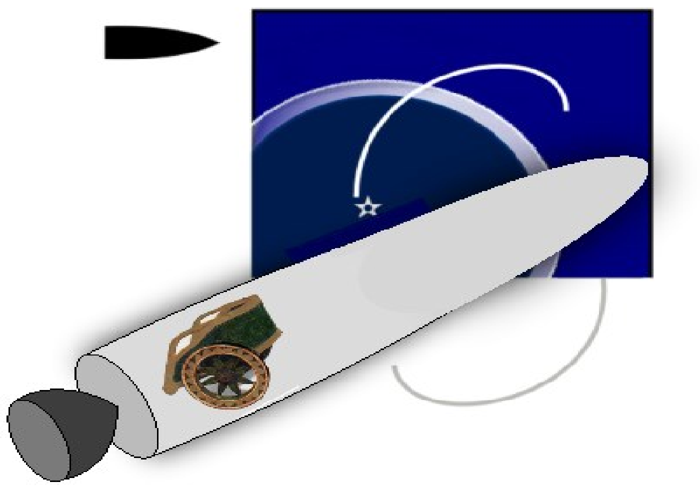

LEO
LAUNCHER
CHARIOT

Program

Customer Payloads

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# USERS' GUIDE FOR LAUNCH SERVICES

## LEO LAUNCHER & LOGISTICS


*Rev.1 Nov-2017* *v.0 Nov-2016*

# ABSTRACT


## Program

The Payload User's Guide is to familiarize potential Space launch vehicle users with LEO launch system – an aircraft which carries and launches an orbital rocket called the "Chariot". LEO Launcher provides the capability for small satellite developers to launch as often as they desire, into orbits from 100 nmi to 1500 nmi, for payloads from 100 to 1500 $lb_m$ into orbits at any inclination and azimuth.

LEO Launcher & Logistics offers an Innovative Business Approach to Orbital Launches. The Chariot LEO vehicles were designed around potential customer requirements. The use of existing, off-the-shelf components leads to the highest level of safety and reliability. Successfully placing satellites in target orbits leads to the higher level of quality offering with our program. LEO Launcher & Logistics meets or exceeds industry standards for Safety, Reliability, and Quality. Because we use proven technology, our prices are among the lowest in the Industry.

The first Launch is Q4 2018. Mission planning takes approximately 12 months, with contracts signing required at least 12-13 months prior to launch date.

## Customer Payloads

LEO Launcher & Logistics executes and assists with management of all life cycle phases of customers' payloads. Satellite owners have many similar requirements which LEO intends to satisfy: Safety, Schedule, Communications, Vibration, and Accuracy. Additional options offered include Intact Abort, Fast Turn-Around, Fast Launch, and Continuous Communication. Multi-Satellite Launches are offered; however, the advantages of single payload launches are accurate orbit placement and reduced liabilities.

Customer Satellite data tables are included in the Users' Guide for collecting information to plan launch missions. These tables are requests for information on launch needs, satellite data or physical elements, engineering documents, hazardous chemicals, requirements for computers, electromagnetics, communications, orbital placement, and external vendor data.

## LEO Systems Identification

LEO Launch systems and Logistic Systems are identified. These are Launching Aircraft, Chariot Launch Vehicle (Rocket), Orbit Insertion, Satellite Support Structure, Payload Systems, Separation Systems, Avionics – Guidance, Navigation, Control Systems, and Coordinate Frame.

Logistic systems are for design and development, acquisition, storage, movement, distribution, maintenance, evacuation, and disposition of space materiel, movement of goods in space, and contracting and supplying any required support services for maintaining space travel.

## LEO Launch Systems

The Launch Systems section discusses Vehicles, systems performances, physical attributes, and thermal & climatic environments.

## LEO Logistics Program

An Operations Work Flow diagram identifies the Logistics elements, integrated with the Launch Operations functions. The Logistics Payload Handling, Communications, and Facilities are discussed. We are launching from government facilities in 2018-2019, and from our facility in Central - South Texas after 2019.

## LEO Operations

Operations include Mission Planning, Launch Operations, Flight Operations, and Customer Data Requests.

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## DOCUMENT VERSIONS

| | | |
|---|---|---|
| Version 0 | November 11 2016<br>Original Document | "USERS' GUIDE FOR LAUNCH SERVICES - LEO LAUNCHER & LOGISTICS"<br>Author: Ken Robinson, VP Product Development, *LEO Launcher & Logistics* |
| Rev. 1 | November 7 2017 | Approval: Gail Williamson, Pres / CSO *LEO Operations Management, Inc.* |

# PROGRAM

## L1. LEO USERS' GUIDE INTRODUCTION

### PURPOSE

This User's Payload Guide is intended to familiarize potential Space launch vehicle users with LEO Launcher & Logistics, Inc. (referred as "LEO" in this document) launch system capabilities & services. The launch system includes the flight vehicle - a horizontal craft, the launch vehicle or rocketry designated as the "Chariot", orbit insertion, and payload housing nose cone.

This document is applicable to the LEO Launcher Chariot vehicle configurations.
This user's guide is intended for pre-contract mission planning and for understanding LEO Launcher's services.

This is a Guide to Operations. It is not a Standard Operations Procedure (SOP), it does not have that formal authority.

### INTENDED AUDIENCE

This manual is designed for use by three groups:

Customers and Potential Customers
Investors and Potential Investors
Those of us who work on the LEO Launchers Chariot Low Earth Orbit Launching System

### THE BUSINESS OF LEO LAUNCHER & LOGISTICS

LEO intends to provide to developers of small satellites the capability to launch as often as they desire, into orbits from 100 nmi to 1500 nmi, for payloads from 100 to 1500 $lb_m$ into orbits at any inclination and azimuth.

## L2. LEO COMPANY BACKGROUND

### COMPANY DESCRIPTION

LEO is based in Southeast Texas. Our company is a Texas corporation which features experienced Aerospace Engineers, Rocket Scientists, Business Planners and Logistics Organizers. We collectively have a greater average amount of experience in space launching and technical business than any other such launch business with the possible exception of NASA or the Russian Space Agency.

LEO Launcher & Logistics was founded specifically to launch commercial satellites into Low Earth Orbits which are less than 1500-pound mass ($lb_m$) to altitudes up to 1500 nautical miles (nmi).

## BRANDING

We are in the Business of doing Business.
Our area of focus is payload and satellite concerns.
Our function is transportation, for low earth orbit deliveries.

The purpose of the LEO Launcher & Logistics is to structure our business to place satellite payloads into orbit, and supply ancillary payload or satellite needs. Using business principles as the forefront purpose of all decisions of conducting business, design and process considerations, and service or product offerings, allows the LEO organization to be flexible to offer optimal solutions to customers.

A secondary purpose of our business is job creation. For this to happen, it is necessary to satisfy demand for products or services. We do this by understanding current and future customers' needs, analyzing multiple applications and solutions, and forecasting new technologies or trends from affecting industries.

## MISSION STATEMENT

**LEO** provides launch services with exceptional reliability and efficiency for its customers, by providing high quality and expedient payload transport and logistics performances through expert specialized LEO companies.

Safety of personnel, environment, public, and LEO Companies' systems leads all operations. LEO Companies strive to be self-sustaining for the continual health of the organization and lucrative financial returns for shareowners, while providing a superb work setting for team members and employees, maintaining rewarding relationships with its team members, partners, and suppliers. The highest ethical and professional standards prevail in all of LEO Companies' activities.

## OBJECTIVES

Launch execution and operations are to exceed industry standards for **Safety**, **Reliability**, and **Quality** of Launches. The timetable for LEO Launch & Logistics Inc. to exceed industry standards is by the end of third year of launch operations.

**Safety** Incidents are less than < 3% of launches. Safety incidents include unplanned events that may cause injury, illness, or property damage.

**Reliability** is greater than > 95%, where Reliability is defined as meeting launch schedules, successfully placing payload in targeted orbit by required schedule and budget, and successful orbit of payload for one orbit; schedule allows mitigating from any aborted launches and re-launch efforts.

**Quality** is ensured when Payloads are successfully placed in target orbits per specifications 99% of the time, which equates to 3 **σ** sigma or greater based on a typical Gaussian curve.

## LEO'S ROLE IN THE COMMERCIAL SATELLITE MARKET

LEO Launcher and Logistics intends to provide an "**Innovative Business Approach to Orbital Launches"**.

***We propose to change the commercial Satellite Market***. From 1990 to 2014 there were 20 to 30 launches* each year for commercial satellites. In 2015, that market increased to about 40 launches** by all launchers world-wide. By LEO's count, there are more than 1200 satellites scheduled to be launched from 2016 to 2023 (this just counts private or commercial satellites, not government, and not individual "cube sats"). Space Daily foresees more than 1220 satellites in the same time frame. AIAA foresees more than 2500 for the next 10 years.

***In fully operational mode, LEO Launch & Logistics will launch 25 to 50 launches each year, doubling current number of launches world-wide.***

* Wikipedia.com **AIAA and Space News

## L3. LEO LAUNCH BUSINESS

### LEO LAUNCH PROGRAM OVERVIEW

The Chariot LEO Launch vehicles were designed around potential customer requirements. To best serve customers, our program allows fastest turnaround to orbit because we have both the most experienced personnel, we use proven tested, previously flown aircraft and rockets, and are using existing, off-the-shelf components as often as possible. This includes use of existing software as well as hardware. This use of existing tested equipment leads to the highest level of safety and reliability.

Our goal is to have greater than 3 σ sigma launch success during flight operations. This means better than 99% success rate, after an extensive program of test, verification, qualification, and validation. Successfully placed satellites in target orbits leads to the higher level of quality offering with our program.

### COMPETITIVE ADVANTAGES

LEO **Competitive Advantages** include company **Objectives** and the **Features of Services.** Objectives include Safety, Reliability, and Quality. Features include Safety, Frequency, Standardization, Intact Abort Capability, Fast Turn-Around, and Accurate Orbital Placement.

See Objectives under *L1. LEO Users' Guide Introduction* and Features of Services under *L17. LEO Launch and Logistics Mission Planning*.

### LAUNCH SCHEDULE

**Table 1 Proposed Schedule Initial Launches to Full Operations**

| Operations Schedule | Number of Launches | OPS Year | Description |
|---|---|---|---|
| Q4 2018 | 1-2 | Yr. 1 | Customer Launches Begin |
| Q1-Q4 2019 | 12 | Yr. 2 | Launch every month |
| Q1-Q4 2020 | 24 | Yr. 3 | Launch every 2 weeks - Full Operations |
| Q1-Q4 2021 | 48 | Yr. 4 | Launch every week - Full Operations Optimal Schedule |

## PRICING

Because we do not need extensive hardware nor software development programs which are required for new development, our prices are among the lowest in the Industry. ***
*** JOURNAL OF PROPULSION AND POWER, Vol. 27, No. 5, September, 2011

### Price per Launch vs. Price per Pound

The question of the cost for launching a satellite has often been couched in terms of minimizing the price per pound to orbit. This sounds like a good measure, until you consider what it means. The real price is price per launch, to get a satellite to the **right orbit** for its function.

There is a basic price to launch any rocket or any large flying body, like a USAF B-52, or a Boeing 747. This minimum price is there whether you launch 25 lbm or 25,000 lbm. The minimum price of putting a pound of mass into orbit, above 150 miles altitude, at 17000 mph or more (necessary to orbit above 150 mi. altitude) is very significant. Like delivering freight on land or delivering satellites to orbit, you get lowest cost per pound delivered if you have a large delivery mechanism (truck or rocket), with a large amount of mass to be delivered. However, if you have a very valuable item, like jewels or a satellite, to be delivered to an exact location (a specific orbit for satellites or a specific street address for parcels), low delivery price per pound becomes less meaningful if the valuable item is delivered to the wrong street address or sub-optimal orbit. You certainly would not want to have a delivery of valuable jewels to be dropped off at the wrong, sub-optimal location, just to save delivery cost.

To reduce the price per pound orbited, rocket companies have gone to larger and larger launchers. At the same time, satellites have become more and more efficient and, hence, lighter for the same functionality. This has led to launching several or many satellites on heavy lift launchers. This concept is the reason that many satellites are being delivered to sub-optimal, and therefore, less useful, orbits.

For this reason, LEO considers that the **price per launch** is more important than price per pound to orbit. Therefore, the LEO launch system has been optimized for smaller satellites, 100 lbm to 1500 lbm. This allows the LEO team to have among the lowest prices per launch.

Therefore, with a LEO Launch system, you get the lowest price possible for delivery to your satellite's exact orbit.

### Pricing for Multiple Payloads

Pricing considerations will be made for launches of multiple payloads. The total pricing of a launch includes more than the flight vehicle and crew, such as mission planning and project management, storage and handling, insurances, trajectory analysis and communications for each satellite payload. Thus, discounts can be made for multiple payloads, but these will not be equally divisible by the count of payloads as each satellite is handled as separate missions.

Two major concerns of multiple payloads on one launch mission include losing the capability of accurate orbit placement, and increased liability of incidents of one payload to other payloads on the same launch flight.

# CUSTOMER PAYLOADS

## L4. PAYLOAD LIFE CYCLE

The life cycle phases include payload manufacture, transport, storage, pre-launch staging (assemble, stage, and load payload for flight), launch, orbit placement, communications, operations, and end of life (retrieve and disposal or salvage).

LEO Launcher & Logistics will assist with management or execution of all life cycle phases of customers' payloads.

