



## 15622 - Confirmation of a Binary Companion to 21900 Orus

Cycle: 25, Proposal Category: GO/DD

(Availability Mode: SUPPORTED)

### INVESTIGATORS

<i>Name</i>	<i>Institution</i>	<i>E-Mail</i>
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### VISITS

<i>Visit</i>	<i>Targets used in Visit</i>	<i>Configurations used in Visit</i>	<i>Orbits Used</i>	<i>Last Orbit Planner Run</i>	<i>OP Current with Visit?</i>
01	(1) ORUS	WFC3/UVIS	1	22-Aug-2018 08:00:17.0	yes
02	(1) ORUS	WFC3/UVIS	1	22-Aug-2018 08:00:19.0	yes
03	(1) ORUS	WFC3/UVIS	1	22-Aug-2018 08:00:21.0	yes
04	(1) ORUS	WFC3/UVIS	1	22-Aug-2018 08:00:23.0	yes
05	(1) ORUS	WFC3/UVIS	1	22-Aug-2018 08:00:24.0	yes
11	(1) ORUS	WFC3/UVIS	1	22-Aug-2018 08:00:26.0	yes

6 Total Orbits Used

## **ABSTRACT**

On August 7 and 8 we obtained the first HST observations of the Trojan 21900 Orus and find possible evidence for the presence of a secondary. If confirmed, this would have a significant impact on the planning of the Lucy Discovery mission. We are requesting DD time for immediate implementation during this opposition to a) confirm this detection and b) determine the component flux ratio. The discovery of a secondary would have a significant impact on the design of target acquisition; Orus is a design driver for navigation because of the high approach phase angle and the existence of a binary could complicate the software and hardware capabilities needed to successfully acquire. The urgency of the mission timeline make a DD the only viable option for confirming this potentially exciting new science opportunity and technical challenge for the Lucy mission.

## **OBSERVING DESCRIPTION**

The primary goal of the proposed observations is to recover and confirm the satellite of Orus detected by us on August 8, 2018.

This will be accomplished with WFC3 UVIS in standard imaging mode using the same sequence used in the original detection. We will use the F438W filter.

We will use the UVIS2-C512C subarray to allow for shorter readout overheads.

Each visit will consist of twelve exposures in the F438W using a 4-point box dither.

Exposure times of 120s will be long enough to reach at least 20,000 e<sup>-</sup> for high S/N that remains below saturation.

We propose a sequence of five orbits with a cadence that samples a possible ~27 hr hour period every 0.2 in orbit phase.

We would also request timing that is non-degenerate in phase for a 13.5 hr period.

This is a similar strategy to what we used for GO 15142.

In addition to the five phased orbits, we request an additional orbit that will be executed as part of a two-orbit sequence, adjacent in time to any one of the five phased orbits.

The purpose of this orbit will be to test for instrumental effects that could mimic effects from a partially resolved binary. In this orbit we will obtain images in both the F555W (Aug 7&8 data) and F438W (proposed for new observations for resolution advantage) to compare performance and eliminate filter effects as a source of possible systematic uncertainty.

