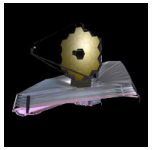

1541 - NIRISS Sensitivity and Stability for Transiting Exoplanet Observations

Cycle: 0, Proposal Category: COM/NIRISS

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OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
Observation Folder				
	1	HAT-P-14 transit (PRIMARY TARGET)	NIRISS Single-Object Slitless Spectroscopy	(2) HAT-P-14
	2	WASP-18b transit (BACKUP TARGET 1)	NIRISS Single-Object Slitless Spectroscopy	(1) WASP-18
	3	K2-34 transit (BACKUP TARGET 2)	NIRISS Single-Object Slitless Spectroscopy	(3) K2-34
	4	WASP-164b transit (BACKUP TARGET 3)	NIRISS Single-Object Slitless Spectroscopy	(4) WASP-164
	5	GR700XD Background Observation	NIRISS External Calibration	(5) ECLIPTIC-RA80

ABSTRACT

In this program, an exoplanetary primary transit will be observed in one of the two science subarrays of the NIRISS Single-Object Slitless Spectroscopy (SOSS) mode, SUBSTRIP256 in order to characterize the sensitivity and stability of the instrument for transiting exoplanet observations in the entire NIRISS/SOSS wavelength range. To this end, spectrophotometric time-series observations (TSOs) will be obtained during the transit of an exoplanet whose transmission spectrum is expected to be featureless down to the expected noise limit of the instrument. This will provide us with a known signal to extract, allowing us to thoroughly characterize the instruments' abilities to extract precise transit spectra. In addition, a key component of this activity is to be able to saturate partially (i.e., close or at the linearity limit of the instrument) or completely (i.e., with pixels reaching their full-well level) a set of pixels in a region of the subarray in the final groups of each integration. This will allow us to study (a) how these pixels respond on non-saturated groups and (b) how nearby, non-saturated pixels respond to their saturated neighbors (i.e., charge spilling).

Update Apr 14, 2022: Observation 5 added to observe zodiacal light through GR700XD to measure the SOSS background.

OBSERVING DESCRIPTION

ACTIVITY TITLE: NIRISS Sensitivity and Stability for Transiting Exoplanet Observations (NIS-034)

DESCRIPTION

In this activity, an exoplanetary primary transit will be observed in one of the two science subarrays of the NIRISS Single-Object Slitless Spectroscopy (SOSS) mode, SUBSTRIP256 (chosen as to be able to extract spectra from the 1st and 2nd orders, which will in turn allow us to characterize the entire SOSS wavelength range) in order to characterize the sensitivity and stability of the instrument for transiting exoplanet observations. To this end, spectrophotometric time-series observations (TSOs) will be obtained during the transit of an exoplanet whose transmission spectrum is expected to be featureless down to the expected noise limit of the instrument. This will provide us with a known signal to extract, allowing us to thoroughly characterize the instruments' abilities to extract precise transit spectra. In addition, a key component of this activity is to be able to saturate partially (i.e., close or at the linearity limit of the instrument) or completely (i.e., with pixels reaching their full-well level) a set of pixels in a region of the subarray in the final groups of each integration. This will allow us to study (a) how these pixels respond on non-saturated groups and (b) how nearby, non-saturated pixels respond to their saturated neighbors (i.e., charge spilling).

This program aims to obtain a ~6-hour science exposure with the GR700XD+CLEAR configuration targeting a transit of an exoplanet, including baseline before and after the event. The time of this science exposure was calculated considering 0.75 hrs. for initial settling time, in addition to T14/2 hours pre-transit (with T14 being the total transit duration), and an additional T14/2 hours post-transit, to which we added an extra hour in order to account for the selected phase-constraint window of one hour. In addition to this, we have also added an exposure using the F277W filter in order to isolate the red end of the 1st-order spectrum.

The original selected target for this program was WASP-18 (J = 8.41; 1000 integrations, 3 groups per integration --- observable in the August-December time-frame), but this had to be changed due to the JWST launch delay of Dec 18, 2021 to HAT-P-14 (J = 9.09; 572 integrations, 6 groups per integration --- observable in the March-September time-frame). The motivation for selecting the original target were several. First, the target is right at the bright limit of what can be observed on SUBSTRIP256 (i.e., no level of saturation is reached in the first group), and thus represents the brightest object with which spectrophotometry can be obtained in this subarray. Second, its transmission spectrum is predicted to be featureless down to the noise level of the instrument (~20-30 ppm amplitudes), due to its massive nature and correspondingly small atmospheric scale-height. Third, the orbital properties of the system (Period P = 0.94 days, T14 = 2.2 hours) and location on the sky of the target makes it a relatively easy event to schedule. Simulations using STScI's NIRISS/SOSS simulator (awesimsoss) predict pixels reaching the linearity limit will be observed on the second group, whereas pixels reaching the full- well levels are only reached in the third group (see Figure 1 of the CAR). Thus, pixels in a region of the subarray will be experiencing all levels of saturation, which would have fit perfectly with the objectives desired to be reached in this activity. These count levels were consistent with the ones found with the JWST ETC.

