

ARMD Urban Air Mobility Grand Challenge Request for Information (RFI)

NASA is hereby requesting information through this notice from interested parties for the following: Industry and other potential partners to participate in NASA's Urban Air Mobility (UAM) Grand Challenge.

Background

The NASA Aeronautics Research Mission Directorate (ARMD) remains committed to enabling new, transformational commercial aviation markets and services with the potential to provide significant societal benefits. In recent years, NASA has strategically invested in technical challenges focused on Unmanned Aircraft Systems (UAS), UAS Traffic Management (UTM), system-wide safety, vertical lift, noise, electrified propulsion, airspace operations, and tools and capabilities to support new aircraft development. These efforts are all examples of well-defined problems that NASA has engaged with diverse partners to achieve specific goals. NASA plans to build on this past experience and lessons learned to help advance the UAM industry. UAM is emerging as one of the most exciting frontiers in aviation history, and the UAM ecosystem and its associated technologies are likely to be among the most complex aviation has ever seen.

The ARMD UAM vision is to revolutionize mobility around metropolitan areas by enabling a safe, efficient, convenient, affordable, environmentally friendly, and accessible air transport system. NASA is committed to working with the emerging UAM community to identify and address the key challenges ahead.

In order to most effectively advance UAM, NASA is planning to host a series of UAM ecosystem-wide Grand Challenges to promote public confidence in UAM safety and facilitate community-wide learning while capturing the public's imagination. NASA anticipates hosting the first of these Grand Challenges, GC-1, as early as the end of calendar year 2020. GC-1 is anticipated to challenge industry and other community participants to address foundational issues related to UAM vehicle design readiness and robustness for UAM operations. Following GC-1, future challenges in this series are anticipated to address key safety and integration barriers across the UAM ecosystem while also emphasizing critical operational challenges, such as commercial viability and public confidence in UAM operations around populated areas.

NASA is seeking highly motivated participants in the Grand Challenge series with the desire of achieving commercial operating capabilities. This is not anticipated to be a monetary award challenge, but rather the Grand Challenge will provide participants the opportunity to demonstrate their fieldable systems in a representative UAM environment.

NASA is releasing this RFI in conjunction with an industry day that can be referenced at <https://www.fbo.gov/index?s=opportunity&mode=form&id=57bbdeecd8e64a6a083ecb19e660cfdb&tab=core&cvview=0> and <https://www.nasa.gov/uamgc>. The industry day will be hosted in Seattle, WA at the Seattle Marriott Waterfront on November 1-2, 2018.

While the Industry Day will allow NASA to have an open interchange with the UAM community and clearly communicate the most recent plans for the UAM Grand Challenge, the responses to this RFI will allow NASA to obtain a more in depth look into the status of the industry and ensure the UAM Grand Challenge addresses the broader community's needs, including understanding critical UAM barriers and how to potentially overcome them. The primary goals of the RFI process are to:

- Collect industry and broader community input to help refine and optimize the Grand Challenge to best enhance and add value to industry efforts in accelerating UAM.
- Allow the government to assess the state-of-the-practice and state-of-the-art of the UAM ecosystem, including vehicle development, airspace capabilities development, and community integration.
- Gauge the level of interest from the UAM community in participating in the Grand Challenge, their ability to bring vehicle, airspace and infrastructure assets, and their anticipated capabilities.

FAA Coordination

NASA and the FAA are planning to collaboratively develop and implement the Grand Challenge series. NASA plans to share RFI responses, data collected, and lessons learned with the FAA throughout the Grand Challenge effort. NASA intends for the Grand Challenge to address information requirements and provide lessons learned to inform FAA policy decisions on safety, certification, operations, and airspace integration aspects of Urban Air Mobility.

Grand Challenge Overview

For the Grand Challenge to be successful, NASA is expecting to partner with industry and other UAM community collaborators that are highly motivated to achieve a commercial operating capability through necessary technology development, testing, regulatory efforts, and other essential activities to enable safe commercial operations. The collaborations NASA feels are essential to make the Grand Challenge most effective include:

- 1) Vehicle developers providing functional UAM vehicles equipped with critical subsystems with a threshold level of demonstrated airworthiness.
- 2) Airspace management system developers providing airspace and air traffic management (ATM) technologies and services built and simulated to a threshold level of UAM airspace management system requirements.

