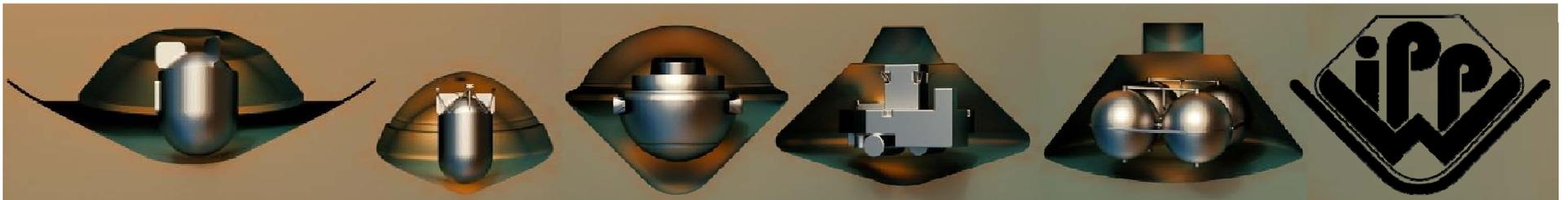


Entry, Descent, and Landing Systems Short Course

Subject: Historical Overview of Probe Decelerator Design and Construction

Author: **Al Witkowski** - Director of Engineering Operations
Zodiac Parachute and Protection America
(a.k.a. Pioneer Aerospace)

sponsored by
International Planetary Probe Workshop 10
June 15-16, 2013
San Jose, California





Outline

- Viking '75 Project
- Pioneer Venus Large Probe
- Galileo Jupiter Probe
- Huygens Titan Probe
- Stardust Sample Return
- Genesis Sample Return
- “Recent” Mars Programs

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Viking '75 Project

- Mortar deployed 16.15 m (53 ft) reference diameter DGB (BLDT measure yields 16.04 m)
- All polyester construction (reports use trade name “Dacron”) ... except ...
- Bridle legs made from “Goodyear proprietary fiber” (believed to be kevlar)



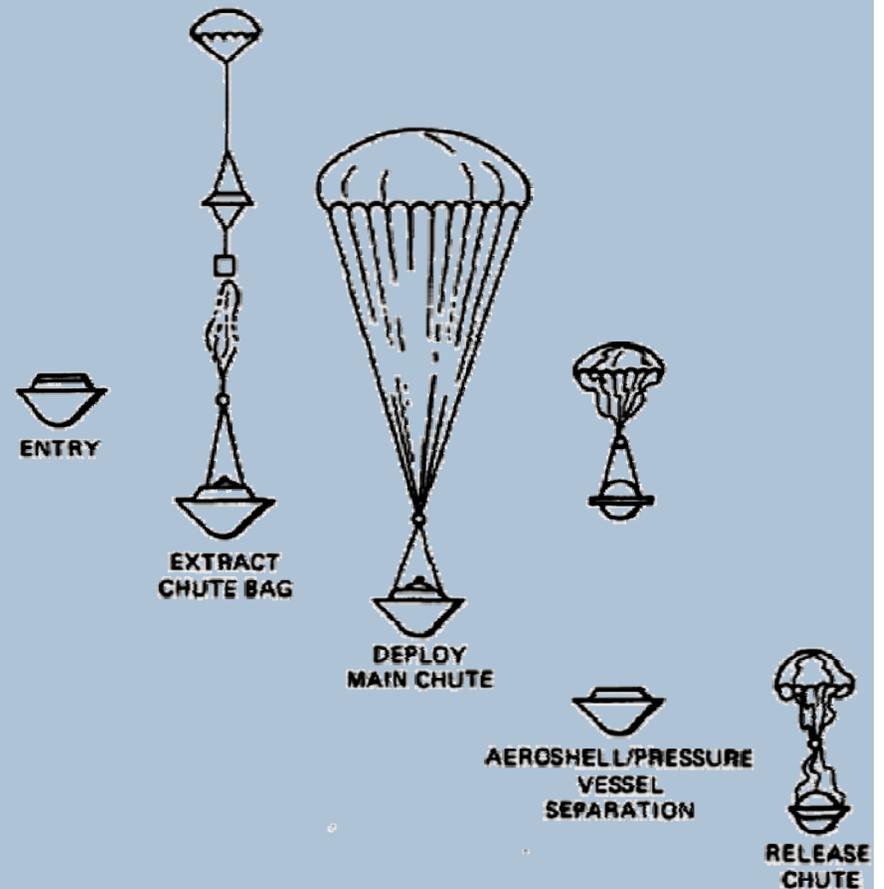
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Pioneer Venus Large Probe

- Mortar deployed 0.76m (2.5 ft) projected diameter Ribless Guide Surface (RGS) Pilot
- 4.94m (16.2 ft) nominal diameter 20° Conical Ribbon (CR) Main
- All textile components were manufactured entirely from Polyester



