Title: RETI-SAT: 3U CubeSat to monitor red tide blooming in Central America.

Primary Point of Contact (POC) & email: Mariela Rojas Quesada- marielarq1915@gmail.com

Co-authors:
E Araya-Gamboa N Bolanos-Murillo, J Campos-Mora, R Céspedes-Ulate, G Fonseca-Naranjo,T Montero-Montoya,P Quinde-Cobos, S Rodriguez-Vargas, O Quirós-Jimenez, F Salazar-López, F Segura-Hernández, M Molina-Montero.

Organization: University of Costa Rica(UCR)

(X) We apply for Student Prize.
( ) Please keep our idea confidential if we are not selected as finalist/semi-finalist.

Sustainable development goals: Zero hunger, Life below water, Life on land, Climate action, Good health and well being, Decent work and economic growth.

Need

Central America and the Caribbean Region has experienced more than 35 red tide blooming [1], with consequences on public health, ocean fauna (fishing industry), and tourism in territorial sea. As an example, in 2003 the death of large quantities of fish was reported, causing sickness to residents near the incident, and between 2006 and 2007 three persons died poisoned due to the intake of contaminated food [1][2]. At the same time, in Costa Rica high mortality of corals was identified at the Pacific Zone, moreover, a significant event happened at the end 1999: an algae bloom was detected in front of the Puntarenas coasts, lasting until March 2002 (in an intermittent manner). During that period its extension encased the north part of Guanacaste to the south of the Pacific coast in Quepos, including ”Golfo Dulce” [3]. This kind of algae blooming has been appearing in all the countries of the region, having similar effects as the ones in Costa Rica. Since 2003 in the Pacific Zone the dominating dinoflagellate was polykrikoides, causing red tide in Mexico with invasive events that spanned several kilometers of coast [4]. In Central America, specifically in El Salvador and Guatemala the blooming of these species was reported at similar times, reappearing in the next months and moving according to the ocean currents. The use of space technology to monitor red tide has been already tested at the Chinese Coast in 2000, at the Arabic Coast in 2008 [5]. Once the images were collected, the point of origin was determined using numerical methods and the evolution of the bloom was monitored. Previously in 2004, NASA used two satellites that brought information about the algae bloom at Florida's coasts during that period, by using MODIS and SeaWiFs, the data collected was not easily analyzed because of the lack of high quality ground measurements.

Mission Objectives

General Objective :

Offer a space system capable of taking multispectral images of different test sites, while also offering a *Store&Forward* capability for sensors placed at specific locations.

Specific Objectives:

- Detect and monitor red tide within selected targets in the territorial sea of Central America.
- Acquire images of red tide in the 450-700 nm range for the scientific analysis of red tide bloomings.
- Provide the space and ground systems necessary for the study of red tide blooming in Central America.

Reti-Sat

Concept of Operations

Ground Segment: This space mission consists not only of the satellite by itself, it's also required a ground segment for communication and the remote station to upload the scientific data to the space segment. The ground station will be a multi-mission station, it will be able to serve different LEO satellites missions in the future.
For the instrumentation a S-band receiver and an UHF/VHF receiver/transmitter will be required. The antennas system (UHF/VHF Yagi antennas and S-Band parabolic dish antenna), will be moved by an azimuth and elevation rotators and controllers. The GBS will use a satellite tracking software to predict when the satellite passes over the GBS footprint and move the antenna tracking system towards the satellite position.
As described previously, a key feature of the mission is the 'Store and Forward' system that will transmit scientific data from Remote Stations (RSS) located on the sea, up to the GBS. The RSS will consist of floating platforms on selected locations of Costa Rican seas, with a UHF/VHF radio system for transmit the data, weather and sea water sensors and an autonomous power system.

Launch Segment: The main option considered for the launch, it's via an ISS (International Space Station) deployment using SSOD(Small Satellite Orbital Deployer) from the Kibo (Japanese) Module. Primarily the idea is to take advantage of past launch services done in a similar project developed in the country.

