This work describes the attitude determination and the gyros drift estimation using the Regularized Particle Filter with Roughening for nonlinear systems. The Particle Filter is a statistical, brute-force approach to state estimation that often works well for problems that are difficult for the conventional Kalman Filter. In real time applications their estimation accuracy and efficiency are significantly affected by numbers of particles.

The Regularized Particle Filter was used for preventing the sample impoverishment, this problem occur when the region of state space in which the posteriori probability density function has significant values does not overlap with the a priori probability density function. This means that if all of our a priori particles are distributed according to a priori probability density function, and compute the posteriori probability density function to resample the particles, only a few particles will be resampled to become a posteriori particles.

The Particle Filter has some similarities with the Unscented Kalman Filter which transforms a set of points (cloud) through known nonlinear equations and combines the results to estimate the mean and covariance of the state. However, in the Particle Filter the points (particles cloud) are chosen randomly, whereas in the Unscented Kalman Filter the points are chosen on the basis of a specific criterion. In this way, the number of points used in a Particle Filter generally needs to be much greater than the number of points in an Unscented Kalman Filter.

Another difference between the two filters is that the estimation error in an Unscented Kalman Filter does not converge to zero in any sense, but the estimation error in a Particle Filter does converge to zero as the number of particle approaches infinity, obviously taking into account that the greatest number of particles will lead to a great computational effort.

The application of the Regularized Particle Filter in this work uses simulated measurements of a real satellite CBERS-2 (China Brazil Earth Resources Satellite 2) which has polar sun-
synchronous orbit with an altitude of 778km, crossing Equator at 10:30am in descending direction, frozen eccentricity and perigee at 90 degrees, and provides global coverage of the world every 26 days. These simulated measurements were provided by the package PROPAT, a Satellite Attitude and Orbit Toolbox for Matlab.

The attitude dynamical model is described by nonlinear equations involving the Euler angles. The attitude sensors available are two DSS (Digital Sun Sensors), two IRES (Infra-Red Earth Sensor), and one triad of mechanical gyros. The two IRES give direct measurements of roll and pitch angles with a certain level of error. The two DSS are mounted on the satellite body such that they are nonlinear functions of roll, pitch, and yaw attitude angles. The gyros are aligned in the 3 satellite axes and furnish the angular measurements in the body frame reference system.

Gyros are very important sensors, as they provide direct incremental angles or angular velocities. They can sense instantaneous variations of nominal velocities. Therefore, an important feature is that it allows the replacement of complex models (several different torques acting on the space environment) by using their measurements to turn the dynamical equations into simple kinematic equations. However gyros present several sources of error of which the drift is the most troublesome. Such drifts yield along time an accumulation of errors which must thus be accounted for in the attitude determination process.

The results in this work show that one can reach accuracies in attitude determination within the prescribed requirements, besides providing estimates of the gyro drifts which can be further used to enhance the gyro error model. Because over time the accumulation of errors hinder the accuracy in the estimation process, such deviations should be accounted for in attitude determination process in order to ensure better performance.