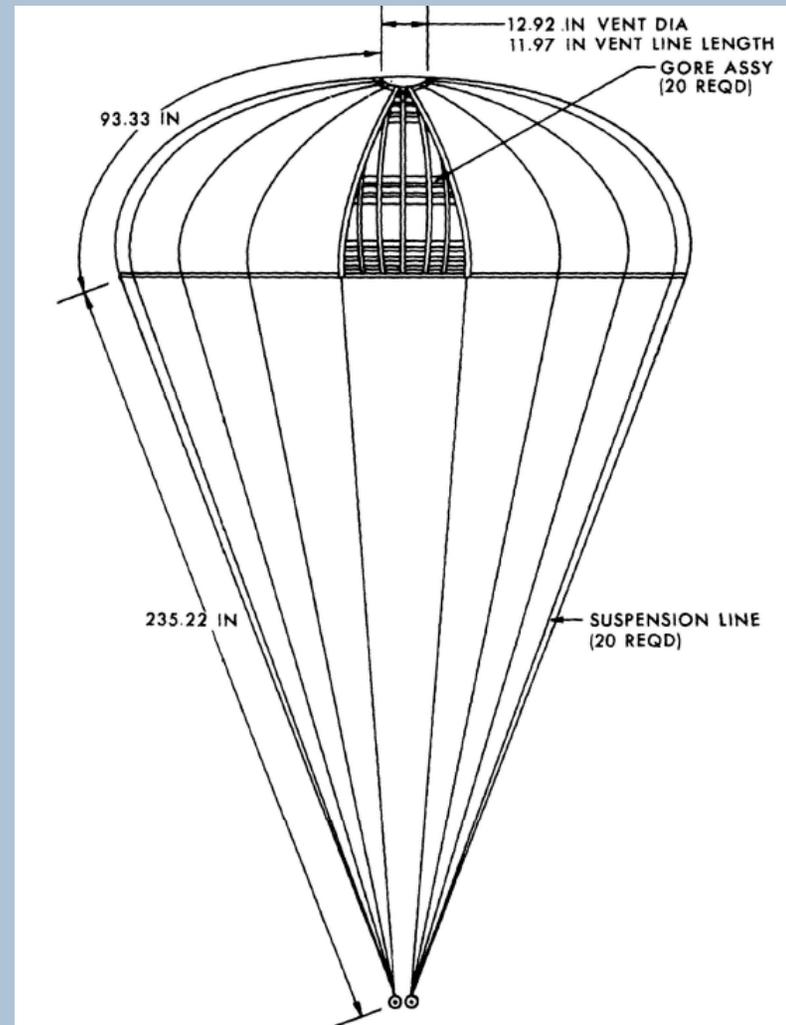
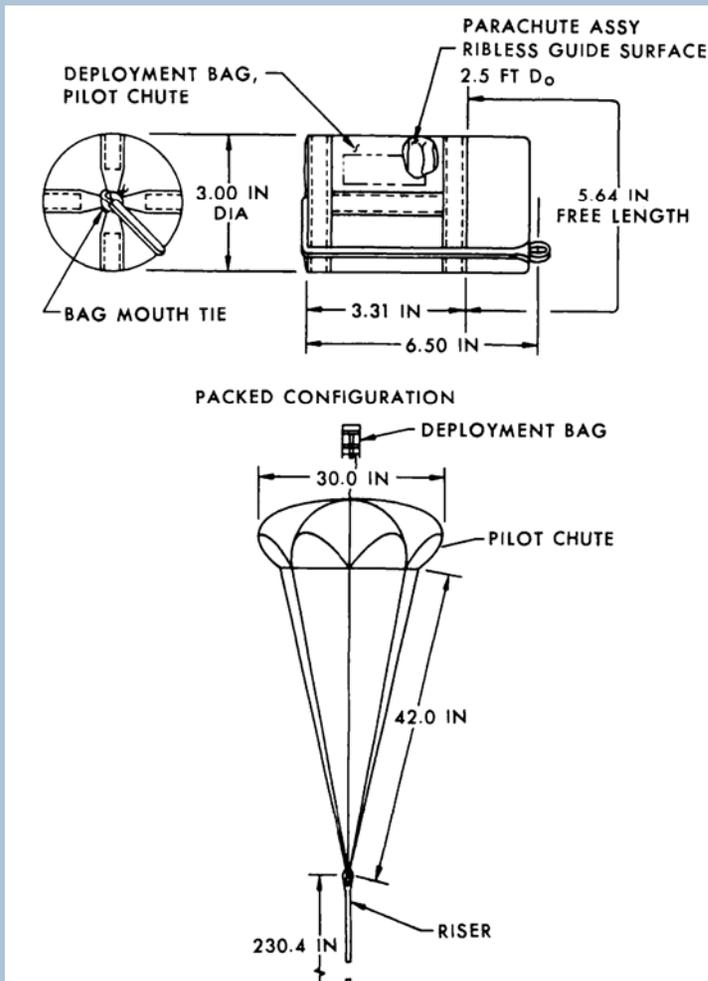
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Pioneer Venus Large Probe



