

Venus Express Mission Analysis

On the use of Aerobraking

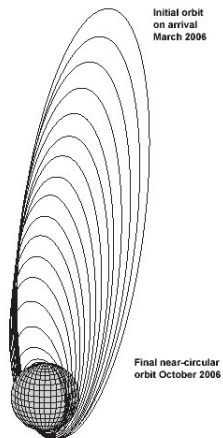
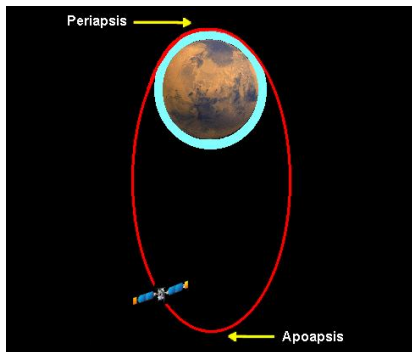
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Aerobraking

Description



Aerobraking

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- **Walk-In**
- **Aerobraking Main Phase**
- **Walk-Out**

Aerobraking

Technical Limitations

Dynamic pressure:

$$P = \frac{1}{2} \rho(\vec{r}) v^2 \quad (F_d = P C_d A)$$

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Aerobraking

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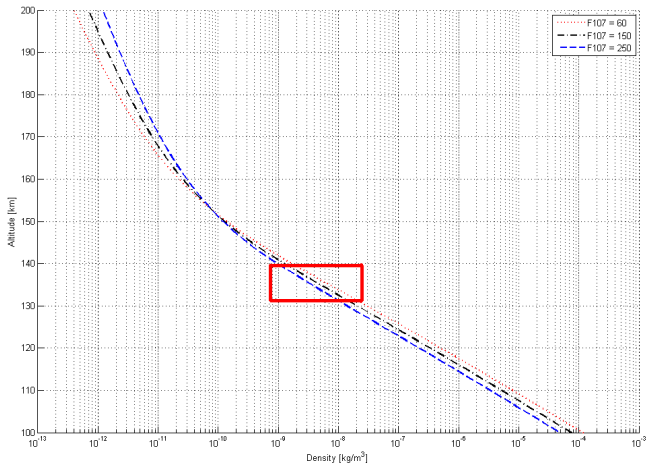
$$P \in [P_{MIN}, P_{MAX}]$$

Heat flux:

$$\dot{Q} = \frac{1}{2} \rho(\vec{r}) v^3$$

Atmosphere Modeling

VTS3 model



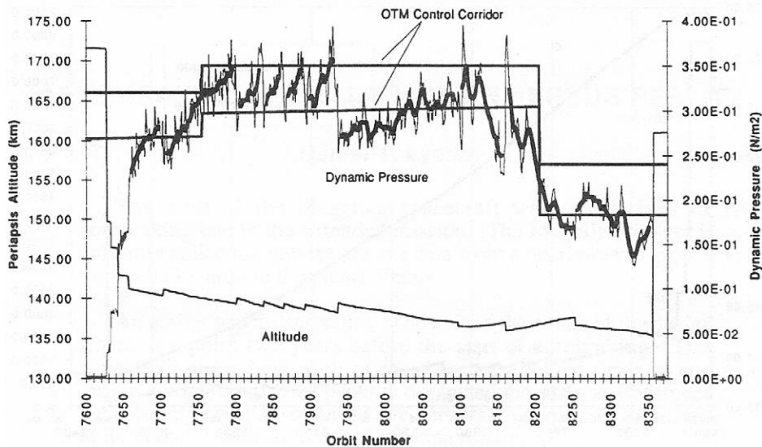
NASA Precedent Experiences

Magellan Aerobraking

- First aerobraking operation, in 1993
- Switching from an elliptic 280 x 8500 km orbit to a near-circular 197 x 541 km orbit
- Reducing the orbital period from 3.22 hours to 1.57 hours
- 730 orbits within 70 days
- 1219 m/s saved

