W. W. Hansen Experimental Physics Laboratory

STANFORD UNIVERSITY
STANFORD, CALIFORNIA 94305 - 4085

Gravity Probe B Relativity Mission

Phase B, C and D of Payload Verification Testing - Test Readiness Review Completion Certificate

GP-B P0512

June 11, 1999

Prepared by: M. R. Anderson **Date**
Systems Engineer

Approved by: John Janicki **Date**
Safety

Approved by: Dorrene Ross **Date**
Quality Assurance

Approved by: Mike Taber **Date**
GP-B Payload Systems Test Manager

Approved by: Ed Ingraham **Date**
ONR

Approved by: Bob Schultz **Date**
Chief Systems Engineer

Approved by: S. Buchman **Date**
Hardware Manager

Phases B, C and D of Payload Testing - Test Readiness Review

Date & Time: June 11, 1999, 9:00 to 11:00 A.M.
Location: HEPL conference room

Purpose:
To ensure that the test article hardware, test facility, ground support personnel, and test procedures are ready for testing, data acquisition, reduction, evaluation, and control.

Scope:
The Payload Phases B,C, and D Testing - Test Readiness Review (TRR) will encompass all Phase B, Phase C and Phase D Payload tests

Agenda:
- Test Flow – Phase B,C, and D Testing
- Test Procedure Status
- Test Resources Status
- Verification Matrix
- Test Support Software Status

Review Team:

Sasha Buchman	Hardware Manager
Bob Schultz	Chief Systems Engineer
Dorrene Ross	Quality Assurance
M. R. Anderson	Systems Engineer
Ed Ingraham	ONR
John Janicki	Safety
Mike Taber	GP-B Payload Systems Test Manager
Paul Ehrensberger	TRE Integrated Product Team Leader
Jim Lockhart	SRE Integrated Product Team Leader
Ted Acworth	AS3 Integrated Product Team Leader
Rob Brumley	DDC Integrated Product Team Leader
Dave Manner	GSS Integrated Product Team Leader
John Thatcher	ECU Integrated Product Team Leader

TRR Exit Criteria:

- All documents (specifications and interface control documents) have been approved and have proper traceability.
- The approved test procedures verify all applicable requirements.
- As-built vs. as-designed is documented.
- The test personnel have received training in test operations procedures.
- The resources are available to adequately support the planned tests as well as contingencies. The test equipment has proper calibration. The hardware buy-off team understands the objective of the test and the critical performance parameters.

- The test support software has been demonstrated to handle test configuration assignments, and data acquisition, reduction, evaluation, control, and archiving.

Attachments:

A. Test Flow – Phase B,C & D Testing
B. Test Procedure Status
C. Test Personnel Status
D. Test Resources Status
E. Verification Matrix
F. Test Support Software Status
G. Data Storage Requirements
H. Action Item Closure List (if applicable)

A. Test Flow

Phase B, C, and D Payload Testing

****notes****

- **Certain items such as flux flush & gyro suspension and slow spin were moved to phase A**
- **The sequence of testing to be performed in phases C and D may change depending on gyroscope testing order**

SCIT-01 Para.	*Test Case ID*	*Test Case or Operation Title*	*P. Document or Operation Number*	*Requirement Owner/Author*	*Procedure Writer*
		GSS / SRE EU Compatibility Test	**P – 0XXX**	**Rob Brumley**	**Rob Brumley**
8.2	**PLSYSPHSB**	**PHASE-B TEST SEGMENTS (Vertical/1.8 K)**			
8.5.4	PLGUARDTNKRSE	Un-vented Rate of Temperature Rise Using Guard Tank	**P - 0515**	**Mike Taber**	**Mike Taber**
		SM P/L Cryo Verif – Position P.L to Horizontal -X up	**P - 0517**	**Mike Taber**	**Dave Murray**
8.3	**PLSYSPHSB**	**PHASE-C TEST SEGMENTS (Horizontal [-X]/1.8 K)**			
8.3.1	PLSFTMP	Support Flange and Telescope Temperature	Perform Probe temperature measurements With 8mW of heat input from telescope		
		This is a 2 day, 24 hours per day test	**P – 0544**	**Dave Murray**	**Dave Meriwether**
8.3.2	PLSTA200TEMP	Station 200 Temperature Measurement Test	Verify temperature at station 200 <= 1.85K while bath is 1.8K)		
		This is a 2 day, 24 hours per day test	**P – 0545**	**Dave Murray**	**Dave Meriwether**
8.3.3	PLECUQBTMP	Quartz Block Temp Controller Functional Test (ECU)	Verify Quartz Block temperature controller operation.		
		This is a 2 day, 24 hours per day test	**P – 0546**	**Dave Murray**	**Dave Meriwether**
8.3.23	PLTREDET	TRE/Detector Bias Stability	Check TRE/Detector Bias stability		
			P – 0491	**Paul Ehrensberger**	**Bob Farley**
		Re-run TRE Local-Closed-Loop Temperature Control Test	**P-0488**	**Paul Ehrensberger**	**Bob Farley**

