Appendix III:

TIMED Project Data Management Plan (PDMP)

The Space Department of
The Johns Hopkins University
Applied Physics Laboratory

Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) Project Data Management Plan

Document: 7363-9330

Version 4

5/31/2020

Signature Page

Thermosphere Ionosphere Mesosphere Energetics and Dynamics Project Data Management Plan (TIMED)	
Project Manager	Date
Program Scientist *<for Directed missions>*	Date
Principal Investigator - GUVI	Date
Principal Investigator - SABER	Date
Principal Investigator - SEE	Date
Principal Investigator - TIDI	Date
Program Manager	Date
Project Scientist for Archives	Date
Project Scientist for Mission	Date
Program Executive	Date
By signing this document, signatories are certifying that the content herein is acceptable direction for managing the project's data and that they will ensure its implementation by those over whom they have authority.	

Change History Log

Revision	Effective Date	Description of Changes
Version 1: Baseline	12/01/1997	Original
Version 2	07/16/2001	Update prior to launch:
Version 3	04/06/2005	Update to remove references to the Space Physics Data System (SPDS).
Version 3 Revision A	07/24/2008	Update to reflect changes in personnel and creation of the Virtual Observatories and the VITMO.
Version 3 Revision B	02/10/2015	Update to designate the recipient of the TIMED archive as the Space Physics Data Facility.
Version 4	03/20/2020	Revised the content and format of the PDMP and added Algorithm Theoretical Basis Document, as Appendix A, for Senior Review 2020 of the Mission Operations and Data Analysis Program for the Heliophysics operating missions.

Table of Contents

Thermosphere Ionosphere Mesosphere Energetics and Dynamics TIMED

PROJECT DATA MANGEMENT PLAN

1. Introduction

1.1 Purpose and Scope

This document, the TIMED Project Data Management Plan (PDMP), describes the TIMED Science Data System, its structure, its policies and its products. This document provides

- Information to the users of the SDS, including an overview of what products are available and how access is provided.
- Guidelines and specific technical information to the SDS implementation teams to aid in construction of the data system.
- Information useful for evaluation of the SDS by program management.

1.2 Plan Development, Maintenance, and Management Responsibility

The TIMED SDS/MDC lead at JHU/APL is responsible for maintaining the PDMP with the instrument teams providing assistance for updating information on their respective instruments.

1.3 Change Control

A version of this document was prepared for launch with subsequent revisions created for organizational and policy changes within NASA. Revisions of this document are to be provided at Senior Review in Section 7 for data volumes and for changes in Final Archive/Mission Archive Plan.

1.4 About This Document

The Mission Overview section briefly summarizes the mission, spacecraft, and/or instruments to provide its role and importance within the context of the SMD portfolio. The Science Instrumentation section summarizes each TIMED instrument to which this PDMP applies [and provides key details as shown in the example below. If the instrument has multiple operational/observation modes, those shall be described here.] The Science Data Products section details the science data products and key parameters produced by each instrument and ground system element. The Ground System section provides details on each element on the ground through which project data is routed. The Data Flow section provides details on the transfer of data between mission elements. The Archiving and Data Access section describes the process for archiving data and how those archives may be accessed.

1.5 Relevant Documents

Table 1 - Project/Mission Documentation

Title	Document Number	Publication Date
TIMED System Requirements	7363-9001	1 Dec 1997

Document		
TIMED General Instrument Interface Specification	7363-9050	11 Nov 1997
1993 Earth Observing System reference handbook	NASA-NP-202	1 Mar 1993

2. Mission Overview

The Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) Program is the initial mission in the Solar Terrestrial Probes Program, part of NASA's initiative to lower mission costs and provide more frequent access to space to systematically study the sun-Earth system. TIMED is exploring the Earth's mesosphere and lower thermosphere (60-180 kilometers), the least explored and least understood region of the atmosphere. It is known that the global structure of this region can be perturbed during periods of stratospheric warming and solar-terrestrial events, but the overall structure and dynamics responses of these effects are not understood. Advances in remote sensing technology employed by TIMED instrumentation enables us to explore this region on a global basis from space.

The TIMED mission is investigating the structure, energetics and chemistry of the mesosphere and lower thermosphere/ ionosphere (MLTI) region. The MLTI is a region of transition within the upper atmosphere in which many important processes change dramatically. It is a region where energetic solar radiation is absorbed, energy input from the aurora maximizes, intense electrical currents flow, and upwardly propagating waves and tides break; and yet, this region had never been the subject of a comprehensive, long-term, global investigation. TIMED is providing a core subset of measurements defining the basic state (density, pressure, temperature, winds) of the MLTI region and its thermal balance.

2.1 Mission Objectives

The overall Science Goal of TIMED is to perform an exploratory study of the physical and chemical processes acting within and upon the coupled lower-thermosphere/ionosphere system between 60 and 180 km. The science objectives are to determine the temperature, density, and wind structure (state parameters) in the Mesosphere, Lower Thermosphere, and Ionosphere (MLTI) region (60-180 km), including seasonal and latitudinal variations, and to determine the relative importance of the various radiative, chemical, electrodynamical, and dynamical sources (input) and sinks (output) of energy for the ML TI region.

The TIMED Science Data System (SDS) is a distributed system with elements that are part of several different facilities. These facilities are listed in Table 1. The SDS manager at JHU/APL coordinates the SDS elements at these facilities. The Mission Data Center (MDC) is the central facility responsible for telemetry distribution and other central functions as outlined in 4.2. The MDC falls completely within the SDS. The Payload Operations Center (POC) facilities are responsible for TIMED instrument operations and assessment as well as data operations, i.e., data reduction, processing and distribution of data analysis products. Only the portions of the POCs involved in data operations fall within the scope of the SDS.

Table 2 - TIMED SDS Facilities

Facility Name	Location	Data System Lead
TIMED Mission Data Center (MDC)	JHU/APL	S. Nylund
SEE Payload Operations Center (POC)	LASP	D. Woodraska
TIDI Payload Operations Center (POC)	University of Michigan	R. Niciejewski
SABER Payload Operations Center (POC)	NASA Langley	L. Gordley
GUVI Payload Operations Center (POC)	JHU/APL	R. Schaefer

2.2 Launch, Orbit, and Operations

The 598-kg TIMED spacecraft was launched December 7, 2001, aboard a Delta-II 7920-10C launch vehicle from the Western Range at Vandenberg Air Force Base, California. It was deployed into a 625-km circular orbit, inclined 74.1º. The orbit precesses at a rate of ≈3° longitude (or about 12 minutes) per day, thus allowing repetitive observations at a specific local time every ≈60 days.

During its two-year primary mission and 16 years of extended operations, TIMED has collected data on the least explored region of the atmosphere, the Mesosphere, Lower Thermosphere/Ionosphere (MLTI) region, to understand the influence of both the Sun and human activities and to improve the prediction of space weather.

There were no special requirements for early on-orbit operations. The SDS activities supporting routine operations will be on-line and tested prior to launch. Spacecraft and instrument check-out were completed on January 22, 2002, at which time science operations began.

The mission operations phase is defined as the time during which the TIMED instruments are acquiring data on orbit and consists of a two-year span for the primary mission and subsequent extended mission operations. During this period, it is the program's responsibility to supply data to TIMED program elements, the scientific community, general public and K-12 educators.

3. Science Instrumentation

Table 3 - Summary of TIMED Instruments

Inst. Name	In situ or Remote Sensing?	Mass (kg)	Power (W)	Data Rate (kbps)	PI	PI Organization	Inst. Status
GUVI	Remote sensing	19.3	24	8.1	Andrew Christensen	Aerospace Corporation	OK
SABER	Remote sensing	65.6	76.5	4.0	James Russell III	Hampton University	OK

SEE	Remote sensing	27	27	0.2	Tom Woods	Laboratory for Atmospheric and Space Physics	OK
TIDI	Remote sensing	41.8	19.3	2.4	Rick Niciejewski	University of Michigan	OK

3.1 Global Ultraviolet Imager (GUVI)

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.

3.1.1 Instrument Measurement Requirements

Table 4 - Required Measurement Parameters of GUVI

Measurement Parameter	Value
Parameter Measured	Spectral irradiance covering 115-180 nm in spectrograph mode. Spectral irradiance reduced to 5 colors in imaging mode: 121.6 nm (Lyman alpha) 130.4 nm (OI) 135.6 nm (OI) 140 to 150 nm (N_2 LBH short) 165 to 180 nm (N_2 LBH long)
Wavelength Range	115 to 180 nm [Baseline]
Wavelength Resolution	narrow slit 1.3 nm intermediate slit 2.0 nm wide slit 4.2 nm

Table 5 lists relevant documents for GUVI

Table 5 - Relevant GUVI documents

Title	Document Number	Publication Date
GUVI Technical Requirements	7366-9001	23 Jan 1998
GUVI Payload Operations Center	7366-9200	6 Feb 1998

3.1.2 Instrument Description

GUVI is an instrument to take images of the Earth's disk and limb in the far ultraviolet. The scanning imaging spectrograph (SIS) 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 and the slit used for any observation is indicated in the level 1B data products.

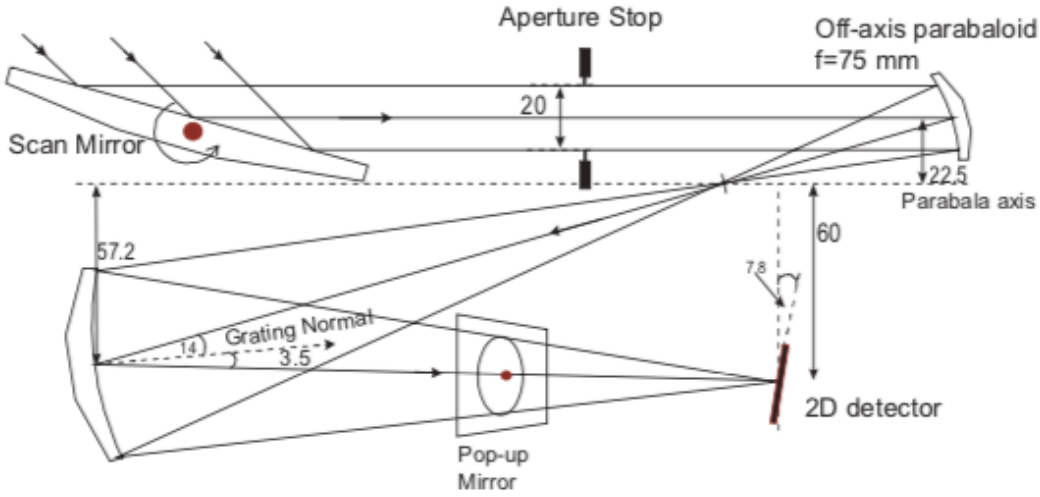


Figure 1 - Schematic of the GUVI optical layout. The dimensions are in mm and the angles are in degrees. Light is initially reflected off of the scan mirror, then focused onto the slit aperture before being diffracted on a toroidal grating. Shown also is a pop up mirror which can be used to divert the optical path to a secondary backup detector should the primary detector fail.

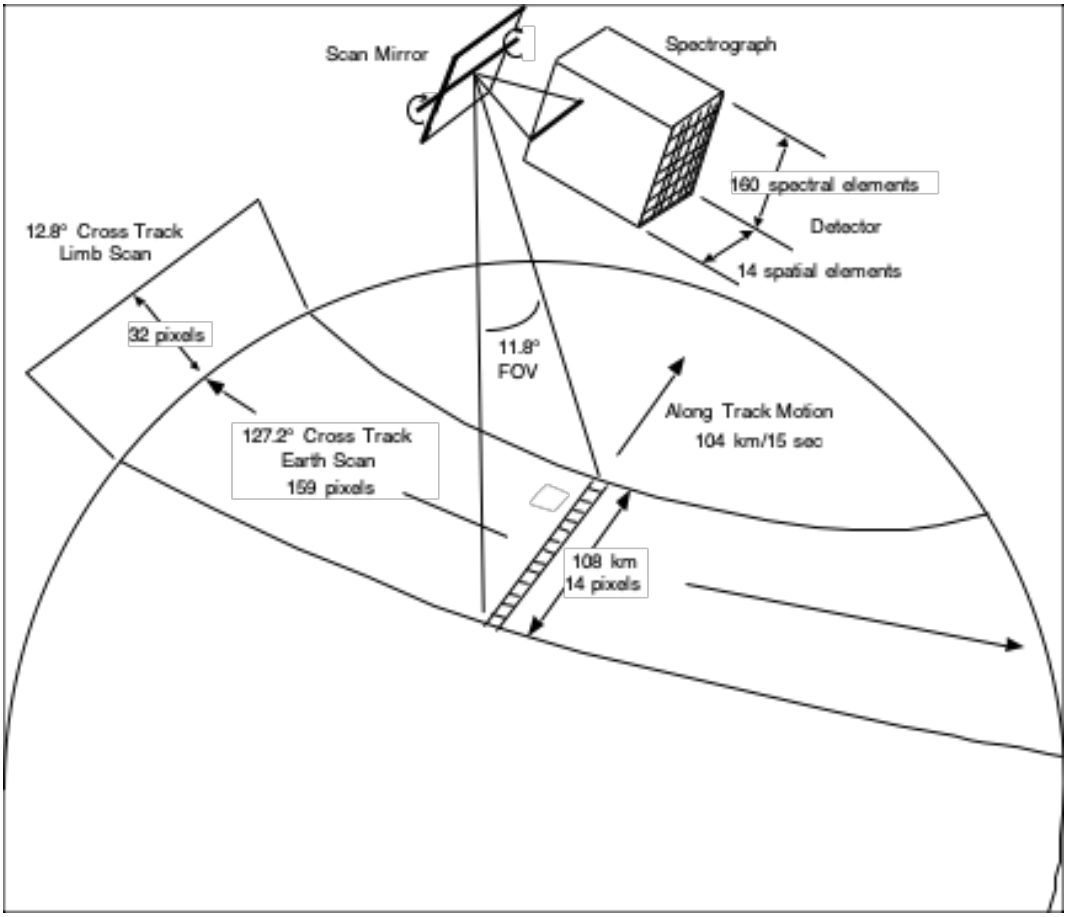


Figure 2 - The SIS produces horizon-to-horizon images at 160 wavelengths simultaneously. In imaging mode the scan mirror moves the slit defined field of view in discrete steps in the cross track direction starting on the limb and sweeping across the disk of the Earth. The limb scan is done with higher angular resolution (smaller step size). The limb is always on the side away from the Sun. The sunward side of the scan covers 60 deg and the anti-sunward side covers 80 deg. The slit field of view appears curved when mapped to the Earth – this is shown schematically in the figure. In spectrograph mode, the scan mirror is fixed and can point at one fixed step in the scan.

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 by 14 along track pixels with five colors. At 80.0° from nadir and a spacecraft altitude of 625 km, the spectrograph will view a tangent point 519 km above the horizon, at a distance of 1215 km. At a more typical limb viewing angle of 68.8, the spectrograph will view a tangent point 152 km above the horizon, at a distance of 2530 km. At a tangent point altitude of 152 km, the footprint of the instrument covers a distance of 530 km, but the viewing point only moves by 105 km in one 15 s scan mirror cycle. Therefore, the same pixel on the limb is resampled on five successive sweeps of the scan mirror on each orbit. The Earth viewing section has a cross track resolution of 0.8° per pixel, and contains 159 cross track pixels by 14 along track pixels and five colors. Pixels are collected from 67.2 from nadir to -60 from nadir (the end of scan).
The components of the GUVI instrument that might be expected to wear out

over time are*:*

- Wearing out of the scan mirror stepper motor. Failure of the motor in 2007 resulted in the instrument being permanently parked in spectrograph mode.
- Aging of the detector. The detector cathode is expected to decay slowly over time, which decrease in sensitivity. This will be monitored with on orbit calibrations and comparisons to similar Special Sensor Ultraviolet Spectrographic Imager instrument measurements of radiance.

