PAYLOAD USER'S GUIDE

AUGUST 2022

VERSION 1.2

TABLE OF CONTENTS

INDEX

1. INTRODUCTION

1.1. Corporate Information

E.A.S.T. CORPORATE ADDRESS	MANUFACTURING & ENGINEERING	
299 FM 1903	299 FM 1903	
Greenville, TX 75402	Greenville, TX 75402	
POINT OF CONTACT:		
Engineering & Technical	Russell Blink CTO	972-974-4779 rblink@EXOSaero.com
Commercial	John Quinn CEO	972-740-8355 jquinn@EXOSaero.com
Payload	Phillip Eaton Ops Manager	214-585-9953 peaton@EXOSaero.com

1.2. Purpose & NASA Flight Opportunities Program

The BLK3 Suborbital Reusable Launch Vehicle (SRLV) is the latest in the SARGE family of vehicles. The BLK3 has significantly increased capability because of increased propellant capacity and the extensive use of carbon fiber composite materials.

This increased performance enables the BLK3 to loft payloads up to 200-kg to 80-km or higher thus qualifying the vehicle for NASA's Flight Opportunities Program. The nominal design reference mission is 135-kg to 100-km from our Spaceport America (NM) launch site.

1.3. Exos HQ, Engineering and Manufacturing Center & Test Site

Are currently collocated in Greenville, TX approximately 50 miles NE of Dallas.

The EXOS suborbital and engine test site is located at Caddo Mills Municipal Airport, TX. Caddo Mills is approximately 10 miles SE of the Greenville HQ facility.

2. BLK3 SRLV

2.1. Heritage

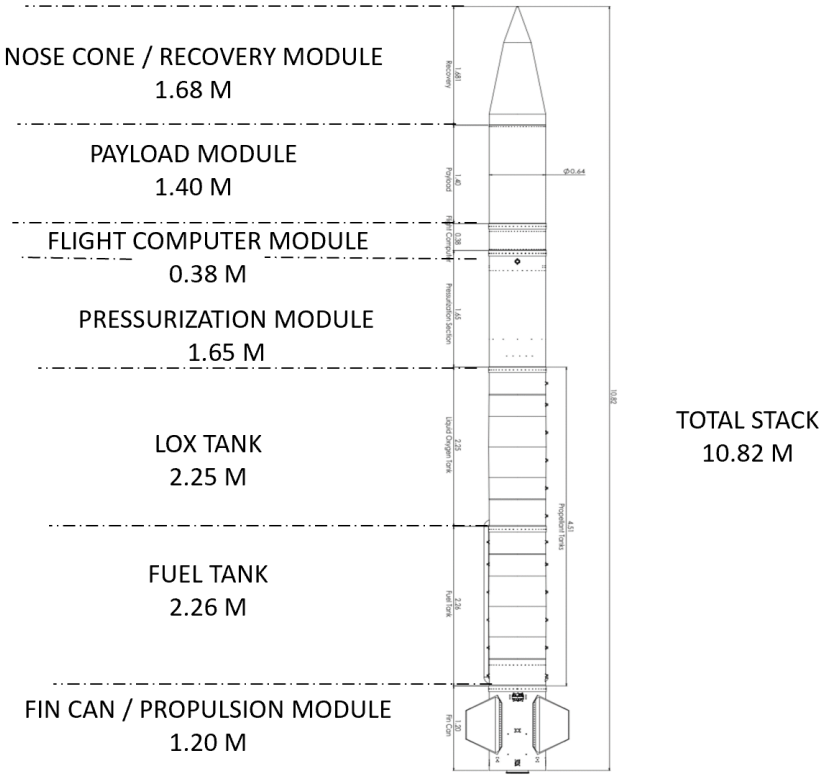
The precursor vehicle to the BLK3 is SARGE which was flown four times at Spaceport America. SARGE was of all-aluminum construction (except fins and nose cone) and 508mm diameter (20”)

In 2021, EXOS was awarded a contract to build the BLK3, a concept ground launched hypersonic test vehicle, by the US Air Force. The purpose was to demonstrate increased performance capability by the extensive use of carbon fiber composite materials to reduce the dry mass of the vehicle.

