National Aeronautics and Space Administration

USLI

university student launch initiative

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What is SLI?

The NASA University Student Launch Initiative (USLI) involves students in designing, building and testing reusable rockets with associated scientific payloads. This unique hands-on experience allows students to demonstrate proof-of-concept for their designs and gives previously abstract concepts tangibility.

Both new and returning teams compete to construct the vehicle that is designed to reach an altitude of one mile above ground level (AGL). In addition to actual vehicle performance, schools are also evaluated on design and other criteria. This educational experience culminates with a launch at Marshall Space Flight Center in the spring.

Suggested Reading
By: Vince Huegele

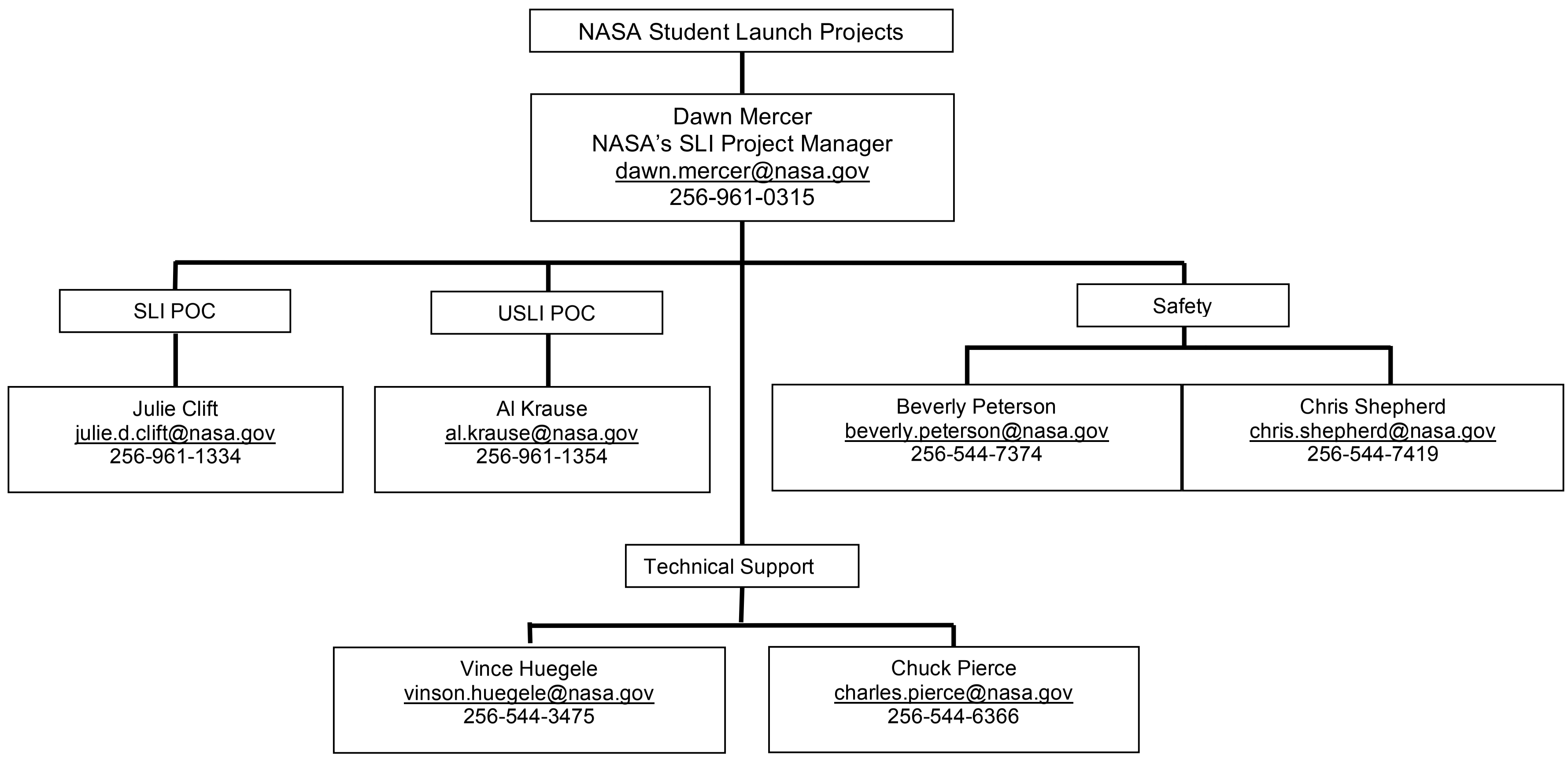
Welcome to NASA's Student Launch Initiative. You have shown you 'know rockets' by succeeding in TARC, now you're on another level to learn real rocket science.

There are two texts I recommend for you to reference. The first is the Handbook of Model Rocketry by G. Harry Stine. This is the true master guide for all things about model rocketry by one of its creators. It would help you for TARC, but it will really help you in SLI.

The other book is Space Mission Analysis and Design (Space Technology Library) by Wiley J. Larson, James Richard Wertz. This is an excellent comprehensive description of how to conduct a full size rocket program. It will show why SLI is structured the way it is.

Both of these books are in paperback and available through usual publication sources. Maybe you can get your library to order them, or one of your sponsors could acquire and donate them.

The USLI Team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University Student Launch Program Distinguished Panel Members & Support Team

1. Dawn Mercer: SLI Program Manager

Dawn Mercer is employed by WILL Technology Inc. at NASA Marshall Space Flight Center in Huntsville, Alabama. She previously worked as project manager of NASA's Engineering Design Challenges (EDC) program from the fall of 2000 to fall of 2003. She developed EDC from its early stages to a program that is now integrated Agency-wide through the NASA Student Involvement Program.

Dawn now manages the NASA Student Launch Initiative Program (SLI).
The SLI program offers grants and mentoring partnerships to High School teams to design, build, and launch rockets to 1 mile. Her job duties include: managing team progress and the process of mentorship, organizing and overseeing curriculum development and alignment, conducting workshops, networking and partnering with outside industry, and managing a team of four people.

Before coming to Marshall Space Flight Center, Ms. Mercer taught high school science for 8 years. She is currently certified in two states and continues teaching through school visits and teacher workshops. She also has 5 years marketing and sales experience in the pharmaceutical industry.

2. Julie Clift: SLI Project Coordinator

Julie is employed by WILL Technology Inc. as an Education Specialist at NASA Marshall Space Flight Center in Huntsville, AL. She supervises the Engineering Design Challenges Program. This program is incorporated Agency-wide through the NASA Student Involvement Program. Engineering Design Challenges provides hands-on classroom challenges for students to design, build, and test models that meet specified criteria. These challenges meet national standards and goals. She is also a team member of the Elementary & Secondary Programs, NASA's Student Launch Initiative Program, the Great Moonbuggy Race, and the Robotics Education Program. Julie is a member of the National Association of Rocketry and is Level 1 Certified.

Prior to working at Marshall Space Flight Center, Julie graduated from Auburn University with a bachelor's degree in Elementary Education. She taught fifth grade at Monrovia Middle and Elementary Schools for 6 years.

3. Al Krause: USLI Project Coordinator

Al is employed by WILL Technology Inc. as an Education Specialist at NASA Marshall Space Flight Center in Huntsville, AL. He supervises the University Student Launch Initiative. This project is the University equivalent to the Middle and High School Student Launch Initiative. Al is also responsible for helping to manage or provide support to projects ranging from Radiation and Human Space Flight, Northern Alabama Girl Scouts, and supporting SLI. He also provides workshops to teachers on various topics during the year.

Before working at Marshall Space Flight Center, Al graduated from Northland College in Ashland, WI earning a degree in Elementary Education with an emphasis in Natural and Environmental Science. He has taught 5th, 7th, and 8th grades during his seven years of teaching in northern Wisconsin.

4. Vince Huegele: Engineer/Panel Member

Vince has been employed with MSFC since 1980 as an optical physicist. He has a B.S. in Physics from David Lipscomb University and an M.S. in Engineering Science from the University of Tennessee. Mr. Huegele worked with designing large deployable space mirrors for the Next Generation Space Telescopes, which will succeed the Hubble and Chandra orbiting observatories. He has designed, fabricated and tested solar concentrators for ground and flight experiments for solar thermal propulsion.

Mr. Huegele has worked with NASA outreach efforts since 1988. He conducts model rocket building and launching sessions for students and has introduced hundreds of children to the science and math of model rocketry. He has written lesson plans and activity guides for teachers and has given presentations in education workshops, including the National Conferences for NSTA and ITEA. He has produced science education material of theoretical narratives and lesson activities that is nationally distributed in the SPIE (International Society for Optical Engineering) Outreach kit.

