Harvey Mudd College

University Student Launch Initiative

Proposal
2011-2012

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I. Introduction and Background

Welcome to the Harvey Mudd USLI Team's 2011-2012 Proposal. While this is the first HMC team to compete in USLI, Harvey Mudd College has a history of academic and hobby rocketry. In 2006 a group of interested students and engineering professor Erik Spjut designed and implemented a class in experimental and hands-on systems engineering, using high-power level 1 rockets as the platform: http://www.eng.hmc.edu/NewE80/CourseInfo.html

The success and popularity of the new engineering class, E80, spawned the Mudd Amateur Rocketry Club (MARC), which has a permanent facility in the school known as the Rocketry Development Lab. MARC has spearheaded two highly technical sounding rocket design efforts, both described in depth on the aforementioned website. The Mudd II was an all-composite, minimum-diameter and minimum-mass rocket built around the Aerotech K700W which was designed for structural analysis of composite rockets at high Mach. While it did not survive its Mach 2+ flight, the lessons learned in its design and construction were incorporated into the design of the Mudd IV. The Mudd IV was to be a course rocket, made in mass for the new E80; based on the high-performance composite airframe design of the Mudd II but with the lessons learned in the new E80 about reliability and durability.

This USLI team is associated with the Mudd Amateur Rocketry Club, though not all USLI members are MARC members and vice versa. We will be sharing both experience and facilities with MARC. If granted the opportunity to compete in the USLI, we look forward to continuing the Mudd tradition of high powered sounding-rockets to the national level.

II. Team Information

Team: Mudd USLI Team
School: Harvey Mudd College, Claremont, CA
Team Website: https://sites.google.com/a/g.hmc.edu/hmc-usli/ or tinyurl.com/hmc-usli
Team Official: Professor Gregory Lyzenga
Safety Officer: Chris
Total Number of Students: 9
NAR Section: Rocketry Organization of California (ROC) - Section #538

A. Non-student Members

Mentor - Professor Gregory Lyzenga

Gregory Lyzenga (NAR #13295) is Professor of Physics at Harvey Mudd College since 1990 and a research scientist at Jet Propulsion Laboratory since 1980. He has been a NAR member since 1969 and is HPR certified Level 3. He is a board member and vice president of ROC. He serves as a rocketry mentor and merit badge advisor for BSA and 4-H.

B. Student Members, Duties, and Resumes

Jane is a sophomore CS major at Harvey Mudd College. She is Level 2 NAR certified. She participated in the SLI competition in 2009 with Ingraham High School and has participated in the Team America Rocketry Challenge for two years in high school. Jane also participated in the 2008-2009 Washington Aerospace Scholars which introduced high school students to science and engineering careers. Jane will act as the team leader for this project.

Tessa is a sophomore physics major at Harvey Mudd College. She is Level 1 NAR certified and attended the Huntsville 2011 USLI Workshop. Tessa also participated in the 2008-2009 Virginia Aerospace Science and Technology Scholars program. Tessa is the assistant team leader and will be in charge of fundraising and educational engagement.

Christopher is a junior Applied Physics major at Harvey Mudd College. He is the president of the Mudd Amateur Rocketry Club (MARC), Tripoli level 1 certified. He has taught NASA curriculum in the Washington Aerospace Scholars program (which he is also a graduate of), and has scratch-built several high-power sounding rockets and their data acquisition systems. He also has a deep background and familiarity with machine shop and prototype production equipment, including CNC operations, and is the head student machine shop proctor for computer-integrated machining operations at Harvey Mudd College. He will be responsible for the design and production of the recovery system for the rocket and its payload, and the production of internal structural components. He will also be responsible for ensuring that the entire process is conducted to the appropriate safety standards.

Jeb is a sophomore computer science major at Harvey Mudd College. His focus is on robotics and how to use various forms of input to allow machines to analyze and interact with their environment. Jeb has been an intern with Vision Robotics for three years and has helped develop vision processing code for agricultural robots. Jeb will be on the payload and electronics team.

Steven is a junior engineering major at Harvey Mudd College. He is Level 2 TRA certified. As an engineer with a focus on computer and electrical engineering, he is primarily interested in software and electronics design. In the summer of 2011, Steven participated in a research project under the Kinohi Institute to design a Spectral Profiling and Imaging (SPI^2) device for exobiological applications. Steven will be in charge of payload design for this project.

Josh is a sophomore engineering major and Shop Proctor at Harvey Mudd College. In 2009 he interned at NASA Marshall Space Flight Center on the Aerodynamics Team performing wind tunnel tests on the Ares V, and he plans to focus on vehicle aerodynamics and propulsion in school. Josh will be in charge of vehicle design for this project.

