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PART NUMBER	SIZE	NEXT ASSEMBLY	QTY./NA	USED ON	EFFECTIVITY-END ITEM SER. NO.	WEIGHT

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APPLIED PHYSICS LABORATORY

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SABER Instrument Specific Instrument Interface Specification

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REVISION LOG

This log identifies the portions of this specification revised since the formal issue date.

SABER SPECIFIC INSTRUMENT INTERFACE SPECIFICATION

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SABER SPECIFIC INSTRUMENT INTERFACE SPECIFICATION

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1.0 General

This specification is a supplement to the General Instrument Interface Specification (GIIS) document 7363-9050, and details the electrical, mechanical, thermal, and environmental interfaces between the SABER instrument and the TIMED spacecraft. The GIIS requirements apply, unless amended herein. Section numbering corresponds with the GIIS, but only those sections needing clarification or that take exception to the GIIS are included. In some cases, new sections are created to include information not found in the GIIS.

1.1 Purpose of Document

This specification assumes general complience with the GIIS, and is used as a means of documenting exceptions and archiving information specific to the SABER instrument (i.e. mass, power, and connector information). The SIIS, together with the GIIS, the TIMED Component Environmental Specification (7363-9010), and the TIMED EMC Specification form the SABER Interface Control Document (ICD).

SABER SPECIFIC INSTRUMENT INTERFACE SPECIFICATION

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2.0 Electrical Interface Requirements

2.2 Variations in Grounding Configuration

The scanning mirror is grounded via the mounting structure and scan motor bearings and does not have a dedicated ground wire.

The deployable cover will be grounded through surface contact with the instrument and via the release mechanism, but will not have a dedicated ground wire.

Note: The proportional controllers used to control the SABER operational heaters are located within the SABER electronics on the primary side of the 28 volt operational heater power bus. This eliminates the power losses that would be incurred due to converter ineffeiciencies if the controllers were placed on the secondary side. There are no electrical connections to the secondary side or to the chassis, so no violation of the system grounding scheme is anticipated. A schematic of the heater control circuitry may be found in the SABER First-Circuit Diagrams (Appendix B).

2.3 Main and Survival Power

The SABER instrument is supplied with unregulated +28 volt DC power from three separate, switched power buses. The main bus provides power to the electronics via three wire-pairs to connector J1. The operational heater bus provides power to the operational heaters via three wire-pairs to connector J4. The survival heater bus provides power to the survival heaters via two wire-pairs also to connector J4. (Note: One wire-pair consists of a 20-gauge wire for +28V power, and a corresponding 20-gauge wire for the return). Each of these three power buses is independently switched and separately fused. Table 2-1 summarizes the SABER power interface. Refer to Appendix B for connector pin-out designations.

Table 2- 1: Saber Power Interface

POWER BUS	PEAK CURRENT	FUSE	# WIRE-PAIRS	CONNECTOR
MAIN	4.57 A @ 24 V	10A	3	J1
OPERATIONAL HEATER	2.45 A @ 35 V	10A	3	J4
SURVIVAL HEATER	2.45 A @ 35 V	7A	2	J4

2.3.2 Component Generated Power Bus Load Characteristics

The primary power turn-on input current transient for the SABER instrument will be as shown in the GIIS, except that the current will be limited to 7A maximum during the 200 ms interval following the initial turn-on transient and prior to the onset of nominal operation. This limit is more restrictive than that shown in the GIIS, and is required to ensure that the primary power fuse is not unduly stressed.

2.3.4 Fusing

Refer to Table 2-1 in section 2.3.

2.3.5 Current Monitors

The SABER instrument current monitors are chosen to accomodate the following range for normal operation:

Primary power = 4.57 Amps max.
Operational Heaters = 2.45 Amps max.
Survival Heaters = 2.45 Amps max.

The current monitor circuitry is the responsibility of APL. The basic circuitry consists of two parallel current resistors, a x100 gain block, and a 12-bit A/D converter with a 0 to 10-volt scale. The resistors are sized such that a single point failure (open) in one resistor will still result in an on-scale current reading. In addition, the resistors can support the transient currents shown in Figure 2-1.

The current monitor resistors for the SABER instrument are as follows:

Table 2- 2: SABER Current Monitor Resistors

POWER BUS	RESISTOR	NET RESISTANCE	FULL-SCALE	CURRENT RESOLUTION
Main	5 milli-ohm	2.5 milli-ohm	40 A	9.77 mA
Operational Heater	10 milli-ohm	5 milli-ohm	20 A	4.88 mA
Survival Heater	20 milli-ohm	10 milli-ohm	10 A	2.44 mA

2.3.7 Main Bus Component Power Dissipation

Tables E-1 and E-2 in Appendix E summarize the average and peak power levels for each operating mode of the SABER instrument. Table E-3 summarizes the SABER orbit-average power by orbit mode. (Note: An orbit mode is a sequence of instrument modes with assigned dwell times, chosen to represent a typical in-flight operational profile that could be expected during an orbit. The dwell time in each instrument mode is used to calculate orbit-average power, expected data volume, etc.).

Figure 2-1 illustrates the power profile in the standard orbital mode. See Appendix E for the average and peak powers of each instrument mode.

2.3.8 Survival Bus Power Dissipation

The survival heater bus power requirements are given in Appendix E.

2.5.1 Spacecraft / Instrument Interface Harness

Appendix B, Tables B-1a through B-1g list the SABER interface connectors, giving connector designation, function, type, pin-out, and signal name information.

Figures B-1 through B-3 in Appendix B show the SABER first-circuit diagrams, including connector and signal shielding diagrams.

2.6.2 Interface Connectors

Table 2- 3: SABER Interface Connectors

Connector No.	Connector Type	Description
A500-J1	DEMM9P	Instrument Power
A500-J2	DEMM9S	Main 1553 bus A
A500-J3	DEMM9S	Main 1553 bus B
A500-J4	DAMM15P	Operational & Survival Heater Power
A500-J5	DBMM25S	Temperature Monitors
A500-J6	DEMM9S	Cooler 1553 bus A
A500-J7	DEMM9S	Cooler 1553 bus B
A500-PG1	SWAGELOK SS-400-XX (or PFA-400-XX)	Purge Intake

