PAYLOAD ORBITAL DELIVERY SYSTEM (PODS)

User's Guide

.

PODS – Users Manual
Rev 1

January 2017

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1 – INTRODUCTION

Overview

This document provides an overview of the rideshare options offered by Space Systems/Loral, LLC (SSL). For the purposes of this document, a rideshare is defined as a satellite that is designed to be a free-flyer and is dispensed from the host spacecraft at some point after the host's initial acquisition of signal. This document specifically does not discuss Hosted Payloads, which are defined as payloads that are permanently integrated onto the host spacecraft. For more information on Hosted Payloads, please refer to SSL's Hosted Payload Planner's Guide.

This document describes two methods to access orbit through ridesharing:

1. Use of the standardized approach to dispense the from an SSL 1300 satellite.
2. Design and build a custom solution to dispense the rideshare from the SSL 1300 spacecraft.

Each option has its own requirements which are described herein. Any custom solutions will have requirements similar to the options described in this document.

This document is a top-level overview of satellite rideshare possibilities. More detailed requirements and interface documents are available after executing nondisclosure agreements. Further inquiries can be directed to PODS@sslmda.com

Introduction to SSL

SSL is the leading supplier of commercial GEO satellites as illustrated in Figure 1. Our satellites provide critical capabilities for Entertainment, Internet Access and Remote and Global Access worldwide. SSL's leadership of the GEO market is demonstrated by:

- Typically 6 to 8 GEO launches annually, most representing rideshare opportunities; 11 launched in 2016
- Over 250 satellites built
- Over 100 1300-series GEO satellites launched and over 80 currently operational as of 4Q 2016
- Over 2200 years of on-orbit experience
- Leadership in GEO Satellite innovation and new service introduction
- Approximately 2500 employees based primarily in Silicon Valley

SSL has developed a rideshare service that grants frequent, cost-effective access for small spacecraft to GTO and GEO by leveraging our frequent access for large commercial satellites.

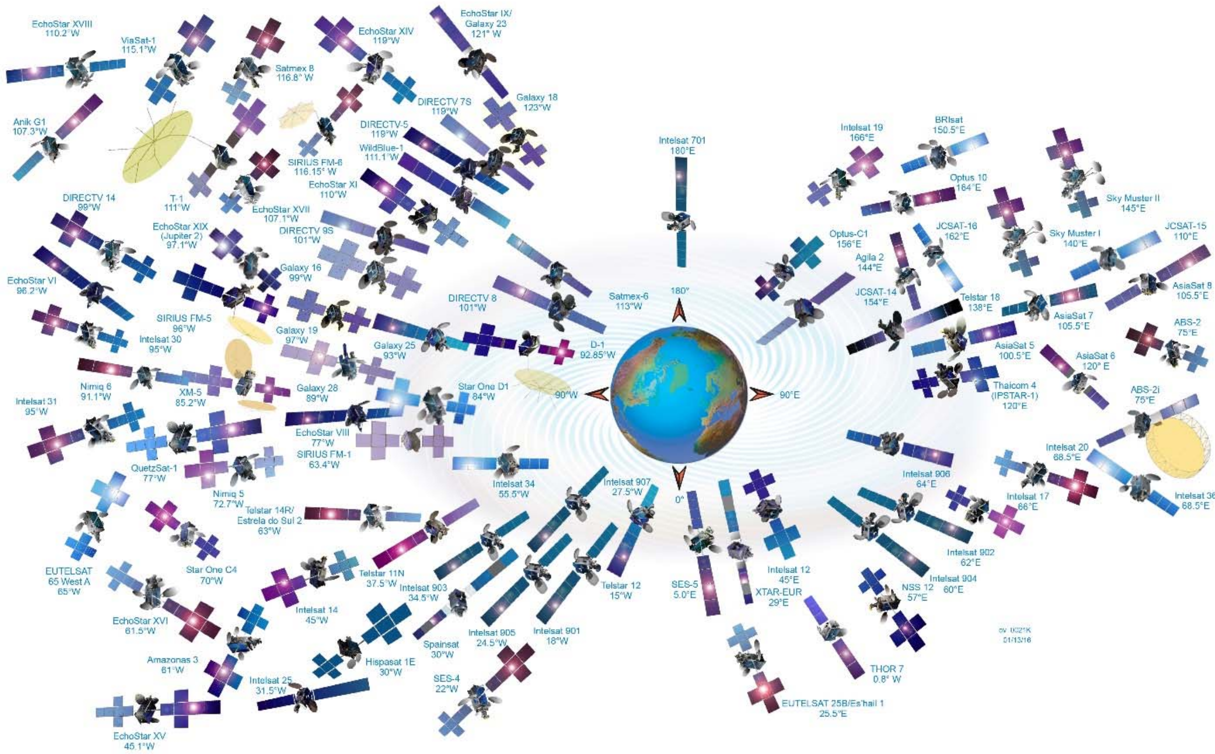

Figure 1. SSL is a World Leader in Commercial GEO Satellites

Introduction to SSL Rideshare

A rideshare is integrated on the host 1300 satellite; this not only yields access to space but it also eliminates any interfaces with the launch vehicle. SSL typically delivers between 6 and 8 spacecraft into geosynchronous orbit (GEO) orbit every year. Many of these spacecraft have the capability to dispense a rideshare partner into geosynchronous transfer orbit (GTO), GEO, or orbits in between. A typical 1300 host spacecraft can accept a rideshare companion of approximately 90 kg and opportunities exist for more substantial rideshares.

