Massachusetts Institute of Technology
Center for Space Research

Coral Reef Mission

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Solicitation of Industrial Partners

The MIT Center for Space Research in association with the Planetary Coral Reef Foundation is working on the design and implementation of a coral reef survey and monitoring mission. Our vision is to operate a modest multispectral instrument in a sun synchronous orbit for a number of years, mapping the location and assessing the health of coral reefs on a global basis. Dr. Phil Dustan of the College of Charleston is serving as the mission Principal Investigator.

While providing top level management and financing of the mission, PCRF has designated MIT as the space flight mission manager, responsible for the procurement of the spacecraft bus and launch services as well as mission systems engineering and instrument fabrication. MIT, in turn, will select industrial partners to provide spacecraft, launch, and mission operations support.

MIT is currently generating a Mission Description Document (MDD) which will define the overall mission design and provide insight into the design of the flight instrument and spacecraft bus, launch opportunities, ground systems, mission operations, science operations, program management approach, and cost. In addition such topics as basic scientific requirements, ground truth surveys, educational programs, and public data dissemination will be addressed by the PCRF and incorporated into the MDD. To be finished in the Fall of 2002, this Document will form the basis first for establishing a projected cost for the mission, and second to support a fund raising effort by PCRF to acquire the money necessary to accomplish the mission. We will not be surprised if final MDD concludes that $75M is necessary for the adequate funding of the Coral Reef Mission.

You are being asked to consider joining the PCRF/MIT team in the implementation of the Coral Reef Mission. At a minimum we seek an organization which will provide the usual and customary services of a spacecraft vendor at a fair and reasonable price. In response to this request we are looking for enough information to form a basis for partner selection, realizing that many details will remain to be worked out in the final negotiation of a contract.

1 Mission Overview

1.1 Science and Public Education

The immediate science goal of the mission is two-fold: to map the location of all shallow ocean reefs around the globe, and to monitor the short and long term health of selected reef systems. The more long range goal of the mission is to increase public awareness of the fragility of the ocean ecosystem and to provide data which will serve both the public and governmental agencies in providing wise stewardship of the world's ocean resources.

1.2 Science Instrument Implementation

We have baselined a multi-spectral optical science instrument whose individual optical systems are hard mounted to a spacecraft instrument deck. The instruments have no scan mechanism. Target acquisition is accomplished by rolling the spacecraft cross track up to 15 degrees and then letting the orbital motion sweep along the (offset) ground track while executing a 1 RPO pitch motion. Pixel resolution is nominally 10 meters.

In detail, there are 12 nominally identical telescopes differing only in the optical filters provided. Each telescope images onto a 1Kx1K visible CCD which is read out row-by-row as the spacecraft passes over the target (referred to as Time Domain Integration or Image Motion Compensation, depending upon your heritage). The 12 focal planes will be cooled both to reduce dark current and to minimize radiation damage.

For many reefs, a single image set of 12 1Kx1K pixels – covering a 10Km x 10Km area – will suffice. For others we will stretch along the direction of flight. Experiment electronics will digitize, cosmic ray reject, evaluate, compress, and packetize the image sets and forward them to the spacecraft for storage prior to downlink. On any given orbit we will only image a few (at most) reefs; the duty cycle is not high.

1.3 Science Data Acquisition

This mission is narrowly targeted to coral reefs and, except for possible calibration targets, we will only take data when a coral reef can be successfully imaged. This means that we only collect, and only telemeter, a highly restricted data set compared to a typical global survey mission. We use this constraint to limit both our RF downlink as well as our science data processing requirements.

1.4 Operations

Mission operations are viewed as being a fairly straightforward proposition – monitoring the health of a mostly autonomous spacecraft and assuring the availability of Level 0 science data. Science operations, on the other hand, will be unusually complicated by the need to work around daily changes in cloud cover and sea state conditions. (We estimate that observing efficiency can be increased by at least a factor of 4 through daily intervention as opposed to weekly target selection.)

2 Requirements and Goals

The order given below should not be taken as any indication of priority.

2.1 Reliability

The instrument and spacecraft design will ensure that very few single point failures will exist which would result in a total loss of mission. Robust design, component selection, redundancy, and manufacturing processes must work together to ensure a reasonable confidence of achieving a ten year operating lifetime. A preliminary mission SR&QA plan, MIT Dwg. No. 43-09001 Rev. 01, is available which addresses these and related Safety, Reliability, and Quality Assurance issues.

2.2 On-line Documentation

All released documentation pertinent to the design and operation of the instrument and spacecraft will be available on-line, accessible in a web browser environment.

2.3 Instrument Mass

The current instrument mass best-guess is 75Kg.

2.4 Instrument Power

The current instrument power best-guess is 50W orbital average, 200W peak (5 minutes).

2.5 Instrument Footprint

The current instrument footprint best-guess is 3000 cm^2 on a nadir-looking platform.

2.6 Instrument Radiator

A dedicated radiator will be required to cool the instrument focal planes; radiator design could be either a spacecraft or an instrument function, but should be assumed to be a spacecraft responsibility for purposes of this solicitation.

2.7 Instrument Data

The instrument will generate a nominal 1Gbyte of compressed, packetized data/day.

2.8 Instrument FOV Knowledge

The mission requirement is to place the instrument boresight on the Earth within 300m of the commanded position and to know the absolute position after the fact to within 100m. Jitter during data acquisition must remain well within the 10 meter pixel size. In order for the image plane to be properly aligned for scanning, the rotation of the spacecraft relative to its flight path will probably have to be controlled to better than 0.1 degrees.

