

## **SMEI Electromagnetic Compatibility**

### **Test Plan**

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## SMEI Electromagnetic Compatibility Test Plan

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## SMEI Electromagnetic Compatibility Test Plan

### 1. Introduction

This document describes the requirements and procedures for Electromagnetic Compatibility testing of the Solar Mass Ejection Imager (SMEI) instrument, which will form part of the Coriolis Mission spacecraft.

### 2. Applicable Documents

The following documents in their latest issue form part of this specification to the extent referenced herein. In the case of conflict between this document and any referenced document, this EMC Test Plan shall take precedence.

MIL-STD-461D "Requirements for the Control of Electromagnetic Interference Emissions and Susceptibility", 11 Jan 1993.

MIL-STD-462D "Test Method Standard for Measurement of Electromagnetic Interference Characteristics", 11 Jan 1993.

### 3. The SMEI Instrument

#### 3.1 Introduction

The SMEI instrument comprises a Data Handling Unit (DHU) and three optical CCD Camera Units. The DHU consists of two fully redundant systems (DHU A and DHU B) each of which has independent power, command and telemetry interfaces with the spacecraft. The only connectors interfacing with the spacecraft are located on the DHU. Each Camera is connected to the DHU via two intra-instrument cable harnesses, one for power and one for signals. Grounding points are provided on the DHU and on each Camera.

The instrument Electrical Ground Support Equipment (EGSE) comprises a PC fitted with a MIL-STD-1553B interface board, together with a small Spacecraft Simulator unit which provides relay command outputs, 1 Hz sync outputs and 28 V power to the instrument.

#### 3.2 Size and Mass

Approximate dimensions and masses of the components of SMEI are given in Table 3.1.

	<b>Dimensions (mm)</b>	<b>Mass (Kg)</b>
DHU	310 x 270 x 95	7.0
Cameras (each)	500 x 460 x 410	7.6
Intra-Instrument Harnesses	Various lengths ~ 1.5 m	Total ~ 1.5

**Table 3.1 - Approximate Dimensions and Masses of SMEI Units**

### 3.3 Electrical Interfaces and Connectors

A block diagram showing the electrical connections between the DHU, spacecraft and cameras is given in Figure 3.1.

The types and functions of the connectors mounted on the DHU are listed in Table 3.1.

Pin allocations for connectors J1 and J2 which, together with the MIL-STD-1553B busses, form the interface with the spacecraft are given in Tables 3.2 and 3.3.

Connector	Type	Function
J1	SND15M	Spacecraft 28V A and B supplies
J2	SND15F	Spacecraft relay commands & 1Hz sync
J3	SND25F	Test Connector (not used during EMC tests)
J4	SDD62F	Camera 1 signals
J5	SDD62F	Camera 2 signals
J6	SDD62F	Camera 3 signals
J7	SDD26F	Camera 1 power
J8	SDD26F	Camera 2 power
J9	SDD26F	Camera 3 power
J10	Trompeter BJ3150	MIL-STD-1553B Bus, DHU A, Ch A
J11	Trompeter BJ3150	MIL-STD-1553B Bus, DHU A, Ch B
J110	Trompeter BJ3150	MIL-STD-1553B Bus, DHU B, Ch A
J111	Trompeter BJ3150	MIL-STD-1553B Bus, DHU B, Ch B

**Table 3.1 - SMEI DHU Connectors**

Pin Number	Signal Name	Description
1	SC_POWER_A+	Spacecraft 28V A positive
2	SC_POWER_A+	Spacecraft 28V A positive
3	SC_POWER_A_RET	Spacecraft 28V A return
4	SC_POWER_A_RET	Spacecraft 28V A return
5	SC_POWER_B+	Spacecraft 28V B positive
6	SC_POWER_B+	Spacecraft 28V B positive
7	SC_POWER_B_RET	Spacecraft 28V B return
8	SC_POWER_B_RET	Spacecraft 28V B return
9	Not used	
10	Not used	
11	Not used	
12	Not used	
13	Not used	
14	Not used	
15	J1_SCREEN	DHU structure

