BREAKOUT SESSION 4.
PROPULSION SYSTEMS: LAUNCH, IN SPACE & RELATED GROUND TECHNOLOGIES

Concern: In 2016, there was focus on improvements in cryogenic cooling, engine system design and turbo machinery. Those are all missing from 2017 drafts. Is that still an area of research interest or is a shift in focus for this topic?
Response: It's a shift in focus. Based on the discussion in NASA and decisions made by the subtopic managers they would like for proposers to focus on the priorities, issues and technologies mentioned in the subtopics drafted for 2017.

Concern: What type of thrust levels are you looking for in the affordable launch vehicle programs and what price points are you trying to hit?
Response: Thrust levels depend on the architecture of the vehicle. We can't say exactly that we have a specific number for thrust but we are interest in seeing small businesses enable some of these people who are trying to develop the actual vehicle systems. We need you to work with people who you can insert your technology with. This is one of the challenges in this area, people are trying to build a piece part, a component but it's very difficult to put the value on it if we cannot see the insertion plan for adding it to the vehicle system. Do some research yourself and who do you think you're going to sell this to. What are their requirements? You need to work on tailoring your technology to meet that requirement.

Concern: Does the NASA NTP program have a stated goal of no release of fission products into the exhaust? If so, can the testing facility rely of this in its design?
Response: What can be achieved is still to be determined.

Concern: Where do you draw the line between NTP and advanced nuclear propulsion? Is NTP specifically NERVA derived designs? And for NTP are you specifically looking at the in-space propulsion?
Response: The NTP program we have now is solid core fission. We are looking at both NERVA-derived and the SNTP program. We are looking at systems that will be under 3000 Kelvin reactor temperature. There are advanced materials, carbides and such, that allow operation above 3000K. There are potential approaches that could push ISP above 1000 seconds, however we consider them risky to take on for the Mars mission within the timeframe we are looking at. For NTP we are looking at strictly space related NTP. For NTP we are looking only at in-space propulsion.

Concern: Is there much thought that's gone into combined systems of an NTP system that can also be converted into modular reactor on a surface of Mars?
Response: There are approaches for fission based surface power for Mars but they only want 40 kilowatts or so. In this case, it is about the gigawatt reactors compared to tens of kilowatts reactor. NTP is not meant to last very long. If we could get two hours of run time out of it before it disintegrated, we achieved our goal. Whereas, a surface power reactor is going to have to operate for years. It is a different architecture.

Concern: How does one go about partnering with a NASA lab to measure e.g. thrust levels? Either for NASA to help businesses with that or learning from the lab how to do it.
Response: Under SBIR, you can't route a subcontract back to the government. We do have at NASA an NCO (NASA Collaborative Opportunity) program through STMD and it is purposely meant to do what you are asking about. If you don't have all expertise or capability you need to develop your technology or your

system and NASA does – the facility, the expertise – we specifically call on the industry to tell us what they need help with and then we will pay the NASA center/facility to do the work that you need support with to advance your technology. (https://www.nasa.gov/nhhpc/collaboration)

Regarding the use of NASA facilities. For Phase I, that will be covered under Section 3.2.4 of the solicitation, however it is usually discouraged given the duration of the Phase I makes it a little impractical for putting the facilities use agreement in place. However, for Phase II's, we ask for those agreements to come in with the proposal or soon after the proposal submission, and it is possible but you need to organize that agreement and get the facilities use waiver cleared in order to do the work with that facility.
Each center has a partnership/agreements office that can work with you to help set up whether you need the use of infrastructure at the center or expertise. However, that is the activity that happens separately from SBIR/STTR Program but it is feasible to leverage the center to help the project.

Concern: Could you please expand on the STTR ETL Detailed Multiphysics Propulsion Modelling & Simulation through Coordinated Massively Parallel Frameworks. In particular, the motivations, ideal outcome and if there is a vision of how the small business would collaborate with the research institution or university.
Response: We are constantly confounded by inability of our modelling to predict reality. We need to continue to get the best modeling in simulation we can get. So when you read the draft some of this is mentioned like acoustics, or multi-face flow, all these are very difficult things to model. So NASA is always looking for new ideas and innovation on how you can do this better, whether it is more efficient or using some new computational technique. All of these things are of interest to NASA. How you interact with a university is more dependent on you and how you interact with people.

Concern: Is there any way to influence what particular topics become SBIR's in the future?
Response: It is impossible, but there are always educated guesses. I would look at what NASA's focus is now and we are very attentive to mission and vision. Whatever the mission is set out for NASA and there will be technology for these missions. NASA is much more interested at this time in technology that will help get them through their upcoming missions. So looking at what the future of SBIR will be, that is a clue, start thinking of what those missions will be and what the challenges are.

