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Experience with Small Cosmic Bodies
or
"Asteroids and Comets I've Known and Loved"

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Where We've Been

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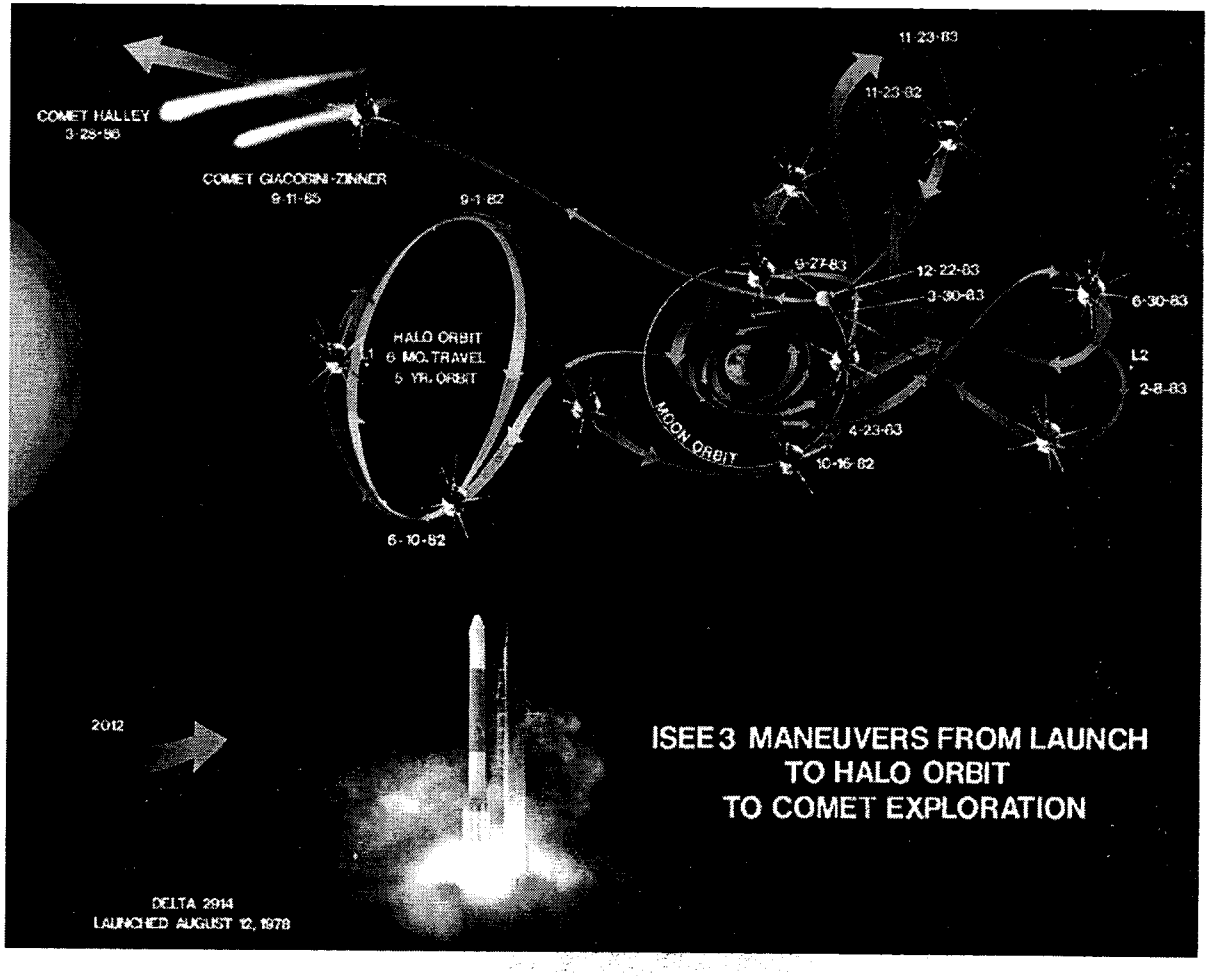
- **Chronologically**

– Sept. 1985	Comet 21P/Giacobini-Zinner	ISEE3/ICE
– March 1986	Comet 1P/Halley	Giotto, Vega, Japan, (ISEE3/ICE)
– Oct. 1991	Asteroid 951 Gaspra	Galileo
– July 1992	Comet 26P/Grigg-Skjellerup	Giotto
– Aug. 1993	Asteroid 243 Ida (Dactyl)	Galileo
– June 1997	Asteroid 253 Mathilde	NEAR
– July 1999	Asteroid 9969 Braille	Deep Space 1
– Feb. 2000	Asteroid 433 Eros	NEAR
– Sept. 2001	Comet 19/P Borrelly	Deep Space 1
– Nov. 2002	Asteroid 5535 Annefrank	Stardust
– Jan. 2004	Comet 9P/Wild 2	Stardust

ISEE3/ICE

- **Comet 21P/Giacobini-Zinner**
  - **First Small Cosmic Body Visited by a Spacecraft**
  - **9/11/85**
- **Comet 1P/Halley**
  - **ISEE3/ICE retargeted to monitor the Solar wind upstream of Halley**
- **Watch for the return of the ISEE3/ICE Spacecraft to near the Earth ca. Aug. 2014**

http://nssdc@gsfc.nasa.gov



Comet Halley

- **Size - 16x8x8 km**

- **Photo - Giotto Flyby 3/13/86**
- **C/A Distance - 596 km**
- **Flyby Speed - >50 km/s**

- **Also visited by:**
  - **Soviet Union (Vega 1 &2)**
  - **Japan (Sakigake and Suisei)**
  - **US (ISEE3/ICE)**

- **Watch for Halley to return again in 2062!**

http://sci.esa.int/home/giotto/index.cfm

Giotto

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- **Retargeted to encounter Comet 26P/Grigg-Skjellerup on 7/10/92**
- **C/A Distance - ~200 km**

