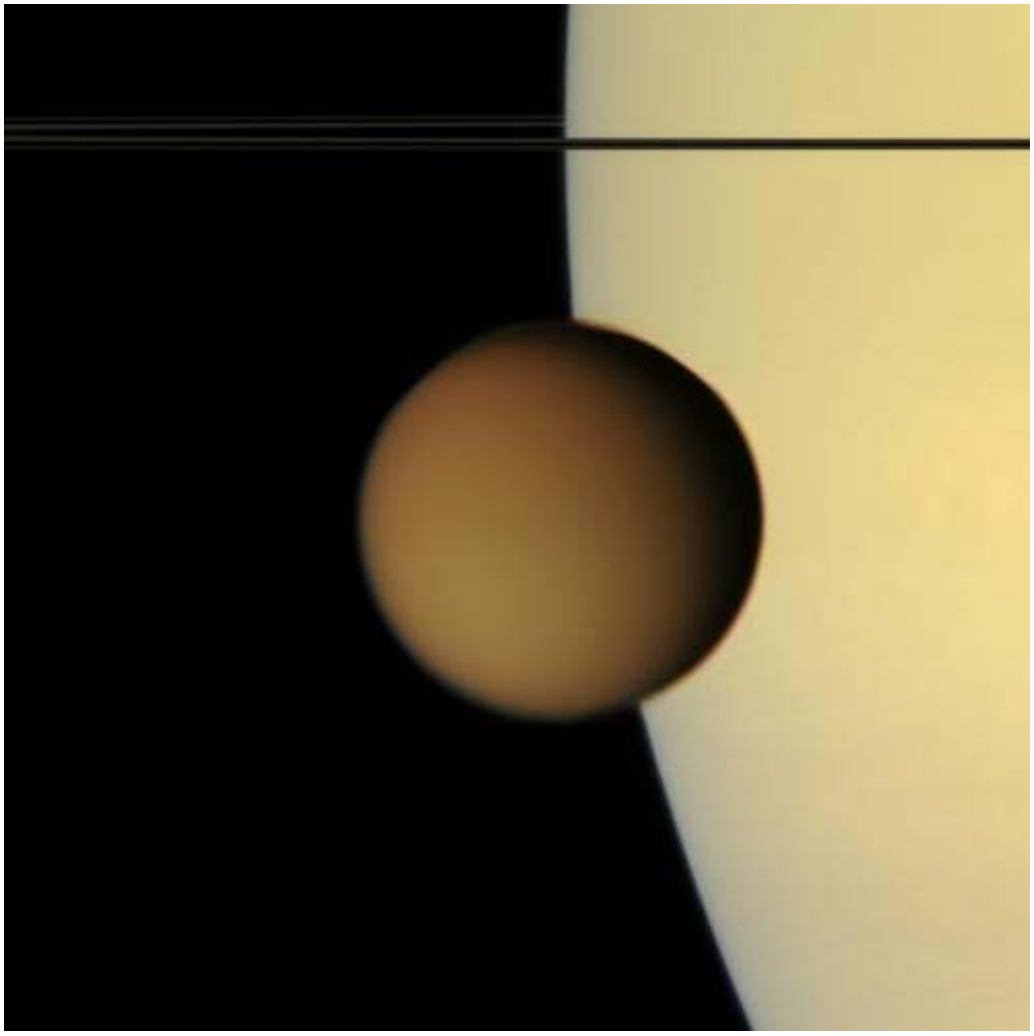
C A S S I N I



T I T A N **0 5 9 T I (T 4 1)** MISSION DESCRIPTION

February 22 2008

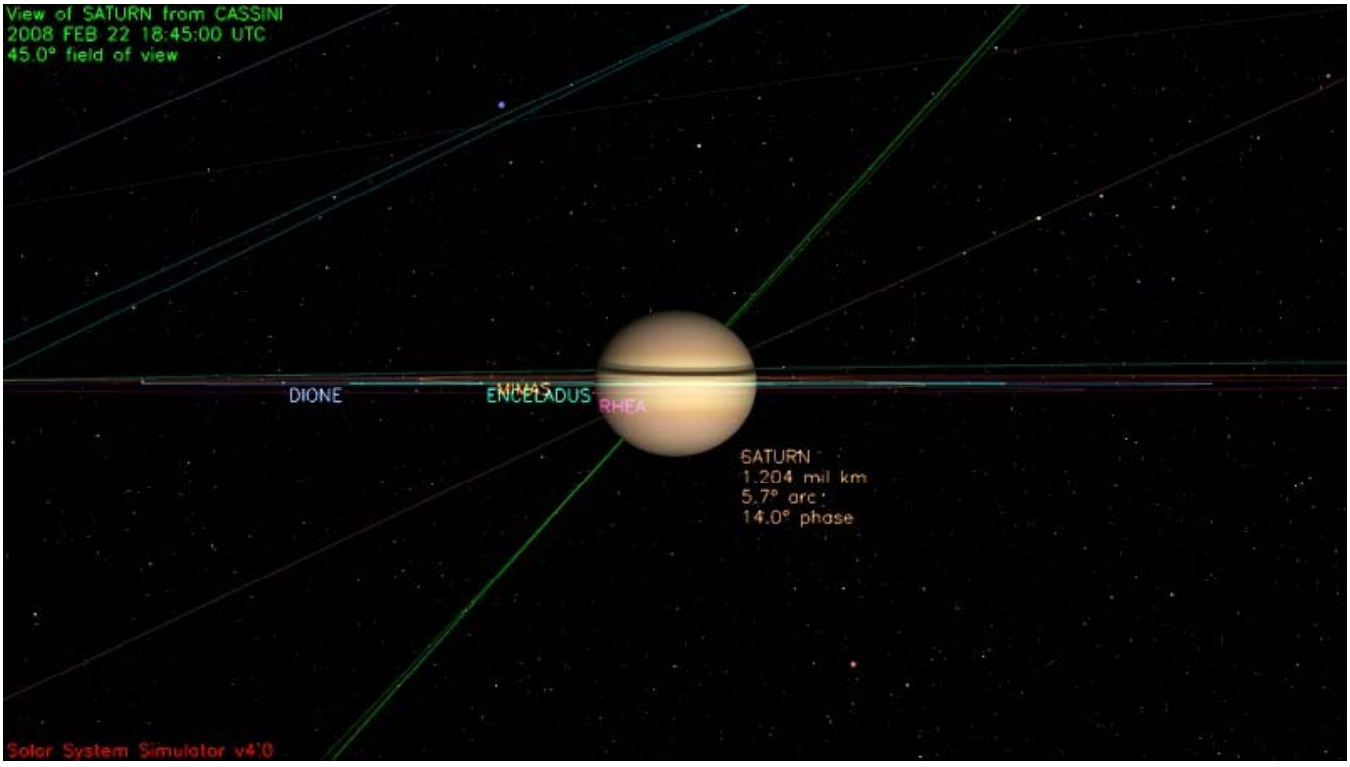
Jet Propulsion Laboratory
California Institute of Technology

