# TECHNICAL REQUIREMENTS SPECIFICATION

# FOR THE

# GLOBAL ULTRAVIOLET IMAGER

# (GUVI)

# INSTRUMENT

**7366-9001**

**Revision: b**

**January 23, 1998**

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## 1. Scope

This specification defines the technical requirements for the Global Ultraviolet Imager (GUVI) program. The requirements for the GUVI flight instrument and ground segment are described in this document. GUVI is an instrument on the Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics (TIMED) spacecraft. GUVI consists of a cross-track scanning imaging spectrograph that operates in the far ultraviolet region. GUVI obtains airglow measurements on a global basis.

## 2. Applicable Documents

TIMED Component Environmental Specification, 7363-9010

TIMED General Instrument Interface Specification, 7363-9050

TIMED EMC Control Plan, 7363-9038

GUVI Specific Instrument Interface Specification, 7363-9046

GUVI Product Assurance Implementation Plan, 7366-9190

GUVI Payload Operations Center Software Requirements Specification, 7366-9200

GUVI Flight Software Requirements Specification, 7366-9040

GUVI Subsystem Electrical Interface Control Document, 7366-9020

## 3. Measurement Requirements

### 3.1 Measurement Objectives

The GUVI airglow measurements are to be used in conjunction with ionospheric models to determine seasonal and local solar time variation of the major species composition in the MLTI region. The airglow measurements will also be used to determine the energy inputs in the auroral region to understand the global MLTI energy balance.

### 3.2 Spectral Range

The spectral range shall be 115 to 180 nm.

### 3.3 Emission Features

GUVI shall measure the emission features at the following wavelengths:
121.6 nm
130.4 nm
135.6 nm
140 to 150 nm
165 to 180 nm

### 3.4 Spectral Resolution

The spectral resolution shall be 5 nm or less.

### 3.5 Intrascene Dynamic Range

The intrascene dynamic range shall be 1000:1 or greater.

### 3.6 Interscene Dynamic Range

The interscene dynamic range shall be 1000:1 or greater.

### 3.7 Responsivity

The minimum responsivity (in counts per second per Rayleigh) at the wavelength regions of interest shall be:

| Wavelength (nm) | Responsivity (c/sec/R) |
|---|---|
| 121.6 | 0.029 |
| 130.4 | 0.058 |
| 135.6 | 0.116 |
| 140 to 150 | 0.289 |
| 165 to 180 | 0.193 |

### 3.8 Limb Altitude Coverage

The limb coverage on the anti-sun side shall range from 60 km to 500 km tangent altitude. No limb coverage on the sun side is required.

### 3.9 Limb Spatial Resolution

The spatial resolution on the limb shall be 0.74 degrees or less.

### 3.10 Limb Spatial Sampling

The spatial sampling interval on the limb shall be 0.4 degrees.

### 3.11 Disk Spatial Coverage

The spatial coverage on the Earth's disk shall range from ±60 degrees with respect to nadir.

### 3.12 Disk Spatial Resolution

The spatial resolution on the disk per pixel shall be a maximum of 1.5 degrees by 1.5 degrees.

### 3.13 Post-Processing Spatial Resolution

After post-processing, the maximum super-pixel spatial resolution shall be:
10 km by 10 km (auroral region)
100 km by 100 km (dayside region)
200 km by 200 km (nightside region)

A super-pixel is formed by co-adding adjacent imaging pixels.

### 3.14 Accuracy Requirements

#### 3.14.1 Calibration Precision

The instrument calibration errors shall be less than 8%.

#### 3.14.2 Counting Statistics

The counting statistics errors per super-pixel shall be less than 4%.

#### 3.14.3 Stray Light

The background count level due to stray light in the spectrograph shall be less than 2%.

#### 3.14.4 Data Compression

The data compression errors per pixel shall be less than 2%.

### 3.15 Pointing Requirements

#### 3.15.1 Pointing Placement

The platform pointing control shall be 1.0 degree or less.

### 3.15.2 Pointing Knowledge

The spectrograph pointing errors, from all sources, shall be 0.3 degrees or less on the limb, and 1.0 degrees or less on the disk. The platform pointing knowledge shall be 0.25 degrees or less.

### 3.15.3 Jitter

The platform attitude control jitter shall be less than 0.04 degrees per 68 milliseconds in pitch and roll.

### 3.15.4 Stability

The platform attitude control long term stability shall be less than 0.1 degrees per 15 seconds, each axis.

### 3.16 Orbital Requirements

### 3.16.1 Altitude

The platform altitude shall be greater than 600 km and less than 900 km. The orbit shall be near circular.

