PURDUE UNIVERSITY

An Approach to Sizing a Dual-Use Ballute for Aerocapture, Descent, and Landing

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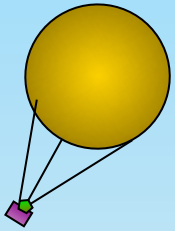

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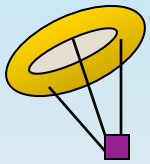

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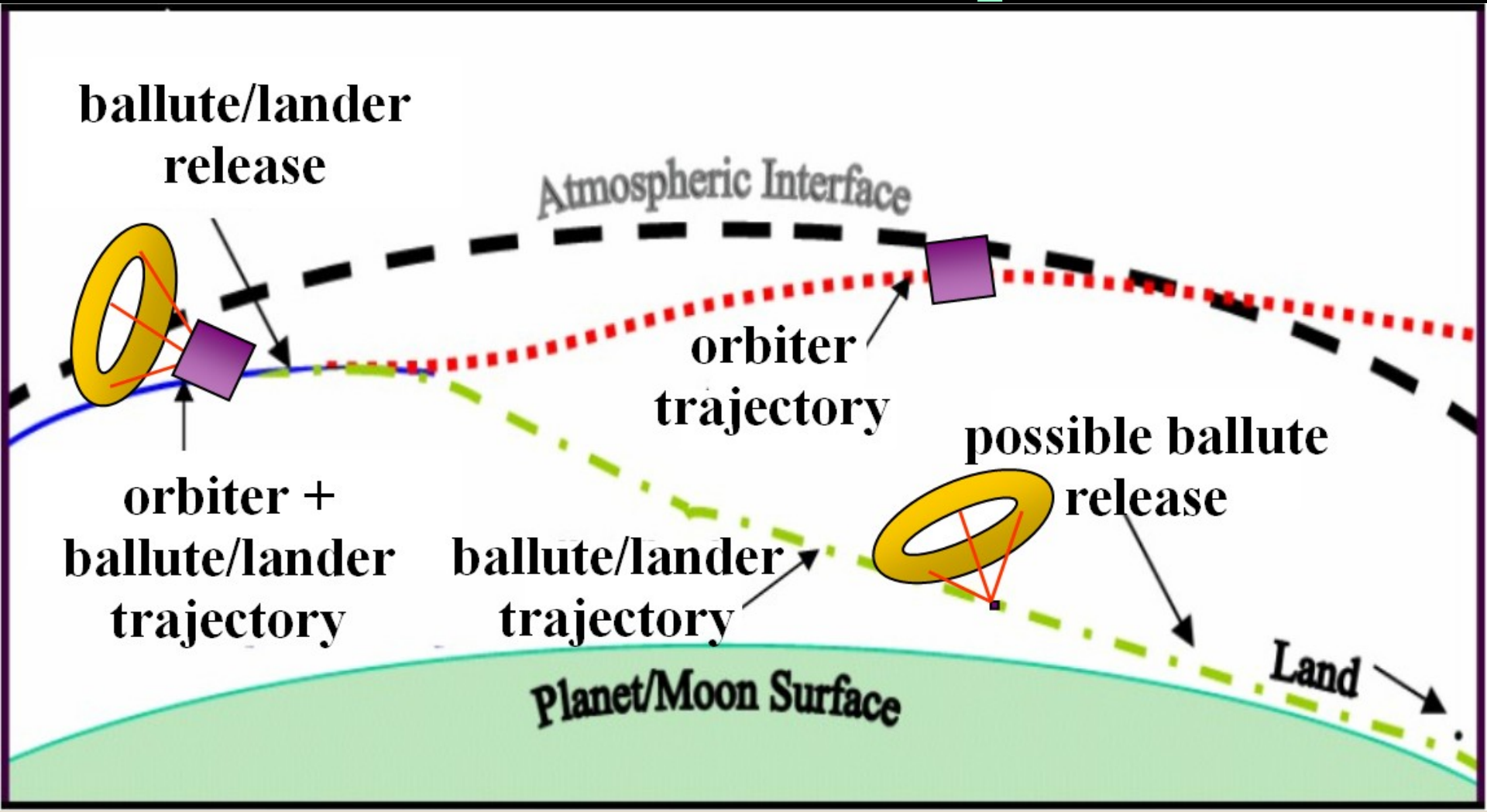
Dual-Use Ballute Concept



Analytic Theory

Modeling Assumptions:

- Planar equations of motion
- Non-rotating planet
- Point-mass vehicle representation
- Locally exponential atmosphere:
- Constant βR (varies with planet)
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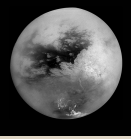
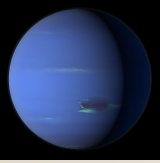
-

Equations of Motion:

Vinh, N. X., Johannesen, J. R., Longuski, J. M., and Hanson, J. M., "Second-Order Analytic Solutions for Aerocapture and Ballistic Fly-Through Trajectories," *The Journal of the Astronautical Sciences*, Vol. 32, No. 4, Oct.-Dec. 1984.