SCIT-01 Para.	Test Case ID	Test Case or Operation Title	P. Document or Operation Number	Requirement Owner/Author	Procedure Writer
8.3.4	PLSQUIDID	SQUID Bracket ID	Characterize the system dynamics for the SQUID bracket thermal control system		
		w/ GSE	**P – 0518**	**Jim Lockhart**	**Jie Li**
8.3.5	PLHPMFUN	Heat Pulse Meter Test	Measure helium mass using primary and redundant heat plate meters		
			P – 0548	**Dave Murray**	**Dave Meriwether**
8.3.6	PLFLMFUN	Flow Meter Test (52 hours total)	Measure helium flow rate using dewar flow meter		
		This is a 2 day, 4 hour, - 24 hours per day test	**P – 0549**	**Dave Murray**	**Dave Meriwether**
		Connect DDC A to Gyro #1	**P – 0481**	**Rob Brumley**	**Rob Brumley**
		Connect DDC B to Gyro #2	**P – 0481**	**Rob Brumley**	**Rob Brumley**
8.3.22	PLPRBVACSU	Leakage Rate Calibration	**P - 0519**	**Rob Brumley**	**Rob Brumley**
		(note: this is movable/ title changed from "Probe Pressure During Spin-up)			
		In parallel with the following Caging and Un-caging, Spin-up/Heater Set Point Determination (1 time test)			
8.3.20	PLDGMACAGE12	Cage Science Gyro #1 and Gyro #2	Cage gyros #1 and #2 and record final resting position		
			P - 0520	**Rob Brumley**	**Rob Brumley**
8.3.21	PLDUNCAGE12	Un-cage and Science Gyro #1 and Gyro #2	Un-cage and Levitation of gyros #1 and #2		
			P - 0521	**Rob Brumley**	**Rob Brumley**
		Levitate Science Gyros #1 and #2	**P – 0481**	**Rob Brumley**	**Rob Brumley**
8.4.2	PLGYR3LOSPIN	Gyro #**2** Low Spin Speed Test	Perform gyro #2 low spin speed (1-3 Hz) spin up.		
		This is a 2 day, 24 hours per day test	**P - 0516**	**Rob Brumley**	**Rob Brumley**
8.4.2	PLGYR3LOSPIN	Gyro #**1** Low Spin Speed Test	Perform gyro #1 low spin speed (1-3 Hz) spin up.		
		This is a 2 day, 24 hours per day test	**P - 0516**	**Rob Brumley**	**Rob Brumley**
		Install Exhaust Line	Connect exhaust line and leak check for flat spin test		
			P –0560	**Mike Taber**	**Mike Taber**

SCIT-01 Para.	Test Case ID	Test Case or Operation Title	P. Document or Operation Number	Requirement Owner/Author	Procedure Writer
		Fast Spin Speed Testing (24 hr. test day)	**P – 0522**	**Rob Brumley**	**Rob Brumley**
		This is a 2 day, 24 hours per day test			
8.3.20	PLDGMACAGE12	Cage Science Gyro #1 and Gyro #2	Cage gyros #1 and #2 and record final position		
			P – 0520	**Rob Brumley**	**Rob Brumley**
		Disconnect DDC A and B	**P – 0481**	**Rob Brumley**	**Rob Brumley**
		SM P/L Cryo Verif – Position P/L to Vertical	**P – 0523**	**Mike Taber**	**Dave Murray**
		SM P/L Cryo Verif - Refill and Recondition Main Tank	**P – 0217**	**Mike Taber**	**Dave Murray**
		This is a 3 day, 24 hours per day procedure			
		Rotate the SMD 90 degrees			
		SM P/L Cryo Verif – Position P/L to Horizontal -Y up	**P - 0524**	**Mike Taber**	**Dave Murray**
8.4	**PLSYSPHSD**	**PHASE-D TEST SEGMENTS (-Y]/1.8 K**			
		Connect DDC A to Gyro #3	**P – 0481**	**Rob Brumley**	**Rob Brumley**
		Connect DDC B to Gyro #4	**P – 0481**	**Rob Brumley**	**Rob Brumley**
8.4.13	PLGMACAGE34	Cage Science Gyros #3 and Gyros #4	Cage gyros #3 and #4 and record the final resting position		
			P – 0520	**Rob Brumley**	**Rob Brumley**
8.4.14	PLUNCAGE34	Un-cage Science Gyros #3 and Gyros #4	Un-cage of gyros #3 and #4		
			P - 0521	**Rob Brumley**	**Rob Brumley**
		Levitate Science Gyros #3 and #4	**P - 0481**	**Rob Brumley**	**Rob Brumley**
8.4.2	PLGYR3LOSPIN	Gyro #3 Low Spin Speed Test	Perform gyro #3 low spin speed (1-3 Hz) spin up.		
		This is a 2 day, 24 hours per day test	**P - 0516**	**Rob Brumley**	**Rob Brumley**
8.4.2	PLGYR3LOSPIN	Gyro #4 Low Spin Speed Test	Perform gyro #4 low spin speed (1-3 Hz) spin up.		
		This is a 2 day, 24 hours per day test	**P - 0516**	**Rob Brumley**	**Rob Brumley**

SCIT-01 Para.	Test Case ID	Test Case or Operation Title	P. Document or Operation Number	Requirement Owner/Author	Procedure Writer
		Fast Spin Speed Testing (24 hr. test day) ***(not needed if performed on Gyros 1 & 2)***		**Rob Brumley**	**Rob Brumley**
8.4.13	PLGMACAGE34	Cage Science Gyros #3 and Gyros #4	Cage science gyros #3 and #4		
			P – 0520	**Rob Brumley**	**Rob Brumley**
		Measure Final Gyro Position (Post final caging)			
		Disconnect DDC A and B	**P - 0481**	**Rob Brumley**	**Rob Brumley**
8.4.15	PLVACBKOUT	Ultra-High Vacuum Bake-out	Perform an ultra-high vacuum bake-out of the SGs following spin-up		
		This is a 2 day, 24 hours per day test	**P – 0547**	**Mike Taber**	**Dave Meriwether**
		Install SRE FEU		**Bob Ajitomi**	
		FEU SRE integration (replaces EU SRE)			
8.4.16	PLSQUIDBRKTMP	SQUID Bracket Temperature Control SQUID Bias Temperature Coefficient Procedure	**P - 0535**	**Barry Muhlfelder**	**Barry Muhlfelder**
		TRE Temperature Stability Test (to ver1ify) 3.7.1.9.3)	**P – 0XXX**	**Paul Ehrensberger**	**Paul Ehrensberger**
8.4.17	PLSYSSQDNSE	SQUID Noise Measurement/AC Magnetic Field Attenuation Measurement			
		This test is 12 contiguous hours	**P – 0526**	**Jim Lockhart**	**Barry Muhfelder**
		Possible GSS/SRE TEST			
		Possible Payload EMC Self Compatibility Test			
		SM P/L Cryo Verif – Position P/L to Vertical	**P – 0523**	**Mike Taber**	**Dave Murray**
		SM P/L Cryo Verif – Return to NBP and refill Main Tank	**P – 0216**	**Mike Taber**	**Dave Murray**
		This is a 3 day, 24 hours per day procedure			
SCIT-01 Para.	***Test Case ID***	***Test Case or Operation Title***	***P. Document or Operation Number***	***Requirement Owner/Author***	***Procedure Writer***

