



# Interface Control Document Science Instrument Cart to Aircraft System SIC\_AS\_01

SOF-AR-ICD-SE03-205

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DFRC  
Dryden Flight Research Center  
Edwards, CA 93523




German Space Agency, DLR  
Deutsches Zentrum für Luft  
und Raumfahrt

ARC  
Ames Research Center  
Moffett Field, CA 94035

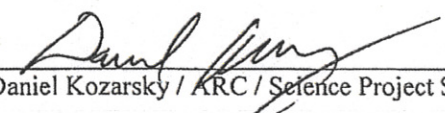
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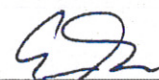
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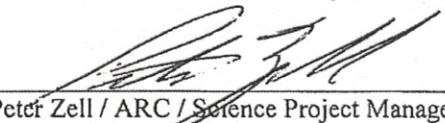
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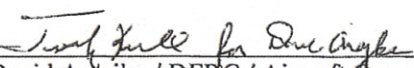
  
Jeffrey Huang / ARC / Science Project Systems Engineer  
Date 3/6/2013

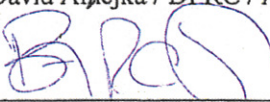
CONCURRENCE:

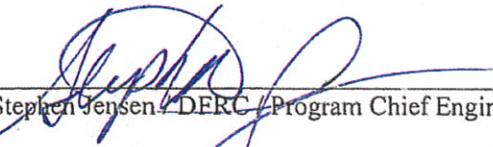
  
Daniel Kozarsky / ARC / Science Project SE&I Lead  
Date 3/6/13

  
Erin Smith / ARC / Science Project Science Instrument Manager  
Date 3/6/2013

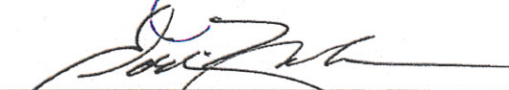
  
Peter Zell / ARC / Science Project Manager  
Date 3/7/13


  
David Ancejka / DFRC / Aircraft Operations Manager  
Date 3/7/2013

  
Brent Cobleigh / DFRC / Airborne Platform Project Manager  
Date 3/7/13

  
Stephen Jensen / DFRC / Program Chief Engineer  
Date 3/8/13

APPROVALS:

  
Eddie Zavala / DFRC / SOFIA NASA Program Manager  
Date 3/11/13

  
Alois Himmes / DLR / SOFIA DLR Program Manager  
Date 3/15/13

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## REVISIONS

REV	DATE	DESCRIPTION	APPROVAL
A	10/5/00	Incorporations of ECO #C73299: - Removed specific references to the SOFIA operational procedures manual. - Added requirements for a SI Cart Braking system.	
	12/14/2009	Based on USRA ICD SIC_AS_01, Revision -. (Document Number: 96162512-000). Changes have been made to ramp, swiveling casters, center of gravity, floor loading, cart control, and forklift requirements. The current version also incorporates requirements from the obsolete USRA ICD SIC_SI_01, Revision -. (Document Number: 96162511-000).	SPCB
B	2/08/2010	SPCB Approved  Added removable cart requirement. Revised ramp and cart raising/lowering requirements. Revised SI installation envelope figure. Removed SI-flange center requirement.	PMB
C	5/7/2012	Updated ICD to reflect lessons learned in Segment 2. Revised title and scope of ICD to include all SI Carts used on the aircraft. Updated dimensions and figures of Door1L Equipment Loading Ramp based upon new ramp design. Clarified SI Cart/Aircraft floor-loading requirements. Revised specific "shall" statements that were not intended to be requirements to operational guidelines instead. Added references to ICD verification process and ICD requirements matrix. Change details and rationale contained in PRG-CCR-097.	PMB_20120507
D	3/4/2013	Incorporated approved changes in PRG-CCR-126 into ICD: removed deadman brake requirement in paragraph 3.4.2, revised parking brake requirement in paragraph 3.4.3.	PMB

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# Interface Control Document

## Science Instrument Cart to Aircraft System, SIC\_AS\_01

### 1. SCOPE

This document covers all interface requirements between Science Instrument Carts (SIC) and the Aircraft System (AS). The interface requirements apply to SI Carts used on the aircraft.

A separate Interface Control Document, SCI-AR-ICD-SE03-2017 (SIC\_SSMO\_01), defines the interface requirements between SI Carts and the SSMO Ground Support Facility at DAOF. SOF-AR-ICD-SE03-205 does not apply to SI Carts that are only used in the Ground Support Facility (i.e., SI Carts that are not used on the aircraft).

There originally existed a third SI Cart ICD (SCI-US-ICD-SE03-204, SIC\_SI\_01) that defined the interface between Science Instruments and a SOFIA Program-provided SI Cart, however the ICD was later declared obsolete and the responsibility was transferred to SI Developers to provide their own SI Carts for transporting Science Instruments (SI Assembly, elements of the SI Assembly, or SI equipment) within the Ground Support Facility and aircraft. The SI Developer is not responsible for providing ground support equipment for the transport of PI Rack(s) or a Counterweight Rack through the SSMO Ground Support Facility or the aircraft. A PI Rack dolly and Counterweight Rack cart are provided by the Program for this purpose.

