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Cluster2
FGM

User's Manual
Appendix B

Commissioning Procedure

Revisions

Issue	Rev.	Date	Sec.	Page	Change
Draft	4	15/03/95			Inserted secondaries patch and updated all subsequent check sums
Draft	4	15/03/95			Used Macros to boot for type 2 sequence and perigee pass. See Instrument boot sequences ref. IC\CLUSTER\A95-0003.DOC Draft 0.
Draft	4	15/03/95			Used ESOC 'E_FGMnnn' commands in type 2 sequence and perigee pass. ESOC commands are true for document 'A95-0002.DOC' draft 0.2 dated 13/03/95.
Draft	4.1	11/04/95			Corrected range patch for Y values and increased dummies to 6. Updated subsequent sum-checks.
Issue 1	0	08/11/95		13	Corrected comment to "Power on DPU2"
Issue 1	0	08/11/95		20	Extended mode test modified to incorporate a new patch version
Issue 1	0	08/11/95			Combined old sections 1 and 2 into new section 2. Added introduction as section 1
Issue 2	0	13/5/99	All		All sections revised for Cluster2 Document reference changed to: 'Users Manual \ Appndx B Com Pro'
Issue 2	1	31/8/99	All		All sections Revised New sequences for: 1. Hardware Functional Tests. 2. Performance Verification and Calibration Tests. 3. TM/TC Functional Test Updated
Issue 2	2	19/9/99	2		Correct ADC Configuration after DPU2 boot: - Sequences number 2, 5 & 6.
Issue 2	3	22/9/99			Correct typo table 2.1 Correct use of INT2 in comments to redundant tests.
Issue 2	4	11/1/99			Section 6. Extended mode test added
Issue 2	5	23/3/00			Extended mode test modified to incorporate a new version of the software patch
Issue 2	6	12/4/00			Length of extended mode coverage reduced from 28 to 24 hours. (P3 and 36)
Issue 3	0	3/7/00	All		All sections revised to reflect that Boot Type 2 into FGMOPM1 includes instrument patches. Reference to patch uplink on P 33 deleted 28 hours to 24 hours page 32

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1. Introduction

1.1 Purpose of Commissioning

This document describes the commissioning for the Cluster2 FGM instrument. It is intended that shortly after launch each FGM (one per spacecraft) will follow this procedure. If this procedure is completed successfully then the FGM is considered to be fully functional and commissioned.

The commissioning of each instrument is separated into four phases:

1. Hardware Functional Tests
2. Instrument Performance Verification and Calibration Tests
3. TM and TC Functional Test
4. Perigee Pass

Each of these phases is described below; the full procedure is given in sections 2 to 5.

1.2 Background

Due to the internal redundancy and cross-strapping within the FGM instrument, there is a large number of hardware configurations which may be selected by telecommand. In order to simplify and categorise, we present the table of allowed configurations below (Table 1). There are four main sub-units within the FGM which may be operated cold-redundant, resulting in 16 possible 'top-level' configurations. Whilst additional selection within these modes is possible, it suffices to adequately represent the FGM redundancy concept. The four sub-units are described below:

1. Power Supply – The FGM Power Supply Main or Redundant is selected by the spacecraft LCL:
   - LCL 'A' connected to PSU Main
   - LCL 'B' connected to PSU Redundant
2. Interface – The FGM Data Interface 1 or 2 is selected by the spacecraft RTU:
   - RTU Main connected to INT1
   - RTU Redundant connected to INT2
3. Data Processing Unit:
   - Either DPU1 or DPU2 may be selected (independent of any spacecraft configuration)
4. Analogue to Digital Converter
   - Either ADC1 or ADC2 may be selected (independent of any spacecraft configuration)

The default operating mode of the FGM (FGMOPM1) is configuration number 1.

Config. Number	***PSU***	***INT***	***DPU***	***ADC***
1	M	1	1	1
2	M	1	1	2
3	M	1	2	1
4	M	1	2	2
5	M	2	1	1
6	M	2	1	2
7	M	2	2	1
8	M	2	2	2
9	R	1	1	1
10	R	1	1	2
11	R	1	2	1
12	R	1	2	2
13	R	2	1	1
14	R	2	1	2
15	R	2	2	1
16	R	2	2	2

Default FGM Configuration (FGMOPM1).
Configurations to be tested during commissioning.
Other possibilities, not required to be tested.

Table 1 – Redundant Configurations of the FGM Instrument

1.3 Hardware Functional Tests

In order to commission the FGM it is not necessary to test all of the 16 configurations in Table 1. The default operating mode, plus the additional shaded lines, provides a sufficient set of knowledge about the hardware functionality. The details of the tests are attached (Sequences number 1 to 6).

1.4 Instrument Performance Verification and Calibration Tests

The choice of sensor (OB or IB) is not included in Table 1 since the sensors are not operated in cold-redundancy (both sensors are normally operated in parallel). However, one sensor is selected as 'Primary'. In order to assess the scientific performance of the instrument (as opposed to pure hardware functionality), we define a set of configurations in Table 2 below:

1. Primary Sensor
   - May be software selected to either OB or IB.
2. Analogue to Digital Converter
3. Range
   - Sensor may be operated in ranges 2,3,4,5 and 7, however only ranges 2 to 5 are calibrated for flight (7 is used for ground testing).

Each of the configurations in Table 2 has a unique set of calibration parameters associated with it, and therefore should be fully exercised during commissioning. The default operating mode of the instrument (FGMOPM1) is configurations 2 to 5. The other configurations would only be used in the event of a hardware failure. However, it is necessary to exercise the shaded functions in the table in order to provide a reference set of data for future contingency operations.

Config. Number	***Primary Sensor***	***ADC***	***Range***
1	OB	1	7
2	OB	1	5
3	OB	1	4
4	OB	1	3
5	OB	1	2
6	OB	2	7
7	OB	2	5
8	OB	2	4
9	OB	2	3
10	OB	2	2
11	IB	1	7
12	IB	1	5
13	IB	1	4
14	IB	1	3
15	IB	1	2
16	IB	2	7
17	IB	2	5
18	IB	2	4
19	IB	2	3
20	IB	2	2

	Default FGM Configuration (FGMOPM1).
	Configurations to be tested during commissioning.
	Other possibilities, not required to be tested.

