GLOBAL ULTRAVIOLET IMAGER

(GUVI)

OPERATIONAL CONCEPT DOCUMENT

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Table of Contents

1.	Scope	4
1.1	Identification	4
1.2	Overview	4
1.3	Definitions	5
2.	Referenced Documents	5
3.	Operations	6
3.1	Operational Overview	6
3.2	Constraints	6
3.3	Operational Processes	6
3.3.1	Command Process	6
3.3.2	Engineering Data Evaluation	7
3.3.3	Data Processing Process	7
4.	System Overview	7
4.1	System Scope	7
4.2	Flight Instrument	8
4.2.1	Operating Modes	8
4.2.1.1	Maintenance Mode	8
4.2.1.2	Test Mode	8
4.2.1.3	Imaging Mode	8
4.2.1.4	Spectrograph Mode	8
4.2.2	Spacecraft Status Message	9
4.2.2.1	Yaw Maneuver	9
4.2.2.2	Solar Panel Maneuver	9
4.2.2.3	Terminator Crossing	9
4.2.2.4	Power Down Warning	9
4.2.3	Special Events	9
4.2.3.1	Sun Event	9
4.2.3.2	1553 Heartbeat	10
4.2.3.3	Out of Limit Current/Temperature Monitors	10
4.2.3.4	Watch-dog Timer	10
4.3	Payload Operations Center	10
4.3.1	Engineering POC Functions	10
4.3.2	Data Processing POC Functions	10
4.3.3	Modes	10
4.3.4	Products	11
5.	Operational Environment	11
5.1	Hardware	11
5.2	Interfaces	11
5.3	Personnel	12
5.4	Users	12
5.5	Security	12
5.6	Backup	12
6.	Operational Scenarios	12
6.1	Pre-Launch Testing	12

6.2 Early Orbit Operations....13
6.3 Commanding....13
6.4 Data Processing....13
6.4.1 Engineering Data Processing....13
6.4.2 Science Data Processing....14
6.5 On-Orbit Calibration....14
6.6 Anomalies....14

1. Scope

1.1 Identification

This document describes the operational concept for the Global Ultraviolet Imager (GUVI) program. The document addresses operational concepts for the GUVI flight and ground segments.

1.2 Overview

GUVI is an instrument on the Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics (TIMED) spacecraft. The GUVI system consists of the GUVI flight instrument and the Payload Operations Center (POC).

The GUVI flight instrument contains a cross-track scanning imaging spectrograph that operates in the far ultraviolet region. GUVI produces simultaneous horizon to horizon line scan images at five far-ultraviolet wavelengths. The GUVI airglow measurements are used in conjunction with ionospheric models to produce the science data products.

The GUVI flight instrument consists of two major subsystems, the scanning imaging spectrograph (SIS) and the electronics control unit (ECU). The scanning imaging spectrograph subsystem includes the spectrograph optics housing and electronics package, and redundant detector tubes, high voltage power supplies, and focal plane electronics. The electronics control unit controls the operation of the spectrograph subsystem and interfaces with the spacecraft power and command and data handling subsystems.

The GUVI Payload Operations Center consists of both engineering and data processing segments. The engineering POC will be used to control the instrument during pre-launch ground testing and post-launch operations. The engineering POC will evaluate instrument health and status data and originate instrument commands. The data processing POC will perform the routine data product generation and data access and distribution functions during post-launch operations. The GUVI POC will control the instrument and access telemetry data through the TIMED ground system.

1.3 Definitions

C&DH	Command and Data Handling
CD	Compact Disk
Co-I	Co-Investigator
DP POC	Data Processing Payload Operations Center
ECU	Electronics Control Unit
EEPROM	Electrically Erasable Programmable Read Only Memory
EPOC	Engineering Payload Operations Center
GIIS	General Instrument Interface Specification
GSE	Ground Support Equipment
GUVI	Global Ultraviolet Imager
ICD	Interface Control Document
I&T	Integration and Test
JHU/APL	The Johns Hopkins University/Applied Physics Laboratory
MDC	Mission Data Center
MOC	Mission Operations Center
OCD	Operational Concept Document
PI	Principal Investigator
POC	Payload Operations Center
S/C	Spacecraft
SIS	Scanning Imaging Spectrograph
TIMED	Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics
UV	Ultraviolet