Mr. Huegele is the Chief Technical Advisor for the MSFC Student Launch Initiative and was instrumental in forming the project. He serves as the SLI and USLI launch director for flight operations and is the board chair of the CDR and FRR for those student presentations. Currently he is the senior Advisor for the Huntsville Area Rocketry Association, where he was president for ten years. He presently serves as the Education Chair for the NAR which he was named to in 2003.

5. Chris Shepherd: Quality/Panel Member

Chris is the Team Lead for the Vehicle Systems Test Assurance Team in the Safety And Mission Assurance Directorate. She has been providing Quality and Safety support to the Department of Defense and NASA for rockets and propulsion systems for 30 years. She is a graduate of the University of Illinois (B.A.), the Defense Ammunition School, and the University of Phoenix (M.A.)

She has tailored quality assurance requirements and implemented quality and safety programs for the following:

Space Shuttle propulsion systems and components; both launch and test operations, (SSME: Space Shuttle Main Engine, RSRM: Reusable Solid Rocket Motor, SRB: Solid Rocket Booster, ET: External Tank), X33, X34, X38, Atlas RD-180, Hybrid Propulsion Demonstration Program, Solid Propulsion Integrity Program, subscale motors for RSRM, Orbital Space Plane RS-88, Next Generation Launch Technology components, hybrid sounding rockets, and various tactical missiles for the Army and Air Force. She is currently working on development testing of the Ares Crew Launch Vehicle and Orion Crew Exploration Vehicle propulsion systems and components, including the Integrated Vehicle Ground Vibration Test, the Upper Stage Main

Propulsion Test, J2X component teting, and the Lunar Ascent engine development test activities. She has supported Student Launch activities since 1999.

6. Chuck Pierce: Engineer/Panel Member

Chuck is currently the Lead Engineer for the Roll Control System for the Ares I-X Demonstration Vehicle.

Interesting Facts:

- 20 years as Liquid Propulsion Engineer with NASA.
    - 10 years as Shuttle OMS/RCS Test Engineer at Kennedy Space Center.
    - 10 years as Spacecraft Liquid Propulsion System Development Engineer at MSFC.
- Current: Sr. Engineer, Spacecraft Liquid Propulsion Systems.
- Bachelor of Science, Mechanical Engineering, Louisiana Tech University, 1987
- Master of Science, Engineering Management, University of Central Florida, 1996
- Model rocketry experience during childhood
- Grew up during the “Space Race” – Mercury, Gemini, Apollo, etc.
- Strong interest in math and physics through high school.
- Rekindled interest in model and high-power rocketry as an adult.
- Member of NAR and TRA, with Level 3 Certification.
- Past President or the Huntsville Area Rocketry Association (HARA), 2001 to 2005.
- Contact via email: charles.pierce@nasa.gov

7. Beverly Peterson: Safety/Panel Member

Beverly is a Safety and Occupational Health Specialist in the MSFC Industrial Safety Department responsible for personnel and facility safety which includes: OSHA (Occupational Safety and Health Administration) compliance, NASA, and MSFC safety policies and requirements.

She strives to prevent human injury and occupational illnesses and safety of all operations and products (by any means at her disposal). In addition, she also interfaces with NASA training for personnel safety certification. She has been a Safety and Occupational Health Specialist for 8 years and has 24 years government service.

Proposal

TIMELINE

(Dates are subject to change.)

August 2007:

10: Request for Proposal goes out to all schools.

September 2007:

7: Distance Learning Event for new teams *(required)*
14: Workshop confirmation required

October 2007:

8: One hardcopy and one electronic version of the completed proposal due to NASA/MSFC.

Send Hardcopy to:
Al Krause
Marshall Space Flight Center
HS30
Huntsville, AL 35812

Send Electronic Copy to:
al.krause@msfc.nasa.gov
julie.d.clift@msfc.nasa.gov
dawn.mercer@msfc.nasa.gov

12: Workshop for new teams *(recommended)*
22: Awards granted. Schools notified of selection.
23: USLI Teams Teleconference *(tentative)*
30: NASA media announces new 2006-2007 SLI Teams

November 2007:

12: Web presence established for each team.

December 2007:

3: Preliminary Design Review Report due

January 2008:

28: Critical Design Review Presentation Slides and CDR Report due

February 2008:

4: Critical Design Review *(tentative)*

March 2008:

31: Flight Readiness Review Presentation Slides and FRR Report due

April 2008:

7: Flight Readiness Review *(tentative)*
18: Flight Hardware Check *(tentative)*
19: Launch Day *(Rain date of April 20)*

May 2008:

12: Post-Launch Assessment Review
26: Announcement of winning USLI team

Design, Development, & Launch of a Reusable Rocket & Science Payload Statement of Work

NASA University Student Launch Initiative (USLI)
Education Programs Department
Period of Performance – Eight (8) months

The Academic Affairs Office at the NASA Marshall Space Flight Center (MSFC) will partner with universities to sponsor the NASA University Student Launch Initiative (USLI) Rocket and Payload Teams during the school calendar year of 2007-2008. The NASA USLI is designed to engage students at the university level in a learning opportunity that involves design, construction, test, and launch of a reusable launch vehicle and science-related payload. The initiative is intended to encourage students to pursue careers in engineering or science-related fields. Teaming with engineers from government, business, and academia, students get a hands-on, inside look at the science and engineering professions. The selected universities will sponsor student teams who will each build and launch a reusable rocket carrying the students' science payload that will launch in the spring of 2008.

USLI is a rocket and payload-building challenge designed for university students. It requires an eight (8) month commitment to successfully design, construct, test, launch, and recover a reusable rocket and science payload. The initiative is more than designing and building a rocket from a commercial kit. It involves diverse aspects such as: scheduling, purchasing, performing calculations, financing the project, coordinating logistics, arranging press coverage, and documenting impact made on education through reports and design reviews. Universities are encouraged to involve a diverse group of departments such as mathematics, science, technology, English, journalism, and art.

All new teams to the USLI project are required to be present for a video teleconference in early September. These same teams will then have the option to attend a workshop during October to be held in Huntsville, AL. While the workshop is optional, attendance is recommended for at least one team member, especially for teams with little experience in high powered rocketry.

All teams, new and returning, must still propose to be a part of the USLI project. All accepted teams will be required to adhere to the requirements for all formal reviews. These include a Preliminary Design Review, Critical Design Review, Flight Readiness Review, Post-Launch Assessment Review, and other reviews as assigned by the USLI panel.

The performance targets for the reusable launch vehicle and payload are:

- The vehicle shall carry a science payload.

- The vehicle shall be developed so that it delivers the science payload to a specific altitude of 5,280 feet above ground level (AGL). The team whose rocket and payload comes the closest (plus or minus) to this altitude best meets this target.

- The vehicle shall carry a Perfect Flight MAWD or ALT15 altimeter for recording of the official altitude used in the competition scoring. Teams may have additional altimeters to control vehicle electronics and payload experiments.

- The launch vehicle and science payload shall be designed to be recoverable and reusable.

- Deployment of the main parachute at apogee is not advised. Separating at apogee increases the risk of drifting outside of the recovery area.

- Preparation of the vehicle and payload on launch day shall not exceed 4 hours.

- Data from the science payload shall be collected, analyzed, and reported by the team following the scientific method.

- A tracking device shall be placed on the vehicle allowing the rocket and payload to be recovered after launch.

- Only Commercially-available, NAR-approved motors (this also covers motors tested by the TRA and CAR, as all three motor-testing organizations accept each other's certifications) shall be used.
  - Solid motor propulsion shall use commercially available ammonium perchlorate composite propellant (APCP) motors
  - Hybrid motors will be allowed with the following understandings:
    - The motors must be commercial motors
    - There will be a strict launch window of 4 hours from the time of arrival at the launch site- NO EXCEPTIONS
    - Teams will have many more issues to defend during review

- Each team shall be responsible for providing their launch equipment if possible, especially if using hybrid motors. The Huntsville Area Rocketry Association (HARA) has launch assets (controller, pads) that can be used for APCP rocket launches and has limited hybrid capability. HARA will provide nitrous oxide and oxygen at the launch site at $1/100cc of tank volume. School teams are certainly welcome, and encouraged, to bring their own hybrid oxidizers.

- All teams, including hybrid motor teams, must launch their full scale rocket prior to launch. The purpose of this test is to test the vehicle structural and recovery systems. A sub-scale motor could be used for the flight tests.

At a minimum, the proposing team shall identify the following in a written proposal due to NASA Marshall by October 8th, 2007:

School Information

1. Name/Title of Project

2. Name and title of the administrative staff member (this person will be referred to as the "team official") dedicated to the project

3. If using APCP motors, each school team shall identify the name and title of a team member who holds an explosives permit with the Bureau of Alcohol, Tobacco, Firearms, and Explosives.

