Atmospheric Infrared Sounder (AIRS) on the Earth Observing System

H. H. Aumann
Jet Propulsion Laboratory
Pasadena, CA 91109, USA

Chris Miller
LORAL Infrared &Imaging Systems
Lexington, MA 02173, USA

ABSTRACT

The Atmospheric Infrared Sounder (AIRS) is a high spectral resolution IR spectrometer. AIRS, together with the Advanced Microwave Sounding Unit (AMSU) and the Microwave Humidity Sounder (MHS), is designed to meet the operational weather prediction requirements of the National Oceanic and Atmospheric Administration (NOAA) and the global change research objectives of the National Aeronautics and Space Administration (NASA). The three instruments will be launched in the year 2000 on the EOS-PM spacecraft. Testing of the AIRS engineering model will start in 1996.

An extensive effort of data simulation and retrieval algorithm development has been used to define the AIRS instrument functional requirements and to demonstrate that the combined AIRS/AMSU/MHS data meet the temperature retrieval accuracy of 1K rms in lkm thick layers and water vapor profiles with 20% rms accuracy in 2 km layers in the troposphere under all-weather day, night and cloudy conditions. Assimilation of data with this accuracy into Global Circulation Models is required to achieve a positive forecast impact.

The AIRS instrument represents a major step forward in satellite based remote sensing technology. In particular, improvements in second generation PV:HgCdTe detector array/readout technology coupled with a rapid advance in long life, low vibration, Stirling/pulse tube cryocooler design have been instrumental, This paper describes the overall hardware design and performance and provides a brief status of the development effort.

Keywords: EOS, AIRS, infrared, sounder, multi-aperture spectrometer, echelle grating, HgCdTe detector, Stirling cycle cryocooler

1. INTRODUCTION

The HIRS (High Resolution Infrared Sounder) and the Microwave Sounding Unit (MSU) on the National Oceanic and Atmospheric Administration (NOAA) polar orbiting satellite system have supported the National Weather Service (NWS) weather forecasting effort with global temperature and moisture soundings for almost two decades. In order to significantly improved weather forecasting capability, the NWS has stated requirements for atmospheric temperature profiles with 1K rms accuracy in 1 km thick layers and humidity profiles with a 20°/0 accuracy in the troposphere. Both requirements are far beyond the capability of the dated sensor technology employed by HIRS/MSU. Recent breakthroughs in IR detector array and cryogenic cooler technology have made it possible to convert the concepts of optimum passive, IR remote sensing into a practical, space-borne instrument: the Atmospheric Infrared Sounder (AIRS). AIRS, working together with the Advanced Microwave Sounding Unit (AMSU) and the Microwave Humidity Sounder (MHS), forms a complementary sounding system for the NASA's Earth Observing System (EOS) to be launched in the year 2000. The three instruments are expected to become the operational sounding system for the U. S. Government's National Polar-Orbiting Operational Environmental Satellite System (NPOESS) to be launched early next century.

The measurement concept employed by AIRS/AMSU/MHS follows the concept used by HIRS/MSU, but with a factor of twenty higher spectral resolution in the infrared: Temperature and moisture profiles are measured by observing the upwelling radiance signature of Carbon Dioxide at 4.2 μm and 15 μm, and of water vapor at 6.3 μm in carefully selected channels, as shown in Figure 1. The much higher spectral resolution of AIRS gives sharper weighting functions and minimizes the contamination of temperature sounding channels with water lines or other atmospheric gases. Based on the accurate knowledge of the radiative properties of CO_2 and H_2O vapor, a computer algorithm on the ground can invert the measured radiometric signal to temperature and moisture distributions as a functions of altitude. Correction for spectral Earth surface emissivity and reflectivity effects can be obtained by observing selected surface channels distributed throughout the 3.8 μm -13 μm region. Accurate retrievals under partly cloudy conditions arc obtained in conjunction with AMSU and MHS data, hence, it is necessary to match scan patterns and observational strategies of all three sounding instruments. As shown in Figure 2, the set of sounding instruments scan the ground track in a synchronized pattern. For each AMSU footprint there are nine AIRS footprints which permit effective cloud clearing using the combined data sets. At a platform altit udc of 705 km, the AIRS field of view of 1.1 degrees provides a 13.5 km spatial footprint and very nearly contiguous along track sampling at nadir view. ±49.5 degrees of crosstrack scanning around nadir provides a full 1850 km swath width coverage every 2.67 scan cycle. Global coverage is obtained twice a day, except very c1osc to the equator. The ground based data processing system combines the data from AIRS, AMSU, and MHS to produce one temperature and moisture sounding for each AMSU footprint.

The AIRS instrument represents a major step forward in satellite based remote sensing technology. In particular: improvements in second generation PV:HgCdTe detector array/readout technology coupled with a rapid advance in long life, low vibration, Stirling/pulse tube cryocooler design have been instrumental. This paper describes the overall hardware design and performance and provides a brief status of the development effort. The AIRS hardware development phase has been underway since 1991, and considerable progress has been made since that time. The Preliminary Design Review (PDR) for AIRS was held in January 1995. Testing of the Engineering Model is expected to be complete in Summer 1997. The delivery of a Protoflight Model is expected in September 1998. AI RS is designed for an operating lifetime of 5 years, with hardware redundancy in all critical subsystems. The AIRS power, size and weight requirement, 256 watts and 156 kg, is comparable to other instruments of this class and is easily accommodated on the EOS-PM satellite.

2.0 AIRS MEASUREMENT REQUIREMENTS AND INSTRUMENT SPECIFICATIONS

The Interagency Temperature Sounder (ITS) Team, with representatives from NASA, NOAA and DOD, was formed in 1987 to convert the NOAA retrieval accuracy requirements to measurement requirements of an operational, high spectral resolution sounder. An extensive effort of data simulation and retrieval algorithm development was required to demonstrate that data from this spectrometer, together with data from the Advanced Microwave Sounding Unit (AMSU) and the Microwave Humidity Sounder (MHS) can meet the NOAA accuracy requirement. A summary of the high level measurement requirements is discussed in Table 1. High spectral resolution and mini mization of spectral sidelobes is important for obtaining sharp weighting functions, avoiding areas where water lines, CO_2 lines and lines from minor atmospheric constituents overlap, and for sounding between lines. The retrieval algorithm assumes that all measurements in one spectrum pertain to the identical footprint at exactly the same time. This property, referred to as measurement simultaneity, is critical for sounding in areas of high spatial contrast, i.e. in the presence of a partial cloud cover, Inadequate measurement simultaneity results in degraded retrievals.

