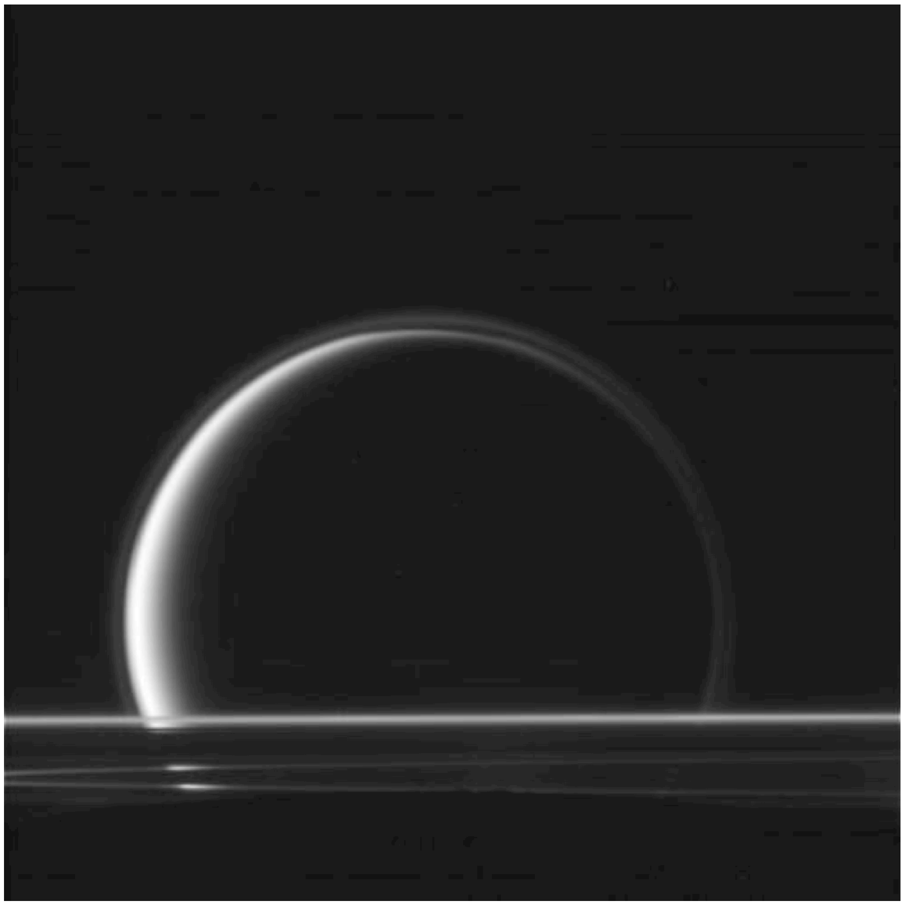
CASSINI



TITAN 132TI(T69) MISSION DESCRIPTION

June 5, 2010

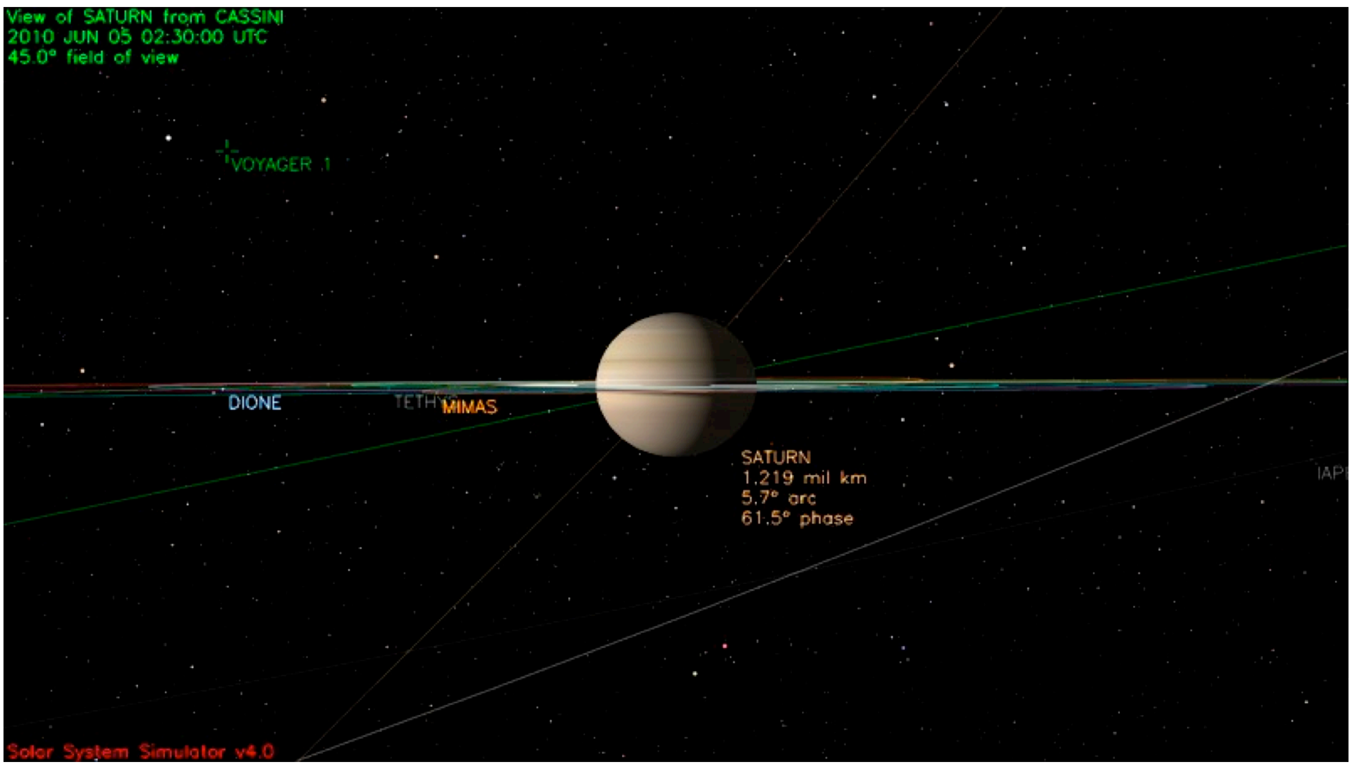
Jet Propulsion Laboratory
California Institute of Technology

Cover image: Enceladus, Titan, and Rings – Raw This raw, unprocessed image of Titan behind Saturn's rings was taken on May 18, 2010, by the Cassini spacecraft.   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 16 day interval since last visiting Titan, Cassini returns to Saturn's largest moon for the mission's seventieth targeted encounter with Titan. The closest approach to Titan occurs on Friday, June 5 at 156T02:26:27 spacecraft time at an altitude of 2044 kilometers (~1270 miles) above the surface and at a speed of 5.8 kilometers per second (~13,025 mph). The latitude at closest approach is 87 degrees N and the encounter occurs on orbit number 132.

This encounter is set up with two maneuvers: an apoapsis maneuver on May 27, and a Titan approach maneuver, scheduled for June 1. T69 is the second outbound flyby in the final set of three outbound encounters in the extended 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 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-69 SCIENCE HIGHLIGHTS

- **VIMS:** During this flyby, VIMS will be prime at C/A and will observe the North-pole area. A mosaic of Kraken Mare (70-75 N, 225 W) may be obtained if the North polar hood has vanished. A mosaic of an area North of Adiri will be obtained at a resolution of 10 km per pixel

- **CAPS:** Data from the magnetospheric boundary campaigns are being used todevelop models of the solar wind interaction with Saturn'smagnetosphere. Additionally, a study is being done to determine theeffects of particle pressure from Titan on the location of themagnetopause on the dayside.
- **ISS** – ISS will acquire a full-disk mosaic of northwestern Adiri and will ride along with VIMS during and after closest-approach to observe parts of Titan's anti-Saturnian hemisphere from the North Pole to the equator. ISS will also ride along with VIMS to

track clouds and will continue to monitor clouds and the evolution thereof for an extra two days after the Titan encounter.

- **CIRS:** Continuation mapping of seasonal temperature and composition effects.
- **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**: T69 is a north polar, dusk flyby, with a minimum altitude of 2100 km. In nominal upstream conditions, Cassini would explore the edge of the north lobe of Titan's magnetic tail.
- **MIMI**: Energetic ion and electron energy input to atmosphere; good 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.

