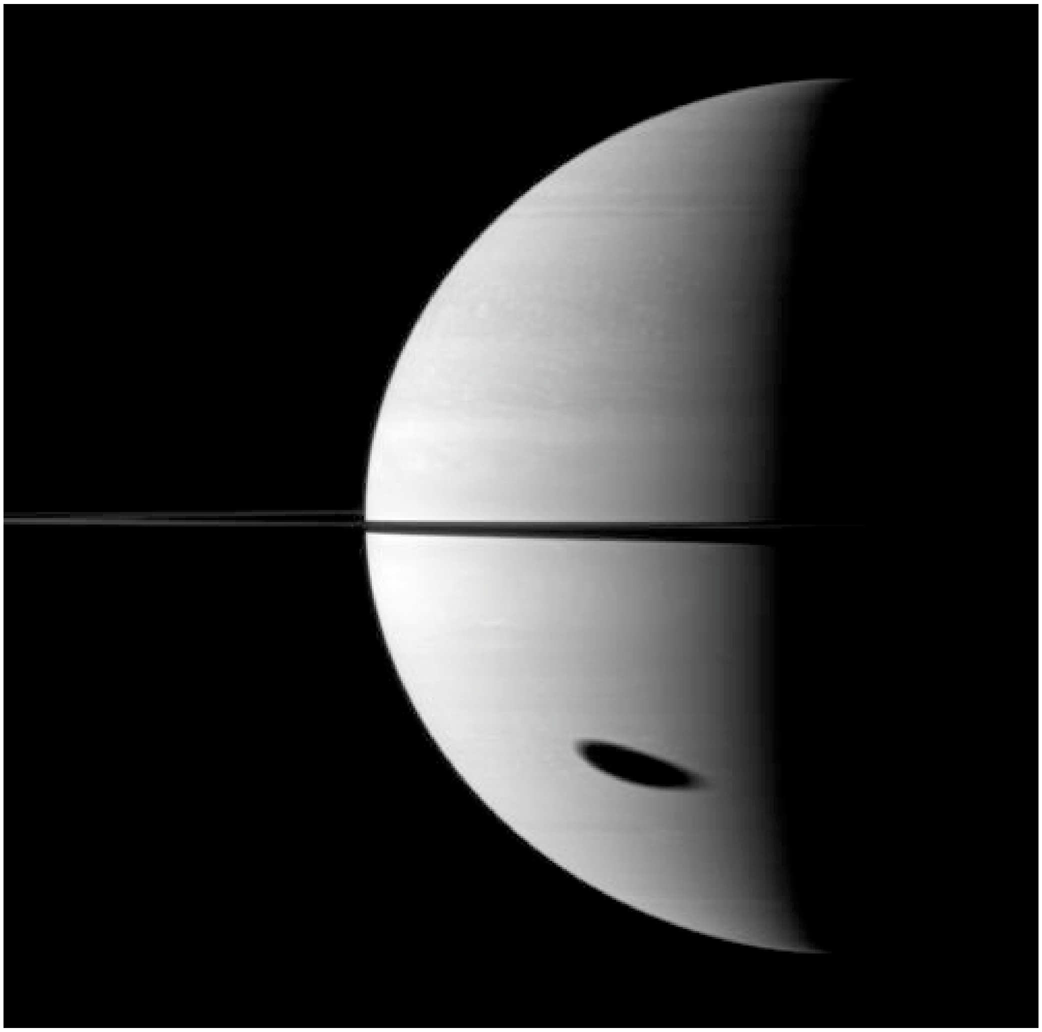
C A S S I N I



T I T A N 1 2 4 T I (T 6 5)
MISSION DESCRIPTION

January 12, 2010

Jet Propulsion Laboratory
California Institute of Technology

Cover image: Enormous Elongated Shadow

The shadow of Saturn's largest moon darkens a huge portion of the gas giant planet.