In 1989 two instrument concepts, a Michelson Interferometer and a grating array spectrometer were proposed to meet the measurement requirements of this ITS. An independent review board recommended the grating array spectrometer implementation, AIRS. AIRS was selected for implementation by NASA. The AIRS Science Team and JPL have translated the AIRS measurement requirements to a full set of AIRS Instrument specifications. The specifications establish the performance requirements in the areas of: (a) spectral coverage, resolution, calibration, and stability, (b) spatial response characteristics including alignment, uniformity, and measurement simultaneity, (c) radiometric and photometric calibration, (d) sensitivity and channel outages, (e) cross track scan motion, and (f) physical characteristics such as size, weight, power and lifetime.

3.0 AIRS SYSTEM DESCRIPTION

The AIRS Instrument, shown in Figure 3, is an array grating spectrometer which provides spectral coverage over the 3.74-4.61 μm, 6.20-8.22 pm, and 8.8-15.4 μm infrared wavebands at a nominal spectral resolution ($\lambda/\Delta\lambda$) of 1200. The

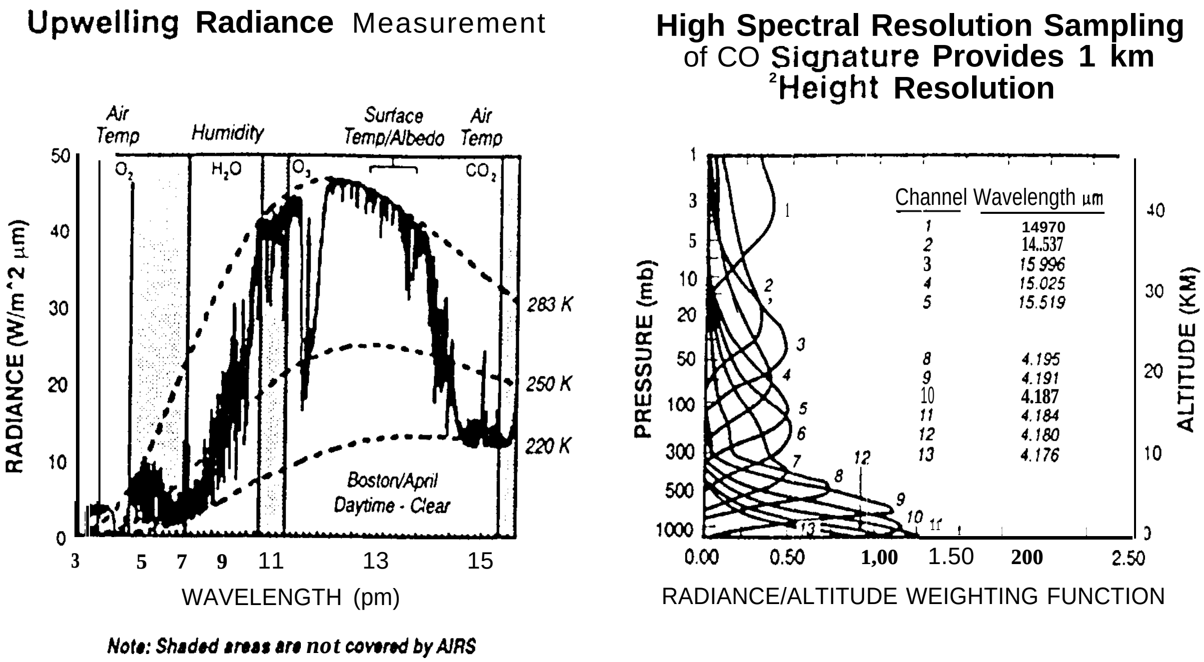

Figure 1. **Atmospheric temperature and humidity** profiles are obtained through measurement of the upwelling infrared radiance of C02 and H20 with spectral resolution $\lambda/\Delta\lambda$=1200.

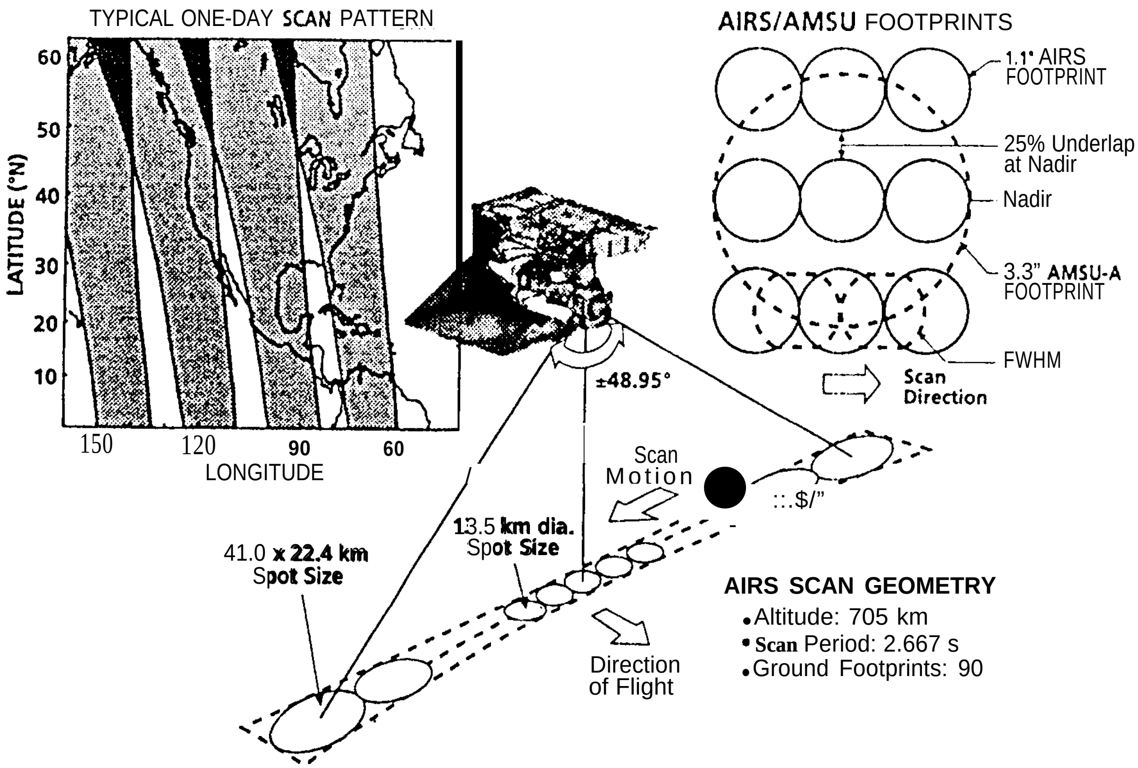

Figure 2. The AIRS **±49.5** degree scan geometry is matched to the advanced the Microwave Sounder Unit's and the Microwave Humidity **Sounder's** scan patterns to provide global measurements twice a day,

