MODIS Calibration Methodology

at

EOS ASTER
Instrument Calibration Peer Review

National Research Laboratory of Metrology (NRLM)
1-1-4, Umezono, Tsukuba-shi, Ibaraki, 305, JAPAN

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MODIS Characterization Support Team (MCST)

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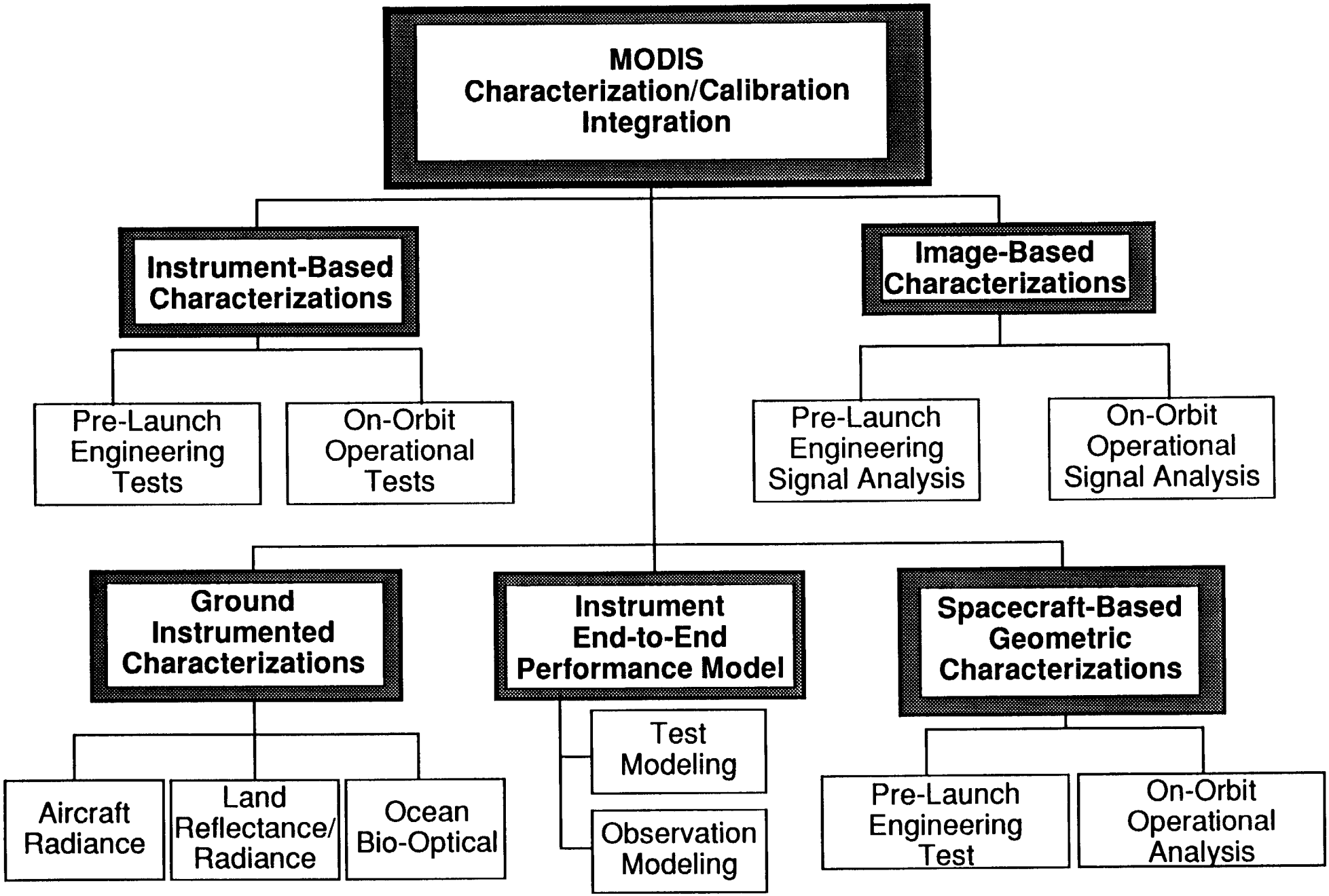
Attachment #1
Tech Team mtg 3/17/93

MODIS Science Calibration Methodology



Filename: MODIS Science Cal. Methodology

John Barker / MCST / 04MAR93 / 12:00:00
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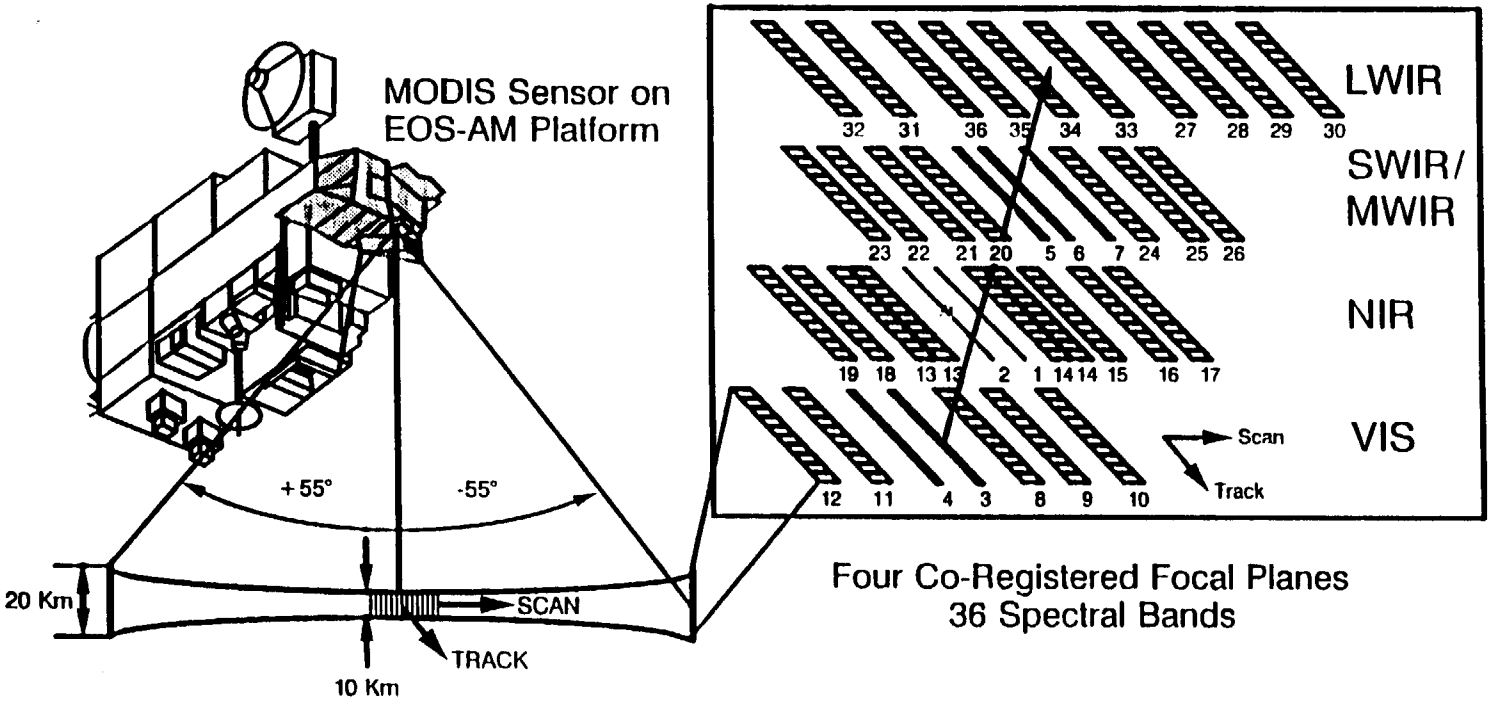
MODIS Earth-View and Focal Planes

