2018 SpaceX Hyperloop Pod Competition

Rules and Requirements

Revision 1.0

September 5, 2017

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1 INTRODUCTION

On August 12, 2013, Elon Musk released a white paper on the Hyperloop, his concept of high-speed ground transport. In order to accelerate the development of a functional prototype and to encourage student innovation, SpaceX announced a Hyperloop Pod Competition in 2015 to design and build a Hyperloop Pod. For this competition, student teams from around the country and world came together for a Design Weekend in January 2016 to share their Pod designs. Top teams advanced to the build phase and spent 2016 turning their designs into working Pods. These teams then competed in the first Hyperloop Pod Competition in January 2017, where they raced their Pods on a Hyperloop test track adjacent to SpaceX's Hawthorne CA headquarters. A second competition was held in August 2017.

Based on the high-quality submissions and overwhelming enthusiasm surrounding the first two competitions, SpaceX is moving forward with a third installment: the 2018 Hyperloop Pod Competition.

This document outlines the competition logistics and rules. The competition is open to new student teams interested in competing on the test track as well as to the existing student teams who have already built and tested Pods to further refine their designs. There will be some updates to the competition rules and track specifications as outlined in this document.

The two key rules for the 2018 competition are:

1. **The competition will be judged solely on one criteria: maximum speed with successful deceleration (i.e. without crashing).**
2. **All Pods must be self-propelled. SpaceX will not provide an external Pusher.**

In addition to the main competition, SpaceX will allow up to three teams take part in a "Levitation Sub-Competition," which is detailed in the last section of this document.

For an updated competition schedule, visit Spacex.com/Hyperloop.

Note: This competition is a SpaceX event. *SpaceX has no affiliation with any Hyperloop companies, including, but not limited to, those frequently referenced by the media.*

Any questions or comments should be submitted to Hyperloop@spacex.com.

2 GENERAL INFORMATION

1. Only student teams are eligible to enter the competition. To determine eligibility:
    - A student team is one that is composed solely of undergraduate and graduate students who are currently enrolled as of the intent to compete deadline of September 29, 2017. Teams can consist of students from multiple schools. We will also accept exceptional high school entrants on a case-by-case basis.
    - The team structure is flexible, with no minimum number of team members and no maximum number (within reason).
    - Each team must have a Faculty Advisor. However, Faculty Advisors should not design the vehicle, nor should they fabricate or assemble more than a minority of the components. Advisors also may not directly participate in creating any documentation or presentation.
    - If there is any question about eligibility, please email Hyperloop@spacex.com.
2. Returning Teams: Teams who have built a Pod for a previous competition are eligible to compete again provided they meet the student team eligibility described above. Returning teams may either build a new Pod or make tangible and clear modifications to their Pod used for the previous competition. Note that the intent of this rule is so that teams do not race the exact same Pod at multiple competitions.
3. Final competition. Selected Pods will compete at the test track during the final competition.
    - At SpaceX's discretion, Pod teams may be allowed to test their Pods on the test track before the final competition.
    - SpaceX, at its sole discretion, may allow or disallow entrants from accessing the test track.
    - No human or animal shall ride in any Pod or other transportation device used within the test track during this competition or during any pre-competition access.
4. SpaceX encourages teams that are not selected for the final competition to still move forward and build Pods. SpaceX, with best effort, will work with teams to allow them to use the test track at a separate time.

3 SCHEDULE

The contest schedule can be seen below. Events in **bold** indicate a deliverable from the contestants.

Due Date	Name
9/5/2017	2018 Hyperloop Pod Competition Announced (this document)
9/29/2017	**Intent to Compete Form Due**
Fall 2017	**Preliminary Design Briefing and Competitor Entry Agreement Due**
Fall 2017	SpaceX announces teams that have advanced
Fall 2017	**Final Design Package Due**
Winter 2018	Final Design Presentations via Skype
Winter 2018	SpaceX announces teams that have advanced
Spring 2018	**Safety Briefing Due**
Summer 2018	SpaceX Hyperloop Pod Competition Testing Week
Summer 2018	2018 SpaceX Hyperloop Pod Competition

4 INTENT TO COMPETE

The Intent to Compete form must be filled out online at: Spacex.com/Hyperloop/Submissions. **The form must be completed in full by 5pm Pacific on Friday, September 29, 2017.**

The form requires information on your team captain, faculty advisor, and university, along with a pdf file of a signed letter from the University Engineering Dean, Assistant Dean, or equivalent in support of the contestants entering this competition.

After the submission of their Intent to Compete form, registered teams will receive a Competitor Entry Agreement form as well as the SpaceX Hyperloop Pod Competition Test Track Specification, which provides more specific technical specifications for the Hyperloop test track pertinent to the competition.

5 PRELIMINARY DESIGN BRIEFING

All teams will be asked to submit a Preliminary Design Briefing document consisting of a PowerPoint slide deck (in PDF format) of no more than 30 slides, along with a signed Competitor Entry Agreement. Exact deadlines and submission instructions will be provided to registered teams.

