Chris Baker (00:14):

Hi, my name is Chris Baker. I am the program executive for the Small Spacecraft Technology program and the Flight Opportunity program. So within NASA space technology, mission directorate. I'm talking to you today, actually about the small spacecraft technology plan that STMD is working on as part of a new star process. You've probably heard a bit about this in some of the other presentations, so hopefully you're already aware.

So why are we here? Well, NASA believes that small spacecraft have the potential to shape what is possible when the agency approaches how we do our missions going forward in the future. This presentation and the full plan that's attached to it and is hopefully available to you online, contain some of the desired future states called outcomes in this presentation that we're looking to enable using these small spacecraft platforms. So there's no one single technological solution and many of these technology gaps or plans that we have here can be approached from a variety of different angles.

So what we're trying to present to you today is a number of potential ways that we can go enable these future missions. And then we're looking for help from [inaudible 00:01:32] and academia and how to close these technology gaps and achieve these desired future states. So I want to highlight as we go through this, that this plan that I'm referencing throughout this is a draft and things will change before it is final. As of the recording of this presentation, there is an RFI that will be imminently released that asks for feedback from the community on the small spacecraft technology plan. So please be looking for that. Small spacecraft are proving to be a disruptive innovation for exploration discovery in the expansion of space commerce. So NASA's pursuing rapid identification development and testing of capabilities that exploit these agile spacecraft platforms and responsive launch capabilities. Again, we're looking to increase the pace of space exploration, scientific discovery, and help expand space commerce.

This plan is largely focused on CubeSats and microsatellites, but again, this is a draft and that size discussion is active and subject to change. And also in this plan, we are talking about some elements of responsive launch, including suborbital capabilities. So expanding the sphere of human presence, economic activity, knowledge deeper into the solar system requires capabilities that can be fielded faster and at lower cost. So how do small spacecraft fit into these architectures for exploration, discovery and space technology that NASA's pursuing? So within exploration, we have exploration precursor missions that are looking for resources that are attempting to identify risks. And then we also have potential exploration infrastructure like communications networks and navigation capabilities that could be potentially fielded around a body like the moon much in the way that we have space infrastructure that helps us navigate and communicate here on earth.

In fact, there's an RFI from the scan group at NASA, out on the street right now about how commercial capabilities could help provide communications capabilities around the moon. And then within scientific discovery, there's a lot of interest in how small spacecrafts can be used for distributed missions, much in the way that small spacecraft constellations are providing new data about the earth. How these distributed systems of small spacecraft can be expanded beyond, used for heliophysics and space weather, telescopes comprised of separate elements that could be used for astrophysics and a number of other innovative ways of using multiple spacecraft for an affordable distributed mission are interesting and potentially of high value to the scientific community. Additionally, similar to the exploration precursor missions, targeted missions to the moon, to Mars, to Venus, and to other places within the solar system using small spacecraft potentially provides a lower cost and more rapid way for us to go make specific measurements about a destination of interest beyond earth.

And then more broadly within the space technology mission directorate, we're trying to embrace within small spacecraft, kind of the agile aerospace practices from industry and use small spacecraft as a platform with which we can rapidly test technologies that are applicable to all of the architectures we just talked about, whether they are for small spacecraft in particular, or might be used on a larger platform. Small spacecraft do provide us that quick, rapid turnaround ability to get that technology on orbit. We have a few desired future states, which we've called outcomes here, but like I said, this is a draft and subject to change. So we're already in discussion that the outcomes are probably not going to look like this when the final version comes out. So instead for the purpose of this discussion, let's think of these as small design reference missions, single line design reference mission.

So what are the desired future states that we are attempting to create? What is the plan that we are putting out supposed to build up to? So I'm just going to highlight a few of them here. So one of the things we're interested in is affordable access to the moon, Mars and the rest of the inner planets and other deep space destinations this side of the asteroid belt. And we're looking to do that with multiple opportunities a year and for a target cost that's under 15 million. And then once there, we're looking for small, rapid and affordable missions that can compete with traditionally scaled systems for targeted measurements at the moon and those other destinations. And again, there we're looking for something that can be developed rapidly. So in this case under three years and at low cost. So we're looking for a mission that can be done for under $30 million, including the launch. And like I said, developed in under three years.

And as referenced earlier, we're also looking at affordable and kind of modular interoperable, communication, navigations, and other support infrastructure that can provide full coverage of the moon and eventually Mars. And again, looking for this to be a low cost system. So how do we build from where we are today to achieving these future outcomes? And so the full plan has a number of these, but I'm just going to give a quick example here today. So looking at that second one, how we develop these small and affordable missions that are competitive with traditional size spacecraft for missions to the moon. There are a number of technologies that feed off of one another and eventually build up to achieving this capability.

So obviously we are doing missions to the moon with small spacecraft, we are doing missions to Mars with small spacecraft, but how do we make those systems more competitive with the larger scale systems? How do we bring that cost and that schedule within these bounds here? And so there's a few technology gaps that we've identified that if closed can help us achieve that outcome. So for example, we need high Delta V propulsion for small spacecraft, and you see that over there as gap SST-01. Now what feeds into that potentially is SST-008, and that is high specific power systems and thermal control for small spacecraft. And you can kind of see the connection there. If you are using for example, electric propulsion to get your high Delta V, you're going to need some source of higher power than we currently have available on these small platforms. And so by achieving those two outcomes, you can see how you build your way forward to having a system that can achieve this desired future state.

