Stanford University

Operation Order No. _____

GRAVITY PROBE B
PROCEDURE FOR
PAYLOAD VERIFICATION

(PTP) ARTIFICIAL STAR 3 FOCUS, SCALE FACTOR AND STREHL RATIO TESTS OF TELESCOPE

P0503 Rev. B
10 May 2001

	Program responsibility:	Signatures:	Date:
Prepared:	Ted Acworth AS3 Science Test Leader		
Approved:	Rob Bernier AS3 Setup, and Alignment Leader		
Approved:	M. Taber Payload Systems Test Manager		
Approved:	Dorrene Ross or Russ Leese QA Inspector		
Approved:	Harv Moskowitz LMSSC		
Approved:	Rob Brumley Payload Technical Manager		

Authority to redline this document (make minor changes during execution of this procedure): Ted Acworth, Rob Bernier

Level of QA required during performance of this procedure:
__√__ Stanford QA Representative
__√__ Government QA Representative All redlines must be approved by QA

Revision Record:

Rev	Rev Date	ECO #	Summary Description
-	10 may 99		Wrote original procedure
A	13 June 00	1168	Bob Farley Incorporated redlines
B	10 May 01	1267	Ted Acworth Incorporated redlines, conformed to new Pdoc format, improved procedure flow, and revised Verification/ Success Criteria

Acronyms and Abbreviations:

Acronym / Abbreviation	**Meaning**
AS3	Artificial Star # 3
TRE	Telescope Readout Electronics
TRE-GSE	Ground Support Equipment rack for reading telescope telemetry
SMD, dewar	Science Mission Dewar
QA	Quality Assurance
GPB, GP-B	Gravity Probe B
CC, cc	Cube corner
AXP, AXN, etc.	TRE-GSE telescope telemetry readout channels
Ix, Iy, etc.	TRE-GSE telescope telemetry slope values in amps
Θx, Θy, etc.	Angle theta of AS3 beam relative to AS3 or the telescope
Fe	Optical power in W/m^2
Active duty slope	TRE-GSE telemetry ramp values that lie between the beginning of the ramp and the end of the ramp where the signal is saturated
p-p, p-v	Peak-to-peak is the same as peak-to-valley
SF	Scale factor
Boresight	The optical axis of the telescope
Reticle	The mirror placed on and facing away from the telescope, used to establish an optical reference angle between AS3 and the telescope
Probe	The science mission assembly containing the gyroscopes and telescope, inserted into the SMD space vehicle

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A **Scope**

Artificial star 3 (AS3) is an instrument used to evaluate the Gravity Probe B (GPB) flight telescope when installed in the flight science mission dewar (SMD). AS3 is capable of projecting a beam of artificial starlight into the telescope, and actuating the beam through a range of calibrated angles relative to the telescope boresight axis. The purpose of this test instrument is to provide data used in the calibration confidence check of the telescope after integration.

This procedure will provide data to plot telescope readout current I vs. AS3 beam scan angle theta (relative to telescope) at known optical intensity, about the central linear readout region of the telescope.

Specifically, the purpose is to determine the slope of the central linear region of the GPB flight telescope, in both X and Y axes. The absolute guide star tracking signal slope (SF) measurement equation

$$SF = \frac{dI}{d\theta} / F_e$$

predicts SF, where:

I = non-normalized angular readout of telescope (amperes) = I_+-I_- where I_+ and I_- are TRE slope values in X or Y direction.

θ = scan angle of AS3 beam relative to telescope boresight (milliarcseconds).

F_e = photon flux exiting AS3 (watts).

Experimentally, SF_x will be the slope of the linear region of the plot of I_x vs. θ_x, divided by the optical power entering the probe. Similarly for the y axis.

The **efficiency of light input to current output**, I/F_e, at each theta data point will be known. The efficiency will be measured about the central linear readout region of the telescope tracking signal. Where the telescope focal spot completely falls onto an individual telescope detector, that detector's transmissibility and uniformity may be determined. The efficiency will also be determined by a second more direct technique, using the sum of the TRE-GSE slope values when the AS3 beam is oriented into the telescope boresight axis. The **minimum efficiency** will be determined using this method.

Additionally, the purpose of this test is to estimate the **system Strehl ratio** of the complete GPB flight telescope system. The Strehl ratio may be estimated by comparing the experimental plot of a normalized SF to the ideal normalized plot predicted by theory. The Strehl Ratio determined from the experimental plot will be a function of the combined Strehl Ratio of the AS3 optic system and the probe optic system. By determining the Strehl Ratio of the AS3 optic system before the payload verification tests, the Strehl Ratio of the probe may be determined during the test sequence outlined in this document.

The **scale factor**, or the telescope readout calibration constant, will be determined from narrow field scans about the telescope boresight axis.

Data is collected at various degrees of AS3 beam defocus centered about the collimation focus. By measuring telescope readout slopes at various beam focus settings, the telescope defocus may be

determined. Also, data is collected "open loop" with the AS3 jitter compensation turned off. Then, data is collected "closed loop" with the AS3 jitter compensation turned on to achieve best precision.

This procedure ☒ Does ☐ Does not provide formal verification of GP-B requirements. This procedure ☐ Does ☒ Does not include restraints or restrictions for the payload.

