Titan Radar Altimeter and Cloud/precipitation Explorer (TRACE)

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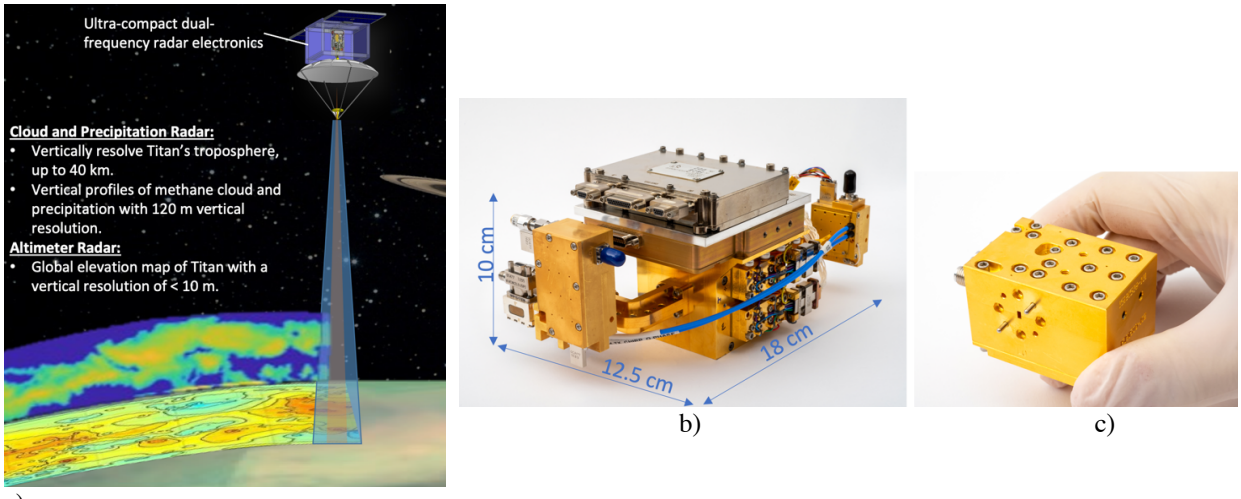
TRACE (Titan Radar Altimeter and Cloud/precipitation Explorer) is a low-cost, multi-functional, compact radar instrument for planetary exploration. TRACE is a millimeter-wave radar instrument that will penetrate through Titan's optically opaque atmosphere to provide: 1) global information on the vertical structure of methane clouds and rainfall and 2) a global topographic map of Titan. These measurements are necessary to understand Titan's weather, climate, and methane-based "hydrology". TRACE is conceived to enable unprecedented measurements of vertical structure of methane clouds and precipitation in the atmosphere of Titan, to fill extensive gaps in the topographic observations of Titan surface left by Cassini, and to provide the large-scale context to the localized observations from the upcoming Dragonfly mission.

TRACE is a dual-frequency radar instrument, operating at Ka/W-bands (35/94 GHz), with two simultaneous observation modes: *cloud/precipitation profiler* and *altimeter.* TRACE's *cloud/precipitation mode* measures the power backscattered by cloud droplets and precipitation raindrops as a function of the distance from the radar. In *altimeter mode*, the range and intensity of the surfaces' echoes are measured to estimate the surfaces' elevation. TRACE, through the *cloud/precipitation and altimeter modes*, will provide direct measurements of weather, surface, and hydrological processes on Titan. Figure 1a illustrates a notional mission instrument concept that supports Titan Orbiter Sciences objectives to 1) characterize Titan's global methane hydrological and sedimentological system, including surface transport/flow rates and cloud distributions and 2) quantify the production, transport and fate of organic molecules in Titan's upper atmosphere and atmospheric and climate evolution in general.

TRACE's radar architecture and electronics are based on CloudCube instrument, an Earth-observing Ka/W/G-band precipitation radar being developed by JPL under a 2019 NASA ROSES IIP. CloudCube's radar architecture significantly increased the ratio of performance vs. SWaP-C (size, weight, power, and cost) for Earth-observing spaceborne radar, see Figure 1b-c. TRACE will adopt these advances and apply them to planetary radar applications.



a) b) c)

Figure 1. a) A notional TRACE-bearing orbiter mission concept. TRACE is W- and Ka-band radar that simultaneously operates as an altimeter and atmospheric sounder. In a polar orbit at 1500 km above Titan's surface and using a 2 m antenna, TRACE is able to globally measure topography with vertical and horizontal resolutions of 7.5 m and 3 km, respectively. Simultaneously, methane cloud and precipitation >-3 dBZ are measured in Titan's troposphere with the same footprint and a 120 m vertical resolution. b) Picture of the complete Ka-band radar electronics. c) The up-conversion block for the W-band radar.