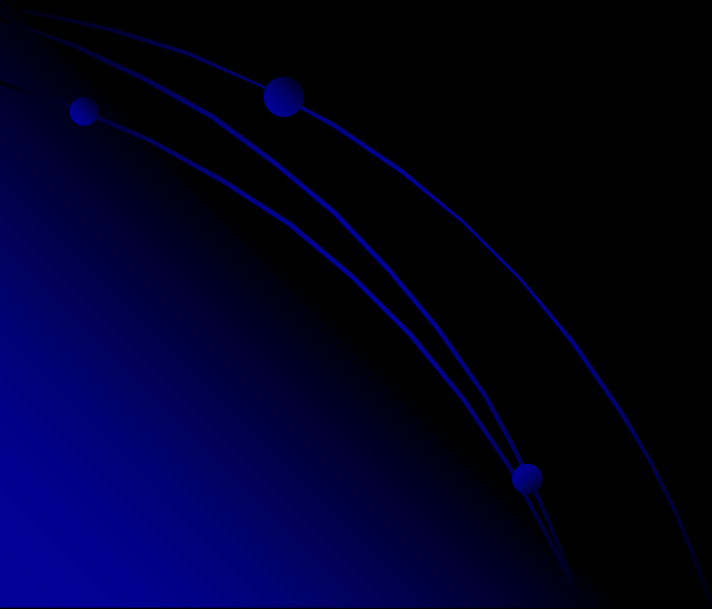
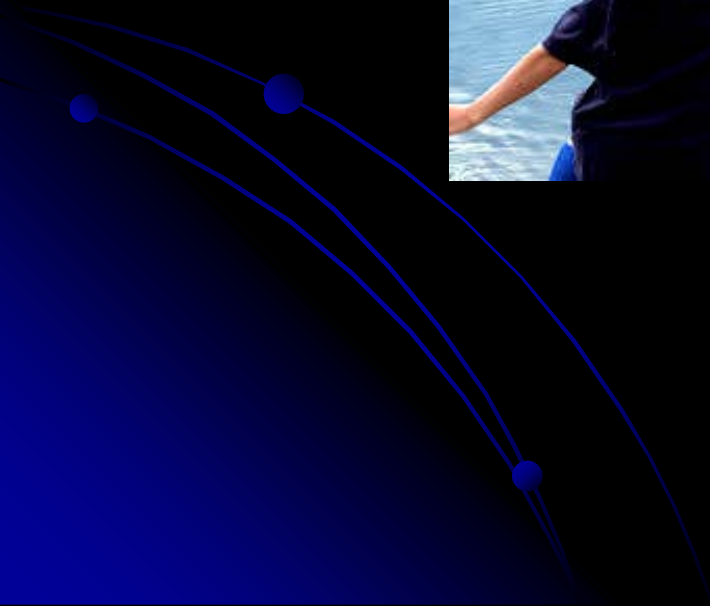
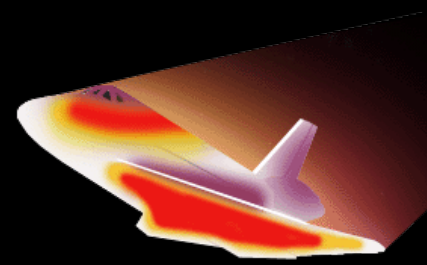
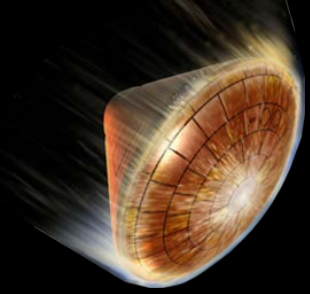


## **ПРОБЛЕМИ УЛАСКА КОСМИЧКИХ ЛЕТЕЛИЦА У ПЛАНЕТСКЕ АТМОСФЕРЕ**

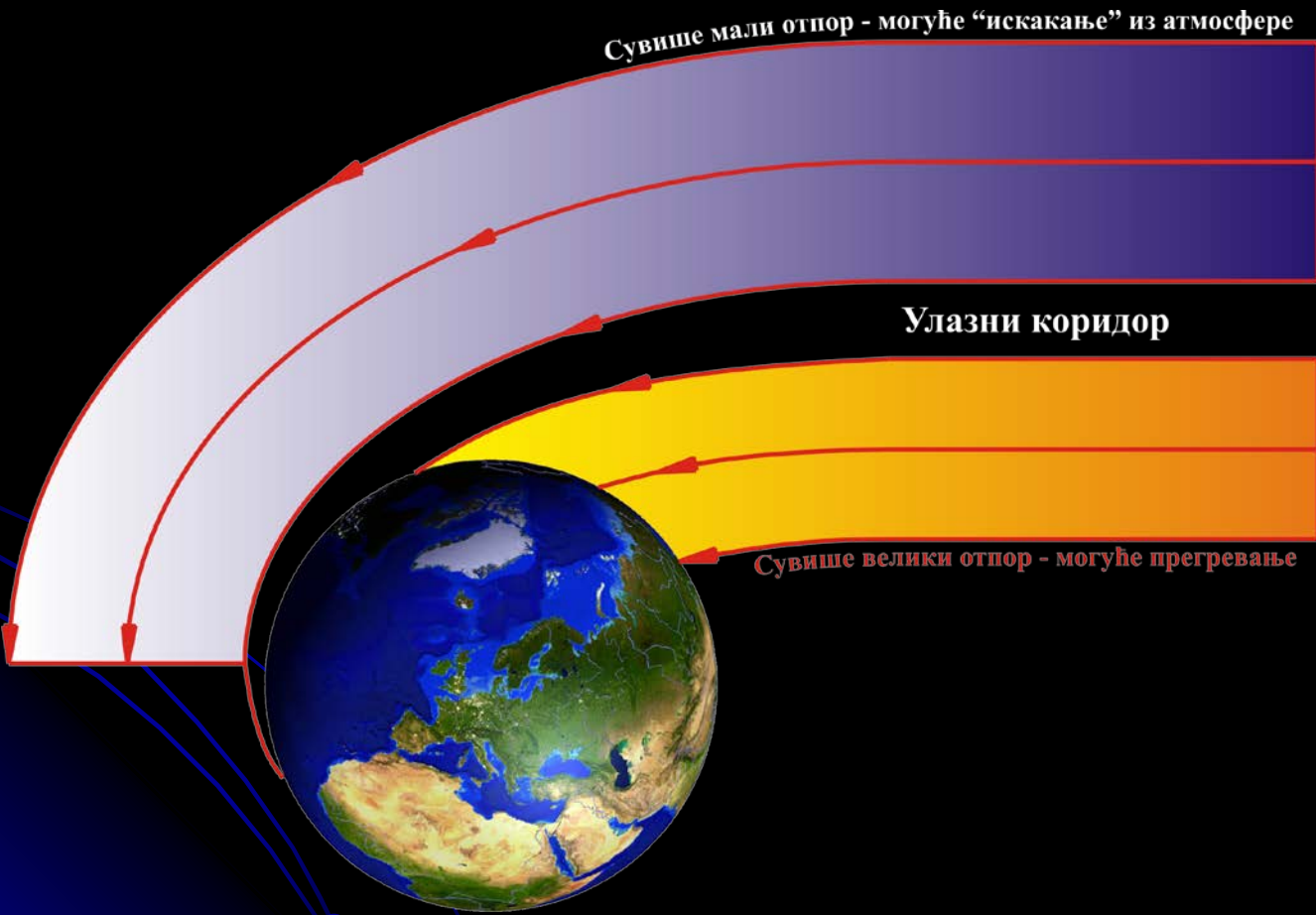
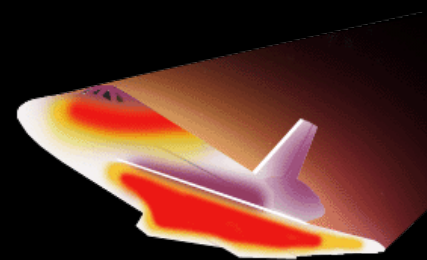
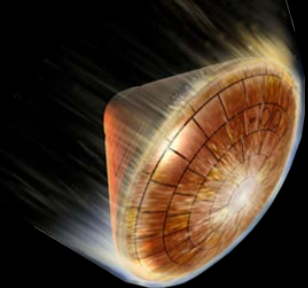


**Душан Марчета**

# БАЛАНС



# УЛАЗНИ КОРИДОР



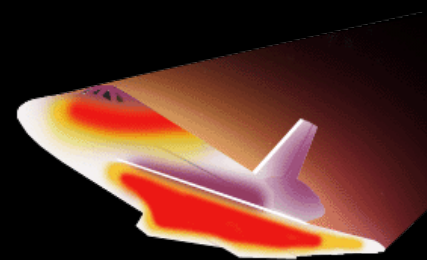
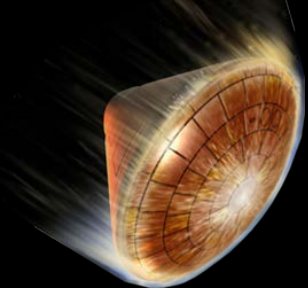
Сувише мали отпор - могуће "искакање" из атмосфере