B **Verification/ Success Criteria**

AS3 is used to perform system level tests of the GPB Payload containing telescope #3 during the payload verification tests. This procedure verifies the requirements listed below.

Req't. Source	Req't Number	Requirement title and description	Ver.
PLSE-12	3.2.1.5.3.2	**Efficiency of Light Input to Current Output –** The efficiency of light input (at Window #4 over the clear aperture of the telescope) to photodetector current output shall be measured with an accuracy of 10% within a wavelength of 100 nm of mid-band (700 nm) for each of the eight (8) detectors. This measurement is made at telescope null and at <= 200 marcsec intervals over a 10 arcsec range centered on null in the two readout axes. The units are A/W.	T
PLSE-12	3.2.1.5.3.2.1	**Minimum Efficiency -** The minimum efficiency of light input to photodetector current output of the sum of the current of all eight detectors shall be >= 0.038 A/W within a wavelength of 100 nm of mid-band (700 nm).	T
PLSE-12	3.2.1.5.3.3	**Strehl Ratio, System** – The Strehl ratio of the optical system (includes the telescope mounted to the quartz block and 4 probe windows) in the Payload configuration shall be >= 50%. Here the Strehl ratio is taken to be the ratio of the actual measured normalized signal slope to the theoretical normalized signal slope of an ideal optical system (no wavefront error). The normalized signal slope is the small normalized signal derivative with respect to angle within 100 marcsec of null. A measurement within a 100 nm wavelength of mid-band (700 nm) provides an acceptable verification.	A, T
T003	7.4.1	**Scale Factor Calibration** – After initial ground calibration, the scale factor shall be known to within 20%	A, T

C **Constraints and Restrictions**

n/a

D **Configuration Requirements**

D.1 The FIST lab area must be seismically and thermally "quiet." Air conditioning, pumps, etc. may need to be turned off as required. Any mechanical noise sources that adversely affect the test will be sought out and shut down with the permission of the Payload Test Director. Temperature in the FIST area should be kept at a stable room temperature.

D.2 Floor plan detailing the positioning of AS3 test equipment in the FIST OPS

D.2.1 Roll-in access to a floor area, of 4 ft x 5 ft minimum, for staging is required, accessible

by the overhead crane to lift the star module onto the probe flange.

D.2.2 The control station requires floor space area of 10 ft x 6 ft minimum, and must be within 24 ft of the probe flange for cabling to reach. A 4 ft x 3 ft space directly next to the dewar and on the floor level is required to set up the vacuum pump.

D.2.3 The flange area of the dewar must be clear out to a radius of at least 4 ft, extending up to the crane on the ceiling, and continuing down at least two feet below the plane of the dewar flange, except for probe pump lines.

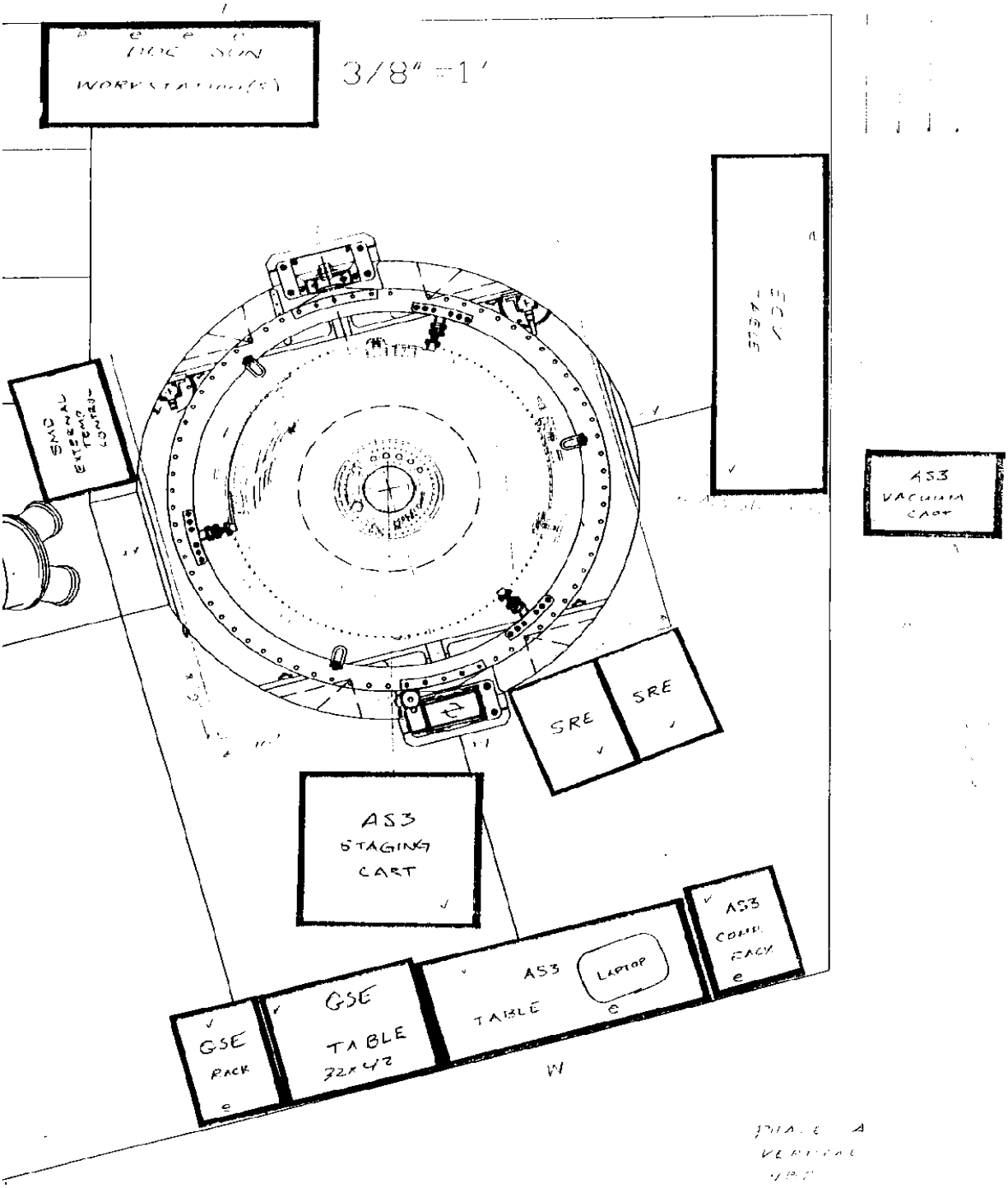
D.3 AS3 operations, once AS3 is installed onto the Probe flange, will be removed from the immediate vicinity of the dewar. Operations will involve the AS3 operators sitting at the AS3 control station and operating optical devices inside the AS3 vacuum chamber

