Orbit Estimators

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- ## Simple orbit estimator

Simple orbit estimator is the alternate of GPS receiver it predicts the position of the satellite in the orbit if the keplerian elements at some instant is known. The position of the satellite in the orbit should be known as for calculating the value of IGRF at the satellites position which is used by the ADCS systems.

The calculation proceeds in the following way:

$$a_R = -4.5 \times 10^{-6}(1+r)\left(\frac{A}{m}\right)$$

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$$n = \sqrt{\frac{2GM_e}{(R_e + a)^3}}$$

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$$E(t) = M(t) + esin(E(t))$$

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The above equations can be solved iterationally by Newtons Raphsons process which gives a good estimate as follows:

$$E_{i+1} = E_i + \frac{M + esin(E_i) - E_i}{1 - ecos(E_i)}$$

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With the number of iterations the accuracy increases. The position in ECOF frame can be given as :

$$r_{oc} = a\begin{bmatrix} cos(E) - e \\ \sqrt{1 - e^2}sin(E) \\ 0 \end{bmatrix}$$

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As IGRF is designed wrt ECEF the position is to be converted to ECEF frame.

$$r_I = R_z(-\Omega)R_x(-i)R_z(-\omega)a\begin{bmatrix} cos(E) - e \\ \sqrt{1 - e^2}sin(E) \\ 0 \end{bmatrix}$$

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$$r_E = R_z(-\Omega + \theta)R_x(-i)R_z(-\omega)a\begin{bmatrix} cos(E) - e \\ \sqrt{1 - e^2}sin(E) \\ 0 \end{bmatrix}$$

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- ## Enhanced orbit estimator:

The enhanced simple orbit estimator considers the orbital perturbations in order to estimate the position of satellite. The position estimated by the enhanced simple orbit estimator is far accurate then the simple orbit estimator. The Enhanced orbit estimator can be given as:

$$\boldsymbol{r_E} - \boldsymbol{R_z}\left(-\left(\frac{d\Omega_0}{\mathrm{dt}} + \left(\frac{d\Omega_{J_2}}{dt} + \frac{d\Omega_{moon}}{dt} + \frac{d\Omega_{sun}}{dt}\right)t\right) + \theta_0 + \omega_e\right)\boldsymbol{R_x}(\;\, i)\boldsymbol{R_z}\left(\;\, \left(\omega_0 + \left(\frac{d\omega_{J_2}}{dt} + \frac{d\omega_{moon}}{dt} + \frac{d\omega_{sun}}{dt}\right)t\right)\right)a\begin{bmatrix} cos(E) - e \\ \sqrt{1-e^2}\,sin(E) \\ 0 \end{bmatrix}$$

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