J SOFTWARE REQUIREMENTS SPECIFICATION

FOR THE

GLOBAL ULTRAVIOLET IMAGER
-GUVI-

PAYLOAD OPERATIONS CENTER
-POC-

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Revision B

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1. SCOPE

1.1 Identification

This Software Requirements Specification (SRS) establishes the requirements for the Payload Operations Center (POC) for the Global Ultraviolet Imager (GUVI) for the Thermosphere, Ionosphere, and Mesosphere Energetics and Dynamics (TIMED) mission. The GUVI POC will meet the requirements as defined by the GUVI science team and the TIMED program office.

1.2 Overview

GUVI is a horizon-to-horizon scanning spectrographic imager operating in the far ultraviolet (FUV: 110 to 180nm). The GUVI spectrograph, with a Rowland Circle mount, uses a two-dimensional detector to record spatial and spectral information for each step position as it scans over 140°. To reduce the downlinked data rate, the GUVI data are processed onboard the TIMED spacecraft to produce five "colors" or monochromatic bands that are useful diagnostics of the dynamics and energetics of the thermosphere and ionosphere.

The GUVI POC will be located at the Johns Hopkins University Applied Physics Laboratory (JHU/APL) during the spacecraft integration and test phase before launch as well as during mission operations. The development of the POC will be a combined effort between JHU/APL, Aerospace Corporation, and Computational Physics, Incorporated. The POC consists of four major functions:

(1) Commanding

(2) Health, status, and trending

(3) Routine data product generation

(4) Data access and distribution

The first two major functions will be developed as part of the Engineering POC (EPOC) by the Aerospace Corporation. The third or data processing portion of the function will re-use software developed for the Special Sensor Ultraviolet Spectrographic Imager (SSUSI) instrument which will fly on the Defense Meteorological Satellite Program's (DMSP) Block 5D-3 spacecraft. The fourth function will use new tools developed to allow users to "survey" the data, request routine data products, and perform some data "mining".

1.3 Document Overview

The purpose of this document is to establish the requirements for the performance, design, development and testing of the GUVI POC. It contains the following information as required by Data Item Description (DID) DI-MCCR-80025A:

Section 1 Identifies the GUVI POC and contains a brief overview.

Section 2 Lists applicable documents.

Section 3 Specifies engineering requirements, including the requirements for external interfaces, capabilities, adaptation, installation dependent data, operational parameters, sizing and timing requirements, safety, security, design constraints, software quality factor, human performance/human engineering, and traceability of the requirements.

Section 4 Specifies the requirements for qualification of the GUVI POC, including qualification methods and special factors.

Section 5 Describes the preparation for delivery of a production version of the software.

Section 6 Gives an alphabetical listing of acronyms and abbreviations used in this document as well as a glossary of selected terms.

2. REFERENCED DOCUMENTS

The following documents form a part of this specification. In the event of conflict between the referenced documents and the contents of this specification, the contents of this specification supersede. If no issue date is listed, the latest revision is applicable. Copies of specifications, standards, drawings, and publications required by suppliers in connection with specified procurement functions shall be obtained from the contracting agency or as directed by the contracting officer.

Reference [1] TIMED Software Quality Assurance Plan, JHU/APL 7363-9101, Sept. 1996

Reference [2] TIMED Concept of Operations, JHU/APL 7363-9037, Mar. 1997

Reference [3] TIMED Systems Requirements Document, JHU/APL 7363-9001, Rev. B

Reference [4] TIMED GUVI DP POC Software Development Plan, JHU/APL 7363-9102, Feb. 1998

Reference [5] SSUSI Auroral E-Region Algorithm Language Independent Description, JHU/APL, May, 1996

Reference [6] Space Department Software Quality Assurance Guidelines, SDO-9989, Sept. 1992

Reference [7] Guidelines for Conducting Design Reviews, SDO-8336, Feb. 6, 1987

Reference [8] NASA Assurance Guidebook, NASA-GB-A201, online via http://satc.gsfc.nasa.gov/homepage.html

Reference [9] NASA Software Documentation Standards, NASA-STD-2100-91, online via http://satc.gsfc.nasa.gov/homepage.html

Reference [10] MIL-STD-498, Military Standard Software Development and Documentation, AMSC

Reference [11] *Software Development Project, Planning, and Management*, P. Bruce and S.M. Pederson, John Wiley & Sons, 1982

Reference [12] *An ISO 9000 Approach to Building Quality Software*, L. Oskarsson and R.L. Glass, Prentice Hall PTK, 1996

Reference [13] *Software Reviews and Audits Handbook*, C.P. Hollocker, John Wiley & Sons, 1990

Reference [14] TIMED Project Data Management Plan, JHU/APL 7363-9330, Nov. 1997

Reference [15] TIMED Spacecraft General Instrument Interface Specification, Section 8, JHU/APL 7363-9050, Oct. 1997

Reference [16] TIMED GUVI Engineering POC Software Development Plan, Aerospace Corp., Jan. 1998

Reference [17] NetCDF User's Guide for C, version 3.0, Unidata Program Center, June 1997

Reference [18] DMSP SSUSI GDAS Software Requirements Specification, JHU/APL 7343-9020, June 1996

3. REQUIREMENTS

This section defines the software requirements for the GUVI POC. These requirements define the baseline for the ensuing software design, development, test and qualification, as outlined in References 4 and 16.

The major functions of the GUVI POC as listed in section 1 are:

(1) Commanding

(2) Health, status, and trending

(3) Routine data product generation

(4) Data access and distribution

Top level partitioning of these functions into components is done to improve readability of this document. This does not imply a specific design or data flow, but an organizational structure for the review of the document.