10:30 AM EOS-AM Platfrom
Sun Synchronous 705 Km Polar Orbit



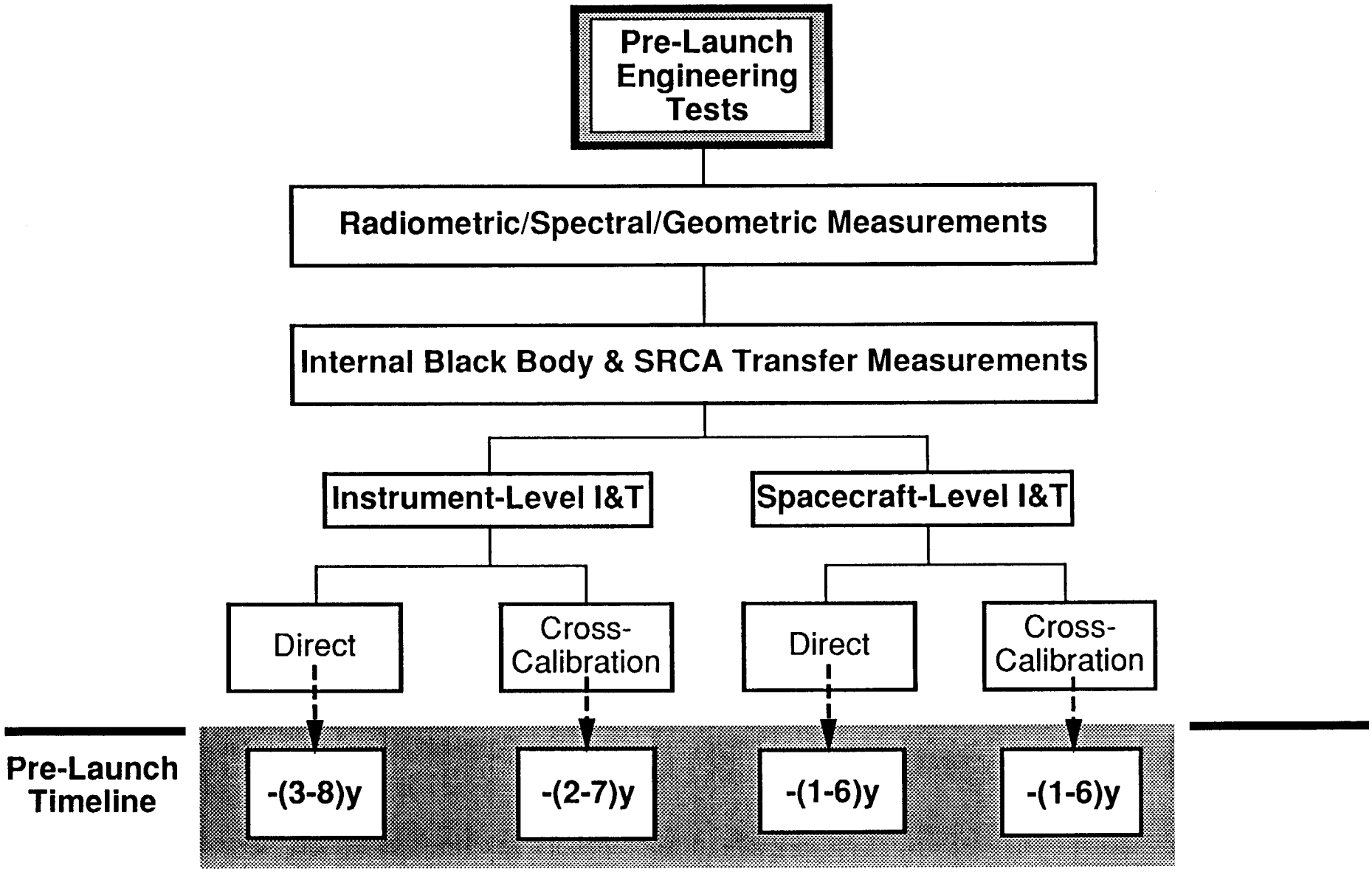
Four Co-Registered Focal Planes
36 Spectral Bands

10-20 Km Along-Track by
2300 Km Along-Scan Swath

A746.004

Timeline for Pre-Launch Engineering Tests

Instrument-Based Characterizations
MODIS Science Calibration Methodology



Filename: Pre-Launch Engineering Tests

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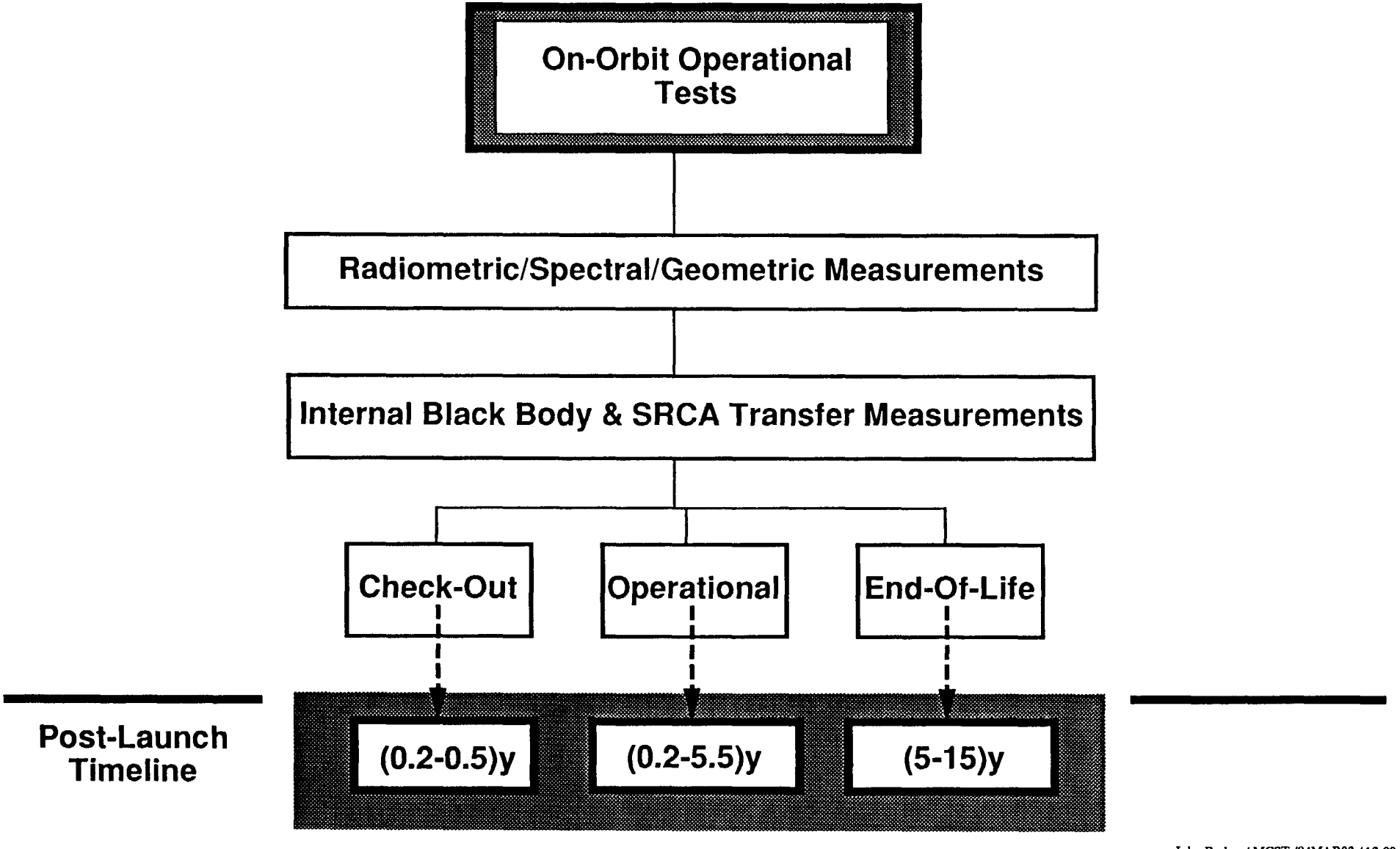
Timeline for On-Orbit Operational Tests

