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SPARC 2015

Student Payload and Rocketry Challenge

Hosted by AIAA OC Section NAR #718

Welcome to SPARC – an engineering adventure sponsored by the AIAA Orange County Section and the National Association of Rocketry (NAR) Section #718 where students in 7th through 12th grades (you are still eligible even if you graduated early) will:

- Build an electronic payload, launch or have it launched to at least 1,000 ft.
- The payload at a minimum will gather specific data, store that data, and transmit that data, during flight, to a ground station.
- There are two challenges – one recommended for Junior High School Students, and one recommended for High School Students.
- Teams will participate in a "Rocket Science Fair" and launch on October 10, 2015 at ROCtober at Lucerne Dry Lake in the Mojave Desert.
- Teams must submit a proposal at the beginning of this competition, provide a brief email status once per month during the competition, write a Final Design Review and submit a draft before the final launch, and add their flight data and submit one final report two weeks after the ROCtober launch.
- The intent of this project is to
    - Promote and practice teamwork as would be found in a real engineering project
    - Learn sound practices
    - Work with real constraints (size, weight, budget, time)
    - Improve technical understanding
    - Improve written communications skills (engineers are notoriously poor writers)
- Will be judged against a standardized scale for SPARC.

Other details:

- Individuals or teams of 2 to 5 members can participate
- Teams are responsible for all costs of their project
- Certificates and Plaques will be awarded to winners of each category
- Entry fee is $10.00 per team

This challenge starts on June 1st and finishes October 10, 2015 at ROCtober where you will officially fly your rocket and show the results during the "Rocket Science Fair". Visit the SPARC web pages at AIAA OC Rocketry: http://aiaaocrocketry.org/?page_id=915

Rules

Safety: All rockets launched and their payloads must comply with the NAR safety code (http://www.nar.org/NARmrsc.html).

The Team: Your team should be small enough so that everyone can make a significant contribution to the project. We recommend no more than five members to make things manageable.

The Primary Mission: Each team must build an electronic Arduino based payload to accomplish the required primary mission. The primary mission is to measure the parameters listed below and (1) transmit the data as telemetry at least once each second to the ground station and (2) record that data on a removable non-volatile media such as an SD Card.

- Air Temperature
- Air Pressure

Teams must analyze the data obtained and display in graphs (for example altitude vs time and temperature vs altitude). This analysis can be done post flight. The payload must have sufficient battery to run on its own for 2 hours (preparation time + sitting on the pad + flight + recovery)

The Secondary Mission: Optionally a team can select to add a secondary mission on to the primary mission. This can be based upon a perceived need for scientific data for a project or any other mission that would fit. Some examples of secondary missions would be:

- Advanced Telemetry – include GPS data, accelerometers, magnetometers, humidity
- Transmit commands to change or trigger some behavior
- Autonomously control the descent of your payload to come as close as possible to a pre-designated target.
- Mechanically deploy something during flight or at landing, such as legs to keep your payload upright
- Simulate a planetary probe by taking measurements on the ground after landing, or even becoming mobile on the ground to explore.
- Add a camera to record photos, or even send back video to the ground station. The CHDK, or Canon Hack Development kit allows you to tailor a point and shoot camera. You can also modify an inexpensive keychain camera and use the Arduino to turn it on.

Payload Options

Your payload must be based on the Arduino Open Source electronics prototyping platform. Arduino has an extremely strong and diverse following because it is easy to learn, the software development tools are freely-available, and a wide array of hardware is available inexpensively

from many vendors with supporting software libraries. Application-specific "shields" are available for a wide variety of purposes which plug directly into the standard Arduino hardware and provide additional functionality easily while many sensors are available on breakout boards which simplify interfacing with your project. There are a plethora of articles and video tutorials available online which demonstrate how to develop projects with Arduino. Many of the vendors also provide links to data sheets and project tutorials for the hardware they carry. We'll also provide tutorials, classes and mentors to help.

Students in 9th through 12th grades (even if they have graduated early) should use the CanSat payload; beginning teams can choose the S4 (Small Satellites for Secondary Students) payload for a more straight-forward challenge.