			SMD Pressurization of Main Tank from Sub-atmospheric to Normal Boiling Point		
			P – 0421		
			SMD NBP Fill with pre-cool from Guard Tank & Well evacuated		
		PAYLOAD ACCEPTANCE REVIEW			

B. Procedure Status

**** note** All procedures shall be written, approved and signed prior to execution**

Phase B,C, and D Payload Test - Procedures

P. Doc Number	Revision Date	Author	Title	Detailed	Written	Approval Status
			PHASE B Procedures			
P0572		Rob Brumley	GSS / SRE EU Compatibility Test	✓		
P0515		Mike Taber	Un-vented Rate of Temperature Rise Using Guard Tank	✓		
P0517		Dave Murray	SM P/L Cryo Verif – Position P/L to Horizontal –X up	✓	✓	✓
			PHASE C Procedures			
P0544		D. Meriwether	Support Flange Temperature	✓		
P0545		D. Meriwether	Station 200 Temperature Measurement Test	✓		
P0546		D. Meriwether	Quartz Block Temp Controller Functional Test	✓		
P0491		Bob Farley	TRE/Detector Bias Stability	✓		
P0518		Jie Li	SQUID Bracket ID Procedure	✓		
P0548		D. Meriwether	Heat Pulse Meter Test	✓		
P0549		D. Meriwether	Flow Meter Test	✓		
P0519		R. Brumley	Leakage Rate Calibration Procedure	✓		
P0520		D. Bardas	Cage Science Procedure	✓		
P0521		D. Bardas	Un-cage Science Gyro Procedure	✓		
P0516		R. Brumley	Gyro Slow Spin Testing Procedure	✓		
P0560		M. Taber	Install Exhaust Line	✓		
P0522		R. Brumley	Gyro Fast Spin Speed Testing Procedure	✓		
P0523		D. Murray	Return P/L to Vertical Procedure	✓		
P0217		D. Murray	SMD Main Tank Sub-atmospheric Fill	✓	✓	✓
P0524		D. Murray	Rotate Payload and Position to Horizontal (–Y up) Procedure	✓		
			PHASE D Procedures			
P0547		D. Meriwether	Ultra-High Vacuum Bake-out	✓		
P0535		B. Muhlfelder	SQUID Bias Temperature Coefficient Procedure	✓	✓	
P0573		P. Ehrensberger	TRE Temperature Stability Test Procedure	✓		
P0526		B. Muhlfelder	SQUID Noise and AC Magnetic Shielding Factor Measurement Procedure	✓	✓	
P0216		D. Murray	SMD Pressurization of Main Tank from Sub-atmospheric to Normal Boiling Point	✓	✓	✓
P0574		B. Muhlfelder	Payload EMC Self-compatibility Test Procedure	✓		

C. Test Personnel Status

Test Conductor / QA

The Test Manager is Mike Taber or designee

The Test Director is the Responsible Engineer for the system being tested

The QA person is Dorrene Ross or designee

The Safety Person is John Janicki or designee

The Requirement Owners and Procedure Writers are the Test Personnel for each step in Payload Verification (see section B).

D. Test Resources Status

Instrumentation, Test Equipment Certification and Facility Requirements are documented in the individual procedures.

E. Verification Matrix (Includes Phase A, B, C & D Test Procedures)

Requirements in PLSE-12

Phase	#	Title	Requirement	Mtd	Verification Plan	REE
	3.2.5.1	Assembly and Test Environments	1) External thermal 180 K to 333 K;2) External contamination class 100,000 Exposure to temperatures above 313 K (40 °C) shall be pre-approved by Stanford.	I		
	3.2.5.2	Transportation Environments	1) External thermal 180 K to 333 K; 2) External contamination open-air exposure near seashore; 3) Loads 2 g axial and 3 g lateral (applied simultaneously) Exposure to temperatures above 313 K (40 °C) shall be pre-approved by Stanford. *Requirement #3 is taken from Space Technology Structural Design Criteria, LMMS D887697.*	I		
	3.2.5.3	Storage Environments	1) Thermal uncontrolled warehouse; 2) External contamination normal warehouse environment Exposure to temperatures above 313 K (40 °C) shall be pre-approved by Stanford.	I		
	3.2.5.4	Launch Vehicle Integration Environments	1) Vandenberg Air Force Base (AFB) Spacecraft Laboratory, Bldg. 836a) Thermal 15.5 to 32.2 °C ± 1.2 °C (60 to 80 ± 2 °F); b) External contamination class 100,000; 2) Launch pad mobile service tower a) Thermal 29 ± 2.8 ° C (75 ± 5° F); b) Relative humidity 30 to 50%; c) External contamination Filtration of 99.97% of particles >= 0.3 µm3) Launch vehicle fairing a) Thermal 15.5 to 32.2 °C ± 1.2 °C (60 to 80 ± 2 °F); b) Relative humidity 30 to 50%; c) External contamination Filtration of 99.97% of particles >= 0.3 µm; Dry nitrogen purge is available; General room cleanliness - class 10,000 *The launch site environments have been updated to reflect the October 1993 version of the Delta II Payload Planners Guide, MDAC H3224C, Section 4*	I		

