Charger Rocket Works Proposal
2008-2009 University Student Launch Program

The University of Alabama in Huntsville Student Launch Initiative Team Charger Rocket Works puts forth this proposal for consideration. Charger Rocket Works wishes to participate in the 2008-2009 University Student Launch Program. The Title of our project will be Osprey, in Honor of the Late Dr. Clark W. Hawk. Dr. Hawk was founder and Director of UAHuntsville Propulsion Research Center and professor of Mechanical and Aerospace Engineering at UAHuntsville. Dr. Marlow Moser will serve as the team official and National Association of Rocketry (NAR) point of contact (POC). Dr Moser and Daniel Cavender hold a High Powered Rocketry Level 2 Certification. The safety officers for the 2008-2009 USLI project are Daniel Carter and Edward Jeffries. Approximately 40 students will participate as team members over two semesters. Personnel resources will be allocated to one or more teams depending on the needs of the team and the member's request.

Teams/Programs and Their Responsibilities

Structures Team:
Responsible for the system level design, construction, and testing of the rocket's airframe.

Propulsion Team:
Responsible for system level propulsion analysis, testing, and selection. Propulsion team will also test the in flight thrust measurement system.

Payload Team:
Responsible for system level design, construction, and testing of scientific payload concepts for the rocket and other scientific instruments on the rocket.

Recovery/Avionics Team:
Responsible for design, construction, testing, and integration of a robust recovery system and the flight computers that controls it.

Ground Support Team:

Responsible for design and construction of launch hardware and other ground support systems that accommodate the needs of the mission in the field.

Outreach Program:
Responsible for reaching out to the community and educating young minds about rocketry and inspire a desire to pursue an education in the fields of Science, Technology, Engineering and Mathematics (STEMs).

Public Relations Program:
Responsible for recording the accomplishments of Charger Rocket Works, maintaining the

webpage and forwarding events of merit on for publication.

Facilities/Equipment

The Charger Rocket Works clubhouse is located in Room 165-D of the Johnson Research Center on the UAH Campus. The doors are locked for security but team members have an access code and are encouraged to work at any time of the day or night. Because the room supports industrial equipment, team members are encouraged not to work on projects alone in the event of an accident. In the case of an emergency, two fire extinguishers and two first aid kits are present and easily accessible.

Osprey will require equipment ranging from standard shop equipment such as table saws, drill presses, miter saws, belt sanders, hand drills, and saudering irons to highly specialized equipment such as CNC machines, high pressure water jet and laser cutting equipment. The clubhouse is also equipped with several tools necessary to construct the electronic devices which will fly as the payload. Such electronics will include multiple altimeters to verify the altitude of the rocket, as well as ensure proper deployment of the recovery devices at the proper altitudes. The team will construct certain jigs for greater precision in the construction of the rocket, thus ensuring a safer and more stable flight. The clubhouse, although located in the central portion of the Johnson Research Center, does have proper ventilation required for a safe work environment if all doors remain open and multiple fans are used.

The clubhouse has three computers for member use only. These computers are loaded with standard Microsoft software, including Microsoft office for document development, and are all connected to the internet. For communication among team members, a Google Group has been set up to share documents and an email list has been setup through the team website. For aid in the design and construction of the rocket, each computer has been outfitted with RockSIM and Solid Edge software packages. RockSIM will be utilized in ensuring a proper stability margin of the rocket and also modeling the projected altitude of the proposed design. Each computer is properly equipped with the necessary equipment needed to perform Video Teleconferencing with MSFC.

Safety & Mission Assurance

The team official as well as several members are NAR members and have a certification level 2 for high powered rockets. Such members include the competition sponsor, Dr. Marlow Moser, who will attend every launch and directly oversee all operations. Each launch activity in which the team is involved will take place at a NAR or a Tripoli sanctioned event, and as such, all team members will precisely comply with the safety regulations and practices of the aforementioned associations. The acting safety officer will apply an Operational Risk Management (ORM) concept adopted from the Air Force. The concept will lead any team member through the six steps of minimizing accidents by smartly viewing a situation and weighing the possible actions that will yield the best result. All team members were given a safety briefing on the six steps of ORM. Also, each students involved in the launching of the vehicle has been briefed, in great detail, on the specifics of the NAR safety regulations. Such briefings include, but are not limited to:

- NAR certifications and how they pertain to the safety and procedures associated with the UAH USLI competition.

