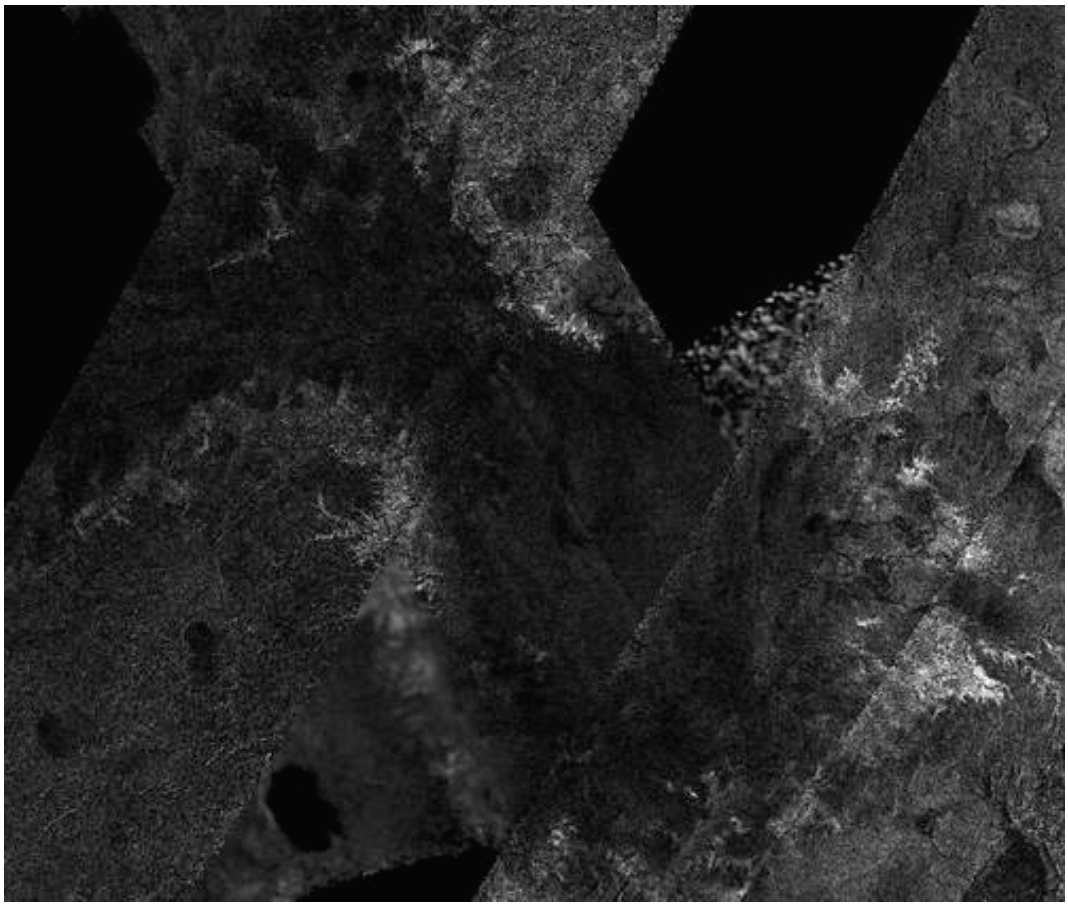
C A S S I N I



T I T A N 117TI(T61) MISSION DESCRIPTION

August 25, 2009

Jet Propulsion Laboratory
California Institute of Technology

Cover image: Lake-like but Different

This mosaic of image swaths from Cassini's Titan Radar Mapper, taken with the synthetic-aperture radar (SAR), features a large dark region several hundred kilometers across that differs in several significant ways from potential lakes observed on Titan. It is not as dark to the radar as many lakes (including lakes seen here), and the nature of the margin is unusual. It has many characteristics in common with lakes, including its channels and interior, yet its differences distinguish it from other similar features. Some similarities are seen with the dark feature in Titan pass T7 (Shoreline on Titan?).

At top (north), the feature has characteristics of a shoreline, with round bay-like margins and channels that drain into it; at left (west) and right (east) it is rimmed by bright, feathery, branching channel-like structures, some of which extend for tens of kilometers. Within the dark feature some details can be seen, some of which seem to be extensions of the channels draining into the dark feature.

