AIAA OC Rocketry

AIAA OC Section – NAR #718

Bits, Bytes, and Rockets

STEM through Rocketry Electronics

ASAT 2016
April 30, 2016
Jann and Bob Koepke

Presentation Goals

The Challenge:

- Do more with rocketry than just Launch & Recover

We will identify:

- What you can do with model rocketry & electronics
- Resources to use in STEM programs
- Existing STEM program

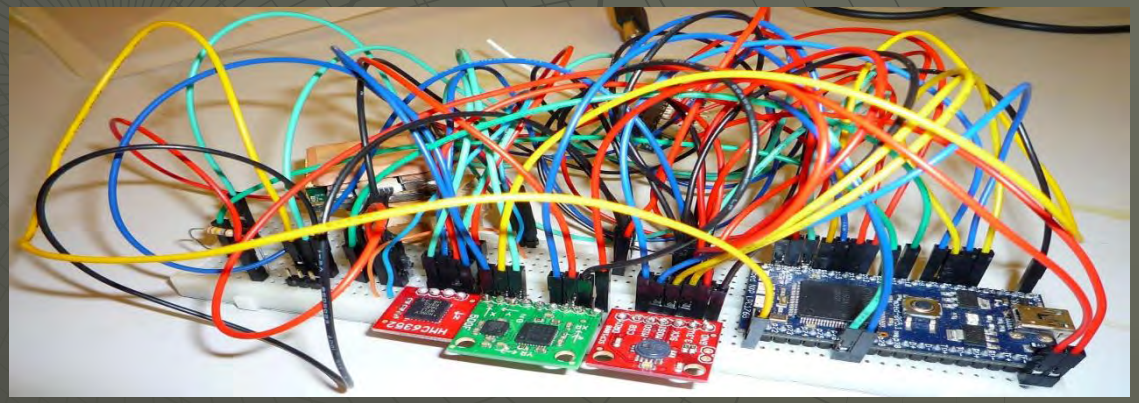


Photo from wecansat.blogspot.com

Cansats

Photo from ESA

A CanSat is a type of Sounding Rocket Payload used to teach space technology. It is similar to the technology used in miniaturized satellites. No CanSat has ever left the atmosphere, nor orbited earth
-Wikipedia

Most CanSat opportunities in the U.S. are targeted to College and University age students

Photo from ESA

Photo from ESA

CanSats - Launch

CanSats are launched from larger model rockets usually to altitudes under a mile

CanSats fit nicely in a 3″ diameter rocket

Photo from NAVRO

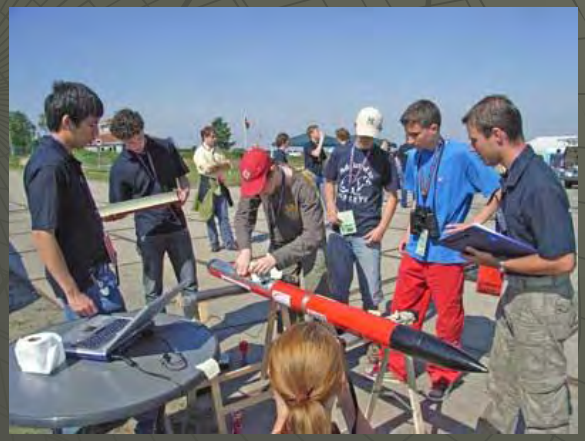


Photo from NAROM

Photo from Southgate ARC

Video Link: https://www.youtube.com/watch?v=EeUNIGFHCYQ

CanSats - Projects

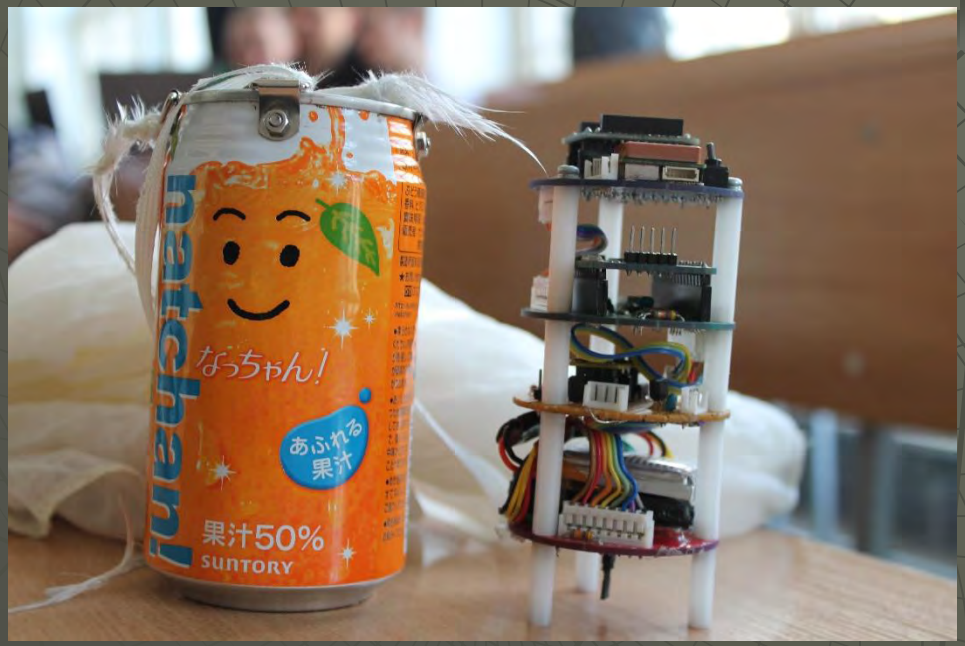


Photo from is.mokslasplius.lt

- Payload must fit inside soda can
  - 65mm in diameter
  - 115mm in height
  - 300g – 350g total mass
- Some University Challenges allow slightly larger payloads – coffee can sized

