# Standard K-1 Active Flight Experiment
# Interface Definition and Requirements Document

## For the

## K-1 Space Launch Vehicle

**NASA Contract Number**
**NAS8-01103**

**DRD 958 CM-009**
**DRD 958 CM-007 (partial submission)**
**DRD 958 VR-001 (partial submission)**

**CHANGE RECORD**

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| A | | Not Released | |
| B | | Not Released | |
| C | P22-0060 | Initial Baseline Release | All |

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# 1. INTRODUCTION

## 1.1 SCOPE

This Interface Definition and Requirements Document (IDRD) describes the standard interfaces on the K-1 Reusable Launch Vehicle (RLV) available for active Add-on Technology experiments. The IDRD is also included as an appendix to the *K-1 Vehicle TA-10 Flight Experiment Design and Requirements Document* (21-Report-N-001) developed for NASA as part of Kistler's flight demonstration contract for the Space Launch Initiative (contract NAS8-01103). This document applies to all standard active technology experiments to be flown on the K-1.

The IDRD describes the physical, functional, and environmental interfaces to experiments on the K-1 vehicle, as well as facility accommodations for experiment processing available at the K-1 launch site in Woomera, South Australia. The IDRD also describes experiment verification requirements to fly on the K-1, describes optional services offered to experimenters by Kistler Aerospace Corporation, and delineates the roles and responsibilities of the experimenter and the integrator, Kistler.

This IDRD serves as the baseline Kistler input to all experiment-specific Interface Control Documents (ICDs). The experiment ICDs capture all K-1 vehicle interfaces described in this IDRD and additional experiment-specific information provided by the experimenter. The ICDs will have the same form and outline as the IDRD. Sections in the IDRD currently marked, "Reserved for Experimenter Input through Detailed Experiment Questionnaire," will appear in the ICDs with input provided by the experimenter through a detailed Experiment Questionnaire.

## 1.2 DEFINITIONS

Active Experiment: An experiment requiring power, command, and/or data monitoring from the K-1 vehicle to meet flight demonstration objectives. All standard Active Experiments are mounted inside the K-1 vehicle.

Passive Experiment: An experiment requiring no power, command, and/or data monitoring input from the K-1 vehicle to meet flight demonstration objectives. Passive experiments have no electrical interface to the K-1 vehicle other than possibly data recording through sensors mounted on the experiment. Passive experiments are externally mounted to the K-1 vehicle.

Standard Experiment: An experiment utilizing previously defined standard interfaces on the K-1 vehicle described in this IDRD.

Non-Standard Experiment: An experiment requiring customization of interfaces to fly on the K-1 vehicle. Interfaces to Non-Standard experiments are not covered in their entirety by this IDRD. This document will be used as a starting point to develop the ICD for Non-Standard Experiments.

Standard Service: A service provided by Kistler to the experimenter to support standard experiments as part of the base integration price paid by NASA, other government agencies, or industry.

Optional Service: A service that can be provided by Kistler to the experimenter to support experiments as an option over the base integration price. Optional services include, but are not limited to, the services described in Section 6 of this IDRD. The price for all optional services is based on the specific details of each service.

Hazardous Operation: A ground processing activity is classified as hazardous based on the following considerations:

(1) Energy is involved and loss of control could result in injury to personnel or damage to equipment.

(2) A significant change from ambient condition will occur; e.g., increase or decrease of oxygen content, pressure, or temperature.

(3) Presence of hazardous materials or physical agents which presents potential exposure to personnel.

## 1.3 DOCUMENT CONVENTIONS

A unique number identifies each requirement in this IDRD. The number is identified in parentheses after the word "shall" and consists of "ACT" followed by the paragraph number. For paragraphs containing more than one requirement, an additional digit is appended to make the requirement identification unique. All requirements are listed with the verification methods identified in Section 4.1.

Design goals are explicitly stated as such and do not require verification. Other descriptive information such as that described by "will" may be included to clarify a requirement. The descriptive information does not constitute a verifiable requirement.

## 1.4 EXPERIMENT DESCRIPTION

Reserved for Experimenter Input through Detailed Experiment Questionnaire.

## 1.5 IDRD/ICD CONTROL PROCESS

Kistler Aerospace Corporation maintains configuration control of this IDRD. This IDRD, which applies to all standard active K-1 flight experiments, will be periodically updated as the interface definition matures. Kistler will also maintain configuration control of the experiment-specific ICD. Kistler will generate a unique ICD for every experiment in coordination with the experimenter. Kistler will deliver the draft and baseline version of the ICD as specified in Section 8 of this document.

## 1.6 IDRD DEVIATIONS AND EXCEEDANCES

Kistler will consider all deviations and exceedances from this IDRD. Any deviations or exceedances will be evaluated by Kistler to assure that no additional risk is added to the mission. Deviations and exceedances may be accommodated for standard experiments as an optional service as described in Section 6.

## 2. REFERENCED DOCUMENTS

The documents listed below form a part of this document to the extent specified herein. Unless otherwise specified, the latest issue of the referenced document shall be used.

### 2.1 KISTLER DOCUMENTS

| | |
|---|---|
| 21-Report-N-001 | K-1 Vehicle TA-10 Flight Experiment Design and Requirements Document |
| K1-01-001 | K-1 Vehicle Payload User's Guide, May 2001 |
| PL-98-042 | System Safety and Personnel Health Plan – Woomera Facility |

### 2.2 EXPERIMENTER DOCUMENTS

Reserved for Experimenter Input through Detailed Experiment Questionnaire.

### 2.3 U.S. GOVERNMENT DOCUMENTS

| | |
|---|---|
| MIL-STD-1246 | Product Cleanliness Levels and Contamination Control Program |
| ISO 14644-1 | Cleanrooms and associated controlled environments - Part 1: Classification of air cleanliness |
| MIL-STD-461 | Requirements For The Control Of Electromagnetic Interference Characteristics Of Subsystems And Equipment |
| MIL-STD-882 | Standard Practice For System Safety Program Requirements |
| MIL-STD-1540 | Product Verification Requirements for Launch, Upper Stage, and Space Vehicles |
| MIL-STD-1553 | Digital Time Division Command/Response Multiplex Data Bus |
| NSTS 22206 | Requirements for Preparation and Approval of Failure Modes and Effects Analysis and Critical Items List |
| OSHA Standard 1910.1200 | Hazard Communication Standard |

### 2.4 OTHER PUBLICATIONS

None.

### 2.5 ORDER OF PRECEDENCE

In the event of a conflict between the text of this document and all references cited herein, the text of this document takes precedence. The experiment ICD will take precedence over this document and all other referenced technical documents. Nothing in this document or any ICD, however, supercedes applicable laws and regulations unless a specific exemption has been obtained.

# 3. INTERFACE SPECIFICATION

## 3.1 STRUCTURAL AND MECHANICAL INTERFACES

Three locations are available to mount Active Experiments inside the K-1 Orbital Vehicle (OV). These locations are in the OV Forward Skirt, OV Mid-Body, and OV Aft Flare, as shown in Figure 3-3 of Kistler document 21-Report-N-001, the *K-1 Vehicle TA-10 Flight Experiment Design and Requirements Document* (hereinafter referred to as the FEDR). All of these three locations are easily accessible during vehicle processing up until stage mate. Two or three Experiment Containment Boxes (ECOBOXes) can be mounted at each of the three locations for protecting, mounting, and interfacing with standard flight experiments. The Kistler-supplied ECOBOXes are shock-mounted to the K-1 vehicle structure. Experimenters integrate their experiments onto standard trays provided by Kistler. Kistler will take the experiments integrated on these trays and install them in the appropriate ECOBOX on the K-1 vehicle.

The OV Forward Skirt and OV Aft Flare mounting locations can each carry two ECOBOXes. The OV Mid Body mounting location can carry three ECOBOXes. Kistler will determine the mounting location used for each experiment and each ECOBOX based on experimenter inputs.

### 3.1.1 ECOBOX Experiment Tray Coordinate System

This document references the coordinate system based on the standard experiment trays provided to the experimenter. This coordinate system and three reference points at vertices on the tray structure are shown in Figure 1. All coordinates are expressed in inches. Refer to Section 3.1.9 and 3.1.10 for more details on the tray.

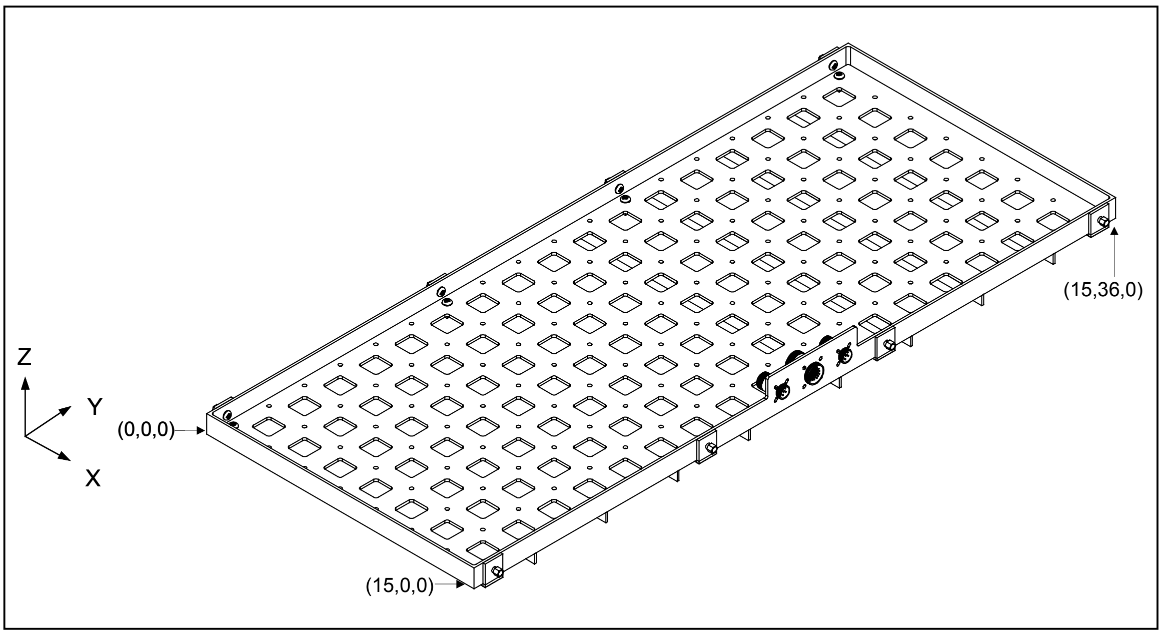


**Figure 1: ECOBOX Experiment Tray Coordinate System**

### 3.1.2 Structural Stiffness and Loads

Figure 2 shows the design limit load factors for experiments internally mounted to the OV with a mass less than 100 lbm. The load factor for experiments greater than 100 lbm is 11.25 g. The load factors apply to all axes (one at a time), and encompass both combined static and dynamic loads.

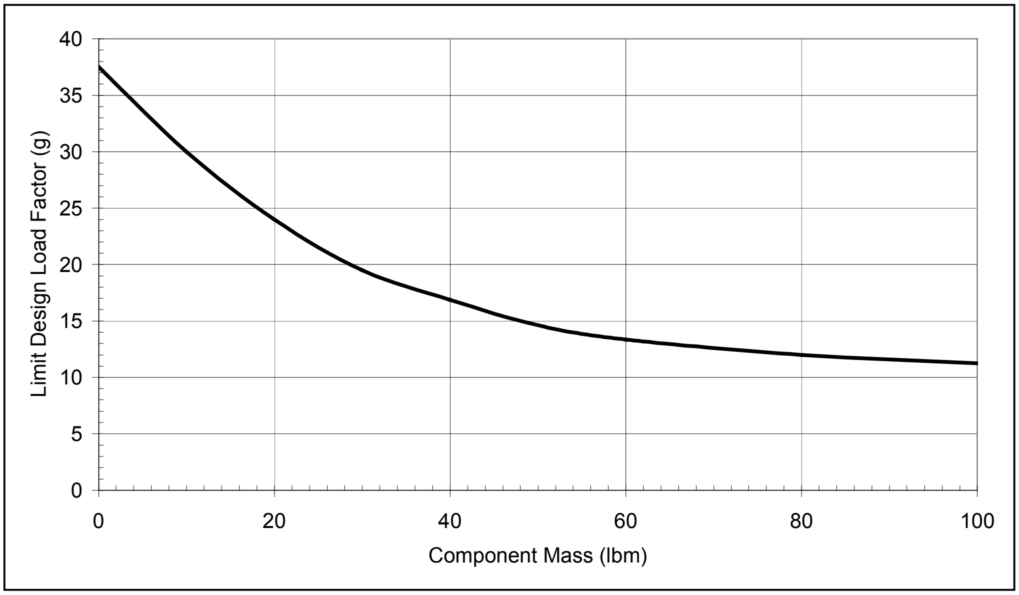


**Figure 2: Load Factors by Component Mass**

Hardware provided by the experimenter shall (ACT.3.1.2.1) be designed to meet the design load factors shown in Figure 2 with an ultimate factor of safety of at least 1.50. There is no requirement for yield factor of safety.

