MODIS-N

MODIS-N, MODIS-T, HIRIS

TO: Jeff Child 7.16.90 FR: RAVI KUMAR

Moderate-Resolution Imaging Spectrometer-Nadir/Tilt

* MODIS-T is an imaging spectrometer with in-track tilt capability
* MODIS-N is an imaging spectrometer with no tilt capability
* Heritage: AVHRR, HIRS, Landsat TM, Nimbus 7 CZCS
* Both measure biological and physical processes
* A table of instrument characteristics and measurement parameters is given in the Appendix.

MODIS is divided into two components. One component is a nadir-scanning (110 degrees scan angle) instrument called MODIS-N (nadir) with a swath width of 2,330 km at an altitude of 705 km. The instrument is presently being designed to have 36 bands (10 to 500 nm bandwidths) supporting observations of the land surface, oceans and atmosphere in the visible (0.4 - 0.7 um), near infrared (0.7 - 1.0 um), short wave infrared (1.0 - 3.0 um), and thermal infrared (3.0 - 14.2 um). It has pixel sizes of 214 m, 428 m and 856 m. MODIS-N is expected to have a mass of 200 kg, data rates of 12.6 Mbps and 2.8 Mbps during the day and night respectively; and requires 250 watts of power. MODIS-N is baselined for the EOS-A polar platform.

Main objectives of MODIS-N include global measurements of surface temperature (land and ocean), ocean color (sediment,

phytoplankton, global vegetation maps, global change (deforestation and desertification), cloud characteristics, properties and concentration of aerosols, temperature and moisture soundings, snow and ice cover characteristics and ocean currents.

MODIS-T is scanning imaging spectrometer for the measurement of biological and physical processes on a 1.1 km x 1.1 km scale with emphasis on the studying oceans. It is a scanning instrument covering a 1,500 km swath centered at nadir, with a 50 degrees tilt (fore and aft along the satellite track) capability for sun-glint and the examination of the bidirectional reflectance distribution function (BRDF) of large homogeneous targets. It has a spectral range of 0.4 to 0.88 um divided into 32 bands. Daylight is 0.4 of the orbit and duty cycle is 100 percent of daylight. MODIS-T has a mass of about 149 kg, data rate of 3 Mbps, and requires 90 watts of power on the average and 150 watts at peak. MODIS-T is baselined for the EOS-A polar platform.

Absolute radiometric accuracy requirements, REQT (one sigma) for MODIS-N and MODIS-T are: up to 3000 nm = 5% ; Above 3000 nm = 1% ; Reflectance calibration = 2% .

MODIS-T is expected to operate in the composite mode where it will meet Phase C/D SNR (Signal-To-Noise) Specifications for a scene having both land and water pixels. This will be achieved primarily by varying the photodiode and CCD (Charged Coupled Device) width depending upon the number of

phytoplankton, global vegetation maps, global change (deforestation and desertification), cloud characteristics, properties and concentration of aerosols, temperature and moisture soundings, snow and ice cover characteristics and ocean currents.

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electrons generated and by using dual gains at the input to the A/D (Analog-To-Digital) converters.

Main objectives of MODIS-T include global measurements of chlorophyll concentration, primary productivity, sediment transport, standing water, wetland extent, vegetation properties, hemispherical albedo, bidirectional reflectance, cloud properties and aerosol radiance.

Tables of MODIS data products that can be expected to be produced at or near launch as well as post launch have been prepared. These tables have also been compiled in a table containing all the products to be expected from the EOS facility instruments. Where the same or very similar geophysical parameter is being observed, this table readily permits comparisons of the accuracies, frequency and extent of coverage for the data product.

MODIS will play a major role in responding to the needs of the Earth Sciences community as described in the attached pages.

MODIS will be extremely valuable in complementing data received from other EOS facility instruments like HIRIS, ITIR and AIRS/AMSU and cross-calibrating HIRIS and ITIR.

A Tropical Region Imaging Spectrometer (TRIS) is a modified copy of MODIS-N and -T in the equatorial orbit that has been

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A Tropical Region Imaging Spectrometer (TRIS) is a modified copy of MODIS-N and -T in the equatorial orbit that has been

approved for concept study on the manned Space Station. William Barnes, Goddard Space Flight Center, is the PI for that effort. This would provide an exciting opportunity to extend the critical EOS/MODIS data set to include diurnal effects and would enable unique multi-angle studies of hemispherical reflectance that would otherwise be unavailable to EOS.

ER: RATI

High-Resolution Imaging Spectrometer

* Pointable pushbroom imaging spectrometer with area array
* Heritage: AIS I and II, AVIRIS
* Provides high spectral and spatial resolution images of Earth
* Can sample any point on the Earth's surface a minimum of every two days

HIRIS is an imaging spectrometer facility instrument that provides both high spectral and spatial resolution images of the Earth and can sample any point on the surface at a minimum of every two days. The reflected solar energy comes from the target and goes through the optical system (pointing mirror ,objective lens, entrance slit, collimator, dispersing element, imaging optics) to arrive at area array. HIRIS covers the 0.4 to 2.45 um wavelength region in 192 spectral bands (64 channels in the Visible and Near Infrared and 128 channels in the Shortwave Infrared Wavelength Region). Nominal spectral sampling is 10 nm and is as uniform as possible over the entire spectral range. It has a pixel size of 30 m and a swath width of 24 km (about 2 degrees) at nadir for EOS platform altitude of 705 km. HIRIS has a mass of 450 kg and requires 300 W of average power and 600 watts of power at the peak. Maximum output data rate of HIRIS is 100 Mbps.

