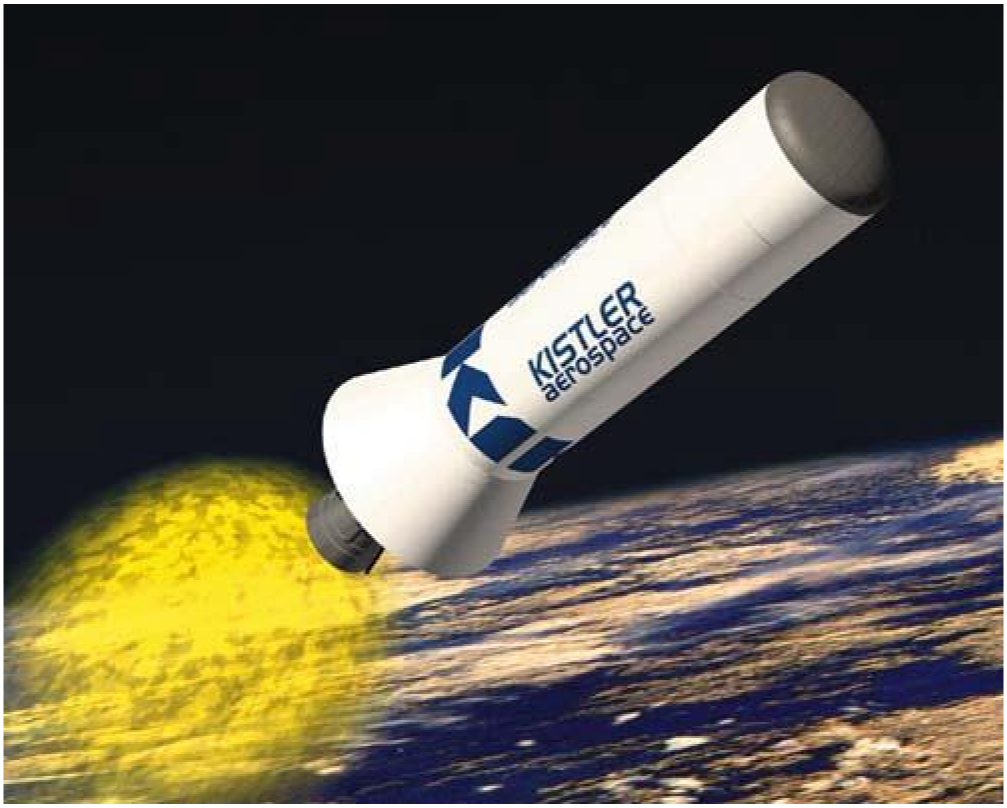
K-1 Vehicle
TA-10 Flight Experiments Design and Requirements Document



For the NASA Space Launch Initiative
2nd Generation RLV Risk Reduction Program (TA-10)

NASA Contract Number NAS8-01103
DRD 958 OP-001
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Revision C
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CHANGE RECORD PAGE

Rev.	Date	Change	Change Authority	Affected Page(s)
A	7/11/01	Initial Release	CM-001	All
B	9/20/01	Added text box to title page. Baselined per NASA Letter dated Aug 30, 2001.	P21-0016A	Title Page (i)
C	12/19/02	Updated to incorporate further definition of accommodations, standard interfaces, and user questionnaires.	P22-0060	Iii, 1, 2, 13-16, 20-22, 24, 27-32 Appendices A-1, A-2, B-1, B-2, C-1, and C-2

FOREWORD

Kistler Aerospace Corporation has been awarded a Flight Demonstration contract under Technology Area 10 (TA-10) of the NASA Space Launch Initiative (SLI), 2nd Generation Reusable Launch Vehicle (RLV) Risk Reduction Program. Kistler will flight demonstrate RLV technologies embedded in its K-1 vehicle in an orbital environment. Kistler will also flight demonstrate Add-on Technology Experiments developed by other SLI contractors.

This document and its appendices define Add-on Flight Technology Experiment accommodations and design requirements for experiments planned to fly on the K-1 vehicle. It also provides a pertinent K-1 vehicle description and performance requirements to support flight experiment to flight vehicle integration. This document is a data deliverable to the NASA Marshall Space Flight Center under Kistler's SLI contract, and is provided to the government with unlimited rights. Kistler will update this document and provide additional detail, as required.

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ABBREVIATIONS AND ACRONYMS

A/D	Analog-to-Digital	LEO	Low Earth Orbit
ACS	Attitude Control System	LHB	Low Temperature Thermal Blanket
CDR	Critical Design Review	LOX	Liquid Oxygen
CRV	Crew Return Vehicle	Mbps	Megabits per second
CTV	Crew Transfer Vehicle	MEC	Main Engine Controller
DFI	Development Flight Instrumentation	MECO	Main Engine Cut-off
ECOBOX	Experiment Containment Box	MOU	Memorandum of Understanding
EGI	Embedded GPS/Inertial Navigation System	NK	N.D. Kuznetsov Samara Scientific & Technical Co.
EMI	Electromagentic Interference	OML	Outer Mold Line
EMU	Experiment Management Unit	OMS	Orbital Maneuvering System
EPM	Extended Payload Module	OV	Orbital Vehicle
FAA	Federal Aviation Administration	PCM	Pulse Code Modulation
FRSI	Felt Reusable Surface Insulation	PDR	Preliminary Design Review
GB	Gigabytes	PPF	Payload Processing Facility
GEO	Geosynchronous Orbit	psi	pounds per square inch
GN&C	Guidance Navigation and Control	RF	Radiofrequency
GN_2	Gaseous Nitrogen	RLV	Reusable Launch Vehicle
GOX	Gaseous Oxygen	RTD	Resistance Temperature Devices
GPS	Global Positioning System	SIRCA	Silicon Infused Reusable Ceramic Ablator
GTO	Geo-Transfer Orbit	SLI	Space Launch Initiative
He	Helium	SSTO	Single-Stage-to-Orbit
HHB	High Temperature Thermal Blanket	TA	Technology Area
HWIL	Hardware-in-the-Loop	TDRSS	Tracking Data Relay Satellite System
ICD	Interface Control Document	TPS	Thermal Protection System
INS	Inertial Navigation System	TSTO	Two-Stage-to-Orbit
IONET	Intelligent Input/Output Network	TTL	Transistor-Transistor Logic
ISS	International Space Station	TVC	Thrust Vector Control
IVHM	Integrated Vehicle Health Management	VPF	Vehicle Processing Facility
LAP	Launch Assist Platform		

I. INTRODUCTION

1.1 Scope of Document

Kistler Aerospace Corporation is developing the world's first two-stage, fully reusable aerospace vehicle, called the K-1 (pictured in Figure 1-1). The K-1 will provide reliable, low-cost access to space for a wide range of space missions, including low-earth orbit missions (LEO), high-energy orbit missions, and potential cargo resupply and return missions to the International Space Station (ISS).

Kistler has been awarded a Flight Demonstration contract by NASA Marshall Space Flight Center under Technology Area 10 (TA-10) of the Space Launch Initiative (SLI) 2nd Generation Reusable Launch Vehicle (RLV) Risk Reduction Program. Under this contract, Kistler will provide NASA with flight data on RLV technologies embedded in the K-1 during its first four flights. NASA has the option to use the K-1 as a test-bed to demonstrate RLV technologies developed by other SLI contractors. Use of the K-1 as a test-bed will provide NASA with insight into 2nd Generation RLV technologies in a true orbital environment. Kistler will provide flight results from these Add-on Experiments.

The purpose of this document is to describe flight accommodations and requirements on the K-1 vehicle for Add-On Technology Experiments. This document includes an overview of the K-1 vehicle and its experiment accommodations. Appendix A includes the Interface Definition and Requirements Documents for experiments flying on the K-1. Appendices B and C include questionnaires, to be completed by experiment developers, for use in the manifesting and integration process.

1.2 Architectures Supported

By flight demonstrating technologies on the K-1, NASA leverages Kistler's considerable commercial investment to support investments in all potential future space transportation architectures, from 2nd to 3rd Generation RLVs. These architectures include:

- Two-Stage-to-Orbit (TSTO)
- Crew Return Vehicle (CRV)
- Crew Transfer Vehicle (CTV)
- Space Shuttle Upgrades
- Reusable First Stage
- Single-Stage-to-Orbit (SSTO)

In addition, the K-1 itself is a medium-lift, reusable, two-stage to orbit launch vehicle. The same vehicle used for SLI flights can fulfill the launch needs of a considerable number of space missions planned in the coming decades by both government and commercial programs, domestic and abroad, in low-earth orbit and beyond.

Figure 1-1: The K-1 Reusable Launch Vehicle provides NASA with a low-cost orbital test-bed

1.3 K-1 Program Overview

Kistler Aerospace Corporation is a privately funded U.S. corporation based in Kirkland, Washington, with less than 50 employees. Kistler is leading the systems engineering and integration effort for the K-1 vehicle through an integrated team composed of Kistler and contractor personnel. The team includes Lockheed Martin Space Systems – Michoud Operations, Northrop Grumman Corporation, GenCorp Aerojet, Draper Laboratory, Honeywell, Irvin Aerospace, and Oceaneering Thermal Systems. The major contractors in Kistler's team are shown in Figure 1-2.

Kistler's first four flights will provide NASA with data on 13 RLV technologies embedded in the K-1. By purchasing the flight results from the first four K-1 flights, NASA leverages Kistler's considerable commercial investment to fulfill 2nd Generation RLV Risk Reduction goals. Add-on Technology Experiments can be placed on K-1 flights #2 - #4 or on subsequent K-1 flights through the end of Kistler's SLI contract in March 2005. NASA will exercise Add-on Technology Experiment flights as options in Kistler's contract.

Figure 1-3 shows the RLV technologies embedded in the K-1 and lists the Add-on Flight Experiment options currently identified in Kistler's contract. Kistler's contract separates Add-on Experiments into Standard and Non-Standard categories. This document defines the requirements for integration of Standard Experiments into the K-1. Standard Experiments are generally externally mounted panels or internally mounted pallets which are not critical to K-1 operations and do not require a complex electrical interface. Non-Standard Experiments may be integrated into the K-1's subsystem or may require more complex interfaces. Flight opportunities exist for both Standard and Non-Standard Add-on Flight Experiments.

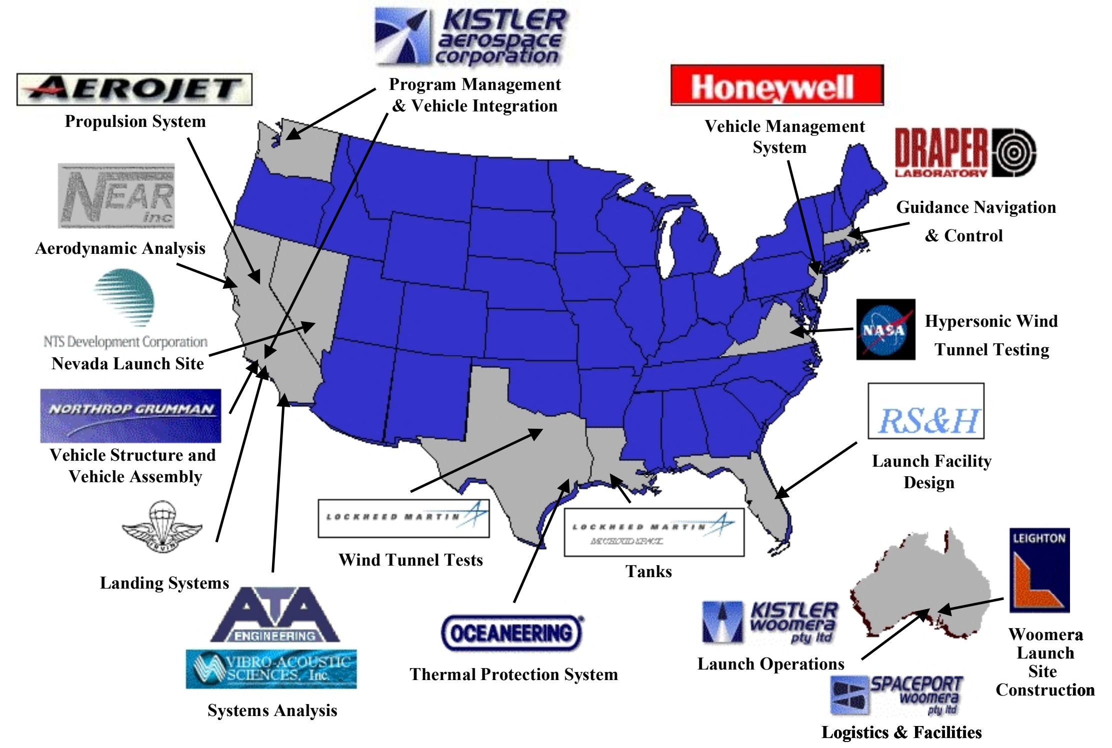
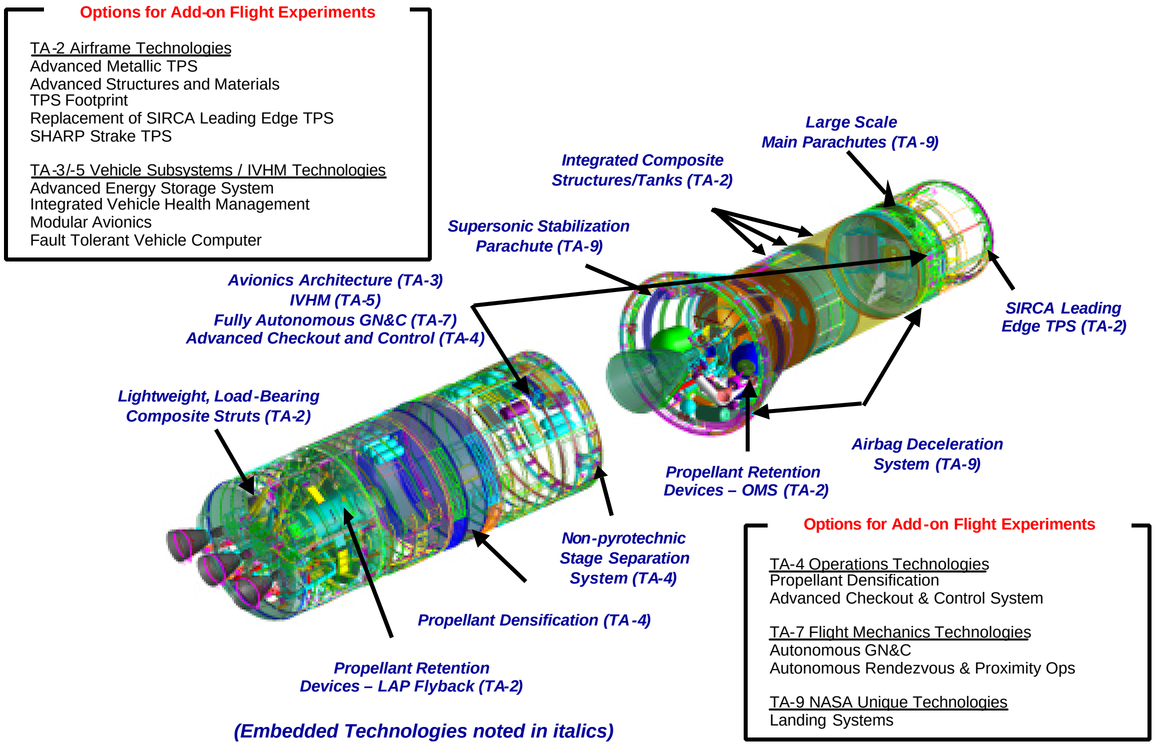


