

IMPROVING DATA TRANSFER QUALITY IN LASER SATELLITE COMMUNICATION THROUGH THERMO-MECHANICAL TOPOLOGY OPTIMIZATION

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Abstract

Thermo-mechanical deformations of optical components can significantly degrade data transfer quality in laser satellite communication systems by inducing optical aberrations. This work presents a topology optimization framework that directly targets communication reliability by decomposing thermo-mechanical mirror deformations into Zernike polynomials. These are mapped to reliability data on the intersatellite link, which was obtained through numerical optical simulations. By means of fitting a smooth reliability response of wavefront errors for Zernike modes, and through combining the obtained reliabilities of individual Zernike modes in different ways, we formulate three reliability constraints of different stringency. We then study the behaviour of each reliability constraint separately by incorporating it into an optimization problem with an eigenfrequency constraint, a tilt constraint and a mass minimization objective. The results demonstrate that directly constraining communication reliability enables lightweight mirror support designs that maintain high data transfer performance under thermo-mechanical loading.