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Galileo Jupiter Probe

- Mortar deployed 1.14m (3.74 ft) constructed diameter 20° Conical Ribbon Pilot with 11.3% geometric porosity
- 3.8m (12.5 ft) constructed diameter 20° Conical Ribbon Main with 22% geometric porosity
- All textile components were manufactured entirely from Polyester except the Main 3-leg bridle, which was Kevlar



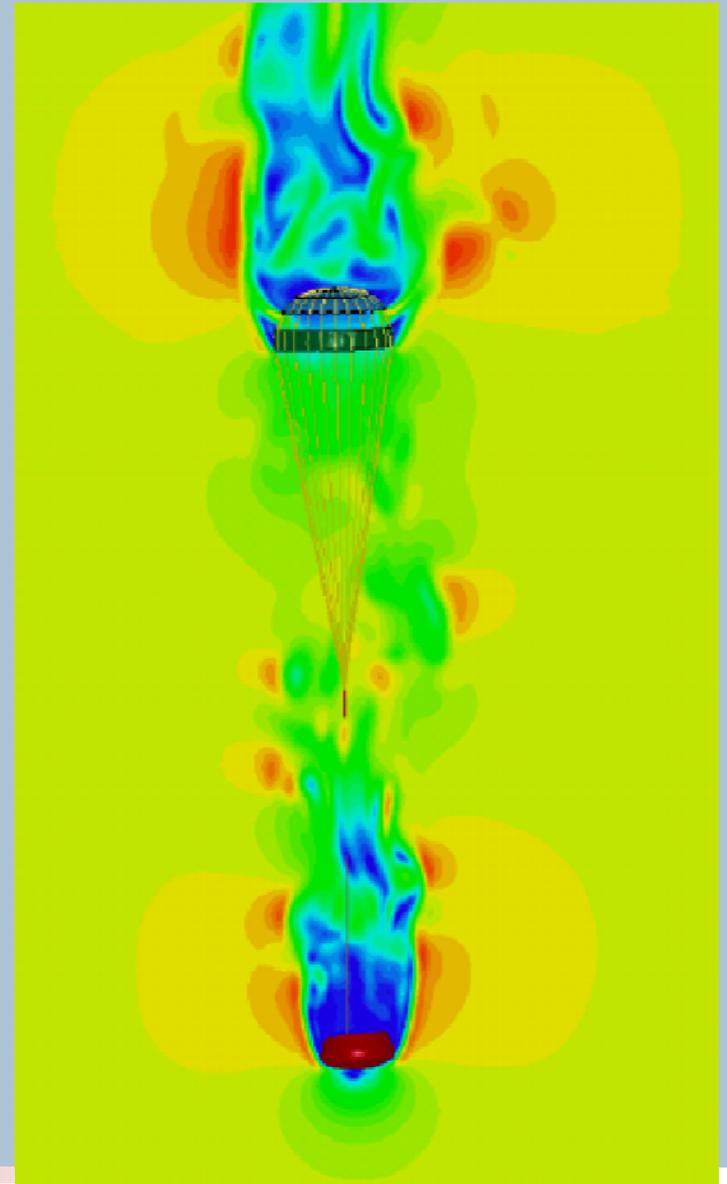
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Huygens Titan Probe

- Mortar deployed 2.59 m reference diameter DGB Pilot/Drogue, 8.3 m DGB Main, 3 m Stabilizing Drogue
- Nylon and kevlar materials
- Increased vent and gap for stability concerns (resulting geometric porosity $\approx 22.4\%$ of reference area for Main and Drogue)



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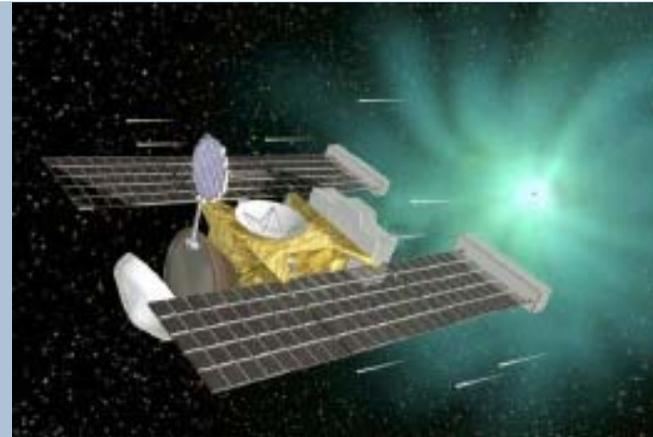
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Stardust Sample Return

Fastest Re-Entry ... Capsule now in “Milestones of Flight” Gallery in the Air & Space Museum at the National Mall in D.C.