Figure 1-2: The K-1 Contractor Team



Options for Add-on Flight Experiments

TA-2 Airframe Technologies
Advanced Metallic TPS
Advanced Structures and Materials
TPS Footprint
Replacement of SIRCA Leading Edge TPS
SHARP Strake TPS

TA-3/-5 Vehicle Subsystems / IVHM Technologies
Advanced Energy Storage System
Integrated Vehicle Health Management
Modular Avionics
Fault Tolerant Vehicle Computer

Options for Add-on Flight Experiments

TA-4 Operations Technologies
Propellant Densification
Advanced Checkout & Control System

TA-7 Flight Mechanics Technologies
Autonomous GN&C
Autonomous Rendezvous & Proximity Ops

TA-9 NASA Unique Technologies
Landing Systems

Figure 1-3: 2nd Generation RLV Technologies Embedded in the K-1 and Add-on Experiment Options

Kistler will work closely with other SLI contractors to integrate experiments into the K-1 vehicle for flight demonstration. With the exception of the first K-1 flight, which will carry no deployable payloads, all K-1 SLI experiment flights will be conducted in conjunction with commercial or government satellite missions. This ridesharing arrangement significantly reduces the launch price for both experiment and satellite payloads.

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II. K-1 VEHICLE DESCRIPTION

This section provides an overall description of the K-1 vehicle to familiarize experimenters with its configuration, subsystems, and flight profile. More detail on the K-1, including payload environments, launch operations, and processing facilities, is available in the *K-1 Payload User's Guide*, published on the web at http://www.kistleraerospace.com.

2.1 Vehicle Overview

The Kistler K-1 is a two-stage, fully reusable launch vehicle. Each stage is fully autonomous from lift-off through landing and incorporates embedded technologies critical to the NASA 2nd Generation RLV Risk Reduction program, ranging from Integrated Vehicle Health Management (IVHM) to advanced composite structures.

Both stages are recovered after launch with parachutes and airbags. The structure of each stage is designed for reuse up to 100 times. The overall vehicle weighs 841,000 lbs at liftoff. The first stage, or Launch Assist Platform (LAP), weighs 551,000 lbs at launch. The second stage, or Orbital Vehicle (OV), weighs 290,000 lbs fully-fueled. A profile of the K-1 vehicle is shown in Figure 2-1.

2.2 Flight Profile

Figure 2-2 shows a representative K-1 flight profile. The LAP's three LOX/kerosene engines accelerate the K-1 to the stage separation point at approximately 139 seconds into the mission at an altitude of 142,000 ft and a velocity of 4,000 ft/second. The LAP center engine re-ignites 4.4 seconds after separation to return the stage to the launch site, following a ballistic trajectory. Two drogue parachutes and two clusters of three main parachutes are used to decelerate the LAP for a soft touchdown on four airbags.

OV main engine ignition occurs 7.3 seconds after separation. Its single LOX/kerosene engine burns typically for 230 seconds to place the vehicle in an elliptical orbit with an apogee at the desired payload deployment altitude. OV main engine cutoff (MECO) occurs at an altitude of approximately 310,000 feet and a velocity of approximately 25,600 ft/second. The OV then coasts to the targeted orbit altitude, at which time the LOX/Ethanol Orbital Maneuvering System (OMS) engine fires to circularize its orbit. Final orbital insertion is complete approximately 60 minutes into the mission. Payload deployment occurs approximately 60-90 minutes into the mission.

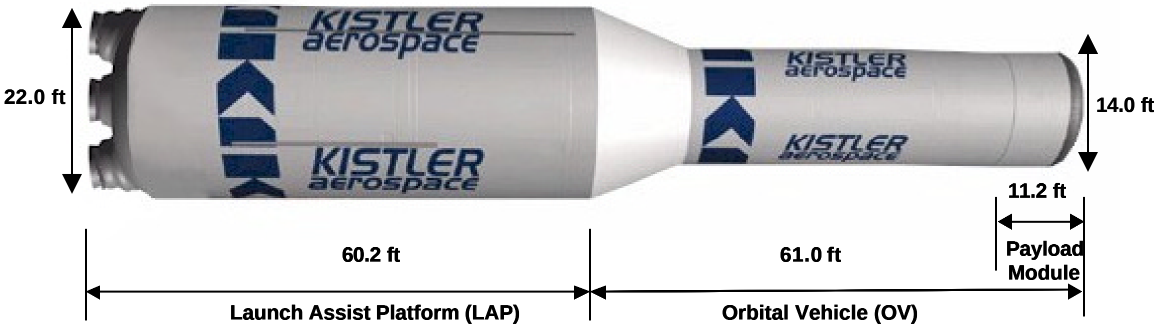
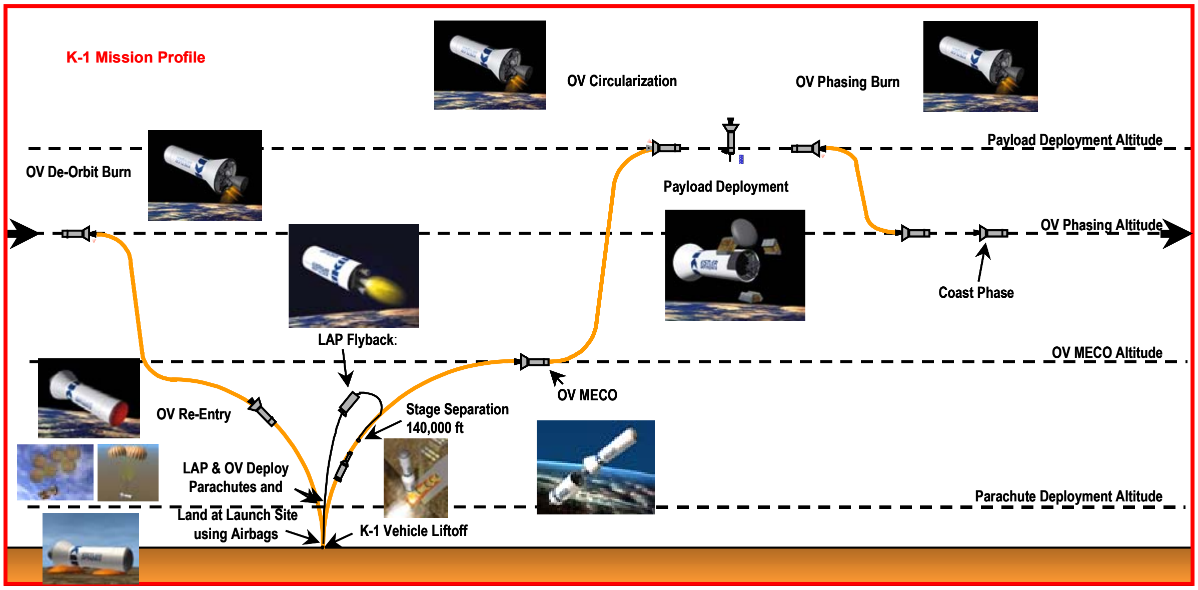


Figure 2-1. K-1 Vehicle Profile



Typical Event Sequence

Event	Time
LAP Ignition	0:00:00
LAP Boost MECO	0:02:20
Separation	0:02:20
LAP Restart	0:02:24
LAP Flyback MECO	0:02:54
LAP Landing	0:10:47

Event	Time
OV Ignition	0:02:27
OV MECO	0:06:19
OMS Insertion Burn	0:50:22
Payload Deployment	1:05:00

Event	Time
OMS Phasing Burn #1	1:30:31
OMS Phasing Burn #2	13:39:06
OMS Re-entry Burn	22:50:22
Re-entry Interface	23:34:22
OV Landing	23:50:04

Time in Hrs:Min:Sec

Figure 2-2. Representative K-1 Flight Profile

After payload deployment, the OMS fires again to place the OV into a phasing orbit with the correct period for reentry. During the coast phase, the OV initiates a slow roll for attitude and thermal control and enters a "sleep mode" to conserve power. Approximately 14.5 hours into the coast phase, the OV briefly exits sleep-mode to perform a period-adjustment burn with its OMS system, if necessary. Approximately 22 hours after payload deployment, the vehicle reorients, performs a deorbit burn with the OMS, and reenters the atmosphere. The OV flies a guided reentry trajectory to the launch site. The OV return approach is similar to that used for the Apollo Command Module. It initiates a lifting bank angle after entry interface and modulates bank angle to control predicted downrange position error to zero. Before parachute deployment, the OV initiates a bank reversal, timed to control predicted crossrange position error to zero.

A stabilization parachute is deployed at Mach 2.5. This is followed by deployment of a single drogue pulling three main chutes. The main parachutes decelerate the stage for a soft touchdown using four airbags. Before touchdown, the OV uses its hot-gas attitude control system (ACS) to align its orientation with the wind to preclude a broadside landing and rollover. Figure 2-3 shows a typical OV reentry profile. Figure 2-4 shows predicted altitude, Mach number, dynamic pressure, and heating loads during a typical OV reentry.

2.3 K-1 Subsystems

This section briefly describes the K-1 subsystem designs to familiarize experimenters with RLV technologies already embedded in the K-1.