The main objectives of HIRIS in various disciplines include: (a) Atmospheric: developing correction algorithms to account for scattering and water vapor absorption; map total column water vapor and accurately determine cloud -radiative parameters. (b) Land/Vegetation: vegetation chemistry related to underlying ecosystems functions such as carbon allocation, decomposition and biogeochemical cycling; monitor physiological and structural changes in the forested and shrubland ecosystems. (c) Land/Water:to model spatial and temporal distributions of rates of snow metamorphism and melt and determine optical properties of snow and ice.

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1. Change Detection/Scaling: HIRIS is suitable for investigation of processes and mapping at scales compatible with the field investigations. HIRIS can be used to examine the changes that occur in transport of nutrients, sediments,

and other solutes to wetlands, rivers, lakes and oceans. HIRIS can detect changes in both processes and Earth surface characteristics at a fine spatial scale before the same changes can be seen with a coarser-resolution sensor. In addition, spatially-hetrogeneous fluxes of radiatively important gases, including water vapor, can be inferred.

2. Energy Fluxes/Clouds: Clouds play a central role in the Earth's radiation budget and in the feedback mechanisms associated with atmospheric dynamics and polar processes. HIRIS will provide, at high spatial resolution, measurements of bidirectional reflectance, cloud heights, thickness, type, three-dimensional structure, thermodynamic phase, and effective droplet and crystal size distributions, to help address these questions.

3. Energy Fluxes/Snow and Ice:
HIRIS can measure energy fluxes over the snow cover and glaciers on Earth's mountain ranges and polar regions. It will thus contribute to the measurement of changes in the global energy budget, detect early signals of changing regional climates, and help measure the changes in the global distribution of snow and ice that contribute to changing sea levels.

4. Productivity and Nutrient Cycling/Oceans and Freshwater:

HIRIS can detect changes in processes and water surface characteristics long before they would be seen with a coarser resolution sensor. HIRIS will resolve phytoplankton patches on scales of tens to hundreds of meters; this small scale variability is an important determinant of food web structure and trophodynamics which ultimately control the flux of carbon in the ocean. HIRIS will be used to infer the flux of riverine nutrients, sediments and other solutes at the land-water interface (estuaries, bays, and beaches).

5. Terrestrial Ecosystem Chemical Composition and Structure: HIRIS will provide data on terrestrial ecosystem chemical composition and structure with sufficient spatial and spectral detail to enable quantification of mass and energy exchanges with the atmosphere and hydrosphere, such as the processes of primary productivity and nutrient cycling. HIRIS' high resolution and multidirectional pointing can be used to estimate chemical composition of vegetation canopies, ecosystem structure, and hemispheric albedo.

6. Geological Processes: HIRIS is ideally suited to observe active geological processes as well as to provide insight into the Earth's history. HIRIS is uniquely designed to observe eolian processes that result in trace nutrients being added to the oceans, volcanic eruptions which affect atmospheric particle loading, and the source and extent of stabilized dune deposits that are important in understanding

climates of the recent past. Present day Earth surface geology contains the record of past climate and can be used to validate global climate model predictions using "backward prediction".

HIRIS will be extremely valuable in complementing data received from other EOS facility instruments like MODIS-N, MODIS-T, ITIR and cross-calibrating them and validating many of the data products produced by them.

Survivability: 95% probability of successful on-orbit operation 5 year on-orbit mission following TITAN IV Launch

Nominal line integration time = 4.42 msec
Polarization < 2% of the signal

HIRIS

HIRIS Parameters

Mass = 450 to 600 kg
Instrument duty cycle = 8%
Average power = 300 W
Peak power = 600 W (≤ 8% duty cycle)
Heater power = TBD
Passive thermal control
Thermal operating range:
Infrared detector = 130 K Structure and optics = 300 K
Visible detector = 300 K Electronics = TBD
Average data rate = 3 Mbps (≥ 1 week)
= 10 Mbps (worst case 2 orbits)
Peak data rate = 100 Mbps (peak buffered output, including editing and compression)

band to band registration knowledge = 0.2 pixels

Pointing requirements (instrument + spacecraft):
control = 293 arcsec (3 sigma total)
knowledge = 117 arcsec (3 sigma total; pending final science team approval)
stability = ~~2.04~~ 2.64 arcsec per 35 ms, 9 arcsec per 34 seconds (3 sigma total)
Instrument view angle = +52° to -30° along-track; ±45° cross-track
Instrument IFOV = 30 m (projected FOV = 24-km cross-track by 30 m down-track, projected at nadir)
Sensitive to contamination: optical and radiator surfaces provided with protective covers
Physical size: 48" x 36" x 91"

Calibration Science Requirements:
Radiometric: 5% absolute (1% goal), 0.5% band to band
Stability: ± 0.5% over 800 line times
Spectral: ± 2 nm

Team Leader

Alexander Goetz

Alexander Goetz holds degrees in physics, geology, and planetary science from the California Institute of Technology; from 1970 to 1985, Dr. Goetz was affiliated with that institution's Jet Propulsion Laboratory. Presently, he is a Professor in the Department of Geological Sciences and Director of the Center for the Study of Earth from Space/CIRES at the University of Colorado. His current scientific interests include applying remote sensing techniques to a wide range of scientific disciplines, including geology, hydrology, ecology, and atmospheric science. He also develops new instrumentation for field application of remote sensing techniques.

