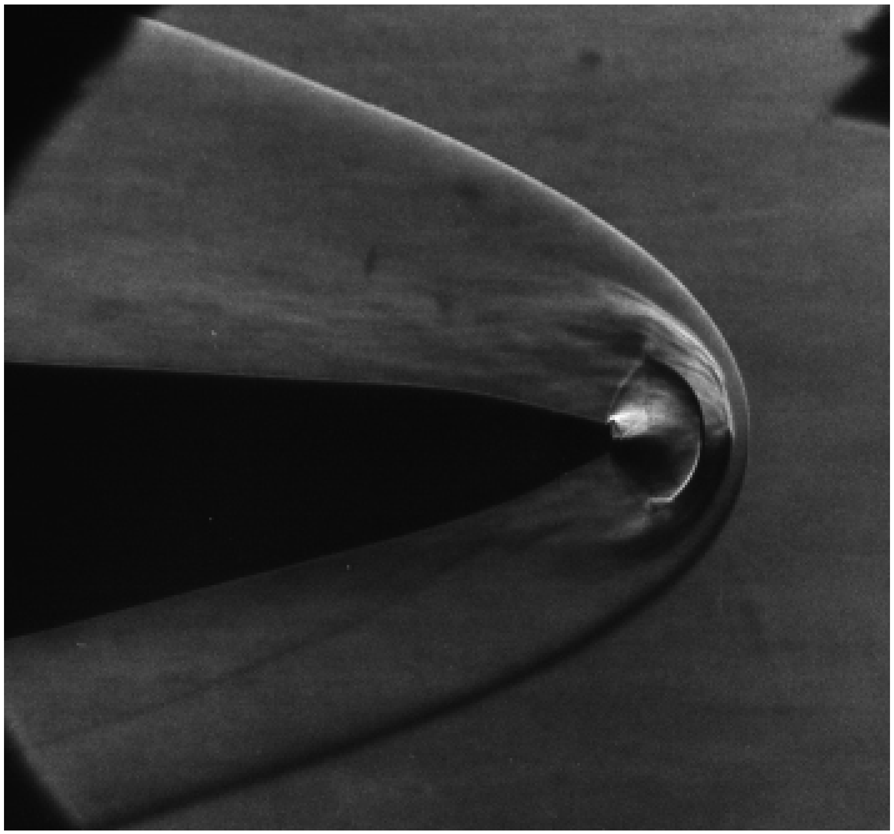
Entry Vehicle Design

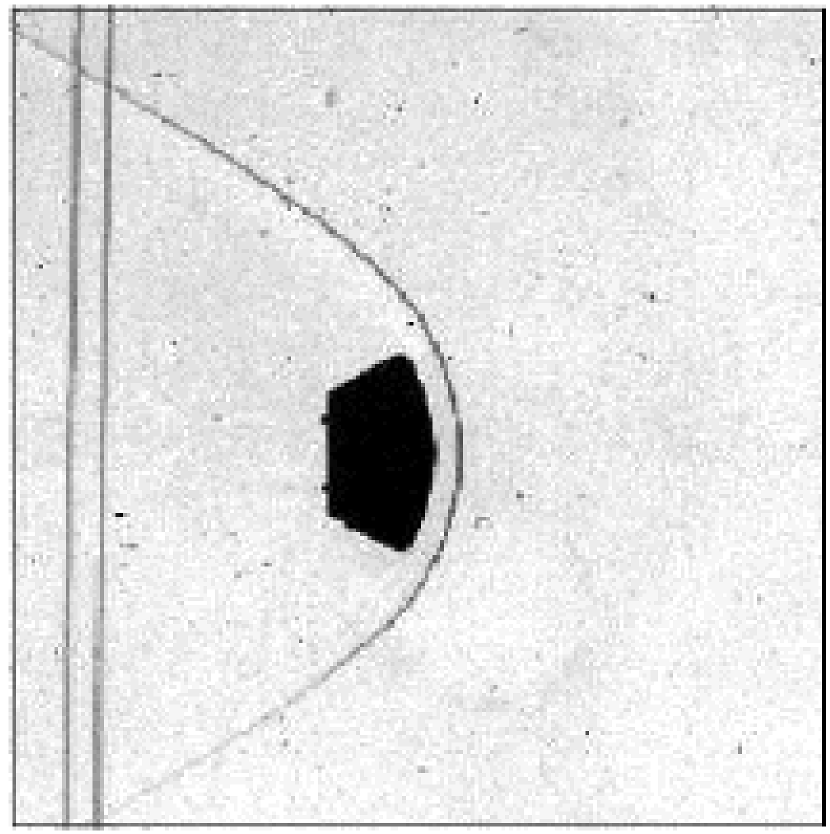
- Everything

Energy in Orbit

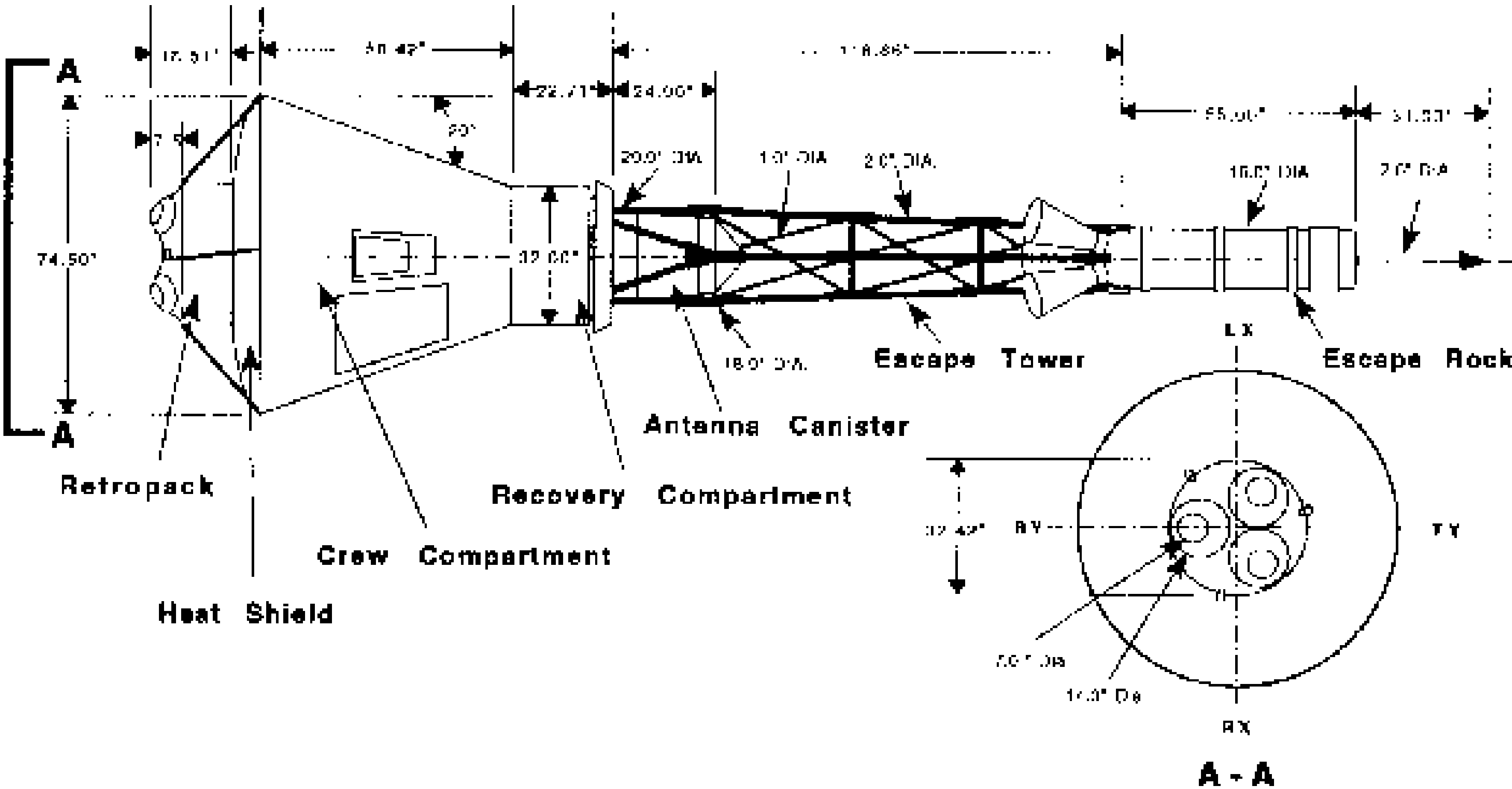
- For 1 kg in a 500 km orbit:
  - Kinetic Energy = 2.9×10^7 J
  - Potential Energy = 4.9×10^6 J
- Assuming primary deceleration occurs over a period of ~10 minutes, the average heating rate is 282 kW/kg!!!

