15976 - Constraining Water Loss from Mars

Cycle: 27, Proposal Category: GO

(UV Initiative)

(Availability Mode: AVAILABLE)

INVESTIGATORS

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VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) MARS1-LS160 WAVE	STIS/FUV-MAMA	2	30-Oct-2019 15:01:10.0	yes
02	(1) MARS1-LS160 WAVE	STIS/FUV-MAMA	1	30-Oct-2019 15:01:11.0	yes
03	(2) MARS1-LS160-BCKSKY WAVE	STIS/FUV-MAMA	1	30-Oct-2019 15:01:12.0	yes
04	(3) MARS2-LS185 WAVE	STIS/FUV-MAMA	2	30-Oct-2019 15:01:13.0	yes
05	(3) MARS2-LS185 WAVE	STIS/FUV-MAMA	1	30-Oct-2019 15:01:13.0	yes

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
06	(4) MARS2-LS185-BCKSKY WAVE	STIS/FUV-MAMA	1	30-Oct-2019 15:01:14.0	yes
07	(5) MARS3-LS210 WAVE	STIS/FUV-MAMA	2	30-Oct-2019 15:01:15.0	yes
08	(6) MARS3-LS210-BCKSKY WAVE	STIS/FUV-MAMA	1	30-Oct-2019 15:01:15.0	yes

11 Total Orbits Used

ABSTRACT

How does water loss at Mars vary with time? Early theory predicted a slow and steady loss, where surface water molecules are dissociated by sunlight into atoms that take dozens of years to diffuse to the upper atmosphere and escape to space. Recent observations showed water escape rates to vary by a factor of 10 with martian seasons, consistent with variations near the surface and lower atmosphere of Mars - the regions that provide water to the upper atmosphere by global turbulent mixing during perihelion. However, key water constituents in the upper atmosphere, hydrogen (H) and its heavier isotope deuterium (D), vary on timescales that differ from the lower atmosphere indicating a surface-to-space water cycle that does not reconcile with theory. Upper atmospheric H and D comprise the escaping components of planetary water. The ratio and variability of their abundance, D/H, is a key metric for determining water loss. Understanding water loss requires establishing a full seasonal timeline of D and H densities. A Mars orbiter can presently make such measurements near perihelion but does not have the sensitivity to measure D near aphelion, thereby leaving a glaring gap in our ability to establish seasonal variations of water escape. Here we propose to observe D at Mars with HST STIS at times when no other instrument can. The results will address a two-part science investigation: to determine the variability of D/H (1) seasonally, and (2) with solar activity using new and archived HST data. The observations will be conducted in parallel with lower (H2O, HDO) and upper (D, H) atmospheric water measurements from orbiting spacecraft. This proposal supports the HST UV initiative.

OBSERVING DESCRIPTION

This program requires high-resolution observations of Mars to resolve the solar Lyman-alpha photons for D and H that are separated by 0.33 Angstrom. The HST STIS E140H echelle spectrograph has a resolution of 0.057 Angstrom using the 0.5 Angstrom aperture and is sufficient to separate the D and H lines. We propose to utilize the TIMETAG configuration with the 52x0.5 arcsec aperture for the STIS observations. The long-aperture mode that provides a higher count rate for the extended emission region, has been well demonstrated in observations of Mars, Jupiter and the interplanetary hydrogen, and can obtain spectra across the entire martian disc and limb. The HST STIS observations requested can be conducted at

any roll angle since we can account for the observing geometry when modeling the lines of sight to Mars.

Both Mars as well Earth's corona emit resonantly scattered solar Lyman-alpha. Past observations have shown the background geocorona emission to be highly variable and would necessitate consistent measurement. Therefore, a sky observation near Mars, during the same visit is needed to accurately subtract the Lyman-alpha emissions of the background geocorona and interplanetary hydrogen. This measurement will require pointing the line of sight at a portion of the sky a few arcmin away from Mars.

This program conforms to safe observing of Mars (where the instrument line of sight is more than 55 degrees from the Sun). Specifically, between March and June 2020. A minimum of three data points of HST-observed D Lyman-alpha emissions are needed during the off-perihelion range in order to disambiguate a linear vs polynomial trend in D variability and to assess sudden vs gradual variations. Visits are therefore requested at Ls of 160, 185, and 210 degrees in order to obtain an adequate slope of the enhancement of D emission brightness and water escape rate as the martian seasons change. A total of 4 orbits are requested when Mars is at Ls of 160, three of which are pointed at the disk of Mars, and one of which points at the sky near Mars to account for sky background during image reduction and analysis. A similar sequence is requested for when Mars is at Ls of 185. Finally, one sequence is requested when Mars is at Ls 210 with 3 orbits requested. Two for Mars and one for the sky near Mars. The orbits with exposures targeting the near-Mars sky background, a pointing offset of ~3 arcmin away from the Mars disk is requested, to gather a background telluric and interplanetary Lyman-alpha signal. The remaining orbits will point at Mars. The STIS E140H 0.5 arcsec aperture gives 5 counts/sec/kR integrating across the 52 arcsec detector. Assuming 2400 second integration per orbit, we would get 300 counts from a 25 Rayleigh emission (expected near aphelion). Three orbits are requested for the first epochs (correponding to Ls 160 and 185 degrees) in order to obtain an adequate signal to noise. Only two orbits would be required for the third visit (requested at 210 degrees Ls) since the D emission is expected to be brighter at that time. Observations from the three visits would be analyzed to calculate the D/H ratio and water escape rate over the present Mars year as the orbital position of Mars progresses toward perihelion. The observations from the three visits will uniquely convey how the properties of water change with season in the present epoch.