Concern: Is NASA pursuing changes in regulations to legally allow LEU reactors to be launched into LEO?
Response: The intent is not to launch the reactor to LEO to leave it there but to launch the reactor to take us to the destination way beyond LEO. We have to convince the decision makers who have legitimate concerns of what could happen to the reactor. A lot of NTP work that we do is to build confidence in people that we know what we are doing and pursuing risk reduction activities and that we can do it safely and correctly.

Small Launch Vehicle – we are not looking for point design technology but we are looking for technology in small launch vehicle structure that is scalable. And in the proposal what you need to explain is now your technology will be better, lighter, stronger than the other. We also expect everyone to understand the launch vehicle environment, the loads and acoustic, the vibration and how you would address those issues. We recognize nobody will build a rocket by themselves so when you bring your technology we can eventually pair you up with the propulsion providers and together you can build a small launch vehicle. But the key word is scalable.

Concern: Related to engine testing. Is there interest in wanting to explore to separate the different effects of the engine to, for example, have neurotics testing possibly in a DOE lab and you can look at the thermohydraulics in the system response treating some neutronic elements as a black box at NASA research center or is it specific to an integral system that incorporates everything at once? Would there be interest in simulant scaled systems or use simulant fluid of sort in order to operate a smaller scale system to reduce cost or would that be too much of a distortion? By simulant, I mean same principle as testing small scale aircraft in a wind tunnel with changed parameters to operate in different conditions that are easier to implement in a lab.
Response: We are currently working with DOE but where we will do the testing has not been decided. We at looking at doing testing in NASA center – it may require licensing and approvals but we are going down the path of exploring this possibility. We are also working with DOE at their Nevada center to test fission power system and we see a possibility of doing the engine testing with them. But we will have to be determined. It has not been rolled out on the NASA side yet. In reference to simulant scaled systems, it seems it would be more of a distortion from where we are headed. E.g. with NTP, we have a strong non-nuclear testing component that we do and here is a lot of thinking and analysis involved to test them in a way that simulates the real reactor. You will never get 100% but you have to get the key parameters right. It is a very helpful approach to go for before moving to the expensive options. However, if there are any other innovative approaches we would be interested in hearing about those ideas.

Concern: For the solar electric propulsion, very large arrays are planned for the missions of hundreds of kilowatts. Could you comment on what you think the feasibility of using current solar technology or what improvements might be needed in solar?
Response: NASA has invested a lot in solar array propulsion and we will continue doing so. There are many challenges with it.

Concern: Cryogenic propulsion, NASA was interested in Zero Boil-Off and integrating cryo coolers into tanks ideas for the past few years. Is this still a part of architecture of cryofuels, etc.?
Response: We have some cryogenic fluid management challenges to solve like Zero Boil-Off and how do you maintain these cryo fluid for a long duration. We haven't invested in it as much as we should. I think this area will grow because we are serious about this and we need to pay more attention to it if we decide that we will go space with the cryo systems. We awarded multiple cryocooler awards last year focusing on LOX/Methane ZBO for Mars.

Concern: Do solar sails still fit under the propulsion topic this year?
Response: Solar sails are still of interest to NASA but it will not a big focus for 2017 call.

Concern: Under the methane space propulsion topic it calls for improved materials that are high temperature and high pressure, is that for pressure bottle? Combustion chamber?
Response: That is for combustion chamber applications.

Concern: Is there interest in investing in modeling 2 phase liquids, like hydrogen and cryogen fluids? And is there interest in solid propellants for micro thrusters application for small satellites?
Response: NASA called it out that they are definitely interested in 2-phase modeling in the cryogen fluid management. Regarding the micro thrusters that would probably be more suitable for the small spacecraft topic – one of the subtopics there is propulsion. However, I don't remember if they are interested in solids.

Concern: Small Launch Vehicle Technologies topic: Is there any interest in technologies that could enable the extension of capabilities of small satellite launchers that are already going to LEO to enable them to go to further out destinations? It is about launch vehicle enhancements like distrusted launch approaches. To keep the launch cost down, is there an interest in technologies related to recovery/reuse of rocket stages, like being done for larger launch vehicles?

Response: There is interest but it would be in small spacecraft topic. In reference to your second Concern, that could be part of the architectural solution. SBIR/STTR have a call specifically about technologies in prototype stages. If you can convince NASA that you are offering the technology that fits into a believable architecture solution then it may work, otherwise they won't see the connection.