Title: Sargassum One: A 3U CubeSat Constellation Mission for Sargassum Monitoring

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Need: Sargassum, a non-anchored floating seaweed, pollutes and negatively impacts the Dominican Republic, the Caribbean, and Latin America. This pollution results in economic losses, health problems, and the shutdown of thermoelectric power plants. However, limited technology and insufficient data hinder progress, leading to slow outcomes.

Mission Objectives

Our mission is responsible for achieving the following set of goals:

• **Detection and monitoring sargassum throughout its life cycle:** This involves studying the behavior, spread, fertilization, and decay.

• **Studying the impact of its gas emissions on our health:** Sargassum pollution poses health risks through emitted decay gases (methane, ammonia, hydrogen sulfide). These gases can cause respiratory issues, skin burns, irritation, unconsciousness, and potential lung/skin cancer. Collected data aids health authorities in prevention and understanding gas extent and harm thresholds.

• **Evaluating its impact on water temperature and its contributions to global warming:** Sargassum causes localized sea warming and releases harmful methane. Approximately 40 million cubic tonnes of sargassum wash up on shores annually, contributing to atmospheric warming as methane absorbs solar heat.

Concept of Operations

In order to accomplish our objectives, it is essential that our mission adheres to the subsequent steps:

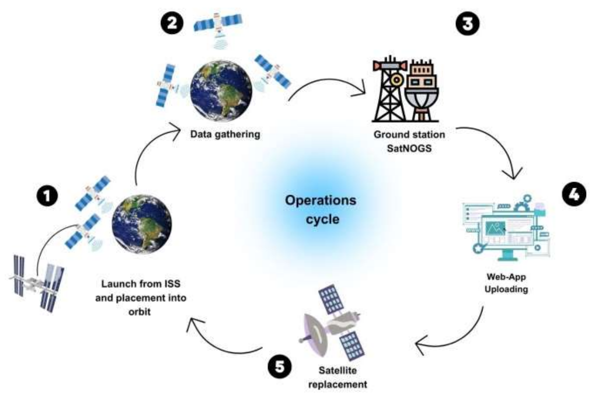
Phase 0 - Sending the CubeSat constellation into space: We aim to launch our constellation via the International Space Station in 2026, targeting a 400 km orbit. Our Guidance, Navigation, and Control System will position the constellation in a polar-circular orbit at 750 km altitude, 14 degrees elevation, and 57 degrees inclination. The Walker Delta pattern (6/3/1) constellation, with 6 satellites in 3 planes, covers and studies the region from West Africa to the Gulf of Mexico, extending slightly to include New York.

Phase I - Data acquisition: Once deployed, the constellation's CubeSats will continuously monitor sargassum with 6-hour intervals, providing near real-time data. Our spectrometer captures gas emissions, chlorophyll levels, sargassum tracking, positioning, and water temperature information.

Phase II - Data transfer: We've partnered with SatNOGS to access and share raw data from our constellation mission, addressing sargassum's global impact. This data supports our web application and worldwide scientific and governmental studies. Collaboration and partnerships are encouraged, and our university's registered ground station is part of the SatNOGS network.

Phase III - Uploading to our web application: Acquired data is filtered, analyzed by AI, and uploaded in real-time to our web application, informing people in the Dominican Republic about sargassum's movements, pollution, and evolution.

Phase IV – End of life and replacement: We will arrange a controlled descent for the non-functional satellites and ensure timely replacement deployment to maintain uninterrupted data transmission.



Short diagram, Phases of our mision.

Key Performance Parameters

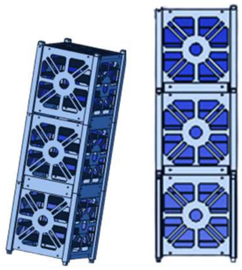
• **Spectrometer:** A spectrometer covering the 555 to 755 nm bands is important for studying sargassum from space. These wavelengths are highly sensitive to the pigments in marine algae, allowing for accurate differentiation and monitoring of sargassum types, distribution, abundance, and long-term changes. The spectrometer provides valuable insights into sargassum dynamics, aiding in effective management strategies for this natural phenomenon.

