Entry Systems & Technology Division

Alvin (Al) Seiff: Thoughts About and Lessons from a Great Engineer

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Ames Research Center

Al Seiff (1973)

NASA

Entry Systems & Technology Division *Aerothermodynamics Branch*

Alvin (Al) Seiff (1922-2000)

NASA Ames 1948-1986; San Jose State University Foundation

- Applied deep knowledge of gas dynamics, aerodynamics and dynamics to devise method of reconstructing atmosphere from entry data; detailed in NASA TN D-1770, April 1963
- Concepts tested, culminating in entry at 6.6 km/s in air (PAET, 1971); complete success
- Used successfully on 9 entry probes and landers at:

Mars: Viking 1 & 2 (1976), V_e = 4.4 km/s
Mars Pathfinder (1997), V_e = 7.5 km/s

Venus: Four Pioneer-Venus (1978), V_e = 11.5 km/s

Jupiter: Galileo (1995), V_e = 48 km/s

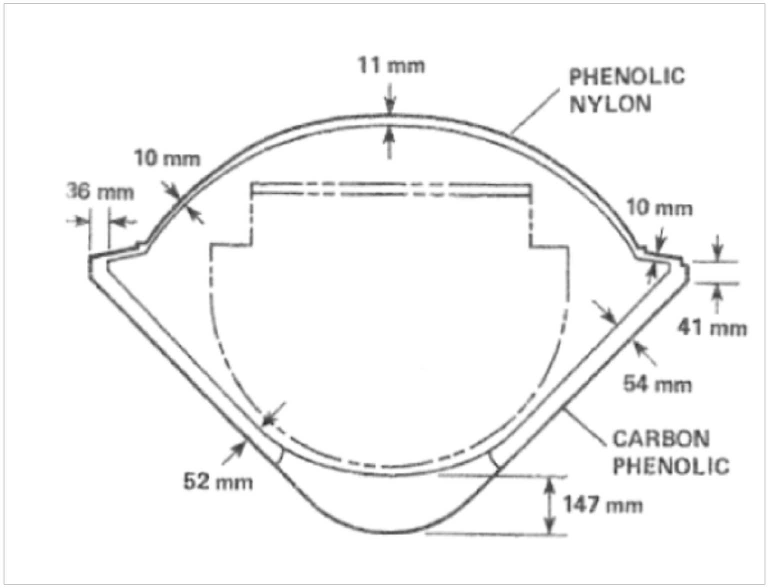
Titan: Huygens (2005), V_e = 6 km/s

Alvin (Al) Seiff (continued)

- Al Seiff hired me in the fall of 1962
- He was Branch Chief, but shortly became Division Chief
- My first task: work with him on heating and heat shielding for human Mars mission vehicles
- Major concern was radiative heating during Mars entry (CN, etc.) and on Earth return (very high V_e)
- In 1962, H.J. Allen, Ames Asst. Director, proposed using conical bodies to limit radiative heating on the frustum
- We applied his concept and calculated “optimum” cone angles that minimized heat loads, but with L/D for 10g limit
- Result was my 1st Ames paper; Tauber & Seiff, at AIAA 1st Entry Technology Conference, Oct. 1964, (AIAA Conf. Public. #9)
- My next major task, 1966: study feasibility of a Jupiter probe

Galileo Jupiter Probe

- Atmospheric entry 1995; primary analysis & design ~ 1975-1983
- Entry conditions: Inertial; V_e = 59.9 km/s, γ_e = –6.64°, lat. = 6.53°
  Relative; V_r = 47.4 km/s, γ_e = –8.4° @ 450 km
- Entry mass = 335 kg; instruments 8%
- Carbon phenolic forebody TPS, 45% mass fraction
- Stagnation point heating – no ablation blockage
  - Max rate = 61 kW/cm^2
    - 66% radiation
    - 34% laminar convection
- Atmosphere, % mole
  H_2 = 86.3
  He = 13.6



