Ask Me Anything Webinars - Session 2

TX04- Robotic Systems and TX10 – Autonomous Systems

TX and Subtopic	Question	Answer
TX10 - Autonomous Systems – A2.02	If submitting under "NDAA compliant flight computers" should the focus be on delivering hardware + interfaces to enable the autonomy goals listed here? Or can the proposal also include development of specific capabilities that match with some of the main A2.02 sections?	You could address the capabilities, or you could address the flight, computer hardware, or both. Those are potential projects that might have compelling infusion opportunities, let's say. Probably not the only ones. Based on the solicitation itself, that's very seems very much focused on this CAS SWIFT project, which is a small to medium size scale.
TX04 - Robotics Systems - H15.01 Autonomous Capabilities for Lunar Surface Mobility Systems	Performance Metrics for High-Progress-Rate Driving: What specific quantitative metrics define high-progress-rate driving, and are there benchmarks or performance standards to be adhered to?	Some of the publicly available documents that you have to dig a little bit for, but one of the biggest things that is emphasized there is speed made good, which is essentially the amount of distance traversed over a set of time. That is a metric that you can think of that takes into account not just instantaneous speed but longevity. Of charge, longevity of mobility, as well as energy considerations. That's one of the things that we're really focusing on, but that can be achieved at that speed. Many good metrics can be achieved in multiple ways. So that isn't an open trade space for people that are responding. The primary metric is "Speed Made Good", the rate of progress over medium-long term from a starting point towards a destination point. Comparison is to other surface rovers (such as VIPER) and Mars rovers.
TX10 - Autonomous Systems – H6.25:	What is the Expected TRL at the end of Phase I for	Phase I is feasibility only, but if you don't show in your proposal that you are acknowledging the issues that would be needed for that eventual deployment, then that's definitely not what we are looking

Trusted Autonomy in Space Systems, Z-ENABLE.05: Extensible Perception, Manipulation, and Interoperability for Autonomous Robotic Systems, H15.01: Autonomous Capabilities for Lunar Surface Mobility Systems	each of the three subtopics? Can we focus on developing novel PoC algorithms or improvements over the state-of-the-art in Phase I while deferring integration with NASA missions in Phase II and Phase III? Can we defer testing novel PoC algorithms or improvements over the state-of-the-art developed in Phase I on hardware that can be deployed to NASA missions in Phase II and Phase III?	for. We are looking for technologies that do have a path to infusion, so that should be demonstratable even in your Phase I plans. The IT is feasibility but critically looking at what are the technical risks and targeting the early ones withing that feasibility is critical. The answer to does it need to be a simulation, prototype, etc? It depends. The context of what technology you are proposing or the solution you are proposing a mismatch there of doing a paper study on one thing or a simulation, or actually building a prototype will depend on the specific technology that you are doing. That has to be matched.
TX04 - Robotics Systems - Z-ENABLE.04: Robotic Hardware for In-Space Manipulation	Where can we find a quantification of the environmental conditions such as temperature range, radiation levels, etc. “for each of the environments in which the end effector must operate, such as Lunar	https://ntrs.nasa.gov/api/citations/20200000867/downloads/20200000867.pdf is a good reference (DSNE)

	Surface, LEO, Gateway, etc.?	
TX04 - Robotics Systems - Z-ENABLE.04: Robotic Hardware for In-Space Manipulation	What level of detail are you expecting for demonstrating a "clear infusion path"?	Commercial partnerships (with commercial space businesses); show support for use cases and functions in the NASA Architecture Definition Document & white papers (https://www.nasa.gov/moontomarsarchitecture/) or other public mission needs definitions
TX04 - Robotics Systems - Z-ENABLE.04: Robotic Hardware for In-Space Manipulation	Do you have any performance or cost targets identified for the end effector?	The emphasized context of this subtopic scope implies approaching the problem from ground-up versus spaceflight-down. In other words, working the gaps in performance and cost to be more in-line with ground-proven technologies.
TX04 - Robotics Systems - Z-ENABLE.04: Robotic Hardware for In-Space Manipulation	Regarding the 'manipulation of softgoods' requirement - what types of fabrics or flexible materials are most critical to handle? Are there specific challenges with current end effectors in managing these materials?	Good examples are: CTBs and cables for mating / demating
TX04 - Robotics Systems - Z-ENABLE.04: Robotic Hardware for In-Space Manipulation	When integrating with existing NASA robots like iMETRO or ISS Astrobee - what are the key interface requirements or constraints that proposals	Astrobee is a robot with defined payload interfaces (which can be found here: https://ntrs.nasa.gov/api/citations/20190002595/downloads/20190002595.pdf). iMETRO is a robotics testing facility that can support a variety of different use cases with different interfaces, but generally the iMETRO interfaces are existing human interfaces with minor modifications for robotic compatibility (see https://ntrs.nasa.gov/citations/20240013956).

