
**STANFORD UNIVERSITY**
W.W. HANSEN EXPERIMENTAL PHYSICS LABORATORY
GRAVITY PROBE B, RELATIVITY GYROSCOPE EXPERIMENT
STANFORD, CALIFORNIA 94305-4085

# SIA TO PROBE INTEGRATION

## GPB SCIENCE MISSION PROCEDURE

8 April, 1999

PREPARED _____ _____
D. Bardas, Integration Manager Date

APPROVED _____ _____
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APPROVED _____ _____
J. Janicki, Safety Engineering Date

APPROVED _____ _____
B. Taller, Quality Assurance Date

APPROVED _____ _____
S. Buchman, Hardware Manager Date

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# 1 SCOPE

This document provides procedures for integrating the Science Mission SIA into the Science Mission Probe (Probe-C). This procedure assumes (1) the SIA is mounted in the X-Y Vertical Manipulator Cart in the Class 10 Cleanroom, in accordance with P0404; (2) the Probe is vertical on the Precision Manipulator, with its vacuum shell removed, and (3) the Spider and its instrumentation blocks are removed from the end of the extrusions and stowed according to P0176.

*Note that due to the repair of the probe caging lines, the procedure P0376(SM), Remove Probe Vacuum Shell, is not used as originally planned. Instead, LMMS shall remove their oversized test Vacuum Can by hand once the probe in mounted on the Precision Manipulator (PM)*

The following operations are contained in this procedure:

- Setup and alignment of SIA and Probe
- Lowering the Probe over the SIA and initial installation of QB bolts
- Installation of the QB Flange bolts
- Installation of QB Flange shims and QB to Probe thermal links
- Final setting of QB Flange bolt pre-loads
- Probe rotation to horizontal
- Install Spider, Terminal Blocks, and Stockades

*Connection of gyro cables, installation and connection of SQUIDs, and installation and testing of caging units are the subject of other procedures (P0431, P0325, and P0415 respectively)*

## 1.1 Acronyms

The following acronyms are used in this document

- QB Quartz Block
- QBA Quartz Block Assembly
- QBF Quartz Block Flange
- QBS Quartz Block Support (aluminum support on probe)
- QB/T Integrated Quartz Block/Telescope
- SIA Science Instrument Assembly
- ITD Integration and Test Director
- Pr-C Probe C, the Science Mission flight probe
- VM SIA precision Vertical Manipulator
- QA Quality Assurance
- TB Terminal Block

# 2 REFERENCES

## 2.1 Plans and Procedures

- P0059 GPB Contamination Control Plan
- P0057 Stanford Magnetic Control Plan
- P0404 Transfer QBA from Optical Table to RM Cart to VM Cart
- P0205(SM) Mounting Probe onto Precision Manipulator
- P0176 Removing Spider and Other Preps for Integration with SIA
- P0419 Operations Manual for the probe Precision Manipulator
- GPB-102235 Memo by Larry Sokolsky, dated 6 August 1997,

## 2.2 Drawings

- 23170 Science Instrument Assembly Kit
- 23171 Science Instrument Assembly
- 1C34121 QBA Mounting Kit
- 1C34103 Probe / SIA Interface
- 1C34355 Pr-C to SU External Interfaces
- 1C34181 Shim, QBA Mounting

# 3 GENERAL REQUIREMENTS

**ONR representative, QA and Safety to be notified prior to beginning this procedure**

## 3.1 Environmental Requirements

This procedure will be conducted in the Stanford Class 10 Cleanroom in the HEPL facility.

### 3.1.1. Cleanliness

The Class 10 clean room where this integration takes place shall be maintained at the cleanliness levels per GPB Contamination Control Plan P0059. Certified Class 10 cloth garments shall be worn in the Class 10 clean room.

### 3.1.2 Particulate Contamination

All parts and tools shall be cleaned at least to the cleanliness levels of the rooms where they are used for assembly or testing. In addition, all flight parts shall be maintained at level 100 cleanliness per GP-B Contamination Control Plan (P0059). Take all necessary precautions to keep tools and handling equipment free of particulate contamination.

