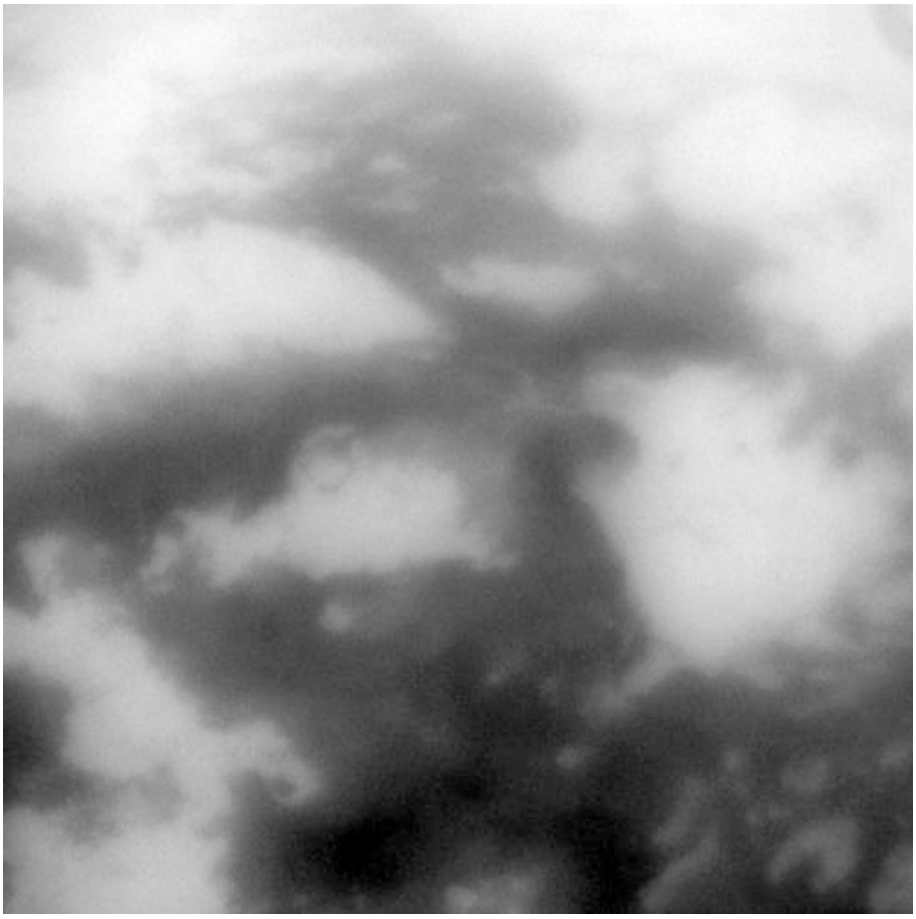
C A S S I N I



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

December 12, 2009

Jet Propulsion Laboratory
California Institute of Technology

Cover image: *Details of Dark Senkyo*

The low albedo feature known as Senkyo is visible through the haze of Titan's atmosphere. See Saturn's View of Titan to learn about this area that appears dark near the moon's equator. This view looks toward Saturn-facing side of Titan (5,150 kilometers, or 3,200 miles across) and is centered on terrain at 1 degree south latitude, 345 degrees west longitude. North on Titan is up and rotated 10 degrees to the right. The image was taken with the Cassini spacecraft narrow-angle camera on Oct. 12, 2009 using a spectral filter sensitive to wavelengths of near-infrared light centered at 938 nanometers. The view was acquired at a distance of approximately 296,000 kilometers (184,000 miles) from Titan and at a Sun-Titan-spacecraft, or phase, angle of 11 degrees. Image scale is 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. Credit: NASA/JPL/Space Science Institute

1.0 OVERVIEW

After sixty-one days without a Titan flyby, Cassini at last returns to Saturn's largest moon for the mission's sixty-fourth targeted encounter with Titan. The closest approach to Titan occurs on Friday, December 11 at 346T01:03:14 spacecraft time at an altitude of 4850 kilometers (~3014 miles) above the surface and at a speed of 6.0 kilometers per second (~13,400 mph). The latitude at closest approach is 33 degrees N and the encounter occurs on orbit number 122.

