

ther gives the operator a better view of the entry to the bus from the smaller vehicle. Control is passed over to the smaller vehicle and, using video feedback from the camera, it is driven up the ramp, turned oblique into the bus, and then sent down the aisle for surveillance.

The demonstrated vehicle was used to scale the steps leading to the interior of a bus whose landing is 44 in. ( $\approx 1.1$  m) from the road surface. This vehicle can position the end of its ramp to a surface over 50 in. ( $\approx 1.3$  m) above ground level and can drive over rail heights exceed-

ing 6 in. ( $\approx 15$  cm). Thus configured, this vehicle can conceivably deliver the smaller robot to the end platform of New York City subway cars from between the rails. This innovation is scalable to other formulations for size, mobility, and surveillance functions. Conceivably the larger vehicle can be configured to traverse unstable rubble and debris to transport a smaller search and rescue vehicle as close as possible to the scene of a disaster such as a collapsed building. The smaller vehicle, tethered or otherwise, and capable of penetrating and tra-

versing within the confined spaces in the collapsed structure, can transport imaging and other sensors to look for victims or other targets.

*This work was done by Michael J. Krasowski, Norman F. Prokop, and Lawrence C. Greer of Glenn Research Center. Further information is contained in a TSP (see page 1).*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18673-1.*

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## Automated Verification of Spatial Resolution in Remotely Sensed Imagery

**Automated tool assesses image spatial resolution without the need for dedicated edge targets.**

*Stennis Space Center, Mississippi*

Image spatial resolution characteristics can vary widely among sources. In the case of aerial-based imaging systems, the image spatial resolution characteristics can even vary between acquisitions. In these systems, aircraft altitude, speed, and sensor look angle all affect image spatial resolution. Image spatial resolution needs to be verified with estimators that include the ground sample distance (GSD), the modulation transfer function (MTF), and the relative edge response (RER), all of which are key components of image quality, along with signal-to-noise ratio (SNR) and dynamic range. Knowledge of spatial resolution parameters is important to determine if features of interest are distinguishable in imagery or associated products, and to develop image restoration algorithms.

An automated Spatial Resolution Verification Tool (SRVT) was developed to rapidly determine the spatial resolution characteristics of remotely sensed aerial and satellite imagery. Most current methods for assessing spatial resolution characteristics of imagery rely on pre-

de-  
employed engineered targets and are performed only at selected times within pre-selected scenes. The SRVT addresses these insufficiencies by finding uniform, high-contrast edges from urban scenes and then using these edges to determine standard estimators of spatial resolution, such as the MTF and the RER.

The SRVT was developed using the MATLAB<sup>®</sup> programming language and environment. This automated software algorithm assesses every image in an acquired data set, using edges found within each image, and in many cases eliminating the need for dedicated edge targets. The SRVT automatically identifies high-contrast, uniform edges and calculates the MTF and RER of each image, and when possible, within sections of an image, so that the variation of spatial resolution characteristics across the image can be analyzed. The automated algorithm is capable of quickly verifying the spatial resolution quality of all images within a data set, enabling the appropriate use of those images in a number of applications.

The SRVT has been validated against traditional techniques using IKONOS and QuickBird satellite imagery of NASA Stennis Space Center engineered edge targets. Preliminary comparisons of SRVT-estimated spatial resolution from naturally occurring edges against those obtained using traditional techniques show excellent agreement.

The SRVT can be used to evaluate the image quality of a single image, a product over time, and products from different systems. In addition to the above image quality metrics, the output of the SRVT could be used to estimate National Imagery Interpretability Rating Scale (NIIRS) values for panchromatic imagery, and serve as the basis for developing multispectral image-quality metrics.

*This work was done by Bruce Davis of Stennis Space Center, Robert Ryan and Kara Holekamp of Science Systems and Applications, Inc., and Ronald Vaughn of Computer Sciences Corporation. For more information Contact the Office of the Chief Technologist at Stennis Space Center, (228) 688-1929. Refer to SSC-00339.*

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## Electrical Connector Mechanical Seating Sensor

*John F. Kennedy Space Center, Florida*

A sensor provides a measurement of the degree of seating of an electrical connector. This sensor provides a number of discrete distances that a plug is inserted into a socket or receptacle. The

number of measurements is equal to the number of pins available in the connector for sensing.