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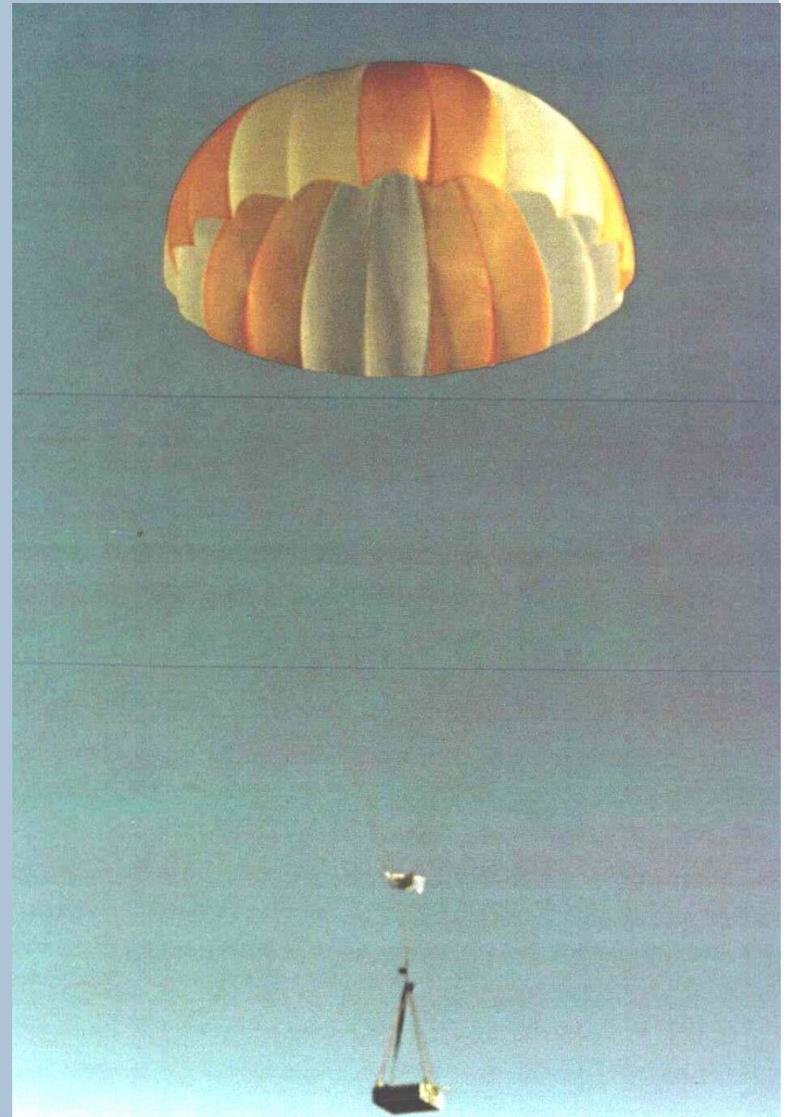
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Stardust Sample Return

- Mortar deployed 0.83 m (2.7 ft) reference diameter DGB Drogue
- 7.3 m (24 ft) reference diameter Triconical Main
- Kevlar and Nylon materials throughout
- Metallized radar “corner reflector” incorporated in suspension lines



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Genesis Sample Return

- Mortar deployed 2.1 m (6.8 ft) reference diameter DGB
- 39 m² (420 ft²) Parafoil Main
- Kevlar and Nylon materials
- Technora “load line” attached to trailing edge of parafoil for mid-air capture
- Spectra parafoil deployment bag



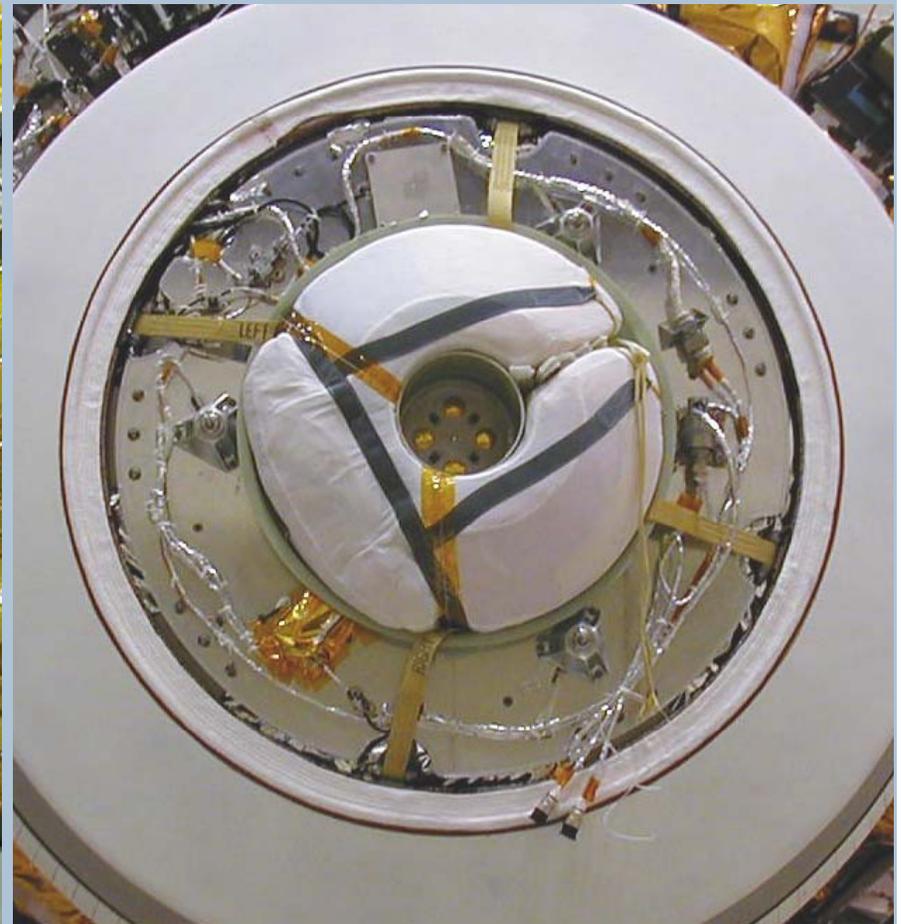
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Genesis Sample Return