- The use of lightweight materials, such as wood, paper, rubber, plastic, and fiberglass for reasons of safety to the team and bystanders.
- The use of certified, commercially manufactured engines and the necessesity of keeping heat sources a safe distance away from any motor.
- The use of electrical launch systems and igniters that are fitted with safety interlocks and the importance of not arming the igniter until the rocket is on the pad.
- The proper procedures to be undertaken in the case of a motor misfire.
- Details concerning launch safety, including the use of a loud, audible countdown, enforcing a safe distance between the rocket and observers, and checking the stability of the rocket before flight. The team extensively utilizes the RockSIM software to ensure rocket stability.
- The importance of choosing a proper launch site with adequate dimensions for the planned flight, and the proper location of the launcher.
- The importance of using a proper recovery system which will ensure that all parts of the rocket are safely returned undamaged in reusable condition, and the importance of not attempting to recover the rocket from power lines, trees or any other hazard.

A safety book has been assembled that includes the safety codes for working with high powered and model rockets and launch area safety etiquette. The students and faculty involved in the USLI competition have researched and verified that the team complies to the city, state, and federal laws concerning the use of explosives and the flight of high-powered rockets, including the Federal Aviation Administration and the United States Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATFE). Because UAH is a state school, it is exempt from the requirement of having a Low Explosives Users Permit (LEUP). This has been verified several times with the ATFE.

A Materials Safety Data Sheet (MSDS) has been assembles for the clubhouse. An appropriate Type-4 explosives storage magazine has been setup and a list of explosives contained and the quantity is placed with the magazine for identification of its contents. The box is locked and only authorized team members trained in the handling of the explosives are allowed access. On launch days, an appropriate Type-3 storage box is used to transport the propellants to and from the desired launch site. Because a majority of the research done at UAH involves propellants, the professors and students alike are well versed in the use of the Type-3 and Type-4 storage devices. All other flammable liquids (spray paint, epoxy, etc.) are stored in a flame proof cabinet that is appropriately marked and has a list of the cabinet's contents and quantity placed on the front. The UAH Campus Environmental and Safety Office is in the same building and we had a representative do a walk through with us to list any deficiencies.

Operational Risk Management Plan

Step 1: Identify the Hazard

A hazard is defined as any real or potential condition that can cause degradation, injury, illness, death or damage to or loss of equipment or property. Experience, common sense, and specific analytical tools help identify risks.

Step 2: Assess the Risk

The assessment step is the application of quantitative and qualitative measures to determine the level of risk associated with specific hazards. This process defines the probability and severity of an accident that could result from the hazards based upon the exposure of humans or assets to the hazards.

Step 3: Analyze Risk Control Measures

Investigate specific strategies and tools that reduce, mitigate, or eliminate the risk. All risks have three components: probability of occurrence, severity of the hazard, and the exposure of people and equipment to the risk. Effective control measures reduce or eliminate at least one of these. The analysis must take into account the overall costs and benefits of remedial actions, providing alternative choices if possible.

Step 4: Make Control Decisions

Identify the appropriate decision-maker. That decision-maker must choose the best control or combination of controls, based on the analysis of step 3.

Step 5: Implement Risk Controls

Management must formulate a plan for applying the controls that have been selected, then provide the time, materials and personnel needed to put these measures in place.

Step 6: Supervise and Review

Once controls are in place, the process must be periodically reevaluated to ensure their effectiveness. Workers and managers at every level must fulfill their respective roles to assure that the controls are maintained over time. The risk management process continues throughout the life cycle of the system, mission or activity.

In addition to the above mentioned safety assurance measures, the Charger Rocket Works team members understand and will abide by the following safety regulations:

1. HARA (Huntsville Area Rocketry Association) will provide range safety inspections of each rocket before it is flown. Each school team shall comply with the determination of the safety inspection.

2. The HARA Range Safety Officer has the final say on all rocket safety issues. Therefore, the HARA Range Safety Officer has the right to deny the launch of any rocket for safety reasons.
3. Any team that is found non compliant with Safety & Mission Assurance (S&MA) will not fly their rocket.