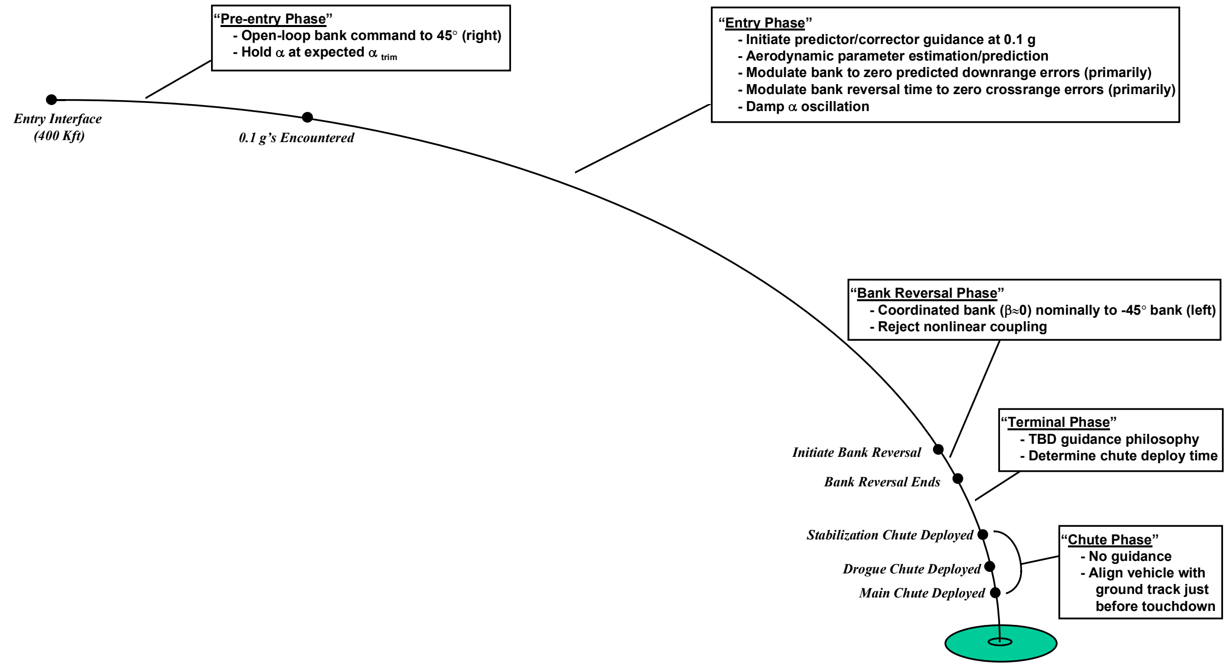


Figure 2-3: K-1 Orbital Vehicle Reentry Profile

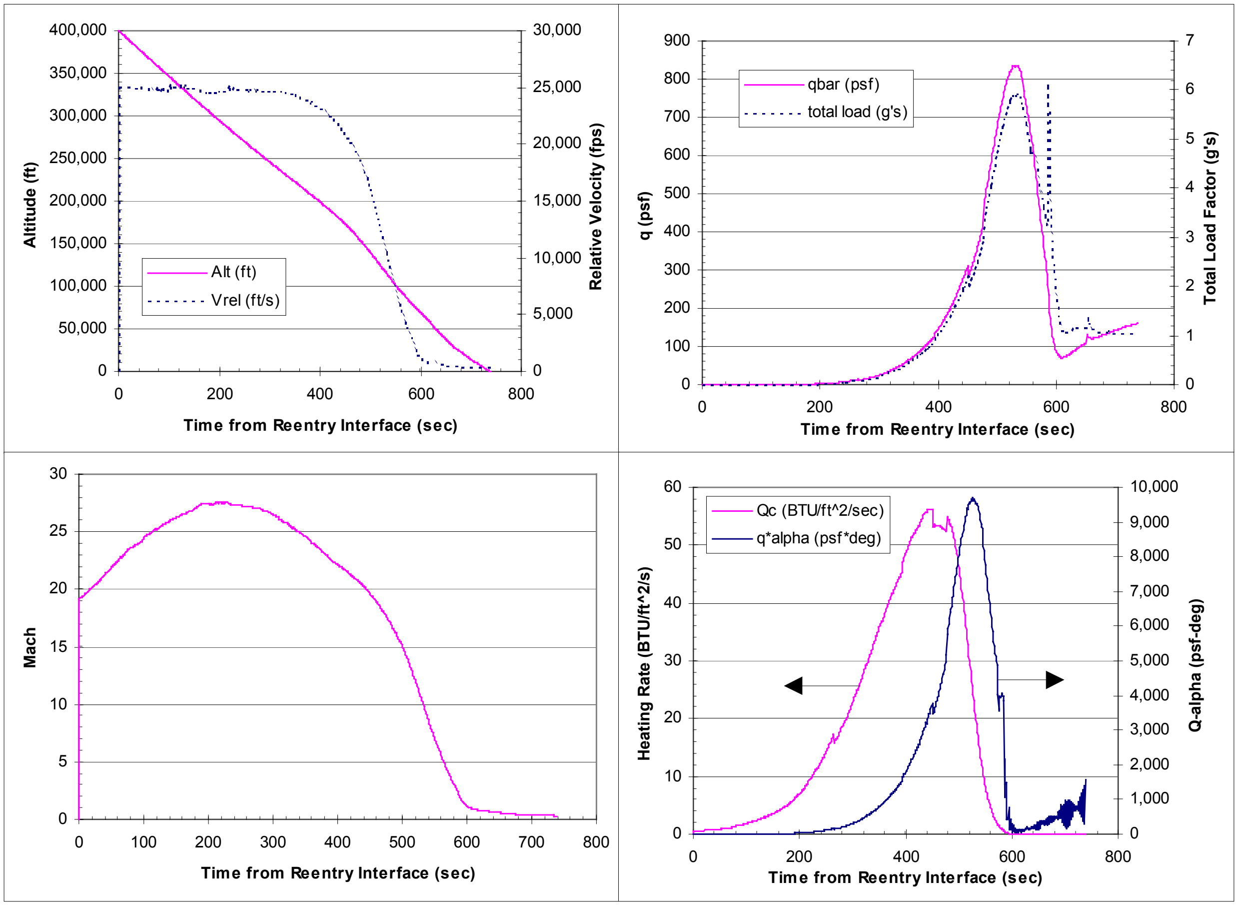


Figure 2-4: Typical K-1 OV Reentry Trajectory

2.3.1 Propulsion

The K-1 main engines are derived from the fully developed core of the Russian NK-33/43 LOX / kerosene engines originally built for the Russian Manned Moon Program. Different nozzles enable the use of this common core on both the LAP and the OV, thereby reducing logistics costs. Aerojet has included modern U.S. electronic controllers, ignition systems, control valves, and TVC systems with the Russian cores, and designated the engines the AJ26 series.

The LAP is powered by two AJ26-58 engines and one AJ26-59 engine. The latter engine is designed for restart in flight to return the LAP to its landing site after staging. Together, the three LAP engines provide 1,020,000 lbf of thrust at liftoff. These engines have an expansion ratio of 27:1 and can be hydraulically gimbaled ± 6º in pitch and yaw. Kistler plans to refurbish these engines after 10 firings and replace them after 20 firings.

The OV uses one AJ26-60 engine for main propulsion. While the core of the AJ26-60 is identical to the AJ26-58 and AJ26-59, it utilizes a bell nozzle optimized for operation in vacuum with an expansion ratio of 80:1. It produces 395,000 lbf of vacuum thrust and is hydraulically gimbaled ± 6º in pitch and yaw to provide TVC. Kistler plans to refurbish these engines after 10 firings and replace them after 20 firings. The NK-43 and NK-33 derived engines are pictured in Figure 2-5.

A unique RLV technology embedded in the K-1 launch system is the use of propellant densification technology to enhance payload performance. At the launch site, propellants are sub-cooled using liquid nitrogen prior to initiation of vehicle loading. Recirculation cooling loops are used for both oxidizer and fuel. The cooling loops remove warm propellants from the top of the storage tanks and return cooled propellants to the bottom.

Figure 2-5: Comparison of NK-43 (left) and NK-33 (right) derived engines

The temperature of the LOX in the main K-1 tanks is less than –310 ºF at lift-off, and the temperature of kerosene in the tanks is less than –30 ºF at lift-off.

The OV uses a pressure-fed OMS engine, delivering 870 lbf of thrust and using LOX and ethanol as propellants. It includes LOX and ethanol propellant tanks (mounted in the OV Aft Flare), cold gas pressurant tanks, an electromagnetic TVC, and associated valves, regulators, and filters. The engine consists of a platelet injector, based on well-proven splash plate technology, and a film-cooled C-103 columbium combustion chamber and nozzle. The OMS system incorporates surface tension zero-g propellant retention devices to enable engine restart in microgravity conditions down to 10% fill level.

The OV and the LAP each have four hot-gas thruster pod triads to provide attitude control, using GOX / Ethanol propellant. Both the LAP and OV thruster pods are mounted in the interstage region.

2.3.2 Avionics and Integrated Vehicle Health Management

Each stage of the K-1 vehicle is completely autonomous from launch to landing. The vehicle also performs pre-launch checkout and control autonomously, relying on an Integrated Vehicle Health Management (IVHM) System and Advanced Checkout and Control System. Stage guidance and control are provided by a triplex, fault-tolerant avionics architecture. These advanced avionics technologies are critical for development of a 2nd Generation RLV.

Vehicle position, velocity and orientation data are provided by three integrated Global Positioning System (GPS) / Inertial Navigation System (INS) units. Vehicle command and control is managed by the Vehicle Management Computer and supported by a Power Controller, a Payload Controller, and a Subsystem Management Unit. These units are responsible for valve actuation, pyro initiation, and subsystem health monitoring. The main engines have their own control units. Data communications are conducted using a triplex 1553 data bus.

The K-1 vehicle avionics includes a Tracking Data Relay Satellite System (TDRSS) transceiver for communicating vehicle status to the ground, for payload separation indication, and for updating wind data to the OV for reentry targeting.

All mission software is fully verified prior to flight in a hardware-in-the-loop facility operated by Draper Laboratory.

The health monitoring of the K-1 differs from conventional practice for launch vehicles. Both the LAP and OV have an onboard Integrated Vehicle Health Management (IVHM) system. It is used after each flight to report on the status of the vehicle and its systems. IVHM of similar concept is used in late-generation commercial aircraft, such as the Boeing 777. After each stage lands, the IVHM reports on the status of all systems and identifies what needs to be serviced. The same IVHM also performs pre-flight checkout.

2.3.3 Structures and Mechanisms

A feature enabling the K-1's reusability and two-stage design is its lightweight and robust structure. The primary structures of both stages are lightweight graphite composites. The primary structural elements are shown in Figure 2-6. The primary structure of the LAP and OV together are constructed from 23 composite panels (Figure 2-7 shows one such panel). The OV kerosene tank is also composite. Lightweight composite thrust rods (shown in Figure 2-8) transfer loads from the three LAP main engines to the primary structure. The K-1 will utilize composite structures more extensively than any launch vehicle that has ever flown.

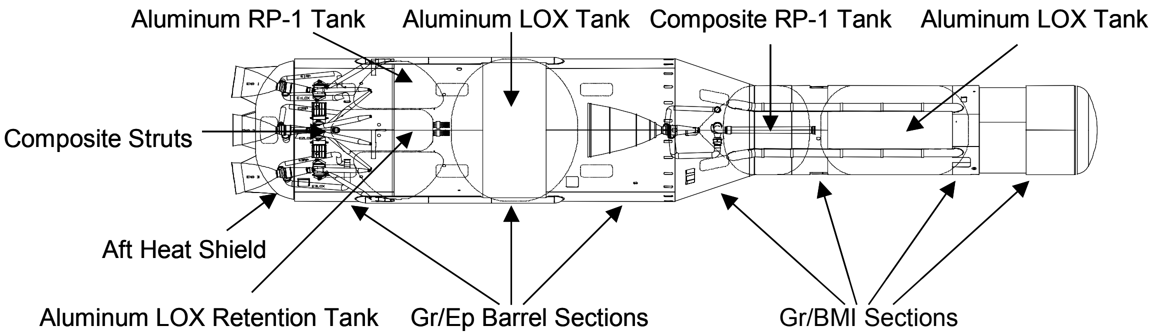


Figure 2-6: K-1 Primary Structures

Figure 2-7: Composite Panel Lay-Up

Lockheed Martin manufactures the aluminum LOX tanks for the LAP and OV and the aluminum kerosene tank for the LAP. These tanks are integrated into the vehicle main structure and designed to carry primary loads.

K-1 engineers have designed a creative solution to supply LOX to the center engine of the LAP after restart for launch site return. A small cryogenic LOX retention tank is nested inside the main LAP kerosene tank and above the center engine. The principal LOX tank for the LAP is located forward of the fuel tank. When stage separation occurs, the LAP undergoes a pitch-over maneuver before center engine restart.

2.3.4 Thermal Protection Systems

The K-1 Thermal Protection System consists of ceramic high temperature thermal blankets (HHB), ceramic low temperature thermal blankets (LHB), and ceramic tile. Thermal boots are also used to close out the aft end of both the LAP and OV, and thermal barriers are required at door interfaces.

Ceramic tile is utilized for the TPS in the areas of the nose cap, flare, and on specific doors and vehicle protuberances. The ceramic tile used on the K-1 is Silicone Infused Reusable Ceramic Ablator (SIRCA-15F), developed by NASA Ames Research Center. SIRCA has enhanced durability and is used in areas where the surface temperature is predicted to exceed 2000 ºF. These tiles are expected to withstand temperatures in excess of 3000 ºF. It is also used at critical thermal barrier interfaces where its superior strength and temperature erosion resistance is required. The Space Shuttle proven ceramic tile attachment system has been maintained, employing a strain adhesive in conjunction with an isolation pad between the tile and structure to compensate for thermal and structural deflections. Figure 2-9 shows a typical ceramic tile installation.

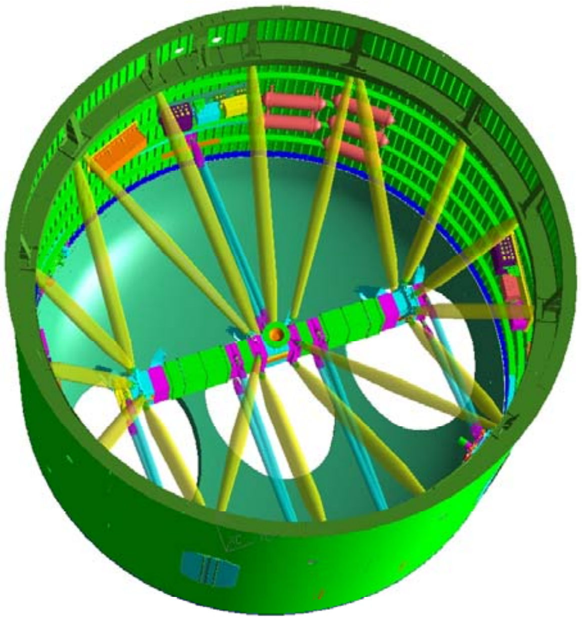


Figure 2-8: Load-Bearing Composite Struts in Aft LAP Thrust Structure

The areas protected by HHB include all of the external OV structure not covered by tile. The HHB consists of a ceramic outer layer fabric, ceramic insulation, and fiberglass inner layer fabric sewn together with a quilt pattern. This insulation system is an upgrade to the original blanket system installed on the Space Shuttle. On the K-1, HHB is used in all areas where the surface temperature during reentry does not exceed 2000 ºF. A 30 x 60 in. standard sized blanket is being used in order to reduce parts and minimize program cost. Space Shuttle Orbiter adhesives and bonding procedures are used on the K-1 to minimize new process development. Figure 2-10 shows a typical flexible blanket installation.

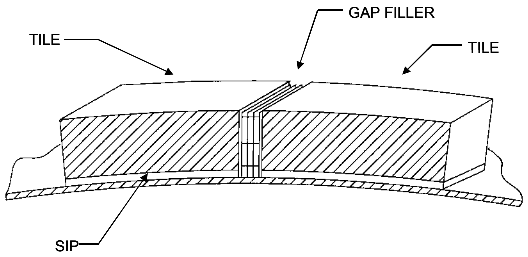


Figure 2-9: Typical Ceramic Tile Installation

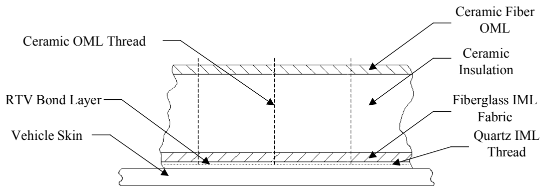


Figure 2-10: Typical Flexible Blanket TPS Installation

LHB is used to protect components and structures within the flare cavity region of the OV because of the relatively lower temperatures (<1200 ºF) in these areas. The LHB is fabricated utilizing woven fiberglass inner/outer cloth and fiberglass insulation materials sewn together in a quilt pattern. On the K-1, LHB is typically mechanically fastened to its underlying components and structures.