### 3.16.2 Inclination

The orbit inclination shall be 70 degrees or greater.

### 3.16.3 Position Knowledge

The position knowledge shall be 1000 meters.

### 3.16.4 Velocity Knowledge

The velocity knowledge shall be 250 meters/second.

## 4. Instrument Requirements

### 4.1 Instrument Description

The GUVI instrument contains a cross-track scanning imaging spectrograph that operates in the far ultraviolet region. GUVI obtains airglow measurements on a global basis. The GUVI instrument produces horizon to horizon line scan images at five simultaneous far ultraviolet wavelengths.

The GUVI instrument consists of two major subsystems: the scanning imaging spectrograph (SIS) and the electronics control unit (ECU). A block diagram of GUVI is shown in figure 1. The scanning imaging spectrograph subsystem includes the spectrograph optics housing and electronics package, and the detector tubes, high voltage power supplies, and focal plane electronics. The electronics control unit contains the processor, interface, and power switching circuitry required by the GUVI instrument.

## 4.2 Operating Modes

### 4.2.1 Imaging

The imaging mode is the primary operating mode of the GUVI instrument. The GUVI instrument builds multi-spectral images by scanning spatially across track. One dimension of the detector array contains 14 spatial pixels (along the spacecraft track), and the other dimension consists of 168 spectral bins over the range of 115 to 180 nm. The scan mirror sweeps the 14 spatial pixel footprint from horizon to horizon perpendicular to the spacecraft motion, producing one frame of 14 cross track lines in 15 seconds. Simultaneous image frames are generated over the entire wavelength range in the imaging mode, but the data rate allocation limits the downlinked image data to five different wavelengths.

The imaging mode scan cycle consists of a limb viewing section followed by an Earth viewing section. Limb viewing pixels are collected from +80.0° from nadir (the start of scan) to +67.2° from nadir. The limb viewing section has a cross track resolution of 0.4° per pixel, and consists of 32 cross track pixels. The limb pixel period is 68 msec. At +80.0° from nadir and a spacecraft altitude of 600 km, the spectrograph will view approximately 500 km above the horizon.

The Earth viewing section has a cross track resolution of 0.8° per pixel, and consists of 14 along track pixels and five wavelengths. The cross track scan covers from +67.2° from nadir to -60.0° from nadir, and contains 159 cross track pixels. The Earth pixel period is 68 msec.

### 4.2.2 Spectrograph

The spectrograph mode is used for on-orbit calibration. In the spectrograph mode, the scan mirror is held at a fixed cross track viewing angle, and the entire far ultraviolet spectrum is downlinked. This mode is used for two purposes: sensor characterization and ground truth. For sensor characterization, an entire spectrum is downlinked and either spectrum line positions are mapped to bins or a calibration is determined based upon observations of known stellar sources. For ground truth, the scan mirror is positioned at an angle that allows GUVI to take high resolution spectral data for comparison to corroborative ground based measurements. Sensor characterization is expected to be a routine procedure that will occur throughout the life of the mission.

In spectrograph mode, the along track dimension of the detector array will consist of 14 spatial pixels. Spectrum data from all 168 bins are produced for the 14 spatial pixels every 3.0 seconds. The scan mirror is held at any selectable position within the cross track field of view.

### 4.2.3 Other Modes

Other modes shall be provided to support instrument operation. A test mode shall be included to downlink the raw detector event pulse height values for diagnostic or calibration purposes. A safe mode shall provide a protected state for the instrument during attitude maneuvers or other special events. A maintenance mode shall be provided to perform processor software uploads.

## 4.3 Scanning Imaging Spectrograph

### 4.3.1 Functional Description

The scanning imaging spectrograph subsystem consists of a cross track scanning mirror at the input to the telescope and spectrograph optics. At the focal plane of the spectrograph are redundant two-dimensional photon-counting detectors. The detectors employ a position sensitive anode to determine the photon event location.

The scanning imaging spectrograph contains three entrance slits of varying widths. The intermediate width slit is used during imaging mode operation. The widest slit would be used in imaging mode to increase the sensitivity should the optical efficiency of the system decrease over time. The narrowest slit is used during spectrograph mode operation to obtain better spectral resolution. While the slit sizes were chosen with this intended operation, any slit can be used in any mode of operation.

### 4.3.2 Spectral Range

The spectral range of the SIS shall be 115 nm to 180 nm.