4. Name and title the individual who will take responsibility for implementation of the safety plan. (Safety Officer)

5. Approximate number of student participants who will be committed to the project and their proposed duties. Include an outline of the project organization that identifies the key managers (students and/or administrators) and the key technical personnel. Short resumes should be included in the report for these key positions.

Facilities/Equipment

1. Description of facilities and hours of accessibility that will be used for the design, manufacture, and test of the rocket components, the rocket, and the science payload.

2. Necessary personnel, facilities, equipment, and supplies (not otherwise provided by the Government) that are required to design and build a competitive rocket and payload. The university shall make provisions for verifying the altitude of the rocket.

3. Computer Equipment: Describe the type of computer equipment accessible to participants for communications; for designing, building and hosting a team web site; and for document development to support design reviews. The school shall provide and maintain a web presence where the status of the project will be posted, as well as a list of needed materials and/or expertise. The team official will provide the capability to communicate via e-mail on a daily basis with the NASA USLI Program Manager. Be sure to include:
    a. The information technology identified could include computer hardware, computer-aided drafting (CAD) system capability
    b. Internet access
    c. e-mail capability
    d. presentation simulation software

    The school shall provide the additional computer equipment needed to perform Video Teleconferencing. Minimum requirements include:
    e. broadband connection
    f. Windows Vista, XP, 2K, ME or 98
    g. Microphone Headset and/or speaker phone capabilities in close proximity to the computer

h. Firewall, USB, and analog video camera
i. Personnel name and contact information for firewall issues

OR

j. Video Teleconferencing Equipment

Please indicate the preferred method of teleconferencing with MSFC.

Safety & Mission Assurance

The Federal Aviation Administration (FAA) [www.faa.gov] has specific laws governing the use of airspace. A demonstration of the understanding and intent to abide by the applicable federal laws (especially as related to the use of airspace at the launch sites and the use of combustible/flammable material), safety codes, guidelines, and procedures for building, testing, and flying large model rockets is crucial. The procedures and safety regulations of the National Association of Rocketry (NAR) [http://www.nar.org/safety.html] should be used for flight design and operations. **If solid propellant is chosen for the rocket design, a NAR certification is required for solid propellant handling.** Lead educators and NAR/TRA mentors shall oversee launch operations and motor handling.

1. Each school team shall have at least one team member (student, mentor, and/or faculty) who is a current member of the National Association of Rocketry (NAR) and **who personally holds a certification for the class of motor they plan to fly**. This is needed to insure that the liability insurance, provided through the NAR, will cover the rocket launch. ***The NAR/TRA member must be LEVEL 2 certified before launch day, April 19th 2008. One level 2 mentor MUST accompany the team to the SLI launch in April.***

2. Written safety plan addressing the safety of the materials used, facilities involved, and person responsible for insuring that the plan is followed. A risk assessment should be done for all these aspects in addition to proposed mitigations. Identification of risks to the successful completion of the project should be included.
   Please include the following safety requirements in your report:

   (a.) Provide a description of the plans for National Association of Rocketry (NAR) personnel to perform or ensure the following:

   - Compliance with NAR high power safety code requirements [http://nar.org/NARhpsc.html]
   - Performance of all hazardous materials handling and hazardous operations.
   - Compliance with all environmental laws and regulations

   (b.) Describe the plan for briefing students on hazard recognition and accident avoidance, and conducting pre-launch briefings.

   (c.) Describe methods to include necessary caution statements in plans, procedures and other working documents.

For example: Control of all hazardous materials (Applicable MSDS: Materials Safety Data Sheets for your project must be included in your proposal under safety plan.)
[www.msdss.com/SearchPage.asp]
[http://ehs.cornell.edu/msdssrch.asp]

3. Each school team shall provide evidence that they are cognizant of federal, state, and local laws regarding un-manned rocket launches and motor handling. Specifically, regarding the use of airspace, Federal Aviation Regulations 14 CFR, Subchapter F, Part 101, Subpart C; the handling and use of low-explosives (Ammonium Perchlorate Rocket Motors, APCP), Code of Federal Regulation Part 55 (note: these regulations are not applicable to most hybrid motors); and fire prevention, NFPA 1127 "Code for High Power Rocket Motors."

4. If using APCP motors, each school team shall provide the name and level of a team member who holds an explosives permit with the Bureau of Alcohol, Tobacco, Firearms, and Explosives.

5. Each school team shall provide a plan to possess the capability to purchase, store, transport, and use their own rocket motors. This is especially applicable to APCP motors.

6. Each team traveling to Huntsville for a rocket launch shall describe in detail their plan to maintain full control of their motor(s), per all applicable federal laws, from purchase of the motors until the motors are used. Specifically, this means that out-of-town schools would have a team member with a current Low Explosives User's Permit (or comparable) who purchases and transports APCP motors to Huntsville and takes personal responsibility for the motor until it is expended. This is especially applicable to the purchase/use of APCP motors.

7. A written statement that all team members understand and will abide by the following safety regulations:

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

    b) The HARA Range Safety Officer has the final say on all rocket safety issues. Therefore, the HARA Range Safety Officer has the right to deny the launch of any rocket for safety reasons

    c) Any team that is found non compliant with Safety & Mission Assurance (S&MA) will not fly their rocket.

Technical Design

1. A proposed and detailed approach to rocket and payload design.
    a. Include projected general vehicle dimensions
    b. Include projected motor type and size

c. Include a projected science payload
d. Address the primary requirements for rocket and payload
e. Include major challenges and solutions.

Outreach

1. A written plan for soliciting additional "community support," which could include, but is not limited to, expertise needed, additional equipment/supplies, monetary donations, services (such as free shipping for launch vehicle components, if required, advertisement of the event, etc.), or partnering with industry or other public, private, or parochial universities.

2. Include plans of at least two outreach projects that engage a combined total of 50 or more younger students in rocketry. Comprehensive feedback on the activities must be developed.

Project Plan

1. A top-level development schedule/timeline which should outline the project milestones and the basic schedule for designing, building, testing, and launching the rocket and payload(s).

2. Budget for all proposed activities. This should include a detailed plan on how the project will be funded.

Second Year or Returning Teams should also include the following:

1. Develop a clear plan for sustainability of the rocket program in the local area. This plan should include how to provide and maintain established partnerships and regularly engage successive classes of students and rocketry. It should also include partners (industry/community), recruitment of students, funding sustainability, and community outreach.

2. A similar rocket project can be proposed if the team is mostly new students who were not involved in the previous year's work, but this needs to be shown. Otherwise the team of returning students must show an advanced project appropriate to a second year of expertise. Keep in mind that veteran teams get no preference in the evaluations and must still compete against all the other school proposals. All reviews must have the required level of detail and must not assume that board/panel remembers what had been accomplished the previous year.

Prior to award, all proposing entities may be required to brief NASA representatives. The time and the place for the briefings will be determined by the NASA/MSFC Education Programs Department.

Deliverables shall include:

1. A reusable rocket and science payload (available for NASA/MSFC display) ready for launch in April of 2008.

2. A scale model of the rocket design with a payload prototype should be flown before Critical Design Review (CDR). A report of the data from the flight as well as the model should be brought to the CDR.

3. Reports and PowerPoint presentations due on December 3, January 28, and March 31 shall be submitted to the Academic Affairs Office on time. Reports and presentations must also be posted on the team website by the due date. *(Dates are tentative at this point. Final dates will be announced at time of award.)*

4. The Post-Launch assessment Review (PLAR) for the rocket and payload shall be due to the MSFC Academic Affairs Office no later than May 12th, 2008.

5. The team(s) shall have a web presence no later than November 12th. The web site shall be maintained/updated throughout the school year. It will be judged at random times throughout the year.

6. Copies of any other products developed (journal, 3-D animation, media coverage, video, scrapbook, etc.) shall be displayed during launch.

7. A safety plan outlining how NAR safety requirements will be implemented and how safety will be incorporated into all manufacturing, testing, and launching activities. The risk assessment will include such things as (but not limited to): risks associated with faculty support, school support, financial/sponsor support, use of facilities, partnering arrangements, schedule risks, risks associated with chosen designs. This will be updated throughout the program and presented at the Critical Design Review (CDR) and Flight Readiness Review (FRR). The initial plan will be due with the Preliminary Design Review on December 3rd, 2007.

