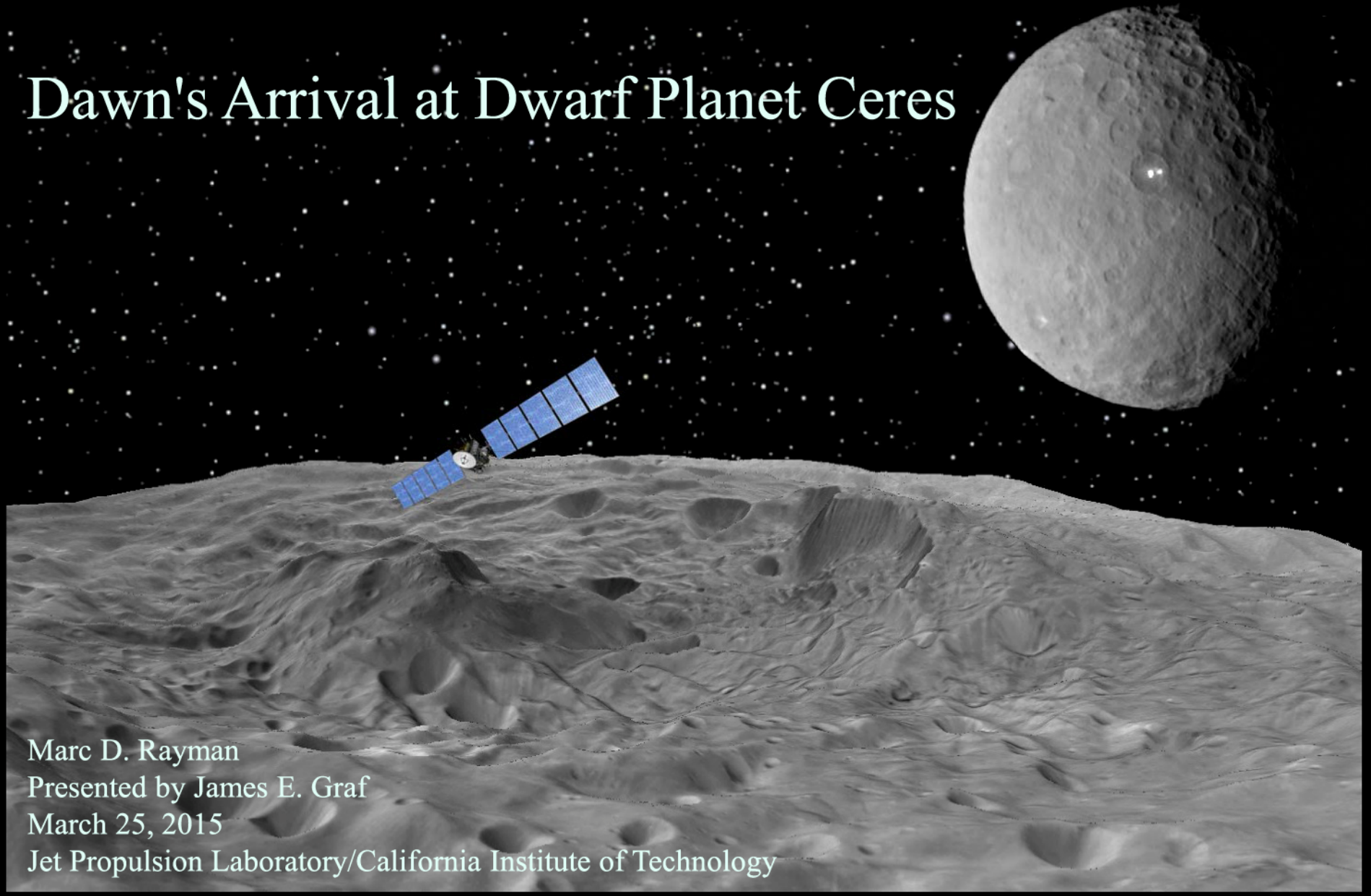
Dawn's Arrival at Dwarf Planet Ceres



Marc D. Rayman
Presented by James E. Graf