Table 2 – Performance Verification and Calibration Runs

1.5 TM and TC Functional Tests

The purpose of this test is to verify the correct commanding of the FGM instrument with the commanding sequences held in the ESOC database. The reference source for these command sequences is the FGM Users Manual Appendix I, though the naming convention used here is the ESOC system. This test also provides the

first opportunity to operate the FGM in Burst Modes 1 and 3, thereby validating the FGM telemetry in normal and burst modes.

1.6 Perigee Pass

This test shall be run once for each instrument, starting approximately 60 minutes before a perigee pass.

1.7 Extended Mode Test

This test shall run once for one instrument. It is designed to check the uplink of the extended mode patch and in-flight performance of this mode. It will run for 24 hours.

2. Functional Test

2.1 Hardware Functional Test - Summary

Functional test sequence to be performed on each instrument.

Outline:

Sequence Number 1	Tests Hardware Configurations number 1 and 2
Sequence Number 2	Tests Hardware Configurations number 3 and 4
Sequence Number 3	Tests Hardware Configuration number 9
Sequence Number 4	Tests Hardware Configurations number 13 and 14
Sequence Number 5	Tests Hardware Configurations number 15 and 16
Sequence Number 6	Tests Hardware Configuration number 8

Each sequence is independent of the others, since each starts and ends with the FGM off. Its is possible therefore to execute the sequences in any order, though for clarity it is recommended to execute them in the given order.

2.2 Hardware Functional Test – Detail

Note:
The minimum time delay between operations should be used whenever possible.

Sequence Number 1

Power FGM on LCL 'A', main RTU channels, and boot with DPU1. Both ADCs will be tested.

Preconditions	S/C actions	Pause (t_d) / s.	FGM commands	Params. changed	Comments
FGM LCLs 'A' and 'B' OFF RTU Configured for FGM Main S/C acquiring HK and NM1 data					
	Switch on FGM LCL 'A'			NO HK DATA	
		5			
	Send ML1		`ZEF1DR0S`	See comment	Dump register 0 command: The contents of INT1 register 0 will appear in the housekeeping but the location is not defined. Expect value 0xC510
	Send ML1		`ZEF1RESE`	NO HK DATA	Enable control of DPU reset on INT1
	Send ML1		`ZEF1DR0S`	See comment	Dump register 0 command: The contents of INT1 register 0 will appear in the housekeeping but the location is not defined. Expect value 0xC710

	Send ML2		`ZEF2ATTS`
			`ZEF2ATCS`
			`ZEF2PRNS,7`
			`ZEF2SRNS,7`
				NO HK DATA	Load auto-boot commands into ML2 FIFO
					Pre-select Manual sensor ranging.

		5			Wait while reg. 0 information is transmitted
	Send ML1		`ZEF1DP1N`		Power on DPU1
		17 S < t_d < 60		Boot type 1 HK config. set, with manual sensor ranging.	Wait for boot to be completed *Configuration Number 1*
		Wait for experimenter to confirm success. $t_d \approx 120$			

	Send ML2		`ZEF2PBAS,0x01`
			`ZEF2PBYS,0xCC`
			`ZEF2PBYS,0x1C`
			`ZEF2PBYS,0x08`
			`ZEF2PBYS,0x00`
			`ZEF2DMPS`
				Base Address Update Set for one reset only.
				Param Byte Count increases to 4.
				Memory Dump ON for one reset only.
					Memory dump results of MSA test

		Wait for experimenter to confirm success. $t_d \approx 30$			
	Send ML2		ZEF2PRNS,0 ZEF2SRNS,0	Primary and Secondary sensor set to auto ranging	
		40			
	Send ML2		ZEF2PCLN,1	Set primary Cal.	
		12			
	Send ML2		ZEF2SCLN,1	Set secondary Cal.	
		12			
	Send ML2		ZEF2PCLN,0	Clear primary Cal.	
		12			
	Send ML2		ZEF2SCLN,0	Clear secondary Cal.	
		12			
	Send ML2		ZEF2PFLN,1	Set primary Flip	
		12			
	Send ML2		ZEF2SFLN,1	Set secondary Flip	
		12			
	Send ML2		ZEF2PFLN,0	Clear primary Flip	
		12			
	Send ML2		ZEF2SFLN,0	Clear secondary Flip	
		12			
	Send ML2		ZEF2PRNS,7 ZEF2SRNS,7	Primary and secondary sensor to manual ranging	
		5			
	Send ML1		ZEF1AD2N	ADC2 ON	
		5			
	Send ML2		ZEF2CALS,0x00 ZEF2CAMS,0x00		Switch to ADC2, Bus2 *Configuration Number 2*
		25			
	Send ML1		ZEF1AD1F	ADC1 OFF	
		12			
	Send ML2		ZEF2PRNS,0 ZEF2SRNS,0	Primary and secondary sensor to auto ranging	

		40			
	Send ML2		ZEF2PCLN,1	Set primary Cal.	
		12			
	Send ML2		ZEF2SCLN,1	Set secondary Cal.	
		12			
	Send ML2		ZEF2PCLN,0	Clear primary Cal.	
		12			
	Send ML2		ZEF2SCLN,0	Clear secondary Cal.	
		12			
	Send ML2		ZEF2PFLN,1	Set primary Flip	
		12			
	Send ML2		ZEF2SFLN,1	Set secondary Flip	
		12			
	Send ML2		ZEF2PFLN,0	Clear primary Flip	
		12			
	Send ML2		ZEF2SFLN,0	Clear secondary Flip	
		12			
	Send ML2		ZEF2ENTN,1	Enable Event Recognition	
		5			
	Send ML2		ZEF2I1FN,1	INT1 IEL set to FAST	
		5			
	Send ML2		ZEF2I2FN,0	INT2 IEL set to SLOW	
		5			
	Send ML2		ZEF2SEUN,0	Disable SEU Monitor	
		5			
	Send ML1		ZEF1INTF ZEF1D1RN	NO HK DATA	Assert DPU1 Reset. Processor is held reset – no telemetry from instrument
		5			
	Send ML2		ZEF2MNTS ZEF2MNCS	NO HK DATA	
		5			
	Send ML1		ZEF1D1RF		Clear DPU1 Reset. Manual boot of DPU1
		17 S < t_d < 60		Manual Boot Selected	Wait for boot to be completed