Cover image: Titan Makes Contact — The murky orange disk of Saturn's moon Titan glides past -- a silent, floating sphere transiting Saturn. Titan's photochemical smog completely obscures the surface in such natural color views. Its high-altitude hazes are visible against the disk of Saturn as they attenuate the light reflected by the planet. Titan is 5,150 kilometers (3200 miles) across. The view was acquired from less than a degree above Saturn's ringplane. Images taken using red, green and blue spectral filters were combined to create this natural color view. The images were obtained with the Cassini spacecraft narrow-angle camera on Aug. 1, 2007, at a distance of approximately 2.4 million kilometers (1.5 million miles) from Titan. Image scale is 15 kilometers (9 miles) per pixel. Credit: NASA/JPL/Space Science Institute

1.0 OVERVIEW

After a 48-day hiatus, Cassini returns to Saturn's largest moon for the mission's forty-second targeted encounter with Titan. The closest approach to Titan occurs on Friday, Feb. 22, at 2008-053T17:32:07 spacecraft time at an altitude of 1000 kilometers (~628 miles) above the surface and at a speed of 6.3 kilometers per second (14,000 mph). The latitude at closest approach is 35 degrees S and the encounter occurs on orbit number 59.

This encounter is set up with two maneuvers: an apoapsis maneuver on Feb. 5, and a Titan approach maneuver, scheduled for Feb. 18. T41 is the sixth in a series of outbound encounters that will last until the end of the prime mission, and it occurs less than two days after Saturn closest approach. This is the sixth in a series of seven Titan southern hemisphere encounters.



ABOUT TITAN

If Titan were a planet, it would likely stand out as the most important planet in the solar system for humans to explore. Titan, the size of a terrestrial planet, has a dense atmosphere of nitrogen and methane and a surface covered with organic material. It is Titan that is arguably Earth's sister world and the Cassini-Huygens mission considers Titan among its highest priorities.

Although it is far colder and lacks liquid water, the chemical composition of Titan's atmosphere resembles that of early Earth. This, along with the 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, which touched down on Titan's surface in January 2005, and the Cassini orbiter has shown that many of the processes that occur on Earth also apparently take place on Titan – wind, rain, volcanism, tectonic activity, as well as river channels, and drainage patterns all seem to contribute in 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 it is methane that performs many of the same functions on Titan that water does on Earth.

The Huygens probe landed near a bright region now called Adiri, and photographed light hills with dark river beds that empty into a dark plain. It was believed that this dark plain could be a lake or at least a muddy material, but it is now known that Huygens landed in the dark region, and it is solid. Scientists believe it only rains occasionally on Titan, but the rains are extremely fierce when they come.

Only a small number of impact craters have been discovered. This suggests that Titan's surface is constantly being resurfaced by a fluid mixture of water and possibly ammonia, believed to be expelled from volcanoes and hot springs. Some surface features, such as lobate flows, appear to be volcanic structures. Volcanism is now believed to be a significant source of methane in Titan's atmosphere. However, there are no oceans of hydrocarbons as previously hypothesized. Dunes cover large areas of the surface.

The existence of oceans or lakes of liquid methane on Saturn's moon Titan was predicted more than 20 years ago. Radar and imaging data from Titan flybys have provided convincing evidence for large bodies of liquid. With Titan's colder temperatures and hydrocarbon-rich atmosphere, these lakes and seas most likely contain a combination of liquid methane and ethane (both hydrocarbons), not water.

The Cassini-Huygens mission, using wavelengths ranging from ultraviolet to radio, is methodically and consistently revealing Titan and answering 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 world as we attempt to constrain scenarios for the formation and evolution of Titan and its atmosphere.