Erik is a junior physics major at Harvey Mudd College. From his participation in the FIRST robotics competition, building a 14 foot composite catamaran, and a summer camp in aeronautical engineering at NC State University, he has experience in design and fabrication. For the past two summers he has done research in Astrophysics, and is interested in astronomical instrumentation. Erik will work on the payload and vehicle design teams.

Will is a junior engineering major at Harvey Mudd College. He has been involved in competitive engineering and robotics competition for eight years, including FIRST as a student and mentor. He specializes in embedded systems and low power operation. Will is currently an engineering consultant with Red Mountain Embedded Systems. For the past two summers he has done research in swarm robotics with the Applied Math Lab at UCLA.

Yeah Moon (Yeahmoon) is a freshman at Harvey Mudd College. He has no experience in rocketry, engineering, or designing, but would like to learn as much as possible, because his dream is to build jet packs. In other experiences, he has placed third as an individual in the California Academic Decathlon Competition, and has placed first as an individual in the United States Online National Academic Decathlon Competition. His team, from John Marshall High School, placed 2nd in the California State Decathlon Competition, and first in the Online National Academic Decathlon Competition.

C. NAR Section

Rocketry Organization of California (ROC) is NAR section #538, based in southern California. ROC hosts regular HPR launches at Lucerne Dry Lake, the site of NSL 2011. ROC will provide all the launch assistance and FAA waiver support required to carry out team launches in compliance with established safety standards and all applicable regulations.

III. Facilities/ Equipment

Facilities

1. Harvey Mudd College Campus
    a. Engineering Computing Facility (ECF)
        Accessible at all hours.
        Commercial software for rocket simulation, CAD/CAM
        CFD and FEM modeling

    b. Janet and Jeffery Mitchell Private Dining Room
        Accessible during mealtimes with reservation.
        Location of weekly Saturday meetings. A conference table and white board are available for use.

    c. Platt Campus Center Meeting Room
        Accessible at all hours with reservation.
        A white board is available for use.

    d. Machine Shops - Parsons Engineering Building B6a and B4
        Accessible anytime when a shop proctor is present - Christopher and Josh are proctors.
        Full machining, sheet metal fabrication, and wood shops, conventional and CNC (list of available machines given below).

    e. Rocket Development Lab (RDL) - Parsons Engineering Building B8
        Accessible at all hours for USLI Team and the Mudd Amature Rocketry Club (MARC) only.
        Dedicated facility for rocket construction and storage.
        Facilities for curing large composite layups.

    f. Harvey Mudd Teleconferencing rooms
        Accessible upon reservation, 24 hour notice
        A/V equipment, full integration into most videoconferencing programs

    g. Wind Tunnel Lab
        Accessible by reservation, 24 hour notice
        200MPH capacity, 12”x12”x30” clear test section
        Strain gauge support structure, RF-transparent Construction.

2. Off-Campus Facilities
    a. Launch Test Site
        Lucerne Valley Dry Lake Bed, Lucerne Valley, CA.
        GPS Coordinates of the launch site are N 34°30.117′ W116°57.560′.

<u>Equipment</u>

1. Manufacturing Equipment
    (3) Tree manual milling machines
    (3) Harrison manual lathes
    Monarch Bed and Turret lathes
    HAAS 20Hp CNC Vertical Mill
    HAAS CNC Lathe
    Southwest Industries TRAK Knee Mill with ProtoTRAK SMX
    Southwest Industries TRAK 16” Lathe with ProtoTRAK SLX
    Epilog Laser Mini Helix 24, 60W CNC Laser
    Shopbot PRS Alpha, 48”x96”
    Thermatron Test Chamber, Usable as a Curing Oven
    Roland MDX-20 Subtractive Rapid Prototyper
    Dimension 3D Printer

2. Safety Equipment
    Machine Shops: Safety Glasses, Gloves, Earplugs.
    RDL: Particulate Filtration Masks, Fume ventilation and filtration

3. Computer Hardware
    ECF Computers: Quad-Core Intel processors, 8GB Ram, Windows 7.
    Access to Engineering Department’s 48-core server

4. Software
    Solidworks Educational Edition 2011, including:
        Solidworks Motion, Solidworks Simulation
    COMSOL Multiphysics
    RockSim 9.0
    RASAero
    Matlab 2011
    Igor Pro
    Mathematica 8
    Maple 14
    MasterCAM X5

More advanced software for FEM/CFD exists on campus, and if we decide to use it we can get the appropriate training.

