Solar Orbiter Mission Operations Report #26

Period [23 November 20 - 06 December 20]

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APPROVAL

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CHANGEOG

Reason for change	Issue Nr.	Revision Number	Date
Updated with reporting for new time period	26	0	**07/12/2020**

CHANGE RECORD

Issue Number 26		Revision Number 0	
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Note: no change record is kept for this document since every new issue corresponds to a new reporting period.

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1 SUMMARY OF ACTIVITIES

This report covers two nominal weeks of cruise in LTP 2 (STPs 123 to 124).

SWA was successfully switched on for a few seconds only on 27/11. Next steps remain to be defined.

On the MOC end, work continues to focus on the VGAM on 27/12 and the 5 weeks navigation window which started on 30/11.

DoY	Date	Activity
328	23/11/2020	***STP 123*** NNO/MLG passes NNO/CEB DDOR WOL
329	24/11/2020	CEB pass SA rotation from 0 to 30 deg
330	25/11/2020	CEB/MLG passes
331	26/11/2020	CEB pass
332	27/11/2020	NNO/MLG passes SWA brief successful switch on
333	28/11/2020	MLG pass SA relubrication
334	29/11/2020	MLG pass
335	30/11/2020	***STP 124*** NNO/MLG passes VGAM TCM-4w (not needed)
336	01/12/2020	NNO/MLG passes NNO/CEB DDOR WOL
337	02/12/2020	NNO/MLG passed MLG/CEB DDOR

DoY	Date	Activity
338	03/12/2020	NNO pass NNO/CEB DDOR
339	04/12/2020	MLG pass
340	05/12/2020	MLG pass
341	06/12/2020	MLG pass MLG/CEB DDOR

At the end of the reporting period (DoY 341, 06/12) Solar Orbiter was at:

- 240.6 million km from the Earth (1.6 AU); the one-way signal travel time was 13 min 23 sec (803 sec). Earth distance decreasing since 28/09 (1.79 AU reached)

- 126.8 million km from the Sun (0.85 AU). Sun distance decreasing since 13/10 (0.98 AU reached)

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2 SATELLITE STATUS

2.1 Platform

2.1.1 *AOCS / propulsion*

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

- o 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

- o 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

STR-A EEPROM dumps were performed on 02/12; dumps completed successfully (with no repetition of SOL_SC-61 : [STR] Failed STR-A EEPROM dump on DOY 157).

   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

- o AOCS Flags
    - Sun Distance flag set to NEAR since 10/11/2020 (DoY 315)
    - Flyby flag set to NO FLYBY since launch

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

- o 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 @ 149.5 bar (PT1)
    - PT2 (between pressure regulator and latch valves 1/2) @ 17.1 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) @ 17.1 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 -4w was not required. See annexes for latest navigation details.

2.1.2 *Mechanisms*

- o SADE
  - SADE A ON and IN-USE
  - SADE B OFF
  - SA @30 degrees since 329.19.25. The next scheduled rotation is on 358.08.56 (23/12) to 56 degrees.

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

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

- o 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.

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).

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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.

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
After heating the SWA electronics box via the SWA heater as well as a heater on the My panel, SWA was switched on for a few seconds only on 27/11 with reception of TM (boot event). Next steps will be discussed in a to come ARB.

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

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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

None

5 ANOMALIES

The following Anomaly Reports were raised in the reporting period:

Spacecraft

None

Ground Segment

None

Non Conformance Reports

None

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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
TCM	DoY 307, 02/11/20	Available TCM slot will be used
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) (3) TCM at VGAM1 -1w (20/12/20 - DoY 355) (4) TCM at VGAM1 -3d (24/12/20 – DoY 359) (5) TCM at VGAM1 -6h (26/12/20 – DoY 361) (6) TCM at VGAM1 +1w (01/01/21 – DoY 001) Note: (4) and (5) are contingency slots
VGAM	DoY 362, 27/12/20	
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 (1)

Email from Frank Budnik, 26/11/2020

This is the first report on the navigation status for the upcoming Venus swing-by. For this first report I provide some auxiliary explanations for the interested reader at the end.

The orbit determination* for the TCM-4w decision point has been performed on 26 November 2020 with a data-cutoff at the end of the New Norcia pass on 26 November 2020. The data arc contains in total 18 Delta-DOR measurements, 6 from the Cebreros - Malargüe baseline and 12 from the Cebreros - New-Norica baseline.

For a prediction into the future the situation is summarised in the attached B-plane** plots (overview and zoomed-in version). The estimated impact point and associated 3-sigma error ellipse before the TCM on 02 November 2020 was executed, is shown in dashed green. The TCM has moved the impact point in the B-plane by 251 km. The green solid impact point and estimated error ellipse shows the the result with that TCM (as designed) included. This impact point also corresponds to the target in the B-plane. The estimated impact point and associated 3-sigma error ellipse which are derived from the aforementioned OD for TCM - 4 weeks is shown in red . The distance from the target point is 11 km and the 3-sigma error ellipse semi axes size is 79 km x 29 km.