Hypersonic Flow Around Entry Vehicles

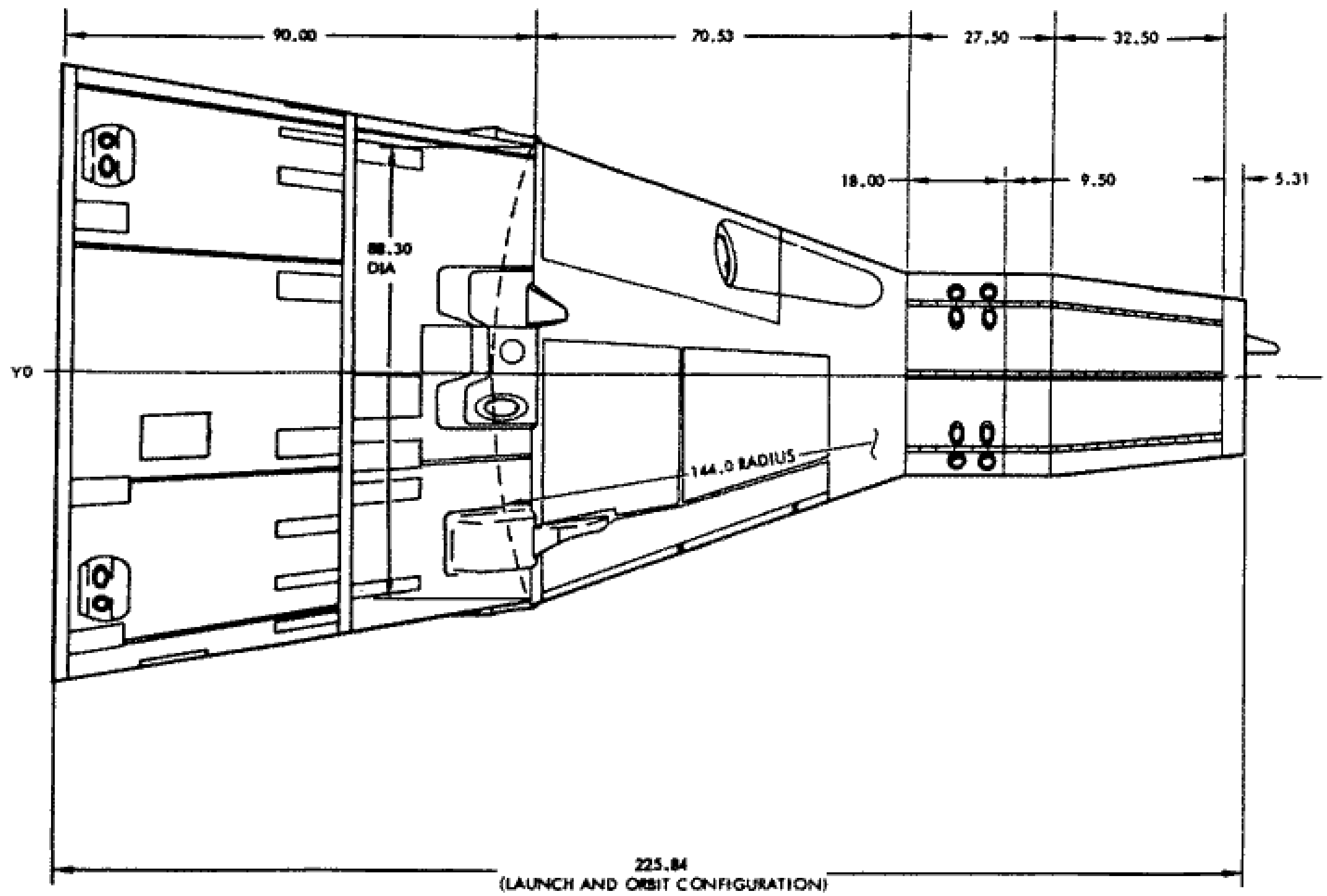




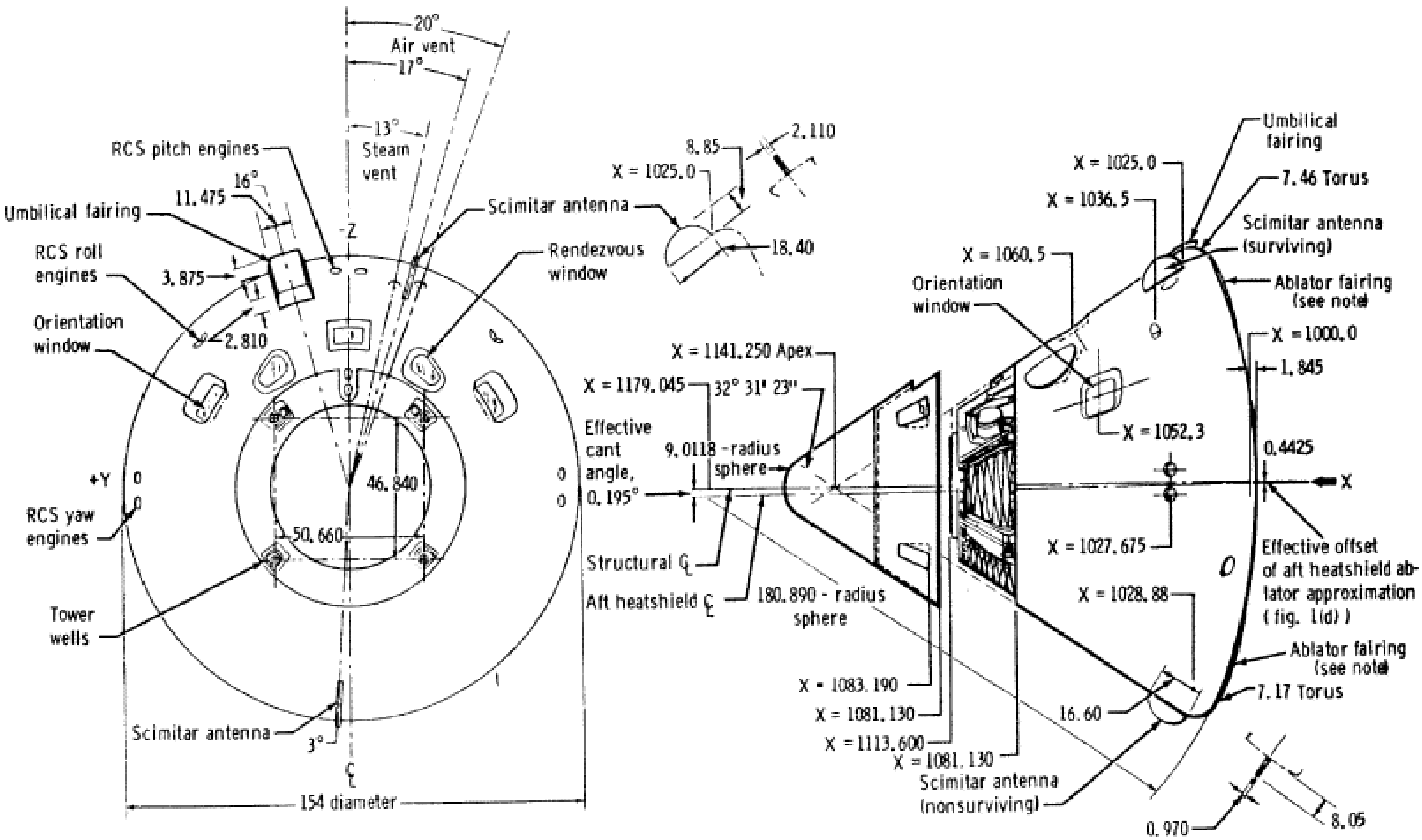
Mercury Spacecraft Configuration



Gemini Spacecraft Configuration



Apollo Command Module Configuration



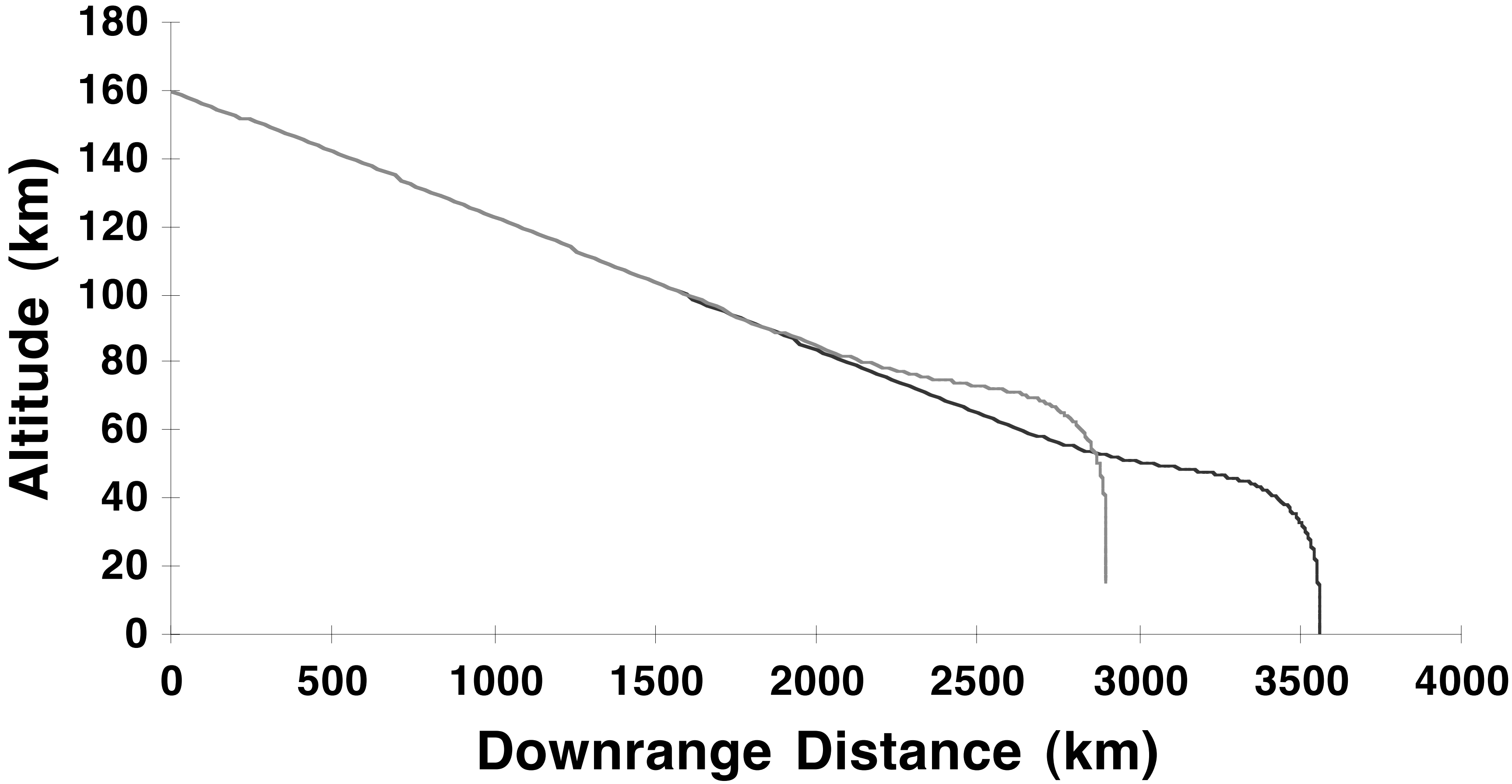
Chapman Heating Equation

