JPL AIRBORNE INSTRUMENTS ACTIVITIES

AN OVERVIEW

Gregg Vane

Two instruments intended for flight aboard aircraft for research in advanced remote sensing of the earth are under development at JPL: the Airborne Imaging Spectrometer (AIS) and the Airborne Visible-Infrared Imaging Spectrometer (AVIRIS). The AIS utilizes a Rockwell 32 x 32 element HgCdTe CCD array to gather 10nm spectral data, initially in the 1.2 - 2.4μm range, with 32 pixels of cross-track spatial data. The instrument acquires 128 channels of spectral data by using a grating spectrometer whose grating is stepped through four positions during a fraction of an IFOV time on the ground. With an IFOV of 2 mrad, the GIFOV at the design altitude of 3 km is 6m. The instrument has several on-board processing capabilities including ax+b corrections for detector calibration, cross-track and down-track pixel summing, spectral band summing, and variable integration time to allow flight at various altitudes and velocities. Flights are planned for September 1982, over the Coaldale Mining District, Nevada in a mineral identification study, and in November 1982, over the Pico Anticline area, Los Angeles County, California in a geobotany study. Because the detector array used has a cutoff wavelength of 4.5μm, the instrument can potentially be reconfigured to cover the mid IR region as well.

The AVIRIS instrument concept is an outgrowth of the study by Vane, Billingsley and Dunne appended at the end of this paper, in which leaders of the various remote sensing research communities were asked for their appraisal of spectral and spatial resolution needs for the next generation of spaceborne systems. The fundamental conclusion of that study was that while there are promising, and in many cases proven uses for high

spectral and spatial resolution data, the data base itself is too limited to specify which combinations of spectral bands and IFOVs will provide the optimum data sets within the constraints of data transmission, handling and storage capabilities to be available by the time such a spaceborne system might be launched. Hence there is a considerable need for such a data set at this time, to allow such trade-off studies to be made in a systematic manner.

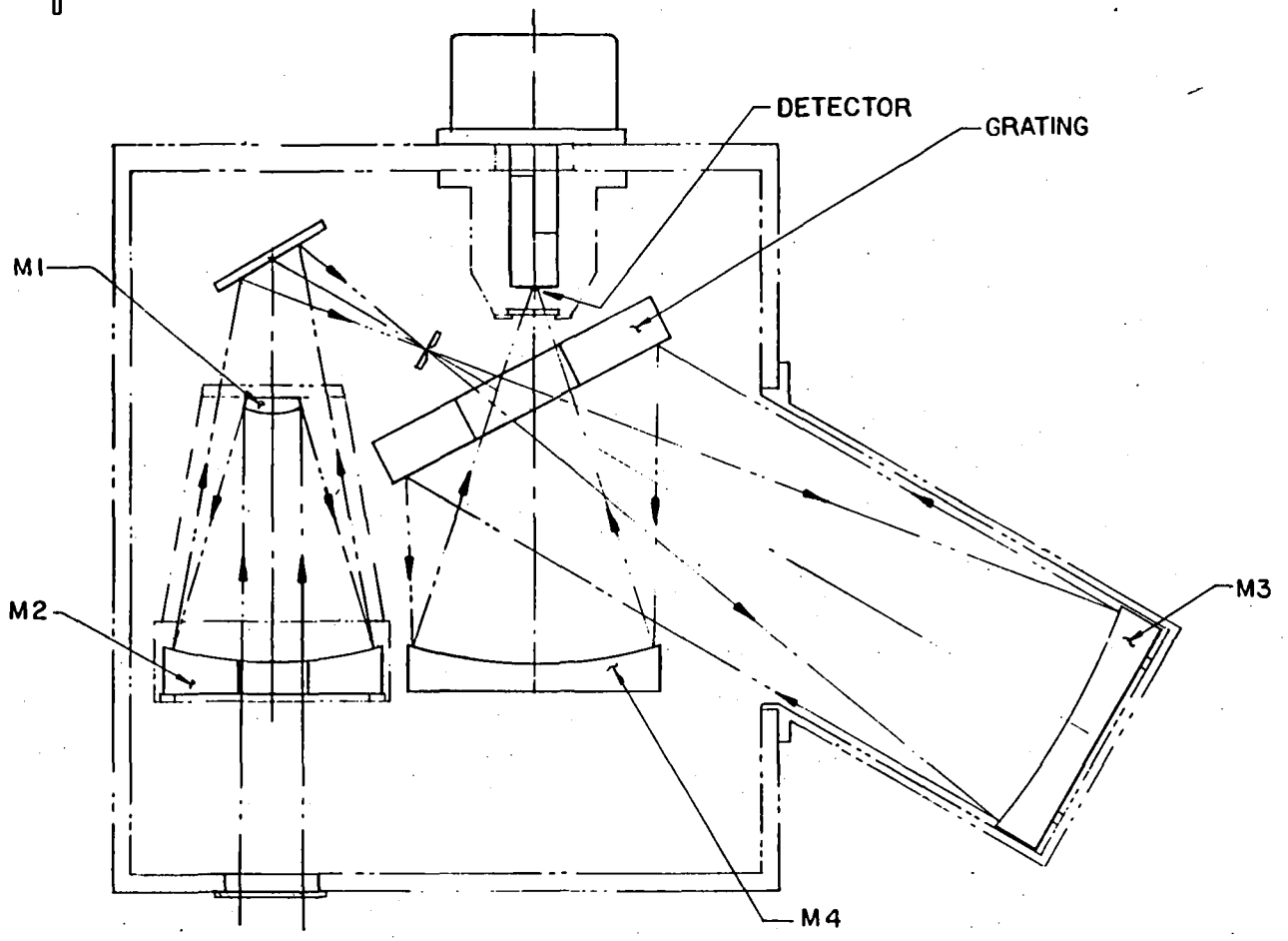
The purpose of AVIRIS then is to gather data, as distinct from demonstrating advanced technology. Hence its design is conservative, using off-the-shelf technology. The heart of the instrument design is the InSb line array detectors made by Cincinnati Electronics, for the short wavelength infrared. Area array technology is not sufficiently well developed yet to make it an option for AVIRIS, whereas the line arrays made by CE are extremely stable, linear in response, and are readily available. Indeed, it is the availability of such detectors that make such an instrument concept possible at this time. For the visible portions of the spectrum silicon reticon line arrays are equally well-developed.