Proposal 15622 - Visit 01 - Confirmation of a Binary Companion to 21900 Orus

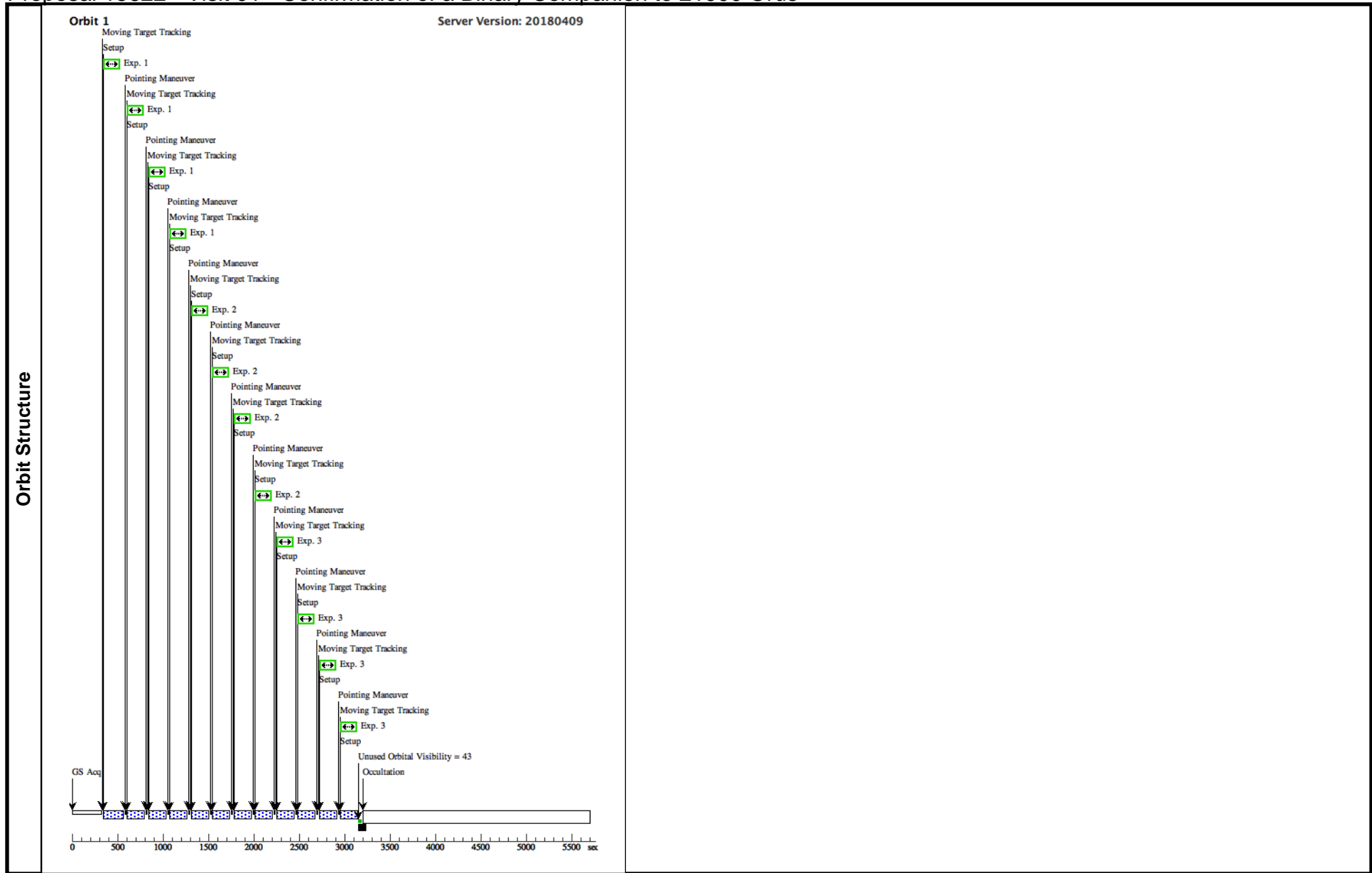
Wed Aug 22 12:00:27 GMT 2018

<b>Visit</b>	<b>Proposal 15622, Visit 01, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none) <i>Comments: timing to be linked to lightcurve maximum - times will be supplied to PC - peaks are separated by 13.5 hours - excel tool is available (with time at target)</i> <i>immediately adjacent to (before or after) visit 11</i>		

<b>Patterns</b>	#	Primary Pattern	Secondary Pattern	Exposures
	(1)	Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.173 Line Spacing=0.112	Coordinate Frame=POS-TARG Pattern Orientation=23.884 Angle Between Sides=81.785 Center Pattern=false	(1), (2), (3)

<b>Solar System Targets</b>	#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
	(1)	ORUS	TYPE=ASTEROID,A=5.13644628693 4752,E=0.03797045685102873,I=8.46 4167968557787 ,O=258.5899988741201,W=182.45037 1734245,M=21.30651185899933,EQU INOX=J2000,EPOCH=29-MAY- 2012:00:00:00,EpochTimeScale=TDB				EARTH
	<i>Comments: Description=Trojan, Lucy target</i> <i>Extended=NO</i>						

