ULYSSES 01{111'1' DETERMINATION AT HIGH DECLINATIONS

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The trajectory of the Ulysses spacecraft carries it over the South polar region of the Sun in mid-1994, albeit at a great distance from the Sun itself. During this time the South Solar latitude of Ulysses' orbit reaches a maximum value of **S0.2** degrees, and the geocentric declination reaches a magnitude of over 75 degrees. As a result, a number of unique and interesting events occur, not the least of which being that Ulysses never sets over the Canberra tracking station of the NASA/JPL Deep Space Network (DSN) for more than two months. A less obvious aspect of the Sull-spacecraft-Earth geometry during this time is the return of solar-induced nutation to the sI)ill-stabilized Ulysses spacecraft, and the consequent use of active nutation control. Both of these events have significant implications for theory and practice of Ulysses' orbit determination during this period, which is the subject of the proposed paper,

While the Ulysses spacecraft has typically received ten hours of tracking time a clay, with both Doppler and range data observations being made simultaneously with telemetry reception, the nutation operations mode requires a continuous uplink without the disturbances caused by ranging modulation. In addition, the active attitude control operates in an unbalanced manner, imparting a llc~tic.cable delta-V to the spacecraft with each control pulse. As this amounts to as much as eight mm/sec/day of acceleration at random intervals, the traditional approach of modelling each maneuver as a discrete event had to be abandoned in favor of the use of stochastic accelerations with process noise levels as high as 3×10^{-10} km/sec^2.

The additional uncertainty imposed on the trajectory reconstruction (which has a 1000 km 1σ requirement) is mitigated by the high declination of the spacecraft, which makes Doppler data highly effective in determining the geocentric position of the spacecraft. Using the Hamilton-Melbourne equation with typical range and declination values for Ulysses, the expected plane-of-sky position uncertainty from a day of continuous tracking is 40 kilometers in each component. While this constrains two of the position components to be well under the requirement, geocentric range information must be inferred from the relative motion of the spacecraft and the Earth over time, which is more difficult to do in the presence of random attitude control activity. Nevertheless, covariance studies have predicted that the accuracy requirement will be met by a reasonable margin, and the orbit determination experience to elate suggests that this is actually the case.

In addition to describing the methods used operationally to determine the orbit of Ulysses, the analytical predictions of angular position uncertainty will be tested against actual experience through the use of short-arc- solution comparisons. The Hamilton-Melbourne equation may also be extended to cover constant accelerations and be expressed as the steady-state solution to a Markov process, in order to accurately predict the short-term behaviour of orbit determination accuracy under this scenario.