ENABLING 5G INNOVATION LEADERSHIP

THROUGH USE CASE-DRIVEN COLLABORATION

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About Us

The Open Generation Consortium is a privately funded research and development community launched by MITRE Engenuity in 2020. It brings together multiple industry sectors, academic institutions, industry associations, along with government perspective, with the mission to achieve breakthrough innovation in the U.S. and democratic societies, by performing use-case driven collaboration that utilizes 5G and beyond capabilities.

In this paper, the Open Generation Consortium elaborates on its initial target areas of impact. We describe our approach to working collaboratively in a virtuous cycle that includes identifying use case challenges with the greatest benefits from 5G, developing architectures and solutions to overcome those challenges and implementing testbeds and experimentation to demonstrate and validate the solutions. Furthermore, we plan to give back to society by providing data, shared knowledge, and experimentation opportunities to help advance commercialization of 5G and beyond enterprise applications to unlock massive economic value in the nation.

Our first set of use cases centers around uncrewed aircraft systems (UAS), in particular those intended to operate beyond visual line of sight (BVLOS) that benefit the most from wide-area cellular network architectures. In this paper, we describe the initially selected BVLOS UAS use cases and introduce the testbed and experimentation efforts that are being developed by the consortium to overcome key challenges and help enable BVLOS UAS operations with 5G capabilities.

Mission

The Open Generation Consortium brings together diverse technical viewpoints and domain expertise from across multiple industries and market verticals to design, develop, demonstrate, and validate solutions that may be uniquely enabled by 5G capabilities.

The key objectives of the Open Generation Consortium are listed below:

- **Cross-domain collaboration:** By acting as a bridge to industry, academia, public safety organizations, and all levels of government, the consortium aims to foster a whole-of-nation perspective that will help find new ways to contribute to our nation's security, prosperity, and resilience.
- **Use case-driven research:** Use case priorities selected by the consortium members are pursued through research initiatives focused on implementing 5G capabilities that will enable and further advance those use cases.
- **Accelerated innovation:** Testbeds developed for the consortium-advanced use cases serve to further a virtuous cycle that leverages participating resources to allow rapid deployment of new solutions, prototyping capabilities to test new concepts, and evaluating new designs.
- **Expedited time to market:** The research and development ecosystem ensures depth and diversity for ideation and collaboration. Advancing both the state-of-the-art and state-of-the-practice will enable commercially viable 5G solutions faster.
- **Consolidated voice**: By growing a national resource for research, prototyping, and experimentation, the consortium will increasingly provide relevant and objective inputs to help advance capabilities and operations in multiple vertical markets. Those inputs may include (1) data-driven findings to be made available to industry and regulators and (2) inputs to standard organizations on suggested solutions, approaches, methods, and performance data.

At the time of publication of this paper, the following entities are participating in the consortium:

- Aloft
- Altiostar
- ATIS
- CTIA
- Drone Responders
- Ericsson
- FirstIZ
- Hush Aerospace
- Nokia
- Northeastern University
- NUAIR
- OST Global
- Qualcomm
- Verizon
- Virginia Tech

Planned Areas of Impact

The Open Generation Consortium plans to focus on advancing vertical markets that will benefit from 5G and beyond. Some of the envisioned areas of opportunity to introduce 5G capabilities include industry segments such as those listed below:

- **Uncrewed Aircraft Systems (UAS):** Opportunities include utilizing sub-6 GHz 5G spectrum to provide connectivity and reliable communications to enable operations beyond visual line of sight (BVLOS) which are restricted today due to safety concerns, as well as utilizing higher frequencies (above 10GHz) to advance use cases that require high throughput or ultra-low latency.
- **Public Safety Applications (beyond those related to UAS):** Opportunities include Internet of Things (IoT) communications related to emergency response, fast deployable private networks for disaster areas, trusted vehicle tracking, etc.
- **Smart Cities:** Opportunities include autonomous vehicles, vehicle-to-everything (V2X) capabilities, city vehicle management, vehicle-city interface (parking, traffic control), and several IoT indoors and outdoors sensor-based applications.
- **Aviation:** Opportunities include transitioning certain functions of crewed aviation systems to commercial 5G services, including secure ground communications and certain surveillance and navigation functions.
- **Health:** Opportunities include remote health monitoring, intelligent mobile treatment centers, remote consultations, and remote surgery.