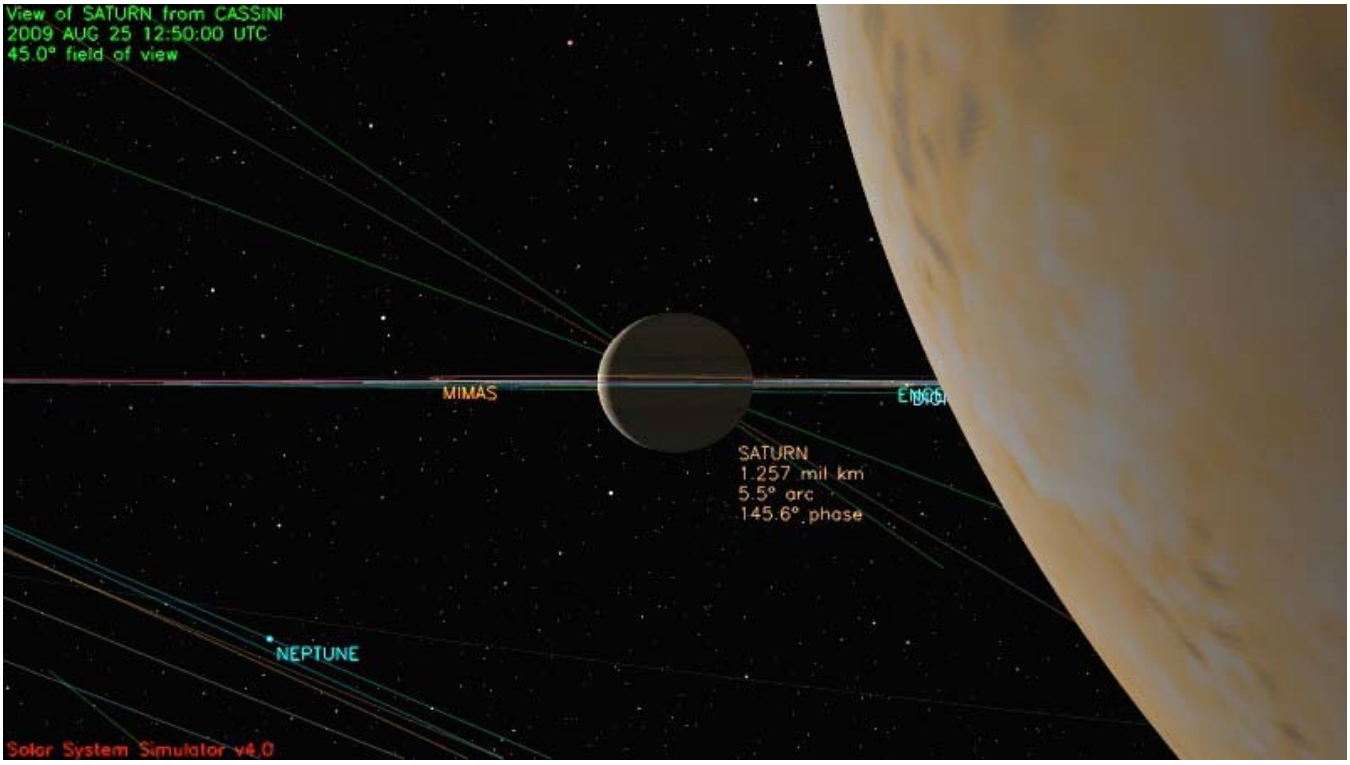
The mosaic is near the south pole, centered near 82 degrees south, 205 degrees west. It includes data from Titan passes T39, T55, T57, T58, and T59, collected between December 2007 and July 2009. The individual swaths vary in resolution and illumination angle, so the edges are visible and surface features look somewhat different across swath boundaries, but the regional view can still be understood. As more SAR image swaths of Titan are collected by Cassini, mosaics of those images reveal features that cannot be appreciated within the individual observations.

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

Barely less than sixteen days since its previous visit, Cassini returns to Saturn's largest moon for the mission's sixty-first targeted encounter with Titan. The closest approach to Titan occurs on Tuesday, August 25 at 237T12:51:38 spacecraft time at an altitude of 970 kilometers (~603 miles) above the surface and at a speed of 6.0 kilometers per second (~13,400 mph). The latitude at closest approach is 19 degrees S and the encounter occurs on orbit number 117.

This encounter is set up with two maneuvers: an apoapsis maneuver on August 16, and a Titan approach maneuver, scheduled for August 21. T61 is the tenth flyby in a series of eleven inbound encounters and the seventeenth Titan encounter in Cassini's Equinox Mission. It occurs just under two days before Saturn closest approach.


