F2G IN-ORBIT TWO-GYRO TEST (Feb. 2005) and TGS-MODE OBSERVATORY VERIFICATION (TGSMOV)

REQUIREMENTS & ACTIVITIES

STScI, Oct. 14, 2004

This document specifies the STScI-identified requirements and activities for F2G, scheduled for Feb. 2005, and for TGSMOV (to be carried out upon entry into operational TGM).

This document is posted at:
http://www.stsci.edu/smov/F2GTGSMOV/F2GTGSMOVRQMTS.pdf

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I. CONCEPTS & GOALS FOR F2G & TGSMOV

1. **F2G:** Characterize TGM science modes for upcoming Cycle 14 TAC.
   - Insure that commonly used modes are still feasible in TGM.
   - Discover any common modes or observing strategies that no longer work properly. (These modes could either be repaired or scheduled early in TGM.)
   - Quantify any changes in science performance under TGM.
   - Understand signal-to-noise calculations in TGM.

2. **F2G:** Identify any development activities needed before operational TGM.
   - e.g. dithering is infeasible, or analysis software doesn't work

3. **F2G & TGSMOV:** Characterize HST pointing and guiding performance in TGM.
   - ability of the FGS to acquire guide stars
   - drift and jitter of the Observatory under 2-guidestar control

4. **F2G & TGSMOV:** Validate HSTSIM predictions.

5. **TGSMOV:** Characterize science performance upon entry into operational TGM.

II. F2G & TGSMOV REQUIREMENTS

Unless otherwise indicated, all of the following requirements apply to both the F2G Test and TGSMOV.

**II.1 ACS Requirements**

**ACS 1.a. ACS PSF as function of exposure time.** The ACS PSF in Two-Gyro Mode (TGM) will be characterized for a range of exposure times from ~1 sec to ~1000 sec in both the WFC and HRC in both a UV (small PSF) and visible (commonly used) filter.

**ACS 1.b. ACS Best- and Worst Case PSF.** The ACS PSF in TGM will be characterized under "best case" and "worst case" HST conditions (i.e. thermal conditions, sun angle, etc.; as available) for commonly used exposure times.
ACS 1.c. ACS PSF as Function of Guidestar Brightness. The ACS PSF in TGM will be characterized over a range of guidestar brightness (e.g. V=9, 13, 14.5) for commonly used exposure times.

ACS 1.d. ACS PSF as Function of Gyro Combinations. The ACS PSF in TGM will be characterized under different gyro failure scenarios (if available) for commonly used exposure times. – REQUIREMENT DELETED (gyro combination 2-4 will be tested in F2G Test)

ACS 2. ACS PSF Repeatability as Function of Exposure Time. The repeatability of the ACS PSF in TGM will be characterized for exposure times from ~1 sec to ~100 sec.

ACS 3. ACS Repeatability of Small Pointing Offsets. The accuracy and repeatability of small pointing offsets in TGM will be characterized. The tested offsets should be similar to commonly used HRC and WFC dither patterns.

ACS 4. ACS Stability across Exposures within Visibility Period. The ACS pointing stability in TGM will be characterized between different exposures within a target visibility period.

ACS 5. ACS Stability across Target Occultations. The ACS pointing stability in TGM will be characterized for observations of a target which are interrupted by earth occultations across several orbits.

ACS 6. ACS Coronographic Acquisitions. The functionality of ACS Coronographic Acquisitions in TGM will be tested.

ACS 7. ACS Repeatability of Coronographic Acquisitions. The repeatability of ACS Coronographic Acquisitions in TGM for different targets will be characterized (i.e. characterize accuracy to which a target and reference star can be placed at the same location behind the occulting mask).

ACS 8. ACS CVZ Pointing Stability. The ACS pointing stability during a multiple-orbit CVZ observation in TGM will be characterized.