2.3.5 Landing Systems

The OV parachute system consists of one Stabilization Parachute, one Ribbon Drogue, and three Ringsail main parachutes. The LAP parachute system consists of two Ribbon Drogues and six Ringsail main parachutes. The design and construction of the parachutes is the same for both the LAP and OV stages with the exception of minor reefing changes.

The OV requires a supersonic stabilization parachute to maintain a low angle-of-attack during transonic/supersonic flight. Kistler chose a Hemisflo Parachute due to its extensive flight history as a supersonic stabilization parachute. The parachute is 23 feet in diameter. It uses a continuous ribbon construction and is built entirely from high temperature materials (e.g., Kevlar and Nomex) to preclude concerns due to stagnation temperature effects.

The Ribbon Drogue design is based on the successful Space Shuttle Orbiter Drag Chute. The size of the Drogue (40.3 feet in diameter) was established to provide commonality and dual flight mode operations for both stages. The Drogue uses cut gore ribbon construction and consists of a hybrid of nylon and Kevlar materials.

Each Ringsail main parachute is made up of five rings and ten sails. The size of the parachute (156 feet in diameter) was established as a result of system analysis, which determined the rate of descent that provided the minimum landing system weight. It is constructed of a Kevlar grid and a nylon drag-producing surface and incorporates a feature allowing rapid removal and replacement of suspension lines (if necessary) for reusability.

The LAP and OV airbag set consists of four large outer stroking airbags, each set consisting of an inner airbag and an outer airbag. The function of the outer airbag is to absorb the landing impact energy while the inner airbag prevents ground contact, and maintains ground clearance during recovery operations. The LAP airbags are cylindrical in design with elliptical endcaps. The LAP outer airbags measure 8.5 feet in diameter and 12.8 feet in length. The OV airbags are spherical in design. The OV outer airbag is approximately 10.0 feet in diameter. All airbags are fabricated with industry standard stitching/bonding adhesive processes and are built from a polyether polyurethane coated (both sides) Kevlar fabric.

The large-scale main parachutes, supersonic stabilization chute, and airbag deceleration, are all RLV technologies that cut across multiple architectures. Figure 2-11 shows a successful six-parachute cluster drop test (simulating LAP return) conducted by Kistler. Figure 2-12 shows the full-size LAP and OV airbags.

2.4 Launch Sites

Kistler will use its dedicated launch facilities in Woomera, South Australia, for K-1 launches, including SLI flights. Launch operations in Woomera are conducted by Kistler's wholly-owned Australian subsidiary, Kistler Woomera. Kistler has already received environmental approval for its operations in Australia and has an Operations Agreement with the Commonwealth of Australia. Kistler's launch site is located at 31.08° South latitude, 136.66° East longitude. Figure 2-13 shows a map of the Woomera launch site location and the preliminary K-1 flight corridors.

After successfully demonstrating K-1 flight operations, reliability, and market viability in Woomera, Kistler plans to develop parallel operations from the Nevada approximately two years after commencing commercial operations in Woomera. Regulatory effort is also underway for the Nevada site.

Figure 2-11: Six-Parachute Cluster Drop Test of First Stage Return

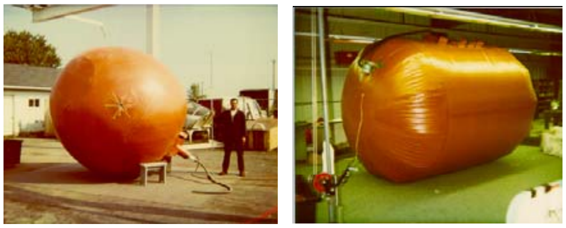


Figure 2-12: Full-Size LAP and OV Airbags

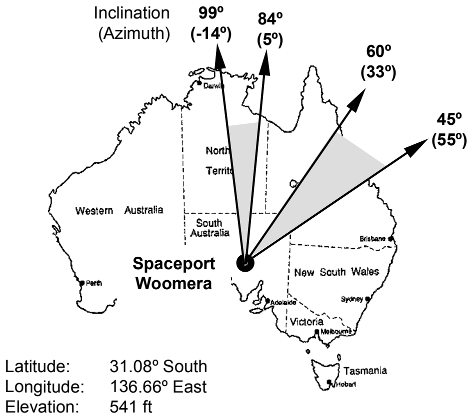


Figure 2-13: Launch Site in Woomera, Australia

III. EXPERIMENT ACCOMMODATIONS

The K-1 can accommodate three different types of experiments. Standard externally mounted, passive Experiments would be mounted on fail-safe test panels and would include advanced materials and TPS experiments. Standard internally mounted, active Experiments can be accommodated in a variety of locations on the second stage, and could include tests of advanced mechanical or electronic systems. Non-standard experiments require K-1 vehicle modifications or replacement of K-1 vehicle hardware.

This section provides an overview of accommodations for standard experiments. Refer to Appendix A for detailed information on interfaces and environments.

3.1 Externally Mounted Experiments

Kistler's approach to externally mounted (termed "Passive") experiments is to replace existing K-1 hardware (access panels, doors, tile, or blanket parts) with technology experiments on fail-safe test panels. Panels will be designed with backup insulation and structure to maintain thermal integrity in the event of an experiment failure. Data recording will be made available through the existing developmental flight instrumentation (DFI) on the K-1 vehicle.

3.1.1 External Mounting Locations

Figure 3-1 shows the six external mounting footprints on the K-1 OV. Table 3-1 shows the body station numbers for each location, along with the theta location. Body station numbers are X-axis locations (in inches) on the vehicle from a reference of 1000 at the OV / LAP interface plane.

Table 3-1: Mounting Footprints for Externally Mounted Experiments

#	Body Station	? Location (in °)
1	1637.13	n/a
2	1495	248
3	1495	203
4	1235	180
5	1064	240
6	1064	180

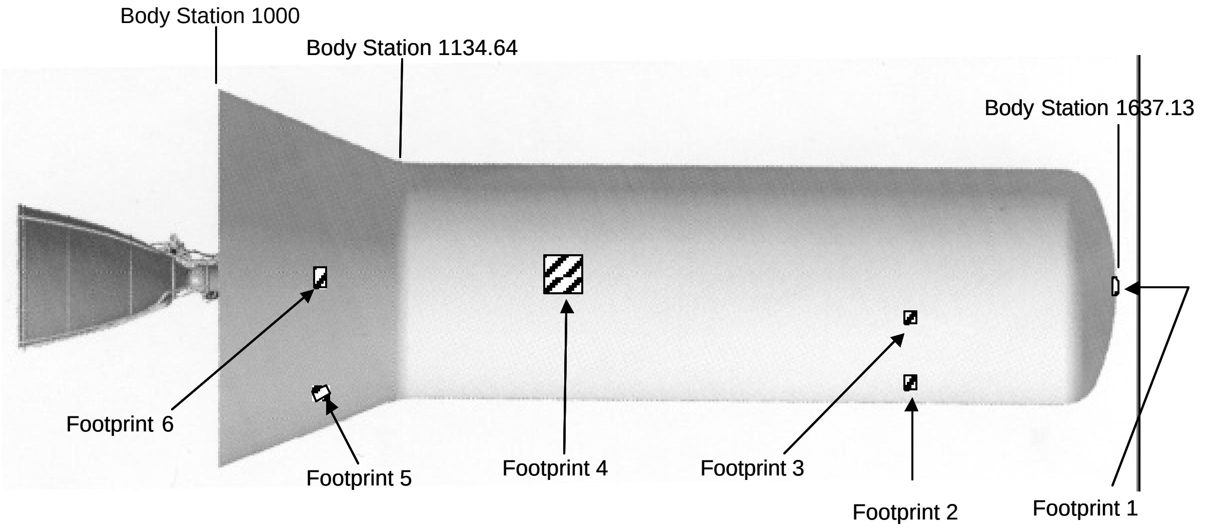


Figure 3-1: Externally Mounted Experiments on K-1 OV

These mounting footprints experience a range of heat loads. Two of the mounting footprints (1 and 5) are in tile and the remainder are in thermal blanket. External mounting footprints are also available on the LAP. These locations experience considerably lower heating loads. Information on LAP mounting footprints is available from Kistler upon request.

3.1.2 External Experiment Interfaces

Figure 3-2 shows a cross-section of the interface for an experiment externally mounted to the OV at Footprints #2 - #4 and #6. The experimenter provides the experiment mounted to a carrier plate and Kistler integrates the experiment onto the K-1. Kistler will install backup insulation in the form of bordering blankets and an ablator bonded to the K-1 structure to maintain thermal integrity.

For tile experiments mounted in Footprint #1 and #5, the experimenter will either bond their tile onto a carrier plate (which Kistler will then mechanically fasten to the K-1), or Kistler will bond the experiment directly to the K-1 structure.

The footprint of each experiment depends on mounting location, as described in section 3.1.3 below. The height of each experiment is generally limited to the TPS Outer Mold Line (OML), approximately 2.0 inches. No experiments at Footprint #1 can exceed the local TPS thickness. OML exceedance of more than 2 inches at Footprints #2-#6 may be allowed, but will require additional aerodynamic analysis and verification.

Kistler can provide data recording to sensors mounted on or around the experiment, such as thermocouples and strain gauges, using its existing DFI system and passing insulated wire through the vehicle structure, ablator, and carrier plate. The capabilities of the DFI system are described in section 3.4.

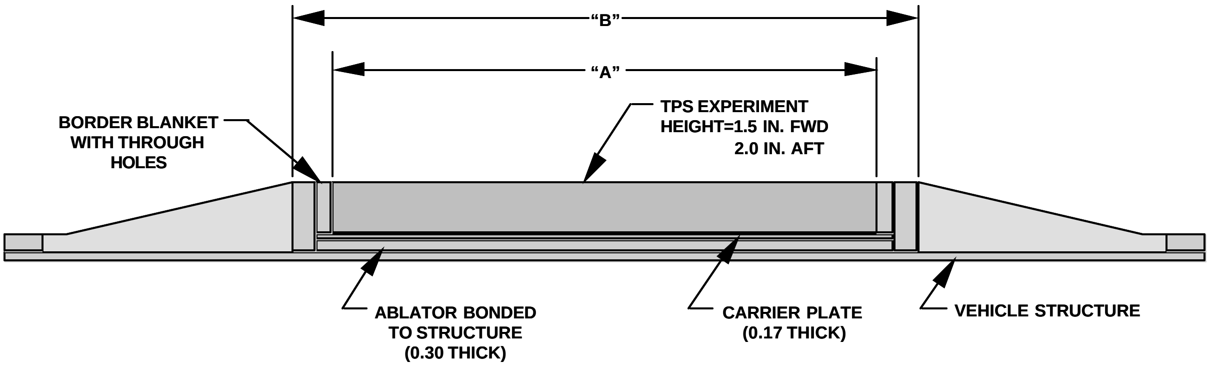


Figure 3-2: Externally Mounted Experiment Footprint

Table 3-2: Externally Mounted Experiment Footprints

#	Location	Type	A* (in.)	B** (in.)
1	Nosecap	Tile Substitution	9.00 x 9.00	9.16 x 9.16
2	Payload Module	Carrier Plate	7.50 x 4.25	10.50 x 7.25
3	Payload Module	Carrier Plate	7.50 x 4.25	10.50 x 7.25
4	Mid Body	Carrier Plate	24.00 x 24.00	27.00 x 27.00
5	Aft Flare	Tile Substitution	9.00 x 9.00	9.16 x 9.16
6	Aft Flare	Carrier Plate	6.00 x 14.00	9.00 x 17.00

*The first and second dimensions are orthogonal. Multiplication of the two values yields the available total experiment footprint.
**The first and second dimensions are orthogonal. These dimensions define the total footprint for closeouts and attachment provisions.

3.1.3 External Experiment Envelopes

Table 3-2 describes the footprint available for experiments in each mounting location. The dimension "A" and "B" correspond to the callouts in Figure 3-2. Mounting Footprints #1 and #5, located in tile, are limited to a 9 x 9 in. platform. All other mounting footprints are limited by the size of existing access panels and doors in that portion of the K-1 structure.

3.1.4 External Experiment Environments

This section describes only relevant flight environments experienced by externally mounted experiments. Unlike internally mounted experiments, externally mounted materials are not sensitive to electromagnetic interference or cleanliness in the integration facility. Material experiments will be exposed to the ambient air at Kistler's launch site in Woomera, Australia.

3.1.4.1 Thermal Environment

Heat loads during reentry drive the design of materials and TPS experiments externally mounted to the OV. Table 3-3 describes the predicted heat environment at each identified mounting location.

Table 3-3: Heating Environment in K-1 OV External Experiment Footprints

#	Peak Heating Rate (BTU / sqft / sec)	Integrated Heat Load (BTU / sqft)	Rad. Eq. Temp (R)	Rad. Eq. Temp. (F)
1	65.0	14,350	3,519	3,060
2	9.5	1,830	2,176	1,716
3	7.6	1,300	2,058	1,598
4	2.2	450	1,509	1,050
5	33.0	5,940	2,971	2,511
6	12.4	2,435	2,326	1,866
NOTE: Radiation equilibrium temperature assumes $\varepsilon = 0.89$ and $\sigma = 4.76E-13$.				

3.1.4.2 Acoustic Environment

Table 3-4 shows the maximum predicted overall sound pressure level (in dB) at each external mounting location, including the phase of flight the maximum environment occurs. If Kistler and the experimenter determine acoustic testing is required, Kistler will provide sound pressure spectrums for verification testing.