**To the maximum extent possible, personnel shall keep their bodies and garments downstream of the SIA, relative to the HEPA wall.**

### 3.1.3. Magnetic Contamination

All parts and tools shall be screened per Procedure P0057. All parts and tools shall be cleaned using methods consistent with achieving Mil Spec Level 100 cleanliness. In addition, all parts shall be maintained at level 100 cleanliness per GP-B Magnetic Control Plan, P0057. Take all necessary precautions to keep tools and handling equipment free of particulate contamination. Tools to be cleaned with Ethyl Alcohol prior to use, or when contaminated.

3.1.4. Electrostatic Discharge Control

To prevent electrostatic charge buildup on the QB/T the particle ionizer shall always be upstream of the QB/T relative to the fan wall and the PM and the QB/PM shall be grounded.

## 3.2 Integration and Test Personnel

3.2.1 Integration and Test Director

The Integration and Test Director (ITD) shall be Dr. Doron Bardas or an alternate that he shall designate. The ITD has overall responsibility for the implementation of this procedure and shall sign off the completed procedure and relevant sections within it.

3.2.2 Integration Engineers and other personnel

All engineers and technicians participating in this procedure shall work under the direction of the ITD who shall determine personnel that are qualified to participate in this procedure. Participants in this procedure are expected to be D. Bardas, G. Asher, C. Gray, J. Stamets, with assistance from LMMS (particularly G. Reynolds) at certain times.

## 3.3 Safety

3.3.1 General

Personnel working in the Class 10 Cleanroom must be cognizant of the base of the Precision Manipulator, and take special care to avoid tripping or bumping into it.

3.3.2 Hardware Safety

Extreme care must be taken to avoid accidentally bumping or scratching the QB/Telescope.

3.3.3 Maximum Number of People in Cleanroom

Under normal operating conditions, there shall be no more than 5 people in the Class 10 Cleanroom. This is to avoid violating legal make up air requirements, and to provide an efficient workspace. Exceptions must be for short periods only, and approved by the ITD.

## 3.4 Quality Assurance

Integration shall be conducted on a formal basis to approved and released procedures. The QA program office shall be notified of the start of this procedure. A Quality Assurance Representative, designated by B. Taller shall be present during the procedure and shall review any discrepancies noted and approve their disposition. Upon completion of this procedure, the QA Program Engineer, B. Taller or his designate, will certify his concurrence that the effort was performed and accomplished in accordance with the prescribed instructions by signing and dating in the designated place(s) in this document. Discrepancies will be recorded in a D-log or as a DR per Quality Plan P0108.

## 3.5 Red-line Authority

3.5.1 Authority to red-line (make minor changes during execution ) this procedure is given solely to the ITD or his designate and shall be approved by the QA Representative. Additionally, approval by the Hardware Manager shall be required, if in the judgment of the ITD or QA Representative, experiment functionality may be affected.

3.5.2 Procedure Computerization Special Requirements

Because of cleanliness requirements in the Class 10 room, and to conveniently record data directly into the procedure thus generating the "as-built" document, the procedure will be handled in a paperless fashion until completed. A Laptop computer containing an electronic version of this procedure will be operated by the ITD or QA Representative and data shall be recorded by typing directly into the electronic file.

3.5.3 Following completion of the procedure, a hard copy of the "as-built" procedure shall be printed ***and signed off by all the designated parties***. It shall then be filed, including an electronic copy into the data base.

The electronic editing of this document shall be as follows:

- Data will be inserted into the document using normal font, i.e. non-bold, non-italic
- "Signatures" shall be designated by **BLACK CAPITAL BOLD LETTERS**.
- "Redlines" shall be in ***RED BOLD ITALICS*** to make them distinguishable both on the Laptop screen and on the hard copy printout.
- If available, digital pictures shall be inserted into the document where appropriate.

## 4 REQUIRED EQUIPMENT

The following equipment shall be in the Class 10 cleanroom.

Ground Support Equipment

- Probe Precision Manipulator
- VM
- Keithley Ohmmeter, Calibration Date _____
- Inclinometer Calibration Date _____

Tools and Miscellaneous

- Ethyl alcohol
- Methanol
- Ultrajet filtered compresses air
- BeCu Allen wrenches
- Precision gauge "horseshoes" 0.110 in. thick for setting belleville preloads on bolts.
- Wrench, for PM
- Socket wrenches for Probe yoke collar and PM tilt plate

# 5 INITIAL MATING OF THE QB/T WITH THE QBS

## 5.1 Vertical Alignment of Probe

5.1.1 With the probe horizontal, remove the spool piece from the X-flange. This ensures clearance to the ceiling when the probe is later raised in its vertical orientation.