### 4.3.3 Spectral Resolution

The spectral resolution as a function of slit position shall be:

| | |
|---|---|
| narrow slit | 1.3 nm |
| intermediate slit | 2.0 nm |
| wide slit | 4.2 nm |

### 4.3.4 Instantaneous Field of View

The instantaneous field of view in the along track dimension shall be 11.84 degrees. The instantaneous field of view in the cross track dimension as a function of slit position shall be:

| | |
|---|---|
| narrow slit | 0.18 deg |
| intermediate slit | 0.30 deg |
| wide slit | 0.74 deg |

#### 4.3.5 Scanned Field of View

The scanned field of view in the cross track dimension shall be 140 degrees, ranging from 80 degrees from nadir on the anti-sun side of the spacecraft to 60 degrees from nadir on the sun side.

#### 4.3.6 Spatial Resolution

The spatial resolution at nadir shall be less than 10 km.

#### 4.3.7 Optical Design Parameters

| | |
|---|---|
| Entrance Aperture | |
| Clear aperture | 20 x 25 mm rectangular |
| Spacing to mirror | 105.2 mm |
| Telescope Mirror | |
| Type | Off-axis parabola |
| Clear aperture | 25 mm by 50 mm |
| Off-axis distance | 22.5 mm |
| Spacing to slit | 75 mm (along parabola axis) |
| Entrance Slit | |
| Intermediate | 0.39 mm by 15.7 mm |
| Wide | 0.97 mm by 15.7 mm |
| Narrow | 0.236 mm by 15.7 mm |
| Spacing to grating | 194.6 mm (along ray) |
| Grating | |
| Radius of curvature | 200 mm (spectral), 193.7 mm (spatial) |
| Clear aperture | 65 mm (groove length) x 54 mm (ruled width) |
| Type | Toroidal |
| Ruling | 1200 grooves/mm |
| Focal Plane | |
| Spatial dimension (Y) | 16.5 mm |
| Spectral dimension (X) | 15.6 mm |
| System Parameters | |
| Effective focal length | 75 mm |
| F/number | 3.0 |
| Beam diameter | 25 mm |

#### 4.3.8 Entrance Baffle

The entrance baffle to the telescope shall reject stray light off the scan mirror from entering into the spectrograph. There shall be no direct optical path from the scan mirror entrance aperture to the telescope mirror.

#### 4.3.9 Reflective Coating

Reflective optics shall be used in the spectrograph. The mirror surfaces shall be aluminum with a magnesium fluoride overcoat. Mirrors shall have a minimum reflectivity of 75% at 135.6 nm. Low outgassing materials shall be used in the spectrograph to prevent contamination of optical surfaces. If it becomes necessary to limit the detector maximum count rate, mirror coatings shall be selected that will attenuate the short wavelength end of the focal plane (115 nm to 133 nm).

### 4.3.10 Scan Mirror

The scan mirror shall be planar, and sized to meet the field of view requirements. The mirror surface shall be aluminum with a magnesium fluoride overcoat. The mirror minimum reflectivity shall be 75% at 135.6 nm. The mirror surface finish shall be 3 Angstrom RMS for extremely low scatter of visible light.

Provision shall be made to locate a witness mirror inside the scan mirror cavity. The witness mirror shall be of size 0.5 inch by 0.5 inch, and shall be removable via the outside of the SIS Housing.

### 4.3.11 Scan Motor

A stepper motor with a single winding and redundant electrical drive circuitry shall be used. The motor output shaft shall have a 0.2 degree per step resolution. The motor direction shall be reversible. The viewing angle moves 0.4 degrees for every 0.2 degree motor step.

The total scan angle shall be +80 to -60 degrees about nadir, to allow for above the horizon viewing of the limb and calibration stars. The motor shall operate at an average scan rate of 140 degrees in 13 seconds during the forward scan, and at an average rate of 140 degrees in 2 seconds during the reverse flyback.

The motor peak overshoot during the limb scan shall be 0.1 degrees. The motor shall settle to less than 15% of a step within 34 msec during the limb scan section.

The motor shall operate at +20 Volts DC. The motor maximum power dissipation shall not exceed 5.0 Watts.

### 4.3.12 Motor Position Indicator

The scan motor position indicator shall identify two motor positions, start of scan and nadir. The accuracy of the position indicator shall be 0.2 degrees (one motor step).

### 4.3.13 Dust Cover

The spectrograph shall include a dust cover over the scan mirror aperture. The cover mechanism shall be activated by redundant bellows motors. The dust cover will not be reclosed on-orbit, but shall be manually re-closable during ground tests. The cover mechanism shall include indicators for the closed and full open positions.

### 4.3.14 Entrance Slit

The spectrograph shall include a mechanism for varying the spectrograph entrance slit. The mechanism shall contain four positions, for the three slits defined in 4.3.7, and a closed position. The accuracy of the slit position shall be 0.1 mm in the spectral dimension. A position indicator shall identify each slit position.