There are tangible benefits from using commercial hosts and standard interfaces. Perhaps most significantly, a standard interface and form factor enables rapid call-up. A commercial host reduces risk of launch delay that can be common with scientific or military launch manifests. Additionally, the payload interface is independent of the launch vehicle -- rideshare requirements are compatible with all launch vehicles described in this document. These aspects of an SSL rideshare enable cost-effective, high tempo access to GTO and GEO for small satellites.

A standard Payload Orbital Delivery System (PODS) interface has been developed which serves as the interface between the host spacecraft and the rideshare partner. In most cases using the standard PODS interface will yield the most cost and time efficient access to space. Alternatively, for customers that require it, the ability to design and build a custom solution and integrate it onto a SSL 1300 spacecraft exists. Pursuing this option gives potential rideshares the ability to trade time and cost for flexibility in mass and volume.

After a rideshare is requested, SSL determines a compatible host from spacecraft currently under construction and also from proposals that are nearing award. SSL will also determine how best to accommodate the rideshare depending on factors including, but not limited to physical volume, mass and preferred dispensing mechanism.

SSL's 1300 series bus is compatible with all major launch vehicles including Ariane 5, Falcon 9, Atlas V, and Proton. SSL typically works directly with each launch vehicle provider on behalf of the host spacecraft for all aspects of the launch including ICD development, applicable analysis, launch operations plan development, safety, related meetings and reviews. As the owner of all aspects of the launch for the host spacecraft, SSL will support and manage all operations including planning, personnel, and support equipment on behalf of any rideshare during the launch and orbit raising campaign.

Procuring SSL Services

Inquiries should include the information listed in Table 1 provided to [PODS@sslmda.com].

Table 1. Initial Inquiry Information

Parameter	Value
Rideshare payload mass	kg
Rideshare payload volume	w x d x h
Preferred Separation System/Dispenser	std. PODS v. Custom
Target Launch Date	mm/yyyy
Target Orbit	GTO or GEO expressed as °E or °W
Propulsion type used, if any	
Power connection required by host, if any	V&W
Data connection required by host, if any	1553, RS-435, Spacewire or ?

Definitions

- **EPL:** The Ejectable Payload (EPL) is the rideshare payload delivered to orbit and ejected from the GEOHost spacecraft.
- **PEM:** The Payload Ejection Mechanism (PEM) ejects the EPL from the GEOHost spacecraft and remains permanently attached to the GEOHost after deployment.
- **PODS:** PODS is the Payload Orbital Delivery System, developed by SSL. PODS delivers the standardized PEM interface for the EPL, simplifying the integration for both the GEOHost and the rideshare payload. The PODS PEM is designed for SSL's 1300 series satellites.

- **GEOHost:** The GEOHost spacecraft is the primary mission that provides the rideshare opportunity.
- **Rideshare Client:** The Rideshare Client provides the EPL that will be delivered to SSL and integrated onto the GEOHost. Depending on the PEM type, the Rideshare Client may also provide the ejection mechanism. SSL may also serve as the manufacturer of the EPL to the specifications of the client.
- **RPA:** The Rideshare Payload Assembly (RPA) is the entire assembly, including the PEM and EPL.
- **Hosted Payload:** Traditionally, Hosted Payloads are defined as a payload that is permanently attached to its host for the duration of the mission. This document defines rideshare payloads that are designed to be ejected and to perform their mission as a free-flying satellite. Using this definition, Hosted Payloads are not discussed in this document. SSL has a separate Hosted Payload Users Guide for interested parties.

Figure 2. A PODS Chassis (left) and a PEM in the Deployed State

1.1 TIMELINE

A typical communications satellite launches 18-36 months from the date of the contract signing. The delivery of the EPL and PEM is required in time to meet the GEOHost S/C integration and test schedule. The delivery schedule to SSL will depend on the type of payload, whether it has flown before on an SSL spacecraft, and whether a high-fidelity simulator exists. Table 2 lists a typical GEOHost/EPL/PEM integration schedule and the milestones that would affect a rideshare payload.

Table 2. Typical GEOHost-Hosted Payload Timeline

Event	Milestone Date
GEOHost Contract Signing	Launch – 24 Months
PEM and EPL Mass Model or EPL Flight Model Delivery to SSL	Launch – 6 Months
EPL Flight Delivery to SSL	Launch – 3 Months
EPL Integration to Host and Ejection Test	Launch – 2 Months
GEOHost with the mated RPA Shipped to Launch Base	Launch – 1 Month
Launch	Launch

1.2 REQUIRED DOCUMENTATION

The Rideshare Client is required to provide documentation for unit level qualification tests of the EPL and PEM and system-level testing of the RPA, support GEOHost design reviews, and support SSL's delivery of safety documentation required by the launch vehicle, range safety, and Department of Transportation by providing any requested material by those third party interests.

1.3 INTEGRATION AND TEST TIMELINE

The timeline discussed below is the nominal expected case. Each GEOHost will have its unique timeline and requirements; SSL can assist in negotiations with a specific GEOHost for alternative timelines as well as contingency plans for late delivery.

