The Requirements Compliance Matrix shall be filled out by the Experimenter and submitted for the design review with NASA. The following definitions of Test, Demonstrate, Analysis and Inspection shall be used.

Analysis – This approach is used to verify compliance to requirements, which are not readily verified by other means. Tools of this verification method include math models, simulations, compilation and extension of test results, etc. *Supporting documentation and analytical results shall be noted and attached.*

Demonstration – This approach is used to illustrate an end-items compliance to requirements by direct observation of the end-items operations.

Inspection – This verification approach is used to verify compliance to requirements through examination of the physical characteristics, visual properties, design schematics, etc., without the use of special laboratory tools, procedures, or services. Common examples are identification, size, weight, dimensions, cleanliness and documented records.

Test – This verification approach is used to verify compliance to requirements through functional measurements such as voltage levels and pulse width characteristics. This common verification method generally requires special laboratory equipment, detailed procedures, manual or automated data recording, etc. *Supporting documentation and test results shall be noted and attached.*

Section	Requirement	Verification				Comments/ Attached Documents
		A	I	D	T	
1.2	All Experimenters shall follow the SET quality assurance and safety requirements specified in the Mission Assurance Requirements for Space Environment Testbeds (SET) Experiments document (LWSSET-QA-0001).					
1.3.1	The provider of the Experiment or CEM shall ensure that the provided article is in compliance with this document.					
1.3.1	The Experiment Provider shall submit an Experiment Accommodations Request Document (Appendix B)					
1.3.1	The experimenter shall submit an initial EARD within one month of the experimenter kickoff meeting.					
1.3.1	The experimenter shall submit a preliminary EARD soon after the experiment preliminary design has started.					
1.3.1	The experimenter shall submit a final EARD 30 days prior to the Experiment Design Review.					
1.3.1	For any noncompliance with the requirements listed herein, the Experimenter provider shall submit a waiver to be approved by the SET Project Manager, the SET Experiment Manager and the SEC Systems Assurance Manager.					

Section	Requirement	Verification				Comments/ Attached Documents
		A	I	D	T	
1.3.1	The Experimenter shall be responsible for submitting a Requirements Compliance Matrix (Appendix A) with supporting material.					
1.3.1	The Experimenter shall be responsible for submitting inputs to a SET Telemetry & Command Handbook (Appendix C).					
1.3.1	The Experimenter shall clearly mark any documents or drawings submitted to the SET Project with proprietary information as “PROPRIETARY”					
2.1.2	Where specified, all Experiments shall meet the interface requirements of the Standby Mode, or alternatively, elect to be un-powered when this mode is selected by the Carrier.					
4.1.1	Experiment boards shall not exceed the dimensions shown in Figure 4-2 through Figure 4-6					
4.1.2	Each single 3U board experiment shall have a maximum mass of 0.25 kg (0.55 lb) measured to ±0.5%.					
4.1.2	A double 6U board experiment shall have a maximum mass of 0.50 kg (1.10 lb).					
4.1.2	The primary resonance frequency of a single or double board shall be greater than 50 Hz.					
4.2	Experimenter-provided boxes shall not exceed 12cm × 18cm ×12cm (4.72in × 7.08in × 4.72in)					
4.2	Experimenter-provided boxes shall not exceed 10 kg (22 lb).					
4.2	The primary resonance frequency of an experimenter-provided box shall be greater than 50 Hz.					
5.2	For +/-5V, +/-15V analog power, load shall be balanced at a minimum of 80% / 20% between plus and minus supplies.					
5.3.1	During normal operating modes, the total maximum power for any Experiment board shall not exceed 4.0 W.					
5.3.1	Board Experiments shall not include radioisotope sources of power.					
5.3.2	During normal operating modes, the total maximum power for any box experiment shall not exceed 10.0 W.					
5.3.2	The portion of maximum power for any box experiment, from regulated secondary sources only, shall not exceed 4.0 W.					
5.3.2	Box Experiments shall not include radioisotope sources of power.					