ECOBOX hardware, including OV mounting structure and internal trays, will be designed to the design load factors in Figure 2 for experiments with the mass property limits described in Section 3.1.4. Kistler will design all ECOBOX hardware with an ultimate factor of safety of at least 1.50.

There is no requirement for experiment stiffness. Kistler will design all ECOBOX hardware to the required stiffness levels when carrying experiments with the mass property limits described in Section 3.1.4.

### 3.1.3 Experiment Envelope

#### 3.1.3.1 Static Envelope

Each ECOBOX has a total interior static envelope of 14.750” x 35.750” x 15.875” (X x Y x Z directions). Each ECOBOX can carry up to four stacked experiment trays. Experimenters can use a single tray or multiple trays. With four trays installed and an equal envelope apportioned to each tray, the static envelope of experiment hardware on a tray shall (ACT.3.1.3.1.1) not exceed 14.250” x 35.250 x 3.000”. The static envelope of experiment hardware on a tray can exceed 3.000” height (Z-direction) if less than four trays are installed in the ECOBOX or if one or more trays is given a larger envelope than other trays. However, the experiment static envelope on any single tray shall (ACT.3.1.3.1.2) not exceed 14.250” x 35.250” x 15.375”. The static envelope shall (ACT.3.1.3.1.3) not impinge on the eight ECOBOX attachment brackets and bolts or the wall mounted electrical receptacle connector as shown in Figure 5 and Figure 6.

#### 3.1.3.2 Dynamic Envelope

Each ECOBOX has a total interior dimensions of 15.000” x 36.000” x 16.125” (X x Y x Z directions) and a volume of 5.0 $ft^3$, approximately equal to 2.5 Middeck Locker equivalents. Each ECOBOX can carry up to four stacked experiment trays. Experimenters can use a single tray or multiple trays. With four trays installed, the dynamic envelope of experiment hardware on a tray cannot exceed 14.500” x 35.500” x 3.125”. The dynamic envelope of experiment hardware on a tray can exceed 3.125” height if less than four trays are installed in the ECOBOX; however, the maximum experiment dynamic envelope on any single tray is 14.500” x 35.500” x 15.500”.

### 3.1.4 Mass Properties

The following mass properties apply to the experiment. The weight of Kistler-supplied interface hardware (including ECOBOXes, trays, fasteners, and electrical connectors) are not included in these requirements:

- The mass of experiments mounted on any single tray shall (ACT.3.1.4.1) not exceed 50 lbm.
- The total mass of each experiment mounted on any number of trays shall (ACT.3.1.4.2) not exceed 120 lbm.
- The experiment $c_g$ shall (ACT.3.1.4.3) have a y-coordinate between 16.0 and 20.0 inches, and an x-coordinate between 6.5 and 8.5 inches.

### 3.1.5 Pressure Tubing / Pressure Vessels

Pressure vessels shall (ACT.3.1.5.1) be designed with an ultimate factor of safety of 4.0. All fluid and gas lines shall (ACT.3.1.5.2) be designed with an ultimate factor of safety of 2.0 or greater. All lines shall (ACT.3.1.5.3) be clamped every 18 inches or less.

### 3.1.6 Coefficient of Thermal Expansion

The experiment shall (ACT.3.1.6.1) match the ECOBOX experiment tray coefficient of thermal expansion ($13.5 \times 10^{-6}$ in/in/° F) sufficiently to limit thermally induced stress in the tray to 10,000 psi at a worst-case temperature of 120° F.

### 3.1.7 Galvanic Corrosion Mitigation

If the experiment consists of any composite material, the experiment shall (ACT.3.1.7.1) place a fiberglass spacer or equivalent insulator between the aluminum experiment tray surface and the experiment.

### 3.1.8 Thermal Conductance

The experiment shall (ACT.3.1.8.1) have an average thermal conductance of at least 30 BTU/hr/ft$^2$/°F over the area of physical contact between the experiment and the ECOBOX experiment tray surface to ensure adequate heat rejection across the interface.

### 3.1.9 Location and Installation Details

Kistler will supply the experimenter with a Mechanical Interface Kit containing the requisite number of trays, fasteners, and electrical connectors by L-5 months before the scheduled flight. The contents of the Mechanical Interface Kit will be formalized in the ICD. As shown in Section 3.1.10, these standard aluminum (alloy 6061-T6) trays contain a pattern of 0.1875" (3/16") bolt-down holes spaced 2.000" apart starting at 0.375" from the edge of the tray, for a total of 136 bolt-down holes per tray. Experimenters will build their experiments on boards with pass-through holes to fasten to the trays at these bolt-down hole locations. Kistler will supply alloy-steel button head socket bolts (8-32 x 0.5") and accompanying washers and nuts, which shall (ACT.3.1.9.1) be secured by the experimenter with a minimum torque of 20.0 lbf-in. Eight of these bolt-down hole locations along the perimeter of the tray are reserved for Kistler use to fasten the tray onto brackets in the ECOBOXes.

Each tray contains a pattern of 1.000" square cut-outs to save weight. If the experiment utilizes multiple stacked trays, these cut-outs can be used to pass wiring between trays. Experimenters can also bond wiring and tube clamps directly to the tray surface.

After installation of the experiment onto the tray(s), the trays can be used for functional and environmental testing, including random vibration testing. When the experiment is ready for flight, experimenters will pack the trays for shipment to Kistler's designated U.S. receiving site (see Section 5.1).

### 3.1.10 Mechanical Interface Drawing

Figure 3 shows an integrated ECOBOX containing one experiment. Figure 4 shows the configuration of one experiment on four experiment trays inside the ECOBOX with its top cover removed. Figure 5 shows detail on a single experiment tray with support brackets attached, as delivered in the Mechanical Interface Kit provided to experimenters. Figure 6 shows a dimensional drawing of an experiment tray, including a section cut drawing.

