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Vibration effects on remote sensing satellite images

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Abstract. Vibration is a source of performance degradation in all optical imaging systems. Performance of high resolution remote sensing payloads is often limited due to satellite platform vibrations. Effects of Linear and high frequency sinusoidal vibrations on the system MTF are known exactly in closed form but the low frequency vibration effects is a random process and must be considered statistically. Usually the vibration MTF budget is defined based on the mission requirements and the overall MTF limitations. For analyzing low frequency effects, designer must know all the systems specifications and parameters. With a good understanding of harmful vibration frequencies and amplitudes in the system preliminary design phase, their effects could be removed totally or partially. This procedure is cost effective and let the designer to eliminate just harmful vibrations and avoids over-designing. In this paper we have analyzed the effects of low-frequency platform vibrations on the payload's modulation transfer function. We have used a statistical analysis to find the probability of imaging with a MTF equal or greater than a pre-defined budget for different missions. The worst and average cases have been discussed and finally we have proposed "look-up figures". Using these look-up figures, designer can choose the electro-optical parameters in such a way that vibration effects be less than its pre-defined budget. Furthermore, using the results, we can propose a damping profile based on which vibration frequencies and amplitudes must be eliminated to stabilize the payload system.

Keywords: remote sensing; modulation transfer function (MTF); image quality; vibration analysis; low frequency vibration; statistical analysis; look-up figures

1. Introduction

Vibration of platform is often affects high resolution imaging satellite cameras by blurring in the focus. This kind of blurring should be distinguished from blurring due to system misalignment or an out-of-focus condition (Ahmad 1999). More sever vibration carry the potential for structural failure of the system. In general, operation is not expected at such levels, only survival. There are two important types of vibration that affect the image quality along with the optomechanical systems: Periodic and jitter. Periodic vibration includes low-frequency vibration (1-40 Hz) and high-frequency vibration (2-20 kHz), with different amplitudes caused by the motors used in different satellite subsystems. Table 1 illustrates typical vibration specifications for both high and low frequencies (Xu 2009 and Xu 2003). It is quiet useful to analyze the relationship between the

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