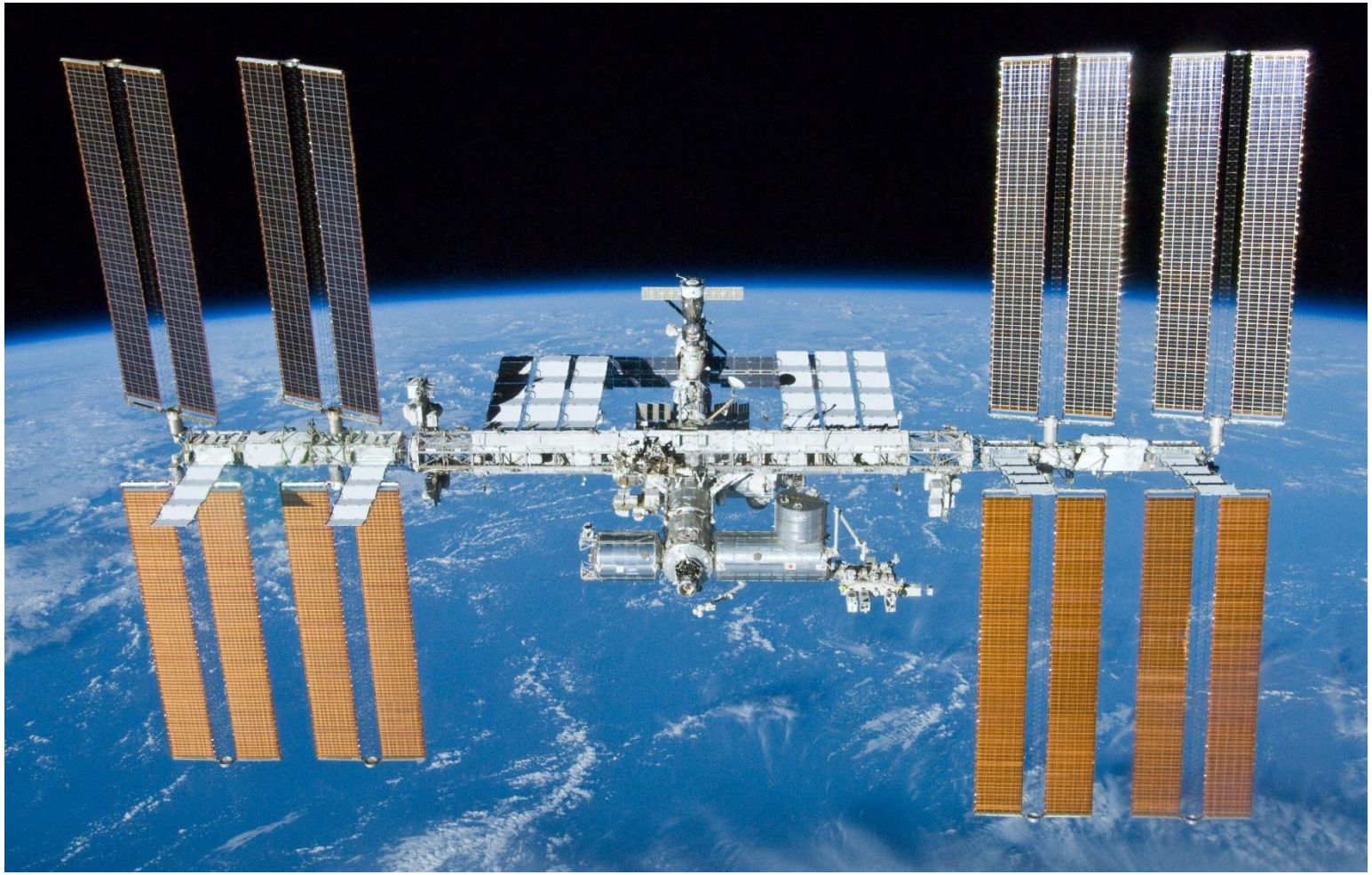
Balloon Satellite – Lesson 1

International Space Station



Try spotting them yourselves!

Satellite Tracker by Star Walk
iOS

Heavens Above
Android

Satellite?

Definition

1. An artificial body placed in orbit round the earth or moon or another planet in order to collect information or for communication.