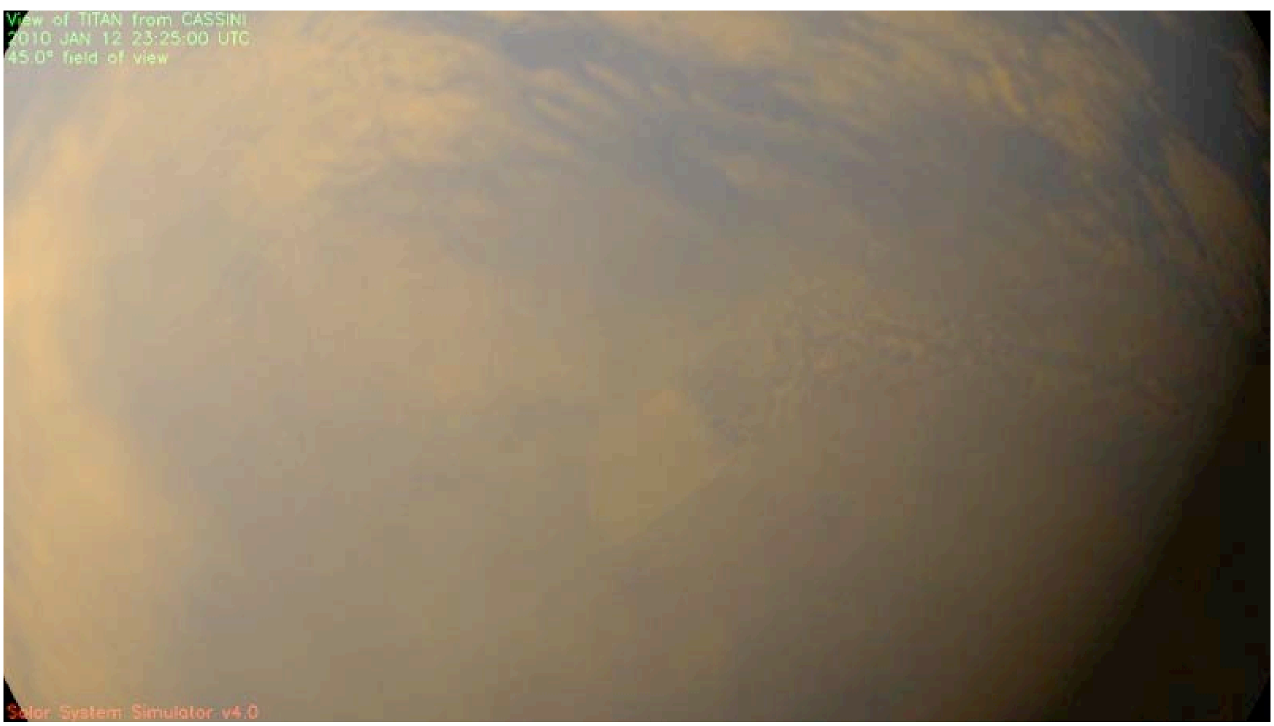
Titan (5,150 kilometers, or 3,200 miles across) is not pictured here, but its shadow is elongated in the bottom right of the image. This view looks toward the northern, sunlit side of the rings from just above the ringplane.

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 imaging operations center is based at the Space Science Institute in Boulder, Colo.Credit: NASA/JPL/Space Science Institute

1.0 OVERVIEW

Sixteen days after last flying by Titan, Cassini returns to Saturn's largest moon for the mission's sixty-sixth targeted encounter with Titan. The closest approach to Titan occurs on Monday, January 12 at 012T23:10:36 spacecraft time at an altitude of 1,073 kilometers (~667 miles) above the surface and at a speed of 5.9 kilometers per second (~13,200 mph). The latitude at closest approach is 82 degrees S and the encounter occurs on orbit number 124.

This encounter is set up with two maneuvers: an apoapsis maneuver on January 4, and a Titan approach maneuver, scheduled for January 9. T65 is the third flyby in a series of four outbound encounters and the twenty-first Titan encounter in Cassini's Solstice Mission. It occurs just under two days after Saturn closest approach.



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 kilometers (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-65 SCIENCE HIGHLIGHTS

- **CAPS:** The third of three opportunities for a CAPS extended mission prime encounter. Both inbound and outbound legs are good opportunities at a distance less than 17 Titan radii. In nominal upstream conditions, very close to the moon. A close comparison with T64 and T63 will give important results on the structure of Titan's tail in the dusk sector.