### 4.3.15 Sun Sensor

A separate sun sensor within the spectrograph is not required. The sun sensor function shall be performed by monitoring the detector input count rate.

### 4.3.16 Pop-up Mirror

A pop up mirror shall be included to allow for selecting either the primary or secondary detector at the spectrograph focal plane. The pop up mirror mechanism shall be reversible. A position indicator shall identify the pop-up mirror position.

### 4.3.17 Purge Connection

The spectrograph shall include hardware to allow for connection of a nitrogen purge line to the instrument. A single fitting shall be located in a position that is easily accessible when GUVI is mounted on the spacecraft.

### 4.3.18 Alignment Cube

The spectrograph shall include an alignment cube for co-aligning the spectrograph optical axes to the spacecraft reference axes. The alignment cube shall be in a location that is viewable when GUVI is mounted on the spacecraft. The alignment cube shall have a surface area of at least 161 square mm on each reference face.

### 4.3.19 Drive Electronics

The spectrograph subsystem shall include the power drive electronics for operating the various motors and subsystems in the spectrograph. Digital control signals and power will be provided to the spectrograph by the GUVI ECU. The drive electronics shall be located in a separate package.

## 4.4 Detector

### 4.4.1 Functional Description

The spectrograph shall include two redundant detectors. Only one detector shall be operated at a time. The detector shall be a two-dimensional photon-counting device.

The use of the secondary detector will lower the sensitivity of the spectrograph due to the extra reflection of the pop up mirror. The sensitivity with the secondary detector in place will be approximately 75% of the sensitivity with the primary detector.

### 4.4.2 Tube Characteristics

The detector tube characteristics shall be:

| | |
|---|---|
| Size | 25 mm diameter |
| Input Window | Magnesium Fluoride |
| Photocathode | Cesium Iodide |
| Quantum Efficiency | 10% at 135 nm |

### 4.4.3 Dynamic Range

The detector subsystem shall operate up to a maximum input count rate of 117,000 counts per second.

### 4.4.4 Integration Period

The minimum integration period shall be 64 msec during the Earth scan, and 34 msec during the limb scan.

### 4.4.5 Position Resolution

The detector position resolution shall be less than 0.300 mm.

### 4.4.6 Position Output

The event position shall be determined to a resolution of 14 elements in the spatial dimension and 168 elements in the spectral dimension.

### 4.4.7 Lifetime

The detector shall meet the lifetime requirements for continuous detector operation in the presence of the expected orbit intensities. The orbit average intensity is estimated to be 1/2 the day side maximum intensity for 50% of each orbit, and 1/2 the night side maximum intensity for 50% of the orbit.

### 4.4.8 Dark Count

The detector dark count shall be less than 30 counts per second over the entire tube active area.

## 4.5 Electronics Control Unit

### 4.5.1 Functional Description

The GUVI electronics control unit consists of the telemetry processor, the detector processor, detector A/D converters, the interface unit, and the power switching unit. The telemetry processor controls the GUVI operation, collects and processes detector data, and communicates with the spacecraft command and data handling subsystems. The detector processor computes the position of each photon event and bins the events from each frame into spatial and spectral pixels. The detector A/D converters digitize the analog pulse height signals from the detector tubes. The interface unit contains the circuitry to interface the telemetry processor to the spacecraft and the spectrograph and detector subsystems. The power switching unit provides the appropriate voltages to the GUVI subsystems, and performs the necessary power switching functions for the GUVI spectrograph and detectors.

### 4.5.2 Telemetry Processor

The telemetry processor is the main control unit of the instrument. The processor shall include three types of memory - PROM, EEPROM, and RAM. The PROM shall contain unchangeable code for processor bootstrap and maintenance operations. The EEPROM shall contain code for the GUVI operating modes, and shall be changeable on-orbit via software uploads. The processor software may execute out of RAM.

The telemetry processor shall control the operation of the spectrograph and detector subsystems, and communicate with the spacecraft command and data handling subsystems. A test connector may be provided on the ECU to provide an external communications interface to the telemetry processor.

#### 4.5.2.1 Detector Control

The telemetry processor shall perform the following detector control functions.

1. Turn on the primary or secondary detector power.
2. Set the detector high voltage level.
3. Control the detector integration period.
4. Send command instructions to the detector processor.
5. Receive and format the binned event data from the detector processor.
6. Accumulate the detector input and output counts per integration period.
7. Monitor the detector input rate and protect the detector against bright objects.

#### 4.5.2.2 Spectrograph Control

The telemetry processor shall perform the following spectrograph control functions.