Key Performance Parameters

- The satellite must be able to receive the data from the RSS and send it back to the Ground Base.
- The onboard camera is able to turn on and take pictures at the selected frequencies.
- Spatial resolution is better than 30m GSD with a swap of no more than 80 km.
- The satellite is pointing towards the pacific and caribbean coasts.

Space Segment Description

Optical Subsystem: RETI- Sat will carry a camera set up as a multispectral line scan device, in order to scan several multispectral bands across 500 nm to 700 nm, in the visible spectrum. The model to use will be a Gecko Imager, with the configuration described above, manufactured by Space Advisory Company. This is a novel solution for multispectral imaging that has a flight heritage since 2017 aboard nSight-1, the first privately funded, commercially developed, South African satellite [7].

Mechanical Subsystem: Taking into consideration important parameters as the weight limitation, life span and components, the principal material on the structure's design of the satellite is Aluminum 6061 or 7075 T-6. The satellite will have dimensions of 10mm x 10mm x 30mm, being 3U standard CubeSat . Solar panels arrays will cover the side edges of the structure which will provide the required power consumption for all the components. The structure will have the required holes for the camera lens.

Thermal Control Subsystem: To maintain the components temperature in the adequate range it is necessary to implement a passive thermal control system. The first factor to deal with, is the external heating source and to prevent the rise of the temperature a Multi-Layer Insulation on the external surface must be use. Also, to release heat generated by the components, the satellite will have a heat sink system.

Command and Data Handling Subsystem: For the control of all satellite subsystems the high performance on-board computer iOBC from Innovative Solutions In Space.Inc (ISIS) has been chosen, because of the large amount of data that need to be processed and stored. Furthermore, each one of the satellite subsystems (i.e: EPS, ADCS, COM and Payload Camera), will have a microcontroller for interfacing with the OBC, through an I2C shared Bus. The communication system of the satellite will consist of a UHF/VHF transceiver from ISIS.Inc, alongside a custom four monopole turnstile antenna for TT&C, this configuration is capable of transmitting and receiving data with a speed of at least 1200 bps, enough for transmit telemetry data and receive commands from ground segment. For downloading the payload data, a high speed transmitter is needed. Therefore the TX-2400 S-Band Transmitter from SpaceQuest Ltd, has been chosen, alongside a S-Band Patch Antenna provided by EnduroSat. This last configuration is capable of establishing a Downlink up to 6 Mbps.

Electrical Subsystem: The satellite has a peak power consumption of 10 W, while the satellite is in the light period, it has an average power consumption of 7.6 W, in the other case, as the satellite is in the eclipse period the average consumption is 6.6W. The camera Gecko Imager from SAC, is the highest consumption equipment with a consumption of 3.5 W while taking images, only when the satellite is on the light side of Earth, while in readout mode it has a consumption of 2.5W. The ADCS system has a consumption of 2 W, as it is integrated with 3 reaction wheels, 3 magnetorquers, a star-tracker and a computer. The CDHS has a consumption of 4.6 W. The satellite will carry 8 battery cells, 13 solar cells and a EPS all made by GOM space in order to maintain compatibility across the subsystem.

Attitude Determination and Control Subsystem: In terms of navigation and control the satellite has the requirement to be three axis stabilized in order to allow for the successful completion of the EO mission [6]. Therefore the ADCS is composed of three reaction wheels, three magnetorquers for attitude control, and for attitude determination a GPS, 3-axis IMU, and a Star Tracker, all of these connected to a control computer. All of them are contained in a single package provided by "Hyperion Technologies" in it's model iADCS 100. The model allows a pointing accuracy of <1 degrees.