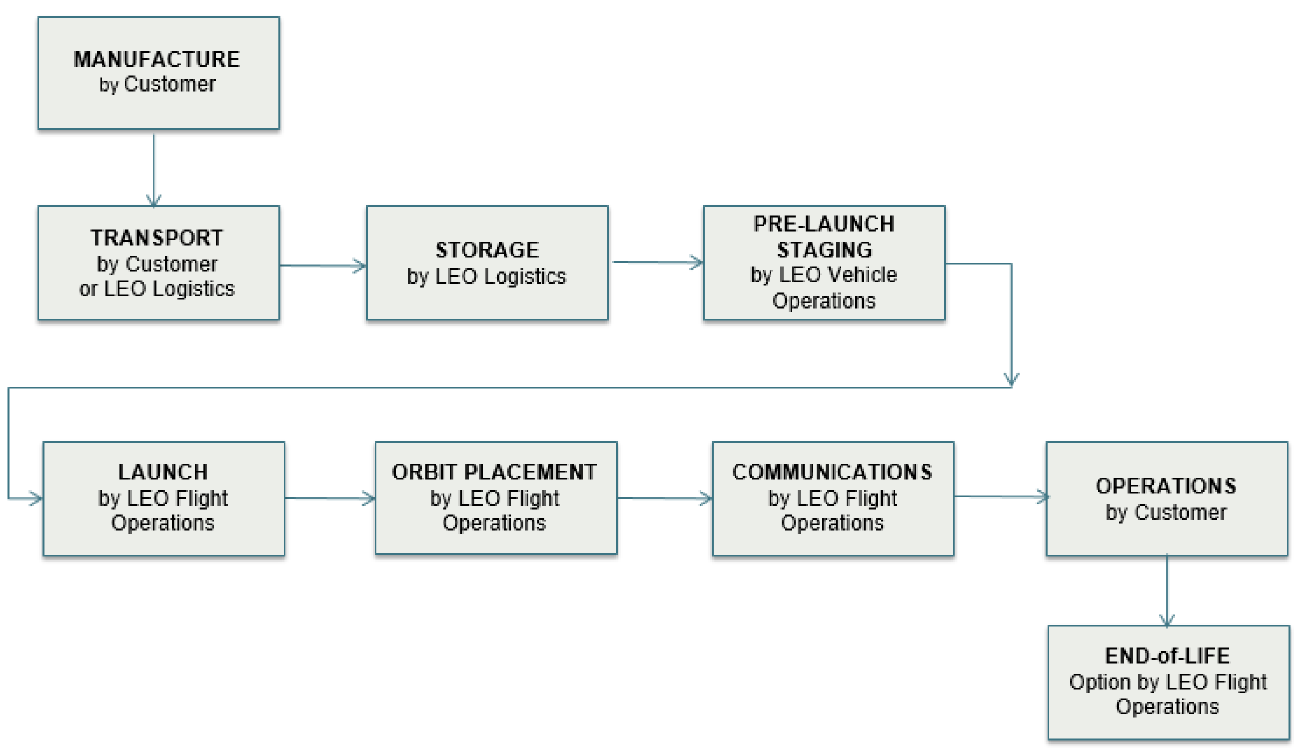
## LEO EXECUTION

LEO executes payload storage, pre-launch staging, launch, set-in-orbit, and communications, as part of the standard launch service.

## LEO MANAGEMENT SERVICES

LEO offers services for managing the manufacture, transport, and operations of the payload.

**Figure 1** **Satellite Payload Life Cycle**



## L5. CUSTOMER'S SATELLITE REQUIREMENTS, CONCERNS, & OPTIONS

### REQUIREMENTS

Satellite owners have many similar requirements which LEO intends to satisfy; examples include:

#### SAFETY

**People** – protect safety of all people involved.
**Equipment** - Safe handling of your satellite, with care and security.
**Mission** - A Safe Launch, which places your satellite into the desired Orbit.

#### SCHEDULE

LEO receives and launches your satellite in timely manner. We launch on the time and date you and LEO negotiate and agree upon. Exceptions to this would be such things as weather, political concerns, licensing, etc.

#### COMMUNICATIONS

TO insure the health of customer satellites, LEO provides communications to and from your satellite from before aircraft take off, and up to release of your satellite into its final correct orbit. Then, customer is on your own to maintain your satellite communications and management.

#### VIBRATION

LEO shock and vibration levels are well within norms for Space Flight and satellites. This is insured by the fact that LEO's Launch rockets have been used successfully on many flights for other successful Launch programs.

#### ACCURACY

**LEO correctly places Customer satellites into the desired orbit, at the right time, with proper spin.**

Accuracy of placement into orbits relies on several elements:

1. Customer's stated required accuracy. Tolerances for Customer satellites must be written and agreed.
2. Inherent accuracy of the rockets LEO uses to attain orbit. Rocket designs which LEO uses have flown dozens of successful flights to the correct required orbits.
3. Orbit insertion rocket and mechanisms must be able to modify their orbital parameters at orbit insertion. LEO has a variable thrust Orbit Insertion stage for fine tuning of accuracy should telemetry show variation from requirements.
4. Navigation, Guidance and Flight Control (GNC) software used must be accurate enough to attain desired orbital parameters during trajectory analysis, both on the ground and on the flight vehicle, before and during flight. The GNC software LEO uses for trajectory analysis is tune-able to tolerances needed.
5. The experience and expertise of the engineering staff performing these operations should be strong and deep. LEO's personnel are experienced, wit Subject Matter Experts (SMEs) in Guidance, Navigation, and Flight Control, and other areas of rocket launches. LEO personnel have successfully launched rockets dozens of times.

## CONCERNS

Satellite owners have similar concerns:

### Launch Prices

LEO's prices are among the lowest in the launch Industry, due to our emphasis on using equipment and procedures which have been successfully used in other orbital programs, such as Space Shuttle, SSUS, PAM-D, USAF & other government programs.

In addition, LEO's launch prices are standard and stable, for the accommodations described in the list of Customer Services & Options Offered, L18. These prices will not change due to normal issues, such as when the launch is to be delayed due to normal considerations, or such as weather or mechanical issues.

### Mission Completion

LEO has a variable thrust liquid propellant Orbit Insertion stage in our launch configuration.  This insures that if there are any variations in orbit initially reached, we can usually modify the final orbit in plane. The usual cause of such variations might be such considerations as upper level winds, etc. LEO personnel have Reliably and Repeatedly participated in numerous orbital flights.

### Other Common Concerns

Most other concerns, such as orbital accuracy and tolerance, vibration, schedule should be stated in the initial requirements (see above), which are agreed to at start of each launch program.  Details of these parameters of these concerns are addressed in the remainder of this Payload Users' Guide.

## OPTIONS

The LEO Launch program has several special features for Customers.

### Intact Abort

Should there be any problems (weather, LEO Launch vehicles, etc.) which delay rocket ignition point, your satellite can be safely returned to the Launch Facility.

Should your satellite have any malfunction or concerns while in flight before rocket ignition, LEO can return your satellite to the Launch Facility for adjustments.

Due to LEO's Fast Turn-Around capability, we can again take-off and prepare to launch very soon after an Intact Abort.  How soon relaunch occurs would be determined by the nature of the cause of the delay. However, this will not normally be weeks or months, as would be the cause of "Launch Scrub" for a vertically launch rocket.

In the future, LEO expects to be able to also return a satellite from orbit, before release of the satellite into final orbit.  This will be a second-generation capability, however, a few years after first launches.

## FAST TURN-AROUND

As mentioned above, the LEO Launch program allows us to launch very soon after a mission "scrub." This could be as little as a few hours, but could be a week or more, depending on the cause of the delay.

## SHORT PREPARATION LAUNCH ("FAST LAUNCH")

LEO reduces prices and time frames by standardizing everything possible. Therefore, LEO could, for most circumstances, prepare for a launch in a much shorter time than usual space programs. The primary limitations on time are expected to be permitting and licensing, not physical nor procedural issues. Also, LEO's frequent schedule allows us to keep crews ready to launch.

If you need to launch "on notice," please contact us to get such a program arranged.

## MULTI-SATELLITE LAUNCHES

After our first five launches, LEO will fly multiple satellites on one launch, for those Customers who want that. These would be for in-plane satellite positions only.

## CONTINUOUS COMMUNICATION

LEO Launch & Logistics, as a standard service of LEO Launches, provides communications to and from your satellite from before aircraft take off up to release of your satellite into its final correct orbit. Then the customer is on your own to maintain your satellite communications and management.

As an optional service, LEO can also provide further communications with your satellite at your determined period as a paid option. This would typically be for 1 complete orbit, or for several orbits, until customer communications are fully operational, or even as a continuing service.

## L6. CUSTOMER DELIVERABLES

### CUSTOMER SATELLITE LAUNCH NEEDS

To insure your success, Customers should provide the LEO Team at least the following information:

1. All orbital element values their satellite requires.
2. Maximum / Minimum Tolerances for each orbital variable.
3. Weight, size, center of gravity (cg) of each satellite.
4. Satellite needs during flight preparation, before Launch, during Flight, and after Separation from the orbit insertion vehicle. These should include at the minimum:
    a. Electrical power
    b. Computer input data and format
    c. Telemetry – including communication bandwidths and tolerance
    d. Radiation and electro-magnetic sensitivity
    e. Sensitivity to G forces including during transportation and handling.
    f. Attachment points for Transport and Handling, Flight and Launch
5. Transportation carrier and method
   LEO requires that satellite carriers have accelerometers attached to satellite, from customer departure point to arrival at the Launch integration facility.
6. Licensing and documentation
7. Any special handling requirements, hazardous materials, propellants, radioactivity, etc.
8. Points of Contact in your Company or Organization-direct phone numbers, email, addresses.
9. Radiation / communications gear onboard the satellite.
10. Communications needs – to and from satellite, to and from your organization
11. Public Relations desires, needs, privacy needs.

## CUSTOMER DATA TABLES

Please use the following Tables to provide LEO Launch & Logistics to prepare for Launch of your satellite, considering the variables above, and any other necessary.

**Table 2 Payloads – Physical Elements**

| **Satellite information** | **Satellite Name:** | | **Other Designators, such as P/N S/N:** | |
|---|---|---|---|---|
| **Company Point of Contact** | Name:<br>Title: | Phone:<br>Email Address: | Mailing Address: | |
| **Weight:**<br>**Lbm, Oz, Kg, gm** | Lbm or Kg or Nt | | | |
| **Coordinate System** | X forward or which direction | | X vertical | Y horizontal |
| **Center of Gravity (CG) Location** | X in. or cm. | Y in. or cm. | Z in. or cm. | |
| **Size** | Longest Dimension | | Max Width | Max Depth |
| **Moment of Inertia** | ω | I | | |
| **Attachment Points Locations: x,y,z** | Launch attach points: | | Transportation attach points: | |
| **Strength of attachment Points** | | | | |
| **"G" Tolerance** | Satellite sensitivity by axis: | X | Y | Z |
| **"G" Tolerance** | Attach pts. sensitivity by axis: | X | Y | Z |
| **Vibration Sensitivity by Axis** | | X | Y | Z |

**Table 3 Payloads – Engineering Documents**

| | | | | |
|---|---|---|---|---|
| **Please provide Engineering drawing(s) of Satellite** | | | Show 3 Views: Plan, Elevation, Orthogonal | |
| **Engineering Drawing(s)** | Drawing Title & Drawing Numbers | Satellite Attachment points | Show x, y, z Coordinates | Show Reference Point |
| **Data Sheets** | Material of Construction | Coating | Fluids | Special Needs / Purging, etc. |

**Table 4 Payloads – Hazardous Chemicals**

| **Temperature** | **Max** | **Min** | **Soak** | |
|---|---|---|---|---|
| **Atmospheric Pressure** | Internal | Max | Min | |
| **Allowed Pressure** | External | Max | Min | |
| **Hazardous Materials** | Material | Quantity | Hazard | |
| **Additional Hazards** | | | | |
| **Radioactive** | Material | Quantity | Hazard | Radiation emissions ($\alpha$, $\beta$, $\gamma$, X, etc.) |
| **Propellants Onboard** | Material | Quantity | Hazard | |
| **Additional Properties** | Is Propellant Storage Required? Y / N | How much ? | How long to be Stored? | |
| | Do you need LEO to fill your satellite propellant? | | | |

**Table 5 Payloads – Computer & Electromagnetic Requirements**

| | | | | | |
|---|---|---|---|---|---|
| **Electrical Power needed by Satellite** | Volts | AC or DC | AMP | Total Power Needs / Hr. | |
| **Battery charging needed?** | Volts | AC or DC | AMP slow or fast charge? (A/Hr.) | Expected Life Years | Will there be a Replacement? Y / N<br>Solar Power? Y / N<br>Nuclear Power? Y / N |
| **Computer Link needed?** | Cable | Internet | Connector types(s) | | |
| **Computer data formats** | OS | Data Bus Format | Data Rate | Storage | |
| **Radiation Sensitivity** | MAX Allowable | Bandwidth | Power Accepted | | |
| **Radiation Emitted** | MAX Emitted | Bandwidth | Power Radiated | | |

**Table 6 Payloads – Communications Requirements**

| Ref. | Frequency Bandwidth | | Application Comms Description | Customer Frequency (HZ) | Dedicated Transmit (T) Receive (R) | Customer User Satellite Network | |
|---|---|---|---|---|---|---|---|
| | | | Ground (G)<br>Launch (L)<br>Aircraft (A)<br>Satellite (S) | | | List User Satellite Network Description | Comms Band Frequency (HZ) |
| | | X-Band | | | | | |
| | | X-Band | | | | | |
| | | X-Band | | | | | |
| | | Ka-Band | | | | | |
| | | Ka-Band | | | | | |
| | | Ka-Band | | | | | |
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| | | C-Band | | | | | |
| | | C-Band | | | | | |
| | | C-Band | | | | | |
| | | S-Band | | | | | |
| | | S-Band | | | | | |
| | | S-Band | | | | | |
| | | UHF | | | | | |
| | | UHF | | | | | |
| | | UHF | | | | | |
| | | VHF | | | | | |
| | | VHF | | | | | |
| | | VHF | | | | | |

**Table 7 Payloads – Communications Requirements - Equipment**

| Reference | Customer Communication Equipment | Manufacturer | Equipment Description | Model No. |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**Table 8 Payloads – Orbital Requirements**

| | Satellite Orbit | Information | Tolerances | |
|---|---|---|---|---|
| Altitude of Perigee | | | | |
| Altitude of Apogee | | | | |
| Orientation | | | | |
| Date need by | | | | |
| Time of day | | | | |
| Spin rate | Axis | | | |
| Coordinate system used _______ | Rate | | | |
| (X, Y, Z, Euler, aircraft?) | Revs/sec. or radians/sec? | | | |
| Pointing? | Pointing to What (e.g. sun, Moon, Earth, etc.) | | | |
| **Orbital Elements** | **Symbol** | **Value at Launch or Orbit** | | |
| Semi Major Axis | a | | | |
| Eccentricity | E | | | |
| Inclination | I | | | |
| Argument of Perigee | ω | | | |
| Ascending Node | Ω | | | Does this matter for your Satellite? |
| True or Mean Anomaly | ν | | | |

**Table 9 Payloads – External Vendor Information**

| **Transportation** | Who will organize transportation? | Your Company Y / N<br>Other Company Y / N<br>LEO Logistics Y / N | | |
|---|---|---|---|---|
| If your company organizes your own transport, please provide to LEO: | Transport Company Full Name | Contact Phone No. | Contact Name | Contact Email |
| Expected **Ship Date** | | | | |
| Expected **Delivery Date** to LEO Facility | | | | |
| **Transport Insurance Co** | Transport Insurer's Full Name | Contact Phone No. | Contact Name | Contact Email |
| Insured Value | | | | |
| **Satellite Insurer** | Satellite in Flight Insurer's Full Name | Contact Phone No. | Contact Name | Contact Email |
| Insured Value | | | | |

If you need more or different data, please send an additional electronic file or spreadsheet.

