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

REMOVE GYROSCOPE FROM SIA

GP-B SCIENCE MISSION PROCEDURE
P0681 Rev A

August 3, 2000

PREPARED	_____	_____
	R. Brumley, Gyroscope RE	Date
APPROVED	_____	_____
	C. Gray, Gyroscope Verification	Date
APPROVED	_____	_____
	K. Bower, Gyroscope Verification	Date
APPROVED	_____	_____
	D. Ross, Quality Assurance and Safety	Date
APPROVED	_____	_____
	G. Keiser, Chief Scientist and Chair Cleanliness Control Committee	Date
APPROVED	_____	_____
	B. Muhlfelder, Technical Manager	Date

REVISION HISTORY

Rev	Date	Description
-	8/2/2000	
A	8/3/2000	Changed ONR and QA notification from 1 hour to 24 hours. Inserted steps to measure capacitance between SQUID leads. Added places to record visual observations.

This procedure describes the removal of a gyroscope from the SIA. It is intended to be used where the desire is to preserve the cleanliness of the rest of the science instrument. It includes the following steps:

- Initial inspection and cleaning of area around the relevant bore in the quartz block
- Install particle collection system
- Disconnect readout leads from SQUID package
- Disconnect all LEMO connectors (suspension lines, ground plane, UV)
- Remove and bag caging assembly
- Remove spinup and exhaust manifolds
- Remove gyroscope stack from bore
- Cleaning of area around empty quartz block bore

This procedure assumes that the probe is already mounted on the precision manipulator, the vacuum can is off, and the probe sits in a horizontal position.

2. REFERENCES

2.1 Plans and Procedures

P0023 GPB Clean Room Procedures

P0057 GPB Magnetic Control Plan

P0059 Probe Contamination Control Plan

P0108 Science Mission Quality Plan

P0147 Relativity Mission Contamination Control Plan, Master

P0327 Gravity Probe B Relativity Mission System Safety Program Plan

P0476 ESD/EOS Risk Mitigation Procedure

3. GENERAL REQUIREMENTS

3.1 Environmental Requirements

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

3.1.1 Room Cleanliness

The Class 10 clean room where this integration takes place shall be maintained at the cleanliness levels per Federal Standard 209E. All personnel in the clean room shall wear Class 10 cloth garments.

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 parts shall be maintained at level 100 cleanliness per GP-B Contamination Control Plan (P0059). A portable particle counter shall be set up on a table downstream of the local work area, and monitored during the work performed. If, at the discretion of the test director or QA, particulate counts rise to an unacceptable level for the specific work being performed, then work shall stop. Work shall not resume until the cause of the extra particulation has been assessed and necessary mitigating steps have been incorporated into the GSE and procedures. Take all necessary precautions to keep tools and handling equipment free of particulate contamination.

Since this operation is performed on extremely delicate flight equipment that is already assembled, there is a limitation on how well inspections and cleaning can be performed. In some cases this means that it will not be possible to rigorously verify level 100 cleanliness. At all times it is important to weigh hardware safety versus verifying and maintaining cleanliness. Therefore the test director and QA have discretion in arriving at the proper balance.

To the maximum extent possible, personnel shall keep all parts of their bodies downstream of the probe, defined by the direction of HEPA airflow.

At all times during the completion of this procedure a portable particle detector shall be situated near the work area to monitor for the generation of particles.

Ensure that properly calibrated ion bars are situated properly and operating.

3.1.3 Magnetic Contamination

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, Science Mission (P0057). Take all necessary precautions to keep tools and handling equipment free of particulate contamination.

Only nonmagnetic materials are allowed to touch the cold end of the probe.

3.1.4 Electrostatic Discharge (ESD)

ESD wrist straps shall be worn by all personnel who touch the probe. Note that per the previous section the steel alligator clips which connect to most wrist straps can not be connected to the cold end of the probe. The Precision Manipulator (PM) is in electrical contact with the probe, and may be used as a grounding site for ESD wrist straps.

3.2 Test Personnel

3.2.1 Test Director

The test director for this procedure shall be Robert Brumley, or his appointed replacement.