3.1.3 Instrument Observation Requirements

Measurement requirements are specified in detail in the GUVI Technical Requirements Document *(7366-9001)*

3.1.4 Instrument Observation Capabilities

Table 6 summarizes the characteristics of the GUVI instrument

Table 6 - Summary of the characteristics of the GUVI instrument

Observation Parameter	**Value**	
	Launch to 2007	**2007 to Present**
Observable	FUV	FUV
Number and Type of Detectors	2 High voltage multichannel plate photomultiplier 2-Dimensional detectors	2 high voltage multichannel plate photomultiplier 2-Dimensional detectors
Data span	5 FUV colors x 14 spatial pixels	176 spectral colors x 14 spatial pixels
Field of View	11.8° along track	11.8° along track
Time Resolution	0.1 sec	3 sec
Positioning	Pointing uncertainty <1.0°	Pointing uncertainty <1.0°
Data Rate	Science data and HK: 8.1 kb per second	Science data and HK: 8.1 kb per second
Sensitivity	Wavelength (nm) / Responsivity (c/s/Rayleigh) 121.6 / 0.029 130.4 / 0.058 135.6 / 0.116 140 to 150 / 0.289 165 to 180 / 0.193	

3.1.5 Data Acquisition

The GUVI instrument operates in 2 types of data packets: imaging and spectrograph modes*:*

- *Imaging: 156x14 spatial pixels (cross track x along track) on the disk, and 32 x 14 (cross track x along track) on the limb for each of the 5 FUV colors every 15 seconds*
- *Spectrograph: 14 spatial pixels (fixed pointing angle) in 176 wavelengths integrated over a 3 second interval*

3.2 Sounding of the Atmosphere using Broadband Emission Radiometry (SABER)

The Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) instrument has produced continuous data since January 2002, shortly after the December 7, 2001 launch on the Thermosphere-Ionosphere-Mesosphere Energetics and Dynamics (TIMED) satellite. The primary goal of SABER is investigation of the thermal structure, chemistry, energetics and long-term changes in the Mesosphere and Lower Thermosphere (MLT). To achieve this goal, SABER measures vertical profiles of limb path atmospheric emission in 10 spectral bands between 1.27 and 15 μm wavelength. SABER measurements are used to retrieve the vertical profiles of temperature, pressure, and molecular density or volume mixing ratios for O_3, H_2O, CO_2, [O], and [H]; profiles of volume emission rates (VER) for NO (5.3 μm), OH (1.6 and 2.0 μm), and O_2 (1.27μm); profiles of cooling rates for 15 μm CO_2, 5.3 μm NO, 9.6 μm O_3, and 6.7 μm H_2O; profiles of solar heating rates for Hartley, Huggins, and Chappius bands of O_3, Schumann-Runge, Herzberg and atmospheric bands of O_2, and 4.3 μm CO_2; and profiles of chemical heating rates for Ox and HOx.

3.2.1 Instrument Measurement Requirements

SABER uses 10 detectors to measure emission from 10 infrared spectral bands shown in *Table 7*. The noise equivalent radiance (NER) values required for these measurements necessitate cooling the focal plane to a temperature of 74 K. This is accomplished using a miniature pulse tube refrigerator that maintains the temperature typically to within 0.2 K.

Table 7 - The SABER channels

Channel Number	**Channel Description**	**Spectral Filter 5% points (cm^{-1})**	**NER ($w/m^2/sr$)**	**Parameter and/or application**	**Range (km)**
1	CO_2 15 μm narrow	649 - 698	2.57e-4	T(P), cooling rates	15 - 110
2	CO_2 15 μm wide	581 - 764	3.07e-4	T(P), cooling rates	15 - 110
3	CO_2 15 μm wide	580 - 763	3.28e-4	T(P), cooling rates	15 - 110
4	O_3 9.6 μm	1015 - 1145	4.18e-4	O_3 VMR, cooling rates	15 - 100
5	H_2O 6.8 μm	1369 - 1567	2.11e-5	H_2O VMR, cooling rates	15 - 90
6	NO 5.3 μm	1865 - 1944	1.23e-6	Thermospheric cooling	100 - 300
7	CO_2 4.3 μm	2303 - 2392	7.35e-7	CO_2 VMR, dynamical tracer	70 - 110
8	OH(υ) 2.0 μm	4510 - 5152	1.21e-6	[O], chemical heating	80 - 100
9	OH(υ) 1.6 μm	5741- 6414	3.37e-6	[O], chemical heating	80 - 100
10	$O_2(^1\Delta)$ 1.27 μm	7704 - 7969	2.51e-6	Day O_3 VMR, solar heating	50 - 100

3.2.2 Instrument Description

The SABER instrument (Figure 3) uses a Cassegrain telescope design with a picket-fence tuning fork chopper at the first focus, and a clamshell re-imager to focus the image on the focal plane. Figure 4 [Tansock et al., 1999] shows the SABER instrument functional diagram. The optical design consists of a high o*ff*-axis rejection telescope, a single axis scan mirror, a chopper, filters and 10

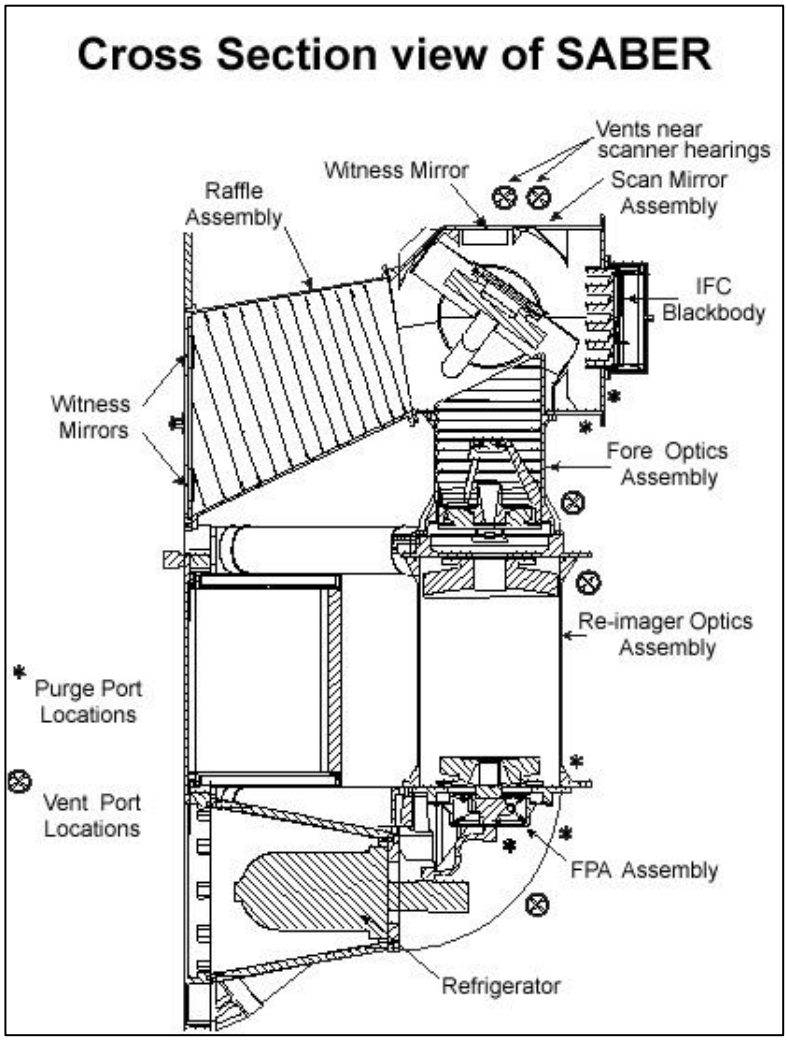


Figure 3 - The SABER instrument

detector focal plane elements. The telescope was designed to reject stray light from the Earth and atmosphere outside the instrument instantaneous field-of-view (IFOV). The baffle assembly contains a single axis scan mirror which permits the 2 km vertical IFOV of each detector to be scanned across the limb from the Earth surface to a 350 km tangent height to produce vertical spectral radiance profiles of the stratosphere, mesosphere and lower thermosphere. The scan mirror velocity and detector sample rate gives five vertical earth limb samples per detector IFOV. The angular range of the scan mirror is approximately 16°, which allows SABER to look from cold space down to hard Earth. Accurate vertical registration of the tangent height of the data in the atmosphere is achieved by analysis of the 15 μm CO_2 channels. The detector focal plane assembly, consisting of a filter array, a detector array, and a Lyot stop is cooled to 74 K by a miniature cryogenic refrigerator. The SABER detector array layout (Figure 5) contains discrete HgCdTe, InSb, and InGaAs detectors [Tansock et al., 1999]. Each detector has an instantaneous field of view (IFOV) of 0.7 mrad by 10 mrad. The 0.7 mrad angular detector width gives a vertical footprint on the earth limb of approximately 2 km for a 60 km tangent height look angle and a 600 km orbit. The focal length of the telescope is 200 mm with an f-number of 2. Each detector or channel is spectrally filtered to a unique passband. The electrical signal from each of the 10 channels is pre-amplified and coherently rectified using phase-lock amplifiers synchronized with the chopper. Each channel contains a 12 bit

analogue-to-digital converter. All 10 channels have multiple gain settings. The instrument contains In-Flight Calibration (IFC) radiation sources to confirm or update sensor calibration during on-orbit operations.

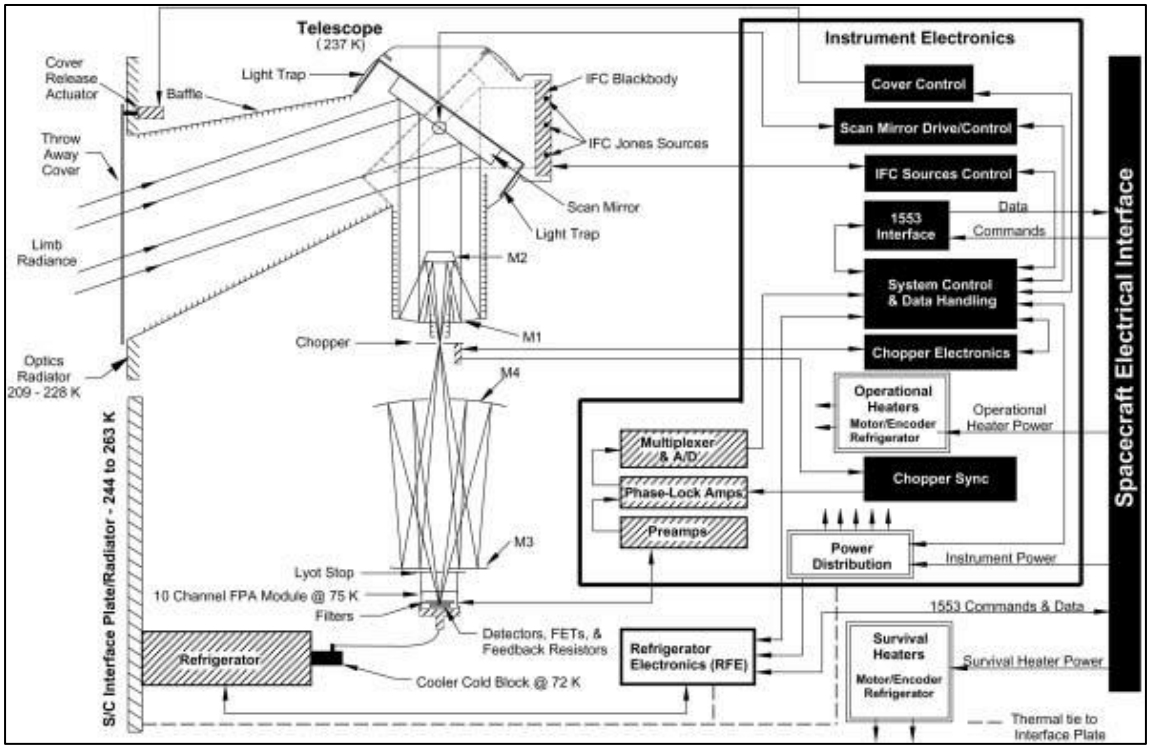


Figure 4 - The SABER instrument functional diagram

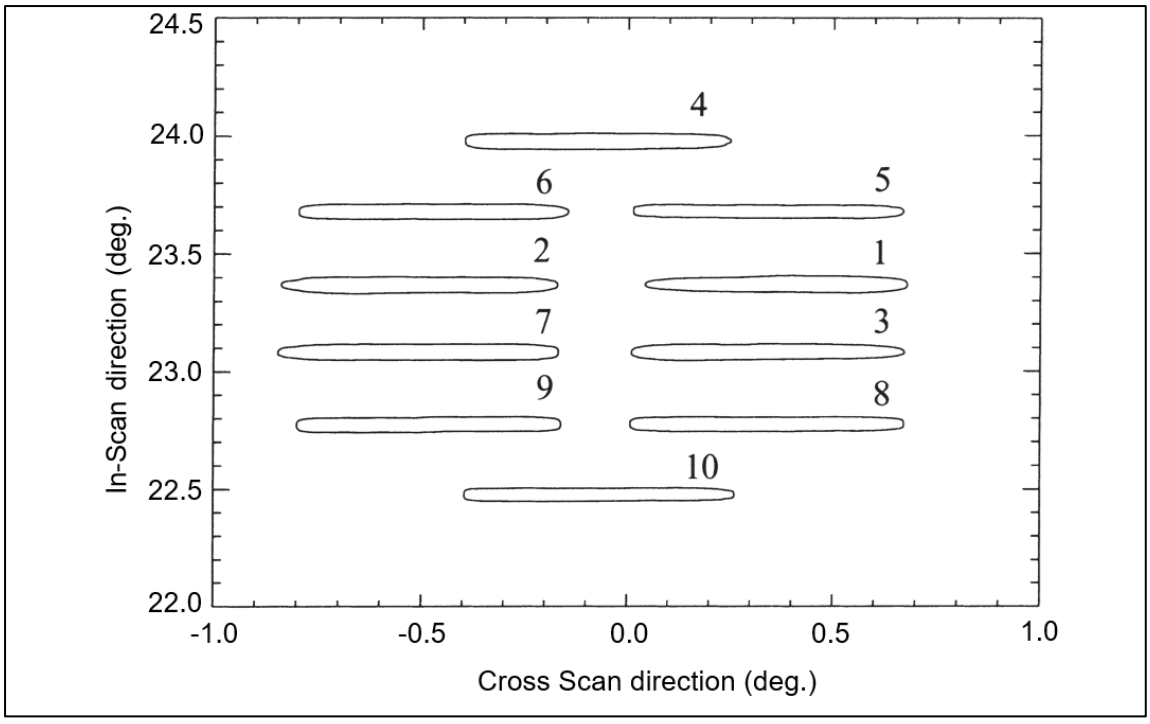


Figure 5 - SABER Instantaneous FOVs showing relative array locations

Error! Reference source not found. shows the cross-scan integrated IFOV responses. The blackbody temperature and neutral density filter settings were optimized to give good signal-to-noise ratios for each channel. These

data show the measurement dynamic range to be nearly four orders of magnitude from the peak instantaneous field-of-view response.

