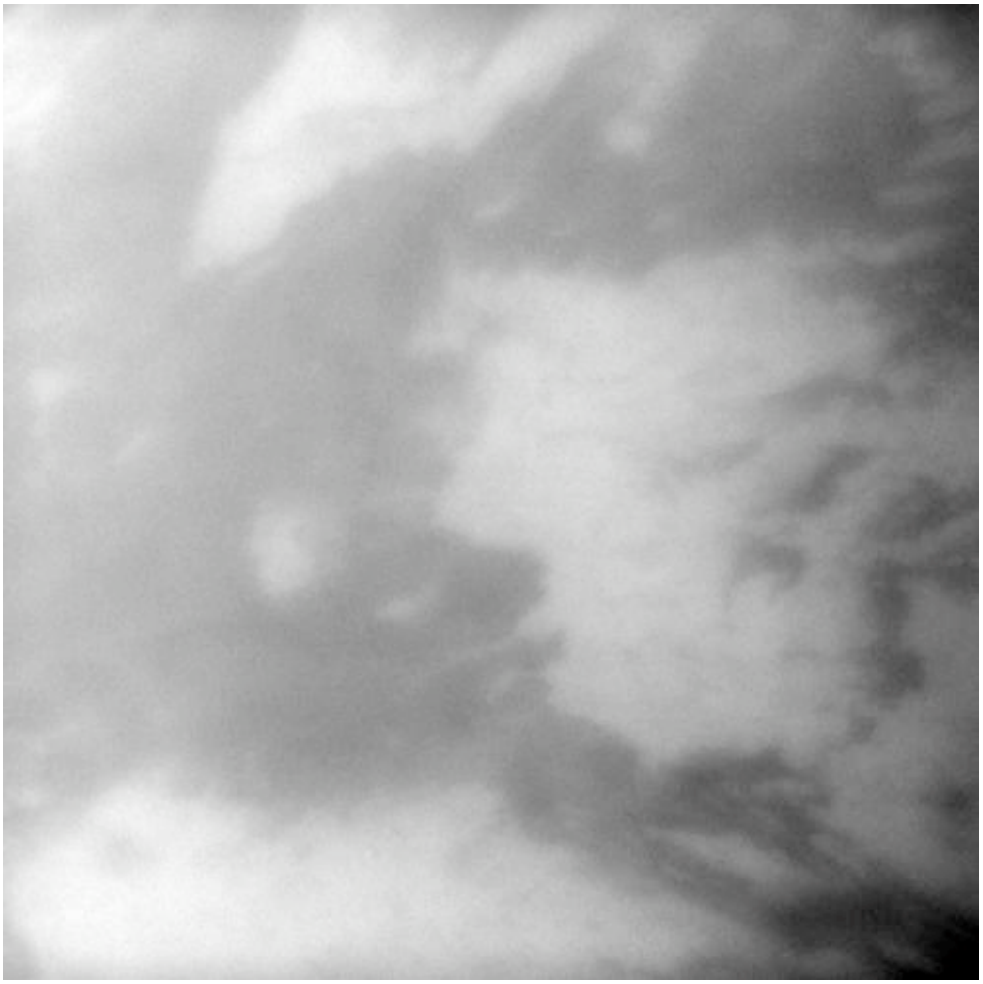
C A S S I N I



T I T A N 1 2 9 T I (T 6 7)
MISSION DESCRIPTION

April 5, 2010

Jet Propulsion Laboratory
California Institute of Technology

Cover image: Zooming in on Adiri

The Cassini spacecraft takes a look through the atmosphere of Saturn's largest moon to spy light and dark in the area called Adiri on Titan.

See Above Adiri to see a wider view of this albedo feature on Titan. This view looks toward the moon's anti-Saturn side and is centered on terrain at 2 degrees south latitude, 218 degrees west longitude. North on Titan (5,150 kilometers, or 3,200 miles across) is up and rotated 6 degrees to the left.

The image was taken with the Cassini spacecraft narrow-angle camera on Jan. 29, 2010 using a spectral filter sensitive to wavelengths of near-infrared light centered at 938 nanometers. The view was acquired at a distance of approximately 285,000 kilometers (177,000 miles) from Titan and at a Sun-Titan-spacecraft, or phase, angle of 45 degrees. Image scale is about 2 kilometers (about 1 mile) per pixel.

