2. The Future: Autonomous GPS microGPS Flight Receiver

The SNOE microGPS experiment is setting the stage for an even more revolutionary change in the way that routine orbit maintenance operations will be performed for future NASA missions. The SNOE ground software is being written as if it were flight software and will be tested and run on processors that are used in space. The goal is to permit eventual migration to space of most if not all of the microGPS processing software (see Figure 2). Thus a future version of the microGPS SNOE receiver would do all its processing on board, providing real-time orbit knowledge to the level of a few hundred meters while still using an insignificant amount of spacecraft resources (power, mass, volume).

The microGPS project brings us closer to a totally autonomous satellite for NASA science missions

Information from the GPS broadcast messages is still required in this autonomous future version of microGPS; the information could be extracted by adding a small chip to periodically track a GPS signal for several minutes (or alternatively, the information could be provided by uploading GPS ephemerides from the ground once a week or so). While present-day, flight-qualified processors are probably capable of handling the computational load, future faster processors will make this option even more attractive. This is not to say that the ground processing for SNOE will be particularly expensive—it will be done in a small PC in a largely automated procedure. Still it is attractive to move all such ground operations into space to enable fully autonomous satellites to, in principle, perform operations orbit maintenance functions.

The two groups leading the microGPS development at JPL are both in section 335. One group pioneered the development of the Rogue and TurboRogue GPS receivers. A flight version of the TurboRogue receiver is currently operating in space on the Microlab satellite for the GPSMET mission, autonomously scheduling and controlling scientific experiments onboard the spacecraft. The other group developed the GIPSY-OASIS orbit determination software, which is run in ground workstations and has been used to produce the most accurate orbits ever reported for GPS satellites and for low-Earth orbiters. The new microGPS software uses features of both. Future flights of the TurboRogue receivers will test portions of the new microGPS software.

In addition, although the initial configuration for microGPS will be to support coarse (few-hundred meter) accuracy operational orbit determination, it can be upgraded to provide ultra-precise orbit determination and attitude products in near-real time.

The microGPS project combines JPL's unique expertise in GPS hardware and in GPS orbit determination applications to produce a new and exciting flight instrument that will bring us closer to being able to provide a totally autonomous satellite for very low-cost, low-mass, low-power NASA science missions. In addition to NASA, the aerospace and satellite communities in general have already taken notice of this little demonstration experiment. JPL has been contacted by several companies and military organizations who are interested in broader application of the new techniques pioneered by microGPS. In fact, a second microGPS experiment is anticipated in 1997 on a British military satellite known as STRV-C, which will fly in an elliptical orbit ranging from geosynchronous to very low-Earth orbit altitudes. For this experiment, the microGPS receiver will be upgraded to provide more accurate observables.

This follow-up experiment will test the capability to track GPS satellites from altitudes well above GPS altitude, which has never been demonstrated before. JPL has claimed that this, theoretically, can be done, and a demonstration will make a whole new regime of satellite tracking with GPS possible, conceivably having a huge impact on the communications industry. Stay tuned!

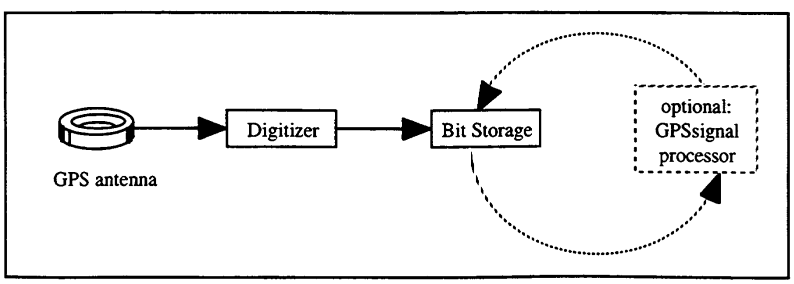
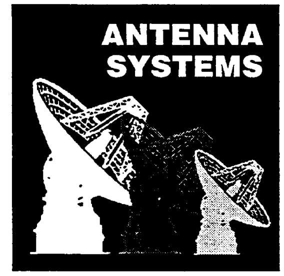


FIGURE 2. HIGH-LEVEL DIAGRAM OF FLIGHT MICROGPS INSTRUMENT SHOWING OPTIONAL ONBOARD PROCESSOR.

