14110 - Charaterizing the atmosphere of the enlarged Neptune-mass planet HAT-P-26b

Cycle: 23, Proposal Category: GO

(Availability Mode: AVAILABLE)

INVESTIGATORS

Name	*Institution*	*E-Mail*
Prof. David Kent Sing (PI) (ESA Member) (Contact)	**University of Exeter**	**sing@astro.ex.ac.uk**
Prof. Jonathan Fortney (CoI) (AdminUSPI)	University of California - Santa Cruz	jfortney@ucsc.edu
Dr. Thomas M Evans (CoI) (ESA Member)	University of Exeter	tevans@astro.ex.ac.uk
Dr. Tiffany Kataria (CoI)	Jet Propulsion Laboratory	tkataria@astro.ex.ac.uk
Dr. Eric David Lopez (CoI) (ESA Member)	University of Edinburgh, Institute for Astronomy	elopez@roe.ac.uk
Dr. Nikolay Nikolov (CoI) (ESA Member)	University of Exeter	nikolov.nkn@gmail.com
Dr. Hannah Ruth Wakeford (CoI)	NASA Goddard Space Flight Center	hannah.wakeford@nasa.gov

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) HAT-P-26 CCDFLAT NONE WAVE	STIS/CCD	5	27-Apr-2016 21:03:22.0	yes
02	(1) HAT-P-26	WFC3/IR	5	27-Apr-2016 21:03:58.0	yes

10 Total Orbits Used

ABSTRACT

Using transits to obtain transmission spectra is a powerful technique to enable detailed studies of exoplanet atmospheres. The Neptune-mass exoplanet HAT-P-26b is one of a small handful of low-mass planets currently accessible to atmospheric measurements. As a large-radius Neptune-mass planet, the planet's low bulk density indicates it must have a substantial atmosphere, with a high hydrogen fraction likely. The atmosphere could have arisen from many different sources resulting in a wide range of possibilities, including ones dominated by hydrogen or heavier species such as water. As the measured mass and radius of a planet do not uniquely specify the atmospheric composition, transmission spectroscopy is the only way to further characterize its chemical makeup. The HST observations proposed here will carry out these vital initial atmospheric observations, with a broad wavelength range covering optical to near-IR sensitive to the expected atmospheric features of water, methane, sodium, potassium, and Rayleigh scattering. With only one in five low-mass exoplanets probed with HST currently showing spectral features, HAT-P-26b is one of the best current candidates likely to have large signals given its large predicted hydrogen fraction. With both optical and near-IR spectra, these observations will measure the atmospheric scale height and definitively determine if the exoplanet has an atmosphere with substantial hydrogen, as predicted by thermal evolution models. HAT-P-26b represents a bridge between the featureless spectra observed in a number of the smaller sub-Neptune/super-Earth exoplanets, and the large-amplitude features observed in hot Jupiters.

OBSERVING DESCRIPTION

With only one in five low-mass exoplanets probed with HST currently showing spectral features, HAT-P-26b is one of the best current candidates likely to have large signals given its large predicted hydrogen fraction. The HST observations proposed here will carry out these vital initial atmospheric observations, with a broad wavelength range covering optical to near-IR sensitive to the expected atmospheric features of water, methane, sodium, potassium, and Rayleigh scattering.

Our immediate scientific objectives are to:

- Characterize the Neptune-mass exoplanet HAT-P-26b by directly measuring the atmospheric scale height, distinguishing between H and metal-rich compositions
- Test the hypothesis that enlarged low-mass exoplanets have H-rich atmospheres
- Identify the expected molecular species of H2O and CH4
- Search for optical Rayleigh scattering signatures of hazes or clouds

Our further strategic scientific aims are to:

- Constrain the abundances of H2O and CH4 searching for super-solar abundances
- Probe the alkali metal and CH4 chemistry in a warm Neptune-mass planet

Observing Strategy

We will use the STIS spectrograph to cover the optical range sensitive to Rayleigh scattering and the alkali metals Na and K, as well as the WFC3 for near-IR coverage which is strongly sensitive to water and methane features. We will repeat our successful observing strategies in which we have now perfected very high S/N optical and near-IR transiting observations with HST (PI Sing: GO-12473, GO-11572, GO-11117; e.g. Sing et al. 2015, Wakeford et al. 2013). We propose to observe HAT-P-26b with both the STIS/G750L and WFC3/G141 during one transit each, each visit consisting of five consecutive orbits (10 total). The spirit of transit observations is to attempt to gather as many spectra as possible before, during, and after a transit event, with each image as identical as possible. As a transit observation consists of measuring a drop in stellar flux during the event, identical exposures are resistant to uncertainties in flat-fielding and very high photometric precisions are possible. The first orbit is expected to have systematically low flux, as consistently observed in previous STIS and WFC3 programs. This is due to telescope thermal relaxation, will likely not be utilized in our study, and is not included in our S/N calculations. This is a well-known phenomenon, and all other similar transiting HST programs over the past 14 years have adopted this strategy, which circumvents the un-correctable systematic errors in the first orbit. During a visit, two orbits will be used to determine the baseline flux, one before and one after transit, while two occur during the transit event.

Signal-To-Noise

STIS: We will use the STIS and G750L gratings to cover the wavelength range from 5500-10200 Ang and use the 52'x2' slit to minimize slit losses. As we have done for GO-12473, we will adopt exposure times close to 279 seconds, with a sub-array size of 128 for faster readout, which will give high S/N per image as well as sufficient time sampling of the HST orbital-phase trend such that it can be modeled and removed successfully. There will not be any gaps for buffer dumps. We used the ETC to calculate the count-rate and S/N levels for HAT-P-26b with the STIS G750L grating. While the ETC error budget is dominated by photon-noise, this error estimation is realistic, as the STIS instrument has repeatedly demonstrated the ability to produce near-Poisson limited high S/N photometric light-curves (see Sing et al. 2011, 2013, 2015). For each orbit, we will take 10 exposures of 279 seconds each, with 20 second overheads. For each exposure, S/N levels per resolution element of 400 at 7500 Ang are reached for the G750L.

WFC3: The visit using the WFC3/G141 will use the same observational strategy as our program GO-12473, which uses spacial scanning mode to dramatically increase observational overheads and obtain vastly higher S/N levels. During spacial scan mode, the telescope is slowly slewed in the cross-dispersion direction while the camera is exposing. The spectra become spread out over a large pixel area of the detector, providing very high S/N levels and vastly improved duty cycles. We will use exposure times close to 90 seconds, which give S/N levels between 1,414 to 1,233 per

resolution element between 1.15 to 1.65 um. With overheads and using subarray readouts, 27 exposures can be taken during each orbit.