CanSats - Projects

Photo from ESA

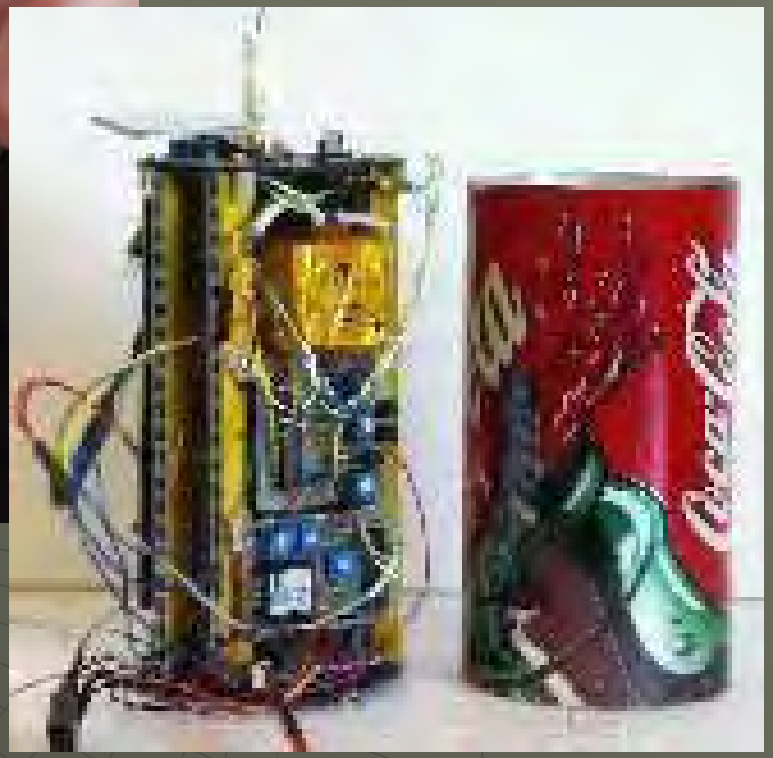


Photo from Andoya Space

The basic payload contains sensors, GPS, telemetry via RF, recording to SD Card

CanSats - Projects

Photo from Naval Research Laboratory

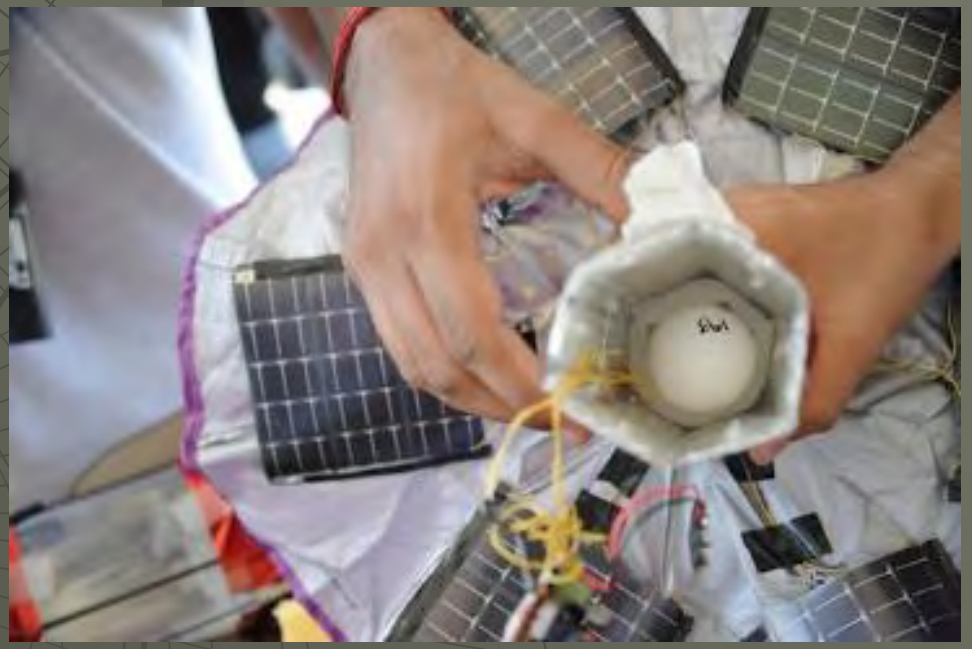
"Helicopter Recovery"

- After Launch, CanSats should come down slowly while collecting data
- Many use parachutes, but any method to slow descent is OK
- Helicopter Recovery adds a mechanical element

CanSats - Projects

"Aero-Braking I"

Competition combined
- Electronic data collection
- Aero-Braking to slow descent (no parachutes)
- Protection of one raw egg



Photos from US Naval Research Laboratory

CanSats - Projects

Photo from US Naval Research Laboratory

"Aero-Braking II"

Competition combined
- Electronic data collectin
- Aero-Braking to slow descent (no parachutes)

CanSats - Projects

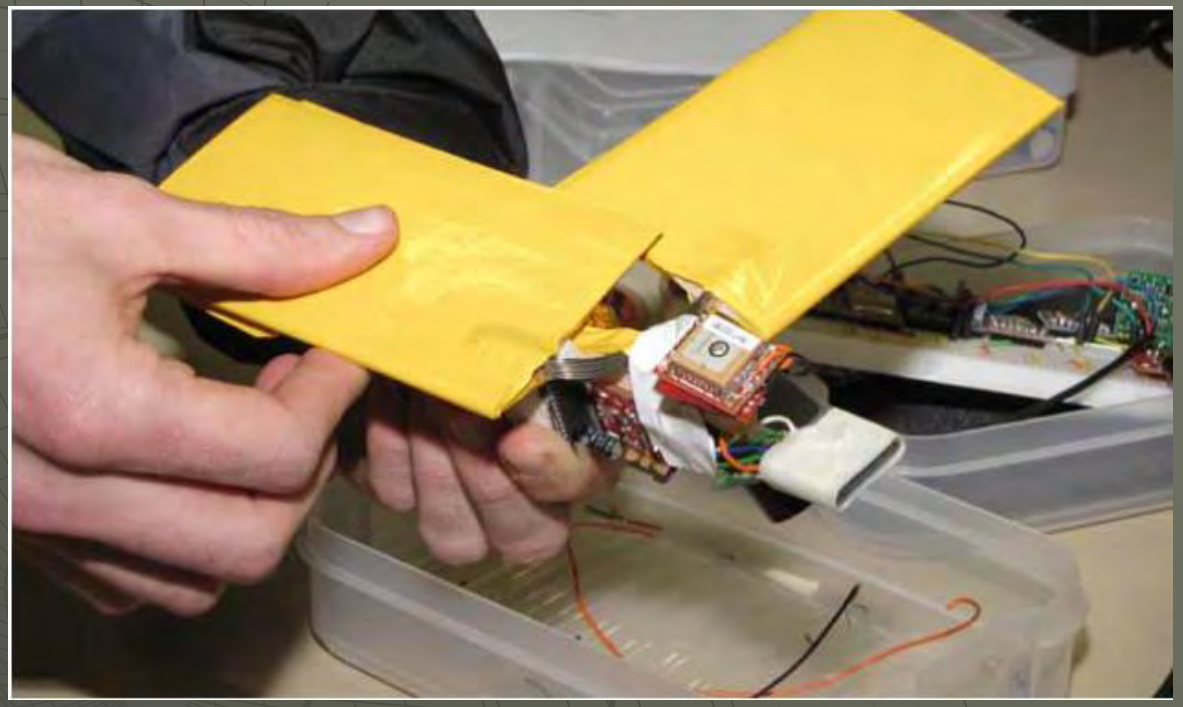


Photo from Popular Mechanics South Africa

Deployable CanSat design that includes small UAV
Nitinol wire folds back, then releases the wings

