HEEO Orbit Stability and Predictability for ECV Mission Design

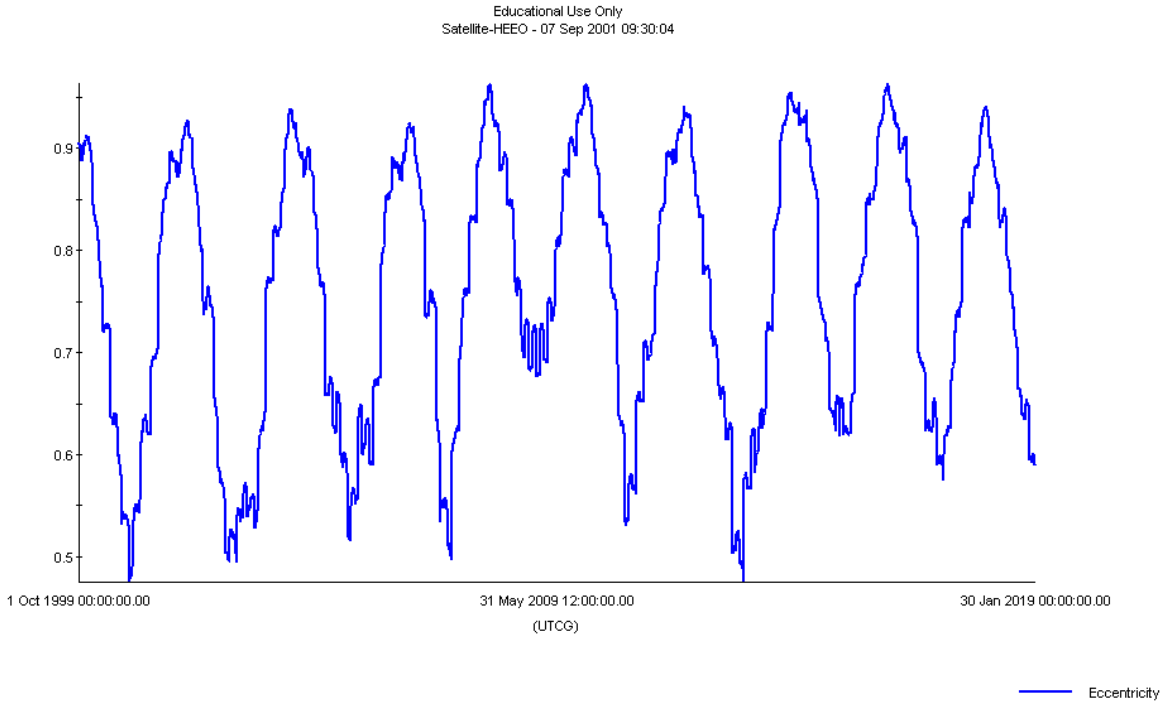
By Jason Stauch 2001 June

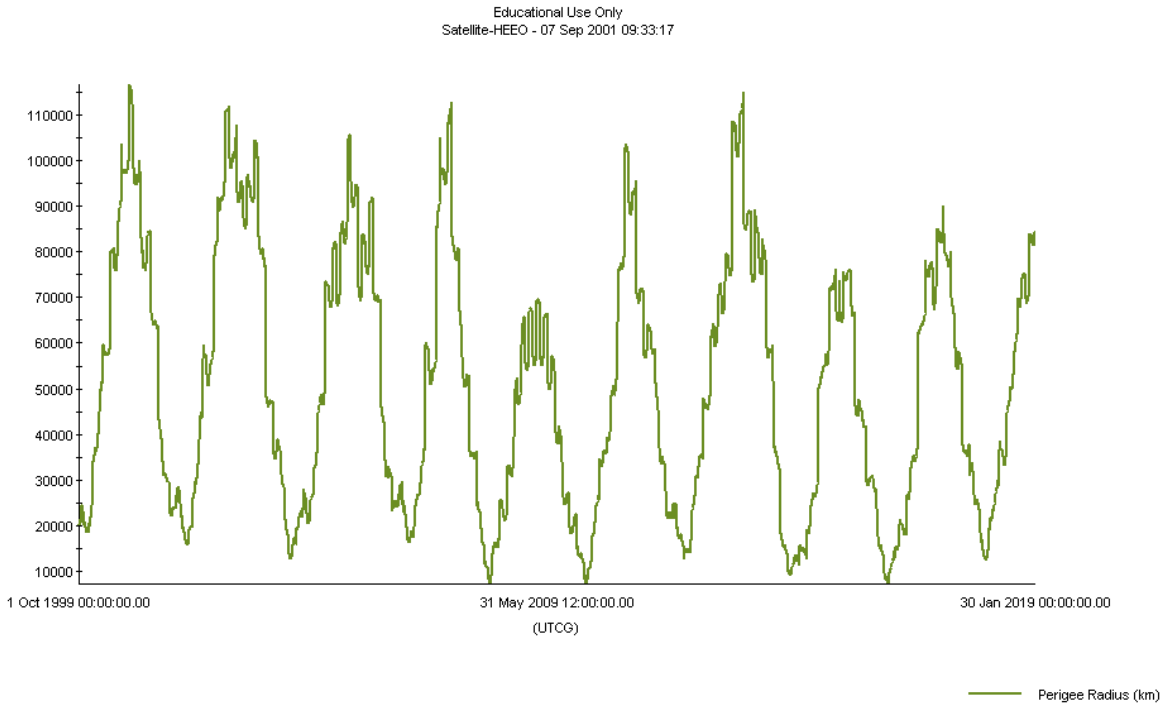
The following plots were generated using STK s HPOP (High Precision Orbit Propagator) tool. A 4 x 4 gravity field was used for the Earth, and lunar and solar gravity were turned on. The initial conditions for the