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Improving the orbits of eclipsing GPS satellites

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The orbits of GPS satellites show a lower performance during Sun-Earth eclipse seasons than during periods outside these seasons. In particular the orbits of GPS II and IIA satellites are worse during eclipses, while GPS IIR satellite orbits are almost unaffected. The cause of this problem is the non-nominal yaw attitude of the satellites during eclipses, i.e. the yaw maneuvers performed at noon, shadow and post-shadow. If the yaw maneuvers are not properly taken into account, two effects appear: 1) the phase measurements are degraded since the modelled position of the satellite's navigation antenna differs from the true position, and 2) the non-conservative forces like solar radiation pressure and Earth radiation pressure are mismodelled due to the wrong orientation of the satellite's surfaces in space.

In this study, we introduce the yaw maneuver information available from models in the computation of solar radiation pressure and Earth radiation pressure acting on a box-wing like satellite. Also the computation of the satellite's navigation antenna position takes into account the yaw maneuver models. The improvement of GPS satellite orbits during eclipse seasons is quantified in terms of orbit predictions after 6 hours and after 4 days for all GPS satellites during 2007 and 2008. Already the use of the currently available yaw maneuver models, with nominal hardware yaw rates, shows an important improvement when combined with our box-wing model. In addition, we have estimated the real hardware yaw rates from PPP residuals and use this information for orbit prediction, obtaining an additional improvement in the orbits of GPS II and IIA satellites during eclipse seasons.