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--------- Additional Comments ----------
STIS visits use the G750L with
Wavecal=No, as in our previous similar programs such as GO 12473 and GO 11740, such that the duty cycle and photometric precision is maximised and the thermal breathing trends can be efficiently removed, which is only possible with an uninterrupted photometric time-series.
Also as in GO 12473, the other STIS settings are set to maximize counts and reduce readout time overheads.
CR-SPLIT=NO,
Gain=4,
Sizeaxis2=128.

Visit

Proposal 14110, HAT-P-26 G750L (01), completed Thu Apr 28 01:04:03 GMT 2016

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/CCD

Special Requirements: SCHED 50%; Period 4.234516 D AND ZERO-PHASE HJD2455304.65122

Comments: HAT-P-26. G750L. STIS visit. It is essential that the five orbits be scheduled in a coninuous block, free of the SAA.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	HAT-P-26	RA: 14 12 37.5370 (213.1564042d)	Proper Motion RA: 39.1 mas/yr	V=11.76	Reference Frame: ICRS
		Dec: +04 03 36.13 (4.06004d)	Proper Motion Dec: -144.3 mas/yr		
		Equinox: J2000	Epoch of Position: 2000		

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Extended=NO

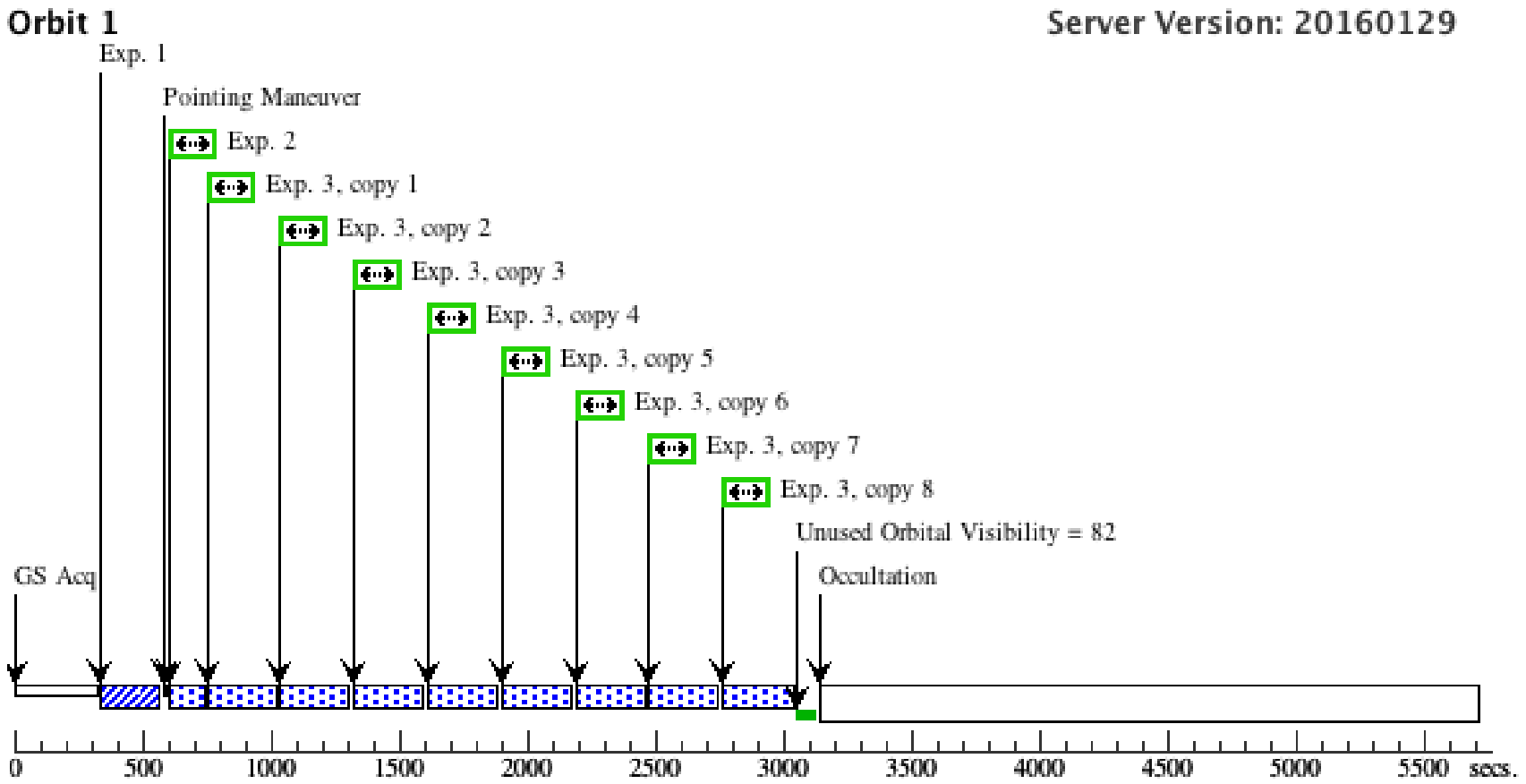
Exposures

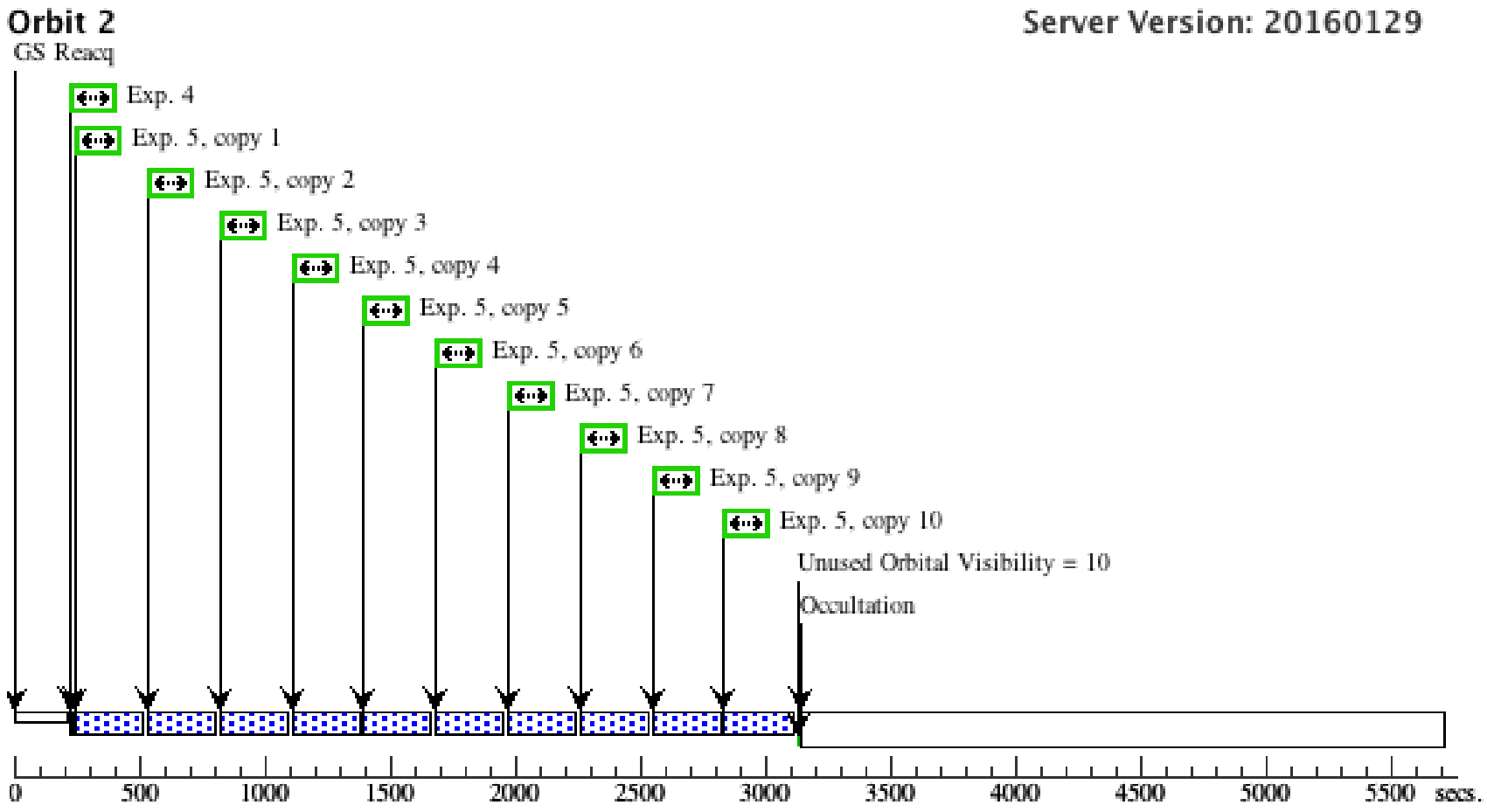
#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	ACQ, phase constrained (STIS.im.720208)	(1) HAT-P-26	STIS/CCD, ACQ, F28X50LP	MIRROR	GAIN=4	PHASE 0.9555 TO 0.9595; GS ACQ SCENARIO BASE1B3		1.5 Secs (1.5 Secs) *[==>]*	***[1]***
2	HAT-P-26 G750L Orbit 1	(1) HAT-P-26	STIS/CCD, ACCUM, 52X2	G750L 7751 A	CR-SPLIT=NO; GAIN=4; SIZEAXIS2=128.0; WAVECAL=NO			1 Secs (1 Secs) *[==>]*	***[1]***
	Comments: Short exposure to minimize instrument systematic of first exposure in each orbit.								
3	HAT-P-26 G750L Orbit 1	(1) HAT-P-26	STIS/CCD, ACCUM, 52X2	G750L 7751 A	CR-SPLIT=NO; GAIN=4; SIZEAXIS2=128.0; WAVECAL=NO			267 Secs X 8 (2136 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]*	***[1]***
4	HAT-P-26 G750L Orbit 2	(1) HAT-P-26	STIS/CCD, ACCUM, 52X2	G750L 7751 A	CR-SPLIT=NO; GAIN=4; SIZEAXIS2=128.0; WAVECAL=NO			1 Secs (1 Secs) *[==>]*	***[2]***
