5. MECHANICAL INTERFACE REQUIREMENTS

5.1 STRUCTURAL / MECHANICAL

This section contains mechanical interface requirements for the payload instruments and the TIMED spacecraft. The mechanical responsibilities, concepts, and high-level mechanical interfaces (e.g. spacecraft coordinate systems definition and origin, surface flatness requirements, not-to-exceed mass allocation, force and torque limitations, caging requirements, etc.) are given in the body of this document. Much of the detailed mechanical interface information (e.g. instrument envelope, location of major components, spacecraft interface bolt hole locations and dimensions, spacecraft interface mounting hardware type, locations of spacecraft interface connectors, purge ports, optical cubes, thermal gaskets, fields-of-view, GSE access, etc.) will be defined in several drawings, each of which may contain several sheets. These drawings will be located in each instrument's SIIS.

5.1.1 Mechanical Responsibilities

APL is responsible for providing the locations to which the payload instrument is mounted. These locations will have bolt hole/inserts in the correct positions to mount the instruments and will provide the stiffness required to maintain the loads at the instrument baseplate at or below those in the TIMED Component Environmental Specification, and will meet the flatness specification given in this document. The instrument locations will also meet the thermal requirements given in Section 4.0. APL is responsible for providing all of the mounting hardware, except for washers to be used for thermally isolating instrument components from the spacecraft. APL is also responsible for mounting the instrument on the spacecraft.

APL is responsible for providing cutouts, panels and brackets of sufficient size to meet the dynamic envelope requirements of all instrument hardware, as specified in each instrument's SIIS. APL is responsible for providing an unobstructed path for the retained and ejectable doors. APL is responsible for providing access to the optical cube, purge ports, GSE test connectors and any arming plugs, as required. APL is responsible for measuring the alignment of the payload instrument alignment cubes and for adjusting the alignment to meet the requirements given in each instrument's SIIS.

APL is responsible for providing, routing, and mounting any spacecraft-instrument interface harness and for routing and mounting any intra-instrument harness that must be routed along the spacecraft structure.

Each IDT shall supply the applicable Interface Control Drawings, Procedures, and Tables for inclusion in the instrument SIIS's are shown in Table 5.1.1-1. APL shall provide general drawings of instrument locations in the SIIS. All dimensions and notes shall be in English units of measure.

TABLE 5.1.1-1

LIST OF INTERFACE CONTROL DRAWINGS, PROCEDURES AND TABLES TO BE SUPPLIED BY ALL IDT'S FOR INCLUSION IN EACH INSTRUMENT'S SIIS.

A) Full-sized Mechanical Interface Control Drawings which contain, at a minimum:

1) definition and origin of instrument reference coordinate system
2) instrument envelope information (include static and dynamic envelopes, actuator movements, envelopes for connectors, connector backshells, harness, harness bending radii, thermal blankets, etc.)
3) flight connector locations and identifications
4) test connector locations and identifications
5) location of purge connector(s)
6) location of pyro actuator(s)
7) optical cube mounting location and dimensions
8) handling fixture interfaces and lift point locations
9) dimensions, sizes, and tolerances of mounting bolt holes
10) mounting hardware and torque specifications
11) mounting interface surface preparations
12) alignment adjustment hardware locations
13) green tag items
14) size, location, material type, etc. of any thermal gaskets
15) heat pipe locations
16) critical harness routing requirements
17) special grounding provisions
    a) location of ground straps for electronic components
    b) location of ground straps for thermal blankets
18) location and size of instrument alignment pins

B) Fields-of-view / trajectory drawings, which contain at a minimum:

1) instrument FOV
2) instrument field of regard (FOR)
3) instrument optical clear field of view (CFOV) requirement
4) instrument radiator CFOV
5) envelope of possible trajectories for ejectable covers

C) Access drawings, which contain at a minimum:

1) size, volume, location, and dynamic envelope of instrument mounted GSE
2) location and description of any red tag items
3) access requirements for:
    a) purge ports
    b) test connectors

c) mounting instrument mounted GSE (i.e., external stimuli)
d) optical cubes
e) instrument maintenance

D) Tables, periodically updated, which contain mass, center of mass, and moments of inertia of the total instrument and itemized by component.