5. Video Conferencing Equipment

Equipment is available by request in any conference room. Computers are available operating Windows Vista with a broadband connection. Other equipment includes Polycom conference phones and Microsoft Lifecams.

For WebEx/connectivity issues, contact information is below:

Computing and Information Services
Sprague 5th Floor
James Sadler
james@hmc.edu
(909) 621-8000 ext. 73498

6. Accessibility Standards

All team members will comply with the Architectural and Transportation Barriers Compliance Board Electronic Information Technology (EIT) Accessibility Standards (36 CFR Part 1194) as described at http://www.acquisition.gov/far/current/html/Subpart%2039_2.html#wp1004775.

IV. Safety Procedures and Risk/Mitigation Tables

Materials Safety Information

This section contains the known hazards of materials we will be using, and how we plan to mitigate them. For the most part, this will only apply to work we do ourselves, by hand: Safety procedures dealing with the machine shop equipment listed above will not be discussed as they are fairly standard. Chris and Josh are shop proctors, responsible student overseers of the machine shop, and will ensure that any team members working in the manufacturing facilities follow the appropriate safety precautions. There are also other school-designated proctors who maintain safety in the machine shops, and may do so if Chris and Josh are unavailable.

MSDS sheets for some of the materials are available on our website under “Our Plan” and “The Proposal”. You can find the links for these at the bottom of the page.

1. Public Missiles Phenolic Tube
    a. Phenolic tubing is a paper-wrapped tube impregnated with a garolite resin, then heat-cured. The resin used may or may not contain formaldehyde (the staggering variety of “phenolic” and “garolite” products available today have inconsistent and contradictory names). We will treat it as a material which is safe to handle but whose dust is toxic; When sanding the tube we will use appropriate ventilation and particulate-filtration masks.
2. Composite Cloths
    a. Composites fibers are hazardous to the respiratory tract. However, the materials we will use are not expected to be splinter hazards. We will only handle and cut the glass cloth in the RDL, which has sufficient ventilation that fibers released by cutting will not be a breathing hazard. Sanding epoxied composites will only be done with particulate filter masks, or with sufficient lubrication (wet-sanding) so as to eliminate dust entirely.
        i. Kevlar composites can not be sanded after set-up due to the materials properties of the kevlar. We will always have a layer of glass over the top of kevlar for this purpose.
3. Chopped Carbon Fiber tow
    a. Will be used as a filler for epoxy fillets. It is a major particulate hazard before being mixed with epoxy and during sanding; these operations will only be conducted with particulate filter masks.
4. Aeropoxy
    a. The Aeropoxy laminating resins we use are non-carcinogenic and have non-toxic fumes. However, we will be working in good ventilation in the Rocket Development Lab and will use gloves to prevent skin contact.
5. MegaFoam
    a. This 2-part expanding foam is non-toxic after cure; the liquid component parts are both toxic but do not fume. We will use gloves to prevent skin contact.
6. JB-Weld
    a. Highly stable, this epoxy is essentially hazard-less; we will use gloves to prevent skin contact.
7. BSI 30-Minute Epoxy
    a. This hobby-grade epoxy is toxic with toxic fumes. We will use gloves to prevent skin contact and only work in the Rocket Development Lab where the ventilation is sufficient to prevent fume accumulation.
8. Performance Rocketry Filament-Wound Fiberglass (G12) Tube

    a. This high-strength product will be machined with adequate lubrication to prevent glass fiber dust; It will only ever be wet-sanded to prevent dust accumulation.
9. G10/FR4/G11 Garolite Fiberglass
    a. Similar to the G12 tubing, it will only be machined with sufficient lubrication to eliminate dust and wet-sanded.
10. 6061-T6 Aluminum and 300-series Stainless Steel
    a. Will be used for small components only; compatible with the NAR safety code. These materials present effectively no hazards.
11. Nylon
    a. Again, this represents essentially no hazard.
12. Solder for electronic payloads
    a. Lead-Free solder will be for all applications.