## PUBLICITY, PRIVACY, SECRECY

Your company and LEO Launch & Logistics will already have a Non-Disclosure Agreement (NDA) signed before work begins. So, all Customer information is considered Confidential, unless Customer authorizes disclosure.

Does your company want publicity or not?

Do you want LEO to organize publicity for your satellite?

May LEO advertise that your Company Satellite is to be launched with us?
Should we Include date of scheduled Launch?

## LICENSING AND DOCUMENTATION

Numerous forms of documentation must be arranged before a space flight – with FAA, Space Agencies, City where Launch will occur, Alternative Landing Sites. Hazardous Materials Reports, etc. LEO Launch & Logistics will need to have copies of Customer legal authorizations before a Flight or Launch. Customers can organize these or LEO could do it for you, for a fee. Some reports, authorizations and arrangements will be made by LEO.

# LEO SYSTEMS IDENTIFICATION

## L7. LEO LAUNCH SYSTEMS

The LEO Launch System consists of the Flight Vehicle, Chariot Launch Vehicle (Rocket), Orbit Insertion, Satellite Support Structure, Payload Systems, Retention – Release – Separation Systems, Avionics – Guidance – Navigation - Control Systems, and Coordinate Frame.

**Figure 2 Flight Vehicle Workflow - Aircraft**

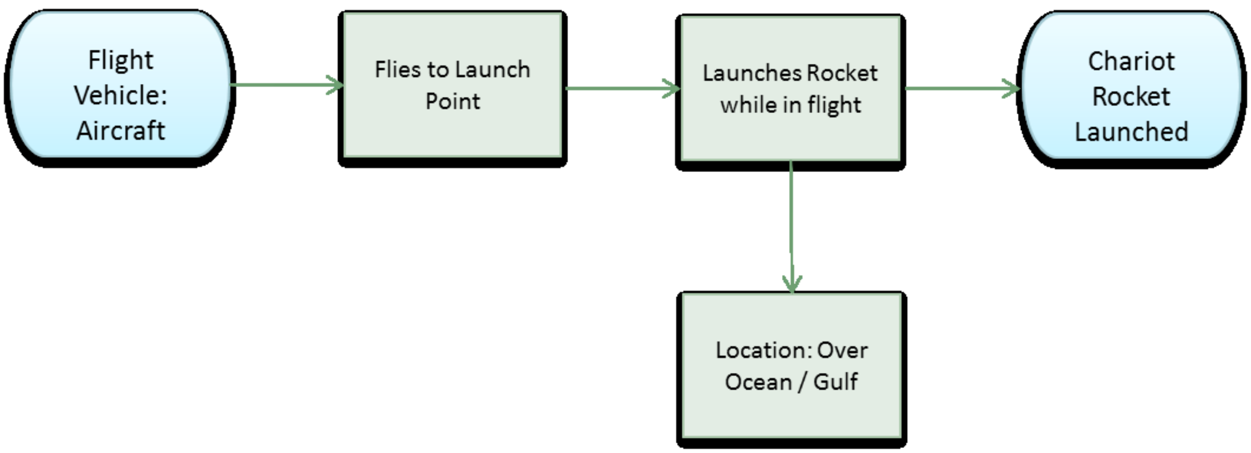


**Figure 3 Chariot Launch Vehicle Workflow - Rocket**

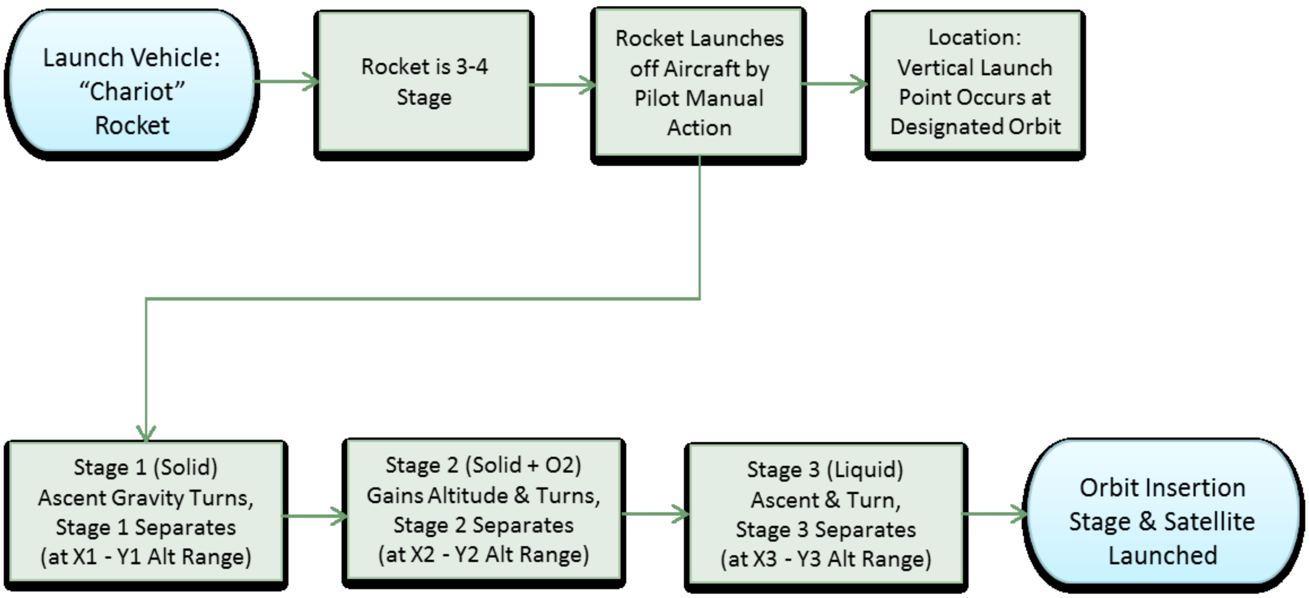
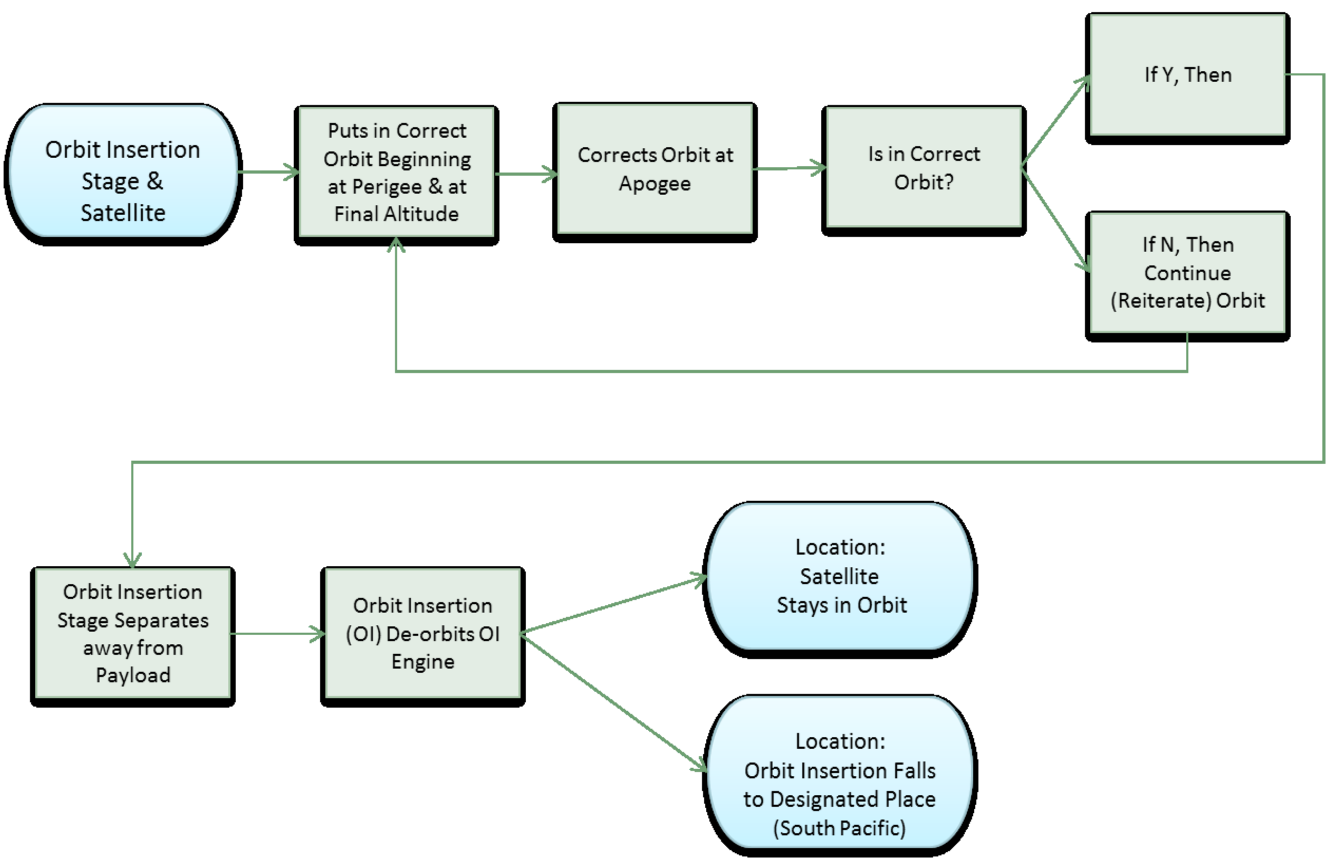



**Figure 4 Launch Orbit Insertion & Payload Workflow**



# L8. LEO LOGISTICS SYSTEMS

## LOGISTICS DEFINITION

Logistics is "the things that must be done to plan and organize a complicated activity or event that involves many people" http://www.merriam-webster.com/dictionary/logistics

According to the AIAA Space Logistics Technical Committee, **space logistics** is

> ... the theory and practice of driving space system design for operability, and of managing the flow of materiel, services, and information needed throughout a space system lifecycle.

However, this definition in its larger sense includes terrestrial logistics in support of space travel, including any additional "design and development, acquisition, storage, movement, distribution, maintenance, evacuation, and disposition of space material", movement of people in space (both routine and for medical and other emergencies), and contracting and supplying any required support services for maintaining space travel. (AIAA)

The Business Dictionary defines Logistics as "Planning, execution, and control of the procurement, movement, and stationing of personnel, material, and other resources to achieve the objectives of a campaign, plan, project, or strategy."
It further describes Logistics Management as the "Application of management principles in logistics operations for efficient, and cost-effective management of goods and personnel".

## LEO LOGISTICS OPERATIONS OVERVIEW

### SPACE TRAVEL

Space travel which LEO Launch & Logistics, Inc. provides and supports, is **just** for physical items, not for people. Physical items are currently focused on Customer payloads and/or satellite assets.

This includes such considerations as transportation of Customer satellite, storage, maintenance, any provisioning necessary, launch into space, and maintenance while ascending to orbit. This also includes licensing and documentation. The Customer can provide any of these items, as they wish. LEO furnishes the rest. Typical Customer supplied items would be surface transport to the launch site, licensing, and insurance.

### LAUNCH SYSTEMS LOGISTICS

The logistics side of LEO Launcher & Logistics Inc. incorporates systems of the flow of material, services, information, and people as described in the definition section above in L8. LEO's logistic systems involve procurement processes including inspection and audits; goods transport, receipt, and storage; and planning of labor, equipment, and materials resources for supporting launch systems. As shown in L7 LEO Launch Systems, the primary launch systems that are supported are the Flight Vehicle (aircraft), Rocketry, and Orbit Insertion & Payload.

#### SPACE TRANSPORTATIONS SYSTEMS

The space transportation systems of LEO are to store, move and distribute Customers' payloads to space. Our systems remove (evacuate) and dispose of the expended space material, i.e., the rockets used to launch your satellites into space. Our flight trajectories remove each expended rocket stage from flight once exhausted, and place these into safe locations. Eventually, we intend to recapture the orbit insertion rockets, and possibly other components.