Улазни коридор

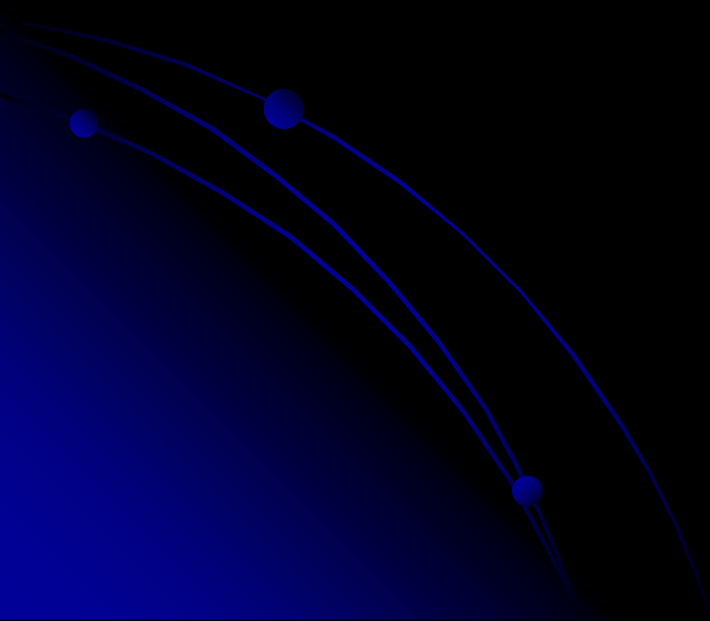
Сувише велики отпор - могуће прегревање



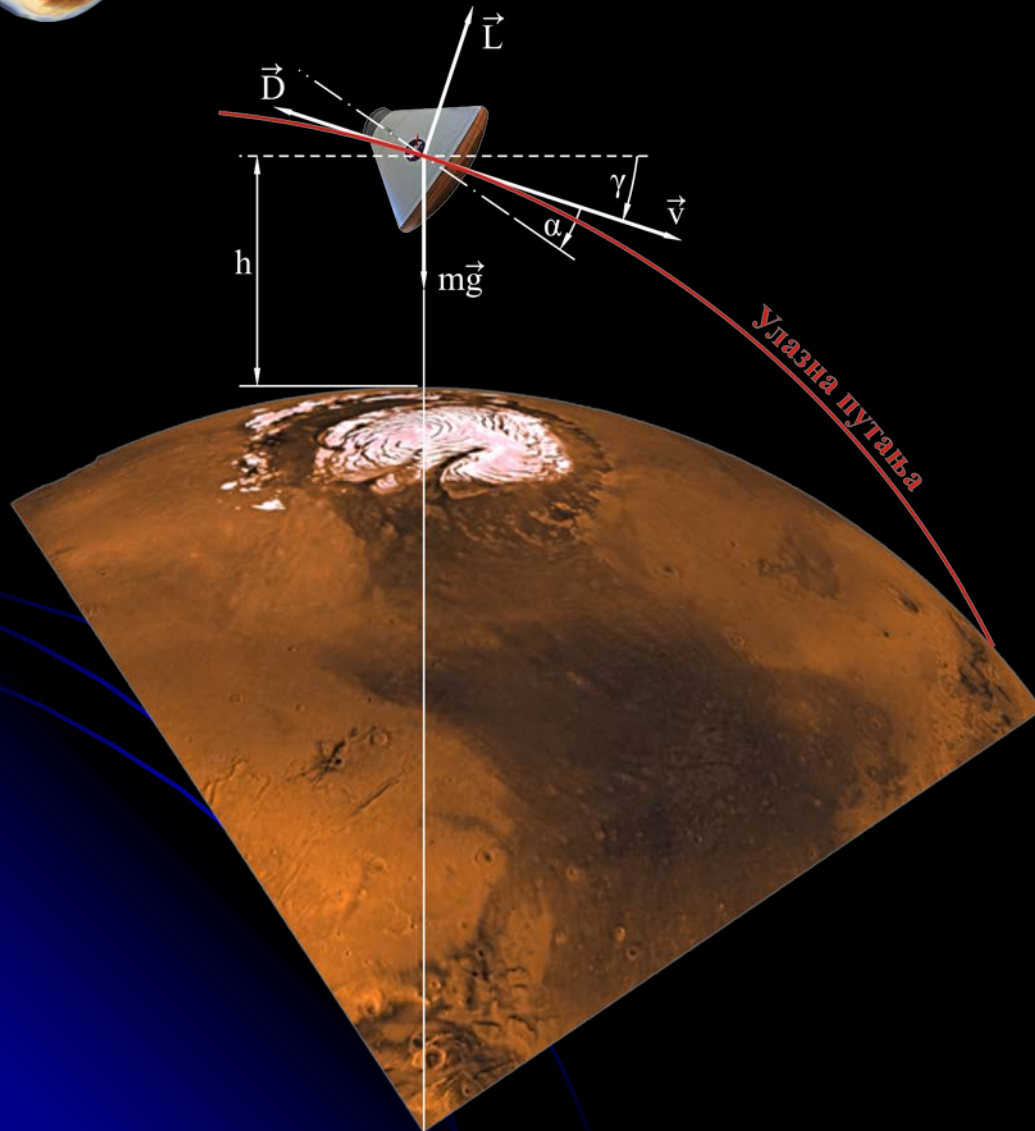
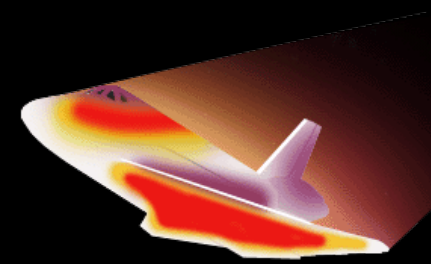
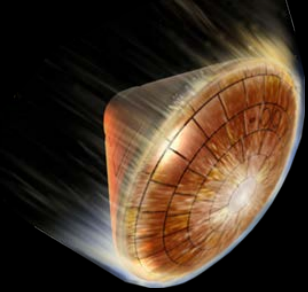
# ЕНЕРГИЈА



$$E_k + E_p \sim 10^{12} J$$



# ОСНОВНЕ ЈЕДНАЧИНЕ



$$\frac{dv}{dt} = -\frac{D}{m} - g \sin \gamma$$

$$v \frac{d\gamma}{dt} = \frac{L}{m} - \left( g - \frac{v^2}{r} \right) \cos \gamma$$

$$\frac{ds}{dt} = \frac{R}{r} v \cos \gamma$$

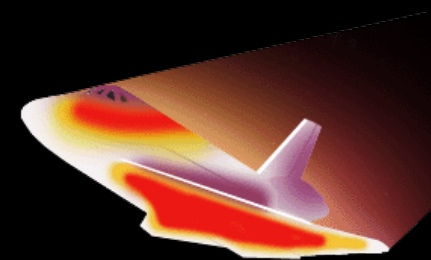
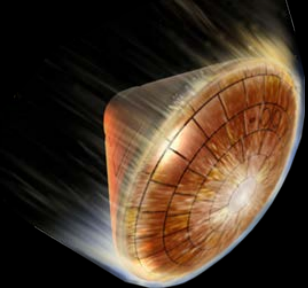
$$\frac{dr}{dt} = \frac{dh}{dt} = v \sin \gamma$$

$$L = \frac{1}{2} \rho v'^2 SC_L$$

$$D = \frac{1}{2} \rho v'^2 SC_D$$

$$g = g_0 \left( \frac{R}{R+h} \right)^2$$

# РОТАЦИЈА АТМОСФЕРЕ



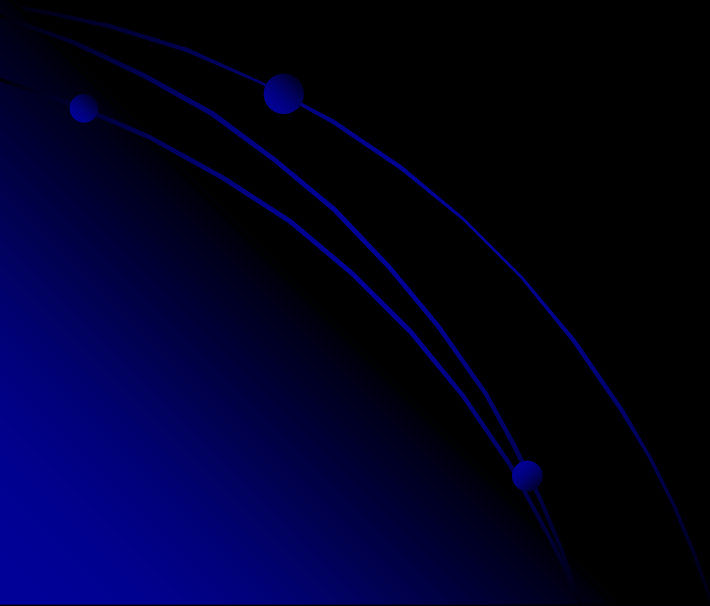
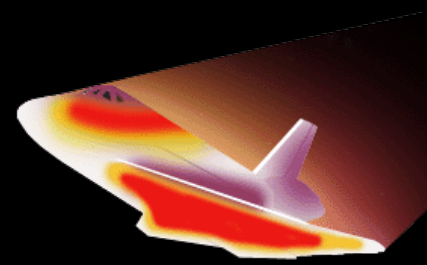
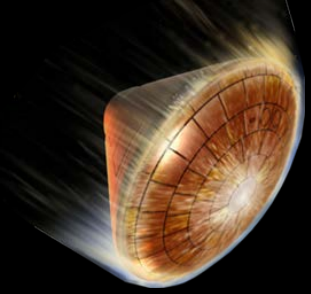
<b>Венера</b>	<b>0%</b>
<b>Земља</b>	<b>6%</b>
<b>Марс</b>	<b>7%</b>
<b>Јупитер</b>	<b>30%</b>
<b>Сатурн</b>	<b>40%</b>

# АПРОКСИМАЦИЈЕ

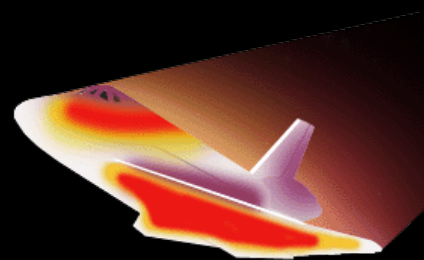
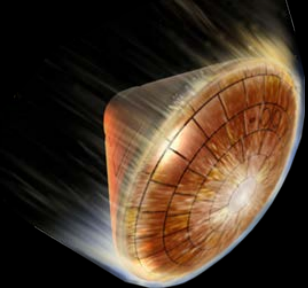
$$\rho(h) = \rho_0 e^{-\beta h}$$

$$g = \text{const}$$

$$\frac{v^2}{r} \approx \frac{v^2}{R} \approx \frac{v^2}{r_e}$$



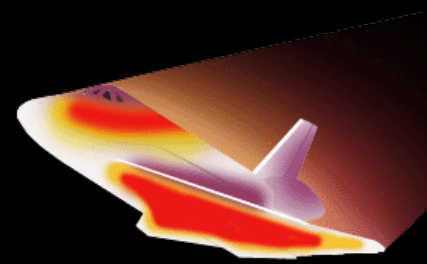
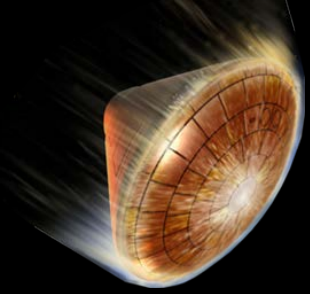
# ТРАНСФОРМИСАНЕ ОСНОВНЕ ЈЕДНАЧИНЕ


$$\frac{d\left(\frac{v^2}{gR}\right)}{d\rho} = \left(\frac{SC_D}{m}\right) \left(\frac{1}{\beta} \sin \gamma\right) \left(\frac{v^2}{gR}\right) + \frac{2}{\rho\beta R}$$