1. Set the entrance slit to the selected position.
2. Set the pop-up mirror to the selected position.
3. Turn the scan mirror heater on and off.
4. Initialize the scan motor position when the motor is first powered.
5. Set the scan motor to a fixed position.
6. Step the scan motor over its scan range during imaging mode.

#### 4.5.2.3 Command Processing

The telemetry processor shall interpret and execute GUVI commands that are received from the spacecraft command and data interface. The telemetry processor shall maintain a time of day clock to execute time tagged commands. GUVI commands are defined in the GUVI Flight Software Requirements Specification.

#### 4.5.2.4 Data Formatting

The telemetry processor shall format the GUVI telemetry packets according to the operating mode in use, and transmit the packets to the spacecraft command and data interface. GUVI packet formats are defined in the GUVI Flight Software Requirements Specification.

### 4.5.3 Interface Unit

#### 4.5.3.1 Spacecraft Interface

The ECU shall interface with the spacecraft command and data handling subsystems via a MIL-STD-1553 bus. The bus requirements are defined in the TIMED General Instrument Interface Specification. The ECU shall provide two redundant 1553 bus transceivers.

#### 4.5.3.2 Spectrograph Interface

The ECU shall interface with the following spectrograph components. The interface signal definitions are included in the GUVI Subsystem Electrical ICD.

1. Entrance Slit Mechanism
2. Pop-up Mirror Mechanism
3. Scan Motor Mechanism
4. Scan Mirror Heater
5. Slit Position Indicator
6. Pop-up Position Indicator
7. Scan Motor Position Indicator
8. Cover Position Indicator
9. Scan Motor Current Monitor
10. Temperature Monitors

#### 4.5.3.3 Detector Interface

The ECU shall interface with the following detector components. The interface signal definitions are included in the GUVI Subsystem Electrical ICD.

1. High Voltage Level
2. High Voltage Monitor
3. Detector Rate Counters
4. Detector Configuration Registers
5. Temperature Monitors

### 4.5.4 Detector Processor

#### 4.5.4.1 Detector Inputs

The detector A/D converters shall receive the photon event pulse height analog signals from the focal plane electronics. Two detector interfaces are required, for the primary and secondary detectors. The detector processor shall receive the digitized photon event pulse height data from the detector A/D converters. Events from only one detector at a time will be processed.

#### 4.5.4.2 Event Processing

The detector processor shall compute the photon event position from the event pulse height values. The detector processor shall accumulate the photon events into 14 spatial by 168 spectral bins during each data frame. The number of bins is independent of the GUVI operating mode. The count in each bin shall be reset at the start of each data frame. The detector processor shall also provide pulse height values for diagnostic use. The detector processor software shall be changeable by the spacecraft software upload capability.

#### 4.5.4.3 Control Functions

The detector processor responds to commands received from the telemetry processor. The data frame period is set by the telemetry processor. The detector processor shall transfer the photon event count in each requested bin to the telemetry processor at the end of the data frame. The telemetry processor may request that all or a subset of all spectral bins be transferred. Any additional control signals that are required for event processing will be generated by the telemetry processor.

### 4.5.5 Power Switching Unit

#### 4.5.5.1 Power Interface

The power interface with the spacecraft is defined in the TIMED General Instrument Interface Specification. The ECU shall receive main, survival heater, and operational heater power busses from the spacecraft. All power busses are +28 Volt DC unregulated power. The spacecraft power grounds shall be isolated from signal grounds within the GUVI instrument.

The spacecraft shall switch the main and heater power busses on and off with relays on the spacecraft side of the interface.

### 4.5.5.2 Secondary Outputs

The power switching unit shall provide the following regulated voltages for the GUVI subsystems. The maximum current capability of the converters and the estimated average current are listed below. Isolated secondary voltages shall be provided for each GUVI subsystem to minimize common mode noise problems. Heater circuits shall be powered by the operational or survival heater power buses.

| Subsystem | Output Voltage (V) | Regulation | Converter Max Current (ma) | Load Avg Current (ma) |
|---|---|---|---|---|
| ECU | +5.0 | ±5% | 1000 | 870 |
| | +15.0 | ±5% | 100 | 35 |
| | -15.0 | ±5% | 100 | 50 |
| SIS | +5.0 | ±5% | 100 | 55 |
| | +20.0 | ±5% | 400 | 200 |
| HVPS | +28.0 | ±5% | 100 | 36 |
| FPE | +6.0 | ±5% | 100 | 70 |
| | -6.0 | ±5% | 100 | 30 |

### 4.5.5.3 Switching Functions

The ECU shall provide the following power switching functions.

