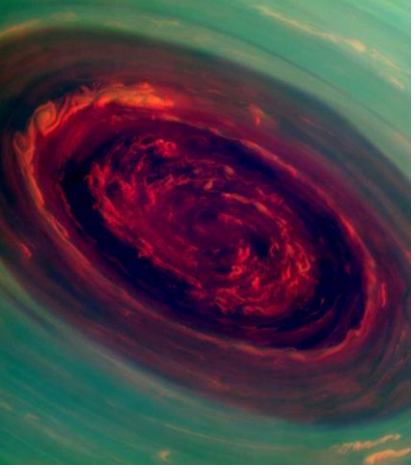
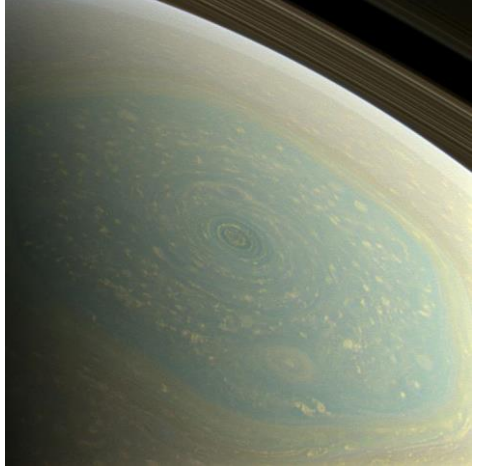
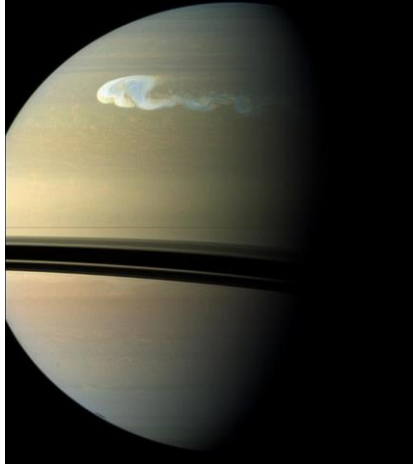


Science Planning & Sequence Team
CASSINI

SATURN TARGET WORKING TEAM

Rev 250 Segment Legacy Package

Segment Boundary: Nov 23, 2016– Nov 26, 2016
2016-328T05:43:00 – 2016-331T05:43:00 (SCET)

Integration Began 11/02/2016
Segment Delivered to S97 Sequence 06/03/2016
Lead Integrator was Martin Brennan

Legacy Package Assembled by Martin Brennan

Table of Contents

Segment Overview and Final Products

Segment Summary

- Saturn 250 was a short apoapse segment (apoapse range of 21.91 R_S) and the start of the S97 sequence, a week before the F-Ring orbits begin. The segment started ~2 hours before apokrone and ended ~ 3 days later.
- The preceding Saturn 249 segment was an adjoining segment, separated by the S97 sequence boundary.
- Saturn science included CIRS Mid-IR mapping, UVIS EUV/FUV, and VIMS mapping of the north pole.
- Notable out-of-discipline activities included a MAG calibration roll and an ISS look at small icy satellites.
- In order to improve the overall segment data volume schedule, the 70M DSN allocation was moved to the end of the segment. Implementing this change, no other data volume issues were found.
- An RSS Occultation ORT was performed during the DOY 329 and 330 passes, which required the use of RSSK RWA-Fast opmode during these passes