	Comments: Short exposure to minimize instrument systematic of first exposure in each orbit.								
5	HAT-P-26 G750L Orbit 2	(1) HAT-P-26	STIS/CCD, ACCUM, 52X2	G750L 7751 A	CR-SPLIT=NO; GAIN=4; SIZEAXIS2=128.0; WAVECAL=NO			267 Secs X 10 (2670 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]*	***[2]***
6	HAT-P-26 G750L Orbit 3	(1) HAT-P-26	STIS/CCD, ACCUM, 52X2	G750L 7751 A	CR-SPLIT=NO; GAIN=4; SIZEAXIS2=128.0; WAVECAL=NO			1 Secs (1 Secs) *[==>]*	***[3]***
	Comments: Short exposure to minimize instrument systematic of first exposure in each orbit.								

7	HAT-P-26 G750L Orbit 3	(1) HAT-P-26	STIS/CCD, ACCUM, 52X2	G750L 7751 A	CR-SPLIT=NO; GAIN=4; SIZEAXIS2=128.0; WAVECAL=NO	267 Secs X 10 (2670 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]*	***[3]***
8	HAT-P-26 G750L Orbit 4	(1) HAT-P-26	STIS/CCD, ACCUM, 52X2	G750L 7751 A	CR-SPLIT=NO; GAIN=4; SIZEAXIS2=128.0; WAVECAL=NO	1 Secs (1 Secs) *[==>]*	***[4]***
Comments: Short exposure to minimize instrument systematic of first exposure in each orbit.							
9	HAT-P-26 G750L Orbit 4	(1) HAT-P-26	STIS/CCD, ACCUM, 52X2	G750L 7751 A	CR-SPLIT=NO; GAIN=4; SIZEAXIS2=128.0; WAVECAL=NO	267 Secs X 10 (2670 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]*	***[4]***
10	HAT-P-26 G750L Orbit 5	(1) HAT-P-26	STIS/CCD, ACCUM, 52X2	G750L 7751 A	CR-SPLIT=NO; GAIN=4; SIZEAXIS2=128.0; WAVECAL=NO	1 Secs (1 Secs) *[==>]*	***[5]***
Comments: Short exposure to minimize instrument systematic of first exposure in each orbit.							
11	HAT-P-26 G750L Orbit 5	(1) HAT-P-26	STIS/CCD, ACCUM, 52X2	G750L 7751 A	CR-SPLIT=NO; GAIN=4; SIZEAXIS2=128.0; WAVECAL=NO	267 Secs X 10 (2670 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]*	***[5]***

12	WAVE	WAVE	STIS/CCD, ACCUM, 52X0.2	G750L 7751 A		*[==>]*	***[5]***
Comments: Explicit WAVECAL, auto-waves disabled to increase duty cycle							
13	Flat	CCDFLAT	STIS/CCD, ACCUM, 0.3X0.09	G750L 7751 A		*[==>(Copy 1)]* *[==>(Copy 2)]*	***[5]***
14	Tungsten Lamp	NONE	STIS/CCD, ACCUM, 0.3X0.09	G750L 7751 A	LAMP=TUNGSTEN; CR-SPLIT=NO; GAIN=4; SIZEAXIS2=128.0	240 Secs X 4 (960 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]*	***[5]***
Comments: Expected peak count level = 50,000 e-							