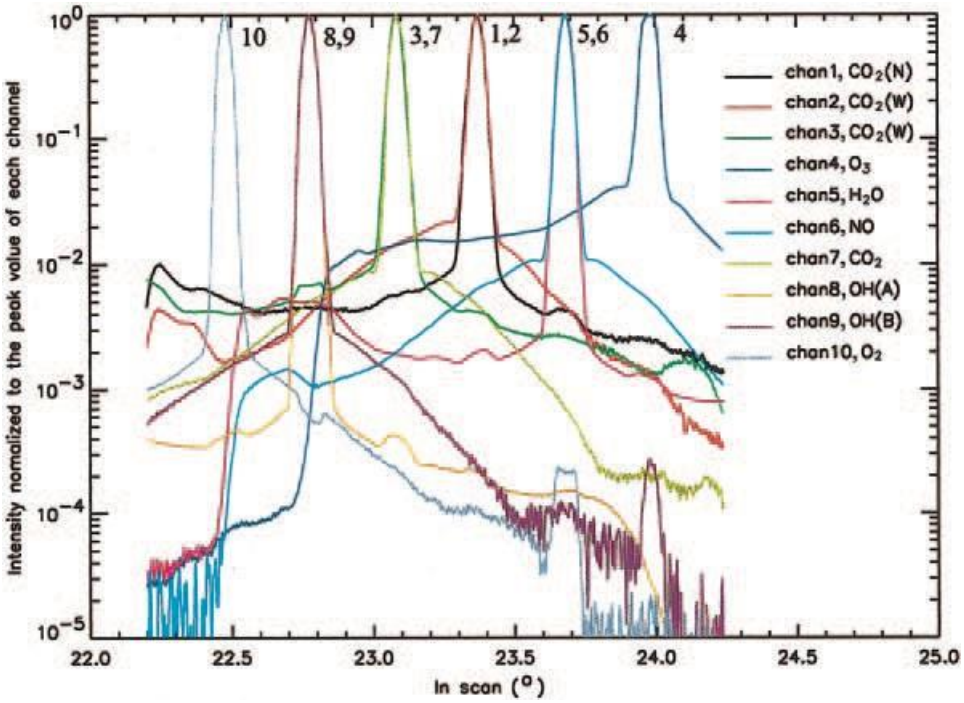


Figure 6 - Cross-scan integrated IFOV response. —Channel 1, CO_2-N; —Channel 2, CO_2- W; —Channel 3, CO_2-W; —Channel 4, O_3; —Channel 5, H_2O; —Channel 6, NO; — Channel 7, CO_2; —Channel 8, OH-A; Channel 9, OH-B; Channel 10, O_2

3.2.3 Instrument, Observation Requirements and Capabilities

The SABER goal to study the mesosphere and lower thermosphere structure and energetics including its seasonal, latitudinal and temporal variations requires a circular Earth orbit inclined at 74.1˚ and at 625 km altitude. The orbit precesses 3˚ per day with respect to the Sun. The precessing orbit requires a yaw maneuver roughly every 60 days to prevent SABER from viewing the Sun. SABER views 90˚ clockwise or counterclockwise (depending on yaw mode) from the TIMED velocity vector so, due to it's inclination, its measurements alternate between north viewing (latitude coverage of 83N to 52S) and south viewing (latitude coverage of 52N to 83S). Figure 7 shows the measurement tangent point track for a north viewing yaw mode. The TIMED orbital period is about 96 minutes thus the SABER measurement track circles the Earth 15 times per day.

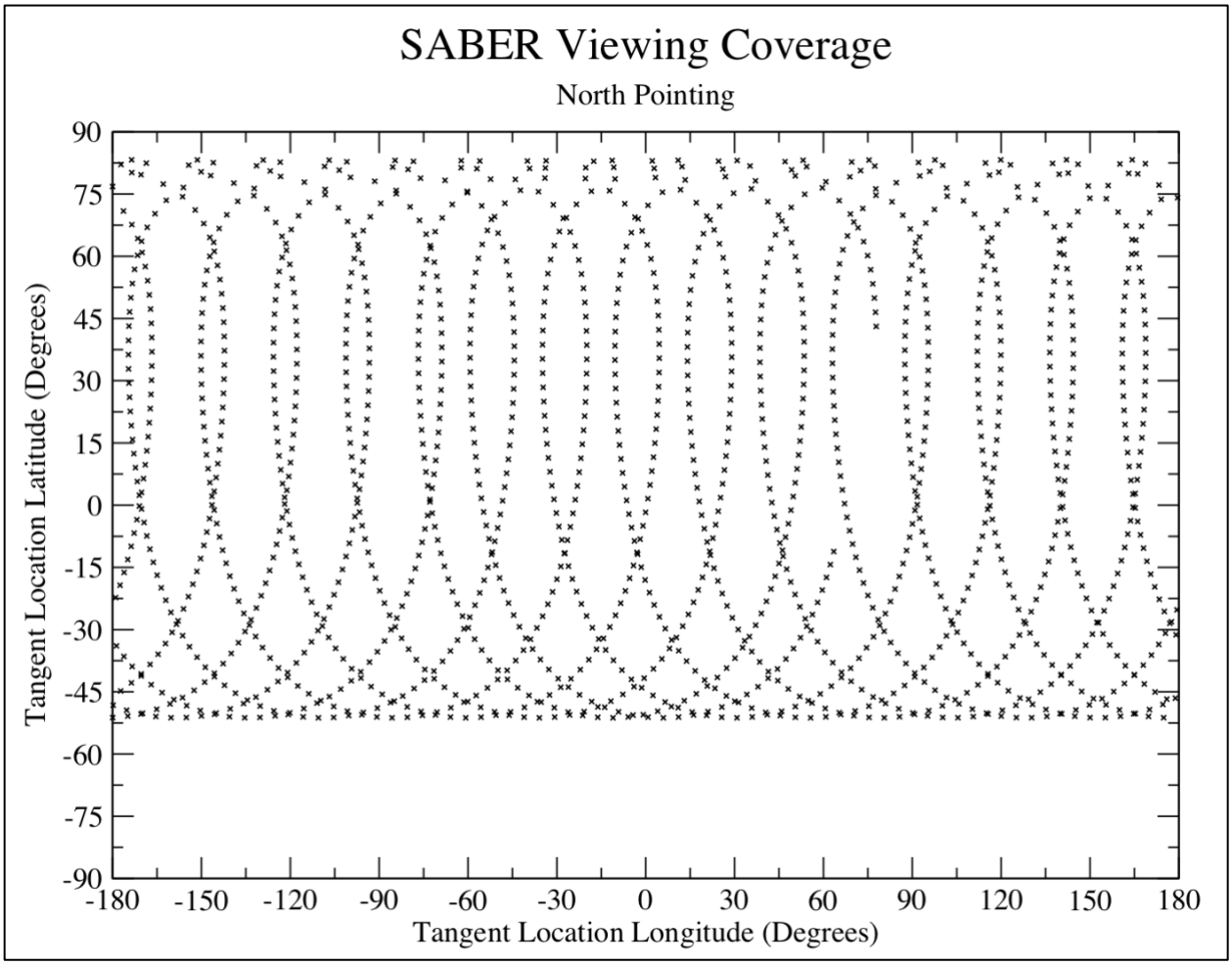


Figure 7 - SABER tangent point track for a typical day during a north viewing yaw mode.

Accurate limb-path emission measurements require detailed characterization of each channel including absolute response (counts to radiance), spectral response, field of view (FOV) response, electronic offsets, internal emission contributions, and IFC characteristics. The pre-launch calibration is transferred to flight measurements by including measurement modes that remove offsets and provide continuous absolute response calibration. This is necessary because the instrument state is constantly changing in response to the orbital environment, changes induced by active control of instrument temperature, and changes in temperature of the IFC and of the detectors. These measurement modes are accomplished on SABER by use of a scanning mirror that views the IFC and provides external view paths ranging from Earth surface to 500 km tangent altitude (space look), including paths through Earth's atmosphere from surface grazing to about 350km tangent altitude (Figure 8). The space view provides offset calibration while the IFC view provides absolute response calibration. The atmosphere scan mode is comprised of an up, down sequence in which the mirror first scans from Earth view to roughly 350km tangent altitude and then back down to Earth view and into the instrument baffle. This is repeated with a space look performed after every other up, down sequence and IFC calibration after every fourth. SABER performs about 49 up, down atmosphere scan sequences (98 full scans of the atmosphere) per orbital period. This is over 1400 scans per day for each of the 10 channels with a sampling

rate that results in approximately 0.38 km spacing between samples for each scan.

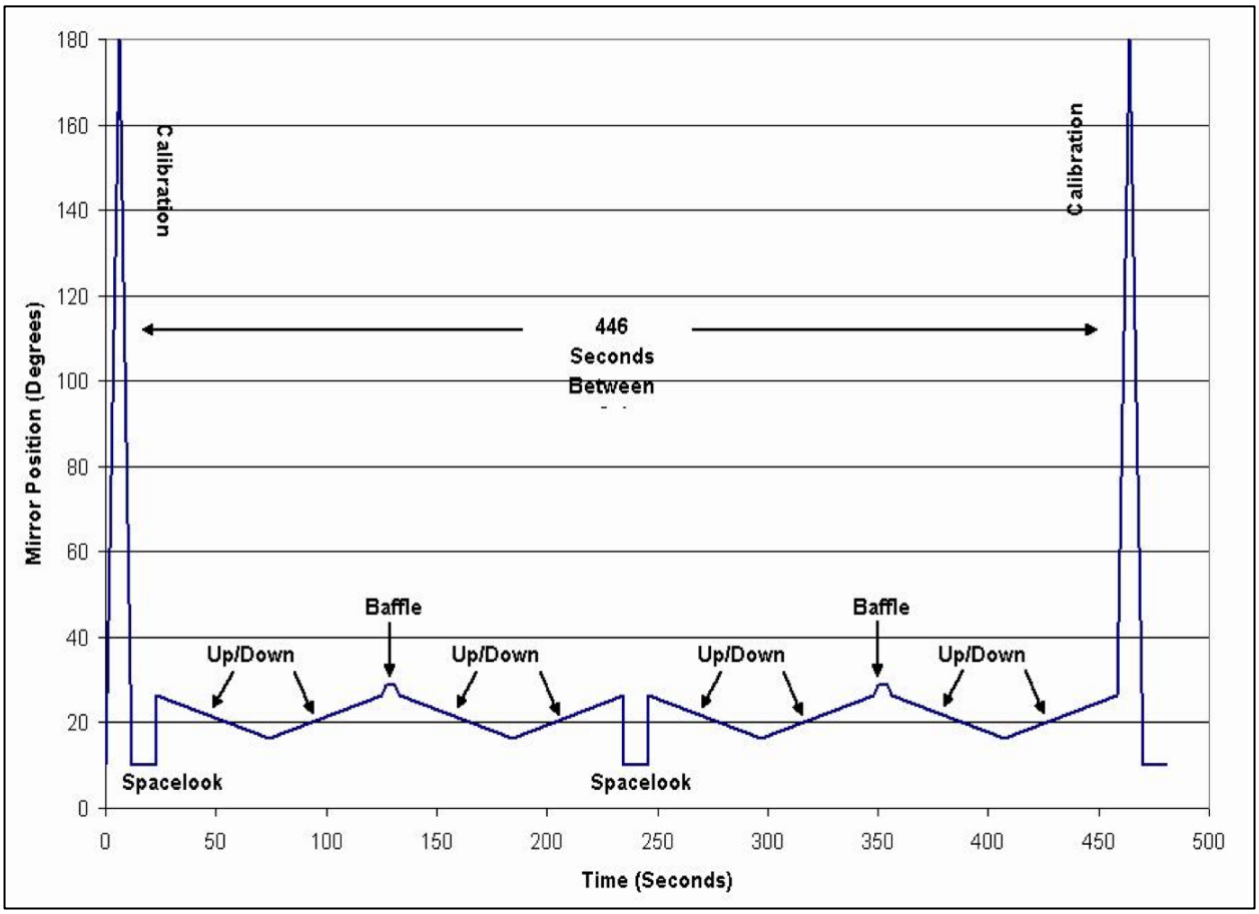


Figure 8 - SABER atmospheric limb scan sequence

3.2.4 Data Acquisition

As described in sections 3.2.1 - **Error! Reference source not found.**, SABER measures atmospheric emission in 10 bandpasses using a scan mirror to sample limb paths with tangent heights from surface to approximately 350 km. SABER also collects housekeeping measurements including numerous temperatures, and voltages (or currents) for critical components. The SABER radiometric and housekeeping data are transmitted directly to the spacecraft on a continual basis (SABER has no internal data storage). The spacecraft stores SABER data until it encounters contact with a ground (or orbiting) receiving station.

3.3 Solar Extreme Ultraviolet Experiment (SEE)

3.3.1 Instrument Measurement Requirements

Table 8 - Summary of the required measurement parameters of SEE

Measurement Parameter	Value
Parameter Measured	Spectral irradiance covering 1-170 nm and once per day [Baseline]
Energy/Wavelength Range	1 to 170 nm [Baseline] 0.1 to 190 nm [Updated 2002]
Energy/Wavelength Resolution	0.4 nm (>30 nm); 2-7 nm (<30 nm) [Baseline]

3.3.2 Instrument Description

The Solar Extreme Ultraviolet Experiment (SEE) instrument measures the daily full-disk solar spectral irradiance in soft X-rays, EUV and FUV wavelengths to support research into sun-earth connections. This portion of the solar spectrum is a major energy source for earth's upper atmosphere driving much of the chemistry and dynamics. The SEE observes the wavelengths that are responsible for ionizing atoms creating the ionosphere, dissociating molecules, and heating the upper atmosphere affecting satellite drag. The SEE measurements are fundamental for the TIMED mission's investigation of the energetics in the tenuous, but highly variable, layers of the atmosphere about 60 km.

The SEE achieves this with a combination two scientific instruments: a moderate resolution Extreme Ultraviolet (EUV) Grating Spectrograph (EGS) and a suite of silicon photodiodes coated with thin film transmission filters called the X-ray Ultraviolet (XUV) Photometer System (XPS). The detectors are controlled through a dedicated microprocessor unit (MU) that executes observation sequences loaded by ground commands. The SEE Solar Pointing Platform (SSPP) is a one-axis rotation platform that points the SEE instruments at the sun along one axis. The perpendicular axis is the sun-drift direction, as seen from the SEE, limiting observations possibilities of the sun to a few minutes each orbit. During an observation sequence, the SSPP axis is well controlled and the sun drifts across the sensor field of view center according to the nadir-pointed spacecraft in its orbit.