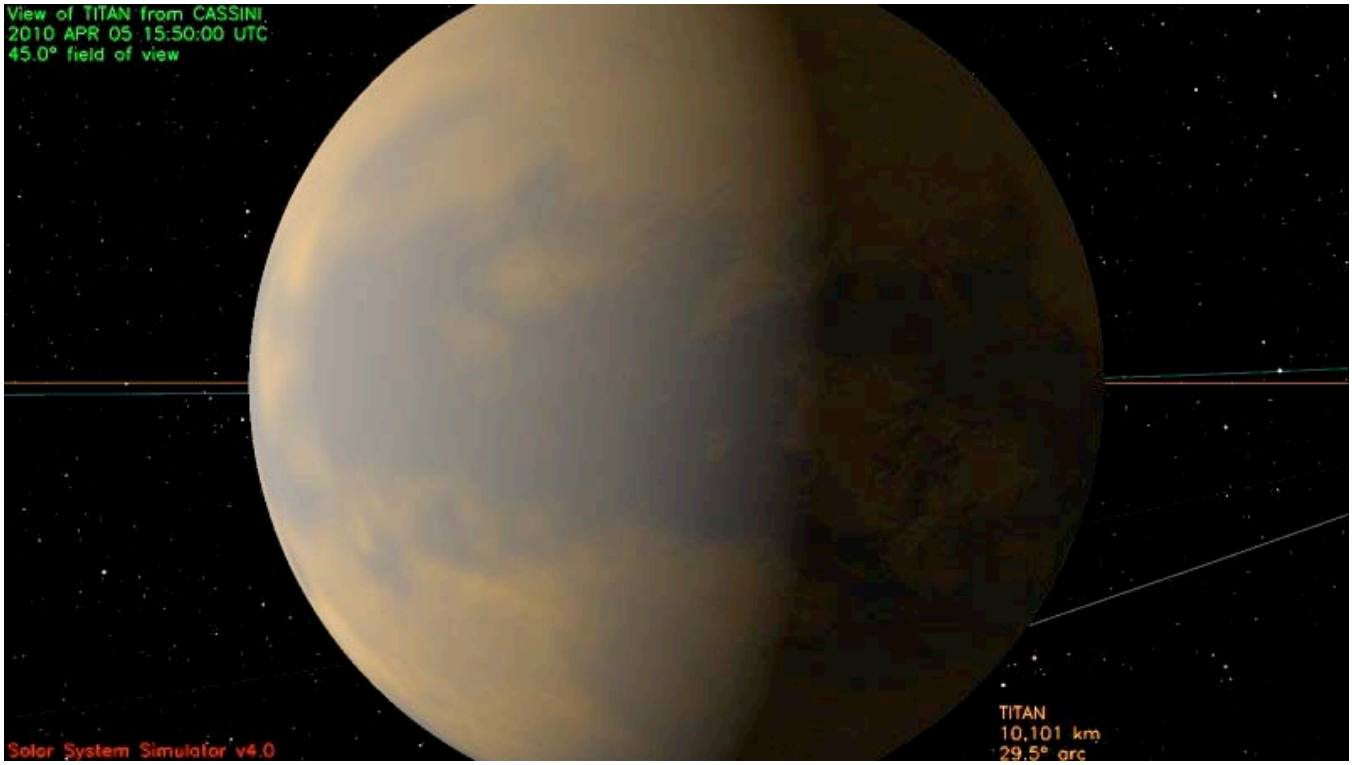
The Cassini-Huygens mission is a cooperative project of NASA, the European Space Agency and the Italian Space Agency. The Jet Propulsion Laboratory, a division of the California Institute of Technology in Pasadena, manages the mission for NASA's Science Mission Directorate, Washington, D.C. The Cassini 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

After a lengthy 65 days since last visiting Titan, Cassini returns to Saturn's largest moon for the mission's sixty-eighth targeted encounter with Titan. The closest approach to Titan occurs on Monday, April 5 at 095T15:50:38 spacecraft time at an altitude of 7,461 kilometers (~4,636 miles) above the surface and at a speed of 5.7 kilometers per second (~12,800 mph). The latitude at closest approach is 0 degrees S and the encounter occurs on orbit number 129.