D.4 Three standard 110 VAC and one 3 phase 208 VAC are required to power AS3 and the vacuum pump respectively. Of three 110 VAC lines, one must be on the circuit specially grounded to the probe.

D.5 Three Ethernet drops must be available for communications – two for AS3 and one for the TRE-GSE.

D.6 The TRE-GSE group is responsible for installing the TRE-GSE readout equipment before the AS3 procedures may begin. The TRE-GSE group will position the TRE-GSE test rack within 12 feet of the AS3 control station (see floor plan) and assure that the TRE-GSE test rack correctly reads out telescope telemetry for AS3 tests to proceed. The AS3 group will provide 9 BNC coax cables and connect these to the TRE-GSE during the AS3 alignment procedure.

D.7 The Artificial Star 3 assembly with window #4 adapter plate will be bolted to the probe flange. Umbilicals will trail off the star module down to the control station and pump.


3/8" = 1'
SMD EXTERNAL TEMP CONTROL
AS3 VACUUM CART
SRE
SRE
AS3 STAGING CART
GSE RACK
GSE TABLE 32x42
AS3 TABLE
LAPTOP
AS3 CONTROL RACK

E Hardware Required

E.1 Cabling list between AS3 star module and control rack station. (clockwise from accessory cable)

Accessory A
Accessory B
Video coax 1
Video coax 2
Video coax 3
Video coax 4
Motor 1
Motor 2
Motor 3
Motor 4
Motor 5
Quad Cells
Vacuum hose for AS3 vacuum bell
Vacuum pressure sensor 1
Vacuum pressure sensor 2
Thermistor coax 1
Thermistor coax 2
Thermistor coax 3
Thermistor coax 4
Jitter A
Jitter B
Jitter C
Laser power
N_2 hose for window #4 purge, 20 foot length, 3/8 inch diameter
Vacuum hose for Window #4/AS3 window vacuum volume

E.2 Cabling list between AS3 control rack and TRE-GSE control rack

Quantity 9 of 20 foot coax with male BNC connectors on both ends

E.3 Equipment requiring formal periodic calibration

Manufacturer	Model	Serial Number	Calibr. Exp. Date
Newport Optical Power Meter	1830-C	1604	11 May 02
Newport Optical Power Meter Detector Head (quantity 2)	818-SL	7761 and 7844	11 May 02
Fluke multimeter “GPB SMD”	85	66500192	16 Nov 01
Torque wrench for tightening flange mount bolts	DA175M and DA130M	STU-0031 and STU-0030	OK to use FIST OPS wrench
Torque wrench (FIST OPS property in bonded storage)		000191	28 Nov 01

E.4 Special AS3 test equipment

Description	Part No.	Rev. no.	Serial No.
AS3 star module	25567	A	none
500 bomb cart for AS3 star module	none	none	none