- **RADAR** is riding along with SAR observations with INMS inbound. There is SAR outbound to 8m SAR over Lacus Ontario
- **INMS** is prime on the inbound leg of T65 and rides along with RADAR outbound. This is the highest southern latitude pass in the mission. The ride along with RADAR provides a look at the polar surface and the polar atmosphere in a single flyby. It also provides excellent temporal proximity to T64 for comparison of the north and south polar regions.
- **CIRS** will obtain most observation types: surface temperature map, stratosphere map, and integrations for trace species and composition.
- **ISS** will ride along with CIRS to track clouds and will continue to monitor clouds and the evolution thereof for an extra day after the Titan encounter. ISS has no illuminated prime observations.
- **VIMS:** During this flyby, VIMS will be riding along with CIRS on the outbound where the phase angle is about 45 degrees. It provides a good opportunity to get a mosaic of the equatorial area between 160 and 270 longitude (corresponding to the western portion of Shangri-la, Adiri, and the probe landing site) at a resolution of 25 to 30 km/pixel. VIMS will keep monitoring for mid-latitude clouds. On the inbound leg, VIMS will look at the terminator.
- **MAG**: The T65 flyby is almost identical to T64, but it is over Titan's south pole. In nominal upstream conditions, Cassini will explore the south lobe of Titan's magnetic tail, very close to the moon. A close comparison with T64 and T63 will give important results on 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.

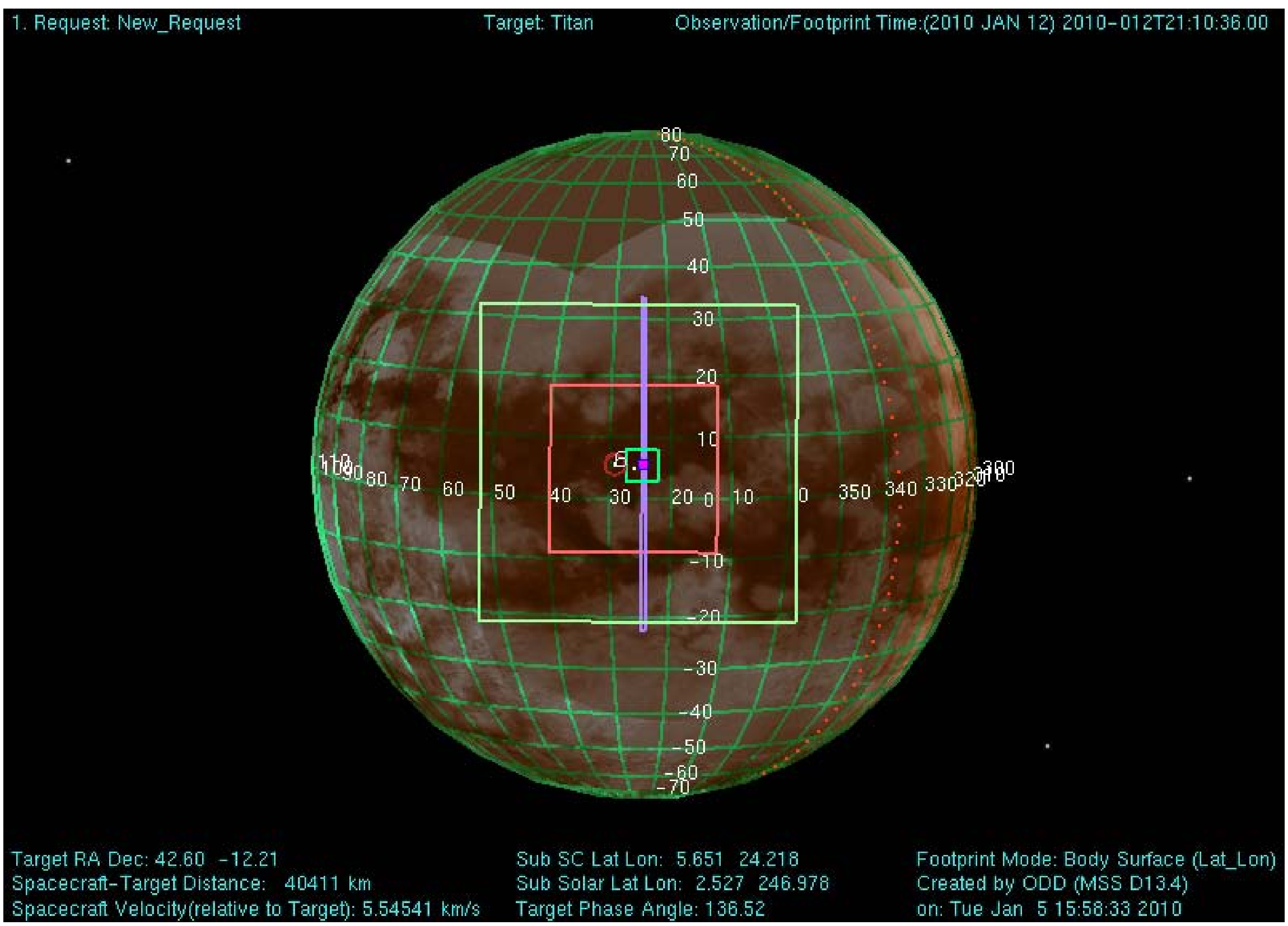
SAMPLE SNAPSHOTS

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.

