

MISSÕES INTERPLANETÁRIAS. ASPECTOS FÍSICOS DAS MANOBRAS ASSISTIDAS POR GRAVIDADE - II

Aula 4 - curso de extensão:

A engenharia das missões espaciais

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Sumário



- Custos da órbita e da manobra
- Swing-by com impulso
- Aero assistência
- Outras técnicas de controle



Custos da órbita e da manobra – Delta V

- Uma missão espacial é composta por uma serie de diferentes órbitas.
- Delta-V é a soma das mudanças na velocidade, e representa a energia necessária para fazer as manobras.
- É usado para calcular o sistema de propulsão. [1]

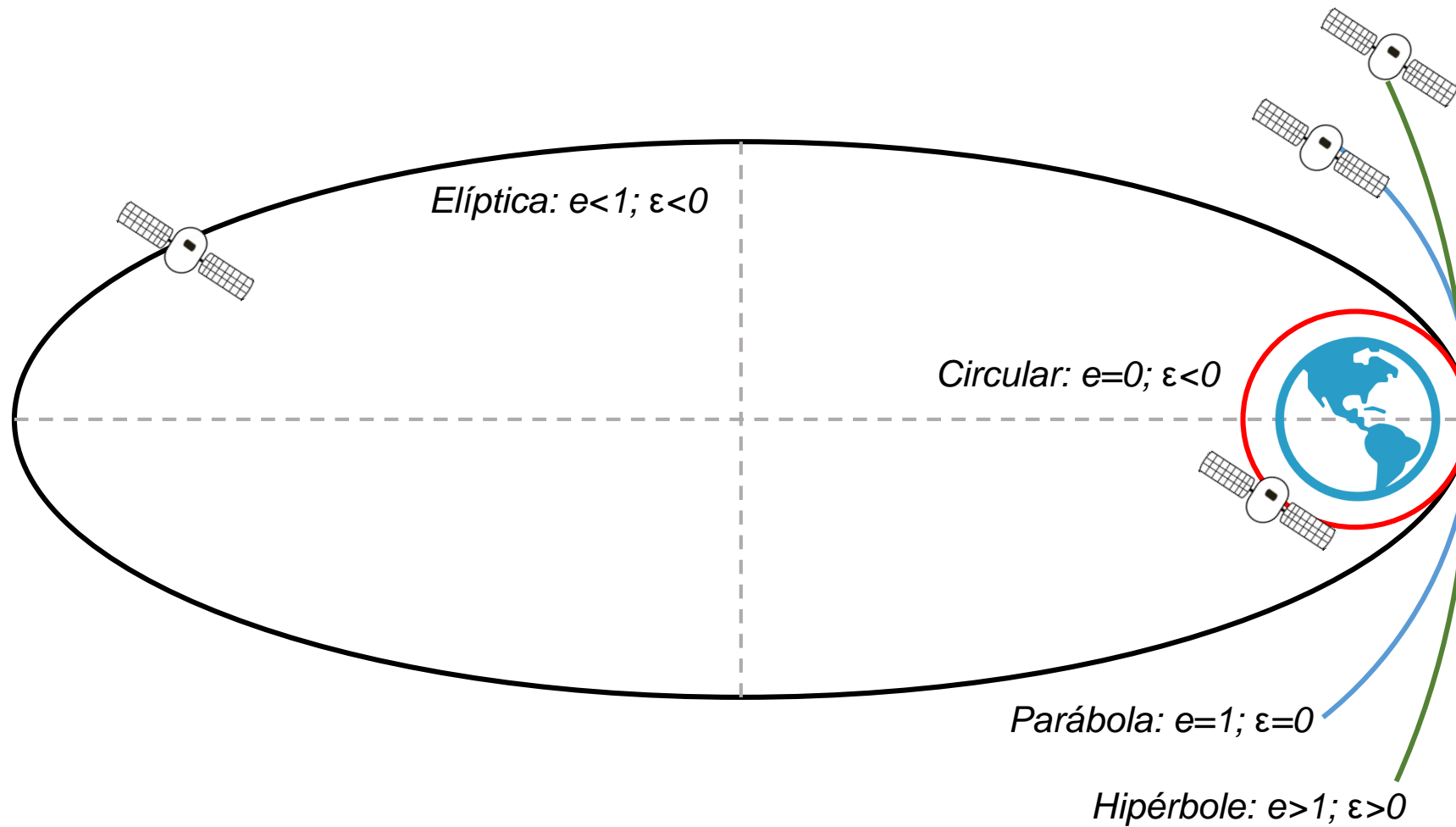


$$m_i = m_0 + m_{prop}$$

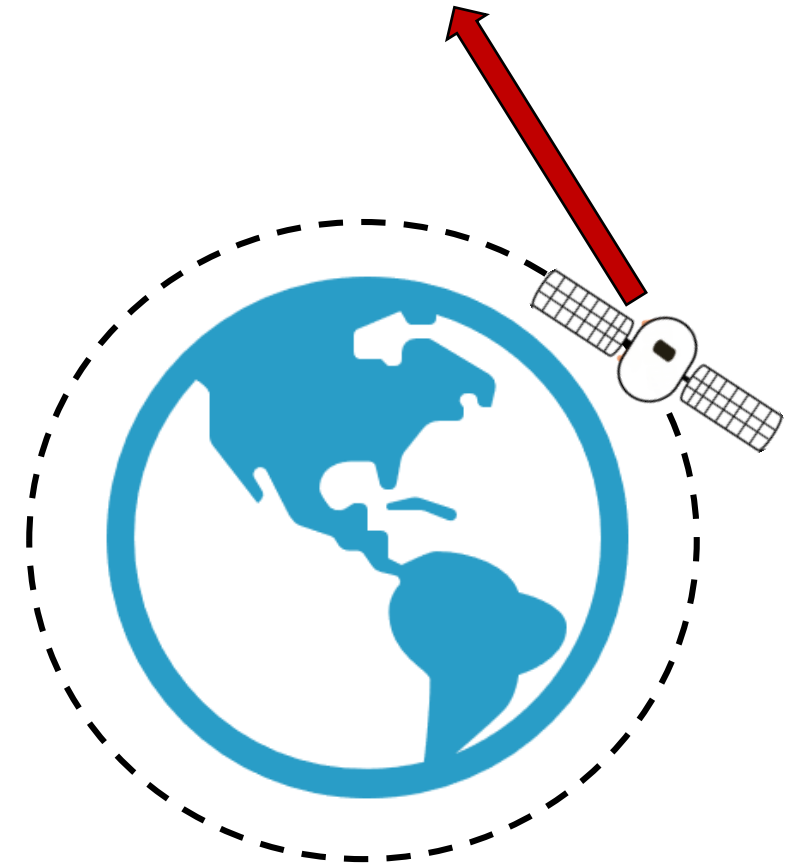
$$m_i = m_0 e^{\left(\frac{\Delta V}{I_{sp} g_0}\right)}$$

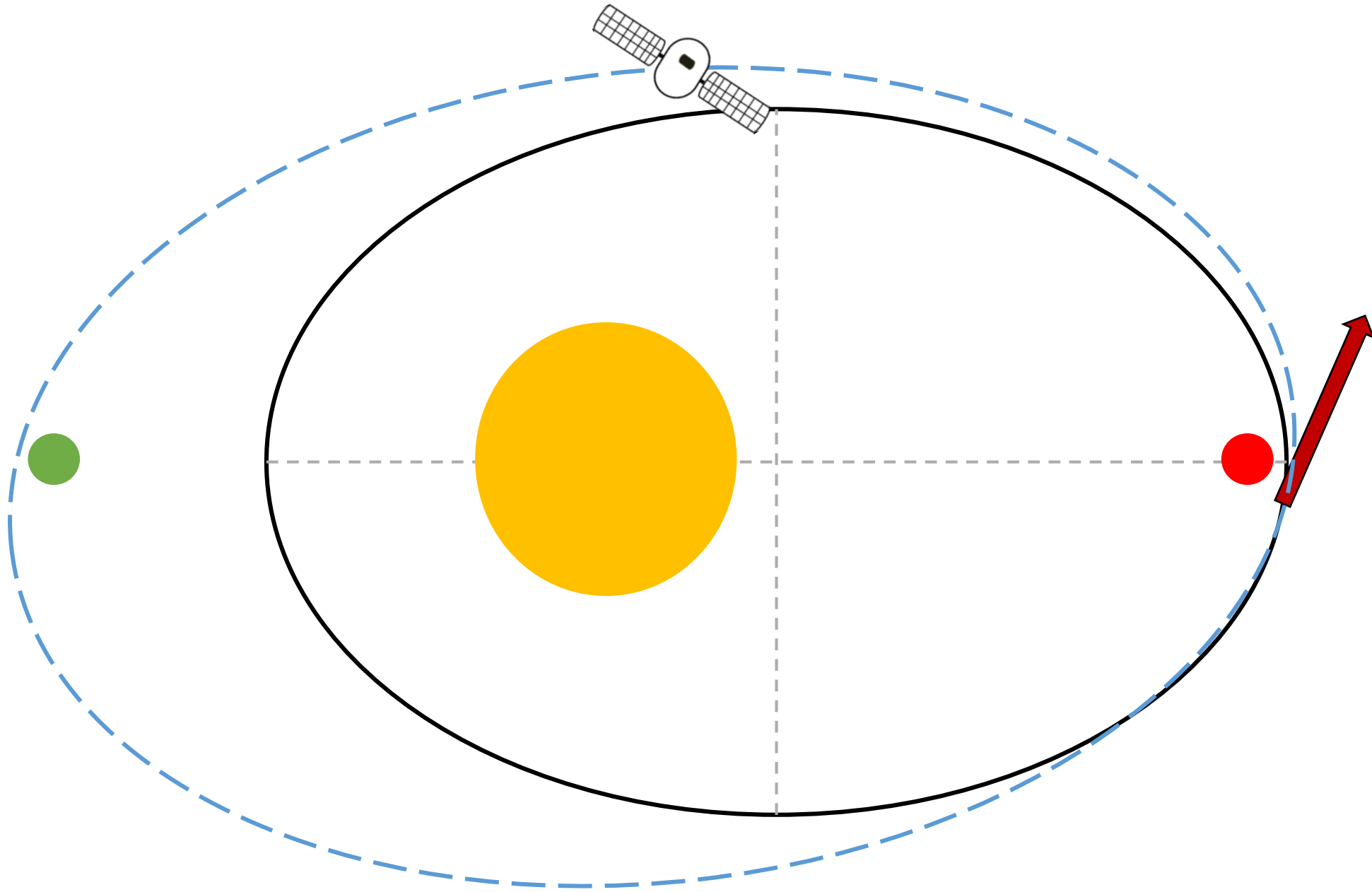
[1] Fonte: Adaptada *Space Mission Engineering: The New SMAD*, p. 251.