This encounter is set up with two maneuvers: an apoapsis maneuver on March 26, and a Titan approach maneuver, scheduled for April 2. T67 is an inbound flyby sandwiched between two series of four outbound encounters and the twenty-third Titan encounter in Cassini's Solstice Mission. It occurs just under two days before a Dione flyby and Saturn closest approach.


View of TITAN from CASSINI
2010 APR 05 15:50:00 UTC
45.0° field of view
TITAN
10,101 km
29.5° arc
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-67 SCIENCE HIGHLIGHTS

- **ISS:** This flyby is the second most important ISS pass in the XM; it is the second of the ~7,000 km flybys. These flybys were designed for gap filling: they are low-phase, over the trailing hemisphere. On this high-altitude encounter, ISS will perform high-resolution observations during and after closest-approach along the equator from eastern Belet across the trailing hemisphere to western Senkyo, imaging Senkyo at very low phase angles (<5°). ISS will also acquire a lowphase-angle global-scale mosaic of

western Senkyo.

- **CIRS** These CIRS observations provide the furthest north vertical profiles of the Extended Mission. The instrument will observe the composition and temperature profile at 70°N, and possibly observe the break up of winter/spring vortex.
- **VIMS:** During this flyby, VIMS will be riding along with ISS at closest approach and will mosaic the equatorial terrains from Belet to Senkyo with a resolution from 4 to 20 km/pixel. It will allow VIMS to get higher resolution images on a circular feature about 500 kilometers in diameter observed during T34.
- **UVIS:** 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.
- **INMS**: This flyby is higher than usually desired for INMS, but INMS will be riding along to take data.