A. Recovery Failures

Failure	Probability	Possible Effects	Mitigation
Shear Pin Failure at Apogee	moderate	main parachute deployment at apogee	Ground testing and flight testing
Separation Failure	low	ballistic re-entry	Ground Testing, Piston system
Premature Deployment	low	very low apogee-drogue damage	Timer activated altimeter (see recovery section)
Tangled Deployment at Apogee or Main	moderate	unstable recovery; bad payload attitude	Lengthy recovery harness, swivels,
Premature Charge detonation	very low	injury to team members	proper arming precautions and g-switch activated deployment electronics will be used

B. Structural Failures

Failure	Probability	Possible Effects	Mitigation
Tube Rupture at deployment	low	disqualification	Ground Testing of BP charges
Fin/landing damage	moderate	disqualification	Composite reinforcement (kevlar and Carbon FIber)
Heat Damage from Motor	very low	Fire/Structural failure	Expanding Fire-retardant Structural Foam
Structural damage to payload	very low	damage to electronic payload	Shock-resistant payload bay with both hard and cushioning layers

C. Payload Failures

Failure	Probability	Possible Effects	Mitigation
Telemetry Loss	moderate	disqualification	Ground and flight testing
Power failure	moderate	microcontrollers power off, loss of telemetry/logging	Redundant High-Current lithium batteries
RF/EM interference	moderate	corruption of data	Ground EMI testing
Static Discharge	moderate	destruction of electronic components	Static-Safe handling procedures; common ground buses

D. Propulsion Failures

Failure	Probability	Possible Effects	Mitigation
CATO	very low	Destruction of motor case, booster section	Consultation with Greg Lyzenga during motor assembly
Ignitor failure	moderately high	Scrubbed Launch; battery run-down	Redundant high-capacity power supplies and large storage capacity
Partial Ignition	very low	partial motor burn; very low/inconsistent thrust	Electronic deployment will recover the rocket safely

Statement of Awareness of Local and Federal Laws

We will conduct all of our operations, including but not limited to launches, static motor tests, telemetry transmissions and tests, under the supervising umbrella of the Rocketry Organization of California and the National Association of Rocketry, through our mentor Greg Lyzenga. They will ensure that we are in accordance with all federal and local laws.

Rocket Motor Handling Procedures

We have access to fire safes at the school which are currently used to store large volumes of NAR-Approved APCP rocket motors; the safe is controlled by LEUP holder Erik Spjut, who along with Greg Lyzenga will ensure that all federal and California state safety codes are enforced. Team members Jane and Steve are both certified under the Tripoli Rocket Association to purchase and handle Level 2 High-power Motors, and they will purchase and handle the motors for the rest of the team. Motors will be purchased only at the launch site during regular insured ROC launches with the support of our ROC liason, and will be flown before leaving the site. In the event of a scrubbed launch, an unused motor will be transported by one of the Level-2 certified team members in our HAZMAT-market field box and stored at the earliest possible opportunity in the aforementioned fire safe.

The entire team hearby states that we understand and will abide by the following safety regulations, as per the NAR High-power safety code:

i. Range safety inspections of each rocketshall be conducted before it is flown, to be conducted by the ROC RSO.

ii. The ROC RSO has the right to deny the launch for any reason, and we agree to abide by his/her ruling.

V. Technical Design

A. Rocket Dimensions and Materials

Rocket specifications:

- length: 74.9”
- nose cone length: 15.5”
- body diameter: 3.13”
- fin span: 3.875”
- fin root length: 7.5”
- stablity margin (unloaded): 6.25
- stability margin (J380-SS): 3.7
- CG distance from nose (unloaded): 39.3”
- CG distance from nose (J380-SS): 47.2”
- CP distance from nose: 58.7”
- proposed weight (including payload, no motor): 7.9lbs