3.2.2 Personnel

The following personnel are qualified to perform this procedure

- Paul Bayer
- Chris Gray
- Ken Bower
- Bruce Clarke
- Robert Brumley
- Dr. Barry Muhlfelder
- Ming Luo

See section 3.4 for details on the requirements for Quality Assurance notification and witnessing of this procedure.

3.2.3 Minimum Personnel

No activity shall be performed on the science mission probe without at least two people in the room, i.e. at least one person to perform the procedure and one person to observe the procedure.

3.3 Safety

3.3.1 Hardware Safety -- General

Great care should be taken in the handling of the gyroscope and its hardware to avoid damage to them.

3.3.2 Electrostatic Discharge

Grounded wrist straps shall be worn when making connections to the readout cable. Also, it is important to use one of the multimeters specified in Section 4 so as to avoid any possibility of damaging the pickup loop.

3.3.3 Personnel Safety

All operations shall take place according to Stanford University safety guidelines. Any person observing a situation which they deem unsafe shall report the fact immediately to the test director. The Quality Assurance representative shall be responsible for monitoring that all activities are performed in a safe manner.

3.4 Quality Assurance

- Stanford QA must be notified at least 24 hours before beginning this procedure.

- ONR QA must be notified at least 24 hours before beginning this procedure.
- D. Ross (or her designate) must be present to monitor the completion of this procedure.

This procedure shall be conducted on a formal basis to its latest approved and released version. The QA Program Engineer shall be notified of the start of this procedure. A Quality Assurance representative designated by D. Ross shall review any discrepancy noted during test. Redlines shall be approved by the QA representative. The QA representative will nominally be Russ Leese. Upon completion of this procedure, the QA Program Engineer, D. Ross or R. Leese, shall certify his or her concurrence that the effort was performed and accomplished in accordance with the prescribed instructions by signing and dating the appropriate approval line at the end of the procedure.

3.5 Red-Line Authority

Authority to red-line (make minor chances during execution) this procedure is given to the qualified personnel listed in section 3.2.2. All redlines must be approved by the QA representative. In addition, approval by the Technical Manager shall be required if, in the judgement of the test director or the QA representative, experiment functionality may be affected.

4. REQUIRED EQUIPMENT

The following equipment is necessary to perform this procedure:

Flight Hardware:

Integrated Probe / SIA Assembly SM-01

GSE Hardware:

Item	Calibration Required
Keithley Model 580 Digital Multimeter or Fluke 85 or Fluke 87	Yes
Standard Gyroscope Non-Magnetic Tool Kit	No
Lemo Removal Tool	No
Secondary Containment for Flight Parts	No
Gyro Non-Magnetic Pusher Tool	No
Snap Ring Installation Tool	No

Clean Cu wire for tying up cables and hardware	No
Clean Teflon Caging Plug	No

5. INITIAL CONDITIONS

5.1 Verify Probe is on the Precision Manipulator in the Class 10 room, the vacuum can is off, and the probe is horizontal. _____

5.2 Verify all initial inspections have been performed, and the initial state of the SIA documented prior to beginning this procedure. _____

6. OPERATIONS

6.1 Procedure Initialization

Start Date: _____ Start Time: _____

Gyroscope being removed: _____

Test Engineer: _____ (print)

QA Representative: _____ (print)

Record Model Numbers, Serial Numbers, and Calibration Dates (if applicable) for the equipment designated in Section 4.

Multimeter Model	**Serial Number**	**Calibration Date**

6.2 Prepare Workspace

6.2.1 A table and workspace needs to be set up underneath the SIA. First, verify that the probe is situated at a height well above the table so that there is no chance that the SIA will be bumped while the table is moved. _____

6.2.2 Inspect and clean the workspace table. Note that this table should have _____

been recently cleaned and certified as part of an overall Class 10 cleanroom cleaning and re-certification.

6.2.3 Note that non-magnetic tools should not be placed on a stainless steel surface, so either clean room wipes or clean bags should be provided on which to place these tools.

6.2.4 Install the particle collection system on the table. This consists of a HEPA vacuum cleaner with special positionable nozzles.

6.3 Disconnect Leads of Readout Cable from SQUID Package

6.3.1 This section should be completed with Barry Muhlfelder or his designate present.

6.3.2 Rotate the probe so that the SQUID for the gyroscope being removed is accessible, yet pointed down as far as feasible so that particles generated during this step tend to fall away from the rest of the science instrument.