We recommend students in 7th and 8th grades use the S4 payload. Students in 7th or 8th grades that have previously completed the S4 payload must either extend the S4 payload with new features, or use the CanSat payload.

CanSat Requirements (High School Students)

The rules for CanSats have been extensively borrowed from "The European CanSat Competition Guidelines" which can be found here:
http://esamultimedia.esa.int/docs/edu/2015_European_CanSat_Competition_Official_Guidelines.pdf
as well as "The CanSat Book 2013 Edition" which can be found here (excellent reference):
https://www.narom.no/bilder/bilde1_20130826154135.pdf

- Highly recommended payload for High School Students (9th – 12th grades – you are still eligible even if you graduated early)
- Launch services will be provided – you need to design and build the CanSat only – not the rocket. Students will share the cost of the motor for the launch, but that cost is not included in the payload cost limitation.
- Your CanSat will be deployed from the rocket and must come down on its own parachute.
- All the components of the CanSat must fit inside a standard soda can (125mm in height and 67mm in diameter) with the exception of the parachute. An additional 75mm in height is available in the launch vehicle for the parachute and other elements such as radio or GPS antennas at the top or bottom of the can (not the sides).
- The CanSat container must adhere to the CanSat dimensions above, but does not need to be a soda can (e.g. you can build your own container out of fiberglass as long as the dimensions are the same).
- Antennas, transducers, or other parts of your CanSat cannot extend beyond the can's diameter will need to be deployed after the CanSat leaves the launch vehicle.
- The mass of the CanSat must be between 300 grams and 350 grams. If your CubeSat is lighter than the minimum, you must add ballast to meet the minimum weight.

- Explosives, detonators, pyrotechnics, and flammable or dangerous materials are strictly forbidden. All materials used must be safe for the personnel, the equipment, and the environment. Material Safety Data Sheets (MSDS) will be requested of in doubt.
- The battery must be easily accessible in case it has to be replaced or recharged
- The CanSat must have an easily accessible master power switch
- The CanSat must have sufficient battery to run on its own for 2 hours (preparation time + sitting on the pad + flight + recovery)
- Inclusion of a retrieval system (beeper, radio beacon, GPS, etc.) is recommended.
- The CanSat must have a recovery system such as a parachute capable of being reused after launch. Bright colors work well to aid in tracking and recovery.
- The parachute connection to the CanSat must be able to withstand up to 1000N of force. The strength of the parachute must be tested, to give confidence that the system will operate nominally.
- A descent rate of 5 – 8 meters per second is generally recommended (it must descend safely). If the launch altitude is high, and the descent rate is low, make certain that you have some method of tracking the location of your CanSat or it may be lost forever as wind carries it away.
- The CanSat must be able to withstand an acceleration of up to 20g
- You must coordinate the frequency that you choose for telemetry with SPARC officials at least 2 months before the October launch. Teams are responsible for providing their own ground stations, although you may borrow some elements from AIAA OC Rocketry at the time of launch.
- The total budget of your CanSat should not exceed $500. This does not include the launch vehicle or launch services, or your ground station

S4 (Small Satellites for Secondary Students – for Junior High School Students – OK for beginning High School Teams)

- Highly recommended for Junior High Students (grades 7 and 8).
- If you have previously participated in SPARC, then you must either extend your S4 payload to add new features, or follow the CanSat rules.
- Students will build their own 3” diameter rocket and launch their rocket and payload on a “G” motor.
- Your S4 payload will remain inside the rocket, and come down on the same parachute as the rocket.
- Students will build the S4 payload and populate as a minimum the Arduino Uno, SD Card, the WiFly module, and the barometric pressure/temperature sensor. Also including the GPS module is highly recommended.
- There are several other sensor positions available on the S4 board for your secondary mission