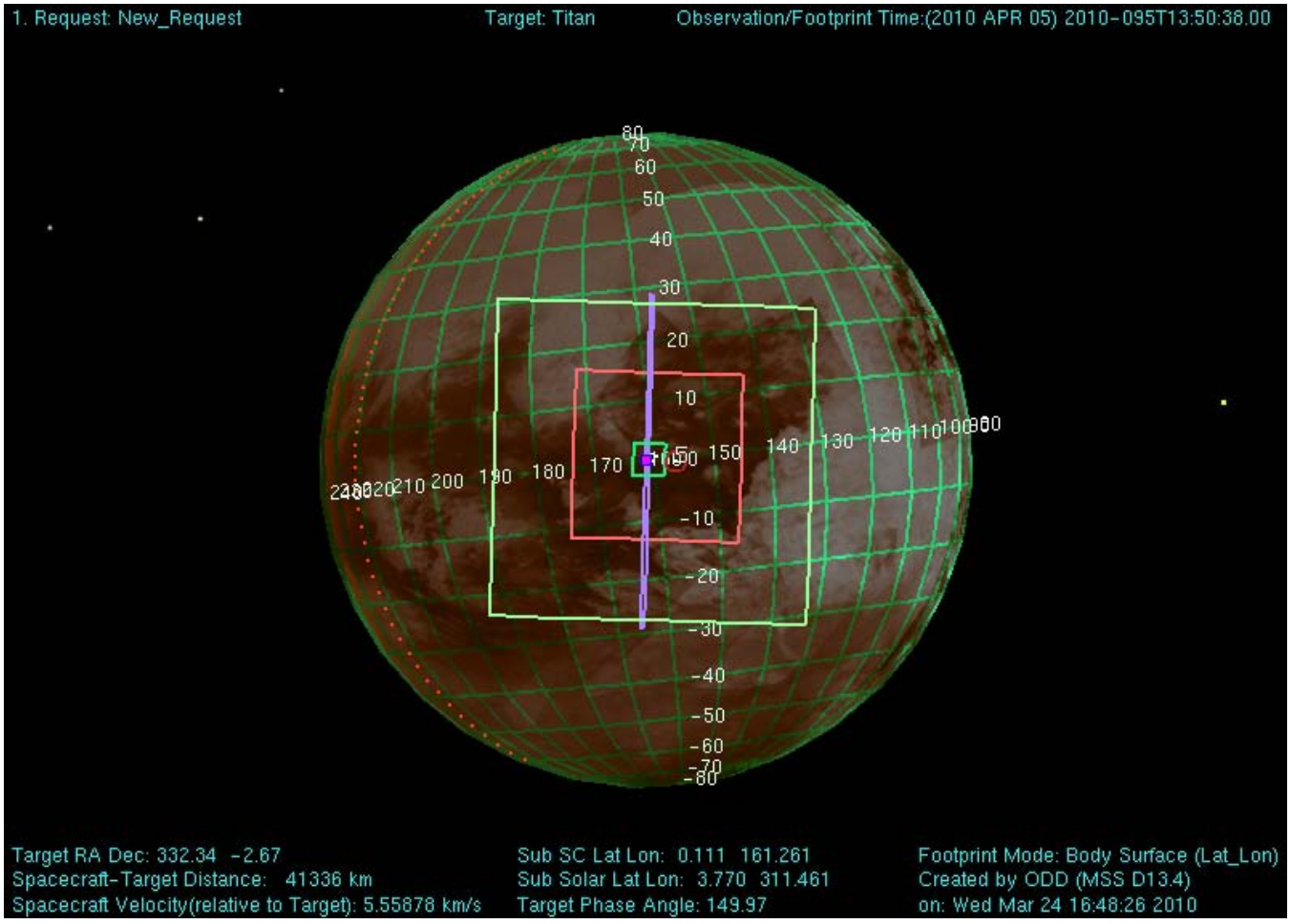
SAMPLE SNAPSHOTS

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.

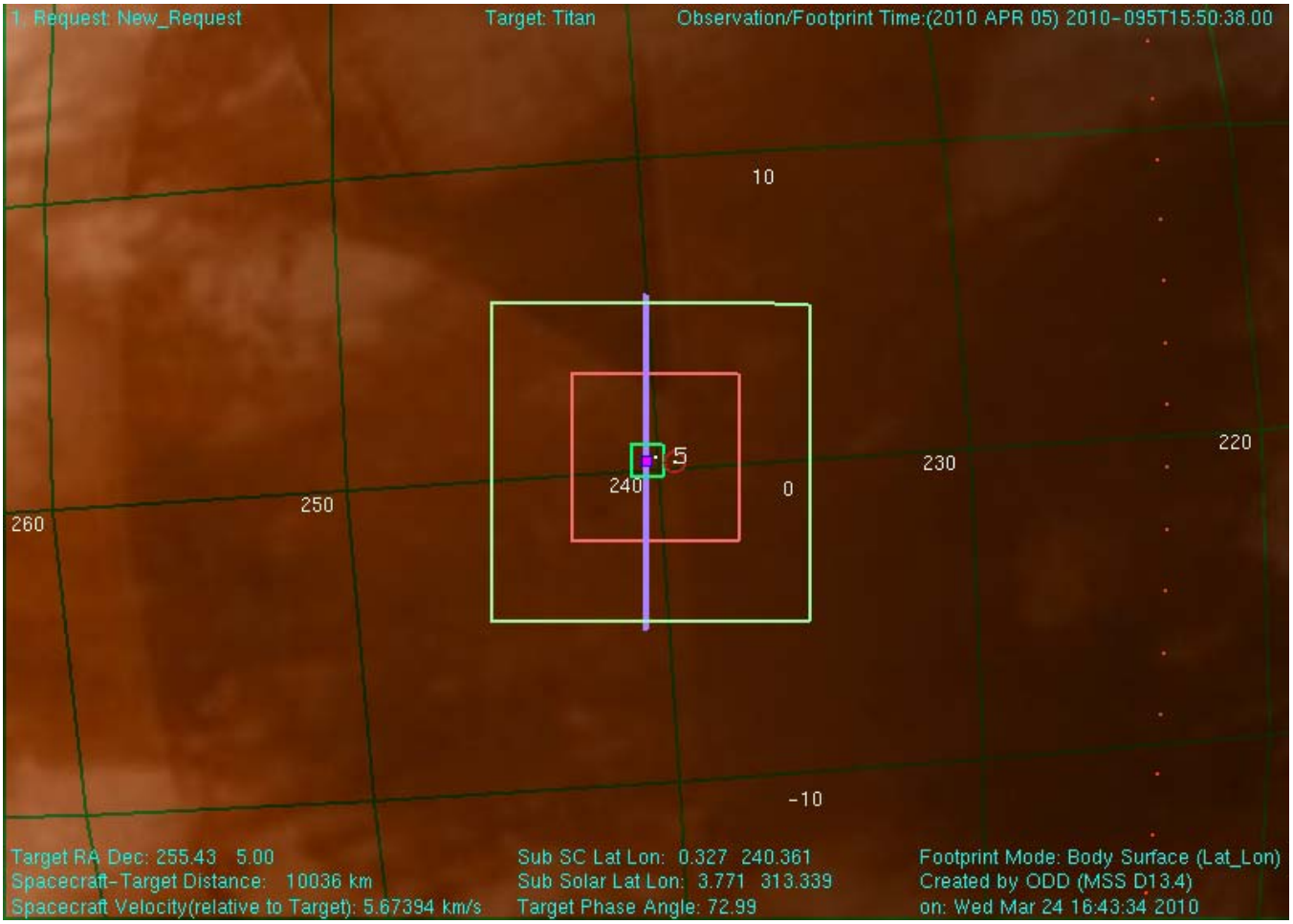
Key to ORS Instrument Fields of View in Figures