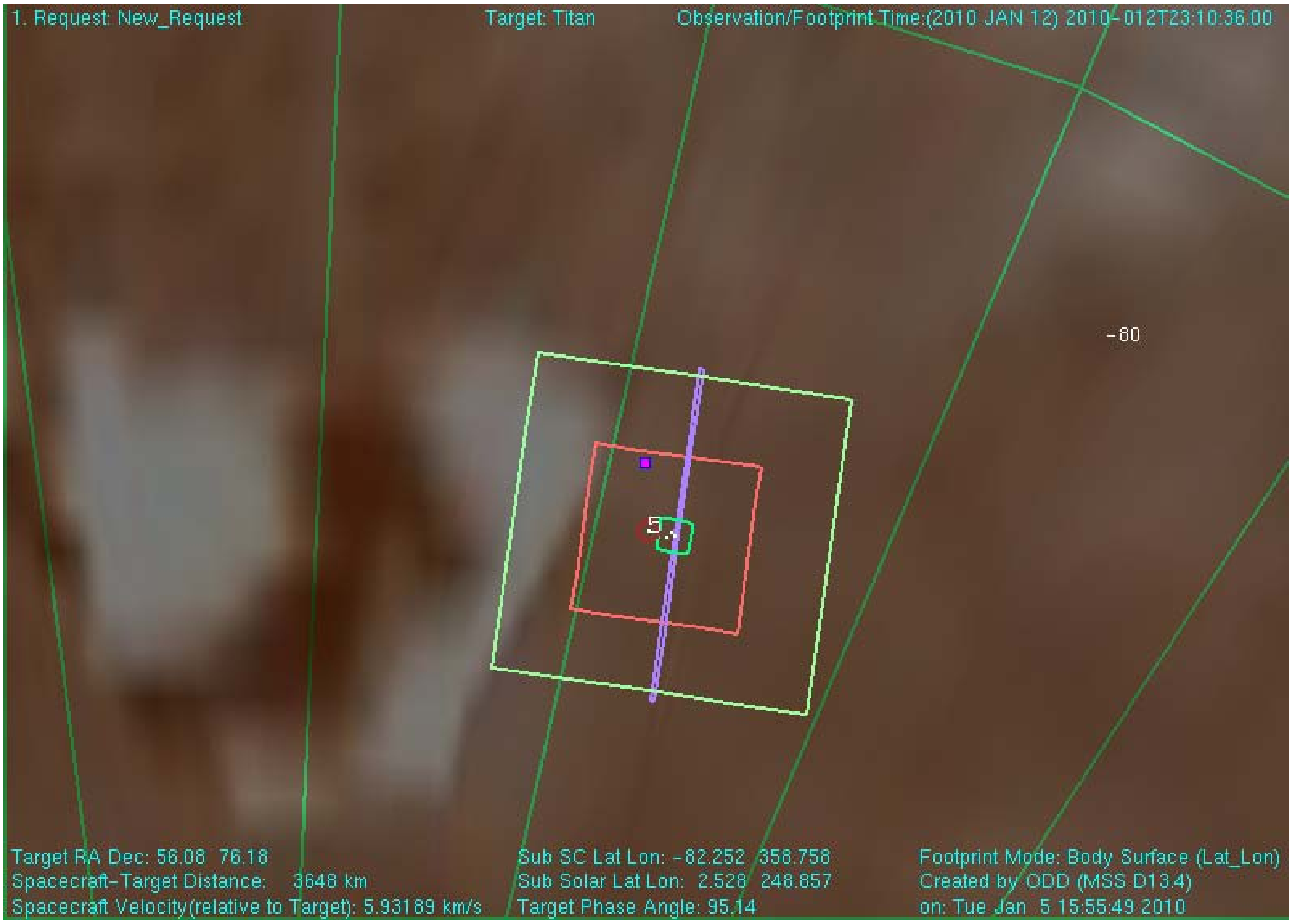
Key to ORS Instrument Fields of View in Figures