## LEO Logistics Payload Handling

### Satellite and Payload Transport

In LEO's systems, management insures that all activities to relocate your satellite from your manufacturing facility to our launch facility are fully defined, and integrated. LEO will oversee, or if you chose, LEO will execute the planning and scheduling to transport customers' satellites from manufacture facilities to the launch site.

### Satellite and Payload Pre-Staging

To the LEO organization, logistics means that we assure that every aspect of launching a satellite or payload into orbit is satisfactorily addressed, either by the LEO team or the customer. LEO provides Customers with a checklist to insure all necessary activities are taken care of by the customer or by LEO.

### Satellite and Payload Manufacture

The manufacture of satellites is a complex operation which can be overseen by LEO Launcher & Logistics, Inc. should the satellite owner-operator chose this option. LEO's oversight will include inspection and audit of specifications, monitoring schedules and tracking of schedule and cost performances during the manufacture cycle.

## Communications

Communications for Launch Operations provides communications and data tracking of the flight vehicles and payloads. Standard communications offered in the standard launch service include communications up to the payload's initial orbit. Optional services which can be purchased include communications for more than one orbit, data collection from the satellite payload, and continuous communication and/or data transfer for specified period of time or throughout the active life of the satellite.

## Facilities

LEO's facilities for handling customers' payloads include receipt, storage, test, integration, and storage accommodations. Cleanrooms are utilized to assure cleanliness, security, and stability of your payload are maintained.

# LEO LAUNCH SYSTEMS

## L9. LEO VEHICLE DESCRIPTIONS

The LEO Launch long-range heavy lift **aircraft** has a range of 6,000 to 10,000 nmi. and a payload capability of well above 100,000 lb. While it has not been finalized, the Boeing 747 is our nominal choice of aircraft. This class of aircraft can easily carry a 60,000 lbm rocket under the wing, under the belly, or on top of the aircraft. There are 75 ft. between front & rear landing gear on the 747. The anticipated length of the LEO Chariot rocket is about 70 ft. long. (By comparison, the extended length Pegasus is about 56 ft. long).

Below the aircraft would be the preferred rocket location for lateral symmetry on this aircraft (aircraft); on top of the aircraft would probably be preferred for a C-5. However, use of US military aircraft may also pose special issues.

Mounted under a wing, the rocket would fit between fuselage and the inner engine, or between engines, or in place of an inner engine. Any of these configurations would be nothing new to heavy aircraft. The 747's sometimes mount a spare engine under a wing for transport purposes. As a 4-engine aircraft, with an under-weight load, one of the inner engines could be removed and the Chariot system installed there. Such engines weigh 8 to 15K lb. B-52's carried the X-15 under the wing. L1011 carries the 40K lbm Pegasus under the belly. The 150,000 lbm Space Shuttle Orbiters were carried on top of a 747. These vehicles were released from these positions, while the aircraft was in flight, near maximum velocity and near maximum altitudes.

**Figure 5 <u>Methods of One Aircraft Carrying Another</u>**



https://www.google.com/?gws_rd=ssl#q=space+shuttle+on+747
http://www.educationalresource.info/NASA/9-x15-b52.htm
http://www.gettyimages.com/pictures/bomber-carrying-beneath-its-belly-the-experimental-xs1-news-photo-3297842

## LEO FLIGHT VEHICLE

A **long-range heavy lift aircraft**, which is already qualified to take-off and land at major airports around the world. The nominal choice candidates are the Boeing 747, 757, 767, MacDonnell-Douglas DC 10, USAF B-52, and C-5. Other excellent choices would be from Airbus and from Russian makers. However, we view these non-US built choices as having too many political, supply-chain, and Export-Import issues.

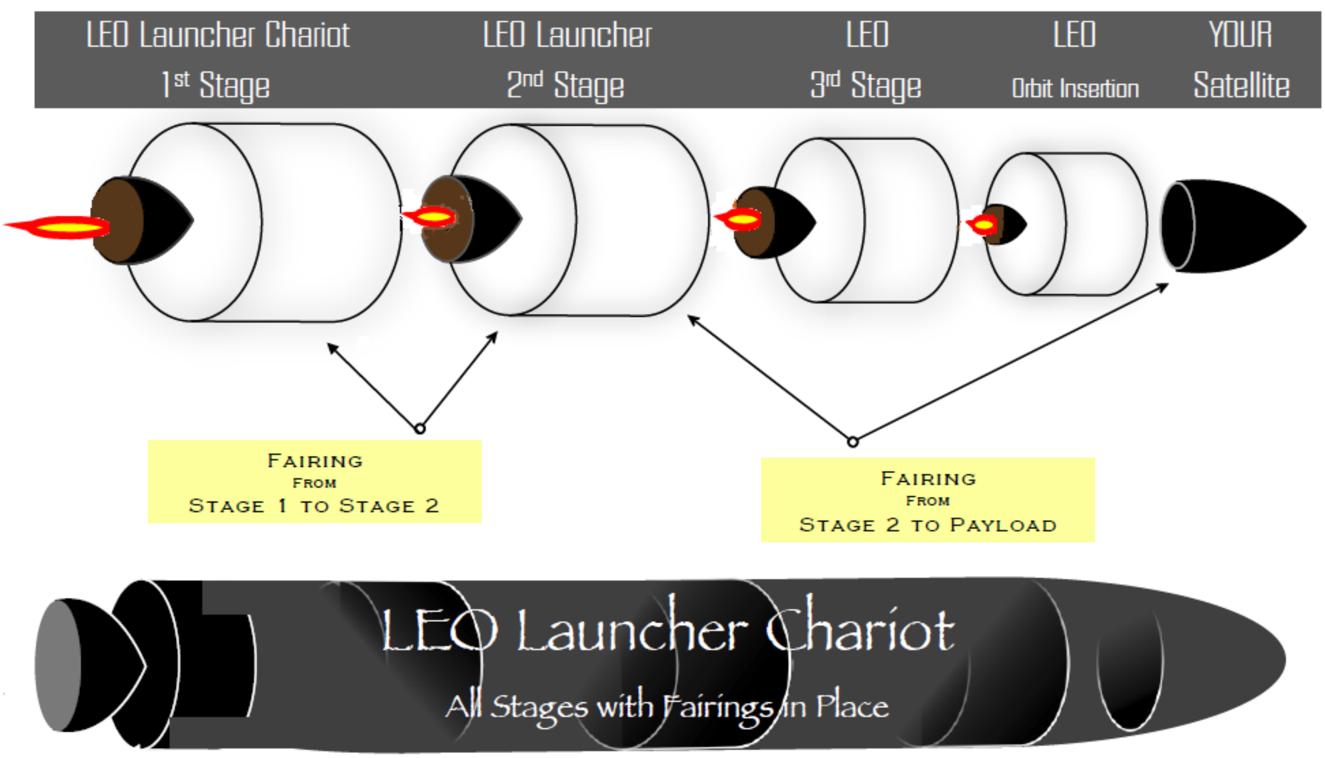
## CHARIOT LAUNCH VEHICLE

A **2 to 3 stage solid fuel rocket** - 3 stages is standard and initial configuration; a 2 stage launch solid rocket stack will normally be used for low orbits (below 400 mi.) of light satellites (below 400 lbm). 2 to 3 Solid rockets compose the primary propulsion. Existing rocket designs LEO favors are derived from Minuteman – ATK Orion 50'S and 38's.

The rocket stages are about 50 in diameter, total weight of the entire stack of rockets would be 40,000 lbm to 60,000 lbm. Total length is about 70 ft. including upper stage. First stage-nominal-ATK 50 ST or ATK 50S XLT (air-ignited, 3 degree vectorable Thrust) about 35 ft. long; 50 in OD. Second stage – nominal choice ATK 50XL, 5 degree vectorable Thrust, about 10 ft. long, 50 in. dia. Third stage – nominally ATK 38 vectorable Thrust, about 6 ft. long, 38 in dia.

An alternative to three solid rockets would be to use one solid rocket stage plus one Liquid Rocket for all the upper stages. We would choose a liquid rocket with a long history of successful use, such as the Aerojet-Rocketdyne RL10. This conversion to fully liquid upper stage rocket may not occur until second or third year of operational flight, if at all.

**Figure 6 <u>LEO's Chariot 3 Stage Rocket</u>**



## ORBIT INSERTION

A very energetic **liquid orbit insertion stage** is used, which has flown before. Nominal design is Aerojet designed Space Shuttle OMS (Orbital Maneuvering System) MMH engines (7 deg. vectorable) 250 lbm, 27 kN, 3.5 ft. dia., 6 ft. long, capable of up to 500 restarts. This engine may be re-engineered for fuels other than MMH. The HAPS would also be a candidate.

## SATELLITE SUPPORT STRUCTURE

Support Structure is a standard base on which to mount the satellite. Specialized structures may be used for special satellite support needs.

## PAYLOAD SYSTEMS

### Shroud / Nose Cone

Two different nosecones may be used, the standard is 5 ft. (1.5 m) length by 38 in diameter; alternate option is a 15 ft. (5 m.) length for longer payloads (longer than 5 ft.). The Nose Cone Shroud is jettisoned before orbit insertion burns, so that shroud is not in the vicinity of the satellite's orbital path. The Nose Cone may also be ejected earlier when the rest of the rocket fairing is jettisoned during third stage flight.

### Payloads

Payloads should be designed to fit within the 37in. by 14 ft. Nose Cone envelope.

Satellites should, if possible, be constructed and configured so that the greatest load-resistant axis is along the rocket shaft axis, since propulsive thrust is normally the greatest load the rocket assembly will encounter. If satellite dimensions prohibit this, the satellite will be oriented so that the longest axis is front to back, along the long axis of the Nose Cone.

The Orbit Insertion vehicle can orient and spin Customers satellites, if requested. To do so requires that satellites by constructed to dimensions which allow the Orbit insertion vehicle with satellite attachment tree to point the satellite in the correct orientation and to spin along the proper axis, while attached to the satellite supports.

## RETENTION, RELEASE, AND SEPARATION SYSTEMS

### Satellite Support, Retention, Release and Separation System

Designs exist, have been tested and flown and are readily available for use.

## AVIONICS, GUIDANCE, NAVIGATION AND CONTROL

As with other components, a standard GNC software package and configuration is used--One which has already reliably predicted and flown launch profiles, trajectories, and orbital element values. 3-DOF and 6-DOF software will both be used, as appropriate.

LEO Teammates have extensive GNC experience in Ascent, Orbit, Deorbit rocket flight software, especially in GN&C.

## COORDINATE FRAME

Standard X, Y, Z aircraft coordinate frame is used, with X-Axis through the long shaft of the Rocket Stack. Angular coordinates are used when appropriate.

# L10. LEO SYSTEMS PERFORMANCES

## INJECTION ORBITS

LEO launches from a trans-oceanic aircraft; thus, the launch direction capability is virtually unlimited.

LEO's Chariot rocket stack has more than enough capability to attain our maximum advertised orbit with maximum payload in any direction.

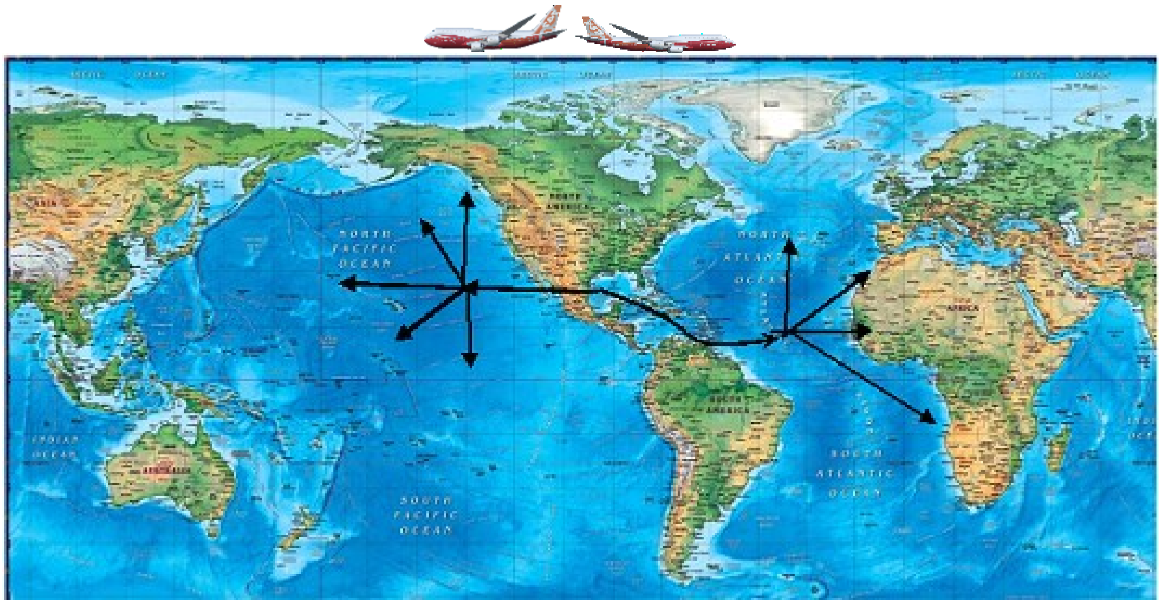
The LEO Chariot Launch system will launch from government facilities in 2018-2019, and from Southeast Texas starting in year 2020. This class of aircraft has a loaded range of 6000 to 10,000 mi. With 60,000 $lb_m$ Chariot rocket and full fuel load, maximum range flights are available; this is well below maximum aircraft payload of any of the aircraft under consideration (over 110,000 $lb_m$). This means that the LEO Launcher integrated vehicle can takeoff from any airport rated for standard heavy-lift long-range aircraft and for hazardous cargo.

