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Solar Orbiter Mission Operations Report #29

Period [21 December 20 - 27 December 20]

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APPROVAL

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CHANGE LOG

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Updated with reporting for new time period	29	0	**28/12/2020**

CHANGE RECORD

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1SUMMARY OF ACTIVITIES

This report covers the last STP in LTP 2 (STP 127), with the Venus flyby.

The flyby successfully took place on 27/12 at 12:39:19 UTC. As far as first telemetry analysis shows, all was nominal. The final orbit determination will be done in the coming days. See the special events section for some more details.

DoY	Date	Activity
356	21/12/2020	***STP 127 (continuation)*** NNO/MLG passes
357	22/12/2020	CEB pass NNO/CEB DDOR MLG/CEB DDOR
358	23/12/2020	NNO/MLG passes NNO/CEB DDOR WOL SA rotation from 30 to 56 deg
359	24/12/2020	NNO/MLG passes TCM -3d, not needed
360	25/12/2020	NNO/MLG passes NNO/CEB DDOR MLG/CEB DDOR
361	26/12/2020	MLG/NNO passes TCM -6h -> not needed
362	27/12/2020	MLG/NNO passes VGAM1

At the end of the reporting period (DoY 362, 27/12) Solar Orbiter was at:

- 231.0 million km from the Earth (1.54 AU); the one-way signal travel time was 12 min 51 sec (771 sec). Earth distance decreasing since 28/09 (1.79 AU reached)
- 108.5 million km from the Sun (0.72 AU). Sun distance decreasing since 13/10 (0.98 AU reached)

2 SATELLITE STATUS

2.1 Platform

2.1.1 *AOCS / propulsion*

The AOCS configuration at the end of the reporting period is:

- AOCS in NCM mode
  - with attitude control based on Wheels (all 4 Wheels)
  - using the gyro stellar estimator (GSE) on STEADY gains
  - with inertial reference attitude guidance

- AOCS Sensors
  - IMU A (all 4 Channels) ON and IN-USE
  - IMU B (all 4 Channels) OFF and all 4 Channels PRESELECTED
  - ACC (all 4 Channels) OFF
  - FSS A (XP and ZM) ON and IN-USE, with FSS A XP having SUN Presence
  - FSS B (XP and ZM) OFF
  - STR A OFF since 05/06 (DoY 157), health set to 2
  - STR B ON (NEAT mode) and IN-USE since 05/06 (DoY 157), health set to 3

AOCS Actuators

- RW 1-4 ON and IN-USE used for Attitude Control since DoY 042 and LEOP day 1
- RW Momentum Target Levels @ 18/-18/-18/18 Nms
- CPS B OFF and PRESELECTED, CPS A OFF

- AOCS Flags
  - Sun Distance flag set to NEAR since 10/11/2020 (DoY 315)
  - Flyby flag set to NO FLYBY since launch
  - The Flyby flag was set to VENUS around VGAM1
  - The SASM2WASM flag was set to false around VGAM1

- AOCS HK and TM mode configuration: Default since DoY 052 (21/02/2020)

- Propulsion system
  - Valves in default configuration (all TLVs + LFLV closed, except for LFLV 3+4)
  - The propulsion system is configured in regulated mode since launch
  - The pressure relief function is activated when needed
  - Pressure levels
    - HE tank pressure @ 149.0 bar (PT1)
    - PT2 (between pressure regulator and latch valves 1/2) @ 16.9 bar
    - NTO tank pressure @ 16.5 bar (PT3)
    - MMH tank pressure @ 16.5 bar (PT4)
    - PT5 (before latch valves 3/4 for MON) @ 16.5 bar
    - PT6 (before latch valves 3/4 for MMH) @ 16.5 bar
    - PT7 (between pressure regulator and latch valves 1/2) @ 16.9 bar

  - Pressure relief function was updated back to 40 days on 21/10 DoY 295 in RAM only; duration unchanged and at 8 cycles. SGM RAM values unchanged (18 days/8 cycles).