While the new target selected for this program, HAT-P-14, is fainter than WASP-18 and has a longer period (P = 4.63), it still retains the majority of the properties that made WASP-18 such a great target. For HAT-P-14b we also predict a relatively featureless transmission spectrum, which is enhanced only because of an AO-detected contaminant (Ngo et al., 2015ApJ...800..138N; implying ~20-30 ppm amplitudes on a flat spectrum). Being the transit duration of this exoplanet the same as that of WASP-18b (T14 = 2.2 hours), using this exoplanet instead of WASP-18b leads to a very similar total science exposure time. Given its fainter nature, the number of groups per integration had to be increased in order to reach the saturated region that we are aiming to generate in this activity. We have ingested our best current estimate in this APT file. This is the target that should be used instead of WASP-18 if at all possible.

In addition to these two targets, we have also added two additional possible backup targets. The first is K2-34 (J=10.53; 236 integrations, 16 groups per integration). This target is fainter than both WASP-18 and HAT-P-14, but saturation can nonetheless be achieved as well with a sufficiently large

number of groups. We expect a flat transmission spectrum as well due to the massive nature of the exoplanet, and the relatively large radii of the stellar host. The transit duration is slightly larger than for WASP-18b and HAT-P-14b (T14 = 2.49 hours); we have thus slightly decreased the time out-of-transit in order to keep the program's requested time consistent with that asked for WASP-18 and HAT-P-14. The period of this exoplanet is relatively short (P = 2.99 days), allowing for multiple opportunities to schedule a transit. We again believe an adjustement on the number of groups will be necessary once on-sky data is obtained so that we achieve saturation in our integrations. We have ingested our best current estimate in this APT file. This target should be observed only if HAT-P-14 and WASP-18 observations cannot be scheduled. Finally, we also added WASP-164 (J=11.36; 128 integrations, 30 groups per integration). This is the fainter target of our backup set, but is also the only observable transiting exoplanet with an expected transmission signal low enough that we would confidently expect a flat transmission spectrum. Its period and transit duration, however, are small enough (P = 1.77; T14 = 1.60 hours) that it should be as easy to schedule as WASP-18. We will most likely not reach saturation with this target due to flux of the target itself, but saturation is expected to be reached randomly in the detector due to cosmic ray hits. We nonetheless believe an adjustement on the number of groups will be necessary once on-sky data is obtained. We have ingested our best current estimate in this APT file. This target should be observed only if K2-34 observations cannot be scheduled.

ACTIVITY EXECUTION METHOD: OPE Commanding.

PRE-REQUISITES AND DEPENDENCIES:

1. NIS-017 GR700XD Flux Calibration (1091) has executed successfully.

CRITICAL START WINDOW? Yes

IF YES, NO-LATER-THAN START TIME: N/A (window in phase: 1 hour)

REAL-TIME CONTACT REQUIRED? No

DURATION: The total duration of the program depends slightly on the final target that is scheduled. For all targets, 6.1 hours are spent on the science integrations (3 groups per integration, with 0.1, 0.1, 0.3 and 0.5 hours spent on the F277W exposures for WASP-18, HAT-P-14, K2-34 or WASP-164, respectively. The total charged time for these integrations is thus about 7 hours. All exposures are not dithered to mimic the normal science operations. The readout pattern is NISRAPID for all integrations in all cases. To avoid contamination from other stars in the field, whose spectra could overlap with our target spectra, a range in orientation (PA) for all targets were calculated using ExoCTK’s Contamination Overlap tool, which was initially developed by D. Lafrenière (U de Montréal). The angles minimize spectral overlap from sources identified in the 2MASS

catalogue with magnitudes down to J~16 that fall inside and just outside the NIRISS FOV. For HAT-P-14, we have also considered Gaia sources not detected by 2MASS in the contamination calculations.