Final Sequenced SPASS

Request	Riders	Start (SCET)	Duration	End	Primary	Secondary	Comments
Sequence S97, length = 72 days		2016-328T05:43:00	072T01:22:00	2017-034T07:05:00			
SATURN_250 Segment		2016-328T05:43:00	003T00:00:00	2016-331T05:43:00			
SP_249EA_S97IVP328_PRIME		2016-328T05:43:00	000T00:06:00	2016-328T05:49:00	XBAND to Earth	NEG_Y to 152.0/-29.0	S97 IVP Gap
ENGR_249SC_KPTYBIAS328_PRIME		2016-328T05:49:00	000T01:30:00	2016-328T07:19:00	NEG_Z to DELTA_H (0.0,0.0,-6.0 deg. offset)	NEG_X to Sun	
SP_249SA_WAYPTTURN328_PRIME		2016-328T07:19:00	000T00:40:00	2016-328T07:59:00	ISS_NAC to Saturn	NEG_X to Sun	
NEW WAYPOINT		2016-328T07:59:00	001T11:14:00	2016-329T19:13:00	ISS_NAC to Saturn	NEG_X to Sun	
CIRS_249SA_MIRMAP001_PRIME	V	2016-328T07:59:00	000T22:00:00	2016-329T05:59:00	CIRS_FP3 to Saturn	POS_Z to NSP	
Apoapse Per = 8.0 d, Inc = ...		2016-328T08:16:38	000T00:00:01	2016-328T08:16:39			
ISS_250OT_SUTSUP047_PRIME		2016-329T05:59:00	000T04:11:00	2016-329T10:10:00	UVIS_FUV to Rocks	NEG_X to Sun	
UVIS_250SA_EUVFUV001_PRIME	C, I	2016-329T10:10:00	000T08:23:00	2016-329T18:33:00	UVIS_FUV to Saturn	NEG_X to Sun	
SP_250EA_DLTURN329_PRIME		2016-329T18:33:00	000T00:40:00	2016-329T19:13:00	XBAND to Earth	NEG_Y to 150.6/-33.6	
NEW WAYPOINT		2016-329T19:13:00	000T11:10:00	2016-330T06:23:00	XBAND to Earth	NEG_Y to 150.6/-33.6	
ENGR_250SC_KPTYBIAS329_PRIME		2016-329T19:13:00	000T01:30:00	2016-329T20:43:00	POS_Z to DELTA_H (0.0,0.0,-17.0 deg. offset)	NEG_X to Sun	
SP_250EA_C34BWGNON329_PRIME	C, R	2016-329T20:48:00	000T08:55:00	2016-330T05:43:00	XBAND to Earth	NEG_Y to 150.6/-33.6	MIMI.NEG_Y to Saturn (0,0,-9.5).SRU. Removed Rolling
SP_250SA_WAYPTTURN330_PRIME		2016-330T05:43:00	000T00:40:00	2016-330T06:23:00	ISS_NAC to Saturn	POS_Z to NSP	
NEW WAYPOINT		2016-330T06:23:00	000T12:50:00	2016-330T19:13:00	ISS_NAC to Saturn	POS_Z to NSP	
MAG_250SU_CALROLL001_PRIME	U	2016-330T06:23:00	000T09:00:00	2016-330T15:23:00	NEG_X to Earth (0.0,0.0,-30.0 deg. offset)	Rolling	
VIMS_250SA_NPOLEMAP001_PRIME	C, I, U	2016-330T15:23:00	000T03:10:00	2016-330T18:33:00	ISS_NAC to Saturn	POS_Z to NSP	
SP_250EA_DLTURN330_PRIME		2016-330T18:33:00	000T00:40:00	2016-330T19:13:00	XBAND to Earth	NEG_Y to 149.0/-35.0	
NEW WAYPOINT		2016-330T19:13:00	000T11:10:00	2016-331T06:23:00	XBAND to Earth	NEG_Y to 149.0/-35.0	
ENGR_250SC_KPTYBIAS330_PRIME		2016-330T19:13:00	000T01:30:00	2016-330T20:43:00	POS_Z to DELTA_H (0.0,0.0,-70.0 deg. offset)	NEG_X to Sun	
SP_250EA_C70METNON330_PRIME	C, R	2016-330T22:43:00	000T07:00:00	2016-331T05:43:00	XBAND to Earth	NEG_Y to 149.0/-35.0	MIMI.NEG_Y to Saturn (0,0,-9.5).SRU. pre-SOST flyby.

