SSUSI and SSUSI-Lite: Providing Space Situational Awareness and Support for Over 25 Years

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ABSTRACT

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INTRODUCTION

The Special Sensor Ultraviolet Spectrographic Imager (SSUSI) family of sensors contributes to deepening our understanding of the space environment and its impact on satellite and other systems as well as our ability to predict anomalous behavior in these systems. With an increasing number of near-peers and peers in space, and the ready access to space provided by a burgeoning commercial space industry, the need to maintain our unique capabilities is even more urgent than it has been in the past.

One of the most difficult problems we face today is characterizing the space environment. APL has a significant presence in space programs and, in particular, a defining presence in geospace programs for research and applications. (Geospace is the space environment that is of direct concern to humans. It is the region of space near Earth and extends from the mesosphere to the outer boundary of the magnetosphere.)

One of APL's contributions is the SSUSI family of sensors, which provide space weather information to deepen our understanding of the near-Earth space environment as well as to support the basic research community (Fig. 1 shows SSUSI and its variants). The SSUSI and Global Ultraviolet Imager (GUVI) websites at https://ssusi.jhuapl.edu/ and http://guvitimed.jhuapl.edu/, respectively, offer a wealth of such information.

APL has a long tradition of providing valuable, innovative solutions to challenging problems. GUVI, developed by APL and flown on the Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) mission, has been in operation since 2001. Four Defense Meteorological Satellite Program (DMSP) satellites currently carry the SSUSI instruments (DMSP F16, F17, F18, and F19) in Earth orbit. They were launched in October 2003, November 2006, October 2009, and April 2014, respectively. APL continues in this tradition with SSUSI-Lite, which builds on the foundation of its predecessors to offer improved capabilities and more flexibility.

All instruments in the SSUSI family are hyperspectral imagers. Scanning hyperspectral imagers produce a two-dimensional spatial image with a third, spectral, dimension. SSUSI produces this image cube by using the cross-track motion of a mirror that this wavelength range, as discussed below, makes these sensors both unique and powerful.

Hyperspectral data can provide the information needed to produce an environmental observation. For SSUSI and GUVI, we have carefully chosen particular groupings of wavelengths in the hyperspectral imager, which we call colors, to produce environmental data records (EDRs) to support our users. EDRs are required to answer many pressing operational and scientific questions. Table 1 summarizes the various records or products these instruments provide.[1]

THE GEOSPACE ENVIRONMENT AND SPACE WEATHER

The SSUSI and GUVI projects have contributed to advancing our understanding of the space environment—in particular from about 100 to 600 km altitude.[2] See Table 1 for a summary of SSUSI and GUVI products. Despite nearly 60 years of operations in space and many more decades of observations from the ground using sounding rockets and optical and radar instruments, only the average characteristics of the space environment are well known, and the SSUSI and GUVI instruments address major gaps in our knowledge. Variability in the space environment have proven to be difficult to characterize and even more difficult to predict.

Anomaly resolution, the process of discerning the cause of a

FUV REMOTE SENSING

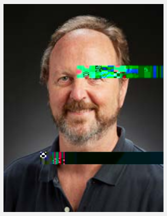
FUV remote sensing (from about 110 nm or 0.11 μm from simple zero-dimensional or point measurements by photometers to imaging cameras to spectrographs.[2] APL flew the first hyperspectral imagers in space on the Midcourse Space Experiment (MSX).[7] The APL FUV instruments are very sophisticated spectrographic imagers and are part of that MSX lineage—that is, they are

determination on the detector as defining a pixel. In imaging mode, the scan mirror sweeps the spatial pixel footprint from horizon-to-horizon perpendicular to the spacecraft motion, producing complete swath every scan period (22 s for SSUSI and 15 s for GUVI).

Because we use a 2-D detector, we accumulate an image with a spatial domain and a spectral domain at each step of the scan mirror. The resultant products can be visualized[14] in a single wavelength as a geographically referenced map using bespoke software or the KML files that Google Earth uses to enable users to customize their view of the horizon-to-horizon images (e.g., Fig. 7). We downlink only five user-selectable spectral segments, which we call colors, to minimize the telemetry impact and maximize the mission return. The SSUSI family of instruments also preserve the option of telemetering the entire spectrum to the ground. In this mode, called

[14]Paxton, L. J., Spisz, T., Crowley, G., Gary, R., Hopkins, M. M., et al., "Interactive Interpretation and Display of Far Ultraviolet Data," *A* . . **22**(11), 1577–1582 (1998).
[15]Zhang, Y., and Paxton, L. J. (eds.), *A D*, , John Wiley & Sons, Hoboken, NJ (2016).
[16]Paxton, L. J., and Zhang, Y., "Far Ultraviolet Imaging of the Aurora," Chap. 13, in *F*

on Space System Operations and Utilization. He is currently president of the American Geophysical Union's Space Physics and Aeronomy Section. His interests include developing innovative ideas and applying them to scientific and technical problems (he has been recognized several times for these efforts); basic scientific research in space physics and aeronomy; and the implications of climate change for national security. His e-mail address is larry.paxton@jhuapl.edu.



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