**Instrument Support Structure**



**to Science Instruments**

**Interface Control Document**

**ICD** **1.5.3/1.9**

**Issued By: Project Support Department**

|  |  |
| --- | --- |
| **Approval required by:** | |
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Version Control

| REVISION CHART | | | |
| --- | --- | --- | --- |
| Version | Author(s) | Description of Version | Date Completed |
| A | David Montgomery | Initial Version | April 22, 1997 |
| B | Unknown | References to instrument cables routing now are in the ICD 1.9/3.6. The drawing GP-1000-0004 showing allowable instrument envelopes was modified, giving more room at the ISS interface | Unknown |
| C | Manuel Lazo, Gabriel Perez, Madeline Close | (1) Updated reference drawings and removed unnecessary drawings.  (2) Removed information about the Gemini Standard Thermal Electronics Enclosures which will not be supplied to future instruments (and related ICD 1.9/3.7 will no longer be supplied either).  (3) Updated M12 fastener torque load to align with ICD-G0015.  (4) Removed example in Allowable Out of Balance.  (5) Added section addressing vibration.  (5) Updated optical interface specification.  (6) Added information about Gemini ballast weight system.  (7) Updated Thermal Control section to clarify the specifications. | October 17, 2014 |
| D | Madeline Close | (1) Incorporated ICD-derived requirements at end of document  (2) Edit section on vibrations  (3) Remove standards now included in Instruments Common Requirements and Standards document. | April 07, 2016  CR-16 2492 |
| E | Jeff Radwick | (1) Added rationales for all requirements in this ICD.  (2) Changed some verification methods.  (3) Added the statement “with a goal of 2000kg.” to ISS.1.6 Mass. This serves to minimize the need to add mass at the telescope to a science instrument. | 18 July 2018 |

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Table 1: Interface Plane Position 6

1. Description

This document defines the interface features between the science instruments and the Instrument Support Structure, which are under formal control. In addition to fastener features and detail, the position and size of ports through which the telescope or calibration beams can be directed are defined. The port detail is defined to assure the fitting of light tight baffles to the interface. The optical interface, space envelope, allowable mass and center of gravity, and thermal and vibration specifications for instruments are also defined.

* 1. Acronyms and Abbreviations

CofG Center of Gravity

CRCoS Cassegrain Rotator Coordinate System

ISS Instrument Support Structure

1. References

|  |  |
| --- | --- |
| Reference Name | Reference Description |
| [ISS Vibration Mitigation](http://dmt.gemini.edu/docushare/dsweb/View/Collection-63159) | DMT collection containing data and results from vibration investigations done at Gemini North and Gemini South. |

|  |  |  |  |
| --- | --- | --- | --- |
| Drawing Number | Vers. | Drawing Name | Description |
| [89-GP-1000-0003](http://dmt.gemini.edu/docushare/dsweb/View/Collection-69277)  1 sheet | A | CASSEGRAIN ROTATOR COORDINATE SYSTEM | Defines the rotator coordinate system relative to the optical instrument support coordinate system |
| [89-GP-1000-0004](http://dmt.gemini.edu/docushare/dsweb/View/Collection-69277)  1 sheet | E | AVAILABLE CASSEGRAIN INSTRUMENT SPACE | Describes the space available for instruments attached to the ISS |
| [89-GP-1000-4001](http://dmt.gemini.edu/docushare/dsweb/View/Collection-69301)  4 sheets | E | BALLAST WEIGHT ASSEMBLY | This is the drawing for a ballast weight assembly, as an example. |
| [89-GP-1000-4002](http://dmt.gemini.edu/docushare/dsweb/View/Collection-69301)  3 sheets | E | BALLAST WEIGHT SUPPORT STRUCTURE, TYPE 1 | This is the drawing for a ballast weight frame, as an example. |
| [89-GP-1000-3001](http://dmt.gemini.edu/docushare/dsweb/View/Collection-69302) 2 sheets | D | INSTRUMENTATION SUPPORT STRUCTURE ASSEMBLY | This is the assembly drawing of the Instrumentation Support Structure |
| [89-GP-1000-3002](http://dmt.gemini.edu/docushare/dsweb/View/Collection-69302) 6 sheets | E | INSTRUMENT SUPPORT STRUCTURE BODY | These are the shop drawings of the support structure body |
| [89-GP-1000-3003](http://dmt.gemini.edu/docushare/dsweb/View/Collection-69302)  2 sheets | C | INSTRUMENT SUPPORT STRUCTURE BASE | These are the shop drawings of the support structure base. |

1. Instrument Builder Statement of Responsibility

The instrument builder is responsible for providing the frame to interface with the ISS, for providing sufficient weight and design of weights for balancing purposes, and for generally ensuring the instrument is compatible with the specifications provided in this document. Gemini can provide details on the standard ballast weight systems used for visiting instruments.

