2025 HuLC Q&A Session
November 7, 2024

The Human Lander Challenge is sponsored by NASA's Exploration Systems Development Mission Directorate's (ESDMD) Human Landing System (HLS) Program Office and managed by the National Institute of Aerospace.

AGENDA

Welcome & Introductions

Context for the Challenge

Questions Received in Advance

Programmatic Remarks

Wrap Up

NIA PROGRAM TEAM

National Institute of Aerospace

SHELLEY SPEARS

Director of Education and Outreach

STACY DEES

Higher Education Challenges Portfolio Manager

VICTORIA "TORI" O'LEARY

HuLC Project Lead

GENEVIEVE "GEN" EBARLE

HuLC Project Coordinator

NASA CHAMPIONS

Esther Lee

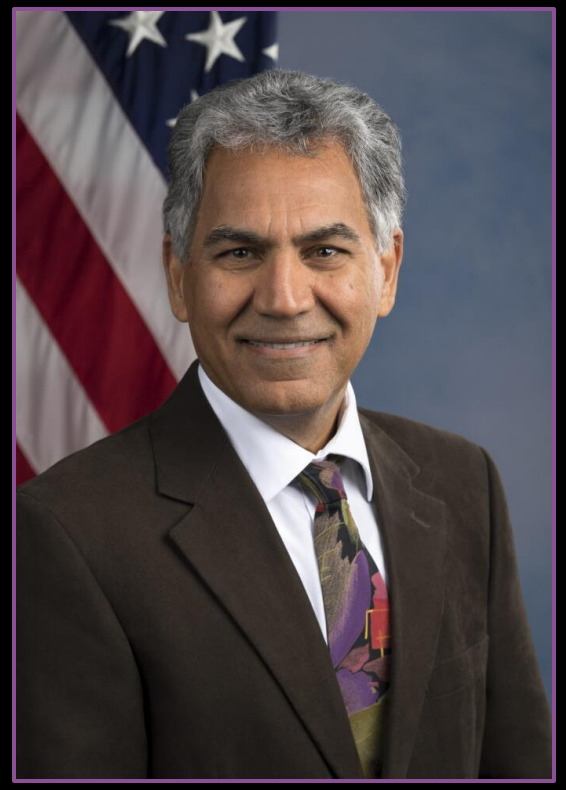
Sponsor, Chair

NASA LaRC

Juan Valenzuela

Technical SME

NASA MSFC



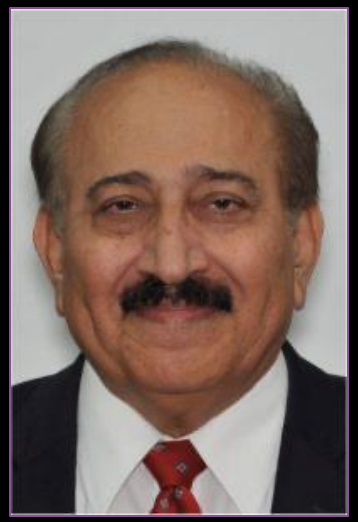
Jamshid Samareh

Sponsor

NASA LaRC

JUDGES

Michael Dipirro
NASA's Goddard Space Flight Center

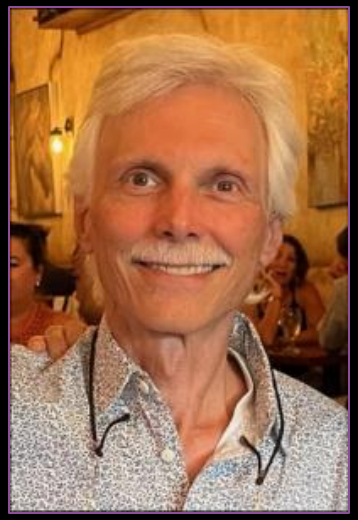


Ali Hedayat
NASA's Marshall Space Flight Center

Wesley Johnson
NASA's Glenn Research Center

Ali Kashani
MEI Company

Reid Ruggles
NASA's Marshall Space Flight Center



Mark Wollen
Innovative Engineering Solutions

Esther Lee
NASA's Langley Research Center

Juan Valenzuela
NASA's Marshall Space Flight Center

BACKGROUND & CONTEXT DISCUSSION FOR 2025 HuLC COMPETITION

2025 THEME: ADVANCED CRYOGENICS

Cryogenic Fluid Management (CFM) is a term used to describe a suite of technologies that store, transfer, and measure ultra-cold fluids—such as liquid hydrogen, liquid oxygen, and liquid methane. In-space propulsion systems utilizing cryogenic liquids as propellants are necessary to achieve NASA's exploration missions to the Moon, and later to Mars. In current state of the art (SOA) human scale, in-space propulsion vehicles, cryogenic liquids can be stored for several hours. **In order for the planned HLS mission architecture to close, cryogenic liquids must be stored on-orbit on the order of several months.**