The functions for the interface to GUVI are:

(1) Commanding:

- Command Generation and Verification
- Authentication
- Command Archive
- Planning Tools

(2) Health, Status, and Trending:

- Displays
- Trending
- Housekeeping
- Autonomous Operation
- Archive of Instrument Anomalies

(3) Routine Data Processing:

- Data Retrieval
- Data Reformatting
- Data Quality Assessment
- Construction of Graphical Overlays
- Calibration, Geolocation, and Gridding
- Algorithms (Night, Day, Auroral)

(4) Data Access and Distribution Functions:

- User Interface
- Data Distribution
- Survey Products
- Data Catalog
- Planning Tools
- Data Server
- Data Archive
- Archive of Instrument Anomalies
- Archive of Instrument Calibration

3.1 Data Product Requirements

The data inversion techniques to be used depend on the geometry of the observations and the emission phenomenology. There are four broad classes:

(1) the analysis of dayside disk images

(2) the inversion of dayside limb scan observations

(3) the analysis of auroral images

(4) the analysis of nightside disk and limb observations

Analysis of the dayside observations will provide the state variables and a proxy of the solar EUV flux. The first step is to reduce the limb observations using an inversion technique based on Discrete Inverse Theory (DIT). This approach is fast, systematic and rigorous. The disk images provide a direct measurement of the column abundance of atomic oxygen relative to molecular nitrogen. By combining the limb scans with the disk images, the horizontal structure will be quantified in terms of the changes in composition. Therefore, GUVI will provide three spatial dimensions of the thermospheric composition, density and temperature and will help facilitate the separation of spatial and temporal effects. In order for GUVI to address TIMED mission science goals we have constructed a data management scheme that tracks the data from the receipt of the raw telemetry through to the stage of producing the routine data products.

3.1.1 Data Levels

The current data level definitions, as defined by the TIMED program (Reference 14) are listed in Table 1.

Table 1. Telemetry Data Levels

Raw Telemetry	Unprocessed digital telemetry
Level 0	Unprocessed instrument data at full resolution that has been separated by instrument or subsystem
Level 1A	Unprocessed instrument data at full resolution, time-referenced and annotated with ancillary information including radiometric and geometric parameters
Level 1B	Level 1A data that has been processed to sensor units (e.g., Rayleighs/color)
Level 1C	Level 1B data mapped onto a uniform earth-referenced grid
Level 2	Derived geophysical variables at the resolution of Level 1C and Level 2A
Level 3	Derived geophysical variables mapped on a uniform, earth referenced, space-time grid
Level 4	Model output or results from analysis of lower level data (e.g., variables derived from multiple measurements)
Survey	Summary or low fidelity data used for quicklook or data mining
Support	Data acquired from non-TIMED sources to supplement data analysis
Educational	Materials designed for K-12 education
Status	Reports and/or timelines describing planning or status information
Collaborative	Data acquired through collaborative sources

The level definitions are generally similar to those followed by TIMED with a few minor differences that are indicated in the following sections.

3.1.1.1 Level 1A Data

The Level 1A files are not tagged with algorithmic information but they are to be tagged with a preliminary data quality flag. This flag indicates the occurrence of any instrument or spacecraft anomalies that would alter the quality of the data. The data are time-tagged and the spacecraft location is specified. The pointing file to be used is also identified. This pointing file manages the transformation from stepper motor position of the scan mirror to an instrument line-of-sight vector. This represents our baseline working archive since these parameters are expected to change slowly if at all.

3.1.1.2 Level 1B Data

The Level 1B processing uncompresses the data (a simple constrained maximum error compression algorithm will be used to achieve modest compression factors) and applies instrument calibration to convert to units of radiance within the specified "color" of the GUVI data (hence, Rayleighs/color).

3.1.1.3 Level 1C Data

The data are next gridded into a GUVI based coordinate system consisting of the along orbit position of the sensor and the angle of the scan from the nadir position. This gridding eliminates overlap from scan to scan due to the large instantaneous field-of-view of GUVI (about 12°) and involves coaddition to place the values on a uniform instrument shared grid.

The next step in processing is to determine whether the data are from day, night, aurora or twilight pixels. To simplify the interpretation of the data and the development of the algorithms, twilight pixels are not processed. The identification of the region of pixel requires spacecraft and ancillary information. The auroral pixels are determined by estimating the auroral boundary location from the data as well as utilizing a climatology to refine that estimate.

3.1.1.4 Level 2 Data

At this point the individual co-added GUVI pixels can be geolocated and the resolution further reduced to form "super pixels". "Super pixels" are created to improve the counting statistics and to reduce the data volume. This is GUVI Level 2A and it is a "virtual" level in that we do not anticipate that it will be permanently archived. Given the large number of application-unique assumptions, it appears to have little utility as a permanent archive.

The Level 2A data are processed by the application of algorithms to yield geophysical parameters such as effective average energy and flux of precipitating electrons and protons. This database of geophysical parameters is Level 2B, which will be referred to as our Level 2 product.

3.1.1.5 Level 3 Data

Some users will want the environmental data records remapped onto a specific grid. This class of user may include GUVI or TIMED science team members or the TIMED data archive. As an example of a specific grid, the O/N_2 ratio could be remapped as a function of latitude and local solar time. We have adopted as a convention for the analysis of GUVI data that Level 3 consists of multiple orbits of data as distinguished from lower level products which consist of a single orbit's data.

3.2 Capability Requirements

The following subparagraphs describe the capability requirements of the GUVI POC software. The software requirements are either directly allocated to, or indirectly derived from specifications referred to in section 2. Descriptions of the specific algorithms developed to fulfill these requirements and the methodology for their implementation will be detailed in the GUVI POC detailed design documentation.

3.2.1 Commanding Function

The Commanding function shall include the following components, whose requirements are described in more detail below:

- Command Generation and Verification
- Authentication
- Command Archive
- Planning Tools

3.2.1.1 Command Generation and Verification

(a) Generate GUVI command messages as selected by the user.

(b) Generate upload messages for upgrades to instrument flight software.

(c) Deliver command messages to the MOC via an Ethernet connection.

(d) Allow for automated test scripts consisting of a predefined series of instrument commands to be executed.

(e) Establish time-out for execution of the command.

(f) Provide a command description block.

3.2.1.2 Authentication

(a) Format command message with appropriate authentication for transmission to the MOC.

(b) Receive an error message if the transmitted commands is not properly received and executed by the instrument.

(c) MOC shall notify POC if a time-out is exceeded.

3.2.1.3 Command Archive

(a) Maintain a log consisting of:

- Commands transmitted
- Command errors
- GUVI verified commands

3.2.1.4 Planning Tools

(a) Planned timeline

(b) As flown timeline

(c) Star calibration tool

3.2.2 Health, Status, and Trending Function

The Health, Status, and Trending function shall include the following components, whose requirements are described in more detail below:

- Displays
- Trending
- Housekeeping
- Autonomous Operation
- Archive of Instrument Anomalies

3.2.2.1 Displays

(a) Receive Level 0 data from the MDC.

(b) Unpack GUVI science data packets.

(c) 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.

(d) Display science data in user selected format. Display 2-D false color images of imaging and spectrograph mode data. Display converted engineering data in text form.

(e) Allow for replay of data from MDC recorded science data to be played back and displayed.