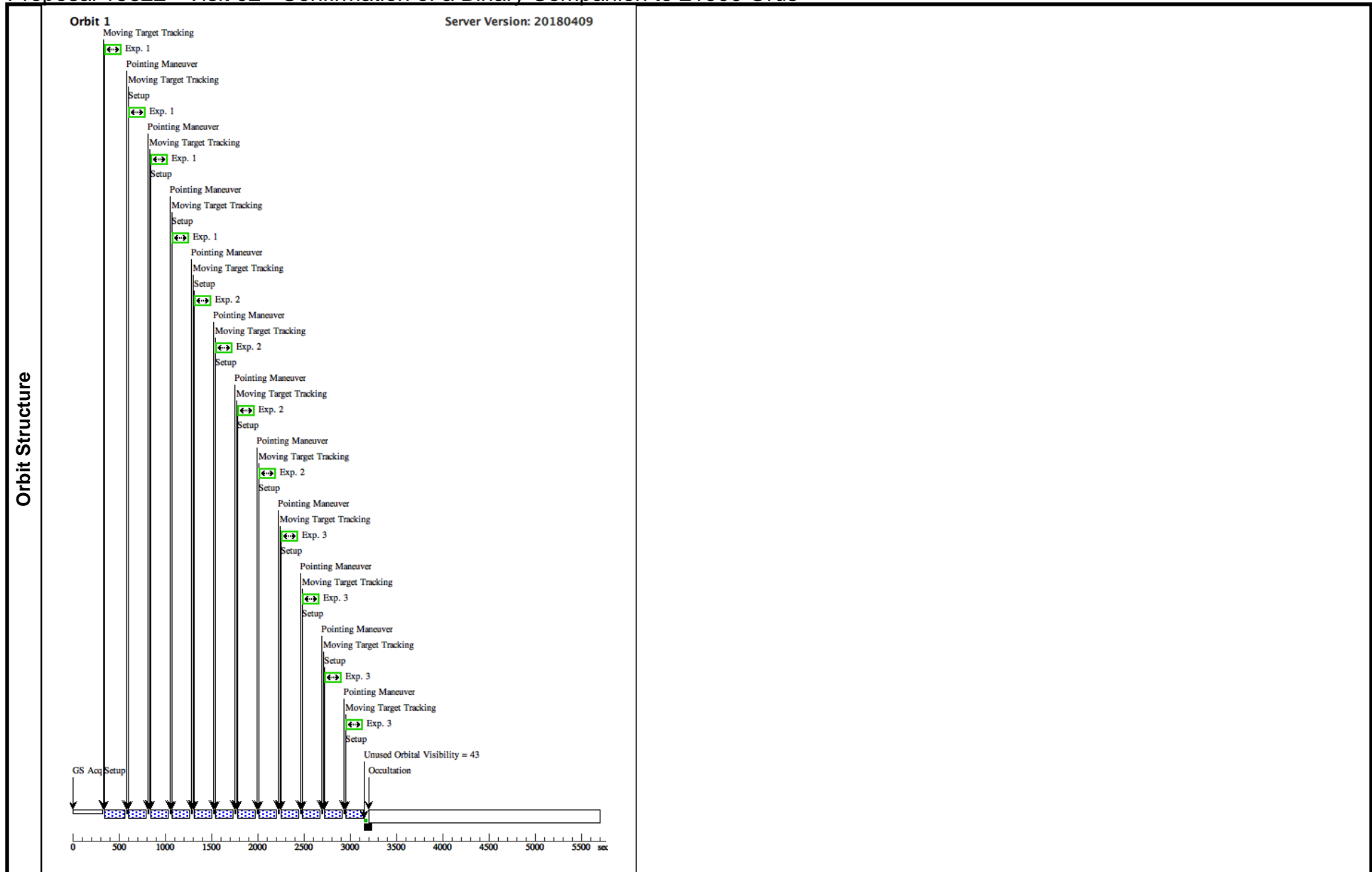
<b>Exposures</b>	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(1) ORUS	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F438W	FLASH=10		Sequence 1-3 Non-Int in Visit 01	140 Secs (560 Secs)	
								Pattern 1, Exps 1-1 in Sequence 1-3 Non-Int in Visit 01 (1)	[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1]
	2		(1) ORUS	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F438W	FLASH=10	POS TARG 0.092,0.098	Sequence 1-3 Non-Int in Visit 01	140 Secs (560 Secs)	
								Pattern 1, Exps 2-2 in Sequence 1-3 Non-Int in Visit 01 (1)	[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1]
	3		(1) ORUS	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F438W	FLASH=10	POS TARG 0.185,0.197	Sequence 1-3 Non-Int in Visit 01	140 Secs (560 Secs)	
								Pattern 1, Exps 3-3 in Sequence 1-3 Non-Int in Visit 01 (1)	[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1]