This encounter is set up with two maneuvers: an apoapsis maneuver on December 3, and a Titan approach maneuver, scheduled for December 8. T63 is the first flyby in a series of four outbound encounters and the nineteenth Titan encounter in Cassini's Equinox Mission. It occurs just under two days before 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-63 SCIENCE HIGHLIGHTS

- **CAPS:** This is the second of three opportunities in the extended mission for a CAPS prime encounter. Magnetosphere and Plasma Science (MAPS) instruments take advantage of this special opportunity to collect data on a relatively unexamined region of the magnetosphere**.** The T63 encounter passes through Titan's wake/magnetotail region, nearly crossing the geometric wake at a range of 1.9 body radii. This is both similar and very complementary to the Voyager and Cassini T9 encounters. This

geometry allows the CAPS observations, combined with those of the other MAPS instruments, to explore the interaction between Titan and Saturn's magnetosphere. The encounter occurs near dusk in Saturn's magnetosphere, unlike Voyager (near noon) or T9 (near midnight).

- **RADAR:** Radiometery inbound
- **ISS** will acquire regional- and global-mapping mosaics of northern Adiri and ride along with VIMS and CIRS to monitor clouds. ISS will also monitor Titan to track clouds and the evolution thereof for an extra day after the Titan encounter.
- **VIMS:** This flyby will allow VIMS to monitor the cloud cover during the inbound period. After closest approach, VIMS will ride along with ISS to acquire a mosaic of Shangri-La and Belet at a resolution of 40 kilometers per pixel. Finally, VIMS will acquire a global map for cloud monitoring**CIRS** carries out far-infrared limb sounding at 70 and 75 degrees latitude south. Observations collect information on the atmospheric temperature, aerosols and composition near 75S.
- **CIRS:** Stratospheric composition and temperature monitoring; seasonal effects.
- **MAG**: T63 is a north polar, dusk, high altitude flyby. In nominal upstream conditions, Cassini would explore the north lobe of the mid-range magnetic tail. With adequate pointing of MAPS plasma instruments MAG data will also permit to obtain valuable information about the pitch angle distribution of Titan's escaping plasma. This flyby will increase our understanding of the properties of Titan's mid range tail acquired during T9.

- **MIMI**. Energetic ion and electron energy input to atmosphere, poor 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.