- 3) The FAA to provide recommendations, guidance, and coordination with NASA.
- 4) Other UAM stakeholders including the general public, supporting infrastructure providers, standards organizations, local regulatory authorities, etc.

Vehicle and airspace participants will each be challenged to complete a series of common safety and integration scenarios. These scenarios are designed to represent real-world UAM operations and barriers necessary for certification and operational approval. An initial draft of the Grand Challenge scenarios is provided in the “UAM Grand Challenge Scenarios” attachment, and it is expected that these scenarios will evolve over time as the Grand Challenge is further defined and the UAM ecosystem progresses toward operational maturity.

GC-1 is anticipated to provide a “proving ground” for vehicle developers to individually demonstrate the design readiness and robustness of their vehicles. The flight demonstrations from GC-1 will help inform means and methods of compliance development with the FAA, standards development, desired future airspace services, and airspace management system requirements. Future challenges in the series are anticipated to directly address complex integrated system-level scenarios necessary for UAM markets to be realized.

Vehicle Developers Envisioned Responsibilities

Vehicle developers are expected to provide and operate functional UAM vehicles with a demonstrated level of airworthiness. Participating vehicle developers will:

- Provide vehicle design, development, and test data to support the NASA airworthiness requirements.
- Conduct prescribed flight tests to benchmark vehicle performance and flight characteristics, including demonstration of the ability to safely handle failures and contingencies.
- Conduct safety and integration scenarios for the Grand Challenge including pre-defined interfaces with airspace management systems.

Vehicles that are proposed for inclusion in the Grand Challenge must be representative in size and configuration of a UAM system. For example, in GC-1, the minimum passenger carrying vehicle size would be one that has a payload capability of at least one person even if the vehicle were to be flown unmanned during the Grand Challenge. Sub-scale vehicles could be accepted in GC-1 if the vehicle meets the minimum size requirement (i.e., the ability to carry a payload equivalent to one person) and the company demonstrates a commitment and path to a full-scale UAM vehicle.

As part of the vehicle design readiness and robustness scenarios for GC-1, vehicle companies would be expected to demonstrate the full extent of their flight envelope, plan and fly predictable trajectories within required and desired performance

metrics, predict and measure energy (e.g., battery and/or fuel) reserves, demonstrate noise, operate in winds, perform balked landings, and handle other simple failures and contingencies such as engine/motor out.

Beyond GC-1, future Grand Challenges in the series are anticipated to address key safety and integration barriers across the entire UAM ecosystem to emphasize critical operational challenges towards UAM operations around populated areas. Additional integrated vehicle, airspace, and community integration scenarios will likely demonstrate: interactions between vehicles and both traditional and UAM airspace management systems; the ability to detect and avoid other aircraft and hazards; handling the loss of primary communications, navigation, and surveillance capabilities; public acceptance or response to vehicle noise; etc.

Airspace and Air Traffic Management Service Suppliers Envisioned Responsibilities

Airspace and air traffic management companies and providers are expected to bring technologies and services built and simulated to be compatible with a baseline UAM ATM system design. These airspace and air traffic management participants will:

- Provide UAM ATM technologies that are compatible with a baseline UAM ATM system design and interfaces.
- Demonstrate capabilities that meet benchmark performance and connectivity requirements through simulations or live testing.
- Conduct safety and integration scenarios during the challenge, including pre-defined interfaces with vehicle systems.

GC-1 will likely implement a baseline UTM system with minimal UAM ATM system components. Company-provided UAM ATM services may be able to be implemented as a part of GC-1 scenarios in a “shadow mode” where they would receive live data and be asked to generate acceptable responses to the safety and integration scenarios, but would likely not directly influence the operations. A caveat to these statements may include a concept where vehicle and airspace management service suppliers team and create a single unified concept of operations for GC-1.

