Assigned Proposal Number:_____

Strategic University Research Partnership
Director's Research and Development Fund Proposal FY 2009
Due Date: December 12, 2008, by 4 PM PST

1. Title

Dartmouth Greencube 2

2. JPL Principal Investigator— include only one JPL PI
First / Last (JPL Org)
Anthony J. Mannucci

JPL Org. No.: 335G

3. Co-Investigator(s)— University and JPL Co-Is; include name, university/dept or JPL org, email

Kristina Lynch
Dartmouth College
Department of Physics and Astronomy
6127 Wilder Lab
Hanover, NH 03755

kristina.lynch@dartmouth.edu

4. Total Budget Request for FY09: $25,000

5. Student Participants— include name, email, and academic level (post doc, grad, undergrad, other)

M. Umair. Siddiqui, undergraduate
M.Umair.Siddiqui@dartmouth.edu
Louis Buck, undergraduate
Louis.H.Buck.III@dartmouth.edu
David Heinicke, undergraduate
David.Heinicke@dartmouth.edu
Phillip Bracikowski, graduate
Phillip.Bracikowski@dartmouth.edu

6. Identify one Primary (P) Topic Area to which your proposal applies and any Secondary (S) Area(s).

P	S	Topical Area
		1. Advance Solar System Exploration in New Directions: To Understand Planetary Formation and Evolutionary Pathways, and to Seek, Discover and Inventory the Organic Materials in the Solar System and Elucidate Their Origins
		2. Determining the Geometry and Structure of Our Universe
		3. Characterizing Exoplanets Where Life Could Exist
		4. An Integrated Earth System Science Information System for Research and Applications
		5. Achieving Breakthrough Increases in Interplanetary Communications
		6. Enabling Robotic Missions to Scientifically Interesting Extreme Environments
		7. Enabling Autonomous Human Missions to the Moon and Mars
		8. Fractionated, Distributed, Repairable, Reconfigurable, Reusable Missions
		9. Large, Precise Space Structures to Enable Future Observing Instruments
P		10. Develop and Nurture the Next Generation of "Rocket Scientists"

7a. General Objectives— Clearly and concisely state the proposed objectives, goals and expected deliverables and/or products of the proposed work.

Overall longterm objectives of GreenCube program:

The Greencube project stems from Prof Lynch's interest in small, autonomous science payloads for multipayload auroral sounding rockets, and from Prof Millan's interest in small, cubesat-like orbiters for future science missions. It is feasible because of the undergraduate students who have been working in our labs for several years, who have taken the shop course and have become familiar with electronics by working on our grant-funded rocket and balloon programs. It is different from these same students working on grant-funded research because it is subject to their own deadlines and structure.

The original goals for the Greencube project were to (1) fly an infrastructure test on a burster balloon in 2008; (2) fly a second version as part of a test rocket flight in a year's time; (3) incorporate the design into small payloads for an LCAS-class auroral sounding rocket to be proposed by Prof Lynch with JPL next summer or the

following, for flight from Poker in 2011 or 2012; (4) on a longer timescale, incorporate the design in Prof Milllan's future plans for small orbiters, which potentially could include student-driven cubesats.

Status of GreenCube program as of late fall 2008:

In the summer of 2008, the students flew a test-flight of the balloon infrastucture from Vermont to Maine, and recovered the system at its landing test. In the fall of 2008, they repeated this flight but this time carried the GreenCube payload, receiving telemetered data throughout the flight (see figures attached at end) and again recovering the system at its landing point. The GreenCube, which was designed and built last year and debugged this past summer, consists of a single board computer (designed by the students with mentoring by our engineers) with power handling, data handling, and digitization of analog inputs, a GPS system, a ham radio system, a fluxgate magnetometer, and several thermistors and other monitors. Thus we have completed step (1) of the original goals listed above, as proposed for and funded by last year's SURP project. One of the undergraduates, Phil Bracikowski, has moved on to become a master's student in our program, and he has begun work under separate funding to develop step (2).

Specifics of GreenCube2 this year described in section 7b below.

For the GreenCube2 program which we propose in this 2009 round of the SURP, we request funding for an enhanced version of step (1), in which we will re-use the successful balloon-borne version of the GreenCube but this time carrying a true science investigation rather than just the infrastructure of the Cube. We detail this in [7b] below.