(f) Out-of-limit engineering parameters shall be highlighted.

(g) Color (red, yellow, and green) shall be used to determine severity of alarm.

3.2.2.2 Trending

(a) Display strip chart graphs of selected engineering parameters for up to 30 days.

(b) Maintain an ASCII tab delimited file of selected science data parameters. Each file to contain a month's worth of data.

(c) Archive all science data messages on data storage peripheral devices. Preferably, at least 24 hours of data can be recorded.

3.2.2.3 Housekeeping

(a) Display current values of selected housekeeping parameters.

(b) Maintain an ASCII tab-delimited file of selected housekeeping parameters. Each file to contain a month's worth of data.

3.2.2.4 Autonomous Operation

(a) Define critical alarms that require immediate attention. For each alarm, generate a phone page with a key code.

(b) Summarize alarms and store.

3.2.2.5 Archive of Instrument Anomalies

(a) The GUVI ECU and the spacecraft generate GUVI error messages. Process all packets pertaining to GUVI in order to maintain this error file.

3.2.3 Routine Data Processing Function

The Routine Data Processing function shall include the following components, whose requirements are described in more detail below:

- Data Retrieval
- Data Reformatting
- Data Quality Assessment
- Construction of Graphical Overlays
- Calibration, Geolocation, and Gridding
- Algorithms (Night, Day, Auroral)

3.2.3.1 Data Retrieval

(a) Retrieve Level 0 data from the MDC.

(b) Retrieve auxiliary information such as ephemeris information from the MDC.

(c) Retrieve predicted orbit information from the MDC.

(d) Using date of file modification, retrieve updated information on the above products.

(e) Retrieve supporting data (solar and geomagnetic indices) from the MDC.

(f) Support TBD backup transmission method.

3.2.3.2 Data Reformatting

(a) Unpack the parameter fields of GUVI instrument packets from the Level 0 file into data structures of 8 bit words, 16 bit words, 32 bit words, or 64 bit words for output.

(b) Preserve the sign of any signed data.

(c) Write the Level 1A files in NetCDF format.

3.2.3.3 Data Quality Assessment

- Criteria for flagging data as invalid.
- Criteria for disregarding packet or scan data.
- Criteria for terminating processing.

3.2.3.3.1 Criteria for Flagging Data as Invalid

(a) Check the packet sequence count for each sensor data packet (frame) to ensure that data received is in the proper sequence; flag the contents of the packet as invalid if the count is out of sequence.

(b) Calculate a checksum for each sensor data packet and compare with the checksum field to detect errors; if inconsistent, flag the contents of the packet as invalid.

(c) Check each data packet header to detect frames, which may have been zeroed out. Discard or disregard any fill packets.

3.2.3.3.2 Criteria for Disregarding Packet or Scan Data

When any of the following error conditions are found, log the appropriate error message, disregard (skip) all other packets in that scan, and continue processing the remaining scans:

(a) When data ranges in the ephemeris data record are invalid.

(b) When the last packet in the image mode or spectrograph mode message is flagged invalid.

(c) When the dark count or background count in the image mode message is invalid.

(d) When the time span identified in the header is inconsistent with the data contained in the file, log the inconsistency and process only the data, which fall within the time span, identified in the header. When invalid timetags exist, interpolate or extrapolate using the times from the most adjacent, valid scans.

3.2.3.3.3 Criteria for Terminating Processing

When any of the following error conditions are found, log the appropriate error message and terminate processing entirely:

(a) When the universal time field in ephemeris data is invalid.

(b) When instrument engineering parameter values for the detector, scan mode, slit width, or mirror angle are invalid.

(c) When ephemeris data are missing for over TBD consecutive seconds.

3.2.3.4 Construction of Graphical Overlays

Throughout each orbit for the TIMED spacecraft, create user selectable graphical overlays that can be placed on the display consisting of the following:

- Geodetic Coordinate Reference at a user selectable altitude
- Geomagnetic Coordinate Reference at a user selectable altitude
- Surface Continental Outlines
- Surface Day/Night Terminator
- Orbit Track
- Orbit Swath
- Uncertainty Contours
- Auroral Boundary (actual and model)
- Another Satellite Groundtrack
- Ground Sites
- Local Solar Time
- Solar Zenith Angle
- Data Region (day, night, auroral)

3.2.3.5 Calibration, Geolocation and Gridding

The data processing function shall calibrate, geolocate and grid GUVI Level 1 file data, and transform it into Level 2 files. The Level 2 files are used by the User Interface for display, and by the nightside, auroral and dayside algorithms to produce parameters stored in the Level 3 files.

3.2.3.5.1 Calibration of Sensor Data

(a) Calibrate only valid sensor scan data.

(b) Perform dark count corrections on all SIS pixels for each SIS bandpass using responsitivity.

(c) Perform background count corrections on all SIS pixels for each SIS bandpass using responsitivity.

(d) Transform corrected image mode counts to Rayleighs for all SIS pixels for each SIS bandpass using responsitivity.

(e) Transform spectrograph counts/second to counts.

(f) Determine and account for spectral overlap.

(g) Accommodate changes to calibration data to reflect recalibration of the SIS.

3.2.3.5.2 Geolocation and Gridding

Determine the following for each Level 1C grid pixel:

(a) Geocentric latitude

(b) Longitude

(c) R geocenter

(d) Local time

(e) Solar zenith angle

(f) Geodetic latitude

(g) Geomagnetic latitude

(h) Geomagnetic longitude

(i) Geomagnetic local time

(j) Accumulate the average for each Level 1C pixel per color band from each SIS scan pixel.

(k) Determine variances in (Rayleighs) for each color band for each Level 1C and Level 2A pixel.

(l) Remove geocoronal background H Lyman α and remove dayglow background from N_2 LBH band emissions from the portion of the auroral region, which is illuminated by the sun.

(m) Determine the region to which each grid pixel belongs. The regions are defined as follows:

Day..... for solar zenith angle 0° .. 90°
Twilight..... for solar zenith angle 90° .. 110°
Night ..... for solar zenith angle > 110°
Auroral..... derived from data at runtime
Unknown..... where unable to determine the region

1.1.1.6 Algorithms (Night, Day, Auroral)

1.1.1.6.1 Nightside Processing

(a) For each night Level 2 disk pixel, compute the line-of-sight Total Electron Content (TEC).

(b) Invert the limb observations to derive electron density profiles (Level 2).