- Empirical formula for convective heating at stagnation point

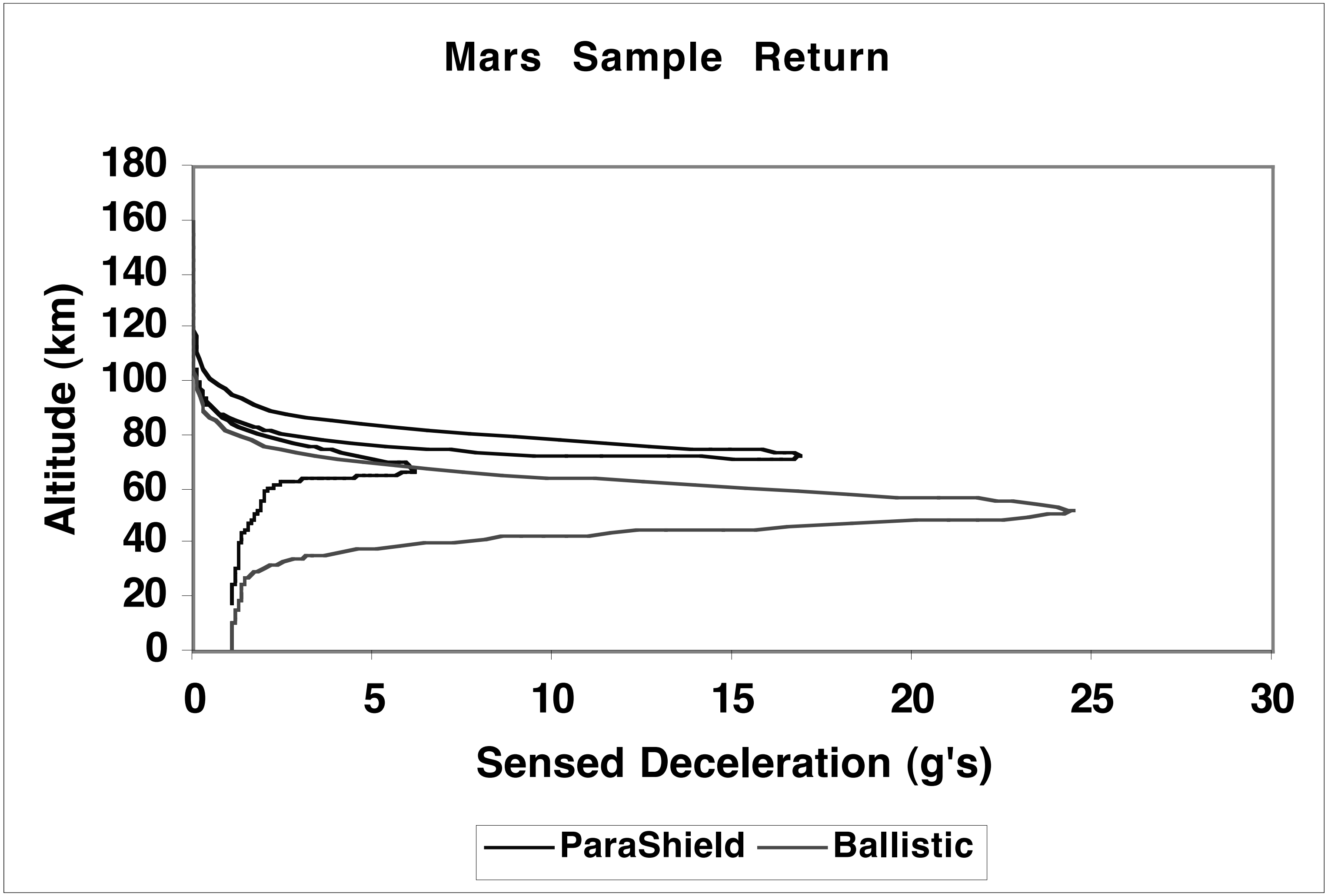
$$\dot{q} = 17\left(\frac{\rho}{R}\right)^{1/2}\left(\frac{v}{1000}\right)^{3}$$

- Where
  - $\dot{q}$ is heat flux (BTU/ft^2-sec)
  - R is leading edge radius (ft)
  - v is flight velocity (ft/sec)
  - ρ is atmospheric density (slugs/ft^3)