2. A celestial body orbiting the earth or another planet.

https://climate.nasa.gov/news/2242/briefing-to-highlight-results-from-new-earth-missions/

History of Satellites

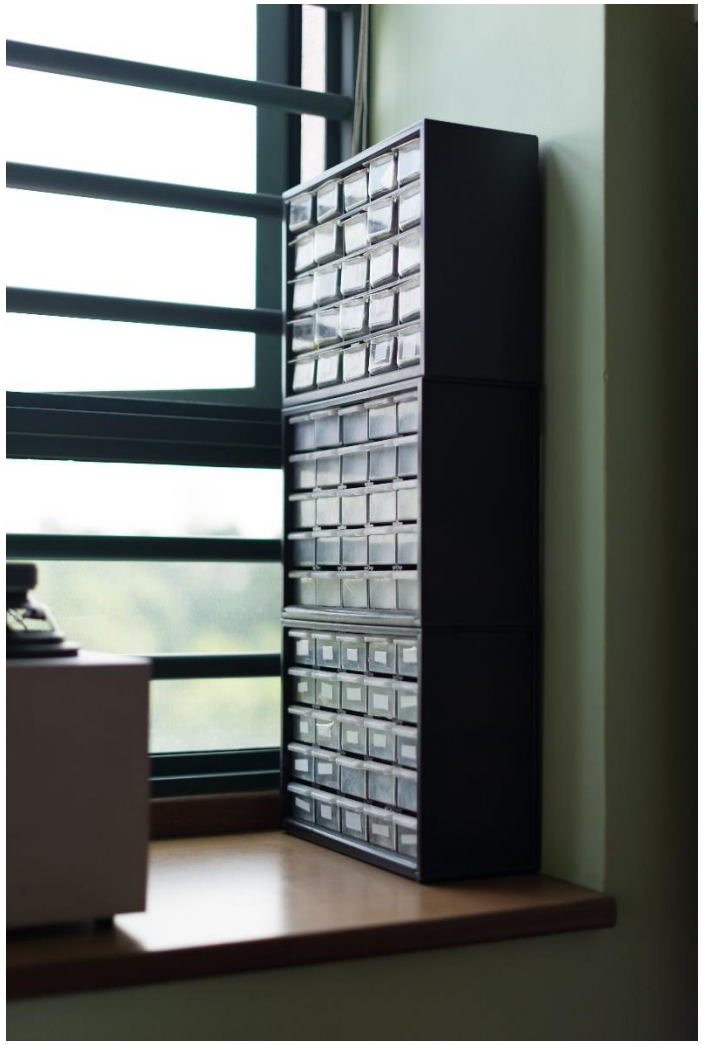
- 4th of Oct 1957 – First satellite in the world, Sputnik 1, was launched by the Soviet Union
- 3rd of Nov 1957 – Sputnik 2 was launched carrying the first living passenger, a dog named Laika, into the orbit.
- 31st of Jan 1958 – The first American satellite, Explorer 1, was launch.
- 16th of July 1969 – Apollo landed the first 2 people on the moon