		Wait for experimenter to confirm success. $t_d \approx 120$			
	Send ML1		ZEF1INTF ZEF1D1RN	NO HK DATA	Assert DPU1 Reset. Processor is held reset – no telemetry from instrument
		5			
	Send ML2		ZEF2ATTS ZEF2ATCS	NO HK DATA	
		5			
	Send ML1		ZEF1D1RF		Clear DPU1 Reset. Auto boot of DPU1
		17 S < t_d < 60		Auto Boot Selected	Wait for boot to be completed
		Wait for experimenter to confirm success. $t_d \approx 120$			
	Send ML1		ZEF1IELD	Disable IEL	
		5			
	Send ML1		ZEF1IELE	Enable IEL	
		5			
	Send ML1		ZEF1MSAF	Power OFF MSA	
		5			
	Send ML1		ZEF1AD1F	Power OFF ADC1 Expect to see ADC Error Flags asserted	
		5			
	Send ML1		ZEF1DP1F	NO HK DATA	Power OFF DPU1
		5			
	Switch OFF FGM LCL 'A'				

Sequence Number 2

Power FGM on LCL 'A', main RTU channels, and boot with DPU2. Both ADCs will be tested.

Preconditions	S/C actions	Pause (t_d)	FGM commands	Params. changed	Comments

FGM LCLs 'A' and 'B' OFF RTU Configured for FGM Main S/C acquiring HK and NM1 data					
	Switch on FGM LCL 'A'			NO HK DATA	
		5			
	Send ML1		ZEF1DR0S	See comment	Dump register 0 command: The contents of INT1 register 0 will appear in the housekeeping but the location is not defined. Expect value 0xC510
	Send ML1		ZEF1RESE	NO HK DATA	Enable control of DPU reset on INT1
	Send ML1		ZEF1DR0S	See comment	Dump register 0 command: The contents of INT1 register 0 will appear in the housekeeping but the location is not defined. Expect value 0xC710
	Send ML2		ZEF2ATTS ZEF2ATCS ZEF2PRNS,7 ZEF2SRNS,7	NO HK DATA	Load auto-boot commands into ML2 FIFO Pre-select Manual sensor ranging.
		5			Wait while reg. 0 information is transmitted
	Send ML1		ZEF1DP2N		Power on DPU2
		17 S < t_d < 60		Boot type 1 HK config. set, with manual sensor ranging, and DPU2 ON with DPU1 OFF	Wait for boot to be completed
		Wait for experimenter to confirm success. $t_d \approx 120$			
	Send ML1		ZEF1AD1N	ADC1 ON	
		5			
	Send ML2		ZEF2CALS,0xFF ZEF2CAMS,0xFF		
		25			
	Send ML1		ZEF1AD2F	ADC2 OFF	*Configuration Number 3*
		12			
	Send ML2		ZEF2PRNS,0 ZEF2SRNS,0	Primary and Secondary sensor set to auto ranging	
		40			
	Send ML2		ZEF2CLBS,1	Cal Mode 1 Active	Execute Calibration Mode Number 1
		120			
	Send ML2		ZEF2PRNS,7 ZEF2SRNS,7	Primary and secondary sensor to manual ranging	
		5			
	Send ML1		ZEF1AD2N	ADC2 ON	

		5			
	Send ML2		ZEF2CALS,0x00 ZEF2CAMS,0x00		Switch to ADC2, Bus2 *Configuration Number 4*
		25			
	Send ML1		ZEF1AD1F	ADC1 OFF	
		12			
	Send ML2		ZEF2PRNS,0 ZEF2SRNS,0	Primary and secondary sensor to auto ranging	
		40			
	Send ML2		ZEF2CLBS,1	Cal Mode 1 Active	Execute Calibration Mode Number 1
		120			
	Send ML1		ZEF1INTF ZEF1D2RN	NO HK DATA	Assert DPU2 Reset. Processor is held reset – no telemetry from instrument
		5			
	Send ML2		ZEF2ATTS ZEF2ATCS	NO HK DATA	
		5			
	Send ML1		ZEF1D2RF		Clear DPU2 Reset. Auto boot of DPU2
		17 S < t_d < 60		Auto Boot Selected	Wait for boot to be completed
		Wait for experimenter to confirm success. $t_d \approx 120$			
	Send ML1		ZEF1MSAF	Power OFF MSA	
		5			
	Send ML1		ZEF1AD1F ZEF1AD2F	Power off ADC's Expect to see ADC Error Flags asserted	
		5			
	Send ML1		ZEF1DP2F	NO HK DATA	Power OFF DPU2
		5			
	Switch OFF FGM LCL 'A'				

Sequence Number 3

Power FGM on LCL 'B', main RTU channels, and boot with DPU1.

Preconditions	S/C actions	Pause (t_d)	FGM commands	Params. changed	Comments

FGM LCLs 'A' and 'B' OFF RTU Configured for FGM Main S/C acquiring HK and NM1 data					
	Switch on FGM LCL 'B'			NO HK DATA	
		5			
	Send ML1		ZEF1DR0S	See comment	Dump register 0 command: The contents of INT1 register 0 will appear in the housekeeping but the location is not defined. Expect value 0xC510
	Send ML1		ZEF1RESE	NO HK DATA	Enable control of DPU reset on INT1
	Send ML1		ZEF1DR0S	See comment	Dump register 0 command: The contents of INT1 register 0 will appear in the housekeeping but the location is not defined. Expect value 0xC710
	Send ML2		ZEF2ATTS ZEF2ATCS ZEF2PRNS,7 ZEF2SRNS,7	NO HK DATA	Load auto-boot commands into ML2 FIFO Pre-select Manual sensor ranging.
		5			Wait while reg. 0 information is transmitted
	Send ML1		ZEF1DP1N		Power on DPU1
		17 S < t_d < 60		Boot type 1 HK config. set, with manual sensor ranging.	Wait for boot to be completed *Configuration Number 9*
		Wait for experimenter to confirm success. $t_d \approx 120$			
	Send ML2		ZEF2PRNS,0 ZEF2SRNS,0	Primary and Secondary sensor set to auto ranging	
		40			
	Send ML2		ZEF2CLBS,1	Cal Mode 1 Active	Execute Calibration Mode Number 1
		120			
	Switch OFF FGM LCL 'B'				

Sequence Number 4

Power FGM on LCL 'B', redundant RTU channels, and boot with DPU1. Both ADCs will be tested.