Instrument-Based Characterizations
MODIS Science Calibration Methodology



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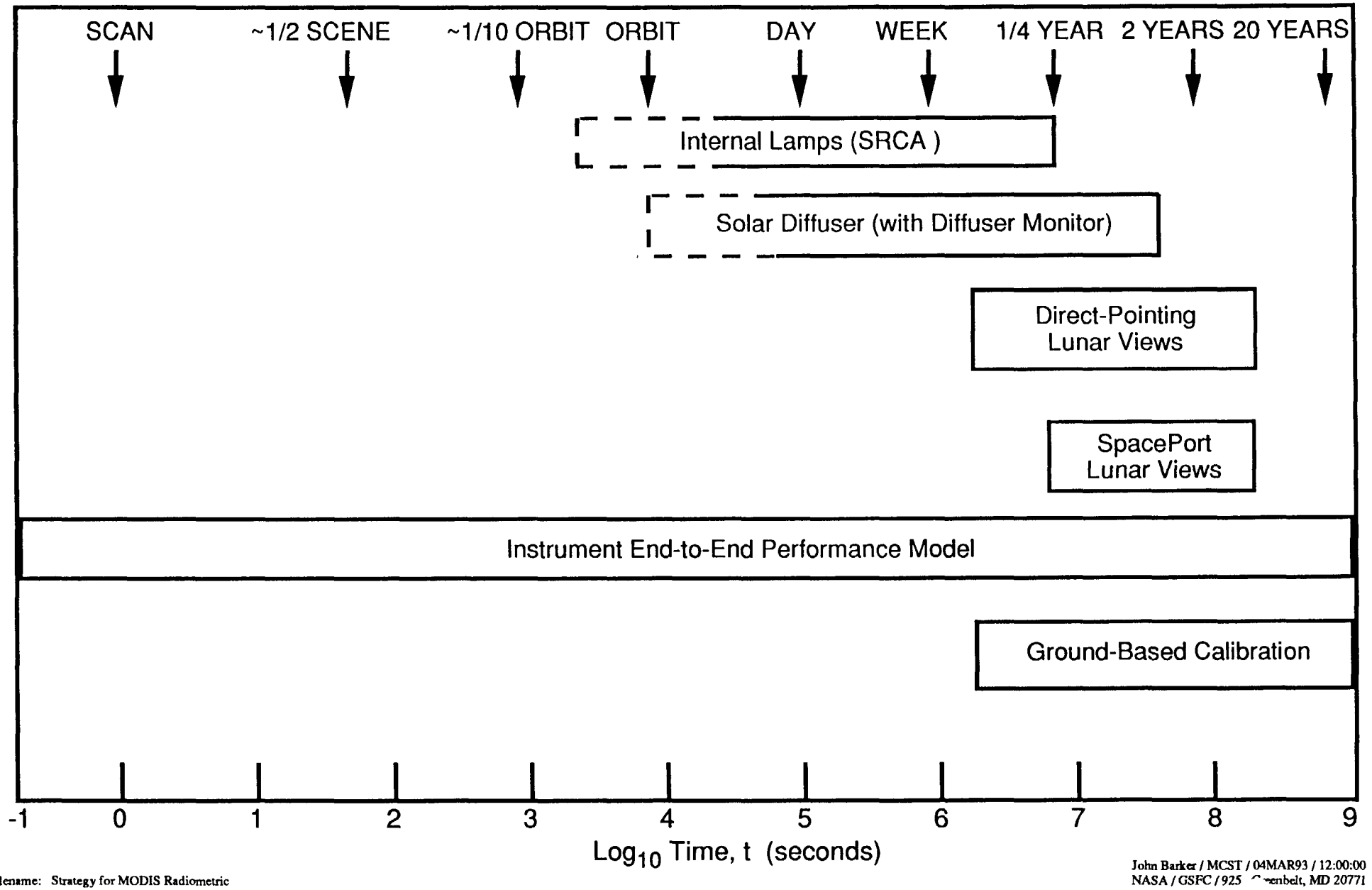
Instrument-Based Radiometric Methodology for On-Orbit Characterization of MODIS Reflective Bands



Filename: Strategy for MODIS Radiometric

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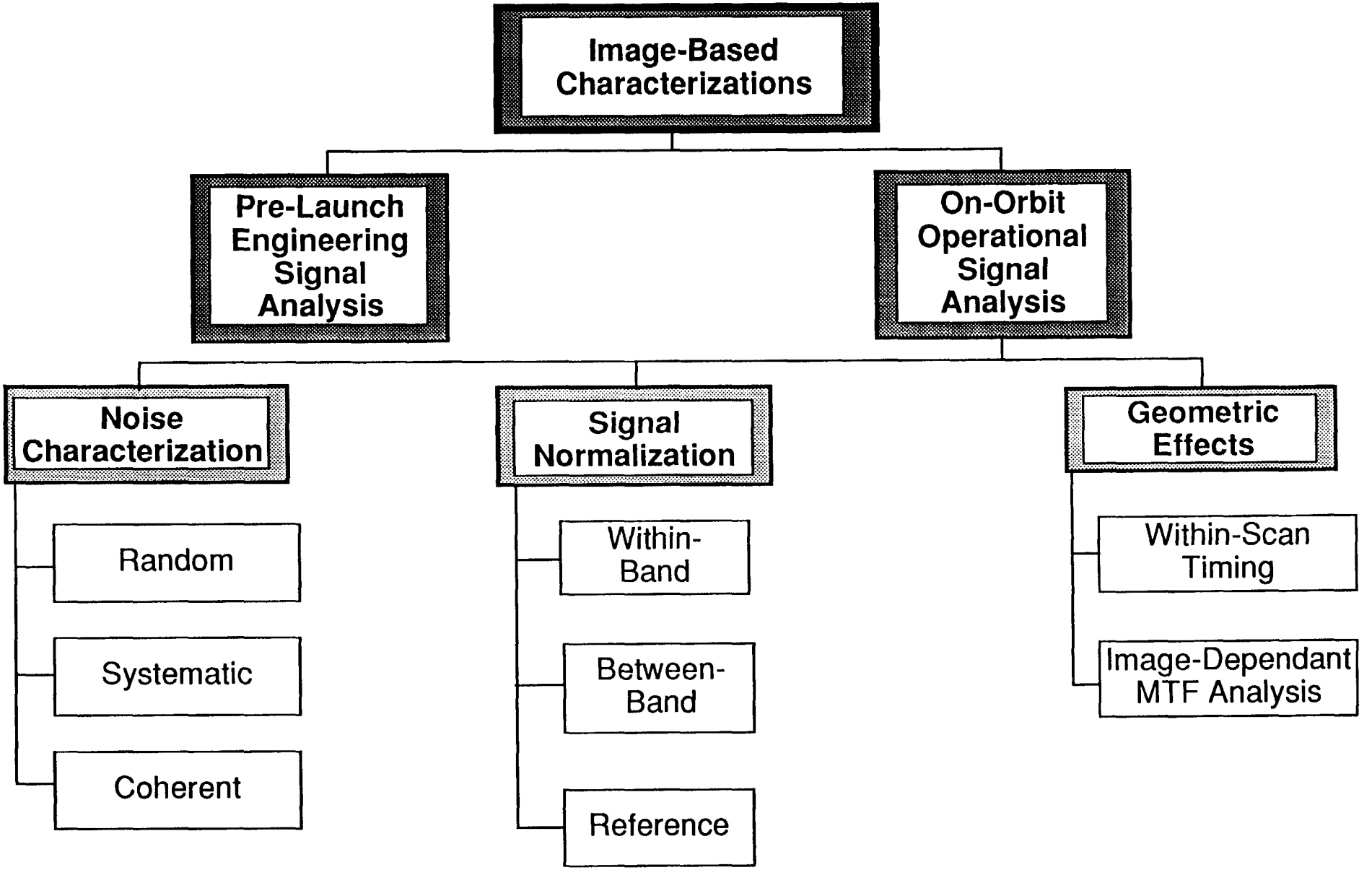
Image-Based Characterizations

