CII Mechanical Guidelines

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Interface Assumptions

- During the matching process, the Host Spacecraft Manufacturer/ Systems Integrator and the Instrument Developer will negotiate detailed parameters of the mechanical interface. The Mechanical Interface Control Document (MICD) will record those parameters and decisions.
- The Host Spacecraft will accommodate fields-of-view (FOV) that equal or exceed the Instrument science and radiator requirements.
- The Host Spacecraft Contractor will furnish all Instrument mounting fasteners.

Mechanical L1 Guidelines

ID	Function	Guidelines	Rationale/Comment
2.2.7.13	Instrument Models	The Instrument Developer should submit finite element, thermal math, mechanical computer aided design, and mass models of the Instrument to the Host Spacecraft manufacturer/ integrator.	The Host Spacecraft manufacturer/integrator requires models of all spacecraft components in order to complete the design portion of the spacecraft lifecycle.

Mechanical L1 Guidelines

ID	Function	Guidelines	Rationale/Comment
2.2.7	Mechanical Interface	The Instrument *should* be capable of fully acquiring science data when directly mounted to the Host Spacecraft nadir deck.	Assessments of potential LEO Host Spacecraft and the responses to the *CII RFI for GEO Hosted Payload Opportunities* indicate nadir-deck mounting of hosted payloads can be accommodated. Alternative mechanical interface locations or kinematic mounts are not prohibited by this guidance but may increase interface complexity.

Mechanical L1 Guidelines

ID	Function	Guidelines	Rationale/Comment
2.2.8	Mechanical Accommodation	[LEO] The Instrument mass *should* be less than or equal to 100kg.	Analysis of the NICM database indicates that a 100kg allocation represents the upper bound for potential hosted payloads
		[GEO] The Instrument mass *should* be less than or equal to 150kg.	Analysis of the responses to the CII RFI for GEO Hosted Payload Opportunities indicate an Instrument of up to 150kg can be accommodated with minimal impact to existing spacecraft design and function. Instruments exceeding 150kg can be accommodated but may require additional resources to address growing impacts to existing designs.

Mechanical L2 Guidelines

ID	Function	Guidelines	Rationale/Comment
6.2.1	Functionality in 1 g Environment	The Instrument *should* function according to its operational specifications in any orientation while in the integration and test environment.	As a hosted payload, the Instrument will attach to one of multiple decks on the Host Spacecraft. Its orientation with respect to the Earth's gravitational field during integration and test will not be known during the Instrument design process. The function of the Instrument and accommodation of loads should not depend on being in a particular orientation.

Mechanical L2 Guidelines

ID	Function	Guidelines	Rationale/Comment
6.2.2	Stationary Instrument Mechanisms	The Instrument *should* cage any mechanisms that require restraint, without requiring Host Spacecraft power to maintain the caged condition, throughout the launch environment.	As a hosted payload, the Instrument should not assume that the Host Spacecraft will provide any power during launch.

Mechanical L2 Guidelines

ID	Function	Guidelines	Rationale/Comment
6.3.1	Dimensions	[LEO] The Instrument and all of its components *should* remain within the detailed Instrument envelope of 400mm x 500mm x 850mm (HxWxL) during all phases of flight.	Engineering analysis determined guideline payload volume based on mass guidelines and comparisons to spacecraft envelopes in the NASA Rapid Spacecraft Development Office (RSDO) catalog.
		[GEO] The Instrument and all of its components *should* remain within the detailed Instrument envelope of 1000mm x 1000mm x 1000mm (HxWxL) during all phases of flight.	Engineering analysis determined guideline payload volume based on mass guidelines and comparisons to spacecraft envelopes in response to the *CII RFI for GEO Hosted Payload Opportunities and Accommodations.*

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.6.1	Documentation of Coordinate System	The MICD will document the Instrument Reference Coordinate Frame.	To ensure there is no ambiguity between Instrument and spacecraft manufacturers regarding the Instrument Reference Coordinate System.
9.3.5.1	Documentation of Mounting	The MICD will document the mounting interface, method, and geometry, including dimensions of the holes for mounting hardware.	To ensure no ambiguity of mounting interface between Instrument and spacecraft.