Technical Design

The table below shows the nominal dimensions and approximate weights for the rocket proposed. The subsystem teams are working together to achieve the goal of 35 pounds and the budget of $5000 for the vehicle. Additional costs for subscale rocket, travel etc. Total cost is $8000

Rocket Weight & Budget Distribution Matrix

TEAM	Total Weight = 35 lbs	Total Budget	General Dimensions
Structures			
Carbon Airframe	9 lb.	$450	9' long, 6" diameter, 1/8" thick
Carbon Fins	0.5 lb.	$175	
Nose cone	1.0 lb.	$100	
Centering rings	0.5 lb.	$50	
motor tube	1 lb.	$25	
misc	2 lb.	$200	
Total	**15 lb.**	**$1000**	
Propulsion			
motor hardware		$400	75mm, 24" long
Propellant		$250	
Total	**8 lb.**	**$650**	
Recovery Avionics			
Flight Computers	1 lb.	$500	6" diameter, 24" long
Batteries	1 lb.	$100	
Chute	0.5 lb.	$100	
Shock cord	1.5 lb.	$40	
Electric matches	0.1 lb.	$10	
Misc	0.9 lb.	$100	
Total	**5 lb.**	**$850**	
Payload			
Flight computers	1 lb.	$500	6" diameter, 24" long
Batteries	0.5 lb.	$100	
GPS/Camera/transmitter	2.5 lb.	$400	
Instrumentation	3 lb.	$1,500	
Total	**5 lb.**	**$2,500**	

Ground Support	N/A	$1,000	N/A
Travel	N/A	$1,000	
Subscale rocket	N/A	$500	
Test Propellant	N/A	$500	
Total (vehicle) **Total Program**	35 lb.	$5,000 $8,000	

Structures

The structure of the rocket will be composed of three primary components: the nosecone, the airframe, and the fins. The entire structure will be approximately 9 feet tall and six inch diameter. The nosecone will be made of fiberglass. Fiberglass provides the best characteristics for weight, strength, price, and performance. The inside volume of the nosecone will be used as payload space for part of the science package thus maximizing the efficient use of available space and potentially making the rocket shorter saving weight, and improving stability by moving the Center of Gravity forward allowing for the use of smaller fins and reducing overal drag on the vehicle. The airframe will potentially be made of a fiberglass wound phenolic tube. Fiberglass wound phenolic tubing comes at a weight and cost penalty, but will benefit design with its drag reduction and strength characteristics. This composite structure will generously handle flight and ground handling loads and protect the rocket and payloads from non-ideal landing cases. Another potential material for the airframe is intermediate modulus filament-wound carbon fiber tube. This option is advantageous in the sense that the increased strength-to-weight ratio would allow the team to use smaller motors and as such lower the overall cost of the rocket. Because there are fewer carbon fiber rocket components available for hobby use, a carbon fiber rocket structure would require a complete fabrication of the tubing, which would include the modeling of the tubes, a netting analysis, and actual design of the winding pattern of the carbon fibers. This process would allow the team to practice more engineering skills, rather than simply "cutting and piecing" off the shelf components. The fins will be carefully designed to ideally stabilize the rocket and minimize the drag penalty. Fins will be made of a fiberglass phenolic sheet and the forward and trailing edges contoured. Other materials may be considered early in the design to increase performance, such as carbon fiber so that weight can be saved in every aspect possible. The aft end of the rocket will probably be straight, rather than a boattail, in order to allow enough room to properly instrument the motor tube.

Propulsion

There are many unknown variables and options for a motor on a rocket. Many variables are related to the rocket itself, which drives a particular aspect of the motor; like overall vehicle weight and diameter. There are other restrictions imposed by the USLI program requirements; like reusability, motor class, and altitude. All of these aspects were examined individually to determine the motor for this rocket.

Due to Dr Moser and Daniel Cavender only being Level 2 certified, the motor class was limited to a maximum motor size of "L" thus eliminating all motors above the “L” class. The altitude requirement is imposed by the ability to reach 1 mile AGL (Above Ground Level). This requirement drives the motor type based on the thrust needed for the rocket with a certain weight and diameter to reach the desired altitude of 1 mile AGL. The requirements also state that the motor must be reusable and commercially available therefore eliminating the motors that were not reusable and not commercially available.

There are other factors, which also affect the motor choice that are determined by the rocket variables. The rocket weight is a major contributor to the thrust needed to achieve 1 mile AGL. The structures used and the payload primarily determines the weight. The payload also drives the diameter and the structure of the rocket. Our team has collectively made estimations on these major factors in order to determine the motor needed. The weight is estimated to be 13.6 kg, the diameter is 150 mm. If an Aerotech L850W is chosen the rocket will reach an altitude of 5,400 ft. AGL. This calculation was performed using a rocket altitude calculator on the web at http://www.markworld.com/.