7b. Quantitative Objectives— Discuss quantitative improvement in capability expected in your results; compare with current capabilities inside and outside of JPL.

GreenCube2 this coming year:

The first year of the GreenCube program (funded under last year's SURP program) was astoundingly successful and we would like to expand upon it. The students have begun to compile a list of potential science investigations which could be carried out by GreenCube2. These include: (a) a study of gravity waves enabled by flying a thermocouple pressure gauge; (b) a study of night-sky-brightness enabled by carrying a photometer developed for a different balloon project by astronomy faculty in our department; (c) an environmental study of some (yet to be determined) parameter of the upper atmosphere; (d) an engineering study of position determination using phase differencing wave measurement techniques. Basically, any physically small probe that can output an analog voltage can be digitized by the circuitry of the GreenCube K111 board, and can return data throughout the balloon flight which we know now reaches 93000 feet in altitude over a 2-hour trajectory.

The objectives of GreenCube2 will be to use the systems developed by GreenCube to investigate an interesting science question.

8. Approach— Describe how you plan to achieve your objectives. Identify specific tasks and milestones that will be accomplished.

Schedule and specific milestones:

Winter term will be spent investigating the interest and feasibility of the various science investigations (among others) listed above, and choosing one of them.

Spring term will be used to implement and test the detector and electronics for the investigation.

Summer term will include the flight(s) and the data analysis and interpretation.

9. Describe the innovative features of this proposal— What new ideas are being applied to produce a new evolutionary or revolutionary advance?

Profs Lynch and Millan were surprised this past year to (re)discover just how important a learning and teaching tool it is to have a student-run project. The combination of training that our rocket and balloon lab work gives the students, with the enhancement of then letting them go on to design and run their own investigation, is surprisingly rewarding and effective. Note that the senior student (Parker Fagrelius) last year from the GreenCube project has now gone on to become a JPL employee this year; a second student (Rachel Hochman) is now a lab technician at UCB/SSL; a third (Phil Bracikowski) is now a graduate student in our program. The lead student this year (Umair Siddiqui) was one of the more junior students last year. The GreenCube program is developing a cadre of capable interested students and is worth continuing, and could well benefit from continued support from the JPL SURP program until it becomes a little more established.

10. Contribution of Partner University— Describe what strengths the partner university brings to the proposed work. List and describe specific tasks, responsibilities, and time periods. Provide sufficient detail so that this may be used as the Statement of Work for a JPL sub-contract to the university, which will expedite the transfer of funds.

The project is an off-spring of existing work at the Lynch rocket lab and the Millan balloon lab, and takes advantage of the lab facilities and student training in place for those larger grant-funded projects.

All the items listed in sections 7, 8, and 9 above will be done at Dartmouth, under the auspices of Prof Lynch's rocket lab and Prof Millan's balloon lab. Engineering mentorship will be provided by Dr Kevin Rhoads, Mr David McGaw, and Mr David Collins, who are all engineers in our groups, and by Mr Dwayne Adams, who is the machinist in the Dartmouth Science Division apparatus shop. We look to JPL for future suggestions about possible subsystems for the payloads

11. Exchange of personnel— Describe any plans to have work performed at JPL by university personnel or at the university by JPL personnel. Commitment by the appropriate JPL and/or university organization to host the proposed personal exchange must be obtained and so stated in this section. (Expenses incurred for any exchange must be included in the budget request.)

N/A

12. Significance and impact of results on JPL missions and programs— How does this effort contribute to accomplishing the strategic challenge?

This proposal addresses JPL's interests in enhancing student preparation for a professional career in space systems/science at JPL or elsewhere. The students will gain experience with instruments of particular interest to JPL, such as GPS and magnetometers.

13. Has the proposal been submitted elsewhere? —If yes, explain.

No.

14. Plans for follow-on funding— Provide a realistic assessment of future funding potential. Discuss how this proposal may enhance the probability of such funding.