The team(s) shall participate in a Preliminary Design Review (PDR) (December 3rd, 2007), Critical Design Review (CDR) (January 28th, 2008), Flight Readiness Review (FRR) (March 31st, 2008), and Launch (April 19th, 2008). *(Dates are tentative and subject to change.)*

The PDR, CDR, and FRR will be presented to NASA at a time and location to be determined by NASA/MSFC Academic Affairs Office. **The presentation will be done using Video Teleconferencing/Web casting capabilities and PowerPoint and should be available on the team website no later than 7 days prior to the review board meetings.**

Vehicle/Payload Criteria

Preliminary Design Review
Vehicle and Payload Experiment Criteria

The PDR demonstrates that the overall program preliminary design meets all requirements with acceptable risk and within the cost and schedule constraints and establishes the basis for proceeding with detailed design. It shows that the correct design options have been selected, interfaces have been identified, and verification methods have been described. Full baseline cost and schedules, as well as all risk assessment, management systems, and metrics are presented. (NPR 7120.5D p.30)

The panel will be expecting a professional and polished report. Please use Arial, size 12 font for your PDR Report. It is advised to follow the order of sections as they appear below.

Preliminary Design Review Report

I) Summary of PDR report (1 page maximum)

Team Summary

- School name
- Location
- Mentors

Launch Vehicle Summary

- Size
- Motor choice
- Recovery system

Payload Summary

- Summarize experiment

II) Changes made since Proposal (1-2 pages maximum)

Highlight all changes made since the proposal and the reason for those changes.

- Changes made to Vehicle Criteria
- Changes made to Payload Criteria
- Changes made to Activity Plan

III) Vehicle Criteria

Selection, Design, and Verification of Launch Vehicle

- Mission Statement, Requirements, and Mission Success Criteria
- Major Milestone Schedule(Project Initiation, Design, Manufacturing, Verification, Operations, and Major Reviews)

- Review the design at a system level, going through each system's functional requirements (Includes sketches of options, selection rationale, selected concept and characteristics)
- Describe the subsystems that are required to accomplish the overall mission:
- Describe the performance characteristics for the system and subsystems and determine the evaluation and verification metrics.
- Describe the verification plan and its status.
- Define the risks and the plans for reducing the risks through analysis or testing for each system. A risk plot that clearly portrays the risk mitigation schedule is highly encouraged. Take all factors that might affect the project including risks associated with testing, delivery of parts, adequate personnel, school holidays, budget costs, etc. Demonstrate an understanding of all components needed to complete the project and how risks/delays impact the project
- Demonstrate planning of manufacturing, verification, integration, and operations. (Include component testing, functional testing, or static testing)
- Confidence and maturity of design
- Include a dimensional drawing of entire assembly, such as a Rocksim graphic.

Recovery Subsystem *(Highlighted Because of Criticality)*
- Demonstrate that analysis has begun to determine size for mass, attachment scheme, deployment process, test results with ejection charge and electronics

Mission Performance Predictions *(Highlighted Because of Criticality)*
- State mission performance criteria
- Show flight profile simulations, altitude predictions with simulated vehicle data, component weights, and simulated motor thrust curve
- Show Stability margin, simulated CP: Center of Pressure/ CG: Center of Gravity relationship and locations

Payload Integration
- Describe integration plan with an understanding that the payload must be co-developed with the vehicle, be compatible with stresses placed on the vehicle and integrate easily and simply.

Launch Operation Procedures
- Determine what type of launch system and platform will be used
- Develop an outline of final assembly and launch procedures

Safety and Environment (Vehicle)
- Identify Safety Officer for your team
- Provide a Preliminary analysis of the failure modes of the proposed design of the rocket, payload integration and launch operations, including proposed and completed mitigations.
- Provide a listing of personnel hazards, and data demonstrating that Safety Hazards have been researched (such as Material Safety Data Sheets, operator's manuals, NAR regulations), and that hazard mitigations have been addressed and mitigated.
- Discuss any environmental concerns.

II) Payload Criteria

Selection, Design, and Verification of Payload Experiment

- Review the design at a system level, going through each system's functional requirements (includes sketches of options, selection rationale, selected concept and characteristics)
- Describe the payload subsystems that are required to accomplish the payload objectives
- Describe the performance characteristics for the system and subsystems and determine the evaluation and verification metrics.
- Describe the verification plan and its status.
- Describe preliminary integration plan
- Determine the precision of instrumentation, repeatability of measurement and recovery system

Payload Concept Features and Definition

- Creativity and originality
- Uniqueness or significance
- Suitable level of challenge

Science Value

- Describe Science Payload Objectives
- State the payload success criteria
- Describe the experimental logic, approach, and method of investigation
- Describe test and measurement, variables and controls
- Show relevance of expected data, accuracy/error analysis
- Describe the Preliminary Experiment process procedures

Safety and Environment (Payload)

- Identify Safety Officer for your team
- Provide a Preliminary analysis of the failure modes of the proposed design of the rocket, payload integration and launch operations, including proposed and completed mitigations.
- Provide a listing of personnel hazards, and data demonstrating that Safety Hazards have been researched (such as Material Safety Data Sheets, operator's manuals, NAR regulations), and that hazard mitigations have been addressed and mitigated.
- Discuss any environmental concerns.

IV) Activity Plan

Show status of activities and schedule

- Budget plan
- Timeline
- Outreach summary

V) Conclusion

Critical Design Review
Vehicle and Payload Experiment Criteria

The CDR demonstrates that the maturity of the program's design is appropriate to support proceeding full-scale fabrication, assembly, integration, and test and that the technical effort is on track to complete the flight and ground system development and mission operations in order to meet overall performance requirements within the identified cost and schedule constraints. Progress against management plans, budget, and schedule, as well as risk assessment, are presented. (NPR 7120.5D p.30)

The panel will be expecting a professional and polished report. Please use Arial, size 12 font for your CDR Report. It is advised to follow the order of sections as they appear below.

Critical Design Review Report

I) Summary of CDR report (1 page maximum)

Team Summary

- School name
- Location
- Teachers/Mentors

Launch Vehicle Summary

- Size
- Motor choice
- Recovery system
- Rail size

Payload Summary

- Summarize experiment

II) Changes made since PDR

Highlight all changes made since PDR and the reason for those changes.

- Changes made to Vehicle Criteria
- Changes made to Payload Criteria
- Changes made to Activity Plan

III) Vehicle Criteria

Design, and Verification of Launch Vehicle

Flight Reliability confidence

- Mission Statement, Requirements, and Mission Success Criteria

- Major Milestone Schedule(Project Initiation, Design, Manufacturing, Verification, Operations, and Major Reviews)
- Review the design at a system level
  - Updated drawings and specifications
  - Analysis results
  - Test results
  - Preliminary Motor Selection
- Demonstrate that the design can meet all system level functional requirements
- Specify approach to workmanship as it relates to mission success
- Discuss planned additional component testing, functional testing, or static testing
- Status and plans of remaining manufacturing and assembly
- Integrity of design
  - Suitability of shape, fin style for mission
  - Proper use of materials in fins, bulkheads, and structural elements
  - Proper assembly procedures, proper attachment and alignment of elements, solid connection points, load paths
  - Sufficient motor mounting and retention
  - Status of verification
- Safety and failure analysis

Recovery Subsystem

- Suitable parachute size for mass, attachment scheme, deployment process, test results with ejection charge and electronics
- Safety and failure analysis

Mission Performance Predictions

- State the mission performance criteria
- Show flight profile simulations, altitude predictions with real vehicle data, component weights, and actual motor thrust curve
- Show thoroughness and validity of analysis, drag assessment, scale modeling results
- Show stability margin, actual CP CG relationship and locations

Payload Integration

Ease of integration

- Describe integration plan
- Installation and removal, interface dimensions and precision fit
- Compatibility of elements
- Simplicity of integration procedure

Launch concerns and operation procedures

- Submit draft of final assembly and launch procedures
- Recovery preparation
- Motor preparation
- Igniter installation
- Setup on launcher
- Troubleshooting
- Post flight inspection

Safety and Environment (Vehicle)

- Identify Safety Officer for your team

- Update the Preliminary analysis of the failure modes of the proposed design of the rocket, payload integration and launch operations, including proposed and completed mitigations.
- Update the listing of personnel hazards, and data demonstrating that Safety Hazards have been researched (such as Material Safety Data Sheets, operator's manuals, NAR regulations), and that hazard mitigations have been addressed and mitigated.
- Discuss any environmental concerns.

