CASSINI

TITAN 125TI(T66) MISSION DESCRIPTION

January 28, 2010

Jet Propulsion Laboratory
California Institute of Technology

Cover image: Tethys Slips Behind Titan

Saturn's moon Tethys with its prominent Odysseus Crater silently slips behind Saturn's largest moon Titan and then emerges on the other side.

Tethys is not actually enshrouded in Titan's atmosphere. Tethys (1,062 kilometers, or 660 miles across) is more than twice as far from Cassini than Titan (5,150 kilometers, or 3,200 miles across) in this sequence. Tethys is 2.2 million kilometers (1.4 million miles) from Cassini. Titan is about 1 million kilometers (621,000 miles) away. See Titan's Halo to learn more about Titan's atmosphere.

These two color views were captured about 18 minutes apart, with the view on the right taking place first. These images are part of a mutual event sequence in which one moon passes close to or in front of another as seen from the spacecraft. Such observations help scientists refine their understanding of the orbits of Saturn's moons.

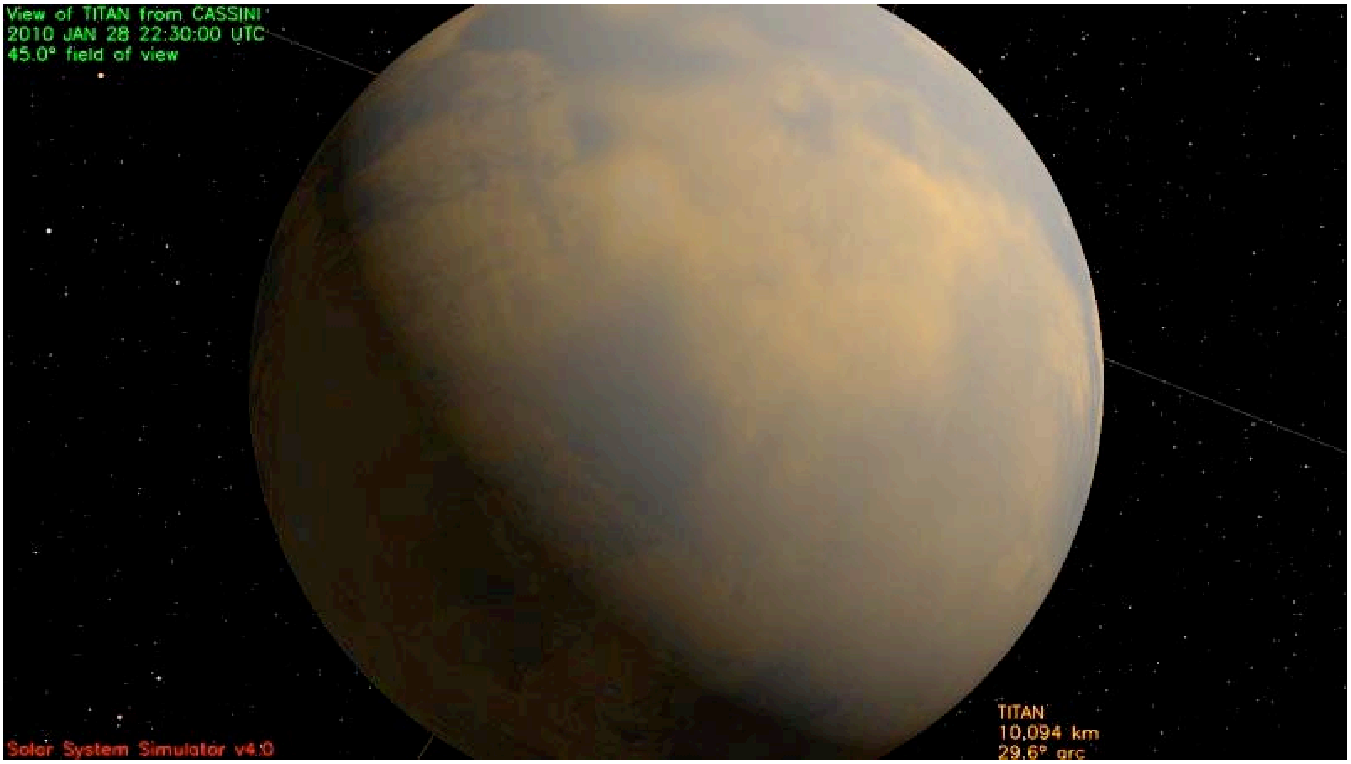
Images taken using red, green and blue spectral filters were combined to create this natural color view. The images were obtained with the Cassini spacecraft narrow-angle camera on Nov. 26, 2009. Image scale is 6 kilometers (4 miles) per pixel on Titan and 13 kilometers (8 miles) per pixel on Tethys.