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

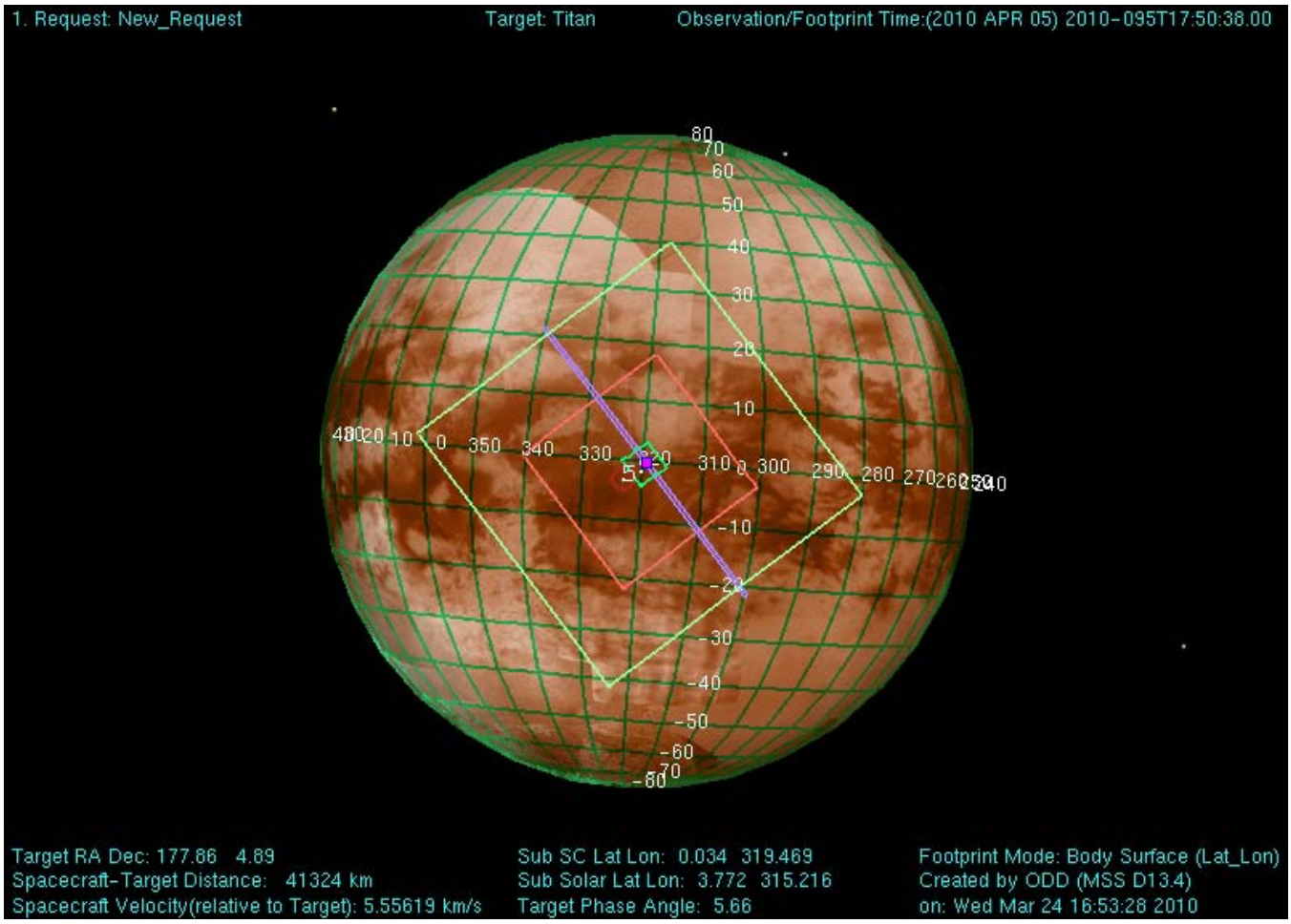
View of Titan from Cassini two hours before Titan-67 closest approach



