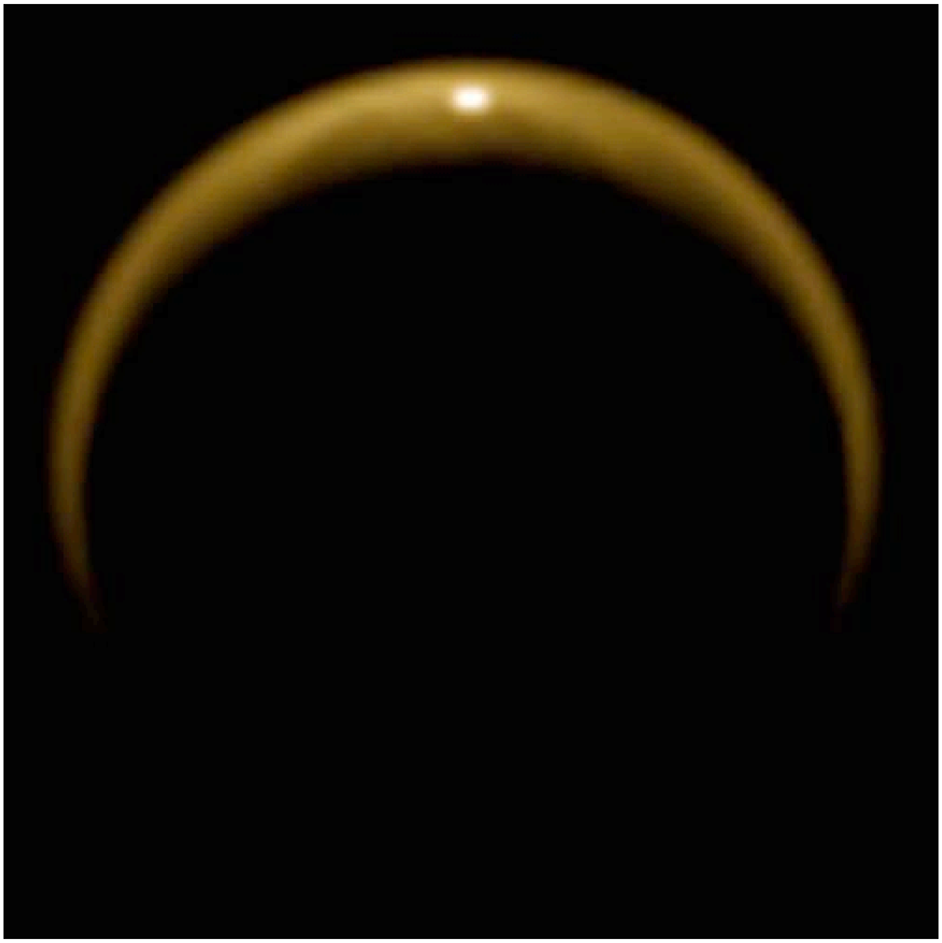
C A S S I N I



T I T A N 1 2 3 T I (T 6 4)
MISSION DESCRIPTION

December 27, 2009

Jet Propulsion Laboratory
California Institute of Technology

Cover image: [Reflection of Sunlight off Titan]

This image shows the first flash of sunlight reflected off a lake on Saturn's moon Titan. The glint off a mirror-like surface is known as a specular reflection. This kind of glint was detected by the visual and infrared mapping spectrometer (VIMS) on NASA's Cassini spacecraft on July 8, 2009. It confirmed the presence of liquid in the moon's northern hemisphere, where lakes are more numerous and larger than those in the southern hemisphere. Scientists using VIMS had confirmed the presence of liquid in Ontario Lacus, the largest lake in the southern hemisphere, in 2008.

The northern hemisphere was shrouded in darkness for nearly 15 years, but the sun began to illuminate the area again as it approached its spring equinox in August 2009. VIMS was able to detect the glint as the viewing geometry changed. Titan's hazy atmosphere also scatters and absorbs many wavelengths of light, including most of the visible light spectrum. But the VIMS instrument enabled scientists to look for the glint in infrared wavelengths that were able to penetrate through the moon's atmosphere. This image was created using wavelengths of light in the 5 micron range.

By comparing the new image to radar and near-infrared light images acquired from 2006 to 2008, Cassini scientists were able to correlate the reflection to the southern shoreline of a Titan lake called Kraken Mare. The sprawling Kraken Mare covers about 400,000 square kilometers (150,000 square miles). The reflection appeared to come from a part of the lake around 71 degrees north latitude and 337 degrees west latitude.