The BLK3 now has nearly the same dry mass as SARGE but with 50% more propellants by virtue of the increased diameter, 635mm (25”). This increased diameter also allows the BLK3 to loft more massive payloads to suborbital space.

2.2. Description

The BLK3 is a single stage vehicle with a pressure fed LOX/Ethanol propulsion system

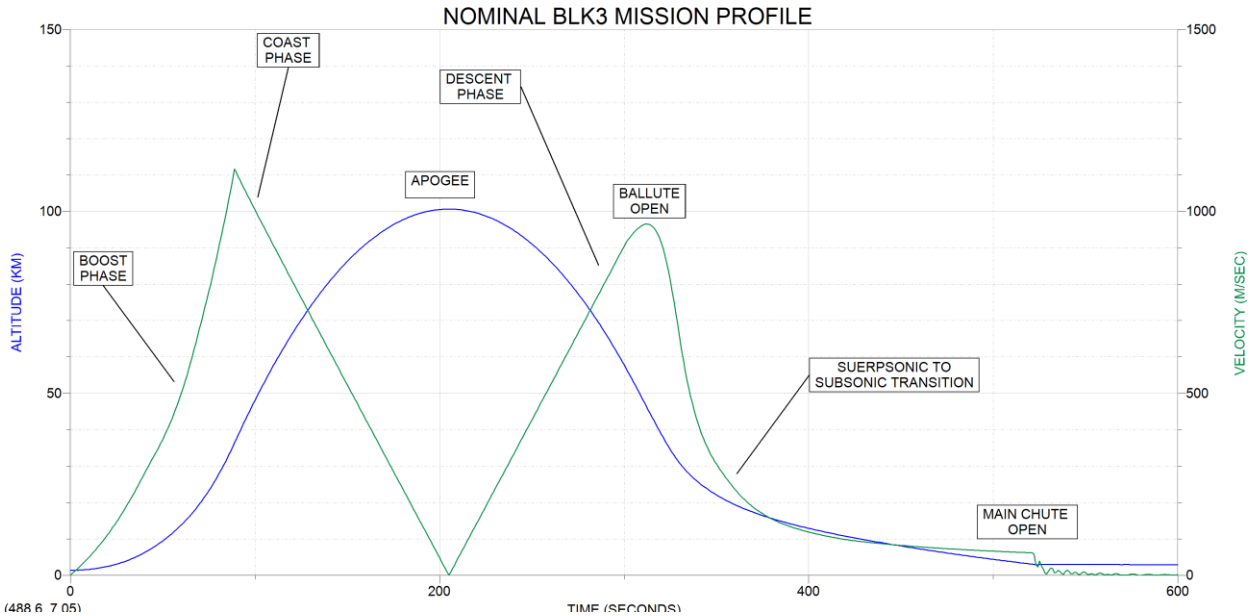


The recovery system is two-stage. A ballute that is deployed at the onset of milli-G to transition the BLK3 through the supersonic state and a ram-air parachute with Autonomous Guidance Unit (AGU) to glide back to the recovery area close to the launch pad and launch control center.

2.3. Nominal Mission Profile

The nominal design mission profile is 135kg to 100km. The graph below shows the velocity and altitude profile with time.

The graph shows the deployment of the main chute at ~520-seconds. The actual time to the vehicle touching down is dependent on the location of the vehicle when the chute opens and the winds aloft as the AGU guides the vehicle back to the launch pad. Typically, the total mission time is approximately 20-25 minutes.