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 and its two onboard cameras were 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 visiting Titan, Cassini returns to Saturn's largest moon for the mission's sixty-seventh targeted encounter with Titan. The closest approach to Titan occurs on Thursday, January 28 at 028T22:28:49 spacecraft time at an altitude of 7,490 kilometers (~4,654 miles) above the surface and at a speed of 5.9 kilometers per second (~12,800 mph). The latitude at closest approach is 53 degrees S and the encounter occurs on orbit number 125.

This encounter is set up with two maneuvers: an apoapsis maneuver on January 20, and a Titan approach maneuver, scheduled for January 25. T66 is the fourth flyby in a series of four outbound encounters and the twenty-second Titan encounter in Cassini's Solstice Mission. It occurs just under two days after Saturn closest approach.


View of TITAN from CASSINI
2010 JAN 28 22:30:00 UTC
45.0° field of view
Solar System Simulator v4.0
TITAN
10,094 km
29.6° arc

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-66 SCIENCE HIGHLIGHTS

- **ISS:** On this high-altitude encounter, ISS will acquire high-resolution observations during and after closest-approach, covering territory from the trailing hemisphere at high southern latitudes northeast to near-equatorial Adiri. *(DOY 028-029)* ISS will also ride along with VIMS to track clouds *(DOY 029)* and will continue to monitor clouds and the evolution thereof for an extra day after the Titan
- **VIMS:** On the inbound leg, VIMS will have the opportunity to do one stellar occultation which will allow us to constrain the composition and the spectral properties of Titan's atmosphere. (*DOY 028)* Then, VIMS will be ridealong with ISS at closest approach and will mosaic an area located South of Adiri with a resolution between 5 and 20 km/pixel. . *(DOY 028-029)* On the outbound VIMS will keep monitoring for mid-latitude clouds which are predicted to vanish during Titan's northern spring according to global circulation models.
- **CIRS** will obtain vertical profiles of gas composition, aerosols and temperature near 45 degrees south.
- **UVIS** will obtain an image cube of Titan's atmosphere at EUV and FUV wavelengths by sweeping its slit across the disk. These cubes provide spectral and spatial information on nitrogen emissions, H emission and absorption, absorption by simple hydrocarbons, and the scattering properties of haze aerosols. This is one of many such cubes gathered over the course of the mission to provide latitude and seasonal coverage of Titan's middle atmosphere and stratosphere.
- **MAG**: This is a second 'blind flyby' since MAG is unlikely to detect Titan's induced magnetosphere. Occurring in the same SLT sector as T52-T62, it will be used to characterize Saturn's background magnetic field variation with SKR longitude at a fixed SLT.
- **MIMI**: Energetic ion and electron energy input to atmosphere (Excellent ENA)
- **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.