Dr. Goetz has spent over 20 years as a Principal Investigator for flight instruments and data analysis projects in various NASA programs including Apollo, Landsat 1, Skylab, and the Space Shuttle. He served as Imaging Spectrometer Program Manager for JPL for 2 years and, as such, developed the concepts for the airborne and spaceborne imaging spectrometers. He was the Principal Investigator for the Shuttle Imaging Spectrometer Experiment, which, although it did not fly, formed the basis for the HIRIS concept. From 1984 to 1987, he chaired the Imaging Spectrometer Science Advisory Group, which developed the requirements for SISEX and HIRIS.

Dr. Goetz's other activities mirror these interests. In addition to being well-published in the current literature, he serves on several advisory boards for the National Research Council; has consulted with private industry both in the U.S. and abroad; has taught an independent short course in advanced remote sensing for geologists and geophysicists; holds four spectral instrument patents; is an associate editor for two journals; and has received numerous performance and special achievement awards.

Team Members

John Aber, University of New Hampshire
Kendall L. Carder, University of South Florida
Roger Nelson Clark, U.S. Geological Survey
Curtiss O. Davis, Jet Propulsion Laboratory
Jeff Dozier, University of California, Santa Barbara
Siegfried Gerstl, Los Alamos National Laboratory
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MODIS-T Parameters

Mass = ~~~140~~ 149 kg
Instrument duty cycle = 100% (day only)
Average power = ~~~130 W~~ 90 W
Peak power = ~~135 W~~ 150 W
Heater power = 22.6 W
Thermal control by cold plate
Thermal operating range = 5°C to 25°C
Average data rate = 1.4 Mbps
Peak data rate = 3.5 Mbps (40% duty cycle, daytime only)
Pointing requirements (spacecraft + instrument):
- control = 95 arcsec (3 sigma)
- knowledge = 60 arcsec (1 sigma)
- stability = 15.6 μrad

Instrument view angle = 90°, ± 45° (1500 km) cross-track
±50° in-track tilt centered at nadir
Instrument IFOV = 1.56 mrad (1.1 km)
Optics have moderate contamination sensitivity
Physical size = 75 cm x 140 cm x 100 cm

MODIS-N Parameters

Mass = ~200 kg
Instrument duty cycle = 100%
Average power = 250 W
Peak power = 262 W
Heater power = 3 W
Passive thermal control
Thermal operating range = +5°C to 25°C
Night ~~Average~~ data rate = ~~11.4 Mbps~~ 2.8 Mbps
Daytime ~~Peak~~ data rate = ~~[illegible]~~ 12.6 Mbps (daytime, 40%)
Pointing requirements (spacecraft + instrument):
- control = 95 arcsec (3 sigma)
- knowledge = 60 arcsec (1 sigma)
- stability = 15.6 μrad

Instrument view angle = 100°, ± 55° (2330 km) cross-track, fixed at nadir
Instrument IFOV = 1.21 mrad (856 m), 0.607 mrad (428 m), 0.303 mrad (214 m)
Optics and passive cooler have moderate contamination sensitivity
Physical size = 1 m x 1.6 m x 1 m

Team Leader

Vincent V. Salomonson

Vincent Salomonson has over 25 years of experience in the fields of meteorology, agricultural engineering, atmospheric science, and hydrology. He was awarded a Ph.D. in atmospheric science from Colorado State University in 1968, the year he joined GSFC. He was recently appointed Director for Earth Sciences at GSFC.

Dr. Salomonson brings substantial experience to his role as Team Leader of MODIS. He has functioned informally and formally as the MODIS Team Leader for the past 4 years. He also has over a dozen years experience as the Landsat 4 and 5 Project Scientist, including the leadership and management of the Landsat Image Data Quality and Analysis (LIDQA) Investigator Team and Thematic Mapper Research in the Earth Sciences Investigator Team. Additional experience includes over 15 years as a line manager of research groups at GSFC and the leadership of the NASA Water Resources Subdiscipline Panel and Program for several years in the 1970s. He has published research materials directly relevant to the investigation and has over 100 refereed publications, conference proceedings, and NASA reports to his credit.

Cited on numerous occasions for his outstanding research and scientific achievement, Dr. Salomonson is the recipient of seven NASA awards for exceptional achievement, service, and performance; the Distinguished Achievement Award of the IEEE Geoscience and Remote Sensing Society; the William T. Pecora Award; and the Distinguished Alumnus Award from Colorado State University.