In Grand Challenge scenarios beyond GC-1, airspace companies would perform airspace management functions that could include: flight plan services, weather services, surveillance services, scheduling services, contingency management, separation services, UAM port operations, etc. It is possible for airspace providers to partner with vehicle developers to interact in real-time with the vehicle interface to perform the challenge scenarios.

Community Integration

Societal integration and acceptance of UAM operations including public acceptance, supporting infrastructure, operational integration, and the local regulatory environment are of paramount importance for UAM to be realized. The UAM Grand

Challenge has potential to include and showcase many mutually beneficial activities. Examples might include infrastructure concepts such as UAM ports (i.e., vertiports, skyports, heliports, etc.) and charging stations being provided by partners, a public outreach campaign targeted at public confidence and acceptance, a strategic partnership with standards and operational organizations, local regulators' assessment of local regulations, and demonstrations of capabilities and benefits of future Smart Cities.

[NASA Airworthiness, Airspace System Interfaces, and Relevant Test Environment](#)

NASA believes that to successfully conduct a UAM Grand Challenge as soon as 2020, essential interfaces and expectations must be available quickly. For GC-1, NASA believes the critical components are: airworthy vehicles; interfaces between vehicles and a basic UTM system; a set of common safety and integration scenarios; a common set of data collection capabilities; and a set of common range requirements to support participation by non-NASA test range providers. For Grand Challenges beyond GC-1, each of the elements above will progress as system-level requirements for vehicles, airspace systems, and test ranges are matured toward the goal of enabling testing of robust and scalable UAM operations.

NASA Airworthiness

For companies who plan to have a business model of passenger carrying aircraft, NASA anticipates providing a man-rated Airworthiness and Safety Review process even if there is no pilot onboard (either during the Grand Challenge or in anticipated future operations). The goal of the airworthiness process is to provide a flexible, risk management-based review that ensures the vehicle is airworthy and can be operated safely with the highest probability of mission success. The process will assess, communicate, and accept the residual risks of vehicle test and operation.

Airworthiness and safety of the vehicle will be evaluated by an independent review team based on the company's derived standards. Attached is NASA's "AFG-7900.3-001" document that can be used as a reference for an airworthiness and flight readiness process. In Appendix B of the "AFG-7900.3-001" document there are sample questions that a review board would ask the company; some of these questions may not be applicable to all vehicles.

Interfaces

NASA anticipates providing a set of interface requirements and Interface Control Documents (ICDs) specifically for the Grand Challenge for vehicle and airspace providers to interact with a UAM ATM system.

For GC-1, it is expected that a UTM system will be provided that UAM airspace and air traffic management stakeholders can utilize in GC-1 to start developing the essential interfaces needed for Grand Challenges beyond GC-1, as well as eventual UAM operations.

For future Grand Challenges, airspace and air traffic management systems developed by Grand Challenge participants will be encouraged. The interface requirements between vehicles and the UAM ATM system will allow vehicles to communicate with the airspace management system in standardized formats and perform functions necessary for UAM operations, such as: filing flight plans, obtaining flight approval, maintaining situation awareness of relevant airspace usage and restrictions, obtaining weather information, etc. The interface requirements between UAM airspace service providers and the UAM ATM system will allow extended services, such as weather, surveillance, scheduling, and conflict management.

Relevant Test Environment

In order to provide the airspace complexity desired for the more advanced scenarios (which will be described in the following section), it is anticipated that the Grand Challenge series will incorporate aspects of a Live, Virtual, Constructive (LVC) environment. An LVC environment enables the integration of live flight assets with virtual aircraft in a virtual airspace in order to ensure safety of the participants, aircraft, and test range while providing an environment that is relevant to each specific Grand Challenge scenario.

For GC-1, the LVC requirements are anticipated to be minimal. For Grand Challenges after GC-1, NASA may provide a testbed infrastructure that incorporates representative airspace, virtual elements, and core airspace and aircraft connection infrastructures to collect necessary data to evaluate aircraft and airspace performance. Connection and data collection requirements may vary based on the nature of a specific scenario and are planned to be defined as part of each scenario description.