NASA Precedent Experiences

Magellan Aerobraking Corridor



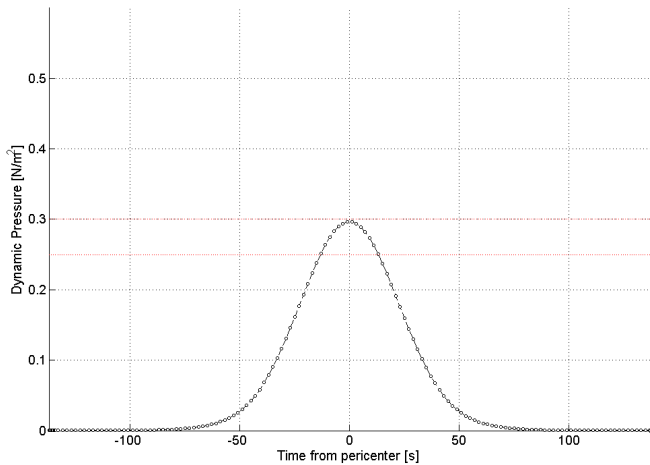
Aerobraking Performances Analysis

Simulation Setup

- **Medium solar activity**
- **Maximum dynamic pressure:** $P_{MAX} = 0.3 \text{ N.m}^{-2}$
- **Variation of the dynamic pressure:** $\delta P = 0.05 \text{ N.m}^{-2}$.
- **Initial orbital elements**
- **Mass of the S/C:** $m = 700 \text{ kg}$
- **Surface area of the S/C useful for aerobraking:** $A = 12 \text{ m}^2$

