Project A.P.E.S. Proposal in Response to NASA University Student Launch Initiative (USLI) RFP

By:

Georgia Institute of Technology Mile High Yellow Jackets

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1.1. *School Information and NAR Section Contacts*

1.1.1. School Information

School Name: Georgia Institute of Technology
Team Name: Mile High Yellow Jackets

Project Title: Active Platform Electromagnetic Stabilization (A.P.E.S.)
Rocket Name: *Vespula*

Project Lead/Team Official: Richard Zappulla II
Safety Officer: Akshaya
Matt
Team Advisors: Dr. Eric Feron
Dr. Marilyn Wolf

NAR Section: Primary: Southern Area Rocketry (SoAR) #571
Secondary: GA Tech Ramblin' Rocket Club #701
NAR Contact: Primary: Matthew Vildzius
Secondary: Jorge Blanco

1.2. *Student Participation*

The Mile High Yellow Jackets will be competing in the 2011-2012 NASA University Student Launch Initiative (USLI) with a new team of students. To work more effectively, the team is broken down into smaller groups, as illustrated in Figure 1.

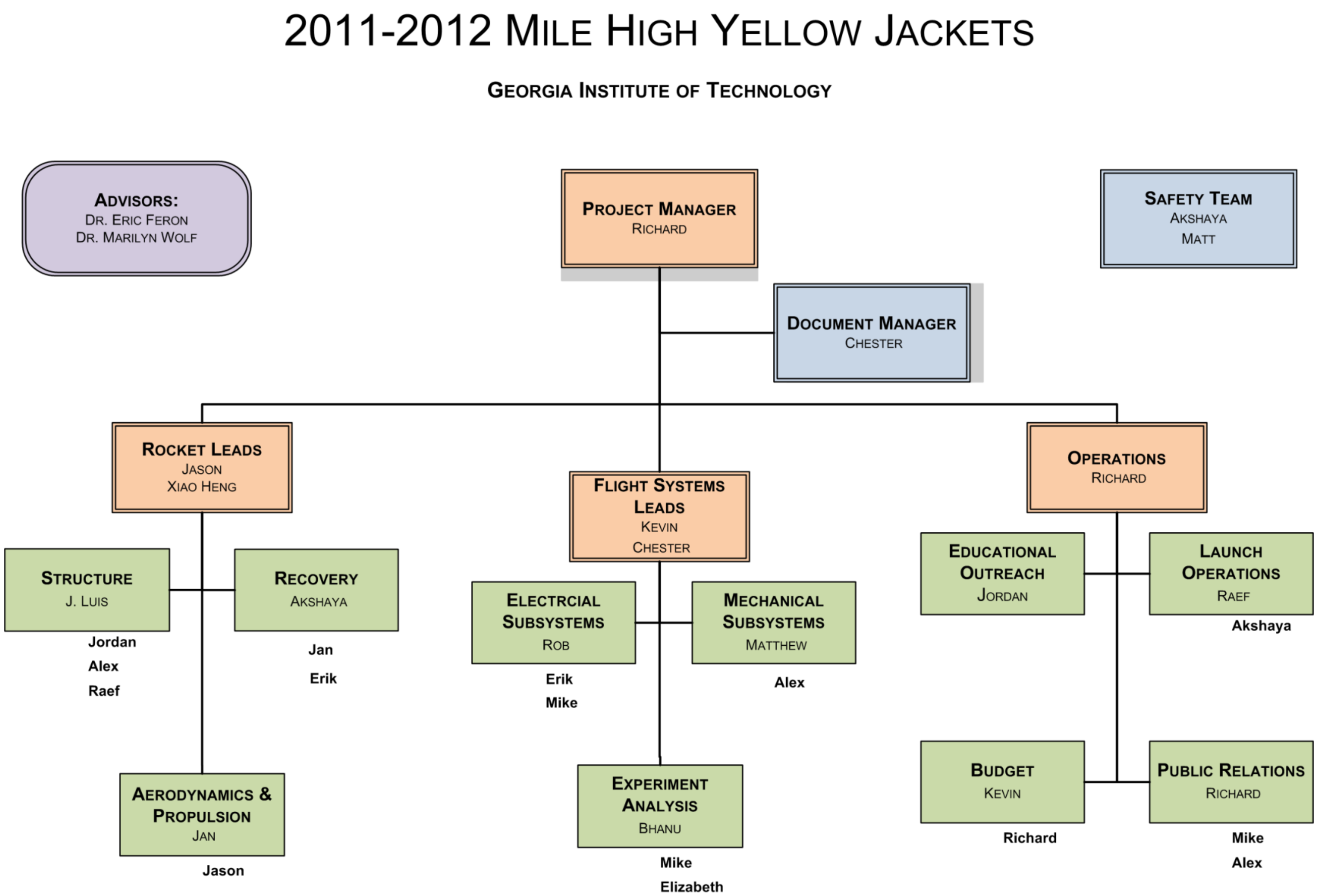


Figure 1. 2011-2012 Mile High Yellow Jacket work breakdown structure.

1.3. *Facilities and Equipment*

This section will list all applicable facilities, equipment, and software that the Mile High Yellow Jackets have access to in the design and testing of Project A.P.E.S.

1.3.1. Facilities

The Mile High Yellow Jackets will utilize the open-circuit, Low-Speed Aerocontrols Wind Tunnel -– illustrated in Figure 2 - to understand and optimize the aerodynamic characteristics of their rocket, *Vespula*. The low speed wind tunnel is equipped with a 42”x 42” x 42” test section, pitot tubes utilizing Barocel vacuum pressure transducers, force-strain stands, and high-speed, multi-channel signal filtering and computer data acquisition systems.

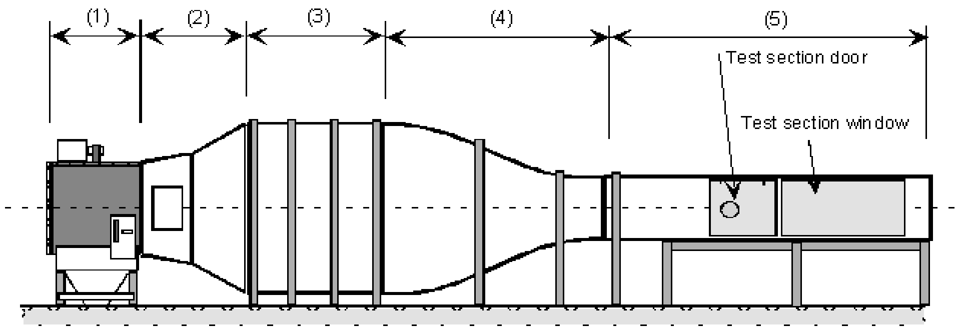


Figure 2. Open-circuit, Low Speed Aerocontrols Wind Tunnel Schematic

In order to fabricate components of the rocket and payload, the Mile High Yellow Jackets have access to the Invention Studio seven (7) days a week, 24 hours a day – pending the supervision of either a Graduate Lab Instructor or an Undergraduate Lab Instructor. The Invention Studio is complete with:

- Water Jet Cutter
- Laser Cutter
- 3-D Printer
- CNC Mill & Lathe
- Mills, Lathes, & Drill Presses
- Basic Hand Tools

Additionally, in order to facilitate the development and construction of electronics specific to Project A.P.E.S., the Mile High Yellow Jackets have access to the Electrical and Computer Engineering (ECE) Senior Design Lab, 24 hours a day, seven (7) days a week. The ECE Senior Design lab is complete with:

- PCB Mill for PCB fabrication
- Oscilloscopes
- Soldering Stations
- Power Supplies
- Electrical and Computer Engineering Senior Design Lab

Moreover, in order to participate in video-teleconferences and off-campus communications, the Mile High Yellow Jackets have access to Cisco Video-Teleconferencing equipment – including a T3 broadband connection, POLYCOM cameras and microphones, speakers, and LG plasma TV's - located in the Vertically Integrated Program (VIP) Labs. This will allow for a high quality Video Teleconferencing sessions in a professional environment. A dedicated website for the Mile High Yellow Jackets will be online which will include current team information, team picture, project documentation, and other relevant information. The Mile High Yellow Jackets will comply with all aspects of the Architectural and transportation Barriers Compliance Board's Electronic and Information Technology (EIT) Accessibility Standards.

1.3.2. Software

All members of the Mile High Yellow Jackets have 24/7 access to a large suite of industry-standard engineering software packages on campus and personal computers including:

- OpenRocket
- MATLAB and Simulink products
- Abaqus, NX7 (FEA)
- Fluent (CFD) and Gridgen
- COSMOL (Multi-physics Modeling and Simulation)
- JMP (Data Analysis/Statistical Software package)
- AutoCAD, Solidworks (CAD and FEA)

These industry-standard software packages are supplemented by standard software suites, such as Microsoft Office 2007 as well as internet capabilities.

2. Safety

2.1. *Vehicle Safety*

Due to the novelty of the Mile High Yellow Jackets' rocket design, a significant amount of ground testing will be used to validate the finite-element structural analysis. More specifically, the ground testing campaigns will test the novel rocket structure using impulsive loading –such as parachute deployment – as well as static loading – periods of constant thrust – tests. These tests will be performed multiple times using a ground testing rig that will be capable of delivering known amounts of energy – for the impulsive loading tests – as well as known amounts of force – for the static loading tests. Additionally, cycle-fatigue testing will be used to understand the stress-cycle characteristics of the rocket structure. Lastly, the results of the various ground tests and validated model results will be used in the creation of a Pre-Flight Inspection Checklist of the airframe components.

2.2. *Mission Assurance*

The Mile High Yellow Jackets' Safety Team will be responsible for ensuring team compliance with the safety plan. The Safety Team will be consist of representatives from both the Rocket and Flight Systems Teams and will work together to implement an effective safety plan that takes into consideration all aspects of the team's launch vehicle and payload designs.

2.3. *Material Handling*

Several potentially hazardous materials will be involved in the construction and flight of the *Vespula* rocket, including, but not limited to: ammonium perchlorate composite propellant (APCP), black powder, and electrical matches. All Material Safety Data Sheets (MSDS) for such substances will be made readily available in close proximity to the substances. Additionally, the Safety team will ensure that all members are briefed on proper handling and storage of any hazardous materials.

2.4. *Purchase, Shipping, Storing, and Transportation of Rocket Motors*

Currently, no members of the Mile High Yellow Jackets currently hold a Low Explosives User Permit (LEUP). As a result, all rocket motors will be acquired from vendors at the launches we attend. Specifically, for the competition launch in April 2012, the Mile High Yellow Jackets' plan to order motors in advance from Huff Performance for use at the HARA launch site.

2.5. *Launch Site Safety*

The team will conduct training in launch hazard avoidance. The safety officer will conduct a full check – utilizing the safety checklist – of all critical rocket components. The safety officer will provide a pre-launch safety briefing covering specific hazards for the launch. All launch safety rules in place by the local NAR section will be reviewed and discussed. Launches will occur at NAR sponsored launch events at high power fields, one such NAR club being Southern Area Rocketry. The competition launch will be regulated by the Huntsville Area Rocketry Association.

2.6. *High Power Rocket Certifications*

Table lists the members of the Mile High Yellow Jackets who currently hold either NAR or TRA certifications.

Table 1. List of Team members who hold High Power Rocket Certifications

Name	*Certifying Agency*	*Certification Level*
Alex B.	NAR	Level 1
Kevin R.	NAR	Level 1
Richard Z.	NAR	Level 1

To purchase and use high power rocket motors, an individual must be certified by either the NAR or TRA. The Level 2 certification allows for the use of J-, K-, and L-class motors. The certification process is designed to allow the candidate to demonstrate their understanding of the basic physics and safety guidelines that govern the use of high power rockets. Level 2 certification requires one to construct, fly, and recover a high power rocket in a condition that it can be immediately flown again, as well as pass a written exam that tests the knowledge of rocket aerodynamics and safety. For the 2011-2012 competition cycle, Richard Z. plans to receive their Level 2 certifications through NAR prior to the end of the year. Additionally, Matt Vildzius will be the Mile High Yellow Jackets' Level 2 sponsor until the team has a Level 2 qualified member.

3. Technical Design

3.1. *Vehicle Technical Design*

3.1.1. Vehicle Requirements

The vehicle must provide a suitable environment for the payload experiment, which includes a stable, vertical orientation until apogee. It will also fly to as close to 5,280 feet as possible without exceeding the 5,600 feet altitude limit. Barring any mishaps, the vehicle will also be completely reusable other than the motor and ejection charges.

3.1.2. General Vehicle Dimensions and Weight Breakdown

Table contains the initial sizing dimensions for the vehicle. The weight breakdown of rocket is shown in Figure 3; the rocket has a gross takeoff weight of 38 lbs.

Table 2: Vehicle Geometry

Parameter	*Value*
Overall Length	114 inches
Body Diameter	5 inches
Nose Cone length	25.5 inches
Fin Height	6 inches
Fin root chord	15 inches
Fin tip chord	3 inches

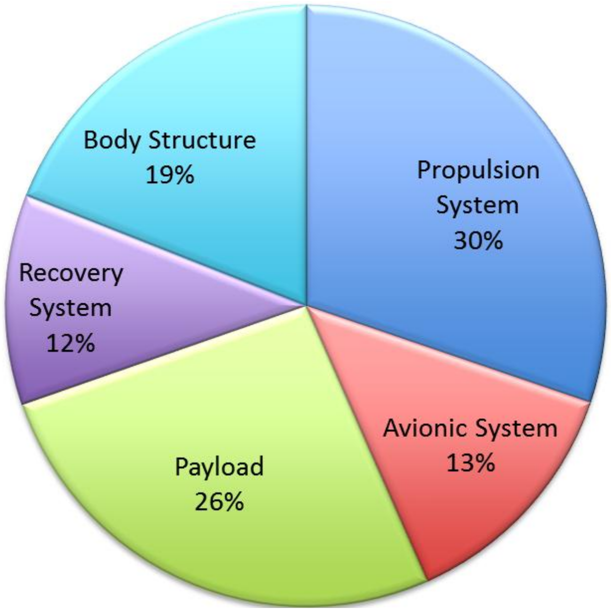


Figure 3. Vespula rocket initial sizing weight break-down.

3.1.3. Vehicle Characteristics

The rocket will have a traditional layout as shown in Figure 4. Starting at the aft end, it will consist of a booster section, a payload section, and a nose cone.

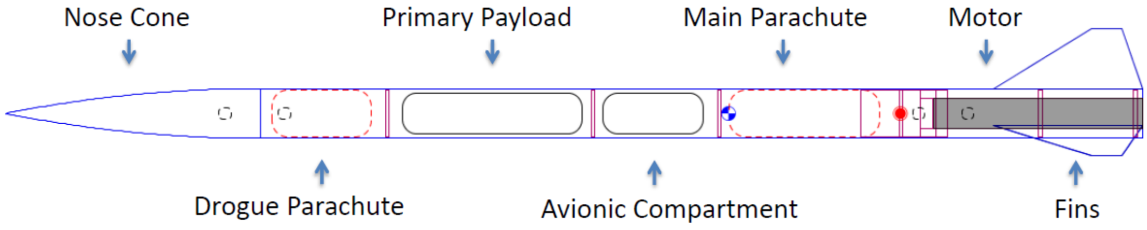


Figure 4: Internal layout of the Vespula Rocket.

3.1.4. Motor Selection

The booster section will house the L850W Aerotech motor and its retention system. This motor is the best option for our current design, predicting an apogee of 5,236 feet with for gross takeoff weight of 38 lbs. The max Mach number was calculated to be 0.52 utilizing OpenRocket software. Furthermore, our motor mount will be capable of fitting AeroTech L1390 or L1520 should additional thrust be required. The retention system will consist of a forward thrust plate integrated into the structure and an aft retention ring fastened to the base.

3.1.5. Recovery

The nose cone will be a hollow Ogive structure to reduced weight and drag during flight and to help house the drogue chute. The main parachute will be housed in the section connecting the booster and payload sections, and the drogue parachute will be located between the payload section and nose cone. Both chutes are made of rip-stop nylon with the main chute measuring six feet in diameter and the drogue at two feet. In order to have the minimum loading on the structure, the drogue chute will be deployed at or soon after apogee. The main chute will be deployed later at a determined altitude. Moreover, to ensure chute deployment, redundant systems will be utilized. Each chute will feature two independent black powder ejection charges with corresponding redundant igniters and altimeters.

3.1.6. Structure

A lightweight structure is key to maximizing payload mass fraction. Most rockets use a thick walled body tube as structural member of the rocket. Though simple, this design is inefficient in its use of material. A bulkhead and stringer design covered by the thin skin can produce a lighter rocket body, and a stronger structure frame, that is easier to repair and integrate with the motor and payload. The Georgia Tech USLI rocket will be a unique vehicle among amateur rocketry that will utilize an internal structure consisting of stringers and ribs, as illustrated by Figure 5. These stringers and bulkheads will be fashioned out of non-metallic material – such as fiberglass. The skin of the rocket will consist of a minimum thickness, flexible material. To further perfect our design, Finite Element Analysis (FEA) will be performed in order to ensure a safety margin of at least 2.5 on the structure given. Additionally, in order to maintain scheduling, an internal review for the novel structural will be held at least two weeks prior to PDR to finalize our decision on the structure design.

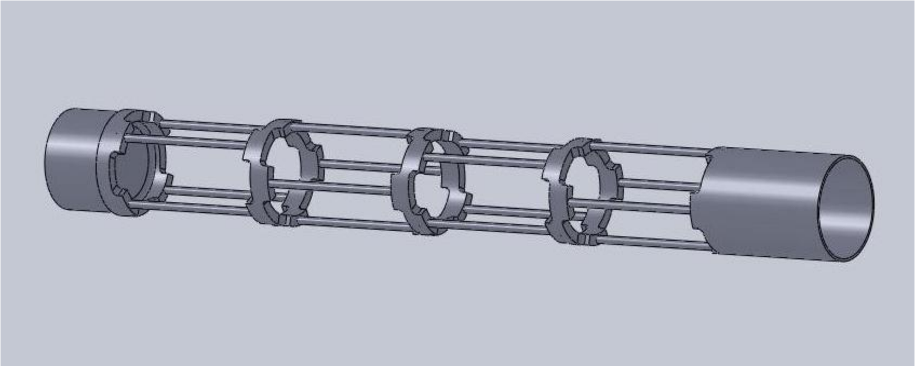


Figure 5: Preliminary Design for the Internal Vehicle Structure

The segments of the structure will feature forward and aft pieces that will slip fit into each other and will be fastened by shear pins to allow chute deployment while preventing premature section separation. Intensive ground and flight tests will be performed prior to the competition flight to ensure understanding and performance of the vehicle and its systems. The fins will be designed in such a way as to give a stable static margin during the flight with a given factor of safety and at the same time, have minimum drag and weight.

3.1.7. Vehicle Performance

Generated using OpenRocket software, Table 3 shows the predicted, mean ascent, and descent profile of the rocket (altitude, vertical velocity, and vertical acceleration). To perform a more accurate simulation, the launch conditions used Huntsville, Alabama weather data for April, as shown in Table 3. Future analysis will include windspeeds to better predict lateral drift.

Table 3: Flight Simulation Conditions

Conditions	*Values*
Windspeed	13.5 ft/sec
Temperature	60.8 °F
Latitude	34° N
Pressure	1013 mbar

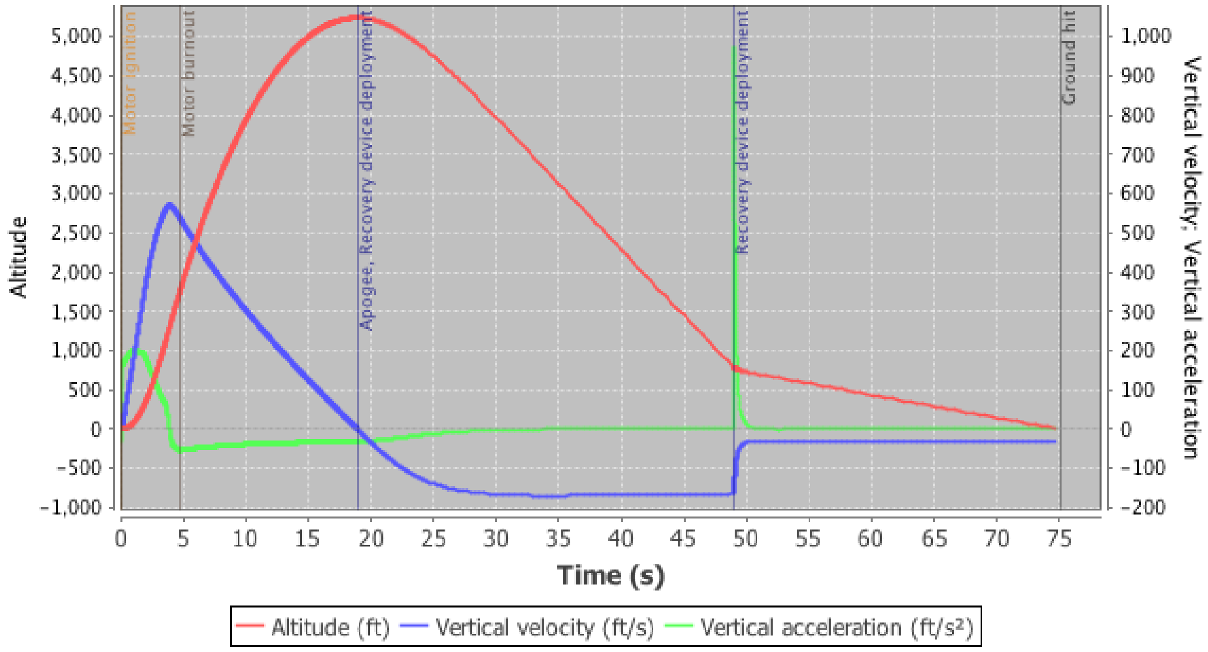


Figure 6: Vespula rocket flight profile from launch to landing.

Figure 6 shows that the rocket reaches apogee at approximately 19 seconds. At apogee, the ejection charges for the drogue parachute will activate. Deployment of the main parachute will occur at 1300 to 400 AGL to further decelerate the rocket to 15 ft/sec or less. The entire process takes slightly over a minute, which is rather slow compare to other rockets, due to the long motor burn time. As mentioned previously, a longer burn time will minimize the amount of loads on the structure, thus making our rocket safer, which our team heavily emphasizes.

In addition, a stability analysis was performed to ensure a safe flight profile as shown in Figure 7The stability margin of our rocket during most of the flight is 4.5 calibers, where one caliber is the maximum body diameter of the rocket. This is higher than the general rule of thumb among model rocketeers that the CP should be 1-2 calibers aft of the CG. However, being over-stable is not bad, it simply means that the rocket will have a greater tendency to weathercock if there is any wind at launch. To counter this, simulations will be run in the future to take into account the effect of extreme windspeeds. In addition, our launch rod will be long enough to allow our rocket to reach a higher lift-off velocity and hence be less affected by the wind.

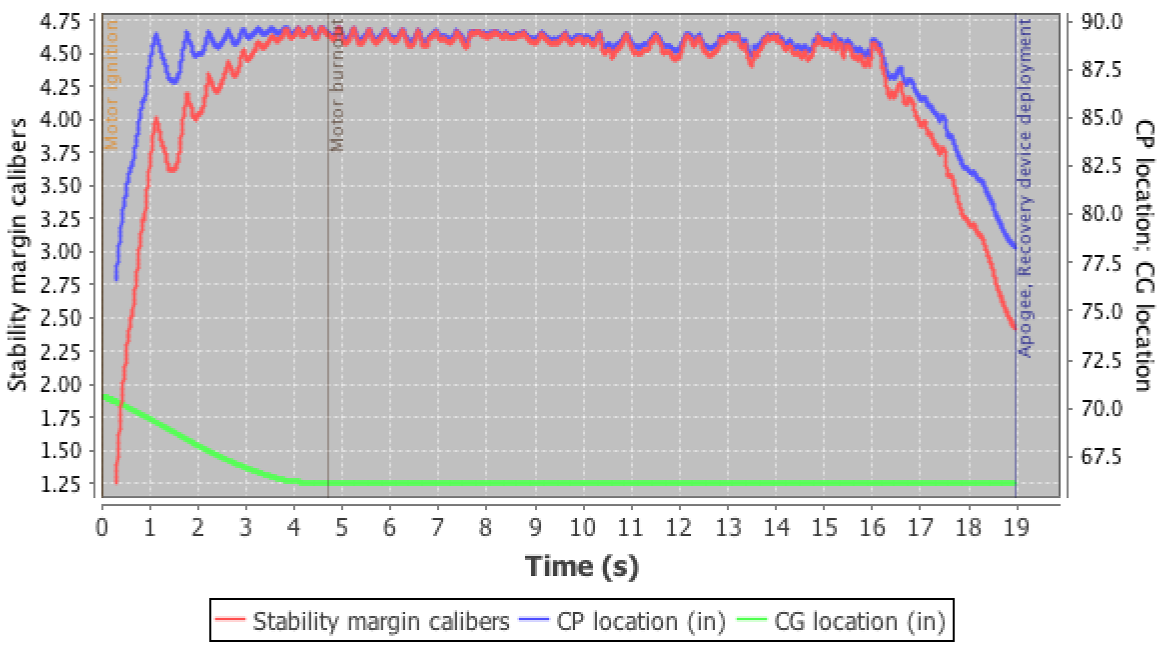


Figure 7: Stability of the Vespula rocket from launch to apogee.

3.2. *Payload Technical Design*

3.2.1. Overview

The 2011-2012 Georgia Tech Mile High Yellow Jackets propose to design, build, and implement a complex engineering and applied science payload system. This system will include the Active Platform Electromagnetic Stabilization, or A.P.E.S., experiment, including custom flight avionics to support all necessary functions of the rocket mission.

3.2.2. Relevance

The top priority of the Flight Systems team during proposal development was to create a payload concept that was highly relevant to NASA missions while also achievable and that could capitalize on the human capital available with the 2011-2012 team. After review by Flight Systems and the Georgia Tech USLI Team, the team decided that the most relevant payload concept would be to demonstrate the stabilization of a conceptual payload fairing levitated by permanent magnets and electromagnets. Benefits of such a system could include decreased axial vibrations and easily adjustable natural frequencies, resulting in lower mass requirements for both launch systems and spacecraft. The Flight Systems team intends to develop a smaller scale model of this concept for the Active Platform Electromagnetic Stabilization, or A.P.E.S., experiment. Deliverables on this experiment will include a comprehensive control theory, ground test data, and flight test data for a small plate levitated within a magnetic field.

3.2.1. Experiment Overview

The choice of the 2011-2012 Georgia Tech Mile High Yellow Jackets team is to pursue NASA payload Option 1 in the design, construction, testing, and flight of an applied science payload. This payload will test the feasibility of using magnetic fields to levitate and actively stabilize a platform or plate during the liftoff, initial coast, and into apogee of the Rocket trajectory.

3.2.2. Major Challenges and Solutions

Important challenges include the ability to successfully start the A.P.E.S. payload on motor ignition, the ability to safely shutdown the payload without unstable release of stored magnetic energy, inefficiency due to heating, high computational latency and data/control modeling latency. Further, electronic components exterior to the A.P.E.S. system must be fully shielded from magnetic interference due to non-static magnetic fields. Power supply usage must be within the safety limits of power supplies allowed by mass and dimensional budgets in the Rocket and Modular Payload System.

3.2.3. Success Criteria

The success criteria of the A.P.E.S. payload are listed below in Table 4. Furthermore, high-level requirements for the Flight Systems and the payload are outlined in Table 5. Additionally, a general timeline to PDR and into CDR is given in Figure 8.

Table 4: A.P.E.S. Success Criteria

	Success Criteria
1	Avoidance of all collisions with the payload container
2	Adequately reduce oscillations of the platform
3	Successful A.P.E.S. startup and shutdown
4	Full completion of data
5	Avoidance of electrical/mechanical failures

Table 5: Flight Systems and Payload Requirements

Requirement Number	*Requirement Definition*
1.1	The Flight Systems Team shall design and build the A.P.E.S. payload.
1.2	The A.P.E.S. platform shall not make contact with the payload container.
1.3	The Flight Systems Team shall produce a working control theory for the A.P.E.S. payload.
1.4	The Flight Systems Team shall ensure that all avionics are properly shielded from the A.P.E.S. payload
1.5	The Flight Systems Team shall design all A.P.E.S. and avionics such that they may be easily integrated with the Modular Payload System of the Payload Bay in the Rocket.
1.6	The Flight Systems Team shall conform to all weight, power, and dimensional requirements as per the Rocket design.
1.7	The A.P.E.S. Payload shall weigh no more than four (4) pounds.
1.7.1	The A.P.E.S. platform shall weigh no more than one half (0.5) pounds.
1.8	The flight computer shall execute all tasks necessary to the operation of the A.P.E.S. payload and avionics.
1.9	The A.P.E.S. payload shall have a dedicated power supply.
1.10	The Flight Systems Team shall ensure redundancy and reliability of all internal electrical hardware.
1.11	The Flight Systems Team shall provide for payload operation with up to 1 hour of wait on the launch pad and 2 hours of wait during preparation of the Rocket.
1.12	The Flight Systems Team shall provide for electrical operations to being at the beginning of the flight trajectory.
1.13	The Flight Systems Team shall ensure that the A.P.E.S. payload is shut down safely during the deployment phase of the flight trajectory.