DIPLEXING IN THE DSN



MARK GATTI

The Deep Space Network antennas provide the collecting aperture for receiving the extremely weak signals sent from the various spacecraft presently flying in our solar system. Two issues ago, Miles Sue described how the performance of these antennas is measured as a function of their gain and their noise temperature. The gain is directly proportional to the size of the collecting aperture, and the noise temperature is related to how much signal is received by the antenna that comes from undesired sources such as the earth, atmosphere, and the cosmic background radiation. Furthermore, the signals that are received are focused into feed systems that route the signal to the low noise amplifiers (LNAs). The LNAs must amplify the signals while also minimizing the degradation due to the LNAs own contribution to the noise of the system. In this issue, Javier Bautista describes the DSN Technology Program's work in that area.

A common situation for the DSN is one where it is desired to both transmit and receive signals at different frequencies, simultaneously. For the two signals to be present in a common path there must be great care taken to isolate the signals. The LNAs are so sensitive that any more than 10^{-10} of the transmitted 20 kW signal will seriously degrade the received signal. A waveguide diplexer is presently used to split the transmitted and received signals and to provide sufficient isolation. When a receiving system is operating at the same time that the transmitter is on, the system is said to be in two-way or diplexed mode. There is something to be paid for the high isolation, specifically that the noise temperature of the receive channel is somewhat higher than a system in one-way mode, i.e., without a diplexer. This is caused by the diplexer itself and the connections required to have the system present. Figure 1 is a block diagram that illustrates both the one-way and two-way modes of operation.

In Figure 1 there is a switch that allows the received signal to bypass the diplexer and be sent to an LNA. This is the one-way mode for which the noise temperature contribution of the diplexer is not present. When the switch is in the other position, the received signal is routed through the diplexer to a different LNA, while the transmitted signal is simultaneously routed out to the feed.

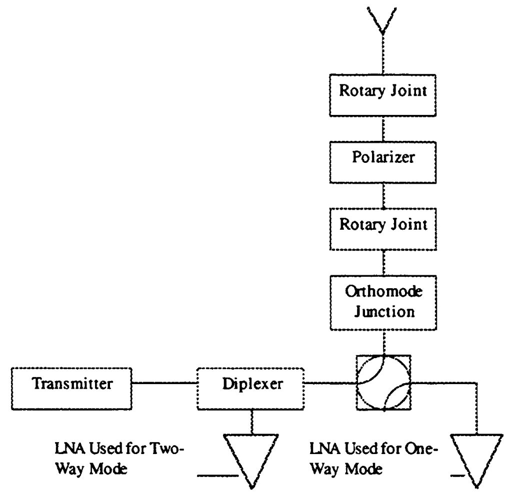


FIGURE 1: A TYPICAL DIPLEXING SCHEME USED IN THE DSN. THE WAVEGUIDE SWITCH SELECTS BETWEEN THE ONE-WAY AND TWO-WAY (DIPLEXED) RECEIVING SYSTEMS.

The excess noise temperature of the diplexer limits the ultimate sensitivity of the receive system. Reducing the noise temperature of the receive system is the ultimate goal and cryogenically cooling the LNAs is an example of reaching for that goal. There are two ways that one might attack the problem of the diplexer; one is to cool the waveguide components, and the other is to remove them altogether. It is not obvious how the waveguide diplexer could be cooled since the transmitted signal (which causes the component to become physically hot) would be working against the cryogenic cooling system, possibly to the degradation of the cooling of the LNA. There is, however, a new diplexer that has been developed and demonstrated in the DSN Technology Program's Antenna Systems Work Area that allows the entire receiving system to be cryogenically cooled and removes the waveguide diplexing components.

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