# C A S S I N I

# T I T A N **1 0 9 T I ( T 5 3 )**
# MISSION DESCRIPTION

April 20, 2009

**Jet Propulsion Laboratory**
California Institute of Technology

*Cover image: Hazy Ring of Titan's Sky*

*From the dark side of Titan, the Cassini spacecraft profiles the moon's atmosphere as sunlight filters through its upper hazes.*

*An airless satellite would appear in this viewing geometry only as a lit crescent. But Titan's thick atmosphere scatters light around all edges of the planet to create a ring of light.*

*Images taken using red, green and blue spectral filters were combined to create this full color view of Titan at high phase. The color in the image on the right has been computer enhanced to bring out the outer haze layer, and the contrast in both images has been enhanced.*

*This view looks toward the Saturn-facing side of Titan. North on Titan is up and rotated 45 degrees to the left. The images were acquired at a distance of approximately 1.8 million kilometers (1.1 million miles) from Titan and at a Sun-Titan-spacecraft, or phase, angle of 157 degrees. Image scale is 11 kilometers (7 miles) 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

A mere 16 days after its previous visit, Cassini returns to Saturn's largest moon for the mission's fifty-fourth targeted encounter with Titan. The closest approach to Titan occurs on Monday, April 20, at 2009-110T00:20:45 spacecraft time at an altitude of 3,600 kilometers (~2,200 miles) above the surface and at a speed of 5.8 kilometers per second (~13,000 mph). The latitude at closest approach is 7.7 degrees S and the encounter occurs on orbit number 109.

This encounter is set up with two maneuvers: an apoapsis maneuver on April 12, and a Titan approach maneuver, scheduled for April 17. T53 is the second flyby in a series of eleven inbound encounters and the ninth Titan encounter in Cassini's Solstice Mission. It occurs just under four days before Saturn closest approach.


View of SATURN from CASSINI
2009 APR 20 00:25:00 UTC
45.0° field of view
TETHYS
RHEA
JUPITER
NEPTUNE
Solar System Simulator v4.0

## 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-53 SCIENCE HIGHLIGHTS

Shortly before the flyby, the Cassini project learned that the primary playback pass for T53 would be affected by unexpected downtime on the Goldstone 70-meter antenna. This pass has since been replaced with a 34-meter station which we can utilize to preserve the highest scientific priority data for this flyby. Almost all the science described below, with the exception of some imaging data outside the closest approach period, will be saved.

- **UVIS**: Solar and stellar 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). On T53 UVIS observes a long stellar occultation and a solar occultation. The two occultation observations probe different parts of the atmosphere. The solar occultation, using the EUV channel, samples the neutral nitrogen from above about 900 kilometers altitude up to about 2300 kilometers. This range overlaps the atmospheric region sampled by INMS and by Cassini's attitude control system, or AACS. Solar occultation measurements give a measure of the density profile of the main constituent of the atmosphere, and the rate of change of the N2 density with altitude gives information on the temperature. There has been a long-running controversy about the density of the high atmosphere. AACS gets a consistently higher number than INMS and UVIS. This is one of the questions we want to attack with this measurement, but in all likelihood it will not be resolved until the extended extended mission when we will have some additional measurements (such as flybys where the navigation team will measure the acceleration, and flybys where UVIS and INMS will conduct atmospheric measurements at the same time). Both the solar and stellar occultations show a complex picture of the upper atmosphere. Density profiles and mixing ratios cannot be described as a simple function of latitude and longitude. There is more going on, perhaps gravity wave activity, perhaps some other phenomena which make the upper atmosphere more variable than simple models would predict. Continued observations like the ones in T53 will help us sort out these issues.