LEO's aircraft can take off with Chariot rocket stack and satellite payload from most major airports in the world. When flown from South-Central Texas, and the aircraft / rocket launch system is over international open water, Atlantic, Pacific, or Caribbean, the rocket will launch. This will occur with the aircraft at near maximum altitude of 40,000 ft. alt. (~8 nmi) and near maximum flight speed of 0.88 Mach (M). At this altitude, 0.88M =~ 580 mph true ground speed.

## LAUNCH DIRECTION CAPABILITIES

The Chariot can launch -- Eastward, Westward, North or South, at almost any inclination.

**Figure 7** **<u>LEO's Possible Flight Paths Before Chariot Launch</u>**




Map by www.worldmapsonline.com

Ascending Node (which is the angle East or West, ± from the Prime Meridian), for the launch is a different matter, and is defined as the location where the Chariot Rocket Launch occurs, when the rocket leaves the aircraft.

Nonetheless, ascending mode only exists until the Earth rotates under your satellite's orbit, and you obtain the desired Nodal orientation. Likely, this angle will make no difference to most Customers. Therefore, the Ascending Node at Launch will usually be an Operational Flight Crew-chosen variable. This increase choices for Launch locations, for most Customers.

For East bound orbits, the carrier aircraft will fly East from base in Texas, then launch Eastward from the Gulf of Mexico or Caribbean Sea. With a maximum fuel load, this category of aircraft could launch a North-South (at or near 90 degrees) inclination rocket from the mid-Atlantic, and still have plenty of fuel margin to return home. Furthermore, we could also perform an Intact Abort and return the entire vehicle home. Alternatively, we could land at any of numerous other airports which are rated for this category of aircraft. From that location, we would refuel and return to home-base.

Likewise, for **Westward launches**, or flights over the Pacific, we fly westward from Texas to the desired Pacific Ocean launch site, then launch the satellite/rocket stack. We could fly 2000 mi over the Pacific, launch, then return to the West coast, or to LEO home-base in Texas.

## ORBIT CHANGES

There is more than enough fuel aboard the Chariot liquid orbit insertion rocket to coast with the payload until proper orbit transfer point, then re-ignite to either circularize or otherwise modify the orbit (in-plane only, of course).

Certain orbits can also be attained by direct injection, without circularization burn.

# L11. PHYSICAL ATTRIBUTES

## MASS TO ORBIT

The **LEO Chariot integrated rocket** is designed to launch the maximum capability of 1500 lb. to maximum advertised orbit of 1500 nmi, into a polar / North-South (nearly 90-degree inclination) orientation. This would be a most energy-intensive orbit. The exact orbital elements and methods of attaining the orbit required depend on the orbital requirements which a Satellite or satellite-customer needs.

## MASS PROPERTIES

### MASS PROPERTIES ACCURACY

The final mass properties statement shall specify payload weight to an accuracy of 0.5 kg, the center of gravity to an accuracy to 6 mm in each axis, and the products of inertia to 0.7 kg-m$^2$. If the payload uses liquid propellant, the slosh frequency must be provided to an accuracy of 0.2 Hz.

### MASS PROPERTIES ANALYSIS, TRACKING AND MAINTENANCE

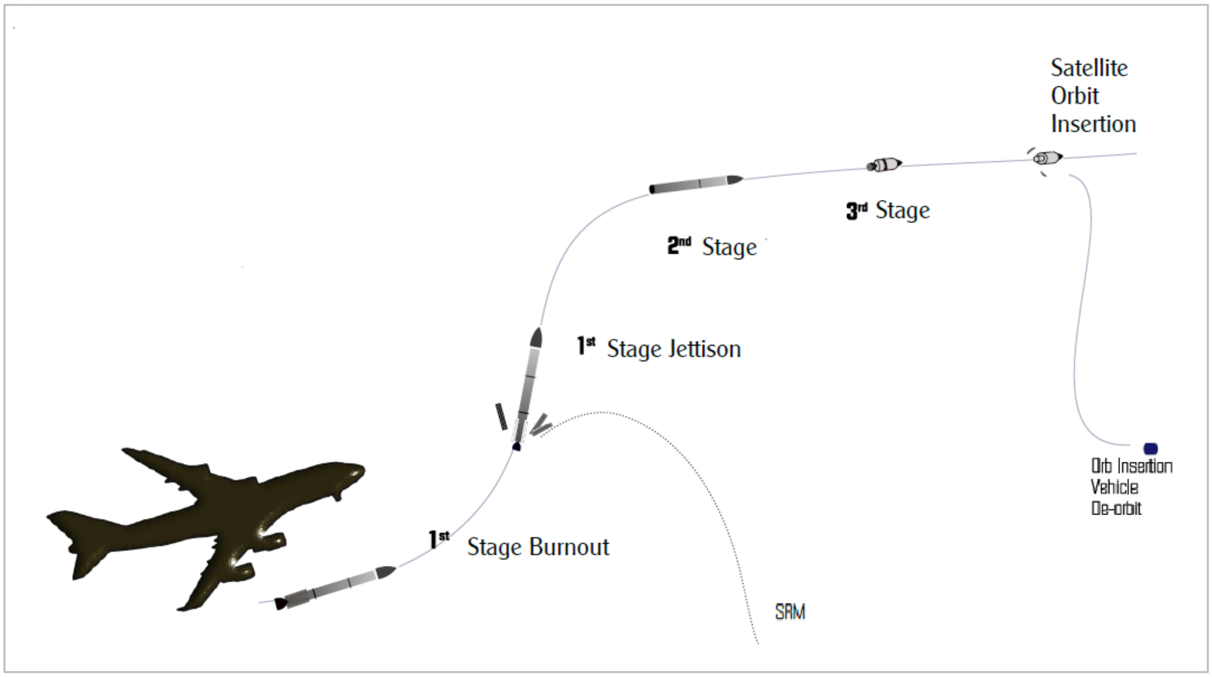
LEO tracks and maintains all mass properties, including inertias, relating to the Chariot launch assembly. Payload-specific mass properties provided to LEO by the customer are included. All flight components are weighed prior to flight and actual weights are employed in final GN&C analyses. LEO requests Customer estimates of the payload mass to facilitate mission planning and analyses. Delivery of the payload mass properties are defined in the flight-specific mission ICD's and tracked in Planning Schedules.

## LAUNCH WINDOWS

The LEO Launcher Chariot launch vehicles can launch any day of the year, at any time of day, subject to environmental limitations and constraints as well as range availability and readiness. Launch window times and durations are developed specifically for each mission; to accommodate customer requirements. Customers will especially benefit from intact abort situations, and recycle operations, which can maximize launch opportunities, if there were reasons to return the launch aircraft with satellite and rocket to base. Satellite health will be continuously monitored during flight, and any abort and return will be a joint decision between satellite owner and LEO Launch management.

## MISSION PROFILE

**Figure 8 LEO Mission Profile**




## ACCURACY

Chariot flights are designed to achieve at least the orbit insertion accuracies listed in below. Accuracies shown are for osculating elements at orbit insertion. Improved orbit insertion accuracy can be provided as a nonstandard service.

**Table 10 Orbit insertion accuracy**

| Mission | Perigee | Apogee | Inclination | Ascending Node | | Insertion Apse Alt | Semi-Major Axis |
|---|---|---|---|---|---|---|---|
| Direct Injection | ± 10 km | ± 10 km | ±0.15 ° | ± 10 km | ±0.15 ° | ± 10 km | ± 15 km |
| 2-step Circularized | ± 10 km | ± 10 km | ±0.15 ° | ± 10 km | ±0.15 ° | ± 10 km | ± 15 km |

Greater accuracy can be attained for those Customers who need it, with more orbital guidance iterations, tighter tolerance, smaller step-size integration, and fine gas jet adjustments on orbit. This service is available as a non-standard service, due to the greater amount of engineering effort and onboard resources involved.

LEO may use Keplerian, mean or osculating (orbit modified for additional environmental anomalies) elements in integration, depending on accuracy desired or required by the satellite customer, and on the Ephemeris for Earth/Sun/Moon data available for the specific orbit required.

## SEPARATION DYNAMICS

Chariot offers 3-axis attitude control or spin-stabilized separation as a standard service. For inertial separation, Chariot will point the second stage and payload to the desired LVLH (Local Vertical / Local Horizontal) attitude and minimize attitude rates. For spin-stabilized separation, Chariot will point the payload to the desired LVLH attitude and initiate a spin about the launch vehicle X-axis at a customer-specified rate dependent upon payload mass properties.

## FLIGHT ENVIRONMENT

**Table 11 <u>Flight Dynamic Environments</u>**

| LEO Chariot vehicle during flight will be subject to these environments: | | | | | |
|---|---|---|---|---|---|
| **Flight Stages** | **Altitudes ft and mi** | **Time in Stage** | **Atmosphere Region** | **Velocity** | **Temperature ° F** |
| **Aircraft** | 0 to 40,000 ft | 1 hr to 5 hrs | Troposphere | 0-0.89 M | 70 ° F to -67 ° F |
| **Stage 1** | 40K to 175K | 77 s | Stratosphere | 500 mph to 5800 mph | -67 ° F to -20 ° F |
| **Coast 1** | 160 to 230K | 96 s | Mesosphere | 5800 mph ~ Constant | -130 ° F |
| **Stage 2** | 200 to 500K | 96 to 269 s | Thermosphere | 5800 mph to 12,000 mph | -75° F to 2000° F |
| **Coast 2** | 470 to 935K | 269 to 380 s | Thermosphere | 12,000 mph | -75° F to 2000° F |
| **Stage 3** | 930K to 945K | 380 to 450 s | Thermosphere | 12,000 mph to 17,000 mph | -75° F to 2000° F |
| **Coast 3** | 945 to 950K | 450 to 510 s | Thermosphere | 17,000 mph | Depends on Sun. Determined by: 1) Sun Angle; 2) Reflectivity & Absorptivity of Your Satellite. |
| **Orbit Insertion** | 200 mi to Orbit Perigee | 510 to 600 s | Exosphere | 17,000 mph to 18,000 mph | |
| **Orbit Transfer Burn 1** | Perigee to near Apogee | 5 min to 90 min | Orbital Space – LEO | Gains < 100 mph | |
| **Orbit Insertion Burn 2** | Min 110 mi Max 1500 mi | 90 min | Low Earth Orbits – LEO | Final Velocity Depends on the Final Altitude | |

The following paragraphs explain the chart above, in words.

The numbers in the chart above will vary, depending on the Final Altitude required to be attained by each satellite launched. The altitudes at stage separations, and coast durations are very different for low altitude flights (100 to 400 mi. altitude) compared to higher altitude flights (400 to 1500 nmi) altitudes.

The **aircraft** with the Chariot vehicle composed of the rockets and satellite or satellites, fly to 40,000 ft. Then the Chariot vehicle separates, the **first stage** ignites, turns upward, then flies upwards, until the first stage burns out at about 160,000 to 175,000 ft altitude (32 to 35 nmi).

Then the second stage separates from the first stage, and, after some separation distance is attained, the first stage control rockets turn it towards the Earth. The flight profile is planned such that the first stage falls into open water in an ocean.

The remaining parts of the Chariot then **coast** for about 1 ½ minutes, while climbing through the very thin upper atmosphere called the Mesosphere, at 5800 mph until the second stage Chariot climbs about 70,000 ft higher, to about 230,000 ft altitude, about 47 miles high.

Then the **second stage** rocket ignites and flies until it burns out about 100 miles (500,000 ft) altitude. While climbing to this altitude, the vehicle, now lighter due to having dropped the first stage structure and having burned the fuel in the second stage, so it could accelerate from 5800 mph to around 12,000 mph. Meanwhile, the second stage also changes travel direction from straight up to tangential to the Earth's surface, in the desired direction the satellite will travel. This is a "gravity turn."

After second stage rocket burnout, the entire **second stage coasts** about 5 minutes, from about 200 to 500 miles upwards, then the second stage separates from the upper stages, and it (2$^{nd}$ stage) turns to re-enter the atmosphere. From these altitudes, this second stage structure will burn up on re-entry to the denser atmosphere. Nonetheless, it is targeted that if any parts did fall to earth, they would land in uninhabited areas of the oceans.

When the **third stage** ignites at near the desired altitude, it has lost some velocity, down to about 9500 mph, because the energy the Chariot had was converted to attaining much higher altitude and turning. The third stage will be now flying almost horizontally, at near the desired altitude. The third stage accelerates the remaining components of the Chariot vehicle from 9000 mph to around 17,000 mph or more, depending on the velocity required for each orbit, while gaining just a few miles of altitude.

Then the third stage separates from the last rocket stage, the orbit insertion stage, which still supports the satellite payload. This is done during an approximately 30 second **third stage coast phase**.

The **orbit insertion** rocket then ignites, and places the satellite into the exact orbit desired. This rocket stage is designed to burn one, two, or more times, to attain the exact altitude, velocity, and orientation for the satellite's required orbit. The satellite can also be imparted a spin if needed. Because of the need for multiple burns, the orbit insertion Chariot stage is a liquid rocket, which can be started and burned several times. It also contains reaction control jets for the perfect orientation and spin satellites need.

Finally, the **satellite** is separated from the rocket stage, and released into its orbit. The orbit insertion Chariot rocket and structure will then be pointed away from the satellites' orbit, and de-orbited.

## LOADS

Shock (TBD) - (50 to 100 G's) dependent on vibration frequency. – These are momentary vibrational loads.

Fairing Internal Pressure: 14.7 psi to 5 psi at separation from aircraft; 5 to 0 psi at 150k ft.

Payload Temperature Exposure during aero Flight -- 78 deg. F to -100 deg F (-60 deg C to – 75 deg. C) in Troposphere on aircraft, to 170 deg F (+80 deg C) – due to heating during Stage 1 to sun heating (0 to 100 deg F) above atmosphere.

