Ask Me Anything Webinars - Session 9

TX05 – Communications, Navigation, and Orbital Debris Tracking and Characterization Systems and TX17 – Guidance, Navigation, and Control (GN&C)

TX and Subtopic	Question	Answer
TX05 - Communications, Navigation, and Orbital Debris Tracking and Characterization Systems - H9.08	1. Will a spot shielding solution directly 3D printed on electronic components will be of interest? 2. Can you suggest a particular electronic component that we can coat? 3. What are the temperature requirements?	In terms of shielding for radiation environments, we're open to any approaches for increasing the performance of those devices on the lunar surface. Whether that's shielding or a device manufacturer difference or up screening? That would all be within the trade space so that would be a possibility of interest. The temperature requirements that we're looking at, ideally we'd like to get to systems that could survive the lunar night and to be able to handle rather extreme temperature ranges. -180 to plus 130C is a full range though that would be for the object that it's mounted to. If the device has some heating or can rely on internal heater cooling within its packaging then that could be taken into consideration too.
TX05 - Communications, Navigation, and Orbital Debris Tracking and Characterization Systems - T5.06	What specific coordinate system representations are being considered, and what are their advantages or disadvantages?	Usually, we look at a Cartesian inertial central body centered frame like EME2000, maybe centered at a different body for at the Moon or Mars and otherwise it could be an orbital element frame. Advantages of that would be the separation of the slow changing elements and the fast-changing elements and different uncertainty propagation accuracies in in either frame.
TX05 - Communications, Navigation, and Orbital Debris Tracking and Characterization	Can specific accuracy tolerances be defined for different orbital types to ensure that risk assessments are based on reliable data?	The accuracy of finding the conjunctions that is just going to be in comparison to other methods that are currently in use. That's the best way to compare accuracy of finding those conjunctions.

Systems - T5.06		
TX05 - Communications, Navigation, and Orbital Debris Tracking and Characterization Systems - T5.06	The document mentions that solutions assuming elliptical orbits are acceptable but does not discuss the limitations of these models. Can specific limitations be addressed and quantified?	Limitations of using elliptical assumptions would just be that it won't apply to any any spacecraft or body that's that's in a hyperbolic or parabolic orbit, not captured. I think that's the only limitation of that. Separating out the the two orbital types because if it's just elliptical, sometimes certain models will will be easier, more efficient or faster.
TX05 - Communications, Navigation, and Orbital Debris Tracking and Characterization Systems - H9.08	1) Does software/CAD development and demonstration of the 3GPP technology (such as RF front-end), meet the suggested Phase I objectives? 2) Are there any preferable 3GPP frequency band for lunar communications (low-band, mid-band, or high-band)? 3) Are there any targeted SWaP requirements for such systems?	For phase I a lot of it is conceptual development and flushing out the plan to get to a phase two. If this is a simulation and modeling or a software development effort, that would be of interest for phase I. Specifically, if that's proving out concepts that could be developed into Phase two technology. For frequency bands, we have interest both at FR1 and FR2 for near term plans. We do have some restrictions on the lunar surface within the shielded zone of the moon. That's set aside for radio astronomy. Those are going to be frequencies that are like sub gigahertz. Those would be a little bit tougher to work with. I don't have any numbers saying if you hit 250 watts that's going to be a deal breaker. But one of the things that I would consider to be a really good figure of merit for a proposed technology is how much it could reduce the swap burden for using the standard on the lunar surface.
TX05 - Communications, Navigation, and Orbital Debris Tracking	What specific metrics or benchmarks will be used to evaluate the efficiency of the proposed	So for efficiency, we're really looking at run times; algorithm run times compared to other methods. So of course, faster methods would be more efficient. In terms of accuracy, just miss distance... smaller misses compared to other existing methods.

