N90-28265

HIGH RESOLUTION INFRARED MEASUREMENTS

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Sample ground-based cloud radiance data from a high resolution infrared Sensor are shown and the Sensor characteristics are presented in detail. The Sensor was funded by NSWC and is dedicated to the Navy's Infrared Analysis Measurement and Modeling Program (IRAMMP) sponsored by ONT. The purpose of IRAMMP is to establish a deterministic radiometric data base of cloud, sea and littoral terrain clutter to be used to advance the design and development of Infrared Search and Track (IRST) systems as well as other infrared devices. The Sensor is a dual band radiometric Sensor and its description, together with that of the Data Acquisition System (DAS), are given in Tables I and II. The Data Acquisition System was designed by NRL and built by Telenetics of Seabrook, Maryland under NRL direction. Its characteristics are described in Table III.

A schematic diagram of the Sensor optics is shown in Figure 1. The optics are a three mirror all reflective system; off-axis, nonspherical surfaces are used to provide good area coverage in the focal plane. The scan mirror is external to the optics assembly which is sealed off from the outside environment by a ZnSe plate. The sealed off optics section is kept at a slight overpressure by exhausting the used dry nitrogen gas used for the J-T cryogenics for the Dewar/detector assemblies. The only other transmissive optical component is a dichroic beamsplitter to separate the 3-5 μm and 8-12 μm radiation. Athermal optics is achieved by using an all aluminum structure for the optical bench and the mirrors.

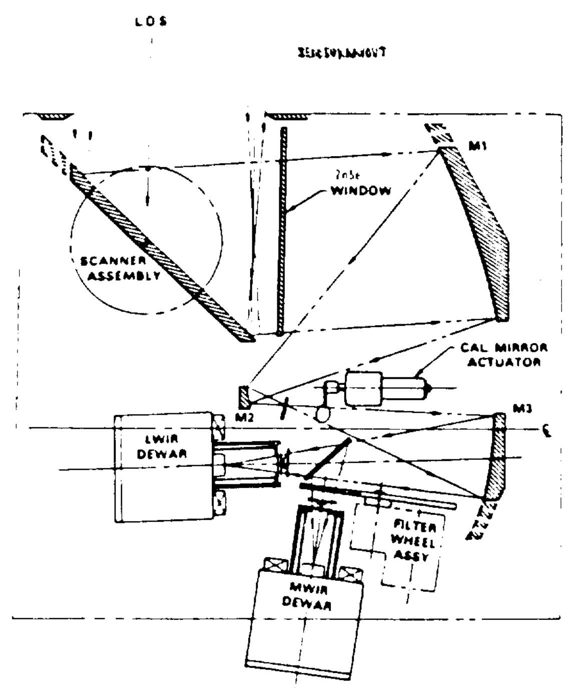

Figure 1

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Table I
Sensor Description

Feature	Description
Dual Window IR operation	nominal 2-5 μm (MWIR) and 8-12 μm (LWIR)
Telescope Aperture	4.2"
f/#	f/3.2
IFOV (AZ.xEL.:mrad)	0.22 x 0.23
Dwell Time	370 μsec
TFOV	
narrow TFOV (AZ)	5 5/8^o
wide TFOV (AZ)	22.5^o
narrow TFOV (EL)	1.6^o
wide TFOV (EL)	3.2^o
Detector crosstalk between channels	<-27db
AZ Scan Rate	33.4^o/sec or 17.4^o/sec
Revisit Time (5 5/8^{o}AZ x 1.6^{o}EL. at 33.4^o/sec scan)	3.5/sec
Sensor Head Weight	80 lbs.
Focal Plane Array Compatibility	Modular Dewars
Detectors	
No. detectors/waveband	120
Detector Size	3 mils x 3 mils
1/f noise shoulder	
MWIR (HZ)	0.4
LWIR (HZ)	300
NEΔT at 33.4^o/sec scan speed	
MWIR	0.047C^o
LWIR	0.032C^o
NEI (W/cm^2)	
MWIR	$2.7 \times 10^{-14} \pm 10\%$
LWIR	$2.7 \times 10^{-13} \pm 10\%$
Detector and Electronics	
Dynamic Range	84db
Pixel Registration	
Single Color	<0.3 x IFOV
Color-to-Color	<0.3 x IFOV
Detector Array	120 detectors, staggered, contiguous
D* Detectivity	MWIR $\simeq 8 \times 10^{10}$ LWIR $\simeq 3.2 \times 10^{10}$
6 Selectable Spectral filters in MWIR	YES
Samples/dwell	3.25
Azimuth Shaft Encoder	18 bits; incremental
Scan Linearity	1/8 IFOV per 4^o of AZ. Scan
Scan Mirror Drive	Digital serve control system
Radiometric Absolute	better than 5%
Repeatability	better than 3%
Temperature Range to be measured	
3-5 μm	270^{o}K to 450^{o}K
8-12 μm	220^{o}K to 700^{o}K

Table I -- Continued
Sensor Description

Feature	Description
Electronics	
Dynamic Range	84db
Video bandpass (3db)	
MWIR	0.0 to 2500 HZ
LWIR	0.4 to 2500 HZ
Cold Shielding	
Geometric Re-imaging cold shielding	>95% effective

Figure 2 is a photograph of the Sensor head.