Galileo Trajectory

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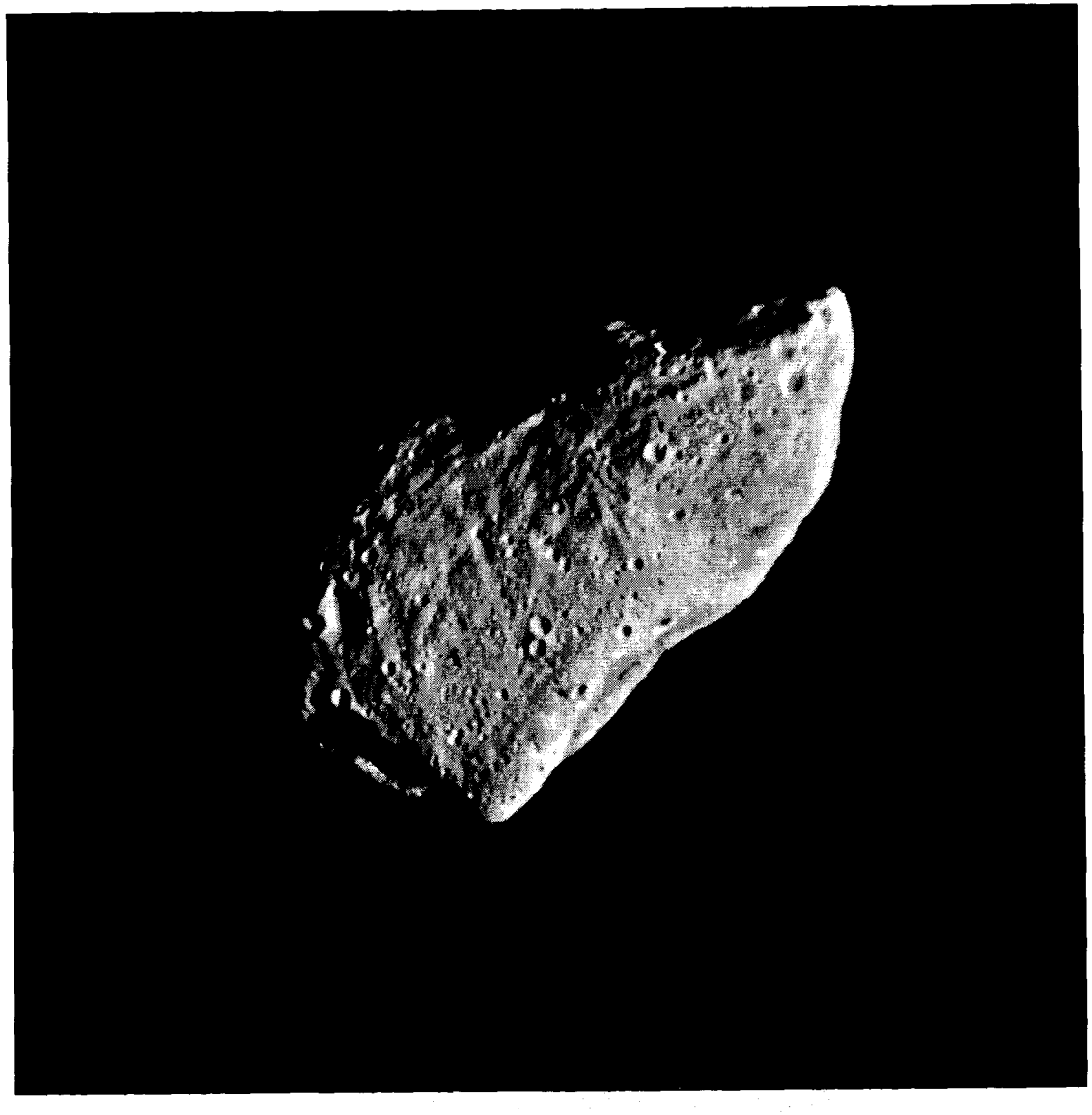
Asteroid Gaspra

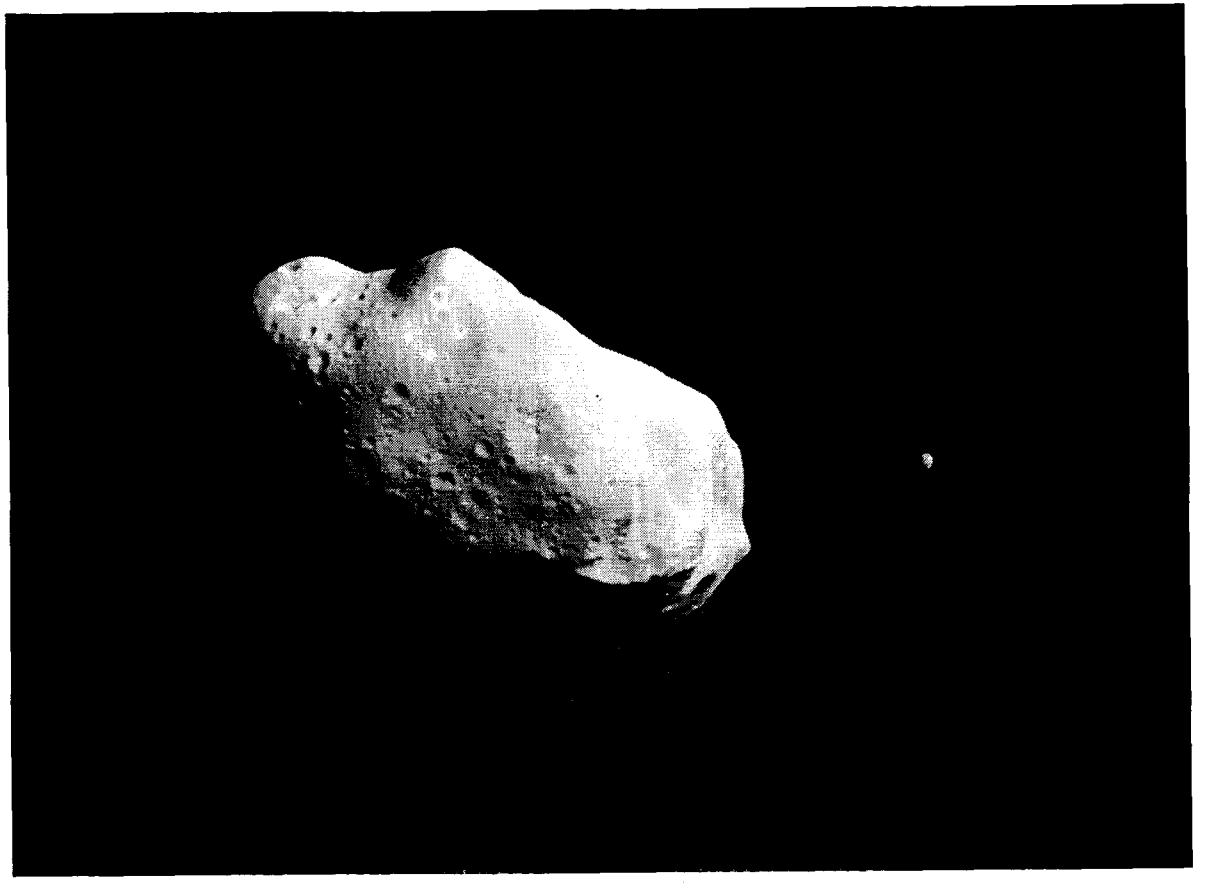
- First flyby of an asteroid
- Size - 19x12x11 km
- Photo - Galileo Flyby 10/29/91
- C/A Distance - 1601 km
- Flyby Speed - 8.0 km/s



