AN APPROACH TO SPATIAL AND TEMPORAL FREQUENCIES FOR AERO-OPTICS CORRECTION

Abstract

by

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Aero-optics refers to the aberrations imposed on an otherwise-planar wavefront of a laser propagated through near-field turbulence in flows over and around a turret on an airborne laser platform. The magnitude of these aberrations can be quite large depending on the flight altitude and Mach number as well as the pointing direction which is commonly described with the azimuthal and elevation angles of the outgoing beam. The magnitude of these aberrations can be sufficiently large to greatly reduce the system’s useful field of regard. Adaptive-optics, which attempts to place a conjugate wavefront on the beam before it propagates through the turbulence, could theoretically reopen the field of regard; however, both the spatial and temporal frequencies contained in the aberrations make conventional adaptive-optic approaches minimally effective and often cause worse aberrations than are present with no “correction.”

Until recently, the only available experimental wavefront measurements of aero-optical disturbances around airborne turrets have come from wind-tunnel experiments and numerical simulations. In addition, no flight-tests were available to verify if the aero-
optical disturbances are also present to the same degree in flight conditions. To address this need, an Airborne Aero-Optical Laboratory was designed, and a series of experiments were carried.

The research described in this dissertation explores new analysis techniques for analyzing and manipulating in-flight measured wavefronts that begin with determining the convective speed and direction of the aberration as functions of aperture location, azimuth and elevation, and flight conditions. The two-dimensional Proper Orthogonal Decomposition is applied to the in-flight measured datasets to characterize the nature of the aberration field around the airborne turret due to flow structures convecting over the aperture. The analysis techniques presented in this research for determining the basic character of the aberrations were also shown to be helpful in determining the spatial and temporal requirements of deformable mirrors in an adaptive-optics correction system for a given turret’s coordinates. In the presence or absence of flow control, this sort of information should be helpful in developing a set of simplified benchmarks and guidelines for determining the minimum requirements an adaptive-optics system needs to meet to effectively mitigate the deleterious aero-optic effects on the beam.