orbit were chosen for a 20,000 x 400,000 HEEO orbit. The inclination and argument of perigee were adjusted until a stable orbit was generated. Using the following initial conditions (on Oct. 1, 1999), a stable 20-year orbit was developed:

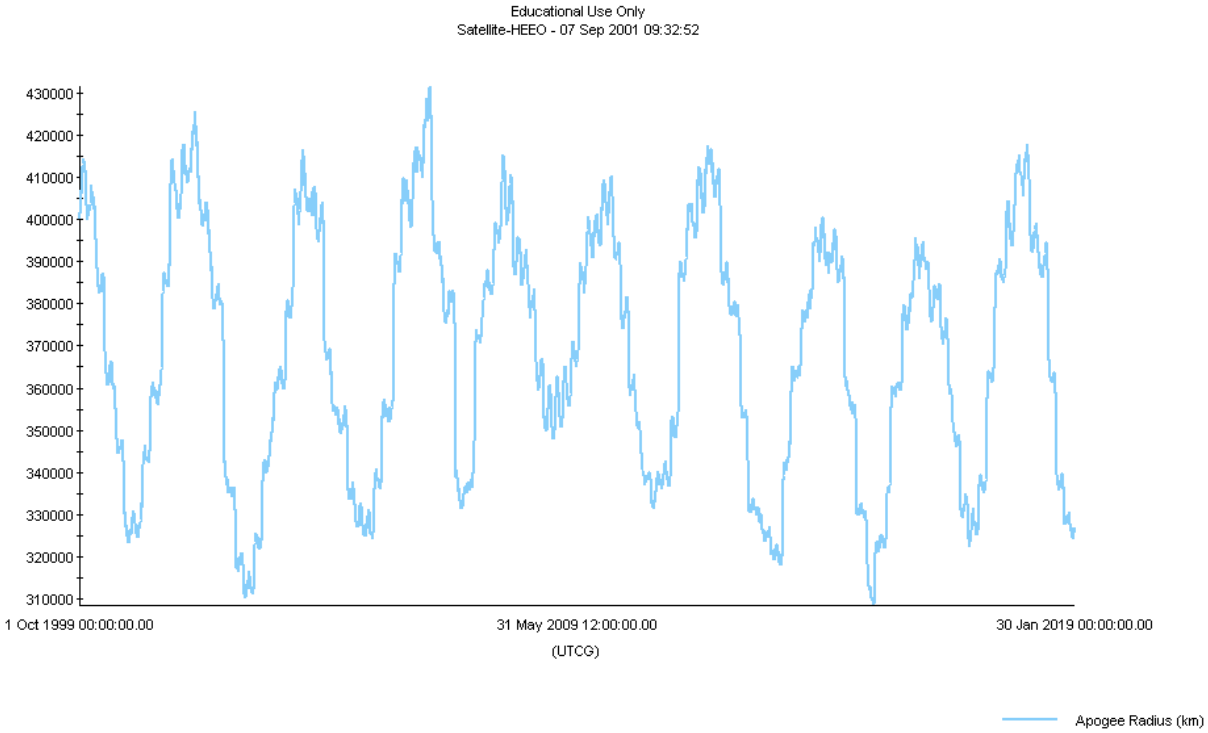
a = 210,000 km
e = 0.9047619
i = 45.15^{o}
Arg. of Perigee = 95.15^{o}
RAAN = 0^{o}
True Anomaly = 0^{o}