Phase	#	Title	Requirement	Mtd	Verification Plan	REE
	3.2.5.5.1	Launch Loads	The load factors for the primary structure are given below:All Except Sunshade (Lateral) ± 2.5g Sunshade (Lateral) ± 20.0g All (Axial) 6.2 ± 0.6Secondary structures design load factors are given by the SSD secondary structure loads curve below, taken from EM 310A/P030739A. Secondary structures include all hardware not in the primary load path,such as plumbing, valves, electronics boxes, connectors, burst discs, etc. *Preliminary launch and ascent coupled loads analyses were conducted by Swales and Associates, Inc , and documented in SAI-ANYS-133, "Gravity Probe-B LTM Responses for Delta-II Liftoff and Air Loads", by Kevin Brenneman, Swales, Inc, 29 Sep 94. A pre-MECO coupled loads analysis was done by MDAC, and documented in A3-L214-LEAL-DELTA-95-041, "Gravity Probe-B/Delta II 9720-10 Second Pre-MECO Dynamic Analysis", by M.L. Stucki, MDAC, 19 May 95. These results were given more conservatism in LMMS document GPB-100526. Reference PCB #28A. LMMS document GPB-100526 updates EM 310 A.*	A	*To be performed during space vehicle acceptance*	
	3.7.1.3.2	Magnetic Requirements		N/A		
B	3.7.1.3.2.1	Steady State Field	The residual field contributed by the SIA to the total residual magnetic field at the Science Gyroscopes shall be consistent with 3.2.1.3.1	A,T	Flux Flush PLGYRFLXMEAS (P0543) *(PCB #362 changes to 3.2.1.3.1)*	
B	3.7.1.3.2.2	Attenuation Factor	The SIA shall provide an attenuation consistent with the requirement of 3.2.1.3.2.	A,T	Squid Noise Test PLSYSSQDNSE (P0526)	
	3.7.1.3.2.3	Magnetic Noise from Conducting Loops	No metallic loop circuits having an enclosed area greater than or equal to 10 cm^2 shall be permitted in Magnetic Zones 1 or 2. Exceptions to this requirement are allowed if reviewed and approved by the Magnetics Committee.	I		
	3.7.1.3.3	Vacuum Requirements		N/A		
C	3.7.1.3.3.1	Vacuum During Spin Up	The SIA shall be capable of spinning up the gyroscope assuming the limitations given in Section 3.2.1.2.1.	T,S	Gyro Fast Speed Spin Test (P0522)	R. Brumley
D	3.7.1.3.3.2	Vacuum After Spin Up and Bakeout	After spin up and low-temperature bakeout, the SIA shall be compatible with the vacuum required in Section 3.2.1.2.2.	T	Ultra-high Vacuum Bakeout PLVACBKOUT (P0547)	M. Taber

Phase	#	Title	Requirement	Mtd	Verification Plan	REE
C	3.7.1.4.8.2	Spin-Up Exhaust Line Gas Conduction	The pressure drop along the spin-up exhaust plumbing line assembly from its interface with the gyroscope to its interface with the probe shall be <= 40 Pa assuming the pressure of 60 Pa at the SIA/probe interface (Section 3.7.2.3.6), the flow rate given in Section 3.2.1.7.1 of He-4 or He-3, and a temperature of <= 7 K. *Flow rate given in Section 3.2.1.7.1: 950 scc/min.*	A	Done in design process – see EM GPB100248	R. Brumley
	3.7.1.6.2.1.4	Linear Range	The linear range and linearity shall meet the requirements of paragraph 7.2.3 in T003.	A	*Analysis*	Mac Keiser
	3.7.1.7.1.2.4	Thermal Interfaces	The operating temperature of each SQUID Package is maintained as specified in Sections 3.7.1.7.2.1.6.4 and 3.7.1.7.2.1.6.5 by an active thermal control system that uses a GRT and a heater mounted on each SQUID Bracket. The Probe maintains a temperature at the mounting as specified in Section 3.7.2.5. The total power delivered to the SQUID Bracket does not exceed that specified in 3.7.2.5.7	N/A	PCB 363	
?	3.7.1.7.2.1.3.1	Harmonic Distortion	The harmonic distortion of the SQUID operating with flux-locked-loop electronics having a disturbance rejection of 100-200 for a 1 kHz signal with an amplitude of 2 flux quanta shall be less than 10^-4.	T	Squid acceptance package	B. Muhlfelder
?	3.7.1.7.2.1.4.2	SQUID Bias Temperature Coefficient	The SQUID shall have a bias temperature coefficient of less than 0.01 flux quanta/K over the temperature range 2.7 K - 3K	T	Squid acceptance package	B. Muhlfelder
A	3.7.1.7.2.1.7	Damping of Cable to Package Joint	The decay time of the SQUID Package Input circuit and Cable to package joint shall be less than 1% in 10 min.	T	Pickup Loop to SQUID Coupling functional test PLSQUIDCPL (P0510)	B. Muhlfelder
A	3.7.1.7.2.1.12	SQUID Bias Current	The SQUID sensor shall have a bias current between 20 microampere and 60 microampere.	T	Squid acceptance package	B. Muhlfelder
?	3.7.1.7.2.1.17	Flux Slipping	It shall be possible to slip a flux quantum in the SQUID loop with a measurement error of less than 1 part in 10^5.	T	Squid acceptance package	B. Muhlfelder
A	3.7.1.9.3	Platform Temperature Variation at Roll Frequency	The DMA platform temperature variation shall be less than or equal to 2 mK (as defined in T003, 7.6.2).	A,T	Telescope Detector Mount Assembly Temperature Control PLTREDMATEMP (P0488) *(in cogitation…)*	P. Ehrensberger