AS3 mounted to bomb cart using three legs setup for on-cart optical transmissibility tests (tabs for holding condenser lens under the AS3 star module	none	none	none
AS3 star module mounting flange		none	none
Torque wrench for tightening flange mount bolts	DA175M	none	STU-0031
Torque wrench for tightening flange mount bolts	DA130M	none	STU-0030
10.75 inch Diameter Mylar sheet for the bottom of the AS3 mounting flange			
N_2 cylinder with valve	none	none	none
AS3 control rack including AS3-PC computer and other instruments	none	none	none
AS3 control station including: 5x video monitors and 2 switch boxes AS3-HR1510 computer, computer monitor, keyboard and mouse AS3-PC computer monitor, keyboard, mouse, and trackball	none	none	none
AS3 vacuum pumping cart:			
Vacuum pump for AS3 vacuum bell	none	none	none
220V power cord	none	none	none
20 feet of QF 50 vacuum hose	none	none	none
Vacuum pump for Window #4/AS3 window vacuum volume (available in FIST OPS)	none	none	none
30 feet of 3/8 inch diameter vacuum hose with QF 10 fittings	none	none	none
mechanical toolbox	none	none	none
¼ inch socket adapter to 5/32 Allen. Note, due to limitation on space, max 1.100 in long.	none	none	none
Allen wrench, 5/32 (in)	none	none	none
6 inch Caliper	none	none	none
electrical toolbox	none	none	none
optics toolbox	none	none	none
AS3 Payload Verification test notebook	none	none	none

E.5 **Tools**

Description	No. Req'd
AS3 Mechanical Toolbox inventoried	1
AS3 Electrical Toolbox inventoried	1
AS3 Optics Toolbox inventoried	1

Toolbox content lists are contained in a separate document titled "AS3 tools list."

E.6 **Computers and software**

Computer	Name	Model	Software Vendor	Software Name	Version No
WinTel	AS3-PC	Industrial PC 133 MHz NT	Microsoft	Windows NT	4.0
			National Instruments	LabView	5.0.1
			National Instruments	NiDaq for Windows	6.0
			MathWorks	Matlab	5.2.1.1420
			MathWorks	Simulink	2.2
			MathWorks	Real Time Toolbox	
			Mathworks	Trace/Cockpit	40 Vs 3.3-32 for DS1003 DSP processor board
Dspace ISA cards	A/D, DSP, and D/A cards	2003-03, 1003-05 768K, 2102-04			
National Instruments	PID motor control board	FlexMotion PCI			
WinTel	AS3-HR1510	Adsys	Microsoft	Windows NT	4.0
			Techsmith	SnagIt 32	
			SPSS Inc	SigmaPlot	5.0 for Windows
			Microsoft	Excel	98

E.7 **Expendables**

Description	Quantity
Optics cleaning supplies	1 bag
JAZ® disks	4
Blank CD-R disks	20
Video camera and media	1
Still Camera and media	1

F **Software Required**

F.1 **Test Support Software**

Version control is implemented using a system where the program file name is followed by an F and a date of last modification, in year month day format. For example, “2D Scale Factor_F_990630.vi” would be the version of “2D Scale Factor_F.vi” last modified on 30 June 1999

Test Software Name	Version No.	QA
Align To Reticle_F.vi	F_990719	
AS3_Analysis_73.vi	73_981014	
Focus Automatic_F.vi	F_990729	
Null_Both_Spots_F.vi	F_990806	
Record Motor Positions_F.VI	F_990809	
Science Tests_F.vi	F_990724	
Spot Nuller_F.vi	F_990716	
turnOFFjitter_F.vi	F_990713	

G **Procedures Required**

Procedure Name	Procedure No.
AS3 adapter flange fit check procedure	P0514
Installation procedure	P0500 Rev A
Alignment procedure	P0501 Rev A
Transmssibility test procedure	P0502 Rev B
Focus, scale factor, and strehl ratio test procedure	P0503 Rev B
Removal procedure	P0504 Rev A
Removing the vacuum cover while the star is mounted to the probe and accessing internal optics	P0347 Operation order
Telescope telemetry setup procedure	P0555

H **Equipment Pretest Requirements**

Equipment	Serial No.	Test Required	Proc. No.	Test Performed	
				Date	By
AS3 star module	none	Reconfirm beam center positions for 1 cm cc, 6" cc, and sliding aperture motor encoders 1 cm cc = _____ticks 6" cc = _____ticks sliding ap=_____ticks	None – performed by E. Acworth and R. Bernier in AS3 lab	May 01	E. Acworth and R. Bernier
AS3 star module	none	internal optics aligned, 1 cm and 6" beams collimated, covered and evacuated, and mounted to transport cart.	P0501	day before test	E. Acworth and R. Bernier

AS3 star module	none	Vacuum system leak tested	None – performed by E. Acworth and R. Bernier in AS3 lab	Jun. 97	E. Acworth and R. Bernier
AS3 star module	none	Vacuum structure and shackle (for crane hook connection) tested to 2x load with chamber at atmospheric and evacuated	None – performed by E. Acworth and R. Bernier in AS3 lab	8 Oct. 97	E. Acworth and R. Bernier
AS3 star module	none	Window #4 space vacuum leak check	None – performed by E. Acworth and R. Bernier in AS3 lab	TBD	TBD
AS3 test wedge	none	Wedge angle calibration	None – Read R. Bernier's lab notebook #7 page 72	21 Feb 01	R. Bernier
AS3 transmissibility	none	Transmissibility calibration	None – performed by E. Acworth and R. Bernier in AS3 lab	22Jun99	E. Acworth

I **Personnel Requirements**

QA Notification

The ONR representative and SU QA shall be notified 24 hours prior to the start of this procedure. Upon completion of this procedure, the QE Manager will certify his/her concurrence that the effort was performed and accomplished in accordance with the prescribed instruction by signing and dating in the designated place(s) in this document.