and Characterization Systems - T5.06	methods for locating the minimum distance and location of the closest approach?	
TX05 - Communications, Navigation, and Orbital Debris Tracking and Characterization Systems - T5.06	The phrase "efficient methods" is used without providing a definition or criteria for efficiency. Can a clear definition and performance metrics be provided for this term?	"Efficiency" would be faster run times of the algorithm for finding the same conjunctions as a other existing comparable methods.
TX05 - Communications, Navigation, and Orbital Debris Tracking and Characterization Systems - T5.06	What criteria will be used to establish collision risk thresholds, and how will these thresholds be validated?	The call recognized this as a gap and so it's asking for studies to establish recommendations for overall environments other than the Earth. Parameterized examination of the environment to develop these thresholds for taking action, so typically based on uncertainties, the uncertainties of the of the ephemeris and so It's requesting, novel ways to come up with these thresholds in order to categorize the risk based on uncertainties.
TX05 - Communications, Navigation, and Orbital Debris Tracking and Characterization Systems - T5.06	What specific obligations do the navigation teams have in providing trajectory data, and what are the repercussions if they fail to do so?	There's a NASA procedural requirement NPR 8079.1 that requires NASA missions to provide ephemeris information for conjunction screenings in environments with multiple resident space objects. For any party operating in that environment, failing to share ephemeris just increases the risk of collisions. Since objects are really not passively trackable at Lunar and Mars distances from the ground, the only way that we can find these conjunctions is by sharing information. And so failing to do that just really increases the risk of collisions.
TX05 - Communications,	Does a system level design and analysis of a	Assuming the radar system is made of a bunch of modules, I think they're asking if they can just simulate a single module. If that's the bottleneck for the full sensor then fine, but we need some

Navigation, and Orbital Debris Tracking and Characterization Systems - Z-EXPAND.04	radar technology along CAD simulation results at the module level meet the suggested Phase I objectives for this topic?	confidence that the resulting full sensor will be able to be used to detect, gain, and then maintain custody of the small debris. For example, it may be the case that multiple radar stations or other sensors are also required to maintain custody of the debris as it goes overhead. A great response would estimate the performance of the full toolchain using this sensor and what the overall performance might be.
TX17 - Guidance, Navigation, and Control (GN&C) - H9.03	For the Autonomous Onboard Spacecraft Navigation and Guidance solicitation, is the development and application of novel computationally efficient physics models, needed for autonomous proximity operations, in scope for Phase I?	As long as the models justify increased computational efficiency of algorithms and software with the applications stated in the solicitation, the development as stated is in scope as it intersects a couple different sub-bullets on it.
TX05 - Communications, Navigation, and Orbital Debris Tracking and Characterization Systems - Z-EXPAND.04	The topic description mentioned that (on page 351) "Radar systems in the X-band (or smaller wavelengths) can detect 1 cm debris". Can you help to point to references for this?	For example, the HUSIR radar is often used to statistically sample the small debris population. Here is a paper that describes such data collection campaigns. Radar Measurements of Orbital Debris from the Haystack Ultra-wideband Satellite Imaging Radar (HUSIR): 2020-2021 https://ntrs.nasa.gov/api/citations/20230014281/downloads/Arnold_HUSIR_IOC%20II_final.pdf
TX17 - Guidance, Navigation, and Control (GN&C) - H9.03	Would a product working with optical communication and autonomous	Generally, just software and algorithm development is referred to subtopic H9.03, with S16.03 looking into hardware development. Depending on what your firm proposes, that would be the general criteria to determine the subtopic in this area.

	relative navigation sensors within scope for this subtopic?	
TX05 - Communications, Navigation, and Orbital Debris Tracking and Characterization Systems - Z-EXPAND.04	What are some of the characteristics of space debris which makes tracking/identifying them difficult? How close are they to each other? Do they constantly collide into each other? Any significant differences between debris size?	There are lots of reasons why it is very difficult to track and maintain custody of small debris in general. It's very small and so it doesn't reflect much light or radars compared to larger objects, but many of those challenges may or may not apply here in the same way. It comes down to doing that initial find and orbital determination and then being able to hand that over quickly to some other beam director. That handoff is not a part of this, but just we need to be able to maintain custody of an object for only a few minutes one object at a time.
TX05 - Communications, Navigation, and Orbital Debris Tracking and Characterization Systems - Z-EXPAND.04	For TX05.6 'Z-EXPAND.04: Low Earth Orbit (LEO) Sustainability (SBIR)' (S14.01), specifically 'Scope Title: Small Debris Tracking to Support Debris Removal', the proposal specifically mentions ground-based solutions to support laser removal of orbital debris. Will space-based solutions that can support laser removal of orbital debris	The method of removing orbital debris that we are exploring here is using a ground based laser. If it is a proposal for a space based laser, then that would be out scope. If the sensor for doing that initial detection and maintaining custody happens to be in space, then that would technically be in scope. You would need to justify why a space based sensor or how many space based sensors would be required to perform.

