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A TECHNICAL EVALUATION OF INTEGRATING OPTICAL INTER-SATELLITE LINKS INTO PROLIFERATED POLAR LEO CONSTELLATIONS

Abstract

This study evaluates the technical requirements, benefits, and limitations of integrating optical inter-satellite links into a proliferated polar LEO constellation. When compared to traditional radio frequency (RF) links, optical links can transmit orders of magnitude more data at much lower powers in a far more secure method. However, these benefits come with stiff coarse and fine pointing requirements, complex thermal and vibrational satellite bus interfaces, as well as sensitivities to atmospheric conditions for LEO-ground connections. This study breaks optical inter-satellite links (OISL's) into three distinct categories; in-plane, out-of-plane (crosslink), and LEO-ground. General commercial off the shelf (COTS) state of the art OISL terminal parameters are established. Based on these parameters, varying constellation level implementation strategies are assessed based on latency, bandwidth increase and technical feasibility using Model Based Systems Engineering principles. These assessments were then re-run at different OISL bandwidths, latencies and costs to evaluate whether the optimal integration technique will change in the future as OISL terminal capability increases. The study finds that the methodology outlined gives crucial insight into future OISL integration and implementation strategies for both current and future mega-constellation architects. Using both current OISL performance parameters as well as future improvements, this study finds that an RF-reliant in-plane architecture is the optimal integration architecture given the constellation configuration constraints. This assessment can help drive the trade space for both OISL vendors producing COTS terminals as well as commercial and military customers looking to integrate OISL terminals into their future constellations.