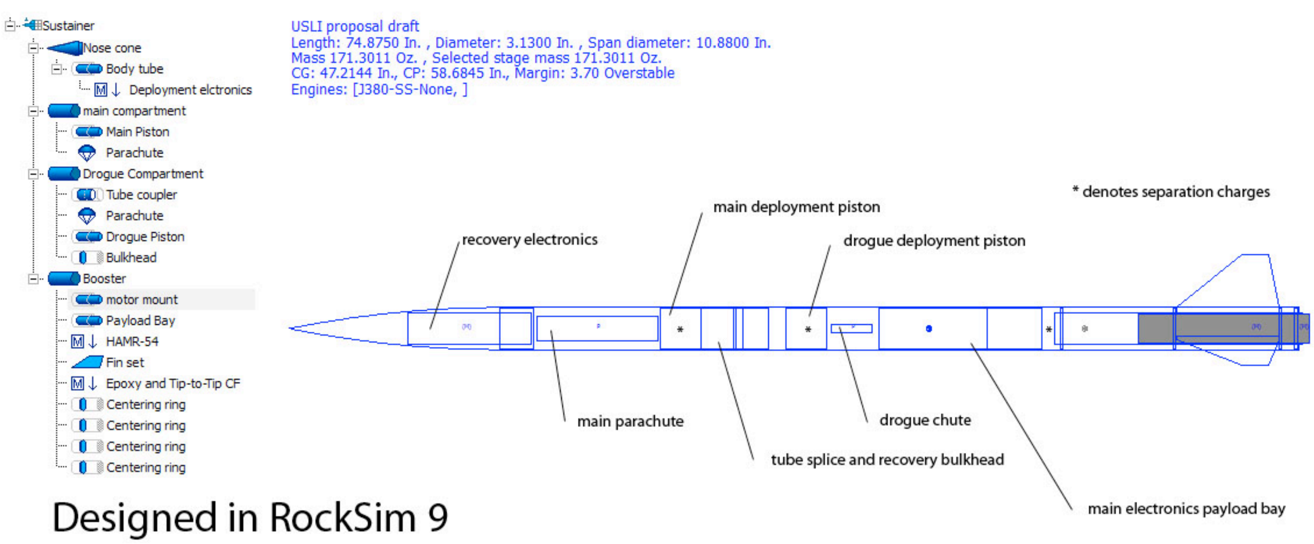


Figure 1: RockSim schematic of the preliminary design with a J380-SS motor loaded

The rocket consists of five main components. The nose cone, containing the deployment electronics, sits inside the main recovery bay. This shall be two tube sections spliced together over the main recovery bulkead, and shall contain both pistons and parachutes. The recovery tube will sit over the

Payload bay, which shall be filament wound fiberglass coupler tube. The payload bay will nest inside the booster.

The rocket body will be PML phenolic tubing, wrapped with Kevlar and fiberglass . The phenolic tubing will keep the rocket light, while the Kevlar and fiberglass strengthens the tubing. We will be using Performance Rocketry branded filament wound cones with an insertable payload bay for the deployment electronics to keep them separate from the main electronics package. The fins will use 1/16” G10 fiberglass laminated with tip-to-tip carbon fiber, for strength and rigidity. They will be attached through-the-wall to the motor mount.

B. Motor/ Propulsion

We would like to use the smallest motor possible for both safety and cost; after conducting simulations on several J and K size motors we found three J motors which reached our desired height and did not overshoot by much: the J825R, the J140P, and the J380-SS. Given our preliminary rocket design the J380-SS, manufactured by Cesaroni, is the preferred motor as it reached maximum height at 5279 feet according to RockSim simulations. This motor is Tripoli and NAR certified. The actual motor choice will be made after the rocket design is finished and simulated with a more accurate program.

Preliminary motor specifications:

- designation: J380-SS
- manufacturer: Cesaroni Technologies
- length: 12.6” for Pro54-3g case
- total impulse: 1043 Ns

C. Payload

The rocket payload will be constructed in accordance with the specifications requested by the Science Mission Directorate at NASA HQ. The electronics package will consist of 3 primary components:

<u>Sensor Hardware</u>

A microcontroller-based system using the ArduPilot Mega open source IMU autopilot will be used to collect and record scientific data. This option was chosen primarily for ease of use, as well as for the robustness of the components. Originally designed to be used in Unmanned Aerial Vehicle applications, the ArduPilot Mega provides plug-and-play support for a variety of avionics. Notable characteristics of the ArduPilot IMU system include:

- ■Onboard 3-axis gyroscope
- ■Onboard 3-axis accelerometer
- ■Barometric pressure sensor
- ■Plug-and-play GPS support
- ■Dedicated telemetry serial outputs
- ■Onboard memory for datalogging purposes
- ■16 channels of Analog I/O

In addition to the sensors provided on the ArduPilot, the following sensors will be implemented for collecting in-flight scientific data:

1. Freescale MPXA6115A Absolute Pressure Sensor

The Freescale MPXA6115A Absolute Pressure Sensor is the same pressure sensor used in the PerfectFlite Alt15K altimeters. It will be calibrated manually using a vacuum chamber and standard atmosphere, in contrast to the ArduPilot sensor which will be factory calibrated. Signal filtering will also be manually implemented for noise reduction. This sensor will be the primary source of altitude data.

2. Two Honeywell HEL-705-T Platinum RTD Sensors

Two high accuracy, linear output, platinum RTD sensors from Honeywell will be used to measure internal and external temperature data. Their fast (<1 sec) response to temperature differentials makes them ideal for rocket applications, where their response must be able to keep up with the rocket itself.