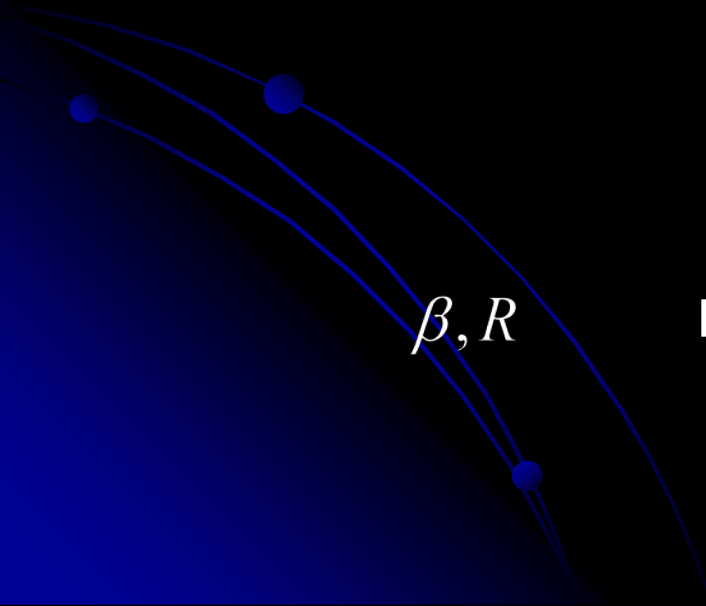
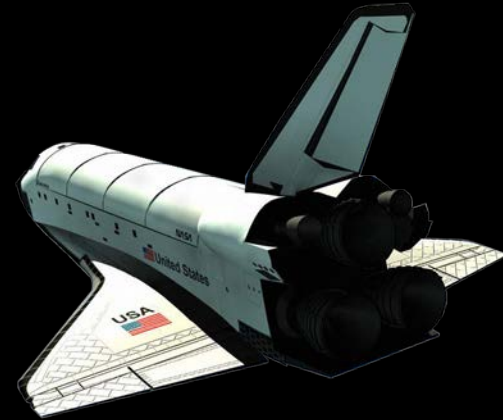

$$\frac{d(\cos \gamma)}{d\rho} = \left(\frac{1}{2\beta}\right) \left(\frac{SC_D}{m}\right) \left(\frac{L}{D}\right) - \left(\frac{gR}{v^2} - 1\right) \frac{\cos \gamma}{\rho\beta R}$$



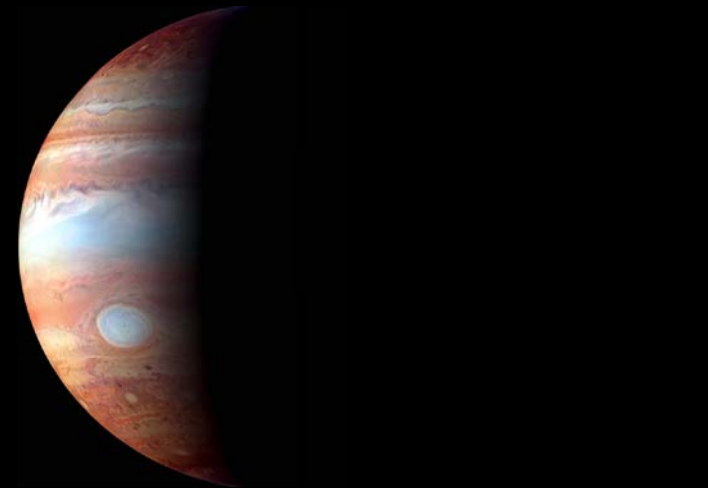
# 4 КЉУЧНА ПАРАМЕТРА



$$\frac{L}{D} \frac{m}{SC_D}$$

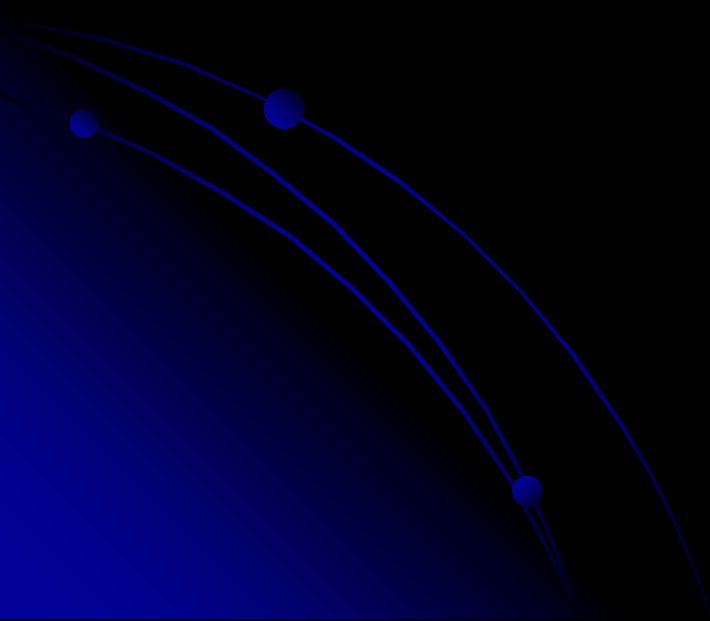
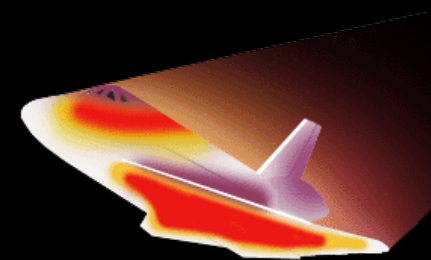
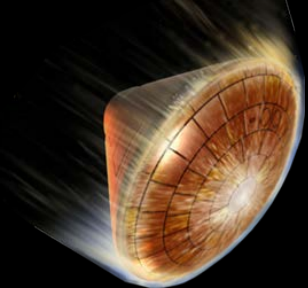


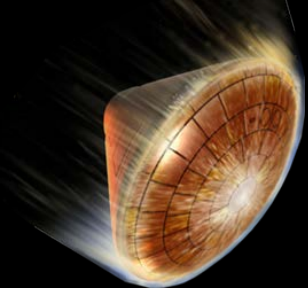
$$\beta, R$$



# ДВЕ ОСНОВНЕ ВРСТЕ УЛАСКА У АТМОСФЕРУ

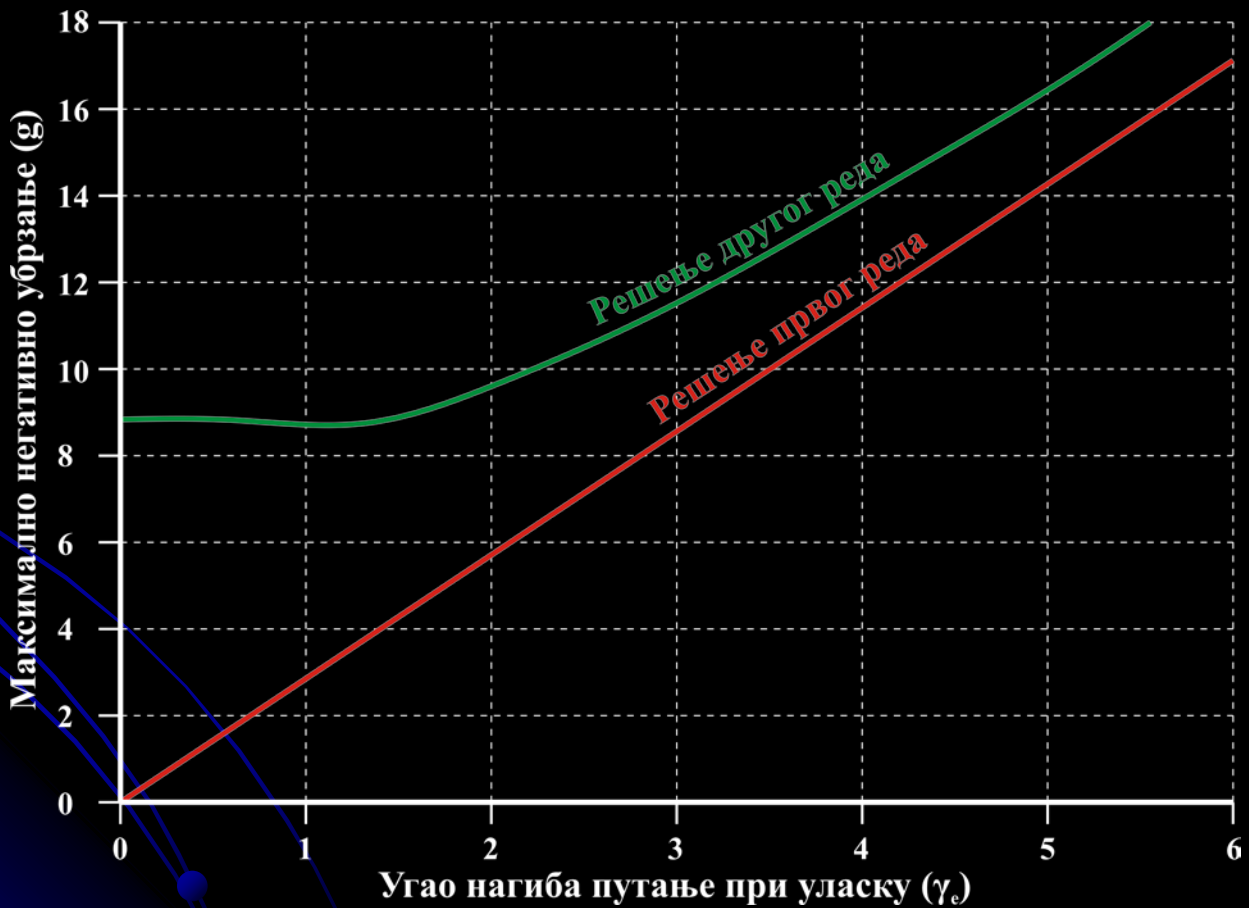
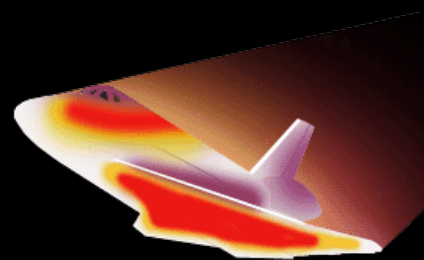
- БАЛИСТИЧКИ УЛАЗАК
- УЗГОНСКИ УЛАЗАК