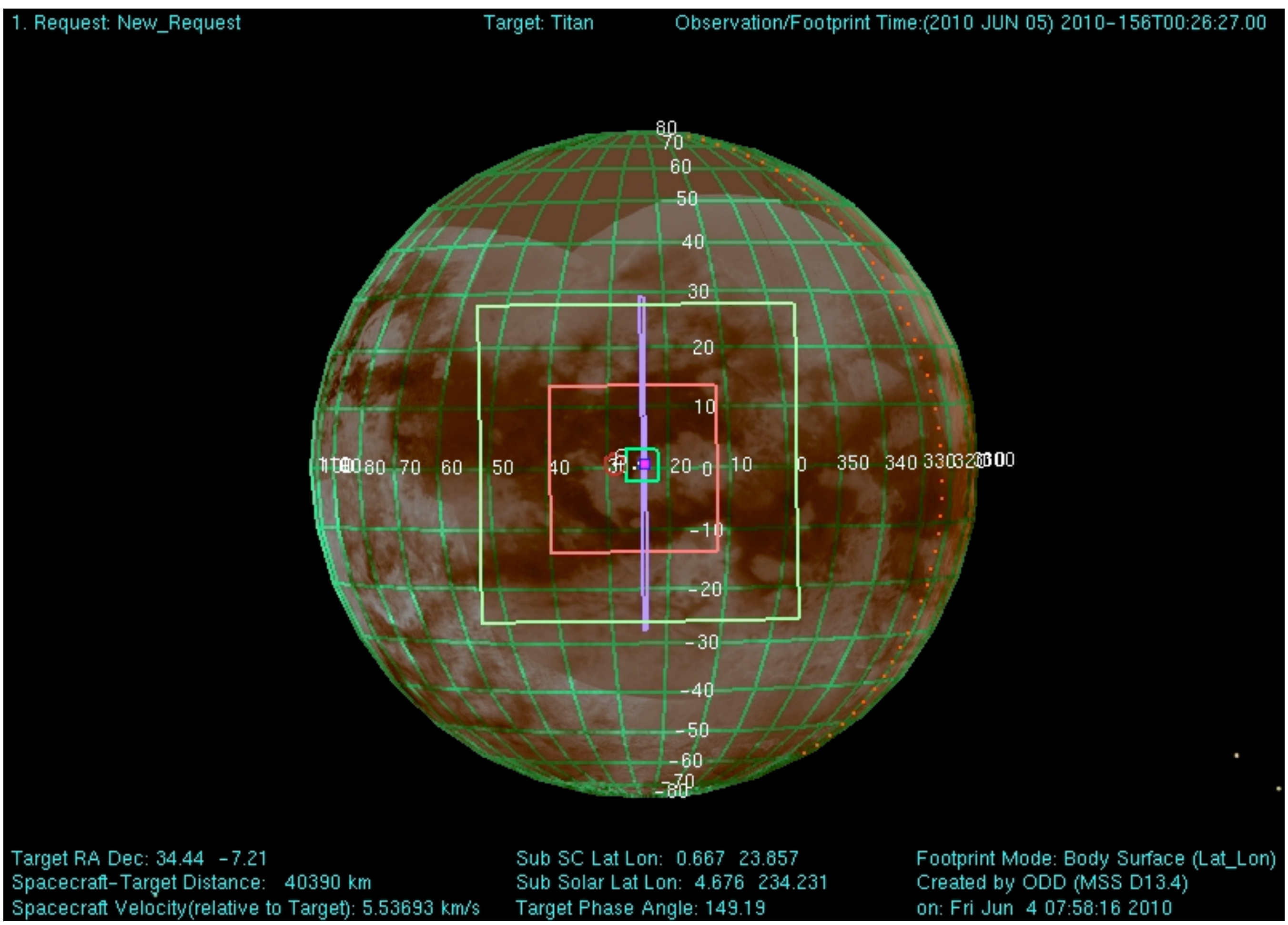
SAMPLE SNAPSHOTS

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.