Note that in addition to the SI Cart interface requirements outlined in SOF-AR-ICD-SE03-205 and SCI-AR-ICD-SE03-2017, there are a number of safety related structural, stability, and pressure system requirements applicable to SI Carts and Stands found within Section 3.5 of SOF-AR-SPE-SE01-2028, SOFIA Science Instrument System Specification.

#### 1.1 Purpose

The purpose of this ICD is to define the interface requirements intended to ensure safe transportation of SI Carts through the aircraft. This includes but is not limited to physical specifications, proper loading, and usage.

### 2. REFERENCE AND APPLICABLE DOCUMENTS

The latest revisions of the following documents form a part of this requirement to the extent specified herein.

#### 2.1 SOFIA Documents

APP-DF-DWG-SE02-2636	Equipment Loading Ramp Assembly
APP-DF-DWG-SE02-2637	Equipment Loading Ramp Details

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SCI-AR-ICD-SE03-2017	ICD SIC_SSMO_01, Science Instrument Cart to SSMO Facility Interface Control Document
SCI-AR-PLA-SV05-2014	Science Instrument System Specification and ICD Requirements Matrix Template
SOF-AR-SPE-SE01-2028	SOFIA Science Instrument System Specification
SOF-DA-ICD-SE03-002	ICD GLOBAL_09, SI Instrument Envelope
SOF-DA-ICD-SE03-004	ICD GLOBAL_07, Aircraft Floor Loading Interface Requirements
SOF-DF-PD-PD-2009	SOFIA Lexicon

### 3. INTERFACE REQUIREMENTS

The SI Cart will be used to transport the Science Instrument (SI Assembly, elements of the SI Assembly, or SI equipment) through the ground facility, up to aircraft Door 1L, and into the aircraft. Furthermore, a SI Cart that transports a SI Assembly will also facilitate the installation of the SI Assembly onto the Telescope Assembly flange. Figure 1 identifies the SI Cart Path area (marked with shading) inside the aircraft for which SI Carts are permitted to travel. To ensure that the cart can safely accomplish this task, the SI Cart must meet the interface requirements defined in this ICD.

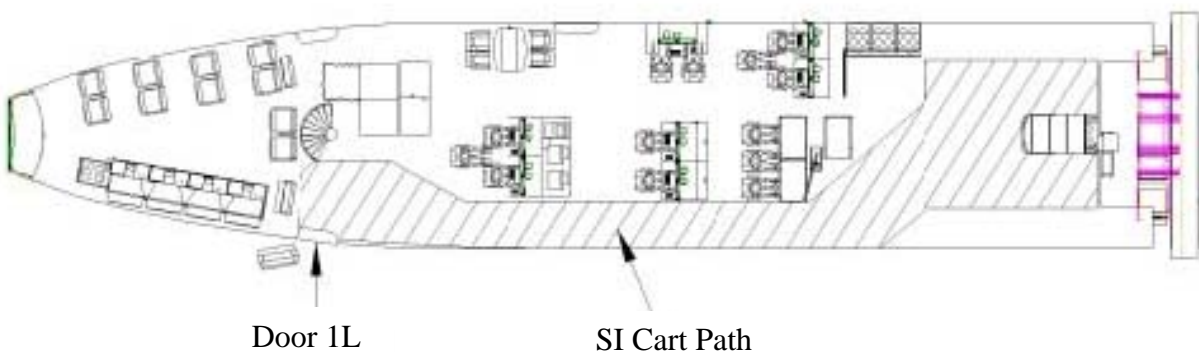


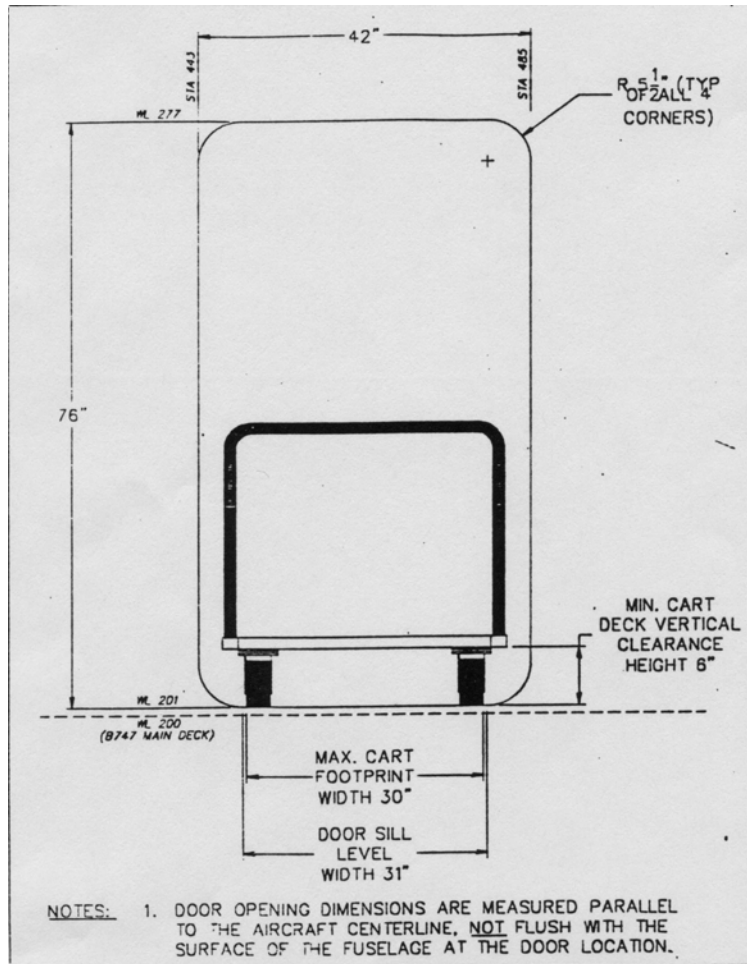
Figure 1. SI Cart path

#### 3.1 Physical

The dimensions of the SI Cart are constrained by the physical limitations that the aircraft dictates. The ramifications of these limitations are presented in section 3.2. The dimensions of Door 1L are: 42-inch width, 31-inch door-sill level width, 76-inch height. These dimensions are shown in Figure 2. Critical features and dimensions within the aircraft are accounted for in the