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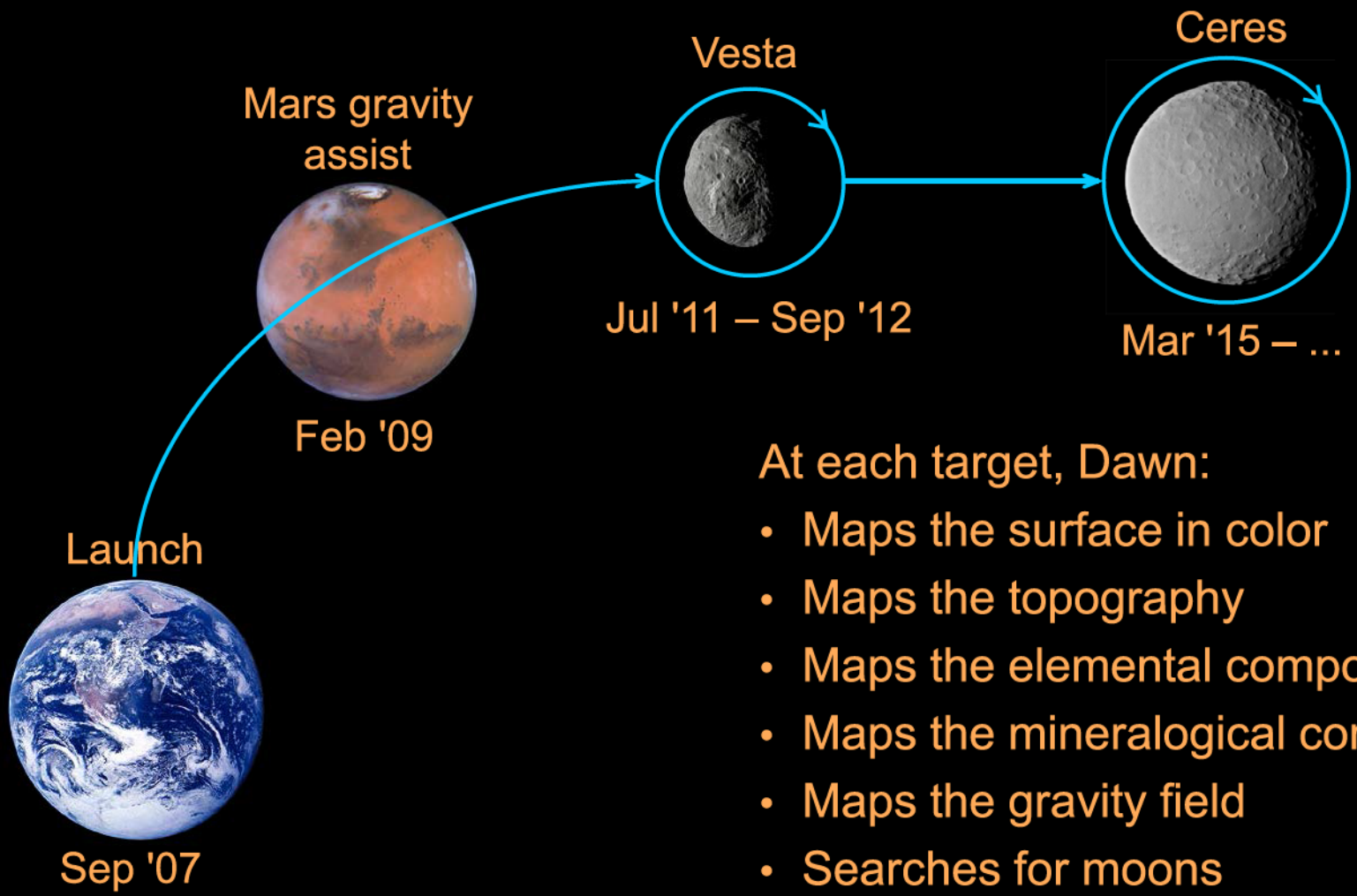
Jet Propulsion Laboratory/California Institute of Technology