Of the potential verticals described above, the first vertical market chosen by Open Generation is UAS operations.

Our Approach: Use Case-Driven Collaboration

With accelerating innovation in mind, the Open Generation Consortium consistently focuses on enabling use cases from the beginning. One of the initial efforts by the consortium is to identify key uses that present challenges for operation, which could potentially benefit from 5G capabilities. After use case identification, architectures and solutions are crafted to address and potentially overcome those challenges. Experiments are proposed to assess performance and test hypotheses. Then, consortium members and external industry collaborators contribute with resources to instantiate some of those architectures through the implementation of testbeds to perform the proposed experiments. Figure 1 illustrates that approach at a high-level.

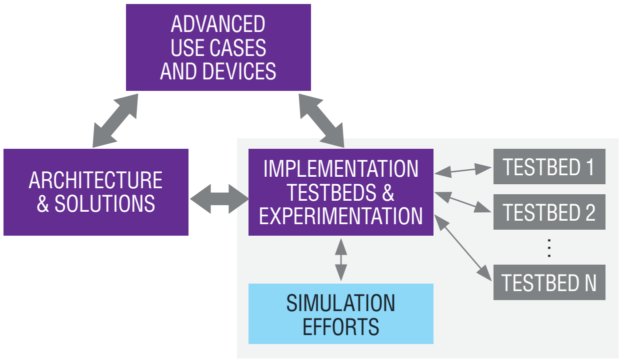

FIGURE 1. USE CASE-DRIVEN COLLABORATION APPROACH

- The **Advanced Use Cases & Devices** workgroup identifies key use cases and corresponding challenges to be addressed; proposes innovation to improve and enable those use cases with 5G capabilities; develops and details selected priority use cases; and develops technical requirements
- The **Architecture & Solutions** workgroup reviews use cases and experiment plans proposed by the other two workgroups; proposes architectures to support each use case; and identifies solutions for feasible implementation within the conditions identified for potential experimentation testbeds.
- The **Implementation, Testbeds, & Experimentation** workgroup plans and details experiments based on the requirements identified by the Advanced Use Case and Devices workgroup; identifies potential testbed locations and feasibility aligned with solutions proposed by the Architecture & Solutions workgroup; coordinates contributions from the consortium members to implement the testbeds; and launches initiatives to perform experiments for targeted use cases in testbeds.
  - Testbed efforts: once a testbed initiative is launched, the collaborating members work to advance its implementation, perform experiments, report results, and note areas for further improvement.
  - Simulation Efforts: In addition to the testbed experimentation efforts, a simulation initiative has been launched to facilitate understanding of network response and help inform expected results prior to experiments at the testbeds.

This approach is currently being executed by the consortium for a set of UAS-related use cases. From this point on, this document describes current efforts to advance UAS operations using 5G capabilities, while following (and evolving as needed) the approach described here.

Initial Focus: Uncrewed Aircraft Systems

As mentioned in the Planned Areas of Impact, the first vertical market chosen by Open Generation is uncrewed aircraft systems (UAS) operations. Prior to describing our activities related to UAS, some high-level definitions are provided here. These definitions are simplified and summarized for convenience, while in alignment with more formal definitions or concept descriptions provided in [1], [2], and [3]:

- Uncrewed aircraft refers to an aircraft operated without the possibility of direct human intervention from within or on the aircraft.
- Uncrewed aircraft system refers to the uncrewed aircraft and its associated elements (including communication links and the components that control the small uncrewed aircraft) that are required for the safe and efficient operation of the uncrewed aircraft in the airspace.
- Remote pilot in command is the person responsible for the safe conduct of the UAS flight, for adhering to operational rules to avoid collisions and respect airspace constraints and restrictions, and for intervening appropriately to preserve safety of flight.
- Ground control station (GCS) of a UAS is the control unit that enables the remote pilot to control an uncrewed aircraft. It typically refers to ground-based hardware and software, fixed or portable, which include a computer, human-machine interface, video displays, and telemetry data information.
- UAS traffic management (UTM) is a system that can safely and efficiently integrate the flying uncrewed aircraft along with other airspace users in low altitude. It encompasses a set of functions and services for managing a range of autonomous vehicle operations (e.g., authenticating, authorizing UAS services, managing UAS policies, and controlling traffic in the airspace).
- UAS service supplier (USS) is an entity that assists UAS operators with meeting UTM operational requirements that enable safe and efficient use of the airspace. A USS can provide any subset of functionalities to meet the provider's business objectives (e.g., UTM, Remote Identification).