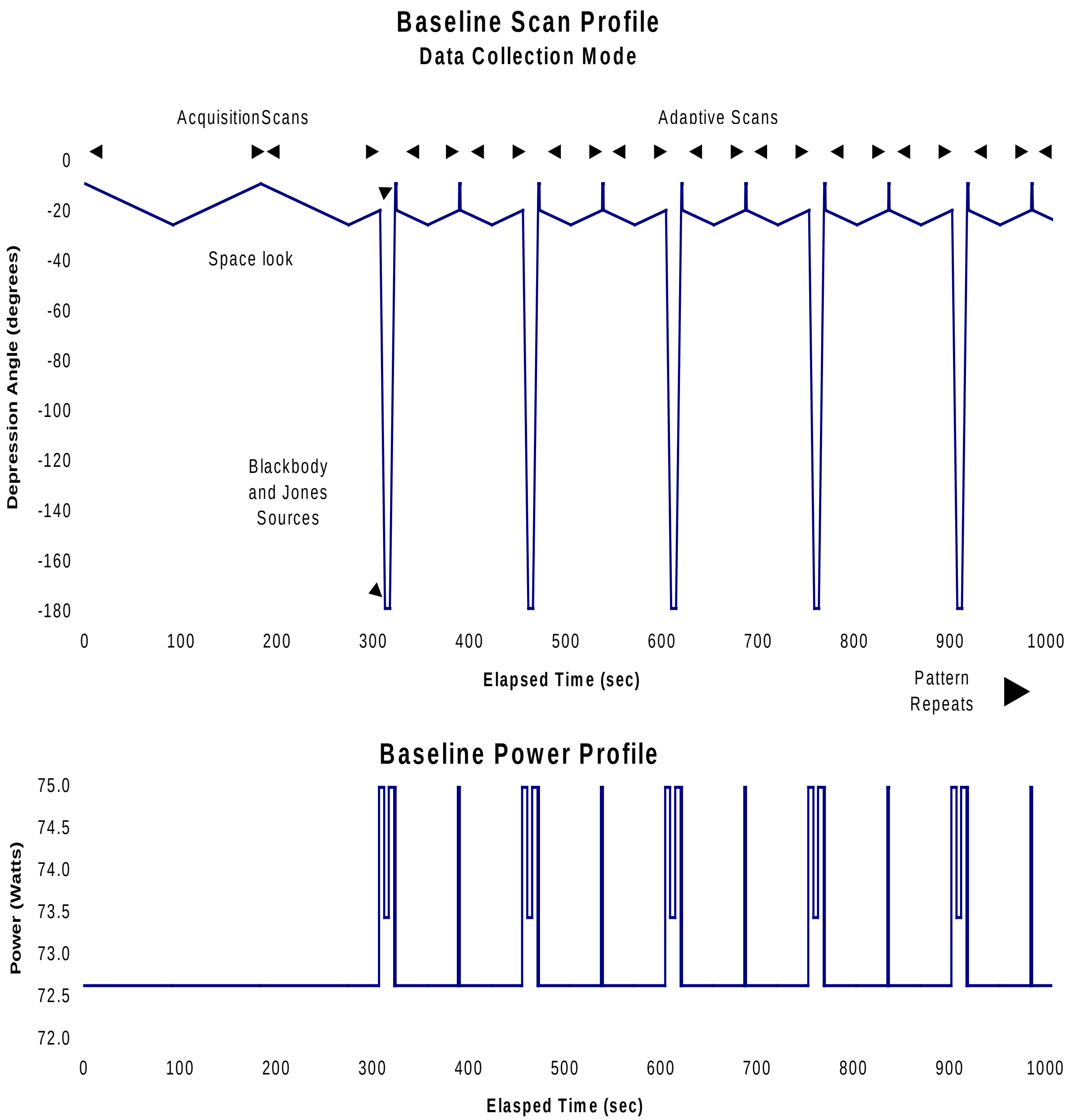

Figure Section 2 :-1: Scan and Power Profile in Standard Orbit Mode

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Section 3 : Command and Data Handling Interface

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3.0 Command and Data Handling Interface Requirements

3.2.3 MIL-STD-1553 Bus Network Services To Instruments

The Spacecraft C&DH system shall provide Remote Terminal to Remote Terminal (RT-RT) transfers between the SABER instrument and the SABER refrigerator electronics. The refrigerator electronics shall reside at remote terminal address 5, and the instrument electronics shall reside at remote terminal address 11. The RT-RT transfers shall be initiated by the spacecraft C&DH system at 1 second intervals. The content of the transfers is described in the sections below.

3.2.3.3 Instrument MIL-STD-1553 bus subaddress assignments

Table 3- 1: SABER Instrument 1553 Sub-addresses

Addr	Receive	Transmit		Addr	Receive	Transmit
0	Illegal	Mode Codes		16	Illegal	Illegal
1	Receive Buffer 1	Transmit Buffer 1		17	Illegal	Illegal
2	Receive Buffer 1	Transmit Buffer 1		18	Illegal	Illegal
3	Receive Buffer 1	Transmit Buffer 1		19	Spacecraft Time	Time Sync
4	Receive Buffer 1	Transmit Buffer 1		20	Spacecraft Status	Illegal
5	Illegal	Transmit Buffer 1		21	Illegal	Illegal
6	Receive Buffer 2	Transmit Buffer 2		22	Illegal	Illegal
7	Receive Buffer 2	Transmit Buffer 2		23	Refrigerator Status	Refrigerator Set Point
8	Receive Buffer 2	Transmit Buffer 2		24	Illegal	Illegal
9	Receive Buffer 2	Transmit Buffer 2		25	Illegal	Illegal
10	Illegal	Transmit Buffer 2		26	Illegal	Illegal
11	Command Status	Telemetry Configuration		27	Illegal	Illegal
12	Illegal	Instrument Status		28	Illegal	Illegal
13	Illegal	Illegal		29	Illegal	Illegal
14	Illegal	Illegal		30	Wrap Around Test	Wrap Around Test
15	Illegal	Illegal		31	Illegal	Mode Codes

Table 3- 2: SABER Refrigerator Electronics 1553 Sub-addresses

Addr	Receive	Transmit		Addr	Receive	Transmit
0	Illegal	Mode codes		16	Illegal	Illegal
1	Illegal	Transmit buffer		17	Illegal	Illegal
2	Illegal	Illegal		18	Illegal	Illegal
3	Illegal	Illegal		19	Illegal	Illegal
4	Illegal	Illegal		20	Illegal	Illegal
5	Receive buffer	Illegal		21	Illegal	Illegal
6	Illegal	Illegal		22	Illegal	Illegal
7	Illegal	Illegal		23	Illegal	Illegal
8	Illegal	Illegal		24	Illegal	Illegal
9	Illegal	Illegal		25	Illegal	Illegal
10	Illegal	Illegal		26	Illegal	Illegal
11	Illegal	Illegal		27	Illegal	Illegal
12	Illegal	Illegal		28	Illegal	Illegal
13	Illegal	Illegal		29	Illegal	Illegal
14	Illegal	Illegal		30	Illegal	Illegal
15	Illegal	Illegal		31	Illegal	Mode codes

3.2.3.4.1 Receive Subaddress Assignments R0 Through R31

SABER Instrument R23

SABER refrigerator status will be loaded into the first six words of R23 via an RT-RT transfer initiated by the spacecraft every second. The six words are as follows:

Table 3- 3: SABER R23 Structure

Word #	Description
1	Bal Pos
2	Comp LVDT
3	Bal Cur
4	Bal Pos
5	Cold Head Temp

6	Accel

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SABER Refrigerator Electronics R5

An RT-RT transfer between the SABER instrument and the TRW refrigerator will be initiated by the spacecraft every second. Two command words will be loaded into R5 of the cooler as follows:

Table 3- 4: Refrigerator R5 Structure

Word #	Description
1	cooler control board address
2	cooler temperature set point

3.2.3.4.2 Transmit Subaddress Assignments T0 through T31

The SABER instrument will transmit a 64-bit status word at subaddress assignment T12. The structure for T12 is given in Table 3-6 on the next page.