Gap 1

Gap 2

Final Sequenced SMT and Data Volume

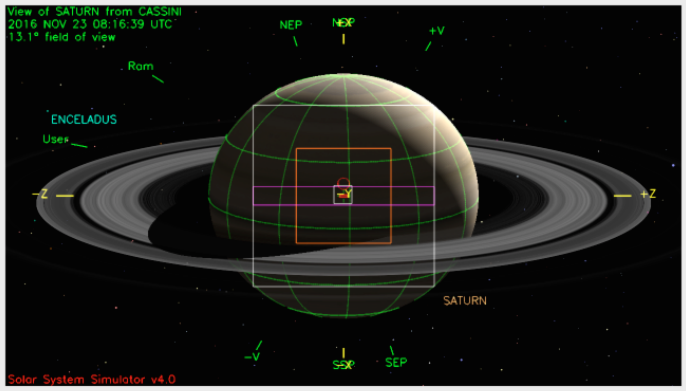
DATA VOLUME SUMMARY --- TRANSFER FRAME OVERHEAD INCLUDED (80 BITS PER 8800-BIT FRAME)

			OBSERVATION_PERIOD							DOWNLINK_PASS							
			P4						P5	RECORDED		PLAYBACK					
DOWNLINK PASS NAME	Start doy hh:mm	End doy hh:mm	START (Mb)	SCI (Mb)	HK+E (Mb)	TOTAL (Mb)	CPACTY (Mb)	MRGN (Mb)	OPNAV (Mb)	SCI (Mb)	ENGR (Mb)	TOTAL (Mb)	CPACTY (Mb)	MARGN (Mb)	NET_MARGN (Mb)	(%)	CAROVR (Mb)
SP_250EA_C34BWGNON329_PRIME	329 20:48	330 05:43	0	1758	165	1923	3322	1399	0	185	53	2161	553	-1608	0	0%	1608
SP_250EA_C70METNON330_PRIME	330 22:43	331 05:43	1608	613	72	2293	3322	1029	0	165	41	2499	2310	-190	0	0%	189

DATA VOLUME REPORT --- TRANSFER FRAME OVERHEAD NOT INCLUDED

Event	Start doy hh:mm	End doy hh:mm	CAPS (Mb)	CDA (Mb)	CIRS (Mb)	INMS (Mb)	ISS (Mb)	MAG (Mb)	MIMI (Mb)	RADAR (Mb)	RPWS (Mb)	UVIS (Mb)	VIMS (Mb)	PROBE (Mb)	ENGR (Mb)	TOTAL (Mb)
OBSERVATION_NOR	328 05:43	329 20:48	0.0	73.7	377.2	28.4	135.0	69.5	119.6	0.0	126.6	151.9	660.0	0.0	163.3	1905.3
SP_250EA_C34BWGNON329_PRIME	329 20:48	330 05:43	0.0	16.8	86.4	3.2	0.0	15.9	27.3	0.0	28.9	4.9	0.0	0.0	0.0	183.4
DAILY TOTAL SCIENCE	328 05:43	330 05:43	0.0	90.5	463.6	31.7	135.0	85.4	146.9	0.0	155.5	156.8	660.0	0.0	163.3	
OBSERVATION_NOR	330 05:43	330 22:43	0.0	32.1	33.6	6.1	150.0	30.2	52.0	0.0	80.1	63.4	160.0	0.0	71.0	678.6
SP_250EA_C70METNON330_PRIME	330 22:43	331 05:43	0.0	13.2	75.6	4.4	0.0	12.4	21.4	0.0	32.8	3.8	0.0	0.0	0.0	163.7
DAILY TOTAL SCIENCE	330 05:43	331 05:43	0.0	45.3	109.2	10.6	150.0	42.7	73.4	0.0	112.9	67.2	160.0	0.0	71.0	