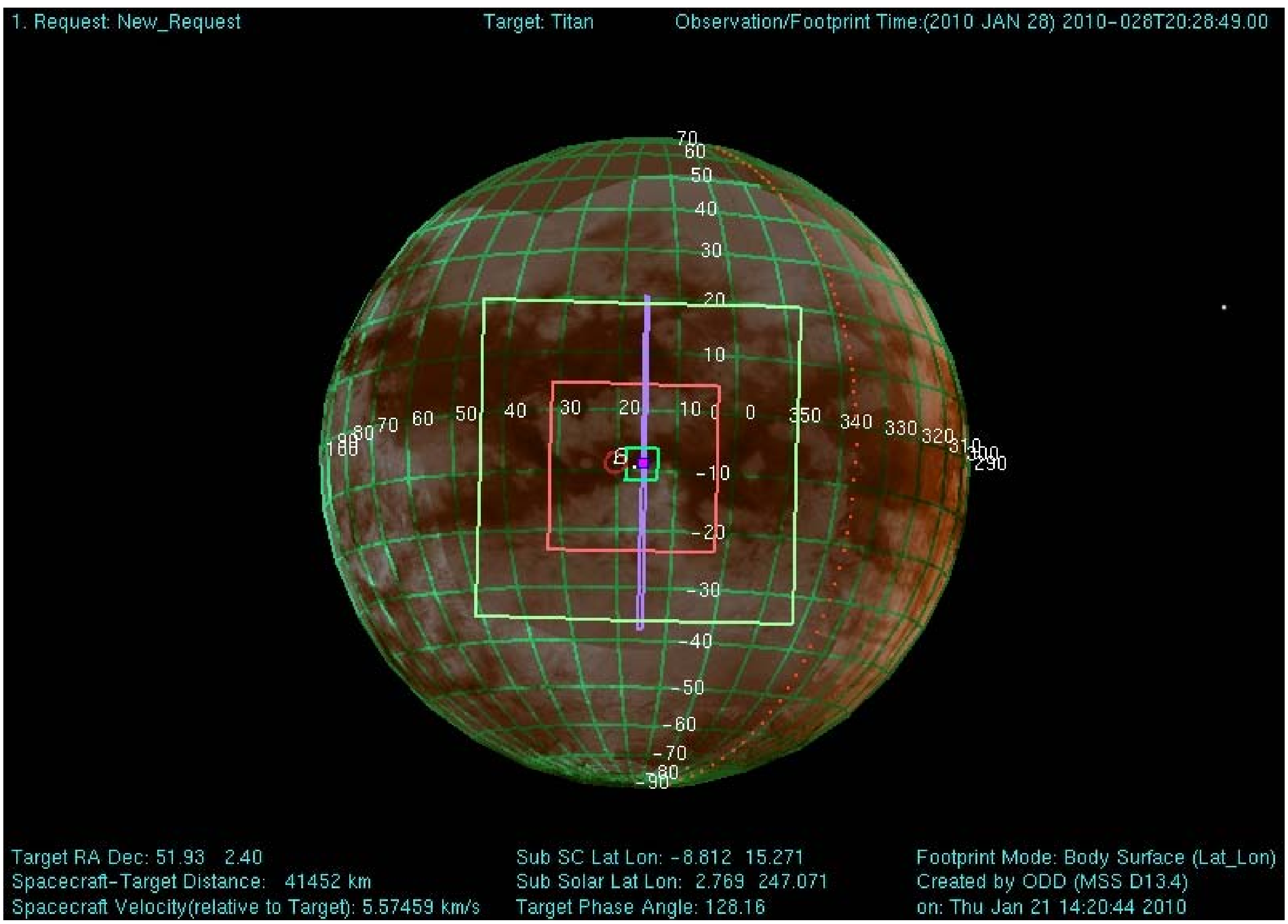
SAMPLE SNAPSHOTS

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.