CanSats - Projects

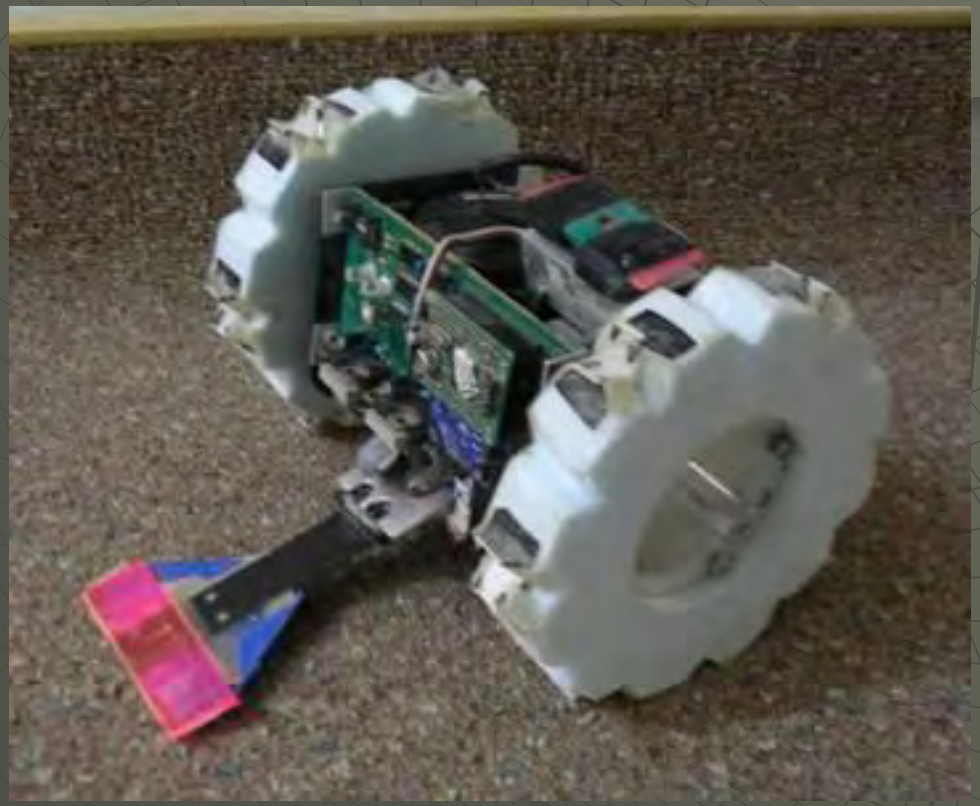


Photo from University Space Engineering Consortium

CanSat Deployed "Rover"

Team needed to get their rover onto the ground quickly to make certain it had enough battery to drive back to the launch point

(Tohoku University)

CanSats - Projects

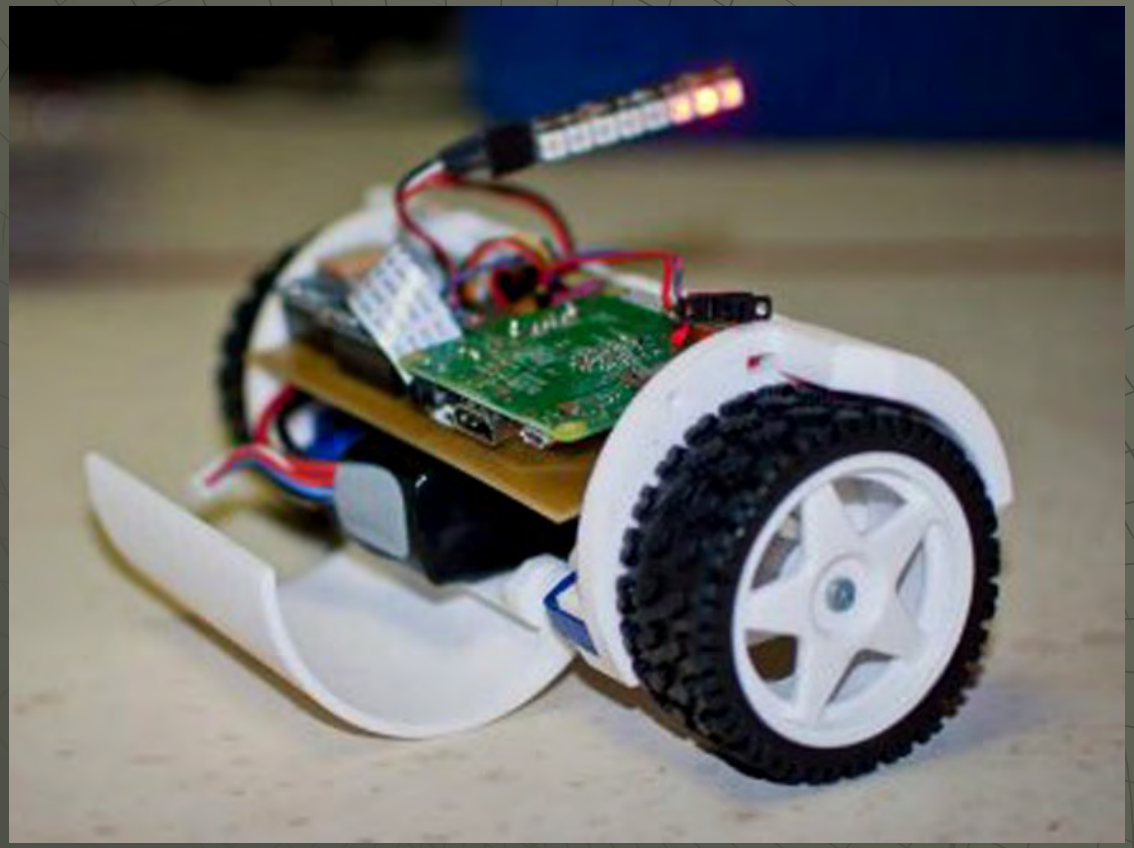


Photo from Planete Sciences

CanSat Deployed "Rover"