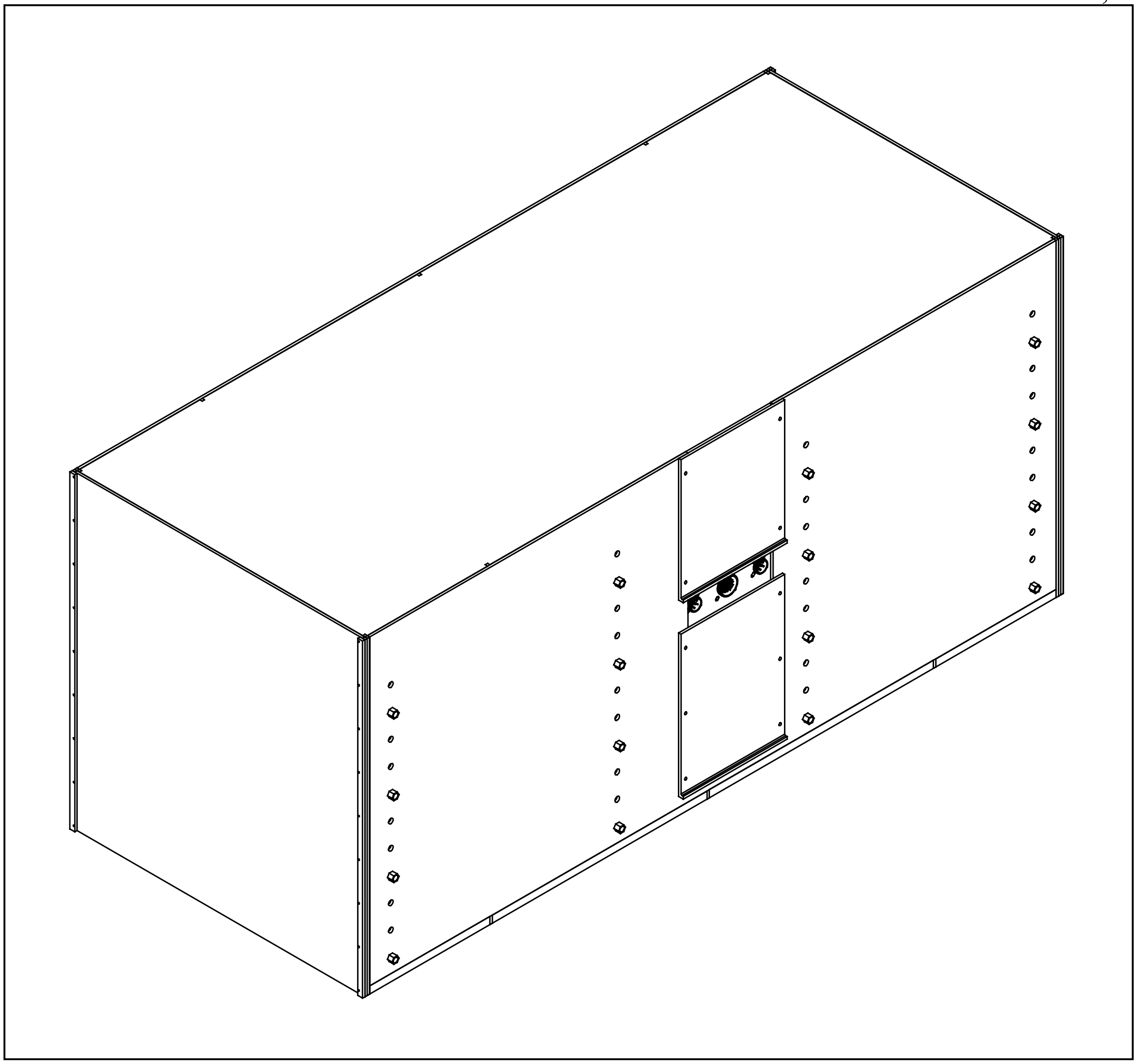

**Figure 3: Integrated ECOBOX Containing One Experiment**

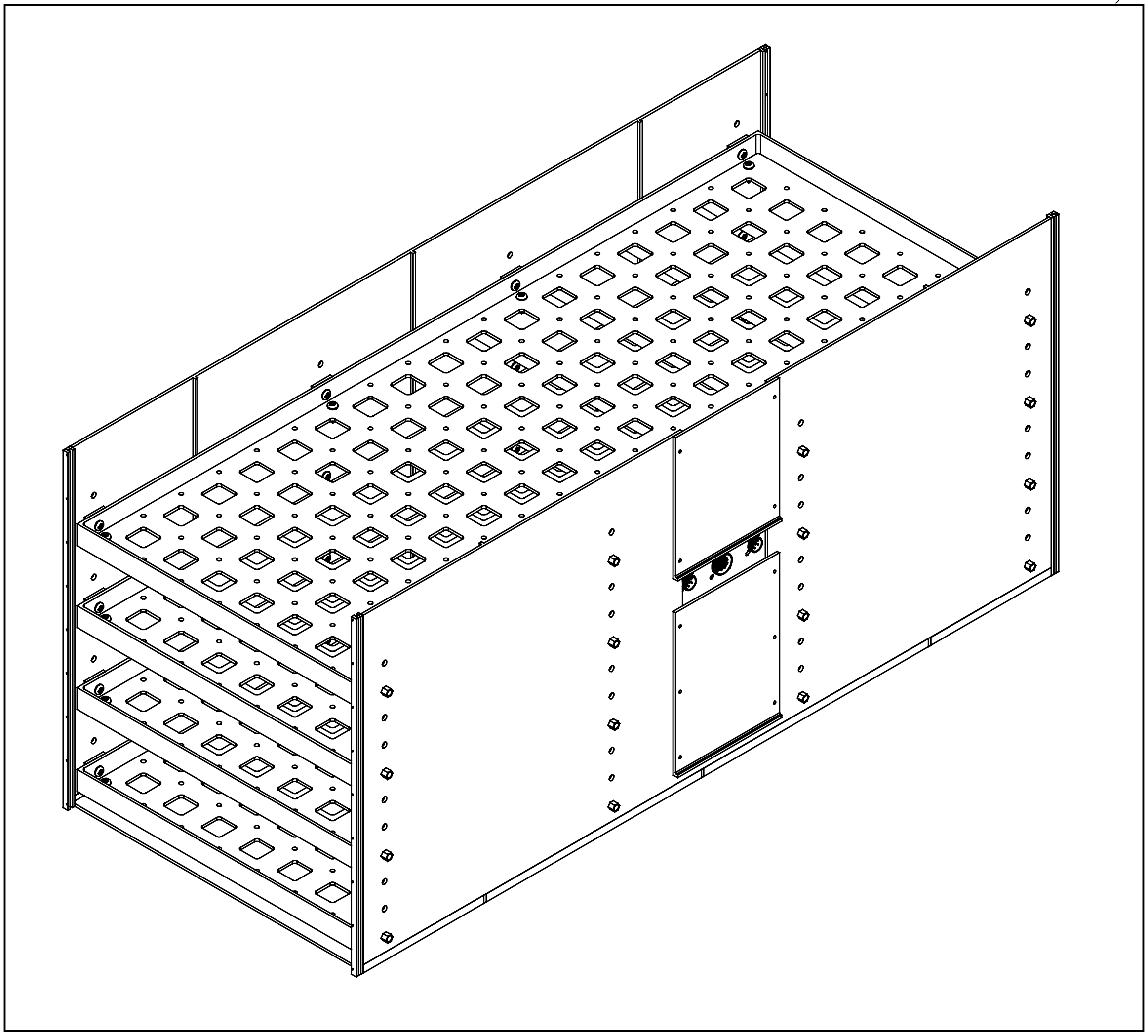

**Figure 4: ECOBOX with Top Cover Removed Containing Four Experiment Trays**

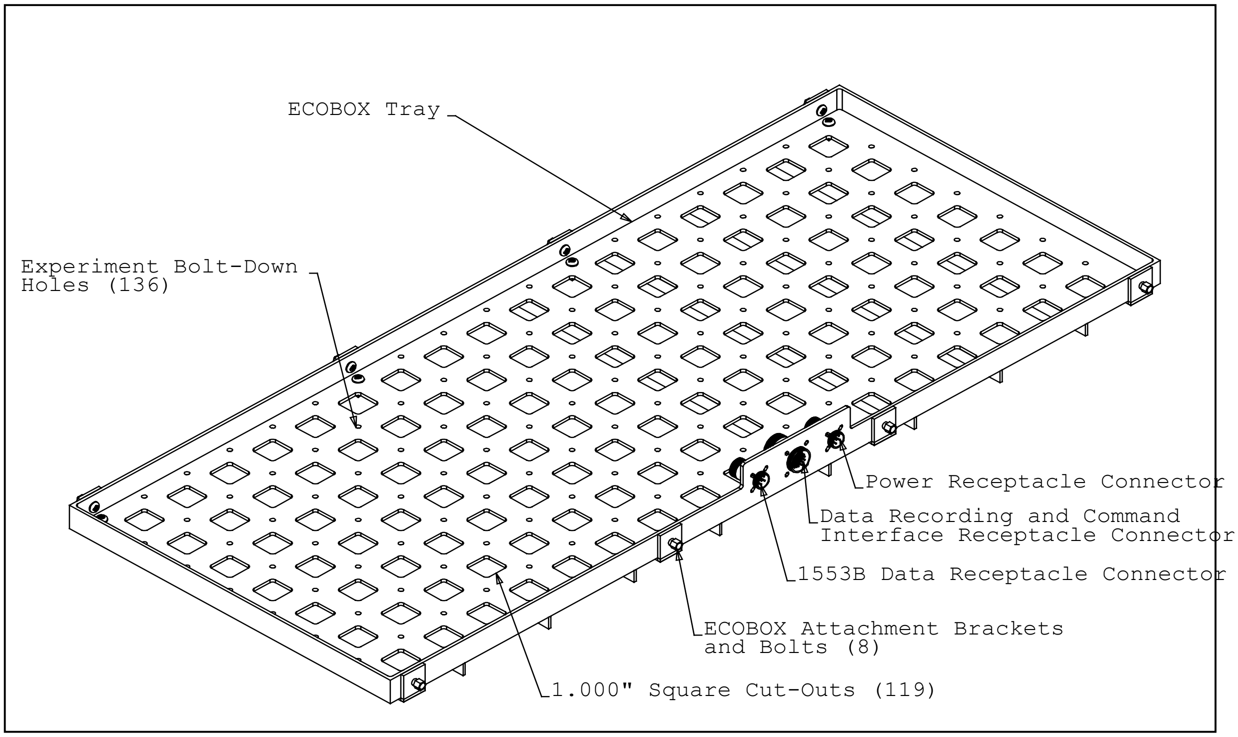


**Figure 5: ECOBOX Experiment Tray with Electrical Connectors Mounted**

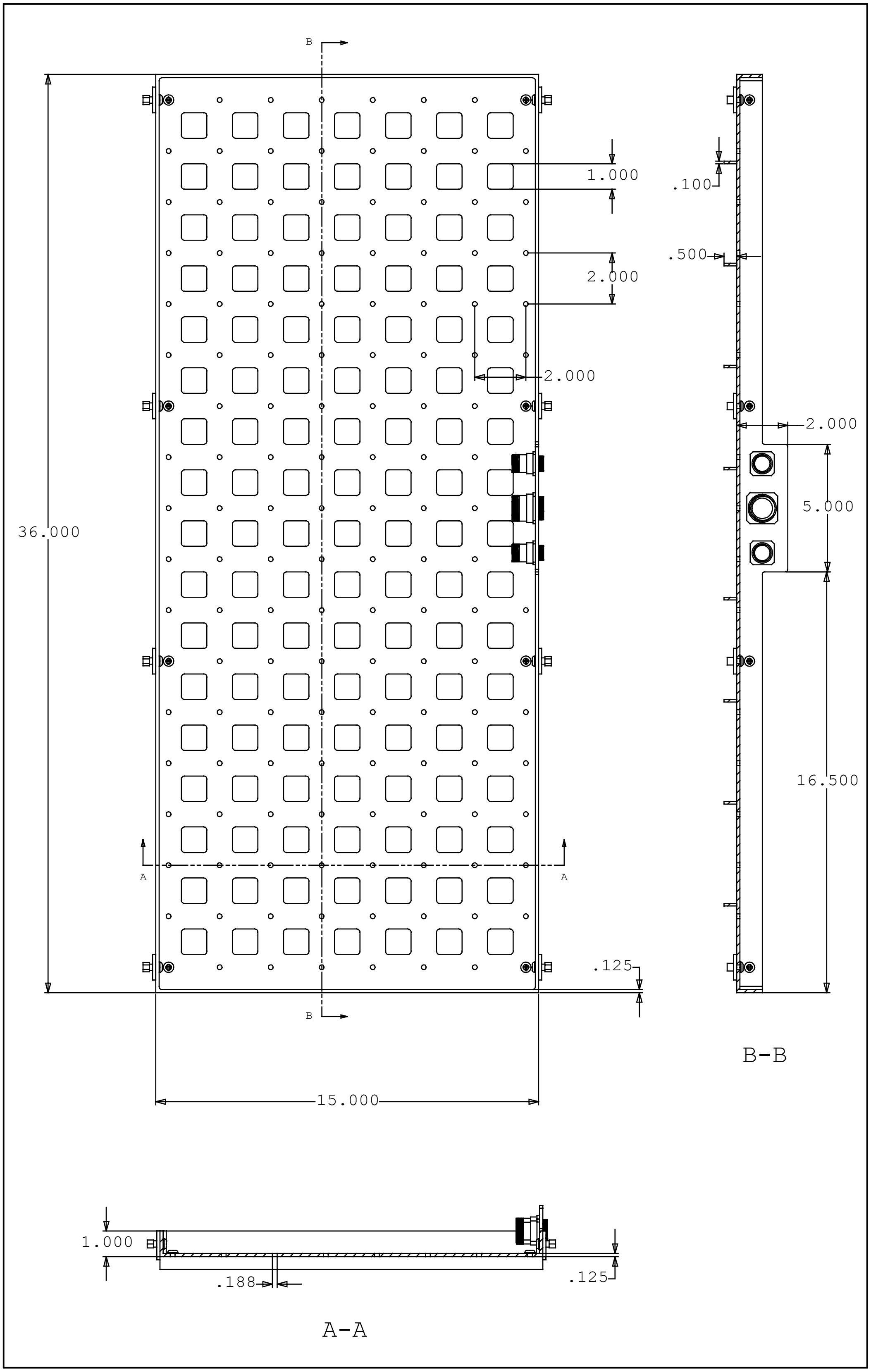


**Figure 6: ECOBOX Experiment Tray Dimensional Drawing**

## 3.2 ELECTRICAL INTERFACES

This section defines the standard electrical interfaces between the K-1 vehicle and standard active flight experiments. Standard active flight experiments may interface with an Experiment Management Unit (EMU), which is installed in the K-1 vehicle. The EMU provides power, data recording (analog-to-digital and digital), discrete command, power switching, and 1553B bus monitoring functions. The programmable EMU utilizes a PowerPC 603e processor and a VxWorks real-time operating system.

Kistler will deliver the experimenter an EMU simulator at L-5 months. The EMU simulator mimics all physical and functional interfaces of the EMU. It will include a launch vehicle electrical interface plug and experiment-specific software to verify power, command discrete, 1553B avionics bus, and data recording interfaces. The EMU simulator will have a pre-loaded Mission Timeline (as specified in Section 3.5.4) so the experimenter can simulate a full mission sequence. The experimenter will return the EMU simulator at the time of experiment delivery in the U.S. by L-1 month, as described in Section 5.1. An EMU simulator will be available at the launch site for final test and checkout.

Figure 7 is a block diagram of the EMU and the electrical interfaces.