Proposal 15622 - Visit 02 - Confirmation of a Binary Companion to 21900 Orus

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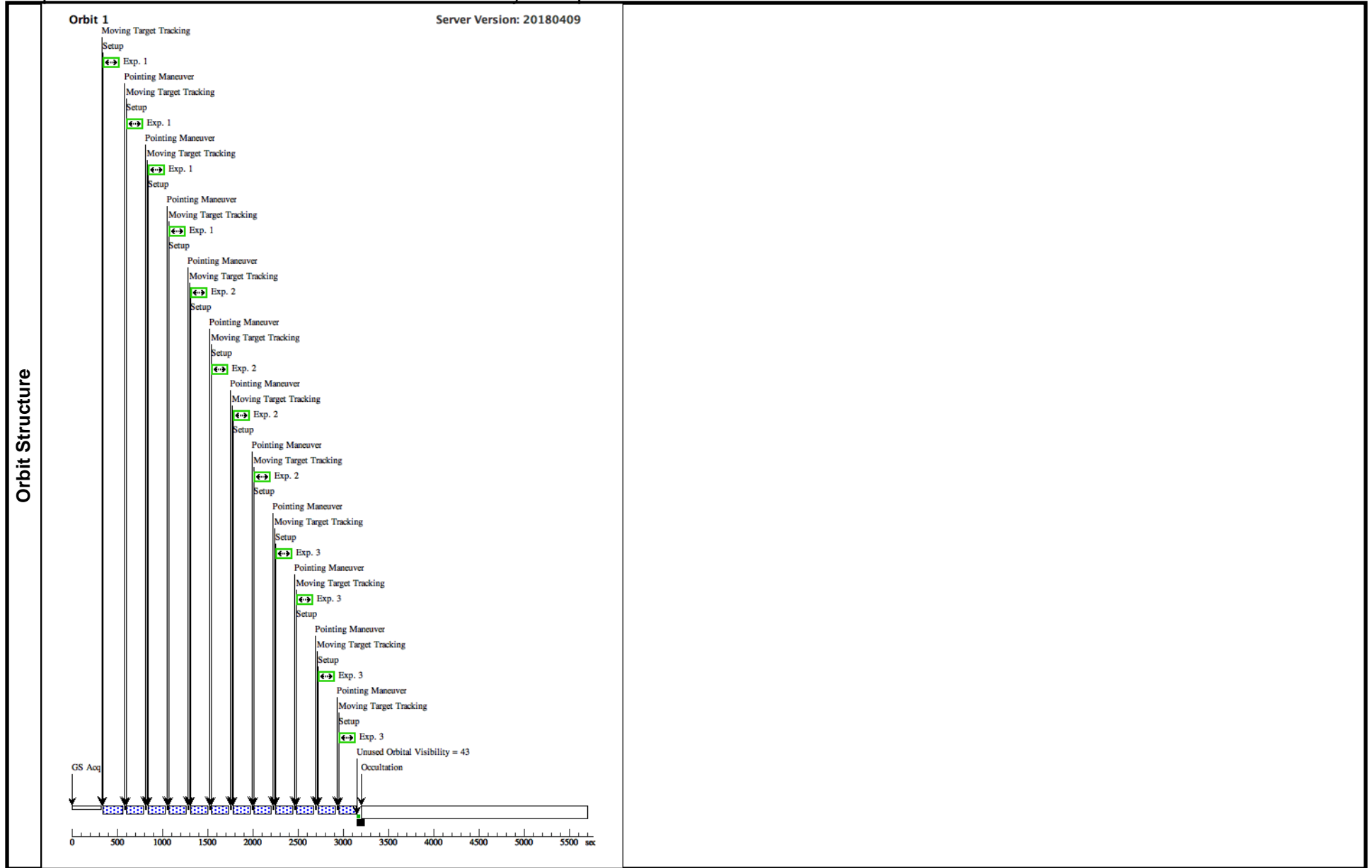
<b>Visit</b>	<b>Proposal 15622, Visit 02, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none) <i>Comments: phased to be after visit 01 by <math>(n + 0.20 + / - 0.05) * 26.9724</math> where <math>n = \text{integer less than or equal to } 12</math></i>  <i>One pair of visits should occur within the same n</i>									
	<b>Patterns</b>	<b>#</b>	<b>Primary Pattern</b>	<b>Secondary Pattern</b>			<b>Exposures</b>			
	(1)	Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.173 Line Spacing=0.112	Coordinate Frame=POS-TARG Pattern Orientation=23.884 Angle Between Sides=81.785 Center Pattern=false				(1), (2), (3)			
<b>Solar System Targets</b>	<b>#</b>	<b>Name</b>	<b>Level 1</b>	<b>Level 2</b>	<b>Level 3</b>	<b>Window</b>	<b>Ephem Center</b>			
	(1)	ORUS	TYPE=ASTEROID,A=5.13644628693 4752,E=0.03797045685102873,I=8.46 4167968557787 ,O=258.5899988741201,W=182.45037 1734245,M=21.30651185899933,EQU INOX=J2000,EPOCH=29-MAY- 2012:00:00:00,EpochTimeScale=TDB				EARTH			
	<i>Comments: Description=Trojan, Lucy target                  Extended=NO</i>									
<b>Exposures</b>	<b>#</b>	<b>Label</b>	<b>Target</b>	<b>Config,Mode,Aperture</b>	<b>Spectral Els.</b>	<b>Opt. Params.</b>	<b>Special Reqs.</b>	<b>Groups</b>	<b>Exp. Time (Total)/[Actual Dur.]</b>	<b>Orbit</b>
	1	(1) ORUS		WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F438W	FLASH=10		Sequence 1-3 Non-Int in Visit 02	140 Secs (560 Secs)	
								Pattern 1, Exps 1-1 in Sequence 1-3 Non-Int in Visit 02 (1)	[=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)] [=>(Pattern 4)]	[1]
	2	(1) ORUS		WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F438W	FLASH=10	POS TARG 0.092,0.098	Sequence 1-3 Non-Int in Visit 02	140 Secs (560 Secs)	
							Pattern 1, Exps 2-2 in Sequence 1-3 Non-Int in Visit 02 (1)	[=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)] [=>(Pattern 4)]	[1]	
3	(1) ORUS		WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F438W	FLASH=10	POS TARG 0.185,0.197	Sequence 1-3 Non-Int in Visit 02	140 Secs (560 Secs)		
							Pattern 1, Exps 3-3 in Sequence 1-3 Non-Int in Visit 02 (1)	[=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)] [=>(Pattern 4)]	[1]	