The test director for this procedure is Ted Acworth

This test to be conducted only by certified personnel: Ted Acworth and Rob Bernier.

A TRE-GSE group representative will be available during all AS3 procedures to monitor the TRE-GSE functionality. Ted Acworth and Rob Bernier have authority to request the presence of a TRE-GSE group representative at any time during the AS3 procedures.

Quality Assurance 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 Dorrene Ross 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, Dorrene Ross or her designate, nominally R. Leese, will certify her concurrence that the effort was performed and accomplished in accordance with the prescribed instructions by signing and dating in the

designated place(s) in the document. Discrepancies will be recorder in a D-log or as a DR per Quality Plan P0108.

J Safety Requirements

J.1 Dewar safety

J.1.1 During the time that this test is in operation personnel will discharge built up static electricity appropriately. Refer to P0476

J.1.2 During the tests no magnetic tools will be allowed to come in contact with the probe

J.1.3 Don't bump the probe unnecessarily

J.1.4 When handling tools or objects above the dewar, special care is to be taken so as not to drop them onto the dewar or equipment. An absolute minimum of tools is to be used above the dewar (torque wrench for tightening adapter flange to sunshield flange)

J.2 Electrical mating and demating of AS3 hardware connectors

J.2.1 Place cable connector A only into socket A, etc.

J.2.2 Strain relieve all cables

J.2.3 Connection and disconnection shall be performed only by Ted Acworth or Rob Bernier, and only when the equipment involved is in a powered-down state (unless otherwise noted)

J.2.4 Connectors shall be inspected for contamination and for bent, damaged, or recessed pins prior to mating.

K General Instructions

K.1 QA and Safety Notification

K.1.1 The ONR representative, SU QA, and Safety Engineering shall be notified 24 hours prior to the start of this procedure. Upon completion of this procedure, the QE Manager will certify his/her concurrence that the effort was performed and accomplished in accordance with the prescribed instruction by signing and dating in the designated place(s) in this document.

K.2 Red-line authority

K.2.1 Redlines may be initiated by Ted Acworth or Rob Bernier. Authority to red-line (make minor changes during execution) this procedure is given solely to the TD or his designate and shall be approved by the QA Representative. Additionally, approval by the Payload Technical Manager shall be required, if in the judgement of the TD or QA Representative, the experiment functionality may be affected.

K.3 **Any nonconformance or test anomaly should be reported by a D-Log or Discrepancy Report. Refer to the Quality Plan, P0108, for guidance. Do not alter or break test configuration if a test failure occurs; notify quality assurance.**

K.4 **Only the following persons have the authority to exit/terminate this test or perform a retest: Ted Acworth**

L References and Applicable Documents

L.1 **Tool list**

M Operations

NOTE:

AS3 Alignment procedure is to have been completed immediately prior to this procedure. All individual procedure sections assume previous procedure sections have been completed in order. Calibration procedures are to be completed immediately before and immediately after science tests to assure currency of the calibration for measurement

NOTE:

The FIST lab area must be seismically and thermally "quiet." Air conditioning, pumps, etc. may need to be turned off as required. Any mechanical noise sources that adversely affect the test will be sought out and shut down with the permission of the Payload Test Director. Temperature in the FIST area should be kept at a stable room temperature.

M.1 Date and time begun: _____

M.2 Thermistor temperature system should be running

M.3 AS3 vacuum pressure monitor system should be running

M.4 (FIST) lab temperature _____, humidity _____

Set up AS3 optical system, calibrate, align to reticle

M.5 Back up data to location _____

M.6 Turn off jitter compensation

M.6.1 Run Labview “turnOFFjitter_F.vi” Version F

M.7 (If not done this day) Set up 10 mm beam (see AS3 alignment procedure P0501 for operation details)

M.8 (If not done this day) Inspect windows and telescope with zoom camera. Look for optical obscuration along beam path

M.9 (if not done within one hour, or if system is not necessarily in thermal and pressure balance) Precalibration (see AS3 alignment procedure P0501 for operation details)

M.9.1 Align AS3 beam normal to telescope reticle

M.9.1.1 Run Labview "Align To Reticle_F.vi" Version F

M.9.1.1.1 Data file name: _____

M.9.1.1.2 Run "SnagIt.exe" to capture the screen window

M.9.1.1.2.1file name: _____

M.9.2 Collimate 150 mm beam

M.9.2.1 Run Labview "Focus Automatic_F.vi" Version F with "150 mm Beam Sliding Aperture" setting of method selection switch

M.9.2.1.1 Data file name: _____

M.9.2.1.2 Run "SnagIt.exe" to capture the screen window

M.9.2.1.2.1file name: _____

M.9.2.2 (optional) 6" cc collimation test

M.9.2.3 (optional) knife edge collimation test

M.10 Run Labview "Record Motor Positions_F.vi" Version F

M.10.1 File name: _____

Completed by:_____
Date/time:_____
QA witness:_____

Set up telescope telemetry, set optical power, and check readout (see P0555)

M.11 See P0555 for detailed step descriptions.

