Cassini Status

10 YEARS at SATURN

Dr. Linda Spilker
Cassini Project Scientist
JPL/Caltech
Outer Planets Assessment Group
23 July 2014
Cassini’s Senior Review Proposal Submitted

Four Budget Scenarios for 3 Fiscal Years
- Guideline
- Descope
- Floor
- Overguide
Cassini-Huygens Mission Timeline
### Cassini Solstice Mission Overview
October 2010 - September 2017

<table>
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<tr>
<th>Year of Tour</th>
<th>7 ’10-’11</th>
<th>8 ’11-’12</th>
<th>9 ’12-’13</th>
<th>10 ’13-’14</th>
<th>11 ’14-’15</th>
<th>12 ’15-’16</th>
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<tr>
<td>Orbits</td>
<td>16</td>
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<td>Titan</td>
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### Enceladus
- Rhea
- Dione
- Tethys
- Methone
- Telesto

### Other Icy Satellites
(under 10,000 km)
- Rhea
- Dione
- Tethys
- Methone
- Telesto

### Saturn
(seen from Sun)

Proximal Orbits
- EOM Sep 15, 2017
Cassini PSD Stand-up Senior Review

- Panel review held May 14th in Columbia, MD
  - Supported in person by Linda Spilker, Earl Maize, Mike Flasar, Dick French, Don Mitchell, Jonathan Lunine, Andy Ingersoll
- Joint Cassini/LRO panel
- 20 questions received
  - 15 Science
  - 1 Technical
  - 2 Archiving
  - 2 EPO
- SR findings and budget initially due in June
- Latest update: end of July
How many early career scientists have been funded by the Cassini Mission?

- 399 early career scientists
- At least 12 went on to become NASA-selected Cassini Participating Scientists
Winner Nicolas Vitebsky on Saturn’s F ring: “A petri dish of the cosmos, this ring is a window to the evolution of solid bodies, explaining how they coalesce and develop. The Cassini mission, with its dedicated team of scientists at the helm, will delve deeper into these questions and, undoubtedly, raise many more in years to come.”

Winners of special Spring 2014 edition of the essay contest include, from left: Emma Spears, Nidhi Nagireddy, Nicholas Vitebsky, Luca P.B. Robinson, Belen Morote, Neha Aryasomayajula and Juliana Yu.
“Supernova” Science At Saturn

Cassini made first ever observation of near-relativistic electrons accelerated within Saturn’s bowshock.

Electrons were accelerated to ultra-high, relativistic energies when an unusually strong blast of solar wind compressed Saturn’s bowshock (blue).

This event is similar to shock-acceleration of particles taking place around supernovas and may be the dominant source of high-energy cosmic rays that pervade our galaxy.
Tracking ‘Space Weather’ from the Sun to Saturn: Cassini Sees the Birth of an Aurora

How does a disturbance from the sun energize a planetary environment different from the Earth? Where do similarities lie and differences begin?

Evidence of newly energized particles is seen by MIMI’s Ion and Neutral Camera

Quiet aurora is observed on Saturn in the infrared before the storm

A burst of radio emission, a known response to solar wind activity, is detected by the radio and plasma wave instrument

A major solar wind disturbance is on its way

Ultraviolet scans of the north pole reveal how the atmosphere responds to the arrival of the solar disturbance

Hubble Space Telescope captures the same event from across the solar system
A New Moon is Born???

Bright ring feature discovered on outer edge of A ring

Appears to be associated with birth of small, icy infant moon nicknamed Peggy

23 July 2014
“Proto-Peggy” Clumps Cast Shadows
Clumps on Outer Edge of B ring
Saturn’s moon Enceladus harbors a large, 10-km deep underground ocean of liquid water underneath south pole.