Table 3-4: Overall Maximum Acoustic Level in K-1 OV External Experiment Footprints

#	Overall Acoustic Level (dB)	Flight Phase
1	160	Transonic Ascent
2	160	Transonic Ascent
3	160	Transonic Ascent
4	148	Lift-Off
5	148	Lift-Off and Supersonic Reentry
6	148	Lift-Off and Supersonic Reentry

3.1.4.3 Design Limit Load Factors

A design limit load factor of 35 g encompasses both predicted static and dynamic loads for externally mounted TPS experiments. This load factor applies to each axis (one at a time).

3.2 Internally Mounted Experiments

Experimenters have the option of placing experiments inside the K-1 vehicle (termed "Active" experiments) to demonstrate the operation of mechanical and electronics technologies in an actual launch, orbital, and reentry environment. These experiments will be mounted on Kistler-supplied trays and in Kistler-supplied boxes, and will not interface directly with the vehicle. An Experiment Management Unit (EMU) on the K-1 provides power, command and control functions, data recording, and 1553 data monitoring.

3.2.1 Internal Mounting Locations

Three mounting locations have been identified in the K-1 OV, including the OV Forward Skirt, the OV Mid-Body, and the OV Aft Flare. These locations are shown in Figure 3-3. Experiments in these locations experience a launch environment, an orbital environment with microgravity conditions, and a reentry environment. Mounting locations are also available on the LAP. Information on LAP mounting locations is available to interested SLI contractors upon request from Kistler.

3.2.2 Internal Experiment Interfaces

This section briefly describes the mechanical and electrical interfaces between the K-1 OV and internally mounted experiments.

3.2.2.1 Internal Mechanical Interfaces

Figure 3-4 through Figure 3-6 show the available volume for experiments in the OV Forward, OV Mid Body, and OV Aft Flare experiment bays, respectively. In all three locations, experiments will be installed in standard Kistler provided Experiment Containment Boxes (ECOBOXes), detailed in Appendix A. Experiments within ECOBOXes are mounted on standard aluminum trays provided by Kistler. The ECOBOXes provide a simple, versatile platform for integration, and protect both the experiment and the K-1 vehicle from potential damage.

In the OV Forward experiment bay, accessible when the Payload Module is removed for processing, two ECOBOXes can be mounted on brackets in an existing frame holding vehicle components. The OV Mid Body experiment bay is accessible through two access doors in the sides of the vehicle. Three ECOBOXes can be mounted to the inside of a main body panel. The OV Aft Flare mounting location is shown in Figure 3-6 without the OV main engine, for clarity. Two ECOBOXes can be mounted in this volume.

3.2.2.2 Internal Electrical Interfaces

Kistler will provide an EMU in the OV, responsible for all power, communication, and control of internally mounted experiments. The EMU supplements the data-recording functions of the DFI system.

Power is supplied at +28 VDC from a separate 100 amp-hour experiment battery, and is switched by the controller processor.