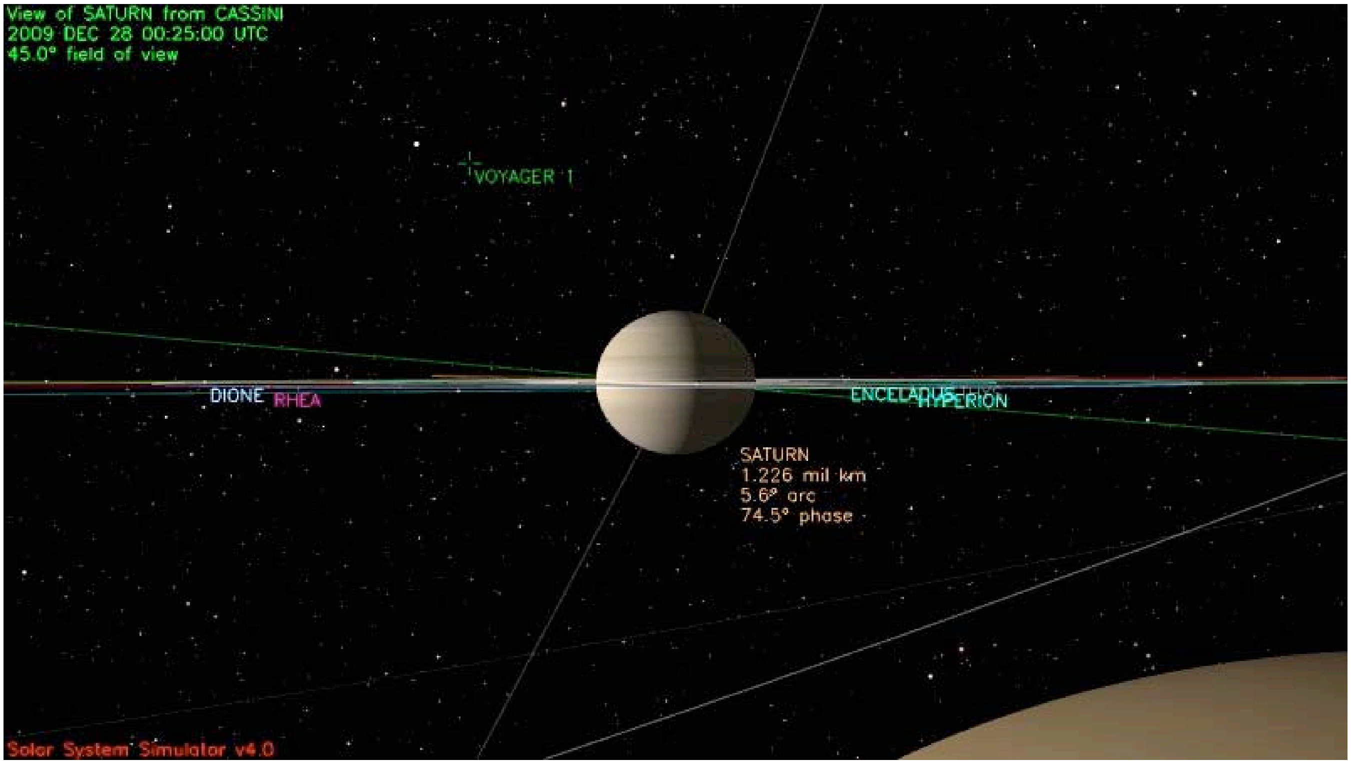
It was taken on Cassini's 59th flyby of Titan on July 8, 2009, at a distance of about 200,000 kilometers (120,000 miles). The image resolution was about 100 kilometers (60 miles) per pixel. Image processing was done at the German Aerospace Center in Berlin and the University of Arizona in Tucson.

The Cassini-Huygens mission is a cooperative project of NASA, the European Space Agency and the Italian Space Agency. The Jet Propulsion Laboratory, a division of the California Institute of Technology in Pasadena, manages the mission for NASA's Science Mission Directorate, Washington, D.C. The Cassini orbiter was designed, developed and assembled at JPL. The visual and infrared mapping spectrometer team is based at the University of Arizona, Tucson. Credit: NASA/JPL/University of Arizona/DLR

1.0 OVERVIEW

Sixteen days after the previous Titan visit, Cassini returns to Saturn's largest moon for the mission's sixty-fifth targeted encounter with Titan. The closest approach to Titan occurs on Monday, December 28 at 362T00:16:59 spacecraft time at an altitude of 955 kilometers (~593 miles) above the surface and at a speed of 6.0 kilometers per second (~13,400 mph). The latitude at closest approach is 82 degrees N and the encounter occurs on orbit number 123.

This encounter is set up with two maneuvers: an apoapsis maneuver on December 19, and a Titan approach maneuver, scheduled for December 24. T64 is the second flyby in a series of four outbound encounters and the twentieth Titan encounter in Cassini's Equinox Mission. It occurs just under two days before Saturn closest approach.


View of SATURN from CASSINI
2009 DEC 28 00:25:00 UTC
45.0° field of view
VOYAGER 1
DIONE
RHEA
ENCELADUS
HYPERION
SATURN
1.226 mil km
5.6° arc
74.5° phase
Solar System Simulator v4.0

ABOUT TITAN

Titan, although a satellite of Saturn, is larger than the terrestrial planet Mercury. It has a dense atmosphere of nitrogen and methane and a surface covered with organic material. In many ways it is Earth's sister world, which is one reason why the Cassini-Huygens mission considers Titan among its highest scientific priorities. Our knowledge and understanding of Titan, Saturn's largest moon, have increased significantly as a result of measurements obtained from the Cassini spacecraft following its arrival at Saturn in June, 2004 and with measurements from the descent of the Huygens probe through Titan's atmosphere and onto the moon's surface in January, 2005.