• **Data fusion:** Plays a crucial role in a CubeSat-based Sargassum observation mission by combining observations from various sources and sensors. This enhances understanding and management of Sargassum dynamics, improving accuracy and providing valuable contextual information.

• **Data transmission:** Transmission of data is vital in a Sargassum monitoring mission as it ensures sufficient storage, enables real-time information, maximizes sampling opportunities, and optimizes resource utilization for efficient data acquisition and analysis

Space Segment Description:

We'll use practical and cost-effective 3U CubeSats for the optimal Walker Delta Constellation. Adhering to NASA guidelines, each 3U CubeSat measures 30×10 cm, weighs 4 kg, and has a volume of 3000 cm^3. Total mass for all satellites is approximately 36 kg. Our system will have an electrical power of 216W and a peak power of 21.7mW, efficiently supplied by solar cells.



Scale model of the satellite.

Required Delta V: To position our satellites in the desired 750 km orbit, we will utilize the International Space Station located approximately 400 km away. This will require a Hohmann Transfer. After some calculations our Delta V will be around: ΔV =186.1686 m/s. Please find below the cost breakdown for our mission

Part number	Structures	Prices (MSRP $) USD	weight (grams)
703-00292	Chassis Walls 13 – skeletonized, 3U	2,955.00	213 g
710-00794	Base Plate Assembly – skeletonized, dual Separation Switches 3	690	55 g
	Rod & Spacer Kit, 3U	330	35.2 mg
710-00650	Hinge for Deployable Solar Panel 25	2,500.00	<0.5 kg
703-00398	Payload Adapter Plate	360	35 g
710-00407	Payload Cover Plate Assembly	495	35 g
710-00784, 710-00783	Cover Plate Assembly for AntS antenna Base Plate Assembly for AntS antenna	1,085.00 955.00	35 g
711-01002	Solar Panel Clips Set for AntS antenna – for 0.031"/0.8 mm side PCBs (set of 4 clips)	395	< 1 g
	Microships		
	CubeSat Kit /dsPIC33, skeletonized, 3 U	11,500.00	200 g
	Communication system		
711-01012 /C0 /F1	GPSRM 1 GPS Receiver Module Kit, utilizing NovAtel® OEM615V-series space-grade GPS receiver. GPS L1 + L2.	17,320.00	35 g
710-00837	(End) solar panel for AntS antenna, 2 largearea triple-junction solar cells, 0.025"/0.6mm thick	4,730.00	275 g
	Power system		
710-00670	Front/Side Panel, 3U, 7 large-area triplejunction solar cells	5,650.00	155 g
632-00413	External Power Supply 6-12Vdc 11	80	45 g
710-01640	Battery Module 2 (BM 2), Intelligent Protected Lithium Battery Module with SoC Reporting with up to eight 18650-size Li-Ion cells.	10,500.00	700 g
711-00338	Linear EPS Module	980	200 g
	Telemetry		
-	HyperScape100 Product	~10000	1.1 kg

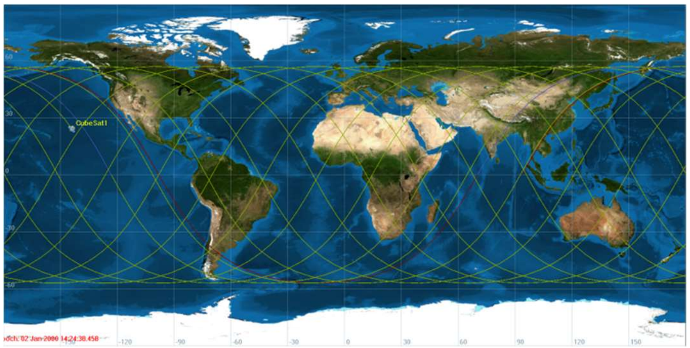
3U CubeSat parts table.