1.1 TITAN-41 SCIENCE HIGHLIGHTS

- **RADAR:** T41 is the prime opportunity for RADAR to observe the Huygens landing site. The landing site (just East of the Adiri bright region) was also observed, from longer range, on T8. The new observations should provide sharper imagery and additional topographic information. The observations will use a unique "switch-hitter" pointing design, switching from right-looking to left-looking in order to observe the Hotei Arcus region (a possibly cryovolcanic area to the southeast of Xanadu) as well as the Huygens landing site.
- **UVIS** has some of the greatest stellar occultation opportunities in the entire prime mission during this flyby, with opportunities to observe both Eta Canis Majoris and Epsilon Canus Majorus as they are occulted by Titan. These occultations are hours after closest approach, and thus can last for hours, allowing UVIS to probe Titan's atmosphere in depth. Epsilon Canus Majorus has an unusual observing geometry; UVIS will actually observe it going in and out of occultation two times. These observations will help UVIS understand the so-called detached haze, seen in images at most latitudes outside the polar vortex region. UVIS measurements of aerosols are consistent with these pictures, and more coverage will give increased understanding of the transition region between the upper haze and lower atmosphere. Voyager also saw the detached haze, but much deeper in the atmosphere, so the haze has changed significantly at Titan over the last two decades. If Titan's atmosphere has a locked-in seasonal change, we should see this over the next few years.
- **VIMS** carries out low resolution mapping and cloud monitoring in order to study cloud formation and evolution.
- **ISS** captures global mapping and full-disk mosaics covering Adiri and East Belet, extending up to high northern latitudes and filling in coverage. The Narrow Angle Camera monitors for surface/atmosphere changes, attempts to see surface color variations, and monitors limb hazes. As the geometry of this flyby and the next three are very similar, we'll be able to monitor how the clouds change in this region every few weeks.
- **CIRS** continues to extend spatial and temporal coverage of Titan, from low-spectral resolution disk maps to high spectral resolution nadir and limb integrations. Getting good time resolution is very important. FIRNADCMP, TEMPMAP. will look for stratospheric oxygen compounds during a far-IR limb observation. The instrument will also perform surface temperature mapping, stratospheric temperature mapping, and continue our search for trace species during a far-IR nadir integration. Each of these observations will be compared to similar ones in the early part of the mission to look for changes in temperatures and composition over time.

- **INMS** rides along on the RADAR closest approach observations; the RADAR orientation is important for INMS mid-southern latitude coverage of Titan. The instrument is also using Titan as a calibration source prior to the upcoming, highly-anticipated Enceladus flyby.
- **RPWS:** As Titan is out "in front" of Saturn, this flyby, and the next three, put the spacecraft in an ideal location to have another opportunity to see Titan outside of Saturn's magnetosphere, in shocked solar wind ahead of the magnetosheath as happened on T32. We are interested in duplicating the flyby geometry to look for shorter time-scale phenomena in Titan's plasma environment, so this series of four flybys, especially T41 through T43, will offer that opportunity.