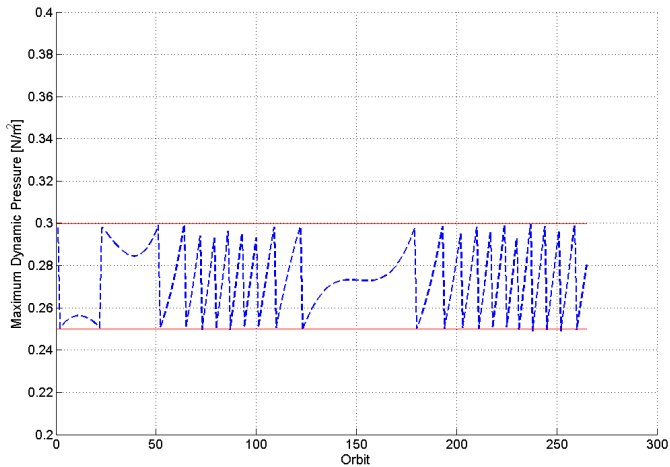
200-day aerobraking campaign

Pressure Profile



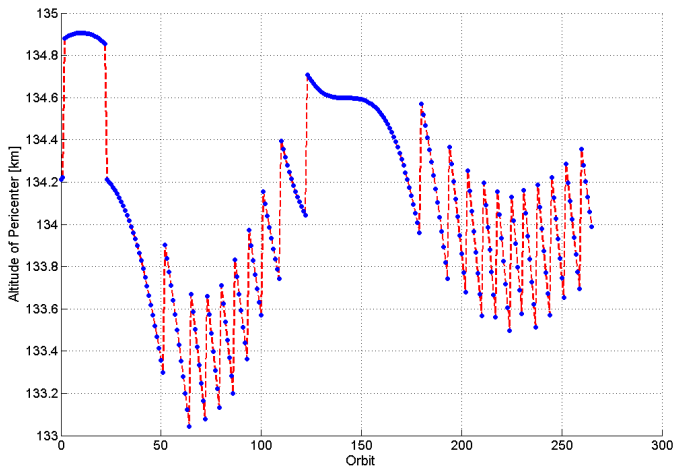
200-day aerobraking campaign

Peak of dynamic pressure



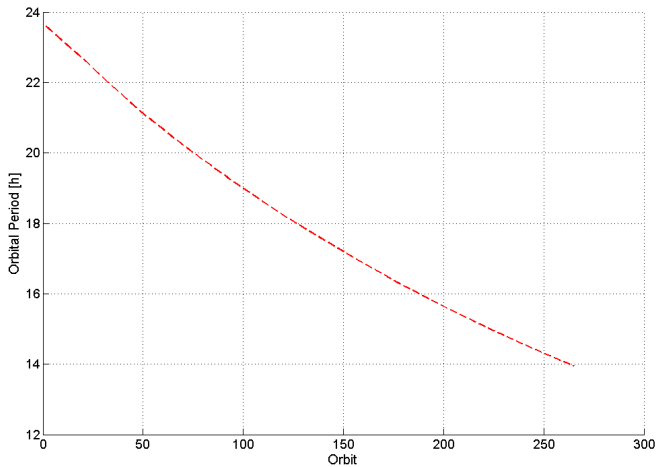
200-day aerobraking campaign

Pericenter altitude evolution



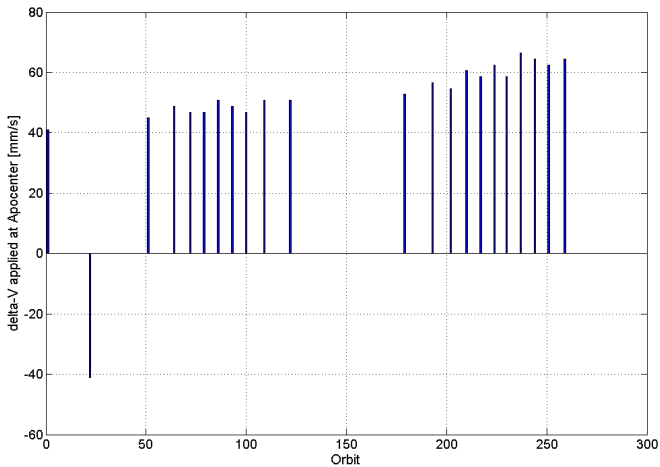
200-day aerobraking campaign

Orbital period evolution



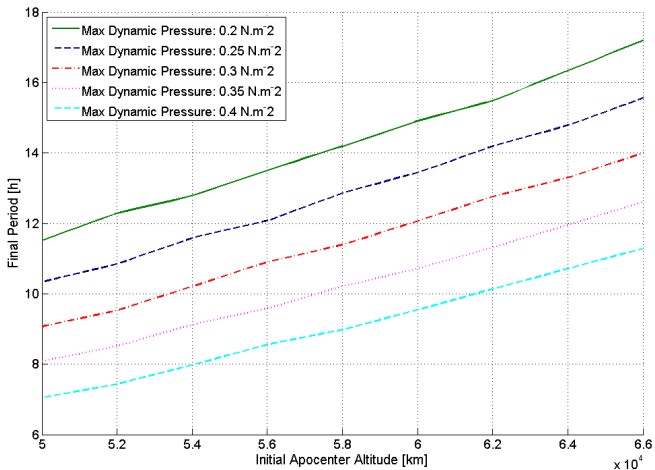
200-day aerobraking campaign

Successive ΔV to be applied at apocenter