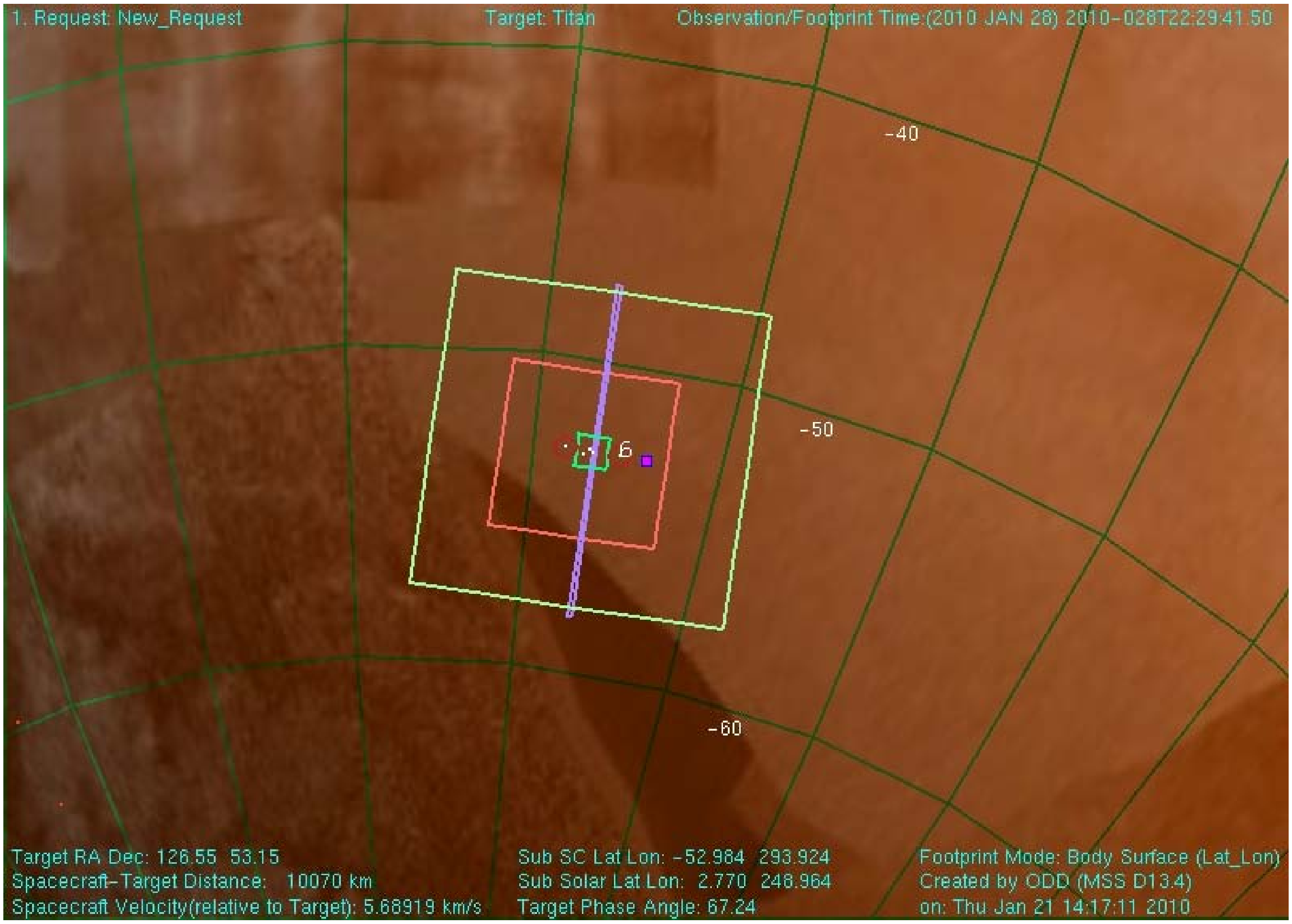
Key to ORS Instrument Fields of View in Figures

