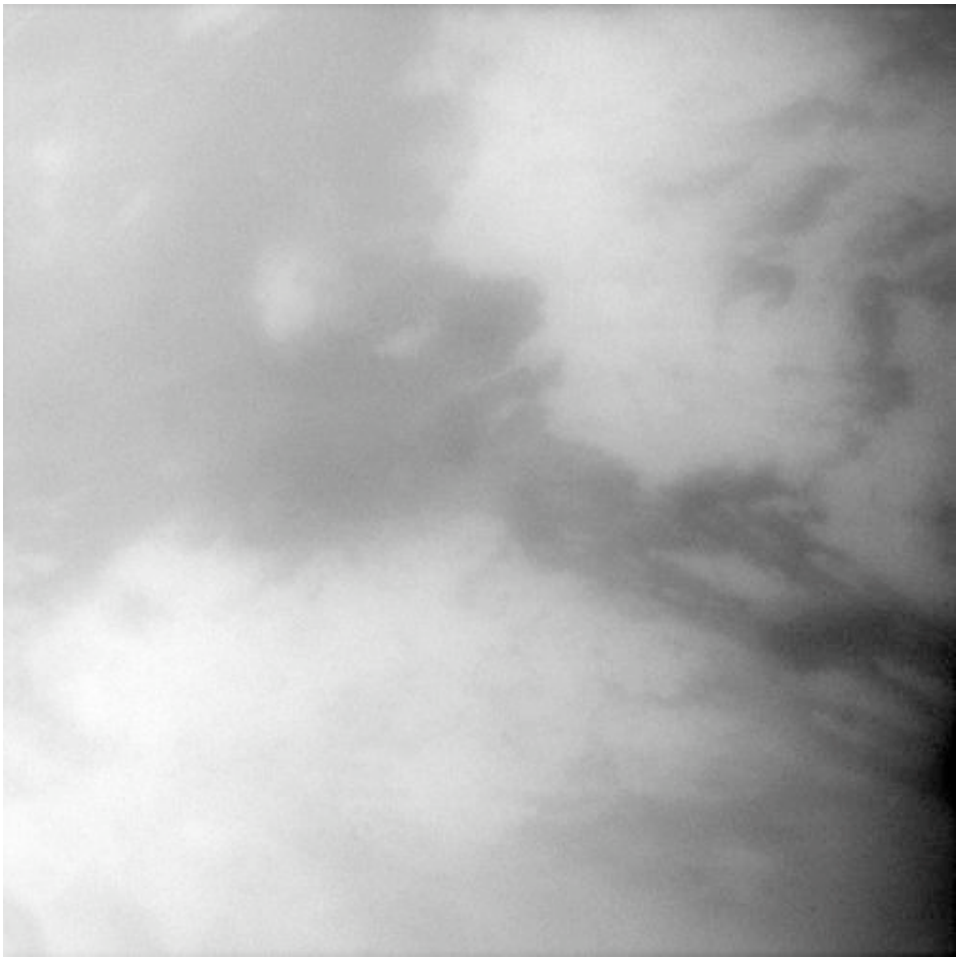
C A S S I N I



T I T A N 1 3 3 T I (T 7 0)
MISSION DESCRIPTION

June 20, 2010

Jet Propulsion Laboratory
California Institute of Technology

Cover image: Belet Close-Up Full-Res: PIA12647

The Cassini spacecraft peers through the atmosphere of Saturn's largest moon, Titan, to examine the dark region Belet.

This large region on the moon's surface has a low albedo, meaning it reflects little light. See Map of Titan - February 2009 to learn more. This view looks toward the trailing hemisphere of Titan (5,150 kilometers, or 3,200 miles across).

The image was taken with the Cassini spacecraft narrow-angle camera on Dec. 28, 2009 using a spectral filter sensitive to wavelengths of near-infrared light centered at 938 nanometers. The view was obtained at a distance of approximately 282,000 kilometers (175,000 miles) from Titan and at a Sun-Titan-spacecraft, or phase, angle of 45 degrees. Image scale is 2 kilometers (1 mile) per pixel.