MODIS Science Calibration Methodology



Filename: Image-Based Characterization

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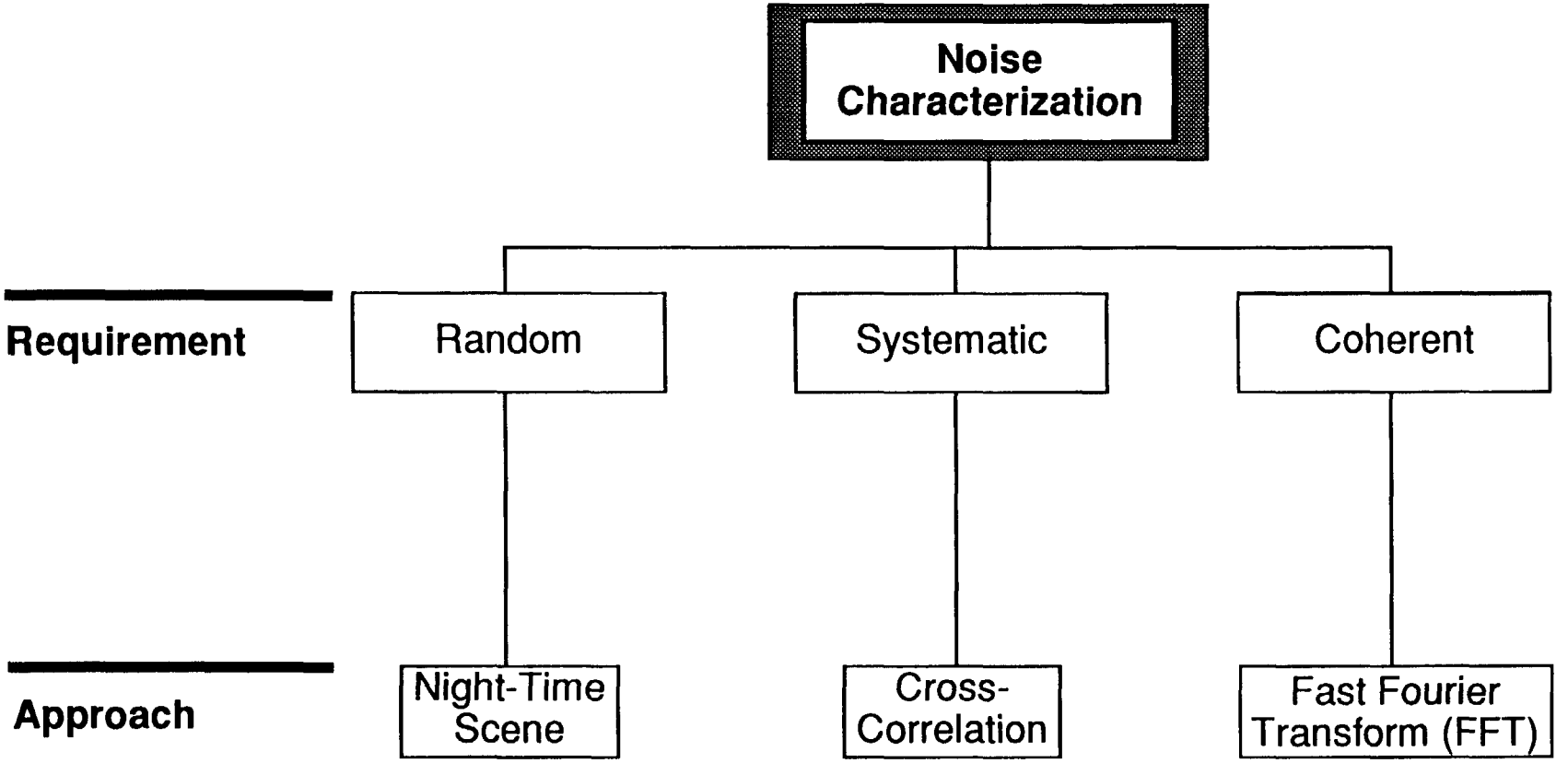
Requirements and Approaches to Noise Characterizations

Image-Based Characterizations
On-Orbit Operational Signal Analysis
MODIS Science Calibration Methodology



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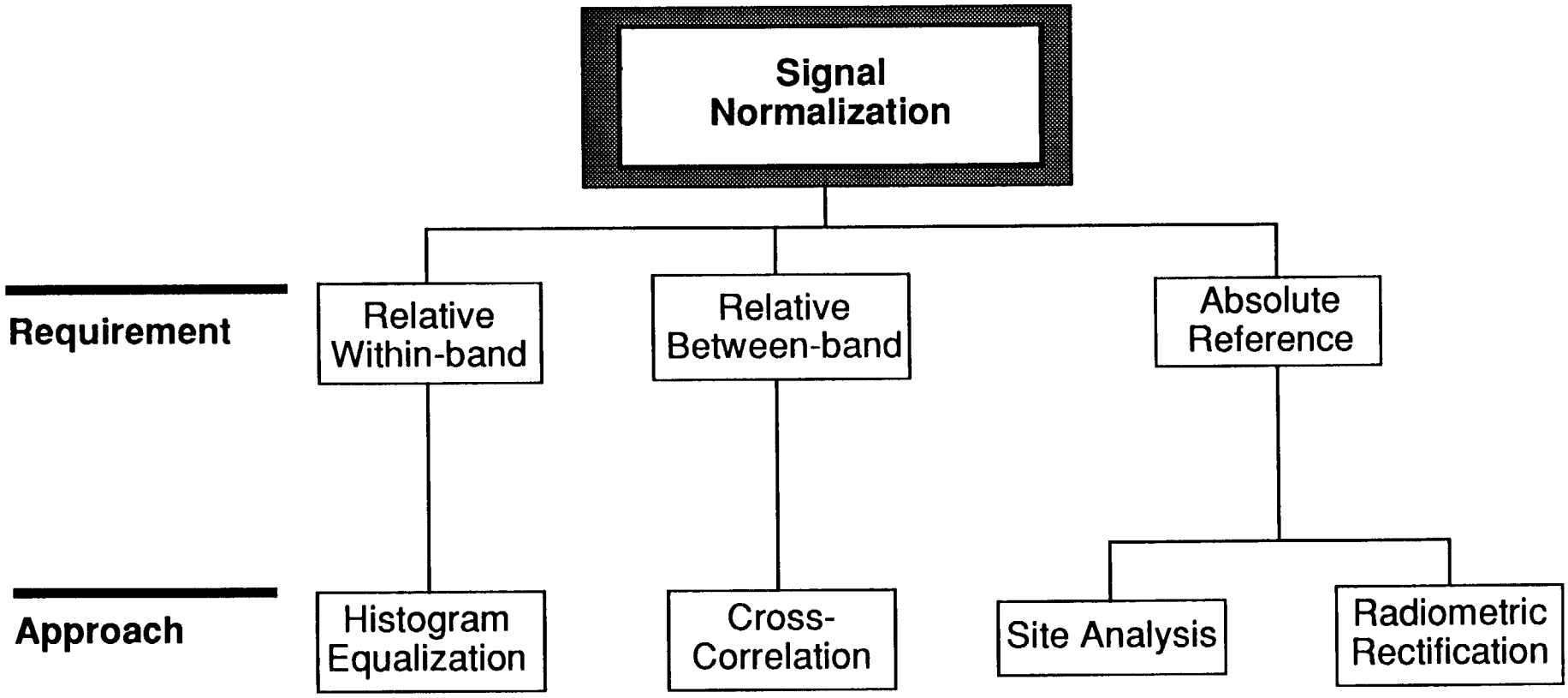
Requirements and Approaches to Signal Normalization

Image-Based Characterizations
On-Orbit Operational Signal Analysis
MODIS Science Calibration Methodology