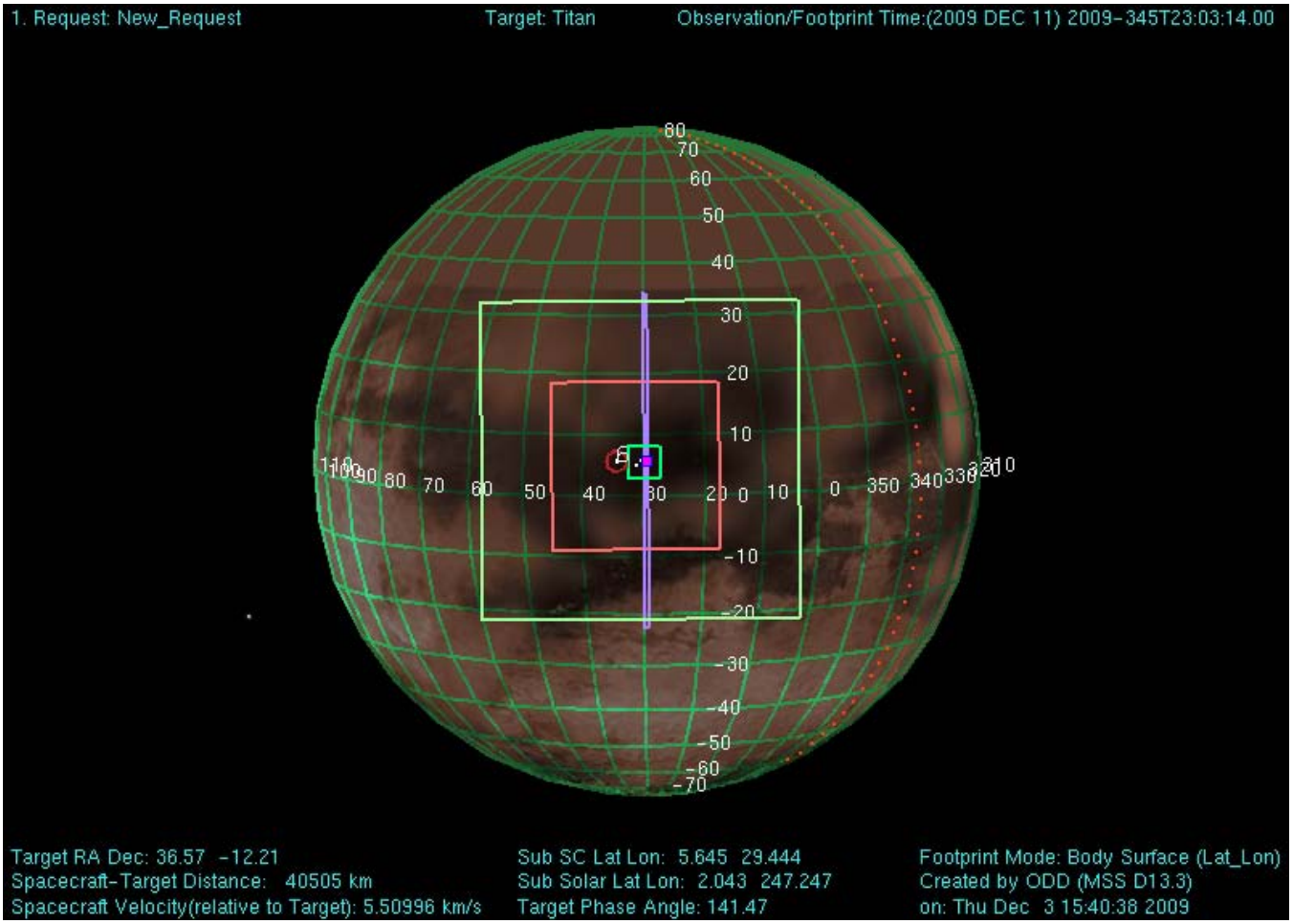
SAMPLE SNAPSHOTS

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.