View of SATURN from CASSINI
2009 AUG 25 12:50:00 UTC
45.0° field of view
MIMAS
SATURN
1.257 mil km
5.5° arc
145.6° phase
NEPTUNE
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-61 SCIENCE HIGHLIGHTS

- **RADAR** carries out scatterometry, altimetry, and SAR during this flyby. The SAR is near-equatorial, covering Dilmun, Adiri and Belet. The SAR parallels and overlaps the T8 flyby, which should provide a good stereo opportunity over the Belet sand dunes as well as expanded coverage of Shangri-La and Belet. The inbound HiSAR observation is a special 'scrub' of the Shangri-La dunes, which were already observed with SAR observations in T58 and T13, where the instrument 'paints' a strip to look for scattering variation with incidence

and azimuth, a possible signature of sub-resolution roughness like transverse dunes superposed on linear dunes

- **INMS** is riding with RADAR on the night side wake at low/equatorial Southern latitudes. This is the only Southern equatorial wake observation in the mission.
- **VIMS**: The outbound leg of T61 is a very good opportunity for optical instruments because the phase angle is about 10 degrees. Just after the RADAR observations at closest approach, VIMS will observe the southern hemisphere at longitudes similar to those observed at T57, T58, T59 and T60. However, this flyby is the best of the group. The resolution can be as good as 5 km/pixel at the beginning of the observation. From T57 to T61, VIMS observed the same area with different phase angles, which should provide a phase curve. This area, where Northeast-Southwest lineaments have been observed during the prime mission and where clouds may be orogenic, was not observed during the prime mission.
- **CIRS** carries out Mid-infrared vertical temperature mapping at high latitudes. Cassini will return to this area in the extended extended mission to look for seasonal change.
- **ISS** will ride along with VIMS from C/A + ~1 hour onward to image western Senkyo at low phase angles and a variety of resolutions as well as to monitor clouds. (0.5-hour illuminated prime observation primarily for photometry.)
- **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.
- **MIMI** measures energetic ion and electron energy input to Titan's atmosphere. This is high value data.
- **MAG**: T61 is an upstream, post-dusk flyby, with a minimum altitude of 1000 km. MAG measurements will provide a description of the draping and the pileup of the external magnetic field around Titan near the terminator. It will be also a good complement to T52, T53, T54, T55, T56, T57, T58, T59 and T60 in order to characterize the background field for a similar local time with respect to Saturn and different SKR longitudes.
- **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

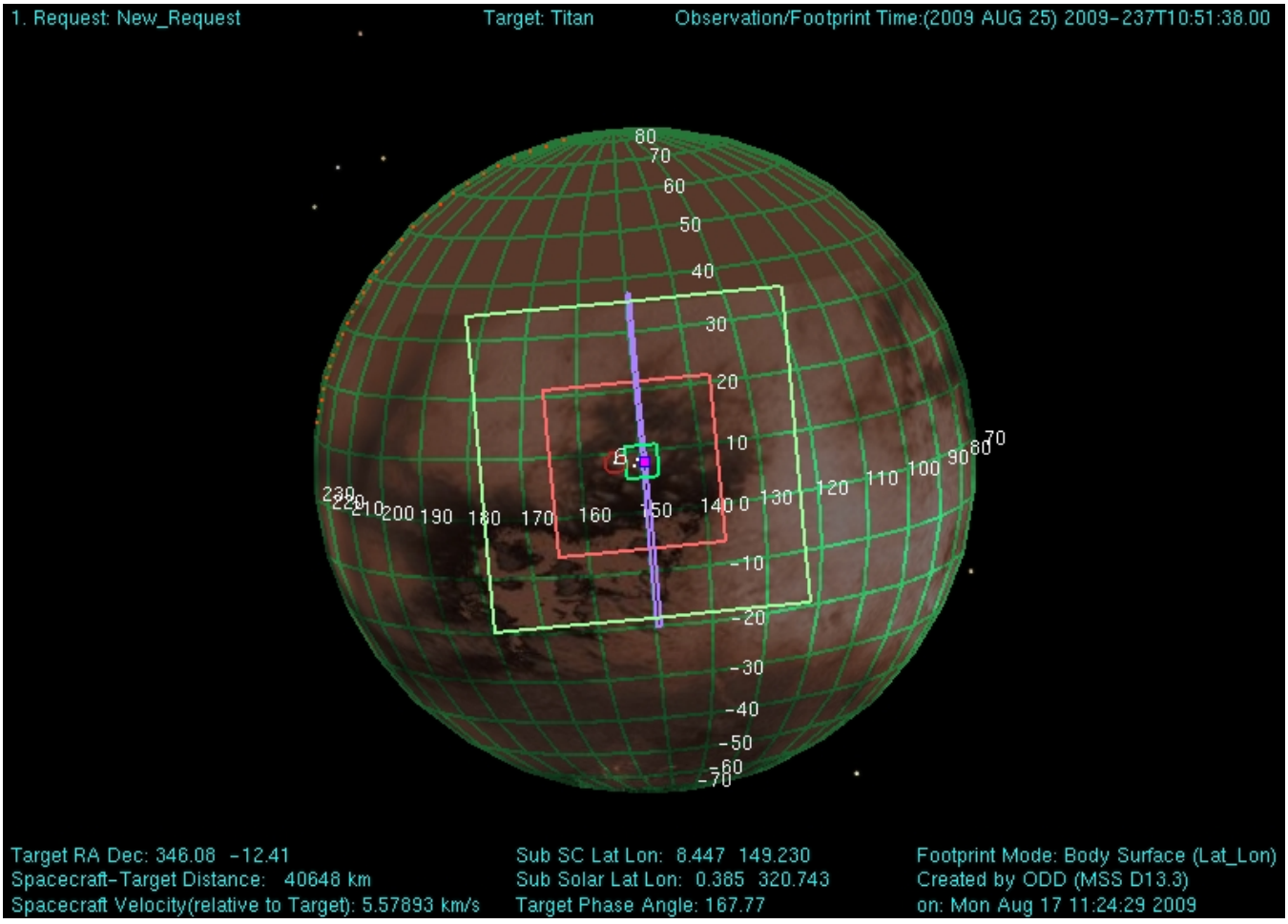
Three views of Titan from Cassini before, during, and after closest approach to Titan are shown below. The views are oriented such that the direction towards the top of the page is aligned with