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determination of the physical size of the SI Installation Envelope that is referenced in section 3.2(A).



### Door 1L Dimensions

Door Full Width:	42 in.
Door Full Height:	76 in.
Door Sill Level Width:	31 in.

Figure 2. Door 1L constraint visual

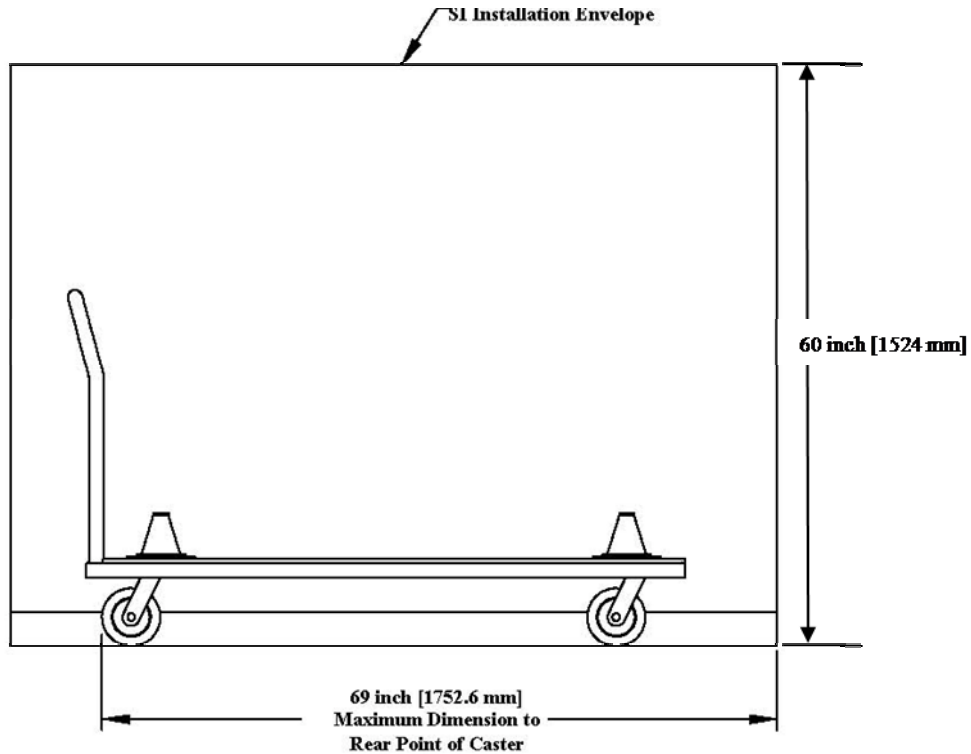
## 3.2 Functional

- A) In order to ensure that a loaded SI Cart is not too large to be transported through the aircraft, its dimensions must comply with the SI Installation Envelope defined in SOF-DA-ICD-SE03-002 (GLOBAL\_09), Section 3.1. The defined envelope is the maximum volume allowed for transport of a SI Cart with payload (e.g., SI Assembly, elements of the SI Assembly, or SI equipment) into the aircraft. First-generation science instrument carts shall utilize at least two swiveling casters, and swiveling casters at all locations if the cart is longer than 65 inches. Non first-generation science instrument carts shall utilize swiveling casters at all wheel locations. Swiveling casters shall have the ability to lock into fixed, angular positions. This will enable a cart to travel in a consistent direction when maneuvering through narrow passageways. Rear casters or wheel mounts shall be positioned so that their rear-most

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point is no more than 69 inches [1752.6 mm] behind the front of the Installation Envelope (see Figure 3). This will help to prevent the rear wheels from translating off of the aircraft floor while turning inside of Door 1L. The maximum SI Cart footprint width shall be 30 inches. Figure 4 shows the spatial limitations inside the aircraft cabin along the port side of the aircraft<sup>1</sup>.



**Figure 3. Rear caster to SI Installation Envelope maximum dimension.**

<sup>1</sup> Note that the Door 2L raft canister protrudes into the SI Cart path, constraining the width of the path to 41 inches. However Door 2L can be opened during SI installation and a safety net temporarily installed in the doorway, effectively eliminating this constraint.