**Table 3.2 - SMEI Power Interface Connector J1**

Pin Number	Signal Name	Description
1	1_HZ_A	1 Hz sync to DHU A
2	1_HZ_A_RET	1 Hz sync return to DHU A
3	Not used	
4	Not used	
5	Not used	
6	RELAY_CMD_SEL_A	Switches on and initiates DHU A
7	RELAY_CMD_SEL_B	Switches on and initiates DHU B
8	RELAY_CMD_POWER_OFF	Switches off both DHUs
9	1_HZ_B	1 Hz sync to DHU B
10	1_HZ_B_RET	1 Hz sync return to DHU B
11	Not used	
12	RELAY_CMD_SEL_A_RET	Relay command return
13	RELAY_CMD_SEL_B_RET	Relay command return
14	RELAY_CMD_POWER_OFF_RET	Relay command return
15	J2_SCREEN	DHU structure

**Table 3.3 - SMEI Discrettes Interface Connector J2**

#### 4 Test Configuration

The DHU and three Cameras shall be installed within the shielded chamber of the EMC test facility and the units shall be connected together using the flight intra-instrument cable harnesses. Each unit shall be grounded by means of a separate bonding strap.

The EGSE shall be installed outside the shielded chamber and screened cable harnesses, together with appropriate filtering at the chamber walls, shall be used for the connections between J1, J2, J10, J11, J110 and J111 on the DHU and the EGSE.

28 V power shall be supplied to the instrument from a standard power source and LISN in the test facility and not from the SMEI EGSE.

Maximum operating power at 28 V is approximately 80 W.