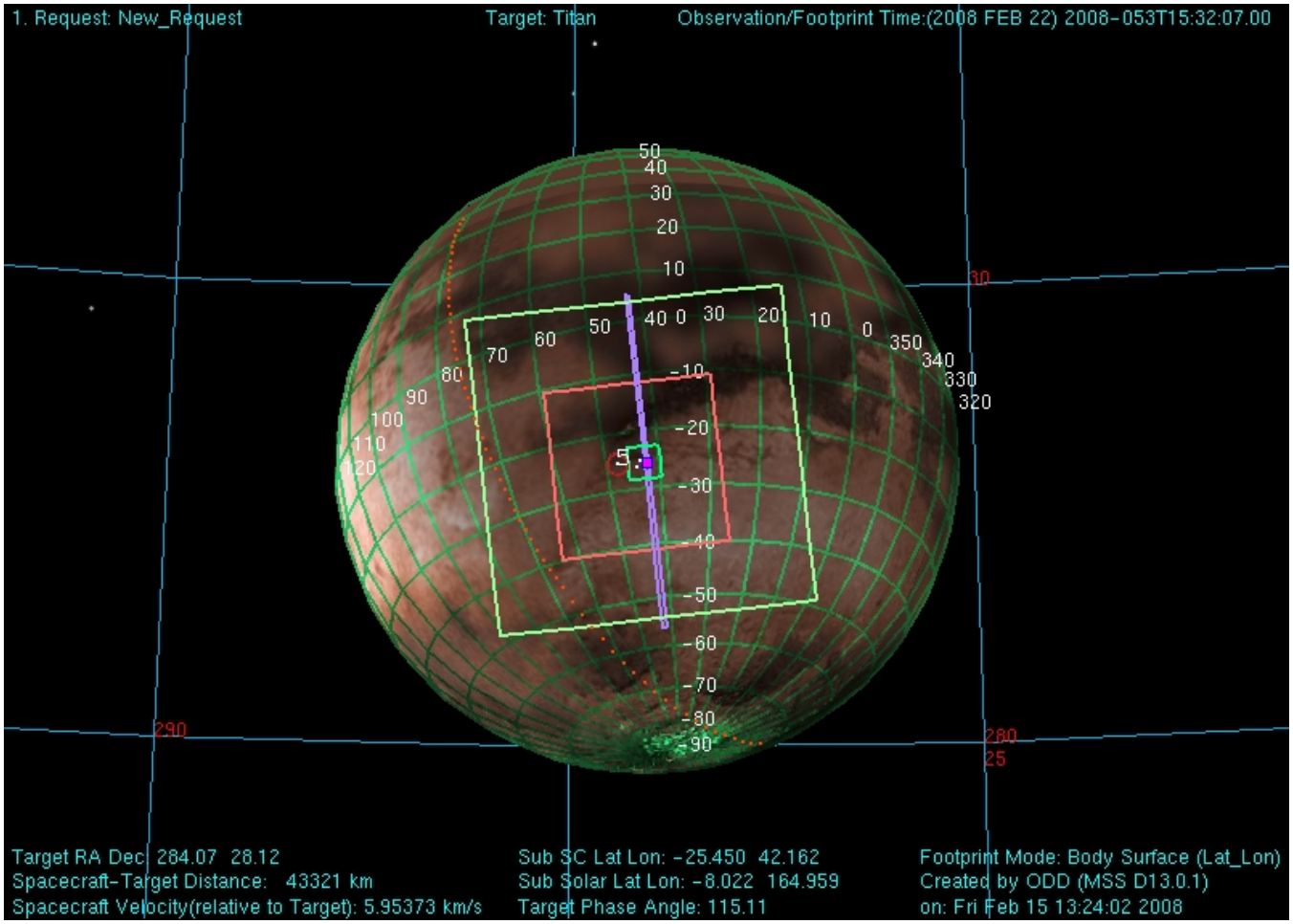
1.2 SAMPLE SNAPSHOTS

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.

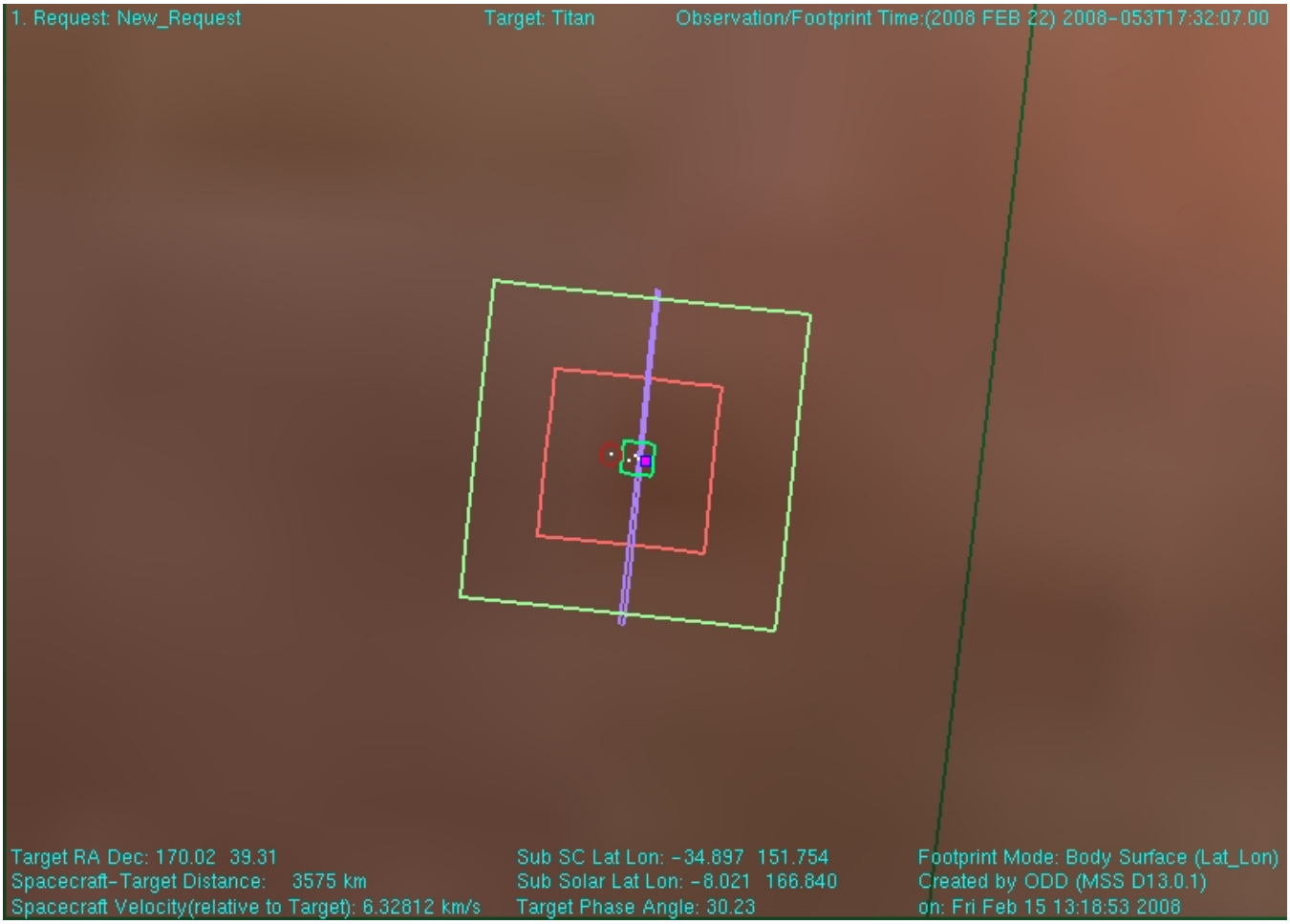
Key to ORS Instrument Fields of View in Figures