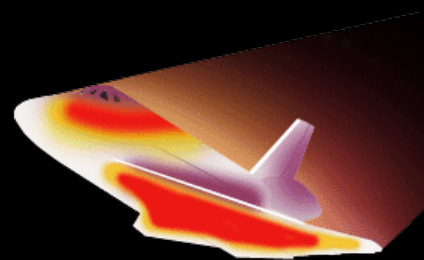
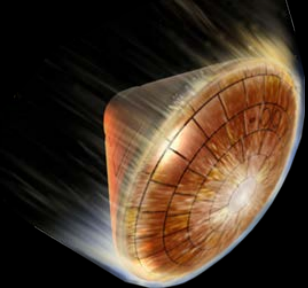




# БАЛИСТИЧКИ УЛАЗАК

## УТИЦАЈ УГЛА НАГИБА ПУТАЊЕ



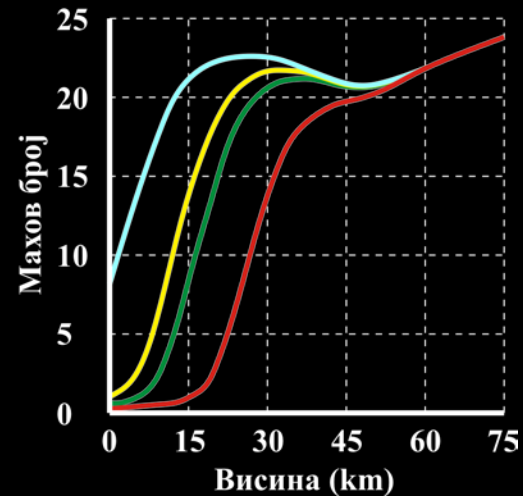
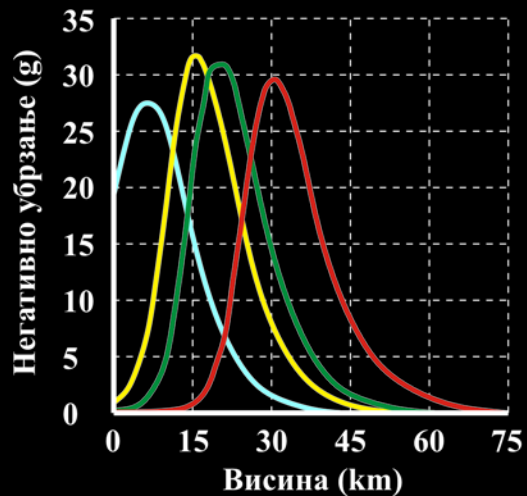
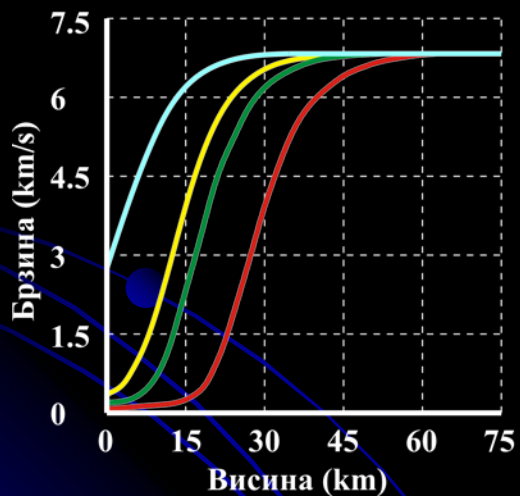


# БАЛИСТИЧКИ УЛАЗАК

## УТИЦАЈ БАЛИСТИЧКОГ КОЕФИЦИЈЕНТА

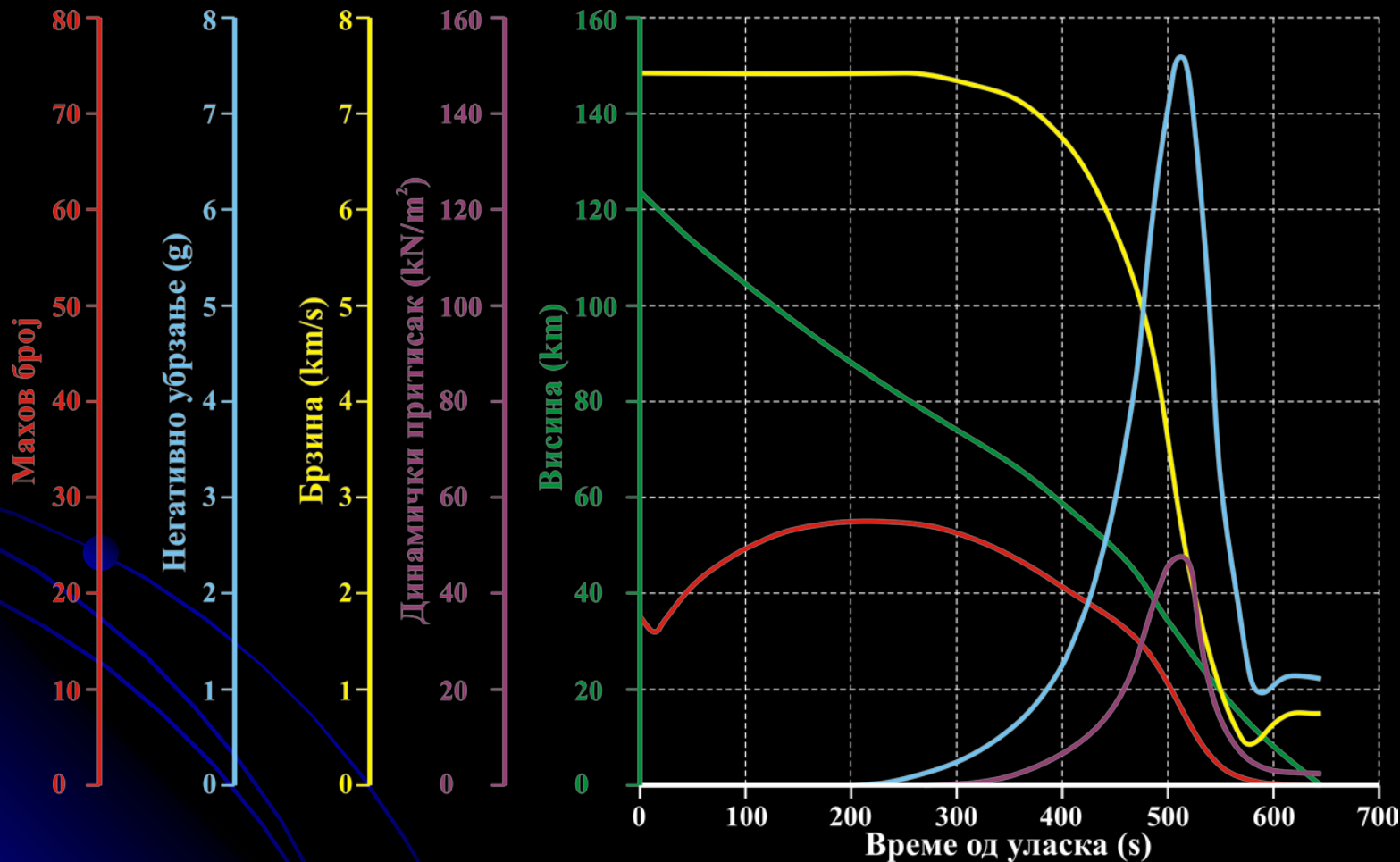
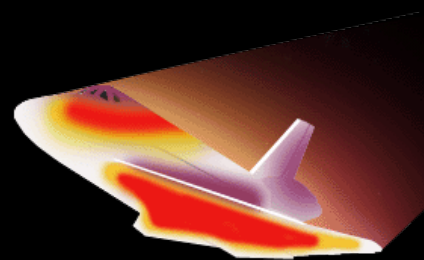
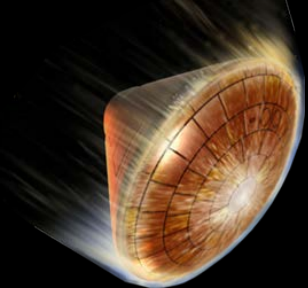
Балистички коефицијент

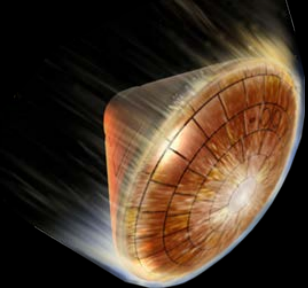
- 100
- 500
- 1000
- 5000



# БАЛИСТИЧКИ УЛАЗАК

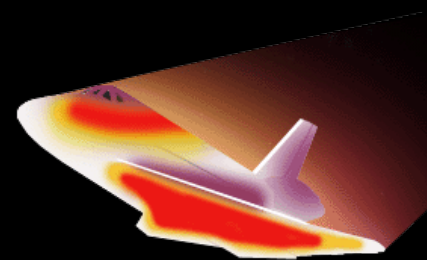
ТИПИЧАН ПРИМЕР ЗА УЛАЗАК СА ЉУДСКОМ ПОСАДОМ





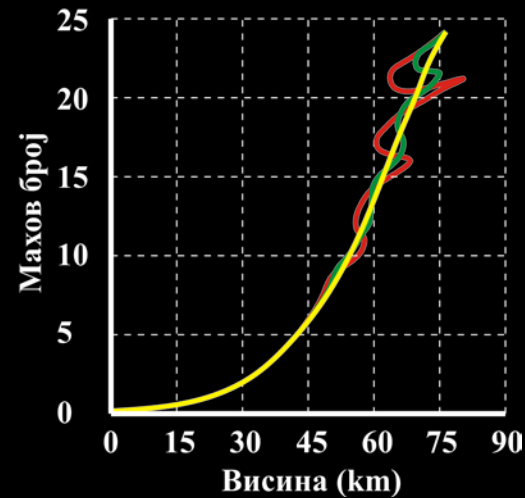
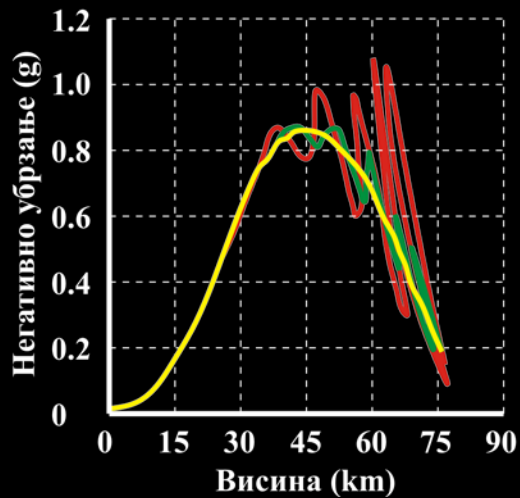
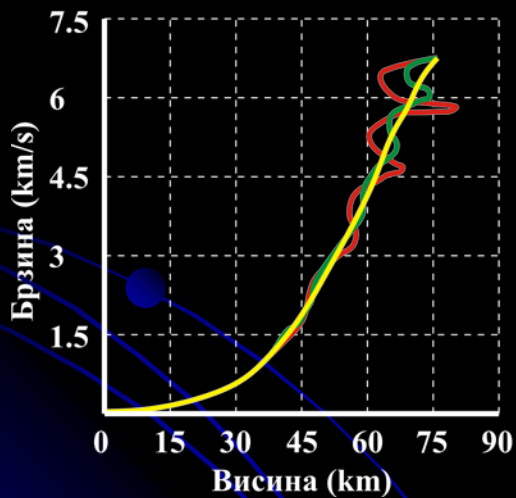
# УЗГОНСКИ УЛАЗАК

