SOFIA Science Instrument System Specification and ICD Requirements Verification Matrix Template

Document Number: SOF-NASA-REP-SV05-2057

Date: **4 November 2015**
Revision: -

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Revision History

Vertical bars in the margin of the page denote revisions to the document from the previous issue.

REV	DATE	DESCRIPTION	APPROVAL
-	11/4/2015	Initial release per OCCB-CCR-0552 to support SOFIA Third Generation Science Instrument Call	OCCB

1.0 Purpose and Scope

This document contains the SOFIA Science Instrument (SI) Requirements Verification Matrix Template to be used as a boilerplate for the development of individual SI verification matrices used for verification planning, tracking status, and recording compliance results of an instrument with the requirements contained within the *SOFIA Science Instrument System Specification* (SOF-AR-SPE-SE01-2028) and SOFIA Science Instrument Interface Control Documents (ICDs). This document is under configuration control by the SOFIA Program and is maintained by SOFIA Systems Engineering and Integration (SE&I).

This matrix template contains all verifiable requirements within the *SOFIA Science Instrument System Specification* and 15 SOFIA ICDs applicable to Science Instruments, and also contains the recommended verification methods(s), phasing, and activities for each requirement based on the engineering judgment and experience of the SOFIA Program with previous SI. Although this verification matrix template is a derivative document that lists all applicable SI requirements from multiple documents in a single document, SI Developers are responsible for first reviewing and becoming familiar with each requirements document (i.e. *SI System Specification* and ICDs) to understand the context and scope of the requirements.

Additional information about the verification and airworthiness processes for instruments can be found in the *SOFIA Science Instrument Developers' Handbook* (SCI-AR-HBK-OP03-2000), section 5.4 "Verification & Validation" and section 8 "Airworthiness Process".

2.0 SI Verification Process / Instructions for Use of the SI Verification Matrix

Figure 1 is a diagram of the verification process flow and Table 1 is a summary of the roles and responsibilities for the key participants and stakeholders of SI compliance verification.

Figure 1. SI Verification Process Flowchart (View 1 of 3)

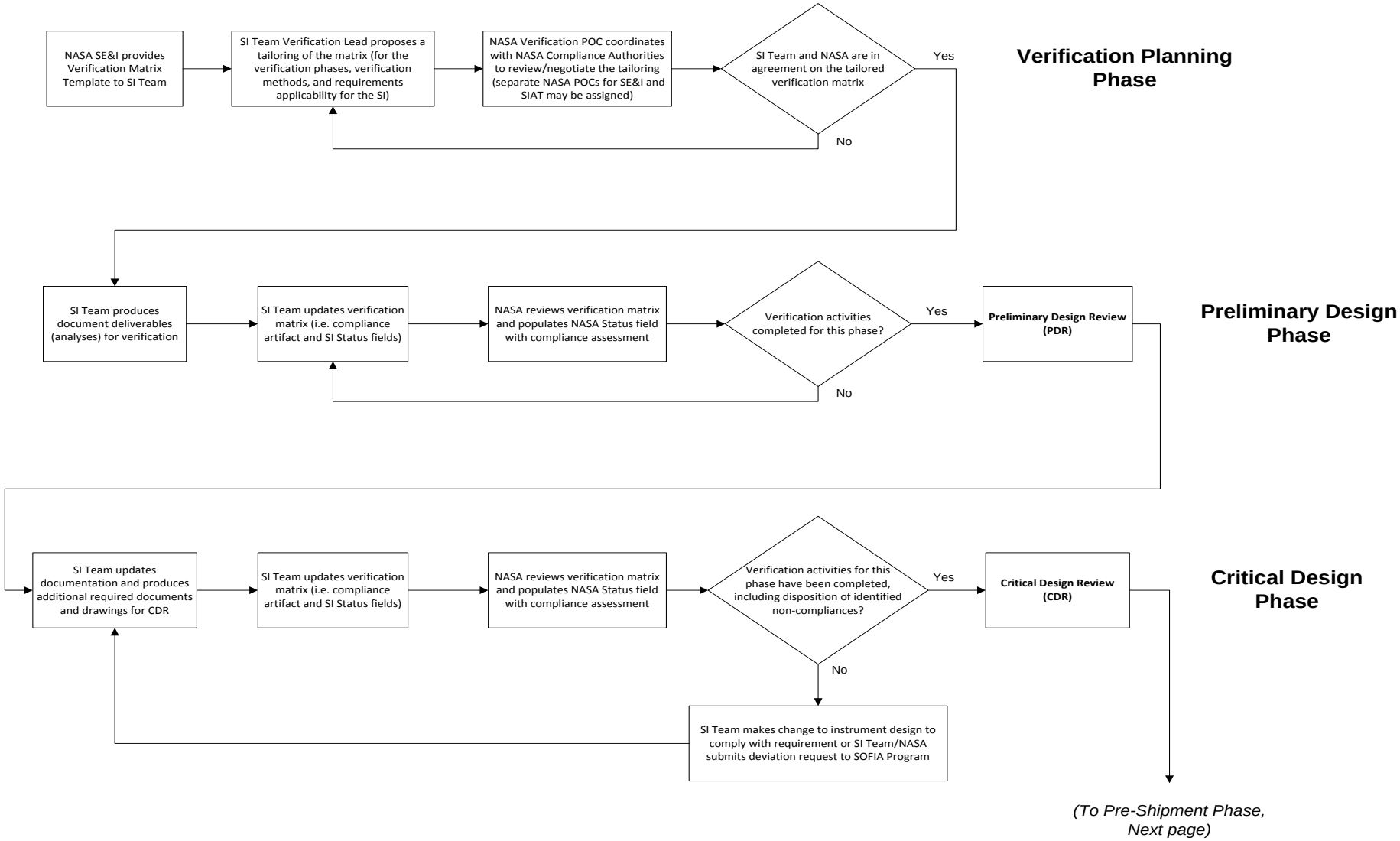

Figure 2. SI Verification Process Flowchart (View 2 of 3)

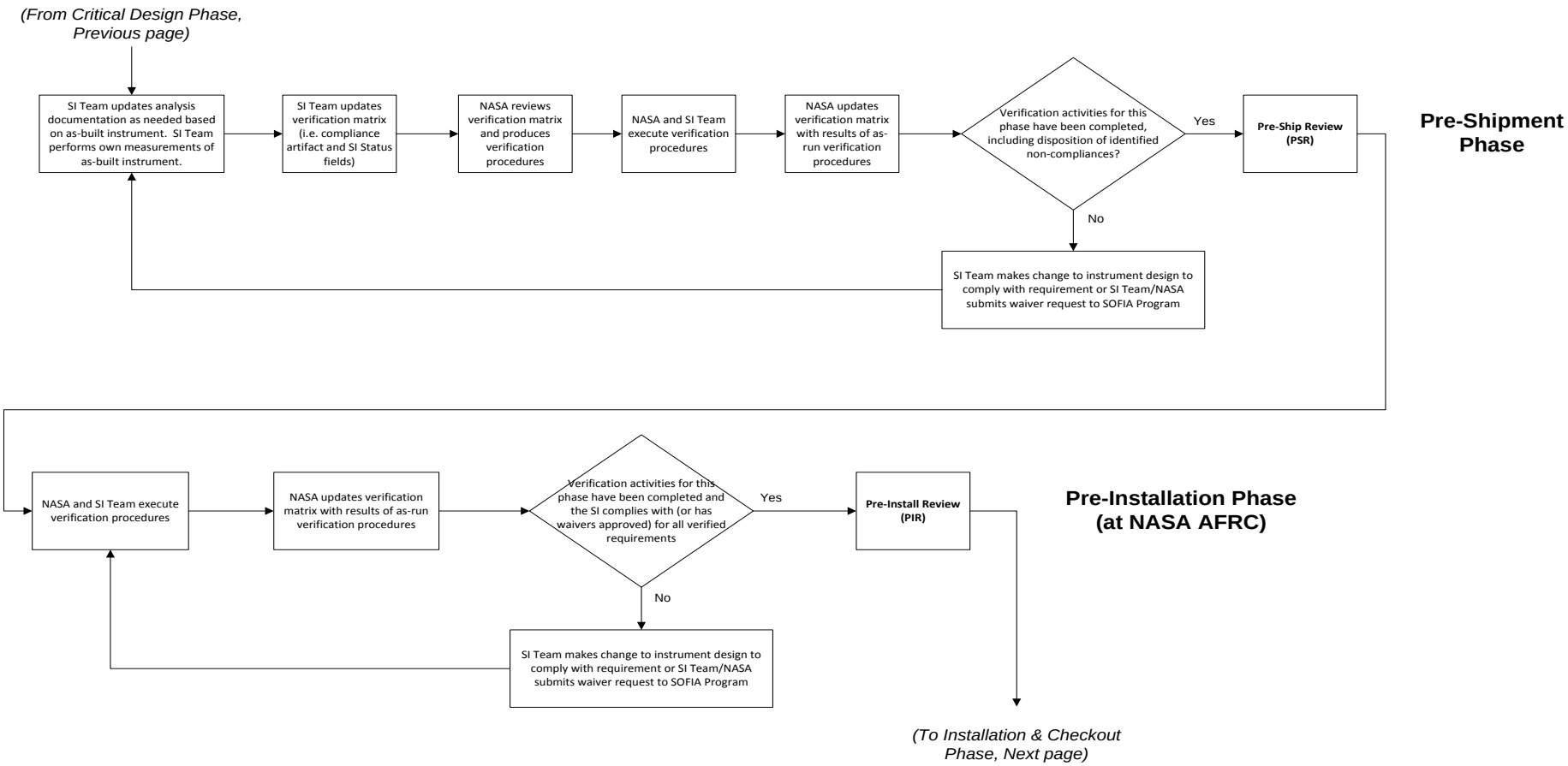

Figure 3. SI Verification Process Flowchart (View 3 of 3)

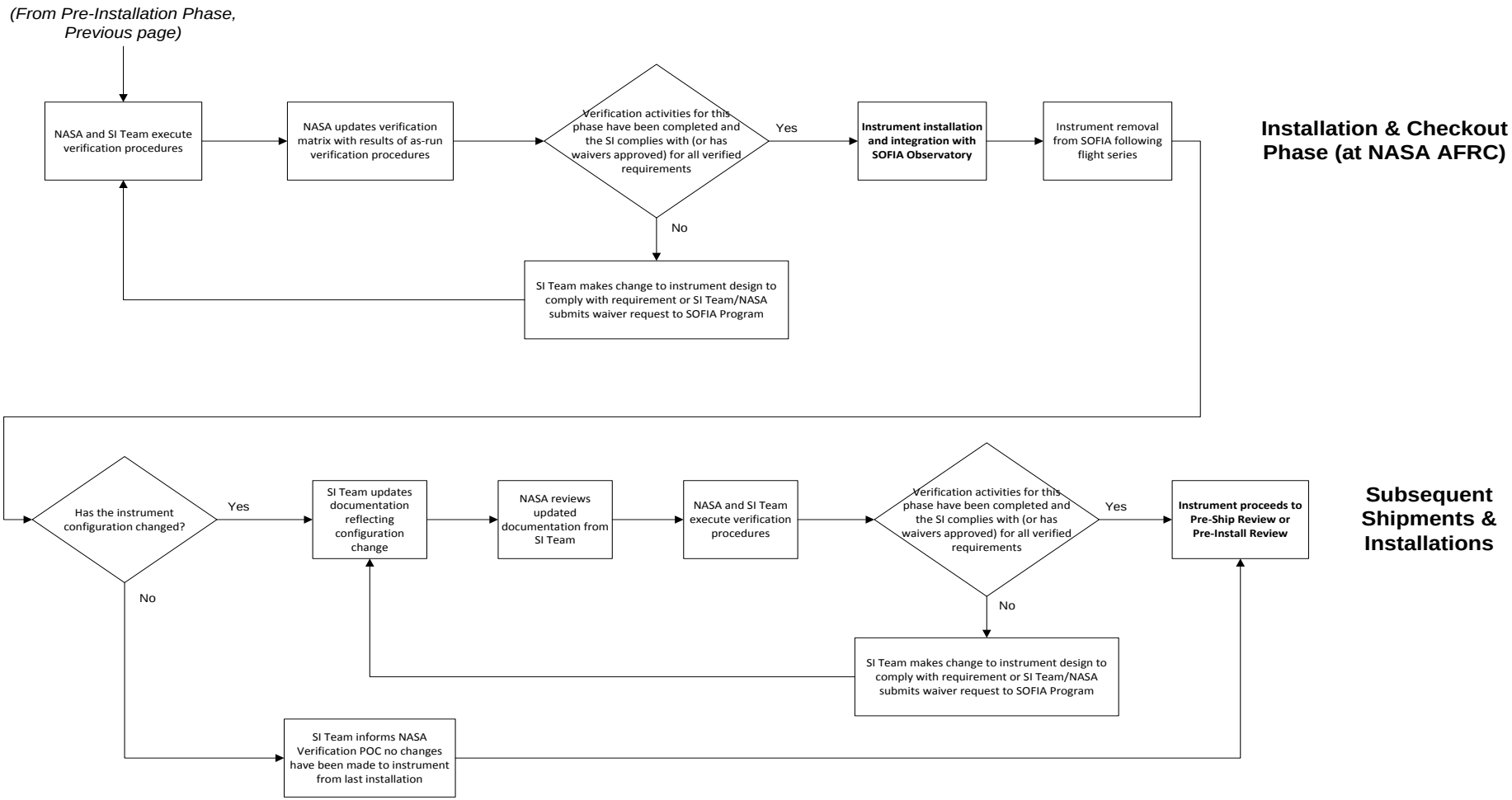

Table 1. Verification roles and responsibilities

Role	Responsibilities
SI Team Verification Lead	Performs verification planning; leads verification activities performed by the SI team; provides procedures for verification close-out activities; provides compliance documents/artifacts to NASA; keeps the SI verification matrix up to date; and presents SI verification status at PDR, CDR, Pre-Ship Review (PSR), and Pre-Installation Review (PIR). The SI Team Verification Lead is a member of the SI development organization.
NASA Verification POC	Single POC to work with the SI Team Verification Lead; coordinates with the NASA Compliance Authorities; updates the NASA verification status columns of the SI verification matrix; and authors SOFIA Discrepancy Reports (DRs) and Requests for Deviation or Waiver (RDWs) when warranted for SI non-compliances.
NASA SOFIA Systems Engineering & Integration (SE&I) Lead	Serves as NASA Compliance Authority for the requirements owned by SE&I; serves on review team at PDR, CDR, PSR, and PIR. Approval signatory on the SI Verification Report.
NASA SOFIA Science Instrument Airworthiness Team (SIAT) Lead	Serves as NASA Compliance Authority for the requirements owned by the SIAT; serves on review team at PDR, CDR, PSR, and PIR; represents SI and SIAT airworthiness certification endorsement to AFRC Airworthiness and Flight Safety Review Board (AFSRB). Approval signatory on the SI Verification Report.
NASA Safety and Mission Assurance (S&MA)	Provides QA witness for verification activities that close out the verification of requirements verified by inspection (I), demonstration (D), or test (T). Concurrence signatory on the SI Verification Report.

2.1 SI Verification Planning

The SI Developer and the SOFIA Program (NASA) will together develop a tailored version of the verification matrix template to define the verification activities that will be performed, and when they will be performed. This aspect of verification planning typically takes place before the instrument Preliminary Design Review (PDR). NASA SE&I will provide the verification matrix template to the SI Developer. The SI Developer will designate an SI Team Verification Lead—a member of the SI Team who will serve as the point-of-contact (POC) for verification and update and maintain SI fields in the verification matrix. Upon receipt of the verification matrix template from NASA, the SI Team Verification Lead will work with the SI Team to propose a tailoring of the matrix template to serve as the individual SI verification matrix for the instrument. This tailoring of the matrix includes identifying which requirements are applicable to the SI and defining the corresponding verification methods, phasing, and activities. The SI Team Verification Lead then sends the proposed verification matrix to the NASA Verification POC, who coordinates NASA review of the matrix and negotiates the tailoring with the SI Team until NASA and the SI Team are in agreement with the SI matrix content. Once initial tailoring of the verification matrix is complete, the matrix will be maintained by the SI Developer the majority of the time.

The SI Developer is responsible for populating the "Compliance / Artifacts" and "SI Status" columns of the SI verification matrix. The SI Developer will periodically transfer the verification matrix to NASA, whom will review the updates made by the SI Team to compliance status, verification results, and compliance artifacts. In the later development phases, NASA will use the "Compliance / Artifacts" field to record verification results and record "as-run" procedure document numbers for formal verification close-out activities performed by NASA (i.e., final verification inspection, demonstration, test).

2.2 SI Verification Execution

Verification activities begin early in the instrument development process, typically as instrument Preliminary Design Review (PDR) approaches. The number of verification activities performed at/before PDR will be limited compared to verification at Critical Design Review (CDR) but are performed to ensure the instrument PDR-level design is on track to comply with SOFIA requirements. The SI Team will populate the "Compliance / Artifacts" field providing the verification artifacts and results, and self-identifying compliance status in the "SI Status" PDR column (i.e. Complies, Does not comply - Corrective Action Planned, Does not comply - Request Waiver, Deferred, N/A). Before PDR the SI Team Verification Lead will send a verification matrix completed up to the PDR phase to the NASA Verification POC. NASA will review the SI verification matrix, perform an inspection of cited SI compliance artifacts, and populate the "NASA Status" PDR column with the NASA compliance assessment results (i.e., Pass, Fail - Corrective Action Needed, Waiver in Work, Waiver Approved, Lien, More Information Required).

This general process repeats for each development phase in the verification matrix: PDR, CDR, Pre-Ship, At AFRC prior to installation, and Installation and checkout. Non-compliance or failure of the instrument to meet a requirement may be encountered during the verification process. Science Instruments are strongly encouraged to comply and bring instruments into compliance with SOFIA requirements. If an instrument fails to meet a requirement and the impact of bringing the instrument into compliance with the requirement is determined by the SI Developer to be significant, the SOFIA Program does have a process in place for evaluating proposed instrument deviation and waiver requests, potentially relieving an instrument from a SOFIA requirement. Section 5.4.4 "Verification Preparation, Execution, and Close-Out" of the *SOFIA SI Developers' Handbook* provides additional information about the deviation and waiver process.

As the instrument design matures, the SI team will further develop and update required documentation to be delivered to the SOFIA Program before CDR. The SI Team Verification Lead will perform a comprehensive update of the verification matrix up to the CDR phase. Before CDR the SI Team Verification Lead will deliver the verification matrix to the NASA. Because the instrument is still in the design phase at CDR, verification performed by NASA will typically consist of inspection of SI documents, analyses, and drawings.