John Barker / MCST / 02MAR93 / 12:00:00
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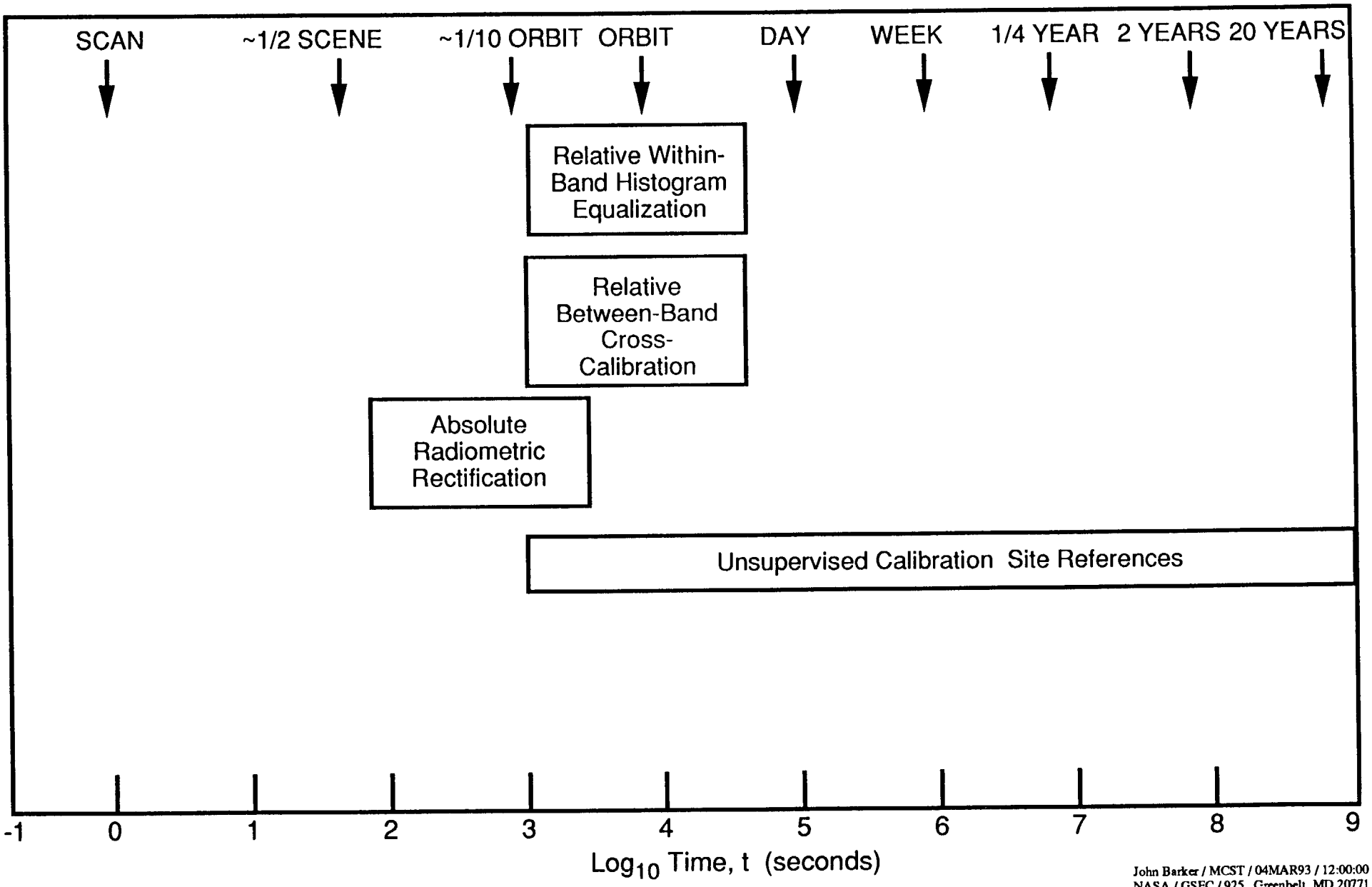
Image-Based Radiometric Signal Normalization Methodology for On-Orbit Characterization of MODIS Reflective Bands



Filename: Strategy for MODIS Radiometric

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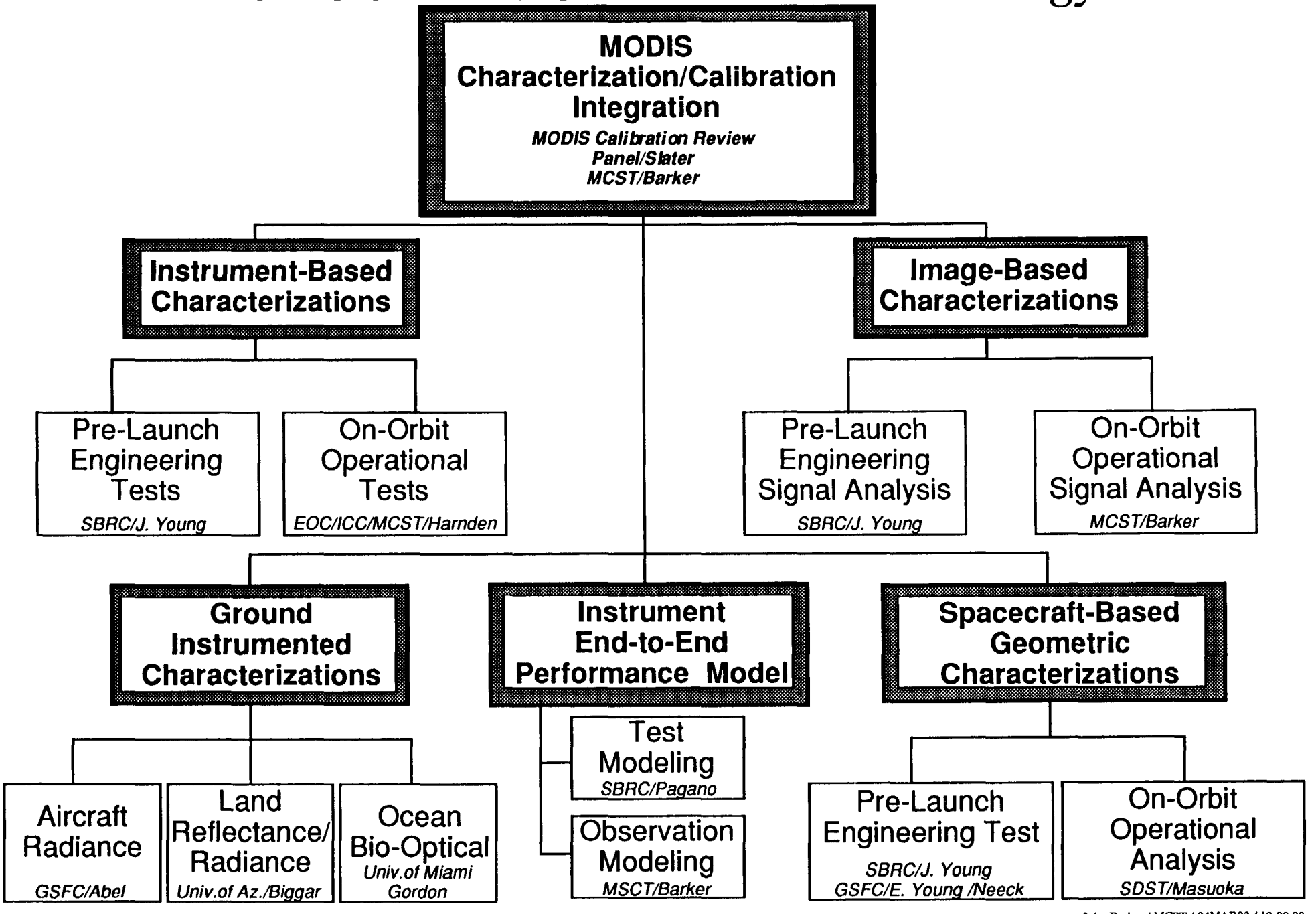
MODIS Science Calibration Methodology