Payload

The payload system for the new rocket design will consist of a pitot-static probe at the nose cone and a chamber pressure measurement of the rocket motor. It is proposed that the payload will contain a scientific package consisting of a pivoting camera with GPS overlay, an accelerometer, 3-D magnetometers, pitot-static probe, battery packs and flight computers. The camera, GPS overlay, and 3-D magnetometer would be used to provide visual data that reflect the location of the payload. The accelerometer would record the acceleration of the payload. The magnetometers would give a means of recording the flight path and rocket orientation. The flight computer is used to record all of this data acquired, and the battery packs are necessary to provide power to all of these devices.

The payload constisting of the pitot-staic probe with be used to measure the actual air speed over the nose cone tip of the rocket. This calculation will be verified (checked) with the use of the calculated air speed by the accelerometer. The actual thrust will be calculated from the accelerometer which can be compared to the theoretical thrust from the chamber pressure measurement which can provide the calculated erosion rate of the nozzle of the motor.

The payload will also perform measurements on the rocket motor to calculate the thrust of the motor during flight. The thrust of the rocket can be calculated by knowing the chamber pressure and the throat area of the motor. The chamber pressure is the key factor in calculating thrust and can be measured using two different methods. The preferred method is to mount a pressure transducer at the forward end of the motor tube. The smoke charge will block the pressure to the pressure transducer so it must be removed. When the smoke charge is removed it will change the volume of the chamber and expose the forward closure to the flame so an inert phenolic insert can replace the smoke charge, while keeping the performance of the rocket motor intact. There is an alternate but less desirable method of measuring the chamber pressure by mounting strain gauges to the exterior of the motor tube. The latter method is not preferred due to an unknown factor of temperature effects on the strain measurement. In either case, extensive ground tests will be conducted to assure reliablity.

These measurements will be recorded during the flight of the rocket and analyzed after the rocket is recovered. The measurements will be recorded to a solid-state data-recording device.

This is the most secure method of recording during flight because it eliminates the need to transmit the data, which reduces complexity, and if there is an anomaly during the flight the solid sate memory will be more capable of surviving an impact as compared to other recording methods.

Avionics:

The vital responsibility of the avionics system is to support the recovery of the rocket. The avionics system requires redundancy in case of hardware failure or malfunction through flight duration. The rocket will have three different methods to ignite the pyrotechnics for recovery separation. Deployment of recovery systems will be managed by redundant use of a R-DAS flight computer, a Perfect Flight computer, and a radio receiver that is manually operated from the ground. The radio receiver is to be used as a last resort if both the R-DAS and PerfectFlite fail to deploy the ignition charges.

The R-DAS is a flight control computer that can be enabled to detect rocket liftoff and collect rocket telemetry data. It has an accelerometer (0-50g), pressure transducer measuring altitude, and ignition switches for deployment of the parachutes. It has EEPROM (Electronically Erasable Programmable Read Only Memory) that can hold between 115 to 462 seconds of telemetry depending on the number of data channels enabled. The PerfectFlite computer is capable of igniting two pyrotecnics charges based on pressure altitude, and records pressure altitude. The use of a remote fail safe is a third method to recover the rocket and is new to the team this year. The use of the HAM radio is to decrease possible frequency interference (such as might be possible with an RF backup system) and possible premature chute deployment.

The avionics system may also have the ability to plot a three dimensional graph of position and orientation versus time of the rocket trajectory. In order to achieve a more accurate three dimensional plot of position versus time Charger Rocket Works is exploring the use of a commercially available Inertial Measurement Unit (IMU). IMU's consists of three dimensional accelerometers and three axis rate gyroscopes. The data from the IMU can be recorded using RS232 or CAN data protocols linked to the appropriate data logger. Ultimately the use of an IMU will be decided by the budget and cost effectiveness.

Recovery

The recovery system is designed to safely land the rocket in a controlled manner, preserving the structure and the payload for data retrieval and future flights. The rocket will use a two stage recovery technique. The first stage of the recovery will use a chute-less drogue technique. In this stage the tail section will be separated from the rocket by a pyrotechnic charged piston. The kevlar cord will alter the rockets aerodynamic profile increasing the drag and ultimately slowing the rocket's descent speed. The second stage of the recovery will use a large main parachute deployed by a second pyrotechnic charged piston at an approximate altitude of 600 feet. The main parachute will be located in the upper airframe behind the nose cone. The diameter of the chute will be between 60 and 80 inches which will be determined upon final weight of the rocket, and the allowable decent rate. The main chute piston system will have a fail safe backup trigger operated by a HAM radio and onboard DTMF (dial tone multi-frequency) controller. The use of the HAM radio is to decrease possible frequency interference and possible premature chute deployment. This two stage recovery system also reduces the recovery area to a more manageable size.