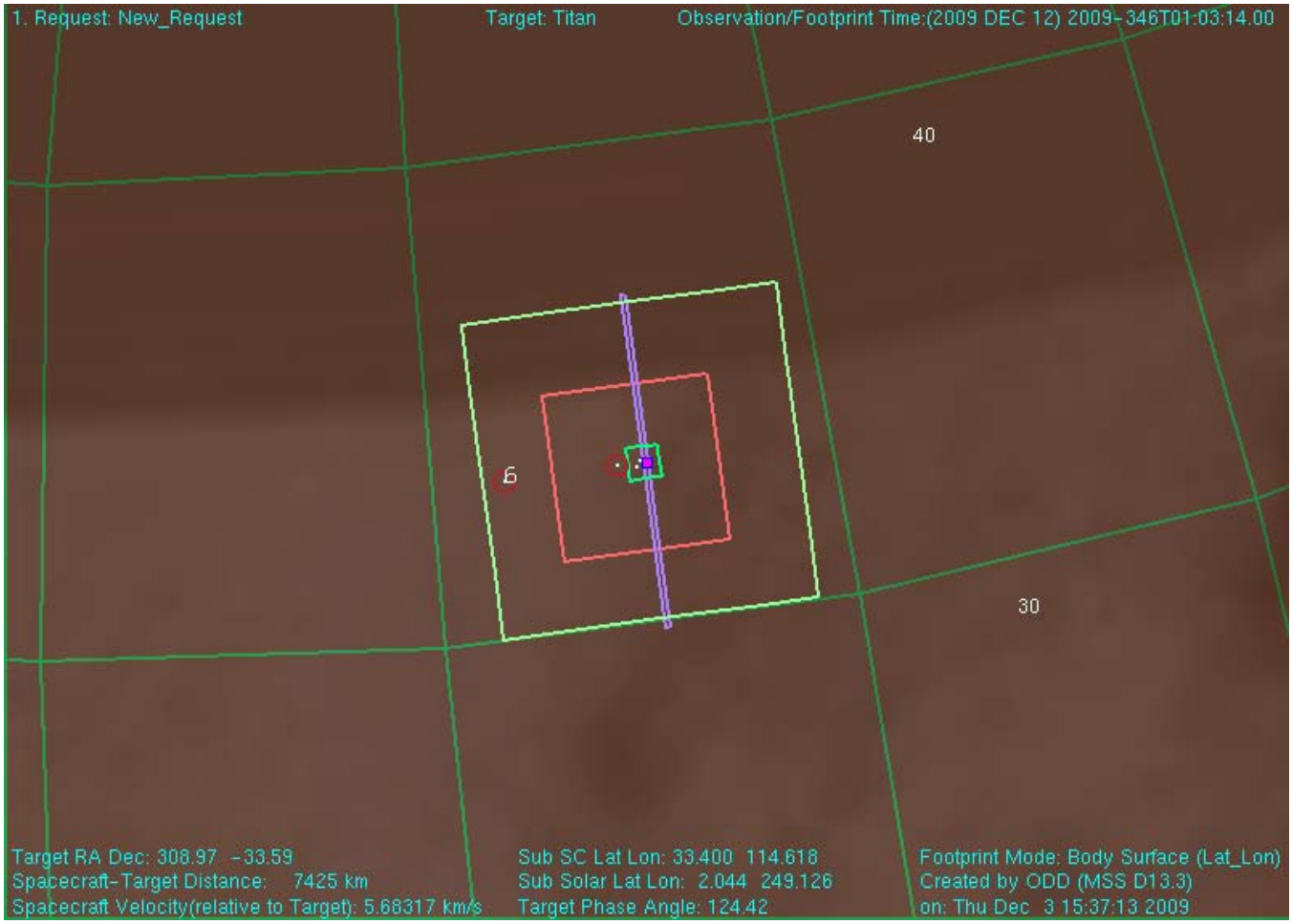
Key to ORS Instrument Fields of View in Figures