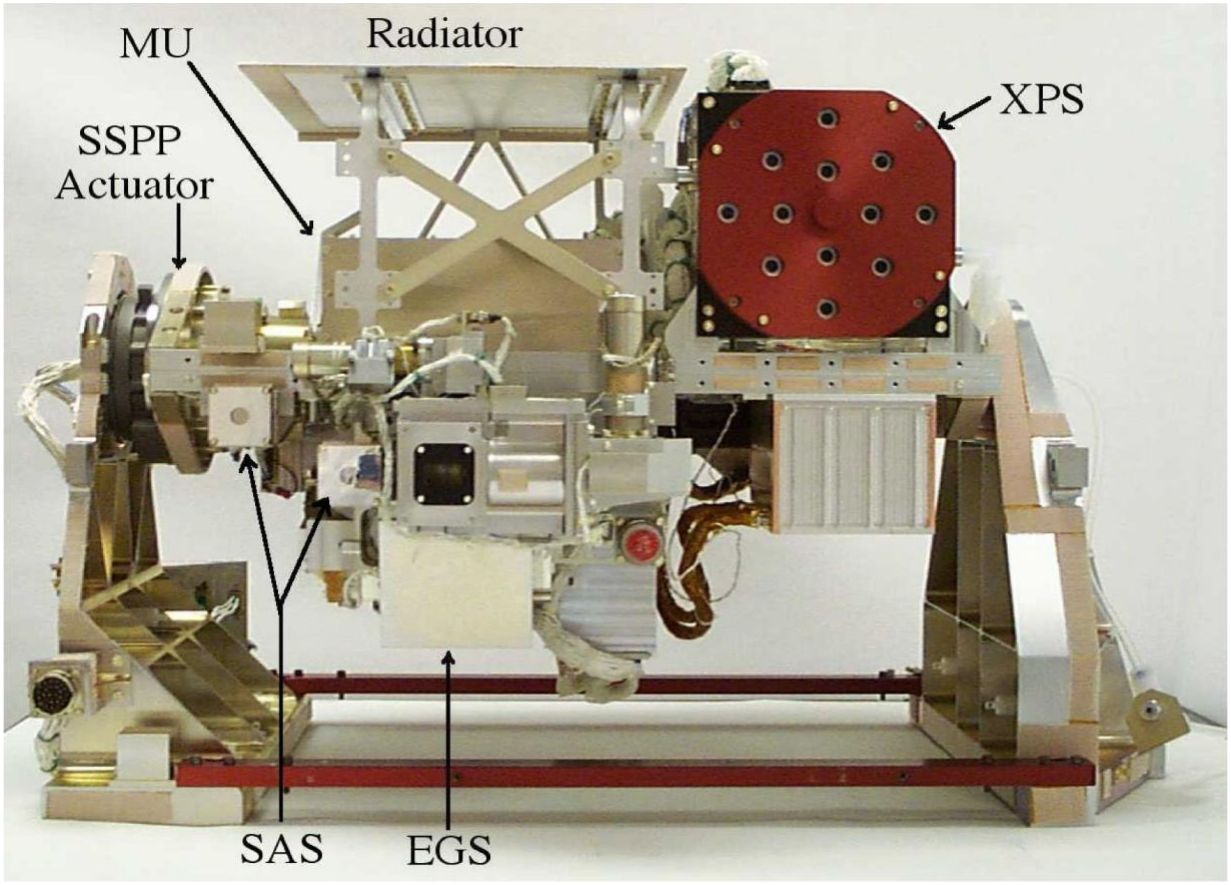


Figure 9 - SEE Instrument

The EGS contains a high voltage grid with a gold coated chevron stacked microchannel plate with a CODACON readout. EUV and FUV photons cause the photoelectric effect from the gold coating that are accelerated through the microchannel plate pores causing a cascade of electrons on the back side that are detected in the CODACON at a position. Over time the electrons are depleted manifesting as degradation.

The EGS is designed with redundant optical paths that conceptually provide a split of the 2-dimensional CODACON array data into a top/bottom half. The normal operation exposes the high-duty cycle optical path (normal slit) to one half of the detector for most observations. Twice each week the low-duty cycle path is used (calibration slit) to track long-term changes. The calibration path receives about 1/50 of the exposure of the normal path. The calibration slit observations are used to transfer degradation corrections to the data reduction of the normal slit primary science data, extending the useful life of the EGS.

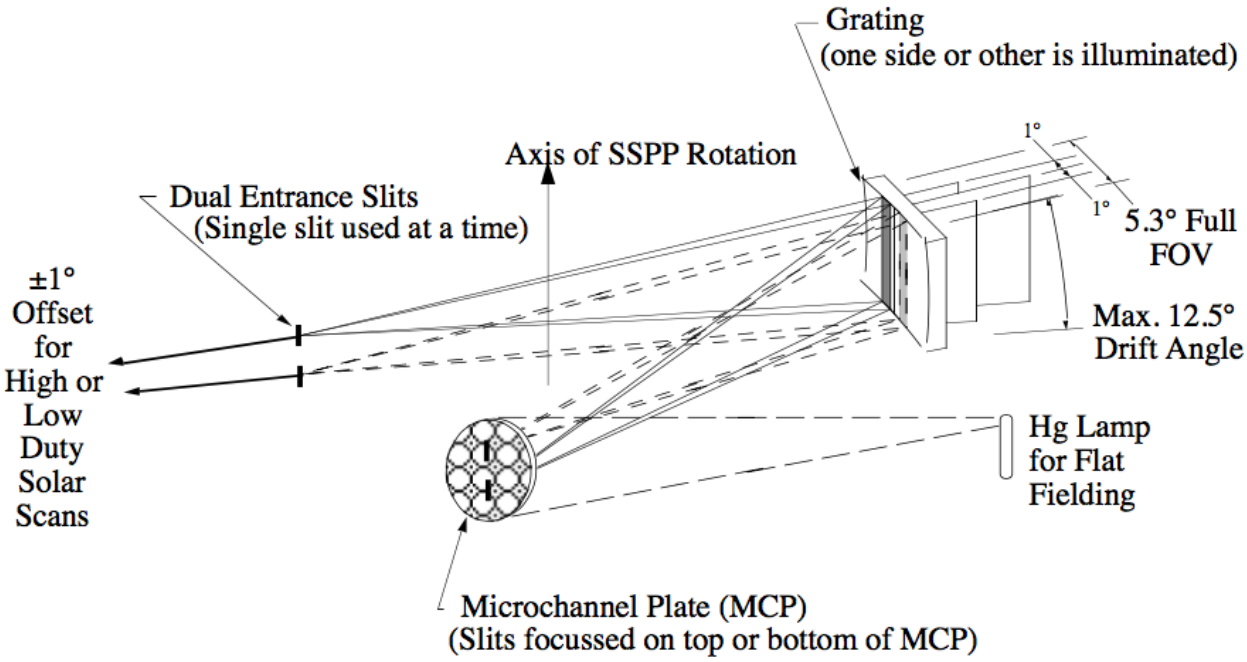


Figure 10 - SEE EUV Grating Spectrograph Reduncant Channel Operation

The XPS diodes are powered on only during solar observations for a 3% duty cycle. Prior to July 24, 2002, the XPS filter wheel rotated to different positions exposing all of the diodes in a sequence. On July 24, 2002 the XPS filter wheel suffered an anomaly and become fixed in one position that exposed only 3 XUV diodes (1, 5, and 10). Diode 1 has a TiC filter and provides 0.1-7 nm measurements. Long-term exposure of the other diodes has changed the bandpasses of the other 2 diodes in non-trivial ways, but primarily increasing the visible light contribution in a way that cannot be measured. However, diode 1 continues to function properly and has not suffered the same problem.

3.3.3 Instrument Observation Requirements

The instrument observation requirements are to:

- provide the full-disk solar irradiance daily
- specify the irradiance with 0.4 nm resolution from 30-170 nm
- specify the irradiance with 2-7 nm resolution from 1-30 nm

3.3.4 Instrument Observation Capabilities

Table 9 - Summary of specific SEE parameters

Observation Parameter	Value
	Launch to Present
Observable	Soft X-rays, EUV, and FUV full disk solar irradiance
Number and Type of Detectors	12 silicon photodiodes with thin film transmission filters in XPS One 64 x 1024 CODACON microchannel plate spectrograph in EGS

Sensitive Area	2048 (wavelength/spectrum) x 1024 (slit image) for each CCD
Field of View	1024 (wavelength/spectrum)
Time Resolution	12.5° (drift) x 5.3° (cross-dispersion controlled by SSPP)
Positioning	Daily spectral product, EGS and XPS both integrate at a 10 second rate for 3 minute each orbit
Sensitivity	EGS: 0.85 arcmin both axes (1-sigma) XPS: 15 arcmin both axes (1-sigma)
Data Rate	Varies with wavelength

3.3.5 Data Acquisition

The EGS performs photon counting with the position given by the 2d CODACON array. The flight software performs on-board summing of each 10-second EGS integration reducing the 1024x64 CODACON array data down to a foreground/background pair of 1024 columnar arrays. During solar observation the EGS and XPS integrate at a 10 second cadence for approximately 3 minutes out of each orbit. In between solar observations the XPS is powered off, but the EGS remains powered on but not solar pointed. The XPS diodes respond to soft x-ray photons that penetrate the filter coatings producing electron hole pairs in the silicon. The electrons per unit time result in a photocurrent that is packetized in telemetry.

The flight software collects dark integrations from the EGS at a 15 second rate and sums the entire 1024x64 array into one number that is stored on the SSR and later sent to the ground. Since the EGS is also sensitive to particle radiation, this is useful for mapping the South Atlantic Anomaly and the Polar Zones when particle disturbances occur.

3.4 TIMED Doppler Interferometer (TIDI)

3.4.1 Instrument Measurement Requirements

Table 10 - Summary of the required measurement parameters of TIDI

Measurement Parameter	Value
Line of sight wind	Required accuracy: 3 m/s in the MLT 15 m /s in the thermosphere
Wavelength Range	Dayside: O2 At (0,0) P15, 765.07 nm, 65-100 km O2 At (0,0) P9, 763.78 nm, 80-115 km OI, 557.7 nm, 110-160 km OI, 630.0 nm, 160-300 km Nightside: O2 At (0,0) P9, 763.78 nm, 80-105 km OI, 630.0 nm, 160-300 km

3.4.2 Instrument Description

The TIMED Doppler Interferometer (TIDI) is investigating the dynamics and energetics of the Earth's mesosphere and lower-thermosphere. TIDI measurements allow us to obtain a global

description of the vector wind fields, as well as important information on gravity waves, species densities, airglow and auroral emission rates and noctilucent clouds. TIDI provides basic information about global winds. TIDI also contributes to the study of energetics.

TIDI comprises three major subsystems: four identical telescopes, a Fabry-Perot interferometer with a CCD detector, and an electronics box. Light from the selected regions of the atmosphere is collected by the telescopes and fiber-optically coupled to the detection optics. The four fields of view are scrambled along with a calibration field input and converted to an array of five concentric circular wedges. This input then passes through a selected filter, then through a Fabry-Perot etalon, and is finally imaged onto a CCD via a circle to line imaging optic (CLIO) device.

Mass:	41.8 kg
Electrical Power:	19.32 watts (orbit ave.)
Heater Power:	11.0 watts
Data Rate:	2494 bits/sec
Observations:	Line of sight winds
Wind accuracy:	3 m/s (line of sight)
Altitude Resolution:	2.5 km
Spectral Range:	550 - 900 nm
Lifetime:	>2 years

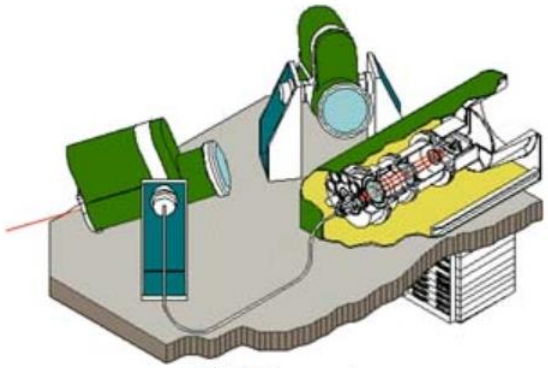


Figure 11 - TIDI System

3.4.3 Instrument Observation Requirements

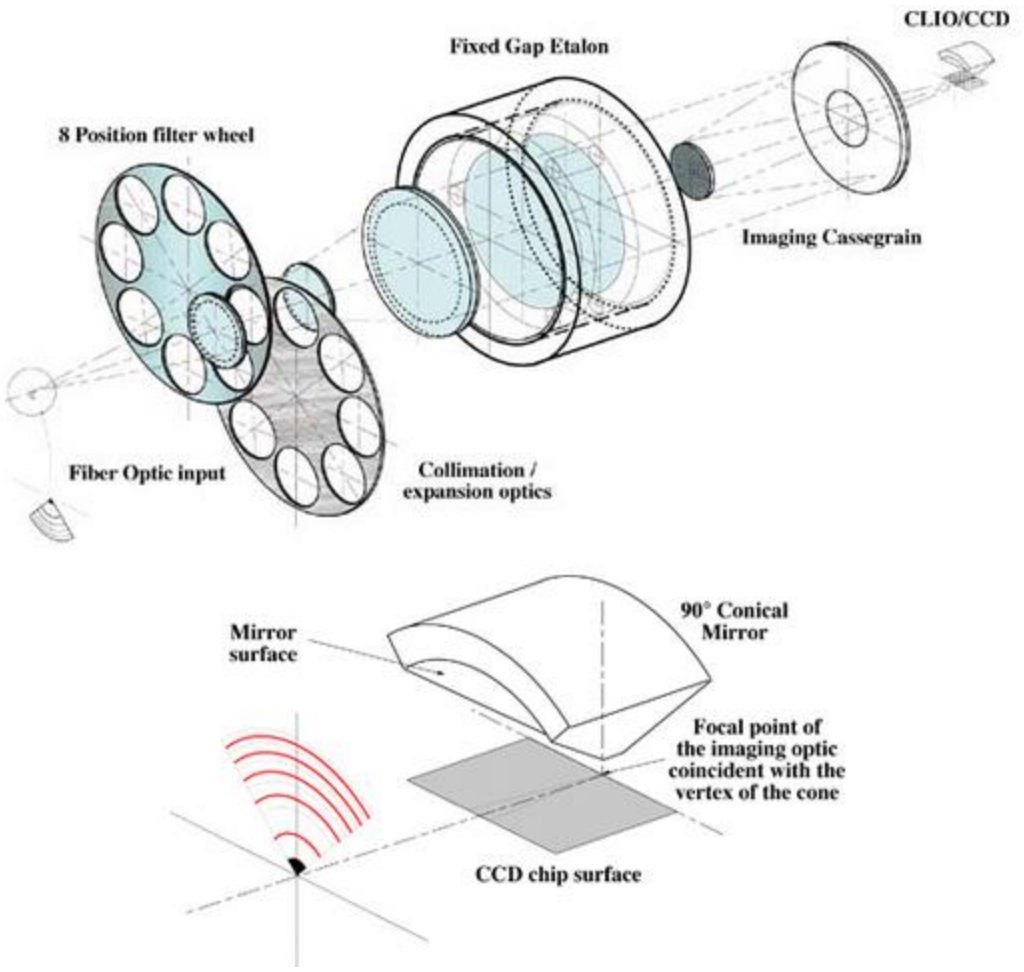
The TIDI interferometer (or Profiler) primarily measures horizontal vector winds from the Earth's limb, with a vertical resolution 2.5 km and with an accuracy that approaches ~3 m/sec under optimum viewing conditions. The TIDI design allows for 100% duty cycle instrument operation during daytime, nighttime, and in auroral conditions. TIDI views emissions from OI 630.0 nm and O_2(0-0) to determine Doppler wind.