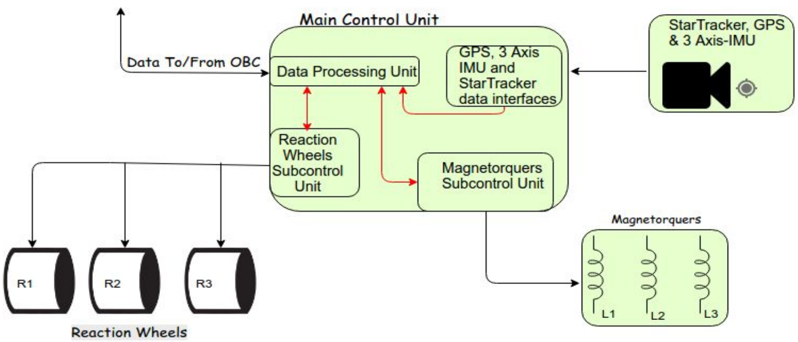

Figure 1: ADCS Block Diagram

Orbit/Constellation Description:

Orbital elements considered for the mission, depend on the launch from ISS and SSOD. The idea is take the advantage of the existing facilities at the ISS, and at the same time to make cheaper the launch and reduce the cost of the satellite project.

Implementation Plan

Currently red tide is one of the most researched natural phenomena, because red tide not only impacts the marine ecosystem it also produces negative economic effects. In response to this many government authorities are looking for integral solutions to the problem. The mission contemplates cooperation with CIMAR(Sea and Limnology Research Center University of Costa Rica) for the scientific interpretation and managing of data, as well as providers for the RSSs. CIMAR will also be responsible to communicate the alerts of red tide detections to the corresponding authorities. The government of Costa Rica, recently created a commision for the study and mitigation of red tide, therefore one our possible principal financial contributors comes from the government. The satellite design, construction and testing corresponds to the Aerospace Engineering Group at the University of Costa Rica, which will provide the students and professors necessary for the space system development as well as the international cooperations needed for testing. The launch service provider selected will be JAXA, with the SSOD. The timeline of development is presented in Table 1. In Table 2, the estimated costs of the mission are presented and in Table 3, possible mission risks are listed.