Through the HuLC competition, NASA is engaging students for ideas to help achieve their lunar exploration goals. **The 2025 HuLC competition asks student teams to develop innovative, systems-level solutions to understand, mitigate potential problems, and mature advanced cryogenic fluid technologies that can be implemented within 3-5 years.**

Technical Questions Received in Advance

TECHNICAL QUESTIONS RECEIVED IN ADVANCE

3. When it specifies "large amounts of fuel", what numerical amount or order of magnitude are we talking? Is this a choice that our team can make itself?

- High level HLS requirements are available to the public that specify the mass of cargo or people required to be delivered to and returned from the lunar surface. Additionally, analysis is available that specifies the delta-V required to transfer from low-Earth orbit (LEO), to near-rectilinear halo orbit (NRHO), NRHO to low Lunar orbit (LLO), and LLO to the surface (and back). There are mathematical methods to estimate the amount of propellant (both fuel and oxidizer) this would require, along with high level estimates of other system masses (structures, power, thermal, etc.). Your team's choice should be supported by appropriate analysis to show that it makes sense in the context of the HLS mission. Do research, reference your sources, make appropriate and well documented assumptions, and justify your approach.
- *See the Q&A Session Summary Document for a list of helpful resources.*

TECHNICAL QUESTIONS RECEIVED IN ADVANCE

4. What is the measurement of "acceptable leakage"?

- Current state of the art flight valves of appropriate size for landers have leakages on the order of 1,000 sccm. Targets could be reduced by at least two orders of magnitude.

TECHNICAL QUESTIONS RECEIVED IN ADVANCE

8. What are the current CFM Challenges for the HLS in terms of structural supports? Inner to Outer Tank? Outer Tank to lander? Multi-Layer Insulation (MLI) Penetration?

- Most flight tanks will not have an inner/outer tank configuration, simply a single wall (insulated) tank that attaches to the vehicle structure. Structural supports between the cold cryogenic tank and warm vehicle structure must be sufficient to support tank and internal fluid mass during periods of high acceleration (1-g ground testing and pre-launch, launch thrust, orbital maneuvering and landing engine thrust). These structural penetrations through the tank insulation can often be the largest source of parasitic heat addition to the tank, resulting in excessive boil-off rates or other fluid management problems.

TECHNICAL QUESTIONS RECEIVED IN ADVANCE

9. **Based on the gateway concept, should we expect the lander to be carrying fuel at launch, or receive all of it from Gateway?**
    - Both SpaceX and Blue Origin use a refueling architecture, but that does not preclude launch with cryogenic propellants onboard. These architectures do not refuel at Gateway.

TECHNICAL QUESTIONS RECEIVED IN ADVANCE

10. **When the Proposal Guidelines document refers to "mission operational life of multiple months" at the bottom of page 4, what is the minimum design threshold for the number of expected performed cycles for the concept to be viable to NASA? What should the minimum operational lifetime be?**
    - HLS-RQMT-001 (Attachment F) requires an orbital loiter capability of at least 90 days in NRHO. This is in addition to any aggregation, transit and surface operations timelines (6.25 days – 33 days).

TECHNICAL QUESTIONS RECEIVED IN ADVANCE

11. **Will components be allowed maintenance intervals and, if so, how frequent and to what extent can the maintenance be performed?**
    - See HLS-RQMT-001 (Attachment F), HLS-SMA-0011 (pg. 48) and HLS-SMA-0028 (pg. 49). For sustained missions, the lander portion is allowed up to 24 hours of maintenance on orbit, but not on the lunar surface. Supporting spacecraft are likely to be uncrewed. A proposed solution that requires crewed or uncrewed maintenance should be appropriately justified and analyzed to consider impacts to other parts of the mission.

TECHNICAL QUESTIONS RECEIVED IN ADVANCE

17. **What are good sources for fluid behavior and data in null gravity conditions, especially pertaining to cryogenic propellants with positive expulsion pressure systems applied to it?**
    - A thorough literature review should uncover papers that have explored this concept extensively.