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.

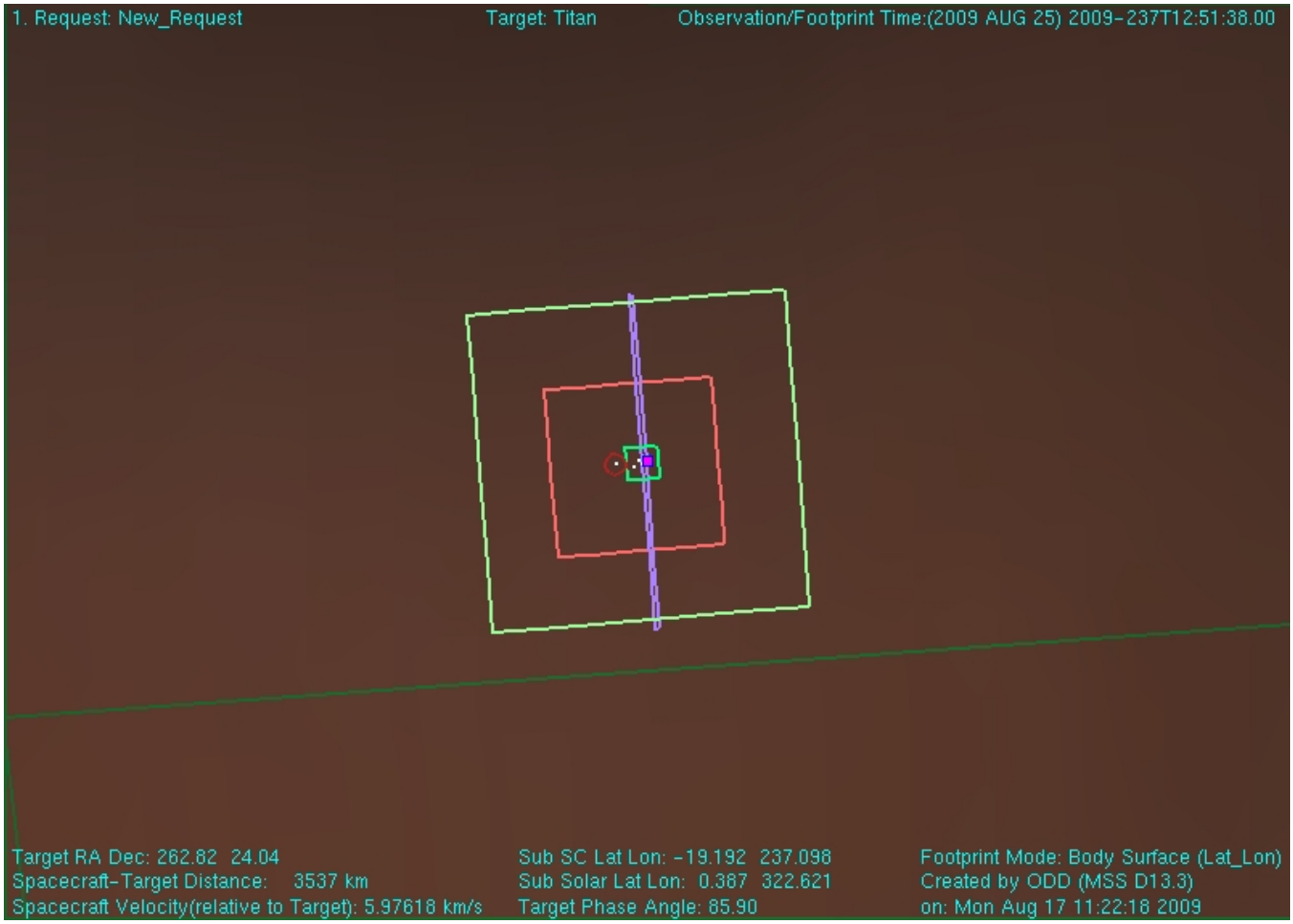
Key to ORS Instrument Fields of View in Figures