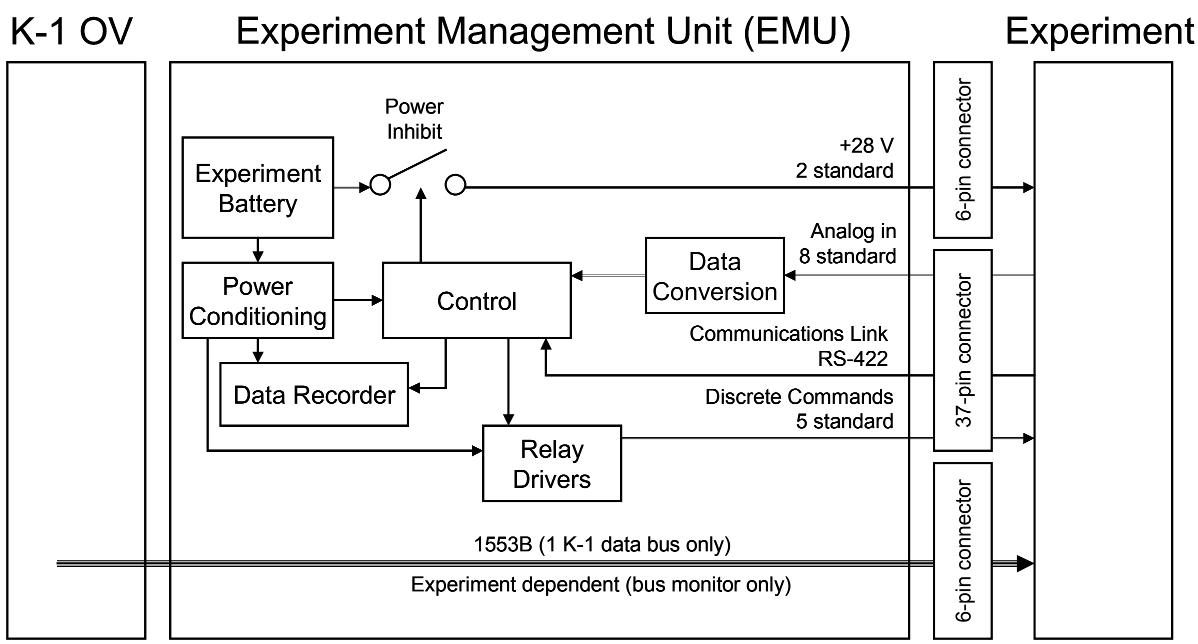


**Figure 7: Standard Active K-1 Flight Experiment Electrical Interface Block Diagram**

### 3.2.1 Connectors and Pin Assignments

Kistler will provide electrical harnesses to connect the experiment with the EMU. On the K-1 vehicle side of the interface, Kistler provides for each experiment one 37-pin plug for data recording and command links (part number D38999/26FD35PN), one 6-pin plug for power (part number D38999/26FA35PN), and one 6-pin plug for 1553B monitoring (part number D38999/26FA35PN). On the experiment side of the interface, Kistler will provide the experimenter with the corresponding 37-pin receptacle connector for data recording and command links (D38999/20FD35SN), 6-pin receptacle connector for power (part number

D38999/20FA35SN), and 6-pin receptacle connector for 1553B monitoring (part number D38999/20FA35SN). These receptables will be mounted on one of the ECOBOX experiment trays provided to the experimenter. Table 1, Table 2, and Table 3 show the interface pin assignments. All wiring will be 22 AWG. In responses to the Detailed Questionnaire, experimenters will state which pins are used and which are unused.

**Table 1: Data Recording and Command Interface Connector Pin Assigments**

| PIN # | Function | Voltage(V) |
|---|---|---|
| 1 | Discrete Command 1+ | 28 ± 3 |
| 2 | Discrete Command 1- | 0 |
| 3 | Discrete Command 2+ | 28 ± 3 |
| 4 | Discrete Command 2- | 0 |
| 5 | Discrete Command 3+ | 28 ± 3 |
| 6 | Discrete Command 3- | 0 |
| 7 | Discrete Command 4+ | 28 ± 3 |
| 8 | Discrete Command 4- | 0 |
| 9 | Discrete Command 5+ | 28 ± 3 |
| 10 | Discrete Command 5- | 0 |
| 11 | Analog Data Channel 1+ | 0-10 |
| 12 | Analog Data Channel 1- | 0-10 |
| 13 | Analog Data Channel 2+ | 0-10 |
| 14 | Analog Data Channel 2- | 0-10 |
| 15 | Analog Data Channel 3+ | 0-10 |
| 16 | Analog Data Channel 3- | 0-10 |
| 17 | Analog Data Channel 4+ | 0-10 |
| 18 | Analog Data Channel 4- | 0-10 |
| 19 | Analog Data Channel 5+ | 0-10 |
| 20 | Analog Data Channel 5- | 0-10 |
| 21 | Analog Data Channel 6+ | 0-10 |
| 22 | Analog Data Channel 6- | 0-10 |
| 23 | Analog Data Channel 7+ | 0-10 |
| 24 | Analog Data Channel 7- | 0-10 |
| 25 | Analog Data Channel 8+ | 0-10 |
| 26 | Analog Data Channel 8- | 0-10 |
| 27 | RX+ RS-422 | +/- 5 |
| 28 | RX- RS-422 | +/- 5 |
| 29 | TX+ RS-422 | +/- 5 |
| 30 | TX- RS-422 | +/- 5 |
| 31 | RS-422 data clock + | +/- 5 |
| 32 | RS-422 data clock - | +/- 5 |
| 33 | Spare | |
| 34 | Spare | |
| 35 | Spare | |

| PIN # | Function | Voltage(V) |
|---|---|---|
| 36 | Spare | |
| 37 | Spare | |

**Table 2: Power Interface Connector Pin Assigments**

| PIN # | Function | Voltage(V) |
|---|---|---|
| A1 | Experiment Power + | 28 ± 3 |
| A2 | Experiment Power - | 0 |
| A3 | Experiment Power + | 28 ± 3 |
| A4 | Experiment Power - | 0 |
| A5 | Spare | |
| A6 | Spare | |

**Table 3: 1553B Bus Monitoring Interface Connector Pin Assigments**

| PIN # | Function | Voltage(V) |
|---|---|---|
| B1 | 1553B+ Bus Monitoring A | |
| B2 | 1553B- Bus Monitoring A | |
| B3 | Spare | |
| B4 | Spare | |
| B5 | Spare | |
| B6 | Spare | |

### 3.2.2 Power Interfaces

The K-1 will provide experiments installed in ECOBOXes with two 28 ± 3 VDC power circuits. The maximum current draw shall (ACT.3.2.2.1) not exceed 5.0 amps on each circuit. The total peak power draw (both circuits combined) shall (ACT. 3.2.2.2) not exceed 280 watts at any time. To minimize heat rejection from the experiment during potentially high ambient temperatures, the experiment shall (ACT. 3.2.2.3) not draw more than 25 watts (both circuits combined) at any time between rollout of the K-1 from the Vehicle Processing Facility and lift-off. The EMU uses a 100 amp-hr battery to supply power to all experiments. Experiments shall (ACT. 3.2.2.4) use a maximum of 25 amp-hrs unless otherwise required and stated in the ICD. Power can be switched by the EMU under software control based on the Mission Timeline provided by the experimenter in Section 3.5.4.

### 3.2.3 Grounding/Isolation

Internal components of the experiment shall (ACT.3.2.3.1) tie their signal grounds together onto the tray structure. Kistler will connect experiment tray grounds to the K-1 vehicle single point electrical ground. The EMU is electrically isolated from other K-1 vehicle systems. There is no requirement for fusing or surge current on the experiment.

### 3.2.4 Bonding

Electrical bonding of the experiment to the K-1 is accomplished by physical contact of the experiment single point ground to the experiment tray. The electrical resistance of this bond shall (ACT.3.2.4.1) be 0.010 ohms or less, and will be re-verified during integration operations.

### 3.2.5 1553B Bus Monitoring Interface

If required, the EMU can provide the experiment access to the MIL-STD-1553B K-1 avionics bus in monitoring mode only. The 1553B interface is a transformer-coupled, long-stub configuration. The EMU supports standard Built-in-Test (BIT) functions in a manner that assures the integrity of all received messages. The EMU's software will control the data received by the experiment such that only 1553B traffic of interest will be transmitted across the interface.

The K-1 vehicle exchanges a large amount of information over the 1553B avionics bus, including propulsion system sensor data, vehicle navigation sensor data, system time, command events to pyros and actuators, and all other information exchanged between avionics equipment in the K-1 OV. The full list of subaddresses is too extensive to include in this document. The Detailed Experiment Questionnaire will ask experimenters to list the types of K-1 vehicle management data of interest to the experiment. Kistler will match these requests to specific subaddresses already in the K-1 avionics system design. Kistler will then document the bit-specific definition of this information in the experiment ICD in accordance with MIL-STD-1553B.

Using the EMU simulator provided by Kistler, the experimenter shall (ACT.3.2.5.1) verify the experiment meets its functional requirements when connected to a 1553B interface specified in the ICD.

### 3.2.6 Data Recording Interfaces

The EMU provides each experiment with up to eight 0-10 VDC analog-to-digital conversion channels to record data from sensors. Table 4 shows the EMU analog-to-digital conversion characteristics.

**Table 4 Analog Input Conversion Characteristics**

| Characteristic | Value |
|---|---|
| Resolution | 12 bits |
| Conversion Time | 50 microseconds maximum |
| Absolute Accuracy | 0.1% full-scale (RMS) |
| Minimum resolution for no missing codes | 11 bits minimum |

The EMU implements first-order low-pass filters on all analog inputs.

The EMU also accepts one RS-422 serial signal from each experiment (capable of transferring 1.0 MB/second) that can be used for digital data recording.

Up to 1,500 MB of flash data recording memory are available in the EMU for all flight experiments at a rate of 10 Mbps. Of this amount, each experimenter should expect an allocation of up to 375 MB, unless otherwise required and stated in the ICD. As an optional service, the total EMU memory storage is expandable to 4,500 MB.

The Detailed Questionnaire will ask the experimenters to specify the types and number of sensors the K-1 will record data from, including required sample rates, sampling times, excitation voltage, units, sensor range, and minimum and maximum expected values. Based on these responses, Kistler will document the detailed interface for data recording in the ICD, which will conform with existing K-1 EMU capabilities. Using the EMU simulator provided by Kistler, the experimenter shall (ACT.3.2.6.1) verify the experiment meets its functional requirements when connected to the data recording interface specified in the ICD.

### 3.2.7 Command Interfaces

The EMU provides each experiment up to five controlled discrete output voltages at +28 VDC at 2.0 Amp maximum. The EMU can set and reset discretes in any combination. The EMU can also perform BIT on discretes during checkout procedures (after installation on the K-1) to determine the experiment's ability to be commanded.

The Detailed Experiment Questionnaire will ask experimenters to provide a Mission Timeline (see Section 3.5.4). One of the functions of this Timeline will be to specify the timing and voltage level of command discretes the EMU will provide to the experiment.

Using the EMU simulator provided by Kistler, the experimenter shall (ACT.3.2.7.1) verify the experiment meets its functional requirements when connected to a command interface with this specification.

### 3.2.8 EMI / EMC

The experimenter shall (ACT.3.2.8.1) provide EMI control, in the form of wire twisting, shielding, and separation in accordance with MIL-STD-461. The ECOBOX itself is expected to provide significant attenuation of any radiated emissions from the experiment. The experimenter will define the predicted electromagnetic emissions from the experiment and electromagnetic susceptibility of the experiment in the Detailed Experiment Questionnaire. Based on this input, Kistler will assess potential EMI issues between the experiment and other experiments on the flight and the K-1 vehicle, applying a 6 dB safety margin. If analysis shows a potential EMI issue between experiments, Kistler will separate these experiments into different ECOBOXes. Kistler will also perform an integrated functional test of each assembled ECOBOX in the U.S. prior to shipment to the Woomera launch site as described in Section 5.1. If interference between two experiments in the same ECOBOX emerges as an issue during this test, Kistler will separate the experiments into separate ECOBOXes for the flight.

### 3.2.9 Pyrotechnic Devices

The experiment shall (ACT.3.2.9.1) not use any pyrotechnic devices.

### 3.2.10 Installation Details

Experimenters will wire their experiments to three electrical receptacle connectors supplied by Kistler (described in Section 3.2.1). Kistler will deliver one tray to each experimenter with the electrical receptacle connectors pre-mounted, and additional trays as needed without electrical connectors. After installation of the trays into ECOBOXes, the receptacle connectors will pass through a hole in the side of the ECOBOX. During installation of the ECOBOXes into the K-1 vehicle, Kistler will connect the corresponding plug connectors running from the EMU on an electrical harness into these receptacle connectors.

The Mechanical Interface Kit delivered to the experimenter by Kistler at L-5 months will contain detailed instructions for wiring the experiment into the connectors, including requisite tools and techniques for crimping and contact insertion.

### 3.2.11 Electrical Interface Drawing

Figure 8 shows the arrangement of pins for the 37-pin data recording and command interface receptacle connector referenced in Section 3.2.1. Figure 9 shows the arrangement of pins for both of the 6-pin connectors used for power and 1553B bus monitoring referenced in Section 3.2.1 without the "A" or "B" prefixes.