http://galileo.jpl.nasa.gov

Asteroid Ida and Its Satellite Dactyl

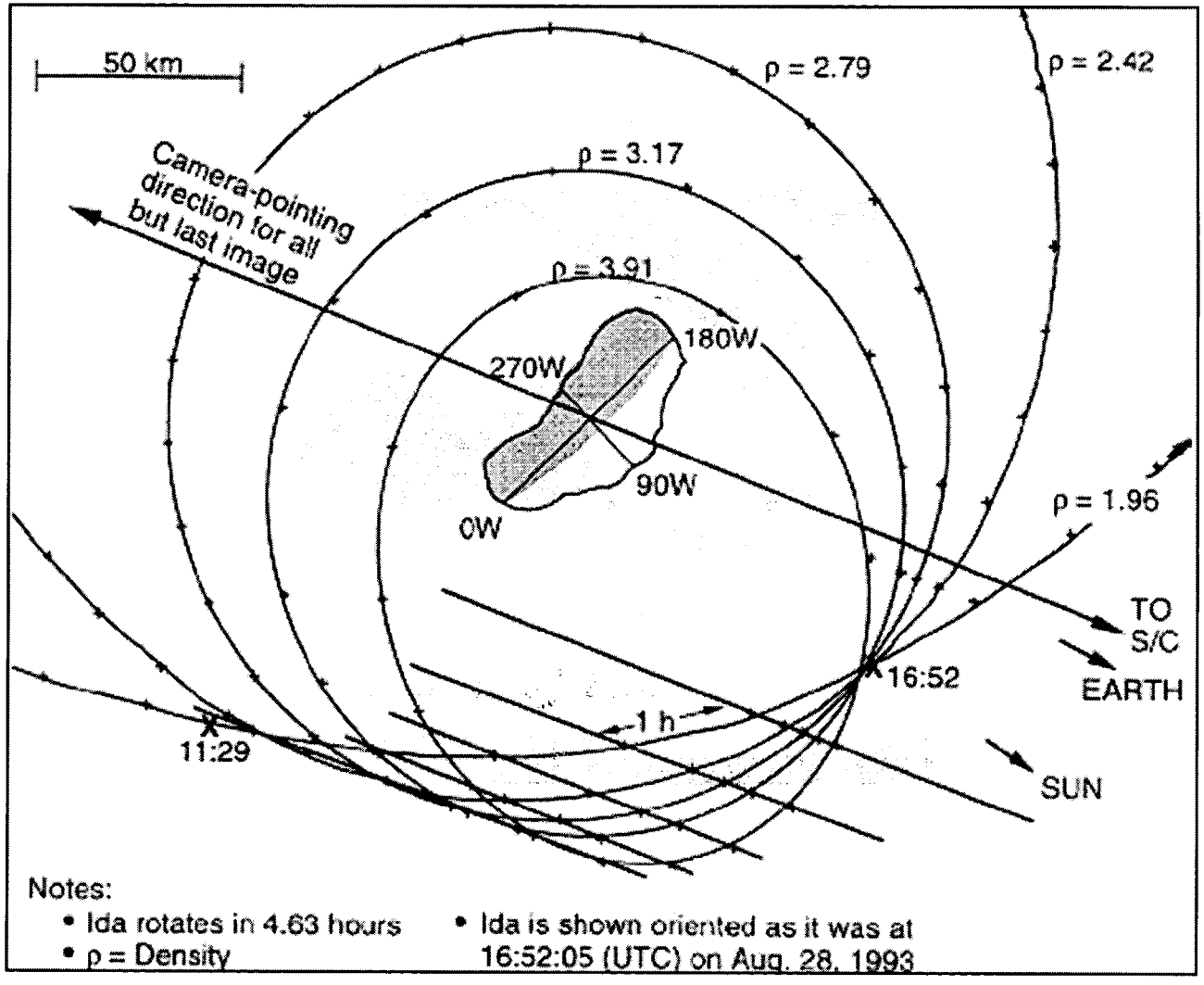
- **First Asteroid known to have a satellite**
- **Size - 55x20x24 km**
- **Photo - Galileo Flyby 8/28/93**
- **C/A Distance - 2400 km**
- **Flyby Speed - 12.4 km/s**



http://galileo.jpl.nasa.gov

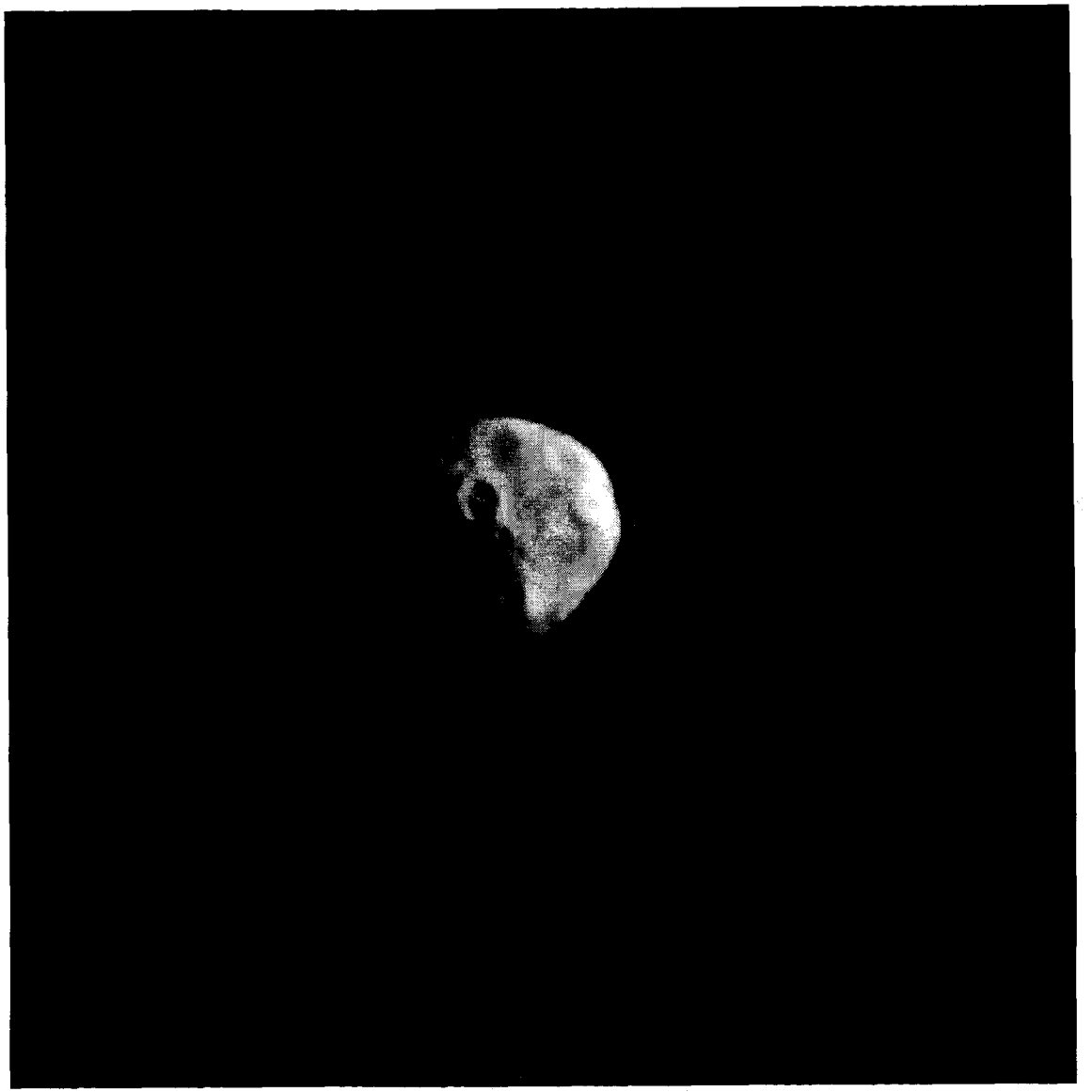
Mass Determination of Ida

- **First asteroid mass/density estimate by actual measurement**
- **2.0-3.1 gm/cm^3**
- **Interesting Problem**
- **D.V. Byrnes and L.A. D'Amario, "Dactyl Orbit Determination Analysis," AAS/AIAA Astrodynamics Specialist Conference, Aug. 1995, Paper AAS 95-315**



