

# FIRST AEROPLANE FLIGHT IN THE BRITISH EMPIRE.

COMMEMORATING

THE WORK OF THE AERIAL EXPERIMENT ASSOCIATION  
WHICH RESULTED IN THE FIRST AEROPLANE FLIGHT  
WITHIN THE BRITISH EMPIRE, MADE BY J.A.D.MCCURDY  
AT BADDECK, NOVA SCOTIA, ON FEBRUARY 23, 1909.

THE AERIAL EXPERIMENT ASSOCIATION WAS FOUNDED  
AT BADDECK BY DR. ALEXANDER GRAHAM BELL.  
THE OTHER MEMBERS WERE: RALPH BALDWIN, WHOSE  
FIRST SUCCESSFUL FLIGHT WAS MADE AT  
HAMMONDSPORT, N.Y. ON MARCH 12, 1908;  
GLEB H. CURTISS, J.A.D.MCCURDY, THOMAS E. SELFRIDGE.  
THEIR CONTRIBUTIONS TO THE ADVANCEMENT OF  
AERONAUTICAL SCIENCE ARE GRATEFULLY ACKNOWLEDGED.  
ERECTED BY CANADIAN AIRING ASSOCIATION.

Wright Flyer 1903



# Aim High with High Power Rocketry

2019 PARC HPR Presentation

Dave Rajnauth  
Tyler Rajnauth

# Who am I?

Dave Rajnauth, VE300I

- ▶ Security Consultant by day and Science and Technology Geek at night
- ▶ McMaster Physics Graduate
- ▶ Classic Case of the “knack”
  - Passion for Science and Electronics
  - Fixed Tube Televisions as a Kid.
  - Avid CB-er in the 70's.
  - Licensed Private Pilot and Glider Pilot
  - Built lots of Microcontroller projects
- ▶ Model Aircraft and High Power Rocket Enthusiast
- ▶ Basic Ticket in 2010 and Advanced in 2012

# Who am I?

Tyler Rajnauth, VA3TJR

- ▶ Body Guard to Dear ol'Dad
  - Red Belt Karate (Next Belt is Black)
- ▶ Grade 10 High School Student
- ▶ Basic Ticket at 13
- ▶ First Lego League Robotics
  - 2x Provincials
  - Provincial Programming Award
- ▶ Boy Scout and Cub Scout
- ▶ Passion for Fast Cars, Space and Physics

# What is a Rocket?

## Aeronautics Act

- ▶ "rocket" means a projectile that contains its own propellant and that depends for its flight on a reaction set up by the release of a continuous jet of rapidly expanding gases
- ▶ Maintains stability by using fins located below the centre of gravity





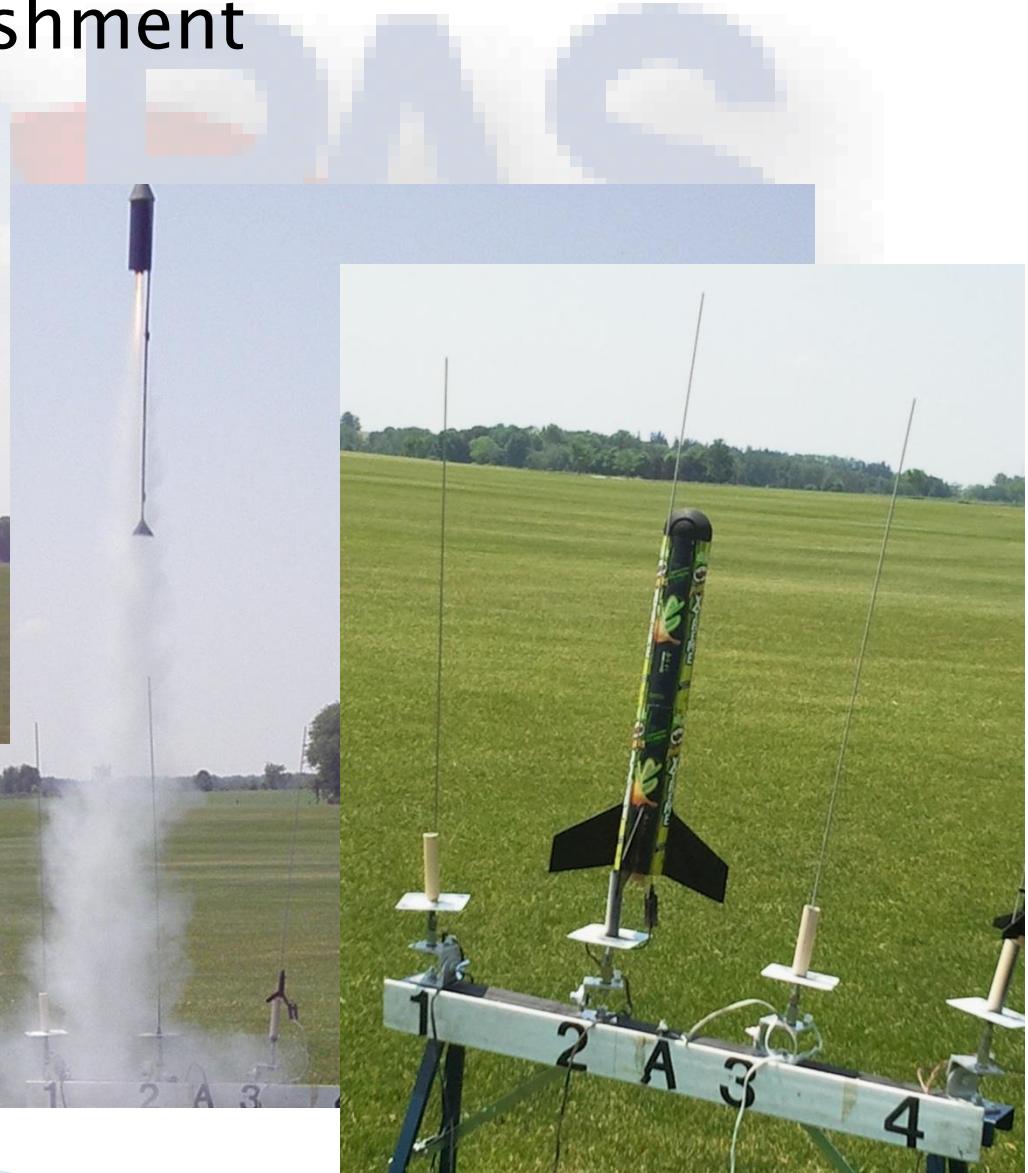
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LDHS XXI

# Why Fly Rockets?

- ▶ Sense of Accomplishment



# Why Fly Rockets?

- ▶ Fixing Rocket



# Why Fly Rockets?

- ▶ Socializing



# Canadian Aviation Regulations

- ▶ 602.43 No person shall launch a rocket, other than a model rocket or a rocket of a type used in a fireworks display, except in accordance with an authorization issued by the Minister pursuant to section 602.44.
- ▶ 602.44 The Minister may issue an authorization referred to in section 602.42 or 602.43 where the release of the balloon or the launch of the rocket is in the public interest and is not likely to affect aviation safety.
- ▶ 602.45 No person shall fly a model aircraft or a kite or launch a model rocket or a rocket of a type used in a fireworks display into cloud or in a manner that is or is likely to be hazardous to aviation safety.
- ▶ “model rocket”
  - “model rocket” means a rocket that
    - (a) is equipped with model rocket motors that will not generate a total impulse exceeding 160 N.s,
    - (b) has a gross weight, including motors, not exceeding 1 500 g (3.3 pounds), and
    - (c) is equipped with a parachute or other device capable of retarding its descent;

# Quadcopters & other UAVs

→ 602.41 No person shall operate an unmanned air vehicle in flight except in accordance with a special flight operations certificate or an air operator certificate.

