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22nd IAA SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Systems and Infrastructures to Implement Sustainable Space Development and Settlement - Technologies (2B)

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# ENVY - EXPLORATION NAVIGATION SYSTEM: USING SMALL SATELLITES TO ENABLE NEXT GENERATION LUNAR NAVIGATION FOR FUTURE MISSIONS

**Abstract**

As the space industry grows rapidly, humanity seeks to go back to the moon to establish a permanent foothold and use the moon as a stepping stone on our way to Mars. The international effort of the Artemis mission by NASA and its partners is only the beginning of a new space era. Recent attempts of landing spacecraft on the surface of the moon highlight the difficulties connected with these maneuvers. With permanent moon-bases and increased activity planned, a dedicated lunar navigation satellite system (LNSS) will play a key role in future infrastructure to support life on the moon. On Earth, GNSS utilizes both satellites and ground stations to obtain high accuracy positional data, however building similar ground stations on the moon might not be feasible. Therefore, a design study and feasibility analysis for a new satellite-to-satellite system has been conducted. The proposed system consists of 105 6U CubeSats, 60 of which are equipped with chemical propulsion booster stages to cover the higher dV planes, spread across seven equidistant orbital planes. It offers uninterrupted connection and ensures high positional accuracy using an optical laser system (DORT). Using satellite-based laser interferometry, each individual satellite can accurately determine its own position. The small size of each individual CubeSat and the use of COTS components reduces the overall cost of the mission compared to large satellites in legacy constellations. This higher number of satellites allows for redundancy, in case of failure of any singular unit over the targeted 5 years lifespan. The CubeSats are equipped with a FEEP electric propulsion unit, to allow for orbit insertion and trajectory correction after deployment. The LNSS signal is generated using a helical

quadrifilar antenna, on the L1 frequency band. The study also includes the finished design of a transfer vehicle carrying all 105 satellites. This vehicle is designed to be launched as payload aboard a Falcon 9 class rocket, carrying all CubeSats into lunar orbit with a single launch. After CubeSat deployment, the transfer vehicle is used as a relay for TTC between earth and the constellation. The result of the conducted study is a preliminary mission design, including orbital mechanics calculations, transfer vehicle and CubeSat mechanical designs including all subsystems, power and mass budget calculations and a thermal analysis of the different mission scenarios. It was found that the constellation would be feasible and highly beneficial to enable more precise lunar navigation in the future.