Following successful completion of CDR, the instrument will begin fabrication, assembly, and integration. The majority of verification close-out activities will be performed before the instrument Pre-Ship Review. Following CDR, the SI Team will again perform an update of documentation and the verification matrix. NASA will review the updated documentation and matrix that reflects the as-built instrument design, as well as perform inspection, demonstration, and test verification activities of the instrument. Some verification in this phase will be performed for verification close-out (i.e., final verification of the instrument against a requirement), while other Pre-Ship verification may be intermediate verification for which final close-out will occur after arrival at Armstrong Flight Research Center (AFRC) Building 703. The general philosophy however, is to complete as much verification as possible before the instrument Pre-Shipment Review (PSR), to reduce the risk and potential impacts of discovering non-compliance of the instrument with a requirement (or requirements) that could have been identified and resolved before shipment.

Following successful completion of remaining verification activities at AFRC B703 and verification close-out of all requirements in the SI System Specification and ICD requirements matrix, NASA will assign a document number to the document, and prepend a cover and signature page to the completed verification matrix to serve as a formal report of verification. The document will then be presented to the SOFIA Observatory Configuration Control Board (OCCB) for approval and acceptance into the SOFIA Configuration Management (CM) System.

2.3 Verification Methods

The verification methods used in the verification process are: Analysis, Inspection, Demonstration, Test. The definitions for these methods of verification used here have been adopted from the *NASA Systems Engineering Handbook* (NASA/SP-2007-6105), Rev. 1, Section 5.3.1.2 "Process Activities", and have been reproduced below:

Analysis: The use of mathematical modeling and analytical techniques to predict the suitability of a design to stakeholder expectations based on calculated data or data derived from lower system structure end product verifications. Analysis is generally used when a prototype; engineering model; or fabricated, assembled, and integrated product is not available. Analysis includes the use of modeling and simulation as analytical tools. A model is a mathematical representation of reality. A simulation is the manipulation of a model.

Demonstration: Showing that the use of an end product achieves the individual specified requirement. It is generally a basic confirmation of performance capability, differentiated from testing by the lack of detailed data gathering. Demonstrations can involve the use of physical models or mockups.

Inspection: The visual examination of a realized end product. Inspection is generally used to verify physical design features or specific manufacturer identification.

Test: The use of an end product to obtain detailed data needed to verify performance, or provide sufficient information to verify performance through further analysis. Testing can be conducted on final end products, breadboards, brass boards or prototypes. Testing produces data at discrete points for each specified requirement under controlled conditions and is the most resource-intensive verification technique.

3.0 Applicable Documents

3.1 Required Documents

APP-DA-ICD-SE03-2059	Rev. -	ICD CRYO_SI_01, Cryocooler System to Science Instrument
SCI-AR-ICD-SE03-2017	Rev. C	ICD SIC_SSMO_01, Science Instrument Cart to SSMO Facility
SCI-AR-ICD-SE03-2027	Rev. B	ICD SI_CWR_01, Science Instrument Equipment to Counterweight Rack
SCI-AR-ICD-SE03-2020	Rev. -	ICD SSMO_SI_02, Telescope Assembly Alignment Simulator to Science Instrument
SCI-AR-SPE-SE01-2028	Rev. B	SOFIA Science Instrument System Specification
SCI-US-ICD-SE03-2023	Rev. E	ICD DCS_SI_01, Data Cycle System
SOF-AR-ICD-SE03-205	Rev. D	ICD SIC_AS_01, Science Instrument Cart to Aircraft System
SOF-AR-ICD-SE03-2029	Rev. C	ICD MCCS_SI_05, Principal Investigator Patch Panel to Principal Investigator Equipment Rack(s)
SOF-DA-ICD-SE03-002	Rev. 2	ICD GLOBAL_09, Science Instrument Envelope
SOF-DA-ICD-SE03-036	Rev. 3	ICD TA_SI_01, Cable Load Alleviator Device/Science Instrument Cable Interface
SOF-DA-ICD-SE03-037	Rev. 1.1	ICD TA_SI_02, Telescope Assembly / Science Instrument Mounting Interface
SOF-DA-ICD-SE03-038	Rev. 2.1	ICD TA_SI_04, TA Chopper Processor / Principal Investigator Computer Direct Analog Interface
SOF-DA-ICD-SE03-051	Rev. 2	ICD TA_SI_05, SI Equipment Rack / TA Counterweight Interface
SOF-DA-ICD-SE03-052	Rev. G	ICD MCCS_SI_04, MCCS to Science Instrument Software Interface (Functional)
SOF-DA-ICD-SE03-2015	Rev. A	ICD SI_AS_01, Principal Investigator Equipment to PI Rack to Aircraft System
SOF-DA-ICD-SE03-2022	Rev. -	ICD VPS_SI_01, Vacuum Pump System (VPS) to Science Instrument ICD

3.2 Other Related Documents

APP-DF-ICD-SE03-2011	MCCS Network ICD
NASA/SP-2007-6105	NASA Systems Engineering Handbook
SCI-AR-HBK-OP03-2000	Science Instrument Developers' Handbook

Document	Paragraph Identification (ParID)	Requirement	Verification Method by Development Phase					Verification Activity Description	Compliance / Artifacts	SI Status (Verification status to be filled out by SI Team)					NASA Compliance Authority	NASA Status (Verification status to be filled out by NASA)				
			PDR	CDR	Pre-Ship	At AFRC prior to installation	Installation and checkout			PDR	CDR	Pre-Ship	At AFRC prior to installation	Installation and checkout		PDR	CDR	Pre-Ship	At AFRC prior to installation	Installation and checkout
SE01-2028 Rev. B (4 Nov. 2015)		**SOFIA SI System Specification**																		
XXXX	*3.Y*	*- Each requirement listed separately in this column.* *- Create additional rows as needed for verification of more than one system with a single requirement (e.g. Installation cart, Lab cart)*	*A, D, I, T or N/A*	*A, D, I, T or N/A*	*A, D, I, T or N/A*	*A, D, I, T or N/A*	*A, D, I, T or N/A*	*Brief description of verification activities.*	*- List each verification compliance reference.* *- SI Developer to record in this field how SI meets this requirement, providing references to SI compliance artifact documents such as analyses, drawings, etc., as needed.* *- NASA to record in this field comments, verification results, and references to as-run records, discrepancy reports, deviations, and waivers.*	*In each column, list one of the following:* Complies Does not comply - corrective action planned Does not comply - request waiver Lien Deferred N/A					*SIAT or SE&I*	*In each column, list one of the following:* Pass Fail - corrective action needed Waiver in work Waiver approved More information required Lien Deferred N/A				
SE01-2028 Rev. B	3.1	**Functional**																		
SE01-2028 Rev. B	3.1.1	Science Instruments shall be tolerant of unannounced removal, reduction or reapplication of input power with no permanent functional or performance degradation.	N/A	A	D		N/A	(CDR) Analysis at CDR identifying any SI equipment or components deemed sensitive to an unannounced removal, reduction or reapplication of power, with power budgets and plans for protecting such equipment or components (i.e., using SOFIA or SI-provided UPS). (Pre-Ship ~ At AFRC prior to installation) Demonstration(s) at SI developer institution and/or at AFRC in SI laboratories / PIF that SI is tolerant of a removal or reduction of input power.							SE&I					
SE01-2028 Rev. B	3.1.2	SOFIA Science Instruments shall send commands, request and receive housekeeping data, store data, and transfer stored science data during flight to the MCCS for archiving in accordance with the Mission Controls and Communications System (MCCS) interface requirements in accordance with SOF-DA-ICD-SE03-052 (MCCS_SI_04), *MCCS to Science Instrument Software Interface (SCL) (Functional)* .	N/A	N/A	D		D	(Pre-Ship ~ At AFRC prior to installation) Demonstration (tier testing) using SIL / HILS. (Installation and checkout) Demonstration on SOFIA during Hangar and/or Line Operations.							SE&I					
SE01-2028 Rev. B	3.1.3	SOFIA Science Instruments shall time stamp UTC date and time, with an accuracy of ≤ 50 milliseconds and a precision of ≤ 1 millisecond relative to SOFIA Observatory provided time, for data transferred to the MCCS.	N/A	N/A	D		D	(Pre-Ship ~ At AFRC prior to installation) Demonstration (tier testing) using SIL / HILS. (Installation and checkout) Demonstration on SOFIA during Hangar and/or Line Operations.							SE&I					
SE01-2028 Rev. B	3.1.4	SOFIA Science Instrument data shall be tagged with position of the observatory.	N/A	N/A	I		I	(Pre-Ship ~ At AFRC prior to installation) Inspection of FITS files generated by SI during tier testing using SIL / HILS to confirm that the simulated LAT/LON is included. (Installation and checkout) Inspection of FITS files generated by the SI on SOFIA during Hangar and/or Line Operations to confirm that LAT/LON is included.							SE&I					
SE01-2028 Rev. B	3.1.5	SOFIA Facility Class Science Instrument (FSI) data processing software shall comply with the requirements for pipeline data processing of Science Instrument data as defined in SCI-US-SPE-SE01-2073, *SOFIA Science Data Processing System Specification* .	I	I & D		I & D		(PDR) SI Developer to provide preliminary draft of SI pipeline requirements document. (CDR ~ Pre-Ship) SI Developer to provide updated draft of SI pipeline requirements document, showing compliance with SCI-US-PLA-SW09-2000 SI Pipeline Acceptance Plan. SI team will coordinate w/ assigned SOFIA Instrument Scientist(s) and the SMOC during development of selected SIs, including arranging for pipeline installation (i.e., alpha, beta versions, and deliverables identified in SCI-US-PLA-SW09-2000) and training for pipeline software operation. (At AFRC prior to installation ~ Installation and checkout) During commissioning flights, the pipeline must be demonstrated using on sky data with appropriate flats, calibration files, etc. in order to produce a Level 2 product. Acceptance of a facility instrument will depend upon successful demonstration of pipeline validity and operability from on sky data taken during commissioning flights along with the verification that all deliverables identified in SCI-US-PLA-SW09-2000 have been met. *[Formal V&V must include Demonstration using data collected during commissioning flights, but earlier Demonstrations and/or Analysis are likely during earlier development phases as a risk mitigation approach]*							SE&I					
SE01-2028 Rev. B	3.2	**Performance**																		
SE01-2028 Rev. B	3.2.1	SOFIA Science Instrument astronomical data shall be flux calibratable to within 20% RMS.	N/A	A	A	N/A	D & A	(CDR) SI team to provide Analysis at CDR showing how their SI data products will be flux calibrated to within 20% RMS, including use of data pipeline post-processing, as defined in SCI-US-SPE-SW01-2028, *Data Processing (Pipeline) Software Requirements Document (SRD) for SOFIA Science Instruments* and further described in SCI-US-POLA-PM17-2010, *Data Processing Plan for SOFIA Science Instruments* . (Pre-Ship) SI team to provide Analysis that references the SI Instrument Commissioning Plan (ICP), showing how the SI data products will be flux calibrated to within 20% RMS using data collected during the SI commissioning flight series. (Installation and checkout) During commissioning flights, SI team to Demonstrate the post-processing and archival of SI data products flux calibrated to within 20% RMS in conjunction with verification of para. 3.1.5 pipeline validity and operability. *[Formal V&V must include Demonstration and Analysis using data collected during commissioning flights, but earlier informal activities are anticipated, e.g., tier testing using SIL / HILS and/or during Line Operations, as a risk mitigation approach]*							SE&I					

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			PDR	CDR	Pre-Ship	At AFRC prior to installation	Installation and checkout			PDR	CDR	Pre-Ship	At AFRC prior to installation	Installation and checkout		PDR	CDR	Pre-Ship	At AFRC prior to installation	Installation and checkout
SE01-2028 Rev. B	3.2.2	SOFIA Facility Class Science Instruments (FSIs) shall provide real-time estimates of cumulative signal-to-noise.	N/A	A	A	N/A	D & A	(CDR) FSI team to provide Analysis at CDR showing how their FSI will implement the capability to provide real-time estimates of cumulative signal-to-noise to support real-time, in-flight decisions about the data acquisition and observing strategy. (Installation and checkout) During commissioning flights and FSI Acceptance Review, FSI team to Demonstrate the capability to provide real-time estimates of cumulative signal-to-noise to support real-time, in-flight decisions about the data acquisition and observing strategy. *[Formal V&V must include Demonstration and Analysis using data collected during commissioning flights, but earlier informal activities are anticipated, e.g., tier testing using SIL / HILS and/or during Line Operations, as a risk mitigation approach]*							SE&I					
SE01-2028 Rev. B	3.2.3	SOFIA Science Instruments shall provide a measurement of the alignment of the SI entrance pupil to the TA exit pupil to within an accuracy as flowed down from the applicable SI-specific throughput performance requirement.	N/A	N/A	D or T	D or T		Depends on specifics of SI design. Some instruments have fine opto-mechanical collimation adjustment capabilities that will allow them to meet this alignment spec. while mounted to the SOFIA TA IMS, while others may need to rely on the Telescope Assembly Alignment Simulator (TAAS) GSE located at the ARC SSC or in the AFRC B703 Preflight Integration Facility (PIF).							SE&I					
SE01-2028 Rev. B	3.5	**Safety**																		
SE01-2028 Rev. B	3.5.1	**Hardware Containment and Foreign Object Debris / Damage (FOD) Control**																		
SE01-2028 Rev. B	3.5.1.1	Screws, bolts, nuts, or other fasteners that are external to the Science Instrument flight hardware, or are used to retain externally mounted components, shall use self-retaining / self-locking features.	N/A	I	I	I	I	(CDR) SI developer to prepare assembly drawings within the Airworthiness Data Package presented at CDR for review (Inspection) by SE&I and SIAT to show how all screws, bolts, nuts or other fasteners that are external to the SI / INF, or are used to retain externally mounted components, use one of the preferred self-retaining / self-locking features (or where use of such preferred fasteners are deemed impractical, present an alternative for review and concurrence by the SIAT). (Pre-Ship ~ Installation and checkout, as scheduled) SI developer to support SIAT physical inspections via site visits at SI development institution / facility (Pre-ship), within the Preflight Integration Facility (PIF) at AFRC prior to installation, and after Installation on SOFIA to confirm as-built SI compliance with approved baseline assembly drawings.							SIAT					
SE01-2028 Rev. B	3.5.2	**Structures**																		
SE01-2028 Rev. B	3.5.2.1	The structure of SOFIA Science Instrument flight hardware shall be designed to maintain positive Margins of Safety (MS) for all handling, ground, airborne and emergency landing load conditions.	N/A	A	A	N/A	N/A	For mechanically induced (non-inertial) load conditions, use the applicable Factor of Safety (FS) as defined in Table 3.5-2 based on the material of the primary structure and the V&V Methodology. Analysis to include mass budget breakdown, CG analyses, load path definition, free body diagram and reaction force / moment calculations, overturning moment calculations, MS calculations. (CDR) SI developer to calculate inertial loads based on estimated mass and applicable Load Factors as defined in Table 3.5-1, and analyze stresses based on calculated loads applied to components' CGs to show that all safety critical structures have a positive Margin of Safety (MS) within the Airworthiness Data Package presented at CDR. (Pre-Ship) SI developer to update analysis provided within the Airworthiness Data Package presented at CDR based on actual component / assembly mass within submittal to SIAT for Airworthiness Certification recommendation.							SIAT					
SE01-2028 Rev. B	3.5.2.2	SI stands and carts to be used at a NASA facility shall be designed to maintain positive Margins of Safety (MS), with a minimum Safety Factor of 2 against deformation or yielding, and a minimum Safety Factor of 3 against collapsing, buckling, exceeding the ultimate load, or failing to support the design load in the vertical/downward direction.	N/A	A	A	N/A	N/A	(CDR) SI developer to provide analysis within the CDR data package showing positive MS with the specified yield and ultimate Safety Factors based on a design load which envelopes all anticipated operations. (Pre-Ship) SI developer to update analysis provided within the CDR Data Package for review by SE&I and S&MA organizations.							SE&I					
SE01-2028 Rev. B	3.5.2.3	SI stands and carts to be used at a NASA facility shall be proof load tested to 125% of the anticipated maximum design load in the vertical/downward direction.	N/A	N/A	T & I	T & I	N/A	(Pre-Ship) SI developer to conduct proof load testing at 125% of the anticipated maximum design load in the vertical/downward direction. A visual inspection shall be performed after the proof test to confirm no signs of yielding, deformation or other discrepancies (e.g., cracked welds, paint or other surface treatment, surface crazing, loose or missing fasteners, etc.). Test records shall be maintained and available for NASA review. (At AFRC prior to installation) If not already completed prior to shipment, proof load Test and post-test Inspection to be completed prior to first use of GSE with SIs at AFRC. [Note: Per NASA-STD-8719.9, *Standard for Lifting Devices and Equipment* , it should be noted that NASA standards also levy requirements for periodic (annual) inspections, and for stands and carts that include lifting mechanisms, periodic (annual) load testing at 100% rated load, and must have a placard stating the design load and the next test due date) . The AFRC Lifting Devices Equipment Manager (LDEM) has declared any lifting of a SOFIA SI at a NASA AFRC facility as a "Critical Lift" operation, so such periodic load testing performed at AFRC cannot use the SI as the test load.]							SE&I					
SE01-2028 Rev. B	3.5.2.4	SI installation and lab carts shall be designed to maintain positive Margins of Safety (MS) while sustaining the forward or rear impact of any one wheel of the cart with a 2 inch high curb.	N/A	A	A	N/A	N/A	(CDR) SI developer to provide analysis within the CDR data package showing positive MS of the fully loaded cart wheel with the specified 2 inch high curb impact, assuming it is brought to rest from a velocity of 2 ft/s (0.6 m/s) in 0.1 s. (Pre-Ship) SI developer to update analysis provided within the CDR Data Package for review by SE&I and S&MA organizations.							SE&I					

