Cycle 28 COS Calibration Plan
Spring Orbit Request

May 2020

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for the COS Team

Summary of COS Orbit Requested for Cycle 28
(Programs Remaining Unchanged since Cycle 27)

Title (PI)	External	Internal	Frequency (orbits x repeats)
FUV Monitors			
COS FUV Detector Dark Monitor (Dashtamirova)		260	5x52
COS FUV Gain Maps (Sahnow)		8	4x2
COS FUV Spectroscopic Sensitivity Monitor (Sankrit)	28		3x6 + 2x5
COS FUV Wavelength Scale Monitor (T. Fischer)	3		3x1
COS FUV Target Acquisition Monitor (Sahnow)	2		2x1
NUV Monitors			
COS NUV Detector Dark Monitor (Magness)		52	2 x26
COS NUV MAMA Fold Distribution (Wheeler)		1	1x1
COS NUV Spectroscopic Sensitivity Monitor (W. Fischer)	4		2x2
COS NUV Wavelength Scale Monitor (T. Fischer)	1		1x1
COS NUV Target Acquisition Monitor (Sahnow)	3		3x1
Contingency Programs			
COS FUV Characterization of Modal Gain When Changing High Voltage (Sahnow)		(2)	
COS FUV Change in Spectroscopic Sensitivity Trends (Sankrit)	(26)		
COS FUV Detector Recovery After Anomalous Shutdown (Wheeler)		(17)	
COS NUV Detector Recovery After Anomalous Shutdown (Wheeler)		(4)	
Cycle 28 Spring Request	41+ (26)	321+(25)	

Cycle 28 vs. Cycle 27

- All of the programs remain unchanging since the Cycle 27 Spring request (which included the new cenwaves G140L/800 and G160M/1533 introduced in Cycle 26 for the entire cycle).
- We have added two new contingency programs to replace the contingency requests in the COS FUV Spectroscopic Sensitivity Monitor and the COS FUV Gain Maps programs.

COS Side 2 Programs Carried Over to Cycle 28

- Programs are carried along each cycle's calibration plan (keeping the same ID) so that the impact of any changes to operating conditions can be evaluated and modifications to the programs implemented as needed.

- No changes are needed to the programs listed below at this time.

- Engineering programs (22 Internal orbits)
  - 13187 - COS Side 2 Dump Test and Verification of COS Memory Loads (1 internal orbit)
  - 13188 - COS Side 2 Science Data Buffer Check/Self-Tests for CS Buffer RAM and DIB RAM (14 internal orbits)
  - 13189 - COS Side 2 NUV Detector Recovery After MEB Side Switch (2 internal orbits)
  - 13190 - COS Side 2 FUV Detector Recovery After MEB Side Switch (4 internal orbits)
  - 13191 - COS Side 2 NUV MAMA Fold Test (1 internal orbit)

- Science programs (7 Internal + 3 external)
  - 13192 - COS Side 2 Initial NUV Channel Checkout (1 external orbits, 1 internal orbit)
  - 13193 - COS Side 2 Initial FUV Checkout (2 external orbits, 1 internal orbit)
  - 13194 - COS Side 2 Internal NUV Wavelength Verification (2 internal orbits)
  - 13195 - COS Side 2 Internal FUV Wavelength Verification (3 internal orbits)

Total Cycle 28 Carry Over: 29 internal + 3 external orbits

FUV Monitors

COS FUV Detector Dark Monitor
PI: Dzhulyia Dashtamirova

Purpose	Perform routine monitoring of FUV XDL detector dark rate. The main purpose is to look for evidence of a change in the dark rate, both to track on-orbit time dependence and to check for a developing detector problem.
Description	Monitor the FUV detector dark rate by taking TIME-TAG science exposures with no light on the detector. Five times every week a 22-min exposure is taken with the FUV detector with the shutter closed. The length of the exposures is chosen to make them fit in Earth occultations. All orbits are < 1800s. Dark rate trends can be viewed on the COS website at https://www.stsci.edu/hst/instrumentation/cos/performance/monitoring.
Fraction GO/GTO Programs Supported	89% of COS exposure time in Cycle 27.
Resources Required: Observations	260 internal orbits. All orbits < 1800s.
Resources Required: Analysis	2 FTE weeks.
Products	Provide ETC and IHB dark rate estimates, along with weekly monitoring for changes and a summary in the end of cycle ISR. Update monitor and COS webpages. As allowed by resources and necessitated by data quality: improve dark subtraction method and update bad-pixel tables.
Accuracy Goals	Obtain enough counts to track 1% level changes on timescales of ~1-3 months.
Scheduling & Special Requirements	5x / week at nominal HV during Earth occultation.
Changes from Cycle 27	No changes.

