean room and multiple workshops;

The CSUM develops its own nanosatellite technology producing 1U and 3U CubeSats with the support of the Van Allen Foundation and the French and European space agencies (CNES and ESA).

***THRUST ME***

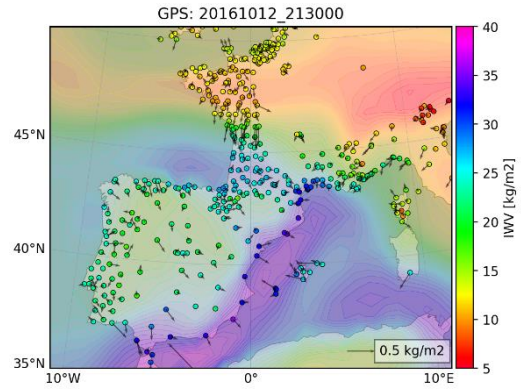
ThrustMe was created to enable an economically and environmentally sustainable space industry. Our core activity is the development, production and commercialization of intelligent fully-integrated space propulsion systems, for next generation satellites. We also provide scientific instruments, such as electrical and plasma equipment, for ground testing of space hardware. We are a highly qualified and multidisciplinary team with expertise in plasma physics, space propulsion, aerospace engineering, fluid dynamics, thermal management, digital and power electronics, and chemistry.

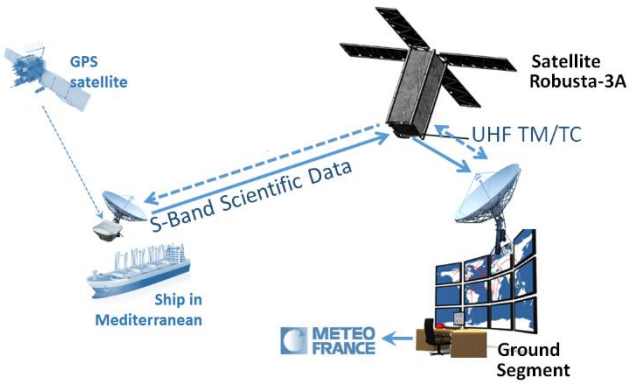
## ROBUSTA 3A & GEMMOC

### ROBSUTA-3A

The Robusta-3A is a nanosatellite project of the CSUM which has the following objectives:

- Technology demonstration of a 3-axis controlled nanosatellite including novel technologies: such as CSUM in house UHF radio or ThrustMe I2T5.
- Participate into education via internships, project and student challenges (300+ students already involved).
- Support the GEMMOC project and weather prediction in southern France region via collection of water content data



## ROBUSTA-3A ADCS


FIGURE 3: ROBUSTA-3A ADCS

The above figure displays the Robusta-3A design elements. Students may find further information in publicly available datasheet. They may also use the information provided by other students that participate in the other challenges and/or information available in publication, conferences ….

## ROBUSTA-3A MECHANICAL AND MASS PROPERTIES

After registration students may contact the CSUM to obtain the following information:

- simplified CAD with elements location,
- reference axes,
- matrix of inertia,
- center of mass coordinate

# I2T5
## COLD IODINE THRUSTER

Imagine having a cold gas thruster without a pressurized propellant tank –such a system is now available!
ThrustMe's I2T5 is a non-pressurized cold gas propulsion system operating with solid iodine propellant. The I2T5 stand-alone system includes the propellant storage, flow control, power processing unit (PPU), as well as thermal management and intelligent operation all embedded into a 0.5U form factor. Its standardized architecture allows for very short lead times and batch production to better serve constellation needs.

## PRODUCT INFORMATION


I2T5

### ADVANTAGES
- ü Safe
- ü Convenient
- ü Economical

### PERFORMANCE & SPECIFICATIONS

| | |
|---|---|
| Thrust | 0.2 mN |
| Total impulse | 75 Ns |
| Form factor | 0.5 U |
| Total wet mass | 0.9 kg |
| Total power | 5 - 10 W |
| Start-up time | 10 min |

### PRICING, DELIVERY & CUSTOMIZATION

| | |
|---|---|
| Price | starts at 14 000 € |
| Delivery | <12 weeks after ordering |
| Customization | Yes-Contact us. |

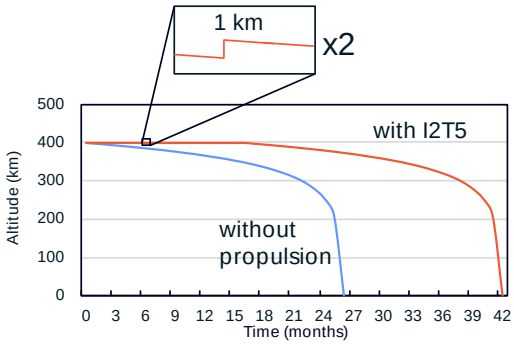
### INTERFACE

| | |
|---|---|
| Input Voltage | 12 –28 V |
| Bus interface | $I^2C$, CAN |

## ENABLING LONGER LIFETIMES AND DEBRIS MITIGATION

### CASE STUDY

| | | |
|---|---|---|
| Platform | Form Factor | 3 U |
| | Total Mass | 4 kg |
| Environment | Altitude | 400 km |
| | Avg. Atm. Density | $3.04^{E}$-12 kg/m$^3$ |
| I2T5 Propulsion | x2 Collision Avoidance ΔV | 1.14 m/s |
| | Atmospheric Drag ΔV | 17.61 m/s |

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## CHALLENGE RULES

Considering the Robusta-3A and I2T5 information given in the previous chapters the challengers shall propose:

**"an AOCS control algorithm" which is able to maintain the I2T5 thrust axis in a cone of 5° with respect to the orbit anti-velocity vector for as long as possible"**

Students shall take into account things such as:

- Reaction wheels momentum saturation,
- Actuator and sensors imperfections,
- Changes in the center of mass and center of inertia due to propellant depletion,
- Etc….

They must describe clearly the hypothesis and the reasons for considering or neglecting items.

**Duration of the challenge:** 4 to 6 months

**Deliverables:** Students may be up to five in the group and must submit:

- a written report, in English, describing the activities carried out, the original goals and the achieved ones with the NanoStar Template.
- a 15min presentation (video conference possible).
- a set of the algorithm developed in MatLab format.

**Composition of the team:** One or more students from the Universities of the NanoStar project. If possible as much women as men and from different countries.

## PRIZE

The winning team will be invited to visit the CSUM and ThrustMe in Montpellier as well as to the first in-orbit Thruster switch on which will be commanded from the CSUM Ground Station.

(IMPORTANT NOTE : No fund will be provided for travel expenses)

You will receive a diploma of participation and goodies from the University Space Center of Montpellier (CSUM), the University of Montpellier (UM) and NanoStar project and others rewards for the most innovative team.

If you are interested in this challenge, contact us at nanostar-projet@umontpellier.fr or on the NanoStar website.