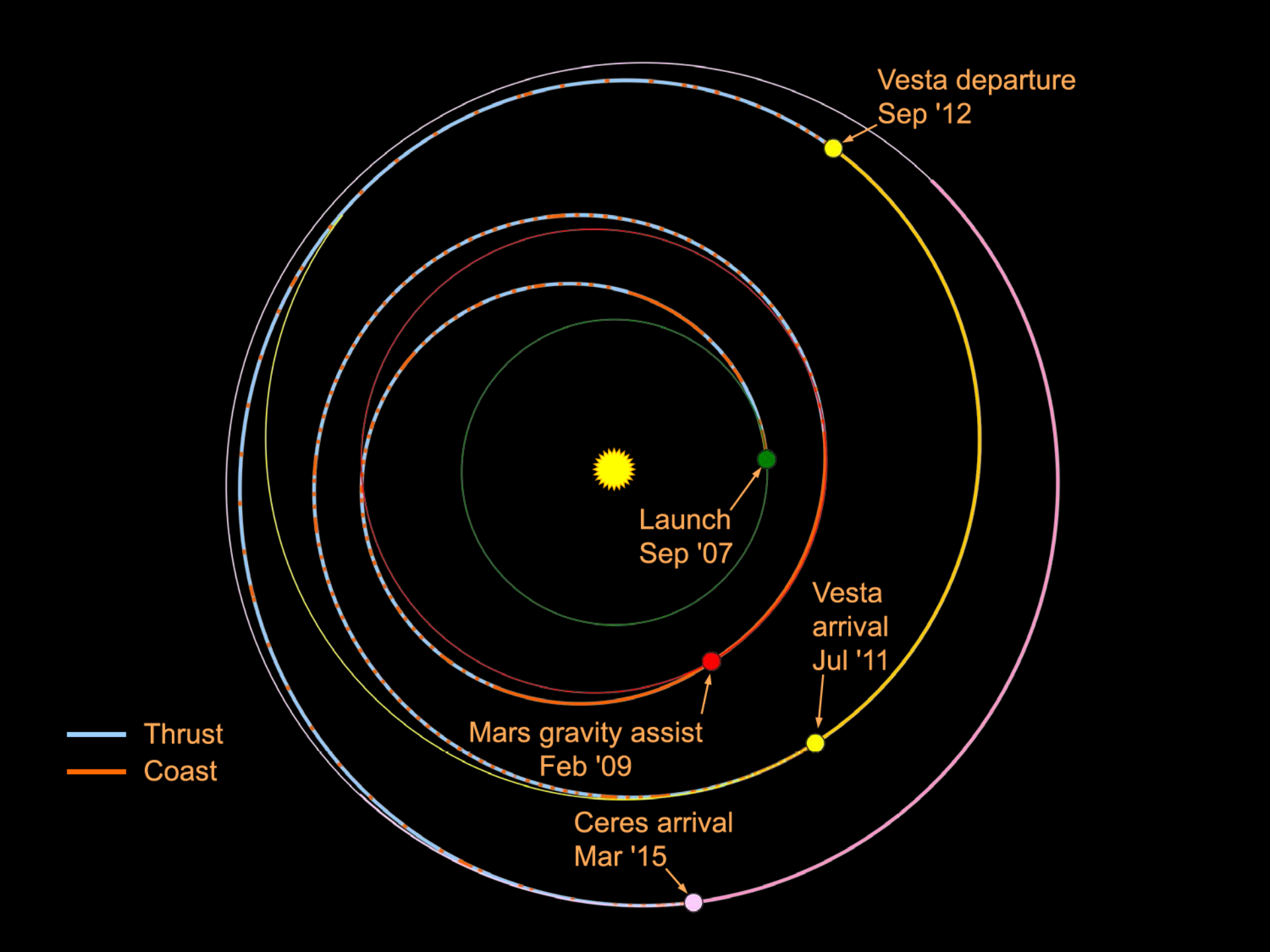
Mission Itinerary



At each target, Dawn:

- Maps the surface in color
- Maps the topography
- Maps the elemental composition
- Maps the mineralogical composition
- Maps the gravity field
- Searches for moons

Note: Text not to scale.


Vesta departure
Sep '12
Launch
Sep '07
Vesta
arrival
Jul '11
Mars gravity assist
Feb '09
Ceres arrival
Mar '15
Thrust
Coast

Ion Thrusting Progress

- Dawn has achieved the greatest propulsive Δv and the longest powered flight by any spacecraft.
- Δv
  - Today: 10.7 km/s
  - End of mission: 11 km/s ≈ Delta II 7925H Δv
- Powered flight time
  - Today: 5.2 years
    - 69% of time since launch
    - $3.8 \cdot 10^{-8}$ % of time since Big Bang
  - End of mission: 5.5 years