Range Requirements

NASA is planning to provide a test range option for challenge participants and is currently considering hosting the Grand Challenge at Edwards Air Force Base (EAFB); however, NASA would consider other test ranges that might be interested in building range capabilities for hosting the Grand Challenge, including company owned or preferred flight locations. The long-term goals of the Grand Challenge series include ensuring there is a national capability that allows UAM developers to test complex scenarios required for vehicle and airspace system development, testing, and verification in an on-demand nature.

The Challenge Scenarios

The Grand Challenge consists of a series of “scenarios” that will provide participants with the ability to demonstrate the capabilities of their systems as a part of a broader, integrated UAM system. These scenarios will progress in difficulty and complexity, including starting with vehicle-only and airspace system-only scenarios

and moving toward challenges that will require integration between vehicle and airspace systems and are representative of UAM operations around populated areas.

For GC-1, which is planned to be hosted in the late 2020 timeframe, vehicle participants will each be challenged to complete a series of performance characterization and safety-focused scenarios with a primary goal of helping move these vehicles toward certification. These scenarios include demonstrating the vehicle's performance and flight envelope over nominal UAM-like missions and in off-nominal situations, such as the loss of an engine or motor.

Following GC-1 by approximately one year, a second challenge, GC-2, is planned to challenge both vehicle and airspace participants to complete a series of common safety and integration scenarios. These scenarios are designed to represent real-world UAM operations and help address barriers to certification and operational approval.

For Grand Challenges that may occur beyond GC-1 and GC-2, it is anticipated that vehicle and airspace participants would each be challenged to complete a series of more complex scenarios that build upon previous scenarios, focus on increased technological capabilities, and demonstrate an increased ability to operate in real urban operating environments and the National Airspace System.

Additional Stakeholder Considerations

NASA plans to engage the community and associated stakeholders through a variety of different means to ensure that the Grand Challenge address as many critical needs and relationships as possible. Accordingly, NASA is considering unique ways to include both "participants" and "partners" in the Grand Challenge series. The distinction is that partners would be organizations that are willing to contribute in-kind directly to the needs of a robust Grand Challenge series in a way that benefits the entire community, rather than solely benefiting their specific organization. Partners may provide infrastructure, airspace management systems that are open and can be leveraged to benefit all Grand Challenge participants, vehicles for internal dry-runs of the challenge, LVC technologies, etc. In particular, NASA sees opportunities for local governments and/or "Smart Cities" to participate as partners to provide guidance and investments around issues such as noise data requirements and community acceptance expectations; possible UAM port interfaces with other transportation modes; and developing requirements for and/or investing in an eventual "test site" in one or multiple metropolitan areas.

The community-wide nature of the challenge provides a unique opportunity to work towards standardization of many technologies and best practices. To best enable a collaborative mindset and work toward standardization and requirements development, NASA will likely implement a working group model in the next several months to solicit feedback from across the entire UAM community. Working groups

may focus on developing and/or standardizing scenarios, the airworthiness process, concepts of operation, specific technologies, security, noise, and so forth.

Respondent Expectations

NASA anticipates a substantial response from the entire UAM community. The primary participant(s) for the Grand Challenge will be asked to meet a broad set of criteria. In order to ensure a broad cross-section of the UAM community is represented, NASA is encouraging responses from many different types of service developers and providers to this RFI. Potential partners who may consider responding include the following sectors of the UAM community:

- UAM vehicle developers/operators
- Aircraft sub-system developers
- Airspace system developers and airspace service providers
- UAS avionics and middleware industry representatives
- Ground and aircraft sensor manufacturers
- Communication/navigation/surveillance service and equipment providers
- Test range operators and other entities that could provide a test range for GC-1 or future challenges in the Grand Challenge Series
- Ground station system and vehicle command and control developers
- Ground infrastructure (e.g., UAM port) developers and operators
- Other organizations that can make significant contributions toward the GC goals. Organizations could include: local and state governments, universities, Smart City planners, etc.
- Additional UAM stakeholders

Sub-component suppliers for vehicle and airspace capabilities are encouraged to respond to this RFI; however, they will likely need to partner with a vehicle or airspace system provider to participate in the Grand Challenge.