2. Referenced Documents

(1) GUVI Technical Requirements Specification, 7366-9001

(2) GUVI Software Quality Assurance Plan, 7366-9003

(3) GUVI Product Assurance Implementation Plan, 7366-9190

(4) TIMED Concept of Operations, 7363-9037

(5) TIMED General Instrument Interface Specification, 7363-9050

(6) Space Department Software Quality Assurance Guidelines, SDO-9989, September 1992

3. Operations

3.1 Operational Overview

The TIMED system was designed to decouple the instrument operations from spacecraft operations. The GUVI instrument operational and data processing functions will be performed from the GUVI POC. The GUVI POC will control the instrument through all phases of the mission, including pre-launch integration and test, early orbit operations, and routine flight operations.

The GUVI POC is divided into engineering and data processing functions. The engineering POC (EPOC) will originate the GUVI commands and process instrument engineering data. The EPOC will operate autonomously. In the event of an instrument alarm that requires operator attention, a message page will be generated. The data processing POC (DP POC) will generate the routine data products and provide the data access and distribution functions during flight operations.

The GUVI flight instrument will normally operate in one main mode, the imaging mode, while on-orbit. The instrument will operate continuously each orbit in imaging mode, generating global images at five far-ultraviolet wavelengths. The only planned mode change will be to perform a star calibration mode approximately once per month. The instrument will remain in calibration mode for approximately five consecutive orbits.

During routine flight operations, instrument commands will be uploaded at most once per week. The GUVI instrument will store on-board the time tagged commands to be executed during the week. The instrument will also respond to event messages broadcast by the TIMED spacecraft.

3.2 Constraints

The TIMED ground system will have one contact per day with the spacecraft during normal operations. The GUVI POC will be limited to one command upload per day of maximum size 2k bytes. The GUVI POC will control all instrument functions except for main and heater power which are controlled by the TIMED MOC.

Telemetry data will be downlinked once per day from the spacecraft recorders by the TIMED ground system. The GUVI POC will receive 24 hours worth of telemetry data once per day for processing.

3.3 Operational Processes

3.3.1 Command Process

The GUVI Principal Investigator (PI) will originate or approve all instrument mode or state changes. The GUVI PI will send planned instrument mode changes to the EPOC operator on a monthly basis. The EPOC operator will generate the command upload files from the planned operating mode list. The command upload files will be sent from the GUVI EPOC to the MOC once per week if any mode changes were planned for that week.

Most instrument mode changes will originate from the GUVI science team, for example, to perform star calibrations or to coordinate instrument operation with ground based measurements. On occasion, the GUVI engineering team may recommend mode or state changes based on analysis of engineering trend data. The engineering based changes may be items such as adjusting the detector high voltage to compensate for a loss in detector gain, or switching to a backup hardware component in the instrument. Any instrument mode change, whether science or engineering driven, will first be approved by the GUVI PI before any command upload is sent to the instrument.

3.3.2 Engineering Data Evaluation

The GUVI EPOC will continuously poll the TIMED MDC for new telemetry data. The EPOC will receive telemetry data once per day from the TIMED MDC. Engineering data processing will begin after the telemetry playback data are received. The EPOC will generate alarms on any out of limit critical parameters. In the event of an alarm, the EPOC will page an operator every 15 minutes until the alarm is answered. The EPOC will produce engineering trend and status data each day. The EPOC will operate autonomously on a daily basis. The EPOC operator will review the trend data on a weekly basis.

3.3.3 Data Processing Process

The GUVI DP POC will also poll the TIMED MDC for new telemetry data, and process the playback data on a daily basis. The science data products will be stored on the POC web server. The data products will also be recorded on compact disk for distribution to the GUVI science team. The DP POC will operate autonomously on a daily basis. The DP POC operator will review the science data products on a weekly basis.