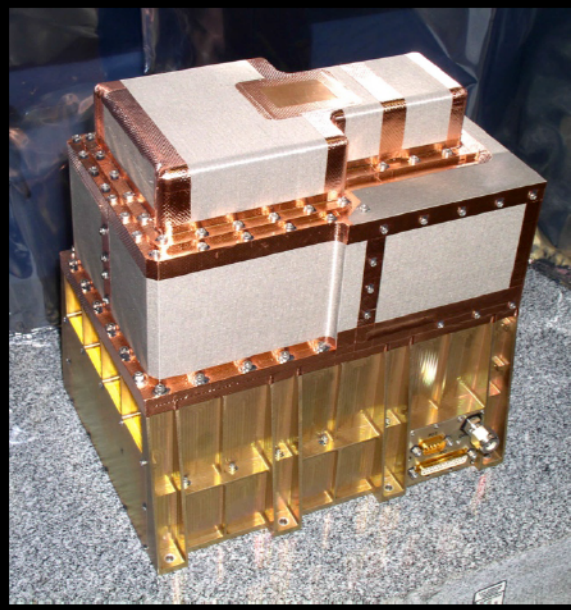
Science Instruments

Redundant Cameras

Provided and operated by Germany's MPS and DLR

Visible and Infrared Mapping Spectrometers

Provided by ASI and the Italian National Institute for Astrophysics, and operated by the Italian Institute for Space Astrophysics and Planetology

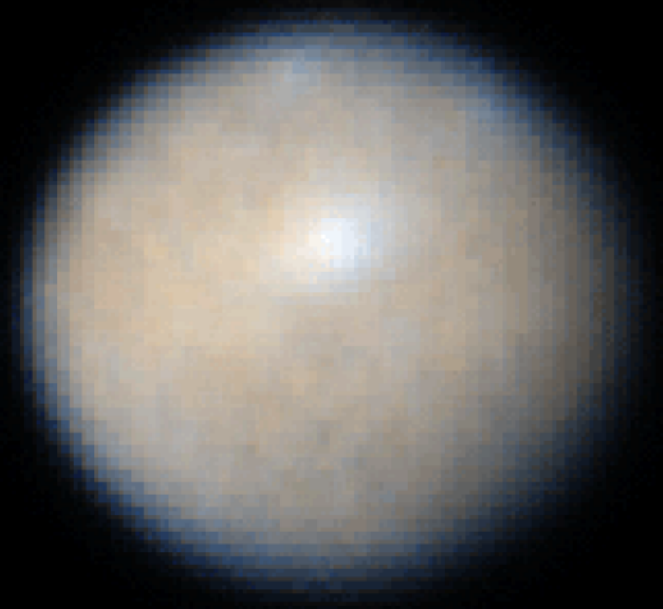


Gamma Ray & Neutron Spectrometers

Provided by Los Alamos National Labs and operated by the Planetary Science Institute

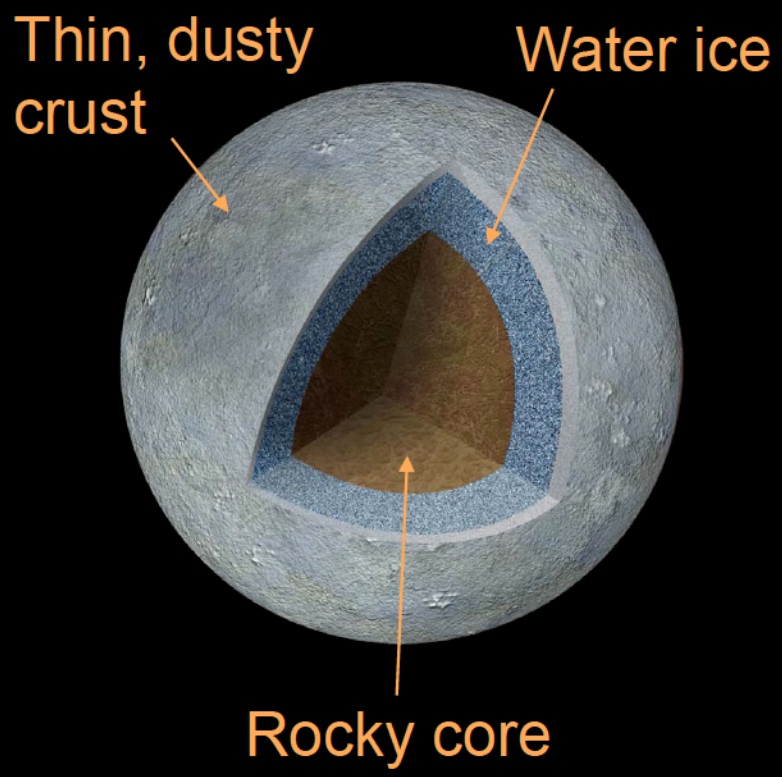
Ceres before Dawn

- The only dwarf planet in the inner solar system
- The largest, most massive body in the main asteroid belt
  - ~ 30% of the mass of the asteroid belt
  - 950 km mean diameter
  - Largest body between the Sun and Pluto not yet visited by a spacecraft
- Tenuous water vapor detected by Hershel Space Observatory