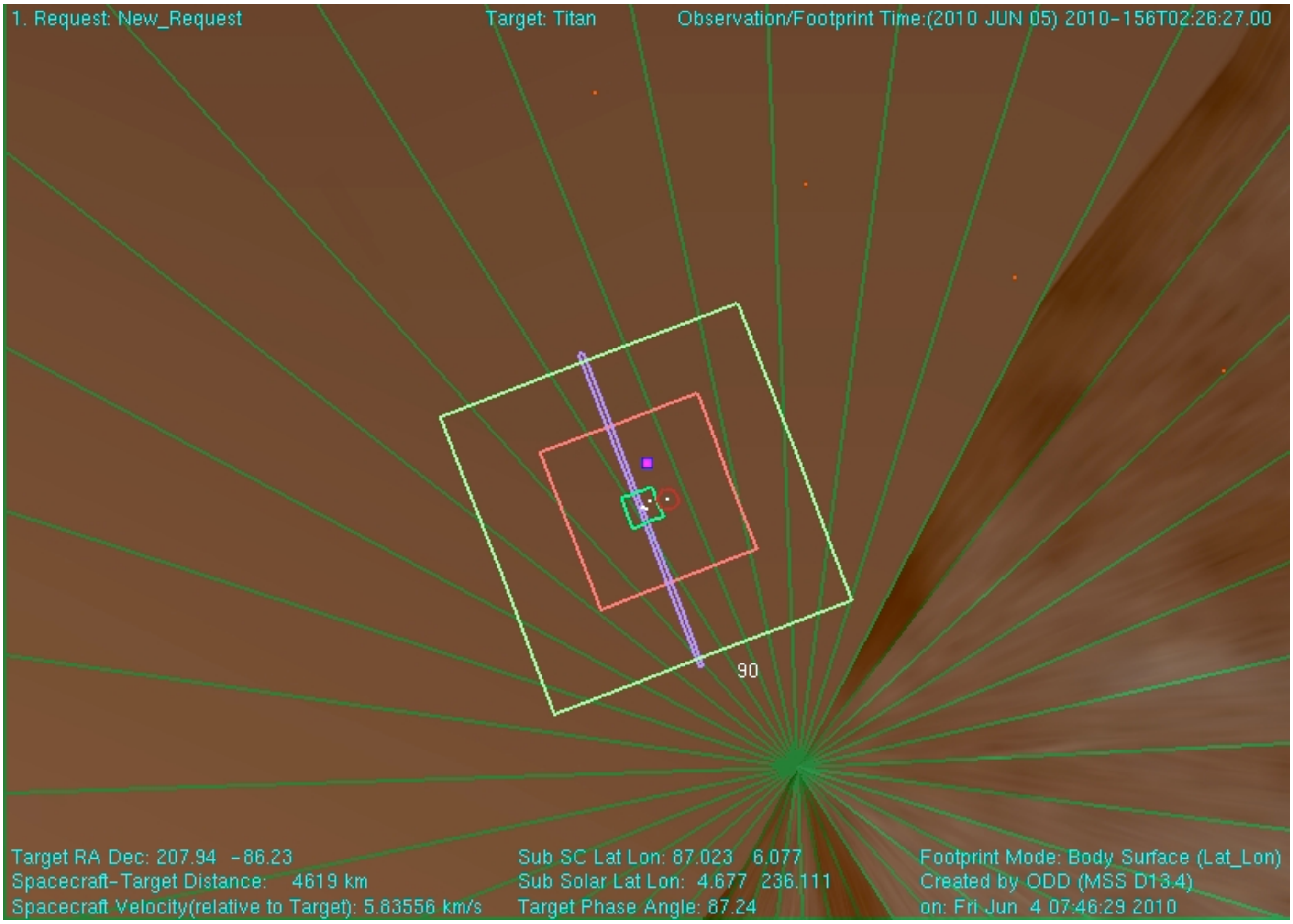
Key to ORS Instrument Fields of View in Figures