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Table 1. High-1evel AIRS Measurement Requirements

PARAMETER	KEY REQUIREMENT	COMMENT
Infrared Spectral Coverage	3.74-4.61 μm	Windows and 4.2 μm lower tropospheric sounding CO_2 band.
	6.20- 8.22μ m	Humidity sounding.
	8.80-15.5pm	Windows, Ozone and 14 μm upper tropospheric sounding CO_2 band
Spectral Resolution	$\lambda/\Delta\lambda > 1200$	Improves the contrast for sounding between lines. Avoids contamination of temperature sounding channels with water lines or other minor constituents.
Spectral Sampling	$\Delta\lambda/2$	Nyquist sampled spectra capture full spectral information content,
95% integrated spectral response	$\Delta\lambda$ from λ	This limits the sidelobe response, thereby decreasing the mixing of response from surface and mid-tropospheric channels. Better retrieval algorithm convergence.
Spectral Calibration Accuracy	$\Delta\lambda/100$	Upwelling spectral radiance is used for primary spectral calibration.
Cross-track Scan Coverage	49.5 degree from nadir	Match the AMSU coverage. Provides nearly complete global coverage from 825 km altitude every 12 hours.
Field of View	1.1 degree, 90 fields cross-track	75% global coverage every 12 hours. 9 infrared fields for each AMSU field. Important for cloud filtering. Matches MHS field of view.
Channel-to-channel Measurement Simultaneity	0.99	Critical for sounding in the presence of clouds. As specified the resulting radiance error with 50% cloud cover equals the random noise.
Sensitivity (NEDT) at 250K typical mid-tropospheric scene temperature.	0.20K at 3.7-4.2 μm	Window channels.
	0.14K at 4.1-4.2 μm	Key lower tropospheric sounding region needs better SNR
	0.2K at 4.2-13.6 μm	Water sounding and window channels.
	0.35K at 13.6-15.4 μm	Upper tropospheric and stratospheric sounding channels.
Radiometric Calibration	Better than 3% absolute	Final sounding accuracy relies on "tuning" of the retrieved profiles relative to ground truth (radio sonde).

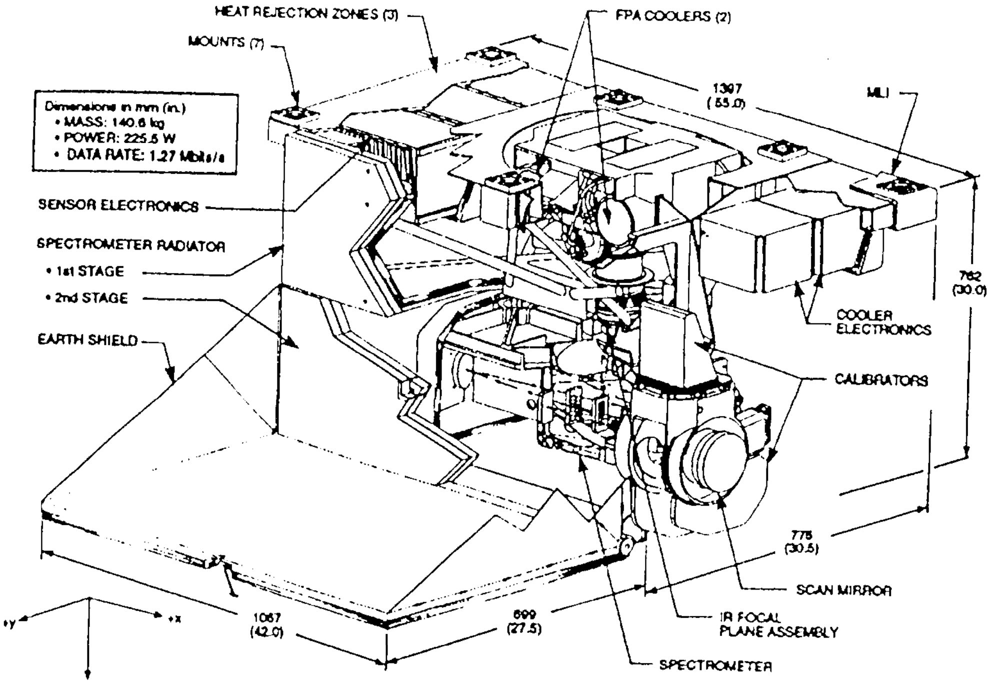


Figure 3. The overall AIRS Instrument illustration showing key hardware elements. **The spectrometer** is small compared to the volume required to support the space radiators and electronics.