	should consider?	
TX04 - Robotics Systems - Z-ENABLE.04: Robotic Hardware for In-Space Manipulation	The scope mentions 'rich sensor feedback' for remote operators - what specific types of feedback are most critical for effective supervisory control?	It depends on the specific application
TX10 - Autonomous Systems – Z-ENABLE.05: Extensible Perception, Manipulation, and Interoperability for Autonomous Robotic Systems	The scope mentions 'hot pixels' from radiation damage - what level of sensor degradation should perception algorithms be robust to while maintaining acceptable performance?	I don't think I can quote a direct like thresholds or goal here with respect to that. In terms of what level of sensor degradation, but just to give to paint the picture, there's been a lot of. Advancements within the robotics realm and industry with respect to computer vision or time of flight, sensors, lidars, etcetera. That are basically making the assumption that you do have relatively perfect data. Obviously, there's noise with respect to that, but radiation effects on some of these sensors creates stuck pixels, burnt out pixels or other things, some of which can be cleared, and those radiation effects on those sensors working around those. It's a different type of noise than, gaussian noise. The goal here is finding algorithms that are robust to those unique radiation environmental. Issues with respect to these sensors, so outside of hardening sensors, algorithmic algorithms that are robust to those are really important as well.
TX10 - Autonomous Systems – Z-ENABLE.05: Extensible Perception, Manipulation, and Interoperability for Autonomous Robotic Systems	How should perception systems handle communication dropouts during teleoperation? What kind of state information needs to be maintained and updated to support smooth resumption of operations?	Definitely account for those types of communication. Dropout as well as different kinds of dropout that can be planned for. Dropouts that we actually see all the time with ISS plan for transitions of satellite coverage for example. Then there are the unexpected dropouts, where you would want your reception system to fail safely. In some cases, just waiting for the next available opportunity or in some cases, responding in a more dynamic way, so that it moves to an area of better communication or where it is safe until things can resume. Some of this does depend on the architecture. I can imagine lunar surface and Artemis to be a different communications environment that perhaps dedicated rovers like VIPER. You see a lot of data being applied to prognostics. Not so much the diagnostics in real time. Using large data analytics, is that something that could be done on board. Those are all important research questions that could be a part of a Phase I proposal.
TX10 - Autonomous	For 'situational awareness'	It depends on the specific application, but generally at a minimum operators should be aware of: 1) robot position/pose; 2) time of last

Systems – Z-ENABLE.05: Extensible Perception, Manipulation, and Interoperability for Autonomous Robotic Systems	during teleoperation - what specific types of perception data are most critical to relay back to operators given bandwidth limitations?	data update for all parameters; 3) pose of known and perceived object in the robot workspace; 4) Health & status information for the robotic system
TX10 - Autonomous Systems – H6.25: Trusted Autonomy in Space Systems	Is prototype software/demo also expected for Phase I? In addition to the literature survey, and description of proposed. Approach asked for?	No, we are not looking for prototypes for demonstrations. If you do propose that that be great, but it is not an expectation.
TX10 - Autonomous Systems – A2.02: Enabling Aircraft Autonomy, Scope Title: Autonomy for Rapid Research	Fault tolerance is mentioned as a barrier for aircraft autonomy especially for flight computers. Is radiation tolerance also a goal?	Radiation atop radiation tolerance is not the highest priority or a high priority on the issue of tolerance for applications in advanced air mobility. That would probably be a lot more of a concern for planetary vehicles. That's not to say that sometimes armd projects or projects are under armd do not address autonomous technologies, or problems that involve vehicles that might be planetary like the Mars helicopter, let's say, or some other kind of Mars vehicle. In which case radiation tolerance would be a concern, but as I read the the actual solicitation, it seemed very focused on Earth advanced air mobility applications. I don't think that is as high as a priority. I wouldn't make that the only issue someone is addressing if they are addressing it.
TX10 - Autonomous Systems – A2.02: Enabling Aircraft Autonomy	For the NDAA compliant flight computer. 1. Do you want any integrated sensors (i.e. Inertial Measurement Units, GPS) or is the assumption this task would be just developing the	1) I would say there isn't. There is not a definitive answer for that. Neither of those possibilities are excluded if the provider has a comprehensive solution where GPSINS solution is incorporated with some other sensors. If it were a flight computer that just had the interfaces for those sense data streams. That would be acceptable as well. 2) I would say based on the solicitation; it looked very much focused on this CAS swift vehicle, which is kind of like a a NASA experimental vehicle for autonomy experiments and flight control law experiments. So usually for those kinds of vehicles, we manage safety through the NASA safety process for flight tests. Single strand would be acceptable if redundancy were part of the solution as part of the technology being developed. 3) I think dual would be fine and be a plus. I think it should address manned aircraft since the in the long-term application intention or utility is for advanced air mobility.