With the existence of high quality line arrays in the visible and SWIR, the design of choice for AVIRIS uses a proven scanning mechanism to acquire the spatial data in a whisk broom mode, obviating expensive and difficult to build wide angle optics. The line arrays are oriented in the spectral direction at the focal plane of a spectrometer, covering the entire spectrum from 0.35 to 2.5 μm at bandwidths ranging from 10 to 20nm. The instrument IFOV is 0.5 mrad giving a GIFOV of 5m at the design altitude of 10km. Variable integration time is provided to permit flying higher or lower than this for atmospheric studies or for a more stable platform (e.g., the ER-2). The scan angle is 60 degrees so that data can be collected for the assessment of off-nadir viewing. Finally, because InSb has a cutoff wavelength of 5.2 μm, the instrument can be configured to acquire spectral data in the mid IR. Instrument design activities are currently underway at JPL and a proposal will be submitted to NASA in August 1982.

AIRBORNE IMAGING SPECTROMETER (AIS)
INSTRUMENT DESCRIPTION

• DETECTOR:	ROCKWELL 32 x 32 HgCdTe CCD
• TELESCOPE OPTICS:	F/3 SCHWARZCHILD CONCENTRIC OBJECTIVE WITH 70.7 mm EFL
• SPECTROMETER OPTICS:	SLIT - 4.23 mm x 142.24 μm
	COLLIMATOR - 300 mm EFL F/3 PARABOLOID
	GRATING - 42 G/mm, BLAZE 1.05-3.16 μm
	CAMERA - 150 mm EFL F/1.5 PARABOLOID
• ELECTRONICS:	AX + B CORRECTION ALGORITHM FOR EACH PIXEL WITH UPGRADING TO MORE SOPHISTICATED ALGORITHM IF NECESSARY
	CROSS-TRACK AND DOWN-TRACK PIXEL SUMMING
	SPECTRAL BAND SUMMING
	VARIABLE INTEGRATION TIME

AIRBORNE IMAGING SPECTROMETER (AIS)



AIRBORNE IMAGING SPECTROMETER (AIS)
OBSERVATIONAL CAPABILITIES

• SPECTRAL RANGE:	1.2 - 2.4 μm
• SPECTRAL BANDWIDTH:	9.6 nanometers
• SPECTRAL CHANNELS:	128
• IFOV:	1.9 mrad
• GIFOV AT 3 km:	5.7 meters
• SWATH WIDTH AT 3 km:	183 meters
• DATA RATE:	100 kbps IN EACH OF 4 CHANNELS

