HuLC

HUMAN LANDER CHALLENGE

Mitigating Lunar Plume Surface Interaction (PSI)
2024 Proposal Guidelines

The HuLC competition is managed by the National Institute of Aerospace (NIA) on behalf of the National Aeronautics and Space Administration (NASA)

HuLC COMPETITION

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CHANGE LOG:

- 3/27/23 – **Page 4,** "**Instrumentation Performance Through the Dust Cloud During Landing"** Changed "NDL systems" to "Lidar systems."
- 8/21/23 – **Page 6, "Eligibility"** Removed "full-time" student requirement.
- 10/23/23 – **Pages 7-8**, **Notice of Intent** deadline is now open on a rolling basis until March 4, 2024

HuLC COMPETITION

Challenge Overview

The Human Lander Challenge (HuLC) is an initiative supporting NASA's Exploration Systems Development Mission Directorate's (ESDMD's) efforts to explore innovative solutions for a variety of known HLS challenge areas. Through this competition, college students become important partners in NASA's advancement of HLS technologies, concepts, and approaches. Improvements in these technology areas have the potential to revolutionize NASA's approach to space exploration, and contributions from the academic community are a valuable part of the journey to discovery.

HuLC is open to undergraduate and graduate students at accredited colleges and universities in the United States. Minority Serving Institutions are encouraged to apply. HuLC projects allow students to incorporate their coursework into real aerospace design concepts and work together in a team environment. Interdisciplinary teams are encouraged.

The 2024 HuLC competition asks teams of students and their faculty advisors to design innovative solutions addressing the mitigation of lunar Plume-Surface Interaction (PSI).

Based on a review of initial proposals, up to 12 teams will be selected to compete at the HuLC Forum in Huntsville, Alabama in June 2024. Each finalist team will receive a $7,000 stipend to facilitate participation in the Forum, which includes the submission of a final technical paper and poster, and presenting their concepts to a panel of NASA and industry subject matter experts during the HuLC Forum. Inclusion of a design model or prototype is encouraged when appropriate. The top three placing teams will share a total prize purse of $18,000.

Context for 2024 Theme: Mitigating Lunar Plume Surface Interaction (PSI)

NASA's Human Landing System (HLS) Program is responsible for the transportation in deep space to carry humans to and from the surface of the Moon for NASA's Artemis lunar exploration program. Crews will board the HLS in lunar orbit and descend to the surface where they will collect samples, perform science experiments, and observe the lunar environment before returning to orbit in the HLS.

To best meet mission needs, NASA is working with U.S. industry to design and develop Artemis lunar landers. While companies develop, test, and iterate on designs, NASA shares its knowledge and maintains oversight of safety.

Artemis missions are uniquely focused on expanding our knowledge and establishing a long-term human presence on and around the Moon. To achieve these goals, NASA is focusing on landing sites around the South Pole, establishing a lunar orbiting platform called the Gateway, and increasing surface expedition durations. Human landing systems of the Artemis era will need to be equipped to meet the challenges of complex missions and the harsh lunar environment. Capabilities include docking with multiple systems, landing in a range of geographic regions, and acting as a crew habitat on the surface for the duration of early expeditions.

Establishing a sustained human presence on the Moon and achieving Artemis mission goals will require solutions to difficult challenges based on the improvement of existing capabilities and the development of new and novel capabilities and technologies.

Mitigating lunar Plume Surface Interaction (PSI), or the effects caused by the impingement of rocket engine exhaust onto the lunar surface, is one such area that must be tackled to ensure the safe landing of human and non-human cargo on the Moon. NASA would like college teams to help explore innovations and potential solutions to lunar PSI risks and challenges.

The Moon's environment presents unique challenges, and lunar dust is one of the principal limiting factors in returning to the lunar surface for missions of any extended duration. The lunar surface consists of highly cohesive, abrasive regolith with wide-ranging particle sizes (from dust to sand) that may be electrostatically charged. In addition to threatening astronaut health, lunar dust issues have also resulted in incorrect instrument readings, vision and optical system obscuration, performance reduction, altered thermal properties, and equipment failure.