Phase	#	Title	Requirement	Mtd	Verification Plan	REE
C	3.2.1.7.1	Final Gyroscope Angular Velocity	The science gyroscopes shall be capable of being spun up to 80-180 Hz using pressurized helium gas at a mass flow rate <= 2.8 mg/s of He4 or <= 2.1 mg/s of He3 (both equivalent to 950 scc/m) supplied to the input of each gyroscope spin-up channel. Further, the above required spin speed shall be achieved with a total helium mass per gyro of < 26.5 g for He4 or < 19.9 g for He3. (equivalent to 950 scc/m for 158 min)	A, T, S	Gyro acceptance package	R. Brumley R. Brumley
	3.7.2.3.3	Gas Flow Rate	The flow rate of the spin-up gas at the interface shall be as per 3.2.1.7.1.	A		
C	3.7.2.3.4	Gas Pressure	The helium gas flow impedance of the probe and SIA shall be such that the spinup inlet gas pressure at the top hat interface shall not exceed 4.0 x 10^4 Pa (300 torr) for the spin-up gas flow rate specified in 3.2.1.7.1.	T	Gyro Fast Speed Spin Test (P0522)	R. Brumley
C	3.7.2.3.5	Gas Temperature	The temperature at temperature sensor of the spin-up gas filter assembly at the inlet interface shall be adjustable over the range of 4- 12 K and stable to ±0.25 K.	T	Gyro Fast Spin Speed Test (P0522) Gyro Slow Spin Speed Test (P0516)	R. Brumley R. Brumley
	3.7.2.3.6	Exhaust Line Pressure Drop	The pressure drop of the exhaust line from the probe/SIA interface to free space shall be <= 60 Pa (0.45 torr) at a flow rate per 3.7.2.3.3 for a gas temperature range of 5 - 7 K.	A		
	3.7.2.3.7	Gas Leakage Into the Probe	The rate of spin-up gas leakage from the gyroscope into the probe interior shall be as per 3.2.1.2.1.	A,T	Gyro Fast Speed Spin Test (P0522)	R. Brumley
C	3.7.2.3.8	Pressure at the SIA During Spin-up	The pressure within the probe at the SIA shall be as per 3.2.1.2.1 for a gas leakage rate as per 3.2.1.2.1.	A,T	Leakage Rate Calibration PLPRBVACSU (P0519) Gyro Fast Speed Spin Test (P0522)	R. Brumley R. Brumley
C	3.7.2.4.5.1	Engagement	The caging mechanism shall be completely engaged in <= 30 minutes from the beginning of pressurization for all pressures in the range specified in 3.7.2.4.3.	T	Gyro Caging Procedure (P520)	R. Brumley
C	3.7.2.4.5.2	Release	The caging mechanism shall be completely disengaged in <= 30 minutes from the beginning of the release of the pressure.	T	Gyro Un-Caging Procedure (P0521)	R. Brumley
C	3.7.2.5.1.1	Support Flange Temperature	The temperature of the Quartz Block Support (QBS) fingers shall meet the requirement specified in 12.8 of T003.	A,T	Support Flange Temperature PLSFTMP (P0544)	M. Taber

Phase	#	Title	Requirement	Mtd	Verification Plan	REE
C	3.7.2.5.1.2	Support Flange Temperature Stability	The temperature of the QBS fingers shall meet the requirement specified in 12.8 of T003	A,T	Support Flange Temperature PLSFTMP (P0544)	M. Taber
C	3.7.2.5.1.3	SQUID Attachment Point Temperature	The temperature of each SQUID platform's attachment points shall meet the requirements specified in 12.8 of T003.	A,T	Support Flange Temperature PLSFTMP (P0544)	M. Taber
C	3.7.2.5.2.1	SQUID Temperature	The temperature of the SQUID packages shall be <= 3.3 K.	T	Support Flange Temperature PLSFTMP (P0544)	M. Taber
C	3.7.2.5.2.2	Extrusion Temperature	The temperature of the birdcage extrusions at the location of the probe suspension and SQUID cable cold-end connectors shall be <= 3.3 K.	A,T	Support Flange Temperature PLSFTMP (P0544)	M. Taber
C	3.7.2.5.2.3	Gyroscope/ Jumper Wire Interface Temperature	The temperature of the jumper wire connector at the science gyroscope shall be <= 3.3 K.	A	Support Flange Temperature PLSFTMP (P0544)	M. Taber
C	3.7.2.5.3	Support Flange Thermal Resistance	The thermal resistance of the SIA/support flange shall be <= 200 K/watt at a temperature of 2 K.	A,T	Station 200 Temperature Measurement Test PLSTA200TEMP (P0545)	M. Taber
C	3.7.2.5.6	Radiation Heat Input to the SIA	The radiation heat load into the SIA during normal operation shall be <= 0.25 mW.	A,T	Station 200 Temperature Measurement Test PLSTA200TEMP (P0545)	M. Taber
various phases	3.7.2.5.7	Heat Power into QBS	The maximum heat power into the QBS will not exceed the values given in the following while Science Data is being collected. (note: actual requirements are listed in 3.7.2.5.7.1 – 3.7.2.5.7.7) Item # of items Power(mW)/item Power (mw) SQUID Bracket Assy 2 0.250 0.500 QB GRTs (lot) 1 0.001 0.001 SDs (lot) not used 1 0.000 0.000 Thermal radiation on QB 1 0.250 0.250 Gyroscope Assemblies 4 0.001 0.004 Telescope DPA (2 ea DMAs) 2 3.000 6.000 QBS heater 1 2.000 2.000 TOTAL 8.755			

Phase	#	Title	Requirement	Mtd	Verification Plan	REE
	3.7.2.5.7.1	QBS Heat Power from SQUID Bracket Assembly	The maximum heat power into the QBS shall not exceed the values given in the following while Science Data is being collected. Item # of items Power(mW)/item Power (mw) SQUID Bracket Assy 2 0.250 0.500	T	PLSQUIDBRKTEMP (P0535)	
	3.7.2.5.7.2	QBS Heat Power from QB GRTs (lot)	The maximum heat power into the QBS shall not exceed the values given in the following while Science Data is being collected. Item # of items Power(mW)/item Power (mw) QB GRTs (lot) 1 0.001 0.001	A		John Thatcher
	3.7.2.5.7.3	QBS Heat Power from SDs (lot) not used	The maximum heat power into the QBS shall not exceed the values given in the following while Science Data is being collected. Item # of items Power(mW)/item Power (mw) SDs (lot) not used 1 0.000 0.000	A		
	3.7.2.5.7.4	QBS Heat Power from Thermal radiation on QB	The maximum heat power into the QBS shall not exceed the values given in the following while Science Data is being collected. Item # of items Power(mW)/item Power (mw) Thermal radiation on QB 1 0.250 0.250	A		
	3.7.2.5.7.5	QBS Heat Power from Gyroscope Assemblies	The maximum heat power into the QBS shall not exceed the values given in the following while Science Data is being collected. Item # of items Power(mW)/item Power (mw) Gyroscope Assemblies 4 0.001 0.004	A		
	3.7.2.5.7.6	QBS Heat Power from Telescope DPA	The maximum heat power into the QBS shall not exceed the values given in the following while Science Data is being collected. Item # of items Power(mW)/item Power (mw) Telescope DPA (2 ea DMAs) 2 3.000 6.000	T	PLTREDMATMP (P0488)	
	3.7.2.5.7.7	QBS Heat Power from QBS heater	The maximum heat power into the QBS shall not exceed the values given in the following while Science Data is being collected. Item # of items Power(mW)/item Power (mw) QBS heater 1 2.000 2.000	T	PLECUQBTMP (P0546)	

