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THE TIMS INSTRUMENT

CHUCK STANICH
DAEDALUS ENTERPRISES, INC.
P.O. BOX 1869
ANN ARBOR, MICHIGAN 48106

I expect that most of the audience is composed of TIMS data users and many of you may not be familiar with the instrument itself. I plan to introduce Daedalus Enterprises, Inc., give background/history on the design and development of TIMS and to cover some of the detailed design considerations. I will provide you with some insights into the design decisions that have taken place and discuss some of the limitations of the system. When I have completed my talk, I would hope that you will be more comfortable with the terminology, concepts, and use of the TIMS airborne line scanner. Possibly some of the information that I will present could find some use in the application of the system.

For those of you not familiar with Daedalus, we were founded in 1968 and are now a publicly-held corporation chartered to pursue all aspects of remote sensing of the environment. We are internationally recognized as the major manufacturer of commercial, airborne optical/mechanical scanner systems. Our systems have been comprised of passive and active systems covering the ultraviolet to the infrared wavelengths and usually are instruments covering one to twelve separate spectral channels. We have designed and delivered systems for four NASA centers: NSTL, MSFC, JSC, and ARC.

The TIMS (Thermal Infrared Multispectral Scanner) system components consist of a scan head/spectrometer and associated electronics.

It was designed as a geologic instrument. In silicate rocks, there is a broad minimum in emissivity between 8 and 11 μm and the depth and position of the band is related to the crystal structure of the constituent minerals. Early attempts to use multispectral image data in this region met with only limited success. In the early seventies, a 24-channel scanner was built for NASA and some promising results were obtained in the thermal infrared region over the East Tintic Mountains in Utah. This scanner reportedly proved to be unreliable and was subsequently dismantled.

After beginning discussions in 1979 with Alex Goetz at JPL, Daedalus was awarded a design study contract for the spectrometer portion of the system in November of 1980. The design consideration given the highest priority was system radiometric sensitivity because the contrast in spectral emittance among rocks is usually less than 15%. After the completion of this design, a contract was received from NASA/NSTL to proceed with the fabrication of the complete system. Before the system was completed, the funds allocated by NASA for the project were depleted. Daedalus then completed the system using its own funds and it was test flown and delivered in March of 1982.

The system has been maintained and modified by NASA since then and possibly some of the information that I will present may not apply to the current TIMS configuration.

A NASA/NSTL Learjet has been specially modified to accommodate the TIMS system. The system normally is flown using this aircraft although it has also been operated in the NASA/ARC C-130 aircraft. The scan head and spectrometer are mounted in the unpressurized tail cone of this aircraft and operate through a hole cut through the skin. The fact that the system would be exposed to the environment outside the skin of the aircraft was an important consideration in the design process.

We feel that the system is quite compact considering the achieved sensitivity. The scan head/spectrometer is slightly over three feet long, 30 inches high and weighs over 220 pounds. The temperature over which the scan head/spectrometer can operate is very large. The number of spectral channels covered is six ranging from 8.2 μm to 12.2 μm. The original specification of the system required a sensitivity of less than .3K in each of the bands. When the system was delivered to NSTL, all bands had a sensitivity of less than .2K with the exception of band 6.

The entrance aperture to the primary optics is 7.5 inches in diameter resulting in an effective collecting area of 36 sq. inches. The system has a variable scan rate which is switch selectable by the operator. The scan rates can be varied from 7.3 to 25 scans/second by adjusting the rotation rate of the scanning mirror to accommodate the different speeds and altitudes of the aircraft.

The digitized field of view contains 638 pixels and covers 76.56 degrees. This digitized field of view is adjusted according to the roll attitude of the aircraft in order to stabilize the image. The unvignetted field of view relates to how large the total optical view can be before an obstruction to the optical path is encountered. Comparing the digitized field of view with the unvignetted field of view would indicate that the system can accommodate approximately 1.5 degrees of roll before a pixel from the edge of the scene will be lost. However, a total of +- 15 degrees of roll can be handled before stabilization of the scene pixels is lost.

The system digitizes each pixel to 8 bits, and the detector analog signals are sampled every 2.08 milliradians. The instantaneous optical field of view is 2.5 milliradians as determined by a field stop aperture which is common to all of the spectral channels. This common aperture ensures that all of the channels are in spatial registration. The output data rate varies from 44 to 150 kbits/sec and each scan line of each channel contains 750 words. The output data is recorded on a wide band instrumentation tape at a density of 10,000 bits per inch per channel.

The scan head contains the primary collecting optics of the system and the two thermal reference sources, determines the instantaneous field of view, receives the motor drive signal for the scanning mirror, and provides an optical and mechanical interface to the spectrometer. The spectrometer collimates the optical energy received from the primary, disperses it using a diffraction grating and focuses the energy onto a series of liquid nitrogen cooled detectors.

The electrical output of the detectors is coupled to the digitizer where the amplitude is adjusted, bandwidth limited, sampled, digitized, and monitored. The digitizer also receives various housekeeping information about the system and aircraft and combines this with the video data from the detectors and conditions it for use by the tape recorder.

The control console is used by the operator to monitor system activities and to control the system functions. The scan speed selection by the operator is distributed to the various units from the control console. The console also accepts the signals from the scan motor encoder and the gyro to perform the roll stabilization. Controls for the two thermal reference sources are contained in the control console.

The assemblies of the scan head are the dc motor, the mirror and the encoder. All timing related activities are synchronized to the encoder including the digitization and tape recorder speed. A gyro is used to determine the roll attitude of the aircraft. The thermal reference sources are mounted on each side of the scan head and consist of large copper plates which are painted black with a paint that has a high emissivity throughout the spectral region. One reference can be set to either above or below the scan head ambient temperature while the other one can only be set to a temperature above the scan head ambient. Each reference is actively controlled and the source temperature is independently measured and inserted into the housekeeping data associated with each channel.

The spectrometer contains the dispersing optics and the array of photoconductive cooled detectors. A set of six electrical preamplifiers are matched to each element of the array and are mounted onto the side of the spectrometer. The spectrometer is sealed and purged with a supply of dry nitrogen gas during each flight.

The TIMS optical system consists of a 19 cm diameter Newtonian reflector telescope mounted behind an object-plane 45° flat scanning mirror and followed by a Czerny-Turner spectrometer.

The primary optical system uses a f1.9 parabolic primary mirror with a field determining aperture located in its focal plane. An off-axis parabolic mirror is used to collimate the energy emerging from the aperture which is then dispersed by the diffraction grating and re-imaged on the detector array by a fast f0.6 germanium lens. All of the primary optical elements, the field stop, the off-axis collimator, and the detector dewar are mounted on sliding blocks controlled by Invar^{R} metering rods to provide the active thermal compensation for scan head ambient temperature changes. The three element germanium imaging lens is also internally thermally compensated for changes in ambient temperature.