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Limits on SI Envelope for Installation

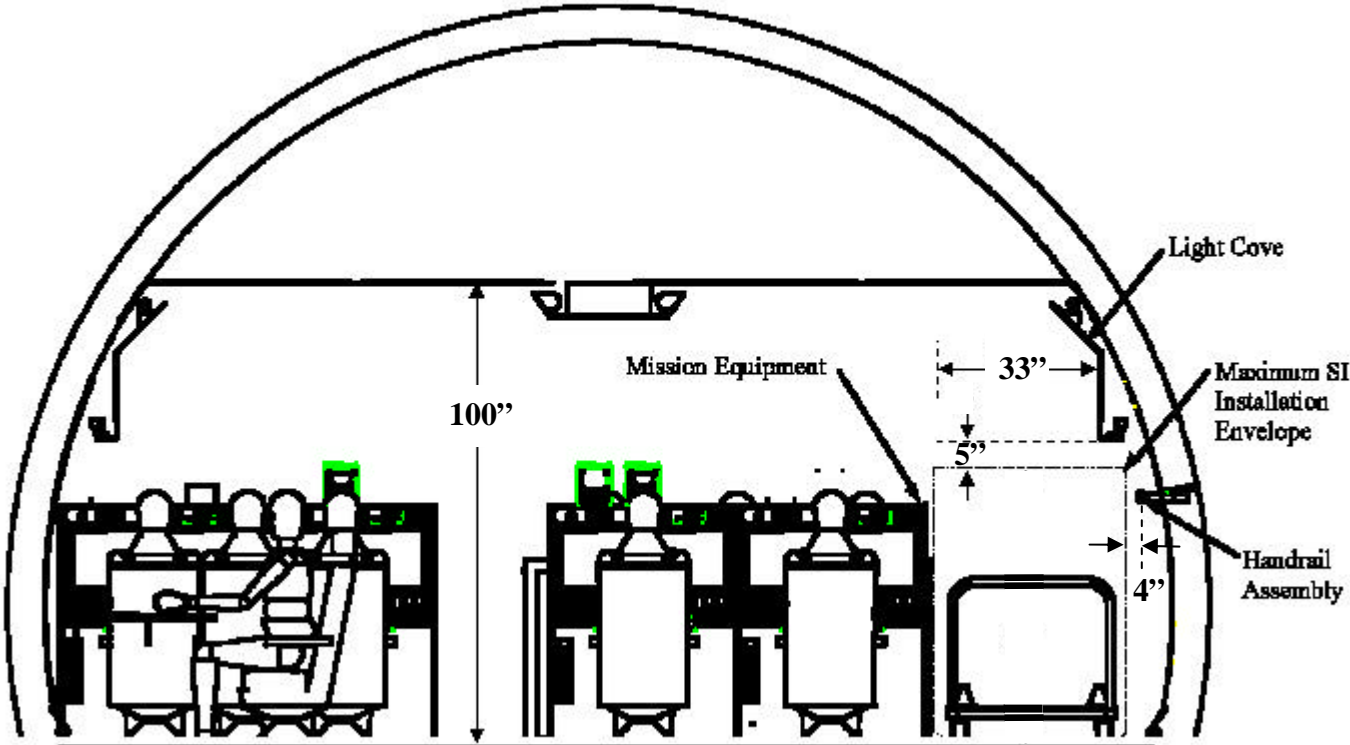
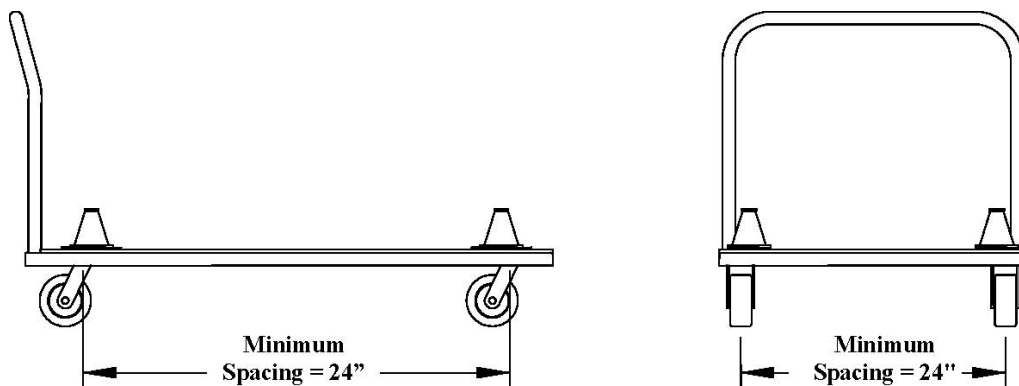


Figure 4. Physical size of the Installation Envelope. SI Cart positioned in cart path at Station 1000.