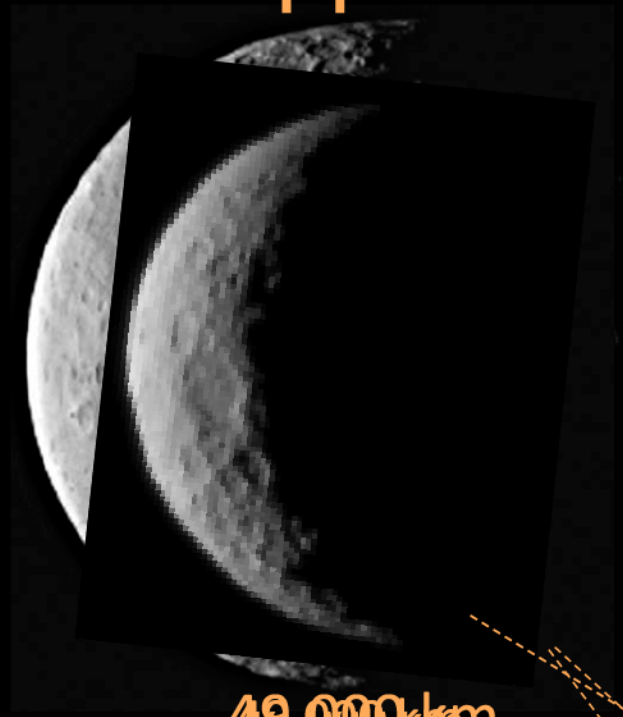
Ceres from Hubble Space Telescope

Ceres before Dawn



Dawn will map the surface properties, probe the interior structure, and characterize the interaction between them

Dawn Approaches



Sun

Ion thrusting

Coasting for imaging & telecommunications

Capture by Ceres' gravity (6 March)

Dawn now

Phase angle too high for imaging (2 March - 9 April)