Visit

Proposal 15976, MARS1-LS160-VISIT1 (01), implementation Wed Oct 30 19:01:16 GMT 2019

Diagnostic Status: Warning

Scientific Instruments: STIS/FUV-MAMA

Special Requirements: BETWEEN 01-MAR-2020:00:00:00 AND 07-MAR-2020:23:59:59; GROUP 01,02,03 WITHIN 1D; VISIBILITY INTERVAL 50 M

Diagnostics

(MARS1-LS160-VISIT1 (01)) Warning (Form): A target acquisition should probably be performed before doing spectroscopy or coronography with STIS or COS.

(Exposure 1 (MARS1-LS160-VISIT1 (01))) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 3 (MARS1-LS160-VISIT1 (01))) Warning (Form): Sensitive exposures should have an ETC run number provided.

Solar System Targets

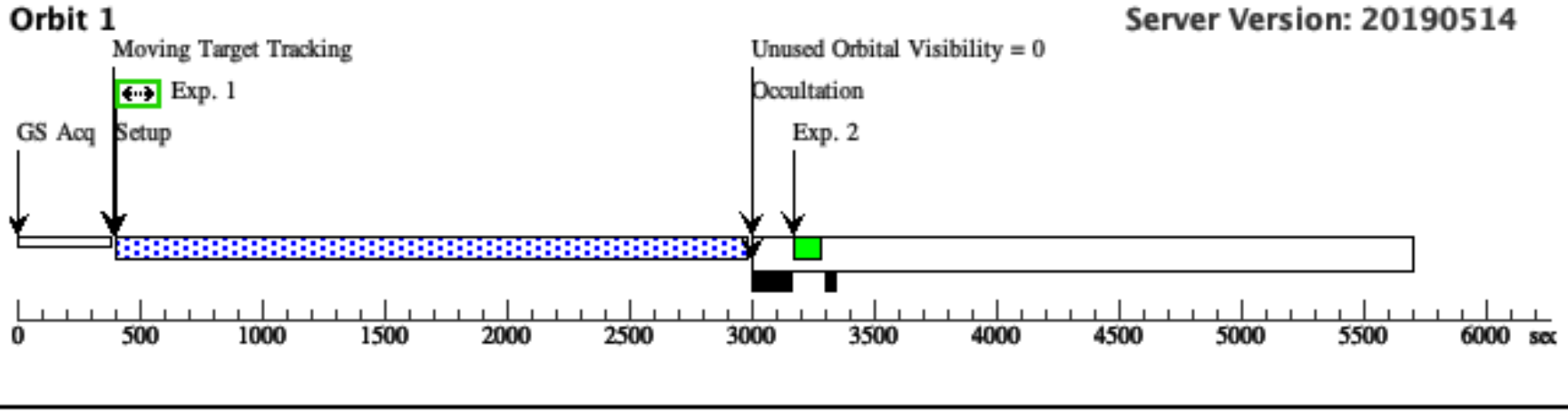
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	MARS1-LS160	STD=MARS				EARTH

