hardness substantially smaller than this dose observed aboard NTS-2.[2] Obviously substantially more shielding than 75 mils of aluminum is required to use these components in the GPS orbit.

A quasiperiodicity can be seen in the data presented in Fig. 1, with an apparent period of approximately 1 month. In order to more accurately determine the period of this variation in the daily radiation dose, the power spectrum of the time series of dose per day was estimated using the Hamming lag window method.[3] The only significant frequency found was in the range of 0.0350-0.0375 cycles/day (and its harmonics). The corresponding period of 26.7-28.6 days brackets the 27.1 days required for the same location on the sun to face the Earth. This result suggests, as have other studies,[4] that modulation of the trapped electron intensity by the solar wind is the cause of the 27-day periodicity observed in the data. High-speed solar wind streams are associated with coronal holes and, since coronal holes persist for times long compared with a solar rotation, a correlation of the outer-zone radiation dose with the solar rotation period would be expected. The period of data collection was during the rise to solar maximum; the sunspot number peaked in November 1979. Several large magnetic storms occurred during this time interval with values of D_{st} substantially larger than $-100\,\gamma$.[5]

Conclusions

1) The radiation dose experienced in the GPS orbit due to energetic electrons was within a factor of 2 of the predictions of the NASA AE-7HI model for a period of more than 1 yr in 1978-1979. The shielding of 75 mils of aluminum corresponds to electrons of ~900 keV.

2) The energetic electron dose is extremely variable on several time scales. A large percentage of the total dose occurs during only a small fraction of the exposure days. The radiation dose rate due to outer zone electrons has a stochastic and periodic character. The stochastic nature is, in some ways, reminiscent of that of solar protons, although the electron dose never went to zero.

The past controversy over the magnitude of the fluxes of the outer-zone electrons would appear to be due substantially to their large variability in intensity. A few extended periods of high solar wind velocity, such as occurred in August 1978 (Fig. 1), would substantially enhance the integrated radiation dose whereas a period without any such enhancement would give a low dose. It should be noted that the higher the energy of outer-zone electrons, the larger the intensity fluctuations.[6] Therefore the highest-energy electrons will be present in significant numbers only occasionally but nevertheless will have a major role in damaging well-shielded components.

3) The electron dose is correlated with solar rotation. Thus it is possible to make relatively short-term predictions of the future radiation dose based upon records of the recent past. This feature of the outer-zone electrons might be quite useful for systems such as the GPS which could benefit from advanced warning of radiation enhancements.

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Information Adaptive System: An Investigation of Onboard Data Processing

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Introduction

THE NASA End-to-End Data System (NEEDS) program was initiated by NASA to improve significantly the state-of-the-art in acquisition, processing, and distribution of space-acquired data for the mid-1980s and beyond.[1] One element under Phase II of this program is the Information Adaptive System[2] which addresses sensor-specific processing onboard the spacecraft. The goal of the IAS effort is to design, develop, and demonstrate in early 1983 a system architecture that utilizes advanced technology for high-speed multispectral image data processing. Processing functions addressed by the IAS development include radiometric correction, data formatting, geometric correction, data editing, packetization, and adaptive system control.

IAS System Design

A functional block diagram of the Information Adaptive System is shown in Fig. 1. This design will serve as the basis for the contractual development of an IAS ground demonstration system. Hardware will be developed to the brassboard level; however, flight requirements will be taken into consideration to allow subsequent implementation in flight-qualified form.

The IAS demonstration system design employs a high-speed (>75 Megabits per second) pipeline architecture whose processing modules are under the control and supervision of a microcomputer-based control system, the adaptive system controller. Image data are input to the pipeline from the sensor simulator which consists of a high-speed buffer memory system. This memory is configured to simulate a pushbroom imaging system with six spectral bands. The IAS processed data are collected in the output buffer memory

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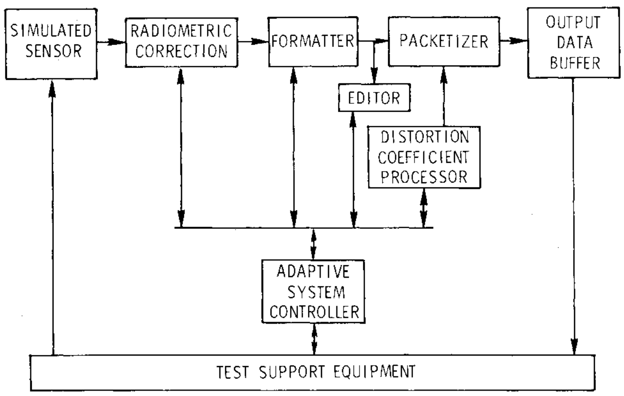

Fig. 1 Block diagram of the IAS demonstration system.