Preconditions	S/C actions	Pause (t_d) / s.	FGM commands	Params. changed	Comments
FGM LCLs 'A' and 'B' OFF RTU Configured for FGM Redundant S/C acquiring HK and NM1 data					
	Switch on FGM LCL 'B'			NO HK DATA	

		5			
	Send ML1		ZEF1DR0S	See comment	Dump register 0 command: The contents of INT2 register 0 will appear in the housekeeping but the location is not defined. Expect value 0xC510
	Send ML1		ZEF1RESE	NO HK DATA	Enable control of DPU reset on INT2
	Send ML1		ZEF1DR0S	See comment	Dump register 0 command: The contents of INT2 register 0 will appear in the housekeeping but the location is not defined. Expect value 0xC710
	Send ML2		ZEF2ATTS ZEF2ATCS ZEF2PRNS,7 ZEF2SRNS,7	NO HK DATA	Load auto-boot commands into ML2 FIFO Pre-select Manual sensor ranging.
		5			Wait while reg. 0 information is transmitted
	Send ML1		ZEF1DP1N		Power on DPU1
		17 S < t_d < 60		Boot type 1 HK config. set, with manual sensor ranging and IEL disabled.	Wait for boot to be completed *Configuration Number 13*
		Wait for experimenter to confirm success. $t_d \approx 120$			
	Send ML2		ZEF2PRNS,0 ZEF2SRNS,0	Primary and Secondary sensor set to auto ranging	
		40			
	Send ML2		ZEF2PCLN,1	Set primary Cal.	
		12			
	Send ML2		ZEF2SCLN,1	Set secondary Cal.	
		12			
	Send ML2		ZEF2PCLN,0	Clear primary Cal.	
		12			
	Send ML2		ZEF2SCLN,0	Clear secondary Cal.	
		12			
	Send ML2		ZEF2PFLN,1	Set primary Flip	
		12			
	Send ML2		ZEF2SFLN,1	Set secondary Flip	
		12			
	Send ML2		ZEF2PFLN,0	Clear primary Flip	
		12			

	Send ML2		ZEF2SFLN,0	Clear secondary Flip	
		12			
	Send ML2		ZEF2PRNS,7 ZEF2SRNS,7	Primary and secondary sensor to manual ranging	
		5			
	Send ML1		ZEF1AD2N	ADC2 ON	
		5			
	Send ML2		ZEF2CALS,0x00 ZEF2CAMS,0x00		Switch to ADC2, Bus2 *Configuration Number 14*
		25			
	Send ML1		ZEF1AD1F	ADC1 OFF	
		12			
	Send ML2		ZEF2PRNS,0 ZEF2SRNS,0	Primary and secondary sensor to auto ranging	
		40			
	Send ML2		ZEF2PCLN,1	Set primary Cal.	
		12			
	Send ML2		ZEF2SCLN,1	Set secondary Cal.	
		12			
	Send ML2		ZEF2PCLN,0	Clear primary Cal.	
		12			
	Send ML2		ZEF2SCLN,0	Clear secondary Cal.	
		12			
	Send ML2		ZEF2PFLN,1	Set primary Flip	
		12			
	Send ML2		ZEF2SFLN,1	Set secondary Flip	
		12			
	Send ML2		ZEF2PFLN,0	Clear primary Flip	
		12			
	Send ML2		ZEF2SFLN,0	Clear secondary Flip	
		12			
	Send ML1		ZEF1INTF ZEF1D1RN	NO HK DATA	Assert DPU1 Reset. Processor is held reset – no telemetry from instrument
		5			

	Send ML2		ZEF2ATTS ZEF2ATCS	NO HK DATA	
		5			
	Send ML1		ZEF1D1RF		Clear DPU1 Reset. Auto boot of DPU1
		17 S < t_d < 60		Auto Boot Selected	Wait for boot to be completed
		Wait for experimenter to confirm success. $t_d \approx 120$			
	Send ML1		ZEF1MSAF	Power OFF MSA	
		5			
	Send ML1		ZEF1AD1F	Power OFF ADC1 Expect to see ADC Error Flags asserted	
		5			
	Send ML1		ZEF1DP1F	NO HK DATA	Power OFF DPU1
		5			
	Switch OFF FGM LCL 'B'				

Sequence Number 5

Power FGM on LCL 'B', redundant RTU channels, and boot with DPU2. Both ADCs will be tested.

Preconditions	S/C actions	Pause (t_d)	FGM commands	Params. changed	Comments
FGM LCLs 'A' and 'B' OFF RTU Configured for FGM Redundant S/C acquiring HK and NM1 data					
	Switch on FGM LCL 'B'			NO HK DATA	
		5			
	Send ML1		ZEF1DR0S	See comment	Dump register 0 command: The contents of INT2 register 0 will appear in the housekeeping but the location is not defined. Expect value 0xC510
	Send ML1		ZEF1RESE	NO HK DATA	Enable control of DPU reset on INT2
	Send ML1		ZEF1DR0S	See comment	Dump register 0 command: The contents of INT2 register 0 will appear in the housekeeping but the location is not defined. Expect value 0xC710
	Send ML2		ZEF2ATTS ZEF2ATCS ZEF2PRNS,7 ZEF2SRNS,7	NO HK DATA	Load auto-boot commands into ML2 FIFO Pre-select Manual sensor ranging.

		5			Wait while reg. 0 information is transmitted
	Send ML1		ZEF1DP2N		Power on DPU2
		17 S < t_d < 60		Boot type 1 HK config. set, with manual sensor ranging, and DPU2 ON with DPU1 OFF, and IEL disabled.	Wait for boot to be completed
		Wait for experimenter to confirm success. $t_d \approx 120$			
	Send ML1		ZEF1AD1N	ADC1 ON	
		5			
	Send ML2		ZEF2CALS,0xFF ZEF2CAMS,0xFF		
		25			
	Send ML1		ZEF1AD2F	ADC2 OFF	*Configuration Number 15*
		12			
	Send ML2		ZEF2PRNS,0 ZEF2SRNS,0	Primary and Secondary sensor set to auto ranging	
		40			
	Send ML2		ZEF2CLBS,1	Cal Mode 1 Active	Execute Calibration Mode Number 1
		120			
	Send ML2		ZEF2PRNS,7 ZEF2SRNS,7	Primary and secondary sensor to manual ranging	
		5			
	Send ML1		ZEF1AD2N	ADC2 ON	
		5			
	Send ML2		ZEF2CALS,0x00 ZEF2CAMS,0x00		Switch to ADC2, Bus2 *Configuration Number 16*
		25			
	Send ML1		ZEF1AD1F	ADC1 OFF	
		12			
	Send ML2		ZEF2PRNS,0 ZEF2SRNS,0	Primary and secondary sensor to auto ranging	
		40			
	Send ML2		ZEF2CLBS,1	Cal Mode 1 Active	Execute Calibration Mode Number 1
		120			