Since the difference from the impact to the target point is smaller than the error ellipse, TCM-4w will not be executed.
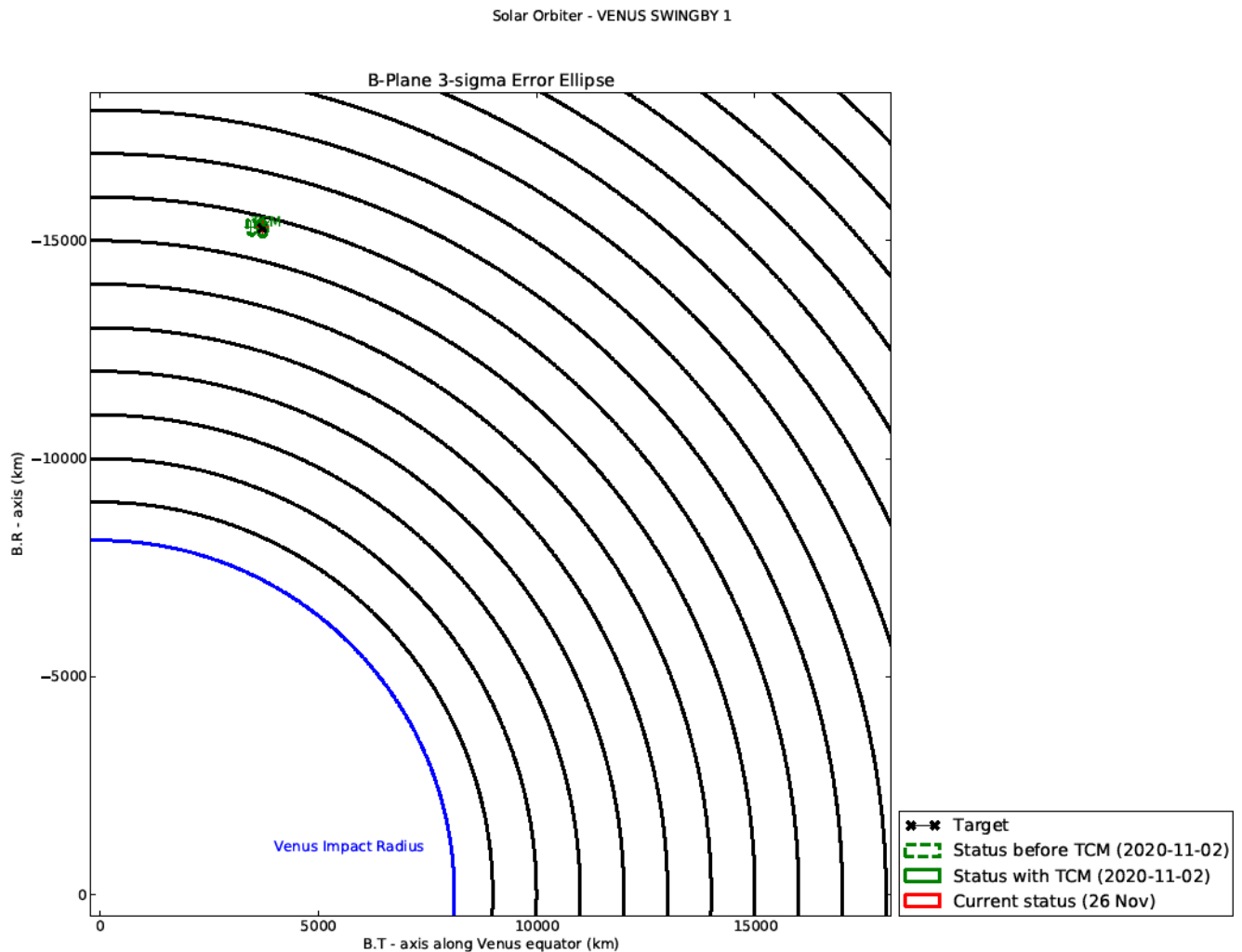
With this, the best estimate for the time of periapsis is on 27 December 2020 at 12:39:20 UTC with a 3-sigma arrival time error of 3 sec. The best estimate for the periapsis distance is 13 510 km with a 3-sigma error of 80 km.

The next report on the navigation status for the Venus swing-by #1 will be provided for the TCM-2 weeks manoeuvre decision point on 10 December 2020.

* The orbit determination runs for the Venus swing-by are based on a tracking data observation arc which starts on 23 September 2020 and will be held fixed. The end time is referred to as Data Cut Off (DCO) and will be moved forward as time progresses. The orbit determination makes use of 2-way X-band Doppler and range data mainly acquired at Malargüe, New Norcia and Cebreros. In addition, Delta-DORs are acquired on a regular basis at the same stations. The estimated spacecraft state and its covariance are subsequently mapped to the time of periapsis at the Venus swing-by. By doing so uncertainties in the execution of future wheel-off loadings (WOLs), the calibration of the solar radiation pressure (SRP) components, and - if applicable - the mechanisation error of any future Trajectory Correction Manoeuvre (TCM) are taken account.

** The Solar Orbiter mapped spacecraft state and its associated covariance at periapsis are suitably represented in the B(ody)-plane of Venus. The B-plane is defined as being orthogonal to the incoming asymptote of the hyperbola relative to Venus and containing the centre of Venus at its origin. The abscissa (B.T axis) within the plane is defined by the trace of the Venus equator of date. The ordinate (B.R axis) within the plane is completing the right-handed triad. In there the estimate of the Solar Orbiter state at periapsis is represented by an 2D impact point and the associated covariance by an error ellipse. The optimum target, which is computed from a full re-optimisation of the future trajectory, is represented by a 2D target point. The distance below which the spacecraft would impact Venus is represented by a circle.

Overview B-plane plot:

Solar Orbiter - VENUS SWINGBY 1

B-Plane 3-sigma Error Ellipse

Legend:
- ✱—✱ Target
- Status before TCM (2020-11-02)
- Status with TCM (2020-11-02)
- Current status (26 Nov)

Axes: B.R - axis (km) vs B.T - axis along Venus equator (km); Venus Impact Radius

Zoomed-in B-plane plot:

Solar Orbiter - VENUS SWINGBY 1

B-Plane 3-sigma Error Ellipse

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