Orbit/Constellation/Description

For our mission analysis, we have selected a circular polar Low Earth Orbit (LEO) at 750km altitude, 14 degrees elevation, and 57 degrees inclination. This configuration provides a coverage area determined by the following formula: $A = \frac{3\sqrt{3}}{2} \times (1{,}781.11km)^2 = 8{,}242{,}014.427km^2$

We will employ the Walker Delta constellation (i: t/p/f) for our mission, which offers near-continuous global monitoring. This constellation type has gained popularity for its effective monitoring capabilities. With the need to cover a large area and diverse satellite positions, the Walker Delta constellation aligns perfectly with our requirements. It consists of 6 satellites distributed across 3 orbital planes (t=6, p=3).

$$\text{Define Pattem Unit. PU} = \frac{360deg.}{t} = \frac{360deg.}{6} = 60deg;\ Inplane\ spacing\ between\ satellites = PU \times p = 60 \times 3 = 180deg;\ Node\ spacing = PU \times s = 60 \times 2 = 120deg;\ Phase\ difference\ between\ adjacent\ planes\colon PU \times f = 60\ x\ 1 = 60deg.$$



The configuration consists of 6 satellites, with 2 per plane and a 120-degree offset between pairs. Nodal separation between planes is 180 degrees. The formation effectively covers the target observation area from West Africa to the Gulf of Mexico, extending further north to include New York, with efficient data transmission periods.

Implementation Plan

We seek collaboration with the Ministries of Environment, Higher Education, Science and Technology, Energy and Mines, and Tourism for our Constellation Mission to tackle sargassum pollution. These ministries will provide funding to support project implementation. However, it is anticipated that the allocated amount may not fully cover the total funding needed for project development.

CubeSat design, assembly, and testing will take place at our UNAPEC laboratory. Each CubeSat is expected to have a lifespan of around 6 years. Please find below a summary of the cost breakdown.

Part number	Structures	Prices (MSRP $) USD	weight (grams)
703-00292	Chassis Walls 13 – skeletonized, 3U	2,955.00	213 g
710-00794	Base Plate Assembly – skeletonized, dual Separation Switches 3	690	55 g
	Rod & Spacer Kit, 3U	330	35.2 mg
710-00650	Hinge for Deployable Solar Panel 25	2,500.00	<0.5 kg
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710-00837	(End) solar panel for AntS antenna, 2 largearea triple-junction solar cells, 0.025"/0.6mm thick	4,730.00	275 g
	Power system		
710-00670	Front/Side Panel, 3U, 7 large-area triplejunction solar cells	5,650.00	155 g
632-00413	External Power Supply 6-12Vdc 11	80	45 g
710-01640	Battery Module 2 (BM 2), Intelligent Protected Lithium Battery Module with SoC Reporting with up to eight 18650-size Li-Ion cells.	10,500.00	700 g
711-00338	Linear EPS Module	980	200 g
	Telemetry		
-	HyperScape100 Product	~10000	1.1 kg
	CubeSat Deployment		
	3U CubeSat deployment from the International Space Station	$270,000	-

3U CubeSat Parts table.

The next set of constellations will be deployed in around 6 years. Considering the expected cessation of operations for the International Space Station by 2030, we will need to explore alternative service providers to meet our mission requirements.

Our project's timeline spans from 2023 to 2024, encompassing 24 months for planning, development, and launch. Initial tasks include defining project objectives and stakeholders, with feasibility analysis conducted in the first 3 months. Material procurement, payload definition, and CubeSat design will take place from months 4 to 6. Subsystem construction, web application development, and AI implementation are scheduled for months 9 to 15. CubeSat testing and assembly will occur from months 16 to 21. During months 22 to 24, we will engage with the appropriate space agency for CubeSat launch, potentially the International Space Station. Phases 0 to 4 of the concept of operations section will be completed beyond month 25.

We currently face the following risks:

Financial constraints: Uncertainty in securing sufficient funds for the project.

Lifespan: Need for scheduled replacements to ensure uninterrupted data transmission.

Solar flares: Potential disruption or damage to satellite electronics.

ISS transition: Transition plan from the retiring ISS to commercially-owned low-Earth orbit destinations (CLDs).

Space debris: Due to its potential to cause damage.

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