Problem Set 3

AA 279D, Spring 2018

Due: May 2, 2018 (Wednesday) at 1:30 pm

Notes:

Submission Instructions

Please continue to document all tasks below in your project report. You should indicate any substantial changes in the change log and highlight them for review.
Please submit your report as a PDF file to the course Canvas website. You should use typesetting software like LaTeX or Microsoft Word to produce your documents. Do not submit extra files.

Topics

Lecture 5: Linearized relative equations of motion.

Problem 1. Linear Relative Motion

We would like to propagate the relative spacecraft motion according to the HCW equations and explore both rectilinear and curvilinear coordinates. To this end, you are asked to perform the following analyses.

(a) Come up with a suitable set of initial conditions for your orbit. You should start with the initial conditions for absolute and relative states determined in Problem Set 2, Problem 1a, then modify them to accommodate the assumptions made by the HCW equations.
In other words, the separations should be small relative to the distance from Earth's center (e.g. $\|\vec{\rho}\| \approx 0.001\|\vec{r}_0\|$), with near-zero eccentricity (e.g. $e \approx 0.001$). Note that if your previous set of initial conditions satisfies these assumptions, there is no need to change them. Otherwise, be sure to justify your final selection.

(b) Use your new set of initial conditions to compute the following at $t_0 = 0$:

  i. Inertial position and velocity (ECI), and orbital elements of chief and deputy
  ii. Relative position and velocity (taken and expressed in the chief RTN frame), and orbit element differences between deputy and chief

(c) Using the parameters from part (b), compute the six integration constants of the HCW equations.

(d) Propagate the relative state in Simulink using the standard solution of HCW expressed in rectilinear coordinates over 15 orbit periods. Plot the resulting relative position and velocity in 3D and in the TR, NR, and TN planes (first letter indicates x-axis, second letter indicates y-axis).

(e) Discuss whether the general behavior matches your expectation given the initial conditions, the integration constants, and the applied orbit element differences. Is the relative motion bounded as expected from $\delta a = 0$ (energy matching condition). If not, why?

(f) Now transform your initial rectilinear relative state into curvilinear coordinates, then re-compute the integration constants and re-propagate the HCW equations in Simulink using curvilinear coordinates instead. Transform the output back to rectilinear coordinates at each time step. Superimpose plots of the resulting relative position and velocity (rectilinear) on the same plots generated in part (d) for your rectilinear propagation.

(g) Discuss the results of your curvilinear simulation as in part (e). What would you expect to be different about along-track drift now?