1. Primary Detector Power
2. Secondary Detector Power
3. Scan Mirror Heater Power

## 4.6 Environmental

### 4.6.1 Thermal

#### 4.6.1.1 Operating Temperature

The operating temperature range for the GUVI components shall be:

| | |
|---|---|
| SIS Housing | -20°C to +25°C |
| All Electronics | -24°C to +55°C |

#### 4.6.1.2 Survival Temperature

The survival temperature range for the GUVI components shall be:

| | |
|---|---|
| SIS Housing | -25°C to +45°C |
| All Electronics | -29°C to +60°C |

#### 4.6.1.3 Temperature Gradient

The maximum temperature gradient across any two points in the SIS Housing shall be 10°C.

### 4.6.2 Vibration

#### 4.6.2.1 Sinusoidal Vibration

The sinusoidal vibration levels are listed below.

**Thrust Axis**

| Frequency (Hz) | Acceleration |
|---|---|
| 5 - 24 | 0.50 in. (double amplitude) |
| 24 - 50 | 15.5 g |
| 50 - 100 | 2.0 g |

Rate = 4 Octaves/minute

**Lateral Axes**

| Frequency (Hz) | Acceleration |
|---|---|
| 5 - 18 | 0.50 in. (double amplitude) |
| 18 - 30 | 8.5 g |
| 30 - 100 | 2.0 g |

Rate = 4 Octaves/minute

#### 4.6.2.2 Random Vibration

The random vibration levels are listed below.

**Each Axes**

| Frequency (Hz) | Power Spectral Density |
|---|---|
| 10 - 50 | 0.06 $g^2$/Hz |
| 50 - 250 | +2.3 dB/oct |
| 250 - 1000 | 0.2 $g^2$/Hz |
| 1000 - 2000 | -5.2 dB/oct |
| 2000 | 0.06 $g^2$/Hz |

| | |
|---|---|
| Overall amplitude: | 17.0 g rms |
| Duration: | 3.0 min/axis |

**4.6.3 Electromagnetic Compatibility**

The GUVI instrument shall be designed to minimize emanation of and susceptibility to spurious electromagnetic signals, both radiated and conducted. EMC testing shall be based on the requirements of MIL-STD-461. The GUVI instrument shall achieve systems compatibility with the TIMED spacecraft as defined in the TIMED EMC Control Plan, 7363-9038.

**4.6.4 Radiation**

The expected 2 year radiation total dose level for this mission is 5,000 rads (Si).

**4.7 Lifetime**

The design life of the GUVI flight instrument shall be 2 years of on-orbit operation.

## 5. Interface Requirements

**5.1 Mechanical**

**5.1.1 Envelope**

The footprint for the scanning imaging spectrograph subsystem shall be 27.0 inch by 16.0 inch. The maximum height of the spectrograph, in launch configuration, shall be 11.25 inch. The maximum height, after deployments on-orbit shall be 14.0 inch.

The electronics control unit footprint shall be 14.28 inch by 9.0 inch. The height of the electronics control unit, including connector access, shall be 6.88 inch.

**5.1.2 Mass**

The mass of the GUVI instrument shall not exceed 20.17 kilogram. This includes all packages, interconnect cables, and thermal blankets.

**5.1.3 Alignment Accuracy**

The GUVI spectrograph optical axes shall be aligned to the platform reference axes to 1.0 degree or less in each axis.

**5.1.4 Alignment Knowledge**

The alignment measurement shall have a precision of 0.05 degrees or less.

### 5.1.5 Clear Field of View

The instrument clear field of view shall be +85° to -62° with respect to nadir in the cross track direction, and ±10° with respect to nadir in the along track direction. A positive cross track angle is on the anti-sun side.

## 5.2 Thermal

### 5.2.1 Thermal Control

The SIS optics housing shall be thermally isolated from the spacecraft deck. All other GUVI electronics packages shall be conductively mounted to the spacecraft deck.

### 5.2.2 Interface Temperature Range

The interface temperature range at the GUVI mounting surface shall be -24°C to +55°C (operational), and -29°C to +60°C (survival).

### 5.2.3 Interface Temperature Stability

The interface temperature stability at the GUVI mounting surface shall be 2°C per minute.

### 5.2.4 Interface Thermal Gradient

The thermal gradient at the GUVI mounting surface shall be less than 15°C between the SIS mounting feet, and less than 4°C across the SIS mounting feet.

### 5.2.5 Temperature Sensors

GUVI shall include two temperature sensors on the SIS optics housing to be monitored by the spacecraft.

## 5.3 Electrical

### 5.3.1 Average Power

The instrument orbit average power dissipation, including operational heater power, shall be less than 31.5 Watt in any mode.

