Lunar CRater Observation and Sensing Satellite

Spacecraft Navigation

Spacecraft navigation consists of determining a spacecraft's orbit and controlling its flight path. The Earth's motions through space are well known. Therefore, the measurements engineers make of a spacecraft's motion, as seen from Earth, can be converted into the sun-centered orbital parameters needed to describe the spacecraft's trajectory[1].

The meaningful measurements engineers can make of the spacecraft's motion from Earth-based radiometric tracking data using NASA's Deep Space Network of radio antennas are:

- The distance from Earth
- The component of its velocity[2] that is directly toward or away from Earth
- The position in Earth's sky

In addition, navigation data can be obtained from images taken by cameras on a spacecraft:

- Optical navigation is a spacecraft-based data type in which a spacecraft uses its imaging instrument to view a target body against background stars

By repeatedly acquiring these three or four data types, a mathematical model may be constructed describing the history of a spacecraft's location in three-dimensional space. The process of spacecraft orbit determination solves for a description of the spacecraft's orbit based on these observations. From there, the spacecraft's orbital parameters may be compared to the desired path and corrected for any discrepancy.

During this process, navigation engineers change their modeled trajectory to best fit the observed tracking data. Engineers perform a mathematical analysis to correctly separate out the factors which could contribute to the difference between their computed trajectory and the observed data as to where the spacecraft really is. The goal is to be able to adjust the trajectory, if needed, with maneuvers, establish predictions of the spacecraft's future path; and perform accurate reconstruction of where it has been.

Overall, five tasks are necessary for successful navigation whether on Earth or in deep space: 1. Obtain a map; 2. Plot a course; 3. Take measurements; 4. Calculate position; and 5. Make course corrections.

Goldstone Apple Valley Radio Telescope (GAVRT) students around the world will be monitoring the LCROSS spacecraft with a 34 meter radio telescope during its cruise phase to the Moon. They will listen for a distress signal from the spacecraft and report such an anomaly to Northrop Grumman engineers to respond. Should they be tracking the spacecraft when it is transmitting to the Earth, students will be able to determine certain parameters of the spacecraft's velocity and position, but not to the accuracy needed for spacecraft navigation.

For more information about spacecraft navigation see
http://www2.jpl.nasa.gov/basics/bsf13-1.html and
http://www.ae.gatech.edu/people/rbraun/classes/astroI06/NavLecture.pdf

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1: Trajectory - the path followed by an object moving through space. 2: Velocity - the speed and direction of motion of a moving body.