The near-term goals seen as extensions to this seed project include both NASA/LCAS sounding rocket science proposals, and CubeSat proposals such as could be funded by the NSF program. This initial SURP funding is getting the Dartmouth cubesat program established, which is critical before a full-up science investigation could be proposed. In the meantime we are also using NH state EPSCOR funding to investigate the incorporation of cubesats and PPods onto sounding rocket platforms, this project is running this year in parallel with our balloon-borne SURP projects.

15. Budget— Please complete the budget sheet below. Contact your Section Administrator or Business Administrator Manager for FY09 rates and for assistance in filling out the form.

16. Partner contract administrator contact information— Provide name of contract administrator, address, phone number, and email.

Trustees of Dartmouth College
Office of Sponsored Projects
11 Rope Ferry Road #6210
Hanover, NH 03755-1404

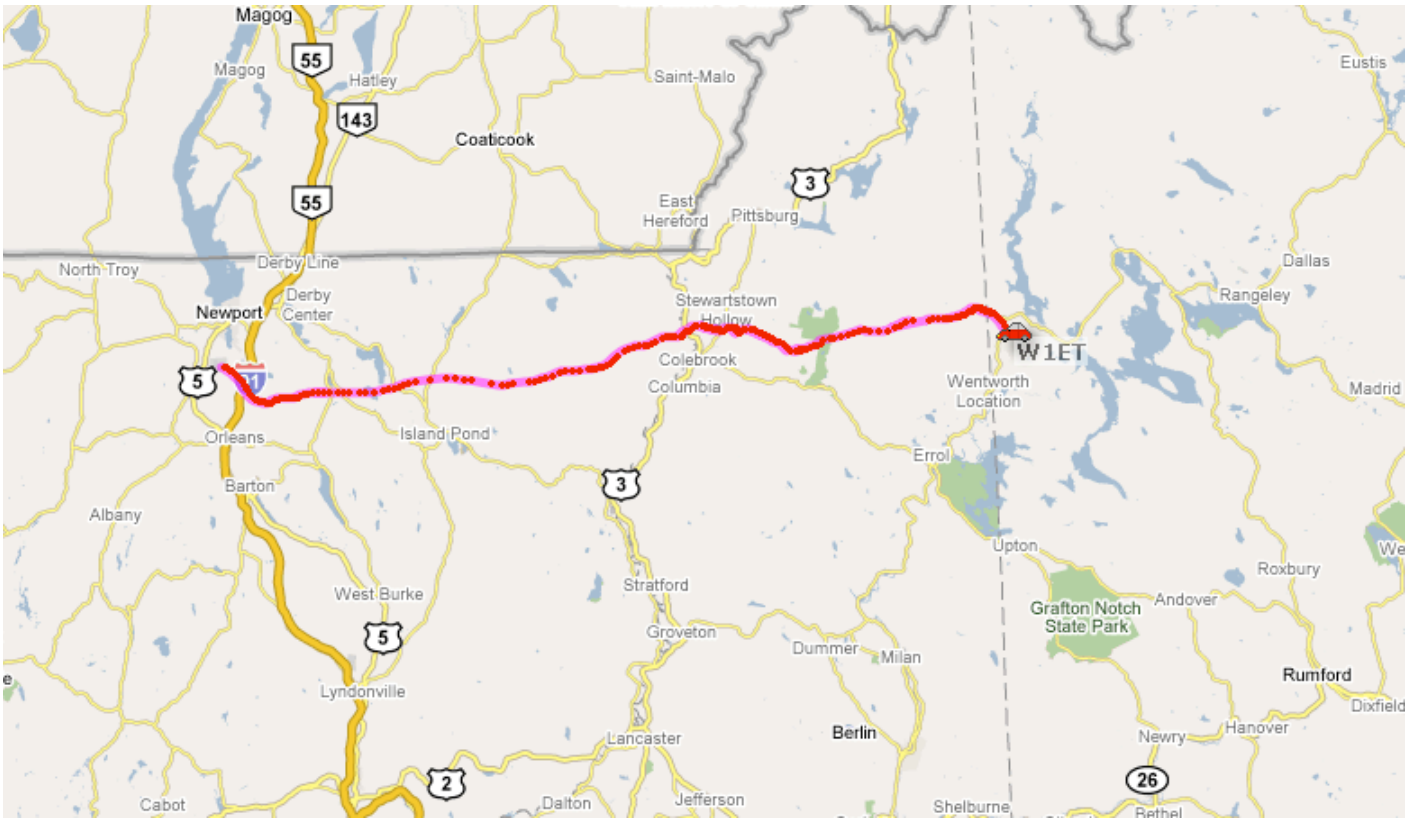
Sponsored.Projects@Dartmouth.edu **603-646-3007**
17. JPL Principal Investigator Signature Name: Org: Signature: _____ Date: _____
18. JPL PI Division Manager Signature Name: Org: Signature: _____ Date: _____
19. University Co-Investigator Signature Name: Signature: _____ Date: _____
20. University Representative with Signature Authority Name: Title: Signature: _____ Date: _____