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.5.2	Documentation of Instrument Mounting Location	The MICD will document the mounting location of the Instrument on the Host Spacecraft.	To ensure no ambiguity of mounting location on spacecraft.
9.3.3.1	Envelope	The MICD will document the Instrument component envelope (including kinematic mounts and MLI) as “not to exceed” dimensions.	Defines the actual maximum envelope within which the Instrument resides.

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.3.2	Mass	[LEO] The MICD will document the mass of the Instrument, measured to ± 1%. [GEO] The ICD will document the mass of the Instrument, measured to less than 0.2%.	To ensure that accurate mass data is provided for analytic purposes.
9.3.6.6	Pointing Accuracy, Knowledge, and Stability	The MICD will document the Host Spacecraft's pointing accuracy, knowledge, and stability capabilities in order for the Instrument to meet its operational requirements.	To establish that spacecraft's pointing accuracy, knowledge and stability specifications meet requirements of Instrument operation.

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.1	Minimum Fixed-Base Frequency	The Instrument *should* have a fixed based frequency greater than 50 Hz.	This minimum fixed-based frequency exceeds the composite guidance of publically available Launch Vehicle Payload Planner's Guidebooks as applicable to primary spacecraft structures operating in both LEO and GEO regimes. To some extent, the Instrument will affect the spacecraft frequency depending on the payload's mass and mounting location. Spacecraft Manufacturers may negotiate for a greater fixed-based frequency for hosted payloads until the maturity of the Instrument can support Coupled Loads Analysis.

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.4.1	Documentation of Dynamic Envelope or Surfaces	The MICD will document the initial and final configurations, as well as the swept volumes of any mechanisms that cause a change in the external envelope or external surfaces of the Instrument.	To define variations in envelope caused by deployables.
9.3.4.2	Documentation of Dynamic Mechanical Elements	The MICD will document the inertia variation of the Instrument due to movable masses, expendable masses, or deployables.	Allows spacecraft manufacturer to determine the impact of such variations on spacecraft and primary payload.

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.5.6	Kinematic Mounts	The Instrument Provider *should* provide all kinematic mounts.	If the Instrument requires kinematic mounts, they should be the responsibility of the Instrument Provider due to their knowledge of the Instrument performance requirements.

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.2	Mass Centering	The Instrument center of mass *should* be less than 5 cm radial distance from the instrument vertical axis, defined as the center of the Instrument mounting bolt pattern.	Engineering analysis determined guideline Instrument mass centering parameters based on comparisons to spacecraft envelope in the *STP-SIV Payload User's Guide*.
		The Instrument center of mass *should* be located less than 1/2 the instrument's height above the Instrument mounting plane.	Engineering analysis determined guideline Instrument mass centering parameters based on comparisons to spacecraft envelope in the *STP-SIV Payload User's Guide.*

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.3.3	Center of Mass	[LEO] The MICD will document the launch and on-orbit centers of mass of each Instrument, references to the Instrument coordinate axes and measured to ±5mm. [GEO] The MICD will document the launch and on-orbit centers of mass of each Instrument, referenced to the Instrument coordinate axes and measured to ±1mm.	To ensure that accurate CG data is provided for analytic purposes.

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.3.4	Moment of Inertia	[LEO] The MICD will document the moments of inertia, measured to less than 10%. [GEO] The MICD will document the moments of inertial, measured to less than 1.5%.	To ensure that accurate moments of inertia data is provided for analytic purposes.
9.3.3.5	Constraints on Moments of Inertia	The MICD will document the constraints to the moments and products of inertia available to the Instrument.	To define the inertial properties envelope within which the Instrument may operate and not adversely affect spacecraft and primary Instrument operations.