Proposal 15622 - Visit 03 - Confirmation of a Binary Companion to 21900 Orus

Wed Aug 22 12:00:27 GMT 2018

<b>Visit</b>	<b>Proposal 15622, Visit 03, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none) Comments: phased to be after visit 01 by $(n + 0.40 \pm 0.05) * 26.9724$ where $n = \text{integer less than or equal to } 12$  One pair of visits should occur within the same n									
	<b>Patterns</b>	<b>#</b>	<b>Primary Pattern</b>	<b>Secondary Pattern</b>			<b>Exposures</b>			
	(1)	Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.173 Line Spacing=0.112	Coordinate Frame=POS-TARG Pattern Orientation=23.884 Angle Between Sides=81.785 Center Pattern=false				(1), (2), (3)			
<b>Solar System Targets</b>	<b>#</b>	<b>Name</b>	<b>Level 1</b>	<b>Level 2</b>	<b>Level 3</b>	<b>Window</b>	<b>Ephem Center</b>			
	(1)	ORUS	TYPE=ASTEROID,A=5.13644628693 4752,E=0.03797045685102873,I=8.46 4167968557787 ,O=258.5899988741201,W=182.45037 1734245,M=21.30651185899933,EQU INOX=J2000,EPOCH=29-MAY- 2012:00:00:00,EpochTimeScale=TDB				EARTH			
	Comments: Description=Trojan, Lucy target Extended=NO									
<b>Exposures</b>	<b>#</b>	<b>Label</b>	<b>Target</b>	<b>Config,Mode,Aperture</b>	<b>Spectral Els.</b>	<b>Opt. Params.</b>	<b>Special Reqs.</b>	<b>Groups</b>	<b>Exp. Time (Total)/[Actual Dur.]</b>	<b>Orbit</b>
	1	(1) ORUS		WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F438W	FLASH=10		Sequence 1-3 Non-Int in Visit 03	140 Secs (560 Secs)	
								Pattern 1, Exps 1-1 in Sequence 1-3 Non-Int in Visit 03 (1)	[=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)] [=>(Pattern 4)]	[1]
	2	(1) ORUS		WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F438W	FLASH=10	POS TARG 0.092,0.098	Sequence 1-3 Non-Int in Visit 03	140 Secs (560 Secs)	
							Pattern 1, Exps 2-2 in Sequence 1-3 Non-Int in Visit 03 (1)	[=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)] [=>(Pattern 4)]	[1]	
3	(1) ORUS		WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F438W	FLASH=10	POS TARG 0.185,0.197	Sequence 1-3 Non-Int in Visit 03	140 Secs (560 Secs)		
							Pattern 1, Exps 3-3 in Sequence 1-3 Non-Int in Visit 03 (1)	[=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)] [=>(Pattern 4)]	[1]	



