GMT NGAO Integrated Modeling

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Abstract

The Giant Magellan Telescope Project relies on a comprehensive integrated modeling tool to evaluate Observatory Performance Modes, ranging from Seeing Limited to Adaptive Optics. This STOP (Structural-Thermal-Optical Performance) model includes the dynamics of each domain-specific model, accounting for time-varying disturbances such as wind jitter, vibrations, and temperature fluctuations. However, creating such a model presents challenges due to the wide range of scientific and engineering expertise required, as well as the large number of degrees of freedom to handle. Adaptive Optics presents additional challenges due to its high sampling rate of 1kHz or more, exacerbated by the need to simulate long science exposures under various operating conditions.

This paper will introduce the main components of the integrated model, including finite element, optical, control, and computational fluid dynamics, as well as the stringent verification and experimental validation processes that the model undergoes. The choice of computing framework that integrates domain-specific models into a unified model is critical and will be described in detail. The development of the integrated model is driven by the need to accurately estimate errors that affect the science instrument data products and mitigate technological risks associated with the telescope. Examples will be given on how the error budgets and risk register are used to set priorities for the integrated modeling simulations queue.

The GMTO project has identified a set of Key Performance Parameters (KPP) that summarize the expected performance for each Observatory Performance Mode. These KPPs are statistical quantities derived from Monte-Carlo simulations of the Observatory under various operating and environmental conditions. This paper will show how Monte-Carlo simulations have been performed at the Observatory level for the Natural Guide Star Adaptive Optics Observatory Performance Mode.

Keywords: integrated modeling, STOP analysis, Monte, Carlo simulations

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