4. System Overview

4.1 System Scope

A block diagram of the GUVI operational system is shown in figure 1. The GUVI flight instrument interfaces with the TIMED spacecraft C&DH subsystem over a 1553 bus. The GUVI POC consists of engineering and data processing POC components. The GUVI POC interfaces with the TIMED MOC for commands and real time data, and with the TIMED MDC for playback data. The GUVI engineering POC

operator has access to the EPOC functions only at the POC location. Engineering POC log files and data processing POC products are stored on a web server for access by the GUVI science team and other science users. The GUVI science team will also receive data products recorded on compact disk.

4.2 Flight Instrument

4.2.1 Operating Modes

The GUVI flight instrument has four operating modes, maintenance, test, imaging, and spectrograph. The instrument has several states that can be varied while operating in any mode. These states include the spectrograph slit position, detector selection, high voltage setting, and scan mirror look angle.

4.2.1.1 Maintenance Mode

Maintenance mode is used to support code uploads and reprogramming of the flight processor EEPROM. It provides a memory dump capability. Maintenance mode is entered at main power on or a watch dog timer reset. The instrument exits maintenance mode by command.

4.2.1.2 Test Mode

Test mode is used primarily during ground testing and calibration to check the detector performance. It downlinks the raw pulse height samples from the detector. Test mode will provide a pulse height distribution in a short period of time (several minutes) as compared to imaging or spectrograph mode (several hours).

4.2.1.3 Imaging Mode

Imaging mode is the main operating mode of the instrument. It generates simultaneous horizon to horizon line scan images at five far-ultraviolet wavelengths. The line scan includes a limb overscan on the anti-sun side. An image frame of size 191 pixels cross track by 14 pixels along track is produced every 15 seconds. The image frame field of view is 140 degrees cross track by 11.8 degrees along track. The five imaging wavelengths can be varied by uploading a new color definition table to the instrument.

4.2.1.4 Spectrograph Mode

Spectrograph mode is used primarily as a calibration mode. In spectrograph mode, the scan mirror is held at a fixed viewing angle anywhere within the 140 degree cross track field of regard. The instrument downlinks an image of the spectrograph focal plane every 3 seconds, which consists of 14 along track pixels by 168 spectral bins. During an on-orbit star calibration, the instrument is placed in spectrograph mode with the scan mirror pointing over the horizon at the calibration star.

4.2.2 Spacecraft Status Message

The instrument response to the spacecraft status message events that appear over the 1553 bus are described in this section.

4.2.2.1 Yaw Maneuver

When a message is received indicating that the spacecraft will begin a yaw maneuver, the GUVI instrument will exit the current operating mode and wait in a safe mode. After exiting the current operating mode, the detector high voltage will be turned off, the scan mirror will be stowed, and the instrument will enter the maintenance mode. The instrument will return to the normal operating mode after a message is received indicating the end of the yaw maneuver.

4.2.2.2 Solar Panel Maneuver

There will be no change in GUVI operating mode when a message is received indicating the start of a solar panel maneuver. A flag will be set in the GUVI telemetry data indicating that a solar panel maneuver is in progress.

4.2.2.3 Terminator Crossing

There will be no change in GUVI operating mode when a message is received indicating a terminator crossing. No change will be made to the spectrograph slit selection. A flag will be set in the GUVI telemetry data indicating that a terminator crossing has occurred.

4.2.2.4 Power Down Warning

When a message is received indicating that main power will be turned off, the instrument will exit the current operating mode, turn off the detector high voltage, and stow the scan mirror. These actions will be completed within 2 seconds of receiving the status message.

4.2.3 Special Events

The instrument response to other special events are described in this section.

4.2.3.1 Sun Event

A sun event will be detected by the instrument processor by monitoring the detector input count rate. When the input count rate exceeds a maximum limit, the detector high voltage will be turned off, the scan mirror will be stowed, and the instrument will enter the maintenance mode. Because the GUVI instrument should only

view the sun if the spacecraft attitude becomes unstable, the instrument will remain in this safe mode until ground commands are received.