### 5.3.2 Peak Power

The instrument peak power dissipation, including operational heater power, shall be less than 46.0 Watt in any mode.

### 5.3.3 Heater Power

The operational heater power shall be less than 7.0 Watt average, 17.0 Watt peak. The survival heater power dissipation shall be less than 11.0 Watt average, 26.6 Watt peak.

## 5.4 Magnetic Field

The magnetic field strength at the SIS housing detector tubes shall not exceed 2 gauss.

## 5.5 Command and Data Handling

### 5.5.1 Command Rate

The instrument average command upload rate shall be 3.2 kbit per week.

### 5.5.2 Software Upload

The instrument maximum software upload size shall be 640 kbit.

### 5.5.3 Data Rate

The instrument daily average data rate shall be less than 8.105 kbit per second. The instrument peak data rate, real time or record, shall be less than 8.105 kbit per second.

### 5.5.4 Duty Cycle

The instrument data rate duty cycle per orbit shall be 100%.

## 5.6 Cleanliness

### 5.6.1 Purge

The instrument shall require a nitrogen purge during integration and test. The nitrogen purge purity shall be at least equivalent to grade C. The purge flow rate shall be between 1.0 to 4.0 liters per minute. The maximum time that the instrument shall be without purge, provided that the spectrograph cover is closed, shall be 2 hours.

### 5.6.2 Hydrocarbon Levels

The instrument shall not be located in an environment in which the hydrocarbon level exceeds 15 parts per million.

### 5.6.3 Clean Room Levels

The instrument integration and test shall be conducted in a clean room of class 100,000 or better.

### 5.6.4 Surface Cleanliness

The spacecraft or instrument surface cleanliness shall be level 1000 or better.

## 6. Product Assurance Requirements

The product assurance requirements for the program are defined in the GUVI Product Assurance Implementation Plan, 7366-9190.

## 7. Ground Segment Requirements

### 7.1 Functional Description

The GUVI ground segment consists of engineering ground support equipment (GSE) and the payload operations center (POC). The engineering GSE shall support instrument testing during stand alone tests before installation on the spacecraft and during spacecraft integration and test. The GUVI POC consists of an engineering POC (EPOC) and a data processing POC (DPPOC). The engineering POC shall control the instrument during pre-launch testing and post-launch operations. The data processing POC will perform the routine data product generation and data access and distribution functions during post-launch operations.

### 7.2 Engineering GSE

The GUVI engineering GSE shall simulate the spacecraft power, command, and telemetry interfaces with the GUVI instrument during stand alone tests. The engineering GSE shall provide remote control of the instrument test lamp during stand alone and spacecraft level tests. The engineering GSE consists of two items, a spacecraft emulator, and a GSE rack.

### 7.2.1 Spacecraft Emulator

The spacecraft emulator provides the command and data interface between the GUVI flight instrument and the GUVI POC during stand alone tests. It emulates the MIL-STD-1553 interface with the instrument on board the spacecraft and the ethernet interface between the POC and the TIMED ground system. The spacecraft emulator hardware and software shall be provided by the TIMED program.

### 7.2.2 GSE Rack

The GSE rack shall simulate the spacecraft power and temperature monitor interfaces with the GUVI instrument. It shall also provide a remote controlled power source for the GUVI test lamp. The GSE rack shall contain a programmable power supply and a digital multimeter.

The programmable power supply shall simulate the spacecraft +28 Volt main, operational, and survival power busses during stand alone tests. The power supply shall provide the +12 Volt power for the instrument test lamp. The programmable power supply shall be controlled by the EPOC computer during stand alone tests and spacecraft I&T. An ethernet interface shall be used to remotely control the power supply during spacecraft I&T. The power bus voltage level shall be remotely adjustable by the EPOC computer. There shall be a current monitor for each power bus that can be read by the EPOC computer.

The digital multimeter shall simulate the spacecraft temperature monitor interface for the two GUVI temperature sensors during stand alone tests. The temperature monitor data shall be accessible by the EPOC computer.

## 7.3 GUVI POC

### 7.3.1 Engineering POC

#### 7.3.1.1 EPOC Description

The engineering POC shall generate the instrument command messages, evaluate the instrument health and status data, and perform limited processing of the science data. The EPOC shall consist of a Power Macintosh computer workstation.

The EPOC computer shall include an ethernet interface to communicate with the spacecraft ground system. The EPOC computer shall include a removable storage device to record instrument data. The computer shall be capable of synchronizing its clock to UTC time.

Two EPOC computers will be required to support the spacecraft I&T phase. The two computers shall be identical, and both shall be capable of controlling the instrument.

#### 7.3.1.2 EPOC Functions

The EPOC shall perform the following functions.