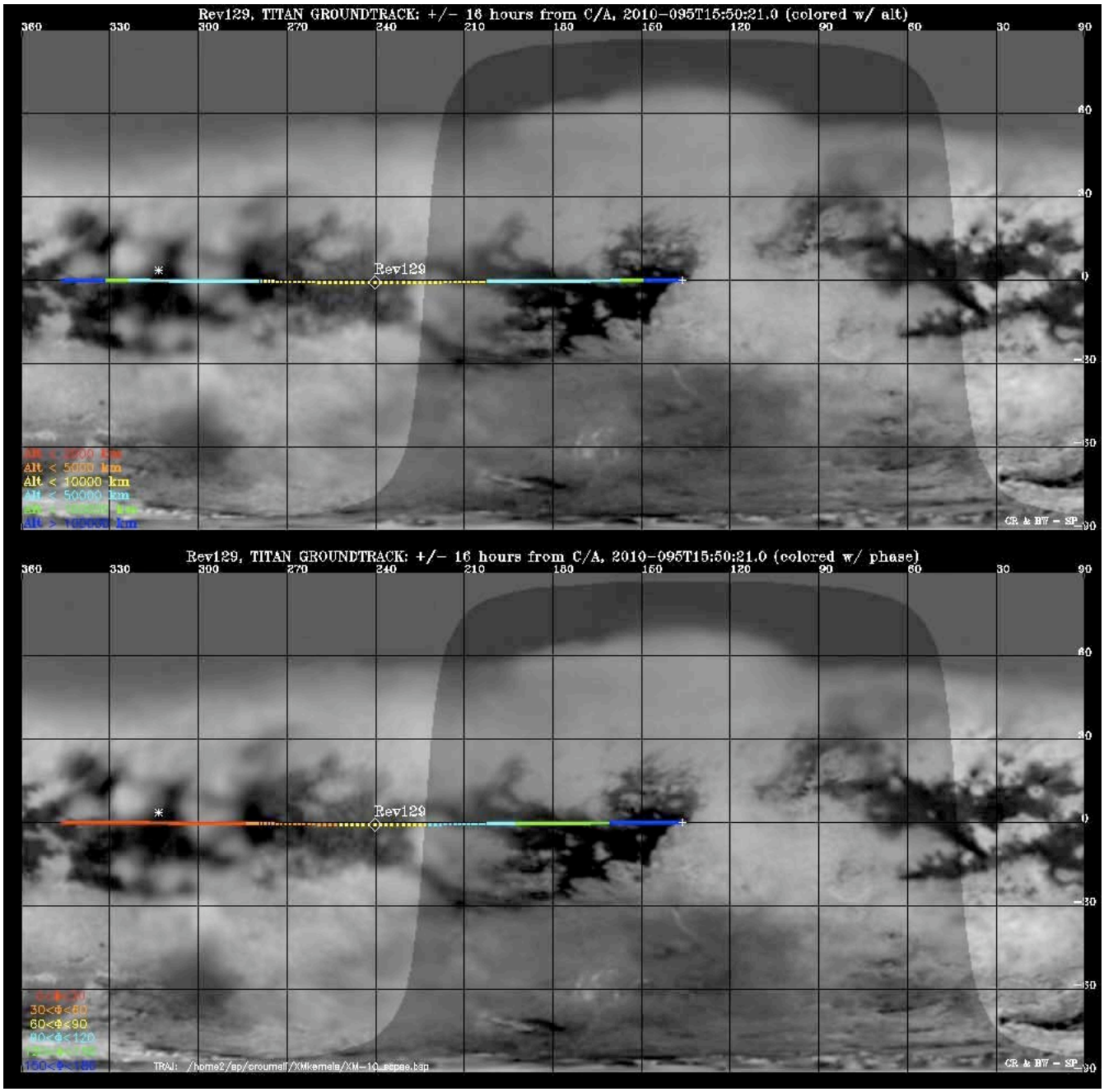
View of Titan from Cassini at Titan-67 closest approach