- A ground station will be available for receiving telemetry from your payload
- The total budget of your S4 payload and any secondary payload extensions must not exceed $300, excluding the vehicle and motors.
- Your rocket must be one of the approved 3" diameter rocket kits with payload bay from Mad Cow Rocketry (cost of under $100)
- Your rocket must return safely on a parachute with a descent rate between 5 and 8 meters per second

Documentation

Proposal: Before you begin your project, your team needs to submit a short proposal describing your experiment. Your proposal must be reviewed by SPARC officials and approved before proceeding on to the project. Your proposal must include

- The name of your team and list of team members
- A description of your mission (primary and secondary) objectives and how your proposed payload meets those objectives
- A definition of the technical requirements necessary to meet those mission objectives and how each requirement for SPARC has been met (if you are using the S4 payload, you must also include which rocket kit and motor you are using, and the estimated altitude)
- Your test plan showing how you will validate that the your design will safely meet the mission objectives
- Your safety plan showing how you will build your rocket and where you will fly your rocket safely.
- Your schedule showing major milestones
- Your budget

Monthly Status Report: At the end of each month, each team needs to submit an informal status email showing their progress. This should include

- A statement of where they are on the project
- A statement of what they have accomplished since the last status report (or since the beginning for the first status report)
- A statement of what they hope to accomplish before the next status report (or the final launch and Rocket Science Fair for the last status report)
- Point out any impediments that you feel are preventing you from making progress

Final Design Review: You will submit a draft copy of the Final Design Review two weeks before the ROCtober launch. After the ROCtober launch and Rocket Science Fair, submit the Review with the flight data results update included. You will also include the report as part of your exhibit at the Rocket Science Fair. It must include the following information:

1. Team name and members
    a. Name of your team's mentor
    b. Name and short bio of each team member
    c. Name of the club and location where you made any test flights
2. Your safety plan showing how you built and flew or will fly your rocket safely
3. Payload design
    a. Show how all of the requirements for SPARC have been fulfilled with your design
    b. Clearly identify your primary and secondary missions, describe how they function, and show you're your design meets those requirements
    c. Include the following diagrams
        i. System block diagram showing your payload and launch vehicle as well as ground station
        ii. Functional block diagram of the payload showing how data moves through your system
        iii. Flow chart or functional description of your payload software
    d. Include a bill of materials
4. Describe your ground station and the frequency you will use
5. Include your test plan and results showing
    a. How you tested your payload (and carrier rocket if flown)
    b. The results of those tests justifying any exceptions to expected results
    c. What you did not test and why
6. Risk management – Identify what you think can go wrong and how you intend to mitigate those risks
7. Your schedule
8. Your budget
9. When submitting your report after the ROCtober launch, include the data you captured, interpreted and graphed. And discuss how well your payload performed and areas in which opportunities for further improvement exist.

3D Printing

3D printing is becoming more accessible, and provides a way of creating parts without the need for a machine or wood shop. A good fit for 3D printing in SPARC is the creation of the payload bay. There is a file suitable for 3D printing on the S4 web site at http://s4.sonoma.edu/wp-content/uploads/2014/09/PayloadCase.zip - this is the bare minimum bay. And you can download a free .STL file viewer at http://www.freestlview.com (does not show dimensions). Later we will post more extensible files for 3D printing not only the basic bay but also bays with extended capabilities. There are several 3D CAD program so you can modify these files or even create your own, such as FreeCad (http://www.freecadweb.org).

Scoring

Scores will be assigned based upon weighting of all basic components of the project as follows:

Requirement	Weighting			
	Technical Excellence	**Exceptional Presentation**	**Scientific Merit**	**Outstanding Innovation**
Proposal	5%	5%	5%	5%
Final Design Review				
Presentation of facts	15%	35%	15%	15%
Met mission objectives	30%	10%	20%	20%
Relevance of secondary payload	15%	5%	30%	10%
Uniqueness of secondary payload	15%	5%	10%	30%
Science Fair Display				
Display	10%	20%	10%	10%
Quality of answers to judges	10%	20%	10%	10%

Flights and Rocket Science Fair

ROCtober Flight: You and your team will have one official flight at ROCtober on October 10, 2014. During that flight you will gather your data to include in your "Final Design Review" and at the "Rocket Science Fair". It is highly suggested that you fly your rocket and gather data during the summer before that flight and include that data in your report and use the official flight as validation of that data. You may fly your rocket as often as you wish during this challenge subject to these rules:

- Flying prior to ROCtober is recommended but not required
- The ROCtober flight is your flight of record.
- All flights must comply with the NAR safety rules.

