Masten

VERTICAL TAKEOFF/VERTICAL LANDING
SUBORBITAL REUSABLE LAUNCH VEHICLES
PAYLOAD USER'S GUIDE

1 Introduction

1.1 Revision History

Date	Version	Description	Author
3/28/2010	1.0	Initial Release	M. Mealling
9/13/2010	1.1	Update with Xaero specifications	M. Mealling, D. Masten, R. Garcia
3/1/2011	1.2.1	Updated Xaero specifications	K. Brown
6/21/2011	1.2.2	Unreleased Updates, addition of more detailed payload requirements	K. Brown
6/23/2011	1.2.3	Addition of payload requirements	K. Brown, C. Ake, D.M. Bushman
11/9/11	1.2.4	Updated & revised for public release pending OSR approval	N. O'Konek

1.2 Purpose

Masten Space Systems, Inc. (Masten) is designing, building and flying fully reusable vertical takeoff and vertical landing (VTVL) launch vehicles which are designed to provide reliable, low cost access to space. Two new vehicles are in active development.

Xombie, the vehicle that won second place in Level I of the NASA funded Northrop Grumman Lunar Lander Challenge (NGLLC) X Prize, is being used for low speed and low altitude testing.

Xoie, the vehicle that won first place in Level II of the Lunar Lander Challenge, was purpose-built for the NGLLC competition and has been retired.

Xaero is Masten's current vehicle for payload flights. It is capable of carrying payloads of up to 12 kg to 30.5 km altitude MSL.

Xogdor is the next vehicle in Masten's line of VTVL rockets. It is currently under development. Masten expects that Xogdor will be capable of carrying payloads to over 100 km altitude MSL.

Program Overview

1.2.1 Advantages of Unmanned Flight

Unmanned suborbital flights have numerous advantages over crewed vehicles:

- Nano-gravity: Unmanned vehicles are capable of providing nano-gravity conditions, unlike manned missions in which natural crew movements complicate efforts to reliably sustain nano-scale gravity (less than 1e-5g) for any useful duration.
- Lower costs: The elimination of the mass of the pressure vessel, life support, and the crew allows for significantly lower costs.
- Faster turnaround: With no need for loading or unloading crew and passengers or cabin reconfigurations, unmanned VTVL vehicles are capable of flying more frequently than their manned competitors.

1.3 Programmatic Information

1.3.1 Service Availability Timeline and Pricing

We expect to begin flights capable of carrying customer payloads on Xaero in 2011. These flights will initially be approximately 5 km altitude MSL and will expand to reach 30.5 km altitude MSL as flight tests continue.

1.3.2 Regulatory Requirements

Xaero is designed to fly within the range of the Federal Aviation Regulations for Unmanned Rockets (CFR 14 Part 101). Though no launch permit or license is required for this vehicle, Masten intends to pursue a launch license for Xaero. As a part of the FAR 101 compliance process, Masten will request the FAA to provide authorization for launches into controlled airspace. The FAA approval process includes consultation with the Office of Commercial Space Transportation (FAA/AST), including a safety review. Masten is currently in the process of preparing an application for a launch license for Xaero. Moving forward, all additional launch systems will be licensed.

The company initially intends to continue flying at its Mojave, CA launch location. Masten also has use of launch facilities near Cantil, CA and is working to secure launch capability at Cape Canaveral Air Force Station in Cape Canaveral, FL.

While not required under FAR 101, Masten will maintain liability coverage to a maximum of $3 million per incident and will continue to carry this as well as any additional liability coverage required by other regulatory regimes.

2 Vehicle Overview

2.1 General Flight Profile Information

Masten's vehicles take off and land vertically at the same location. The vehicles developed in the course of the 2009 Northrup Grumman Lunar Lander Challenge (Xoie and Xombie), both demonstrated sub 24cm (10in) landing accuracy. Masten's standard flight profile consists of launch, acceleration until the vehicle reaches its expected altitude, then the engine goes to

minimum throttle through apogee and descent until full throttle is required to decelerate the vehicle for a soft landing.

Flight profiles have some flexibility for payload specific needs and are assessed on a per payload basis. Flight profiles can be modified for lower accelerations with loss of altitude and reduced gravity time. Contact Masten for details.