1. Generate GUVI command messages as selected by the operator.
2. Maintain a log of commands transmitted.
3. Generate upload messages for upgrades to instrument flight software.
4. Receive and unpack GUVI science data messages.
5. Perform limited processing of GUVI science data. Processing shall include unpacking of imaging mode and spectrograph mode data in 2-D image frames, conversion of analog telemetry values, computing image frame dark counts, computing detector pulse height distributions.

6. Display science data in operator selected format. Display 2-D false color images of imaging and spectrograph mode data. Display converted engineering data in text form. Out of limit engineering parameters shall be highlighted.

7. Maintain graphs in real time of selected engineering parameters vs. time for up to the previous 24 hours.

8. Maintain a log of selected science data parameters.

9. Archive all science data messages on data storage device. Preferably, at least 24 hours of data can be recorded on one data cartridge.

10. Allow for recorded science data to be played back and displayed on EPOC computer.

11. Allow for automated test scripts to be executed.

12. Transmit command and science data logs to the mission operations center when requested.

13. EPOC computer internal clock shall be time synchronized to UTC.

### 7.3.2 Data Processing POC

The data processing POC shall perform the routine data product generation and distribution functions. The data processing POC functions shall be performed on a workstation separate from the EPOC computer. The DPPOC shall consist of a Hewlett Packard computer workstation. Only one DPPOC computer is required to support GUVI pre-launch testing and post-launch operations.

The data processing POC software requirements are defined in the GUVI POC Software Requirements Specification, 7366-9200.

## 7.4 Test Environments

### 7.4.1 Stand Alone Tests

During instrument stand alone tests, the power, 1553, and temperature monitor interfaces will be provided by the spacecraft emulator and GSE rack. The instrument test lamp will be powered by the GSE rack. The EPOC computer will control the GUVI instrument. Instrument commands will be originated by the EPOC computer, and test data will be evaluated at the EPOC computer. The DPPOC computer is not required.

### 7.4.2 Spacecraft I&T

During the spacecraft I&T phase, the instrument will interface with the spacecraft subsystems. The instrument test lamp will be powered by the GSE rack. The EPOC computer will control the instrument by interfacing with the spacecraft mission operations computers via the ethernet interface.

Two identical EPOC computers will be needed during spacecraft I&T. One computer will reside in the GUVI flight POC, and the second computer will reside in the test

POC. The flight POC will be located at APL room TBD. The test POC will be located in the spacecraft clean room at APL during initial I&T, and near the mission operations center during the later stages of spacecraft I&T. Both computers shall be capable of controlling the instrument.

The GSE rack will be located near the spacecraft to control the GUVI test lamp. Should it become necessary to perform a stand alone test after the instrument is installed on the spacecraft, the instrument can be connected to the GSE rack and spacecraft emulator, and the test can be controlled by the EPOC computer.

### 7.4.3 Post-launch Operations

During post-launch operations, the instrument will be controlled by the EPOC computer located at the GUVI flight POC. Only one EPOC computer will be used during post-launch operations. The same EPOC software that was used during spacecraft I&T shall be used to control the instrument and evaluate instrument health and status during post-launch operations. The EPOC computer will communicate with the spacecraft mission operations computers over the ethernet interface.

## 8. Acronyms & Abbreviations

| | |
|---|---|
| C | Celsius |
| cps | counts per second |
| cnt | count |
| dB | decibel |
| DC | Direct Current |
| deg | degree |
| dia | diameter |
| ECU | Electronics Control Unit |
| EMC | Electromagnetic Compatibility |
| FOV | Field of View |
| FPE | Focal Plane Electronics |
| GSE | Ground Support Equipment |
| GUVI | Global Ultraviolet Imager |
| HVPS | High Voltage Power Supply |
| Hz | Hertz |
| ICD | Interface Control Document |
| JHU/APL | The Johns Hopkins University/Applied Physics Laboratory |
| kbit | kilobit |
| km | kilometer |
| kR | kilo-Rayleigh |
| lbs | pounds |
| ma | milliampere |
| MCP | Microchannel Plate |
| MHz | Mega-Hertz |
| MLTI | Mesosphere, Lower Thermosphere, Ionosphere |

| | |
|---|---|
| mm | millimeter |
| msec | millisecond |
| N/A | Not Applicable |
| nm | nanometer |
| POC | Payload Operations Center |
| R | Rayleigh |
| RMS | Root Mean Square |
| sec | second |
| Si | Silicon |
| SIS | Scanning Imaging Spectrograph |
| TIMED | Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics spacecraft |
| UV | Ultraviolet |
| V | Volt |