1.1.1.6.2 Auroral Processing

(a) Use the auroral E-Layer algorithm defined in the Auroral Language Independent Description (Reference 5).

(b) For each auroral Level 2 pixel on the disk region, compute the following:

- Proton average energy

- Proton energy flux
- Electron average energy
- Electron energy flux
- E-Region electron density profile

1.1.1.6.3 Dayside Processing

(a) For each Level 2A day profile in the disk region, compute the following:

- O/N_2 Column Density (O column abundance relative to N_2 column abundance).

(b) Compute one value of Solar EUV Energy Flux (Q_{euv}) for the entire day disk.

(c) For each Level 2A day pixel in the limb region, compute the following:

- Neutral Density Profiles (NDP): O, O_2, and N_2
- Temperature profile
- Ratio of O to N_2 vertical column densities

1.1.1.6.4 Error Estimation

Determine variance on all Level 2 parameters, concurrent with their calculation by nightside, auroral and dayside processing.

1.1.4 Data Access and Distribution Function

The Data Access and Distribution function shall include the following components, whose requirements are described in more detail below:

- User Interface
- Data Distribution
- Survey Products
- Catalog
- Planning Tools
- Data Server
- Data Archive
- Archive Instrument Anomalies
- Archive Instrument Calibration

1.1.4.1 User Interface

(a) Provide the user with the ability to select Level 1C, Level 2, or Level 3 GUVI data files.

(b) Provide the user with organized graphical views of selected GUVI Level 1C, Level 2, and Level 3 parameters.

(c) Support creation of display types and options identified in Table 2.

(d) For each execution of the software, allow multiple processes and windows on the workstation, with only one window active at a given time.

(e) Provide a consistent framework for user inputs, generation and manipulation of displays, navigation and help.

(f) Establish the default startup configuration and the control flow based on display preferences.

(g) Verify the existence of input files selected by the user. If no errors result, read and convert such data into an appropriate format for display. For non-existent files, provide an error message to the user, and allow another opportunity to select other files.

(h) Display graphical overlays and provide text identifying the overlay displayed.

(i) Provide the capability to select map projections when displaying disk Level 2 data and provide text identifying the map projection displayed. Use Level 2 grid coordinates for display of the Level 1 user grid.

(j) For map projections, provide the capability to select a viewing perspective, based on geographic position for the center of the display and provide text identification of the perspective.

(k) Define screen layouts to fit within a 1280 wide by 1024 high screen pixel grid.

(l) Within each display window, include display zones for display identifiers. Include the main menu, if appropriate, near the top of the window with other text messages, such as help, additional identifiers and date and time fields, placed in the same relative positions and sized according to the specific application and information to be displayed. Display zones for an active window shall always be visible.

(m) Support the following image processing tools: color bar/palette control, movie (2-10 frames), image zoom redraw, geodetic/geographic position readout, and great circle distance between two selected points.

(n) Provide for modification of the display preferences to vary default start-up configuration including: initial color bar selection, initial Level 2 or Level 3 overlays, map projection, viewer perspective.

(o) Provide the capability to overlay uncertainties for any product.

(p) Allow the user to define or request a revised list of operational sites for the graphical overlays on the map projection.

(q) Provide the capability to read and plot orbital overlays from a file on the map projection.

(r) Allow the user to print selected text and graphics files, and to select which printer to use.

Table 2. GUVI POC User Interface Displays

Type	Description	Data Displayed	Display Options
Global Perspective	Level 1C, Level 2 or Level 3 and associated data displayed on a global map projection	**Day**: O/N_2 and Q_{euv} (non-graphical) **Night**: TEC **Auroral**: Q, <E> **Uncertainties** **Average counts**	map projection perspective selection graphical overlays image processing tools multiple windows
Density Profile(s) (Line Plots)	Electron and neutral density profiles at selected lat/long positions	**Day**: Temperature, Limb NDPs (O,O_2, N_2) **Night**: Limb EDP **Auroral**: E-Layer EDP, Auroral boundaries	multiple windows
Flat Grid	Level 1C Rayleighs for one entire orbit displayed as along track versus cross track	Average Rayleighs and Uncertainties	image processing tools multiple windows
Spectrograph Mode Display	Level 1C counts for one entire orbit displayed as along track vs. wavelength	Counts	image processing tools multiple windows

1.1.4.2 Data Distribution

(a) All data stored on the POC computers shall be accessible by the GUVI Investigators from the Internet.

(b) CD-ROMs shall be produced and delivered to each Co-Investigator with Level 1, Level 2, Level 3, and Survey products within 2 weeks of data receipt.

1.1.4.3 Survey Products

Provide GUVI formatted images for survey consisting of:

(a) Limb images

(b) Disk images

(c) Calibration files as a function of time; archived and used in algorithms

(d) Solar index by time

(e) Geophysical parameters, K_p, A_p, Dst, etc. by time

(f) Instrument state, health, and data quality report

(g) Other instrument state

1.1.4.4 Catalog

(a) Provide an on-line searchable catalog for all GUVI products.

(b) Provide the MDC with information for an on-line searchable catalog for GUVI products.

(c) Catalog will contain at a minimum:

- Time range of the product

- Product version number
- URL to the product
- TBD summary information including instrument mode

1.1.4.4.1 GUVI Team Access Only

(a) General Access catalog functions

(b) Merged command history

1.1.4.4.2 General Access

(a) List of data products that have been produced for a given day.

(b) Website utilized to provide information.

(c) Security to prevent access to GUVI team only information.

1.1.4.5 Planning Tools

(a) Provide access to predicted orbit information.

(b) Provide access to TIMED contact schedule.

(c) Provide ability to coordinate with other instruments/sites.

(d) Provide access to planned and as flown timelines.

1.1.4.6 Data Server

(a) Provide the MDC with information about all Level 1 through Level 4 data products.

- New data within 12 hours of generation in a TBD format
- The information (per product) will contain time of generation, epoch of product, version, TBD quality flag, instrument modes and other TBD information

(b) Provide the MDC with URLs to Level 1 through Level 4 data.

- New data within 12 hours of generation
- Updates to existing data within 4 hours of regeneration

(c) Access to release GUVI data from community/public outreach.

1.1.4.7 Data Archive

(a) Collect and organize Level 1C, Level 2, and Level 3 data for final archive.

(b) Support up to three deliveries of data to the MDC (timing specified by the MDC).