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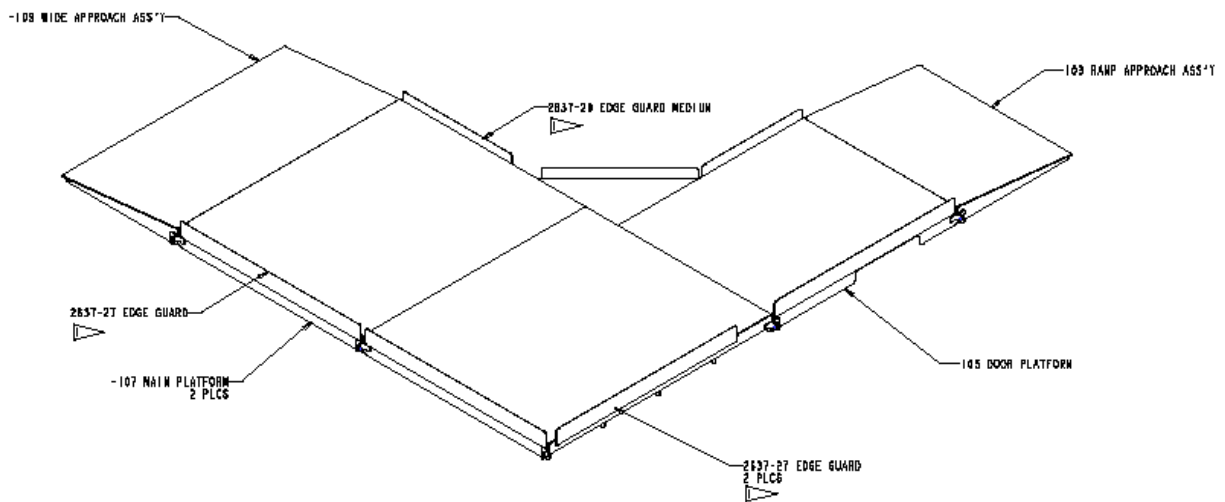
- B) The loaded SI Cart shall be capable of successfully negotiating the Equipment Loading Ramp shown in Figure 6 and 7. Each of the two inclines of the Equipment Loading Ramp assembly has an angle of 7.5 degrees and 3.25 inches height. Note the incline angle of the SI Loading Platform is greater than the incline angles of the Equipment Loading Ramp. Refer to SCI-AR-ICD-SE03-2017 Section 3.1.3(D) for details about the SI Loading Platform. The minimum SI Cart deck vertical clearance shall be 6 inches. No elements of the SI Cart (including payload) shall interfere or apply any load to the reveal lip surrounding Door 1L. No elements of the SI Cart (including payload) shall interfere with the Equipment Loading Ramp. The loaded SI Cart shall be able to negotiate the ramp with all wheels maintaining contact with the floor. This can be accomplished either by limiting the wheel arrangement to two rows of wheels, or by utilizing a suspension system.
- C) The aircraft main deck floor panels are the portion of the aircraft that limit the loads that can be safely supported. The panels along the SI Cart path (shown in Figure 1) have been upgraded to an aluminum honeycomb material that can withstand the SI traffic. SI Carts may only be transported along the path of reinforced floor panels on the aircraft. See SOF-DA-ICD-SE03-004 (GLOBAL\_07) for more aircraft main deck floor loading information. To prevent damage to the aircraft floor structure by SI Cart usage, the requirements within this section must be met. The floor contact pressure of a SI Cart caster shall not exceed 500 psi. A number of factors can affect contact pressure including: castor width and size, caster material, number of casters used at a caster-mounting location (e.g., single or double-unit). The floor contact pressure requirement applies to all SI Carts. Two additional requirements apply to SI Carts (loaded and unloaded) that weigh 600 lbs [272 kg] or more, which address the floor loading limits of the aircraft floor structure along the SI Cart path. SI Carts (loaded or unloaded) weighing 600 lbs or more shall have a minimum distance of 24 inches [609.6 mm] between caster-mounting locations. Figure 5 shows the required wheel spacing for a generic SI Cart. SI Carts (loaded or unloaded) weighing more than 600 lbs shall not exceed 600 lbs at any caster-mounting location. This requirement applies to both single and double wheel caster locations.