Section	Requirement	Verification				Comments/ Attached Documents
		A	I	D	T	
5.4	When requested by the Carrier to enter Standby mode, experiments shall limit their maximum total power draw to less than 100 mW for boards and 300 mW for boxes. This maximum limit applies to the combined power of all boards in a multi-board Experiment unless otherwise negotiated with the SET project.					
5.5	The maximum in-rush transient current required by any experiment shall be no greater than 1.5 times its steady state value for duration of less than 50 milliseconds.					
5.7.1	All experiments shall utilize individual returns with each voltage as listed in Table 5-1.					
5.7.2	Experiments shall maintain DC isolation of at least 1MΩ between all voltages/returns and chassis.					
5.7.2	Tie in points on board, thermal conductance strip, and keep out area around board shall be tied to chassis ground.					
5.7.3	Experiments shall maintain DC isolation of at least 1MΩ between secondary voltages/returns and 28V primary voltage/return.					
5.7.4	Experiments shall maintain DC isolation of at least 10KΩ between secondary digital voltages/return and secondary analog voltages/return.					
5.7.5	Experiments shall maintain DC isolation of at least 1MΩ from 0 V reference to any voltage or return.					
6.1	The analog telemetry outputs from the Experiments shall consist of four (4) signals: one dedicated to a dosimeter monitor function, one dedicated to a Thermistor monitor function, and two functions (as desired) to be defined by the user and compatible with the voltage monitor convention defined in section 6.1.3					
6.1.1	Dosimeter monitors shall be implemented using the NMRC ESAPMOS4 300/50 RADFETs (RADFET#1).					
6.1.2	A temperature monitor shall be implemented on each Experiment using 311P18-05T76R thermistors (5kΩ at 25 °C) per the GSFC procurement specification S-311-P-18 for thermistors.					

Section	Requirement	Verification				Comments/ Attached Documents
		A	I	D	T	
6.1.3	Those Experiments using the voltage monitor shall conform to the convention shown in Figure 6-3 with either terminal not exceeding ±13.0 VDC.					
6.2	For commanding Experiments and collecting digital telemetry, all Experiments shall communicate with the carrier via an asynchronous full duplex serial bus.					
6.2.1.1	Experiments utilizing the RS-422 physical layer shall meet the EIA standard with termination and common mode filtering as illustrated in Figure 6-4 for box Experiments and Figure 6-5 for board Experiments.					
6.2.1.1	Box Experiments shall provide at least 3 chassis ground connected pins within the serial port connector for optional shield grounding within the mating harness.					
6.2.1.2	Board Experiments shall utilize the glonal reset signal provided by the carrier or incorporate a reset command transmitted via the command channel in the serial bus.					
6.2.1.2	Board Experiments shall utilize the standby signal provided by the carrier or incorporate a standby command transmitted via the command channel in the serial bus.					
6.2.1.2	If experiments incorporate a standby command, they shall also be able to return from standby via command.					
6.2.2.1	Experiment command and telemetry interfaces shall nominally operate at a common programmable rate from 1.2K up to a maximum rate of 57.6K baud.					
6.2.2.2	Experiments utilizing the HDLC-Unbalanced Connectionless Class, *UCC12,15.1* of data link layer shall conform to all requirements documented in the ISO/IEC 13239 standard and SEARS Section 6.2.2.2. The ISO standard shall take precedence with respect to any discrepancies between this description and the ISO standard.					
6.2.2.2.2	Stations (Carrier or Experiment) shall continuously monitor the byte stream for the flag value, which when received, shall indicate start and/or end of a frame.					
6.2.2.2.3	The address byte shall always refer to the Experiment, whether in a command frame from the Carrier or a response frame from the Experiment.					