M.12 Connect 9 BNC cables from the TRE-GSE rack to the AS3-PC NIDAQ card breakout terminal

M.13 Prepare AS3 optical power for payload telescope low gain mode readout

Completed by:_____
Date/time:_____
QA witness:_____

M.13.1 Set up jitter compensation system for functionality at this AS3 optical power setting and return spot diameter. Follow steps in P0555 L.7. If jitter compensation system will

function with less light, then decrease light level to minimum required. If jitter system will not function with this light level, then the saturation method failed – go to M.13.2 below

GO / NO GO:_____
Completed by:_____
Date/time:_____
QA witness:_____

M.13.2 If NO GO above **(annular filter method)**

GO / NO GO:_____
Completed by:_____
Date/time:_____
QA witness:_____

M.14 Check telescope telemetry readout into AS3-PC

NOTE:

If timing is not set correctly to capture active duty slopes over the entire scan field, science test data will be inaccurate. If timing ever includes saturated data points, slope estimation will be incorrect!

Completed by:_____
Date/time:_____
QA witness:_____

M.15 (if not done within one hour, or if system is not necessarily in thermal and pressure balance) Precalibration (see AS3 alignment procedure P0501 for operation details)

M.15.1 Align AS3 beam normal to telescope reticle

M.15.1.1 Run Labview "Align To Reticle_F.vi" Version F

M.15.1.1.1 Data file name: _____

M.15.1.1.2 Run "SnagIt.exe" to capture the screen window

M.15.1.1.2.1file name: _____

M.16 Align AS3 beam normal to telescope reticle

M.17 Extend ND filter

M.18 Align to Reticle

M.19 Run Labview "Record Motor Positions_F.vi" Version F

M.19.1 File name: _____

Completed by:_____
Date/time:_____
QA witness:_____

AS3 system is set up and ready for telescope science tests (Optical power is set and checked in low gain mode with jitter compensation functional. 150 mm beam is collimated and aligned normal to reticle. Acquisition and fine/focus mounts are calibrated against the test wedge)

M.20 **Focus/Scale Factor/Strehl scan using ff mount, without jitter compensation**

M.20.1 Null AS3 beam to telescope boresight

M.20.1.1 Turn off jitter compensation

M.20.1.1.1 Run Labview "turnOFFjitter_F.vi" Version F

M.20.1.2 Note ff az =_____, ff el = _____

M.20.1.3 Run Labview "Null_Both_F.vi" Version F to telescope boresight using "ff->payload telescope" and "ffc->source" settings

M.20.1.3.1 150 mm beam is nulled to center of telescope boresight

M.20.1.3.2 Source spot is nulled to center of source quad cell

M.20.1.3.3 Reticle return spot is nulled to center of return quad cell

M.20.1.4 Note ff az =_____, ff el = _____

M.20.2 Check ff and ffc motor ranges before executing scans, to be sure not to hit a limit

M.20.3 Collimate 150 mm beam at least 3 times

M.20.3.1 Run Labview "Focus Automatic_F.vi" Version F with "150 mm Beam Sliding Aperture" setting of method selection switch

M.20.3.1.1 Data file name: _____

M.20.3.1.2 80 mm lens position = _____ ticks

M.20.3.1.3 Data file name: _____

M.20.3.1.4 80 mm lens position = _____ ticks

M.20.3.1.5 Data file name: _____

M.20.3.1.6 80 mm lens position = _____ ticks

M.20.4 **Run one low resolution 3D focus scan without jitter compensation - 7x11x11 – for sanity check**

M.20.4.1 10 arcsec course focus scan #1 without jitter compensation (at various focal settings **+2λ …-2λ** through detector centers to determine tel focus, scale factor, strehl ratio)

M.20.4.1.1 Run Labview "Science Tests_F.vi" Version F with mode selector switch set to "3D" and jitter switch set to "off"

M.20.4.1.2 Fill out scan parameters in Excel spreadsheet used for this test series: "Payload Verification xx Tests Record Vxx.xls" (latest version)

M.20.4.1.3 scan dataset filename #1 _____

M.20.4.1.4 Run “SnagIt.exe” to capture the screen window

M.20.4.1.4.1file name: _____

M.20.5 Analyze scan data to assure that settings are at best telescope focus, that focus scan Z range covers both sides of telescope best focus - repeat scans if necessary

M.20.6 **Run one high resolution 1D Strehl scan without jitter compensation - 1x101x101**

M.20.6.1 10 arcsec focus scan #1 without jitter compensation

M.20.6.1.1 Run Labview “Science Tests_F.vi” Version F with mode selector switch set to “3D” and jitter switch set to “off”

M.20.6.1.2 Fill out scan parameters in Excel spreadsheet used for this test series: "Payload Verification xx Tests Record Vxx.xls" (latest version)

M.20.6.1.3 scan dataset filename #1 _____

M.20.6.1.4 Run “SnagIt.exe” to capture the screen window

M.20.6.1.4.1file name: _____

M.20.7 **Run two high resolution 2D raster scans to test telescope detector orthogonality – 51x51**

M.20.7.1 Confirm that f/f mount won’t run into limits during this test

M.20.7.2 Null AS3 beam to telescope boresight

M.20.7.3 120 arcsec 2D f/f scan with jitter compensation -focus scan #1 with jitter compensation