COS FUV Detector Gain Maps
PI: David Sahnow

Purpose	Obtain gain maps of the FUV detector periodically during the cycle. These data will be used to track the modal gain as a function of time.
Description	Use the deuterium lamp to illuminate the appropriate LP2/LP3/LP4 regions of the COS FUV detector at the following times: • LP4 Standard Modes: Snapshot to monitor the change in gain every 6 months (2 orbits) • LP4 G130M/1222: Snapshot to monitor the change in gain every 6 months (2 orbits) • LP3 Standard Modes: Snapshot to monitor the change in gain every 6 months (2 orbits) • LP2 Blue Modes: Snapshot to monitor the change in gain every 6 months (2 orbits)
Fraction GO/GTO Programs Supported	89% of COS exposure time in Cycle 27.
Resources Required: Observations	8 internal orbits
Resources Required: Analysis	2 FTE weeks. Existing CCI / gain map procedures will be used to process these data as part of normal gain monitoring.
Products	Gain map files. These will be used to update the GSAGTAB (and possibly the BPIXTAB), and also improve the models of gain vs. HV and gain vs. exposure.
Accuracy Goals	0.1 pulse height bin
Scheduling & Special Requirements	Every 6 months.
Changes from Cycle 27	Moved contingency orbits into separate contingency program.

COS FUV Spectroscopic Sensitivity Monitor
PI: Ravi Sankrit

Purpose	Monitor the sensitivity of each FUV grating to detect any change due to contamination or other causes. The FUV gratings are the most heavily used modes on COS and have also experienced several changes in the time-dependent spectroscopic sensitivity since launch. These trends are grating, segment, and wavelength dependent.
Description	To track the TDS as a function of wavelength we obtain exposures of two standard stars (WD0308-565 and GD71) every 2 months with all FUV gratings. The monitoring sequence consists of two visits, for a total of 5 orbits. The 2-orbit visit (GD71) covers the G130M/1096/FUVB, G160M/1533/FUVA, G160M/1577/FUVA, and G160M/1623/FUVA modes. The 3-orbit visit (WD0308-565) covers G130M/1222, G130M/1291, G130M/1327/FUVA, G130M/1055/FUVA, G160M/1533/FUVB, G160M/1577/FUVB, G160M/1623/FUVB, G140L/800, G140L/1105, and G140L/1280 modes. The standard shortest and longest wavelength settings for each grating, the G130M "blue-modes" and 1291, and the two new cenwaves are covered in the program. TDS trends can be viewed on the COS website at https://www.stsci.edu/hst/instrumentation/cos/performance/sensitivity.
Fraction GO/GTO Programs Supported	89% of COS exposure time in Cycle 27.
Resources Required: Observations	28 external orbits
Resources Required: Analysis	6 FTE weeks
Products	Time-Dependent Sensitivity reference file as necessary, update to ETC throughputs, the COS monitoring webpages, and a summary ISR
Accuracy Goals	- SNR of 15 per resel at wavelength of least sensitivity for the standard modes, SNR of 25 per resel at wavelength of most sensitivity for the blue modes. For the blue modes, this will ensure S/N > 15 for l> 1030 Å for 1096/FUVB, l>1130 Å for 1055/FUVA and 1222/FUVB. SNR of 5 per resel in the short wavelength region for G140L/800, which yields SNR of 32 per 20 Å bin (used in the TDS analysis). - TDS calibration better than 2% for standard modes and 10% for blue modes
Scheduling & Special Requirements	• Monitoring sequence should occur every 2 months starting in December 2020 • The FUVA turn-off of the GD71 visit should be hidden in the GS-ACQ • GD71 is not visible from late April to early August 2021, resulting in a reduced monitoring sequence for the month of June (1 visit)
Changes from Cycle 27	Moved contingency orbits into separate contingency program.