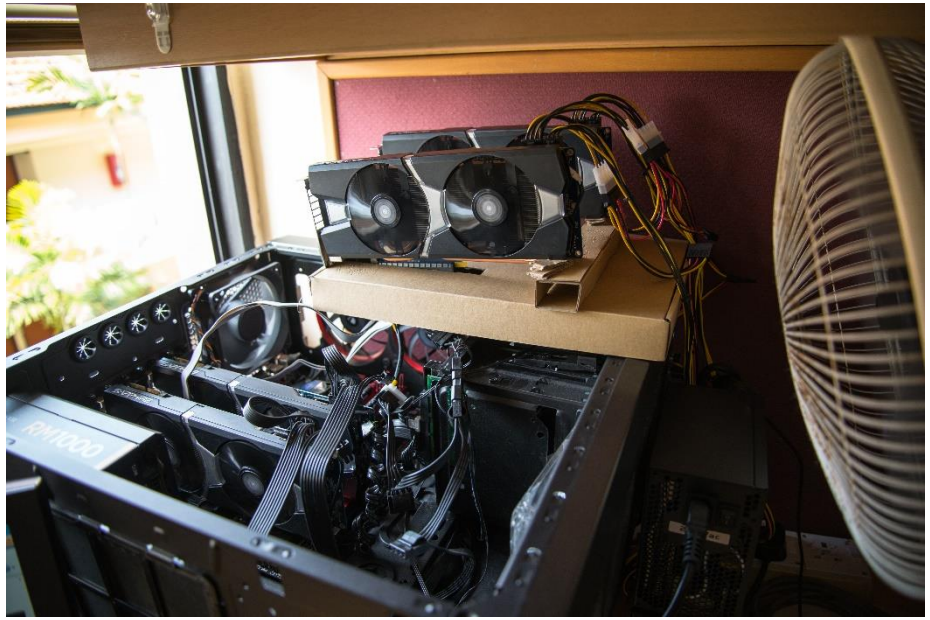
But first…

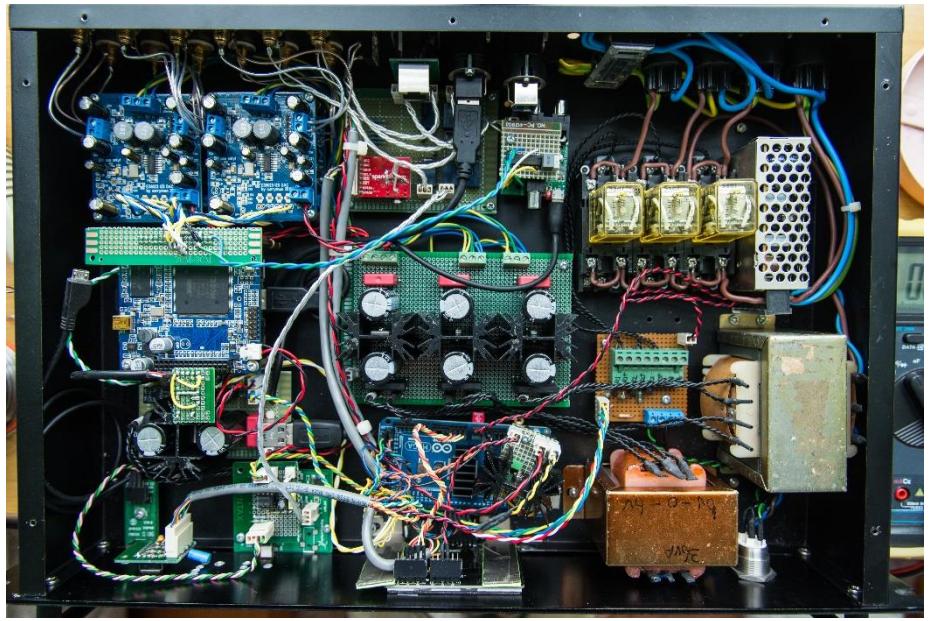
A bit about myself…


United States
NO PARKING

I am a Geek







*This picture is not my coil gun

Back to the Satellites

- Derivation of Escape Velocity
- Conservation of Energy

$$PE_0 + KE_0 = PE_f + KE_f$$

$$KE = \frac{1}{2}mv^2$$

$$PE = \frac{GM_e m}{r_e}$$

Back to the Satellites

- Sending satellites into space
  - Escape velocity

$$v_e = \sqrt{\frac{2GM}{R_e}}$$

$Re = 6371\ km$

$M = mass\ of\ Earth = 5.972 * 10^{24}\ kg$

$G = Universal\ Gravitational\ Constant = 6.67\ *\ 10^{-11}\ m^3\ kg^{-1}s^{-2}$

Rockets

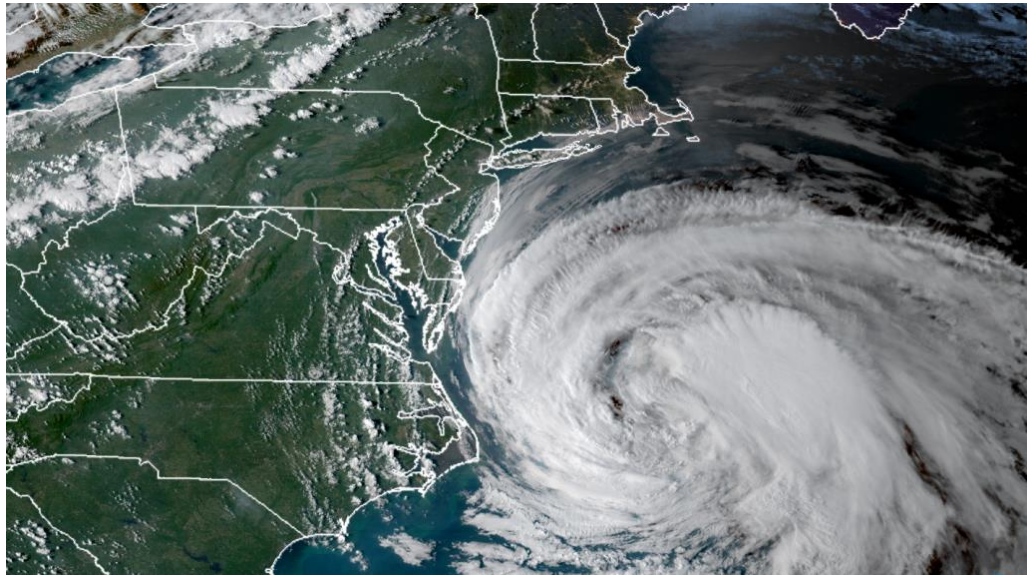
- Rockets are the only way to bring something up into space and making it enter an orbit