TECHNICAL QUESTIONS RECEIVED IN ADVANCE

21. How long has cryogenics been used in space travel? (What is the track record of safety?)

- HLS would be the first time that cryogenic propellants have been stored for more than several hours on orbit or been transferred between tanks on different vehicles on orbit.

TECHNICAL QUESTIONS RECEIVED IN ADVANCE

23. **What strategies are competitors in the HuLC Human Lander Challenge employing to develop sustainable and resource-efficient landing systems that minimize fuel consumption and optimize power usage?**
    - If you have a concept for cryogenics for HLS applications that addresses this topic, you tell us! Proposals are due on March 3rd. We can't know what competing teams will propose until we receive submissions. However, you may want to do research on SpaceX's Starship and Blue Origin's Blue Moon lander to understand their strategies.

TECHNICAL QUESTIONS RECEIVED IN ADVANCE

33. Can computational models predict the behavior of gases and liquids at cryogenic temperatures?

- Computational models can predict the behavior of cryogenic fluids. Computational models are only as good as the physics that they have been verified to. The challenge is modeling the behavior of these fluids in zero g. NASA has been working on multiple computational software packages to validate them and is also working to obtain the data to validate the models to. A thorough literature review should uncover papers that have explored this concept extensively.

TECHNICAL QUESTIONS RECEIVED IN ADVANCE

34. How does microgravity affect cryogenics? How do scientists mitigate the effects of microgravity on cryogenics?

- Microgravity affects cryogenic fluids mainly by changing the forces that cause different fluid densities (or phases) to move in certain relative directions. For some general initial guidance: In the absence of gravity (or at very low gravity), fluid behavior and orientation is more strongly influenced by surface tension. Cryogenic fluids have very low contact angles with most solid materials, meaning they “like” to wet solid surfaces and will move towards orientations that minimize the free surface area (i.e. one or more spherical vapor bubbles will form). Thermal gradients also play a role, and liquid will tend to migrate towards colder regions of a tank, while vapor pockets form around zones of heat leakage into the tank. This can be mitigated in multiple ways, and we look forward to seeing different proposals that suggest mitigations. Details are complicated, and proposers are encouraged to do a thorough literature search if interested in this topic.

TECHNICAL QUESTIONS RECEIVED IN ADVANCE

41. Is designing a testing apparatus to model a positive expulsion system an appropriate approach for this project?

- Depending on what is being proposed, a testing apparatus and physical model may be appropriate, viable, and beneficial. Keep in mind that it may be possible to demonstrate various aspects of cryogenic fluid management devices by using much easier-to-handle ambient fluids, even water.

TECHNICAL QUESTIONS RECEIVED IN ADVANCE

47. Should we design our system(s) for use only in-orbit only or both in-orbit and on the surface of a terrestrial body such as the Moon?

- This is up to you and dependent on your concept. Do research and justify your approach.

Miscellaneous Questions Received in Advance

MISCELLANEOUS QUESTIONS RECEIVED IN ADVANCE

7. **How will NASA assist teams in securing partnerships with commercial space entities or suppliers for component sourcing?**
    - Neither NASA nor NIA can facilitate partnerships for teams. Teams are also not expected to build with space qualified parts or materials. Prototypes are a highly valued but optional part of each team's work, so keep that in mind if your team chooses to build one.

MISCELLANEOUS QUESTIONS RECEIVED IN ADVANCE

9. **What is the backup plan if something goes wrong during important parts of the project, such as technical difficulties or hurricane weather?**
    - You should build contingencies and extra time into your work plan. Make sure everyone within your team has a full contact list for each other, agrees on the contingency plan and their role within it, and has practiced the plan at least once. For example, if you plan to store and work within Google drive, make sure the owner of each document understands who needs access and understands what they need to do when a deadline for that document is approaching. Someone else should also know if and when it's their responsibility to download offline copies for record keeping / backups.

Programmatic Questions Received in Advance

PROGRAMMATIC QUESTIONS RECEIVED IN ADVANCE

1. **Are entrances into a specific category being judged solely against the requirements and/or competing concepts in the same category or concepts in all available categories? If we have a concept that solidly meets the requirements for multiple categories, can we present the same concept for multiple design categories?**
    - All proposals will be judged against each other. The categories are meant to help judges understand a little more about what your concept hopes to achieve, not separate proposals for selection. The proposal form has a checkbox selection for categories that allows multiple selections and has a section for “other.” You do not need to submit your proposal more than once; select all that apply, or write-in your own category to tell us what cryogenics topic you’re addressing.