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

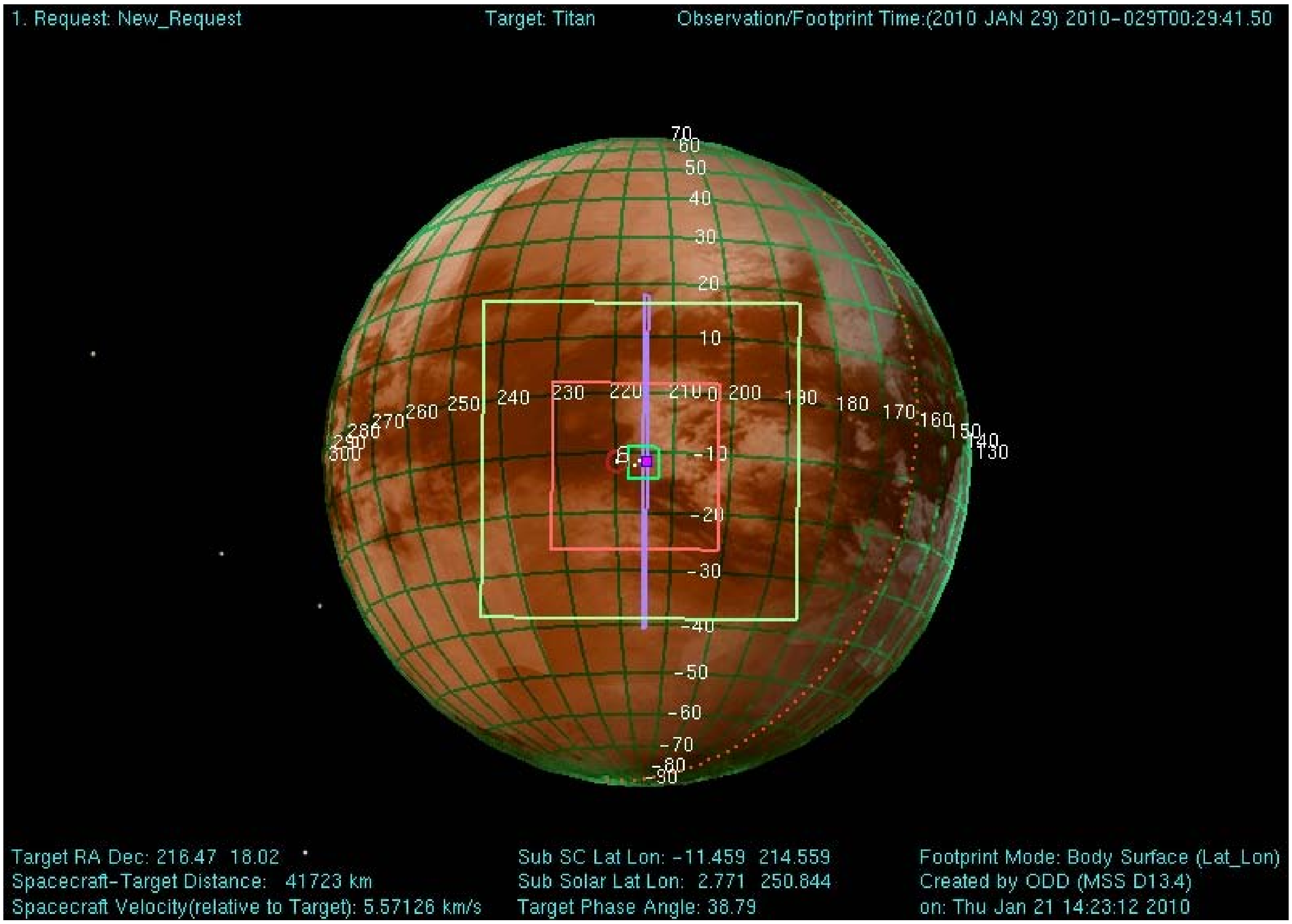
View of Titan from Cassini two hours before Titan-66 closest approach