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			PDR	CDR	Pre-Ship	At AFRC prior to installation	Installation and checkout			PDR	CDR	Pre-Ship	At AFRC prior to installation	Installation and checkout		PDR	CDR	Pre-Ship	At AFRC prior to installation	Installation and checkout
SE01-2028 Rev. B	3.5.2.5	Lifting hardware GSE (e.g. hoists, slings, rigging, chains, spreader bars, etc.) provided by an SI developer for use at a NASA facility, including lifting hardware incorporated into SI carts and stands (e.g., jacks) shall be designed and tested in accordance with the requirements of NASA-STD-8719.9, *Standard for Lifting Devices and Equipment* , Sections 6, 7, 8, 10, and 13, as applicable.	N/A	A	A, T & I		N/A	Analyses should be performed and submitted as soon as practical (preferably in the CDR timeframe) and updated as needed for review at Pre-Ship and/or Pre-Install Reviews. Where possible, Tests and Inspections should be performed at the SI developer's institution prior to shipment to AFRC. A visual inspection shall be performed after any proof test to confirm no signs of yielding, deformation or other discrepancies (e.g., cracked welds, paint or other surface treatment, surface crazing, loose or missing fasteners, etc.). Test records shall be maintained and available for NASA review. V&V activities to be determined and scheduled based on specifics of SI GSE designs and applicable sections / paragraphs of NASA-STD-8719.9.							SE&I					
SE01-2028 Rev. B	3.5.2.6	SI flight hardware to be hoisted at a NASA facility shall be designed to maintain positive Margins of Safety (MS) with a dynamic load factor of 1.5g in both the upward and downward direction.	N/A	A	A	N/A	N/A	(CDR) SI developer to provide analysis within the CDR data package showing positive MS of the SI flight hardware with the specified dynamic load factor in the upward and downward direction. (Pre-Ship) SI developer to update analysis provided within the CDR Data Package for review by SE&I and S&MA organizations.							SE&I					
SE01-2028 Rev. B	3.5.2.7	SI Ground Support Equipment (GSE) to be hoisted at a NASA facility shall be designed to maintain positive Margins of Safety (MS) with a dynamic load factor of 1.15g in both the upward and downward direction while loaded per the applicable operational scenario.	N/A	A	A	N/A	N/A	(CDR) Where applicable, SI developer to provide analysis within the CDR data package showing positive MS of the fully loaded SI GSE hardware with the specified dynamic load factor in the upward and downward direction. (Pre-Ship) SI developer to update analysis provided within the CDR Data Package for review by SE&I and S&MA organizations.							SE&I					
SE01-2028 Rev. B	3.5.2.8	SI stands and carts shall be designed to ensure that no foot or wheel loses contact with the ground when a load factor of 0.17 or 70 lb-f, whichever is greater, is applied at the highest CG of the combined assembly in any horizontal axis.	N/A	A	A	N/A	N/A	(CDR) SI teams shall provide mass and center of gravity (CG) information for the Science Instrument only and also mass and CG for the combined Science Instrument and SI Cart, considering all applicable operational scenarios (e.g., cryogen load, full range of cart lift jack, etc.). Stability analysis shall be provided to assure that no wheel will lose contact with the ground with the specified applied load. (Pre-Ship) SI developer to update analysis provided within the CDR Data Package for review by SE&I and S&MA organizations.							SE&I					
SE01-2028 Rev. B	3.5.2.9	Screws, nuts, bolts or other threaded fasteners that are part of a Science Instrument flight hardware structural load path for design characteristics classified as Critical and are needed to maintain positive Margins of Safety (MS) shall use self-retaining or self-locking features.	N/A	I	I	I	I	(CDR) SI developer to prepare assembly drawings within the Airworthiness Data Package presented at CDR for review (Inspection) by SE&I and SIAT to show how all screws, bolts, nuts or other fasteners that are part of an SI flight H/W structural load path for design characteristics classified as Critical and are needed to maintain positive MS, use one of the preferred self-retaining / self-locking features (or where use of such preferred fasteners are deemed impractical, present an alternative for review and concurrence by the SIAT). (Pre-Ship ~ Installation and checkout, as scheduled) SI developer to support SIAT physical inspections via site visits at SI development institution / facility (Pre-ship), within the Preflight Integration Facility (PIF) or SI Labs at AFRC B703 prior to installation, and after Installation on SOFIA to confirm as-built SI compliance with approved baseline assembly drawings.							SIAT					
SE01-2028 Rev. B	3.5.3	**Pressure Vessels and Pressurized Systems (PVS)**																		
SE01-2028 Rev. B	3.5.3.1	SOFIA Science Instrument cryogen reservoirs or dewars (inner vessel), cryostats (outer shell), and pressure couplers (where applicable) shall be designed to withstand the worst-case pressure and inertial loads.	N/A	A	A or A & T	N/A	N/A	The structural analysis must consider and incorporate the material properties at cryogenic temperatures, where applicable. These analyses must include: 1. Stress analysis of the inner vessel due to internal pressure loads (considering the evacuated jacket outside this vessel) 2. Stress analysis of the outer vessel, optical window, and pressure coupler (where applicable) due to the (single acting) effects of external pressure and emergency landing (inertial) loads Analyses must show positive Margins of Safety (MS) and are to be provided to the SIAT for airworthiness review. The SIAT may request that optical windows which comprise a portion of the SOFIA cabin pressure boundary (when the TA Gate Valve is open) be proof pressure tested to a 1 atmosphere pressure differential to ensure integrity. (CDR) SI developer to provide analyses within the CDR data package showing positive Margins of Safety (MS), to be provided to the SIAT for airworthiness review. (Pre-Ship) SI developer to update analysis provided within the CDR Data Package for review by SIAT and airworthiness certification.							SIAT					

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SE01-2028 Rev. B	3.5.3.2	**Cryogen Reservoir Venting Safety**																		
SE01-2028 Rev. B	3.5.3.2.1	Each Liquid Helium (LHe) and Liquid Nitrogen (LN2) cryogen reservoirs shall have two (2) independent vent and/or fill "neck" tubes, as follows: 1. Primary vent neck tube for nominal (slow) venting of cryogen evaporate, outfitted with a PRV or equivalent "non-return" device; and 2. Backup (or emergency) vent / fill neck tube, outfitted with a burst disk, code certified to open at a pressure at or below the pressure to which the reservoir has been tested [ref.: ParID 3.5.3.3.1 and Table 3.5-3].	N/A	A & I	I	I	N/A	(CDR) Inspection of cryogen reservoir design drawings to show that each reservoir has two (2) independent vent and/or fill "neck" tubes, and Analysis to show that the geometry of the backup (emergency) vent / fill neck tube for the LHe reservoir matches the neck tube design parameters provided by the SI developer prior to CDR by the SOFIA SIAT to support their P_{max} analysis. (Pre-Ship) Inspection of burst disk and PRV specifications and certification paperwork to show that bust disk on backup (or emergency) neck tube is certified to open at a pressure at or below the pressure to which the LHe reservoir has been tested, and that the PRV on this backup (or emergency) neck tube (where applicable) has a cracking pressure above that of the PRV(s) on the primary neck tube. (At AFRC prior to installation) Inspect "must-work" pressure relief devices and associated certification paperwork. Analyses, cryogen reservoir neck tube and vent plumbing designs, and PRD certifications are to be provided to the SIAT for airworthiness review.							SIAT					
SE01-2028 Rev. B	3.5.3.2.2	The backup (or emergency) neck tube for Cryogenic Liquid Helium (LHe) reservoirs, with its integrated code certified burst disk, shall be able to safely vent the very rapid LHe boil-off associated with a heat load of 4.0 W / cm^2.	A	A	N/A	I	N/A	(PDR) Analysis in PDR data package identifying failure modes and estimated heat loads into cryogen reservoir, and cryogen reservoir maximum pressure due to failure of dewar vacuum jacket and resulting rapid LHe boil-off per Appendix C. (CDR) Analysis of the maximum cryostat pressure resulting from a vacuum jacket failure of a liquid Helium reservoir will be conducted prior to CDR by the SOFIA SIAT, based on preliminary cryostat and neck tube design parameters to be provided by the SI developer. (At AFRC prior to installation) Inspect "must-work" pressure relief devices and associated certification paperwork. Analyses, cryogen reservoir neck tube and vent plumbing designs, and PRD certifications are to be provided to the SIAT for airworthiness review.							SIAT					
SE01-2028 Rev. B	3.5.3.2.3	Cryogen reservoir outer vacuum jackets shall include redundant pressure relief capability, each adequately sized to safely relieve the rapid boil-off that would result from the rupture of the internal cryogen reservoir or neck tube, bellows, etc.	A	A	D		N/A	(PDR) Analysis in PDR data package identifying estimated heat loads into cryogen reservoir, and maximum LHe boil-off mass flow rate per Appendix C. (CDR) Analysis in CDR data package showing flow area of pressure relief port(s) (drop plate opening(s)) of cryogen reservoir outer vacuum jacket needed to safely relieve the rapid boil-off mass flow rate per Appendix C (updated to reflect detailed design of LHe reservoir and expanded due to lower pressure / density). (Pre-Ship ~ At AFRC prior to installation) Demonstrate that relief port drop-off plates open when there is a Loss of Vacuum (LOV) within the outer shell. Note: Though outside the scope of SI verification of SE01-2028, SI developers are advised that these relief port drop-off plates must be recertified periodically to Demonstrate proper operation as a normal Operations & Maintenance activity. Initially, the recertification interval is anticipated to be on the order of 2 years or prior to each observing campaign cool-down, in accordance with DCP-S-065 § 11.1 and NASA-STD-8719-17 § 4.10.1.7 and 4.10.1.12. Analyses, cryogen reservoir neck tube and vent plumbing designs, and PRD certifications are to be provided to the SIAT for airworthiness review.							SIAT					
SE01-2028 Rev. B	3.5.3.3	**Qualification and Acceptance of Pressure Vessels and Pressurized Systems (PVS)**																		
SE01-2028 Rev. B	3.5.3.3.1	Cryogen reservoirs for SOFIA Science Instruments shall be shown to be safe via: 1. An analysis showing positive Margin of Safety (MS) with a Factor of Safety (FS) against yield strength of 2.25 x MNOP for LN2 reservoirs, or 2.25 x P_{max} for LHe reservoirs AND 2. Hydrostatic or pneumatic testing at the Qualification pressure level as defined in Table 3.5-3, *Qualification and Acceptance pressure test levels for cryogen reservoirs, other pressure vessels, lines and components*	N/A	A	T	N/A	N/A	(CDR) Analysis of cryogen reservoirs in CDR data package showing positive MS with a FS against yield strength of 2.25 x MNOP for LN2 reservoirs, or 2.25 x P_{max} for LHe reservoirs (Pre-Ship) Hydrostatic or pneumatic pressure testing to Qualification pressure level(s) as defined in Table 3.5-3. Note: COTS components of cryogen reservoir vent / fill tube assemblies that are excluded from integrated assembly level pressure test (e.g., metal bellows excluded due to component rated pressure and concern re: yield or permanent deformation of flight hardware at the prescribed test pressure) must be Qualified via standalone testing of a representative Qualification Model (QM) test article to the applicable Qualification pressure level, without rupture or release of test fluid (yield is acceptable). Once such components have been successfully Qualified, replacement Flight Model (FM) components of the same design and pedigree may be added to the integrated cryogen reservoir assembly. To verify workmanship and integrity of the completed assembly, the integrated cryogen reservoir and vent / fill tube assembly must be pressurized to 1.1 x P_{max} and leak tested. An SIAT representative or designee, and NASA Quality inspector, will be present at all tests to witness the test, to confirm no rupture or release of test fluid, and to perform pre- and post-test 10x visual inspections to confirm no formation or propagation of cracks at welds and geometric discontinuities. Test reports and analyses are to be provided to the SIAT for airworthiness review.							SIAT					

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SE01-2028 Rev. B	3.5.3.3.2	Pressure vessels and pressurized lines and components of SOFIA Science Instruments shall be qualified via Analysis, Inspection of CoCs, or Test, and undergo hydrostatic or pneumatic pressure testing to acceptance pressure levels based on the Maximum Normal Operating Pressure (MNOP) of each component and the applicable factor as defined in Table 3.5-3, *Qualification and Acceptance pressure test levels for cryogen reservoirs, other pressure vessels, lines and components* .	N/A	A, I or T	T	N/A	N/A	(CDR) Analysis, Inspection of COTS CoCs, or Testing to show certification of PVS components to qualification pressure levels as defined in Table 3.5-3. (Pre-Ship) Hydrostatic or pneumatic pressure testing to acceptance pressure levels as defined in Table 3.5-3. Test reports / COTS documentation are to be provided to the SIAT for airworthiness review.							SIAT					
SE01-2028 Rev. B	3.5.3.4	Pressure systems downstream of pressure regulators shall be designed for either the Maximum Normal Operating Pressure (MNOP) of the pressure source or appropriate pressure relief devices (PRDs) to accommodate a full open regulator failure.	N/A	A	I		N/A	(CDR) Analysis of PVS designs to show that all components downstream of a regulated pressure source are capable of safely handling a full open regulator failure, via component pressure ratings or use of adequately sized PRDs. (Pre-Ship ~ At AFRC prior to installation) Inspection of hardware at Pre-Ship Review / On-dock @ AFRC to assure conformance to reviewed designs and calibration / cert. status of PRDs.							SE&I					
SE01-2028 Rev. B	3.5.3.5	All pressurized systems within SOFIA Science Instrument GSE that are being used at any NASA facility shall comply with NASA-STD-8719.17A, *NASA Requirements for Ground-Based Pressure Vessels and Pressurized Systems (PVS)* .	N/A	A	A, I & T		N/A	(CDR) Analysis of PVS designs to define applicability of NASA-STD-8719.17. (Pre-Ship ~ At AFRC prior to installation) V&V activities to be determined and scheduled based on specifics of SI GSE designs and applicability of NASA-STD-8719.17. Formal verification will be expected for the following paragraphs from NASA-STD-8719.17A, and any other paragraphs from this standard that are applicable to SOFIA SI GSE: ¶ 4.4.3.1 ¶ 4.10.1.11 ¶ 4.10.2.1.2							SE&I					
SE01-2028 Rev. B	3.5.3.6	Flexible hose ends that could subject personnel to a whipping hazard in the event of end connection failure shall be restrained at each end and at least every six feet.	N/A	N/A	N/A	I		(At AFRC prior to installation ~ Installation and checkout) Inspection of applicable hoses to ensure that they have been appropriately restrained. Depending on the location of the hose, this may be done in the AFRC laboratories / PIF and/or on the SOFIA aircraft.							SE&I					
SE01-2028 Rev. B	3.5.4	**Electrical**																		
SE01-2028 Rev. B	3.5.4.1	Wiring to Science Instrument design characteristics classified as Critical shall be routed separately from other wiring.	N/A	A	I		N/A	(CDR) At CDR, SI developer to present analysis of wiring for circuit designs classified as Safety Critical to confirm that it is not subject to common mode failure. (Pre-Ship ~ At AFRC prior to installation) Inspection of hardware at Pre-Ship Review / On-dock @ AFRC to assure conformance to reviewed designs.							SIAT					
SE01-2028 Rev. B	3.5.4.2	All electrically conductive external surfaces of each item of powered Science Instrument equipment shall be electrically grounded, with a resistance of no greater than 70 mΩ (0.07 ohm) measured between the Science Instrument equipment conductive surface and the applicable local grounding interface location, as defined in Table 3.5-4, *Local electrical grounding interface locations for SI equipment* .	A	A	I & T		N/A	(PDR) At PDR, SI developer to present SI equipment grounding plan showing implementation for compliance with this specification. (CDR) At CDR, SI to present design drawings documenting implementation of SI equipment grounding. (Pre-Ship ~ At AFRC prior to installation) After build-up of SI to the necessary level of integration (i.e., pre-ship or after SI delivery to AFRC), Inspection of SI equipment and Test (resistance measurements) to show compliance with this specification.							SE&I					
SE01-2028 Rev. B	3.5.4.3	Any ground wire, jumper or strap necessary for Science Instrument equipment compliance with the resistance specification of paragraph 3.5.4.2 shall have a conductor sized to accommodate the maximum current that can be provided by the upstream power interface.	A	A	I		N/A	(PDR) At PDR, SI developer to present SI equipment grounding plan showing implementation for compliance with this specification. (CDR) At CDR, SI to present design drawings documenting implementation of SI equipment grounding. (Pre-Ship ~ At AFRC prior to installation) After build-up of SI to the necessary level of integration (i.e., pre-ship or after SI delivery to AFRC), Inspection of SI equipment to show compliance of as-built configuration with the CDR design.							SE&I					
SE01-2028 Rev. B	3.5.4.4	All electrical wiring used within or between elements of a Science Instrument installation shall have a wire conductor size that is specified in accordance with FAA Advisory Circular (AC) 43.13 Chapter 11, *Aircraft Electrical Systems* , Section 5, *Electrical Wire Rating* , with a current carrying capacity at least as high as the upstream overcurrent protection device(s), where applicable.	N/A	A	I		N/A	(CDR) At CDR, SI to present SI Electrical Analysis Report and design drawings documenting implementation of SI power distribution wiring and internal overcurrent protection. (Pre-Ship ~ At AFRC prior to installation) After build-up of SI to the necessary level of integration (i.e., pre-ship or after SI delivery to AFRC), Inspection of SI equipment to show compliance of as-built configuration with the CDR design.							SIAT					