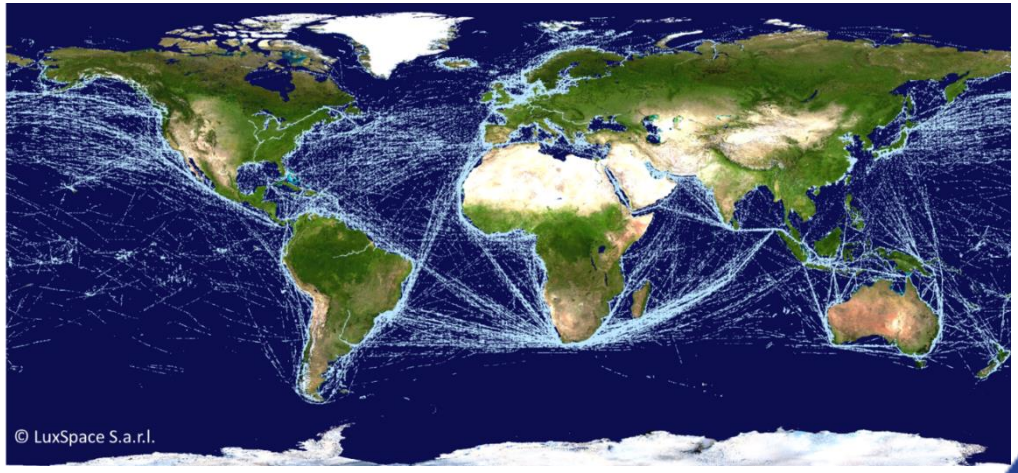
Applications of Satellites

- For monitoring of Earth Activities
  - Imaging
  - Listening in on RF communication activities
- To provide communication services in rural areas
- Exploration of Space

Application – Monitoring

- Imaging
  - Weather forecast and monitoring
  - Disaster monitoring
  - Food security
  - City planning
  - Insurance
  - Google Earth
  - Spying…
- Radio Frequency
  - Airplane and ship monitoring
  - Spying…