THE FIRST VERTICAL MARKET CHOSEN BY OPEN GENERATION IS UNCREWED AIRCRAFT SYSTEMS (UAS) OPERATIONS.

Key Challenges

Certain types of operations present inherent concerns related to the safety of life and property:

- Operation beyond visual line of sight (BVLOS)
- Operation of multiple small uncrewed aircraft by one person
- Carrying hazardous materials
- Operation over human beings

- Operation in certain restricted airspaces (e.g., sharing airspace with crewed aircraft, areas of limited ground-based surface)
- Passenger-carrying flights (Advanced Air Mobility)

The operations listed above face some common challenges that may be addressed by 5G and beyond:

- Reliable and uninterrupted communications: a key challenge is the need to improve the connectivity and reliability of the command and control (C2) channel beyond existing methods to ensure consistent and continuously available communications. The utilization of 5G capabilities for the C2 channel is expected to improve that connectivity and reliability compared to existing methods, as will be discussed further in this document.
- Collision avoidance: a key challenge is the need to improve the ability for aircraft to detect and avoid (DAA) other aircraft (crewed and uncrewed) and obstacles. Current approaches for avoiding collisions utilize a varied set (or combination) of techniques. These may include onboard and ground-based surveillance sensors, such as ADS-B In receivers, radars, and optical/acoustic sensors. Most ground-based DAA approaches rely on the C2 channel, for instance with drones transmitting awareness data to ground, and ground station transmitting ground-based surveillance systems (GBSS) data and commands to drone. The utilization of 5G provides several benefits, including increasing DAA reliability, and allowing new methods for drone position broadcasting, drone-to-drone communications, and potentially utilizing the cellular 5G network as a GBSS. Additionally, cellular 5G networks can be used to provide localization where GPS signal is not available (e.g. indoors) or as backup to GPS in case of outage.

In addition to addressing safety concerns above, 5G may help overcome challenges of use cases that require more advanced capabilities related to the UAS operation mission, such as high video throughput, low latency, and user data processing/learning capability in support of complex operations in dynamic and high-density environments.

Collecting and assessing data will help quantify how a subsystem's performance addresses these challenges and supports the safety case for certain UAS operations. Experimental data produced by the consortium may be useful to inform regulatory developments.

A KEY CHALLENGE IS THE NEED TO IMPROVE THE CONNECTIVITY AND RELIABILITY OF THE COMMAND AND CONTROL (C2) CHANNEL BEYOND EXISTING METHODS TO ENSURE CONSISTENT AND CONTINUOUSLY AVAILABLE COMMUNICATIONS.

TABLE 1. ROADMAP FOR DRONE OPERATIONS MILESTONES USING 5G CAPABILITIES

	2020	2021	2022	2023
Air-ground connectivity	Early proof of concept: utilizing 5G for C2 link	Enable and demonstrate reliable BVLOS C2 over 5G network	Improved performance for BVLOS C2	
Air-air capabilities		Enable early drone-to-drone communications	Enable and demonstrate Detect and Avoid (DAA) functionality using D2D links Enable Remote ID over 5G	Navigation for flight operations
Drone payload-related capabilities		Early BVLOS improvements in air-ground link reliability, availability, throughput, latency	Support ultra-low-latency applications Enable real-time high-resolution video	Support ultra-low-latency applications
Intelligent & connected operations			Enable real-time high-resolution video-XR/AR drone control	Enable swarm operations with self-separation
Indoor operations			Support ultra-low-latency applications Enable real-time high-resolution video-autonomous flight of drones indoors	Indoor drone swarms
Drone to 5G operator communications			Authorization and authentication on networks; validate that drone is allowed to operate Drone API or exposure function; predictive capacity assignment; ORAN RIC interfacing capability	Network geofencing
Drone-aerial networks			Networks using drones as aerial gNodeB's	

Technical Roadmap: Areas of Impact

The availability of several new capabilities (listed below) of 5G has offered multiple opportunities that were not supported in earlier generations of communications technologies:

- Multilayer Massive Multiple Input Multiple Output (MIMO) techniques and antenna beamforming allows better throughput and interference mitigation, increasing spectral efficiency.
- Additional spectrum bands (from 400MHz to 90GHz) and increased bandwidths supported by 5G increase the opportunity to serve new verticals.
- Network slicing allows flexibility to fully support and reserve resources for services with different quality-of-service (QOS) levels, allowing the deployment of use cases with a variety of performance priorities (e.g., reliability, low latency, high throughput).
- Native separation of the Control Plane (CP) and the User Plane (UP) adds flexibility to deploy different architectures, enabling the freedom to scale and locate the CP and UP functions independently
- Radio Access Network (RAN) disaggregation with separation of the Central Unit (CU), Distributed

Unit (DU), and Radio Unit (RU) functions of a gNB and the open interfaces defined by 3GPP and the O-RAN alliance allow integration of multi-vendor RAN deployment. The Radio Intelligent Controller (RIC) allows 3rd party applications (rApps and xAPPs, supporting respectively non-real time and near-real time control loops) to optimize RAN resources and functionalities.

- Service-based architecture in the core network allows faster deployment of new services.
- Native cloud computing environment supports multi-access edge computing (MEC), which allows the intelligent computation needed to process user data at the edge of the network, where it can be done while keeping latency low and minimizing the volume of data that needs to be transferred to centralized network components. This capability enables the introduction of machine learning and artificial intelligence applications leveraging user data at the network edge.

To leverage several of these 5G opportunities to benefit UAS use cases, the consortium has agreed to target key operational milestones to enable UAS operations, as depicted in Table 1.

The corresponding 5G capabilities to enable those milestones are highlighted in Table 2. They serve as an initial roadmap of the targeted 5G capabilities to focus on deployment and experimentation in the first testbeds and to plan the testbed evolution over the next years.

TABLE 2. FOUNDATIONAL 5G CAPABILITIES SUPPORTING MILESTONES

	2020	2021	2022	2023
5G Capabilities	Experiments in lab environment (successful 5G NSA C2 connection)	Baseline 5G private network testbeds, assess performance Early improvements in performance through radio resource management optimization Early edge computing architecture for distributed applications and RAN optimization (MEC, REC) Increase peak data-rate to the drone(s) while in flight Support for private networks	Create a 5G slice dedicated to drones (separate from ground users); slice for drones (or) separate slices for C2 and for enterprise (e.g., payload) Enhance edge computing architecture for distributed applications and RAN optimization (MEC, RIC) Create dedicated mechanisms for drones (xApps and rApps over RIC, apps on the MEC) to optimize drone performance: optimize QoS and network slicing policies; optimize beam forming; support low latency (uRLLC) applications Enable drone-to-drone communications (e.g., DAA) through side-link capability	Enhance 5G architecture and capabilities Leverage user data and introduce AI-based mechanisms to improve performance while supporting multiple use cases.
Spectrum		Low, middle, high band operations	Low, middle, and high band operations	Navigation for flight operations
Security			Implement 5G security baseline Application-level drone security (e.g., apps or embedded in application function)	Leverage AI based security mechanisms

Priority Use Cases for 2021

The Open Generation Consortium has selected four BVLOS use cases in 2021 to analyze in detail, identify challenges, develop technical requirements and solutions, and propose experiments aimed at enabling each of those use cases through the use of 5G capabilities.

The four use cases were selected to represent a wide range of possible scenarios and to capture the most popular UAS applications. There is one indoor use case and three outdoor use cases. One of the outdoor use-cases is localized to a limited geographical area while the two others are operations over a large area. Some of the use-cases require manual piloting while others assume a higher degree of automated UAS operation. In turn, the four use-cases pose different challenges on the individual 5G communication link as well as the overall 5G system supporting the connectivity over the entire operating area.

Emergency Response

Within the broad category of Emergency Response, there are several specific use cases, for example, drone as a first responder, damage assessment, hazmat incident response, lost person search. A common thread for these use-cases is the need to provide high-quality visual as well as other types of sensor data to incident responders. Given the fluid situation as incidents unfold, and due to the unstructured environment the drone needs to operate in, there is a need for manual piloting of the drones to maneuver the drone into proper positions. Multiple drones may be in use concurrently at an incident as well as other manned aircraft, such as helicopters, may be operating at a low altitude in the area. Sophisticated detect-and-avoid (DAA) solutions need to be in place for these operations.