6.3.3 Power up the particle collection system and position dust collection nozzles to trap released particles. This position may be changed during the procedure as required so that the suction is focused on the work area.

6.3.4 Using care to prevent damage to the screw, break the epoxy bond on each of the four screws which hold the lid on the SQUID. This can only be performed by Ken Bower or Chris Gray. Both have carefully calibrated their "feel" for how much torque is necessary and allowed in this process. If there is difficulty in breaking the staking, then a calibrated torque driver set to 50 oz in. shall be used. It is not necessary to use a calibrated torque driver if C. Gray and K. Bower feel that they are not approaching the yield strength of the screw (this is because they have much better "feel", and there is lower particulation risk, with the use of a standard hex wrench).

6.3.5 Remove the four screws on the lid. Place these screws in a clean room bag, mark the bag, and remove from the work area.

6.3.6 Carefully remove the lid to the SQUID. Place the lid in a clean room bag, mark, and remove from the work area.

6.3.7 Remove the lead gasket. Place in a clean room bag, mark, and remove from the work area.
Note: this should leave the connection between the readout cable and the SQUID exposed, but DO NOT remove the shield over the main SQUID electronics.

6.3.8 Using the multimeter, measure the resistance across the readout cable. This is the parallel resistance of SQUID and pickup loop.

For Information Only: For the gyro #4 installation which finished 6/28/99, this was 107.9 Ω. The Input resistance of the SQUID was 109.4 Ω, and gyro pickup loop round-trip resistance before hookup was 7.17 kΩ.

R(parallel) = _____ *Ω*

6.3.9 Using the multimeter, measure the resistance between the pickup loop and ground. This should be approximately 2 MΩ.

R(to ground) = _____ *Ω*

6.3.10 Now disconnect the readout cable from the SQUID input. Do not remove the capacitor kit from the SQUID.

6.3.11 Using the multimeter, measure the SQUID input resistance (gyro loop disconnected).

For Information Only: For the gyro #4 installation which finished 6/28/99, this was 109.4 Ω

R(SQUID Input) = _____ *Ω*

6.3.12 Using the multimeter, measure gyroscope round-trip resistance (disconnected from the SQUID)

For Information Only: For the gyro #4 installation which finished 6/28/99, this was 7.17 kΩ

R(gyro loop) = _____ *Ω*

6.3.13 While gently wiggling readout cable, re-measure gyro loop resistance

R(gyro loop) = _____ *Ω*

6.3.14 (Optional) This step may only be performed if authorized by Dr. Barry Muhlfelder. In addition, the person performing this step must be approved by Dr. Barry Muhlfelder.

Remove the cover on the SQUID and perform a visual inspection.

Step Performed (circle one): Yes No

Observations:

_____

_____

_____

_____

_____

6.3.15 Using care to prevent damage to the screw, break the epoxy bond on each of the four screws which hold on the capacitor kit. _____

6.3.16 Inspect area around screws and remove any large pieces of epoxy which came loose but were not removed by the particle collection system. _____

6.3.17 Remove capacitor kit assembly from SQUID package. Check again gyroscope readout loop round-trip resistance.

R(gyro loop) = _____ Ω _____

6.3.18 Visually inspect the edge of the SQUID package and the capacitor kit which were made visible by the de-mating. Take digital pictures of the hardware. Record any observations below:

6.3.19 Measure feedback coil resistance at top hat and record.

R(feedback coil) = _____ Ω

6.3.20 Remove capacitor kit assembly from gyroscope readout cable. Place the capacitor kit in a clean room bag and label. Include the serial number of the capacitor kit in the label. Check again gyroscope readout loop round-trip resistance.

R(gyro loop) = _____ Ω

Record any observations about the state of the wedge and other

disassembled hardware below.

6.3.21 Starting furthest from the gyroscope, for each of the readout cable clamps, perform the following steps:

(a) Position the particle collection system close to the epoxy staking

(b) Carefully break the epoxy bond on the screw

(c) Inspect and clean the area where the epoxy was broken

(d) Remove the screw and clamp from the probe. Label, bag, and remove from the work area.