	also be considered?	
TX05 - Communications, Navigation, and Orbital Debris Tracking and Characterization Systems - Z-EXPAND.04	An additional follow up on TX05.X, Z-EXPAND.04: What are some of the characteristics of space debris which makes tracking/identifying them difficult? How close are they to each other? Do they constantly collide into each other? Any significant differences between debris size? Can you help to point to some references to these?	If you are trying to build a catalog and maintain custody of these objects over longer periods of time, indeed it's a function of that. There's so many of them that it makes it very difficult that you may have a lot of tracks that appear to be relatively overlapping, and it's difficult to correlate measurements from 1 overpass to the next. Most of those concerns don't come into play for SBIR because we're not trying to maintain custody over the course of multiple revolutions. We just need to see the things that come up over the horizon and then be able to follow it for 2 minutes perhaps. The shape of these things will have an effect if they're sort of plate like and they're rotating, you may be trying to engage it when the debris is edge on to your sensor as opposed to perpendicular to the sensor which will change the amount of signal that you get back. These are some of the the considerations that make it hard to detect and then follow these types of objects.
TX05 - Communications, Navigation, and Orbital Debris Tracking and Characterization Systems - Z-EXPAND.05 - HEO	Are there any specific phenomologies in mind? referring to HEO Orbit Tracking	We are not prescribed to any type of phenomenology. We just need to track the objects. Typically, the challenge is that these objects appear typically in low Earth orbit and higher Earth orbit. If you have another phenomenology that can go from Leo to Geo to do the tracking or be able to track it, one area to be able to accurately predict the orbits, the other areas, that's great as well.
TX05 - Communications, Navigation, and Orbital Debris Tracking and Characteriza	Non-Earth Orbit Conjunction Risk Analysis, have any algorithms or frameworks been developed in previous STTR efforts? If so, what are the	The answer is no. There haven't been any previous STTRs developing methods specifically for non-Earth conjunction assessment.

tion Systems - T5.06	evaluation metrics and methodologies used to assess their effectiveness?	
TX17 - Guidance, Navigation, and Control (GN&C) - Z-EXPAND.03, Enhanced Space Traffic Management Technologies for Small Spacecraft Swarms and Constellations	For small satellite identification and tracking systems, is the focus on passive systems, or can active systems be proposed if they are operated independently of the host spacecraft?	The bottom line answer is yes. However, we have to look at if the independent method is not really part of the platform itself. Then there has to be a fairly reliable system of being able to main track of the item which were questioning. Yes, it could be an active system, but that active system must be able to assure with some high degree of reliability that it can maintain the lock with regard to the item of interest.
TX05 - Communications, Navigation, and Orbital Debris Tracking and Characterization Systems - T5.07: Communications Quality of Service (QoS) Optimization Through Network Autonomy (STTR)	Are there examples benchmarks/workloads that are preferred for testing our QoS approaches?	There aren't a lot of benchmarks available for space networks, but an approach that I would recommend would be developing something like a lunar scenario or a set of multiple nodes. There's a wide variety of free simulators and network emulators that could be set up. That would be the comparison that we could use to develop your own benchmark.
TX05 - Communications,	For t5.07 is a rad hardened router and encryption	It would be related, it's not specifically routing, but a router would be a component. We're also looking for things that would be an emulation of the nodes and service. There'll be several pieces