Seções cônicas

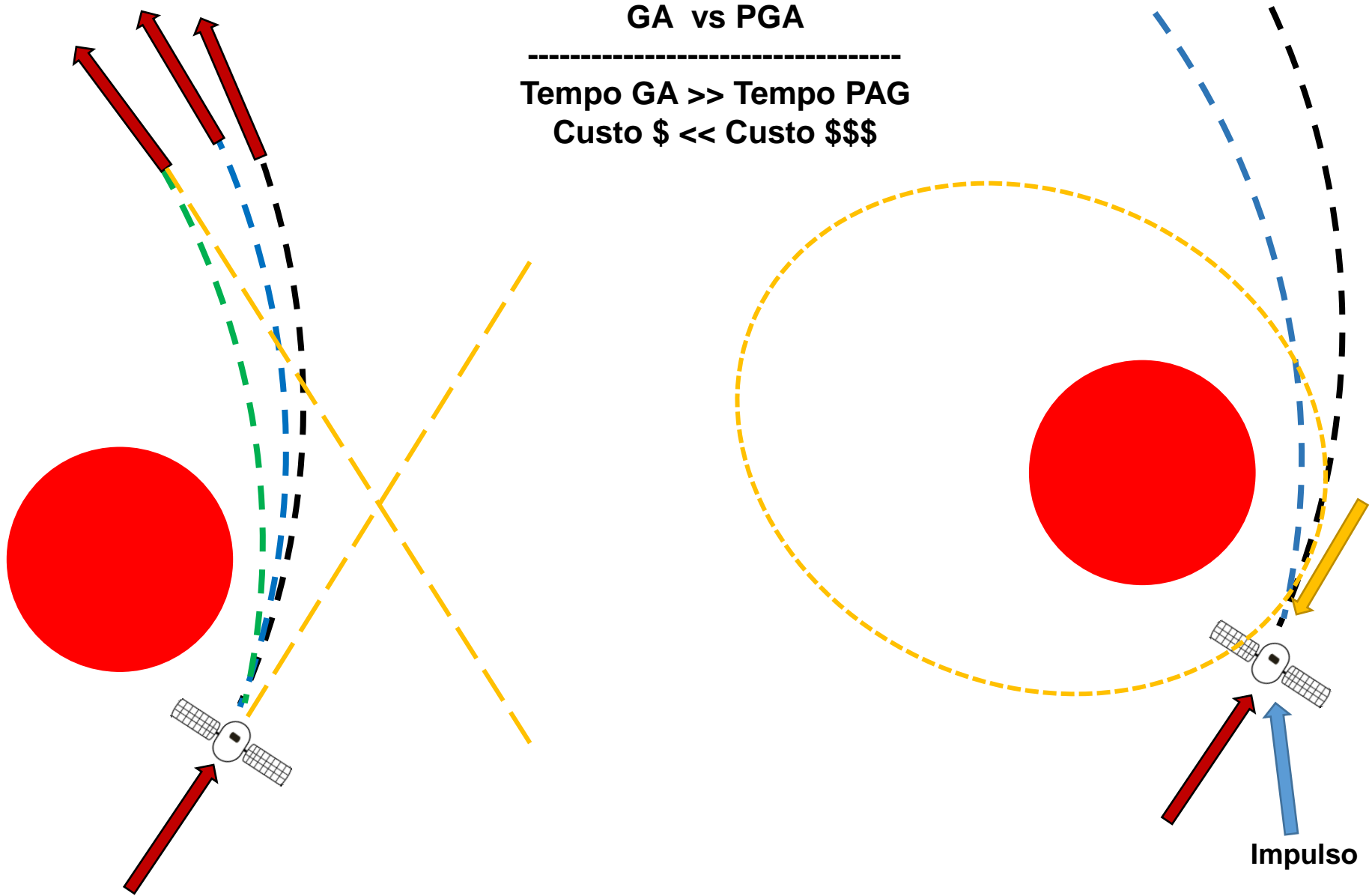


| Inicio | Final | Delta-V |
|--------|-------|----------------------|
| Terra | LEO | Ao redor de 9 km/s |
| LEO | GEO | Maior do que 3.5km/s |
| LEO | Lua | Maior do que 4km/s |





