2021 BIG Idea Challenge
Q&A Session Summary Document
October 14, 2020; 3:30 – 5:30 PM Eastern

General Technical Questions

1. **What is the budget for a cleaning device?**
   - Answer: For the BIG Idea Challenge, we are expecting proposals in the range of $50-180K.

2. **What percentage of dust is expected to be removed?**
   - Answer: This is dependent on the system being targeted for the technology.

3. **Are we responsible for power generation or are we allotted a certain amount of power for our device? If so, what is the maximum power (I.e., power constraints) allowed or available for this challenge? Do they differ based on implementation? For instance, spacesuit power constraints, habitat power constraints, exterior power constraints?**
   - Answer: The solicitation does not mention specific power requirements, as all systems are different. In general, dust mitigation solutions should not substantially increase the volume, mass, and power consumption of the system it is designed to protect. (Make an informed assumption and provide your rationale for your power needs)
   - At this time there is not an Interface Control Document (ICD) that specifies power constraints for systems on lunar spacesuits, lunar habitats or human landing systems. Some of the CLPS landers have limitations listed in their payload users guides. Make an informed assumption and provide your rationale. Remember power is an expensive resource on the lunar surface so large power requirements will not help your technology in system trades.

4. **What is the maximum wattage that can be supplied over brief periods of time?**
   - Answer: See response above. Specifications for the payload power have not been developed (landers, habitats, or lunar power systems). There will be surge protection but limits have not yet been specified. Provide your assumptions based on existing systems. You may want to consider incorporating an energy storage capability on your system if your technology requires peak power loads outside of what is typically available.

5. **Are there recommended mass and volume budgets for our concept? What are the mass and volume constraints of the concept, including any material which is used for dust mitigation?**
   - Answer: The solicitation does not mention specific mass and volume requirements. In general, dust mitigation solutions should not substantially increase the volume, mass, and power consumption of the system it is designed to protect. Decide what size, mass, and power needs you have and make a good justification for those decisions.

6. **How will the airlock be pressurized (on the lunar habitat)?**
   - Answer: Current airlocks are pressurized by the air inside the cabin through valves. This will most likely be the case for the lunar habitat.

7. **What are the volume constraints during transportation?**
   - Answer: At this time there is not an Interface Control Document (ICD) that specifies power constraints for systems on lunar spacesuits, lunar habitats or human landing systems. Some of the CLPS landers have limitations listed in their payload users guides. Make an informed assumption and provide your rationale. Remember power is an expensive resource on the lunar surface so large power requirements will not help your technology in system trades.

8. **How could we recreate no gravity and generally test with it?**
   - Answer: It is the responsibility of each team to propose ways they can best simulate the lunar environment here on Earth as a part of their testing.

9. **What is an acceptable weight limit for the cleaning device?**
   - Answer: As light as you can make it. Weight limits will be set in the future by mission and vehicle capabilities.

10. **Will lunar dust/regolith samples be recommended or provided?**
    - Answer: Refer to the document entitled “2016 Dust Mitigation Gap Assessment Report” on the Challenge website in the Resources section.

11. **What is the expectation for level of fidelity for lunar regolith simulants?**
    - Answer: Fidelity of the simulant depends on fidelity of the test. Using the appropriate type of simulant is important. For instance, if looking at wear of simulant on surface or material, an abrasive simulant is important.

12. **How much time and what level of difficulty are allowable for the initial setup of a cleaning apparatus. What tools will be available?**
    Answer: Tools have not been decided. Minimizing time for tool setup and use is ideal.

13. **Will any excess air and water be transported to the lunar station? If so, how much? If not, how much excess could be transported?**
    - Answer: Most likely very little excess will be transported. One of NASA’s plans is to produce it on the surface through a process called In-Situ Resource Utilization (ISRU) where oxygen and hydrogen are chemically pulled from the surface rocks. Combining them creates electrical power and water.

14. **What is the flight plan/orbital plan of the Gateway?**

- Answer: The Gateway will be in NRHO (near-rectilinear halo orbit) which has a period of roughly 7 days. This will allow the crew several days at the Gateway prior to departing to the lunar surface and then on the post mission to allow for transfer of equipment and checkouts. See these resources for additional information on NRHO: (Options for Staging Orbits in cis-Lunar Space and NRHO Chart)

15. **What are the protocols for attaching systems and deploying from the Gateway?**
    - Answer: The plan is to use an IDSS compliant docking system with the Gateway providing the passive side. The external payload fixtures for the Gateway are similar to what's on the ISS, and should be researchable, with similar shape, power, size, and data requirements.
    - For additional information, please see Gateway Payload Interfaces.

16. **What are the dimensions of the payload in the Gateway?**
    - Answer: It is unclear what payload you are referring to, but many of the modules are still in the design stage. The external payload fixtures for the Gateway are similar to what's on the ISS (which are easily researchable) with similar shape, power, size, and data requirements.
    - For additional information, please see Gateway Payload Interfaces.

17. **What is the aim/expectations for the lifespan of the lunar habitats and systems?**
    - Answer: An assumption could be similar to the ISS which is 15-30 years.

18. **Is there a selected landing/staging area for Artemis? If so, is the depth of regolith (to bedrock) in the area known?**
    - Answer: The landing area being considered is the lunar south pole, and the depth of regolith to bedrock in that area is unknown.

19. **What is the expected location for the 2026 Artemis 5 mission relevant to this project?**
    - Answer: The landing area being considered for this project is the lunar south pole.

20. **Is each cycle of the device renewable, in other words, once the device completes one cycle, how will it start another?**
    - Answer: That is up for you to determine and design for.

21. **How portable are we attempting to make this device?**
    - Answer: It will depend on the application. The mass and volume of your device should be small relative to the mass and volume of the system it is designed to protect.

22. **Would the device send diagnostics that could be resolved from Earth?**
    - Answer: Of course there will be data and telemetry that will be sent back to Earth from the moon. If there is a reason your devise would need to send diagnostics to Earth for resolution, justify why. But there will be capability for regular data transfer between the moon and Earth.

23. **Is there a time limit or constraint you would like the decontamination or removal of dust to be executed in? Hours? Days? Minutes?**
    - Answer: It will depend on the application, but usually within minutes. If your system needs more time, provide a good rationale for why.

24. **How are waste materials disposed of?**

- Answer: For 2024, waste can be left in the Lunar lander to be disposed of. Long term, the materials can be left in the Gateway Logistics module for disposal.

25. **It seems like temperature requirement is between -49oC to -243oC, however, [maximum temperature is 123ºC.](#) In this case, which temperature range we should include our experimental environment?**
    - Answer: The temperatures given were taken from the document linked in the Challenge guidelines entitled "Lunar Environment – 2019 NASA Cross-Program Design Specification for Natural Environments (DSNE), Rev. G". NASA's plan is to send astronauts to the lunar south pole.

26. **In required design constraints it says that the proposal should have Technology Readiness Level (TRL) of 4, at the end of the project is a TRL of 4 is enough or TRL of 5 should be satisfied?**
    - Answer: For the sake of this challenge, a TRL 4 would fulfill the requirements. However, a TRL 5 is desired, and proposals that can demonstrate movement towards a TRL 5 will be favorable.

27. **How much access do we have to NASA technical standards?**
    - Answer: NASA technical standards documents are publicly available on the website: standards.nasa.gov (Note: Don't click the "Login" button, which is just for NASA users. Instead, click the "NASA Technical Standards" link on the left-hand navigation bar.)
    - Direct link: https://standards.nasa.gov/nasa-technical-standards

28. **Will we be allowed to program anything? (we are thinking on making an artificial black hole, is that safe?)**
    - Answer: Teams are able to program various aspects of your concept, but we want to remind you that the BIG Idea Challenge is focused on tech development and finalists must build and test some sort of prototype. Teams are encouraged to be creative and design their own accurate and realistically simulated verification testing as possible. Physics-based modeling may support verification but is not a sufficient replacement for hardware testing.
    - In response to the question about the artificial black hole, the judges would need more information and context before answering. We will say that safety is a responsibility of the university and all finalists will be required to have their university safety officer sign a letter indicating they are aware of your testing plans, they approve of them from a safety standpoint, and that all relevant team members have received the proper safety training to perform the proposed testing. The university will review and approve your safety plan – not NASA.

Questions for Landing Dust Prevention & Mitigation

29. **What are the exhaust temperatures of the HLS?**
    - Answer: Rocket exhaust temperatures when they impinge on the lunar soil are typically 1000 to 3000 degrees C depending on the propellants and the height of the vehicle.

30. **What kind of thrusters are used in the Orion Human Landing System?**
    - Answer: The thrusters on the Lunar Lander are still TBD, as each of the three potential HLS vendors have various designs under considerations (An HLS system has not yet been selected. 3 companies (Blue Origin, Dynetics, and SpaceX have each been awarded 1- month study contracts. The lander most likely to be ready for a 2024 landing will go forward.)

31. **What are the dimensions of the HLS? And its weight?**
   - Answer: It is different for each of the three companies. A picture of each of the competing systems with humans for scale is here.

32. **What type of landing leg and footpad will be used on the HLS/Other landing systems? What material will the footpad be made of?**
   - Answer: It differs for each of the three competing designs. No more information is currently available.

33. **Will the HLS be launching from the surface too?**
   - Answer: The different lander companies might plan to have the entire HLS lift off the surface, or they might plan to leave the descent stage behind (as in Apollo) and launch the ascent stage off that as a launch pad. It depends on the design they choose.

34. **What is the maximum weight allowance and maximum surface area allowance for this project? (Payload restrictions)**
   - Answer: See answer in section above. No restrictions, but your choices will need to be justified.

35. **What kind of power supplies are prohibited/frowned upon?**
   - Answer: It is preferred to avoid nuclear wherever possible due to concerns with radiation and licensing.

36. **When using magnets, are there EMI (Electromagnetic Interference) issues that need to be considered?**
   - Answer: Static magnets do not create EMI, although certain technologies like the old cathode ray tubes (CRTs) cannot operate near powerful magnets. In general, it is not a problem to incorporate strong magnets in technology.

37. **Is there an already established procedure for identifying the amount of dust in the air/surfaces?**
   - Answer: There are numerous technologies that can measure the quantity of dust in air, such as lasers or LEDs with a sensor to detect how much the light is attenuated by dust.

38. **Types of dust-monitoring systems?**
   - Answer: May be specified by proposal team.

39. **Does NASA have plume physics models?**
   - Answer: Yes, but they have significant gaps in the physics. It is not clear yet what size rocket can dig a deep hole in lunar soil. If a deep hole is not dug, then the soil will be scoured from the surface, and in that case the models that predict the rate the soil is scoured are not very accurate. NASA is currently working to improve the models.
   - Plume/soil models have not yet been validated, but this is in work. Some examples are Eulerian/Eulerian and Eularian/Lagrangian. Plume models using CFD and engineering models (e.g. SPF3) have been partially validated and verified.

Questions for Spacesuit Dust Tolerance & Mitigation

40. **What are nearby surface assets?**
    - Answer: Anything that is already on the lunar surface that NASA would not want harmed; like a habitat, infrastructure, vehicle, etc.

41. **Should we use a specific spacesuit design (has a space suit design been selected for Artemis)? Will specific details of the suit be provided such as material properties etc.?**
    - Answer: The space suit design for Artemis is the Exploration Extravehicular Mobility Unit (xEMU). Wikipedia also has some info on the materials used.

42. **What is the outermost material of the suit made of?**
    - Answer: Spacesuits have multiple layers with each layer tailored to the expected use. Ortho-fabric is the predominately used material of the PGS (Pressure Garment System) - the overall outer layer of the suit. The outermost layers on spacesuit gloves are probably the most demanding for abrasion resistance. For abrasion resistance on gloves, materials such as Twaron, Teflon coated Vectran, and Silver coated Nylon have been used. This helps prevent the dust from working its way into the fibers and getting to the restraint layer and bladder layer.

43. **Will there be any loose pieces of the astronauts' suits that will be affected by moderate or high wind speeds?**
    - Answer: It depends on the air flow you are looking at. Space Suits tend to be pretty robust so blowing dust off with reasonable levels of airflow should be OK. There may be Velcro hold-downs or similar that could be affected with very high airflow from blowers or compressed air. Good operational procedures could mitigate a lot of the concerns.

44. **What is the expectation for level of fidelity for xEMU (spacesuit) simulants?**
    - Answer: Fidelity of the simulant will depend on fidelity of the test. Having a mechanically representative simulant is ideal for textiles, such as an abrasive simulant.

Questions for Exterior Dust Prevention, Tolerance & Mitigation

45. **Is the entrance to the lunar habitat load-bearing?**
    - Answer: This hardware has not yet been designed nor are there any existing requirements for the hardware at this time. To date, the only known loads will be the compression loads between the door and the seals.

46. **To what extent will dust abrasively damage the space suit and visor?**
    - Answer: During Apollo, helmet visors were visibly scratched toward the end of the mission. Also, as documented in NASA –TP-2009-214786, for the Apollo suits lunar dust created "...progressive fabric wear ..."

47. **What are the size requirements for doors in the lunar station?**

- Answer: This hardware has not yet been designed nor are there requirements. However, other hardware being designed for the lunar surface have hatch openings of at least 1.0x1.5 meters. It is conceivable that the lunar station hatch could grow to a size in which a person in a suit could walk through it.

48. **What pressure differential and volume flow rates can be generated using pumps already existent at the habitat?**
    - Answer: These pumps have not yet been designed. However, the pressure inside the habitat will most likely be similar to the Space Shuttle or Space Station. That pressure is 14.7 psi. In the very low atmospheric pressure on the Moon, the pressure differential will be 14.7 psi.

49. **Should we design our device with any particular lander in mind? In that vein, can we specify which lander our concept is designed for?**
    - Answer: Aim for broader use.

50. **How can we best demonstrate that electrostatic discharges will not interfere with existing technologies?**
    - Answer: Perform Electromagnetic Interference (EMI) tests on your device while in operation.

51. **Is there an example habitat we should use to model lunar surface in our experiments?**
    - Answer: See NASA-CR-195687 for an example. One of the existing candidates is an inflatable habitat.

52. **How much would it need to be used?**
    - Answer: It will depend on the application. Optical instruments, visors, and cameras might need cleaning per EVA. Thermal radiators might need cleaning once day. You tell us how often your system should be used for optimal performance of its intended use.

53. **How long would it be between two uses? (round about).**
    - Answer: See previous question.

54. **How long would it be in use for? (depending on efficiency)**
    - Answer: Ideally, dust removal should last a few minutes at the most and should operate for the duration of the mission. Again, think in terms of years.

55. **How far would it need to move around? Would it be possible to attach it to something?**
    - Answer: You tell us how far your device would potentially need to move around. A device designed for a movable system can be attached to the system if its mass and volume are small relative to the device and if there is no electrical or mechanical interference with the operation of the system.

Questions for Cabin Dust Tolerance & Mitigation

56. **Can we assume there will be some sort of airlock chamber or do we need to include that in our design?**
    - Answer: The lunar habitat will most likely have an airlock. The lander might not.

57. **What would be the ambient air conditions inside the cabin?**
    - Answer: Most likely close to 14.7 psi with conditions similar as on Earth.

58. **How much dust is expected to be reintroduced to the module on a regular basis?**
   - Answer: That is very mission specific and also greatly depends on the dust mitigation technologies (that you are helping us develop) that have been deployed for the specific mission.
   - Note that EVAs on the ISS are still not routine and regular, even after a couple decades of crewed operations. There is a great deal of uncertainty about when lunar surface EVAs will become "regular". The Initial Human Landing systems are expected to support up to 5 EVAs per mission.

59. **What kind of outlets (power source) do they have on the module? What voltage?**
   - Answer: At this time there is not an Interface Control Document (ICD) that specifies power connectors for auxiliary systems on lunar habitats or landers. The ISS uses 120V DC and the most common voltage for space systems is 28V DC. Make an assumption and provide your rationale.

60. **What is the power constraint that can be used from the lander?**
   - Answer: For a human scale lander that will depend on the specific lander selected and all are in early development. For the CLIPS landers you can find some information in the Payload User's guide. Again, make a reasonable assumption and provide some rationale.

61. **Are there certain kinds of materials that are not allowed on the module?**
   - Answer: Materials which evaporate under low pressure as well as any potentially explosive or corrosive materials.

62. **Is there expected to be at least one person in the Orion lander at all times, or are there times when the lander will be empty?**
   - Answer: Most likely empty during surface operations.

Miscellaneous Questions

63. **What is the maximum allowable duration for cleaning?**
   - Answer: It will depend on the application, but usually within minutes. If your system needs more time, provide a good rationale for why.
   - This is an operational issue and will likely not be known for some time. Make an assumption and provide rationale. If cleaning times are excessive for your dust mitigation solutions then it will impact how cost effective it is since crew time on the lunar surface is very valuable.

64. **How much quantitative data is enough in order to produce precise and accurate results for our prototype for your standards?**
   - Answer: Propose your error analyses and confidence level

65. **To what degree can we expect radiation to affect our materials?**
   - Answer: Cosmic radiation does not have much effect over the amount of time involved in these missions. Ultraviolet light can break down molecules causing some materials to become brittle or bleached. Electronic systems in a lunar radiation environment may be susceptible to single event upsets and non-recoverable latch-ups.

66. **What types of treatments are used to prevent the cold welding of metals in space?**
   - Answer: We encourage you to do an internet search – there is a wealth of information on this topic publicly available online.

67. **Will dust cleaning be done for astronauts consecutively, or will there be downtime between each use?**
   - Answer: You tell us how your solution is designed to operate most effectively

68. **How does NASA keep water liquid in space?**
   - Answer: You need a pressure vessel. A combination of pressure and temperature are needed to maintain liquid water above the triple point. In the near vacuum on the lunar surface, water can only be maintained in a solid or a gaseous state.

69. **What is the duration of an expected mission?**
   - Answer: The early human missions will likely be under a lunar day however we want to move toward a permanent human presence on the moon. Your Concept of Operations should describe the mission assumptions that your dust mitigation technology is being developed for. We want to be moving toward long duration – depending on the architecture, there will be assets on the surface longer than one lunar day. So plan for your concept to operate for many years (15-30 years).

70. **Has building with regolith been sufficiently explored?**
   - Answer: No. NASA is actively looking at a wide array of ISRU construction methods that utilize regolith. We also need a better understanding of the regolith itself and performing realistic Earth based testing of construction methods using lunar simulants is very challenging.

71. **What is the definition of "cost-effective" for NASA's budget?**
   - Answer: A rough estimate for the cost of payloads to be delivered to the Lunar Surface is $1,000,000/kg so mass is a huge driver for cost effectiveness. Often, we use “equivalent system mass” in our trade studies. As an example, do we want a dust mitigation system that requires large amounts of compressed air (logistics) to clean a surface when a simple peel away cover can be used that has very low mass and technical risk? Your proposal can compare (at an overview level) alternative solutions that may not be high tech but cost much less it develop and deliver. There is also a cost associated with systems that have high power and consumable (I.e. replacement filters) requirements.

72. **A required design constraint is “Technologies should reach a minimum Technology Readiness Level (TRL) of 4.” Is this implying that proposed technologies should reach a TRL of 4 prior to the proposal deadline (December 13)?**
   - Answer: No. TRL 4 is a proof of concept demonstration which is not needed until selected teams have received funding to buy the parts they need. If a proof of concept of this technology already exists and you are trying to achieve a higher TRL then it is OK to discuss in the proposal.

73. **Is having simulation data from ANSYS, CFD, etc helpful in the proposal?**
   - Answer: It can be. It is helpful if it aids in describing previous closely related work the team has performed, illustrating the proposed technology, or demonstrating an understanding of the problem/possible solutions.

74. **Are the thermal and/or vacuum testing, and use of appropriate dust simulants enough to simulate the Natural Environment on Lunar surface? Could you be more specific about appropriate dust simulants? Could you be more specific about vacuum testing?**
   - Answer: Each team is required to propose their own testing environment, simulating the lunar environment to the best of their ability. Thermal and vacuum testing with simulants is an excellent start, and could be sufficient (depending on your proposed concept, of course). Each concept will be so different that they will each require different testing environments.
   - Dust Simulants: When proposing testing etc., be aware the dust particle sizes range from sub micron to large sizes. And the morphology of the regolith is not friendly to 'soft' polymeric materials. For the proposal, the judges simply want to see that teams have made an effort to identify and at least think about how they might obtain simulants and how they might test with them.
   - Vacuum Testing: Unsure what specifics you are asking for. NASA is not providing a "how-to" guide for vacuum testing. It is up to the proposer to tell us how/if you plan on using various testing facilities.

75. **For the lunar environment, do any of the NASA centers allow the collaboration between universities and centers to test the proposed idea? If so, can we include expenses regarding travel, accommodation etc. to our budget?**
   - Answer: Teams may reach out to NASA personnel to identify potential test facilities and discuss opportunities for advancing your ideas (except for BIG Idea Challenge judges), but it is not encouraged for this year. Due to the Covid-19 pandemic, it is currently a very difficult time for on-site visitors and collaboration (and availability is extremely limited). Mission critical testing has priority in the testing facilities and they are currently running behind schedule as a result of Covid-19 delays. We are hoping that much of your testing can be done at your university or other nearby facility.
   - NASA can support finalist teams in trying to obtain necessary testing facilities, but there are no guarantees that the facilities will be available.
   - Please include any related testing expenses to your budget (including travel expenses). But note that if you want to utilize NASA testing facilities (which again is highly discouraged this year), this will be a very tricky part of the budget to navigate, as you will not be able to get any estimates on NASA testing costs until you have a fully defined test plan and parameters (which we do not expect any teams to have at the proposal stage). For the proposal, testing costs at NASA facilities will most likely need to be estimated. Note that each NASA testing facility is operated independently and may or may not choose to support requests. If you feel you must reach out to a NASA facility, please allow adequate time (I.e., a month or more) to hear back from them.

76. **Are teams allowed to approach known NASA employees (not in an official status) for advice on their project?**
   - Answer: See answer to Question 75. It is possible, but you will be responsible for testing costs and it is risky (due to the aforementioned reasons). Additionally, be aware of the current access restrictions at NASA facilities. For 2021, use of NASA facilities is not encouraged. Note that each testing facility is operated independently and may or may not choose to support requests.

77. **Can the selected teams utilize NASA facilities to perform any testing? Such as vacuum chambers, lunar regolith bin etc.**
   - Answer: See previous answer). It is possible, but you will be responsible for testing costs. Additionally, be aware of the current access restrictions at NASA facilities and contact the NASA POCs associated with those facilities to understand availability risk. Note that each testing facility is operated independently and may or may not choose to support requests.

78. **Is there anyone that we can contact for further information and questions about the lunar habitat?**
- Answer: A specific lunar habitat has not yet been developed.

Programmatic Questions

79. **What level of depth is expected for the proposal?**
- Answer: The proposal needs to be detailed enough to provide credibility to your concept and to successfully "sell" your concept to the judges. If there are high risk areas in the concept that would benefit from an in-depth analysis to provide needed credibility then it may make sense to include that. With that said, the initial proposal is not intended to be a research paper and there are some pretty limiting page counts to include all of the information requested.

80. **Any specific tips on content that you look for when examining a proposal? What makes a proposal really stand out?**
- Answer: Judges will be looking for innovative ideas that offer the most value with the lowest risk. Review the proposal evaluation criteria (on the 2021 Challenge Deliverables page) and you'll see exactly what they judges will be looking for when examining the proposal.

- Proposals that are well organized and that instill confidence that the team can accomplish what is proposed will stand out. Proof-read your document for spelling and grammatical errors. Ensure that you've done your research and are aligning with NASA's exploration goals and challenge guidelines (refer to NASA's Plan for sustained Lunar Exploration and Development).

81. **What should be accomplished by the Project Plan Proposal submission date to maximize our chances of moving forward in the challenge?**
- Answer: At the proposal stage, all we expect is a really well-thought out proposal. NASA certainly doesn't expect teams to begin working on something prior to being selected for funding.

82. **Are we required to build a proof of concept (prototype)?**
- Answer: Yes. Claiming TRL 4 requires proof of concept demonstration. The Big Idea Challenge sponsors really want the teams to build and test some hardware to give students a chance to go beyond paper studies and learn what is required to build hardware.

83. **If two proposals are submitted and accepted, will the funding be for two separate projects, or will it awarded under a single project?**
- Answer: A separate award will be made for each finalist project

84. **Would we have to program ourselves or can we get some help?**
- Answer: Your team can propose to outsource certain aspects of your plan, but that needs to be clearly spelled out in your proposal and budget. A letter of support from any entity you are outsourcing to is highly recommended to demonstrate they can do the work you are asking them to do for the price you have budgeted.

85. **Stipends for Summer Student Work/Research are allowed. How about stipends (research assistantships) during the school year?**
   - Answer: Yes – stipends for work related to this award during any portion of the year are acceptable (for US Citizens only). However, tuition costs, room and board, books, and other fees are not allowable costs for this award.

86. **Do we need to have all team members defined by the proposal submission deadline?**
   - Answer: No, but you do want your proposal to demonstrate that you have the right resources (including people) to successfully do what you are proposing.

87. **Is a team member eligible to compete if they graduate before November 2021?**
   - Answer: Yes

88. **When is the deadline for any technical submissions?**
   - Answer: See the 2021 Dates webpage. All proposals and accompanying videos are due on December 13, 2020. For finalist teams only: Mid-Project Reports are due on May 20th; Technical Papers are due on October 27th; and Presentation Files and Digital Poster Files are due on November 15th.

Questions Received on Call

89. **Where would you say is the highest priority area that dust mitigation is needed?**
   - Answer: The four theme areas all share equal priority. Each one is critical.

90. **Is there interest in mitigating dust greater than 50 µm?**
   - Answer: In general, all particulates on the lunar surface can provide some kind of a hazard, depending on how something is used. So, particles that are 100 or 50 µm can still reduce the power output of a solar cell. Specifically with 50 µm, we'd expect that those particles would fall down in the atmosphere and you'd be able to brush them off in a cabin environment. In flows, there may be a need to filter larger particles.

91. **Is there a pressure drop limit for air filtration? I.e. what is the current pressure drop for the air filters that are currently being used or have been used in the past?**
   - Answer: Ideally, you want the lowest pressure, but most filters we have tested are very similar to what you'd find in a terrestrial application for similar airflow rates and similar efficiencies. Do an internet search.

92. **Any thought on the daily dust deposition rate in grams/m2 on solar panels or external surface?**
   - Answer: Depends on the operations that are happening around it. In the natural lunar environment, dust deposition would be extremely low. You need to look at the operations occurring nearby. Also look at photos from Apollo to see how dirty these items got.

93. **Is microgravity testing required to achieve TRL 5?**
   - Answer: Depends. If you're operating on the lunar surface, no. If you're operating around the lunar surface in microgravity environment, that is something to consider. But in general, we're talking about things that are primarily happening on the lunar surface, so the most likely answer is no.

94. **What is the process for egress in ingress for the lunar lander after it has landed on the moon? What method is expected to be used for future lunar habitats?**
   - Answer: A good baseline would be to go and look at what they did with Apollo. Also look at Blue Origin, SpaceX, and Dynetics design. I think all of them would have detailed enough pictures to give a good idea how an astronaut would get out of that lander.

95. **What is the date that the team list needs to be finalized? What is the minimum team member requirement, and can there be less than the minimum at the proposal stage as long as there is the minimum by the end?**
   - Answer: For our finalist teams, we fully expect that they will add folks after they've been selected. Please include everyone who has worked on a project up to the point when each deliverable is due. We don't need a list of team members at any specific point other than on the cover page of the proposal, mid-project review, and technical paper submissions.
   - At the proposal stage, you need to be meeting the minimum requirements: at least 1 U.S.-based faculty advisor from the lead institution and 5 U.S. citizen students from the university who work on the project and present at the Forum, up to a maximum of 25 students.

96. **It was mentioned that the xEMU device will be used for the lunar missions. Is there any freedom for design changes to the xEMU or will technologies for the spacesuit have to be designed around existing, public specifications of the xEMU?**
   - Answer: It can go either way. Whether you are suggesting a design change or working around the published design, both is ok. Make a case why it should be changed or how you would work around the existing design.

97. **Is it ok to focus on just one section of the suit (i.e.: boots, visor, etc.) or is it expected to have an answer for the whole suit itself?**
   - Answer: An aspect of the suit would be OK. We would need to look at the concept's overall impact on the Agency's dust mitigation strategy.

98. **From what you referred: it seems that the scale of the mitigating system should not be greater than the scale of the system from which you remove/mitigate dust. Is this really true and if so, is this the "scale of operation" or possibly the scale of the system during transportation?**
   - Answer: In general, that's true. If you're putting a coating on a solar panel, that isn't going to exceed the scale of it. There might be unique cases where that wouldn't be the case, but in general that would be a true statement.

99. **Regarding lunar dust mitigation/removal for spacesuits, is there a preference as to whether a real-time or post-EVA solution is wanted?**
   - Answer: There's the potential for both to work. If an astronaut falls on the surface of the moon, they may need to clean their suit immediately. Under nominal operational circumstances, an astronaut doesn't fall and dust doesn't impact an EVA, then we'd be looking primarily at the end of the mission. During Apollo, they were cleaning things throughout the EVAs on the lunar surface.

100. **Do we know if pressurized air will be available in the lander?**
   - Answer: We will repressurize portions or all of the lander. Compressed gas will be coming back into the volume of the lander, and you could potentially exploit that for dust mitigation purposes.

101. **Is it necessary to design an orbital injection and descent plan to land a device on the lunar surface?**
   - Answer: From the viewpoint of dust mitigation, no.

102. **What is the method of the lunar habitat becoming pressurized? Is liquid air likely to be available in the lunar habitat?**
   - Answer: A good baseline would be to go and look at what they did with Apollo. Also look at Blue Origin, SpaceX, and Dynetics design. I think all of them would have detailed enough pictures to give a good idea how an astronaut would get out of that lander.

103. **What is the true possible extent of collaboration with industry? E.g. Would using an existing technology and incorporate it in our device fair game (with appropriate credit given)?**
   - Answer: Collaboration with industry is allowed and encouraged. If teams work with industry partners, they must have a clear understanding of what is considered proprietary information and handle it accordingly. The forums and reports will be made publicly available and your designs must be explained in reasonable detail. It will be up to you to get consensus from any industry partners on what can be shared.
   - Developing a system that is greater than the sum of its parts is the goal and using existing technologies to do this is also encouraged. Providing credit where it is due is always best practice and is expected to be documented in your deliverables.

104. **Would you recommend seeking ideas or concepts not mentioned in the Dust Mitigation Gap Assessment Report (Ex. EDS) or are original variations of those technologies preferred?**
   - Answer: We are open to all ideas! Concepts that are not mentioned in the Gap Assessment may have a longer road for development, but that does not mean that we are not open to those ideas.

105. **Let's say our method of mitigation leads to opportunity of additional mitigation or ability; However, we don't have the ability to go above and beyond and take this opportunity. Will the fact our design has implications of more use lead to a greater reception from the judges compared to designs that don't have the upside we have but do accomplish the same goal?**
   - Answer: Yes. Showing potential long-term and cross-cutting benefits will improve the value of the technology development effort.

106. **Do you have a mass and particle size vs altitude above surface distribution function?**
   - Answer: In the natural lunar environment, dust deposition would be extremely low. Depends on the operations that are happening around it. Launches and landings create a dust field around the area, but the local geology features affect this distribution. EVAs and rover operations will have a different local effect. You need to look at the operations occurring nearby. Also look at photos from Apollo to see how dirty these items got.