2.2 Xaero

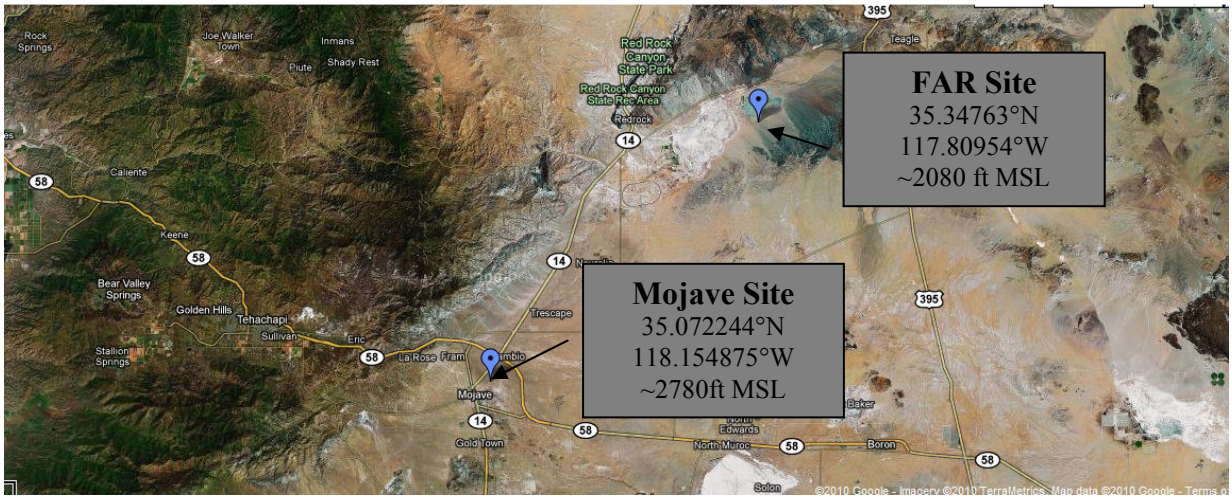
Xaero is the company's first vehicle to use an aeroshell, enabling faster flight modes and to higher altitudes. The primary payload bay allows most payloads to be placed in the nose cone. Payload space may also be available in smaller areas toward the aft end of the vehicle. Payload items not located in the payload area under the nose cone are considered "non-standard."

2.3 Xogdor

Xogdor is a vehicle that is in development and has not flown to date. Current designs call for Xogdor to be capable of 100 km altitude MSL with payload on board. Xogdor will have significantly higher payload capabilities, both in terms of mass and volume. Notional numbers are available upon request.

2.4 Launch/Landing Sites

Masten is based at Mojave Air and Spaceport in Mojave, CA. Masten currently uses two launch sites in the Mojave area; the Mojave Air and Spaceport, and the Friends of Amateur Rocketry (FAR) site near Cantil, CA.



Mojave Launch Sites

Masten is also currently in the process obtaining authorization to conduct high altitude launches from Launch Complex 36 at Cape Canaveral Air Force Station.
Ground operations and infrastructure requirements are minimal enough that Masten can fly almost anywhere that has reasonably clear air traffic and minimal exposure to populated areas.

Contact Masten for details on launching from other locations. The suitability of a launch or landing site is determined by available facilities, cost of insurance, certain regulatory costs, and flight rate.

2.5 Launch Windows and Flight Rates

Launch windows are available with short lead times from established sites. Turn around time between individual flights of a multi-flight schedule determined by refueling time, air space availability, and payload servicing, including data access. Air space availability is an uncontrollable component that is affected by existing airspace and range capabilities. Masten has processes and relationships in place with the air space management authorities to coordinate this activity and reduce uncertainty. Standard service is one flight per day. Two or more flights per day may be available as a "non-standard" service.

3 Facilities Overview

3.1 Mojave, CA

Engineering, assembly and test facilities are located at the Mojave Air and Space Port located in Mojave, CA.

4 General Payload Information

4.0.5 Payload qualifications

Payloads are required to meet the following requirements before they can be flown:

All payloads are subject to a Masten technical review and are accepted on a case by case basis.

4.1.1 Mounting

The payload must mount to a Masten approved and/or provided payload mounting plate. A secondary payload mounting plate is provided for physical integration as part of the standard service.

4.1.2 Standard

A secondary payload plate will be provided.

4.1.3 Non-Standard

A primary (payload base plate) mockup can be provided if a payload will not fit or mount to a secondary plate.

This plate will have holes and access openings machined and/or marked that match the flight article.

A fully machined primary plate can be provided. Note: The payload plate must be attached to the vehicle before the payload is mounted.

Masten - and potentially a subcontractor focusing on payload integration - will work with the payload provider if any non-standard services or hardware are required to ensure that the payload meets requirements.

4.1.4 Physical documentation

Documentation indicating the Center of Gravity (CG) in three dimensions, payload mass in a flight ready condition, a list of liquids and or gasses used or generated and a basic theory of operation. In addition to data received by the payload provider, approved subcontractors in the areas of payload integration may be used to help determine final information.