Swing-by com impulso

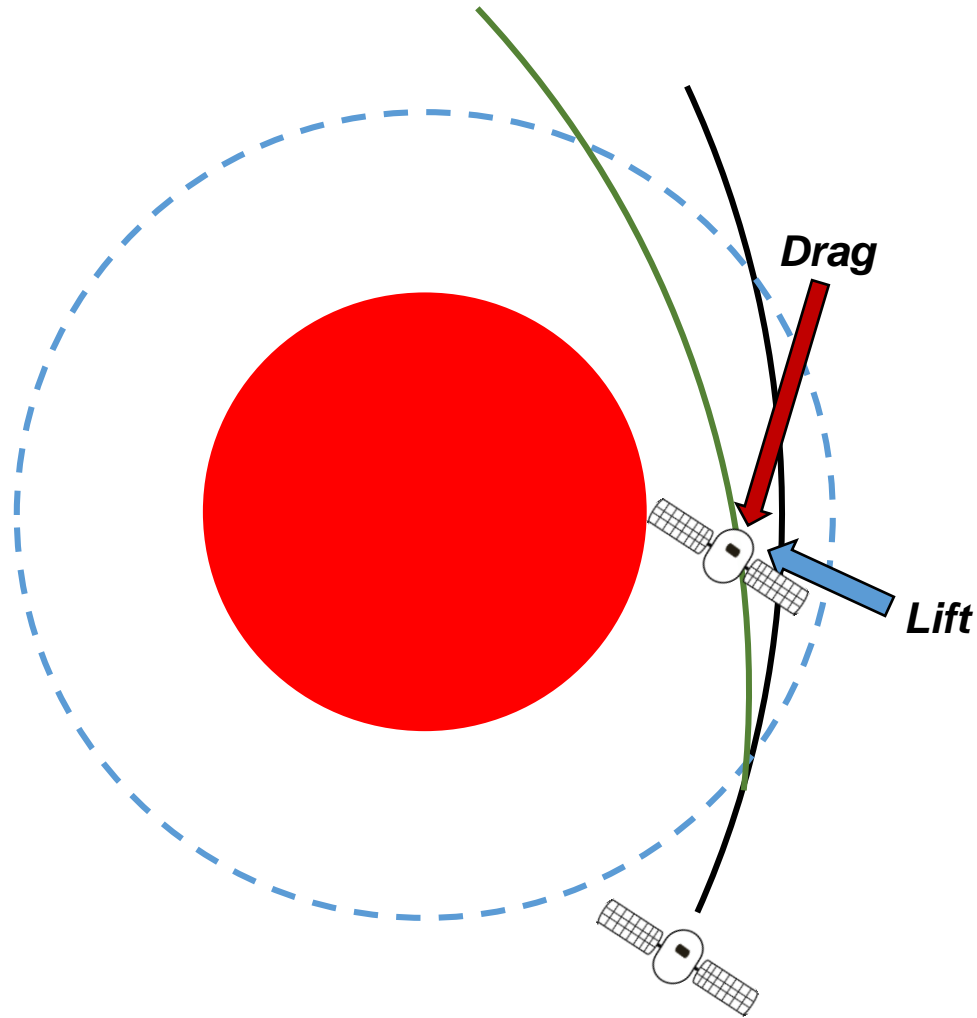


GA vs PGA

Tempo GA >> Tempo PAG
Custo \$ << Custo \$\$\$