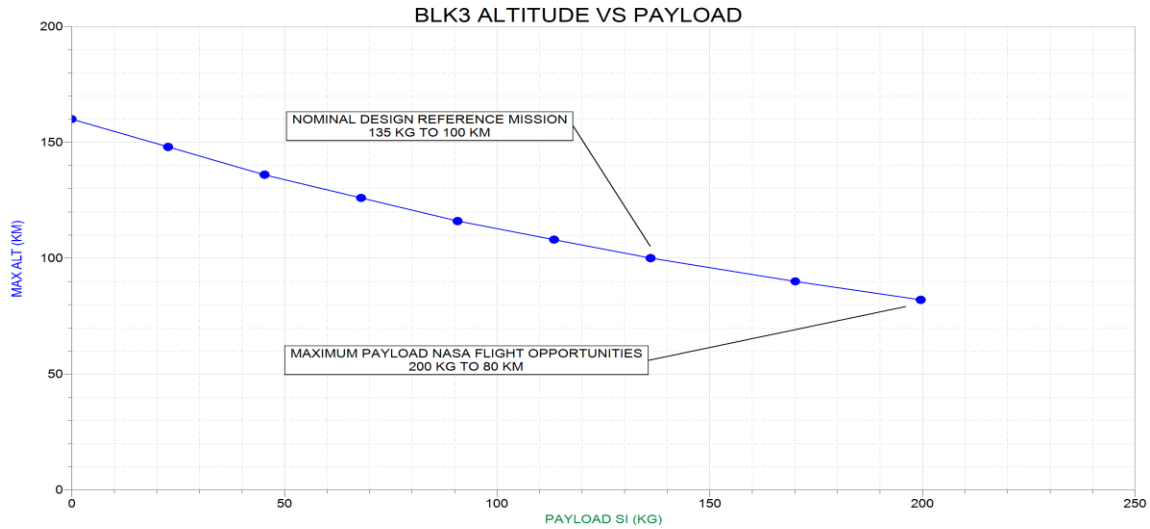
The graph below shows the G-loads on the BLK3.

Unlike solid rocket boosters, the boost G-load profile is benign peaking at less than 4Gs at MECO (Main Engine Cut-Off)

The approximate mission timeline is

T + 0	Engine Ignition & Boost Phase Start
T + 90	MECO and Peak Boost G-Load 3.8 G
T + 130	Onset of Zero-G
	“Zero G Phase” ~150 seconds
T + 280	End of Zero-G
T + 285	Onset of milli-G (>0.001 G) and Ballute Deploy
T + 330	Peak Ballute G-Load 4.3 G
T + 520	Main Chute Deploy & Peak Shock Load 6.8 G
T +~1,500	Touch Down & Landing Shock Load ~7 G max

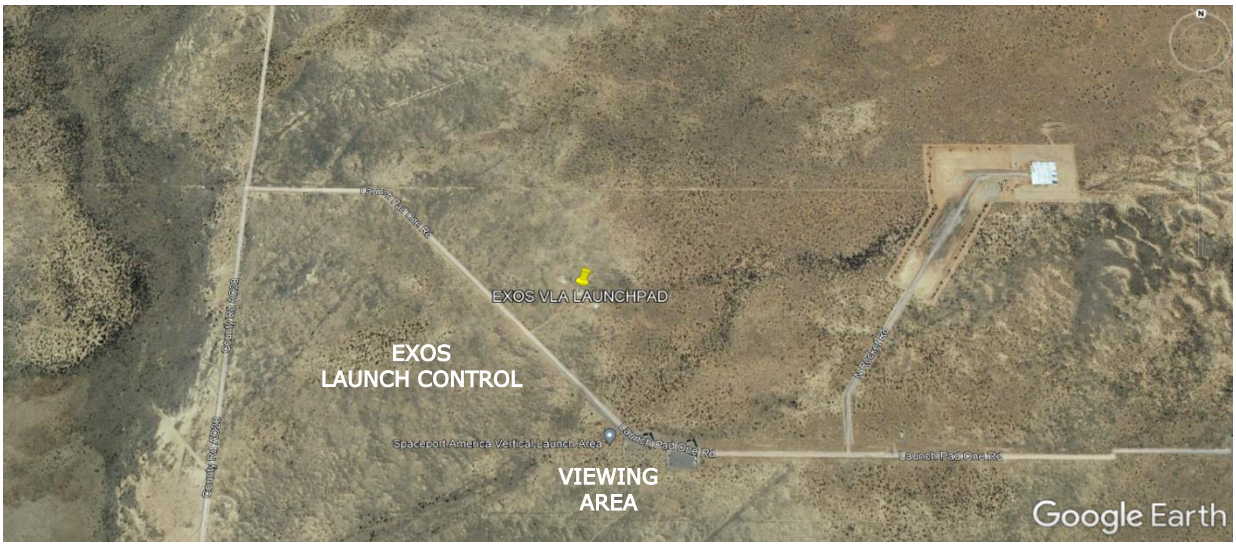
The actual altitude capability and Zero-G Phase time is dependent on payload mass.