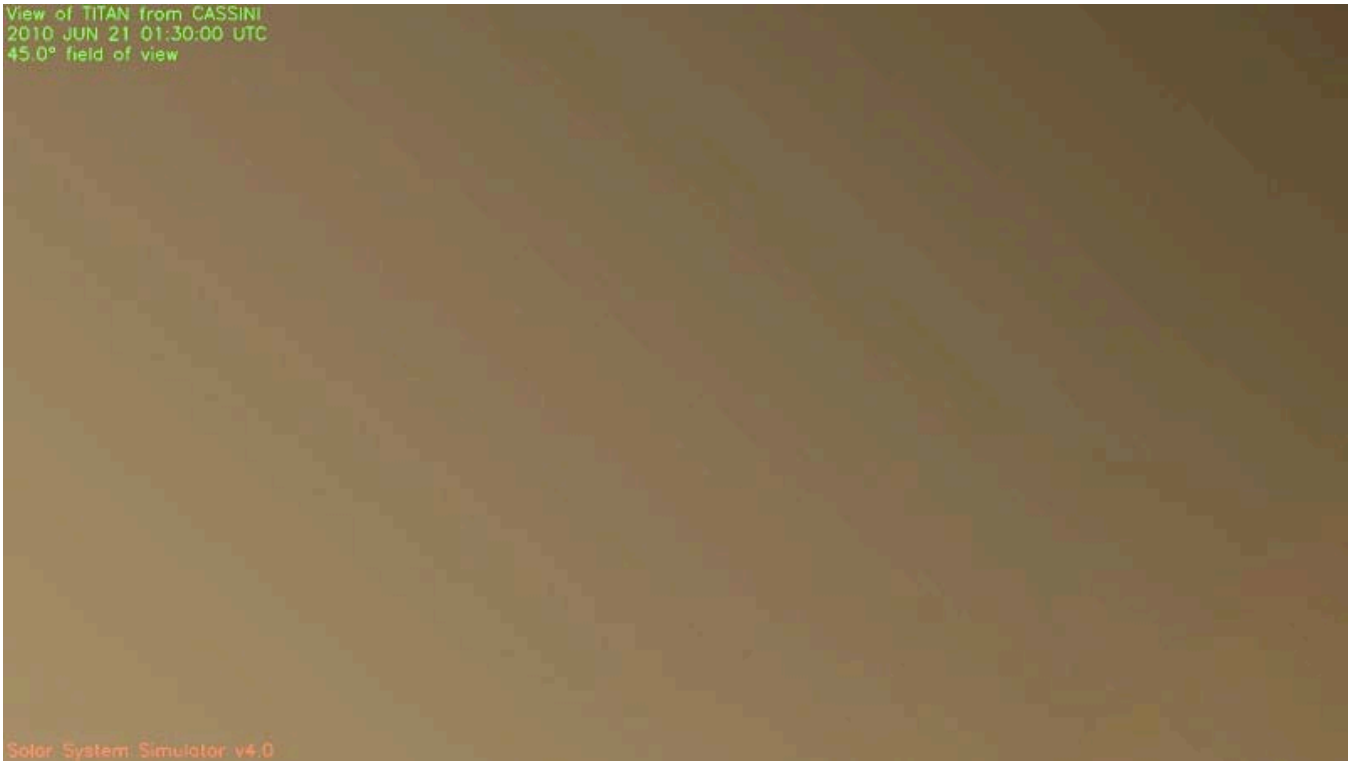
The Cassini-Huygens mission is a cooperative project of NASA, the European Space Agency and the Italian Space Agency. The Jet Propulsion Laboratory, a division of the California Institute of Technology in Pasadena, manages the mission for NASA's Science Mission Directorate, Washington, D.C. The Cassini 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 16 day interval since last visiting Titan, Cassini returns to Saturn's largest moon for the mission's seventy-first targeted encounter with Titan. The closest approach to Titan occurs on Sunday, June 20 at 172T01:27:43 spacecraft time at an altitude of 880 kilometers (~547 miles) above the surface and at a speed of 5.9 kilometers per second (~13,200 mph). The latitude at closest approach is 82 degrees N and the encounter occurs on orbit number 133.