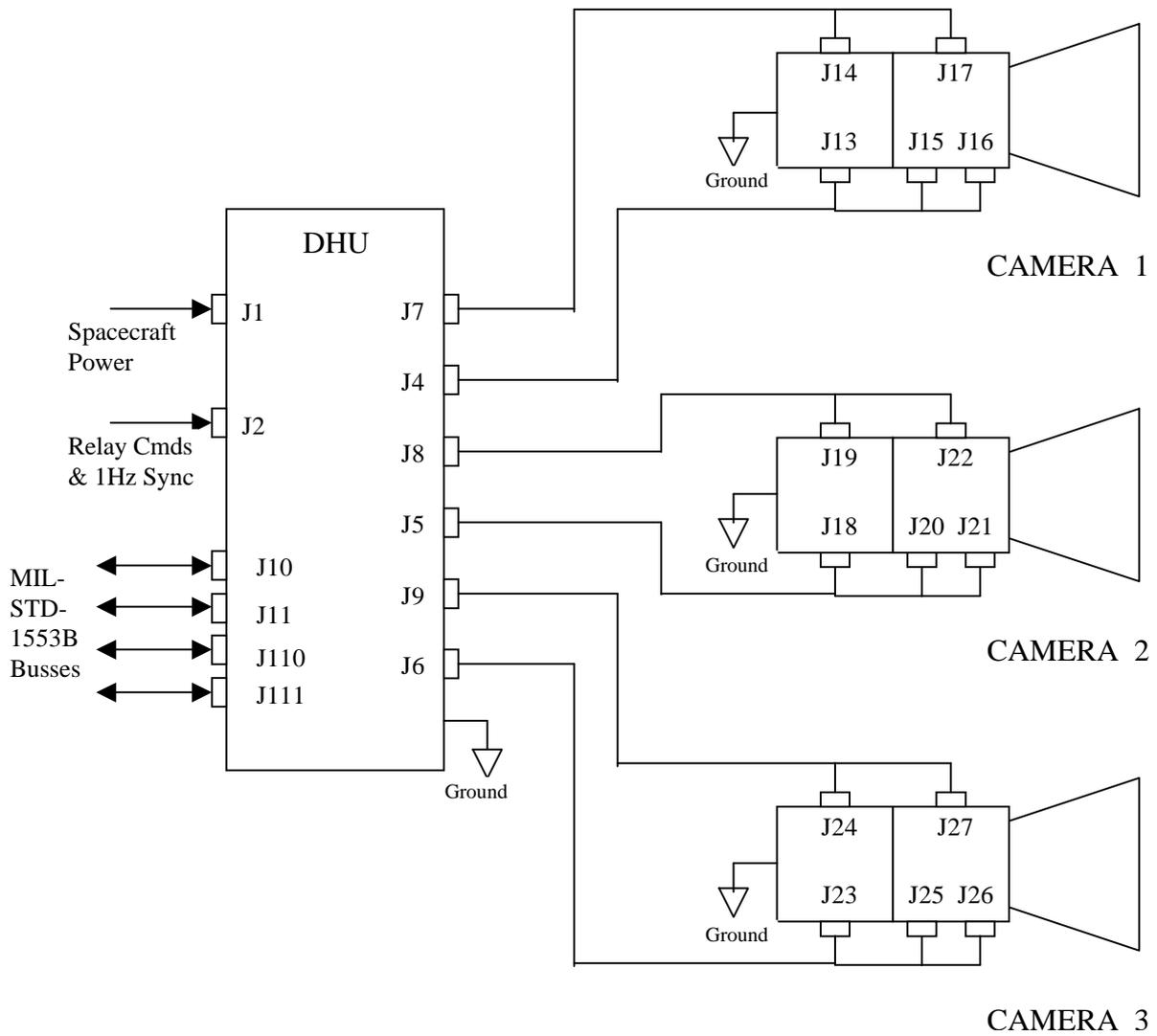


Figure 3.1 - Electrical Interconnections between the DHU, Spacecraft and Cameras

## 5. Test Specifications and Methods

### 5.1 Emission

#### 5.1.1 Conducted Emissions

##### 5.1.1.1 Conducted Emissions, Power Leads

The instrument shall be tested according to the procedures and requirements of MIL-STD-461D/462D CE102, over the range 10 kHz to 10 MHz.

Each 28V supply lead (A and B) and return on connector J1 shall be tested.

For the duration of the test, the SMEI instrument and EGSE will be configured and operated as follows:

- Camera Doors will be in *closed* position.
- The appropriate DHU (A or B) will be activated, depending on the supply lead being tested.
- The instrument will be operated in *Observing Mode*, with all three cameras taking exposures at the normal 4s cadence.
- The EGSE will be used to acquire and record telemetry data via the appropriate MIL-STD-1553B bus interface at the normal 64 kbps data rate.

#### 5.1.2 Radiated Emissions

##### 5.1.2.1 Radiated Emissions, Magnetic Field

A test of AC radiated emissions, magnetic field according to the procedures of MIL-STD-461D/462D RE101 is not required.

However, the DC dipole moment of each camera shall be determined by measuring the magnetic fields in each of the three camera axes at a distance of 1m from the camera.

##### 5.1.2.2 Radiated Emissions, Electric Field

The instrument shall be tested according to the procedures of MIL-STD-461D/462D RE102, over the range 10 kHz to 40 GHz. Above 30 MHz the test shall be performed for both vertically and horizontally polarised fields.

Radiated emissions limits are as for RE102, Navy and Air Force (External) **except that, in order to ensure compatibility with the rest of the Coriolis payload and spacecraft, reduced emissions limits apply at specific notch frequencies as listed in Tables 5.1 and 5.2.**

At frequencies other than those listed in Tables 5.1 and 5.2, the emissions limit in the range 18 to 40 GHz shall be 69 dB $\mu$ V/m.

The overall emissions limits for SMEI are shown in Figure 5.1.