Dawn at Ceres

Maneuverability with ion propulsion

Mapping Orbits

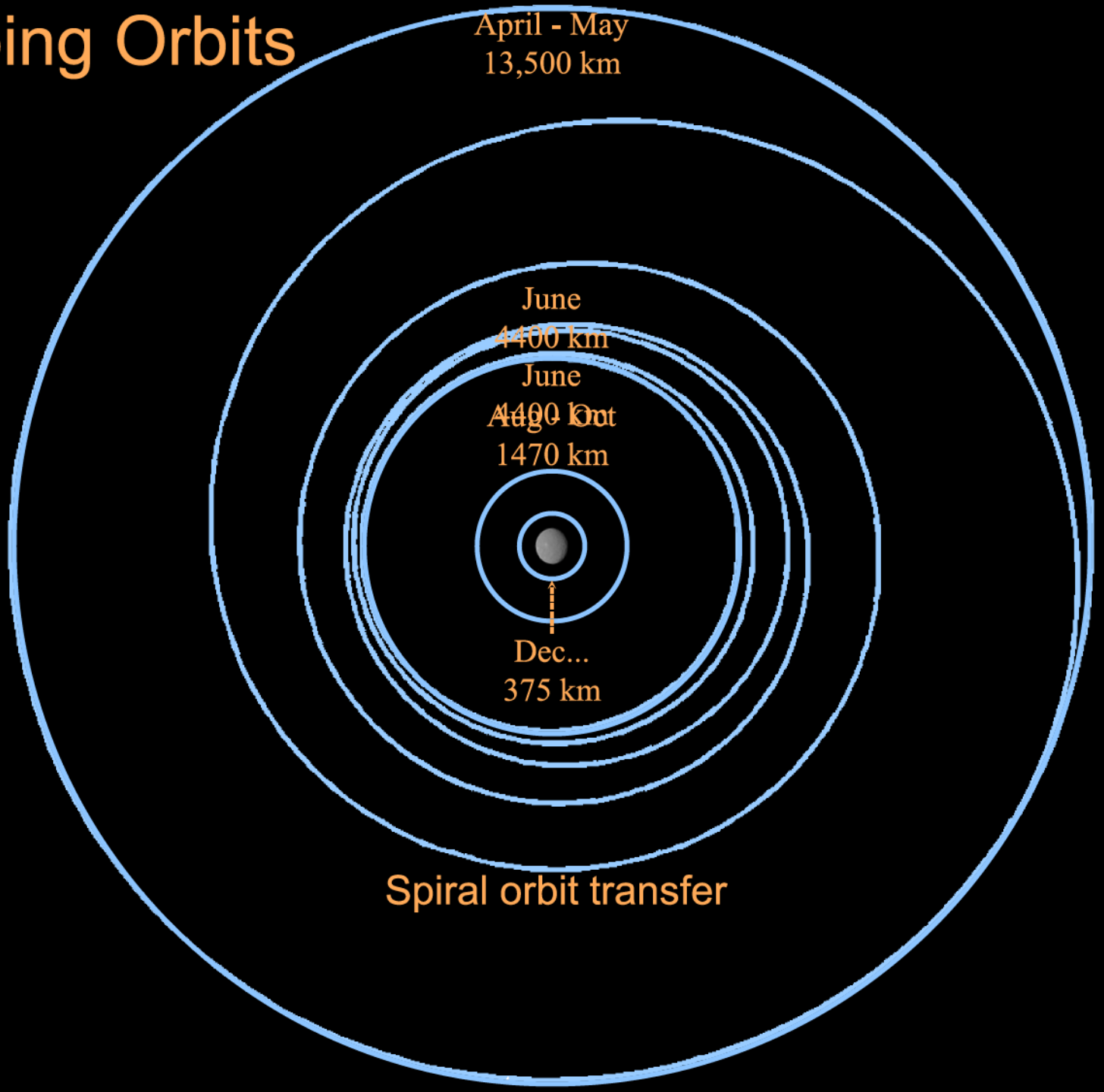
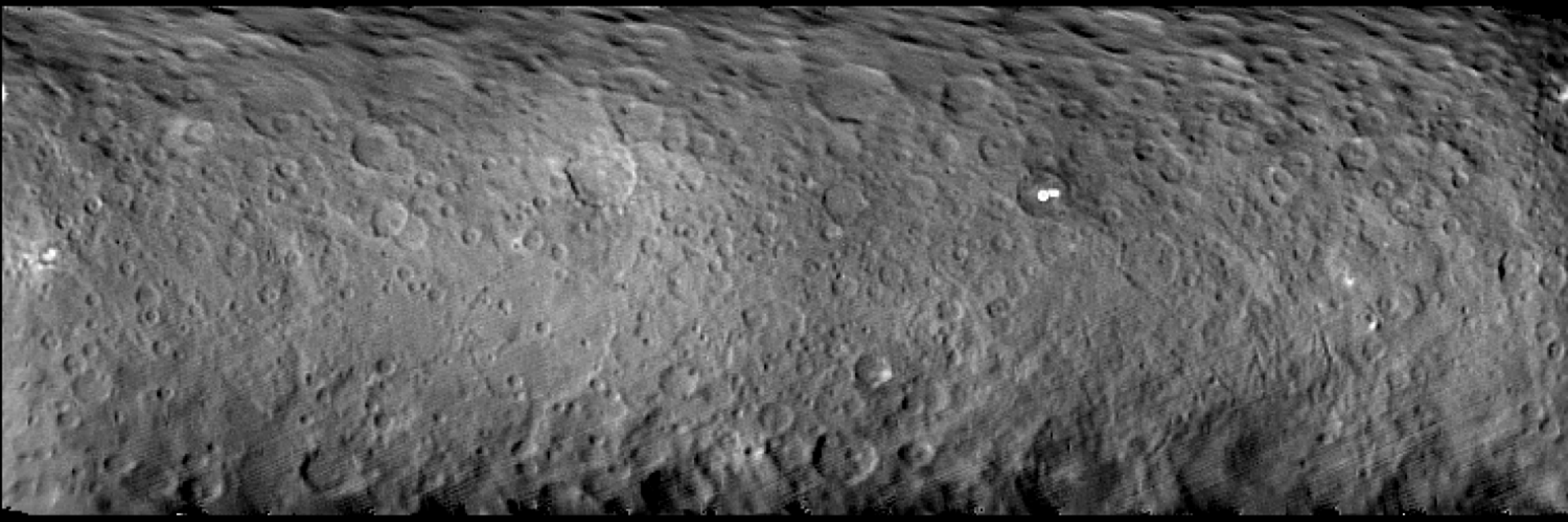


