# ASTER CALIBRATION REQUIREMENT

(FIRST DRAFT, JANUARY 1992)

Content

# 0 Introduction

The document of ASTER Calibration Requirement specifies the following items related to spectral and rediometric characteristics of the ASTER instrument:

① Characteristics whose knowledge is specified,
② Requirement for knowledge of the characteristics,
③ Methodology for characteristics evaluation, and
④ Supplementary information and data related with characteristics evaluation.

This document is applicable to the document of the ASTER Instrument Specification on Observational Performances, and will be a part of the ASTER Calibration Plan.

ASTER Calibration Requirement is scheduled to establish the concept and framework by March 1992 when the 5th Calibration and Data Validation Panel Meeting is held, and to determine details including requirement values and evaluation methodologies by October 1992 around which the Calibration Peer Review may be held. The ASTER Calibration Plan is planned to finish by the same time.

[CHARACTERISTICS WHOSE KNOWLEDGE IS TO BE SPECIFIED]

1. Center wavelength and half width of operating band
2. Offset
3. Nonlinearity
4. Absolute responsivity, gain ratio, and temperature scale
5. Responsivity ratio and temperature scale difference among bands
6. Responsivity ratio and temperature scale difference among detector elements in a band
7. Polarization characteristics
8. Stray light characteristics

[COMPOSITION OF DOCUMENT]

[Knowledge]

1. Knowledge requirements for individual characteristics of the instrument are specified.

[Verification]

2. Methodology for calibration and uncertainty analyses are required to be reported by the contractors in terms of budget and design so that the instrument provider verifies the knowledge requirements from the uncertainty analyses.

[Supplementary information]

3. Supplementary information related to the instrument calibration is required to be reported by the contractors so that the instrument users understand nature and quality of the instrument data.

# 1. Spectral Characteristics of Operating Band

## 1.1 Requirement for knowledge of spectral characteristics

The center wavelengths of bands and band widths shall be evaluated within the accuracies in 3$\sigma$ listed in Table 1.1 until the end of anticipated life, i.e. 5 years.

Table 1.1 Requirement for knowledge of spectral characteristics

| Band No. | Center Wavelength/$\mu$m | Band Width/$\mu$m |
|---|---|---|
| 1 | ±0.005 | ±0.01 |
| 2 | ±0.005 | ±0.01 |
| 3N | ±0.005 | ±0.01 |
| 3B | ±0.005 | ±0.01 |
| 4 | ±0.005 | ±0.01 |
| 5 | ±0.0035 | ±0.005 |
| 6 | ±0.0035 | ±0.005 |
| 7 | ±0.0035 | ±0.005 |
| 8 | ±0.005 | ±0.0075 |
| 9 | ±0.005 | ±0.0075 |
| 10 | ±0.04 | ±0.04 |
| 11 | ±0.04 | ±0.04 |
| 12 | ±0.04 | ±0.04 |
| 13 | ±0.05 | ±0.06 |
| 14 | ±0.05 | ±0.06 |

1.2 Methodology for spectral characteristics evaluation

The sources of knowledge uncertainty as listed in Table 1.2 shall be evaluated by testing and/or analysis, and Table 1.2 shall be filled out.

Table 1.2 Uncertainty in the Prelaunch Knowledge of Center Wavelength of Operating Bands (Band No.: )

| Sources of uncertainty | | Uncertainty/$\mu$m ($3\sigma$) | | Method of testing, analysis, and evaluation |
|---|---|---|---|---|
| | | Budget | Design* | |
| 1. Spectral transmissivity of band pass filter | | | | RSS of sources |
| Source | Measurement | | | |
| | Nonuniformity | | | |
| | Air-to-vacuum shift | | | |
| 2. Spectral responsivity of detector elements | | | | RSS of sources |
| Source | Measurement | | | |
| | Nonuniformity | | | |
| 3. Spectral reflectivity/transmissivity of dichroic mirror | | | | same as the measurement uncertainty |
| Source | Measurement | | | |
| 4. Spectral transmissivity and reflectivity of optical system | | | | same as the measurement uncertainty |
| Source | Measurement | | | |
| 5. Total spectral responsivity | | | | RSS of sources |
| Source | Measurement | | | |
| | Nonuniformity | | | |
| Total (RSS) | | | | |

* Present design status

1.3 Supplementary information and data for evaluation of spectral characteristics
The following information and data of spectral characteristics shall be submitted.