  The stellar occultations use the UVIS far ultraviolet (FUV) channel. The target star has some extreme UV emission, which is unusual for stellar spectra. The longer wavelengths do not give a good measure of N2, but do sample a number of hydrocarbons and haze from about 300 kilometer altitude to 1600 kilometer altitude. The upper end of this altitude range overlaps with INMS and the lower end overlaps with CIRS. UVIS fills a gap in altitude which some have misnamed the 'ignorosphere'. INMS, CAPS and UVIS have shown that complex organic chemistry is going on at the 1000-kilometer level. This was a bit of a surprise, but in retrospect maybe it should not have been since people who construct chemical models have known that ion-neutral reactions proceed at a much faster rate than neutral-neutral reactions in the lower atmosphere. In any case, the discovery of a very active thermosphere is exciting and feeds into the bigger picture of the haze formation. At visible wavelengths, as seen by ISS and VIMS, Titan is shrouded in a thick haze layer extending up to more than 500 kilometers. Previous UVIS stellar occultations have shown that the haze extends all the way up to 1000 kilometers where the complex chemistry is occurring. There is a prominent 'detached' haze layer near 510 kilometer altitude, seen at all latitudes outside the north polar hood (the north polar hood boundary is near 55 degrees latitude). Recently a paper in press (Lavvas, Yelle, and Vuitton) proposed that the detached haze layer is formed when small spherical haze particles coagulate to form much larger aggregate particles. If so, this idea provides support for previous models of aggregate particles and identifies a key location in the process. Previous UVIS occultation results were used as input to that paper. The stellar occultation in T53 is a very slow one, the slowest in the XM, but not the slowest in the mission so far. Slow occultations allow us to acquire more signal at a given altitude range, and are therefore more valuable.

- **RADAR** captures radiometry outbound.
- **VIMS** will ridealong with CIRS for daytime observations 2 hours after closest approach. Along with monitoring of tropical clouds, VIMS may get images at 20 km/pixel resolution of an area located in the southern hemisphere close to the South pole (30-90 South, 240-300 W).
- **CIRS** conducts far-infrared vertical temperature and aerosol mapping at low latitudes.
- **ISS** will ride along with VIMS to image Titan's trailing hemisphere at high southern latitudes and with CIRS to monitor clouds. (0.5-hour illuminated prime observation primarily for photometry.)
- **MIMI** measures energetic ion and electron energy input to Titan's atmosphere. Sun obscures ENA.
- **MAG**: T53 is another flank-out, post-dusk, high altitude flyby that will be a good complement to T52 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.