Slewing cross-track to acquire a new target within the same orbit is probably desirable, but we have not yet done the analysis to tell us the effects of slew rate on observing efficiency.

2.9 Contamination Control

Especially given the desire for a long mission life, the Observatory will require a unified Contamination Control Plan. Volatiles which can re-condense on the cold CCD focal planes or the telescope optics will have to be avoided through careful parts selection and bakeout. Similarly, long life of thermal protection systems and radiators requires care. Thermal-vacuum verification testing, for example, will require chambers which can support single-digit TQCM readings with the flight hardware installed.

2.10 Command and Data Handling

Command and telemetry packets will conform to CCSDS standards. Electrical interfaces will be MIL-STD-1553 except for science data which will be RS-422.

2.11 RF Systems

A single S-band ground station is assumed, although other scenarios may be proposed. A continuous UHF transmission (Automatic Picture Transmission format) of the latest image taken must also be provided.

2.12 Spacecraft Autonomy

An observing schedule will be uplinked daily with targets specified by longitude, latitude, and length of swath. The spacecraft must autonomously place the instrument boresignt on target and send commands to the instrument to start and stop data acquisition. (On-board ephemeris determination is assumed.)

An adequate "safe hold" mode or modes should be implemented; in case of operational error or anomaly the spacecraft should automatically avoid permanent damage to itself or the science instruments. There must not be any requirement for rapid reaction by ground control.

2.13 Launch Options

We believe that the potential spacecraft providers will have more insight into launch options than MIT. There are several factors which must be considered here, including compatibility of the proposed spacecraft design with the launcher, cost of launch services, and schedule impacts of meeting statutory requirements; e.g. ITAR. We expect that any response to this solicitation would address launch options and associated costs.

2.14 Orbit Acquisition and Maintenance

We wish to operate in a (nominal) 500Km, sun-synchronous orbit at local noon. A hydrazine propellant system is assumed for initial orbit acquisition and periodic maintenance (stay within 20 minutes of the local noon/midnight line).. Momentum dumping should be autonomous.

3 Program Considerations

3.1 Technical Content

We seek a response to this solicitation that, as a minimum, addresses the issues raised in Section 2 above. We do not need to be convinced that momentum wheels work, nor that your facilities are exemplary (we will discover that for ourselves in a site visit). What we do need to get is a feeling that your engineering team understands what about this spacecraft bus is routine, and what areas will require original thought. We seek to optimize the entire mission, so to some extent your response needs to address how more (or less) effort put into the flight systems will result in less (or more) effort in ground systems.

3.2 Organizational Support

It is necessary that the selected organization commit to supporting, using its own resources, the preparation of the Mission Description Document. Your contribution to that document will need to address issues of design, performance, management, quality assurance, and cost in some detail.

3.3 Cost Estimating

MIT would appreciate your providing us an estimated cost based upon a fixed price contract along with a general schedule of payments. We will, in the end, entertain any reasonable financial proposal – including cost plus or incentive contracts – but we wish to evaluate all responses to this solicitation on a consistent basis. You may, if you wish, provide us with an indication of your preferences in this area.

Experience with missions in a more advanced stage of definition than this one has taught that, in the evaluation process, much adjustment has to be made to the cost numbers in light of the specific technical implementation chosen. A low cost without a basis for the savings, or a high cost without a basis for the extra expense will not fare well here.

3.4 Launch Costs

A launch vendor contract could be issued directly by MIT or managed by the spacecraft vendor. For any launch scenario presented a cost (and basis for the estimate) should be provided as a separate line item.

3.5 Ground Operations

Ground operations, data transfer from ground station to the mission operations center, and Level 0 data management may be separately proposed by the spacecraft vendor, but this is not required. As there is a possibility that these services may be donated in whole or in part, no commitments in this area will be made until the program is well under way.

The usual operations support to L+30 should be included as part of your standard pricing.

3.6 Schedule for Planning Purposes Ground Operations

Although we have given a development schedule below for planning purposes, the spacecraft vendor should propose whatever schedule is optimum considering cost and development risk which satisfies the target launch date.

- Release of RFI: 1 April
- Response due: 1 June
- Partner selection: 1 July
- Teaming agreement: 1 August
- Mission Description completed: 1 November
- Phase 1 Funding Available: June 03
- Start Instrument Design: June 03
- Phase 2 Funding Available: January 04
- Spacecraft Phase A Funding: January 04
- S/C Requirements Review: March 04
- Spacecraft Flight Funding: June 04
- Observatory Integration: January 06
- Ship to Launch Site June 06

3.7 Proprietary Information

All responses to this solicitation will be treated as proprietary information, to be disclosed only to those employees of MIT and PCRF who are party to the evaluation and decision making process. Upon request all submissions will be returned to the submitting organization following partner selection.

Please note that MIT will conduct this mission in the spirit of an academic environment. Once under contract, all technical data specific to this mission and its flight hardware are expected to be in the public domain. Exceptions for specific company-confidential matter can be made, but only on a case-by-case basis, and in limited number.

3.8 Teaming Agreement

Upon selection a formal teaming agreement will be executed between the spacecraft vendor and MIT/PCRF.

4 References

- MIT Center for Space Research: http://space.mit.edu/
- Planetary Coral Reef Foundation: http://www.pcrf.org/
- Technical questions:

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