The TCM -3d and -6h were not required. See annexes for latest navigation details.

2.1.2 *Mechanisms*

- SADE
  - SADE A ON and IN-USE
  - SADE B OFF
  - SA @ 56 degrees since 358.08.56. The next scheduled rotation is on 366.03.22 (31/12) to 60 degrees.

AR SOL_SC-69 is being discussed with Airbus (minor SA issues during recent de-icing maneuver).

- HGA APME
  - HGA Deployment Status = TRUE
  - HGA selected as PRIME Antenna (PM and SGM RAM)
  - APME A OFF and PRESELECTED
  - APME B OFF

- MGA APME
  - MGA Deployment Status = TRUE
  - MGA is selected as PRIME Antenna (SGM RAM) since DoY 058

- APME A OFF and PRESELECTED
- APME B OFF

2.1.3 *TT&C*

The performance of the subsystem is nominal

- TRSP-1 X-band up and down via HGA, 4 kbps uplink, downlink bit rate is selected according to the used ground station
- TWTA-1 is in use, RF power nominal (from Helix Current telemetry reading)
- TRSP-2 back-up uplink is configured for X-band reception at 7.8 bps via LGA-1 since DoY 178 26/06/2020. LGA-1 is the better antenna till at least end of LTP 3.
- TWTA-2 is OFF and in cold redundancy
- MGA is selected as safe mode antenna since DoY 058.
- PN ranging is fully validated and used by default since DoY 057 (26/02). This allows to currently be on the max TM bit rate.

DST 1 and 2 output power was reduced on 19/06 as the TWTA was in overdrive.

The change was also applied in SGM.

2.1.4 *Thermal*

The thermal configuration has been updated with CSW 3.1.1 loading which takes into account most changes since launch. The following changes (which will be included in CSW 3.1.2 under preparation) were applied during the safe mode recovery on 10/09:

TL044 (METIS Ebox)	updated to: -16.5°C / -16°C
TL045 (PHI Ebox)	updated to: : -16.5°C / -16°C
TL048 (MY RS zone)	updated to: : -15.5°C / -15°C
TL093 (EPD SIS)	updated to: : -24°C / -20°C
TL098 (MAG OBS)	updated to: : -90°C / -88°C

Post de-icing slew, FDIR triggered on EUI thermal line 60 due to a too cold temperature. Settings will need to be further fine-tuned. The heat-up of 6 degC post slew was not enough.

The set points of the Thermal Control Line #50 (SWA Electronic box) were changed stepwise from [-15.0,-12.0] degC to [4.0,5.0] degC between 2020-328T00:00:00 and 2020-329T02:00:00 in order to acquire a more benign temperature of the SWA Ebox before the next attempt to switch the instrument ON.
Upon request from SWA, and after agreement on a dedicated ARB, the thresholds for the TCL#48 MY Panel Zone Heater were changed from originally [-15.5,-15.0] degC to [0.5, 1.0] degC in an attempt to increase the temperature of the SWA electronics Box.

After the update of the SWA heater set-points (Thermal Control Line #50) to [4,5] in PM RAM on DOY 329, the set-points were updated correspondingly in SGM EEPROM as well during the NNO/311 pass on DOY 351.

Heater set-points were updated for EPD EPT-HET 1&2 thermal lines 91 and 92 to avoid big temperature drops when EPT-HET 1&2 are switched off.
The new heater set-points are:
EPT-HET 1 -20 -15
EPT-HET 2 -15 -10

NONOP FDIR limits were applied to survival heaters around VGAM1.

2.1.5 *Power*

The subsystem is in its nominal configuration and performing nominally.

- PCDU A OFF
- PCDU B ON and in use

PCDU A and B EEPROM table updates took place in flight on 05/06.

PCDU-B SGM & PM RAM health is set to 3 since 03/07 (to make B the preferred choice and avoid changing the SCV config in SGM EEPROM).

2.1.6 *Data handling*

The subsystem is in its nominal hardware and software configuration.

