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## THE THIRD INTERNATIONAL SUN-EARTH EXPLORER, THE FIRST HALO ORBITER

**Abstract**

The Third International Sun-Earth Explorer (ISEE-3) was launched on 12 August 1978 and performed a maneuver on 20 November 1978 that inserted the spacecraft into a periodic halo orbit about the Sun-Earth L1 Lagrange Point, the first artificial satellite to ever be put in a halo orbit (or in any orbit about a libration-point). For four years, ISEE-3 accomplished two important “firsts”, being the first to continuously monitor solar wind conditions 1.5 million kilometers upstream from the Earth, and was the first to provide real-time warning of geomagnetic storms. ISEE-3 was a particles and fields spacecraft; it had no cameras. Its primary purpose was to measure the solar wind input to the Earth’s geomagnetic field, which was measured closer to Earth by the ISEE-1 and ISEE-2 spacecraft, in similar elliptical orbits. The International Sun-Earth Explorer program was a joint effort by NASA and ESRO/ESA to study the interaction between the Earth’s magnetic field and the solar wind.

After Robert Farquhar failed to convince NASA to place a comm sat in a lunar halo orbit to allow communication with the Apollo astronauts while they were over the lunar far side, he turned his efforts towards promoting the use of halo orbits for geomagnetic studies. Some of the struggles that Farquhar overcame, both technical and political, will be recounted, to achieve this first halo-orbiting mission. Farquhar was later criticized for using a tight control strategy for maintaining ISEE-3’s halo orbit that was robust, but not fuel-optimal. Farquhar countered that such a mission had never been flown before, so a method to cancel the unstable component of the motion that had a high likelihood for success was selected.

From ISEE-3’s halo orbit vantagepoint, effectively the highest-possible apogee whose orbit remained bound to the Earth without escaping into heliocentric orbit (actually, by their definition, Sun-Earth libration-point spacecraft are in both geocentric and heliocentric orbits), Farquhar realized that, with only very small delta-V maneuvers, the spacecraft’s orbit could be drastically changed to go to entirely different destinations. ISEE-3’s extended missions to the Earth’s geomagnetic tail, and as the International Cometary Explorer (ICE) to become the first spacecraft to ever visit a comet (Giacobini-Zinner in 1985), will be recounted.

Much about this remarkable mission is described by Robert Farquhar himself [1].

[1] R. W. Farquhar, “The Flight of ISEE-3/ICE: Origins, Mission, History, and a Legacy”, *Journal of the Astronautical Sciences*, Vol. 49, pages 23-73, 2001.