M.20.7.3.1 Run Labview “Science Tests_F.vi” Version F with mode selector switch set to “2D” and jitter switch set to “on”

M.20.7.3.2 Fill out scan parameters in Excel spreadsheet used for this test series: "Payload Verification xx Tests Record Vxx.xls" (latest version)

M.20.7.3.3 scan dataset filename _____

M.20.7.3.4 Run “SnagIt.exe” to capture the screen window

M.20.7.3.4.1file name: _____

M.20.7.4 120 arcsec 2D f/f scan with jitter compensation -focus scan #2 with jitter compensation

M.20.7.4.1 Run Labview “Science Tests_F.vi” Version F with mode selector switch set to “2D” and jitter switch set to “on”

M.20.7.4.2 Fill out scan parameters in Excel spreadsheet used for this test series: "Payload Verification xx Tests Record Vxx.xls" (latest version)

M.20.7.4.3 scan dataset filename _____

M.20.7.4.4 Run “SnagIt.exe” to capture the screen window

M.20.7.4.4.1file name: _____

M.20.8 Collimate 150 mm beam at least 3 times

M.20.8.1 Run Labview “Focus Automatic_F.vi” Version F with “150 mm Beam Sliding Aperture” setting of method selection switch

M.20.8.1.1 Data file name: _____

M.20.8.1.2 80 mm lens position = _____ ticks

M.20.8.1.3 Data file name: _____

M.20.8.1.4 80 mm lens position = _____ ticks

M.20.8.1.5 Data file name: _____

M.20.8.1.6 80 mm lens position = _____ ticks

Completed by:_____
Date/time:_____
QA witness:_____

Note: Preferably, repeat the following scans each night for two or three consecutive nights:

M.21 **Focus/Scale Factor/Strehl scans using ff mount, with jitter compensation (to test both the Absolute Guide Star Tracking Signal Slope requirement and the Strehl Ratio requirement)**

M.21.1 Set up AS3 beam, assure that everything is calibrated and initialized correctly

M.21.2 Null AS3 beam to telescope boresight

M.21.2.1 Turn off jitter compensation

M.21.2.1.1 Run Labview “turnOFFjitter_F.vi” Version F

M.21.2.2 Run Labview “Null_Both_F.vi” Version F to telescope boresight using “ff->payload telescope” and “ffc->return” settings

M.21.2.2.1 150 mm beam is nulled to center of telescope boresight

M.21.2.2.2 Reticle return spot is nulled to center of return quad cell

M.21.3 Check ff and ffc motor ranges before executing scans, to be sure not to hit a limit

M.21.4 Collimate 150 mm beam at least 3 times

M.21.4.1 Run Labview "Focus Automatic_F.vi" Version F with "150 mm Beam Sliding Aperture" setting of method selection switch

M.21.4.1.1 Data file name: _____

M.21.4.1.2 80 mm lens position = _____ ticks

M.21.4.1.3 Data file name: _____

M.21.4.1.4 80 mm lens position = _____ ticks

M.21.4.1.5 Data file name: _____

M.21.4.1.6 80 mm lens position = _____ ticks

M.21.5 **Run two high resolution Strehl scans with jitter compensation - 1x101x101 (45 minutes each)**

M.21.5.1 10 arcsec strehl scan #1 with jitter compensation (through detector centers to determine tel focus, scale factor, strehl ratio)

M.21.5.1.1 Null to boresight

M.21.5.1.2 Run Labview "Science Tests_F.vi" Version F with mode selector switch set to "3D" and jitter switch set to "on"

M.21.5.1.3 Fill out scan parameters in Excel spreadsheet used for this test series: "Payload Verification xx Tests Record Vxx.xls" (latest version)

M.21.5.1.4 scan dataset filename #1 _____

M.21.5.1.5 Run "SnagIt.exe" to capture the screen window

M.21.5.1.5.1file name: _____

M.21.5.2 10 arcsec strehl scan #2 with jitter compensation

M.21.5.2.1 Null to boresight

M.21.5.2.2 Run Labview "Science Tests_F.vi" Version F with mode selector switch set to "3D" and jitter switch set to "on"

M.21.5.2.3 Fill out scan parameters in Excel spreadsheet used for this test series: "Payload Verification xx Tests Record Vxx.xls" (latest version)

M.21.5.2.4 scan dataset filename #2_____

M.21.5.2.5 Run "SnagIt.exe" to capture the screen window

M.21.5.2.5.1file name: _____

M.21.6 **Run one very-high resolution Strehl scan with jitter compensation - 1x401x401 (~ 3 hours)**

M.21.6.1 Null to boresight

M.21.6.2 10 arcsec strehl scan #3 with jitter compensation

M.21.6.2.1 Run Labview "Science Tests_F.vi" Version F with mode selector switch set to "3D" and jitter switch set to "on"

M.21.6.2.2 Fill out scan parameters in Excel spreadsheet used for this test series: "Payload Verification xx Tests Record Vxx.xls" (latest version)

M.21.6.2.3 scan dataset filename _____

M.21.6.2.4 Run "SnagIt.exe" to capture the screen window

M.21.6.2.4.1.1file name: _____

M.22 Determine from the data whether the probe passes the **Efficiency requirements**

M.22.1 Refer to p53 of Payload Ver I Test Notebook, and efficiency data gathered in P0502

M.22.2 Generate a plot of SF_x vs θ_x through telescope boresight, for both redundant readout channels

M.22.2.1 File name: _____

M.22.2.2 Maximum slope through the boresight equals _____

M.22.3 Generate a plot of SF_Y vs θ_Y through telescope boresight, for both redundant readout channels

M.22.3.1 File name: _____

M.22.3.2 Maximum slope through the boresight equals _____

M.22.4 Attach the plots to this document, label the slope values through the boresight for each detector plot.