Galileo Probe Cone Frustum Heating including effects of ablation

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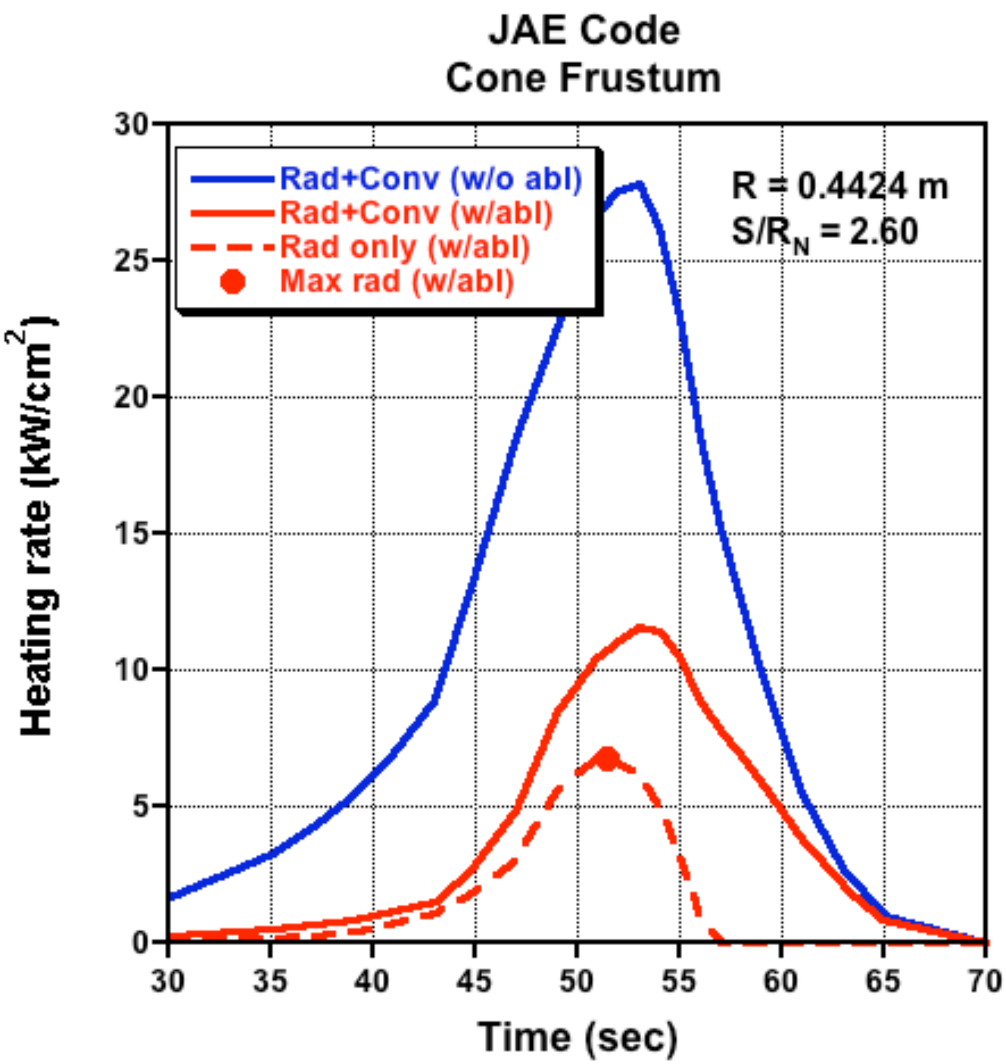
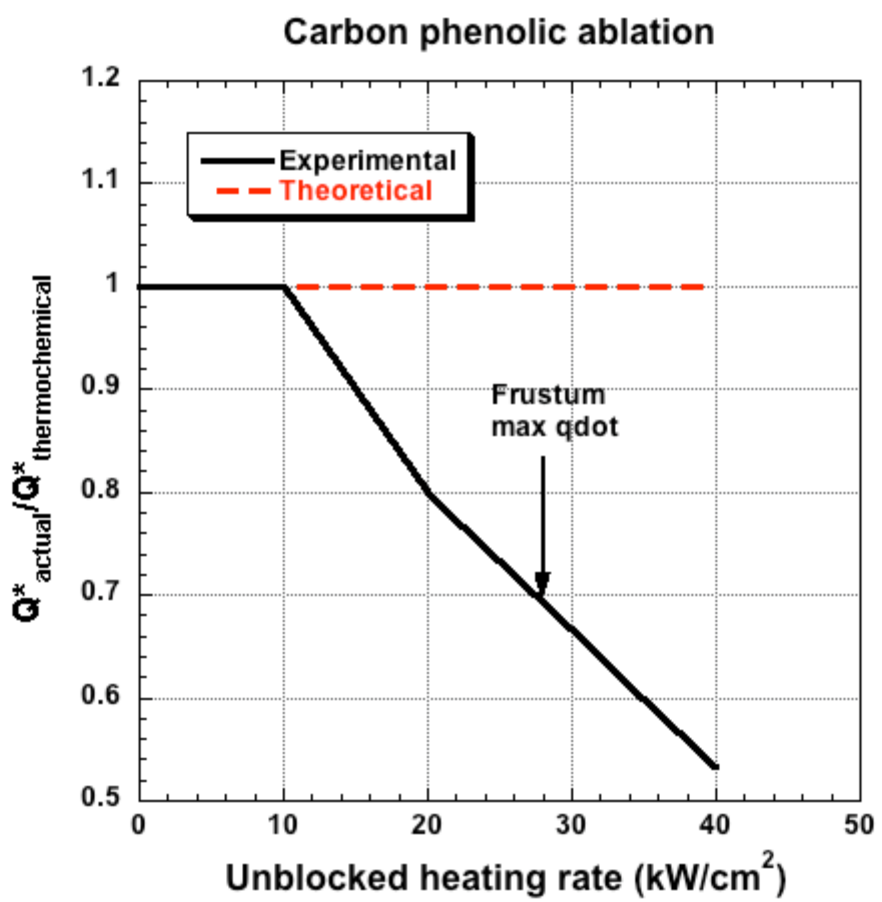