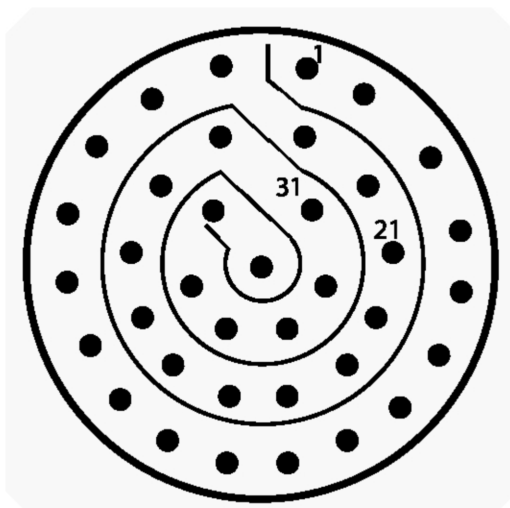


**Figure 8: Data Recording and Command Interface Connector and Pin Locations**

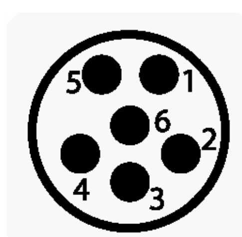


**Figure 9: Pin Locations for Power and 1553B Monitoring Interface Connectors**

## 3.3 ENVIRONMENTAL INTERFACES

This section describes the predicted environments experienced by active flight experiments on the K-1 vehicle during both ground and flight phases resulting from sources exterior to the ECOBOX. Experiment operations within the ECOBOX may effect the actual flight environment (e.g., the thermal environment may be effected by operation of experiment electronics).

### 3.3.1 Thermal

Experiments shall (ACT.3.3.1.1) satisfy their performance requirements after extended exposure to temperatures between -15ºF and 120ºF. For ECOBOX configurations with high power draw during mission phases with high ambient temperatures, Kistler may require the experimenters to perform a thermal analysis to verify adequate heat rejection, or to submit a thermal model for Kistler to perform a thermal analysis. If required, this will be documented in the ICD.

### 3.3.2 Humidity

The experiment shall (ACT.3.3.2.1) satisfy its performance requirements after extended exposure to a relative humidity 0 - 60%, non condensing, through the temperature range specified in Section 3.3.1.

### 3.3.3 Contamination

Kistler can provide the experimenter with a Class 8 clean environment per ISO 14644-1 to process experiments. Kistler can also integrate experiments into ECOBOXes in a ISO Class 8 environment. Surfaces within Kistler clean areas are cleaned to Level 750B particulate per MIL-STD-1246. Unless the ECOBOX is pressurized (an optional service – see Section 6.3) the experiment will be exposed to the ambient air environment of the Woomera launch site once integrated into the vehicle in the K-1 Vehicle Processing Facility (VPF). Ambient air will be able to diffuse into the ECOBOX through its vent holes.

### 3.3.4 Pressure

ECOBOXes are unpressurized containers. The experiment shall (ACT. 3.3.4.1) satisfy its performance requirements after exposure to an ambient pressure ranging from sea level through 300,000 feet.

During ascent, experiments in ECOBOXes may undergo rapid depressurization. At stage separation, a positive pressure in the Interstage forces the stages apart (approximately 139 seconds after liftoff). After this event, the pressure in the Interstage and all adjacent cavities, including the OV Mid Body and OV Aft Flare, drops rapidly. The experiment shall (ACT.3.3.4.2) satisfy its performance requirements after exposure to rapid depressurization from 7 psi to 0.02 psi in 0.4 seconds.

Kistler can provide experiments with a pressurized ECOBOX as an optional service (see Section 6.3).

### 3.3.5 EMI / RF

The electromagnetic environment to which experiments will be exposed are generated primarily from the vehicle itself. The K-1's TDRSS, used for data uplink and downlink (2106.4 MHz and 2287.5 MHz, respectively) produces a total radiated power of approximately 5 watts. The electric field generated by TDRSS at all experiment locations is estimated to be less than 3.4 V/m.

The K-1 also includes a U.S. FAA beacon. This device operates at 1060 ± 30 MHz. Analyses of generated electric fields indicate levels below 6.1 V/m at all internal experiment locations.

In some cases, Kistler may place multiple experiments in the same ECOBOX. Kistler will not place two experiments in the same ECOBOX if data provided by experimenters in the Detailed Questionnaire indicates a potential EMI issue with less than 6 dB of safety margin. The predicted electromagnetic environment generated by other experiments on the flight will be documented in the ICD. Kistler will also perform an integrated functional test of each ECOBOX just prior to shipping experiments to the launch site (see Section 5.1).

The experiment shall (ACT.3.3.5.1) satisfy its performance requirements after exposure to the EMI/RF environment specified in the ICD.

### 3.3.6 Random Vibration

As a standard service, Kistler provides a shock mount between the K-1 vehicle and ECOBOX interface. Maximum anticipated random vibration environments in the OV mounting locations after shock mounting are shown in Table 5 for three different experiment weights mounted on a single tray. Random vibration levels plateau between 100 and 500 Hz. To complete the profile, ramp up at +8 dB/octave between 20 and 100 Hz and ramp down -3 dB/octave between 500 and 2000 Hz.

**Table 5: Maximum Random Vibration Levels in OV Internal Mounting Locations**

| Location | Random Vibration Levels ($g^2$/Hz) | | |
|---|---|---|---|
| | 10 lbs | 25 lbs | 50 lbs |
| OV Forward | 0.18 | 0.11 | 0.08 |
| OV Mid Body | 0.22 | 0.13 | 0.09 |
| OV Aft Flare | 0.32 | 0.20 | 0.15 |

The experiment shall (ACT.3.3.6.1) satisfy its performance requirements after exposure to the random vibration environment specified in Table 5.

### 3.3.7 Acoustics

The acoustic environment experienced by experiments installed in ECOBOXes is not a design driver.

### 3.3.8 Shock

The shock environment experienced by experiments installed in ECOBOXes is not a design driver. The design load factors described in Section 3.1.2 encompass the requirements generated by the expected shock environment.

### 3.3.9 Microgravity Environment

During its coast phase, the OV experiences a prolonged microgravity environment. This environment may be interrupted for a time to perform a period-adjustment burn with the OMS engine. Table 6 describes the timing, duration, and quality of the expected OV microgravity environment, assuming a clean-up burn is necessary. Kistler can provide additional vibration isolation to improve microgravity quality as an optional service (see Section 6.6).

**Table 6: OV Microgravity Environment**

| Event Start (from start of LAP Main Engines) | Approximate Duration | Microgravity Quality (g) |
|---|---|---|
| +02:52:12 | 14.5 hours | $< 10^{-5}$ |
| +17:40:35 | 5 hours | $< 10^{-5}$ |

## 3.4 FACILITY INTERFACES

This section describes experimenter interfaces to the K-1 launch facility in Woomera, Australia, if experimenter personnel must be on-site during integration and flight operations. Experimenter personnel have access to processing facilities and support personnel in Woomera to accomplish the technology experiment mission.

### 3.4.1 Pre-Launch Site Visits

Rationale for a pre-launch visit (defined as a visit occurring before L-4 weeks) to the Woomera launch site will be mutually agreed upon and documented in the ICD. Kistler support of a pre-launch site visit may include access to launch site facilities and Kistler technical personnel for site surveys, as well as training and assistance in obtaining facility clearance, training, accommodations, transportation, and other logistics as defined in Sections 3.4.8 through 3.4.11. No more than five experimenter personnel will be accommodated on the K-1 launch site for pre-launch site visits at any one time.

If required, additional site visits of longer duration, or for a larger number of personnel, can be accommodated as an optional service.

### 3.4.2 Pre-flight and Post-flight Experiment Access

The last opportunity for the experimenter to physically access experiments occurs at approximately L – 24 hours for experiments in OV Forward and OV Mid Body, and L - 36 hours for experiment in the OV Aft Flare. The flight experiment can be uninstalled from the K-1 and given to experimenter personnel (if present at the launch site) approximately 24 hours after the OV lands.

### 3.4.3 Facility Space

#### 3.4.3.1 Processing Space

Kistler will provide work areas for experimenters to perform test, checkout, and other processing of their experiments at the launch site before integration to the K-1 vehicle. The work area will be located in a Highbay within the K-1 Payload Processing Facility (PPF) as described in Section 8.2 of K1-01-001, or within the K-1 Vehicle Processing Facility (VPF). If required, the work area will be maintained at a Class 8 cleanliness level, per ISO 14644-1. Kistler will provide clean room garments (sizes up to XXL) and change areas. If the work area is located in the VPF, cleanliness will be maintained within a tented area provided by Kistler. Environmental conditions can be controlled to a set point of 65 to 75 ° F with a tolerance of ± 5° F, and 50 ± 5% relative humidity. The Highbay can support limited hazardous processing operations, but does not support safe containment and removal of toxic waste from fueling operations.

Kistler will allocate a minimum of 200 $ft^2$ of processing space to each experimenter. In the VPF Highbay, a 7.5-ton crane with a 10-meter hook height is available, if required. If multiple experimenters are in the same room in the PPF or VPF, Kistler will provide fabric walls to partition the experimenters' work areas.

The processing space will be available from L – 2 weeks to L + 3 days.

Additional processing space and/or processing space for longer periods can be provided as an optional service.

#### 3.4.3.2 Office Space

Kistler will provide limited office accommodations for experimenter personnel to support experiment integration and mission operations. Accommodations may be inside the K-1 Payload Processing Facility, Vehicle Processing Facility, or in another structure designated by Kistler, including temporary structures and structures in Woomera village (14 km from the launch site). A minimum of 100 $ft^2$ of space will be available to each experimenter. This space includes standard office furniture (desk, chairs, filing cabinets), electrical power, a telephone, and nearby access to at least one copy machine and at least one fax machine. The office space will be available from L – 4 weeks to L + 1 week. If the experiment is reflown on the K-1 on one or more consecutive flights, Kistler will provide this office space from L-4 weeks before the first launch to L + 1 week after the last launch.

Additional processing space and/or processing space for longer periods can be provided as an optional service.

#### 3.4.3.3 Storage Space

Limited space will be provided by Kistler for storage of equipment required for the experimenter to process experiments at the launch site. Storage accommodations will be in a secure, covered, non-climate controlled facility on the Woomera launch site designated by Kistler. A minimum of 100 $ft^2$ of space with a minimum 8-foot ceiling height will be available to each experimenter. The storage space will be available from L – 4 weeks to L + 2 weeks. If the experiment is scheduled for reflight on the K-1 in the future, Kistler will provide this storage space from L-4 weeks before the first launch to L + 2 weeks after the last launch.

Additional storage space, climate-controlled space, and/or processing space for longer periods can be provided as an optional service.

#### 3.4.3.4 Janitorial Service

Kistler will provide regular janitorial service for all processing areas and office areas used by the experimenter.

### 3.4.4 Utilities

Kistler will provide facility power in processing and office areas. Power in processing areas will be uninterruptible with a frequency of 50 Hz at 220 V or 60 Hz at 120 V, as required. In office areas, power will be 50 Hz at 220 V.

If required, 125-psi compressed shop air can be provided to the experimenter.

Other commodities (including gaseous nitrogen, helium, deionized water, and isopropyl alcohol) are available as an optional service.

### 3.4.5 Hazardous Processing Area

Experimenters will not have access to the K-1 Hazardous Processing Area.

### 3.4.6 Communications

At least one local and international telephone connection, and one internet connection with a minimum transfer rate of 128 kbps will be available to experimenters in Kistler provided office areas. Kistler will bill the experimenter separately for all long distance telephone charges incurred. Kistler will provide wireless radio units and/or cellular phones (with local access only) for mobile communications on the launch site and processing areas. The experimenter is responsible for compliance with all U.S. export regulations, including International Traffic in Arms (ITAR) regulations, in communication of information from the U.S.

### 3.4.7 Experiment Ground Support Equipment

As a standard service, Kistler will not supply ground support equipment to support experiment processing and checkout not specifically mentioned in this IDRD. If the experimenter requires Kistler to provide ground support equipment at the launch site not specifically mentioned in this document (such as work benches, load cells, hand tools, etc.), the experimenter should include a list of this equipment in responses to the Detailed Questionnaire. This equipment may be provided by Kistler as an optional service at an additional price if equivalent surplus equipment is not already available at the launch site. The experiment-specific ICD will capture the list of all additional ground support equipment provided by Kistler to the experimenter.