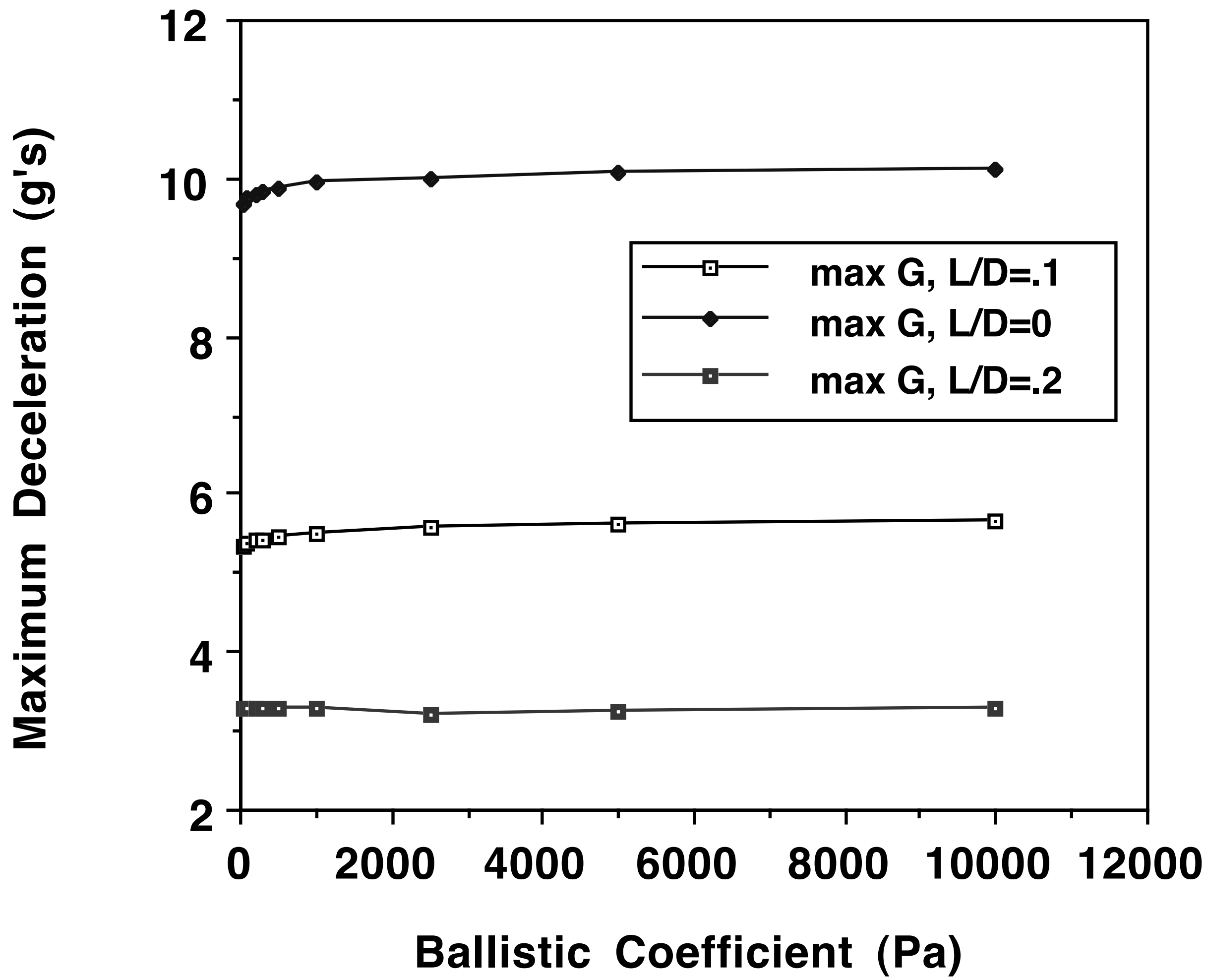
Entry Trajectories vs. Ballistic Coefficient