Proposal 15622 - Visit 04 - Confirmation of a Binary Companion to 21900 Orus

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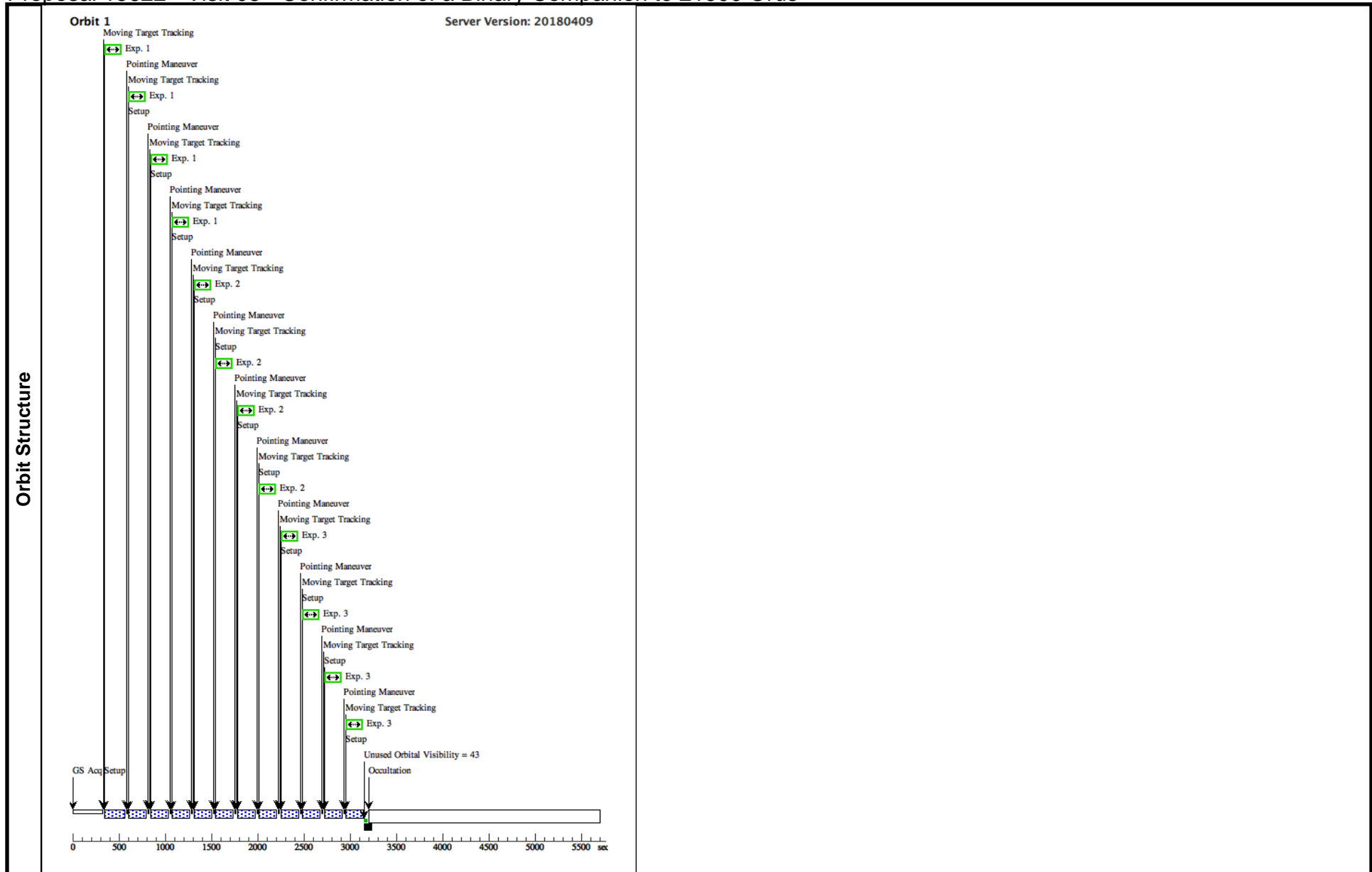
<b>Visit</b>	<b>Proposal 15622, Visit 04, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none) <i>Comments: phased to be after visit 01 by <math>(n + 0.60 + / - 0.05) * 26.9724</math> where <math>n = \text{integer less than or equal to } 12</math></i>  <i>One pair of visits should occur within the same n</i>									
<b>Patterns</b>	<b>#</b>	<b>Primary Pattern</b>			<b>Secondary Pattern</b>		<b>Exposures</b>			
	(1)	Pattern Type=WFC3-UVIS-DITHER-BOX Coordinate Frame=POS-TARG Pattern Orientation=23.884 Purpose=DITHER Angle Between Sides=81.785 Number Of Points=4 Center Pattern=false Point Spacing=0.173 Line Spacing=0.112					(1), (2), (3)			
<b>Solar System Targets</b>	<b>#</b>	<b>Name</b>	<b>Level 1</b>	<b>Level 2</b>	<b>Level 3</b>	<b>Window</b>	<b>Ephem Center</b>			
	(1)	ORUS	TYPE=ASTEROID,A=5.13644628693 4752,E=0.03797045685102873,I=8.46 4167968557787 ,O=258.5899988741201,W=182.45037 1734245,M=21.30651185899933,EQU INOX=J2000,EPOCH=29-MAY- 2012:00:00:00,EpochTimeScale=TDB				EARTH			
