Space Launch
Sample Mission 1

Mission Requirements Document (MRD)
F0XXXXXX
D.O. SM-1

18 May 2011

REVISION HISTORY			
REVISION	DATE	SECTION AFFECTED	COMMENTS
BASIC	18 May 2011	N/A	N/A

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1 INTRODUCTION

1.1 OVERVIEW

This document provides the mission requirements for the Orbital Suborbital Program Contract – 3 (OSP-3) launch of a satellite under Sample Mission 1 (SM-1). The SM-1 is a space mission being sponsored by the Navy. The US Air Force, Space and Missile System Center (SMC) Rocket Systems Launch Program (RSLP) office, Space Development and Test Directorate (SD)/Launch Systems Division (SDL), will provide the Launch Vehicle (LV) and launch services for the SM-1 mission through the OSP-3 contract. The Navy will be responsible for coordination of the Space Vehicle (SV) activities.

The baseline launch location for this mission will be from Vandenberg AFB.

The Initial Launch Capability (ILC) is June 2015.

This will be an OSP-3 Category 2 mission, with flightworthiness certified by SMC.

1.2 SCOPE

The purpose of this document is to serve as the controlling source and authority for the SM-1 mission requirements. In addition to specifying mission requirements, this Mission Requirements Document (MRD) will:

a. Identify roles and responsibilities and interfaces among the various contractors and Government agencies supporting the mission.

b. Document data provided by the agencies furnishing the SV to be used by the LV Contractor (LVC) in developing the LV configuration, integrating the SV, targeting the LV, processing the flight hardware, and conducting the mission.

c. Identify constraints and environments the SV must meet.

d. Identify test and analysis requirements to verify interfaces between the SV and LV and to verify required SV characteristics.

e. Define mission specific SM-1 requirements.

The MRD will be maintained by SMC/SDL. In many cases, the detailed requirements and data will be specified in other documentation, which will be referenced herein. This includes documents such as the OSP-3 Statement of Work (SOW) and the LV/SV Interface Control Document (LV/SV ICD), which identifies detailed SV interface requirements and the range requirements documentation developed in accordance with the Universal Documentation System (UDS).

1.3 MISSION OBJECTIVES

The primary goal of the SM-1 mission is to launch an SV with and astrometric optical payload into a circular sun synchronous orbit with a local time of ascending node of 6:00 am at an altitude of 900 kilometers (km), with high insertion accuracy.
The SV will be launched into an insertion orbit by the LV. The SM-1 SV will separate from the LV via a SV provided motorized lightband separation system. Following the separation event, the LV will perform a Collision/Contamination Avoidance Maneuver (C/CAM) to minimize contamination and potential recontact with the SV. The orbit shall nominally be a circular 900 km with a SM-1 baseline inclination of 99 degrees.

Specific objectives for the boost and insertion portion of the mission are as follows:

Insertion Orbit: Deliver the SV to a 900 ± 18.5 km circular orbit at an inclination of 99 ± 0.05 degrees.

Collision Avoidance: The LV shall perform a collision avoidance maneuver to minimize payload contamination and preclude re-contact between the deployed SV and the LV.

Environments: Provide a boost environment that does not exceed the levels defined in the LV Users Guide. Specific environments will be defined in the LV/SV ICD.

Telemetry: Telemeter navigation, attitude, and environments to verify mission requirements and post flight evaluation through all mission events. No SV data will be embedded in LV telemetry.

1.4 ROLES AND RESPONSIBILITIES

The roles and responsibilities among agencies and contractors that will support the SM-1 mission are described below.

Customer: The SV provider and customer of RSLP. The Customer Space Vehicle Contractor (SVC) is responsible for manufacturing and testing the SV as well as supporting joint LV/SV integration procedures. Additionally, the SV Space Program Office (SPO) will provide submissions for the LVC's Range Safety documentation at the request of SMC/SDL.

SMC/SDL: SMC/SD is located at Kirtland AFB, NM, is responsible for launch services including range support, LV integration, SV interface and mating, and launch services. Within SMC/SD, SDL is the division for Research and Development (R&D) and Space launch missions and is responsible for the OSP-3 launch systems and launch operations.