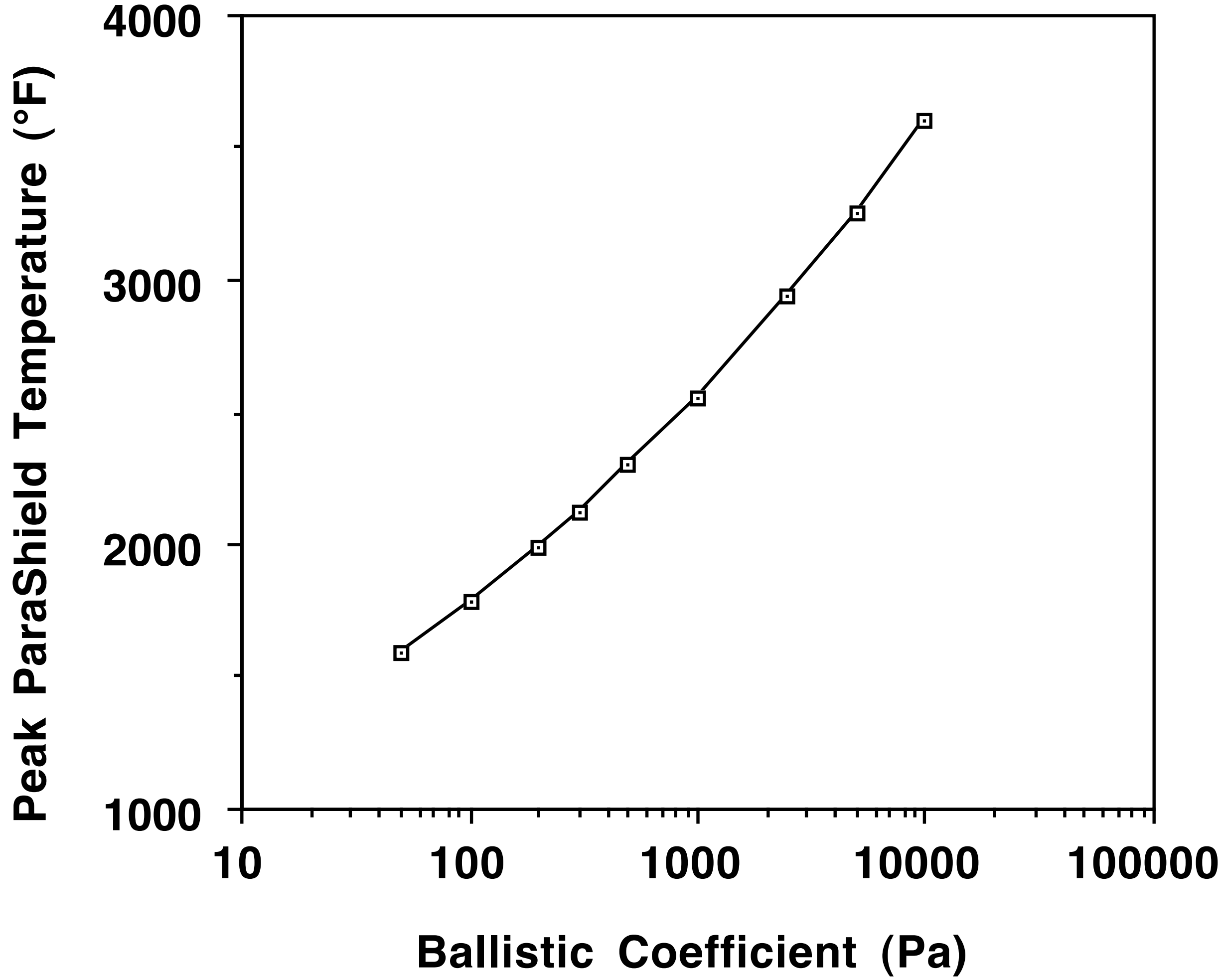
Acceleration vs. Altitude



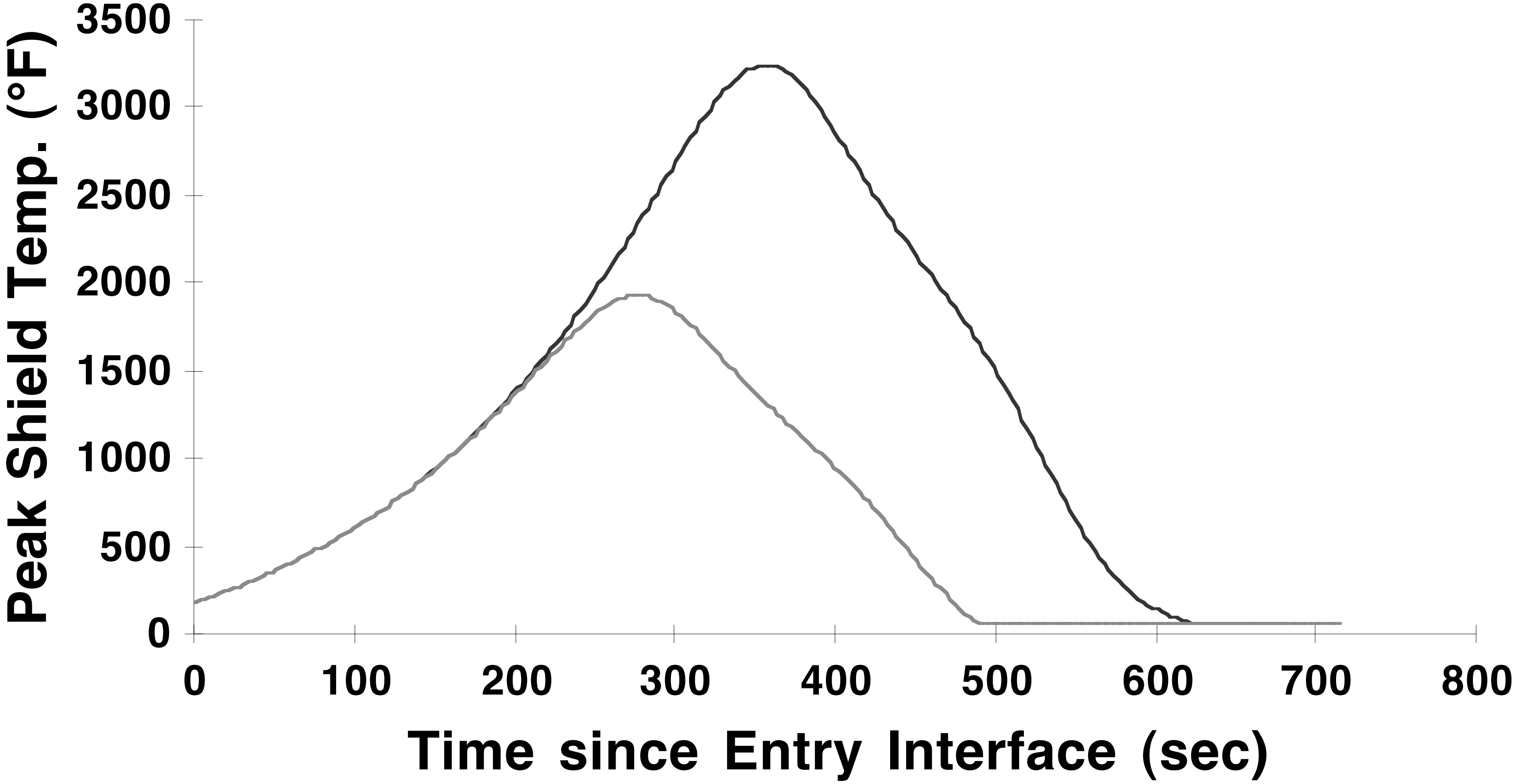