SABER Instrument T23

The SABER instrument will issue two command words to the refrigerator electronics which are transferred via an RT-RT transfer initiated by the spacecraft every second. The description is as follows:

Table 3- 5: SABER T23 Structure

Word #	Description
1	cooler control board address
2	cooler temperature set point

Table 3- 6: SABER T12 Structure

Word Bit Position	Number of Bits	Definition
0,15	1	heart beat
0,14	1	zero
0,13-11	3	command packet receive count
0,10-8	3	command packet reject count
0,7-5	3	mirror stall count
0,4-3	2	mirror reset count
0,2-0	3	refrigerator overstroke count
1,15	1	uplink OK
1.14	1	uplink incoming message
1,13	1	incorrect number of words
1,12	1	CRC error
1,11-10	2	zeros
1,9-0	10	word count in current session
2,15	1	relay 7—refrigerator cage/uncage
2,14	1	relay 6—RFE primary/secondary
2,13	1	relay 5—wax actuator secondary on/off
2,12	1	relay 4—wax actuator primary on/off
2,11	1	relay 3—power group #3 on/off
2,10	1	relay 2—power group #2 on/off
2,9	1	relay 1—refrigerator on/off
2,8	1	Jones source #1 on/off
2,7	1	Jones source #2 on/off
2,6	1	Jones source #3 on/off
2,5-4	2	refrigerator mode
2,3-0	4	instrument mode
3,15-4	12	refrigerator cold sting temperature
3,3-0	4	zeros

SABER Refrigerator Electronics T1

The refrigerator electronics issues six words of refrigerator status which will be transferred to the SABER instrument via a RT-RT transfer initiated by the spacecraft every second. The six words are described as follows:

Table 3- 7: Refrigerator Electronics T1 Structure

Word #	Description
1	Bal Pos
2	Comp LVDT
3	Bal Cur
4	Bal Pos
5	Cold Head Temp
6	Accel

3.3 Packetized Telemetry Format

The following application ID numbers apply:

Table 3- 8: Application ID Numbers

Application ID			
bits 10-7	Formatter Mode bits 6-5	Subframe bits 4-0	Description
1011	00, Housekeeping	N/A	housekeeping data
1011	01, Data Collection	subframe ID	data collection data
1011	10, Memory Dump	N/A	S/C memory dump data

3.5 Summary of the SABER Instrument Data Requirements

APL will allocate sufficient data handling resources to accommodate data generated by the SABER instrument at the rates given in Table 3-9.

Table 3- 9: SABER Command And Data Rates

Command requirements	2 Kbytes per day
Daily Average Data Rate	3.97 kbps
Peak Recording Data Rate	3.97 kbps
Peak Real-time Data Rate	3.97 kbps

3.6 Caging Relay Tell-Tale First Circuit Interface

The SABER instrument refrigerator compressor does not have a tell-tale circuit for the caging relay. In order to determine if the refrigerator compressor is caged the following procedure will be implemented.

1. While on, the current level for the SABER refrigerator compressor will be noted.
2. SABER refrigerator compressor and electronics will be turned off.
3. Caging relay will be toggled to cage position.
4. SABER refrigerator compressor and electronics will be turned on.
5. The current level for the compressor will be noted. Note: Caging the compressor shorts the windings for the compressor. The additional current due to the short will serve as the tell-tale.

SABER SPECIFIC INSTRUMENT INTERFACE SPECIFICATION

Section 4 : Thermal Interface

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4.0 Instrument Thermal Interface Requirements

Much of the detailed thermal interface information for the SABER instrument (e.g. heater, thermostat, temperature sensor, thermal blanket, thermal control coatings, connector locations, etc.) is given in the Thermal Interface Control Drawings (Appendix C).

4.2 Thermal Control Concept

Thermal control of the SABER instrument is maintained using a combination of passive radiators, active operational and survival heaters, multi-layer insulation (MLI) blankets, thermal isolators, and a mechanical cryogenic refrigerator. Heat generated by the instrument is dissipated using two passive radiators (one warm, one cold) mounted on the +Y side of the instrument. The instrument is conductively and radiatively isolated from the TIMED spacecraft.

The SABER instrument contains three temperature zones - the focal plane assembly (FPA), the telescope assembly, and the electronics and remaining structure. The focal plane assembly is cooled to 75 K by the mechanical refrigerator. A flexible thermal link provides a high conductivity thermal path between the FPA and the refrigerator cold block. To reduce parasitic heat loads and refrigerator cooling requirements, the FPA is thermally isolated from the telescope assembly by thin walled G-10 tubes and MLI blankets.

The telescope assembly is cooled by the optics radiator to an operating range between 214 and 237 K at the telescope radiator interface. The telescope assembly is wrapped in MLI to reduce radiative heat loads, and is attached to the baseplate using G-10 struts which thermally isolate the cold telescope from the warm baseplate. Operational and survival heaters on the encoder assembly maintain the encoder temperature above 223 K in operating modes, and above 218 K in survival mode.

The instrument electronics, refrigerator electronics, and refrigerator compressor are mounted to the baseplate radiator which operates between 244 and 263 K. Operational and survival heaters on the refrigerator mount maintain the refrigerator above 260 K in operating modes and above 250 K in survival mode.

4.3 Mounting Interface

All SABER components will be mounted to a baseplate which will be delivered with the instrument. The baseplate will be mounted to the +Y side of the spacecraft. The dimensions of the SABER instrument and details of its mechanical interface are given in the Mechanical Interface Control Drawings (Appendix A).

4.3.1 Interface Surface

The SABER baseplate will be thermally isolated from the spacecraft using low conductivity materials which provide a total resistance across the interface of > 5 degrees C per Watt. The mounting surface must be able to support the proposed isolation technique.

