Transcript of the 2018 BIG Idea Challenge Q&A Session (October 4, 2017)

Overview on the 2018 BIG Idea Challenge Theme, by Principal Technologist Lee Mason

We're early in the process of looking at Mars surface missions, but we recognize power is one of the real key challenges. In my role as the Principal Technologist for Power within the Space Technology Mission Directorate, it's been put high on my list of important things to work on. Although we have done robotic missions on Mars, we haven't landed any power systems that could sustain a human presence. The Mars exploration rovers (Curiosity, Phoenix, etc.) have had power systems 200 W or less, but we really expect a human mission on Mars to require at least 40 kW, to produce propellant, power habitats and labs, and recharge rovers.

To avoid confusion, we're not asking you to supply 40 kW; we want great ideas on packaging solar arrays, large solar arrays, that would help to meet that 40 kW requirement. We see that being met by a number of power supplies, maybe nuclear supplies, or radioisotope power supplies, certainly batteries, fuel cells and other sources. The solar array would be one element in that architecture, but we want innovative ideas on packaging, deployment, and implementation as a piece of a much greater architecture. The Mars environment is a tough place for power systems. Partial gravity, CO2 atmosphere, reduced solar flux, long nights, dust storms, big temperature cycles, all things working against Mars systems, especially ones for humans. Take into account extreme environment conditions and your design for packing solar arrays.

Technical Questions Received in Advance

Power

Q1: Does our power storage only need to ensure that we reach the constant 40 kW power output, both day and night?
A1: The solar arrays we're asking you to develop are one piece of a larger architecture, so no. But, we do want the arrays to supply as much power as possible, and we want you to tell us how they might vary in power production over a Martian year or depending on latitude.

Q2: If we use RTG for thermal backup functionality only, would it count as another source of power other than solar?
A2: We're asking you to focus on solar arrays. We'll handle the thermal backup, so focus on the solar arrays.

Q3: Can we use radioisotopes?
A3: Same as A2.

Q4: Is there a specification on how much power the arrays must generate within 1 Martian sol?
A4: Not a specification. We did provide a guideline of 1,000 square meters as the amount of solar array that we foresee being needed in a single lander. The amount of power that would be produced by that 1,000 square meter array would vary based on the design of the array, the cells used, the time of day or year, dust storms, etc., so we just want you to maximize power output from a single lander.

Q5: Can we be expected to land with a preexisting power output from an already charged power storage?
A5: I think we indicated that yes, the lander would have power for deploying solar arrays. We're interested in power requirements for deployment, so please tell us.

Design

Q6: How much can we base our designs off of existing technologies? What is a good balance between innovation and proof-of-concept? Essentially, what TRLs are we aiming for? (Similarly asked: Is it expected to use any pieces of already existing architecture? Can we use purely theoretical ideas that haven't been tested before? Can empirical tests be run to support a theoretical technology?)

A6: These missions are likely to occur no sooner than the 2030s, so we have some time to mature the technologies. TRL: 2-4. We're not providing money to build hardware, although some of your stipends (received by the 4 finalist teams) can be used for prototyping.

Q7: How functional does our proof-of-concept have to be? Can it be a digitally CAD-ed proof-of-concept, or does it need to be a scaled-down physical prototype of our project?

A7: We are primarily looking for CAD models. We strongly urge you to look at the evaluation criteria. The prototype is 10 points – almost extra credit. Main things we're looking for are: feasibility of design, adequacy of engineering and analysis, and Concept of Operations (CONOPS). You'll be much more productive with computer methods as opposed to prototypes.

Q8: The website makes clear that prototyping is strongly encouraged if your proposal is accepted. Is prototyping necessary for the proposal?

A8: It is not necessary for the proposal stage, and for finalists, it would be considered extra credit. It might make the difference between an 80 and a 90 score, so see what you can do. We would expect any prototype would be made from pieces from the hardware store, certainly nothing more than $1,000 for a prototype, if you choose to make one.

Q9: Do the solar panels all have to connect or can the design encompass several smaller arrays that can detach from one another?

A9: It can be a modular design, with wings, or perhaps a monolithic structure. Solar arrays typically consist of strings, with a number of cells or panels connected to get a certain voltage, perhaps 120 volts would be a good reference. We expressed a special interest in the ability to restow/relocate the arrays which would count as an "extra-credit" capability. Primarily, we're looking for the ability to deploy 1,000 square meters off the lander.