Segment Geometry




```
Rev 250  INBOUND
2016 -  328T08:16:39 SCET
2016 NOV 23 08:16:39 SCET
2016 NOV 23 09:48:07 ERT
Apoapse__250 + -00:00:00
Periapse_250 - 003T23:37:21
Light time:    91.5 min
Orbit period:   8.0 days
Radius      1320351 km      21.91 Rs
Rad_cyl     1283682 km      21.30 Rs
Z_ht_cyl     309011 km       5.13 Rs
Mag_L         23.18
Semi_axs     769354 km      12.77 Rs
Eccentricity    0.716
Inclination    61.36 deg
Sun_range      10.05 AU
Earth_range    11.00 AU
--- DSN ELEV -- D/L -- U/L --------
Goldstone     -69.6  -61.2
Canberra        2.5   38.7
Madrid         12.4  -18.3
------- LOOK DIRECTION INFO -------
FOV            13.1 deg  228.1 mrad
RA            112.584 deg
DEC           -15.619 deg
Crosses_RP_@    0.000 Rs
EPS             1.501 deg
SEP            15.460 deg
ORS b/s angle  50.7 deg
ORS rad angle  52.2 deg  *
```

Point NEG_Y at SATURN and align POS_X = Up with NSP

User vector - RA: +162.607 DEC: +3.717 Paste Current RA/DEC

Tilt L | Up | Tilt R | Left | Reset | Right | Image | Down | Hi Res

Zoom Out | Fill Screen | Zoom In | Labels | Axes | Orbits | Vectors | FOVs | Lat/lons

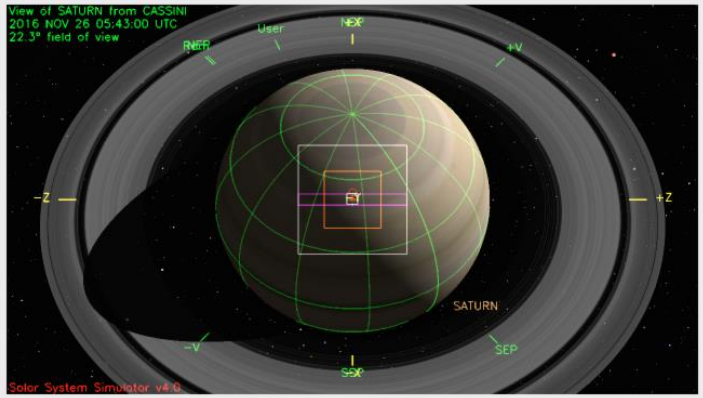
Year | Month | Day | Hour | Minute | Second

Turn analyzer: SATURN to EARTH about Z on RWA = 6.8 min / 51.8 deg Event

BODY	S/C OCC?	SAT OCC?	RANGE (km)	RANGE (Rs)	ALTITUDE (km)	ALTITUDE (Rs)	PHASE (deg)	ANGLR_DIAMETER (deg)	ANGLR_DIAMETER (mrad)	SUB_S/C LON	SUB_S/C LAT	ALON (deg)	VREL (km/s)	Z_HGHT (km)	ANGLE_FROM_ SATRN	ANGLE_FROM_ EARTH	ANGLE_FROM_ RAM
SATURN	--	--	1320351	21.91	1260394	20.91	129.2	5.23	91.32	243	14	0	2.9	0	0.0	51.8	90.0
MIMAS	--	--	1317962	21.87	1317765	21.87	123.7	0.02	0.31	88	13	85	14.8	-3924	8.2	57.5	83.3
ENCELADUS	--	--	1507497	25.01	1507243	25.01	126.8	0.02	0.34	38	12	141	14.3	18	6.0	54.4	84.3
TETHYS	--	--	1130397	18.76	1129863	18.75	120.7	0.05	0.96	127	16	43	11.0	-171	10.6	60.5	82.7
DIONE	--	--	1441961	23.93	1441399	23.92	119.8	0.04	0.78	63	12	102	11.2	-174	14.9	61.4	77.1
RHEA	--	--	1599432	26.54	1598668	26.53	118.4	0.05	0.96	51	11	113	9.9	-2121	17.7	62.8	74.2
TITAN	--	--	2482289	41.19	2479714	41.14	124.4	0.12	2.07	11	7	152	7.4	7731	14.9	56.8	75.2
HYPERION	--	--	2496978	41.43	2496857	41.43	144.6	0.01	0.13	99	41	-142	6.8	23676	20.2	36.0	102.7
IAPETUS	--	--	4660358	77.33	4659611	77.31	120.8	0.02	0.32	9	8	144	5.5	835248	33.1	60.5	57.0
PHOEBE	--	--	15270511	253.38	15270400	253.37	136.4	0.00	0.02	117	-6	163	2.0	5797447	37.6	44.7	59.8
SATURN	--	--	1320351	21.91	1260394	20.91	129.2	5.23	91.32	243	14	0	2.9	0	0.0	51.8	90.0

