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An Automated Low-Earth Orbit Determination System with High Accuracy Real-Time Capability

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The Topex/Poseidon (T/P) satellite has been carrying a high-accuracy GPS flight receiver in low-Earth orbit since August 1992. The flight data have been combined at JPL with ground GPS data from a global network to routinely produce precise T/P orbits. When dual frequency GPS tracking data arc used, the T/P orbits have root-mean-square (RMS) accuracies of about 2 cm in altitude and about 10-15 cm in cross- and down-track components. Since anti-spoofing (AS) was activated, however, the JPL T/P orbit sol ut ions have been based on only single frequency data (L1 -C/A) from the flight receiver, An automated data processing system has been set up at JP1. to: retrieve GPS ground data in near-real time from selected sites from the global network; retrieve the flight data in near-real time from the low-Earth orbiter (through TDRS); run the JPL orbit determination software (GIPSY OASIS II) to obtain precise orbits for T/P as we] 1 as all the GPS satellites in a process noise filter; and propagate the T/P orbits into the future to provide real-time knowledge of the satellite position and velocity. 'I'he tests show that sub-meter orbit accuracy is possible in near real-time with such an automated system with minimal human intervention. Prediction of the ephemeris determined in near-real time can then provide real-time knowledge of the satellite position to better than 1 meter.

In addition to analyzing the actual flight data from T/P, a number of trade-off studies have been performed to assess the cost/performance relationship for various simplified, less demanding tracking scenarios for low-Earth orbiters in general. In these studies we address real-time and non-real time orbit production applicable to orbit requirements ranging from better than 1 meter to several hundreds of meters. We also describe the savings in cost, power, and mass which can be realized for the lower accuracy missions. A range of altitudes have been studied. The results will be presented in the paper.

This work is significant because it shows how a low-Earth orbiter carrying a GPS receiver could achieve autonomous navigation. Even when very stringent (sub-meter) accuracy requirements are desired, an automated processing system can be designed to these performance specifications, as shown by the recent T/P 1.1-C/A results at JPL, at relatively low cost overall. For the more commonly encountered navigation requirements at the 100-m level or several hundred meter-level, a number of simplifications can be made (such as dispensing with the ground data altogether) to the system which could lower costs even further.

This work should be of interest to various government agencies, including NASA and the military, as well as to the private sector, because it describes an automated orbit determination system which could utilize relatively inexpensive 1.1 -C/A flight receivers to produce orbits in real time to the level of 1 to 100+ meters accuracy, depending on a. number of design factors.