Impulso

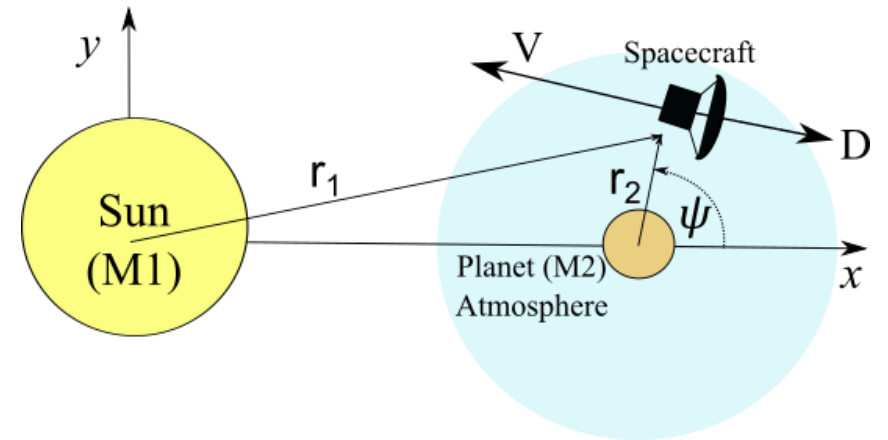
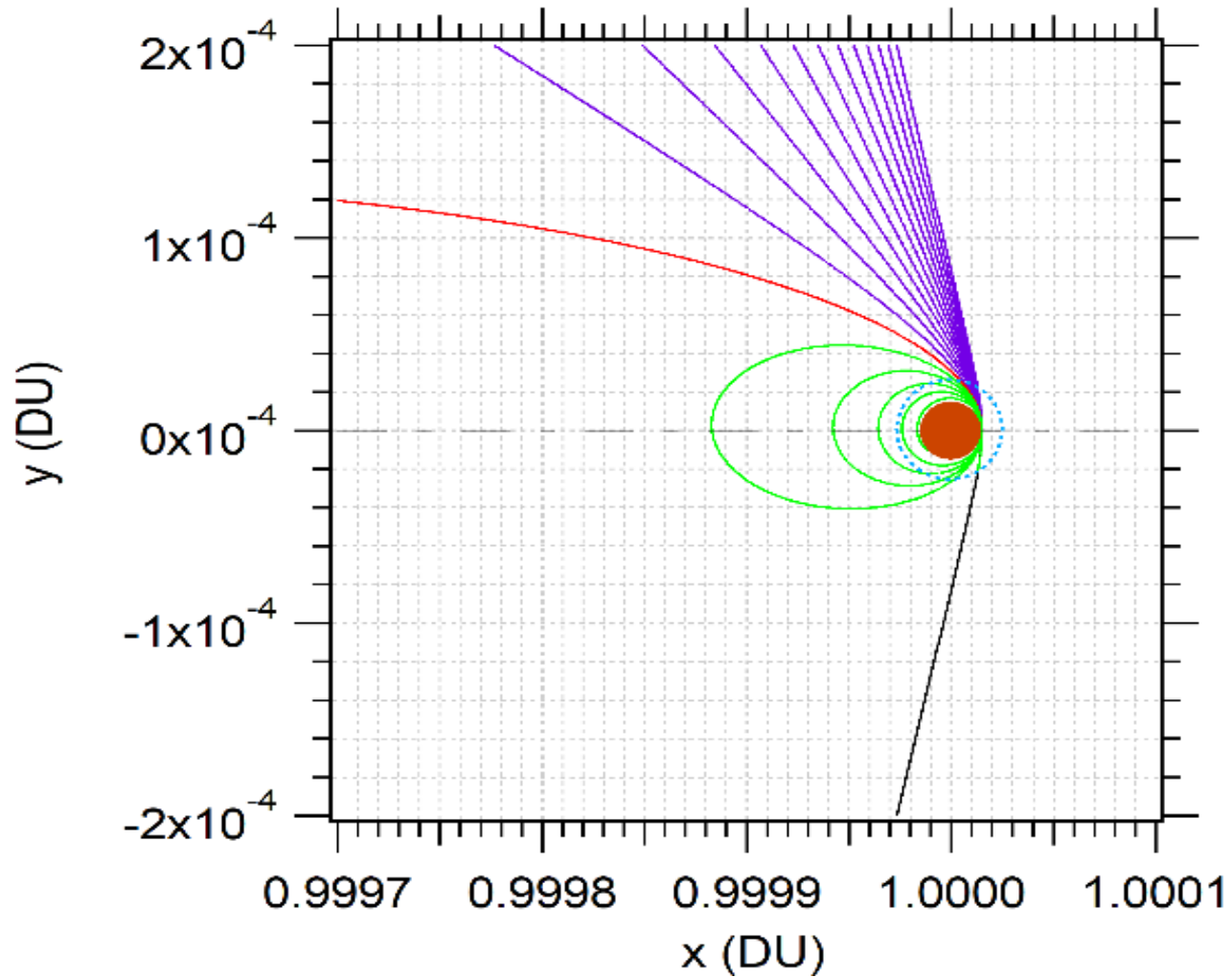
Aero assistência