4.3.2 Mounting Interface Temperature Limits

The temperatures to which APL will control the +Y panel at the mounting interface are defined in Table 4-1. The SABER IDT should use these temperatures as boundary conditions for thermal analysis. Test limits will be addressed in the Acceptance Test Plan.

Table 4- 1: Mounting Interface Temperature Limits

Mounting Interface	In-spec operating	Survive / Non-op
+Y S/C Panel	-29 to +30 °C	-34 to +60 °C

4.3.3 Mounting Interface Temperature Rate of Change Limits

A temperature rate-of-change of no more than 0.1 K/minute is to be maintained at the mounting interface.

4.3.4 Temperature Gradient Requirements

The temperature gradient across the mounting interface must be < 15 K from any one point to another.

4.3.5 Power Density Limits

There is no requirement to limit the power density at the baseplate.

4.4 Thermal Control Hardware

All thermal control hardware for the SABER instrument is documented in the Thermal Interface Control Drawings (Appendix C). The drawings show:

- radiator locations and sizes,
- MLI locations and attach points,
- MLI grounding strap locations,
- operational and survival heater/thermostat locations,
- heater part number and resistance values,
- thermostat part number and set points,
- spacecraft and instrument temperature sensor locations and types,
- thermal control coatings,
- thermal isolation hardware

Operate, survive, and test temperature specifications for individual box, major subassembly, and critical components are specified in the Instrument Specification Document SDL/95-009.

4.4.1.1 Operational Heaters

The location and designation of the operational heaters for SABER are shown in the Thermal Interface Control Drawings (Appendix C). Details of the electrical interface are given in the SABER First Circuit Diagrams (Appendix B). The SABER IDT is responsible for all hardware up to and including the interface connector. The operational heaters are powered from a dedicated 28-volt power bus that is separately switched and separately fused (refer to section 2.3). Proportional controllers are used to maintain the motor encoder temperature at a set-point of 223 K, and the cooler baseplate at a set-point of 260 K.

4.4.1.2 Survival Heaters

The location and designation of the survival heaters and thermostats for SABER are shown in the Thermal Interface Control Drawings (Appendix C). Details of the electrical interface are given in the SABER First Circuit Diagrams (Appendix B). The SABER IDT is responsible for all hardware up to and including the interface connector. The survival heaters are powered from a dedicated 28-volt power bus that is separately switched and separately fused (refer to section 2.3). On /off controllers under thermostatic control are used to maintain the motor encoder temperature at a minimum of 218 K, and the cooler baseplate at a minimum of 250 K. The thermostats have a 7 K hysteresis / deadband.

4.4.2 Temperature Sensors

4.4.2.1 Spacecraft-Monitored Temperature Sensors

The SABER instrument will have four redundant temperature sensors (eight total), provided by APL and installed in four locations within the instrument by the IDT, as shown in Appendix C. The sensor is a platinum resistor (S100480PFY72B), having a nominal resistance of 1000 ohms at room temperature and a minimum temperature range of -80 to +100 °C. Details of the electrical interface are given in the SABER First Circuit Diagrams (Appendix B). The sensor outputs will be monitored by circuitry on the spacecraft and reported in telemetry.

4.4.2.2 Instrument-Monitored Temperature Sensors

Details of the instrument-monitored temperature sensors are given in the Thermal Interface Control Drawings (Appendix C). These sensors are provided and installed by the SABER IDT. The temperatures are monitored by the SABER electronics and included in the instrument data packet.

4.4.3 Radiators

The SABER optics thermal radiator is located on the spacecraft +Y panel. The radiator is cantilevered from the SABER telescope and is not structurally tied to the spacecraft. The optics thermal radiator will be provided as part of the instrument, and is the responsibility of the SABER IDT. The radiator size, location, thermal control coatings, etc. are detailed on the Thermal Interface Control Drawings (Appendix C). The clear field of view and solar keep-out zone are given in SABER Thermal / Optical Field of View Drawing (Appendix A).

The SABER electronics thermal radiator also serves as the instrument baseplate and the main structure for attachment of SABER to the spacecraft. The baseplate is mounted to the +Y side of the spacecraft.

The TIDI instrument is presently within the SABER radiator clear field-of-view. The encroachment appears to be acceptable, and the SABER IDT has agreed to allow small portions of both the TIDI telescopes and TIDI Profiler to overhang the SABER FOV. All such impingements of the SABER FOV are subject to review, analysis, and final approval by the SABER IDT.

4.4.4 Thermal Control Coatings

Details of the thermal control coating type, thickness, and locations are given on the Thermal Interface Control Drawings (Appendix C).

4.4.5 Thermal Blankets

Details of the thermal blanket sizes and locations, and grounding strap locations are given in the Thermal Interface Control Drawings (Appendix C) and will be agreed to by the spacecraft thermal engineer.

SABER SPECIFIC INSTRUMENT INTERFACE SPECIFICATION

Section 5 : Mechanical Interface

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5.0 Mechanical Interface Requirements

This section contains mechanical interface requirements for SABER and for the TIMED spacecraft. Much of the detailed information is contained in the Mechanical Interface Control Drawings (Appendix A).

5.1.1 Mechanical Responsibilities

With reference to TABLE 5.1.1-1 in the GIIS the following modifications apply:

Item A-4: Not Applicable. SABER has no test connectors.
Item A-6: Not Applicable. SABER does not use pyro actuators.
Item A-14: Not Applicable. SABER does not use thermal gaskets.
Item A-15: Not Applicable. SABER has no heat pipes.
Item A-16: The general requirement is to keep S/C harnesses as far as possible from the SABER detector array and its harness.
Item C-3b: Not Applicable. SABER has no test connectors.

The remaining items are addressed in the following documents:

Item A: Refer to the Mechanical ICD drawings in Appendix A.
Item B: Refer to the drawings in Appendix A.
Item C: Refer to the drawings in Appendix A.
Item D: Refer to the tables in Appendix D.

5.1.2 Instrument Mounting Concept

Refer to Appendix A.

5.1.3 Reference Coordinate Systems

5.1.3.2 Instrument Component Reference Coordinate Systems

Refer to Appendix A.

5.1.4 Instrument/Component Mounting

5.1.4.1.1 Instrument Mounting Locations

The mounting location on the spacecraft of the SABER instrument is shown in the +Y Side Top Assembly Drawings (Appendix A).

5.1.4.1.1.1 Instrument Mounting Hardware

The SABER instrument will be mounted with fasteners provided by APL as shown in the +Y Side Top Assembly Drawings (Appendix A).