II.2 WFPC2 Requirements

WFPC1. WFPC2 PSF as Function of Exposure Time. The WFPC2 PSF in Two-Gyro Mode (TGM) will be characterized for a range of exposure times from ~1 sec to ~300 sec for both PC1 and WFC in a commonly used filter.
II.3 NICMOS Requirements

NICMOS 1. NICMOS Multiaccum PSF. The NICMOS PSF for multiaccum mode will be characterized for all three cameras. The shape of the PSF will be measured as will the FWHM in various directions.

NICMOS 2. NICMOS Sub-Pixel Dithering. The ability to reconstruct subsampled images with sub-pixel dithering will be assessed.

NICMOS 3. NICMOS Coronagraphic Acquisition: Accuracy and Repeatability. The structure and stability of the coronagraphic PSF will be tested.

NICMOS 4. NICMOS Grism Observations: Line spread function. The loss of resolution for grism observations will be determined for the two gyro mode. Planetary nebulae used for wavelength calibrations will be observed.

II.4 FGS Requirements

FGS 1. FGS Guidestar Magnitude Test. Fine guiding with dominant guide star magnitudes of V=9, 13, and 14.5 shall be tested. FGS ID of dominant guider is a free parameter.

FGS 2. Monitor Jitter and Drift with FGS. The third FGS shall be used in Position mode to track a bright star, if available, in parallel with SI tests, without interfering with the prime instrument.
   –Tracking a bright star provides the highest fidelity data for monitoring jitter & drift
   –Assumes astrometry commanding is supported in F2G test.
   - dependent STScI assessment of the workload for F2G implementation

FGS 3. (TGSMOV only) Astrometry Science – Transfer Mode observation of a bright standard star in FGS1r
   –Position Mode observation of a standard astrometric cluster (e.g., M35, NGC 188)

II.5 OTA Requirements

OTA 1. HST Focus Measurement. The accuracy of the measurement of the HST focus position using well-exposed ACS/HRC and WFPC2/PC images of point sources shall be determined.
* If the accuracy is inadequate to maintain the mean HST focus position within the required 
+/- 2.5 of nominal, SMOV tests shall include different methods to measure focus, such as 
extremely short images and/or images obtained in time-tag mode.

II.6 PCS Requirements

**PCS 1. TGN Operations.** All F2G guide star acquisitions shall be preceded by typical Two 
Gyro Normal (TGN) Mode operations including T2G Attitude Hold and On-Board Attitude 
Determination (OBAD).

**PCS 2. Guide Star Magnitudes.** Actual FGS guide star magnitudes shall range from 9 mv 
to 14.5 mv. Guide stars 13 mv and fainter are preferred. [Worst-case F2G performance 
(quiescent jitter, maneuver tracking, disturbance rejection) occurs with faint guide stars.]

**PCS 3. Gx Control FGS.** The SMS shall allow each of the three FGSs at least one 
opportunity to control the F2G-FL Gx-Axis.

**PCS 4. Dominant Guide Star.** Guide star pairs specified in the SMS shall include cases 
where the primary guide star is the dominant guide star.

**PCS 5. F2G-FL Maneuver.** Perform at least one (1) Vehicle Offset Slew (Command #43) 
of at least 60 arcsec about an axis to be specified by PCS. Guide stars shall be located at FGS 
FOV positions with the lowest FGE Gain Ratio. [Tests FGS tracking performance in F2G-FL 
during worst-case #43 or #44 commands under maximum acceleration levels (0.2 arcsec/sec²) 
for at least 10 seconds.]

**PCS 6. Gyro Bias Updates.** Autonomous on-board gyro bias updates shall be enabled.

**PCS 7. Guiding Interval Duration.** At least five (5) F2G guiding intervals shall be at least 
20+ minutes in duration to allow on-board computation of Gyro Bias Updates.

**PCS 8. Overall F2G-FL Duration.** The minimum overall time in F2G-FL shall be 12 hours. 
[PCS predicts approximately 1 FGS Loss of Lock per day in F2G, but the purpose of this 
requirement is not to verify the PCS prediction. At least a half-day in F2G is of sufficient 
length to give PCS an approximate frequency of Loss of Lock.]

