# Open-Loop Radio Reception during the Cassini Saturn Orbit Insertion and the Huygens Mission to Titan

Sami Asmar and Doug Johnston

Jet Propulsions Laboratory, California Institute of Technology, Pasadena, CA 91109, USA

**Abstract:**

Radio communications between the Cassini spacecraft and ground stations during the critical Saturn Orbit Insertion maneuver required the use of specialized open-loop instrumentation at NASA's Deep Space Network called the Radio Science Receivers (RSR). Due to the attitude of the spacecraft during the maneuver, a signal was transmitted from the back-up low-gain antenna precluding the ability to send telemetry due to the lower link margin. The only possible tool to monitor the progress and completion of the maneuver was to rely on the information inherent in the Doppler profile. A model of the expected Doppler shift of the received signal was generated in advance of the event; data from the RSR processed in real-time was superimposed on the prediction model. This method successfully provided the information needed to ensure the execution of the planned spacecraft sequence. The spacecraft later pointed its high gain antenna to Earth and transmitted the required data.

The Cassini spacecraft carried to the Titan system the European Space Agency's Huygens probe. During the entry, descent, and landing of the Huygens probe onto the surface of the Moon Titan, radio signals were transmitted from the probe to the Cassini orbiter. In order to provide a back-up and an enhancement to the Doppler Wind Experiment (an investigation of the speed and direction of the wind in the atmosphere of Titan), one radio link references to an atomic clock on the probe was also received directly at ground-based radio telescopes. The same Radio Science Receivers were loaned to two large radio telescopes in West Virginia and Australia to capture the Huygens signals and salvage the Doppler Wind Experiment, which was not successfully captured in the flight instrument.

This paper functionally describes the Radio Science Receiver instrument, designed for Radio Science experiments with the Deep Space Network such as atmospheric occultations, gravity fields, solar science, and the investigation of aspects of the theory of General Relativity. The use of the tuning prediction-driven RSR during the two historic events will be described including the generation of prediction models and corresponding post-event data processing. Results of the Cassini Saturn Orbit Insertion as well as the

wind information deduced from the Doppler Wind Experiment captured at the radio telescopes will be shown.