Although Titan is far colder and lacks liquid water, the chemical composition of Titan's atmosphere resembles that of early Earth. This, along with the surprisingly complex organic chemistry that takes place in Titan's atmosphere, prompts scientists to believe that Titan could provide a laboratory for seeking insight into the origins of life on Earth. Data from the Huygens probe and the Cassini orbiter has shown that many of the processes that occur on Earth also apparently take place on Titan – impact cratering, wind, possible volcanism, as well as rain, river channels, lakes and even seas all contribute to shaping Titan's surface. However, at an inhospitable -290 degrees Fahrenheit (-179 degrees Celsius), the chemistry that drives these processes is fundamentally different from Earth's. For example, methane plays many of the roles on Titan that water does on Earth. Large tectonic structures seem to be lacking from Titan; however, as on Earth, such structures would be eroded by flowing liquid and material blowing across the surface, making them difficult to identify.

The Huygens probe landed near a bright region now called Adiri. Images sent back to Earth showed light hills cut by dark river beds that empty into a dark plain. Before the Huygens probe arrived, scientists believed that this dark plain could be a lake or at least a muddy material. But Huygens actually landed *in* this dark plain, revealing a surface of gravel and small boulders made of water ice. Scientists believe it only rains occasionally on Titan, but that the methane rains are extremely fierce when they come, carving channels in the surface similar to those observed in arid regions on Earth.

Only a small number of impact craters have been discovered. This suggests that, like Earth, Titan's surface is constantly being resurfaced by erosion, caused by both flowing liquid and wind. Cryovolcanism may be another resurfacing mechanism, with the lava consisting of a fluid mixture of water and possibly ammonia, believed to be expelled from volcanoes and hot springs. Some surface features, such as lobe-shaped flows, appear to be volcanic in origin, giving further support to the cryovolcanism theory. In addition, volcanism is now believed to be a significant source of methane in Titan's atmosphere, since there are no oceans of hydrocarbons as had been hypothesized previously.

Dunes cover large areas of the surface. The dunes may be made of hydrocarbon particulate material, or possibly solid accumulations of hydrocarbons. Whatever their nature, the dunes contain less water ice than other parts of Titan's surface, and might consist of haze particles produced in the atmosphere rather than being composed of the equivalent of sand produced by erosion.

The existence of oceans or lakes of liquid methane on Saturn's moon Titan was predicted more than 20 years ago. Radar, imaging and spectral data from Titan flybys have provided convincing evidence for large bodies of liquid near Titan's north and south poles. With Titan's colder temperatures and hydrocarbon-rich atmosphere, these lakes and seas contain a combination of liquid methane and ethane (both hydrocarbons), not water. Ongoing monitoring of the lakes will tell us more about Titan's methane cycle and methane table, and if these are subject to seasonal change. Radar mapping and gravity data suggest that Titan has an interior ocean of liquid water and ammonia, perhaps 100 km (60 miles) below the surface.

Cassini-Huygens arrived at Saturn during the planet's northern winter and southern summer (roughly the equivalent of mid-January on Earth). During Cassini's four-year nominal mission, as Saturn has moved towards its vernal equinox (which it reached in August 2009), changes in Titan's cloud distribution have been observed that may be due to the advancing seasons. In the early part of the Cassini mission, large convective cloud systems were observed at the south (summer) pole, but these have become less common, while long streaks of clouds have been seen progressively further north. Titan's detached haze layer may also be subject to seasonal changes that push its altitude higher.

The Cassini-Huygens mission, using wavelengths ranging from ultraviolet to radio, continues to reveal more of Titan and answer long-held questions regarding Titan's interior, surface, atmosphere, and the complex interaction with Saturn's magnetosphere. While many pieces of the puzzle are yet to be found, with each Titan flyby comes a new data set that furthers our understanding of this fascinating world.

1.1 TITAN-64 SCIENCE HIGHLIGHTS

- **INMS:** INMS is prime on the inbound leg of T64, and riding with RADAR outbound. This nearly North polar pass is critical when paired with T65, which is nearly South polar. Scientists are eager to take advantage of the opportunity to view the North and South poles in close temporal proximity to compare the atmosphere and the surface topography. This pass will also help study the seasonal variation that may have occurred in the north pole since the early part of the nominal tour.

- **RADAR:** Observations include altimetry, ridealong SAR with INMS inbound to Titan, SAR outbound, altimetry, and HiSAR SAR over North polar lakes to perform stereo and/or seasonal change detection. This is the only north polar SAR in the extended mission.
- **VIMS:** This flyby will allow VIMS to acquire a mosaic of Titan between 160 and 300 longitudes at a resolution of 20 km/pixel. VIMS will keep monitoring for mid-latitude clouds and will survey the evolution of the North polar hood
- .**CIRS** will obtain mid-northern latitude composition and temperature vertical profiles.
- **ISS** will acquire a full-disk mosaic of Adiri and will ride along with VIMS to observe Adiri at higher-resolution and to monitor clouds. ISS will also monitor Titan to track clouds and the evolution thereof for an extra day after the Titan encounter.
- **MAG**: T64 is a north polar, dusk, flyby, with a minimum altitude of 955 km. In nominal upstream conditions, Cassini would explore the north lobe of Titan's magnetic tail, very close to the moon. Due to the location of the point of closest approach, it is potentially important regarding the detection of an intrinsic magnetic field, but not as good as T70. With adequate pointing of MAPS plasma instruments MAG data will be extremely helpful in the identification of escaping particles similar to those that could be seen in T63. If the upstream conditions are similar to T63, T64 will be extremely important to have an idea of the structure of Titan's magnetic tail in the dusk sector.
- **MIMI**. Energetic ion and electron energy input to atmosphere, high value.
- **RPWS** will measure thermal plasmas in Titan's ionosphere and surrounding environment; search for lightning in Titan's atmosphere; and investigate the interaction of Titan with Saturn's magnetosphere.