3.4.4 Instrument Observation Capabilities

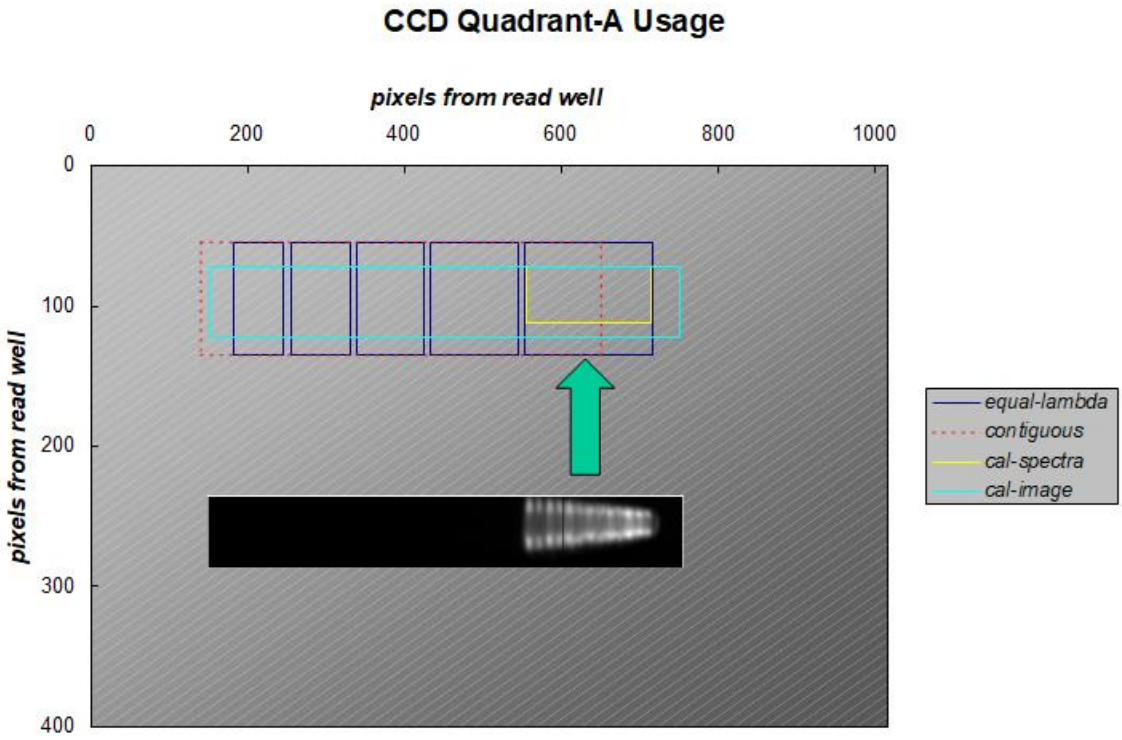
Table 11 - Summary of specific TIDI parameters

Observation Parameter	Value
	Launch to 2020
Observable	O2 At (0,0) P9, O2 At (0,0) P15, OI (557.7 nm), OI (630.0 nm)
Number and Type of Detectors	1 1024 x 400 pixel quadrant of a SiTE CCD
Sensitive Area	255 x 1 (wavelength/spectrum) collapsed from a 510 x 81 pixel CCD area
Field of View	4 orthogonal limb views each being 2.5° (horiz) x 0.05° (vert) oriented at 45°, 135°, 225°, and 315° to the orbital path
Time Resolution	Dayside: 1 sec. Nightside: O2 At (0,0) P9 3 sec., OI (630.0 nm) 4 sec.

3.4.5 Data Acquisition



The science operational modes employed by the TIDI experiment have remained constant since 15-JANUARY-2010 for dayside data acquisition and 19-JUNE-2009 for nightside measurements. The operational mode consists of 1) daytime science operations, 2) nighttime science operations, 3) daily calibration verification, and 4) weekly normalization calibration. The daytime science mode uses the O_2 Atmospheric A band P9 and P15 rotational lines to obtain winds from 65 to 115 km altitude, the O(^{1}S) green line for the range 110 to 160 km and the O(^{1}D) red line to continue to 300 km. The O(^{1}D) red line was added in 2008 and extended the altitude coverage of TIDI into the upper thermosphere. This emission provides an excellent monitor of thermosphere dynamics. The nighttime science mode is similar but limited in scope to using the P9 lines to measure winds near the mesopause and the O(^{1}D) line to measure the winds in the thermosphere. The daily calibration verification consists of a full complement of tests to monitor instrument performance. These daily tests are divided equally amongst 14 day-to-night transitions, each segment taking 5 minutes to complete while the spacecraft flies through the terminator. These tests verify instrument throughput, detector noise and gain, and etalon finesse. In addition, the data are used to monitor the long-term drift of the instrument. The weekly normalization mode uses four daytime passes to gather data to calibrate the relative sensitivity of each spectral channel.



Binning strategies employed by on-board TIDI software. The *contiguous* strategy is employed for all airglow and NORCAL spectra, is 510x81 pixels and is binned into a 255x1 spectrum "image". The *cal-spectra* region is used for all calibration lamp spectra (white-light and neon lamp) comprised of 159 channels across by 40 pixels vertically, which is collapsed into a 159x1 spectrum. The *cal-image* region is illuminated by a white light source that collapses the Fabry – Perot fringe quadrant imaged by the 90 degree CLIO mirror CLIO mirror into striped lines. The striping is due to the bundling of the optical fibre cable.

4. Data Products

Table 12 - Summary list of the TIMED instruments

Inst. Name	Parameters Measured [Baseline performance]	Instrument Type	Instrument Status
GUVI	Spectral irradiance in the 115-180 nm range; 5 color bands in imaging, 176 wavelengths in spectrograph	Far-ultraviolet imaging spectrograph	Only spectrograph data produced after 10 Dec 2007.
SABER	Radiance profiles Profiles of kinetic temperature, pressure, density Profiles of emission rates of NO, OH, O_2	Multichannel infrared radiometer	OK
SEE	Solar irradiance	Spectrometer, Photometers	OK

TIDI	Line-of-sight quantities Retrieved profiles Vector wind profiles	Fabry-Perot Interferometer	OK

Data Content Classes are used to refer to the type of data contained in a TIMED product. Data levels are adapted from the EOS Handbook (see relevant documents, #3). The data levels are supplemented with additional product content classes for products that are not easily classified by the data level scheme.

Table 13 - TIMED Data Level Definitions

Data Level	Data Format	Brief Description	Source
Raw Telemetry	CCSDS Supplemented Transfer Frames	Raw data stored in time order of ground receipt and indexed by spacecraft-generation time. Data is retrievable by packet APID.	MOC
Level 0	CCSDS Packets	Unprocessed instrument data at full resolution that has been separated by instrument or subsystem	MDC
Level 1a	netCDF	Unprocessed instrument data at full resolution, time-referenced and annotated with ancillary information including geometric parameters as well as information necessary for conversion of the data into radiometric units	POC
Level 1b	netCDF	Level 1a data that have been processed to radiometric units (e.g. photons/furlong2/fortnight)	POC
Level 2	netCDF	Derived geophysical variables at the resolution of retrieval	POC
Level 3	netCDF	Variables mapped on a uniform, earth referenced, space-time grid	POC
Level 4	netCDF	Model output or results from analyses of lower level data (e.g., variables derived from multiple measurements)	POC
Status	netCDF	Data products that contain information about the TIMED spacecraft or data products	MDC

4.1 TIMED MDC Data Products

4.1.1 TIMED MDC Data Products Functional Description

Table 14 - Summary of TIMED MDC Data Products, mapped by data level

Data Level	Data Format	Brief Description
Level 0	CCSDS	Spacecraft and instrument packet data
Level 2	netCDF	Ephemeris, velocity, attitude and time (PVAT) data

4.2 GUVI Science Data Products

4.2.1 GUVI Data Products Functional Description

GUVI data is primarily in netCDF format, one of the recommended formats of the Heliophysics Science Data Management Policy (Version 1.2, 2016).

Data Level Definitions

Table 15 - GUVI Data Level Definitions

Data Level	Data Format	Brief Description	Source
Level 0	CCSDS data packets	Time-ordered raw data, with communication artifacts removed	TIMED MDC
Level 1	netCDF4	1A: Packet data converted to Netcdf 1B: Calibrated radiances; geolocated pixels 1C: Data binned and gridded	GUVI POC
Level 2	netCDF4, IDL saveset	Orbit by orbit environmental parameter retrievals	GUVI POC
Level 3	PDF, PNG, GIF	Daily summaries,	GUVI POC

Table 16 - Summary of GUVI Data Products, mapped by data level

Data Level	Data Format	Brief Description
Level 0	CCSDS	instrument packet file data
Level 1A – spectrograph	netCDF	Raw detector count data
Level 1B – disk & limb	netCDF	5 color calibrated and geolocated UV radiance image data.
Level 1B – spectrograph	netCDF	Single pointed full wavelength calibrated and geolocated
Level 1C – disk, limb spectrograph	netCDF	5 color radiance data binned onto a uniform grid
Level2B – limb NDP	IDL saveset	Neutral density data derived from limb data
Level2B – limb EDP	netCDF and IDL saveset	Electron density profiles derived from limb data
Level 2B Auroral	netCDF	Electron energy flux (Q), Electron mean energy (E_0), auroral poleward and equatorial boundaries, electron densities
Level 3 – O/N_2	netCDF and IDL saveset	Daily O/N_2 ratios
Survey Images L1B imaging data	PNG	All GUVI limb images for one day on a single plot one plot; all GUVI disk
Survey Images L1C disk data by orbit	PNG	GUVI L1C data plotted for single orbits.

Survey Images L1C Auroral disk data by orbit	PNG	GUVI L1C polar region images for a single orbit
Nightside Cylindrical Composite Disk Images	PNG	GUVI Level 1C nightside multicolor disk image for a complete day
Strip Disk Composite Images	PNG	GUVI Level 1C dayside multicolor disk image for a complete day
Strip Limb Composite Images	PNG	GUVI Level 1C dayside and nightside multicolor limb image for a complete day
Survey Images level 3 Auroral	PNG, postscript	Orbit by orbit plots of Q and E_0
Survey Images Level 3 Thermospheric	GIF, postscript	Global plots of O/N_2
Survey Images Level 3 O/N_2 and CODE-TEC	GIF, postscript	Global plots of O/N_2 compared with CODE-TEC
Survey Images Level 3 EDP	PDF, postscript	Global plots of daily Electron Density Profile data (HmF2, NmF2, TEC)

Table 17 - Summary of GUVI Metadata Products

Data Product	Brief Description	Source	Host
Housekeeping Data	ASCII Text Data files produced daily that show all instrument and relevant spacecraft housekeeping data	GUVI POC	GUVI website

4.2.2 GUVI Science Data Distribution

Table 18 - Summary of GUVI data products

Level	Components	Time Resolution	Time Span	Processing Cadence	Daily Volume (GB)	Public release of day N data	Date Modified

L1B imaging	L1A L1B disk and limb Expanded L1B (SL1B) L1C disk L1C-2-Disk, L1C Limb	0.1 sec L1A, L1B	1 orbit (~100 min.)	1/day	0.045 L1A 1.2 L1B 1.1 SL1B 0.5 L1C	day N+3	[v13 release]
L1B spectrograph	L1A L1B Expanded L1B (SL1B) L1C, L1C-2	3 sec L1A, L1B	1 orbit (~100 min.)	1/day	0.04 L1A 0.25 L1B 0.03 SSL1b 0.015 L1C	day N+3	[updated v13 release]
L2	Electron Density profiles Neutral density profiles Auroral parameters	1 orbit (~100 minutes)	1 orbit (~100 min.)	1/day	0.026 (imaging only)	day N+3	[updated v13 release]
L3	Daily summary map images O/N2 maps Auroral summaries Electron densities	1 orbit (~100 minutes)	1 day	1/day	0.04	day N+3	[baseline]

4.3 SABER Science Data Products

SABER science data products fall into two categories: calibrated radiances profiles (level 1 products, Table 19), and retrieved geophysical products (level 2 products, Table 20. The Level 1 geo-located radiance profiles are calculated for each of the 10 broadband channels from the raw Level0 data and telemetry data. The Level2 retrieved parameters are calculated from the Level1 radiance profiles and ancillary data using radiative transfer and photochemical models.

Table 19 - SABER L1 Primary Products

Product	Altitudes	Source Measurement
Channel 1 Radiance ($w/m^2/sr$)	<0 to ~350 km	15 µm CO_2 narrow band
Channel 2 Radiance ($w/m^2/sr$)	<0 to ~350 km	15 µm CO_2 wide band
Channel 3 Radiance ($w/m^2/sr$)	<0 to ~350 km	15 µm CO_2 wide band

Channel 4 Radiance (w/m^2/sr)	<0 to ~350 km	9.6 µm O_3 band
Channel 5 Radiance (w/m^2/sr)	<0 to ~350 km	6.8 µm H_2O band
Channel 6 Radiance (w/m^2/sr)	<0 to ~350 km	5.3 µm NO band
Channel 7 Radiance (w/m^2/sr)	<0 to ~350 km	4.3 µm CO_2 band
Channel 8 Radiance (w/m^2/sr)	<0 to ~350 km	2.0 µm OH band
Channel 9 Radiance (w/m^2/sr)	<0 to ~350 km	1.6 µm OH band
Channel 10 Radiance (w/m^2/sr)	<0 to ~350 km	1.27 µm O_2 band

Table 20 - SABER L2 primary products

Product	Altitudes	Source
Temperature (K)	~15 to ~110 km	Channels 1 and 3
Pressure (mb)	~15 to ~110 km	Channels 1 and 3
Density (/cm^3)	~15 to ~110 km	Channels 1 and 3
O_3 VMR (from 9.6 µm)	~15 to ~110 km	Channel 4
O_3 VMR (from 1.27 µm)	~40 to ~110 km	Channel 10
H_2O VMR	~15 to ~100 km	Channel 5
CO_2 VMR	~65 to ~110 km	Channel 7
O VMR	~40 to ~100 km	Channels 4, 8, 9 and 10
H VMR	~40 to ~100 km	Channels 4, 8, 9, and 10
NO 5.3 µm VER (ergs/cm^3/s)	~40 to ~280 km	Channel 6
OH 2.0 µm VER (ergs/cm^3/s)	~40 to ~150 km	Channel 8
OH 1.6 µm VER (ergs/cm^3/s)	~40 to ~150 km	Channel 9
O2 1.27 µm VER (ergs/cm^3/s)	~40 to ~150 km	Channel 10
CO_2 cooling rates (K/day)	~15 to ~110 km	Channel 1
H_2O cooling rates (K/day)	~15 to ~100 km	Channel 5
O_3 cooling rates (K/day)	~15 to ~110 km	Channel 4
O_3 solar heating rates (K/day)	~15 to ~110 km	Hartley, Huggins, Chappius
O_2 solar heating rates (K/day)	~15 to ~110 km	Lyman-alpha, Herzberg, Schumann-Runge, atmospheric bands
Chemical heating rates (K/day)	~40 to ~100 km	$H+O_2+M$, $H+O_3$, $O+O_3$, O+OH, $O+HO_2$, $O+O+M$, $O+O_2+M$

4.3.1 Data Products Functional Description

SABER data products are produced for 3 levels, L0, L1, and L2. L2 is available in several subsets, L2A, L2B, and L2C, as described in Table 4.3-3. In addition to these data, other products (not described in the table) are available (from saber.gats-inc.com) such as updates to atomic oxygen (Panka, P.A., et al., "Atomic oxygen retrieved from the SABER 2.0 and 1.6 um radiances using new first principles nighttime OH(v) model", Geophysical Research Letters, 45, 5798-5803, https://doi.org/10.1029/2018GL077677) and monthly files containing subsets of the retrieved parameters.