Section	Requirement	Verification				Comments/ Attached Documents
		A	I	D	T	
6.2.2.2.3	All Experiments shall provide a jumper configurable 8 bit address. Installation of a jumper shall indicate a logic value 0. With no jumpers installed (all ones) or all jumpers installed (all zeros), the address shall be disabled and the Experiment shall respond to all addresses except all zeros, 00000000.					
6.2.2.2.4	The control byte field shall indicate the type of command or response of the frame.					
6.2.2.2.5	The Information field for UI commands and responses shall contain Experiment commands and telemetry respectively.					
6.2.2.2.5	The Information field for Test commands and responses shall contain test patterns for verifying the communication channel.					
6.2.2.2.7	Experiments shall accept the UI and Test Commands and be capable of replying with UI and Test Responses.					
6.2.2.3	For Experiment Defined Class, the data link layer protocol shall utilize the byte format defined in section 6.2.2.1, shall be well defined by the Experimenter and shall use frames with deterministic boundaries (i.e. beginning and end).					
6.2.2.3	For Experiment Defined Class, the expected response for each individual command shall also have a defined length.					
6.2.3	Command and Telemetry data transmitted to and received from Experiments shall be embedded within the Data Link Layer Frames.					
6.2.3	**For UCC HDLC frames, the data shall be contained in the information fields of the UI and I command and response frames.**					
6.2.3	For user-defined frames, the location of this information within the frame shall be defined by the Experimenter. The form and definition of commands and telemetry shall be determined by the Experimenter within a limited set of requirements imposed by the project.					
6.2.3.1	For each Experiment, the maximum information field size for any frame shall be negotiated with the SET Project and shall not exceed 128 bytes					
6.2.3.2	Only one command shall be permitted per frame.					
6.2.3.2	Each command shall require a telemetry response that shall, at a minimum, acknowledge correct receipt of the command.					

Section	Requirement	Verification				Comments/ Attached Documents
		A	I	D	T	
6.2.3.2	Commands shall be transmitted individually with no further commands being transmitted until a telemetry response is received or a timeout condition occurs.					
6.2.3.2	Timeout values may be defined by the Experimenter but shall have a maximum value of 10 msec.					
6.2.3.2	Within the requirements of the data link layer frame formats, the Experimenter shall define the form and function of all serial commands and telemetry (see Appendix C of this document), and submit them to the Project for inclusion in the SET Telemetry & Command (T&C) Handbook.					
6.2.3.2	Each command defined shall be labeled with a mnemonic, a byte pattern, an associated telemetry response, and a telemetry response timeout. If required by utilization of a user defined data link layer, the length of the telemetry response shall also be given.					
6.2.3.2	Command timeout values may be defined by the Experimenter but shall have a maximum value of 10 msec.					
6.2.3.2	The Experimenter shall define the form and function of all serial commands and telemetry and shall submit them to the Project for inclusion in a Telemetry & Command Handbook. Each command defined shall be labeled with a mnemonic, a byte pattern, an associated telemetry response, and a telemetry response timeout. Additionally, if required by utilization of a user defined data link layer, the length of the telemetry response shall also be given.					
7.2	The Experimenter shall define commands and associated responses for their Experiment and shall submit them for inclusion in the SET-n T&C Handbook.					
7.2	All commands and associated responses shall have a predetermined maximum execution time.					
7.2.1	For every serial command, the experimenter shall provide a serial telemetry response.					
7.2.1	The Experimenter shall specify no more than 128 bytes of data for each serial command embedded in a frame defined by one of the data link layer protocols specified in section 6.2.2.					

Section	Requirement	Verification				Comments/ Attached Documents
		A	I	D	T	
7.2.1	A maximum telemetry length shall be specified for the telemetry response of each associated command.					
7.2.4	All Experiments shall have a minimum set of commands, including Reset and Standby.					
7.2.4.1	Box Experiments and Board Experiments not using the provided reset signal at the Experiment port shall be required to have a RESET command. This command shall be used to reset the Experiment to a known state.					
7.2.4.2	All Experiments that have a standby mode requiring power shall have a STANDBY command, which will place the Experiment in standby mode.					
7.2.4.2	For Experiments that elect to be un-powered during standby mode, no serial command for standby is required, and the second SET-n T&C Handbook command listed shall be defined as the Carrier Command, “Experiment #xx Power Off.”					
7.3	Based on the maximum execution time of the commands and responses within each sequence, a maximum execution time for each sequence shall be determined and specified in the SET-n T&C Handbook. within each sequence, a maximum execution time for each sequence shall be determined by each experimenter and provided for inclusion in the SET-n T&C Handbook					
7.3	Execution of command sequences shall be limited in duration to one sequence per ETS. The Experimenter shall ensure that the maximum sequence execution duration is less than the ETS duration.					
7.8	The Experimenter shall be responsible for bounding the Experiment’s behavior and demonstrating their Experiment operates in a deterministic and safe manner through all possible paths of execution.					
8.1	Board Experiments shall interface to a back plane with a board mounted 80-pin connector made by Airborn Inc., part number WG80PR7SY.					
8.1	Board experiments – Auxiliary (spare interconnect) and Carrier Housekeeping Power signals shall not be connected in Experiment electronics without prior review and approval from the SET Project.					