In practice, altitude would be limited to 110 km in the immediate future.

2.4. Launch Site

EXOS' primary launch site is Spaceport America (NM) from the Vertical Launch Area at the Southern end of the range.



The EXOS Launch Control Trailer is approximately 150 m away from the launch tower and just outside the Explosive Debris Range for an event on the pad. The remote viewing area for involved parties is approximately 450 m away. Payload providers who need urgent access to their payloads can be stationed here during the mission.

The precise pad location is,
32 deg 53 min 58 sec, -106 deg 55 min 48 sec
1,400 m MSL
and the primary FHA (Flight Hazard Area) is a 6,500 m circle centered on the launch pad. The GNC (Guidance, Navigation and Control) software is designed to terminate thrust if it determines that the vehicle would exit the FHA at any point during the boost phase. The Spaceport America MHF (Main Hangar Facility) and other large facilities are just outside this FHA.

The launch team, payload providers and other personnel use Las Cruces as the base of operations. The drive to the Spaceport is approximately 90 km and takes an hour entering through the Spaceport main gate from the Southern Access Road.

2.5. Launch Windows

The current Agreement with NMSA (New Mexico Spaceport Authority), WSMR (White Sands Missile Range), and the FAA (Federal Aviation Authority) requires that EXOS give a minimum 30 days advance notice of a launch. EXOS typically requests a two-day window with the second day being a "scrub" day in the event of weather or technical delays.

The actual window is from 07:00 hrs. to 12:00 hrs. local time and during this window the FAA closes the airspace to traffic. Also, the Launch License issued by FAA AST requires that the vehicle be on the ground before the window closes. This requires that we initiate the launch by 11:30 hrs. latest.

Launching at other times of day is feasible with sufficient notice. However, the ground wind speed at the site tends to pick up around noon and EXOS has a flight rule that we will not launch if the wind speed is greater than 10 m/sec (~20 mph)

2.6. Reusability & Frequency

A second flight can be accommodated two days after the first mission by using a secondary recovery system and high pressure helium system (to save time repacking the chutes and re-pressurizing the helium bottle). This allows time for a thorough post-mission physical inspection and evaluation of the telemetry from the first flight.

3. PAYLOAD PROVIDER INFORMATION

4.1 Payload Mass & Physical Size

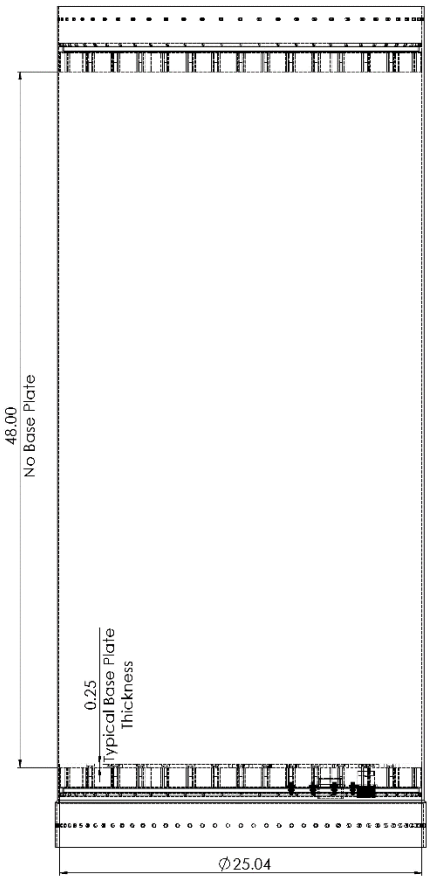
EXOS requires that the payload provider complete an interactive Payload Information Sheet as the first step to reserving a launch slot on the BLK3.

