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ScienceDirect
Planetary and Space Science 55 (2007) 2015–2024
Planetary and Space Science
www.elsevier.com/locate/pss

Topography and geomorphology of the Huygens landing site on Titan

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Accepted 13 April 2007
Available online 27 April 2007

Abstract

The Descent Imager/Spectral Radiometer (DISR) aboard the Huygens Probe took several hundred visible-light images with its three cameras on approach to the surface of Titan. Several sets of stereo image pairs were collected during the descent. The digital terrain models constructed from those images show rugged topography, in places approaching the angle of repose, adjacent to flatter darker plains. Brighter regions north of the landing site display two styles of drainage patterns: (1) bright highlands with rough topography and deeply incised branching dendritic drainage networks (up to fourth order) with dark-floored valleys that are suggestive of erosion by methane rainfall and (2) short, stubby low-order drainages that follow linear fault patterns forming canyon-like features suggestive of methane spring-sapping. The topographic data show that the bright highland terrains are extremely rugged; slopes of order of 30° appear common. These systems drain into adjacent relatively flat, dark lowland terrains. A stereo model for part of the dark plains region to the east of the landing site suggests surface scour across this plain flowing from west to east leaving ~100-m-high bright ridges. Tectonic patterns are evident in (1) controlling the rectilinear, low-order, stubby drainages and (2) the "coastline" at the highland–lowland boundary with numerous straight and angular margins. In addition to flow from the highlands drainages, the lowland area shows evidence for more prolific flow parallel to the highland–lowland boundary leaving bright outliers resembling terrestrial sandbars. This implies major west to east floods across the plains where the probe landed with flow parallel to the highland–lowland boundary; the primary source of these flows is evidently not the dendritic channels in the bright highlands to the north.

Keywords: Titan; Huygens Probe; DISR; Topography; Stereogrammetry; Methane; Drainage; Fluvial; Dendritic; Tectonic

1. Introduction

The Descent Imager/Spectral Radiometer (DISR) carried aboard the Huygens Probe (Tomasko et al., 2002) acquired 1134 visible-light images with its three cameras during descent to and following landing on Titan's surface (Tomasko et al., 2005). These cameras returned the first ever high-resolution (~60 m/pixel to a few mm/pixel) images of the surface. About half of these images were lost due to the failure to receive the Channel A data from the Huygens Probe at the Cassini Orbiter (Tomasko et al., 2005) but 580 were successfully returned to Earth. Of these, 223 images were returned from the surface after landing. Of the remaining returned descent images, 240 were acquired below 40 km at about the altitude where surface detail began to emerge through Titan's thick, scattering aerosol haze. While much of the stereo coverage was lost with the Channel A data, the image set does provide extensive coverage of the region around the Huygens landing site. The analysis of some of the remaining stereo coverage is the main subject of this paper.

The three DISR visible-light cameras include: the high-resolution imager (HRI), the medium-resolution imager

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doi:10.1016/j.pss.2007.04.015

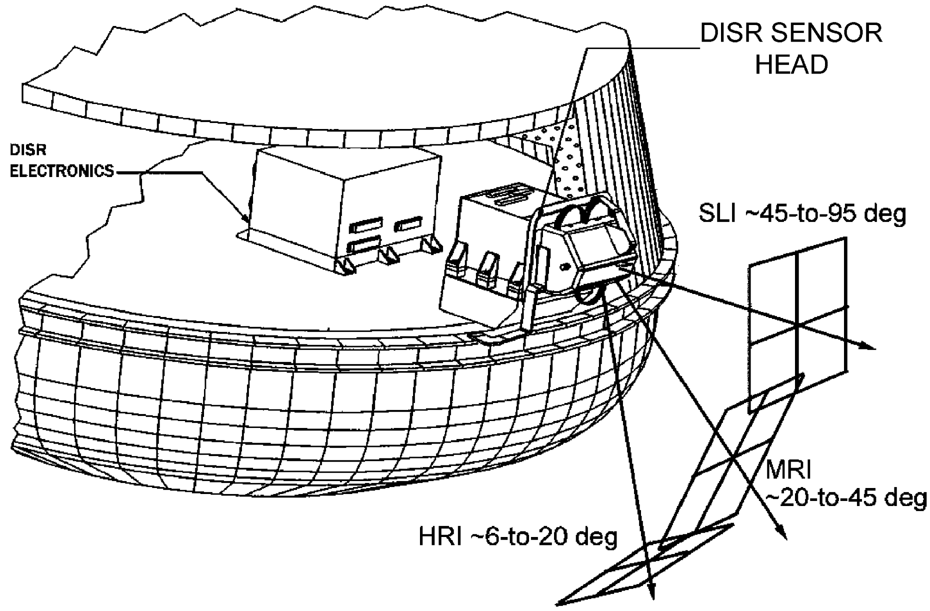

Fig. 1. Schematic layout of the fields-of-view (FOVs) of the DISR visible-light cameras. Angles denote approximate positions of the tops and bottoms of the FOVs from nadir. See Table 1 for further detail.

Table 1
Summary characteristics of the DISR camera

Camera	Format, pixels	Pixel (deg.)	Range from Nadir (deg.)	Azimuth range (deg.)
Side-looking imager—SLI	128 × 256	0.20	45.2–96.0	25.6
Medium resolution imager—MRI	176 × 256	0.12	15.75–46.25	21.1
High resolution imager—HRI	160 × 256	0.06	6.5–21.5	9.6

(MRI), and side looking imager (SLI); Fig. 1 shows the general layout and Table 1 provides basic geometric properties of the cameras. During imaging sequences all three cameras were exposed simultaneously providing a strip of image coverage from just off of nadir to j ust above the horizon. As the probe spun and drifted laterally during descent, panoramas were built up in cartwheel patterns.

2. Stereo coverage

The descent plan called for useful stereo coverage to be collected only with the HRI and MRI cameras; the surface resolution and emission angles from the SLI would not be appropriate for this application. For lateral view directions (i.e. perpendicular to the drift direction) HRI–HRI and MRI–MRI provide stereo; for the fore and aft directions HRI–MRI pairs can also be used. The DISR imaging sequence was designed to acquire stereo coverage assuming substantial eastward drift of the probe during descent driven by the prograde zonal wind. It was thought that the surface could become visible between 50 and 90 km and the wind drift would be 10–50 m/s. Thus it was anticipated that the imaging coverage might be spread out eastward several hundred km.

During the actual descent two major factors affected the stereo coverage: (1) the troposphere was hazier than anticipated so that the surface was not adequately resolved to accurately measure photogrammetric positions until reaching ~20 km altitude and (2) by that altitude the wind speed had dropped to ~4 m/s, continued to decrease with altitude, and actually reversed below ~7 km drifting back to the northwest at ~1 m/s (Tomasko et al., 2005). As a result, in the last 20 km the descent was almost straight down with little lateral drift. Fig. 2 shows the geometry of the descent below 20 km where photogrammetrically usable stereo image data were acquired for the two regions in region of the Huygens landing site (HLS) for which digital terrain models (DTMs) were generated in this work. Table 2 provides current best estimates (Karkoschka, 2006) of the camera positions for the seven DISR images of the stereo pairs depicted in Fig. 2. Fig. 3 shows the larger region of the full DISR image coverage.

Because of the rapid decrease in lateral drift rate below 20 km, DISR returned a series of panoramas mostly of the same region but each with increasingly higher resolution than the last. This was fortunate for several reasons: (1) owing to the loss of the Channel A data each panorama was partial and repeated coverage ultimately provided useful images of the entire landing site region, (2) having