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BC-SIM-PL-006
SIMBIO-SYS Checkout#04
Test Summary

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1. Introduction

1.1. Scope

In this document we describe all the tests to be performed during the Instrument CheckOut (ICO) # 04 for the Spectrometers and Imagers for MPO BepiColombo Integrated Observatory SYStem (SIMBIO-SYS).

1.2. Reference Document

[RD.1] BC-SIM-TN-003_-_Reports_and_Note_Layout_and_Flow v2, 10.20371/INAF/TechRep/179

[RD.2] BC-SIM-GAF-MA-002 10 001 – SIMBIO-SYS User Manual

[RD.3] BC-SIM-TR-002_-_HRIC_NECP_report, 10.20371/INAF/TechRep/32

[RD.4] BC-SIM-TR-012_-_HRIC_ICO#01_report, 10.20371/INAF/TechRep/97

[RD.5] BC-SIM-TR-018_-_HRIC_ICO#02_report, 10.20371/INAF/TechRep/134

[RD.6] BC-SIM-TR-007_-_STC_dNECP_report, 10.20371/INAF/TechRep/71

[RD.7] BC-SIM-TR-025_-_HRIC_ICO#03_report, 10.20371/INAF/TechRep/190

[RD.8] BC-SIM-TR-026_-_STC_ICO#03_report, 10.20371/INAF/TechRep/186

[RD.9] BC-SIM-TN-008_-_SIMBIO-SYS_FOP_update_after_ICO#02, 10.20371/INAF/TechRep/162

[RD.10] BC-ASD-SP-00176

1.3. 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
LFB	Low Freq Behaviour
ME	Main Electronics
NECP	Near Earth Commissioning Phase
OBCP	On-Board Control Procedure
POR	Payload Direct Operation Request
PDS	Planetary Data System
PE	Proximity Electronics
PNG	Portable Network Graphics
PSC	Packet Sequence Control
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

1.4. Document format and Repository

This document is compliant with the SIMBIO-SYS Report and Note Layout and Flow [RD.1] and will be archived both on the INAF Open Access repository and the SIMBIO-SYS team Archive.

1.5. Document Organization

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

- Section 2 – ICO#04 objective, with a brief description (see Section 8.2.2 of [RD.2] for details) of the functional tests we are going to execute
- Section 3 – ICO#04 implementation and validation, with:
  - a brief description of which Flight Operation Procedures (FOPs) and Payload Operation Requests (PORs) we are going to use to perform the required test
  - the results of the sequence validation using a Simulation Software developed within the team
  - an estimation of the required resources in terms of Data Volume, duration and expected number of frames for each sequence
- Section 4 – ICO#04 timeline, with the list of activities to be performed logically ordered to optimize instrument activations and test duration

2. Test objective

The scope of the SIMBIO ICO#04 is the periodic (i.e., fourth) verification of the health status of the instrument at channel and system level. Few performance tests are also planned to monitor the evolution of some key instrument parameters.

2.1. Functional Test

During the ICO#04 the SIMBIO-SYS functionality shall be verified by means of dedicated Functional Test procedures on the following elements:

- HRIC, with the verification of:
  - PE, TEC and detector activation
  - memory/registers status
  - science acquisition capability
- STC, with the verification of:
  - PE, TEC and detector activation
  - memory/registers status
  - science acquisition capability

2.2. Performance Test

During the ICO#04 the SIMBIO-SYS performance shall be verified by means of minimal Performance test procedures on the following elements:

- HRIC, with the verification of the Dark Current (DC) behaviour for the nominal Integration Time (IT) just on few points of the Panchromatic filter
- STC, with the verification of:
  - DC behaviour for the nominal IT and high Repetition Time (RT)
  - DC and DSNU for nominal GM acquisitions modes and a detailed analysis for a specific region of the detector
  - Test of the applicability of the Mitigate strategy to mitigate DC in CM mode.
- VIHI, with the verification of:
  - General performances and operability of all the major subsystems (TEC, Detector, Shutter, Lamp and LED).