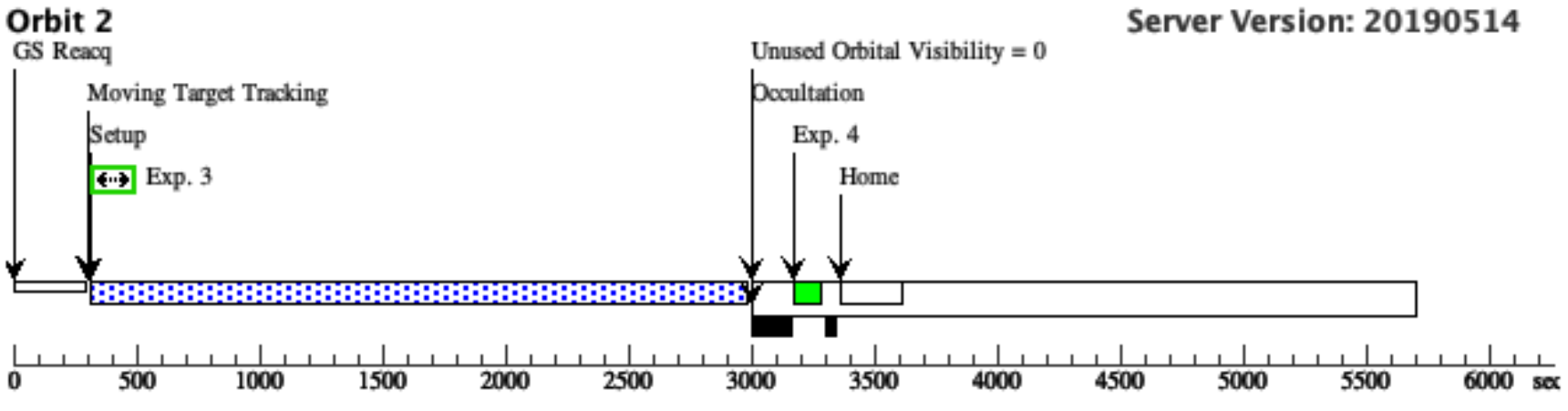
Comments: Description=Planet MARS
Extended=YES

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) MARS1-LS160	STIS/FUV-MAMA, TIME-TAG, 52X0.5	E140H 1234 A	BUFFER-TIME=1250; WAVECAL=NO			2500 Secs (2429 Secs) *[==>2429.0 Secs]*	***[1]***
2		WAVE	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1234 A				*[==>]*	***[1]***
3		(1) MARS1-LS160	STIS/FUV-MAMA, TIME-TAG, 52X0.5	E140H 1234 A	BUFFER-TIME=1365; WAVECAL=NO			2730 Secs (2616 Secs) *[==>2616.0 Secs]*	***[2]***
4		WAVE	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1234 A				*[==>]*	***[2]***

Orbit Structure





Visit

Proposal 15976, MARS1-LS160-VISIT2 (02), implementation Wed Oct 30 19:01:16 GMT 2019

Diagnostic Status: Warning

Scientific Instruments: STIS/FUV-MAMA

Special Requirements: BETWEEN 01-MAR-2020:00:00:00 AND 07-MAR-2020:23:59:59; VISIBILITY INTERVAL 50 M

Diagnostics

(MARS1-LS160-VISIT2 (02)) Warning (Form): A target acquisition should probably be performed before doing spectroscopy or coronography with STIS or COS.

(Exposure 1 (MARS1-LS160-VISIT2 (02))) Warning (Form): Sensitive exposures should have an ETC run number provided.

Solar System Targets

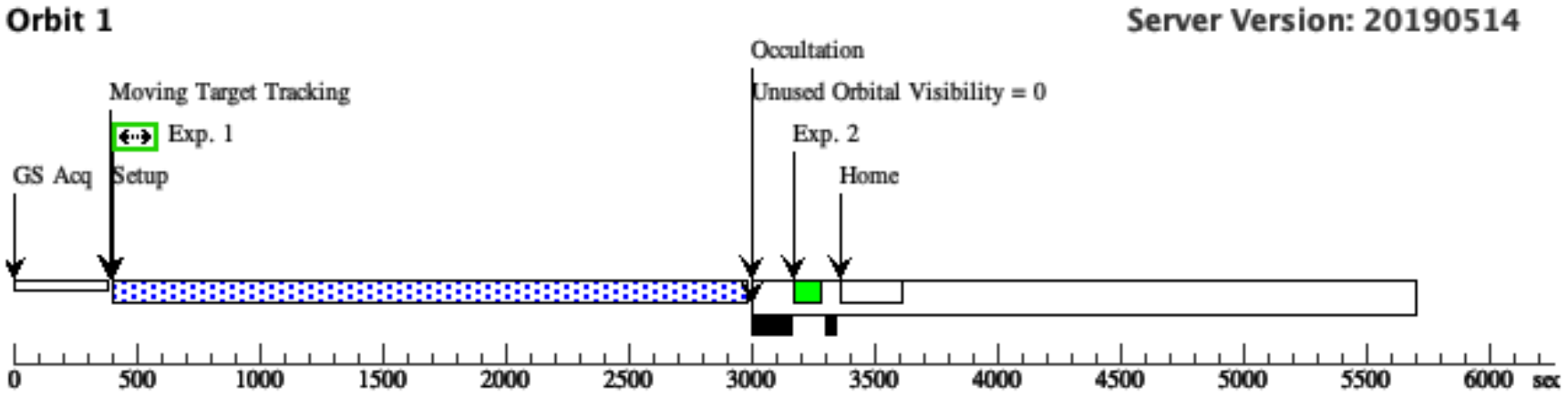
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	MARS1-LS160	STD=MARS				EARTH