→ 602.45 No person shall fly a model aircraft or a kite or launch a model rocket or a rocket of any type used in a fireworks display into cloud or in a manner that is or is likely to be hazardous to aviation safety

Interim Order Respecting the Use of Model Aircraft that weighs over 250 g and under 35 kg

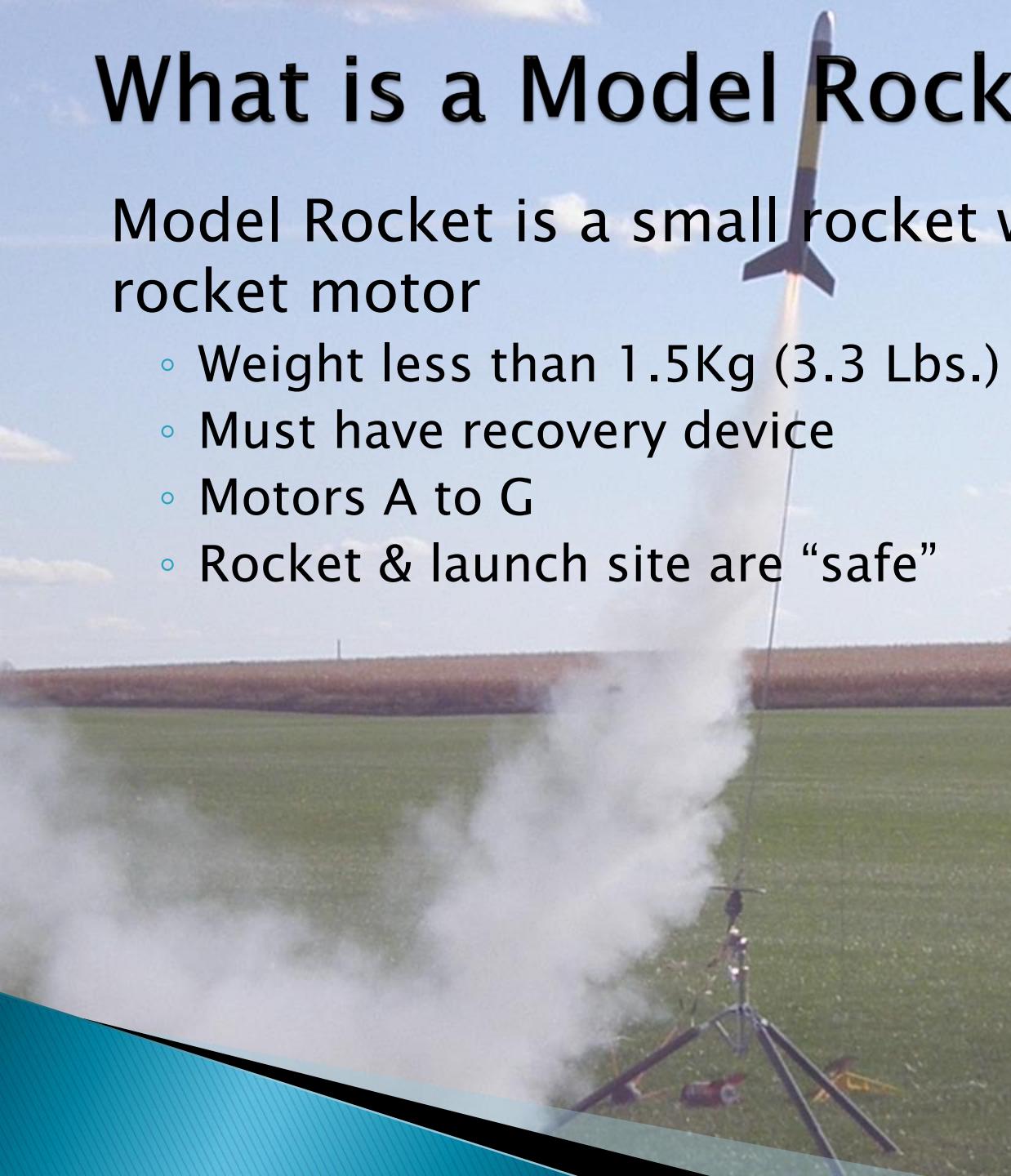
Fly your drone:

- “unmanned air vehicle”
  - below 90 m above the ground
    - at least 30 m away from vehicles, vessels and the public (if your drone weighs over 250 g and up to 1 kg)
      - at least 75 m away from vehicles, vessels and the public (if your drone weighs over 1 kg and up to 35 kg)
      - at least 5.5 km away from aerodromes (any airport, seaplane base or area where aircraft take off and land)
      - at least 1.8 km away from heliports or aerodromes used by helicopters only
      - outside of controlled or restricted airspace
      - at least 9 km away from a natural hazard or disaster area
      - away from areas where its use could interfere with police or first responders during the day and not in clouds
    - within your sight at all times
    - within 500 m of yourself
    - only if clearly marked with your name, address and telephone number
    - +more recreational purposes and that is not designed to carry persons or other living creatures

# What is a Model Rocket?

Model Rocket is a small rocket with small rocket motor

- Weight less than 1.5Kg (3.3 Lbs.)
- Must have recovery device
- Motors A to G
- Rocket & launch site are “safe”



# What is a High Power Rocket?

- ▶ Any rocket that is not a model rocket
- ▶ Weight more than 1.5 Kg
- ▶ Larger motor than a G
- ▶ Must be 18 years old to purchase motor and launch
- ▶ Must be certified for the type of motor
- ▶ Rockets reach altitudes of thousands of feet
  - Some rockets fly to well over 20,000 feet or to the edge of space
- ▶ **Need Minister's Authorization**



## APPENDIX A

### Rocket (High Power) Launch Authorization – December 21, 2011

1. NAPAS must notify Transport Canada Aerodromes and Air Navigation Regional Office in writing 15 working days prior to each launch event in order to process the request for restricted airspace.
2. NAPAS must ensure that the telephone number published for the Controlling Agency in the NOTAM is manned at all times during the launch event.
3. When contacted by affected aircraft operators, NAPAS must make all reasonable efforts to allow aircraft to transit through the restricted airspace established for rocket launches.
4. The Civil Aviation Regional Duty Officer must be notified at 416-346-2178 to cancel the NOTAM if any portion of the airspace restriction is no longer needed (e.g. if the rocket launch meet is cancelled for any reason or if rocket launching is completed sooner than published in the NOTAM).
5. The Toronto Area Control Centre, Shift Manager must be notified at 905-676-4509 if the rocket launch meet is cancelled for any reason or if rocket launching is completed sooner than requested in the authorization.
6. The rockets are launched from the range specified by a circle with a radius of 1.5 nm centered at

