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Gravity Probe B Relativity Mission

Gyroscope Suspension System (GSS) Performance Verification Test Test Readiness Review Completion Certificate

S0702 Rev -

September 04, 2002
Action items completed and updated September 23, 2002

Anthony J Joyce for Rich Whelan 9/23/02
Prepared by: Rich Whelan, System Engineering Date

Dorrene Ross 9/23/02
Approved by: Dorrene Ross, Quality Assurance Date

Robert Schultz 9/23/02
Approved by: Bob Schultz, Chief System Engineer Date

23 SEP 02
Approved by: Bill Bencze, GP-B Electronics Manager Date

Ronald D. Singley 9/23/02
Approved by: Ron Singley, GP-B Program Manager Date

9/26/02
Approved by: Ed Ingraham, Resident NASA Manager Date

ITAR Assessment Performed ____________
Tom Langenstein

ITAR Control Req'd? Yes [✓ No] 10/11/02

GSS Performance Verification Test Readiness Review (TRR)

Date & Time: September 9, 2002, 2:00 PM

Location: GP-B HEPL Conference Room

Purpose:

To ensure that the flight hardware, test facility, test equipment, and test procedures are ready for testing, data acquisition and reduction.

Scope:

The GSS Performance Verification Test Readiness Review (TRR) will encompass Flight GSS unit #5 (Flight Spare) flight hardware (Fwd + Aft units) operating with gyroscope simulation hardware and software. The results of this test will support requirements verification that cannot be achieved otherwise.

Agenda:

- Test Personnel Status
- Test Resources Status
- Test Support Software Status
- Procedure Status
- Requirements Status

This TRR focuses on the conduct of multiple tests run under a single Procedure (P0918). P0918 contains much of the content of a typical TRR. Some data is repeated here from P0918.

Review Team:

Ron Singley	Program Manager
Bob Schultz	Chief Systems Engineer
Bill Bencze	Electronics Manager
Dorrene Ross	Systems Effectiveness
Harv Moskowitz	Safety
Ed Ingraham	NASA Representative

TRR check list:

- Confirm that all specifications and interface control documents are approved and have proper traceability.
- Confirm that the requirement verification matrix has accounted for all of the specification requirements.
- Confirm that test procedures approved.
- Confirm that sufficient and detailed resources are allocated and certified.
- Confirm that test support software has been released.

1.0 Entry criteria

Testing may begin when the following criteria are met:

- Approved Procedure (s)
- Facilities identified, available for planned test date
- Certified Test Equipment (GSE / Testbed / Gyro simulator)
- TRR Signed off (required actions completed)

2.0 Exit criteria

Testing may be considered complete (ready for configuration break) when the following criteria are met:

- Completion of data taking

  At the conclusion of the test, it shall be evident to the test conductor that sufficient data has been collected. For many aspects of this test, a real-time quick look at the validity of the data will be available. For some portions of the test, post processing will be necessary to determine verification. [note that for these areas, sufficient 'trial' runs have been conducted to provide high confidence of overall test success.]
- Complete "Run for Record" of test procedure with no DRs.
- Test Conductor and QA signoff completion of test.

3.0 Test Facilities

repeated here from P0918:

3.1. Primary facility: GSS Integrated Systems Lab, ES3, room 175, Stanford University.

4.0 Test equipment, and Test Configuration

4.1. See P0918 for details (P0918 Figure 1 shows the test configuration, Test Equipment details in P0918 section 11). Flight-like equipment is used to verify the flight software. While the GSS (fwd & aft) is the flight spare unit, an earlier DR against a HVA board (not used in this test) has resulted in a change to the box configuration where this board is being removed and a flight equivalent HVA card is being installed.

4.2. Actual Test Configuration (19-Sep-02 update): GSS HVA PN 8A01879J SN 001 has been removed and replaced with GSS FEU HVA PWA SN NFI001. Flight unit SN 001 has DR 429 open against it and thus is not suitable for use in this test. NFI001 has been tested and shown to be fully functional per P0829A (HVA board level test procedure); this test data has been attached to the P0918 package.