Section	Requirement	Verification				Comments/ Attached Documents
		A	I	D	T	
8.2	Boxes shall interface to the Carrier via harness between a Carrier bulkhead connector and a connector on the box Experiment.					
8.2	Box experiments – Auxiliary (spare interconnect) and Carrier Housekeeping Power signals shall not be connected in Experiment electronics without prior review and approval from the SET Project.					
9.2.3.1	Experimenters shall provide periodic mission status reports (form and substance to be negotiated with the MOPT on an experiment specific basis) through the duration of the experiment life. Reports shall include, yet not be limited to, experiment status, objectives met, anomalies encountered, and operational summaries.					
9.2.3.3	Experimenters shall provide processed data products to the SET project within six months of the end of experiment operations (in accordance with NRA 02-OSS-04).					
9.2.3.3	CEM providers shall provide products to the SET Project on a negotiated mission by mission basis; more frequent product delivery may be required during early orbit or contingency recovery operations.					
10	With the boundary conditions that are listed in Table 10-1, the Experiments shall maintain junction temperatures, and case temperatures, in accordance with the LWSSET-QA-0001 Rev A and GSFC-PPL-21.					
10.1	For each of the flight hardware items that the Experimenter provides, the Experimenter shall perform a thermal analysis, determine the thermal control system requirements, and provide geometric and finite difference thermal mathematical models (e.g, TSS and SINDA).					
10.1	All components dissipating over 50 mW of power shall be explicitly modeled, while the heat load from the remaining devices should be equally distributed across the circuit board.					
10.1	Thermal analysis of the Experiment shall be delivered to the SET Project for integration into the payload thermal model.					

Section	Requirement	Verification				Comments/ Attached Documents
		A	I	D	T	
10.2.2	The Experiment boards shall survive within the extremes of -40°C and +80°C when powered OFF and return to full performance after power is re-applied and temperatures are within operational limits.					
10.3	The Experimenter shall identify any specific requirement for control of the interface temperature rate of change.					
10.4	The Experimenter shall identify any specific requirement for limiting mounting interface temperature gradients.					
10.5.1	The Experiment board mechanical design shall incorporate features that allow the Experiment boards to dissipate the majority of thermal power into the Carrier by conduction through the board mechanical interface to the Carrier chassis.					
10.5.1.1	Components with significant power consumption shall be either mounted directly to the underlying structure, or have dedicated thermal vias for removing heat.					
10.5.1.2	To meet the radiant heat path recommendation in 10.5.1.2, all external aluminum surfaces shall be black anodized per MIL-A-8625, Type II, Class 2.					
10.5.2	The Experiment box mechanical design shall incorporate features that allow the Experiment to dissipate the majority of thermal power by radiation.					
10.5.2.1	The Experiment boxes shall be thermally isolated from the host spacecraft.					
10.5.2.2	To meet the radiant heat path recommendation in 10.5.2.2, all external aluminum surfaces for box experiments shall be black anodized per MIL-A-8625, Type II, Class 2.					
10.5.2.2	The solar absorptance (α) and IR emittance (ε) for all external surfaces exposed to the space environment shall be identified in the Experiment Accommodations Request Document (Appendix B).					
10.6	The Experiments shall identify all thermal control materials and coatings as a part of the materials list mentioned in LWSSET-QA-0001.					
10.7	The Experiments shall identify the mass of all thermal control materials.					