# Motor Comparison

## Model

- A-E 1–40 N.s
- F-G 40–160 N.s

## High Power (Level 1)

- H-I 160–640 N.s

## High Power (Level 2)

- J-L 640–5,120 N.s

## Level 3

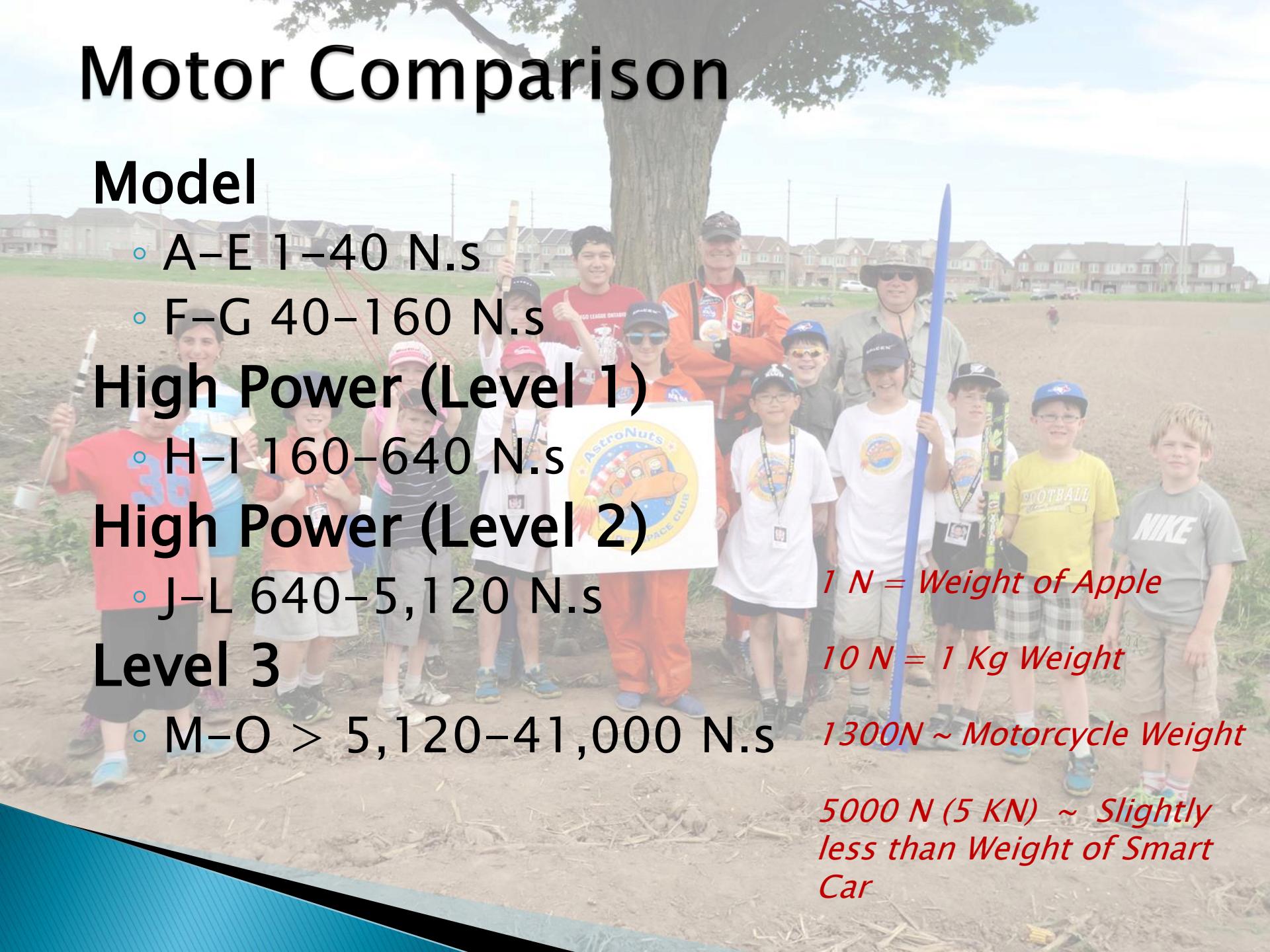
- M-O > 5,120–41,000 N.s

1 N = Weight of Apple

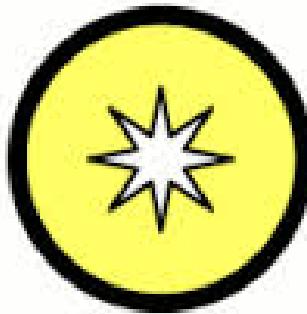
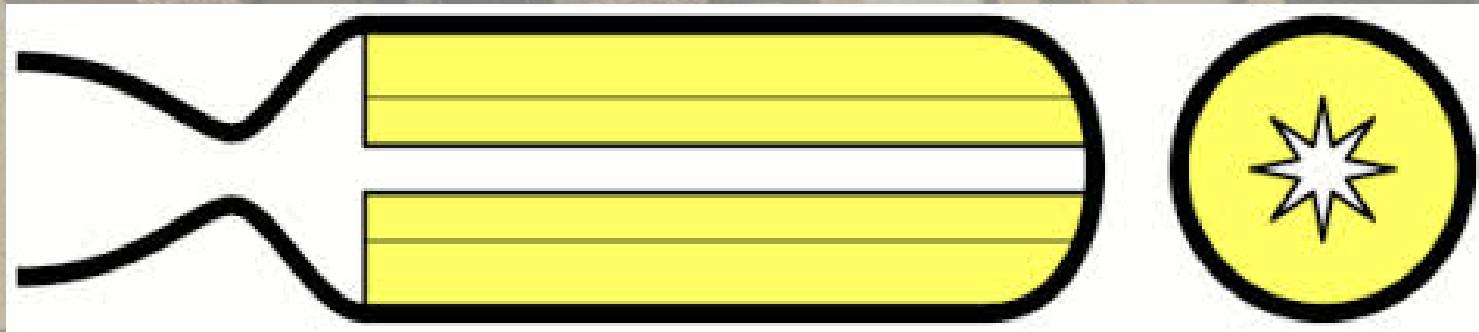
10 N = 1 Kg Weight

1300N ~ Motorcycle Weight

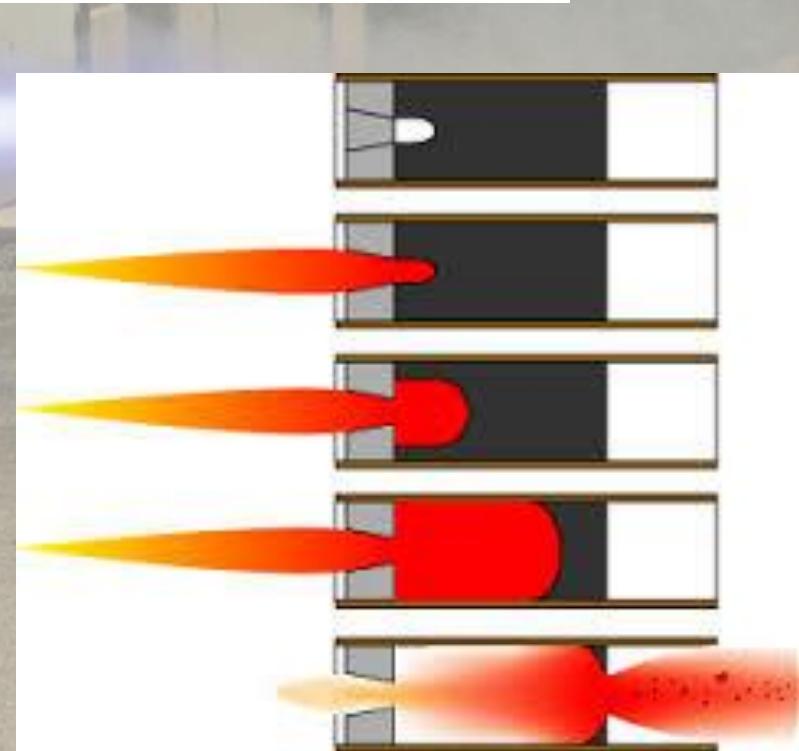
5000 N (5 KN) ~ Slightly less than Weight of Smart Car