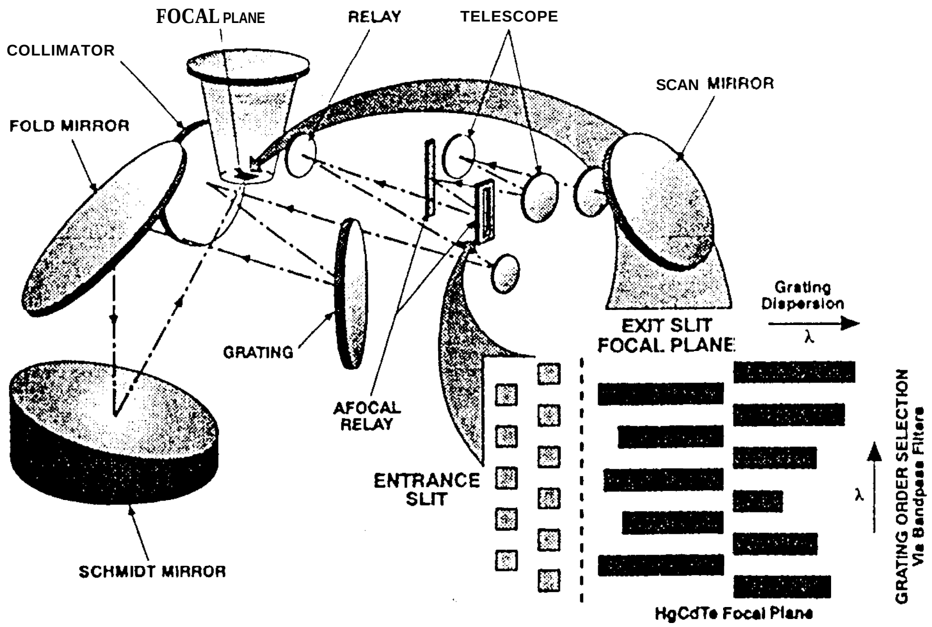


Figure 4. The multi-aperture array grating spectrometer concept disperses infrared **energy across** linear arrays of detectors. Each entrance aperture in the series is imaged onto a focal plane array. Order sorting and array color band selection are determined via bandpass filters.

usc of arrays gives the spectrometer the multiplex advantage in terms of signal-to-noise ratio without moving parts. In addition to the infrared data, arrays of silicon detectors provide spatially contiguous, along track coverage in the visible and near infrared (VIS/NIR) region.

Every 8/3 second the instrument generates a scan line of IR data which includes 90 ground footprints, each with a 1.1 degree diameter IFOV, 4 independent views of cold space, 1 view into a 310K radiometric calibrator, 1 view into a 330K spectral calibrator, and 1 view into a photometric calibrator. AIRS obtains a complete 1 R spectrum of 2378 spectral samples during each 22.41 ms ground footprint period. The VI S/NIR photometer, with a 0.185 degree IFOV, will be boresighted to the IR spectrometer to allow simultaneous visible and infrared scene measurements. A two speed scan mirror generates the crosstrack ground coverage, directing radiation from the scene, space, and the calibrators to the IR spectrometer and the VIS/NIR photometer.

The diffraction grating in the IR spectrometer disperses the radiation onto arrays of HgCdTc detectors. The IR spectrometer is cooled to 150K by a two stage radiative cooler. The IR focal plane is cooled to 60K by a Stirling/pulse tube cryocooler. The scan mirror is cooled to 273K by radiative coupling to the Earth and space scenes and to the 150K IR spectrometer. Cooling of the IR optics and detectors is necessary to achieve the required instrument sensitivity. The VIS/NIR photometer uscs optical filters to define four spectral bands in the 400 nm to 1000 nm region. The VI S/NIR detectors arc not cooled and operate in the 293K to 300K ambient range of the instrument housing.

Signals from both the IR spectrometer and the VIS/NIR photometer are passed through onboard signat and data processing electronics, which perform functions of radiation circumvention, gain and offset correction, signal integration, and output formatting and buffering to the high rate science data bus. in addition, the AIRS Instrument contains command and control electronics whose functions include communications with the satellite platform, instrument redundancy reconfiguration, the generation of timing and control signals necessary for instrument operation, and collection of instrument engineering and housekeeping data, The Stirling/pulse tube cryocoolers are driven by separate electronics which control the phase and amplitude of the compressor moving elements to minimize vibration. Heat from the electronics is removed through coldplates connected to the spacecraft's heat rejection system.

3.1 Array grating spectrometer

The heart of the AIRS Instrument is the array grating spectrometer. The major elements of this spectrometer are shown in Figures 4 and 5. Two kcy features of this spectrometer design are: (1) a one to onc mapping of an entrance slit to a corresponding focal plane detector array, and (2) the use of common front end optics and a single field stop to assure that all spectral samples simultaneously view the same IFOV. Except for optics inside the IR detector dewar assembly, the entire spectrometer operates at 150K to reduce photon noise in the detectors. Spectral separation is accomplished by a combination of spectral filters and the diffraction grating: Spectral filters at each entrance slit and at each focal plane array are used to isolate the grating order of interest; the echelle diffraction grating disperses the filtered energy within a grating order across linear arrays of detectors.

The front end of the IR spectrometer is an off-axis four mirror telescope with a rectangular 30 mm by 80 mm entrance pupil and a 150 mm focal length. A single 1.1 degree diameter field stop is located at a well corrected focus of the front telescope . The collimated optical energy from the telescope is incident on eleven different spectrometer entrance slits (apertures) arranged in two staggered columns. These slits arc located at a conjugate plane of the entrance pupil, making the spectrometer a pupil rather than a field imaging design. Each slit is covered by an optical bandpass filter, which forms the first stage of spectral separat ion. Ultimately, these eleven slits arc imaged to the focal plane, where each slit image contains the energy from a single grating order. This relationship is shown in Figure 6. Spectral dispersion by the diffraction grating spreads the slit images into bands at the focal plane. The dual entrance slit arrangement allows the use of detector arrays with shorter lengths without having to contend with spectral gaps at the array edges. The staggered slit arrangement is required to prevent overlapping grating orders and to minimize stray (out-of-band) energy on the focal plane detectors. The entrance slits establish the multi-aperture configuration of the spcctromcter, essentially creating eleven different spectrometers viewing the same IFOV.