Orbit Structure

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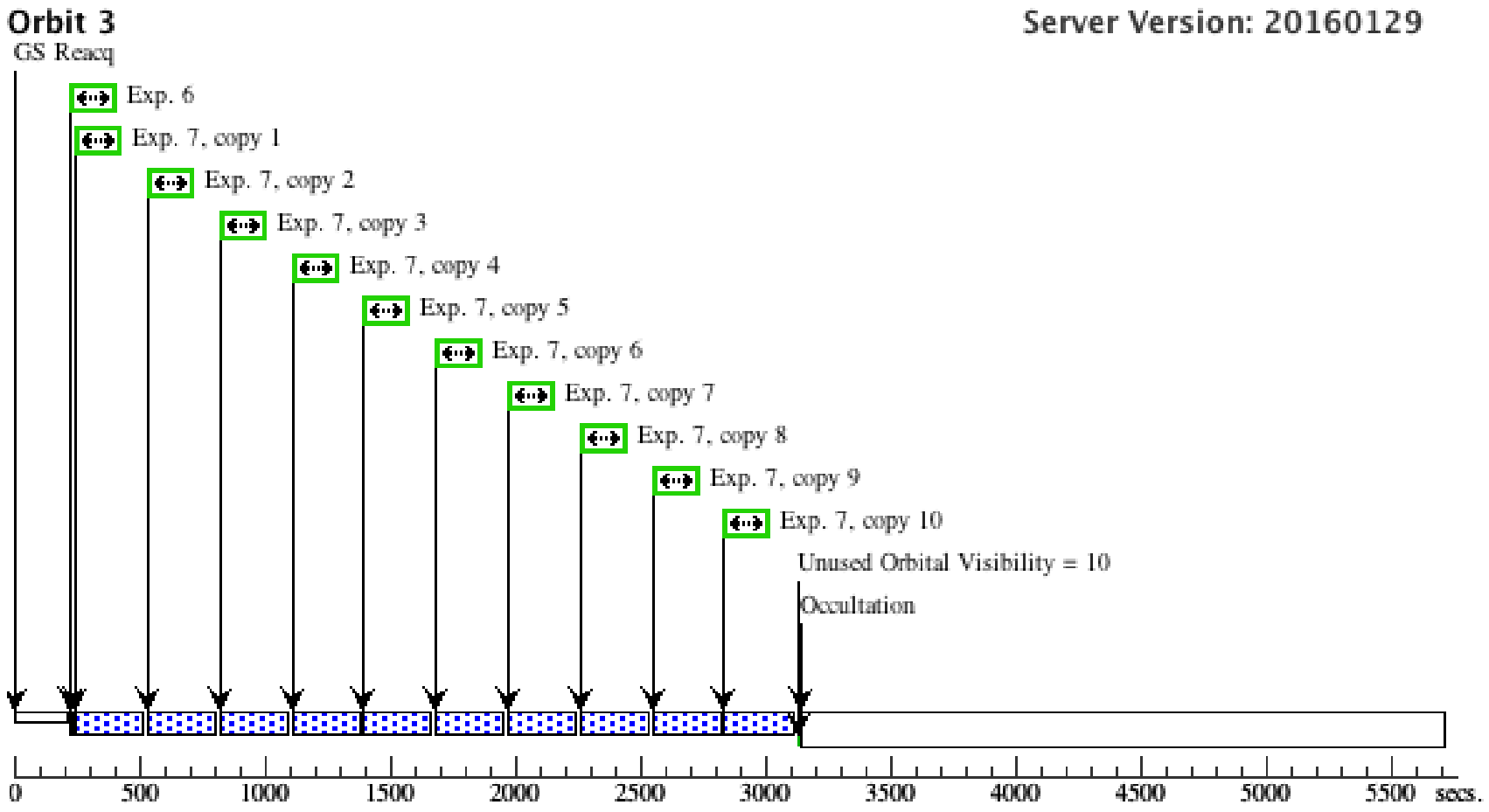
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Exp. 7, copy 4
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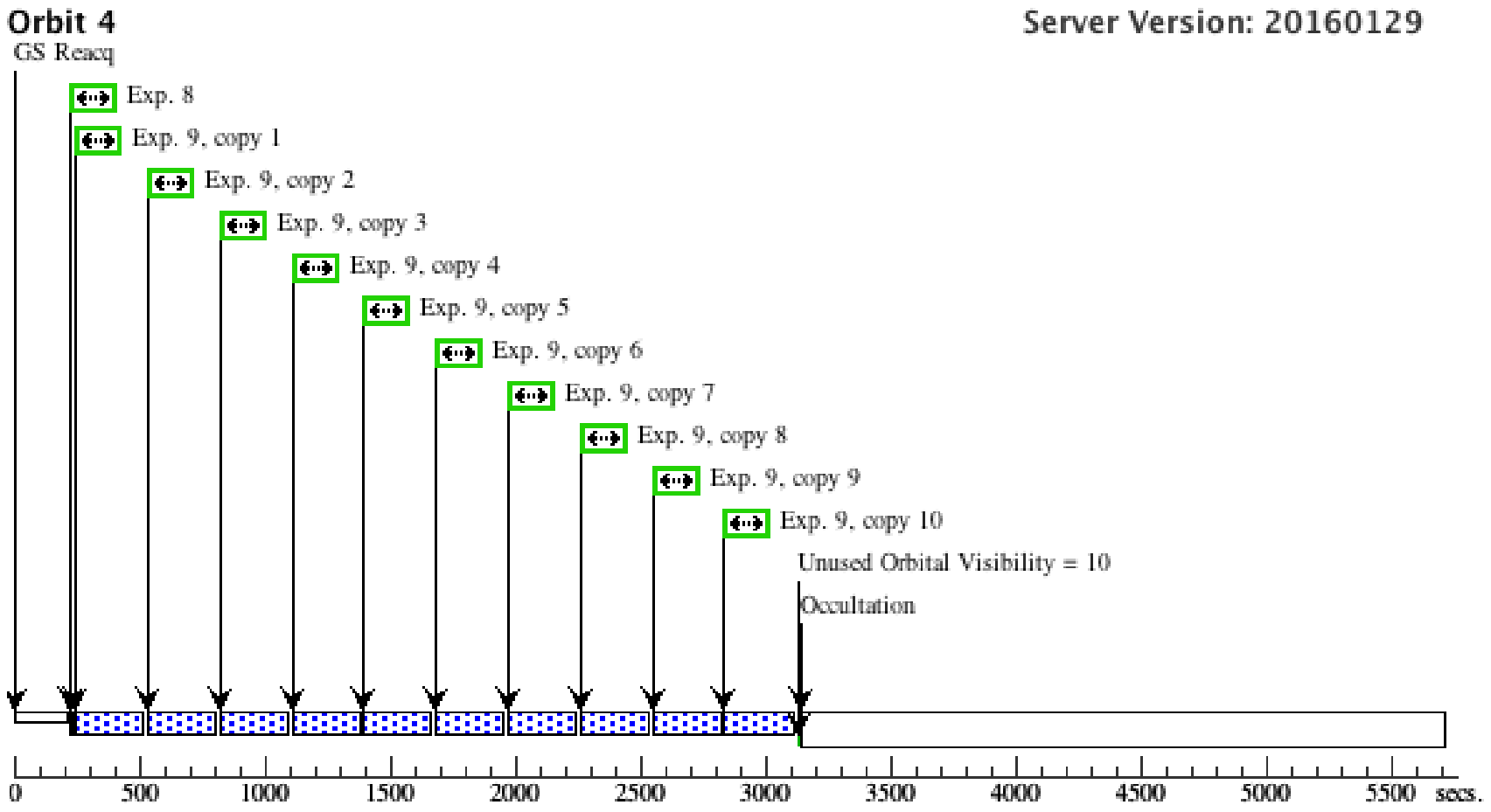
