BC-SIM-PL-001
The Test Planning for the SIMBIO-SYS Near Earth Commissioning Phase

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1. Document Change record

Issue	Revision	Date	Affected Pages	Change description
1	0	27/06/2019	All	First issue

2. Introduction

2.1. Scope

In this document we describe all the tests to be performed during the Near Earth Commissioning Phase (NECP) for the Spectrometers and Imagers for MPO BepiColombo Integrated Observatory SYStem (SIMBIO-SYS).
Differently from the date in the header, present Technical Note refers to activities performed in 2018 in preparation of the first commissioning of the instrument occurred in December 2018.

2.2. Reference Documents

[RD.1] The Flight Operation Procedures of the SIMBIO-SYS instrument aboard the BepiColombo ESA mission BC-ASD-SP-00176_1_4 SIMBIO URD, http://hdl.handle.net/20.500.12386/23810
[RD.2] BC-ASD-SP-00176_1_4 SIMBIO URD
[RD.3] BC-SIM-GAF-MA-002 10 001 – SIMBIO-SYS User Manual

2.3. Acronyms

APID	Application Process Identifier
ASW	Application SoftWare
CSV	Comma Separated Values
FPA	Focal Plane Assembly
FOP	Flight Operation Procedure
HK	Housekeeping
HRIC	High spatial Resolution Imaging Channel
ICO	Instrument Checkout
IT	Integration Time
ME	Main Electronics
NECP	Near Earth Commissioning Phase
OBCP	On-Board Control Procedure
PDOR	Payload Direct Operation Request
PDS	Planetary Data System
PE	Proximity Electronics
PNG	Portable Network Graphics
PSC	Packet Sequence Control
RT	Repetition Time
SIMBIO-SYS	Spectrometers and Imagers for MPO BepiColombo Integrated Observatory SYStem
SSC	Source Sequence Count
STC	STereo imaging Channel
TC	Telecommand
TEC	Thermo-Electric Cooler
TM	Telemetry

VIHI	VIsible and Hyper-spectral Imaging channel
XML	eXtensible Markup Language

2.4. Document Organization

This document is organized in sections whose topics are listed as follows:

- Section 3 – NECP objective, with a brief description (see section 8.2.1 of [RD.3] for details) of the functional tests we are going to execute
- Section 4 – NECP implementation, with a brief description of which Flight Operation Procedures (FOPs) and Payload Direct Operation Requests (PDORs) we are going to use to perform the required test
- Section 5 – NECP timeline, with the list of activities to be performed during the NECP and logically ordered to optimize instrument activations and test duration

3. Test Objectives

The scope of the SIMBIO NECP is to verify the health status of the instrument at channel and system level after launch. Few performance tests are also planned to monitor the evolution of some key instrument parameters.

3.1. Functional Test

During NECP the SIMBIO-SYS functionality shall be verified by means of dedicated Functional Test procedures on the following elements:

- ME, with the verification of:
  - MAIN and REDUNDANT channel operativity
  - loaded Application SoftWare (ASW) version
- HRIC, with the verification on both on the MAIN and REDUNTANT channel of the ME of:
  - PE, TEC and detector activation
  - memory/registers status
  - science acquisition capability
- STC, with the verification on both on the MAIN and REDUNTANT channel of the ME of:
  - PE, TEC and detector activation
  - memory/registers status
  - science acquisition capability
- VIHI, with the verification on both on the MAIN and REDUNTANT channel of the ME of:
  - PE, TEC and detector activation
  - memory/registers status
  - science acquisition capability

3.2. Performance Test

During NECP the SIMBIO-SYS performance shall be verified by means of minimal Performance test procedures on the following elements:

- HRIC, with the measurements of:
  - Compression Module behaviour with variable compression factor
  - Dark Current (DC) behaviour for the nominal Integration Time (IT) on FPAN and BB filters with low and high priority
  - Spurious Charge (PC) behaviour with several acquisitions of BB filters (complete and small version) read in different order and with different integration time
  - Detector Reset behaviour, with several acquisition of small region of the detector at different combination of integration and repetition time
- STC, with the measurements of:
  - reduced dark current campaign for the Color Mode and Global Mapping operation modes (high priority).
  - reduced dark current campaign for the separated filters (high priority).
  - reduced spurious charge calibration (low priority) campaign of the FPA.