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

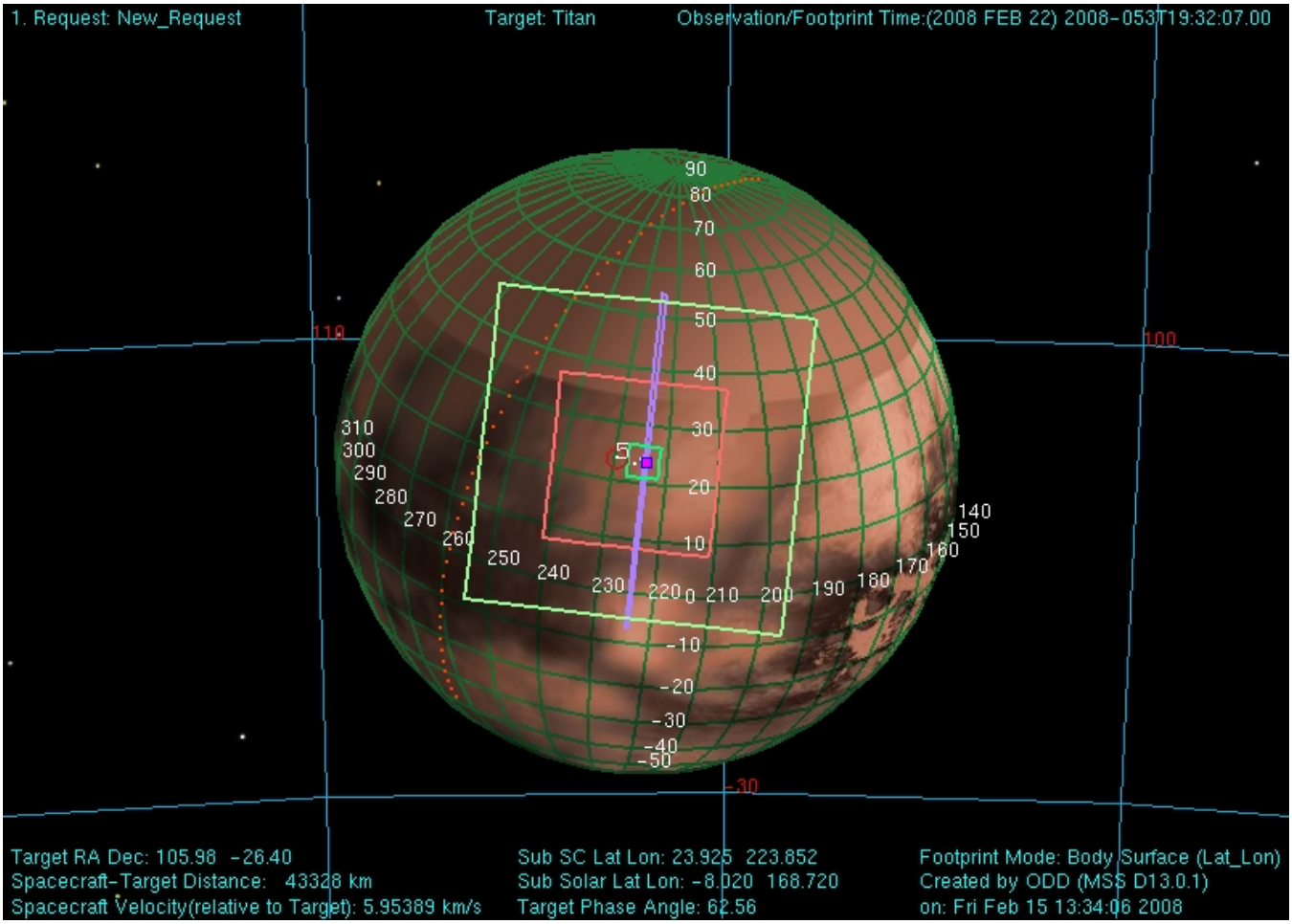
View of Titan from Cassini two hours before Titan-41 closest approach



