Proceedings of International Conference on Astronomy and Space Science
Celebrating 20th Anniversary of Korea Space Science Society, Jeju, 2004

STATION-KEEPING MANEUVER SIMULATION FOR THE COMMUNICATION, OCEAN AND METEOROLOGICAL SATELLITE

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(Received September 25, 2004; Accepted October 1, 2004)

ABSTRACT

Automated east/west and north/south station-keeping maneuvers were simulated for the geostationary COMS (Communication, Ocean and Meteorological Satellite) satellite that will be launched around year 2008. The satellite has to be maintained within $\pm 0.05°$ at the nominal longitude of 128.2° E. The general perturbation method was used to keep the position of the geostationary satellite. Weekly based east/west and biweekly based north/south station-keeping maneuvers were investigated. The sun-pointing perigee control method and two-burn strategy were used for the east/west station-keeping maneuver. Switching the right ascension of the ascending node to descending node was adopted for the north/south station-keeping maneuver. One year station-keeping maneuver was demonstrated and various station-keeping orbital parameters were analyzed.

Keywords: satellite station-keeping, orbit maneuver, COMS

1. INTRODUCTION

The COMS (Communication, Ocean and Meteorological Satellite)-1 is Korea's first geostationary satellite to establish an early prediction system against meteorological disasters, and to observe the status of the ocean. The COMS will be launched in 2008 and be positioned at $\pm 128.2°$ E. In this paper, the automation algorithm of analyzing and scheduling the station-keeping maneuver was developed for the satellite. The perturbation analysis for keeping the position of the geostationary satellite was also performed by using analytical methods (Choi et al. 1986, 1987, 2004).

Seven-day based East/West Station-Keeping (EWSK) and fourteen-day based North/South Station-Keeping (NSSK) maneuver were performed. To achieve more effective ESSK maneuvers, the sun-pointing perigee strategy and two part maneuver were used (Soop 1994). A numerical program for the simulations was developed from algebraic manipulation by computer. The simulation was performed for 1 year, and the results showed that station-keeping maneuvers were accomplished just as we planned. Hence, we proposed that this algorithm could be applied to the station-keeping maneuver of the COMS.

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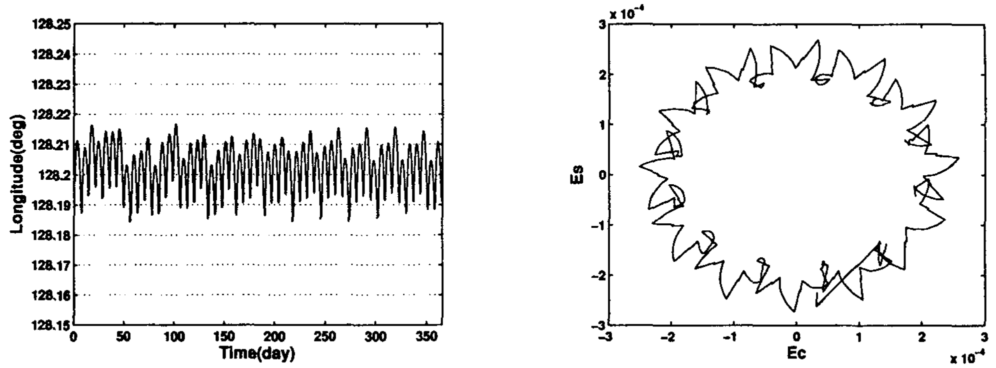


(a) Mean longitude (b) Eccentricity

Figure 1. East/West station-keeping maneuver simulation results (1 year).

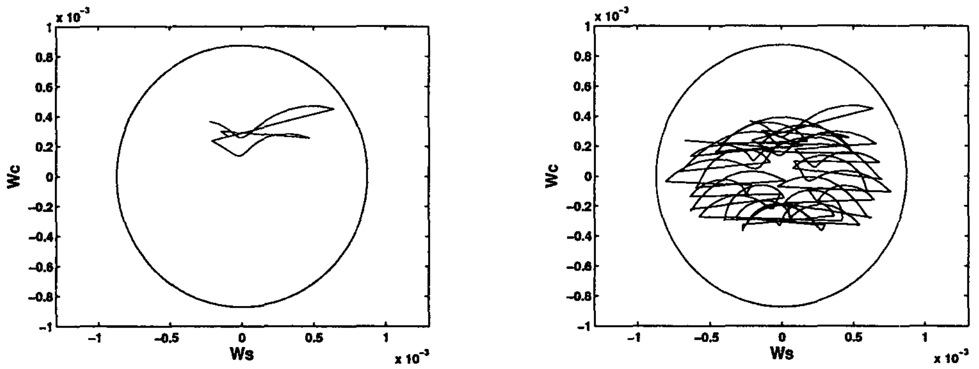
2. PROBLEM FORMULATION

The non-spherical gravitational forces of the Earth and solar radiation pressure give changes in the east/west position of the geostationary satellite. The perturbations caused by the Sun and the Moon yield predominantly out-of-plane effects forcing changes in the north/south position of the satellite (Pocha 1987). The EWSK maneuver must control both the mean longitude and the eccentricity simultaneously, whereas the NSSK maneuver must control the orbital inclination. To avoid singular problems at the geostationary orbit, the revised orbit elements were used.

The general perturbation technique is to find solutions by a series expansion of the Lagrange equation. We simulated the effects of perturbations by algebraic manipulations. This analytic method for the station-keeping of geostationary satellite yields faster computations and makes it possible to analyze each perturbation force separately (Lee 2000). These advantages correspond with demands of the COMS. Because the COMS will be controlled by an internal processor, quick analysis will be a necessity.

Each station-keeping period was determined by error analysis and periodic features of perturbations. The EWSK maneuver was performed on a 7-day cycle time, as the NSSK maneuver was performed on a 14-day cycle time. For the EWSK maneuver, the two-part maneuver was used. The longitude control can be made anywhere, while eccentricity control must be made at specific positions in the orbit (Pocha 1987). To reduce fuel consumption, ESSK maneuver must be implemented twice a day; consequently, a two-part maneuver. For NSSK maneuver, switching the right ascension of the ascending node to descending node was applied.

The station-keeping maneuvers were simulated for 1 year. EWSK is required a ΔV of 2.98 m/s and NSSK is required a ΔV of 58.9 m/s for 1 year. Figure 1 and 2 demonstrate that the simulations were performed properly. E_S and E_C are the sine and cosine component of the eccentricity respectively. W_C is the cosine component and W_S is the sine component of $\sin i$(i is the inclination). Each value of mean longitude, eccentricity and inclination is maintained in permitted limit properly. However, these values are a little larger than those from fuel-optimal station-keeping simulations. Therefore, a fuel-optimal technique would be needed for better performance analysis.



(a) 1 month (b) 1 year

Figure 2. North/South station-keeping maneuver simulation results.

3. CONCLUSIONS

A total of 1 year of station-keeping simulations for the COMS was performed using analytic methods. The perturbation analysis was performed by algebraic manipulations, and a 7-day EWSK cycle and 14-day NSSK cycle were applied to maintain COMS spacecraft within ±0.05° error of its desired position. The perturbation analysis by analytic methods has the advantage of performing demanded calculations quickly. It is a suitable algorithm for the COMS, moreover, it can be used vitally in an emergency situation. From the simulations, we confirm that the algorithms developed appropriately perform. However, for more effective station-keeping maneuvers, additional fuel-optimal methods would be required.

ACKNOWLEDGEMENTS: The present work was supported by ETRI grant No. 03MR3240-RR200400106.

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