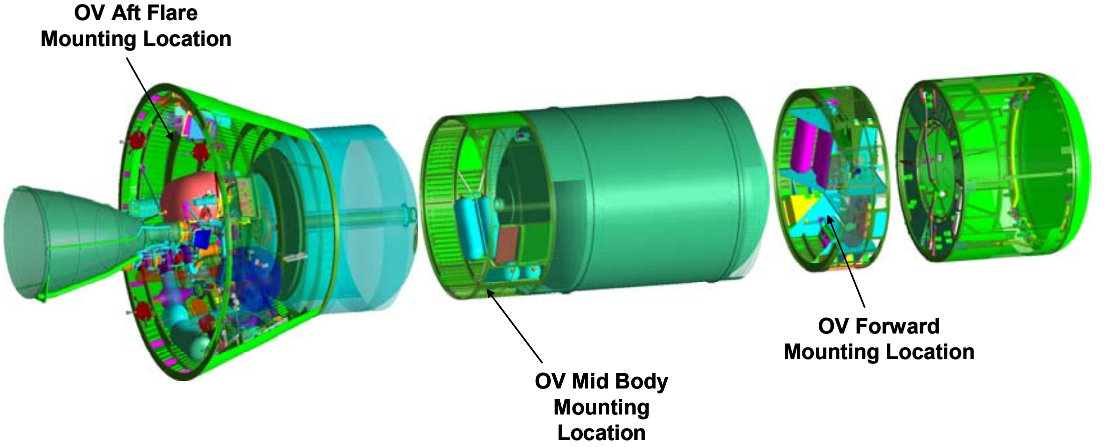


Figure 3-3: OV Internal Experiment Mounting Locations

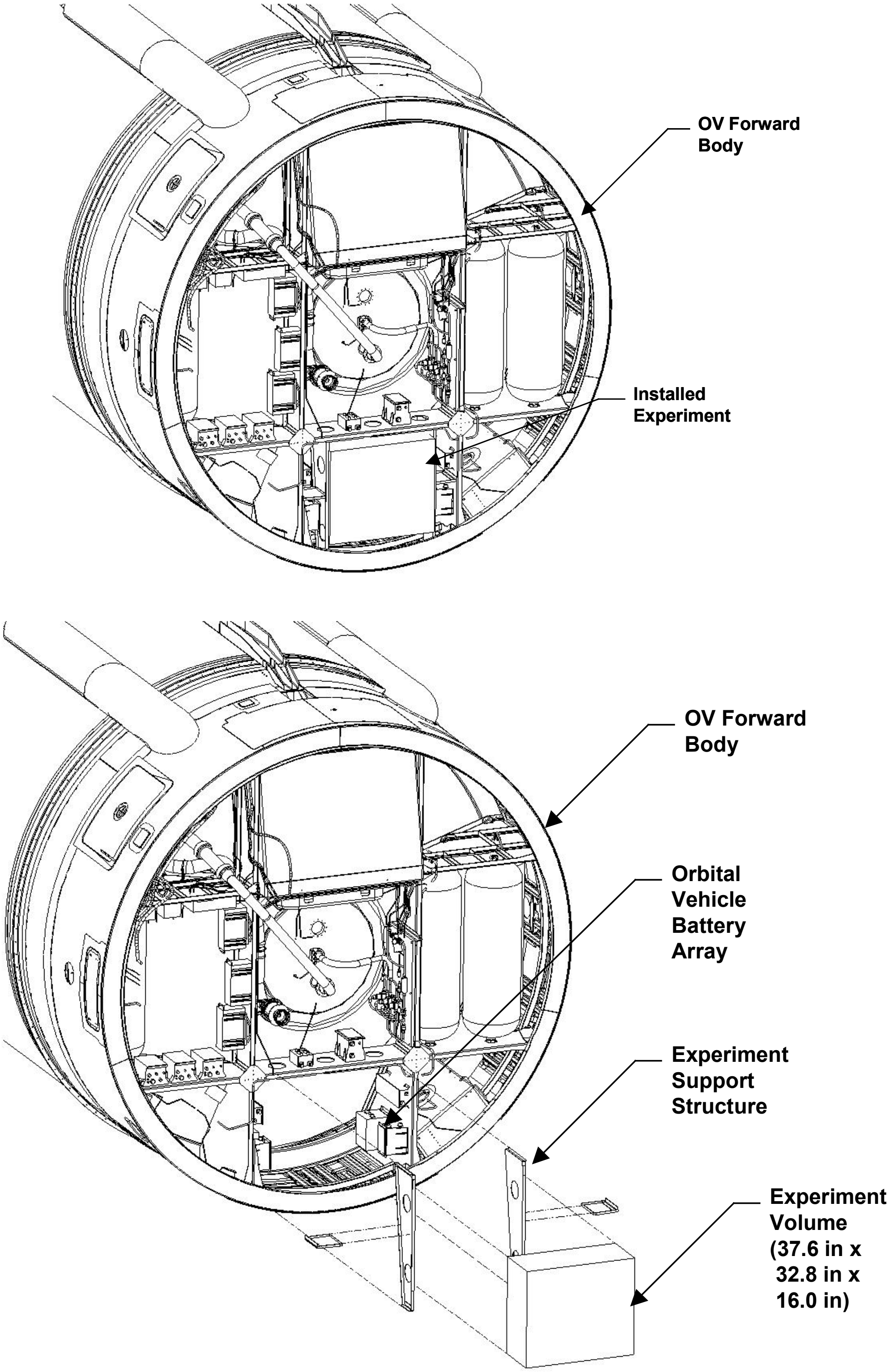


Figure 3-4: Mounting Structure for Internal Mounting Location in OV Forward

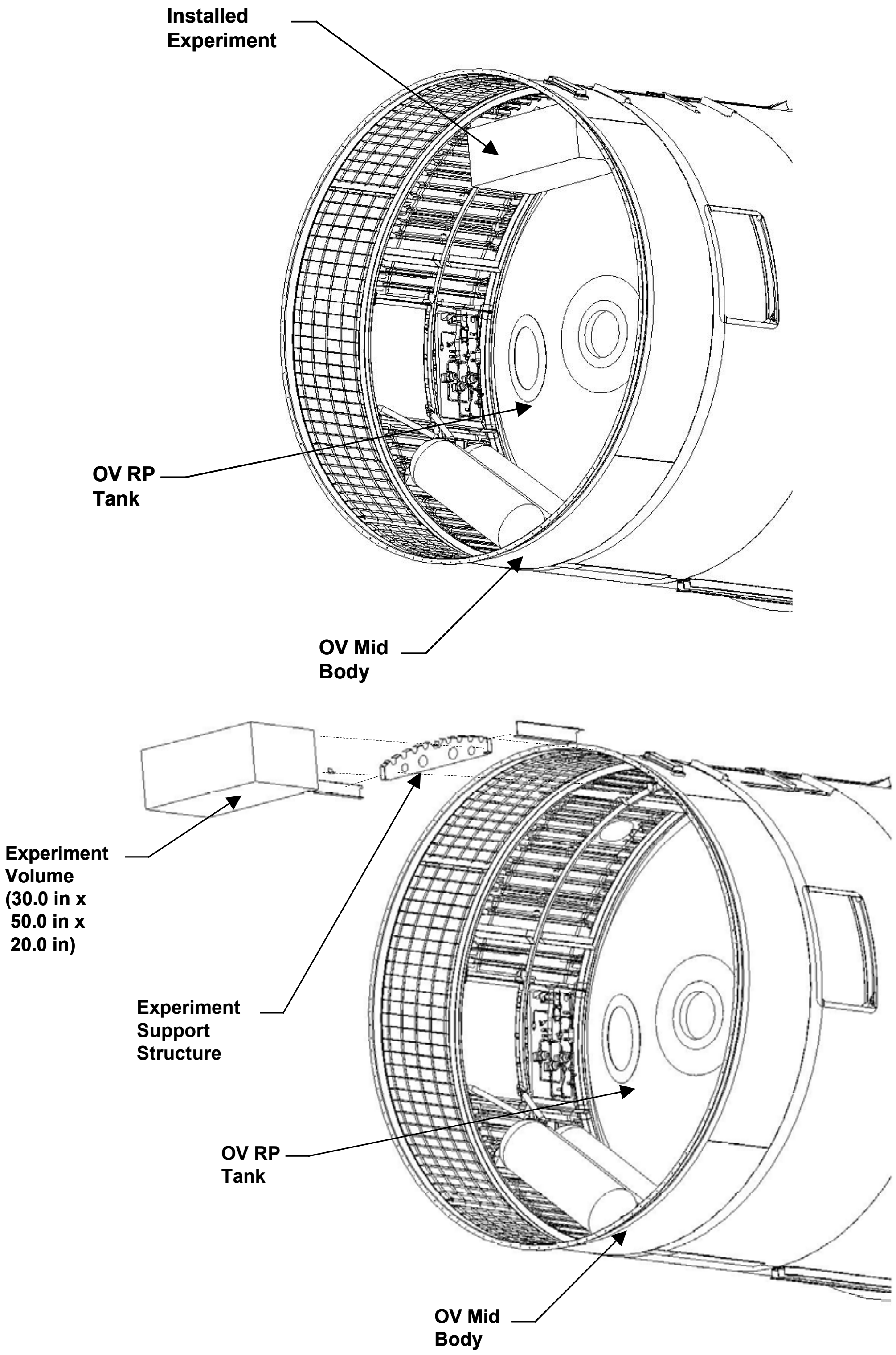


Figure 3-5: Mounting Structure for Internal Mounting Location in OV Mid Body

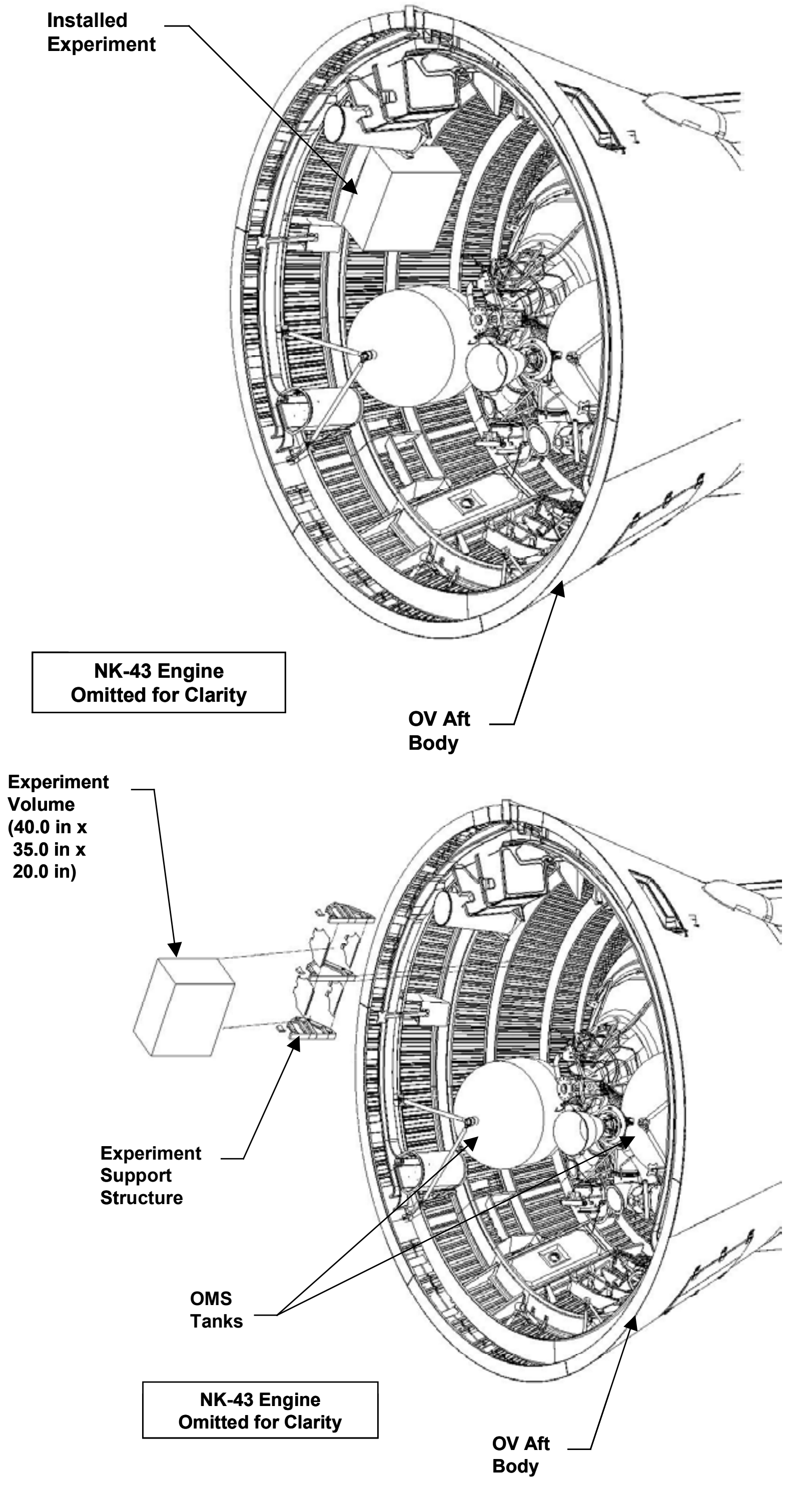


Figure 3-6: Mounting Structure for Internal Mounting Location in OV Aft Flare

Analog signals from sensors are passed through an A/D-converter and placed into the data recorder, along with digital signals passed by the RS-422 interface. The data recorder has a maximum data rate of 10 Mbps and a capacity of 1.5 GB (expandable to 4.5 GB). The signal processing and data recording hardware will be the same as that used in each node of the existing DFI system, with 31 channels of signal processing available. The EMU commands and controls the experiments as needed using TTL-compatible digital discretes. One of the three K-1 1553 data buses is also available for use in a bus-monitoring fashion only, so that an experiment may monitor variables, modes or vehicle health information being transmitted on the bus.

3.2.3 Internal Experiment Envelopes

Table 3-5 shows the maximum volume and mass of ECOBOXes integrated with experiments in each of the three experiment bays. The total mass of all experiments, ECOBOXes, and attachment hardware on a given K-1 flight is contractually limited to 300 lbs. Appendix A describes the mass limits for an experiment on each tray and in each ECOBOX.

Table 3-5: Volume and Mass Limitations of OV Internal Experiment Mounting Locations

Location	Volume	Mass (lbs)
OV Forward	37.6 x 32.8 x 16.0	300
OV Mid-Body	30.0 x 50.0 x 20.0	200
OV Aft Flare	40.0 x 35.0 x 20.0	200

3.2.4 Internal Experiment Environments

This section describes the environments expected throughout the mission profile in ECOBOXes mounted in all experiment bays. Detailed environments are described in Appendix A-1. As an optional service at an additional price, Kistler can provide additional thermal control and vibration isolation if predicted environments exceed the limitations of the experiment.

3.2.4.1 Cleanliness / Contamination

As described in section 3.5, if required, Kistler can provide experimenters with a payload station in Kistler's Payload Processing Facility (PPF). The PPF is described in section 8.2 of the *K-1 Payload User's Guide*. It is maintained at a Class 8 clean environment in accordance with ISO 14644-1, a temperature of 75 ± 5° F, and a relative humidity of 50 ± 5%. Integration of the experiment to the K-1 will occur in the adjoining Vehicle Processing Facility (VPF). Any contamination-sensitive components in an experiment must be sealed in the PPF before transfer to the VPF for integration.

3.2.4.2 EMI / RF Environments

At the launch sites, the electromagnetic environment that experiments will be exposed to are generated primarily from the vehicle itself. The K-1's TDRSS, used for data uplink and downlink in the S-band 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.

3.2.4.3 Electrostatic Potential

Kistler will attach ECOBOXes to a single point electrical ground. This single point ground is electrically common to the vehicle's single point ground. Electrostatic grounding provisions are provided during all phases of integration and launch operations. The electrical resistance of the ECOBOX to K-1 interface will be 0.010 ohms or less and will be verified during integration operations.

3.2.4.4 Acceleration Environment

Figure 3-7 shows the design limit load factors for experiments internally mounted to the OV during a nominal K-1 integration cycle and mission profile. The load factors apply to all axes (one at a time), and encompass both static and dynamic loads.

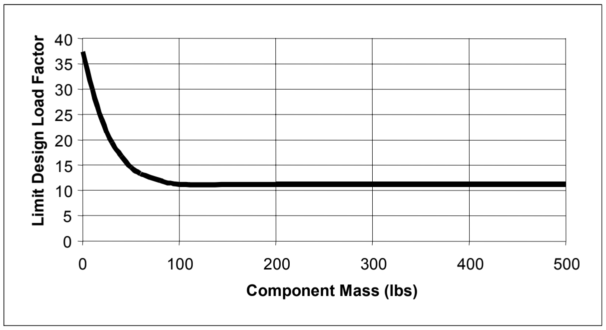


Figure 3-7: Load Factors by Experiment Mass

During its coast phase, the OV experiences a prolonged microgravity environment. This environment may be interrupted once to perform a period-adjustment burn with the OMS engine. Table 3-6 describes the timing, duration, and quality of the expected OV microgravity environment, assuming a clean-up burn is necessary.

Table 3-6: 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	$< 10^{-5}$

3.2.4.5 Vibration Environment

Maximum anticipated random vibration environments in shock-mounted ECOBOXes are shown in Table 3-7 for three different experiment weights. 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 3-7: 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

3.2.4.6 Thermal Environment

The nominal temperature range experienced by experiments in the OV is -15 °F to 120 °F.

3.2.4.7 Pressure Decay

ECOBOXes will be unpressurized and will experience the same pressure environment as in the experiment bay. 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, from 6 psi to nearly 0 psi in 0.2 seconds. The OV Forward pressure decay is more gradual, with a maximum rate of -0.54 psi/sec for approximately 5 seconds.

To provide flexibility in locating ECOBOXes, experimenters should design to the rapid pressure decay rate in the OV Mid Body and OV Aft Flare. If required, Kistler can provide a pressurized ECOBOX as an optional service at an additional price.

3.3 Non-Standard Experiments

Non-standard experiments are those requiring customization of interfaces or major modifications / hardware replacements to the K-1 vehicle. Examples of this type of experiment include:

- Addition of structures or TPS exceeding the OML by greater than 2 inches;
- Replacement of one or more of the K-1's main engines with upgraded engine(s)

utilizing advanced materials, mechanical subsystems, and IVHM;

- Replacement of one of the K-1's batteries with higher energy density storage devices;
- Replacement of one of the K-1's structural elements, such as propellant tanks, with elements utilizing advanced materials.
- Software-only experiments hosted on the EMU.

Due to the increased risk and complexity of this type of experiment, experimenters interested in this option should contact the Kistler SLI Program Manager as early as possible. Requirements for these experiments are highly system specific and are not fully described in this document. Section 2.3 briefly describes the critical elements embedded in the K-1 RLVs subsystems to familiarize prospective experimenters.

3.4 K-1 Development Flight Instrumentation System

Data recording is available to all categories of SLI experiments through the K-1's existing DFI system. The DFI system was designed to provide a modular, tailorable system for measurement of data required for final verification of the K-1 RLV. Approximately 270 parameters will be measured using the system on the first four K-1 flights. Data measurement instruments in the basic DFI system include thermocouples, strain gauges, accelerometers, pressure transducers, temperature gas probes, Resistance Temperature Devices (RTDs), and microphones. Kistler can leave all of part of the DFI system in the K-1 vehicle to support NASA Add-on Technology Experiment flights, and can reconfigure and expand the DFI system over 50% to meet mission needs.

The Kistler baseline DFI system is a distributed data acquisition system with data nodes located in all OV and LAP compartments as shown in Figure 3-8. There are three LAP nodes and four OV nodes. Each node is capable of supporting up to 31 channels of analog/digital signal processing. The number of measurements that a channel can handle is dependent upon the type of signal being processed. For example:

- A thermocouple channel (card) can process 8 thermocouples
- An accelerometer channel (card) can process 2 accelerometers
- A bridge circuit channel (card) can process 4 bridge circuits

Each node is capable of streaming 10 Mbps. The processing rates for the DFI system configuration on the first four K-1 flights, along with the expansion capability available, is shown in Table 3-8 and Table 3-9. This information is provided for planning purposes to give experimenters a general idea of system capability. For SLI Add-On Technology Experiment Flights, Kistler can reconfigure existing DFI channels for experiment use or expand the number of channels used.

Table 3-8: LAP DFI Processing Rates

Node	Samples per Second Processed ($x10^6$)	Channels Currently Used	Expansion Available
LAP 1	0.834	12	19
LAP 2	0.599	10	21
LAP 3	1.076	20	11
Total	2.509	42	51

Table 3-9: OV DFI Processing Rates

Node	Samples per Second Processed ($x10^6$)	Channels Currently Used	Expansion Available
OV 1	2.895	17	14
OV 2	1.210	13	18
OV 3	0.762	10	21
OV 4	0.699	10	21
Total	5.566	50	74

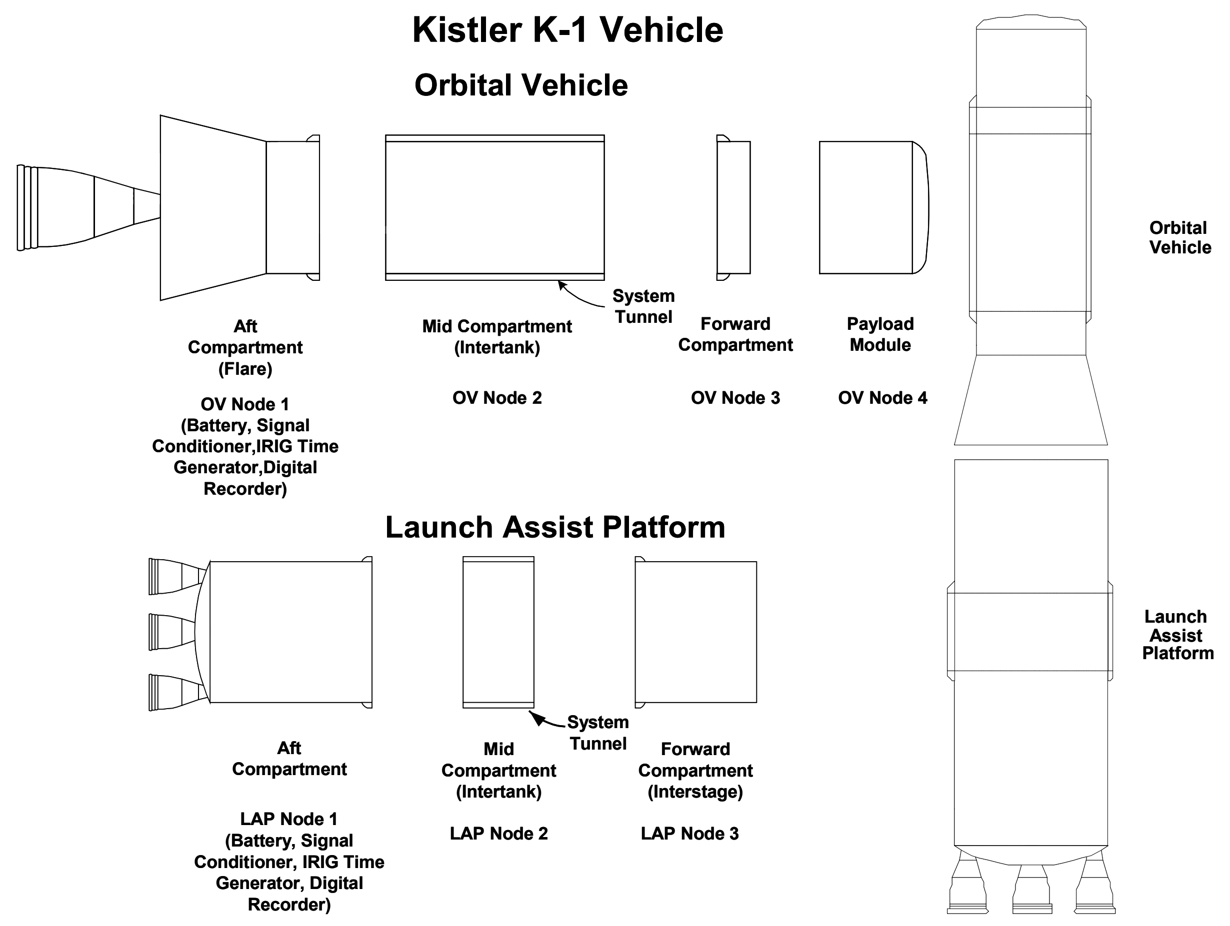


Figure 3-8: Baseline K-1 Distributed DFI System

The baseline DFI system does not send DFI data to the ground. Real time data is collected and recorded in a solid-state recorder (one each on the LAP and OV stages). Each recorder is capable of recording four 10 Mbps Pulse Code Modulation (PCM) streams simultaneously. The baseline memory in each recorder is 1 GB, expandable to 4.5 GB. If required, limited telemetry downlink can be provided for an additional price. Kistler will work with experimenters who require telemetry to further define this capability.