5.1.2 Instrument Mounting Concept

Instrument mounting concepts are described in each instrument's SIIS.

5.1.3 Reference Coordinate Systems

5.1.3.1 Spacecraft Reference Coordinate System

The coordinate system, shown in Figure 5.1.3.1-1, is a spacecraft-fixed, right-handed, rectangular coordinate system of order X,Y,Z. The spacecraft reference coordinate system is used as a reference for physical positioning within the spacecraft and for viewing angle for all instruments on the spacecraft. The X-Y plane is defined by the spacecraft-launch vehicle separation plane. The X-axis is defined as being parallel to the +Y side of the aft deck of the spacecraft and laying in the separation plane. The Y-axis is orthogonal to the X-axis and also lays in the separation plane. The Z-axis is the longitudinal centerline of the spacecraft body, and its origin is at the center of the launch vehicle-spacecraft separation plane, as defined by the spacecraft separation flange. The orthogonal coordinate system defined by the separation plane and the +Y side of the aft deck shall be mapped into a master spacecraft optical cube, which will be fastened to the spacecraft structure. This master cube shall then become the spacecraft coordinate system angular reference.

5.1.3.2 Instrument Component Reference Coordinate Systems

The payload instrument reference coordinate systems and origins shall be defined in the Mechanical Interface Control Drawings and included in each instrument's SIIS.

5.1.4 Instrument/Component Mounting

Instrument components shall not require assembly or disassembly to accomplish installation on, or removal from, the spacecraft.