Similarly, you're going to need deep space communication, you're going to need earth and GPS independent navigation and timing, and there are elements that potentially feed into there. If you're going to go do something around an asteroid or a low orbit, you're going to need some kind of proximity operations capability. And again, there are all elements of these technologies that are being worked on today, but what we're looking here is to identify the gaps that we want to close. And in the next couple of slides, I'll give you a few examples of those gaps and some of the specifications we're looking for there. First example here is that aforementioned high Delta V propulsion for small spacecraft. So again, enabling many of these missions we have envisioned for this small class of spacecraft. They're going to require two to five kilometers of Delta V over a multi-year life of the mission.

So if we're going to enable that level of propulsive capability in CubeSats or similarly sized or slightly larger microsatellites, it's going to have to be high impulse per unit spacecraft, high total impulse, and still remain low power per unit of spacecraft and compatible with secondary payload launch restrictions. Another example here is earth and GPS independent position navigation and timing. So again, as we expand small spacecraft further to deep space, we're going to need highly accurate position knowledge and precision timing that doesn't rely on GPS or other earth centric aids. So future spacecraft are going to need to be able to determine and potentially transmit this relative and absolute position, as well as keep and exchange precise timing. This is required for these standalone missions, for exploration precursor missions or discovery missions. But also if small spacecraft they're going to act as infrastructure for exploration, and especially if they're going to be used for distributed missions that are comprised in multiple small spacecraft.

So some potential technology techniques here could include enhanced visual navigation capabilities like star trackers that can also be used for relative navigation using surface features or other spacecraft to things that may be a little bit more exotic, like measuring x-ray emissions from pulsars, laser range finding. These are not necessarily new technologies, but these capabilities within this form factor and at these price points potentially requires additional technology investment. So again, we need to be compatible with the inherent size, weight, and power constraints of CubeSats and other microsatellites, and they need to be processed on board, which can also be a challenge. And then finally, one of the things that we think is somewhat inherent to our use of small spacecraft going forward is the ability to produce these spacecraft in batches and make them modular. So the interchangeable hardware and software standardizations that allow these spacecraft to be built from somewhat plug and play capabilities allows us to tailor spacecraft designs for novel applications and deep space applications without requiring significant modification from commercial off the shelf platforms.

So this modularity can also be used to increase this reliability and introduce these new functionality without sacrificing the ability to leverage the innovations from the commercial sector. So we want to partner with industry on how we can make small spacecraft in these large batches that are going to be required for distributed missions like synthetic apertures and disaggregated science observations, or these planetary relay constellations. And also how we can leverage the advances that are occurring with commercial off the shelf hardware and yet also customize those spacecraft to a degree for these NASA unique and deep space applications. So going forward, how does the plan help you? Well, again, this is still a draft plan. It is subject to change and is already changing since we've first made this presentation or recording this talk.

The objective of the plan is to clearly communicate NASA's needs as we currently see them. We're in the process of having NASA prioritize what the technology gaps that we are attempting to invest in are, and that will inform future solicitation and investments, including SBIR topics. And we're going to be putting out an RFI is hopefully out by the time you see this for the feedback on this full plan for the small spacecraft element of it. And we welcome your feedback on how you think we should go after our desired future states, if we have identified the correct technology gaps, and if there are any other alternative approaches or additional information that you think NASA should have when looking at how we move forward and how we enable these new capabilities that we are looking for with small spacecraft. Because again, we want to work with industry and academia to adapt these commercial solutions and these terrestrial technologies for deep space and for other NASA unique capabilities.

And before we close here, I want to make a quick plug for the two programs I am the program executive of and how the small businesses such as yourself can take advantage of or participate in those programs. So Small Spacecraft Technology program, here we're looking to expand the ability to execute unique missions through rapid development demonstration of small spacecraft for exploration science and the commercial space sector. So Small Spacecraft Technology often leverages SBIR develop technologies to help bring them to flight. And so SBIR companies, I would say should generally stay aware of the program's activities and opportunities. And if you go to the link at the bottom there, you'll be brought to the website where there is a link you can navigate to our currently open opportunities. That's one of the places where we're going to post this RFI I've mentioned a few times. And then with my other hat on, the Flight Opportunities program facilitates rapid demonstration of promising technologies for space exploration discovery, and again, expansion of space commerce through suborbital testing with industry flight providers.

So we have an annual solicitation that provides funds for suborbital flight tests with commercial providers. Companies that already have SBIR phase one awards are eligible to come to us and have flight opportunities, explore facilitating testing via phase three. If that test is of interest to both the commercial entity and into NASA, we can help facilitate that. And also Flight Opportunities can act as a so-called external investor in a post phase two activity that includes suborbital flight testing. So if you're looking at a phase two E or X and suborbital flight testing is part of your plan, you can come to us and potentially we can help provide that matching funding that is needed for those awards. So with that, I will hopefully be available later this week, if depending on the time you're looking at this, for a live session to answer any questions you might have. So please check the schedule for that. And again, thank you very much. Appreciate your attention.