

3.3. Student Launch Task 2 – Centennial Challenge Design, Development, and Launch of Autonomous Ground Support Equipment (AGSE)

Task Name: Centennial Challenge MAV Project (for colleges, universities, and non-academic teams)

Governing Office: NASA Marshall Space Flight Center Centennial Challenges Office

3.3 Student Launch (Task 2) Centennial Challenge

3.3.1 Introduction

The Mars Ascent Vehicle (MAV) Project is based on the MAV Mission as part of the robotic Mars Sample Return (MSR) mission baseline architecture, and includes a sample to be cached on the surface of Mars for an extended duration. The next phase of the mission must land a MAV with relatively close proximity to the cache, grapple the cache, insert the cache into a horizontal MAV, seal and erect the MAV, and finally launch and deploy the sample container into Mars orbit. This chain of events will be performed without human intervention beyond potential go/no-go decisions.

The MAV Project within the NASA Centennial Challenges Office located at the Marshall Space Flight Center is cooperatively working with the NASA Student Launch (SL) who is coordinating and conducting the launch portion of the MAV Project including manpower, infrastructure, safety oversight, review/design support, and launch support. Many of the requirements in both MAV and Student Launch are universal and must be obeyed by all teams, but each project differs in its research focus.

The Centennial Challenges Program, part of NASA's Science and Technology Mission Directorate, awards incentive prizes to generate revolutionary solutions to problems of interest to NASA and the nation. The program seeks innovations from diverse and non-traditional sources, and the challenges are open to private companies, student teams and independent inventors. The competitors are not supported by government funding, and awards are only made to successful teams when the challenges are met. More than \$6 million in prize money has been awarded in over 20 competitions

The Centennial Challenges Office will award prizes to college, university and non-academic teams for successful demonstration of the MAV Project. The first place award for the MAV Project is \$25,000, the second place team receives \$15,000, and the third place team receives \$10,000. MAV Project teams will only be eligible for prize money after the successful completion of all parts of the MAV Project competition.

3.3.2 MAV Project – Competition and AGSE Requirements

3.3.2.1 The MAV Project will provide each team with the opportunity to develop a unique method to capture, contain, and launch a payload with limited human intervention. In addition, teams will develop a launch system that erects a rocket from a horizontal to vertical position, and has its igniter autonomously installed. The AGSE will be demonstrated at LRR and will follow this general procedure. Requirements 3.3.2.1.1 – 3.3.2.1.4 shall be conducted autonomously from start to finish within a 10 minute time limit. The only allowed human interaction is the activation of the master switch.

3.3.2.1.1 Teams will position their launch vehicle horizontally on the AGSE.

3.3.2.1.2 A master switch will be activated to power on all autonomous procedures and subroutines.

- 3.3.2.1.3** All AGSEs will be equipped with a pause switch in the event that a judge needs the AGSE to be temporarily halted for any reason. The pause switch halts all AGSE procedures and subroutines. Once the pause switch is deactivated the AGSE resumes operation.
- 3.3.2.1.4** Once the judge signals “START”, the AGSE will begin its autonomous functions in the following order: 1) capture and containment of the payload; 2) erection of the launch platform from horizontal to 5.0 degrees off vertical (85.0 degrees), 3) insertion of the motor igniter. The judge may re-enable the pause switch at any time at his/her discretion. If the pause switch is re-enabled all systems and actions shall cease immediately. The judge will only do this if there is a question about safe operation of the AGSE. The judge and team leader will discuss and decide if the team will be allowed to continue their attempt. No modifications to the hardware or software will be allowed prior to a rerun.

3.3.3 The Autonomous Ground Support Equipment (AGSE)

- 3.3.3.1** For the purpose of this challenge, the ASGE is defined as all mechanical and electrical components not part of the launch vehicle, and is provided by the teams. This includes, but is not limited to, the payload containment and igniter installation devices, computers, electric motors, batteries, etc.
- 3.3.3.2** All AGSE systems shall be fully autonomous. The only human interaction will be if the judge pauses the AGSE.
- 3.3.3.3** The AGSE shall be limited to a weight of 150 pounds or less and volume of 12 feet in height x 12 feet in length x 10 feet in width.