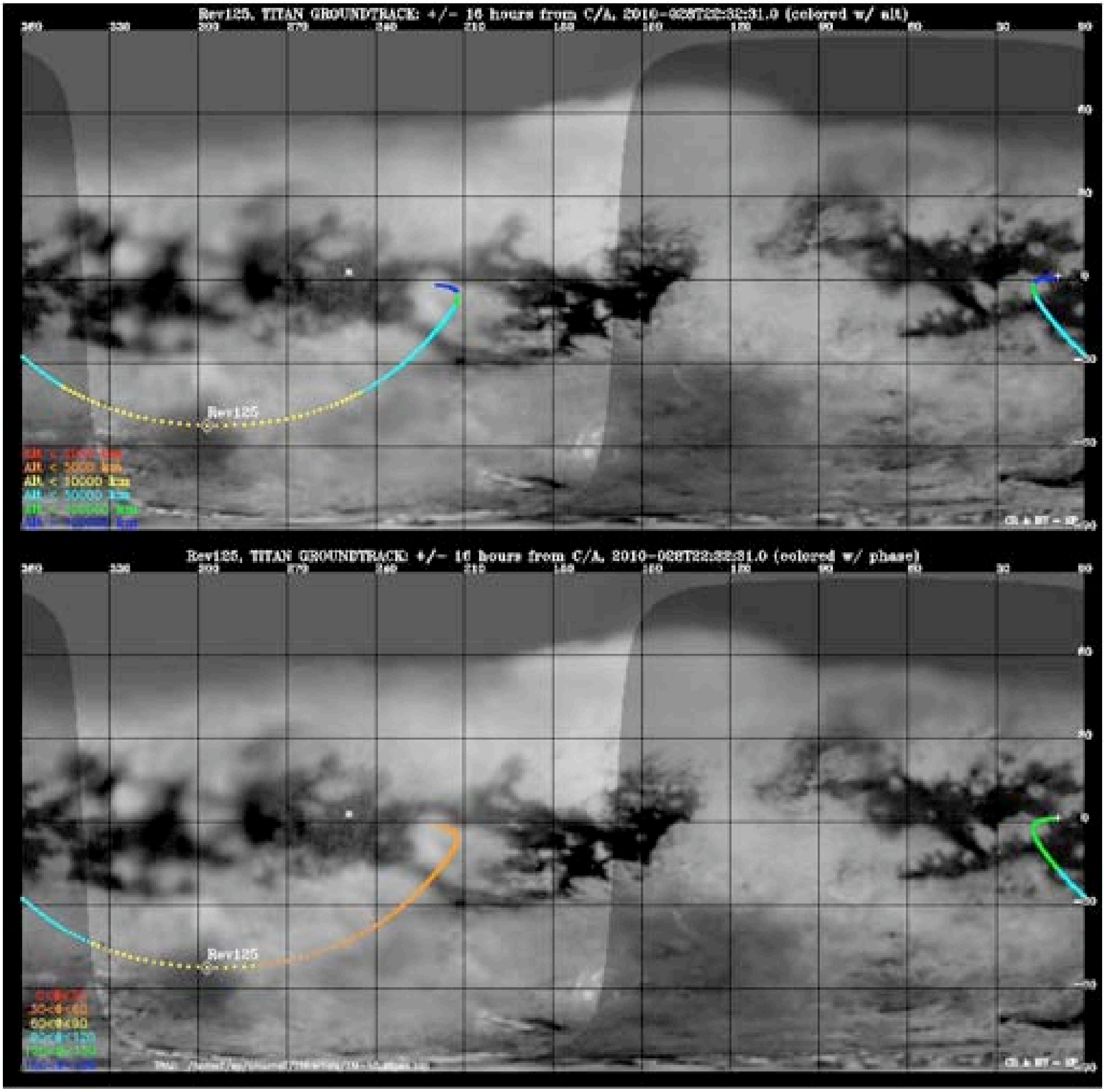
View of Titan from Cassini at Titan-66 closest approach