PROGRAMMATIC QUESTIONS RECEIVED IN ADVANCE

6. Since the NOI is non-binding, can I add/remove/replace team members and mentors?

- Absolutely! You can make most changes without contacting us, but if your team leads or primary faculty advisor change, please send their updated name, email, and phone number to HuLC@nianet.org so we can update your team's contact information. Finalist teams should list all contributors on their final technical paper, even if they only assisted on the proposal.

PROGRAMMATIC QUESTIONS RECEIVED IN ADVANCE

9. **What are the expectations on behalf of the judges with respect to concept testing in terms of cryogenic and other performance thresholds?**
    - There are no direct expectations for teams to build prototypes or do testing, but it will almost always add credibility to your concept. You can read papers from last year's finalists to learn more about what has been successful in the past or review the proposal evaluation matrix to learn more about the scoring criteria.

PROGRAMMATIC QUESTIONS RECEIVED IN ADVANCE

19. If we have any queries along the way, until the deadline, whom can we contact?

- If you have any additional questions, please reach out to the HuLC Program Team at HuLC@nianet.org and we will get a response for you from the appropriate person. All questions and their answers are ultimately posted to the HuLC FAQs webpage. We try our best to remove information that could give away a team's unique concept or design.
- Please also be cognizant of weekends and holidays when sending your questions. Questions should be sent well in advance of the associated deadline to ensure a response is received with enough time for you to incorporate it into your work.

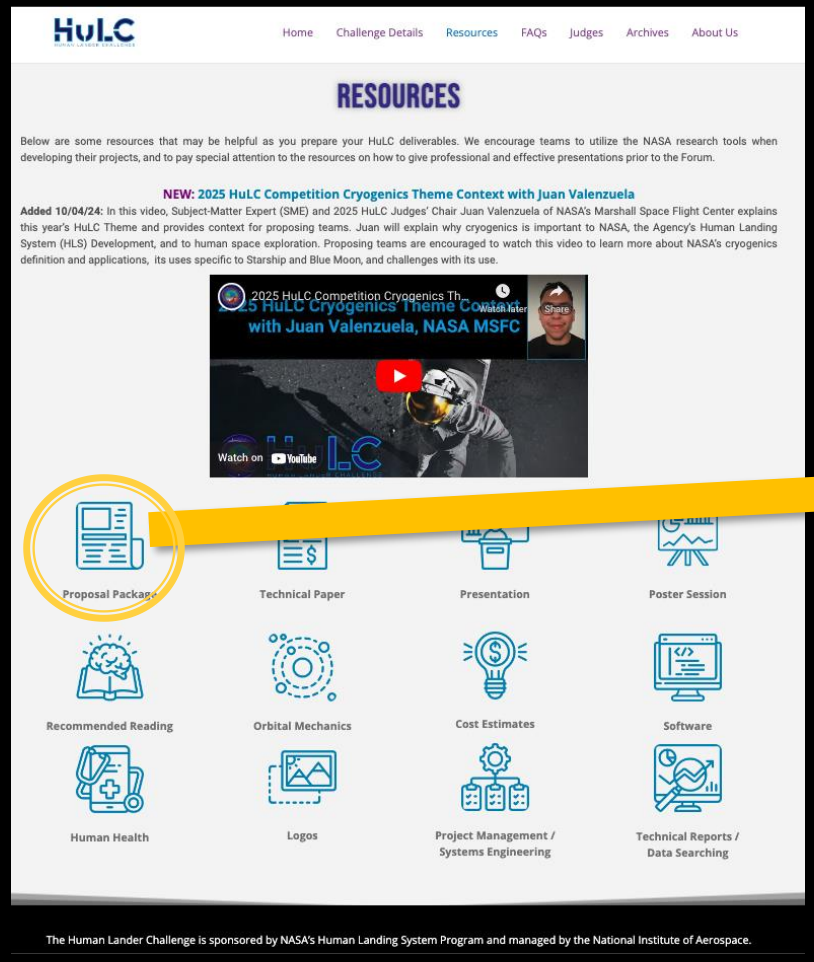
ADDITIONAL QUESTIONS?