Effective Heat of Ablation at high radiative heating rates



$$Q^* = \frac{\dot{m}}{\dot{q}_{rad}}$$

Effect of Ballistic Coefficient on Heat Load

Entry trajectory $$-\frac{dV}{dt} = \frac{D}{m} = \frac{1}{2\rho_1 V_1^2}\left(\frac{C_D A}{m}\right)$$

and heating $$\frac{dq}{dt} \sim \rho_1^n V_1^m$$

and heat load $$q \sim \left(\frac{m}{C_D A}\right)^n$$

Boundary layer; lam n = 0.5, turb n = 0.8

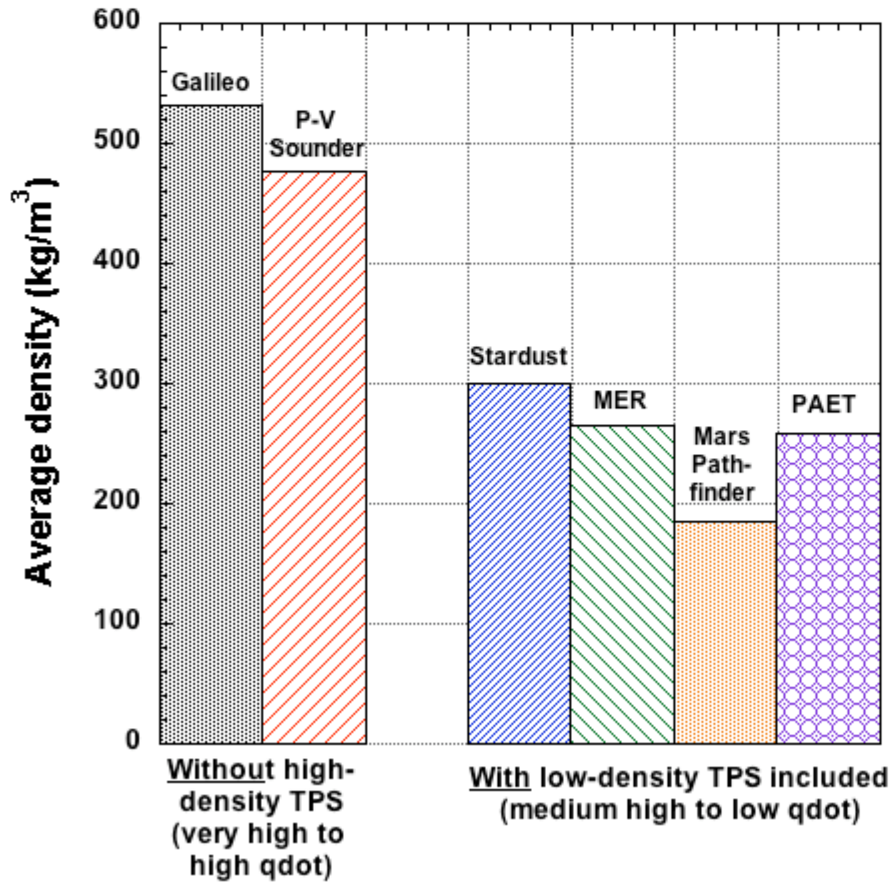
Radiation; inner planets n = 1.19-1.22

Radiation; outer planets n = 1.17-1.45

But

$$\frac{m}{C_D A} = \frac{(density)(vol.)}{C_D A} = \frac{(density)\, f(d)}{C_D}$$

Average Densities of Entry Probes



Cone angle choices

Cone Angle	Planet(s)	V_E km/s	Atm.	Press. Vessel	Max. Heating w/o Ablat. kW/cm2	Rel. Time	C_D
70°	Mars	6-7	Thin triatom.	no	Low (~0.1)	short	1.7
60°	Earth	11-13	Med. Diatom.	no	Med (~1.0)	Med.	1.5
45°	Venus	11-12	Dense triatom.	yes	High (~5.0)	Very long	1.0
45°	Jupiter	48	Med. Diatom.	yes	Severe (~50.0)	long	1.0
45°	Other outer planets	25-30	Med. Diatom.	yes	High (~5.0)	Very long - long	1.0

Mass Increase From Inception to Launch

Complexity, Difficulty, etc.	Examples	Approx Δm
• Experience from prior successful mission(s)	Mars Exploration Rover (MER) Mars Science Laboratory (MSL)	Modest ~ 20%
• Very high entry speed, heating & TPS material response uncertain • • Limited applicable TPS data • • Lack of precise atm. data	Jupiter Galileo Pioneer-Venus?	High ~ 60%
• New TPS material; high speed	Stardust	
• Change objective; added rover	Mars Pathfinder	