2.3. Interchannel Test

Analysing the HRIC data obtained during the tests performed in Near Earth Commissioning Phase (NECP) it was discovered an unexpected trend (i.e., Low Frequency Behaviour – LFB) in the detector reset level (for more details see [RD.3]). This trend was confirmed by the HRIC data obtained during its functional test performed in ICO#01 and ICO#02 (for more details see [RD.4] and [RD.5]). The same behaviour was observed on STC data obtained during the orbit test performed in dNECP (for more details see [RD.6]).
The test was repeated more in details during the ICO#03 determining that the origin of the disturbance is internal (details can be found in [RD.7] and [RD.8]). However, the new test shows a possible dependence of the fluctuation on the RT parameter of the Science TC. For this reason, a new test with variable RT will be prepared. In the new test, also the VIHI channel will be included to verify the presence of the fluctuation and its influence on the other channels.

3. Test implementation

3.1. Tools

Tests reported in the following sub-sessions shall be executed by means of proper FOPs, On-Board Control Procedures (OBCPs) and PORs listed in the following subsections and described in [RD.9], [RD.10] and Annexed files.

3.2. Available resources

As per ESA-ESOC official communication by Tiago Costa and Silvano Manganelli emails, the SIMBIO-SYS ICO#04 test will take place on 14/12/2020 at 21:00:00 UTC and the available time and Data-Volume resources will be:

- test duration: 8 hours
- Data-Volume: 450 Mbytes

3.3. SIMBIO-SYS Functional Tests

3.3.1. HRIC Functional Test

3.3.1.1. Scope

The aim of this test is:

- to check the status and the functionality of the following electric components of the channel:
  - Proximity Electronic (PE),
  - Detector and
  - Thermo-Electric Cooler (TEC);
- to modify some configuration parameters;
- to perform a science acquisition.

3.3.1.2. Preparation

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

Waiting for SIMBIO-SYS ME Application SoftWare (ASW) update which should also affect the parameters for the correct TEC activation, a dedicated TCs sequence has been prepared to upload the nominal TEC parameters. With reference to the **ESA-ESOC recommendation on the POR generation for the ICOs activities** (i.e., minimize the number of produced PORs to simplify their import and verification) this sequence has been included in the POR used for the test (see following section).

3.3.1.3. Description

A POR with **SPOT ID BPSS00680** and named **SIMBIOSYS_HRIC_ICO#04_functional_test** has been prepared which contains the following operations:

1. SIMBIO-SYS ME switch-on via OBCP
2. the dedicated TC sequence for the nominal TEC parameters upload
3. the HRIC functional test with a sequence of FOPs call that implements the checks listed in Section 3.3.1.1.

Note: to reduce the Data Volume request in order to be compatible with the allocated resources (see Section 3.2) the following updates have been applied to the usual procedure used in previous ICOs:

1. only 1 Science TC with 6’ duration for LFB monitoring
2. reduce size image from 640x204 pixels to 512x512
3. increase the RT from 1s to 2s

3.3.1.4. Validation

The POR **SIMBIOSYS_HRIC_ICO#04_functional_test** has been validated by means of a Simulation Software and produces the following results:

Sequence duration			**00:28:15**		
Sequence Data Volume					
-	**ME**	**HRIC**	**STC**	**VIHI**	**Overall**
Science	-	0.0236 [Gb]	0 [Mb]	0 [Mb]	0.0236 [Gb]
HK	0.0189 [Mb]	0.5935 [Mb]	0 [Mb]	0 [Mb]	0.6124 [Mb]
Total	0.0189 [Mb]	0.0242 [Gb]	0 [Mb]	0 [Mb]	0.0242 [Gb]

To note that above resources computation has to be considered as upper limits since for their computation the Simulation Software needs to introduce some fake TCs (i.e., ME and channel switch-on) in order to reproduce the correct SIMBIO-SYS state for the analysis.