M.22.5 With these plots, the efficiency should be known to within 10% (Efficiency of Light Input to Current Output requirement)

M.22.6 Probe _____ passes, _____ does not pass the Efficiency of Light Input to Current Output requirement

M.22.7 (From P0502) Probe efficiency equals _____ A/W +- _____ % error. If the efficiency is greater than 0.038 A/W (minimum efficiency verification requirement), then the probe passes this requirement.

M.22.8 Compare to efficiency values calculated from scan data above.

M.22.9 Probe _____ passes, _____ does not pass the minimum efficiency requirement

Completed by:_____
Date/time:_____
QA witness:_____

M.23 Determine from the data whether the probe passes the **Strehl Ratio requirement**

M.23.1 Generate plots of normalized telescope readout I vs θ for both channels in both axes.

Overlay with the family of idealized theoretical curves for various defocus values. Determine which defocused curve the experimental data closest matches. The Strehl Ratio used to make this defocus curve is the estimated Strehl Ratio of the probe.

M.23.1.1 File name: _____

M.23.2 Attach the plots to this document, label the defocs curve used to estimate probe Strehl Ratio.

M.23.3 If the probe Strehl Ratio is greater than 50% (Strehl Ratio requirement), then the probe passes this requirement.

M.23.4 Probe _____ passes, _____ does not pass the Strehl Ratio requirement

Completed by:_____
Date/time:_____
QA witness:_____

M.24 Determine from the data whether the probe passes the **Scale Factor requirement**

M.24.1 Generate plots of scale factor vs θ for both channels in both axes. (refer to Ted Acworth's Ph.D. dissertation, or AS3 Payload Verification I sDoc for method)

M.24.1.1 File name: _____

M.24.2 Attach the plots to this document.

M.24.3 If the probe scale factor is known to within 20% (scale factor requirement), then the probe passes this requirement.

M.24.4 Probe _____ passes, _____ does not pass the scale factor requirement

Completed by:_____
Date/time:_____
QA witness:_____

Start this program last thing at night

M.24.5 **Run one high resolution focus scan with jitter compensation - 7x101x101 (7 hours) (time permitting, add 2 or 4 more focus levels)**

M.24.5.1 10 arcsec focus scan #1 with jitter compensation (at various focal settings - **-2λ - +2λ** through detector centers to determine tel focus, scale factor, strehl ratio)

M.24.5.1.1 Run Labview "Science Tests_F.vi" Version F with mode selector switch set to "3D" and jitter switch set to "on"

M.24.5.1.2 Fill out scan parameters in Excel spreadsheet: "Payload Verification Tests record.xls"

M.24.5.1.3 scan dataset filename #1 _____

M.24.5.1.4 Run "SnagIt.exe" to capture the screen window

M.24.5.1.4.1file name: _____

Next morning first thing

M.24.6 Collimate 150 mm beam at least 3 times

M.24.6.1 Run Labview "Focus Automatic_F.vi" Version F with "150 mm Beam Sliding Aperture" setting of method selection switch

M.24.6.1.1 Data file name: _____

M.24.6.1.2 80 mm lens position = _____ ticks

M.24.6.1.3 Data file name: _____

M.24.6.1.4 80 mm lens position = _____ ticks

M.24.6.1.5 Data file name: _____

M.24.6.1.6 80 mm lens position = _____ ticks

M.24.7 Plug data sets into Excel data analysis files and check results are as expected

M.25 Run Labview "Record Motor Positions_F.vi" Version F

M.25.1 File name: _____

M.26 Backup data

M.26.1 Data file name and directory path: _____

M.26.2 Location of data analysis (lab book, matlab file, EM, etc.):
_____

Completed by:_____
Date/time:_____
QA witness:_____

M.27 (optional) At each focus setting, plots of

M.27.1 3D and contour of I_x vs. θ_x and θ_y

M.27.2 3D and contour of I_y vs. θ_x and θ_y

M.27.3 I_{xP} , I_{xN} , and I_x vs θ_x through telescope boresight

M.27.4 I_{yP} , I_{yN} , and I_y vs θ_y through telescope boresight

M.27.5 Normalized SF_x vs θ_x through telescope boresight with AS2 experimental and theoretical results overlaid

M.27.6 Normalized SF_y vs θ_y through telescope boresight with AS2 experimental and theoretical results overlaid

M.28 **Review all data sets to be sure enough data has been taken – don't complete procedure until all science tests have sufficient useful data.**

N Procedure Completion.

Completed by: _____
Witnessed by: _____
Date: _____
Time: _____

Quality Manager _____ Date _____
Payload Test Director _____ Date _____