IV) Payload Criteria

Testing and Design of Payload Experiment

- Review the design at a system level
  - Drawings and specifications
  - Analysis results
  - Test results
  - Integrity of design
- Demonstrate that the design can meet all system level functional requirements
- Specify approach to workmanship as it relates to mission success
- Discuss planned component testing, functional testing, or static testing
- Status and plans of remaining manufacturing and assembly
- Describe integration plan
- Precision of instrumentation, repeatability of measurement
- Safety and failure analysis

Payload Concept Features and Definition

- Creativity and originality
- Uniqueness or significance
- Suitable level of challenge

Science Value

- Describe Science Payload Objectives
- State the payload success criteria
- Describe the experimental logic, approach, and method of investigation
- Describe test and measurement, variables and controls
- Show relevance of expected data, accuracy/error analysis
- Describe the experiment process procedures

Safety and Environment (Payload)

- Identify Safety Officer for your team
- Update the Preliminary analysis of the failure modes of the proposed design of the rocket, payload integration and launch operations, including proposed and completed mitigations.
- Update the listing of personnel hazards, and data demonstrating that Safety Hazards have been researched (such as Material Safety Data Sheets, operator's manuals, NAR regulations), and that hazard mitigations have been addressed and mitigated.
- Discuss any environmental concerns.

V) Activity Plan

Show status of activities and schedule

- Budget plan
- Timeline
- Outreach summary

VI) Conclusion

Critical Design Review Presentation

Please include the following information in your presentation:

- Rocket flight stability in Rocksim static margin diagram
- Thrust to weight motor selection in flight simulation
- Rail exit velocity
- Parachute sizes and descent rates
- Test plans and procedures
- Scale model flight test
- Dual deployment avionics test
- Ejection charge amount test
- Payload integration feasibility

The Critical Design Review will be presented to a panel that may be comprised of any combination of scientists, engineers, safety experts, education specialists, and industry partners. It is expected that the **students** deliver the report and answer all questions.

The presentation of the CDR shall be well prepared with a professional overall appearance. This includes but is not limited to: easy to see slides; appropriate placement of pictures, graphs, and videos; professional personal appearance of the presenters; speaking clearly and loudly; looking into the camera; referring to the slides-not reading them; and communicating to the panel in an appropriate and professional manner.

Flight Readiness Review
Vehicle and Payload Experiment Criteria

The FRR examines tests, demonstrations, analyses, and audits that determine the overall system (all projects working together) readiness for a safe and successful flight/launch and for subsequent flight operations. It also ensures that all flight and ground hardware, software, personnel, and procedures are operationally ready. (NPR 7120.5D p.30)

The panel will be expecting a professional and polished report. Please use Arial, size 12 font for your PDR Report. It is advised to follow the order of sections as they appear below.

Flight Readiness Review Report

I) Summary of FRR report (1 page maximum)

Team Summary

- School name
- Location
- Teachers/Mentors

Launch Vehicle Summary

- Size
- Motor choice (Final)
- Recovery system
- Rail size

Payload Summary

- Summarize experiment

II) Changes made since CDR

Highlight all changes made since CDR and the reason for those changes.

- Changes made to Vehicle Criteria
- Changes made to Payload Criteria
- Changes made to Activity Plan

III) Vehicle Criteria

Testing and Design of Vehicle

Flight Reliability confidence. Demonstrate that the design can meet mission success criteria. Discuss analysis, component testing, functional testing, or static testing.

- Describe proper use of materials in fins, bulkheads, and structural elements. Explain composition and rationale behind selection.
- Explain strength of assembly, proper attachment and alignment of elements, solid connection points, and load paths. (Looking for optimum assembly quality.)
- Shows sufficient or exemplary motor mounting and retention.
- Integrity of design- used analysis to improve design. Suitability of shape, fin style for mission.
- Specify approach to workmanship as it relates to mission success. Neatness of workmanship, quality of appearance, attractiveness
- Safety and failure analysis. Include table with failure modes, causes, effects, and risk mitigations.

Recovery Subsystem
- Suitable parachute size for mass, attachment scheme, deployment process, test results with ejection charge and electronics
- Safety and failure analysis. Include table with failure modes, causes, effects, and risk mitigations.

Mission Performance Predictions
- State the mission performance criteria
- Flight profile simulations, altitude predictions with real vehicle data, component weights, and actual motor thrust curve. Include real values with optimized design for altitude. Include sensitivities.
- Thoroughness and validity of analysis, drag assessment, scale modeling results. Compare math analysis and models to measured values.
- Stability margin, actual CP CG relationship and locations. Include dimensional moment diagram **or** derivation of values with points indicated on vehicle. Include sensitivities.
- Safety and failure analysis. Include table of failure models, causes, effects, and risk mitigations.

Safety and Environment (Vehicle)
- Identify Safety Officer for your team
- Update the Preliminary analysis of the failure modes of the proposed design of the rocket, payload integration and launch operations, including proposed and completed mitigations.
- Update the listing of personnel hazards, and data demonstrating that Safety Hazards have been researched (such as Material Safety Data Sheets, operator's manuals, NAR regulations), and that hazard mitigations have been addressed and mitigated.
- Discuss any environmental concerns.

Payload Integration
- Describe integration plan
- Compatibility of elements- show fit at interface dimensions.
- Payload housing integrity- describe and justify.
- Demonstration of integration- show diagram of components and assembly with documented process.

IV) Payload Criteria

The approach for evaluating the USLI science payloads will be similar to judging a 'science fair' project. The payload will also be evaluated on actual flight worthiness as the rocket is; however, the majority of the payload evaluation focuses on experiment value and potential scientific results.

Experiment Concept
This concerns the quality of science. Give clear, concise, and descriptive explanations.

- Creativity and originality
- Uniqueness or significance
- Suitable level of challenge

Science Value
Describe Science Payload Objectives in a concise and distinct manner

- State the mission success criteria
- Describe the experimental logic, scientific approach, and method of investigation
- Explain how it is a meaningful test and measurement, explain variables and controls
- Relevance of expected data, accuracy/error analysis (include: tables and plots)
- Detailed experiment process procedures.

Experiment Design of Payload
Review the design at a system level, describe integration plan, and demonstrate that the design can meet all mission goals.

- Precision of instrumentation, repeatability of measurement. (Include calibration with uncertainty included.)
- Application of engineering, functionality, feasibility
- Flight performance predictions (flight values integrated with detailed experiment operations.)
- Flight preparation procedures
- Specify approach to workmanship as it relates to mission success
- Discuss completed component testing, functional testing, or static testing

Assembly
Give clear details of how it is put together.

- Integration and compatibility simplicity
- Structural integrity for flight
- Quality of construction

Safety and Environment (Payload)
This will describe all concerns, research, and solutions to safety issues related to the payload.

- Identify Safety Officer for your team

- Update the Preliminary analysis of the failure modes of the proposed design of the rocket, payload integration and launch operations, including proposed and completed mitigations.
- Update the listing of personnel hazards, and data demonstrating that Safety Hazards have been researched (such as Material Safety Data Sheets, operator's manuals, NAR regulations), and that hazard mitigations have been addressed and mitigated.
- Discuss any environmental concerns.

V) Launch Operations Procedures

Checklist
Provide detailed procedure and check lists for the following.

- Recovery preparation
- Motor preparation
- Igniter installation
- Setup on launcher
- Launch procedure
- Troubleshooting
- Post flight inspection

Safety and Quality Assurance
Provide detailed safety procedures for each of the categories in the Launch Operations Procedures. Include the following:

- Provide data demonstrating that risks are at acceptable levels.
- Risk assessment for the launch operations, including proposed and completed mitigations.
- Discuss environmental concerns.
- Identify individual that is responsible for maintaining safety, quality and procedures checklist.

VI) Activity Plan

Show status of activities and schedule

- Budget plan
- Timeline
- Outreach summary

VII) Conclusion

Flight Readiness Review Presentation

Please include the following information in your presentation

- Rocket flight stability in Rocksim static margin diagram
- Thrust to weight motor selection in flight simulation
- Rail exit velocity
- Parachute sizes and descent rates
- Test plans and procedures
- Scale model flight test
- Dual deployment avionics test
- Ejection charge amount test
- Payload integration feasibility

The Flight Readiness Review will be presented to a panel that may be comprised of any combination of scientists, engineers, safety experts, education specialists, and industry partners. It is expected that the **students** deliver the report and answer all questions.

The presentation of the FRR shall be well prepared with a professional overall appearance. This includes but is not limited to: easy to see slides; appropriate placement of pictures, graphs, and videos; professional personal appearance of the presenters; speaking clearly and loudly; looking into the camera; referring to the slides-not reading them; and communicating to the panel in an appropriate and professional manner.

Launch Readiness Review
Vehicle and Payload Experiment Criteria

The Launch Readiness Review (LRR) is the final review prior to actual launch in order to verify that Launch System and Spacecraft/Payloads are ready for launch. (NPR 7120.5D p.30)

The Launch Readiness Review will be conducted by National Association of Rocketry (NAR) members in person one or two days prior to launch if possible. Students should be well prepared to answer any and all questions about their rocket. Mentors will be asked to remain to the side during the LRR. Only upon specific direction of the NAR personnel conducting the LRR should a mentor become involved.