3.3.1.5. Expected Science data

In the following table it is reported the number of frames that are expected to be produced during the test:

HRIC		STC		VIHI	
TC	**# frames**	**TC**	**# frames**	**TC**	**# frames**
1	180				
-	180				

3.3.2. STC Functional Test

3.3.2.1. Scope

The aim of this test is:

- to check the status and the functionality of the following electric components of the channel:
  - PE,
  - Detector and
  - TEC;
- to modify some configuration parameters;
- to perform some science acquisitions in nominal modes.

3.3.2.2. Preparation

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

See Section 3.3.1.2.

3.3.2.3. Description

A POR with **SPOT ID BPSS00679** and named **SIMBIOSYS_STC_ICO#04_init and func** has been prepared which contains the following operations:

1. the dedicated TC sequence for the TEC parameters upload
2. the STC functional test via FOP SS-TST-020 whose details can be found in [RD.9].
3. An additive science TC (differently by other previous ICOs) to monitor the LFB minimizing DV thank to the acquisition of Win-X filter using FCP320 (see [RD.9] for details)

3.3.2.4. Validation

The POR **SIMBIOSYS_STC_ICO#04_init and func** has been validated by means of a Simulation Software and produces the following results:

Sequence duration			**00:31:50**		
Sequence Data Volume					
-	**ME**	**HRIC**	**STC**	**VIHI**	**Overall**
Science	-	0 [Mb]	0.0626 [Gb]	0 [Mb]	0.0626 [Gb]
HK	0.0314 [Mb]	0 [Mb]	0.6004 [Mb]	0 [Mb]	0.6318 [Mb]
Total	0.0314 [Mb]	0 [Mb]	0.0632 [Gb]	0 [Mb]	0.0633 [Gb]

To note that above resources computation has to be considered as upper limits since for their computation the Simulation Software needs to introduce some fake TCs (i.e., ME and channel switch-on) in order to reproduce the correct SIMBIO-SYS state for the analysis.

3.3.2.5. Expected Science data

In the following table it is reported the number of frames that are expected to be produced during the test:

HRIC		**STC**		**VIHI**	
TC	**# frames**	**TC**	**# frames**	**TC**	**# frames**
-	-	1	30	-	-
		2	30		
		3	125		
		4	55		
		5	270		
		-	510		

3.4. SIMBIO-SYS Performance Tests

3.4.1. HRIC Performance Test

3.4.1.1. Scope

The aim of this test is to perform several acquisitions in dark condition and variable integration times to monitor the DC evolution during the cruise phase.

3.4.1.2. Preparation

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

See Section 3.4.1.2.

3.4.1.3. Description

A POR with **SPOT ID BPSS00682** and named **SIMBIOSYS_HRIC_ICO#04_dc_test** has been prepared which contains repeated acquisition with different Integration Time (IT).

To note that, in order to minimize the Data-Volume request, above-described POR differs from the one used in ICO#03 on the following points:

1. only the FPAN filter region of the detector will be acquired (in ICO#03 also the BroadBand filters were acquired)
2. the number of ITs which became 9 instead of 17
3. the number of repetition of each acquisition which passed from 10 to 9

3.4.1.4. Validation

The POR **SIMBIOSYS_HRIC_ICO#04_dc_test** has been validated by means of a Simulation Software and produces the following results:

Sequence duration			00:05:20		
Sequence Data Volume					
-	**ME**	**HRIC**	**STC**	**VIHI**	**Overall**
Science	-	1.4864 [Gb]	0 [Mb]	0 [Mb]	1.4864 [Gb]
HK	0.0191 [Mb]	0.5040 [Mb]	0 [Mb]	0 [Mb]	0.5231 [Mb]
Total	0.0191 [Mb]	1.4869 [Gb]	0 [Mb]	0 [Mb]	1.4869 [Gb]

To note that above resources computation has to be considered as upper limits since for their computation the Simulation Software needs to introduce some fake TCs (i.e., ME and channel switch-on) in order to reproduce the correct SIMBIO-SYS state for the analysis.