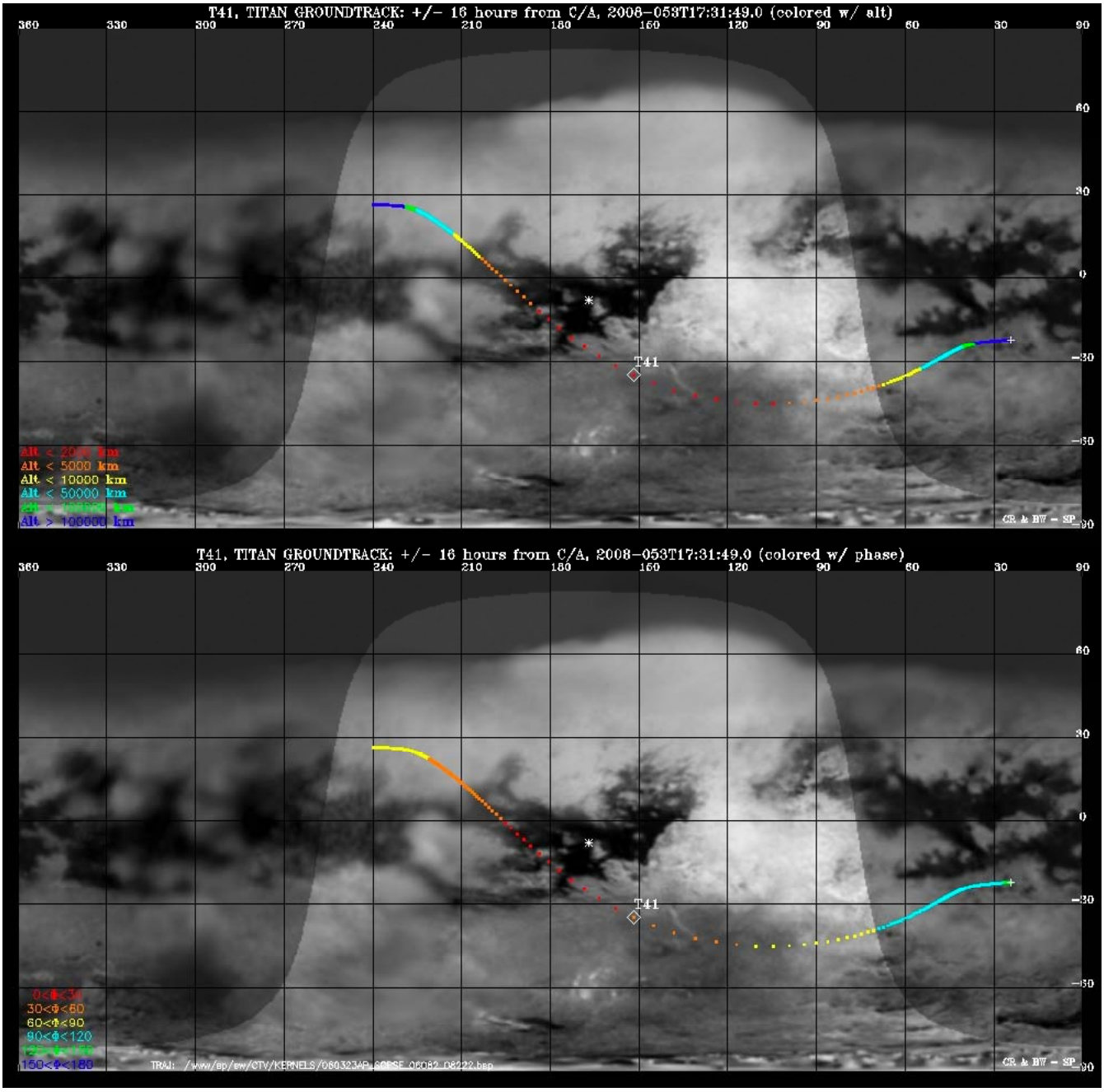
View of Titan from Cassini at Titan-41 closest approach



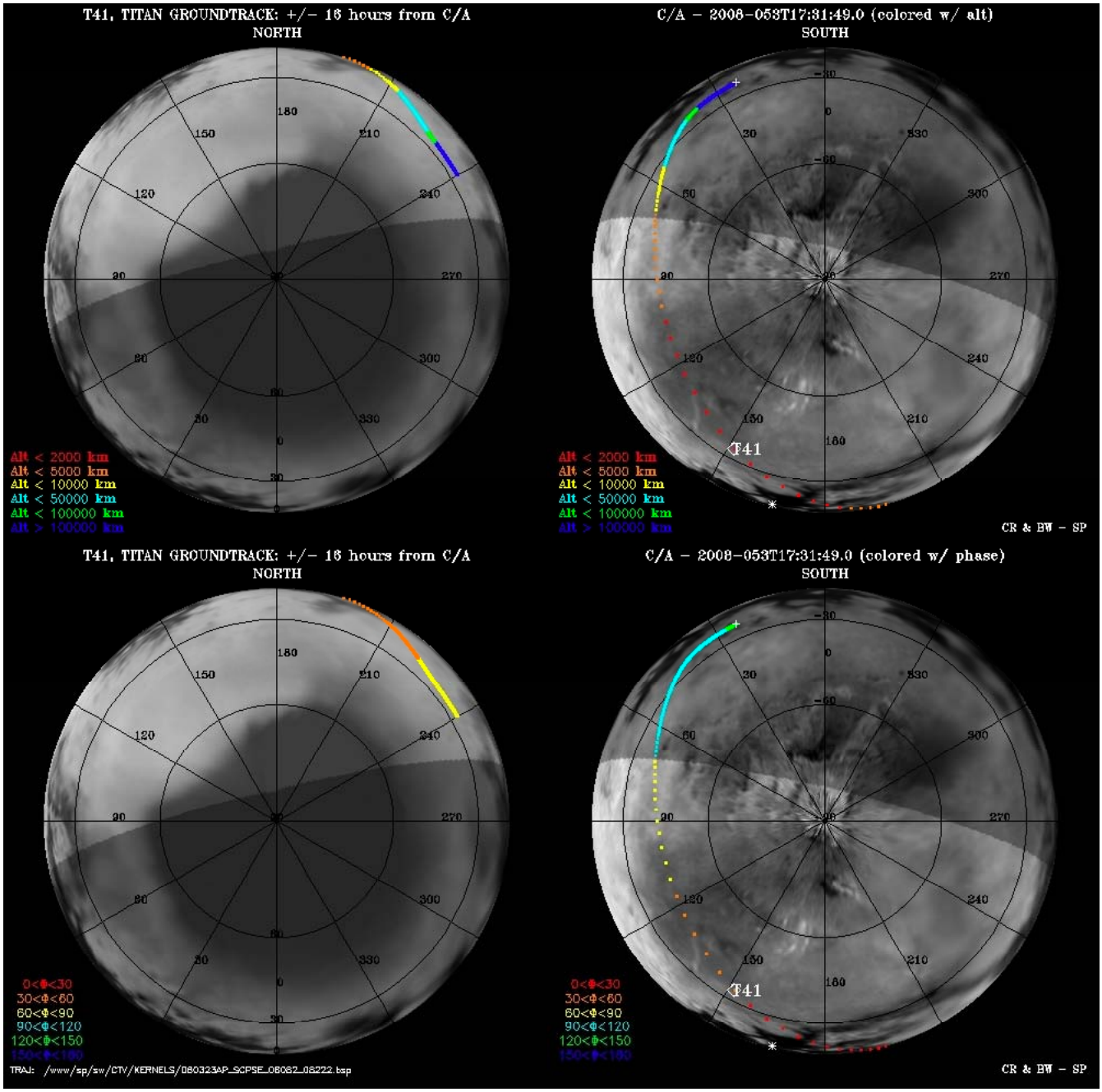
View of Titan from Cassini two hours after Titan-41 closest approach



