Faculty of Electrical Engineering & Computer Science
Master Degree Course Electronics Engineering, MSc EE

HSB
Hochschule Bremen
City University of Applied Sciences

Master 2015

Prudhvi Kumar Bheemisetty

Extended Kalman Filter for GNSS Navigation in Transfer to GEO with Electrical Propulsion.

ABSTRACT - Masterthesis

The Airbus DS LION Navigator GNSS receiver is used for onboard autonomous GNSS navigation in Low Earth Orbit (LEO) and Geostationary Orbit (GEO). The navigation solution implements a Kalman Filter (Reference Filter with Position, Velocity and Air-drag as a state vector).

Onboard autonomous navigation, i.e. the position, velocity and time (PVT) of the user spacecraft (S/C), is calculated either by a classical single point solution (kinematic) or by a sequential filtered solution (Kalman filter). The single point solution requires that at least four GNSS satellites (SVs) are in track. The Kalman filter solution update requires that at least two GNSS SVs are in track.

The Kalman filter is based on an orbit model and force models (e.g. gravitational force of the Earth, the Sun, etc.), as well as the statistical knowledge of process and measurement noise. The filter uses pseudorange and range rate measurements. An update requires that at least two GNSS SVs are in track. If less than two GNSS satellites are in track the PVT solution is based solely on propagation using the orbit model.

For user S/C at higher altitudes - i.e. Geostationary Orbits (GEO) and Geostationary Transfer Orbits (GTO) - GNSS SVs from behind the Earth have to be used. This results in poor visibility conditions and low signal power levels. The GNSS SV visibility depends most notably on the altitude and orientation of the user S/C. Visibility gaps and signal outages may last for several hours. For applications in GEO and GTO, only the Kalman filter solution can be used for onboard autonomous navigation (considering signal outages and the limited CPU power onboard the S/C).

The Kalman filter is capable of considering external accelerations from thrust maneuvers via Tele Command (TC). A considerable source of error is the uncertainty in modeling thrust vector magnitude and direction, especially in GTO using electrical propulsion.

This thesis is the extension of the Kalman filter (EKF) in order to estimate the acceleration due to thrust manoeuvers which is a major error contributor in GTO. The development was based on the current version of the LION Navigator Kalman filter.

The new Kalman filter is used to investigate the GNSS navigation performance for transfer orbits to GEO (focusing on electrical propulsion). The GNSS constellations used are GPS and Galileo. The GNSS navigation investigation is based on an in-house simulation tool (AOSEGnssSim) based on Matlab/Simulink.

The following activities include

>- Implementation of the new extended Kalman Filter

>- Test/verification of the new Kalman filter algorithms using in-house simulation tool

>- Investigation of GNSS navigation performance for selected GTO Scenarios