Table 21 - SABER Data Level Definitions

Data Level	Data Format	Brief Description	Source
L0	Raw CCSDS data	Time-ordered raw data, with communication artifacts	POC

	packets, real-time Level 0 files and SSR binary files.	removed	
L1	netCDF	The measurements processed to account for instrument artifacts and calibrations, producing orbit files of calibrated radiance profiles for each channel and event – see Table 19.	SPOC
L2	netCDF	The science data processed from the L1 radiance data and radiative transfer and photochemical models, producing the data described in Table 20.	SPOC
L2A	netCDF	A subset of the L2 data that contains only the directly retrieved geophysical parameters such as trace gas VMR and the volume emission rates (VMR) shown in Table 20.	SPOC
L2B	netCDF	A subset of the L2 data that contains derived products such as the cooling and heating rates shown in Table 20.	SPOC
L2C	netCDF	A special product containing retrieved CO_2, produced using a new 2-channel algorithm.	SPOC

4.3.2 SABER Science Data Distribution

SABER science data is available through the SABER Science Data Center (SDC, online at saber.gats-inc.com). The SDC processes the SABER data from level 0 through the retrieval of the baseline science products (L2). All products are validated by the SABER team, archived, and disseminated to the community via the SABER webpage (saber.gats-inc.com). The processing keeps up with the stream of new observations, and we will reprocess all data when a new algorithm version comes online. The current SOFIE data version (2.0) and the prior version (1.07) are available on the SABER webpage. The L1 and L2 data lags by approximately 3-5 days due to lag in precise orbital data and availability of required ancillary data (NCEP data, solar flux data, etc.).

4.4 SEE Science Data Products

4.4.1 SEE Data Products Functional Description

The SEE science data processing system retrieves all SEE packets, selected spacecraft packets, selected ancillary MDC products, and exchanges various planning products to support operations and routine science processing functions. The data processing produces science products to meet several different needs. The primary science product that meets all requirements is the Level 3 daily average. This product and others are repackaged into a mission-merged file for user convenience.

The SEE instrument packets and necessary science packets that are retrieved from the MDC are defined as level 0a. These are decomposed and merged with selected spacecraft ancillary files (PVAT, etc) to create level 0b.

The level 0b files are decomposed packet data that are merged into integrations, time annotated, converted to engineering units, and separated by packet type and instrument. Level 0b data retains has the science potential. There are 3 level 0b products, EGS, XPS, and HK. Common SEE instrument housekeeping data are separated into another level 0b product. The level 0b products are not publicly available since they are difficult to interpret.

Sub-daily averaged products contain the letter "a" in the level.

All TIMED-SEE data product files span one UT day unless otherwise indicated.

Table 22 - SEE Data Level Definitions

Data Level	Data Format	Brief Description	Source
Level 0a	Binary CCSDS telemetry packets	Time-ordered raw SEE packet data with spacecraft APID 4 and 7, with communication artifacts removed	POC
Level 0b eng	Binary IDL saveset format	Decomposed telemetry packet data for EGS, HK, XPS, spacecraft APID 4 and 7.	POC
Level 0b EGS	netCDF	Low level counts assembled into integrations (foreground spectra, background spectra), time tagged with ancillary data in engineering units (degrees, volts, currents, etc)	POC
Level 0b EGS image	netCDF	Low level counts in full EGS 2d array data from calibration data including flatfield, dark, and solar data. Usually one or less image is created each day.	POC
Level 0b EGS occult	netCDF	Low level counts assembled into integrations (foreground spectra, background spectra) from special occultation observations. Same as level0b EGS but for occultation observations.	POC
Level 0b XPS	netCDF	Low level counts separated by diode, time tagged with ancillary data converted to engineering units (degrees, volts, currents, etc)	POC
Level 0b Dark	netCDF	Time tagged count rates for the EGS and XPS detectors every 15 seconds, except during solar observation times. Includes latitude and longitude for tracking SAA and polar zone features.	POC
Level 1 EGS	netCDF	EGS 10-second cadence irradiance spectra and uncertainties, corrected for dark, gain, wavelength motion, bandpass, linearity, flatfield, scattered light, field of view, and responsivity.	POC
Level 1 EGS occult	netCDF	EGS 10-second cadence irradiance spectra during occultations. Analogous to level 1 EGS observations, but measuring the solar spectrum through earths atmosphere.	POC
Level 1 XPS	netCDF	XPS 10-second diode iradiance and uncertainties plus XUV currents, corrected for dark current, visible light current, gain, field of view, responsivity, and degradation.	POC

Level 2 EGS	netCDF	Daily averaged EGS spectra integrated to a common wavelength scale, corrected for long-term degradation effects, with calibration slit spectra applied to the normal slit spectra at full resolution 0.1 nm sampling and at 1-AU. A mission-duration merged file is also available.	POC
Level 2 EGS Cal	netCDF	Daily averaged EGS low duty cycle calibration slit spectra at full resolution and at 1-AU. A mission-duration merged file is also available.	POC
Level 2 XPS	netCDF	Daily averaged XPS irradiances at 1-AU. A mission-duration merged file is also available.	POC
Level 2a EGS	netCDF	Observation (3-minute) averages of fully calibrated and degradation corrected EGS normal solar spectral irradiances at full resolution at 1-AU.	POC
Level 2a EGS Cal	netCDF	Observation (3-minute) averages of fully calibrated and degradation corrected EGS calibration slit solar spectral irradiances at 1-AU.	POC
Level 2a EGS other	netCDF	Observation (3-minute) averages of special experiments including FOV scans, non-EGS SAS tracking, and other non-nominal observation at 1-AU.	POC
Level 2a XPS	netCDF	Observation (3-minute) averages of normal XPS broadband solar irradiances at 1-AU.	POC
Level 2a XPS other	netCDF	Observation (3-minute) averages of off-nominal XPS broadband solar irradiances at 1-AU.	POC
Level 2b EGS occult	netCDF	Observation (3-minute) averages of EGS relative atmospheric transmissions from in daily files at 0.1 nm sampling. A mission-duration merged file is also available.	POC
Level 3	netCDF	Daily averaged fully calibrated solar spectral irradiance combining the EGS spectra and the level 4 model spectra from 0.5-190 nm at 1 nm sampling. A mission-duration merged file is also available.	POC
Level 3a	netCDF	Observation (3-minute) averages of EGS solar spectral irradiance combining the EGS spectra and the level 4a model spectra spanning 0.5-189.5 nm. A mission-duration merged file is also available.	POC
Level 4	netCDF	Model spectrum at 0.1 nm sampling from 0.05-40 nm based on 10-second XPS level 2 diode measurements, temperature from the GOES XRS ratio, and CHIANTI spectra provided in daily files. A mission-duration XPS Level 4 merged file of daily averages of the 10 second data is provided as well.	POC
Level 4a	netCDF	Observation averaged model spectrum from 0.05-40 nm at 0.1 nm sampling that matches the XPS Level 2a times, merged to include data from the whole mission.	POC

Table 23 - Summary of SEE Data Products, mapped by data level

Data Level	EGS	XPS
L0a	Raw CCSDS data packets, time-ordered with communication artifacts removed	Raw CCSDS data packets, time-ordered with communication artifacts removed
L0b eng	Decomposed telemetry packet data for EGS, HK, XPS, spacecraft APID 4 and 7.	Decomposed telemetry packet data for EGS, HK, XPS, spacecraft APID 4 and 7.
L0b EGS, EGS image, EGS occult	Assembled spectra and images separated into integrations, time tagged, with relevant ancillary data in engineering units.	
L0b XPS		Data separated into integration for each channel, time tagged, with relevant ancillary data in engineering units.
L0b Dark	Time tagged total count rates for the EGS every 15 seconds, between solar observations.	Time tagged count rates from XPS detectors every 15 seconds, between solar observations.
L1 EGS, L1 EGS Occult	EGS 10-second cadence irradiance spectra and uncertainties, corrected for dark, gain, wavelength motion, bandpass, linearity, flatfield, scattered light, field of view, and responsivity. Occultation data is similar measuring the solar spectrum through earth's atmosphere.	
L1 XPS		XPS 10-second diode iradiance and uncertainties plus XUV currents, corrected for dark current, visible light current, gain, field of view, responsivity, and degradation.
L2 EGS	Daily averaged EGS spectra integrated to a common wavelength scale, corrected for long-term degradation effects, with calibration slit spectra applied to the normal slit spectra at full resolution 0.1 nm sampling and at 1-AU.	
L2 XPS		Daily averaged XPS irradiances at 1-AU.
L2a EGS, L2a EGS cal, L2a EGS other	Observation (3-minute) averages of fully calibrated and degradation corrected EGS normal solar spectral irradiances at full resolution at 1-AU.	
L2a XPS, L2a XPS other		Observation (3-minute) averages of normal XPS broadband solar irradiances at 1-AU.
L2b EGS	Observation (3-minute) averages of EGS relative atmospheric transmissions from in daily files at 0.1 nm sampling.	
L3	Daily averaged fully calibrated solar	Daily averaged Level 4 irradiance model

	spectral irradiance from the EGS spans 27-190 nm at 1 nm sampling.	based on XPS measurements spans 0.5-27 nm at 1 nm sampling.
L3a	Observation (3-minute) averaged fully calibrated solar spectral irradiance from EGS spanning 27-190 nm at 1 nm sampling.	Observation (3-minute) averaged Level 4 irradiance model based on XPS measurements spans 0.5-27 nm at 1 nm sampling.
L4		Model spectrum at 0.1 nm sampling from 0.05-40 nm based on 10-second XPS level 2 diode measurements, temperature from the GOES XRS ratio, and CHIANTI spectra provided in daily files.

4.4.2 SEE Science Data Distribution

Table 24 - Summary of SEE Data Products

Level	Components	Time Resolution	Time Span	Processing Cadence	Daily Volume (MB)	Public release of day N data	Date Modified
L2 EGS	EGS	1 day	1 day	Daily after L1	0.102	Hour 4-5 on day N+2	Sept 2002 [Baseline], Oct 2017 Version 12 release
L2 XPS	XPS	1 day	1 day	Daily after L1	0.00393	Hour 4-5 on day N+2	May 2002 [Baseline] Sept 2002 updated for filter wheel anomaly, Oct 2017 Version 12 release
L2a EGS	EGS	3 minutes once per orbit	1 day	Daily after L1	0.663	Hour 4-5 on day N+2	July 2004 first release as new product, Oct 2017 Version 12 release

L2a XPS	XPS	3 minutes once per orbit	1 day	Daily after L1	0.00658	Hour 4-5 on day N+2	July 2004 first release as new product, Oct 2017 Version 12 release
L2b EGS occult	EGS	3 minutes once per orbit	1 day	As needed	Varies up to 1.018	-	Oct 2007 [Baseline], Oct 2012 Version 11 updated with final occultation observations
L3	EGS, XPS	1 day	1 day	Daily after L4	0.0189	Hour 4-5 on day N+2	Mar 2003 [Baseline], Oct 2017 Version 12 release
L3a	EGS, XPS	3 minutes once per orbit	1 day	Daily after L4	0.186	Hour 4-5 on day N+2	July 2004 first release as new product, Oct 2017 Version 12 release
L4	XPS	10 seconds	1 day	Daily after L2	0.424	Hour 4-5 on day N+2	Apr 2007 first release as new product, Oct 2017 Version 12 release
L4 merged	XPS	24 hours	Full mission 2002-present	Daily after L2	10.9 (mission to date)	Hour 4-5 on day N+2	Apr 2007 first release as new product, Oct 2017 Version 12 release

L4a merged	XPS	3 minutes once per orbit		Daily after L2	158. (mission to date)	Hour 4-5 on day N+2	Apr 2007 first release as new product, Oct 2017 Version 12 release
Merged L2b occultations	EGS	3 minutes once per orbit	9 years from 2002-2011	As needed	34. (mission total)	-	Oct 2007 [Baseline], Oct 2012 Version 11 updated with final occultation observations
L3 merged	EGS, XPS	24 hours	Full mission 2002-present	Daily after L4	19.5 (mission to date)	Hour 0-1 on day N+2	Mar 2003 [Baseline], Oct 2017 Version 12 release
L3a merged	EGS, XPS	3 minutes each orbit	Full mission 2002-present	Daily after L4	255. (mission to date)	Hour 0-1 on day N+2	July 2004 first release as new product, Oct 2017 Version 12 release

The total data volume for TIMED-SEE easily fits within a single disk on most modern computers. Including all calibration data, analysis data, and a duplicate testing version of all the data products the disk usage is less than 700 GB for the entire mission so far. Over 3 TB of disk space remain available.

The TIMED-SEE public data products use approximately 14 GB of disk space on the web server. The daily-only products grow about 1.4 MB/day.

The internal data is located on a mirrored disk array for routine storage to provide minimal single fault tolerance. Data and all code is rsynced weekly to another disk on site to support rapid recovery if needed. Additional off-site storage of public products is supported by SPDF, off-site telemetry storage is provided by the MDC, and software is configuration managed and mirrored to an on-site system.

Data accessibility and interactivity is supported through the LASP Solar Irradiance Data Center (LISIRD) at https://lasp.colorado.edu/lisird/data and searching for “TIMED SEE”. The SPDF provides a final archive location.

4.5 TIDI Science Data Products

4.5.1 TIDI Data Products Functional Description

Table 25 - TIDI Data Level Definitions

Data Level	Data Format	Brief Description	Source
Level 0	TM packets	Packets include 1) science data, 2) engineering housekeeping data, 3) status message packets	POC
Level 1	netCDF	Results of the line-of-sight data retrieval program: 1) time/tangent point/spacecraft information, 2) scan filter/telescope/component temperature data, 3) processing status and line-of-sight brightness and wind, 4) raw detector output and observed spectra	SPOC
Level 2	netCDF	Results of the profile inversion program: 1) file global and control attributes, 2) retrieval altitude grid and profile record content data, 3) inverted line-of-sight volume emission rate and wind altitude profiles	SPOC
Level 3	netCDF	Results of the wind vector construction program mapped onto an evenly spaced track angle grid: 1) file global attributes, 2) the retrieval altitude grid, 3) vector wind and volume emission rate profiles smoothed along the track, 4) ancillary data	SPOC

Table 26 - Summary of TIDI Data Products, mapped by data level

Data Level	TIDI
L0	Raw TM data packets written with the TIDI TM Packet Format
L1	Observed spectra; line-of-sight brightness; line-of-sight wind
L2	Inverted line-of-sight volume emission rate; inverted line-of sight wind
L3	Volume emission rate profiles; vector wind profiles

4.5.2 TIDI Science Data Distribution

Table 27 - Summary of TIDI Data Products

Level	Components	Time Resolution	Time Span	Processing Cadence	Daily Volume (MB)	Public release of day N data	Date Modified
L1	Spectra, brightness, winds	1-4 sec	24 hour	After L0	160	day N+3	

L2	Ver, winds	~100 sec	1 day	1/day	1	day N+3	
L3	Ver, winds	~100 sec	1 day	1/day	0.5	day N+3	

4.6 Converted TIMED Instrument Science Data Products

4.6.1 Converted TIMED Instrument Science Data Products Functional Description

TIMED instrument science data products are downloaded to the SPDF. These data products, primarily in netCDF format, are converted to CDF format and archived. They also may serve as input to CDAWeb services (data plotting, listing, etc.) for the science community.

Table 28 - Summary of Converted TIMED Instrument Science Data Products, mapped by data level

Data Level	Instrument	Data Format	Name	Brief Description
L1B	SABER	CDF	TIMED_L1BV20_SABER	IR Radiances in 10 channels (1.27 to 17ym) from 0 to 150 km
L1C	GUVI	CDF	TIMED_L1CDISK_GUVI	Airglow fluxes at 5 wavelengths bands
L1C	GUVI	CDF, GIF	TIMED_L1CDISK_GUVI_<wavelength>_MERC_MOVIES	Airglow flux 14 day movies in Mercator Projection, at wavelengths: 1216A, 1394A, 1356A, LBH1, LBH2
L1C	GUVI	CDF, GIF	TIMED_L1CDISK_GUVI_<wavelength>_NP_MOVIES	Airglow flux 14 day movies in North Polar Projection, at wavelengths: 1216A, 1394A, 1356A, LBH1, LBH2
L1C	GUVI	CDF, GIF	TIMED_L1CDISK_GUVI_<wavelength>_SP_MOVIES	Airglow flux 14 day movies in South Polar Projection, at wavelengths: 1216A, 1394A, 1356A, LBH1, LBH2
L2A	SABER	CDF	TIMED_L2AV207_SABER	O3, CO2, H2O Mixing Ratios and O, O2, OH, NO Volume Emission Rates, also NMC Neutral Temp., Density, and Pressure
L2B	GUVI	CDF	TIMED_EDP_GUVI	Electron Density Profiles
L3	TIDI	CDF	TIMED_WIND VECTORS NCAR_TIDI	Zonal and meridional winds at 60 to 180 km
L3A	SEE	CDF	TIMED_L3A_SEE	Solar irradiances 0.1 - 194 nm

5. Ground System

5.1 Ground System Architecture

The primary elements of the TIMED mission ground system are the ground stations, the TIMED Mission Operations Center (MOC), the TIMED Mission Data Center (MDC), and four TIMED instrument Payload Operations Centers.