COS FUV Wavelength Scale Monitor
PI: Travis Fischer

Purpose	This program monitors the offset (zero-point) between the wavelength scale set by the internal wavecal versus that defined by absorption lines in external target AV 75 obtained through the PSA.
Description	This program monitors the zero-point offset between the internal and external wavelength scales. To verify and monitor this, the program takes spectra of AV 75 with the G130M/1096-1222-1291-1327, G160M/1577-1623, and G140L/1105-1280 cenwaves. Spectra are compared to convolved STIS spectra and those obtained with previous iterations of the program.
Fraction GO/GTO Programs Supported	89% of COS exposure time in Cycle 27.
Resources Required: Observations	3 external orbits
Resources Required: Analysis	4 FTE weeks
Products	Update of wavelength dispersion reference file, if necessary, and a summary ISR
Accuracy Goals	G140L 150 km/s, 9 pixels G130M 7.5 km/s, 3 pixels (G130M/1096 15 km/s, 6 pixels) G160M 7.5 km/s, 3 pixels
Scheduling & Special Requirements	Executes once per cycle. ORIENT is set to avoid bright field targets, so visibility is restricted. March (15 days): preferred window to maintain pattern of ~12 months between visits.
Changes from Cycle 27	No changes.

COS FUV Target Acquisition Monitor
PI: David Sahnow

Purpose	Monitor COS FUV ACQ/PEAKD and PEAKXD Performance at LP4 (with NUM_POS > 1).
Description	At LP4 the cross-dispersion (XD) target acquisition (TA) uses the NUM_POS > 1 algorithm for ACQ/PEAKXD. This is the same algorithm used for ACQ/PEAKD, but oriented in the XD direction. Because there are detector effects such as gain sag and Y-walk, and areas of the detector with non-uniform response, it is desirable to monitor the FUV PEAKXD centering over multiple cycles to watch for unexpected changes. Each FUV grating is tested, and the G130M test includes an along-dispersion ACQ/PEAKD to verify the NUV-to-FUV LP4 SIAF entries in both AD and XD.
Fraction GO/GTO Programs Supported	~3% of Cycle 27 target acquisitions used the FUV channel.
Resources Required: Observations	2 external orbits.
Resources Required: Analysis	1 FTE weeks for analysis and documentation.
Products	Summary ISR.
Accuracy Goals	FUV Spectroscopic XD TAs are required to center the target to within ±0.3" (~ ±3 rows), with the goal of routine centering to ± 0.1" (~ 1 row). Targets not centered to within 0.3" are subject to vignetting and loss of spectral resolution. Along-dispersion centering requirements are cenwave-specific, but the strictest requirement is ±0.106" for the G130M grating.
Scheduling & Special Requirements	Executes annually, and should execute within ± 30 days from Visit PB of NUV program (same target).
Changes from Cycle 27	No changes.

NUV Monitors

COS NUV Detector Dark Monitor
PI: Camellia Magness

Purpose	Perform routine monitoring of the MAMA detector dark current. The main purpose is to look for evidence of a change in the dark rate, both to track on-orbit time dependence and to check for a developing detector problem.
Description	Monitor the NUV detector dark rate by taking TIME-TAG science exposures without illuminating the detector. Twice every other week a 22-min exposure is taken with the NUV (MAMA) detector with the shutter closed. The length of the exposures is chosen to make them fit in Earth occultation. All orbits are < 1800s. Dark rate trends can be viewed on the COS website at https://www.stsci.edu/hst/instrumentation/cos/performance/monitoring.
Fraction GO/GTO Programs Supported	11% of COS total exposure time in Cycle 27.
Resources Required: Observations	52 internal orbits. All orbits < 1800s.
Resources Required: Analysis	2 FTE weeks.
Products	Provide ETC and IHB dark rate estimates, along with weekly monitoring for changes and a summary in the end of cycle ISR. As allowed by resources and necessitated by data quality: update bad-pixel tables. Update monitor webpage
Accuracy Goals	30%
Scheduling & Special Requirements	Twice every other week, in Earth occultation
Changes from Cycle 27	No changes.