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

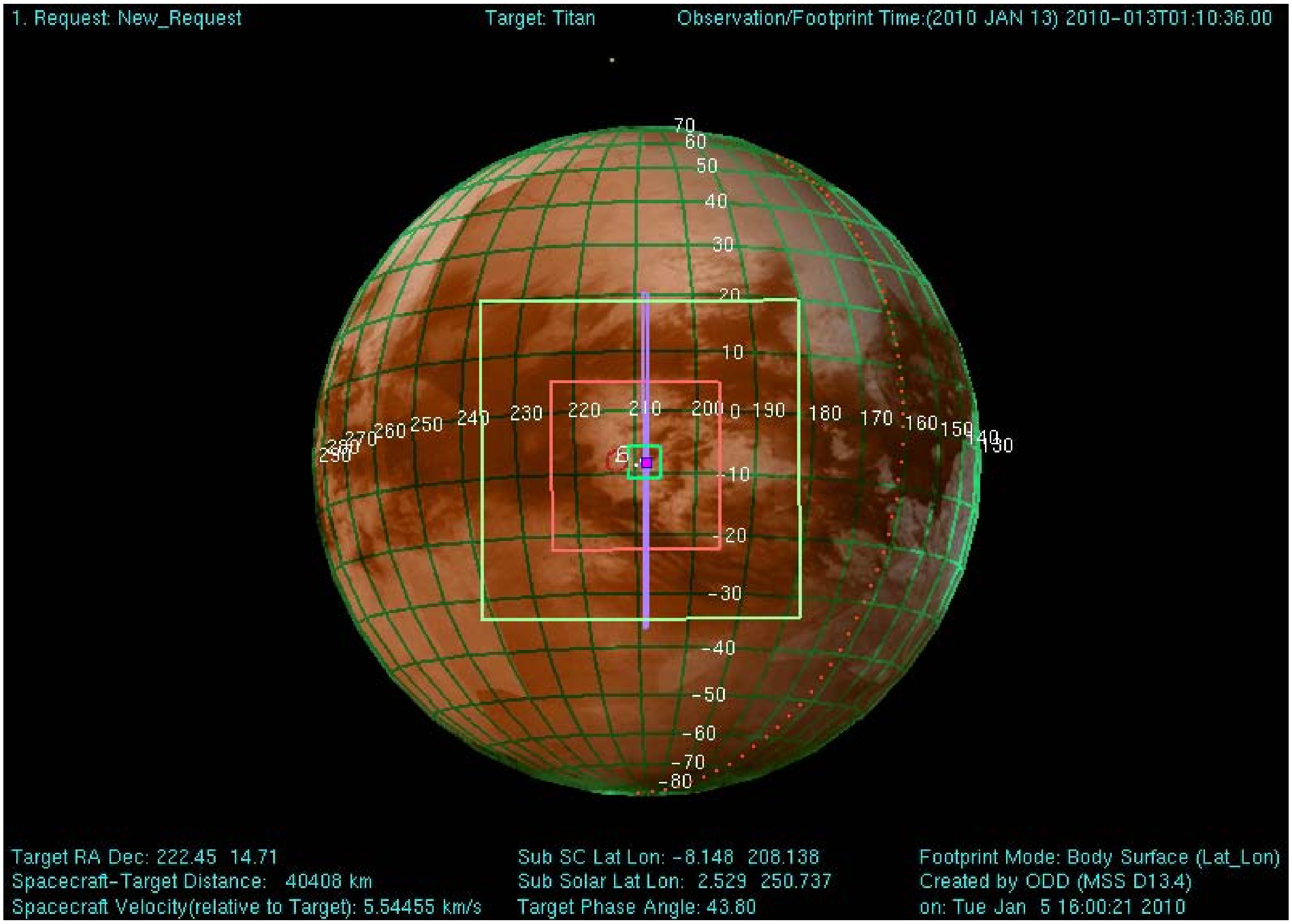
View of Titan from Cassini two hours before Titan-65 closest approach