**Table 12** **Payload adapter-induced shock at the satellite separation**

| Frequency (Hz) | SRS (g) |
|---|---|
| 100 | 30 |
| 1000 | 1,000 |
| 10000 | 1,000 |

## VIBRATION LEVELS

During flight, the payload will experience a range of axial and lateral accelerations. Axial acceleration is driven by vehicle thrust and drag profiles; lateral acceleration is primarily driven by wind gusts, engine gimbal maneuvers, first-stage engine shutdown and other short-duration events. Both the first- and second-stage engine burn profiles may be modified to help maintain launch vehicle and payload steady state acceleration limits.

The design load factors provided here are expected to be conservative (worse than expected) for most payloads. Payloads with greater than usual frequency and mass center of gravity range can also be accommodated, but will take usual attention. LEO should be notified of such situations.

### SINUSOIDAL VIBRATION

Chariot has no sustained sinusoid vibration during flight. Maximum predicted Chariot vibration environments represent the vibration levels at the top of the payload attach fitting for all stages of flight.

Since Chariot accommodates a variety of payloads, results of coupled loads analysis are dependent on the payload and its attachment points to at the payload interface.

At Frequencies from 5 to100 Hz, expected sinusoidal Acceleration (g) should be < 0.1 to 1.0 g's.

## ACCELERATIONS

**Table 13 X-Axis Acceleration by Flight Stages**

| Flight Stages | Acceleration | Altitudes |
|---|---|---|
| aircraft | 0 -.5 g's | 0 ft. to 40,000 ft. |
| Stg 1 | 2 - 9 g's | 40K - 190Kft (38 mi.) |
| Stg 2 | 1.5-5 g | 230K – 630Kft (26mi) |
| Stg 3 | 2 - 4 g | 80mi-400mi |
| Orb Insertion | 1 – 2 g | 100mi – 1600 mi. |

## AXIAL ACCELERATION LOADS

**Table 14 3-Axis Vibro-Accelerations by Flight Stages**

| Environment | Ax - g's | | Ay - g's | | Az - g's | | |
|---|---|---|---|---|---|---|---|
| | Steady St | Quasi Static | Steady St | Quasi Static | Steady St | Quasi Static | |
| Test, Abort, normal Flt | ± 1.0 | none | ± 0.7 | none | + 1.0 | 2.5 / -2.0 | |
| Transient | none | ± 0.5 | none | ± 0.5 | none | ± 3.85 | |
| Aero Pull-up | | ± 1.0 | ± 0.3 | ± 0.9 | -2.33 | ± 1.0 | |
| Stage 1 Ignition | none | 2-9.0 | none | 0.3 | none | +2.5 / - 0.5 | |
| Stage 1 Burnout | 9.5 | ± 1.0 | ± 0.2 | ± 1.0 | ± 0.2 | ± 1.0 | |
| Post Stg 1 Burnout | ± 0.2 | ± 1.0 | ± 0.2 | ± 2.0 | ± 0.2 | ± 2.0 | |
| Stage 2 Ignition | 4.0 | 4-6.0 | Same as above | Same as above | Same as above | Same as above | |
| Stage 2 Burnout | 7-10 | | Same as above | Same as above | Same as above | Same as above | |
| Post Stg 2 Burnout | ± 0.2 | ± 1.0 | Same as above | Same as above | Same as above | Same as above | |
| Stage 3 Ignition | 5.1 - 7 | | Same as above | Same as above | Same as above | Same as above | |
| Stage 3 Burnout | 5 – 12 | | Same as above | Same as above | Same as above | Same as above | |
| Post Stg 1 3Burnout | ± 0.2 | ± 1.0 | Same as above | Same as above | Same as above | Same as above | |

These values are based on standards for the nominal rockets planned, and on ballistic calculation. Ref ATK Catalog for Orion 38 and 50 rocket stages.

Random vibration load is provided after testing is complete.

Depressurization rate – As might be predicted, the pressure inside the Fairing (non-pressurized payloads) will drop from 14.7 psi at sea level to 4 psi at rocket Stage 1 ignition, to nearly 0 psi during Stage 2 flight.

## ACOUSTICS

Sound Pressure is normally in the 80 to 125 dB range during rocket flight. Acoustic vibration is generally caused by air buffeting during aircraft flight, and later, rocket engine sound, then vibration from rocket burns, and rocket stage transitions.

A +6dB factor should be added to the sound spectrum for 75 sec. to account for fatigue duration effects, to accommodate multiple launch attempts and powered flights.

During flight, the payload is subjected to a varying acoustic environment. Levels are highest near rocket launch and during transonic rocket flight, due to aerodynamic excitation. The acoustic environment is characterized by both full and third-octave curves. Predicted acoustic levels for a specific mission depends on the payload's size and volume with smaller payloads generally having lower acoustic levels. Margin for qualification testing is not included in the curves below.

# L12. THERMAL & CLIMATIC ENVIRONMENTS

## FLIGHT TRANSPORTATION ENVIRONMENTS

Temperatures to which a payload is subjected are:

1. Atmospheric heating due to friction at hypersonic speeds in upper atmosphere during 1st stage. However, first stage flight time is short enough--less than 2 minutes--that significant air-friction heating would not normally occur.
2. Cooling due to low atmospheric temperatures (-50 degrees F to -100 degrees F) within the atmosphere during 1st stage combats frictional heating. However, 1st stage flight phase lasts less than 2 minutes, including coast time, so this should not pose a problem, either.
3. Of greater concern is that the Chariot vehicle and payload is subjected to 1 to 7 hours of flight time. The payload and rocket are on the exterior of the aircraft at 8 mi altitude, as the aircraft flies to the launch point. The launching location could be 3,000 miles from takeoff. This altitude is in the upper Troposphere, which has a nearly constant Temperature of – 67 degrees F (-55 deg C). This long-term cooling should be anticipated and your vehicle tested for behavior in this environment, particularly if your vehicle is powered up during before launch.

   If your payload is sensitive to low temperatures, LEO can make provisions for cooling or heating it in transit. However, planning and arrangements must be made well in advance of flight, if LEO is to supply heating or cooling. Either customer or LEO can supply heating and cooling to payloads. LEO has capability and plans to provide heating and cooling to Customer satellites, if required.
4. Finally, above the atmosphere, your vehicle will be subjected to solar heating and cooling at 'blackbody' temperature transfer rates. If your payload requires a particular solar attitude, please so specify in your list of orbit insertion requirements. Please also insure that you know the Temperature transfer rate for your satellite skin. If heating or cooling is required, LEO engineering shall also be told this temperature transfer rate.

The Chariot payload fairing is a composite structure consisting of 1 in. thick aluminum sheathing with carbon fiber. The emissivity of the payload fairing is approximately 0.9. The fairing thermal insulation is sized such that the composite never exceeds an atmospheric boundary layer temperature profile of about 175 degrees F.

## TEMPERATURE, HUMIDITY AND CLEANLINESS

During preparation for flight, your payload will be kept in a temperature-controlled environment, for temperature, humidity and cleanliness. If you have ground storage or handling temperature or humidity requirements, please so specify.

Southeast Texas, where LEO Launchers operate our usual facilities, is subjected to high humidity usually, 50% - 100% are typical and are Not 3 sigma Standard deviations. Outdoors Temperatures vary from lows of 20 degrees F (-6 degrees C) winters, to 110 degrees F (44 degrees C) summers.

## FLIGHT ENVIRONMENTS

LEO Aircraft operates from a few feet above sea level to about 40,000 ft. at rocket launch.
Chariot Rockets operate from 40,000 ft. to 1600 nmi.

Following transportation of the Chariot vehicle to the Flight Pad, the fairing is continuously purged with conditioned filtered air. During ground operations, the temperature of the conditioned air, as measured at the fairing inlet, is maintained between 13º to 30 ºC (55º to 85ºF). The relative humidity of the conditioned air is maintained to ≤55%. During captive carry, the ambient external air temperature within the fairing is significantly colder than the measured inlet air temperature due to the cold ambient conditions at altitude. The atmospheric temperature at 40,000 ft. where most of the flight occurs, is -30 ºF to -70 ºF. The bulk air temperature within the fairing during the approximately 3-hour long captive carry are typically between -20 º F and 0 º F. If your payload needs higher or lower temperatures, please notify LEO Management for heating or cooling arrangements.

# LEO LOGISTICS SYSTEMS

## L13. LEO LAUNCHER & LOGISTICS OPERATIONS

The core business of LEO Launcher & Logistics Inc. is Payload Launching. Major functions of the Payload Launching are LOGISTICS OPERATIONS and LAUNCHES OPERATIONS, as described below.

### LOGISTICS OPERATIONS

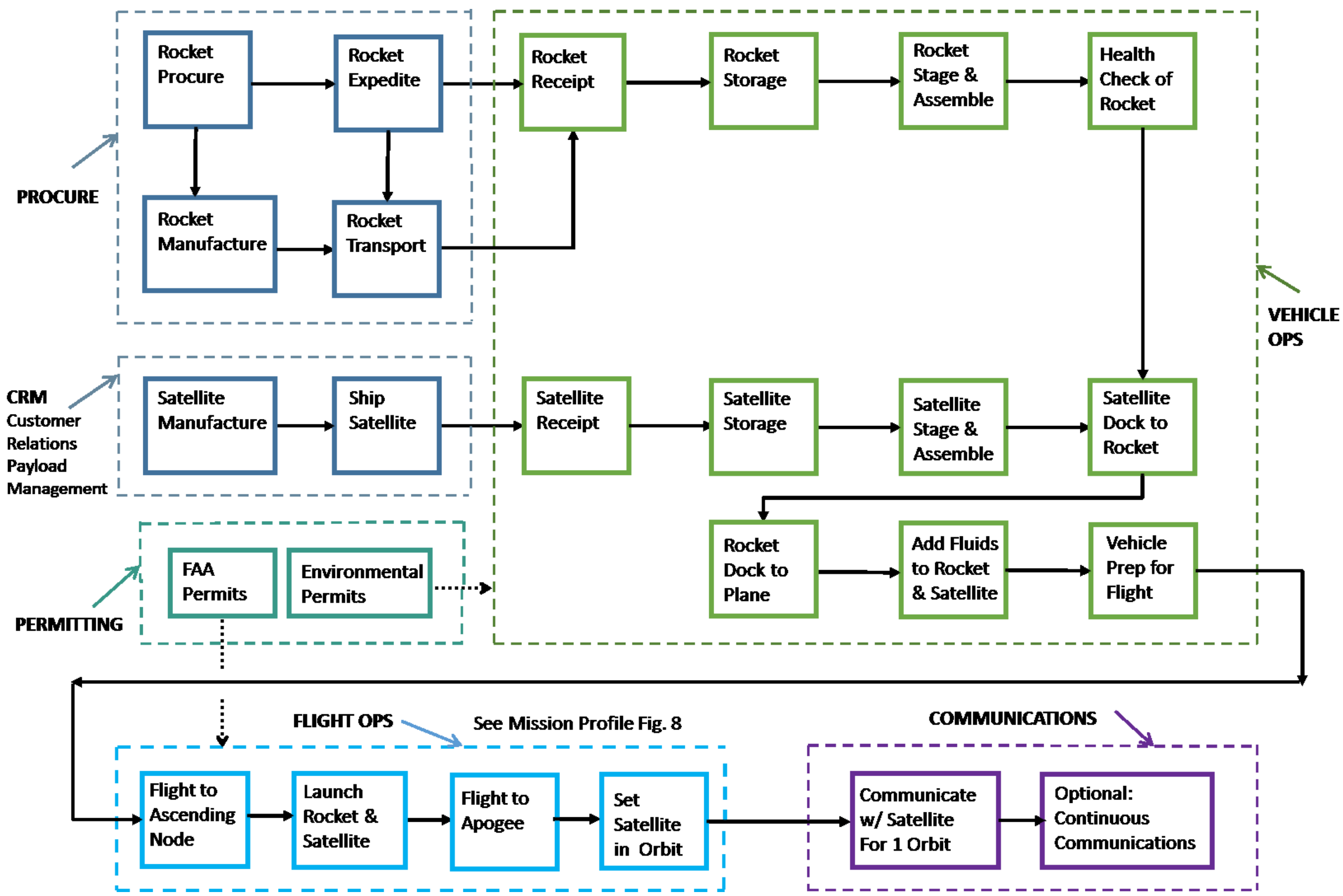
Logistics Operations involves **Procurement** processes, Customer Relations Management (**CRM**) handling of customers' satellites (includes marketing, customer liaison, and overseeing customer's interests throughout the mission), **Vehicle Operations** for Transportation-Storage-Assembly of rockets and satellite payloads, **Permit** functions for flights and ground operations, and designing **Communications** Systems of Launch Vehicles (Flight Vehicles, Chariot Rocket Vehicles, Payload Satellites) and Data Capture.

Operations and Maintenance of Facilities, and Maintenance of Launch Vehicles and Communication Systems are included in LEO's Logistics Operations systems.

### LAUNCH OPERATIONS

LEO's Launch Operations, also called **Flight Operations**, involve operations of Flight Vehicles, Chariot Rocket Vehicles, Communications Systems, and Mission Control which is a subset of Communication Systems.

**Figure 9** **LEO Launcher & Logistics Operations Flow Chart**




## L14. PAYLOAD HANDLING

## PAYLOADS TRANSPORT

Customer satellite and payload transportation from Customer site to LEO Launch Facility must be planned, organized and completed early enough to be integrated into LEO's Chariot launch vehicle.

In some cases, the ground or air transportation to the Flight and Launch Facility causes the greatest shocks to payloads in transit. (this was famously the case during US-Russian Space Shuttle activities, when NASA found that transporting payloads onboard a railway carrier to the Baikonur Cosmodrome for launch in Kazakhstan. In that case the limiting shock design factor was the train ride from Moscow to Baikonur, not the rocket flight.