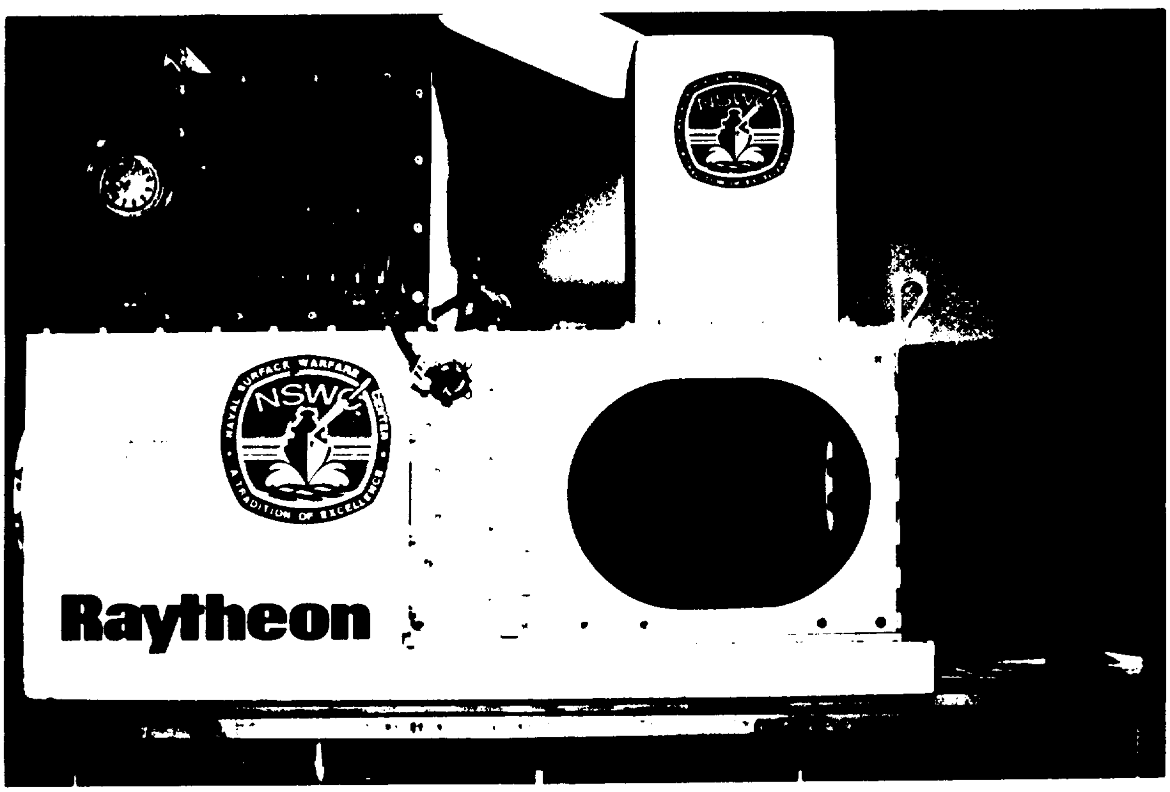

Figure 2

Table II
MWIR Spectral Bandpass Filters

Filter No	Cut-On (microns)	Cut-Off (microns)	% T
1	1.96	6.15	80
2	2.21	2.45	77
3	2.98	5.05	87
4	3.45	4.18	79
5	3.79	4.87	92

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Table III

DAS(NRL)

Sensor Inputs	DAS Action
analog: -10v to +10v(LW)	Digitized to 15 bits
0v to +10v(MW)	Digitized to 14 bits
rms noise ≃ 0.0007v	1 bit = 0.00061v
	Digitization rate is 8800 128-word samples/sec
digital:	
scan mirror shaft position	15 bits recorded, 1 bit = 47.937 μr (average) of optical scan angle
housekeeping	recorded in header words (see attached sheet) Digital time (to 0.1ms) obtained from time code generator Synchronization words put in header for recognition at playback
Sample clock	8800 HZ.
Angular spacing of sample	0.0664 mr/sample
Samples per detector for 5.6^{o} picture = 1480	
Total data for each 5.625^{o}picture	380 kB
Data rate	4.5 MB/sec
One HDDR tape	30 minutes of real time data 60 standard 9-track tapes (6250 ips)
Bit error rate (BER)	10^{-8} to 10^{-9}
NRL "Quick-Look"	To examine data base in the field (VAX 11725)
Data Base Management System (DBMS)	Questech Incorporated

The point response function for the Sensor is shown in Figure 3. The sampling resolution is 0.0664 mr. It can be seen that the half power full width is approximately 3.6 samples in LWIR and 3.9 in MWIR. Since there are 3.25 samples/dwell the resolution is 3.6/3.25 = 1.1 IFOV for LWIR and 3.9/3.25 = 1.2 IFOV in MWIR. This translates into 1.1 x 0.22mr = 0.24mr LWIR and 1.2 x 0.22mr = 0.26mr MWIR.