This encounter is set up with two maneuvers: an apoapsis maneuver on June 12, and a Titan approach maneuver, scheduled for June 17. T70 is the final flyby in the extended mission.


View of TITAN from CASSINI
2010 JUN 21 01:30:00 UTC
45.0° field of view
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-70 SCIENCE HIGHLIGHTS

- **MAPS:** T70 is the flyby with highest priority for MAG. With an unprecedented altitude of 880 km at closest approach (in the dayside ionosphere), the measurements obtained by MAG will provide important pieces of evidence in favor or against the presence of a dynamo generated magnetic field.

- **UVIS:** Stellar occultation outbound from Titan. Occultations by Titan are the most valuable Titan observations for UVIS because they provide detailed vertical profiles of nitrogen (in the

EUV channel during solar occultation) and hydrocarbons, HCN, and aerosols (in the FUV channel during stellar occultations). The experiment is selfcalibrating (the information comes from a ratio of signal during occultation to signal of the unocculted sun or star just before or after occultation). These profiles probe altitudes between 300 km and 2400 km, which fill the gap between CIRS and INMS measurements. Much of the chemistry and aerosol formation occurs in this vertical region. Observations taken over the course of the mission will collectively provide coverage at many latitudes and local times and these will be used to study meridional and local time gradients in the upper atmosphere. Knowledge of these gradients is important for understanding the meridional circulation and other dynamical and chemical processes.

- **VIMS** will ride along with UVIS just after C/A for stellar occultation. Then VIMS will perform a mosaic of Adiri at 20 km per pixel.
- **CIRS –** Composition and temperature at mid-northern latitudes.
- **ISS** will ride along with VIMS to observe Adiri at moderate resolutions and will monitor Titan to track clouds and the evolution thereof for an extra two days after the Titan encounter. (0.5-hour illuminated prime observation primarily for photometry.)
- **MIMI**: Excellent energetic ion and electron energy input to atmosphere
- **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.