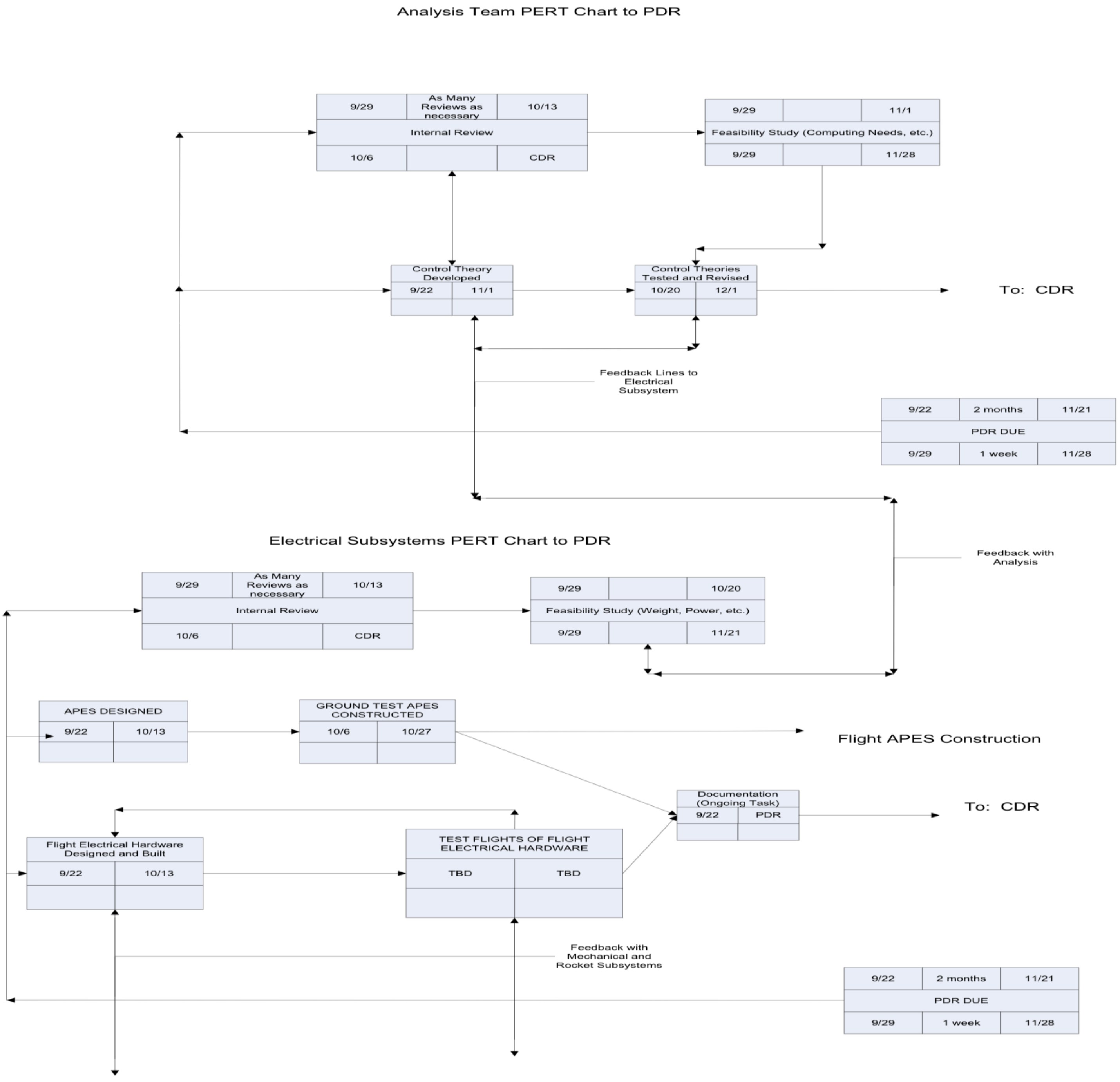


Figure 8: Flight Systems PERT Chart

3.2.4. Scientific Background

According to Earnshaw's Theorem, only diamagnetic materials can be maintained in stable equilibrium by the interaction of electrical, magnetic, and gravitational forces. Diamagnetism is caused by the interaction of any material with a magnetic field. A magnetic field will alter the motion of electrons in an atom, changing the magnetic dipole moment in a way such that a repulsive force will be created between the material and the magnet. In some materials the magnetic behavior can be characterized as largely diamagnetic. As a diamagnetic material repulses the magnet, the application of a magnetic field to the material will create a force that can be used to levitate the object.

$$\boldsymbol{B_z}\frac{\boldsymbol{\partial B_z}}{\boldsymbol{\partial z}} = \mu_0\rho\frac{g}{\chi} \tag{1}$$

This is the condition on $\boldsymbol{B}$ for magnetic levitation of a diamagnetic object with ρ and χ as its density and magnetic susceptibility, respectively.

3.2.5. Analysis and Control

3.2.5.1. Data

Data collection requirements for the payload could include (but not be limited to) acceleration of the levitated payload and the distance of the payload relative to some reference points in the APES container. In addition to this, several magnetometers may be used to measure the magnetic field at various points in the container. The current in each solenoid will also need to be known. As the project progresses, other possible data requirements will be generated as the need arises.

3.2.5.2. Control System

The control system in the APES device will be responsible for varying the magnetic fields produced by the solenoid electromagnets in response to acceleration of the levitated object. The magnetic fields must be changed to prevent contact of the object with the inner boundary walls. Preliminary equations will be developed from theoretical physics principles about electromagnetic forces and Maxwell's Equations. In addition, the positions of the solenoids, the materials used in the payload and the solenoid cores, and the physical design of the payload for levitation will further influence the equations. Due to the limitations of the hardware, various simplifying assumptions will have to be made in order to produce equations which can be run by the microcontrollers attached to the experiment. The control equations will also be affected by the limits of the sensors used by the microcontrollers and the adjustable parameters such as solenoid current. These equations will be loaded onto the hardware for APES and experimentally tested in order to assess their validity, after which refinements will be made to improve performance. Refinement will continue until a satisfactory system of equations - which minimizes maximum acceleration of the object to an acceptable threshold - is achieved. These equations will be used for the purpose of levitating a small payload in our experiment, but the mathematical model's validity could be extended to larger systems enabling the future large-scale implementation. A diagram of the overall process that the control system must accomplish is shown below, in Figure 9.

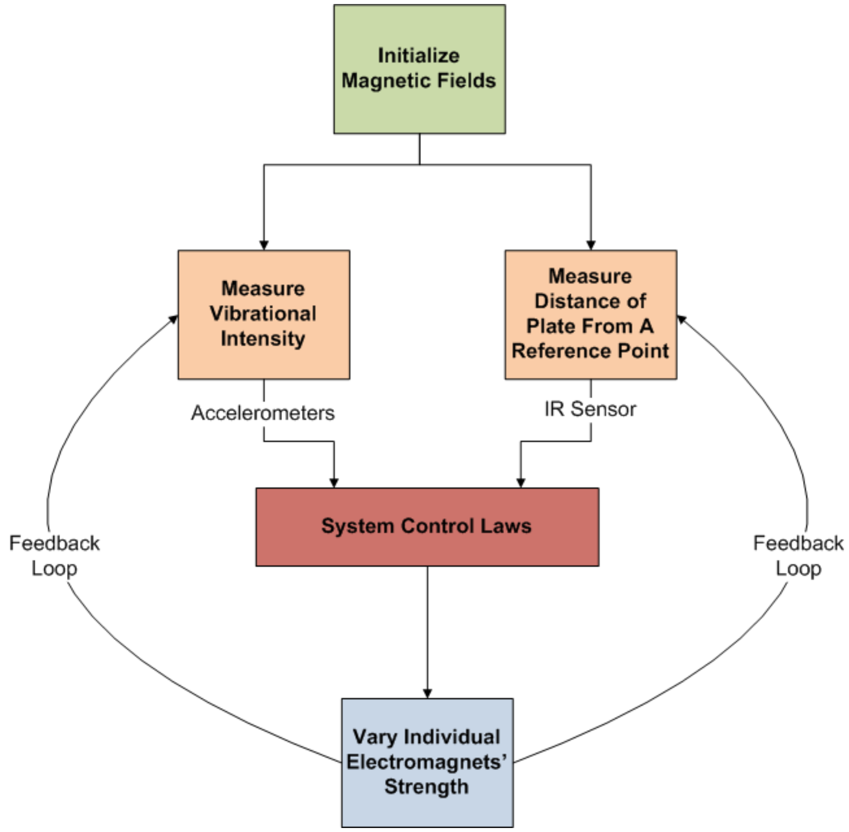


Figure 9. Functional block diagram of the control system.

3.2.6. A.P.E.S. Electrical Systems

Our electrical design methodology attempts to optimize weight, power consumption, and simplicity while meeting our success conditions and ensuring proper redundancy. There are five electrical design configurations proposed to implement the Active Platform Electrical

Stabilization (A.P.E.S.) system. All designs are based on the principles of electromagnetism. The system shall detect the position of the platform relative to the magnets and compensate the fields appropriately in order to isolate and stabilize the platform.

Our design shall use a series of laser infrared sensors to detect the precise location and orientation of the levitated platform. The data from the sensors gets transmitted to the main controller board where the data is aggregated and a representation of the platform is computed. Based on the position of the platform and its distance from each side of the system, the corresponding magnetic fields are strengthened and weakened by increasing or decreasing the current to the solenoids surrounding the platform. The system will repeat this process quickly and continuously, ensuring the stability and isolation of the platform.

3.2.6.1. Cubic Design

One proposed configuration is a cubic structure with solenoids on the inner side of each face. Additionally, one IR sensor on each axis would detect the position of the platform, and the six (6) solenoids would keep the platform suspended and stable in the middle of the container. This design is illustrated in Figure 10.

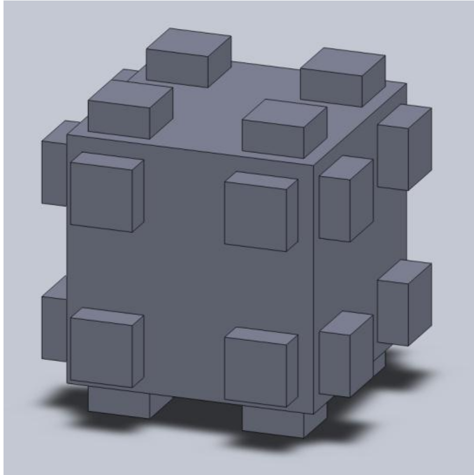


Figure 10: CAD Drawing of Cubic Design

3.2.6.2. Three (3) Degree of Freedom Design

Another proposed design is similar to Cubic Design, but has a more open configuration. The system has 6 solenoids, 2 for each axis of the system, and 3 IR sensors, 1 for each axis. The platform would be spherical and there would be no bounding box as in the Cubic Design.

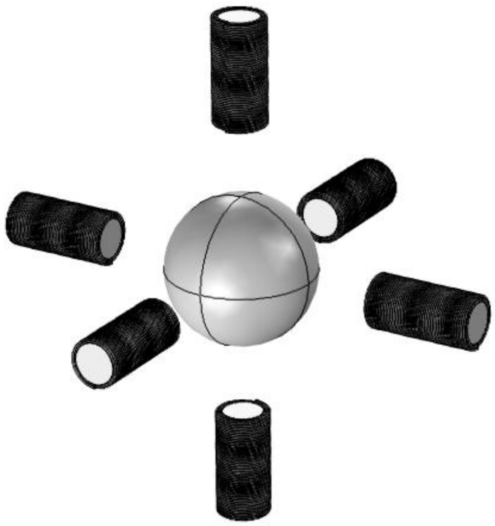


Figure 11: CAD Drawing of 3 Degree of Freedom Design

3.2.6.3. Radial Design

Additionally, a radial platform with 2 legs and a total of 5 solenoids may be implemented. This would provide a shorter distance from each surface of the platform to the solenoids and decrease the power requirements from the previous 2 designs. However, this would leave less room for oscillation, which would need to be minimized. Also a flat platform surface would better suit a payload.

3.2.6.4. I-Design

One of the more complicated designs has better projected stability than other designs at the cost of complexity. The design consists of a platform in the shape of an "I" with a payload receptacle in the center and solenoids below and perpendicular to the ends of the platform, as illustrated in Figure 12. This would provide a stable platform while minimizing the distance from the each surface to the solenoid repelling or attracting

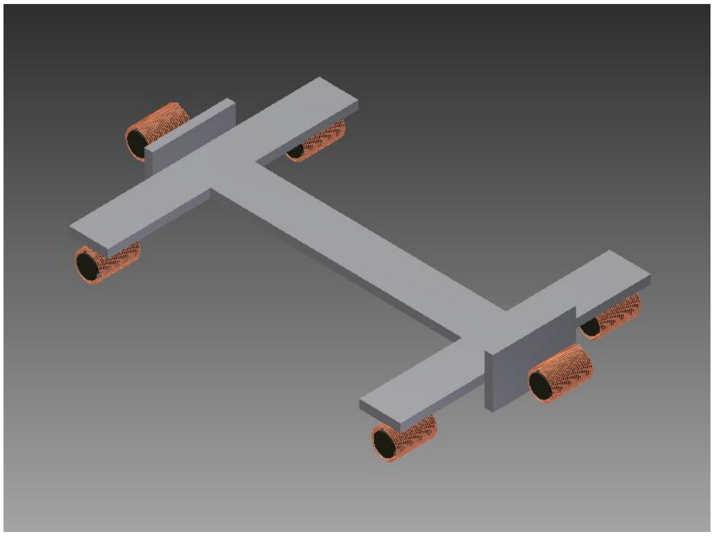


Figure 12. CAD Drawing of I-Design

it.

3.2.6.5. Cylinder

The final design emulates the structure of a magnetic bearing commonly used in Maglev Trains. The inner side of the cylinder is rigged with a series of solenoids and analog IR distance sensors. The output from the distance sensors is amplified and fed directly back to the solenoids, ensuring the field strengths shift appropriately and the platform remains in the center. Figure 13 displays one possible control configuration. All of these designs will be simulated in COMSOL Multiphysics or a comparable physics simulation software package. The 2 best performing designs based on our design methodology will be prototyped and tested further.

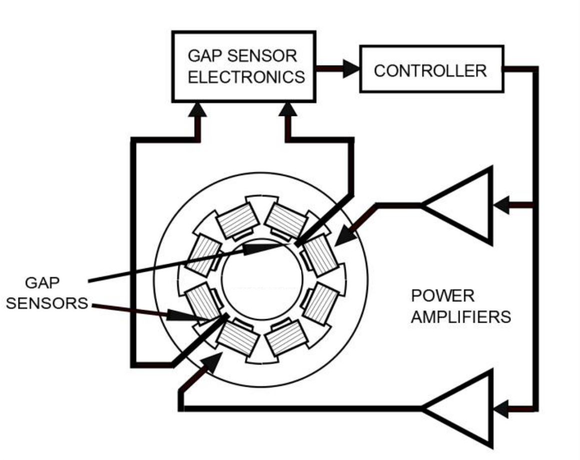


Figure 13: Conceptual Diagram for a magnetically stabilized rotor.

3.2.7. A.P.E.S. Mechanical Systems

Due to Georgia Tech USLI's unique rocket structure the integration of the payload and flight systems will require developing a specialized rib solution at each mounting position. The payload APES system structure may act as its own mount by directly integrating with the structure in place of one or more of the ribs. This would allow for the maximization of space for the payload. However this would restrict the removability of the payload itself. A closer design solution would utilize a universal mounting system that would allow for the flight system control boards and power supplies or the payload structure to be quickly and securely attached to the rocket structure. Universal mounting will increase reusability for the rocket system and cut down on manufacturing times and development. The payload and flight systems will require accessibility and additionally removability in the case of the payload. The specific rib and stringer design being used for the rocket structure can also be further modulated with differing lengths of stingers to increase space for the payload if necessary.

3.3. *Avionics*

3.3.1. Overview

The 2011-2012 Georgia Tech Mile High Yellow Jackets Avionics team will provide innovative solutions to data recording and monitoring. Extensive data collection will provide a basis for model validation of the rocket flight dynamics as well as provide for stable and reliable control systems in the A.P.E.S. payload and further redundancy in recovery deployment and instrument data acquisition.

3.3.2. Flight Computer

The preliminary design for the flight computer will utilize a microcontroller in a custom fabricated circuit. This microcontroller will control the APES payload sensors and the data processing for the flight system instruments. For system fault protection and faster computing speed, one microprocessor will control the data collection from the flight sensors while the other microcontroller will handle the APES control and data collection. To incorporate redundancy in the flight system and APES payload control, the microcontrollers will utilize multiple cores that process the same information simultaneously. For APES payload control, a filter system is present that will best optimize data collection.

Table 6: Flight Computer Comparison Table

Processor Type	*Cost*	*Mass(g)*	*Max Power(W)*
Propeller	$8.00	0.06	1
ARM	$20-$220	0.1	0.5 - 5
ATMEL	$3-$20	0.06	0.7
Microchip	$3-$20	0.06	0.7

3.3.2.1. Description of Parallax Propeller Microcontroller

The flight computer shall handle transmission and receiving of control and programming data to external computing devices, send control signals to sub-systems of the rocket, process sensor data, and store flight data to a removable storage medium. Figure 14 depicts the layout of the proposed Parallax Propeller chip, which is comprised of eight 32-bit Reduced Instruction Set Computing (RISC) cores. The microcontroller has an adjustable clock rate ranging from 12kHz to 80MHz and 32 general-purpose I/O pins. Each core has access to shared I/O, System Counter, Data Bus, Address Bus, and memory, assembled into a low profile design (SMD package). Each core is equipped with two counters and RAM, and is capable of computing up to 20 Million Instructions Per Second (MIPS) and simultaneously writing to mutually-exclusive system resources such as shared memory. Power consumption and voltage requirements are very similar to other single core microcontroller architectures such as ATMEGA and PIC. Therefore the Parallax Propeller chip will provide enhanced computational architecture through parallelism and pipeline operations for data command networks.

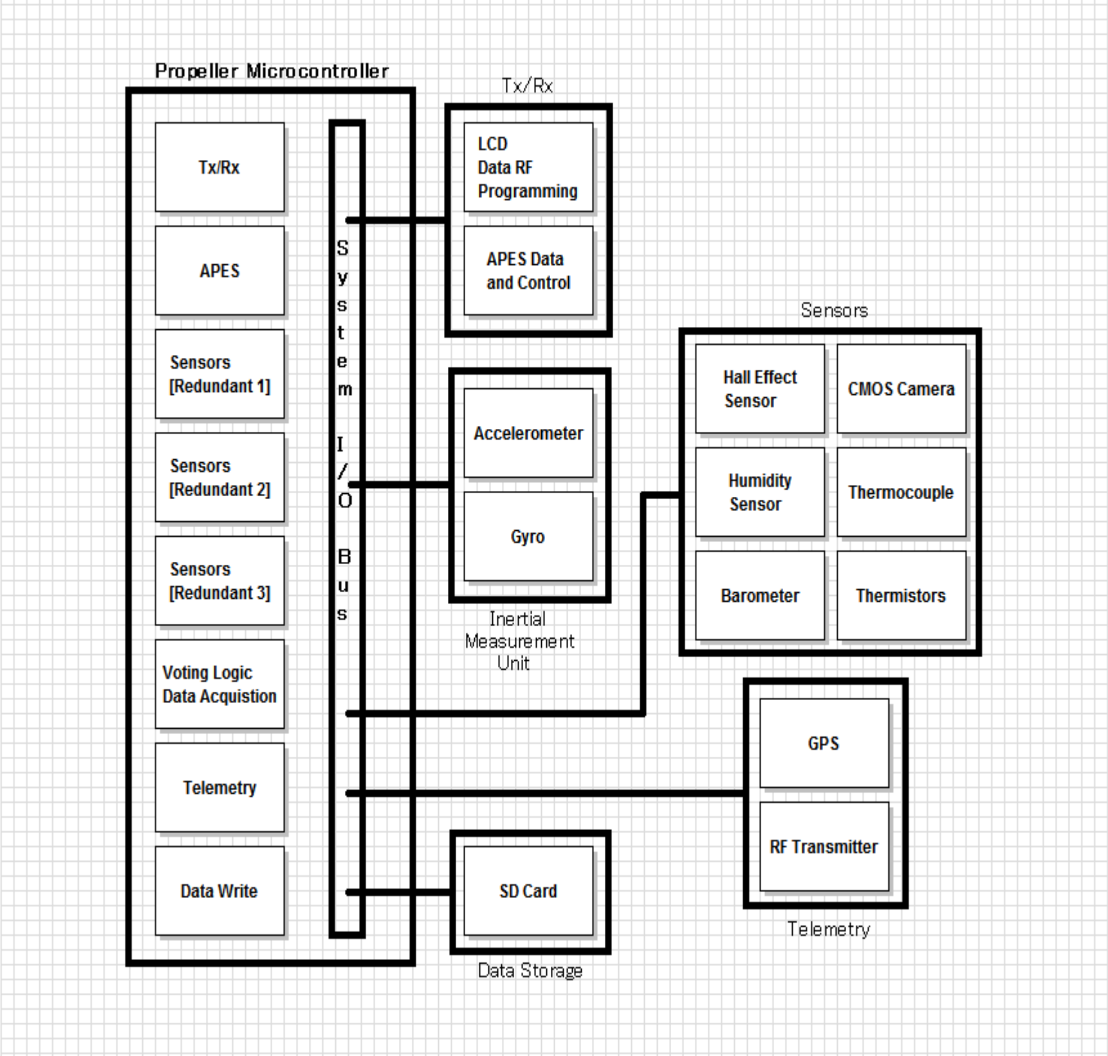


Figure 14: Parallax Architecture Diagram.

3.3.3. Sensing

Sensors provide a variety of important information during and after rocket flight. Instrument data can be used to gain valuable post-flight trajectory and system behaviors for improving future rocket designs. Data acquired from sensors can also be used in real time to detect anomalies of flight systems. Possible sensing configurations for various tasks are listed in Table 7.

Table 7: Sensor Functions, Descriptions, and Possibilities

Sensor Function	*Description*	*Sensors*
Critical System Monitor	Detect System conditions in flight critical systems such as engine, avionics bay, payload bay, and other structure locations.	IMU, Thermistors, Humidity Sensor, Strain Gauges, Thermocouples, Hall Effect Sensors
Telemetry	Transmit rocket location to ground station	Transmitter, Antenna, GPS, Altimeters
Recovery	Engage chutes, provide flight data, competition altimeter	Altimeters
Payload	Detect Magnetic field direction and strength and distance measurement internally for APES	Hall Effect Sensors, IR or Laser Based Distance Sensors
Flight Science Instruments	Other data	Thermistors, CMOS Photo Camera, CMOS IR Camera

3.3.4. Recovery System

The recovery system will use two PerfectFlite miniAlt/WD (MAWD) altimeters. One altimeter is used as the main altimeter while the second altimeter is used for redundancy purposes. Table 8 lists the requirements for the recovery system. Furthermore, to prevent accidental firing of the recovery system by electronic signals from transmitting device(s), the recovery system is electronically shielded.

Table 8. Recovery System Requirements

Requirement Number	*Requirement Definition*
2.1	The recovery system shall be designed to be armed on the pad.
2.2	The recovery system electronics shall be completely independent of the payload electronics.
2.3	The recovery system shall contain redundant altimeters. The term "altimeters" includes both simple altimeters and more sophisticated flight computers.
2.4	Each altimeter shall be armed by a dedicated arming switch.
2.5	Each arming switch shall be a maximum of six (6) feet above the base of the launch vehicle.
2.6	Each altimeter shall have a dedicated battery.
2.7	Each arming switch shall be accessible from the exterior of the rocket airframe.
2.8	Each arming switch shall be capable of being locked in the ON position for launch.

3.3.5. Electromagnetic Shielding

Due to the nature of our experiment our flight computers and other sensitive electronics are going to have to be shielded from the electromagnetic fields that the APES system is going to generate. There are three distinct possibilities of shielding depending on final strength and shape of the APES magnetic field.

3.3.5.1. Faraday Shielding

The Faraday Shield consists of an iron, aluminum, or copper mesh to displace and cancel a majority electromagnetic field created by the APES system. This type of passive shield is best used in cases of magnetic fields that quickly vary and generate many eddy currents.

3.3.5.2. Passive Shielding

The next type of possible electromagnetic shielding is another passive shield created by using a high magnetic permeability metal alloy. This protects best against static or slowly varying electromagnetic fields. In our case the best type of metal would be aluminum. All flight systems and sensitive electronics would be contained inside a case lined with the aluminum. This case would not so much block the electromagnetic field but redirect it around the sensitive electronics to prevent them from reaching the electronics.

3.3.5.3. Active Shielding

An active shielding system consists of a solenoid or Helmholtz Coil that is placed near or around the flight system and sensitive equipment. A portion of our processing power would thus be used in combination with sensors to create a magnetic field to cancel out the field generated by the APES system. This form of shielding would require the use of more resources from our on-board computer systems and add more to the power requirements but can negate any type of field (static, or varying).

The Active shielding will place a solenoid in between the electronic systems and APES. The strength of the APES combined magnetic field will be sent from the control systems to the negation solenoid. This will negate most of the magnetic field generated by APES system and allow a secondary passive system to protect the sensitive electronics effectively.

3.3.5.4. Dual Passive Shielding

From the forces that are going to result from the APES platform being inside a rocket the types of magnetic fields are going to range from slow varying, and fast varying magnetic fields. During initial launch the APES system will be compensating for large acceleration forces on the suspended objected and quickly adjusting the magnetic fields to try and keep it as stable as possible. To protect from these fast varying electromagnetic fields a Faraday Shield would encompass the APES system greatly decrease the electromagnetic field outside of the shield. A greatly weakened field would be present outside of the Faraday Shield from the resulting eddy currents. Once the rockets acceleration decreases, the magnetic fields will vary at a slower rate and passive shielding will become effective. Lining the sensitive electronics container with aluminum to redirect the electromagnetic fields around the container will help protect the equipment. This passive shielding will also shield against the eddy currents generated in the highly varying magnetic fields.

3.3.5.5. Cabling Shielding

To prevent voltage or current spikes in the wiring surrounding the cables would need to be shielded using a metal mesh. All sensitive cables around the APES system or flowing into the electronics would need to be shielded.

3.3.5.6. Mass Consideration

All methods of shielding will add more weight to the overall system. The passive systems will add the least amount of weight. The active shielding will require more materials overall and add a greater amount of weight to the system.

4. Community Engagement

It is very important to the Georgia Tech Mile High Yellow jackets to have support from the community. The USLI competition has been made into a highly-integrated, class-based, team project through the Vertically Integrated Program (VIP).

4.1. *Community Support*

Since the Georgia Tech Mile High Yellow Jackets' are a relatively young team, their exposure to the community is very limited. In order to gain support from the community, the Mile High Yellow Jackets will pursue advertising opportunities through the local newspapers and on-campus events. This will allow the Team to gain exposure to local business and organizations that could help support the Team throughout the project.

The Mile High Yellow Jackets have received financial support from the Georgia Space Grant Consortium. The Team has received tutorials and hands-on training on building high powered rockets from the Georgia Tech Ramblin' Rocket Club.

4.2. *Educational Outreach*

The goal of Georgia Tech's outreach program is to promote interest in the Science, Technology, Engineering, and Mathematics (STEM) fields. The Mile High Yellow Jackets' intend to conduct various outreach programs targeting middle school Students and Educators. The Mile High Yellow Jackets will have an outreach request form on their webpage for Educators to request presentations or hands-on activities for their classroom.

4.2.1. Young Astronauts Program

The Mile High Yellow Jackets are planning to work in conjunction with the Georgia Tech Space Systems Design Lab (SSDL) to put on the Young Astronauts program at Madras Middle School in Newnan, Ga. The intent of this program is to expose Middle School Students to various topics in the Aerospace and STEM fields. This will be accomplished by meeting twice a month and discussing a topic followed by a related hands-on project that actively engages both Students and Educators.

4.2.2. FIRST Lego League

FIRST Lego League is an engineering competition designed for middle school children in which they build and compete with an autonomous MINDSTORMS robot. Every year there is a new competition centered on a theme exploring a real-world problem. The Mile High Yellow Jackets plan to have a booth at the Georgia State FIRST Lego League Tournament and illustrate how the skills and ideas utilized in the competition translate to real world applications, like a rocket with autonomous capabilities. In addition we plan to help judge the tournament.

5. Project Plan

5.1. *Project Schedule*

The Mile High Yellow Jacket's project is driven by the design milestone's set forth by the USLI Program Office. These milestones – and their dates – are listed in Table 9.Additionally, a preliminary Gnatt Chart is provided in Appendix I. It is important to note that due to the complexities of both the Mile high Yellow Jackets' rocket and payload designs, the Gantt chart will contain only high-level activities. In order to visualize the major tasks/steps in our design, the Team will utilize a PERT Chart/Network Diagram. This will allow for the identification of the critical path(s) that will ensure a successful launch.

Table 9. Design milestones set by the USLI Program Office.

Milestone	*Date*
Proposal	26 SEP
Team Selection	17 OCT
Web Presence Established	4 NOV
PDR Documentation	28 NOV
PDR Telecon	5-14 DEC
CDR Documentation	23 JAN
CDR Telecon	1-10 FEB
FRR Documention	26 MAR
FRR Telecon	2-11 APR
Competition	18-21 APR
PLAR Documentation	7 MAY

5.2. *Estimated Budget*

In order to ensure a successfully competition entry, the Team will be receiving both donations in the form of either financial donations or material donations. Figure 15 and Table 10 illustrate the breakdown of the (estimated) budget across the various sections of the project. Since the Mile High Yellow Jackets are designing a unique rocket structure, a substantial amount of ground testing will be performed to ensure the structure will perform satisfactorily under the loads of powered flight.

Table 10. Estimated budget for the various sections of the 2011-2012 project.