<i>Comments: Description=Trojan, Lucy target Extended=NO</i>										
<b>Exposures</b>	<b>#</b>	<b>Label</b>	<b>Target</b>	<b>Config,Mode,Aperture</b>	<b>Spectral Els.</b>	<b>Opt. Params.</b>	<b>Special Reqs.</b>	<b>Groups</b>	<b>Exp. Time (Total)/[Actual Dur.]</b>	<b>Orbit</b>
	1	(1) ORUS		WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F438W	FLASH=10		Sequence 1-3 Non-Int in Visit 04 Pattern 1, Exps 1-1 in Sequence 1-3 Non-Int in Visit 04 (1)	140 Secs (560 Secs) [=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)] [=>(Pattern 4)]	[1]
	2	(1) ORUS		WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F438W	FLASH=10	POS TARG 0.092,0.098	Sequence 1-3 Non-Int in Visit 04 Pattern 1, Exps 2-2 in Sequence 1-3 Non-Int in Visit 04 (1)	140 Secs (560 Secs) [=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)] [=>(Pattern 4)]	[1]
	3	(1) ORUS		WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F438W	FLASH=10	POS TARG 0.185,0.197	Sequence 1-3 Non-Int in Visit 04 Pattern 1, Exps 3-3 in Sequence 1-3 Non-Int in Visit 04 (1)	140 Secs (560 Secs) [=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)] [=>(Pattern 4)]	[1]