Foreign respondents electing to participate in the Grand Challenge will be subject to additional requirements. These are requirements initiated outside of NASA and include, but are not limited to, the Wolf Amendment ([Public Law 112-55, SEC. 539](#)) and personnel access requirements to facilities not owned by NASA. NASA may have restrictions on subsequent interactions with foreign companies submitting responses to this RFI due to internal requirements. However, NASA's does intend to consider foreign companies as participants in the Grand Challenge and will initiate discussions with foreign companies as part of the Grand Challenge development process.

RFI Response Instructions

NASA seeks responses to the questions in Appendix A. Interested parties are requested to respond to this notice with an information package, which should include an organizational point of contact. The information packages are due no later than November 16, 2018 and shall be submitted via email only to hq-armd-strategy@mail.nasa.gov and jenny.y.staggs@nasa.gov.

NASA will not publicly disclose Respondents' proprietary information obtained in response to this RFI. Proprietary and export-controlled information should be marked appropriately in your response. To the full extent that it is protected pursuant to the Freedom of Information Act and other laws and regulations, information identified by a Respondent as "Proprietary or Confidential" will be kept confidential. NO CLASSIFIED INFORMATION SHOULD BE INCLUDED IN ANY RFI RESPONSE. No solicitation exists; therefore, do not request a copy of the solicitation. If a solicitation is released, it will be synopsisized on the FedBizOpps and/or NASA Acquisition Internet Service websites. It is the responsibility of any potential offerors/bidders to monitor these sites for the release of any solicitation or synopsis.

Appendix A: RFI Questionnaire

The RFI response information package should be submitted in either Microsoft PowerPoint, Microsoft Word, or PDF format and include the following (partial responses are welcome):

Priority Question(s):

1. Clearly state if you plan to participate in the Grand Challenge Series, in particular GC-1.
2. Provide your thoughts on the planned timing of both GC-1 (~late 2020) and GC-2 (~late 2021).
 - a. Describe what capabilities you could bring to the Grand Challenge, in particular GC-1.
 - b. With reference to the attached the “UAM Grand Challenge Scenarios” document, which scenarios do you feel your company/organization will have appropriate levels of technology to complete or contribute to?
3. Describe the elements of a UAM Grand Challenge that are most important to your organization, and comment on the ability for the planned effort to address those elements.

General:

4. Describe your company/organization, including: UAM sector(s) that your organization represents (e.g., vehicle developer, candidate airspace services supplier, UAM port development, smart city, etc.), business size and location, years of operation, overview of facilities, and your long-term vision for contributing to UAM.
5. Describe your system readiness for the Grand Challenge in the 2020 time-frame and the confidence level that you would expect in your systems.
6. Describe your technology maturation plan from your current system to the one that you propose to bring to GC-1 in 2020.
7. Describe any partnership agreements with other organizations or companies that you plan to leverage to achieve the goals of the demonstration.
8. List any questions, comments, suggestions, clarifications, and data that would be helpful for you to participate in the Grand Challenge.
9. Describe any reservations that you would have regarding participating in the Grand Challenge and how NASA could tailor the Grand Challenge to mitigate these concerns.
10. Comment on the scenarios, range requirements, and other assumptions that are part of NASA’s initial planning for the Grand Challenge described in this RFI.

11. Describe your requirements or concerns with regard to protecting proprietary data.
12. Provide any other feedback, comments, and/or suggestions that you feel would be helpful to NASA in preparing the Grand Challenge.

Added Question 1: Describe your interest in participating in NASA working groups to help enable the Grand Challenge and eventual standardization of critical pieces of the Grand Challenge Series.

Added Question 2: Describe your desire to contribute directly to the Grand Challenge by being a partner, as opposed to a participant. (Partners would be expected to provide in-kind contributions toward the Grand Challenge, and we are interested in potentially partnering with organizations from across the entire UAM ecosystem.) Describe the nature of the contribution you would make.