Rocket Science Fair: We will have a "Rocket Science Fair" area at the ROCtober launch with ROC at Lucerne Dry Lake. Your team will have a six foot table for your display. You should have a science fair type display describing your rocket and payload. And you should have your rocket and payload on display. You should also show the results of any testing and test flights. At least one team member should be present to answer questions. We will have judges from AIAA Young Professionals, Aerospace corporations, and industry.

- Technical Excellence
- Exceptional Presentation
- Scientific Merit for Scientific Payloads
- Outstanding innovation for Engineering Payloads

Costs and Schedule

Costs: Students are responsible for all costs for their projects. Reasonable estimates are:

- Rocket kit with payload section: $75
- Arduino controller board $20 - $35
- Arduino sensors and shields: $10 - $200 (dependent upon your payload)
- "G" motor $21 each (Cesaroni)
- Parachute $15 (CanSat) - $25 (S4)

Schedule:

June 1 – June 30, 2015	Signup period (send an email to rkoepke@socal.rr.com)
June 12 – 14, 2014	ROCstock at Lucerne Dry Lake with Rocketry Organization of California
July 10, 2014	Proposal submission deadline (Submit proposals early for approval to give yourself plenty of time to work on your rocket and payload)
July 11, 2015	Optional ROC launch at Lucerne Dry Lake
July 28, 2014	Resubmission deadline (if proposal changes are needed after review)
July 31, 2015	July Status email due
August 8, 2015	Optional ROC launch at Lucerne Dry Lake
August 10, 2015	Frequency request due (to make certain we have no CanSat conflicts)
August 31, 2015	August status email due (including final telemetry frequency)
September 12, 2015	Optional ROC launch at Lucerne Dry Lake
September 27, 2015	Draft of Final Design Review submission deadline
September 30, 2015	September status email due
October 10, 2015	ROCtober – final flight and Rocket Science Fair
October 25, 2015	Final Design Review submission deadline

Rocket and Electronics Sources

Rocket Vendors: You will need a 3" diameter rocket kit with a payload bay. Several vendors sell these rockets. Mad Cow sells the Sport-X and will give SPARC teams a 15% discount when purchased: http://www.madcowrocketry.com/3-sport-x and payload bay: http://www.madcowrocketry.com/standard-3-payload-kit

Mad Cow Rocketry: http://www.madcowrocketry.com

Discount Rocketry: http://www.discountrocketry.com

Apogee Rocketry: https://www.apogeerockets.com

Payload Electronics: We have provided a list of Arduino electronics vendors and tutorials on our web site at http://aiaaocrocketry.org/?page_id=1545, and will post more as they are complete. These include basics, information on how to use sensors, and how to modify an inexpensive keychain camera to be turned on and off by the Arduino. The Arduino home web site is http://www.arduino.cc. You can Google Arduino to find many, many more sources for hardware and tutorials. You may use the carrier board from the S4 (Small Satellites for Secondary Students) in your project (http://s4.sonoma.edu/?page_id=169). The Cansat Book at https://www.narom.no/bilder/bilde1_20130826154135.pdf is also an excellent reference.

Rocket Design & Simulation software: You should not need rocket design and simulation software, since launch services are provided for the CanSats and there are recommended kits for the S4 boards. But it is a good idea to check the stability of your rocket with the Payload. Rocksim is available for purchase and Open Rocket can be downloaded free:

RockSim (Apogee Rocketry): http://www.apogeerockets.com/Rocksim/Rocksim_information

Open Rocket (Sourceforge Projects): http://openrocket.sourceforge.net

For more information visit http://aiaaocrocketry.org or contact:

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