5.1.4.1.1.2 Instrument Mounting Repeatability

If the SABER instrument is removed from the spacecraft, proper alignment must be verified upon re-installation. If necessary, shimming to achieve proper alignment will be performed by the APL Integration and Test team, with SABER personnel in attendance. Alignment verification shall consist of a remapping of the SABER instrument optical cube into the spacecraft master optical cube. A repeat of the mapping offsets between the cubes (as measured in the initial instrument integration) shall be verification of correct alignment of the SABER instrument.

5.1.4.1.2 Instrument Bolt Hole Locations

Refer to Appendix A. A template will be supplied by the SABER IDT so that the mounting holes on the spacecraft may be located with a tighter tolerance than would otherwise be possible.

5.1.4.1.3 Thermal Gaskets and Washers

The SABER IDT will supply hardware used to thermally isolate SABER from the spacecraft structure. Details of the thermal interface are shown in the Thermal Interface Control Drawing (Appendix C) and the Mechanical Interface Drawings (Appendix A).

5.1.4.1.4 Grounding Strap

The instrument locations to which ground straps will be tied are shown in the Mechanical Interface Drawings (Appendix A).

5.1.5 Mass Properties

5.1.5.1 Mass

Refer to Table D-1, Appendix D.

5.1.5.2 Center-of-Mass Location

Refer to Table D-2, Appendix D.

5.1.5.3 Moments of Inertia

Refer to Table D-2, Appendix D.

5.1.6 Envelopes and Fields-of-view

5.1.6.1 Static Envelope

The SABER instrument's static envelope is given in the SABER Envelope ICD Drawing (Appendix A).

5.1.6.2 Dynamic Envelope

The SABER instrument's dynamic envelope is given in the Mechanical Interface Drawing (Appendix A).

5.1.6.3 Integration and Test Access Requirements

Prior to integration of the SABER instrument into the TIMED spacecraft, a full cover deployment test will be conducted. A functional class 100 environment must be available for this test. (Refer to section 7.6.1). Following integration, a cover release mechanism check will be conducted as part of the standard warm functional test. The cover is captured and remains seated during the warm functional, but access to the SABER cover release mechanism will be required to inspect and manually reset the cover release mechanism after each test.

Access to the SABER thermal radiators is required prior to thermal vacuum testing so that the protective covers on the radiators may be removed. Access is required following thermal vac to re-install the protective covers.

5.1.6.4 Payload Instrument Fields-of-view

Refer to the Thermal / Optical Field-of-View Drawing in Appendix A.

5.1.6.5 Thermal Radiator Field-of-View

Refer to the Thermal / Optical Field-of-View Drawing in Appendix A.

5.1.7 Payload Instrument Alignment Provisions

5.1.7.1 Alignment Position Requirement

APL shall mount the SABER instrument such that the total of all alignment position errors and alignment knowledge errors are less than or equal to 0.9° about the X axis and 1.05° about the Y and Z axes. This total error budget, including instrument and spacecraft error sources, shall be to the SABER instrument boresight and shall include pointing control, initial alignment errors, initial alignment knowledge, geometric tolerancing errors, thermal distortion, 1g to 0g transition, and launch stress effects. The errors shall be allocated so that the spacecraft has a budget of 0.6° total to the spacecraft / instrument interface about the X axis and 0.75° total to the spacecraft / instrument interface about the Y and Z axes, including 0.5° allotted in each axis for pointing control. The SABER instrument shall be allocated 0.3° in each axis to the spacecraft / instrument interface. This position error shall be verified by mapping the instrument boresight to the instrument optical cube and mapping the spacecraft coordinate system to the spacecraft optical cube, and then mapping the instrument cube into the spacecraft cube to determine the offset between the two systems.

5.1.7.2 Alignment Knowledge Requirement

APL shall provide knowledge of the alignment of the SABER instrument boresight with respect to the spacecraft coordinate system to within 0.2°. This number is included as part of the total alignment position budget. This alignment knowledge error shall be allocated so that spacecraft error sources have a budget of 0.1° for all spacecraft alignment knowledge errors, and the SABER instrument shall have a budget of 0.1° for all instrument alignment knowledge errors.

5.1.7.3 Optical Alignment Cube

The SABER IDT shall provide the instrument optical alignment cube per drawings shown in appendix A. The all-aluminum cube will be permanently attached to the instrument prior to all precision alignment measurements. The boresight orientation of the instrument will be mapped into the cube before delivery of the instrument to APL.

5.1.7.4 Optical Alignment Cube Location

Refer to the Mechanical Interface Drawing (Appendix A).

5.1.8 Mechanisms, Moving Parts, and Dynamics

The SABER instrument has the following moving parts: scanning mirror, optical chopper, and refrigerator compressor. The aperture cover will be ejected within the first few weeks of the mission and is a non-recurring event.

5.1.8.1 Operation

Dynamic forces and torques induced at the component mount by the SABER instrument are described and recorded within this section by the SABER IDT and shall comply with the limits specified within the GIIS.

5.1.8.1.1 Non-recurring Transient Events

The deployment of the SABER apperture cover shall impart the only non-recurring force and torque to the spacecraft from the SABER instrument. The momentum transfer will have a duration of less than one second. The force and torque for this event are summarized in the following table:

Table 5- 1: Non-Recurring Forces And Torques

Event	Force* (N)	Torque** (N-m)	Angular Momentum * (kg m^2/s)
Cover Deployment	0 **i** + 134 **j** + 0 **k**	(2.27×10^{-2}) **i** + 0 **j** + 0 **k**	0 **i** + 0 **j** + 0 **k**

* Vectors are specified along the axes of the SABER instrument coordinate system, which is parallel to the S/C coordinate system.

** This is the torque at the origin of the SABER coordinate system.

5.1.8.1.2 Recurring Forces and Torques (spectra)

The continuous operation of the SABER cooler, chopper, and the scanner motor/encoder produce the only recurring forces or torques within the instrument.

The cooler produces about 0.1 N at 52 Hz (and its higher harmonics up to 500 Hz.) The chopper produces about 0.01 N at 1000 Hz. The motor/Encoder is capable of imparting a peak torque of 0.282 N-m at certain parts of the instrument scan profile.

Table 5- 2: Recurring Forces and Torques

Maneuver	Force* (N)	Torque* (N-m)
Cooler	0 **i** + 0.1 **j** + 0 **k**	0 **i** + 0 **j** + 0 **k**
Chopper	0.01 **i** + 0 **j** + 0 **k**	0 **i** + 0 **j** + 0 **k**
Scanner	0 **i** + 0 **j** + 0 **k**	0.282 **i** + 0 **j** + 0 **k**

* Vectors are specified along the axes of the SABER instrument coordinate system, which is parallel to the S/C coordinate system.

5.1.8.2 Caging

The SABER instrument scan mirror shall be caged at launch. The SABER IDT is responsible for the design, development and operation of the caging mechanism. A verification that the scan mirror is in the caged position shall be conducted before any transport of the SABER instrument and as part of the final checkout at the launch pad.

