Reentry

Col John E. Keesee
MIT Dept of Aeronautics and Astronautics
November 25, 2003

Background

- An ICBM with a range of 6500 miles has a stagnation temperature of 12,000 ºF, 2000 ºF hotter than the surface of the sun
- Calculations showed that the optimum design for structural strength, resistance to heating, and free flight stability was a long, needle nosed reentry body
  - But it would vaporize during reentry

Background

- Harry Julian Allen proposed an alternate solution, using pencil and paper
  - Contradicted 50 years of research
  - Suggested a blunt body would better put more of the heat the air and less into the body
  - Strong bow shockwave

Background

- Still needed unusual materials to survive the extreme heating conditions
  - Heat sinks
    - Copper, tungsten, molybdenum, beryllium
    - Shuttle
  - Ablators
    - Teflon, nylon, fiberglass
    - Mercury, Gemini, Apollo, ICBMs

Thermal Barrier

$$KE = \frac{1}{2} m V_c^2 = Q$$

$$\frac{Q}{m} = \frac{V_c^2}{2}$$

Material	Energy to Vaporize BTU/lb	Melting Temperature ºR
Tungsten	1870	6500
Titanium	3865	3700
Beryllium oxide	13,400	2900
Graphite	28,700	6800

Stagnation Temperature

$$C_p T_o = C_p T_\infty + V_\infty^2 / 2$$

$$T_o = V_\infty^2 / 2C_p$$

V (fps)	To ºR
10,000	8,325
20,000	33,300
26,000	56,277

How Much Heat Actually Enters the Body

Reentry Body Shapes

- http://kittyhawk.public.hq.nasa.gov/essay/Evolution_of_Technoogy/reentry/Tech19.htm