4.2.3.2 1553 Heartbeat

A 1553 bus heartbeat monitor will be implemented by the spacecraft. If the spacecraft C&DH subsystem detects no response from the GUVI instrument over the 1553 bus, the spacecraft will turn the GUVI main power off, then on, in an attempt to reset the instrument. If there is still no response from the instrument, then the main power will be turned off until action can be taken from the ground.

4.2.3.3 Out of Limit Current/Temperature Monitors

The spacecraft will check the GUVI main and heater current monitors and two temperature monitors for out of limit conditions. The action to be taken in the event of an out of limit parameter is TBD.

4.2.3.4 Watch-dog Timer

The GUVI telemetry processor board includes a watch-dog timer that will reset the processor if the processor should hang up. After the processor reset, the instrument will execute the normal start up procedure, and then enter the previously selected operating mode.

4.3 Payload Operations Center

4.3.1 Engineering POC Functions

The engineering POC provides the commanding and health, status, and trending functions for the GUVI POC. The EPOC generates command messages, authenticates commands, and maintains a command log file. The EPOC processes engineering data, generating files of trend parameters, selected housekeeping data, and an alarm log. Critical alarms that require immediate operator attention will generate a phone page with a key code. The EPOC will also display engineering data parameters during real time tests.

4.3.2 Data Processing POC Functions

The DP POC provides the routine science data processing, data product generation, and data access and distribution functions. GUVI data products will be stored on a web server for access by external users. The web server is part of the DP POC.

4.3.3 Modes

The GUVI EPOC can process both real time and playback data. Real time data processing will be performed during pre-launch testing and early orbit operations. Playback data processing will be performed during flight operations. Both the EPOC and DP POC can operate autonomously, polling the TIMED MDC for new playback data each day. The EPOC will generate alarm pages for critical out of limit parameters. In addition to routine data processing, the DP POC will provide planning tools for generating star calibration commands and updating the planned and as flown timelines.

4.3.4 Products

The EPOC generates the following data products.

- Command logs
- Alarm logs
- Trend files

The DP POC generates the following data products.

- Science data products
- Survey products
- Catalog
- Planning Tools

5. Operational Environment

5.1 Hardware

The GUVI POC will be located at JHU/APL. The EPOC and DP POC hardware may be located in different rooms at APL. There are currently no plans to use the Aerospace Corporation as a backup GUVI POC site.

The EPOC will contain one Macintosh computer. A second EPOC will be available during pre-launch testing as requested by the TIMED program. The DP POC will include two Sun Ultra workstations. One Sun workstation will function as the web server.

5.2 Interfaces

The GUVI flight instrument and POC interfaces are defined in the TIMED General Instrument Interface Specification. The flight instrument receives commands and broadcast messages and transmits telemetry data over the 1553 bus on the TIMED spacecraft.

The GUVI EPOC sends command packets to the TIMED MOC, and receives command verification from the MOC. The EPOC receives real time telemetry data from the MOC. The EPOC and DP POC receive playback telemetry data from the

MDC. The EPOC sends log files to the DP POC web server. External users access the GUVI data products from the DP POC web server.

5.3 Personnel

Continuous staffing of the GUVI POC is not required. Instrument health checks and commanding will be performed weekly by the EPOC operator. Data quality checks will be made weekly by the DP POC operator. It is desired to have two EPOC operators and two DP POC operators to provide backup personnel coverage.

5.4 Users

The GUVI engineering team are the users of the EPOC. The engineering team will evaluate instrument performance from the EPOC during pre-launch and early orbit testing. The EPOC operator performs instrument commanding and engineering data analysis using the EPOC Macintosh computer.

The GUVI science team are the primary users of the DP POC products. Other science users will also access GUVI data products. Data products are accessed from the POC web server. GUVI science team members will also receive data products recorded on compact disk. User display software will be provided to the GUVI science team to be used locally in displaying GUVI data products.

5.5 Security

Command messages from the GUVI POC to the MOC will be formatted with the appropriate authentication information. The GUVI EPOC software will protect the commanding function against unauthorized network access.

5.6 Backup

The second EPOC computer, to be used during pre-launch testing in the GUVI test POC, will be available as a spare computer in the GUVI EPOC. The EPOC computer includes an uninterruptable power supply to provide autonomous operation. No spare DP POC computers will be purchased. DP POC hardware will be repaired as needed.