Maximum Decel vs. L/D



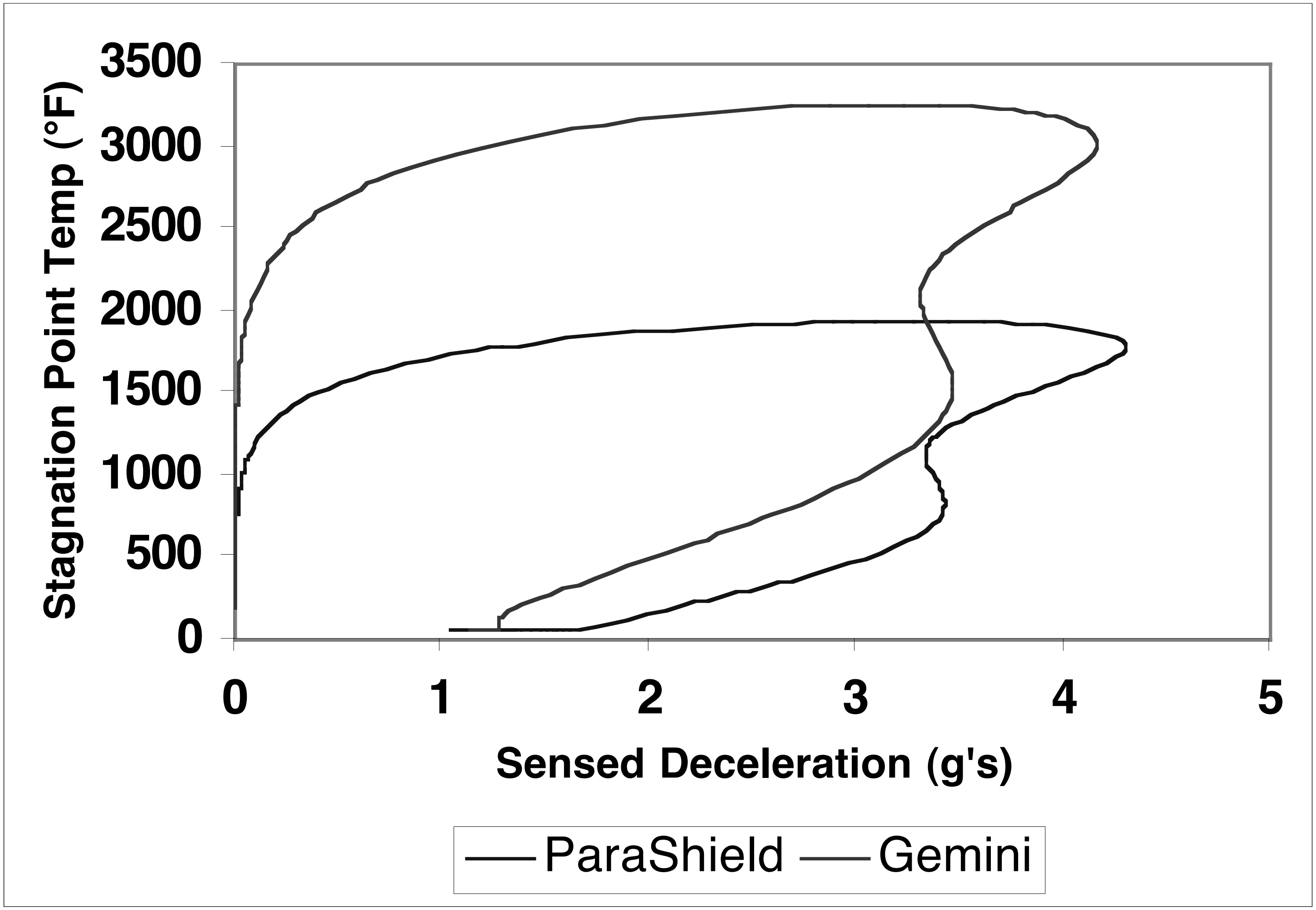
Peak Temperature vs. Ballistic Coefficient



