## CHARM: Cassini-Huygens Mission to Saturn $8^{\text {th }}$ Anniversary, Titan Highlights

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## Cassini Mission Overview

Four-Year Prime Tour, Equinox Mission, and Solstice Mission (Proposed), May 2004 - September 2017

|  | P r | m e M | 4 i s s | i 0 n | Equinox | Mission |  | 1 s | t i c | e | M i | s i | - n |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Year of Tour | '04-'05 | $\left\|\begin{array}{c} 2 \\ 05-06 \end{array}\right\|$ | $\begin{gathered} 3 \\ \prime 06-07 \end{gathered}$ | $\left\lvert\, \begin{gathered} 4 \\ \prime 07-08 \end{gathered}\right.$ | $\begin{gathered} 5 \\ \prime 08-09 \end{gathered}$ | $\left\lvert\, \begin{gathered} 6 \\ \prime-10-10 \end{gathered}\right.$ | '10-11 | $\begin{gathered} 8 \\ \cdot 11-12 \end{gathered}$ | $\left\lvert\, \begin{gathered} 9 \\ \cdot 12-13 \end{gathered}\right.$ | $\left\lvert\, \begin{gathered} 10 \\ \cdot 13-' 14 \end{gathered}\right.$ | $\left\lvert\, \begin{gathered} 11 \\ \cdot 14-15 \end{gathered}\right.$ | $\left\lvert\, \begin{gathered} 12 \\ \prime 15-16 \end{gathered}\right.$ | $\left\lvert\, \begin{gathered} 13 \\ \cdot 16-17 \end{gathered}\right.$ |
| Orbits | 11 | 15 | 22 | 27 | 39 | 21 | 16 | 19 | 25 | 12 | 12 | 20 | 56 |
| Titan | - | $\bigcirc$ | 0 | - | 0 | 0 | - | - 0 | 0 | - 0 | - | 0 | - |
| *Huygens | ${ }^{*}$ - | $\bigcirc$ | 0 | - | 0 | - | - | - | - 0 | - | - | - | - 0 |
|  | $\bigcirc$ | 0 | 0 | $\bigcirc$ | 0 | 0 | 0 | $\bigcirc$ | - 0 | 0 | 0 | - 0 | 0 |
|  |  | 0 | 0 | 0 | 0 | 0 | $\bigcirc$ |  | $\bigcirc$ | 0 | 0 | 0 |  |
|  |  | $\bigcirc$ | $\bigcirc$ | - | 0 | 0 |  |  |  | 0 | $\bigcirc$ | - |  |
|  |  |  | 0 | - | 0 | - |  |  |  | $\bigcirc$ |  | $\bigcirc$ |  |
| Enceladus | 7 | $?$ |  | 9 | 90 | 00 | 00 | 00 |  |  |  | 00 | , |
|  |  |  |  |  | 0 | 00 | 0 | 00 |  |  |  | 0 |  |
|  |  |  |  |  |  |  |  | 00 |  |  |  |  |  |
| Other IcySatellites | YPhoebe | Otethys OHyperion ODione Telesto ORhea |  |  |  | Onimas | Orhea | $\bigcirc$ Dione | ORhea |  | ODione | ODione | d) |
|  |  |  |  | Clapetus |  | Orhea | OHelene | Oione |  |  | OTethys | WEpinathers | , |
| (under 10,000 km) |  |  |  | ()Epimeneus |  | OHelene |  | OTethys |  |  |  | $J \mathrm{G}$ arc |  |
|  |  |  |  |  |  | ODione |  | OMethone |  |  |  |  |  |
|  |  |  |  |  |  |  |  | Telesto |  |  |  |  |  |

## Titan Encounters:

## T78, 12 Sept 2011 T79, 13 Dec 2011 T80, 2 Jan 2012 T81, 30 Jan 2012 T82, 19 Feb 2012 T83, 22 May 2012

## T84, 6 June 2012 T85, 24 July 2012 T86, 26 Sept 2012

## ISS map of Titan

## Map of Saturn's Moon Titan - April 2011



## Seasonal changes

- Voyager 1, Nov. 1980 ~ March 29
- Voyager 2, Aug. $1981 \approx$ April 8
- Cassini SOI, 2 July 2004 ~ mid-January
- 11 August $2009 \approx$ Northern vernal equinox
- 27 Sept. 2010 ~ early April; low-latitude storm
- 25 Sept. 2012 ~ late April
- May 2017 ₹ Northern summer solstice