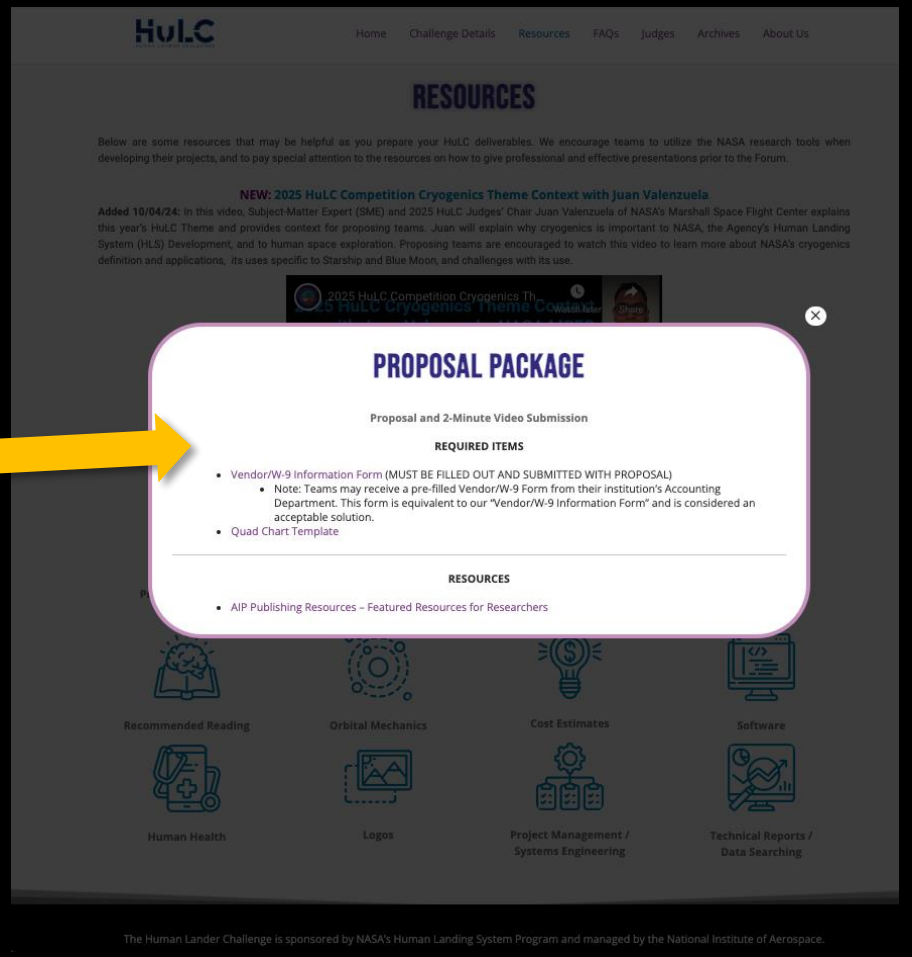
Please use the “raise the hand” function to ask questions, or enter them in the chat.

We will call on participants to unmute their mic to ask questions, or we will ask your question for everyone to hear.

RESOURCES

Please check out our extensive **Resources** page on the website for useful tools and information that will support your proposal development.





Eligibility & Upcoming Deadlines

National Institute of Aerospace

Abridged Eligibility Requirements:

- **At a minimum, teams must contain one (1) faculty advisor at an accredited U.S.-based academic institution, and two (2) students from that institution** who work on the project and present at the HuLC Forum in June 2024. There is no limit to the number of students who participate throughout the year on a team.
- A faculty advisor is **strongly encouraged** to attend the Forum with each team.

Scan QR Code to View Full 2025 HuLC Challenge Guidelines

Upcoming Dates & Deadlines:

Next Deadline:

Proposal & Video Submission Deadline
March 3, 2025

Teams Notified
April 3, 2025

Technical Paper Deadline
May 28, 2025

Presentation & Poster Deadline
June 20, 2025

2025 HuLC Competition Forum in Huntsville, AL
June 24 - 26, 2025

Future Questions?

Please direct all future questions to the HuLC Program Team at HuLC@nianet.org.

Each question will be responded to directly as well as posted on the FAQs page for everyone to view. Questions asked on the call will be transcribed and posted to the HuLC FAQs Webpage about 1 week from today.

https://HuLC.nianet.org/faqs

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Thank you, and best of luck to all teams!
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