Section	*Cost*
Flight System	$3,481.08
Rocket	$2,538.67
Testing	$3,595.38
Travel	$1,300.00
Outreach	$650.00
Motors	$933.70
Total Budget:	$12,498.82

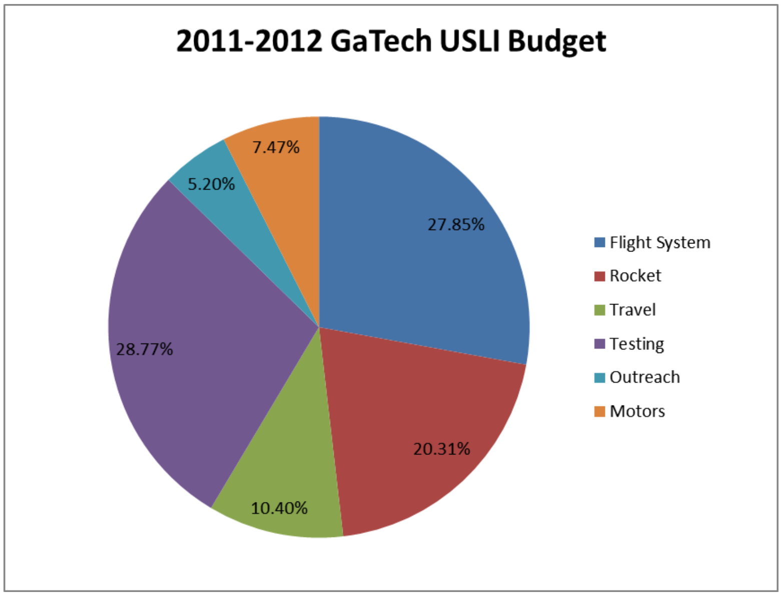


Figure 15. Estimated budget for the 2011-2012 USLI competition.

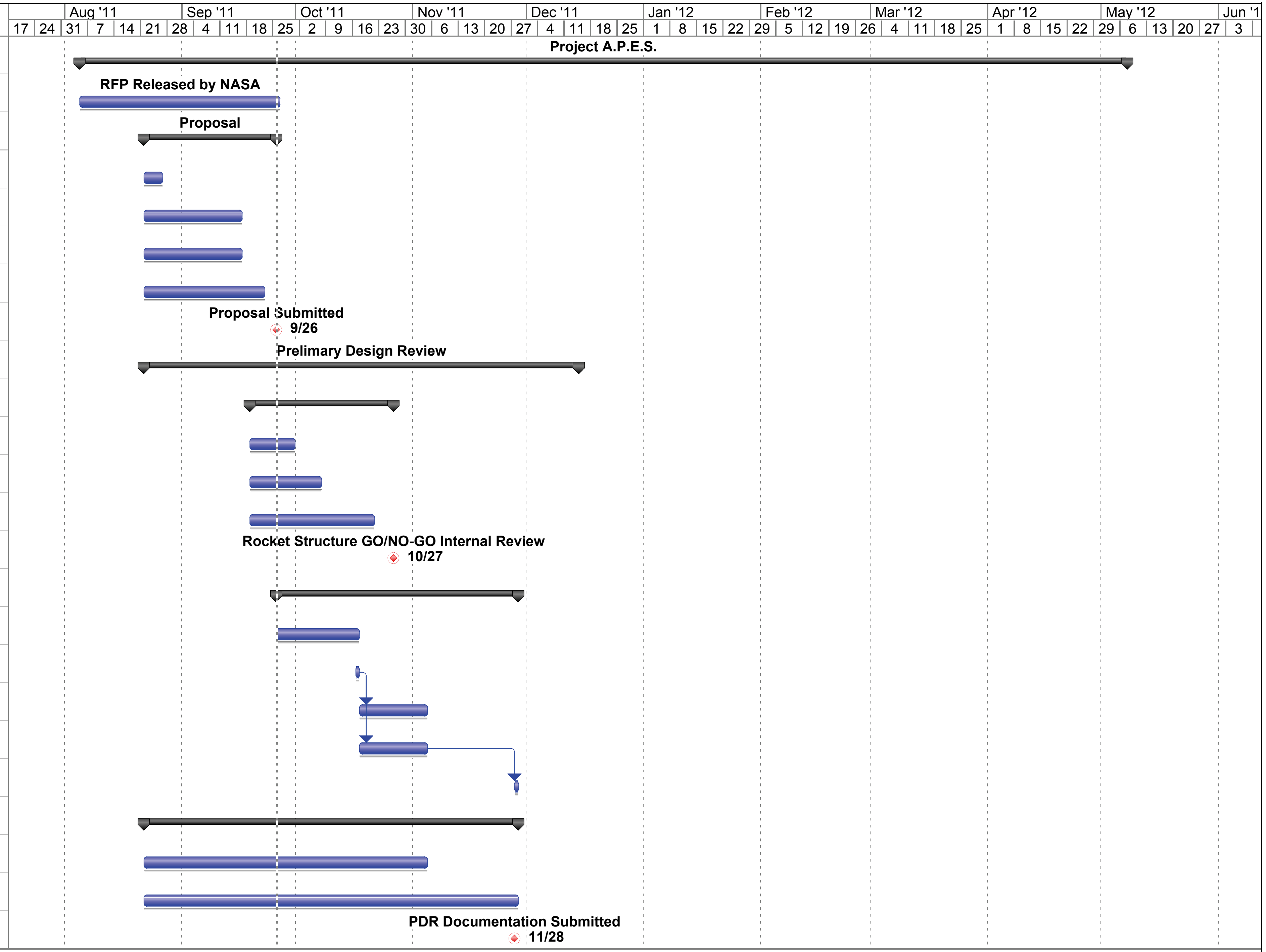
Currently, our only source of funding is from the Georgia Space Grant Consortium, which is providing the team with $3,500. The team is actively looking for more both sponsorships within the Georgia Tech community as well as corporate sponsors, such as Lockheed Martin, Coca-Cola, Boeing, et cetera.

6. Returning Team Information

Recognizing the opportunities and experience gains offered by the NASA USLI competition, the Georgia Tech Mile High Yellow Jackets have worked with Georgia Tech to offer the USLI competition as a highly integrated team project through the Vertical Integrated Program (VIP). The VIP program provides the necessary infrastructure and environment that allows for a highly-integrated design utilizing inputs from the aerospace, mechanical, and electrical engineering disciplines. Additionally, the VIP program provides technical elective credit for all students – both undergraduate and graduate.

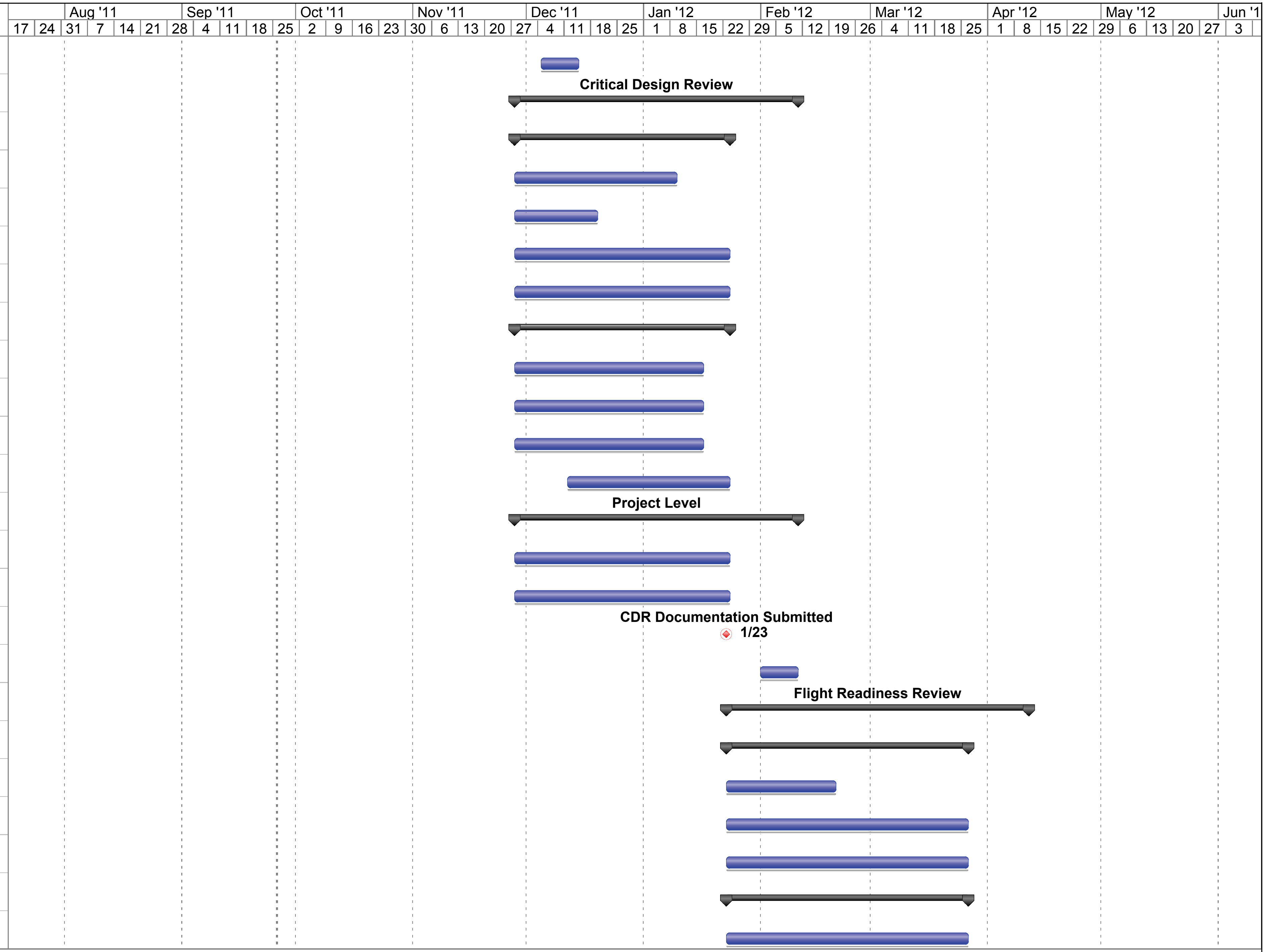
Appendix I: Mile High Yellow Jacket Preliminary Gnatt Chart

ID	Task Name
1	**Project A.P.E.S.**
2	RFP Released by NASA
3	**Proposal**
4	Team Formation
5	Initial Rocket Design
6	Flight Experiment Definition
7	Internal Proposal Review
8	Proposal Submitted
9	**Prelimary Design Review**
10	**Rocket**
11	Structure Test Rig Design and Fabrication
12	Rocket Stucture Design and Simulations
13	Rocket Structure Component Testing
14	Rocket Structure GO/NO-GO Internal Review
15	**Flight Systems**
16	Component Downselection
17	Scientifc Theory Refinement
18	Experiment Modeling and Preliminary Design
19	Control System Preliminary Design
20	Preliminary Ground Testing
21	**Project Level**
22	Establish Web Presence
23	Fundrasing / Sponsorhip
24	PDR Documentation Submitted



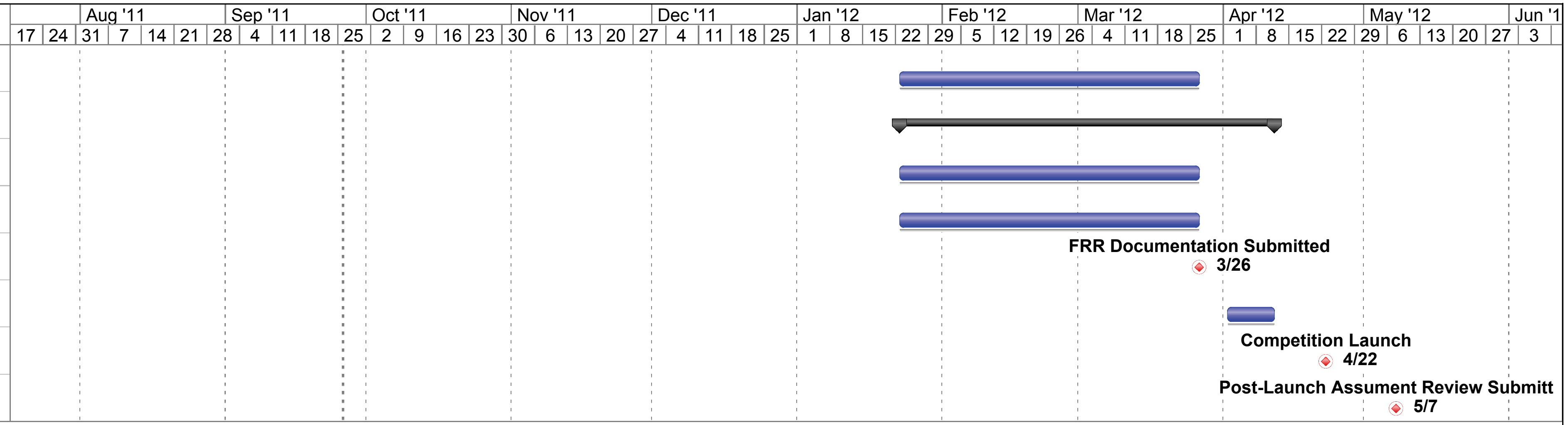
Project: 2011-2012 USLI Gnatt Chart Date: Mon 9/26/11	Task		Progress		Summary		External Tasks		Deadline
	Split		Milestone		Project Summary		External Milestone		

ID	Task Name
25	PDR Telecon
26	**Critical Design Review**
27	**Rocket**
28	Full-Scale Structure Build
29	Recovery System Ground Test
30	Competition Rocket Build
31	Initital Test Flight
32	**Flight Systems**
33	Flight Systems Integration
34	Control System Detailed Design
35	Detailed Experiment Modeling
36	Experiment Refinement
37	**Project Level**
38	Website Updates
39	Outreach Events
40	CDR Documentation Submitted
41	CDR Telecon
42	**Flight Readiness Review**
43	**Rocket**
44	Final Test Preparation
45	Final Test Flight
46	Competition Launch Preparation
47	**Flight Systems**
48	Experiment Refinement



Project: 2011-2012 USLI Gnatt Chart Date: Mon 9/26/11	Task		Progress		Summary		External Tasks		Deadline
	Split		Milestone		Project Summary		External Milestone	

ID	Task Name
49	Control System Refinement
50	**Project Level**
51	Website Updates
52	Outreach Events
53	FRR Documentation Submitted
54	FRR Telecon
55	Competition Launch
56	Post-Launch Assument Review Submitted



Project: 2011-2012 USLI Gnatt Chart
Date: Mon 9/26/11

Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

Appendix II: Detailed Science Overview

AI.1 Maxwell's Equations

Maxwell's equations are the four most fundamental equations of classical electromagnetism, governing the interaction of electric charges and currents to produce electric and magnetic fields. These equations dictate the generation of the fields from charges and currents, as well as from time-changing electric and magnetic fields. Listed below in integral form, they are

Gauss's Law: $\boldsymbol{E}, q,$ and ϵ_0 are electric field, charge inside volume V, and permittivity of free space, respectively. The integral is taken over the closed surface around V.

$$\oiint_V \boldsymbol{E} \cdot d\boldsymbol{A} = \frac{q}{\epsilon_0} \tag{1}$$

Gauss's Law of Magnetism: $\boldsymbol{B}$ is magnetic field,

$$\oiint_V \boldsymbol{B} \cdot d\boldsymbol{A} = 0 \tag{2}$$

Faraday's Law: Φ_B is magnetic flux through closed curve C.

$$\oint_C \boldsymbol{E} \cdot d\boldsymbol{s} = -\frac{\partial \Phi_B}{\partial t} \tag{3}$$

Ampère's Law: I is the current passing through the closed curve C, Φ_E is electric flux through same curve, and μ_0 is the permeability of free space.

$$\oint_C \boldsymbol{B} \cdot d\boldsymbol{s} = \mu_0 I + \mu_0 \epsilon_0 \frac{\partial \Phi_E}{\partial t}, \tag{4}$$

AI.2 Magnetic Forces and Properties

The problem of levitating a material using electromagnetic forces against gravity has been studied extensively. According to Earnshaw's Theorem, it has been proven that a collection of point charges cannot be maintained in stable equilibrium by only electrical, magnetic, and gravitational forces. This property also applies to ferromagnetic materials, paramagnetic materials, as well as other permanent magnets. However, diamagnetic materials only display repulsive forces against magnetic fields, while Earnshaw's theorem only applies to objects that exhibit both attraction and repulsion.

Diamagnetism is caused by the interaction of any material with a magnetic field. A magnetic field will alter the motion of electrons in an atom, changing the magnetic dipole moment. According to Lenz's Law, the change should oppose the field changes, so the magnetic flux lines will curve away from the material, hence causing a repulsive force between the material and the magnet. Diamagnetism in most materials is completely overpowered by ferromagnetism or some other form of magnetism, but in some materials the magnetic behavior can be characterized as largely diamagnetic.

The magnetic permeability μ of a diamagnetic material is less than the permeability of free space μ_0; therefore the relative permeability $\mu_r = \frac{\mu}{\mu_0}$ of a diamagnetic material is less than 1 and the magnetic susceptibility $\chi = \mu_r - 1$ is less than zero. The magnetic permeability of a material is a measure of the magnetization that occurs in the material in the presence of an external magnetic field; for substances whose magnetic moments are aligned with the field have positive susceptibility and those whose magnetic moments are aligned in an opposite direction (diamagnetics) have negative susceptibility.

As a diamagnetic material repulses the magnet, the application of a magnetic field to a diamagnetic material will create a force against the material. This can be used to levitate the object. Suppose our object has density ρ, volume V, and the magnetic field is $\boldsymbol{B}$ where we wish to calculate the force. The force of gravity is

$$\boldsymbol{F} = \rho V \boldsymbol{g} \tag{5}$$

The force against the object due to the field, with $\boldsymbol{M}$ as the magnetic moment is known to be

$$\boldsymbol{F} = \boldsymbol{M} \cdot \nabla \boldsymbol{B} \tag{6}$$

For levitation, the z component of both forces must be equal and in opposite directions. We have

$$\boldsymbol{M} = \frac{\chi}{\mu_0} V \boldsymbol{B} \tag{7}$$

Substituting, we have that the z component of

$$\boldsymbol{F} = \frac{\chi}{\mu_0} V \boldsymbol{B} \cdot \nabla \boldsymbol{B} = \left(\frac{\chi}{2\mu_0} V\right) \nabla \boldsymbol{B}^2 \tag{8}$$

equals $\rho V g$. Finding the z component of the above force and equating to the gravity force,

$$\boldsymbol{k} \cdot \left(\frac{\chi}{2\mu_0} V\right) \nabla \boldsymbol{B}^2 = \left(\frac{\chi}{\mu_0} V\right) \boldsymbol{B}_z \frac{\partial \boldsymbol{B}_z}{\partial \boldsymbol{z}} = \rho V g \tag{9}$$

$$\boldsymbol{B}_z \frac{\partial \boldsymbol{B}_z}{\partial \boldsymbol{z}} = \mu_0 \rho \frac{g}{\chi} \tag{10}$$

Therefore, we have this condition on $\boldsymbol{B}$ for magnetic levitation of a diamagnetic object with ρ and χ as its density and magnetic susceptibility, respectively.

Appendix III: Student Participant Resumes

ALEX C. BUCHANAN

abuchanan3@gatech.edu

(704) 236 – 8389

Highly motivated mechanical engineering student graduating from Georgia Tech with academic honors and prior experience in research and development in a professional setting. Experienced in prototyping and fabricating designs with well developed planning and execution skills. Adaptable with a willingness to learn new skill-sets as required on the job. Seeking a demanding mechanical or systems engineering position where an innovative mindset, persistence, and prior professional experience are desired.

EDUCATION

2006 – 2011 **Georgia Institute of Technology** Atlanta, Georgia
B. S. Mechanical Engineering **GPA : 3.38**

2010 **Green Bus Research Project** Atlanta, Georgia
Completely redesigned the drivetrain on a TC2000 diesel school bus into a hybrid hydraulic vehicle system as part of a green initiative for the public school system of Atlanta to reduce fuel consumption and save costs.

2009 Summer **Oxford Study Abroad Program** Oxford, Great Britain

2007 Spring **Plate Defect Analysis Research Project** Atlanta, Georgia
Initiated development of a novel nondestructive photogrammetric method for detection of defects in oscillating plates.

2006 **International Science and Engineering Fair Finalist** Indianapolis, Indiana
Presented a method of correlating stereo images utilizing a wavelet based technique.

2005 – 2006 **Siemen's Westinghouse Competition Semifinalist** Charlotte, North Carolina
Developed a novel method of performing pulmonary spirometry using a novel photogrammetric technique based on wavelet analysis.

EXPERIENCE

2009 Spring, Fall **Georgia Tech Research Institute Co-Operative Internship** Atlanta, Georgia

Wind Tunnel Research Assistant – Worked as a research assistant in the wind tunnel where projects included circulation control airfoils and experimental aircraft models.

Unmanned Aerial Vehicle Model Researcher – Designed and manufactured a rig to determine the accurate center of mass and to determine the rotational inertia of an experimental UAV.

Marine Tiger Shark Engine Test Bed Designer – Designed and manufactured an experimental engine test stand for the analysis of a modified high altitude USMC Tigershark engine.

2007 Summer-Fall **NASA Jet Propulsion Laboratory Co-Operative Internship** Pasadena, California

Advanced Communications Telescope – Worked on a novel photogrammetric metrology system for determining the surface accuracy of a flexible 30m diameter kapton dish.

Mars Science Lab Rover – Sample Selection, Processing, And Handling – Automated a clogged pore analysis program for the sifter mechanism that conserved man-hours and streamlined a previously labor intensive system.

ACTIVITIES

2009 – 2011 **Pi Tau Sigma Mechanical Engineering Honor Society** Georgia Tech

2009 – 2011 **Briaerean Co-Operative Honorary Society** Georgia Tech

2009 – 2011 **Invention Studio Undergraduate Lab Instructor** Georgia Tech
Assisted undergraduates in the completion of build projects and was responsible for supervising students in the use of major manufacturing equipment.

2008 – 2011 **Outdoor Programs Backpacking Instructor and Gear Chair** Georgia Tech
In charge of initiating purchasing orders every semester for group gear.

2008 – 2010 **Technique Student Newspaper Writer** Georgia Tech
Researched and wrote stories for the Technique and was in charge of initiating an interview and writing an article on division one football head coach Paul Johnson

2008 – 2011 **Chi Psi Fraternity** Georgia Tech

SKILLS

Programs : Excel, Word, PowerPoint, Mathematica, Matlab,
CAD / FEA : Solidworks, Solidedge, Solidworks Solid Modeling, Solidworks Rendering Software, NX. 7
Shop : Waterjet, Laser Etching, Mill, Lathe, General Shop Skills, Experience in materials selection for projects
Programming Languages Experience : C, C++, Java, Arduino

Akshaya Srivastava

akshaya.srivastava@gatech.edu

Cell Phone: (732) 882-5629

US Citizen

Campus Address:
331188 Georgia Tech Station
Atlanta, Georgia, 30332-1365

Permanent Address:
1801 Mindy Lane
Piscataway, NJ 08854-5989

OBJECTIVE:

Highly motivated, decisive and results-oriented individual seeking a Summer Research/Internship opportunity as an Aerospace Engineering student (undergraduate - Junior) in the areas of Space Exploration Systems and Design, Spacecraft and Aircraft Propulsion, Flight Research, and in related areas to learn from these programs and contribute back to aerospace industry as a well-educated and experienced engineer.

EDUCATION:

Georgia Institute of Technology, Atlanta, GA — Fall 2009 - Present

- Working towards B.S. in Aerospace Engineering
- Graduating in Fall 2012 (Current – Junior)
- Institutional GPA: 2.7
- Cumulative GPA (with Transferred Credits): 3.0

WORK EXPERIENCE:

Langley Aerospace Research Summer Scholars, Hampton, VA — Jun 2011 – Aug 2011

- Worked as a summer intern.
- Worked on ADS-B Integration with a UAV
- Presented at an Aeronautics Forum
- Also worked on Microgravity Simulation on the side

RESEARCH EXPERIENCE:

Undergraduate Student Launch Initiative (USLI) — Fall 2011 - Present

- **Rocket Recovery System Lead**
  - Worked under guidance of Professor Eric Feron
  - Worked on recovery system of a level 2 rocket.

Experimental Aerodynamics Lab, Georgia Institute of Technology — Fall 2010 - Present

- **Fish Motion Analogy to Wind Energy Extraction** (Undergraduate Research Program)
  - Working on undergraduate thesis under guidance of Professor Narayanan Komerath
  - Undergraduate Research Assistant
  - Received Dash Undergraduate Research Fellowship
  - This research will experimentally investigate the dynamics of a free-to-pitch finite wing executing large amplitude plunge oscillations in a low speed wind tunnel.
  - The results will help develop renewable energy devices as well as aquatic propulsion technology.
- **Flow Imaging Research** (Undergraduate Research Program)
  - Flow Imaging Research involved flow imaging and analysis using Tomographic Particle Image Velocimetry (TPIV) to map airflow around rotor blades.
  - Worked on hub drag experiments to measure pressure differentials behind a rotating hub.

Space Systems Design Lab, Georgia Institute of Technology — Fall 2009

- **Rapid Reconnaissance and Response Design Competition** (Nano-Satellite Competition)
  - Worked under guidance of Professor David Spencer
  - Worked on programming and debugging of Edge Detection Algorithms and other image processing tasks design, and modeling using Matlab programming.

SKILLS:

- **Programming**: Matlab, Maple, Java, Basic Web Design, LaTeX
- **CAD**: AutoCAD, Inventor
- **Technical Documentation**: Word, Excel, PowerPoint (on both Mac OS and Windows)
- **Engineering expertise**: Low Speed Aerodynamics, High Speed Aerodynamics, Engineering Graphics & Visualization, Dynamics, Thermodynamics & Compressible Flow, System Dynamics & Control, AE Vehicle Performance, Rocket and Jet Propulsion, Flight Dynamics and Controls

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Permanent Address:
1801 Mindy Lane
Piscataway, NJ 08854-5989

AWARDS AND MEMBERSHIPS:

- **Scholarship**: Richard/Elizabeth Stirni Scholarship
- **Fellowship**: Dash Undergraduate Research Fellowship
- Cadet Officer - Civil Air Patrol (CAP)
- Student Member - American Institute of Aeronautics and Astronautics (AIAA)
- "General Billy Mitchell Award" in 2008 (Civil Air Patrol)
- "Private Pilot License" in 2008 (Federal Aviation Administration)

CLUBS AND EXTRACURRICULAR ACTIVITIES:

- Astronomy Club at Georgia Institute of Technology
- Yellow Jackets Flying Club at Georgia Institute of Technology (pursuing Instrument Rating Certification)
- RoboJackets Robotics Club at Georgia Institute of Technology
- Ramblin' Rocket Club at Georgia Institute of Technology
- Hapkido (martial art) at Georgia Institute of Technology

BHANU S. KUMAR
595 Oakstone Glen, Milton, GA 30004 | bkumar30@gatech.edu | Home (678) 393-2777 - Cell (678) 735-0350

EDUCATION

Georgia Institute of Technology, Atlanta, Georgia - August 2010-present
Majors: Aerospace Engineering and Applied Mathematics double major
Anticipated graduation May 2014, current GPA: 4.00/4.00

Milton High School, Milton, Georgia, Class of 2010
Numeric Average (based on Grades 9 through 12): 102.6050, Rank in Graduating Class: 1 out of 560 students

RESEARCH ACTIVITIES AND PROJECTS

Georgia Tech NASA University Student Launch Initiative Team (USLI): Payload Lead, September 2011 - present

GA Governor's Honors Program (GHP): Mathematics Major – June - July 2009
- Selected for GHP after county and then state level interview.
- Reviewed collegiate mathematics literature, conducted investigation and research into generalized complex numbers in relation to the Mandelbrot set, and attended classes over 6 weeks.
- 2nd place out of 110 Math Majors in 6-week long Problem of the Day competition.

ACTIVITIES AND ORGANIZATIONS

American Institute of Aeronautics and Astronautics (AIAA) Member (September 2010-present)
Georgia Tech Ramblin' Rocket Club Member (September 2010-present)
Georgia Tech Astronomy Club Member (September 2010-present)
Georgia Tech Club Math Member (February 2011-present)
Due for Induction in Georgia Alpha Chapter of Tau Beta Pi Engineering Honor Society in November 2011

PREVIOUS ACTIVITIES AND LEADERSHIP

Georgia ARML (American Regions Mathematics League) state math team member – May 2009-June 2010
- Represented Georgia along with other team members at national competition in June 2010.
- Member of 6-person team (Georgia ARML 2) that finished 10th internationally out of ~60 teams in the 2010 ARML Local Contest (contest takes place locally through internet, it is not a local level competition)
- ARML team winner on Georgia A2 team at 2010 national competition for highest individual score on team.

Math Team – (10th, 11th, 12th grade; Co-president/de facto teacher in 12th Grade)
- Placed in the top ten individuals at 9 state-level math tournaments, including one hosted by Georgia Tech
- Qualified for 2010 MAA American Invitational Mathematics Examination after top 5% AMC 12 (qualifying test) score in nation. Earned score of 9 (average: 4.124) on 2010 AIME 1 (6th best in Georgia)
- Improved the Milton team from merely average to one of the best in Georgia. Quadrupled practice time and reorganized practices. As a result, team won 4th at 2010 state math tournament, up from ~15th in 2009.

Milton HS Science Olympiad Team - (11th and 12th Grade)
- 3rd place Physics Lab team at regional competition in 12th grade.