	Send ML1		ZEF1INTF ZEF1D2RN	NO HK DATA	Assert DPU2 Reset. Processor is held reset – no telemetry from instrument
		5			
	Send ML2		ZEF2ATTS ZEF2ATCS	NO HK DATA	
		5			
	Send ML1		ZEF1D2RF		Clear DPU2 Reset. Auto boot of DPU2
		17 S < t_d < 60		Auto Boot Selected	Wait for boot to be completed
		Wait for experimenter to confirm success. $t_d \approx 120$			
	Send ML2		ZEF2PBAS,0x01 ZEF2PBYS,0xCC ZEF2PBYS,0x1C ZEF2PBYS,0x08 ZEF2PBYS,0x00 ZEF2DMPS	Param Byte Count increases to 4. Memory Dump ON for one reset only.	Memory dump results of MSA test
		Wait for experimenter to confirm success. $t_d \approx 30$			
	Switch OFF FGM LCL 'B'				

Sequence Number 6

Power FGM on LCL 'A', redundant RTU channels, and boot with DPU2.

Preconditions	S/C actions	Pause (t_d)	FGM commands	Params. changed	Comments
FGM LCLs 'A' and 'B' OFF RTU Configured for FGM Redundant S/C acquiring HK and NM1 data					
	Switch on FGM LCL 'A'			NO HK DATA	
		5			
	Send ML1		ZEF1DR0S	See comment	Dump register 0 command: The contents of INT2 register 0 will appear in the housekeeping but the location is not defined. Expect value 0xC510
	Send ML1		ZEF1RESE	NO HK DATA	Enable control of DPU reset on INT2
	Send ML1		ZEF1DR0S	See comment	Dump register 0 command: The contents of INT2 register 0 will appear in the housekeeping but the location is not defined. Expect value 0xC710

	Send ML2		ZEF2ATTS ZEF2ATCS ZEF2PRNS,7 ZEF2SRNS,7	NO HK DATA	Load auto-boot commands into ML2 FIFO Pre-select Manual sensor ranging.
		5			Wait while reg. 0 information is transmitted
	Send ML1		ZEF1DP2N		Power on DPU2
		17 S < t_d < 60		Boot type 1 HK config. set, with manual sensor ranging.	Wait for boot to be completed
		Wait for experimenter to confirm success. $t_d \approx 120$			
	Send ML1		ZEF1AD2N	ADC2 ON	
		5			
	Send ML2		ZEF2CALS,0x00 ZEF2CAMS,0x00		
		25			
	Send ML1		ZEF1AD1F	ADC1 OFF	*Configuration Number 8*
		12			
	Send ML2		ZEF2PRNS,0 ZEF2SRNS,0	Primary and Secondary sensor set to auto ranging	
		40			
	Send ML2		ZEF2CLBS,1	Cal Mode 1 Active	Execute Calibration Mode Number 1
		120			
	Switch OFF FGM LCL 'B'				

3. Scientific Performance Verification

3.1 Performance Verification and Calibrations Runs – Summary

Outline (Ref. to Table 2):

Sequence Number 7	Provide a reference set of data for OB Sensor operated with ADC1 in all ranges.
Sequence Number 8	Provide a reference set of data for OB Sensor operated with ADC2 in all ranges.
Sequence Number 9	Provide a reference set of data for IB Sensor operated with ADC1 in all ranges.
Sequence Number 10	Provide a reference set of data for IB Sensor operated with ADC2 in all ranges.

Each sequence is independent of the others, since each starts and ends with the FGM off. Its is possible therefore to execute the sequences in any order.

Each sequence lasts approximately half an hour. It is intended that these sequences will be scheduled close to the execution time, such that the FGM team can predict in advance whether the ambient magnetic field will be low enough to allow the FGM to auto-range into its lowest operating range (range 2). Since this cannot be guaranteed, the FGM is never commanded into this range. The lowest commanded range is range 3, which can be guaranteed in advance by analysis of the orbit and mission plan.

Therefore, since the success of these tests is dependent on the ambient field, they may need to be repeated until the FGM team has the necessary reference set of data. For this purpose, the project team shall allocate a number of half hour slots during the commissioning phase (nominally one per spacecraft per orbit) where these tests shall be run. The detailed planning shall be iterated before and during the commissioning phase.

These sequences shall be executed after the hardware functional test sequences (numbers 1 to 6) have been completed for that instrument. These sequences may be run 'off-line', i.e. it is not necessary for real-time monitoring of the data. FGM personnel may or may not be present in ESOC whilst these sequences are executed.

Since the FGM may only operate in Earth's field range (range 7) during ground operations, part of each sequence shall not be executed during SVT or other validation exercises on the ground. These sections are shaded grey in each sequence.

3.2 Performance Verification and Calibrations Runs – Detail

Sequence Number 7

Default Configuration of the FGM – OB Sensor is Primary and ADC1 is used.

Preconditions	S/C actions	Pause (t_d)	FGM commands	Params. changed	Comments
FGM LCLs 'A' and 'B' OFF RTU Configured for FGM Main S/C acquiring HK and NM1 data					
	Switch on FGM LCL 'A'			NO HK DATA	
		5			
	Send ML1		ZEF1DR0S	See comment	Dump register 0 command: The contents of INT1 register 0 will appear in the housekeeping but the location is not defined. Expect value 0xC510
	Send ML1		ZEF1RESE	NO HK DATA	Enable control of DPU reset on INT1
	Send ML1		ZEF1DR0S	See comment	Dump register 0 command: The contents of INT1 register 0 will appear in the housekeeping but the location is not defined. Expect value 0xC710
	Send ML2		ZEF2ATTS ZEF2ATCS ZEF2PRNS,7 ZEF2SRNS,7	NO HK DATA	Load auto-boot commands into ML2 FIFO
		5			Wait while reg. 0 information is transmitted
	Send ML1		ZEF1DP1N		Power on DPU1
		30		Boot type 1 HK config. set with manual sensor ranging.	Wait for boot to be completed
	Send ML2		ZEF2PRNS,0	Primary sensor to auto range.	Select autoranging on primary sensor only.
		50			Allow primary sensor to autorange down to Range 2 if ambient field allows.
	Send ML2		ZEF2CLBS,1	Cal Mode 1 Active	Execute Calibration Mode Number 1
		300			
	Send ML2		ZEF2PRNS,3	Primary Ranging Manual Primary Sensor set to Range 3.	FOR IN-FLIGHT COMMISSIONING ONLY NOT TO BE EXECUTED DURING GROUND TESTS
		15			
	Send ML2		ZEF2CLBS,1	Cal Mode 1 Active	Execute Calibration Mode Number 1
		300			
	Send ML2		ZEF2PRNS,4	Primary Ranging Manual Primary Sensor set to Range 4.	FOR IN-FLIGHT COMMISSIONING ONLY NOT TO BE EXECUTED DURING GROUND TESTS
		15			