On at least two occasions, the Shuttle Program has suffered serious time delays

and incurred excessive costs simply because a plug was not seated well within a receptacle. Two methods were designed to address this problem: (1) the resistive pin technique and (2) the discrete

length pins technique. In the resistive pin approach, a standard pin in a male connector is replaced with a pin that has a uniform resistivity along its length. This provides a variable resistance on that pin that is dependent on how far the pin is inserted into a socket. This is essentially a linear potentiometer.

The discrete approach uses a pin (or a few pins) in the connector as a displacement indicator by truncating the pin length so it sits shorter in the connector than the other pins. A loss of signal on this pin would indicate a discrete amount of displacement of the connector. This approach would only give dis-

crete values of connector displacement, and at least one pin would be needed for each displacement value that would be of interest.

*This work was done by Ellen Arens, Janine Captain, and Robert Youngquist of Kennedy Space Center. Further information is contained in a TSP (see page 1). KSC-13210/559*

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## **In Situ Aerosol Detector**

*Goddard Space Flight Center, Greenbelt, Maryland*

An affordable technology designed to facilitate extensive global atmospheric aerosol measurements has been developed. This lightweight instrument is compatible with newly developed platforms such as tethered balloons, blimps, kites, and even disposable instruments such as dropsondes. This technology is based on detection of light scattered by aerosol particles where an optical layout is used to enhance the performance of the laboratory prototype instrument, which allows detection of smaller aerosol particles

and improves the accuracy of aerosol particle size measurement.

It has been determined that using focused illumination geometry without any apertures is advantageous over using the originally proposed collimated beam/slit geometry (that is supposed to produce uniform illumination over the beam cross-section). The illumination source is used more efficiently, which allows detection of smaller aerosol particles. Second, the obtained integral scattered light intensity measured for the particle can be corrected for the beam

intensity profile inhomogeneity based on the measured beam intensity profile and measured particle location. The particle location (coordinates) in the illuminated sample volume is determined based on the information contained in the image frame. The procedure considerably improves the accuracy of determination of the aerosol particle size.

*This work was done by Andrei Vakhtin of Vista Photonics and Lev Krasnoperov of New Jersey Institute of Technology for Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15879-1*

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## **Multi-Parameter Aerosol Scattering Sensor**

*John H. Glenn Research Center, Cleveland, Ohio*

This work relates to the development of sensors that measure specific aerosol properties. These properties are in the form of integrated moment distributions, i.e., total surface area, total mass, etc., or mathematical combinations of these moment distributions. Specifically, the innovation involves two fundamental features: a computational tool to design and optimize such sensors and the embodiment of these sensors in actual practice.

The measurement of aerosol properties is a problem of general interest. Applications include, but are not limited to, environmental monitoring, assessment of human respiratory health, fire detection, emission characterization and control, and pollutant monitoring. The objectives for sensor development include increased accuracy and/or dynamic range, the inclusion in a single sensor of the ability to measure multiple aerosol properties, and developing an overall physical package that is rugged,

compact, and low in power consumption, so as to enable deployment in harsh or confined field applications, and as distributed sensor networks. Existing instruments for this purpose include scattering photometers, direct-reading mass instruments, Beta absorption devices, differential mobility analyzers, and gravitational samplers.

The family of sensors reported here is predicated on the interaction of light and matter; specifically, the scattering of light from distributions of aerosol particles. The particular arrangement of the sensor, e.g. the wavelength(s) of incident radiation, the number and location of optical detectors, etc., can be derived so as to optimize the sensor response to aerosol properties of practical interest. A key feature of the design is the potential embodiment as an extremely compact, integrated microsensor package. This is of fundamental importance, as it enables numerous previously inaccessible applications.

The embodiment of these sensors is inherently low maintenance and high reliability by design.

The novel and unique features include the underlying computational underpinning that allows the optimization for specific applications, and the physical embodiment that affords the construction of a compact, durable, and reliable integrated package. The advantage appears in the form of increased accuracy relative to existing instruments, and the applications enabled by the physical attributes of the resulting configuration.

*This work was done by Paul S. Greenberg and David G. Fischer of Glenn Research Center. Further information is contained in a TSP (see page 1).*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18634-1.*