  - several acquisitions of the mitigation windows (low priority) to test the reset capabilities of the detector
- VIHI, with the measurements of:
  - Internal calibration unit performances
  - reduced dark current campaign

3.3. Inter-channel Test

During the NECP SIMBIO-SYS SYS SW performance shall be verified by means of a dedicated Performance Test procedure which involve all the three channels. In particular, we need to perform:

- a MAX Stress test, to verify the capability of the entire instrument (i.e., PE and ME) to manage SIMBIO-SYS acquisitions with all on-board processing functionalities active (i.e., binning, compression and amount of data);
- a MAX DataRate (DR) test, to verify the capability of the ME to manage the three channels while operating in their nominal max data production configuration;
- an ORBIT test, to simulate a generic orbit during the Global Coverage Phase (GCP) of SIMBIO around Mercury.

4. Test implementation

Tests reported in Section 3 shall be executed by means of proper FOPs, On-Board Control Procedures (OBCPs) and PDORs listed in the following subsections and described in [RD.1], [RD.2] and Annexed files.

4.1. SIMBIO-SYS Functional Tests

4.1.1. ME Functional Test

The scope of this test is to check the ME functionality on both MAIN and REDUNDANT channels after launch.

4.1.1.1. Starting conditions

To execute this test SIMBIO-SYS shall be in the following status:

Unit	Status
ME	OFF
HRIC	OFF
STC	OFF
VIHI	OFF

4.1.1.2. Preparation activities

The instrument shall be warmed up by means of S/C heaters in order to put the SIMBIO-SYS TRP in the nominal thermal operative conditions necessary to correctly switch-on all the channels.

4.1.1.3. Execution

The ME functionality will be tested by means of the following TCs sequence:

- ME switch-on on the REDUNDANT channel by means of an OBCP (i.e., ZSSK4000) whose specifications can be found in [RD.1];
- Dump of memory area;
- ME switch-off by means of an OBCP (i.e., ZSSK4001) whose specifications can be found in [RD.1]
- ME switch-on on the MAIN channel by means of an OBCP (i.e., ZSSK4000) whose specifications can be found in [RD.1];
- Dump of memory area;

Above listed checks have been included in the FOP SS-TST-001 whose details can be found in [RD.1].

4.1.2. HRIC Functional Test on MAIN ME Channel

The aim of this test is to check the functionality of the channel units and the capability to perform some science acquisitions.

4.1.2.1. Starting conditions

To execute this test SIMBIO-SYS shall be in the following status:

Unit	Status
ME	ON (on the MAIN channel)
HRIC	OFF
STC	OFF
VIHI	OFF

4.1.2.2. Preparation activities

None

4.1.2.3. Execution

The HRIC functionality on the MAIN ME channel will be tested by means of the following TCs sequence:

- Proximity Electronics (PE) switch-on
- Detector switch-on
- Thermo-Electric Cooler (TEC) switch-on
- Test of the reading and writing of a specific memory address
- The following science acquisitions:
  - 2 minutes of 640x2048 window size acquisitions with Repetition Time (RT) = 1s, Integration Time (IT) = 50 μs and IBR=32
  - 2 minutes of 640x2048 window size acquisitions with RT = 1s, IT = 315 ms and IBR=32
  - 10 acquisitions of 640x2048 window with RT = 1s, IT = 50 μs and IBR=32
- TEC switch-off
- Detector switch-off
- PE switch-off

Above listed checks have been included in the FOP SS-TST-010 whose details can be found in [RD.1].

To note that the execution of each TC will be commanded from ground after the verification by the Science Team of the correct status of the channel derived from the analysis of the House-Keeping (HK) downloaded from the Space-Craft (S/C).

4.1.3. STC Functional Test on MAIN ME Channel

The aim of this test is to check the functionality of the channel units and the capability to perform some science acquisitions.