5.0 Test Schedule

Completion of the test will take approximately 3 days following initial calibration and certification of test equipment and confidence testing of the flight hardware.

6.0 Test Personnel

repeated here from P0918:

This test procedure is to be conducted only by the following personnel, or others designated by the GSS RE at the time of test (redline names in below as required)

6.1. William Bencze

6.2. Yoshimi Ohshima

6.3. David Hipkins

6.4. Rob Brumley

7.0 Data Transfer and Storage

Data collected during testing is recorded locally in the test equipment. After testing, data is copied to the GPB Server (\\GSS-SERVER\Release\drop_box\T003). This server receives regular backups. Additionally, test data will be archived on data CD.

8.0 Procedures

8.1. repeated here from P0918:

Document No.	Title	Release Status	Author
P0918	T003 Related Performance Verification Procedure for the Gyroscope Suspension System (GSS)	released	Yoshimi Ohshima
P0758	GSS GSE Electrical Test Procedure (ETP)	released	
P0749	Gyroscope Simulator Commissioning Procedure	released	
P0892	On-Board A/D AND D/A Converter Calibration Procedure for GSS Forward Suspension Units (FSU)	released	
P0772	Full Functional Test of ASU	released	
P0702	Full Functional Test of FSU	released	

8.2. Other Documents

Document No.	Title	Release Status	Author
S0703	Simulator inputs from box thermal vacuum testing for box temperature coefficients.	released	Bill Bencze

9.0

10.0 Software

repeated here from P0918 (section 12):

10.1. Flight Software:

GSW version 2.1.1.0.

10.2. Test Software

Software	**Author**	**Version / Version Control**
PitView software tools on the Testset computer	Yoshimi Ohshima	located in directory …/projects/gpbvx/hwQual/T003.]
MATLAB	Commercial Product	Release 12
Control Desk, dSPACE, Inc [simulator software]	Commercial Product	Version 3.2
Associated applications developed for the test (Control Desk applications)	Yoshimi Ohshima	

Software versions are documented in S0704 (SW VDD for GSS Performance Test)

Control Desk Applications	Development	**Author**
T003_mission_A1.cdx	completed ✓	Yoshimi Ohshima
T003_mission_A2.cdx	completed ✓	Yoshimi Ohshima
Fancy_analog.cdx	completed ✓	Yoshimi Ohshima

Data collection .m file and GUI package for data analysis (written in Matlab)	**Development**	**Author**
Save_simulation_data.m	completed ✓	Yoshimi Ohshima
T003Verification.m	completed ✓	Yoshimi Ohshima
Specver.m	completed ✓	Yoshimi Ohshima
T003ver.m	completed ✓	Yoshimi Ohshima
T003Ver_each.m	completed ✓	Yoshimi Ohshima
VerifySelected.m	completed ✓	Yoshimi Ohshima
MassageData.m	completed ✓	Yoshimi Ohshima
GSS_plot.m	completed ✓	Yoshimi Ohshima
RotX.m	completed ✓	Yoshimi Ohshima
RotY.m	completed ✓	Yoshimi Ohshima
RotZ.m	completed ✓	Yoshimi Ohshima
Set_chan.m	completed ✓	Yoshimi Ohshima
X2c.m	completed ✓	Yoshimi Ohshima
Var_def.m	completed ✓	Yoshimi Ohshima

GSW script files	**Development**	**Author**
Start.scp	completed ✓	Yoshimi Ohshima
T003InitialConfig.scp	completed ✓	Yoshimi Ohshima
AOD220levitation.scp	completed ✓	Yoshimi Ohshima

11.0 GSE Certification and Calibration

repeated here from P0918:

Item	**Certification Frequency**	**Procedure**
Spacecraft Emulator GSE	within the past 180 days or since the rack has been moved	P0758
gyroscope simulator facility	within the last 30 days	P0749
Full Functional Test of ASU	within the last 30 days	P0772
Full Functional Test of FSU	within the last 30 days	P0702