Another rover from the CanSat competition in France

CanSats - Projects

Nihon University

CanSat takes a photo with a CMOS camera, then sends it back via SSTV

Photos from University Space Engineering Consortium

CanSats - Projects

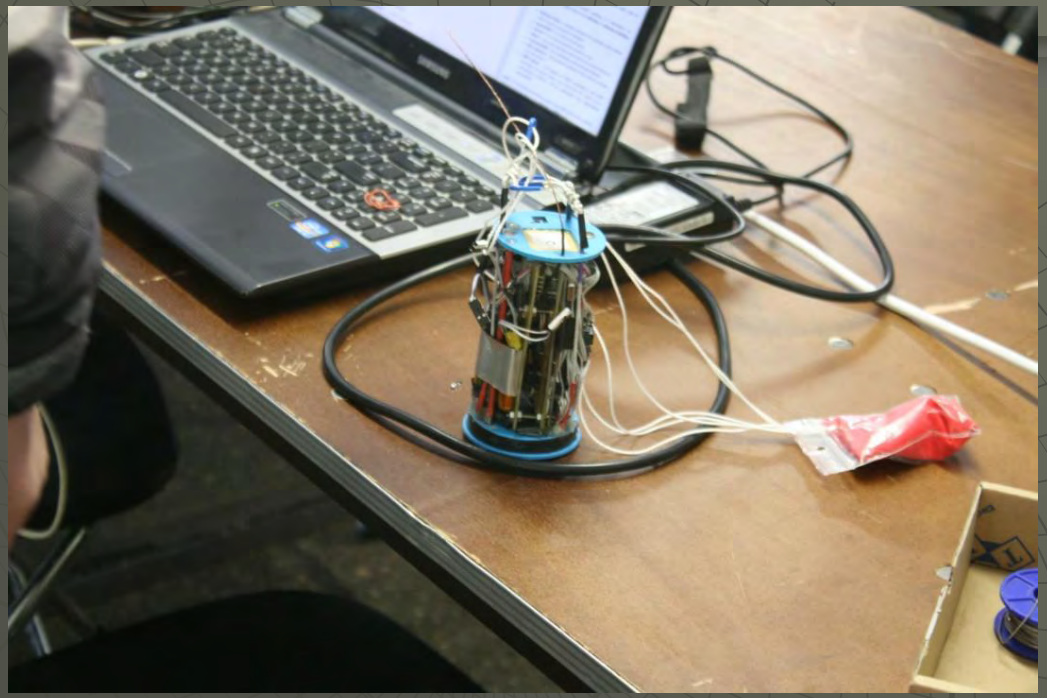
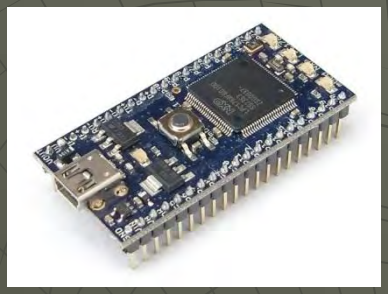


Photo from Kraksat.pl

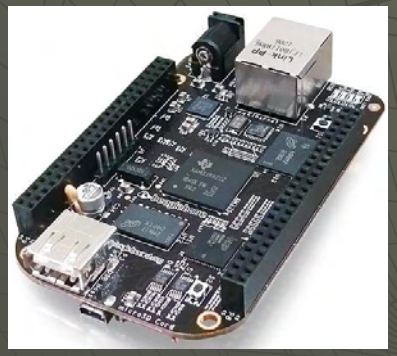
Most payloads will contain a small microprocessor that controls the experiment and gathers the data

The microprocessor is programmed using commonly available tools on a PC

What to Use ï Processor Boards

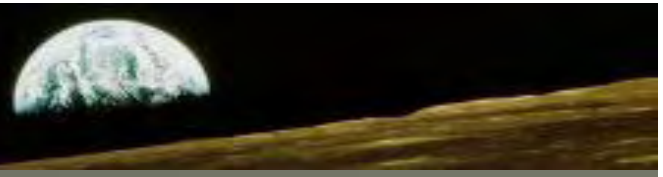


- Mbed: 96MHz ARM processor
- 44mm x 26mm
- 512KB Flash, 32KB Ram
- CAN, SPI, I2C, ADC, DAC, USB, Ethernet
- $49



- Beaglebone; 1GHz ARM processor
- 89mm x 55mm
- 4GB Flash, 512MB Ram
- USB, UART, SPI, Ethernet
- $55

- Intel Edison; 500 MHz Intel Atom
- 36mm x 25mm
- 4GB Flash, 1GB Ram
- WiFi, Bluetooth, UART, I2C, SPI, USB, SD Card
- $50



What to Use ï Processor Boards

- Raspberry Pi 3: 1.2GHz ARM processor
- 85mm x 56mm
- 1GB Ram, SD Card
- UART, SPI, I2C, USB, HDMI, Bluetooth, Ethernet, 802.11n
- $40

- Arduino Uno: 16MHz ATmega processor
- 69mm x 54mm
- 32KB Flash, 2KB Ram
- UART, SPI, I2C, ADC, USB
- $25

- Arduino Teensy 2.0: 16MHz ATmega processor
- 31mm x 18mm
- 32KB Flash, 2KB Ram
- UART, SPI, I2C, ADC, USB
- $16