## Seasonal changes:

## altitude of Titan's detached haze layer



# Seasonal changes: <br> Dissipation of north-polar cthane cloud 

Dec. 28, 2006


Mar. 27, 2009

Mar. 26, 2008
May 12, 2008


May 28, 2008


June 6, 2009

May 5, 2009


Le Mouelic et al., 2012
CHARM: Cassini's 8th Anniversary -- Titan!

## Seasonal changes:

## Dissipation of north-polar ethane cloud



Le Mouelic et al., 2012
CHARM: Cassini's 8th Anniversary -- Titan!

## Seasonal changes: Development of southpolar vortex and hood of high-altitude haze



T83
VIMS, 22 May and 7 June 2012

- Short video of polar vortex rotation @ ails/?videolD=247


## Dunes, Ksa Crater, and northwest Xanadu



# Dunes exhibit variations with latitude and altitude (Le Gall et al., Icarus, 2012) 

## Belet dunes

(2)


## Fensal dunes

## Lakes and methane supply



- Comparison of Ontario Lacus with Earth's Etosha salt pan (Cornet et al., 2012)
- Low-latitude oases near Shangri-La? (Griffith et al., 2012)
- Methane age <1 Gyr (CIRS data: Nixon et al., 2012; Cassini INMS, \& Huygens GCMS data: Mandt et al., 2012)


## Shape and internal structure



- Moment of inertia and 10-m tides consistent with differentiated interior and internal global ocean (Fortes, PSS, 2012; less et al., Science 2012)
- (Animated illustration of tides @ hito:://saturn.ipl.nasa.gov/video/videodetails/?videoID=246)
- Extra global flattening due to Titan's weather and carbon cycle? (Choukroun and Sotin, GRL, 2012)


## Titan 86 Flyby

26 Sept. 2011

- C/A altitude $=956 \mathrm{~km}$

Checking Titan's lonosphere

- INMS profile through ionosphere
- RADAR SAR imaging of southwest Ligeia Mare
- ISS, UVIS, CIRS observations including coverage of Adiri and the region where extensive surface changes were observed in the fall of 2010
- ISS cloud-tracking for an extra day after the encounter


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| Titan | $\bigcirc$ | 0 | 0 | 0 | 0 | 0 | 0 | - | 0 | 0 | 0 | - 0 | $\bigcirc$ |
| *Huygens V | ${ }^{*}{ }^{\circ}$ | 0 | 0 | 0 | 00 | 0 | 0 | - | 0 | 0 | 0 | - | 0 |
|  | $\bigcirc$ | $\bigcirc$ | 0 | $\bigcirc$ | 0 | - | 0 | - | - 0 | - 0 | - | - | 0 |
|  |  | $\bigcirc$ | 0 | 0 | 0 | 0 | $\bigcirc$ |  | $\bigcirc$ | 0 | 0 | 0 |  |
|  |  | $\bigcirc$ | 0 | - | 0 | 0 |  |  |  | 0 | $\bigcirc$ | - |  |
|  |  |  | 0 | - | 0 | - 0 |  |  |  | - |  | - |  |
| Enceladus | 39 | $?$ |  | $\bigcirc$ | 90 | 00 | 00 | 00 |  |  |  | 00 | - |
|  |  |  |  |  | $\bigcirc$ | 00 | 0 | 00 |  |  |  | $\bigcirc$ | , |
|  |  |  |  |  |  |  |  | 00 |  |  |  |  |  |
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| (under 10,000 km) |  | ODione |  | (2Epinenels |  | OHelene |  | OTethys |  |  |  | $J \mathrm{Garc}$ |  |
|  |  | Telesto |  |  |  | $\bigcirc$ Dione |  | OMethone |  |  |  |  |  |
|  |  | ORhea |  |  |  | $J_{G \text { arc }}$ |  | Telesto |  |  |  |  |  |