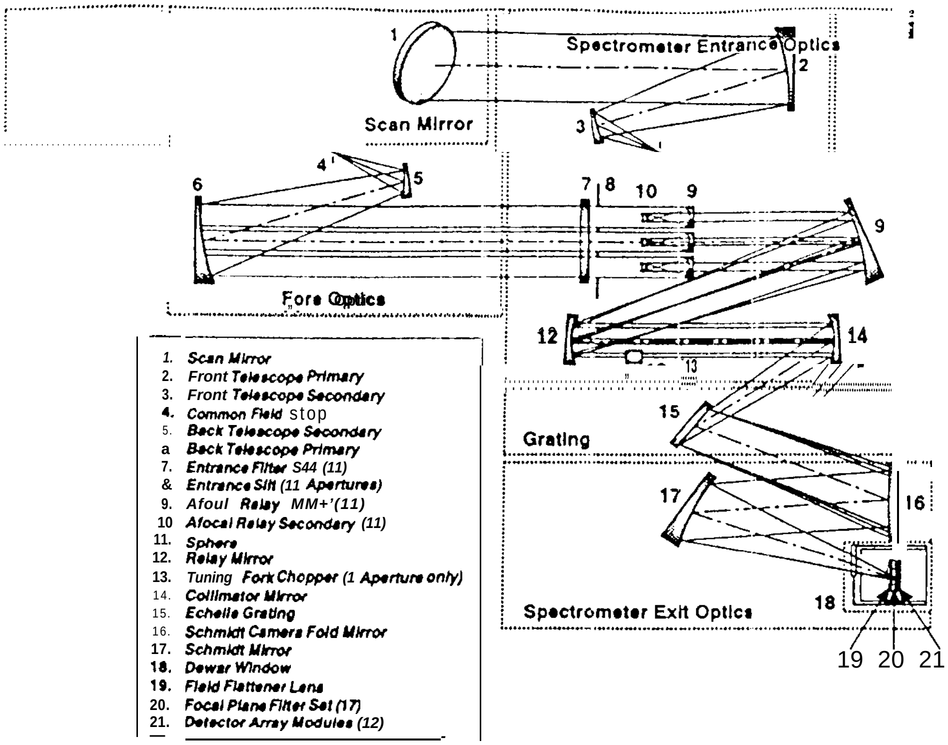


Figure 5. The AIRS optical design uses a low order echelle grating format in combination with F1 .7/F2.O off-axis folded Schmidt exi' optics to provide wide spectral coverage at high spectral resolution and minimum detector **size. The spectrometer temperature is 150K** for improved sensitivity.

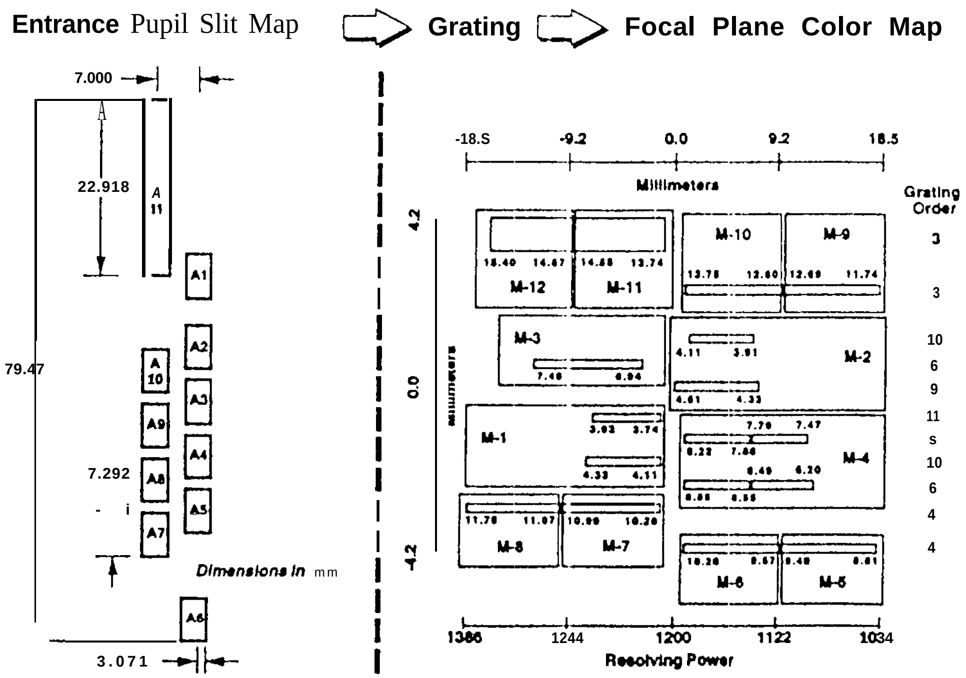


Figure 6. The AIRS focal plane is an image of the multi-aperture entrance slit dispersed by the grating. Eleven apertures are imaged onto 17 linear arrays. The FPA consists of 4500 HgCdTe detectors arranged in 12 modules: 10 photovoltaic and 2 photoconductive, with each module individually optimized.

The afocal relay assembly following the entrance slits has been incorporated to minimize the scan mirror size. These eleven relays change the slit height to cross-dispersed pitch ratio between the focal plane and the entrance slit plane. By compressing the slit height spacing at the entrance slit plane a much smaller scan mirror can be used. The sphere and relay mirrors transfer an image of the entrance slits to the chopper plane, which is conjugate to the entrance slit plane. A chopper is incorporated for reduction of l/f noise by modulating the signal falling on LWIR photoconductive (PC) detector arrays. The PC detector arrays are constrained to a single entrance slit, which is chopped at a 357 Hz rate. The chopper operates at a temperature of 150K. There arc no hard apertures at the chopper plane.

A collimator mirror directs the energy from the chopper plane onto a 130 mm by 150 mm diffraction grating located at a plane conjugate to the field stop. The light is incident on the grating at a nominal angle of 32 degrees. The diffraction grating, an echelle ruled with 12.89 lines/mn~ and operated in orders 3 through 11, diffracts light over an angular range of O ± 4.6 degrees. The diffraction grating is ruled in gold coated aluminum and has an aspheric surface to correct for aberrations in the Schmidt camera.

The back end spectrometer optics consists of a fold mirror, an off-axis Schmidt camera mirror with a 226 mm focal length, a germanium window on the detector dewar, a field flattening lens, and a set of 17 optical bandpass filters. The F/l .7: F/2,0 Schmidt mirror was chosen because of the wide spectral bandpass, a low F/number capability, and moderate field-of-view requirements. The zinc selenide field flattener lens is located inside the detector dewar's cold space and corrects the curved Petzval surface of the Schmidt mirror. The cold bandpass filters provide a final stage of bandpass definition, grating order isolation, and stray radiation rejection for each detector array.

The multi-aperture array grating spectrometer has a number of advantageous design features:

a) The pupil imaging design minimizes the effects of detector spatial non-uniformities,
b) It offers higher optical efficiency than a dual, crossed dispersed -spectrometer, .
c) The height of each entrance slit can be individually tailored to provide control of the throughput (AΩ) of each slit, and
d) The bandpass order sorting approach provides ideal focal plane design flexibility, since all dispersed orders are parallel and array separation is controlled by the entrance slit pitch.