Comments: Description=Planet MARS
Extended=YES

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) MARS1-LS160	STIS/FUV-MAMA, TIME-TAG, 52X0.5	E140H 1234 A	BUFFER-TIME=1250; WAVECAL=NO			2500 Secs (2429 Secs) *[==>2429.0 Secs]*	*[1]*
2		WAVE	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1234 A				*[==>]*	*[1]*

Orbit Structure



Visit

Proposal 15976, MARS1-LS160-VISIT3 (03), implementation Wed Oct 30 19:01:16 GMT 2019

Diagnostic Status: Warning

Scientific Instruments: STIS/FUV-MAMA

Special Requirements: BETWEEN 01-MAR-2020:00:00:00 AND 07-MAR-2020:23:59:59; VISIBILITY INTERVAL 50 M

Diagnostics

(MARS1-LS160-VISIT3 (03)) Warning (Form): A target acquisition should probably be performed before doing spectroscopy or coronography with STIS or COS.

(Exposure 1 (MARS1-LS160-VISIT3 (03))) Warning (Form): Sensitive exposures should have an ETC run number provided.

Solar System Targets

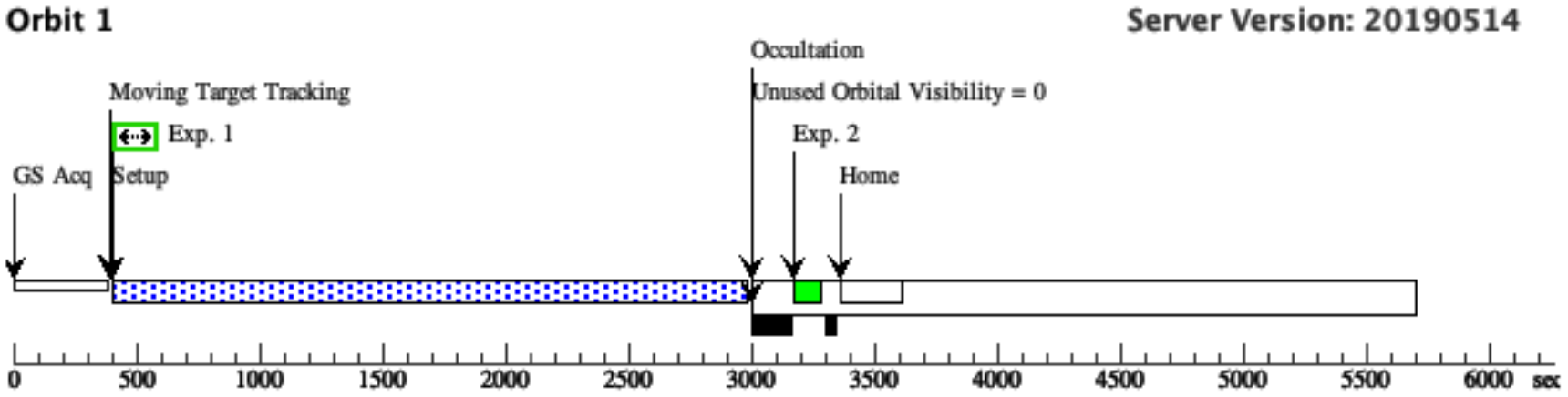
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(2)	MARS1-LS160-BCKSKY	STD=MARS	TYPE=POS_ANGLE,RAD=300,ANG=0,REF=NORTH		NOT OCC OF MARS1-LS160-BCKSKY BY MARS FROM EARTH, SEP OF MARS1-LS160-BCKSKY MARS FROM EARTH GT 10"	EARTH

Comments: Description=Planet MARS
Extended=YES

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(2) MARS1-LS160-BCKSKY	STIS/FUV-MAMA, TIME-TAG, 52X0.5	E140H 1234 A	BUFFER-TIME=1285; WAVECAL=NO			2570 Secs (2429 Secs) *[==>2429.0 Secs]*	*[1]*
2		WAVE	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1234 A				*[==>]*	*[1]*

Orbit Structure



Visit

Proposal 15976, MARS2-LS185-VISIT1 (04), implementation Wed Oct 30 19:01:16 GMT 2019

Diagnostic Status: Warning

Scientific Instruments: STIS/FUV-MAMA

Special Requirements: BETWEEN 12-APR-2020:00:00:00 AND 21-APR-2020:23:59:59; GROUP 04,05,06 WITHIN 1D; VISIBILITY INTERVAL 50 M

Diagnostics

(MARS2-LS185-VISIT1 (04)) Warning (Form): A target acquisition should probably be performed before doing spectroscopy or coronography with STIS or COS.

(Exposure 1 (MARS2-LS185-VISIT1 (04))) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 3 (MARS2-LS185-VISIT1 (04))) Warning (Form): Sensitive exposures should have an ETC run number provided.