5.1.2 Rotate the probe to vertical and lower it so that the cylindrical section of the QBS is accessible. Unlock the Z-axis brake so that the probe can be rotated by grabbing the QBS.

5.1.3 Rotate the probe so that the +X and +Y axes make are approx. 45° with respect to the HEPA wall. *Note, if circumstances require it the ITD may alter this orientation as needed.*

5.1.4 Using the digital inclinometer against the side of the QBS in two orthogonal locations, corresponding to the orthogonal tilt adjustment mechanisms on the probe yoke and the PM, adjust the tilts as necessary, to bring the probe vertical to within approx. ≤ 0.1°.

5.1.5 Now raise the probe to a sufficient height so that the end of the extrusions are about 6 in. higher than the highest point on the telescope assembly. (The QB/T is already in the VM, P0404)

## 5.2 Pre-assemble Finger Bolts

5.2.1 Pre-assemble 20 finger bolts, 1C34166-101, by threading a flat washer, 1C34361-113, 6 ea. Belleville washers, 3 each opposed as shown in Figure 1, followed by a second flat washer, the shouldered Vespel washer, 1C34600-102 and the Vespel washer, 1C34600-101 onto the bolt.

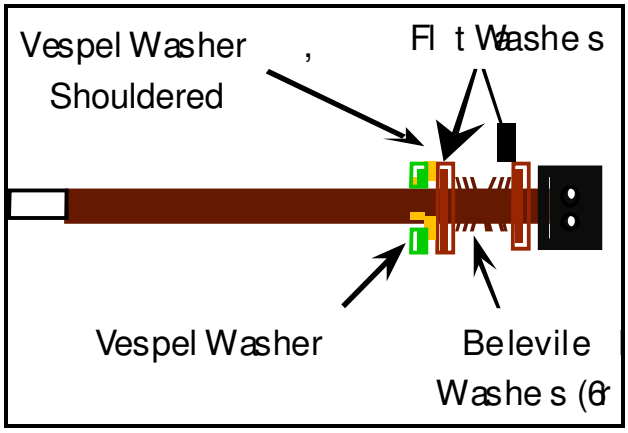


**Figure 1. Pre-assembled Finger Bolt**

## 5.3 Position the SIA under Probe

5.3.1 Visually position the SIA in the VM under the probe by carefully rolling the cart under the probe. Two people should hold onto the cart while rolling it along the floor. Orient the VM cart so that its long axis isparallel to the front of the PM and the adjustment knob for the slide providing motion perpensicular to the HEPA wall faces the PM. Unlock the rotation paltform on the VM.

5.3.2 Ensure that the QB/T is rotated so that X and Y axes are aligned properly with those of the QBS. This is determined by matching the extrusion hardware that services the various parts of the QB/T respectively. *The SIA's position can be adjusted in X, Y, θ, and Z by turning the appropriate knobs for the four stages supporting the clamp which holds the QB/T*

5.3.3 By holding the inclinometer against two orthogonal sides of the telescope main tube, lower the jacks of the VM cart to lock its movement and adjust the QB/T to vertical within ≤ 0.1°.

5.3.4 Lower the QBS slowly until the end of the extrusions are just above the top plate of the Telescope, adjusting X, Y, and θ as necessary. The setup should look similar to Figure 2.