Either the customer or LEO may organize the transportation. In either case, the transportation carrier should be bonded and insured, and experienced with sensitive cargo, such as satellites. Satellite owners should be sure that your satellite and carrier vehicles attachment points match and will secure your satellite during transportation.

All payloads so transported by any means should be equipped at the Customer shipping site with all-axis accumulation accelerometers, which show both maximum loads and total summed accelerations in all axes.

## RECEIVING AT THE LEO LAUNCH FACILITY

Immediately after arrival, customers' payloads are tested to insure they are still in good condition. The accelerometers are examined. Their data values are recorded and relayed back to the Customer. At that time, other tests on Customer satellite can also be performed, at Customer request.

Customers shall provide in advance a list of satellite properties and systems to be tested, and customers' methods of assuring proper functionality of the satellite. A customer representative should be on hand at receiving and testing. Each Satellite to be launched has a designated LEO **Mission Project Manager**, who acts as Customer liaison and representative between LEO and the Customer.

## PAYLOADS STORAGE

All payloads received, are stored in accordance with customer instructions, until preparation for Launch. Usual storage is in a "clean room" facility.

# L15. LEO COMMUNICATIONS

## COMMUNICATION CAPABILITIES

LEO's communication goal is that Flight Communications equipment is to be active in flight, from Launch System (aircraft plus Chariot rocket stack plus Customer Satellite payload) from before aircraft rollout at the Launch Site airport, to completion of Customer's satellite first orbit.

LEO has designed a complete Communications system, which can address, handle, and insure satisfactory communications for all aspects of aircraft, rocket, and satellite communications.

We have designed a ground station at our primary launch facility, and mobile ground stations and communications support on launch and tracking aircraft. We will also maintain communications through other communication ground and satellite systems.

This includes, but is not limited to:

**Radar** – X, Ku, Ka, C, and S-Band radar types are available for tracking and communications with payload satellites, as well as other communications equipment.

**GPS** – Transponders and transmitters are available and used both for tracking and for navigation input.

**Audio – UHF** and VHF capability are provided by LEO, from all LEO control centers, to LEO aircraft, to Customer site(s).

**Video** capability are provided by LEO, to and from all LEO control centers, to and from LEO aircraft, to Customer site(s), during testing and during Flights and Launches.

## COMMUNICATION OPERATIONS

### GROUND

LEO Launcher has both fixed and mobile ground tracking, telemetry, and communications facilities.

### MISSION CONTROL

Voice, video and radar are all used in LEO ground control centers.

### CARRIER AIRCRAFT

Carrier aircraft has similar communications to LEO Launcher ground facilities. Downrange aircraft also has a complete communications gear set. These downrange aircraft control centers can maintain communications after the Chariot is launched from the carrier aircraft.

### MOBILE

Mobile Control Center(s) are used for a variety of purposes, such as downrange tracking, tracking at Customer sites, as backup to fixed Mission Control, etc. These Centers could be used for customers who desire full coverage of their satellite(s) after release from LEO's Launch Chariot rocket stack.

### CHARIOT LAUNCH VEHICLE (ROCKET STACK PLUS PAYLOAD)

All components of the launch systems, from Stage 1 rocket, through the orbit insertion vehicle, and to the satellite payloads has communications to the tracking support systems, both airborne and on the ground.

### AFTER SEPARATION

Payloads placed in orbit by the LEO Launcher Chariot system continue tracking the satellite through completion of the first orbit. However, after separation and re-contact avoidance procedures have completed, the payload is under control of the payload provider.

Special arrangements can be made for LEO to continue to track and control a satellite after first orbit, should the customer so desire.

### TELEMETRY DATA

Satellite Customers can receive all telemetry data received at LEO Mission Control.

Communications Information LEO operations and integration groups need from customers are in table below. Customers, please fill in any data you will need or information to or from your satellite communications system in the chart below.

**Table 15 Satellite Customer Communications Parameters**

| Equipment Description | Radio Frequency | Power | Bandwidth | Range |
|---|---|---|---|---|
| GPS | | | | |
| UHF | | | | |
| Radar Altimeter | | | | |
| S-band | | | | |
| C-band | | | | |
| Ku-band | | | | |
| Ka-band | | | | |
| X-band | | | | |
| Tlm parameters | | | | |
| To TLM location(s) | | | | |
| Accelerometers | | | | |
| Gyroscopic | | | | |
| Other data, TLM, or communication types | | | | |

# L16. LEO FACILITIES

## FACILITIES OVERVIEW

LEO's usual mode of operation after 2020 will be to fly and launch from our facility in South Texas. Sites under consideration are Ellington Spaceport in Houston TX; Kelly AFB Airport in San Antonio, TX; Victoria Regional Airport in Victoria TX; and Midland Spaceport in Midland, TX.

Because of the mobile nature of the LEO Launcher standard aircraft, we have the ability to launch from most major airports around the world, at Customer request. This includes NASA and USAF sites which have provided accommodations to other orbital and suborbital commercial carriers. These facilities include NASA sites with large runways such as Kennedy Space Flight Center in Florida, Wallops Island in Virginia, and USAF facilities such as Vandenberg AFB., Cal; Ascension Island AFB., Alaska, and others, such as Hawaii and American Samoa.

LEO will use 2 or more Clean rooms and integration facilities. Each of the launch locations have adequate space, adequate runways, and a clear flight path to either Ocean.

## LAUNCH LOCATIONS

Launching from a Trans-Oceanic aircraft with 6500 + nmi range fully loaded allows LEO pilots to travel to:

the Gulf of Mexico for Eastward Launches,
the Atlantic Ocean, for high inclination Eastward and Polar Launches, and
the Pacific Ocean for all angles Westward and Polar Launches.

For Intact Aborts, or contingency landings, the still fully loaded LEO carrier aircraft with Chariot Launch rocket stack still attached, could return to LEO home base in South-Central Texas or to numerous other airports equipped for heavy aircraft with hazardous cargo. These include but are not limited to Kennedy in Florida, for Eastward and Atlantic Polar launches and Vandenberg Air Force Base in California, for Westward and Pacific Polar launches. On such aborts, we anticipate that hazardous fuels will be evacuated before Return to a Landing Site.

## DELIVERY AND TRANSPORTATION

Delivery and Transportation for standard service processing and integration payloads should be delivered to the launch site eight weeks prior to launch. Alternative delivery schedules can be arranged as a nonstandard service. Non-US payloads coming to the LEO Launch facility must clear customs at any US port of entry prior to arrival.

As a standard service, LEO arranges for the customer's payload container and all associated test and support equipment to be offloaded from the plane and transported to the payload processing facility. Ground transport services can also be provided by any carrier the customer arranges. LEO can facilitate transport, if the customer requests.

## PROCESSING - CLEAN ROOM & INTEGRATION

LEO provides ISO Class 8 (Class 100,000 +) cleanroom integration spaces for the payload and Ground Support Equipment.

## TESTING FACILITY

LEO performs a series of predefined Health Checks when receiving Customer payloads. Additional Customer-defined Health Tests will also be conducted at that time. Other Customer requested tests can be arranged, if LEO is given adequate notice. LEO maintains contact with a variety of Industry, commercial, private, University and government testing facilities. These include such facilities as Vibration Tables, de-pressurization chambers, radiation chambers, electronic communications test facilities, pyro facilities, and others.

### AIRCRAFT TESTS

Although many tests can be performed at any airport which can accommodate LEO's aircraft type, LEO aircraft testing will usually start at our Operational Launch home base in South Texas. This simplifies training and logistics. Flight tests will be performed over the Gulf of Mexico, the Atlantic and Pacific Oceans, as the tests require.

### ROCKET TESTS

Rocket tests are a different matter. Due the cost and resources needed, some rocket tests will be performed at the manufacturers' sites, and at government facilities, as available. Integrated rocket tests, those while mounted on the aircraft, will also be performed at LEO's home base, when resources and scheduling demands allow. Alternative sites in South-Central Texas are also available for flight tests.

### SATELLITE TESTS

A variety of tests for Customer satellites will be performed at LEO's Integration and Launch Facility in South-Central Texas. Some of these will routinely be performed as part of Launch preparation and integration. Among these will be receiving and Intact Abort Health checks, if necessary. Intact Abort checks should be Customer defined well before a Flight.

These tests will be jointly defined between Customer and LEO team. Additional tests of Customer satellite systems may be organized and performed at Customer requests.

## CHEMICAL HANDLING

Customers shall inform the LEO team at contract time of all chemicals your satellite will contain, whether on arrival at the LEO Integration & Launch Facility, or loaded before Launch

LEO has chemical storage facilities, and handling chemical capabilities.
Special consideration will be given to propellants.
Please provide us with your chemical storage needs:

- Chemical Name
- Chemical Composition
- Boiling Point
- Freezing Point
- Flash Point
- Quantity
- Duration of Storage, noting your Launch schedule and contingency dates thereafter.
- MSDS for the Chemicals (most of the information above should be on an MSDS)

# LEO OPERATIONS

## L17. LEO LAUNCH AND LOGISTICS MISSION PLANNING

### ASCENT TRAJECTORY PLANNING & SIMULATIONS

The LEO team members have expertise in providing Trajectory, Guidance, and Navigation Planning and operations support to NASA, USAF and other Space Programs for decades before LEO was formed. We will continue competently, reliably, repetitively providing these services to LEO Launch's customers, for years to come.

Each Satellite's trajectory to the desired orbital elements and location are calculated and provided to the Customer. The final orbit(s) will be agreed to upon contract signing. Our Onboard Guidance, Navigation & Control (GNC) and associated Ground Guidance calculations use proven existing computer routines and computer systems. Each satellite individual actual Ascent Trajectory parameters will be available for viewing at LEO Launcher facilities as well as remotely. These Ascent and On-Orbit tracks are obtained from LEO Launcher's Communications & Tracking network, as well as from other facilities.

Before each launch, LEO ensures each flight path and launch trajectory is safe. To insure this certainty, we coordinate with the FAA, NASA, USAF, and AIS, the Ships Automatic Identification System (ships at sea, to avoid rocket debris)) to insure collision avoidance for LEO flights and payloads. In addition, our extensive communications network and onboard communications and tracking systems search our flight paths and trajectories.

### MISSION MANAGEMENT

To streamline communication and ensure customer satisfaction, LEO Launcher provides each Chariot launch customer with a single technical point of contact from contract award through launch. This point of contact is a project manager, called the **Mission Manager**.

**Mission Manager** for each Customer satellite is responsible for coordinating mission integration analysis and documentation deliverables, planning integration meetings and reports, conducting mission-unique design reviews (as required) and coordinating all integration and test activities associated with the mission. The Project Manager also coordinates all aspects of launch vehicle production, range and range safety integration, and all mission-required licensing leading up to the launch campaign. The Project Manager works closely with the customer, LEO Launcher technical execution staff and all associated licensing agencies to achieve a successful mission.

The Mission Manager is a project manager who works with the customer to create a satellite to launch-vehicle **Interface Control Document** (ICD). This becomes the master document for a Chariot mission. Following signature approval of the ICD, LEO maintains configuration control of the document.

Once the payload arrives at the launch site, physical accommodation of customer hardware and associated ground support equipment is managed by the LEO payload integrator. However, the Mission Manager continues to be the customer's primary LEO Launch point of contact at the launch site and coordinates all launch site activities to ensure customer satisfaction during this critical phase.

## CUSTOMER INTERFACES CHARACTERISTICS

Following are sample ICD (Interface Control Document) interface characteristics. All connections between Customer satellites and LEO Launch vehicle shall be included.

**Table 16 Satellite Customer Sample Interface Data**

| | | | | | |
|---|---|---|---|---|---|
| **Physical Interfaces** | Primarily Attachment Points | Pt.1: x= y= z= | Pt.2: x= y= z= | Pt.3: x= y= z= | Pt.4: x= y= z= |
| **Sizes** | x | y | z | | |
| **Electrical Interfaces** | | | | | |
| **Computer Interfaces** | Kinds of Connectors | Data Formats | Computer Speed | Computer Capacity | I/O Rates |
| **Power needs parameters:** | volts amps | | | | |
| **Radiation Ouput** | | | | | |
| **All Other Interfaces** | | | | | |

# SERVICES

## SERVICE FEATURES
## (REFERENCE: Competitive Advantages)

As part of a LEO Launchers Chariot launch, LEO provides:

* A **Safe** Flight – Safe for the satellite, for the environment, for all personnel, for the mission, and for all equipment involved.

* Capability to Launch your satellites **Frequently**, monthly.

* A **Standardized Launch** Package – every flight from home base uses the same launch procedures, and a similar launch vehicle, every time.

* **Intact Abort Capability –** The Chariot carrier aircraft is designed to return and land the entire launch vehicle configuration, before rocket ignition, for any kind of contingency.

* **Fast Turn-Around** – The LEO Launcher program is designed for fast flight / launch turn-around capability:

1. If there was an Intact or Contingency Abort before rocket ignition, or
2. If a customer needs to launch a satellite on a short notification. This capability will be slowed only by permitting and Integration. The Standardization of Integration allows fast attachments and checkout of the integrated components.

* **Accurate Orbital Placement** – Accuracy insures Customer satellites can attain the exact Orbital Elements.

* **Vibrations and Loads –** LEO rocket designs have flown many missions with sensitive payloads. These same rocket designs works well for LEO Customers' payloads, as for previous government and commercial launches.

## SPECIFIC STANDARD SERVICES

LEO **p**rovides mission planning, launch vehicle, payload integration, and launch.
Obtain licensing - Federal Aviation Administration (FAA), State Department licenses, (Customers must obtain launch specific licenses).