4.1.5 Regulatory documentation

All payloads that have regulatory requirements must have the appropriate documentation of regulatory compliance and approvals. Certain regulated payloads may be considered non-standard. Some regulated payloads may not be able to be launched from established Masten launch sites. As Masten's launch licenses are procured, this section may be updated with payload class information.

4.1.6 Customer support personnel

A customer representative that is familiar with the payload may be present (physically or telephonically) during integration, testing .and flight of the payload. The representative shall have the technical knowledge that will make him/her capable of answering specific questions about the payload and shall have the authority to make decisions regarding integration, modification and flight of the payload.

4.1.7 Containment

The payload must provide containment for any liquids or gases used or generated. Any liquids or gases used or generated may trigger the non-standard payload definition.

4.1.8 RFI and EMI

Payloads must not interfere with vehicle electrical or communications systems.

Xaero communicates in the 2.4gHz and 900mHz bands.
An on-vehicle test will be performed to verify non-interference.

4.1.9 Vibration and shock

The payload must pass a shock and vibration test to a minimum of twice the following amplitude values at the frequencies mentioned:

Vertical
Maximum vertical shock acceleration +/- 45 m/s^2 or +/- 5.59 g.
3 sigma vertical acceleration of +/- 24 m/s^2 or +/- 2.45 g.
Mean vertical acceleration of 9.8 m/s^2 or 1.0 g.
Frequencies range from 1 to 10 Hz

Lateral
Maximum lateral shock acceleration +/- 41 m/s^2 or 4.2 g.
3 sigma lateral acceleration of +/- 20 m/s^2 or 2.04 g.
Mean lateral acceleration of 0.0 m/s^2 or 0.0 g.
Frequencies range from 1 to 30 Hz

The following criteria must also be met:

No external or internal part of the payload shall detach or shift for standard payloads.
The structure of the payload shall not be damaged or deformed.
Liquid containment systems must remain intact.

4.2 Payload Fairing Data Rate for Telemetry Data

Masten Space Systems does not currently provide telemetry for payloads. Experiments should be designed to operate and record data autonomously. Masten can accommodate antenna emplacements for customer supplied telemetry equipment as a non-standard service.

4.3 Payload Environment

The payload bay is round with a conical section on top. The available payload area is shown in the drawings at the end of this document.

It may be possible to add payload adapter facilities at the base of the vehicle and along the fuselage. Use of these additional facilities will require additional non-recurring engineering (NRE) and if acceptable will be provided as a non-standard service.

Controlled Environment Payload Carrier

Payloads are typically mounted inside a payload container fastened to the Payload Mounting Plate. The carrier maintains pressure between 75.3kPa (10.9psi) and the ambient pressure at the

launch site. Standard payload service mandates the payload container be sealed during flight service.

The temperature range is between 0°C and 60°C. This range does not take into account heat generated by the payload.

Tighter control of the temperature and pressure within the payload canister can be provided as a non-standard service.

Figure 2, below, shows the elevation view of the pressurized payload carrier envelope. Figure 1 shows the primary and secondary payload plates.

Please note: There is a pressure control port in the mounting plate, this port is for maintaining pressure within the carrier (if used) and must NOT be blocked or isolated. If the payload requires a geometry that blocks or isolates this port, a custom mounting plate can be designed as a non-standard service.

Up to two bulkhead plates with up to two connectors each for signal/antenna wiring can be added to the mounting plate as a part of our standard service. Additional bulkhead connectors can be added, with an additional NRE charge. Note that mounting of payload components outside of the payload bay typically requires additional NRE.

One bulkhead plate is reserved for vehicle payload temperature and pressure sensors. This connection also includes provisions for two "dry" switches for payload operations.

4.3.1 Electrical Interfaces

The vehicle is equipped with two "dry" switches for payload power and/or activation as a standard service. These switches are located at the vehicle servicing port. Each switch is capable of 4A @ 48v. Payloads can be turned on or activated by the Masten ground crew twenty minutes before and after flight. Customers will need to provide a mating connector(s) to interface to their payload with the delivery of the payload. Additional switches or indicator/display lines may be possible as a non-standard item. Power is not supplied to the payload from the launch vehicle.

4.4 Data Storage Capabilities / Constraints

Xaero and Xogdor do not provide data storage interfaces.

4.5 Fields of View

Xaero and Xogdor do not have standard mechanisms for providing fields of view outside the vehicle for payloads mounted inside the payload canister. It may be possible to mount small remote sensing devices at various locations on the vehicle. Sensor mounting can be accomplished in many places on the vehicle depending on the physical aspects of the sensor. Windows can be assessed as requested and could potentially be added. This would be a non-standard service.