Solar System Targets

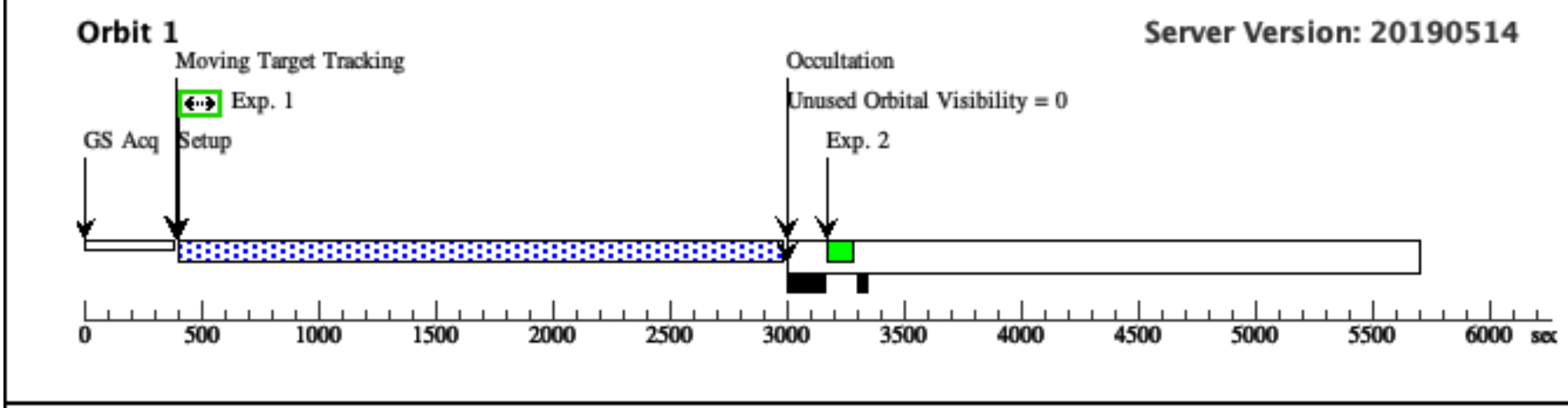
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(3)	MARS2-LS185	STD=MARS				EARTH

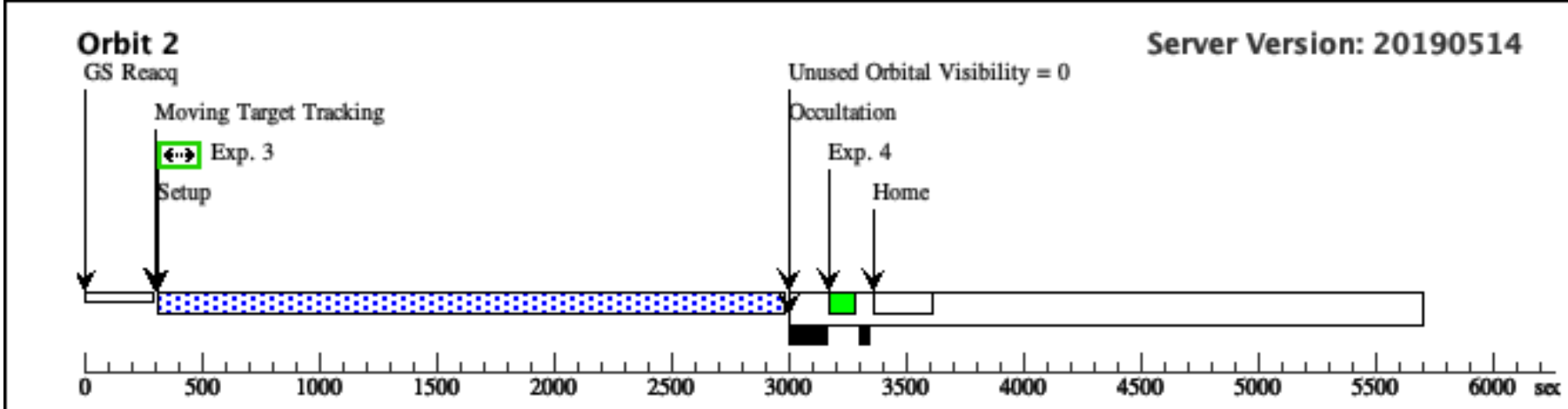
Comments: Description=Planet MARS
Extended=YES

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(3) MARS2-LS185	STIS/FUV-MAMA, TIME-TAG, 52X0.5	E140H 1234 A	BUFFER-TIME=1250; WAVECAL=NO			2500 Secs (2429 Secs) *[==>2429.0 Secs]*	*[1]*
2		WAVE	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1234 A				*[==>]*	*[1]*
3		(3) MARS2-LS185	STIS/FUV-MAMA, TIME-TAG, 52X0.5	E140H 1234 A	BUFFER-TIME=1365; WAVECAL=NO			2730 Secs (2616 Secs) *[==>2616.0 Secs]*	*[2]*
4		WAVE	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1234 A				*[==>]*	*[2]*