The SABER instrument's Refrigerator Compressor shall be caged for launch. The SABER IDT is responsible for the design, development and operation of the caging mechanism. A verification that the compressor is in the caged position shall be conducted before any transport of the SABER instrument and as part of the final checkout at the launch pad. (Refer to section 3.6).

5.1.10 Protective Covers (Flight, Red Tag, etc.)

The SABER instrument will have the following 'remove before flight' items:

1. Deployable Cover Retaining Clamps: These clamps hold the cover in place during integration and testing. They will be removed only during the cover deployment test and just prior to flight.

2. Radiator Protective Cover: The two SABER instrument radiators will be covered during integration and testing except during the space simulation test and just prior to flight.

5.2 Payload Instrument Identification and Marking

The SABER instrument will consist of a single integrated module, and shall be marked with the identification A-500. Interface connectors shall be clearly labeled (e.g. A500-JXX).

SABER SPECIFIC INSTRUMENT INTERFACE SPECIFICATION
Section 6 :Navigation and Attitude Control Interface Section
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6.0 Navigation and Attitude Control

6.3.1 Pointing Knowledge

A break-down of the pointing accuracies on the spacecraft side and on the instrument side is contained in the SABER S/C Resource Requirements Table. See Appendix F.

SABER SPECIFIC INSTRUMENT INTERFACE SPECIFICATION

Section 7 : Integration, Qualification, and Field Test Requirements
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7.0 Integration, Qualification, and Field Test Requirements

7.2.2 Mechanical GSE

The SABER instrument does not require mechanical GSE after integration into the TIMED spacecraft. Therefore it will not be necessary, and at present it is not planned, to transport the SABER mechanical GSE to Goddard or to the Western Test Range. The handling fixtures will be transported to all test sites so that the instrument may be removed from the spacecraft as needed.

7.5 Purge Requirements

7.5.5 Instrument Purge Flow Rates

The SABER instrument will require 0.5 scfm purge of high purity nitrogen with a minimum line pressure of 4 psi at the SABER connection, while purging. The SABER instrument will use in-line gas snubbers to reduce the pressure and distribute the purge gas to the various optical compartments. The purge design satisfies the requirement of complete gas exchange within the SABER optics every 4-5 minutes. The internal optics and cold post compartment will be isolated from the external thermal insulation, electronics boxes, and surrounding spacecraft. The purged compartments will be tight enough to allow short periods (a few hours) of interrupted purge without significant reabsorption of atmospheric moisture.

7.6 Environmental Requirements

7.6.1 Cleanliness Requirements

The SABER instrument requires that a functional class 100 environment be available for initial functional tests following delivery of the instrument to APL, and prior to integration onto the spacecraft. Use of a portable clean tent is acceptable if precautions are taken to ensure that a functional class 100 environment is maintained. Such precautions would include establishing sufficient positive air flow through the tent, limiting the number of persons in the tent, and monitoring the particle count near the the aperture of the SABER instrument. The tent will be used for various post-shipment tests and procedures including removal of detectors from the shipping container / GSE, removal of witness mirrors mounted in the SABER instrument, and a full cover deployment test that exposes the input aperture. The tent shall be supplied by TBD. During spacecraft integration, the environmental requirement is Class 100,000, and the cover will remain seated against the input aperture during all testing.

7.7 Safety

7.7.2.8 Pressurized Systems

The TRW cooler is nominally constructed to MIL-STD-1522, but further information from TRW is pending. Some exceptions may apply.

7.8 Contamination Control

7.8.1 Instrument Cleanliness

The SABER instrument has stringent internal contamination control requirements that are necessary to maintain the integrity of the low scatter optics. These requirements are fully described in the SABER Contamination Control Plan, SDL/95-035. The SABER instrument design is largely isolated from the external contamination environment, so that the spacecraft cleanliness requirements are more easily maintained. However, there are some tests to be conducted prior to spacecraft integration that require special consideration. The SABER instrument contamination control requirements that constrain spacecraft integration or pre-launch operations are identified below.

The SABER instrument will be delivered to APL with clean internal optics. Verification of cleanliness level will be by inspection of witness mirrors mounted on the cover and scanner compartment. Removal of the witness mirrors will follow the full functional test, and will require the use of the clean tent described previously. Solvent wipes will be used for cleanup of external surfaces prior to witness mirror removal and cover deployment tests. SABER will need to use isopropyl alcohol and, on a limited basis, acetone for spot cleaning of external instrument surfaces before and after installation on the spacecraft. Permission will be obtained from the appropriate APL contamination control personnel prior to cleaning after integration with the spacecraft. Whenever possible, the SABER cover and silver-teflon radiator surfaces should be protected using a spacecraft-approved clean conductive bagging material to cover the critical surfaces during spacecraft integration. The cover assembly should be recleaned at the latest possible time (access-permitting) prior to launch to minimize the risk of particulate accumulation that may enter the optical compartment during on-orbit cover deployment. At the time of the last cover cleaning, the cleanliness level should be measured using the tape lift analysis method. The prelaunch external cleanliness of the cover shall be less than or equal to the Level 300 SABER goal at this time.

SABER SPECIFIC INSTRUMENT INTERFACE SPECIFICATION

Section 8 :Payload Instrument Ground Support Equipment
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8.0 Ground System and Payload Operations Center (POC) Interface

8.2.3.1 Command Messages

Packet size for command messages is 2000 bits.

8.2.3.4 Ad Hoc Housekeeping Log

A complete housekeeping log will be generated for the test conductor. Re-formatting, parsing, merging, or other manipulations on the data will be the responsibility of the test conductor.

APPENDIX A

SABER INSTRUMENT INTERFACE CONTROL DRAWINGS

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APPENDIX B

SABER FIRST-CIRCUIT DIAGRAMS

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Table B- 1 : Connectors and Pinouts

TABLE B-1a

Pin #	Name: A500 J1 Function: 28V Instrument Power Type: DEMM9P
1	+28 V Main A
2	Main A Return
3	+28 V Main B
4	Main B Return
5	
6	+28 V Main C
7	Main C Return
8	
9	Chassis

TABLE B-1b

Pin #	Name: A500 J2 Function: 1553 A Bus Main Type: DEMM9S
1	1553 A Bus Main +
2	
3	
4	
5	
6	1553 A Bus Main -
7	
8	
9	

TABLE B-1c

Pin #	Name: A500 J3 Function: 1553 B Bus Main Type: DEMM9S
1	1553 B Bus Main +
2	
3	
4	
5	
6	1553 B Bus Main -
7	
8	
9	