Outreach

The UA Huntsville Charger Rocket Works team plans to solicit community support for the project in several forms. Financial support has been obtained from the Alabama Space Grant Consortium and from corporate sponsors such as ATK. Expertise will be provided from industry volunteers. Current volunteers include Mr. William T. Bradshaw, and Mr. Jason Winningham. Mr. Bradshaw brings 30 years of experience as a Missile Technician and Logistics expert to the rocket team and serves as an Assistant Team Leader. Mr. Jason Winningham is the IT and computer expert for the Engineering Department at UA Huntsville. His design will be used for the DTMF backup triggering system in the rocket recovery system. He will be donating his time and expertise for the fabrication of this system and other electronic portions of the rocket build.

Charger Rocket Works plans to initiate several outreach efforts over the course of this project. The first of which will be as an exhibitor at the Sally Ride Science Festival for Middle School Aged Girls that will be held on the campus of UA Huntsville. This festival has served to spark interest in the sciences and engineering fields for thousands of school aged girls during its existence. Charger Rocket Works hopes to further this cause by promoting interest in the field of aerospace engineering and rocketry among middle school aged girls. Also, a rocket demonstration is planned for a local Boy Scout troop. The goal is to get these boys excited about the possibilities in the field of engineering while furthering the Boy Scout troop's science education objectives. In addition to these two engagements, the possibility of doing demonstrations at several school's has been discussed.

Project Plan

The table below shows the current schedule for the proposed rocket build.

Charger Rocket Works 2008-2009 Timeline	
Month	**Event**
August	28- Begin Conceptualization
September	14- Finalize Concepts and Requirements
October	3-Complete Initial Design
	8- Proposals due
	10- Begin Construction of Subscale Rocket
November	**12- Web Presence Established**
	14- Complete Construction of Subscale Rocket
	24- Flight testing of Subscale Rocket
	28- Last Day of Fall Semester

December	**3- Preliminary Design Review**
January	19- Additional Flight Subscale Testing (If Needed)
	25- Full Scale Redesign Complete/ Begin Construction
	28- Critical Design Review
February	27- Complete Full Scale Construction
March	12- Complete Full Scale Ground Testing
	15- Flight Testing of Full Scale Rocket
	22-Flight Testing of Full Scale Rocket
	31- Flight Readiness Review
April	16- Competition Prep Complete
May	**19- Competition Launch** **12- Post Launch Assessment Review**

As previously mentioned, the budget for this project will be approximately $5,000. This is expected to be provided primarily by the Alabama Space Grant Consortium. Some of the purchases may also be funded directly by UAH and corporate sponsors such as ATK. For specific budget allotments, please refer to the "Rocket Weight and Budget Distribution Matrix" mentioned earlier in this proposal.

Charger Rocket Works as a Returning Team:

The University of Alabama is committed to the continued success of the University Student Launch Program through its continued offering of the senior level elective class "MAE 496: Student Launch Initiative" to students majoring in all fields of engineering. Continued success is encouraged and ensured by the passionate support and dedication of the UAHuntsville engineering faculty. Also, government and industry partner interest has continually risen at an exciting rate. We believe that continued success of the program will attract future industry partners and community involvement. The faculty and students will continue to pursue partners from the community to help in the endeavors of Charger Rocket Works, which we hope will help to spur the interest of future students in the program. Funding sustainability will occur through the continued financial support of the University of Alabama in Huntsville, annual reapplication for Alabama Space Grant Consortium Funding, and solicitation for funding from community and industry partners. Community outreach will continue to be an important part of the Charger Rocket Works philosophy to ensure that excitement over the program continues to grow.

While Charger Rocket Works is a returning team to USLP competition, most of the students on the team are new to the competition. Some similarities may exist between the current proposed design and prior competition rockets, but strong efforts have been made to learn from the successes of the past and to be innovative in the design of this year's submission. It is the hope of this year's team that the strengths of previous designs will be fully utilized while implementing new and exciting improvements over all other prior Charger Rocket Works rockets. It is the goal of this team to continually improve upon our best efforts and ensure the continued success of this program.