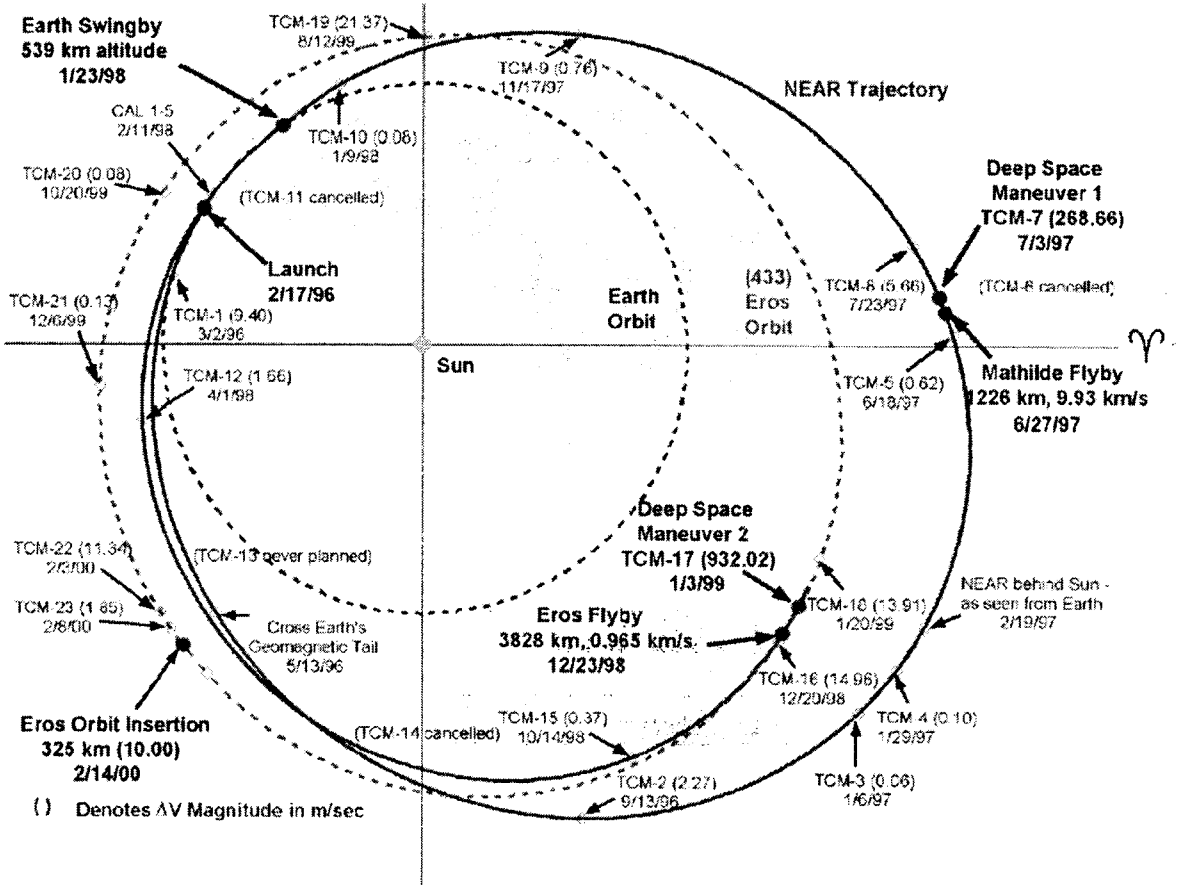
Asteroid Dactyl

- **Size - 1.6x1.4x1.2 km**
- **Photo - Galileo Flyby 8/28/93**



NEAR Trajectory to Mathilde and Eros

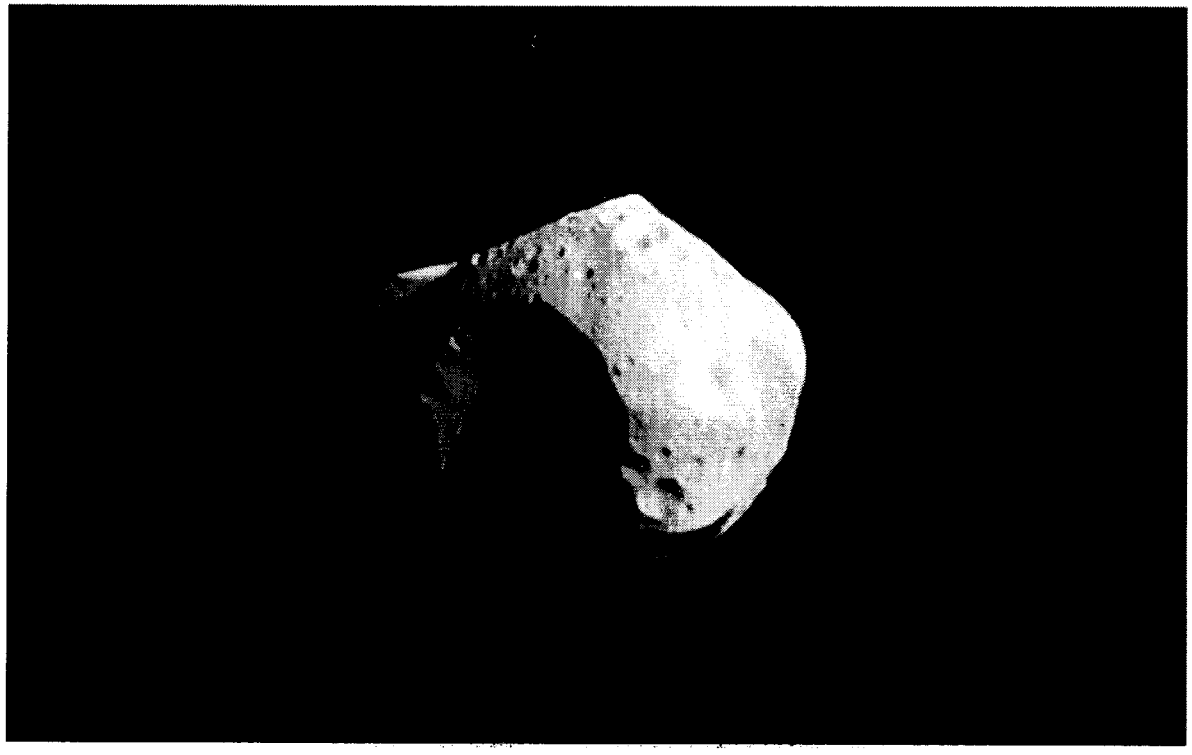
- **The first Discovery Mission**
- **Mathilde Flyby**
- **Eros Rendezvous**
- **Orbital Operations**
- **End-of-Mission: Landing!**