Image resolut
by ~ 120 x by



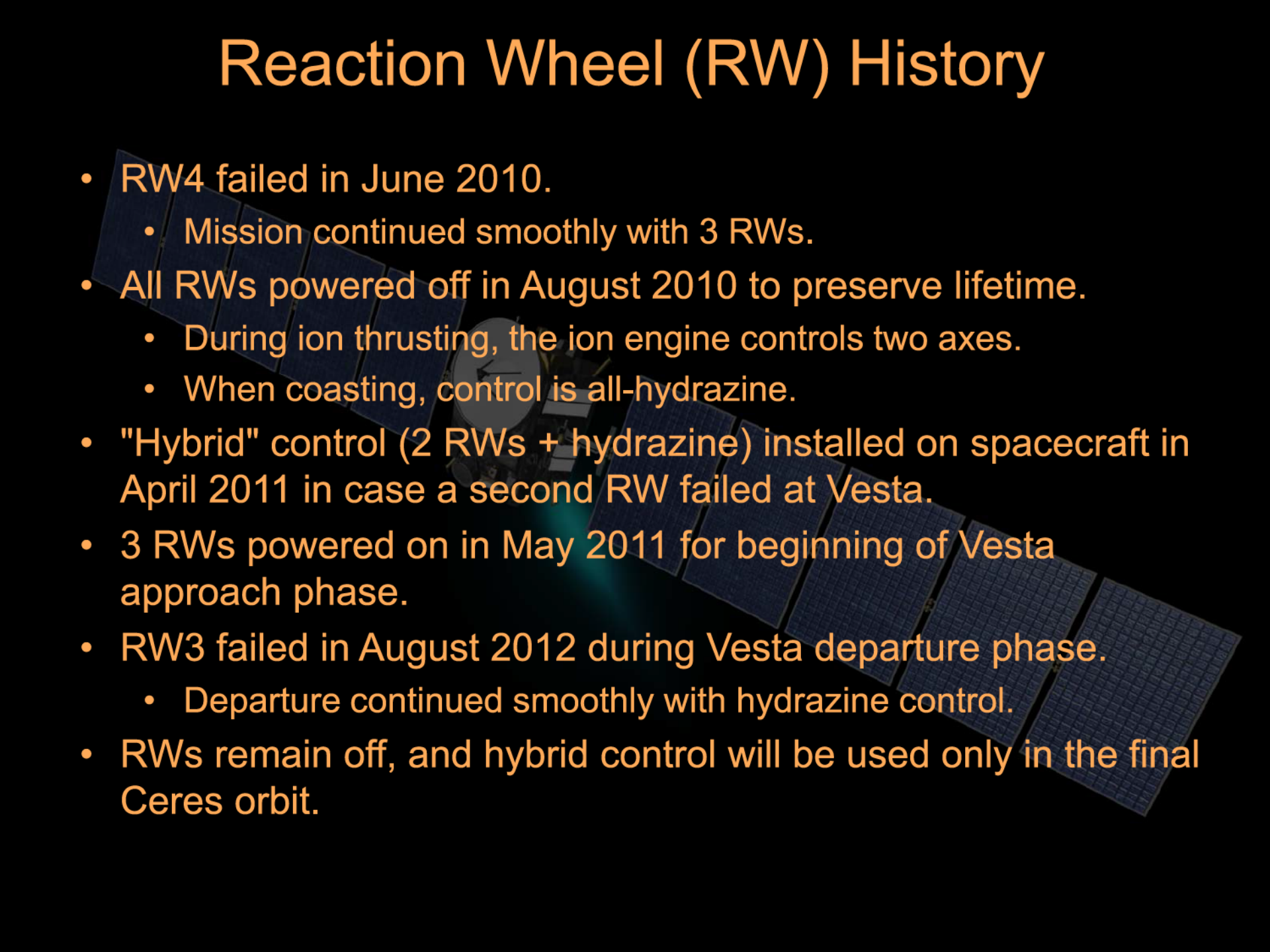
Selected Milestones

- Moon search concludes in April
- Search for water vapor in early May
  - Density observed by Herschel ~ Earth's atmosphere at 600 km
  - Dawn's instruments were designed for solid bodies
- Stereo mapping in August - October
- Expected accomplishment of primary mission objectives by March 2016
  - Extended mission duration highly constrained by hydrazine, given loss of two reaction wheels.
    - Robust margin for primary mission with zero reaction wheels
  - Planetary protection precludes contact with surface for at least 20 years.
    - Final mapping orbit at 375 km is stable for >> 50 years.