Filename: MODIS Science Cal. Method #2

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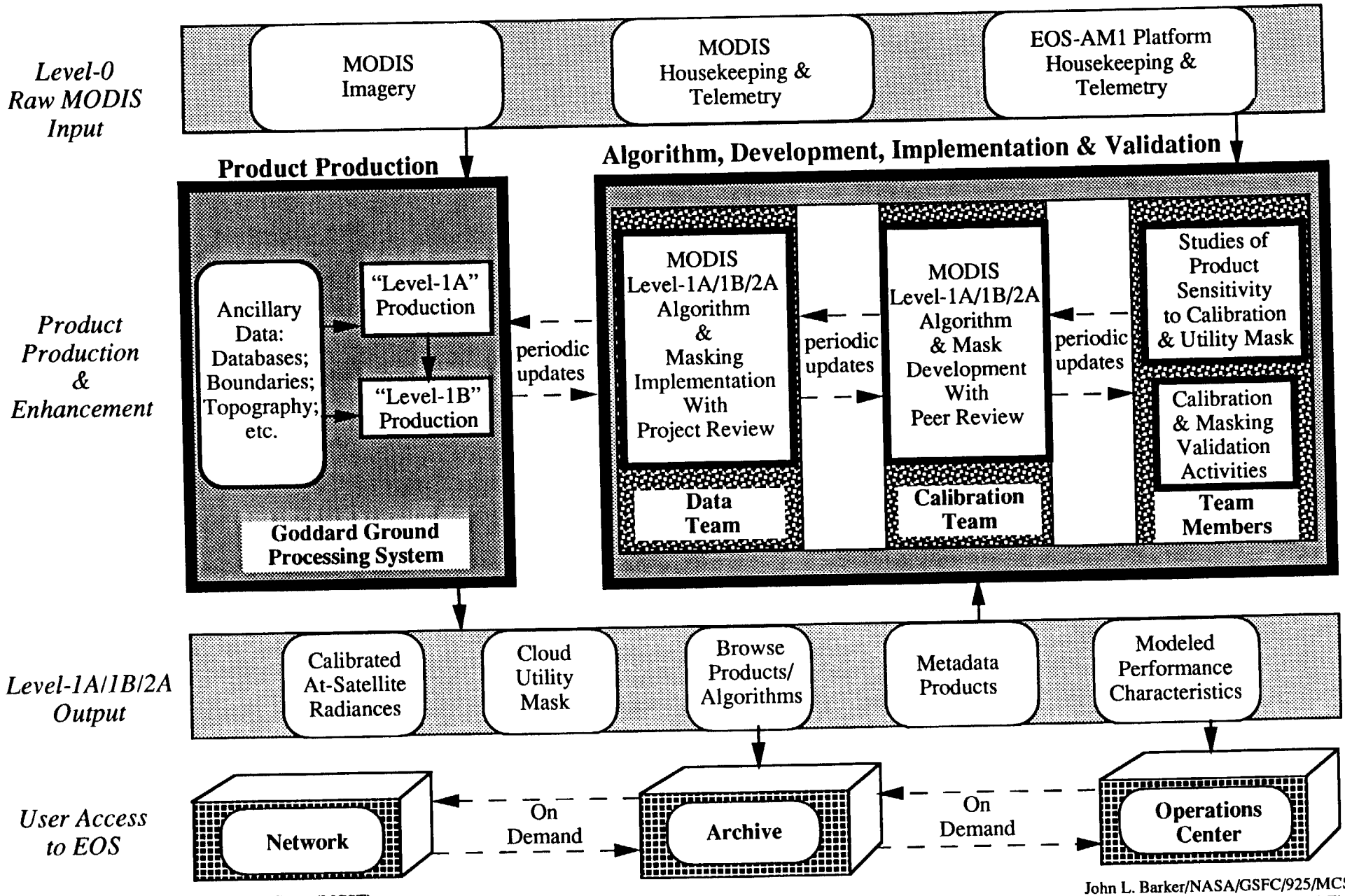
MODIS Level-1 Calibration & Utility Mask Products

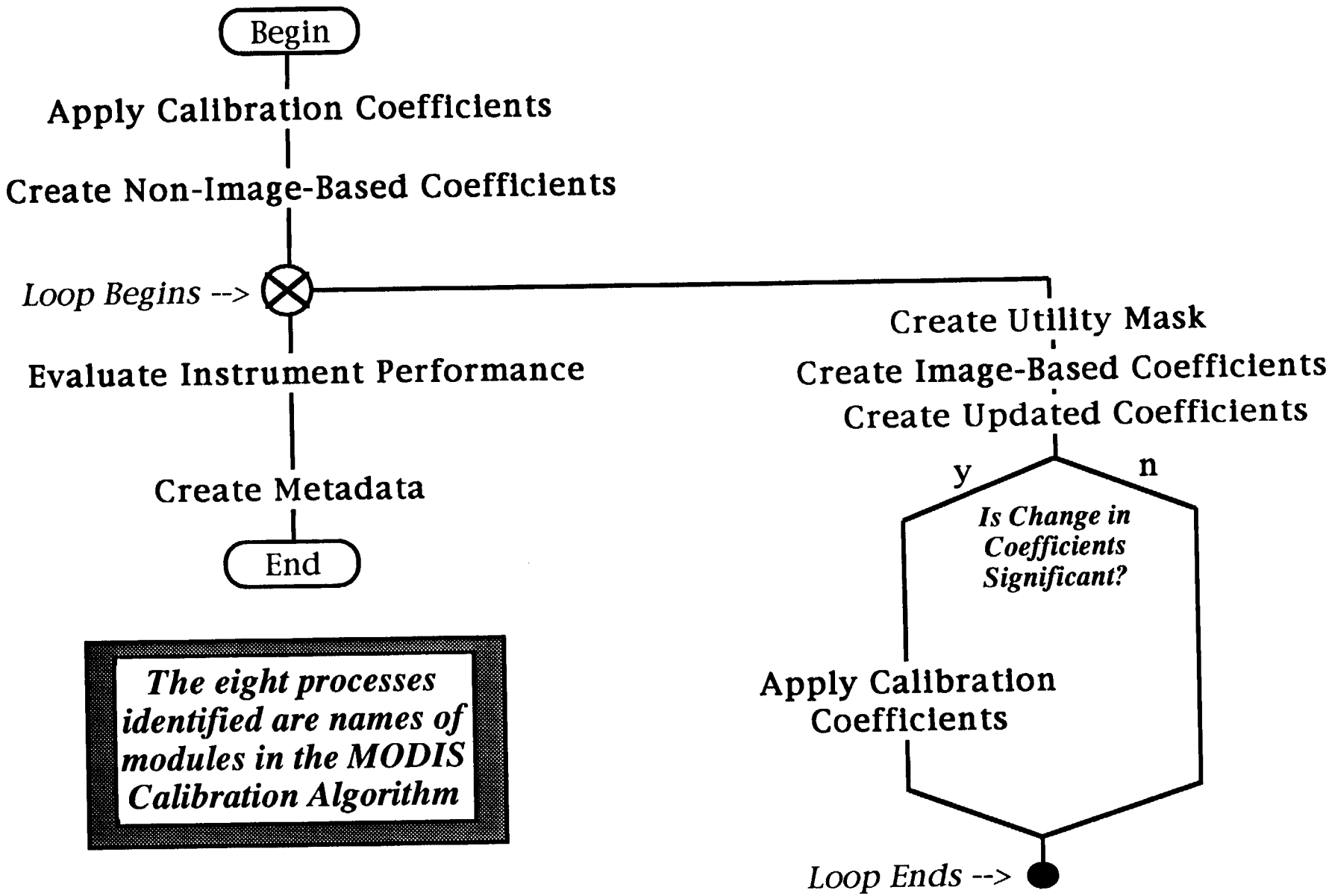
Illustrative Flow Diagram



EOS MODIS Characterization Support Team (MCST)
Date: 12/31/92 Time: 3:05 p.m.

John L. Barker/NASA/GSFC/925/MCST
File: Fig2 L-1 Flow

Top-Level Overview of MODIS Level-1 Calibration Processing



The eight processes identified are names of modules in the MODIS Calibration Algorithm

From MCST L-1 Calib. Algo. Plan 5FEB93 [See Figure 1 Page 5]
Filename: L1B CFD #1