Budget Sheet

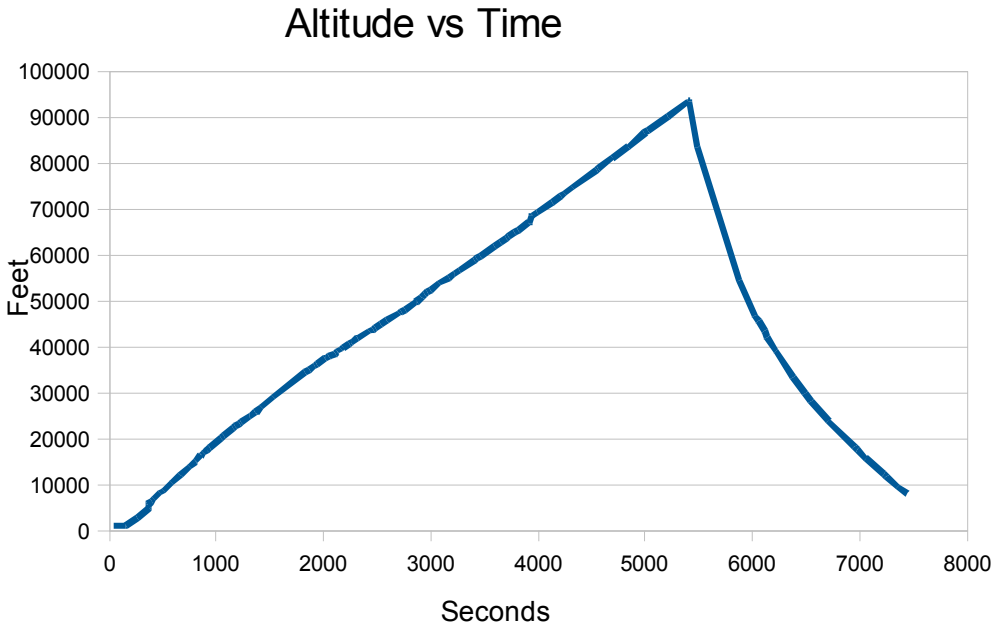
Category	**AT JPL**	**AT EXTERNAL INSTITUTION(S)**
DIRECT COST		
1. Salaries (Itemize) *(Only "itemize" the person names or job classifications and the number of hours for each. You can show one total $ salary figure for labor.)*	$1,350 – 18hrs – Tony Mannucci	$10,000
2. Labor Fringe Rates - Employee Benefits	$650	
3. Cat A Labor (Itemize) *(Only "itemize" the person names or job classifications and the number of hours for each. You can show one total $ figure for labor.)*	0	
4. Procurements –Equipment, Materials and Supplies (Itemize). JPL - Do not list the contracts for outside collaborators. This total is on line #12 on the external collaborator column.	0	$2,559
5. Procurements – Subcontracts (Itemize) *(PS – contracts other than with collaborators)*	0	0
6. Services – (Itemize) *(JPL be sure to include in-house services at JPL)*		0
7. Domestic Travel *(only as a research cost; and domestic conference travel is allowed up to a maximum 5% of the total budget*) Itemize with what and where the travel is required.		Travel to Spring AGU, May 2009, one student $1,200.
8. Other (Itemize) *(Chargebacks, etc.)*	$150	0
9. Total Direct Costs (total of dollars 1 through 8)	$2,150	$13,759
10. ALLOCATED DIRECT COSTS (ADC)	$850	
ADC **FY09** - See Section Administrator or Business Administration Manager for current rates. ADC costs are calculated on the JPL's total direct costs Item #9 and the external institution(s) budget item #12.		
ADC at JPL consisting of: a. Labor ADC b. RSA Contract ADC c. Other Contracts ADC d. Purchase Orders e. General ADC Enter total on Item #10	0	
11. Overhead -external Institution		$8,241
12. Individual Budget: *(JPL add Item #9 Direct Cost and #10 ADC costs for total JPL budget)* *External Institution add Item #9 and Item #11 Overhead for total)*	$3,000 $22,000	$22,000
13. Combined Budget: *(JPL Budget plus External Institution Budget)*	$25,000	