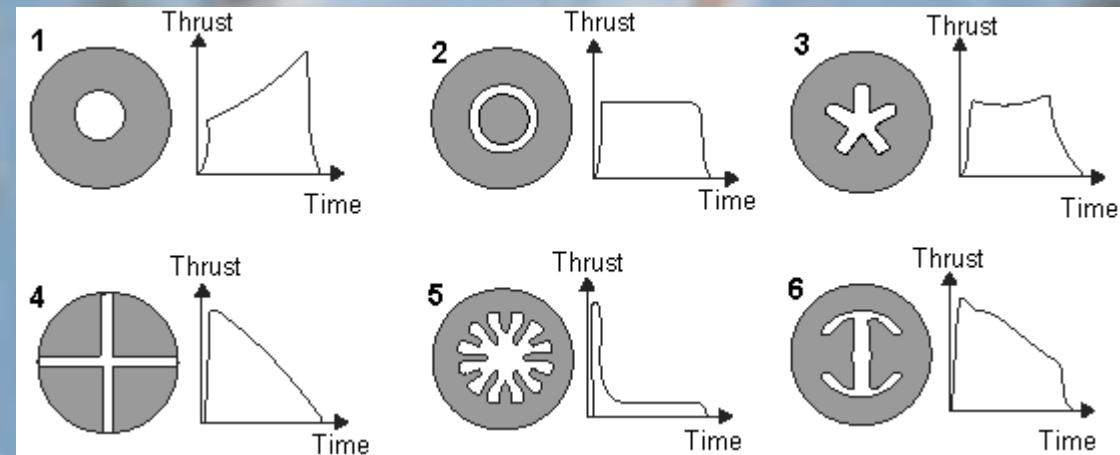
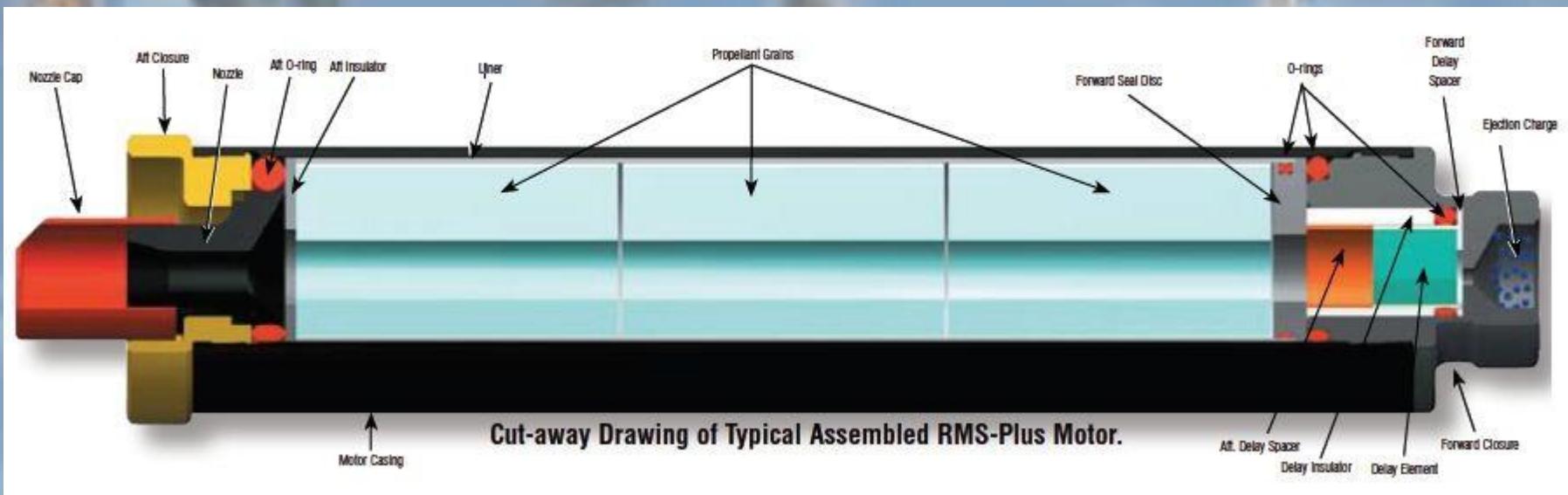
# Rocket Motors



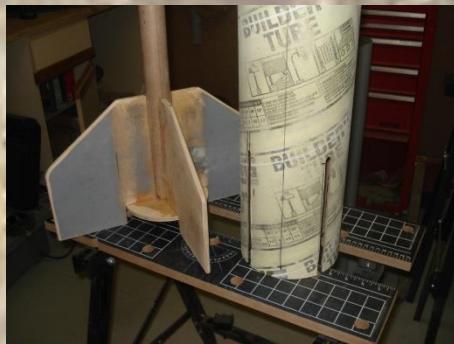
- Propellant Burns and Creates Pressure that escapes as thrust
- Model Rockets use Black Powder
- High Power Rockets use Aluminum Perchlorate



# High Power Rocket Motors



# How Big?



# It Actually Flies...

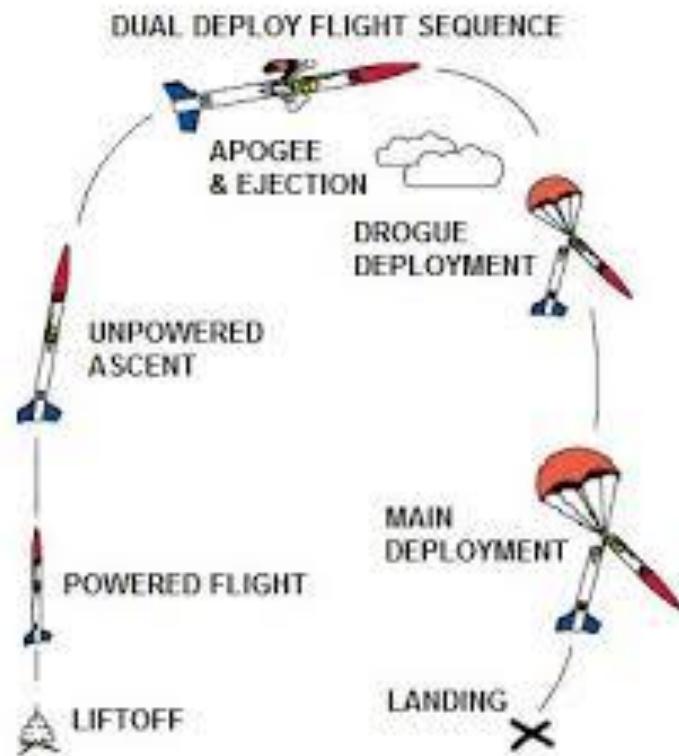
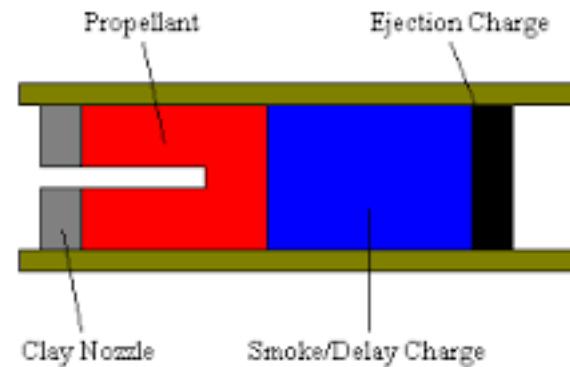


# Now the Fun Stuff....



# Recovery

- ▶ Ejection charge separates rocket and deploys parachute
- ▶ Most rocket motors have an internal delay and ejection charge
  - ▶ A8-3, D12-5, 286H100-15A
- ▶ Basically hope engine choice opens rocket at apogee