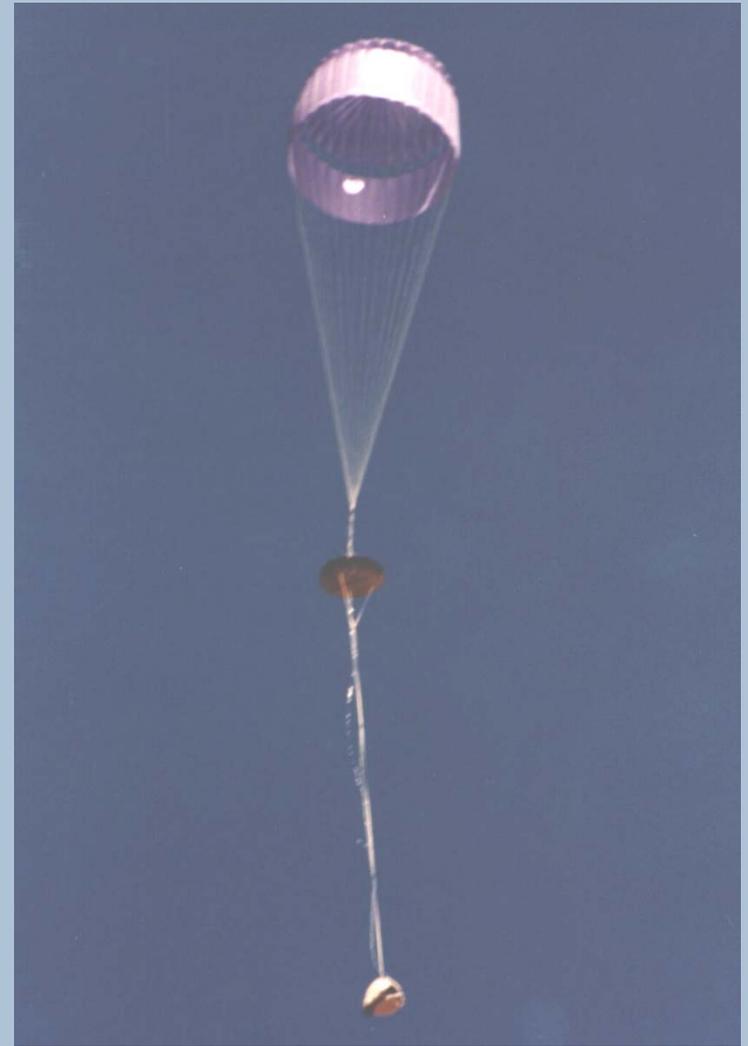
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Mars Pathfinder + Mars Exploration Rovers

- MPF 12.74 m reference diameter DGB, MER 14.1 m reference diameter DGB
- MPF polyester and kevlar, MER nylon, polyester and kevlar
- Extended bands to increase stability:
MPF $\approx 1.9 \times$ Viking
MER $\approx 1.8 \times$ Viking