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

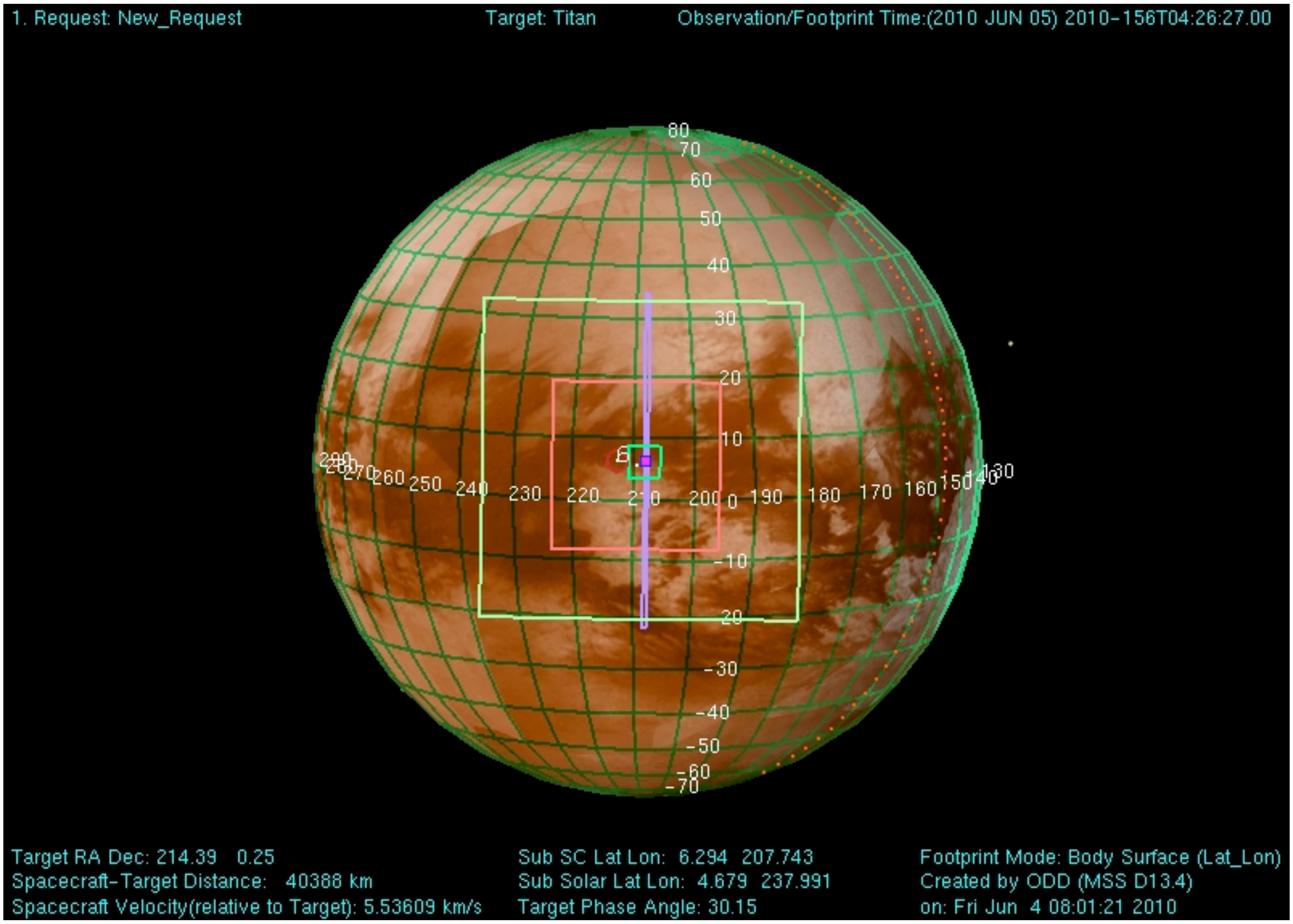
View of Titan from Cassini two hours before Titan-69 closest approach