**Figure 5. Minimum spacing between caster-mounting locations.**

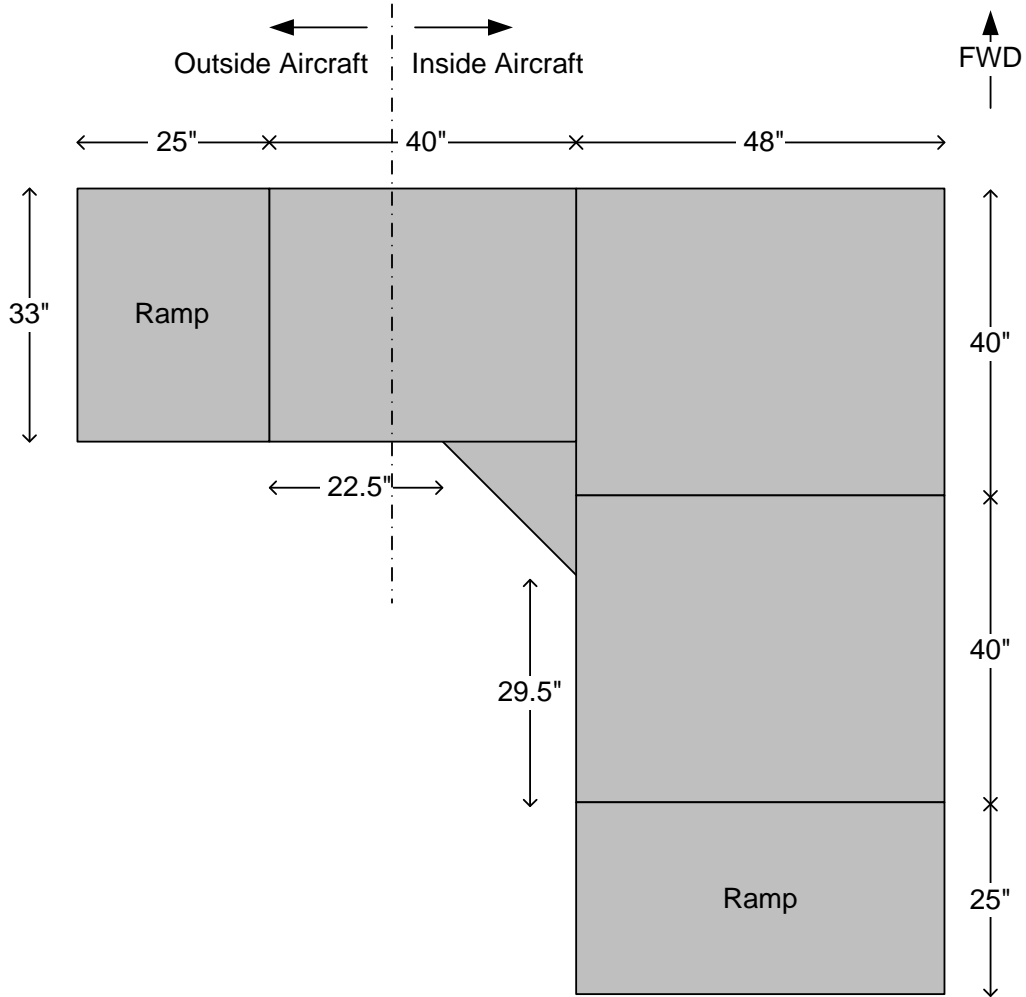
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- D) The SOFIA Program will provide an Equipment Loading Ramp to protect the reveal lip surrounding Door 1L. Figure 6 shows an isometric view of the Equipment Loading Ramp. A SI Cart that will be brought onto the aircraft will first be transported from the hangar floor to the bed of the Ground Facility Scissor Lift Truck by one of three methods (i.e., SI Loading Platform, direct forklift, or Scissor Lift Truck lift gate) described in SCI-AR-ICD-SE03-2017 Section 3.1.3. The bed of the Scissor Lift Truck (and SI Cart) will then be raised to aircraft Door 1L. Next the Equipment Loading Ramp is installed. A SI Cart will then traverse the Equipment Loading Ramp from the bed of the Ground Facility Scissor Lift Truck into the aircraft, executing a 90-degree turn in the process. Note that in the previously described steps, a SI Cart is secured to prevent unwanted movement of the cart during transport. Figure 7 shows the top view of the ramp. See drawing APP-DF-DWG-SE02-2636 for ramp details.



**Figure 6. Isometric view of Equipment Loading Ramp**

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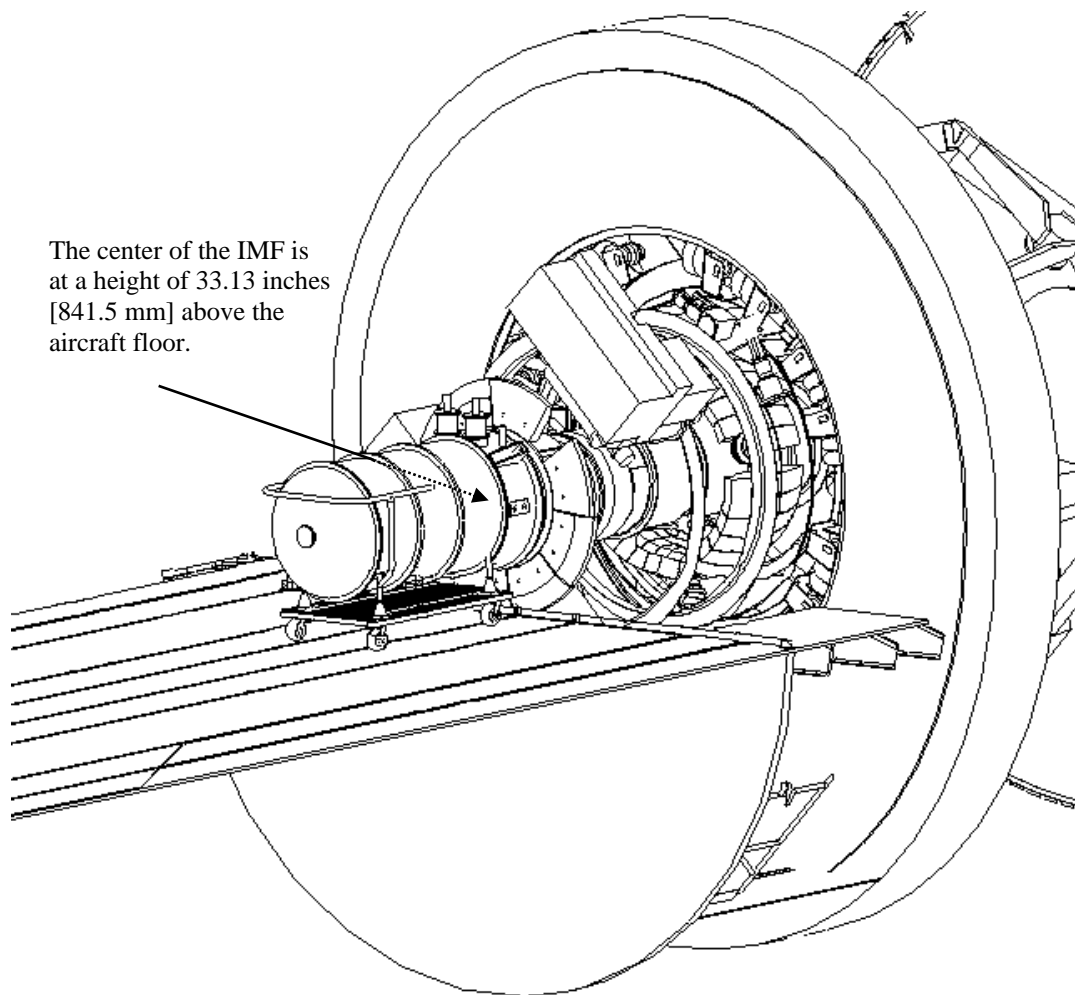