5.1.4.1 Mounting Interface Description

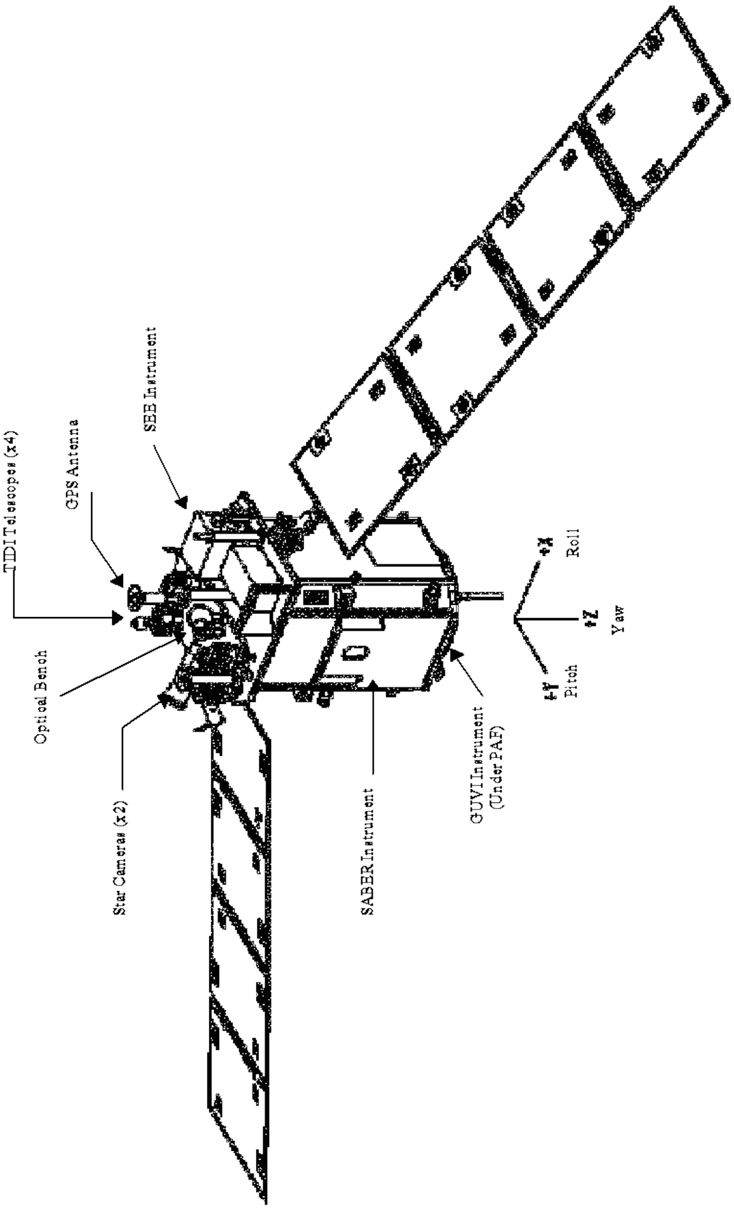
5.1.4.1.1 Instrument Mounting Locations

The mounting location of each payload instrument on the spacecraft is shown in Figure 5.1.3.1-1, and more specifically in the TIMED Spacecraft Panel Top Assembly Drawings in each instrument's SIIS.

5.1.4.1.1.1 Instrument Mounting Hardware

Payload instrument enclosures will be mounted with fasteners as given in the TIMED Spacecraft Panel Top Assembly Drawings. APL is responsible for providing the mounting hardware as specified in this drawing.

Fig. 5.1.3.1-1. TIMED Spacecraft Reference Coordinate System and Spacecraft Layout.



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5.1.4.1.1.2 Instrument Mounting Repeatability

All instruments which must be removed and replaced after optical axis alignment shall provide means of preserving alignment on repeated mountings, or having their alignments re-verified (e.g., via alignment cubes and possibly pinning). Instruments which could shift significantly during exposure to the launch environment shall have their mounting feet pinned to preclude such shifts. The method of preserving alignment shall be documented in each instrument's SIIS.

5.1.4.1.2 Instrument Bolt Hole Locations

The dimensions, locations and tolerances of the bolt holes on the payload instrument mounting plates are given in each instrument's SIIS.

5.1.4.1.3 Thermal Gaskets and Washers

Thermally conducting gaskets, as required, will be supplied by APL. Each IDT is responsible for providing the thermal isolation to be used for their instruments' thermally-isolated components. The physical characteristics and location of the thermal gaskets and washers will be documented in each instrument's SIIS.

5.1.4.1.4 Grounding Strap

Grounding straps which will ground the instrument to the spacecraft will be provided by APL. Ground straps which will be tied between instrument components and baseplate will be provided by the IDT. Ground straps for thermal blankets will be provided by the thermal blanket provider. These ground straps shall be documented within each instrument's SIIS.

5.1.4.2 Spacecraft Mounting Surface

The spacecraft will provide a planar mounting surface to which the payload instrument components are attached. The surface will be flat to less than 0.010 inches per foot, and to less than 0.015 inches across the entire mounting surface. The spacecraft's mounting surface shall be free of paint as discussed in section 2.2.2.2.

5.1.4.3 Payload Instrument Mounting Surface

Payload instrument components shall provide a planar surface for mounting to the spacecraft. The surface shall be flat to less than 0.015 inches across the longest span of the instrument. The surface roughness height rating shall not exceed 0.015 inches along the instrument's longest dimension. The instrument's mounting surface shall be free of paint as discussed in section 2.2.2.2.

5.1.5 Mass Properties

The "not-to-exceed" total mass allocation of the payload instruments, and the accuracies to which the mass properties must be measured (or calculated) are given in this section. A detailed listing of the individual component masses and moments of inertia, and the instrument's center of gravity is given in each instrument's SIIS.