John Barker / MCST / 4MAR93 / 9:20 p.m.
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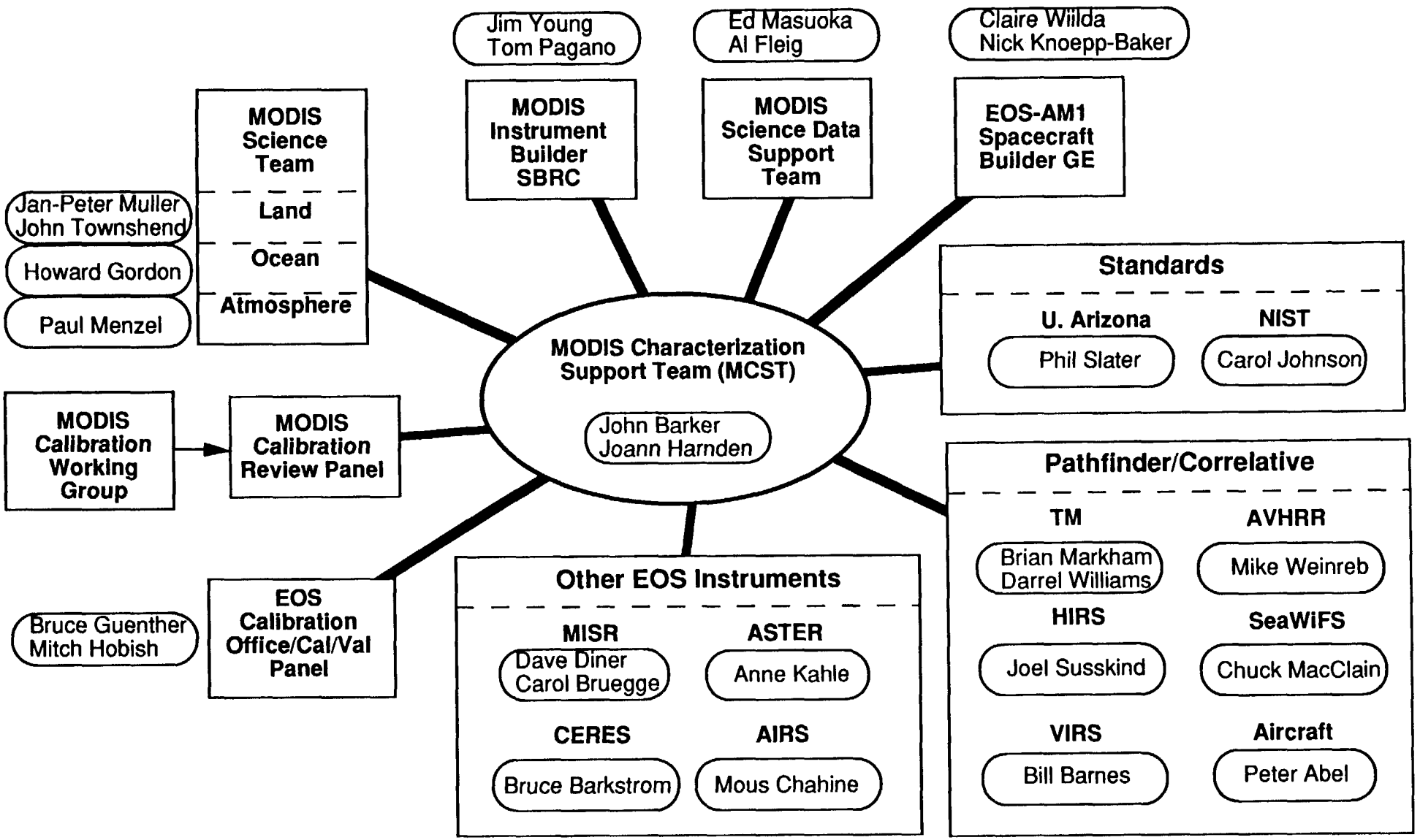
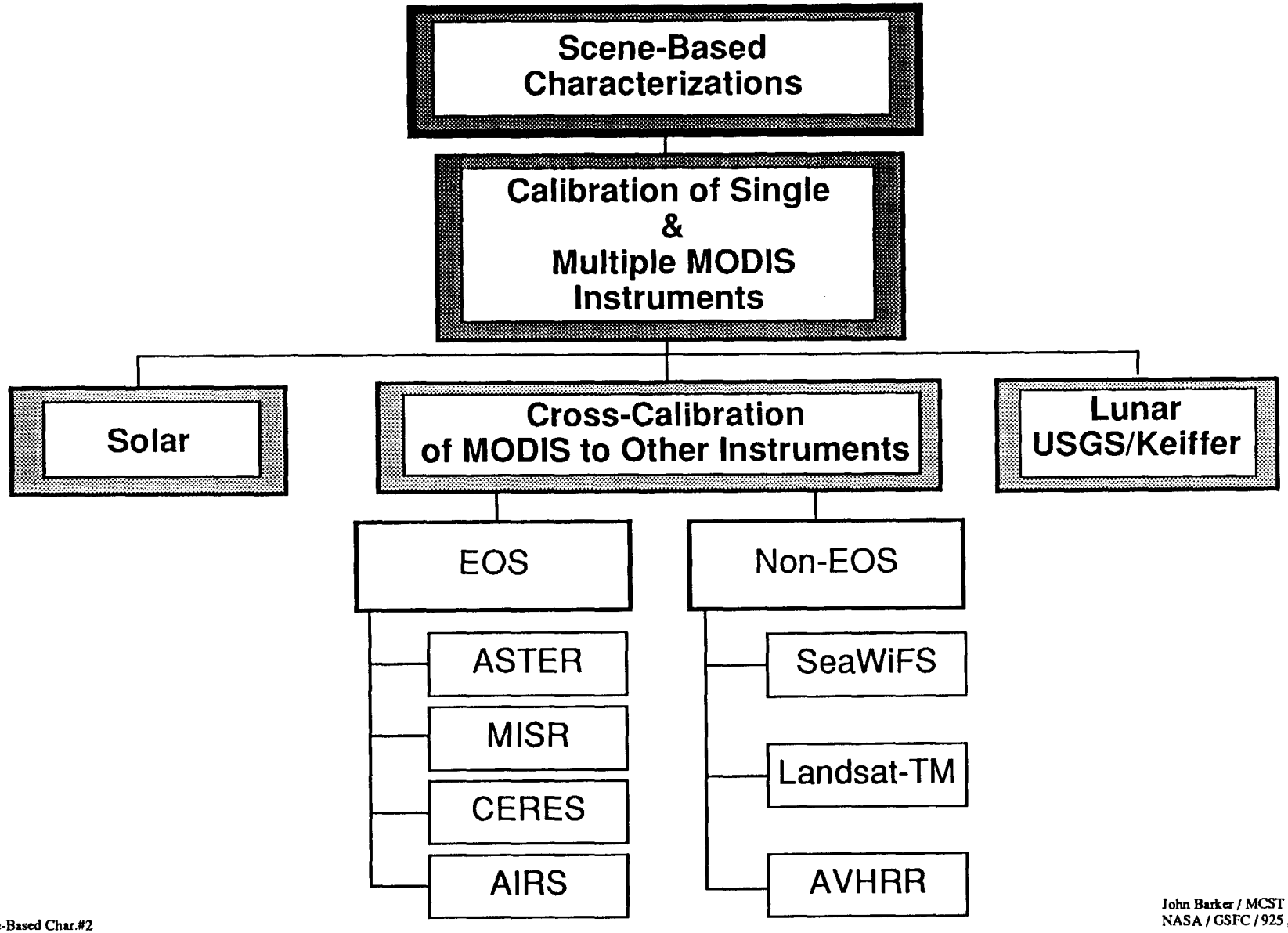
MODIS Calibration Interfaces (Context Diagram)



Cross-Calibration Overview
Scene-Based Characterizations
MODIS Science Calibration Methodology



Filename: Scene-Based Char.#2

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Appendix

Table 1: MODIS Instrument Requirements

Table 2a: Reflective Bands Scientific Purposes

Table 2b: Emissive Bands Scientific Purposes

Table 3a: Reflective Band Requirements for MODIS Instruments

Table 3b: Emissive Band Requirements for MODIS Instruments

Table 1
MODIS Instrument Requirements

Variable/Parameter	Symbol	Requirement
Equatorial Crossing Time	t	10:30 AM Descending EOS-AM Orbit Platforms 1:30 PM Ascending EOS-PM Orbit Platforms
Platform Altitude	H	705 Km
Number of Spectral Bands	N	36 from 0.41 to 14.4 μm
Ground Swath	GFOV	2330 Km Along-Scan by 10-20 Km Along-Track
Angular Swath	FOV	$\pm$ 55° Along-Scan by 14 milliradians Along-Track
Ground Resolution	GIFOV	Band-Dependent 250m, 500m and 1000m @Nadir Band-Dep. 375m, 750m and 1500m at $\pm$ 45° Band-Dep. 500m, 1000m and 2000m at $\pm$ 55°
Angular Resolution	IFOV	0.354 mr, 0.709 mr, 1.418 mr (all $\pm$ 6%)
Band-to-Band Registration	BBR	< 0.1 IFOV goal, < 0.2 IFOV Requirement (3σ)
Quantization	n	10-12 Bit (to meet Signal-to-Noise (SNR) Spec)
Modulation Transfer Function	MTF	0.3 at Nyquist Frequency
Polarization Factor Insensitivity	PF	< 2%, 0.41 to 2.2 μm
Volume (Length x Width x Height)	V = l x w x h	< 1 x 1.6 x 1 m
Mass	M	< 250 Kg
Power	P	< 225 W average, < 275 W peak
Operating/Duty Cycle	OC	100%
Data Rates (with overhead)	DR	< 11 Mbps (Day Mode) < 3 Mbps (Night Mode)
Pointability Angle of Optical Axis	PA	$\pm$ 20° from Horizon (Full Phase of Moon)
Absolute Radiometric Accuracy	AL	$\pm$ 5% (1σ) $\leq$3 μm, $\pm$ 1% (1σ) > 3 μm
On-Orbit Reflectance Precision	PR	$\pm$ 2% (1σ) $\leq$ 3 μm relative to the Sun