Package Delivery

There is high interest in using UAS to increase product distribution, reduce product delivery times and achieve corresponding potential cost savings. This use-case is focusing on the last delivery segment of a package to its final destination from a distribution center. We assume that the delivery drones are stationed at a warehouse infrastructure that allows loading/unloading of packages, and take-off and landing of multiple drones. The warehouse and its immediate proximity is covered by a private 5G network while the actual delivery segment of the flight is supported by a public 5G network. Flight operations are automated including DAA mechanisms.

THERE IS HIGH INTEREST IN USING UAS TO INCREASE PRODUCT DISTRIBUTION, REDUCE PRODUCT DELIVERY TIMES AND ACHIEVE CORRESPONDING POTENTIAL COST SAVINGS.

Deliveries can be in urban, suburban, and rural areas each of which is presenting unique challenges for the UAS operation as well as for the communication technology.

Static Infrastructure Inspection

There are 60,000 distribution substations in the United States energy grid. Efficient maintenance of a large and often remote set of stations is a key industry challenge. Drone-in-a-box solutions provide potential remedies for costly inspections. For this use case we have a limited geographical area, where drone inspection flights take place. The delimited operation area provides opportunities to relax some operational requirements as well as allows for a local 5G network to support operations.

Indoor Inspection

Drones are used indoors to fly programmatically defined missions within warehouses and other large indoor spaces, to collect images and/or stream video for indoor inspections, warehouse inventory management, or indoor security. The communication is supported by an indoor private 5G network. Given the indoor operation, typical airspace regulations are not applicable. However, worker safety is a key concern and mechanisms need to be in place to prevent injuries and equipment damage. When people and drones are working in the same space, connecting other safety systems to the 5G network, for example, emergency shutoff buttons scattered on the warehouse floor will be likely required for worker safety.

Vision for UAS Experimental Environment

The Open Generation Consortium envisions achieving its milestones through a gradual evolution of experimental capabilities that bring together systems, solutions and technologies across multiple stakeholders (Table 3).

In the first half of 2021, as an early proof of concept, the Open Generation Consortium has successfully conducted measurement and flight experiments at Virginia Tech's Drone Park (a netted drone cage), where we implemented end-to-end 5G New Radio (NR) communications between a 5G drone and ground-based computers for command and control (C2) and payload applications (streaming real-time video in-flight from drone to ground server). In these

TABLE 3. OPEN GENERATION'S EXPERIMENTAL ENVIRONMENT VISION

EARLY 2021	2021-2022	2022-2023
Drone Cage	**10-Mile Drone Path**	**50-Mile Aviation Range**
• Private 5G environment • Drone testing conducted in 5G non-standalone (NSA) • Ecosystem/members collaboration • Data collection for 5G key performance indicators (KPIs) • Virginia UAS test site	• Private 5G environment with multiple cells and handoffs • Member-led use cases testing • Experimentation to collect data for impactful results • Policy/regulation formalization • Multiple locations (NY, VA, MA)	• Test park with public/private network • Data collection to inform stakeholders • Device and pilot certification • Identify procedures to commercialize drone corridors • Identified NY 50-mile corridor

experiments, we used a portable research-grade private 5G network as detailed further in Section 4.5.

In the second half of 2021 and early 2022, we are working to install and deploy an industrial-grade multi-cell private 5G network at a few test sites. These sites will serve as semi-permanent testbeds for the experiments currently being designed for the selected use cases. By enabling the drone to use a combination of the private 5G network and the commercial 5G service in the surrounding area, we plan to identify a 10-mile flight path and conduct experiments that simulate longer BVLOS flights.

In 2022-2023, we are looking into expanding the 10-mile flight path to a broader area, potentially enabling a 100-mile path over a 50-mile aviation range that transitions through a combination of private and commercially-operated 5G networks. This set up can be used for experimentation and also for other purposes such as device and pilot certification and as a reference model that can be used by drone operators for testing and procedure development.

Early Proof of Concept: UAS Operation Using 5G

Between late 2020 and March 2021, the first Open Generation testbed team, consisting of MITRE Engenuity and Virginia Tech technical staff, has collaborated to implement an early proof-of-concept testbed. The efforts included initial tests at MITRE 5G lab in McLean, VA; at Virginia Tech's 5G lab in Arlington, VA; and field tests at Virginia Tech's Drone Park in Blacksburg, VA. At the conclusion of this proof-of-concept phase, the team accomplished the following, which are further illustrated in Figure 2:

IN 2022-2023, WE ARE LOOKING INTO EXPANDING THE 10-MILE FLIGHT PATH TO A BROADER AREA.