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SE01-2028 Rev. B	3.8	**Logistics**																		
SE01-2028 Rev. B	3.8.1	Science Instruments with cryostats using expendable cryogens shall meet functional and performance requirements with cryogenic servicing no more frequent than once per 24 hours.	N/A	A	D		D	(CDR) Analysis or thermal model of cryostats / dewar assemblies to predict heat intrusion and boil-off rates and estimate hold times, considering reduced pressure observing operations at altitude. (Pre-Ship ~ At AFRC prior to installation) Demonstration of cryostat / dewar hold times for LN2 and LHe, as applicable during laboratory cold testing at SI developer institution and/or at AFRC. (Installation and checkout) Confirm hold times during SI commissioning flight series, making any necessary adjustments to SI Operations & Maintenance (O&M) Manual deliverables for presentation at Commissioning / Acceptance Review.							SE&I					
SE01-2028 Rev. B	3.8.2	The design and operations of SOFIA Science Instruments shall permit removal from the SOFIA aircraft within a 10 hour period.	N/A	A		A	A	(CDR ~ Pre-Ship) At CDR, SI developer to prepare analysis to estimate timelines for installation and removal of SI from observatory, including cryofill, optical alignment, functional checkout ops., etc. (At AFRC prior to installation) Validation and optimization of SI install / removal procedures using TAAS, and updates to procedures. (Installation and checkout) Validation of SI install / removal procedures during SI commissioning flight series, and updates to SI Operations & Maintenance (O&M) Manual and SI install / removal procedures deliverables for presentation at Commissioning / Acceptance Review.							SE&I					
SE01-2028 Rev. B	3.8.3	The design and operations of SOFIA Science Instruments shall permit installation on the SOFIA aircraft, optical alignment, cryogenic servicing and cold functional check-out of Science Instruments within a 12 hour period.													SE&I					
SE01-2028 Rev. B	3.9	**Human Factors**																		
SE01-2028 Rev. B	3.9.1	The design, operations and in-flight access of SOFIA Science Instruments shall be consistent with the following operational constraints and limitations: 1. Access to the SI Forward Side while the telescope is inertially stabilized and tracking (only those portions accessible with the TA Barrier raised). 2. Access to the SI Top, Port and Starboard Sides to the flange while the TA is braked. 3. Access to the Forward Side of the counterweight rack while the TA is braked at a nominal elevation of 20 degrees. 4. Access to the SI Bottom Side while the TA is braked and caged.	A		A & D		D	(PDR ~ CDR) Analysis of SI CONOPS and preliminary designs at PDR, and updates at CDR, reflect an understanding of these in-flight SI access constraints and have allocated components and physical human interfaces to the SI assembly, CWR and PI Rack(s) appropriately. (Pre-Ship ~ At AFRC prior to installation) Analysis and Demonstration of SI operations at SI developer institution and/or at AFRC indicate that SI operations are feasible within SI access constraints, and any design changes needed to reallocate components or physical human interfaces are considered for implementation. (Installation and checkout) Demonstration of SI operations with instrument and CWR installed to TA (e.g., during Line Ops, commissioning flight series) confirm operability within SI access constraints.							SE&I					
SE01-2028 Rev. B	3.10	**Parts, Materials and Processes**																		
SE01-2028 Rev. B	3.10.1	**Metal Stock Material Certifications**																		
SE01-2028 Rev. B	3.10.1.1	Any metal material used for the fabrication of Science Instrument Flight Hardware design characteristics classified as Critical, including raw material incorporated into threaded fasteners, shall be accompanied by a Certified Material Test Report (CMTR) to be obtained from the material distributor.	N/A	N/A	I	N/A	N/A	(Pre-Ship) Inspection of CMTRs for each metal stock material delivery for compliance with criteria established below; CMTR records to be maintained. Inspection should be done at Pre-Ship stage but may be deferred to At AFRC prior to installation, if necessary. Each delivery shall be reviewed upon receipt to verify that: a. It came from a firm that the manufacturer confirms is an authorized distributor. b. The reported test data conforms to the max / min values in the applicable specification for: - Chemical composition (e.g., alloying elements), and - Physical properties (e.g., strength, hardness, ductility). c. The received materials / articles are marked or bagged and tagged with an identity that is traceable to the CMTR. d. The reported test data is traceable to a single original manufacturer and their single production lot, batch or heat number. e. The report contains no format, data or language errors that might indicate counterfeit material and/or fraudulent test results.							SIAT					
SE01-2028 Rev. B	3.10.1.2	Any metal material used for the fabrication of Science Instrument GSE design characteristics classified as Critical, including raw material incorporated into threaded fasteners, shall be clearly identified, including heat treatment (or "temper") where applicable, in specifications and drawings.	N/A	I		N/A	N/A	(CDR ~ Pre-Ship) Inspection of material specifications and dimensions for each metal stock material used in the fabrication and assembly of critical GSE design characteristics. Where material specifications and/or dimensions cannot be obtained (e.g., COTS items), NDE testing may be requested by NASA S&MA in order to validate a low positive MS.							SE&I					

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SE01-2028 Rev. B	3.10.2	**Electrical Systems**																		
SE01-2028 Rev. B	3.10.2.1	**Cable and Connector Labeling**																		
SE01-2028 Rev. B	3.10.2.1.1	Each Science Instrument cable shall be labeled at each connector with a unique cable identifier and a unique connector identifier.	N/A	I	I		N/A	(CDR) Inspection at CDR of cable harness design drawings to confirm labeling of each observatory interface connector with a unique cable and connector ID. (Pre-Ship ~ At AFRC prior to installation) Inspection of SI installation to confirm labeling at each observatory interface connector with a unique cable and connector ID.							SE&I					
SE01-2028 Rev. B	3.10.2.2	**Wire Insulation**																		
SE01-2028 Rev. B	3.10.2.2.1	Use of wires coated in polyvinylchloride (PVC) insulation or jacketing shall be prohibited.	N/A	I	I	N/A	N/A	(CDR) Inspection at CDR of SI cable harness design drawings to confirm specification of non-PVC insulation and jacketing (and to confirm that SIAT has been engaged for case-by-case approval of any Requests for Deviation or Waivers (RDWs) re: use of PVC insulation or jacketing that is deemed impractical to replace with non-PVC alternatives). (Pre-Ship) Inspection of SI cables / harnesses to assure conformity with cable harness design drawings reviewed at CDR, and to confirm SIAT approval of any RDWs re: use of PVC insulation or jacketing material. Inspection should be done at Pre-Ship stage but may be deferred to At AFRC prior to installation, if necessary.							SIAT					
SE01-2028 Rev. B	3.10.2.3	**Connectors** The following requirement paragraphs 3.10.2.3.1 through 3.10.2.3.3 are applicable for all connectors mounted on aircraft pressure bulkheads:																		
SE01-2028 Rev. B	3.10.2.3.1	Connectors shall be sealed to prevent leakage through wiring and contact installations.	N/A	I	I	N/A	N/A	(CDR) Inspection at CDR of SI design drawings to confirm specification of pressure bulkhead mounted connectors includes sealing plugs or contacts in all contact locations, and is appropriately sealed with the flange and a sealing gasket or material on the pressurized side of the bulkhead, to prevent leakage through the connector installation. (Pre-Ship) Inspection of SI installation to assure conformity with connector sealing specifications reviewed at CDR. Inspection should be done at Pre-Ship stage but may be deferred to At AFRC prior to installation, if necessary.							SIAT					
SE01-2028 Rev. B	3.10.2.3.2	Connector receptacles installed on aircraft pressure bulkheads shall be mounted and sealed with the connector flange on the pressurized side of the bulkhead.														SIAT				
SE01-2028 Rev. B	3.10.2.3.3	A sealing gasket or proper sealing material such as a room temperature vulcanizing (RTV) or aircraft sealant shall be used to prevent pressure leakage at the aircraft bulkhead connector flange.														SIAT				

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SE01-2028 Rev. B	3.11	**Interface**																		
SE01-2028 Rev. B	3.11.1	SOFIA Science Instruments shall comply with the installation, static, and dynamic envelopes as defined within SOF-DA-ICD-SE03-002 (ICD Global_09), *Science Instrument Envelope* .							Refer to SI ICD Matrix worksheet tab											
SE01-2028 Rev. B	3.11.2	SOFIA Science Instruments shall comply with the interface requirements of SOF-DA-ICD-SE03-037 (TA_SI_02), *Telescope Assembly / Science Instrument Mounting Interface* .							Refer to SI ICD Matrix worksheet tab											
SE01-2028 Rev. B	3.11.3	SOFIA Science Instruments shall comply with the interface requirements of SOF-DA-ICD-SE03-2015 (SI_AS_01), *PI Equipment to PI Rack to Aircraft System* .							Refer to SI ICD Matrix worksheet tab											
SE01-2028 Rev. B	3.11.4	SOFIA Science Instruments shall comply with the interface requirements of SOF-DA-ICD-SE03-036 (TA_SI_01), *Cable Load Alleviator Device / Science Instrument Cable Interface* .							Refer to SI ICD Matrix worksheet tab											
SE01-2028 Rev. B	3.11.5	SOFIA Science Instruments that utilize the Counterweight Rack (CWR) on the TA for electronic equipment shall comply with the interface requirements of SOF-DA-ICD-SE03-051 (TA_SI_05), *SI Equipment Rack / TA Counterweight Interface* .							Refer to SI ICD Matrix worksheet tab											
SE01-2028 Rev. B	3.11.6	SOFIA Science Instruments that utilize the Counterweight Rack (CWR) on the TA for electronic equipment shall comply with the interface requirements of SCI-AR-ICD-SE03-2027 (SI_CWR_01), *SI Equipment to Counterweight Rack ICD* .							Refer to SI ICD Matrix worksheet tab											
SE01-2028 Rev. B	3.11.7	SOFIA Science Instruments shall store all imaging and spectroscopic data (for in-flight and post-flight analysis) in Flexible Image Transport System (FITS) format files that adhere to the FITS Standard (v3.0, 10 July 2008) and the SOFIA keyword list as documented within SCI-US-ICD-SE03-2023 (DCS_SI_01), *Data Cycle System (DCS) of the SOFIA Project ICD* .							Refer to SI ICD Matrix worksheet tab											
SE01-2028 Rev. B	3.11.8	SOFIA Science Instruments shall comply with the physical interface requirements for connectivity with the Mission Controls and Communications System (MCCS) as defined within SOF-AR-ICD-SE03-2029 (MCCS_SI_05), *PI Patch Panel to PI Equipment Rack(s)* .							Refer to SI ICD Matrix worksheet tab											
SE01-2028 Rev. B	3.11.9	SOFIA Science Instruments that make use of the Telescope Assembly's secondary mirror chopping shall support synchronization with the chopping secondary mechanism via SI-provided synchronization signal or TA-provided synchronization signal as defined within SOF-DA-ICD-SE03-038 (TA_SI_04), *TA Chopper Processor / Principal Investigator Computer Direct Analog Interface* .							Refer to SI ICD Matrix worksheet tab											
SE01-2028 Rev. B	3.11.10	SOFIA Science Instrument carts and stands to be used within the SOFIA Science and Mission Operations (SSMO) Facility shall comply with the requirements of SCI-AR-ICD-SE03-2017 (SIC_SSMO_01), *SI Handling Cart to SSMO Facility Interface* .							Refer to SI ICD Matrix worksheet tab											
SE01-2028 Rev. B	3.11.11	SOFIA Science Instrument carts and stands to be used within the SOFIA aircraft shall comply with the requirements of SOF-AR-ICD-SE03-205 (SIC_AS_01), *SI Handling Cart to Aircraft System ICD* .							Refer to SI ICD Matrix worksheet tab											
SE01-2028 Rev. B	3.11.12	SOFIA Science Instruments that utilize the TA Alignment Simulator (TAAS) for optical alignment and checkout shall comply with the interface requirements of SCI-AR-ICD-SE03-2020 (SSMO_SI_02), *TA Alignment Simulator (TAAS) to Science Instrument ICD* .							Refer to SI ICD Matrix worksheet tab											
SE01-2028 Rev. B	3.11.13	SOFIA Science Instruments that make use of the SOFIA Vacuum Pump System (VPS) shall comply with the interface requirements of SOF-DA-ICD-SE03-2022 (VPS_SI_01), *SI to Aircraft Vacuum Pump* .							Refer to SI ICD Matrix worksheet tab											
SE01-2028 Rev. B	3.11.14	SOFIA Science Instruments that utilize the Cryocooler System shall comply with the interface requirements of APP-DA-ICD-SE03-2059 (CRYO_SI_01), *Cryocooler System to Science Instrument ICD* .							Refer to SI ICD Matrix worksheet tab											

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			PDR	CDR	Pre-Ship	At AFRC prior to installation	Installation and checkout			PDR	CDR	Pre-Ship	At AFRC prior to installation	Installation and checkout		PDR	CDR	Pre-Ship	At AFRC prior to installation	Installation and checkout
XXXX	*Y.Y*	*- Each requirement listed separately in this column.* *- Create additional rows as needed for verification of more than one system with a single requirement (e.g. Installation cart, Lab cart)*	*A, D, I, T or N/A*	*A, D, I, T or N/A*	*A, D, I, T or N/A*	*A, D, I, T or N/A*	*A, D, I, T or N/A*	*Brief description of verification activities.*	*- List each verification compliance reference.* *- SI Developer to record in this field how SI meets this requirement, providing references to SI compliance artifact documents such as analyses, drawings, etc., as needed.* *- NASA to record in this field comments, verification results, and references to as-run records, discrepancy reports, deviations, and waivers.*	*In each column, list one of the following:* Complies Does not comply - corrective action planned Does not comply - request waiver Lien Deferred N/A					*SIAT or SSP SE&I*	*In each column, list one of the following:* Pass Fail - corrective action needed Waiver in work Waiver approved More information required Lien Deferred N/A				
General Notes: 1) Any requirement identified to be not applicable to a Science Instrument, should be declared not applicable in the "Compliance / Artifacts" field by the Science Instrument Developer, for review and concurrence by NASA. 2) Abbreviations for methods of verification used in the "Verification Method by Development Phase" columns are: Analysis (A), Demonstration (D), Inspection (I), Test (T).																				
SOF-DA-ICD-SE03-002 (GLOBAL_09) Revision 2: Science Instrument Envelope																				
SE03-002	3.1 a	The SI shall comply with the stay-in Dynamic Envelope defined in Figures 3.1-1A through 3.1-1D.	A	A	A & I	N/A	N/A	(PDR) SI Developer to provide preliminary Dynamic Envelope analysis. A CAD model of the ICD Dynamic Envelope from the SOFIA Program is available upon request by the SI Developer. (CDR) SI Developer to provide updated analysis for instrument CDR design. (Pre-Ship) SI Developer to provide final updated analysis for as-built SI. NASA to inspect hardware.							SSP SE&I					
SE03-002	3.1 b	The SI shall comply with the stay-in Static (Service) Envelope defined in Figures 3.1-2A and 3.1-2B.	A	A	A & I	N/A	N/A	(PDR) SI Developer to provide preliminary Static Envelope analysis. A CAD model of the ICD Static Envelope from the SOFIA Program is available upon request by the SI Developer. (CDR) SI Developer to provide updated analysis for instrument CDR design, including support ground support equipment (such as installation cart and cryogen service dewars). (Pre-Ship) SI Developer to provide final updated analysis for as-built instrument and installation cart. NASA to inspect hardware.							SSP SE&I					
SE03-002	3.1 c	The SI shall comply with the stay-in Installation Envelope defined in Figures 3.1-3A and 3.1-3B.	A	A	A & I	N/A	N/A	(PDR) SI Developer to provide preliminary Installation Envelope analysis. A CAD model of the ICD Installation Envelope from the SOFIA Program is available upon request by the SI Developer. (CDR) SI Developer to provide updated analysis for instrument CDR design. (Pre-Ship) SI Developer to provide final updated analysis for as-built SI. NASA to inspect hardware.							SSP SE&I					
SOF-DA-ICD-SE03-037 (TA_SI_02) Revision 1.1: Telescope Assembly/Science Instrument Mounting Interface																				
SE03-037 Rev. 1.1	4.1	The mass of the SI Assembly shall not exceed 600 kg (1,320 lbm).	A	A	A or A & T	T	N/A	(PDR) SI Developer to provide preliminary mass analysis of SI Assembly. (CDR) SI Developer to provide updated mass analysis for instrument CDR design, including cabling and cryogens. (Pre-Ship) SI Developer to provide final updated mass analysis. A measurement of the total mass of the SI Assembly is preferred but mass determination from CAD model of the as-built instrument design or certain components is acceptable. Analysis should include mass contribution from cryogens and cables. (At AFRC prior to installation) NASA to measure weight of SI Assembly.							SIAT					
SE03-037 Rev. 1.1	4.1	SIs with a lower mass may opt to use a different flange configuration (e.g., an incomplete bolt circle) and/or fewer fasteners, however structural analyses shall be provided by the SI Developer reflecting positive Margin of Safety (MS) for all bolts in tension as well as shear tear-out and bearing failure modes at bolt locations, considering the emergency crash load factors in each direction.	A	A	A	N/A	N/A	(PDR) SI Developer to provide preliminary SI Flange structural analysis. (CDR) SI Developer to provide updated analysis for instrument CDR design. (Pre-Ship) SI Developer to provide final updated analysis for as-built flange and instrument.							SIAT					
SE03-037 Rev. 1.1	4.1.2	SI Flanges which use the TA IMF O-ring seal to effect the seal shall have an inner diameter (ID) of no greater than 884 mm [34.80 inch].	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide SI Flange and instrument assembly drawings. (Pre-Ship) SI Developer to provide SI Flange post-fabrication inspection report with measurement results from manufacturer.							SSP SE&I					
SE03-037 Rev. 1.1	4.1.2	The annular region between this ID and the IMF OD shall meet the planarity specification defined in para. 4.1.6.4. <u>Note:</u> The entire mating surface of a SI Flange which mates with the IMF must meet the planarity value specified in para. 4.1.6.4.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide SI Flange and instrument assembly drawings. (Pre-Ship) SI Developer to provide SI Flange post-fabrication inspection report with measurement results from manufacturer.							SSP SE&I					

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SE03-037 Rev. 1.1	4.1.3.1	SI Flange bolt circle diameter shall be DB= 990 mm [38.976 inch] and centered on the IR beam.	N/A	A	I	D		(CDR) SI Developer to provide SI Flange and instrument assembly drawings. (Pre-Ship) SI Developer to provide SI Flange post-fabrication inspection report with measurement results from manufacturer. (At AFRC prior to installation ~ Installation and checkout) At the discretion of NASA, the SI Developer may be required to perform a fit-check demonstration of the SI Flange/SI Assembly on the TAAS or SOFIA TA to verify fit, if the SI Flange post-fabrication report is determined to be inadequate for verification close-out of this requirement before shipment.							SSP SE&I					
SE03-037 Rev. 1.1	4.1.3.5	Angular spacing of bolt holes on the SI Flange shall follow the bolt hole angular spacing pattern defined in figure 4-1.	N/A	A	I	D		(CDR) SI Developer to provide SI Flange and instrument assembly drawings. (Pre-Ship) SI Developer to provide SI Flange post-fabrication inspection report with measurement results from manufacturer. (At AFRC prior to installation ~ Installation and checkout) At the discretion of NASA, the SI Developer may be required to perform a fit-check demonstration of the SI Flange/SI Assembly on the TAAS or SOFIA TA to verify fit, if the SI Flange post-fabrication report is determined to be inadequate for verification close-out of this requirement before shipment.							SSP SE&I					
SE03-037 Rev. 1.1	4.1.3.8	The bolt hole diameter for the SI Flange shall be between 17/32 inch [13.5 mm] and 9/16 inch [14.3 mm].	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide SI Flange and instrument assembly drawings. (Pre-Ship) SI Developer to provide SI Flange post-fabrication inspection report with measurement results from manufacturer.							SSP SE&I					
SE03-037 Rev. 1.1	4.1.3.8	If bushings or other inserts are to be used at the bolt hole locations (e.g., dielectric material to effect electrical isolation between the TA IMF and the SI Flange), such bushings shall be captive to avoid FOD concerns associated with small, loose components (e.g., interference fit).	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide SI Flange and instrument assembly drawings. (Pre-Ship) NASA to inspect hardware.							SIAT					
SE03-037 Rev. 1.1	4.1.4.5	The SI Flange shall position a hole with a diameter as defined above *[see note below]* , centered at the Dowel Pin location used for location and shear loads. <u>Note:</u> The bore hole diameter on the SI side is to be 1 inch [+0,+0.003 inch] or equivalently 25.4 mm [+0, +0.08 mm].	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide SI Flange and instrument assembly drawings. (Pre-Ship) SI Developer to provide SI Flange post-fabrication inspection report with measurement results from manufacturer. NASA to inspect hardware.							SIAT					
SE03-037 Rev. 1.1	4.1.4.5	The SI Flange shall position a slotted hole centered at the Dowel Pin location opposite the one defined above for location and shear loads.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide SI Flange and instrument assembly drawings. (Pre-Ship) NASA to inspect hardware.							SSP SE&I					
SE03-037 Rev. 1.1	4.1.4.5	The minor dimension (width) and tolerance of this slot shall match the Dowel Pin Bore hole diameter on the SI Flange.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide SI Flange and instrument assembly drawings. (Pre-Ship) SI Developer to provide SI Flange post-fabrication inspection report with measurement results from manufacturer.							SSP SE&I					
SE03-037 Rev. 1.1	4.1.4.5	The major dimension (length) of this slot shall be between 1.12 inch [28.5 mm] and 1.25 inch [31.8 mm] and shall be oriented such that it points to the center of the flange (i.e., is aligned with the IR beam center).	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide SI Flange and instrument assembly drawings. (Pre-Ship) SI Developer to provide SI Flange post-fabrication inspection report with measurement results from manufacturer.							SSP SE&I					
SE03-037 Rev. 1.1	4.1.4.5	If bushings or other inserts are to be used at any of the Dowel Pin Bore Hole locations (e.g., dielectric material to effect electrical isolation between the TA IMF and the SI Flange, or to achieve the correct diameter), such bushings shall be captive to avoid FOD concerns associated with small, loose components (e.g., interference fit), and should be adequately robust to preclude damage due to crushing upon SI installation.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide SI Flange and instrument assembly drawings. (Pre-Ship) NASA to inspect hardware.							SIAT					
SE03-037 Rev. 1.1	4.1.4.5	The SI Flange shall position oversized clearance holes with diameter of at least 1.12 inch [28.5 mm] centered at the remaining two (2) Dowel Pin locations.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide SI Flange and instrument assembly drawings. (Pre-Ship) SI Developer to provide SI Flange post-fabrication inspection report with measurement results from manufacturer.							SSP SE&I					