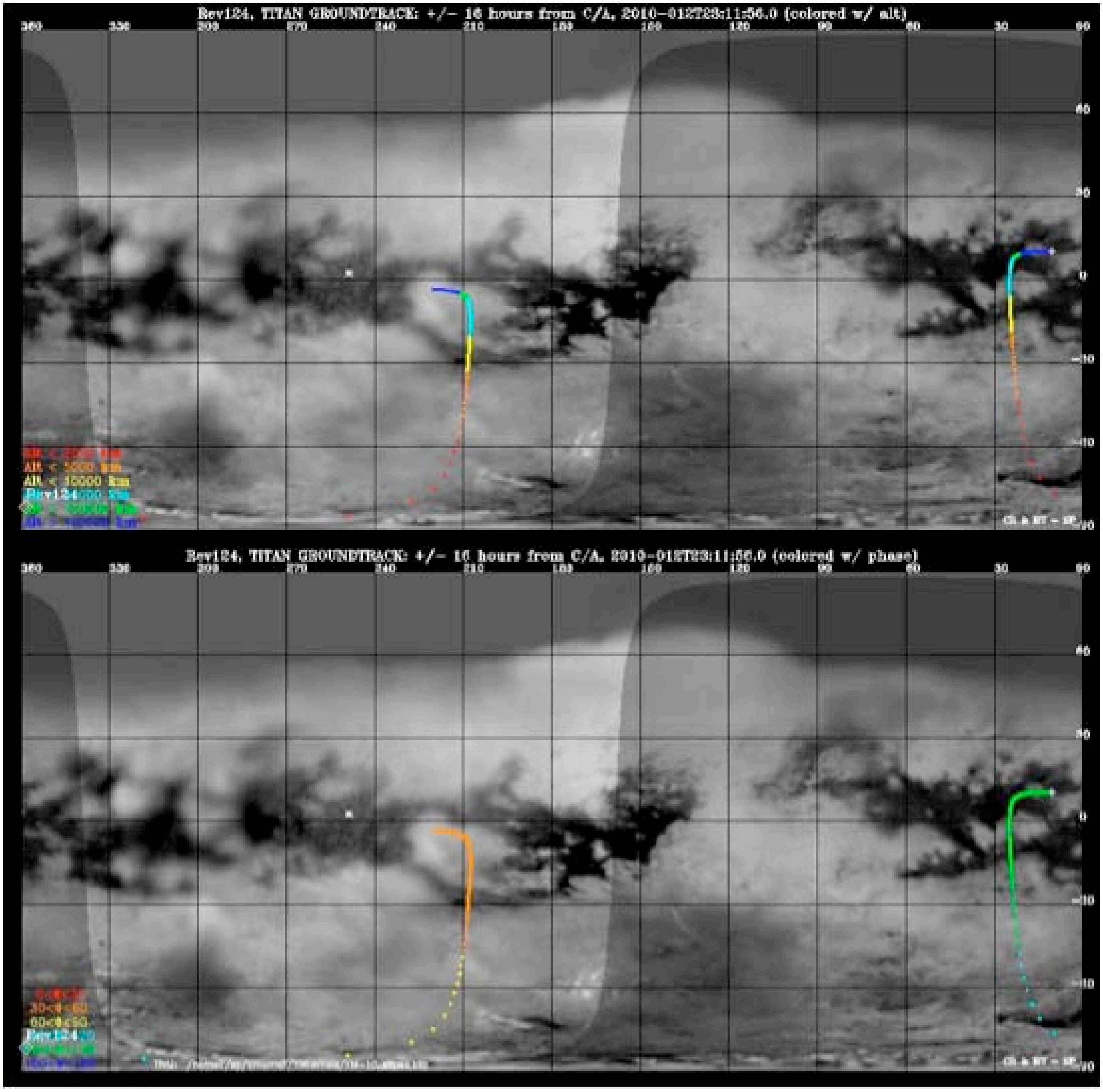
View of Titan from Cassini at Titan-65 closest approach