3.2 IR focal plane assembly

The IR focal plane uses a hybrid PV/PC:HgCdTe multi-linear array approach. The focal plane layout is shown in Figure 6. The IR focal plane is comprised of 12 detector modules, where each module contains either 1, 2 or 4 arrays of detectors. The arrays within a given module are manufactured with detector material grown on a common substrate. Hence, each detector module may be individually optimized to provide the best performance for its assigned waveband. Modules Ml through Ml O arc fabricated with PV:HgCdTe detector arrays. The arrays are bump mounted to silicon readout integrated circuits which perform the functions of detector biasing, signal integration, sampling, and multiplexing on the focal plane. Modules M 11 and M 12 arc fabricated using PC:HgCdTe detectors. The PC detectors arc used in arrays covering the 13.74 µm to 15.40 µm waveband, where low detector resistance makes interfacing to readout circuits difficult. The individual detectors in these arrays arc wired directly to preamplifiers located outside the detector dcwar.

The PV:HgCdTc detectors in modules M 1 through M1O arc in bilinear arrays. The individual detector elements are each 50 µm by 100 µm and arc located on a 50 µm pitch down the length of the arrays. The two adjacent detectors in the cross dispersed direction form one spectral sample, This configuration was selected because: (a) it enhances sensitivity, (b) it provides a degree of redundancy to detector outages, and (c) it increases detector array yields. Two adjacent spectral samples in the dispersed direction form one spectral resolution element providing Nyquist sampling of the spectrum The PC: HgCdTc detectors in modules M 11 and Ml 2 arc in single arrays. Each detector is 35 µm by 800 µm and is located on a 50 µm pitch. There is no detector redundancy in the PC arrays. However, as with the PV arrays, two adjacent spectral samples provide Nyquist sampling for a spectral resolution element. The PC arrays have about 3.2 times the throughput of the PV arrays to improve system sensitivity.

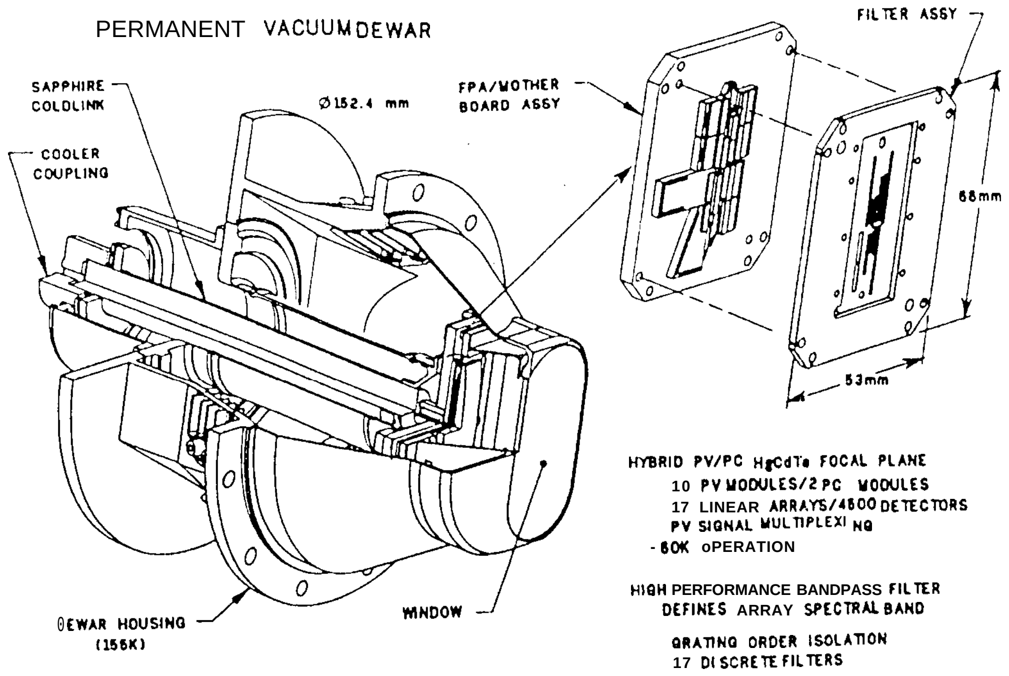


Figure 7. The AIRS focal plane assembly operates at 60K and is packaged in a permanent vacuum dewar to minimize on-orbit contamination. Thermal attachment to the FPA cryocooler is provided through a sapphire crystal rod with flex coupling.