Figures, Graphics, Tables, etc.

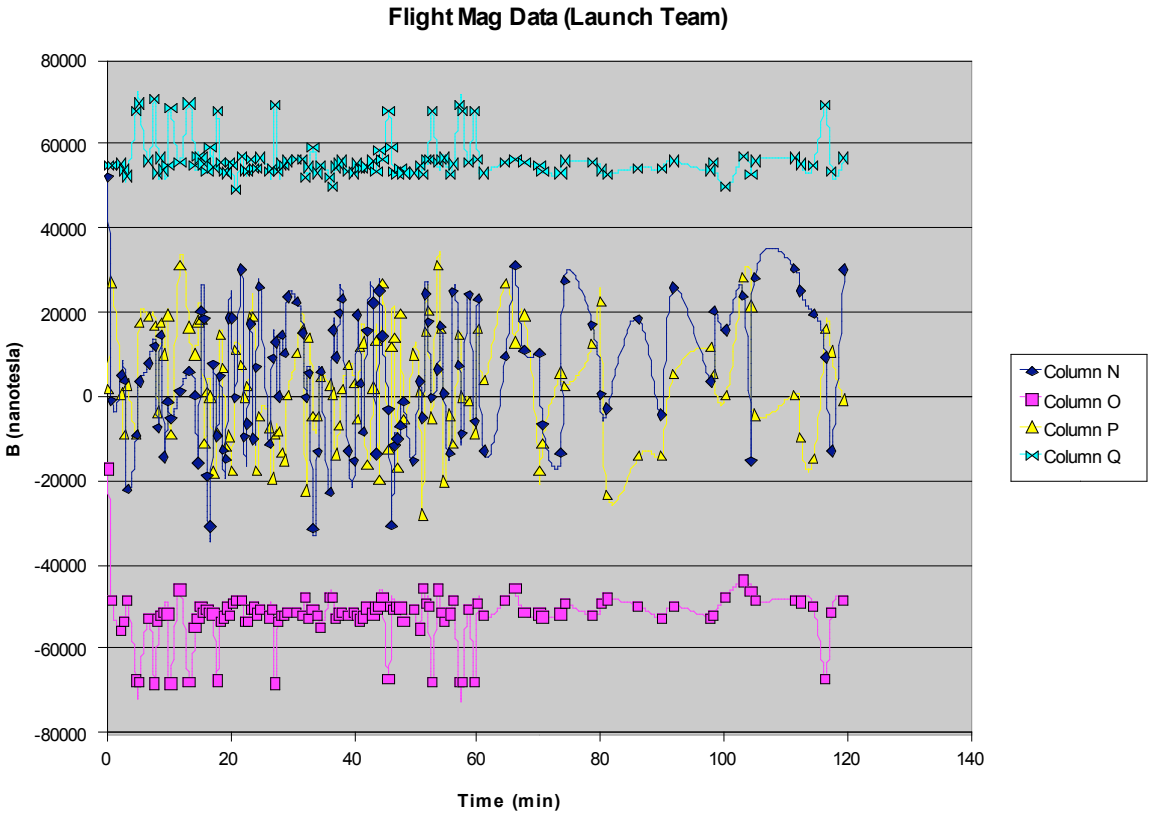
(Please do not use "text-wrapping" when incorporating graphics at the end of the report.)