Table 2a

Band N	Ground Resolution GIFOV [m]	FWHM Band Pass* Lower Bandpass λMin [nm]	FWHM Band Pass* Upper Bandpass λMax [nm]	Primary Scientific Purpose
1	250	620	670	Vegetation Chlorophyll Absorption Land Cover Transformations Cloud/Edge Detection/Masks
2	250	841	876	Cloud/Vegetation/Water/Edge Detection Land Cover Transformations/Masks
3	500	459	479	Soil & Vegetation Differences
4	500	545	565	Green Vegetation
5	500	1230	1250	Leaf & Canopy Properties
6	500	1628	1652	Snow & Cloud Differences/Masks
7	500	2105	2155	Land & Cloud Properties
8	1000	405	420	Water Color (Chlorophyll/Pigments/Sediments) Atmospheric Scattering/Cloud Mask
9	1000	438	448	Water Color
10	1000	483	493	Water Color
11	1000	526	536	Water Color
12	1000	546	556	Sediments
13	1000	662	672	Sediments, Atmosphere
14	1000	673	683	Chlorophyll Fluorescence
15	1000	743	753	Aerosol Properties
16	1000	862	877	Aerosol and Atmospheric Properties
17	1000	890	920	Water Vapor/Atmospheric Properties
18	1000	931	941	Water Vapor/Atmospheric Properties
19	1000	915	965	Water Vapor/Atmospheric Properties
26	1000	1360	1390	Cirrus Cloud/Cloud Mask

*** FWHM (Full Width at Half Maximum) = λMax-λMin, where $\lambda Max=\lambda_c+(BW/2)$ and $\lambda Min=\lambda_c-(BW/2)$**

Ref: NASA/GSFC/EOS Document: MODIS-N Spec.,as amended to 12/23/92, Ref#422-20-02, Greenbelt, MD 20771

Table 2b

Band N	Ground Resolution GIFOV [m]	FWHM Band Pass* Lower Bandpass λMin [nm]	FWHM Band Pass* Upper Bandpass λMax [nm]	Primary Scientific Purpose
20	1000	3660	3840	Sea Surface Temperature
21	1000	3931	3987	Forest Fires / Volcanoes
22	1000	3929	3989	Cloud
23	1000	4020	4080	Cloud / Surface Temperature/Cloud Mask
24	1000	4433	4498	Cloud / Surface Temperature/Cloud Mask
25	1000	4482	4549	Tropical Temperature / Cloud Fraction
26	**Moved to Table 2a**			
27	1000	6535	6895	Tropical Temperature / Cloud Fraction
28	1000	7175	7475	Mid-Tropical Humidity
29	1000	8400	8700	Upper-Tropical Humidity
30	1000	9580	9880	Surface Temperature/Cloud Mask
31	1000	10780	11280	Total Ozone
32	1000	11770	12270	Cloud / Surface Temperature
33	1000	13185	13485	Cloud / Surface Temperature
34	1000	13485	13785	Cloud Height & Fraction
35	1000	13785	14085	Cloud Height & Fraction
36	1000	14085	14385	Cloud Height & Fraction

*** FWHM (Full Width at Half Maximum) = λMax-λMin, where $\lambda Max=\lambda_c+(BW/2)$ and $\lambda Min=\lambda_c-(BW/2)$**

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Table 3a

Band N	Ground Resolution GIFOV [m]	Center Wavelength λ [nm]	Center Wavelength Tolerance TCW [nm,1σ]	Band Width Δλ [nm]	Band Width Tolerance TBW [nm,1σ]	Max Spectral Radiance LMax [W/m^2-μm)]	Noise Equiv. Spectral Radiance NEdL [W/m^2-μm)]	Signal to Noise Ratio SNR [unitless]	Max Reflectance * RMax [unitless]
1	250	645	4	50	4.0	685	0.169	128	1.43
2	250	858	2.2	35	4.3	285	0.123	201	0.96
3	500	469	4	20	2.8	593	0.145	243	1.01
4	500	555	4	20	3.3	518	0.127	228	0.93
5	500	1240	5	20	7.4	110	0.073	74	0.78
6	500	1640	7	** 25	9.8	70	0.027	275	1.02
7	500	2130	8	50	12.8	22	0.009	110	0.81
8	1000	412	2	15	1.5	175	0.051	880	0.33
9	1000	443	1.1	10	1.6	133	0.050	838	0.23
10	1000	488	1.2	10	1.7	101	0.040	802	0.18
11	1000	531	2	10	1.9	82	0.037	754	0.14
12	1000	551	5	10	1.4	64	0.028	750	0.12
13	1000	667	[+1, -2]	10	1.7	32	0.010	910	0.08
14	1000	678	1	10	1.7	31	0.008	1087	0.07
15	1000	748	2	10	1.9	26	0.017	586	0.07
16	1000	869	5	15	4.3	16	0.012	516	0.06
17	1000	905	2.3	30	5.4	185	0.060	167	0.67
18	1000	936	2.3	10	5.6	256	0.063	57	1.00
19	1000	940	2.4	50	5.6	189	0.060	250	0.74
26	1000	1375	6	30	8.0	** 90	0.040	150	1.00

Ref: NASA/GSFC/EOS Document: MODIS-N Spec.,as amended to 12/23/92, Ref#422-20-02, Greenbelt, MD 20771

* Used to derive MODIS Specification.
** Band Width = 24.6 and Max Spectral Radiance = 89.9 as stated in MODIS Specification.

Table 3b

N	Ground Resolution GIFOV [m]	Center Wavelength λ [nm]	CW Tolerance TCW [nm,1σ]	Band-width Δλ [nm]	BW Tolerance TBW [nm,1σ]	Max. Spectral Radiance LMAXλ [W/m^2-μm)]	Noise Equivalent Spectral Radiance NEdL [W/m^2-μm)]	Maximum Temperature * TMax [K]
20	1000	3750	19	180	22.5	1.71	0.001	335
21	1000	3959	20	59.4	23.8	86.00	0.150	500
22	1000	3959	20	59.4	23.8	1.89	0.002	328
23	1000	4050	20	60.8	24.3	2.16	0.002	328
24	1000	4465	22	65	26.8	0.34	0.002	264
25	1000	4515	22	67	27.1	0.88	0.006	285
26	**Moved to Table 3a**							
27	1000	6715	34	360	40.3	3.21	0.011	271
28	1000	7325	37	300	44.0	4.46	0.017	275
29	1000	8550	43	300	51.3	14.54	0.009	324
30	1000	9730	49	300	58.4	6.34	0.022	275
31	1000	11030	55	500	66.2	13.25	0.007	324
31-hi	1000	11030		500		29.08	0.247	400
32	1000	12020	60	500	72.1	12.10	0.006	324
32-hi	1000	12020		500		25.07	0.198	400
33	1000	13335	67	300	80	6.56	0.018	285
34	1000	13635	68	300	81.8	5.02	0.016	268
35	1000	13935	70	300	83.6	4.42	0.014	261
36	1000	14235	71	300	85.4	2.96	0.015	238

Note: The high range of nonlinear Bands 31 & 32 is 324K to 400K.

Ref: NASA/GSFC/EOS Document: MODIS-N Spec.,as amended to 12/23/92, Ref#422-20-02, Greenbelt, MD 20771

*Used to derive MODIS Specification.