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Paul Menzel, NOAA/NESDIS
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John Parslow, CSIRO
Steven W. Running, University of Montana
Philip N. Slater, University of Arizona
Alan H. Strahler, Boston University
Joel Susskind, Goddard Space Flight Center
Didier Tanre, Univ. des Sciences et Techniques de Lille
Vern Vanderbilt, Ames Research Center
Zhengming Wan, Institute of Remote Sensing Application

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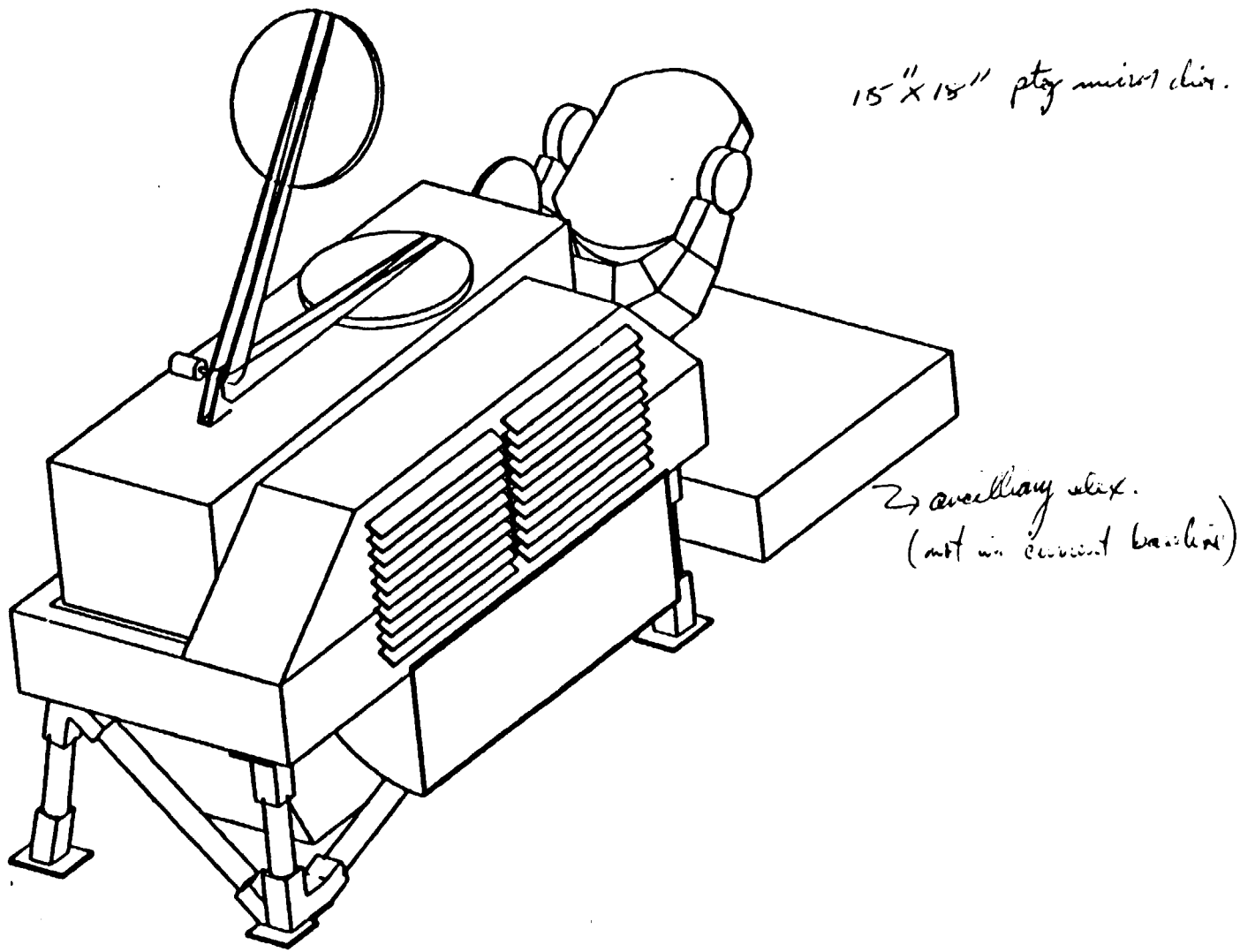
HIRIS OUTLINE DRAWING