Apoapse (Left)

Seg 250 End (below)




```
Rev 250  INBOUND
2016 -  331T05:43:00 SCET
2016 NOV 26 05:43:00 SCET
2016 NOV 26 07:14:31 ERT
Apoapse__250 + 002T21:26:21
Periapse_250 - 001T02:11:00
Light time:    91.5 min
Orbit period:   8.0 days
Radius      772415 km      12.82 Rs
Rad_cyl     505439 km       8.39 Rs
Z_ht_cyl    584086 km       9.69 Rs
Mag_L         29.93
Semi_axs    769299 km      12.76 Rs
Eccentricity    0.716
Inclination    61.35 deg
Sun_range      10.04 AU
Earth_range    11.00 AU
--- DSN ELEV -- D/L -- U/L --------
Goldstone     -68.4  -32.4
Canberra       30.6   66.9
Madrid        -11.0  -45.5
------- LOOK DIRECTION INFO -------
FOV            22.3 deg  389.3 mrad
RA            149.577 deg
DEC           -47.396 deg
Crosses_RP_@    0.000 Rs
EPS             1.254 deg
SEP            12.870 deg
ORS b/s angle  94.4 deg
ORS rad angle  53.5 deg  *
```

Point NEG_Y at SATURN and align POS_X = Up with NSP

User vector - RA: +162.607 DEC: +3.717 Paste Current RA/DEC

Tilt L | Up | Tilt R | Left | Reset | Right | Image | Down | Hi Res

Zoom Out | Fill Screen | Zoom In | Labels | Axes | Orbits | Vectors | FOVs | Lat/lons

Year | Month | Day | Hour | Minute | Second

Turn analyzer: SATURN to EARTH about Z on RWA = 10.1 min / 95.2 deg Event

BODY	S/C OCC?	SAT OCC?	RANGE (km)	RANGE (Rs)	ALTITUDE (km)	ALTITUDE (Rs)	PHASE (deg)	ANGLR_DIAMETER (deg	ANGLR_DIAMETER mrad)	SUB_S/C LON	SUB_S/C LAT	ALON (deg)	VREL (km/s)	Z_HGHT (km)	ANGLE_FROM_ SATRN	ANGLE_FROM_ EARTH	ANGLE_FROM_ RAM
SATURN	--	--	772415	12.82	715470	11.87	85.5	8.95	156.21	37	49	0	7.0	0	0.0	95.2	43.6
MIMAS	--	--	799090	13.26	798896	13.26	74.9	0.03	0.52	70	46	92	20.5	-1917	13.5	106.0	34.8
ENCELADUS	--	--	901757	14.96	901505	14.96	81.2	0.03	0.57	38	40	132	19.5	10	13.7	99.8	30.2
TETHYS	--	--	905657	15.03	905124	15.02	103.0	0.07	1.19	319	40	-117	9.8	-1028	18.1	77.8	53.3
DIONE	--	--	940764	15.61	940202	15.60	72.6	0.07	1.20	39	38	113	16.9	-164	22.8	108.5	25.0
RHEA	--	--	911930	15.13	911166	15.12	112.3	0.10	1.68	317	40	-86	4.3	3228	35.2	68.0	73.1
TITAN	--	--	1681916	27.91	1679341	27.86	67.5	0.18	3.06	16	20	122	12.4	-230	44.1	113.7	12.9
HYPERION	--	--	2034064	33.75	2033934	33.75	113.4	0.01	0.16	277	11	-165	9.4	22182	34.3	67.7	40.1
IAPETUS	--	--	4060892	67.38	4060146	67.37	101.0	0.02	0.37	1	10	163	9.4	704547	52.4	80.1	21.8
PHOEBE	--	--	14507232	240.71	14507122	240.71	136.3	0.00	0.02	292	-7	-163	6.9	5899229	72.1	44.6	57.7
SATURN	--	--	772415	12.82	715470	11.87	85.5	8.95	156.21	37	49	0	7.0	0	0.0	95.2	43.6

