





Capability Driven Lunar Services







# Destination Moon

Masten started by winning the NASA Centennial Challenge Northrop Grumman Lunar Lander X-Prize - Now we want to do it for real.

- Transportation to create and support a CisLunar economy
- Lay the groundwork for future manned exploration
- New exploration we will discover amazing things!

### LUNAR CATALYST Lunar CArgo Transportation And Landing by Soft Touchdown

### <u>Award</u> Masten Space Systems Astrobotic Moon Express

### Public Private Partnership

- Develop robotic landers
- Integrate work into future missions
- Deliver payloads to the Moon!

"Working with NASA CATALYST has been technically motivating. There is no other single source of knowledge, expertise, engineering resources and management tools as deep or with the same command of subject matter."

> - Matt Bergman, XL-1T Project Lead / Masten Space Systems





# **CLPS:** Returning to the Moon!

- Commercial and private partners
- Accelerates lunar missions by 2-3 years
- Multiple companies, similar to NASA Flight Opportunities program
- IDIQ (Indefinite Duration, Indefinite Quantity)
- Pathway towards larger missions
- "Shots on goal" NASA Administrator Bridenstine

# CLPS: Capability Driven Approach





- Changes the mission thought process decouples from the traditional mission focused architecture
- Benefits to both science and industry



# Masten has over a decade of experience in achieving responsive capability driven missions







# Flying: We Love It



- We understand mission needs from FLYING them
- Every flight campaign is a progression - increasing our capabilities to meet your needs
- Work to add mission value and increase chances of payload success





**5 Reusable Lander Vehicles Demonstrated** 600+ Flights - Multiple Flights per Day - Small Team Operations

# 5 Flights, One Day

# 9:09 am 9:24 am 9:45 am 10:00 am 10:19 am

Honeybee Robotics PlanetVAC 2018 NASA Flight Opportunities

## ADAPT: LVS & G-FOLD

"This represents a huge step forward in our future capabilities for safe and precise Mars landing, and demonstrates a highly effective approach for rapid, low-cost validation of new technologies for the entry, descent and landing of spacecraft"

- Chad Edwards, chief technologist of the Mars Exploration Directorate at JPL.

# **COBALT**: LVS Flight Testing

Masten Space Systems, Mojave, California, conducted the April 6th, 2017, commercial flight on its Xodiac rocket launching from Mojave Air and Spaceport, California, carrying the NASA CoOperative Blending of Autonomous Landing Technologies (COBALT) payload led by NASA JSC. Supported by NASA's STMD, HEO & AES



Credits: NASA Photo / Ken Ulbrich

# XL-1T: Risk reduction for the Moon

- Being built now, flying in 2019.
- Used as risk reduction for lunar technology.
- Will enable lunar payload integration testing in a terrestrial environment.
- Bridges the gap from our current EDL testbeds to the Moon.



# XL-1T In Fabrication

# **XL-1T**: Safer Propellants





### Masten MXP-351

- "Green" Hypergol
- Reduced toxicity & improved performance over traditional options
- Continuing to refine and test the design as part of XL-1T



Honeybee Robotics PlanetVAC 2018 NASA Flight Opportunities

# XL-1: Lunar Lander



# **XL-1**: Delivering payloads to the Moon





# XL-1: Hardware Development













### **Main Engine Testing**

- Cold Flows
  - 142
- Hot Fires

# XL-1: Payloads

- 100 kg of payload per lander
  - $\circ$  2 payload bays, one per side
  - Low to the ground for easy instrument deployment
- 50-100 W of payload power
  - 0.5-1.0 W/kg, varies by landing location & time
- 5 Mb/s coms link for instrument data after landing
- Custom mounting locations available



# XL-1: Propulsion System



### Main Propulsion System:

- 4x 225 lbf descent thrusters
- Throttleable, 5:1
- Hypergolic (MXP-351)

### **Reaction Control System:**

- 16x 5 lbf RCS thrusters
- On-off (bang-bang control)
- Hypergolic (MXP-351)



# XL-1: Landing Plume

- Plume effects and interactions with regolith on landing
- Will work with payloads to model & minimize effects
- Also pursuing rover solutions











Thermal conditions for payloads & experiments



# From Earth to the Moon





Upper Stage Jettison

# **XL-1**: Design Reference Missions

- Aristarchus
- Reiner Gamma
- Malapert Massif
  Peak
- Ina Caldera



# **LEAG:** Recommended Landing Sites





# **XL-2**: Evolving Capabilities