	Send ML2		ZEF2CLBS,1	Cal Mode 1 Active	Execute Calibration Mode Number 1
		300			
	Send ML2		ZEF2PRNS,5	Primary Ranging Manual Primary Sensor set to Range 5.	FOR IN-FLIGHT COMMISSIONING ONLY NOT TO BE EXECUTED DURING GROUND TESTS
		15			
	Send ML2		ZEF2CLBS,1	Cal Mode 1 Active	Execute Calibration Mode Number 1
		300			
	Send ML2		ZEF2FILN,0	Filtering Disabled	Disable filtering of primary sensor vectors
		15			
	Send ML2		ZEF2PRNS,0	Primary sensor set to autorange.	Enable autoranging on Primary Sensor
		100			Allow primary sensor to autorange down to lowest range allowed by ambient field.
	Power OFF FGM LCL 'A'				

Sequence Number 8

OB Sensor is Primary and ADC2 is used.

Preconditions	S/C actions	Pause (t_d)	FGM commands	Params. changed	Comments
FGM LCLs 'A' and 'B' OFF RTU Configured for FGM Main S/C acquiring HK and NM1 data					
	Switch on FGM LCL 'A'			NO HK DATA	
		5			
	Send ML1		ZEF1DR0S	See comment	Dump register 0 command: The contents of INT1 register 0 will appear in the housekeeping but the location is not defined. Expect value 0xC510
	Send ML1		ZEF1RESE	NO HK DATA	Enable control of DPU reset on INT1
	Send ML1		ZEF1DR0S	See comment	Dump register 0 command: The contents of INT1 register 0 will appear in the housekeeping but the location is not defined. Expect value 0xC710
	Send ML2		ZEF2ATTS ZEF2ATCS ZEF2PRNS,7 ZEF2SRNS,7	NO HK DATA	Load auto-boot commands into ML2 FIFO
		5			Wait while reg. 0 information is transmitted
	Send ML1		ZEF1DP1N		Power on DPU1
		30		Boot type 1 HK config. set with manual sensor ranging.	Wait for boot to be completed

	Send ML1		ZEF1AD2N	ADC2 ON	
		5			
	Send ML2		ZEF2CALS,0x00 ZEF2CAMS,0x00		Switch to ADC2, Bus2
		25			
	Send ML1		ZEF1AD1F	ADC1 OFF	
		12			
	Send ML2		ZEF2PRNS,0	Primary sensor to auto range.	Select autoranging on primary sensor only.
		50			Allow primary sensor to autorange down to Range 2 if ambient field allows.
	Send ML2		ZEF2CLBS,1	Cal Mode 1 Active	Execute Calibration Mode Number 1
		300			
	Send ML2		ZEF2PRNS,3	Primary Ranging Manual Primary Sensor set to Range 3.	FOR IN-FLIGHT COMMISSIONING ONLY NOT TO BE EXECUTED DURING GROUND TESTS
		15			
	Send ML2		ZEF2CLBS,1	Cal Mode 1 Active	Execute Calibration Mode Number 1
		300			
	Send ML2		ZEF2PRNS,4	Primary Ranging Manual Primary Sensor set to Range 4.	FOR IN-FLIGHT COMMISSIONING ONLY NOT TO BE EXECUTED DURING GROUND TESTS
		15			
	Send ML2		ZEF2CLBS,1	Cal Mode 1 Active	Execute Calibration Mode Number 1
		300			
	Send ML2		ZEF2PRNS,5	Primary Ranging Manual Primary Sensor set to Range 5.	FOR IN-FLIGHT COMMISSIONING ONLY NOT TO BE EXECUTED DURING GROUND TESTS
		15			
	Send ML2		ZEF2CLBS,1	Cal Mode 1 Active	Execute Calibration Mode Number 1
		300			
	Send ML2		ZEF2FILN,0	Filtering Disabled	Disable filtering of primary sensor vectors
		15			
	Send ML2		ZEF2PRNS,0	Primary sensor set to autorange.	Enable autoranging on Primary Sensor
		100			Allow primary sensor to autorange down to lowest range allowed by ambient field.
	Power OFF FGM LCL 'A'				

Sequence Number 9

IB Sensor is Primary and ADC1 is used.

Preconditions	S/C actions	Pause (t_d)	FGM commands	Params. changed	Comments
FGM LCLs 'A' and 'B' OFF RTU Configured for FGM Main S/C acquiring HK and NM1 data					
	Switch on FGM LCL 'A'			NO HK DATA	
		5			
	Send ML1		ZEF1DR0S	See comment	Dump register 0 command: The contents of INT1 register 0 will appear in the housekeeping but the location is not defined. Expect value 0xC510
	Send ML1		ZEF1RESE	NO HK DATA	Enable control of DPU reset on INT1
	Send ML1		ZEF1DR0S	See comment	Dump register 0 command: The contents of INT1 register 0 will appear in the housekeeping but the location is not defined. Expect value 0xC710
	Send ML2		ZEF2ATTS ZEF2ATCS ZEF2PRNS,7 ZEF2SRNS,7	NO HK DATA	Load auto-boot commands into ML2 FIFO
		5			Wait while reg. 0 information is transmitted
	Send ML1		ZEF1DP1N		Power on DPU1
		30		Boot type 1 HK config. set with manual sensor ranging.	Wait for boot to be completed
	Send ML2		ZEF2POBS,0 ZEF2SOBS,1	Primary sensor is inboard, secondary is outboard.	Swap logical assignment of sensors.
		15			Settling time.
	Send ML2		ZEF2PRNS,0	Primary sensor to auto range.	Select autoranging on primary sensor only.
		50			Allow primary sensor to autorange down to Range 2 if ambient field allows.
	Send ML2		ZEF2CLBS,1	Cal Mode 1 Active	Execute Calibration Mode Number 1
		300			
	Send ML2		ZEF2PRNS,3	Primary Ranging Manual Primary Sensor set to Range 3.	FOR IN-FLIGHT COMMISSIONING ONLY NOT TO BE EXECUTED DURING GROUND TESTS
		15			
	Send ML2		ZEF2CLBS,1	Cal Mode 1 Active	Execute Calibration Mode Number 1
		300			