5.1.5.1 Mass

Not-to-exceed masses for TIMED instruments are given in Table 5.1.5.1-1. Each instrument's mass, itemized by component, is given in the appropriate SIIS. Each component's mass will be measured to within ± 0.05 kg.

TABLE 5.1.5.1-1

TIMED INSTRUMENTS' NOT-TO-EXCEED MASSES

TIMED Instrument	Not-to-Exceed Mass (kg)
GUVI	20.17
SABER	64.78
SEE	27.9
TIDI	40.95

5.1.5.2 Center-of-Mass Location

The payload instruments' centers-of-mass, both in the launch and flight configurations, shall be determined and specified with respect to the instrument's coordinate system in each instrument's SIIS. The centers-of-mass locations will be calculated or measured to within ± 0.25 inches with respect to the instrument's reference coordinate system origin.

5.1.5.3 Moments of Inertia (MOI's)

The moments of inertia for the payload instruments in the launch configuration shall be determined by measurement or analysis in all three reference coordinate system axes to within ±5%. The MOI's are measured with respect to the instrument launch configuration center-of-mass.

The flight configuration MOI's shall be derived analytically from the launch configuration MOI's and should be given with respect to the instrument flight configuration center-of-mass. The MOI's should be given in all three reference coordinate system axes to within ±5%.

The moments of inertia for the payload instruments in the flight and launch configurations are given in each instrument's SIIS.

5.1.6 Envelopes and Fields-of-view

5.1.6.1 Static Envelope

Each payload instrument's static envelope is given within the instrument's Mechanical Interface Control Drawing contained in that instrument's SIIS. These drawings include envelopes for connectors, connector backshells, harness, harness bending radii, thermal blankets, actuator movements if appropriate, etc.

5.1.6.2 Dynamic Envelope

APL is responsible for providing the clear volume for the payload instruments dynamic envelopes. These dynamic envelopes are shown in each instrument's SIIS.

5.1.6.3 Integration and Test Access Requirements

Requirements given in this section apply only to spacecraft integration and subsequent testing. The location, clearance, and access requirements for electrical test connections, electrical test harness, purge connectors and lines, optical alignment cubes, and all test equipment that attaches directly to the payload instruments are given in the Instrument Access Drawings which are part of each instrument's SIIS. Instrument access drawings shall contain a separate sheet for each of the different test configuration required during spacecraft integration and test (i.e. thermal vacuum).

5.1.6.4 Payload Instrument Fields-of-view

The primary active field-of-view requirements of the payload instruments are contained in each instrument's SIIS. The information shall include location and size of apertures, boresight directions, instantaneous fields-of-view and fields-of-regard. The glint-free or clear fields-of-view shall also be provided as required.

5.1.6.5 Thermal Radiator Fields-of-View

The fields-of-view of each payload instrument's thermal radiators are contained in each instrument's SIIS. IDT's shall provide detailed drawings which fully define the thermal radiator field-of-view.

5.1.6.6 Ejectable Item Trajectory

The envelope of possible trajectories for the payload instruments employing ejectable covers shall be included in each instrument's SIIS. IDT's shall provide detailed drawings which fully define the possible ejection trajectories.

5.1.7 Payload Instrument Alignment Provisions

Establishment of initial instrument alignment shall be accomplished by dimensional control of the instrument mounting hole locations and/or other indexing schemes. The locations of the mating spacecraft mounting hardware shall be dimensionally controlled by configured drawings as specified in Section 5.1.4.1.1. If alignment requirements are tighter than can be achieved by dimensional control, then alignment adjustment capability must be provided.

5.1.7.1 Alignment Position Requirement

The requirement for aligning each instrument with respect to the spacecraft coordinate system will be documented within each instrument's SIIS. The initial alignment value, and the allowable tolerance for the initial alignment, shall be stated within each instrument's SIIS.