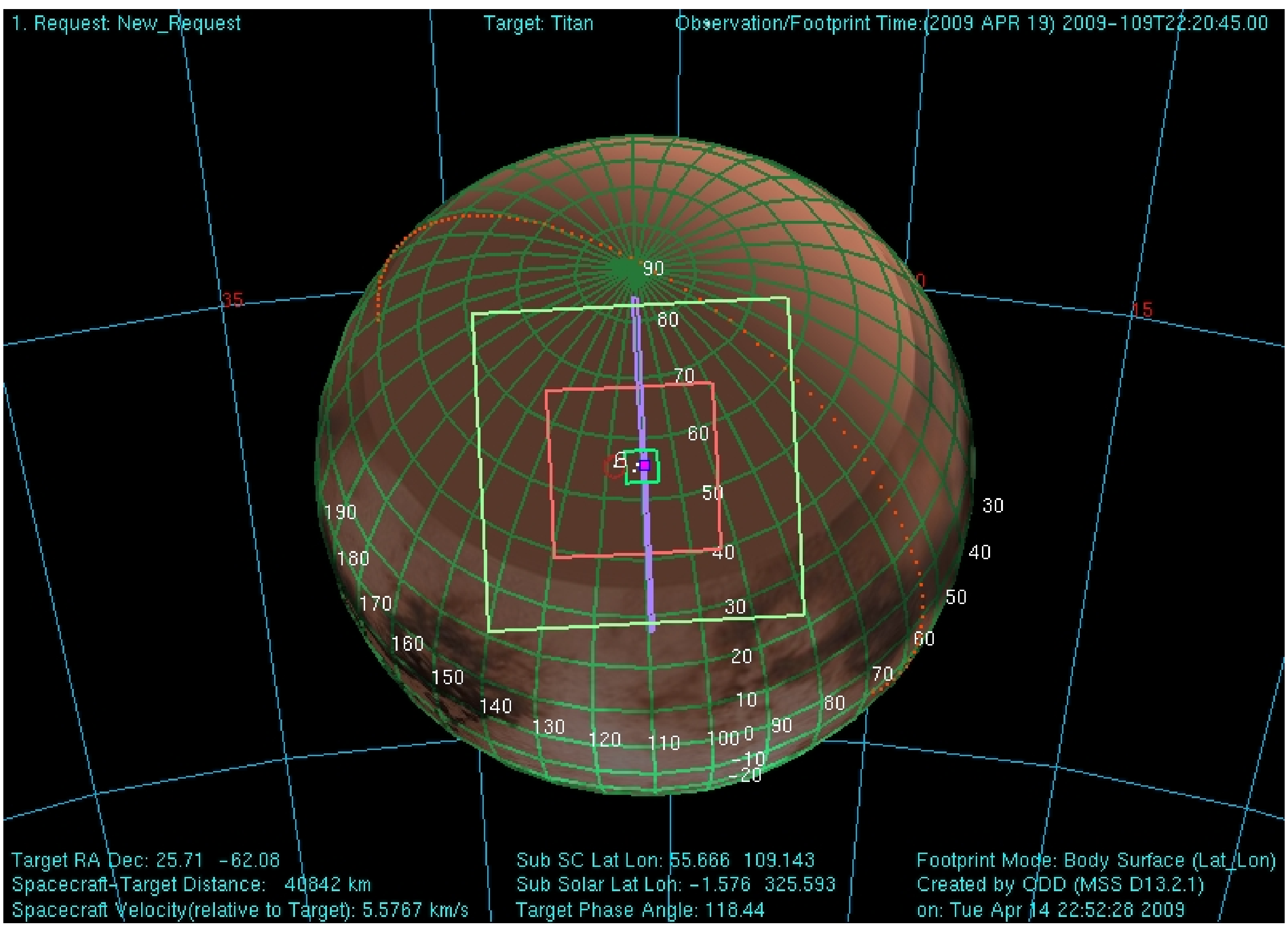
**SAMPLE SNAPSHOTS**

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.