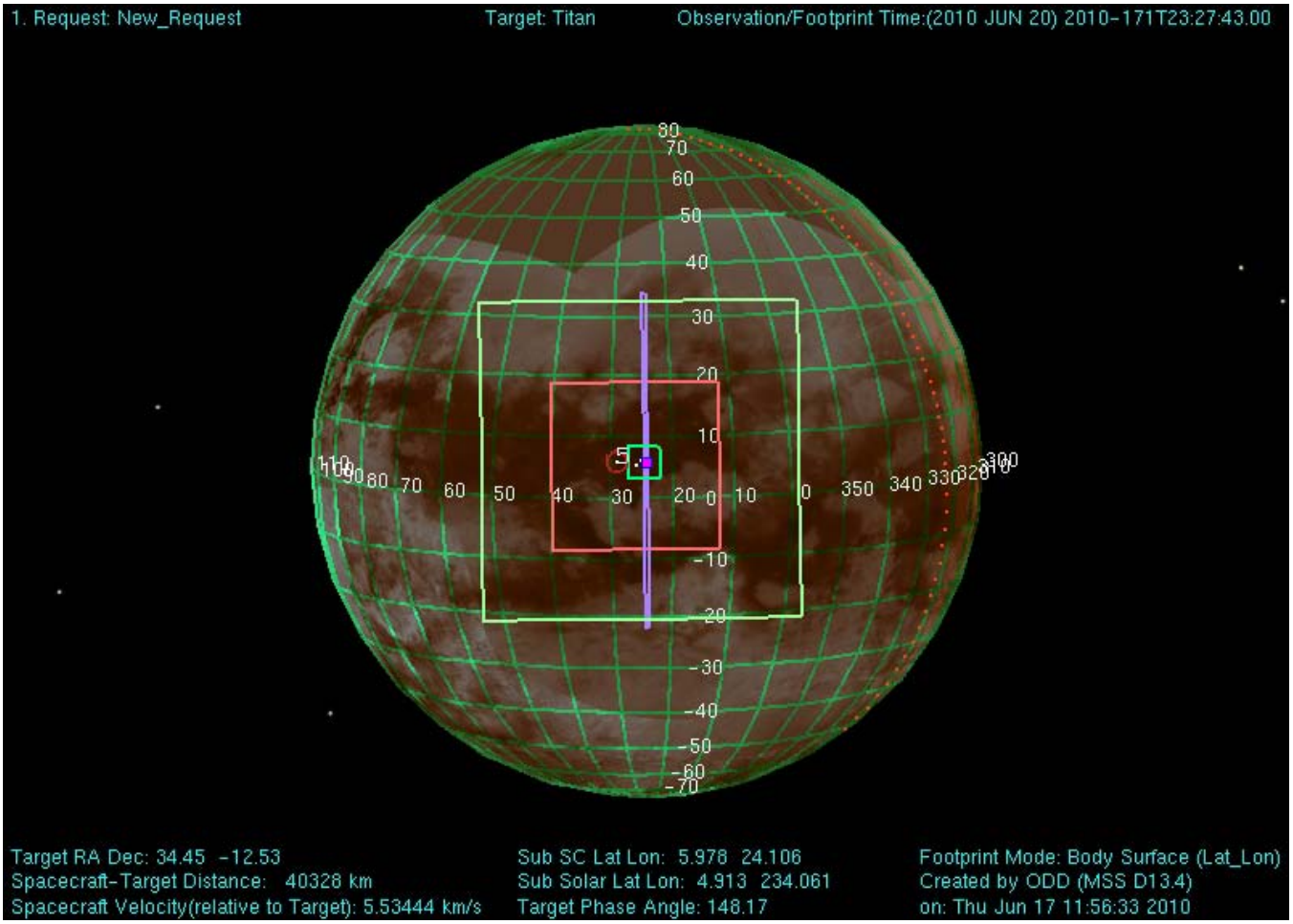
SAMPLE SNAPSHOTS

Two views of Titan from Cassini before 