Version 1.0 – June 1, 2016

SPARC 2016

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 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 three challenges – one recommended for Junior High School Students, and one recommended for High School Students, and a third which is open - you decide the experiment and the platform.
- Teams will participate in a "Rocket Science Fair" and launch on October 8, 2016 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, and keep an Engineering Notebook. The Engineering Notebook will be reviewed during the Science Fair and the final submission with launch data from the ROCtober launch is due 2 weeks after the Science Fair.
- 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)
- Projects will be judged against a standardized scale for SPARC.

Other details:

- We recommend a team size of 2 to 5 members. Teams with more than 5 members should consider splitting into multiple teams.
- 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 due at the Rocket Science Fair in October

This challenge starts on June 1st and finishes October 8, 2016 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 (CanSat and S4): 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 (CanSat and S4): 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” can be purchased for a wide variety of purposes. These plug directly into the standard Arduino hardware and provide added functionality easily while many sensors can be found on breakout boards which simplify interfacing with your project. There are a plethora of articles and video tutorials 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 also provide tutorials and mentors to help.

Students in 9th through 12th grades we recommend that students 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.

In the “Open” challenge, we will consider unique payload ideas that fall outside of the CanSat and S4 payloads. Please talk to us or email your idea before submitting your proposal so we can make certain it is (1) safe and (2) feasible in the time allotted.

CanSat Requirements

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

- Recommended payload for High School Students (9th – 12th grades)
- If you choose to use them, launch services will be provided (just as in industry, the owner of the satellite will contract with a company providing launch services) – 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. If you prefer, you can also build your own launch vehicle, although it can be challenging to deploy your CanSat without damage.
- Your CanSat will be deployed from the rocket and must come down untethered on its own parachute.

- All the components of the CanSat should 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 and transducers. These must be at the top or bottom of the can (not the sides), but you will need additional protection from the "g" forces during launch and deployment.
- 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 cardboard or fiberglass as long as the dimensions are the same).
- The mass of the CanSat must be between 300 grams and 350 grams. If your CanSat 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 if 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 (this occurs during launch and deployment) including shock.
- 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 – let us know what you need and we can determine if it is available.
- We have the unpopulated shield (Printed Circuit Board only – no parts) for CanSats referenced in the above documents available at no charge if you choose to use it – just email us (sparc@aiaaocrocketry.org).
- 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)

- 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 build the CanSat payload instead.
- Students will build their own 3" diameter rocket KIT 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 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.
- We have the bare S4 Printed Circuit Board available at no charge – just send us an email (sparc@aiaaocrocketry.org)

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 progress on your project and progress on the Engineering Notebook.
- 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 – we will try to help you resolve

Engineering Notebook: Many companies require engineers to keep an Engineering Notebook. This is done to document progress and to allow the development team to go back and review why decisions were made. And it is a legal document to prove the origin and time of an idea that may be patentable. A generic description of an engineering notebook can be found here: http://www.slideshare.net/dsphudson/pltw-edd-engineering-notebook. We will use the guidelines provided as part of the TARC competition, with changes for a payload design instead of a rocket design:

- **GENERAL**
  - Engineering notebooks submissions may either be electronic or physical. Physical notebooks must be no less than 203.2mm (8.0 inches) by 254mm (10.0 inches), and must not exceed 254mm (10.0 inches) by 304.8mm (12.0 inches). Notebooks should be hardbound. Loose leaf binder compositions are not permitted. You may use any notebook that meets these specifications.
  - Electronic submissions should be a scanned page by page copy of an original hard copy notebook. Pages must be numbered and all notebook entries must be made in pen, contain titles, and the full date (Month Day, Year) in the upper outer corner of each entry. New entries must be made on a new page of the notebook and remain in chronological order. Entries must be made neatly and with enough detail that another person familiar with electronics could replicate your process and results. The initials of each team member who is present during each entry must be documented in addition to the dated signatures of both the student team leader and the team supervisor (if present).

- **TITLE PAGE**
  The title page must be contained on either the inside cover of the notebook or the first page. The title page must include the team name, team members (with the identification of the team leader), the teacher/adult supervisor, the date the engineering notebook was created, contact information of the team, and the volume of the notebook should there be more than one notebook created as part of the Competition

- **TABLE OF CONTENTS**
  A 2-3 page table of contents must be added after the front of the notebook. Each entry, and its corresponding page number, should be contained within the table of contents.

- **CONTENT**
  All entries must be recorded as they occur. Group meetings, discussions, ideas, questions, and notes may be included as part of the engineering notebook. References to relevant articles or research findings must be made such that the reference can easily be retrieved by another person familiar with the aspects of your project. The contents of the notebook should clearly state the objective of your payload, contain preliminary payload plans and how each element supports your objective. As you refine your design include the reasoning behind project decisions. You should also include all testing as well as results. If you finish an entry before the end of a page within a notebook, draw a large X taking up the remainder of the page. This prevents new content from being added to the notebook after the fact.