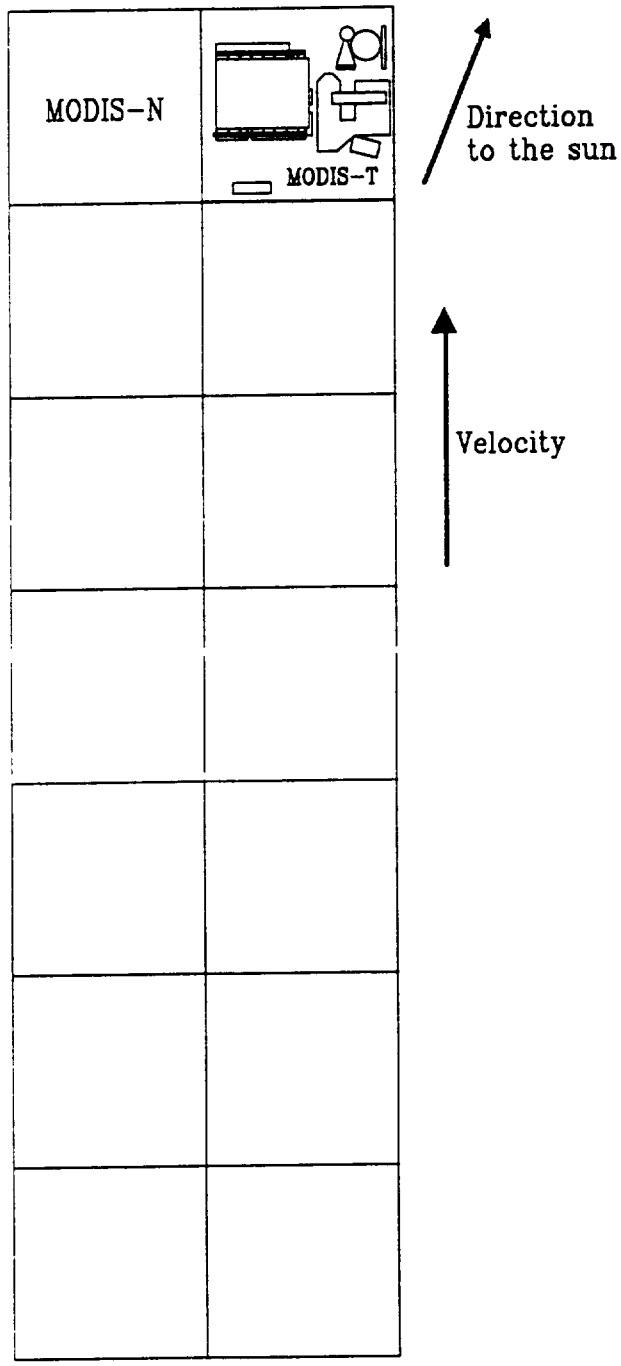


Figure 3-2. MODIS-T location on the Eos platform

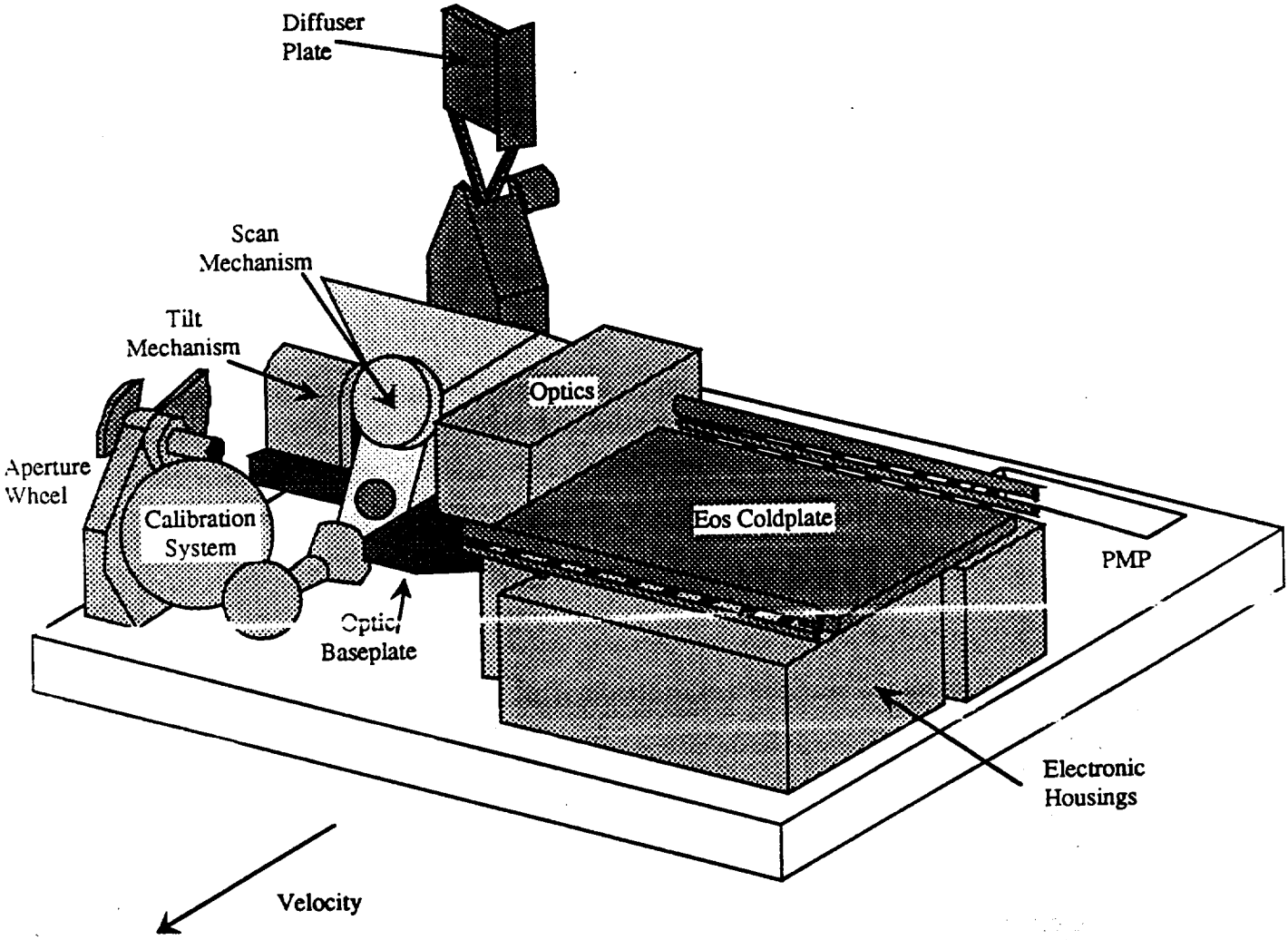


Figure 3-1. MODIS-T payload mounting plate layout.

