Vibration Measurement in Astronomical Observatories

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Vibrations are one of the main limiting factors in the image resolution of high performance ground based telescopes with adaptive optics. Because vibrations have large implications for image quality and cannot always be eliminated, TMT is the one of the first telescopes to have a “vibration budget” integrated into the design phase of development. The vibration budget is a design tool that informs engineers about vibration specifications of different components required to meet the optical performance goals of the telescope. Physical vibration testing and analysis must be performed to validate many of the assumptions and models used in the creation of the budget. This project is focused around creating and refining software tools in order to streamline the data acquisition and analysis process for vibration tests. MATLAB was used to create programs that plot, analyze, and save data sent from National Instruments Data Acquisition hardware. These programs were validated by comparing their acceleration-over-force frequency response estimation of an object to the inverse mass of that object. Once validated, these programs were then used to collect and analyze vibration data from the Multi-Segment Integration and Testing structure (MSIT) using accelerometers and an impact hammer. Vibrational characteristics such as damping ratios and transfer functions were cataloged and compared to previously estimated values from Finite Element Models (FEM). This work confirmed the accuracy of existing models and will expedite future vibrational testing. The tools developed for this project provides valid insights only for relatively low frequencies where only rigid body modes are excited. As such, an extension to this project would be to develop methods for accurately characterizing the force generated by vibrations of an object outside of its rigid body modes.