Rockets certified by NAR personnel will be able to fly during the official SLI launch. Teams needing to make repairs or changes as a result of the initial LRR results can request a second LRR to occur on launch day. NAR personal will reevaluate the rocket for launch readiness and make a determination on whether to allow the rocket to launch at that time. Teams who need to conduct their LRR on launch day due to travel restrictions will still be held to the launch window of 4 hours.

Post-Launch Assessment Review

Vehicle and Payload Experiment Criteria

The Post-Launch Assessment Review (PLAR) is an assessment of system in-flight performance. (NPR 7120.5D p.30)

Instructions for completing the PLAR will be given around the time of launch.

Safety

WELCOME TO THE NATIONAL ASSOCIATION OF ROCKETRY

High Power Rocket Safety Code

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 not allow smoking, open flames, nor heat sources within 25 feet of 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 launch pad or in a designated 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. I will ensure that no person is closer to the launch pad than allowed by the accompanying Minimum Distance Table, and that a means is available to warn participants and spectators in the event of a problem. 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 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 dry grass is cleared around each launch pad in accordance with 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, nor 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 is likely to recover in spectator areas or outside the launch site, nor attempt to catch it as it approaches the ground.

MINIMUM DISTANCE TABLE

Installed Total Impulse (Newton-Seconds)	Equivalent High Power Motor Type	Minimum Diameter of Cleared Area (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 -- 1,280.00	J	50	100	200
1,280.01 -- 2,560.00	K	75	200	300
2,560.01 -- 5,120.00	L	100	300	500
5,120.01 -- 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

Revision of July 2006

Failures, Hazards and Risk

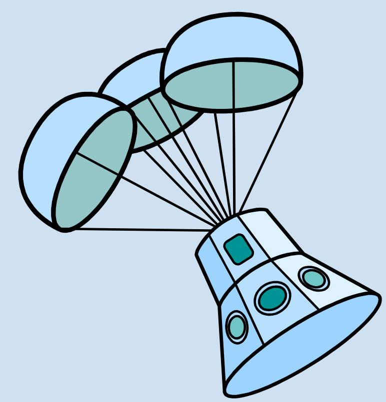
How to Identify, Track and Mitigate

Examples from Home

- Getting to work on time ("mission success")
  - **Risks**: weather, traffic jam, alarm doesn't ring
    - How do we plan for these risks?
  - **Failure**: the car doesn't start
    - How do we try to make sure that it will start?
  - **Hazard**: bad roads, other drivers, sudden changes in traffic flow
    - How do we plan for this and avoid problems?
- Getting to work on time means that we have recognized the risks, failure modes, and hazards, and have taken action to reduce their probability and impact.
- This same approach improves the probability of success for a project.

Risk Definition

- The combination of the probability of an undesired event and the consequences, impact, or severity of the event.
- Risk assessment includes
  - What can go wrong
  - How likely is it to occur
  - What the consequences are
- Risk Mitigation is
  - Application of methods to lessen the probability and/or impact of the undesired event



Examples of Risk

- Planned design will be over budget
- Key personnel will leave the program
- Unavailability of equipment when needed to support schedule
- Students have many other demands on time and do not have time to finish the project
- Parts unavailability
- Mishaps
- Communication issues
- Bad weather on launch day

Risk Management

- “Risk management is a continuous process that
  - identifies risks;
  - analyzes their impact and prioritizes them;
  - develops and carries out plans for risk mitigation or acceptance;
  - tracks risks and the implementation of mitigation plans;
  - supports informed, timely, and effective decisions to control risks and mitigation plans;
  - and assures that risk information is communicated and documented.
  - Risk management is driven by established success criteria and is performed by the whole team”
  - (from NASA Program and Project Management Processes and Requirements)

Examples of Tables to Include in PDR, CDR, FRR

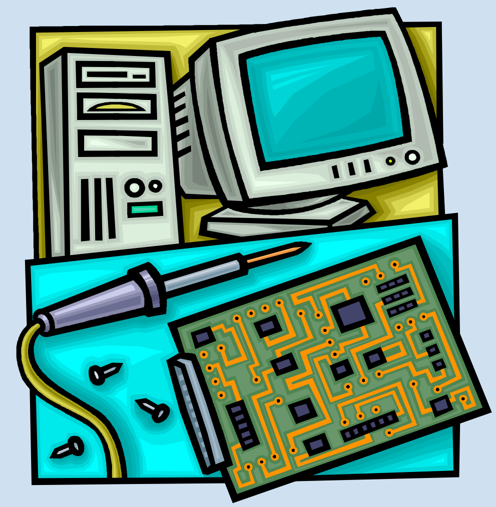
Risk	Probability	Impact	Mitigation
Project falls behind schedule due to multiple demands on time	Highly probable	Late delivery of PDR, CDR, FRR; incomplete project	Create a schedule with margin for problems, track progress; divide work among team
Parts are unavailable	Probability is low	Last minute design changes	Have design options and multiple sources; finalize design and order parts early
Key personnel leave project	Probability is low	Extra work for members; late delivery; incomplete project	Have primary and backup assignments; document activities; communicate
Project is over budget	Highly probably	Last minute design changes for cost cutting; incomplete project	Track progress; have multiple funding sources

Failures

- During the rocket design process, each component and system should be analyzed for failure modes:
  - How can it fail
  - What are the consequences of the failure
  - How can the failure be prevented
- This includes system integration and ground support equipment, as well as the rocket and payload
- Document the analysis and update as necessary

Failure Examples

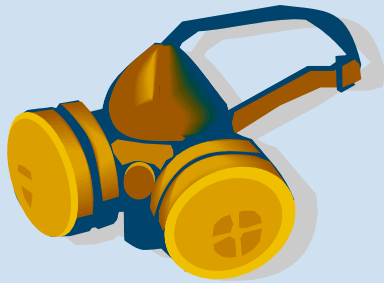
- Parachutes fail to deploy
- Failure to ignite
- Unstable flight
- Failure to collect data
- Power loss



Examples of Tables to Include in PDR, CDR, FRR

Failure Modes and Effects Analysis of Propulsion System
Propulsion Team: Daniel Chhitt, Jason Back

Function	*Potential Failure Mode*	*Potential Effects of Failure*	*Failure Prevention*
1	Propellant fails to ignite.	Total mission failure, rocket does not take off.	Proper ignition system setup.
2	Propellant ignites but extinguishes before desired burn time.	Rocket may not reach desired height, payload failure.	Proper motor and propellant inspection and testing.
3	Motor mounting fails and motor launches through the rocket.	Possible destruction of all systems; avionics, recovery, payload	Proper motor mounting structure and load testing of mounting structure.
4	Propellant ignites but causes a catastrophic explosion.	Possible destruction of all systems; avionics, recovery, payload, structure.	Proper motor and propellant inspection and testing.
5	Propellant ignites but burns through motor casing.	Severe loss of stability, possible destruction of all systems.	Proper testing of motor casing and propellant.
6	Motor casing becomes detached during flight.	Rocket may not reach desired height, motor becomes a projectile.	Proper testing and mounting of motor casing to the structure.

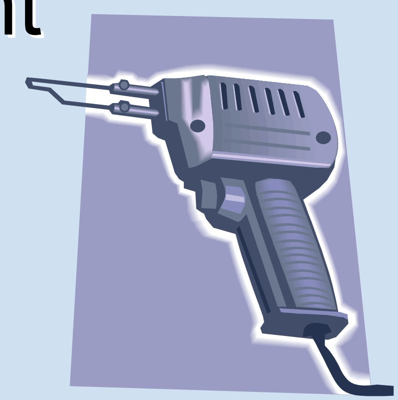


Hazards

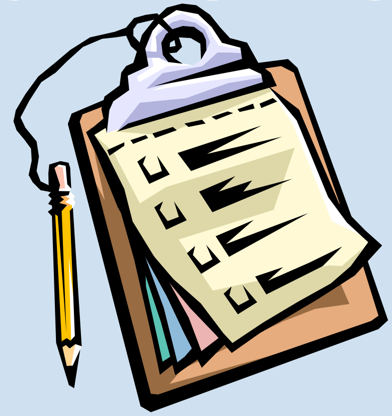
- The project can be done safely and successfully, but a few hazards must be clearly recognized, understood, and mitigated.
- Safety of the students is NASA’s first priority and must never be compromised.
- There are many resources available to help with this concern.