1.3.1 Measurement apparatus and method of analysis for spectral characteristics evaluation

1.3.2 Measurement apparatus and method of analysis for in-orbit degradation

1.3.3 Spectrum and numerical table of filter transmissvity
To be taken at the both ends, the middle, a quarter, and three quarters of band.

1.3.4 Spectrum and numerical table of transmissivity and reflectivity of dichroic mirror
To be taken at the both ends, the middle, a quarter, and three quarters of band.

1.3.5 Spectrum and numerical table of transmissivity and reflectivity of optical system

1.3.6 Spectrum and numerical table of responsivity of detector elements
To be taken at the both ends, the middle, a quarter, and three quarters of band.

1.3.7 Spectrum and numerical table of total responsivity, and the 1st-, 2nd-, and 3rd-order moments
To be taken at the both ends, the middle, a quarter, and three quarters of band.

## 2 Offset

### 2.1 Requirement for knowledge of offset

The instrument offset shall be determined at any instance of the life within the accuracies listed below for the individual gain setting.

Table 2.1 Requirement for knowledge of offset

| Band No. | Knowledge (3σ) | | | |
|---|---|---|---|---|
| | High Gain | Normal gain | Low gain-1 | Low gain-2 |
| 1 | ±4 DN | ±2 DN | ±2 DN | N/A |
| 2 | ±4 DN | ±2 DN | ±2 DN | |
| 3N | ±4 DN | ±2 DN | ±2 DN | |
| 3B | ±4 DN | ±2 DN | ±2 DN | |
| 4 | ±4 DN | ±2 DN | ±2 DN | ±2 DN |
| 5 | ±4 DN | ±2 DN | ±2 DN | ±2 DN |
| 6 | ±4 DN | ±2 DN | ±2 DN | ±2 DN |
| 7 | ±4 DN | ±2 DN | ±2 DN | ±2 DN |
| 8 | ±4 DN | ±2 DN | ±2 DN | ±2 DN |
| 9 | ±4 DN | ±2 DN | ±2 DN | ±2 DN |
| 10 | N/A | ± 6 DN* | N/A | N/A |
| 11 | | ± 7 DN* | | |
| 12 | | ± 8 DN* | | |
| 13 | | ±11 DN* | | |
| 14 | | ±12 DN* | | |

* Offset knowledge related to only instrument temperature variation is specified in 2.1. Offset knowledge related to onboard blackbody is specified as knowledge of temperature scale in 4.2.

## 3 Nonlinearity

The nonlinearity of input-to-output relation, NL, is defined as the ratio of the deviation of the input-to-output curve from the line connecting the output for the high level input and the offset to the response for the high level input as referred to in the ASTER Instrument Specification.

### 3.1 Requirement for knowledge of nonlinearity

Table 3.1 Requirement for knowledge of VNIR and SWIR nonlinearity, NL

| Band No. | NL knowledge (3σ) |
|---|---|
| 1 | ±1 % |
| 2 | ±1 % |
| 3N | ±1 % |
| 3B | ±1 % |
| 4 | ±1 % |
| 5 | ±1 % |
| 6 | ±1 % |
| 7 | ±1 % |
| 8 | ±1 % |
| 9 | ±1 % |

Table 3.2 Requirement for knowledge of TIR nonlinearity, NL

| Band No. | NL knowledge (3σ) |
|---|---|
| 10 | ±1 % |
| 11 | ±1 % |
| 12 | ±1 % |
| 13 | ±1 % |
| 14 | ±1 % |

## 4 Absolute Responsivity, Gain Ratio, and Temperature Scale

### 4.1 Requirements for the knowledge of absolute responsivity, temperature scale, and gain ratio

Requirements for the knowledge of absolute responsivity and temperature scale are referred to the item of 20 of the ASTER Performance Specification. The requirements are specified at the high level input radiance for VNIR and SWIR and all through the anticipated ASTER life time.

Knowledge of the gain ratios among the high, normal, low-1, and low-2 gains should is required to be the same level as the item 28 of ASTER Performance Specification, i.e. 1%.