	Saturn Range	Phase Angle	Sub-S/C Lat.
Segment Start	21.90	130.4	+13
Apoapse	21.91	129.2	+14
Segment End	12.82	85.5	+49

Solar Geometry – ORS Boresight Concerns

No ORS Boresight Solar Constraints on Science Pointing Noted

Daily Science Highlights

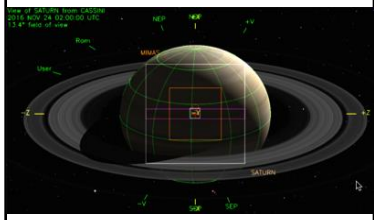
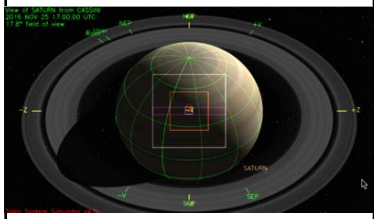
DOY 328 (23 November 2016): The short Saturn 250 segment began the S97 sequence continuing on from the Saturn 249 segment, separated just by the sequence boundary. CIRS executed a mid-IR map to determine Saturn's upper troposphere and tropopause temperature of the northern hemisphere for 2 full rotations of the planet (22hr) with spatial resolution of about two degrees of latitude and longitude (ISS and VIMS ride along).

DOY 329 (23 November 2016): ISS performed a solo study of the irregular moon Suttungr for 4hr. UVIS then acquired an EUV/FUV mapping of the planet for over 8.5hr, to study the distribution of hazes and organic compounds high in Saturn's Northern hemisphere atmosphere. CIRS and ISS rode along

DOY 330 (23 November 2016): MAG did a 9hr of field calibration rolls by rolling about an axis other than Z for determining sensor offsets. The segment concluded with a VIMS mosaic mapping of Saturn's northern pole region followed by a single image centered on the North Pole. CIRS, ISS, and UVIS rode along.

Segment Integration Planning

Timeline Gaps and Suggested Observations

Gap	Start	End	Duration	Phase angle (range)	Rs range	Sub-S/C Lat.	Snapshot (mid-gap)
1	2016-328T07:59:00	2016-329T18:33:00	001T10:34:00	129.4° to 113.1°	21.91 to 19.89	+13 to +28	
2	2016-330T15:23:00	2016-330T18:33:00	000T03:10:00	99.8° to 97.2°	16.46 to 15.75	+38 to +41	

Initial SMT and Data Volume

Beginning of Integration:

DATA VOLUME SUMMARY --- TRANSFER FRAME OVERHEAD INCLUDED (80 BITS PER 8800-BIT FRAME)

			OBSERVATION_PERIOD							DOWNLINK_PASS						
			P4						P5	RECORDED		PLAYBACK				
DOWNLINK PASS NAME	Start doy hh:mm	End doy hh:mm	START (Mb)	SCI (Mb)	HK+E (Mb)	TOTAL (Mb)	CPACTY (Mb)	MRGN (Mb)	OPNAV (Mb)	SCI (Mb)	ENGR (Mb)	TOTAL (Mb)	CPACTY (Mb)	MARGN (Mb)	NET_MARGN (Mb)	CAROVR (%)
SP_250EA_C34BWGNON329_PRIME	329 20:43	330 05:43	0	1809	165	1974	3322	1348	0	186	53	2213	558	-1656	801	23% 1655
SP_250EA_C70METNON330_PRIME	330 20:43	331 05:43	1655	179	63	1897	3322	1425	0	201	53	2151	2953	801	801	27% 0