3. Honeywell HIH-4030 Relative Humidity Sensor

The Honeywell HIH-4030 Sensor was chosen for its near-linear voltage output vs. humidity. Its ease of use relative to other, capacitive humidity sensors made it the preferred choice. Saturated salt baths will be used for calibration. It will be used for external humidity measurements.

4. Thorlabs FGAP71 GaP Photodiode, Thorlabs FDS100 Si Photodiode, and Thorlabs FGA21 InGaAs Photodiode.

Solar irradiation and UV radiation measurements will be acquired using a series of 3 photodiodes:

The Thorlabs FGAP71 Photodiode will be used to measure solar radiation in the 150-550nm range. It will be used to calculate UV radiation levels. A shortpass 400nm filter will be installed in front of the diode to prevent light of wavelengths greater than 400nm from entering the photodiode.

The Thorlabs FDS100 Photodiode will be used to measure solar radiation in the 350-1100nm range. A longpass 400 nm filter will be installed in front of the diode to prevent light of wavelengths smaller than 400nm from entering the photodiode.

The Thorlabs FGA21 InGaAs Photodiode will be used to measure solar radiation in the 800-1800nm range.

5. u-Blox GS407 GPS receiver

The u-Blox GS407 is a 50-channel GPS receiver equipped with a helical antenna for high sensitivity and reliable GPS locking. It was chosen for its fast locking time and plug-and-play compatibility with the ArduPilot Mega system. Data from the GPS will be logged and transmitted wirelessly through the telemetry unit to the base station.

Each sensor output will be signal conditioned as appropriate to match the input sensitivity of the ArduPilot Mega system. Regulated and redundant power supplies will be implemented to avoid power cutout during launch and landing.

<u>Video Hardware</u>

In-flight video will be taken by 4 cameras, one of which will be transmitting wirelessly to the base station:

1. RHPC-2000 Video Camera

The RHPC-2000 is a 768x494pix resolution video camera which will be installed separately from the ArduPilot Mega system. It will communicate with its own 200mW receiver for bandwidth reasons. A reflector will be installed in front of the camera in order to record simultaneous video of the ground and the horizon during launch.

2. 2x OmniVision OV9712 720p HD Cameras

Two OmniVision OV9712 720p HD cameras will be installed to record high resolution video which will be stored on onboard removable memory. One camera will point towards the ground and the other towards the horizon during launch. The ArduPilot Mega will be used to switch the cameras on and off when necessary to preserve onboard storage.

Telemetry Hardware

The XBee Pro 900 wireless data transmission system will be used to transmit scientific and location data back to the ground station before, during, and after launch. It was chosen for its plug-and-play compatibility with the ArduPilot and for its long range of up to 6 miles. Built in support for two-way telemetry will allow the ground station to control the operation of certain payload electronics such as the 2 HD cameras. It will also allow manual control over datalogging in order to preserve the onboard data storage.

The ground station will consist of a laptop equipped with an XBee Pro 900 receiver and software for real time processing and filtering of the data received.

Summary of Major Payload Components:

Part	Cost
ArduPilot Mega	$64.00
ArduPilot IMU Shield	$159.95
Freescale Semiconductor MPXA6115AC7U Absolute Pressure Sensor	$15.38
Honeywell HEL-705-T-1 Platinum RTD sensor	2 @ $59.45 each
Honeywell HIH-4030 Relative Humidity Sensor	$16.95
Thorlabs FGAP71 GaP Photodiode	$85.90
Thorlabs FDS100 Si Photodiode	$13.10
Thorlabs FGA21 InGaAs Photodiode	$192.00
Edmund Optics Shortpass 400nm Filter	$80.00
Edmund Optics Longpass 400nm Filter	$80.00
u-Blox GS407 GPS receiver	$85.90
XBee Pro 900 Telemetry Kit for ArduPilot Mega	$150.00
OEMCameras RHPC-2000 Video Camera + 200mW transmitter	$199.99
OmniVision OV9712 720p HD Cameras	2 @ $39.99 each
Miscellaneous Signal and power conditioning components	$49.97
1532mAh disposable lithium-on batteries	4 @ $7.99 each
Total	**$1423.98**

D. Recovery

As per USLI requirements, the rocket shall use electronic dual deployment, with a drogue parachute bringing the rocket down quickly from high altitude and a large main parachute being deployed comparatively close to the ground for safe recovery. The electronics to control this will be in their own fiberglass cushioned payload bay, housed in the nose cone, so that pre-launch preparations of the recovery electronics can be completed by a different individual than the payload preparation. The main parachute will be a Giant Leap Rocketry Spherachute 60”, a true hemispherical panel chute. The drogue device will be a Public Missiles 18” reinforced drogue, also a nylon panel chute. The parachute deployments will be done through Public Missiles style pistons.