- Integrated a drone with a 5G user equipment (UE) and performed both command and control communications and payload data (video) streaming over the 5G link
- Implemented end-to-end communication between the ground control station (GCS) and the drone, connected to a 5G non-standalone (NSA) base station (gNB)
- Realized end-to-end 5G NR communications between the drone and computers for the following:
  - Drone C2 telemetry (sensor data from drone to GCS)
  - Drone C2 commands (commands from GCS to drone)
  - Stream real-time video in-flight from drone to ground server
- Performed flight tests with the 5G drone operating in the following modes:
  - Loiter (hold position and altitude based on GPS & barometric altimeter)
  - Auto (flight along pre-defined path)
  - Guided (send commands to proceed to each waypoint, in real time over cellular connection)

FIGURE 2. FIELD PHOTOS FROM PROOF-OF-CONCEPT EXPERIMENT WITH DRONE OPERATING OVER 5G AT VIRGINIA TECH'S DRONE PARK

Drone Paths: Testbeds Development and Simulations

The consortium is working on the set of testbeds shown in Table 4. By conducting extensive experiments at these testbeds, we aim to identify and overcome safety and operational gaps, and to demonstrate enabling 5G solutions. As a result, we expect to accelerate deploying and adopting 5G for industry verticals (specifically for the UAS vertical).

The focus is to create an environment that allows both assessing performance and testing innovative 5G-based solutions, which will enable the consortium to innovate, demonstrate, and improve use case performance, and publish data resulting from it.

The following testbeds are currently in the early stages of development (Table 4).

TABLE 4. OPEN GENERATION'S CURRENT TESTBED EFFORTS

Testbed Host	Description
NUAIR Rome, New York	Private 5G network over a 5-mile radius, adjacent to public network coverage Use cases to be instantiated through experiments in this testbed: • Emergency Response • Package Delivery • Static Infrastructure Inspection
Virginia Tech Blacksburg, Virginia	Private 5G network at a rural farm environment outfitted to safely facilitate experimental operations of uncrewed aircraft. Use cases to be instantiated through experiments in this testbed: • Static Infrastructure Inspection • Package Delivery
Northeastern University Burlington, Massachusetts	An indoor-outdoor facility, specialized for testing uncrewed, autonomous technologies with applications for surveillance, cybersecurity, and disaster response on private networks. The use case to be instantiated here is: • Indoor Inspection

The status of each of these efforts is highlighted below:

- For the **Rome, NY NUAIR** testbed, initial member contributions have been identified, procurement of network equipment has been initiated, and network installation is planned for Fall 2021. The spectrum planned for this testbed includes sub-6 GHz and mmWave bands. Drone integration with 5G UE is in progress, with the plan to have it available for experiments when the network installation is concluded.
- For the **Blacksburg, VA Virginia Tech testbed**, initial member contributions have been identified, procurement of network equipment has been initiated, and network installation, drone integration and experiments are being planned in a similar timeframe as with the former testbed. The spectrum planned for use in this testbed includes a sub-6 GHz band.
- For the **NEU testbed**, initial member contributions have been identified, procurement of network equipment has been initiated, and network installation is planned for Fall 2021. The spectrum planned for this testbed includes sub-6 GHz and mmWave bands. The testbed integrates software-defined radios (SDRs) operating both as 5G UEs and gNBs. Drone integration with 5G UE is in progre ss, with the plan to have it available for experiments when the network installation is concluded.

Figure 3 illustrates in a notional block diagram the key components that are part of the outdoor testbeds at NUAIR and Virginia Tech facilities. The initial deployments will be 3GPP Release 16 compliant, utilizing industry-grade private 5G stand-alone wireless network with multiple radio access points available for experimentation.

- For the Burlington, MA Northeastern University indoor testbed, initial member contributions have been identified and procurement is planned to take place in early Fall 2021 based on the expected roadmap of open-source software for software-defined radios used at this testbed. Network installation and drone integration will take place late in the Fall, and baseline experiments should start by late 2021. Since the indoor facility is within an anechoic chamber, there is flexibility on the choice of spectrum for experiments.
- Simulation efforts: Complementing the three testbeds described above, the consortium is also running simulation experiments using custom system simulators. Selected experiments from the identified use cases will be simulated prior to performing the activities in the field. The simulation efforts facilitate:
  - Understanding of network response to common UAS functions prior to performing live testing.
  - Understanding of network response to complex test scenarios (interference, interference mitigation responses, large density UAS effects etc.) which cannot be tested easily in live environments
  - Simulate future, innovative applications and features that the consortium members propose in the course of testing.