Ice crust 30-40 km thick

Potential habitat for life
Three firsts for Cassini Radio Science (RSS)
- First time bouncing a RSS radio signal off from Titan seas (bistatic experiment)
- First ever detection of Ka-band echoes off of Titan during a RSS bistatic experiment
- First radio occultations of Titan’s atmosphere with new “2-way” radio science mode

Bistatic experiments yield information on a surface’s electrical properties, and in turn composition, and on surface roughness
Occultations provide information on the thermal structure of the atmosphere
A Salty Sea and Methane Hot-Spots

A relatively high density, equivalent to the saltiest bodies of water on Earth, was required for Titan's ocean in order to explain the gravity data.

The moon's icy shell is rigid and in the process of freezing solid so any outgassing of methane into Titan's atmosphere must happen at scattered "hot spots".
Cassini Sends 50th Anniversary Greetings to Deep Space Network

“Congratulations Deep Space Network on 50 Years of Communications and Discovery!”
On June 30, 2014, Cassini marked 10 years of exploring the Saturn system.
Naming Contest for Final orbits: Cassini Grand Finale
Cassini’s Final Four Years: Unique Science

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- Explore new seasons at Saturn and Titan until northern summer solstice
- Titan: Look for waves on lakes and seas; measure depth of largest lake
- Enceladus: Sample plume at maximum emission for the first time; best high resolution view of the north pole
- Rings: Best lighting angle on lit rings (spring 2015 onward)
- Late, close orbits provide completely new, *in-situ* measurements
- 2014-2016 accomplishes great science while setting up proper orientation of final orbits
- Without Cassini, these types of observations could not be fulfilled for decades to come
Radio Science shines on this 100th pass to:
1) improve the measurement of tides to confirm the presence of a global subsurface ocean
2) determine the exact shape and the presence of large scale gravity anomalies
3) determine the rheology of how the icy crust changes

Note that the data presented here is minimally processed and is undergoing refinement and analysis.
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Saturn’s moon Enceladus harbors a large, 6-mile deep underground ocean of liquid water, indicated by gravity measurements by the Cassini spacecraft and Deep Space Communications network.

- Radio measurements of Enceladus’ gravity indicate an interior reservoir of liquid water, which may be connected to water jets gushing from fractures near the small moon’s south pole.

- The newly reported finding validates the inclusion of Enceladus among the most likely places in our solar system to potentially host life.

“Supernova” Science At Saturn

The next best thing to a spacecraft orbiting a supernova is Cassini being present for the first ever observation of near-relativistic electrons accelerated within Saturn’s bowshock (represented by blue region in the graphic below).

Electrons were accelerated to ultra-high, relativistic energies when an unusually strong blast of solar wind compressed the bowshock, the region where Saturn’s magnetosphere meets the solar wind.

This event is similar to shock-acceleration of particles taking place around supernovas and may be the dominant source of high-energy cosmic rays that pervade our galaxy.

Cassini data is providing unprecedented insights into how energetic particles are generated at supernova boundaries.


This artist’s concept illustrates Saturn's invisible magnetic field lines (gray) and the invisible bowshock (blue) where Saturn's magnetic field is compressed by the incoming super-sonic solar wind.
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“Shishi Odoshi” Effect Controls the Frequency of Filling and Flushing Saturn’s Magnetosphere

Cassini data have shown that Saturn’s magnetosphere fills with material from Enceladus’ jets and Saturn’s rings. Some of this mass becomes ionized by sunlight and migrates to Saturn’s night side where it stretches out the magnetotail and is shed from the system. With the mass unloaded, the magnetosphere elastically returns to its co-rotating flow around the planet. The period is estimated to take 8 to 31 hours.

New research suggests that this cycle may speed up by hours when, for example, Enceladus is more active, or near the Saturnian solstice (when more of the rings are in sunlight) or near solar maximum (when the Sun is brightest).

A “shishi odoshi” collects dripping water and when full, tips to empty its load. It returns to its resting state for the process to repeat. A faster flow of water means the bamboo tips more often.

A greater rate of mass flow into Saturn’s magnetosphere will increase the frequency of mass unloading and restoration of the magnetosphere to its “refill” state.
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