



# The Platform Design of Space-based Optical Observations of Space Debris

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**Abstract** The basic method to design a platform for the space-based optical observations of space debris is introduced. The observation schemes of GEO (geosynchronous equatorial orbit) and LEO (low Earth orbit) debris are given respectively, including the orbital parameters of platforms and the pointing of telescopes, etc. The debris studied here are all taken from the foreign catalog. According to the real orbits of space debris, the observational results of different schemes are simulated. By studying the single platform, the optimal observing altitude for the GEO debris and the optimal telescope's deflection angles at different altitudes for the LEO debris are given. According to these, the multi-platform observation networks are designed. By analyzing the advantages and disadvantages of different schemes, it can provide a reference for the application of space-based optical observations of space debris.

**Key words** telescopes—astrometry—celestial mechanics—methods: observational—data analysis

## 1. INTRODUCTION

The flight safety of orbiting spacecrafts is seriously menaced, and the problem of space environment becomes more and more critical, because of the increasingly frequent space activity and sudden space accident, the number of space debris increases rapidly. According to the catalog published abroad, at present the number of the on-orbit observable space debris with a size over 10 cm exceeds 15000, while the number of invisible space debris

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with a size in the order of 1 cm attains several hundred thousands as estimated by models. It is necessary to observe and to catalogue continuously these space debris so as to take precautions against the potential menace of space debris to orbiting spacecrafts.

There are two means for the space debris observation: spaces-based and ground-based, equipped mainly with the radar and optical telescope as observational devices. For the space-based observation, the observational device is set on a satellite platform, and the space debris are directly observed in space. The limited power of the space-based radar restricts the effective distance of space-based observation, hence at present the space-based optical observations are developed as the principal means for the space debris cataloguing observations. The space-based observation has become the main trend of space debris observations, because it is not restricted by the weather, background sky light, region, etc., and without the influence of day and night, the all-weather observation can be made.

This paper studies the design method of space-based optical observation platforms, and makes numerical simulations respectively for the observations of the GEO and LEO debris, to get the optimal design schemes which are suitable to both cases, including the orbital design of platform, the pointing of telescope, and the network-forming strategy of platforms, etc.

## 2. SPACE-BASED OPTICAL OBSERVATION OF SPACE DEBRIS

The first space-based optical observation project was the space-based visible light sensor (SBV) aboard the Middle Section Space Experimental Satellite launched by the United States in 1996, which played an important role in the observation of GEO space debris. In Europe, the ESA (European Space Agency) developed also the study of space-based observation of space debris in 2003, and devoted itself to track the non-catalogued debris with a size in the order of millimeters. In addition, Canada launched the Sapphire heliosynchronous satellite in 2013 with an orbital altitude of 786 km, and it could observe the debris with a middle-and-high altitude in the range from 6 000 to 40 000 km <sup>[1–4]</sup>. By the space-based observation of space debris, a wealth of debris which can not be detected by the ground-based observation can be discovered, and the information of catalogued debris can be supplemented and perfected.

The observational schemes studied in this paper are aimed at the catalogue maintenance of orbiting space debris. The observational schemes must meet the needs of data collection for cataloguing and orbit determination, so in the choice of an optimal space-based observational platform, the following factors must be considered: (1) the debris observable are as many as possible; (2) the orbital data obtained from observations are complete enough; (3) the observational continuity is strong; (4) the cost is low. Because the cost to build a space-based platform is more expensive in comparison with the ground-based one, the number of platforms and the viewing field of telescopes must be controlled as far as possible, so that the optimal results may be obtained with the lowest cost.

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