4.1.3.1. Starting conditions

To execute this test SIMBIO-SYS shall be in the following status:

Unit	Status
ME	ON (on the MAIN channel)
HRIC	OFF
STC	OFF
VIHI	OFF

4.1.3.2. Preparation activities

None

4.1.3.3. Execution

The STC functionality on the MAIN ME channel will be tested by means of the following TCs sequence:

- PE switch-on
- Detector switch-on
- TEC switch-on
- Test of the reading and writing of a specific memory address
- The following science acquisitions:
  - 2 minutes of CM compressed acquisitions with RT = 400 ns, IT = 50 μs and IBR=63
  - 50 CM compressed acquisitions with RT = 400 ms, IT = 50 μs and IBR=63
  - 50 CM compressed acquisitions with RT = 200 ms, IT = 50 μs and IBR=63
  - 10 CM compressed acquisitions with RT = 2s, IT ~ 1s and IBR=63
- TEC switch-off
- Detector switch-off
- PE switch-off

Above listed checks have been included in the FOP SS-TST-020 whose details can be found in [RD.1].

As per test described in section 4.1.2, the execution of each check will be commanded from ground after the verification by the Science Team of the correct status of the channel derived from the analysis of the HK downloaded from the S/C.

4.1.4. VIHI Functional Test on the MAIN ME Channel

The aim of this test is to check the functionality of the channel units and the capability to perform some science acquisitions.

4.1.4.1. Starting conditions

To execute this test SIMBIO-SYS shall be in the following status:

Unit	Status
ME	ON (on the MAIN channel)
HRIC	OFF
STC	OFF
VIHI	OFF

4.1.4.2. Preparation activities

None

4.1.4.3. Execution

The VIHI functionality on the MAIN ME channel will be tested by means of the following TCs sequence:

- PE switch-on
- Detector switch-on
- TEC switch-on
- Shutter close and open
- Lamp switch-on and off
- LED switch-on and off
- Test of the reading and writing of a specific memory address
- The following science acquisitions:
  - 5.2 s of full frame acquisitions with RT = 0.1s, IT = 205.5 μs and IBR=0
  - 5.2 s of full frame acquisitions with RT = 0.1s, IT = 137 μs, Dark subtraction and IBR=0
- TEC switch-off
- Detector switch-off
- PE switch-off

Above listed checks have been included in the FOP SS-TST-037 whose details can be found in [RD.1].

As per test described in section 4.1.2 and 4.1.3, the execution of each check will be commanded from ground after the verification by the Science Team of the correct status of the channel derived from the analysis of the HK downloaded from the S/C.

4.1.5. HRIC Functional Test on REDUNDANT ME Channel

The aim of this test is to verify the operative capabilities detailed in section 4.1.2 also when using the ME REDUNDANT channel.

4.1.5.1. Starting conditions

To execute this test SIMBIO-SYS shall be in the following status:

Unit	Status
ME	ON (on the REDUNDANT channel)
HRIC	OFF
STC	OFF
VIHI	OFF

4.1.5.2. Preparation activities

None

4.1.5.3. Execution

The HRIC functionality on the REDUNDANT ME channel will be tested by means of a TCs sequence similar to the one used for the check detailed in section 4.1.2 but with:

- Only 1 Science TC with 2 minutes of 640x2048 window size acquisitions, RT = 1s, IT = 50 μs and IBR=32
- less on-ground interaction (i.e., just for the switch-on and for the science acquisition).

The TCs sequence used for this test have been included in the FOP SS-TST-011 whose details can be found in [RD.1].

4.1.6. STC Functional Test on REDUNDANT ME Channel

The aim of this test is to verify the operative capabilities detailed in section 4.1.3 also when using the ME REDUNDANT channel.