TASC: Systems Engineering and Technical Advisor to SMC/SDL. TASC provides Mission Assurance (MA) and Independent Verification and Validation support to the program. Higher level risks identified by TASC will be sent to the Customer in monthly status updates provided by the Mission Manager (MM) and overall risk assessments of the program will be addressed in design reviews and readiness reviews.

LV Contractor: SMC/SDL contracted with LV Contractor (LVC) to provide the LV design, integration, and interface to the SV, vehicle mating, mission planning and launch of the LV.

2 LAUNCH SYSTEM CONFIGURATION

The proposed LV system configuration will meet the Technical Requirements Document (TRD) requirements.

The OSP-3 enhanced capabilities for this mission are:

- Enhanced fairing cleanliness Level 300
- Enhanced insertion accuracy (Hydrazine Auxiliary Propulsion System(HAPS))
- Conditioned air
- Extra access panel
- Soft Ride

Mission specific additional performance capabilities are detailed in the LV/SV ICD.

3 SPACE VEHICLE REQUIREMENTS

3.1 SPACE VEHICLE CONFIGURATION

Envelope:

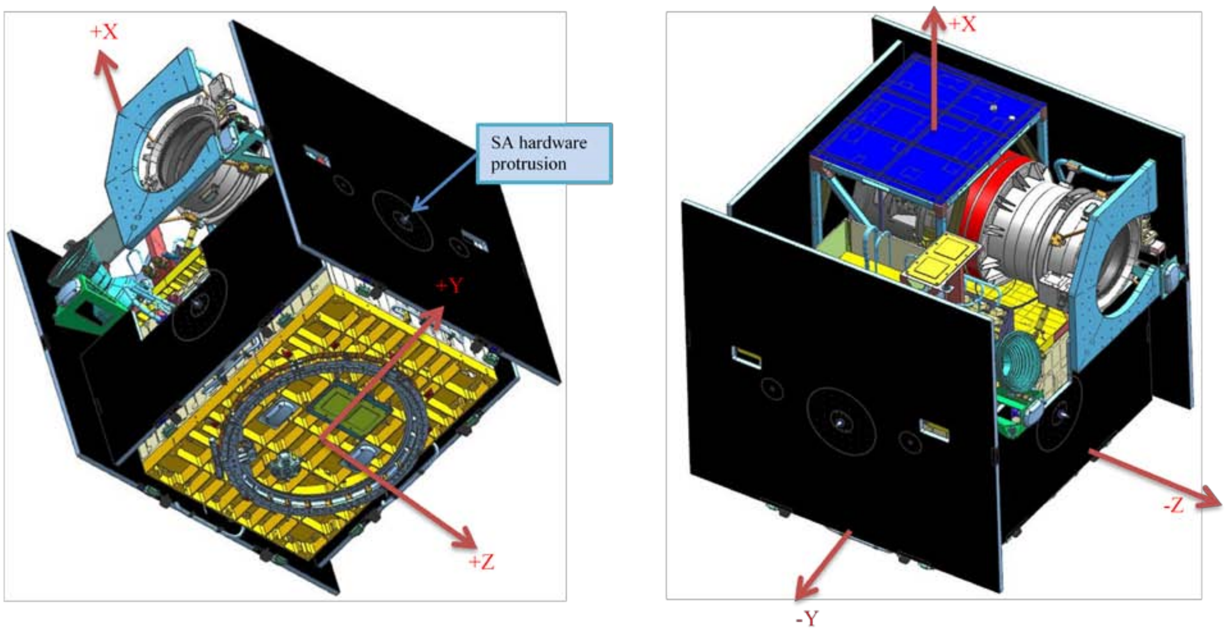

Figure 3-1: SM-1 SV Static Envelope

	Inches	Main Envelope Description	Inches	Extended Envelope Description
X-Direction	38.03	Radiator to bottom of Bus	40.13	Radiator to bottom of Light Band
Y-Direction	34.96	From +Y to –Y Solar Array Panels	32.86	SA Hardware Protrusion
Z-Direction	37.85	Edge of +/- Y SA to GPS Antenna on ST Bracket		

Table 3-1: Envelope Parameters

Interface: The SV shall interface using a 19.7 inch diameter motorized lightband separation system.