5.2 Ground Stations

5.2.1 *Satellite Communication Facility*

The Satellite Communication Facility (SCF) is the primary ground station for TIMED flight operations. Located on the JHU/APL campus, the SCF employs a 60-ft antenna to operate at a 4-mbps downlink data rate and, in case of a spacecraft emergency, at a lower 10-kbps rate. Between two and four contacts are made daily with the spacecraft. All contacts outside business hours are unattended, lights-out operation.

5.2.2 *Universal Space Network*

The Universal Space Network (USN) provides emergency and supplemental ground station services as needed. USN was extensively used during the launch and early operations phase of the mission.

5.2.3 *Tracking and Data Relay Satellite System*

The Tracking and Data Relay Satellite System (TDRSS) network of communications satellites and ground stations is used during roughly bi-monthly TIMED yaw maneuvers.

5.3 Mission Operations Center

The Mission Operations Center is responsible for the operation and control of the TIMED spacecraft and monitoring spacecraft health and status. The MOC is to plan and execute effective mission operations in accordance with the science objectives of the TIMED program; command the spacecraft from launch to end of mission; collect, process and transmit instrument commands from the TIMED instrument Payload Operations Centers to the instruments; collect all raw telemetry; process all spacecraft health and status telemetry data and maintain the spacecraft; assess spacecraft performance and adapt operations to changes; and maintain spacecraft command and telemetry dictionaries during flight phase.

5.4 Mission Data Center

The Mission Data Center is the central facility responsible for telemetry retention and distribution, production of mission position and attitude determination and other ancillary data, and maintaining mission web services. The MDC is to archive and serve all raw telemetry; serve all data products necessary to support the TIMED mission; provide timely data distribution among TIMED program elements; provide scientifically useful products derived from the TIMED measurements to the scientific community in a timely manner; provide for the long-term utility and archiving of data products generated by the TIMED program in cooperation with the Space Physics Data Facility.

5.5 Payload Operation Centers

Each TIMED instrument – GUVI, SABER, SEE and TIDI – maintains a Payload Operation Center (POC) which is responsible for the operation and control of the instrument; monitoring and assessment of instrument health and status; and the routine production, reduction, archiving and distribution of instrument data products.

6. Data Flow

6.1 Overview of End-to-End Data Flow

6.1.1 Data Flow to Spacecraft

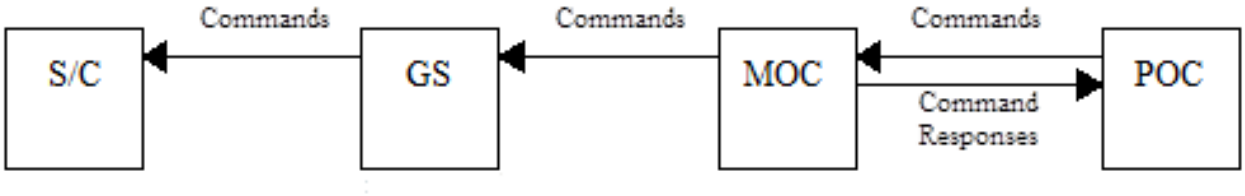


Figure 12 - TIMED Command Delivery

Figure 12 depicts a high level overview of the command flow through the TIMED system. The Payload Operation Centers (POCs) issue instrument command messages to the Mission Operations Center (MOC). The MOC forward validated spacecraft and instrument commands to the Ground Station (GS) for telemetering to the spacecraft. TIMED instruments operate independently of each other on a noninterference basis, so coordination of command is not necessary. The MOC also returns command responses to the POCs indicating command delivery status as it can be determined. The POCs and MOC are synchronized to Universal Time (UT). The POCs use Internet access to connect to the MOC with priority delivery of USB flash drives as an emergency alternative.

The spacecraft records on the solid-state recorder (SSR) housekeeping information indicating successful or failed command delivery to instruments and subsystems as well as pertinent engineering, position, and attitude data. The instruments that receive their commands transmit data to the spacecraft indicating successful or failed command delivery and execution as well as instrument science data. The spacecraft records this instrument housekeeping and science data, as well as any telemetry data being issued to the spacecraft from any of its subsystems, on the SSR for relay to the ground during a scheduled contact with the Ground Station.

6.1.2 Data Flow from Spacecraft

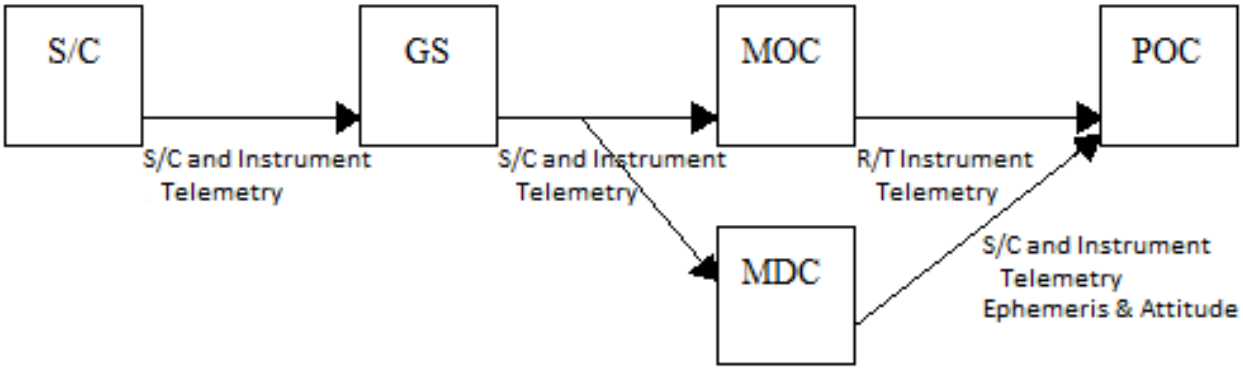


Figure 13 - TIMED Telemetry Delivery

During a scheduled contact with the Ground Station, the spacecraft relays the contents of the SSR (Playback Telemetry) to the ground as well as any telemetry data currently being issued to the spacecraft from any of its subsystems and any of the instruments (Real-time Telemetry). The Ground Station forwards downlinked telemetry to both the MOC and the Mission Data Center (MDC). The MOC uses the spacecraft telemetry to monitor spacecraft health and command delivery status. The MDC archives the telemetry for playback to the instrument POCs. The MDC computes S/C ephemeris and attitude from the telemetry and stores this data in Position, Attitude, Velocity and Time (PVAT) files. The POCs receive real-time instrument telemetry and retrieve playback instrument telemetry of interest from the MDC, via TCP/IP socket streams, for instrument health monitoring and data processing, completing the circle of command and telemetry flow in the TIMED system. The MOC is able to server the real-time telemetry stream to the POCS as a backup to the MDC.

6.2 Data Handling and Timeline

Table 29 - Summary of spacecraft data flow and the transfer method

Flow	Data Product	Timeline	Transfer Method
SCF to MOC	S-band data Real-time spacecraft and instrument TLM Playback spacecraft and instrument TLM	Approximately 10 minutes of downlink Real-time TLM: ~10 minutes Playback TLM: 20 to 26 hours of playback telemetry	TCP/IP via JHU/APL Wide Area Network
SCF to MDC	S-band data Real-time spacecraft and instrument TLM Playback spacecraft and instrument TLM	Approximately 10 minutes of downlink Real-time TLM: ~10 minutes Playback TLM: 20 to 26 hours of playback telemetry	TCP/IP FTP via Wide Area Network

MDC to POC	S-band data Real-time spacecraft and instrument TLM Playback spacecraft and instrument TLM	Approximately 10 minutes of downlink Real-time TLM: ~10 minutes Playback TLM: 20 to 26 hours of playback telemetry	TCP/IP via Internet

Level 0 S/C and Instrument Telemetry will be available in the MDC to the POCs 30 hours after its acquisition on orbit. An initial version of MDC and POC routine Level 1 and higher data products should be available to users within 54 hours.

7. Archiving and Data Access

Table 30 summarizes data volumes of the data sets archived at TIMED facilities.

Table 30 - Summary of data volumes of data sets archived at TIMED facilities

Prime Mission and Extended Missions – Launch + 45 days (Jan 22, 2002) to present				
Instrument/Data Set	**Annual (Uncompressed)**	**18-Year Total (Uncompressed)**	**Annual (Compressed)**	**18-Year Total (Compressed)**
SABER				
Level 0 Data	37 GB	0.7 TB		
Level 1 Data	89 GB	1.6 TB	72 GB	1.3 TB
Level 2 Data	80 GB	1.4 TB	42 GB	0.7 TB
SABER Total	206 GB	3.7 TB	114 GB	2.0 TB
SEE				
Level 0a Data	11 GB	200 GB	4.5 GB	83 GB
Level 1 Data	7.0 GB	127 GB	5.5 GB	100 GB
Level 2 Data	235 MB	4.2 GB	208 MB	3.7 GB
Level 3 Data	71 MB	1.3 GB	18 MB	0.3 GB
Level 4 Data	144 MB	2.5 GB	116 MB	2.18 GB
Space Weather Products	0.8 MB	15 MB	0.2 MB	3.7 MB
SEE Total	18.4 GB	335 GB	10.3 GB	189 GB
TIDI				
Level 0 Data	8.4 GB	0.15 TB		
Level 1 LOS Data	62.3 GB	1.10 TB	30 GB	549 GB
Level 2 Profile Data	0.4 GB	0.01 TB	0.2 GB	3.8 GB
Level 3 Vector Data	0.3 GB	0.01 TB	0.1 GB	2.0 GB
TIDI Total	72 GB	1.3 TB	30 GB	555 GB
TIMED MDC				
Level 0 Telemetry	324 GB	5.7 TB	105 GB	1.86 TB
Level 1 Ephemeris	7.7 GB	140 GB	6.1 GB	110 GB
TIMED MDC Total	332 GB	5.8 TB	111 GB	2.0 TB
	Launch + 45 days through Dec 2007		**Dec 2007 to present**	

Instrument/Data Set	Annual (Compressed*)	7-Year Total (Compressed*)	Annual (Compressed*)	11-Year Total (Compressed*)
GUVI				
Level 1 Data	394 GB	2.6 TB	109 GB	1.3 TB
Level 2 Data	16.7 GB	115 GB		
Level 3 Data	103 MB	0.7 GB	163 MB	2.0 TB
GUVI Total	411 GB	2.7 TB	109 GB	3.3 TB

* GUVI netCDF-4 files employ internal data compression

The TIMED data in *Table 30*, which is primarily in netCDF format, are mirrored in the SPDF archive. *Table 31* summarizes data volumes of these data sets archived at the SPDF.

Table 31 - Summary of data volumes of data sets archived at SPDF

Prime Mission and Extended Missions – Launch + 45 days (Jan 22, 2002) to present		
	Annual (Compressed)	**18-Year Total (Compressed)**
SABER		
Level 1 Data	72 GB	1.3 TB
Level 2 Data	42 GB	0.7 TB
SABER Total	114 GB	2.0 TB
SEE		
Level 0a Data	11 GB	83 GB
Level 1 Data	7.0 GB	100 GB
Level 2 Data	235 MB	3.7 GB
Level 3 Data	71 MB	0.3 GB
Level 4 Data	144 MB	2.18 GB
Space Weather Products	0.8 MB	3.7 MB
SEE Total	18.4 GB	189 GB
TIDI		
Level 0 Data	8.4 GB	
Level 1 LOS Data	62.3 GB	549 GB
Level 2 Profile Data	0.4 GB	3.8 GB
Level 3 Vector Data	0.3 GB	2.0 GB
TIDI Total	72 GB	555 GB
TIMED Spacecraft		
Level 0 Telemetry	324 GB	1.86 TB
Level 1 Ephemeris	7.7 GB	110 GB
Spacecraft Total	332 GB	2.0 TB

	Launch + 45 days through Dec 2007		Dec 2007 to present	
Instrument/Data Set	**Annual (Compressed*)**	**7-Year Total (Compressed*)**	**Annual (Compressed*)**	**11-Year Total (Compressed*)**
GUVI				
Level 1 Data	394 GB	2.6 TB	109 GB	1.3 TB
Level 2 Data	16.7 GB	115 GB		
Level 3 Data	103 MB	0.7 GB	163 MB	2.0 TB
GUVI Total	411 GB	2.7 TB	109 GB	3.3 TB

* GUVI netCDF-4 files employ internal data compression

At the SPDF, additional TIMED data products are generated by converting them from netCDF format into CDF format and archived at the SPDF. These converted TIMED data products are summarized in *Table 32*.

Table 32 - Summary of data volumes of converted data sets archived at SPDF

Prime Mission and Extended Missions – Launch + 45 days (Jan 22, 2002) to present		
Instrument/Data Set	**Annual (Uncompressed)**	**18-Year Total (Uncompressed)**
SABER		
Level 1 CDF Data	57 GB	1.01 TB
Level 2 CDF Data	19 GB	0.35 TB
SABER Total	76 GB	1.36 TB
SEE		
Level 3 CDF Data	16.8 MB	307 MB
TIDI		
Level 3 CDF Data	0.3 GB	2.45 GB

	Launch + 45 days through Dec 2007	
Instrument/Data Set	**Annual (Uncompressed*)**	**7-Year Total (Uncompressed*)**
GUVI		
Level 2 Data	107 GB	647 GB
Level 2 Movies	33 GB	200 GB
Level 2 Data	2.5 GB	15 GB
Level 3 Data	16.6 MB	100 MB
GUVI Total	143 GB	862 GB

7.1 Current Archive Locations

During the operational mission, all TIMED data products are archived in the distributed repositories of the TIMED project teams – the MDC and four instrument POCs. Specifically, the MDC is the repository of all TIMED Level 0 telemetry and S/C position/velocity/attitude/time files (PVATs) with the responsibility to serve these data through TCP/IP protocols and protect these data from loss and corruption; each POC is the repository of its respective Level 0 and higher instrument data, as described in section 4, with the responsibility to serve all data files through TCP/IP protocols and protect these data from loss and corruption.

As the latest data is posted at the repositories of the TIMED project team, these data are sensed at the SPDF and downloaded early to the SPDF Final Archive, generally within 24 hours, for mirroring to the science community through TCP/IP protocols. TIMED data product files, primarily in netCDF format, are converted to CDF format and archived. They also serve as input to CDAWeb services (data plotting, listing, etc.) for the science community.

Table 33 lists the on-line, publicly accessible data archives of TIMED data products.