Phase	#	Title	Requirement	Mtd	Verification Plan	REE
D	3.7.2.5.8	Low Temperature Bake-Out of the SIA	During the special operation of low temperature bake-out, it shall be possible to raise the temperature of a sufficiently large (90%) area of the SIA to >= 6 K, by heating the QBS, without raising the temperature of any part of the lead bag above the temperature specified in 3.7.5.5.7.	A, T	Ultra-high Vacuum Bakeout PLVACBKOUT (P0547)	M. Taber
B	3.7.2.5.9	Flux Flushing of the SIA	During the special operation of flux-flushing, it shall be possible to raise the temperature of the SIA (exclusive of the telescope) to >= 12K in <= 12 hours, by heating the QBS, without raising the temperature of any part of the lead bag above the temperature specified in 3.7.5.5.7.	A,T	Final Flux PLGYROFLXFLSH Final Flux Flush (P0542) PLGYRFLXMEAS (P0543)	M. Taber
B	3.7.2.6.1	DC Magnetic Field	The steady state magnetic field shall be as specified in 3.2.1.3.1.	A,T	Flux Flush PLGYRFLXMEAS (P0543)	M. Taber
C	3.7.3.5.1	Vacuum During Spin-up	The probe shall be designed to achieve the vacuum requirements of 3.2.1.2.1.	T	Leakage Rate Calibration PLPRBVACSU (P0519)	R. Brumley
D	3.7.3.5.2	Vacuum at End of Low Temperature Bakeout	The probe shall provide the capability to reach <= 1.3 x 10-5 Pa (1 x 10-7 torr) after 4-12 hours of pumping during the low-temperature bakeout before temperature is reduced. This capability will be verified on the ground by measuring the partial pressure of helium at the pressure sensing device located at the top of the Quartz Block pressure sensing line.	T	Ultra-high Vacuum Bakeout PLVACBKOUT (P0547)	M. Taber
A	3.7.3.7.3	Optical System Transmissibility	The probe optical system shall meet the transmission band requirements of 3.2.1.5.3.1 and the following requirements.	A,T	Science Payload Test PLTELTRANS (P0503)	T. Acworth/P. Ehrensberger
A	3.7.4.2.1	Top Hat to Top Plate Resistance	The resistance across the interface between the probe top hat and the top plate of the dewar vacuum shell shall be <= 10 mohms.	T	Science Payload Test PLTHTPRES (P0507)	M. Taber
C	3.7.5.11.1	Heat Pulse Meter	A heat pulse meter shall be provided for measuring the residual superfluid helium in the main tank while in orbit, to within ± 5% of its true value. *(Verify that we can see the result of the heat pulse…)*	T	Heat Pulse Meter Test PLHPMFUN (P0548)	M. Taber *(Dave Frank's calc's…)*
C	3.7.5.11.2	Flow Meter	A flow meter shall be provided for measuring the helium flow rate to the spacecraft thrusters while in orbit, to within ± 5% of its true value.	A, T, I	Flow Meter Test PLFLMFUN (P0549)	M. Taber

Requirements in T-002

Phase	#	Title	Requirement	Mtd	Verification Plan	REE
	5.	Science Gyroscope Readout	The SG readout system shall have a linearity consistent with an error of less than 0.3 marcsec/year. The gyroscope readout system single-sided noise spectral density at a roll period of 3 minutes or less and a spin speed of 130 Hz shall be less than 190 marcsec/sqrt(Hz) (corresponding to a 10 hour integration time to resolve a 1 marcsec angle).	T, A	Harmonic Distortion Test? (linearity) SQUID Noise Measurement Test PLSYSSQDNSE (noise) (P0526)	B . Muhlfelder
	6.	Science Gyroscope Spinup and Alignment	The Science Gyroscope rotors shall be spun up to a speed in the range 80 to 180 Hz. After spin up, the spin axes of the gyroscopes shall be aligned in a specified direction with respect to the line of sight to the guide star with an accuracy better than 10 arcsec maximum.	T, A	Gyro High Speed Spin Test (spin speed) (P0522)	R. Brumley Bill Bencze
	7.	Science Telescope (ST)	After appropriate filtering and calibration, the ST's (and accompanying electronics') resolution error and deviation from linearity shall not exceed 3.0 marcsec within the central range of ±60 marcsecs and shall be stable to 0.1 marcsec. The noise properties and biases shall be consistent with the requirements stated in requirement 8A below.	A		M. Keiser
	8.	Pointing	A. Guide Star Valid (GV): The total pointing error shall be such that the optical image of the reference star remains within the linear range of the ST as specified in requirement 7 and such that any errors in the SGs are consistent with total measurement error as specified in requirement 2. B. Guide Star Invalid (GI): The Pointing System shall keep the ST directed within the reacquisition range of the telescope and pointing control systems.	A		J. Kirchenbau m

Phase	#	Title	Requirement	Mtd	Verification Plan	REE
	10.	Bias Rejection	The joint effects of all bias drifts, including electronic, magnetic, optical, thermal, and mechanical, on the SG and ST readouts and on the science-data instrumentation and data reduction systems shall be reduced to less than 0.15 marcsec/year when referenced to inertial space.	A		Mac Keiser