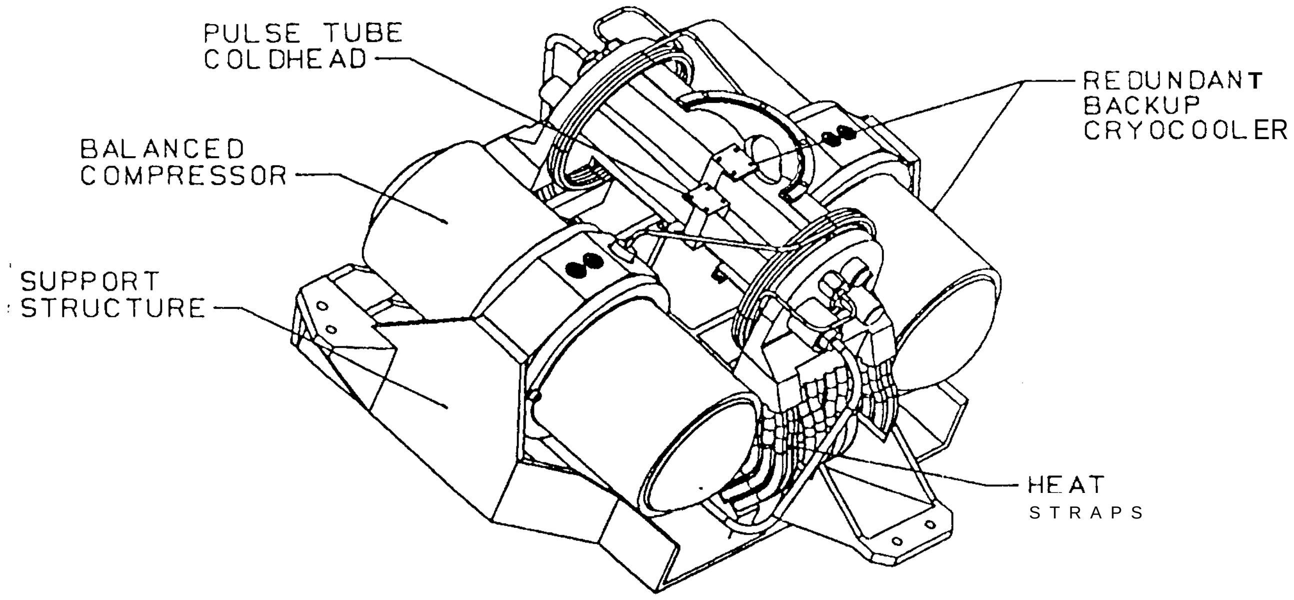


Figure 8. Focal plane cooling is provided by an advanced low vibration Stirling/pulse tube cryocooler arranged in a redundant configuration to ensure a 5 year operating life. The system provides 1.25 W net cooling at 55K with 100 W power input.

output from the cold **head on the focal plane assembly.** 'I'he pulse tube cold head is a more robust design than the Stirling cold head and can support larger loads. It is smaller in size and can be more easily packaged into the system.

The hardware elements associated with the AIRS cryosystem include the cryogenic coolers, associated support hardware, the thermal link coupling assembly between the cooler cold heads, and the focal plane assembly. Mechanically the two compressors are mounted on a common support structure which interfaces mechanically and thermally with the AIRS instrument. The two cold heads are mounted in a vacuum housing which also interfaces with the AIRS instrument mechanically and serves as part of a vacuum enclosure in the AIRS instrument for ground testing. Thermal straps arc used to transfer the heat generated by the cold heads to the AIRS instrument via the compressor support structure. The electronics arc mounted separate from the compressors on their own support structure and cooling plate. The interface between the cooler and the focal plane is provided by the thermal link coupling assembly. This assembly consists of a cold head mounting plate, a flexible copper braid, a thermal shrink fit coupling, and the dcwar sapphire cold link connecting rod. This assembly provides the required thermal heat transfer with a minimum temperature drop between the cooler and focal plane. It also provides ease of assembly and the capability to accommodate thermal contraction and environmental effects.

3.4 Signal and data processing electronics

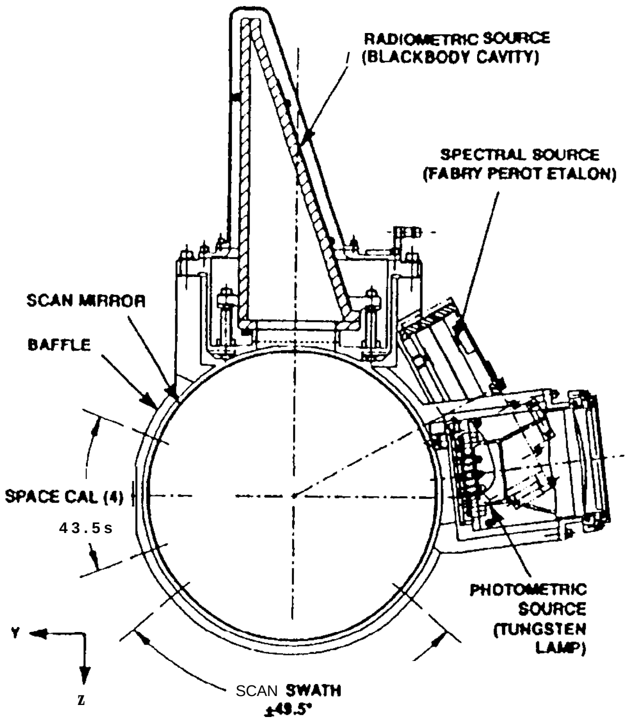
Because the photovoltaic (PV) detector readout circuits perform signal integration and multiplexing on the focal plane and the chopped photoconductive (PC) detector circuits do not, the signal processing of the PV and PC detector channels is slightly different. In the PV channels 26 high level analog outputs from the focal plane readout circuits are simply buffered, resampled, and multiplexed before being digitized by an analog-to-digital converter (ADC) with 12 bit resolution. Conversely, each of the 274 low level PC detector channels are hard wired to individual low noise preamplifiers located off the focal plane. The outputs of these preamplifiers are then integrated for periods roughly equal to the on focal plane integration periods of the PV detectors. The integrated outputs are then sampled and multiplexed before being combined with the PV detector data for digital conversion.

Following digital conversion, the detector data is combined into a single stream for signal processing. The PV and PC detector data arc processed similarly, except that PC detector data undergoes a subsample diffcrcncing operation to remove 1/f noise from the chopped signal, while the PV detector data is passed through a double differencing, radiation event circumvention algorithm. The two detector pixels which form each PV spectral sample arc then gain corrected to maximize signal-to-noise ratio and summed together. After addition of processed VIS/NIR photometric data and instrument housekeeping data, the data stream is formatted, buffered, and transmitted to the satellite platform at a 1.27 Mbps average rate on a high rate science data bus, All signal processing electronics arc dual redundant.

3.5 In-flight calibration

The AIRS Instrument has very demanding requirements on radiometric accuracy (<3% absolute), on spectral knowledge (<1% of the instrument resolution), and on spectral stability (<5% of the instrument resolution shift over a 24 hour period). In addition, there arc requirements to provide long term (< 1% relative) stability in the VIS/NIR photometer over the 5 year mission lifetime. These requirements have dictated that in-flight calibration sources be included in the AIRS instrument. These sources are located around the periphery of the scan head, as shown in Figure 9, and provide full field/full aperture spectral, radiomctric, and photometric calibration capability. The calibration sources, as well as four indcpcndcnt cold space views, can be observed during every 8/3 second scan period.

The primary spectral calibration is based on the precise knowledge of the spectral features in the upwelling radiance spectra. A Fabry-Perot plate is used as a transfer standard between arrays and functional testing when upwelling spectra are not available. The Fabry Perot etalon has a 750 μm plate spacing, and a rectangular clear aperture of 3.33 cm by 13.5 cm. An extended, thermally controlled, 330K source viewed through the etalon provides approximately 100 fixed spectral lines with signal-to-noise ratios in excess of 100:1 over the 3.7 μm to 1S.4 μm region. The etalon characteristics assure that at least three fixed spectral lines appear in each detector array.



