



Technology Focus: Data Acquisition

Wind and Temperature Spectrometry of the Upper Atmosphere in Low-Earth Orbit

Multi-point measurements can enhance the capabilities of the GPS network, as well as other communication applications.

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Wind and Temperature Spectrometry (WATS) is a new approach to measure the full wind vector, temperature, and relative densities of major neutral species in the Earth's thermosphere. The method uses an energy-angle spectrometer moving through the tenuous upper atmosphere to measure directly the angular and energy distributions of the air stream that enters the spectrometer. The angular distribution gives the direction of the total velocity of the air entering the spectrometer, and the energy distribution gives the magnitude of the total velocity. The wind velocity vector is uniquely determined since the measured total velocity depends on the wind vector and the orbiting velocity vector.

The orbiting spectrometer moves supersonically, Mach 8 or greater, through the air and must point within a few de-

grees of its orbital velocity vector (the ram direction). Pointing knowledge is critical; for example, pointing errors 0.1° lead to errors of about 10 m/s in the wind. The WATS method may also be applied without modification to measure the ion-drift vector, ion temperature, and relative ion densities of major ionic species in the ionosphere. In such an application it may be called IDTS: Ion-Drift Temperature Spectrometry.

A spectrometer-based coordinate system with one axis instantaneously pointing along the ram direction makes it possible to transform the Maxwellian velocity distribution of the air molecules to a Maxwellian energy-angle distribution for the molecular flux entering the spectrometer. This implementation of WATS is called the gas kinetic method (GKM) because it is applied to the case of the Maxwellian distribution.

The WATS method follows from the recognition that in a supersonic platform moving at 8,000 m/s, the measurement of small wind velocities in the air on the order of a few 100 m/s and less requires precise knowledge of the angle of incidence of the neutral atoms and molecules. The same is true for the case of ion-drift measurements. WATS also provides a general approach that can obtain non-equilibrium distributions as may exist in the upper regions of the thermosphere, above 500 km and into the exosphere. Finally, WATS serves as a mass spectrometer, with very low mass resolution of roughly 1 part in 3, but easily separating atomic oxygen from molecular nitrogen.

This work was done by Federico Herrero of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15753-1

Health Monitor for Multitasking, Safety-Critical, Real-Time Software

A single software module addresses many health management problems.

John F. Kennedy Space Center, Florida

Health Manager can detect "Bad Health" prior to a failure occurring by periodically monitoring the application software by looking for code corruption errors, and sanity-checking each critical data value prior to use. A processor's memory can fail and corrupt the software, or the software can accidentally write to the wrong address and overwrite the executing software. This innovation will continuously calculate a checksum of the software load to detect corrupted code. This will allow a system to detect a failure before it happens.

This innovation monitors each software task (thread) so that if any task reports "bad health," or does not report to

the Health Manager, the system is declared bad. The Health Manager reports overall system health to the outside world by outputting a square wave signal. If the square wave stops, this indicates that system health is bad or hung and cannot report. Either way, "bad health" can be detected, whether caused by an error, corrupted data, or a hung processor.

A separate Health Monitor Task is started and run periodically in a loop that starts and stops pending on a semaphore. Each monitored task registers with the Health Manager, which maintains a count for the task. The registering task must indicate if it will run more

or less often than the Health Manager. If the task runs more often than the Health Manager, the monitored task calls a health function that increments the count and verifies it did not go over max-count. When the periodic Health Manager runs, it verifies that the count did not go over the max-count and zeroes it. If the task runs less often than the Health Manager, the periodic Health Manager will increment the count. The monitored task zeroes the count, and both the Health Manager and monitored task verify that the count did not go over the max-count.

The Health Manager reports its system health status to the outside world by tog-

gling an output pin creating a square wave signal. If the system hangs completely prior to reporting its health status, the square wave is no longer generated. This absence of the square wave, whether intentional or because the Health Manager is hung, indicates bad health, analogous to a deadman switch. This is done by

creating a Health Manager Reporting Task, which loops and pends on a semaphore. A timer Interrupt Service Routine gives the semaphore that allows the Health Manager to run. When the Health Manager Reporting Task receives the semaphore, it reads the system health status. If the status is good, an output pin is

toggled. If the status is bad health, it latches the system's bad health variable so it can never switch back to good health and stops the square wave.

This work was done by Roger Zoerner of Kennedy Space Center. Further information is contained in a TSP (see page 1). KSC-12809

Stereo Imaging Miniature Endoscope

This endoscope can be used in minimally invasive surgery, in geological resource exploration, and in miniature analytical tools.