Navigation, and Orbital Debris Tracking and Characterization Systems - T5.07	unit sufficient to satisfy the phase 1 requirements	developing an algorithm, but definitely including things like what would that hardware look like, the swap and radiation tolerance that would all be excellent things to include.
TX05 - Communications, Navigation, and Orbital Debris Tracking and Characterization Systems - Z-expand.04 - ADR	For Z-expand.04 ADR are the debris objects satellites or spent rocket bodies, or debris from collisions? Or is a solution that addresses all of these desired?	We can already maintain custody of large debris objects like large intact spacecraft, upper stages, etc. But as those objects either release debris as part of their normal missions, you could think flyaway bolts or deployment devices, sometimes they accidentally explode and generate small fragments. Very rarely do things collide and generate new fragments. We're looking at generally fragments of things that used to be active and we can track already anything that is 10 centimeters and larger. We are interested in ways of gaining temporary custody of objects that are smaller, at least as small as one centimeter.
TX05 - Communications, Navigation, and Orbital Debris Tracking and Characterization Systems - Z-EXPAND.05 - HEO	Are desired solutions primarily on the hardware side, or would improvements in software / tracking algorithms potentially meet the needs of this scope?	SW solutions utilizing the network of existing sensor networks would be preferred, but advanced HW systems that might provide significant improvements over any SW solution alone would also be of interest.
TX05 - Communications, Navigation, and Orbital Debris Tracking and Characterization Systems - Z-EXPAND.04 - Small	Can you define "removal" of space debris? Should the debris be vaporized, pushed out of orbit, or something else?	The scope of the EXPANDO 4 is not to develop the removal technology, it is before the removal technology could be applied. We must be able to find and lock onto these small pieces of debris and trying to address the concept of operations, however that the sensor sort of capabilities that were asking for the remediation capability would be nominally to use a laser that could generate a small amount of ablation. Laser nudging just the find the debris and follow it.

Debris Tracking to Support Debris Removal		
TX05 - Communications, Navigation, and Orbital Debris Tracking and Characterization Systems - Z-EXPAND.04 - Small Debris Tracking to Support Debris Removal	Space Debris Prevention for Small Spacecraft (SBIR) (Previously Z8.13): Does NASA have data on the relative threat of dead cubesats on orbit vs. other debris? Basically we're trying to quantify the significance of dead cubesats specifically? (DOA/failed cubesats that can't deploy their deorbit devices)	This study from 2024, and the previous study from 2023 (not linked but publicly available), give a sense for the relative risk associated with large vs small debris. In general, tracked debris are sources of small debris due to fragmentation events; thus, the risk they pose is in proportion to their mass because more mass means more potential small fragments. Cost and Benefit Analysis of Mitigating, Tracking, and Remediating Orbital Debris https://www.nasa.gov/wp-content/uploads/2024/05/2024-otps-cba-of-orbital-debris-phase-2-plus-svgs-v3-tjc-tagged.pdf?emrc=675c53c77755f
TX05 - Communications, Navigation, and Orbital Debris Tracking and Characterization Systems - Z Expand.04 ADR	Following up on Z Expand.04 ADR, the solicitation asks for controlled reentry of large debris greater than 1000km, but in your latest clarification you cited the most interest is in debris smaller than 10cm…this seems contradictory, do you want solutions for	The focus is not on small debris. It is generally on larger debris and we're looking for ways of getting controlled reentry of objects that are larger than 1000 kilogram or what's called just in time collision avoidance, which is when you have two large objects that might be about to hit each other. You could avoid that collision by nudging one of those objects out of the way of the impending collision. That could also be done with a laser.