3.5 Experiment Integration Facilities

Integration facilities required by experiment support crews vary on a case-by-case basis. As a baseline approach, Kistler will set aside space in its VPF for use by the experiment's support crew as required. Kistler's approach to SLI experiments is to integrate them as part of the normal maintenance and refurbishment process of the K-1 stages. Therefore, placing the experimenter's support facilities in the VPF will facilitate experiment integration into the K-1, which is refurbished and maintained in the same room. If required, Kistler can segregate the experimenter's area within the

VPF, or provide a separate facility outside the VPF for use by experimenters.

If clean facilities are required, Kistler can also provide the experiment support crew with a payload station in its PPF. The availability of the payload station is subject to coordination with Kistler's payload customers. The PPF is designed to support satellite processing, test, and integration. The PPF includes two highbay payload processing work areas, two processing control rooms, a highbay payload module processing and hazardous operations area, a master airlock, a support equipment storage area, and the necessary office and personnel facilities. The Kistler Mission Control Center is also located in the PPF. Processing areas in the PPF are ISO Class 8 clean facilities. Ultimately, experiments in the clean facility must be moved into the VPF for integration into the K-1.

Section 8 of the *K-1 Payload User's Guide* describes Kistler's Woomera launch site in greater detail. It also includes information on accommodations and transportation in the Woomera area. The VPF and PPF are pictured in Figures 3-9 and 3-10.

Section 3.4 of Appendix A-1 and A-2 detail the specific allocation of processing, office, and storage space given to each experimenter as a standard service.

3.6 Optional Services

Experiments requiring K-1 accommodations beyond those described in this document are not necessarily Non-Standard Experiments. Some additional accommodations for standard experiments can be provided as optional services. All optional services are offered for an additional integration price, to be determined by the specific detail of the service. Some optional services include:

- Additional flight-phase power
- Excess data storage
- Pressurized ECOBOX
- Additional launch-site processing, office, or storage facilities

Section 6 of Appendix A-1 and A-2 detail the optional services available for standard experiments.

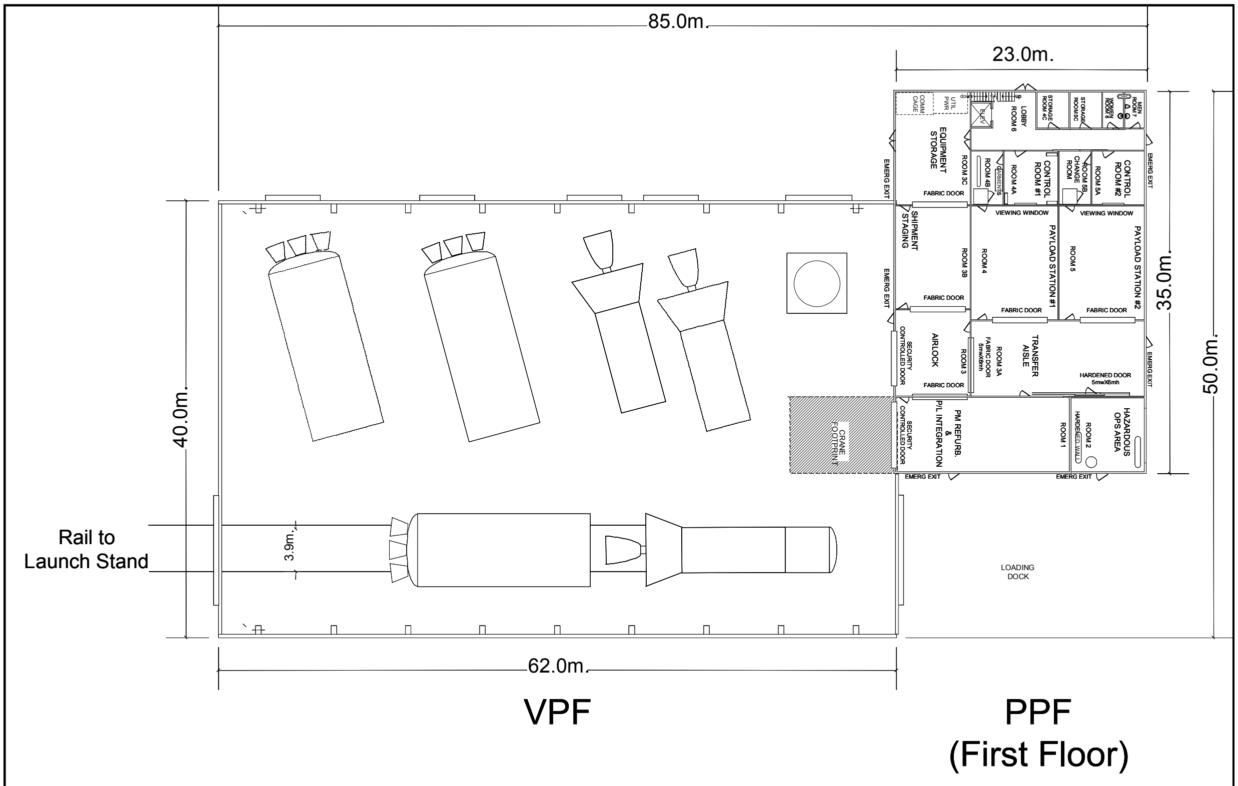


Figure 3-9: Vehicle Processing Facility and Payload Processing Facility

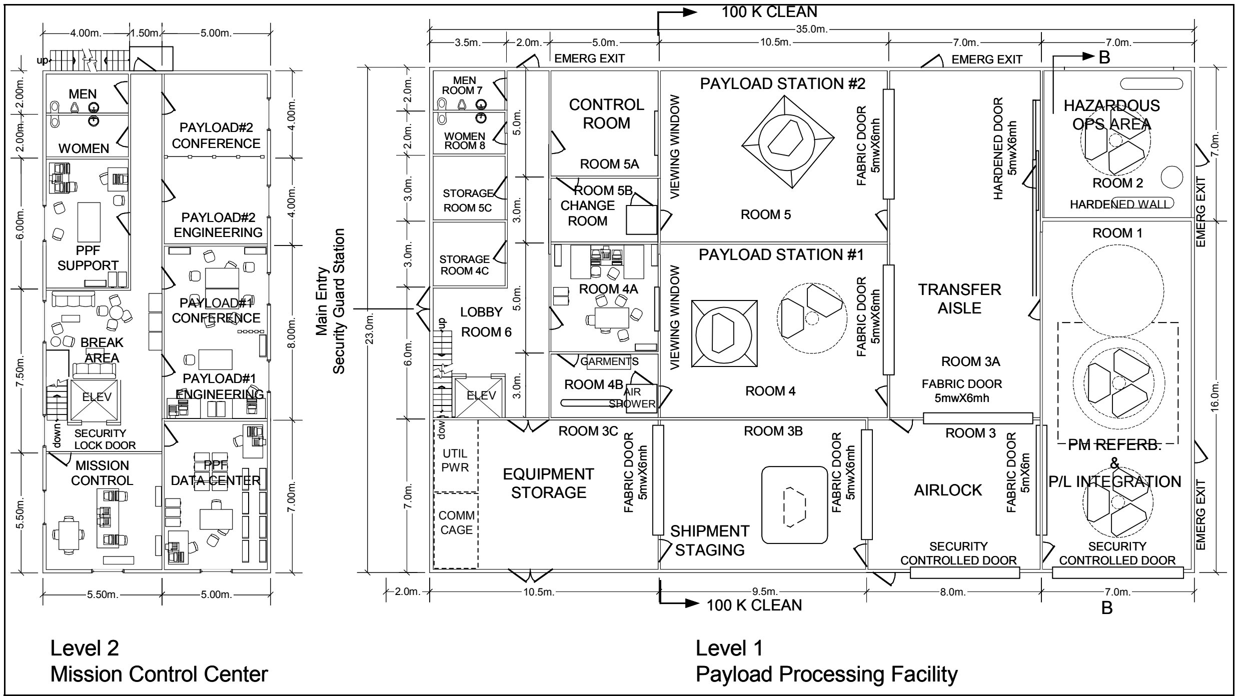


Figure 3-10: Payload Processing Facility

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IV. DESIGN AND VERIFICATION REQUIREMENTS

This section provides an overview of requirements guidelines for the design and verification of experiments intended for flight on the K-1 as part of the NASA SLI program. Section 4 of Appendix A-1 and A-2 contain additional detail. Kistler suggests using MIL-STD-1540 as a guide for conducting verification. Verification requirements for each experiment will be documented in the Experiment Interface Control Document (ICD). Guidelines for externally mounted (passive) and internally mounted (active) experiments are presented. Unless otherwise noted, analysis and testing is the responsibility of the experiment contractor.

4.1 General Requirements

This section presents general requirements guidelines for all SLI experiments to be flown on the K-1 vehicle.

4.1.1 Failure Modes Analysis

Kistler expects the experimenter will perform a Failure Modes Analysis early in the program to document the potential consequences of experiment faults. If the experimenter requires data on the K-1 vehicle to complete this analysis, Kistler will support this activity.

4.1.2 Fit Check

A fit check will be performed to verify critical mechanical interfaces between the experiment and the vehicle. Actual Kistler-provided interface flight hardware (trays, carrier plates, and electrical connectors) and electrical interface simulators between the K-1 and the experiment will be used during the manufacturing process to assure satisfactory fit check results.

4.1.3 Ordnance and Hazardous Materials

Kistler cannot allow experiments with pyrotechnic devices or hazardous materials to be installed on the K-1 vehicle.

4.1.4 Reflight of Experiments

Once an experiment has successfully flown on the K-1, Kistler expects the experimenter will conduct verification activities prior to the next flight of the same experiment.

4.2 Verification for Externally Mounted Experiments

This section presents guidelines for verification requirements of experiments externally mounted in the K-1 OV. Some experiments may require more verification activities than outlined here, such as thermal vacuum or thermal cycling tests.

4.2.1 Bond Verification

All bonding operations of a TPS material to a carrier plate will be verified by the experimenter using procedures based on Space Shuttle bond verification. For tile experiments directly mounted to exterior of the K-1, Kistler will perform the bond verification test in the VPF after integration.

These tests will verify bond integrity for all predicted static and dynamic loads.

4.2.3 Arcjet Testing

Table 3-3 describes predicted heating environments experienced at different mounting locations during OV reentry. A qualification flight article of the externally mounted experiments should be verified through arcjet testing to these environments with 25% margin added in each case, unless existing test data on the material to the required test environment exists.

4.2.4 Aerodynamic Verification

Additional aerodynamic analysis and testing may be necessary for experiments planning to exceed the vehicle OML by greater than 2 inches. No OML exceedance is allowed for experiments mounted in Footprint #1. Kistler will work with the experimenter to define what, if any, additional verification activities will be required.

4.3 Verification for Internally Mounted Experiments

This section presents guidelines for test requirements of experiments internally mounted in the K-1. In certain cases, if adequate test data on sensitive components does not already exist, a thermal vacuum test, a thermal cycling test, hardware-in-the-loop testing, or other tests and analysis may be required.

4.3.1 Factors of Safety

The limit load factors for flight of internally mounted experiments are given in Figure 3-7. Ultimate load factors are obtained by multiplication of the limit load factors by a factor of safety of 1.5. The experiment must be capable of sustaining the loading cases derived from the ultimate load factors.

4.3.2 Structural Load Tests

Static load testing is performed by the experimenter to demonstrate the design integrity of the payload primary structural elements. Static load testing should be performed unless the design factor of safety is 2.0 or greater. The maximum load factors given in Figure 3-7 are to be multiplied by 1.10 to determine the acceptance static test load.

4.3.3 Vibration Test

Table 3-6 describes the predicted vibration spectrum in each mounting location. Random vibration testing on the flight article should be performed unless existing test data exists for all vibration-sensitive components. The test environment should be applied in all three axes, one at a time. The random vibration margins and duration for acceptance testing are +3 dB over predicted flight levels for 60 seconds.

4.3.4 RF / EMI Compatibility Evaluation

As described in section 5.4.4, Kistler performs RF/EMI compatibility evaluation as part of its standard mission analysis for every launch. The experimenter must supply the RF/EMI characteristics of their experiment to support this activity.

V. MISSION MANAGEMENT

5.1 Roles and Responsibilities

Figure 5-1 shows the top-level organization of the K-1 Flight Demonstration Project under the SLI. The Flight Demonstration project is integrated into the existing Kistler organization responsible for the design and development of the K-1 vehicle. Kistler's Chief Engineer serves as Program Manager for the SLI Flight Demonstration contract. The Kistler Deputy Program Manager will manage the integration of Add-On Technology Flight Experiments and is the primary point of contact for SLI experimenter contractors.

SLI experiment contractors are responsible for designing and developing their technology experiment and performing verification activities required by Kistler to fly on the K-1. Kistler will be responsible for K-1 preparation, mission planning and analysis, and flight operations. Vehicle preparation includes all modifications to the vehicle required to integrate the experiment, instrumentation calibration, and installation support. Mission planning and analysis includes all compatibility analysis required to verify that the experiment is ready for integration and flight. Flight operations includes test & checkout, verification of flight readiness, vehicle fueling, launch, mission support, and vehicle recovery. The launch facility at Woomera, Australia provides space for each experiment supplier to integrate and checkout its equipment prior to flight, as described in section 3.5.

The specific responsibilities of Kistler Aerospace and each experiment contractor are described here.