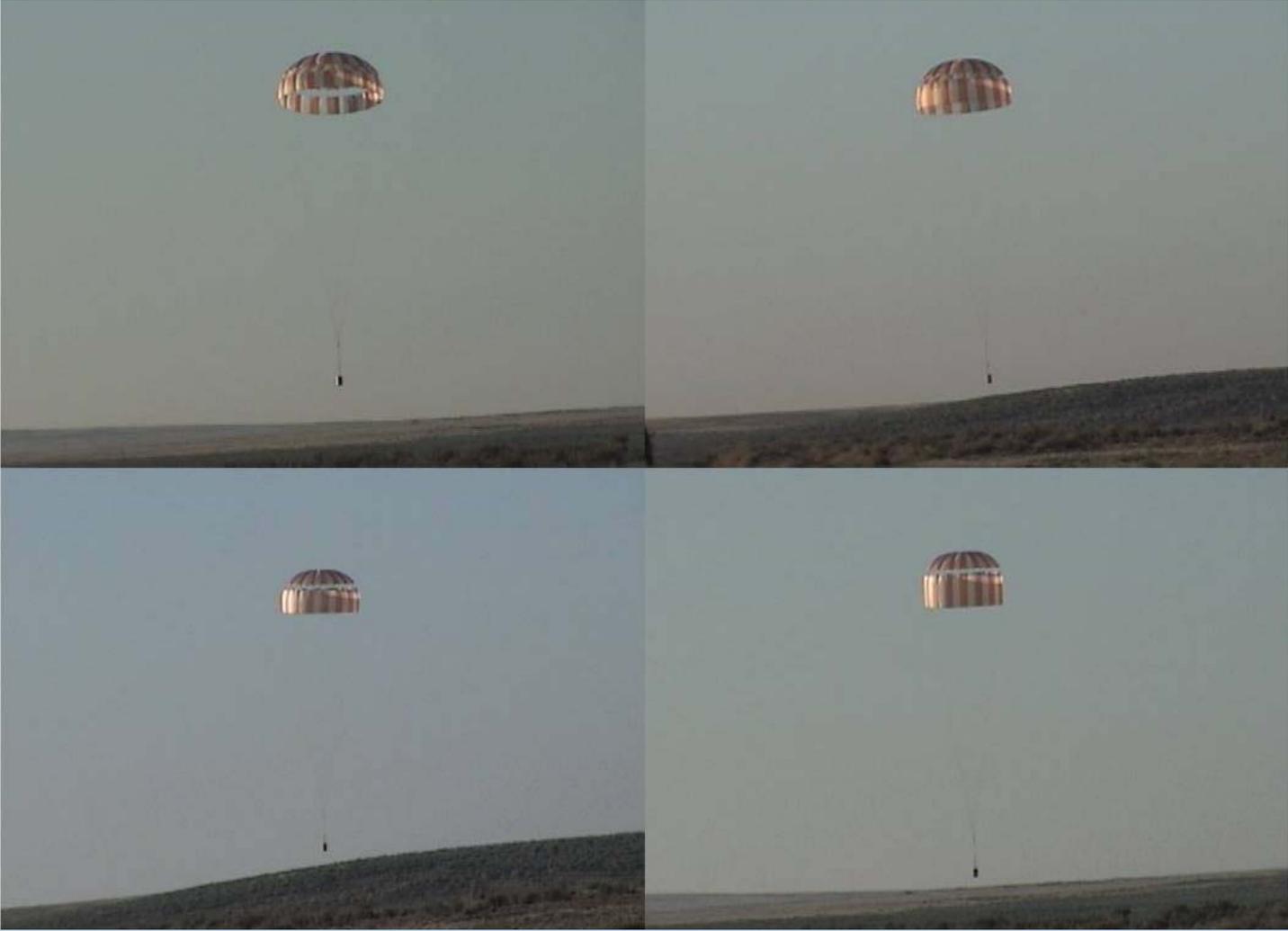
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Mars Pathfinder + Mars Exploration Rovers