1.1.4.8 Archive of Instrument Anomalies

(a) Maintain an archive of instrument anomalies

1.1.4.9 Archive of Instrument Calibration

(a) Archive instrument calibration data

1.3 External Interface Requirements

All external interfaces, including specific data items and formats, shall be fully defined in the Ground System/POC Interface Specification (Reference 15).

1.3.1 GUVI POC - MDC Interface

- GUVI POC shall receive on-line access to Level 0 data via playback from the MDC.
- GUVI POC shall receive auxiliary information such as command history and ephemeris information from the MDC.
- GUVI POC shall receive predicted orbit information from the MDC.
- GUVI POC shall receive supporting data (solar and geomagnetic indices and satellite ephemeris) from the MDC.
- GUVI POC shall provide the MDC with uniform data product naming schemes.
- GUVI POC shall provide the MDC with information about all Level 1 through Level 4 data.
    - New data within 12 hours of generation in a TBD format.
    - The information (per product) shall contain time of generation, epoch of product, version, TBD quality flag, instrument modes and other TBD information.
- GUVI POC shall provide the MDC with URLs to Level 1 through Level 4 data.
    - New data within 12 hours of generation
    - Updates to existing data within 4 hours of regeneration
- GUVI POC shall provide the MDC with data product version information when an update occurs.
- GUVI POC shall provide MDC with planned instrument mode configurations for 7 days in the future.
- GUVI POC shall deliver the entire Level 1 through Level 4 dataset on TBD media 3 times during the mission for mastering of the TIMED Science Data Archive. **NOTE**: The first delivery shall be 1 year after launch, the second delivery shall be at the end of spacecraft operations and the final delivery shall be at mission close-out.
- GUVI POC shall deliver K-12 products to the MDC on a TBD basis.

1.3.2 GUVI POC - MOC Interface

- GUVI POC shall generate GUVI instrument commands.
- GUVI POC shall establish a time-out for execution of a command.
- GUVI POC shall deliver command messages to the MOC via an Ethernet connection.
- GUVI POC shall deliver automated test scripts to the MOC via an Ethernet connection.
- GUVI POC shall generate upload messages for upgrades to instrument flight software.
- GUVI POC shall be notified if a command time-out is exceeded.
- GUVI POC shall be provided a confirmation of command receipt from the spacecraft.
- GUVI POC shall provide a method to produce ASCII time-tagged engineering logs of uplinked commands and of all downlinked telemetry for troubleshooting.
- GUVI POC shall provide the capability to electronically transfer time-tagged command and telemetry engineering logs to the MOC.
- GUVI POC shall generate an ASCII file of critical alarms that shall be transferred to the MOC.

1.3.3 GUVI POC - User Interface

- GUVI POC shall provide the user interface displays identified in Table 2.
- GUVI POC shall allow the user to print selected text and graphics files to a user selectable printer.
- GUVI POC shall provide a customizable start-up configuration.
- GUVI POC shall display science data in user selected format.

- GUVI POC shall display strip charts of selected engineering parameters for up to the previous month.
- GUVI POC shall display user selectable graphical overlays and provide text identifying the overlay displayed.

1.3.4 GUVI POC - GUVI POC Interface

- The GUVI POC actually consists of 2 separate POCS, the Data Processing POC and the Engineering POC. The EPOC operator will FTP newly created and/or revised planned and as-flown timelines to the DP POC. The DP POC operator will FTP revised as-flown timelines to the EPOC. The planned and as flown timelines are documented in the TIMED GIIS, section 8 and updates will be provided to the MDC.

1.3.5 External Data Files

The external data files required for the GUVI POC are described in Table 3. These interfaces include files that contain sensor and ephemeris data provided by the TIMED Mission Data Center, calibration data provided by JHU/APL, and solar and geomagnetic indices obtained from a TBD server on a routine basis. Files written by the GUVI POC will have a standard NetCDF format.

Table 3. GUVI POC Data Products

Data Product	Description	Mode
GUVI POC Data Products		
Level 1	GUVI telemetry processed to sensor units	Output and Input
Level 2	Derived geophysical variables at the resolution of retrieval	Output and Input
Level 3	Multiple orbits; higher level products	Output
Catalog	On-line, searchable catalog for all GUVI products; for GUVI team access only	Output
Data Server	Access to release GUVI data from community/public outreach	Output
Survey Products	GUVI formatted images for survey	Output
Archive Products	GUVI data archived	Output
Status Report	GUVI instrument status to MDC	Output
TIMED MOC/MDC Data Products		
Level 0	Unprocessed instrument data separated by instrument	Input to Data Processing
Satellite Attitude/ Ephemeris - As Flown	Definitive position information; received from MDC	Input to Data Processing
Satellite Attitude/ Ephemeris - Predicted	Predicted position information; received from MDC	Input to Data Processing
Right ascension of ascending node	Intersection of spacecraft orbit with equatorial plane where spacecraft is crossing from southern into northern hemisphere	Input to Data Processing
Inclination	Angle between the spacecraft orbital plane and the Earth's equatorial plane	Input to Data Processing
Semimajor axis	Size of the spacecraft orbital plane	Input to Data Processing
Eccentricity	Shape of the spacecraft orbital plane	Input to Data Processing
Argument of perigree	Angle from the ascending node to the eccentricity vector measured in the direction of the spacecraft's motion	Input to Data Processing
True anomaly	Angle from the eccentricity vector to the spacecraft position vector measured in the direction of the spacecraft's motion	Input to Data Processing
Command History	Merged command history from MDC, sent and verified	Input to Catalog
Supporting Data		
Solar Indices	Daily and 81-day mean $F_{10.7}$ solar flux	Input to Data Processing
Geomagnetic Indices	K_p and A_p indices every 3 hours	Input to Data Processing

1.4 Internal Interface Requirements

All internal interfaces for the Data Processing POC, including specific data items and formats, shall be fully defined in the GUVI Data Processing POC Software Design Document and are depicted in Figure 2. These shall include, but are not necessarily limited to, the following requirements:

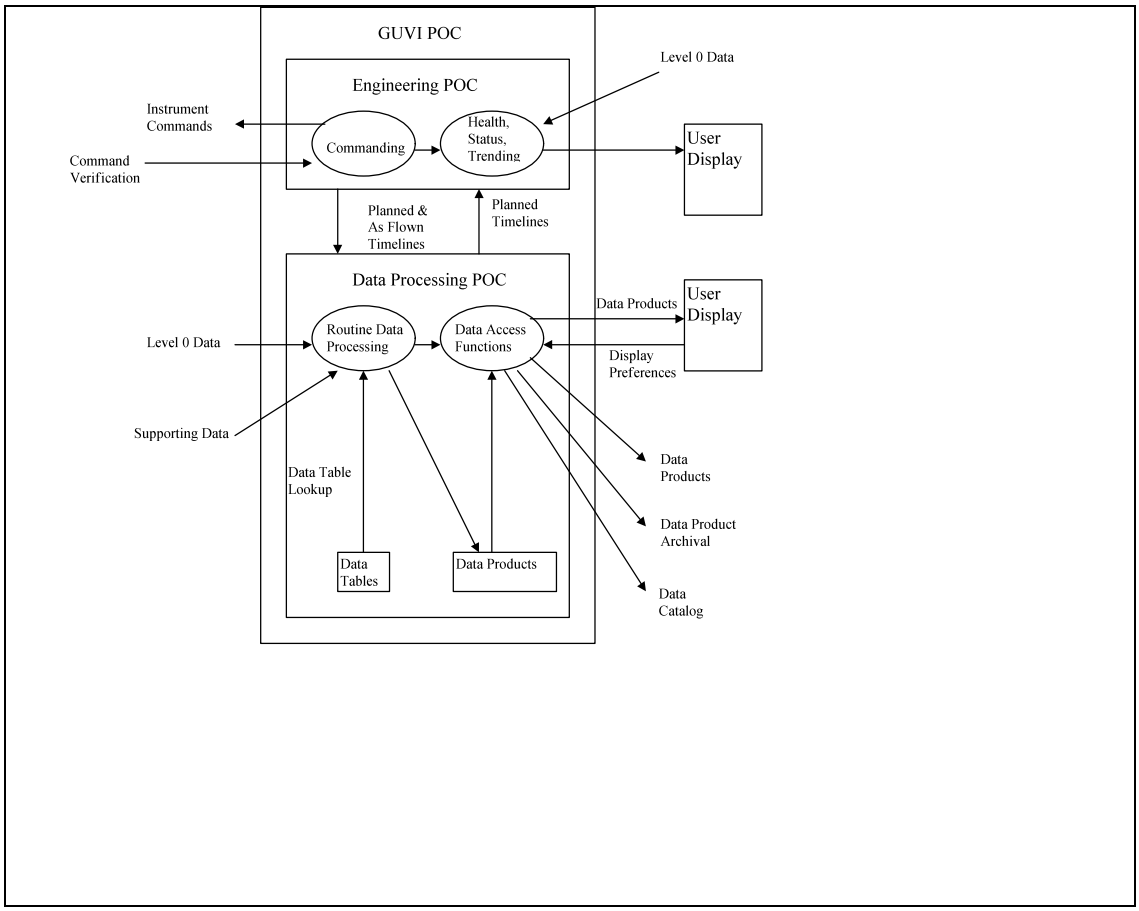

Figure 2. GUVI POC Functions and Interfaces

1.4.1 GUVI Data Tables

Data Tables will be used within the Data Processing Function to compute Level 2 and Level 3 GUVI products. The list of data tables that will be used is provided in Table 4.

Table 4. GUVI POC Data Tables

1	Aurora Coefficients	Constants, coefficients, and variances used by the GUVI Aurora E-Region algorithm.
2	Aurora Rectification	Data used to rectify aurora slant path intensities (i.e., to determine effective nadir viewing intensities from slant viewing geometries).
3	Calibration	Coefficients used for calibration of GUVI SIS, and for implementing of geolocation pointing algorithms. The calibration coefficients include factors for background and dark scatter adjustment, separation of overlap of the 1304A and 1356A signal, and responsitivity of the instruments to spectral stimuli.
4	Day Rectification	Data used to rectify daytime slant path intensities (i.e., to determine effective nadir viewing intensities from slant viewing geometries).

5	Decompression	Data used to decompress SIS image and spectrograph counts.
6	DITF	Dayside Discrete Inverse Theory implementation, including intensity data, density data, N_2 scale factors, O_2 scale factors, and O scale factors.
7	Geomagnetic	Conversion factors needed to convert geodetic coordinates to geomagnetic.
8	Midlatitude Background	Data needed for background subtraction of the aurora.
9	Q_{euv}	Values needed to calculate the effective solar EUV (extreme ultraviolet) flux (below 40 nm), given input values of 1356 intensity (Rayleighs), the ratio of the vertical column densities of O and N_2, and the solar zenith angle.
10	ROVCDN2VCD	Values needed to calculate the column density ratio of O over N_2 given the solar zenith angle and the ratio of the 1356 intensity over the LBH2 intensity.
11	Statistical Aurora	Data necessary to determine the statistical likelihood that a given pixel is auroral.

1.4.2 Display Preferences

The User Interface shall read and write text- and graphics-format, which establish a preferred start-up configuration.

1.5 Adaptation Requirements

1.5.1 Installation-Dependent Requirements

(a) The commanding and health, status, and trending functions will require a Power Macintosh with an Ethernet interface.

(b) The data processing function will require an Ethernet interface compatible with Netscape.

(c) All hardware dependencies shall be isolated to ensure transportability of the code.

1.5.2 Operational Parameters

(a) Data storage of at least 24 hours will be available on the Power Macintosh system. Access to trending information will be available from the Engineering POC throughout the mission.

(b) Level 0, Level 1, Level 2, and Level 3 data will be available throughout the mission.

1.6 Sizing and Timing Requirements

(a) Health and status displays shall be capable of receiving Level 0 data without dropping packets.

(b) The data processing function shall be capable of processing an entire day of data within 24 hours.

(c) On-line capacity magnetic/optical disks shall be provided for the storage of Level 1, Level 2, Level 3 data and survey products.

1.7 Safety Requirements

The safety requirements for the GUVI POC are as follows:

(a) Hazardous commands must be verified by the user, i.e. detector activation, high voltage, etc.

(b) Alarms will be generated for events that require immediate attention.

1.8 Security and Privacy Requirements

The GUVI POC is unclassified. The commanding function must be protected from general network access.

1.9 Design Constraints

(a) The algorithms used for the data processing functions of :

- Data Reformatting
- Data Quality Assessment
- Calibration, Geolocation, and Gridding
- Algorithms (Night, Day, Auroral)

Shall be duplicated from the SSUSI GDAS software with adaptations only for new TIMED format of Level 0 data, new format of ephemeris data, lack of photometer data, and lower altitude.

(b) Health, status and trending functions shall be developed in support of the GUVI Ground Support Equipment.