TABLE B-1d

Pin #	Name: A500 J4 Function: Heater Power Type: DAMM15P
1	Operational Heater +28 V A
2	Operational Heater Return A
3	Operational Heater +28 V B
4	Operational Heater Return B
5	Operational Heater +28 V C
6	Operational Heater Return C
7	
8	Chassis
9	Survival Heater +28 V A
10	Survival Heater Return A
11	Survival Heater +28 V B
12	Survival Heater Return B
13	Survival Heater +28 V C
14	Survival Heater Return C
15	

TABLE B-1e

Pin #	Name: A500 J5 Function: Temperature Monitors Type: DBMM25S
1	SABER1A+
2	SABER1A-
3	SABER1B+
4	SABER1B-
5	SABER2A+
6	SABER2A-
7	SABER2B+
8	SABER2B-
9	SABER3A+
10	SABER3A-
11	SABER3B+
12	SABER3B-
13	
14	SABER4A+
15	SABER4A-
16	SABER4B+
17	SABER4B-
18	SABER3B-
19	SABER4A-
20	SABER4B-
21	
22	
23	
24	
25	

TABLE B-1f

Pin #	Name: A500 J6 Function: 1553 A Bus Cooler Type: DEMM9S
1	1553 A Bus Cooler +
2	
3	
4	
5	
6	1553 A Bus Cooler -
7	
8	
9	

TABLE B-1g

Pin #	Name: A500 J7 Function: 1553 B Bus Cooler Type: DEMM9S
1	1553 B Bus Cooler +
2	
3	
4	
5	
6	1553 B Bus Cooler -
7	
8	
9	

APPENDIX C

SABER INSTRUMENT THERMAL INTERFACE CONTROL DRAWINGS

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APPENDIX D

SABER INSTRUMENT MECHANICAL PROPERTIES SUMMARY

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SABER SPECIFIC INSTRUMENT INTERFACE SPECIFICATION

Appendix D
SABER Instrument Mechanical Properties Summary
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Table D- 1: SABER Mass Summary

INSTRUMENT MASS BY SUBSYSTEM

SABER Component	Mass (Kg)
Telescope Assembly	26.63
Refrigerator Assembly	9.40
Support Structure Assembly	12.64
Instrument Electronics Assembly	9.27
S/C Electrical Interface Assembly	2.72
Purge System	1.47
MLI Blanketing	2.20
Other	1.3
Total @ Launch	65.63
Total (Cover Deployed)	65.18

Table D- 2: SABER Moments of Inertia

		Ixx $Kg\text{-}m^2$	Iyy $Kg\text{-}m^2$	Izz $Kg\text{-}m^2$	Ixy $Kg\text{-}m^2$	Iyz $Kg\text{-}m^2$	Ixz $Kg\text{-}m^2$
Launch Configuration		16.26	14.38	4.796	0.02110	5.005	0.1230
Cover Deployed		16.19	14.37	4.73	0.02135	4.984	0.1231

Table D- 3: SABER Center of Mass

	X(mm)	Y(mm)	Z(mm)
Launch Configuration	11	170	372
Cover Deployed	11	170	372

APPENDIX E

SABER INSTRUMENT POWER CONSUMPTION

SABER SPECIFIC INSTRUMENT INTERFACE SPECIFICATION

Appendix E
SABER Instrument Power Consumption Summary
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Table E- 1: Average Power Profile

SABER INSTRUMENT: AVERAGE POWER DISSIPATION , ITEMIZED BY ASSEMBLY AND INSTRUMENT MODE

Updated 9/6/97

ID	Element	SABER Average Power Dissipation Per Instrument Mode (W)							
		OFF	POWER-UP	SAFE	STANDBY	STABILIZE	DATA COLLECTION	CALIBRATION	DIAGNOSTIC
	Optics								
	Scan Mirror (Motor & Encoder)	0.0	0.0	0.0	1.6	1.6	4.1	4.1	4.1
	Chopper	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
	Full Aperture BB and Jones Sources	0.0	0.0	0.0	1.5	1.5	1.5	1.5	1.5
	Refrigerator	0.0	0.0	0.0	14.8	14.8	14.8	14.8	14.8
	Refrigerator Electronics (RFE)	0.0	0.0	0.0	11.6	11.6	11.6	11.6	11.6
	Instrument Electronics								
	Signal Processing	0.0	0.0	0.0	7.1	7.1	7.1	7.1	7.1
	System Control and Data Handling	0.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
	Analog Controllers/Chopper	0.0	0.0	0.0	0.9	0.9	0.9	0.9	0.9
	Scan Mirror Controller	0.0	0.0	0.0	1.5	1.5	1.5	1.5	1.5
	Chopper Control & Sync	0.0	0.0	0.0	0.4	0.4	0.4	0.4	0.4
	Power	0.0	2.0	2.0	15.3	15.3	15.7	15.7	15.7
	SUBTOTAL:	0.0	8.0	8.0	60.8	60.8	63.7	63.7	63.7
Operational Heaters (cold case Beta=90))		0.0	66.5	43.0	8.9	8.9	8.9	8.9	8.9
Survival Heaters (cold case Beta=90))		28.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL:	28.5	74.5	51.0	69.7	69.7	72.6	72.6	72.6

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Table E- 2: Peak Power Profile

SABER INSTRUMENT: ORBIT-PEAK ELECTRICAL POWER DISSIPATION, ITEMIZED BY ASSEMBLY AND INSTRUMENT MODE

ID	Element	SABER Orbit-Peak Power Dissipation Per Instrument Mode (W)							
		OFF	POWER-UP	SAFE	STANDBY	STABILIZE	DATA COLLECTION	CALIBRATION	DIAGNOSTIC
	Optics								
	Scan Mirror (Motor & Encoder)	0.0	0.0	0.0	1.6	1.6	6.5	6.5	6.5
	Chopper	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
	Full Aperture BB and Jones Sources	0.0	0.0	0.0	1.5	1.5	2.3	2.3	2.3
	Refrigerator	0.0	0.0	0.0	14.8	14.8	24.0	24.0	24.0
	Refrigerator Electronics (RFE)	0.0	0.0	0.0	11.6	11.6	12.7	12.7	12.7
	Instrument Electronics								
	Signal Processing	0.0	0.0	0.0	7.1	7.1	7.1	7.1	7.1
	System Control and Data Handling	0.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
	Analog Controllers/Chopper	0.0	0.0	0.0	0.9	0.9	1.7	1.7	1.7
	Scan Mirror Controller	0.0	0.0	0.0	1.5	1.5	3.2	3.2	3.2
	Chopper Controller & Sync	0.0	0.0	0.0	0.4	0.4	0.4	0.4	0.4
	Power	0.0	2.0	2.0	15.3	15.3	19.8	19.8	19.8
	SUBTOTAL:	0.0	8.0	8.0	60.8	60.8	83.8	83.8	83.8
Operational Heaters (35 V)*		0.0	66.5	66.5	8.9	8.9	8.9	8.9	8.9
Survival Heaters (cold case Beta=90))		86.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL:	86.1	74.5	74.5	69.7	69.7	92.7	92.7	92.7