Secure third-party liability insurance for the launch. (Note: Customer retains responsibility for satellite insurance.)

Provide all range and safety documents.

Handle the range and range safety process.

Provide in-flight connect & disconnect electrical.

Provide a payload adapter and separation system.

Organize transportation for the customer's satellite or customers can provide transportation themselves. This will be a customer cost item.

Provide appropriate (ISO Class 8 cleanroom 100,000 +) integration space and storage for your payload.

Provide mating of the payload to the payload adapter, integrate payload to launch vehicle. Customer and LEO must agree and understand satellite attachments before shipping.

**Table 17 Customer Satellite Attachment Points**

| | LEO Satellite | Attachment Points | | | |
|---|---|---|---|---|---|
| **Satellite Number** | Satellite Name | | | | |
| **Your Satellite Coordinate System** | X, Y, A relative to point on your satellite | X: | Y: | Z: | |
| **Attach Point #** | X location | Y location | Z location | Kind of Attachment - Name | Pull or G Strength Attach Point |
| **Sample Example** | X=3.62 cm | Y=9 cm (3.5 in) | Z = 0. cm | Hook | |
| **1** | | | | | |
| **2** | | | | | |
| **3** | | | | | |
| **4** | | | | | |

Process the launch vehicle, integrate and encapsulate the payload within the fairing, and test electrical interfaces with the payload.

Provide temperature control in the fairing and integrated assembly during ground processing.

Conduct integrated testing of customer vehicle with flight vehicle and LEO mission control.

Launch the payload into the specified orbit within the specified constraints.

Perform multi-axis attitude control for satellite.

Separate satellite from the launch vehicle and provide an orbit injection report.

Deliver a final post-flight report, which includes payload separation orbital elements, ephemeris, payload environment, significant events and any mission-impacting anomalies.

Provide a detailed statement of work and deliverables list, including these standard services, will be developed during contract negotiation.

## COLLISION AVOIDANCE

As LEO's Launch vehicle (aircraft + rockets + satellites) travels from take-off at an airport, to orbit, the various LEO flight vehicles must avoid contact with other aircraft, rockets, and people on the ground.

LEO Aircraft Collision avoidance: The LEO aircraft with Chariot rocket outboard usually travels several thousand miles to Launch point.

1. During most of the time during these flights, the flight path planned will be in lightly traveled corridors. This reduces likelihood of contacting other aircraft, balloons, drones, and helicopters. This is one way to avoid collisions. Other methods of collision avoidance are as follows.

2. LEO, as required, files complete flight plans with FAA and all other agencies with jurisdiction, and stay in radio contact with FAA and other ground operators.
3. LEO uses a Traffic alert and Collision Avoiding System or TCAS, which is a system that identifies the location and tracks the progress of any other aircraft equipped with beacon transponders. US military and commercial aircraft are required to carry TCAS systems.
4. LEO's aircraft has extensive advanced RADAR systems onboard for aircraft and rocket flight use. These are both the usual intercontinental passenger aircraft flight RADAR, and RADAR and tracking systems on LEO's Carrier Aircraft Mission Control Center electronics.

## CHARIOT LAUNCH ROCKET COLLISION AVOIDANCE DURING ASCENT

The LEO Chariot rocket travels several thousand miles to orbit insertion. The first stage part of this flight only takes about 2 minutes. During that time, the Chariot rocket assembly will fly from 39,000 ft. altitude at launch from the carrier aircraft, to about 200,000 ft altitude, which is about 40 miles high.

First Stage Rocket Ascent: LEO, as required, files complete flight plans with FAA, NASA, the US Office of Commercial Space Transportation, referred to as FAA/AST, and all other agencies with jurisdiction, and stay in contact with all appropriate ground operators. This is similar to the flight plans which aircraft must file, when flying in the US. However, LEO launches will be scheduled to only Launch over international waters. Above the Chariot Launch altitude of 40,000 ft., there will be no other flying objects, except high-altitude balloons, other rockets and military aircraft. Filing flight plans with organizations listed here should abrogate any such concerns. (But, just in case –see next paragraph below.)

LEO's aircraft has extensive advanced RADAR systems onboard for aircraft and rocket flight use. These are both the usual intercontinental passenger aircraft flight RADAR, and RADAR and tracking systems on LEO's Carrier Aircraft Mission Control Center electronics.

The flight tracking and detection system capabilities included in these systems detect any such upper atmospheric vehicles, and delay Launch for a few moments, until such obstacles have cleared the Chariot's ascent trajectory envelope.

Rocket Debris from Launch: Of much greater concern, but vastly easier to avoid, would be any of the rocket stages falling on people on Earth. This issue must be addressed by every multi-stage rocket launched.

The Chariot Rocket consists of 4 stages. The last three stages are high enough, (above 50 miles altitude), fast enough, (faster than 7000 mph) and small enough that they will burn up in re-entry to Earth's atmosphere. To reclaim any of these vehicles, they would have to be slowed enough to not be incinerated during re-entry. "At a press briefing (in 2011), NASA said, 'there's generally little danger of death by space debris. Since the dawn of the Space Age some five decades ago, no human has been killed or even hurt by an artificial object falling from the heavens. http://news.nationalgeographic.com/news/2011/09/110909-nasa-space-debris-uars-satellite-top-five-science/

## ORBIT PLACEMENT AND CONTROL / COLLISION AVOIDANCE

Before each satellite launch, LEO Mission Planning will notify the USAF Space Surveillance Network, and NASA, and, if needed, the UN Committee on Outer Space. Thereby, LEO Mission Planning insures there are no other space objects in the target orbit, nor crossing the orbits, of the Customer's desired orbit. If there is any such potential interference, small adjustments can usually be made to a target orbit, during the trajectory planning phase. Such minor adjustments usually have little or no effect on the satellites intended performance.

## PERMITTING

Some of the permitting for space flights is required for the purposes of collision avoidance, as discussed above, in the preceding paragraph. Also, there are other permits, licenses and paper work required. LEO will obtain these licenses which are usual for LEO space flights.

However, some of these are specific to each Customer satellite and its orbit. These permits can normally be obtained by the Customer organization. The LEO team will provide guidance here, if necessary. We will provide Customers with a specific checklist for your satellite. LEO can also fill out and obtain such permits, etc. for an additional fee.

One cause of customer permitting is to handle hazardous chemicals, especially propellants. Other requirements involve radiation on orbit especially for communications satellites, and radioactive material on a satellite, such as used by nuclear power supplies.

### FILE FLIGHT PATHS

As mentioned above under Collision Avoidance, LEO will file Flight Plans and Alternative Flight Plans for each Flight, per the FAA guidance.
http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/air_traffic_services/flight_plan_filing/

LEO will also file an INTERNATIONAL FLIGHT PLAN (ICAO**), FAA Form 7233-4**

## SCHEDULING

### COMMERCIAL LAUNCH FLIGHTS

First Commercial Launch Flight is scheduled in 2018. **SIGN UP TODAY!!**

Your mission preparation will be tracked weekly by LEO Program and Project Management. Launch Flight status will be tracked and documented on the LEO Launcher & Logistics website.

Each Launch Flight scheduled will have a LEO Project Manager assigned to help the Customer follow and provide input to Flight Preparations. Customer input is key to your success and ours!

## CUSTOMER SERVICES AND OPTIONS OFFERED TABLE

**Table 18 Customer Services & Options Offered**

| STANDARD LEO SERVICES | |
|---|---|
| Provide statement of work | |
| Mission planning | |
| Payload integration | |
| Launch | |
| Licensing: - FAA | |
| - State Dept. | |
| - NORAD | |
| - Local | |
| Provide range / safety documents | |
| Manage range safety | |
| Provide electrical connectivity | |
| Provide payload adapter | |
| Manage satellite transportation | |
| Provide cleanroom | |
| Mate the payload | |
| Conduct integrated testing | |
| Launch | |
| Perform satellite attitude control | |
| Separate satellite | |
| Communicate through 1 orbit | |
| Provide orbit report | |
| Deliver post-flight report | |
| **OPTIONAL SEVICES** | |
| Communications for more than 1 orbit | |
| Communication for additional orbit rotations | |
| Continuous communication after initial orbit - up to active life of satellite | |
| Project Management & / or Expediting of Payload Manufacturing | |
| Transportation of Payload to LEO facility | |
| Insurance: - Liability | |
| - Other | |
| Sales Interface of your Satellites | |
| Integration of Satellite Assembly | |
| Orbit Placement Permitting | |

## L18. LEO LAUNCH OPERATIONS

### LEO MISSION CONTROL CENTER

**A LEO Mission Control Center** provides complete instrumentation and coverage of each launch. If takeoff is not from LEO facilities, a LEO mobile control Center will be in place for the Launch. Arrangements for Launch for Flights from other facilities must be made jointly at least 1 year before launch.

### INTACT ABORT / MISSION RETURN

As discussed under Section L5. Customer's Satellite Requirements, Concerns, & Options, the LEO Launch system can return Customer Satellites intact to the Launch Site. This might occur if there be any problems (weather, LEO Launch vehicles, satellite non-response, etc.) before rocket ignition point, your satellite can be safely returned to the Launch Facility. for adjustments.

Due to **LEO's Fast Turn-Around capability**, we can again take-off and prepare to launch very soon after an Intact Abort. How soon relaunch occurs would be determined by the nature of the cause of the delay. However, for LEO, this will normally be hours or days, not weeks or months, as would be the cause of "Launch Scrub" for a vertically launch rocket.

## L19. LEO FLIGHT OPERATIONS

### TAKEOFF

The launch checklist begins prior to Carrier Aircraft engine start and continues until after Chariot is released. All members of the Launch Team and the aircraft crew work from this procedure. Abort and emergency procedures will be also available to customers.

At the launch airport, about 1 hour before Takeoff, launch drop system power is turned on and all inhibits are verified, and safing pins are removed. At that time, the aircraft and the Chariot are ready for Takeoff.

LEO arranges for Chariot telemetry and tracking services during captive carry and Chariot powered flight. Data are sent to the LEO mission control consoles.

Once airborne, Chariot is configured to launch readiness by switching the carrier support and Chariot systems to internal batteries.

The vehicle drop system, and command currents are verified. Once this is completed, Chariot is Ready for Launch. LEO relays this "Ready" from the Chariot control center to the aircraft pilot and commander. After confirmation from the aircraft commander of a Ready for Launch, Mission Control Center performs the drop countdown. The Aircraft Commander has final authority of GO or NO GO for the Chariot Launch. The pilot or Aircraft Commander will release Chariot on the Mission Control command.

### LAUNCH AND ASCENT

After the aircraft commander releases the Chariot Ascent to Orbit Vehicle, command of the rocket stack is semi-autonomous. By this is meant that control of each flight is programmed into the Chariot GNC system. But, it can be over-ridden if necessary. Mission controllers, both in Ground Mission Control and in the on-aircraft Control Centers monitor the flight trajectory. Control could be exercised by either the Ground or the Airborne Control Centers. However, primary control and command authority rests with Ground Control. The Airborne Control Center will take control only in an emergency or if Ground Control was to lose contact with the spacecraft during ascent.

**First-stage powered flight** lasts one to two minutes, with commanded shutdown of the first stage engines based on calculated Ascent Guidance parameters, and the Trajectory sought. Then, the first stage falls away. Then, there will be a Chariot coast phase, the duration of which is determined by the actual Trajectory for each satellite, short for lower orbits, longer for higher orbits.

**The second stage** burns an additional two to five minutes to reach burnout. The Chariot separates from the second stage. Then Chariot coasts again.

**The third stage** burns 6 to 10 minutes, with deployment of the fairing typically taking place during third-stage powered flight. During the Fairing separation sequence, the computer timer actuates pyrotechnics that release both halves of the fairing, which then fly away on either side of the flight vehicle. The Pyros include a separation device at the nose, bolt cutter pairs for the external straps fore & aft the cylindrical fairing section, a breakable joint at the fairing base, and a gas thruster for deployment.

## ORBIT INSERTION

**Orbit Insertion stage** is unique to each mission but may include multiple coast-and restart phases while LEO adjusts and perfects Customer's satellite orbit. At this stage, corrections and minor modifications can be made to the orientation and orbit of the satellite, until the satellite is released and separated**.**

## SATELLITE SEPARATION

After reaching the spacecraft injection orbit and attitude, the Chariot vehicle issues a spacecraft separation command, providing the electrical impulses necessary to initiate spacecraft separation. Indication of separation is available in telemetry. at the Ground Control Center, onboard the Airborne Control Center, and, if desired, at Customer sites.
Shortly after Separation, the Orbit Insertion vehicle will receive thrust to turn it down, away from the satellite's orbit. This is to prevent the possibility of recontact with the now orbiting satellite.

In the future, LEO intends to retrieve spent the Chariot Orbit Insertion vehicles, for possible re-use. A little further in the future will be the possibility of safely returning Customer satellites if they have any problems during Ascent, before separation.

## AFTER SEPARATION

After the satellite is released, it is typically under the command, control, and in communication with the Customer. LEO can provide additional or even continuing Communication, as well as Command functions, at Customer request.

# L20. CUSTOMER DATA REQUESTS

## CUSTOMER DATA REQUESTS

Satellite and payload Customers can receive data from LEO during operations, before, during and after a Launch. Customers shall provide LEO a list of the kinds and details of that information you request.
Customers should ask us for what you want and need. Be specific. What data do you want? When do you want it? Where and how shall LEO provide it to you? What parameters and units should the data have for your use? Customers can get live LEO Mission Control telemetry, before and during flight operations, as well as before, during, and after any testing on Customer's owned satellites.

After completion of a satellite launch on the LEO Chariot Launch system, LEO will provide the Customers with full reports on the entire launch operation. The LEO Mission Manager generally will be responsible for overseeing preparation and delivery of this or these reports to their Customer.

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