To land large payloads on the Moon, the HLS uses rocket engines for descent, landing, and ascent. High-velocity dust ejected by descent engine exhaust can cause damage to a lander, as well as nearby surface assets, which will have negative consequences as NASA strives for sustainable lunar exploration. When the plumes interact with the lunar regolith, surface erosion and cratering begin, and the interaction produces high-speed ejecta. The lofted regolith and high velocity ejecta can reduce visibility of sensors and optics, sandblast nearby landed assets, and erode the surface around the vehicle. These interactions between the plume(s), surface, erosion, and ejecta are termed Plume-Surface Interaction (PSI); and understanding and mitigating PSI effects are critical for safe landings and sustainable exploration on the Moon.

We have learned from the Apollo missions that the mean time to failure of a system can be significantly reduced by the presence of lunar dust on materials and mechanisms. Upcoming lunar lander missions are expected to force dust transport across the Moon whenever a lander's rocket plume impinges on the lunar surface eroding the surface and ejecting particles at high speeds. As a result, this interaction poses multiple risks to future lunar exploration missions, especially for astronauts. Thus, understanding and mitigating PSI processes is paramount to the safety of the lunar exploration program.

Challenge Description and Proposal Categories

NASA is engaging students for ideas to help achieve their lunar exploration goals (refer to NASA's Plan for Sustained Lunar Exploration and Development) through the HuLC competition, which is **asking student teams to develop innovative, systems-level solutions to understand, mitigate, and manage the impacts of lunar PSI that can be implemented within 3-5 years.** The potential solutions teams can propose to could include, but are not limited to, the following categories:

- **Trade Studies on Landing Trajectories that Minimize PSI** – Exploration of concept of operations and associated Deorbit, Descent, and Landing trajectories that permit vehicle design closure and performance margins while producing terminal landing environments that are more benign in terms of PSI.

- **Reduction / Mitigation of Erosion (Cratering) and Ejecta during Descent, Landing, and Ascent –** Erosion can result in the formation of craters, potentially leading to destabilization of the lander upon touchdown and violation of lander tilt requirements. Ejecta from the landing of Apollo 12 sandblasted the Surveyor 3 lander, 525 feet away, causing visible degradation of exposed hardware. Ejecta impacts will affect other lunar assets and outposts and potentially nearby critical hardware as well.

- **Development of PSI Flight Instrumentation / Measurement Methods and Concepts –** Understanding the environments induced by PSI requires knowledge of the plume, erosion, and ejecta behaviors as a function of time during descent and landing. Specialized instrumentation and measurement methods and concepts are needed to obtain valuable in-situ data for PSI during lunar landings.

- **Tracking Dust During Descent, Landing, and Ascent** – Dust will be lofted during the landing and ascent phases, as well as through routine surface operations. Tracking how much dust is transported and how much adheres to surfaces are important to developing mitigations, both passive and active.

- **Instrumentation Performance Through the Dust Cloud During Landing –** Ejecta impacts and the creation of optically dense fields of view due to the liberation of regolith from the surface by PSI may lead to loss of instrumentation or function, damage to the lander/surrounding structure, lack of landing visibility and can spoof radar and Lidar systems.

- **HLS Asset Safety (ejecta damage, excessive lander heating, etc.)** – Apollo missions experienced descent engine structural failures due to overpressure during touchdown. Plume effects on the lander can lead to aerodynamic destabilization and high convective heating during powered descent and landing. Such impacts must be considered to enable safe and reliable operation of ascent systems and hardware.

- **PSI Modeling and Validation –** Validated modeling approaches across a range of fidelity are of immense value in predicting, bounding, and assessing the environments produced by PSI. Relevant modeling scope includes (but is not limited to) impinging plume effects, erosion and ejecta physics, physics-based dust dynamics prediction tools, and developing physics-informed ground tests. Relevant validation data must be identified and uncertainties for developed models quantified.