### 3.4.8 Security

The Kistler launch site lies within the restricted Woomera Prohibited Area (WPA), operated by the Australian government. The WPA authorities must authorize by name all personnel entering the WPA. This provides the first level of security.

Security is also subject to compliance with all applicable U.S. export regulations, including International Traffic in Arms Regulations (ITAR).

A Kistler Woomera guard station has been established on Koolymilka Road, the only road access to the launch complex. Access to the launch site is controlled by this checkpoint 24 hours a day, 7 days a week.

There are established guard posts outside and inside the VPF/PPF to control personnel and equipment entering these facilities. Inside the PPF, coded cipher locks are used to control access to key areas. All Kistler provided processing, office, and storage spaces will either be in these facilities, or will have a level of security similar to these facilities.

### 3.4.9 Training

Kistler will provide required safety and procedural training to experimenter personnel for access and use of Kistler facilities, including:

- General site orientation
- Site security
- Safety equipment and procedures
- Hands-on training to experimenter personnel for the use of required facility equipment

### 3.4.10 Accommodations

Kistler will provide support to the experimenter in securing visas, accommodations, meal service, recreation, and other services for experimenter personnel working at the Woomera launch site. The experimenter is responsible for all accommodation costs incurred for its personnel.

### 3.4.11 Transportation

Kistler's standard experiment integration price includes transportation of the experiment from the United States to the Woomera launch site. Kistler will take receipt of packaged experiment in the U.S. (location TBD) and deliver the package to the K-1 VPF (see Section 5.1).

If experimenter personnel must be at the launch site during integration and flight operations, Kistler will provide support to the experimenter in securing air/ground transportation for experimenter personnel and test equipment to the Woomera area. Kistler will also provide support in securing rental cars and trucks in the Woomera area. The experimenter is responsible for all costs incurred for the aforementioned transportation services. Kistler will operate a regular scheduled bus service between Woomera village and the launch site as a standard service. Kistler will have an on-call taxi service available during normal work hours for travel between Woomera Village and the launch site.

## 3.5 OPERATIONS INTERFACE

This section is primarily reserved for experimenter input on the procedures required to integrate their standard active flight experiments with the K-1 vehicle at the launch site.

### 3.5.1 Installation Procedure

Kistler will deliver packaged experiment trays to the Woomera launch site as detailed in Section 5.1. After unpacking the trays in Woomera, Kistler will deliver the trays to experimenter personnel (if present at the launch site) for final test and checkout of the experiment. If experimenter personnel are not present for the flight, Kistler can perform final test and checkout per Section 3.5.3. If required, ISO Class 8 clean facilities can be provided for unpacking, test, and checkout. An EMU simulator is available for use by the experimenter (as described in Section 4.2).

No later than L-24 hours, Kistler Woomera personnel will perform final installation of the experiment into the K-1. Final mechanical installation of experiment trays into ECOBOXes is performed in the K-1 PPF or VPF, and is accomplished by fastening each tray to 8 brackets (described in Section 3.1.10) mounted on the sides of the ECOBOXes. A set of 8 brackets is installed first; followed by installation of the first tray; followed by installation of additional bracket sets and trays, if any. Trays are installed sequentially, from the lowest tray to the highest. Kistler may integrate trays from different experimenters into the same box.

If a single experiment utilizes multiple trays, the experimenter will be required to provide excess wiring length between trays to insure each can be mechanically integrated separately.

After installation of all trays in an ECOBOX, Kistler will check the electrical bonding resistance of the experiment-to-tray and tray-to-ECOBOX interface (per Section 3.2.4). Kistler will then close out the ECOBOX cover, attach cover plates between each electrical connector, and mechanically mount the ECOBOX into the appropriate K-1 vehicle location. Kistler will connect the electrical interface to the EMU, and power-on the EMU briefly to perform experiment continuity testing and other final testing specified in Section 3.5.3.

### 3.5.2 Hazardous Operations

Experimenters will not have access to the Hazardous Processing Area at the Woomera launch site. All processing operations must be safely performed in the Non Hazardous Processing Area. Kistler will not dispose of hazardous waste for experimenters.

### 3.5.3 Test and Checkout Procedure

Reserved for Experimenter Input through Detailed Experiment Questionnaire.

### 3.5.4 Mission Timeline

The EMU will use a pre-loaded standard set of software to control each experiment. Through the Detailed Experiment Questionnaire, the experimenter will specify the mission timeline that the EMU will use to control the experiment. This timeline will include the mission power profile, and the timing of data recording, discrete commands, and data transmission through the 1553B K-1 avionics bus.

The experimenter will use as a reference the Mission Elapsed Time with a zero reference at LAP main engine start. To complete the Detailed Experiment Questionnaire, the experimenter will assume the K-1 Mission Event Sequence described in Table 3-2 of the *K-1 Payload User's Guide*. The Detailed Experiment Questionnaire will include notes for the experimenter to describe if a specific EMU command is tied to a specific K-1 mission event (e.g., OV Main Engine Cut-Off). When the trajectory plan for the flight is finalized, the Mission Timeline in this section will be adjusted, if necessary.

#### 3.5.5 Procedure to Uninstall Experiment

Reserved for Experimenter Input through Detailed Experiment Questionnaire.

### 3.6 SAFETY AND MISSION INSURANCE

#### 3.6.1 Australian Government Requirements

Experiments shall (ACT.3.6.1.1) be designed and operated in accordance with Australian government requirements as defined in PL-98-042 for both ground and flight operations.

#### 3.6.2 Hazards

All hazards will be identified in the System Safety/Hazard Analysis submitted to Kistler by the experiment (see Section 8.2.4), prepared in accordance with MIL-STD-882. Kistler will incorporate the experiment's hazard analysis into the System Safety/Hazard Analysis Report specific to the Add-on Technology Experiment flight (see Section 8.2.7).

#### 3.6.3 Debris

Standard Active Experiments shall (ACT.3.6.3.1) be designed such that no debris is generated during mission operations.

# 4. INTERFACE VERIFICATION MATRIX

## 4.1 VERIFICATION MATRIX DEFINITIONS

### 4.1.1 Inspection (I)

Verification will be performed by comparison of the experiment or its component parts with approved design or specification documents. Inspections as defined herein will include such assessments as physical measurements, surface finish inspections, process and certification verifications, physical or electronic feature identification, x-ray examinations, and visual inspections. Quantitative data is collected.

### 4.1.2 Demonstration (D)

Verification will be performed by visual confirmation of functional performance and/or interface compatibility using information provided during normal system operation. No quantitative performance data is required.

### 4.1.3 Analysis (A)

Verification will be performed by mathematical proofs and calculations that demonstrate compliance between numerical design requirements and the manufactured experiment and/or its component assemblies. This method is most frequently used when quantitative performance data is critical, and the performance of a test, or tests, is impractical or cost/schedule prohibitive. Analysis can also be used in conjunction with test data to establish experiment performance characteristics. Quantitative performance data, including the supporting analysis, is required.

### 4.1.4 Test (T)

Verification will be performed by conducting conclusive tests to establish performance characteristics of the experiment or its component assemblies. Calibration test instrumentation, providing data of sufficient resolution and accuracy are required to collect the test results. Test results may require data reduction and analysis to establish the performance characteristics of the unit under test. Quantitative performance data, including the supporting analysis, is required.

## 4.2 VERIFICATION RESPONSIBILITIES

The experimenter will be responsible for fulfilling the verification requirements described in Section 4.3. The experimenter may use its own facilities or any commercial laboratory acceptable to Kistler. The experimenter will document verification results in a Verification Report, as described in Section 8.2.13. Kistler reserves the right to perform any of the verifications necessary to ensure the item confirms to the prescribed requirements.

## 4.3 VERIFICATION REQUIREMENTS

Each experiment requirement will be verified by the corresponding methods defined by Table 7. The experimenter will use MIL-STD-1540 as a guide for verification methods, but may suggest tailoring these requirements consistent with the intent of the standard. Kistler is willing to work with experimenters on the specific verification methods in this table. For example, for requirements calling for a verification test, the test may not be necessary if the experiment uses only off-the-shelf components for which manufacturer test data exists. Any modifications to these requirements will be documented in the ICD.

**Table 7: K-1 Active Flight Experiment Verification Requirements**

| | | Verification Method | | | | |
|---|---|---|---|---|---|---|
| **Requirement #** | **Paragraph Title** | **I** | **D** | **A** | **T** | **Comment** |
| ACT.3.1.2.1 | Structural Stiffness and Loads | | | X | X | See Note 1 |
| ACT.3.1.3.1.1 | Static Envelope | X | | | | |
| ACT.3.1.3.1.2 | Static Envelope | X | | | | |
| ACT.3.1.3.1.3 | Static Envelope | X | | | | |
| ACT.3.1.4.1 | Mass Properties | X | | | | |
| ACT.3.1.4.2 | Mass Properties | X | | | | |
| ACT.3.1.4.3 | Mass Properties | | | X | | |
| ACT.3.1.5.1 | Pressure Tubing / Pressure Vessels | | | X | | |
| ACT.3.1.5.2 | Pressure Tubing / Pressure Vessels | | | X | | |
| ACT.3.1.5.3 | Pressure Tubing / Pressure Vessels | X | | | | |
| ACT.3.1.6.1 | Coefficient of Thermal Expansion | | | X | | |
| ACT.3.1.7.1 | Galvanic Corrosion Mitigation | X | | | | |
| ACT.3.1.8.1 | Thermal Conductance | | | X | | |
| ACT.3.1.9.1 | Location and Installation Details | X | | | | |
| ACT.3.2.2.1 | Power Interfaces | | | | X | See Note 2 |
| ACT. 3.2.2.2 | Power Interfaces | | | | X | See Note 2 |
| ACT. 3.2.2.3 | Power Interfaces | | | | X | See Note 2 |
| ACT. 3.2.2.4 | Power Interfaces | | | | X | See Note 2 |
| ACT.3.2.3.1 | Ground/Isolation | X | | | | |
| ACT.3.2.4.1 | Bonding | X | | | | |
| ACT.3.2.5.1 | 1553B Bus Monitoring Interface | | | | X | See Note 2 |
| ACT.3.2.6.1 | Data Recording Interface | | | | X | See Note 2 |
| ACT.3.2.7.1 | Discrete Command Interface | | | | X | See Note 2 |
| ACT.3.2.8.1 | EMI/EMC | X | | | | |
| ACT.3.2.9.1 | Pyrotechnic Devices | X | | | | |
| ACT.3.3.1.1 | Thermal | | | | X | See Note 3<br>See Note 4 |
| ACT.3.3.2.1 | Humidity | | | | X | See Note 3 |
| ACT. 3.3.4.1 | Pressure | | | | X | See Note 3 |
| ACT. 3.3.4.2 | Pressure | | | | X | See Note 3 |
| ACT.3.3.5.1 | EMI/RF | | | X | | |

| | | Verification Method | | | | |
|---|---|---|---|---|---|---|
| **Requirement #** | **Paragraph Title** | **I** | **D** | **A** | **T** | **Comment** |
| ACT.3.3.6.1 | Random Vibration | | | | X | See Note 3<br>See Note 5 |
| ACT.3.6.1.1 | Australian Government Requirements | X | | | | |
| ACT.3.6.3.1 | Orbital Debris | X | | | | |

Note 1: (A) only if ultimate factor of safety of 2.0 or greater is used; otherwise, (A) and (T). If (T) required, acceptance test level is 1.10 x limit load.

Note 2: Hardware-in-the-loop test using Kistler provided EMU simulator.

Note 3: (T) can be replaced by (A) if suitable test data for all sensitive components at the predicted flight environment already exists.

Note 4: (A) may be required for experiments with high power draw during flight phases with high temperature environment. An analysis requirement, if any, will be documented in the ICD.

Note 5: Acceptance test level is predicted flight load +3 dB for 60 seconds, each axis.