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.

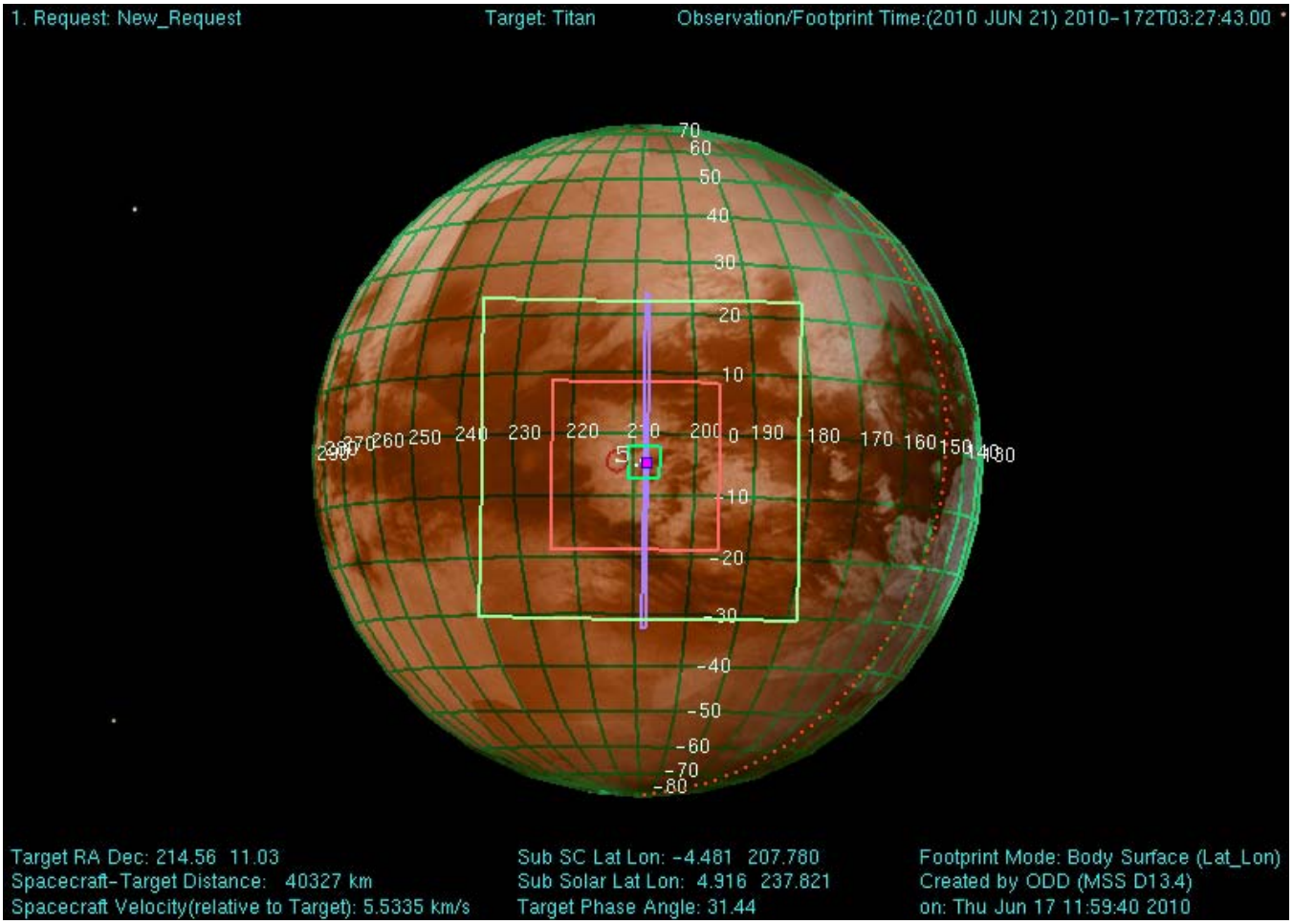
Key to ORS Instrument Fields of View in Figures