# Jordan 99 & Pitbull

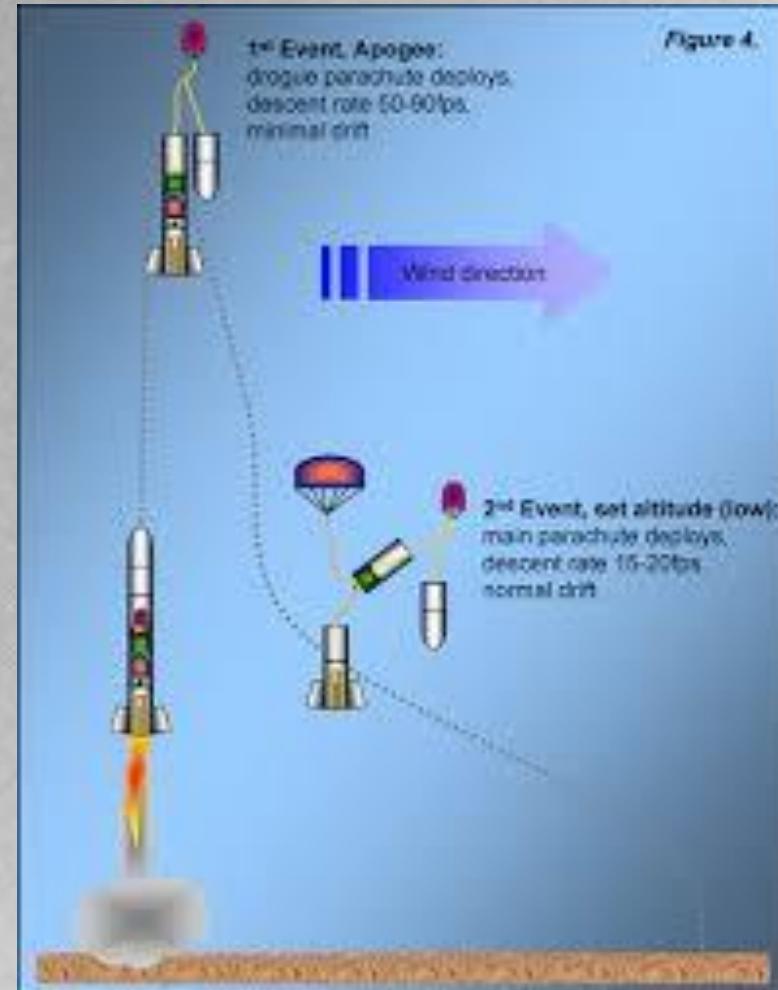


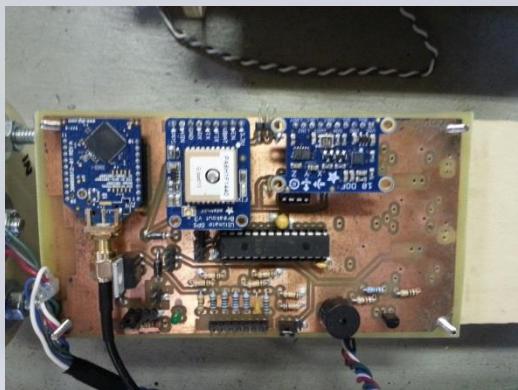
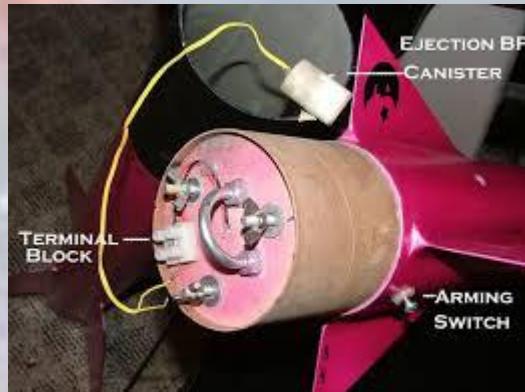
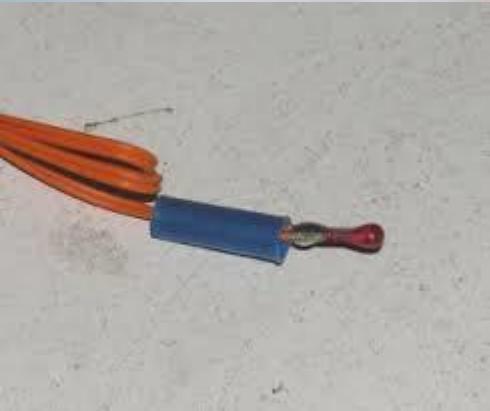
# Big Bertha (D)- Deployment and Drift



# Dual Deploy Recovery

- ▶ Use electronics and ejection charges to open rocket
- ▶ Motors L and above are plugged and needs electronics to deploy at apogee
- ▶ Can use electronics to “Dual Deploy”
- ▶ Rocket breaks apart at Apogee (first event)
- ▶ Rocket open again at 800 feet and chute opens (second event)