The target acquisition will be performed on the science target using the SUBTASOSS subarray, on the SOSSFAINT Acquisition Mode for all targets. We decide here to obtain one integration with 19 groups for HAT-P-14, which is about 60% from saturation (34 groups). This should give a SNR of about 400, which is excellent for the purposes of centroiding.

DATA REQUIREMENTS: The data volume will be about 3.7 GB for either of the targets.

ANALYSIS & EXPECTED RESULTS: These observations will allow us to characterize the TSO capabilities of the instrument on a real transiting exoplanet observation. Time-correlated noise sources on time-scales of a typical transit duration (2-3 hours) will be able to be characterized. The behavior during the TSO exposure of saturated (or close to saturated) pixels will be able to be studied, along with the behavior of nearby pixels in the center and outside the traces (see Figure 1 of the CAR). These quantities will inform us of the science readiness of the instrument for transiting exoplanet observations, along with the true, on- sky bright limits of the instrument. This will in turn inform the instrument team (and thus observers) on the capabilities of the instrument on bright sources on the full dynamic range of the instrument.

IS YOUR INSTRUMENT DRIVING TELESCOPE POINTING? Yes

IS THIS ACTIVITY PREFERABLY DONE IN PARALLEL? No

COMMENTS:
1. This commissioning activity is complementary to the NIS-017 activity. The main differences are (a) the study of the bright limits of the instrument and (b) the actual TSO capabilities on a real transiting exoplanet observation (which involves an actual astrophysical signal to be extracted, along with a slightly longer science exposure).
2. Updated version that includes feedback from the PIT meeting of May 6, 2020 (Action item 95).
3. Updated version with new targets to cover gaps in the schedule due to JWST launch delay.
4. Updated version adds tigher limits on the PA ranges to avoid contamination on HAT-P-14 from Gaia sources as well as 2MASS sources. It also updates the ephemerides thanks to TESS data --- this gave a time-of-transit uncertainty of 1-minute on May 26, 2022. Finally, it places HAT-P-14 as the primary target, assuming a launch date on the December-January period.

September 24, 2021.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	WASP-18	RA: 01 37 25.0708 (24.3544617d) Dec: -45 40 40.06 (-45.67779d) Equinox: J2000	Proper Motion RA: 0.002408593746637531 sec of time/yr Proper Motion Dec: 0.020597 arcsec/yr Epoch of Position: 2015.5	
	Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. *Category=Star* *Description=[Exoplanet Systems, Exoplanets, F dwarfs, F stars]* *Extended=NO*			
(2)	HAT-P-14	RA: 17 20 27.8812 (260.1161717d) Dec: +38 14 31.81 (38.24217d) Equinox: J2000	Proper Motion RA: 1.9022116831581468E-4 sec of time/yr Proper Motion Dec: -0.006714000005558773 arcsec/yr Epoch of Position: 2015.5	
	Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. *Category=Star* *Description=[Exoplanet Systems, Exoplanets, F dwarfs, F stars]* *Extended=NO*			
(3)	K2-34	RA: 08 30 18.8936 (127.5787233d) Dec: +22 14 9.31 (22.23592d) Equinox: J2000	Proper Motion RA: -0.0010224348723513407 sec of time/yr Proper Motion Dec: 0.001046 arcsec/yr Epoch of Position: 2015.5	
	Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. *Category=Star* *Description=[Exoplanet Systems, Exoplanets, F dwarfs, F stars]* *Extended=NO*			
(4)	WASP-164	RA: 22 59 29.6611 (344.8735879d) Dec: -60 26 52.15 (-60.44782d) Equinox: J2000	Proper Motion RA: 0.002727810888667905 sec of time/yr Proper Motion Dec: -0.0021929999320491333 arcsec/yr Epoch of Position: 2015.5	
	Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. *Category=Star* *Description=[Exoplanet Systems, Exoplanets, F dwarfs, F stars]*			
(5)	ECLIPTIC-RA80	RA: 08 16 24.2140 (124.1008917d) Dec: +19 13 52.54 (19.23126d) Equinox: J2000		
	Comments: *Category=Calibration* *Description=[External flat field]*			

Observation

Proposal 1541, Observation 1: HAT-P-14 transit (PRIMARY TARGET) Thu Apr 14 21:01:16 GMT 2022

Diagnostic Status: Warning

Observing Template: NIRISS Single-Object Slitless Spectroscopy

Comments: This object is to be observed instead of WASP-18b in case the comissioning window for this program does not match any transit of WASP-18b.