Requirements in T-003

Phase	#	Title	Requirement	Mtd	Verification Plan	REE
B	1.5	Trapped Flux	The trapped magnetic flux in the gyro rotor shall correspond to an average magnetic field of less than 3e-6 Gauss. This will be verified with an analysis of the readout magnitude during ground gyroscope operation.	T	Flux Flush PLGYRFLXMEAS (P0543)	M. Taber
	2.7	Suspension Electrical Interference	The suspension system electromagnetic interference coupled to the SQUID readout system under science data acquisition conditions shall not cause violation of the readout resolution and noise requirements of section 3 and document T002, #2 and #5. This will be verified in ground test by operating the suspension bridge and control effort at science mission levels.	A,T	Payload EMI/EMC Self-Compatifility Test PLEMIEMCSLF (P0XXX –not yet assigned – 9/6/99) (to be performed at Space Vehicle level)	B. Muhlfelder
D	3.2.2	Noise	The gyroscope readout system single-sided noise spectral density at the roll frequency shall be less than 190 marcsec/sqrt-Hz (corresponding to a 10 hour integration time to resolve a 1 marcsec angle) for roll period of 3 minutes or less and gyroscope spin speed >=130Hz.	A,T	SQUID Noise Measurement Test PLSYSSQDNSE (P0526)	B. Muhlfelder
D	3.4	Temperature Control	The readout SQUIDs shall be maintained at their nominal operating temperatures between 2.5K and 3.1K with (a) a stability of 5 micro-Kelvin rms over a 3 mHz frequency band centered on roll frequency, (b) a long-term drift averaged over 1 year of <=30 mK/year, and (c) a long-term stability of 30mK rms within a 1 Hz bandwidth, while Science Data is collected.	A,T,S	SQUID Bracket Temperature Control Procedure PLSQUIDBRKTMP (P0526)	J. Lockhart

Phase	#	Title	Requirement	Mtd	Verification Plan	REE
C	3.7	Signal Processing – Measurement of Changes in the R/O Sys.Scale Factor Using Flux Quantum in the SQU	The Readout System shall have the capability of measuring changes in the scale factor to an accuracy of better than 1e-5 using the flux quantum in the SQUID.	A,T	Support Flange Temperature PLSFTMP (P0544)	M. Taber
D	6.	Science Gyroscopes – Evacuation. (U)	Ultrahigh vacuum bakeout of the SGs shall be performed after spinup to achieve an effective pressure between the SG rotors and the housings of not more than 1.3 e-9 Pa (1e-11 Torr). *This low pressure is required to reduce the spindown rate and maintain low torque on the gyroscopes due to gas pressure (keeping the differential damping induced drift below 0.001 marcsec/year).*	T	Ultra-High Vacuum Bakeout PLVACBKOUT (P0547)	M. Taber
	7.2.3	Linear Range	The fused quartz ST shall meet the linear range and error requirements of T002, Reqmt 7.	A		Mac Keiser
	7.4.1	Scale Factor Calibration	After initial ground calibration, the scale factor shall be known to within 20%.	A		P. Ehrensberger
B	8.2	Steady State Field	The total steady state field at the SGs shall be less than 3 e-10 T (3 e-6 Gauss).	T	Flux Flush PLGYRFLXMEAS (P0543)	M. Taber
D	8.3	Attenuation	The magnetic shielding factor against variations in the external field at roll frequency shall be 1 e-12 or less.	S	SQUID Noise Measurement Test PLSYSSQDNSE (P0526)	B. Muhlfelder
	8.4	External Field	The variable (in body coordinates) instantaneous magnetic field generated by the spacecraft at the nominal position of the opening of the lead bag (in the absence of the lead bag and cryoperm shield) shall not exceed 1 e-5 T (0.1 Gauss) in addition to the Earth's field in any direction and under any operating condition.	A		S/C Guys
D	12.3.1	Vacuum	The probe shall satisfy the vacuum requirements delineated in sections 6.	T	Ultra-High Vacuum Bakeout PLVACBKOUT (P0547)	M. Taber
A	12.7	Heaters	The probe shall support heaters for magnetic flux flushing of the SGs (to meet the magnetic requirements), for low temperature bakeout of the QBA (to meet the gyroscope vacuum requirements), and for evaporation of gas condensation on the windows.	T	Science Payload Test PLECUPRBCHEAT (P0540)	M. Taber

Phase	#	Title	Requirement	Mtd	Verification Plan	REE
D	12.8	Thermal Requirements	The probe has a thermal design consistent with the Dewar lifetime requirement (Section 13). During on-orbit operation when the heat power in the QBS meets the requirements in 3.7.2.4.7 of PLSE-12, the probe thermal design shall (a) provide a temperature of the QBS fingers of <= 3.0K with the capability of being maintained with a stability of 1.0 mK rms in a 100 mHz bandwidth and with a stability of 0.2 mK in a 3 mHz bandwidth centered on roll frequency, and it shall (b) provide a temperature at the SQUID bracket attachment point of <= 3.0 K.	A,T	SQUID Bracket Temperature Control PLSQUIDBRKTMP (P0535)	J. Lockhart
C	12.9	Spinup	The probe supports a spinup system supplying each SG with low-temperature helium gas. Spinup gas leakage out of the channel shall be vented by a common line through the neck tube at a rate ensuring that the pressure between the SGs and the housing does not exceed 7.1 e-2 Pa (5.7 e-4 Torr). A gate valve on the front of the probe is opened during spinup to vent to space the residual gas leaking into the probe. During launch and measurement of Science Data the gate valve is closed.	A,T	Gyro Slow Spin Speed Test Procedure PLGYR3LOSPIN (P0516)	R. Brumley
SV	16.5	Payload Absolute Time Standard	The GPS PPS signal and the associated GPS time from the corresponding GPS solution shall be the standard for absolute time for the Payload. *Note: The GPS system will determine on board the GPS Time of the PPS pulse to an accuracy and precision of less than 500 ns each time a GPS solution is obtained. Post processing on the ground is expected to provide the GPS Time of each GPS PPS pulse to an accuracy and precision of less than 100 ns.*	I		S/C Guys

F. Test Support Software Status

Specific Test Support Software is identified in each individual Procedure

- **One copy filed on the Payload Server**
- **One copy filed with Mae Sato**

G. Data Storage Requirements

G.1 Electronic Data Storage

Payload Verification data archival has been configured on the Payload Server and fully tested. Directories have been established for each functional area, user groups defined and backup schemes implemented. Program management direction has been to store ALL test data on the Payload Server. The data will be mirrored to two separate disks, and a daily tape backup shall be created of the data. Every Friday a full backup will be performed. In addition, two duplicate weekly tapes will be made, one stored on site, and the other stored remotely.