Hazard Examples

- Adhesives, solvents, and paint
- Black Powder and solid propellant
- Use of Tools
- Launch site failures
- Pressurized/cold hybrid systems
- Other hazards associated with a particular design



Safety Resources and Methods



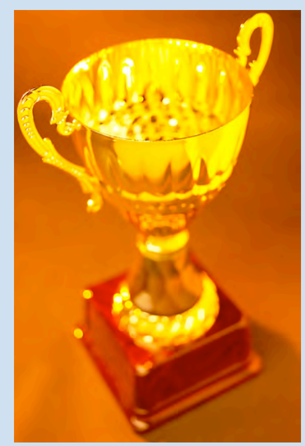
- NAR Safety Codes and Mentors
- NAR certifications and training
- Material Safety Data Sheets
- Operators Manuals
- Development and adherence to assembly and launch procedures
- Equipment, such as goggles, gloves, sturdy shoes, hard hats, cotton clothing, fire extinguishers
- Environment, such as good ventilation, restricting cell phones around electric matches
- Planning and communication; designate someone responsible to look at activities from a safety perspective
- Use the buddy system

Examples of Tables to Include in PDR, CDR, FRR

Hazard	Effect of Hazard	Mitigation
Chemicals in paint, solvent, adhesive	Possible respiratory and skin irritation	Read MSDS for precautions; wear gloves; have good ventilation
Ignition of black powder or other pyrotechnic or explosive compounds	Fire, damage to equipment, personal injury	Follow safety rules; wear cotton clothing; do not smoke or have other static or spark producing items in the area
Use of power tools	Cuts or other injuries, damage to equipment, flying debris	Follow manufacturer's safety instructions; wear goggles; do not operate without supervision
Misfire, hangfire on launch pad	Rocket may not be safe to approach	Write procedures to plan for this contingency and follow; be patient and wait; consult with experts

Mission Success

- Mission Success is the result of attention to detail, and a thorough, honest assessment of risks, failure modes and hazards.
- Failure is often the best teacher, so plan to test as much as possible.
- Teamwork and communication are essential for a successful project.



Understanding MSDS's

By: Jeff Mitchell

MSFC Environmental Health

What is an MSDS?

- A Material Safety Data Sheet (MSDS) is a document produced by a manufacturer of a particular chemical and is intended to give a comprehensive overview of how to safely work with or handle this chemical

What is an MSDS?

- MSDS's do not have a standard format, but they are all required to have certain information per OSHA 29 CFR 1910.1200
- Manufacturers of chemicals fulfill the requirements of this OSHA standard in different ways

Required data for MSDS’s

- Identity of hazardous chemical
- Chemical and common names
- Physical and chemical characteristics
- Physical hazards
- Health hazards
- Routes of entry
- Exposure limits

Required data for MSDS’s (Cont.)

- Carcinogenicity
- Procedures for safe handling and use
- Control measures
- Emergency and First-aid procedures
- Date of last MSDS update
- Manufacturer’s name, address, and phone number

Important Agencies

- ACGIH
  - The American Conference of Governmental Industrial Hygienist develop and publish occupational exposure limits for many chemicals, these limits are called TLV's (Threshold Limit Values)

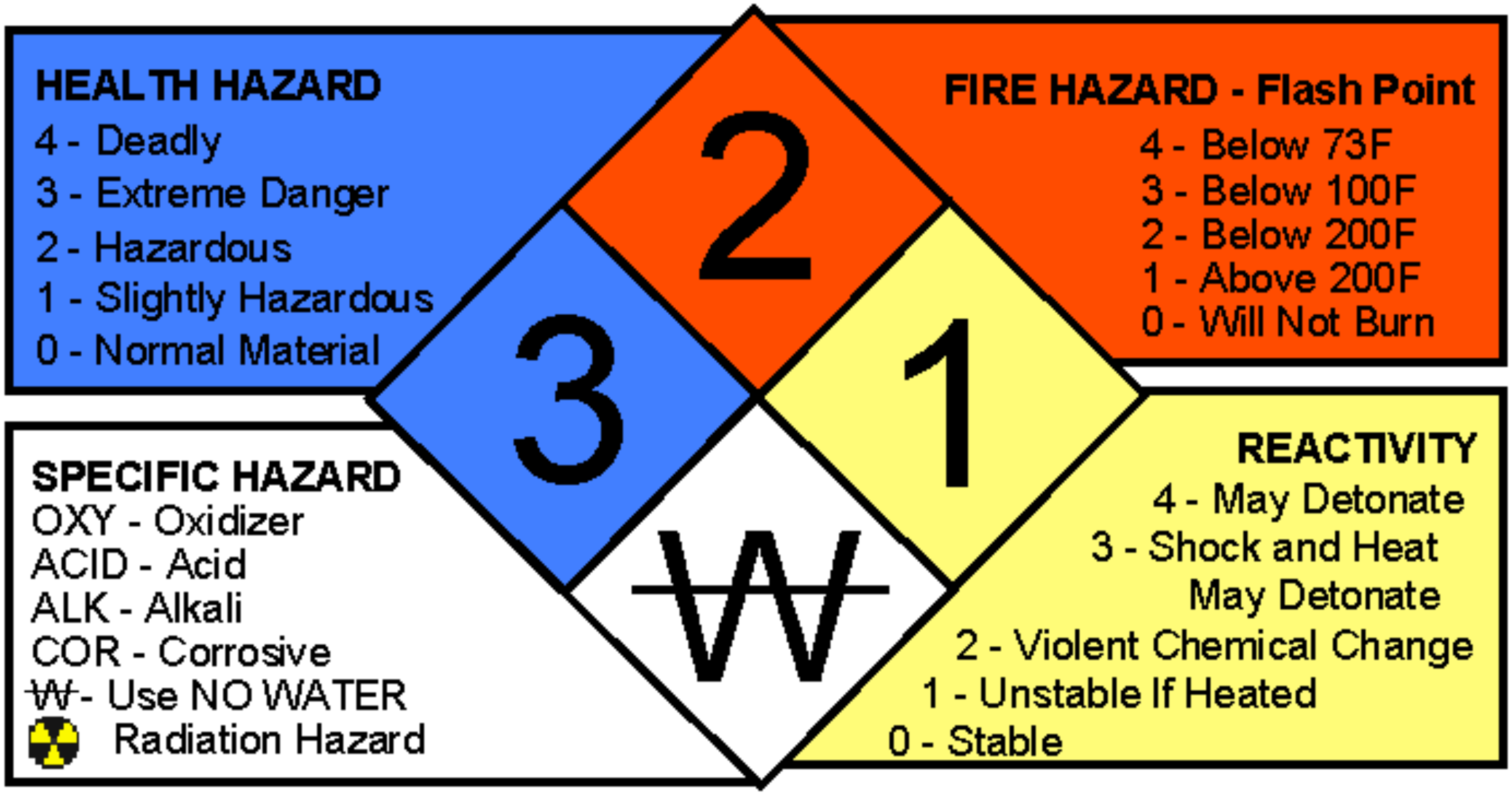
Important Agencies (Cont.)

- ANSI
  - The American National Standards Institute is a private organization that identifies industrial and public national consensus standards that relate to safe design and performance of equipment and practices

Important Agencies (Cont.)

- NFPA
  - The National Fire Protection Association, among other things, established a rating system used on many labels of hazardous chemicals called the NFPA Diamond
  - The NFPA Diamond gives concise information on the Health hazard, Flammability hazard, Reactivity hazard, and Special precautions
  - An example of the NFPA Diamond is on the next slide

NFPA Diamond



Important Agencies (Cont.)

- NIOSH
  - The National Institute of Occupational Safety and Health is an agency of the Public Health Service that tests and certifies respiratory and air sampling devices. It also investigates incidents and researches occupational safety

Important Agencies (Cont.)

- OSHA
  - The Occupational Safety and Health Administration is a Federal Agency with the mission to make sure that the safety and health concerns of all American workers are being met

Exposure Limits

- Occupational exposure limits are set by different agencies
- Occupational exposure limits are designed to reflect a safe level of exposure
- Personnel exposure above the exposure limits is not considered safe

Exposure Limits (Cont.)

- OSHA calls their exposure limits, PEL's, which stands for Permissible Exposure Limit
  - OSHA PEL's rarely change
- ACGIH, establishes TLV's, which stands for Threshold Limit Values
  - ACGIH TLV's are updated annually

Exposure Limits (Cont.)

- A Ceiling limit (noted by C) is a concentration that shall never be exceeded at any time
- An IDLH atmosphere is one where the concentration of a chemical is high enough that it may be Immediately Dangerous to Life and Health

Exposure Limits (Cont.)