	computer and sensor data would be coming in over a bus from the ship or an external sensor? 2. Any there any redundancy requirements or is single string ok? 3. Is this solely for manned aircraft or is it potentially dual use with unmanned aircraft as well? 4. Are there SWAP-C or thermal requirements?	Addressing the ability to commercialize the product into something that is useful to manned aircraft is going to be a plus. 4) I did not see any in the solicitation, so I don't want to say what those are. I would just use your best judgment in terms of the scale of the vehicle. For an experimental vehicle, wouldn't be very small, but it would probably would not be a full size vehicle that carries passengers. Given that it's also an experimental vehicle, having more endurance is always a plus.
TX10 - Autonomous Systems – A1.11: Health Management and Sensing Technologies for Sustainable Aviation Vehicles	Health management technologies for the sensing, diagnosis, and prognosis of degradation and faults in flight quality electrical hardware and systems. Overall power quality including degradation/faults leading to voltage ripple, power instabilities, etc. Questions:	The general response to that is we're not going to necessarily prescribe methods to solve the problem. We would hope for the proposers to make the case as to the weights is integration etcetera of the sensor system within their response to the proposal call, not prescribing it per say. We're not going to say what size and weight it should be, etcetera, but one should make the case within the proposal.

	(1) Is there a Size, weight and power constraint for the sensor? (2) Is there an expected cost per unit when in production? (3) Should the sensor be integrated with other sensors/modules and share a data processor, or it should have its own data processor and provide estimation results?	
TX04 - Robotics Systems - S13.01 - Robotic Mobility, Manipulation, and Sampling	The topic explains more of manipulation and handling. Not much of mobility. So is the interest in NASA for the former types? Second question - Are aerobots and ocean world mobility in scope and of interest?	Mobile manipulation is where mobility comes in. There are other topics that focus on mobility system specifics. However, there is overlap between sensing and control needs between mobility and robotics technologies.
TX04 - Robotics Systems	Is a simulation pk for phase 1 deliverable?	It depends. As long as the simulation is relevant to the technology risks. For example, a simulation for an algorithm working within Mujoco might make sense for some things whereas simulation of failures for sensors in another might makes sense for others. Moreover, a hardware effort will focus on testing.
TX04 - Robotics Systems	Is there any interest in resilient data management	That depends on the application. In human exploration there's a there a lot of tasks that are at human scale. Something similar does not have to be humanoid, but it can be that at a similar scale of object and range of motion as a human can be slower. A lot of

	across the robotic systems?	things can be accomplished during times when the crew aren't there. It just depends on whether you're trying to capture free flying objects or something like that requires a very fast system versus objects that are relatively stable. It all depends on your application and if we have needs in all those areas.
TX04 - Robotics Systems	Do you want an end effector that is already commercially available or is an end effector not yet on the market also valuable?	Innovative uses of existing end effectors as well as new design end effectors are all in scope if the proposed research supports a NASA mission need.
TX10 - Autonomous Systems	Are you all looking for SENSOR Internet of Things to manage maintenance of the vehicles? Geospatial location of Aviation Vehicles?	We are not necessarily after geolocation for that. Sensor Internet of Things, not necessarily where we would let proposer make a case of how their technology address health management and sensing technologies for. Sustainable aviation vehicles, although there is an aspect to this where maintenance is being addressed and where, for example, looking across multiple vehicles and understanding the data coming from them would be of help.
TX10 - Autonomous Systems – Z-ENABLE.05: Extensible Perception, Manipulation, and Interoperability for Autonomous Robotic Systems	Is it safe to assume there is a CAD model available for object classification, pose estimation, and grasp planning or is it more valuable to assume no CAD model is available?	It depends on the application and the task at hand. Certainly, within habitat, there are CAD models of the robotic system or big parts of the habitat itself, but when looking at tasks with regards to CTP manipulation or cable manipulation, the CAD mouse can be of limited use. If you're looking at lunar surface applications, that's a whole other thing. Again, it really depends on your task and your concept. But certainly, could be valuable to not assume you have that CAP model.
TX10 - Autonomous Systems – A2.04: Aviation Cybersecurity	Is there any interest in wireless communications (C2) for lunar autonomous systems?	Specific wireless communication technologies would probably be covered in another scope. But their relation to autonomy or requirements for robotics may be related to these scopes, but it really depends on the context there.