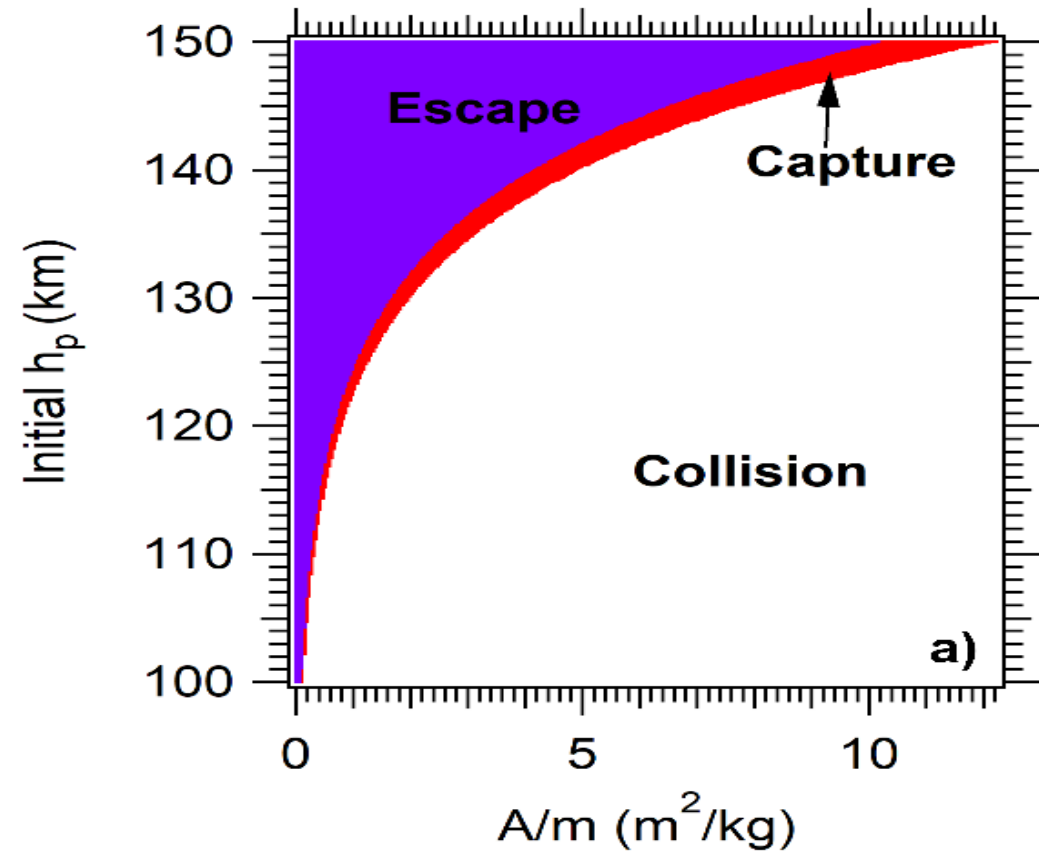
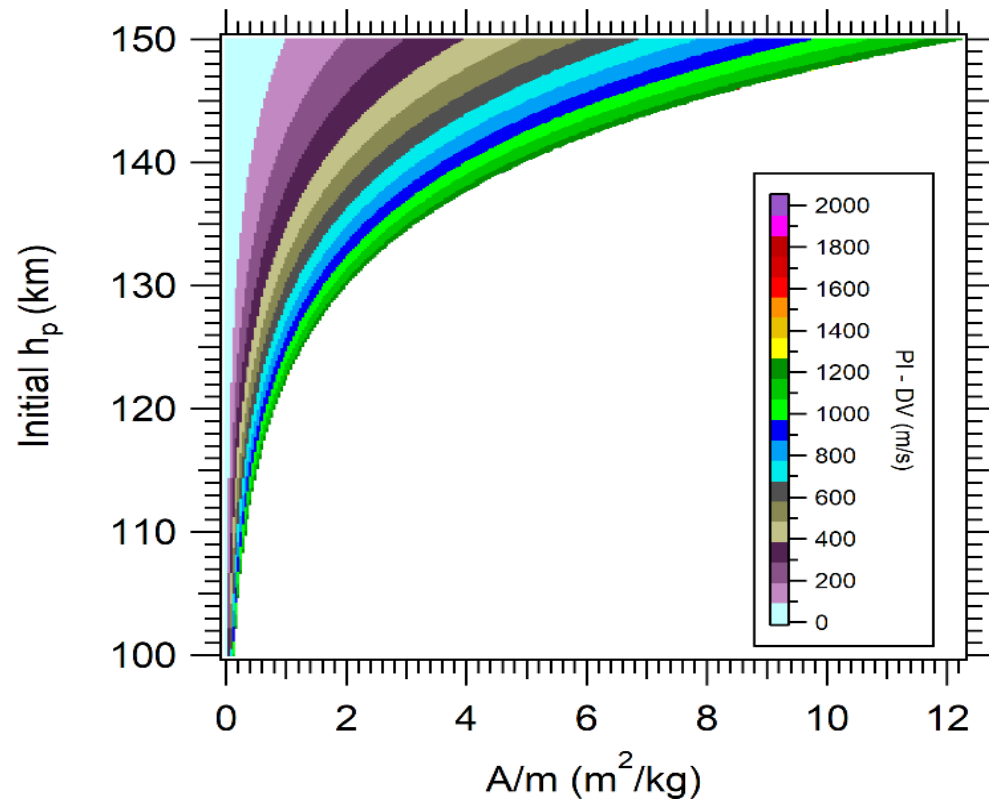
$$a_D = \frac{1}{2} \rho \frac{A}{m} C_D V_w^2$$