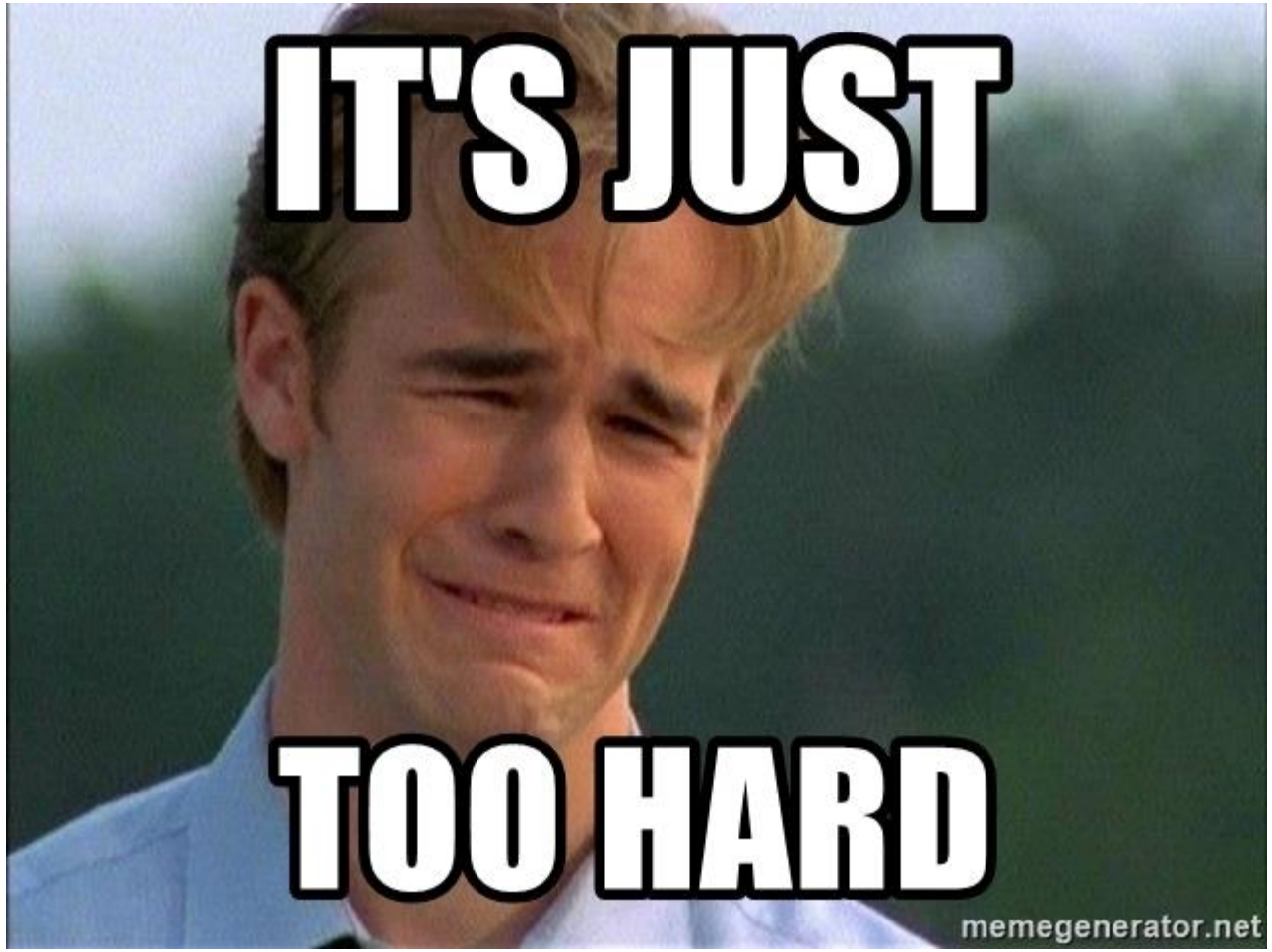
Application – Communication

- A large part of the Earth is still not connected: ~85%
  - Middle of ocean, sparsely populated areas
- Satellite communications are the only means of relaying information to these areas

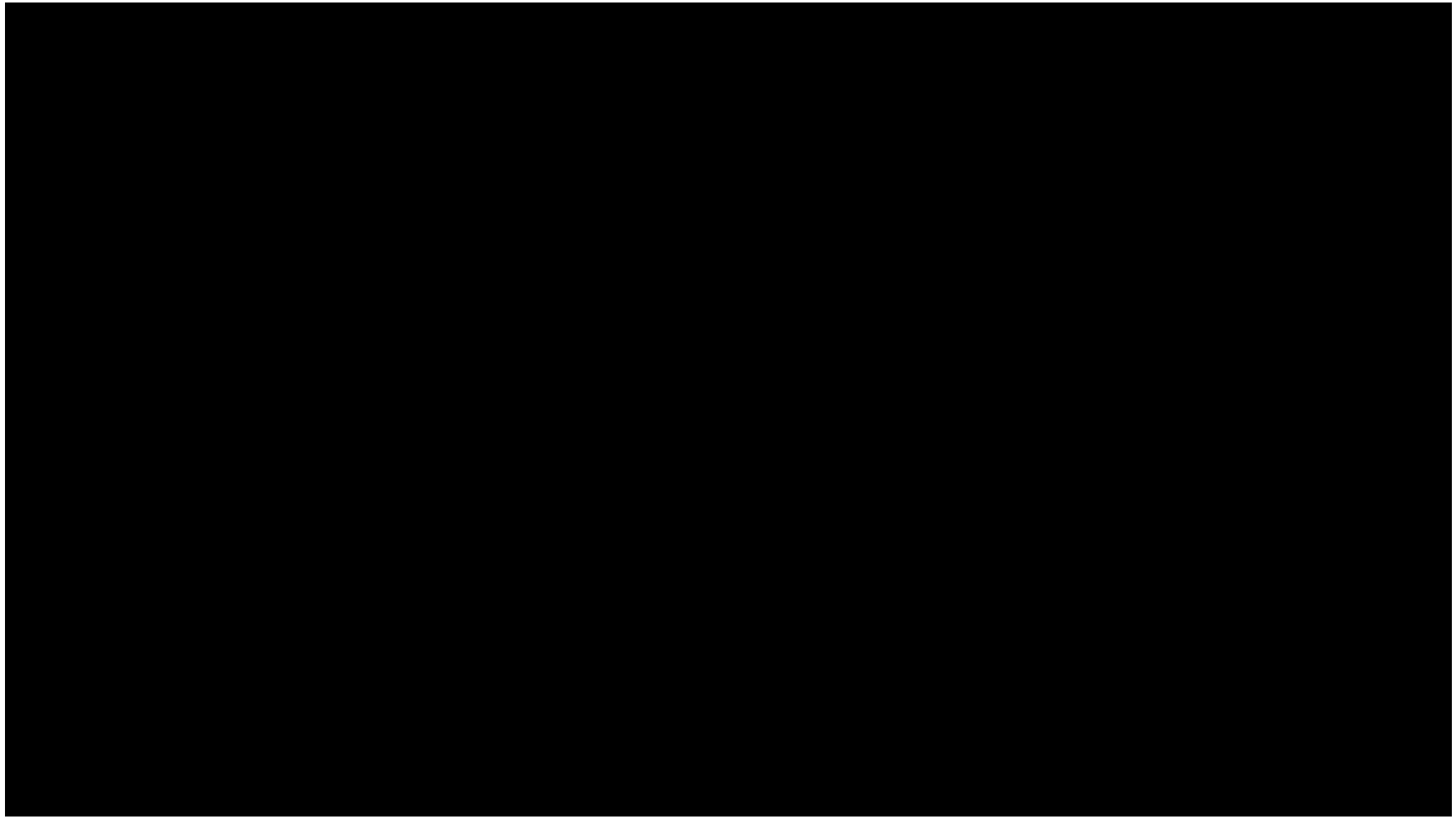
Application – Space Exploration

- Exploring other planets
  - Mars
  - Pluto
  - Venus
  - Sun
- Exploring our galaxy
  - Voyager

Satellites for Me???