COS NUV MAMA Fold Distribution
PI: Thomas Wheeler

Purpose	The fold analysis provides a measurement of the distribution of charge cloud sizes incident upon the anode providing some measure of changes in the pulse-height distribution of the MCP and, therefore, MCP gain.
Description	While globally illuminating the detector with a flat field, the valid event (VE) rate counter is monitored while various combinations of row and column folds are selected.
Fraction GO/GTO Programs Supported	~97% of Cycle 27 target acquisitions use the NUV.
Resources Required: Observations	1 internal orbit
Resources Required: Analysis	0.5 FTE day.
Products	The results are sent to the COS Team and Ball Aerospace (Steve Franka)
Accuracy Goals	5% accuracy on the peak position of the fold distribution
Scheduling & Special Requirements	This proposal is executed annually.
Changes from Cycle 27	No changes.

COS NUV Spectroscopic Sensitivity Monitor
PI: Will Fischer

Purpose	Monitor sensitivity of NUV gratings to detect any change due to contamination or other causes. Track time dependence of the sensitivity with wavelength. The NUV gratings on COS have degraded at an overall steady rate since the start of on-orbit operations, with the bare-Aluminum gratings (G225M and G285M) degrading at a faster rate (~-3 and -11%/yr) than the MgF_2 coated gratings (G185M and G230L, ~0%/yr).
Description	This program obtains exposures with NUV gratings using external targets WD1057+719 (G230L) and G191B2B (G185M, G225M). The following modes are monitored: G230L/2635-2950, G185M/1786-1921-2010, and G225M/2186-2306-2410. Due to its rapidly declining sensitivity, G285M was removed from the monitoring in Cycle 26. These cenwaves constitute the reddest, middle, and bluest central wavelengths containing only first-order light, with the exception of G230L. Current data indicate a wavelength dependence of the TDS. To better characterize this effect, observations of G185M/2010 and G225M/2306-2410 were added to the monitoring program in Cycle 24 to provide data at both the extreme cenwaves and the middle cenwaves for the M gratings. Data from another cycle are needed before reliable fits and conclusions can be made. TDS trends can be viewed on the COS website at https://www.stsci.edu/hst/instrumentation/cos/performance/sensitivity.
Fraction GO/GTO Programs Supported	11% of COS total exposure time in Cycle 27
Resources Required: Observations	4 external orbits - 2 visits of 2 orbits each.
Resources Required: Analysis	5 FTE weeks
Products	Time-Dependent Sensitivity Reference File and a summary ISR. As permitted by resources and data quality: add wavelength dependence to TDS reference files.
Accuracy Goals	Characterize evolution of TDS within 2% .
Scheduling & Special Requirements	Observe at 6 month intervals.
Changes from Cycle 27	No changes.

COS NUV Wavelength Scale Monitor
PI: Travis Fischer

Purpose	This program monitors the offset (zero-point) between the wavelength scale set by the internal wavecal versus that defined by absorption lines in external target HD 6655 obtained through the PSA.
Description	This program monitors the zero-point offset between the internal and external wavelength scales. To verify and monitor this, the program takes spectra of HD 6655 with the G185M/2010, G225M/2217, and G230L/2635-2950-3000 cenwaves. Spectra are compared to convolved STIS spectra and those obtained with previous iterations of the program.
Fraction GO/GTO Programs Supported	11% of COS total exposure time in Cycle 27.
Resources Required: Observations	1 external orbit. Schedulability is set to 60% to fit all observations within the orbit.
Resources Required: Analysis	3 FTE weeks
Products	Update of wavelength dispersion reference file, if necessary, and a summary ISR
Accuracy Goals	G230L 175 km/s, 2.0-3.7 pixels G185M 15 km/s, 1.7-2.4 pixels G225M 15 km/s, 2.3-3.2 pixels
Scheduling & Special Requirements	Executes once per cycle. Star is in a crowded field, and all the stars have significant proper motion. Careful selection of guide stars is required. Aug/Sept (31 days): preferred window to maintain pattern of ~12 months between visits, acquire good GS pair
Changes from Cycle 27	No changes.