## УТИЦАЈ НАГИБА ПУТАЊЕ



Почетни угао нагиба путање ( $\gamma_e^\circ$ )

- 0.1
- 1.0
- 2.5



# ХИПЕРСОНИКА

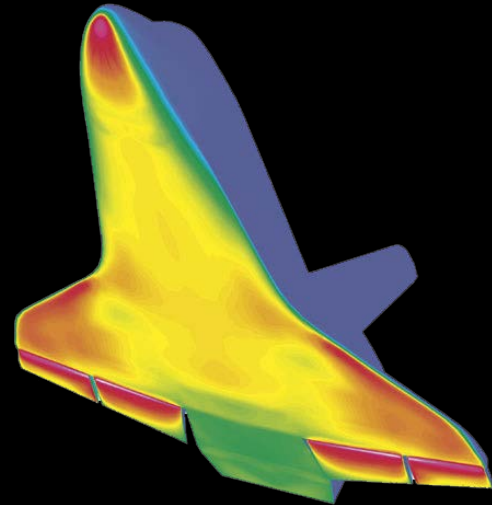
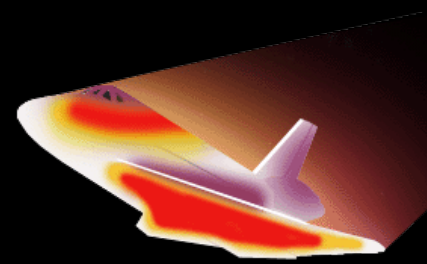
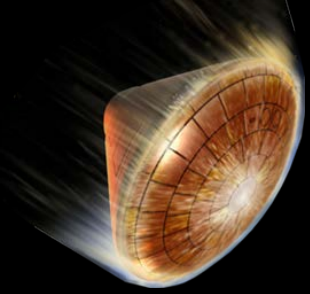
## ЗАГРЕВАЊЕ

Дисипација енергије се врши једино помоћу отпора атмосфере који је сразмеран квадрату брзине:

$$D = \frac{1}{2} \rho v'^2 S C_D$$

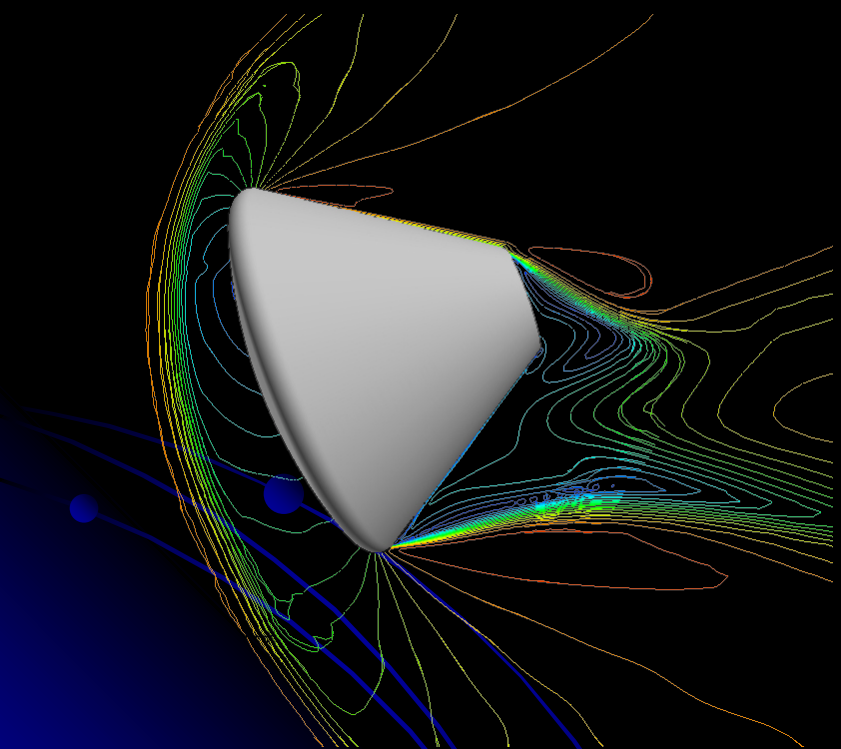
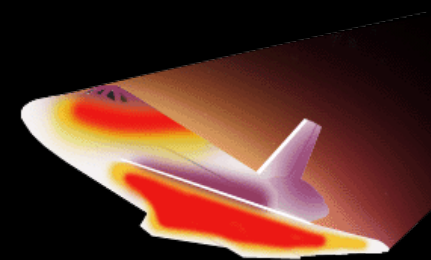
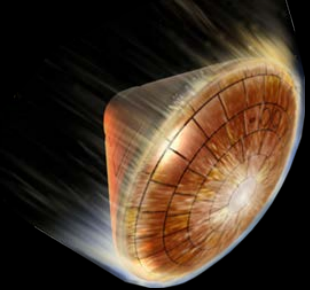


$$\frac{dE}{dt} = Dv \sim \rho v^3$$

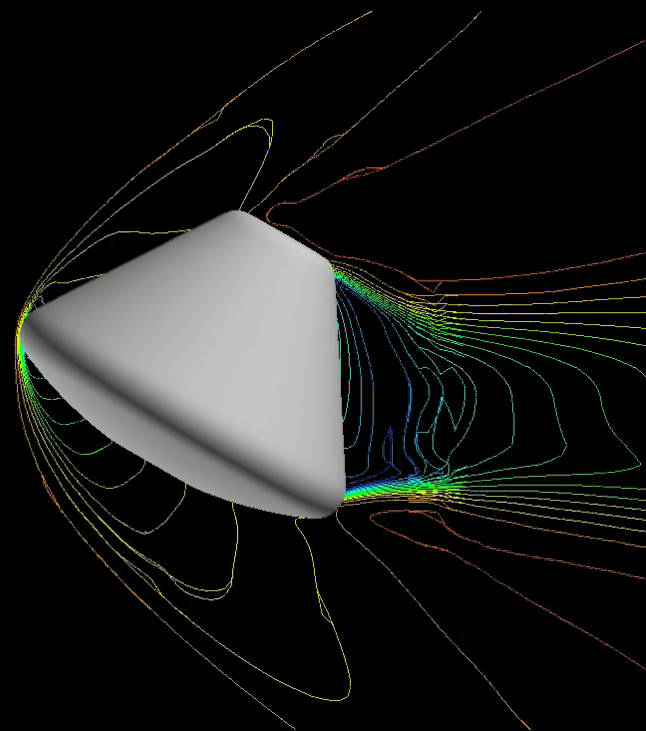


# ХИПЕРСОНИКА

## НУМЕРИЧКЕ СИМУЛАЦИЈЕ



Брзина

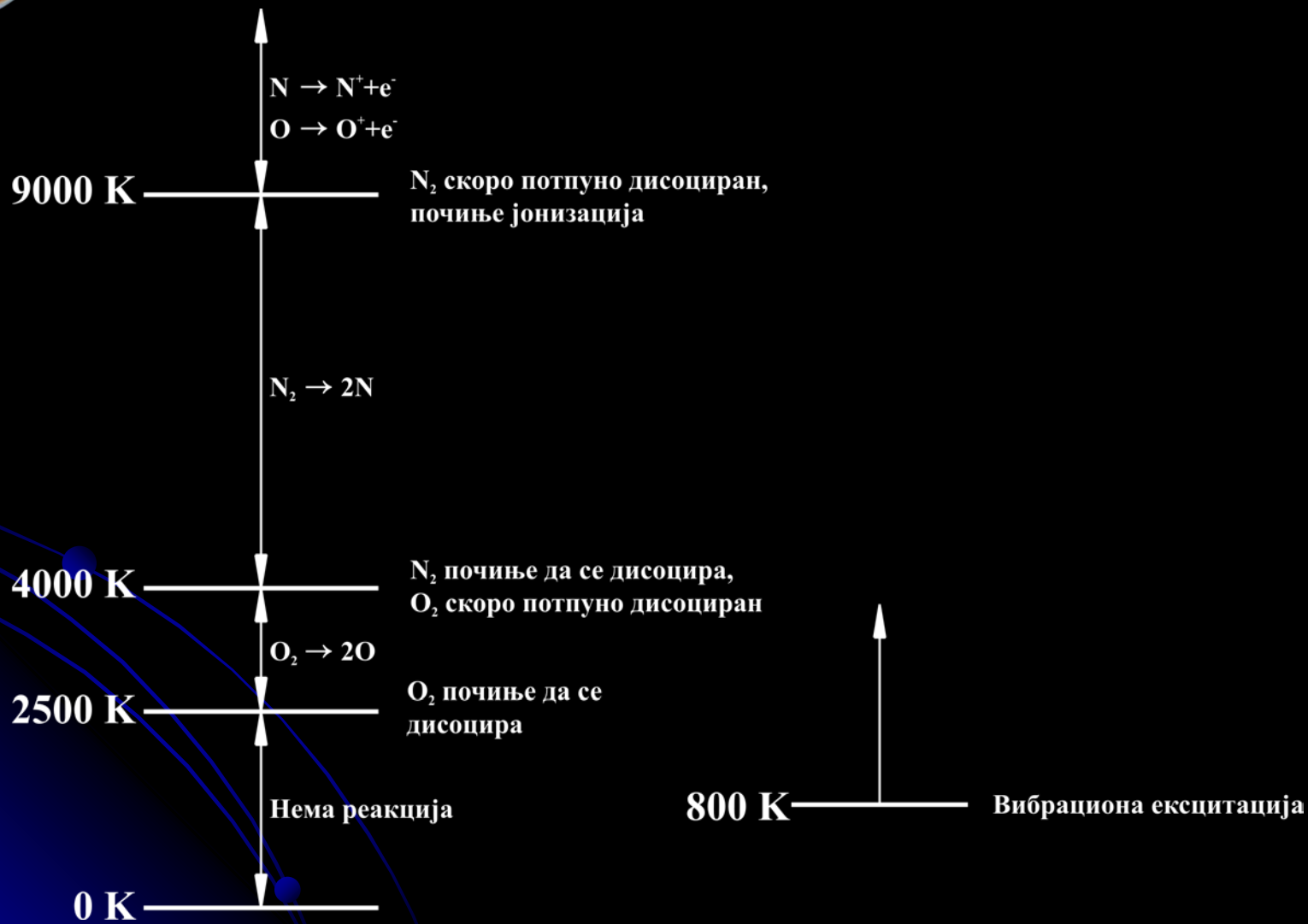
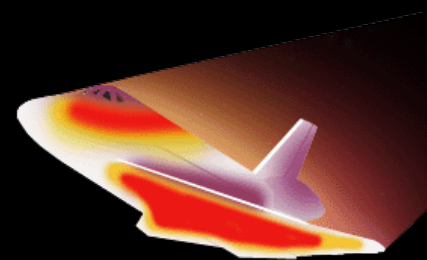
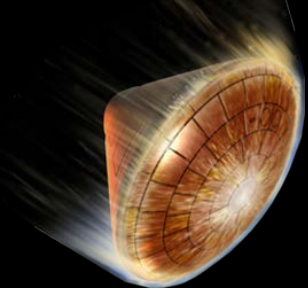


