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DESIGN, TEST AND ON-ORBIT RESULTS OF RELATIVE GPS NAVIGATION FOR H-II TRANSFER VEHICLE

Abstract

H-II Transfer Vehicle (HTV) is an unmanned vehicle that transfers cargo to the ISS. One of the key technologies for a safe and precise rendezvous of HTV to the ISS is relative navigation system. We have three relative navigation systems and switch the navigation system according to the distance from the ISS. After the HTV enters the communication zone with the ISS, firstly we use differential GPS (DGPS) navigation where the absolute navigation filter outputs at HTV is subtracted by those at ISS. Secondly, we use relative GPS (RGPS) navigation where the GPS measurements at HTV are subtracted by those at ISS. When the HTV approaches about five hundred meters below the ISS, the rendezvous sensor (RVS) captures the target markers attached to the ISS. Then we use the line of sight navigation. We will describe the design philosophy of the RGPS filter and report its performance results of HTV-1 and HTV-2.

The RGPS filter needs to accommodate for a large dynamic range. Therefore, we have taken much care to balance accuracy and robustness when we designed the RGPS filter. The developed RGPS filter has the following features 1, 2 for accuracy and 3, 4 for robustness.

1. It integrates the HTV position numerically considering J2 and higher earth oblateness effects.

2. It compensates the clock bias error contained in the measurement time tag.

3. The process noise is set larger than the anticipated relative air drag and higher order effects of the earth oblateness in order to account for the unmodeled dynamics.

4. It has a three layered FDIR (fault detection, isolation and recovery). The lowest layer checks the raw data in view of its format compliance, range limits and others. The middle layer checks the measured data against estimated data. The highest layer checks the covariance of the filter.

The RGPS filter performance is checked against the DGPS filter. The quick analysis of the on-orbit flight data of HTV-1 and HTV-2 shows that the difference between the outputs of RGPS and DGPS are well within the specification values and are quite similar to those observed during the on-ground tests. The RGPS filter outputs are also compared against the RVS outputs and their differences are within the specification values. The analysis shows that the RGPS performance was as good as expected.