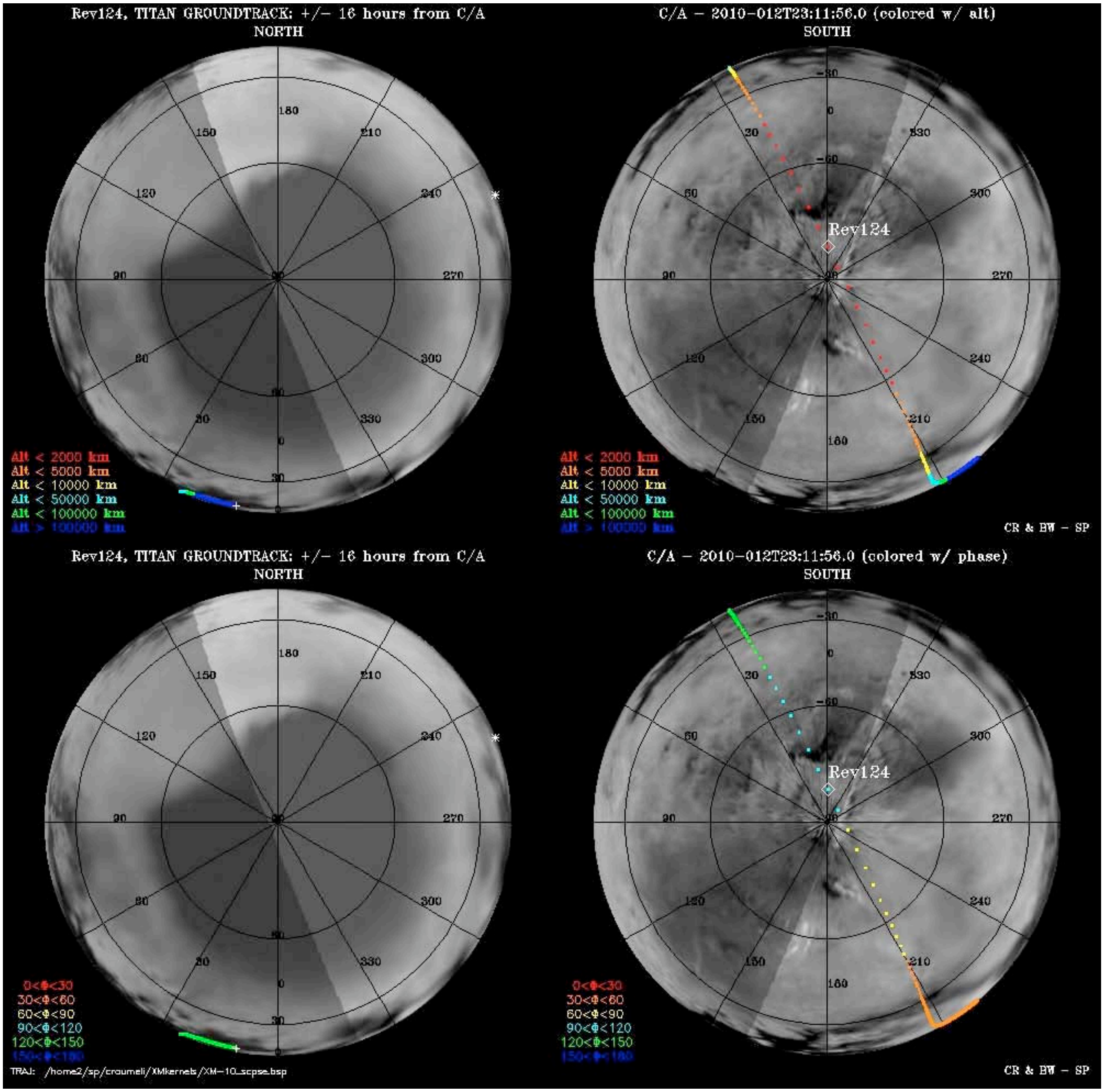
View of Titan from Cassini two hours after Titan-65 closest approach



Titan Groundtracks for T65: Global Plot



Titan Groundtracks for T65: Polar Plot



The T65 timeline is as follows:

Cassini Titan-65 - January 2010

Colors: yellow = maneuvers; blue = geometry; pink = T65-related; green = data playbacks