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.4.3	Caging During Test and Launch Site Operations	Instrument mechanisms that require caging during test and launch site operations *should* cage when remotely commanded.	To allow proper Instrument operation during integration and test.
		Instrument mechanisms that require uncaging during test and launch site operations *should* uncage when remotely commanded.	To allow proper Instrument operation during integration and test.
		Instrument mechanisms that require caging during test and launch site operations *should* cage when accessible locking devices are manually activated.	To allow proper Instrument operation during integration and test.

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.4.3 (Cont'd)		Instrument mechanisms that require uncaging during test and launch site operations *should* uncage when accessible unlocking devices are manually activated.	To allow proper Instrument operation during integration and test.
9.3.5.3	Metric Units	The MICD will specify whether mounting fasteners will conform to SI or English unit standards	Metric hardware not exclusively used industry wide. Choice of unit system likely will be set by spacecraft manufacturer.

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.5.4	Documentation of Finish and Flatness Guidelines	The MICD will document finish and flatness guidelines for the mounting surfaces.	To ensure no ambiguity of finish and flatness requirements at Instrument interface.
9.3.5.5	Drill Template Usage	The MICD will document the drill template details and serialization.	Drill template details will be on record.
		The Instrument Developer *should* drill spacecraft and test fixture interfaces using the MICD defined template.	A common drill template will ensure proper alignment and repeatability of mounting holes.

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.5.7	Fracture Critical Components of Kinematic Mounts	Kinematic mounts *should* comply with all analysis, design, fabrication, and inspection requirements associated with fracture critical components as defined by *Fracture Control Requirements for Spaceflight Hardware (NASA-STD-5019).*	Kinematic mount failure is a potential catastrophic hazard to the Instrument and the Host Spacecraft.

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.6.2	Instrument Interface Alignment Cube	If the Instrument has critical alignment requirements, the Instrument *should* contain an Interface Alignment Cube (IAC), an optical cube that aligns with the Instrument Reference Coordinate Frame.	To aid in proper alignment of the Instrument to the spacecraft during Integration and Test.
		The Spacecraft *should* contain an IAC that aligns with the Instrument Reference Coordinate Frame.	

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.6.3	Interface Alignment Cube Location	The Instrument Developer *should* mount the IAC such that it is visible at all stages of integration with the Spacecraft from at least two orthogonal directions.	Observation of IAC from at least two directions is required for alignment.
9.3.6.4	Interface Alignment Cube Documentation	The MICD will document the location of all optical alignment cubes on the Instrument.	To have a record of the IAC locations.
9.3.6.5	Instrument Boresight	The Instrument Developer *should* measure the alignment angles between the IAC and the Instrument boresight.	Since this knowledge is critical to the Instrument provider they should be responsible for taking the measurement.

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.7.1	Installation/ Removal	The Instrument *should* be capable of being installed in its launch configuration without disturbing the primary payload.	Primary payload safety.
		The Instrument *should* be capable of being removed in its launch configuration without disturbing the primary payload.	

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.7.2	Mechanical Attachment Points	The Instrument *should* provide mechanical attachment points that will be used by a handling fixture during integration of the Instrument.	The handling fixtures will be attached to the Instrument while in the Integration and Test environment.
		The MICD will document details of the mechanical attachment points used by the handling fixture.	To ensure handling fixture attachment points are properly recorded.

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.7.3	Load Margins	Handling and lifting fixtures *should* function according to their operational specifications at five (5) times limit load for ultimate.	All three load margins maintain personnel and Instrument safety.
		Handling and lifting fixtures *should* function according to their operational specifications at three (3) times limit load for yield.	
		Handling fixtures *should* be tested to two (2) times working load.	
9.3.7.4	Responsibility for Providing Handling Fixtures	The Instrument Provider *should* provide proof-tested handling fixtures for each component with mass in excess of 16 kg.	This guideline ensures personnel safety.

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.7.5	Accessibility of Red Tag Items	All items intended for pre-flight removal from the Instrument *should* be accessible without disassembly of another Instrument component.	Instrument safety.