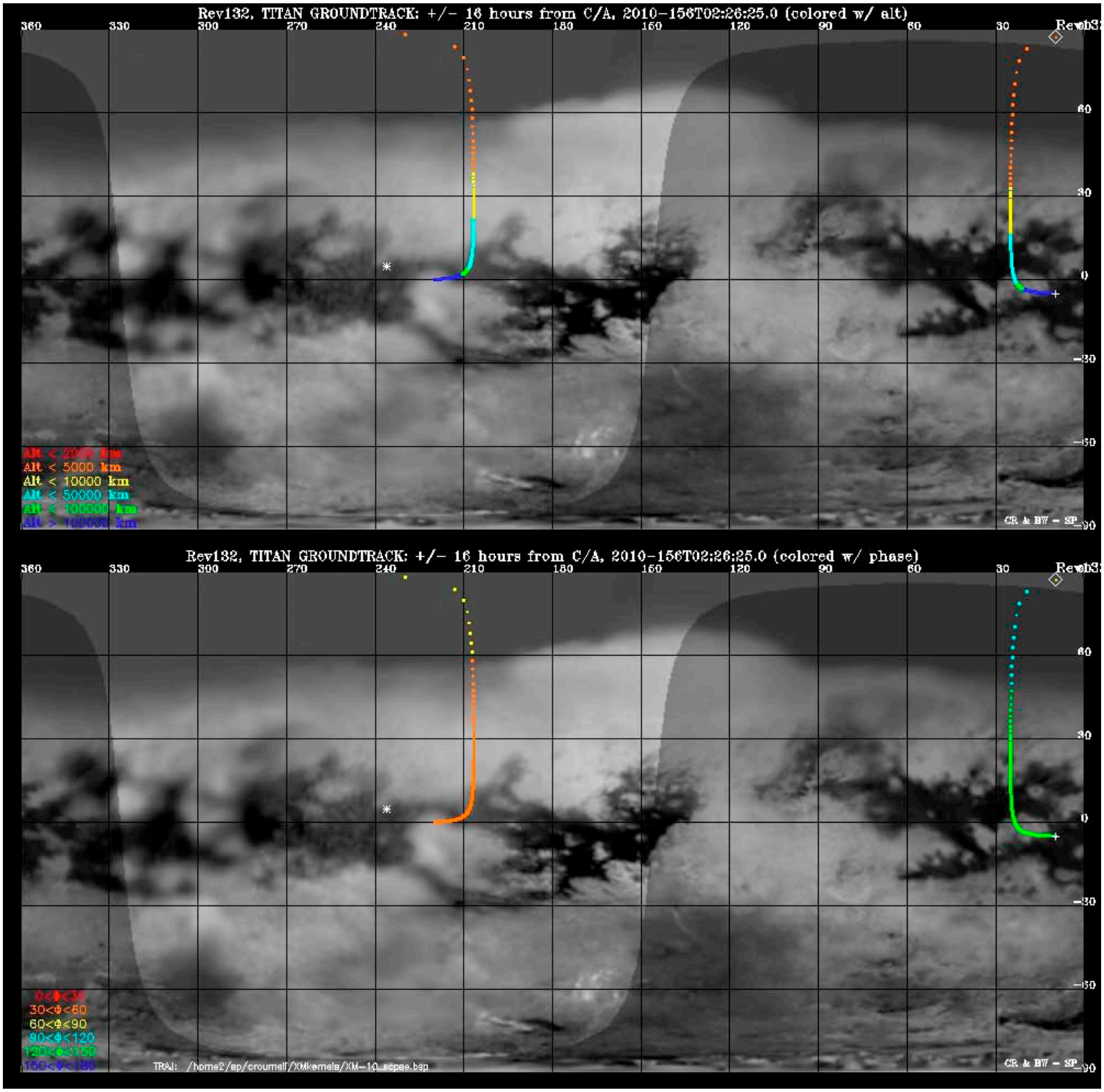
View of Titan from Cassini at Titan-69 closest approach