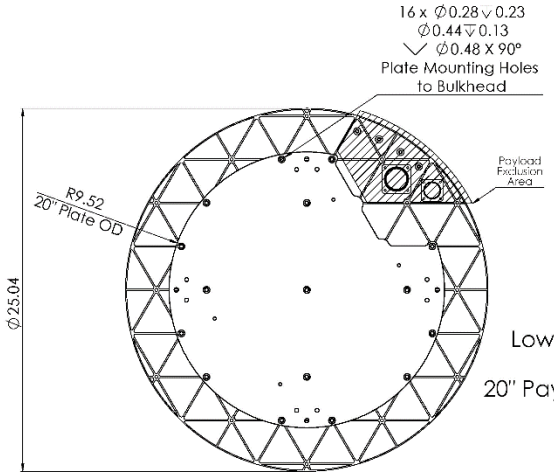
Worksheet Instructions: In the center Column, the Clear fields require information to be typed in directly. The Green fields are pull down menus that will appear when you click the green field. When the small triangle appears at the lower right of the field, click that tab and select from the list the description that best fits your payload. If one of the selections brings up additional questions, please answer in the adjacent clear fields.

Payload Information Sheet

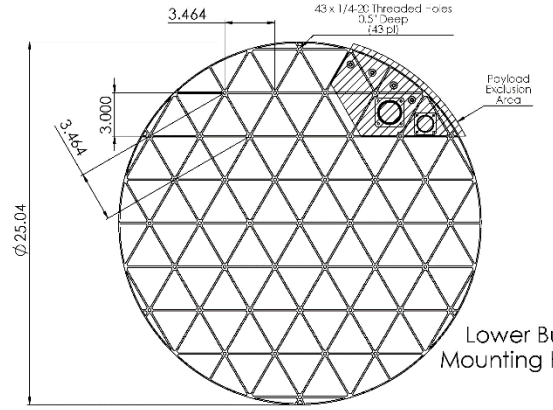
Information Required	Select or fill in fields below.	Additional Notes
Customer Name		Name of Contract Entity
Payload Name		Payload Reference Name
Payload Class	**Select using the arrow -->**	(Select from List to the left)
Payload Description or Operation Details		Brief Detail of the Payload Purpose.
Power Required on Payload?	**No**	**Not Powered, or power supplied with internal batteries.**
Payload integration assistance needed?	**Select using the arrow -->**	**(Select from List at left)**
Payload Mass in kg	1.000	(Enter Value in kg)
Payload Length in mm	100	(Enter Value in mm)
Payload Width in mm	100	(Enter Value in mm)
Payload Height in mm	113.5	(Enter Value in mm)
Total Volume in cm^3	1135.00	(Calculated Value)
Volume in Units "U"	1.000	(Calculated Value)
Flight Parameters	**Select using the arrow -->**	(Select from List at Left)
Additional Environmental Needs?	**Select using the arrow -->**	(Select from List at left)
Hazardous Materials? (Regardless of Quantity)	**Select using the arrow -->**	(Select from List at Left)
Payload Special Access?	**Select using the arrow -->**	(Select from List at left)
Payload Customer		Payload Contract Entity
Payload Administrator		Person in control of payload integration
Phone Number		POC Phone number, Cell phone preferred.
Email		Preferred Email Address for Documents.
Billing/Contract Address		Address for Contract Documents and Invoicing
City		
State/Province		
Zip Code		
Country		
Shipping Address Address		Address for Return shipping of Payloads
City		
State/Province		
Zip Code		
Country		