Section	Requirement	Verification				Comments/ Attached Documents
		A	I	D	T	
11.1	The Experimenter shall perform structural analysis and a vibration test on their hardware prior to delivery to the carrier.					
11.1	All Box and Board Experiments shall meet all of the mechanical requirements per section 11.					
11.1	Experimenters shall qualify flight hardware design through test. Qualification by analysis or by similarity shall be submitted by the experimenter for review and approval by the SET Project on a case-by-case basis.					
11.1.1	All Experiments shall meet the factor of safety requirements listed in Table 11-1.					
11.1.2	Limit loads shall be considered to act in any direction for design.					
11.1.2	All Experiments shall meet the load factors for low frequency loads requirements listed in Table 11-2.					
11.1.3	All Experiments shall meet the component random vibration limit levels requirements listed in Table 11-3.					
11.1.3	Experiments shall be powered off during vibration tests.					
11.1.3	Experiment functional tests shall be performed before and after each vibration test.					
11.1.3	Experiments shall undergo a random vibration test after integration to the Carrier in accordance with acceptance levels shown in Table 11-3**Error! Reference source not found.**.					
11.1.4	All Experiments shall satisfy the hardware test requirements listed in Table 11-4.					
11.1.4	Sine burst testing shall be done at a frequency sufficiently below primary resonance as to ensure rigid body motion.					
11.2	Experimenter requirements for contamination emitted by the Experiment shall be flight-dependent and negotiated with the Host spacecraft provider.					
11.3	Experimenters shall perform an analysis and/or test for electromagnetic compatibility (EMC) to ensure that their Experiment will neither be a source of electromagnetic interference (EMI), nor be susceptible to EMI when integrated to other payload/host spacecraft systems.					

Section	Requirement	Verification				Comments/ Attached Documents
		A	I	D	T	
11.3	EMI/EMC testing shall be performed in accordance with the standard procedures and requirements of MIL-STD-461E, as amended in the Payload specific Environmental Specifications.					
11.3	Experiments shall be powered on and operated in their noisiest mode during EMI testing, and in their most sensitive mode when performing EMC testing.					
11.3	Experiments shall meet test requirements for conducted emissions on power lines specified in MIL-STD 461E, CE101 and CE103, except with limit curves extended to the limit frequencies as specified in Table 11-5**Error! Reference source not found.**.					
11.4	Prior to the Carrier TB/TV test, Experiments shall have completed board level thermal testing.					
11.4	Each Experiment shall perform a subsystem thermal vacuum and/or thermal cycle test. A minimum of 4 cycles shall be performed.					
11.4	Using MIL-STD-1540B as a guideline, Acceptance Test temperatures shall be ±11°C beyond the operating limits.					
11.4	Proto-flight temperatures shall be ±16°C beyond the operating limits and Qualification Test temperatures shall be ±21°C beyond the operating limits.					
11.4	Functional tests, and all modes of operation shall be tested at each thermal plateau, and during at least one transition from hot to cold, and one from cold to hot. A survival hot soak and cold soak shall also be demonstrated.					
11.4	Turn-on capability shall be demonstrated under vacuum at least twice at both the low and high temperatures, as applicable.					
11.4	The ability to function through the voltage breakdown region shall be demonstrated as applicable to mission requirements (all elements that are operational during launch).					
11.4	Experimenters shall support the integrated SET Payload thermal test, which executes continuously 24 hours a day, to send commands and receive telemetry from their Experiments.					
11.4	Experimenters shall support integrated thermal tests following integration with the Host Spacecraft by reviewing telemetry from the test, and providing a verification of the Experiment performance.					