Solar Arrays: The SV is powered by 4 hinged solar arrays as shown.

Ordnance: Initiation of motorized lightband

Propulsion System: The SV has no Propulsion.

Hazardous Systems: The SV has a Lithium Ion Battery.

3.2 MASS PROPERTIES

Weight = 218.43 kg (Includes SV and lightband only!)

SV Center of Gravity			SV Inertias					
inches			$lb_m \cdot in^2$					
x	y	z	Ixx	Iyy	Izz	Ixy	Ixz	Iyz
17.51	-0.148	-0.232	71,650.47	79,533.33	90,289.47	3,676.67	495.27	294.26

Table 3-2: Mass Properties

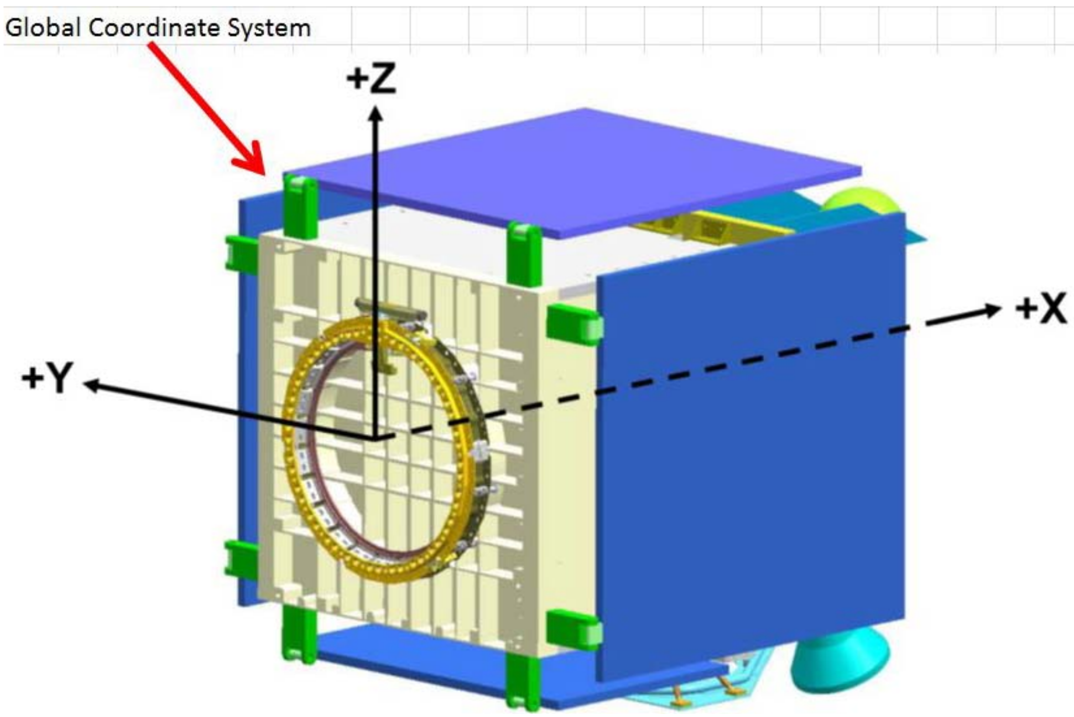

Figure 3-2: SM-1 SV Mass Properties Coordinate System

3.3 SPACE VEHICLE ENVIRONMENTS AND STRUCTURAL CHARACTERISTICS

The SV, when integrated with the separation system and payload, shall have a first modal frequency as detailed in the LV/SV ICD. An initial Finite Element Model (FEM) of the SV shall be provided to the LVC for use in the Coupled Loads analysis (CLA). The FEM will be test-verified to ensure the FEM used for the CLA is accurate.

3.4 SPACE VEHICLE ELECTRICAL INTERFACES

3.4.1 Space Vehicle Separation Signals

The separation system is SV provided and will be separated via primary and redundant commands from the LV. The LV shall detect a positive indication of SV separation and include a separation confirmation in the LV telemetry data, through a minimum of two loopbacks.

3.4.2 Communication Interfaces

The SV will not require communication with the LV. The LV will provide pass through circuits for SV communication with SV GSE.