12.0 Requirements

T003 & PLSE 13	Title	T003 Requirement	GSS Requirement	P0918 ref.
T003 N/A PLSE 13 3.1.1.1	Description		The suspension Electronics shall suspend the science gyroscopes (except the gyroscope being used as a drag-free sensor) to keep them from contacting the internal surface of the gyro cavities. Ver: A	--
T003 2.2 PLSE 13 N/A	Voltage Applied to Electrodes	Definition: Si is the sum of the squares of the voltages applied to the opposite electrodes on the electrode axis designated by i. The two electrode axes which lie at 45 degrees to the satellite roll axis are designated by a and b, and the electrode axis which lies at 90 degrees to the satellite roll axis is designated as the c axis. The voltage on each electrode is defined relative to the voltage on the ground plane. The voltage applied to each electrode includes the control voltage used to keep the rotor centered, the voltage applied by the capacitive sensing bridge, and any voltage applied to measure the rotor potential.		--
T003 2.2.1 PLSE 13 3.4.2.1	Average value of Si on Any Axis	Given the acceleration for the GP-B mission, the value of Si averaged over one year along any one of the three electrode axes shall be less than 0.08 V^2.	Given the acceleration for the GP-B mission, the value of Si averaged over one year along any one of the three electrode axes shall be less than 0.08 volts^2. Ver. A, T	17.2
T003 2.2.2 PLSE 13 3.4.2.2	Difference between Si on Different Axes	Given the acceleration for the GP-B mission, the value of Si along the c electrode axis (perpendicular to the roll axis) averaged over one year shall be equal to the average value of Si along the a and b axes (the two axes which lie at 45 degrees to the spacecraft roll axis) to within 0.04 V^2.	Given the acceleration for the GP-B mission, the value of Si along the c electrode axis (perpendicular to the roll axis) averaged over one year shall be equal to the average value of Si along the a and b axes (the two axes which lie at 45 degrees to the spacecraft roll axis) to within 0.04 volts^2. Ver. A, T	17.2
T003 2.2.3 PLSE 13 N/A	Roll Frequency Variation in Mismatch of Si along Different Axes	Given the acceleration for the GP-B mission, the roll frequency variation in the mismatch of Si along the a and b electrode axes, averaged over one year, has the following requirements:		--
T003 2.2.3.1 PLSE 13 3.4.2.3.1	Roll Frequency Variation in Mismatch of Si along Different Axes	The roll frequency variation in the mismatch of Si along the a and b electrode axes, averaged over one year, shall be less than 1.7e-6 V^2.	The roll frequency variation in the mismatch of Si along the a and b electrode axes, averaged over one year, shall be less than 1.7e-6 volts^2. Ver. A, T	17.2
T003 2.2.3.2 PLSE 13 3.4.2.3.2	Random Variation in Roll Frequency Variation in Mismatch along Different Axes	The random variation in the mismatch of Si along the a and b electrode axes at roll frequency shall have a single-sided spectral density at roll and within a bandwidth of twice roll of 0.0016 V^2/rt(Hz).	The random variation in the mismatch of Si along the a and b electrode axes at roll frequency shall have a single-sided autospectral density at roll and within a bandwidth of twice roll of 0.0016volts^2/sqrt-Hz. Ver. A, T	17.2
T003 2.2.4 PLSE 13 3.4.2.4	Roll Frequency Variation in Si along Any Axis	Given the acceleration for the GP-B mission, the roll frequency variation in Si along any one of the three electrode axes shall be less than 1.7e-5 V^2 averaged over one year.	Given the acceleration for the GP-B mission, the roll frequency variation in Si along any one of the three electrode axes shall be less than 1.7e-5 volts^2 averaged over one year. Ver. A, T	17.2
T003 2.2.5 PLSE 13 3.4.2.5	Twice Roll Frequency Variation in Si along Axis	Given the acceleration for the GP-B mission, the twice roll frequency variation in Si along any of the three electrode axes shall be less than 0.05 V^2 averaged over one year.	Given the acceleration for the GP-B mission, the twice roll frequency variation in Si along any of the three electrode axes shall be less than 0.05 volts^2 averaged over one year. Ver. A, T	17.2

