Use of the Earth-Moon Lagrange Points for Improving Lunar Navigation Performance

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With the increased international interest in missions to the Moon over the next two decades, several key technologies are required to ensure the success of these missions. One of these critical capabilities is the development of reliable and accurate positioning and navigation services, which will be fundamental for mission success. With international collaboration underway between major space agencies to develop reliable, interoperable navigation systems beyond Earth orbit, there currently exists a rare opportunity to define the system architectures, which will lay the foundations for the networks of the future. The research in this paper discusses the navigation performance improvements achieved via the use of additional GNSS satellites at the Earth-Moon Lagrange points. This includes the benefits and limiting factors of the technique, with analysis of several key case studies representative of expected upcoming mission profiles. Via the use of these satellites at the Lagrange points, combined with the terrestrial GNSS networks, the geometric distribution of weak navigation signals can be significantly improved at and near the Moon. In particular, with augmentation satellites situated near the L_2, L_4, and L_5 points, the geometric dilution of precision experienced by a Lunar receiver can be improved by approximately two orders of magnitude when compared with the use of terrestrial GNSS sources alone.