5.1.7.2 Alignment Knowledge Requirement

The accuracy with which each payload instrument shall be mapped shall be given in each instrument's SIIS. The accuracy shall be subdivided into mapping error allocations due to the instrument level mappings and the spacecraft level mappings. The instrument error budget shall include knowledge of boresight orientation, instabilities due to thermal and mechanical distortions, and mapping technique errors. The spacecraft error budget shall include knowledge of spacecraft coordinate system, attitude determination errors, thermal and mechanical spacecraft distortions, and optical mapping errors.

5.1.7.3 Optical Alignment Cube

Payload instruments requiring precision alignment or alignment knowledge shall be equipped with an optically reflective cube. APL is responsible for providing each IDT with all required optical alignment cubes. Optical alignment cubes (0.750 +/- 0.020 inches per side) shall have all edges beveled with a 1 mm maximum bevel. Material is to be fused silica or Zerodur or equivalent. The cube shall have five faces polished to 1/10 wave flatness at 633 nm wavelength, and coated with aluminum with SiO protective overcoat. The surface quality of five coated surfaces (scratch and dig spec.) is to be 80-50. The sixth surface is to be left fine ground, uncoated, and parallel to opposite face to within 1 arc minute. The included angles between the five coated surfaces is to be 90 degrees +/- 10 arc seconds. The cubes shall be calibrated so their orthogonality is measured to within 1 arc second accuracy.

Optical cubes will be permanently affixed to the instrument by the IDT prior to delivery of the instrument for spacecraft integration and test. The preferred adhesive for attachment of the cube is 3M 2216 clear epoxy. Underlying structure of the mounting shall have a coefficient of thermal expansion which, along with the temperature extremes expected for the cube, shall not cause the cube to break due to differential thermal expansion. The boresight orientation of the instrument shall have been mapped into the cube before delivery of the instrument to APL.

5.1.7.4 Optical Alignment Cube Location

Alignment cubes shall be located on the instrument component such that two faces are accessible for direct viewing by a theodolite mounted external to the spacecraft when the component is installed on the spacecraft and the spacecraft is configured for integration. Installation location and orientation of the optical cube(s) is given in each instrument's SIIS. Preferably, the cube will be oriented so that it is aligned with the instrument's coordinate system within 0.1 degrees. One face of the cube shall be oriented so its normal vector is nominally aligned with the instrument's boresight. The optical cube location on the instruments must be approved by APL, and will be documented within the instrument's SIIS's. APL is responsible for providing viewing paths for instrument alignment cubes.

5.1.8 Mechanisms, Moving Parts, and Dynamics

Instrument components employing moveable mechanisms shall be designed to minimize disturbances on the spacecraft. Moveable mechanisms, their operation and possible effect on the spacecraft shall be defined by the IDT and documented in the instrument specific SIIS documents.

5.1.8.1 Operation

Operation of mechanisms shall produce minimal effects on the static and/or dynamic performance and characteristics of the spacecraft. Dynamic forces and torques induced at the component mount shall be described and recorded in each instrument's SIIS and shall comply with the limits specified within the GIIS.

5.1.8.1.1 Non-recurring Transient Events

The forces, torques, and/or total momentum imparted to the spacecraft by each non-recurring transient event shall be defined by each IDT and will be documented within each instrument's SIIS. Once any force or torque has been identified, the IDT must seek APL approval for that force or torque.