(e) Measure the gyroscope pickup loop resistance and record in the following table.

At the discretion of the Test Director, at each step gently wiggle the cable while checking continuity to see if the connection is intermittent.

Clamp (1= closest to SQUID)	**Resistance (kΩ)**

Observations:

6.3.22	Install heat shrink cover for readout cable leads.	
6.3.23	Secure readout cable against damage during future operations.	

6.4 Disconnect LEMO Connectors

6.4.1	Rotate probe as required for access to LEMOs and cabling	
6.4.2	Position particulate collection system nozzles as required to catch any particles generated when working with the Kapton sleeves and the epoxy staking on the connectors.	
6.4.3	Remove Kapton sleeves around suspension line and ground cable connections as required.	
6.4.4	Carefully remove spiral wrap which groups the Gyro 4 UV fibers with the Gyro 3 UV fibers. *Caution: These fibers are extremely delicate so great care must be taken not to damage the fibers.*	
6.4.5	Using the LEMO disconnection tool, fully disconnect all LEMO connectors for the gyroscope being removed. After each LEMO is disconnected, inspect the area and remove any large epoxy particles which may have not been removed by the vacuum.	
6.4.6	Remove grommet plugs from birdcage as required to allow removal of the gyroscope cables. Store in a properly labeled clean room bag.	
6.4.7	Disengage upper cable grommet from birdcage for each applicable gyroscope cable and remove the cable from the birdcage.	

6.5 Remove Caging Assembly

6.5.1	Cleanliness around the gyroscope housing is critical during this process. Inspect and re-clean as required.	
6.5.2	Rotate the probe such that the gyro retainer is facing down and away	

	from the air flow.	_____
6.5.3	Position the particulate collection nozzles as required near one of the nuts which hold on the caging assembly.	_____
6.5.4	Moisten the threaded post of the nut with Ethanol as required. This helps to lubricate the thread and trap any particles generated during the unscrewing process.	_____
6.5.5	Using a nut driver, carefully break the epoxy on the wet caging nut.	_____
6.5.6	Remove any large loose piece of epoxy which was not removed by the vacuum.	_____
6.5.7	With the vacuum nozzles positioned close to the nut, slowly unscrew the nut and remove.	_____
6.5.8	Inspect the threaded post and clean with care as required.	_____
6.5.9	Repeat 6.5.3 through 6.5.8 for the other two nuts which hold on the caging assembly.	_____
6.5.10	Place the three nuts in a clean room bag, label, and remove from the work area.	_____
6.5.11	Gently disengage caging lines from the birdcage clips as required.	_____
6.5.12	Carefully remove caging mechanism from the gyroscope housing, bending the caging lines with care as required, and being careful not to form a bend with a radius less than 0.25".	_____
6.5.13	Inspect and clean caging assembly as required. Bag and secure the caging mechanism to protect it during future probe rotations.	_____
6.5.14	Carefully reclean threaded posts.	_____
6.5.15	Rotate probe so that the gyroscope retainer is facing slightly up.	_____
6.5.16	Insert a clean gyroscope housing plug into the caging hole in the gyroscope housing.	_____
6.5.17	Disengage lower grommets from the retainer for all cabling.	_____
6.5.18	Bundle cabling for easy future handling.	_____
6.5.19	Visually inspect for particles on gyroscope housing as possible.	_____

6.6 Remove Spinup and Exhaust Manifolds

6.6.1	Rotate probe such that the Spinup/Exhaust manifold assembly is pointed down and away from the air flow.	_____
6.6.2	Position nozzles of particulate collection system as required.	_____
6.6.3	Disconnect exhaust manifold elbow from short tube (gyro side)	_____

6.6.4	Disconnect exhaust manifold elbow from the probe exhaust line. Immediately bag the end of the probe exhaust line.	_____
6.6.5	Bag the exhaust manifold elbow and set aside.	_____
6.6.6	Remove the short tube from the exhaust side of the spinup/exhaust assembly. Label, bag, and set aside.	_____
6.6.7	Remove the Teflon spinup line from the spinup/exhaust assembly. Immediately bag the exposed end of the spinup line of the probe.	_____
6.6.8	Place the Teflon spinup line in a clean room bag, label, and set aside.	_____
6.6.9	If the alignment of the gyroscope relative to the quartz block was not previously measured, measure it now using the latest revision of P0206.	_____