### 4.2 Methodology for evaluation of responsivity, gain ratio, and temperature scale

VNIR and SWIR is calibrated referring to the absolute standards of spectral radiance. TIR is calibrted referring to the temperature standards.

Uncertainty in the responsivity determination of VNIR and SWIR should be analyzed to fill out the following table.

Table 4.1 Analysis of uncertainty in the responsivity determination of VNIR and SWIR

| Phase | Source of uncertainty | Uncertainty /% (3σ) | | Comments |
|---|---|---|---|---|
| | | Budget | Design | |
| Prelaunch | Fixed-point blackbody | | | |
| | Standard spectrometer | | | |
| | Variable temperature blackbody | | | |
| | Comparison spectrometer | | | |
| | Integrating sphere | | | |
| | Radiometer output measurement | | | |
| | Photomonitor output measurement | | | |
| | Air-to-vacuum shift of center wavelength | | | |
| | Subtotal (RSS) | | | |
| Postlaunch | Temperature of photomonitor | | | |
| | Degradation of photomonitor | | | |
| | Photomonitor output measurement | | | |
| | Gravity shift of lamp radiance | | | |
| | Radiometer output measurement | | | |
| | (Nonuniform contamination of radiometer aperture optics) | | | |
| | Subtotal (RSS) | | | |
| | Total (RSS) | | | |

## 5 Responsivity Ratio and Temperature Scale Difference among Bands

### 5.1 Requirement for knowledge of responsivity ratio and temperature scale difference among bands

Table 5.1 Requirement for knowledge of responsivity ratio and temperature scale difference among bands

| Operating bands | Knowledge of responsivity ratio and temperature scale difference among bands, (3σ) |
|---|---|
| VNIR | 6% |
| SWIR | 6% |
| TIR | |
| 200 K～240 K | 1.5 K |
| 240 K～270 K | 1.0 K |
| 270 K～340 K | 0.5 K |
| 340 K～370 K | 1.0 K |

## 6 Responsivity ratio and temperature scale difference among detector elements of a band

### 6.1 Requirement for knowledge of responsivity ratio and temperature scale difference among detector elements of a band

Table 6.1 Requirement for knowledge of responsivity ratio and temperature scale difference among detector elements of a band

| Operating bands | Knowledge of responsivity ratio and temperature scale difference among detector elements in a band (3σ) |
|---|---|
| VNIR | 2% |
| SWIR | 2% |
| TIR | |
| 200 K～240 K | 0.8 K |
| 240 K～270 K | 0.5 K |
| 270 K～340 K | 0.25K |
| 340 K～370 K | 0.5 K |

# 7 Polarization Characteristics

## 7.1 Requirement for knowledge of polarization characteristics

Table 7.1 Requirement for knowledge of polarization characteristics

| Operating band | Knowledge of polarization characteristics (3σ) |
|---|---|
| VNIR | 1% |
| SWIR | 1% |
| TIR | NA |

## 8 Stray Light Characteristics

### 8.1 Requirement for stray light characteristics and its knowledge

Radiometer response may change for radiant sources with different sizes even if the radiance is exactly same due to stray light effect of radiometers. The stray light characteristics is defined by the relative response difference of radiometer when observing the earth disk and the standard radiation source (integrating sphere for VNIR and SWIR, and standard blackbody for TIR) which is required to be less than the required values listed in the following table.

Table 8.1 Requirement for stray light characteristics

| Operating band | Stray light characteristics |
|---|---|
| VNIR | 2% |
| SWIR | 2% |
| TIR | 1% |

The stray light characteristics shall be determined with the knowledge as listed in the following table.