**PCS 9. Recorder Coverage.** Record engineering telemetry to the SSR/ESTR for the entire 
on-orbit test.

**PCS 10. Telemetry Format.** H-Format shall be preferred during F2G guiding intervals.

**PCS 11. F2G-FL Roll Accuracy.** Roll pointing errors in F2G-FL shall not exceed 0.1 
degrees rms. [Targets centered in the NIC1 aperture to within 2 arcsec rms require absolute 
roll errors not exceeding 0.1 degrees rms. Roll errors exceeding 0.1 degrees rms reduces NIC1
observation efficiency. Science observations shall target fields with known orientations from previous HST observations, and position angle of the field as observed shall be converted into a telescope roll measurement and compared with the requested roll.]

**PCS 12. FHST Usage.** FHST 3 shall be used to control the Gx-Axis in T2G prior to at least ten (10) different F2G acquisitions. [Gyros 2 and 4 and FHST 3 produces worst-case T2G jitter and tests F2G-CT performance.]

**PCS 12a. FHST Usage in TGSMOV.** PCS may specify an FHST for control of the Gx-Axis in T2G prior to at least ten (10) different F2G acquisitions.

**PCS 13. F2G Rate Gyro Pair.** Rate Gyros 2 and 4 shall be the two-gyro pair used to control the F2G Ga and Gn axes. [Gyros 2 and 4 produce worst-case F2G quiescent jitter.]
III. F2G & TGSMOV ACTIVITIES

Unless otherwise indicated, all of the following activities apply to both the F2G Test and TGSMOV.

III.1 ACS Activities

ACS01. ACS PSF and Pointing Stability TGM Test
(Requirements ACS 1a, 1d, 2, 4, 5)

A dense star cluster (47 Tuc) is observed with the HRC and WFC using a range of exposure times from 1s to 1000s.

Multiple exposures are obtained at each exposure time to test PSF, PSF stability, and pointing stability between exposures.

Exposure times 1, 10, 100, 300, and 1000s with emphasis on short and middle exposures.

Filters: visible (F606W) and UV (HRC F250W?).

No dithers.

Repeat some portion if more that one gyro failure scenario can be tested.

Possibly use auto-parallel mode (HRC F606W and WFC F625W, or WFC F606W and HRC F555W).

Possibly replace some data (e.g. repeatability testing) with STIS time-tag data if more efficient and workable.

Total 6+ orbits.

ACS02. ACS Best / Worst Case TGM Test
(Requirements ACS 1b, 1c, 2, 4, 5)

Observations are made in best and worst case HST pointing control scenarios (guide star brightness, sun angle, roll angle, etc.).

Two dense star cluster(s) with HRC F606W.

Multiple exposures 1, 10, 100 sec over two orbits per target.
Total 4 orbits.

ACS03. ACS Dither TGM Test  
(Requirements 3, 4)

A dense star cluster (47 Tuc) is observed with the HRC and F606W.

Pointing dithers are made similar to those in popular dither patterns. Repeat at least once during orbit.

Exposures ~100 sec per pointing.

Total 1 orbit.

ACS04. ACS Coronographic TGM Test  
(Requirements 6, 7)

Coronographic acquisition is performed on a bright target (with neighboring stars for astrometry) several times over two orbits with HRC.

Second orbit will demonstrate impact of occultation on ability to center target.

Observations are then repeated on second target for one orbit at same roll angle to test ability to subtract PSF wings of different targets in presence of jitter / differing guidestars.

Possibly combine with other tests if target suitable.  
Total 3 orbits.

ACS05. ACS CVZ Pointing Stability.  
(Requirement ACS 8)

- Activity summary TBD.

III.2 WFPC2 Activities

WFPC01. WFPC PSF TGM Test  
(Requirement WFPC1)

A dense star cluster (47 Tuc) is observed with exposures from 1s to 300s.

Exposure times 1, 10, 100, 300. A few images in each.
Filters F555W.

No dithers.

Do in parallel with ACS if possible.

Total <=1 orbit.