Asteroid Mathilde

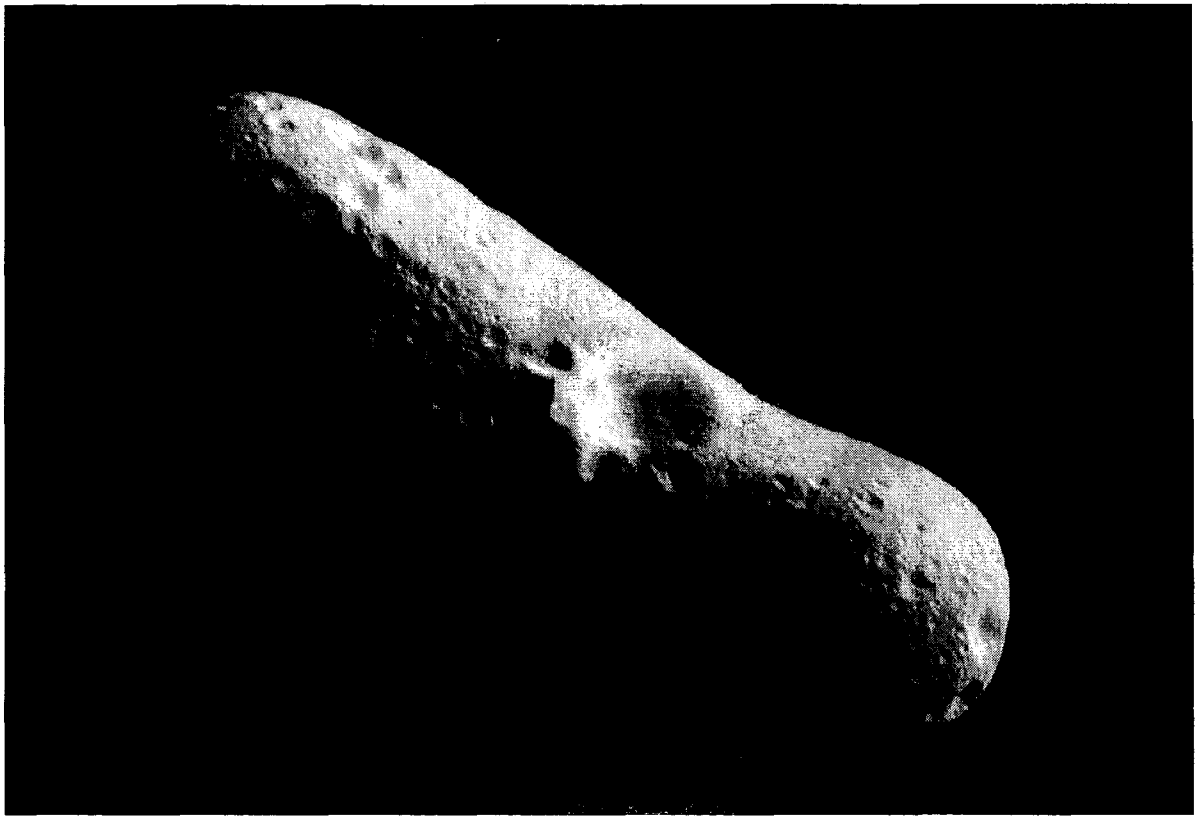
- **Size - 66x48x46 km**
- **Photo - NEAR Flyby 6/27/97**
- **C/A Distance - 1200 km**
- **Flyby Speed - 9.9 km/s**
- **Mass/density determined: 1.34 gm/cm^3**

http://near.jhuapl.edu



Asteroid Eros

- **Size - 33x13x13 km**
- **Photo - NEAR On Approach 2/12/00**
- **Density 2.7 gm/cm^3**



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Asteroid Eros

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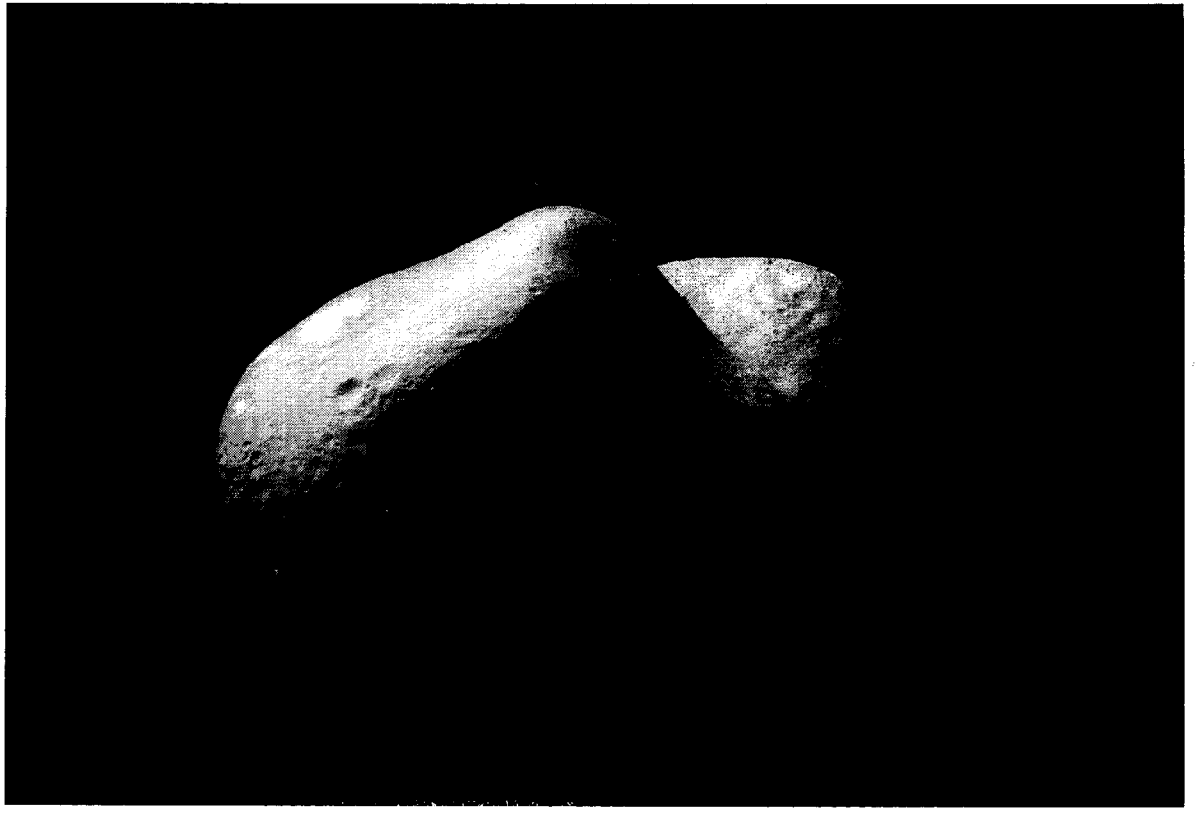