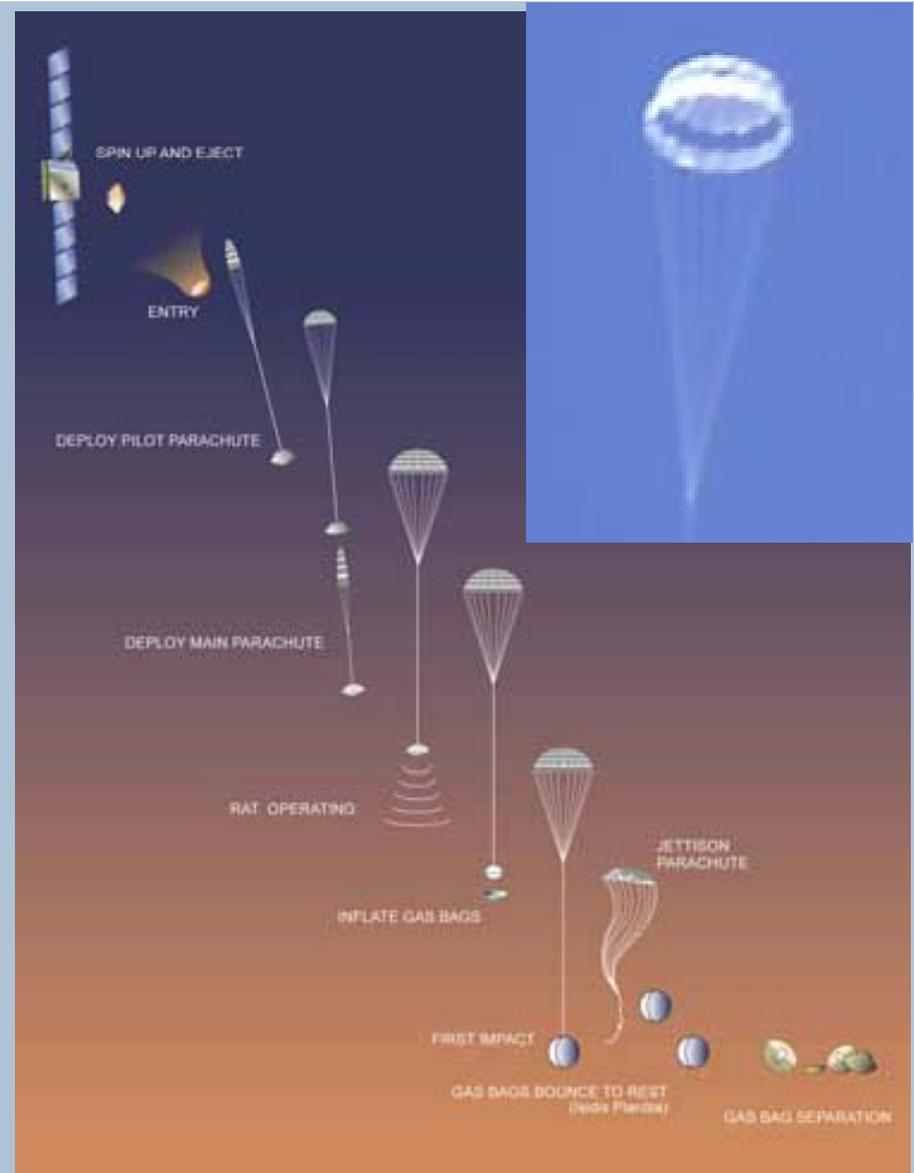
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Beagle II Mars Probe

- Two canopy decelerator system
- 3.2 m DGB Drogue, 10 m Ringsail Main
- Nylon, kevlar and spectra materials
- Huygens-style DGB Drogue
- Lightweight nylon fabric in Main



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Phoenix Mars Scout + Mars Science Laboratory

- **Viking-style DGBs:**
PHX 11.8 m reference diameter
MSL 21.35 m reference diameter
- PHX nylon and kevlar
- MSL nylon, polyester, kevlar and technora
- MER, PHX, and MSL used “continuous line” construction



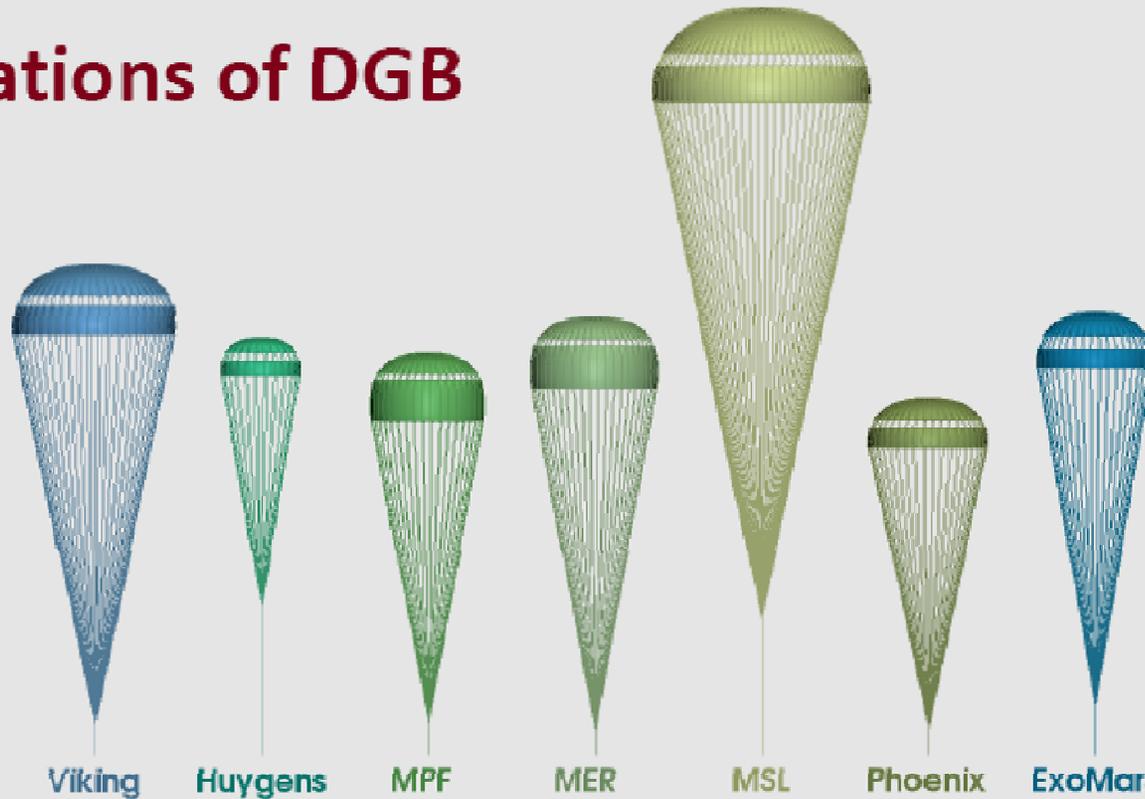
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Summary