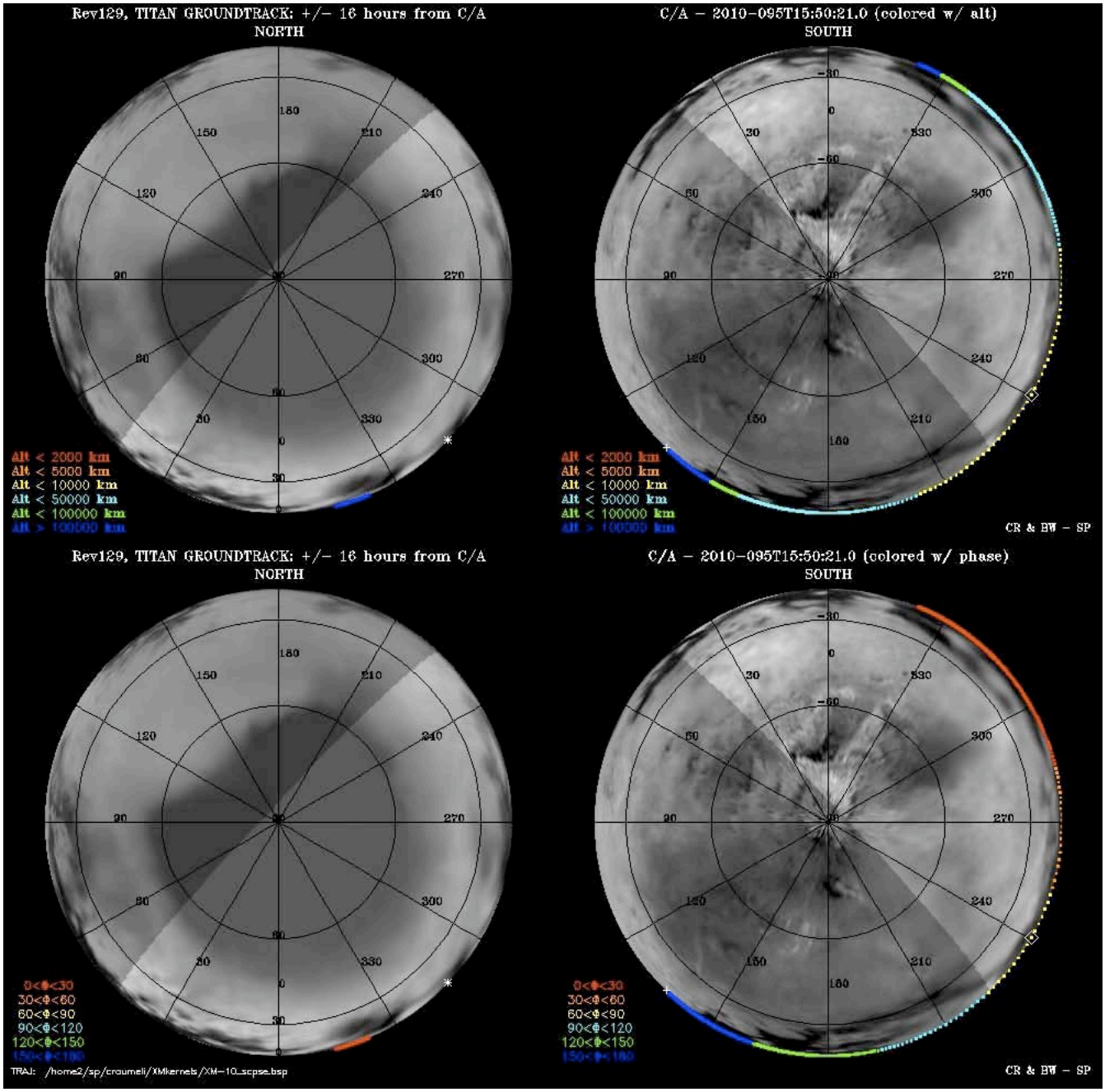
View of Titan from Cassini two hours after Titan-67 closest approach



Titan Groundtracks for T67: Global Plot



Titan Groundtracks for T67: Polar Plot



The T67 timeline is as follows:

Cassini Titan-67 - April 2010

Colors: yellow = maneuvers; blue = geometry; pink = T67-related; green = data playbacks