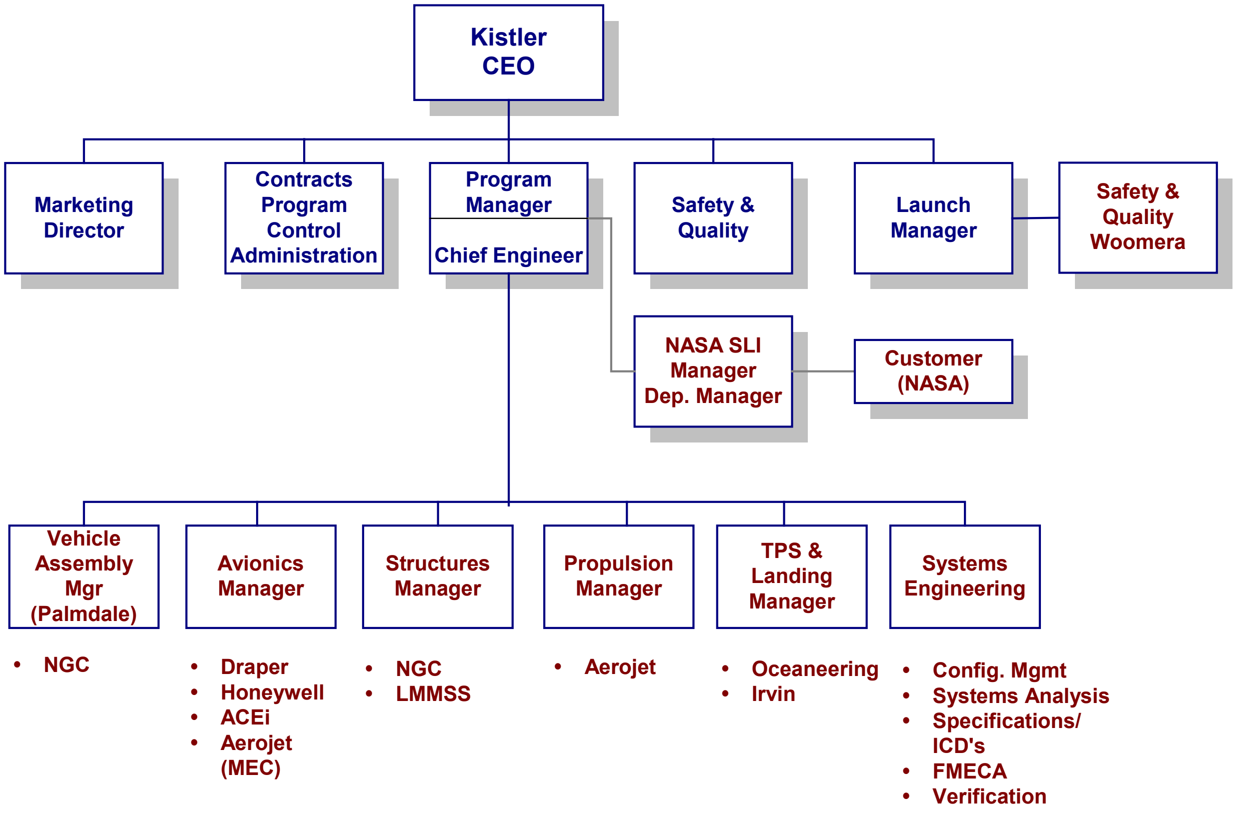

Figure 5-1: Kistler SLI Organization

Responsibilities of each flight experiment supplier include:

- Design and develop the flight experiment.
- Perform all research and development of the risk reduction technology as contracted.
- Review FEDR (including IDRD) and provide response to Preliminary and Detailed Experiment Questionnaire.
- Perform verification activities on the experiment hardware, including risk assessment, as specified in the ICD.
- Provide technical data to support Kistler's evaluation of the experiment to ensure K-1 vehicle safety and integrity.
- Support experiment installation at the launch facility.
- Support experiment test and checkout at the launch facility.
- Support experiment removal and return to supplier facility.

Responsibilities of Kistler Aerospace include:

- Provide overall program management functions for flight demonstrations and experiment integration.
- Develop integrated schedule for each manifested flight.
- Verify safety and readiness of each flight experiment (via oversight and analysis) prior to vehicle integration.
- Design and develop the standard mechanical and electrical interfaces (including the EMU) to K-1 vehicle and document in the FEDR
- Develop the ICD between the experiment and the K-1 based on the FEDR and the Detailed Experiment Questionnaire provided by the Flight Experiment Supplier. Kistler will approve and control this document.
- Provide facility space in Woomera, Australia for technology experiments.
- Provide all of the launch services support required to integrate, prepare, launch, and recover the K-1 vehicle.
- Reduce flight data and provide flight evaluation reports for each experiment.
- Shipping of hardware to and from the launch facility in Woomera, Australia and obtaining appropriate approvals for export control with the Department of State.

5.2 Standard Integration Process Flow

Figure 5-2 defines the nominal experiment integration process flow from experiment conception through flight. Experiment development milestones are not included in the figure. The integration process for Non-Standard experiments requiring significant modification to the K-1 (such as replacement of a tank or an engine) or for a pallet-mounted experiment requiring significant instrumentation and data recording may require a more complex integration process.

5.3 Standard Mission Scheduling

The NASA SLI Program Office will exercise options for Add-on Technology Experiment Flights on the K-1. Kistler will work with the NASA SLI Program Office and TA2-9 contractors to coordinate and integrate as many experiments as possible on each technology flight while maintaining an acceptable level of risk and staying within the bounds of the experiment accommodations described in this document.

The first Add-on Experiment Flights can occur in conjunction with K-1 flights #2 - #4. The amount of lead-time required before flight will vary depending on the complexity of the experiment. Externally mounted experiments or internally mounted experiments, for example, will be easier to integrate and verify than Non-Standard Experiments. A representative 10-month schedule for integration and launch of a standard active experiment is shown in Figure 5-3. The nominal passive experiment schedule is nearly identical. This schedule assumes development of the flight technology experiment is complete or nearly complete. The integration process for Non-Standard experiments requiring significant modification to the K-1 (such as replacement of a tank or an engine) or for a pallet-mounted experiment requiring significant instrumentation and data recording may require more time.

5.3 Meetings and Reviews

A series of meetings and reviews will support coordination between Kistler, NASA, and the experiment contractor. Figure 5-2 and Figure 5-3 show a representative series of reviews for flight demonstration missions, including a Kickoff Meeting/Requirements Review early in the program, an Integrated Experiment Design Review, and a Flight Readiness Review before launch. Section 8 of Appendix A-1 and A-2 provides greater detail on the purpose and goals of each meeting.

5.4 Documentation

Figure 5-3 lists the titles and nominal due dates of all documents (data deliverables) to accomplish integration of standard experiments onto the K-1 vehicle. Section 8 of Appendix A-1 and A-2 provides greater detail on the content of each document.

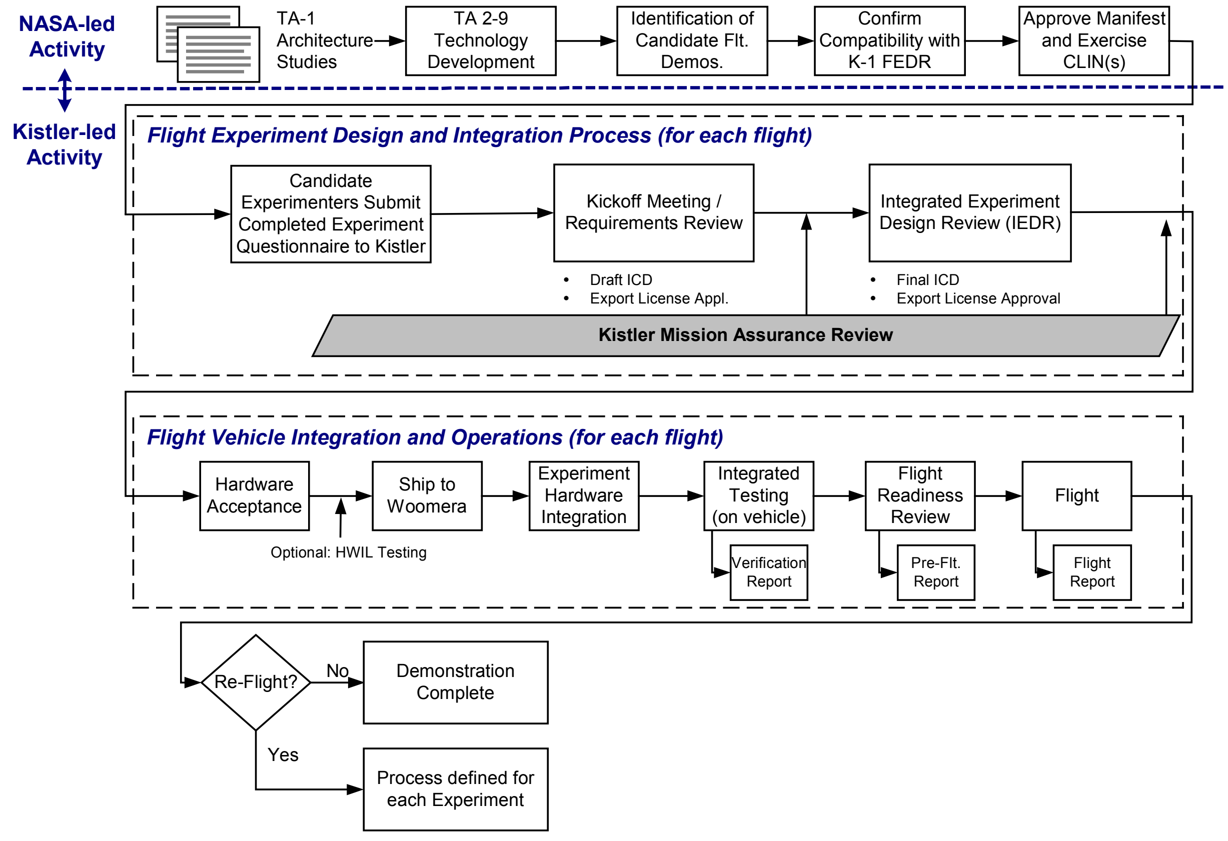

Figure 5-2: Integration Flow for Standard Flight Experiment on K-1

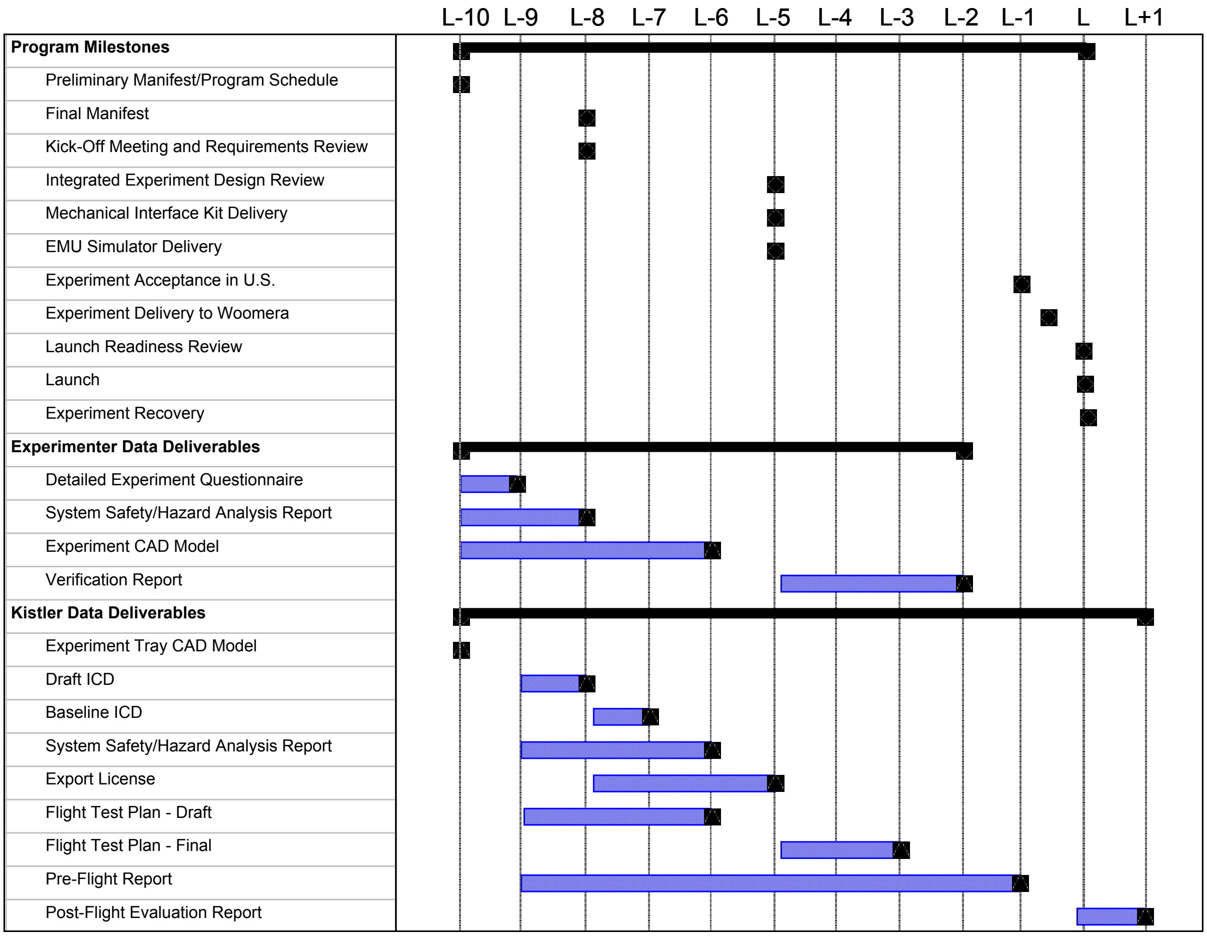

Figure 5-3: Schedule for Integration of Representative Standard Active Experiment on K-1