Qualification of Maritime and Sustainability issues arising from damming of Mekong river using 3U Cubesat hyperspectrometry

Vesta Tian Su-en [1]

[1] School of Life Sciences and Chemical Technology, Ngee Ann Polytechnic

1 Introduction

The Mekong River, one of the world's most significant waterways, serves as a lifeline for millions of people across Southeast Asia. However, the construction of dams along the Mekong has introduced a myriad of maritime and sustainability issues, destabilizing the region around Singapore. This proposal aims to qualify the impacts of this ecological disaster, by using satellites SAR and employing altimetry to study water flow and quality. Uniquely, satellite data available can provide information of high veracity to better advise policymakers and scientists in Southeast Asia, supporting Singapore's interests in a stable, secure, and sustainable region.

1.1 Contribution

- Replicate that the rapid expansion of hydropower is more important to the decimation of lower Mekong fisheries than extra low rainfall and the El Nino effect.
- Investigating changes in water levels and flow patterns in local basins, lakes, and rivers, and impacts on droughts and water scarcity.
- Assess levels of trash, sediment, and pollutants in the water, as well as the occurrence of algal blooms during monsoon pulses, to understand broader environmental degradation.
- Predict effects on fishing yields, crop production, biodiversity, of the Indochina region.

2 Science Objectives

The Tonle Sap river's annual monsoon flow reversal causes the lake to expand to five times its dry season size and move enormous amounts of sediment, organic material, fish eggs, and young fish (Brian Eyler, 2021) which are responsible for supporting the entire fishing industry and ecology. Satellite data can provide in real-time the current statistics, for comparison with historical trends.

A dedicated LEO nanosatellite earth observer will fill temporal gaps in aerospatial data on the water level, flow, trash, sediment levels in the Mekong region, which will explain changes in volume of fishing and biodiversity in the Mekong region, so as to inform responses to drought and a catastrophic fishing economy and ecology. This will clarify trends still being established by other earth observers, and include sensors calibrated specifically for water body observation. A focus on fluvial geomorphology will also aid policymakers to identify sources of the degradation of the annual monsoon flow reversal.

Satellites also help cover large areas inaccessible by land, provide a whole view of the entire river basin, and offer consistent and long-term monitoring to detect gradual changes and trends with diverse equipment such as LiDAR, SAR, and Hyperspectrometers. However, on-the-ground efforts are still paramount for a hollistic understanding.

2.1 Literature Review

Local governments, Mekong River Commission (MRC) and grassroots efforts are responsible for managing the development of the Mekong River. However, China and MRC have been obstructionist to qualifying and managing the impact of hydroelectric installations on droughts, despite that damming is known to disrupt thermal and flow regulation of other large river bodies. (Yang et al., 2022)

From space, grassroots work has been supported by NASA's open-science SERVIR-Mekong, Earth Observation Fleet, demonstrating enhanced Mekong flood response, drought Resilience, crop yield security, and reduced forest fires (USAID.gov, n.d.).

In other water bodies, water availability prediction models for conservation have been successfully constructed using just Google Earth and regression AI (Evans et al., 2021), yet SERVIR has neglected such areas, with satellite data missing on the the death of biodiversity, health of fisheries, reduced clean water availability, and fluvial geomorphology of the Mekong.

Thus, there is a data niche to be filled by a cross selection of data with NASA's MODIS and IKONOS, and a new LEO orbiting nanosatellite with RAAN matching daytime over the Mekong. This possibility was addressed in a 2007 satellite-driven report of the Mekong(Gupta et al., 2007), but it is more necessary now, 20 years later, as the monsoons are failing to bring 70-90% of fish into Tonle Sap.

3 Scientific Requirements

3.1 Geomorphology Measurements

Of the Mekong River, Mekong Basin, Tonle Sap Lake: Channel bed height m, surface height m, lake surface area m^2, surface flow velocity ms^{-1}. Use of rapidly shot still imagery and Synthetic Aperture Radar. Of floodplain: Elevation m , cross sectional profile, surface roughness $m/100m$. Use to quantify channel migration, bank erosion, and sediment deposition.

3.2 Solid and Organic Suspensions Measurements

Organic sediment concentration and grit size distribution m^{-2}(% of $400-800nm$) wavelength reflected back). Wavelength corresponds to UV-visible which is absorbed greatly by organic grit, and can penetrate water to a certain depth.

3.3 Biomass estimations

Of floodplain, normalized Difference Vegetation Index m^{-2}(% of $630-680nm$, $780-900nm$) wavelength reflected back. Vegetation health reflects on time averaged water availability. mates from ground sampling. Of water, surface Temperature, Fish shoaling and migration m^{-2}(% of $750-1000nm$) wavelength reflected back.

3.4 Data Collection and Analysis Requirements

Temporal Resolution Daily to weekly revisit times for all instruments. **Calibration and Validation** Correct interference from the atmosphere. Ensure accuracy and reliability of satellite data with on-the-ground measurements, cross-validation with existing satellite data (MODIS, IKONOS). **Data Integration** Combine satellite data with historical records and on-the-ground observations, AI-based models for prediction and analysis.