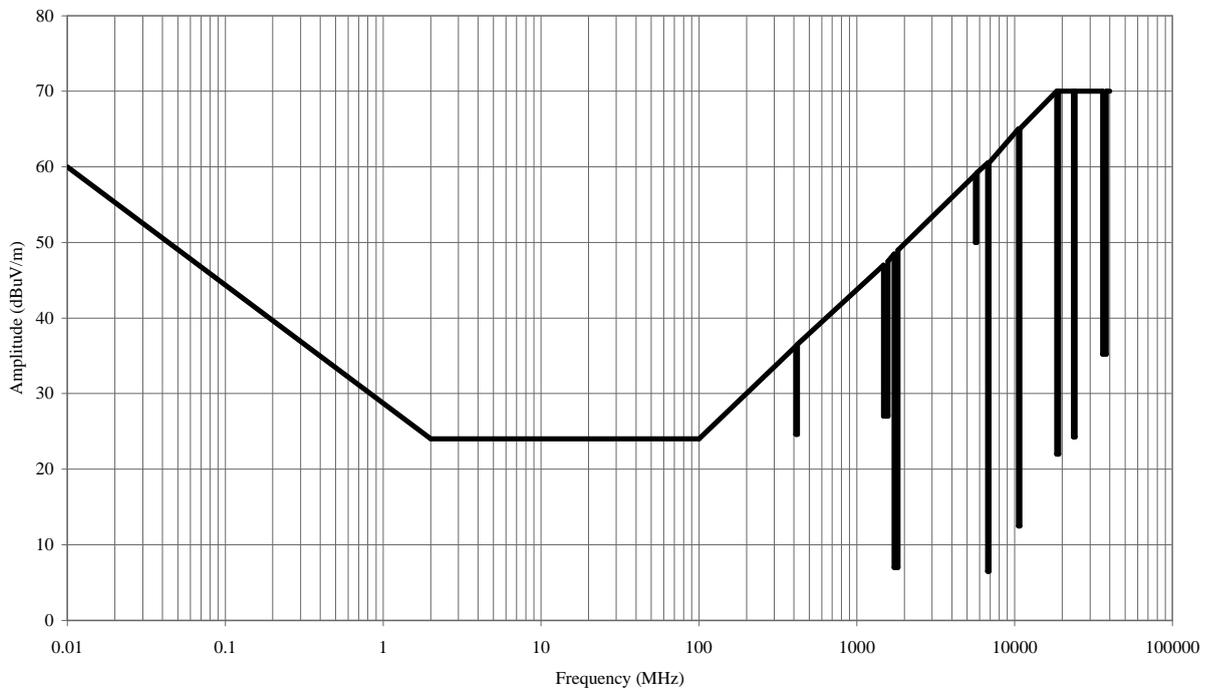
**Note:** The reduced emission limits at 416.5 and 5690 MHz shown in Figure 5.1 do not apply to SMEI since they relate to Range Safety and Launch Vehicle receivers and SMEI is not powered during launch

<b>Centre Frequency (GHz)</b>	6.8	10.7	18.7	23.8	37.0
<b>Bandwidth (MHz)</b>	125.0	300.0	750.0	500.0	2000.0
<b>Emissions Limit (dB<math>\mu</math>V/m)</b>	6.34	14.3	23.9	24.3	35.3

**Table 5.1 - Emissions Limits and Bandwidths for WindSat Radiometers**

Receiver	Centre Freq (MHz)	Emissions Limit (dB $\mu$ V/m)	3 dB Bandwidth (MHz)
SGLS	1771.7	7	10
GPS	1575.8	27	100

**Table 5.2 - Emissions Limits and Bandwidths for S/C Receivers**



**Figure 5.1 - Modified RE102 Emissions Limits**

The DHU and one Camera shall be located as close together as practicable in the test set-up and the antenna in use shall be at a distance of approximately 1m in the direction of maximum emission. This direction shall be established by means of an initial high-speed scan in each frequency band.

The test shall be performed using either DHU A or DHU B, **but not both**.

For the duration of the test, the SMEI instrument and EGSE will be configured and operated as follows:

- Camera Doors will be in *open* position, with the baffle apertures covered by protective bagging.
- Camera Shutters will be in *open* position.