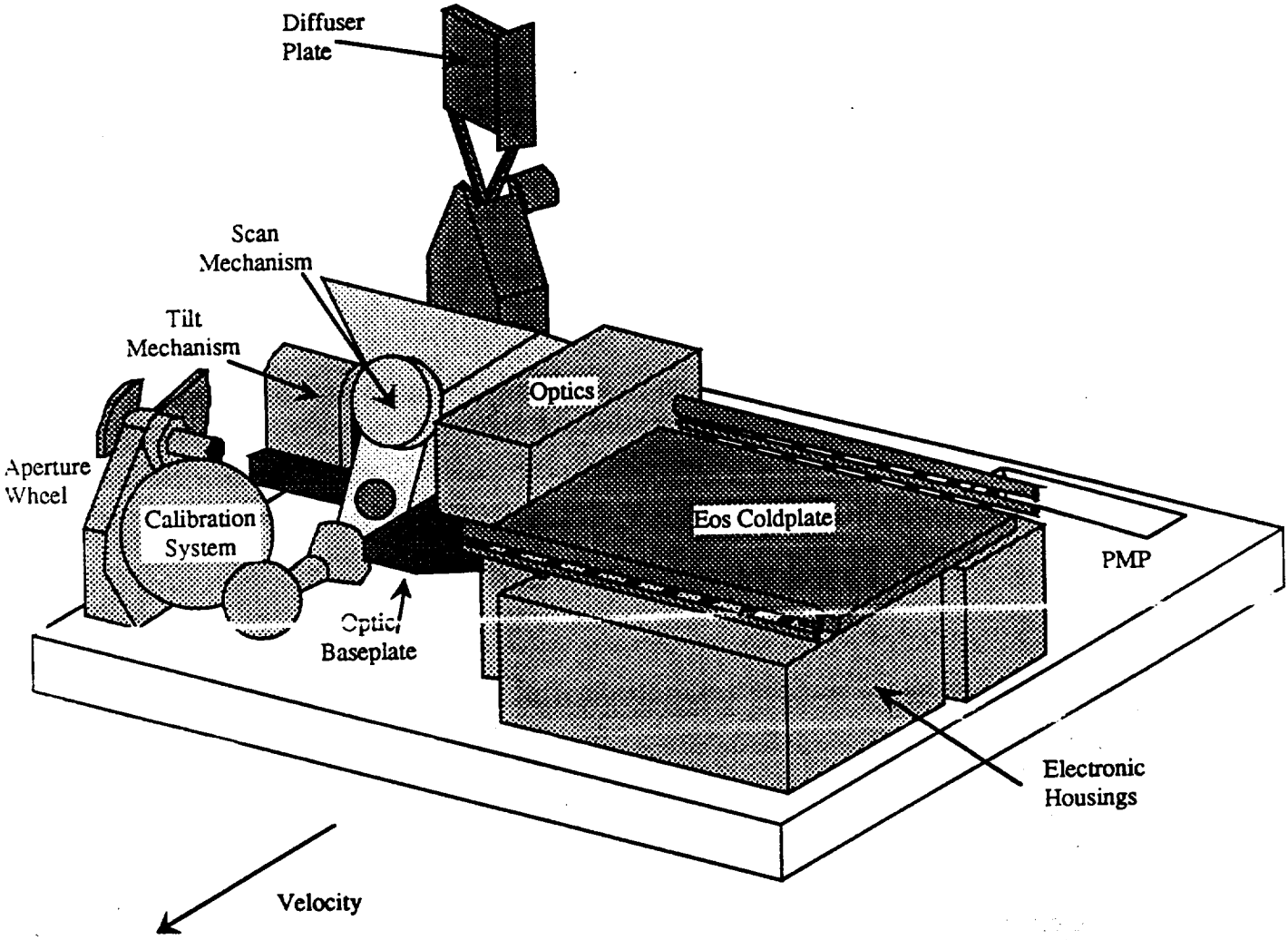


Figure 3-1. MODIS-T payload mounting plate layout.

MODIS-N SPECTRAL BAND CHARACTERISTICS

BAND	CENTER WAVELENGTH (nm)	BANDWIDTH (nm)	IFOV (m)
1	659 ± 5	50	214
2	865 ± 5	40	214
3	470 ± 5	20	428
4	555 ± 5	20	428
5	1240 ± 6	20	428
6	1640 ± 8	20	428
7	2130 ± 10	50	428
8	415 ± 2	15	856
9	443 ± 1	10	856
10	490 ± 1	10	856
11	531 ± 2	10	856
12	565 ± 5	10	856
13	653 +1, -2	15	856
14	681 ± 1	10	856
15	750 ± 2	10	856
16	865 ± 5	15	856
17	905 ± 1	30	856
18	936 ± 1	10	856
19	940 ± 1	50	856
20	3750 ± 19	180	856
21	3750 ± 19	50	856
22	3959 ± 20	50	856
23	4050 ± 20	50	856
24	4465 ± 22	50	856
25	4515 ± 22	50	856
26	4565 ± 23	50	856
27	6715 ± 34	360	856
28	7325 ± 37	300	856
29	8550 ± 43	300	856
30	9730 ± 49	300	856
31	11030 ± 55	500	856
32	12020 ± 60	500	856
33	13335 ± 67	300	856
34	13635 ± 68	300	856
35	13935 ± 70	300	856
36	14235 ± 71	300	856