The EPL and PEM are required for testing and integration. As shown in Table 3, the PEM should be delivered to the spacecraft prior to Spacecraft Thermal Vacuum (SCTV) and must be delivered prior to Dynamics. The EPL should be delivered to the spacecraft prior to Dynamics and must be delivered during final testing prior to shipment.

Schedules: The schedules are specific for each GEOHost and a typical schedule is described here. When considering schedules, it is to the Rideshare Client's benefit to present the lowest possible risk to the GEOHost.

Electrical Simulator: The completion of a non-flight payload and/or dispenser electrical simulator is required if power or data interfaces to the host is needed. The electrical simulator is a Rideshare Client deliverable and nominally will be needed about 11 months before launch. Note that interfaces to the GEOHost beyond the deployment interface will require additional oversight by SSL and potentially the GEOHost customer.

Table 3. Typical Integration Schedule

	Preferred Insertion Point (For Typical 1300 Integration)	NTE Insertion Point (For Typical 1300 Integration)
Electrical Simulator	Effective date of contract	Launch – 12 Months
PEM	Launch – 12 Months	Launch – 5 Months
EPL	Launch – 5 Months	Launch – 2 Months

Spacecraft Thermal Vacuum: SCTV testing of the GEOHost is typically performed 7 months before launch. It is preferable to integrate the PEM prior to SCTV as it reduces risk and access to the spacecraft interior is better.

Dynamics Testing: For Dynamics testing, the PEM is required. A high-fidelity mass model or the flight EPL are also required. This phase of testing typically occurs 5 months before launch. It is preferable to integrate the EPL prior to Dynamics as it represents the lowest risk for the GEOHost.

Flight Hardware Delivery: The flight EPL will be required for the Final Operations Phase which occurs 2 months before launch. Once the flight EPL is integrated on the GEOHost, it is no longer physically accessible.

GEOHost Spacecraft Design

As shown in Figure 3, the spacecraft overall configuration consists of a central cylinder and rectangular, Faraday-caged main body.

The central cylinder is the primary load path to the launch vehicle and ultimately is what supports the RPA. .

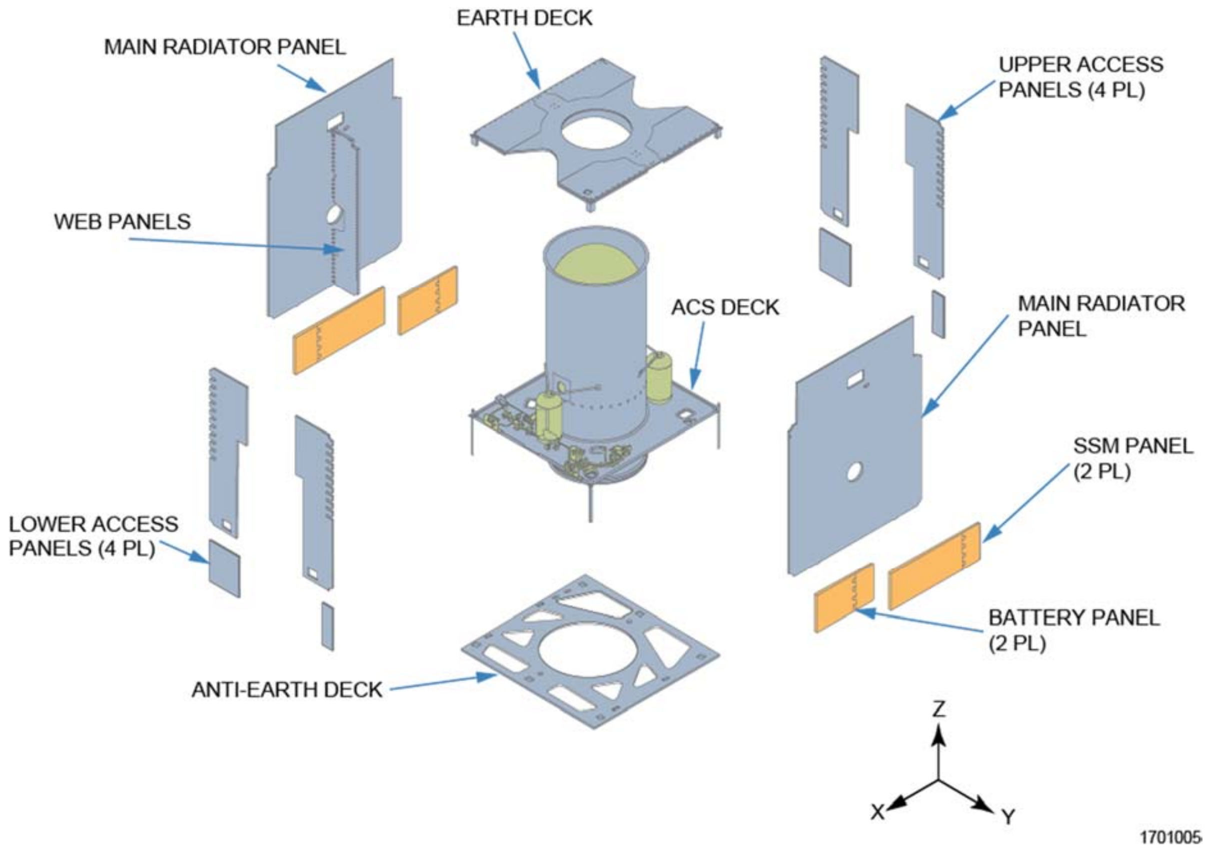

Figure 3. Spacecraft Expanded View

Payload Accommodation

Two locations have been identified where an RPA can be hosted on an SSL 1300 spacecraft. The more compact "Standard RPA," utilizing the standard PODS location, will be hosted in available space on the East or West side of the spacecraft. SSL's advantage for ridesharing is in the frequency of opportunities. For example in 2016, 11 spacecraft (80%) were launched with available capacity.

