ASTEROID APPROACH

12/10/14

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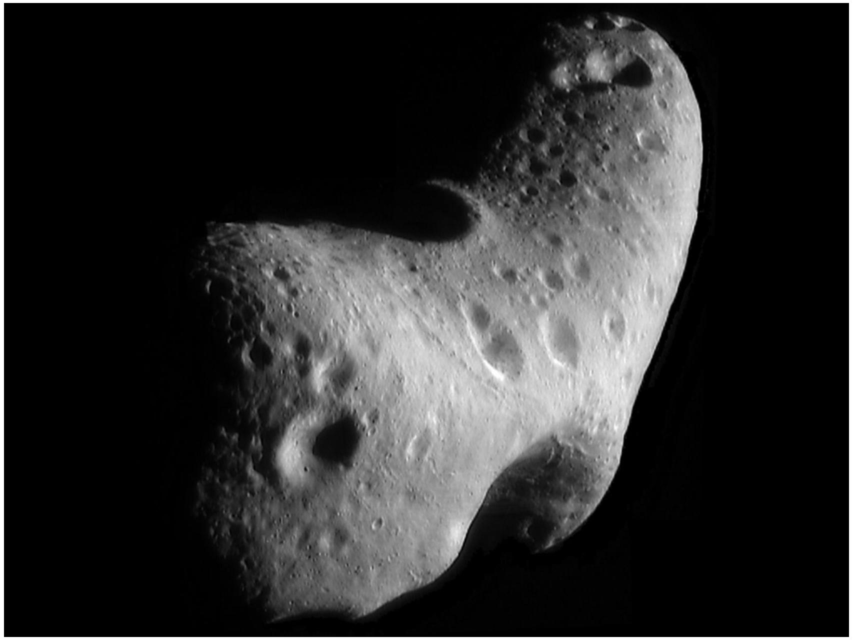
Motivation



Credit: NASA

Motivation

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Prior Work

- Government Missions
  - Near Earth Asteroid Rendezvous
  - Rosetta and Philae
  - Asteroid Redirect Mission
- Commercial
  - Planetary Resources
  - Deep Space Industries
- Verification
  - Monte Carlo methods
  - Lunar landing
  - Satellite rendezvous in low earth orbit

Initial Assumptions

- 2 DOF system – approach axis translation and rotation
- Constant acceleration due to gravity
- Constant mass spacecraft
- Fixed braking acceleration
- Time-triggered controller
- No orbital mechanics

Control & Invariant

- Derive safety from equations of motion

$$v_f^2 = v_i^2 + 2a(p_f - p_i)$$

$$\Downarrow$$

$$p \geq \frac{-v^2}{2(g - B)}$$

- Predict forward and check braking condition

$$p - v * T - \frac{1}{2} g T^2 > \frac{-(v + g * T)^2}{2(g - B)}$$

Fuel Use – Key Variables

- dm – dry mass of the satellite (no fuel)
- M – fuel mass
- mi – initial mass of the satellite, mi = dm + M
- m – current mass of satellite, initially mi
- f – constant force output of the thruster
- I_{sp} – specific impulse, "engine efficiency"