**Figure 7. Top view of Equipment Loading Ramp**

The interface requirements defined in Section 3.2E through Section 3.2G apply specifically to SI Carts that are used to transport a SI Assembly and are used for installation of a SI Assembly to the Telescope Assembly flange.

- E) The center of the TA Instrument Mounting Flange (IMF) (which is also the location of the telescope IR beam center) is at a height 33.13 inches [841.5 mm] above the aircraft floor. The SI Assembly will be mounted to the TA when the TA is oriented at 40° elevation. Figure 8 is an example showing a SI Assembly mounted to the IMF during installation. The SI Cart shall be removable from the SI Assembly when the Assembly is mounted to the TA. The SI Cart will reside in the SSMO Ground Support Facility during in-flight operation of the SI.

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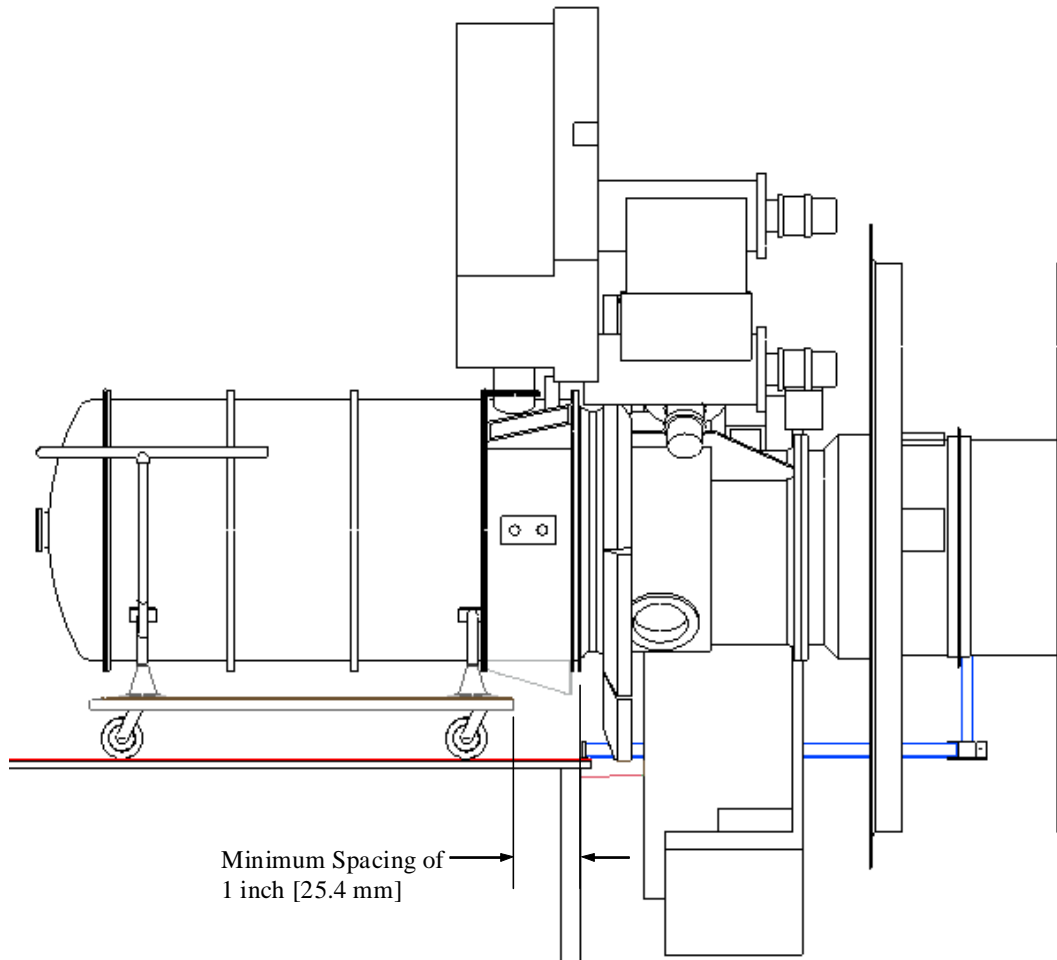


**Figure 8. Position of a loaded SI Cart during installation and removal. (Example)**

- 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 devices. The SI Cart shall have provisions to tilt the SI Flange  $\pm 0.3$  degrees with respect to a plane perpendicular to the aircraft floor. The intent of these requirements is to enable slight adjustments to be made to the position of the SI Assembly/SI Flange during installation.
- G) The SI Assembly shall be mounted on the SI Cart so that no portion of the cart impedes the free movement of the SI Assembly to the IMF. In order for a SI Assembly to mate with the IMF, the SI Assembly must be mounted so that no part of the cart comes into contact with an obstruction before the SI Flange mates with the IMF. The SI Flange mating surface of the SI Assembly shall be a minimum of one

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inch [25.4 mm] forward of the leading edge of the cart, as shown in Figure 9.