Titan Groundtracks for T41: Global Plot



Titan Groundtracks for T41: Polar Plot



The T41 timeline is as follows:

Cassini Titan-41 Timeline - February 2008

Colors: yellow = maneuvers; blue = geometry; pink = T41-related; green = data playbacks

Orbiter UTC	Ground UTC	Pacific Time	Time wrt T41	Activity	Description
047T11:51:00	Feb 16 13:03	Sat Feb 16 05:03 AM	T41-06d06h	Start of Sequence S38	Start of Sequence which contains Titan-41
050T02:36:00	Feb 19 03:48	Mon Feb 18 07:48 PM	T41-03d15h	OTM #145 Prime	Titan-41 targeting maneuver.
051T17:50:48	Feb 20 19:02	Wed Feb 20 11:02 AM	T41-01d24h	Pan Non-Targeted Flyby	Altitude = 79,887 Km (~ 49,640 miles)
051T17:51:11	Feb 20 19:03	Wed Feb 20 11:03 AM	T41-01d24h	Descending Ring Plane Crossing	
051T18:19:21	Feb 20 19:31	Wed Feb 20 11:31 AM	T41-01d23h	Prometheus Non-Targeted Flyby	Altitude = 65,802 km (~40,890 miles)
051T18:29:13	Feb 20 19:41	Wed Feb 20 11:41 AM	T41-01d23h	Pandora Non-Targeted Flyby	Altitude = 66,233 km (~41,160 miles)
051T19:08:26	Feb 20 20:20	Wed Feb 20 12:20 PM	T41-01d22h	Janus Non-Targeted Flyby	Altitude = 110,070 km (~68,400 miles)
051T19:23:18	Feb 20 20:35	Wed Feb 20 12:35 PM	T41-01d22h	Saturn Periapse	Saturn periapse, R = 3.3 Rs, lat = -21 deg, phase = 150 deg
052T02:36:00	Feb 21 03:48	Wed Feb 20 07:48 PM	T41-01d15h	OTM #145 Backup	
053T03:51:00	Feb 22 05:03	Thu Feb 21 09:03 PM	T41-13h41m	Start of the TOST segment	
053T03:51:00	Feb 22 05:03	Thu Feb 21 09:03 PM	T41-13h41m	Turn cameras to Titan	
053T12:47:07	Feb 22 13:59	Fri Feb 22 05:59 AM	T41-04h45m	New waypoint	
053T04:21:00	Feb 22 05:33	Thu Feb 21 09:33 PM	T41-13h11m	Deadtime	8 minutes 7 seconds long; used to accommodate changes in flyby time
053T04:29:07	Feb 22 05:41	Thu Feb 21 09:41 PM	T41-13h03m	Titan atmospheric Observations-CIRS	Obtain information on CO, HCN, CH4. Integrate on disk at airmass 1.5--2.0.
053T07:32:07	Feb 22 08:44	Fri Feb 22 12:44 AM	T41-10h00m	Titan atmospheric observations-ISS	WAC photometry. Particle properties, vertical distributions
053T08:32:07	Feb 22 09:44	Fri Feb 22 01:44 AM	T41-09h00m	Titan Regional Map-VIMS	
053T12:17:07	Feb 22 13:29	Fri Feb 22 05:29 AM	T41-05h15m	Turn cameras to New Waypoint	
053T12:47:07	Feb 22 13:59	Fri Feb 22 05:59 AM	T41-04h45m	New waypoint	
053T12:47:07	Feb 22 13:59	Fri Feb 22 05:59 AM	T41-04h45m	Titan RADAR observations	Inbound radiometry of unique NW terrain at high latitudes
053T16:02:07	Feb 22 17:14	Fri Feb 22 09:14 AM	T41-01h30m	Titan RADAR observations	Inbound scatterometry of unique NW terrain at high latitudes
053T16:40:07	Feb 22 17:52	Fri Feb 22 09:52 AM	T41-00h52m	Transition to thruster control	
053T16:41:07	Feb 22 17:53	Fri Feb 22 09:53 AM	T41-00h51m	Titan RADAR observations	Inbound altimetry of Titan
053T17:17:07	Feb 22 18:29	Fri Feb 22 10:29 AM	T41-00h15m	Titan RADAR observations	Inbound low rate SAR of Titan
053T17:25:07	Feb 22 18:37	Fri Feb 22 10:37 AM	T41-00h07m	Titan RADAR observations	High rate SAR
053T17:32:07	Feb 22 18:44	**Fri Feb 22 10:44 AM**	T41+00h00m	**Titan-41 Flyby Closest Approach Time**	**Altitude = 1000 km (628 miles), speed = 6.3 km/s (14,000 mph); 30 deg phase at closest approach**