UAM Vehicle Developers:

13. Details about your prospective aircraft, mission descriptions, and concept of operations (ConOps).
 - a. Describe the entire vehicle system you could bring to the Grand Challenge, including configurations, dimensions, weight, payload capacity, propulsion system.
 - b. Describe how your vehicle is “piloted” (i.e., remote-pilot, on-board pilot, autonomous systems).
 - c. If piloted or remotely piloted, describe your pilot’s airmen qualifications.
 - d. Describe your vehicle performance and mission/flight capabilities, any on-board sub-systems and sensors, and any ground infrastructure and data that would be leveraged doing flight.
 - e. Describe your flight envelope, how it has been cleared, and any limitations. Describe your anticipated flight envelope for GC-1 if it were held at Edwards Air Force Base (wind limits, temperature, altitude, speeds, etc.)
 - f. Describe your concept of operations (ConOps) for the Grand Challenge, including flight procedures and flight profiles; re-charge/fuel requirements and turn-around times; and ground infrastructure requirements.
 - g. Describe any autonomy or autonomous functions (on the vehicle or ground station) that that you will be including in your vehicle that would be demonstrated as part of the Grand Challenge.
 - h. Describe any ground support equipment that is required for your vehicle and your plans to bring this to the Grand Challenge.
 - i. Describe your ability to meet the NASA vehicle airworthiness and flight release process. If your vehicle is unmanned, describe any challenges that you anticipate in meeting NASA airworthiness and

- flight release, and whether these requirements would restrict your participation.
- j. Describe any specific safety equipment and procedures/restrictions required for operating your vehicle. If unpiloted, describe any flight termination or emergency land functions, and how they work.
 - k. List and describe any communications and external sensors that you anticipate having on the vehicle and your ground station. Include equipment such as: communication equipment and operating frequencies, cameras, lasers, radar, etc.
 - l. Describe any special ITAR or security considerations
 - m. Describe if the technology and ConOps will be capable of operating in and have missions specific to Urban Environments.
 - n. Describe features to address contingency scenarios, originating either internal or external to the vehicle.
14. Information on your plan for technology maturation (including hardware, modeling and simulation, flight testing, etc.) between now and GC-1, which is planned for late 2020.
- o. Describe what technology development will occur between now and late 2020 (DAA, C2, contingency management testing, etc).
 - p. Describe what you specifically plan to demonstrate in 2020 and your confidence level in it being ready for the GC-1.
 - q. List and describe the Grand Challenge scenarios that you anticipate being able to accomplish or contribute to.
 - r. If your vehicle is unmanned, describe any challenges that you anticipate in meeting NASA airworthiness and flight release, and whether these requirements would restrict your participation.
15. Describe your ability to act as an “integrator” by bringing a fully integrated vehicle and/or airspace system to the demonstration.
16. Do you plan to partner with an airspace service provider? Will you be ready to work with that developer by the anticipated date of GC-1 (~late 2020)? Or GC-2 (~late 2021)? If so, which company or companies?
17. Describe your approach to obtaining FAA flight/operational approval through Type Certification:
- s. Include the relevant status of on-going type certification projects
 - t. Describe the approach to type certification (i.e., which Part and means of compliance are you using)
18. Describe any sensitivities to working in proximity to other vehicle providers during the Grand Challenge.

Airspace System/Service Providers:

19. Information is requested that describes technologies, and services for airspace integration that could potentially support the Grand Challenge. Information might include concepts, databases, services, software architectures, interface standards, and ground and airborne equipment for surveillance, communications, command, and control. Information on

functional and software components relating to those described above is sought along with their data requirements.

