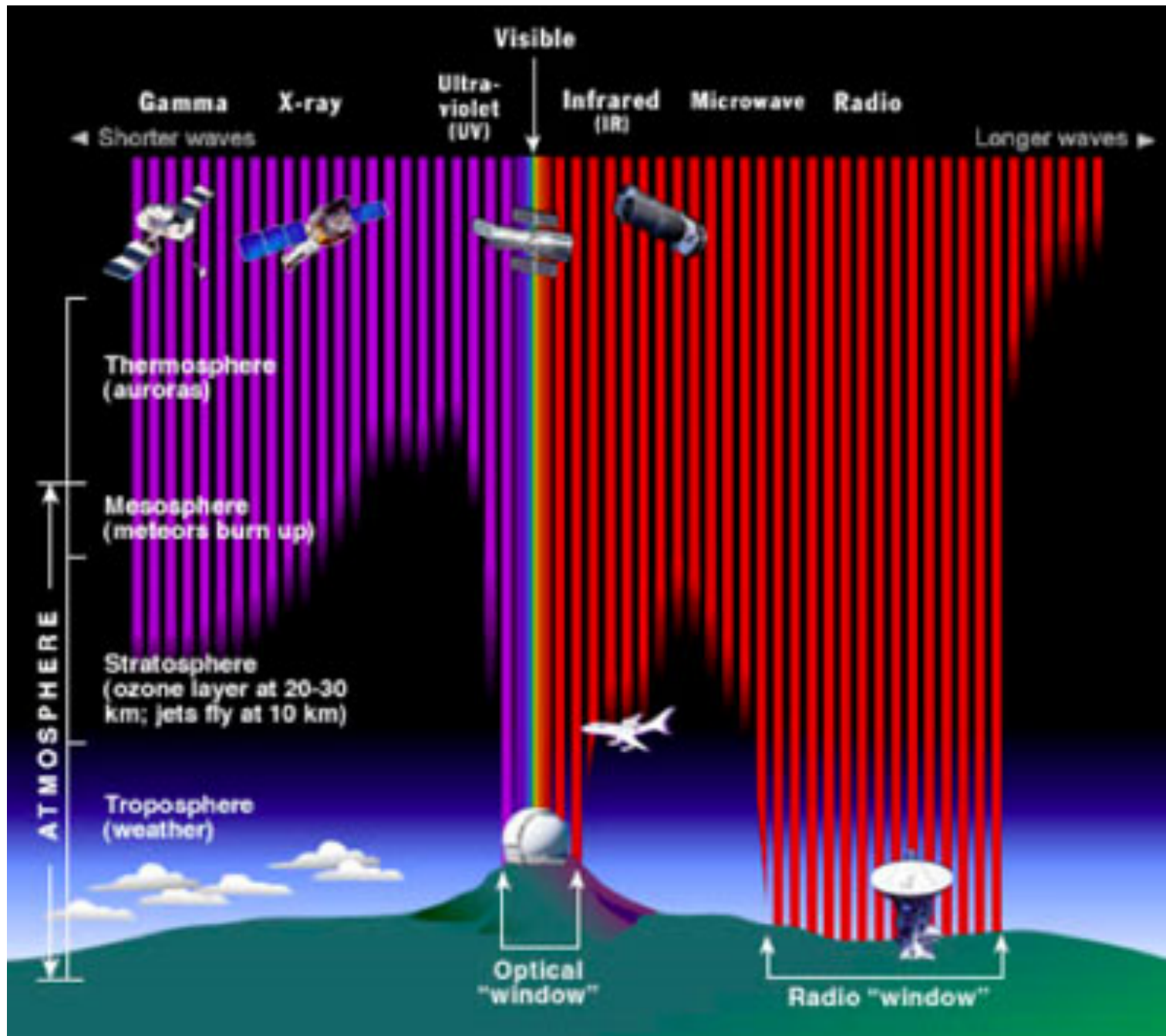


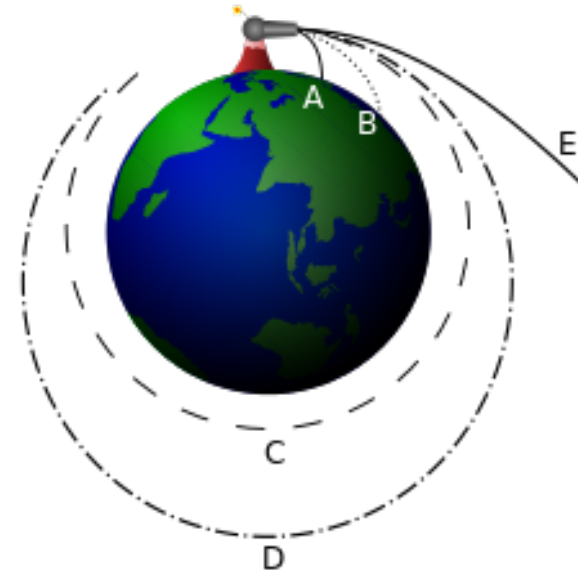
# Suborbital Vehicles

Chuck Lillie  
June 25, 2015



# Definitions

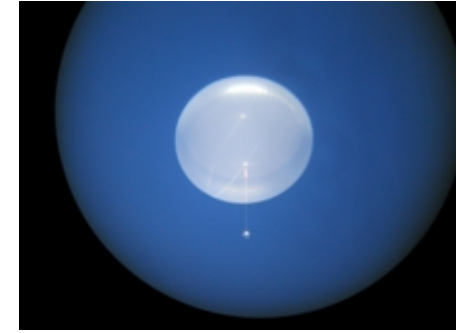
- Sub-orbital Vehicles
  - Elliptical orbits with apogee  $>100$  km, perigee  $< 0$  km
  - Delta-V  $> 1.1\text{km/sec}$ ,  $< 7.7$  km/se
- Coast to peak altitude after rocket engine burnout
- Peaks altitude and downrange impact distance increases with Delta-V



Isaac Newton's Cannonball. Paths A and B depict a sub orbital trajectory. Paths C and D are orbital trajectories, and path E is an escape trajectory.

# Available Vehicles

- Balloons - up to 40 km
  - Standard – 5 days
  - Ultra long Duration – 50+ days