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

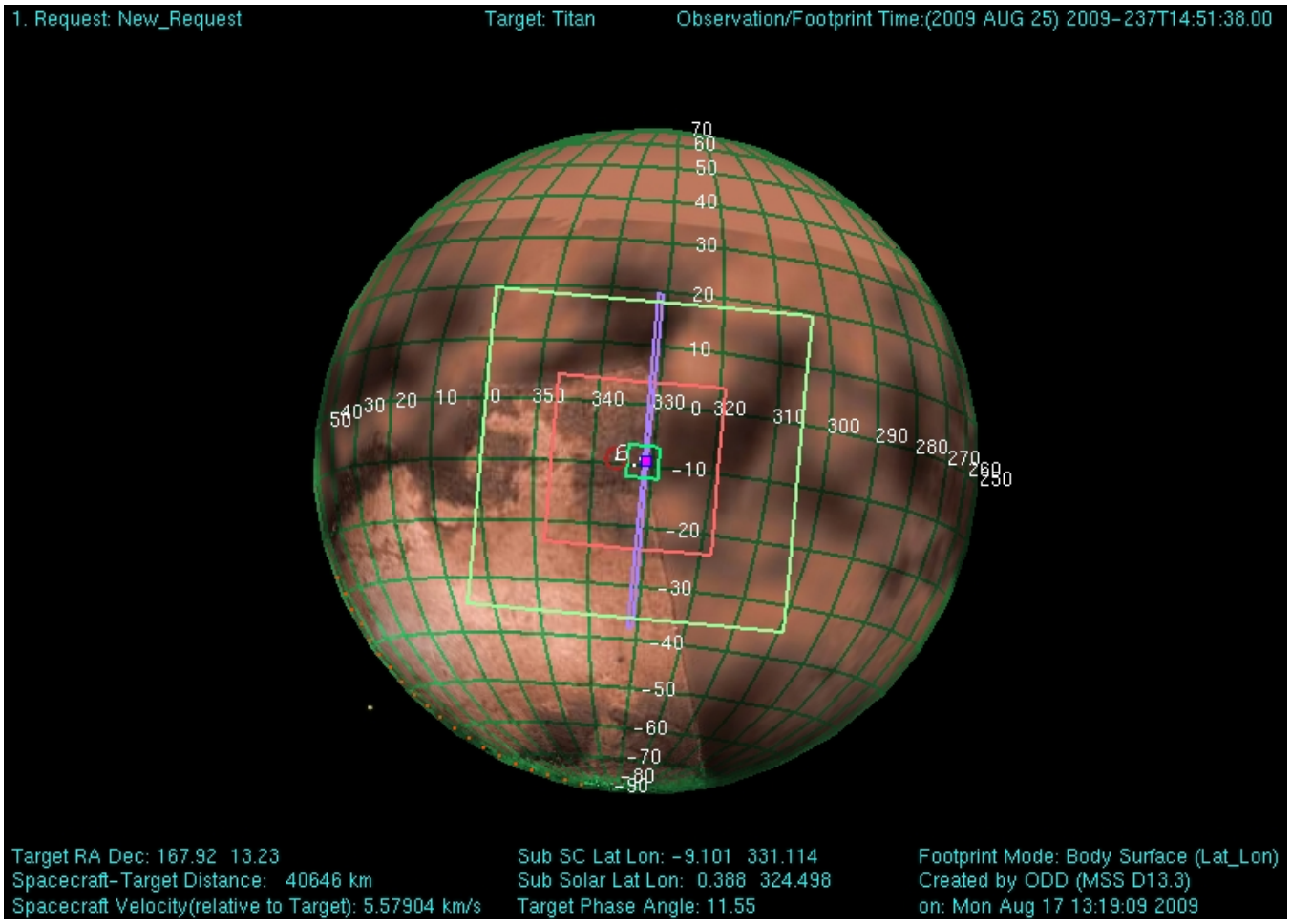
View of Titan from Cassini two hours before Titan-61 closest approach