A larger "Extended RPA" may be hosted on the East or West side of the spacecraft at the mid-panel location. Figure 4 illustrates these locations of the RPA on a representative GEOHost.

In Figure 4, the location marked 1 is the mid-panel location for a potential Extended RPA. The location marked 2 is a battery compartment location, containing a standard PODS RPA. A concept of both a Standard and Extended RPA is shown in Figure 5.

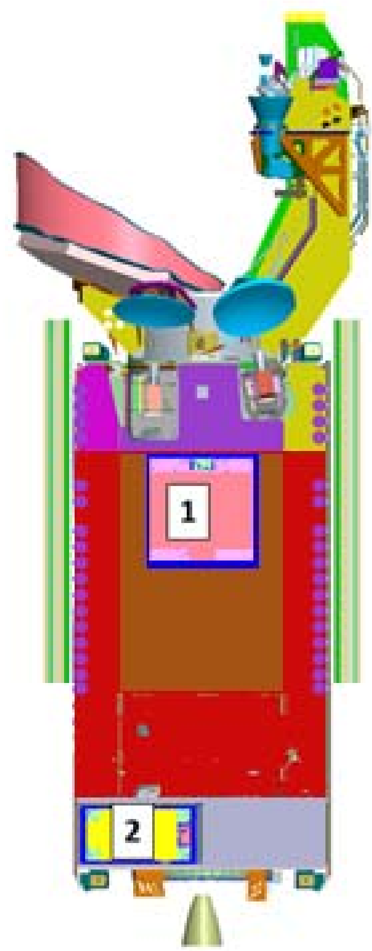

Figure 4. SSL 1300 Host S/C RPA Mounting Locations

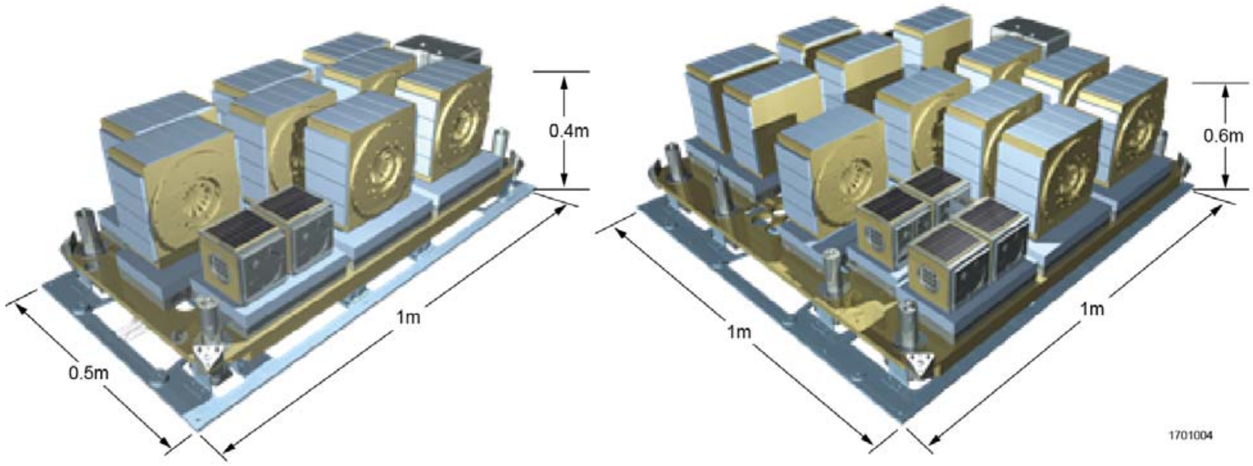

Figure 5. Standard and Extended RPA with Sample Payloads in the Launch Configuration

The EPL is deployed at the specified time and in a specified direction that was previously agreed upon by the Rideshare Client. Knowledge of the GEOHost attitude, velocity, and position can be provided in near real-time to the Rideshare Client and/or EPL operator. After ejection, location data can be provided with accuracy that is commensurate with ranging that is widely accepted in GEO satellite operations. Ejection characteristics are dependent on the PEM selected. Camera views of the ejection can be provided upon request. Further details are available upon request.

The EPL shall remain in the powered off or in a passive state before ejection. Thermistor telemetry of the PEM will be available shortly after Initial Acquisition of the GEOHost after tip off from the Launch Vehicle.

The GEOHost remains in the power on state for the ascent phase, separation from the launch vehicle and the entire mission life. The GEOHost can control heaters on the PEM and/or EPL prior to ejection. Any GEOHost controlled heaters would be electrically isolated from the RPA and not available after the EPL has been ejected.