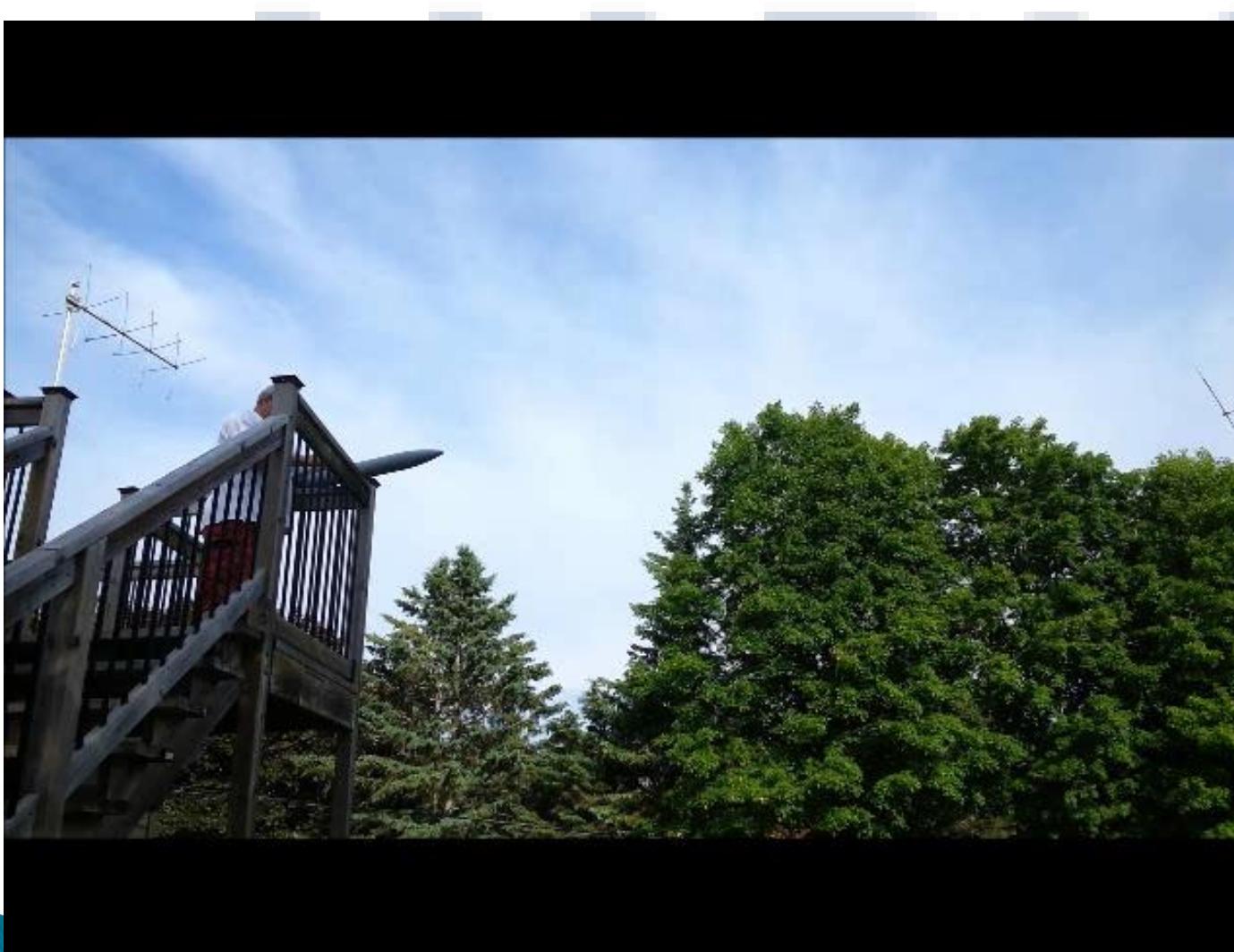




# Onboard Dual Deploy Video



# Importance of Testing



Chute  
Pulled out

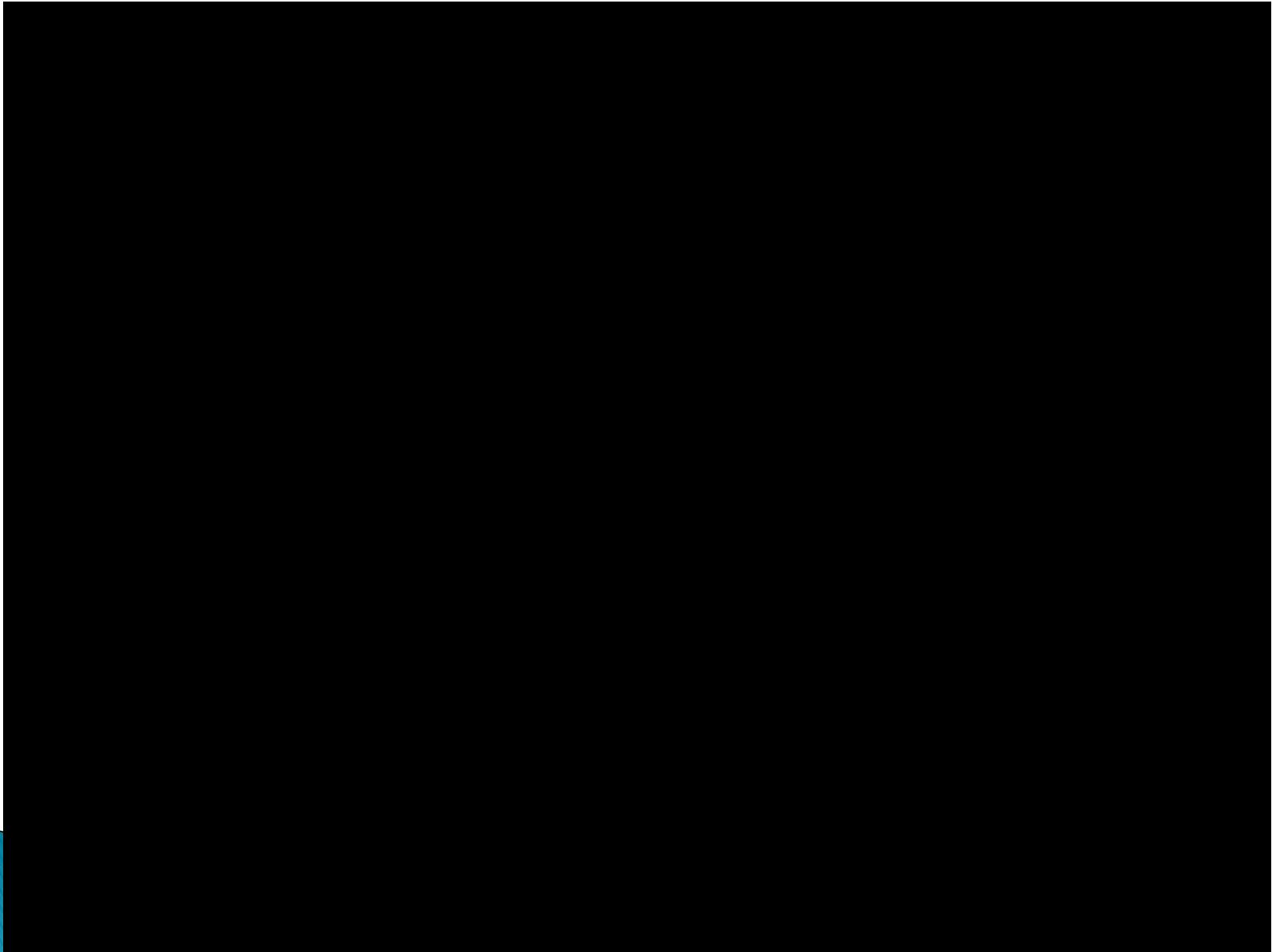
# Failure **IS** Always an Option



# Failure **IS** Always an Option



# Kaputnik K560- Reward of Testing



# Air Starts

- ▶ Ignite second stage during flight
  - Motor-Motor. Some model rocket motors have a 0 delay
  - Use electronics with ematch
- ▶ Two types of electronic systems
  - Timer Based – i.e. x seconds after lift off
  - Acceleration Based – Acceleration from 1<sup>st</sup> stage drops