4.1.6.1. Starting conditions

To execute this test SIMBIO-SYS shall be in the following status:

Unit	Status
ME	ON (on the REDUNDANT channel)
HRIC	OFF
STC	OFF
VIHI	OFF

4.1.6.2. Preparation activities

None

4.1.6.3. Execution

The STC functionality on the REDUNDANT ME channel will be tested by means of a TCs sequence similar to the one used for the check detailed in section 4.1.3 but with:

- Only 1 Science TC with 2 minutes of CM in continuous mode, RT =00ms, IT = 50 μs and IBR = 63
- less on-ground interaction (i.e., just for the switch-on and for the science acquisition).

The TCs sequence used for this test have been included in the FOP SS-TST-021 whose details can be found in [RD.1].

4.1.7. VIHI Functional Test on REDUNDANT ME Channel

The aim of this test is to verify the operative capabilities detailed in section 4.1.4 also when using the ME REDUNDANT channel.

4.1.7.1. Starting conditions

To execute this test SIMBIO-SYS shall be in the following status:

Unit	Status
ME	ON (on the REDUNDANT channel)
HRIC	OFF
STC	OFF
VIHI	OFF

4.1.7.2. Preparation activities

None

4.1.7.3. Execution

The VIHI functionality on the REDUNDANT ME channel will be tested by means of a TCs sequence similar to the one used for the check detailed in section 4.1.4 but with:

- Only 1 Science TC with 35s of full frame acquisitions, RT = 0.505s, IT = 205.5 μs and IBR = 0
- less on-ground interaction (i.e., just for the switch-on and for the science acquisition).

The TCs sequence used for this test have been included in the FOP SS-TST-033 whose details can be found in [RD.1].

4.2. SIMBIO-SYS Performance Tests

4.2.1. HRIC Performance Tests

The aim of this test is to perform several science acquisitions to evaluate the channel Dark Current (DC), Spurious Charge (SC), compression and detector-reset performance just after launch.

4.2.1.1. Starting conditions

To execute this test SIMBIO-SYS shall be in the following status:

Unit	Status
ME	ON (on the MAIN channel)
HRIC	ON
STC	OFF
VIHI	OFF

4.2.1.2. Preparation activities

None.

4.2.1.3. Execution

The HRIC performance will be tested by means of the execution of the following 4 pre-defined PDORs:

1. HRIC compression test: a window of 512x512 pixels is acquired with variable compression factor (see HRIC_COMPRESSION_TEST_PDOR in the Timeline table of Section 5 for details)
2. HRIC DC test: reduced dark current calibration campaign is performed on FPAN and BB filters with low and high priority (see HRIC_DC_TEST_PDOR in the Timeline table of Section 5 for details)
3. HRIC SC test several acquisitions of BB filters (complete and small version) are performed changing their reading order and with different integration time (see HRIC_SC_TEST_PDOR in the Timeline table of Section 5 for details):
4. HRIC detector_reset test: several acquisition of small region of the detector at different combination of integration and repetition time (see HRIC_RESET_TEST_PDOR in the Timeline table of Section 5 for details)

Differently from the Functional Tests described in previous sections, the execution of the tests session will be automatic with no interaction from ground by the Science Team.

4.2.2. STC Performance Tests

The aim of this test is to perform several science acquisitions to evaluate the channel DC, SC and detector-reset performance just after launch.

4.2.2.1. Starting conditions

To execute this test SIMBIO-SYS shall be in the following status:

Unit	Status
ME	ON (on the MAIN channel)
HRIC	OFF
STC	ON
VIHI	OFF

4.2.2.2. Preparation activities

None.

4.2.2.3. Execution

The STC performance will be tested by means of the execution of the following 4 pre-defined PDORs:

1. STC nominal test: reduced dark current campaign for the Color Mode and Global Mapping operation modes with low and high priority (see **STC_NOMINAL_TEST_PDOR** in the Timeline table of Section 5 for details)
2. STC single filter test: reduced dark current campaign for the separated filters with high priority (see **STC_SINGLE_FILTER_TEST_PDOR** in the Timeline table of Section 5 for details)
3. STC out filter test: reduced spurious charge calibration campaign of the FPA in low priority (see **STC_OUT_FILTER_TEST_PDOR** in the Timeline table of Section 5 for details)
4. STC detector_reset test: several acquisitions of the mitigation windows to test the reset capabilities of the detector with low priority (see **STC_DETECTOR_RESET_TEST_PDOR** in the Timeline table of Section 5 for details):

As per HRIC Performance Tests, the execution of the tests session will be automatic with no interaction from ground by the Science Team.