Orbit Structure





Visit

Proposal 15976, MARS2-LS185-VISIT2 (05), implementation Wed Oct 30 19:01:16 GMT 2019

Diagnostic Status: Warning

Scientific Instruments: STIS/FUV-MAMA

Special Requirements: BETWEEN 12-APR-2020:00:00:00 AND 21-APR-2020:23:59:59; VISIBILITY INTERVAL 50 M

Diagnostics

(MARS2-LS185-VISIT2 (05)) Warning (Form): A target acquisition should probably be performed before doing spectroscopy or coronography with STIS or COS.

(Exposure 1 (MARS2-LS185-VISIT2 (05))) Warning (Form): Sensitive exposures should have an ETC run number provided.

Solar System Targets

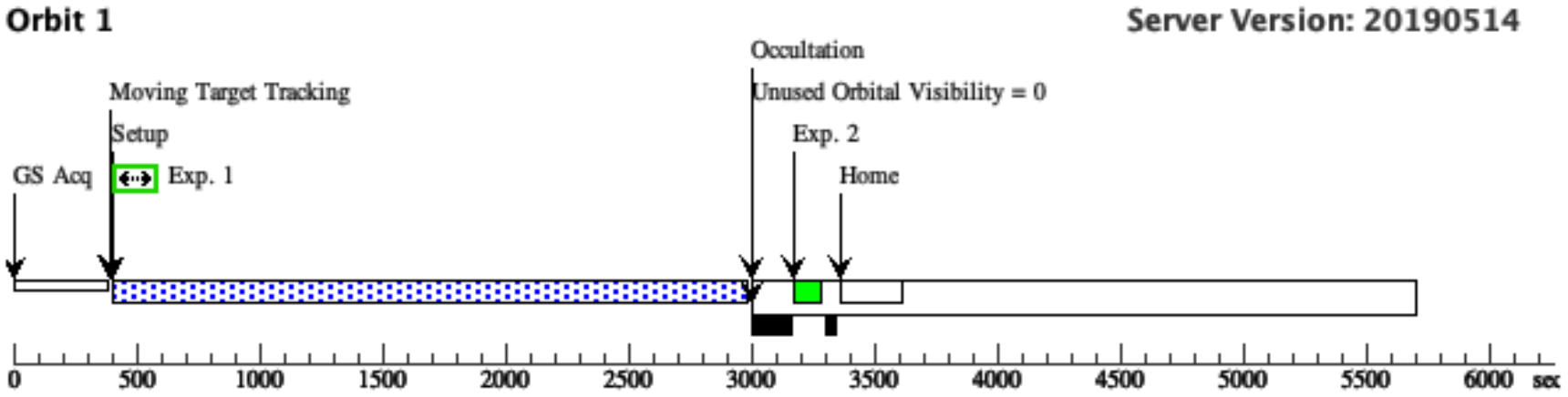
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(3)	MARS2-LS185	STD=MARS				EARTH

Comments: Description=Planet MARS
Extended=YES

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(3) MARS2-LS185	STIS/FUV-MAMA, TIME-TAG, 52X0.5	E140H 1234 A	BUFFER-TIME=1250; WAVECAL=NO			2500 Secs (2429 Secs) *[==>2429.0 Secs]*	*[1]*
2		WAVE	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1234 A				*[==>]*	*[1]*

Orbit Structure



Visit

Proposal 15976, MARS2-LS185-VISIT3 (06), implementation Wed Oct 30 19:01:16 GMT 2019

Diagnostic Status: Warning

Scientific Instruments: STIS/FUV-MAMA

Special Requirements: BETWEEN 12-APR-2020:00:00:00 AND 21-APR-2020:23:59:59; VISIBILITY INTERVAL 50 M

Diagnostics

(MARS2-LS185-VISIT3 (06)) Warning (Form): A target acquisition should probably be performed before doing spectroscopy or coronography with STIS or COS.

(Exposure 1 (MARS2-LS185-VISIT3 (06))) Warning (Form): Sensitive exposures should have an ETC run number provided.