	Send ML2		ZEF2PRNS,4	Primary Ranging Manual Primary Sensor set to Range 4.	FOR IN-FLIGHT COMMISSIONING ONLY NOT TO BE EXECUTED DURING GROUND TESTS
		15			
	Send ML2		ZEF2CLBS,1	Cal Mode 1 Active	Execute Calibration Mode Number 1
		300			
	Send ML2		ZEF2PRNS,5	Primary Ranging Manual Primary Sensor set to Range 5.	FOR IN-FLIGHT COMMISSIONING ONLY NOT TO BE EXECUTED DURING GROUND TESTS
		15			
	Send ML2		ZEF2CLBS,1	Cal Mode 1 Active	Execute Calibration Mode Number 1
		300			
	Send ML2		ZEF2FILN,0	Filtering Disabled	Disable filtering of primary sensor vectors
		15			
	Send ML2		ZEF2PRNS,0	Primary sensor set to autorange.	Enable autoranging on Primary Sensor
		100			Allow primary sensor to autorange down to lowest range allowed by ambient field.
	Power OFF FGM LCL 'A'				

Sequence Number 10

IB Sensor is Primary and ADC2 is used.

Preconditions	S/C actions	Pause (t_d)	FGM commands	Params. changed	Comments
FGM LCLs 'A' and 'B' OFF RTU Configured for FGM Main S/C acquiring HK and NM1 data					
	Switch on FGM LCL 'A'			NO HK DATA	
		5			
	Send ML1		ZEF1DR0S	See comment	Dump register 0 command: The contents of INT1 register 0 will appear in the housekeeping but the location is not defined. Expect value 0xC510
	Send ML1		ZEF1RESE	NO HK DATA	Enable control of DPU reset on INT1
	Send ML1		ZEF1DR0S	See comment	Dump register 0 command: The contents of INT1 register 0 will appear in the housekeeping but the location is not defined. Expect value 0xC710
	Send ML2		ZEF2ATTS ZEF2ATCS ZEF2PRNS,7 ZEF2SRNS,7	NO HK DATA	Load auto-boot commands into ML2 FIFO

		5			Wait while reg. 0 information is transmitted
	Send ML1		ZEF1DP1N		Power on DPU1
		30		Boot type 1 HK config. set with manual sensor ranging.	Wait for boot to be completed
	Send ML1		ZEF1AD2N	ADC2 ON	
		5			
	Send ML2		ZEF2CALS,0x00 ZEF2CAMS,0x00		Switch to ADC2, Bus2
		25			
	Send ML1		ZEF1AD1F	ADC1 OFF	
		12			
	Send ML2		ZEF2POBS,0 ZEF2SOBS,1	Primary sensor is inboard, secondary is outboard.	Swap logical assignment of sensors.
		15			Settling time.
	Send ML2		ZEF2PRNS,0	Primary sensor to auto range.	Select autoranging on primary sensor only.
		50			Allow primary sensor to autorange down to Range 2 if ambient field allows.
	Send ML2		ZEF2CLBS,1	Cal Mode 1 Active	Execute Calibration Mode Number 1
		300			
	Send ML2		ZEF2PRNS,3	Primary Ranging Manual Primary Sensor set to Range 3.	FOR IN-FLIGHT COMMISSIONING ONLY NOT TO BE EXECUTED DURING GROUND TESTS
		15			
	Send ML2		ZEF2CLBS,1	Cal Mode 1 Active	Execute Calibration Mode Number 1
		300			
	Send ML2		ZEF2PRNS,4	Primary Ranging Manual Primary Sensor set to Range 4.	FOR IN-FLIGHT COMMISSIONING ONLY NOT TO BE EXECUTED DURING GROUND TESTS
		15			
	Send ML2		ZEF2CLBS,1	Cal Mode 1 Active	Execute Calibration Mode Number 1
		300			
	Send ML2		ZEF2PRNS,5	Primary Ranging Manual Primary Sensor set to Range 5.	FOR IN-FLIGHT COMMISSIONING ONLY NOT TO BE EXECUTED DURING GROUND TESTS
		15			
	Send ML2		ZEF2CLBS,1	Cal Mode 1 Active	Execute Calibration Mode Number 1
		300			

	Send ML2		ZEF2FILN,0	Filtering Disabled	Disable filtering of primary sensor vectors
		15			
	Send ML2		ZEF2PRNS,0	Primary sensor set to autorange.	Enable autoranging on Primary Sensor
		100			Allow primary sensor to autorange down to lowest range allowed by ambient field.
	Power OFF FGM LCL 'A'				

4. TM and TC Functional Test

4.1 TM and TC Functional Test – Summary

The purpose of this test is to verify the correct commanding of the FGM instrument with the commanding sequences held in the ESOC database. The reference source for these command sequences is the FGM Users Manual Appendix I, though the naming convention used here is the ESOC system.

This test also provides the first opportunity to operate the FGM in Burst Modes 1 and 3. The test sequence is summarised below:

- Power on FGM into FGMOPM1
- Execute the following sequence of FGM telemetry option changes:
  C ⇒ B ⇒ C ⇒ A ⇒ C ⇒ B ⇒ A ⇒ C ⇒ A ⇒ B ⇒ C ⇒ 3 ⇒ 2 ⇒ 3 ⇒ C ⇒ 4 ⇒ 2 ⇒ 4 ⇒ C
- Set spacecraft to gather BM1 telemetry and set instrument to FGM telemetry option D
- Execute Calibration Mode 1
- Store a block of data to MSA
- Set spacecraft to gather BM3 telemetry and set instrument to FGM telemetry option F
- Set spacecraft to gather NM1 telemetry and set instrument to FGM telemetry option C
- Disable event recognition and clear the MSA. Now, the instrument is in FGMOPM1, its default operating mode.