Diagnostics

(HAT-P-14 transit (PRIMARY TARGET) (Obs 1)) Warning (Form): Exposure Duration exceeds the limit of 10000.0 seconds. Above this limit it is possible that a High Gain Antenna move may occur during the exposure.

(Exposure) Warning (Form): Exposure Duration exceeds the limit of 10000.0 seconds. Above this limit it is possible that a High Gain Antenna move may occur during the exposure.

(Visit 1:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(2)	HAT-P-14	RA: 17 20 27.8812 (260.1161717d) Dec: +38 14 31.81 (38.24217d) Equinox: J2000	Proper Motion RA: 1.9022116831581468E-4 sec of time/yr Proper Motion Dec: -0.006714000005558773 arcsec/yr Epoch of Position: 2015.5	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Star
Description=[Exoplanet Systems, Exoplanets, F dwarfs, F stars]
Extended=NO

Acquisition

#	Target	Acquisition Mode	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	SAME	SOSSFAINT	F480M	NISRAPID	19	1	1	1.024	37406

Template

Subarray	Include F277W Exposure?
SUBSTRIP256	true

Spectral Elements

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	NISRAPID	6	572	1	572	22009.691	37406
2	NISRAPID	6	10	1	10	384.785	

Special Requirements

Phase 0.9645357887086446 to 0.973539599841821 with period 4.62767 Days and zero-phase 2459030.9299226585 HJD
Aperture PA Range 74 to 97 Degrees (V3 73.43012982 to 96.43012982)
Aperture PA Range 157 to 215 Degrees (V3 156.43012982 to 214.43012982)
Aperture PA Range 268 to 270 Degrees (V3 267.43012982 to 269.43012982)
Time Series Observation
No Parallel

Observation

Proposal 1541, Observation 2: WASP-18b transit (BACKUP TARGET 1) Thu Apr 14 21:01:16 GMT 2022

Diagnostic Status: Warning

Observing Template: NIRISS Single-Object Slitless Spectroscopy

Comments: This object is the object to be observed in this comissioning program. HAT-P-14b should be observed only if WASP-18b is not able to be observed due to observatory observability constraints.

Diagnostics

(WASP-18b transit (BACKUP TARGET 1) (Obs 2)) Warning (Form): Exposure Duration exceeds the limit of 10000.0 seconds. Above this limit it is possible that a High Gain Antenna move may occur during the exposure.

(Exposure) Warning (Form): Exposure Duration exceeds the limit of 10000.0 seconds. Above this limit it is possible that a High Gain Antenna move may occur during the exposure.

(Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	WASP-18	RA: 01 37 25.0708 (24.3544617d) Dec: -45 40 40.06 (-45.67779d) Equinox: J2000	Proper Motion RA: 0.002408593746637531 sec of time/yr Proper Motion Dec: 0.020597 arcsec/yr Epoch of Position: 2015.5	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Star
Description=[Exoplanet Systems, Exoplanets, F dwarfs, F stars]
Extended=NO

Acquisition

#	Target	Acquisition Mode	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	SAME	SOSSFAINT	F480M	NISRAPID	15	1	1	0.823	37406

Template

Subarray	Include F277W Exposure?
SUBSTRIP256	true

Spectral Elements

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	NISRAPID	3	1000	1	1000	21996.48	37406
2	NISRAPID	3	15	1	15	329.947	

Special Requirements

Phase 0.82763 to 0.87193 with period 22.5948582 Hours and zero-phase 2458022.12523 HJD
Aperture PA Range 0 to 10 Degrees (V3 359.43012982 to 9.43012982)
Aperture PA Range 33 to 67 Degrees (V3 32.43012982 to 66.43012982)
Aperture PA Range 277 to 324 Degrees (V3 276.43012982 to 323.43012982)
Time Series Observation
No Parallel

Observation

Proposal 1541, Observation 3: K2-34 transit (BACKUP TARGET 2) Thu Apr 14 21:01:16 GMT 2022

Diagnostic Status: Warning

Observing Template: NIRISS Single-Object Slitless Spectroscopy

Comments: This object is to be observed instead of WASP-18b or HAT-P-14b in case the comissioning window for this program does not match any transit of WASP-18b or HAT-P-14b.

Diagnostics

(K2-34 transit (BACKUP TARGET 2) (Obs 3)) Warning (Form): Exposure Duration exceeds the limit of 10000.0 seconds. Above this limit it is possible that a High Gain Antenna move may occur during the exposure.