1. Physical Interfaces
   1. Mechanical Interfaces

There are three science instrument positions on the ISS. The mechanical interfaces are provided on faces 1, 3 and 5. Faces 3 and 5 are called `side looking' while face 1 is `upward looking' (a reference while pointing towards zenith). They may also be referred to as the ‘side ports’ and ‘bottom port’ respectively. The mechanical interface between the science instruments and the ISS consists of a set of circular raised machined bosses. The bosses are coplanar and each provides one central locating hole and Pitch Circle Diameter of tapped holes for fasteners. Each instrument is expected to use a subset of the bosses depending on its size and configuration[[1]](#footnote-1).

The interface boss detail is shown on drawing 89-GP-1000-3002 for Ports 3 and 5, and on drawing 89-GP-1000-3003 for Port 1.

Suggested Verification: Inspection

* + 1. Allowable Loads on Instrument Mount Bosses

These loads must not be exceeded and must include induced clamping loads (un-even interface surfaces) as well as gravity-induced loads[[2]](#footnote-2).

* Tension: 10,000N
* Shear: 10,000N
* Moment: 1,000Nm
  + 1. Fastener Loads

The M12 fasteners shall be torqued to 68 N-m (50 ft-lb).[[3]](#footnote-3) The design of the instrument mechanical interface shall ensure the induced loads in the fasteners will not exceed 80% of this value for any load condition[[4]](#footnote-4).

* + 1. Theoretical Position of Mech. Interfaces w.r.t Cassegrain Rotator Coordinate System

The theoretical (perfect) position for the interfaces can be defined in terms of theCRCoS as follows:

Table 1: Interface Plane Position

|  |  |  |
| --- | --- | --- |
| Face | Parallel with | Perpendicular distance from origin,  normal to plane (mm) |
| 1 | XY | Z = -1,600 |
| 3 | XZ | Y = 800 |
| 5 | XZ | Y = -800 |

* + 1. Space Envelope

The allowable space envelope is defined by considering safe clearances to the telescope structure, Cassegrain rotator and cable wrap. Additional constraints are placed by the requirement to be able to operate instruments on any of the upward or side looking ports. Further restrictions are dictated by operational considerations, handling and personnel access. The space envelope allowed for instruments is shown on drawing 89-GP-1000-0004. This space envelope must include the instrument electronics and thermal enclosure(s)[[5]](#footnote-5). Extension into the ISS (such as to add an entrance shutter) will require a waiver of the space envelope and must be coordinated with the Gemini Development Division.

The space envelopes on the drawing 89-GP-1000-0004 are represented by dotted and solid lines. The solid lines are ‘hard’ limits in the sense that they are defined by fixed parts of the telescope structure and therefore cannot be compromised. The dotted lines represent limits dictated by access and ease of handling considerations. In principal they can be violated but doing so will cause some difficulty and therefore this must only be done after agreement with the Gemini Development Division.

* + 1. Mass and Center of Gravity (CofG)

The weight on the ISS science instrument port faces (1,3 and 5) must be trimmed to be 2,000kg[[6]](#footnote-6) with a CofG located 1,000 mm out from the ISS mechanical interface. The CofG position, when projected perpendicularly onto the mechanical interface plane shall be central to the science port.[[7]](#footnote-7) This must include the thermal electronics enclosure(s) and all cabling/services connections. Gemini has standard and long ballast weight systems for visiting instruments and can provide drawings of the structures. The ballast weight structures are empty frames upon which to mount instruments and add weight. The moveable ballast weights include metal plates and disks in multiple sizes.

* + 1. Out of Balance

In any orientation of the telescope or rotator, the out of balance caused by the instrument must not exceed 500Nm with respect to the telescope elevation axis. This will include static imbalance and any change in mass moment due to moving elements or LN2 boil-off/topping up.[[8]](#footnote-8)

* + 1. Vibrations

To address vibration issues, during the early design stages of ISS-mounted instruments, Gemini mechanical engineers will work closely with the instrument build team to provide information and access to Gemini vibration and FEA data, analysis and reports. The end goal will be to determine the vibration constraints for the instrument. [[9]](#footnote-9)

* 1. Optical Interface

The optical interface for the instruments is a circular port 400mm in diameter through which the telescope or calibration beam can be directed. The port is central to the ISS face and the beam emerges perpendicular to the interface plane. A machined land is provided to make a light tight seal with the instrument. When mounted on the ISS, the instrument shall accept the Gemini

telescope beam.[[10]](#footnote-10) Fastener detail for mounting a baffle component can be provided as needed.