Asteroid Eros

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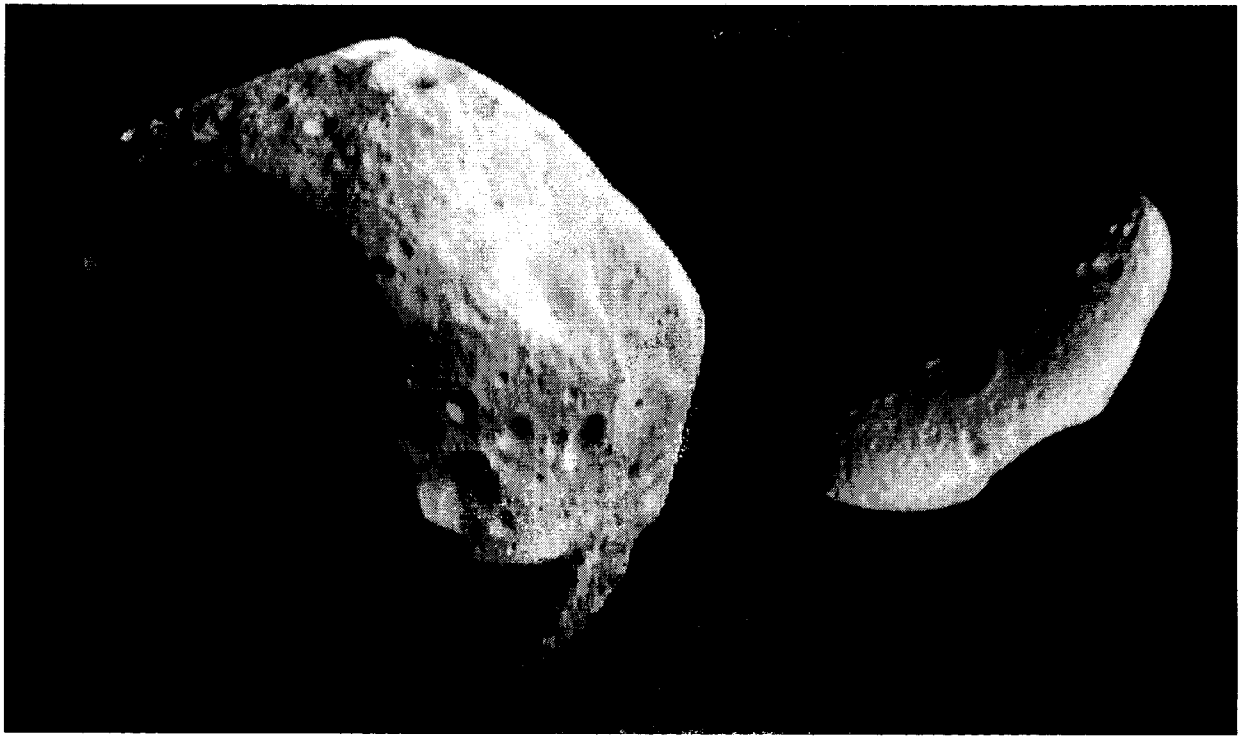
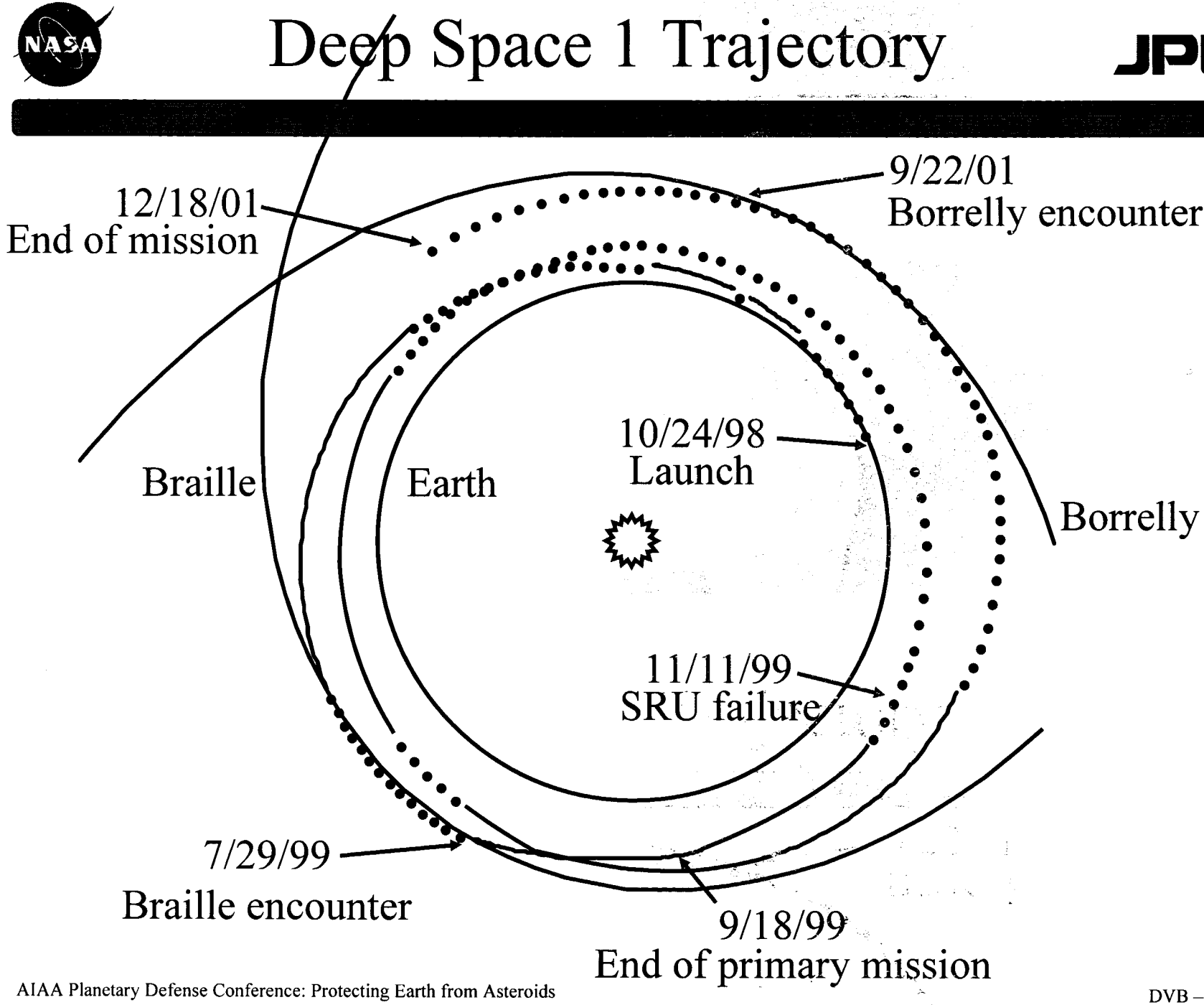
Asteroids Mathilde and Eros

- **Photo - NEAR**
- **To Scale in Size, not Brightness**
- **Eros is actually about six times brighter than Mathilde**