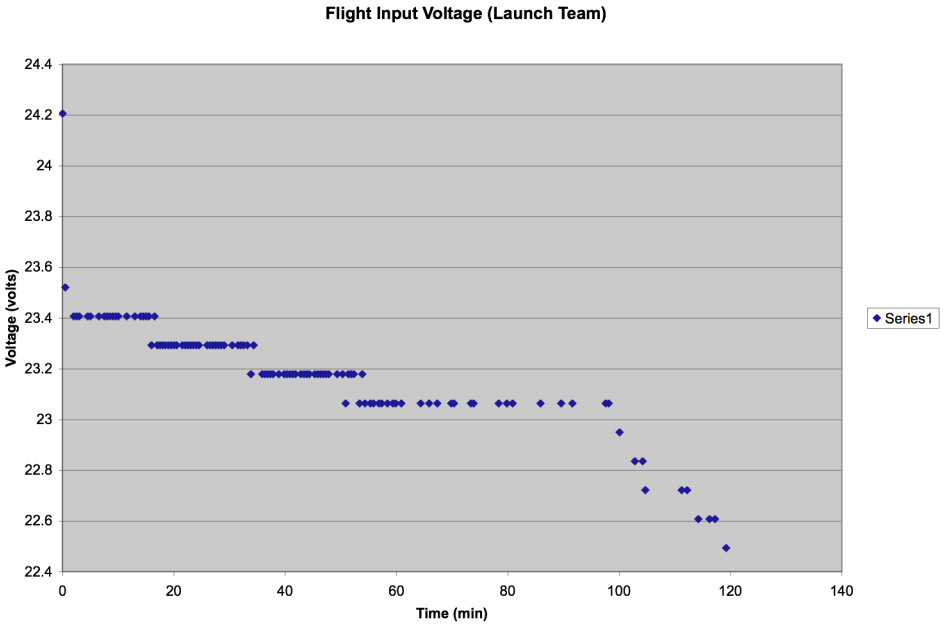
Flight trajectory of the GreenCube during the November 2008 launch, recorded from the ham radio downlink of the GPS position data.

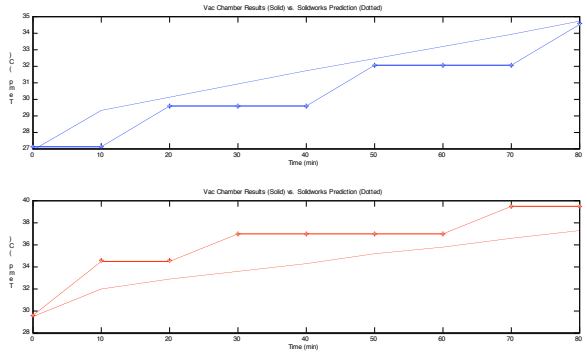


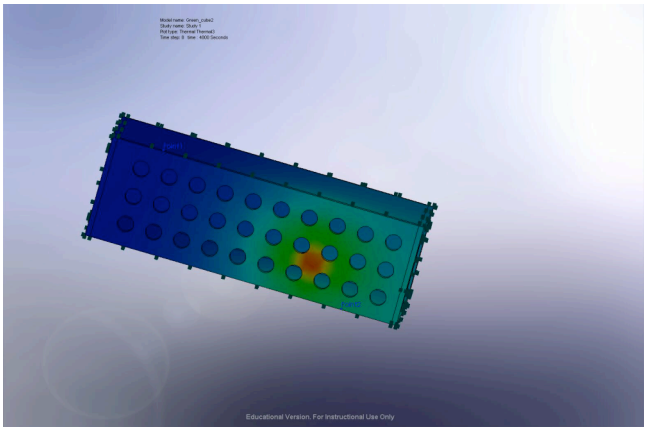
Altitude vs time plot of the GreenCube on the November 2008 flight, from the GPS data.



Magnetometer data from the GreenCube's November 2008 launch, as recorded by the launch team in Newport VT. The purple series is the z-axis, the yellow and blue the x and y axes, and the turquoise is the overall magnetic field magnitude. The data resolution decreases in the second half of the flight because the payload moved out of range of the launch team's data reception station. This part is better received by the recovery team, however their data are still being resolved. The dropouts in the Column 0 data are under investigation. Plot below shows battery voltage recorded during the flight.







Solidworks thermal vacuum model (convection turned off) of the Greencube, done by undergraduate David Heinicke and compared to vacuum test thermal data recorded by undergraduate Louis Buck. The thermal model and the recorded data are well-matched.