DATA VOLUME REPORT --- TRANSFER FRAME OVERHEAD NOT INCLUDED

Event	Start doy hh:mm	End doy hh:mm	CAPS (Mb)	CDA (Mb)	CIRS (Mb)	INMS (Mb)	ISS (Mb)	MAG (Mb)	MIMI (Mb)	RADAR (Mb)	RPWS (Mb)	UVIS (Mb)	VIMS (Mb)	PROBE (Mb)	ENGR (Mb)	TOTAL (Mb)
OBSERVATION_NOR	328 05:43	329 20:43	0.0	73.6	0.0	28.4	1375.7	69.4	119.3	0.0	126.4	0.0	0.0	0.0	163.0	1955.8
SP_250EA_C34BWGNON329_PRIME	329 20:43	330 05:43	0.0	17.0	86.4	3.2	0.0	16.0	27.5	0.0	29.2	4.9	0.0	0.0	0.0	184.3
DAILY TOTAL SCIENCE	328 05:43	330 05:43	0.0	90.5	86.4	31.7	1375.7	85.4	146.9	0.0	155.5	4.9	0.0	0.0	163.0	
OBSERVATION_NOR	330 05:43	330 20:43	0.0	28.3	0.0	5.4	0.0	26.7	45.9	0.0	70.7	0.0	0.0	0.0	62.7	239.7
SP_250EA_C70METNON330_PRIME	330 20:43	331 05:43	0.0	17.0	86.4	5.2	0.0	16.0	27.5	0.0	42.2	4.9	0.0	0.0	0.0	199.2
DAILY TOTAL SCIENCE	330 05:43	331 05:43	0.0	45.3	86.4	10.6	0.0	42.7	73.4	0.0	112.9	4.9	0.0	0.0	62.7	

Waypoint Selection

Good Waypoints

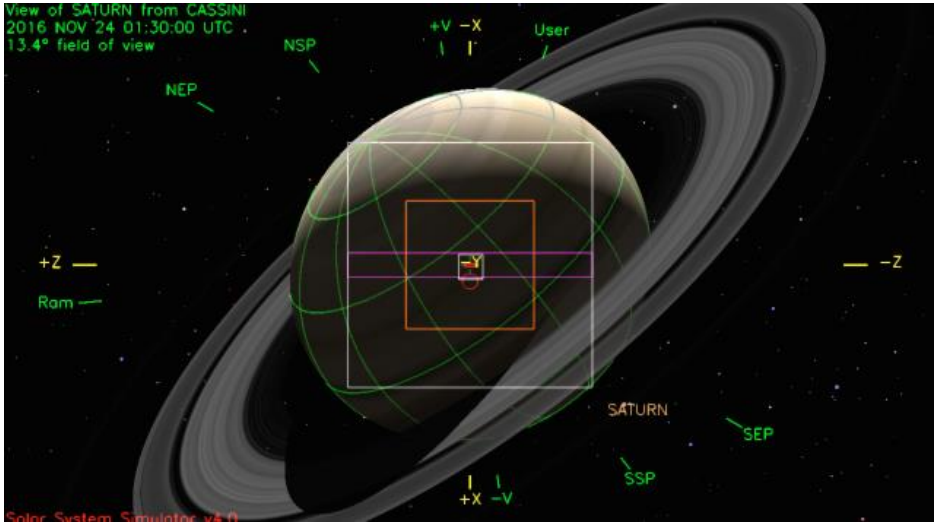
OBS_NAME	START	END	POS_X_2_NSP	POS_X_2_NEP	NEG_X_2_NSP	NEG_X_2_NEP	POS_Z_2_NSP	POS_Z_2_NEP	NEG_Z_2_NSP	NEG_Z_2_NEP	NEG_X_2_SUN	NEG_Z_2_EARTH
SP_249NA_OBSERV328_NA	2016-328T05:43:00	2016-329T20:43:00	**BAD**	**BAD**	OK	OK	OK	OK	**BAD**	**BAD**	OK	OK
SP_250NA_OBSERV330_NA	2016-330T05:43:00	2016-330T20:43:00	**BAD**	**BAD**	OK	OK	OK	OK	**BAD**	**BAD**	OK	OK