5 Operations Information

Customer access to the payload can be provided as specified in the launch services contract.

5.1.1 Launch Opportunities

Current turn around time between flights is approximately four hours (excluding any payload changes). If the contract on which the payload is being flown requires access to payload for data download, additional time may be required. The exact turn around time will be determined on a case-by-case basis and will depend on the exact details of the services required. Limitations on cadence and flight window availability are weather, air space, crew work time regulations and launch site. Each launch site comes with its own set of restrictions on air space and range imposed schedules. Mojave Air and Space Port has regular air traffic which limits actual launch time. Other launch sites have similar restrictions.

5.2 Payload Integration

5.2.1 Integration Schedule

The payload integration process will begin at a time determined by Masten and approved by payload integration subcontractor specialists. Prior to launch, the payload will be integrated with the vehicle to perform mechanical fit and electrical checks. Subject to Masten scheduling and payload processing requirements, the payload may remain integrated with the vehicle. The day prior to flight or before, the payload will again be integrated with the launch vehicle if it has been previously removed. The customer may schedule personnel to be at the Masten shop for the fit and function test. Customer personnel will need to be available for the final integration of the payload and should be both technically familiar with the payload and have the authority to approve changes or modifications as needed.

5.2.2 Standard Services

A standard payload on board a Masten sRLV is defined by the following characteristics:

Mass	Xaero: 12 kg Xogdor: 25 kg
Volume	Xaero: 3854.6 cubic inches Xogdor: 14313 cubic inches
Environment	Closed payload canister, canister pressure 10 psi
Flight Rate	Restricted to one flight per day
Power	Self contained in payload, no power received from vehicle
Data	Data acquisition and storage self contained in payload
Content Restrictions	No biological materials, radioactive materials, or fluids on board

Dry Switch	The Masten standard dry switch is available for standard payloads
Antennae	Standard payload processing and integration includes 0 (zero) antennae external to the payload canister.
Integration	Physical payload integration must be conducted at Masten shop. Final payload access is available 3 hours prior to hazardous operations and the dry switch can be activated less than one hour prior to flight by the Masten ground crew.
Mounting Plate	The payload mounting plate, identified internally as a "secondary mounting plate" will be provided to the payload provider for mounting. The plate weighs 0.70 kg

5.2.3 Non-standard Services

Examples:

- External Antenna(e).
- External and/or through structure sensors.
- Additional dry switches and/or displays/indicators
- Masten payload preparation/modification
- Servicing of the payload at the launch site
- Multiple flights in one day
- Custom flight profiles

5.3 Launch Operations

5.3.1 Pre-launch Payload Access

Customer personnel have access to the payload up until two hours before the close of business the day prior to the scheduled flight. Payload access the day of the flight or on-pad servicing of the payload can be included in the contract as a non-standard service .

5.3.2 Flight

Pre-Flight

The morning of the flight, a mandatory safety briefing will be held for all hands within the flight facility test area. The vehicle will be moved from the Masten shop to the launch site. When the vehicle has arrived and the site is ready, the vehicle will be taken through a checkout routine. Payload checks can be scheduled during this period. Immediately before liquid oxygen loading, the launch site is cleared of all non-essential personnel. Once loading commences, operations continue directly to flight.

The flight will last anywhere from five to ten minutes depending on vehicle configuration and trajectory.

Post-flight Payload Access

Customer personnel will again have access to the payload after the vehicle is returned to the Masten shop. Please allow one hour or longer for any time critical payload requirements. On pad servicing may be available as a "non-standard" service. Customers requiring on-pad servicing of their payload should expect a minimum of thirty minutes from the landing of the vehicle before they will be able to access their payload.

5.3.3 Personnel location during flight operations

Customers are invited to attend the launch of their payload. Room for one or two people is available at the launch control facility, depending on safety approvals from the relevant authorities. If organizational safety requirements prevent customer representatives from attending the launch at launch control facility , a viewing site will be offered a safe distance from the launch pad . All other customer personnel will be located at a viewing site a safe distance from the launch pad. All personnel are required to attend the pre-flight safety briefing.

Long pants and closed toed shoes are required at the launch site.

6 Safety

6.1 Safety Requirements

All payload components must be in compliance with recognized aerospace standards.

7 Administrative Information

7.1 Masten Point of Contact for Additional Information

Colin Ake
Business Development
Masten Space Systems
cake@masten-space.com
888.488.8455

7.2 Pricing Information

Contact Masten for current pricing information. For existing contracts,
see pricing information and available line items in previously submitted proposal(s).