TX04 - Robotics Systems - Z-ENABLE.04	Are you expecting either a digital simulation or a physical proof of concept as part of the deliverables for Phase I?	It's not a hard requirement, but typically you want to demonstrate that a phase two would be appropriate. That's one of your goals of your phase one, right? You want to show the feasibility of your concept and that could be with a variety of different types of simulation tools. It could be a by analysis, a foam core mockup or prototype. etc.
TX10 - Autonomous Systems – S17.03 Fault Management Technologies	Will bandwidth availability increase or create limitations with onboard fault management implementation? is there a priority for fault management models like sensor integrity etc?	From an architectural perspective, bandwidth to earth; those kind of things is going to be one of the most limiting factors within the next few years for lunar surface applications. For those reasons for the stress on onboard fault management. The computational and bandwidth limitations are an important part and relevant to the scope of the subtopic. As a part of the solution, that is something that we are interested in. As far as models that would include or have capacity, to measure sensor integrity and things like that, that's definitely also something we are interested in.
TX10 - Autonomous Systems – A2.02: Enabling Aircraft Autonomy	For the NDAA compliant flight computer. What are the current state of the art computers you use and what is their workflow? Are there any references or documentation we can read?	The short answer is no. I would focus more on what the capabilities that this type of research platform would utilize. High redundancy for safety would be something that's a lot more applicable to commercialization. In the context of the solicitation, which seems to be focusing on the cast, swift vehicle, that doesn't seem to be the critical area. It wouldn't have been necessarily some kind of triples or quad redundant flight control computer, but probably a computer that hosts the kind of experiments or algorithms that would utilize the kind of data described in the solicitation. The solicitation addresses stabilizing control laws for vehicles that could be various configurations. There's no particular kind of flight computer that is being utilized at the moment. The workflow is usually something like autocoding Simulink and MATLAB.
TX04 - Robotics Systems - Z-ENABLE.05	Regarding improving the interoperability of ROS and spaceflight software architectures: Is there particular interest on a	I'd go in the direction of ladder definitely into operation. There are some specific systems like CFS and Ras referenced in the solicitation, and so I'd take some direction from that. There's a lot of frameworks that have been proven within the robotics community as well as the Space Flight community and the important piece to stress within that is the interoperability understanding that there are pros and cons. The ensuring that those capabilities and those frameworks can be leveraged to across those frameworks to demonstrate capabilities is more important.

	particular flight software (say, cFS) or is there equal interest/need for general interoperation with flight software tools in general (for instance F').	
TX10 - Autonomous Systems – H6.25: Trusted Autonomy in Space Systems	It is mentioned briefly in the subtopic description, but can you confirm that if we have an ML alternative to convolutional neural networks that is better suited for autonomous and continuous learning at the edge, we could apply under this subtopic?	We do talk a little bit about CNNs in the topic, but the topic is really about the verification of machine learning. If you have an Amal that is not a CNN that you want to verify, you are welcome to propose that. We are not trying to restrict the verification of ML to be only on convolutional neural networks. But we are not looking for proposals that are on different or new machine learning techniques. If there are alternatives to CNN that have their verifiable in different ways, or that improve the verifiability, we're very interested in those. We are interested in computation at the edge and reducing the power and computational requirements for all that. So that combination of doing it at the edge in real time and verifiability of that I think is of interest.
TX10 - Autonomous Systems	Does TX10 include computer vision AI-powered remote monitoring for plant health? Specifically, human autonomous system integration for deep space tactical anomaly response in smart habitats	The purpose is designing smart habits with anomaly response capabilities that are designed for crew interaction and integration of crew and ground input. When we say anomaly incidents, we're really focused on vehicle sub system related incidents.