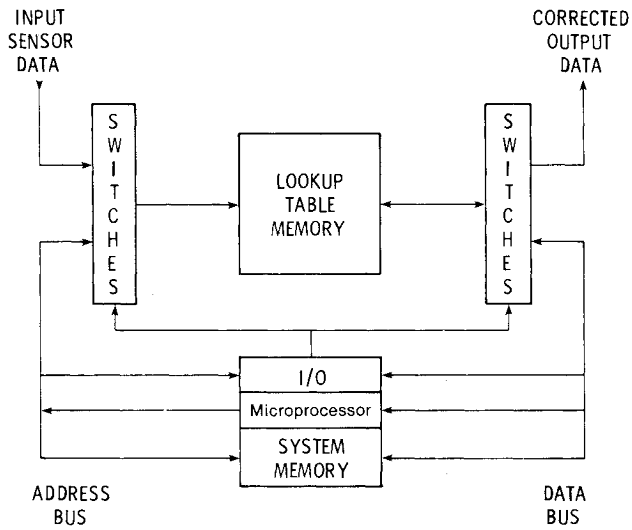

Fig. 2 Lookup table design for radiometric correction.

which is read by the test support computer. The test support equipment evaluates and displays the processed data and is capable of examining the performance of the individual processing functions. Each function will contain bypass circuitry which allows any processing module to be selected or disabled by the adaptive system controller.

Radiometric Correction

The radiometric correction function will compensate for nonuniformities in the outputs of the photodetectors. Two approaches for providing this correction are under investigation for the IAS. The first approach employs a four-segment linear curve-fit, which utilizes four gain and four offset coefficients for each detector response curve. The selected gain and offset are applied to the input data by a high-speed multiplier/accumulator integrated circuit.

The second approach involves a hardware implementation of the lookup table technique. This technique offers improvements in accuracy by mapping each detector value to its corrected output value. The breadboard system of Fig. 2 was constructed to evaluate this approach.[3] A microprocessor generates the desired output values and loads these values into the lookup table. The microprocessor then instructs the bus switches to disconnect the lookup table from the address and data bus. Sensor data are applied to the address lines of the memory to select the location from which the desired output value is read. It was determined from the evaluation of the breadboard test system that the ultimate sampling rate for the lookup table approach is limited only by the access time of the memory employed in the system.

Data Formatter

The format of data produced by a multispectral imaging system is usually the result of design tradeoffs for the sensor and does not consider the processing requirements downstream from the sensor. The task of data formatting is to reorganize the sensor data into a form appropriate to the subsequent processing function. One approach that has been investigated is an alternating buffer memory system with both input and output controllers.[4] This approach employs two high-speed memory systems which can accommodate a continuous input data stream by alternating their roles as input and output buffers. The proper sequence of addresses are applied to the memory serving as the output buffer by a lookup table memory which resides in the output controller.

Geometric Correction

Space-acquired image data exhibit geometric distortions due to variations in spacecraft emphemeris and attitude, sensor misalignment, and Earth curvature. Geometric correction will compensate for these distortions by converting the input data from the space frame of reference to a known Earth-centered map projection. The IAS demonstration system will include a dedicated microcomputer to calculate a set of distortion coefficients for each input scan line. These coefficients are a measure of the displacement between the input pixels and the undistorted pixels of the output map projection. This information is transferred with the processed data to the test support computer. To complete the geometric correction process the data must be resampled. The task of resampling is to compute a set of intensity values for the output pixels based on the intensity of neighboring input pixels and the correction coefficients. For the IAS, the test support computer will resample the data, which is analogous to performing that task on the ground.

Editing

The IAS will be capable of controlling the flow of image data based upon certain editing criteria such as time of day, position in orbit, and cloud cover. Since the adaptive system controller maintains cognizance of time and position, it can easily enable or disable the processing/transmission sequence as a function of those parameters. The most challenging and desirable editing criterion involves the detection of regions where useful image data are obscured by cloud cover. The Feature Identification and Location Experiment (FILE) program[5] is investigating algorithms for discriminating between various ground features. The FILE II algorithm considers the ratios of three spectral bands and threshold techniques to distinguish clouds from other features. For the IAS demonstration, this algorithm will be implemented using high-speed multipliers and comparator circuits. A pixel counter will monitor the number of cloud pixels in each image line for insertion into the data packet. A decision to discard the data based on an excessive cloud pixel count can be made on the ground or the data can be deleted from the transmission process on a line-by-line basis by the adaptive system controller.

Data Packetization

The IAS processed data will be partitioned into data packets to facilitate the management of spacecraft data in real time. Special purpose packetization hardware is under development for the IAS demonstration which will inject primary and secondary header information into the processed data stream. The primary header will identify the mission and the data source, while the secondary header includes information such as time, spacecraft position and attitude, and data which are unique to the specific experiment. In the secondary header for the IAS, these data consist of the cloud pixel count and geometric distortion coefficients. In addition to the primary and secondary headers, error checking codes will be appended to the tail of the packet following the processed data.

The data packetization unit will employ high-speed memories in a ping-pong configuration. This configuration allows a line of image data to be loaded into a buffer, while the previous line is simultaneously read from a second buffer. The header parameters are stored in a separate memory. The contents of this memory and the ping-pong buffer are output to parallel-to-serial converters during the output cycle. The combined serial data enters a code generator where the error check bits are produced. Each bit of the data packet is then serially clocked from the packetization module to the output buffer memory.

Adaptive System Controller

The adaptive system controller (ASC) is the executive control system for the IAS which is responsible for maintaining control, observing system status, and providing high-speed transfer of information to and from each processing module. The ASC architecture will include a general-purpose microcomputer and the circuitry necessary to interface that computer to each processing element and to the test support computer. Communications with the test support computer will simulate the exchange of data and commands between the IAS and the spacecraft computer. The adaptive system controller will initialize the IAS components, establish and maintain programmed operating modes, maintain cognizance of time, position and attitude, and provide computational support to other modules of the Information Adaptive System.

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