Table 8.2 Requirement for knowledge of stray light characteristics

| Operating band | Knowledge of stray light characteristics |
|---|---|
| VNIR | 1% |
| SWIR | 1% |
| TIR | 0.5% |

# ERROR BUDGET FOR VNIR & SWIR RESPONSIVITY CALIBRATION

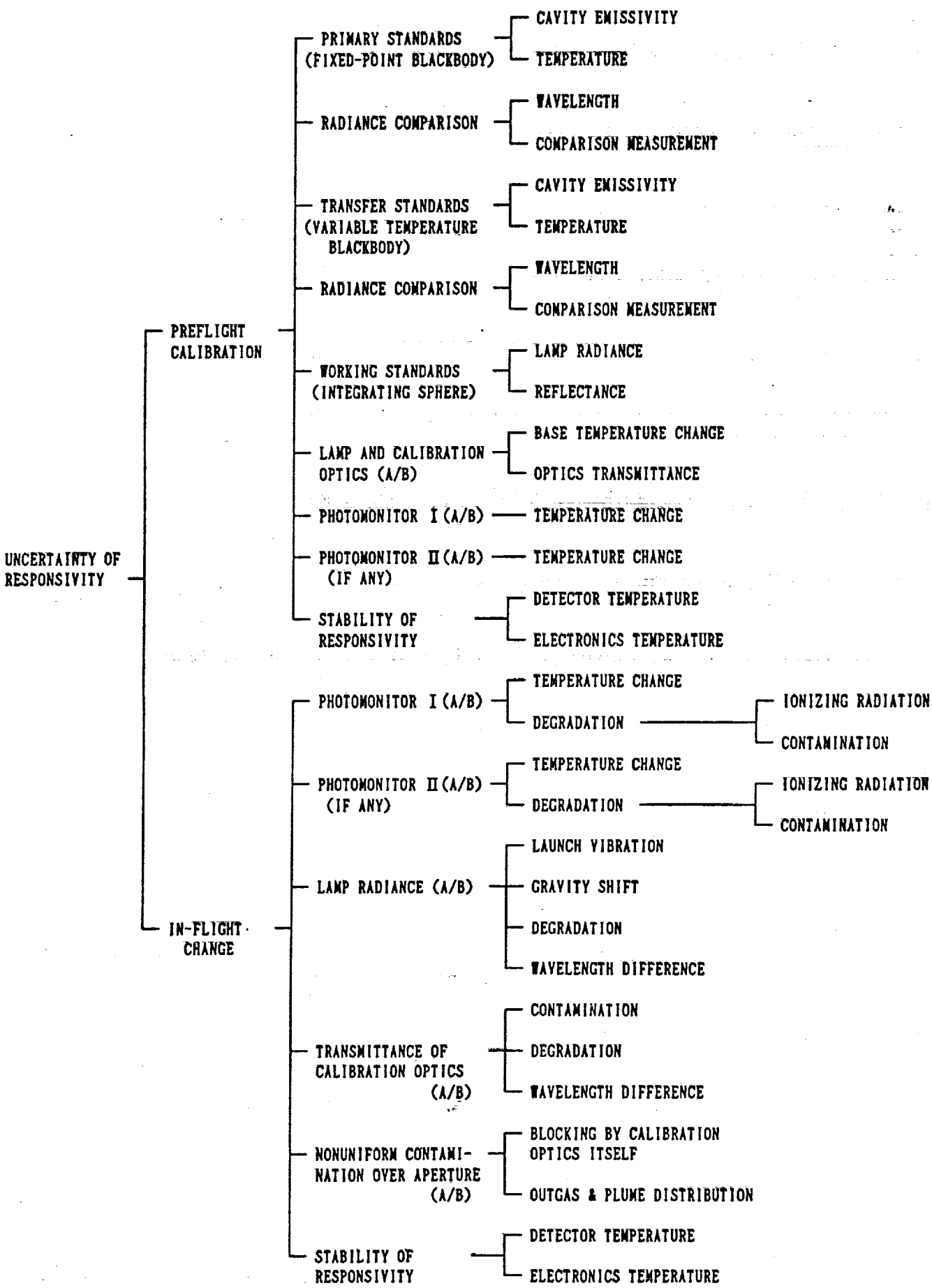

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Table 8.1 Requirement for stray light characteristics

| Operating band | Stray light characteristics |
|---|---|
| VNIR | 2% |
| SWIR | 2% |
| TIR | 1% |

The stray light characteristics shall be determined with the knowledge as listed in the following table.

Table 8.2 Requirement for knowledge of stray light characteristics

| Operating band | Knowledge of stray light characteristics |
|---|---|
| VNIR | 1% |
| SWIR | 1% |
| TIR | 0.5% |

# ERROR BUDGET FOR VNIR & SWIR RESPONSIVITY CALIBRATION