*power does not change at 35 V except during initial power up or safe since proportional heaters are used

Table E- 3: Orbit Average Power

SABER INSTRUMENT: ORBIT-AVERAGED ELECTRICAL POWER DISSIPATION, ITEMIZED BY OPERATING MODE

Orbit Mode	Instrument Mode	Duty Cycle of Instrument Mode	Average Power of Instrument Mode (W)	Orbit-Averaged Power of Orbit Mode (W)
Standard	Data Collection	77 %	72.6	72.6
	Calibration	23 %	72.6	

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APPENDIX F

SPACECRAFT RESOURCE REQUIREMENTS TABLE

GUVI SPECIFIC INSTRUMENT INTERFACE SPECIFICATION

Appendix F
SABER Instrument Resource Requirements Summary
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SABER System Engineer (SDL)

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Rev #	Date	DYK	KJH	SB	DEF		
A							
B							
C							
D							
E							
F							
G							
H							
I							
J							

FSCM NO.	SIZE	DWG. NO.	
88898	A	7363-9047	A
SCALE	DO NOT SCALE PRINT	SHEET	

Table F- 1: SABER Spacecraft Resource Requirements

	SABER S/C RESOURCE REQUIREMENTS		
			SABER
Space Craft Resource Requirements11_97.xls		11/10/97	**Sounding of the Atmosphere using**
			Broadband Emission Radiometry
Mechanical Requirements:			-
	Dimensions	(cm)	77.47 (W) x 104.24 (H) x 62.56 (D)
	Mounting Configuration (footprint, etc.)	(cm)	77.475 (W) x 62.89 (H)
	Weight	(kg)	65.63
	Center of Gravity	(cm)	1.10(x), 17.00(y), 37.20(z)
	Pointing Direction(s)		90° Off-Ram, Anti-sun side, On-Limb
	Alignment Position Requirement (To SABER interface, including all alignment position and knowledge errors)	(deg)	±0.6°(X), ±0.75° (Y,Z) (See SIIS Sect. 5.1.7.1)
	Alignment Knowledge Requirement (All S/C alignment knowledge errors from S/C coordinate system to the SABER interface)	(deg)	±0.01° (See SIIS Sect. 5.1.7.2)
	Clear Field(s) of View		±29° horiz; 23° vert (top), 54° vert (bot)
	Pinning req'd		No
	Jitter		**see GIIS Fig 6.2.5-1**
Thermal Requirements (for each piece):			
	I/F temperature range	(deg C)	-29 to +30C (operate); -34 to +60C (survive)
	I/F temperature stability	(deg C/min)	.1 K/min.
	I/F thermal gradients	(deg C)	<15 K between any two points
	#, range of S/C monitored temp sensors		4; -80 to +100C
	S/C provided radiators		None
	Instrument provided radiator CFOV:		
	Optical radiator	(deg)	180 x 360; +Y side
	Interface radiator	(deg)	180 x 360; +Y side
Attitude and Navigation Requirements:			
	Attitude control (S/C axes to the desired attitude)	(deg)	**0.5°, each axis, 3s (See GIIS Sect. 6.2.3)**
	Stability		***see GIIS Fig 6.2.5-1***
	Pointing knowledge (star camera boresight to SABER mounting location; includes attitude, thermal and mechanical sources)		***0.1°, each axis, 3 s (See GIIS Sect. 6.3.1)***
	Position knowledge	(km)	0.3 radial; 1.0 other 2 orthogonal axes; (3s)
	Velocity Knowledge	(m/s)	3 (each axis, 3s)
	Keep out zones (such as sun, moon, earth)		sun on radiator, ram (long term)
	Perturbing Mechanisms		scan mirror (1E-4 N-m-s), chopper (<0.006 lbf),
			refrigerator compressor (<0.02 lbf)

Table F-1 (Cont.): SABER Spacecraft Resource Requirements

Command and Data Handling Requirements			
	Number and type of commands		on-off, 7modes;general CMD word; 2 KBytes/day up
	Instrument modes		8-off, pwr up, safe, stndby, stblize, data coll, cal, diag
	Orbit modes		Data Coll/ Cal
	Daily avg data rate	(kbps)	3.97
	Peak record data rate	(kbps)	0, 0.132, 0.132, 3.97, 0.132, 3.97, 3.97, 3.97
	Peak real time downlink data rate	(kbps)	3.97
	Duty cycle		100%
	Time knowledge	(ms)	100
	Special data needs (terminator crossings, etc.)		Time, S/C pos, S/C velocity, orbit ephemaris, sun angle, terminator info
	Preferred S/C data interface concept		MIL-STD-1553
Power Requirements:			
	Avg pwr / instrument mode (includes htr pwr)	(watt)	28.5, 75.4, 51.0, 69.7, 69.7, 72.6, 72.6, 72.6
	Peak pwr / instrument mode (includes htr pwr)	(watt)	86.1, 74.5, 74.5, 69.7, 69.7, 92.7, 92.7, 92.7
	Peak Power duration (includes htr pwr)	(msec)	100
	Orbit avg pwr / orbit mode (includes htr pwr)	(watt)	**72.6**
	Operational htr pwr [OAP (cold case); Peak pwr (35v)]	(watt)	8.9, 8.9
	Survive htr pwr [OAP (cold case); Peak pwr (35v)]	(watt)	28.5, 86.1
	Voltage Range	(volts)	22 to 35
	# of relays		3
Cleanliness Requirements:			
	Acceptable Cleanliness Levels for S/C Intgr		Class 100,000
	S/C Surface Cleanliness		**Level 750**
	Hydrocarbon levels		15 ppm
	Purge Requirements (type, purity, flow rate, max time w/o, pad req't)		N2 purge, boil off gas from liquid LN2, 0.5 SCFM @ 4 psi delivery pressure
	Bakeout req'ts on S/C		Bakeout all mechanical hdwr, thermal blankets, cables, and electronic assys
Special Requirements For:			
	Integration and Test		requires LN2 for cooling
	A#s		A500 (SABER)
	Arming plug on S/C side		No
	Mission Operations (such as deployments)		door release attitude; yaw maneuver
	Safety (such as a radiation source)		Pressure system (refrigerator), cryo (flight refrigerator and GSE test chamber), purge, lasers (GSE only)
	EMC		S/C EMC self compatibility test must be done in @ S/C TV
	TV test		view cold background in Class 100 environment