NOTES: 1) BANDWIDTH TOLERANCE = ± 1/2% OF CENTER WAVELENGTH (± 1/4% FOR BANDS 8 - 16)
2) INTEGRATED OUT-OF-BAND RESPONSE <5%

D137.005

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2	865 ± 5	40	214
3	470 ± 5	20	428
4	555 ± 5	20	428
5	1240 ± 6	20	428
6	1640 ± 8	20	428
7	2130 ± 10	50	428
8	415 ± 2	15	856
9	443 ± 1	10	856
10	490 ± 1	10	856
11	531 ± 2	10	856
12	565 ± 5	10	856
13	653 +1, -2	15	856
14	681 ± 1	10	856
15	750 ± 2	10	856
16	865 ± 5	15	856
17	905 ± 1	30	856
18	936 ± 1	10	856
19	940 ± 1	50	856
20	3750 ± 19	180	856
21	3750 ± 19	50	856
22	3959 ± 20	50	856
23	4050 ± 20	50	856
24	4465 ± 22	50	856
25	4515 ± 22	50	856
26	4565 ± 23	50	856
27	6715 ± 34	360	856
28	7325 ± 37	300	856
29	8550 ± 43	300	856
30	9730 ± 49	300	856
31	11030 ± 55	500	856
32	12020 ± 60	500	856
33	13335 ± 67	300	856
34	13635 ± 68	300	856
35	13935 ± 70	300	856
36	14235 ± 71	300	856

NOTES: 1) BANDWIDTH TOLERANCE = ± 1/2% OF CENTER WAVELENGTH (± 1/4% FOR BANDS 8 - 16)
2) INTEGRATED OUT-OF-BAND RESPONSE <5%

D137.005

TABLE 3.3.3

MODIS-T OCEAN REQUIREMENTS

BAND	CENTER WVLNGTH (nm)	TYPICAL REFLEC.	LTYPICAL (**)	LMAX (**)	SNR	LCLOUD (**)
1*	410	0.071	45.9	561	880	472
2*	425	0.072	43.8	561	859	510
3*	440	0.075	42.0	561	838	522
4*	455	0.055	39.1	561	826	592
5	470	0.044	36.4	561	814	570
6*	485	0.032	33.6	546	802	560
7*	500	0.041	30.9	531	786	564
8*	515	0.057	29.1	516	770	556
9	530	0.055	26.7	501	754	571
10*	545	0.053	24.3	495	752	557
11*	560	0.041	21.0	488	750	538
12	575	0.042	20.0	481	736	545
13	590	0.043	19.0	473	724	505
14*	605	0.044	18.1	463	711	522
15*	620	0.044	17.0	454	699	507
16*	635	0.043	16.1	445	661	488
17	650	0.040	14.9	436	616	466
18*	665	0.037	13.7	422	571	460
19*	680	0.039	13.1	408	558	441
20	695	0.041	12.5	394	546	424
21*	710	0.043	11.9	381	535	408
22	725	0.043	11.2	367	522	398
23	740	0.044	10.5	353	508	374
24*	755	0.044	9.9	337	495	370
25*	770	0.045	9.3	322	490	355
26	785	0.043	8.8	307	472	348
27	800	0.041	8.3	291	454	336
28	815	0.039	7.8	19	435	326
29	830	0.037	7.3	18	417	315
30	845	0.036	6.8	17	398	304
31*	860	0.035	6.3	16	380	294
32	875	0.034	5.8	270	362	286

* REQUIRED OCEAN CHANNELS

** UNITS OF Watts/sq.meter/um/st.

LTYPICAL=RADIANCE OF A SCENE WITH TYPICAL SURFACE REFLECTANCE AND SOLAR ZENITH ANGLE OF 70 DEGREES

LMAX=RADIANCE OF SCENE WITH SURFACE REFLECTANCE OF 95% AND A SOLAR ZENITH ANGLE OF 22.5 DEGREES

LCLOUD=RADIANCE OF A CLOUD WITH A SOLAR ZENITH ANGLE OF 22.5 DEGREES

TABLE 3.3.3

MODIS-T OCEAN REQUIREMENTS

BAND	CENTER WVLNGTH (nm)	TYPICAL REFLEC.	LTYPICAL (**)	LMAX (**)	SNR	LCLOUD (**)
1*	410	0.071	45.9	561	880	472
2*	425	0.072	43.8	561	859	510
3*	440	0.075	42.0	561	838	522
4*	455	0.055	39.1	561	826	592
5	470	0.044	36.4	561	814	570
6*	485	0.032	33.6	546	802	560
7*	500	0.041	30.9	531	786	564
8*	515	0.057	29.1	516	770	556
9	530	0.055	26.7	501	754	571
10*	545	0.053	24.3	495	752	557
11*	560	0.041	21.0	488	750	538
12	575	0.042	20.0	481	736	545
13	590	0.043	19.0	473	724	505
14*	605	0.044	18.1	463	711	522
15*	620	0.044	17.0	454	699	507
16*	635	0.043	16.1	445	661	488
17	650	0.040	14.9	436	616	466
18*	665	0.037	13.7	422	571	460
19*	680	0.039	13.1	408	558	441
20	695	0.041	12.5	394	546	424
21*	710	0.043	11.9	381	535	408
22	725	0.043	11.2	367	522	398
23	740	0.044	10.5	353	508	374
24*	755	0.044	9.9	337	495	370
25*	770	0.045	9.3	322	490	355
26	785	0.043	8.8	307	472	348
27	800	0.041	8.3	291	454	336
28	815	0.039	7.8	19	435	326
29	830	0.037	7.3	18	417	315
30	845	0.036	6.8	17	398	304
31*	860	0.035	6.3	16	380	294
32	875	0.034	5.8	270	362	286