$$a_L = \frac{1}{2} \rho \frac{A}{m} C_L V_w^2$$

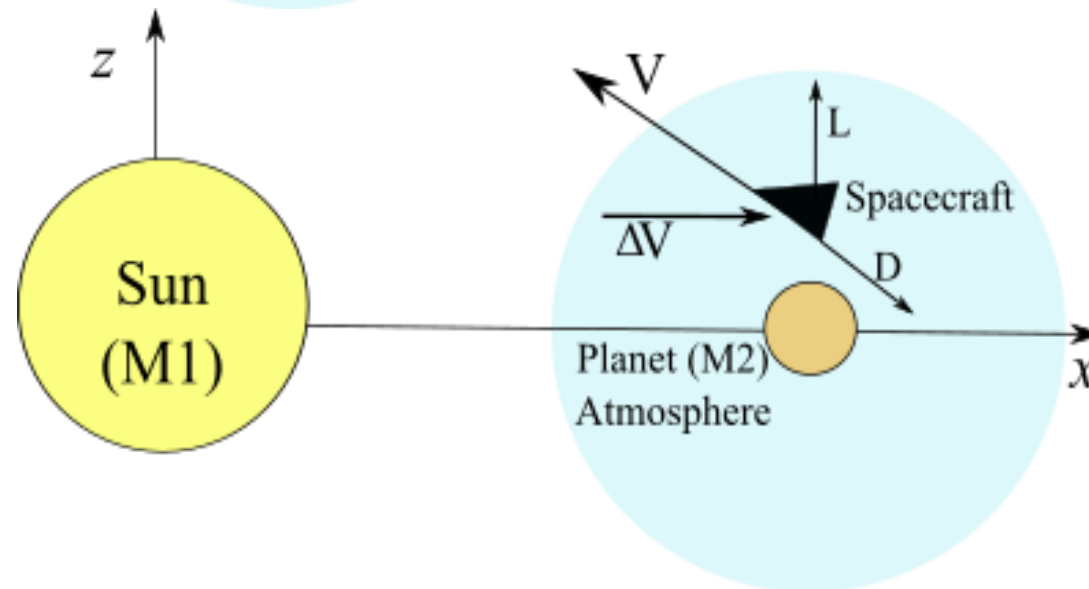
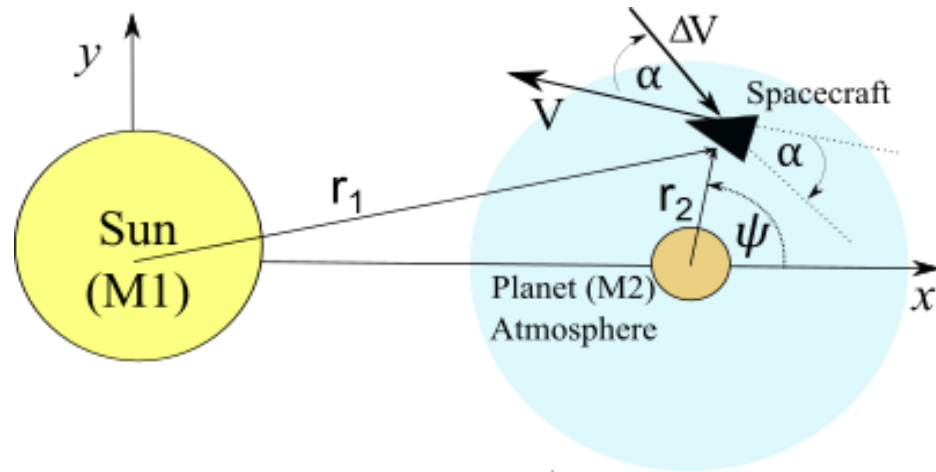
Aero assistência - *drag*