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

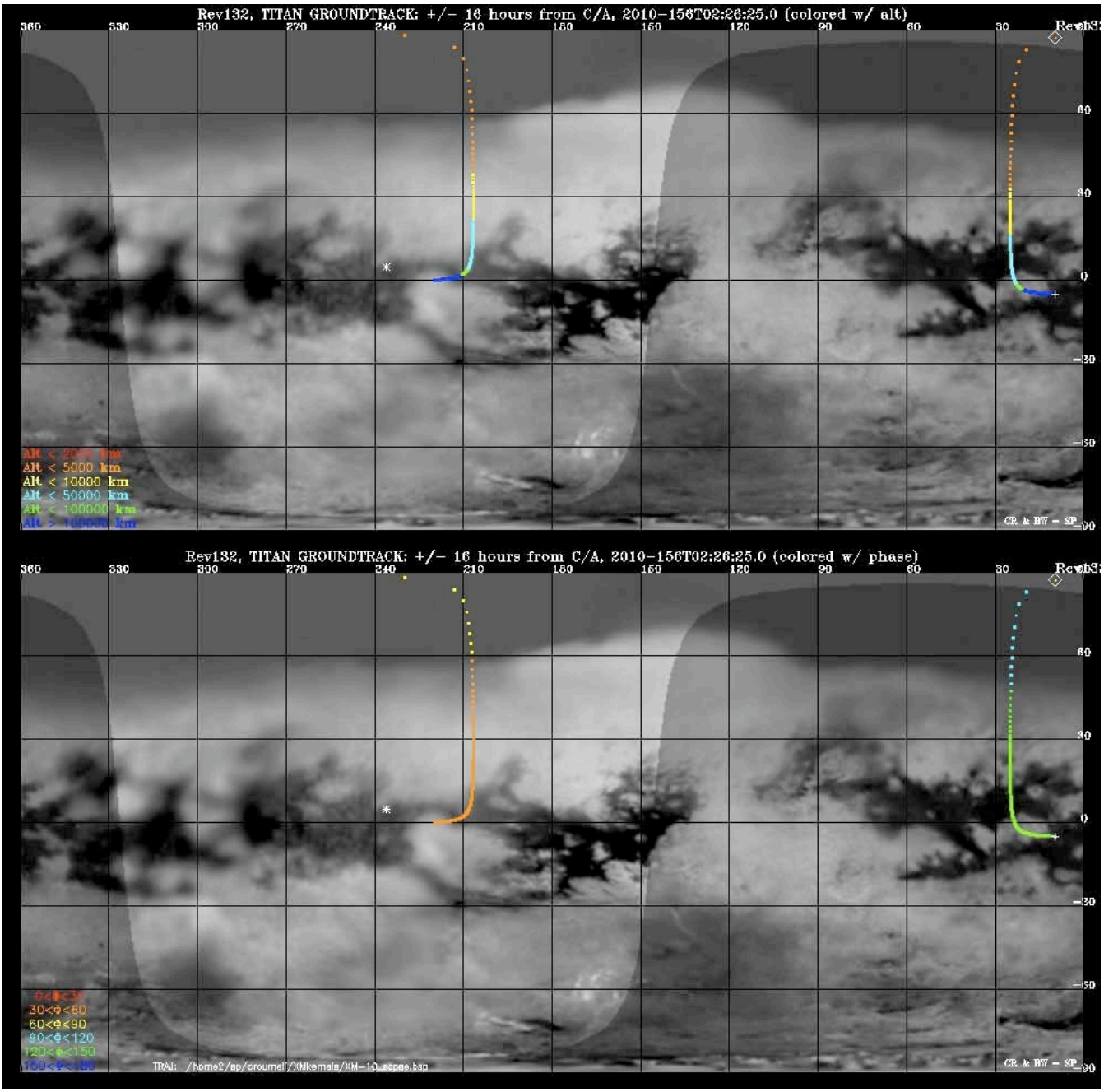
View of Titan from Cassini two hours before Titan-70 closest approach