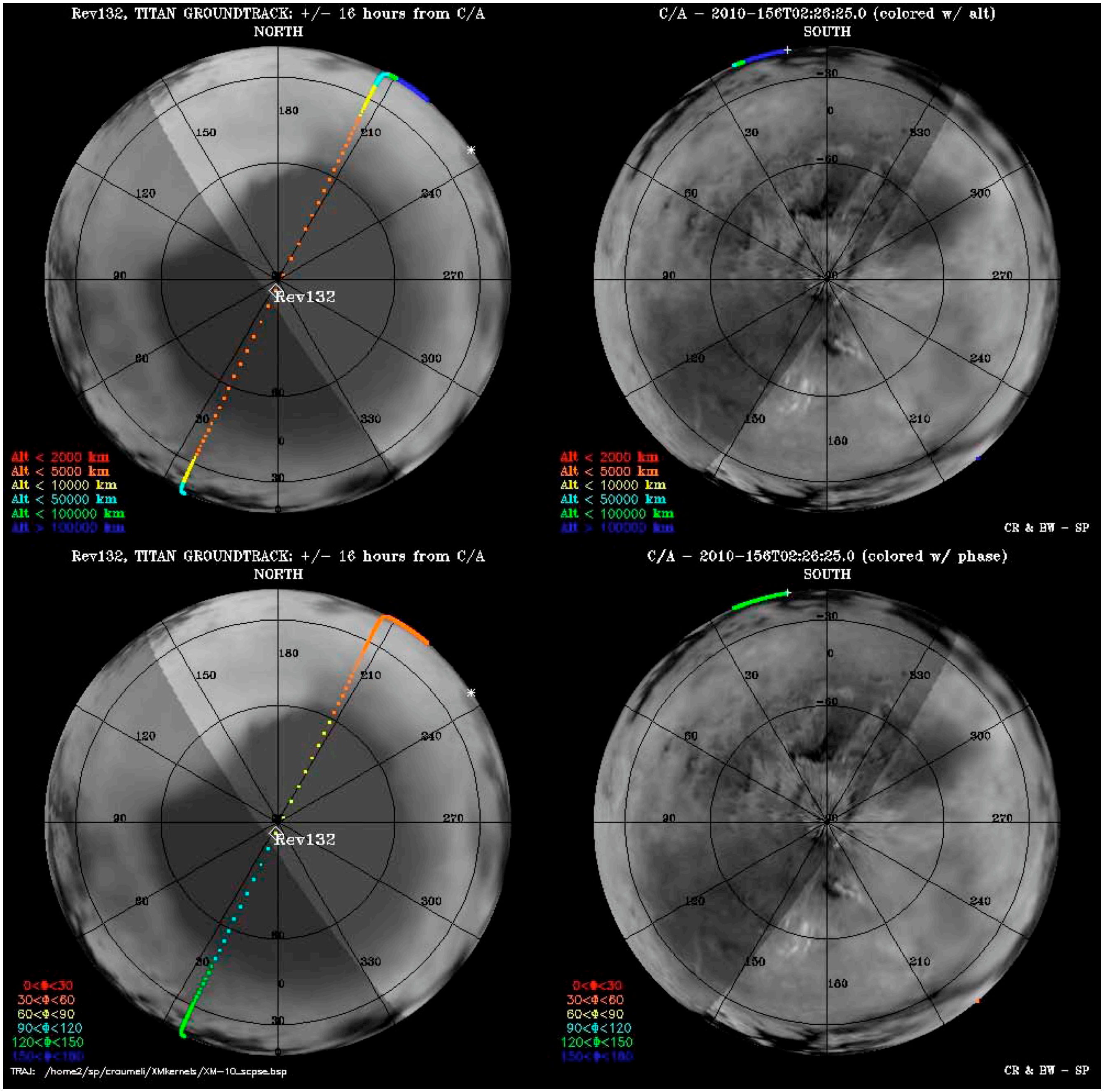
View of Titan from Cassini two hours after Titan-69 closest approach



Titan Groundtracks for T69: Global Plot



Titan Groundtracks for T69: Polar Plot



The T69 timeline is as follows:

Cassini Titan-69 - June 2010

Colors: yellow = maneuvers; blue = geometry; pink = T69-related; green = data playbacks