(c) Internet access may be limited to certain Co-Investigator sites. Distribution of Level 1, Level 2, and Level 3 data is currently specified as CD-ROMs. If access speeds provide the needed capacity during spacecraft operations, all transfers will be across the Internet.

1.10 Software Quality Factors

The GUVI POC shall be evaluated in accordance with the GUVI POC software development plans (References 4 and 16) and based on the JHU/APL Space Department Software Quality Assurance Guidelines, (Reference 6).

1.11 Human Performance/Human Engineering Requirements

The design of the GUVI POC shall include consideration of applicable human performance and human engineering principles using MIL-STD-1472D as a guide.

1.12 Requirements Traceability

All items listed in section 3.2 of the SRS with an alphabetic indicator, such as (a), shall be traced using the section number and the alphabetic indicator (e.g., "requirement 3.2.1.2(a)") for validation and verification (V&V) purposes.

The format and content of the internal interfaces described in Section 3.3 will be validated, but not traced as a functional requirement for the software.

No explicit traceability of this SRS to higher level requirements shall be provided.

2. QUALIFICATION REQUIREMENTS

2.1 QUALIFICATION METHODS

During the software development process, the design of the system and subsystem will be checked against the requirements from section 3. In the following, the requirements are given a general qualification methodology to act as a guide during the software development process:

Demonstration: Qualification that relies on observed functional operation.

Test: Specific test plans to match performance criteria and characteristics.

Analysis: The processing of accumulated data obtained from other qualification methods. Usually requiring results from multiple tests from other requirements.

Inspection: Visual examination of system components, documents, etc.

No other qualification methods are identified for GUVI POC software.

All requirements listed in section 3 of the SRS shall be verified using the above criteria. An independent breakdown of each requirement and which method of verification will be utilized to qualify it shall be provided in the GUVI POC Software Test Description document.

2.1.1 Verification and Validation

Verification and validation (V&V) is defined in the GUVI POC Software Development Plans (References 4 and 16).

3. PREPARATION FOR DELIVERY

A production version of the GUVI POC software shall be delivered on a medium to be designated by Critical Design Review (CDR). The version of the software will be re-loaded into a test environment. Acceptance testing shall then be performed prior to introduction into the production environment.

4.

NOTES

4.1 ACRONYMS AND ABBREVIATIONS

Å	Angstrom
A_p	Planetary Geomagnetic Amplitude
ASCII	American Standard Code for Information Interchange
CDF	Common Data Format
CDR	Critical Design Review
CoI	Co-Investigator
CPI	Computational Physics, Inc.
DID	Data Item Description
DITF	(Dayside) Discrete Inverse Theory Function
DMSP	Defense Meteorological Satellite Program
DP POC	Data Processing POC
EDP	Electron Density Profile
EDPP	EDP Parameters (i.e. TEC)
EDR	Environmental Data Record
<E>	Effective* average energy
EOS	Earth Observing System
EPOC	Engineering POC
EUV	Extreme Ultraviolet
$F_{10.7}$	Solar Flux Index
FTP	File Transfer Protocol
FUV	Far Ultraviolet
GSE	Ground Support Equipment
GUVI	Global Ultraviolet Imager
JHU/APL	Johns Hopkins University/Applied Physics Lab
K-12	Kindergarten through Secondary Education
K_p	Planetary Geomagnetic Index
LBH	Lyman-Birge-Hopfield molecular nitrogen emission bands
LID	Language Independent Description
MDC	(TIMED) Mission Data Center
MOC	(TIMED) Mission Operations Center
NDP	Neutral Density Profiles (O, O_2, and N_2)
NetCDF	Network Common Data Format
PDR	Preliminary Design Review
PI	Principal Investigator
POC	Payload Operations Center
Q	Effective* energy flux
Q_{euv}	effective solar EUV (extreme Ultra-violet) flux (below 40 nm)
ROVCDN2VCD	Ratio of O vertical column density to N_2 vertical column density
SDD	Software Design Document
SDP	Software Development Plan
SDR	Science Data Record
SEE	Solar EUV Experiment
SIS	Scanning Image Spectrograph
SRS	Software Requirements Specification
SSUSI	Special Sensor Ultraviolet Spectrographic Imager
STP	Software Test Plan

SZA	Solar Zenith Angle
TBD	To Be Determined
TEC	Total Electron Content
TIDI	TIMED Doppler Interferometer
TIFF	Technical Interchange File Format
TIMED	Thermosphere, Ionosphere, and Mesosphere Energetics and Dynamics
URL	Uniform Resource Locator
V&V	Verification and Validation
TMDC	TIMED Mission Data Center
WWW	World Wide Web

* Effective assumes precipitating particles are pure electrons

4.2 GLOSSARY OF SELECTED TERMS

a_p, Planetary Geomagnetic Amplitude	Average deviation over a three hour period of the most disturbed component of the geomagnetic field from the average quiet-day value; the scale is linear with a_p ª 0 representing quiet conditions and a_p ª 430 representing the largest disturbance likely to be seen; within ±10%, $a_p = \exp[(K_p + 1.6)/1.75]$ in units of g, corresponding to about 0.6 nanoteslas at 50° geomagnetic latitude .
Airglow Algorithms	Algorithms developed by Phillips Laboratory, which provide parameters for electron density profiles in night region and form the basis of GUVI nightside processing.
Along Track Orbit Angle	Position angle of spacecraft along orbital track measured as Argument of Latitude from the ascending node; often referred to as "SATH" angle in relation to Air Force orbit propagation algorithms.
Å, Angstrom	10^{-10} meters.
Ascending Node	Intersection of spacecraft orbit with equatorial plane where spacecraft is crossing from southern into northern hemisphere.
Auroral Region	Annular region surrounding each geomagnetic pole where intensities of 1356Å, LBH1 and LBH2 UV wavebands exceed a specified threshold.
Average Intensity	Intensity in Rayleighs associated with a Level 1C pixel for a particular bandpass which represents an average of several overlapping scans, has been calibrated to remove background or dark count and instrument sensitivity variations.
Cross Track Nadir angle	Position angle of SIS scan perpendicular to the plane of the spacecraft orbit.
Dark Count	SIS detector noise level due to sensitivity determined by sampling from the outer region of the focal plane.
Day Region	Region of Earth disk or limb where the solar zenith angle <= 90°.
Disk	The portion of the Earth's surface visible from the spacecraft
Earth Mean Equator and Equinox of 1950	1950 Celestial coordinate system or inertial reference frame in which the x-direction corresponds to the location of the vernal equinox or ascending node of the sun's apparent motion relative to the stellar background on Jan 1, 1950, the z-direction corresponds to the north celestial pole on that date and the y-direction is the cross product of the z and x directions (i.e., right handed