Section	Requirement	Verification				Comments/ Attached Documents
		A	I	D	T	
11.5	Experiments shall meet the radiation susceptibility requirements for part selection as documented in the Appendix in the Mission Assurance Requirements document LWSSET-QA-0001 Rev A.					
11.6	Experimenters shall not bring any radioactive sources to GSFC or launch site facilities.					
11.6	Calibration of any detectors shall be performed at the Experimenter facility.					
11.7	If implementing batteries within the experiment, experimenters shall implement certain controls to mitigate failure mechanisms within the Experiments battery electrical design, such as diode protection against charging, and fusing to prevent shorting. Battery capacity shall be 200mA/hr or less.					
11.8	Experimenters shall conformal coat all circuit boards in consideration for possible temperature and humidity test requirements					
12	Each Experimenter shall produce and deliver an I&T plan for their Experiment to demonstrate understanding and compliance with I&T requirements.					
12	If it is discovered during I&T that the Experimenter is unable to meet a requirement, a waiver shall be submitted for SET Project approval within 24 hours of the discovery.					
12.1	Experiment flight hardware shall undergo a standalone testing program prior to delivery to GSFC and integration to the Carrier.					
12.4	If required on a mission specific basis, Experimenters shall support I&T operations at the host facility.					
12.4	Experiment modes of operation, command sequences, and telemetry verifications shall be provided several weeks prior to the actual test.					
12.4	Experimenters shall assess functionality of their hardware post-test, and provide acknowledgement that their hardware is ready for launch.					

Section	Requirement	Verification				Comments/ Attached Documents
		A	I	D	T	
12.5	Electrical Ground Support Equipment (EGSE) required for testing of the Experiment shall be provided by the Experimenter to support I&T at the Experimenter's and GSFC facilities. The EGSE shall interface with the SET GDS to send commands and receive telemetry during I&T operations.					
12.6	Experimenters shall support certain I&T payload-level operations at GSFC including: mechanical/electrical integration, functional testing, integrated Experiment and payload system-level functional testing, EMI/EMC testing, vibration testing, and thermal vacuum/balance testing.					
12.6	Experimenters shall be responsible to support mission simulations, verification of command uplink procedures, and analysis of telemetry files from their facilities.					
12.7	Experimenters shall provide a set of test and as-built hardware documentation two weeks prior to GSFC I&T processing. The documentation shall also be supplied at hardware delivery as part of the Acceptance Data Package outlined in LWSSET-QA-0001.					
13	The Experiment shall include the common components listed in Table 13-1.					
13	Some components are common to each Experiment and shall be identical for each Experiment. They are listed in Section 13.					
C.1.1 Experiment Minimal Command Set	Each experiment shall define a minimal set of commands, including: Reset, Standby, PWRON, LOWPWRON, PWROFF, TLMREQ					
C.1.1 Experiment Minimal Command Set	All experiments shall implement a RESET command. If the experimenter chooses not to use the RST pulse, they shall define an experiment serial command to cause the experiment to reset.					
C.1.1 Experiment Minimal Command Set	All experiments that employ a standby mode shall implement a STANDBY command. If the experimenter chooses not to use the STANDBY electrical signal and intends to implement a standby mode, they shall define two experiment serial commands to cause the experiment to enter standby mode and to enter normal mode.					

Section	Requirement	Verification				Comments/ Attached Documents
		A	I	D	T	
C.1.1 Experiment Minimal Command Set	All experimenters shall identify which of the available voltages are required to be on for the experiment to be considered fully powered.					
C.1.1 Experiment Minimal Command Set	If a specific order is required, the experimenter shall identify the proper sequence with integers where one (1) is the first to be powered.					
C.1.1 Experiment Minimal Command Set	If a time delay is necessary between the powering on of each different voltage, the experimenter shall indicate the delay as the number of whole seconds since the previous step.					
C.1.1 Experiment Minimal Command Set	If an experiment implements a low-power mode, they shall identify which of the available voltages are required to be on for the experiment to be considered in a low power state.					
C.1.1 Experiment Minimal Command Set	The experimenter shall identify any sequence required for powering down the experiment and any delays as shown in the PWRON sequence example above.					
C.1.1 Experiment Minimal Command Set	All experiments that have telemetry beyond the standard experiment telemetry of dosimeter, temperature and the two experimenter defined analog values, shall supply at least one TLMREQ command. This command shall be an experiment serial command whose response will be treated as an experiment telemetry packet.					