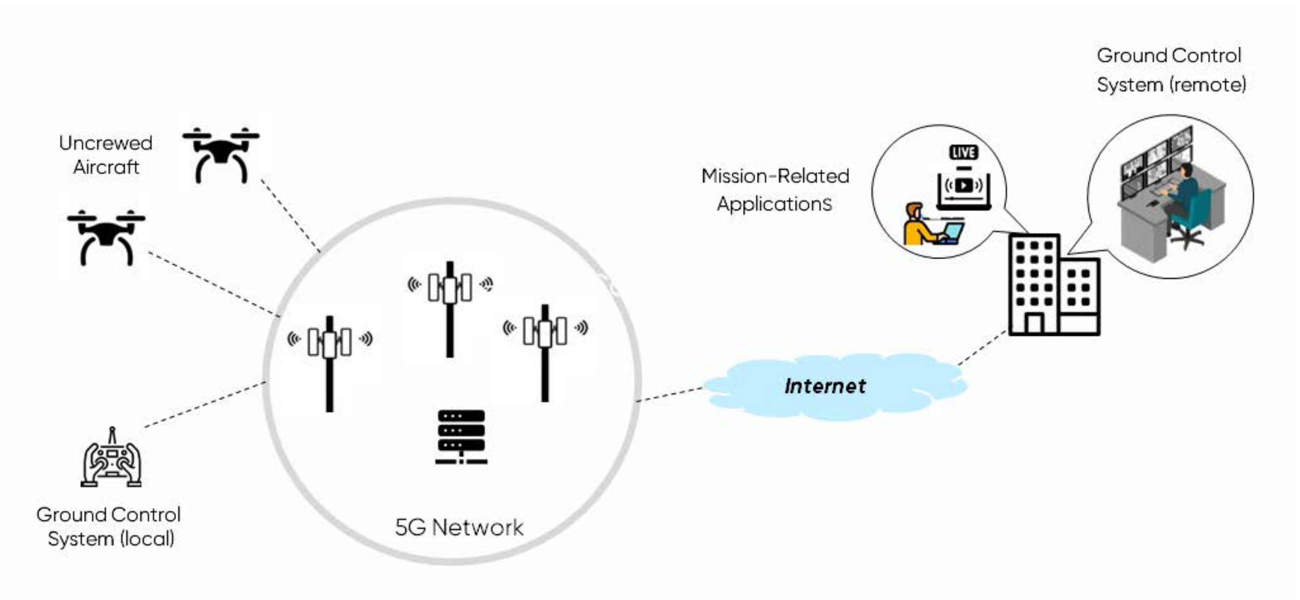

FIGURE 3. HIGH-LEVEL ARCHITECTURE FOR OUTDOOR TESTBEDS

Towards a 50-Mile UAS Corridor

Further down in our experimental evolution path, we plan to expand the testbed efforts to create a 5G-enabled drone path for drone operators to conduct testing and certification. A notional view of the potential location for this corridor is illustrated in Figure 5. The initiative to deploy at this location has just been announced by New York State Governor Kathy Hochul [4]. A round trip test path would be identified over the illustrated 50-mile corridor. This concept is in the early stages of development and further details on the mechanisms offered to facilitate drone operators testing and certification are being identified.

With our rigorous experiments in the testbeds and simulations, and by publishing the results and performance metrics, we expect to show the feasibility and benefits of commercial 5G drone operations and alleviate concerns for operational risks, specifically with BVLOS operations. Moreover, the test sites will also provide a platform for commercial providers to get certified and launch their drone operations or service.