The most cost-effective approach is for the RPA to not require a power or data connection from the GEOHost. Notwithstanding, the design can accommodate modest levels of power and data supplied to the RPA after launch and before release from the GEOHost. Power availability is negotiated as part of the Rideshare contract. Power accommodation is discussed in more detail in later sections.

RPA Integration

The PEM will be permanently integrated onto the GEOHost at the SSL facility before the GEOHost undergoes dynamic testing; the PEM and a mass simulator (or a flight EPL) shall be part of spacecraft level dynamic testing.

The flight EPL will be integrated on to the spacecraft prior to shipping and no later than L-2. Once the EPL has been integrated onto the GEOHost, it is typically no longer physically accessible.

CONOPS Summary

After launch, the GEOHost will be in a Geosynchronous Transfer Orbit (GTO). GTO typically has an orbital period of about 12 hours with an apogee at or near GEO and a perigee of a few hundred kilometers. Initial Acquisition of Signal (AOS) of the GEOHost typically occurs about 45 minutes after launch. The exception to AOS being about 45 minutes after launch is when a Proton launch vehicle is used when separation occurs near apogee, or 9 hours after launch. Thermistor telemetry from the PEM will be available after AOS. The Launch and Early Orbit Phase (LEOP) consists of the GEOHost maneuvering from GTO to GEO. Typically the EPL would be ejected near GEO in an orbit with a period of about 23.5 hours, but other ejection locations may also be possible at some point prior to reaching GEO from GTO.

The lowest risk approach is to leave the EPL unpowered during LEOP of the GEOHost and until the ejection event. Notwithstanding, the EPL shall remain in a passive state until after the ejection event.

After ejection from the GEOHost, the EPL will execute its remaining mission objectives and the GEOHost will finalize its LEOP phase and transition to its commercial mission in its final GEO orbital slot. EPL sequence of events after ejection from the GEOHost are not considered in this document. Most GEOHost's LEOP phase will last from approximately 10 days; the exception os for spacecraft that employ a significant amount of electric orbit raising when LEOP can last several months.

The ejection event will be tightly controlled by the GEOHost and SSL. This includes maintaining GEOHost attitude for required thermal environment and TT&C coverage and monitoring EPL separation telemetry to verify the separation events in real-time.

Upon ejection, data is provided to the EPL owner/operator to determine its initial orbit. Although the EPL is required to be passive until ejection, data from the PEM is available (e.g. status monitor and temperature sensors). Additionally, there is an option to monitor in near-real-time the ejection sequence by video equipment on the GEOHost.

2 – REQUIREMENTS AND GUIDELINES

Detailed Interface Control Documents (ICDs) governing the GEOHost and RPA are necessary and will be made available after NDAs are in place and contracts are signed. This document provides a top-level overview.

The ICDs define requirements for physical interfaces, electrical interfaces, environmental interfaces, EMC/EMI, thermal interfaces, reliability, flight requirements, and ground operations. The ICD will be jointly agreed upon by and documented between SSL, the GEOHost owner/operator, and the RPA owner/operator. The section below describes some of the high level requirements and guidelines:

- Deployment of any mechanisms internal to the EPL while hosted on the GEOHost spacecraft shall be prohibited. A minimum distance from the EPL to the GEOHost for deployment shall be determined. The EPL shall not restrict GEOHost thruster usage or RF transmissions.
- The lowest risk implementation is for the GEOHost to provide no power to the EPL. Delivery of power can be negotiated, but this may restrict the number of potential GEOHosts. The GEOHost has the capability to provide the EPL nominally up to 300W at 28V to the RPA.The EPL must be in a passive state until after ejection.
- The EPL ejection event shall be designed and configured such that it is passively safe from contacting the GEOHost. Neither the GEOHost nor the EPL shall be required to perform a maneuver to avoid contact after the ejection event. The GEOHost will command the ejection of the EPL.
- The RPA shall be electromagnetically compatible with the GEOHost, the launch vehicle and the launch site. The allowable RF environment may govern when the EPL transmitter(s) can be turned on after the ejection event from the GEOHost.
- The RPA materials shall be required to comply with outgassing requirements and be appropriate for use in the space environment. Any processes taking place on the RPA are required to comply with requirements and be appropriate for use in the space environment.

Physical

The mass and volume limits for each RPA option are listed in Table 4. There will be 25 mm of clearance around the installed RPA to ensure a clean ejection.

Table 4. Mass and Volume Limits Restricting the RPA

	Mass (kg)	Volume (m)
Standard RPA	90	1 x 0.5 x 0.4
Extended RPA	150	1 x 1 x 0.6

The Standard RPA height dimension may be negotiated to be more than 0.4 m on a case by case basis. Relaxing the constraint beyond 0.4 m may limit the number of compatible GEOHosts. The constraint on the height dimension is interference with the GEOHost and also LV fairings. It is unlikely the height constraint can be relaxed for the Extended RPA due to interference with the GEOHost

Electrical

The lowest risk implementation is for the GEOHost to provide no power or data to the EPL. The GEOHost can power and control heaters on the RPA; any such heaters would be electrically isolated from the RPA power and data subsystems. The GEOHost will provide power to and control the separation monitor loop-back sensing circuits.