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SE03-037 Rev. 1.1	4.1.4.6	The SI Flange shall have a pattern of 4 dowel pin clearance holes and slot with 90-degree angular spacing on a 990 mm [38.976 inch] bolt circle centered on the IR beam, as shown in Figure 4-1, and as described in paragraph 4.1.4.5.	N/A	A	I	D		(CDR) SI Developer to provide SI Flange and instrument assembly drawings. (Pre-Ship) SI Developer to provide SI Flange post-fabrication inspection report with measurement results from manufacturer. (At AFRC prior to installation ~ Installation and checkout) At the discretion of NASA, the SI Developer may be required to perform a fit-check demonstration of the SI Flange/SI Assembly on the TAAS or SOFIA TA to verify fit, if the SI Flange post-fabrication report is determined to be inadequate for verification close-out of this requirement before shipment.							SSP SE&I					
SE03-037 Rev. 1.1	4.1.5	The SI Flange shall position no holes in any of the four IMF jack screw locations.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide SI Flange and instrument assembly drawings. (Pre-Ship) NASA to inspect hardware.							SSP SE&I					
SE03-037 Rev. 1.1	4.1.6.4	An annular portion of the SI Flange surface from ø884 mm (34.80 inch) ID to ø928.6 mm (36.56 inch) OD which mates with the O-ring shall have a planarity of ≤ 0.4 mm [0.016 inch].	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide SI Flange and instrument assembly drawings. (Pre-Ship) SI Developer to provide SI Flange post-fabrication inspection report with measurement results from manufacturer.							SSP SE&I					
SE03-037 Rev. 1.1	4.1.6.4	An annular portion of the SI Flange surface from ø884 mm (34.80 inch) ID to ø928.6 mm (36.56 inch) OD which mates with the O-ring shall have a surface finish / roughness of Ra ≤ 0.8 micron [32 micro-inch].	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide SI Flange and instrument assembly drawings. (Pre-Ship) SI Developer to provide SI Flange post-fabrication inspection report with measurement results from manufacturer.							SSP SE&I					
SE03-037 Rev. 1.1	4.1.6.4	SI Flange edges that contact the TA IMF O-ring seal shall be chamfered or otherwise deburred / broken with a minimum edge radius of 0.2 mm [0.008 inch] to prevent damage to the seal material.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide SI Flange and instrument assembly drawings. (Pre-Ship) SI Developer to provide SI Flange post-fabrication inspection report with measurement results from manufacturer.							SSP SE&I					
SE03-037 Rev. 1.1	4.1.6.4	SIs which position the SI Flange such that it does not make direct metal-to-metal contact with the TA IMF (e.g., those which are electrically isolated using a dielectric material at the mechanical interface between the TA IMF and the SI Flange) shall ensure that the O-ring seal is compressed no less than 15% of the O-ring cross-sectional thickness upon SI installation, considering the thickness and placement of the dielectric material, stack-up of all dimensional tolerances, and the TA IMF O-ring and gland dimensions defined in Figure 4-3.	N/A	A	A	N/A	N/A	(CDR) SI Developer to provide SI/IMF O-ring compression analysis (e.g. thickness and flatness of dielectric spacer) for instrument CDR design. (Pre-Ship) SI Developer to provide updated O-ring compression analysis for as-built SI.							SSP SE&I					
SE03-037 Rev. 1.1	4.2.1	The SI Assembly c.g. in the longitudinal direction (U coordinate axis) shall be between U= 3285 mm [129.33 inch] and U= 1785 mm [70.28 inch].	A	A	A	N/A	N/A	(PDR) SI Developer to provide preliminary SI Assembly C.G. and moments analysis. (CDR) SI Developer to provide updated analysis for instrument CDR design. (Pre-Ship) SI Developer to provide final updated analysis for as-built SI.							SSP SE&I					
SE03-037 Rev. 1.1	4.2.1	The SI Assembly c.g. in the radial direction shall be within a cone shaped moment envelope defined by connecting adjacent points with straight lines in Figures 4.2.1-1 and 4.2.1-2.	A	A	A	N/A	N/A	(PDR) SI Developer to provide preliminary SI Assembly C.G. and moments analysis. (CDR) SI Developer to provide updated analysis for instrument CDR design. (Pre-Ship) SI Developer to provide final updated analysis for as-built SI.							SSP SE&I					
SE03-037 Rev. 1.1	4.2.2	SIs which use expendable liquid cryogens to cool their instrument shall exhibit a moment change of not more than 800 Nm around the XEL and LOS axes, and not more than 400 Nm around the EL axis, over a 10-hour flight, resulting from SI mass and c.g. change during flight due to the depletion of the cryogens in the SI dewar.	A	A	A	N/A	N/A	(PDR) SI Developer to provide preliminary SI Assembly C.G. and moments analysis. (CDR) SI Developer to provide updated analysis for instrument CDR design. (Pre-Ship) SI Developer to provide final updated analysis for as-built SI.							SSP SE&I					
SE03-037 Rev. 1.1	4.3.5.2	The pressure coupler flange shall have clearance holes with a diameter between ø0.323 inch (P drill size) [8.2 mm] to ø0.332 inch (Q drill size) [8.4 mm].	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide pressure coupler flange and assembly drawings. (Pre-Ship) SI Developer to provide pressure coupler flange post-fabrication inspection report with measurement results from manufacturer.							SSP SE&I					
SE03-037 Rev. 1.1	4.3.5.3	[Pressure coupler interface flange]: Number of bolts ≤ 16, equally spaced in angular direction (refer to fig. 4-7a). The number of bolts, clearance holes and threaded inserts used by the SI Developer shall be substantiated by a structural analysis provided by the SI Developer reflecting positive Margin of Safety (MS) considering the emergency crash load factors in each direction.	N/A	A	A & I	N/A	N/A	(CDR) SI Developer to provide pressure coupler part & assembly drawings and structural analysis. (Pre-Ship) SI Developer to provide updated structural analysis for as-built pressure coupler. NASA to inspect hardware.							SIAT					
SE03-037 Rev. 1.1	4.3.5.4	The bolt circle diameter of the pressure coupler / optical window assembly flange that interfaces with the GVPP pressure coupler / optical window interface shall be 275 mm [10.83 inch] centered on IR beam, as shown in fig. 4-7a.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide pressure coupler flange and assembly drawings. (Pre-Ship) SI Developer to provide pressure coupler flange post-fabrication inspection report with measurement results from manufacturer.							SSP SE&I					

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SE03-037 Rev. 1.1	4.3.5.5	The angular spacing of clearance holes on the pressure coupler / optical window assembly flange shall use the threaded insert angular spacing pattern shown in Figure 4-7a.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide pressure coupler flange and assembly drawings. (Pre-Ship) SI Developer to provide pressure coupler flange post-fabrication inspection report with measurement results from manufacturer.							SSP SE&I					
SE03-037 Rev. 1.1	4.3.6.1	The inner diameter of the O-Ring gland at the pressure coupler / optical window assembly mating surface shall be between 230 mm [9.06 inch] and 240 mm [9.449 inch].	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide pressure coupler flange and assembly drawings. (Pre-Ship) SI Developer to provide pressure coupler flange post-fabrication inspection report with measurement results from manufacturer.							SSP SE&I					
SE03-037 Rev. 1.1	4.3.6.2	The O-ring thickness shall be ≤ 6 mm [0.236 inch].	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide pressure coupler assembly drawing; drawing should include O-ring manufacturer and part number. (Pre-Ship) NASA to inspect hardware. Inspection may be performed on a spare O-ring if unit is from the same production lot.							SIAT					
SE03-037 Rev. 1.1	4.3.6.3	Pressure Coupler surfaces which interface with the TA Pressure Window Subassembly and O-Ring seal (including the bottom surface of the Pressure Coupler O-Ring seal gland) shall have a planarity ≤ 0.3 mm [0.012 inch].	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide pressure coupler flange and assembly drawings. (Pre-Ship) SI Developer to provide pressure coupler flange post-fabrication inspection report with measurement results from manufacturer.							SSP SE&I					
SE03-037 Rev. 1.1	4.3.6.3	Pressure Coupler surfaces which interface with the TA Pressure Window Subassembly and O-Ring seal (including the bottom surface of the Pressure Coupler O-Ring seal gland) shall have a surface finish / roughness Ra ≤ 0.8 micron [32 micro-inch]; Alternatively, the surface finish / roughness may be relaxed to Ra ≤ 1.6 micron [64 micro-inch] with the additional specification of a concentric surface texture lay.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide pressure coupler flange and assembly drawings. (Pre-Ship) SI Developer to provide pressure coupler flange post-fabrication inspection report with measurement results from manufacturer.							SSP SE&I					
SE03-037 Rev. 1.1	4.3.6.3	The (pressure coupler) O-ring seal and corresponding seal gland shall be dimensioned so as to ensure that the O-ring seal is compressed no less than 15% of the O-ring cross-sectional thickness upon assembly, considering a worst-case stack-up of all applicable dimensional tolerances.	N/A	A	A	N/A	N/A	(CDR) SI Developer to provide pressure-coupler O-ring compression analysis. (Pre-Ship) SI Developer to provide updated analysis for as-built pressure coupler assembly.							SSP SE&I					
SE03-037 Rev. 1.1	4.3.7	The pressure coupler diameter shall be limited to ø300 mm [11.81 inch] between U = 1800 mm [70.87 inch] and U = 1885 mm [74.21 inch].	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide pressure coupler flange and assembly drawings. (Pre-Ship) SI Developer to provide pressure coupler flange post-fabrication inspection report with measurement results from manufacturer.							SSP SE&I					
SE03-037 Rev. 1.1	4.3.7	Pressure coupler assembly length shall be limited to 485 mm [19.09 inch], the distance between the GVPP mounting interface (U = 1800 mm [70.87 inch]) and the IMF interface (U = 2285 mm [89.96 inch]).	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide pressure coupler flange and assembly drawings. (Pre-Ship) NASA to inspect hardware.							SSP SE&I					
SE03-037 Rev. 1.1	4.3.8	The pressure coupler shall be able to accommodate a 0.1 mm [0.004 inch] range of motion in the U-direction, resulting in an additional tilt of approximately 0.03 degrees. Note: SOFIA SE&I has requested and is awaiting clarification from Kayser-Threde on how SI that use the GVPP hardpoints, are expected to show compliance with this requirement (May 2014)	N/A	A	D	N/A	N/A	(CDR) SI Developer to provide analysis of pressure coupler range of movement. (Pre-Ship) SI Developer to demonstrate range-of-movement of pressure coupler.							SSP SE&I					
SE03-037 Rev. 1.1	4.4.3	The mechanical (outer) diameter of the Optical Window Assembly and flange shall be limited to the same diameter as the pressure coupler (refer to section 4.3.7).	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide optical window flange and assembly drawings. (Pre-Ship) SI Developer to provide optical window flange post-fabrication inspection report with measurement results from manufacturer.							SSP SE&I					
SE03-037 Rev. 1.1	4.4.3	If an SI Assembly uses the maximum SI depth in the INF as defined in RD5, the Optical Window Assembly depth in the U-direction shall be limited to 85 mm [3.34 inch].	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide optical window flange and assembly drawings. (Pre-Ship) NASA to inspect hardware.							SSP SE&I					
SE03-037 Rev. 1.1	4.4.4	Bolt circle diameter, bolt size, bolt pattern, and mounting screw clearance hole diameter shall be identical to the dimensions defined for the pressure coupler interface (section 4.3, figure 4-7 a).	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide optical window flange and assembly drawings. (Pre-Ship) SI Developer to provide optical window flange post-fabrication inspection report with measurement results from manufacturer.							SSP SE&I					
SE03-037 Rev. 1.1	4.4.5	The seal between the Optical Window Assembly and the Flange Assembly shall match the specifications defined for the pressure coupler (section 4.3.6).	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide pressure coupler part & assembly drawings and O-ring compression analysis. (Pre-Ship) SI Developer to provide optical window flange post-fabrication inspection report with measurement results from manufacturer.							SSP SE&I					
SE03-037 Rev. 1.1	4.4.6	Pressure Coupler Assemblies and Optical Window Assemblies mounted to the GVPP Pressure Coupler / Optical Window interface shall not exceed 10 kg. Larger masses may have to be supported by other means as well as by the window fixture.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide mass analysis of pressure coupler / optical window assembly loading on GVPP mounting interface. (Pre-Ship) SI Developer to provide updated mass analysis based on as-built pressure coupler / optical window assembly. NASA to inspect hardware.							SSP SE&I					

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SE03-037 Rev. 1.1	4.5.3	Hoses that connect to the cabin side KF-25 Quick Flanges on the INF shall be KF-25 Quick Flanges.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide assembly drawings, showing part number of SI hoses, fittings, and clamps to interface with TA INF tub cabin-side port. (Pre-Ship) NASA to inspect hardware.							SSP SE&I					
SE03-037 Rev. 1.1	4.5.3	Standard hinged clamps and centering rings shall be used for fixation and sealing.	This ICD requirement is on SOFIA Mission Operations; MOPS provides these fittings																	
SE03-037 Rev. 1.1	4.10.1	SI equipment mounted to the GVPP hardpoints shall engage both threaded inserts for each hardpoint, using 1/2-20 screws (see 4.10).	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide instrument assembly drawings, showing the instrument installation configuration and hardware used to mount to the GVPP hardpoints, including part number of mounting fasteners. (Pre-Ship) NASA to inspect hardware.							SIAT					
SE03-037 Rev. 1.1	4.10.1	SI equipment loading on individual GVPP hardpoints shall not exceed the limit loads (forces and moments) specified in this section and Figure 4-10.	N/A	A	A	N/A	N/A	(CDR) SI Developer to provide analysis of loading on GVPP hardpoints. (Pre-Ship) SI Developer to provide updated analysis for as-built SI.							SIAT					
SOF-DA-ICD-SE03-2015 (SI_AS_01) Revision A: Principal Investigator Equipment to PI Rack to Aircraft System Interface																				
SE03-2015 Rev. A	3.3	For a PI rack that will contain both SI equipment and the MADS unit, the PI shall allocate sufficient space for the installation of the MADS unit and cable connections to the FCD. <u>Notes:</u> 1) Dimensions of the MADS unit is 19"W x 6.97"H x 10.5"D. 2) The default installation location of the MADS unit is in the Auxiliary PI Rack. 3) Two MADS units are now available for installation in the Auxiliary or Science Instrument PI Racks; current ICD describes only one MADS unit. This expanded MADS capability will be reflected in the next revision of this ICD.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide drawing of PI Rack configuration, showing allocated space for installation of MADS unit. (Pre-Ship) NASA to inspect PI Rack.							SSP SE&I					
SE03-2015 Rev. A	3.3	The PI shall include the MADS unit in the rack loading and overturning moment considerations as described in Section 4.2 for a PI rack that will contain both SI equipment and the MADS unit.	N/A	A	A	N/A	N/A	(CDR) SI Developer to provide PI Rack overturning moment analysis. (Pre-Ship) SI Developer to provide updated overturning moment analysis for populated rack configuration.							SIAT					
SE03-2015 Rev. A	3.4	PI equipment attached to the rack shall not interfere with the removal or re-installation of the PI Rack bar handles.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide drawing of PI Rack configuration, including rack bar handles. (Pre-Ship) NASA to inspect PI Rack.							SSP SE&I					
SE03-2015 Rev. A	4.3	The total SI payload loading of the PI rack structure shall be 600 lbs or less.	A	A	A & T	T	N/A	(PDR) SI Developer to provide preliminary PI Rack mass analysis. (CDR) SI Developer to provide updated mass analysis for instrument CDR design. (Pre-Ship) SI Developer to provide final updated payload mass analysis based on reported measured weight of individual rack components. Weight contribution from cables within the rack should be included. It is preferred the team also provide a weight measurement of the fully populated PI Rack (weight of the empty PI Rack is 64 lbs). (At AFRC prior to installation) NASA to measure weight of PI Rack.							SIAT					
SE03-2015 Rev. A	4.3	The total payload weight for any individual bay shall be 300 lbs or less.	A	A	A & T	I	N/A	(PDR) SI Developer to provide preliminary PI Rack mass analysis. (CDR) SI Developer to provide updated mass analysis for instrument CDR design. (Pre-Ship) SI Developer to provide final updated payload analysis based on the reported measured weights of individual rack components. (Pre-Ship/At AFRC prior to installation) NASA to inspect PI Rack.							SIAT					
SE03-2015 Rev. A	4.4	The overturning moment for the rack shall be 1000 ft-lbs (12,000 in-lbs) or less.	N/A	A	A	I	N/A	(CDR) SI Developer to provide PI Rack overturning moment analysis. (Pre-Ship) SI Developer to provide updated overturning moment analysis for the populated rack configuration. (At AFRC prior to installation) NASA to inspect PI Rack.							SIAT					
SE03-2015 Rev. A	4.5	Support trays shall be used to support all free-standing equipment with the exception of those items placed on top of the rack.	N/A	A	I		N/A	(CDR) SI Developer to provide assembly drawings of the PI Rack, including the configuration of each tray (i.e., equipment mounted to tray and mounting hardware). (Pre-Ship / At AFRC prior to installation) NASA to inspect PI Rack.							SIAT					
SE03-2015 Rev. A	4.5	Any support tray used shall be attached to both the forward and aft attach posts of a bay.	N/A	A	I		N/A	(CDR) SI Developer to provide drawings of PI Rack configuration. (Pre-Ship ~ At AFRC prior to installation) NASA to inspect PI Rack.							SIAT					