Backup

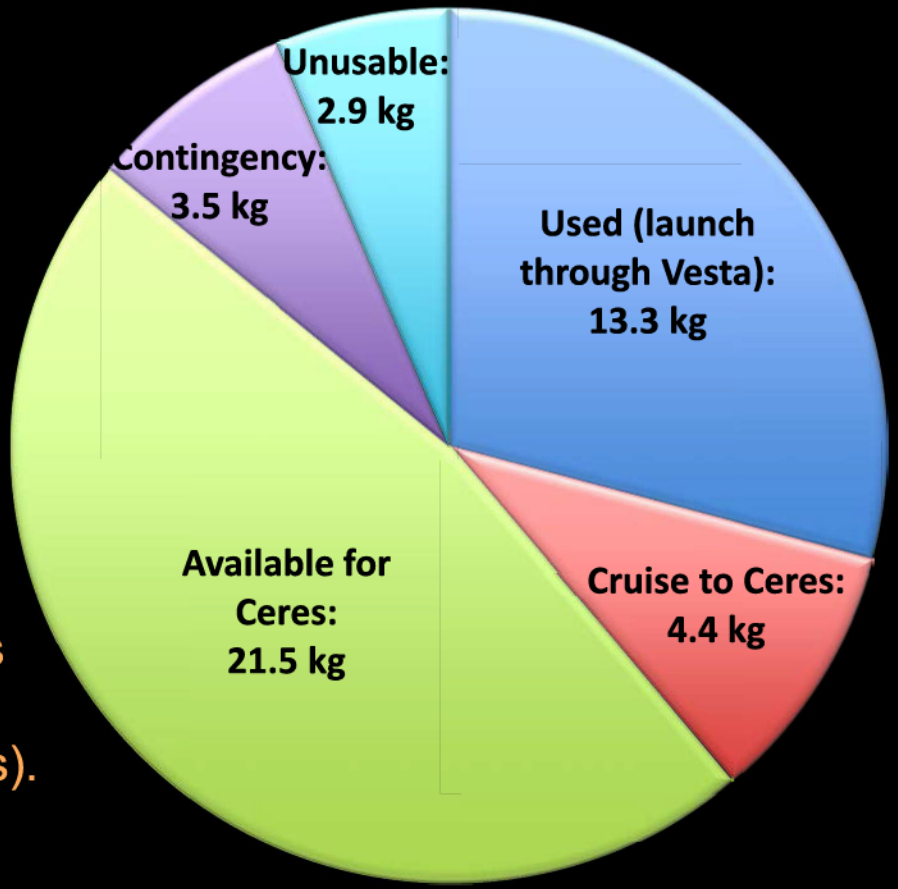
Reaction Wheel (RW) History

- RW4 failed in June 2010.
  - Mission continued smoothly with 3 RWs.
- All RWs powered off in August 2010 to preserve lifetime.
  - During ion thrusting, the ion engine controls two axes.
  - When coasting, control is all-hydrazine.
- "Hybrid" control (2 RWs + hydrazine) installed on spacecraft in April 2011 in case a second RW failed at Vesta.
- 3 RWs powered on in May 2011 for beginning of Vesta approach phase.
- RW3 failed in August 2012 during Vesta departure phase.
  - Departure continued smoothly with hydrazine control.
- RWs remain off, and hybrid control will be used only in the final Ceres orbit.



Hydrazine Conservation

- The day the second RW failed, the project began an intensive hydrazine conservation campaign, assessing ~ 50 changes.
  - That effort was extremely productive. Among the changes implemented:
    - We reduced the spacecraft rotation rate from 0.1°/s to 0.025°/s.
    - We increased the interval between pauses in thrusting for telecom from 1 week to 4 weeks.



Ceres plan requires 16.2 ± 4 kg (assuming 0 wheels).