The GEOHost may nominally provide up to 300W at 28V to the RPA. This type of implementation will require additional oversight by SSL and possibly the GEOHost customer and may limit the number of rideshare opportunities. The EPL shall remain in a passive state until after the ejection event.

The electrical connectors between the GEOHost S/C and the RPA will be specified by part numbers. The location and orientation of each electrical connector will be defined with an ICD. Connector pin assignments (including voltage and current limitations) will also specified.

The GEOHost can provide a data interface drop to the RPA.

Thermal

The RPA shall be required to survive the nonoperational temperature range from -20° C to +50° C. The GEOHost can power and control heaters on the RPA; any such heaters would be electrically isolated from the RPA power and data subsystems.

The GEOHost thermal design shall minimize thermal conduction between the RPA and GEOHost interface.

Mission-specific attitude maneuvers to provide or preclude certain sun angles are discouraged. Any such requirements will need to be agreed upon via ICD between SSL, the GEOHost owner/operator and the RPA owner/operator. Mission specific attitude maneuver requirements may limit the number of rideshare opportunities. TC&R coverage requirements of the GEOHost will be taken into consideration when assessing the acceptability of conducting maneuvers for purposes of changing the Sun angle.

Environmental

The launch configuration of the RPA shall have a minimum natural frequency of 10 Hz in lateral (xs/c and ys/c) and axial (zs/c) in the GEOHost coordinate system. The lowest risk approach is a minimum natural frequency of 100 Hz, as this simplifies modelling assumptions for the Coupled Loads Analysis and will allow for a maximum number of rideshare opportunities with a minimum of time from contract signing to launch.

The RPA shall meet the envelope of the launch provider internal fairing maximum acoustic pressure from the lift off to the fairing separation as specified in Table 5.

Volatile Condensable Materials

Per NASA-RP-1124, the RPA shall meet volatile condensable materials (VCM) outgassing requirements of a maximum total mass loss of 1.0 percent. The RPA shall meet VCM outgassing requirements of a maximum collected volatile condensable materials of 0.1 percent.

Payload Separation Verification

Payload separation is defined as the instant of loss of physical contact between the spacecraft and the EPL. EPL ejection will be verified by telemetry. Separation will be monitored with GEOHost to RPA loop-back circuits.

Dismount Accessibility

It shall be possible to dismount partially or totally, temporary or permanently, the RPA at any phase of the spacecraft integration and test on ground while minimizing the regression testing required and without invalidating the qualification validation of the spacecraft.

Collision Avoidance

The EPL separation trajectory is determined by the GEOHost spacecraft. No maneuvering capability of the EPL by itself is allowed.

In order to preclude recontact between the EPL and the GEOHost separation dynamics will be defined. These dynamics will include the definition of a minimum linear ejection speed, maximum allowable angular rotation, a maximum torque exerted on the GEOHost by the EPL, an ejection vector defined in degrees from the PEM baseplate, and a maximum non-compensated momentum contribution for the non-ejectable payload.

Ejection Dynamics

Any thrusters or ACS residing on the EPL shall remain off until the EPL has ejected from the GEOHost by a distance that will be agreed to between SSL, the GEOHost owner/operator, and the

RPA owner/operator. The EPL shall have an inhibit feature that will prevent accidental actions by the EPL while mounted to the GEOHost.

RF Emissions

The RPA shall leave RF equipment residing on the EPL powered off until after the ejection event and the EPL has separated from the GEOHost by a distance that naturally reduces the field strength to a determined distance. An ICD will define the field intensity vs. distance relationship and agreed to by the GEOHost, rideshare partner and SSL.

The RPA shall be designed to comply with the GEOHost radiated emissions requirements (including transmitter spurious radiations, receiver oscillator radiation, various other spurious emissions, transients, and broadband interference).

RF Susceptibility

The launch vehicle imposes RF emission and susceptibility requirements on the GEOHost and RPA. The RPA attached to the spacecraft will be directly exposed to the launch base radiated emission sources and must meet its functional and performance requirements when subjected to the radiated fields. These fields are quantified by each LV vendor and composite requirement will be made available in the detailed environmental ICD.

3 – TESTING

Before integration into the host spacecraft, the PEM and the EPL will be fully tested to ensure compatibility with the GEOHost, to ensure the requirements of range safety are met, and to ensure that they can survive the ground, launch, and mission environments.

Additionally, the RPA will also be subjected to a set of tests while integrated with the host spacecraft before the launch to ensure compatibility and successful separation/release in orbit.

The sections below describe a generic RPA test plan.

Thermal and Thermal Vacuum

The RPA supplier shall verify thermal models by test and provide the resulting thermal conductance and radiation interface data to SSL prior to Spacecraft ThermalVac (SCTV) of the GEOHost. The number of weeks this information will be required prior to SCTV will be specified by the specific Rideshare SOW, but will typically be about 10 to 15 weeks.

Testing on the GEOHost will be conducted by SSL to verify the RPA's thermal interfaces to the GEOHost. The PEM and an EPL thermal model is required to be integrated to the GEOHost prior to SCTV. If the flight EPL at the time of SCTV is available it will be a significant risk retirement to test it at the time of SCTV.

Fit Checks, Separation Test, and Functional Test

The joint test campaign for every flight RPA and host spacecraft will include a fit check and ejection test. The EPL will need to have Mechanical Aerospace Ground Equipment (MAGE) to allow for a 1g ejection test.