Heating Rate

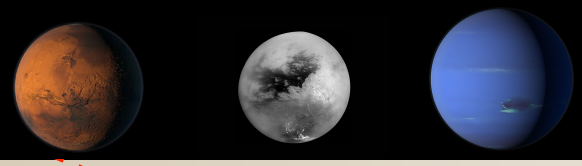
Stagnation-Point Heating Rate:

Derivation based on Vinh's 2nd order capture theory

Maximum Heating Rate Expression:

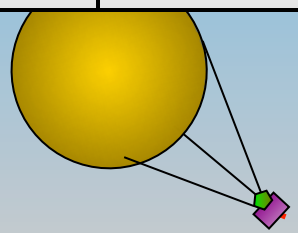
(contains approximately 150 terms!)

Parameters



for Dual-Use Ballute Applications at Earth, Mars, Titan and Neptune

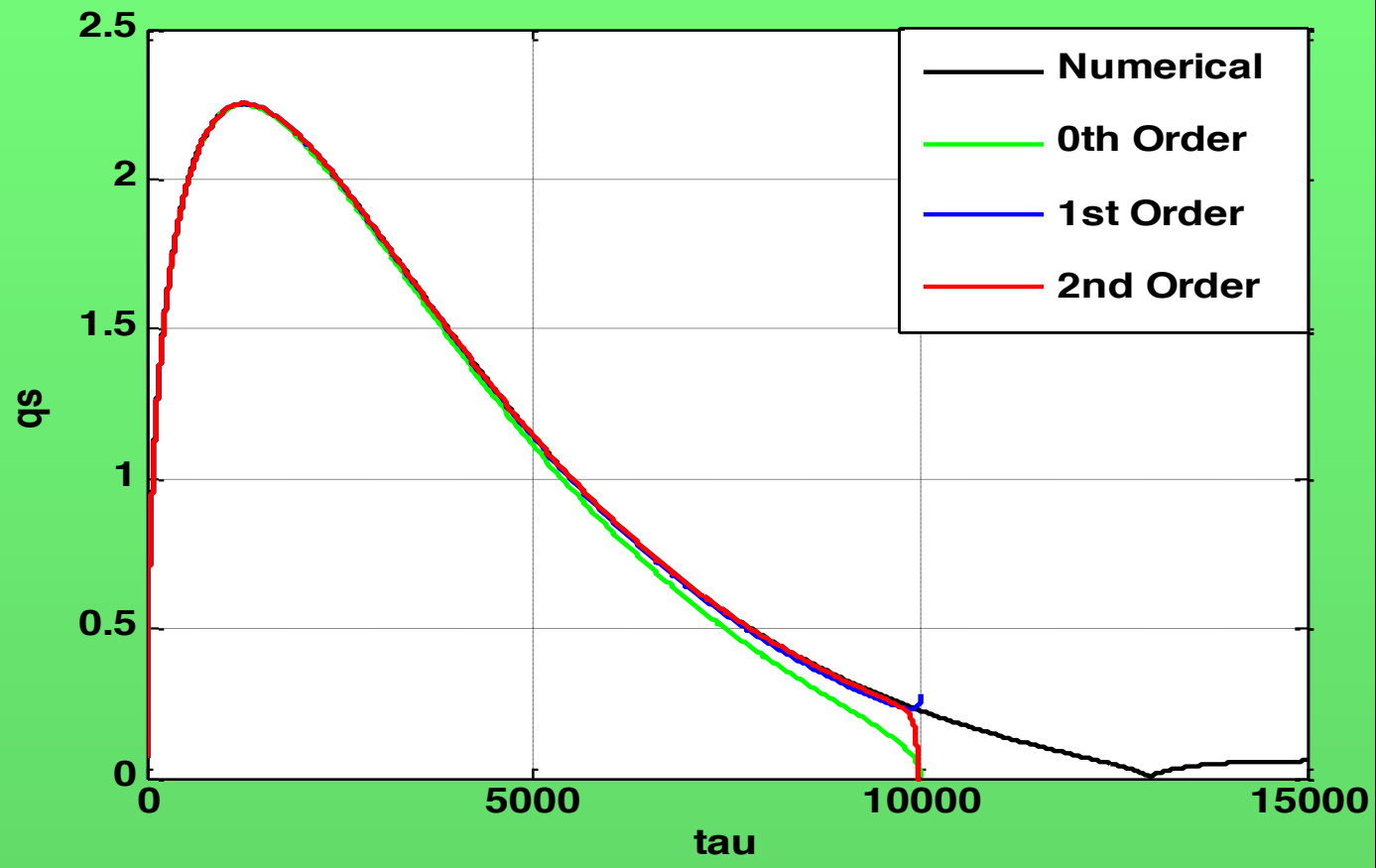
Parameter	Orbiter	Ballute/Lander
m	400 kg	100 kg
C_D	1.37	1.37
A	2 m^2	500-3000 m^2
R_n	0.8 m	15.5 m
C_B	$m/(C_D A)$	0.730-0.122 kg/m^2



