

An Overview of Ground-based Radar and Optical Measurements Utilized by the NASA Orbital Debris Program Office

Alyssa Manis⁽¹⁾, Jessica A. Arnold⁽²⁾, James Murray⁽²⁾, Brent Buckalew⁽²⁾, Corbin Cruz⁽²⁾, and Mark Matney⁽¹⁾

⁽¹⁾ NASA Orbital Debris Program Office, NASA Johnson Space Center, Mail Code XI5-9E,
2101 NASA Parkway, Houston, TX 77058, USA

⁽²⁾ Jacobs, NASA Orbital Debris Program Office, Johnson Space Center, Mail Code XI5-9E,
2101 NASA Parkway, Houston, TX 77058, USA

ABSTRACT

For over 30 years, the NASA Orbital Debris Program Office (ODPO) has led the characterization of orbital debris (OD) too small to be tracked by the U.S. Space Surveillance Network (SSN), yet which may pose the greatest threat to human spaceflight and robotic missions. Measurements from specialized sensors, including ground-based radars and telescopes capable of detecting smaller objects, provide the foundation for developing statistical models to describe the current state and future evolution of the OD environment from low Earth orbit (LEO) to geosynchronous Earth orbit (GEO). Since 1990, the ODPO has partnered with the U.S. Department of Defense and the Massachusetts Institute of Technology Lincoln Laboratory (MIT/LL) to collect data using the Haystack Ultrawideband Satellite Imaging Radar (HUSIR) – formerly Haystack – to characterize OD in LEO with a sensitivity of approximately 5 mm at 1000 km altitude. In addition, since 1993, the Goldstone Orbital Debris Radar, operated by NASA’s Jet Propulsion Laboratory, has provided data on OD as small as approximately 2-3 mm for altitudes below 1000 km, some of the most sensitive ground-based measurements achievable at these altitudes. Recently, collaborations with the 18th Space Control Squadron of the U.S. Space Force have also provided the ODPO with special datasets from the Space Fence to extend coverage below the historical SSN limit of 10 cm and to characterize individual breakup events in LEO. For GEO altitudes, the Eugene Stansbery Meter Class Autonomous Telescope (ES-MCAT), a joint NASA-Air Force Research Laboratory project that reached full operational capability in 2021, collects data on debris smaller than 1 m and provides coverage of debris in historically under-sampled high-altitude orbital regimes. This paper summarizes the radar and optical sensors utilized by the ODPO, their unique capabilities, and recent datasets and applications for statistical sampling of the dynamic OD environment.