3.3.4 Prohibited Technology for AGSE

- 3.3.4.1.1** As one of the goals of this competition is to develop equipment, processes, and technologies that could be implemented in a Martian environment, the AGSE and any related technology cannot employ processes that would not work in such environments. Therefore, prohibited technologies include:
 - 3.3.4.1.2** Sensors that rely on Earth’s magnetic field
 - 3.3.4.1.3** Ultrasonic or other sound-based sensors
 - 3.3.4.1.4** Earth-based or Earth orbit-based radio aids (e.g. GPS, VOR, cell phone).
 - 3.3.4.1.5** Open circuit pneumatics
 - 3.3.4.1.6** Air breathing systems

3.3.5 Payload

- 3.3.5.1** Each launch vehicle must have the space to contain a cylindrical payload approximately 3/4 inch inner diameter and 4.75 inches in length. The payload will be made of 3/4 x 3 inch Schedule 40 PVC tubing filled primarily with sand and may include BBs, weighing approximately 4 ounces and capped with domed PVC end caps. Each launch vehicle must be able to seal the payload containment area autonomously prior to launch.
- 3.3.5.2** A diagram of the payload and a sample payload will be provided to each team at time of acceptance into the competition. In addition, Teams may construct practice payloads according to the above specifications; however, each team will be required to use a regulation payload provided to them on launch day.
- 3.3.5.3** The payload will not contain any hooks or other means to grab it.
- 3.3.5.4** The payload shall be placed a minimum of 12 inches away from the AGSE and outer mold line of the launch vehicle in the launch area for insertion, when placed in the horizontal position on the AGSE and will be at the discretion of the team as long as it meets the minimum placement requirements.
- 3.3.5.5** Gravity-assist shall not be used to place the payload within the rocket. If this method is used no points shall be given for payload insertion.
- 3.3.5.6** Each team will be given 10 minutes to autonomously capture, place, and seal the payload

within their rocket, and erect the rocket to a vertical launch position five degrees off vertical. Insertion of igniter and activation for launch are also included in this time. Going over time will result in the team's disqualification from the MAV Project competition.

3.3.6 Safety and AGSE Control

3.3.6.1 Each team must provide the following switches and indicators for their AGSE.

3.3.6.1.1 A master switch to power all parts of the AGSE. The switch must be easily accessible and hardwired to the AGSE.

3.3.6.1.2 A pause switch to temporarily terminate all actions performed by AGSE. The switch must be easily accessible and hardwired to the AGSE.

3.3.6.1.3 A safety light that indicates that the AGSE power is turned on. The light must be amber/orange in color. It will flash at a frequency of 1 Hz when the AGSE is powered on, and will be solid in color when the AGSE is paused while power is still supplied.

3.3.6.1.4 An all systems go light to verify all systems have passed safety verifications and the rocket system is ready to launch.

3.3.7 Failure of the MAV Project

3.3.7.1 Any team who fails to complete any of the procedures in requirement 3.3 will be ineligible of obtaining Centennial Challenges prizes.

3.3.7.2 The head judge and the MAV Project Manager will have the final decision authority to determine if the procedures in requirement 3.3 have been met.

3.3.8 General Requirements Unique to Centennial Challenge MAV Project

3.3.8.1 Any academic team or non-academic team may participate in the MAV Project, however, to be eligible for prize money, less than 50% of the team make-up may be foreign nationals and the team entity must be a United States entity.

3.3.8.2 Name of person or business or entity who will be receiving the award check in the event the team places in the competition and address. If a business or other entity is to receive the check then also provide a tax identification number.

3.3.8.3 In addition to SL requirements, for the CDR presentation and report, teams shall include estimated mass properties for the AGSE.

3.3.8.4 In addition to SL requirements, for the FRR presentation, teams shall include a video presented during presentation of an end-to-end functional test of the AGSE. The video shall be posted on the team's website with the other FRR documents. Teams shall also include the actual mass properties for the AGSE.