TX04 - Robotics Systems - Z-ENABLE.04	What is the minimum TRL of interest to NASA for end effectors?	As low as TRL 1; but the more mature the design is the better for demonstrating the potential of the design concept. The better case you can make in your proposal going into the feasibility study, there's an expectation with phase one right that you have to have a pretty well formed idea of what you want to do and show how that connects to NASA mission and needs the relevant to your sub topic. You don't have to have it fully fleshed out, building it and environmental testing it, for example. But you need to think about those things and what your plan is, at least at the high level. As long as you can connect it to a unique mission need and show how that's not met by the existing state-of-the-art.
TX04 - Robotics Systems - Z-ENABLE.04	Is there a baseline reference or target for force range, limb size, speed?	Depends on the application; for supporting human exploration missions, several classes of robot are of interest: 1) Human-scale (ability to do task humans would do, but not necessarily the same way that humans do them); 2) Greater than human scale (e.g., heavy cargo handling); 3) Sub-human scale (e.g., surgical robots, inspection robots (free-flier, "snake" robot, etc.).
TX10 - Autonomous Systems - H6.25: Trusted Autonomy in Space Systems	Do we need to investigate verification for Large Language Models as well? (Which are also Deep Learning models). Or do we focus on models such as Convolutional Networks in use in NASA Autonomous systems?	We're really looking for verification for things that we would use for critical technologies in a flight system. If a large language model application for that comes to mind for you from a NASA perspective, and you have an idea on that, that's great. But we are really looking for things that we would need to verify because they are doing task planning, or anomaly detection, or those sorts of things for one of our spacecrafts.
TX10 - Autonomous Systems	How general purpose should our approach to FM operations be? Should it be generalizable to any kind of subsystem, or can we focus on a specific set of subsystem types?	Either in this case would be fine. We have funded fault management technologies that were, for generalized to any subsystem or ones that focused on specific ones. I don't think for S 1703 that there's any limitation or necessarily a preference.

TX10 - Autonomous Systems	For TX10 computer vision AI-powered remote monitoring for plant health, environmental and microbiome determinations from plant biomarker observations could be made within smart habitats. Is this a relevant fit?	We do. Autonomous systems do apply to smart habitats. We have this topic specifically focused on human autonomous system interaction for smart habitats.
TX10 - Autonomous Systems - Z-ENABLE.05	Does this subtopic encompass flexible coordinated action capabilities and mission planning for a heterogeneous team of autonomous machines to operate autonomously?	In general, we are interested in how multiple robots or agents can work together. In general, we're not as interested in what would be referred to as swarm types of applications, but more about cooperative, at least in the robotic standpoint. We're interested in maybe cooperative manipulation between multiple robots working together.
TX10 - Autonomous Systems - Z-ENABLE.04	Can you recommend the appropriate NASA document that specifies and quantifies Space Environment Conditions - like temp range, radiation exposure, etc. for the	NASA has a public document called the Cross Program Design specification for natural environments DSNE or Disney, as we sometimes refer to it. That document has most of the answers that are needed. DSNE is where to go: https://ntrs.nasa.gov/citations/20200000867

	different space environments?	
TX10 - Autonomous Systems – A2.02	What are the expectations for interoperability with current/state-of-the-art autonomy-enabling technologies?	The priority is to look at new ways to close the gap on dealing with unanticipated events. Interoperability is something we'd probably worry about down the road, at least initially. All in order to generate a procedure to go and address this problem. Find ways to both recognize and deal with unanticipated problems. Whether or not it actually integrates at this point with existing autonomy technologies less important.
TX04 - Robotics Systems	A suggestion was made regarding the need to show a "path to infusion" with systems like Artemis; but, how would one learn where the ICD may be and what is needed at the Artemis systems level?	Yes. It requires a little bit of research to find, but you can find public documentation at some level for different types of for example payload user guides, Pu GS for example for the commercial litter payload services providers, the Lander providers. And also, various payloads on, for example, ISS National Laboratory. Some of this information you have to request. It might not be posted on the Internet, but with a little bit of mining you can find these types of interfaces, even if you don't have a pre-existing relationship with a space provider. M2M ADD: https://www.nasa.gov/wp-content/uploads/2024/01/rev-a-acr23-esdmd-001-m2madd.pdf?emrc=67574f0376860 M2M White Papers: https://www.nasa.gov/moontomarsarchitecture/ M2M Executive Summary: https://www.nasa.gov/wp-content/uploads/2024/01/2023-moon-to-mars-architecture-executive-overview.pdf?emrc=67574f0376687
TX10 - Autonomous Systems – A2.02	For the NDAA compliant flight computer. Are there any bus protocols that specifically should be supported?	Not that I know of, unfortunately.
TX04 - Robotics Systems - Z510 Scope Title: Sensing and Perception Software for Autonomous Manipulation and	For vision system that can perform Object/obstacle detection and segmentation. • Object classification and/or registration. • Pose	I'd say while that this subtopic doesn't rule it out. It's deemphasized, and in fact there's likely other subtopics that are far more relevant to that area of technology development.

Utilization Tasks	estimation. • Grasp detection and planning Are you interested in on-orbit servicing and active debris removal area? If so, are you interested in performing operations around non-cooperative RSOs where the CAD model is unknown?	