Design Constraints and Guidelines

The conditions for lunar PSI are different from PSI on Earth (different gravity, atmosphere, regolith, etc.). Technologies, instrumentation, designs, and approaches developed for HuLC must survive and operate in the extreme environments on the Moon. Additional constraints include:

- Minimal barriers to NASA adoption (e.g., low mass, small size, low power, etc.)
- Minimal landings required and no assumptions of pre-existing surface assets or infrastructure
- No additional risks posed to crew
- Ability to operate in harsh lunar environments (i.e., vacuum, extreme temperatures, etc.)
- Non-toxic solutions

Proposed Solutions Must Consider

Proposals must be innovative and include a clear description of the need, utilization or application, impacts, and outcomes in reducing and mitigating the risk posed by PSI. Proposing teams should clearly identify their assumptions and provide rationale to support them. The list below includes some recommended assumptions, but adjustments are permitted if a good rationale to do so is provided.

- Targeted use on the Moon near-term (within 3 to 5 years)

- Cost-effectiveness with well justified estimates. Solutions should be affordable enough to merit consideration for implementation.
- Simplicity of implementation, operational use, and interpretation
- Design for the lunar environment
    - Refer to the SLS-SPEC-159 NASA Cross-Program Design Specification for Natural Environments (DSNE) Revision G (2019, Dec 11).
- Deployment on or implementation for a NASA/commercial HLS lunar surface system
- Key technologies where relevant, including technology readiness levels (TRLs), as well as the systems engineering and architectural trades that guide the recommended approach.
- Technical merit and rationale of mission operations in support of an exciting and sustainable space exploration program.
- Supporting engineering analysis and justification of assumptions
- Realistic assessment of project schedule and milestones, as well as realistic development and annual operating costs (i.e., budget).
    - Realistic assessment of costs includes technology maturation, system development, mission infusion/adoption, integration, and operations (as appropriate).
- Adherence to the requirements and constraints of the design competition

How to Compete in the HuLC Competition

1. Thoroughly review this document (and the challenge website).
2. Find a qualified advisor and a team of students with diverse skills.
3. Ensure that your team meets the eligibility requirements.
4. Submit a Notice of Intent (NOI) by the deadline. Please note that the NOI is non-binding.
5. It is recommended that interested teams participate in scheduled Question & Answer Sessions.
6. Develop and submit a proposal and video by the deadline.
7. Submissions will be reviewed and evaluated by the HuLC judges.
8. Selected teams will advance as finalists invited to attend the HuLC Forum in June 2024.
9. Participation in the HuLC Forum includes a presentation and submission of a technical paper, technical poster, and/or design model or prototype demonstration (if applicable to team's proposed concept), by the appropriate deadlines.

Stipends and Prizes

Finalist teams will each receive $7,000 in stipend funding to facilitate full participation in the HuLC competition, including development of a technical paper, technical poster, and/or a design model or prototype demonstration when applicable to team's proposed concept) and culminating in a presentation during the HuLC Forum in June 2024 at or near NASA's Marshall Space Flight Center in Huntsville, Alabama.

A total prize purse of $18,000 will be dispersed between the top 3 placing teams.

- First Place - $10,000
- Second Place - $5,000
- Third Place - $3,000

Additional recognition awards may include Best Technical Paper, Best Technical Poster, Best Prototype Demonstration, or other awards given at the discretion of the judging panel.

Eligibility

HuLC is open to full-time undergraduate and graduate students at an accredited U.S.-based university. Teams may include senior capstone students, clubs, multi-university teams, or multi-disciplinary teams.

University Design Teams Must Include:

- Team sizes vary widely, but must contain, at a minimum, one faculty advisor with an affiliation at the primary proposing university, and 2 students from that U.S.-based university who work on the project and present at the HuLC Forum. There is no limit to the number of students who can participate throughout the year on a team.
  - If finalist teams desire to bring more than 10 students to the HuLC Forum, permission must be requested from the HuLC Program Staff prior to registering. Requests will be reviewed, and approvals will be granted on a case-by-case basis, space permitting.
- A faculty advisor is ***strongly encouraged*** to attend the Forum with each team.
  - The Forum offers faculty networking opportunities that can lead to exciting new partnerships and/or future collaboration opportunities that are beneficial to the universities. Additionally, teams with involved faculty advisors tend to become more competitive in NASA competitions each year.

Special Eligibility Considerations

- An individual may join more than one team.
- A faculty advisor may advise more than one team.
- A university may submit more than one proposal.
- Team members may not be a federal employee acting within the scope of employment (this includes co-op/Pathways students with civil servant status).
- During times of an active Fall or Spring NASA internship, non-federal interns may participate in HuLC only if their work/research/project is not directly related to their HuLC project. (e.g.: An intern who is conducting research on dust mitigation COULD NOT contribute to a HuLC team).

Eligibility Statement Regarding Federal Co-op/Pathways Interns

Federal Co-Op/Pathways Interns may participate in HuLC anytime when they are on Leave Without Pay (LWOP). Federal Co-Op Interns can also participate in HuLC if the following criteria are met:

1. HuLC funds cannot be used to support travel for Civil Service Interns who are operating in an active federal work status (i.e., during a timeframe when they are working and receiving pay).
2. During times of active work at a government agency, federal co-op/Pathways interns may participate in HuLC only if their paid work/research/project is not directly related to their HuLC project. (e.g.: An intern who is conducting research on dust mitigation COULD NOT contribute to a HuLC team).

Foreign Students/Universities

Foreign Nationals attending US Universities

Foreign Nationals (FNs) attending the proposing U.S.-based university can fully participate on a HuLC Team, and at the HuLC Forum, with several notable exceptions.

1. Due to prohibitive restrictions and ever-changing NASA security regulations, foreign nationals may not be approved to attend culminating HuLC Forum events that take place on-site at a NASA Center (including tours). If Foreign Nationals are approved to attend events on a NASA Center, they will need to provide current passport information via their Forum Registration, ~1.5 months prior to the Forum.
2. Occasionally, the HuLC Forum includes supplementary recruiting events for companies who support the competition, and these companies are typically only able to hire U.S. Citizens or Lawful Permanent Residents. Neither NASA nor NIA have any control over these hiring conditions.

Foreign Universities

Eligibility is limited to universities in the United States. Foreign universities are not eligible to participate in the HuLC competition.

Team Categories: Undergraduate and Graduate

Teams can be comprised of a mix of undergraduate and graduate students, if desired. A team is classified as an "undergraduate team" if the majority of the student members are undergraduate students. Similarly, a team is classified as a "graduate team" if the majority of the student members are graduate students.

Dates and Deadlines

All deadlines must be met by 11:59 p.m. EST on the date specified below, unless otherwise indicated.

Proposed Date	Description
Wed., April 19, 2023 Noon EST	Deadline for teams to submit questions in advance for Q&A Session #1
Fri., April 28, 2023 2:00 – 3:30 p.m. EST	Q&A Session #1
Sun., October 22, 2023 *Now rolling until March 4, 2024*	Notice of Intent (NOI) Deadline
Tues., October 31, 2023 Noon EST	Deadline for teams to submit questions in advance for Q&A Session #2
Wed., November 8, 2023 2:00 – 3:30 p.m. EST	Q&A Session #2
Monday, March 4, 2024	Proposal & Video Submission Deadline
Fri., March 29, 2024	Teams are notified of their selection status
Wed., June 5, 2024	Technical Paper and/or Technical Demonstration Submission Deadline
Mon., June 24, 2024 Noon EST	Presentation & Digital Poster Files Submission Deadline (Noon EST)
Mon., June 24, 2024 Time TBD	Team Check-in at the HuLC Forum
June 25-27, 2024	HuLC Forum at or near NASA's Marshall Space Flight Center in Huntsville, Alabama

Notice of Intent

Notice of Intent Deadline: by 11:59 p.m. EST on March 4, 2024

Interested teams are strongly encouraged to submit a Notice of Intent (NOI) to compete by the deadline to stay informed of competition updates, and to ensure an adequate number of reviewers. Teams who submit NOIs by the deadline will be invited to participate in an exclusive Q&A session with the judges prior to the proposal due date. Please visit the *Challenge Details* page on the HuLC website to complete the brief online NOI submission form. **NOIs are non-binding.**

The following information will be required or requested on the NOI submission form:

- University name
- University or industry partners, if any
- Project title, if known
- Team category (Undergraduate or Graduate)
- Contact information for the primary faculty advisor and & two student team leads.
- Synopsis of the concept (limited to 3,000 characters) providing a high-level overview of the proposed concept or potential concepts.
    - **Note:** We understand that NOI's are due early in the development process, and teams will still be in the process of fleshing out many of the details of their concepts. We fully expect that teams' concepts will change and evolve between the NOI and Proposal submissions, as in-depth research and analysis is conducted. Teams have the flexibility to change ideas and/or category selection as they work over the course of the semester, and the idea/category submitted in the NOI does not need to match the proposal submission.

Proposal and 2-Minute Video Submission Guidelines

Proposal Submission Deadline: by 11:59 p.m. EDT on March 4, 2024

Robust proposals are expected that demonstrate significant progress in your design and analysis. The HuLC judges will be looking for mature mission concepts at the proposal stage. The proposal should reflect the total scope planned for the final paper. All analysis results to-date (in summary form if necessary due to space limitations) should be included (leaving placeholders for analysis not yet completed). Please visit the *Challenge Details* page on the HuLC website to visit the Proposal and Video submission form.

Proposal Expectations

- Proposals should be 5-7 pages in length.
- Proposals should clearly articulate the innovation and design being proposed, including original engineering analysis planned and/or in progress. **It will not be enough for teams to indicate they will address the requirements later in the Technical Paper.**
- Submissions must be original; the work must be of the proposers and must not violate the rights of other parties.
    - Each submitting team represents and warrants that the team is the sole author and owner of the submission, that the submission is original, that it does not infringe on any copyright or any other rights of any third party of which the team is aware, and that the electronic proposal and video submission is free of malware.

The Proposal Should Include:

- A cover page (not included in the page limitation) with the following information:
  - University name
  - Project title
  - Full names of all team members [including faculty advisor(s)], along with major course of study and academic level of each student (undergraduate or graduate)
  - Graphic or image of part or all of your concept (no hand-drawn sketches, please)
  - Faculty advisor signature of review and approval on the Cover Page
    - Note: Submissions without a valid faculty signature will be deemed non-compliant and will not be reviewed.
- Quad Chart (not included in page limitation)
  - Please use the HuLC Quad Chart Template found on the "Proposal" section of the *Resources* page)
  - A Quad Chart is a way for teams to display some standardized information that helps evaluators quickly compare many projects. For the HuLC competition, teams must use the provided template to create a quad chart and insert the chart into their proposal. Quad charts must address:
    - The team's major objectives and technical approach to the problem being addressed in their chosen PSI category
    - An image/graphic of part or all of the concept
    - Key design details & innovations of the concept
    - A summary of schedule and cost for the proposed solution's path to adoption
- The body of the proposal should outline/include (max 7 pages):
  - Summary Statement/Executive Summary (max 150 words)
    - An overall summary of the innovative solution, including a title of the project, a synopsis of the specific PSI challenge being addressed, an overview of the proposed solution, and a statement of the impact the innovative solution will have on lunar exploration goals.
  - Identification of the PSI category team is addressing, what you are proposing, and why it is important.
  - How does your proposed solution address NASA's lunar exploration challenges due to PSI? (see NASA's Plan for Sustained Lunar Exploration and Development)?
  - How the proposed solution is applicable to the lunar environment (SLS-SPEC-159 NASA Cross-Program Design Specification for Natural Environments (DSNE) Revision G (2019, Dec 11).
  - Indicate ***WHY*** you chose your solution / design / approach in terms of ***VALUE*** in the areas of potential mission / system impacts, technology readiness, affordability, programmatic implementation, and risk.
  - Detailed information on the verification and validation of the solution.
    - Teams need to prove their analysis is correct and believable to the judges. They should clearly detail how they are solving what they set out to solve, and that they are solving the problem in the appropriate manner with the appropriate tools/equipment.
    - Capture risks associated with development, verification, and validation of the solution – and define mitigation plans for them.
  - Innovative approaches/capabilities/technology
  - Realistic technology assumptions, including realistic NASA Technology Readiness Level Definitions and justifications where appropriate.
  - Original analysis and engineering
  - Detailed information about the work conducted in various trades, concepts, and technical analyses.

  - Key findings supporting the envisioned solution.
  - Adherence to the Design Constraints and Guidelines
  - Mass and size estimates (as appropriate)
  - A realistic budget assessment (including an assessment of cost margin) and **an explanation of your assumptions**. Use of NASA costing tools is strongly encouraged.
  - Proposed path-to-flight project timeline for Development, Test, and Evaluation (DT&E) of proposed solution – assuming a mission to the Moon in the next 3-5 years.
- Appendices (not included in page limitation)
  - **Appendices are to be used for references and calculations ONLY.** There is no preference in citation formatting, but references must be formatted uniformly and correctly. Just listing a link to the source is not acceptable.
  - **Judges are not obligated to look at the appendices.** Include important details in the body of your paper to ensure they are reviewed.

Proposal Formatting Guidelines

Teams are responsible for the formatting and appearance of their proposal. Figures and tables should be legible without magnification. We recommend teams use image files with a *minimum* dpi of 150.

- Proposals should be 5-7 pages in length. This includes all text that describe the concept and analysis plan, and any additional graphics, tables, and/or charts (a well-conceived graphic can convey multiple pages worth of text and convey a deeper understanding of the problem and solution).
  - The Cover Page, Table of Contents (if used), Quad Chart, and Appendices **do not count** toward the minimum or the maximum page limitations.
  - Papers should be single spaced and single column.
  - Margins should be a standard 1" (2.54 cm) all the way around (top, bottom, left, and right).
- Please use fonts common to Macintosh and PC platforms, (i.e., Times, Times New Roman, Helvetica, or Arial for text Symbol for mathematical symbols and Greek letters).
- Font size should be 11 or 12 pt. (including in all tables, charts, and graphs).
- Proposals must be submitted as PDF files.

Tips From the Judges

- Read ALL the HuLC competition guidelines and requirements found in this Challenge Guidelines document.
- **Research and justify your assumptions.** An important part of conceptual design is the ability to make reasonable assumptions to address uncertainties and to understand the consequences of those assumptions. Provide adequate analysis and documentation (i.e., support) for your expected outcomes.
- Do not simply include information found in Google searches. Analyze your research findings.
- Find a balance between sound technical analysis and revolutionary concepts. Innovation will be rewarded, and is highly desired, but not at the expense of fundamentals.
- Start with a big picture view of your concept, rationale, and goals. Don't jump immediately into the details of design or tool development, etc. Find balance between accurately addressing the overall approach and supporting specific focuses within your solution. If you drill down and focus your research and engineering on a particular design element to validate, you will still need to provide sufficient relevance, connection, and context to the broader solution.
- A picture is worth a thousand words and can convey a lot of information. Pictures for the proposal are a plus. Show us your innovation! (The proposal should not contain any hand-drawn sketches of your solution).

- If results/details are not available yet or are still being finalized, it is still valuable to indicate that you will have them and how you are determining them, sources of validation, etc. If it is not mentioned, judges will assume it is not being addressed.
- Consult the technical resources provided by NASA and the Judging Panel and make use of published papers and reports available to you. See the *Resources* page for a preliminary list of resources and recommended reading.
- Do not use lengthy appendices! Appendices are for citations and references only.
- Participate in the Q&A webinar(s).
- Utilize all available page space.
- Do not include hard-to-read figures, charts, or text in your proposal. Follow established font size requirements.
- Report quality will impact the judges' scoring. Poor grammar, typographical errors, etc. do not reflect well on your team.
- Submit all materials on time; late submissions will not be accepted.

General Video Formatting Instructions

As a part of the proposal submission process, teams will be required to include a 2-minute video. The intent is for the video to augment each team's proposal by including animation, graphics, or other creative ways of showcasing unique aspects of their proposed concept.

- Videos are limited to a maximum length of 2-minutes.
- Videos should be uploaded to YouTube, and teams will provide their video's YouTube URL on the online proposal submission form. Other types of video files will not be eligible for consideration.
- Videos need to be publicly viewable via a link. Videos should be "Unlisted" or "Public" on YouTube.
  - Troubleshooting Tip: YouTube accounts sometimes need to be verified prior to being able to fully upload videos. If your video is stuck in the "processing" stage, check to make sure your YouTube account is verified.
- All team members should appear in the video, if possible (still images are OK)
- Your university name and project title should appear in text at the front of the video.
- Do not use music or images which may violate copyright law. You may use images created by NASA.
  - It is the responsibility of the team to follow copyright law. Neither NASA nor NIA can approve the use of copyrighted material.

Submitting the Proposal and Video

To upload your proposal and video (.pdf file and link), please visit the *Challenge Details* page on the HuLC website to complete the online proposal submission form. Teams are encouraged to review the *Resources* page on the HuLC website, which provides resources to assist in the development of your proposal.

No revisions can be accepted after submission, so please proof your proposal and video files very carefully before submission. If there are any technical problems with the content of your proposal or video (for example, your file was corrupted or a URL link was broken), we will try to contact you immediately, so it is very important that you provide us with up-to-date contact information on the submission form. **Late submissions will not be accepted**, and the submission form will close promptly at midnight.

The following information will be required or requested on the Proposal Submission Form:

- University name
- University or industry partners, if any
- Project title
- Team category (undergraduate or graduate)
- Contact information for primary faculty advisor & two student team leads.
- Contact info for any additional advisors, if applicable
- File upload for PDF proposal document (Max 95 MB)
- URL link for team YouTube video (must be "unlisted" or "public")
- A 2-3 sentence synopsis of the proposed project that briefly highlights any innovations (max 600 characters)
- Mailing address & Point of Contact (POC) for stipend checks - for use if a team is a selected finalist.
- Vendor W9 Form for the lead/primary university (to be completed by the accounting department at the university)
    - A Template Vendor Form can be downloaded from the Resources Webpage under "*Proposal.*" Alternatively, teams may receive a pre-filled alternative IRS W-9 form from their institution's accounting department; this form is equivalent to our "Vendor/W-9 Form," and is considered an acceptable substitution.
- Acceptance of the HuLC Intellectual Property and Media Release statements

Proposal Evaluation Criteria

The 2023 HuLC Proposal Scoring Matrix can be found on the *Challenge Details* page on the HuLC website.

The evaluation criteria used to evaluate proposal and video submission include:

- Technical Innovation (Max 40 points)
    - How innovative is the proposed solution?
    - How clearly articulated and motivated are the proposed solution's objectives?
    - How well does the proposed solution enable NASA's exploration goals and align with the HuLC guidelines related to PSI? (Refer to NASA's Plan for Sustained Lunar Exploration and Development)

- Technical Credibility (Max 40 points)
    - Is the proposed solution appropriate for application and operation in the lunar environment?
    - How feasible is the proposed solution in addressing risks posted by PSI in terms of technical maturity, adherence to the HuLC constraints, and potential to directly contribute to resolving HLS challenges associated with PSI?
    - Has the team proposed a solution to PSI with system-level impacts, realistic assumptions, and rigorous technical analysis and design?
    - How feasible and thorough is the verification and validation for the proposed solution?
    - Are the risks associated with development, verification, and validation of the solution well captured and mitigation plans defined?

- Technical Management (Max 15 points)
    - Is the proposed development and implementation plan adequate and thorough, with a path-to-adoption schedule and milestones clearly defined and reasonable?

  - Are the estimated costs and any carried margins/uncertainties reasonable and reflective of proposed solution's required technical development and maturity?
  - Does the proposed solution have a high likelihood of success?
  - How well written, organized, and communicated is the proposal?

- Video (Max 5 points)
  - Video highlights aspects of the team's concept(s) and/or increases understanding of proposed solution.
  - Video content is aesthetic, organized, and flows. Ideas are communicated clearly, and viewers can easily follow the material.

Intellectual Property (IP) and Media Release

Proposers must acknowledge that they have read and agree to abide by the full Intellectual Property and Media Release Statements. An excerpt is included below.

Intellectual Property - Summary

In addition to any rights granted to NIA, as applicable, recipients of monetary awards under the Human Landing System (HuLC) competition agree to grant to NASA and the Federal Government, as the source of awards funding, the Rights in Data and Patent Rights set forth in detail below. In summary, awardees agree to grant to NASA and the Federal Government (i) a license to use, distribute, reproduce, perform, display, and prepare derivative works, any data first produced by recipient in carrying out recipient's responsibilities under this award in which the recipient asserts copyright, or data for which copyright ownership was acquired under the grant for Federal purposes and to have or permit others to do so for Federal purposes only, and (ii) a license to practice or have practiced for or on behalf of the United States any invention of the recipient conceived or first actually reduced to practice in the performance of work under this award if recipient chooses to retain title to such invention, and NASA may elect to obtain title or patent such invention if recipient chooses not to do so, all as set forth more particularly in the below Rights in Data and Patent Rights provisions.

Media Release

The recipients of monetary awards under the HuLC competition ("Teams") agree to give permission to be recorded, photographed and/or videotaped by or for NIA, NASA or their representatives or designees for the purpose of announcements and other outreach or informational purposes, including public announcements, external media coverage, and other promotional opportunities concerning the Challenge.

The Teams further give permission to NIA, NASA or their representatives or designees to use, reproduce, prepare derivative works, publish, distribute to the public, perform publicly, and/or publicly display all deliverables, including excerpts and any ancillary material, which may include each team participants' names, affiliations (schools), images, voice, and/or likenesses. NIA or NASA may distribute the materials, including excerpts therefrom, and any ancillary material through a variety of media in existence now or in the future, including but not limited to print, television, websites, radio, or any other means. NASA may also permit a third party to exercise NASA's rights, including but not limited to the right to display or distribute the recording, including excerpts therefrom, and any ancillary material, in any manner NASA deems appropriate.

The teams also understand that this permission to use each participant's name, image, voice and/ or likeness in such materials is not limited in time and team participant will not receive compensation for granting this permission.

Teams acknowledge that NASA has no obligation to use any participant's name, affiliation, image, voice, and/or likeness in any materials produced by NASA, but if NASA so decides to use them, each participant waives the right to inspect or approve any such use. Teams hereby unconditionally release NASA and its representatives from any and all claims and demands arising out of the activities authorized under this Media Release.

Deliverables for Finalist Teams

Teams Who Are Selected to Attend the HuLC Forum Will Be Required To:

- Submit a 10-15 page written technical paper to be submitted electronically.
- Prepare a technical poster to be submitted electronically and presented at the HuLC Forum.
- Give a 25-minutes presentation, with an additional 20-minutes of Q&A at the HuLC Forum.
- Prepare a Prototype / Capability Demonstration to present at the HuLC Forum (this is optional for research-based concepts).

Additional details on these deliverables will be communicated to finalist teams after selection.

Resources

Please visit the *Resources* page on the HuLC website to find resources and information for developing your HuLC concept.

Contact Information

The HuLC Program Team will respond to questions presented by eligible students and faculty from accredited colleges and universities in the United States. Questions may be emailed to HuLC@nianet.org.

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