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

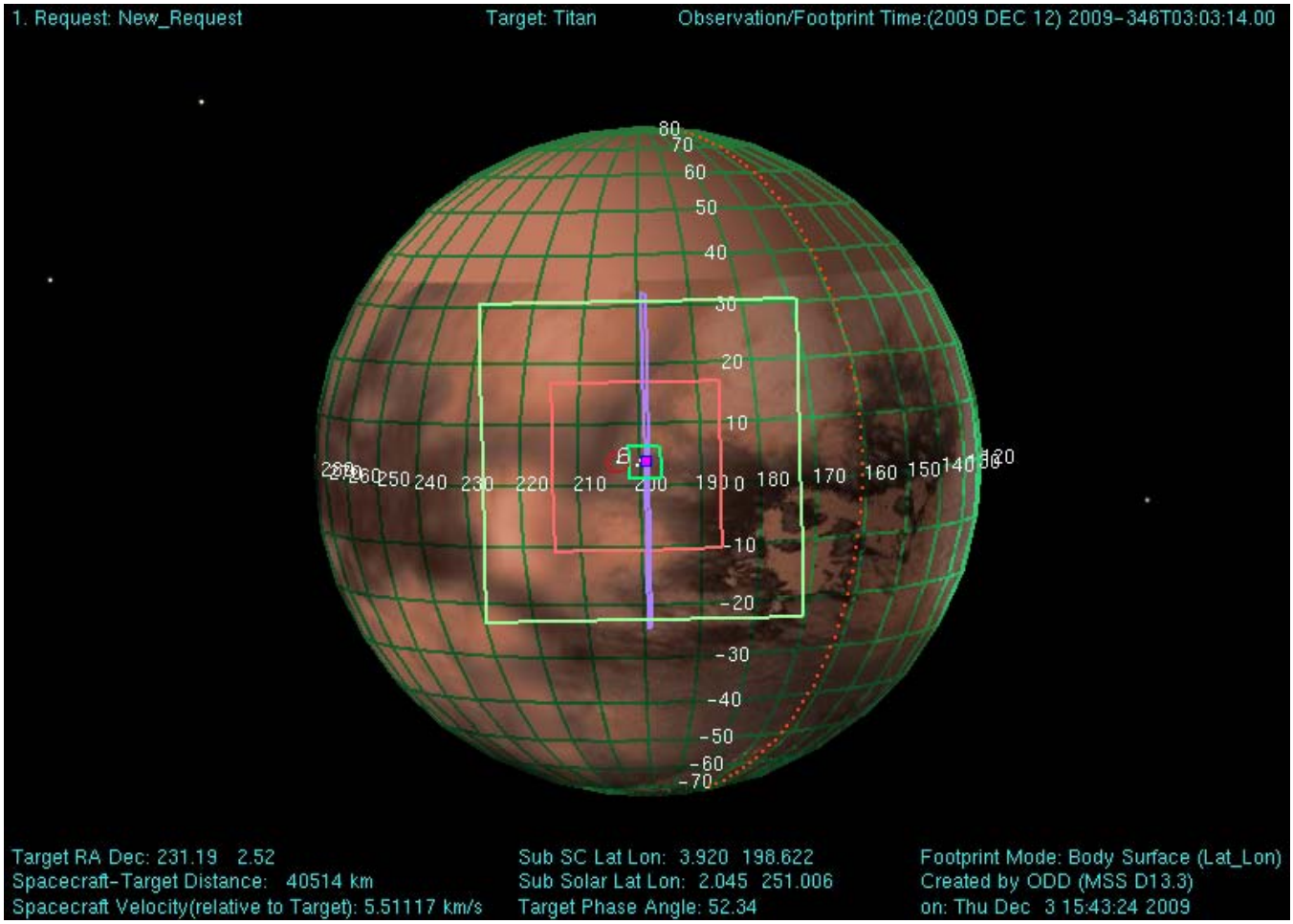
View of Titan from Cassini two hours before Titan-63 closest approach