# 5. PACKAGING AND SHIPPING

## 5.1 SHIPPING PROCESS FLOW

As a standard service for experimenters located in the United States, Kistler will take receipt of experiments in the U.S. The experimenter is responsible for packing the experiment and any experiment ground support equipment in an appropriate container and shipping the experiment to a location TBD by Kistler in the U.S. by no later than L-1 month. Experiment acceptance will be conducted at this designated location.

Before shipping the experiment to the Woomera launch site, Kistler will assemble experiment trays into flight configuration ECOBOXes, and using the EMU simulators, power on each experiment to perform a functional test. The purpose of this integrated test is to identify any mechanical and electromagnetic compatibility issues between experiments not captured by previous analysis. If a problem emerges during the test, Kistler may still accept the hardware for flight by separating experiments into separate ECOBOXes. After the integrated test, the experiment trays will be diassembled from the ECOBOXes for shipment.

Kistler will deliver the experiment to the Woomera launch site no later than L-2 weeks before launch. If experimenter personnel are present at the launch site for the experiment flight, Kistler will deliver the experiment package to them for final test and checkout. If experimenter personnel will not be present, Kistler will unpackage the experiment, perform final test and checkout per the ICD, and install the experiment in the K-1 vehicle.

After the experiment flight, Kistler will uninstall the experiment according to the instructions in Section 3.5.5, and repackage the experiment according to the instructions in Section 5.3. Kistler will ship the experiment back to the experimenter's facility in the U.S. in the container it arrived in by no earlier than L+2 weeks after its last launch, and no later than L+4 weeks after its last launch.

## 5.2 SHIPPING CONTAINER LABELLING INSTRUCTIONS

Experimenter shipping containers containing experiment trays or experiment ground support equipment will be clearly marked with the following information:

- Experiment Name
- Owner Name and Address
- Shipping Container Number (e.g., 1 of 3)
- "K-1 Experiment Flight Hardware" or "K-1 Experiment Ground Support Equipment," as appropriate

## 5.3 PACKING INSTRUCTIONS FOR EXPERIMENT RETURN

Reserved for Experimenter Input through Detailed Experiment Questionnaire.

## 5.4 PACKING LIST FOR EXPERIMENT SHIPMENT

Reserved for Experimenter Input through Detailed Experiment Questionnaire.

## 5.5 MATERIAL SAFETY DATA SHEETS

The experimenter will include in the experiment shipping container any applicable Material Safety Data Sheets if their experiment contains materials that are a potential hazard, as defined in OSHA Standard 1910.1200.

## 5.6 HAZARDOUS WASTE DISPOSAL

Kistler will not dispose of any hazardous waste for experimenters.

# 6. OPTIONAL SERVICES

Kistler can provide a number of optional services for standard experiments if the standard services described in this IDRD do not satisfy experiment requirements. The prices for these optional services are based on the details on the service, subject to negotiation, and may be contracted for directly with Kistler. Optional services include, but are not limited to, the services described in this section. Some of these optional services (e.g., thermal control, in-flight telemetry, or excess power) may require Kistler to place a Kistler-supplied experiment tray into the ECOBOX with the flight experiment, reducing the total envelope available for the experiment.

## 6.1 IN-FLIGHT TELEMETRY

The baseline EMU does not send experiment data to the ground. Real time data is collected and recording in a solid-state recorder as specified in Section 3.2.6. Data is downloaded from the recorder after recovering the second stage. As an optional service, limited telemetry downlink can be provided. Kistler will work with experimenters who require telemetry to further define this capability.

## 6.2 THERMAL CONTROL

As an optional service, Kistler can provide experiments in ECOBOXes with passive or active thermal control, as required, through the use of coatings, cooling loops, radiators, etc. Kistler will work with experimenters to understand experiment requirements and define K-1 capabilities in this area.

## 6.3 PRESSURIZED EXPERIMENT ACCOMMODATIONS

Kistler can provide a pressurized ECOBOX to maintain a pressure level equal to the local pressure at the Woomera launch site during seal.

## 6.4 EXCESS POWER REQUIREMENTS

Kistler can provide power to the experiment beyond the total draw described in Section 0. Kistler will work with experimenters to understand experiment requirements and define K-1 capabilities in this area.

## 6.5 EXCESS DATA MEMORY

Kistler can provide memory for flight measurements from experiment beyond the 1,500 MB described in Section 3.2.6, up to 4,500 MB. Kistler will work with experimenters to understand experiment requirements and define K-1 capabilities in this area.

## 6.6 VIBRATION ISOLATION FOR MICROGRAVITY EXPERIMENTS

If the quality of the microgravity environment described in Section 3.3.9 does not meet experiment requirements, Kistler can provide some vibration isolation by placing shock mounts at the K-1 / ECOBOX interface. Kistler will work with experimenters to understand experiment requirements and define K-1 capabilities in this area.

## 6.7 ENGINEERING ANALYSES AND TESTING

As an optional service, Kistler can support experimenters in fulfilling the verification requirements described in Section 4 of this IDRD. This includes, but is not limited to, engineering analysis and testing to fulfill the requirements of the verification matrix in Section 4.

## 6.8 SPECIAL FACILITIES AND UTILITIES

Storage space, processing space, office space, logistical support, and utilities exceeding the specifications and/or duration described in Section 3.4 can be provided as an optional service. Kistler will work with experimenters to understand experiment requirements and define K-1 capabilities in this area.

## 6.9 TECHNICAL SHOP SUPPORT

As an optional service, Kistler can provide the experimenter with unplanned technical shop support as required at the launch site. Services and capabilities that can be provided include a calibration lab for electronic ground support equipment, and machine shop support including a metal working lathe, milling machine, drill press, welding/soldering equipment, hand tools, and machinists.

## 7. ROLES AND RESPONSIBILITIES

Experimenters are responsible for designing and developing their technology experiment and performing verification activities (described in Section 4) required by Kistler to fly on the K-1. Kistler will have approval authority for verification activities performed by the experimenter. Kistler will also be responsible for K-1 preparation and flight operations. Section 5.1 of 21-Report-N-001 describes the specific responsibilities of the experimenter and Kistler in greater detail.

## 8. SCHEDULE

Kistler will work with experimenters to develop an experiment integration program schedule for each Add-on Technology experiment flight. Integration activities begin after NASA releases a Preliminary Manifest for the experiment flight. Figure 10 shows a typical integration program schedule (in terms of major program milestones and data deliverables) from the point the Preliminary Manifest is published.

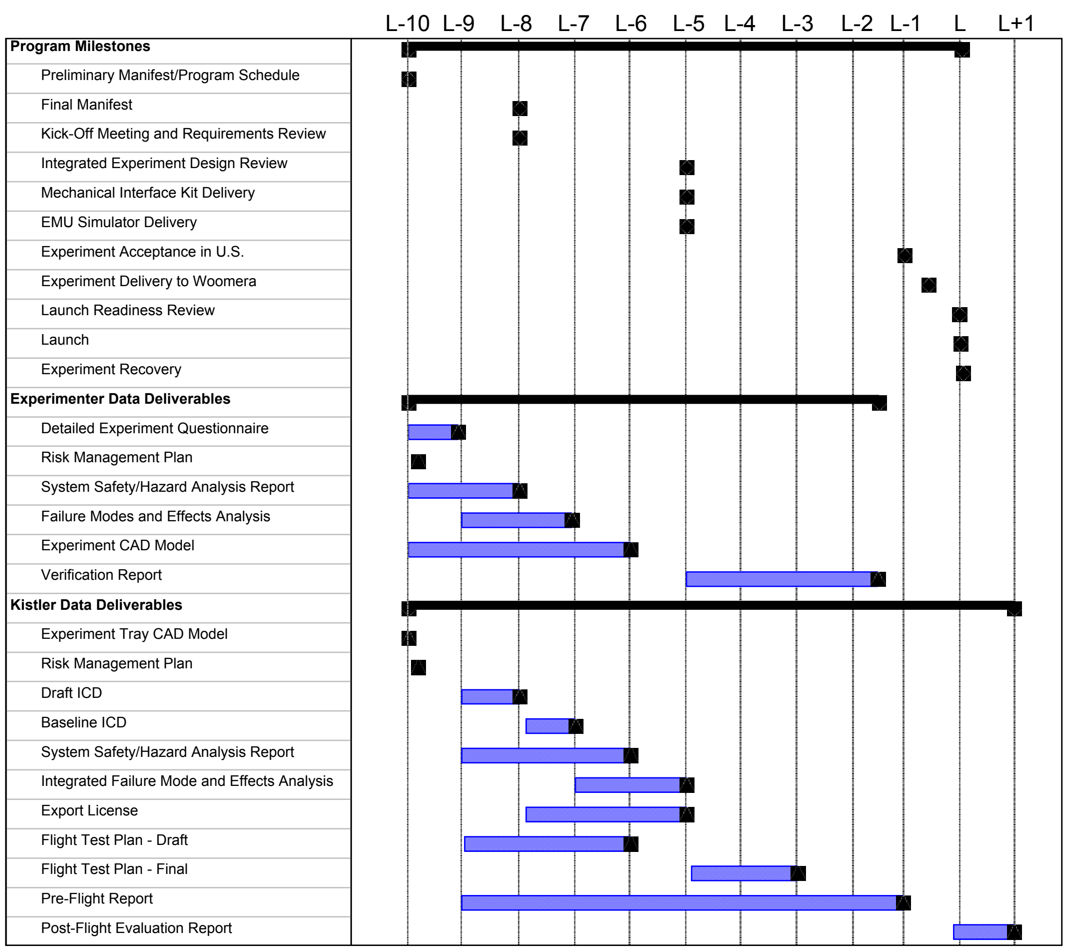


**Figure 10: Typical Add-on Technology Experiment Integration Schedule**

The following sections describe this typical integration program schedule for major program milestones and data deliverables in greater detail, relative to the scheduled experiment launch date.

## 8.1 PROGRAM MILESTONES

This section describes the nominal schedule of major milestones (including reviews and hardware deliveries) in a standard Add-on Technology Experiment flight program.

### 8.1.1 Preliminary Manifest/Program Schedule

NASA will announce a Preliminary Manifest/Program Schedule for the experiment flight at L-10 months based on feedback it has received from Preliminary Experiment Questionnaires and coordination with Kistler. At this time, experimenters on the Manifest are requested to complete a Detailed Experiment Questionnaire and return it to Kistler (with a also copy delivered to NASA) by L-9 months.

### 8.1.2 Final Manifest

NASA will announce a Final Manifest for the experiment flight at L-8 months based on feedback it has received from Preliminary and Detailed Experiment Questionnaires and coordination with Kistler.

### 8.1.3 Kick-Off Meeting and Requirements Review

Kistler will hold a one-day Kick-Off Meeting and Requirements Review with all experimenters manifested on a flight to review the Draft ICDs. This meeting will occur at L-8 months at Kistler Aerospace facilities in Kirkland, Washington.

### 8.1.4 Integrated Experiment Design Review (IEDR)

Kistler will hold an IEDR (typically for three days) with all experimenters manifested on a flight to review integrated requirements. This review will bring all experimenters on a particular flight together to review interfaces, environments, and vehicle accommodations, and any potential interactions between different experiments. This review will occur at L-5 months at Kistler Aerospace Corporation facilities in Kirkland, Washington.

### 8.1.5 Mechanical Interface Kit Delivery

Kistler will deliver a Mechanical Interface Kit (described in Section 3.1.9), including the requisite number of trays, fasteners, and connectors, to each experimenter by L-5 months.

### 8.1.6 EMU Simulator Delivery

At L-5 months, Kistler will deliver an EMU simulator to the experimenter as described in Section 3.2 to perform electrical interface verification testing.

#### 8.1.7 Experiment Acceptance in the U.S.

No later than L-1 month, the experimenter will deliver the experiment and return the EMU simulator to a U.S. location TBD by Kistler. At this location, Kistler and experimenter personnel will unpack the experiment container, and Kistler will accept the experiment. At least one representative of the experimenter must be present. Acceptance includes visual inspection of the hardware for damage, comparison of the experiment with drawings in the ICD, comparison of container contents with the packing list for completeness, and inspection of Materials Safety Data Sheets. Acceptance may also include use of the EMU simulator to run test scripts as specified by the experimenter and documented in the ICD.