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SE03-2015 Rev. A	4.5	An analysis shall be provided showing that free-standing equipment secured to a support tray withstands the emergency landing load conditions. Note: Emergency landing load conditions are specified in the "Equipment mounted to Cabin / Airframe" column of SOF-AR-SPE-SE01-2028, *SOFIA SI System Specification* , Appendix A Table 3.5-1.	N/A	A	I		N/A	(CDR) SI Developer to provide structural analysis for free-standing equipment secured to support trays. (Pre-Ship ~ At AFRC prior to installation) NASA to inspect PI Rack.							SIAT					
SE03-2015 Rev. A	4.5	Aircraft-certified fastener hardware shall be used to attach any support tray to the PI rack.	N/A	A	I		N/A	(CDR) SI Developer to provide PI Rack configuration / assembly drawings, identifying part numbers of fasteners used to mount SI equipment to the rack. (Pre-Ship ~ At AFRC prior to installation) SI Developer to provide fastener Certificates of Conformance (CoCs). NASA to inspect certs, fastener hardware, and rack configuration.							SIAT					
SE03-2015 Rev. A	4.5	The load per tray shall be 150 lbs or less for either free-standing equipment or when supporting a chassis assembly.	N/A	A	A or T	N/A	N/A	(CDR) SI Developer to provide mass analysis of equipment mounted to each NASA-provided support tray used. (Pre-Ship) SI Developer to measure and provide measurement of payload weight on each NASA support tray; or an updated mass analysis for each tray.							SIAT					
SE03-2015 Rev. A	4.5	The cumulative overturning moment of all the equipment on a tray shall be 900 inch-pounds or less as measured from the upper surface of the tray.	N/A	A	A	N/A	N/A	(CDR) SI Developer to provide overturning moment analysis of equipment mounted to each NASA-provided PI Rack support tray. (Pre-Ship) SI Developer to provide updated analysis for as-assembled / populated tray configuration.							SIAT					
SE03-2015 Rev. A	4.5	PI-provided support trays shall withstand the emergency landing load conditions for the maximum payload-weight the tray is designed to handle.	N/A	A	I		N/A	(CDR) SI Developer to provide structural analysis for any PI-provided support trays. (Pre-Ship / At AFRC prior to installation) NASA to inspect PI Rack.							SIAT					
SE03-2015 Rev. A	4.6	An analysis shall be provided showing that attachment of SI equipment to the PI rack structure withstands the emergency landing load conditions.	N/A	A	I		N/A	(CDR) SI Developer to provide structural analysis for all equipment mounted to the PI Rack. (Pre-Ship ~ At AFRC prior to installation) NASA to inspect PI Rack.							SIAT					
SE03-2015 Rev. A	4.6	Aircraft-certified fastener hardware shall be used to attach SI equipment to the PI rack.	N/A	A	I		N/A	(CDR) SI Developer to provide PI Rack configuration / assembly drawings, identifying part numbers of fasteners used to mount SI equipment to the rack. (Pre-Ship ~ At AFRC prior to installation) SI Developer to provide fastener Certificates of Conformance (CoCs). NASA to inspect certs, fastener hardware, and rack configuration.							SIAT					
SE03-2015 Rev. A	4.6	An analysis shall be provided showing that PI-provided structural-support hardware withstands the emergency landing load conditions in its used configuration.	N/A	A	I		N/A	(CDR) SI Developer to provide structural analysis for PI-provided structural support hardware. (Pre-Ship ~ At AFRC prior to installation) NASA to inspect PI Rack.							SIAT					
SE03-2015 Rev. A	4.6	Bearing angles or large-area washers shall be used with any panel-mounted chassis unit that has slotted attach-holes.	N/A	A	I		N/A	(CDR) SI Developer to provide PI Rack configuration / assembly drawings, identifying part numbers of fasteners used to mount SI equipment to the rack. (Pre-Ship ~ At AFRC prior to installation) SI Developer to provide fastener Certificates of Conformance (CoCs) (if used). NASA to inspect certs, fastener hardware, and rack configuration.							SIAT					
SE03-2015 Rev. A	4.7.1	An analysis shall be provided showing that equipment installed on the top of the rack withstands the emergency landing load conditions.	N/A	A	I		N/A	(CDR) SI Developer to provide structural analysis for equipment mounted to the top of the PI Rack. (Pre-Ship ~ At AFRC prior to installation) NASA to inspect PI Rack.							SIAT					
SE03-2015 Rev. A	4.7.2	The motion of sliding rails shall be constrained in the stowed position.	N/A	A	D		N/A	(CDR) SI Developer to provide assembly drawings for custom slide-rail designs or manufacturer & part number for COTS slide-rail hardware. (Pre-Ship ~ At AFRC prior to installation) SI Developer to demonstrate slide rails are constrained in the stowed position.							SIAT					
SE03-2015 Rev. A	4.7.2	An analysis shall be provided showing that the sliding-rail mechanism and lock mechanism withstand the emergency landing load conditions in the stowed position.	N/A	A	I		N/A	(CDR) SI Developer to provide structural analysis of slide-rail and lock mechanism in stowed position. (Pre-Ship ~ At AFRC prior to installation) NASA to inspect PI Rack.							SIAT					
SE03-2015 Rev. A	4.7.2	For SI equipment used in the slide-out position for prolonged periods of time, the PI shall provide an analysis showing that the sliding-rail mechanism and lock mechanism withstand the maximum in-flight inertia load conditions defined in SOF-1030.	N/A	A	A	N/A	N/A	(CDR) SI Developer to provide structural analysis for slide-rail and slide-out lock mechanism. (Pre-Ship) SI Developer to provide updated analysis if as-built design has any changes from CDR design.							SIAT					

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SOF-DA-ICD-SE03-036 (TA_SI_01) Revision 3: Cable Load Alleviator Device/Science Instrument Cable Interface																				
SE03-036 Rev. 3	4.1.3.3	The PI shall provide all jumper cable assemblies used to route power between the Power SI Patch Panel (Panel U402) and TA-mounted SI equipment.	N/A	A	I	I	N/A	(CDR) SI Developer to provide system wiring diagram; diagram should include cable numbers / identifiers and show connections to SOFIA patch panel interfaces. (Pre-Ship) SI Developer to provide final updated system wiring diagram for as-built instrument. (At AFRC prior to installation) NASA to inspect cables.							SSP SE&I					
SE03-036 Rev. 3	4.1.3.3	SI connectors that interface with Panel U402 shall use the mating connector part numbers (or equivalent) as listed in Table 1-A.	N/A	A	I	I	N/A	(CDR) SI Developer to provide cable assembly drawings; drawings should include connector part numbers. (Pre-Ship) SI Developer to provide final updated cable assembly drawings for as-built cables. (At AFRC prior to installation) NASA to inspect cables.							SSP SE&I					
SE03-036 Rev. 3	4.1.3.3	The contact assignments for SI connectors that interface with Panel U402 shall be as listed in SOF-AR-ICD-SE03-2029, Tables 15-18, for connections used by the PI. Note: This citation is out of date; the applicable tables from SOF-AR-ICD-SE03-2029, (MCCS_SI_05) Rev. C are now Tables 16-20. This editorial change will be made in the next revision of ICD TA_SI_01.	N/A	A	A	T	N/A	(CDR) SI Developer to provide cable assembly drawings; drawings should include connector part numbers. (Pre-Ship) SI Developer to provide final updated cable assembly drawings for as-built cables. (At AFRC prior to installation) NASA to inspect and test power cables.							SSP SE&I					
SE03-036 Rev. 3	4.1.3.3	The PI shall provide all jumper cable assemblies to route signal between the Signal SI Patch Panel (Panel U403) and TA-mounted SI equipment.	N/A	A	I	I	N/A	(CDR) SI Developer to provide system wiring diagram; diagram should include cable numbers / identifiers and show connections to SOFIA patch panel interfaces. (Pre-Ship) SI Developer to provide final updated system wiring diagram for as-built instrument. (At AFRC prior to installation) NASA to inspect cables.							SSP SE&I					
SE03-036 Rev. 3	4.1.3.3	SI connectors that interface with Panel U403 shall use the mating connector part numbers (or equivalent) as listed in Table 1-B.	N/A	A	I	I	N/A	(CDR) SI Developer to provide cable assembly drawings; drawings should include connector part numbers. (Pre-Ship) SI Developer to provide final updated cable assembly drawings for as-built cables. (At AFRC prior to installation) NASA to inspect cables.							SSP SE&I					
SE03-036 Rev. 3	4.1.3.3	The contact assignments for SI connectors that interface with Panel U403 shall be as listed in SOF-AR-ICD-SE03-2029, Tables 8-14, for connections used by the PI. Note: This citation is out of date; the applicable tables from SOF-AR-ICD-SE03-2029, (MCCS_SI_05) Rev. C are now Tables 9-15. This editorial change will be made in the next revision of ICD TA_SI_01.	N/A	A	A	I	N/A	(CDR) SI Developer to provide cable assembly drawings; drawings should include connector part numbers. (Pre-Ship) SI Developer to provide final updated cable assembly drawings for as-built cables. (At AFRC prior to installation) NASA to inspect signal cables.							SSP SE&I					
SE03-036 Rev. 3	4.1.3.6	The resistance between the SI Assembly and the Panel U402 ground terminal strip shall be no greater than 10 mΩ (0.010 ohms).	N/A	A	A	N/A	T	(CDR) SI Developer to provide system electrical ground diagram or schematic for instrument CDR design. (Pre-Ship) SI Developer to provide final updated system electrical ground diagram for the as-built SI. (Installation and checkout) NASA to measure resistance.							SSP SE&I					
SE03-036 Rev. 3	4.1.3.6	The SI Assembly shall provide a designated test point (or grounding lug) for which this safety ground resistance measurement can be made.	N/A	A	I	N/A	N/A	(CDR) SI Developer to identify location of electrical ground test point on instrument in drawing or documentation. (Pre-Ship) NASA to inspect hardware.							SSP SE&I					
SE03-036 Rev. 3	4.1.3.6	The PI shall provide any needed jumper cable assembly used between the SI Assembly and the Panel U402 ground terminal strip. Note: This applies if more than 10 mΩ resistance between SI Assembly and Panel U402 ground terminal strip is anticipated due to electrical characteristics such as a non-conductive SI Flange surface.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide system electrical ground diagram or schematic, and assembly drawings for any needed safety ground cables or straps. (Pre-Ship) NASA to inspect cables.							SSP SE&I					
SE03-036 Rev. 3	4.1.3.8	The PI shall use the designated emergency power shutdown pins on Panel U403-J79 to shutdown any PI-provided TA-mounted UPS unit whenever the Observatory Emergency Power Disconnect (EPD) signal is enabled.	Verification of this requirement is covered by SE03-2029 (MCCS_SI_05), Par ID 3.2.1.1																	
SOF-DA-ICD-SE03-051 (TA_SI_05) Revision 2: SI Equipment Rack/TA Counterweight Interface																				
SE03-051 Rev. 2	3.1 f	The total weight of a CWR installation shall be between 220 lbs (100 kg) and 330 lbs (150 kg) inclusive. Note: The weight of the CWR installation includes the empty CWR, SI payload, and associated CWR-to-CWP mounting hardware (e.g., struts, brackets, spacers, fasteners, etc.).	Verification of this requirement is covered by SE03-2027 (SI_CWR_01), Par ID 3.1 a																	
SCI-AR-ICD-SE03-2027 (SI_CWR_01) Revision B: Science Instrument Equipment to Counterweight Rack Interface																				

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			PDR	CDR	Pre-Ship	At AFRC prior to installation	Installation and checkout			PDR	CDR	Pre-Ship	At AFRC prior to installation	Installation and checkout		PDR	CDR	Pre-Ship	At AFRC prior to installation	Installation and checkout
SE03-2027 Rev. B	3.1 a	The total weight of the SI payload in the CWR shall be between 123 lbs (55.8 kg) and 233 lbs (105.7 kg) inclusive. Notes: 1) The weight of an empty CWR structure is 83 lbs. The total weight associated CWR-to-CWP mounting hardware is 14 lbs. 2) If the PI elects not to use the CWR, NASA will supply a CWR loaded with ballast weights such that the weight of the CWR installation is within the required weight range specified in SE03-051 (TA_SI_05), section 3.1 f.	A	A	A & T	T	N/A	(PDR) SI Developer to provide preliminary CWR mass analysis. (CDR) SI Developer to provide updated mass analysis for instrument CDR design. (Pre-Ship) SI Developer to provide final updated payload mass analysis based on measured weight of individual rack components. Weight contribution of from cables should be included. It is preferred the team also provide a weight measurement of the fully populated CWR. (At AFRC prior to installation) NASA to measure weight of CWR and cables.							SIAT					
SE03-2027 Rev. B	3.1 a	If the total weight of SI equipment, SI mounting hardware and fasteners, SI cables that interface between payload equipment within the CWR, and Electronic Interface Channels used is less than 123 lbs (55.8 kg), supplemental ballast weights shall be added to compensate at the very least to the 123 lb (55.8 kg) minimum.	Verification of this requirement is covered by SE03-2027 (SI_CWR_01), Par ID 3.1 a																	
SE03-2027 Rev. B	3.1 b	The center of gravity of the populated rack (excluding CWR-to-CWP mounting hardware) shall be within the following envelope: • In the u-direction, at a location 16.14 inch (410 mm) or less from the fwd surface of the CWP. • In the v-direction, at a location +/- 2.5 inch (63.5 mm) centered about the CWR central plane. • In the w-direction, at a location +/- 1 inch (25.4 mm) from 11.01" (279.9 mm) below the top of the CWR (top of the extrusion excluding the flange).	N/A	A	I		N/A	(CDR) SI Developer to provide analysis of CWR C.G. (Pre-Ship ~ At AFRC prior to installation) NASA to perform inspection to verify Counterweight Rack configuration conforms to SI drawings and documentation.							SIAT					
SE03-2027 Rev. B	3.1 c	An analysis shall be provided showing that each piece of SI equipment remains attached to the CWR under the emergency landing load conditions specified in the "Equipment mounted to Telescope Assembly" column of SOF-AR-SPE-SE01-2028, Table 3.5-1. (Reproduced from SOF-AR-SPE-SE-01-2028, Table 3.5-1) Overall system flight and emergency landing static ultimate load factors are: • 9G FWD (+ u-direction), 1.5G AFT (- u-direction) • 6G DWN (- w-direction), 3G UP (+ w-direction) • 6G SIDE (± v-direction)	N/A	A	I		N/A	(CDR) SI Developer to provide structural analysis of CWR equipment. (Pre-Ship ~ At AFRC prior to installation) NASA to inspect Counterweight Rack configuration.							SIAT					
SE03-2027 Rev. B	3.1 e	All SI payload attachment to the CWR shall use aircraft-certified fastener hardware.	N/A	A	I		N/A	(CDR) SI Developer to provide CWR configuration / assembly drawings, identifying part numbers of fasteners used to mount SI equipment to the rack. (Pre-Ship ~ At AFRC prior to installation) SI Developer to provide fastener Certificates of Conformance (CoCs). NASA to inspect certs, fastener hardware, and rack configuration.							SIAT					
SE03-2027 Rev. B	3.1 f	SI equipment inside each section of the CWR shall not exceed the following SI electronics equipment envelope: • 22" (558.8 mm) SI equipment depth (forward/aft, u-direction) • 21.65" (549.9 mm) SI equipment height (left/right, v-direction) • 17.75" (450.9 mm) SI equipment width (up/down, w-direction) Note: The envelope applies only to the portion of SI equipment that resides within the CWR.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide an envelope (size) analysis of CWR equipment. (Pre-Ship) NASA to inspect Counterweight Rack.							SSP SE&I					
SE03-2027 Rev. B	3.2 b	Single attachment points of SI equipment on the CWR electronics attachment flange shall not exceed the following maximum loads: • Shear Tearout and Bearing Failure on a CWR electronics attachment flange hole = 825 lbf (3670 N) • Fwd/Aft Load on CWR electronics attachment flange = 500 lbf (2224 N) • Moment on CWR electronics attachment flange = 180 in-lbf (20337.3 N-mm)	N/A	A	I		N/A	(CDR) SI Developer to provide structural analysis for loading on mounting flange of CWR structure. (Pre-Ship ~ At AFRC prior to installation) NASA to inspect Counterweight Rack.							SIAT					
SCI-US-ICD-SE03-2023 (DCS_SI_01) Revision E: Interface Control Document for the Data Cycle System																				
SE03-2023 Rev. E	4.0	The SI shall define Astronomical Observing Templates (AOTs) for all configurations and observing modes of the instrument, in an instrument-specific SI-to-DCS ICD.	N/A	A	A		N/A	(CDR) SI Developer to define AOTs for all configurations/observing modes of the instrument in a draft instrument-specific SI-DCS ICD. Appendix A contains an AOT Definition Template which SI should follow. (Pre-Ship ~ At AFRC prior to installation) SI Developer to update instrument SI-DCS ICD as needed, with review and concurrence from SOFIA Data Cycle System (DCS) & Data Processing System (DPS) teams.							SSP SE&I					
SE03-2023 Rev. E	6.2	If SI will be providing a data manifest for archiving of SI data into the DCS, the SI Data Manifest XML document shall comply with the structure and grammar rules for Data Manifests specified in Appendix C. Note: It is optional for SI Developers to provide Data Manifest(s)	N/A	N/A	I & D		D	(Pre-Ship ~ At AFRC prior to installation) SI Developer to deliver data manifest document to SOFIA DCS team for inspection, and demonstration of ingestion of simulated FITS data file into DCS using data manifest XML file. (Installation and checkout) SI Developer to demonstrate ingestion/initial archiving of SI Line Ops or Commissioning FITS data using SI data manifest.							SSP SE&I					