- Sub-orbital Aircraft - ` – 110 km
  - X-15– 5 minutes
  - Space Ship 2 – 5 minutes
  - XCOR – 5 minutes
- Sounding Rocket – 100 TO 1500 km
  - Black Brandt X, XII – 5 to 6 minutes
  - Terrier MK70-Improved Orion
- Space Planes – 300 to 800 km (?)
  - X-37B

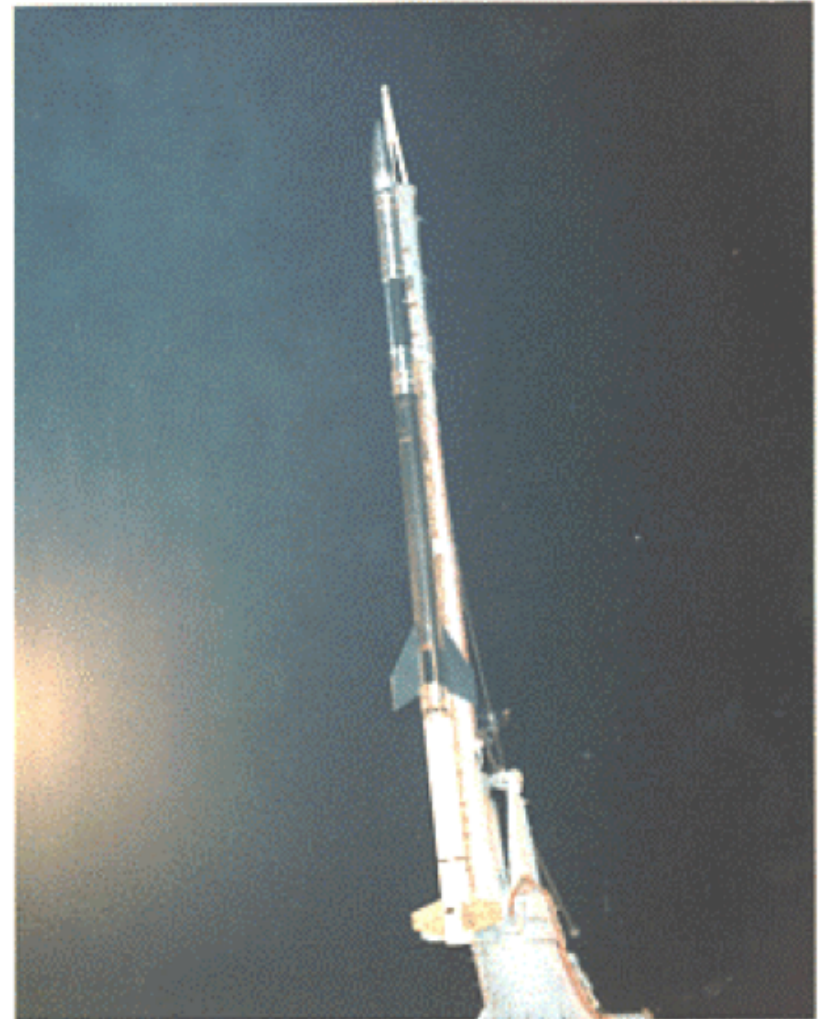


# Advantages

- Relatively low cost
- Rapid response
- New Technology demonstration and maturation
  - Instrument architectures, detectors, coatings, optics, gratings, etc
- Training for future investigators
  - Graduate student experiments, thesis data
- Focused, cutting-edge science investigations
- Payload recover, modification, reuse
- In-situ observations at sub-orbital altitudes
  