Table 33 - List of on-line, publicly accessible data archives of TIMED data products

Archive Locations		
Science Data Products	**Access**	**URL**
GUVI		
Levels 1A, 1B, 1C, 2B and 3	Webpage table with links to data-levels access, via a GUI browser, and http download of specific data files. Descriptions and data availability is provided.	http://guvitimed.jhuapl.edu/data_products
Levels 1A, 1B, 1C, 2B and 3	SPDF Final Archive	https://spdf.gsfc.nasa.gov/pub/data/timed/guvi/levels/ https://spdf.gsfc.nasa.gov/pub/data/timed/guvi/levels/level1c/disk_movies/
SABER		
Data Guidelines	Webpage of Information	http://saber.gats-inc.com/data_services.php
Overview of data	Webpage of Information	http://saber.gats-inc.com/data.php
Levels 1B, 2A and 2B	Webpage GUI to select data level and time and then ftp download specific data files	http://saber.gats-inc.com/browse_data.php
Levels 1B, 2A and 2B	SPDF Final Archive	https://spdf.gsfc.nasa.gov/pub/data/timed/saber/
SEE		
Levels 2, 2a, 2b 3, 3a, 4 and SpWx	Webpage table with links to data-levels access, via either a calendar GUI or annual data directories, and http download of specific data files.	http://lasp.colorado.edu/home/see/data/
Levels 2, 2a, 2b 3, 3a, 4 and SpWx	SPDF Final Archive	https://spdf.gsfc.nasa.gov/pub/data/timed/see/data/
TIDI		
Overview of data access	Webpage of information and links	http://tidi.engin.umich.edu/html/go?access_data/main_data_access.html&menu_home.html
Level 1 (LOS)	ftp access to annual data directories for each data level	ftp://tidi.engin.umich.edu/tidi/los/
Level 2 (Profile)		ftp://tidi.engin.umich.edu/tidi/profile/
Level 3 (Vector)		ftp://tidi.engin.umich.edu/tidi/vector/
Levels 1, 2 and 3	SPDF Final Archive	https://spdf.gsfc.nasa.gov/pub/data/timed/tidi/
TIMED		
Level 0 Telemetry Download Utility	Webpage GUI to download telemetry	http://www.timed.jhuapl.edu/WWW/mdc/DownloadTelemetry/mdc_DownloadTelemetry.pl

Level 0 Telemetry	SPDF Final Archive	https://spdf.gsfc.nasa.gov/pub/data/timed/mdc/archives/
Ephemeris, velocity, attitude and time files (PVAT)	http access to annual data directories of PVAT files (.pos)	http://www.timed.jhuapl.edu/WWW/mdc/data/OrbitFiles/
Ephemeris, velocity, attitude and time files (PVAT)	SPDF Final Archive	https://spdf.gsfc.nasa.gov/pub/data/timed/mdc/data/OrbitFiles/
Timeline Report files	http access to annual data directories of timeline report files (.rpt)	http://www.timed.jhuapl.edu/WWW/mdc/data/timeline/

The long-term archive of TIMED data, documentation and tools is the NASA Space Physics Data Facility (SPDF) at the Goddard Space Flight Center (GSFC). Through an on-going active system at the SPDF, all TIMED data products generated from launch to the present have been downloaded early and new files continue to be downloaded. Current volumes are described in Section 7.1. In preparing the Final Archive products at mission termination, a run of the final data reduction software on the underlying uncalibrated data may be required for deliver to the SPDF Final Archive.

7.2 Data Access and Processing Tools

7.2.1 GUVI

The GUVI POC supplies a variety of tools for data file reading and analysis. The tools described in this section are all publicly available through the GUVI website at http://guvitimed.jhuapl.edu/science_software.

A general IDL tool for reading netCDF files is supplied for reading any and all GUVI netCDF products (read_ncdf.pro). This will read any netCDF file and return the data in an IDL structure for easy access to all netCDF fields. In addition, a tool to interpolate PVAT data onto the GUVI time grid is available (guvi_pvat.pro**)**.

The GUVI website also provides an interface (http://guvitimed.jhuapl.edu/guvi-gallerydaily) to browse daily summary plots for disk and limb scan data, and also orbit by orbit level 1C disk images. These images have been made available to VITMO which also provides a means to rapidly browse of daily summary plots as well select science data by simply selecting the appropriate browse images.

7.2.2 SABER

The SABER POC supplies a variety of tools for data selection and download, display, reduction, listing on its website. The SABER Browse Data service provides download access to Levels 1 and 2 netCDF files at http://saber.gats-inc.com/browse_data.php along with browse images of seven different for reviewing the data. The SABER Custom Data Tool creates a reduced-sized Level 2 netCDF containing up to four parameters selected from a set of 28 parameters; the tool is available at http://saber.gats-inc.com/data.php. The SABER Coincidence Tool generates an ASCII text list of orbit number, event number, date, time, latitude, longitude and solar zenith angle for each orbit event at approximately the 90km tangent point; the tool is available at

http://saber.gats-inc.com/coin.php.

7.2.3 SEE

The SEE POC supplies a variety of tools for reading and plotting netCDF files. The tools are all publicly available through the SEE website at http://lasp.colorado.edu/home/see/data/.

7.2.4 TIDI

The TIDI website provides access to Quick-Look plots of five different views at http://tidi.engin.umich.edu/html/go?access_data/main_data_access.html&menu_home.html.

7.2.5 TIMED MDC

The TIMED SDS supplies support tools, shared software and support for the netCDF format. The tools described in this section are all publicly available through the TIMED website at http://www.timed.jhuapl.edu/WWW/index.php. The shared software and netCDF support are publicly available through the SDS website at http://www.timed.jhuapl.edu/WWW/scripts/mdc_sharedsw.pl and http://www.timed.jhuapl.edu/WWW/scripts/mdc_readers.pl, respectively.

Table 34 - TIMED MDC Support Tools

Tool Name	Description	Type	Availability from the TIMED MDC
Coincidence Calculator	Determine coincidences of observation of the TIMED instruments and ground-based observations from Mission TLE files	Pointing/Attitude	Yes, downloadable applet
Orbit Plotter	Provide spacecraft ground tracks from Mission TLE files	Orbit	Yes, downloadable applet
Telemetry Archive Download Utility	Provide output file of telemetry data	Telemetry	No, local TIMED website service
Telemetry Archive Map Utility	Provide lists of contiguous telemetry data	Telemetry	No, local TIMED website service

7.3 Documentation and Metadata

In addition to the documentation described in this Section 7.3, data product information and SPASE descriptions have been registered in the Heliophysics Data Portal and VSPO for the TIMED data products of Section 4.

7.3.1 GUVI

Documents describing each GUVI data product are available from the GUVI POC web page at http://guvitimed.jhuapl.edu/.

The following documentation is available:

- Separate documents for each data product can be found at the “Info” links on the GUVI Data Products page (http://guvitimed.jhuapl.edu/data_products)

- Data Product versions are clearly indicated in the GUVI filenames. Information about the differences between the data product versions and the software that produce them is also available from the GUVI website (http://guvitimed.jhuapl.edu/data_versions).
- A detailed description of the calibration procedures for both on-orbit and ground, the results of the calibrations, calibration tables, points of contact, and an on-orbit stellar calibration log are all available on the GUVI website at (http://guvitimed.jhuapl.edu/data_calibration).
- A GUVI publications bibliography is available at http://guvitimed.jhuapl.edu/pub_biblio and a presentations list at http://guvitimed.jhuapl.edu/pub_swg_guvi_pres

7.3.2 SABER

Documentation for the SABER data formats is available on the SABER website at http://saber.gats-inc.com/documentation.php.

The following documentation is available:

- Level 1B netCDF File Description
- Level 2, 2A, & 2B File Differences
- Level 2 netCDF File Description
- Level 2A netCDF File Description
- Level 2B netCDF File Description

7.3.3 SEE

The SEE POC provides an ASCII README file containing release notes for each major data product version on their data Products webpage at http://lasp.colorado.edu/home/see/data/. All SEE-specific data products are updated with the same major version number. The current version number is 12, and the release notes are available at http://lasp.colorado.edu/data/timed_see/SEE_v12_releasenotes.txt. All previous release notes are also available for download from the same directory. The SEE Documents webpage at http://lasp.colorado.edu/home/see/documents/ provides access to Instrument documents, Calibration/Validation documents, Annual Reports, and a Publications list.

7.3.4 TIDI

Documentation for TIDI data formats and data processing algorithms resides on the TIDI website at http://tidi.engin.umich.edu/html/go?/scripts/info/docs.pl&menu_home-new.html where a complete set of references can be found. Key papers dealing with the instrument, operations and algorithms are found on the TIDI website at http://tidi.engin.umich.edu/html/go?scripts/info/bib.pl&menu_docs.html.

7.3.5 TIMED MDC

The documentation for the TIMED mission is listed in *Table 35*.

Table 35 - TIMED Mission Documentation

Product Name	Description
7363-9046	GUVI Specific Instrument Interface Specification (SIIS)
7363-9047	SABER Specific Instrument Interface Specification (SIIS)
7363-9048	SEE Specific Instrument Interface Specification (SIIS)
7363-9049	TIDI Specific Instrument Interface Specification (SIIS)
Johns Hopkins APL Technical Digest, TIMED Technology	TIMED Technology Advances: Guest Editor's Introduction
	TIMED: From Concept to Realization
	TIMED Mission Science Overview
	TIMED Science: First Light

Advances Vol. 24, No. 2 (2003)	An Overview of the TIMED Spacecraft
	TIMED Instruments
	TIMED Mission System Engineering and System Architecture
	TIMED Launch Operations
	TIMED GPS Navigation System (GNS): Design, Implementation, and Performance Assessment
	TIMED Integrated Electronics Module (IEM)
	TIMED Autonomy System
	TIMED Ground System and Mission Operations
	It's About TIMED: APL's Education and Public Outreach Initiative
Data Management Plan	TIMED Data Management Plan - Describes the TIMED Science Data System, its structure, its policies and its products.
SRS-98-157	TIMED Position and Attitude Geometry Description - Details the coordinate systems, attitude specification and timing conventions and summarizes the major modes and states of the Navigation and Attitude systems aboard TIMED.

In addition to the TIMED spacecraft documentation listed in *Table 36*, all of the mission design reviews are available. There are also numerous TIMED assembly and component drawings that constitute part of the mission Archive.

Table 36 - TIMED Spacecraft Documentation

Program Doc. No.	Title
7363-9001	TIMED Requirements Document
7363-9010	TIMED Component Environmental Specification
7363-9020	TIMED Test Plan
7363-9021	Mission Operations Requirements Document
7363-9022	TIMED Spacecraft Harness Specification
7363-9028a	TIMED Product Assurance Implementation Plan
7363-9029a	TIMED Procurement Product Assurance Requirements
7363-9030	TIMED Launch Vehicle Interface Document
7363-9031	TIMED Spacecraft Contamination Control Plan
7363-9035	Mission Operations Center Software Development Plan
7363-9036	Mission Operations Center Preliminary Software Design Specification
7363-9037	Concept of Operations Document
7363-9038	TIMED EMC Control Plan and EMI Performance Requirements Specification
7363-9048	SEE Instrument Specific Instrument Interface Specification
7363-9050	TIMED Spacecraft General Instrument Interface Specification
7363-9065	TIMED Program Safety Plan
7363-9054	TIMED Launch Site Test Plan
7363-9068	TIMED Orbital Debris Assessment
7363-9101	TIMED Software Quality Assurance Plan
7363-9102	TIMED Mission Data Center Software Development Plan
7363-9103	TIMED Attitude S/W Development Plan
7363-9111	TIMED C & DH 1553 Bus Specification
7363-9300	TIMED Command & Data Handling Computer Software Development Plan
7363-9318	TIMED Ground Station Requirements Document
7363-9329	TIMED Tailored EWR-127-1
7363-9331	S/W Development Plan for the GPS Navigation Subsystem

7363-9333	Software Requirements Specification for the GPS Navigation Subsystem
7363-9336	TIMED GPS Navigation System Requirements
7363-9337	TIMED GPS Navigation System Processor Software Detailed Design Document
7363-9348	Software-Hardware Interfaces for the GPS Navigation System (GNS)
7363-9354	TIMED Boot Program, Software Requirements Document (SRS).
7363-9355	TIMED Boot Program, Detailed Design Document (SDD).
7363-9372	TIMED Guidance and Control Software Interface Control Document
7363-9373	TIMED Guidance and Control 1553 Bus Interface Control Document
7363-9374	TIMED Attitude Interface Unit Command and Telemetry Specifications
7363-9358	TIMED Boot Software Detailed Design Interface Control Document
TIMED CDR	TIMED Critical Design Review presentations

7.4 Final Archive/Mission Archive Plan

7.4.1 Data Products

During the operational mission, the latest version of TIMED data products, as detailed in Section 4, are downloaded by the SPDF as the products are generated or updated. At mission termination after the completion of the operational mission, for any TIMED data product not already delivered early to the SPDF Final Archive, a delivery will transfer to the SPDF the final and definitive version of the TIMED data products; for already delivered data products, a run of the final data reduction software on the underlying uncalibrated data may be required.

7.4.2 Analysis Tools

For any TIMED analysis tools not already delivered to the SPDF Final Archive, a final archive delivery after the completion of the operational mission will transfer to the SPDF the definitive version of the analysis tools.

7.4.3 Documentation

For any TIMED documentations not already delivered to the SPDF Final Archive, a final archive delivery after the completion of the operational mission will transfer to the SPDF definitive version of the documentation.

7.4.4 Final Archive Access and Distribution

The SPDF will serve the TIMED Final archive of data, tools and documentation and provide access through its services such as CDAWeb.

Appendix A. Calibration and Measurement Algorithms Document (CMAD)

Appendix B. Acronyms and Abbreviations

APL	Applied Physics Laboratory
CCB	Change Control Board
CDF	Common Data Format (see netCDF)
CEDAR	Coupling Energetics and Dynamics of Atmospheric Regions
CI	Collaborative Investigator
Co-I	Co-investigator
DAF	Data Analysis Facility
DEC	Declination
DQ	Data Quality
ECI	Earth-Centered Inertial
EOS	Earth Observing System
EUV	Extreme Ultraviolet
FTP	File Transfer Protocol
GB	Gigabyte
GBI	Ground Based Investigator
GSFC	Goddard Space Flight Center
GIIS	General Instrument Interface Specification
GPS	Global Positioning System
GUI	Graphical User Interface
GUVI	Global Ultraviolet Imager
I&T	Integration and Test
ICD	Interface Control Document
IDS	Interdisciplinary Scientist
ITM	Ionosphere, Thermosphere Mesosphere
JHU	the Johns Hopkins University
K-12	Kindergarten through secondary education
LASP	Laboratory for Atmospheric and Space Research
MB	Megabyte
MDC	Mission Data Center
MHR	Millstone Hill Radar
MLTI	Mesosphere and lower thermosphere/ ionosphere
MLTR	Mesosphere and Lower Thermosphere Radar
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
netCDF	Network Common Data Format
NMC	National Meteorological Center
PDMP	Project Data Management Plan
PI	Principle Investigator
POC	Payload Operations Center
PVAT	Position, Velocity, Attitude and Time
RA	Right Ascension
SABER	Sounding of the Atmosphere using Broadband Emission Radiometry
SDS	Science Data System
SEE	Solar EUV Experiment
SEE	Solar EUV Experiment

SPDF	Space Physics Data Facility
SPOC	Science Payload Operations Center
SuperDARN	Super Dual Auroral Radar Network
SWG	Science Working Group
TBD	To Be Determined
TCP/IP	Transmission Control Protocol/Internet Protocol
TIDI	TIMED Doppler Interferometer
TIMED	Thermosphere Ionosphere Mesosphere Energetics and Dynamics
TLM	Telemetry
VITMO	Virtual ITM Observatory
Web	World Wide Web (also WWW)
WWW	World Wide Web (also Web)