AIRBORNE IMAGING SPECTROMETER (AIS)
FLIGHT OPERATIONS FOR 1982

SEPTEMBER	AIRCRAFT:	C130, AMES
	ALTITUDE:	15,000 feet
	GIFOV:	8 meters
	AREA:	COALDALE MINING DISTRICT, NEVADA
	APPLICATION:	GEOLOGY - MINERAL STUDIES
NOVEMBER	AIRCRAFT:	DC3, DRYDEN
	ALTITUDE:	7,500 feet
	GIFOV:	4 meters
	AREA:	PICO ANTICLINE, LOS ANGELES COUNTY
	APPLICATION:	GEOBOTANY

AIRBORNE VISIBLE – INFRARED IMAGING SPECTROMETER
(AVIRIS)

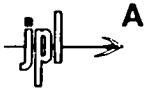
PROGRAM OBJECTIVES

- EXPLORE THE UTILITY OF HIGH SPECTRAL AND SPATIAL RESOLUTION DATA AND DEVELOP NEW EXPERIMENT METHODOLOGIES FOR USING THESE DATA
- PROVIDE HARD EXPERIMENTAL GUIDANCE FOR FUTURE OBSERVATIONAL REQUIREMENTS FOR SPACEBORNE SENSORS. SPECIFICALLY:
  - ESTABLISH OPTIMUM SPECTRAL CHANNELS FOR THE MAJOR REMOTE SENSING DISCIPLINES
  - ESTABLISH THE EFFECTS OF SPATIAL RESOLUTION ON SYSTEM PERFORMANCE.
  - ASSESS THE EFFECTS OF OFF-NADAR VIEWING.
  - ASSESS THE EFFECTS OF THE ATMOSPHERE ON SYSTEM PERFORMANCE.

AIRBORNE VISIBLE – INFRARED IMAGING SPECTROMETER
(AVIRIS)

PROGRAM FUNCTIONAL DESCRIPTION

- AS A RESEARCH INSTRUMENT DEDICATED TO ACQUIRING DATA, AVIRIS IS DESIGNED FOR MAXIMUM RELIABILITY, USING PROVEN TECHNOLOGY
- AVIRIS IS A SCANNING INSTRUMENT USING SILICON AND INDIUM ANTIMONIDE LINE ARRAYS TO COVER THE 0.4 TO 2.5 μm REGION
- THE INSTRUMENT WILL PROVIDE IN-FLIGHT CALIBRATION
- AVIRIS WILL BE CAPABLE OF OPERATION AT SEVERAL ALTITUDES
- DATA PROCESSING PLANS WILL BE GENERATED IN ADVANCE TO PROVIDE 4-8 WEEK DATA OUTPUT IN A FORMAT USEABLE AT THE RESEARCHER'S HOME INSTITUTION



AIRBORNE VISIBLE – INFRARED IMAGING SPECTROMETER
(AVIRIS)

INSTRUMENT DESCRIPTION

INSTANTANEOUS FIELD OF VIEW	0.5 mrad
DESIGN ALTITUDE	10 km
GROUND IFOV AT 10 km	5 meters
SCAN ANGLE	60 degrees
SWATH WIDTH AT 10 km	11.5 km
NUMBER OF BITS PER PIXEL	8
SPECTRAL COVERAGE	0.35-2.55 μm
SPECTRAL BANDWIDTH	10-20 nm
NUMBER OF SPECTRAL CHANNELS	170
DATA RATE AT 200 knots, 10 km ALTITUDE	55 Mbps

AIRBORNE VISIBLE – INFRARED IMAGING SPECTROMETER (AVIRIS)

SPECTRAL COVERAGE

SPECTRAL BAND (micron)	SPECTRAL RESOLUTION (nm)	# OF SPECTRAL CHANNELS	DETECTOR MATERIAL	NEdR %
0.35 - 0.70	10	35	Si	0.5
0.70 - 1.00	10	30	Si	0.5
1.00 - 1.40	10	40	InSb	1.0
1.40 - 1.85	15	30	InSb	1.0
1.85 - 2.55	20	35	InSb	1.5