- A STEL, is a <u>S</u>hort <u>T</u>erm <u>E</u>xposure Limit and is used to reflect a 15 minute exposure time
- A TWA, is a <u>T</u>ime <u>W</u>eighted <u>A</u>verage and is used to reflect an 8 hour exposure time

Chemical and Physical Properties

- Boiling Point
  - The temperature at which the chemical changes from liquid phase to vapor phase
- Melting Point
  - The temperature at which the chemical changes from solid phase to liquid phase
- Vapor Pressure
  - The pressure of a vapor in equilibrium with its non-vapor phases. Most often the term is used to describe a liquid’s tendency to evaporate
- Vapor Density
  - This is used to help determine if the vapor will rise or fall in air
- Viscosity
  - It is commonly perceived as "thickness", or resistance to pouring. A higher viscosity equals a thicker liquid

Chemical and Physical Properties (Cont.)

- Specific Gravity
  - This is used to help determine if the liquid will float or sink in water
- Solubility
  - This is the amount of a solute that will dissolve in a specific solvent under given conditions
- Odor threshold
  - The lowest concentration at which most people may smell the chemical
- Flash point
  - The lowest temperature at which the chemical can form an ignitable mixture with air
- Upper (UEL) and lower explosive limits (LEL)
  - At concentrations in air below the LEL there is not enough fuel to continue an explosion; at concentrations above the UEL the fuel has displaced so much air that there is not enough oxygen to begin a reaction

Things you should learn from MSDS's

- Is this chemical hazardous?
  - Read the Health Hazard section
- What will happen if I am exposed?
  - There is usually a section called Symptoms of Exposure under Health Hazard
- What should I do if I am overexposed?
  - Read Emergency and First-aid procedures
- How can I protect myself from exposure?
  - Read Routes of Entry, Procedures for safe handling and use, and Control measures

Take your time!

- Since MSDS’s don’t have a standard format, what you are seeking may not be in the first place you look
- Study your MSDS’s before there is a problem so you aren’t rushed
- Read the entire MSDS, because information in one location may compliment information in another

The following slides are an abbreviated version of a real MSDS

Study it and become more familiar with this chemical

MSDS: METHYL ETHYL KETONE

Abbreviated MSDS

SECTION 1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

MDL INFORMATION SYSTEMS, INC.
14600 CATALINA STREET
1-800-635-0064 OR
1-510-895-1313

Manufacturer name
and phone #

FOR EMERGENCY SOURCE INFORMATION
CONTACT: 1-615-366-2000 USA

CAS NUMBER: 78-93-3
RTECS NUMBER: EL6475000
EU NUMBER (EINECS):
201-159-0
EU INDEX NUMBER:
606-002-00-3

SUBSTANCE: METHYL ETHYL KETONE

TRADE NAMES/SYNONYMS:
BUTANONE; 2-BUTANONE; ETHYL METHYL KETONE; METHYL ACETONE; 3-BUTANONE; MEK; SCOTCH-GRIP ® BRAND SOLVENT #3 (3M); STOP, SHIELD, PEEL REDUCER (PYRAMID PLASTICS, INC.); STABOND C-THINNER (STABOND CORP.); OATEY CLEANER (OATEY COMPANY); RCRA U159; UN1193; STCC 4909243; C4H8O; OHS14460

Last revision

CHEMICAL FAMILY:
Ketones, aliphatic

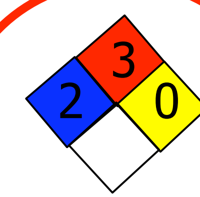
CREATION DATE: Sep 28 1984
REVISION DATE: Mar 30 1997

SECTION 2. COMPOSITION, INFORMATION ON INGREDIENTS

COMPONENT: METHYL ETHYL KETONE
CAS NUMBER: 78-93-3
PERCENTAGE: 100

SECTION 3. HAZARDS IDENTIFICATION

NFPA RATINGS (SCALE 0-4): Health=2 Fire=3 Reactivity=0



Good info for labeling containers

EMERGENCY OVERVIEW:
COLOR: colorless
PHYSICAL FORM: liquid
ODOR: minty, sweet odor
MAJOR HEALTH HAZARDS: respiratory tract irritation, skin irritation, eye irritation, central nervous system depression
PHYSICAL HAZARDS: Flammable liquid and vapor. Vapor may cause flash fire

POTENTIAL HEALTH EFFECTS: What happens when exposed?
INHALATION:
SHORT TERM EXPOSURE: irritation, nausea, vomiting, difficulty breathing,

SKIN CONTACT:
SHORT TERM EXPOSURE: irritation
LONG TERM EXPOSURE: same as effects reported in short term exposure
EYE CONTACT…
INGESTION…

CARCINOGEN STATUS:
OSHA: N
NTP: N
IARC: N

Does it cause cancer?

SECTION 4. FIRST AID MEASURES

INHALATION…
SKIN CONTACT…
EYE CONTACT…
INGESTION…

What should you do if exposed?

SECTION 5. FIRE FIGHTING MEASURES

SECTION 6. ACCIDENTAL RELEASE MEASURES

AIR RELEASE:
Reduce vapors with water spray
SOIL RELEASE:
Dig holding area such as lagoon, pond or pit for containment. Absorb with…

SECTION 7. HANDLING AND STORAGE

Store and handle in accordance …

SECTION 8. EXPOSURE CONTROLS, PERSONAL PROTECTION

EXPOSURE LIMITS:
METHYL ETHYL KETONE:
METHYL ETHYL KETONE:
200 ppm (590 mg/m3) OSHA TWA
300 ppm (885 mg/m3) OSHA STEL
200 ppm (590 mg/m3) ACGIH TWA
300 ppm (885 mg/m3) ACGIH STEL

8 hr avg (OSHA TWA, ACGIH TWA)
15 min avg (OSHA STEL, ACGIH STEL)

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

COLOR: colorless
PHYSICAL FORM: liquid
ODOR: minty, sweet odor
MOLECULAR WEIGHT: 72.12
MOLECULAR FORMULA: C-H3-C-H2-C-O-C-H3
BOILING POINT: 176 F (80 C)
FREEZING POINT: -123 F (-86 C)
VAPOR PRESSURE: 100 mmHg @ 25 C
VAPOR DENSITY (air = 1): 2.5
SPECIFIC GRAVITY (water = 1): 0.8054
WATER SOLUBILITY: 27.5%
PH: No data available
VOLATILITY: No data available
ODOR THRESHOLD: 0.25-10 ppm
EVAPORATION RATE: 2.7 (ether = 1)
VISCOSITY: 0.40 cP @25 C
SOLVENT SOLUBILITY: alcohol, ether, benzene, acetone, oils, solvents

MYTH: if it smells bad it is harmful, if it smells good it is safe

MEK vapor is heavier than air

MEK liquid will float on stagnant water

Not very soluble in water

Will likely smell MEK before being overexposed

Goes to vapor easy

SECTION 10. STABILITY AND REACTIVITY

SECTION 11. TOXICOLOGICAL INFORMATION

SECTION 12. ECOLOGICAL INFORMATION

SECTION 13. DISPOSAL CONSIDERATIONS

SECTION 14. TRANSPORT INFORMATION

SECTION 15. REGULATORY INFORMATION

SECTION 16. OTHER INFORMATION

MSDS's have an abundance of information useful in many different aspects

Awards

USLI Competition Awards

Award:	*Award Description:*	*Determined by:*	*When awarded:*
Vehicle Design Award	Awarded to the team with the most creative and innovative overall vehicle design for their intended payload while still maximizing safety and efficiency.	USLI panel	Launch Day
Payload Design Award	Awarded to the team with the most creative and innovative payload design while maximizing safety and science value.	USLI panel	Launch Day
Project Review (CDR/FRR) Award	Awarded to the team that is viewed to have the best combination of written reviews and formal presentations	USLI panel	Launch Day
Outreach Award	Awarded to the team that is determined to have best inspired the study of rocketry and other science, technology, engineering, and math (STEM) related topics in their community. This team not only presented a high number of activities to a large number of people, but also delivered quality activities to a wide range of audiences.	USLI panel	Launch Day
Web Design Award	Awarded to the team that has the best, most efficient website with all documentation posted on time.	USLI panel	Launch Day
Closest to Altitude*	Awarded to the team that is the closest to one mile above ground level at apogee.	USLI panel	Launch Day
Best Looking Rocket	Awarded to the team that is judged by their peers to have the "Best Looking Rocket"	Peers	Launch Day
Best Team Spirit	Awarded to the team that is judged by their peers to display the "Best Team Spirit" on launch day.	Peers	Launch Day
Rookie Award*	Awarded to the top overall rookie team using the same criteria as the Overall Winner Award. (Only given if the overall winner is not a rookie team).	USLI panel	May 26th, 2008
Overall Winner*	Awarded to the top overall team. Design reviews, outreach, website, safety, and a successful flight will all factor into the Overall Winner.	USLI panel	May 26th, 2008

**** Only teams who use the required altimeter for competition scoring will be eligible.***

National Aeronautics and Space Administration

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