RBOT Friendly Waypoints

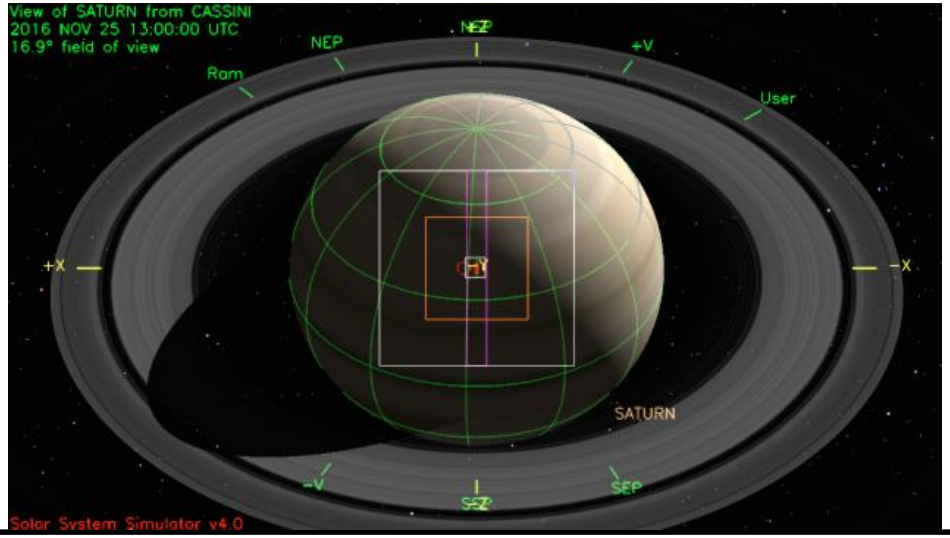
OBSERVATION PERIOD	START	END	POS_X	NEG_X	POS_Z	NEG_Z
SP_249NA_OBSERV328_NA	2016-328T05:43:00	2016-329T20:43:00	191.6/ 34.3	------	191.6/ 34.3	------
SP_250NA_OBSERV330_NA	2016-330T05:43:00	2016-330T20:43:00	191.6/ 34.4	------	191.6/ 34.4	------

Waypoints Chosen

Waypoint 1 (2016-328T07:59:00 – 2016-329T19:13:00): ISS_NAC to Saturn, NEG_X to Sun



Waypoint 2 (2016-330T06:23:00 – 2016-330T19:13:00): ISS_NAC to Saturn, POS_Z to NSP



Notes

- Pointing:
  - RBOT friendly waypoints used when compatible with science.
- Data Volume:
  - No SMT warnings.
  - SSR cleared by end of segment.
- DSN:
  - No Level 3 requests
  - Disposition ap_downlink report check warnings (except %70M stations, ignore)
    - Ignore “Warning: 70m usage for sequence exceeds project commitment of <= 35%; is at 50%”
    - Ignore “Warning: number of sequence upload passes is 0; should be 5 or more”
  - Differences from DSN strawman:
    - C34BWGNON329 downgraded from 70M (Part of Swap with following 70M pass downgrade)
    - C70METNON220 upgraded from 34BWG
- Resource checker:
  - None
- Opmodes:
  - RSSK RWA-Fast (2016-329T20:37:50 – 330T05:41:12) : Verified by Aseel Anabtawi via email 11/04/15
  - RSS2 RWA-Fast (2015-330T20:42:54 – 331T05:41:12) : Verified by Aseel Anabtawi and Laura Burke via email 01/11/16
- Hydrazine:
  - N/A
- Special Activities:
  - None

This document has been reviewed and determined not to contain export controlled technical data

Liens

Sequence Liens (should all be SPLAT items):

- List any Liens to be worked in SIP
  - None

This document has been reviewed and determined not to contain export controlled technical data