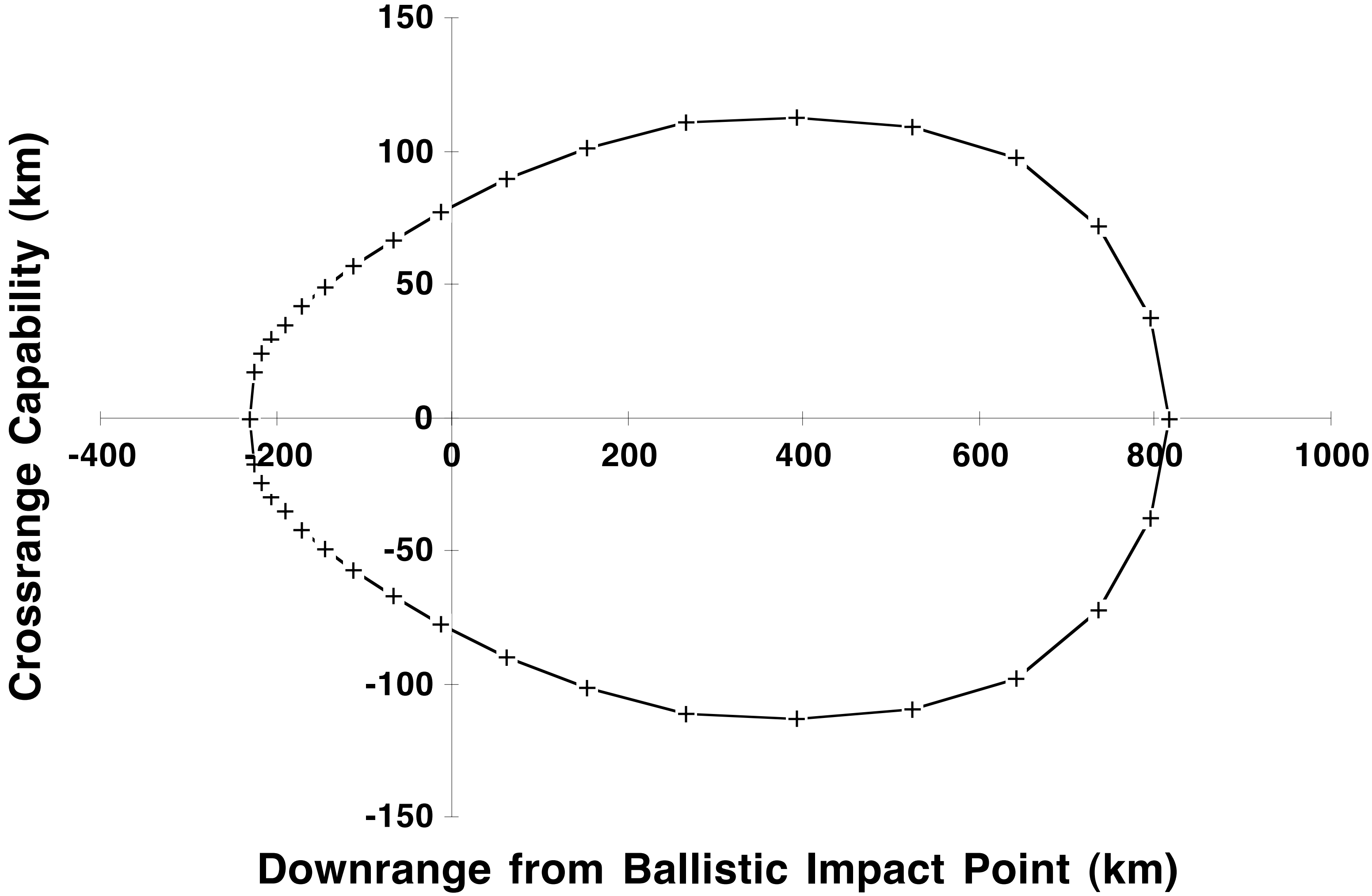
Entry Temperature vs. Ballistic Coefficient