house?  
execute?  
!!  
and  
blue  
and  
get



# Freaky Flyer - First N3180, Airstart 4 x K650



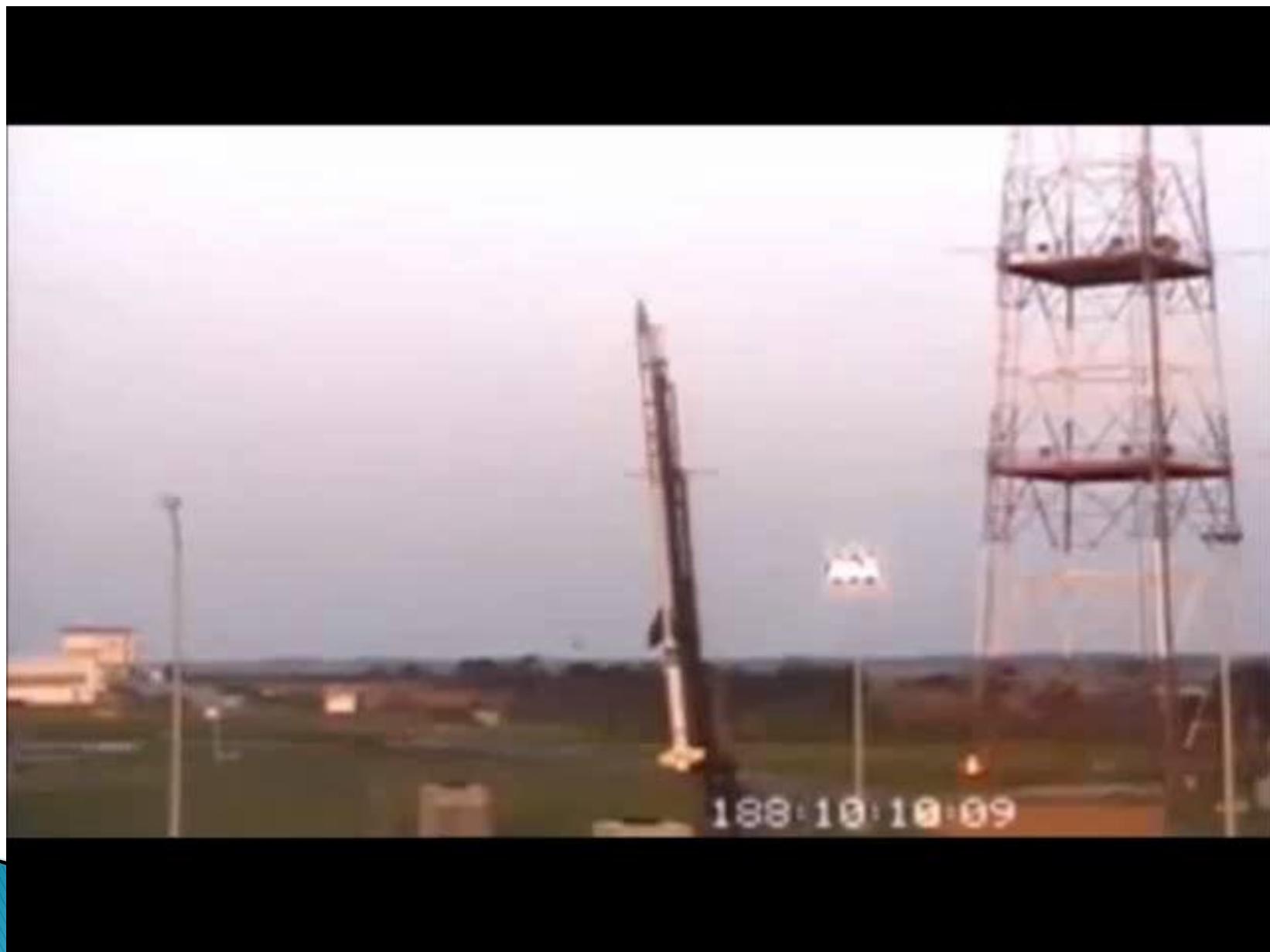
# Freaky Flyer – On Board Video



# Air Start from Different Perspectives



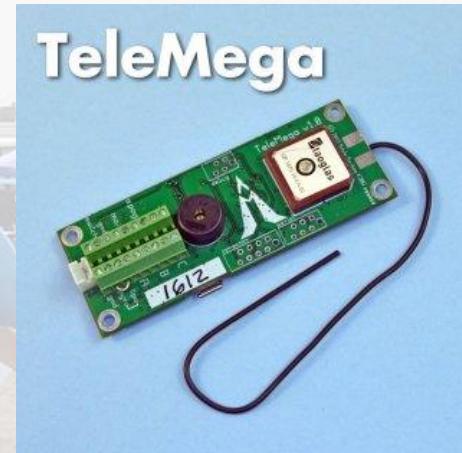
# NASA Wallops – Black Brant IX



# Telemetry

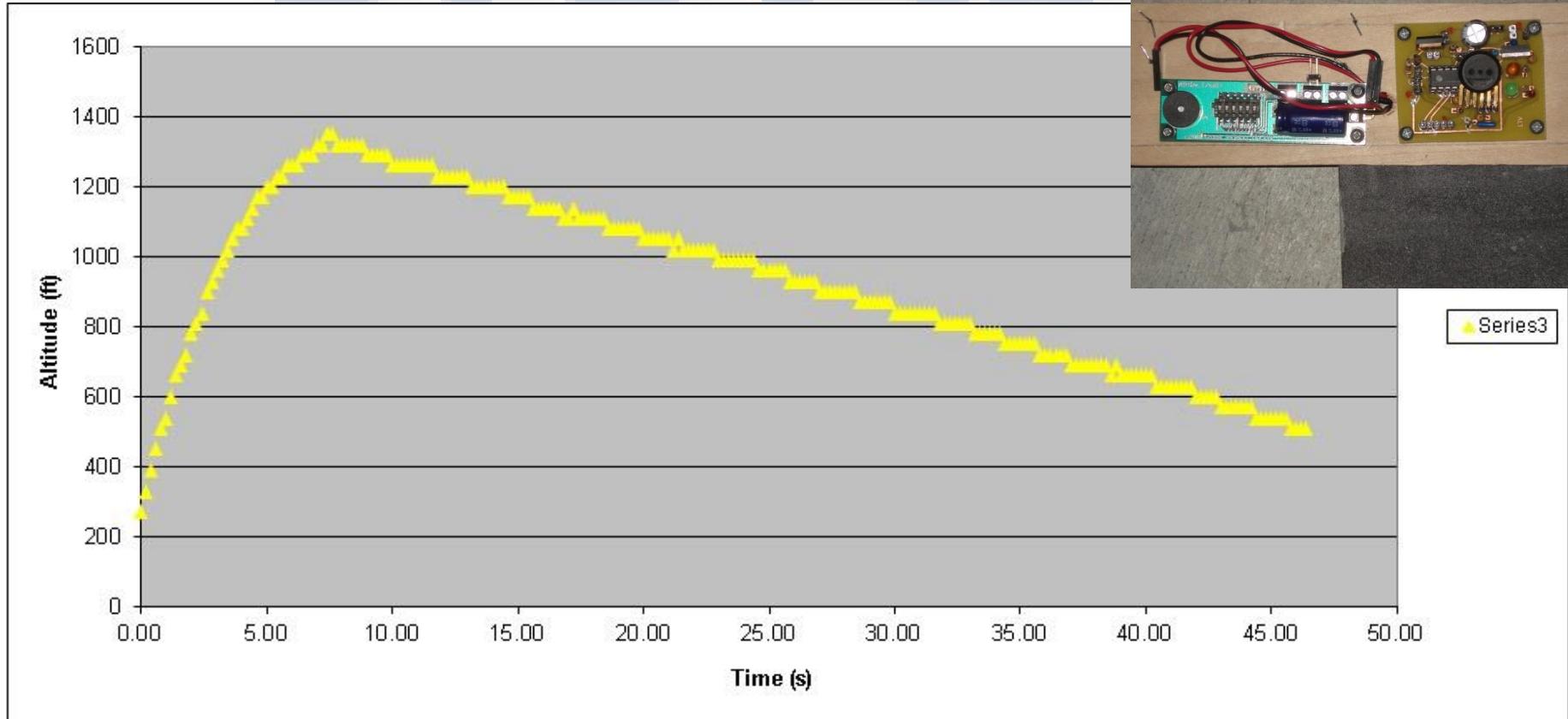
## Commercial Flight Computers

- ▶ Dual Deploy
- ▶ Collects Telemetry
  - Accelerometers, Pressure Sensors, Gyro, GPS, etc
- ▶ Transmits via RF Downlink
- ▶ Usually 70cm Band



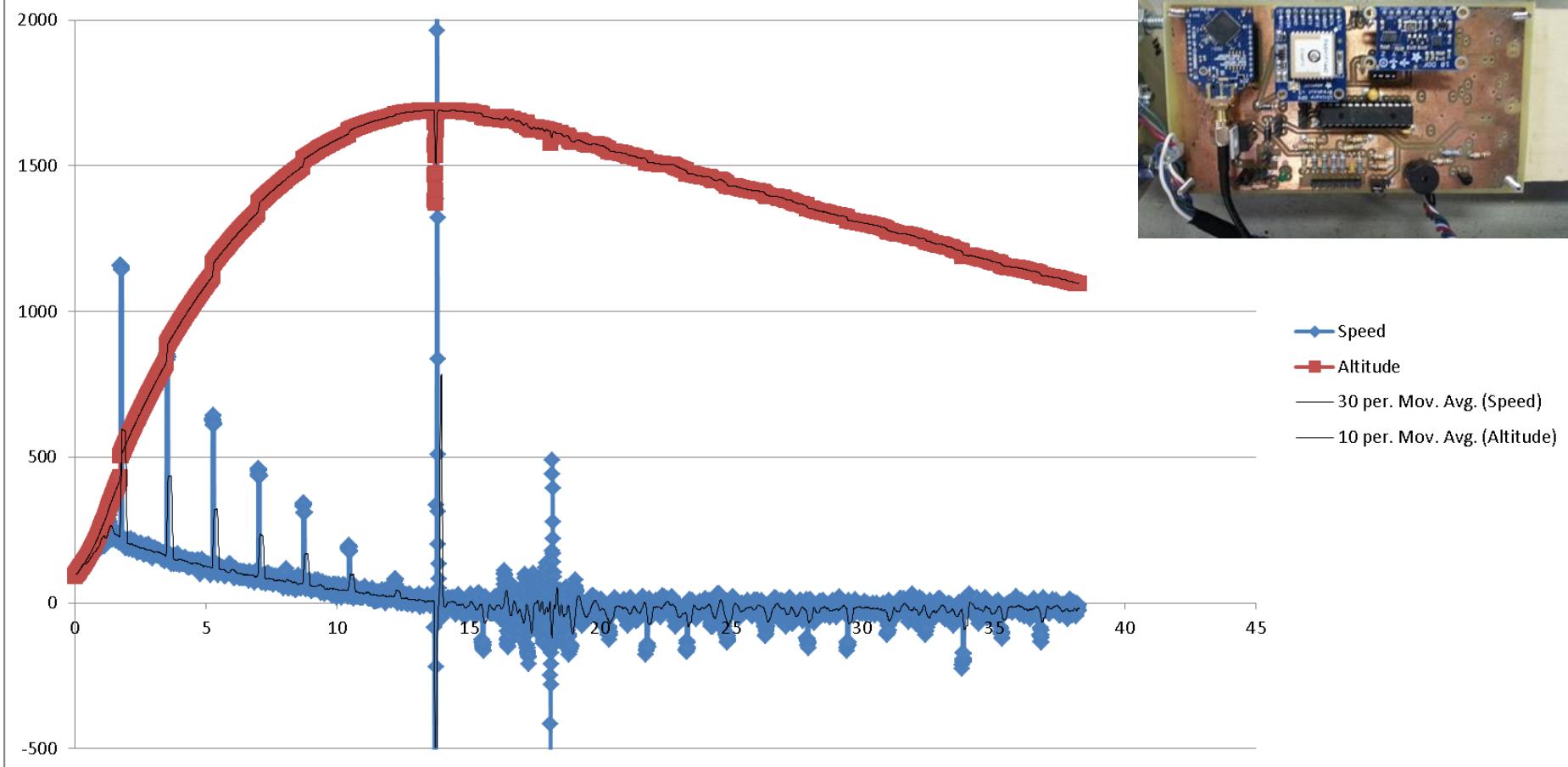
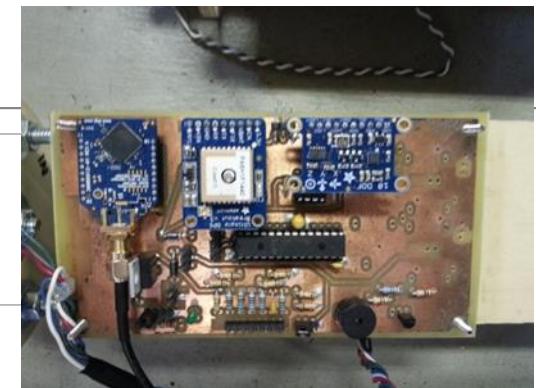
Some in the ISM Band

# Home Made Altimeter Data



Why the flat data points?