Orbiter UTC	Ground UTC	Pacific Time (PST)	Time wrt T65	Activity	Description
356T23:26:00	Dec 23 00:44	Tue Dec 22 04:44 PM	T65+344d00h	Start of Sequence S56	Start of Sequence which contains Titan-65
009T13:29:00	Jan 09 14:47	Fri Jan 09 06:47 AM	T65-03d10h	OTM #232 Prime	Titan-65 targeting maneuver.
010T06:59:00	Jan 10 08:17	Sat Jan 10 12:17 AM	T65-02d16h	OTM #232 Backup	
012T08:14:00	Jan 12 09:32	Mon Jan 12 01:32 AM	T65-14h56m	Start of the TOST segment	
012T08:14:00	Jan 12 09:32	Mon Jan 12 01:32 AM	T65-14h56m	Turn cameras to Titan	
012T08:54:00	Jan 12 10:12	Mon Jan 12 02:12 AM	T65-14h16m	New waypoint	
012T08:54:00	Jan 12 10:12	Mon Jan 12 02:12 AM	T65-14h16m	Deadtime	13 minutes 40 seconds long; used to accommodate changes in flyby time
012T09:07:40	Jan 12 10:25	Mon Jan 12 02:25 AM	T65-14h03m	Titan surface observations-VIMS	Cloud Mapping
012T14:10:36	Jan 12 15:28	Mon Jan 12 07:28 AM	T65-09h00m	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.
012T18:10:36	Jan 12 19:28	Mon Jan 12 11:28 AM	T65-05h00m	Titan atmospheric observations-CIRS	Obtain information on surface & tropopause temperatures, and on tropospheric CH4. Scan or contiguous steps across disk. POINTING: -y to Titan, x away from sun. Z axis generally aligned N/S or E/W, perpendicular to scan or steps.
012T20:55:36	Jan 12 22:13	Mon Jan 12 02:13 PM	T65-02h15m	Transition to thrusters	
012T20:56:36	Jan 12 22:14	Mon Jan 12 02:14 PM	T65-02h14m	MAPS campaign-CAPS	
012T22:47:36	Jan 13 00:05	Mon Jan 12 04:05 PM	T65-00h23m	RADAR/INMS observations	Inbound SAR riding along with INMS
012T23:10:36	**Jan 13 00:28**	**Mon Jan 12 04:28 PM**	**T65+00h00m**	**Titan-65 Flyby Closest Approach Time**	**Altitude = 1073 km (~667 miles), speed =5.9 km/s (13,200 mph); 95 deg phase at closest approach**
012T23:10:36	Jan 13 00:28	Mon Jan 12 04:28 PM	T65+00h00m	RADAR Observations	Outbound SAR for Ontario Lacus
012T23:26:36	Jan 13 00:44	Mon Jan 12 04:44 PM	T65+00h16m	MAPS campaign-CAPS	
013T00:49:31	Jan 13 02:07	Mon Jan 12 06:07 PM	T65+01h39m	Transition off of thrusters	
013T01:10:36	Jan 13 02:28	Mon Jan 12 06:28 PM	T65+02h00m	Titan atmospheric observations-CIRS	Obtain information on surface & tropopause temperatures, and on tropospheric CH4. Scan or contiguous steps across disk.
013T02:03:23	Jan 13 03:21	Mon Jan 12 07:21 PM	T65+02h53m	Descending Ring Plane Crossing	
013T04:10:36	Jan 13 05:28	Mon Jan 12 09:28 PM	T65+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.
013T08:10:36	Jan 13 09:28	Tue Jan 13 01:28 AM	T65+09h00m	Titan atmospheric observations-CIRS	Obtain information on CO, HCN, CH4. Integrate on disk at airmass 1.5--2.0.
013T13:10:36	Jan 13 14:28	Tue Jan 13 06:28 AM	T65+14h00m	Titan atmospheric observations-CIRS	Obtain information on the thermal structure of Titan's stratosphere.
013T18:31:36	Jan 13 19:49	Tue Jan 13 11:49 AM	T65+19h21m	Titan atmospheric observations-CIRS	Titan Composition
013T22:10:36	Jan 13 23:28	Tue Jan 13 03:28 PM	T65+23h00m	Deadtime	23 minutes 23 seconds long; used to accommodate changes in flyby time
013T22:34:00	Jan 13 23:52	Tue Jan 13 03:52 PM	T65+23h24m	Turn to Earth-line	
013T23:14:00	Jan 14 00:32	Jan 13 16:32	T65+01d00h	Playback of T65 Data	Madrid 34m
014T08:14:00	Jan 14 09:32	Wed Jan 14 01:32 AM	T65+01d09h	Turn cameras to Titan	
014T08:54:00	Jan 14 10:12	Wed Jan 14 02:12 AM	T65+01d10h	New waypoint	
014T08:54:00	Jan 14 10:12	Wed Jan 14 02:12 AM	T65+01d10h	Titan atmospheric observations-ISS	Titan cloud monitoring campaign and gap filling
014T14:00:00	Jan 14 15:18	Wed Jan 14 07:18 AM	T65+01d15h	CAPS	Magnetosphere and Plasma Science campaign
014T16:00:00	Jan 14 17:18	Wed Jan 14 09:18 AM	T65+01d17h	Titan surface observations-ISS	Titan cloud monitoring campaign and gap filling