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INTEGRATED ANALYSIS OF SPACE ENVIRONMENT EFFECTS ON SPACE-BASED VISIBLE CAMERA

Abstract

Space-based visible (SBV) camera can acquire detailed information of space targets, so that an increasing number of SBV cameras are being developed and applied in recent years. SBV camera is subject to motion, vibration, weightlessness, temperature change and other factors in the launching process and space environment, which will seriously affect the image quality. In order to improve the imaging quality, the whole SBV camera as well as its subassemblies have to be not only strictly examined through relevant environment experiments and tests, but also should be analyzed by mathematical model and digital simulation. The constituents of orbital environment vary with position, local time, season and solar activity. It is very difficult to analyze every isolated factor in space environment. This paper presents an integrated method based on modulation transfer function (MTF) to analyze space environment effects on SBV camera. The method takes image quality as the final criterion and MTF as the evaluation index, and synthesizes the effects of dynamic, thermal, and stray light. Furthermore, it establishes quantization relations of SBV physical parameters to the space environment factors. Firstly, an overview of the space environment and its effects on SBV camera design, development, and operation is introduced, and some of the new developments in science and technology for space environment effects on SBV camera are highlighted. Secondly, the imaging mechanism is analyzed and the integrated MTF model of SBV camera is established. According to the components of SBV camera, Mathematical MTF model of camera is calculated. Then, the MTF models of image motion, defocus, and stray light of visible camera based on their inducing mechanisms are established. Under linear theory and cascading rule, the integrated MTF model is set up by multiplying these MTF models together. Thirdly, the degradation of the image quality caused by the space environments is computed concretely according to the data from one typical SBV camera. The MTF value of image motion, defocus, stray light and integrated effects are calculated respectively. Then the curves of space environment effects with SBV technology parameters are plotted. The simulation results and analysis method can provide reference for establishing the test condition, better understand the space environment and its effects on SBV camera, enable program management to more effectively minimize program risks and costs, optimize design quality, successfully achieve mission objectives, and ensure that the SBV camera works reliably in its entire period.