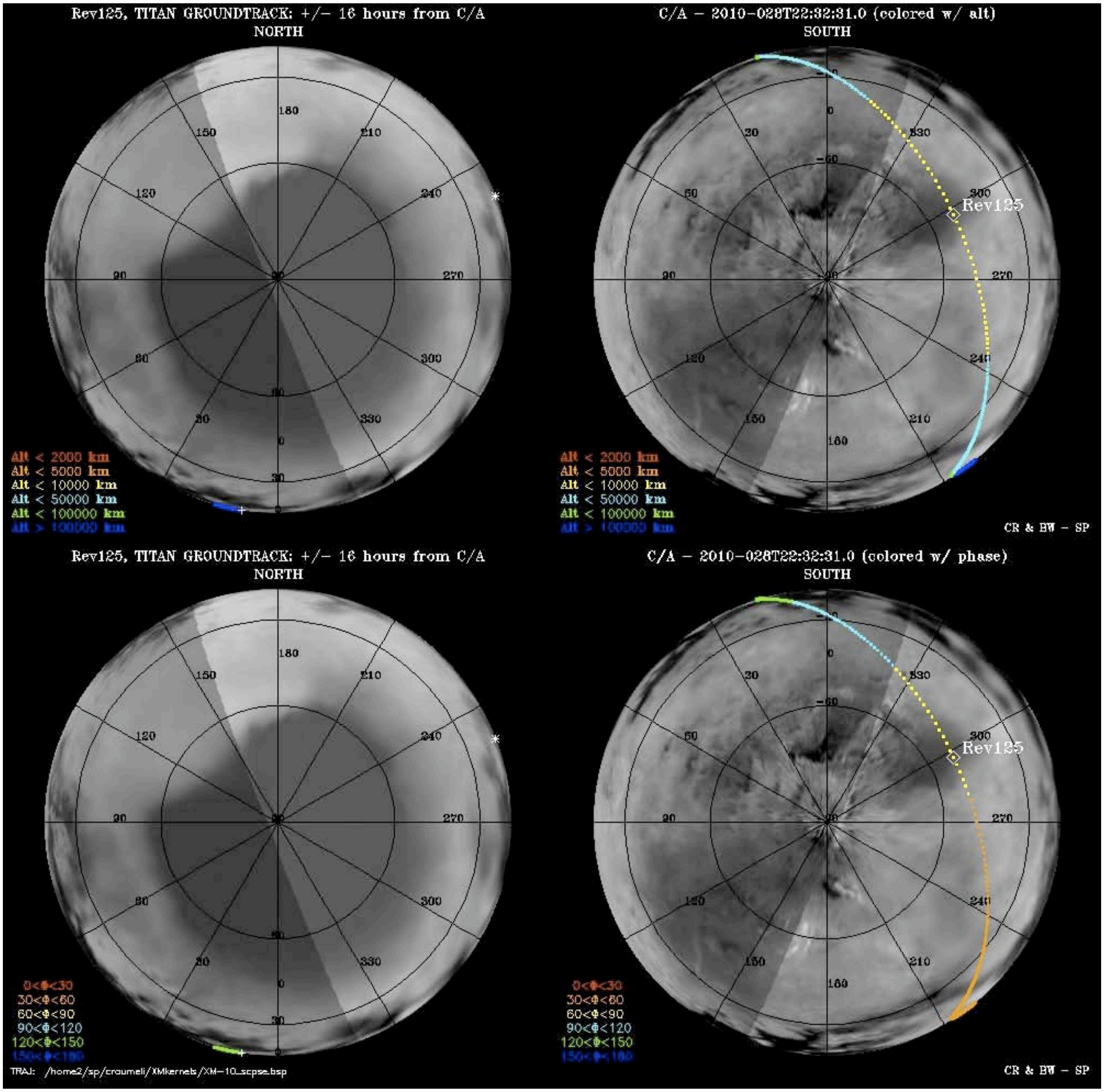
View of Titan from Cassini two hours after Titan-66 closest approach



Titan Groundtracks for T66: Global Plot



Titan Groundtracks for T66: Polar Plot



The T66 timeline is as follows:

Cassini Titan-66 - January 2010

Colors: yellow = maneuvers; blue = geometry;
pink = T66-related; green = data playbacks