BLK3 PAYLOAD ASSEMBLY DRAWING

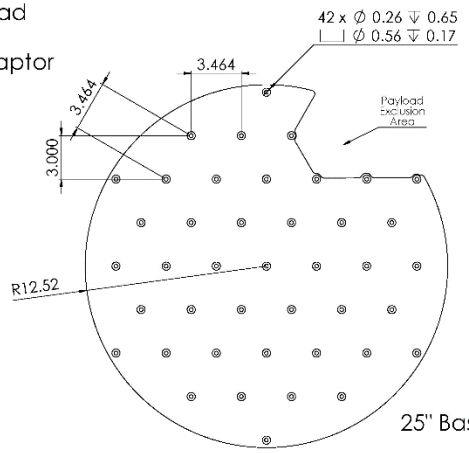




Lower Bulkhead
with
20" Payload Adaptor
Plate



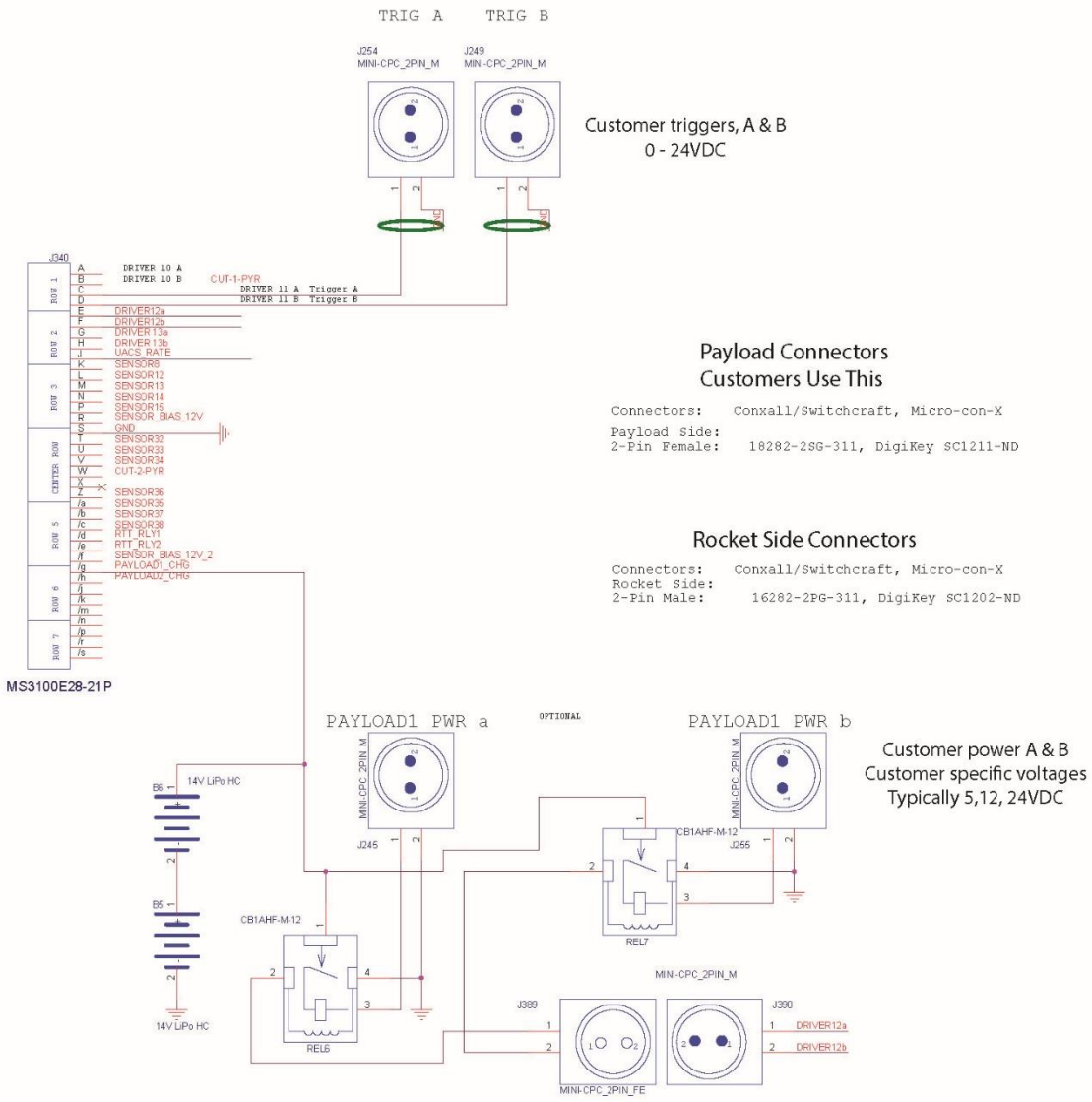
Lower Bulkhead
Mounting Holes Only



25" Base Plate

The standard Payload Bay is 636 mm (25.04”) ID & 1219 mm (48”) without an internal base plate.

BLK3 PAYLOAD CUSTOMER CONNECTIONS



3.2. Payload Environment

The Payload Module is not environmentally controlled. However, unless the payload is generating significant heat loads, the temperature inside the Module should not exceed $60^{O}C$.

The ambient pressure at Spaceport America is 86 kPa (12.5 psia.) and the payload module is sealed with double O-rings. The actual minimum observed pressure should not be less than 70 kPa (10 psia).

The payload vibration environment is reasonably benign, but there are shock loadings at MECO, Drogue Deploy, Main Chute Deploy and Touch-Down (see Section 2.3). During the boost phase there is a slight "transonic shudder" of +/- 1.5 G's in the 1-5 Hz range and for the remainder of the boost phase the vibration is +/- 0.5 G's maximum across a frequency range of 10-50 Hz.

3.3. Standard Integration Services

EXOS will mount the payload on a standard mounting plate but no power connections, verify that its operation does not interfere with the BLK3 vehicle operation (eg EMI test) during the Combined Systems Test (CST) and validate that it is acceptable to FAA AST per the BLK3 Launch License.

3.4. Non-Standard Integration Services

The list of potential non-standard services is lengthy. Here is a partial listing of some of the more common requests which can be provided at additional cost.

Custom payload adapter plate
Multiple payloads
Modify payload bay to allow vacuum operation
Mount single payload provider supplied antenna
Mount single payload provider supplied external camera
Provision of triggering signal based on telemetry (onset micro-G, apogee,…)
Triggering signals can be singular or multiple
Provide payload power (5 / 12 / 24V DC)
External viewport or window (optical or EM transparent)
Realtime downlink
Pointing capability
Payload ejection
Special payloads (biological, radiological,…)

4. PAYLOAD INTEGRATION