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SE03-2023 Rev. E	7.1.1	SI FITS files submitted to the DCS shall contain the required and conditionally required SOFIA keywords and values, specified in *Appendix D SOFIA FITS Keywords Table* , that are needed for archive ingestion, data processing, and archive search. Note: Conditionally required keywords are keywords that apply depending on the configuration and operating modes of the instrument.	N/A	A	A & D		D	(CDR) SI Developer to identify and list all SOFIA keywords to be included in FITS file metadata, in draft instrument-specific SI-DCS ICD. (Pre-Ship ~ At AFRC prior to installation) SI Developer to update instrument SI-DCS ICD keyword list as needed, with review and concurrence from SOFIA DCS & DPS teams. SI Developer to demonstrate ingestion of simulated FITS data into DCS. For FSI data, keyword check may first be performed by DPS before data is ingested into DCS. (Installation and checkout) SI Developer to demonstrate ingestion of Line Ops or Commissioning FITS data into DCS.							SSP SE&I					
SE03-2023 Rev. E	7.1.1	SI FITS files submitted to the DCS shall contain the instrument-unique SI keywords and values, specified in the instrument-specific SI-to-DCS ICD, that are needed for data processing, reduction, and calibration.	N/A	A	A & D		D	(CDR) SI Developer to identify and list all SOFIA and instrument-unique FITS keywords required for data processing/reduction for the instrument, in draft instrument-specific SI-DCS ICD. (Pre-Ship ~ At AFRC prior to installation) SI Developer to update instrument SI-DCS ICD keyword list as needed, with review and concurrence from SOFIA DCS & DPS teams. SI Developer to demonstrate ingestion of simulated FITS data into DCS. For FSI data, keyword check may first be performed by DPS before data is ingested into DCS. (Installation and checkout) SI Developer to demonstrate ingestion of Line Ops or Commissioning FITS data into DCS. *[Pipeline processing requirements and verification for Facility Science Instruments is covered by SOF-AR-SPE-SE01-2028, Rev. A, Par ID 3.1.5]*							SSP SE&I					
SE03-2023 Rev. E	7.2.1	SI FITS files submitted to the DCS shall adhere to the FITS Standard (v3.0, 2008 July 10)	N/A	A	I & D		N/A	(CDR) SI Developer to identify the standard that SI FITS files will meet in instrument-specific SI-DCS ICD. (Pre-Ship ~ At AFRC prior to installation) SOFIA DCS team to inspect simulated FITS file data provided by SI Developer. SI Developer to demonstrate simulated SI FITS data can be ingested by DCS (and processed/reduced/calibrated by DPS for FSI data).							SSP SE&I					
SE03-2023 Rev. E	7.2.1	Individual SI FITS files submitted to the DCS shall have a file size no greater than 2 GB. Note: If the SI team expects to produce files larger than 2 GB, the SI team should contact the SOFIA DCS team to evaluate a possible increase to the (2 GB) maximum file size limit for individual files downloaded/retrieved from the SOFIA Archive.	N/A	N/A	D		D	(Pre-Ship ~ At AFRC prior to installation) SI Developer to demonstrate ingestion of simulated FITS data file into DCS, which is representative of the maximum single FITS file size the SI will send to the DCS. (Installation and checkout) SI Developer to demonstrate successful ingestion of Line Ops or Commissioning FITS data into DCS.							SSP SE&I					
SOF-AR-ICD-SE03-2029 (MCCS_SI_05) Revision C: Principal Investigator Patch Panel to Principal Investigator Equipment Rack(s) Interface																				
SE03-2029 Rev. C	3.1.1	The PI shall provide all jumper cable assemblies used to route power and signal between the PI Patch Panel-MCCS Side (Panel U401) and the PI rack(s).	N/A	A	I	I	N/A	(CDR) SI Developer to provide system wiring diagram; diagram should include cable numbers / identifiers and show connections to SOFIA patch panel interfaces. (Pre-Ship) SI Developer to provide updated system wiring diagram for as-built instrument. (At AFRC prior to installation) NASA to inspect cables.							SSP SE&I					
SE03-2029 Rev. C	3.1.1	SI connectors that interface with Panel U401 shall use the mating connector part numbers (or equivalent) as listed in Table 2.	N/A	A	I	I	N/A	(CDR) SI Developer to provide cable assembly drawings; drawings should include connector part numbers. (Pre-Ship) SI Developer to provide updated cable assembly drawings for as-built cables. (At AFRC prior to installation) NASA to inspect cables.							SSP SE&I					

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SE03-2029 Rev. C	3.1.2	The PI shall provide all jumper cable assemblies used to route power and signal between the PI Patch Panel-SI Side (Panel U400) and the PI rack(s).	N/A	A	I	I	N/A	(CDR) SI Developer to provide system wiring diagram; diagram should include cable numbers / identifiers and show connections to SOFIA patch panel interfaces. (Pre-Ship) SI Developer to provide updated system wiring diagram for as-built instrument. (At AFRC prior to installation) NASA to inspect cables.							SSP SE&I					
SE03-2029 Rev. C	3.1.2	SI connectors that interface with Panel U400 shall use the mating connector part numbers (or equivalent) as listed in Table 3.	N/A	A	I	I	N/A	(CDR) SI Developer to provide cable assembly drawings; drawings should include connector part numbers. (Pre-Ship) SI Developer to provide updated cable assembly drawings for as-built cables. (At AFRC prior to installation) NASA to inspect cables.							SSP SE&I					
SE03-2029 Rev. C	3.2.1	The contact assignment for SI connectors that connect to Panel U401 shall be as listed in Tables 4 through 8, for connections used by the SI.	N/A	A	A	T	N/A	(CDR) SI Developers to provide cable assembly drawings showing internal wiring and contact pin-out. (Pre-Ship) SI Developer to provide updated cable assembly drawings for as-built cables. (At AFRC prior to installation) NASA to inspect and test cables.							SSP SE&I					
SE03-2029 Rev. C	3.2.1.1	The power drawn by the SI from Panel U401-J0 (230 VAC, 50Hz, UPS power) shall not exceed 1 kVA.	A	A	T or A	T	N/A	(PDR) SI Developer to provide preliminary SI power analysis, indicating expected power draw from each SOFIA SI power bus (e.g., J0, J1, J2, J3). (CDR) SI Developer to provide updated power analysis for instrument CDR design. (Pre-Ship) SI Developer to measure and provide power measurement results, or provide a final updated power analysis for the as-built SI. (At AFRC prior to installation) NASA to measure power draw of the SI.							SSP SE&I					
SE03-2029 Rev. C	3.2.1.1	The power drawn by the SI from Panel U401-J1 (115 VAC, 60 Hz, FC power) shall not exceed 3.5 kVA.	A	A	T or A	T	N/A	(PDR) SI Developer to provide preliminary SI power analysis, indicating expected power draw from each SOFIA SI power bus (e.g., J0, J1, J2, J3). (CDR) SI Developer to provide updated power analysis for instrument CDR design. (Pre-Ship) SI Developer to measure and provide power measurement results, or provide a final updated power analysis for the as-built SI. (At AFRC prior to installation) NASA to measure power draw of the SI.							SSP SE&I					
SE03-2029 Rev. C	3.2.1.1	The power drawn by the SI from Panel U401-J2 (115 VAC, 60 Hz, UPS power) shall not exceed 2 kVA.	A	A	T or A	T	N/A	(PDR) SI Developer to provide preliminary SI power analysis, indicating expected power draw from each SOFIA SI power bus (e.g., J0, J1, J2, J3). (CDR) SI Developer to provide updated power analysis for instrument CDR design. (Pre-Ship) SI Developer to measure and provide power measurement results, or provide a final updated power analysis for the as-built SI. (At AFRC prior to installation) NASA to measure power draw of the SI.							SSP SE&I					
SE03-2029 Rev. C	3.2.1.1	The power drawn by the SI from Panel U401-J3 shall not exceed 85 watts (or 3 amperes).	A	A	T or A	T	N/A	(PDR) SI Developer to provide preliminary SI power analysis, indicating expected power draw from each SOFIA SI power bus (e.g., J0, J1, J2, J3). (CDR) SI Developer to provide updated power analysis for instrument CDR design. (Pre-Ship) SI Developer to measure and provide power measurement results, or provide a final updated power analysis for the as-built SI. (At AFRC prior to installation) NASA to measure power draw of the SI.							SSP SE&I					

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SE03-2029 Rev. C	3.2.1.1	The PI shall use the Observatory Emergency Power Disconnect (EPD) signal carried over Panel U401-J3, pins 7 and 8, to shutdown all PI-provided UPS in the event the EPD signal goes to 28 VDC. Errata: Through testing on the Observatory, the logic of the EPD signal has been identified to be reversed; 28 VDC is present at all times across the J3 pins designated for the EPD when the Observatory/Aircraft is operating normally. In the event of an emergency, the voltage across the J3 EPD pins will become 0 Volts, which is the signal indication that SI must shutdown all SI-provided UPS. The voltage logic of this EPD signal and required SI response will be changed in the next revision of this ICD, MCCS_SI_05 to match the EPD implementation on the aircraft. SI Developers who use or plan to provide their own UPS units should design their EPD-handling circuitry to respond to the SOFIA EPD logic/behavior described in this errata. Notes: 1) This pertains to PI-provided UPS units (e.g., in PI Racks, SI Assembly, CWR). 2) Refer to Table 13 for pins on J79 to be used by the SI for shutting down PI-provided TA-mounted UPS units.	A	A	A	D	N/A	(PDR) SI Developer to provide system functional flow diagram (block level) showing SI UPS and routing of SOFIA EPD signal. (CDR) SI Developer to provide updated system functional flow diagram, system wiring diagram, instrument EPD-handling circuit schematic, and cable assembly drawings for instrument CDR design. Documentation should show how the SI will respond to the SOFIA EPD signal. (Pre-Ship) SI Developer to provide final updated documentation for as-built SI. (At AFRC prior to installation) SI Developer to demonstrate shutdown of SI UPS in lab at AFRC B703.							SSP SE&I					
SE03-2029 Rev. C	3.2.1.6	PI computers or PI-provided network equipment directly interfacing with the MCCS shall use the fixed IP addressing scheme detailed in APP-DF-ICD-SE03-2011, *MCCS Network Subsystem ICD* .	N/A	A	A	N/A	N/A	(CDR) SI Developer to provide system wiring diagram and list of SOFIA IP addresses to be used by SI. (Pre-Ship) SI Developer to provide final updated system wiring diagram and list of SOFIA IP addressed to be used for the as-built SI.							SSP SE&I					
SE03-2029 Rev. C	3.2.2	The contact assignment for SI connectors that connect to Panel U400 shall be as listed in Tables 9 through 20, for connections used by the SI.	N/A	A	A	I or I & T	N/A	(CDR) SI Developers to provide cable assembly drawings showing internal wiring and contact pin-out. (Pre-Ship) SI Developer to provide final updated cable assembly drawings for as-built cables. (At AFRC prior to installation) NASA to inspect signal cables. NASA to inspect and test power cables.							SSP SE&I					
SE03-2029 Rev. C	3.2.2.3	The SI shall carry the Observatory Emergency Power Disconnect (EPD) signal through J79 of the PI Patch Panel-SI Side (U400) as needed to disable any TA-mounted UPS as shown in Table 13.	A	A	A	D	N/A	(PDR) SI Developer to provide system functional flow diagram (block level) showing SI UPS and routing of SOFIA EPD signal. (CDR) SI Developer to provide updated system functional flow diagram, system wiring diagram, instrument EPD-handling circuit schematic, and cable assembly drawings for instrument CDR design. Documentation should show how the SI will respond to the SOFIA EPD signal. (Pre-Ship) SI Developer to provide final updated documentation for as-built SI. (At AFRC prior to installation) SI Developer to demonstrate shutdown of SI UPS in lab at AFRC B703.							SSP SE&I					
SE03-2029 Rev. C	3.2.2.3	Whenever the EPD signal goes to 28 VDC, all SI-provided UPS shall shutdown.	Verification of this requirement is covered by SE03-2029 (MCCS_SI_05), Par ID 3.2.1.1																	
SE03-2029 Rev. C	3.2.2.3	The maximum voltage transmitted over Panel U400 cable lines J124 through J127 by the SI shall be 10 kVDC or less, for connections used by the SI.	A	A	T or A	T	N/A	(PDR) SI Developer to provide preliminary power analysis, identifying any voltages greater than 230VAC transmitted by the SI through the Observatory patch panels. (CDR) SI Developer to provide updated analysis for instrument CDR design. (Pre-Ship) SI Developer to measure and provide voltage measurement results for transmitted voltages greater than 230VAC; or provide a final updated power analysis for the as-built SI. (At AFRC prior to installation) NASA to perform voltage measurement in lab.							SSP SE&I					
SE03-2029 Rev. C	3.3	All SI-to-Observatory interface connectors shall adhere to environmental specifications as listed in USRA-DAL-1093-00.	Verification of this requirement is covered by SE03-2029 (MCCS_SI_05), Par ID 3.1.1																	
SOF-DA-ICD-SE03-038 (TA_SI_04) Revision 2.1: TA Chopper Processor/Principal Investigator Computer Direct Analog Interface																				
SE03-038 Rev. 2.1	4.1	The PI shall provide all jumper cable assemblies used to route signal from SI electronics and the Secondary Mirror Assembly (SMA) Interface Junction Box.	N/A	A	I	I	N/A	(CDR) SI Developer to provide system wiring diagram; diagram should include cable numbers / identifiers and show connections to SOFIA patch panel interfaces. (Pre-Ship) SI Developer to provide final updated system wiring diagram for as-built instrument. (At AFRC prior to installation) NASA to inspect cables.							SSP SE&I					

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SE03-038 Rev. 2.1	4.1	SI cables that interface with the SMA Interface Junction Box shall use the mating connector part numbers (or equivalent) as listed in Table 8.1 Note: The SI connector part number PL75C-306 has not yet been formally specified in Table 8.1. Both ICD MCCS_SI_05 & TA_SI_01 identify PL75C-306 to be the mating part number of part BJ73.	N/A	A	I	I	N/A	(CDR) SI Developer to provide cable assembly drawings; drawings should include connector part numbers. (Pre-Ship) SI Developer to provide final updated cable assembly drawings for as-built cables. (At AFRC prior to installation) NASA to inspect cables.							SSP SE&I					
SE03-038 Rev. 2.1	4.2.6	If directly commanding the angle between the chopper base and SM in the SMA local φ_R coordinate, the SI shall provide an analog reference waveform axis R (Analog-R-In) with voltage between +/- 9.0 volts,	N/A	A	T	T	N/A	(CDR) SI Developer to provide profile of voltage waveform which the SI will use to drive the TA chopper. (Pre-Ship) SI Developer to provide measurement of output voltage waveform from as-built chopper electronics. (At AFRC prior to installation) NASA to measure output voltage of SI chopper electronics.							SSP SE&I					
SE03-038 Rev. 2.1	4.2.7	If directly commanding the angle between the chopper base and SM in the SMA local φ_S coordinate, the SI shall provide an analog reference waveform axis S (Analog-S-In) with voltage between +/- 9.0 volts,	N/A	A	T	T	N/A	(CDR) SI Developer to provide profile of voltage waveform which the SI will use to drive the TA chopper. (Pre-Ship) SI Developer to provide measurement of output voltage waveform from as-built chopper electronics. (At AFRC prior to installation) NASA to measure output voltage of SI chopper electronics.							SSP SE&I					
SE03-038 Rev. 2.1	4.2.8	The external TTL chopper synchronization signal transmitted by the SI to the SMA shall be a TTL square wave between 0.5 Hz and 20 Hz for 2-point chop mode, and between 1 Hz and 40 Hz for 3-point chop mode.	N/A	A	T	T or D		(CDR) SI Developer to identify chop mode type and intended chop frequency (or frequencies) used. (Pre-Ship) SI Developer to provide measurement of chop sync signal. (At AFRC prior to installation / or Installation and checkout) NASA to measure SI chop sync waveform, or SI Developer to demonstrate chopping on TAAS or TA during Line Ops.							SSP SE&I					
SCI-AR-ICD-SE03-2017 (SIC_SSMO_01) Revision C: Science Instrument Cart to SSMO Facility Interface																				
SE03-2017 Rev. C	3.2 A	A SI Cart including cart payload shall be able to maneuver through a double-door opening without any physical interference. Note: The dimensions of double-door openings in the PIF and IRRs are specified in Section 3.1.1-A.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide drawings or analysis identifying the maximum width and height of the instrument on cart. This applies to instrument installation and lab carts which are used to transport the instrument in and out of the SI Labs (as applicable) at AFRC B703. If a cart will only be transported into the lab without instrument, the SI Developer must show the dimensions of the empty cart do not exceed the dimensions of the door opening. (Pre-Ship) NASA to inspect hardware.							SSP SE&I					
SE03-2017 Rev. C	3.2 A	A SI Cart including cart payload shall be able to negotiate the turn identified in Figure 3 without any physical interference.	N/A	A	A	N/A	N/A	(CDR) SI Developer to provide a clearance analysis of the instrument on cart maneuvering through the SI lab/hallway turn geometry identified in Figure 3 of this ICD. (Pre-Ship) SI Developer to provide updated clearance analysis for as-built SI and cart, if any changes were made from the original CDR design.							SSP SE&I					
SE03-2017 Rev. C	3.2 B	The SI Cart shall be capable of being transported to the bed of the Scissor Lift Truck via lift gate, forklift, or SI Loading Platform.	N/A	A	A	N/A	N/A	(CDR) SI Developer to provide documentation or drawings identifying method(s) to be used for transporting the SI on cart from the hangar floor to the SOFIA Scissor-Lift Truck. SI Developer to also provide a clearance analysis for the transport method(s) to be used (e.g., SOFIA SI Loading Platform, forklift) showing no interference of the instrument and cart with the floor or any ground support equipment. (Pre-Ship) SI Developer to provide update to analysis for as-built SI and cart if any changes have been made from the CDR design.							SSP SE&I					