6.7 Remove the Gyroscope from the bore

6.7.1	Cut gyroscope GRT and heater wires on both gyro and probe sides. Remove the connector from the probe.	_____
6.7.2	Engage a snap ring installation tool on each retention rod. Apply compression from the retainer side as required. Ensure that each tool properly engages the rods and washers.	_____
6.7.3	Applying necessary compression, remove snap rings from the retention rods.	_____
6.7.4	Keeping positive pressure on the Spinup/Exhaust assembly, iteratively compress each rod and loosen slightly each tool until all retention springs are fully relaxed.	_____
6.7.5	Keeping positive pressure on the Spinup/Exhaust assembly, disengage each tool, collecting washers.	_____
6.7.6	Keeping positive pressure on the Spinup/Exhaust assembly, slip the pusher tool through the gyro retainer, past the cable bundle, and over the gyro housing plug.	_____
6.7.7	Keeping positive pressure on the Spinup/Exhaust assembly, carefully push the gyro housing stack through the bore using the pusher tool. Back off if index plate/spacer assembly, the dowel pins, or the gyro housing binds in the bore.	_____
6.7.8	Keeping positive pressure on the Spinup/Exhaust assembly and pusher, remove the dowel pins from the index plate/space assembly and gyro housing once fully exposed.	_____
6.7.9	Continue pushing the gyro housing. Monitor the cable bundle and prevent connectors from snagging the retainer.	_____
6.7.10	Once the pusher is through the bore, disengage it from the gyro housing	_____

and remove. _____

6.7.11 Fully disengage the gyro housing stack and cabling from the bore -- continue to maintain the stack (do not let the pieces disengage from each other). _____

6.7.12 Place the gyro housing stack on the counter and examine for particulate or other contamination. Record observations below: _____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

6.7.13 Remove the gyro housing from the index plate/spacer assembly and remove the dowel pins. Use care to prevent snagging GRT and heater cables. _____

6.7.14 Immediately place the gyroscope housing in its container. _____

6.7.15 Disassemble the index plate/spacer assembly, washers, and spinup/exhaust assembly. _____

6.7.16 Remove retention rod stacks from the quartz block. Store in a properly marked clean room bag. _____

6.7.17 Carefully disconnect final filter ground lines from retention rod washer with trapped hole.

Caution: These wires are extremely delicate and great care must be taken to not break them. _____

6.7.18 Remove retainer assembly from bore. _____

6.7.19 Inspect the quartz block in the area around the bore. Take pictures to document the state of the instrument. Make notes below. _____

_____

6.7.20 Carefully clean the quartz block in the area around the empty bore. This may include small dabs of Braycote grease as well as particulate contamination.

6.8 Storage and Documentation of "Used" Flight Hardware

6.8.1 Place all flight parts that are to be reused in a secondary containment vessel marked "SIA FLIGHT PARTS REMOVED FROM PROBE" and mark the relevant gyroscope number and date. These are to be stored in gyroscope bonded stores in the Class 10,000 room.

Note: Each part requires QA and ONR approval to reuse for flight. This entails the use of a special traveler for each part which documents its history while removed from the probe, and a new cleaning and inspection. For parts which contain portions of epoxy staking, the preference is to scrap the parts removed and replace with new parts.

6.8.2 Update special SIA kit list attached to the end of this procedure to document what was taken off of the SIA, and which parts are intended for reuse.

7. PROCEDURE COMPLETION

Record completion of this procedure in the traveler, as appropriate.

Record any abnormalities or deviations from this procedure in the D-Log. If the QA representative decides it is appropriate, open a Discrepancy Report to document the event.

This test has been completed according to the procedure contained herein. All redlines used have been integrated into this document.

Test Director:	_____ (sign) _____ (print)	(date and stamp)
(optional) **Test Engineer:**	_____ (sign) _____ (print)	(date and stamp)
(optional) **Test Engineer:**	_____ (sign) _____ (print)	(date and stamp)
QA Representative:	_____ (sign) _____ (print)	(date and stamp)