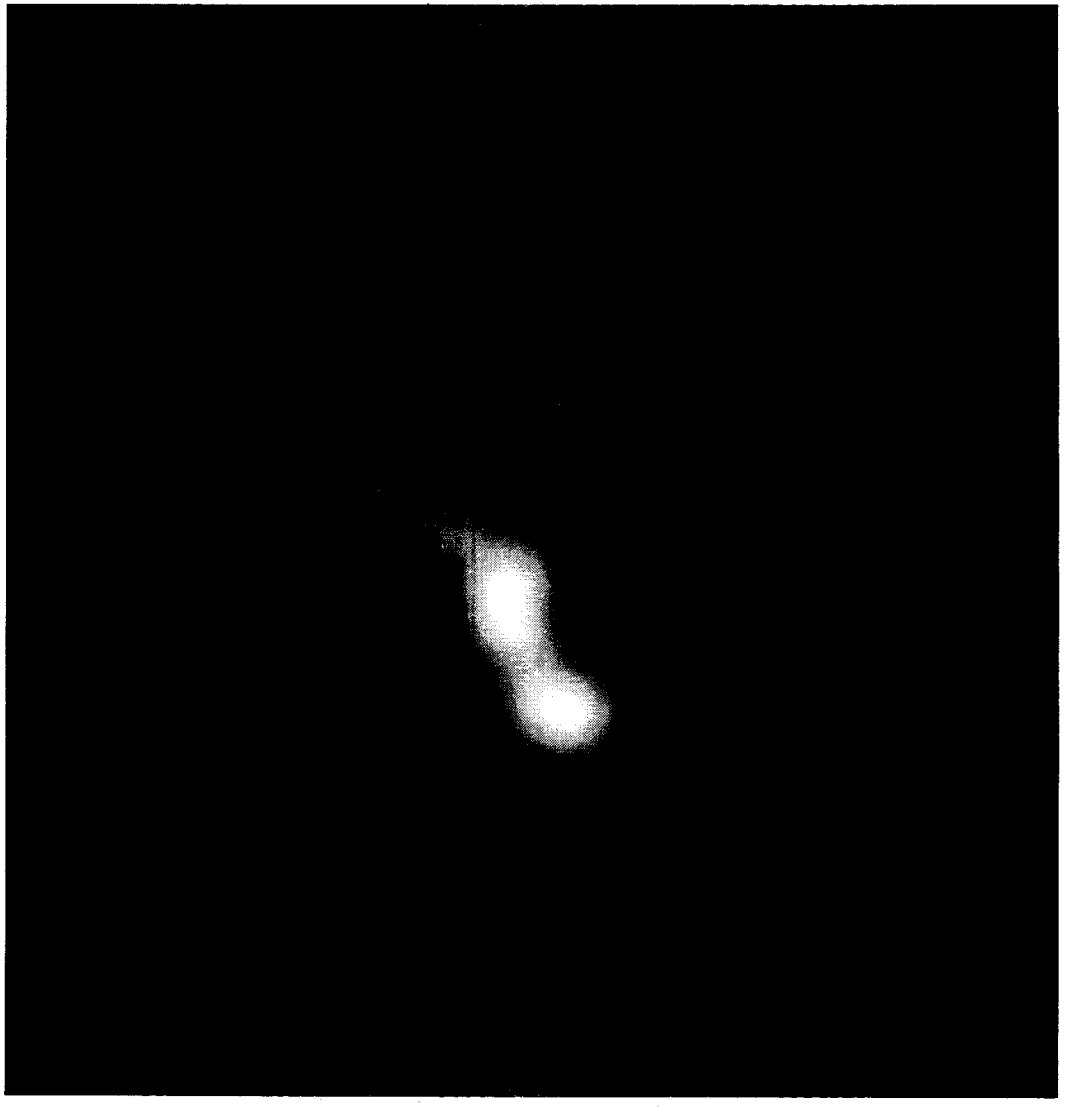


Deep Space 1 Trajectory



Asteroid Braille

- **Size - 2.2x1.0x? km**
- **Photo - Deep Space 1 Flyby 7/29/99**
- **C/A Distance - 26 km, closest flyby ever**
- **Flyby Speed - 15.5 km/s**



http://nmp.jpl.nasa.gov/ds1

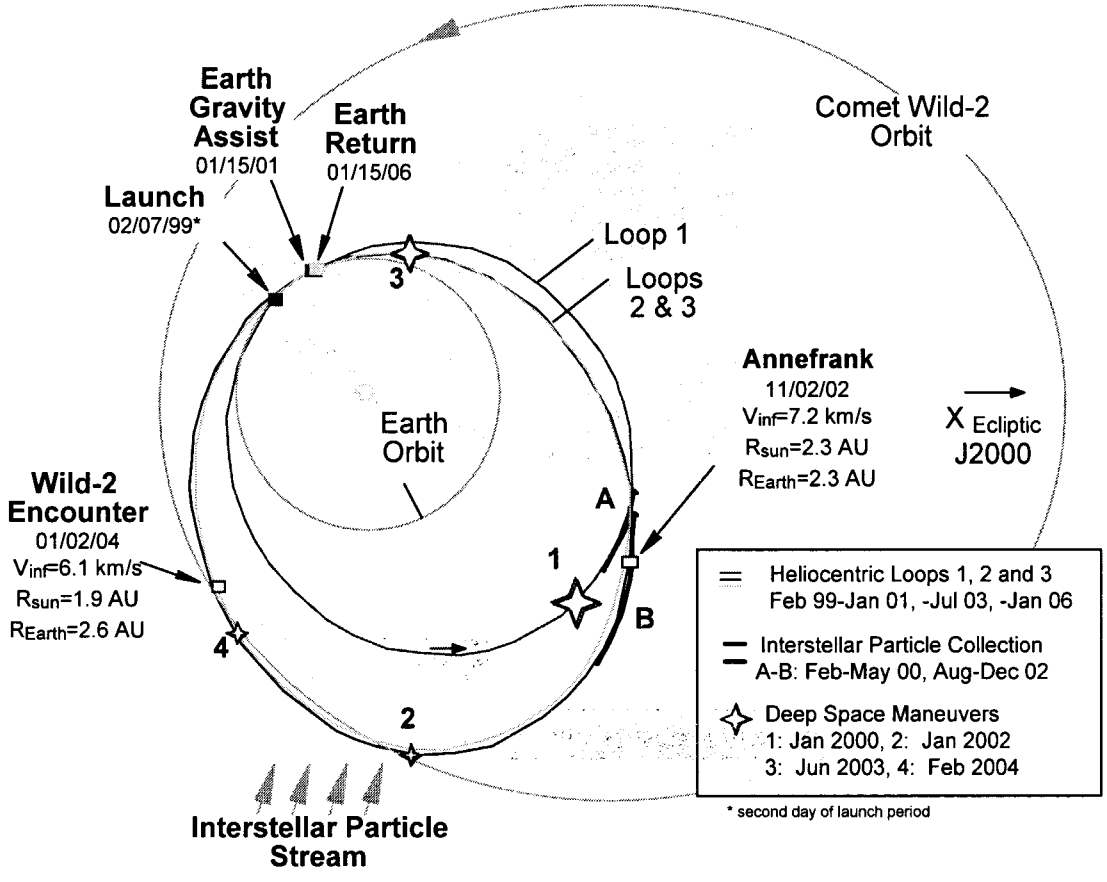
Comet Borrelly

- **Size - 8x3x? km**
- **Photo - Deep Space 1 Flyby 9/22/01**
- **C/A Distance - 2171 km**
- **Flyby Speed - 16.6 km/s**