T003 & PLSE 13	Title	T003 Requirement	GSS Requirement	P0918 ref.
T003 2.3 PLSE 13 N/A	Rotor Centering Accuracy	The capacitive center is defined as the position at which the capacitance between the rotor and the two electrodes on the same axis are equal. Miscentering of the rotor is defined to be the displacement of the rotor from the capacitive center of the housing.		--
T003 2.3.1 PLSE 13 3.4.3.1	Random Rotor Miscentering	The autospectral density of the random miscentering within a band of (2/year) about roll frequency shall be less than 1.0 um/rt(Hz) single-sided on each electrode axis.	The autospectral density of the random miscentering within a band of (2/year) about roll frequency shall be less than 1.0 micrometer/sqrt-Hz single-sided on each electrode axis. Ver. A, T	17.2
T003 2.3.2 PLSE 13 N/A	Body-Fixed Miscentering	The DC (zero frequency) body fixed rotor miscentering has the following requirements:		--
T003 2.3.2.1 PLSE 13 3.4.3.2.1	Miscentering on Any Axis	The miscentering parallel to each of the electrode axes, averaged over any one month period, shall be less than 0.6 um.	The miscentering parallel to each of the electrode axes, averaged over any one month period, shall be less than 0.6 micrometers. Ver. A, T	17.2
T003 2.3.2.2 PLSE 13 3.4.3.2.2	Miscentering Parallel to the S/V Roll Axis	The miscentering parallel to the S/V Roll Axis, averaged over one year, shall be less than 0.6 um.	The miscentering parallel to the S/V Roll Axis, averaged over one year, shall be less than 0.6 micrometers. Ver. A, T	17.2
T003 2.3.3 PLSE 13 N/A	Sinusoidal Miscentering	Any sinusoidal rotor miscentering has the following requirements:		--
T003 2.3.3.1 PLSE 13 3.4.3.3.1	Sinusoidal Miscentering at Roll	Any sinusoidal rotor miscentering in a direction perpendicular to the S/V roll axis at roll frequency and within a band of 2/(1year) centered at roll frequency shall be less than 0.3 nm.	Any sinusoidal rotor miscentering in a direction perpendicular to the S/V roll axis at roll frequency and within a band of 2/(1year) centered at roll frequency shall be less than 0.3 nm. Ver. A, T	17.2
T003 2.3.3.2 PLSE 13 3.4.3.3.2	Sinusoidal Miscentering at Roll Modulated by Annual	Any sinusoidal miscentering in a direction perpendicular to the S/V roll axis at roll frequency modulated by annual shall be less than 1 nm.	Any sinusoidal miscentering in a direction perpendicular to the S/V roll axis at roll frequency modulated by annual shall be less than 1 nm. Ver. A, T	17.2
T003 2.3.3.3 PLSE 13 N/A	Sinusoidal Miscentering at Roll Modulated by Twice Orbital	Any sinusoidal rotor miscentering at roll modulated by twice orbital has the following requirements:		--
T003 2.3.3.3.1 PLSE 13 3.4.3.3.3.1	Sinusoidal Miscentering at Roll Modulated by Twice Orbital Parallel to Roll Axis	Any sinusoidal rotor miscentering at roll modulated by twice orbital in a direction parallel to the S/V roll axis shall be less than 25 nm.	Any sinusoidal rotor miscentering at roll modulated by twice orbital in a direction parallel to the S/V roll axis shall be less than 25 nm. Ver. A, T	17.2
T003 2.3.3.3.2 PLSE 13 3.4.3.3.3.2	Sinusoidal Miscentering at Roll Modulated by Twice Orbital Perpendicular to Roll Axis	Any sinusoidal rotor miscentering at roll modulated by twice orbital in a direction perpendicular to the S/V roll axis shall be less than 3 nm.	Any sinusoidal rotor miscentering at roll modulated by twice orbital in a direction perpendicular to the S/V roll axis shall be less than 3 nm. Ver. A, T	17.2
T003 2.4 PLSE 13 N/A	Rotor Potential Determination	The suspnesion system shall have the capability for determining the SG rotor potential with an accuracy sufficient for meeting the rotor potential requirement in section 2.5.	The suspension system shall have the capability for determining the SG rotor potential with an accuracy sufficient for meeting the rotor potential requirement in Section 2.5. Ver. A, T	--
T003 2.5.2 PLSE 13 N/A	Induced rotor Potential	The rotor potential induced by voltages applied to the electrodes from the suspension system shall be <= 0.015 V rms.	The rotor potential induced by voltages applied to the electrodes from the suspension system shall be<= 0.015 volts rms. Ver. : A	17.2
T003 N/A PLSE 13 3.4.15.1	Position command offset range		The gyroscope position shall be commandable to any position within a 10.0 um sphere about the capacitive center of the housing.	17.5