Milton HS National French Honor Society – (12th grade, Co-president)
Milton HS National Honor Society Member - (12th grade)
Milton HS National Science Honor Society Member - 12th grade

HONORS AND AWARDS

National Science Foundation MCTP Scholarship Recipient, 2011
2010 National Merit Scholarship Recipient, National AP Scholar
2010 United States Presidential Scholars Program Semifinalist (one of 560 semifinalists out of 3,000 candidates)

SKILLS AND COURSE WORK

Coursework in calculus, ODE's, PDE's, statics, dynamics, aerodynamics, thermodynamics, mechanics of materials
Proficient in Java, MATLAB, AutoCAD, Autodesk Inventor, Engineering Drawing, Microsoft Office, French, Hindi

135 Wilson Garage Rd. Commerce, GA 30529 678-863-8846 ebrown41@gatech.edu

Erik J. Brown

Objective

To apply the knowledge and skills learned in my classes to real world applications and design project. To further my understanding of electrical systems and pushing out of my comfort zone to do things I have never done before.

Technical Skills/Proficiencies

- Consumer Relations
- Microsoft Office Applications
- Windows XP/Vista/7/8 Dev Build
- C, and VHDL Programming
- Software Debugging Specalist
- Basic Java, Python, and SQL Programming

Experience

June 2003 - August 2009 Waters Brothers Inc. Commerce, GA

- Information Specialist
- Quality Control, Phone Sales, Customer Service, Bookkeeping, Troubleshooting, Account Representative

September 2008 – December 2009 Gainesville State College Oakwood, GA

- Information Desk Worker
- Assisting students and Guests, Word Processing, Room Reservations, Basic Tech Support

September 2010 – May 2011 Georgia Institute of Technology: OIT Atlanta, GA

- Tech Support Specialist
- Hardware and Software Troubleshooting and Repair
- Assisting Students with Various Issues
- Tier 1 Tech Support

May 2011 - Present Georgia Institute of Technology: Psychology Department Atlanta, GA

- MYSQL Server Maintenance
- Web Hosting Troubleshooting and Setup
- Network Troubleshooting
- Server Installation and Setup
- Software and Hardware Tech Support
- Network Security

Education

Commerce High School 2007 *Commerce, GA*

- *Received College and Technical Prep Diploma*
- *Enrolled in AP and Honor Classes All Four Years*

Gainesville State College 2007 – 2009 *Oakwood, GA*

- *Pursuing a Electrical Engineering Degree*
- *Enrolled in Honor Physics Courses*

Georgia Institute of Technology 2010 - Present *Atlanta, GA*

- *Pursuing a Electrical Engineering Degree*

Awards/Accomplishments

Honor Graduate	*May 2007*
Captain of Academic Team	*2006-2007*
President of High School Chess Club	*2005-2007*
Treasurer of Engineering Club	*2008-2009*
Member of NSHSS	*2007-Present*

Jan Agudo

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324460 Georgia Tech Station
Atlanta, GA 30332
770-654-7798

Home Address:
1740 Montrachet Drive
Lawrenceville, GA 30043
678-226-4847

Objective

To acquire an entry-level aerospace engineer position that will utilize technical & team-oriented skills and academic experience in a challenging and creative environment.

Education

Georgia Institute of Technology, College of Engineering — Atlanta, Georgia

- Bachelor of Science, Aerospace Engineering, — 8/2008- Present
- Projected graduation: 05/2012

Experience

NASA University Student Launch Initiative — 2011- Present

- The project goal is to work with NASA engineers and construct a rocket that can deliver a scientific payload at a given altitude.
- Undergraduate team leader for researching and developing the rocket's aerodynamics and propulsion.
- Designing motor and motor mounting configuration.

AIAA Undergraduate Team Design Competition — 2011- Present

- Developing a humanitarian response unmanned aircraft.

World Class Taekwondo — 2006-2010

2nd degree Black Belt Instructor

- Leadership and discipline training
- Taught and managed martial arts classes for school owner

Private Tutor — Summer 2009

- Assessed physics and algebra/calculus knowledge of middle/high school students

Skills & Activities

Computer Software: AutoCAD 2012, CATIA, Matlab/Simulink, Mathematica, Microsoft Office (Word, Excel, Powerpoint), OpenRocket, Solid Works, Vic-3D Stress/Strain Analysis

Projects

- Flight Stability Simulator — Summer 2011
  - Built a Matlab-based aircraft simulator for the longitudinal and lateral dynamics.
  - Applied various techniques to design a controller for the simulated aircraft.
- Flight Profile Numerical Simulator — Spring 2011
  - Utilized Matlab to calculate and optimize any inputted air & rotorcraft's flight.
- Hydrogen powered airliner aircraft design — Spring 2011

Knowledgeable languages: French, Japanese, and Tagalog

American Institute of Aeronautics & Astronautics — 2011- Present

Member

Filipino Student Association — 2009 - 2010

Treasurer

- Managed organization bank account
- Prepared budget and acquired $1,000 of funds from Georgia Tech SGA
- Participated and staffed annual cultural events

Jason Thrasher
jthrasher6@gatech.edu

School Address	Permanent Address
1031 State Street, Apt. 208	67 Covert Lane
Atlanta, GA 30318	Ellisville, MO 63021
(314) 610-9311	(636) 394-9978

Objective To obtain an engineering position in the aerospace industry

Education

Georgia Institute of Technology — May 2012
M.S. Aerospace Engineering — GPA: 3.47/4.0

Missouri University of Science and Technology — May 2010
B.S. Aerospace Engineering (Summa cum laude) — GPA: 3.933/4.0
Minor: English Literature

Lafayette Senior High School — May 2006
Class Rank: 5 of 488 — GPA: 4.4/4.0

Experience

Space Exploration Technologies (SpaceX) — May '11 to August '11
Propulsion Manufacturing Intern — Hawthorne, CA

- Created Manufacturing and Fabrication Orders (MFOs) for Dragon Thermal Control System (TCS)
- Wrote engineering dispositions for manufacturing nonconformances
- Supported TCS proof pressure and leak testing

Georgia Tech School of Aerospace Engineering — August'10 to May '12
Graduate Teaching Assistant — Atlanta, GA

- Setup experiments for undergraduate Fluids Mechanics Lab class
- Taught lab sections
- Graded data and formal reports from students

Blue Origin — June '10 to August '10
Propulsion Intern — Kent, WA

- Developed a Electromechanically Actuated Control Valve from COTS parts
- Set up test bench for valve controller tuning
- Tuned and tested controller and valve components

Missouri S&T Aerospace Plasma Lab — Sept '09 to May '10
Undergraduate Research Assistant — Rolla, MO

- Modeled magnetic field configurations for a Cusped Field Thruster
- Confirmed simulations through laboratory testing
- Presented research to the Missouri Space Grant Consortium

ATK – Tactical Propulsion and Controls June '09 to August '09
Propulsion Analysis Intern Elkton, MD

- Collected performance data on solid rocket motor igniters
- Ran propellant grain burn simulations using in-house codes
- Determined dependency of ignition delay times on igniter parameters

Missouri S&T M-SAT Student Design Team August '08 to May '10
Propulsion Engineer Rolla, MO

- Design experiments and tests for refrigerant-based propulsion
- Researched feasibility, design, and limits of Pulsed Plasma Thrusters
- Designed a propellant distribution system for the Missouri-Rolla satellite

Georgian Aerospace May '08 to August '08
Structural Engineer Intern Chesterfield, MO

- Designed and drew repairs for Sabreliner Sabre T-39s,
- Wrote corresponding repair reports
- Learned types and uses of various aerospace-grade fasteners

Missouri S&T Formula SAE August '06 to May '08
Student design team Rolla, MO
Manufacturing Machinist and Aerodynamicist

- Manufactured chassis and suspension components
- Tested the feasibility of leading edge slats on the wing elements
- Ran CFD for validation of design using Gambit/Fluent/Ensight
- Tested designs in Wind Tunnel 8 at JE Jacobs Drivability Test Facility in Michigan

Computer Skills

Pro/Engineer	NX (Unigraphics)	AutoCAD
MATLAB	Microsoft Office	Microsoft Outlook
Powerdraft	WordPerfect	Fluent/ Gambit Maxwell
Oscilloscopes	Pitot Tubes	

Honors & Activities

Eagle Scout
NASA-Missouri Space Grant Recipient
Editor-in-Chief of Southwinds Literary Magazine
Freshman and Sophomore design project team leader
Tau Beta Pi engineering honor society member
Sigma Gamma Tau Aerospace Engineering honor society member
Kappa Mu Epsilon mathematics honor society member
American Institute of Aeronautics and Astronautics member
Bright Flight Scholarship Recipient

Josémari Luis Soriano

Current: 335318 Georgia Tech Station **|** Atlanta, GA 30332 **|** 409.454.3202 **|** jsoriano6@mail.gatech.edu
Permanent: 8075 Wilcox Lane **|** Beaumont, TX 77706

Objective

Aerospace Engineering student seeking an entry-level technical position to utilize skills and academic background.

Education

Georgia Institute of Technology Atlanta, Georgia
Bachelor of Science: *Aerospace Engineering*
Certificate: *Industrial/Organizational Psychology*
Anticipated Date of Graduation: May 2012

Portsmouth Abbey School Portsmouth, Rhode Island
Diploma: May 2007

Projects

NASA University Student Launch Initiative (USLI) 2011-2012: Rocket Team
-Assisting with CFD analysis on the preliminary design of the launch vehicle.

Undergraduate Team Aircraft Design Competition (AIAA) 2011-2012:
- Performing preliminary design analysis for a Humanitarian Response Unmanned Aircraft System (HR-UAS).

Georgia Tech Motorsports 2011-2012: Aerodynamics Team
-Assisting in the design and implementation of an aerodynamic package on the GTMS 2011-2012 FSAE competition car.
-Performing baseline CFD analysis on selected airfoils to optimize aerodynamic gains of the front and rear wings of the FSAE competition car.

Human Factors Design Analysis
-Examined human factors design implications on existing navigation and climate-control systems in automobiles and implemented practical design solutions aimed at decreasing driver distraction.
-Optimized menu layouts, positioning, and sizing of the climate control and navigation systems.

C-130 Case Study
-Analyzed baseline performance characteristics of the C-130G aircraft and conducted performance estimates of the C-130J aircraft.

Activities

American Institute of Aeronautics and Astronautics (AIAA) **Member** 2010-Current
Georgia Tech Motorsports **Member** 2011-Current

Software

Microsoft Word & Excel, Matlab, Maple, SolidWorks, ANSYS, Autodesk Inventor

Jordan Bell
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Jbell44@gatech.edu

Education
Georgia Institute of Technology, Honors Program, Bachelor of Science in Aerospace Engineering, 2014. GPA: 3.6

Pre-College Engineering Program, Chantilly Academy, Chantilly, Virginia

September 2008 – June 2010
Engineering Systems I – Girls Exploring Engineering GE^2
Engineering Physics II

Westfield High School, Advanced Diploma, June 2010. Cumulative GPA 4.0.
Advanced Placement Courses:
World History, United States History, English Literature and Composition,

Calculus AB, Physics C Mechanics, Physics C Electricity and Magnetism,
US Government, English Language and Composition.

Elective Courses: Aerospace Sciences I and Aerospace Sciences II

Technical Skills
- Proficient in Microsoft Word, Microsoft Excel, MatLab, and Python
- Proficient in the use of a CNC, Lathe, Mill, and other power tools

Employment, Internship, and Volunteer Experience

August 2011 to present
Resident Advisor
Georgia Institute of Technology
Atlanta, Georgia

I create and maintain an environment conducive to academics and personal growth. In addition, I create and run programs to build community, encourage personal development, explore diversity, and enable academic success. I enforce housing policies and serve as the RA on duty.

June 20011 to August 2011
Discovery Station Intern
National Air and Space Museum, Udvar Hazy Center
Chantilly, Virginia

I coordinated and documented the Discovery Stations, stations which explain various science and historical concepts in visual ways to elementary aged children. In addition, I created content and helped run the monthly Super Science Saturdays which is a monthly event focused on a specific area such as electricity.

June 2009 to August 2009
NASA Intern- INPSIRE Program
Langley Research Center
Hampton, Virginia

At NASA, served on a college student team developing Educational Outreach programs. Created aeronautics problems for students in grades K-12 in every subject area aligned with the National Curriculum. At the end of the eight weeks, the team presented in the first annual Aeronautics Forum. Curriculum problems were delivered to the NASA Classroom of the Future to be field tested. If approved, they will be incorporated into NASA websites and K-12 curriculum across the country. Additionally at NASA, participated in STEM lessons and created content for the INSPIRE Online Community.

November 2008 to June 2010
Discovery Station Worker
Smithsonian Air and Space Museum, Udvar Hazy Center
Chantilly, Virginia
Operated Discovery Stations that teach children flight principles, the history of flight, and other science and technology content.

July 2008
Junior Counselor
Camp Potomac Woods
Girl Scout Counsel of the Nation's Capital
Loudoun County, Virginia
Organized and led camping and craft related activities for girls ages 8-12 years. Planned the weekly schedule, supervised campers, and led workshops in developing teamwork skills.

July 2007
Counselor-in-Training
Camp Potomac Woods
Girl Scout Council of the Nation's Capital
Loudoun County, Virginia
Aquired valuable leadership, teamwork, and problem solving skills, in personal interactions with younger children, my peers, and my superiors.

Awards, Honors, Memberships

- •Member, Mars Desert Research Station Crew 101, Georgia Tech, 2010-2011
- •Member, Mars Society, Georgia Tech, 2010-present
- •Member, Society of Women Engineers, Georgia Tech, 2010- present
- •Bassist, Assistant Principle, Georgia Tech Symphony Orchestra, 2010-present

Kevin Reilley

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Education

B.S. Aerospace Engineering, Georgia Institute of Technology Expected 2013
GPA: 3.48

Research Experience

- Energy Harvesting Systems — 11 January 2011- 6 May 2011
  - Leading experimentation, testing, and development of micro renewable energy systems
- Wind Protection Systems for Sample Delivery — August 2010 – December 2010
  - Assisted in with theoretical analysis
  - Co-managed the testing phase with the project manager, specifically with regards to video
  - Assisted with experimental setup and data analysis
- Acoustic Dampening Using Acrylic Plates — May 2010-August 2010
  - Designed, built, and tested systems laying the groundwork for multiple-plate acrylic systems for acoustic dampening

Publications/Presentations

- NASA's Jet Propulsion Laboratory (JPL) — Presented: 8 January 2011
  - Authored a detailed presentation with my two team-members on research findings for a project tied to the Mars Science Laboratory mission scheduled to reach Mars in 2012
  - Invited to present findings to JPL leadership and completed a multi-hour presentation at their campus in Pasadena, CA

Industry Experience

- Internship at Georgia Tech Research Institute — May 2010-August 2010
  - Assisted research engineers with acoustic testing in an anechoic chamber
  - Assisted with a sponsored research project for developing micro renewable energy systems

Academic Projects and Programs

- Georgia Tech University Student Launch Initiative, Flight Systems Co-Lead — August 2011-Present
- Georgia Tech Language in Business and Technology, Paris — June 2011-July 2011
- Georgia Tech University Student Launch Initiative, Payload Team — September 2009-May 2010

Affiliations/Memberships

- President, Georgia Tech Rocket Club — May 2011-Present

Skills

- French Proficiency (18 hours of Georgia Tech French)
- MATLAB

Interests

- Civilian space exploration and technological development
- International cooperation on space objectives
- Computational modeling and simulation

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Statham, GA 30666

Matthew T. Schumann
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Objective:

Education:

Georgia Institute of Technology, Atlanta, GA — **Aug 2008-Present**
Cumulative Institute GPA 3.55/4.0
Bachelor of Science in Mechanical Engineering — **Expected May 2013**
Minor in Nuclear & Radiological Engineering — **Expected May 2013**
Dean's List

Undergraduate Research — **January 2010 – May 2010**
Georgia Institute of Technology, Atlanta, GA
Working with Professor of Physics David Ballantyne assisting with research on modeling the observed high energy gamma ray source at the Galactic Center. Implementing changes in current model to reflect time dependence, running the model, and reporting the results.
D. R. Ballantyne, M. Schumann, B. Ford, 2011, MNRAS, 410, 1521-1526

North Oconee High School, Bogart, GA — **Aug 2004 – May 2008**
Graduated with GPA 3.97/4.0
Honorarian
Oconee County School Superintendent's Advisory committee

Experience:

Information Technology Architect — **May 2011 – Aug 2011**
Alere Health, Atlanta, GA
Researched health topics for the expansion of Alere Health into foreign countries. Completed data models for use with Data Governance implementation in IT systems.

Intern – Executive Assistant for Deputy Director Strategic Planning — **May 2010 – Aug 2010**
Test Resource Management Division, Arlington, VA
Collected and researched DoD documents in support of Strategic Planning Division. Prepared, conducted analysis, and wrote reports in support of the 2012 Strategic Plan for DoD Test and Evaluation Resources.

Tutor — **March 2010 – May 2010**
Georgia Institute of Technology, Atlanta, GA
Tutored peers through the Student Success Program. In the areas of physics, computer science, statics, and computer related engineering design (class specific).

Sonic Drive-In, Athens, GA — **May 2009 – August 2009**
Took orders, cooked prepared and bagged food, made drink orders, kept all food supplies properly stocked, rotated oil, cleaned all cooking surfaces, restocked fridge/freezer, and disposed of trash.

Youth Apprenticeship Program — **Spring Semester 2008**
University of Georgia Athens, Athens, GA
Worked with Professor of Physics Uwe Happek conducting research projects on high energy physics and energy efficient lighting. Assisted in the development of an electron measurement instrument and in data acquisition/analysis for tests on efficient phosphor lighting.

Skills:

Software: Microsoft Office Suite, Inventor, AutoCAD
Programming Experience: Java, Matlab, P-Basic, Perl
Equipment: Milling machine, Lathe, Soldering Iron, Hack, Circular and ban saws

Activities:

Service Trip to Haiti (March 19-26/2011)
Assisted Bohoc community with sanitation and kids at local orphanages.
Yellow Jacket Archery Club
Participated in National Tournament (Feb. 27-28/ 2010)
Georgia Tech Marching Band
Participated in the Macy's Thanksgiving Day parade

MICHAEL E. CATO

mike.cato@gatech.edu
cell: 1*-912-663-1893

EDUCATION

***Bachelor of Science in Computer Engineering*,**
Anticipated Graduation: Fall 2012, *Georgia Institute of Technology, Atlanta, Georgia*
Transferred from: *Armstrong Atlantic State University, Savannah, Georgia*

WORK, INTERNSHIP, AND RESEARCH EXPERIENCE

Microsystems Packaging Research Center, Georgia Institute of Technology, ***Atlanta, GA***
MICROSYSTEMS PACKAGING RESEARCH INTERN — *AUGUST 2010 TO PRESENT*

- UV Lithography, Chemical Process, Etching, Developing, Plating, Lamination, Plasma Etching, Analysis

Humanoid Robotics Lab, Georgia Institute of Technology, ***Atlanta, GA***
STUDENT RESEARCHER — *AUGUST 2009 TO December 2011*

- HGR Humanoid (30cm height): Hardware testing, Solidworks/Dimensioning, C++, ZMP Walking Algorithm
- Golem Krang Humanoid (1.8m height): Tele-operation, Video/Vision Processing, Circuits, Embedded Systems, Hardware I/O, Path Planning

CREATE, Georgia Institute of Technology, ***Savannah, GA***
RESEARCH ASSISTANT — *JUNE 2009 TO AUGUST 2009*

- Parallel Computing, MMU, Software Transactional Memory Model Assessment, Perl Scripting

NASA Reduced Gravity Student Flight Opportunities Program, ***Houston, Texas***
TEAM LEAD AND ORGANIZER — *OCTOBER 2008 TO DECEMBER 2008*

- Proposed experiment to analyze fluid flow in aquatic habitats in micro/hyper gravity, for optimization of filtration for minimal effect on aquatic life. (Experimental test setup, control methods, preliminary analysis of safety vulnerabilities)

Robotics Academy, NASA Goddard Space Flight Center, ***Greenbelt, MD***
ASSOCIATE RESEARCH INTERN — *JUNE 2008 TO AUGUST 2008*

- Technical documentations, Research, Development, Analysis of a vast array of sensors, Intelligent Robot Design
- Restructuring, design, and testing of 2009 National VEX Robotics Competition

Undergraduate Research, Armstrong Atlantic State Universtiy, ***Savannah, Georgia***
STUDENT RESEARCHER — *MARCH 2008 TO AUGUST 2009*

- Project focus on a simple but sensory rich intuitive human haptic feedback and control mechanism (glove) for future robotic and virtual reality system interactions, experimentation performed on a 6 DOF robotic arm.

Live Performance Solutions/Gaster Engineering, ***Savannah, Georgia***
MULTIFACETED TECHNICIAN — *SEPTEMBER 2005 TO MARCH 2008*

- Large Live Audio Systems (i.e. Savannah's Yearly: Irish, Pirates, Asian, Jazz Festivals)
- Design of Large/Small Static Systems (i.e. Tubby’s Tank House (1-2), Fiddlers Crab House, Jinx, and Residential)
  - Also: Recording Studio Assistant, Programmed DSP Systems, Ran Wiring, Soldered, Construction, Office Work

Also worked: Children Camps (yearly for 5 years), DJ/Audio/Video Technician, AASU Computer Lab Tech

Raef Eagan
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(678)458-5070

Objective

Gain experience by doing work in areas of research pertaining to my major so that I may be of more use to companies, professors, and so I may perform my own research in the future.

Relevant Skills

1. Basic Computer Skills – Proficient in operating computers: TecPlot, Excel, MATLAB, Microsoft Word, PowerPoint, Java
2. Leadership Skills – Group leader in Engineering Graphics Project and Introduction to Aerospace Project; Experience with directing a group and delegating tasks to appropriate members, while maintaining effective working relationship between group/team members
3. Initiative – I volunteered to help with a graduate research group my first semester at GA Tech at the Aerospace Systems Design Lab(NEREUS Project) while still an undergraduate, and have contributed significant effort to the group's objectives

Achievements

1. With the NEREUS Project, by researching fuel consumption in Naval ships, I determined that all fuel being used by ships "not underway" was being used to generate electricity for Hotel Loads(electricity used for Heating/Air, computers, lighting, utilities), prompting the group to look into ways of generating electricity for ships in port through new "green" means to help reduce the Navy's reliance on foreign oil.
2. 4/2/2011. I became Level 1 Certified by the National Association of Rocketry by designing, constructing, successfully launching and recovering a low/mid-power rocket with the Rocket Club.
3. Summer 2011 – I taught myself Tecplot, and created multiple High-Resolution graphs to be published

Education

Gainesville State College
A.S. Engineering December 2009

Georgia Institute of Technology
B.S. Aerospace Engineering, Expected 2013

Experience

Undergraduate Researcher	Harper Wind Tunnel Lab	5/11-8/11
	Aerospace Systems Design Lab	9/10-4/11
Server	IHOP	9/08-2/10
	Austin's Steak and Seafood	12/07-6/08
	Indigo Joe's	12/06-10/07
Bookkeeper	Ingles Markets	4/02-10/06

ROBERT R. RHINEHART

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(404) 683-1142 Atlanta, GA 30318

EDUCATION

Georgia Institute of Technology **Graduating Spring 2012**

- Candidate for Bachelor of Science, Computer Science **CS GPA: 3.3**
- Candidate for Bachelor of Science, Electrical Engineering
- Dean's List 2007-2011

Shanghai Jiao Tong University - 上海交通大学 **Summer 2008**

- Study Abroad program

WORK EXPERIENCE

Athina, LLC: Central Technology Officer **Summer 2011**

- Co-founded web startup to switch eBooks to a subscription model
- Sole developer of ~30kloc web application with mobile counterparts
- Tech stack: Django, Python, MySQL, MongoDB, jQuery, FB API, Android
- Machine Learning and statistical analysis system for recommendation engine with SciPy, statsmodels, R, and PyBrain
- Security Auditing with metasploit

Synthelix: Software Engineering, Wrocław, Poland **Fall 2009**

- Developed advanced web-based Course Management system for Poland's higher education system. More info: www.synthelix.com
- Worked on multi-cultural team
- Tech stack: Apache Tomcat, MySQL, Hibernate (ORM), Spring Framework, Spring Security, Java EE, Java Mobile, .NET 3.5, SOAP/WSDL web services
- Testing, profiling, database tuning: JUnit, Selenium, VisualVM, Spring Insight

RESEARCH

NASA University Student Launch Initiative **Present**

- NASA-sponsored project to analyze Active Platform Electromagnetic Stabilization (A.P.E.S) on board a mid-sized rocket
- Uses a variable electromagnetic field to stabilize a payload during rocket launch
- Head of Electronic Systems team
- Antenna & transmitter design and analysis, embedded development with multiple sensors and actuators, adaptive control algorithms in C, fail safe mechanisms

PERSONAL PROJECTS

- Telemety.js - WebGL Satellite Tracker and Telemetry Information in browser
- Built Ham Radio antennas and receivers
- WREK android app: https://github.com/engibeer/wrek-android
- sansori.org social enterprise entrepreneurship network
- Custom built/configured/administrated linux HTTP/FTP/SMTP server
- projecteuler.com and topcoder.com competitor

SKILLS

Embedded Systems

- Microcontrollers Used – MSP430, PIC18, ATMEGA328
- Systems Design – Branching, Pipelining, Interrupts, Memory Virtualization
- C Programming for minimal power consumption, Assembly (PIC18, x86 + some extensions, and MIPS)

Networking

- C sockets api, RIP, OSPF, BGP routing protocols
- security: cryptography, pentesting, metasploit, nmap, netcat, wireshark, tcpdump, reversing (IDA)
- IPv6, IPv4, TCP/UDP protocol fundamentals, HTTP(S), FTP, DNS, SMTP application layer protocols

- Link layer: 802.11, 802.15.4 standards

Electrical Engineering

- Circuit Analysis, Signal Processing, Microelectronics, RF communication
- FPGA prototyping, VHDL, ASIC use, MATLAB, EagleCAD, PSPICE

High Level Programming

- C++ with GCC, LLVM/Clang, MSVC++, Bash, Python 2.7/3.2, C# 4.0, Java 6, Processing, PHP, web development (HTML, CSS, SQL, JavaScript)
- Familiar with common data structures and algorithms; concurrent programming with pthreads, CUDA, OpenCL
- GUI Software – Eclipse 3.x, AutoCAD 2011 Inventor, Visual Studio 2010
- OS – Ubuntu Linux Desktop/Server (customized kernel), Windows NT

ACTIVITIES/HONORS

- **IEEE Student Branch President** **2010-2011**
  - Increased Membership 30% Fall 2010
  - Manage over 1000 members, 14 officers, 3 teams
  - Attended Professional Electrical Engineering Conferences
- ARRL Member **2011 - Present**
- IEEE Vice Chair **2009 - 2010**
- IEEE Technology Chair **2008 - 2009**
- Sigma Nu Social Fraternity **2007 - Present**
- AIESEC Georgia Tech **2008 - Present**
- Astronomy Club **2007 - Present**
- TEAM BUZZ community service **2008** - **Present**
- STAR Student Scholarship: highest SAT score in class **2007 - Present**
- Xerox award for Innovation in Information Technology **2007**

Xiaoheng Pan (US Citizen)
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Aspiration

Seeking a full-time position employing my propulsion expertise starting March 2012.

Education

Georgia Institute of Technology, *Atlanta GA*
MS in Aerospace Engineering with focus in combustion, GPA 3.4/4.0, Dean's list — Aug '10 - Dec '11
BS in Aerospace Engineering with High Honor, GPA 3.5/4.0, Dean's list — Aug '06 - May '10

Nanyang Technological University, *Study Abroad, Singapore* — Aug '08 – Nov '08
Shanghai Jiao Tong University, *Study Abroad, Shanghai, China* — May '07 – July '07

- Learned to establish rapport quickly with individuals in unfamiliar environment & communicate despite barriers.
- Studied with multinational students & interacted with business executives from leading Asian companies.

Relevant Experience

Georgia Institute of Technology, *Atlanta GA*

NASA University Student Launch Initiative — Aug '11 – Present
- Designing 10ft tall recoverable rocket to carry scientific payload to achieve an altitude of 1 mile from the ground.
- Rocket team leader, responsible for structure, aerodynamics, propulsion, and recovery system.

Graduate Teaching Assistant for Aerospace Senior Design Course — Aug '10 - Present
- Provide instructional guidance and support to AE senior design students.
- Grading assistance, one-on-one tutoring, and lab supervision.

Scramjet Engine Research — Jan '10 - May '10
- Designed and setup planar laser-induced florescence system for improved flow visualization and measurement.
- Laboratory computer technician providing IT support and upgrading computer hardware.

Senior Design Deputy Manager — Jan '10 - May '10
- Designed long-range passenger transport aircraft utilizing hydrogen fuel for clean emission.
- Performed aircraft optimization, cost analysis & reduction, trade studies.
- Guided, oversaw, and assigned tasks to group of 10 members.

Solar Renewable Energy Research — May '08 - May '09
- Initiated research program and expanded to 6-member team.
- Performed thermal and cycle efficiency analysis for solar collector with various piping configurations.
- Built parabolic trough solar collector with wooden support frame.
- Presented research results at campus Honors Research Symposium.

GE Aviation, *Evandale OH*

Infrastructure Engineering Intern — May '11 - Aug '11
- Investigated IGV lever arm failure for engine 956-009/01 after block test and discovered aero stall stress equivalent to 0.2% yield strength with no safety margin. Led to departmental Tech Review and redesigned of IGV lever arm.
- Enhanced compressor blade leading edge profiles to provide improvement to engine SFC margin by 0.01% and implemented cost reduction strategies through manufacturer cooperative work.
- Drafted and modified CAD models/drawings for GENX compressor components utilizing NX Unigraphics.
- Material analysis of yield strength vs. residual stress for compressor seal teeth for crack prevention. Study was published in GE Aviation Design Record Book.
- Created and managed GENX High Pressure Compressor module online storage database. Worked cooperatively with key team members to ensure web-based information archive for future needs and reference.