- The instrument will be operated in *Observing Mode*, with all three cameras taking exposures at the normal 4s cadence.
- The EGSE will be used to acquire and record telemetry data via the appropriate MIL-STD-1553B bus interface at the normal 64 kbps data rate.

## 5.2 Susceptibility

### 5.2.1 Conducted Susceptibility

#### 5.2.1.1 Conducted Susceptibility, Power Leads

The instrument shall be tested according to the procedures and requirements of MIL-STD-461D/462D CS101, over the range 30 Hz to 50 kHz.

The test shall be performed on 28V A supply input only, with DHU A activated. 28V B supply and DHU B shall **not** be tested.

For the duration of the test, the SMEI instrument and EGSE will be configured and operated as follows:

- Camera Doors will be in *closed* position.
- The instrument will be operated in *Observing Mode*, with all three cameras taking exposures at the normal 4s cadence.
- The EGSE will be used to acquire and record telemetry data via the appropriate MIL-STD-1553B bus interface at the normal 64 kbps data rate.
- SOH data will be monitored on the EGSE in order to verify that there is no unexpected response, malfunction or degradation of the instrument that results in out-of-specification performance.

Subsequent to the test, a representative sample of recorded science data will be examined to verify that there is no degradation in performance of the CCD cameras. In addition to determining that there is no malfunction of the CCD image readout, an appropriate criterion will be set for the maximum allowable increase in readout noise.

**Note:** The configuration with the Camera Doors closed will result in the CCD images being only dark charge, which is the most sensitive case for detecting degradation in performance of the cameras.

#### 5.2.1.2 Conducted Susceptibility, Bulk Cable Injection

The instrument shall be tested according to the procedures and requirements of MIL-STD-461D/462D CS114 (space), over the range 10 kHz to 200 MHz.

The test shall be performed only on the cable bundles which form the interface with the spacecraft, i.e. on connectors J1 and J2. These bundles may be tested together. There is **no** requirement to repeat the test with the power returns excluded from the bundle (as specified in MIL-STD-462D, Method CS114, Section 4c).

The test shall be performed with DHU A activated only. DHU B shall **not** be tested.

For the duration of the test, the SMEI instrument and EGSE will be configured and operated as follows:

- Camera Doors will be in *closed* position.

- The instrument will be operated in *Observing Mode*, with all three cameras taking exposures at the normal 4s cadence.
- The EGSE will be used to acquire and record telemetry data via the appropriate MIL-STD-1553B bus interface at the normal 64 kbps data rate.
- SOH data will be monitored on the EGSE in order to verify that there is no unexpected response, malfunction or degradation of the instrument that results in out-of-specification performance.

Subsequent to the test, a representative sample of recorded science data will be examined to verify that there is no degradation in performance of the CCD cameras. In addition to determining that there is no malfunction of the CCD image readout, an appropriate criterion will be set for the maximum allowable increase in readout noise.

**Note:** The configuration with the Camera Doors closed will result in the CCD images being only dark charge, which is the most sensitive case for detecting degradation in performance of the cameras.

### 5.2.1.3 Conducted Susceptibility, Power Bus Transients

The instrument shall be tested to demonstrate that it is capable of withstanding spacecraft power bus transients of amplitude  $\pm 18V$  with respect to the nominal 28V bus supply voltage, and with an integrated transient voltage-time of 150 V- $\mu s$ . This test shall be carried out on both 28V A and 28V B supply rails, with the appropriate DHU (A or B) activated.

### 5.2.2 Radiated Susceptibility

#### 5.2.2.1 Radiated Susceptibility, Magnetic Field

Not required.

#### 5.2.2.2 Radiated Susceptibility, Electric Field

The instrument shall be tested according to the procedures and requirements of MIL-STD-461D/462D RS103, over the range 10 kHz to 18 GHz. The field strength used shall be 20 V/m, except at the spacecraft transmitter frequencies listed in Table 5.3.

