Comparisons of a Constrained Least Squares Model versus Human-in-the-loop for Spectral Unmixing to Determine Material Type of GEO Debris

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Spectral reflectance data through the visible regime was collected at Las Campanas Observatory in Chile using an imaging spectrograph on one of the twin 6.5-m Magellan telescopes. The data were obtained on 1-2 May 2012 on the 'Landon Clay' telescope with the LDSS3 (Low Dispersion Survey Spectrograph 3). Five pieces of Geosynchronous Orbit (GEO) or near-GEO debris were identified and observed with an exposure time of 30 seconds on average. In addition, laboratory spectral reflectance data was collected using an Analytical Spectral Device (ASD) field spectrometer at California Polytechnic State University in San Luis Obispo on several typical common spacecraft materials including solar cells, circuit boards, various Kapton materials used for multi-layer insulation, and various paints.

The remotely collected data and the laboratory-acquired data were then incorporated in a newly developed model that uses a constrained least squares method to unmix the spectrum in specific material components. The results of this model are compared to the previous method of a human-in-the-loop (considered here the traditional method) that identifies possible material components by varying the materials and percentages until a spectral match is obtained. The traditional model was found to match the remotely collected spectral data after it had been divided by the continuum to remove the space weathering effects, or a “reddening” of the materials. The constrained least-squares model also used the de-reddened spectra as inputs and the results were consistent with those obtained through the traditional method. For comparison, a first-order examination of including reddening effects into the constrained least-squares model will be explored and comparisons to the remotely collected data will be examined. The identification of each object’s suspected material component will be discussed herein.