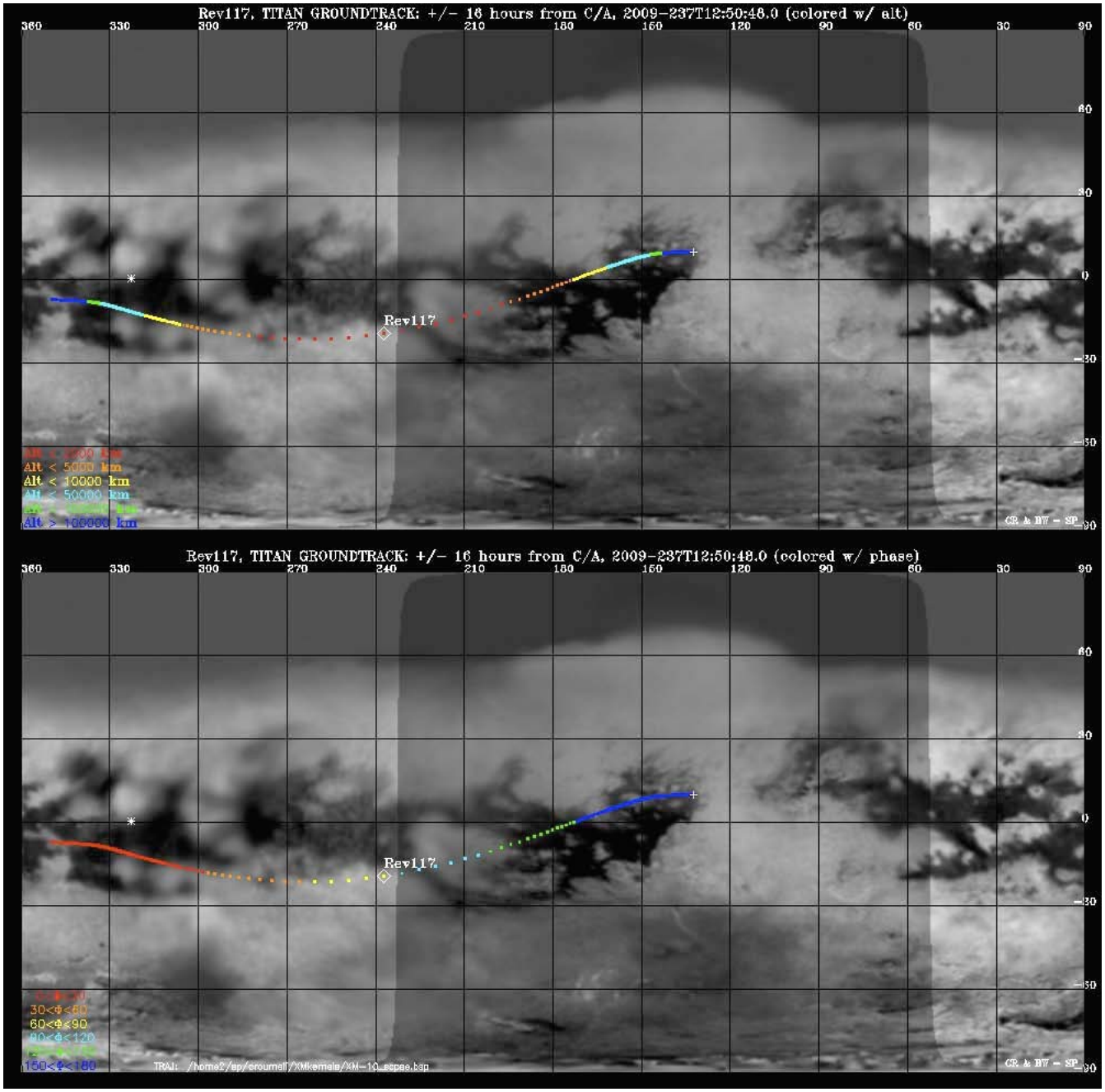
View of Titan from Cassini at Titan-61 closest approach