# Kaputnik Data

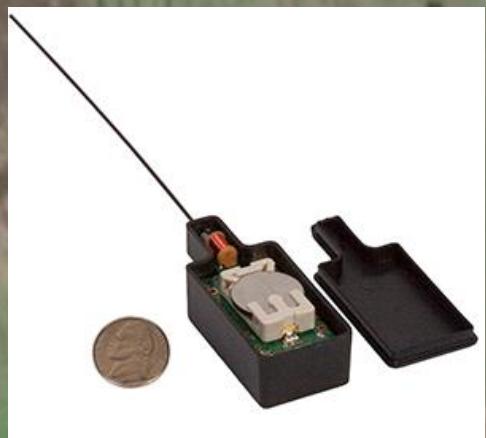


Why the periodic spikes?

# Finding Rockets – Beacon

## Electronic Locator Transmitter

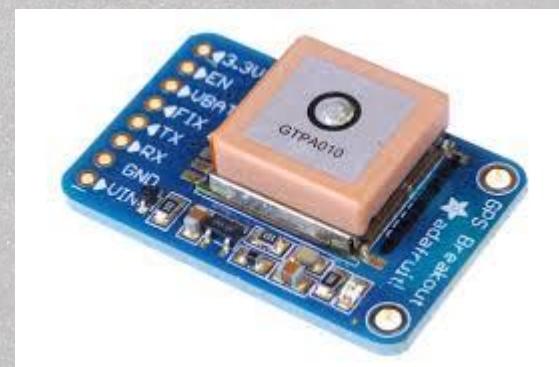
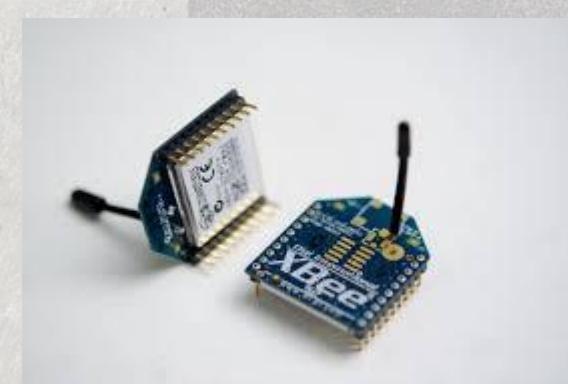
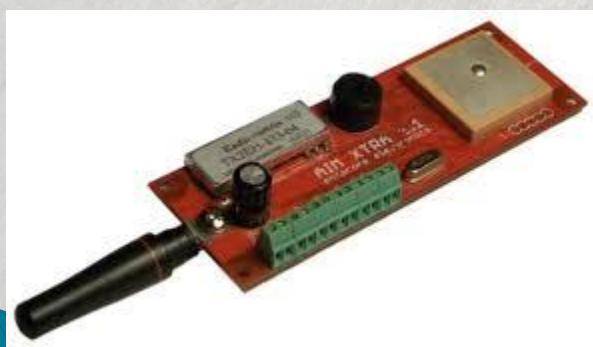
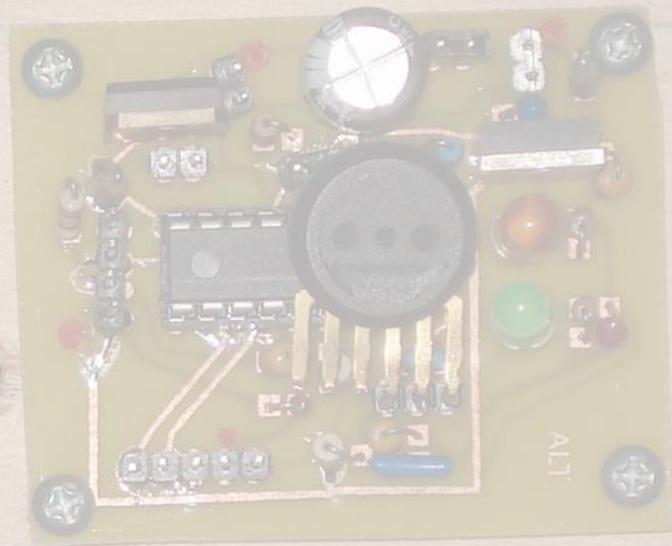
- ▶ SSB/CW
- ▶ 135cm Band (222-225 Mhz)
- ▶ 50 mW
- ▶ 5+ Miles



# Finding Rocket – RF Data

## Use GPS with RF Downlink

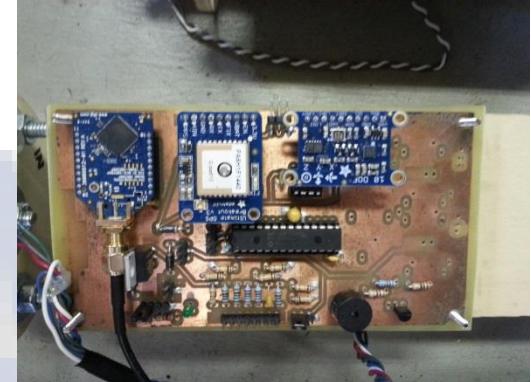
- Sends Lat and Long
  - Overlay on Google Maps
- Few use APRS
- Expensive (Rockets Blow Up)



# My Current Projects

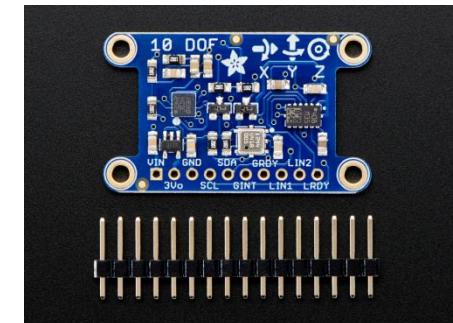
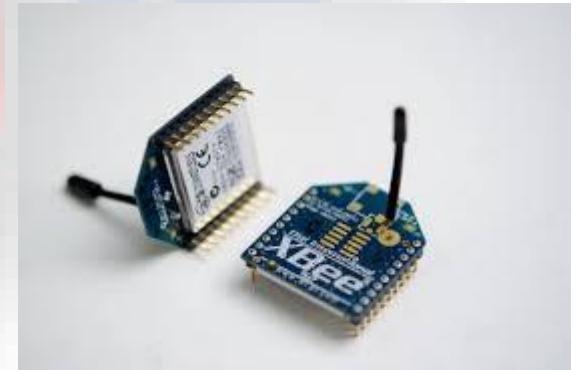
## Homebrew Flight Computers – Kaputnik

- ▶ Triple Axis Accelerometer
- ▶ Triple Axis Gyro
- ▶ Triple Axis Compass
- ▶ Temperature Sensor
- ▶ Pressure Sensor
- ▶ GPS
- ▶ 3 Km RF Downlink via 50mW XBee (ISM Band)



## DDS HF Multiband Beacon

- ▶ DDS60 vs Chinese AD9850 vs Si5351
- ▶ Any HF Band
- ▶ Reverse Beacon, Telemetry via NVIS/Groundwave?
- ▶ Antenna Issues – Currently looking at
  - Shortened Vertical Dipole
  - End-Fed Antenna



# Questions?

“From 1956 until the mid 1980s...the Churchill Research Range...played a central role in the development of Canadian rocketry, in particular the development of the Black Brant rocket”

Manitoba History: Exploring Northern Skies: The Churchill Research Range

by C. J. Taylor  
Parks Canada, Calgary