3.4.1.5. Expected Science data

In the following table it is reported the number of frames that are expected to be produced during the test:

HRIC		**STC**		**VIHI**	
TC	**# frames**	**TC**	**# frames**	**TC**	**# frames**
1	9	-	-	-	-
2	9				
3	9				
4	9				
5	9				
6	9				
7	9				
8	9				
9	9				
-	81				

3.4.2. STC Performance Test

3.4.2.1. Scope

The aim of this test is to acquire the Dark Current in order to study its evolution during the cruise phase and to test the Mitigate strategy to be used in CM to mitigate the DC reset for a long waiting time.

3.4.2.2. Preparation

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

See Section 3.4.1.2.

3.4.2.3. Description

A POR with **SPOT ID BPSS00697** and named **SIMBIO-SYS_STC_ICO#4_Performance has** been prepared which contains the following operations:

1. Repetition of the DC and DSNU measurement (ICO#3) for GM with high RT
2. Repetition of the DC and DSNU verification (ICO#3) for GM with nominal RT
3. DC and DSNU for a selected region of the FPA, repetition of the Mitigate test (see [RD.6]) to verify the strategy for the mitigation of the DC in Color Mode strategy.

To note that, in order to minimize the Data-Volume request, above described POR differs from the one used in ICO#02 and ICO#03 on the number of ITs which became 5 instead of 21.

3.4.2.4. Validation

The POR **SIMBIO-SYS_STC_ICO#4_Performance** has been validated by means of a Simulation Software and produces the following results:

Sequence duration			**00:32:50**		
Sequence Data Volume					
-	**ME**	**HRIC**	**STC**	**VIHI**	**Overall**
Science	-	0 [Mb]	1.0765 [Gb]	0 [Mb]	1.0765 [Gb]
HK	0.0376 [Mb]	0 [Mb]	1.2696 [Mb]	0 [Mb]	1.3072 [Mb]
Total	0.0376 [Mb]	0 [Mb]	1.0777 [Gb]	0 [Mb]	1.0778 [Gb]

To note that above resources computation has to be considered as upper limits since for their computation the Simulation Software needs to introduce some fake TCs (i.e., ME and channel switch-on) in order to reproduce the correct SIMBIO-SYS state for the analysis.

3.4.2.5. Expected Science data

In the following table it is reported the number of frames that are expected to be produced during the test:

HRIC		**STC**		**VIHI**	
TC	**# frames**	**TC**	**# frames**	**TC**	**# frames**
		1	30		
		2	30		
		3	30		
		4	30		
		5	20		
		6	20		
		7	20		
		8	20		
		9	20		
		10	20		
		11	20		
		12	20		
		13	20		
		14	20		
		15	20		
		16	20		
		17	20		
		18	20		
		19	20		

		20	20		
		21	20		
		22	20		
		23	20		
		24	20		
		25	20		
		26	50		
		27	2		
		28	50		
		29	4		
		30	50		
		31	10		
		32	50		
		33	30		
		34	30		
		35	30		
		36	30		
		37	30		
		38	20		
		39	20		
		40	20		
		41	20		
		42	20		
		43	20		
		44	20		
		-	1046		

3.4.3. VIHI Performance Test

3.4.3.1. Scope

The test will be devoted to the accurate description and understanding of the Dark Current management. Indeed, the standard Dark Current acquisition is commanded by the parameter "Dark_Macro", of the TC_Science, which when activated triggers a sequence of actions and acquisitions commanded directly by the ME to PE (without additional TCs from ground) which will implement the proper Dark Current management. The sequence activated by the Dark_Macro parameter (in conjunction with the other parameters "Dark_Subtraction" and "Dark_Acquisition") is the following:

1. S/C to ME; TC Science with Dark Macro = 1; Dark Acquisition=0; Dark Subtraction=1
2. ME to PE Send command close shutter
3. PE execute Close shutter
4. ME to PE send command acquire Science with Dark Acquisition bit=1 and Dark subtraction=0
5. PE acquire science frame and stores it in Dark Storage Area
6. PE to ME: send same dark frame
7. ME receive data; first frame will be discarded as first acquisition could be corrupted
8. ME to PE send command acquire Science with Dark Acquisition bit=1 and Dark subtraction=0
9. PE acquire science frame and stores it in Dark Storage Area
10. PE to ME: send same dark frame
11. ME receive data
12. ME to S/C; upload Dark frame without compression
13. ME to PE send command open shutter
14. PE execute Open Shutter
15. ME to PE send command acquire Science with Dark Acquisition bit=0 and Dark subtraction=1
16. PE acquire science frame and subtract the stored frame (dark)
17. PE to ME Send dark subtracted frame
18. ME receives the dark subtracted frame; ME applies binning and compression as commanded.
19. ME to S/C; upload processed frame
20. ..... Continue until Stop Science

The above sequence cannot be commanded before the upload of the new application software as the shutter current value presently implemented in the code is larger than its nominal value. Consequently, to avoid possible damages to the shutter blade we decided to avoid using the Dark_Macro capability for the time being.
Until that time we need to perform all the above steps manually.
The scope of this test is exactly the optimisation of this manual capability.
The sequence will include acquisition of the dark and of the LED signal, with different modalities of binning/compression and of dark acquisition and subtraction.

3.4.3.2. Preparation

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

See Section 3.3.1.2.

3.4.3.3. Description

A POR with **SPOT ID BPSS00705** and named **SIMBIOSYS_VIHI_ICO#04_test** has been prepared which contains the following operations:

1. VIHI Power On and initialisation
2. Dark Frame Acquisition; Dark storage; no Dark Subtraction
3. Dark Frame Acquisition; Dark storage AND Dark Subtraction.
4. Dark Frame Acquisition; Dark storage AND Dark Subtraction; includes Spectral Binning
5. Dark Frame Acquisition; Dark storage; no Dark Subtraction
6. Power ON LED
7. Frame Acquisition with LED ON, no dark acquisition, WITH Dark subtraction
8. Frame Acquisition with LED ON, no dark acquisition, NO Dark subtraction
9. Frame Acquisition with LED ON, no dark acquisition, WITH Dark subtraction: Spatial and Spectra Binning without compression

10. Frame Acquisition with LED ON, no dark acquisition, WITH Dark subtraction; Spatial and Spectral Binning with compression
11. Frame Acquisition with LED ON, WITH dark acquisition, WITH Dark subtraction;
12. Power OFF LED
13. Power Off VIHI

3.4.3.4. Validation

The POR **SIMBIOSYS_VIHI_ICO#04_test** has been validated by means of a Simulation Software and produces the following results:

Sequence duration			**00:23:24**		
Sequence Data Volume					
-	**ME**	**HRIC**	**STC**	**VIHI**	**Overall**
Science	-	0 [Mb]	0 [Mb]	0.0923 [Gb]	0.0923 [Gb]
HK	0.0257 [Mb]	0 [Mb]	0 [Mb]	0.7549 [Mb]	0.7807 [Mb]
Total	0.0257 [Mb]	0 [Mb]	0 [Mb]	0.0931 [Gb]	0.0931 [Gb]

To note that above resources computation have to be considered as upper limits since for their computation the Simulation Software needs to introduce some fake TCs (i.e., ME and channel switch-on) in order to reproduce the correct SIMBIO-SYS state for the analysis.

3.4.3.5. Expected Science data

In the following table it is reported the number of frames that are expected to be produced during the test:

HRIC		**STC**		**VIHI**	
TC	**# frames**	**TC**	**# frames**	**TC**	**# frames**
				1	23
				2	23
				3	23
				4	9
				5	9
				6	9
				7	2
				8	2
				9	9
				-	109

3.5. SIMBIO-SYS Interchannel Test

3.5.1. Scope

The aim of this test is to evaluate if and how the cameras (i.e., HRIC and STC) detector reset fluctuations change with respect to the Repetition Time parameter contained in their Science TC.
In addition, the test will indicate if the operativity of the VIHI channel influences or not such a fluctuation.