3.4.3 RF Sources

The LV and the SV shall include the RF sources and receivers identified in Table 3-3. The SV transmitters shall not be turned on prior to separation from the LV. The LVC will verify compatibility of the selected frequencies for any pre-launch periods in which simultaneous operation is present or implement procedures so that no simultaneous operations occur.

SOURCE	FREQUENCY (MHz)
LV	
Telemetry Transmitter	TBD
C-Band Radar Transponder	
Transmit	TBD
Receive	TBD
GPS Transmitter	TBD
Command/Destruct Receiver	TBD
PAYLOAD	
SGLS Receiver	1781.818359
SGLS Transmitter	2225.1
X band Transmit	8190

Table 3-3: RF Sources

3.4.4 Ground Power

The launch system shall provide pass through for the SV Electrical Ground Support Equipment (EGSE) to provide power to the SV through circuits to be defined in the LV/SV ICD

3.4.5 Command, Control, and Monitor

The launch system shall provide the maximum number of ground umbilical circuits to the SV until launch. The ground umbilical circuits shall include at least six pairs of twisted shielded cable that is suitable for RS-422 serial communications, in addition to the power requirement in 3.4.5. The umbilical shall provide the capability to remotely control and monitor the SV and charge batteries using GSE furnished by the SV contractor.

3.4.6 Space Vehicle Initialization Signal Sequence

The SM-1 SV shall require four primary, and four redundant 26V - 34V, 5amp to 12amp initialization signals. Each signal shall be 0.05 seconds in duration. The first pair of primary initialization signals will be commanded 2 seconds after the LV completes maneuvers to the required separation attitude, defined in section 5.4, redundant initialization signals will be commanded 0.25 seconds after the primary signals. The second pair of primary initialization signals will be commanded 30 seconds after the first pair of redundant initialization signals followed by redundant initialization signals commanded 0.25 seconds after the second pair of primary signals.

3.5 THERMAL ENVIRONMENT

The SV shall be maintained within a temperature range of +55° F to +84° F during ground processing up until launch. SV thermal heat load from SM-1 core electronics will be defined in the LV/SV ICD. The internal wall temperature of the payload fairing shall be maintained below 200 deg F during ascent to minimize payload heating. Thermal environment and relative humidity conditioning must be provided to the SV at all times prior to launch except during transport to West Coast Spaceport and during the Upper Stack Emplacement, subsequent to further analysis and understanding of the thermal environments during transport and emplacement by the SV customer. Relative temperature and humidity requirements will be defined in the LV/SV ICD.

3.6 CONTAMINATION

The SV must be maintained at a surface cleanliness level of 300 or better throughout all launch processing activities through separation. During ground processing, the SV shall be bagged and purged with clean nitrogen meeting the requirements of the cleanliness specification. SV operations that require removal of the protective bagging material (eg. Encapsulation processing), shall be performed in a class 100 clean tent. Even while bagged the vehicle shall be maintained in a class 100,000 (preferably 10,000) clean room facility.

The fairing shall be cleaned and verified to level 300 or better prior to encapsulation. The environment internal to the fairing after encapsulation shall be configured and monitored to maintain level 300 surface cleanliness until launch. Air flow into the fairing shall be filtered and conditioned to maintain this cleanliness level. Any entry to the fairing after encapsulation shall take proper precautions to maintain cleanliness levels. It is anticipated that a positive pressure of filtered and conditioned air or nitrogen shall always be present inside the fairing. In addition, the SV payload instrument shall have a fly away nitrogen purge connection and shall be kept under constant purge until launch. Temporary loss of fairing air conditioning for lifting operations may be possible but instrument purge must remain at all times.

3.7 Electromagnetic Interference/Electromagnetic Compatibility (EMI / EMC)

The LVC shall establish maximum radiated and conducted emission levels that the LV might generate. These levels will be documented in the LV/SV ICD. The SV will incorporate these criteria as well as environments from the applicable launch site (radars, etc) in their design requirements. The LVC shall also establish maximum levels the SV can conduct or radiate while mated to the LV. In general, the SV shall not radiate any time after encapsulation in the fairing and until a defined time after separation from the LV after orbital insertion. Any required deviations to this requirement shall be coordinated with the LVC and documented in the LV/SV ICD. The SV provider shall ensure these requirements are met through good design practices and analysis.