Orbiter UTC	Ground UTC	Pacific Time (PDT)	Time wrt T67	Activity	Description
092T07:49:00	Apr 02 09:00	Apr 02 02:00	T67-03d08h	OTM #241 Prime	Titan-67 targeting maneuver.
093T07:34:00	Apr 03 08:45	Apr 03 01:45	T67-02d08h	OTM #241 Backup	
095T02:49:00	Apr 05 04:00	Sun Apr 04 09:00 PM	T67-13h01m	Start of Sequence S59	Start of Sequence which contains Titan-67
095T02:49:00	Apr 05 04:00	Sun Apr 04 09:00 PM	T67-13h01m	Start of the TOST segment	
095T02:49:00	Apr 05 04:00	Sun Apr 04 09:00 PM	T67-13h01m	Update vectors	
095T02:55:00	Apr 05 04:06	Sun Apr 04 09:06 PM	T67-12h55m	Turn cameras to Titan	
095T03:29:00	Apr 05 04:40	Sun Apr 04 09:40 PM	T67-12h21m	New waypoint	
095T03:29:00	Apr 05 04:40	Sun Apr 04 09:40 PM	T67-12h21m	Deadtime	15 minutes 18 seconds long; used to accommodate changes in flyby time
095T03:44:18	Apr 05 04:55	Sun Apr 04 09:55 PM	T67-12h06m	Titan atmospheric observations-CIRS	Obtain information on CO, HCN, CH4. Integrate on disk at airmass 1.5--2.0.
095T05:50:39	Apr 05 07:01	Mon Apr 05 12:01 AM	T67-10h00m	Titan atmospheric observations-ISS	Nightside WAC Photometry
095T06:50:39	Apr 05 08:01	Mon Apr 05 01:01 AM	T67-09h00m	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.
095T10:50:39	Apr 05 12:01	Mon Apr 05 05:01 AM	T67-05h00m	Titan atmospheric observations-CIRS	Obtain information on surface & tropopause temperatures, and on tropospheric CH4. Scan or contiguous steps across disk.
095T13:35:39	Apr 05 14:46	Mon Apr 05 07:46 AM	T67-02h15m	Titan atmospheric observations-CIRS	Limb condensate search.
095T14:35:39	Apr 05 15:46	Mon Apr 05 08:46 AM	T67-01h15m	Titan atmospheric observations-CIRS	Limb scanning for aerosols.
095T15:05:39	Apr 05 16:16	Mon Apr 05 09:16 AM	T67-00h45m	Titan atmospheric observations-CIRS	Vertical temperature sounding of Titan's tropopause & stratosphere. Slow radial scans.
095T15:35:39	Apr 05 16:46	Mon Apr 05 09:46 AM	T67-00h15m	Titan surface observations-ISS	Very high resolution imaging
095T15:50:38	**Apr 05 17:01**	**Mon Apr 05 10:01 AM**	**T67+00h00m**	**Titan-67 Flyby Closest Approach Time**	**Altitude = 7461 km (~4636 miles), speed =5.7 km/s (~12,800 mph); 73 deg phase at closest approach**
095T17:50:39	Apr 05 19:01	Mon Apr 05 12:01 PM	T67+02h00m	Titan surface observations-ISS	NAC Regional Map
095T19:50:39	Apr 05 21:01	Mon Apr 05 02:01 PM	T67+04h00m	Titan atmospheric observations-CIRS	Obtain information on surface & tropopause temperatures, and on tropospheric CH4. Scan or contiguous steps across disk.
095T20:50:39	Apr 05 22:01	Mon Apr 05 03:01 PM	T67+05h00m	Titan Surface observations--ISS	NAC Regional Map
096T00:50:39	Apr 06 02:01	Mon Apr 05 07:01 PM	T67+09h00m	Titan Surface observations--VIMS	Global Mapping
096T05:50:39	Apr 06 07:01	Tue Apr 06 12:01 AM	T67+14h00m	Titan Surface observations--VIMS	Global Mapping
096T06:39:18	Apr 06 07:50	Tue Apr 06 12:50 AM	T67+14h49m	Deadtime	14 minutes 42 seconds long; used to accommodate changes in flyby time
096T06:54:00	Apr 06 08:05	Tue Apr 06 01:05 AM	T67+15h04m	Turn to Earth-line	
096T07:34:00	Apr 06 08:45	Apr 06 01:45	T67+15h44m	Playback of T67 Data	Canberra 70m