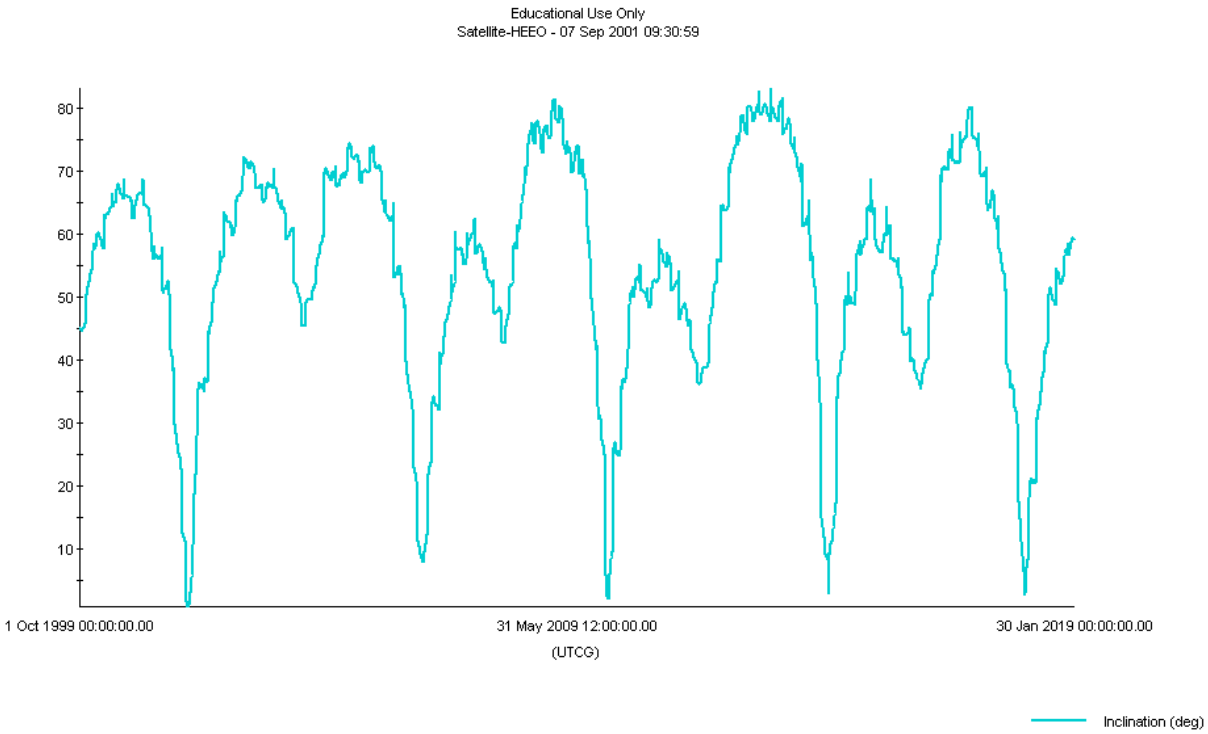
A plot of the eccentricity, radius of perigee, radius of apogee, inclination, RAAN, and argument of perigee for the 20-year period are shown below. These plots indicate that the eccentricity, radius of perigee, radius of apogee and inclination are periodic with a period of a little more than 2 years. The RAAN and argument of perigee are also periodic with a period of twice that of the eccentricity. These results indicate that it is possible to design an ECV mission that will rendezvous with the sample containers (in HEEO) without adding fuel contingency for out-of-plane maneuvers or semi-major axis uncertainties. The launch date would simply be chosen at the optimal point in the 2-year HEEO cycle for which the ECV mission is designed.