The joint test campaign for every flight RPA will include integration/functional tests of the RPA in the GEOHost as appropriate for Reference Performance testing, SCTV, Dynamics testing, and Final Performance testing phases as noted in Table 2.

Vibration and Acoustic Testing

The RPA shall demonstrate by test to withstand vibration, shock and acoustic levels associated with the launch environment; details will vary by launch vehicle and will be specified by contract. A generic composite of all commercial launch vehicle's shock/vibe/acoustic levels can be made available after an NDA is executed with SSL. The mission specific levels given may change based on GEOHost, launch vehicle and the location of the RPA on the GEOHost (Location 1 or 2 as shown in Figure 4).

If S/C vibration testing must be notched in a manner that precludes the full verification of RPA compatibility, the RPA components will be verified by test separately.

Ejection Testing

Ejection testing shall verify both the mechanical release of the EPL and telemetry verification of the ejection event, the physical separation and the successful change in status of the ejection monitor. This testing may take place on a bench using MAGE rather than on the host S/C itself. However, commanding of the separation shall be initiated by the GEOHost via appropriate cable harnessing.

4 – DEPLOYMENT OPTIONS

The two options for PODS RPA are described in this section. The most standardized option allows the RPA owner/operator to build their own payload on top of the PODS chassis which attaches to the PEM. The second option allows the RPA owner/operator to build a payload that interfaces directly with the PEM.

PODS Chassis Integration

The PODS chassis provides a standard interface between a custom payload and the PEM interface. The combination of the PODS chassis and the custom payload makes the EPL.

The RPA owner/operator integrates the payload on top of the PODS chassis which attaches to the PEM. This option provides an interface to the PEM that has been tested and verified.

In the standard RPA configuration, the PODS chassis is secured to the PEM using four Separation Nuts and one Frangibolt. The four SepNuts are used to provide structural support to secure the POD chassis to the PEM during the period starting with final integration and testing and extending to EPL ejection. During EPL ejection, the four SepNuts are released, then a single Frangibolt actuation releases the EPL. The release of the central Frangibolt allows the PEM to eject the EPL using torsional springs. The Frangibolt is the final release mechanism.

The PEM is designed to keep the top ejection frame parallel to the baseplate through the full range of travel. Springs acting along the hinge line provide the ejecting force. The PEM is capable of deploying a typical EPL with a tumble rate <0.5 degrees/second/axis.

As shown in Figure 6, the POD chassis has 145 ¼-28 UNF Tangless Locking Heli coil inserts arranged in rows which are designed for a NAS1130-4FL15D fastener. The POD chassis also has 4 5/16-18 UNC-2B Tangless Locking Heli coil Inserts on the left and right sides meant to be ground handling points which are designed for a NAS1130-5CL15D fastener.

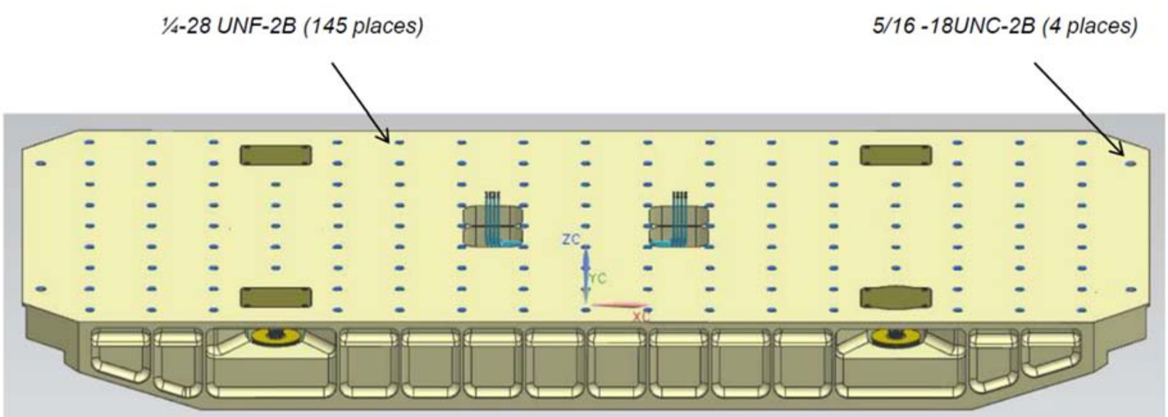

Figure 6. The POD Chassis

Custom PODS Chassis

This option allows the customer to build their own custom chassis that attaches to the spacecraft. SSL will assist in designing mechanisms that will minimize the impact to the overall system.

Imaging System Option

The GEOHost is capable of incorporating a camera to verify successful ejection of the EPL. The camera is capable of coarse real-time video and high resolution still images for downlink. Hi-Res images may not be available in real-time.

5 – ANALYSIS

Various analyses will be performed on the RPA payload. The analyses are listed in this section and will be document in mission specific documents.

Structural Analysis

The RPA manufacturer shall provide their structural Finite Element Model(s) to SSL and the GEOHost owner/operator for incorporation into the LV Coupled-Loads Analysis (CLA) cycle. Node IDs used in the Finite Element Models provided to SSL shall be greater than 8,000,000 to avoid node numbering conflicts with the S/C FEM.