### III.3 NICMOS Activities

**NICMOS01. NICMOS Multiaccum PSF with Bright Star** (Requirement NICMOS 1) A bright star (9th magnitude) will be observed with the shortest multiaccum sequence to trace the jitter sequence with NIC1, NIC2 and NIC3 (1 orbit).

**NICMOS02 NICMOS Multiaccum PSF with Faint Star** (Requirement NICMOS 1) A relatively faint star will be observed with a long multiaccum sequence ~100 seconds for all three cameras (1 orbit)

**NICMOS03 NICMOS Sub-Pixel Dithering** (Requirement NICMOS 2) A dense star cluster will be observed with NIC1, NIC2 and NIC3 using a multiaccum sequence and will be dithered for typical dither patterns used. (1 orbit)

**NICMOS04 Coronagraphic Acquisition** (Requirement NICMOS 3) Coronographic acquisition mode will be carried out for an h=4.5 magnitude star and will be repeated for another orbit to test for stability (2 orbits)

**NICMOS05 NICMOS Grism Test** (Requirement NICMOS 4) Grism observation of HB12 for wavelength calibration. (1 orbit)

**NICMOS06 NICMOS Best/Worst Case Parallel** (Requirements NICMOS 1, 2) Peform NICMOS observations in parallel with ACS02 (AS Best / Worst Case TGM Test).

### III.4 FGS Activities

**FGS-01 FGS Guidestar Magnitude Test**

(Requirement FGS 1)

Fine guiding with dominant guide star magnitudes of V=~9, 13, and 14.5 shall be tested.

– FGS ID of dominant guider is a free parameter.

– 3 orbits if not done in parallel with other SI observations
FGS-02. Monitor Jitter and Drift with FGS. The third FGS shall be used in Position mode to track a bright star, if available, in parallel with SI tests, without interfering with the prime instrument.

– Tracking a bright star provides the highest fidelity data for monitoring jitter & drift
– Assumes astrometry commanding is supported in F2G test.

dependent STScI assessment of the workload for F2G implementation

FGS-03. (TGSMOV only) Astrometry Science—Transfer Mode observation of a bright standard star in FGS1r

– Position Mode observation of a standard astrometric cluster (e.g., M35, NGC 188)
  - One dedicated orbit
– Transfer Mode observation of a bright standard star in FGS1r
  - One dedicated orbit

III.5 OTA ACTIVITIES

OTA01 TGM FOCUS CHECK ACTIVITY
(Requirement OTA 1)

Verification of the accuracy of focus measurements will use well-exposed images of point sources in a variety of exposure times taken in both ACS/HRC and WFPC2/PC in the same filters as the current focus measurements (Proposal 10013). Focus exposures must be taken at least five orbits after major commanded repointings of the telescope, to insure that the telescope has reached thermal stability to the level possible in two-gyro mode. Focus exposures should be taken at least a day after the transition to two-gyro mode. Comparable three-gyro focus exposures taken in the same area of the sky within two days of the two-gyro test would be valuable to provide a comparison point. Compatible exposures taken for other tests can be used for the focus test as well, as long as the exposures cover a time interval of at least half orbit.

IIIL6 PCS ACTIVITIES - Except for PCS 5, the PCS requirements are assumed to be satisfied at the scheduling level by virtue of the scheduling of other activities.

PCS 5. F2G-FL Maneuver. At least one (1) Vehicle Offset Slew (Command #43) of at least 60 arcsec about an axis to be specified by PCS will be performed. Guide stars shall be located at FGS FOV positions with the lowest FGE Gain Ratio. [Tests FGS tracking performance in F2G-FL during worst-case #43 or #44 commands under maximum acceleration levels (0.2 arcsec/sec²) for at least 10 seconds.]
IV. SUMMARY TABLE.

The following table summarizes the activities identified so far for the F2g Test (Feb. 2005) and for the TGSMOV (upon entry into operational TGM). The orbit allocations are only rough estimates. Observations scheduled in parallel may prove feasible during the scheduling process. Except for PCS 5, the PCS requirements are assumed to be satisfied at the scheduling level by virtue of the scheduling of other activities.

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