Transmitter	Centre Freq (MHz)	Field Strength at SMEI (V/m)	3 dB BW (MHz)	60 dB BW (MHz)
LV C-Band	5765	55	6	TBS
SGLS (Zenith)	2212.5	30	4	18

**Table 5.3 - Spacecraft Transmitter Characteristics**

Above 30 MHz the test shall be performed for both vertically and horizontally polarised fields.

The DHU and one Camera shall be located as close together as practicable in the test set-up and the antenna in use shall be at a distance of approximately 1 m from the connector face of the DHU and from the Strong-Box of the Camera.

In the case of the test at the launch vehicle C-Band frequency, the test shall be performed with the instrument switched off, and it is only necessary to demonstrate that the instrument can be switched on and activated successfully subsequently.

For all other radiated susceptibility testing, the tests shall be performed with DHU A activated only. DHU B shall **not** be tested.

For the duration of the test, the SMEI instrument and EGSE will be configured and operated as follows:

- Camera Doors will be in *open* position, with the baffle apertures covered by protective bagging.
- Camera Shutters will be in *closed* position (see note below).
- The instrument will be operated in *Observing Mode*, with all three cameras taking exposures at the normal 4s cadence.
- The EGSE will be used to acquire and record telemetry data via the appropriate MIL-STD-1553B bus interface at the normal 64 kbps data rate.
- SOH data will be monitored on the EGSE in order to verify that there is no unexpected response, malfunction or degradation of the instrument that results in out-of-specification performance.

Subsequent to the test, a representative sample of recorded science data will be examined to verify that there is no degradation in performance of the CCD cameras. In addition to determining that there is no malfunction of the CCD image readout, an appropriate criterion will be set for the maximum allowable increase in readout noise.

**Note:** The configuration with the Camera Doors open but with the Camera Shutters closed will minimise stray light reaching the CCDs, thereby resulting in maximum sensitivity for detecting degradation in performance of the cameras. However, the test will be performed with the Shutters in the *open* position if it is found that the stray light level is negligible.

### 5.2.2.3 Radiated Susceptibility, ESD

The instrument shall be tested in the presence of a 10 kV electrostatic discharge (arc) at a distance of 30 cm and at a rate of 1 to 10 arcs per second for a period of not less than 30 seconds.

The DHU and one Camera shall be located as close together as practicable in the test set-up and the discharge shall be at a distance of approximately 30 cm from the connector face of the DHU and from the Strong-Box of the Camera.

For the duration of the test, the SMEI instrument and EGSE will be configured and operated as follows:

- Camera Doors will be in *open* position, with the baffle apertures covered by protective bagging.
- Camera Shutters will be in *closed* position (see note below).
- The instrument will be operated in *Observing Mode*, with all three cameras taking exposures at the normal 4s cadence.
- The EGSE will be used to acquire and record telemetry data via the appropriate MIL-STD-1553B bus interface at the normal 64 kbps data rate.

- SOH data will be monitored on the EGSE in order to verify that there is no unexpected response, malfunction or degradation of the instrument that results in out-of-specification performance.

Subsequent to the test, a representative sample of recorded science data will be examined to verify that there is no degradation in performance of the CCD cameras. In addition to determining that there is no malfunction of the CCD image readout, an appropriate criterion will be set for the maximum allowable increase in readout noise.

**Note:** The configuration with the Camera Doors open but with the Camera Shutters closed will minimise stray light reaching the CCDs, thereby resulting in maximum sensitivity for detecting degradation in performance of the cameras. However, the test will be performed with the Shutters in the *open* position if it is found that the stray light level is negligible.

## 6. Summary of Test Requirements

The following summarises the requirements for MIL-STD-461D tests to be performed on the SMEI instrument:

CE101	Not required	RE101	Not required
CE102	Required	RE102	Required - enhanced specification
CE106	Not required	RE103	Not required
CS101	Required	RS101	Not required
CS103	Not required	RS103	Required
CS104	Not required	RS105	Not required
CS105	Not required	ESD Test	Required
CS109	Not required	DC Mag Dipole	Required
CS114	Required	Pwr Bus Trans	Required
CS115	Not required		
CS116	Not required		

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