20. Describe your airspace system technologies ability to provide airspace services, including:
- a. **Operator network scheduling:** considers factors such as passenger trip demand and UAM port availability to develop a strategic schedule preference consistent with the transportation network of UAM operator(s).
 - b. **4D flight planning:** specifies each flight's expected/preferred departure time, routing, altitude, speed profile, and arrival time. This function would likely iterate with an operator's network scheduling and might consider conflict prevention and onboard navigational precision for route selection.
 - c. **Constraint and weather provisioning:** supports flight-planning by providing spatial (including geographic) and temporal constraints and environmental conditions affecting UAM airspace operations. Data provided would include airspace availability, atmospheric conditions, terrain elevation, and urban obstructions.
 - d. **Trajectory prediction:** supports flight planning and traffic management services by generating 4D predictions for each flight. This is a core function that relies on aircraft state, nominal routing, aircraft performance characteristics, and atmospheric conditions.
 - e. **Traffic-flow management:** constrains or adjusts flight schedules, routes, or intended speed/altitude profile in order to balance UAM port demand and capacity and mitigate airspace congestion.
 - f. **Conflict detection:** detects conflicts with other traffic using trajectory prediction. This function informs humans and/or automation responsible for conflict resolution actions involving adjustments to departure time, speed, altitude, routing, or arrival time.
 - g. **Strategic conflict resolution:** relies on trajectory prediction and conflict detection functions to make adjustments – just prior to departure – to a flight's departure time or intended speed, altitude, and routing profile in order to prevent downstream traffic conflicts and check that destination UAM ports are accessible.
 - h. **Tactical conflict resolution:** In-flight updates to intended route, speed, or altitude profile in order to resolve downstream traffic conflicts and further ensure UAM port accessibility upon arrival.
 - i. **In-flight collision avoidance:** capabilities that support the detection and avoidance of imminent collisions with other aircraft, terrain, or urban obstacles.
 - j. **Additional services:** describe any additional airspace services and capabilities that you could bring to the Grand Challenge.
21. Describe the entire system you could bring to the Grand Challenge. Details about prospective airspace technology, mission descriptions, and additional technologies required

- k. Describe your concept of operations for the Grand Challenge, including airspace system functionality and capabilities, vehicle information and performance requirements, infrastructure requirements, etc.
 - l. Describe your process for dealing with cyber security.
 - m. List and describe any communications equipment and sensors that would be part of your airspace system. Include equipment such as: communication equipment and operating frequencies, cameras, lasers, radar, etc.
 - n. Describe the associated ConOps to be leveraged in the Grand Challenge by the company pursuing a commercial or civil business case.
 - o. Describe if the technology and ConOps will be capable of operating, and have mission's specific to Urban Environments.
22. Information on your plan for technology maturation (including hardware, modeling and simulation, flight testing, etc.) between now and GC-1, which is anticipated in late 2020.
- p. Describe what technology development will occur between now and late 2020 (DAA, C2, contingency management testing, etc.)
 - q. Describe what you specifically plan to demonstrate in 2020 and your confidence level in it being ready for the GC-1.
 - r. List and describe the Grand Challenge scenarios that you anticipate being able to accomplish or contribute to.
 - s. Include any expected operational limitations (geographic, regulatory, technological, etc.) that your airspace may be constrained by.
23. Describe your ability to act as an “integrator” by bringing a fully integrated vehicle and/or airspace technology to the demonstration.
24. Do you plan to partner with any vehicle developers? Will you be ready to work with that developer by the anticipated date of GC-1 (~late 2020)? Or GC-2 (~late 2021)? If so, which company or companies?

Additional UAM Stakeholder Community members:

25. **Ground Infrastructure:** Describe any ground infrastructure that you could provide for the Grand Challenge, such as a UAM port (i.e., vertiport, skyport, heliport, etc.). What would this look like and what would be its capabilities, instrumentation, and portability? Would you build or transport this to the test range for the Grand Challenge? What other logistics/facilities are required for you to participate?
26. **Range:** NASA is anticipating considering providing a test range option for challenge participants; however, NASA is interested to know if other ranges are available or if facilities are interesting is building a test range for hosting the Grand Challenge. Describe a test range that you would propose providing for the Grand Challenge. Describe current and required capabilities of the test site, location, size, instrumentation, costs, ease of access, special

requirements for vehicles, airspace, spectrum, access control, on-site facilities, etc.

- 27. Local government and “Smart Cities”:** Describe the types of activities you would use grand challenge to inform. Describe additional components NASA could add to the Grand Challenge to better enable UAM at a local level.
28. Others that want to participate in-kind (e.g., FFRDCs, local municipalities, standards organizations, etc.), please describe the role you could play in the Grand Challenge.