Kistler reserves the right to return the experiment to the experimenter if a problem is identified during the inspection process. If the experiment is accepted, Kistler will repack the container for delivery to the Woomera launch site.

#### 8.1.8 Experiment Delivery to Woomera

Kistler will deliver the experiment to the launch site no later than L-2 weeks.

#### 8.1.9 Launch Readiness Review

At L-1 day, the Kistler Director of Flight Operations will conduct a Launch Readiness Review at the Woomera launch site to determine if the mission is ready for launch. Present at this meeting will be members of the Kistler launch team, the Woomera Range Administrator, and the Launch Director of the primary payload customer. Experimenter personnel are welcome to attend this meeting if they are present at the launch site; however, experimenters have no control authority over the go/no-go decision for the launch. The Director of Flight Operations will take into account input from experimenters before making the final go/no-go decision.

#### 8.1.10 Experiment Recovery

Approximately 24 hours after launch, the OV will return to the launch site. Kistler personnel will uninstall the experiment and make it available to the experimenter personnel (if they are present at the launch site) approximately 24 hours after OV landing. Kistler will also download data from the EMU at this time, in preparation for delivering the Post-Flight Evaluation Report to the experimenter. The experiment will be shipped back to the experimenter between L+2 weeks and L+4 weeks of the last launch of the experiment.

### 8.2 DELIVERABLES

This following sections describe the general content and nominal delivery schedule of major data deliverables developed by Kistler and the experimenter for a specific technology flight experiment. Table 8 lists all the data deliverables, the responsible parties, and a typical delivery schedule. This table does not include any briefing materials required to support the reviews described in Section 8.1. The table also does not include the set of standard documentation Kistler has developed to cover all experiment flights, such as Kistler's Program Management Plan, Configuration Management Plan, and Off-Site Contractor Safety Program Plan.

**Table 8: Data Deliverable Responsible Parties and Typical Delivery Schedule**

| Deliverable | Responsible Party | Typical Delivery Date |
|---|---|---|
| Flight Experiment Design and Requirements Document | Kistler | Delivered |
| Preliminary Experiment Questionnaire | Experimenter | Prior to L – 10 months |
| Experiment Tray CAD Model | Kistler | L – 10 months |
| Risk Management Plan | Kistler | L – 10 months |
| Risk Management Plan | Experimenter | L – 10 months |
| Detailed Experiment Questionnaire | Experimenter | L – 9 months |
| Draft ICD | Kistler | L – 8 months |
| System Safety/Hazard Analysis Report | Experimenter | L – 8 months |
| Baseline ICD | Kistler | L – 7 months |
| Failure Modes and Effects Analysis (FMEA) | Experiment | L – 7 months |
| System Safety/Hazard Analysis Report | Kistler | L – 6 months |
| Experiment CAD Model | Experimenter | L – 6 months |
| Flight Test Plan – Draft | Kistler | L – 6 months |
| Integrated FMEA | Kistler | L – 5 months |
| Export License | Kistler | L – 5 months |
| Flight Test Plan – Final | Kistler | L – 3 months |
| Verification Report(s) | Experimenter | L – 6 weeks |
| Pre-Flight Report | Kistler | L – 1 month |
| Post-Flight Report | Kistler | L + 1 month |

### 8.2.1 Flight Experiment Design and Requirements Document (FEDR)

The FEDR (21-Report-001) describes Kistler's mission approach for standard flight experiments, and defines the standard interface to the K-1 vehicle. The FEDR is available immediately to all prospective experimenters and includes the appendices described in Section 8.2.1.1 through 8.2.1.3.

#### 8.2.1.1 Preliminary Experiment Questionnaire

The Preliminary Experiment Questionnaire is a simple, one-page form designed to provide data to support early mission planning and manifesting. Prospective experimenters should fill out the Preliminary Questionnaire at the earliest possible stage (before the release of the Preliminary Manifest) and return a copy to Kistler to assist in advance planning and flight scheduling.

#### 8.2.1.2 Interface Definition and Requirements Document (IDRD)

This IDRD defines the standard K-1 physical, functional, and operational interface to flight experiments, including design requirements for flight experiments. The FEDR contains the IDRD for both Active and Passive flight experiments.

#### 8.2.1.3 Detailed Experiment Questionnaire

Using feedback from Preliminary Questionnaires, Kistler will develop a Preliminary Flight Manifest (see Section 8.1.1) and inform all experimenters on the manifest of the flight opportunity. Typically at L-9 months, experimenters will submit a completed Detailed Experiment Questionnaire to Kistler. The Detailed Experiment Questionnaire form is available to experimenters immediately. Through the Questionnaire, experimenters will provide detailed interface data on their experiments, including an assessment of whether the K-1 standard experiment interface described in the IDRD is compatible with the experiment, what interface modifications Kistler may have to make, and what optional services the experimenter may require.

### 8.2.2 Experiment Tray CAD Model

At L-10 months, after NASA has published the Preliminary Manifest for the flight, Kistler will deliver, via an e-mail attachment, a Unigraphics CAD model (.prt file) of the experiment tray to each experimenter on the manifest. A STEP translated file (in ASCII format) can be delivered if the developer does not use Unigraphics.

### 8.2.3 ICD

Based on this IDRD and responses received from experimenters in the Detailed Experiment Questionnaire, Kistler will deliver a Draft ICD to the experimenter at a Kick-Off Meeting and Requirements Review (see Section 8.1.3) typically occurring at L-8 months. Based on the results of this meeting and ongoing communication with the experimenter, Kistler will deliver a Baseline ICD to the experimenter (see Section 8.1.4) at L-7 months. For subsequent revisions, the ICD will be updated as required through Kistler's change control process.

### 8.2.4 Risk Management Plan and Reports – Kistler

Kistler has developed a Risk Management Plan to serve as a baseline document for planning, control, and implementation of Kistler's risk management program. Kistler will deliver an electronic copy of this plan to the experimenter once the Preliminary Flight Manifest is published by NASA (typically at L – 10 months). Kistler will also deliver Risk Management Reports to the experimenter; these documents provide a status of risk mitigation plans of activities specific to the Add-on Technology Experiment flight, and are already a data deliverable to NASA. Kistler will deliver these reports to the experimenter in the same format and same frequency as required by NASA.

### 8.2.5 Risk Management Plan and Reports – Experimenter

NASA will require the experimenter to submit a Risk Management Plan and Risk Management Reports to the SLI Flight Demonstration Program Office. The experimenter will also deliver a copy of the Risk Management Plan and any Risk Management Reports to Kistler to support the Risk Management program. The Risk Management Plan addresses how NASA risk management requirements are to be implemented throughout the program's life cycle. The Risk Management Report provides a status of risk mitigation plans and activities. The format and content of these documents agreed to between NASA and the experimenter will be acceptable to Kistler. The experimenter's Risk Management Plan will be delivered to Kistler once the Preliminary Manifest is published (typically at L - 10 months). Risk Management Reports will be delivered as required by the experimenter's contract with NASA.

### 8.2.6 Hazard Analysis Report – Experimenter

The experimenter will deliver a System Safety/Hazard Analysis Report to Kistler using MIL-STD-882 as a guide. This report will identify hazards unique to its experiment, evaluate risk, and evaluate verification methods. This report will be delivered typically at L-8 months.

### 8.2.7 System Safety/ Hazard Analysis Report - Kistler

Kistler will deliver a System Safety/Hazard Analysis Report, specific to one Add-on Technology flight, to all experimenters with experiments on the flight. This report will identify hazards unique to the flight, evaluate risk, and evaluate verification methods. This report will be delivered typically at L-6 months.

### 8.2.8 Failure Modes and Effects Analysis - Experimenter

The experimenter will deliver a Failure Modes and Effects Analysis (FMEA) to Kistler. The FMEA is an analysis of the experiment to determine possible modes of failure and their effects on mission success, with provisions for identifying each failure by its criticality category number. The FMEA will be prepared using NSTS 22206 as a guide. This analysis will typically be delivered and baselined at L – 7 months.

### 8.2.9 Integrated Failure Modes and Effects Analysis

Kistler will deliver a FMEA integrating all experiments on the flight to NASA and each experimenter on the flight. This analysis will be delivered at the IEDR, typically at L – 5 months.

### 8.2.10 Experiment CAD Model

The experimenter will deliver a complete Unigraphics CAD model of the experiment integrated with the CAD model of the experiment tray(s) previously supplied by Kistler (see Section 8.2.2). The CAD model will include the complete static envelope of the experiment and physical interfaces (including protrusions of bolt heads and attached fluid and wire routing). A STEP translated file (in ASCII format) will be accepted if the developer does not use Unigraphics. The experimenter will also deliver a Microsoft Powerpoint file showing isometric views of the experiment (hidden lines removed) for visualization purposes. The model will typically be delivered at L – 6 months.

### 8.2.11 Export License

Kistler will begin the process of applying for an export license for U.S. experiments after the Kick-off Meeting at L-8 months. Typically, Kistler will receive approval of the export license from the U.S. State Department by the time of the Integrated Experiment Review at L-5 months. Kistler will forward a copy of the approved export license to the experimenter.

### 8.2.12 Flight Test Plan

Kistler will deliver a draft Flight Test Plan to each experimenter by L-6 months and a final Flight Test Plan to each experimenter by L-3 months. One plan is generated for the entire flight. This plan defines all aspects of the launch campaign for all experiments, including transportation and storage, integration activities, launch operations, vehicle checkout, launch commit processes, security, communications, export control issues, and launch site safety. Integration activities for all experiments and payloads on the flight are described in this document.

### 8.2.13 Verification Report(s)

The experimenter will deliver a Verification Report(s) to Kistler by L - 6 weeks. This report describes the methodology and results of all required verification activities described in Section 4.3.

### 8.2.14 Pre-Flight Report

At L-1 month, Kistler will deliver a Pre-Flight Report to the experimenter, documenting the expected results of the technology mission. The Pre-Flight Report will include information such as the designed flight profile (including trajectory), flight test objectives, measurement requirements, predicted values and performance, and success criteria. Kistler will generate the report based on flight-specific mission analysis performed by Kistler, data contained in the ICD, and additional support, as required, from the experimenter.

### 8.2.15 Post-Flight Report

At approximately L+1 month, Kistler will submit a Post-Flight report to the experimenter. The Post-Flight report will include a description of the success of the flight operation, and the degree to which expected results (relative to Pre-Flight Report predictions) were achieved. It will include final trajectory performance data, major event timelines, environments, and data from on-board sensors. A description of any problems encountered, and any recommendations for future flights, will also be included.

## 9. ACRONYMS

| | |
|---|---|
| Amps | amperes |
| AWG | American Wire Gauge |
| BIT | Built-in-Test |
| CAD | Computer-Aided Design |
| DB | decibels |
| ECOBOX | Experiment Container Box |
| EMI | Electromagnetic Interference |
| EMU | Experiment Management Unit |
| FEDR | Flight Experiment Design and Requirements Document |
| FMEA | Failure Modes and Effects Analysis |
| ft | foot |
| G | gravity |
| Hz | Hertz |
| Hz | Hertz |
| ICD | Interface Control Document |
| IEDR | Integrated Experiment Design Review |
| IDRD | Interface Definition and Requirements Document |
| ITAR | International Traffic in Arms Regulations |
| Lbf | pound-force |
| Lbs | pounds |
| MB | Megabyte |
| Mbps | Megabits per second |
| MHz | Megahertz |
| MLE | Middeck Locker Equivalent |
| ºF | Degrees Fahrenheit |
| OV | Orbital Vehicle |
| PPF | Payload Processing Faccility |
| psi | pounds per square inch |
| RF | Radiofrequency |
| RLV | Reusable Launch Vehicle |
| RMS | Root-Mean-Square |
| TBD | To Be Determined |
| TDRSS | Tracking and Data Relay Satellite System |
| V | Volts |
| V/m | Volts per meter |
| VDC | Volts Direct Current |
| VPF | Vehicle Processing Facility |
| WPA | Woomera Prohibited Area |