Proposal 15622 - Visit 05 - Confirmation of a Binary Companion to 21900 Orus

Wed Aug 22 12:00:27 GMT 2018

<b>Visit</b>	<b>Proposal 15622, Visit 05, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none) <i>Comments: phased to be after visit 01 by <math>(n + 0.80 + / - 0.05) * 26.9724</math> where <math>n = \text{integer less than or equal to } 12</math></i>  <i>One pair of visits should occur within the same n</i>									
<b>Patterns</b>	<b>#</b>	<b>Primary Pattern</b>			<b>Secondary Pattern</b>		<b>Exposures</b>			
	(1)	Pattern Type=WFC3-UVIS-DITHER-BOX Coordinate Frame=POS-TARG Pattern Orientation=23.884 Purpose=DITHER Angle Between Sides=81.785 Number Of Points=4 Center Pattern=false Point Spacing=0.173 Line Spacing=0.112					(1), (2), (3)			
<b>Solar System Targets</b>	<b>#</b>	<b>Name</b>	<b>Level 1</b>	<b>Level 2</b>	<b>Level 3</b>	<b>Window</b>	<b>Ephem Center</b>			
	(1)	ORUS	TYPE=ASTEROID,A=5.13644628693 4752,E=0.03797045685102873,I=8.46 4167968557787 ,O=258.5899988741201,W=182.45037 1734245,M=21.30651185899933,EQU INOX=J2000,EPOCH=29-MAY- 2012:00:00:00,EpochTimeScale=TDB				EARTH			
<i>Comments: Description=Trojan, Lucy target Extended=NO</i>										
<b>Exposures</b>	<b>#</b>	<b>Label</b>	<b>Target</b>	<b>Config,Mode,Aperture</b>	<b>Spectral Els.</b>	<b>Opt. Params.</b>	<b>Special Reqs.</b>	<b>Groups</b>	<b>Exp. Time (Total)/[Actual Dur.]</b>	<b>Orbit</b>
	1	(1) ORUS	(1) ORUS	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F438W	FLASH=10		Sequence 1-3 Non-Int in Visit 05	140 Secs (560 Secs)	
								Pattern 1, Exps 1-1 in Sequence 1-3 Non-Int in Visit 05 (1)	[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1]
	2	(1) ORUS	(1) ORUS	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F438W	FLASH=10	POS TARG 0.092,0.098	Sequence 1-3 Non-Int in Visit 05	140 Secs (560 Secs)	
							Pattern 1, Exps 2-2 in Sequence 1-3 Non-Int in Visit 05 (1)	[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1]	
3	(1) ORUS	(1) ORUS	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F438W	FLASH=10	POS TARG 0.185,0.197	Sequence 1-3 Non-Int in Visit 05	140 Secs (560 Secs)		
							Pattern 1, Exps 3-3 in Sequence 1-3 Non-Int in Visit 05 (1)	[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1]	



Proposal 15622 - Visit 11 - Confirmation of a Binary Companion to 21900 Orus

Wed Aug 22 12:00:27 GMT 2018

<b>Visit</b>	<b>Proposal 15622, Visit 11, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none) <i>Comments: immediately adjacent to (before or after) visit 01</i>									
	<b>Patterns</b>	<b>#</b>	<b>Primary Pattern</b>			<b>Secondary Pattern</b>		<b>Exposures</b>		
(1)		Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.173 Line Spacing=0.112			Coordinate Frame=POS-TARG Pattern Orientation=23.884 Angle Between Sides=81.785 Center Pattern=false		(1), (2), (3)			
<b>Solar System Targets</b>	<b>#</b>	<b>Name</b>	<b>Level 1</b>	<b>Level 2</b>	<b>Level 3</b>	<b>Window</b>	<b>Ephem Center</b>			
	(1)	ORUS	TYPE=ASTEROID,A=5.13644628693 4752,E=0.03797045685102873,I=8.46 4167968557787 ,O=258.5899988741201,W=182.45037 1734245,M=21.30651185899933,EQU INOX=J2000,EPOCH=29-MAY- 2012:00:00:00,EpochTimeScale=TDB				EARTH			
<i>Comments: Description=Trojan, Lucy target</i>										
<i>Extended=NO</i>										
<b>Exposures</b>	<b>#</b>	<b>Label</b>	<b>Target</b>	<b>Config,Mode,Aperture</b>	<b>Spectral Els.</b>	<b>Opt. Params.</b>	<b>Special Reqs.</b>	<b>Groups</b>	<b>Exp. Time (Total)/[Actual Dur.]</b>	<b>Orbit</b>
	1	(1) ORUS		WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F438W	FLASH=10		Sequence 1-3 Non-Int in Visit 11 Pattern 1, Exps 1-1 in Sequence 1-3 Non-Int in Visit 11 (1)	140 Secs (560 Secs) [=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)] [=>(Pattern 4)]	[1]
	2	(1) ORUS		WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F555W	FLASH=10	POS TARG 0.092,0.098	Sequence 1-3 Non-Int in Visit 11 Pattern 1, Exps 2-2 in Sequence 1-3 Non-Int in Visit 11 (1)	120 Secs (480 Secs) [=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)] [=>(Pattern 4)]	[1]
	3	(1) ORUS		WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F438W	FLASH=10	POS TARG 0.185,0.197	Sequence 1-3 Non-Int in Visit 11 Pattern 1, Exps 3-3 in Sequence 1-3 Non-Int in Visit 11 (1)	140 Secs (560 Secs) [=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)] [=>(Pattern 4)]	[1]