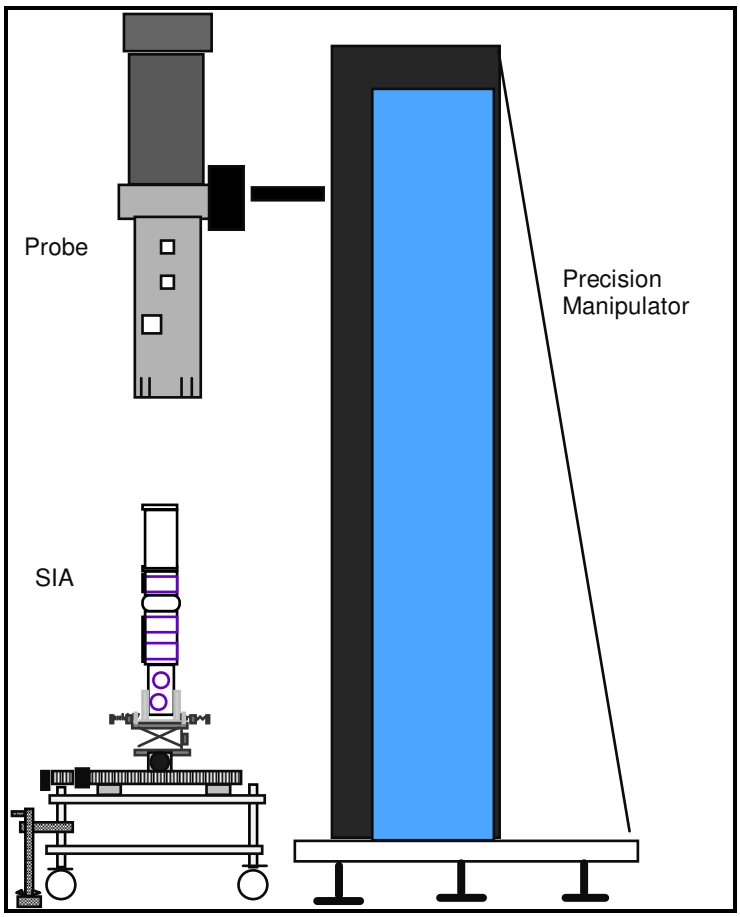


**Figure 2. Probe and SIA in Integration Positions**
(Elements of SIA cart rotated for clarity)

*Take picture*

## 5.4 Lower the Probe over SIA

*Note, the ITD may modify this procedure if problems become apparent or a better procedure becomes evident. Doring this process, representatives of the telescope group shall be present.*

5.4.1 Ensure that the extrusions are evenly spaced around the front flange of the telescope and that the DPA's and all telescope cabling and wires will not interfere with the extrusions.

5.4.2 With two people watching for possible interference, another operates the PM, in accordance with P0419, to slowly lower the probe over the QB/T. Stop and adjust the QB/T position as necessary, so that the QB/T and probe do not touch.

**CAUTION: Pay particular attention to clearances of the telescope as it passes through the fingers and subsequent probe saddles, as well as the QB flanges as they enter the extrusions. Adjust the X-Y table and its rotation feature as necessary. Proceed in slow small increments, stopping to evaluate the clearances and making appropriate adjustments.**

5.4.3 Stop when the DPA's and their cables are visible through the set of windows in the QBS before reaching the final probe saddle that they must pass through. This will be approximately 1 to 2 in. before the to plate of the telescope passes through the last saddles during its installation.

5.4.4 Reach through these apertures and remove the cables attached to the top of the Keider unfolding them and so that they lie flat in their final positions against the telescope.

5.4.5 Lower the probe until the probe finger shoes are within about 1/4" of the QBA flanges. Stop the PM and make fine adjustments of the VM support to ensure centering.

5.4.6 Manually raise the scissors jack on the VM cart under the QBA until the molibdenum shoes are within about 0.1 inch of the QB flange surfaces.

5.4.7 Place 1 ea. Teflon pad with 5 holes, designed to be sandwiched between the finger pads and the QB flange, in between the flange and the pads so that each of the holes is centered over the respective Quartz Block Flange hole.

5.4.8 Loosen the clamp holding the aft end of the QB/T so that it will not be over-constrained when the flange bolts are inserted. The QB/T will still be supported safely by the sponge pad and cannot fall because the flange will be within the QBS ring.

5.4.9 Install the Finger Alignment Ring by first attaching the four aluminum arcs to the fingers with 4-40 Ti screws. Attach the split ring, around the QBS so that the micrometers line up with the center of the finger support arcs. Secure in place by tightening the clamp system against the four the ring spacers placed on the outside of main ribs of the QBS.