* REQUIRED OCEAN CHANNELS

** UNITS OF Watts/sq.meter/um/st.

LTYPICAL=RADIANCE OF A SCENE WITH TYPICAL SURFACE REFLECTANCE AND SOLAR ZENITH ANGLE OF 70 DEGREES

LMAX=RADIANCE OF SCENE WITH SURFACE REFLECTANCE OF 95% AND A SOLAR ZENITH ANGLE OF 22.5 DEGREES

LCLOUD=RADIANCE OF A CLOUD WITH A SOLAR ZENITH ANGLE OF 22.5 DEGREES

TABLE 3.3.3 (Cont'd)

MODIS-T NON-OCEAN REQUIREMENTS

BAND	WVLNGTH (nm)	TYPICAL REFLEC.	LTYPICAL (**)	LMAX (**)	SNR	LCLOUD (**)
1	410	0.071	45.9	561	289	472
2	425	0.072	43.8	561	289	510
3	440	0.075	42.0	561	289	522
4	455	0.072	41.2	561	289	592
5	470	0.070	40.3	561	289	570
6	485	0.080	38.3	546	274	560
7	500	0.090	36.2	531	259	564
8	515	0.100	34.1	516	244	556
9	530	0.100	32.0	501	229	571
10	545	0.100	30.9	495	221	557
11	560	0.110	29.7	488	213	538
12	575	0.110	28.5	481	205	545
13	590	0.090	24.9	473	183	505
14	605	0.080	23.1	463	173	522
15	620	0.070	21.2	454	163	507
16	635	0.060	19.3	445	153	488
17	650	0.060	17.4	436	142	466
18	665	0.080	18.8	422	156	460
19	680	0.100	20.2	408	170	441
20	695	0.120	21.5	394	185	424
21	710	0.170	25.2	381	222	408
22	725	0.220	28.9	367	260	398
23	740	0.300	38.3	353	344	374
24	755	0.310	37.5	337	356	370
25	770	0.310	36.6	322	368	355
26	785	0.340	35.7	307	379	348
27	800	0.400	38.7	291	431	336
28	815	0.410	36.9	19	439	326
29	830	0.410	36.6	18	438	315
30	845	0.410	37.5	17	437	304
31	860	0.410	38.4	16	437	294
32	875	0.410	39.3	270	437	286

** UNITS OF Watts/sq.meter/um/st.

LTYPICAL=RADIANCE OF A SCENE WITH TYPICAL SURFACE REFLECTANCE AND SOLAR ZENITH ANGLE OF 70 DEGREES

LMAX=RADIANCE OF A SCENE WITH SURFACE REFLECTANCEOF 95% AND A SOLAR ZENITH ANGLE OF 22.5 DEGREES

LCLOUD=RADIANCE OF A CLOUD WITH A SOLAR ZENITH ANGLE OF 22.5 DEGREES

TABLE 3.3.3 (Cont'd)

MODIS-T NON-OCEAN REQUIREMENTS

BAND	WVLNGTH (nm)	TYPICAL REFLEC.	LTYPICAL (**)	LMAX (**)	SNR	LCLOUD (**)
1	410	0.071	45.9	561	289	472
2	425	0.072	43.8	561	289	510
3	440	0.075	42.0	561	289	522
4	455	0.072	41.2	561	289	592
5	470	0.070	40.3	561	289	570
6	485	0.080	38.3	546	274	560
7	500	0.090	36.2	531	259	564
8	515	0.100	34.1	516	244	556
9	530	0.100	32.0	501	229	571
10	545	0.100	30.9	495	221	557
11	560	0.110	29.7	488	213	538
12	575	0.110	28.5	481	205	545
13	590	0.090	24.9	473	183	505
14	605	0.080	23.1	463	173	522
15	620	0.070	21.2	454	163	507
16	635	0.060	19.3	445	153	488
17	650	0.060	17.4	436	142	466
18	665	0.080	18.8	422	156	460
19	680	0.100	20.2	408	170	441
20	695	0.120	21.5	394	185	424
21	710	0.170	25.2	381	222	408
22	725	0.220	28.9	367	260	398
23	740	0.300	38.3	353	344	374
24	755	0.310	37.5	337	356	370
25	770	0.310	36.6	322	368	355
26	785	0.340	35.7	307	379	348
27	800	0.400	38.7	291	431	336
28	815	0.410	36.9	19	439	326
29	830	0.410	36.6	18	438	315
30	845	0.410	37.5	17	437	304
31	860	0.410	38.4	16	437	294
32	875	0.410	39.3	270	437	286

** UNITS OF Watts/sq.meter/um/st.

LTYPICAL=RADIANCE OF A SCENE WITH TYPICAL SURFACE REFLECTANCE AND SOLAR ZENITH ANGLE OF 70 DEGREES

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