http://nmp.jpl.nasa.gov/ds1

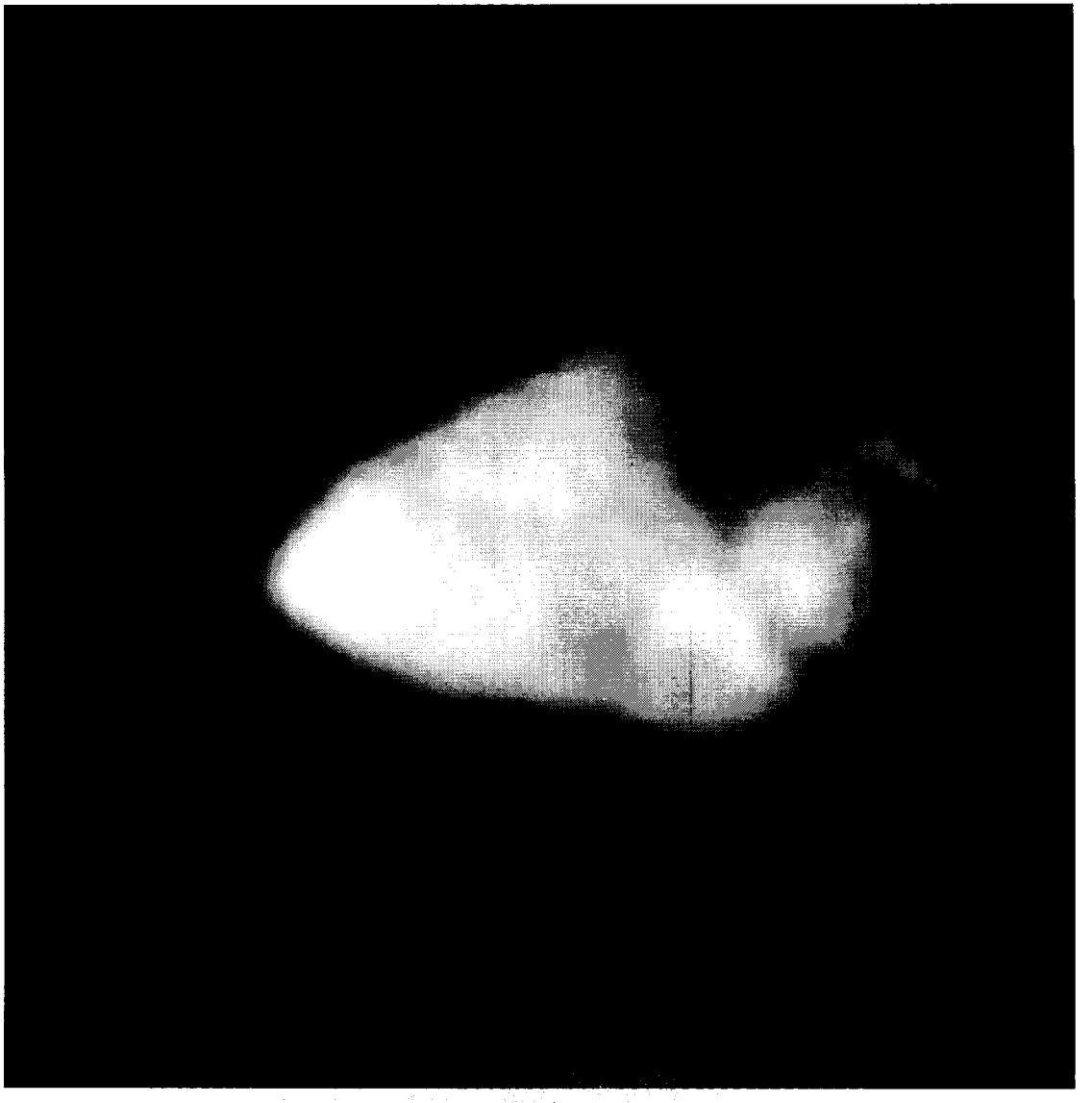
Stardust Trajectory

- **First planned sample return**
  - **Dust from flyby captured in aerogel**
- **Asteroid Annefrank flyby**
- **Comet Wild 2 Flyby**
  - **Dust sample**
  - **Nucleus imaging**
- **Earth Return 1/15/06**



Asteroid Annefrank

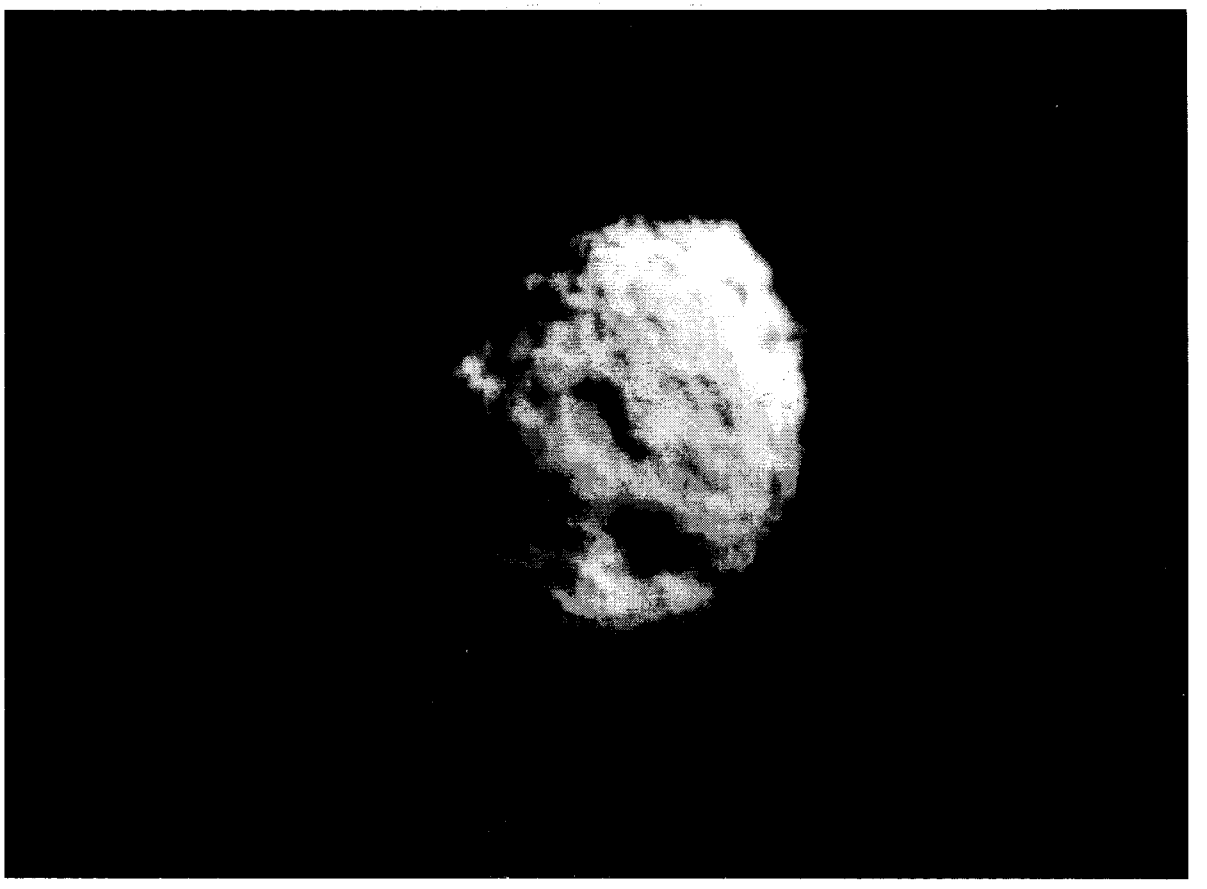
- **Size - 8x5x? km**
- **Photo - Stardust Flyby 11/2/02**
- **C/A Distance - 3300 km**
- **Flyby Speed - 7 km/s**



http://stardust.jpl.nasa.gov/

Comet Wild-2

- **Size - 5 km diameter**
- **Photo - Stardust Flyby 1/2/04**
- **C/A Distance - 240 km**
- **Flyby Speed - 6.1 km/s**



http://stardust.jpl.nasa.gov/

Comet Wild-2 Movie

QuickTime™ and a
GIF decompressor
are needed to see this picture.