The SSMM is ON and fully configured in 3 MM Configuration.

The TC Link Monitor is configured to a time-out of 4 days since 27/11 (DoY 332).
This is the configuration for the VGAM phase which is now set as follows (TC link TH1/TC link TH1 increase/TC link TH2):
PM RAM: 4d/12h/7d + 34h
SGM RAM: 4d/12h/4d + 34h

The TM generation mode is configured to NOMINAL.

The current DMS configuration is:

Item	A	B
OBC PM	Active	Off
OBC CSW Image Select	1	1
OBC CSW Version	3.1.1	3.1.1
OBC CSW RAM version	3.1.1	3.1.1
OBC EEPROM Segs	1 : Code 2: Data	1 : Code 2: Data
RM PAP Prog. Set	1 (PM-A Nominal)	1 (PM-A Nominal)
RM	Enabled	Enabled
SSMM SV	Active	Off
SSMM ASW Image	1	1
SSMM ASW Version	02.07.00	02.07.00
RIU	Active	Off
OMM	On and in use (slave)	On and in use (Master)

Updated eclipse files for SGM EEPROM A and B (unique eclipse in the mission is during the EGAM in Nov 2021) were commanded to the SC on 22/1120.

CSW 3.1.2 PM A and B images 0 and 1 are on board (delayed TC files) since 20/12/2020.

The SWA anomaly @ 2020.308.01.17 (AR SOL_SC-67), lead to SWA switch off. The CSW did not block S20 TCs to the failed unit as would be expected (SOL_SC-68). This lead to the SpW network being overloaded, the SPICE heartbeat counter being above limit, in turn switching off SPICE. Addressing what is believed to be a newly discovered CSW issue is pending discussions with Airbus.

2.2 Instruments

EPD
Nothing to report.

EUI
Nothing to report.

MAG
Nothing to report.

METIS
Nothing to report.

PHI
Nothing to report.

RPW
Nothing to report.

SWA
Nothing to report.

SoloHi
Nothing to report.

SPICE
Nothing to report.

STIX
Nothing to report.

Decontamination heater status
Current status:

- SPICE OU = ON
- SPICE CE = ON
- METIS = OFF
- EUI OU = OFF

3 GROUND FACILITIES

3.1 Ground Stations

During the reporting period mission operations have been conducted with the three ESA stations.

Station coverage has increased, including several DDORs in view of the VGAM navigation window which has started.

3.2 Control Centre

SolO MCS SW version D3.19.6 is used on all operational machines since 20/11/2020.
This version uses:

- GFTS SW version 3.3.3 since 16/10
- EDDS SW version 2.4.0 on 07/07 (with latest stream client now available)
- NIS SW version 5.3.1 since 21/10
- FARC SW version 3.2.1

4 SPECIAL EVENTS

The VGAM1 took place @ 12:39:19 UTC.

This is a high level timeline of key events.
First TM analysis shows all was nominal.

(1) 362.00.00 the SASM2WSM flag was set to false in SGM. The SC would perform the flyby in SASM mode in case of safe mode and remain in that mode.
(2) 362.08:00 the SC performed a roll from 0 to 130 deg to improve star tracker visibility.
(3) WOL @ 09:55
(4) Between 10:35 to 15:40, the NONOP FDIR limits to survival HTRs were applied
(5) 10:39, the flyby flag was set to Venus. Among other things, the flag relaxes some AOCS FDIR thresholds around the flyby.
(6) STR B was brought out of the loop between 12:04 till 16:00.
(7) @ 13:14 the flyby and SASM2WSM flags were reset
(8) WOL @ 14:49
(9) 16:54 start fine pointing

5 ANOMALIES

The following Anomaly Reports were raised in the reporting period:

Spacecraft

None

Ground Segment

None

Non Conformance Reports

None

6 FUTURE MILESTONES

This is the timeline of future milestones:

Milestone	Date	Comment
LTP2	DoY 181, 29/06/20	LTP 2 runs till 01/01/2021 00:00
VGAM navigation window	DoY 335, 30/11/20 00:00 To DoY 004, 04/01/21 00:00	Slots for possible Trajectory Control Manoeuvres around VGAM1 are fixed as follows: (1) TCM at VGAM1 -4w (30/11/20 - DoY 335) -> Not needed. (2) TCM at VGAM1 -2w (13/12/20 - DoY 348) -> Not needed. (3) TCM at VGAM1 -1w (20/12/20 - DoY 355) -> Not needed. (4) TCM at VGAM1 -3d (24/12/20 – DoY 359) -> Not needed. (5) TCM at VGAM1 -6h (26/12/20 – DoY 361) -> Not needed. (6) TCM at VGAM1 +1w (01/01/21 – DoY 001) Note: (4) and (5) are contingency slots
VGAM	DoY 362, 27/12/20	@ 12:39:19 UTC
LTP3	DoY 001, 01/01/21	LTP 3 runs till 28/06/2021 00:00
TBC CSW 3.1.2 upload	TBC STP 131 DoY 017, 17/01/21 20:52 to DoY 024, 24/01/21 21:10	TBC CSW 3.1.2 upload to the SC This will be a full SW load, requiring all instruments off. The new SW will address the AOCS pointing stability issues
Conjunction	DoY 030 30/01/21 to DoY 042 11/02/21	limited access to the SC (TM and TC) With the Sun Earth SC angle < 5 deg

7 ANNEX 1, SOLAR ORBITER: NAVIGATION STATUS REPORT FOR THE VENUS SWING-BY #1 (4)

Email from Frank Budnik, 25/12/2020

This is to report on the navigation status for the Venus swing-by #1, 2 days before closest approach. In summary, the navigation is nominal.

The orbit determination has been performed today with a data-cutoff at 07:06 UTC, shortly before the end of the New Norcia pass on 25 December. The data arc contains in total 60 Delta-DOR measurements, 24 from the Cebreros - Malargüe baseline and 36 from the Cebreros - New-Norica baseline.

For a prediction into the future the situation is summarised in the attached B-plane plot. The dashed ellipses are the same as in the previous navigation report. The dotted yellow error ellipse is a repetition of the OD performed for TCM-1w, but with changed uncertainty assumed for the Venus ephemeris, which we found was set too conservatively. This causes the ellipse to shrink mainly along the B.T direction i.e. along the Venus equator. However, this correction would not have changed the decision to not execute TCM-1w.