4.1. Procedure for Approval

In response to a launch request, EXOS will verify that the proposed vehicle is capable of successfully meeting the mission criteria. This will include a safety analysis, which is conducted regardless of payload for any EXOS test flight, incorporating the Mission Risk Assessment posed by the payload.

On accepting a payload for flight, EXOS will formally review the payload and its integration requirements using an ICD or interface control document to manage the process. This review will include a CST or combined systems test with all systems running and in simulated flight mode (a static ground based test that feeds fake data to the main flight computer), ensure any triggering signal is delivered on a timely basis and that there are no adverse interactions between the payload and the vehicle (or other payloads if flying on the same mission). This by necessity includes a physical fit-up test and demonstration of payload accessibility at our Greenville HQ or, if deemed feasible, at the launch site.

4.2. FAA AST Payload Approval

All licensed flights require that the payload(s) be reviewed by FAA/AST to ensure that they do not prejudice the safety of the mission with respect to potential for injury or damage to third party public or property. However, EXOS will manage and be responsible for this activity as part of the integration service.

EXOS is also working with FAA/AST to create classes of payloads that are “pre-approved” and requiring only superficial analysis and a minimal notification period. The BLK3 Launch License already includes safety approval for a wide range of payloads.

4.3. Combined Systems Test (CST)

The Combined Systems Test or CST will be undertaken at our Greenville HQ. It is recommended, but not necessarily essential, that the payload provider be present at the time of the CST. This test is designed to demonstrate that there are no interference effects caused by the payload during a fake engine mode run. Primarily the test is designed to evaluate EMI issues especially if there is an external antenna transmitting real time data during flight. The CST should be undertaken no later than the week prior to flight and preferably sooner.