Q10: Does our design start from within the transport pod or is it already stationed on Mars and we are only responsible for its movement on Mars?

A10: You don't have to land it, or do anything with EDL. Assume a lander with the solar array system is already on Mars. The diameter will be between 5-10 meters, based on rocket sizes.

Q11: Do we need to design a means of communication with the array system on Mars to NASA on Earth?

A11: No, absolutely not.

Q12: Do we need to design how the system will move around on Mars to relocate itself?

A12: In the solicitation, it's listed as a special interest. More of an "extra-credit" capability to retract and relocate. Teams can envision how that would take place, and we could provide some ideas NASA has for transporters, although none are very definite at this time. If you want to relocate, you should assume there will be a system that could do the relocation for you.

Technical Questions Received in Advance cont'd…

13: Are there any restrictions within the system or materials not stated in the document?
A13: No, everything should be available in the document and on the website.

Q14: On the website, it states: *"Of special interest are modular array designs that are self-supporting in 1 -g and can be autonomously deployed, and optionally retracted, relocated, and interfaced with other power sources on the Mars surface."*

- **Does the retraction also have to be autonomous or would it be assumed that a human crew would perform this?**
  A14a: You can assume that the crew would be there during retraction; we're only asking for autonomous deployment.
- **Does relocation mean relocation of the lander, or physical removal of the power system from the lander, with it being installed somewhere else, or even by itself?**
  A14b: It means the power system would come off the lander. No one's thinking of moving a lander, once it lands.

Q15: Are there any specifics for the lander geometry? If so, could you provide existing lander and payload architecture dimensions? (Similarly asked - Can the lander geometry be neglected for weight and space constraints)
A15: Quite a few concepts have been proposed, but nothing is baselined. Should be between 5-10 meters in diameter, but otherwise you'll need to assume the geometry. There are some references to size and shape of landers in the documents found on the Resources section of the BIG Idea website (Competition Basics Page).

Q16: What is the tolerance of magnetic and electrical fields on the entire launch architecture?
A16: We've provided no specifications for those two things. Dust devils on Mars have electric fields, so anything you could do to see how those would affect your design would help.

Usage

Q17: How long after the deployment of the solar power systems will the manned crews land? Will it be a week? A month? Years? When will you be using this technology?
A17: Assume the next landing opportunity, so 26 months after the power system is delivered.

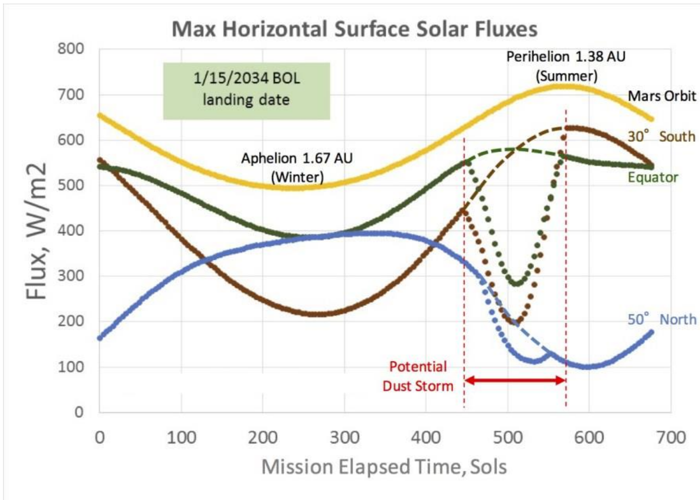
Q18: About the "largeness" of the solar panels. What are we using this for?
A18: Go back to the Competition Basics document. Power for the habitat, communication, resource utilization, labs – this will power anything for missions.

Q19: Does the minimum lifetime requirement of 10 years mean a minimum of 10 earth years or a minimum of 10 Mars years?
A19: A minimum of 10 Earth years.

Q20: Does the 10-year life span mean it needs to last for 10 years without any human maintenance?
A20: Yes. The goal is to operate without human intervention. If your design requires maintenance, then please describe the scope, duration, and interval.

Technical Questions Received in Advance cont'd…

Q21: Do we have an approximate location of where the system will land so we can consider the type or terrain we are dealing with and how much sunlight? (Specifically, how long does the sun shine on the deployment spot each day?)
A21: That will vary by location and time. For the parametric analysis, we want the latitude and season to be dependent variables. The image below should help explain, and a larger version can also be found under the "Resources" section of the BIG Idea Website.



Q22: Do we need to take into account solar conjunction, during which communication with Earth is lost?
A22: No.

Dust

Q23: Are we to anticipate dust storms that could potentially bury our lander?
A23: The short answer is "No." The landers will be elevated per the details. There shouldn't be that much dust, as we wouldn't land in a sand pit. During dust storms, teams should assume one could occur during the Martian year as shown in the solar flux chart found under the "Resources" section of the BIG Idea Website.

Q24: Should we assume the lander geometry to be a factor, when considering dust collection on the solar system.
A24: It should be considered. The approach used for integrating the arrays with the lander may influence the amount of dust that could accumulate or aid in ways for mitigation of dust.

Programmatic Questions

Q25: What is the biggest weakness you have seen in proposals in the past BIG Idea competitions?
A25:

- Teams not clearly describing ConOps and the various design trades/assumptions made. The judges want to see the justification/reasoning behind your design choices.
- Spelling and grammatical errors. Proofread your submissions carefully.
- Failure to include innovative or novel ideas.
- Lack of original analysis. Please avoid simply cutting and pasting information gleaned solely from internet searches.
- Not addressing ALL of the key design and operational challenges.

Programmatic Questions cont'd…

Q26: If a member is currently a student applying for a master's degree this upcoming spring, and does not get accepted, does another person need to take their place?
A26: Assuming this student is currently a senior graduating in December 2017, he/she can still participate in the 2018 BIG Idea Challenge. NASA allows for students to begin an internship within six months of graduation, as well as continue working on a challenge for up to six months after their graduation.

Q27: The references are said to be included in the total number of pages in one place, but then said to not be included in the total number elsewhere. Do the references count towards the total number of pages or not?
A27: We are sorry for the confusion, but can't seem to find anywhere that states the references are to be included in the total number of pages. References (which should be included as an appendix) DO NOT COUNT toward the total number of pages.

Q28: Our advisor currently works for JPL. Is this ok?
A28: We encourage you to utilize resources from industry. You may have an industry advisor work with your team as long as that person is not a NASA Civil Servant. However, you will need also need to have a faculty advisor from your university supporting your team in some capacity.

Questions Received During the Call

Q29: Can you state, what is your #1 and #2 challenge in implementing PV for Mars applications?
A29: For this application, one of the key challenges is the ratio of stowed volume to deployed area and performing the deployment autonomously in a difficult environment. Second is dust mitigation and build-up and possible ways to prevent dust accumulation. #3 is Wind Loads. We're worried about Mars' winds destroying lightweight solar arrays, so any analysis you can perform on the effects of dust storms or dust devils on a lightweight solar array would be appropriate.

Q30: Cost analysis? Any limitations/requirements for costing?
A30: We did not want to constrain this technical study based on cost as a limiting factor. Certainly cost will be a strong consideration when we design, build and deliver a lander on Mars, but we hate for it to be a factor early on in these trade studies. There are opportunities for considering low-cost solar arrays, but those aren't practical choices based on our power-output and durability/life requirements. ***We'd rather you focus on the technical.*** We don't want to build structures which are massive/heavy. It's hard to specify a watt/kilogram parameter. Lightweight usually means lower cost.

Q31: Designing the structure for stowage: Do you also want us to design the type of solar panels for consideration?
A31: Yes. It should be the structure, with the cells, and the analysis of how much power you'd produce with that design. The full array design.

Q32: Efficiency/Dust Storms: When we're thinking of dust removal designs, do we need to encompass suspended dust particles, or are we more concerned about surface dust particles on the arrays?
A32: During a dust storm, you'll have a loss of light - account for that. Also, continuous buildup between cleaning cycles will diminish output. It's a 2-part problem.

Questions Received During the Call cont'd…

Q33: Power: Battery Packs: do we need to include the use of battery packs or a type of power storage?
A33: We're wanting you guys to focus on the arrays. We understand they'll need to work with some other power source, but we want you to focus on innovative ways to package solar arrays and operate them in a Martian environment. You'll need to account for power demand associated with charging of the energy storage and day/night cycles, but don't focus on batteries.

Q34: Are we to anticipate dust storms which could bury the lander?
A34: No, we don't anticipate the lander would get buried.

Q35: What is the current solution from NASA on Dust Mitigation for rovers?
A35: We're using the environment currently. Dust storms clear off the array. Nothing has been done actively to remove it; it's more passive. ***However, don't expect that to be a solution for solar arrays used on human missions!***

Q36: How rigorously do we need to estimate how auxiliary accessories will fit inside lander packing with solar cells?
A36: We don't want you to focus on that. We want you to focus on the packaging of arrays, just considering that you need to leave storage space for other items. We don't want you to design other systems, just make accommodations for them.

Q37: Are you looking for a finished product, or more a concept without a specific, exact numbers? Or, where the electronics are placed? How much detail?
A37: We want you to design these systems sufficiently to be able to characterize their performance on various environments on Mars including latitude, types of year, dust conditions. We're asking for analysis. More than a sketch/concept; it has to have some engineering analysis supporting it.

Technical Questions Already Addressed on the FAQs page

Q: Do we need to account for cables running more than a kilometer from the landing site to the astronaut habitat?
A: Although cables up to 1 km long might eventually be run between landers or between landers and habitats, BIG Idea Challenge teams should focus primarily on the solar power system for a single lander and not on cabling to connect multiple landers.

Q: How much do we have to design for the lander, since the focus of the competition is on the solar array? Do we just have to choose a landing type and design the lander around that, or should we go into details on the aerodynamics of atmospheric entry and descent?
A: Mars lander designs are notional, but their diameter will likely be between 5 and 10 meters. Teams should select a reasonable concept for the lander and describe all assumptions about the size and shape. Ideally the teams will consider how variations in lander design will affect their selected solar array design. Teams **do not** need to consider the entry, descent, and landing phase.

Q: What is the longest storm (period of no sun) we should account for?
A: Teams can assume the longest global dust storm is 120 days. NASA estimates that approximately 30% of the solar flux will still reach the surface during the worst dust storm.

Q: Can we use non-planar photovoltaic structures (not panels) like inflatables, balloons, or fiber optics? If so, does the 1,000 square meter minimum refer to the photovoltaic surface area or the amount of land the array takes up?

A: The 1,000 square meter minimum refers to the photovoltaic surface area. NASA believes this size will generate about 10 kW of electrical power continuously (day and night) with suitable energy storage, and about 50-80 kW peak, near the equator in the daytime with clear skies. Any technology that autonomously deploys from a single lander and generates similar power levels using solar radiation is acceptable.

Q: 1,000m^2 of solar panels fitting in 10m^3 would only be 1cm thick, this thickness seems a bit small and this is without the inclusion of a shell for entry into Martian atmosphere, landing equipment, a deployment mechanism, or any batteries. Is this correct? If there were proposed alternatives to power generation would they be accepted?

A: NASA expects large solar arrays for Mars surface power generation will have solar cells mounted to thin tensioned flexible substrates. Examples of spacecraft that use this type of lightweight solar cell "blanket" are the International Space Station (ISS) and the Cygnus ISS resupply vehicle. The recent Roll Out Solar Array (ROSA) experiment on ISS is another example of advanced, lightweight array/cell technology. Although most spacecraft and terrestrial solar arrays use thick rigid panels, they would require too much launch volume for Mars arrays. The solar array 10 m^3 volume goal includes the solar array mechanisms but not the other non-solar array items you mentioned.

NASA is only looking for solar power generation systems in this challenge. Other methods of power generation will not be considered.

Q: The challenge requires a mass of 1500 kg or less. Does that mass refer to the solar array or the total mass of the lander and the solar array?

A: The 1500 kg does not include the lander mass – just the solar array.

Q: Can we packaging the solar cell system in a payload that fits on top of the entire architecture? Or can the shape be anything that fits in 10 m^3?

A: The packaged 1,000 m^2 solar array system can have any shape with approximately 10 m^3 of total volume. Teams should select a reasonable lander geometry and show how the solar array can be packaged, constrained for launch, and then autonomously deployed. Novel solutions could propose designing the large solar array system as an integral part of the lander rather than as an attached payload.

Q: Is there a specific areocentric latitude range for which the lander will land on Mars?

A: Teams should assess solar array performance as a function of latitude. Human missions will probably land between 30 deg south and 50 deg north latitude.