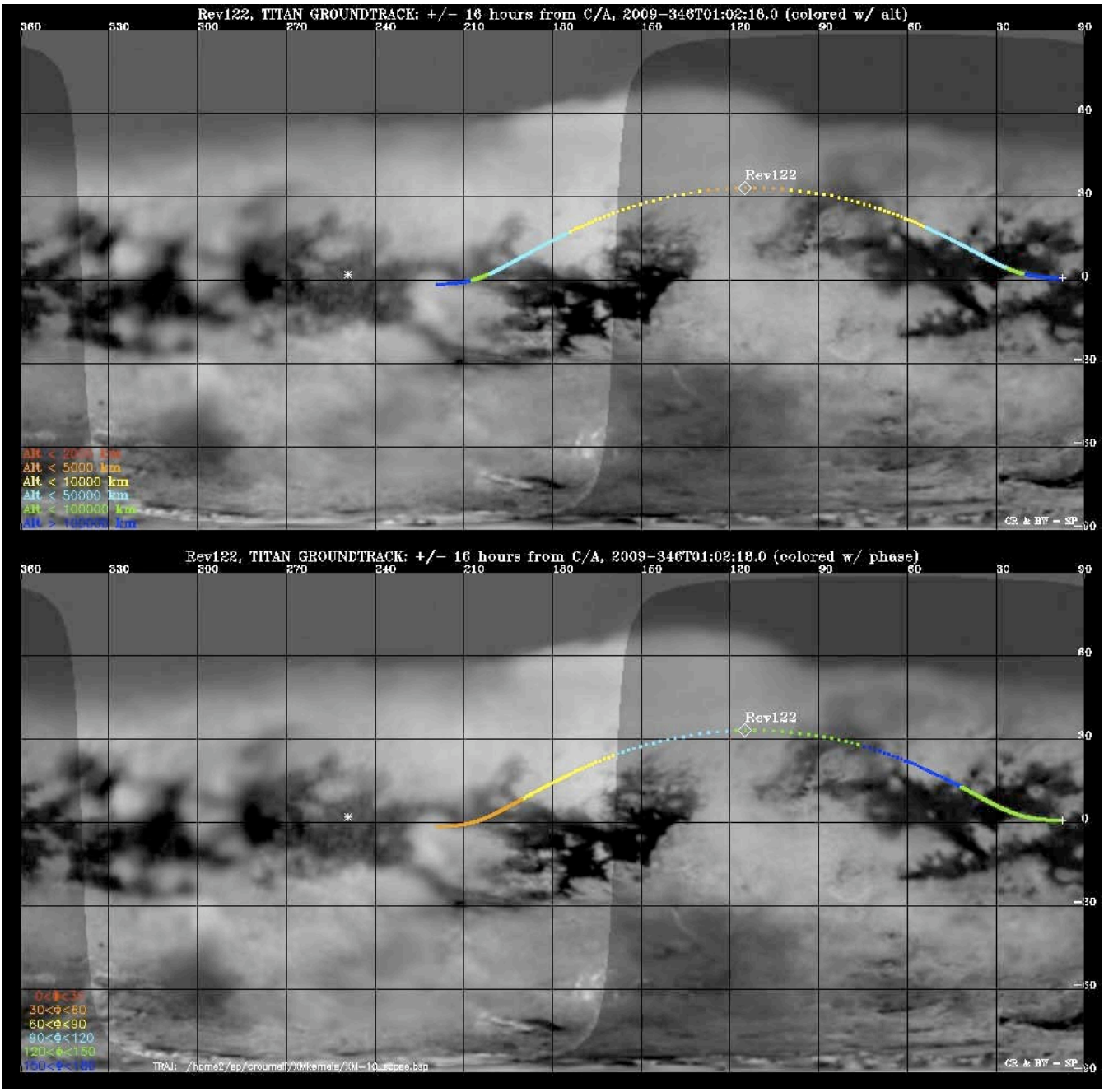
View of Titan from Cassini at Titan-63 closest approach