Figure 4 shows a sample "carpet plot" of cloud radiance against azimuth using the new IRAMMP Sensor. Results of a fractal characterization analysis of similar data, taken by a similar, progenitor Sensor under the older, Navy Background Measurement and Analysis Program (BMAP) are given elsewhere at this meeting.[1]

1 Patricia H. Carter and Robert Cawley, "Fractal characterization of infrared cloud radiance", ASTEX Workshop, Monterey, 12 July, 1989.

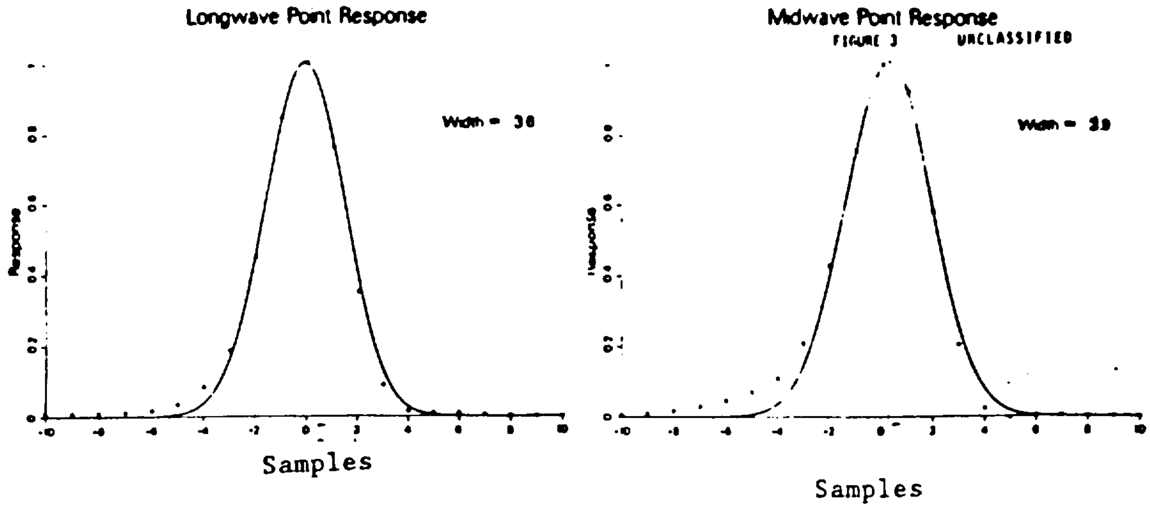

Figure 3

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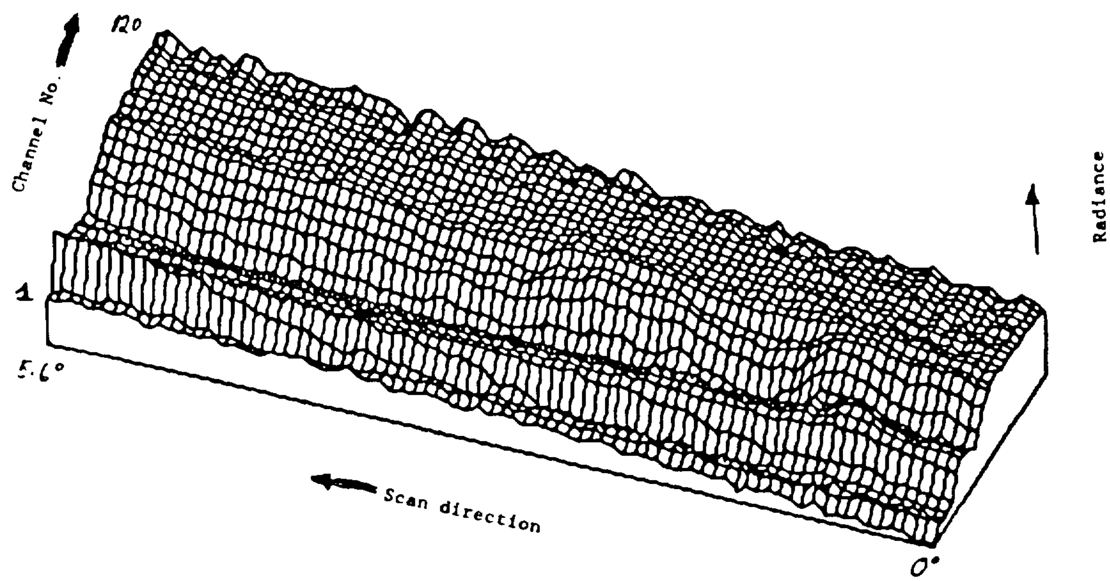

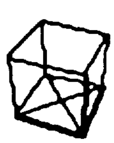

Carpet Plot of Cloud; MWIR (New IRAMMP Sensor)

Figure 4