Orbiter UTC	Ground UTC	Pacific Time (PST)	Time wrt T66	Activity	Description
023T15:00:00	Jan 23 16:14	Sat Jan 23 08:14 AM	T66-05d07h	Start of Sequence S57	Start of Sequence which contains Titan-66
025T12:16:00	Jan 25 13:30	Mon Jan 25 05:30 AM	T66-03d10h	OTM #235 Prime	Titan-66 targeting maneuver.
025T22:31:00	Jan 25 23:45	Mon Jan 25 03:45 PM	T66-02d24h	OTM #235 Backup	
028T07:16:00	Jan 28 08:30	Thu Jan 28 12:30 AM	T66-15h12m	Start of the TOST segment	
028T07:16:00	Jan 28 08:30	Thu Jan 28 12:30 AM	T66-15h12m	Turn cameras to Titan	
028T07:56:00	Jan 28 09:10	Thu Jan 28 01:10 AM	T66-14h32m	New waypoint	
028T07:56:00	Jan 28 09:10	Thu Jan 28 01:10 AM	T66-14h32m	Deadtime	11 minutes 18 seconds long; used to accommodate changes in flyby time
028T08:07:18	Jan 28 09:21	Thu Jan 28 01:21 AM	T66-14h21m	Titan atmospheric observations-CIRS	Obtain information on CO, HCN, CH4. Integrate on disk at airmass 1.5--2.0.
028T12:28:49	Jan 28 13:42	Thu Jan 28 05:42 AM	T66-10h00m	Titan atmospheric observations-ISS	Wide angle camera photometry
028T13:28:49	Jan 28 14:42	Thu Jan 28 06:42 AM	T66-09h00m	Titan atmospheric observations-UVIS	Several slow scans across Titan's visible hemisphere to form spectral images
028T19:58:49	Jan 28 21:12	Thu Jan 28 01:12 PM	T66-02h30m	Titan atmospheric observations-CIRS	Vertical sounding of stratospheric compounds on Titan, including H2O. Integrations at 2 locations on the limb displaced vertically.
028T20:29:28	Jan 28 21:43	Thu Jan 28 01:43 PM	T66-01h59m	Descending Ring Plane Crossing	
028T21:06:49	Jan 28 22:20	Thu Jan 28 02:20 PM	T66-01h22m	Titan atmospheric observations-CIRS	Limb scanning for aerosols. This observation includes a VIMS atmosphere occultation of alpTau
028T21:40:19	Jan 28 22:54	Thu Jan 28 02:54 PM	T66-00h48m	Titan atmospheric observations-CIRS	Vertical temperature sounding of Titan's tropopause & stratosphere. Slow radial scans.
028T22:13:49	Jan 28 23:27	Thu Jan 28 03:27 PM	T66-00h15m	Titan surface observations-ISS	Very high resolution imaging
028T22:28:49	Jan 28 23:42	**Thu Jan 28 03:42 PM**	T66+00h00m	**Titan-66 Flyby Closest Approach Time**	**Altitude = 7490 km (~4654 miles), speed =5.9 km/s (12,800 mph); 69 deg phase at closest approach**
029T00:28:49	Jan 29 01:42	Thu Jan 28 05:42 PM	T66+02h00m	Titan atmospheric observations-UVIS	Several slow scans across Titan's visible hemisphere to form spectral images
029T07:28:49	Jan 29 08:42	Fri Jan 29 12:42 AM	T66+09h00m	Titan atmospheric observations-CIRS	Obtain information on CO, HCN, CH4. Integrate on disk at airmass 1.5--2.0.
029T12:28:49	Jan 29 13:42	Fri Jan 29 05:42 AM	T66+14h00m	Titan Surface observations--VIMS	Global Mapping
029T21:28:49	Jan 29 22:42	Fri Jan 29 02:42 PM	T66+23h00m	Deadtime	7 minutes 11 seconds long; used to accommodate changes in flyby time
029T21:36:00	Jan 29 22:50	Fri Jan 29 02:50 PM	T66+23h08m	Turn to Earth-line	
029T22:16:00	Jan 29 23:30	Jan 29 15:30	T66+23h48m	Playback of T66 Data	Madrid 70m
030T07:16:00	Jan 30 08:30	Sat Jan 30 12:30 AM	T66+01d09h	Turn cameras to Titan	
030T07:56:00	Jan 30 09:10	Sat Jan 30 01:10 AM	T66+01d09h	New waypoint	
030T07:56:00	Jan 30 09:10	Sat Jan 30 01:10 AM	T66+01d09h	Titan atmospheric observations-ISS	Titan cloud monitoring campaign and gap filling
030T12:00:00	Jan 30 13:14	Sat Jan 30 05:14 AM	T66+01d14h	CAPS	Magnetosphere and Plasma Science campaign
030T14:00:00	Jan 30 15:14	Sat Jan 30 07:14 AM	T66+01d16h	Titan surface observations-ISS	Titan cloud monitoring campaign and gap filling
030T21:26:00	Jan 30 22:40	Sat Jan 30 02:40 PM	T66+01d23h	Turn to Earth-line	
030T22:01:00	Jan 30 23:15	Jan 30 15:15	T66+01d24h	Playback of T66 Data	Madrid 70m