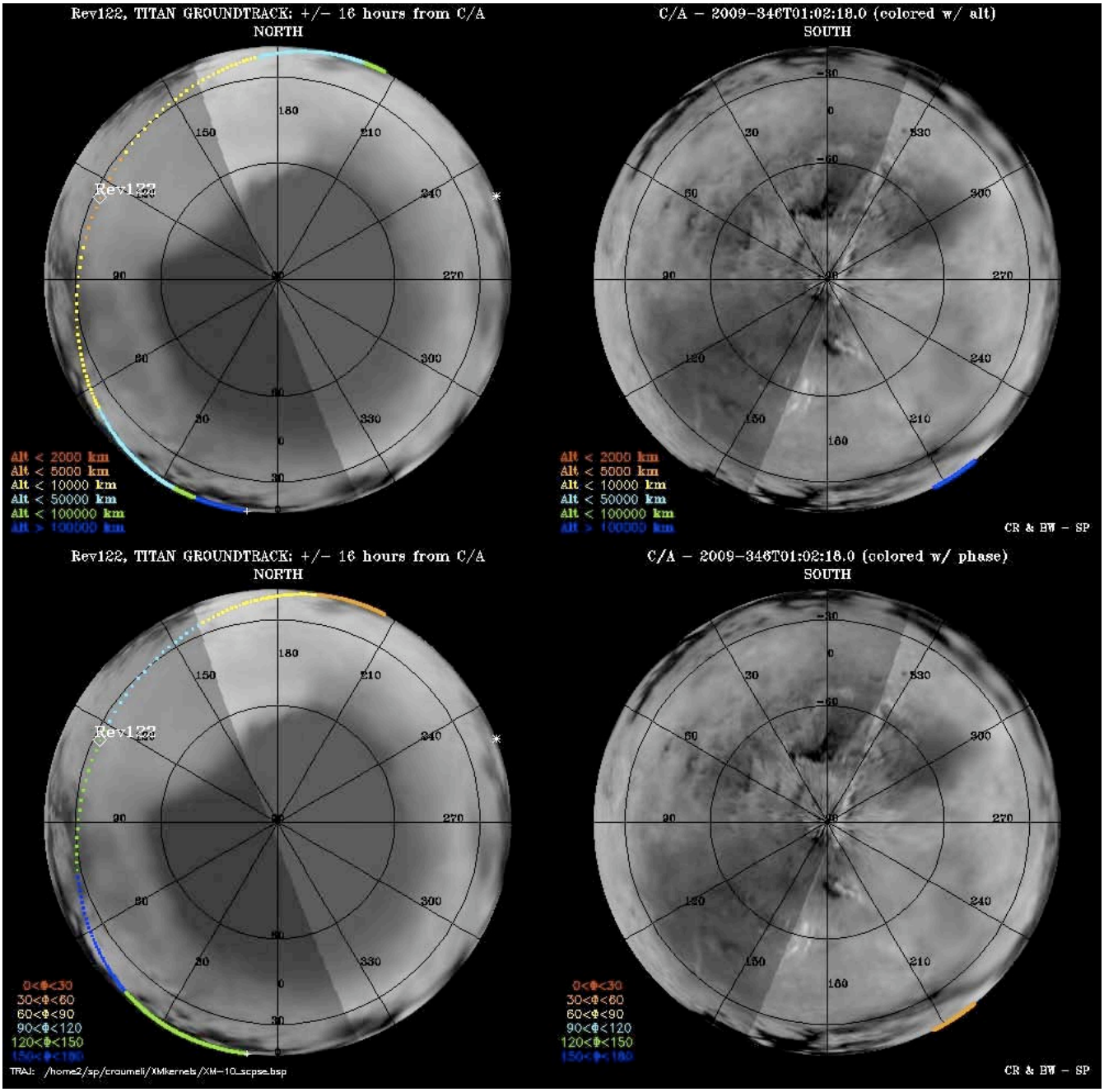
View of Titan from Cassini two hours after Titan-63 closest approach



Titan Groundtracks for T63: Global Plot



Titan Groundtracks for T63: Polar Plot



The T63 timeline is as follows:

Cassini Titan-63 Timeline - December 2009

Colors: yellow = maneuvers; blue = geometry; pink = T63-related; green = data playbacks