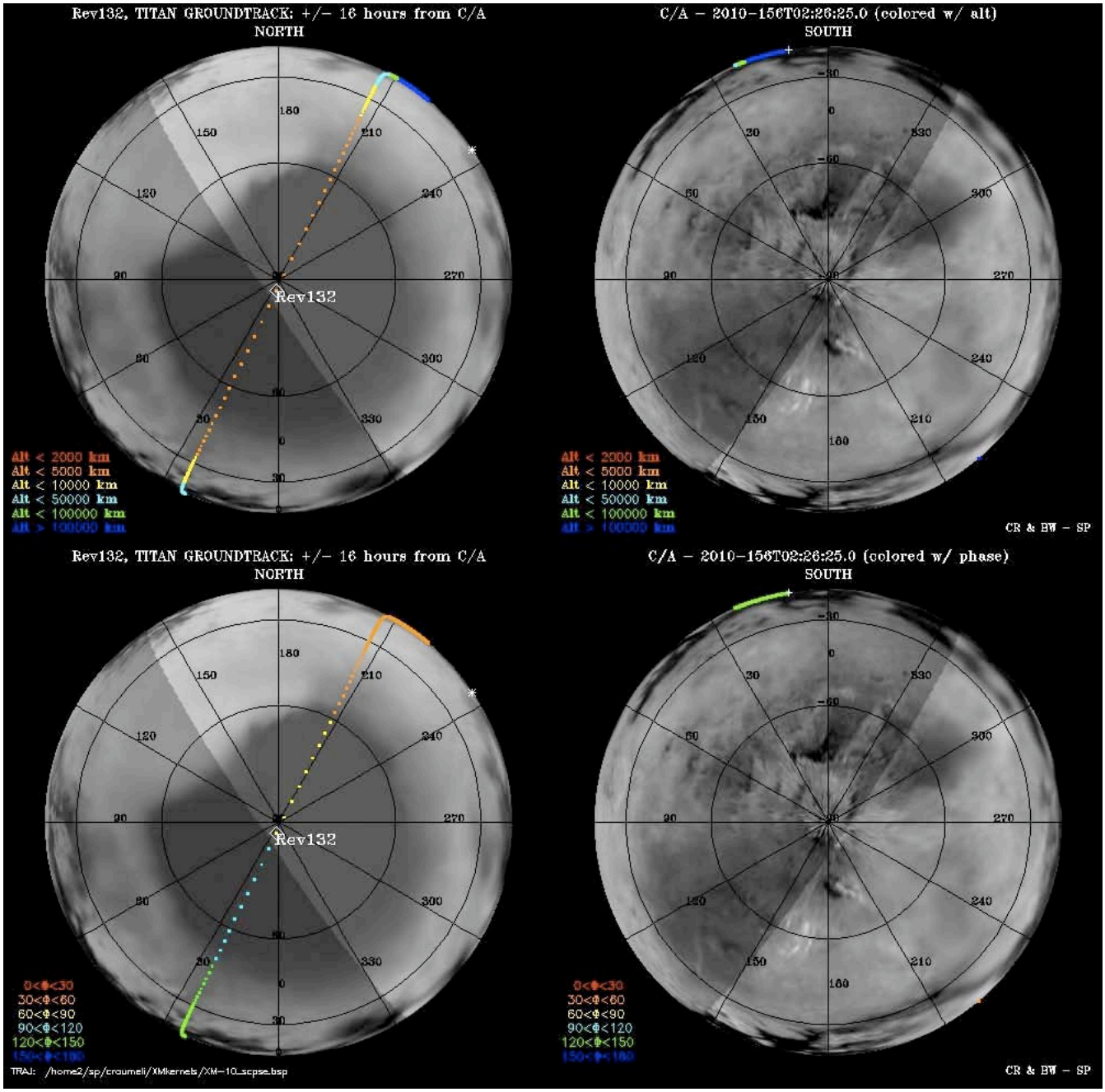
View of Titan from Cassini two hours after Titan-70 closest approach