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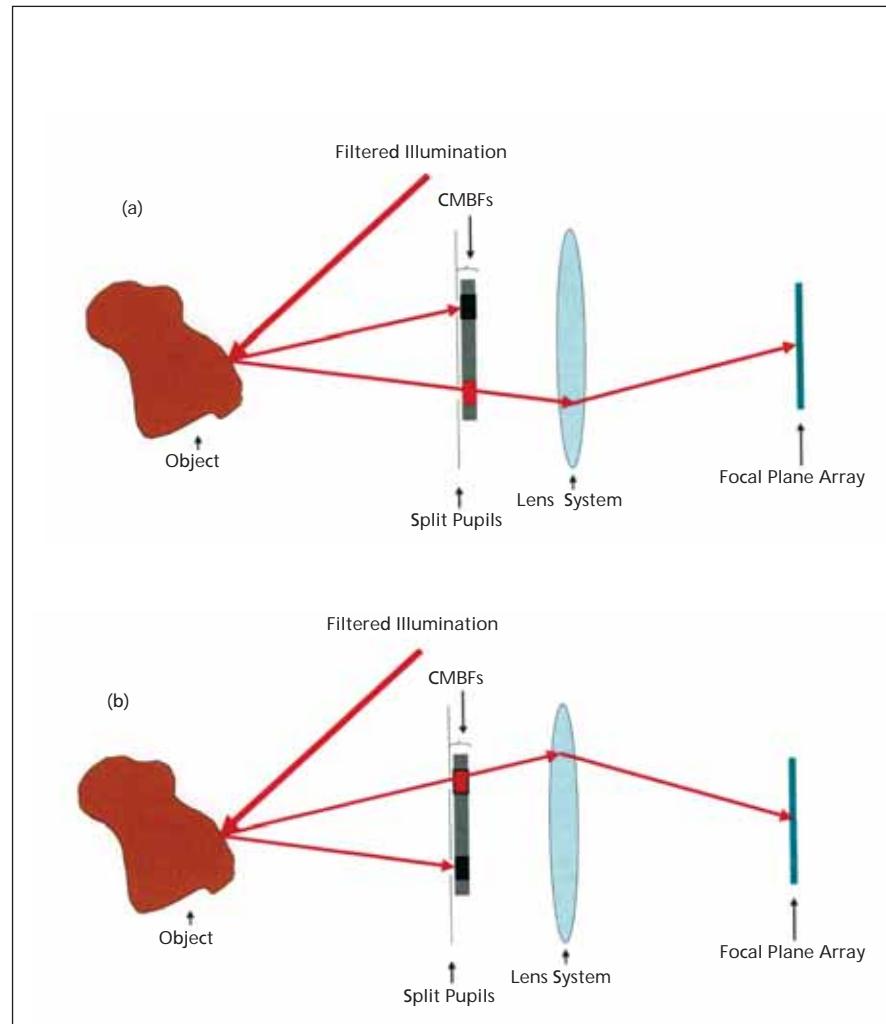
Stereo imaging requires two different perspectives of the same object and, traditionally, a pair of side-by-side cameras would be used but are not feasible for something as tiny as a less than 4-mm-diameter endoscope that could be used for minimally invasive surgeries or geoexploration through tiny fissures or bores. The proposed solution here is to employ a single lens, and a pair of conjugated, multiple-bandpass filters (CMBFs) to separate stereo images. When a CMBF is placed in front of each of the stereo channels, only one wavelength of the visible spectrum that falls within the passbands of the CMBF is transmitted through at a time when illuminated. Because the passbands are conjugated, only one of the two channels will see a particular wavelength. These time-multiplexed images are then mixed and reconstructed to display as stereo images.

The basic principle of stereo imaging involves an object that is illuminated at specific wavelengths, and a range of illumination wavelengths is time multiplexed. The light reflected from the object selectively passes through one of the two CMBFs integrated with two pupils separated by a baseline distance, and is focused onto the imaging plane through an objective lens. The passband range of CMBFs and the illumination wavelengths are synchronized such that each of the CMBFs allows transmission of only the alternate illumination wavelength bands. And the transmission bandwidths of CMBFs are complementary to each other, so that when one transmits, the other one blocks.

This can be clearly understood if the wavelength bands are divided broadly into red, green, and blue, then the illumination wavelengths contain two bands in red (R1, R2), two bands in green (G1, G2), and two bands in blue (B1, B2).

Therefore, when the objective is illuminated by R1, the reflected light enters through only the left-CMBF as the R1 band corresponds to the transmission window of the left CMBF at the left pupil. This is blocked by the right CMBF.

The transmitted band is focused on the focal plane array (FPA). Here, the FPA does not include color filter array (black and white); hence, the image sensors only measure light intensities. Similarly, when the object is illuminated by R2, it is



Schematic showing the principle of the Stereo Imaging Endoscope using CMBFs. (a) The first illumination band passes through the left CMBF to cast an image at the focal plane, but is blocked by the right CMBF. (b) The second illumination band passes through the right CMBF to cast an image at the focal plane, but is blocked by the left CMBF.