The Preliminary Design Briefing will include:

1. Description of team and updated list of all associated team members and advisors
2. Top-level design description for Pod. Teams are allowed to revise their design in subsequent submissions, so consider the Preliminary Design Briefing to be a "best initial guess." At a minimum, this should include, where applicable:
    a. Estimated Pod dimensions
    b. Estimated Pod mass by subsystem
    c. Estimated Pod power consumption by subsystem
    d. Pod navigation mechanism
    e. Pod levitation mechanism (if any)
    f. Pod propulsion mechanism
    g. Pod braking mechanism
    h. Pod stability mechanisms (e.g. attitude and lateral motion)
3. List and description of any stored energy on the Pod (e.g. pressure vessels, batteries)
4. List of hazardous materials, if any
5. Top-level description of safety features
6. If a returning Pod, highlight the modifications and upgrades made

The purpose of this briefing is for SpaceX to "sanity check" the design and ensure the entrant is heading in a viable direction. Following the submission, there may be a down-select decision in order to properly manage the number of entrants.

6 FINAL DESIGN PACKAGE

All entrants who have successfully advanced past the Preliminary Design Briefing phase will be asked to submit a Final Design Package.

The Final Design Package must consist of:

1. Description of team and updated list of all associated team members and advisors
2. Design description for Pod. At a minimum, this should include:
    a. Pod top-level design summary
    b. Pod dimensions
    c. Pod mass by subsystem
    d. Pod payload capability
    e. Pod materials
    f. Pod power source and consumption
    g. Pod navigation mechanism
    h. Pod levitation mechanism (if any)
    i. Pod propulsion mechanism
    j. Pod braking mechanism
    k. Pod stability mechanisms (e.g. attitude and lateral motion)
    l. Pod aerodynamic coefficients
    m. Pod magnetic parameters (if applicable)
3. Predicted Pod thermal profile
4. Predicted Pod trajectory (speed versus distance)
5. Predicted vibration environments
6. Pod structural design cases: at a minimum, this shall include initial acceleration, nominal deceleration, and a reasonably foreseeable off-nominal crash
7. Pod production schedule
8. Pod cost breakdown
9. Sensor list and location map
10. Comments on scalability to an operational Hyperloop with respect to:
    a. System size (increased tube length, tube diameter, and Pod size)
    b. Cost (both production and maintenance)
    c. Estimated Pod mass and cost if built full-scale
    d. Maintenance (e.g. not requiring specialized alignment tools, hot-swappable subsystems)
11. Loading and unloading plan
    a. Full descriptions of all functional tests (see Sections 10 and 12)
    b. Full description of Ready-to-Launch checklist/state (e.g. Loop Computer in “Launch Mode” and sending telemetry, Pod hovering at 0.25 inches)
    c. Full description of Ready-to-Remove checklist/state (e.g. Wheels locked, Power Off)
    d. Description of how Pod is moved from Staging Area to Hyperloop
    e. Description of how Pod is moved from Hyperloop to Exit Area
12. List and description of any stored energy on the Pod (i.e. pressure vessels, batteries)

13. List of any hazardous materials, if any
14. Description of safety features including:
    a. Hardware and software inhibits on braking during the acceleration phase
    b. Mechanisms to mitigate a complete loss of Pod power
    c. Pod robustness to a tube breach resulting in rapid pressurization
    d. Fault tolerance of braking, levitation, and other subsystems
    e. Single point of failures within the Pod
    f. Recovery plan if Pod becomes immovable within tube
    g. Implementation of the Pod-Stop command
15. Component and system test program before the Pod arrives for the Competition
16. Vacuum Compatibility Analysis
17. If a returning Pod, highlight the modifications and upgrades made

7 FINAL DESIGN PRESENTATIONS

Based on the Final Design Packages, SpaceX will select certain teams to present their designs, via video conference, to a SpaceX judging panel. These presentations will be no more than 30 minutes, with a 15 minute Q&A session, and will take place in winter 2018. Following this, SpaceX will notify teams who are advancing to the build phase of the competition.

8 SAFETY PACKAGE

Before attending the final competition, competitors must submit a complete Safety Package, which is detailed in the separate Competition Checklist document. Most of the information can be extracted from the previous submissions.

9 POD REQUIREMENTS

The Pod requirements for the competition are intentionally broad in order to encourage diversity of design. Email any questions to Hyperloop@spacex.com.

1. Mass: Less than 3,300 lbm (1,500 kg).
2. Dimensions: Pods shall fit within the cross-section provided within the SpaceX Hyperloop Test Track Specification. Pod minimum length is 5 feet. Pod maximum length is 24 feet.
3. Service Propulsion System: The Pod shall be moveable at low speeds when not in operation, which may be accomplished by physically pushing it (wheels), physically lifting it (even with a dolly), or remotely controlling it.
4. Dummy Passenger: While not a hard requirement, it is suggested that the Pod accommodate at least 1 dummy. The dummy does not have to be given a life support system, but should be physically in the Pod in a reasonable orientation for the duration of the test. The dimensions of the dummy are up to the entrants, who should be prepared to explain their choice of size.
5. See separate Test Track Specification for detailed safety requirements.

10 LEVITATION SUB-COMPETITION

For Pods without their own propulsion system, up to three teams will be allowed to take part in a levitation sub-competition concurrent to the main competition. These teams shall go through all of the Safety Procedures as the other onsite Pods, with the exception that they are not required to be vacuum-tested. The sub-competition rules are as follows:

1. The Pod will start at one end of a 150 foot external subtrack.
2. Upon a “go” signal, the Pod will levitate and translate (at least) 75 feet down the subtrack
3. The Pod will then translate in reverse and return to its original position
4. The Pod must be levitating for the entire duration (wheels do not count as levitation)
5. If levitation energy is provided through air tanks, the tank pressures must be less than 1,500 psi

Fastest time without crashing wins!