6. Operational Scenarios

6.1 Pre-Launch Testing

Two GUVI EPOCs will be available during spacecraft I&T for controlling the GUVI instrument. The GUVI test EPOC will be located near the spacecraft test equipment. The GUVI instrument can also be controlled from the flight POC located at APL. The GUVI EPOC will execute functional test scripts during spacecraft I&T. The

EPOC will receive real time data from the MOC and evaluate instrument performance during the tests.

6.2 Early Orbit Operations

GUVI early orbit testing will be conducted in two phases. An aliveness test of the instrument will be performed shortly after launch and before the GUVI spectrograph cover is opened. The cover will be opened approximately 14 days after launch. A detailed functional test will be performed after the cover is opened.

The aliveness test will check the command and data interface with the instrument, verify proper operation of the spectrograph slit and pop-up mirror mechanisms, and test the detector electronics and dark count performance. It will take about 4 passes, at 8 minutes duration per pass, to perform the aliveness test. The instrument will only be powered on during the pass.

The spectrograph cover will be opened approximately 14 days after launch. The instrument must be powered on when the cover pyros are fired so that the scan mirror can be held in place while the cover opens.

The final early orbit functional test will check the scan motor performance, detector response to airglow signals, imaging mode operation, and the star calibration sequence. It will take about 10 passes to complete the final early orbit testing. The instrument will be ready for normal operations after the final test is completed.

6.3 Commanding

A commanding timeline for routine operations is shown in figure 2. A planned timeline will be available two weeks before the desired command upload time. The EPOC will send the command packet to the MOC one day prior to the desired upload time. The command packet is uploaded to the spacecraft, and command receipt is verified within one day. The command packet contains commands to be executed over the next week by the instrument. The commands are stored in the instrument memory. After a command is executed, a command execute verify will be included in the next day data downlink.

GUVI commands will be uploaded to the instrument once per week. The commanding timeline will be repeated on a weekly basis. Planned timelines will also be updated once per week, and the timeline will show planned instrument commands for the following three weeks.

6.4 Data Processing

6.4.1 Engineering Data Processing

The data processing timeline for routine operations is shown in figure 3. The spacecraft recorders will be downlinked to the ground station once per day. The EPOC polls the MDC for new data. Playback data will be available to the GUVI EPOC from 0 to 3 hours after the downlink. It will take the EPOC about 6 hours to process 24 hours worth of engineering data. Critical alarms will generate phone pages as they are detected. This process will repeat every 24 hours after each recorder dump.

6.4.2 Science Data Processing

The DP POC also polls the MDC for new data. Playback data will be available to the DP POC from 1 to 3 hours after the recorders are downlinked. Science data processing of the previous day's data will be completed within 12 hours. GUVI data products will be available on the web server within 24 hours of the downlink. The data product compact disks will be sent to the GUVI Co-I's within 14 days of the products being available.

6.5 On-Orbit Calibration

On-orbit calibration will be performed approximately once per month. During calibration the instrument operates in spectrograph mode while pointing at a star. The calibration mode duration will be 5 minutes per orbit for 3 to 5 consecutive orbits.

The calibration sequence will be controlled by time tagged commands. The instrument will switch to spectrograph mode at a time when the star will be in view. The scan mirror will be set to a look angle pointing at the star. After 5 minutes the instrument along track field of view will walk through the star, and the instrument will be returned to imaging mode operation. The star should be observable for 3 to 5 consecutive orbits. Calibration will only be performed on the active detector.

6.6 Anomalies

The EPOC will detect out of limit critical parameters during routine processing. In the case of an alarm, the GUVI payload operator will be responsible for evaluating the alarm condition and generating a plan of action. The instrument contains redundant detectors and motor drive circuits if needed.

A sun event will put the instrument in a safe mode until ground action is taken. The sun event should only occur if the spacecraft attitude was unstable, causing the instrument to scan through the sun. The instrument should stay in the safe mode until the cause of the sun event is determined.