Directories have been established for each functional area (see attached excel spreadsheet), and only group owners and group members have read/write/execute/delete privileges for their respective directory (and any subsequently created sub-directories).

The only remaining task for data archival will be to install two new ethernet switches to accommodate all payload verification activities within the FIST OPs Lab. The following number of ethernet drops will be available (all at 10 Mbps access to the payload server):

DDC Sun w/s	**4 drops**
DDCs	**4 drops**
ECU Test Set	**1 drop**
SRE racks	**1 drop**
AS3 computer rack	**1 drop**
AS3 laptop (or equivalent)	**1 drop**
TRE GSE rack	**1 drop**
Cryogenic ops	**13 drops**

(all existing drops will remain available as configured)

	Cryogenic	**ECU**	**gas_vac**	**gyroscope**	**SQUID**	**telescope**
Directory Name	cryogenic	ecu	gas_vac	gyroscope	squid	telescope
Group Name	cryogen	ecu	gas_vac	gyro	squid	scope
Directory Owner	murray	root	taber	brums	jim	paule
Group Members	taber	root	doron	brums	barry	paule
	murray	anderson	taber	benzce	jim	farley
	anderson	jeff	jeff	jeff	jeff	acworth
	jeff	davem	anderson	anderson	anderson	jeff
			murray			anderson
Subdirectories	/data					
	/grdops					
	/simdata					

IP address change needed on FIST Ops database
10 Mbps pipes for each port
Only the Owner and Group members can read or write data to a directory

G.2 Paper Storage

Payload Verification Paper Archival Plan:

1) (Original copy) All P-Docs containing Payload Test Procedures have the annotation (PTP) at the start of their titles

2) (Original copy) All (PTP) signed originals will be stored in Mae Sato's files

3) (Working copy) The working copy of each PTP will be stored in binders in the FIST Ops Laboratory. These copies marked with signature blocks, QA stamps, data recording, and/or red-lines.

4) At the completion of each Procedure, System Engineering will make two copies of the Working copy:
- **(Library copy) Working copy will become the Library copy and will be stored in the Systems Engineering office**
- **(Archive copy) one copy will be archived in HEPL locked storage**
- **(Lab copy) one copy will be returned to the FIST Ops Lab as a reference**

H. Action Item Closure Status

Phase B, C & D Test Readiness Review prep meeting was held on 6/11/99 in HEPL

Phase B, C & D are the final three stages of testing after probe insertion that take place at Stanford University. Phase B testing is to start approximately 18 July 99

NOTE: A daily test meeting ("Payload Morning Standup") will be held in the GP-B conference room at 8:30-9:00. This activity will likely start for Probe Insertion activities around the 25th of June.

Attendees: M.R. Anderson, Paul Ehrensberger, Bob Farley, Bob Schultz, Byron Oh, Mike Taber, Dave Murray, John Turneaure, Dave Meriwether, Barry Muhlfelder, Ed Ingraham, Jie Li, Jim Lockhart, Bill Thrasher, Howard Demroff, Jim Burns, Jeff Vanden Beukel

Action Item Assignees:
M.R. Anderson #1, #3, #4, #5, #10, #11
Sei Chun #9
Jim Lockhart #7
Dorrne Ross #2, #7
Bob Schultz #6, #8
Mike Taber #2, #10
Dave Meriwether #10

Action items:
1) Update TRR package with red-lines taken during the prep meeting. Assignee: M.R. Anderson

Closed: All red-lines were updated

Note: An "operations log" will be maintained for all tests (in the FIST Ops area)

2) Apply sticker "for indication only" on test equipment that is not used for payload test or for equipment that does not require calibration. Assignee: Mike Taber, Dorrene Ross

Closed: Stickers are being fabricated for equipment not requiring calibration used during testing.

3) Assign a P-doc number to each operation identified by a CSTOL script. The P-doc will invoke the CSTOL script and the P-doc will include the CSTOL version number and CSTOL date. Assignee: M.R. Anderson

Closed: P. Doc. Numbers were assigned to all CSTOL scripts

4) Obtain an estimated completion date for all P-docs and CSTOLS. Assignee: M.R. Anderson

Closed: All procedure authors were queried and estimated completion dates entered in the "Payload Test Plan" spreadsheet for tracking.

5) Determine if "Gyro Charge Control" procedure was removed from phase A with (see Rob Brumley and Sasha Buchman). Assignee: M.R. Anderson

Closed: Meeting was scheduled and it was decided to complete "Gyro Charge Control" in Phase A.

6) Work with Dorrene Ross to confirm that verifications performed by inspection are correct and verifiable. Pass PCB to update if necessary. Also, update the old launch interface information. Assignee: Bob Schultz

Closed: PCB has been written to document required changes.

7) Dorrene Ross and Jim Lockhart to perform inspection to verify 3.7.1.3.2.3. Assignee: Dorrene Ross and Jim Lockhart

Closed: 3.7.1.3.2.3 inspection was performed.

8) Search LMMS document database to find EM to verify 3.7.1.4.8.2. Search for "payload exhaust line" and search for documents prepared by Goodman. Assignee: Bob Schultz

Closed: LMMS EM # GPB100248 "Probe Pressure Drop during Gyro Spin up" was found to verify 3.7.1.4.8.2

9) Verify that the PLSE-12 requirements verification database is current so that we only review requirement that still need to be verified. Assignee: Sei Chun

Closed: PLSE-12 verification database has been updated and is current.

10) Mark Anderson will re-write requirement 3.7.2.5.7 (Heat power into QBS) as a proper heat power test with the help of Mike Taber, Dave Meriwether, and others as required.

Closed: Requirement re-written to reflect separate requirements for each functional area.

11) Mark Anderson will define data archival process and procedures. This will include hard copy requirements and possibly definition of a "traveler" to log operations sequence and completion.

Closed: Data archival process has been identified and implemented and travelers have been developed.