This sequence is a stand-alone test to be run on each instrument. It should be executed after the hardware functional tests.

4.2 TM and TC Functional Test – Detail

Preconditions	S/C actions	Pause (t_d) / s.	FGM commands	Params. changed	Comments
FGM LCLs 'A' and 'B' OFF RTU Configured for FGM Main S/C acquiring HK and NM1 data					
	Send ESOC sequence (FGM Boot Type 2)		1SFGMM000		On completion FGM is in FGMOPM1
		30			
			E_FGM002()		Switch to FGM telemetry option B
		240			
			E_FGM008()		Switch to FGM telemetry option C
		15			
			E_FGM003()		Switch to FGM telemetry option A
		300			
			E_FGM00A()		Switch to FGM telemetry option C
		15			
			E_FGM002()		Switch to FGM telemetry option B
		15			
			E_FGM009(0		Switch to FGM telemetry option A
		15			
			E_FGM00A()		Switch to FGM telemetry option C
		15			
			E_FGM003()		Switch to FGM telemetry option A
		15			
			E_FGM00B()		Switch to FGM telemetry option B
		15			
			E_FGM008()		Switch to FGM telemetry option C
		15			
			E_FGM005()		Switch to FGM telemetry option 3
		240			
			E_FGM018()		Set MSA trigger

		420			Default delay is 0x10 reset frames. Therefore the telemetry option switches from 3 to 2 after a period of 82 to 88 sec.
			E_FGM019()		Clear MSA trigger
		30 S < t_d < 60 S			Unit should switch from telemetry option 2 to 3.
			E_FGM00C()		Switch to FGM telemetry option C
		15			
			E_FGM004()		Switch to FGM telemetry option 4
		240			
			E_FGM018()		Set MSA trigger
		420			Default delay is 0x10 reset frames. Therefore the telemetry option switches from 4 to 2 after a period of 82 to 88 sec.
			E_FGM019()		Clear MSA trigger
		30 S < t_d < 60 S			Unit should switch from telemetry option 2 to 4.
			E_FGM00C()		Switch to FGM telemetry option C
		15			
Set s/c to acquire BM1 telemetry from the main s/c interface of the FGM.		Wait for s/c to change TM mode			
			E_FGM006()		Switch to mode D
		60			
			E_FGM019()		Clear MSA Trigger
			E_FGM011(0,1)		Execute cal mode 1
		56			
			E_FGM018()		Trigger MSA
		180			
Set s/c to acquire BM3 telemetry from the main s/c interface of the FGM.		Wait for s/c to change TM mode			
			E_FGM00F()		Switch D to C (as D to F not permitted)
		5			
			E_FGM007()		Switch C to F
		300			
Set s/c to aquire NM1 telemetry from the main s/c interface of the FGM.		Wait for s/c to change TM mode			
			E_FGM010()		

			E_FGM017()		
			E_FGM019()		
	Switch OFF FGM LCL 'A'				

5. Perigee pass

5.1 Perigee Pass Summary

This test is summarised below:

- Ensure instrument is operating in FGMOPM1 and begin gathering data $\approx$ 60 Min. before perigee.
- Ensure primary sensor is OB, Secondary Sensor is IB
- At perigee trigger MSA.
- After filling MSA switch primary sensor to IB and secondary sensor to OB.
- Gather data for $\approx$ 30 Min.
- Switch to FGMOPM3 with primary sensor OB secondary sensor IB
- Gather data for $>$ 66 Min.

This sequence shall be run on each instrument.

5.2 Perigee Pass Detail

Preconditions	S/C actions	Pause (t_d)	FGM commands	Params. changed	Comments
FGM LCLs 'A' and 'B' OFF RTU Configured for FGM Main S/C acquiring HK and NM1 data				TBD	
	Send ESOC sequence (FGM Boot Type 2)		1SFGMM000		On completion FGM is in FGMOPM1
		30			
			E_FGM019()		Untrigger MSA
		Td>30 Min			Wait for perigee
			E_FGM018()		Trigger MSA
		Td>5 Min			
			E_FGM03E(0 , 1)		Set primary to IB secondary to OB, auto-ranging
		Td=30 Min			
			E_FGM03E(1 , 0)		Set primary to OB secondary to IB, auto-ranging
			E_FGM003()		Set telemetry mode A. FGMOPM3
		Td>66 Min			
			E_FGM00A()		Restore telemetry mode C. FGMOPM1
	Switch OFF FGM LCL 'A'				

6. Extended Mode Test

Extended Mode Test Summary

This test is summarised below:

- Ensure instrument is operating in FGMOPM1.
- Ensure primary sensor is OB, secondary sensor is IB.
- Switch secondary sensor into range 7.
- Switch to FGMEXT.
- Gather data for ~~28~~24 hours.
- Switch to FGMOPM1.
- Configure instrument for BM3.
- Switch to FGMOPM8.
- Leave for 300s.
- Power off instrument.

This sequence shall be run on one instrument.

Preconditions	S/C actions	Pause (t_d) / s.	FGM commands	Params. changed	Comments
FGM LCLs 'A' and 'B' OFF RTU Configured for FGM Main S/C acquiring HK and NM1 data					
	Send ESOC sequence (FGM Boot Type 2)		1SFGMM000		On completion FGM is in FGMOPM1
		30			
	Send ML2		ZEF2PRNS,0	Primary sensor to autoranging	
		5			
	Send ML2		ZEF2PBAS,63 ZEF2PBYS,FF	Base address update set for one reset only. Parameter Byte count increases to 2. HK data only.	Uplink 0xff to address 0x63 of parameter table which switches the instrument into extended mode.
		24 hrs			
	Send MACRO		E_FGM00C()	Telemetry option to C	Switch instrument to telemetry option C.
		5			
Set s/c to acquire BM3 telemetry from the main s/c interface of the FGM.		Wait for s/c to change TM mode			
	Send MACRO		E_FGM007()	Telemetry option to F	Switch instrument to telemetry option F. This dumps the contents of the MSA.
		300			
	Send ML1		ZEF1DP1F	No HK data	Power off DPU1
	Switch OFF FGM LCL ‘A’				