4.2.3. VIHI Performance Tests 1

The scope of this test is to perform a set of measurements in dark conditions and with the calibration units (i.e., Lamp and LED) for monitoring the performance of the letters after launch.

4.2.3.1. Starting conditions

To execute this test SIMBIO-SYS shall be in the following status:

Unit	Status
ME	ON (on the MAIN channel)
HRIC	OFF
STC	OFF
VIHI	OFF

4.2.3.2. Preparation activities

None.

4.2.3.3. Execution details

The STC performance will be tested by means of the execution of the FOP SS-FCP-031 that contains the following TCs (see [RD.1] for details):

- Dark acquisition: 4 acquisitions with variable ITs
- Science acquisition: 4 acquisitions with the same IT as the Dark acquisitions
- Lamp acquisition with shutter open: 5 acquisitions with variable ITs
- LED acquisition with shutter open: 4 acquisitions with variable ITs

As per HRIC and STC Performance Tests, the execution of the test session will be automatic with no interaction from ground by the Science Team.

4.2.4. VIHI Performance Tests 2

The scope of this test is to perform a set of calibration measurements for monitoring the VIHI performance after launch.

4.2.4.1. Starting conditions

To execute this test SIMBIO-SYS shall be in the following status:

Unit	Status
ME	ON (on the MAIN channel)
HRIC	OFF
STC	OFF
VIHI	OFF

4.2.4.2. Preparation activities

None.

4.2.4.3. Execution details

The STC performance will be tested by means of the execution of the FOP SS-FCP-032 that contains the following TCs (see [RD.1] for details):

- Dark acquisition: 7 acquisitions with variable ITs
- Science acquisition: 14 acquisitions with variable ITs

As per HRIC and STC Performance Tests, the execution of the test session will be automatic with no interaction from ground by the Science Team.

4.3. SIMBIO-SYS Interchannel Tests

4.3.1. MAX Stress Test

The scope of this test is to verify the capability of the SIMBIO-SYS ME to manage all the three channels operating in parallel in an operative mode that stress at maximum the on-board processing capabilities of the PE and ME.

4.3.1.1. Starting conditions

To execute this test SIMBIO-SYS shall be in the following status:

Unit	Status
ME	ON (on the MAIN channel)
HRIC	ON
STC	ON
VIHI	ON

4.3.1.2. Preparation activities

None.

4.3.1.3. Execution details

The SIMBIO performance will be tested by means of the execution for about 10 minutes of the following 3 TCs (see **SIMBIO_MAX_STRESS_TEST_PDOR** in the Timeline table of Section 5 for details):

1. HRIC: acquisition of 512x512 pixels with 8x8 binning, IBR=63 and RT=0.5s
2. STC: acquisition in CM with IBR=63 and RT=0.2s
3. VIHI: full frame acquisition with dark subtraction and RT=40ms

As per all Performance Tests, the execution of the test session will be automatic with no interaction from ground by the Science Team.

4.3.2. MAX DataRate Test

The scope of this test is to verify the capability of the SIMBIO-SYS ME to manage all the three channels operating in parallel in producing their nominal max flux of data.

4.3.2.1. Starting conditions

To execute this test SIMBIO-SYS shall be in the following status:

Unit	Status
ME	ON (on the MAIN channel)
HRIC	ON
STC	ON
VIHI	ON

4.3.2.2. Preparation activities

None.

4.3.2.3. Execution details

The SIMBIO performance will be tested by means of the execution for about 1 minute of the following 3 TCs (see **SIMBIO_MAX_DR_TEST_PDOR** in the Timeline table of Section 5 for details):

1. HRIC: FPAN acquisition with IBR=63 and RT=1.115s
2. STC: acquisition in CM with IBR=63 and RT=0.2s
3. VIHI: full frame acquisition with IBR=1 and RT=40ms

As per all Performance Tests, the execution of the test session will be automatic with no interaction from ground by the Science Team.