Температура



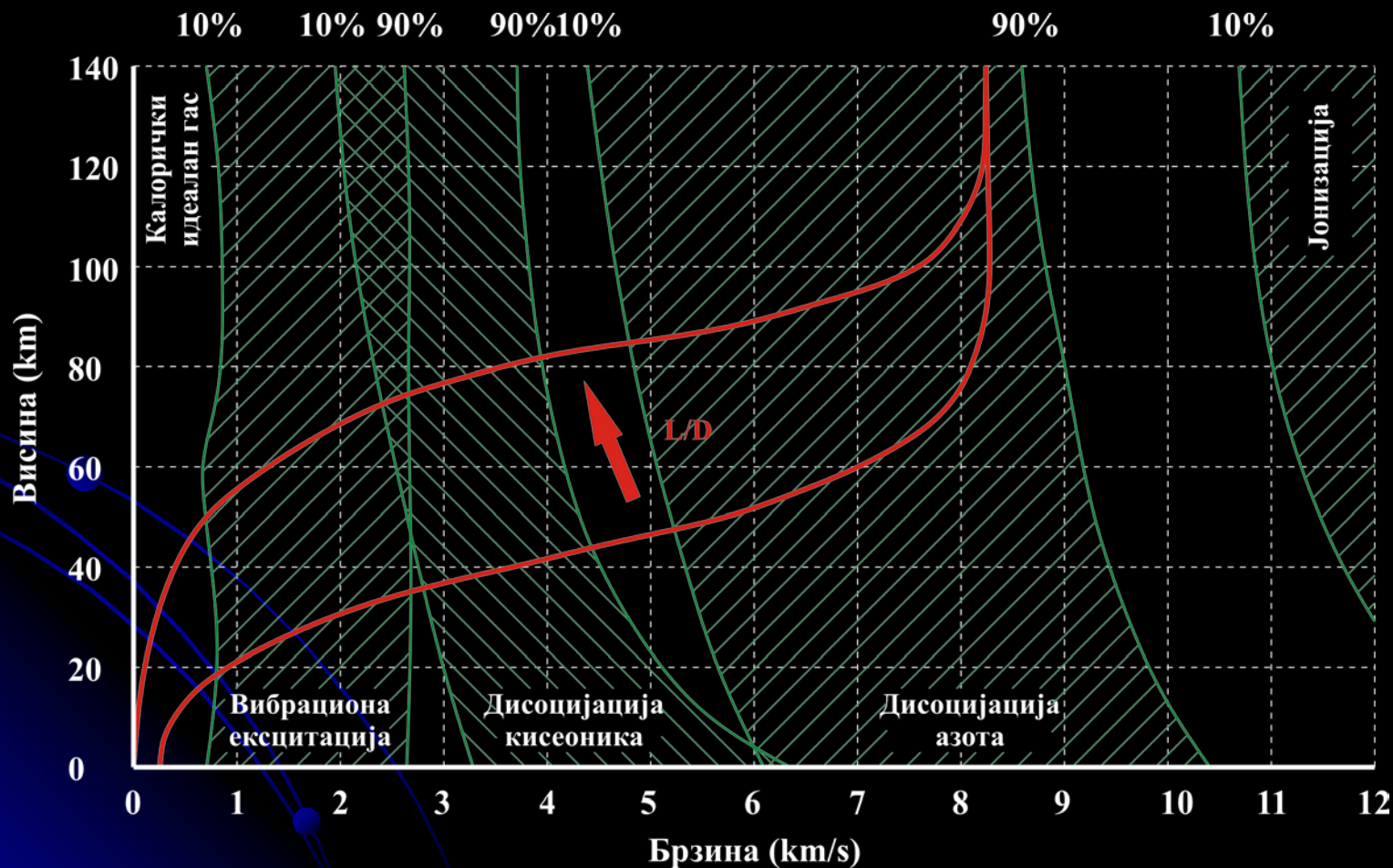
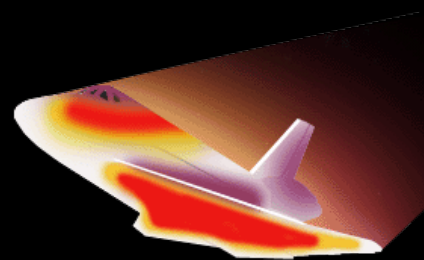
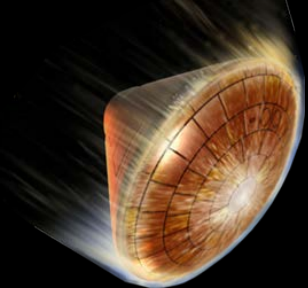
# ХИПЕРСОНИКА

## РЕАКЦИЈЕ

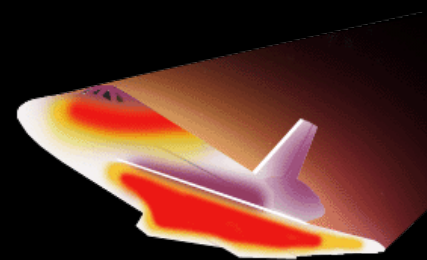
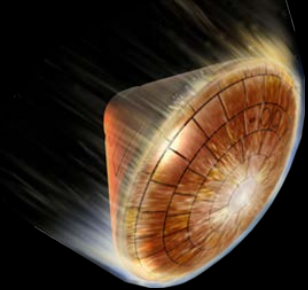


# ХИПЕРСОНИКА

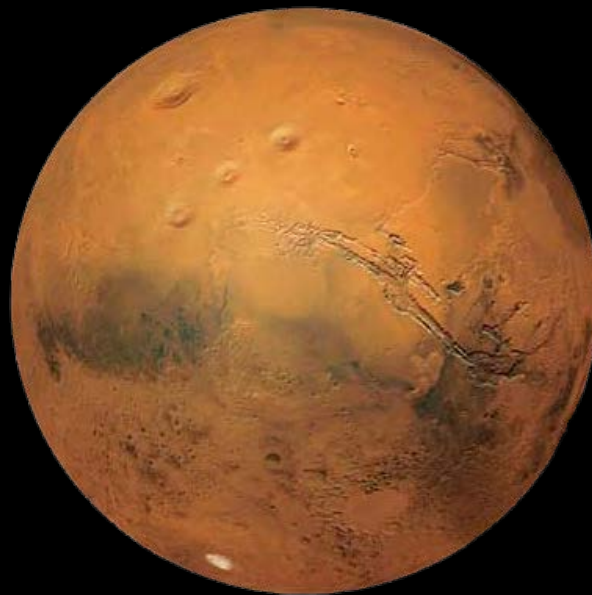
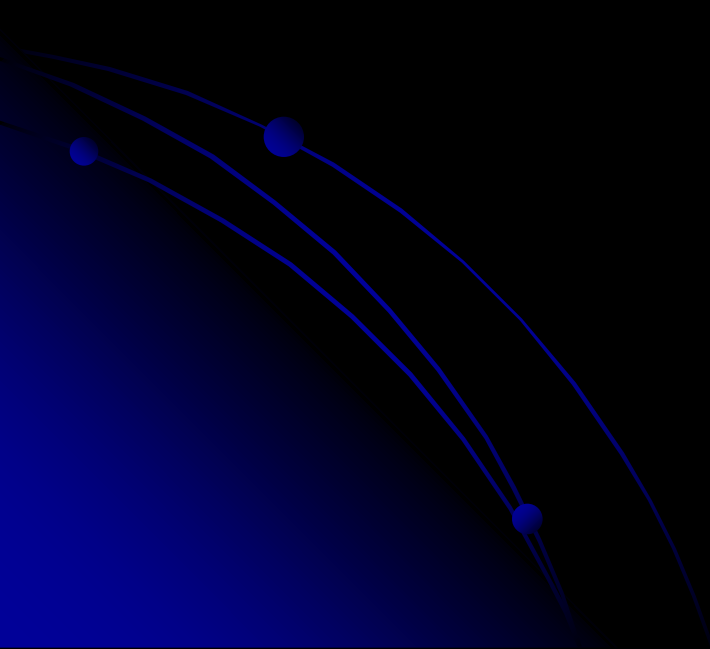
## РЕАКЦИЈЕ