Solar System Targets

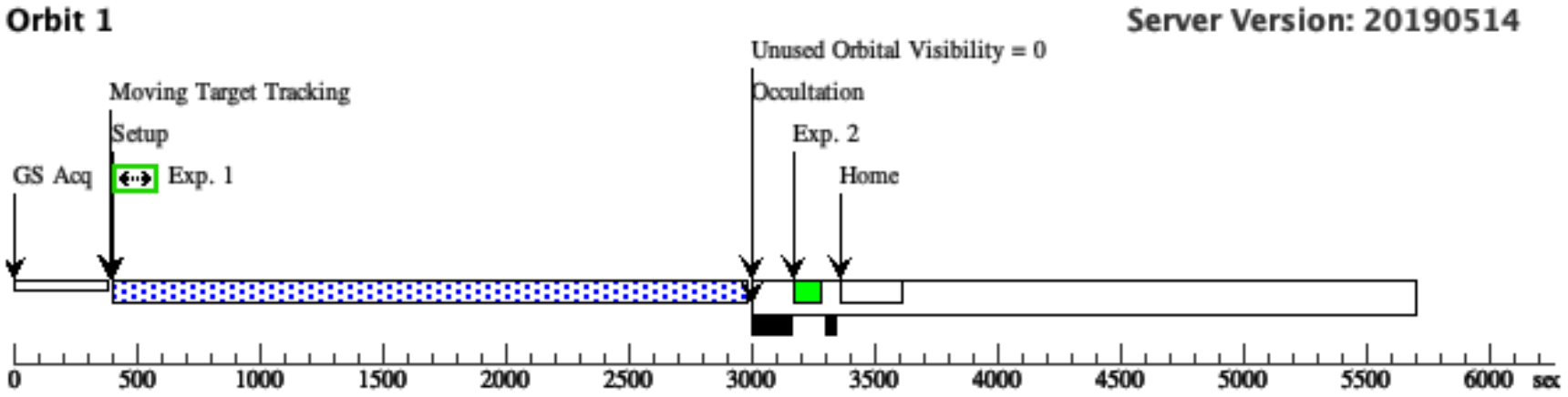
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(4)	MARS2-LS185-BCKSKY	STD=MARS	TYPE=POS_ANGLE,RAD=300,ANG=0,REF=NORTH		NOT OCC OF MARS2-LS185-BCKSKY BY MARS FROM EARTH, SEP OF MARS2-LS185-BCKSKY MARS FROM EARTH GT 10"	EARTH

Comments: Description=Planet MARS
Extended=YES

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(4) MARS2-LS185-BCKSKY	STIS/FUV-MAMA, TIME-TAG, 52X0.5	E140H 1234 A	BUFFER-TIME=1285; WAVECAL=NO			2570 Secs (2429 Secs) *[==>2429.0 Secs]*	*[1]*
2		WAVE	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1234 A				*[==>]*	*[1]*

Orbit Structure



Visit

Proposal 15976, MARS3-LS210-VISIT1 (07), implementation Wed Oct 30 19:01:16 GMT 2019

Diagnostic Status: Warning

Scientific Instruments: STIS/FUV-MAMA

Special Requirements: BETWEEN 27-MAY-2020:00:00:00 AND 02-JUN-2020:23:59:59; GROUP 07,08 WITHIN 1D; VISIBILITY INTERVAL 50 M

Diagnostics

(MARS3-LS210-VISIT1 (07)) Warning (Form): A target acquisition should probably be performed before doing spectroscopy or coronography with STIS or COS.

(Exposure 1 (MARS3-LS210-VISIT1 (07))) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 3 (MARS3-LS210-VISIT1 (07))) Warning (Form): Sensitive exposures should have an ETC run number provided.

Solar System Targets

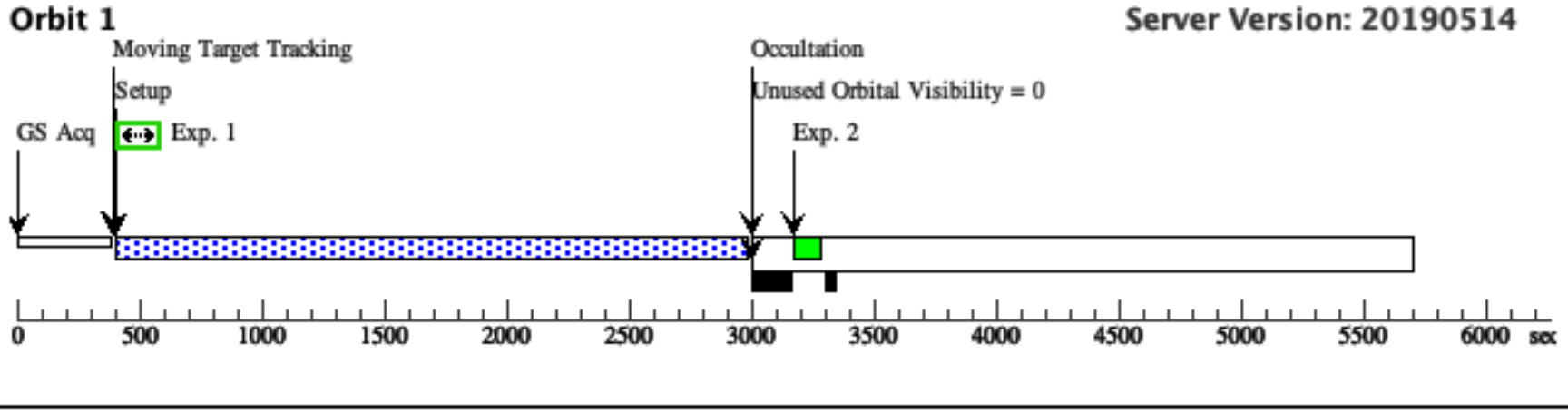
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(5)	MARS3-LS210	STD=MARS				EARTH