The planned recovery scheme will rely on a triple-redundant set of flight-computers wired in parallel:

- (1) Featherweight Electronics Raven2
- (1) AED Electronics RDAS-Tiny
- (1) PerfectFlite HiALT45K OR (1) MissileWorks RRC2

In addition, the nosecone payload bay will contain the two official Perfectflite Alt15k/WD’s for NASA altitude verification. They will be installed in a shock-protected mount in an interior fiberglass tube inside the fiberglass nosecone. They will draw from individual 9V high-current batteries, but their outputs will be shorted in parallel, so only a single set of recovery wires need be run through the rocket. This will be accomplished by the use of tubular nylon shock cord (containing the wires) connecting all parts of the rocket body.

The initial deployment event at apogee will actually trigger two different charges, one to separate the payload bay from the booster and one embedded in the drogue deployment piston to push out the drogue chute. The payload bay will be strung between the drogue and the booster to try to keep it oriented vertically. At the main deployment altitude (TBD), a charge embedded in the main deployment piston will go off, pushing out the main chute. The payload bay will still be suspended between the main/drogue and the booster, helping to keep it in the vertical orientation until touchdown.

E. Flight Plan

a. Ignition. Accelerometers in RDAS, Raven, ArduPilot trigger data logging.
b. Burnout. Registered by recovery electronics with accelerometers.
c. Apogee. Deployment electronics trigger dual separations to extract the payload bay and the drogue chute; payload continues to log data now that it is in open air.

d. Main Deployment. At an altitude detected by the recovery electronics, the main chute should be ejected. The payload bay will continue to hang in open air between the drogue/main and the booster.
e. Touchdown. The booster will touch down first, nearly halving the amount of mass suspended by the main. This will slow the descent rate of the payload bay even further, ensuring that it settles gently to the ground.

VI. Educational Engagement

The HMC USLI team aims to educate and involve the community by maintaining the website and though hands-on events at local schools.

The team website is found at the following address:
https://sites.google.com/a/g.hmc.edu/hmc-usli/ or tinyurl.com/hmc-usli
Through this website, we will publish photos, videos, and documentation of our progress using the website blog, which each team member will distribute using his or her personal social media.

In addition to the website, the team will be holding liquid bottle rocket workshops in for groups of approximately 25 students each at local high schools. Below is the current list of contacts who have agreed to host these demonstrations.

Claremont High School
1601 North Indian Hill Boulevard, Claremont, CA
(909) 624-9053 ext 30854

Science Department Chair: Linda Moule
lmoule@cusd.claremont.edu

Physical Science Teacher: Marizka Rivette
mrivette@cusd.claremont.edu

Physics Teacher: Ryan Pettibone
rpettibone@cusd.claremont.edu

High Tech High International
2855 Farragut Road, San Diego, CA 92106-6025
(619)-398-4900

Dean of Students: Melissa Agudelo

VII. Funding

Estimated Expenses

Rocket Body, Payload, and Recovery Systems:

Subscale Rocket	~$100
1.7OZ Kevlar	$99.40
Carbon Fiber 2X2 Twill	$224
Veil Glass	$52
Deployment Avionics	$700
G10 Tubes (Av-Bays) (Custom-Ordered)	~$125 (Predicted)
G12 Nose Cone	$59.00
Phenolic Tubes	$29.35
Misc. Hardware (pistons, G10 sheet, quik-links)	~$50
Payload Hardware (details in payload description)	$1425.33
Parachutes	$140.95
SUBTOTAL	**$3005.03**

Educational Engagement:

Bottle Rocket Workshop Supplies	$400
Team Shirts	$50
Transportation/Gas	$20
SUBTOTAL	**$470**

Transportation/ Lodgings

Shipping Rocket To/From Hunstville	$400
Flights for 8 Team Members To/From Hunstville	$4000
Hotel Rooms for Launch Week	$1000
Meals for Launch Week	$500
SUBTOTAL	**$5900**

Total Estimated Expenses: $9375.03

Funding

We are currently exploring a wide variety of sources with regards to funding. Listed below are our major possible contributers.