McGuire & Son Heating and Air INC., *Richmond Hill GA*

AC Technician — June '09 - Aug '09
- Performed routine maintenance and part replacement for commercial and residential buildings.

Skills

CAD Modeling: Solid-Edge, AutoCAD, and NX Unigraphics.
Computer/Software: Mathworks Matlab & Simulink, Chemkin, GasEq, and NPSS.
Technical: Lathe, Mill, Surface Grinder, Pedestal Grinder, Band Saw, and Drill Press (Certificate in Machining, 32 hours).
Linguistic: Chinese (fluent), English (fluent), and Spanish (elementary)

Awards

- Taiwan Huayu Scholarship recipient — May '11
- Georgia's Hope Scholarship recipient — Aug '06 - Dec '09
- Georgia Institute of Technology International Plan Scholarship recipient — Aug '08
- Sam Walton Scholarship recipient — Aug '06

Richard Zappulla II
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Permanent Address:
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Boca Raton, FL 33498

Education:

M.S in Aerospace Engineering

Georgia Institute of Technology, Atlanta, GA **08/2011 – Present**
Expected Graduation: 05/2013

B.S (with highest honors) in Aerospace Engineering

Georgia Institute of Technology, Atlanta, GA **08/2006 – 05/2011**
Overall GPA: 3.8/4.00

Research:

Experimental Aerodynamics Design Group:

- Sample Protection Systems for In-Situ Robotic Science Missions, JPL June 2010-June 2011
- Low-Cost Vertical Axis Wind Turbine Development: Team Lead 1/2010 – 5/2010
- High Reynolds Number Laminar Wing Flow Analysis: Team Lead 8/2008-12/2008

Relevant Experience:

- **Warner Robins Air Force Base – Aerospace Sustainment (Internship):** May 2011 – August 2011
  - C-130 Structural Engineer
    - Aided in the analysis, design, and implementation of repairs for the C-130 structure.
    - Gained experience with repairing:
      - Corrosion, double-drilled holes, aerospace-grade paint flaking, et cetera
    - Gained experience in the types and uses of aerospace-grade fasteners
- **Jet Propulsion Laboratory (JPL) (Internship)**: June 2010 – August 2010
  - Mars Science Laboratory (MSL) Surface Sampling and Science
    - Development and Testing of Wind Guard System for MSL Sample Drop-off System
    - Risk Assessment and Mitigation of Thermally – Induced Venting
    - Risk Assessment of MSL Sample Drop-off System
    - Supported Mechanism Hardware/Software Testing and Calibration
- **HEICO Aerospace(CO-OP)**:
  - *January 2009 – April 2010: (CO-OP) Jet Avion and Airfoil Business Unit*
    - Fixture and Tooling Design utilizing Geometric Dimensioning & Tolerancing
    - Systems Optimization and Program/Application Development
    - Lean/Six-Sigma Activities:
      - Utilizing Lean/Six-Sigma techniques to reduce a tremendous backlog in another Business unit within HEICO Aerospace.
        - Process Improvement and Support
        - Programming/Application Engineering
  - *August 2008 – December 2008:*
    - Engineering Consultant
  - *May 2008 – August 2008: (CO-OP) Airfoil Business Unit*
    - Six-Sigma Green Belt Training.
      - Worked on 3 various teams improving various process flows and provided solution support
    - Programming/Application Engineering
      - Developed the *Next Generation Non-Conforming Materials Reporting Database.*
      - Further automation of the Forecasting process utilizing MATLAB.
        This includes, but not limited to:
        - Memory Usage and Speed Optimization
        - Standardization and Defining multiple inputs
  - *June 2007 – December 2007: (CO-OP) Airfoil Business Unit*
    - Automation of the Forecasting process utilizing MATLAB.
    - Development and implementation of a Process Improvement Tool: Paperless Workstation System

- **NASA University Student Launch Initiative (USLI) Competition:**
  - 2011-Present: *Project Manager*
  - 2009 – 2010: *Payload Manager:*
    Facilitate the development of the payload from concept to final flight experiment.
    Primary Investigator:
    Responsible for the theoretical and physical development of the scientific experiment
  - 2008-2009: *Payload Integration:*
    Coordinated development of payload hardware and implement installation of payload hardware; developed post-processing routines
- **Prox-1 University Nanosat Mission (UNP-6): 01/2011 – Present**
  - Project System Engineer
  - Command and Data Handling Subsystem / Flight Software:
    - Developing and implementing the Flight Computer, instrument interfaces, and Flight Software for the Prox-1 satellite.
- **Rapid Reconnaissance and Response (R^3) University Nanosat Mission (UNP-6): 8/2010 – 1/2011**
  - Command and Data Handling Subsystem / Flight Software:
    - Developed and implemented Subsystem Micro-Controllers (SMC) to aid in information collection and command dissemination

Skills:
- Software: Windows XP and Vista, SolidEdge, Solid Works, Pro-Engineer, Microsoft Word, Excel, PowerPoint, Access, Publisher, OneNote, MiniTab, CFD modeling and analysis
- Programming: MATLAB/Simulink, Visual Basic.net ,C#.net, C/C++, vPython, Python, HTML
- ASME Y14.5M: Geometric Dimensioning and Tolerancing (GD&T)
- Embedded systems design and micro-controller/micro-processor programming
- Operation of Cessna 152, 172 (All Non-RG Variants),182 (All Non-RG Variants) aircraft

Honors and Accomplishments:
- SMART Scholar, 2010 Cohort
- Faculty Honors – Spring 2008, Fall 2008,
- Dean's List – Fall 2006, Spring 2007, Fall 2009, Spring 2010, Fall 2010
- Private Pilots' License with IFR rating
- National Association of Rocketry (NAR) Certified Level 1 High-Powered Rocket User

Extra Curricular Activities:
- Founder: Ramblin' Rocket Club (Georgia Tech)
  - President: January 2007 – December 2007
  - Secretary: August 2010 - Present
- Civil Air Patrol : Search and Rescue, Disaster Relief, Counter-Drug, Homeland Security 06/2002 – Present
  - Search and Rescue Officer: Coordinate training and mission support of Ground Team personnel and resources
- Sport Rocketry 08/2005 - Present
- Aviation 08/2002 – Present
- Wind Ensemble, Marching Band, Orchestra, Symphonic Band, Chamber Ensembles (Brass Quintet, Tuba-Baritone Ensemble, etc.) at Georgia Tech: 08/2006 – Present

References:

Daniel Limonadi	Michael Williams	Rick Sigman
Jet Propulsion Laboratory	HEICO Aerospace	Torque Products, Inc
4800 Oak Groove Dr.	3000 Taft St.	4286 Bells Ferry Rd
Pasadena, California 91109	Hollywood, Fl 33021	Kennesaw, GA 30144
Phone: 818.653.8203	Phone: 954.673.1934	Phone: 770.331.4245

Appendix IV: Material Safety Datasheets

AeroTech Division, RCS Rocket Motor Components, Inc.
Material Safety Data Sheet & Emergency Response Information
Prepared in accordance with 29 CFR § 1910.1200 (g)

Section 1. Product Identification

Model rocket motor, high power rocket motor, hobby rocket motor, composite rocket motor, rocket motor kit, rocket motor reloading kit, containing varying amounts of solid propellant with the trade names White Lightning™, Blue Thunder™, Black Jack™, Black Max™, Redline™, Warp-9™ or Mojave Green™. These products contain varying percentages of Ammonium Perchlorate, Strontium and/or Barium Nitrate dispersed in synthetic rubber with lesser amounts of proprietary ingredients such as burn rate modifiers and metal fuels. Rocket motor ejection charges contain black powder.

Section 2. Physical Characteristics

Black plastic cylinders or bags with various colored parts, little or no odor

Section 3. Physical Hazards

Rocket motors and reload kits are flammable; rocket motors may become propulsive in a fire. All propellants give off varying amounts of Hydrogen Chloride and Carbon Monoxide gas when burned, Mojave Green propellant also produces Barium Chloride.

Section 4. Health Hazards

Propellant is an irritant in the case of skin and eye contact, may be extremely hazardous in the case of ingestion, and may be toxic to kidneys, lungs and the nervous system. Symptoms include respiratory irritation, skin irritation, muscle tightness, vomiting, diarrhea, abdominal pain, muscular tremors, weakness, labored breathing, irregular heartbeat, and convulsions. Inhalation of large amounts of combustion products may produce similar but lesser symptoms as ingestion.

Section 5. Primary Routes of Entry

Skin contact, ingestion, and inhalation.

Section 6. Permitted Exposure Limits

None established for manufactured product.

Section 7. Carcinogenic Potential

None known.

Section 8. Precautions for Safe Handling

Disposable rubber gloves are recommended for handling Mojave Green propellant. Keep away from flames and other sources of heat. Do not smoke within 25 feet of product. Do not ingest. Do not breathe exhaust fumes. Keep in original packaging until ready for use.

Section 9. Control Measures

See section 8.

Section 10. Emergency & First Aid Procedures

If ingested, induce vomiting and call a physician. If combustion products are inhaled, move to fresh air and call a physician if ill effects are noted. In the case of skin contact, wash area immediately and contact a physician if severe skin rash or irritation develops. For mild burns use a first aid burn ointment. For severe burns immerse the burned area in cold water at once and see a physician immediately.

Section 11. Date of Preparation or Revision

July 20, 2010

Section 12. Contact Information

AeroTech Division, RCS Rocket Motor Components, Inc. 2113 W. 850 N. St. Cedar City, UT 84721
(435) 865-7100 (Ph)
(435) 865-7120 (Fax) Email: customerservice@aerotech-rocketry.com Web: http://www.aerotech-rocketry.com Emergency Response: Infotrac (352) 323-3500

MATERIAL SAFETY DATA SHEET

REVISION DATE: 04-1-2001 SUPERSEDES: 08-21-2001

SECTION 1. CHEMICAL PRODUCT AND COMPANY IDS IDENTIFICATION

COMPANY INFORMATION

Global Coatings Division

H.B. Fuller Company

2900 Granada Lane

Oakdale,MN 55128

Phone: 651-236-3700

Medical Emergency Phone Numbs (24 Hours): 1-888-853-1758

Transport Emergency Phone Number (CHEMTREC): 1-800-424-9300

PRODUCT INFORMATION

PRODUCT IDENTIFIER: 810564PM
PRODUCT NUMBER: IF1947T
PRODUCT DESCRIPTION: Powder coating

SECTION 2: COMPOSITION/INFORMATION ON INGREDIENTS

Unlisted ingredients are not 'hazardous' per the Occupational Safety and Health Administration Hazard Communication Standard (29 CFR 1910.1200) and/or are not found on the Canadian Workplace Hazardous Materials Information System ingredient disclosure list See Section 8 for any additional exposure limit guidelines.

Chemical Name	CAS #	PERCENT	OSHA PEL
Epoxy resin	25036-25-3	50 - 70	Not established
Calcium carbonate	1317-65-3	10 - 30	TWA (Total dust) 15 MG/M3 TWA (Respirable dusty 5 MG/M3
Epoxy resin	28064-14-4	10 - 30	Not established
Bisphenol A	80-05-7	1-5	No established
Iron oxide	1332-37-2	1-5	TWA (as Fe) Fume 10 MG/M3
Aromatic amine	693-98-1	0.1-1	Not established
Crystalline silica	14808-60-7	0.1-1	TWA (Respirable dust) 0.1 MG/M3

SECTION 3: HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

Dust clouds in air can be ignited by electric sparks, hot surfaces and open flame.

MATERIAL SAFETY DATA SHEET

Can cause skin imitation. May cause allergic skin reaction.
May cause an allergic respiratory reaction.
Harmful if swallowed.
Cancer hazard.

HMIS RATING: HEALTH -- 1 FLAMMABILITY -- 1 REACTIVITY -- 0
See SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION for personal protective equipment recommendations.

POTENTIAL HEALTH EFFECTS BY ROUTE OF ENTRY

EYE: Can cause minor irritation, tearing and reddening. Can cause mechanical irritation if dusts are generated.
SKIN: Continued or prolonged contact may irritate the skin and cause a skin rash (dermatitis). May cause sensitization.
Can cause light sensitivity that results in a skin rash when exposed to sunlight or ultraviolet light sources.

INHALATION: Can cause minor respiratory irritation Dust may be slightly irritating to the respiratory tract.
Inhalation of dusts produced during cuffing, grinding or sanding of this product may cause irritation of the respiratory tract
May cause allergic respiratory reaction.
Overexposure to iron oxide dust/fume may cause siderosis. Overexposure to crystalline silica may cause silicosis.

INGESTION: Ingestion is not an anticipated route of exposure. Harmful if swallowed.

LONG-TERM (CHRONIC) HEALTH EFFECTS
TARGET ORGAN(S): Skin, Lungs

REGULATED CARCINOGEN STATUS:
Unless noted below, this product does not contain regulated levels of NTP, IARC, ACGIH, or OSHA listed carcinogens.

Crystalline silica

EXISTING HEALTH CONDITIONS AFFECTED BY EXPOSURE: Skin disease including eczema and sensitization; Lung disease

SECTION 4: FIRST AID MEASURES

IF IN EYES: Immediately flush eyes with plenty of water for at least 20 minutes retracting eyelids often. Tilt the head to prevent chemical from transferring to the uncontaminated eye. Get immediate medical attention and monitor the eye daily as advised by your physician Flush eye with water for 20 minutes. Get medical attention.

IF ON SKIN: Wash with soap and water. Remove contaminated clothing, launder immediately, and discard contaminated leather goods. Get medical attention immediately.

If VAPORS INHALED: Remove to fresh air. Call a physician if symptoms persist.

IF SWALLOWED: No hazard in normal industrial use. Do not induce vomiting. Seek medical attention if symptoms develop. Provide medical care provider with this MSDS.

SECTION 5: FIRE FIGHTING MEASURES

FLASH POINT:	Not applicable
AUTOIGNITION TEMPERATURE:	Not established
LOWER EXPLOSIVE LIMIT (% in air):	Not established
UPPER EXPLOSIVE LIMIT (% in air):	Not established
EXTINGUISHING MEDIA:	Use water spray, foam, dry chemical or carbon dioxide.

MATERIAL SAFETY DATA SHEET

UNUSUAL FIRE AND EXPLOSION HAZARDS: Material will burn in a fire. Normal LEL for powder coatings 0.04 to 0.07 ounces/cubic foot. Strong explosions are not expected below 0.4 to 0.7.

SPECIAL FIRE FIGHTING INSTRUCTIONS: Persons exposed to products of combustion should wear self contained breathing apparatus and full protective equipment.

HAZARDOUS COMBUSTION PRODUCTS: Carbon dioxide, Carbon monoxide

SECTION 6: ACCIDENTAL RELEASE MEASURES

SPECIAL PROTECTION: No health effects expected from the cleanup of this material if contact can be avoided. Follow personal protective equipment recommendations found in Section 8 of this MSDS.

CLEAN-UP: Avoid creating dusts. Eliminate ignition sources. If a vacuum is used, ensure that the material is wetted or otherwise treated so an explosive dust atmosphere is not created within the vacuum.

Transport Emergency Phone Number (CHEMTREC): 1-800-424-9300

SECTION 7: HANDLING AND STORAGE

Handling: Mildly irritating material. Avoid unnecessary exposure. Avoid creating dusts as an explosive dust air mixture can be created at high concentrations. If dusts are created, ensure no sources of ignition are present. Take precautionary measures to prevent electrostatic discharges.

Storage: Store in a cool, dry place.

Consult the Technical Data Sheet for specific storage instructions.

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

EYE PROTECTION: Wear safety glasses with side shields when handling this product. Wear additional eye protection such as chemical splash goggles and/or face shield when the possibility exists for eye contact with splashing or spraying liquid, or airborne material. Have an eye wash station available.

SKIN PROTECTION: Prevent contact with this product. Wear chemically resistant gloves, long sleeved shirt, an apron, and other protective equipment depending on conditions of use.

GLOVES: Nitrite

RESPIRATORY PROTECTION: Respiratory protection may be required to avoid overexposure when handling this product. Use a respirator if general room ventilation is not available or sufficient to eliminate symptoms. NIOSH approved air ~ Expiator with dust/mist filter. Respirators should be selected by and used following requirements found in OSHA's respirator standard (29 CFR 1910.134).

VENTILATION:

EXPOSURE LIMITS:

Chemical Name	ACGIH EXPOSURE LIMITS	AIHA WEEL
Epoxy resin	Not established	Not established
Calcium carbonate	TWA (Total dust) 10 MG/M3	Not established

MATERIAL SAFETY DATA SHEET

Epoxy resin	Not established	Not established
Bisphenol A	Not established	Not established
Iron oxide	TWA (as Fe) Fume 5 MG/M3	Not established
Aromatic amine	Not established	Not established
Crystalline silica	TWA (Respirable dust) 0.05 MG/M3	Not established

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL STATE: Solid
COLOR: Red
ODOR: Neutral
ODOR THRESHOLD: Not established
WEIGHT PER GALLON (Ibs.): 11.58
SPECIFIC GRAVITY: 1.39
SOLIDS (% by weight): 100.0
Not applicable

pH: Not established
BOILING POINT (deg. C): Not established
FREEZING/MELTING POINT (dew C): Not established
VAPOR PRESSURE (mm Hg): Not established
VAPOR DENSITY: Not established
EVAPORATION RATE: Not established
OCTANOL/WATER COEFFICIENT: Not established

SECTION 10: STABILITY AND REACTIVITY

STABILITY: Stable under normal conditions.
CHEMICAL INCOMPATIBILITY: Not established
HAZARDOUS POLYMERIZATION: Will not occur.
HAZARDOUS DECOMPOSITION PRODUCTS: Carbon monoxide, Carbon dioxide

SECTION 11: TOXICOLOGICAL INFORMATION

CHEMICAL NAME	LD50/LC50
Epoxy resin	Oral LD50 Rat > 30 g/kg Inhalation LC50 Rat > 800 mg/cu m/4H Dermal LD50 Rabbit > 3 g/kg
Calcium carbonate	Not established

MATERIAL SAFETY DATA SHEET

Epoxy resin	Not established
Bisphenol A	Oral LD50 Ret = 3250 mg/kg Dermal LD50 Rabbit = 3 ml/kg
Iron oxide	Not established
Aromatic amine	Not established
Crystalline silica	Not established

TOXICOLOGY SUMMARY: No additional health information available.

SECTION 12: ECOLOGICAL INFORMATION

OVERVIEW: No ecological information available

No levels of volatile organic compound emissions are expected at ambient temperatures and pressure. Depending on powder chemistry, however, higher levels of VOC and low molecular weight hydrocarbons may be emitted at cure temperatures. Emissions data are best developed by monitoring actual plant conditions.

SECTION 13: DISPOSAL CONSIDERATIONS

To the best of our knowledge, this product does not meet the definition of hazardous waste under the U.S. EPA Hazardous Waste Regulations 40 CFR 261. Disposal via incineration at an approved facility is recommended. Consult state, local or provincial authorities for more restrictive requirements.

SECTION 14: TRANSPORTATION INFORMATION

Consult Bill of Lading for transportation information.

SECTION 15: REGULATORY INFORMATION

INVENTORY STATUS

U. S. EPA TSCA: This product is in compliance with the Toxic Substances Control Act's Inventory requirements.

CANADIAN CEPA DSL: This product is in compliance with the Canadian Domestic Substance List requirements.

If you need more information about the inventory status of this product call 651-236-5858.

TSCA Section 12(b) - Export Notice Requirements
This product contains a chemical substance that is currently on the EPA's Section 12(b) Export List. Contact the company Global Regulatory Group at 651/236-5858 for the identity of the Section 12(b) chemical(s).

FEDERAL REPORTING
EPA SARA Title III Section 313
Unless listed below, this product does not contain toxic chemical(s) subject to the reporting requirements of section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA) and 40 CFR part 72. EPA has advised that when a percentage range is listed the midpoint may be used to fulfill reporting obligations.

Chemical Name	CAS#	%
4,4'-Isopropylidenediphenol	80-05-7	1- 5

MATERIAL SAFETY DATA SHEET

WHMIS STATUS: Unless listed below, this product is not controlled under the Canadian Workplace Hazardous Materials Formation System.

D2B D2A

STATE REPORTING
This MSDS is not prepared for distribution in California.

SECTION 16: ADDITIONAL INFORMATION

This Material Safety Data Sheet is prepared to comply with the United States Occupational Safety and Health Administration (OSHA) Hazard Communication Standard (29 CFR 1910.1200) and the Canadian Workplace Hazardous Materials Information System (WHMIS).

Prepared by: The Global Regulatory Department
Phone: 651-236-5842

The information and recommendations set forth herein are believed to be accurate. Because some of the information is derived from information provided to the H.B. Fuller Company from its suppliers, and because the H.B. Fuller Company has no control over the conditions of handling and use, the H.B. Fuller Company makes no warranty, expressed or implied, regarding the accuracy of the data or the results to be obtained from the use thereof. The information is supplied solely for your information and consideration, and the H.B. Fuller Company assumes no responsibility for use or reliance thereon. It is the responsibility of the user of H.B. Fuller Company products to comply with all applicable federal, state and local laws and regulations.

OWENS CORNING ™

MATERIAL SAFETY DATA SHEET

Section 1: Product and Company Information

<u>Product Name(s)</u>: Woven Unidirectional Fiberglass Fabric (A-Style Warp Unidirectional), Stitchbonded Fiberglass Fabric, Woven Fiberglass Fabric

<u>Manufacturer</u>: Owens-Corning, World Headquarters, One Owens-Corning Parkway
Attn. Product Stewardship, Toledo, OH, 43659,
Telephone: 1-419-248-8234 (8am-5pm ET weekdays).
OC Fabrics, 1851 S. Sequin Ave., New Braunfels, TX, 78130
Telephone: 1-210-629-4009 (8am-5pm CT weekdays).

<u>Emergency Contacts</u>:
Emergencies ONLY (after 5pm ET and weekends): 1-419-248-5330,
CHEMTREC (24 hours everyday): 1-800-424-9300,
CANUTEC (Canada- 24 hours everyday): 1-613-996-6666.

<u>Health and Technical Contacts</u>:
Health Issues Information (8am-5pm ET):1-419-248-8234,
Technical Product Information (8am-5pm ET): 1-800-GET-PINK.

Section 2: Composition and Ingredient Information

Common Name	Chemical Name	CAS No.	Wt. %
Non-Hazardous Ingredients			
Fiber Glass Continuous Filament (non respirable)	Fibrous Glass	65997-17-3	94-100
Size	Size	None	0-2
Polyester Yarn	Polyester Yarn	None	0-4

<u>Note</u>: See Section 8 of MSDS for exposure limit data for these ingredients.

MATERIAL SAFETY DATA SHEET

Section 3: Hazards Identification

Appearance and Odor: White/off-white colored solid with no odor.

Emergency Overview

No unusual conditions are expected from this product

Primary Route(s) of Exposure: inhalation, skin, eye

Potential Health Effects:

ACUTE (short term): Fiber glass continuous filament is a mechanical irritant. Breathing dusts and fibers may cause short term irritation of the mouth, nose and throat. Skin contact with dust and fibers may cause itching and short term irritation. Eye contact with dust and fibers may cause short term mechanical irritation. Ingestion may cause short term mechanical irritation of the stomach and intestines. See Section 8 for exposure controls.

CHRONIC (long term): There is no known health effects connected with long term use or contact with this product. See Section 11 of MSDS for more toxicological data.

Medical Conditions Aggravated by Exposure: Long term breathing or skin conditions that are aggravated by mechanical irritants may be at a higher risk for worsening from use or contact with this product.

Section 4: First Aid Measures

Inhalation: Move person to fresh air. Seek medical attention if irritation persists.

Eye Contact: Flush eyes with running water for at least 15 minutes. Seek medical attention if irritation persists.

Skin Contact: Wash with mild soap and running water. Use a washcloth to help remove fibers. To avoid more irritation, do not rub or scratch affected areas. Rubbing or scratching may force fibers into skin. Seek medical attention if irritation persists.

Ingestion: Ingestion of this material is unlikely. If it does occur, watch the person for several days to make sure that intestinal blockage does not occur.

Section 5: Fire Fighting Measures

Flash Point and Method: None

Flammability Limits (%): None.

Auto Ignition Temperature: Not Applicable.

Extinguishing Media: Water, foam, CO_2 or dry chemical.

Unusual Fire and Explosion Hazards: None known.

Fire Fighting Instructions: Use self contained breathing apparatus (SCBA) in a sustained fire.

Hazardous Combustion Products: Primary combustion products are carbon monoxide, carbon dioxide and water. Other undetermined compounds could be released in small quantities.

Section 6: Accidental Release Measures

Land Spill: Scoop up material and put into suitable container for disposal as a non-hazardous waste.

Water Spill: This material will sink and disperse along the bottom of waterways and ponds. It can not easily be removed after it is waterborne; however, the material is non-hazardous in water.

Air Release: This material will settle out of the air. If concentrated on land it can then be scooped up for disposal as a non-hazardous waste.

Section 7: Handling and Storage

Storage Temperature: Not applicable.

Storage Pressure: Not applicable.

General: No special storage or handling procedures are required for this material.

MATERIAL SAFETY DATA SHEET

Section 8: Exposure Controls and Personal Protection

Ingredient	OSHA PEL (8-hr TWA)	ACGIH TLV (8-hr TWA)
Fiber Glass Continuous Filament	5 mg/m^3 (respirable dust) 15 mg/m^3 (total dust 1 fiber/cc (proposed)	10 mg/m^3 (inhalable) 3 mg/m^3 (respirable)
Size	None Established	None Established
Polyester Yarn	5 mg/m^3 (respirable dust) 15 mg/m^3 (total dust	10 mg/m^3 (inhalable) 3 mg/m^3 (respirable)

Ventilation: General dilution ventilation and/or local exhaust ventilation should be provided as necessary to maintain exposures below regulatory limits.

Personal Protection:

Respiratory Protection: A properly fitted NIOSH/MSHA approved disposable dust respirator such as the 3M model 8210 (or 8710) or model 9900 (in high humidity environments) or equivalent should be used when: high dust levels are encountered; the level of glass fibers in the air exceeds the OSHA permissible limits; or if irritation occurs. Use respiratory protection in accordance with your company's respiratory protection program, local regulations and OSHA regulations under 29 CFR 1910.134.

Skin Protection: Loose fitting long sleeved shirt that covers to the base of the neck, long pants and gloves. Skin irritation is known to occur chiefly at pressure points such as around neck, wrist, waist and between fingers.

Eye Protection: Safety glasses or goggles.

Work and Hygienic Practices: Handle using good industrial hygiene and safety practices. Avoid unnecessary contact with dusts and fibers by using good local exhaust ventilation. Remove material from the skin and eyes after contact. Remove material from clothing using vacuum equipment (never use compressed air and always wash work clothes separately from other clothing. Wipe out the washer or sink to prevent loose glass fibers from getting on other clothing). Keep the work area clean of dusts and fibers made during fabrication by using vacuum equipment to clean up dusts and fibers (avoid sweeping or using compressed air as these techniques re-suspend dusts and fibers into the air.) Have access to safety showers and eye wash stations.

Section 9: Physical and Chemical Properties

Vapor Pressure (mm Hg @ 20^{o}C): Not Applicable

pH: Not Applicable

Vapor Density (Air=1): Not Applicable

Specific Gravity (Water=1): 2.60

Boiling Point: Not Applicable

Solubility in Water: Insoluble

Viscosity: Not Applicable

Appearance: Solid

Physical State: Solid

Odor Type: None

Freezing Point: Not Applicable

Evaporation Rate (n-Butyl Acetate=1): Not Applicable

Section 10: Stability and Reactivity

General: Stable

Incompatible Materials and Conditions to Avoid: None

Hazardous Decomposition Products: Sizings or binders may decompose in a fire. See Section 5 of MSDS for combustion products statement.

Hazardous Polymerization: Will not occur.

Section 11: Toxicological Information

CARCINOGENICITY: The table below indicates whether or not each agency has listed each ingredients as a carcinogen:

Ingredient	ACGIH	IARC	NTP	OSHA
Fiber Glass Continuous Filament	A4	3	No	No
Size	No	No	No	No
Polyester Yarn	No	No	No	No

	LD_{50} Oral (g/kg)	LD_{50} Dermal (g/kg)	LC_{50} Inhalation (ppm, 8 hrs.)
Fiber Glass Continuous Filament	Not Available	Not Available	Not Available
Size	Not Available	Not Available	Not Available
Polyester Yarn	Not Available	Not Available	Not Available

Fiber Glass Continuous Filament: The International Agency for Research on Cancer (IARC) in June, 1987, categorized fiber glass continuous filament as not classifiable with respect to human carcinogenicity (Group 3). The evidence from human as well as animal studies was evaluated by IARC as insufficient to classify fiber glass continuous filament as a possible, probable, or confirmed cancer causing material.

Section 12: Ecological Information

This material is not expected to cause harm to animals, plants or fish.

Section 13: Disposal Considerations

RCRA Hazard Class: Non-hazardous.