3.5.2. Preparation

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

See Section 3.3.1.2.

3.5.3. Description

A POR with **SPOT ID BPSS00688** and named **SIMBIO-SYS_ALL_ICO#4_interference_test** has been prepared which contains the following operations:

1. HRIC, STC and VIHI switch-on/off
2. the TC sequence for the TECs parameters upload
3. HRIC, STC and VIHI Science acquisitions with different combination of RT

Note: to reduce the Data Volume request in order to be compatible with the allocated resources (see Section 3.2) the following settings have been used:

1. HRIC acquisitions are of 256x256 pixels and IBR=8
2. STC acquisitions are with the FilterX (i.e., 64x64 pixels) and IBR=8
3. VIHI acquisitions are of 64x128 pixels and IBR=8

3.5.4. Validation

The POR **SIMBIO-SYS_ALL_ICO#4_interference_test** has been validated by means of a Simulation Software and produces the following results:

Sequence duration			**03:20:50**		
Sequence Data Volume					
-	**ME**	**HRIC**	**STC**	**VIHI**	**Overall**
Science	-	0.196 [Gb]	0.020 [Gb]	0.056 [Mb]	0.273 [Gb]
HK	0.153 [Mb]	0.187 [Mb]	0.197 [Mb]	0.124 [Mb]	0.6628[Mb]
Total	0.153 [Mb]	0.196 [Gb]	0.0208[Gb]	0.056 [Mb]	0.274 [Gb]

To note that above resources computation have to be considered as upper limits since for their computation the Simulation Software needs to introduce some fake TCs (i.e., ME and channel switch-on) in order to reproduce the correct SIMBIO-SYS state for the analysis.

3.5.4.1. Expected Science data

In the following table it is reported the number of frames that are expected to be produced during the test:

HRIC		**STC**		**VIHI**	
TC	**# frames**	**TC**	**# frames**	**TC**	**# frames**
1	360	1	840	1	1800
2	360	2	1680	2	1800
3	360	3	840	3	1800
4	420	4	1680	4	1482
5	360				
6	360				
7	360				
8	420				
9	360				
10	360				
11	360				
12	420				
13	360				
14	360				
15	360				
16	420				
-	6000	-	5040	-	6882

4. Timeline

With reference to the tests described in the previous sections, the following timeline applies:

ID	Description	Estimated duration	Estimated Data Volume	XML file
1. SIMBIOSYS_HRIC_ICO#04_functional_test	SIMBIO-SYS ME switch-on via OBCP, HRIC nominal TEC parameters upload and HRIC functional test with memory read/write tests and 1 Science acquisition	00:28:15	0.0236 [Gb]	¤ BPSS00680_00202.BC
2. SIMBIOSYS_HRIC_ICO#04_dc_test	HRIC DC verification	00:05:20	1.4869 [Gb]	¤ BPSS00682_00202.BC
3. SIMBIOSYS_STC_ICO#04_init and func	STC nominal TEC	00:31:50	0.0633 [Gb]	¤ BPSS00679_00202.BC

	parameters upload and STC functional test with memory read/write tests and several Science acquisitions			
4. SIMBIO-SYS_STC_ICO#4_Performance	STC DC monitoring and verification of Mitigate strategy capability.	00:32:50	1.0778 [Gb]	¤ BPSS00697_00202.BC
5. SIMBIOSYS_VIHI_ICO#04_test	VIHI nominal TEC parameters upload and VIHI performance verification with nominal operative parameters	00:23:24	0.0931 [Gb]	¤ BPSS00705_00202.BC

6. SIMBIO-SYS_ALL_ICO#4_interference_test	Channels nominal TEC parameters upload and Science acquisitions in several RT configurations	03:20:50	0.274 [Gb]	¤ BPSS00688_00202.BC