053T17:39:07	Feb 22 18:51	Fri Feb 22 10:51 AM	T41+00h07m	Titan RADAR observations	Outbound low rate SAR of Titan
053T17:47:07	Feb 22 18:59	Fri Feb 22 10:59 AM	T41+00h15m	Titan RADAR observations	Outbound altimetry of Titan
053T18:02:07	Feb 22 19:14	Fri Feb 22 11:14 AM	T41+00h30m	Titan RADAR observations	Outbound scatterometry of Titan landing site.
053T18:22:17	Feb 22 19:34	Fri Feb 22 11:34 AM	T41+00h50m	Ascending Ring Plane Crossing	
053T18:44:07	Feb 22 19:56	Fri Feb 22 11:56 AM	T41+01h12m	Turn cameras to New Waypoint	
053T18:53:07	Feb 22 20:05	Fri Feb 22 12:05 PM	T41+01h21m	Turn to UVIS observation attitude	
053T18:55:07	Feb 22 20:07	Fri Feb 22 12:07 PM	T41+01h23m	Transition off of thruster control	
053T19:18:07	Feb 22 20:30	Fri Feb 22 12:30 PM	T41+01h46m	Titan atmospheric observations-UVIS	Titan occults Eta Cma
053T20:02:07	Feb 22 21:14	Fri Feb 22 01:14 PM	T41+02h30m	Titan atmospheric observations-UVIS	EUVFUV Imaging of Titan. Several slow scans across Titan's visible hemisphere to form spectral images
053T22:32:07	Feb 22 23:44	Fri Feb 22 03:44 PM	T41+05h00m	Titan surface observations-ISS	NAC Global Map
054T02:08:07	Feb 23 03:20	Fri Feb 22 07:20 PM	T41+08h36m	Titan atmospheric observations-ISS	WAC photometry
054T02:32:07	Feb 23 03:44	Fri Feb 22 07:44 PM	T41+09h00m	Titan atmospheric observations-CIRS	Obtain information on CO, HCN, CH4. Integrate on disk at airmass 1.5--2.0.
054T04:32:07	Feb 23 05:44	Fri Feb 22 09:44 PM	T41+11h00m	Titan atmospheric observations-ISS	NAC monitoring for surface/atmosphere changes; attempt to see surface color variations; monitor limb hazes.
054T06:32:07	Feb 23 07:44	Fri Feb 22 11:44 PM	T41+13h00m	Titan atmospheric observations-VIMS	Global Map
054T07:32:07	Feb 23 08:44	Sat Feb 23 12:44 AM	T41+14h00m	Turn to Earth-line	
054T08:02:07	Feb 23 09:14	Sat Feb 23 01:14 AM	T41+14h30m	Playback of T41 Data	Goldstone 70 arrayed
054T12:02:07	Feb 23 13:14	Sat Feb 23 05:14 AM	T41+18h30m	Turn cameras to New Waypoint	
054T12:32:07	Feb 23 13:44	Sat Feb 23 05:44 AM	T41+19h00m	New waypoint	
054T12:32:07	Feb 23 13:44	Sat Feb 23 05:44 AM	T41+19h00m	Titan atmospheric observations-CIRS	Obtain information on the thermal structure of Titan's stratosphere.
054T15:25:07	Feb 23 16:37	Sat Feb 23 08:37 AM	T41+21h53m	Titan atmospheric observations-UVIS	Titan occults Eps Cma
054T17:55:07	Feb 23 19:07	Sat Feb 23 11:07 AM	T41+01d00h	Titan atmospheric observations-CIRS	Obtain information on the thermal structure of Titan's stratosphere.
054T21:20:07	Feb 23 22:32	Sat Feb 23 02:32 PM	T41+01d04h	Titan atmospheric observations-UVIS	Titan occults Eps Cma
054T23:35:07	Feb 24 00:47	Sat Feb 23 04:47 PM	T41+01d06h	Titan atmospheric observations-CIRS	Obtain information on the thermal structure of Titan's stratosphere.
055T01:27:07	Feb 24 02:39	Sat Feb 23 06:39 PM	T41+01d08h	Deadtime	23 minutes 53 seconds long; used to accommodate changes in flyby time
055T01:51:00	Feb 24 03:03	Sat Feb 23 07:03 PM	T41+01d08h	Turn to Earth-line	
055T02:21:00	Feb 24 03:33	Sat Feb 23 07:33 PM	T41+01d09h	Playback of T41 Data	Goldstone 70 arrayed