LUNAR SCOUT TWO SPACECRAFT GRAVITY EXPERIMENT; Andrew F. Cheng, Johns Hopkins Applied Physics Laboratory, Laurel, MD, 20707.

Measurement of the gravity field of the Moon has a high science priority because of its implications for the internal structure and thermal history of the Moon, and it has a high priority for future exploration activities because of the influence of lunar gravity on spacecraft navigation and orbit maintenance. The current state of knowledge in the lunar gravity field (and the uncertainty in the knowledge) is based primarily on data accumulated from the Lunar Orbiter and Apollo programs. Data are sparse and emphasize the equatorial band (± 30°) on the near side of the Moon. There are no tracking data on the far side and only the Lunar Orbiter V provides a small amount of high inclination data. A host of gravity models developed from different combinations of tracking data have large discrepancies in their predictions of spacecraft motion and orbit lifetimes. There are also large disagreements in the Mercator projections of the gravity acceleration from each model, especially on the far side, where the contours tend to have no obvious relationship with the local topography. The science and engineering requirements for global gravity field mapping will be satisfied with continuous radiometric tracking of Lunar Scout I in a low polar orbit using the Deep Space Network and Lunar Scout II in a high elliptical orbit.

In order to meet the science gravity field requirements, it has been estimated that the radiometric velocity measurements should be less than 0.5 mm/s and possibly as low as 0.1 mm/s to average 10 seconds of gravity acceleration. This can be met using coherent two-way doppler with a DSN measurement accuracy of 0.3-1.0 mm/s with S-band. This accuracy will satisfy exploration requirements for spacecraft navigation, expressed as spacecraft position error propagation with time.

The gravity field of the Moon will be mapped during the Scout Program using a two spacecraft concept. In the two spacecraft concept, one spacecraft is placed in a high altitude eccentric orbit while the second spacecraft is in a low altitude polar orbit. The gravity experiment requires a radio frequency that will permit two-way Doppler tracking between the spacecrafts and the DSN. Both spacecraft carry NASA standard transponder systems for data transmission to Earth as well as for tracking and orbit determination. Data sufficient to produce a gravity field map could be acquired within one month with this system.

The nominal Scout Program mission plan calls for Lunar Scout I to remain in the 100km polar mapping orbit at the end of its mapping phase while Lunar Scout II will be inserted into an elliptical orbit for far-side tracking of Scout I. (DSN tracking of Lunar Scout I during its low altitude orbit will provide an initial gravity map of the Moon. Substantial improvements in the lunar gravity model can be obtained by this method.) Full scale global mapping with the high precision achievable with the two spacecraft concept will be completed during the flight of Lunar Scout II.

A possible alternative is the utilization of a spacecraft subsatellite released by a parent orbiting spacecraft and subsequently tracked. The changes in the relative distances between the two spacecraft as the Moon is orbited provide a precise measurement of the lunar gravity field.