* + 1. Face 1 Port Position

The port center is at (in mm) X = 0, Y = 0, Z = -1595, the machined land is parallel to the XY plane at Z = -1595 mm.

* + 1. Face 3 Port Position

The port center is at (in mm) X = 0, Y = -795, Z = -800, the machined land is parallel to the XZ plane at Y = -795 mm.

* + 1. Face 5 Port Position

The port center is at (in mm) X = 0, Y = 795, Z = -800, the machined land is parallel to the XZ plane at Y = 795 mm.

* + 1. Optical Alignment

Differential temperature effects between the ISS and instrument shall not impact the instrument optical alignment, and the different materials composing the ISS and instrument should be considered.[[11]](#footnote-11)

* 1. Electrical Interface

There are no electronic connections between the instruments and the ISS. However, the allowable space envelope for instrument structure takes into consideration access to the connector panels on the Cassegrain cable wrap. These services are defined and controlled by ICD 1.9/3.6 Science Instruments to ISS System Services.

* 1. Thermal Interface

The heat released by each instrument must be controlled to reduce telescope `seeing' and to avoid distortion of the optics and support structures. To this end, the instrument electronics will be located in insulated and thermally conditioned enclosures. It is important that the enclosures also be sealed as condensation and ice may build up on the heat exchangers if the system is open to ambient air during periods of high humidity.

* + 1. Allowable Unconditioned Heat Released from Instrument

The total heat released to the environment by the instrument including the thermal electronics enclosure(s) shall not exceed 100W as a threshold and 50W as an objective value.[[12]](#footnote-12) Individual elements exposed to the environment shall not attain a temperature 2°C above ambient.[[13]](#footnote-13)

* + 1. Allowable Unconditioned Heat into ISS

The instrument may have a number of mechanisms and detector assemblies in close proximity to the telescope beam. In some cases, the instrument/ISS assembly comprises a volume, which is not well ventilated. The limit conducted from the instrument into the ISS structure shall not exceed 50W.[[14]](#footnote-14)

1. Software Interface

There is no software interface between the instruments and the ISS.

Appendix A: ISS Interface Requirements

The Instrument as it is referred to below, shall include the set of components and ancillary equipment necessary to mount and operate the instrument on the ISS. This includes subsystems, enclosures, frames, weights, coolant, connectors, cabling, etc.

## Mechanical Interface

### Instrument Mount Bosses

The instrument shall use a subset of the ISS mechanical bosses for ISS mounting as defined in drawings 89-GP-1000-3002 and 89-GP-1000-3003.

Suggested Verification Method: Inspection

### Loads on Instrument Mount Bosses

When mounted on the ISS, the instrument shall not exceed loading on the instrument mount bosses of 10,000N in Tension, 10,000N in Shear and 1,000N-m in Moment under any loading conditions.

Rationale: Structural and material limits of the ISS, specifically the instrument

bosses.

Suggested Verification Method: Analysis

### Instrument Fastener Torqueing

The instrument M12 fasteners shall be torqued to 68 N-m (50 ft-lb).

Rationale: It is not acceptable to put large side forces on the M12 tapped. fastener holes on the ISS or the 30mm diameter position defining hole during the mounting process. This could cause damage (up to and including stripping of the internal threads of the instrument mount bosses) or rapid wear to the ISS that would be very difficult and costly to repair and is potentially dangerous.

Suggested Verification Method: Inspection, Analysis

### Loads on Instrument M12 Fasteners

When mounted on the ISS, the instrument shall not exceed loading on the instrument M12 fasteners of 54 N-m (40 ft-lb) under any loading conditions.

Rationale: So as to not exceed tension and shear limitations on the instrument bosses.

Suggested Verification Method: Analysis

### Space Envelope

When mounted on the ISS, the instrument shall not violate the space envelope as defined in drawing 89-GP-1000-0004.

Rationale: To prevent mechanical interference with other instruments and telescope systems, and to allow sufficient clearance for access to and handling of the instrument.

Suggested Verification Method: Inspection (of the drawings/model of the instrument, as well as measurement upon instrument arrival)

### Mass

The instrument mass shall not exceed 2000kg, with a goal of 2000kg.

Rationale: Structural limits of the ISS, specifically the instrument bosses. When mounted on the ISS, the instrument shall not exceed loading on the instrument mount bosses of 10,000N in Tension, 10,000N in Shear and 1,000N-m in Moment under any loading conditions.