Section 14: Transport Information

DOT Shipping Names: Not regulated

Hazard Class or Division: None

Secondary: None

Identification No.: None

Packing Group: None

Label(s) required (if not excepted): None

Special Provisions: None

Packaging Exceptions: None

Non-bulk Packaging: None

Bulk packaging: None

EPA Hazardous Substances: None

RQ: None

Quantity Limitations: **Passenger Aircraft:** None
Cargo Aircraft: None

Marine Pollutants: None

Freight Description: None

Hazardous Material Shipping Description: None

Transportation of Dangerous Goods - Canada

Proper Shipping Name: Not Regulated

TDG Hazard Classification: (Primary): None **(Secondary):** None

IMO Classification: None

ICAO/IATA Classification: None

Product Identification Number: None

Packing Group: None

Control Temperature: None

Emergency Temperature: None

Schedule XII Quantity Restriction: None

Reportable Quantity for US Shipments: None

IATA Packing Instructions:

Passenger/Cargo: None
Cargo Only: None
Limited Quantity: None

Maximum Net Quantity per Package:

Passenger/Cargo: None
Cargo Only: None
Limited Quantity: None

Special Provisions: None

MATERIAL SAFETY DATA SHEET

Section 15: Regulatory Information

TSCA Status: Each ingredient is on the Inventory.

NSR Status (Canada): Each ingredient is on the DSL.

SARA Title III:

Hazard Categories:

Acute Health:	Yes
Chronic Health:	No
Fire Hazard:	No
Pressure Hazard:	No
Reactivity Hazard:	No

Reportable Ingredients:

Sec. 302/304:	None
Sec. 313:	None

California Proposition 65: No ingredient is listed.

Clean Air Act: No ingredient is listed.

WHMIS (Canada): **Status:** Not Controlled
WHMIS Classification(s): None

Section 16: Other Information

HMIS and NFPA Hazard Rating:

Category	HMIS	NFPA
Acute Health	1	1
Flammability	0	0
Reactivity	0	0

NFPA Unusual Hazards: None.
HMIS Personal Protection: To be supplied by user depending upon use.

Revision Summary: This is a new MSDS. (Reformatted 11/25/98)

MATERIAL SAFETY DATA SHEET

Prepared to U.S. OSHA, CMA, ANSI and Canadian WHMIS Standards .This Material Safety Data Sheet is offered pursuant to OSHA's Hazard Communication Standard (29 CFR 1910.1200). Other government regulations must be reviewed for applicability to these products.

WARNING: PRODUCT COMPONENTS PRESENT HEALTH AND SAFETY HAZARDS. READ AND UNDERSTAND THIS MATERIAL SAFETY DATA SHEET (M.S.DS.). ALSO, FOLLOW YOUR EMPLOYER'S SAFETY PRACTICES. This product may contain Chromium and/or Nickel which are listed by OSHA, NTP, or IARC as being a carcinogen or potential carcinogen. Use of this product may expose you or others to fumes and gases at levels exceeding those established by the American Conference of Governmental Industrial Hygienists (ACGIH) or the Occupational Safety and Health Administration (OSHA) The information contained herein relates only to the specific product. If the product is combined with other materials, all component properties must be considered. **BE SURE TO CONSULT THE LATEST VERSION OF THE MSDS. MATERIAL SAFETY DATA SHEETS ARE AVAILABLE FROM HARRIS PRODUCTS GROUP** salesinfo@jwharris.com 513-754-2000

www.harrisproductsgroup.com

STATEMENT OF LIABILITY-DISCLAIMER

To the best of the Harris Products Group knowledge, the information and recommendations contained in this publication are reliable and accurate as of the date prepared. However, accuracy, suitability, or completeness are not guaranteed, and no warranty, guarantee, or representation, expressed or implied, is made by Harris Products Group as to the absolute correctness or sufficiency of any representation contained in this and other publications; Harris Products Group. assumes no responsibility in connection therewith; nor can it be assumed that all acceptable safety measures are contained in this and other publications, or that other or additional measures may not be required under particular or exceptional conditions or circumstances . Data may be changed from time to time.

PART I *What is the material and what do I need to know in an emergency?*

1. PRODUCT IDENTIFICATION

TRADE NAME (AS LABELED): **LEAD SOLDER**
CHEMICAL NAME/CLASS: Metal Alloy
SYNONYMS: Not Applicable
PRODUCT USE: Soldering
DOCUMENT NUMBER: 0126
SUPPLIER/MANUFACTURER'S NAME: **HARRIS PRODUCTS GROUP**
ADDRESS: 4501 Quality Place, Mason, Ohio 45040
EMERGENCY PHONE: CHEMTREC: 1-800-424-9300
BUSINESS PHONE: 513-754-2000 **FAX** 513-754-8778
DATE OF PREPARATION: July 12, 2007 **REVIEWED** October 22, 2004

2. COMPOSITION and INFORMATION ON INGREDIENTS

NOMINAL COMPOSITION WEIGHT % Wire							
TRADE NAME	**30/70**	**40/60**	**50/50**	**60/40**	**63/37**	**70/30**	**90/10**
Tin (Sn)	30%	40%	50%	60%	63%	70%	90%
Lead (Pb)	70%	60%	50%	40%	37%	30%	10%

NOMINAL COMPOSITION WEIGHT % Flux Core				
TRADE NAME	**Activated Rosin CAS # 8050-09-7**	**Ammonium Chloride CAS #**	**Zinc Chloride CAS # 7646-85-7**	**Water CAS #**
ACID CORE		< 20%	< 70%	Balance
ROSIN CORE	100%			

2. COMPOSITION and INFORMATION ON INGREDIENTS (Continued)

CHEMICAL NAME	CAS #	% w/w	EXPOSURE LIMITS IN AIR					
			ACGIH-TLV		OSHA-PEL		NIOSH	OTHER
			TWA mg/m^3	STEL mg/m^3	TWA mg/m^3	STEL mg/m^3	IDLH mg/m^3	mg/m^3
Activated Rosin Exposure limits are for Rosin Core Solder Decomposition Products, as resin-acids-colophony	8050-09-7	See Table Previous Page	Sensitizer; reduce exposure to as low as possible	NE	NE	NE	NE	DFG MAK: TWA = Danger of sensitization of the skin.
Ammonium Chloride Exposure limits are for Ammonium Chloride, fume	12125-02-9	See Table Previous Page	10	20	10 (Vacated 1989 PEL)	20 (Vacated 1989 PEL)	NE	NIOSH REL: TWA = 10 STEL = 20
Lead Exposure limits are for Lead, elemental & inorganic compounds, as Pb	7439-92-1	See Table Previous Page	0.05 , A4 (Not Classifiable as a Human Carcinogen)	NE	0.05 (see 29 CFR 1910.1025)	NE	100	NIOSH RELs: TWA = < 0.1 (blood Pb < 0.060 mg/100 g whole blood) DFG MAKs: TWA = 0.1 (Inhalable Fraction) PEAK = 10•MAK 30 min., average value DFG MAK Pregnancy Risk Classification: B Carcinogen: EPA-B2, IARC-2B, TLV-A3
Tin Exposure limits are for Tin, Metal	7440-31-5	See Table Previous Page	2	NE	2	NE	100	NE
Zinc Chloride Exposure limits are for Zinc Chloride, fume	7646-85-7	See Table Previous Page	1	2	1	2 (Vacated 1989 PEL)	50	NIOSH RELs: TWA = 1 STEL = 2 Carcinogen: EPA-D

NE = Not Established. See Section 16 for Definitions of Terms Used.

NOTE (1): The ACGIH has an established exposure limit for Welding Fumes, Not Otherwise Classified. The Threshold Limit Value is 5 mg/m^3. NIOSH classifies welding fumes as carcinogens. Single values shown are maximum, unless otherwise noted.

NOTE (2): ALL WHMIS required information is included in appropriate sections based on the ANSI Z400.1-1998 format. These products have been classified in accordance with the hazard criteria of the CPR and the MSDS contains all the information required by the CPR.

3. HAZARD IDENTIFICATION

EMERGENCY OVERVIEW: These products consist of odorless, lead/tin alloy wires, which have a metallic luster and may have a flux core. There are no immediate health hazards associated with these products, as wires. When heated during soldering operations, these products may generate irritating and toxic fumes of lead oxide, tin oxides, hydrogen chloride, zinc oxides, and ammonium compounds. There is a danger of cumulative effects if fumes or dusts from these products are inhaled or ingested. Contact with the rosin core of these wires can result in allergic reaction and sensitization to the skin in susceptible persons. These products are not reactive. If involved in a fire, these products may generate irritating fumes and a variety of metal oxides, as described above. Finely divided dusts of these products may result in explosive air/dust mixtures. Emergency responders must wear personal protective equipment suitable for the situation to which they are responding.

SYMPTOMS OF OVER-EXPOSURE BY ROUTE OF EXPOSURE: During soldering operations, the most significant route of over-exposure is via inhalation of fumes.

INHALATION: Inhalation of large amounts of particulates generated by these products during soldering operations may be physically irritating and cause deposits of dust in nasal passages. Due to the presence of lead, inhalation of fumes or dusts from these products can result in lead poisoning. Symptoms of poisoning include headache, fatigue, nausea, metallic taste in the mouth, abdominal cramps, joint pain, metallic taste in the mouth, vomiting, constipation, bloody diarrhea, and harmful effects on the central nervous system. Exposure to lead can cause significant cumulative toxic effects, effects on the reproductive system and may cause cancer. See information under “Other Health Effects” for additional information. When heated to decomposition, the rosin core of some of these products can include toxic compounds, including formaldehyde, acetaldehyde, or malonaldehyde. Inhalation of these fumes can result in irritation to the respiratory system.

3. HAZARD IDENTIFICATION (Continued)

INHALATION (continued): Exposure to dust or fumes of the Tin components is known to cause a benign pneumoconiosis (stannosis). This form of pneumoconiosis produces distinctive progressive x-ray changes of the lung as long as exposure persists, but there is no distinctive fibrosis, no evidence of disability, and no special complicating factors. In addition, inhalation of large amounts of dusts or fumes of these products, can cause metal fume fever. Symptoms of metal fume fever include flu-like symptoms, metallic taste, fever, sweating, chills, cough, weakness, chest pain, muscle pain, cardiac abnormalities, and increased white blood cell count. Damage to lungs can occur. Symptoms of metal fume fever can be delayed 24-48 hours. Refer to Section 10 (Stability and Reactivity) for information on the specific composition of soldering fumes and gases. There is some evidence that inhalation of fumes from the Ammonium Chloride component of these products may cause respiratory sensitization in susceptible individuals. Symptoms may include difficulty breathing, persistent coughing and wheezing.

FOR WIRES

HAZARDOUS MATERIAL IDENTIFICATION SYSTEM

HEALTH		(BLUE)	0
FLAMMABILITY		(RED)	0
REACTIVITY		(YELLOW)	0
PROTECTIVE EQUIPMENT			X
EYES	RESPIRATORY	HANDS	BODY
	See Section 8		See Section 8

For routine industrial applications for the rods

See Section 16 for Definition of Ratings

FOR FUMES OR DUSTS

HAZARDOUS MATERIAL IDENTIFICATION SYSTEM

HEALTH		(BLUE)	3
FLAMMABILITY		(RED)	0
REACTIVITY		(YELLOW)	0
PROTECTIVE EQUIPMENT			X
EYES	RESPIRATORY	HANDS	BODY
	See Section 8		See Section 8

For routine industrial applications for the rods

See Section 16 for Definition of Ratings

CONTACT WITH SKIN or EYES: Contact of the wire form of these products with the skin is not anticipated to be irritating. Contact with the wire form of these products can be physically damaging to the eye. Fumes generated during soldering operations can be irritating to the skin and eyes. Symptoms of skin over-exposure may include irritation and redness; prolonged or repeated skin over-exposures may lead to dermatitis. Contact with the rosin core can result in allergic reaction and skin sensitization in susceptible individuals. Symptoms could include dermatitis, itching and persistent rash. Contact with the molten core or wire will burn contaminated skin or eyes.

SKIN ABSORPTION: Skin absorption is not known to be a significant route of over-exposure for any component of these products.

INGESTION: Ingestion is not anticipated to be a route of occupational exposure for these products; however, if proper hygiene (e.g. washing of hands) is not followed during handling and use of these products, ingestion of lead from contamination of the hands can occur, resulting is Lead poisoning.

INJECTION: Though not a likely route of occupational exposure for these products, injection (via punctures or lacerations in the skin) may cause local reddening, tissue swelling, and discomfort.

OTHER HEALTH EFFECTS: Due to the presence of Lead in these products, exposure to dusts or fumes may result in significant adverse acute and chronic health effects, as follows. Long-term, low-level lead exposure has resulted in harm to the central nervous system and brain function. Symptoms of chronic, low to moderate levels include forgetfulness, irritability, tiredness, headache, fatigue, impotence, decreased libido, dizziness, altered mood states and depression.

(continued on following page)

OTHER HEALTH EFFECTS (continued): Symptoms of chronic exposure to moderate to high lead levels include disturbances in hand to eye coordination, reaction times, visual motor performance, mental performance, gradual decrease in visual acuity with slow recovery or possible blindness, changes in hearing ability, and in worse cases, encephalopathy (a progressive degeneration of the brain and its functions). Early symptoms of encephalopathy include dullness, irritability, poor attention span, muscular tremor, headache, and loss of memory and hallucinations. Severe, chronic exposure to Lead at high concentration can result in symptoms on the central nervous system, including delirium, lack of coordination, convulsions, paralysis, coma and death.

Exposure to Lead can also result in significant adverse results on the peripheral nervous system, including harm to nerves in hands, legs and feet. These effects can be reversible if exposure is short term (5 months or less) and treatment is received; if not, these effects can become permanent. A syndrome known as "Lead Palsy" can occur, with symptoms such as weakness of legs or arms, weakness and paralysis of the wrist, fingers and ankles. At lower exposure levels decreased hand dexterity has been reported. At higher exposure levels an ability to hold the foot or hand in extended position can occur.

Exposure to Lead can also cause adverse effects on the gastrointestinal system, including loss of appetite, inflammation of the stomach walls (gastritis), colic, severe abdominal pain, cramps, nausea, vomiting, constipation, anorexia, weight loss and decreased urination. In severe cases of Lead poisoning, a deposit of Lead occurs in the gums near the base of the teeth, resulting in a visible blue-gray line. Reversible kidney injury has been observed in some cases of workers exposed to Lead at chronic, low to moderate levels. Death due to kidney failure has occurred to workers chronically exposed to Lead at moderate levels.

Exposure to Lead can cause harmful effects to certain types of blood cells, including reduced hemoglobin production and reduced life-span and function of red blood cells. This harm can cause anemia in workers exposed to moderate levels. Low, moderate and high level exposure to Lead may increase blood pressure, especially in men. Some studies have indicated that moderate exposure to Lead can result in electrocardiographic abnormalities. There is some evidence that low-level exposure to Lead can cause harmful effects on the thyroid and immune systems, including possible susceptibility to colds and flu infections.

Exposure to Lead, especially at high levels, has resulted in significant adverse effects in the reproductive systems of both men and women. Refer to Section 11 (Toxicological Information, Reproductive Toxicity Information) for additional information.

HEALTH EFFECTS OR RISKS FROM EXPOSURE: An Explanation in Lay Terms. Symptoms associated with over-exposure to these products and the fumes generated during soldering operations are as follows:

ACUTE: Inhalation of large amounts of particulates generated by these products during metal processing operations may be physically irritating and cause deposits of dust in nasal passages. Inhalation of dusts and fumes of these products can cause metal fume fever or irritation of the respiratory system. Contact with the molten material will burn contaminated skin or eyes. Significant adverse effects on the blood, kidneys, gastrointestinal system, central and peripheral nervous systems.

CHRONIC: Chronic skin over-exposure to the fumes of these products during soldering operations may produce dermatitis (red, inflamed skin). Repeated or prolonged over-exposures, via inhalation, to the dusts generated by these products may cause pulmonary fibrosis (scarring of lung tissue). Chronic inhalation of fumes or dusts of the components of these products, can result in severe, adverse effects on the blood and heart, kidneys, thyroid and immune systems, and central and periphery nervous system, due to the presence of Lead. Contact with the rosin core of some of these products can cause an allergic skin reaction and sensitization in susceptible individuals. Due to the presence of the Ammonium Chloride compound in the flux core of some of these products, inhalation of fumes from soldering may cause allergic respiratory reaction and respiratory sensitization in susceptible individuals. Due to the Lead component in these products, contact may result in significant adverse effects on the reproductive system. See Section 11 (Toxicological Information) for additional information.

TARGET ORGANS: For fumes: ACUTE: Skin, eyes, respiratory system, blood system, central nervous system, peripheral nervous system, gastrointestinal system. CHRONIC: Skin, central nervous system, kidneys, heart, blood, central nervous system, thyroid, immune system, reproductive system.

PART II *What should I do if a hazardous situation occurs?*

4. FIRST-AID MEASURES

Victims of chemical exposure must be taken for medical attention. Rescuers should be taken for medical attention, if necessary. Take a copy of label and MSDS to health professional with victim.

SKIN EXPOSURE: If fumes generated by soldering operations involving these products contaminate the skin, begin decontamination with running water. If molten material contaminates the skin, immediately begin decontamination with cold, running water. Minimum flushing is for 15 minutes. Victim must seek medical attention if any adverse reaction occurs.

4. FIRST-AID MEASURES (Continued)

EYE EXPOSURE: If fumes generated by soldering operations involving these products enter the eyes, open victim's eyes while under gently running water. Use sufficient force to open eyelids. Have victim "roll" eyes. Minimum flushing is for 15 minutes. Victim must seek immediate medical attention.

INHALATION: If fumes generated by soldering operations involving these products are inhaled, remove victim to fresh air. If necessary, use artificial respiration to support vital functions.

INGESTION: If swallowed call physician immediately! Do not induce vomiting unless directed by medical personnel. Rinse mouth with water if person is conscious. Never give fluids or induce vomiting if person is unconscious, having convulsions, or not breathing.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: Skin, respiratory, blood, central nervous system and peripheral system, and kidney disorders, may be aggravated by prolonged over-exposures to the dusts or fumes generated by these products.

RECOMMENDATIONS TO PHYSICIANS: Basic Treatment: Establish a patent airway. Suction if necessary. Watch for signs of respiratory insufficiency and assist ventilations if necessary. Administer oxygen by non-rebreather mask at 10 to 15 L/minutes. Monitor for shock and treat if necessary. Anticipate seizures and treat if necessary. For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with normal saline during transport. Do not use emetics. For ingestion, rinse mouth and administer 5 mL/kg up to 200 mL of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. Administer activated charcoal.

Advanced Treatment: Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious. Use hyperventilation to help control increased intracranial pressure. Start an IV with lactated Ringer's to support vital signs. For hypotension with signs of hypovolemia, administer fluid cautiously. Watch for signs of fluid overload. Treat seizures with diazepam (Valium). Use proparacaine hydrochloride to assist eye irrigation. The treatment of lead poisoning is based on the prompt termination of exposure and on the use of chelating agents. The first requirement is categorical. The second is determined by the severity of poisoning; at present, the greatest issue is whether a symptomatic patients should be treated or not. The most commonly used therapeutic chelating agents are CaEDTA, BAL, and D-penicillamine can be given. DMSA should also be considered.

5. FIRE-FIGHTING MEASURES

FLASH POINT: Not flammable.

AUTOIGNITION TEMPERATURE: Not applicable for products. Dust clouds of Lead, a possible main component of these products, have a minimum ignition temperature range of 270-790°C (518-1454°F).

FLAMMABLE LIMITS (in air by volume, %):

Lower (LEL): Not applicable.
Upper (UEL): Not applicable.

FIRE EXTINGUISHING MATERIALS: These products are not flammable; use fire-extinguishing agents appropriate for surrounding materials.

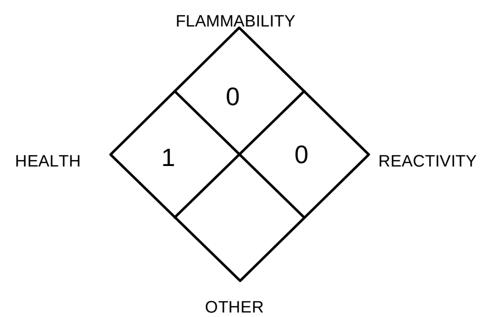
Water Spray: YES	Carbon Dioxide: YES
Halon: YES	Foam: YES
Dry Chemical: YES	Other: Any "ABC" Class

UNUSUAL FIRE AND EXPLOSION HAZARDS When involved in a fire, these products may decompose and produce lead oxide, tin oxides, hydrogen chloride, zinc oxides, and ammonium compounds. The hot material can present a significant thermal hazard to firefighters.

Explosion Sensitivity to Mechanical Impact: Not sensitive.

Explosion Sensitivity to Static Discharge: Although these products are not sensitive to static discharge, dusts of these products can form explosive air/dust mixtures and can be ignited by static discharge.

NFPA RATING



See Section 16 for Definition of Ratings

SPECIAL FIRE-FIGHTING PROCEDURES: Lead and its decomposition products are hazardous to health. Fire-fighters should not enter an area in which a fire involves these products without wearing specialized protective equipment suitable for potential Lead exposure. Normal fire-fighter bunker gear is not adequate to protect against exposure to Lead and its decomposition products. A full-body, encapsulating chemical resistant suit with positive-pressure Self-Contained Breathing Apparatus may be necessary.

6. ACCIDENTAL RELEASE MEASURES

SPILL AND LEAK RESPONSE: Not applicable.

7. HANDLING and STORAGE

WORK PRACTICES AND HYGIENE PRACTICES: As with all chemicals, avoid getting these products ON YOU or IN YOU. Wash thoroughly after handling these products. Do not eat or drink while handling these products. Use ventilation and other engineering controls to minimize potential exposure to these products. If dusts or fumes of these products are present, use of a suitable NIOSH approved respirator must commence immediately to protect against possible Lead poisoning. Unprotected workers must avoid all contact with these products.

STORAGE AND HANDLING PRACTICES: All employees who handle these products should be trained to handle it safely, following the requirements of the OSHA Lead Standard (29 CFR 1910.1025). Use in clearly posted areas(s) indicating Lead hazard. Access doors must remain closed while these products are being used or stored. When handling Lead powder on a large scale, closed-handling systems for processes should be used. If this is not possible, use in the smallest possible amounts in appropriate labeled, containment devices (e.g. fume hood). Containment devices should be made of smooth, unbreakable compatible material. Maintain containment devices at appropriate air-flow and negative pressure. Check regularly. Use in a well-ventilated location. Avoid the generation of dusts and prevent the release of fumes to the workplace. Avoid breathing fumes of these products generated during soldering operations. Open containers on a stable surface. Cover surfaces in which these products are being used with compatible, chemical resistant and/or disposable material for easier containment and clean-up. Good housekeeping is very important. Keep work areas clean. Packages of these products must be properly labeled. When these products are used during soldering operations, follow the requirements of the Federal Occupational Safety and Health Welding and Cutting Standard (29 CFR 1910 Subpart Q) and the safety standards of the American National Standards Institute for welding and cutting (ANSI Z49.1). Store packages in a cool, dry location. Store away from incompatible materials (see Section 10, Stability and Reactivity).

PROTECTIVE PRACTICES DURING MAINTENANCE OF CONTAMINATED EQUIPMENT: Not applicable.

8. EXPOSURE CONTROLS - PERSONAL PROTECTION

VENTILATION AND ENGINEERING CONTROLS: As per the OSHA Lead Standard, 29 CFR 1910.1025, the employer shall assure that no employee is exposed to Lead at concentrations greater than 50 μg/cubic meter averaged over an 8-hour period. If an employee is exposed to Lead for more than 8 hours in any work day, the permissible exposure limit, as a TWA for that day, shall be reduced according to the following formula: Maximum permissible limit (in μg/cubic meter) = 400 divided by the number of hours worked in the day. Use with adequate ventilation to ensure exposure levels are maintained below these limits and the limits for Lead and other components of these products provided in Section 2 (Composition and Information on Ingredients). Prudent practice is to ensure eyewash/safety shower stations are available near areas where these products are used.

RESPIRATORY PROTECTION: Maintain airborne contaminant concentrations below guidelines listed in Section 2 (Composition and Information on Ingredients). If respiratory protection is needed (i.e. a Weld Fume Respirator, or Air-Line Respirator for welding in confined spaces), U.S. Federal OSHA Standard (29 CFR 1910.134), applicable U.S. State regulations, or the Canadian CSA Standard Z94.4-93 and applicable standards of Canadian Provinces. Respiratory Protection is recommended to be worn during welding operations. Oxygen levels below 19.5% are considered IDLH by OSHA. In such atmospheres, use of a full-facepiece pressure/demand SCBA or a full facepiece, supplied air respirator with auxiliary self-contained air supply is required under OSHA's Respiratory Protection Standard (1910.134-1998). The following are NIOSH recommendations for respirator selection for Ammonium Chloride, Lead, Welding fumes, Rosin Core, Pyrolysis Products, Tin and Zinc Chloride, and are provided for additional information:

LEAD

CONCENTRATION	**RESPIRATORY PROTECTION**
Up to 0.5 mg/m^3:	Any Air-Purifying Respirator with a high-efficiency particulate filter, or any Supplied-Air Respirator (SAR).
Up to 1.25 mg/m^3:	Any SAR operated in a continuous-flow mode, or any powered, air-purifying respirator with a high-efficiency particulate filter.
Up to 2.5 mg/m^3:	Any Air-Purifying, Full-Facepiece Respirator with a high-efficiency particulate filter, or any SAR that has a tight-fitting facepiece and is operated in a continuous-flow mode, or any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter, or any Self-Contained Breathing Apparatus (SCBA) with a full facepiece, or any SAR with a full facepiece.
Up to 50 mg/m^3:	Any SAR operated in a pressure-demand or other positive-pressure mode.
Up to 100 mg/m^3:	Any SAR that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.

(continued on following page)

RESPIRATORY PROTECTION (continued): NIOSH recommendations for respiratory protection, continued.

LEAD CONCENTRATION **RESPIRATORY PROTECTION (continued):**

Emergency or Planned Entry into Unknown Concentrations or IDLH Conditions: Any SCBA that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode, or any SAR that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary SCBA operated in pressure-demand or other positive-pressure mode.

Escape: Any Air-Purifying, Full-Facepiece Respirator with a high-efficiency particulate filter, or any appropriate escape-type, SCBA.

ROSIN FLUX PYROLYSIS PRODUCTS

CONCENTRATION **RESPIRATORY PROTECTION**

At Concentrations above the NIOSH REL, or where there is no REL, at any Detectable Concentration: Any Self-Contained Breathing Apparatus (SCBA) that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode, or any Supplied-Air Respirator (SAR) that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary SCBA operated in pressure-demand or other positive-pressure mode.

Escape: Any Air-Purifying, Full-Facepiece Respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister having a high-efficiency particulate filter, or any appropriate escape-type, SCBA.

TIN CONCENTRATION **RESPIRATORY PROTECTION**

Up to 10 mg/m^3: Any dust and mist respirator.

Up to 20 mg/m^3: Any dust and mist respirator except single-use and quarter-mask respirators, IF NOT present as a fume, or any Supplied-air Respirator (SAR).

Up to mg/m^3: Any SAR operated in a continuous-flow mode, or any Powered, Air-Purifying Respirator with a dust and mist filter, IF NOT present as a fume.

Up to 100 mg/m^3: Any Air-Purifying, Full-Facepiece Respirator with a high-efficiency particulate filter, or any Self-Contained Breathing Apparatus (SCBA) with a full facepiece, or any SAR with a full facepiece.

Emergency or Planned Entry into Unknown Concentrations or IDLH Conditions: Any SCBA that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode, or any SAR that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary SCBA operated in pressure-demand or other positive-pressure mode.

Escape: Any Air-Purifying, Full-Facepiece Respirator with a high-efficiency particulate filter, or any appropriate escape-type, SCBA

WELDING FUMES

CONCENTRATION **RESPIRATORY EQUIPMENT FOR WELDING FUMES**

At Concentrations above the NIOSH REL, or where there is no REL, at any Detectable Concentration: Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode; or any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.

Escape: Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister having a high-efficiency particulate filter; or any appropriate escape-type, self-contained breathing apparatus

NOTE: IDLH Concentration: Potential NIOSH carcinogen. [Not determined yet].

ZINC CHLORIDE

CONCENTRATION **RESPIRATORY PROTECTION**

Up to 10 mg/m^3: Any dust, mist, and fume respirator, or any Supplied-Air Respirator (SAR).

Up to 25 mg/m^3: Any SAR operated in a continuous-flow mode, or any Powered, Air-Purifying Respirator (PAPR) with a dust, mist, and fume filter.

Up to 50 mg/m^3: Any Air-Purifying, Full-Facepiece Respirator with a high-efficiency particulate filter, or any PAPR with a tight-fitting facepiece and a high-efficiency particulate filter, or any Self-Contained Breathing Apparatus (SCBA) with a full facepiece, or any SAR with a full facepiece.

Emergency or Planned Entry into Unknown Concentrations or IDLH Conditions: Any SCBA that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode, or any SAR that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary SCBA operated in pressure-demand or other positive-pressure mode.

Escape: Any Air-Purifying, Full-Facepiece Respirator with a high-efficiency particulate filter, or any appropriate escape-type, SCBA.

8. EXPOSURE CONTROLS - PERSONAL PROTECTION (Continued)

EYE PROTECTION: Safety glasses. When these products are used in conjunction with soldering, wear safety glasses, goggles, or face-shield with filter lens of appropriate shade number (per ANSI Z49.1-1988, "Safety in Welding and Cutting") and U.S. OSHA 29 CFR 1910.133 and appropriate Canadian Standards.

HAND PROTECTION: Wear gloves for routine industrial use. When these products are used in conjunction with soldering, wear gloves that protect from sparks and flame (per ANSI Z49.1-1988, "Safety in Welding and Cutting"). If necessary, refer to U.S. OSHA 29 CFR 1910.138 and appropriate Standards of Canada.