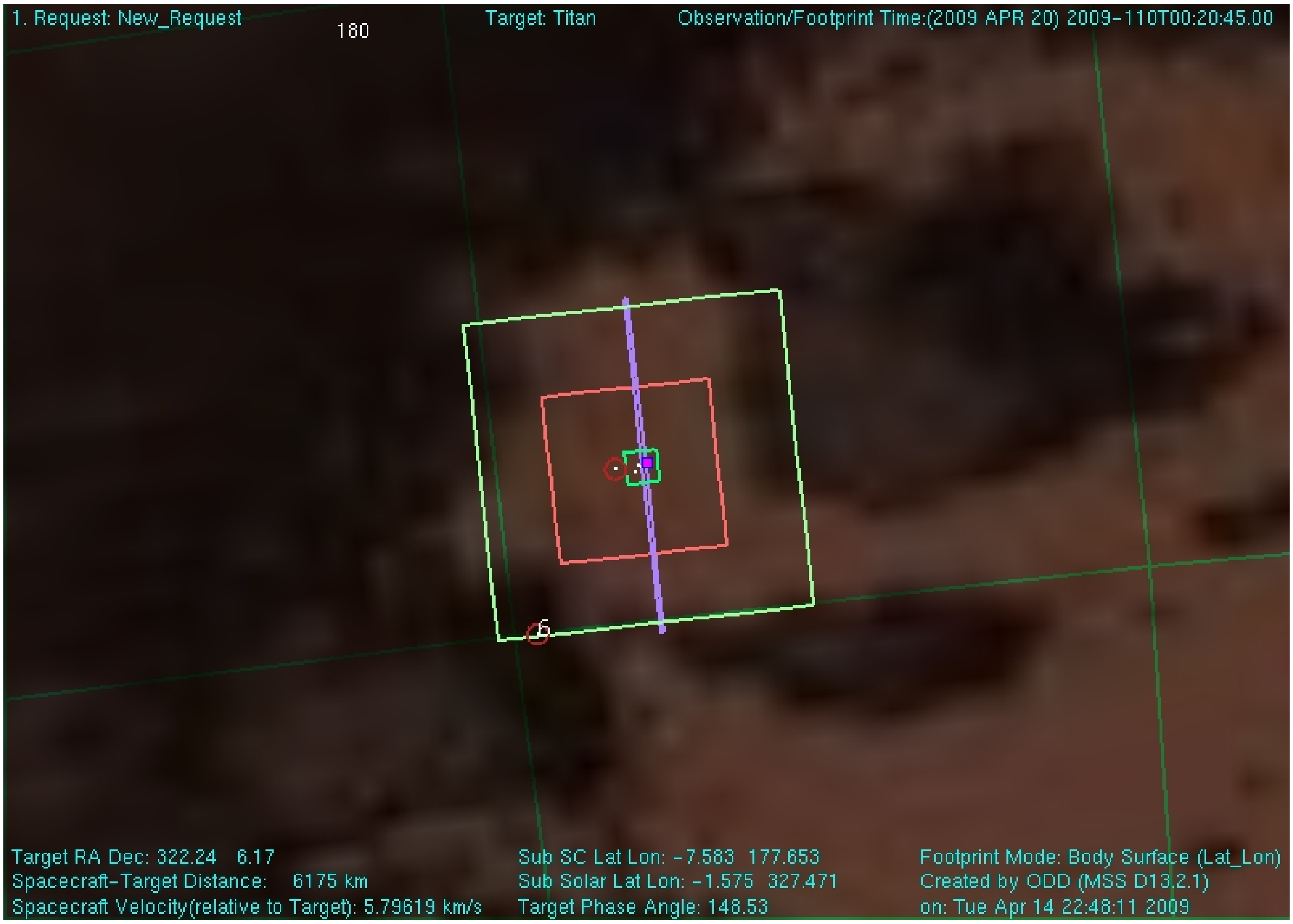
**Key to ORS Instrument Fields of View in Figures**

| 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 |