4.3.3. ORBIT Test

The scope of this test is to verify the capability of the SIMBIO-SYS ME to manage all the three channels operating in parallel in a typical configuration expect during the Global Coverage phase (i.e., STC and VIHI operating in continuous mode in different configurations simulating orbit segmentation; HRIC operating in target mode with three acquisitions).

4.3.3.1. Starting conditions

To execute this test SIMBIO-SYS shall be in the following status:

Unit	Status
ME	ON (on the MAIN channel)
HRIC	ON
STC	ON
VIHI	ON

4.3.3.2. Preparation activities

None.

4.3.3.3. Execution details

The SIMBIO performance will be tested by means of the execution for about 1 hour with (see **SIMBIO_ORBIT_TEST_PDOR** in the Timeline table of Section 5 for details):

1. HRIC: 3 FPAN acquisitions with IBR=32 and RT=1.115s, 2s and 2.5s
2. STC: continuous acquisition changing the IT, the RT and the cross-track dimension of the filters for 9 different section of orbit. The channel operates in Global Mapping mode with IBR = 32 changing its cross-track window size from 128 px to 640 px.
3. VIHI: continuous acquisition changing the IT and the RT for 8 different sections of orbit

As per all Performance Tests, the execution of the test session will be automatic with no interaction from ground by the Science Team.

5. Timeline

With reference to the tests described in Section 3 and 4, the following timeline applies:

ID	Description	Attached XML file of PDOR package
1. SS-TST-001	ME Functional Test	-
2. SS-TST-010	HRIC Functional Test on MAIN ME Channel	-
3. SS-TST-020	STC Functional Test on MAIN ME Channel	-
4. SS-TST-037	VIHI Functional Test on MAIN ME Channel	-
5. HRIC_COMPRESSION_TEST_PDOR	HRIC compression module monitoring test	¤_hric_comp_test_noOBCP_00166.BC
6. HRIC_DC_TEST_PDOR	HRIC DC behaviour monitoring test	¤_hric_dc_test_noOBCP_00167.BC
7. HRIC_SC_TEST_PDOR	HRIC windowing behaviour monitoring test	¤_hric_sc_test_noOBCP_00169.BC
8. HRIC_RESET_TEST_PDOR	HRIC detector reset test	¤_hric_reset_test_noOBCP_00168.BC
9. SS-FCP-001	ME switch-on on MAIN channel via OBCP	-
10. SS-TST-011	HRIC Functional Test on REDUNDANT ME Channel	-
11. SS-TST-021	STC Functional Test on REDUNDANT ME Channel	-
12. SS-TST-033	VIHI Functional Test on REDUNDANT ME Channel	-
13. STC_NOMINAL_TEST_PDOR	STC DC behaviour monitoring test	¤_stc_nominal_test_00151.BC
14. STC_SINGLE_FILTER_TEST_PDOR	STC DC behaviour monitoring test for the single filters	¤_stc_single_filters_test_00154.BC
15. STC_OUT_FILTER_TEST_PDOR	STC SC behaviour monitoring test	¤_stc_out_filter_test_00152.BC
16. STC_DETECTOR_RESET_TEST_PDOR	STC detector reset test	¤_stc_reset_test_00153.BC

17. SS-FCP-001	ME switch-on on MAIN channel via OBCP	-
18. SS-FCP-031	VIHI Performance test 1	-
19. SS-FCP-032	VIHI Performance test 2	-
20. SIMBIO_MAX_STRESS_TEST_PDOR	SIMBIO MAX Stress Test	¤_max_stress_noME_00176.BC
21. SIMBIO_MAX_DR_TEST_PDOR	SIMBIO MAX DR Test	¤_max_dr_test_noME_00175.BC
22. SIMBIO_ORBIT_TEST_PDOR	SIMBIO Orbit Test	¤_orbit_test_noME_00177.BC