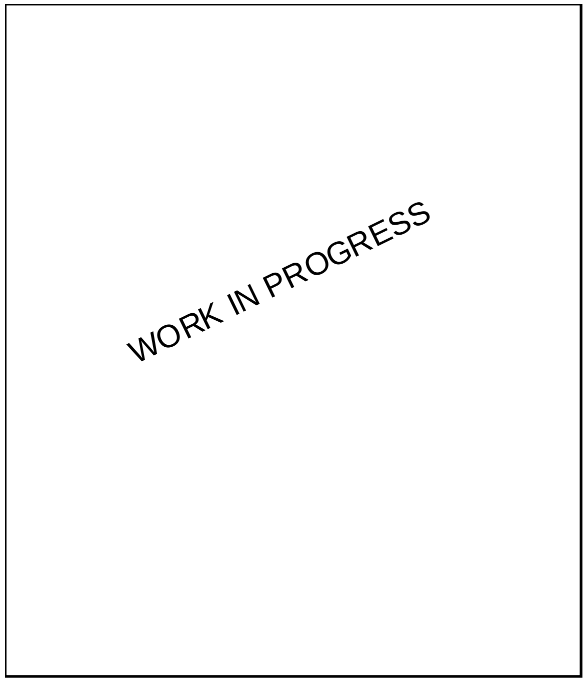
5.1.8.1.2 Recurring Forces and Torques (Spectra)

No instrument shall exert a torque in excess of **<TBD>** N-m root-mean-square on each axis. Instrument-generated disturbance torques at the component mount shall be defined by the IDT's and documented in each instrument's SIIS and are subject to APL's approval. IDT's must provide torque versus time profiles in order for APL to perform a jitter analysis. Figure 5.1.8.1.2-1 shows the spectrum of the maximum allowable net torque for *all* of the payload instruments taken together.

5.1.8.2 Caging

Caging is a locking mechanism used to hold a component in a fixed position during launch. Mechanisms requiring caging shall not require power to maintain the caged condition. Each IDT shall list all components that require caging and document them in each instrument's SIIS. If caging is not required, the IDT shall provide an analysis justifying that decision.

Figure 5.1.8.1.2-1. Spectrum of the maximum allowable net torque exerted by all payload instruments.



5.1.9 Component Harness Routing and Tie Points

5.1.9.1 Intra-Instrument Harness

Each IDT is responsible for providing all intra-instrument harnesses and for providing the routing and tie downs for all intra-instrument harnesses that are completely contained within the instrument envelope. APL is responsible for the routing and tie downs of any intra-instrument harnesses that must be routed along the spacecraft structure.

5.1.9.2 Spacecraft / Instrument Interface Harness

APL is responsible for providing, routing, and tying down all spacecraft-instrument interface harnesses. Any interface harness routing along a payload instrument structure will be mutually agreed to by the IDT's and APL.

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

Protective covers (flight and non-flight) associated with the payload instruments shall be documented by the IDT's and included in the appropriate interface drawings within each instrument's SIIS. Non-flight covers required during spacecraft integration and handling operations shall be bright red in color (or red-tagged) and clearly marked “Remove Before Flight”. Flight covers shall not produce damaging in-orbit debris when opened. "Install Before Flight" flight covers shall be colored green or have a green tag attached to them.

5.1.10.1 Arming Plugs

Arming plugs shall be handled as "Green Tag" items. These are APL's responsibilities.

5.1.10.2 Structural Model

The IDT's shall provide an analytic instrument structural model in accordance with agreements made with the spacecraft design team. Typically, this model shall consist of fewer than 1000 nodes, but shall be decided on a case-by-case basis in consultation with the spacecraft structural engineer.

5.2 PAYLOAD INSTRUMENT IDENTIFICATION AND MARKING

All flight hardware, including the payload instruments, shall be marked with appropriate (AXXX) identification. The markings shall be permanent, resistant to chipping and located away from points of physical wear. Interface connectors shall be clearly labeled. (AXXX-JXX). These “A” numbers shall be supplied by the spacecraft design team and documented in each instrument's SIIS.

5.3 PAYLOAD INSTRUMENT MAINTAINABILITY

The maintainability guidelines presented below shall be considered to the extent practical during all design efforts.

a) Instrument components should avoid projecting parts which may be easily damaged during handling.
b) Components should be configured to stand alone in a stable manner.
c) All design components which may be inadvertently reversed or misaligned during integration should be keyed.
d) Instruments shall be designed to prevent ESD malfunctions caused by normal space laboratory handling and integration practices.