figure depicts a conventional receiving system, in which the receiver and decoder are uncoupled, and which is also called a non-data-aided system because output data from the decoder are not used in the receiver to aid in recovering the carrier phase. The receiver tracks the carrier phase from the residual carrier signal and uses the carrier phase to wipe phase noise off the data signal. The receiver typically includes a phase-locked loop (PLL) or Costas loop that requires no delay or perhaps a single sample delay.

The lower part of the figure depicts a basic coupled receiver/decoder — a data-aided system that would implement an iterative receiving/decoding process. The receiver would include a PLL or a Wiener filter that, to the extent possible, would track the residual carrier signal, wipe phase noise off the data signal, then send the result to the turbo decoder. Recovery of timing could be effected by, for example, a digital transition tracking loop (DTTL) or other, similar loop. The first iteration of turbo decoding would yield soft data symbols, which would be sent back to the receiver for use in softly wiping off the data signal in an effort to recover the residual carrier signal. The wiped signal would contain a relatively large carrier-phase component that could be tracked by use of a second Wiener filter.

The refined phase estimate generated by the second Wiener filter would be used to wipe the phase noise from a delayed replica of the incoming data signal. The resulting refined data signal would then be sent to the turbo decoder for the second iteration. The soft symbols from the second iteration would be sent back to the receiver as in the first iteration, and the process repeated.

For recovery of timing, the output of the turbo decoder would be used in place of what, in a usual DTTL, would be a transition-detector arm, in which hard decisions on consecutive symbols are based on raw symbol-by-symbol channel input, with no coding gain. The use of the turbo-decoder output would afford the benefit of the coding gain, thereby improving the output of the transition detector. Overall, the two-way communication between the receiver and the decoder would improve the performance of both the receiver and the decoder.

This work was done by Jon Hamkins and Dariush Divsalar of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
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Processing GPS Occultation Data To Characterize Atmosphere

NASA's Jet Propulsion Laboratory, Pasadena, California

GOAS [Global Positioning System (GPS) Occultation Analysis System] is a computer program that accepts signal-occultation data from GPS receivers aboard low-Earth-orbiting satellites and processes the data to characterize the terrestrial atmosphere and, in somewhat less comprehensive fashion, the ionosphere. GOAS is very robust and can be run in an unattended semi-operational processing mode. It features sophisticated retrieval algorithms that utilize the amplitudes and phases of the GPS signals. It incorporates a module that, using an assumed atmospheric refractivity profile, simulates the effects of the retrieval processing system, including the GPS receiver. GOAS utilizes the GIPSY software for precise determination of orbits as needed for calibration. The GOAS output for the Earth's troposphere and mid-to-lower stratosphere consists of high-resolution (<1 km) profiles of density, temperature, pressure, atmospheric refractivity, bending angles of signals, and water-vapor content versus altitude from the Earth's surface to an altitude of 30 km. The GOAS output for the ionosphere consists of electron-density profiles from an altitude of about 50 km to the altitude of a satellite, plus parameters related to the rapidly varying structure of the electron density, particularly in the E layer of the ionosphere.

This program was written by George Hajj, Emil Kursinski, Stephen Leroy, Byron Iijima, Manuel de la Torre Juarez, Larry Romans, and Chi Ao of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

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