Nanosatellites



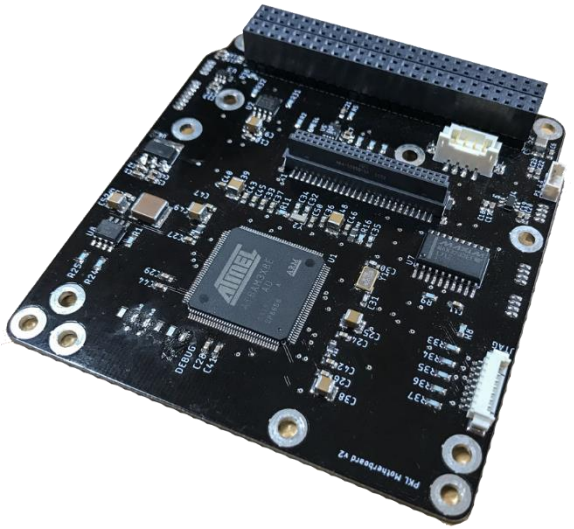
Break

Nanosatellites – Subsystems

Subsystem	Function
On-board Computer (OBC)	Brains of the entire satellite. Makes sure that all the other subsystems are healthy and carries out missions instructed from the ground.
Tracking, Telemetry & Command (TT&C)	Establishes RF link with the ground to relay telemetry information about the satellite's condition to the ground control staff.
Electrical Power System (EPS)	Energy source for the entire satellite.
Attitude Determination & Control System (ADCS)	Orientates & Stabilises spacecraft in a space environment where there is no gravity or air resistance.
Thermal	Equivalent to the sweat glands of the body to make sure the satellite maintains at a comfortable temperature.
Structure	The backbone of the entire satellite to holder everything together
Payload	The function of the satellite. Eg: Camera gives the satellite the ability to perform remote sensing.

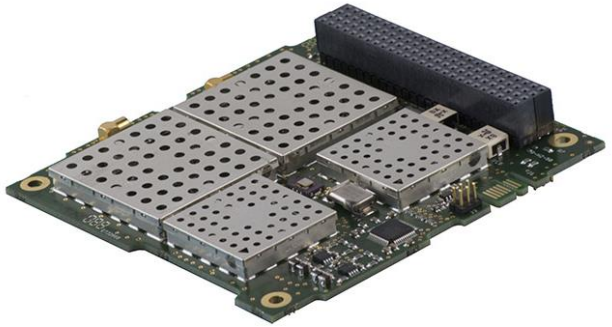
On-Board Computer

- Functionality usually achieved with a micro-controller
- Interfaces with rest of the subsystems in the satellite to know the overall condition of the satellite
- Satellites (or most systems in general) usually have a common communication bus for all subsystems to communicate with each other
- Able to do some decision making for the entire satellite in order to ensure survival of satellite
- Stores commands from the ground control station and executes them when necessary



TT&C

- Provides the RF capability to the satellite for it to communicate with the ground control station
- Converts data into RF signals and transmits them over the air to the ground
- RF has to travel over >500km in order to reach the ground
- Works hand in hand with the OBC to provide a full picture to the ground control staff

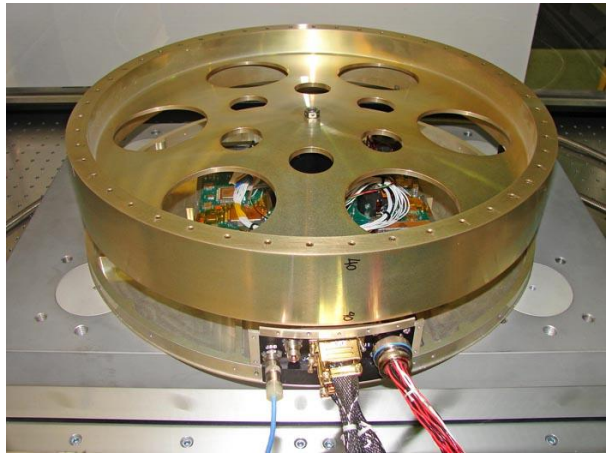


EPS

- Consists of batteries, maximum power point tracking for solar panels, voltage regulators, electrical switches, latch-up protection
- Takes in converted power from the solar panels, conditions it and stores it in the batteries
- Energy from the batteries are then regulated for the consumption by other subsystems in the satellite (5V & 3.3V)
- Protects the satellite from anomalies such as an overcurrent/surge event (latch-up protection)