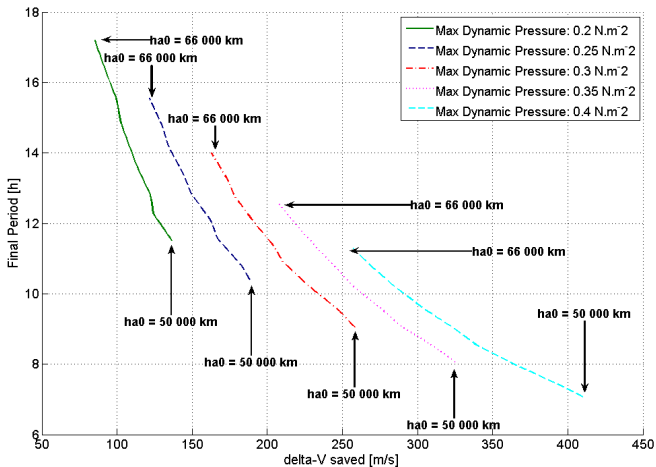
Fixed-Duration Aerobraking

Influence of maximum dynamic pressure



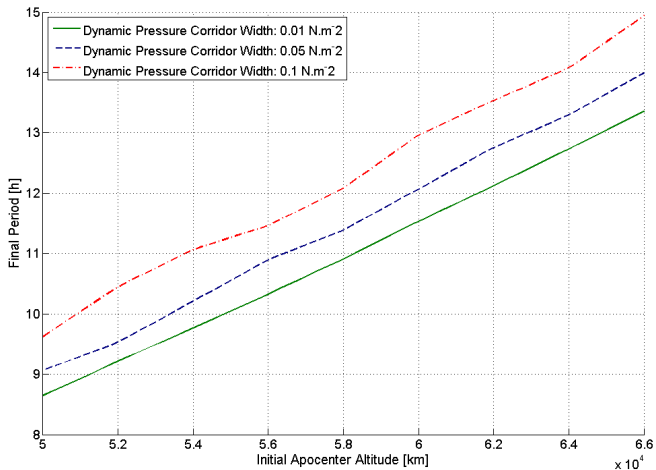
Fixed-Duration Aerobraking

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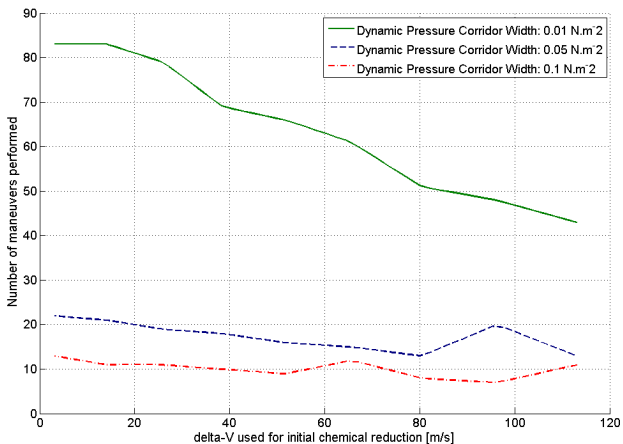
Fixed-Duration Aerobraking

Influence of the dynamic pressure corridor width



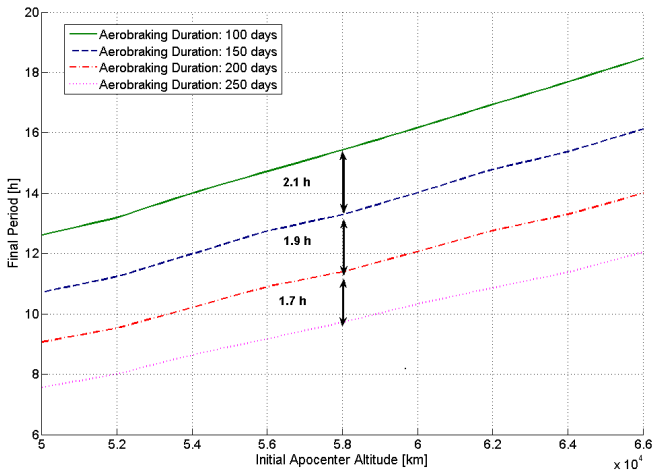
Fixed-Duration Aerobraking

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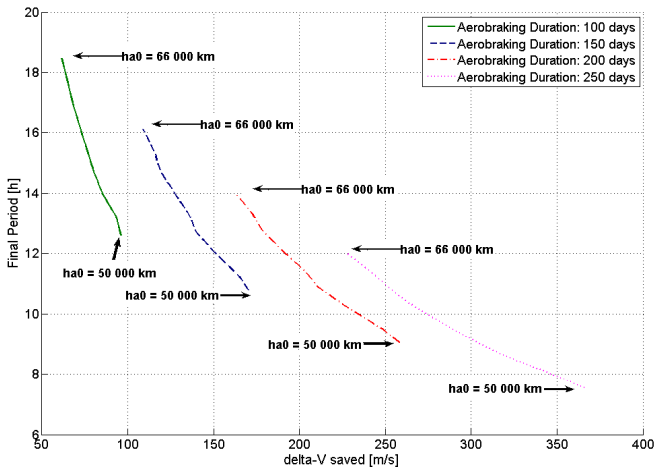
Fixed-Duration Aerobraking