COS NUV Target Acquisition Monitor
PI: David Sahnow

Purpose	Monitor COS NUV Target Acquisition (TA) Parameters and Performance. Measure/monitor the WCA-to-PSA/BOA offsets used for imaging target acquisition, and WCA-to-PSA offsets for NUV spectroscopic TAs.
Description	There are 4 NUV ACQ/IMAGE mechanism combinations: 2 science apertures (SAs: PSA & BOA) x 2 mirror modes (MIRRORA & MIRRORB). During SMOV, the WCA-to-PSA+MIRRORA offset was determined by an aperture scan; the other WCA-to-SA offsets were bootstrapped from this offset. We verify the ACQ/IMAGE co-alignment in a similar manner. Three targets of different brightnesses are required to bootstrap across the pairings. All NUV spectroscopic WCA-PSA offsets, all WCA-SA imaging offsets, and co-alignment for all ACQ/IMAGE modes are monitored by this program. PSA spectra of the targets are obtained with all NUV gratings to track any changes in the spectroscopic WCA-to-PSA offsets as a function of time.
Fraction GO/GTO Programs Supported	~97% of Cycle 27 target acquisitions used the NUV.
Resources Required: Observations	3 external one-orbit visits. Each visit uses a target of different brightness to match the ACQ/IMAGE modes being verified.
Resources Required: Analysis	2 FTE weeks for analysis, and verifying WCA-to-SA offsets. Should changes be warranted to existing offsets, additional effort will be needed, as this requires changes to the COS flight software (FSW) or SIAF.
Products	Updated NUV imaging WCA-to-SA offsets, NUV Spectroscopic WCA-to-PSA offsets and summary ISR.
Accuracy Goals	Imaging WCA-to-SA offsets need to be known to better than 0.5 NUV pixels in both dispersion and cross-dispersion (XD). Spectroscopic WCA-to-PSA offsets to 0.5 XD pixel.
Scheduling & Special Requirements	Executes annually (in the Fall). All three visits should execute within 30 days of each other.
Changes from Cycle 27	No changes.

Contingency Programs

COS FUV Change in Spectroscopic Sensitivity Trends
PI: Ravi Sankrit

Purpose	To supplement the COS FUV Spectroscopic Sensitivity Monitor that runs every 2 months in the event that TDS trends change rapidly. With the extra orbits in this program, the TDS trends will be observed monthly.
Description	To track the TDS as a function of wavelength we obtain exposures of two standard stars (WD0308-565 and GD71) every 2 months with all FUV gratings. This program, along with the standard COS FUV Spectroscopic Sensitivity monitor (which also runs every 2 months), will increase the TDS monitoring observations to be monthly. This program will be activated if we find the TDS trends changing and need to increase our monitoring cadence. The monitoring sequence consists of two visits, for a total of 5 orbits. The 2-orbit visit (GD71) covers the G130M/1096/FUVB, G160M/1533/FUVA, G160M/1577/FUVA, and G160M/1623/FUVA modes. The 3-orbit visit (WD0308-565) covers G130M/1222, G130M/1291, G130M/1327/FUVA, G130M/1055/FUVA, G160M/1533/FUVB, G160M/1577/FUVB, G160M/1623/FUVB, G140L/800, G140L/1105, and G140L/1280 modes.
Fraction GO/GTO Programs Supported	89% of COS exposure time in Cycle 27.
Resources Required: Observations	26 external orbits
Resources Required: Analysis	6 FTE weeks
Products	These data will be used along with the data obtained in the COS FUV Spectroscopic Sensitivity Monitor to create a new Time-Dependent Sensitivity reference file, update ETC throughputs, update the COS monitoring webpages, and write a summary ISR.
Accuracy Goals	- SNR of 15 per resel at wavelength of least sensitivity for the standard modes, SNR of 25 per resel at wavelength of most sensitivity for the blue modes. For the blue modes, this will ensure S/N > 15 for l> 1030 Å for 1096/FUVB, l>1130 Å for 1055/FUVA and 1222/FUVB. SNR of 5 per resel in the short wavelength region for G140L/800, which yields SNR of 32 per 20 Å bin (used in the TDS analysis). - TDS calibration better than 2% for standard modes and 10% for blue modes
Scheduling & Special Requirements	• The extra monitoring sequence should occur every 2 months starting in the month the program is activated and should be the alternate month of the standard COS FUV TDS program • The FUVA turn-off of the GD71 visit should be hidden in the GS-ACQ • GD71 is not visible from late April to early August 2021, resulting in a reduced monitoring sequence for the months of May and July (1 visit)
Changes from Cycle 27	This is a new program that contains 26 contingency orbits that were previously included as a part of the COS FUV Spectroscopy Sensitivity Monitor program.