Orbiter UTC	Ground UTC	Pacific Time (PDT)	Time wrt T69	Activity	Description
137T13:31:00	May 17 14:48	Mon May 17 07:48 AM	T69-18d13h	Start of Sequence S60	Start of Sequence which contains Titan-69
152T13:44:00	Jun 01 15:01	Tue Jun 01 08:01 AM	T69-03d13h	OTM #250 Prime	Titan-69 targeting maneuver.
153T13:44:00	Jun 02 15:01	Wed Jun 02 08:01 AM	T69-02d13h	OTM #250 Backup	
155T12:13:00	Jun 04 13:30	Fri Jun 04 06:30 AM	T69-14h13m	Start of the TOST segment	
155T12:13:00	Jun 04 13:30	Fri Jun 04 06:30 AM	T69-14h13m	Turn cameras to Titan	
155T12:53:00	Jun 04 14:10	Fri Jun 04 07:10 AM	T69-13h33m	New waypoint	
155T12:53:00	Jun 04 14:10	Fri Jun 04 07:10 AM	T69-13h33m	Deadtime	06 minutes 35 seconds long; used to accommodate changes in flyby time
155T13:08:02	Jun 04 14:25	Fri Jun 04 07:25 AM	T69-13h18m	Titan surface observations-VIMS	Global mapping
155T17:08:27	Jun 04 18:25	Fri Jun 04 11:25 AM	T69-09h18m	Titan atmospheric observations-CIRS	Obtain vertical profiles of temperatures in Titan's stratosphere.
155T21:26:27	Jun 04 22:43	Fri Jun 04 03:43 PM	T69-05h00m	RADAR	Inbound radiometry
156T00:26:27	Jun 05 01:43	Fri Jun 04 06:43 PM	T69-02h00m	RADAR	Inbound scatterometry
156T01:14:27	Jun 05 02:31	Fri Jun 04 07:31 PM	T69-01h12m	RADAR	Inbound HiSAR
156T02:11:27	Jun 05 03:28	Fri Jun 04 08:28 PM	T69-00h15m	Titan surface observations-VIMS	Regional Map
156T02:26:27	**Jun 05 03:43**	**Fri Jun 04 08:43 PM**	**T69+00h00m**	**Titan-69 Flyby Closest Approach Time**	**Altitude = 2044 km (~1270 miles), speed =5.8 km/s (~13,025 mph); 87 deg phase at closest approach**
156T04:26:27	Jun 05 05:43	Fri Jun 04 10:43 PM	T69+02h00m	Titan atmospheric observations-UVIS	EUVFUV Imaging of Titan: several slow scans across Titan's visible hemisphere to form spectral images
156T11:26:27	Jun 05 12:43	Sat Jun 05 05:43 AM	T69+09h00m	Titan atmospheric observations-CIRS	Obtain information on CO, HCN, CH4. Integrate on disk at airmass 1.5--2.0.
156T14:26:27	Jun 05 15:43	Sat Jun 05 08:43 AM	T69+12h00m	Titan surface observations-ISS	NAC Monitor
156T16:26:27	Jun 05 17:43	Sat Jun 05 10:43 AM	T69+14h00m	Titan surface observations-VIMS	Global mapping
156T18:33:02	Jun 05 19:50	Sat Jun 05 12:50 PM	T69+16h07m	Deadtime	14 minutes 58 seconds long; used to accommodate changes in flyby time
156T18:48:00	Jun 05 20:05	Sat Jun 05 01:05 PM	T69+16h22m	Turn to Earth-line	
156T19:28:00	Jun 05 20:45	Sat Jun 05 01:45 PM	T69+17h02m	Reaction Wheel bias	
156T20:58:00	Jun 05 22:15	Jun 05 15:15	T69+18h32m	Playback of T69 Data	Goldstone 34m
157T02:43:00	Jun 06 04:00	Jun 05 21:00	T69+01d00h	Playback of T69 Data	Canberra 70m
157T06:48:00	Jun 06 08:05	Sun Jun 06 01:05 AM	T69+01d04h	Turn cameras to Titan	
157T07:28:00	Jun 06 08:45	Sun Jun 06 01:45 AM	T69+01d05h	New waypoint	
157T07:28:00	Jun 06 08:45	Sun Jun 06 01:45 AM	T69+01d05h	Titan surface observations-ISS	Titan cloud monitoring and gap filling
157T12:00:00	Jun 06 13:17	Sun Jun 06 06:17 AM	T69+01d10h	MAPS survey	MAPS suvery with prime pointing
157T14:00:00	Jun 06 15:17	Sun Jun 06 08:17 AM	T69+01d12h	Titan surface observations-ISS	Titan cloud monitoring and gap filling
157T18:48:00	Jun 06 20:05	Sun Jun 06 01:05 PM	T69+01d16h	Turn to Earth-line	
157T19:28:00	Jun 06 20:45	Sun Jun 06 01:45 PM	T69+01d17h	MAPS survey	MAPS suvery with prime pointing
157T20:58:00	Jun 06 22:15	Jun 06 15:15	T69+01d19h	Playback of T69 Data	Goldstone 34m
158T02:28:00	Jun 07 03:45	Jun 06 20:45	T69+02d00h	Playback of T69 Data	Canberra 70m
158T06:48:00	Jun 07 08:05	Mon Jun 07 01:05 AM	T69+02d04h	Turn cameras to Titan	
158T07:28:00	Jun 07 08:45	Mon Jun 07 01:45 AM	T69+02d05h	New waypoint	
158T07:28:00	Jun 07 08:45	Mon Jun 07 01:45 AM	T69+02d05h	Titan surface observations-ISS	Titan cloud monitoring and gap filling
158T12:00:00	Jun 07 13:17	Mon Jun 07 06:17 AM	T69+02d10h	MAPS survey	MAPS suvery with prime pointing
158T14:00:00	Jun 07 15:17	Mon Jun 07 08:17 AM	T69+02d12h	RADAR calibration	