3.8 SAFETY DOCUMENTATION

RSLP will provide system safety documentation (including range approved SV related safety documentation) to the LVC for attachment to the LVC safety documentation, as required. The LVC shall submit all LV safety documentation for range approval in accordance with AFSPCMAN 91-710 requirements. The LVC shall ensure hazards have been adequately addressed at the system level. Documentation from the Navy for the SV will include as a minimum:

a. Preliminary Hazards Analysis identifying potential hazards and plans for mitigating them.

b. A System Hazards Analysis Report (SHAR) or equivalent documentation demonstrating that all hazards are identified and controlled in compliance with AFSPCMAN 91-710 and RCC 319.

All other interfaces (e.g. telemetry, flight safety, ground safety, CONOPS, etc) shall be documented in the UDS documentation.

4 VERIFICATION REQUIREMENTS

Verification testing shall be conducted to verify the compatibility of hardware supplied by different contractors/government agencies and to verify certain SV/LV integration characteristics. Analyses may be used in place of testing upon approval by SMC /SDL.

LV top-level test requirements are defined in the following paragraphs. Detailed test requirements will be documented by the LVC as part of the Integrated Test Plan. These requirements will be coordinated with the participating agencies and approved by SMC/SDL. The test procedures prepared by the test conductor shall also be submitted 30 days prior to testing, for review, to ensure compliance with the approved test requirements.

4.1 DESIGN VERIFICATION TESTS

Design verification tests are conducted to establish confidence in compatibility between two or more contractors' hardware. The test conductor shall prepare a test report summarizing the test set up, the results, and any anomalies.

4.1.1 Integrated Mechanical / Structural Analysis and Verification Tests

A series of mechanical/structural tests shall be conducted at the LVC facilities. The LVC shall conduct the testing with the greatest level of SV Team participation possible. The LVC and SV provider will provide flight representative hardware to support conduct of the testing.

4.1.1.1 Launch Vehicle / Space Vehicle Mechanical Interface Verification

A mechanical fit check shall be performed to verify LV/SV ICD mechanical compatibility between the LV and the SVseparation system, including cable routing and connections and any areas where there are potential interference issues. The LVC and the separation system provider will provide flight representative hardware to support the fit check. The fit check will be performed at LV Ktr facility.

4.1.1.2 Launch Vehicle / Space Vehicle Coupled Loads Derivation

A CLA will be performed by the LVC to predict the maximum loads that can be expected by the SV during the spacelift event. The CLA will address key loading events including lift-off, maximum dynamic pressure, transonic, staging/ignition events and will include steady state conditions. Preliminary CLAs will be performed based on preliminary SV provided models to support SV design and test programs. A final verification loads cycle will be performed with test verified models.

4.1.1.3 Space Vehicle Structural Integrity Test

The SV provider will verify that integrated loads derived through the CLA, described in Section 4.1.1.2, are acceptable for their SV or otherwise design the necessary modifications to meet those loads.

The SV provider will be responsible for all structural tests required on the SV side of the interface to verify this requirement. The required tests will be conducted by the SV using flight representative hardware and will require a loads profile from the LVC, in order to conduct the analysis and run the test. Also, it is desirable for the SV provider to have access to the separation system during the test.

4.1.1.4 Modal Survey

Finite Element models of the LV and the SV are required for flight analysis. The payload provider will provide a preliminary SV math model for initial flight analysis. A test verified SV math model will be provided for the final flight analysis and final load cycle analysis. A modal survey (preferred) or other SV approved method is required.

4.1.2 Electrical Verification Tests

4.1.2.1 Aerospace Vehicle Equipment (AVE) Electrical Verification

Testing shall be conducted to verify the electrical interface between the LV and SV. The test will use flight representative hardware furnished by the LVC and applicable SV components furnished by the SV and separation system contractor. The test shall include the complete exercise of all electrical interfaces between the LV, separation system and the SV. Integrated test procedures shall be reviewed and approved by participating agencies. The location of the test will be proposed by the LVC.