- Downside = limited observing time at altitudes  $> 40$  km

# Black Brant X

- Three Stage vehicle
  - third stage motor is ignited once the vehicle system reaches exoatmospheric conditions
  - The standard payload configuration for the Black Brant X vehicle is 17.26 inches in diameter with a 3:1 ogive nose shape. Payload length and weight limits for the Black Brant X are not defined as they are for the Black Brant V and specific limitations for this system are determined as the situation warrants.



# Black Brandt X Performance

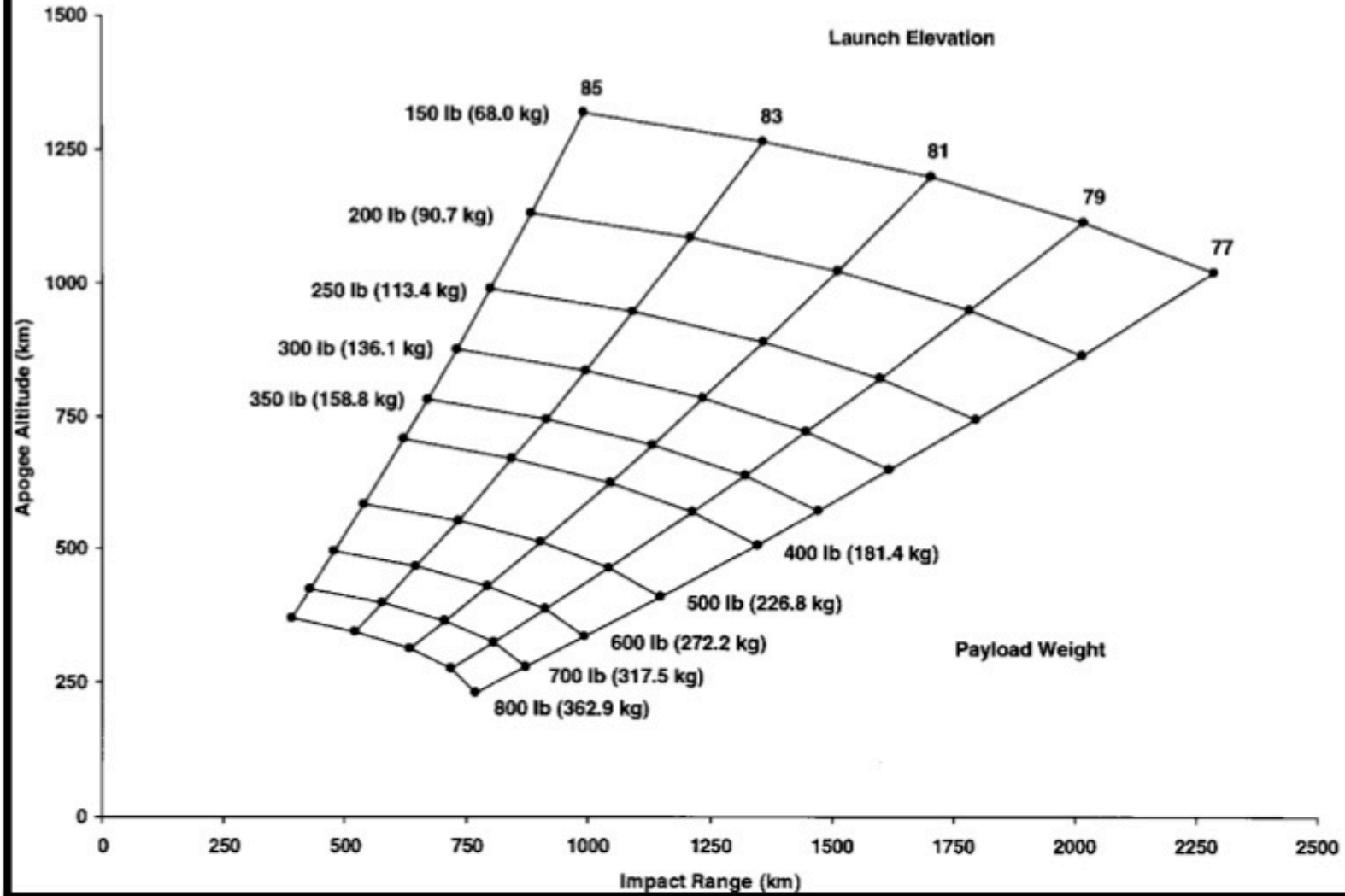


Figure F.4-2: Black Brant X Launch Vehicle Performance