COS FUV Characterization of Modal Gain When Changing High Voltage
PI: David Sahnow

Purpose	Obtain gain maps of the FUV detector before and after changes to the nominal high voltage levels. These data will be used to check that the expected modal gain is achieved for HV changes.
Description	Two one-orbit contingency visits will be needed for each HV change made during Cycle 28. One will be taken immediately before the change using the current HV values, and one will be taken after at the new value. The deuterium lamp will be used to illuminate the regions of the COS FUV detector currently in use.
Fraction GO/GTO Programs Supported	89% of COS exposure time in Cycle 27.
Resources Required: Observations	2 internal orbits
Resources Required: Analysis	1 FTE week. Existing CCI / gain map procedures will be used to process these data as part of normal gain monitoring.
Products	Gain map files. These will be used to check that the expected modal gain is achieved after the HV has changed.
Accuracy Goals	0.1 pulse height bin
Scheduling & Special Requirements	This is a contingency proposal only activated immediately before and immediately after any HV change.
Changes from Cycle 27	This is a new program that contains two contingency orbits that were previously included as a part of the COS FUV Gain Maps program.

COS FUV Detector Recovery after Anomalous Shutdown
PI: Thomas Wheeler

Purpose	The safe and orderly turn-on and ramping-up the COS FUV high voltage in a conservative manner after a HV anomalous shutdown.
Description	Day 01 activities, visits 01-07, contain both QE grid off and on HV ramping to HVLow (100/100) with diagnostics (DCE dumps) and darks to exclude QE grid involvement in the shutdown. Subsequent to day 01, all HV rampings, diagnostics and darks will be with the QE grid on. The HV commanded values for the subsequent days are: 154/151, 160/157, 167,163, etc. until the desired HV is obtained.
Fraction GO/GTO Programs Supported	This is a contingency proposal and only activated in the event of an anomalous shutdown of the FUV detector.
Resources Required: Observations	17 internal orbits
Resources Required: Analysis	If activated, 0.5 FTE day per test.
Products	After thorough data analysis for each test day, a Go/No-Go to proceed will be given.
Accuracy Goals	
Scheduling & Special Requirements	This is a contingency proposal activated only in the event of an anomalous shutdown.
Changes from Cycle 27	No changes.

COS NUV Detector Recovery after Anomalous Shutdown
PI: Thomas Wheeler

Purpose	The safe and orderly recovery of the NUV-MAMA detector after an anomalous shutdown.
Description	The recovery procedure consists of four separate tests (i.e. visits) to check the MAMA's health after an anomalous shutdown. Each must be successfully completed before proceeding onto the next. They are: (1) signal processing electronics check, (2) slow, intermediate voltage high-voltage ramp-up, (3) ramp-up to full operating voltage, and (4) fold analysis test.
Fraction GO/GTO Programs Supported	This is a contingency proposal and only activated in the event of an anomalous shutdown of the NUV detector.
Resources Required: Observations	4 internal orbits
Resources Required: Analysis	If activated, 0.5 FTE day per visit.
Products	For tests 1-3, only a Go/No-Go to proceed will be given. For test 4, the results will be sent to the COS Team and Ball Aerospace (Steve Franka).
Accuracy Goals	
Scheduling & Special Requirements	This is a contingency proposal activated only in the event of an anomalous shutdown.
Changes from Cycle 27	No changes.