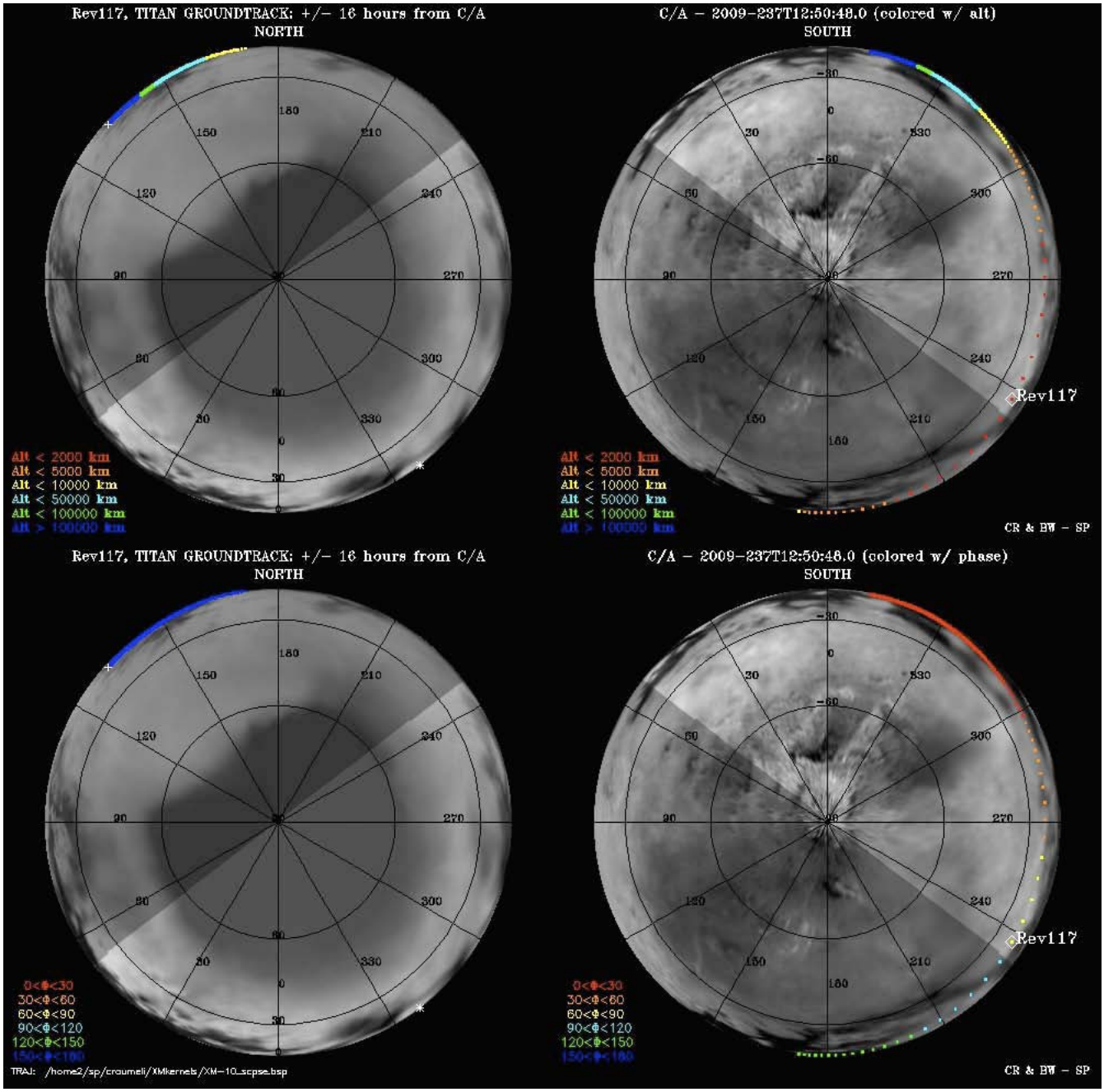
View of Titan from Cassini two hours after Titan-61 closest approach