4.4. Physical Integration

The physical integration check can be done at the same time as the CST. If the payload provider has potential concerns then an earlier physical fit-up is recommended. EXOS will supply the payload provider with a mounting plate that can be used to ensure there are no alignment issues. This adapter plate is then mounted by EXOS to the bulkhead coupler at the bottom of the payload module. Custom adapters are supplied as an optional service and we require only the mounting hole details … centers, diameter, clearance or tapped.

4.5. Launch Operations

Launch operations follows a tightly scripted protocol developed over the past several years and in accordance with the FAA AST Launch License

Launch – 4 Days
Launch Control Trailer, GSE Crane Truck, Propellants, Supplies and Launch Vehicle depart Greenville.

Launch - 3 Days
Launch team departs Greenville
Both crews arrive Las Cruces launch logistics base

Launch – 2 Days
Launch team arrives Spaceport America VLA early morning
Set-Up day at VLA

Launch – 1 Day
Conduct a dry run and abort practice
Payloads can be installed in vehicle, powered down or on charge
Vehicle is stored in environmentally controlled trailer for the night
Mandatory Mission Readiness Review (MRR) at Spaceport America facility

Launch Day
Launch team and all involved parties convoy to VLA for early arrival
Vehicle prep and pre-flight checklist
Roll out to launch pad and erection on launch tower
EXOS Safety Officer agrees with Range Safety & FAA AST launch is go
Corridor closed to air traffic
Involved parties retreat to secondary safety area
Third parties retreat outside the 6.5 km Flight Hazard Area (FHA)
Launch Team goes “on checklist” and commences hazardous ops
XSO countdown to launch (live with FAA online)
Nominal recovery is 25-30 minutes after launch
Launch Control Officer (LCO) conducts post flight ops to “Flight Secure”
Vehicle is recovered, payloads removed and returned to providers
Launch team breaks down the launch site and packs for return travel
XSO conducts a post-mission review with FAA AST and Spaceport America
In the event of a scrub for weather or technical delay, repeat next day

Launch Day +
Return travel to Greenville

5. ITAR

5.1. Introduction

The U.S. Government views the sale, export, and re-transfer of defense articles and defense services as an integral part of safeguarding U.S. national security and furthering U.S. foreign policy objectives. The Directorate of Defense Trade Controls (DDTC), in accordance with 22 U.S.C. 2778-2780 of the Arms Export Control Act (AECA) and the International Traffic in Arms Regulations (ITAR) (22 CFR Parts 120-130), is charged with controlling the export and temporary import of defense articles and defense services covered by the United States Munitions List (USML).

EXOS takes its responsibilities under the ITAR regulations very seriously. Fortunately, the technologies and hardware involved are for the most part "off the shelf" and only a few items are considered ITAR sensitive. To protect these technologies EXOS has developed an operational protocol described below.

5.2. ITAR Integration & Launch Protocol, Telemetry Data

The items considered ITAR sensitive are:

- Unrestricted GPS
- Engine Design & Injector Technology
- Detailed Mission Telemetry

To protect the GPS, the unique, one-time unlock codes are installed at the EXOS R&D facility and neither recorded nor kept with the vehicle. The GPS itself is installed in the vehicle and is only accessible to EXOS personnel.

No photographs of the engine internal configuration are allowed, and the engine nozzle will be covered until the vehicle is physically on the launch pad at which time the EXOS pad crew will remove it for flight. The recovery team will re-install the cover before other parties are allowed to approach the vehicle.

The high-resolution telemetry data stream is available only to EXOS and FAA/AST for mission analysis. Payload providers will be provided "sanitized" data in graphical format that meets their mission requirements for validation of the scientific experiment.

All involved parties including foreign nationals who will be present at the launch will be required to attend a Mission Readiness Review (MRR) at which time the above protocol will be explained. For the duration of the mission, including pre-launch and post-launch, the EXOS will be responsible for ensuring that the above protocol is followed.