The initial orbit elements were chosen by adjusting the inclination and argument of perigee until a stable 20-year orbit was produced. This was done with a limited knowledge of orbit stability, thus if more thought were put into the initial orbit, the results are likely to be adjustable.

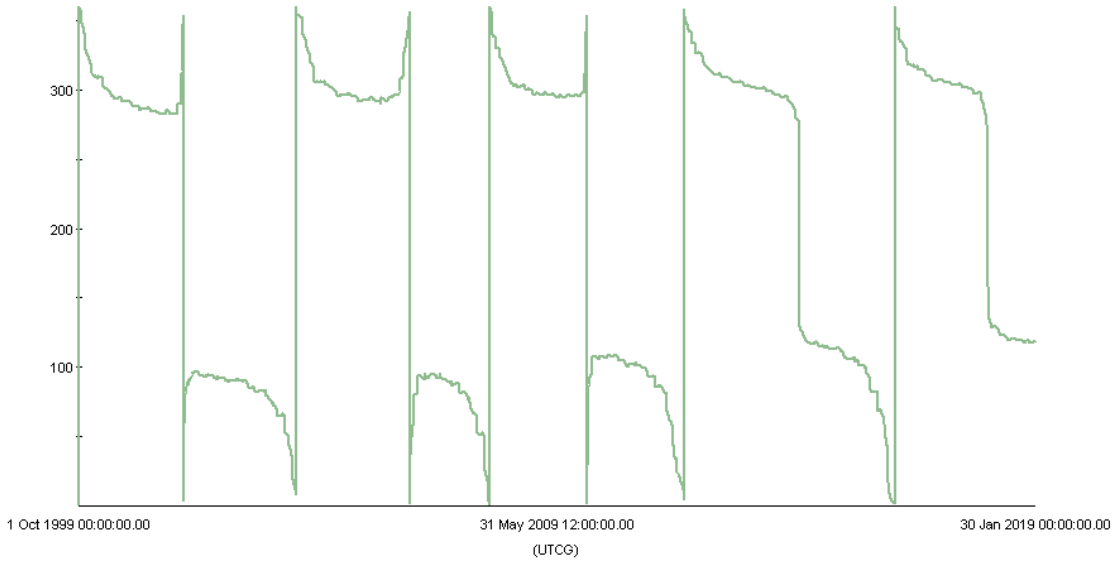

Educational Use Only
Satellite-HEEO - 07 Sep 2001 09:30:04
0.9
0.8
0.7
0.6
0.5
1 Oct 1999 00:00:00.00
31 May 2009 12:00:00.00
30 Jan 2019 00:00:00.00
(UTCG)
Eccentricity


Educational Use Only
Satellite-HEEO - 07 Sep 2001 09:33:17
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
1 Oct 1999 00:00:00.00
31 May 2009 12:00:00.00
30 Jan 2019 00:00:00.00
(UTCG)
Perigee Radius (km)


Educational Use Only
Satellite-HEEO - 07 Sep 2001 09:32:52
430000
420000
410000
400000
390000
380000
370000
360000
350000
340000
330000
320000
310000
1 Oct 1999 00:00:00.00
31 May 2009 12:00:00.00
30 Jan 2019 00:00:00.00
(UTCG)
Apogee Radius (km)


Educational Use Only
Satellite-HEEO - 07 Sep 2001 09:30:59
80
70
60
50
40
30
20
10
1 Oct 1999 00:00:00.00
31 May 2009 12:00:00.00
30 Jan 2019 00:00:00.00
(UTCG)
Inclination (deg)

Educational Use Only
Satellite-HEEO - 07 Sep 2001 09:31:23



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