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.7.6	Marking and Documentation of Test Points and Test Guidelines	All test points and I&T interfaces on the Instrument *should* be visually distinguishable from other hardware components to an observer standing 4 feet away.	Clear visual markings mitigate the risk that Integration and test personnel will attempt to connect test equipment improperly, leading to Instrument damage. Four feet exceeds the length of most human arms and ensures that the technician would see any markings on hardware he intends to connect test equipment to.

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.7.6 (cont'd)		The MICD will document all test points and test guidelines.	To ensure no ambiguity of Integration and Test interfaces and test points and to aide in developing I&T procedures.
9.3.7.7	Orientation Constraints During Test	The MICD will document Instrument mechanisms, thermal control, or any exclusions to testing and operations related to orientations.	This documents any exceptions to the 1 g functionality described in section 6.2.1.

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.7.8	Temporary Items	All temporary items to be removed following test *should* be visually distinguishable from other hardware components to an observer standing 4 feet away.	Any preflight removable items need to be obvious to casual inspection to mitigate the risk of them causing damage or impairing spacecraft functionality during launch/ operations.
		The MICD will document all items to be installed prior to or removed following test and all items to be installed or removed prior to flight.	To ensure no ambiguity of installed and/or removed items during Integration and Test through documentation.

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.7.9	Temporary Sensors	The Instrument *should* accommodate temporarily installed sensors and supporting hardware to support environmental testing. (Examples of these include acceleration sensors and thermal monitors.)	To facilitate environmental testing.
9.3.7.10	Captive Hardware	The Instrument Developer *should* utilize captive hardware for all items planned to be installed, removed, or replaced during integration, except for Instrument mounting hardware and MLI.	Captive hardware reduces the danger to the Host Spacecraft, Instrument, and personnel from fasteners dropped during integration.

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.7.11	Venting Documentation	The MICD will document the number, location, size, vent path, and operation time of Instrument vents.	This eliminates ambiguity regarding venting the Instrument and how it may pertain to the Host Spacecraft and primary Instrument operations.
9.3.7.12	Purge Documentation	The MICD will document Instrument purge guidelines, including type of purge gas, flow rate, gas purity specifications, filter pore size, type of desiccant (if any), and tolerable interruptions in the purge (and their duration).	This ensures compatibility of Instrument purging procedures with respect to the Host Spacecraft and primary Instrument.

Mechanical Best Practices

ID	Function	Guidelines	Rationale/Comment
9.3.7.13	Combined Structural Dynamics Analysis Results	The Spacecraft Manufacturer *should* furnish the combined structural dynamics analysis results to the respective Instrument Provider.	To ensure the combined structural dynamics does not impede Instrument operations.
9.3.7.14	Non-Destructive Evaluation	Kinematic mounts used on flight hardware *should* show no evidence of micro cracks when inspected using Non-Destructive Evaluation (NDE) techniques following proof loading.	To ensure kinematic mounts meet load requirements without damage.
		The MICD will document the combined structural dynamics analysis.	Record maintenance.

Summary of Mechanical Guidelines

- **2.0 Level 1 Design Guidelines**
  2.2.7 Mechanical Interface
  2.2.8 Mechanical Accommodation

- **6.0 Mechanical Level 2 Guidelines**
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  6.2.2 Stationary Instrument Mechanisms
  6.3.1 Dimensions

- **9.0 Reference Material / Best Practices**
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  9.3.2 Mass Centering
  9.3.3 Documentation of Mechanical Properties
    9.3.3.1 Envelope
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    9.3.3.3 Center of Mass
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    9.3.4.1 Documentation of Dynamic Envelope or Surfaces
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  9.3.5 Instrument Mounting
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    9.3.5.4 Documentation of Finish and Flatness Guidelines

Summary of Mechanical Guidelines

- **9.0 Reference Material / Best Practices (cont'd)**
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  - 9.3.5.6 Kinematic Mounts
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  - 9.3.6 Instrument Alignment
    - 9.3.6.1 Documentation of Coordinate System
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