Titan Groundtracks for T61: Global Plot



Titan Groundtracks for T61: Polar Plot



The T61 timeline is as follows:

Cassini Titan-61 Timeline - August 2009

Colors: yellow = maneuvers; blue = geometry;
pink = T61-related; green = data playbacks

Orbiter UTC	Ground UTC	Pacific Time (PDT)	Time wrt T61	Activity	Description
233T21:34:00	Aug 21 23:00	Fri Aug 21 04:00 PM	T61-03d15h	OTM #214 Prime	Titan-61 targeting maneuver.
234T21:34:00	Aug 22 23:00	Sat Aug 22 04:00 PM	T61-02d15h	OTM #214 Backup	
237T00:04:00	Aug 25 01:30	Mon Aug 24 06:30 PM	T61-12h47m	Start of Sequence S53	Start of Sequence which contains Titan-61
237T00:04:00	Aug 25 01:30	Mon Aug 24 06:30 PM	T61-12h47m	Start of the TOST segment	
237T00:04:00	Aug 25 01:30	Mon Aug 24 06:30 PM	T61-12h47m	Vector table load	
237T00:10:00	Aug 25 01:36	Mon Aug 24 06:36 PM	T61-12h41m	Turn cameras to Titan	
237T00:44:00	Aug 25 02:10	Mon Aug 24 07:10 PM	T61-12h07m	New waypoint	
237T00:44:00	Aug 25 02:10	Mon Aug 24 07:10 PM	T61-12h07m	Deadtime	15 minutes 50 seconds long; used to accommodate changes in flyby time
237T01:00:38	Aug 25 02:26	Mon Aug 24 07:26 PM	T61-11h51m	Titan atmospheric observations-ISS	WAC Nightside imaging
237T03:51:38	Aug 25 05:17	Mon Aug 24 10:17 PM	T61-09h00m	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.
237T07:41	Aug 25 09:07	Tue Aug 25 02:07 AM	T61-05h10m	Titan surface observations-VIMS	Regional mapping
237T10:31:38	Aug 25 11:57	Tue Aug 25 04:57 AM	T61-02h20m	RADAR	Inbound scatterometry
237T11:39:38	Aug 25 13:05	Tue Aug 25 06:05 AM	T61-01h12m	RADAR	Inbound HiSAR
237T12:21:38	Aug 25 13:47	Tue Aug 25 06:47 AM	T61-00h30m	Transition to thruster control	
237T12:22:38	Aug 25 13:48	Tue Aug 25 06:48 AM	T61-00h29m	RADAR	Inbound altimetry
237T12:33:38	Aug 25 13:59	Tue Aug 25 06:59 AM	T61-00h18m	RADAR	Inbound and outbound SAR
237T12:51:38	**Aug 25 14:17**	**Tue Aug 25 07:17 AM**	**T61+00h00m**	**Titan-61 Flyby Closest Approach Time**	**Altitude = 970 km (~603 miles), speed =6.0 km/s (13,400 mph); 86 deg phase at closest approach**
237T13:16:38	Aug 25 14:42	Tue Aug 25 07:42 AM	T61+00h25m	Transition off of thruster control	
237T13:35:43	Aug 25 15:01	Tue Aug 25 08:01 AM	T61+00h44m	Titan surface observations-VIMS	Titan mosaic
237T14:55:31	Aug 25 16:21	Tue Aug 25 09:21 AM	T61+02h04m	Descending Ring Plane Crossing	
237T21:21:38	Aug 25 22:47	Tue Aug 25 03:47 PM	T61+08h30m	Titan atmospheric observations-ISS	WAC Photometry
237T21:51:38	Aug 25 23:17	Tue Aug 25 04:17 PM	T61+09h00m	Titan surface observations-VIMS	Global mapping
238T02:51:38	Aug 26 04:17	Tue Aug 25 09:17 PM	T61+14h00m	Titan surface observations-VIMS	Global mapping
238T13:51:38	Aug 26 15:17	Wed Aug 26 08:17 AM	T61+01d01h	Deadtime	32 minutes 22 seconds long; used to accommodate changes in flyby time
238T14:24:00	Aug 26 15:50	Wed Aug 26 08:50 AM	T61+01d02h	Turn to Earth-line	
238T15:04:00	Aug 26 16:30	Aug 26 09:30	T61+01d02h	Playback of T61 Data	Goldstone 70m