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SE03-2017 Rev. C	3.2 C	A SI Cart that will be transported to the bed of the Scissor Lift Truck using the SI Loading Platform shall be able to negotiate the ramp angle specified in Section 3.1.3(D).	N/A	A	A	D	N/A	(CDR) SI Developer to provide clearance analysis identifying the minimum clearance between the instrument on cart with the SOFIA SI Loading Platform and floor moving both up and down the ramp of the platform. (Pre-Ship) SI Developer to provide update to analysis for as-built SI and cart. (At AFRC prior to installation) SI Developer to demonstrate instrument on cart can be rolled on and off the SOFIA SI Loading Platform with no interference.						SSP SE&I					
SE03-2017 Rev. C	3.4.2	A SI Cart used to support the load of a Science Instrument shall have brakes that are integral to the cart to prevent inadvertent movement of a parked cart.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide part and assembly drawings of SI cart, including manufacturer and part number of casters and brake hardware. (Pre-Ship) NASA to inspect SI Cart.							SSP SE&I					
SE03-2017 Rev. C	3.4.2	The braking mechanism shall be integral to at least one left wheel/caster and one right wheel/caster, relative to the typical direction of travel of the SI Cart when the cart is moved.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide assembly drawings of SI Cart. (Pre-Ship) NASA to inspect SI Cart.							SSP SE&I					
SE03-2017 Rev. C	3.4.2	Due to hazards and risk of injury, neither engagement nor disengagement of the brakes of the SI Cart shall require personnel to reach near or manipulate the wheels/casters directly by hand.	N/A	A	D	N/A	N/A	(CDR) SI Developer to provide cart assembly drawings, product/datasheets of COTS brakes or drawings of custom-made brakes, and description of how the SI team will operate the brakes. (Pre-Ship) SI Developer to demonstrate cart brakes can be engaged and disengaged without direct manipulation by hand (i.e., grasping casters or brakes underneath the cart by hand).							SSP SE&I					
SOF-AR-ICD-SE03-205 (SIC_AS_01) Revision D: Science Instrument Cart to Aircraft Structure Interface																				
SE03-205 Rev. D	3.2 A	First-generation SI Carts with an Installation Envelope length (including payload) of less than 65 inches shall have at least two swiveling casters. <u>Note:</u> The First-generation SOFIA Science Instruments are FORCAST, GREAT, HIPO, FLITECAM, EXES, FIFI-LS, and HAWC (HAWC-1G).	N/A	A	I & D	N/A	N/A	(CDR) SI Developer to provide Installation Envelope analysis (refer to ICD GLOBAL_09 parID 3.1-c), cart assembly drawings, and caster manufacturer & part number information. (Pre-Ship) NASA to inspect hardware.							SSP SE&I					
SE03-205 Rev. D	3.2 A	First-generation SI Carts with an Installation Envelope length of 65 inches or more shall have swiveling casters at all caster locations.	N/A	A	I & D	N/A	N/A	(CDR) SI Developer to provide Installation Envelope analysis (refer to ICD GLOBAL_09 parID 3.1-c), cart assembly drawings, and caster manufacturer & part number information. (Pre-Ship) NASA to inspect hardware.							SSP SE&I					
SE03-205 Rev. D	3.2 A	Non first-generation SI Carts shall have swiveling casters at all wheel locations.	N/A	A	D	N/A	N/A	(CDR) SI Developer to provide SI cart assembly drawings and caster manufacturer & part number information. (Pre-Ship) SI Developer to demonstrate all casters swivel.							SSP SE&I					
SE03-205 Rev. D	3.2 A	Swiveling casters of SI Carts shall have the ability to be locked into fixed, angular positions.	N/A	A	D	N/A	N/A	(CDR) SI Developer to provide SI cart assembly drawings and manufacturer & part number of swivel locks. (Pre-Ship) SI Developer to demonstrate caster swivel position can be locked.							SSP SE&I					
SE03-205 Rev. D	3.2 A	The rear-most point of the SI Cart rear casters shall be no more than 69 inches behind the front of the SI Installation Envelope.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide Installation Envelope analysis (refer to ICD GLOBAL_09 parID 3.1-c) and SI cart assembly drawings. (Pre-Ship) NASA to inspect hardware.							SSP SE&I					
SE03-205 Rev. D	3.2 A	The maximum SI Cart footprint width shall be 30 inches.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide SI Cart assembly drawing and analysis showing maximum SI cart footprint width. (Pre-Ship) NASA to inspect SI Cart.							SSP SE&I					
SE03-205 Rev. D	3.2 B	The loaded SI Cart shall be able to negotiate the Equipment Loading Ramp shown in Figure 6 and 7.	N/A	A	A	D	N/A	(CDR) SI Developer to provide clearance analysis showing no part of the SI on cart will interfere with the SOFIA Equipment Loading Ramp. (Pre-Ship) SI Developer to provide updated analysis for as-built SI and cart, if any changes have been made to the CDR design of each. (At AFRC prior to installation) SI Developer to demonstrate rolling the SI on cart over the SOFIA Equipment Loading Ramp, performed either in the Pre-Flight Integration Facility or on the hangar floor.							SSP SE&I					
SE03-205 Rev. D	3.2 B	The minimum SI Cart deck vertical clearance shall be 6 inches.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide SI cart assembly drawings and analysis showing height of bottom frame of cart from the floor. (Pre-Ship) NASA to inspect SI Cart.							SSP SE&I					

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SE03-205 Rev. D	3.2 B	No elements of the SI Cart (including payload) shall interfere or apply any load to the reveal lip surrounding Door1L.	N/A	A	A	D	N/A	(CDR) SI Developer to provide clearance analysis showing no part of the SI or cart will contact the SOFIA Door1L doorsill. (Pre-Ship) SI Developer to provide updated analysis for as-built SI and cart. (At AFRC prior to installation) SI Developer to demonstrate maneuvering the SI on cart over the SOFIA Equipment Loading Ramp in the Pre-Flight Integration Facility or on the hangar floor, with objects positioned to simulate the boundaries of the SOFIA Door1L doorsill.							SSP SE&I					
SE03-205 Rev. D	3.2 B	No elements of the SI Cart (including payload) shall interfere with the Equipment Loading Ramp.	Verification of this requirement is covered by an earlier requirement in SE03-205 (SIC_AS_01), Par ID 3.2B																	
SE03-205 Rev. D	3.2 B	The loaded SI Cart shall be able to negotiate the Door1L Equipment Loading Ramp with all wheels maintaining contact with the floor.	N/A	A	A	D	N/A	(CDR) SI Developer to provide analysis showing all casters of the cart remain in contact with the floor or SOFIA Equipment Loading Ramp at all time. (Pre-Ship) SI Developer to provide updated analysis for as-built SI and cart. (At AFRC prior to installation) SI Developer to demonstrate and maneuver SI on cart over the SOFIA Equipment Loading Ramp in the Pre-Flight Integration Facility or on the hangar floor.							SSP SE&I					
SE03-205 Rev. D	3.2 C	The floor contact pressure of a SI Cart caster shall not exceed 500 psi.	N/A	A	A	N/A	N/A	(CDR) SI Developer to provide C.G. analysis of instrument on cart and analysis of caster/floor contact pressure. (Pre-Ship) SI Developer to provide updated analyses for as-built SI and cart.							SSP SE&I					
SE03-205 Rev. D	3.2 C	SI Carts (loaded or unloaded) weighing more than 600 lbs shall not exceed 600 lbs at any caster-mounting location.	N/A	A	A	N/A	N/A	(CDR) SI Developer to provide C.G. analysis of instrument on cart and analysis of load at each wheel location. (Pre-Ship) SI Developer to provide updated analyses for as-built SI and cart.							SSP SE&I					
SE03-205 Rev. D	3.2 C	SI Carts (loaded or unloaded) that weigh 600 lbs or more shall have a minimum distance of 24 inches between all caster mounting locations.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide SI cart loads analysis and cart assembly drawings. (Pre-Ship) NASA to weigh and inspect SI Cart.							SSP SE&I					
SE03-205 Rev. D	3.2 E	The SI Cart shall be removable from the SI Assembly when the SI is mounted to the TA.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide documentation showing or describing removal of the SI Cart following instrument installation. (Pre-Ship) NASA to inspect hardware.							SSP SE&I					
SE03-205 Rev. D	3.2 F	The SI Cart shall have provisions to raise and lower the SI-Flange center over at least the height range of 32.13 inches [816.1 mm] to 34.13 inches [866.9 mm] with respect to the aircraft floor when loaded, without assistance from any external lifting device.	N/A	A	D	N/A	N/A	(CDR) SI Developer to provide an analysis of the vertical range of travel of the SI the installation cart is capable of providing, with respect to the nominal SI installation height at the TA Instrument Mounting Flange (IMF). (Pre-Ship) SI Developer to demonstrate range of travel for which the installation cart is able to raise and lower the SI Assembly.							SSP SE&I					
SE03-205 Rev. D	3.2 F	The SI Cart shall have provisions to tilt the SI Flange +/- 0.3 degrees with respect to a plane perpendicular with the aircraft floor.	N/A	A	D	N/A	N/A	(CDR) SI Developer to identify the mechanism or method by the which the cart can tilt the instrument (and SI Flange), as well as an analysis specifying the expected angular tilt capability. (Pre-Ship) SI Developer to demonstrate angular tilt range-of-motion of instrument on cart.							SSP SE&I					
SE03-205 Rev. D	3.2 G	The SI shall be mounted to the SI Cart so that no portion of the cart impedes the free movement of the SI to the INF.	Verification of this requirement is covered by SE03-205 (SIC_AS_01), Par ID 3.2 G requirement below.																	
SE03-205 Rev. D	3.2 G	The mating surface of the SI Flange shall be a minimum of 1 inch [25.4 mm] forward of the leading edge of the SI Cart.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide drawings of instrument assembly on cart and analysis showing the distance between the leading edge of cart and the front (mating surface) of the SI Flange. (Pre-Ship) NASA to inspect instrument on SI Cart.							SSP SE&I					
SE03-205 Rev. D	3.4.3	A SI Cart used to transport a Science Instrument shall have brakes that are integral to the cart to prevent inadvertent movement of a parked cart.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide part and assembly drawings of SI cart, including manufacturer and part number of casters and brake hardware. (Pre-Ship) NASA to inspect SI Cart.							SSP SE&I					
SE03-205 Rev. D	3.4.3	The braking mechanism shall be integral to at least one left wheel/caster and one right wheel/caster, relative to the direction of travel of the SI Cart.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide assembly drawings of SI Cart. (Pre-Ship) NASA to inspect SI Cart.							SSP SE&I					

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			PDR	CDR	Pre-Ship	At AFRC prior to installation	Installation and checkout			PDR	CDR	Pre-Ship	At AFRC prior to installation	Installation and checkout		PDR	CDR	Pre-Ship	At AFRC prior to installation	Installation and checkout
SE03-205 Rev. D	3.4.3	Due to hazards and risk of injury, neither engagement nor disengagement of the brakes of the SI Cart shall require personnel to reach near or manipulate the wheels/casters directly by hand.	N/A	A	D	N/A	N/A	(CDR) SI Developer to provide cart assembly drawings, product/datasheets of COTS brakes or drawings of custom-made brakes, and description of how the SI team will operate the brakes. (Pre-Ship) SI Developer to demonstrate cart brakes can be engaged and disengaged without direct manipulation by hand (i.e., grasping casters or brakes underneath the cart by hand).							SSP SE&I					
SCI-AR-ICD-SE03-2020 (SSMO_SI_02) Revision -: Telescope Assembly Alignment Simulator to Science Instrument Interface																				
SE03-2020 Rev. -	2.1	The mechanical interface between the SI and the TAAS shall be identical to the SI to SOFIA Telescope Assembly interface, as defined in the ICD, *Telescope Assembly / Science Instrument Mounting Interface* , SOF-DA-ICD-SE03-037, TA_SI_02_FL.	Verification of SI interface mechanical mounting requirements is covered by SE03-037 (TA_SI_02 ICD); TAAS mounting interface is identical to TA mounting interface																	
SE03-2020 Rev. -	2.2.2	The SI shall connect to the TAAS Chopper Drive Control Unit (CDCU) with BNC-terminated (male) coaxial cables.	N/A	A	I		N/A	(CDR) SI Developer to describe how TAAS will be used, including how chopping and/or nodding will be performed, what inputs will be used to perform these functions (e.g. external TTL-level input signal or internal CDCU input signal), chop and/or nod frequencies, interface connector part numbers, and cable schematic showing SI connections to the TAAS. (Pre-Ship / At AFRC prior to installation) NASA to inspect hardware.							SSP SE&I					
SE03-2020 Rev. -	2.2.3	The SI shall provide a 0-1 Hz TTL-level nod signal, if the SI will be performing nod operations on the TAAS using an external nod input signal.	N/A	A	T		N/A	(CDR) SI Developer to specify whether the SI will provide an external TTL input signal or use an internal signal generated by the CDCU to perform nodding, and specify the nod frequency or frequencies. (Pre-Ship / At AFRC prior to installation) NASA to verify SI nod TTL waveform with electronic test equipment.							SSP SE&I					
SE03-2020 Rev. -	2.2.3	The SI shall provide a 1-20 Hz TTL-level chop signal, if the SI will be performing chop operations on the TAAS using an external chop input signal.	N/A	A	T		N/A	(CDR) SI Developer to specify whether the SI will provide an external TTL input signal or use an internal signal generated by the CDCU to perform chopping, and specify the chop frequency or frequencies. (Pre-Ship / At AFRC prior to installation) NASA to verify SI chop TTL waveform with electronic test equipment..							SSP SE&I					
SE03-2020 Rev. -	2.3.1	The SI shall provide a computer with Ethernet connection and common web browser, if the SI will be controlling Small Chopped Hot Plate (SCHP) operations directly.	N/A	A	I		N/A	(CDR) SI to provide cable schematic showing electrical connections to the TAAS. (Pre-Ship / At AFRC prior to installation) NASA to inspect hardware.							SSP SE&I					

Document	Paragraph Identification (ParID)	Requirement	Verification Method by Development Phase					Verification Activity Description	Compliance / Artifacts	SI Status (Verification status to be filled out by SI Team)					NASA Compliance Authority	NASA Status (Verification status to be filled out by NASA)				
			PDR	CDR	Pre-Ship	At AFRC prior to installation	Installation and checkout			PDR	CDR	Pre-Ship	At AFRC prior to installation	Installation and checkout		PDR	CDR	Pre-Ship	At AFRC prior to installation	Installation and checkout
SOF-DA-ICD-SE03-2022 (VPS_SI_01) Revision -: Vacuum Pump System to Science Instrument Interface																				
SE03-2022 Rev. -	5.4	SI shall use KF40 flanges to connect USRA-supplied vacuum lines to the VPS interface at the TA Counterweight Plate (CWP).	N/A	A	I			(CDR) SI Developer to provide assembly drawings, identifying part number of SI QD flanges that interface with SOFIA VPS. (Pre-Ship / At AFRC prior to installation) NASA to inspect hardware.							SSP SE&I					
SE03-2022 Rev. -	5.4	If an SI is utilizing the INF vacuum connection as a feed-through to an SI-provided structure contained in the INF (e.g., a pressure coupler), then the SI shall connect to a SSMO / USRA- provided KF25 adapter to ¾" NPT fitting.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide assembly drawings, showing part number of SI hoses, fittings, and clamps interfacing with SSMO / USRA provided KF25 (adapter) port inside the INF tub. (Pre-Ship) NASA to inspect hardware.							SSP SE&I					
SE03-2022 Rev. -	5.4	If an SI is utilizing the VPS bleed / backfill connection(s) to introduce helium or nitrogen to the evacuated system via the VPS vacuum lines, then the SI GSE shall connect to the VPS Bleed / Backfill valves depicted in Figure 4 using ¼ inch hose barb fittings.	N/A	A	I			(CDR) SI Developer to provide assembly drawings, identifying part number of SI hose barb fittings that interface with SOFIA VPS. (Pre-Ship / At AFRC prior to installation) NASA to inspect hardware.							SSP SE&I					
APP-DA-ICD-SE03-2059 (CRYO_SI_01) Revision -: Cryocooler System to Science Instrument ICD																				
SE03-2059 Rev. -	4.1	SI-provided flex lines shall be terminated with ¾ inch (-12 size) 5400 series female QD halves with Buna-N elastomeric seals (note that -146 Buna-N is not the standard Neoprene elastomer seal material for this QD series). Note: Other common designations for Buna-N are Nitrile Butadiene Rubber (NBR), Nitril-Kautschuk Perbunan, Nitril-Butadien-Kautschuk, and other variants. The exact Eaton / Aeroquip QD P/N will be dependent on the style and size of the end fitting and hose adapters selected by the SI developer for the Supply and Return connections to their cold head.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide assembly drawing for flex lines showing manufacturer and part number of QDs and elastomeric seals. (Pre-Ship) NASA to inspect Certificates of Conformance (CoCs) for parts of QD assemblies.							SSP SE&I					
SE03-2059 Rev. -	4.1	For compliance with NPD 8710.5, *Policy for Pressure Vessels and Pressurized Systems (PVS)* , NASA-STD-8719.17 and DCP-S-065, all pressurized flexible lines shall be properly restrained at both ends and at intermediate intervals as necessary to mitigate hazards from whipping hoses.	N/A	N/A	N/A	N/A	I	(Installation and checkout) NASA to inspect configuration of installed instrument and flex lines.							SSP SE&I					
SE03-2059 Rev. -	4.2.5	To interface with this Cryocooler System to SI signal interface, the SI shall provide a D38999/20ZH55PN bulkhead receptacle (pin contacts) at the aft facing bay of an SI PI Rack, that is wired to interface with the Cryocooler System signal interface umbilical cable contact assignments, as defined in Table 4.2.5-1.	A	A	I	N/A	N/A	(PDR) SI Developer to provide system block diagram, showing interface connection to SOFIA Cryocooler System umbilical cable. (CDR) SI Developer to provide assembly drawings showing bulkhead receptacle part number and contact pin-out/function. (Pre-Ship) NASA to inspect hardware and connector.							SSP SE&I					
SE03-2059 Rev. -	4.2.5.1	These momentary contact state transitions shall be of a duration between 5 milliseconds (ms) to 1 second. Note: The four (4) command inputs from the SI PI Rack to the Cryocooler System are momentary Normally OPEN (NO) contacts, with the exception of the Compressor Drive Stop (REMCDSTOP) signal, which is a Normally CLOSED (NC) contact.	N/A	A	N/A	N/A	D	(CDR) SI Developer to provide documentation (e.g. product datasheets for COTS electronics, state / logic timing diagram) showing that contact state transitions will occur within the required 5 ms to 1 second time range. (Installation and checkout) SI Developer to demonstrate operation of SOFIA Cryocooler compressor.							SSP SE&I					
SE03-2059 Rev. -	4.2.5.1	The SI interface relay or switch contacts and associated circuitry shall be adequately sized for 24 VDC @ 500 mA, minimum.	N/A	A	I	N/A	N/A	(CDR) SI Developer to provide documentation (e.g. product datasheets, circuit schematics, assembly drawings specifying wire part number and gauge, etc.) to show SI relay or switch contacts and associated circuitry meet the requirement current and voltage values. (Pre-Ship) NASA to inspect hardware and component part numbers.							SSP SE&I					
SE03-2059 Rev. -	4.2.5.2	To ensure the integrity of the parameter calibrations, the SI A/D input impedance shall be no less than 1000 Ω.	N/A	A	I or T	N/A	N/A	(CDR) SI Developer to provide documentation (e.g., product datasheet for COTS electronics, circuit schematics) that show SI A/D input impedance meets this requirement. (Pre-Ship) NASA to perform inspection or test of hardware.							SSP SE&I					