## СЛЕТАЊЕ НА МАРС

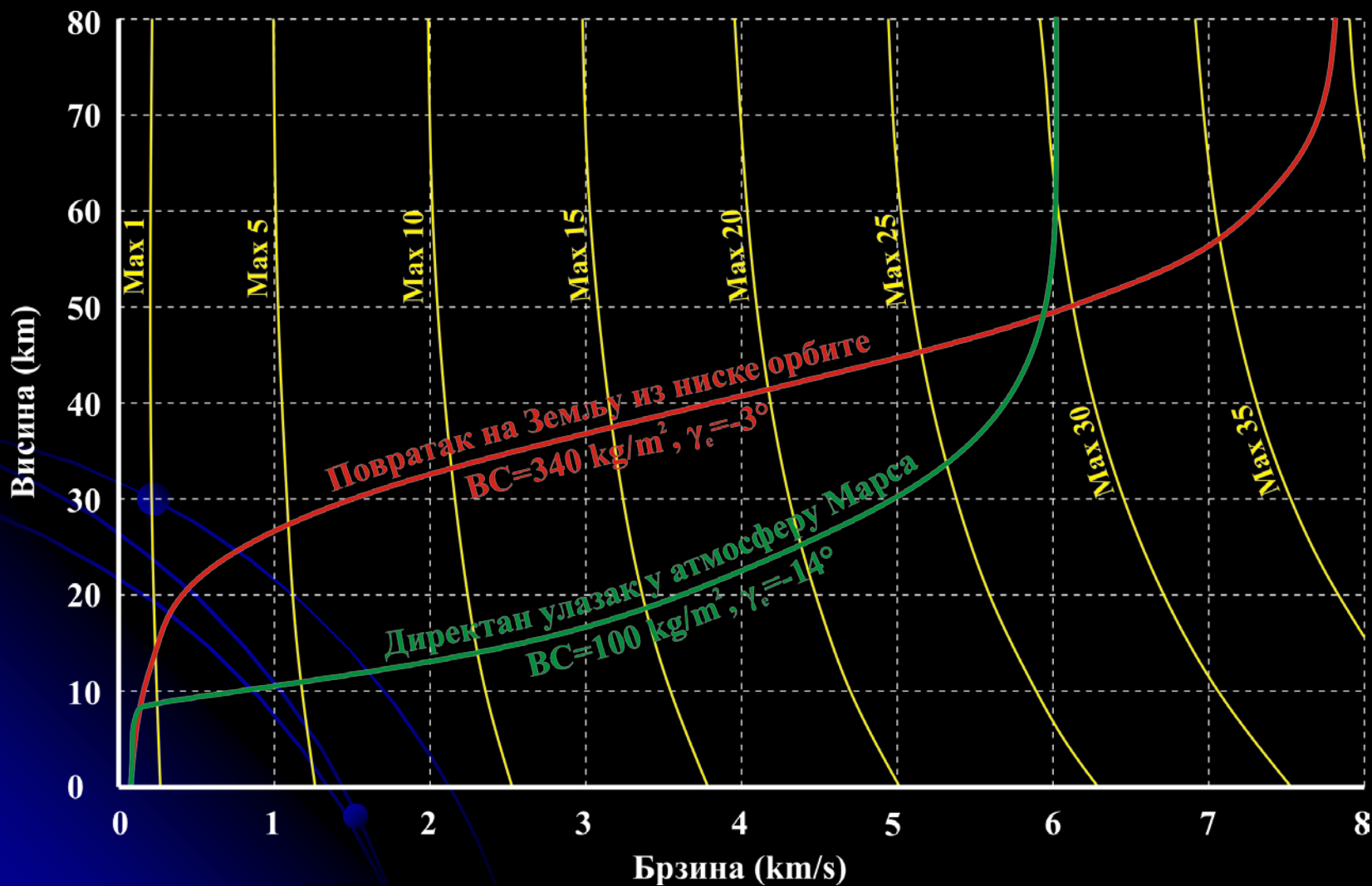


**Атмосфера Марса је довољно густа и дебела да узрокује проблеме прегревања летелице а недовољно да успори летелицу до брзина прихватљивих за меко слетање.**

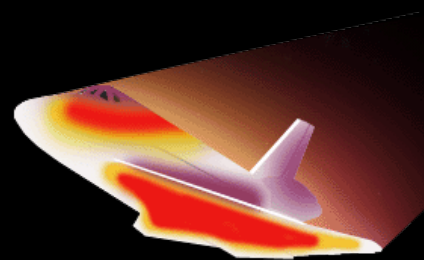
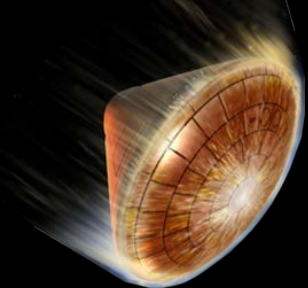


# СЛЕТАЊЕ НА МАРС

## ПОРЕЂЕЊЕ СА ЗЕМЉОМ



# СЛЕТАЊЕ НА МАРС



Viking



3.505 m

MPF/MER/  
Phoenix

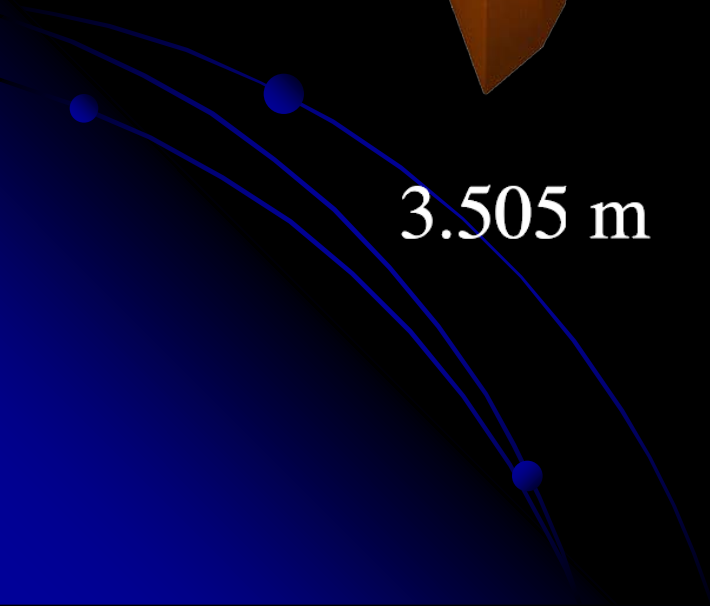


2.65 m

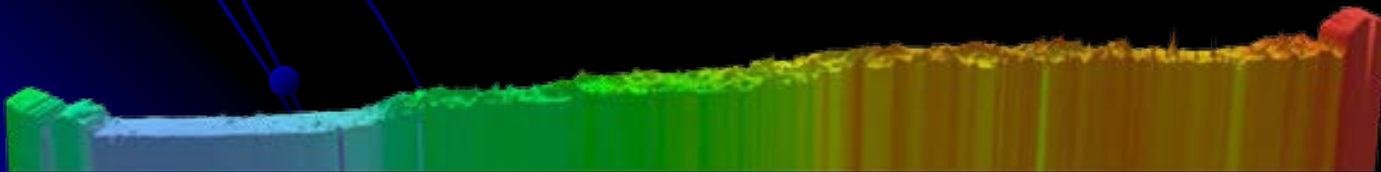
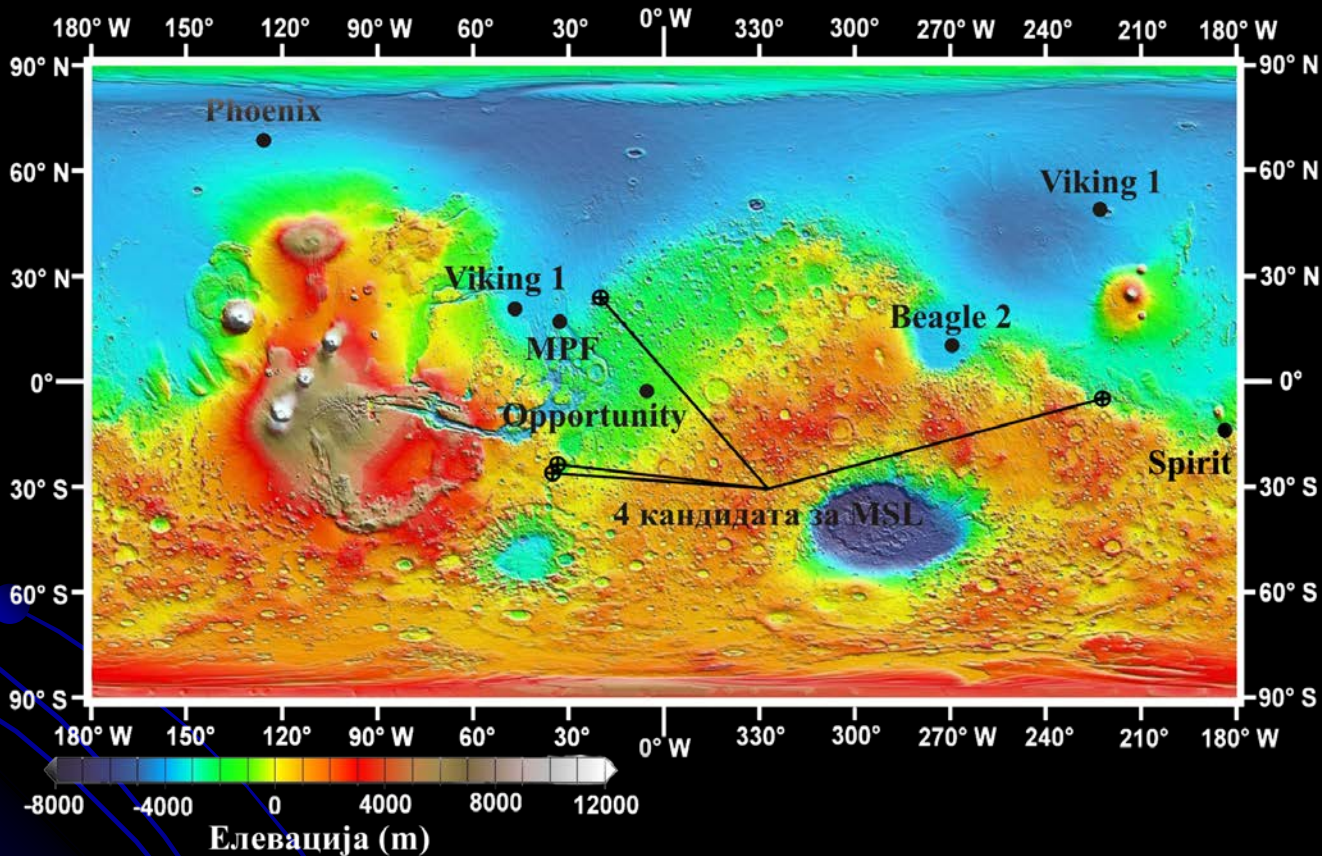
MSL