	coordinate system).
Level 2 Grid	The grid used for computing and displaying the Level 2 data.
$<E_e>$, Average Energy	Average energy associated with precipitating electrons in auroral region; units are keV.
Data Packet	One-second frame of GUVI sensor data (3816 bits).
E-Layer	The ionospheric region between 90 and 150 km.
Electron Density Profiles	Number densities of free electrons as a function of altitude.
Ephemeris	Positions of heavenly bodies on a number of dates in an orderly sequence.
Epoch	A point in time associated with a particular event.
F-Layer	The region of the ionosphere which extends from an altitude of 150 km to more than 600 km. This region is divided into the two distinct subregions: F_1 (150-200 km) and F_2 (> 200 km) during daytime.
$F_{10.7}$, Solar Flux Index	Index of solar activity based on solar electromagnetic radiation around 10.7 cm in wavelength; units are 10^{-22} W m^{-2} Hz^{-1}.
$\overline{F}_{10.7}$, Solar Flux Index	The average of $F_{10.7}$.
Geocoronal Background	The geocorona, also known as the exosphere, is the extended region of collision-free hydrogen that surrounds the Earth.
Geoid	Model representing mean sea level on Earth's surface (usually an oblate spheroid or ellipsoid).
Geolocation	The process of establishing a reference location which is fixed with respect to the Earth, usually in terms of geodetic latitude and longitude and altitude above the reference geoid.
Geomagnetic Latitude/Longitude	Coordinate frame derived from a rotation of geodetic latitude/longitude reference frame such that the new north pole is the north magnetic pole (78.1°N, 69°W); for day, night and auroral algorithms, latitude is further transformed to represent dip angle of magnetic field line.
Great Circle	Arc tracing out path of minimum surface distance between two points on the Earth.
Image Mode	SIS spatial scanning mode of operation in which five colors are recorded over a range of along-track and cross-track positions; two variations are possible: reduced scan (GLOB present on spacecraft) or full scan (no GLOB).
K_p Planetary Geomagnetic Index	Average deviation over a three hour period of the most disturbed component of the geomagnetic field from the average quiet-day value; the scale is quasi-logarithmic with $K_p = 0$ representing quiet conditions and $K_p = 9$ representing the largest disturbance likely to be seen.
Level 1C Grid	Location grid associated with each revolution of TIMED spacecraft, in which overlapping scans are combined and all sensor pixel intensities have been corrected, calibrated and rectified, and dimensioned as along-track by cross-track position in image mode or along-track position by spectral bin in spectrograph mode.
Limb	The edge of the Earth's atmosphere defined by lines of sight which do not intersect the disk.
Local Solar Time	Time based on the Sun's angle from the local zenith.
Lyman alpha, H Lyman alpha	Emission line at 1216Å, associated with fundamental energy transition in atomic hydrogen (HI).
LBH	Molecular nitrogen emission bands. LBH 1, from 1400Å to 1500Å, and LBH

	2, 1650Å to 1800Å are used as GUVI color definitions.
Mercator	Map projection with rectangular grid which is conformable and on which any curve line is represented by a straight line.
Meridional Wind Field	Components of thermospheric wind vectors parallel to magnetic field lines provided by VSH model and used for dayside processing.
Mixed Region	Region within a Level 2 pixel containing any combination of day, night, auroral and twilight sub-grid pixels.
Nadir	Point on Earth's surface below an observer formed by the intersection of the line of sight normal to the surface
Neutral Density Profiles	Number densities of the neutral gas species atomic oxygen (O), molecular nitrogen (N_2) and molecular oxygen (O_2) in cm^{-3}, as a function of altitude.
Night Region	Region of Earth disk or limb where the solar zenith angle is greater than or equal to 110°.
O/N_2 Ratio	Ratio of atomic oxygen column density to molecular nitrogen column density above the point at which the N_2 column reacts, 10^{17} cm^{-2}.
Q_{euv}, Solar EUV Energy Flux	Proxy for average EUV solar energy deposition per unit area in ergs cm^{-2} s^{-1}.
Qp, Energy Flux of Precipitating Protons	Rate of proton energy deposition per unit area in the auroral region in ergs cm^{-2} s^{-1}.
Qe, Energy Flux of Precipitating Electrons	Rate of electron energy deposition per unit area in the auroral region in ergs cm^{-2} s^{-1}.
Orthographic	Map projection based on lines of sight as viewed by an observer at infinity.
Rayleigh	Unit of measure for omnidirectional photon emission rate in a column of unit cross section (1 Rayleigh = 10^6 photons cm^{-2} s^{-1}).
Rectification	Process of correcting dayside disk pixel intensities for observer-dependent effects such as path length and solar zenith angle so that the observed emission appears as it would if the observer were always directly over the source and the Sun were directly overhead.
Scan Grid	Grid associated with each SIS scan; in imaging mode, comprises 22-sec sampling interval with 16 along-track pixels by 132 (reduced scan) or 156 (full scan) cross-track pixels on disk and eight along-track by 24 cross-track pixels on limb for each of five UV bandpasses; for spectrograph mode, SIS scan is limited to three seconds with cross-track direction fixed, eight along-track pixels and 168 UV spectral bins.
Sigma	One standard deviation or square root of variance.
Solar Zenith Angle	Angle between local vertical at a location and the vector to the Sun.
Spectral Cross-talk	Events at one wavelength appearing as events at another wavelength.
Spectrograph Mode	SIS mode of operation in which all spectral elements are read out. The mirror is not scanning in this mode.
Sub-Grid Pixel	Reduced pixel sizes used in auroral region or constituents of mixed region pixels associated specifically with night, day, auroral or twilight.
Tangent Altitude	In a line-of-sight, the altitude of the point tangent to the Earth's surface.
TEC, Total Electron Content	Number density of electrons in a vertical column of unit cross-sectional area; units are cm^{-2}.
Temperature Profile	MSIS neutral temperature profile; units are kelvin.
Twilight Region	Region of Earth disk or limb where the solar zenith angles between 90° and

	110°.
World Geodetic System 1972	A specific model for the Earth in which the geoid is described as an ellipsoid whose equatorial semiaxis is 6378.1350 km and whose polar semiaxis is 6356.7505 km.

END OF GUVI SRS