4.1.2.2 Space Vehicle / Launch Site Electrical Compatibility

A design compatibility test to establish high confidence in electrical compatibility of the SV and SV Ground Support Equipment (GSE) with the launch complex will be performed at the launch site. The SV provider will prepare the test procedure and conduct the test. The LVC and the Range will support the test as required. The LVC will only need to provide support personnel and the SVC will supply all GSE (dependent upon review of the proposed launch site).

4.2 LAUNCH VERIFICATION TESTS

These tests are the receipt-through-launch processing in support of each flight. An Integrated Field Processing Procedure (IFPP) will be prepared by the test conductor in each test. No formal test reports are required; however, all anomalies shall be documented by the LVC. The results of the tests are assessed in post-test readiness reviews, and the test team certifies flight readiness.

4.2.1 Launch Vehicle / Space Vehicle Processing

Integrated LV/SV processing is performed in preparation for emplacement on the booster at the launch site. The LVC shall mate the SV to the LV with the SV contractor's support. The SV contractor shall furnish certified handling/GSE required to interface from the crane hook (or other GSE) to the SV, which is required during the integration process. GSE at launch base will likely consist of a communication rack, power rack, crypto equipment, front end command/telemetry processor, and test equipment. This equipment will be used for SV State of Health (SOH) testing, LV interface verification, pre-launch configuration of the SV, and Air Force Satellite Control Network (AFSCN) compatibility testing.

Payload processing facility requirements include a Class 100K payload processing area of at least 150 sqft, and an enclosed GSE area of at least 1050 sqft, and use of an overhead crane rated to at least 3000 lbs. SV personnel will have access to the SV 24/7 up to a three week period prior to payload integration with the LV. Navy will select a processing location that best meets these overall requirements. A class 100 clean tent shall be made available to support encapsulation operations when the SV will be outside its protective bagging material.

4.2.2 Flight Integration Test with Launch Vehicle

The flight integration test shall be performed using the flight hardware to verify electrical compatibility and system performance with the LV upper stack and stages prior to stacking at the launch site. Integrated operations will be performed using procedures approved by participating agencies. The LVC will provide hardware for any LV required tests and the SV contractor will provide hardware for any SV required tests.

4.2.3 Space Vehicle Support Equipment Installation and Ground System Checkout

The SV contractor will install the required SV Support Equipment (SE) at the launch site in locations to be defined in the LV/SV ICD. The SV contractor will test the installed equipment with support from the LVC.

4.2.4 Launch Vehicle / Space Vehicle Emplacement

The SV shall be integrated and encapsulated at a facility at Vandenberg AFB, mated with the LV, then erected on the launch pad. This process will include mechanical mating, spurious voltage checks, and electrical connection.

4.2.5 Space Vehicle Post-Mate Checks

The SV post-mate checks will include the SV operational assurance tests and a compatibility test of the LV and SV systems, and the GSE interfaces. These checks will be conducted at the launch site by the SV provider, after SV mating with the LV is performed by the LVC.

4.2.6 Mission Simulation Test

A mission simulation test, or other suitable combined systems test, will be performed by the LVC and will include a simulated countdown exercising range interfaces to verify the operational readiness of the entire AVE and ground system. The term AVE refers to the entire launch system.

4.2.7 Mission Dress Rehearsal

A Mission Dress Rehearsal will be conducted with the entire launch team and will include a simulated countdown, exercising range interfaces to verify the operational readiness of the entire AVE/ground system. In addition, communication only practice countdowns and a “green card” exercise to practice anomaly handling and resolution will be conducted by key members of the launch team.

4.2.8 Launch Day Operations

The launch day operations shall include backout, prelaunch checkout, launch countdown, and site shutdown. The LVC shall prepare the countdown manual and procedures, incorporating inputs received from the SV, Range and RSLP program office (SMC/SDL). A Mission Constraints Document will be prepared by the LVC with inputs from the SV, and coordinated with SMC/SDL.

5 ORBITAL TARGETING REQUIREMENTS

5.1 FLIGHT PROFILE

The vehicle shall be placed in a 900 km circular sun synchronous orbit with a Local Time of ascending node at 6:00 am.

5.2 PLUME EFFECTS

The deployment sequence and thruster actions from the LV Attitude Control System (ACS) shall be performed in a manner to minimize interaction of the plumes with the SV. Plume effects will be verified through analyses by the LVC.