*NOTE: This mechanism is used to push the bonded finger groups radially in so that the QBF bolts can be installed with minimum stress on the quartz. The QBS fingersare purposelypre-loaded at room temperature; they become relaxed at cryogenic temperatures. The epoxied finger/moly pad assembly is already displaced radially inward by approx. 0.0145 in. The Finger alignment ring is used to push the fingers in an additional 0.004 in.*

5.4.10 Turn the micrometers until they ratchet against the arcs. Note the reading on the micrometers and dial them inwards an additional 0.004 to 0.005. This sets the fingers in approximately the right locations, and only fine adjustment is later needed.

5.4.11 Raise the QB/T with the manual Z adjustment on the VM until the gap has been narrowed to about 0.03.

5.4.12 Make incremental adjustments of the micrometers if necessary until 1 bolt can easily be inserted into the center finger at each QB flange. During this process, ensure that the Teflon pad has been captured properly. Tighten the bolt in until the washer under the head just touches the Belleville without compressing them.

5.4.13 Now install the outer bolts of each flange (positions 1 and 5), being careful to not to force the bolt into the finger. Make small movements of the finger adjustment ring as necessary.

5.4.14 Watch that the Teflon pad has been captured and that all three bolts easily have passed through their respective holes.

5.4.15 Now carefully raise the SIA manually until QBF is in uniform contact with the Teflon/Moly pads. Continue to raise the vertical jack stand until the sponge supporting the SIA becomes slightly compressed. This insures intimate contact at the interface.

5.4.16 Tighten the bolts until the bellevilles are just touching the upper and lower washer

5.4.17 Tighten all 12 bolts in star pattern working across the block, until the washers just snug up against the spacer "horseshoe" gauge which is 0.110 in. thick. Back of each bolt approx. 12˚ (~ 0.001 in.) so that the spacer gauge can be removed.

*Note: This pre-loads each bolt to approximately 50 lb. and thus twelve bolts easily supports the SIA (weight ~ 90 lb.) with a high margin,*

5.4.18 Open the support clamp of the VM completely and slowly lower the VM away from the aft end of the block.

5.4.19 Raise the probe and QB/T using the PM until the aft end of the QB clears the VM.

5.5.20 Unlock the stops on the X-Y Cart, and carefully remove the it out of the Class 10 room.

*Take picture*

**SECTION 5. Completed:**

Integration Engineer(s) _____ Date _____

_____ Date _____

_____ Date _____

Discrepancies if any:

Disposition./.sign-off: _____ Date _____
ITD

Concurrence: _____ Date _____
QA Representative

*Take picture*

# 6 INSTALL SHIMS, THERMAL LINKS, SET BOLT PRE-LOAD

## 6.1 Measure Gaps between QB and Birdcage Ring

6.2.1 Use the plastic feeler gauges of multiple sizes to measure the gap between each flange and the birdcage ring along the surface of the QBF, in the areas adjacent to the bolts. Record the gaps measured in Table 1 below.

6.2.2 Determine a combination of shims such that the residual gap at ambient room temperature is 22.5 – 25.5 mils. Available shims are:

- The large area shims, P/N 1C34181-101 through 108, cover the entire flange surface and are attached to bolts 2 and 4. These shims are available in thickness 3, 5, 7, 10, 13, 16, 20, and 24 mils for –101 through – 108 respectively.
- The end shims, P/N 1C34181-109 through 111, and middle shims, P/N 1C34181-112 through 114, come in thickness 3, 5, and 7 mils respectively. The end shims are identical for bolts 1 and 5, but bent in opposite directions.
- The shim closest to the QB Flange should be a large area shim.

6.2.3 Record the shim combinations to be use in Table 1. *NOTE: The shims verify Requirement 3.7.2.1.5 of the Payload Spec, PLSE-12 V4.1, which states that the residual gap shall be 0.004 – 0.007 inch when the temperature is 4.2 K. Since the aluminum will shrink 0.0185 inch between room temperature and 4.2 K, the residual gap should be .0225 – .0255 inch at RT.*