Shanahan Endowed Student-Directed Projects Fund
- proposal submitted, awaiting reply
- between $2000 and $10000

California Spacegrant
- contacted; awaiting response
- amount unknown

Mudd Amateur Rocketry Club
- $250 authorized to fund initial efforts

NASA Subsidized Payload
- $3000 for recommended payload

In addition, we may consider requesting sponsorship from the following companies:

Wolftech
Sparkfun
Thorlabs

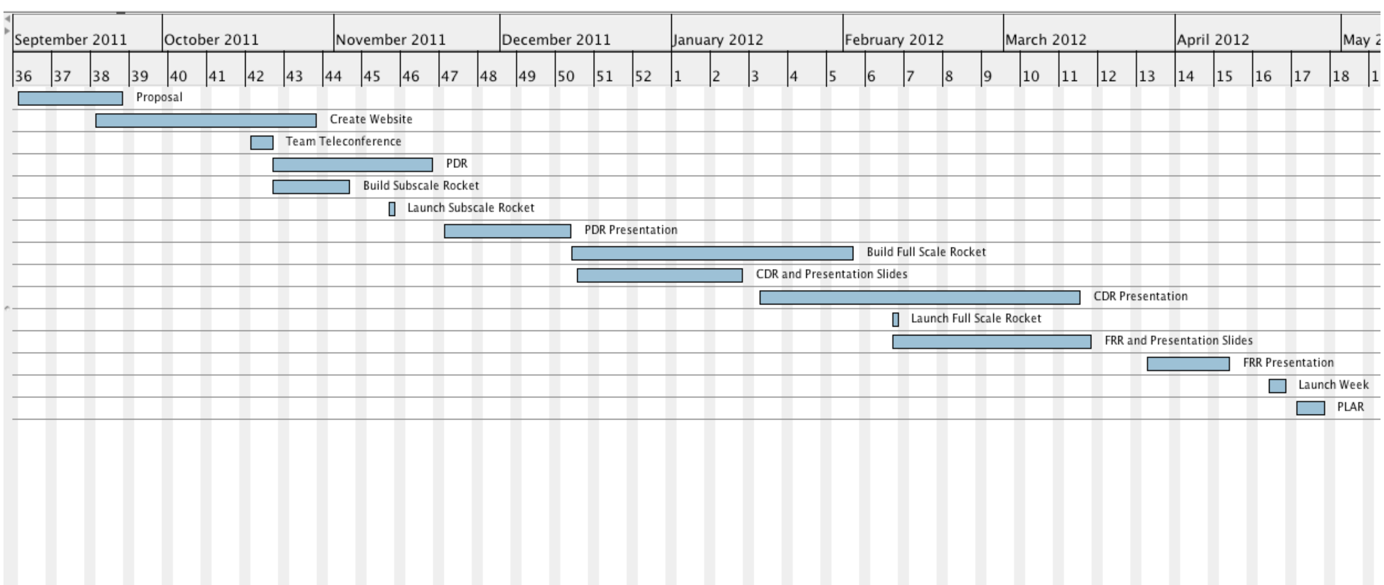
VIII. Project Plan and Internal Due Dates

Weekly meetings are scheduled for every Saturday starting at 5 pm in the Janet and Jeffery Mitchell Private Dining Room. The meeting will last until all items of importance have been addressed. Other meetings may be scheduled as needed.

For each due date listed below, we have decided upon an internal due date by which major contributions by each team member are due. These will allow for a team editing period before each final due date.

Requirement	Internal Due Date	Actual Due Date
Proposal	Sept. 17th, 2011	Sept. 26, 2011
Website Presence Established	Oct. 29th, 2011 (Complete Sept, 24, 2011)	Nov. 4, 2011
Preliminary Design Review (PDR) and slides posted on website	Nov. 19th, 2011	8:00 am central time, Nov. 28, 2011
Completion of Sub-scale construction	Nov. 4, 2011	NA
Sub-scale Launch	ROCstock XXXIV (Nov. 11-13, 2011)	NA
Critical Design Review (CDR) report and slides posted on website	Jan. 14, 2012	8:00 am central time, Jan. 23, 2012
Completion of Full-scale construction	February 3, 2012	NA
Full-scale Launch	February 11, 2012	NA
Flight Readiness Review (FRR) report and slides posted on website	Mar. 17, 2012	8:00 am central time, Mar. 26, 2012
Post-Launch Assessment Review (PLAR) posted on website	Apr. 28, 2012	8:00 am central time, May. 7, 2012

For more details on the project plan, see the Gantt chart below:



IX. Conclusion

With this proposal, the Harvey Mudd College USLI Team would like to officially express their interest in participating in the 2011-2012 University Student Launch Initiative. Our team is deeply committed to the project and agrees to follow all NASA and NAR safety guidelines and other regulations.

For questions or concerns, contact our team leader, Jane, at jhoffswell@hmc.edu.