(Exposure) Warning (Form): Exposure Duration exceeds the limit of 10000.0 seconds. Above this limit it is possible that a High Gain Antenna move may occur during the exposure.

(Visit 3:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(3)	K2-34	RA: 08 30 18.8936 (127.5787233d) Dec: +22 14 9.31 (22.23592d) Equinox: J2000	Proper Motion RA: -0.0010224348723513407 sec of time/yr Proper Motion Dec: 0.001046 arcsec/yr Epoch of Position: 2015.5	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Star
Description=[Exoplanet Systems, Exoplanets, F dwarfs, F stars]
Extended=NO

Acquisition

#	Target	Acquisition Mode	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	3 K2-34	SOSSFAINT	F480M	NISRAPID	19	1	1	1.024	79493

Template

Subarray	Include F277W Exposure?
SUBSTRIP256	true

Spectral Elements

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	NISRAPID	16	236	1	236	22046.761	
2	NISRAPID	16	10	1	10	934.185	

Special Requirements

Phase 0.9412088641476888 to 0.9551180001021486 with period 2.995633 Days and zero-phase 2457141.35125 HJD
Aperture PA Range 90 to 104 Degrees (V3 89.43012982 to 103.43012982)
Time Series Observation
No Parallel

Observation

Proposal 1541, Observation 4: WASP-164b transit (BACKUP TARGET 3) Thu Apr 14 21:01:16 GMT 2022

Diagnostic Status: Warning

Observing Template: NIRISS Single-Object Slitless Spectroscopy

Comments: This object is to be observed instead of WASP-18b, HAT-P-14b or K2-34b in case the comissioning window for this program does not match any transit of WASP-18b, HAT-P-14b or K2-34b.

Diagnostics

(WASP-164b transit (BACKUP TARGET 3) (Obs 4)) Warning (Form): Exposure Duration exceeds the limit of 10000.0 seconds. Above this limit it is possible that a High Gain Antenna move may occur during the exposure.

(Exposure) Warning (Form): Exposure Duration exceeds the limit of 10000.0 seconds. Above this limit it is possible that a High Gain Antenna move may occur during the exposure.

(Visit 4:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(4)	WASP-164	RA: 22 59 29.6611 (344.8735879d) Dec: -60 26 52.15 (-60.44782d) Equinox: J2000	Proper Motion RA: 0.002727810888667905 sec of time/yr Proper Motion Dec: -0.0021929999320491333 arcsec/yr Epoch of Position: 2015.5	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Star
Description=[Exoplanet Systems, Exoplanets, F dwarfs, F stars]

Acquisition

#	Target	Acquisition Mode	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	4 WASP-164	SOSSFAINT	F480M	NISRAPID	19	1	1	1.024	79494

Template

Subarray	Include F277W Exposure?
SUBSTRIP256	true

Spectral Elements

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	NISRAPID	30	128	1	128	21802.813	
2	NISRAPID	30	10	1	10	1703.345	

Special Requirements

Phase 0.9167231952198461 to 0.9401692977413995 with period 1.7771255 Days and zero-phase 2457203.85378 HJD
Aperture PA Range 32 to 41 Degrees (V3 31.43012982 to 40.43012982)
Aperture PA Range 200 to 295 Degrees (V3 199.43012982 to 294.43012982)
Time Series Observation
No Parallel

Observation

Proposal 1541, Observation 5: GR700XD Background Observation Thu Apr 14 21:01:16 GMT 2022

Diagnostic Status: Warning

Observing Template: NIRISS External Calibration

Diagnostics

(Visit 5:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(5)	ECLIPTIC-RA80	RA: 08 16 24.2140 (124.1008917d) Dec: +19 13 52.54 (19.23126d) Equinox: J2000		

Comments:
Category=Calibration
Description=[External flat field]

Acquisition

#	Target
1	NONE

Template

Pointing Type
PRIME

Mosaic

Rows	Columns	Row Overlap %	Column Overlap %	Row shift	Column shift	Tile Order
6	3	92.5	92.0	0.0	0.0	DEFAULT

Dithers

#	Pattern Type	Image Dithers	Primary Dithers	Subpixel Positions	Pattern Size
1	NONE				

Spectral Elements

#	Subarray	Aperture	Filter Wheel	Pupil Wheel	Readout Pattern	Groups/Int	Integrations/Exp	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	FULL	DEFAULT APERTURE	CLEAR	GR700XD	NISRAPID	28	1	1	1	311.366	

Special Requirements	No Parallel