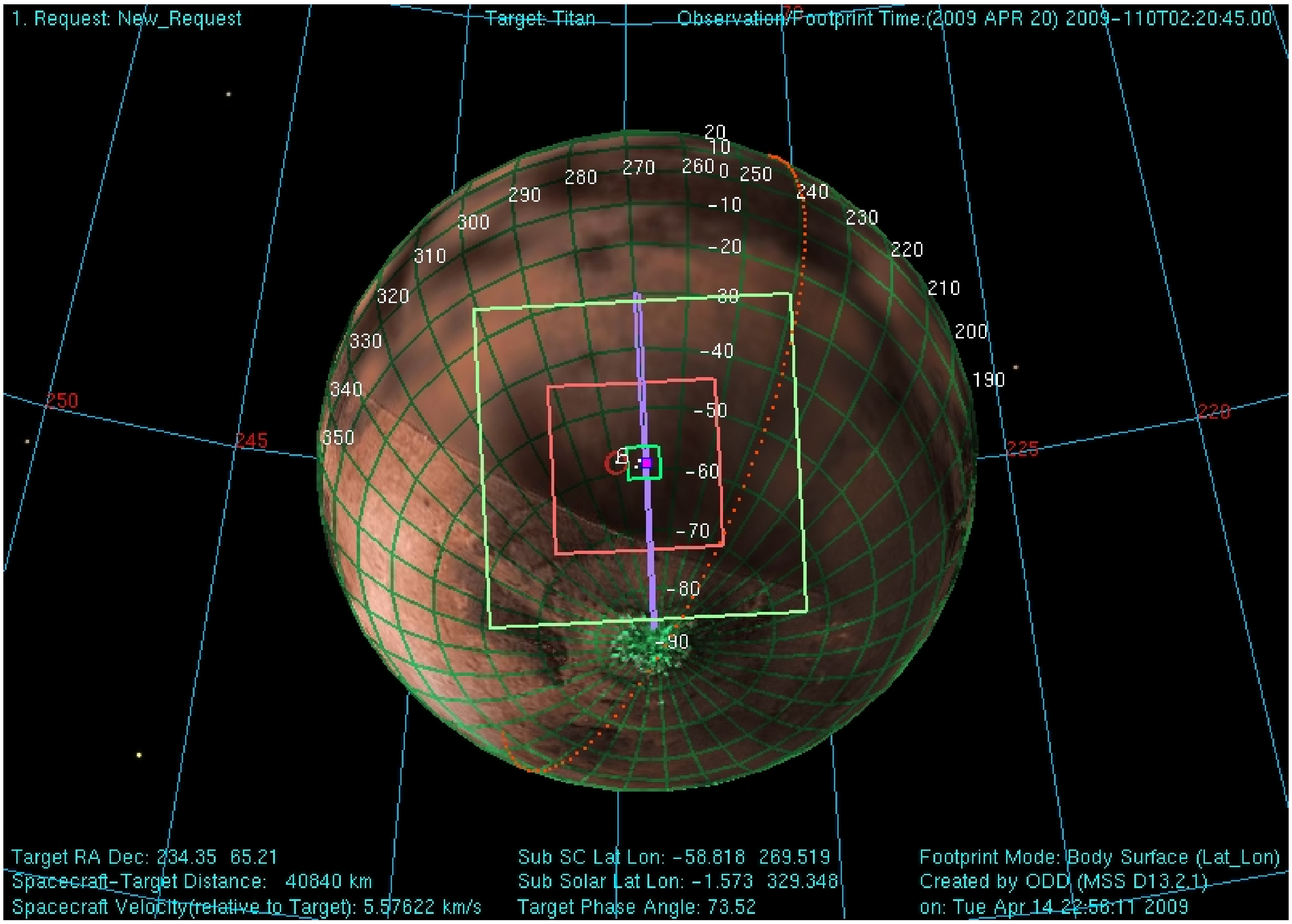
**View of Titan from Cassini two hours before Titan-53 closest approach**