BODY PROTECTION: Use body protection appropriate for task. If a hazard of injury to the feet exists due to falling objects, rolling objects, where objects may pierce the soles of the feet or where employee's feet may be exposed to electrical hazards, as described in U.S. OSHA 29 CFR 1910.136.

9. PHYSICAL and CHEMICAL PROPERTIES

The following information is for Lead, a possible main component:

RELATIVE VAPOR DENSITY (air = 1): Not applicable.
EVAPORATION RATE (nBuAc = 1): Not applicable.
SPECIFIC GRAVITY @ 20°C (water = 1): 11.34
FREEZING/MELTING POINT: 327.4°C (621.36°F)
SOLUBILITY IN WATER: Insoluble.
pH: Not applicable.
VAPOR PRESSURE, mm Hg @ 980°C: 1
BOILING POINT: 1740°C (3164°F)
ODOR THRESHOLD: Not applicable.
VAPOR DENSITY (air = 1): 7.14
COEFFICIENT OF OIL/WATER DISTRIBUTION (PARTITION COEFFICIENT): Not applicable.

The following information is for Tin, a possible main component:

RELATIVE VAPOR DENSITY (air = 1): Not applicable.
EVAPORATION RATE (nBuAc = 1): Not applicable.
SPECIFIC GRAVITY @ 20°C (water = 1): 7.28
FREEZING/MELTING POINT: 232°C (4506°F)
SOLUBILITY IN WATER: Insoluble.
pH: Not applicable.
VAPOR PRESSURE, mm Hg @ 1492°C: 0
BOILING POINT: 2270°C (4118°F)
ODOR THRESHOLD: Not applicable.
VAPOR DENSITY (air = 1): Not applicable.
COEFFICIENT OF OIL/WATER DISTRIBUTION (PARTITION COEFFICIENT): Not applicable.

The following information is for the products:

APPEARANCE AND COLOR: These odorless products consist of tin/lead alloy with a metallic lust and may have a flux core.

10. STABILITY and REACTIVITY

STABILITY: Normally stable. These products can oxidize rapidly to form an insoluble layer of basic lead carbonate.
DECOMPOSITION PRODUCTS: Lead oxide, tin oxides, hydrogen chloride, zinc oxides, and ammonium compounds.
NOTE: The composition and quality of soldering fumes and gases are dependent upon the metal being soldered, the process, the procedure, and the alloys used. Other conditions that could also influence the composition and quantity of fumes and gases to which workers may be exposed include the following: any coatings on metal being welded (e.g. paint, plating, or galvanizing), the number of work stations and the volume of the work area, the quality of ventilation, the position of the work stations with respect to the fume plume, and the presence of other contaminates in the atmosphere. When the alloy is consumed, the fume and gas decomposition products generated are different in percent and form from the ingredients listed in Section 2 (Composition and Information on Ingredients). Fume and gas decomposition products, and not the ingredients in the solders, are important. Concentration of the given fume or gas component may decrease or increase by many times the original concentration. New compounds may form. Decomposition products of normal operations include not only those originating from volatilization, reaction, or oxidation of the product's components but also those from base metals and any coating (as noted previously). The best method to determine the actual composition of generated fumes and gases is to take an air sample from the breathing zone. For additional information, refer to the American Welding Society Publication, "Fumes and Gases in the Welding Environment".
MATERIALS WITH THESE PRODUCTS ARE INCOMPATIBLE: These products will be attacked or can react with strong acids, strong bases, hydrogen peroxide (52% or greater- in presence of manganese dioxide), sodium azide, ammonium nitrate, sodium acetylides, sodium carbide, zirconium, or chlorine trifluoride. The flux or rosin core of these products are incompatible with potassium, strong acids, alkalis, interhalogens, strong oxidizers, ammonium nitrate, hydrogen cyanide, potassium chlorate and lead salts (not lead metal) and silver salts.
HAZARDOUS POLYMERIZATION: Will not occur.
CONDITIONS TO AVOID: Avoid uncontrolled exposure to extreme temperatures and incompatible materials.

PART IV *Is there any other useful information about this material?*

11. TOXICOLOGICAL INFORMATION

TOXICITY DATA: Presented below are human toxicological data available for the components of these products present in concentration greater than 1%. Other data for animals are available for the components of these products, but are not presented in this Material Safety Data Sheet.

LEAD:
Cytogenetic Analysis-Human-Unreported 50 μg/m
TCLo (Inhalation-Human) 10 μg/m^3: Gastrointestinal tract effects: LIV
TDLo (Oral-Woman) 450 mg/kg/6 years: Peripheral nervous system effects: Central nervous system effects

ZINC CHLORIDE:
TCLo (Inhalation-Man) 4800 mg/m^3/30 minutes: Pulmonary system effects
TCLo (Inhalation-Human) 4800 mg/m^3/3 hours
LCLo (inhalation, human) = 300 μg/m^3/ 10 years/ intermittent; systemic effects

ZINC CHLORIDE (continued):
TDLo (Oral-Child) 169 mg/kg: Lungs, Thorax, or Respiration: dyspnea; Blood: changes in serum composition (e.g. TP, bilirubin, cholesterol); Skin and Appendages: dermatitis, other (after systemic exposure)

SUSPECTED CANCER AGENT: The components of these products are listed as follows:

LEAD: ACGIH TLV-A3 (Confirmed Animal Carcinogen), EPA-B2 (Probable Human Carcinogen - Sufficient Evidence from Animal Studies; inadequate evidence or no data from epidemiologic studies); IARC-2B (Possibly Carcinogenic to Humans)

ZINC CHLORIDE: EPA-D [dusts & mists] (Not Classifiable as to Human Carcinogenicity)

The other components of these products are not found on the following lists: FEDERAL OSHA Z LIST, NTP, IARC, and CAL/OSHA and therefore are not considered to be, nor suspected to be, cancer-causing agents by these agencies.

IRRITANCY OF PRODUCT: Dusts or fumes of these products may be irritating to contaminated skin and eyes. Fumes may be irritating to the respiratory system.

SENSITIZATION TO THE PRODUCT: There is some evidence that inhalation of fumes from the Ammonium Chloride component of some of these products may cause respiratory sensitization in susceptible individuals. Symptoms may include difficulty breathing, persistent coughing and wheezing. Contact with the rosin core can result in allergic reaction and skin sensitization in susceptible individuals.

REPRODUCTIVE TOXICITY INFORMATION: Listed below is information concerning the effects of these products and their components on the human reproductive system.

Mutagenicity: These products are not reported to produce mutagenic effects in humans. Cytogenic analysis studies of human cells (cell type and duration of exposure unreported) have produced positive results at a level of 50 μg/mL. In *vitro* assays of human lymphocytes indicate that the Zinc Chloride may cause chromosomal aberrations. In animal studies, positive mutagenic results (chromosome aberrations) have been reported in rats, mice and monkeys exposed orally to the Lead component of these products. Positive results were obtained in chromosomal aberrations tests involving the Ammonium Chloride component of these products using cultured Chinese hamster fibroblast cells, with no metabolic agitation.

Embryotoxicity These products are not reported to produce embryotoxic effects in humans. There is evidence that high Lead levels in human mother's blood can significantly increase the risk of spontaneous abortions. The Lead, and Zinc Chloride components of these products have produced embryotoxic effects in animal studies.

Teratogenicity: These products are not reported to cause teratogenic effects in humans. Lead has an adverse effect on human fetuses, particularly in the later stages of development. Distribution of lead in fetal tissues was examined in a case in which a woman was exposed during pregnancy. The female worker was exposed to lead dust for 8 hours daily when conception occurred. Measurements of Lead content were started after the end of the exposure and continued for 6 months until normal values were obtained. Because of half-life of nearly 20 days for lead elimination from blood, the estimated body burden at the end of exposure was about 1200 ppb. The fetal tissue samples contained between 0.4 (brain) and 7.9 (liver) μg Pb/grams dry weight. The fetal lead was stored mainly in bone, blood, and liver. The Lead component of this product has produced teratogenic effects in animal studies.

Reproductive Toxicity: These products are not reported to cause reproductive effects in humans; however, the Lead component of this product has produced embryotoxic effects in humans. There is convincing evidence that Lead is transferred to neonates via maternal milk. It appears that maternal milk might be a source of Lead for the neonates, particularly when metal levels are elevated in the mother. Chronic exposure to Lead in human males has been found to produce infertility, germinal epithelium damage, oligospermia and testicular degeneration, decreased sperm motility, and prostatic hyperplasia. The Lead component of this product has produced reproductive effects in animal studies. Injections of the Zinc Chloride component of these products has produced testicular tumors in animal tests.

A mutagen is a chemical, which causes permanent changes to genetic material (DNA) such that the changes will propagate through generational lines. An embryotoxin is a chemical, which causes damage to a developing embryo (i.e., within the first eight weeks of pregnancy in humans), but the damage does not propagate across generational lines. A teratogen is a chemical, which causes damage to a developing fetus, but the damage does not propagate across generational lines. A reproductive toxin is any substance, which interferes in any way with the reproductive process.

11. TOXICOLOGICAL INFORMATION (Continued)

BIOLOGICAL EXPOSURE INDICES: The following BEIs are applicable to the Lead component of these products.

CHEMICAL DETERMINANT	SAMPLING TIME	BEI
LEAD • Lead in blood Note: Women of child-bearing potential, whose blood Pb exceeds10μg/dl, are at risk of delivering a child with a blood Pb over the current Centers for Disease control guideline of 10μg/dl. If the blood Pb of such children remains elevated, they may be at increased risk of cognitive deficits. The blood Pb of these children should be closely monitored and appropriate steps should be taken to minimize the child's exposure to environmental Lead.	• Not Critical	• 30 μg/100 mL

12. ECOLOGICAL INFORMATION

ALL WORK PRACTICES MUST BE AIMED AT ELIMINATING ENVIRONMENTAL CONTAMINATION.

ENVIRONMENTAL STABILITY: Components of these products will react with water and air to form a variety of stable metal oxides.

EFFECT OF MATERIAL ON PLANTS or ANIMALS: Due to the Lead component, adverse effect may occur to animals which come into contact with these products. No data is available on the components of these products and plants

EFFECT OF CHEMICAL ON AQUATIC LIFE: Due to the Lead component of these products, a release of product to an aquatic environment may have a significant adverse effect.

13. DISPOSAL CONSIDERATIONS

PREPARING WASTES FOR DISPOSAL: Waste disposal must be in accordance with appropriate Federal, State, and local regulations. These products, if unaltered by use, may be disposed of by treatment at a permitted facility or as advised by your local hazardous waste regulatory authority.

EPA WASTE NUMBER: Wastes of these products should be tested per the Toxicity Characteristic Leaching Procedures requirements of RCRA to determine if such wastes meet the following characteristics: D008 (Lead).

14. TRANSPORTATION INFORMATION

THESE PRODUCTS ARE NOT HAZARDOUS (Per 49 CFR 172.101) BY THE U.S. DEPARTMENT OF TRANSPORTATION.

PROPER SHIPPING NAME: Not applicable.
HAZARD CLASS NUMBER and DESCRIPTION: Not applicable.
UN IDENTIFICATION NUMBER: Not applicable.
PACKING GROUP: Not applicable.
DOT LABEL(S) REQUIRED: Not applicable.
NORTH AMERICAN EMERGENCY RESPONSE GUIDEBOOK NUMBER, 2000: Not applicable.
MARINE POLLUTANT: No component of these products is designated as a marine pollutant by the Department of Transportation (49 CFR 172.101, Appendix B).

TRANSPORT CANADA TRANSPORTATION OF DANGEROUS GOODS REGULATIONS: These products are not considered as dangerous goods, per regulations of Transport Canada.

15. REGULATORY INFORMATION

ADDITIONAL U.S. REGULATIONS:

U.S. SARA REPORTING REQUIREMENTS: The components of these products are subject to the reporting requirements of Sections 302, 304 and 313 of Title III of the Superfund Amendments and Reauthorization Act, as follows:

CHEMICAL NAME	SARA 302 (40 CFR 355, Appendix A)	SARA 304 (40 CFR Table 302.4)	SARA 313 (40 CFR 372.65)
Ammonium Chloride	NO	YES	NO
Lead	NO	YES	YES
Zinc Chloride	NO	YES	NO

U.S. SARA THRESHOLD PLANNING QUANTITY: There are no specific Threshold Planning Quantities for any component of these products. The default Federal MSDS submission and inventory requirement filing threshold of 10,000 lb (4,540 kg) may apply, per 40 CFR 370.20.

ADDITIONAL U.S. REGULATIONS (continued):

U.S. TSCA INVENTORY STATUS: The components of these products are listed on the TSCA Inventory.

U.S. CERCLA REPORTABLE QUANTITY (RQ): Ammonium Chloride = 5000 lb (2270 kg); Lead = 10 lb (4.540 kg); Zinc Chloride = 1000 lb (454 kg)

OTHER U.S. FEDERAL REGULATIONS: Components of these products have requirements under other U.S. Federal regulations, as follows:

AMMONIUM CHLORIDE: EPA: Ammonium Chloride is designated as a hazardous substance under Section 311(b)(2)(A) of the Federal Water Pollution Control Act and further regulated by the Clean Water Act Amendments of 1977 and 1978. These regulations apply to discharges of this substance.

LEAD: EPA: Lead is listed as a hazardous air pollutant (HAP) generally known or suspected to cause serious health problems. The Clean Air Act, as amended in 1990, directs EPA to set standards requiring major sources to sharply reduce routine emissions of toxic pollutants. EPA is required to establish and phase in specific performance based standards for all air emission sources that emit one or more of the listed pollutants. Lead is included on this list. Lead is designated as a toxic pollutant, pursuant to Section 307(a)(1) of the Clean Water Act and is subject to effluent limitations. Lead is designated as a hazardous substance under Section 311(b)(2)(A) of the Federal Water Pollution Control Act and further regulated by the Clean Water Act Amendments of 1977 and 1978. These regulations apply to discharges of Lead.

OSHA: Employers are required to follow the exposure limits and other requirements as defined under the Lead Standard, 29 CFR 1910.1025.

ZINC CHLORIDE: EPA: Zinc Chloride is designated as a hazardous substance under Section 311(b)(2)(A) of the Federal Water Pollution Control Act and further regulated by the Clean Water Act Amendments of 1977 and 1978. These regulations apply to discharges of this substance. Zinc Chloride is a designated as a toxic pollutant designated pursuant to Section 307(a)(1) of the Clean Water Act and is subject to effluent limitations.

U.S. STATE REGULATORY INFORMATION: The components of these products are covered under specific State regulations, as denoted below:

Alaska-Designated Toxic and Hazardous Substances: Ammonium Chloride, Lead, and Zinc Chloride.

California-Permissible Exposure Limits for Chemical Contaminants: Ammonium Chloride, Lead, Tin, and Zinc Chloride.

Florida-Substance List: Ammonium Chloride, Lead, Tin, and Zinc Chloride.

Illinois-Toxic Substance List: Ammonium Chloride, Lead, and Zinc Chloride.

Kansas-Section 302/313 List: Lead.

Massachusetts-Substance List: Ammonium Chloride, Lead, Tin, and Zinc Chloride.

Michigan - Critical Materials Register: Lead.

Minnesota-List of Hazardous Substances: Ammonium Chloride, Lead, Tin, and Zinc Chloride.

Missouri-Employer Information/Toxic Substance List: Ammonium Chloride, Lead, Tin, and Zinc Chloride.

New Jersey-Right to Know Hazardous Substance List: Ammonium Chloride, Lead, Tin, and Zinc Chloride.

North Dakota-List of Hazardous Chemicals, Reportable Quantities: Ammonium Chloride, Lead, and Zinc Chloride.

Pennsylvania-Hazardous Substance List: Ammonium Chloride, Lead, Tin, and Zinc Chloride.

Rhode Island-Hazardous Substance List: Ammonium Chloride, Tin, and Zinc Chloride.

Texas-Hazardous Substance List: Lead, Tin, and Zinc Chloride.

West Virginia-Hazardous Substance List: , Tin, Zinc Chloride.

Wisconsin-Toxic and Hazardous Substances: Lead, Tin, and Zinc Chloride.

CALIFORNIA SAFE DRINKING WATER AND TOXIC ENFORCEMENT ACT (PROPOSITION 65): The Lead component of these products is on the California Proposition 65 Lists. **WARNING: These products contain a chemical that is known to the State of California to cause cancer and reproductive harm. In addition, these products, when used for soldering may produce fumes or gases containing chemicals, known to the State of California to cause cancer, and/or birth defects (or other reproductive harm.)**

LABELING (Precautionary Statements): DANGER OF CUMULATIVE EFFECTS IF DUSTS OR FUMES ARE INHALED! POSSIBLE CANCER AND REPRODUCTIVE HAZARD. CONTAINS POTENTIAL TERATOGEN AND/OR MUTAGEN.

WARNING:

PROTECT yourself and others. Read and understand this information.

FUMES AND GASES can be hazardous to your health.

ARC RAYS can injure your eyes and burn skin.

ELECTRIC SHOCK can kill.

- Before use, read and understand the manufacturer's instructions. Material Safety Data Sheets (MSDSs), and your employer's safety policies.
- Keep your head out of the fumes.
- Use enough ventilation, exhaust at the arc, or both, to keep fumes and gases from your breathing zone and the general area.
- Wear correct eye, ear, and body protection.
- See American National Standard Z49.1 *Safety in Welding, Cutting, and Allied Processes*, published by the American Welding Society, 550 N.W. LeJeune Road, Miami, Florida 33126. OSHA Safety and Health Standards, *29 CFR 1910*, available from the U.S. Government Printing Office, Washington, DC 20402.

DO NOT REMOVE THIS INFORMATION

15. REGULATORY INFORMATION (Continued)

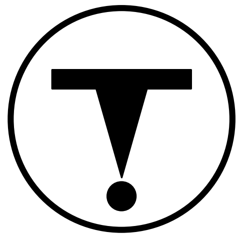
ADDITIONAL CANADIAN REGULATIONS:

CANADIAN DSL/NDSL INVENTORY STATUS: The components of these products are on the DSL Inventory.

OTHER CANADIAN REGULATIONS: Not applicable.

CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA) PRIORITIES SUBSTANCES LISTS: No component of these products are on the CEPA Priority Substances Lists (PSL).

CANADIAN WHMIS SYMBOLS: D2A: Poisonous and Infections Material - Other Effects: Very Toxic (chronic toxicity, embryotoxicity, teratogenicity, reproductive toxicity, carcinogenicity); **D2B:** - Poisonous and Infections Material - Other Effects: Toxic (mutagenicity).



16. OTHER INFORMATION

PREPARED BY: CHEMICAL SAFETY ASSOCIATES, Inc.
9163 Chesapeake Drive, San Diego, CA 92123-1002
858/565-0302

DATE OF PRINTING: July 13, 2007

This Material Safety Data Sheet is offered pursuant to OSHA's Hazard Communication Standard (29 CFR 1910.1200). Other government regulations must be reviewed for applicability to these products. The information contained herein relates only to the specific products. If the products are combined with other materials, all component properties must be considered. To the best of the Harris Products Group knowledge, the information and recommendations contained in this publication are reliable and accurate as of the date of issue. However, accuracy, suitability, or completeness are not guaranteed, and no warranty, guarantee, or representation, expressed or implied, is made by Harris Products Group., Inc. assumes no responsibility in connection therewith; nor can it be assumed that all acceptable safety measures may not be required under particular or exceptional conditions or circumstances. Data may be changed from time to time. Be sure to consult the latest edition.

DEFINITIONS OF TERMS

A large number of abbreviations and acronyms appear on a MSDS. Some of these, which are commonly used, include the following:

CAS #: This is the Chemical Abstract Service Number, which uniquely identifies each constituent.

EXPOSURE LIMITS IN AIR:

ACGIH - American Conference of Governmental Industrial Hygienists, a professional association which establishes exposure limits. **TLV -** Threshold Limit Value - an airborne concentration of a substance, which represents conditions under which it is generally believed that nearly all workers, may be repeatedly exposed without adverse effect. The duration must be considered, including the 8-hour Time Weighted Average **(TWA)**, the 15-minute Short Term Exposure Limit, and the instantaneous Ceiling Level **(C)**. Skin absorption effects must also be considered.

OSHA - U.S. Occupational Safety and Health Administration.

PEL - Permissible Exposure Limit - This exposure value means exactly the same as a TLV, except that it is enforceable by OSHA. The OSHA Permissible Exposure Limits are based in the 1989 PELs and the June, 1993 Air Contaminants Rule (Federal Register: 58: 35338-35351 and 58: 40191). Both the current PELs and the vacated PELs are indicated. The phrase, "Vacated 1989 PEL," is placed next to the PEL, which was vacated by Court Order. **IDLH -** Immediately Dangerous to Life and Health **-** This level represents a concentration from which one can escape within 30-minutes without suffering escape-preventing or permanent injury. **The DFG - MAK** is the Republic of Germany's Maximum Exposure Level, similar to the U.S. PEL. **NIOSH** is the National Institute of Occupational Safety and Health, which is the research arm of the U.S. Occupational Safety and Health Administration (**OSHA**). NIOSH issues exposure guidelines called Recommended Exposure Levels (**REL**s). When no exposure guidelines are established, an entry of **NE** is made for reference.

HAZARD RATINGS:

HAZARDOUS MATERIALS IDENTIFICATION SYSTEM: Health Hazard: **0** (minimal acute or chronic exposure hazard); **1** (slight acute or chronic exposure hazard); **2** (moderate acute or significant chronic exposure hazard); **3** (severe acute exposure hazard; onetime overexposure can result in permanent injury and may be fatal); **4** (extreme acute exposure hazard; onetime overexposure can be fatal). Flammability Hazard: **0** (minimal hazard); **1** (materials that require substantial pre-heating before burning); **2** (combustible liquid or solids; liquids with a flash point of 38-93°C [100-200°F]); **3** (Class IB and IC flammable liquids with flash points below 38°C [100°F]); **4** (Class IA flammable liquids with flash points below 23°C [73°F] and boiling points below 38°C [100°F]. Reactivity Hazard: **0** (normally stable); 1 (material that can become unstable at elevated temperatures or which can react slightly with water); **2** (materials that are unstable but do not detonate or which can react violently with water); **3** (materials that can detonate when initiated or which can react explosively with water); **4** (materials that can detonate at normal temperatures or pressures).

NATIONAL FIRE PROTECTION ASSOCIATION: Health Hazard: **0** (material that on exposure under fire conditions would offer no hazard beyond that of ordinary combustible materials); **1** (materials that on exposure under fire conditions could cause irritation or minor residual injury); **2** (materials that on intense or continued exposure under fire conditions could cause temporary incapacitation or possible residual injury); **3** (materials that can on short exposure could cause serious temporary or residual injury); **4** (materials that under very short exposure causes death or major residual injury). Flammability Hazard and Reactivity Hazard: Refer to definitions for "Hazardous Materials Identification System".

FLAMMABILITY LIMITS IN AIR:

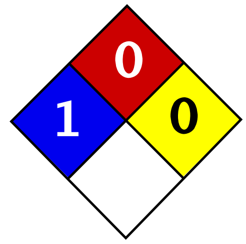
Much of the information related to fire and explosion is derived from the National Fire Protection Association (**NFPA**). Flash Point - Minimum temperature at which a liquid gives off sufficient vapors to form an ignitable mixture with air. Autoignition Temperature: The minimum temperature required to initiate combustion in air with no other source of ignition. LEL - the lowest percent of vapor in air, by volume, that will explode or ignite in the presence of an ignition source. UEL - the highest percent of vapor in air, by volume, that will explode or ignite in the presence of an ignition source.

TOXICOLOGICAL INFORMATION:

Human and Animal Toxicology: Possible health hazards as derived from human data, animal studies, or from the results of studies with similar compounds is presented. Definitions of some terms used in this section are: **LD_{50}** - Lethal Dose (solids & liquids) which kills 50% of the exposed animals; **LC_{50}** - Lethal Concentration (gases) which kills 50% of the exposed animals; **ppm** concentration expressed in parts of material per million parts of air or water; **mg/m^3** concentration expressed in weight of substance per volume of air; **mg/kg** quantity of material, by weight, administered to a test subject, based on their body weight in kg. Other measures of toxicity include **TDLo**, the lowest dose to cause a symptom and **TCLo** the lowest concentration to cause a symptom; **TDo**, **LDLo**, and **LDo**, or **TC**, **TCo**, **LCLo**, and **LCo**, the lowest dose (or concentration) to cause lethal or toxic effects. **Cancer Information:** The sources are: **IARC** - the International Agency for Research on Cancer; **NTP** - the National Toxicology Program, **RTECS** - the Registry of Toxic Effects of Chemical Substances, **OSHA** and **CAL/OSHA**. IARC and NTP rate chemicals on a scale of decreasing potential to cause human cancer with rankings from 1 to 4. Subrankings (2A, 2B, etc.) are also used. **Other Information: BEI** - ACGIH Biological Exposure Indices, represent the levels of determinants which are most likely to be observed in specimens collected from a healthy worker who has been exposed to chemicals to the same extent as a worker with inhalation exposure to the TLV. **Ecological Information:** EC is the effect concentration in water. **BCF** = Bioconcentration Factor, which is used to determine if a substance will concentrate in lifeforms which consume contaminated plant or animal matter. Coefficient of Oil/Water Distribution is represented by **$\log K_{ow}$** or **$\log K_{oc}$** and is used to assess a substance's behavior in the environment.

REGULATORY INFORMATION:

This section explains the impact of various laws and regulations on the material. **U.S.: EPA** is the U.S. Environmental Protection Agency. **DOT** is the U.S. Department of Transportation. **SARA** is the Superfund Amendments and Reauthorization Act. **TSCA** is the U.S. Toxic Substance Control Act. **CERCLA (or Superfund)** refers to the Comprehensive Environmental Response, Compensation, and Liability Act. Labeling is per the American National Standards Institute (**ANSI Z129.1**). **CANADA: CEPA** is the Canadian Environmental Protection Act. **WHMIS** is the Canadian Workplace Hazardous Materials Information System. **TC** is Transport Canada. **DSL/NDSL** are the Canadian Domestic/Non-Domestic Substances Lists. **The CPR is the Canadian Product Regulations.** This section also includes information on the precautionary warnings, which appear, on the materials package label.



Health	1
Fire	0
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
Ferrosoferric Oxide, Black Powder MSDS

Section 1: Chemical Product and Company Identification

Product Name: Ferrosoferric Oxide, Black Powder

Catalog Codes: SLF1477

CAS#: 1317-61-9

RTECS: Not available.

TSCA: TSCA 8(b) inventory: Ferrosoferric Oxide, Black Powder

CI#: Not available.

Synonym: Iron Oxide

Chemical Name: Ferrosoferric Oxide, Black Powder

Chemical Formula: Fe3-O4

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Ferrosoferric Oxide, Black Powder	1317-61-9	100

Toxicological Data on Ingredients: Ferrosoferric Oxide, Black Powder: ORAL (LD50): Acute: 5000 mg/kg [Rat].

Section 3: Hazards Identification

Potential Acute Health Effects: Slightly hazardous in case of skin contact (irritant), of eye contact (irritant), . Non-irritant for lungs.

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Classified None. by NTP, None. by OSHA, None. by NIOSH.
MUTAGENIC EFFECTS: Not available.
TERATOGENIC EFFECTS: Not available.
DEVELOPMENTAL TOXICITY: Not available.
The substance is toxic to lungs, upper respiratory tract.
Repeated or prolonged exposure to the substance can produce target organs damage.

Section 4: First Aid Measures

Eye Contact: No known effect on eye contact, rinse with water for a few minutes.

Skin Contact:
After contact with skin, wash immediately with plenty of water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Be particularly careful to clean folds, crevices, creases and groin. Cover the irritated skin with an emollient. If irritation persists, seek medical attention.

Serious Skin Contact: Not available.

Inhalation: Allow the victim to rest in a well ventilated area. Seek immediate medical attention.

Serious Inhalation: Not available.

Ingestion:
Do not induce vomiting. Loosen tight clothing such as a collar, tie, belt or waistband. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek immediate medical attention.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Non-flammable.

Auto-Ignition Temperature: Not applicable.

Flash Points: Not applicable.

Flammable Limits: Not applicable.

Products of Combustion: Not available.

Fire Hazards in Presence of Various Substances: Not applicable.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available.
Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions: Not applicable.

Special Remarks on Fire Hazards: Material is not combustible. Use extinguishing media suitable for other combustible material in the area

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:

Do not ingest. Do not breathe dust. If ingested, seek medical advice immediately and show the container or the label.

Storage:
No specific storage is required. Use shelves or cabinets sturdy enough to bear the weight of the chemicals. Be sure that it is not necessary to strain to reach materials, and that shelves are not overloaded.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection: Safety glasses. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid. (Solid powder.)

Odor: Odorless.

Taste: Not available.

Molecular Weight: Not available.

Color: Black

pH (1% soln/water): Not available.

Boiling Point: 1000°C (1832°F)

Melting Point: Not available.

Critical Temperature: Not available.

Specific Gravity: 4.6 (Water = 1)

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: Not available.

Solubility: Not available.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Not available.

Incompatibility with various substances: Not available.

Corrosivity: Not available.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: No.

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Dermal contact. Eye contact. Inhalation.

Toxicity to Animals: Acute oral toxicity (LD50): 5000 mg/kg [Rat].

Chronic Effects on Humans:
CARCINOGENIC EFFECTS: Classified None. by NTP, None. by OSHA, None. by NIOSH.
The substance is toxic to lungs, upper respiratory tract.

Other Toxic Effects on Humans:
Slightly hazardous in case of skin contact (irritant), .
Non-irritant for lungs.

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Not available.