Fuel Use – Key Equations

- Dynamic braking acceleration

$$B \equiv \frac{f}{m}$$

- Dynamic mass

$$\dot{m} = \frac{f}{I_{sp} * g_e}$$

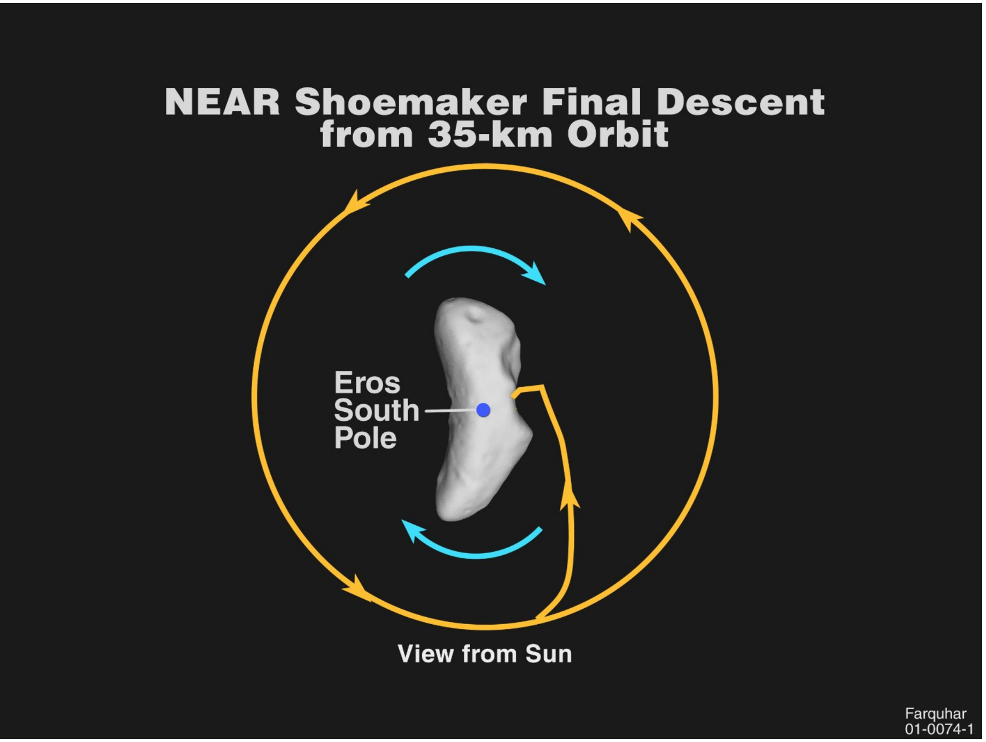
- Conservative fuel mass bound

$$m - dm \geq \frac{f}{I_{sp} * g_e} * \frac{\sqrt{v^2 + 2gp}}{g}$$

Fuel Use – Application

- NEAR Shoemaker
  - I_{sp}=325 Seconds
  - f = 450 Newtons
  - dm (dry mass) = 478 Kilograms
  - M (fuel mass) = 300 Kilograms
  - p_i = 1000 Meters
  - v_i = 3 Meters/Second
  - g = 0.0059 Meters/Second^2
  - Predicts 735 Kilograms of fuel

Fuel Use – Application



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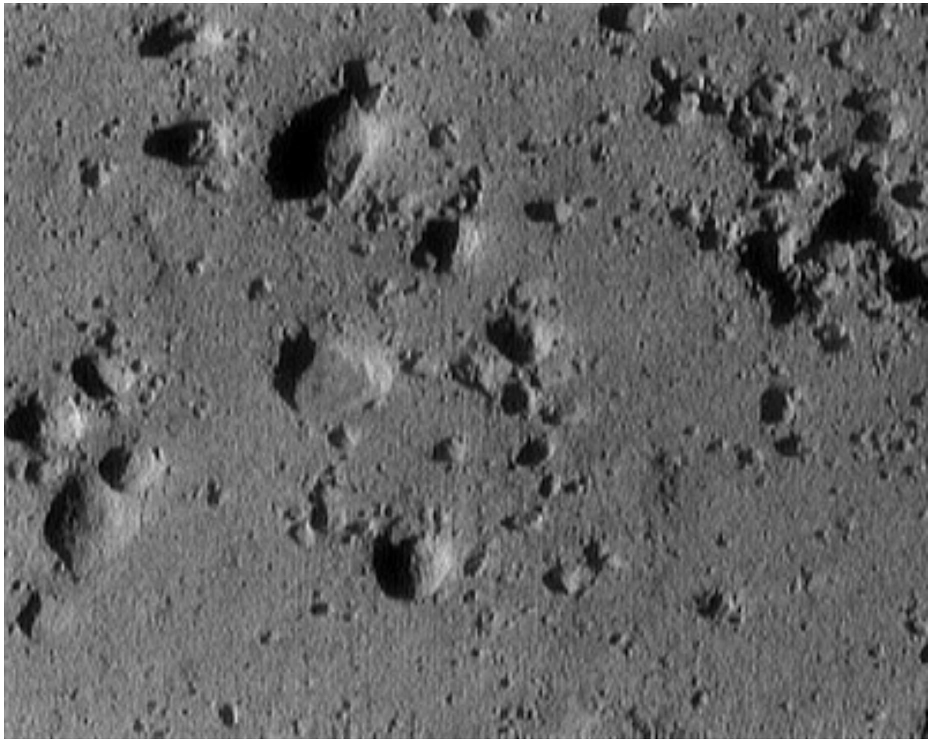

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Questions?