Orbiter UTC	Ground UTC	Pacific Time (PDT)	Time wrt T63	Activity	Description
317T19:21:00	Nov 13 20:41	Fri Nov 13 01:41 PM	T63-28d06h	Start of Sequence S55	Start of Sequence which contains Titan-63
342T15:24:00	Dec 08 16:44	Tue Dec 08 09:44 AM	T63-03d10h	OTM #226 Prime	Titan-63 targeting maneuver.
343T00:24:00	Dec 09 01:44	Tue Dec 08 06:44 PM	T63-03d01h	OTM #226 Backup	
345T10:10:00	Dec 11 11:30	Fri Dec 11 04:30 AM	T63-14h53m	Start of the TOST segment	
345T10:10:00	Dec 11 11:30	Fri Dec 11 04:30 AM	T63-14h53m	Turn cameras to Titan	
345T10:50:00	Dec 11 12:10	Fri Dec 11 05:10 AM	T63-14h13m	New waypoint	
345T10:50:00	Dec 11 12:10	Fri Dec 11 05:10 AM	T63-14h13m	Deadtime	15 minutes 56 seconds long; used to accommodate changes in flyby time
345T11:05:56	Dec 11 12:25	Fri Dec 11 05:25 AM	T63-13h58m	Titan atmospheric observations-CIRS	Obtain information on CO, HCN, CH4. Integrate on disk at airmass 1.5--2.0.
345T15:03:14	Dec 11 16:23	Fri Dec 11 09:23 AM	T63-10h00m	Titan atmospheric observations-ISS	Wide Angle Camera Photometry
345T16:03:14	Dec 11 17:23	Fri Dec 11 10:23 AM	T63-09h00m	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.
345T20:03:14	Dec 11 21:23	Fri Dec 11 02:23 PM	T63-05h00m	Titan RADAR observations	Inbound radiometry
345T22:58:14	Dec 12 00:18	Fri Dec 11 05:18 PM	T63-02h05m	Titan atmospheric observations-CIRS	Vertical temperature sounding of Titan's tropopause & stratosphere.
346T01:03:14	**Dec 12 02:23**	**Fri Dec 11 07:23 PM**	T63+00h00m	**Titan-63 Flyby Closest Approach Time**	**Altitude = 4850 km (~3014 miles), speed =6.0 km/s (13,400 mph); 124 deg phase at closest approach**
346T03:48:14	Dec 12 05:08	Fri Dec 11 10:08 PM	T63+02h45m	Titan atmospheric observations-CIRS	Obtain information on surface & tropopause temperatures, and on tropospheric CH4. Scan or contiguous steps across disk.
346T04:48:14	Dec 12 06:08	Fri Dec 11 11:08 PM	T63+03h45m	Titan surface observations-ISS	Narrow Angle Camera Global Map
346T10:03:14	Dec 12 11:23	Sat Dec 12 04:23 AM	T63+09h00m	Titan surface observations-VIMS	Global mapping
346T15:03:14	Dec 12 16:23	Sat Dec 12 09:23 AM	T63+14h00m	Titan atmospheric observations-CIRS	Obtain information on the thermal structure of Titan's stratosphere. Slew across disk at 4 microrad/s.
346T16:22:31	Dec 12 17:42	Sat Dec 12 10:42 AM	T63+15h19m	Descending Ring Plane Crossing	
346T20:03:14	Dec 12 21:23	Sat Dec 12 02:23 PM	T63+19h00m	Titan atmospheric observations-CIRS	Titan composition
347T00:03:14	Dec 13 01:23	Sat Dec 12 06:23 PM	T63+23h00m	Deadtime	26 minutes 46 seconds long; used to accommodate changes in flyby time
347T00:30:00	Dec 13 01:50	Sat Dec 12 06:50 PM	T63+23h27m	Turn to Earth-line	
347T01:10:00	Dec 13 02:30	Dec 12 19:30	T63+01d00h	Playback of T63 Data	Madrid 70m
347T10:10:00	Dec 13 11:30	Sun Dec 13 04:30 AM	T63+01d09h	Turn cameras to Titan	
347T10:50:00	Dec 13 12:10	Sun Dec 13 05:10 AM	T63+01d10h	New waypoint	
347T10:50:00	Dec 13 12:10	Sun Dec 13 05:10 AM	T63+01d10h	Titan atmospheric observations-ISS	Titan monitoring campaign
347T12:00:00	Dec 13 13:20	Sun Dec 13 06:20 AM	T63+01d11h	CAPS	Magnetosphere and Plasma Science campaign
347T14:00:00	Dec 13 15:20	Sun Dec 13 08:20 AM	T63+01d13h	Titan surface observations-VIMS	Global mapping
348T00:30:00	Dec 14 01:50	Sun Dec 13 06:50 PM	T63+01d23h	Turn to Earth-line	
348T01:10:00	Dec 14 02:30	Dec 13 19:30	T63+02d00h	Playback of T63 Data	Madrid 70m