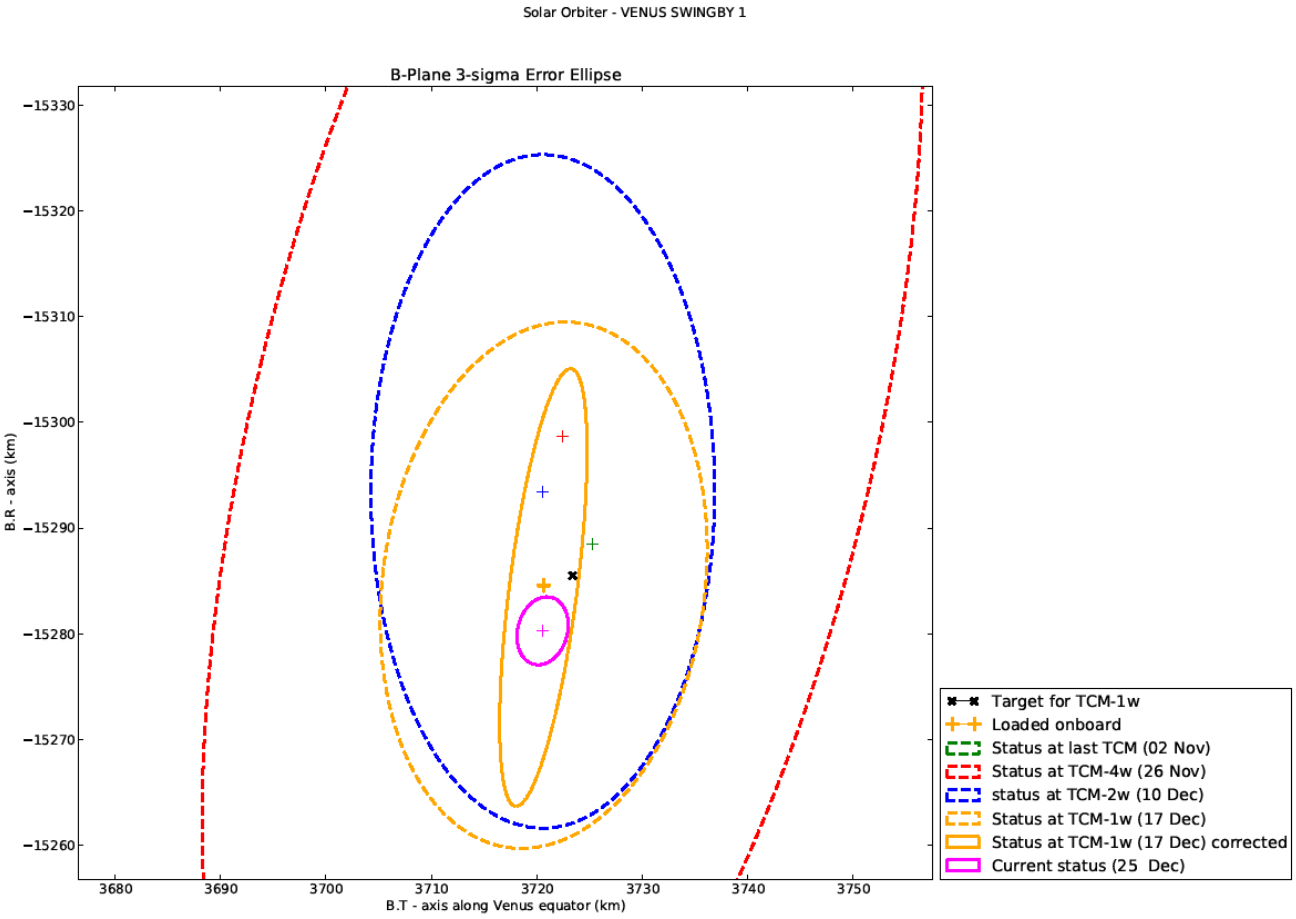
The estimated impact point and associated 3-sigma error ellipse which are derived from todays OD are shown in magenta and has a a size of 2 km x 3 km in semi-axes. The FD products covering the swing-by, that had been generated and delivered last week and which are by now loaded onboard are based on the impact point labelled as orange cross. It is 4 km away from the current estimate.

Solar Orbiter will enter the Venus sphere of influence tomorrow, 26 December at around 22:00 UTC, meaning that the main attracting body is no longer the Sun but Venus. This means also that the orbit uncertainty will go rapidly down from then onwards.

The best estimate for the time of periapsis is on 27 December 2020 at 12:39:19.83 UTC with a 3-sigma arrival time error of 0.15 sec. The best estimate for the periapsis distance is 13 489 km with a 3-sigma error of 3 km.

This is the last navigation report before the swing-by. The formal decision point for the execution of emergency TCM-6h is tomorrow, 26 December at 14:00 UTC with a data cut-off at 11:00 UTC. The final navigation report will be provided after the swing-by on 29 December 2020.

B-plane plot:


Solar Orbiter - VENUS SWINGBY 1
B-Plane 3-sigma Error Ellipse
B.R - axis (km)
B.T - axis along Venus equator (km)
−15330
−15320
−15310
−15300
−15290
−15280
−15270
−15260
3680
3690
3700
3710
3720
3730
3740
3750
Target for TCM-1w
Loaded onboard
Status at last TCM (02 Nov)
Status at TCM-4w (26 Nov)
status at TCM-2w (10 Dec)
Status at TCM-1w (17 Dec)
Status at TCM-1w (17 Dec) corrected
Current status (25 Dec)