secs.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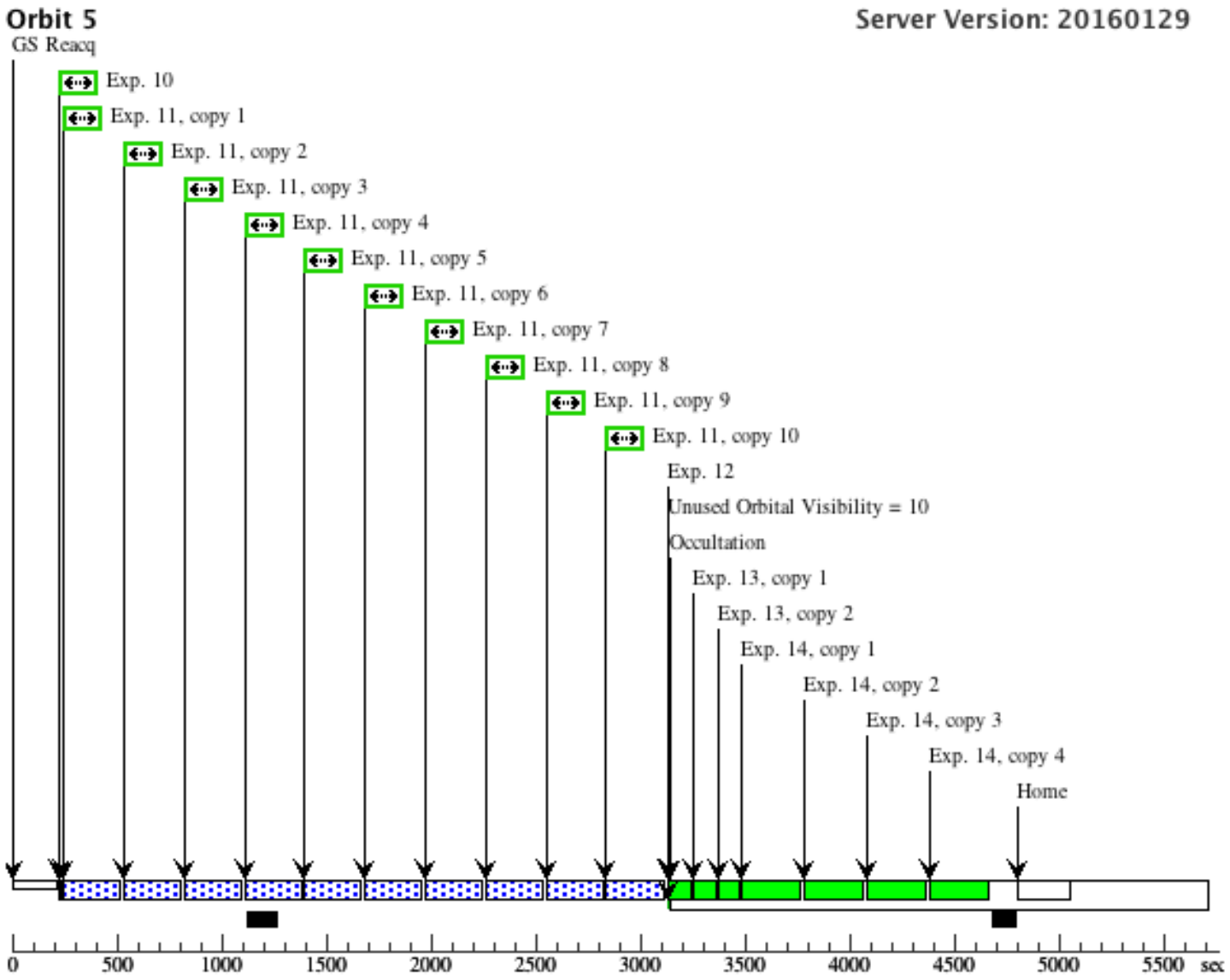
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Exp. 12
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Exp. 14, copy 3
Exp. 14, copy 4
Home
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Visit