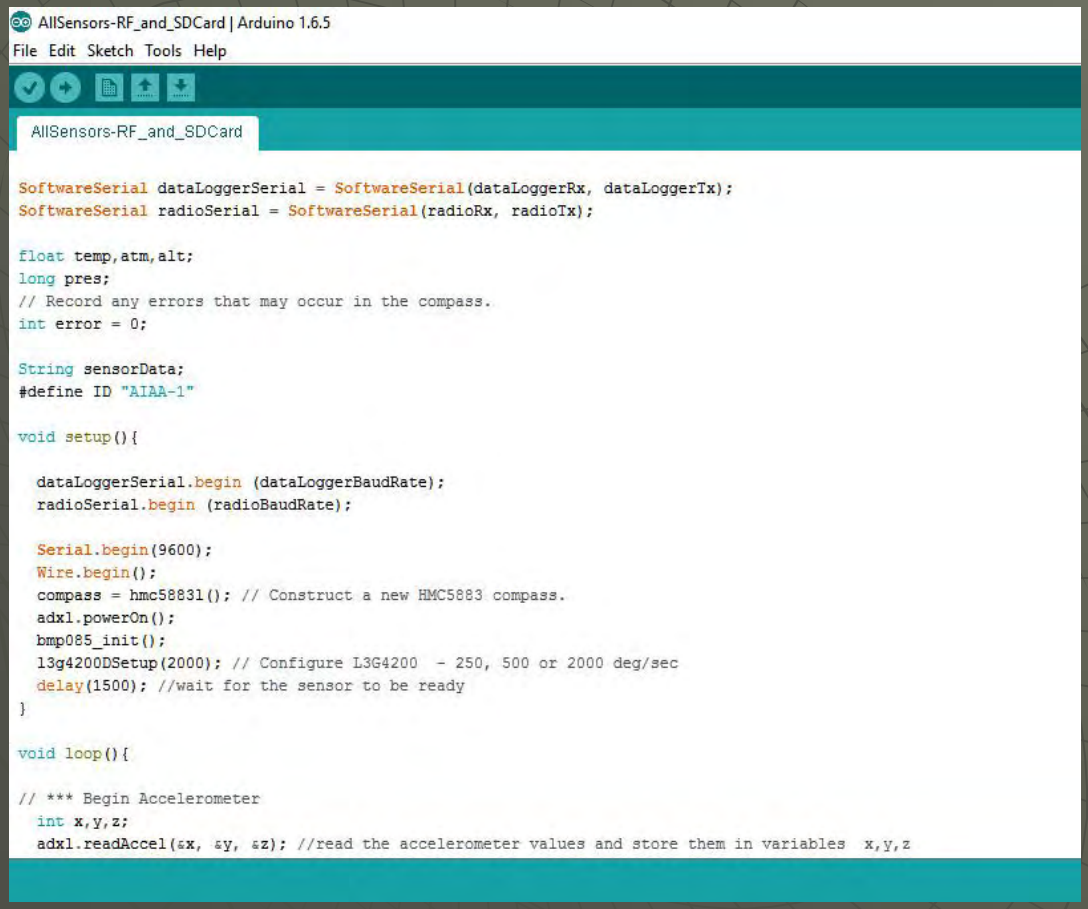
Point of Comparison
Original IBM PC

- Released August 12, 1981
- Intel 8088 4.77 MHz
- 508mm x 406mm x 140mm
- 20″ x 16″ x 5.5″
- 64Kb – 256Kb RAM

$1,565 (down from $9 million for an IBM computer 20 years earlier)

IDE ï For Firmware Development

(Integrated Development Environment)



Arduino IDE

Most of the microprocessor development platforms have a free development environment available

- Editor
- Compiler
- Serial Monitor

CHDK ï Canon Hack Development Kit

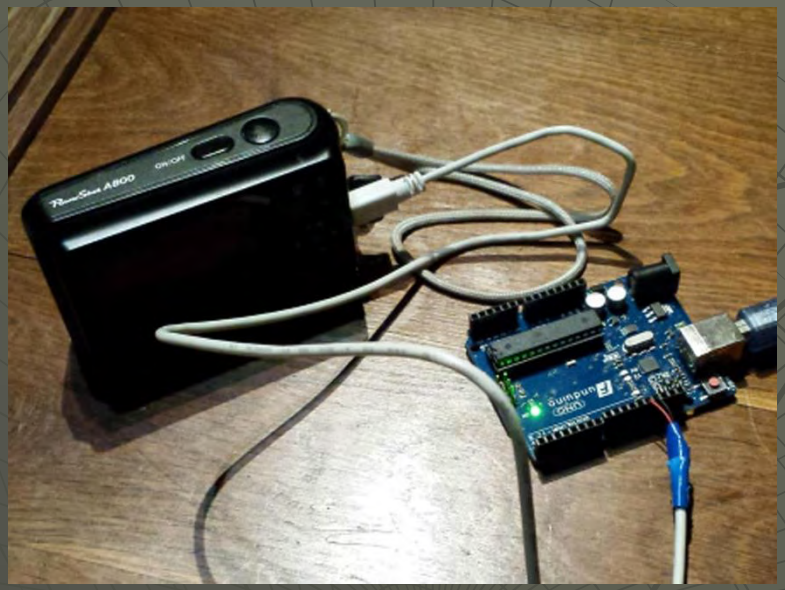


Photo from Pouicr Blog

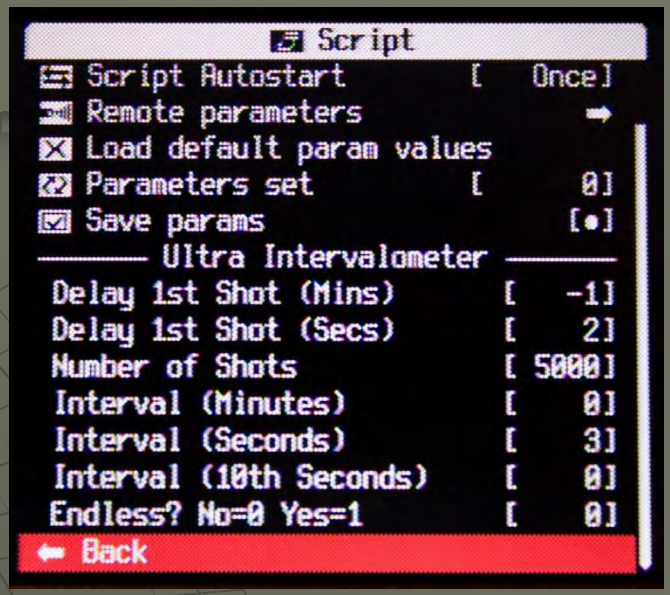
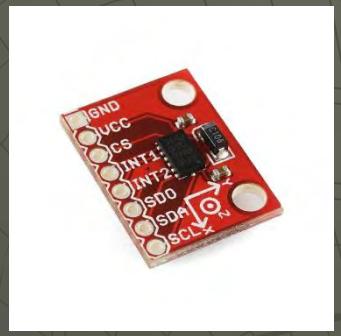


Image from TimeLapseBlog

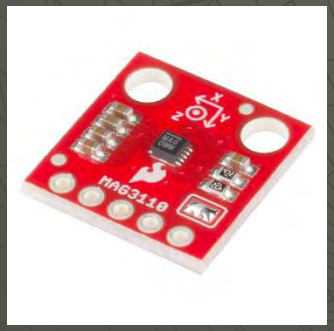
Use CHDK (Canon Hack Development Kit) to control most Canon cameras from an external microcontroller such as an Arduino

The microcontroller determines when the picture(s) should be taken and tells the camera to take a picture, or start recording video

What to Use ï Sensors



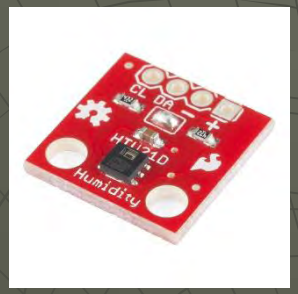
- Triple Axis Accelerometer Breakout Board
- Up to 16g with resolution of 13 bit
- I2C or SPI Interface
- Less than 25mm on a side
- $17.95 (Sparkfun)



- Triple Axis Magnetometer Breakout Board
- Full Scale +/- 1000 uT; sensitivity of .10uT
- I2C Interface
- Approximately 15mm on a side
- $14.95 (Sparkfun)