Additionally, data collected during this test support the GSS Box Specification requirements 3.4.14.3.5 to 3.8 (though these requirements are not fully verified by this testing alone).

Meeting Minutes / Action Item Closure Status

September 9th GSS Performance Verification TRR (HEPL conference room) :

12.1.1. Attendance:

Name	Org. / Function	**Email** (1) = @relgyro.Stanford.edu (2) = @lmco.com (3) = @msfc.nasa.gov
1. Bill Bencze	SU Elect. Mgr	bencze (1)
2. Bob Schultz	LM CSE	schultz (1)
3. Rich Whelan	LM SE	rwhelan (1)
4. Chris Koch	LM SE	chris.koch (2)
5. Ed Ingraham	MSFC Res. Mgr	ingraham (1)
6. Kelly Burlingham	SU SW QA	
7. Dorrene Ross	SU QA	dorrene (2)
8 Yashimi Oshima	SU Eng	yoshimi (1)
9 Anthony Logan	LM SE	alogan (1)
10Jeff Kolodziejczak	MSFC	Jeffery.Kolodziejczak (3)
11.Tim Krisher	MSFC	timothy.krisher (3)
12. Jim Looney	MSFC	James.Looney (3)
13. Brian Mulac	MSFC	Brian.Mulac (3)
14. Gray Settle	MSFC	Gray.Settle (3)
15. Ron Singley	SU Pgm Mgr	singley (1)

Action Items	Assignee	ECD	Comment
1. Release P0918	Bencze	9-9-2002	Rel 9/12/02
2. Release S0703	Bencze	9-11-2002	Rel 9/1/02
3. Release S0704	Bencze	9-11-2002	Complete; K. Burlingham requests withhold her sig until she verifies test configuration during execution of P0918
4. Compete Matlab M files not yet competed (section 9)	Yoshimi	9-11-2002	Complete 9/12/02
5. Add supplemental sheet to P0918 regarding hardware configuration (HVA board) and update S0702 TRR doc section 4.1 with HVA board data.	Bencze / Yoshimi	9-11-2002	P0829 run on PWA NFI001; Sec 4.1 updated to as-run config; supplemental data sheet added to P0918
6. How do we verify that the simulator covers the worst case? (data originates from Mac's S0269). Sdoc	Yoshimi		Not required for start of test.
7. How do we certify the results of this test considering that the software will be updated from 2.1.1.0 to 2.2 for flight.	Bencze		not required for TRR sign-off to test start.
8. When submitting T003 VLOAs, need to reference a new Sdoc that covers all realistic "what ifs" in addition to the explicit analysis of the P0918. Why is this test valid for the flight configuration and the expected on-orbit environments.	SE – T003 VLOAs; Bencze: Sdoc		not required for TRR sign-off to test start.
9. Send other referenced Pdocs (released P0749, P0772, P0702, P0758 + P0892) to Brian @MSFC	Bencze	9-10-2002	Done 9-9-2002