Target Body	Entry Speed (km/s)
Mars	5.75-11.0
Titan	6.50-10.0
Earth	12.9
Neptune	23.6

Stagnation-Point Heating Rate

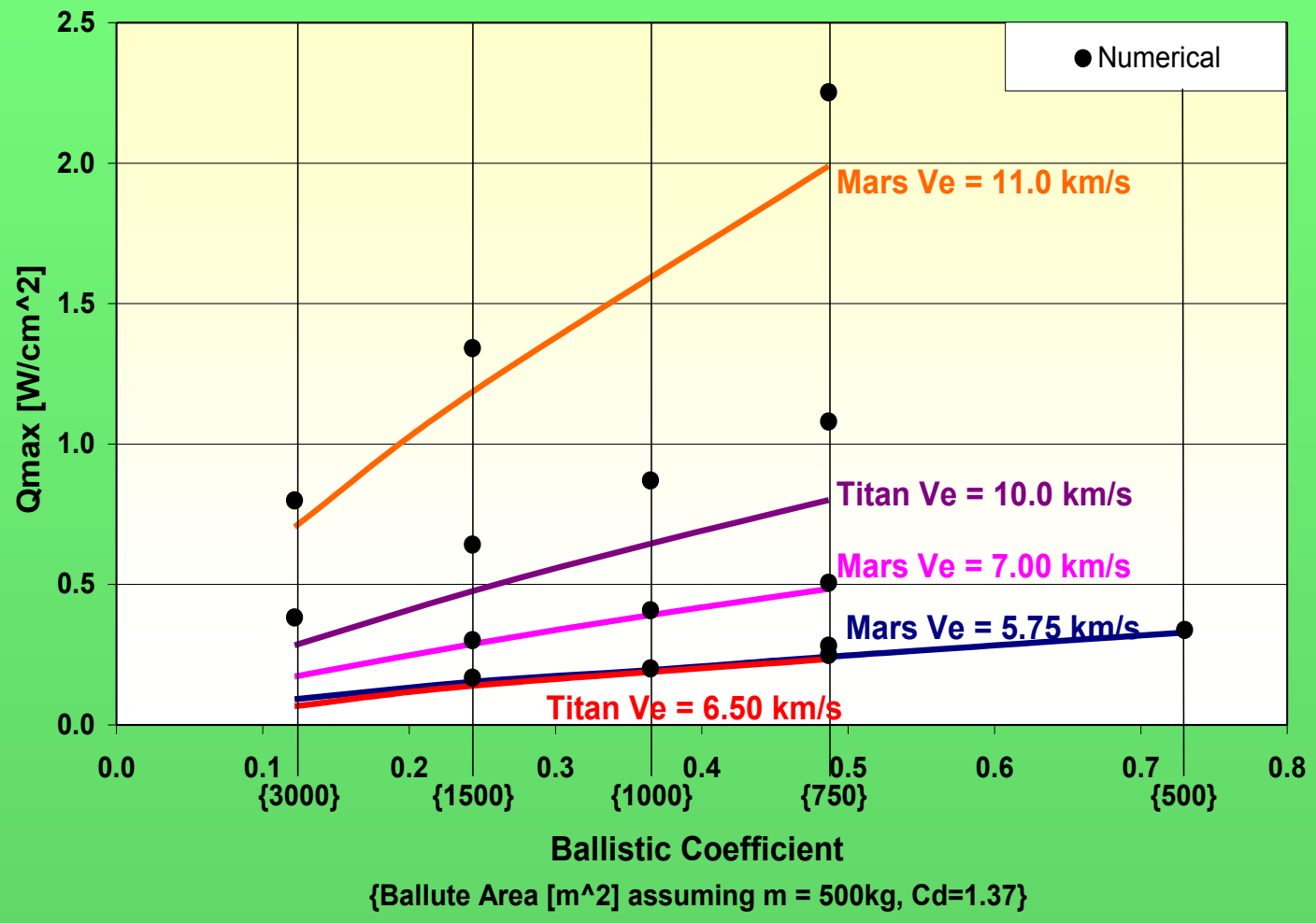
Stagnation-Point Heating Rate vs. Speed Variable (τ) at Mars with v_e=5.75 km/s