Variations of DGB



Viking	Huygens	MPF	MER	MSL	Phoenix	ExoMars
Baseline	Double gap	1.9 x band	1.8 x band	Viking	Viking	Huygens
Cd = 0.61	Cd = 0.5	Cd = 0.41	Cd = 0.43	Cd = 0.61	Cd = 0.61	Cd = 0.50
Trim = 15°	Trim = <3°	Trim = 0°	Trim = 0°	Trim = 15°	Trim = 15°	Trim = <3°

Graphic from 2013 AIAA ADS Seminar, courtesy of Steve Lingard, Vorticity Ltd

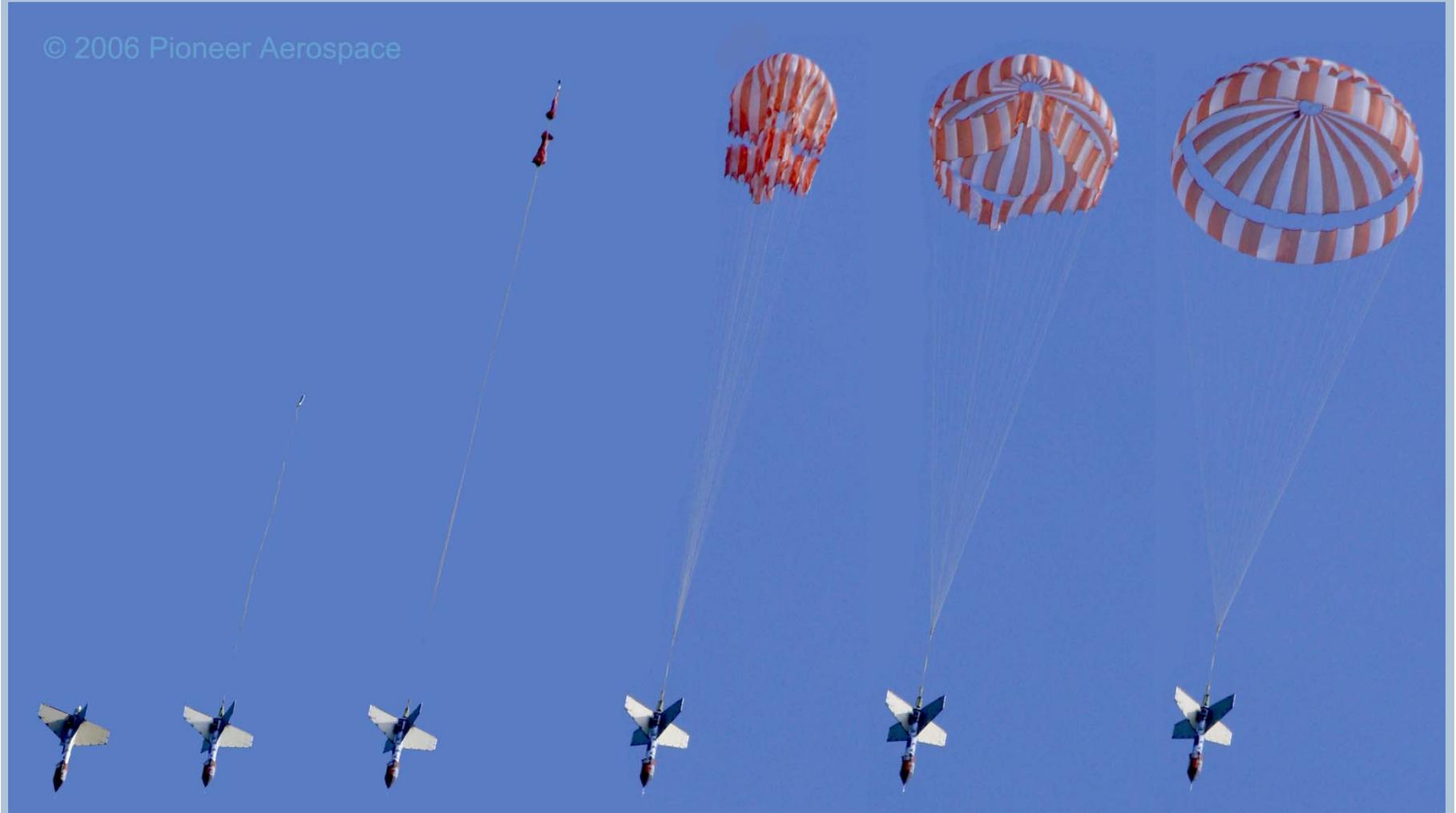
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Questions?

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