Proposal 14110, HAT-P-26 WFC3 (02), implementation Thu Apr 28 01:04:04 GMT 2016

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: Period 4.2345005277 D AND ZERO-PHASE HJD2456363.277385

Comments: WFC3 IR transit of HAT-P-26. It is essential that the five orbits be scheduled in a coninuous block, free of the SAA.

We will use the spacial scanning mode to lengthen the spectrum along the slit during the exposures, to avoid saturation on relatively long exposures. This mode greatly increases the efficiency.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	HAT-P-26	RA: 14 12 37.5370 (213.1564042d)	Proper Motion RA: 39.1 mas/yr	V=11.76	Reference Frame: ICRS
		Dec: +04 03 36.13 (4.06004d)	Proper Motion Dec: -144.3 mas/yr		
		Equinox: J2000	Epoch of Position: 2000		

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	HAT-P-26 WFC3, phase constrained (WFC3IR.im.719990)	(1) HAT-P-26	WFC3/IR, MULTIACCUM, GRISM256	F130N	SAMP-SEQ=RAPID; NSAMP=7	PHASE 0.9540 TO 0.9595		1.944705 Secs (1.945 Secs) *[==>]*	***[1]***

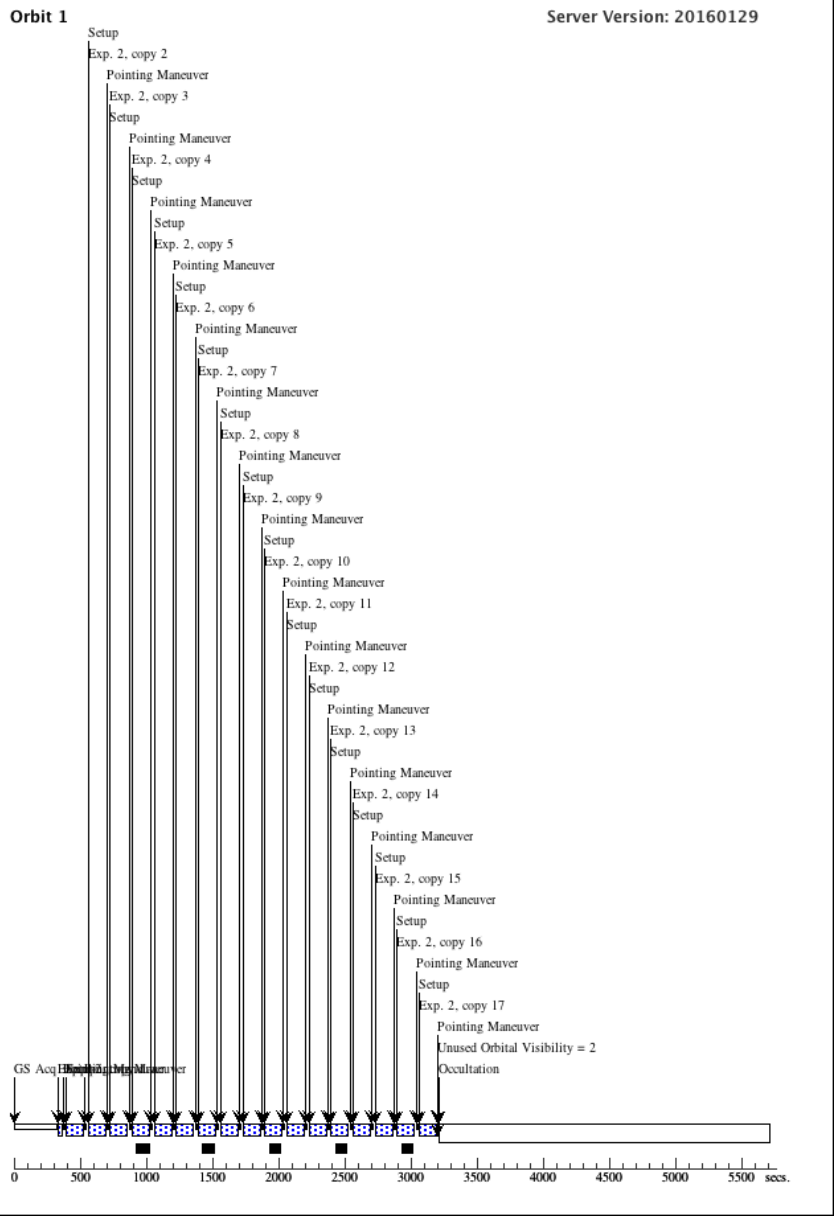
Comments: Direct image for wavelegnth calibration. Phase constrained so transit occurs between 2nd and 3rd contact.

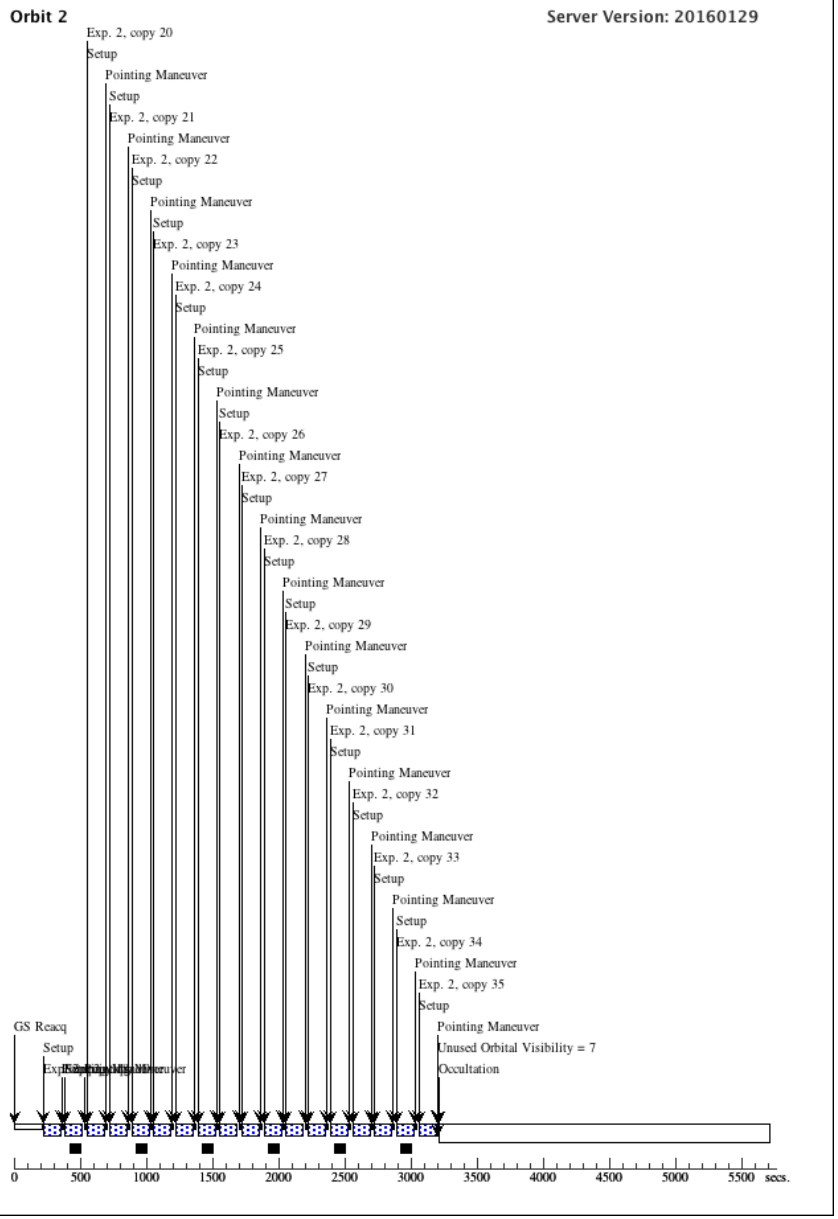
	2	HAT-P-26 WFC3 (WFC3IR.ss .770303)	(1) HAT-P-26	WFC3/IR, MULTIACCUM, GRISM256	G102	SAMP-SEQ=SPARS 10; NSAMP=15	POS TARG 0.0,0.0; SPATIAL SCAN 0.0 315,90.0 Degrees,Forward	103.128633 Secs X 89 (9178.448 Secs)	
								[==>(Copy 1)] *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]* *[==>(Copy 11)]* *[==>(Copy 12)]* *[==>(Copy 13)]* *[==>(Copy 14)]* *[==>(Copy 15)]* *[==>(Copy 16)]* *[==>(Copy 17)]*	***[1]***
								[==>(Copy 18)] *[==>(Copy 19)]* *[==>(Copy 20)]* *[==>(Copy 21)]* *[==>(Copy 22)]* *[==>(Copy 23)]* *[==>(Copy 24)]* *[==>(Copy 25)]* *[==>(Copy 26)]* *[==>(Copy 27)]* *[==>(Copy 28)]* *[==>(Copy 29)]* *[==>(Copy 30)]* *[==>(Copy 31)]* *[==>(Copy 32)]* *[==>(Copy 33)]* *[==>(Copy 34)]* *[==>(Copy 35)]*	***[2]***