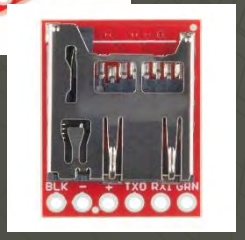
- Barometric Pressure Sensor Breakout Board
- 300 to 100 hPa accuracy to 0.02hPa
- I2C Interface
- Approximately 15mm on a side
- $9.95 (Sparkfun)

What to Use ï Sensors



- Humidity and Temperature Breakout Board
- I2C Interface
- Approximately 15mm on a side
- $14.95 (Sparkfun)

- GPS
- 48 Channel; -163dBm sensitivity
- 2.5m Positional Accuracy
- 30mm x 30mm
- UART Interface
- $39.95



- microSD card interface Breakout Board
- Up to 64GB micro SD Card
- Socket and “smart” electronics
- Approximately 20mm on a side
- $14.95 (Sparkfun)

What to Use ï IMUôs & Radios

(Inertial Measurement Unit)

- 9 Degree of Freedom IMU
- 3 axis Gyro, triaxial accel, 3 axis magnetic field
- 22mm x 16mm
- $8.81 (DX – DealExtreme)

- Transceiver for data
- 250 Kbps (2.4GHz) or 156 Kbps data (900 MHz)
- 60mW 2.4GHz – 1 mile range
- 50mW 900 MHz – 6 mile range with gain antenna
- UART Interface
- $37.95 (2.4GHz) $54.95 (900MHz)

- Transceiver for data
- 1200 to 57600 bps
- 431 – 478 MHz (Ham License Required)
- 800 – 1000 meter range
- UART Interface
- $28.95 (two tx/rx, antenna, USB adapter – DX)

Development Environment

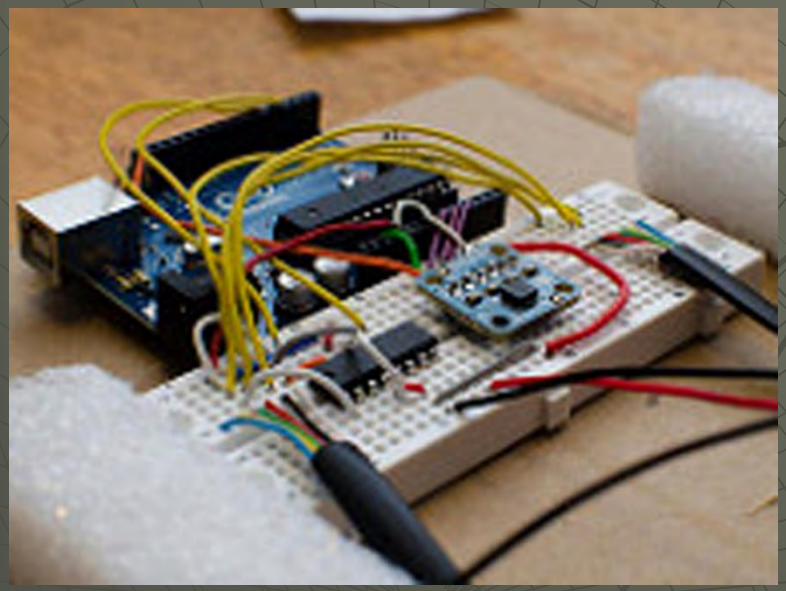


Photo from FlikrHiveMind.net

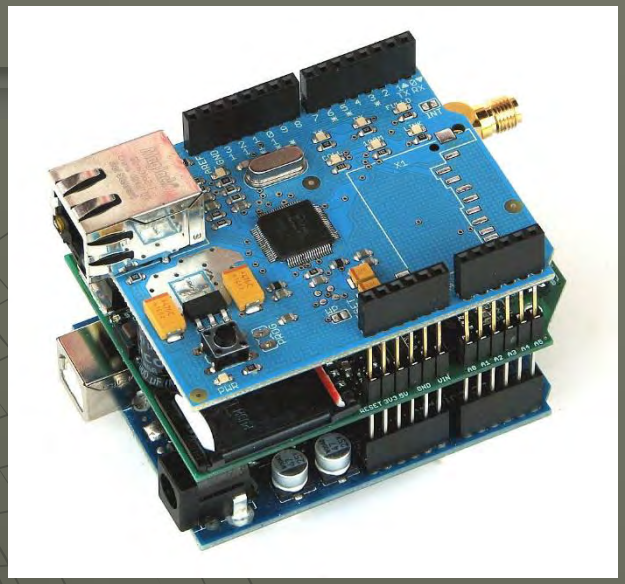


Photo from HWKitchen.com

The development platforms make it easy to breadboard circuits to program and test

Some platforms like Arduino use plug in boards called Shields to add hardware functionality

CanSat Competition

The "CanSat Competition" is jointly organized by AIAA and the AAS and is open to Colleges and Universities

It is a true end-to-end life cycle experience of a real engineering project

Students build a science vehicle and a re-entry container (CanSat)

When released the container glides in a circular path, recording air pressure and temperature and taking pictures. The container sends telemetry data and receives commands via an RF link

Arliss

A Rocket Launch for International Student Satellites

ARLISS
Black Rock Desert, Nevada

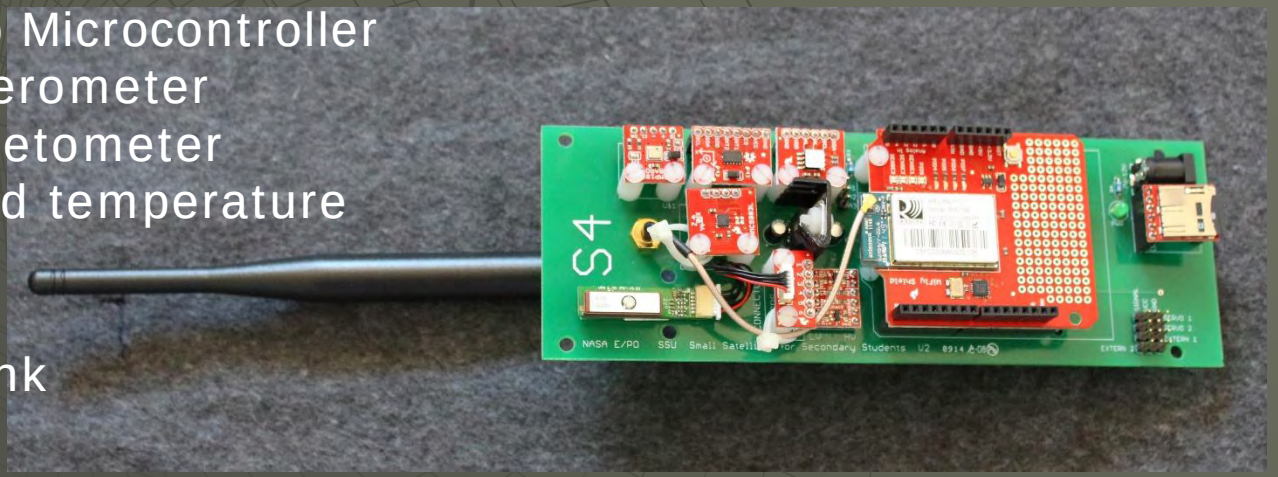
- Targeted towards university level and advanced high school students
- Stanford University with other educational institutions
- Provides infrastructure, launch site, launch vehicles and operation
- From CanSats to Open Class of single coffee can sized payload
- Open Class
  - Payload capable of autonomous operation
  - Real time bidirectional radio communications
  - Robotic design
  - GPS

ESRAôs IREC

World's Largest University Rocket Competition

- Intercollegiate Rocketry Engineering Competition
- "World's Largest University Rocket Competition"
- Typical competition
  - Design Build and Launch a rocket
  - With at least a 10 lb payload of their own design
  - To an altitude of at least 10,000 ft to 23,000 ft

- High School Students (we include Junior High)
- Provides an important missing link in NASA's educational pipeline between TARC (Team America Rocketry Challenge) and the sounding rocket flights conducted by graduate students at research institutes
- Payload is a carrier board with
  - Arduino Uno Microcontroller
  - 3 axis accelerometer
  - 3 axis magnetometer
  - Humidity and temperature
  - GPS
  - SD Card
  - WiFi radio link



Student Launch Projects

- Students design a rocket and payload
- Rocket goes to 1 mile high
- Handled like real engineering project
  - Proposal, PDR, CDR, FRR, PLAR
  - Reviews via WebEx to NASA Huntsville
- Final launch in Huntsville

- High School
  - Students design their payload with science value
- University Age
  - Landing Hazards Detection
  - Liquid Sloshing in micro-g
  - Propulsion system analysis
  - Payload fairing design and deployment
  - Aerodynamics analysis
  - MAV (Mars Ascent Vehicle)

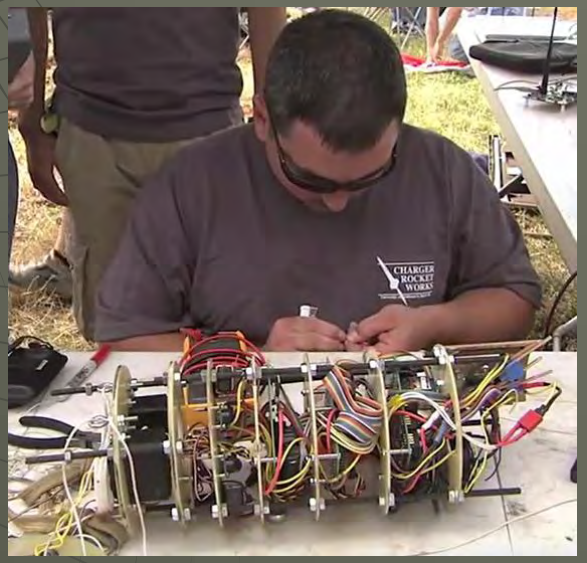
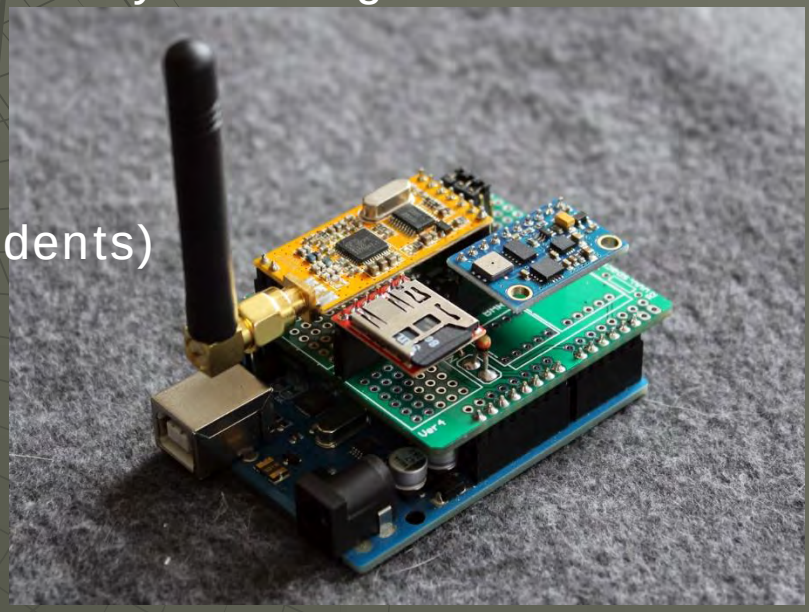


Photo from NASA Video

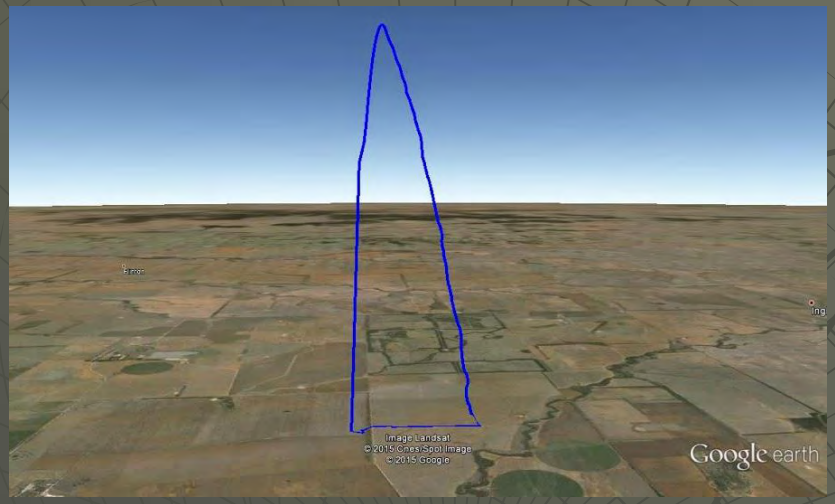
SPARC

Student Payload and Rocketry Challenge

- Junior High and High School
- CanSats (Arduino + Shield to start)
- S4 (Small Satellites for Secondary Students)
- Open
  - Guided Parachute Descent
  - Pitot Tube
  - Strain Gauges
- Rocket Science Fair at Launch Site



SPARC



3D Rocket track using GPS data from S4 board and KML file interpreted by Google Earth

Pitot Tube

SPARC

Autonomously Guided Recovery

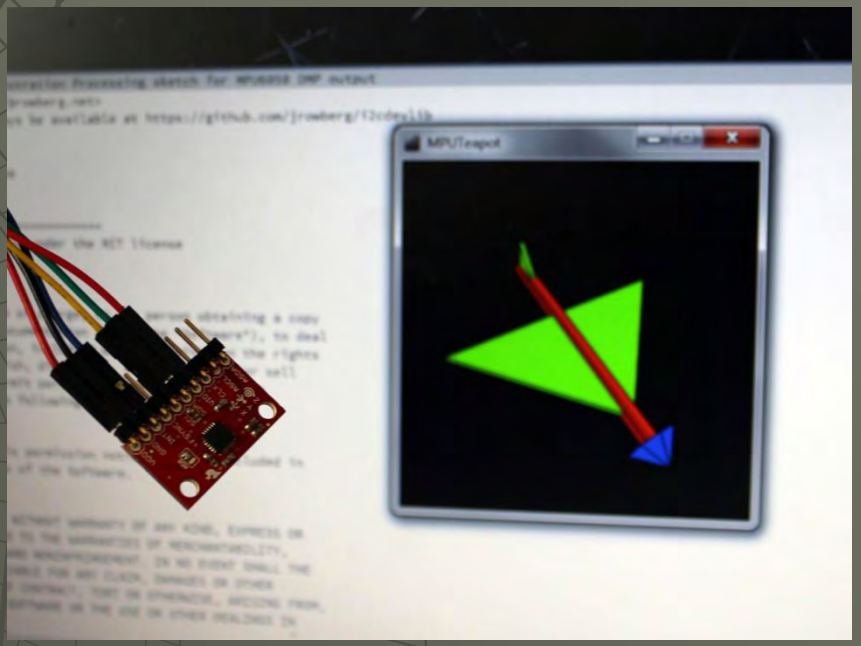
Science Fair

High Velocity Parachute Deployment

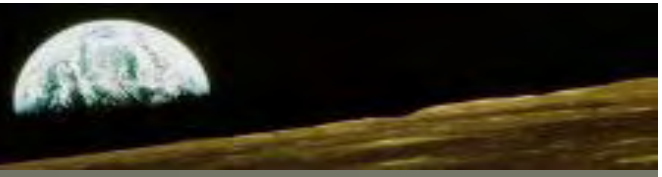
TARC

Altitude control through Airbrakes (Arduino controlled)

General

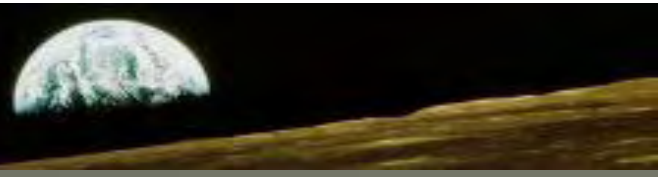


Real Time graphic indication of attitude using accelerometer



Thank you

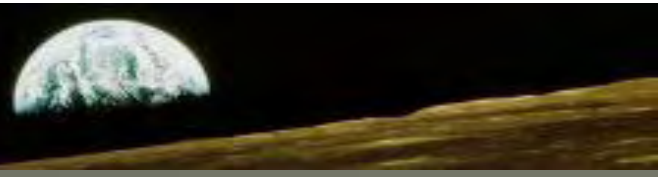
Questions?



Additional Information

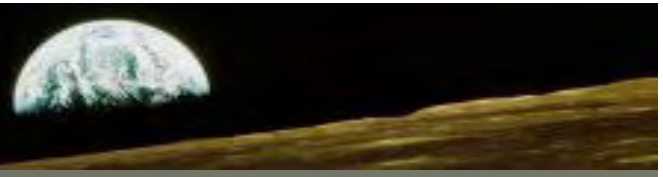
We have visited all of these links; neither Norton nor Malwarebytes found issues. But many are international links, so please be careful

- AIAA OC Rocketry SPARC: http://aiaaocrocketry.org/?page_id=915
- Aalborg University Student Space: http://www.space.aau.dk/
- NASA SLI: http://www.nasa.gov/audience/forstudents/studentlaunch/home/index.html
- S4 (Small Satellites for Secondary Students)
  - http://s4.sonoma.edu/
- ARLISS (A Rocket Launch for International Student Satellites)
  - http://www.arliss.org/
- ESRA (Experimental Sounding Rocket Association
  - http://www.soundingrocket.org/
- IREC (Intercollegiate Rocket Engineering Competition)
  - http://www.soundingrocket.org/2016-irec.html
- CHDK (Canon Hack Development Kit): http://chdk.wikia.com/wiki/CHDK
- Sparkfun: https://www.sparkfun.com/



Links

- Using the S4 board to measure magnetic variations and compare to bird migration patterns: http://s4.sonoma.edu/?page_id=48517
- Arliss Video: Measure Pollution, Magnetometer: https://www.youtube.com/watch?v=zKTUsB7F0PY
- Arliss Overview Presentation: http://www2.isunet.edu/index2.php?option=com_docman&task=doc_view&gid=2379&Itemid=26
- Andoya Space Center: http://andoyaspace.no/?page_id=325&paged=8
- ESA CanSats: http://www.esa.int/Education/CanSat
- ESA CanSats in Europe: http://www.esa.int/SPECIALS/CanSat/SEM9HVCKP6G_1.html
- ESERO (European Space Education Resource Office): http://esero.ie/project/cansat-201516/
- Kraksat Projects: https://www.kraksat.pl/2013/?attachment_id=979



Links

- Lithuanian Iterptines Sistemos: http://is.mokslasplius.lt/en/bepilocius-aparatus-ir-palydovus-kuria-jaunimas/
- NAVRO Launcher: http://www.navro.nl/en/news/cansat09picture
- NAVRO CanSats: http://www.navro.nl/en/news/cansat08
- Naval Research Laboratires: http://www.nrl.navy.mil/media/news-releases/2015/nrl-aerospace-industry-hosts-11th-annual-cansat-student-challenge
- Planete Sciences: http://www.planete-sciences.org/espace/activites/CanSat/?lang=en
- Popular Mechanics South Africa: http://www.popularmechanics.co.za/blogs/promising-rocket-scientists-uct-blast/
- Southgate ARC: http://www.southgatearc.org/
- Technology.org: http://www.technology.org/2014/09/22/nrl-aerospace-industry-hosts-10th-annual-cansat-student-challenge/

Links

- UNISEC (University Space Engineering Consortium): http://www.unisec.jp/history/arliss2006tohoku-r-koriki-e.html
- University of Alabama Huntsville: http://space.uah.edu/cansat/
- WeCansat: http://wecansat.blogspot.com/2011/03/new-electronic-system.html
- Australian Rocketry: http://ausrocketry.com/forum/viewtopic.php?f=72&t=4888&start=15
- Time Lapse Blog: http://timelapseblog.com/2009/07/06/install-a-chdk-intervalometer-on-your-powershot/