SSL shall assess the results of dynamic environment analyses performed by the Launch Service Provider with regard to RPA compatibility and coordinate that assessment with the RPA provider.

Collision Avoidance

SSL shall perform an analysis to show that within 3□ sigma probability, there are no collisions between the EPL and the GEOHost in the first three orbits and that the minimum separation between any two bodies increases by at least 5,000 m each orbit after the first. A collision is defined as an approach of any two bodies to within 1,000 m. The ICD specifies a minimum EPL ejection velocity requirement. The EPL is expected to achieve a distance of 1,000 m from the GEOHost within 2 hours after separation.

Flight Loads

The Launch Service provider shall analyze the dynamic environment imposed on the spacecraft during critical launch and flight events and will provide the results to the host spacecraft manufacturer for evaluation. These analyses will include calculations of the satellite loads and accelerations for all significant launch vehicle events and the maximum aerodynamic loads.

RF Analysis

RF compatibility among all involved subsystems (RPA, GEOHost and the launch base/vehicle) will be fully analyzed and verified. This joint responsibility among all the responsible parties will be allocated among the contractual SOWs.

Thermal Analysis

SSL shall analyze expected RPA temperatures from the integration through EPL separation. The integrated thermal model supplied by the RPA owner/operator will be used for this analysis.

The integrated thermal model shall be developed in time to support SCTV as described above in Section 3 and may be required for LV CDR, if that predate SCTV. Contractual need dates will be specified in mission-specific SOWs. The LV analysis will provide aero-thermal heating, GEOHost boundary temperatures, etc. for a final iteration of RPA Payload thermal analysis.

The RPA owner/operator shall perform a thermal analysis to predict RPA temperatures for all phases of integrated ground operations and testing with the host spacecraft, LV processing, LV flight, and LEOP to the point of the ejection from the GEOHost. The analysis will envelope the worst-case hot and cold RPA temperatures.

The thermal analysis process will be iterative, with one cycle providing inputs to the GEOHost and thence to the LV's thermal analysis, and a later cycle incorporating results from the GEOHost and LV analyses for final RPA mission temperatures. The contractual need dates for the delivery of thermal analysis models and results will be specified by mission specific SOWs.

RPA thermal analysis shall include a thermal model uncertainty margin of 5°C to the acceptance temperature limits.

Venting Analysis

The RPA owner/operator shall provide a venting analysis to SSL. The contractual need dates for the venting analysis will be specified by mission specific SOWs.

Volatile Condensable Materials Analysis

The RPA and RPA Payload manufacturers shall provide an outgassing analysis to SSL establishing compliance with this specification. The contractual need dates for the volatile condensable materials analysis will be specified by mission specific SOWs.

6 – FLIGHT REQUIREMENTS

The EPL will be ejected before the GEOHost's final maneuvers, either slightly below or slightly above geostationary orbit. The orbital insertion details (e.g. the point during the GEOHost mission timeline that separation occurs, and the resulting orbit of the EPL at ejection) will be specified on a mission-specific basis as per Table 5. SSL will provide the RPA mission operator with the orbital data before and after EPL ejection in the same format as Table 5.

Table 5. Sample Format for Defining and Reporting POD Separation Orbit

No.	Parameter	Units	Dispersions	Design Value	Actual Value****
1	State vector measurement time (osculation moment)	Date and time (mm/dd/yyyy) (hr., min, sec (UTC)*)			
2	Semi-major axis (a)**	km			
3	Eccentricity (e)**	-			
4	Inclination (i)**	Degrees			
5	Right ascension of ascending node (Ω)**	Degrees			
6	Argument of perigee (ω)**	Degrees			
7	True anomaly (θ)**	Degrees			
8	Perigee altitude***	km			
9	Apogee altitude***	km			

Notes:

* UTC - Universal Time Coordinated (GMT).

** Values in lines 2 - 9 are osculating (Osculation time is the S/C separation time). The values in lines 4 - 7 are defined relative to the Earth-Centered Inertial coordinate system.

*** Osculating value of perigee/apogee altitudes are obtained from the perigee/apogee radius and based on the spherical Earth radius of 6378 km.

**** Actual values based on transfer orbit ranging data.

7 – GROUND HANDLING AND SAFETY

The RPA shall be designed to meet all launch vehicle range safety requirements listed in Table 6.

Any non-flight covers will remain installed until the last available access, except for any removals required to support GEOHost testing (e.g., TVAC or S/C Dynamics Testing). The last available access is typically immediately before LV encapsulation.

Table 6. Applicable Documents

Document Number and/or Revision	Document Name (or placeholder)	Responsible Organization
20512-211254 latest revision	Generic RPA Assembly	SSL
CSG-RS-10A-CN, June 11 2006	CSG Safety Regulations	Centre Spatial Guyanais
LKET-9707-0375 Rev 3, Sept 10 2003	Proton Launch Operations Safety Plan	International Launch Services
ERR 127-1, 1995, Tailored for FS1300 [TBR]	CCAFS Range Safety Regulations [Tailored for SSL]	SSL, CCAFS [TBS]
D688010024-1, July 16 1998	Sea Launch Safety Regulations Manual	Sea Launch
August 30, 2010	SpaceX Customer Range Safety Guide	Space Exploration Technologies