Titan Groundtracks for T70: Global Plot



Titan Groundtracks for T70: Polar Plot



The T70 timeline is as follows:

Cassini Titan-70 - June 2010

Colors: yellow = maneuvers; blue = geometry;
pink = T70-related; green = data playbacks

Orbiter UTC	Ground UTC	Pacific Time (PDT)	Time wrt T70	Activity	Description
137T13:31:00	May 17 14:48	Mon May 17 07:48 AM	T70-34d12h	Start of Sequence S60	Start of Sequence which contains Titan-70
168T20:11:00	Jun 17 21:28	Thu Jun 17 02:28 PM	T70-03d05h	OTM #253 Prime	Titan-70 targeting maneuver.
169T11:46:00	Jun 18 13:03	Fri Jun 18 06:03 AM	T70-02d14h	OTM #253 Backup	
171T11:11:00	Jun 20 12:28	Sun Jun 20 05:28 AM	T70-14h16m	Start of the TOST segment	
171T11:11:00	Jun 20 12:28	Sun Jun 20 05:28 AM	T70-14h16m	Turn cameras to Titan	
171T11:51:00	Jun 20 13:08	Sun Jun 20 06:08 AM	T70-13h36m	New waypoint	
171T11:51:00	Jun 20 13:08	Sun Jun 20 06:08 AM	T70-13h36m	Deadtime	15 minutes 26 seconds long; used to accommodate changes in flyby time
171T12:06:26	Jun 20 13:23	Sun Jun 20 06:23 AM	T70-13h21m	Titan atmospheric observations-CIRS	Obtain information on CO, HCN, CH4. Integrate on disk at airmass 1.5--2.0.
171T16:27:43	Jun 20 17:44	Sun Jun 20 10:44 AM	T70-09h00m	Titan atmospheric observations-ISS	Wide Angle Camera photometry
171T16:27:43	Jun 20 17:44	Sun Jun 20 10:44 AM	T70-09h00m	Titan atmospheric observations-CIRS	Obtain vertical profiles of temperatures in Titan's stratosphere.
171T20:27:43	Jun 20 21:44	Sun Jun 20 02:44 PM	T70-05h00m	Titan atmospheric observations-CIRS	Obtain information on surface & tropopause temperatures, and on tropospheric CH4. Scan or contiguous steps across disk.
171T23:12:43	Jun 21 00:29	Sun Jun 20 05:29 PM	T70-02h15m	Titan atmospheric observations-CIRS	Vertical sounding of stratospheric compounds on Titan, including H2O. Integrations at 2 locations on the limb displaced vertically.
172T00:14:43	Jun 21 01:31	Sun Jun 20 06:31 PM	T70-01h13m	Transition from reaction wheels to thrusters	
172T00:15:43	Jun 21 01:32	Sun Jun 20 06:32 PM	T70-01h12m	MAPS campaign	
172T00:58:43	Jun 21 02:15	Sun Jun 20 07:15 PM	T70-00h29m	Turn to attitude for closest approach	
172T01:27:43	**Jun 21 02:44**	**Sun Jun 20 07:44 PM**	**T70+00h00m**	**Titan-70 Flyby Closest Approach Time**	**Altitude = 880 km (~547 miles), speed =5.9 km/s (~13,200 mph); 82 deg phase at closest approach**
172T01:54:43	Jun 21 03:11	Sun Jun 20 08:11 PM	T70+00h27m	Transition from thrusters to reaction wheels	
172T02:15:48	Jun 21 03:32	Sun Jun 20 08:32 PM	T70+00h48m	Titan atmospheric observations-UVIS	Titan Occults Alpha Vir. UVIS FUV Occultation slit boresite on star for the entire time.
172T02:34:43	Jun 21 03:51	Sun Jun 20 08:51 PM	T70+01h07m	Titan surface observations-VIMS	Regional mapping of Titan
172T03:27:43	Jun 21 04:44	Sun Jun 20 09:44 PM	T70+02h00m	Titan surface observations-VIMS	Regional mapping of Titan
172T04:15:41	Jun 21 05:32	Sun Jun 20 10:32 PM	T70+02h48m	Ring plane crossing	
172T06:27:43	Jun 21 07:44	Mon Jun 21 12:44 AM	T70+05h00m	Titan surface observations-VIMS	Regional mapping of Titan
172T09:57:43	Jun 21 11:14	Mon Jun 21 04:14 AM	T70+08h30m	Titan atmospheric observations-ISS	Wide Angle Camera photometry
172T10:27:43	Jun 21 11:44	Mon Jun 21 04:44 AM	T70+09h00m	Titan surface observations-VIMS	Global mapping of Titan
172T15:27:43	Jun 21 16:44	Mon Jun 21 09:44 AM	T70+14h00m	Deadtime	15 minutes 17 seconds long; used to accommodate changes in flyby time
172T15:43:00	Jun 21 17:00	Mon Jun 21 10:00 AM	T70+14h16m	Turn to Earth-line	
172T16:23:00	Jun 21 17:40	Jun 21 10:40	T70+14h56m	Playback of T70 Data	Madrid 70m
172T22:00:00	Jun 21 23:17	Jun 21 16:17	T70+20h33m	Playback of T70 Data	Goldstone 34m
174T04:56:00	Jun 23 06:13	Tue Jun 22 11:13 PM	T70+02d03h	Turn cameras to Titan	
174T05:36:00	Jun 23 06:53	Tue Jun 22 11:53 PM	T70+02d04h	New waypoint	
174T05:36:00	Jun 23 06:53	Tue Jun 22 11:53 PM	T70+02d04h	MAPS survey	
173T07:36:00	Jun 22 08:53	Tue Jun 22 01:53 AM	T70+01d06h	Titan surface observations-ISS	Titan cloud monitoring and gap filling
173T17:46:00	Jun 22 19:03	Tue Jun 22 12:03 PM	T70+01d16h	Turn to Earth-line	
173T18:26:00	Jun 22 19:43	Tue Jun 22 12:43 PM	T70+01d17h	MAPS suvery	MAPS suvery with prime pointing
173T19:56:00	Jun 22 21:13	Jun 22 14:13	T70+01d18h	Playback of T69 Data	Goldstone 34m