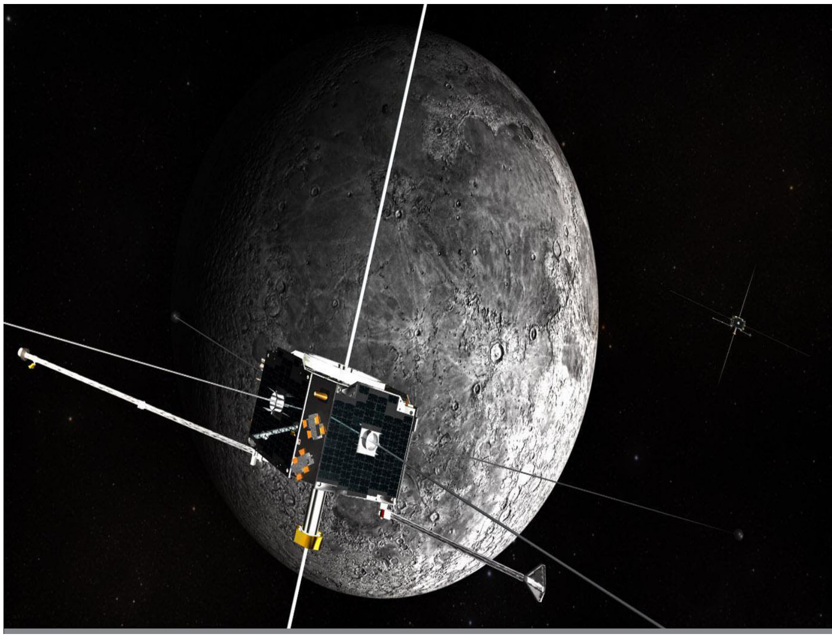

National Aeronautics and
Space Administration

TECHNOLOGY SOLUTION

Aerospace

Method for Transferring a Spacecraft from Geosynchronous Transfer Orbit to Lunar Orbit

Spacecraft rideshare via a GEO launch

This novel innovation from Ames Research Center allows spacecraft to share rides with larger spacecraft which are headed to Geosynchronous Earth Orbit (GEO). The secondary spacecraft is dropped off Geosynchronous Transfer Orbit (GTO) at any time during the day or year and will subsequently enter lunar orbit, with no constraint on the lunar orbit inclination. The secondary spacecraft can be relatively small, riding as a secondary payload with a larger primary spacecraft. The secondary spacecraft is intended to be controllable (i.e., maneuverable).

BENEFITS

- A relatively small and maneuverable spacecraft can ride as a secondary payload with a larger primary spacecraft decreasing launch cost
- Enter lunar orbit with possibility of achieving any inclination and perilune altitude from an initial GTO
- There are no restrictions on launch time or date
- Increased launch flexibility
- Shorter mission duration
- Consistency of design

APPLICATIONS

The technology has several potential applications:

- Moon Exploration
- Establishing lunar orbit
- Moon observation
- Mining of Helium-3 nuclear fuel
- Launch-base for space missions
- Mining of rare earth elements
- Geology
- Mapping
- Astronomy
- Space communication

THE TECHNOLOGY

The invention presents a trajectory design whereby a spacecraft can be launched as a secondary payload into a Geosynchronous Transfer Orbit (GTO) and through a series of maneuvers to reach lunar orbit. The trajectory analysis begins by identifying acceptable ranges of lunar orbit altitude and inclination values. The unique features of this method includes the use of either a leading or trailing edge lunar flyby to achieve an orbit inclination in the lunar orbit plane from a GTO launched at any time of day. This technique is applicable to secondary spacecraft that share a ride to space resulting in a substantially reduced cost, and with no control of the launch conditions. Major advantages of this design include the relatively short (maximum) lunar transfer duration (<3 months, less than half of that required for a Sun-Earth weak-stability boundary transfer), simplicity and consistency of design (again compared to a Sun-Earth weak stability boundary transfer).

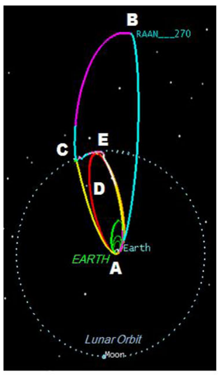

Figure 1

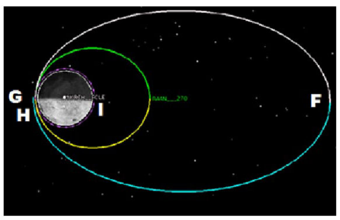

Figure 2

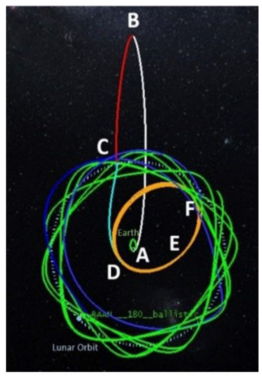

Figure 3

Figures 1 and 2: Transfer Trajectory from GTO to lunar orbit, with initial GTO RAAN of 270 degrees, viewed in the Earth-centered, Earth inertial frame (Figure 1) and the Moon-centered, Moon inertial frame (Figure 2).
Figure 3: Transfer Trajectory from GTO to lunar orbit via ballistic lunar capture, with initial GTO RAAN of 180 degrees, viewed in the Earth-centered, Earth inertial frame.

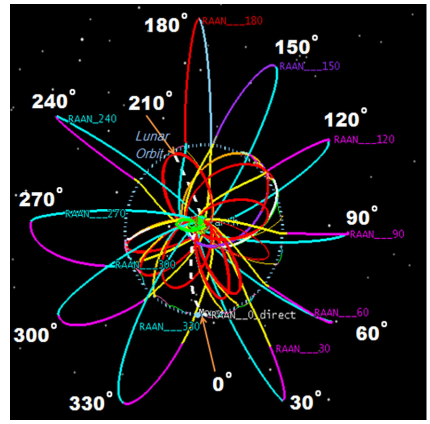

Figure 4: Transfer Trajectory solutions for a 360 degree range in RAAN (in 30 degree increments) of the starting GTO through lunar orbit, shown in the Earth-centered, Earth inertial frame.

PUBLICATIONS

Patent No: 10,696,423

- Genova, A. L. et. al, Trajectory Design from GTO to Lunar Equatorial Orbit for the Dark Ages Radio Explorer Spacecraft, Proceedings of the 25th AAS/AIAA Space Flight Mech. Mtg., Williamsburg, VA, Jan. 11-15, 2015.

- Genova, A. L., & Kaplinger, B., From GTO to Ballistic Lunar Capture using an Interior Lagrange Point Transfer, Proceedings of the 27th AAS/AIAA Astrodynamics Specialist Conf., Stevenson, WA 98648, Aug. 20-24, 2017.

More Information

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