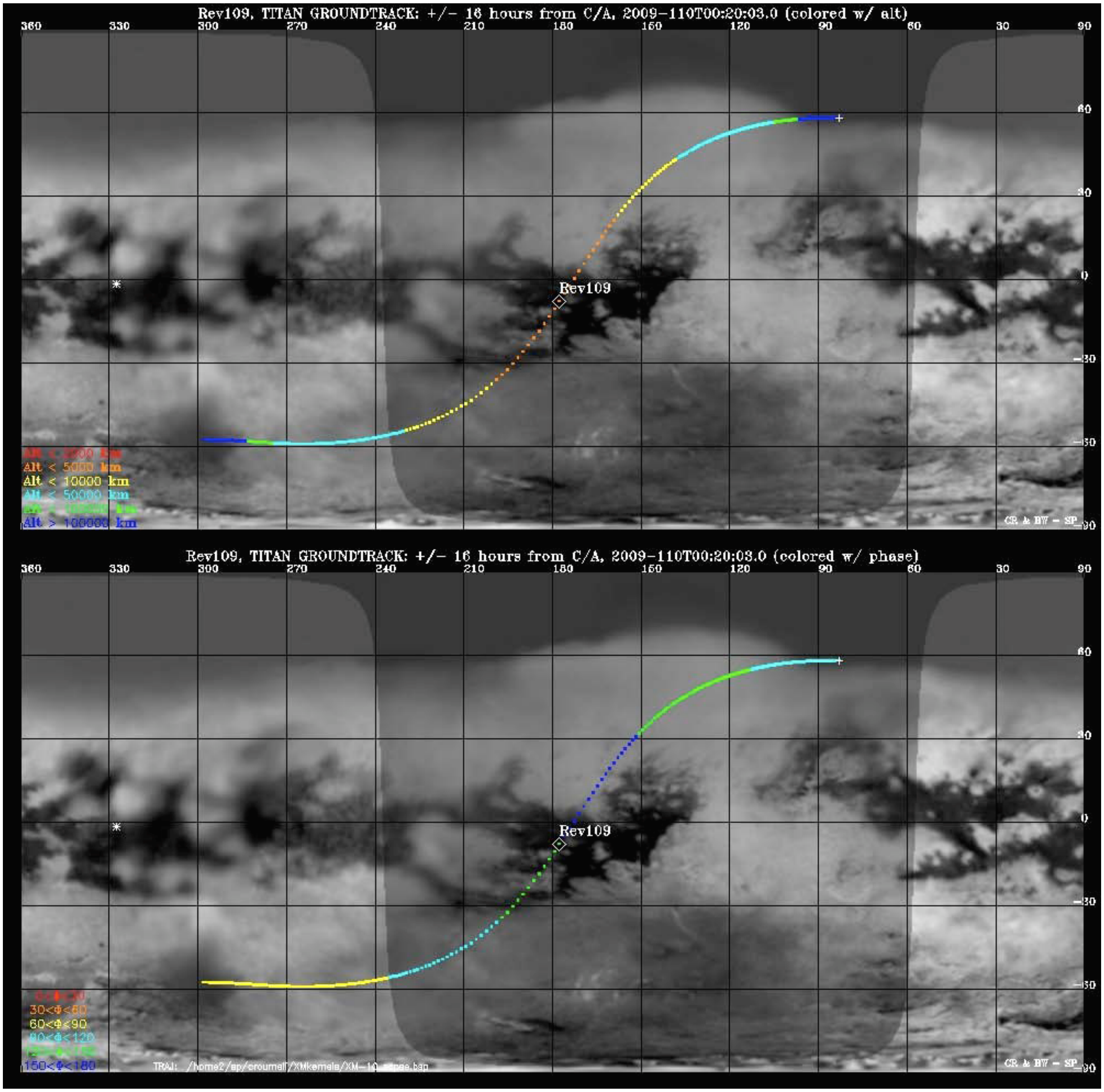
**View of Titan from Cassini at Titan-53 closest approach**