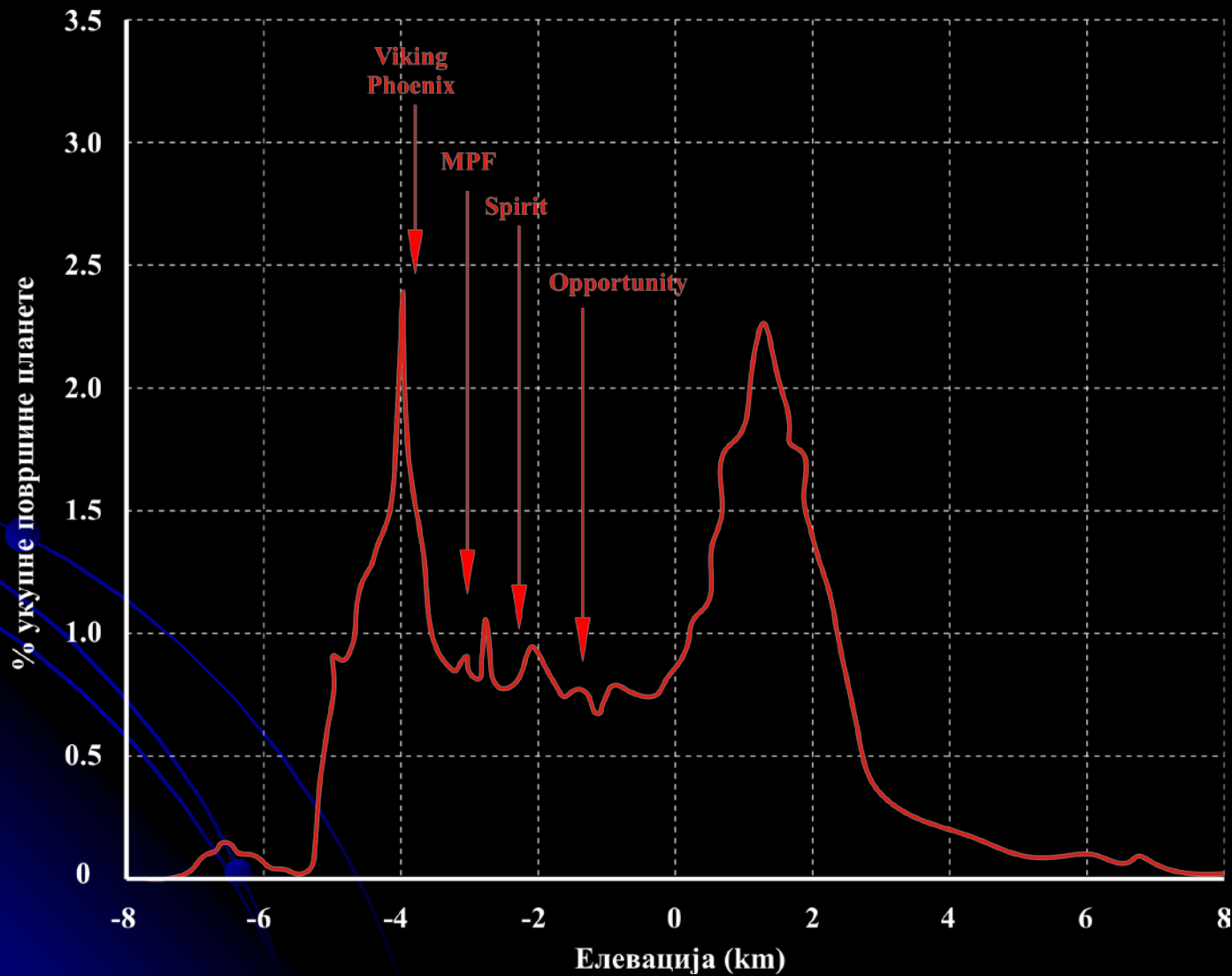
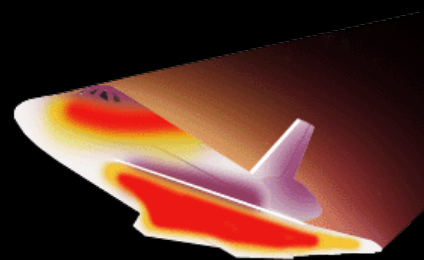
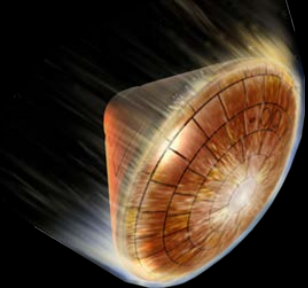
4.6 m



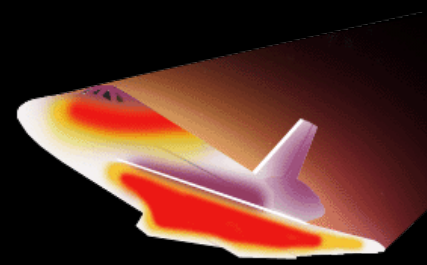
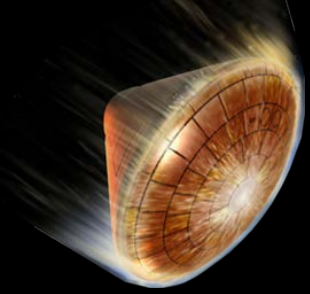
# СЛЕТАЊЕ НА МАРС



# СЛЕТАЊЕ НА МАРС

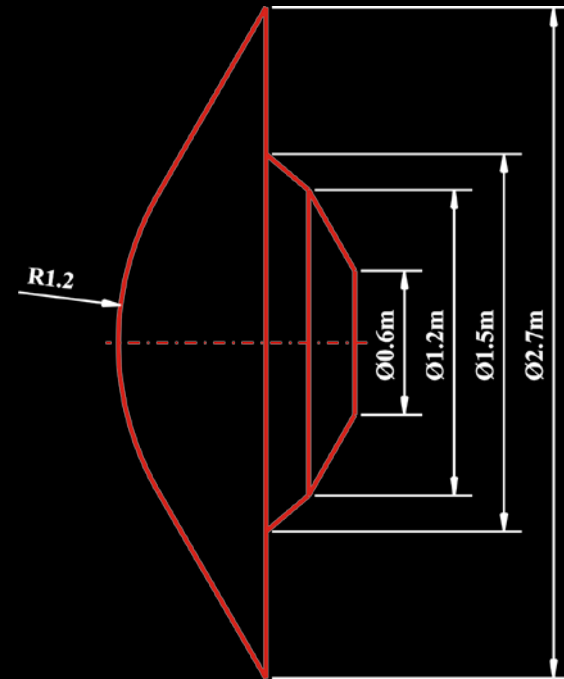
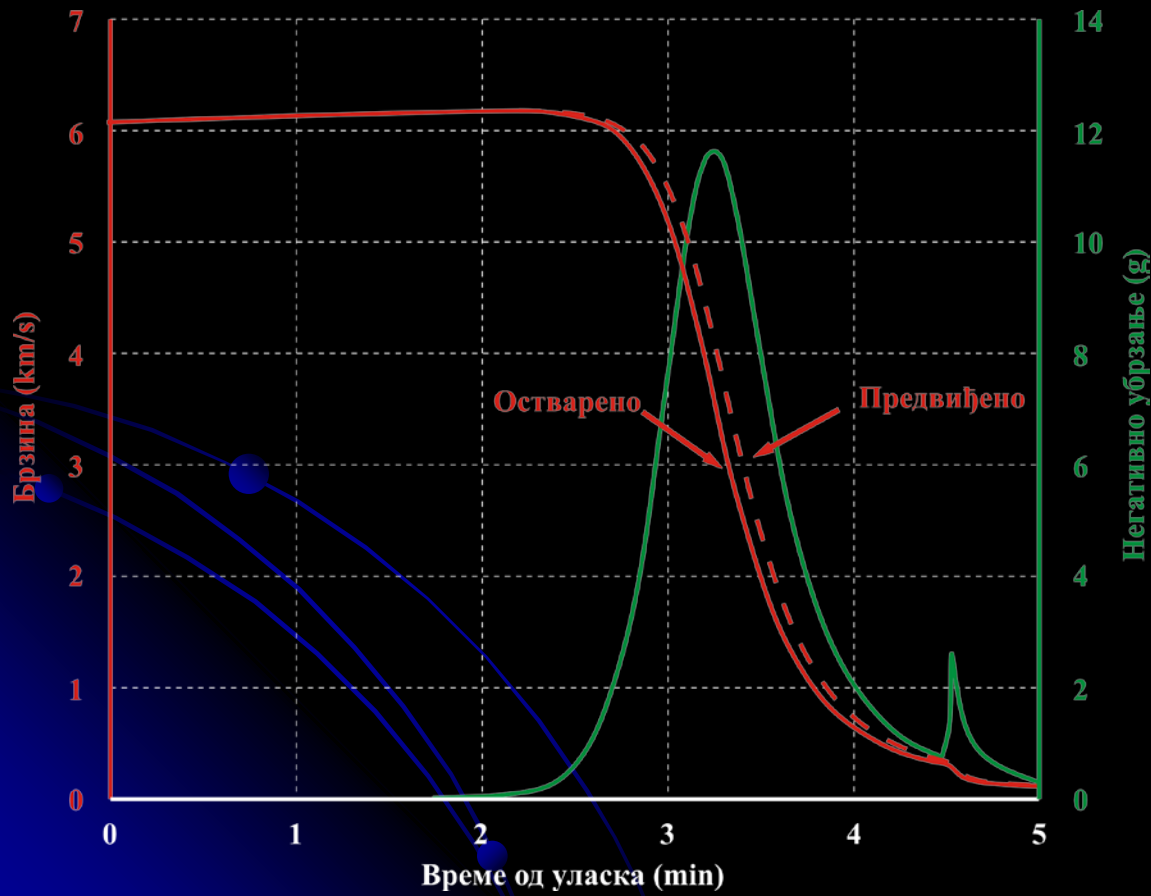
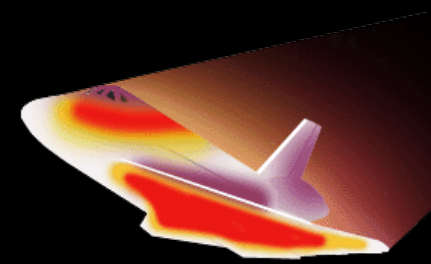
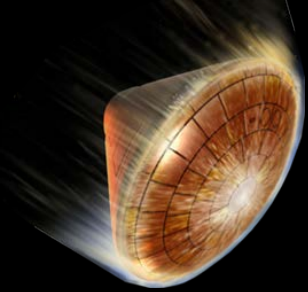


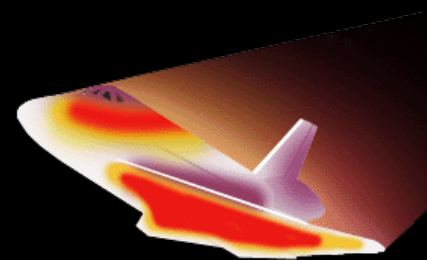
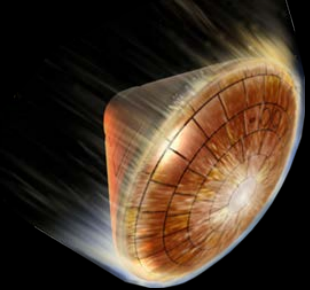
# СЛЕТАЊЕ НА ВЕНЕРУ





# СЛЕТАЊЕ НА ТИТАН





**ХВАЛА НА ПАЖЊИ**