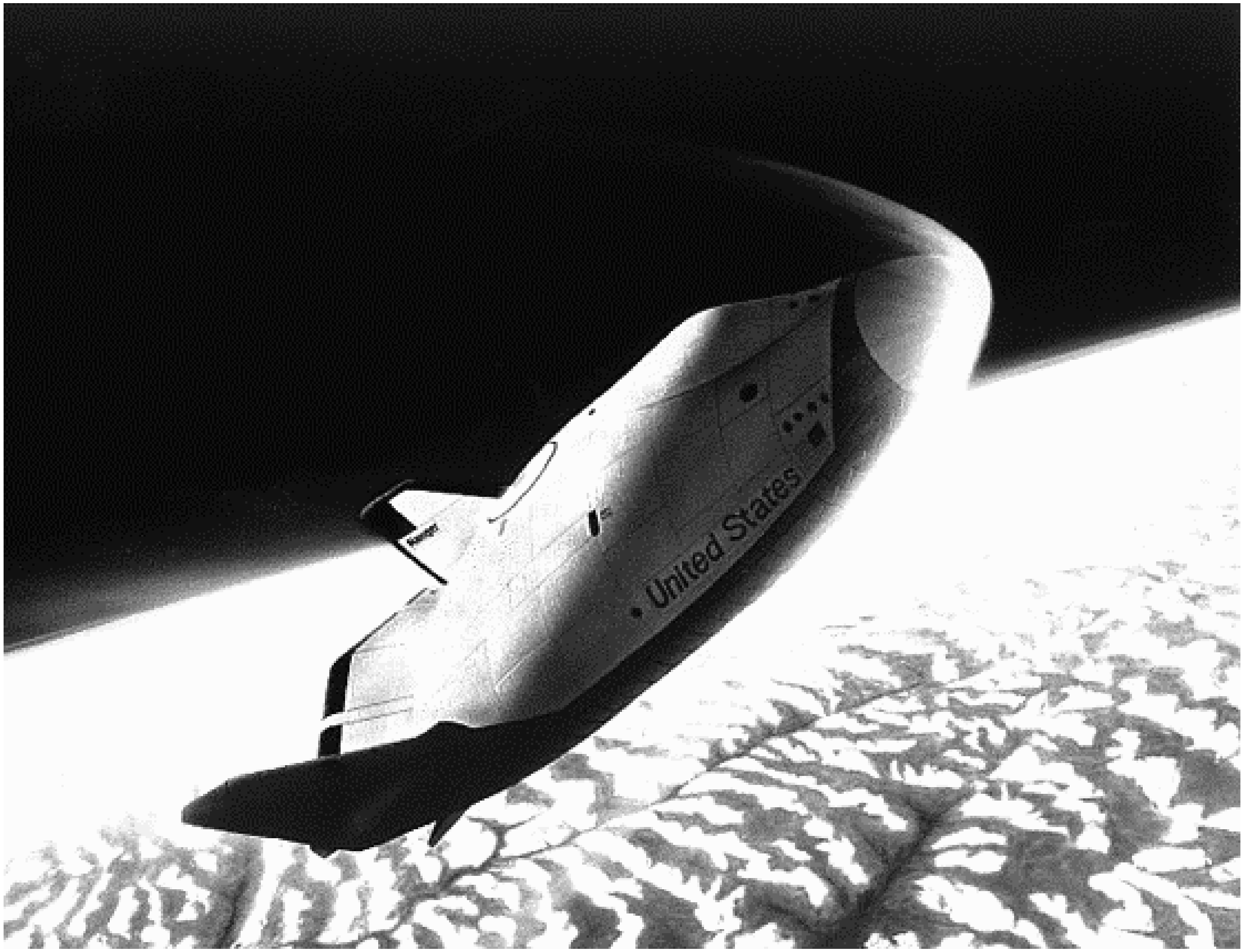
Deceleration vs. Temperature



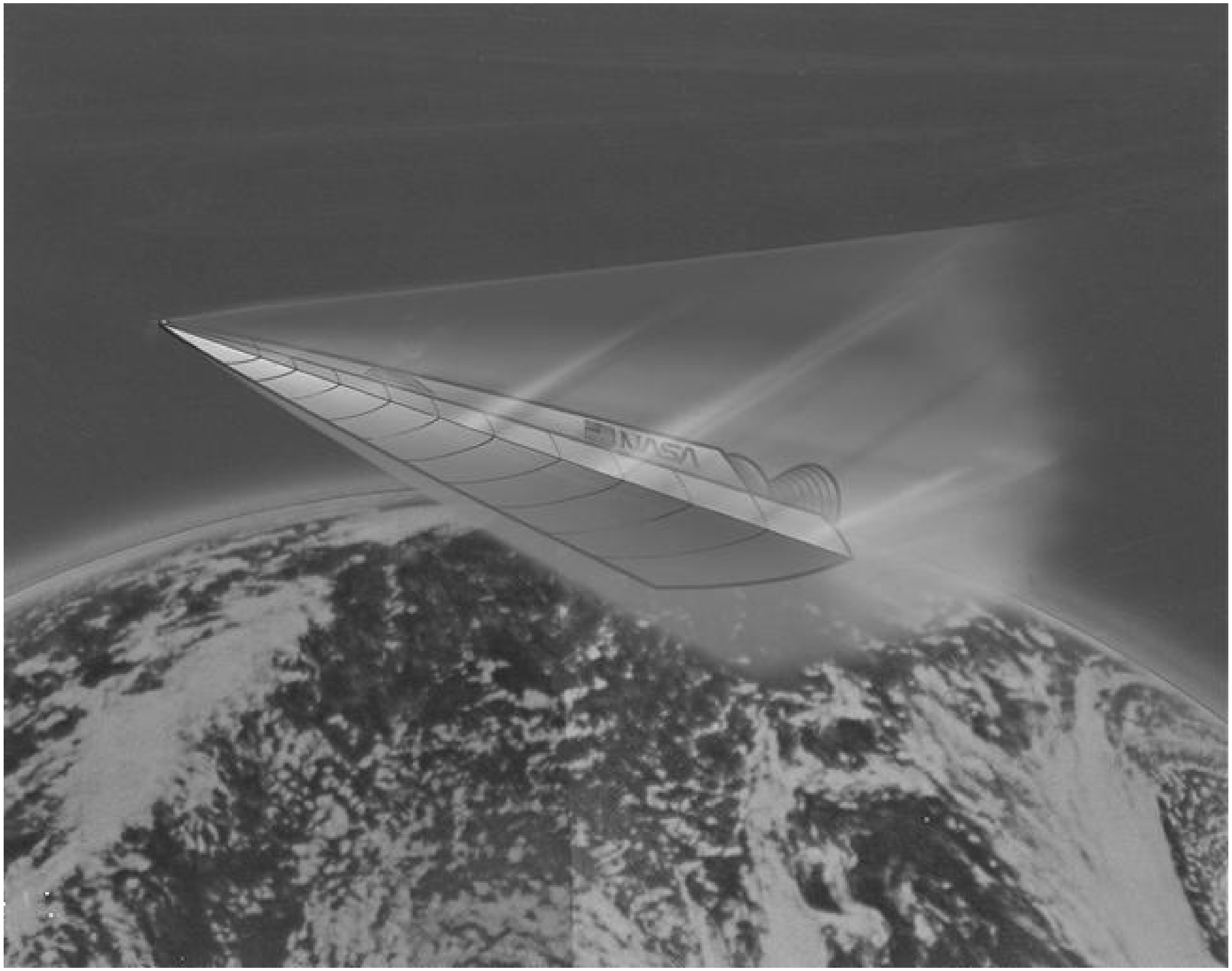
Typical Entry Landing Footprint (L/D=0.23)



Lifting Body (X-38)



High Hypersonic L/D Vehicle ("Waverider")



ParaShield Vehicle