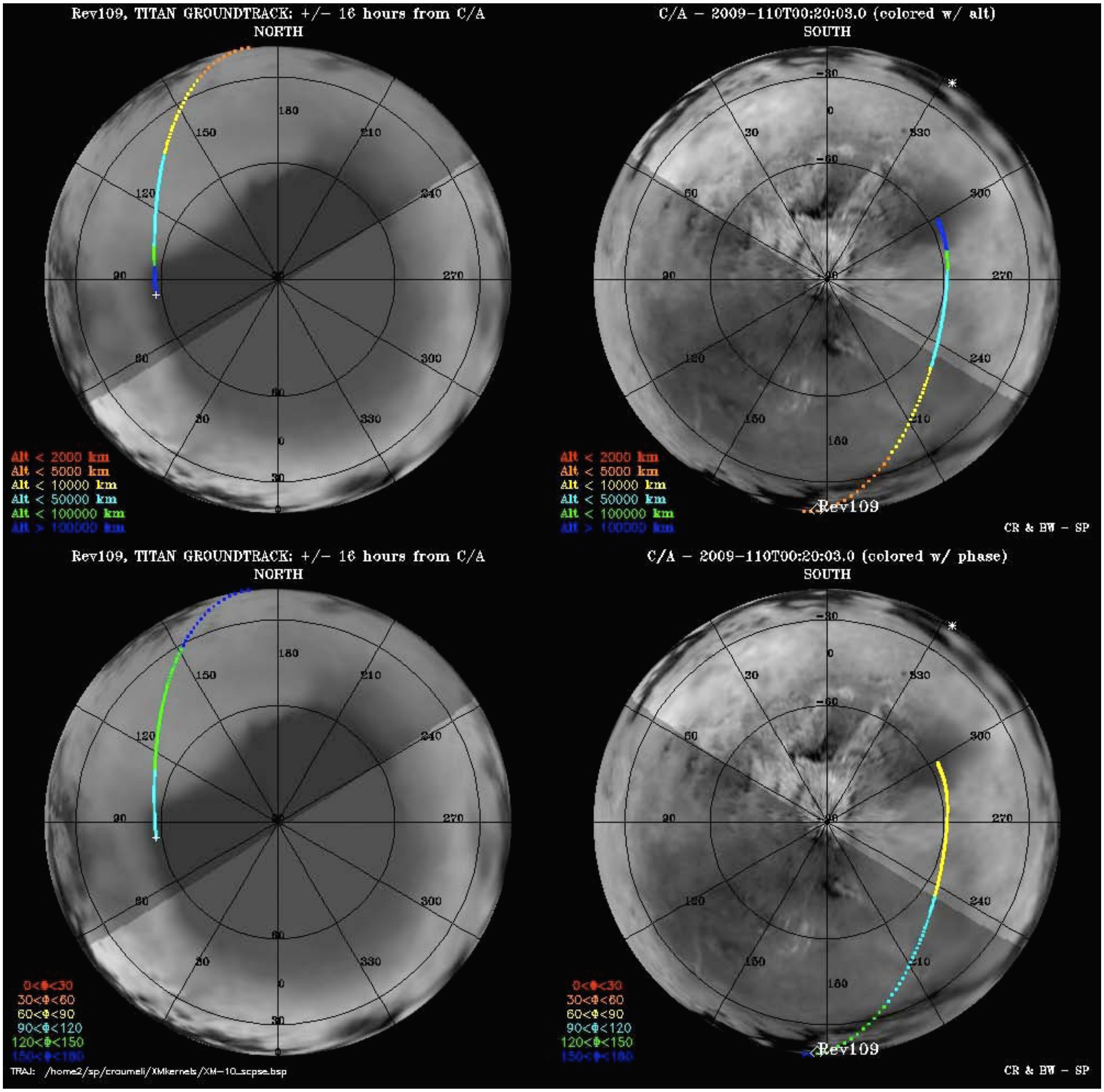
**View of Titan from Cassini two hours after Titan-53 closest approach**