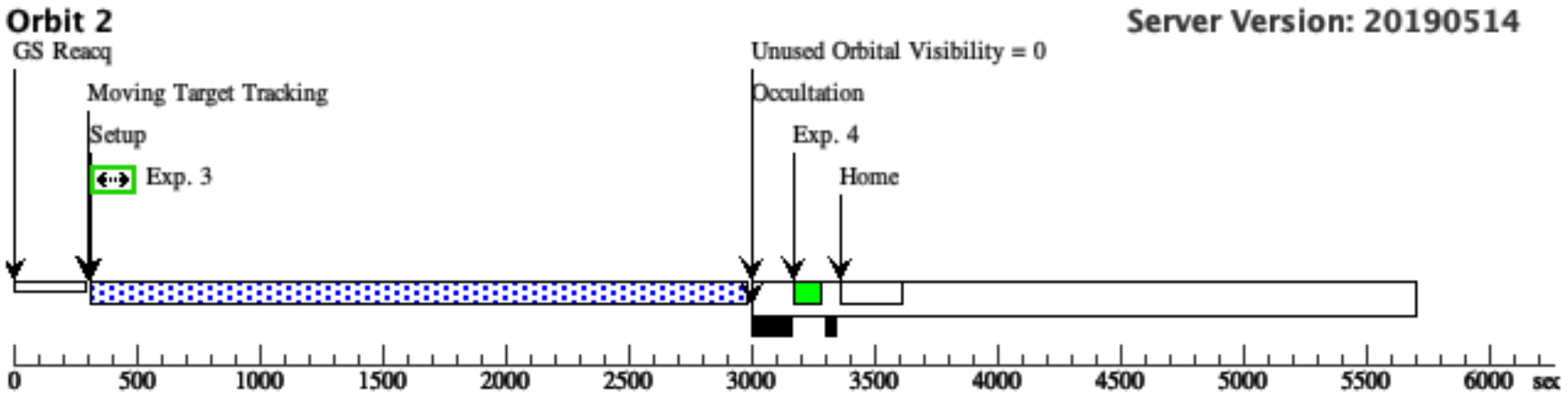
Comments: Description=Planet MARS
Extended=YES

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(5) MARS3-LS210	STIS/FUV-MAMA, TIME-TAG, 52X0.5	E140H 1234 A	BUFFER-TIME=1250; WAVECAL=NO			2500 Secs (2429 Secs) *[==>2429.0 Secs]*	*[1]*
2		WAVE	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1234 A				*[==>]*	*[1]*
3		(5) MARS3-LS210	STIS/FUV-MAMA, TIME-TAG, 52X0.5	E140H 1234 A	BUFFER-TIME=1365; WAVECAL=NO			2730 Secs (2616 Secs) *[==>2616.0 Secs]*	*[2]*
4		WAVE	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1234 A				*[==>]*	*[2]*

Orbit Structure





Visit

Proposal 15976, MARS3-LS210-VISIT2 (08), implementation Wed Oct 30 19:01:16 GMT 2019

Diagnostic Status: Warning

Scientific Instruments: STIS/FUV-MAMA

Special Requirements: BETWEEN 27-MAY-2020:00:00:00 AND 02-JUN-2020:23:59:59; VISIBILITY INTERVAL 50 M

Diagnostics

(MARS3-LS210-VISIT2 (08)) Warning (Form): A target acquisition should probably be performed before doing spectroscopy or coronography with STIS or COS.

(Exposure 1 (MARS3-LS210-VISIT2 (08))) Warning (Form): Sensitive exposures should have an ETC run number provided.

Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(6)	MARS3-LS210-BCKSKY	STD=MARS	TYPE=POS_ANGLE,RAD=300,ANG=0,REF=NORTH		NOT OCC OF MARS3-LS210-BCKSKY BY MARS FROM EARTH, SEP OF MARS3-LS210-BCKSKY MARS FROM EARTH GT 10"	EARTH

Comments: Description=Planet MARS
Extended=YES

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(6) MARS3-LS210-BCKSKY	STIS/FUV-MAMA, TIME-TAG, 52X0.5	E140H 1234 A	BUFFER-TIME=1285; WAVECAL=NO			2570 Secs (2429 Secs) *[==>2429.0 Secs]*	*[1]*
2		WAVE	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1234 A				*[==>]*	*[1]*

Orbit Structure