Max. Heating Rate on Ballute

Ballute

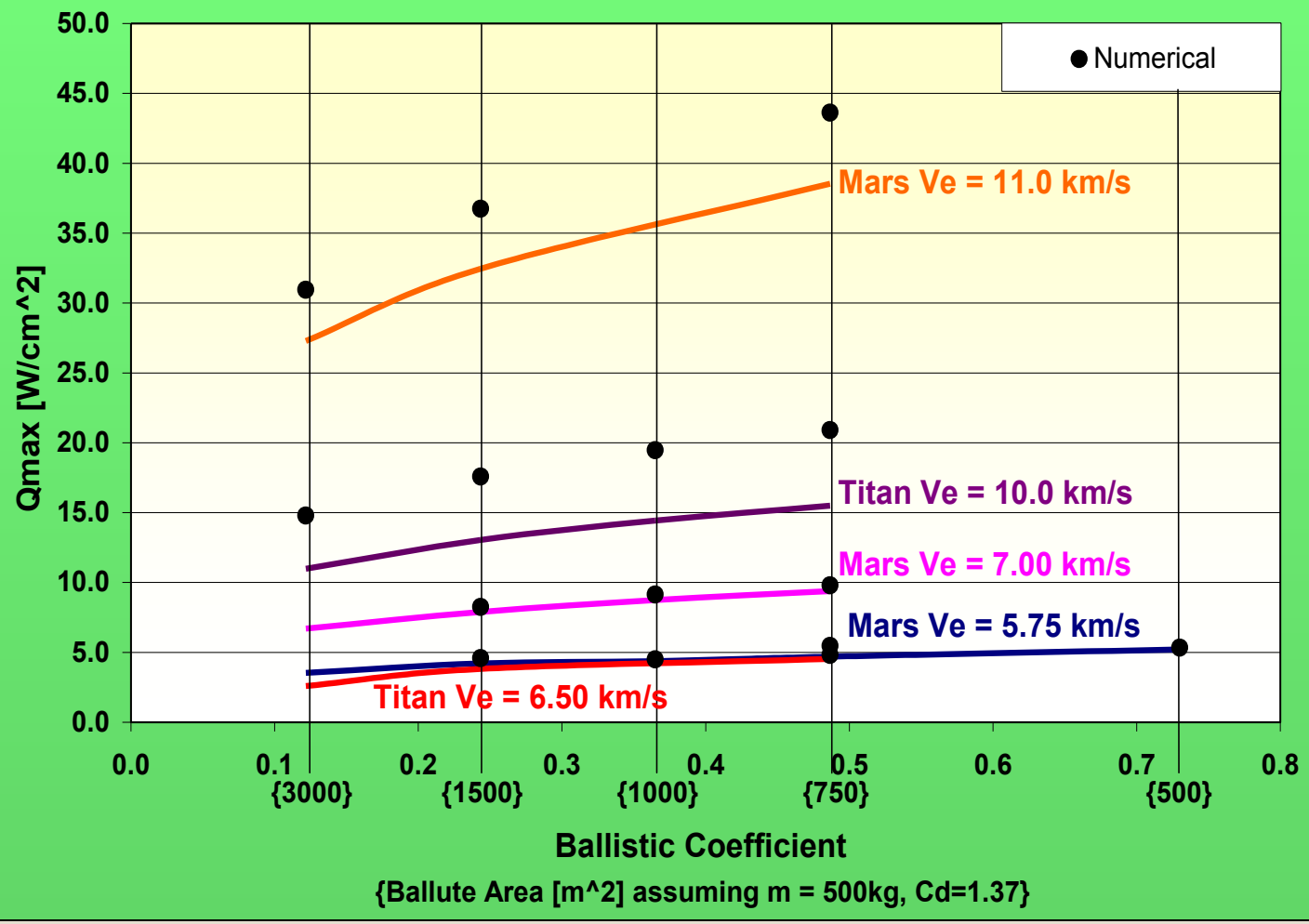
R_n is calculated assuming a spherical ballute



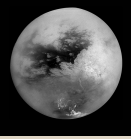
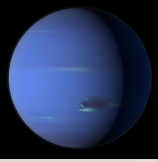
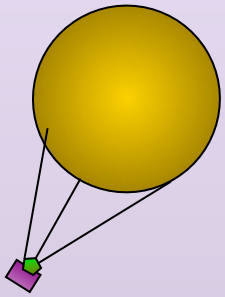
Max. Heating Rate on Orbiter

Orbiter

R_n= 0.8 m



Conclusions




- Analytic theory gives adequate results to size the ballute
- For practical ballute sizes, the dual-use ballute concept appears feasible at Mars, Titan, and Earth (but Neptune is a challenge!)
- Offers a significant new technique and tremendous advantages for exploration of the Solar System