# Titan Groundtracks for T53: Global Plot



## Titan Groundtracks for T53: Polar Plot



# The T53 timeline is as follows:

**Cassini Titan-53 Timeline - April 2009**

Colors: yellow = maneuvers; blue = geometry; pink = T53-related; green = data playbacks

| Orbiter UTC | Ground UTC | Pacific Time (PDT) | Time wrt T53 | Activity | Description |
|---|---|---|---|---|---|
| 085T10:05:00 | Mar 26 11:17 | Thu Mar 26 04:17 AM | T53-24d14h | Start of Sequence S49 | Start of Sequence which contains Titan-52 |
| 106T23:33:00 | Apr 17 00:45 | Thu Apr 16 05:45 PM | T53-03d01h | OTM #190 Prime | Titan-53 targeting maneuver. |
| 107T23:33:00 | Apr 18 00:45 | Fri Apr 17 05:45 PM | T53-02d01h | OTM #190 Backup | |
| 109T08:18:00 | Apr 19 09:30 | Sun Apr 19 02:30 AM | T53-16h02m | Start of the TOST segment | |
| 109T08:18:00 | Apr 19 09:30 | Sun Apr 19 02:30 AM | T53-16h02m | Turn cameras to Titan | |
| 109T08:58:00 | Apr 19 10:10 | Sun Apr 19 03:10 AM | T53-15h22m | New waypoint | |
| 109T08:58:00 | Apr 19 10:10 | Sun Apr 19 03:10 AM | T53-15h22m | Deadtime | 15 minutes 42 seconds long; used to accommodate changes in flyby time |
| 109T09:13:42 | Apr 19 10:25 | Sun Apr 19 03:25 AM | T53-15h07m | Titan atmospheric observations-CIRS | Obtain information on CO, HCN, CH4. Integrate on disk at airmass 1.5--2.0. |
| 109T14:20:45 | Apr 19 15:32 | Sun Apr 19 08:32 AM | T53-10h00m | Titan surface observations-ISS | Global Map |
| 109T15:20:45 | Apr 19 16:32 | Sun Apr 19 09:32 AM | T53-09h00m | Titan surface observations-VIMS | Observation of the night side of Titan at phase angle of 110. Look for clouds and emission features. |
| 109T19:20:45 | Apr 19 20:32 | Sun Apr 19 01:32 PM | T53-05h00m | Titan surface observations-VIMS | Regional Map |
| 109T21:20:45 | Apr 19 22:32 | Sun Apr 19 03:32 PM | T53-03h00m | Titan atmospheric observations-UVIS | UVIS FUV observation of Titan occulting Alpha Eri |
| 109T22:45:45 | Apr 19 23:57 | Sun Apr 19 04:57 PM | T53-01h35m | Titan atmospheric observations-CIRS | Limb scanning for aerosols. |
| 109T23:22:55 | Apr 20 00:34 | Sun Apr 19 05:34 PM | T53-00h58m | Titan atmospheric observations-CIRS | Vertical temperature sounding of Titan's tropopause & stratosphere. Slow radial scans. |
| 110T00:10:45 | Apr 20 01:22 | Sun Apr 19 06:22 PM | T53-00h10m | Titan atmospheric observations-UVIS | This is a solar occultation by Titan. EUV solar occultation port centered on sun Slit aligned tangent to limb. |
| 110T00:07:22 | Apr 20 01:19 | Sun Apr 19 06:19 PM | T53-00h13m | Earth occultation | 13 minute duration |
| 110T00:09:26 | Apr 20 01:21 | Sun Apr 19 06:21 PM | T53-00h11m | Solar occultation | 9 minute duration |
| **110T00:20:45** | **Apr 20 01:32** | **Sun Apr 19 06:32 PM** | **T53+00h00m** | **Titan-53 Flyby Closest Approach Time** | **Altitude = 3600 km (~2,200 miles), speed =5.8 km/s (13,000 mph); 149 deg phase at closest approach** |
| 110T00:46:45 | Apr 20 01:58 | Sun Apr 19 06:58 PM | T53+00h26m | Titan atmospheric observations-CIRS | Bistatic scattering measurments at three radio wavelengths to determine the physical properties of Titan's surface, including reflectivity, dielectric constant, and roughness. |
| 110T00:41:13 | Apr 20 01:53 | Sun Apr 19 06:53 PM | T53+00h21m | Descending Ring Plane Crossing | |
| 110T01:35:45 | Apr 20 02:47 | Sun Apr 19 07:47 PM | T53+01h15m | Titan surface observations-VIMS | Titan mosaicking / regional mapping. Phase ~75 deg. A cube every 5 min. Phase = 76 deg. Lat = -60, Lon = 255 New territory at 20 km/pixel |
| 110T02:20:45 | Apr 20 03:32 | Sun Apr 19 08:32 PM | T53+02h00m | Titan surface observations-RADAR | Outbound Radiometry |
| 110T06:20:45 | Apr 20 07:32 | Mon Apr 20 12:32 AM | T53+06h00m | Titan surface observations-VIMS | Regional mapping and mosaics |
| 110T08:50:45 | Apr 20 10:02 | Mon Apr 20 03:02 AM | T53+08h30m | Titan surface observations-ISS | NAC Global Map |
| 110T09:20:45 | Apr 20 10:32 | Mon Apr 20 03:32 AM | T53+09h00m | Titan surface observations-VIMS | Global Map |
| 110T14:20:45 | Apr 20 15:32 | Mon Apr 20 08:32 AM | T53+14h00m | Titan atmospheric observations-CIRS | Obtain information on the thermal structure of Titan's stratosphere. |
| 110T22:20:45 | Apr 20 23:32 | Mon Apr 20 04:32 PM | T53+22h00m | Deadtime | 17 minutes 14 seconds long; used to accommodate changes in flyby time |
| 110T22:38:00 | Apr 20 23:50 | Mon Apr 20 04:50 PM | T53+22h18m | Turn to Earth-line | |
| 110T23:18:00 | Apr 21 00:30 | Apr 20 17:30 | T53+22h58m | Playback of T53 Data | Goldstone 70m |
| 111T08:18:00 | Apr 21 09:30 | Apr 21 02:30 | T53+01d08h | Playback of T53 Data | Canberra 70m |