5.3 ACCURACY

Launch vehicle accuracy requirements are defined per the OSP-3 Technical Requirements Document (TRD), Insertion and non insertion apses accuracy ± 18.5 km, Inclination accuracy ± 0.05 degrees.

5.4 SEPARATION REQUIREMENTS

TBD

Figure 5-1: Origin of the SV Coordinate System

	LV Parameter	SV Parameter	Nominal Value	Tolerance (3 σ)
a.	Attitude Control +XLV Axis	+ZSV	Aligned with + Zenith	**1° half cone angle**
b.	Attitude Control +YLV Axis	+YSV	Constrained by X & Z axis Requirements	**1° half cone angle**
c.	Attitude Control -ZLV Axis	+XSV	Aligned to Positive Orbit normal	**5° half cone angle**
d.	Attitude Rate - Pitch and Yaw	N/A	1.0 deg/sec	**N/A**
e.	**Attitude Rate - Roll (Stabilized)**	**N/A**	**0± 1.0 deg/sec**	**N/A**

Table 5-1: Launch Vehicle separation Attitude and Rates

5.5 MISSION SPECIFIC C/CAM REQUIREMENTS

The LV shall perform C/CAMs as necessary after deployment to preclude re-contact with the SV, and meet the following 3 Sigma mission requirements:

Delta -V Axis: Negative Velocity Vector, Delta -V: 0.425 m/sec +/- 0.175 m/sec, (+/- 3 Sigma) Timing: Payload Deployment +TBD seconds.

6 ACRONYM LIST

ACS	Attitude Control System
AFB	Air Force Base
AVE	Aerospace Vehicle Equipment
C/CAM	Collision/Contamination Avoidance Maneuver
CG	Center of Gravity
CLA	Coupled Loads Analysis
D.O.	Delivery Order
EGSE	Electrical Ground System Equipment
EMI/EMC	Electromagnetic Interference/Electromagnetic Compatibility
FEM	Finite Element Model
FRR	Flight Readiness Review
GFE	Government Furnished Equipment
GSE	Ground Support Equipment
IBR	Integrated Baseline Review
ICD	Interface Control Document
IFPP	Integrated Field Processing Procedure
ILC	Initial Launch Capability
IRRT	Independent Readiness Review Team
km	kilometers
LEO	Low Earth Orbit
LRR	Launch Readiness Review
LV	Launch Vehicle
LVC	Launch Vehicle Contractor
MA	Mission Assurance
MDR	Mission Design Review
MM	Mission Manager
MOI	Moment of Inertia
MRD	Mission Requirements Document
MRR	Mission Readiness Review
NRO	National Reconnaissance Office
OSC	Orbital Sciences Corporation
OSP-3	Orbital Suborbital Program Contract – 3
PFR	Post Flight Review
PSR	Pre-ship Review
R&D	Research and Development
RAAN	Right Ascension of the Ascending Node

RF	Radio Frequency
SM-1	Sample Mission 1
RSLP	Rocket Systems Launch Program
SDL	Launch Systems Division
SE	Support Equipment
SHAR	System Hazards Analysis Report
SLV	Small Launch Vehicle
SMC	Space and Missiles Systems Center
SMC/SD	Space Development and Test Directorate
SMC/SDL	Launch Systems Division
SOH	State of Health
SOW	Statement of Work
SPO	Space Program Office
SRR	Systems Requirements Review
SVC	Space Vehicle Contractor
SV	Space Vehicle
TBD	To Be Decided
TDM	Technical Direction Meetings
TI/TD	Technical Interchange/ Technical Direction Meetings
TRD	Technical Requirements Document
UDS	Universal Documentation System
VAFB	Vandenberg Air Force Base

REFERENCES

Reference 1. OSP-3 TRD

Reference 2. AFSPCMAN 91-710

Reference 3. Range Commander's Council Flight Termination Systems Commonality Standard, Document 319-99, Sept 1999.

Reference 4. RCC 324-01, Global Positioning and Inertial Measurements Range Safety Tracking Systems' Commonality Standard, June 2001

Note: The Basic Contract takes precedence over any of the cited reference documents should a conflict exist.