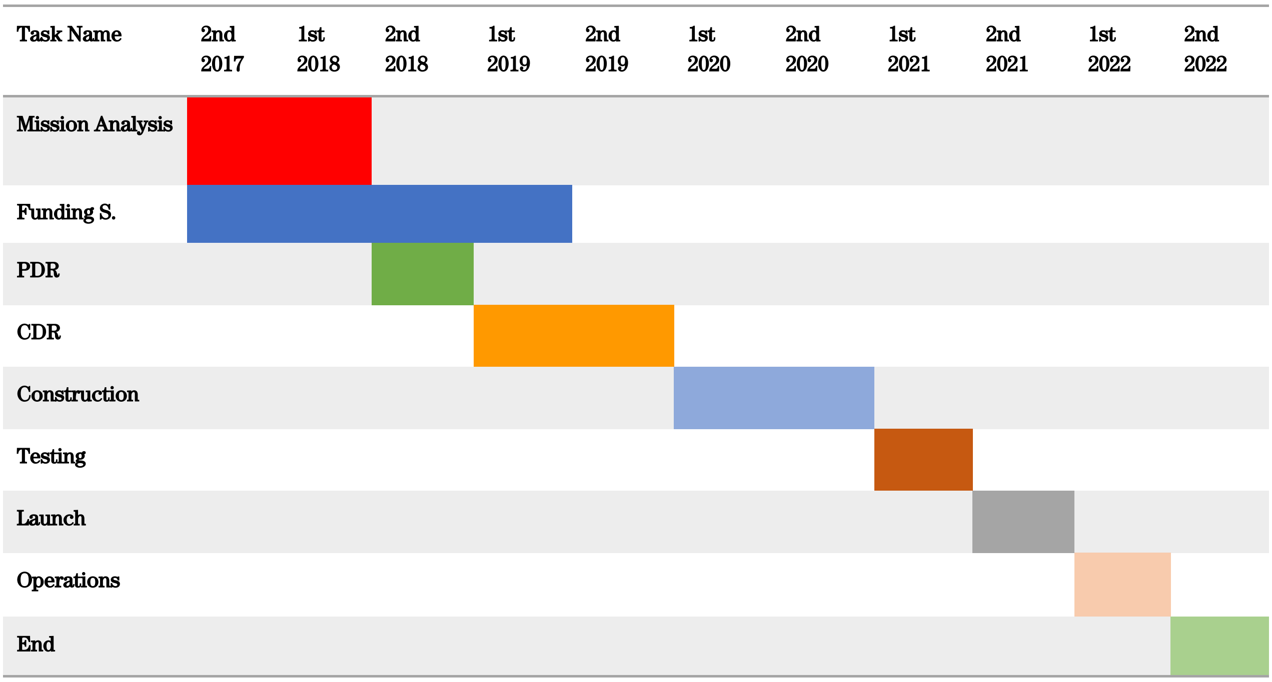

Table 1. Implementation Plan proposed timeline

Item	**Company/Model**	**Description**	**Price (USD)**
Camera	Chameleon Imager(Space Advisory Company)	Gecko Imager setup as a multiespectral line scanner.	2, 000
Solar Panels	P110 Solar Panel (GOM space)		
Mechanical Structure	In House	UCR Model	
Batteries	Nano Power BPX (GOM space)		
Electrical Power System			
OBC	iOBC (ISIS)	ISIS On Board Computer / Possibilities of building it in-house	11,600
Communications			
ADCS	iADCS-100(Hyperion Tech.)	Integrated ADCS System	35,000

Launch	JAXA/Kibo		72,000
Ground Base Station	In-House	Ground Station facilities in the Costa Rican Institute of Technology.	0
Marine Station	In-House	Marine Station system developed by UCR Students(CIMAR)	20,000
Total			

Table 2. Preliminary Estimated Costs of Mission

RISK	**PROBABILITY**
Images with not enough resolution for mission needs.	MEDIUM
Collision with space debris in LEO.	LOW
Inexperience caused failures for being developed mainly by students.	MEDIUM
No capture of red tide events during time of mission, because of their sporadic nature.	MEDIUM
Acquisition and lost of signal from orbit or weather reasons.	MEDIUM
Insufficient funding for mission development	HIGH

Table 3. Identified Mission Risks

References

[1] P. Blanco*, Países de la región se preparan ante las mareas rojas en el mar Caribe.* University of Costa Rica. Feb 2018, taken from*:* https://www.ucr.ac.cr/noticias/2018/02/28/paises-de-la-region-se-preparan-ante-las-mareas-rojas-en-el-mar-caribe.html

[2] E. Calvo, *Factores Bióticos y Abióticos Relacionados con la Distribución del Dinoflagelado Tóxico Pyrodinium bahamense var. compressum (Plate 1906) en el Golfo de Nicoya, Costa Rica.* Ph.D thesis, Universidad Nacional, 2002.

[3] E. Freer and M. Vargas Montero, *Floraciones algales nocivas en la costa pacífica de Costa Rica: Toxicología y sus efectos en el ecosistema y salud pública*, 2003.

[4] M. Cortes Lara, R. Cortés Altamirano, and A. Sierra Beltrán, *Presencia de Cochlodinium catenatum (Gymnodiniales: Gymnodiniaceae) en mareas rojas de Bahía de Banderas, Pacífico Mexicano*, Revista Biología Tropical, vol. 52, no. I, pp. 35–49, 2004.

[5] J. Zhao and H. Ghedira, *Monitoring red tide with satellite imagery and numerical models: A case study in the Arabian Gulf*, Marine Pollution Bulletin 79, vol. 79, pp. 305–313, 2014.

[6] Wertz and W. Larson, *Space mission analysis and design*, 3rd ed. Torrance, Calif.: Microcosm, 1999.

[7] D. Malan, W. Kannas, H. Burger and L. Visagie, *The Development of 'nSight-1' - Earth Observation and Science in 2U*, SCS Aerospace Group, South Africa, 2017.