Aero assistência - drag

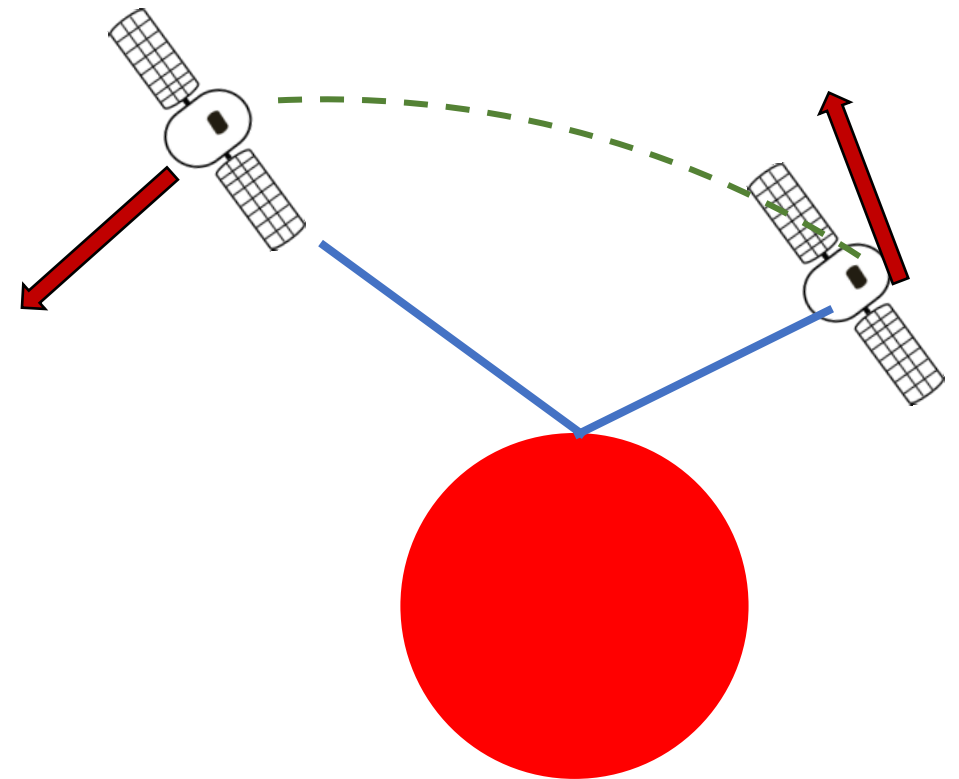
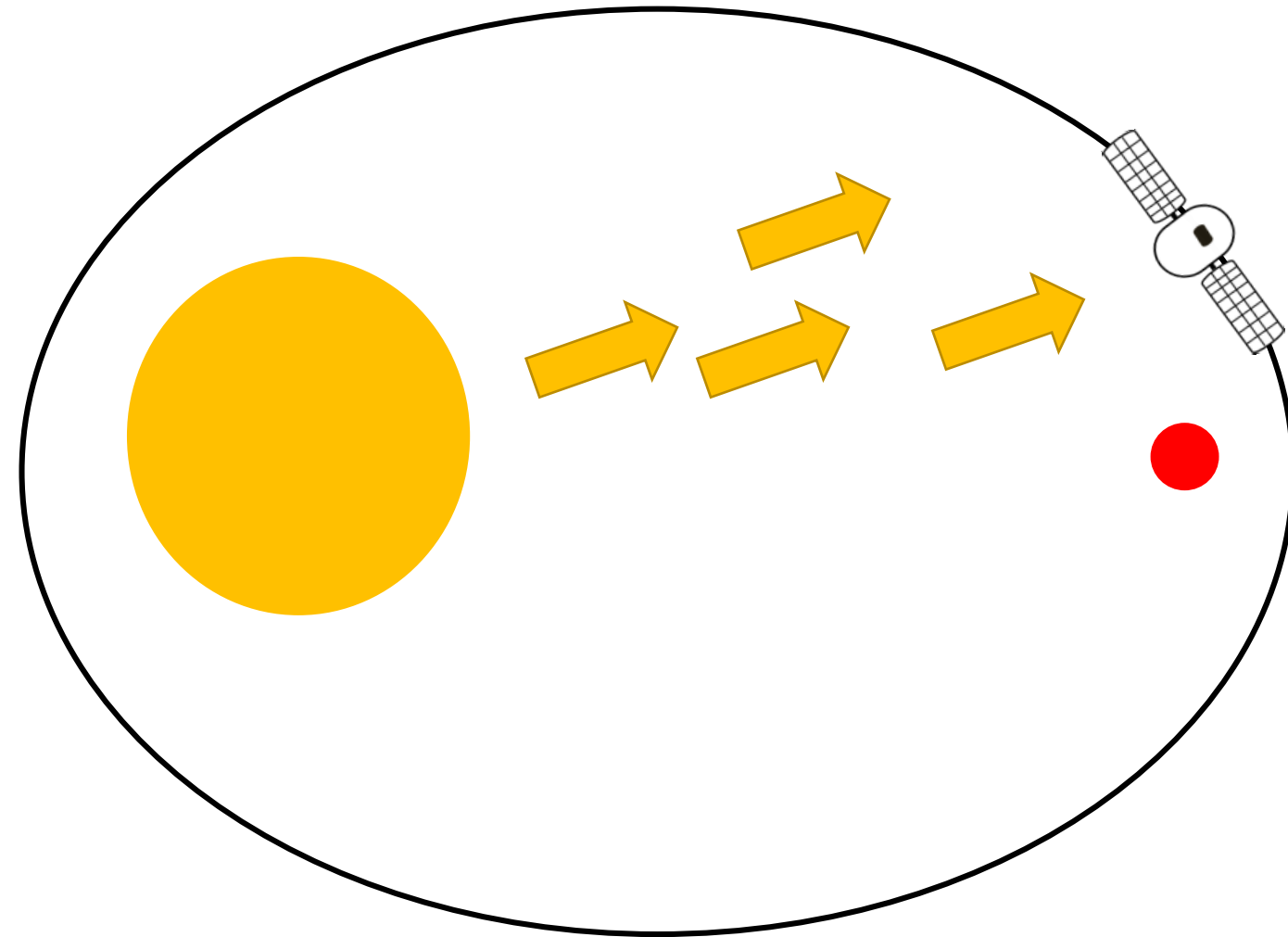


Aero assistência - *lift*



Outras técnicas de controle

- Solar sails (Koblik et al., 2003)
- Tethers (Ferreira et al., 2020; Prado, 2015).



Para finalizar

Os diferentes tipos de manobras durante o *swing-by* permitem:

- Diminuir o tempo de voo.
- Aumentar o Delta de V por outros médios.
- Controlar a órbita resultante e direção da espaçonave depois da passagem.

Referências

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Perguntas?



Obrigado!