ADCS

- No friction/gravity in space. Perform its function entirely based on the principal of conservation of momentum
- To change the orientation of the satellite, reaction wheels or magnetorquers are employed
- Magnetorquers are electromagnets that interacts with the Earth's magnetic field to effect a change in the satellites orientation
- Reaction wheels are spinning wheel masses to increase/decrease the entire satellite's momentum to effect a orientation change

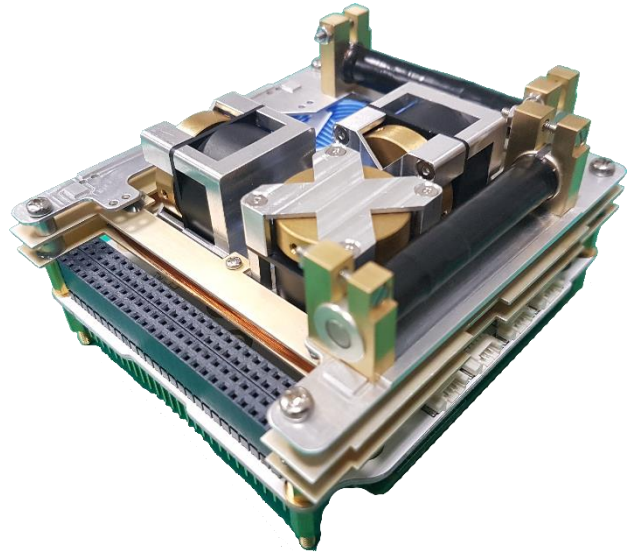


Reaction Wheel

Magnetorquers

ADCS

- Many sensors on the satellite allows the satellite to figure out its orientation
  - Coarse and Fine Sun Sensors
  - Magnetometers
  - Gyro Sensors
  - Star Sensors
- Another microcontroller on the ADCS takes in all the sensor readings to figure out the orientation of the satellite
- ADCS will then control the actuators to achieve the overall effect of controlling the satellites orientation
- Based on the commands from the OBC, the ADCS can also make the satellite point at a desired target. Example: Imaging a particular location



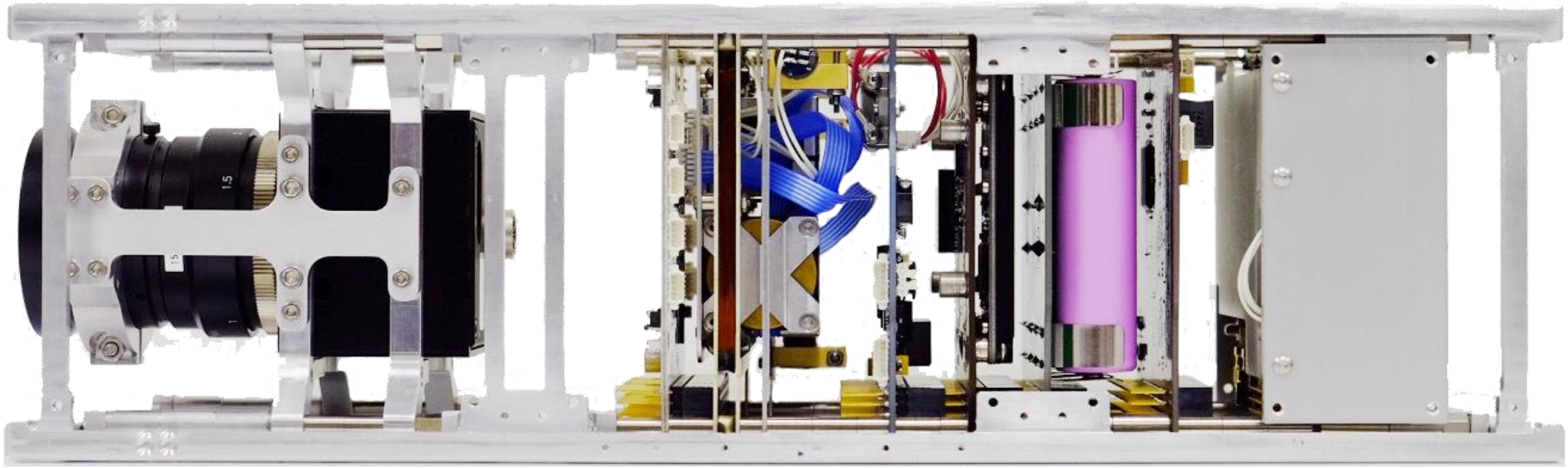
Structure

- Skeleton of satellite to hold everything in place
- Undergoes a lot of stress during the launch phase with all the shocks and vibrations
- May be integrated with deployable mechanisms. Eg: Solar Panel Deployable

Payload

- Camera
- RF Receivers
- RF Transmitters
- Experiments to conduct in space
  - Cell mutation due to space radiation
  - Bacteria & viruses in survivability in space conditions

Putting It All Together



Inspired?