**Figure 9. SI Fore-Aft installation position.**

### **3.3 Environmental**

Not Applicable

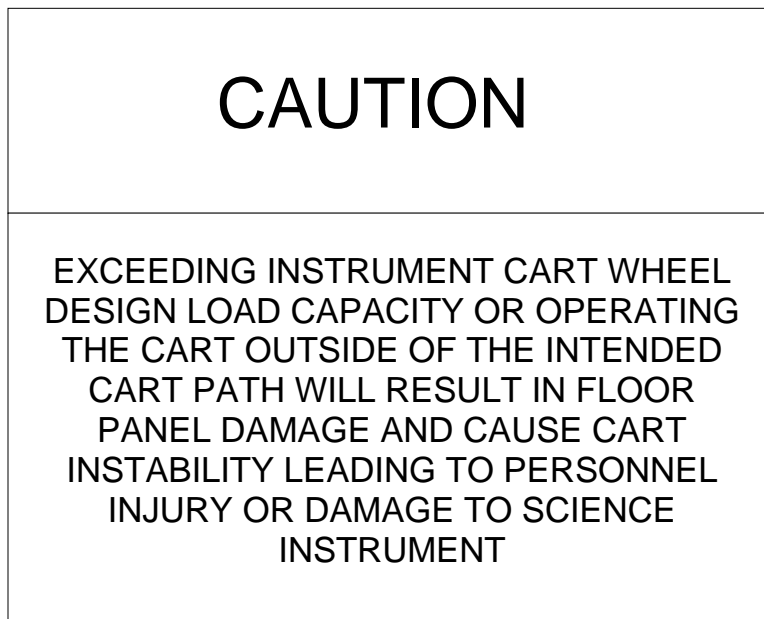
### **3.4 Safety**

In order to safeguard the aircraft, the SI, the SSMO Ground Support Facility, and most importantly, the people using them, certain precautions must be taken when operating SI Carts. This section will present the safety features required in SI Carts and provide guidance for SI Cart handling and operation.

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### 3.4.1 Floor Panel Failure

The manner in which a SI Cart is loaded is critical due to the load limitations of the aircraft floor panels as described in Section 3.2 C. If the loading requirements are not followed, the floor panels could be damaged causing the cart to become unstable and tip over. This could result in injury to personnel and damage to equipment.



### 3.4.2 Cart Maneuvering

Science Instruments are generally heavy, unwieldy and fragile. Therefore, great care should be taken when maneuvering a loaded SI Cart. If care is not exercised, serious damage and injury may result. The following precautions should be taken:

- Caution must be used when manually maneuvering SI Carts to maintain control.
- SI Cart procedures should ensure that there are sufficient numbers of appropriately trained personnel controlling and monitoring movement of the cart, particularly when the cart is being moved over ramps and/or through doorways, to ensure that the risk of a loss of control is adequately mitigated.
- To optimize SI Cart stability and minimize the hazard of tipping, SI Cart designs and operational procedures should keep payload and therefore the CG of the loaded SI Cart, as low as possible except when it is necessary to raise a SI Assembly in order to clear objects or for SI installation/removal.

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- Prior to moving a loaded SI Cart, the entire pathway should be inspected for any potential hazards. This may include hazards to the SI Cart or equipment that could be damaged by the cart.

### 3.4.3 Securing the Cart

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. 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. 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.

#### Notes:

- Wheel/caster locks are one form of an integral brake mechanism that is widely available from a number of manufacturers.
- The brakes of a SI Cart do not necessarily need to be actuated simultaneously by a single control system; the brakes may be operated independently (e.g., locking one caster first and then locking another caster).
- Casters can be acquired through many manufacturers including Albion Industries Inc., E.R. Wagner Manufacturing Co., Hamilton Caster & Mfg. Co., and Payson Caster Inc.

### 3.4.4 Safety Personnel

A SOFIA Safety Representative will be present to witness the moving of a SI Cart from the IRR/PIF onto the Aircraft and SI installation to ensure no oversights are made.

## 4. QUALITY ASSURANCE PROVISIONS

The process for verifying SI compliance with the specified requirements of Section 3 is described in the *Science Instrument Developers' Handbook* (SCI-AR-HBK-OP03-2000). The *Science Instrument System Specification and ICD Requirements Matrix Template* (SCI-AR-PLA-SV05-2014) contains a complete list of requirements from the Science Instrument System Specification and the electrical and mechanical SI ICDs, and includes all SI interface requirements within this ICD. The template specifies verification method listed by development phase, expected verification activity, and the SI compliance authority for each SI interface requirement.

## 5. ACRONYMS

The definitions, abbreviations, and acronyms used in this document are referenced in the SOFIA Lexicon, SOF-DF-PD-PD-2009.

AS	Aircraft System
DAOF	Dryden Aircraft Operations Facility
ICD	Interface Control Document
IMF	Instrument Mounting Flange
INF	Instrument Flange
IR	Infrared
IRR	Instrument Readiness Room
LH	Left-hand
NASA	National Aeronautics and Space Administration
PI	Principal Investigator
PIF	Pre-Flight Integration Facility
SI	Science Instrument
SIC	Science Instrument Cart
SSMO	SOFIA Science and Mission Operations
TA	Telescope Assembly