4 Proposed Payload

4.1 Instrumental Requirements Measurements

LiDAR High-resolution (<10m), ability to penetrate vegetation for Height Volume Topography. **Synthetic Aperture Radar (SAR)** High spatial resolution (<30m), capability to penetrate clouds and operate day/night for Floodplain and Floodway Profile. **Hyperspectral Sensors** High spectral resolution (10 nm or better), multiple bands covering visible to near-infrared spectrum, for quantifying sediments, organic materials, and fish habitats. **UV-IR Sensor** Moderate to high spatial resolution (5-30 meters) to monitor conditions for Sediments, Organic Grit, Biomass. **High-Resolution Optical Cameras** Very high spatial resolution (sub-meter), capability to capture clear images under various lighting conditions to identify trash, pollutants, and build floodplain profile. *See Annex for budgeting and scheduling.*

5 Proposed Mission Configuration and Profile

Sun Synchronous Orbit, crossing 13-20°N latitude and 103°E longitude $SMA = 7078km, ECC = 0, INC = 98, RAAN = 103, AoP = 0, TA = 0$: RAAN, AoP, TA are values upon injection. RAAN precess at approximately 1° per day.

System Requirements High precision (less than 0.1 degrees) to ensure accurate targeting of regions of interest, maintain optimal sun angle for passive optical sensors; typically 10-30 degrees off nadir for best illumination

5.1 Mission Requirements

- Revisit time over the target area no longer than 24 hours, ensuring frequent data acquisition.
- Novel data generated shall be downloaded within one orbit after acquisition to ensure timely availability for analysis.
- Regular calibration and validation with on-ground measurements and cross-validation with existing satellite data (MODIS, IKONOS).
- Integrate collected data with historical records and on-the-ground observations, utilizing AI-based models for prediction and analysis.
- Employ atmospheric correction algorithms to remove interference from the atmosphere and enhance data accuracy.

6 Annex

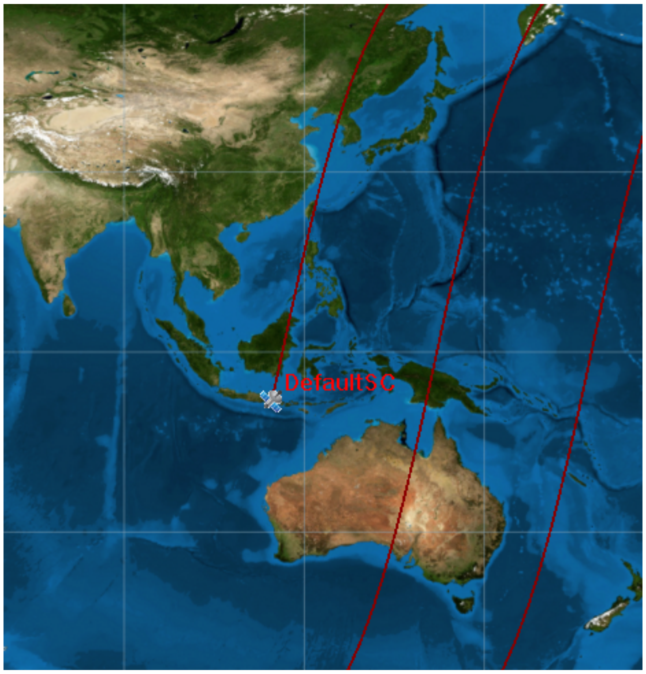

Figure 1. Satellite Mission Path

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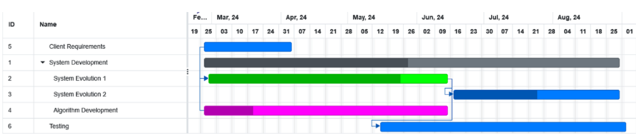

Figure 2. Project Schedule and Deliverables

Item	Data Rate/Mbps	Size/cm3	Mass/kg	Power/W	TLR
Optical Camera	60	200	0.3	10	9
LiDAR	10-20	200	0.3	15	9
SAR	50	200	0.3	20	9
UV-IR	20-40	200	0.3	5	7
Total	150-200	800	1.2	50	8.5

Table 1
Performance Budget

Acknowledgements

Proposal Template jointly provided by CAS, ESA Thanks to support of my wife Evelyn Dai.

Launch Phase	Coordinate with Launch provider and undergo initital depolyment and system checks
Commissioning Phase	Detailed calibration of all instruments will be conducted to ensure they operate correctly. Baseline measurements taken.
Operational Phase	Daily Routine Data collection with Periodic calibration and cross-validation with historical records
Science Phase	Analysis and Distribution of Data to the Scientific Community.
Decommissioning	Controlled Deorbiting

Table 2
Mission Life Cycle

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