		[==>(Copy 36)] *[==>(Copy 37)]* *[==>(Copy 38)]* *[==>(Copy 39)]* *[==>(Copy 40)]* *[==>(Copy 41)]* *[==>(Copy 42)]* *[==>(Copy 43)]* *[==>(Copy 44)]* *[==>(Copy 45)]* *[==>(Copy 46)]* *[==>(Copy 47)]* *[==>(Copy 48)]* *[==>(Copy 49)]* *[==>(Copy 50)]* *[==>(Copy 51)]* *[==>(Copy 52)]* *[==>(Copy 53)]*	***[3]***
		[==>(Copy 54)] *[==>(Copy 55)]* *[==>(Copy 56)]* *[==>(Copy 57)]* *[==>(Copy 58)]* *[==>(Copy 59)]* *[==>(Copy 60)]* *[==>(Copy 61)]* *[==>(Copy 62)]* *[==>(Copy 63)]* *[==>(Copy 64)]* *[==>(Copy 65)]* *[==>(Copy 66)]* *[==>(Copy 67)]* *[==>(Copy 68)]* *[==>(Copy 69)]* *[==>(Copy 70)]* *[==>(Copy 71)]*	***[4]***

		[==>(Copy 72)] *[==>(Copy 73)]* *[==>(Copy 74)]* *[==>(Copy 75)]* *[==>(Copy 76)]* *[==>(Copy 77)]* *[==>(Copy 78)]* *[==>(Copy 79)]* *[==>(Copy 80)]* *[==>(Copy 81)]* *[==>(Copy 82)]* *[==>(Copy 83)]* *[==>(Copy 84)]* *[==>(Copy 85)]* *[==>(Copy 86)]* *[==>(Copy 87)]* *[==>(Copy 88)]* *[==>(Copy 89)]*	***[5]***