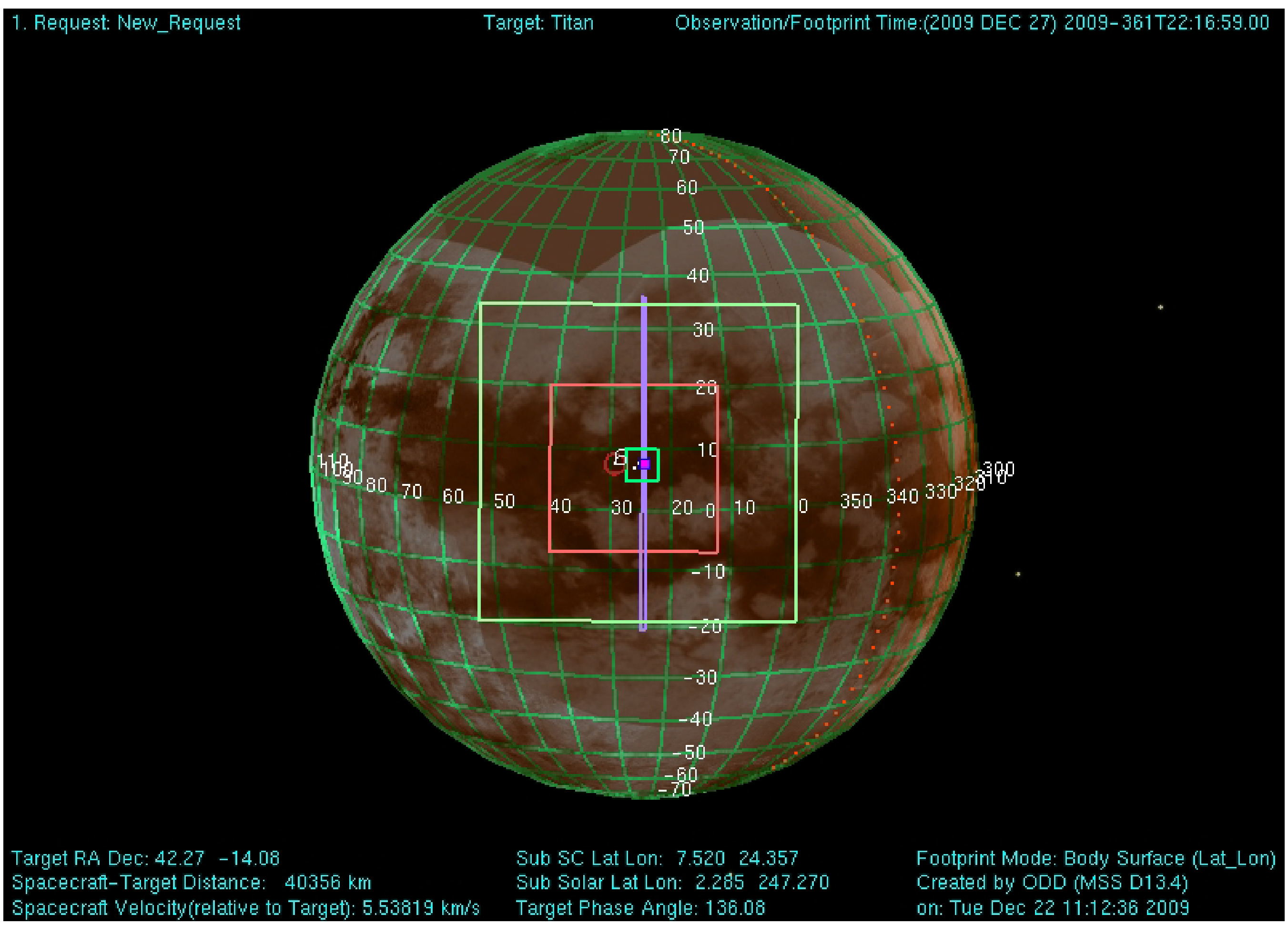
SAMPLE SNAPSHOTS

Three views of Titan from Cassini before, during, and after closest approach to Titan are shown below. The views are oriented such that the direction towards the top of the page is aligned with the Titan North Pole. The optical remote sensing instruments' fields of view are shown assuming they are pointed towards the center of Titan. The sizes of these fields of view vary as a function of the distance between Cassini and Titan. A key for use in identifying the remote sensing instruments fields of view in the figures is listed at the top of the next page.

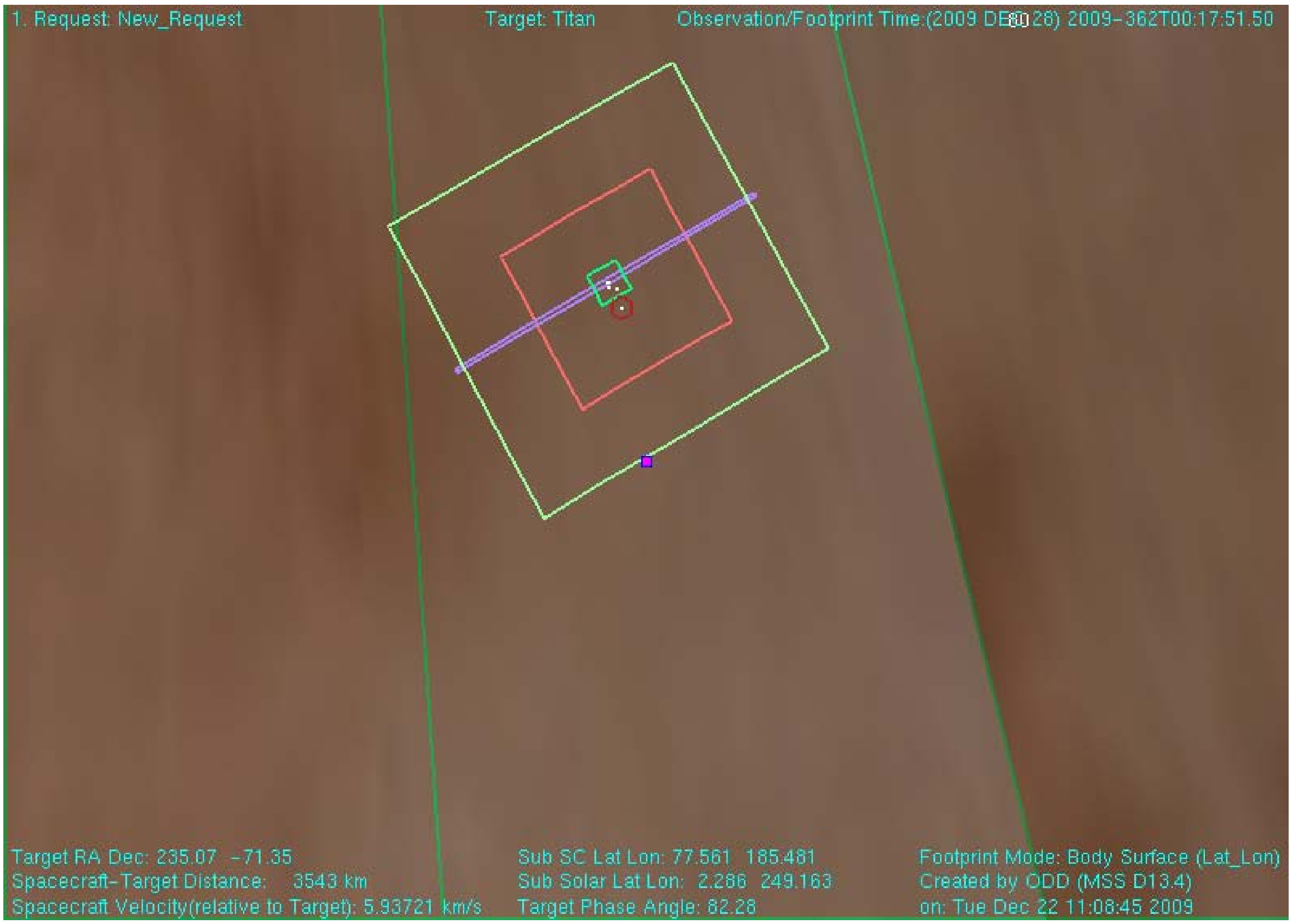
Key to ORS Instrument Fields of View in Figures

Instrument Field of View	Depiction in Figure
ISS WAC (imaging wide angle camera)	Largest square
VIMS (visual and infrared mapping spectrometer)	Next largest pink square
ISS NAC (imaging narrow angle camera)	Smallest green square
CIRS (composite infrared spectrometer) – Focal Plane 1	Small red circle near ISS_NAC FOV
UVIS (ultraviolet imaging spectrometer)	Vertical purple rectangle centered within largest square

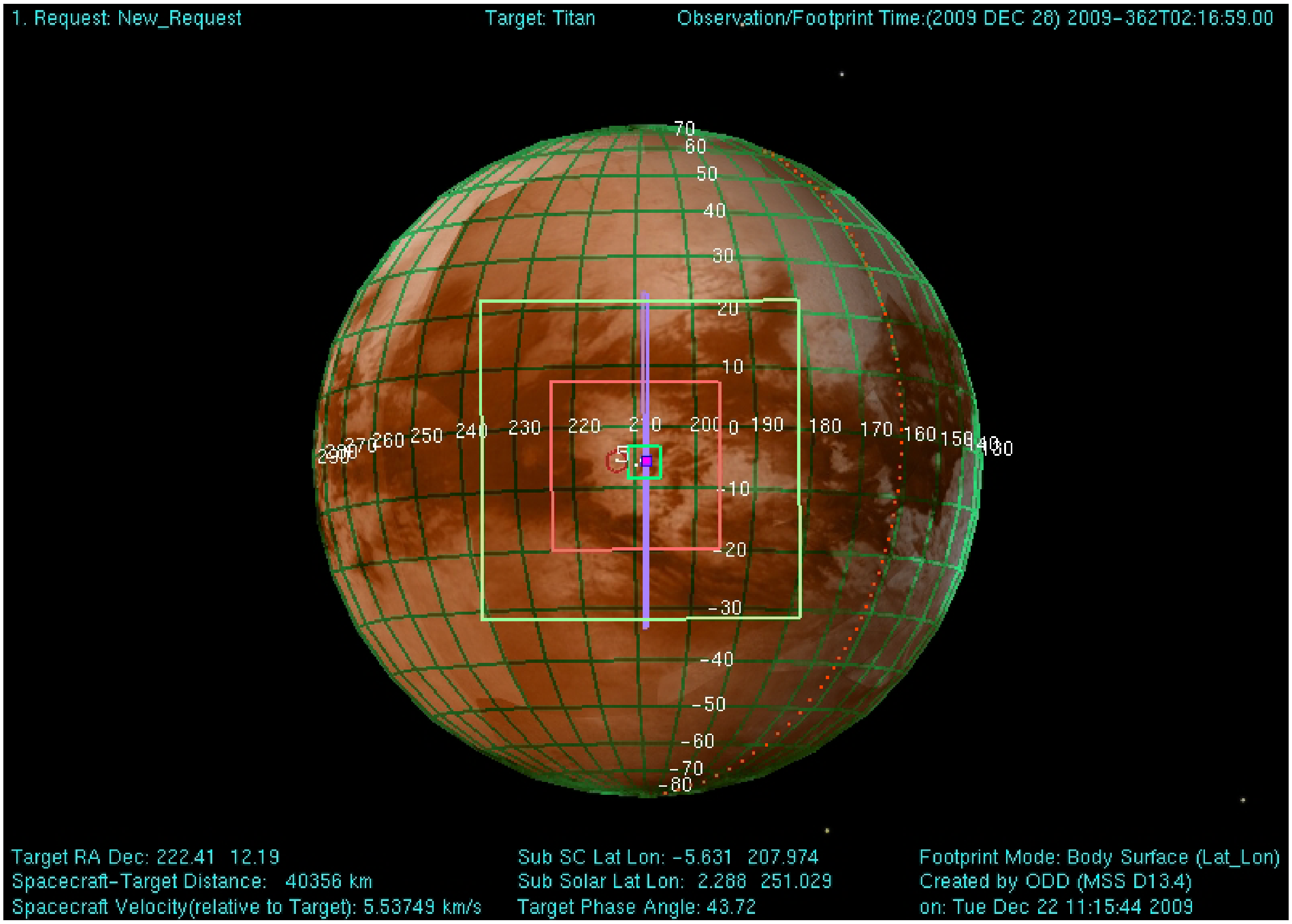
View of Titan from Cassini two hours before Titan-64 closest approach



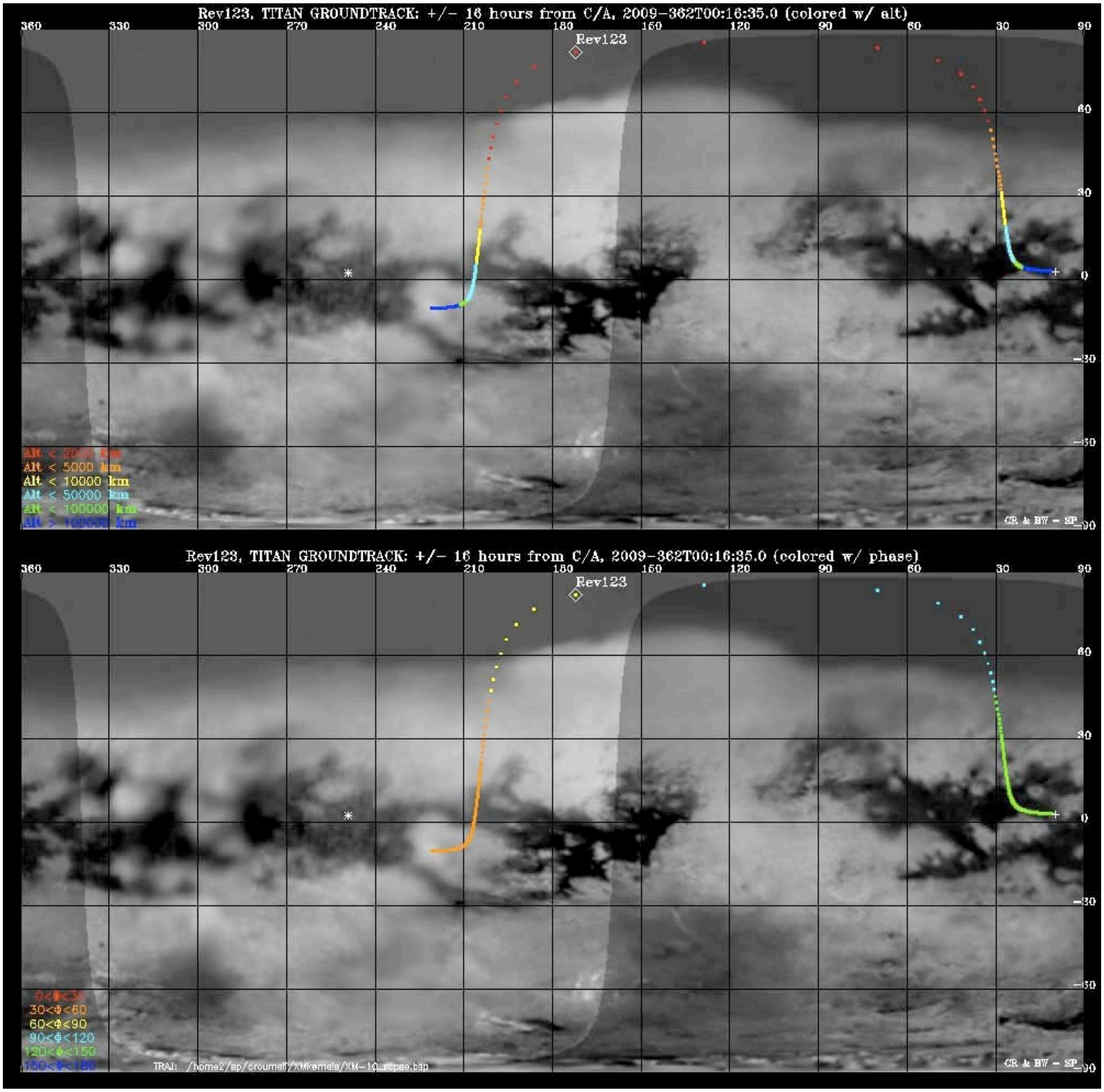
View of Titan from Cassini at Titan-64 closest approach



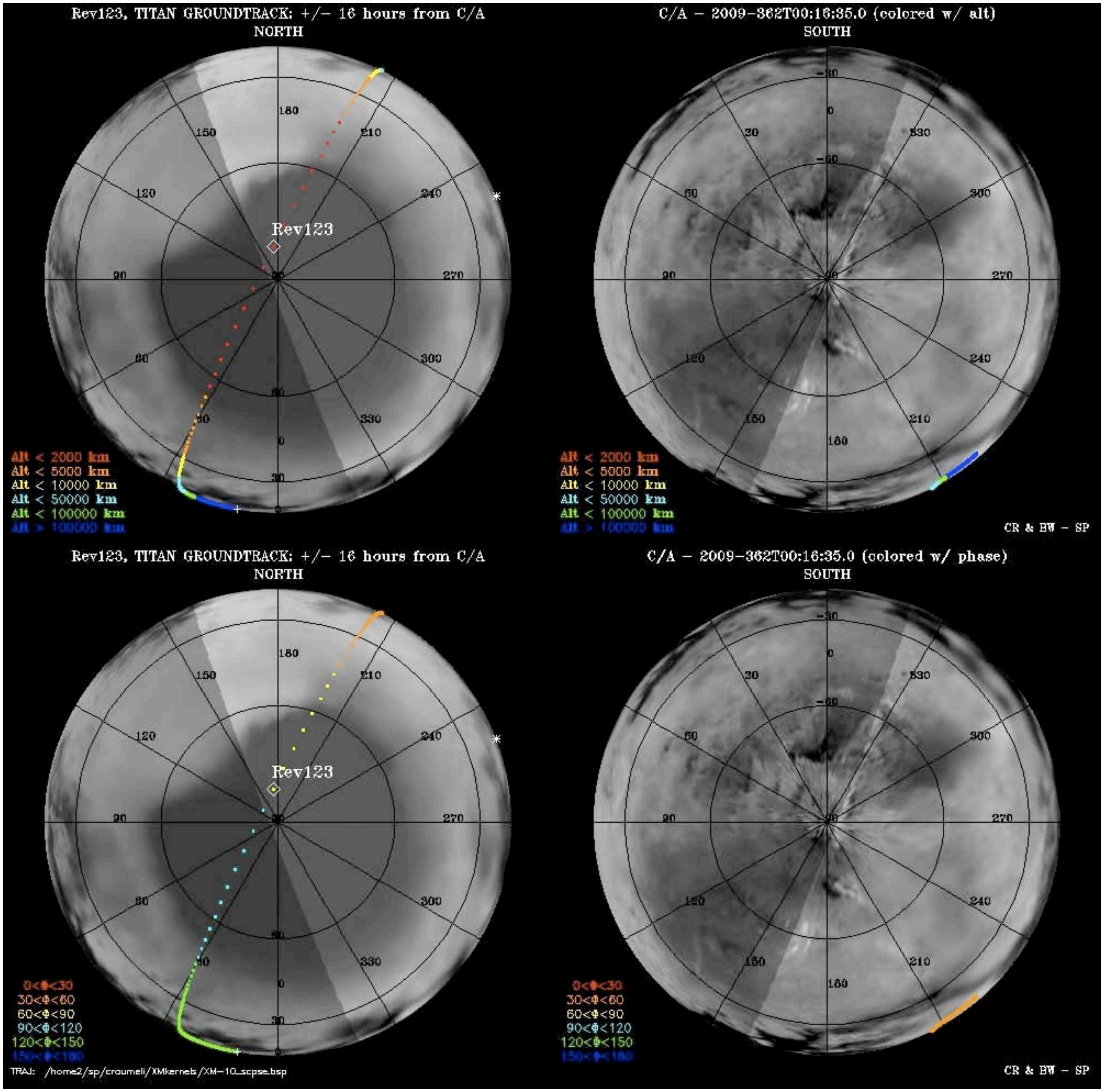
View of Titan from Cassini two hours after Titan-64 closest approach



Titan Groundtracks for T64: Global Plot



Titan Groundtracks for T64: Polar Plot



The T64 timeline is as follows:

Cassini Titan-64 Timeline - December 2009

Colors: yellow = maneuvers; blue = geometry; pink = T64-related; green = data playbacks

Orbiter UTC	Ground UTC	Pacific Time (PST)	Time wrt T64	Activity	Description
356T23:26:00	Dec 23 00:44	Tue Dec 22 04:44 PM	T64-05d01h	Start of Sequence S56	Start of Sequence which contains Titan-64
358T14:26:00	Dec 24 15:44	Thu Dec 24 07:44 AM	T64-03d10h	OTM #229 Prime	Titan-64 targeting maneuver.
359T07:57:00	Dec 25 09:15	Fri Dec 25 01:15 AM	T64-02d16h	OTM #229 Backup	
361T09:12:00	Dec 27 10:30	Sun Dec 27 02:30 AM	T64-15h04m	Start of the TOST segment	
361T09:12:00	Dec 27 10:30	Sun Dec 27 02:30 AM	T64-15h04m	Turn cameras to Titan	
361T09:52:00	Dec 27 11:10	Sun Dec 27 03:10 AM	T64-14h24m	New waypoint	
361T09:52:00	Dec 27 11:10	Sun Dec 27 03:10 AM	T64-14h24m	Deadtime	15 minutes 56\\24 seconds long; used to accommodate changes in flyby time
361T10:07:24	Dec 27 11:25	Sun Dec 27 03:25 AM	T64-14h09m	Titan atmospheric observations-CIRS	Obtain information on the thermal structure of Titan's stratosphere.
361T14:16:59	Dec 27 15:34	Sun Dec 27 07:34 AM	T64-10h00m	Titan atmospheric observations-ISS	Wide Angle Camera Photometry
361T15:16:59	Dec 27 16:34	Sun Dec 27 08:34 AM	T64-09h00m	Titan atmospheric observations-CIRS	Obtain vertical profiles of temperatures in Titan's stratosphere. The arrays are stepped along the limb at two altitudes at 5 degree latitude intervals.
361T19:16:59	Dec 27 20:34	Sun Dec 27 12:34 PM	T64-05h00m	Titan atmospheric observations-CIRS	Obtain information on surface & tropopause temperatures, and on tropospheric CH4. Scan or contiguous steps across disk.
361T22:01:59	Dec 27 23:19	Sun Dec 27 03:19 PM	T64-02h15m	Titan atmospheric observations-CIRS	Vertical sounding of stratospheric compounds on Titan, including H2O. Integrations at 2 locations on the limb displaced vertically.
361T23:00:59	Dec 28 00:18	Sun Dec 27 04:18 PM	T64-01h16m	Transition to thrusters	
361T23:01:59	Dec 28 00:19	Sun Dec 27 04:19 PM	T64-01h15m	Titan atmospheric observations-CIRS	Vertical temperature sounding of Titan's tropopause & stratosphere.
361T23:38:59	Dec 28 00:56	Sun Dec 27 04:56 PM	T64-00h38m	RADAR Observations	Inbound Altimetry
361T23:58:59	Dec 28 01:16	Sun Dec 27 05:16 PM	T64-00h18m	RADAR Observations	Inbound SAR
362T00:04:59	Dec 28 01:22	Sun Dec 27 05:22 PM	T64-00h12m	INMS MAPS campaign	RADAR SAR ride-along
362T00:16:59	**Dec 28 01:34**	**Sun Dec 27 05:34 PM**	**T64+00h00m**	**Titan-64 Flyby Closest Approach Time**	**Altitude = 955 km (~593 miles), speed =6.0 km/s (13,400 mph); 86 deg phase at closest approach**
362T00:16:59	Dec 28 01:34	Sun Dec 27 05:34 PM	T64+00h00m	RADAR Observations	Outbound SAR
362T00:34:59	Dec 28 01:52	Sun Dec 27 05:52 PM	T64+00h18m	RADAR Observations	Outbound Altimetry
362T00:46:59	Dec 28 02:04	Sun Dec 27 06:04 PM	T64+00h30m	RADAR Observations	Outbound HiSAR
362T01:14:59	Dec 28 02:32	Sun Dec 27 06:32 PM	T64+00h58m	Transition off of thrusters	
362T01:36:04	Dec 28 02:54	Sun Dec 27 06:54 PM	T64+01h20m	Titan atmospheric observations-VIMS	High-resolution Regional mapping
362T02:16:59	Dec 28 03:34	Sun Dec 27 07:34 PM	T64+02h00m	Titan atmospheric observations-VIMS	Regional mapping
362T02:57:03	Dec 28 04:15	Sun Dec 27 08:15 PM	T64+02h41m	Descending Ring Plane Crossing	
362T05:16:59	Dec 28 06:34	Sun Dec 27 10:34 PM	T64+05h00m	Titan atmospheric observations-CIRS	Obtain vertical profiles of temperatures in Titan's stratosphere. The arrays are stepped along the limb at two altitudes at 5 degree latitude intervals.
362T09:16:59	Dec 28 10:34	Mon Dec 28 02:34 AM	T64+09h00m	Titan atmospheric observations-CIRS	Obtain information on CO, HCN, CH4. Integrate on disk at airmass 1.5--2.0.
362T12:16:59	Dec 28 13:34	Mon Dec 28 05:34 AM	T64+12h00m	Titan surface observations-ISS	NAC Monitor
362T14:16:59	Dec 28 15:34	Mon Dec 28 07:34 AM	T64+14h00m	Titan surface observations-VIMS	Global mapping