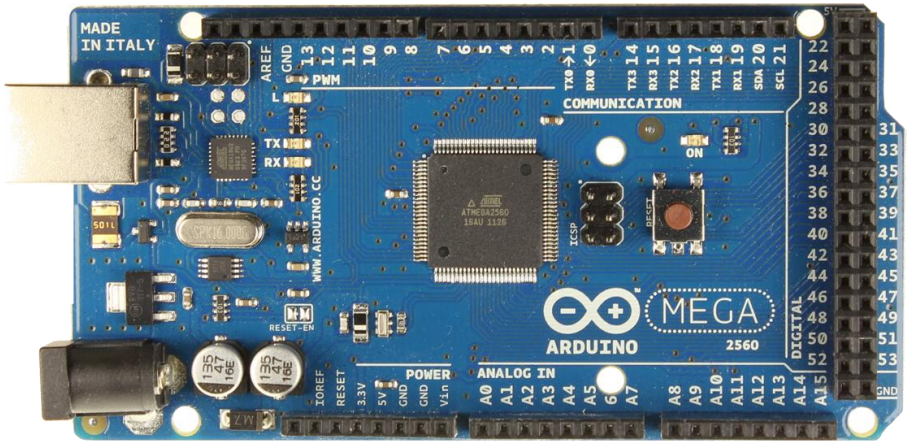
Let us start somewhere…

Balloon Satellite

- To expose students to:
  - Microcontroller programming
  - Scaled down version of each satellite's subsystem
  - Interfacing with sensors
  - Working with actuators
  - Overall system consideration and programming
  - Structure design and fabrication
  - Concept of subsystems

Balloon Satellite

- Students will be working with the following components:



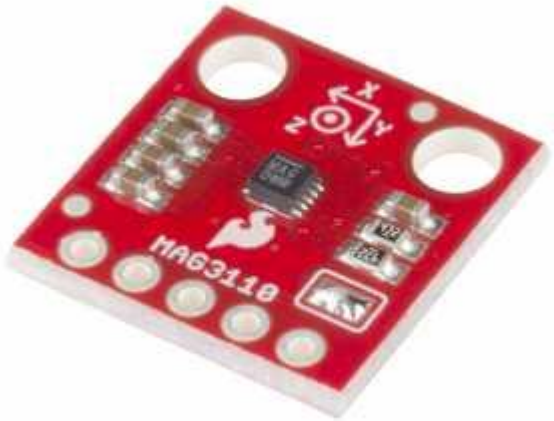
Arduino Mega 2560

Xbee Wireless Communication

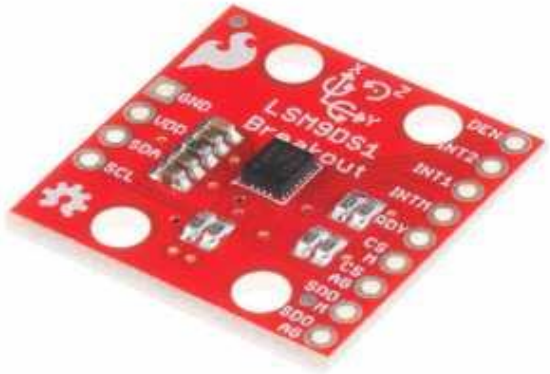
Barometric Pressure Sensor

Balloon Satellite

Humidity Sensor



3-Axis Magnetometer



9DOF Inertial Measurement Unit

Servo Motor Assemblies

LCD

SD Card Module

Topics Covered

- Analog to Digital Conversion (ADC)
- Digital I/O Ports
- Serial Peripheral Interface (SPI)
- Pulse Width Modulation
- Two Wire Interface (TWI) or Inter-Integrated Circuit (I2C)
- Universal Asynchronous Receiver and Transmitter (UART)

Final Outcome

- Students will have to design, build and operate a balloon satellite system that will be flown in the sky with a tethered weather balloon
- Balloon satellite system includes the ground control station with a wireless link to control the balloon satellite in the air
- Balloon satellite must be no larger than 16cm x 16cm x 16cm and be under 1.2kg

Schedule

- 17th August – Student groups to make a presentation on what will your balloon satellite do

- 16th Nov – Test flight of balloon satellites!

Conclusion

- Introduction to Satellites
- Applications of Satellites
- Satellite Subsystems
- Project Brief

Thank You

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