**Table 1.**

| Flange | Bolt Location (1 Is Most Clockwise w.r.t. +Z) | Gap (mils) | Total Shim Thickness Needed (mils) | # Of Shims Of 1c34181 Shim Dash Numbers Written As #Of Shims (–1nm) | Total Of Actual Shim Thickness (mils) |
|---|---|---|---|---|---|
| +X | 1 | | | | |
| +X | 2 | | | | |
| +X | 3 | | | | |
| +X | 4 | | | | |
| +X | 5 | | | | |
| +Y | 1 | | | | |
| +Y | 2 | | | | |
| +Y | 3 | | | | |
| +Y | 4 | | | | |
| +Y | 5 | | | | |
| -X | 1 | | | | |
| -X | 2 | | | | |
| -X | 3 | | | | |
| -X<br>-X | 4<br>5 | | | | |
| -Y | 1 | | | | |
| -Y | 2 | | | | |
| -Y | 3 | | | | |
| -Y | 4 | | | | |

| | | | | | |
|---|---|---|---|---|---|
| -Y | 5 | | | | |

## 6.3 Install Shims and Thermal Link Bolts on Each Flange

6.3.1 Starting with the -X flange, install the shims as described below. Bend the tabs of the shims so that they are perpendicular to the main part of the shim and face towards the QB.

6.3.2 First install the large shim. Remove the Vespel washer from bolts 2 and 4, and insert the bolts through the selected shim(s) such that the they are captured between the Vespel shoulder washer and the Vespel flat washer.

6.3.3 Feed the two bolts (#2 and #4) over the correct thermal link(s) for this flange, making sure the orientation of the indium pads is towards the QBF.

6.3.4 Carefully slide the shim(s) between the QB flange and birdcage ring, while inserting the bolts into holes 2 and 4 of that QBF. Set the pre-load of these two bolts by snugging them up on the "Horseshoe" gauge and then backing them off approx. 10˚ to withdraw the gauge.

5.3.5 Now tighten each bolt so that the belleville stack is compresed to 0.107 in. This is accomplished by turning the bolt clockwise ~ 46˚

*(ref: Memo by Larry Sokolsky, GPB-102235, dated 6 August 1997, where a new calculation was done requiring a RT 70 ± 15 lb. preload ,rather than 50 ± 15 lb., due to the modification of the bolt washers for probe-C.)*

6.3.6 For a side shim remove the bolt (first or fifth), and insert the shim(s) as above, between the Vespel shoulder washer and the Vespel flat washer.

6.3.7 Carefully slide the shim(s) between the large area shim and birdcage ring, while inserting the bolt through the thermal link washer assembly into the bolt hole. Secure using the method described in 5.3.5 an 5.3.6.

6.3.8 Use the same method for a middle shim after removing the bolt.

6.3.9 Repeat all of Section 6.3 for each flange in turn until all shims, thermal washers and bolts are installed.

6.3.10 Complete installation of thermal links by installing a 4-40 screw through the washer at the other end of each set of links and secure it into its threaded hole in the adjacent extrusion. Ensure that the wires of the thermal links are properly bent.

Note that some flanges utilize two extrusions to tie down thermal links while others only one.

## 6.4 Rotate Probe

6.4.1 Rotate the probe about its lateral axis using the ratchet wrench on the Precision Manipulator, so that the probe is visually horizontal with the cold end facing the observation window

6.4.2 Position a table under the probe. Place the probe to a comfortable working height of approximately 4 feet.

6.4.3 Position the ion bar array upstream of the QBA.

**SECTION 6 Completed:**

Integration Engineer(s) _____ Date _____

_____ Date _____

_____ Date _____

Discrepancies if any:

Disposition./.sign-off: _____ Date _____
ITD

Concurrence: _____ Date _____
QA Representative

*Take picture*

## 7 PROCEDURE COMPLETION

The results obtained in the performance of this procedure are acceptable:

Integration Engineer _____ Date _____

ITD _____ Date _____

The information obtained under this assembly and test procedure is as represented and the documentation is complete and correct:

QA Representative _____ Date _____

QA Program Engineer_____ Date _____

Copy discrepancies to D-Log and open Discrepancy Reports when required.

Hardware Manager _____ Date _____

Systems Engineering _____ Date _____

## 8 DATA BASE ENTRY

The following data shall be entered into the GP-B Data Base:

1) Name, number and revision of this procedure

2) Part numbers and serial numbers of QB and Telescope.