Influence of the duration of the aerobraking campaign

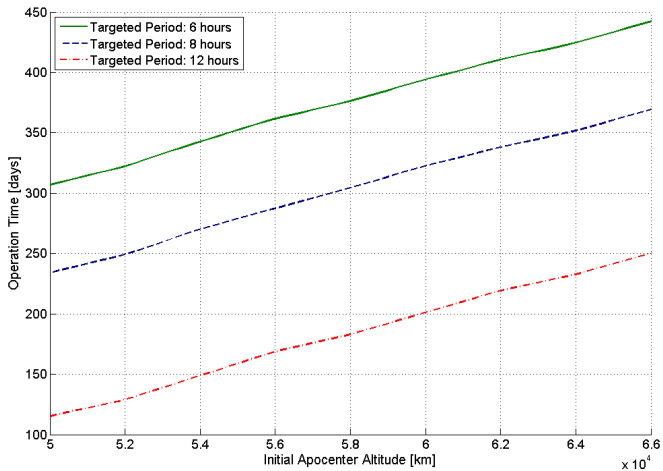


Fixed-Duration Aerobraking

Influence of the duration of the aerobraking campaign



Targeted-Period Aerobraking



Achievable performances

Final orbital period (h)	Duration (days)	Total ΔV needed (m/s)	Maneuvers
12	115	133	8
8	234	137	14
6	305	140	17

Table: Initial apocenter altitude: 50 000 km

Final orbital period (h)	Duration (days)	ΔV needed (m/s)	Maneuvers
12	250	23	25
8	369	27	38
6	442	30	45

Table: Initial apocenter altitude: 66 000 km

Recommendations

- To investigate on maximum dynamic pressure
- To set up atmospheric modeling with other parameters
- To investigate on fuel consumptions
- To investigate on the corrections required
- To figure out how to use VEX data to improve performances



Achievable performances

Final orbital period (h)	Duration (days)	ΔV needed (m/s)	Maneuvers
12	182	71	13
8	304	75	25
6	376	78	28

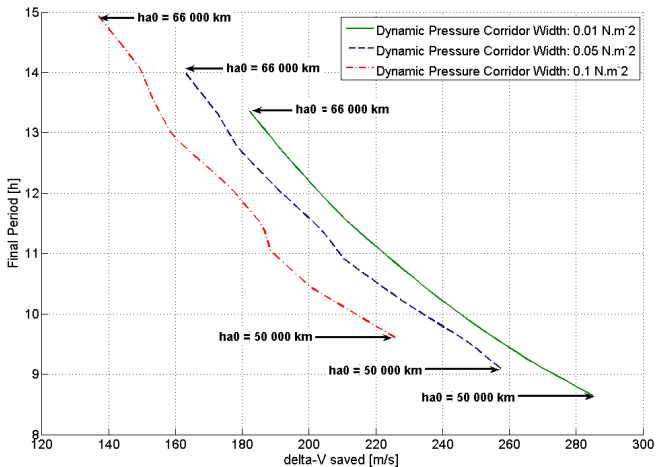
Table: Initial apocenter altitude: 58 000 km

Capability to perform aerobraking

S/C	Cross section (m ²)	Mass (kg)	A/m (m ² .kg ⁻¹)	
VEX	12	700	0.017	
Magellan	24	≈1200	0.020	+18%
MEX	15	620-640	0.023-0.024	+35%
MRO	37.5	≈1500	0.025	+47%

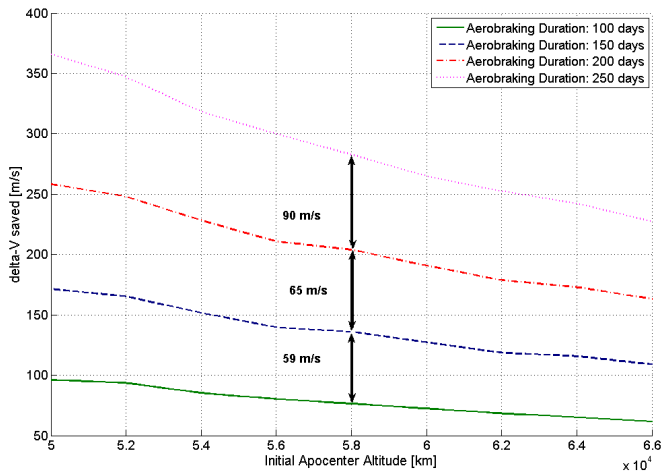
Fixed-Duration Aerobraking

Influence of dynamic pressure corridor width



Fixed-Duration Aerobraking

Influence of the duration of the aerobraking campaign



Targeted-Period Aerobraking Aerobraking

Influence of maximum dynamic pressure for a 12H final orbit