	large debris as well?	
TX17 - Guidance, Navigation, and Control (GN&C) - S16.03	Would proposals to develop low SWaP high-resolution sub-components of inertial measurement units (IMUs) be acceptable for GNC applications? For example, sensor development is solely focused on accelerometers or gyroscopes.	The development of submodules of an IMU would be acceptable, especially if they produce savings in swap, especially size and and power or increased performance.
TX17 - Guidance, Navigation, and Control (GN&C) - H9.03	The scope mentions several capabilities already developed by NASA such as cFS, GIANT, etc. Is it required that proposals incorporate existing NASA tech? Is it expected that integration with these packages occurs during Phase I?	It is not required but is highly encouraged. An infusion process enables awareness that connects capability and deliverables to our bigger picture NASA mission program needs. If you do decide to do so, it does not need to occur during Phase 1 but should be considered as the technology develops.
TX05 - Communications, Navigation, and Orbital Debris Tracking and Characteriza	Regarding hardware for extreme lunar temperatures (-180°C to +130 °C on the lunar surface):	Yes. Speaking to hardware operation for temperature, I think it would be a two-part answer. If we just had hardware that could survive the lunar night and become operable again during the next lunar day, that would be of interest. If you have hardware that could operate throughout the lunar night, that would be of more interest, but we'd be interested in both types of technologies.

tion Systems - H9.08: Lunar 3GPP Technologies	-Does the hardware need to be operable at those extreme temperatures, or it only needs to survive (and not necessarily operate/communicate) in extremes temperature? -Are technologies that only focus on radiation tolerance in lunar environment (that basically assume presence of other cooling/heating mechanisms outside of the wireless hardware) acceptable for this topic?	
TX17 - Guidance, Navigation, and Control (GN&C) - Z-expand-03	Has language "Highly desired technologies include those based on fueled propulsion systems using nontoxic fuels, “green technologies,” and propellants. What is defined as "Green Tech and propellants? Is Green based upon immediate	With respect to green propellants, green technologies, that's a very popular term. It doesn't identify specific fuel mixtures in regard to that, but in general it's addressed as a propellant that doesn't leave toxics of any sort relative to it. It's also one that does not leave large particulates as a result of the burn. FM ascent in hand are green propellants, but also in terms of green propulsion, you have solar sailing and some other techniques that are used that essentially are very green with respect to the residuals. They might leave as a as they do the propulsion activity.

	hazard to human technicians or long term persistent hazards such as mutagens, carcinogens, etc? Is a green propellant allowed to any of the popular propellants such as AFM-315E, ASCEND, HAN, ? Is there a particular size of propulsion that is allowed or not allowed?	
TX05 - Communications, Navigation, and Orbital Debris Tracking and Characterization Systems - T5.07: Communications Quality of Service (QoS) Optimization Through Network Autonomy (STTR)	What is meant by network autonomy? Is this referring to the network nodes adapt their own QoS policies given reliability metrics (e.g., dropped packets) or will the changes still involve some human-in-the-loop?	It is more closely the first part where you're saying where the network would be adapting. To reliability metrics and performance there, there still would be because this is a policy management, there would still be the concept of there's a user and then there is a service agreement as part of the network. But then it's taking actions in an autonomous manner.
TX05 - Communications, Navigation, and Orbital Debris	Is it assumed that the propulsion tech operate for the duration of the mission. Is there	It is not an assumption that the propulsion system would operate for the duration if the means actively engaged in propelling. It is assumed that the propulsion system would work when they require it to work during the entire mission and there is no specific quantitative numbers of starts and stops. If that's referring back to the amount of particulates are contaminants set at may result in

Tracking and Characterization Systems - Z-expand-03	an expected number of starts, or delta - v?	that would be dependent upon the mixtures of the propellant as to what that would be. Then you would need to know how many active propulsion events you had.
TX17 - Guidance, Navigation, and Control (GN&C) - S16.03 Guidance, Navigation, and Control	High temperature superconductor attitude control system is applicable?	I take this to be if our high temperature superconductor is something that we would be looking for. I wouldn't rule them out. It would depend on their application to basically making higher performance lower swap. Add to control systems, so it depends on what the application is.
TX17 - Guidance, Navigation, and Control (GN&C) - Z-Expand-03	Is there a minimum number of starts, that would be of interest for propulsion tech?	There is no minimum number of starts. All of that is very mission dependent. They would have to just quantify on the basis of extreme scenarios. Relative to normal type of mission executions.