  Although not required (but will weigh in your favor with the judges), it is beneficial to include a decision matrix, or Pugh Matrix to show why major decisions were made (see https://blogs.nd.edu/jlugo/2012/09/24/pugh-method-how-to-decide-between-different-designs/ for more information. And a risk analysis that will help you think through problems that may occur and help prevent them before they happen (see https://www.youtube.com/watch?v=ku0DvsnsLCA – this is on business risks, but the same principles apply to engineering risks.) There are many examples of risk analysis charts on line.

- **PAYLOAD DESIGNS**
  Payload descriptions must contain schematics, block diagrams, program flow charts and relevant program segments. Also include a parts list, or Bill of Materials (BOM) for electronics and mechanical carriers. Descriptions should also include dimensions, materials, and fabrication process information. Payload designs may be drawn directly into the notebook. Payload designs that are completed electronically may be printed and affixed to the notebook. Any payload dimensions must be labeled in millimeters. Include sourcing information for all non-trivial parts of your payload.

- **TEST DATA**
  For each test that you run, record the material required as well as the setup for the test and results. Include enough information so that the reader of the notebook knows what they need to recreate the test, exactly how to run the test and what results you obtained to compare against their own. And include any other information that you feel is necessary or useful.

- **PAYLOAD MODIFICATIONS**
  Modifications that are made to the payload after the initial design in your notebook must be documented. Your notebook entry should specify the reasons for the modifications and the specific components of the payload that were modified.

- **AFFIXED MATERIALS**
  Materials that are affixed to the notebook must be securely attached with clear tape or staples. This may be done by taping each corner of the materials that are to be affixed to the notebook. Affixed materials should contain the date they were added, titles, the reason for their addition, a description, and be initialed by the team leader.

- **REVISIONS**
  Errors in the notebook should not be omitted from the submission. Correction tape or white out should not be used to write over errors that are present. Errors may be corrected by crossing them out with an X or a single line. Errors should still be legible despite the X or single line. Pages should not be removed from the notebook.

- **UPDATES**
  Updates that specifically reference previous entries may be made by creating a new entry, referencing the page number that the update pertains to, and continuing the entry as normal.

- **EXAMPLES**
  - **Blank Engineering Notebook:** http://www.bookfactory.com/engineering-notebooks/engineering-notebooks.html
  - **TARC Example 1:** http://3384f12ld0l0tjlik1fcm68s.wpengine.netdna-cdn.com/wp-content/uploads/2015/08/Space-Potatoes.pdf
  - **TARC Example 2:** http://3384f12ld0l0tjlik1fcm68s.wpengine.netdna-cdn.com/wp-content/uploads/2015/08/A-Bunch-of-Cool-Dudes.pdf

Scoring

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

Element	Weight
Proposal	10%
Engineering Notebook	50%
Science Fair Display	20%
Quality of answers to judges at Science Fair	20%

Flights and Rocket Science Fair

ROCtober Flight: You must have at least one successful flight with your rocket and payload. You and your team will have the opportunity to fly at ROCtober on October 8, 2016. During that flight you will gather your data to include in your Engineering Notebook 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 Engineering Notebook. That way you are done before the science fair and if you choose to, use the ROCtober 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
- 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 or 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 judging in the following areas:

- 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)
- An unpopulated S4 board or shield for the CanSat kit is available at no charge – email us
- “G” motor $21 each (Cesaroni); “H” motor $38 each (Cesaroni)
- Parachute $15 (CanSat) - $25 (S4)

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Schedule:

June 1 – July 2, 2016	Signup period (send an email to sparc@aiaaocrocketry.org)
June 8 – 12, 2016	ROCstock & LDRS at Lucerne Dry Lake with Rocketry Organization of California
July 11, 2016	Proposal submission deadline (Submit proposals early for approval to give yourself plenty of time to work on your rocket and payload)
July 9, 2016	Optional ROC launch at Lucerne Dry Lake
July 25, 2016	Resubmission deadline (if proposal changes are needed after review)
August 1, 2016	July Status email due
August 13, 2016	Optional ROC launch at Lucerne Dry Lake
August 29, 2016	August status email due (including final telemetry frequency)
September 10, 2016	Optional ROC launch at Lucerne Dry Lake
September 26, 2016	September status email due
October 8, 2016	ROCtober – final flight and Rocket Science Fair
October 22, 2016	Final Engineering Notebook submission deadline

Rocket and Electronics Sources

Rocket Vendors: You will need a 3" diameter rocket kit with a payload bay for S4 project. 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. These include basics, information on how to use sensors, GPS, and telemetry. 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.

Payload Photos and Video: Video often adds a lot of excitement to a project, and it is fun to post to Youtube. You can use an inexpensive ($10-15 keychain camera from Ebay, Amazon etc. – many require that you purchase a separate Micro-SD Card) either by itself or you can use the Arduino to control it (http://nerdfever.com/driving-the-808-keychain-camera-with-a-microcontroller). A second option is to use an older, small Canon point and shoot camera with the Canon Hack Development Kit (http://chdk.wikia.com/wiki/CHDK).

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Rocket Design & Simulation software: For the CanSats you should not need rocket design and simulation software, since launch services are provided for the CanSats unless you to choose to build y our own launch vehicle. 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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