End to end, full throughput calibration approach

Radiometric & Spectral calibrations every 2.67 s scan cycle

- Gain: **High stability,** deep cavity **BB**
- **Offset:** Space view
- **Spectral Fabry-Perot etalon cavity**

Vis/NIR photometric calibration once per orbit

- **Gain: Tungsten lamp, triple redundant**

Figure 9 In-flight IR radiometric and spectral calibration is provided every 2.67 second scan cycle via on-board blackbody and Fabry Perot etalon sources. VIS/NIR photometric calibration is provided once per orbit via an incandescent lamp.

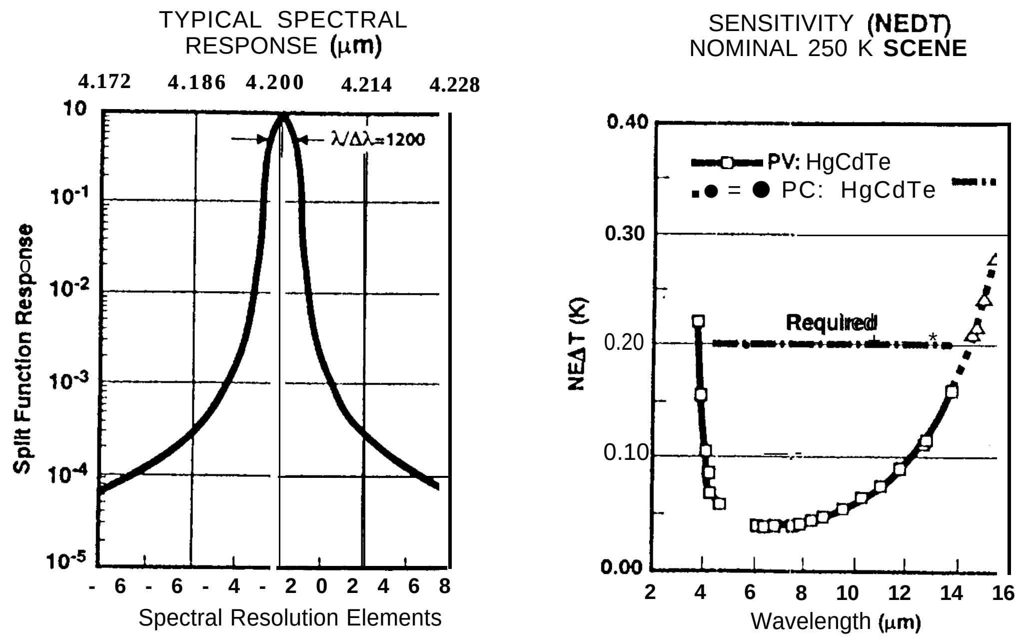


Figure 10 Instrument slit function response and IR **sensitivity** (NEAT) projections are based on detailed system modeling, analyses and measurement of prototype components.

The radiometric calibrator is a deep cavity blackbody design with a rectangular 5.7 cm by 9.5 cm clear aperture. The depth of the blackbody cavity is two times the diagonal of the clear aperture. The blackbody housing and cavity are beryllium, and the cavity is painted to maintain a high emissivity specular surface. The end of life emissivity is expected to be no lower than 0.993. The blackbody is temperature controlled to 3 10K using tailored tape heaters to maintain temperature uniformity to O. lK. Multiple, redundant, temperature sensors monitor the temperature distribution over the cavity surface every scan period to an accuracy of 40 mK.

The photometric calibrator uses triple redundant tungsten lamps behind a collimating mirror and a diffuser screen to provide a uniform illumination for the VIS/NIR photometer. A photodiode detector mounted in the scanner housing monitors the diffuse output from the calibrator. The photodiode signal provides the reference signal for the long term relative calibration of the VI S/NIR photometer. While photometric calibration could be performed as frequently as every scan period, the expected photometric calibration period is once every 100 minute orbital period.

4. AIRS PERFORMANCE PREDICTIONS

Two key performance parameters for the AIRS Instrument are its spectral response and its sensitivity. The spectral response of the AIRS Instrument establishes the spectral resolution which can be applied to the atmospheric radiance measurements. Achieving an instrument spectral resolution ($\lambda/\Delta\lambda$) of 1200 is necessary to achieving the science requirement of 1 km spatial layer resolution in the atmosphere. AIRS has been designed to provide an instrument spectral resolution greater than 1200 in the two C02 temperature sounding bands at 4.2 μm and 15.0 pm. The AIRS spectral response function for a wavelength of 4.2 μm is shown in Figure 10. This response function meets the AIRS requirements of 50'% energy within ±0.5 resolution clement, 95% energy within ±1 resolution clement. The wing response is so low that the integrated response from all wavelengths more than 6 resolution elements from the function's center contributes, under worst case conditions, less than one instrument NEAT to the inband measured brightness temperature.

Achieving a noise equivalent temperature difference (NEAT) of less than 0.2K at wavelengths shorter than 13.4 μm and less than 0.35K at longer wavelengths is instrumental in achieving the overall science objectives of determining atmospheric temperatures to a 1K accuracy. Emphasizing the importance of this objective, the required NEAT in the critical 4.2 μm C02 temperature sounding band is O. 14K. All of these NEAT requirements are referenced to a scene temperature of 250K. The projected ability of the AIRS Instrument, as of August 1995, to meet these sensitivity requirements is shown in Figure 10. These projections are based on extensive modeling of the AIRS Instrument, supported with measurement of bread-board components or technology demonstration models of all order isolation filters, the dewar window, the chopper, PV detector arrays, PC detector arrays and the Sterling/pulse tube cryocooler. All sensitivity requirements are currently being met at all wavelengths except at 3.74 μm where excessive l/f noise in signal starved readout circuits on the focal plane has had an adverse impact.

5. SUM MARY

The AIRS Instrument represents a major advance in passive IR remote sensing technology . AIRS will provide new and more accurate data about the atmosphere, land and oceans for application to climate studies and weather prediction, AIRS, along with AMSU and MHS, is expected to play a key role in fulfilling the future operational sounding needs of the converged U, S. Meteorological Systcm, NPOESS.

6. ACKNOWLEDGEMENTS

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