Special Remarks on other Toxic Effects on Humans: Not available.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations:
California prop. 65: This product contains the following ingredients for which the State of California has found to cause cancer, birth defects or other reproductive harm, which would require a warning under the statute: Ferrosoferric Oxide, Black Powder
Massachusetts RTK: Ferrosoferric Oxide, Black Powder
New Jersey: Ferrosoferric Oxide, Black Powder
TSCA 8(b) inventory: Ferrosoferric Oxide, Black Powder

Other Regulations:
OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200).
EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada): CLASS D-2B: Material causing other toxic effects (TOXIC).

DSCL (EEC):
This product is not classified according to the EU regulations.

HMIS (U.S.A.):

Health Hazard: 1

Fire Hazard: 0

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 1

Flammability: 0

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves.
Lab coat.
Dust respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate.
Safety glasses.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/09/2005 05:33 PM

Last Updated: 11/06/2008 12:00 PM

Appendix V: NAR High Power Rocket Safety Code

NAR High Power Rocket Safety Code

Approved March 2006

1. **Certification**. I will only fly high power rockets or possess high power rocket motors that are within the scope of my user certification and required licensing.

2. **Materials.** I will use only lightweight materials such as paper, wood, rubber, plastic, fiberglass, or when necessary ductile metal, for the construction of my rocket.

3. **Motors.** I will use only certified, commercially made rocket motors, and will not tamper with these motors or use them for any purposes except those recommended by the manufacturer. I will keep smoking, open flames, and heat sources at least 25 feet away from these motors.

4. **Ignition System.** I will launch my rockets with an electrical launch system, and with electrical motor igniters that are installed in the motor only after my rocket is at the launching or prepping area. My launch system will have a safety interlock that is in series with the launch switch that is not installed until my rocket is ready for launch, and will use a launch switch that returns to the "off" position when released. If my rocket has onboard ignition systems for motors or recovery devices, these will have safety interlocks that interrupt the current path until the rocket is at the launch pad.

5. **Misfires.** If my rocket does not launch when I press the button of my electrical launch system, I will remove the launcher's safety interlock or disconnect its battery, and will wait 60 seconds after the last launch attempt before allowing anyone to approach the rocket.

6. **Launch Safety.** I will use a 5-second countdown before launch, and will ensure that everyone in the launch site is paying attention and that no person is closer to the launch pad than allowed by the accompanying Minimum Distance Table. I will check the stability of my rocket before flight and will not fly it if it cannot be determined to be stable.

7. **Launcher.** I will launch my rocket from a stable device that provides rigid guidance until the rocket has attained a speed that ensures a stable flight, and that is pointed to within 20 degrees of the vertical. If the wind speed exceeds 5 miles per hour I will use a launcher length that permits the rocket to attain a safe velocity before separation from the launcher. I will use a blast deflector to prevent the motor's exhaust from hitting the ground. I will ensure that there is no dry grass within a clear distance of each launch pad determined by the accompanying Minimum Distance table, and will increase this distance by a factor of 1.5 if the rocket motor being launched uses titanium sponge in the propellant.

8. **Size.** My rocket will not contain any combination of motors that total more than 40,960 N-sec (9208 pound-seconds) of total impulse. My rocket will not weigh more at liftoff than one-third of the certified average thrust of the high power rocket motor(s) intended to be ignited at launch.

9. **Flight Safety.** I will not launch my rocket at targets, into clouds, near airplanes, or on trajectories that take it directly over the heads of spectators or beyond the

boundaries of the launch site, and will not put any flammable or explosive payload in my rocket. I will not launch my rockets if wind speeds exceed 20 miles per hour. I will comply with Federal Aviation Administration airspace regulations when flying, and will ensure that my rocket will not exceed any applicable altitude limit in effect at that launch site.

10. **Launch Site.** I will launch my rocket outdoors, in an open area where trees, power lines, buildings, and persons not involved in the launch do not present a hazard, and that is at least as large on its smallest dimension as one-half of the maximum altitude to which rockets are allowed to be flown at that site or 1500 feet, whichever is greater.

11. **Launcher Location.** My launcher will be at least one half the minimum launch site dimension, or 1500 feet (whichever is greater) from any inhabited building, or from any public highway on which traffic flow exceeds 10 vehicles per hour, not including traffic flow related to the launch. It will also be no closer than the appropriate Minimum Personnel Distance from the accompanying table from any boundary of the launch site.

12. **Recovery System.** I will use a recovery system such as a parachute in my rocket so that all parts of my rocket return safely and undamaged and can be flown again, and I will use only flame-resistant or fireproof recovery system wadding in my rocket.

13. **Recovery Safety.** I will not attempt to recover my rocket from power lines, tall trees, or other dangerous places, fly it under conditions where it may recover in spectator areas or outside the launch site, or attempt to catch it as it approaches the ground.

MINIMUM DISTANCE TABLE				
Installed Total Impulse (N-sec)	**Equivalent Motor Type**	**Minimum Clear Distance (ft.)**	**Minimum Personnel Distance (ft.)**	**Minimum Personnel Distance (Complex Rocket) (ft.)**
0 - 320.00	H or smaller	50	100	200
320.01 - 640.00	I	50	100	200
640.01 - 1280.00	J	50	100	200
1280.01 - 2560.00	K	75	200	300
2560.01 - 5120.00	L	100	300	500
5120.01 - 10,240.00	M	125	500	1000
10,240.01 - 20,480.00	N	125	1000	1500
20,480.01 - 40,960.00	O	125	1500	2000

Note: A complex rocket is one that is multi-staged or that is propelled by two or more rocket motors

Appendix VI: Signed Mile High Yellow Jacket Safety Agreements

Georgia Institute of Technology USLI 2011-2012

Safety Agreement

I, Raet Eagan, hereby agree to comply with all laws, regulations and procedures outlined by the following: Federal Aviation Administration (FAA) regulations relating to high power rocketry, all State of Georgia Environmental Health and Safety laws, the (NAR) High Power Rocket Safety Code and Handbook, and all Material Safety Data Sheets for all materials used. I will abide by these laws, regulations, and procedures throughout every phase of the project from the initial planning, design, and construction of Georgia Tech Mile High Yellow Jackets University Student Launch Initiative (USLI) entry through the completion of the project.

I understand that before launch, the rocket will be subject to a mandatory safety inspection by the Huntsville Area Rocketry Association (HARA) Range Safety Officer (RSO). I also understand that the Safety Officer has the full authority to deny the launch of any rocket if it is deemed unsafe, and that the determination of flight worthiness is at the sole discretion of the RSO.

I agree to comply with all instructions, requests, and rulings of the RSO. I also understand that if I or any one member or members of the team fail to comply with all instructions, requests, and rulings of the RSO the entire team will be denied the opportunity to launch the rocket.

I agree to comply with all requests, rules and demands of the Georgia Tech USLI Team's Faculty Advisor, NAR Mentor, and Team Leader in relation to the safety of the project, even if these requests, rules and demands are beyond, or in addition to, those of the entities specified in the first paragraph of this document. I also agree to adhere to all safety rules and regulations when working in laboratories or machine shops on projects associated with USLI, including those rules and regulations specific to the laboratories and machine shops, or at any time during the manufacture of components for the project. I understand that I must either have the proper authority to use any and all facilities in the manufacture of project components, or operate under the supervision of someone who does.

I understand that failure to comply with any of the above requirements will result in my being permanently removed from the Georgia Tech USLI team and barred from all related activities.

Raet Eagan

Name (Printed)

Raef Eagan

Name (Signature)

9/23/2011

Date

Georgia Institute of Technology USLI 2011-2012

Safety Agreement

I, Jordan Bell, hereby agree to comply with all laws, regulations and procedures outlined by the following: Federal Aviation Administration (FAA) regulations relating to high power rocketry, all State of Georgia Environmental Health and Safety laws, the (NAR) High Power Rocket Safety Code and Handbook, and all Material Safety Data Sheets for all materials used. I will abide by these laws, regulations, and procedures throughout every phase of the project from the initial planning, design, and construction of Georgia Tech Mile High Yellow Jackets University Student Launch Initiative (USLI) entry through the completion of the project.

I understand that before launch, the rocket will be subject to a mandatory safety inspection by the Huntsville Area Rocketry Association (HARA) Range Safety Officer (RSO). I also understand that the Safety Officer has the full authority to deny the launch of any rocket if it is deemed unsafe, and that the determination of flight worthiness is at the sole discretion of the RSO.

I agree to comply with all instructions, requests, and rulings of the RSO. I also understand that if I or any one member or members of the team fail to comply with all instructions, requests, and rulings of the RSO the entire team will be denied the opportunity to launch the rocket.

I agree to comply with all requests, rules and demands of the Georgia Tech USLI Team's Faculty Advisor, NAR Mentor, and Team Leader in relation to the safety of the project, even if these requests, rules and demands are beyond, or in addition to, those of the entities specified in the first paragraph of this document. I also agree to adhere to all safety rules and regulations when working in laboratories or machine shops on projects associated with USLI, including those rules and regulations specific to the laboratories and machine shops, or at any time during the manufacture of components for the project. I understand that I must either have the proper authority to use any and all facilities in the manufacture of project components, or operate under the supervision of someone who does.

I understand that failure to comply with any of the above requirements will result in my being permanently removed from the Georgia Tech USLI team and barred from all related activities.

Jordan Bell

Name (Printed)

Jordan Bell 9/23/11

Name (Signature) Date

Georgia Institute of Technology USLI 2011-2012

Safety Agreement

I, Akshaya Srivastava, hereby agree to comply with all laws, regulations and procedures outlined by the following: Federal Aviation Administration (FAA) regulations relating to high power rocketry, all State of Georgia Environmental Health and Safety laws, the (NAR) High Power Rocket Safety Code and Handbook, and all Material Safety Data Sheets for all materials used. I will abide by these laws, regulations, and procedures throughout every phase of the project from the initial planning, design, and construction of Georgia Tech Mile High Yellow Jackets University Student Launch Initiative (USLI) entry through the completion of the project.

I understand that before launch, the rocket will be subject to a mandatory safety inspection by the Huntsville Area Rocketry Association (HARA) Range Safety Officer (RSO). I also understand that the Safety Officer has the full authority to deny the launch of any rocket if it is deemed unsafe, and that the determination of flight worthiness is at the sole discretion of the RSO.

I agree to comply with all instructions, requests, and rulings of the RSO. I also understand that if I or any one member or members of the team fail to comply with all instructions, requests, and rulings of the RSO the entire team will be denied the opportunity to launch the rocket.

I agree to comply with all requests, rules and demands of the Georgia Tech USLI Team's Faculty Advisor, NAR Mentor, and Team Leader in relation to the safety of the project, even if these requests, rules and demands are beyond, or in addition to, those of the entities specified in the first paragraph of this document. I also agree to adhere to all safety rules and regulations when working in laboratories or machine shops on projects associated with USLI, including those rules and regulations specific to the laboratories and machine shops, or at any time during the manufacture of components for the project. I understand that I must either have the proper authority to use any and all facilities in the manufacture of project components, or operate under the supervision of someone who does.

I understand that failure to comply with any of the above requirements will result in my being permanently removed from the Georgia Tech USLI team and barred from all related activities.

Akshaya Srivastava

Name (Printed)

[signature] 9/23/11

Name (Signature) Date

Georgia Institute of Technology USLI 2011-2012

Safety Agreement

I, Matthew Schumann, hereby agree to comply with all laws, regulations and procedures outlined by the following: Federal Aviation Administration (FAA) regulations relating to high power rocketry, all State of Georgia Environmental Health and Safety laws, the (NAR) High Power Rocket Safety Code and Handbook, and all Material Safety Data Sheets for all materials used. I will abide by these laws, regulations, and procedures throughout every phase of the project from the initial planning, design, and construction of Georgia Tech Mile High Yellow Jackets University Student Launch Initiative (USLI) entry through the completion of the project.

I understand that before launch, the rocket will be subject to a mandatory safety inspection by the Huntsville Area Rocketry Association (HARA) Range Safety Officer (RSO). I also understand that the Safety Officer has the full authority to deny the launch of any rocket if it is deemed unsafe, and that the determination of flight worthiness is at the sole discretion of the RSO.

I agree to comply with all instructions, requests, and rulings of the RSO. I also understand that if I or any one member or members of the team fail to comply with all instructions, requests, and rulings of the RSO the entire team will be denied the opportunity to launch the rocket.

I agree to comply with all requests, rules and demands of the Georgia Tech USLI Team's Faculty Advisor, NAR Mentor, and Team Leader in relation to the safety of the project, even if these requests, rules and demands are beyond, or in addition to, those of the entities specified in the first paragraph of this document. I also agree to adhere to all safety rules and regulations when working in laboratories or machine shops on projects associated with USLI, including those rules and regulations specific to the laboratories and machine shops, or at any time during the manufacture of components for the project. I understand that I must either have the proper authority to use any and all facilities in the manufacture of project components, or operate under the supervision of someone who does.

I understand that failure to comply with any of the above requirements will result in my being permanently removed from the Georgia Tech USLI team and barred from all related activities.

Matthew Schumann

Name (Printed)

Matthew Schumann

Name (Signature)

d/23/2011

Date

Georgia Institute of Technology USLI 2011-2012

Safety Agreement

I, Jan Agudo, hereby agree to comply with all laws, regulations and procedures outlined by the following: Federal Aviation Administration (FAA) regulations relating to high power rocketry, all State of Georgia Environmental Health and Safety laws, the (NAR) High Power Rocket Safety Code and Handbook, and all Material Safety Data Sheets for all materials used. I will abide by these laws, regulations, and procedures throughout every phase of the project from the initial planning, design, and construction of Georgia Tech Mile High Yellow Jackets University Student Launch Initiative (USLI) entry through the completion of the project.

I understand that before launch, the rocket will be subject to a mandatory safety inspection by the Huntsville Area Rocketry Association (HARA) Range Safety Officer (RSO). I also understand that the Safety Officer has the full authority to deny the launch of any rocket if it is deemed unsafe, and that the determination of flight worthiness is at the sole discretion of the RSO.

I agree to comply with all instructions, requests, and rulings of the RSO. I also understand that if I or any one member or members of the team fail to comply with all instructions, requests, and rulings of the RSO the entire team will be denied the opportunity to launch the rocket.

I agree to comply with all requests, rules and demands of the Georgia Tech USLI Team's Faculty Advisor, NAR Mentor, and Team Leader in relation to the safety of the project, even if these requests, rules and demands are beyond, or in addition to, those of the entities specified in the first paragraph of this document. I also agree to adhere to all safety rules and regulations when working in laboratories or machine shops on projects associated with USLI, including those rules and regulations specific to the laboratories and machine shops, or at any time during the manufacture of components for the project. I understand that I must either have the proper authority to use any and all facilities in the manufacture of project components, or operate under the supervision of someone who does.

I understand that failure to comply with any of the above requirements will result in my being permanently removed from the Georgia Tech USLI team and barred from all related activities.

Jan Agudo

Name (Printed)

[signature]

Name (Signature)

9/23/11

Date

Georgia Institute of Technology USLI 2011-2012

Safety Agreement

I, J.Luis Soriano, hereby agree to comply with all laws, regulations and procedures outlined by the following: Federal Aviation Administration (FAA) regulations relating to high power rocketry, all State of Georgia Environmental Health and Safety laws, the (NAR) High Power Rocket Safety Code and Handbook, and all Material Safety Data Sheets for all materials used. I will abide by these laws, regulations, and procedures throughout every phase of the project from the initial planning, design, and construction of Georgia Tech Mile High Yellow Jackets University Student Launch Initiative (USLI) entry through the completion of the project.

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I agree to comply with all instructions, requests, and rulings of the RSO. I also understand that if I or any one member or members of the team fail to comply with all instructions, requests, and rulings of the RSO the entire team will be denied the opportunity to launch the rocket.

I agree to comply with all requests, rules and demands of the Georgia Tech USLI Team's Faculty Advisor, NAR Mentor, and Team Leader in relation to the safety of the project, even if these requests, rules and demands are beyond, or in addition to, those of the entities specified in the first paragraph of this document. I also agree to adhere to all safety rules and regulations when working in laboratories or machine shops on projects associated with USLI, including those rules and regulations specific to the laboratories and machine shops, or at any time during the manufacture of components for the project. I understand that I must either have the proper authority to use any and all facilities in the manufacture of project components, or operate under the supervision of someone who does.

I understand that failure to comply with any of the above requirements will result in my being permanently removed from the Georgia Tech USLI team and barred from all related activities.

J.Luis Soriano

Name (Printed)

Luis Soriano

Name (Signature)

9/23/11

Date

Georgia Institute of Technology USLI 2011-2012

Safety Agreement

I, Kevin Reilley, hereby agree to comply with all laws, regulations and procedures outlined by the following: Federal Aviation Administration (FAA) regulations relating to high power rocketry, all State of Georgia Environmental Health and Safety laws, the (NAR) High Power Rocket Safety Code and Handbook, and all Material Safety Data Sheets for all materials used. I will abide by these laws, regulations, and procedures throughout every phase of the project from the initial planning, design, and construction of Georgia Tech Mile High Yellow Jackets University Student Launch Initiative (USLI) entry through the completion of the project.

I understand that before launch, the rocket will be subject to a mandatory safety inspection by the Huntsville Area Rocketry Association (HARA) Range Safety Officer (RSO). I also understand that the Safety Officer has the full authority to deny the launch of any rocket if it is deemed unsafe, and that the determination of flight worthiness is at the sole discretion of the RSO.

I agree to comply with all instructions, requests, and rulings of the RSO. I also understand that if I or any one member or members of the team fail to comply with all instructions, requests, and rulings of the RSO the entire team will be denied the opportunity to launch the rocket.

I agree to comply with all requests, rules and demands of the Georgia Tech USLI Team's Faculty Advisor, NAR Mentor, and Team Leader in relation to the safety of the project, even if these requests, rules and demands are beyond, or in addition to, those of the entities specified in the first paragraph of this document. I also agree to adhere to all safety rules and regulations when working in laboratories or machine shops on projects associated with USLI, including those rules and regulations specific to the laboratories and machine shops, or at any time during the manufacture of components for the project. I understand that I must either have the proper authority to use any and all facilities in the manufacture of project components, or operate under the supervision of someone who does.

I understand that failure to comply with any of the above requirements will result in my being permanently removed from the Georgia Tech USLI team and barred from all related activities.

Kevin Reilley

Name (Printed)

[signature]

Name (Signature)

9/23/11

Date

Georgia Institute of Technology USLI 2011-2012

Safety Agreement

I, Erik Brown ____________________ , hereby agree to comply with all laws, regulations and procedures outlined by the following: Federal Aviation Administration (FAA) regulations relating to high power rocketry, all State of Georgia Environmental Health and Safety laws, the (NAR) High Power Rocket Safety Code and Handbook, and all Material Safety Data Sheets for all materials used. I will abide by these laws, regulations, and procedures throughout every phase of the project from the initial planning, design, and construction of Georgia Tech Mile High Yellow Jackets University Student Launch Initiative (USLI) entry through the completion of the project.

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I agree to comply with all requests, rules and demands of the Georgia Tech USLI Team's Faculty Advisor, NAR Mentor, and Team Leader in relation to the safety of the project, even if these requests, rules and demands are beyond, or in addition to, those of the entities specified in the first paragraph of this document. I also agree to adhere to all safety rules and regulations when working in laboratories or machine shops on projects associated with USLI, including those rules and regulations specific to the laboratories and machine shops, or at any time during the manufacture of components for the project. I understand that I must either have the proper authority to use any and all facilities in the manufacture of project components, or operate under the supervision of someone who does.

I understand that failure to comply with any of the above requirements will result in my being permanently removed from the Georgia Tech USLI team and barred from all related activities.

Erik Brown

Name (Printed)

[signature]

Name (Signature)

Sept 23 2011

Date

Georgia Institute of Technology USLI 2011-2012

Safety Agreement

I, Jason Thrasher, hereby agree to comply with all laws, regulations and procedures outlined by the following: Federal Aviation Administration (FAA) regulations relating to high power rocketry, all State of Georgia Environmental Health and Safety laws, the (NAR) High Power Rocket Safety Code and Handbook, and all Material Safety Data Sheets for all materials used. I will abide by these laws, regulations, and procedures throughout every phase of the project from the initial planning, design, and construction of Georgia Tech Mile High Yellow Jackets University Student Launch Initiative (USLI) entry through the completion of the project.

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I agree to comply with all requests, rules and demands of the Georgia Tech USLI Team's Faculty Advisor, NAR Mentor, and Team Leader in relation to the safety of the project, even if these requests, rules and demands are beyond, or in addition to, those of the entities specified in the first paragraph of this document. I also agree to adhere to all safety rules and regulations when working in laboratories or machine shops on projects associated with USLI, including those rules and regulations specific to the laboratories and machine shops, or at any time during the manufacture of components for the project. I understand that I must either have the proper authority to use any and all facilities in the manufacture of project components, or operate under the supervision of someone who does.

I understand that failure to comply with any of the above requirements will result in my being permanently removed from the Georgia Tech USLI team and barred from all related activities.

Jason Thrasher

Name (Printed)

[signature]

Name (Signature)

9/23/11

Date

Georgia Institute of Technology USLI 2011-2012

Safety Agreement

I, Alex Buchanan, hereby agree to comply with all laws, regulations and procedures outlined by the following: Federal Aviation Administration (FAA) regulations relating to high power rocketry, all State of Georgia Environmental Health and Safety laws, the (NAR) High Power Rocket Safety Code and Handbook, and all Material Safety Data Sheets for all materials used. I will abide by these laws, regulations, and procedures throughout every phase of the project from the initial planning, design, and construction of Georgia Tech Mile High Yellow Jackets University Student Launch Initiative (USLI) entry through the completion of the project.

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I agree to comply with all instructions, requests, and rulings of the RSO. I also understand that if I or any one member or members of the team fail to comply with all instructions, requests, and rulings of the RSO the entire team will be denied the opportunity to launch the rocket.

I agree to comply with all requests, rules and demands of the Georgia Tech USLI Team's Faculty Advisor, NAR Mentor, and Team Leader in relation to the safety of the project, even if these requests, rules and demands are beyond, or in addition to, those of the entities specified in the first paragraph of this document. I also agree to adhere to all safety rules and regulations when working in laboratories or machine shops on projects associated with USLI, including those rules and regulations specific to the laboratories and machine shops, or at any time during the manufacture of components for the project. I understand that I must either have the proper authority to use any and all facilities in the manufacture of project components, or operate under the supervision of someone who does.

I understand that failure to comply with any of the above requirements will result in my being permanently removed from the Georgia Tech USLI team and barred from all related activities.

Alex Buchanan

Name (Printed)

Alex Buchanan

Name (Signature)

09/23/2011

Date

Georgia Institute of Technology USLI 2011-2012

Safety Agreement

I, Xiaoheng Pan, hereby agree to comply with all laws, regulations and procedures outlined by the following: Federal Aviation Administration (FAA) regulations relating to high power rocketry, all State of Georgia Environmental Health and Safety laws, the (NAR) High Power Rocket Safety Code and Handbook, and all Material Safety Data Sheets for all materials used. I will abide by these laws, regulations, and procedures throughout every phase of the project from the initial planning, design, and construction of Georgia Tech Mile High Yellow Jackets University Student Launch Initiative (USLI) entry through the completion of the project.

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I understand that failure to comply with any of the above requirements will result in my being permanently removed from the Georgia Tech USLI team and barred from all related activities.

Xiaoheng Pan

Name (Printed)

[signature]

Name (Signature)

9-22-2011

Date

Georgia Institute of Technology USLI 2011-2012

Safety Agreement

I, Bhanu Kumar, hereby agree to comply with all laws, regulations and procedures outlined by the following: Federal Aviation Administration (FAA) regulations relating to high power rocketry, all State of Georgia Environmental Health and Safety laws, the (NAR) High Power Rocket Safety Code and Handbook, and all Material Safety Data Sheets for all materials used. I will abide by these laws, regulations, and procedures throughout every phase of the project from the initial planning, design, and construction of Georgia Tech Mile High Yellow Jackets University Student Launch Initiative (USLI) entry through the completion of the project.

I understand that before launch, the rocket will be subject to a mandatory safety inspection by the Huntsville Area Rocketry Association (HARA) Range Safety Officer (RSO). I also understand that the Safety Officer has the full authority to deny the launch of any rocket if it is deemed unsafe, and that the determination of flight worthiness is at the sole discretion of the RSO.

I agree to comply with all instructions, requests, and rulings of the RSO. I also understand that if I or any one member or members of the team fail to comply with all instructions, requests, and rulings of the RSO the entire team will be denied the opportunity to launch the rocket.

I agree to comply with all requests, rules and demands of the Georgia Tech USLI Team's Faculty Advisor, NAR Mentor, and Team Leader in relation to the safety of the project, even if these requests, rules and demands are beyond, or in addition to, those of the entities specified in the first paragraph of this document. I also agree to adhere to all safety rules and regulations when working in laboratories or machine shops on projects associated with USLI, including those rules and regulations specific to the laboratories and machine shops, or at any time during the manufacture of components for the project. I understand that I must either have the proper authority to use any and all facilities in the manufacture of project components, or operate under the supervision of someone who does.

I understand that failure to comply with any of the above requirements will result in my being permanently removed from the Georgia Tech USLI team and barred from all related activities.

Bhanu Kumar

Name (Printed)

______________________________ September 22, 2011

Name (Signature) Date

Georgia Institute of Technology USLI 2011-2012

Safety Agreement

I, _______Michael Cato_________ , hereby agree to comply with all laws, regulations and procedures outlined by the following: Federal Aviation Administration (FAA) regulations relating to high power rocketry, all State of Georgia Environmental Health and Safety laws, the (NAR) High Power Rocket Safety Code and Handbook, and all Material Safety Data Sheets for all materials used. I will abide by these laws, regulations, and procedures throughout every phase of the project from the initial planning, design, and construction of Georgia Tech Mile High Yellow Jackets University Student Launch Initiative (USLI) entry through the completion of the project.

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I understand that failure to comply with any of the above requirements will result in my being permanently removed from the Georgia Tech USLI team and barred from all related activities.

__Michael Cato___________________

Name (Printed)

__Michael Cato //Electronically Signed _____9/23/2011___

Name (Signature) Date

Georgia Institute of Technology USLI 2011-2012

Safety Agreement

I, ________Robert Rhinehart_____ , hereby agree to comply with all laws, regulations and procedures outlined by the following: Federal Aviation Administration (FAA) regulations relating to high power rocketry, all State of Georgia Environmental Health and Safety laws, the (NAR) High Power Rocket Safety Code and Handbook, and all Material Safety Data Sheets for all materials used. I will abide by these laws, regulations, and procedures throughout every phase of the project from the initial planning, design, and construction of Georgia Tech Mile High Yellow Jackets University Student Launch Initiative (USLI) entry through the completion of the project.

I understand that before launch, the rocket will be subject to a mandatory safety inspection by the Huntsville Area Rocketry Association (HARA) Range Safety Officer (RSO). I also understand that the Safety Officer has the full authority to deny the launch of any rocket if it is deemed unsafe, and that the determination of flight worthiness is at the sole discretion of the RSO.

I agree to comply with all instructions, requests, and rulings of the RSO. I also understand that if I or any one member or members of the team fail to comply with all instructions, requests, and rulings of the RSO the entire team will be denied the opportunity to launch the rocket.

I agree to comply with all requests, rules and demands of the Georgia Tech USLI Team's Faculty Advisor, NAR Mentor, and Team Leader in relation to the safety of the project, even if these requests, rules and demands are beyond, or in addition to, those of the entities specified in the first paragraph of this document. I also agree to adhere to all safety rules and regulations when working in laboratories or machine shops on projects associated with USLI, including those rules and regulations specific to the laboratories and machine shops, or at any time during the manufacture of components for the project. I understand that I must either have the proper authority to use any and all facilities in the manufacture of project components, or operate under the supervision of someone who does.

I understand that failure to comply with any of the above requirements will result in my being permanently removed from the Georgia Tech USLI team and barred from all related activities.

____

Name (Printed)

_________________________________ ________________

Name (Signature) Date

Robert Rhinehart //Electronically Signed 9/25/2011

Georgia Institute of Technology USLI 2011-2012

Safety Agreement

I, **CHESTER ONG**, hereby agree to comply with all laws, regulations and procedures outlined by the following: Federal Aviation Administration (FAA) regulations relating to high power rocketry, all State of Georgia Environmental Health and Safety laws, the (NAR) High Power Rocket Safety Code and Handbook, and all Material Safety Data Sheets for all materials used. I will abide by these laws, regulations, and procedures throughout every phase of the project from the initial planning, design, and construction of Georgia Tech Mile High Yellow Jackets University Student Launch Initiative (USLI) entry through the completion of the project.

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I understand that failure to comply with any of the above requirements will result in my being permanently removed from the Georgia Tech USLI team and barred from all related activities.

CHESTER ONG

Name (Printed)

CHESTER ONG // ELECTRONICALLY SIGNED **9/24/2011**

Name (Signature) Date

Georgia Institute of Technology USLI 2011-2012

Safety Agreement

I, _______Richard Zappulla II_____ , hereby agree to comply with all laws, regulations and procedures outlined by the following: Federal Aviation Administration (FAA) regulations relating to high power rocketry, all State of Georgia Environmental Health and Safety laws, the (NAR) High Power Rocket Safety Code and Handbook, and all Material Safety Data Sheets for all materials used. I will abide by these laws, regulations, and procedures throughout every phase of the project from the initial planning, design, and construction of Georgia Tech Mile High Yellow Jackets University Student Launch Initiative (USLI) entry through the completion of the project.

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I understand that failure to comply with any of the above requirements will result in my being permanently removed from the Georgia Tech USLI team and barred from all related activities.

__Richard Zappulla II____________

Name (Printed)

__Richard Zappulla II //Electronically Signed_ ____9/23/2011___

Name (Signature) Date