Orbit Structure

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Pointing Maneuver
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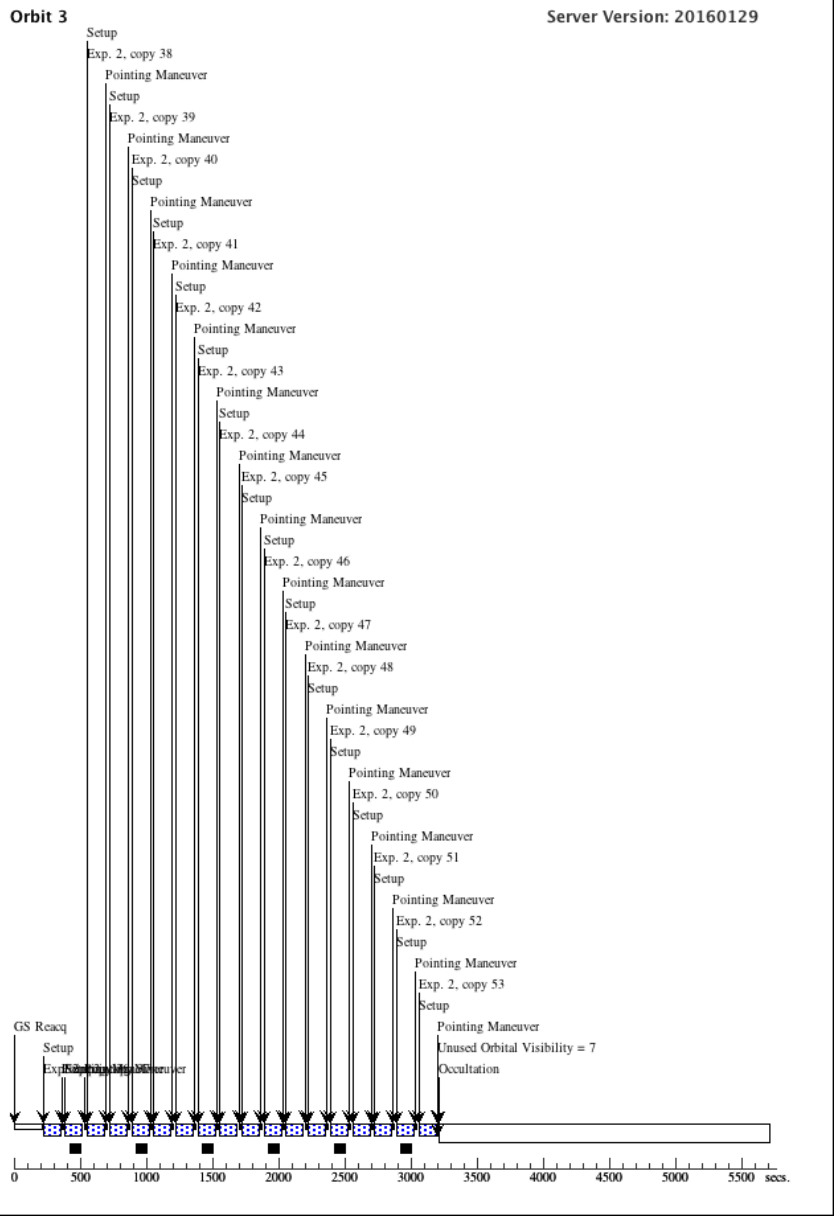
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Unused Orbital Visibility = 7
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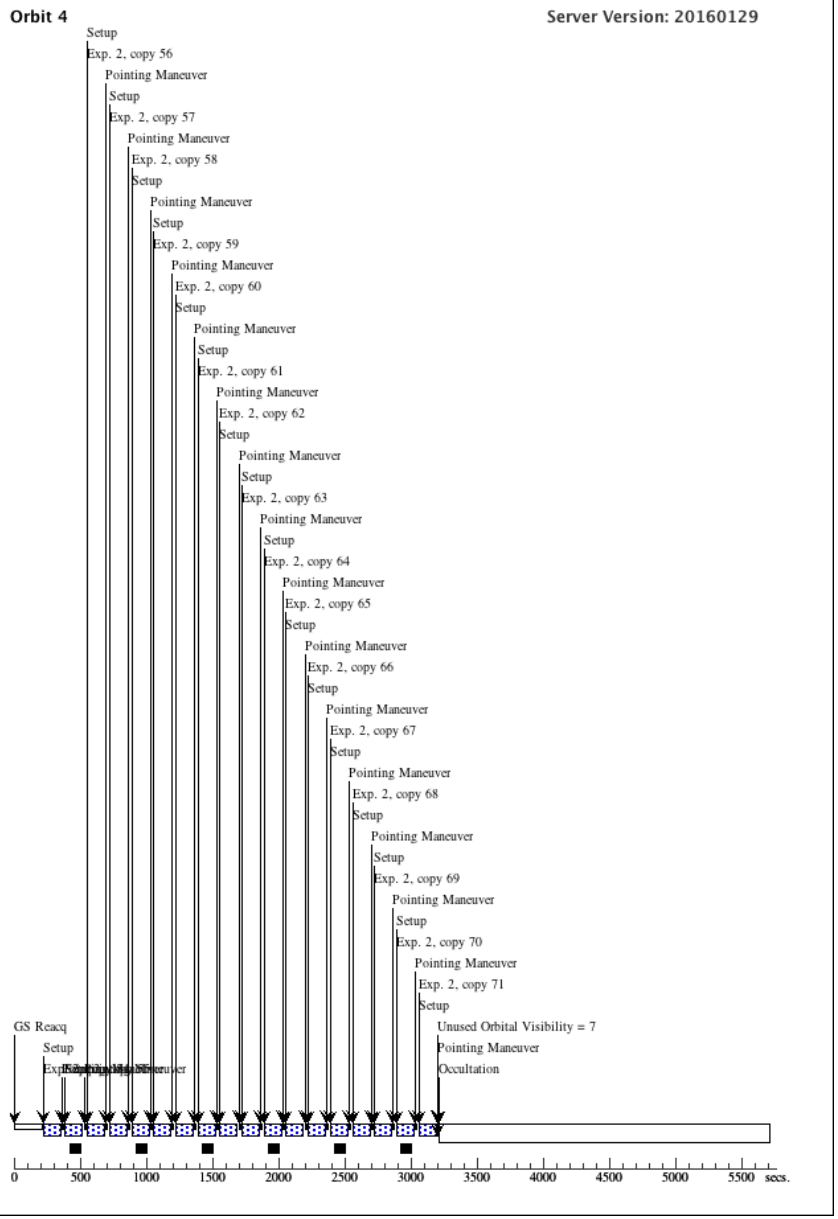
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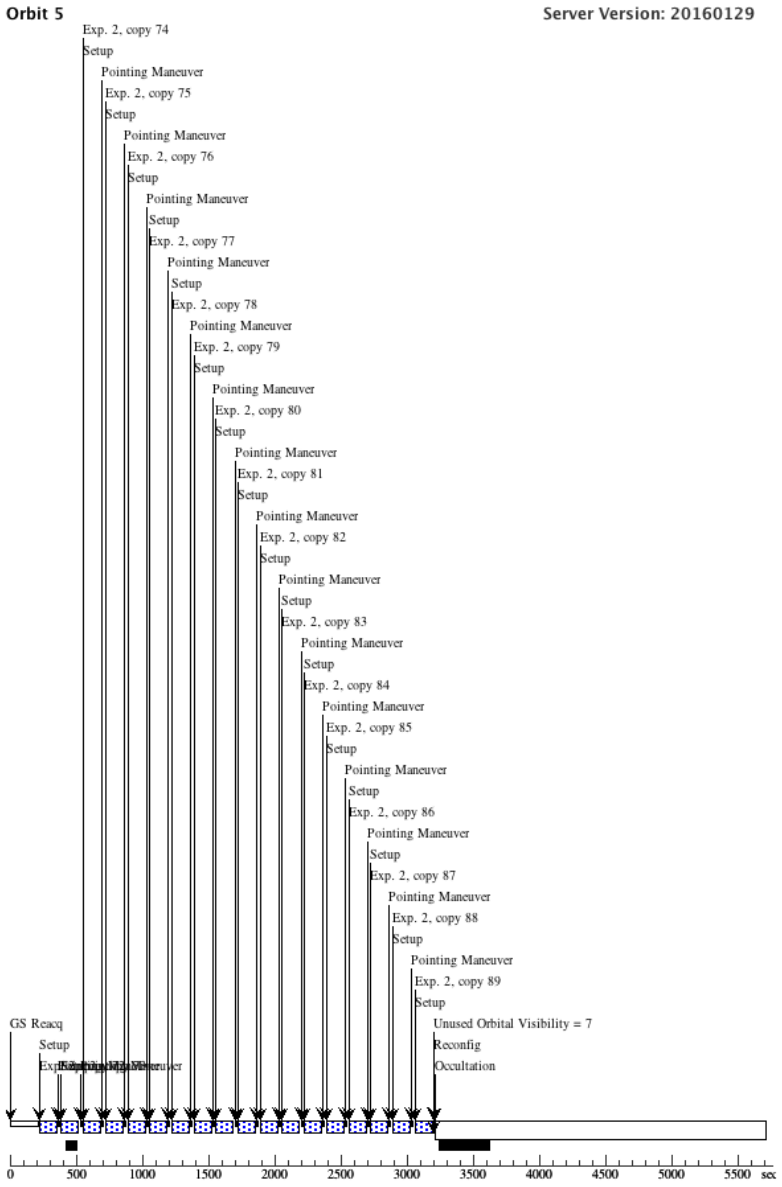
Setup
Exp. 2, copy 59
Pointing Maneuver
Exp. 2, copy 60
Setup
Pointing Maneuver
Setup
Exp. 2, copy 61
Pointing Maneuver
Exp. 2, copy 62
Setup
Pointing Maneuver
Setup
Exp. 2, copy 63
Pointing Maneuver
Setup
Exp. 2, copy 64
Pointing Maneuver
Exp. 2, copy 65
Setup
Pointing Maneuver
Exp. 2, copy 66
Setup
Pointing Maneuver
Exp. 2, copy 67
Setup
Pointing Maneuver
Exp. 2, copy 68
Setup
Pointing Maneuver
Setup
Exp. 2, copy 69
Pointing Maneuver
Setup
Exp. 2, copy 70
Pointing Maneuver
Exp. 2, copy 71
Setup
Unused Orbital Visibility = 7
Pointing Maneuver
Occultation
GS Reacq
Setup
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs.


Orbit 5
Server Version: 20160129
Exp. 2, copy 74
Setup
Pointing Maneuver
Exp. 2, copy 75
Setup
Pointing Maneuver
Exp. 2, copy 76
Setup
Pointing Maneuver
Setup
Exp. 2, copy 77
Pointing Maneuver
Setup
Exp. 2, copy 78
Pointing Maneuver
Exp. 2, copy 79
Setup
Pointing Maneuver
Exp. 2, copy 80
Setup
Pointing Maneuver
Exp. 2, copy 81
Setup
Pointing Maneuver
Exp. 2, copy 82
Setup
Pointing Maneuver
Setup
Exp. 2, copy 83
Pointing Maneuver
Setup
Exp. 2, copy 84
Pointing Maneuver
Exp. 2, copy 85
Setup
Pointing Maneuver
Setup
Exp. 2, copy 86
Pointing Maneuver
Setup
Exp. 2, copy 87
Pointing Maneuver
Exp. 2, copy 88
Setup
Pointing Maneuver
Exp. 2, copy 89
Setup
Unused Orbital Visibility = 7
Reconfig
Occultation
GS Reacq
Setup
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec