FY17 RASC-AL Competition
Questions and Responses for the Q&A Session, November 21, 2016

General

1. How technical should the abstract be?
   - **a.** The abstract should be detailed enough to convey that you have a solid understanding of the engineering and programmatic aspects of your concept. Consider cost and viability; we're looking for innovative applications of existing technologies to meet mission objectives stated in the RASC-AL themes. **Internet cut and paste will be detected and rejected!**
   - **b.** Have a solid plan; trade space is important; provide enough information to convey you have a real understanding of what you intend to do, and what that plan is for achieving what you propose. The judges aren't looking for structural details at this point. Attract their interest.

Lightweight Exercise Suite

1. Would a design that is not a fixed apparatus or module, but a wearable system, meet project constraints or requirements?
   a. Potentially, as long as it provides adequate load and/or stroke rates, maintains bone mass, muscle strength, and cardiovascular health. Wearable systems shouldn't pose any wearability or hygiene issues.
2. Could long duration low level physical resistance be a viable replacement for the high intensity short duration exercises currently used with the ARED?
   a. Potentially, however low level physical resistance might not protect all systems targeted with exercise countermeasures, and if used for extended periods of time, might pose crew comfort issues. Note that ISS exercise prescriptions used for crewmembers are individualized and many prefer high intensity training.
3. Would we be able to allot additional training time to familiarize astronauts with the system before implementation in space?
   a. Yes, crewmembers are trained on the exercise devices prior to flight.
4. Should our submission include a detailed training regimen for the apparatus?
   a. Yes. Novel devices should be accompanied by a proposed training regimen that, used on a candidate exercise device, protects bone, muscle, and cardiovascular health.
5. What is the expected lifetime of the system?
   a. **At least** 20 years or more. The system should outlast the station that it's on. Device should require low maintenance and minimize replacing parts since it will be difficult to do in deep space.

6. How often do astronauts deviate from standard exercise procedures?
    a. Exercise prescriptions for the crewmembers are individualized based on crew capability, need, and how they are feeling.

Airlock Design

1. What can we assume as a power source?
    a. Assume power is provided by the module the airlock is attached to via a solar array. You do not need to put your own power system on the airlock. Make sure your airlock doesn't consume 100s of kW of power; make it something reasonable and back-up your requirements with data.
2. Do we assume we will not be restocked in space? Or, if we are what is the timeline?
    a. This would be part of a long-term sustained program, and we'd be operating in space for a decade or more. Based on the current crew rotation of once per year, **expect at least one logistics resupply per year**. If your design requires more, tell us why and when.
3. Does the requirement to test future EVA compatibility refer to the current series of NASA Z-suits? If not, what does this requirement mean?
    a. The NASA Z-2 Suit is a leading candidate for what we're talking about, but suit ports and suit locks can be considered, or even the chameleon type suits. We're looking for innovation! If you have a better EVA system, let us know! We're looking for your fresh ideas.

Commercially Enabled LEO/Mars Habitable Module

1. What kind of commercial applications did you have in mind for the module while operating in LEO? Is it up to us to decide?
    a. It's up for you to decide, but you have to justify your decisions. Do a cost analysis. This low-Earth orbit capability would be an extension or replacement for ISS. Look at the current commercial science payloads on ISS (check CASIS) for examples. You tell us: what would make a commercially viable LEO capability? And, what is NASA's role?
2. Could you clarify if this theme involves aspects of space tourism or a more ambitious direction along the lines of asteroid mining? Given the 5-year time frame, what would be considered commercially practical?
    a. No asteroid mining in a 5-year time frame. Look to current commercial science payloads on ISS for examples (check CASIS).
3. Would cleaning up orbital space debris be considered a commercial application given the threat to commercial satellites?
    a. Show a profitable use case and it could be. It's possible, but show how you're getting paid to do this.

4. What exactly are commercial operations hardware? Does it deal with the necessary operation systems specific to our respective commercial application or are there an additional aspect that we have to address?
    a. Commercial operations hardware is going to be unique to your design. For space tourism, you'd need amenities for tourists (private rooms, activity spaces, private facilities, etc). If you're talking satellite servicing, you'll need completely different hardware.
5. Does the 5-year time frame for the LEO Module rule out experimental development? Would certain innovations (space tethers for artificial gravity, Bigelow B330 modules, etc) be considered too theoretical to implement over the 5 year time frame?
    a. The innovation we're looking for isn't just technology, but also new uses for existing technology, or better system designs. If there's a smaller scale use for tethers or artificial gravity for test facilities, we're open to those ideas. You need to justify how the technologies reduce risk or make money at what scale and for what applications.
6. NASA's 2009 *Handbook for MMOD Protection* listed experimentally determined acceptable areal densities for multi-shock shielding in table 4-11 (e.g. 0.63 g/cm^2 required to stop a 0.62 cm wide high-velocity projectile given 20 cm shield thickness). Based on the B330's publicly-released internal volume and external dimensions, they seem to be using a ~30 cm shield thickness with an area density closer to ~0.07 g/cm^2. Their shielding design is proprietary, so may we use this lower value in our shielding assumptions or do we have to design our own 16ish-layer shield design and calculate an appropriate level of protection from first principles? i.e. Is it possible to just say that we'll use whatever shell material Bigelow's developed and work from there? -
    a. People like Bigelow are in the industry to make money; they keep their secrets close. If you can identify and mitigate threats, and the consequences of not addressing those threats, you'll be good. Show us that you understand where the gaps in understanding are, and document possible solutions. Identifying the threat and understanding where the gaps are is almost as important as the solution.
7. Can we assume that the SLS Block 2 cargo rocket fairing (31.1 m height by 10 m diameter) is the largest available fairing for the purpose of this mission? Our current module design may not fit in this space, even though it is less massive than 130 metric tons, the payload constraint for SLS Block 2 launch to LEO. i.e. Could we simply assume that a taller rocket fairing could be custom-made for our module's launch?
    a. In the time frame we're talking about, there will be no SLS cargo vehicle available. There are a host of rockets that can get large payloads to LEO that you can use. You may need two flights, but in this timeline, no block two SLS will be available, and even a block one Cargo SLS will not be available. Look towards Falcon Heavy if you need a heavy lifter in that time period.

8. Does the "common module" aspect of the mission statement indicate a module that links to itself to form an ISS-style station? Or is the module common for both LEO and Mars transit operations…indicating either single module or station architectures are valid?
    a. We are looking for commonality across LEO, commercial, and Mars transit applications. We want to know how a version of your LEO systems can be developed for Mars transit, or for a smaller habitat that may be needed for a Mars mission (rovers, landers, etc.). NASA is looking for a common investment across what we're doing in LEO and what we could do in a Martian environment.
9. Can you provide any information regarding the Mars mission structure? Timeframe, transfer orbit, final orbit around Mars, other operations that should be considered?
    a. Check AIAA Space or IEEE Aerospace Conference papers. We will make some available on the website, but you can do an Internet search for EMC Hybrid Mars Architecture, EMC SEP Chemical Architecture, or EMC Habitation. The papers are all within the last 2 years, and those architecture constructs and the requirements for the Mars habitat are there.
10. What specific type of applications will the LEO habitable station need towards Mars? Will the module need to go to Mars or will the module need to be able to attach to a module that goes to mars?
    a. A second version of the LEO module will go to Mars, and the one you design would stay in LEO as a commercial foothold after ISS. You don't need to worry about getting your module to Mars.
11. How many people would be expected to make up the crew of the LEO habitable station?
    a. It should be extensible to a Mars mission with a crew of 4 plus 1100 days of logistics and supplies. That could translate to the ability to accommodate a much larger crew in LEO, but consider the extensibility.
12. How often will the module be able refuel supplies such as food, water, etc?
    a. It will be in LEO, so its resupply would be governed by what launch systems are available to access it. The minimum would be ISS's current resupply schedule. There could be more launches – you tell us and justify your choices.
13. How long would the crew be on the station for one mission?
    a. Depends on the crew's mission and their available resources. You tell us.
14. Will there be multiple modules?
    a. It is acceptable to use several modules, but you must be able to justify why you made the design choices you made. You want to leverage this for a Mars mission in the future, so justify your choices based on synergy, cost, etc.
15. What are the primary objectives of the Mars Transit Vehicle? Is it a manned mission?
    a. Yes, this is a crewed Mars mission. The primary objectives of the Mars Transit Vehicle are in the papers posted on the Resources page.
16. What is the minimum TRL (Technology Readiness Level) we should be using in our design concept?

   a. This should be today's technology for the most part, as it needs to be on orbit in 5 years. You can explore commercial technology as well (SpaceX, Boeing, Orbital, etc.). If you want to explore new technology in non-essential systems, that's fine. Inflatables are a flight-tested technology and may be used.

17. What is the definition of a deliverable "common" module, precisely?
    a. The LEO module could have systems and configuration common to a Mars transit module. Map those upgrades to the commercial needs that are viable. Don't pick things because they're cool; pick them because of your operational scenario and consumer base.
18. Can we cater transit upgrades of our module to specific customer needs?
    a. Sure, but map those upgrades to commercial needs that are viable. Pick something because it makes sense – not because it is cool.
19. What are the requirements of the Mars transit?
    a. Please see papers in the Resources section.
20. Is a propulsion system required to get the module from LEO to Mars?
    a. No, you do not need to develop the transfer mission concept. Your focus should be solely on the habitat module and its associated subsystems. Your design should be extensible to a Mars mission.
21. Are there specific requirements for launch locations for getting the module to LEO?
    a. The ISS vicinity is one consideration, but you could make a case for another orbit if your use case (commercial aspects, expiration risk reduction, etc.) makes an argument for a different orbit. No one should try to build a whole new facility in 5 years, but justify your business case.
22. Are we responsible for launch vehicle systems to get the module and astronauts to LEO?
    a. Just identify which vehicles you will assume and count their use towards your cost. You're not designing a launch vehicle; you're selecting one already in existence.

Logistics Delivery System

1. Can we accomplish the 360-day mission resupply in one launch or do we have to defer to a 2-launch program?
   a. That is up to you; just justify why.
2. Does the Logistics Module have to perform the transfer to cis-lunar space itself? Can we use the upper stage of our launch vehicle?
   a. It doesn't have to perform the transfer itself; you can (but are not required to) use the launch vehicle upper stage.
3. Does the Logistics Module have any down-mass requirements or need any re-entry capabilities?
   a. No reentry capabilities. Don't assume any down-mass requirements. It's in cislunar space; it's not coming back to Earth.

4. What happens to the vehicle after its job is done? Should it be disposed of? Should it remain as part of the cis-lunar habitat?
    a. Both are valid options to be traded in your strategy. There's nothing wrong with taking the module and making a facility bigger, or another option to dispose of it in deep space. Justify your choice.
5. Where are we being launched from?
    a. Earth.
6. Can we draw power from the cislunar station?
    a. Yes, identify how much, but you may need to supply power in transit. So when you get to the cislunar station, you may connect to it for power. But you need batteries in transit if anything needs to be cooled or heated.
7. Are there any cost limitations or budget restraints?
    a. The concepts with highest value to cost ratios will be the most intriguing. Be innovative, but take reality into account. NASA spends 8 billion dollars a year on human space flight exploration. Do a good cost analysis for your system.

Additional Questions On-Call

1. NASA's Human Integration Design Handbook states that crew members on ISS have emphasized the importance of designated areas for dining, exercise, work, hygiene, and sleep to ensure habitability in orbit. Are there any additional standard procedures for loading and unloading? Locations or preferred areas?
    a. Not that we know of, but that doesn't mean they don't exist. If you can't find anything, make a reasonable assumption and work those into your design. The standard mentioned means that a bathroom shouldn't be placed next to food storage. Your systems will be even smaller than the ISS, so look for even more synergy across systems, innovative packaging, new layouts, and multi-function spaces.
2. The RASC-AL competitions focus heavily on budget. How do we balance cost vs. innovation?
    a. All these themes are near-term, so you should have a pretty good degree of fidelity in costing, technology, etc. This year, we're looking for use-cases and innovative approaches. If you're concerned about scoring well, look at the evaluation rubric and use that to set your priorities.
3. Would you clarify what you mean on "upgrading the module for Mars transit?" Would it be a redesign of the module, or upgrades to components?
    a. Either! Your strategy should be to minimize the delta investment to get to Mars capability. Must be able to perform operations in both environments. The systems don't need to work in both, but the entire facility should be useable. Module v1 and module v2 look similar from the outside, but one is in LEO and one goes to Mars.
4. What level of detail is expected for the abstract? We may not have all of the details figured out by then. How do we explain that?

   a. Should demonstrate a good understanding of the problem, a good understanding of the engineering trades, and a good understanding of the system and what the system needs to encompass. We're looking for a demonstration of your understanding. We don't need structural analysis; we want to know you understand the customer's needs.
5. For the Logistics Delivery System: We are concerned about variation in the size of cargo. Could you give us more information, beyond rations for astronauts?
   a. We will post some papers that will have the logistics needs for cislunar space. Build to those specifications. NASA usually figures out how many supplies a logistics system can carry and then builds the length of the mission around the available supplies. If you can, tell us what you can carry based on the launch vehicle. Or, focus on the minimum (30 days) and build your system based on that. We will let you know about a logistics "set" at a later date. Also, make sure you use standard hatches, and that your logistics can fit through the hatches.
6. For the Logistics Delivery System: Some systems have an unpressurized section where certain items can be placed so they don't need to go through the hatch. Is our system expected to have an unpressurized section?
   a. It would be excellent to have an unpressurized section. It probably wouldn't need to be as large as the ISS's section. You tell us.
7. For the Commercially Enabled LEO/Mars Habitable Module: Do we need to transport live cargo (experiments, test animals)?
   a. It's up to you whether or not it would be capable of carrying live cargo. You won't be penalized for not including it, but we would certainly like to see that be an option. Just provide some information of what you're expecting to transport and how you'd support it. If the support systems are built in to the vehicle, you would design them; if they're a part of the payload, you wouldn't need to design them (but would need to accommodate supporting them in your system).
8. What online resources are available to us?
   a. The RASC-AL website has a large resources page at your disposal. If you do an internet search, you should be able to find almost anything. The NASA Technical Report Server is a good place to start, but it is on you to conduct your own research.
9. For the Logistics Delivery System: When attaching to the habitable module, is it possible to leave part of it behind as extra storage? Does the air lock need to be free for future missions?
   a. Of course; just justify your reasoning. You can make some assumptions about your theme, just try to make it reasonable, and take everything in to account. Factor in accommodating future payloads.
10. For the Logistics Delivery System: What systems can we consider already on the habitat we're connecting to? Can we assume the habitat has water reclaimers, air scrubbers, solar power, etc…?
    a. Make the assumption on what's there based on what you think is needed for a 30 or 60 day mission. Specify what you think you'll need to bring. We will be posting some papers

that should help in making some of those trades. If you assume that a system is on the habitat, mention that in your paper and how it plays into the requirements.

11. For the Logistics Delivery System: How flexible should we be in terms of propulsion capabilities?
    a. If you want to build a business case for something other than the standard, you're welcome to. Your system just needs to get itself out and docked to the habitat reliably. Add a little margin.