Suggested Verification Method: Inspection

### Center of Gravity Location

When mounted on the ISS, the instrument center of gravity shall be located at the point of intersection of the plane parallel to ISS mounting face elevated 1000 mm above surface and science port central axis.

Rationale: Rationale: Minimize forces and torques on the ISS to avoid exceeding 1,000N-m in Moment in any direction.

Suggested Verification Method: Analysis, Inspection

### Out of Balance

When mounted on the ISS, the instrument shall not cause out of balance in excess of 500Nm with respect to the telescope elevation axis, in any orientation of the telescope or rotator.

Rationale: Minimize forces and torques on the ISS to avoid exceeding 1,000N-m in Moment in any direction.

Suggested Verification Method: Analysis, Test

### Induced Vibrations in ISS

The instrument shall not transmit vibrations with PSD exceeding XX at frequencies from XX - XX Hz. The vibration constraint for a specific instrument will be determined early in the Design Phase.

Rationale: Vibrations transmitted from the instrument to the ISS have the potential to impact science on other instruments and on itself. It is a complex problem to directly quantify the maximum allowable vibration. GPI at GS provides one example of vibrations that required remedial work. The GPI cryocoolers are a source of 60 Hz vibrations that couple into the mirror cell and primary mirror, producing a focus-like variation in the wavefront of about 4.35E-4 g2/Hz at 60 Hz, significantly degrading the instrument performance [from arXiv:1407.7893v1]. An active cancellation system installed on the cryocoolers reduced the 60 Hz power by almost two orders of magnitude. Another example, at GN, is that the GNIRS instrument cryocoolers excite a 12 Hz resonance in the primary mirror support structure, causing oscillations in tilt in the image delivered to the focal plane. Many factors must be considered including (but not limited to) cryocooler use, type, and mounting; other vibration sources; vibration mitigation techniques; and the gravity variant environment.

Suggested Verification Method: Test

## Optical Interface

### Instrument Optical Interface

When mounted on the ISS, the instrument shall accept the Gemini telescope beam.

Rationale: The nominal telescope F/16 focus is 300mm from the mechanical interface of the ISS. The plate scale at focus corresponds to 1.611 arc seconds per mm. The ports are detailed on drawings 89-GP-1000-3001, 89-GP-1000-3002, and 89-GP-1000-3003.

Suggested Verification Method: Test

### Instrument Optical Interface

When mounted on the ISS, the instrument optical alignment shall not be impacted by differential temperature effects between the ISS and the instrument.

Rationale: Differential temperature effects (CTE mismatch) must not affect pointing.

Suggested Verification Method: Analysis, Test

## Thermal Interface

### Heat Released into Dome Environment

The instrument shall not release heat to the dome environment in excess of 100W, with a goal of 50W.

Rationale: The telescope environment should be free (or brought to the lowest level achievable) of thermal contamination, 100W is the maximum allowable heat for the whole instrument. This is required to avoid thermal gradients that affect the image quality of the telescope.

Suggested Verification Method: Analysis

### Instrument Temperature

The instrument shall not have exposed components with a temperature greater than 2 degrees Celsius above the dome ambient temperature.

Rationale: This is required to avoid thermal gradients that affect the image quality of the telescope. 2 degrees of temperature delta has an appreciable impact on the seeing of the telescope environment.

Suggested Verification Method: Analysis

### Heat Released into ISS Environment

The instrument shall not release heat into the ISS internal environment in excess of 50W.

Rationale: The ISS cube is a more demanding environment in terms of heat

load, because it is close to the optical beam of the telescope, max 50W shall be

the allowed limit. This also should be included in the thermal load error budget.

Suggested Verification Method: Analysis

1. REQ ISS.1.1 [↑](#footnote-ref-1)
2. REQ ISS.1.2 [↑](#footnote-ref-2)
3. REQ ISS.1.3 [↑](#footnote-ref-3)
4. REQ ISS.1.4 [↑](#footnote-ref-4)
5. REQ ISS.1.5 [↑](#footnote-ref-5)
6. REQ ISS.1.6 [↑](#footnote-ref-6)
7. REQ ISS.1.7 [↑](#footnote-ref-7)
8. REQ ISS.1.8 [↑](#footnote-ref-8)
9. REQ ISS.1.9 [↑](#footnote-ref-9)
10. REQ ISS.2.1 [↑](#footnote-ref-10)
11. REQ ISS.2.2 [↑](#footnote-ref-11)
12. REQ ISS.3.1 [↑](#footnote-ref-12)
13. REQ ISS.3.2 [↑](#footnote-ref-13)
14. REQ ISS.3.3 [↑](#footnote-ref-14)