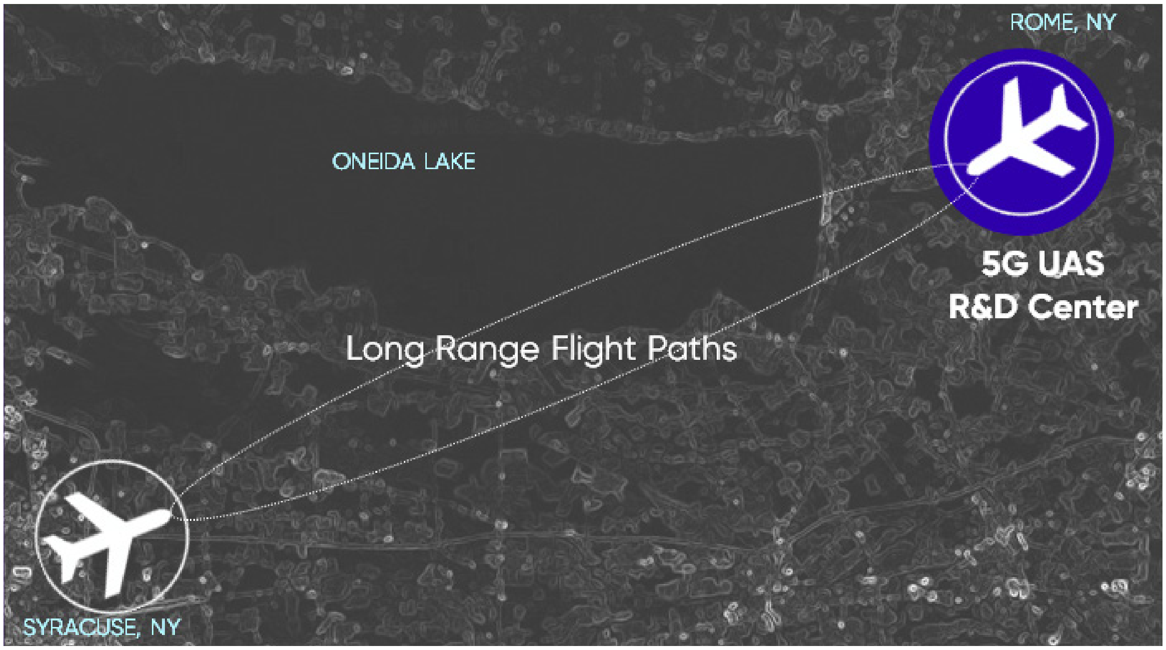

FIGURE 4. NOTIONAL DEPICTION OF DRONE PARK AREA OVER A 50-MILE DRONE CORRIDOR IN NY

Key Takeaways

The Open Generation consortium is aiming to make a significant impact at accelerating 5G deployments in the nation through radical collaboration. We are getting ready with our testbeds to conduct experiments with use cases to further advance the adoption of 5G.

For the first area of focus, UAS, the consortium has identified a path forward to deliver an operational transformation in enabling UAS use cases.

Key 5G capabilities that allow that transformation include massive MIMO and beamforming antennas, network slicing, xApps over RIC, and native cloud edge computing allowing machine learning and artificial intelligence at the edge.

With these capabilities, improvements in UAS operations are expected to occur in several aspects. Operations will benefit from better interference mitigation, individualized QoS settings for different UAS functions, and customization of RAN resources management, cell selection & handoff for drones. We expect to improve C2 link reliability, enable new methods and improve DAA functions, enable real time high-resolution, and low latency applications, among other operational increments.

From what we learn from these experiments, we plan to publish data evidence of 5G as a reliable method for C2 and DAA in BVLOS, and data on 5G performance for mission and payload. We also plan to report experiments and results and propose improvement methods to standards bodies.

Along the way, we will be creating 'experimental sandboxes' that can be further leveraged by the community, with plans to grow from 10-mile to a 50-mile test environment and foster additional innovation.

Overall, we expect this first vertical, UAS, to be the initial step towards our mission to advance 5G innovation and competitiveness in the U.S. and democratic societies, by advancing standards that support UAS operations with 5G, advancing data to support regulations for BVLOS operations, and advancing the business case for the several industry sectors (telecommunications, UAS, service providers).

THE OPEN GENERATION CONSORTIUM IS AIMING TO MAKE A SIGNIFICANT IMPACT AT ACCELERATING 5G DEPLOYMENTS IN THE NATION THROUGH RADICAL COLLABORATION.

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As MITRE's tech foundation for public good, MITRE Engenuity collaborates with the private sector on challenges that demand public interest solutions, to include cybersecurity, infrastructure resilience, healthcare effectiveness, microelectronics, quantum sensing, and next generation communications.

For more information on the Open Generation consortium mission and progress of activities, please check our web page at: https://opengeneration.mitre-engenuity.org/ or contact lribeiro@mitre-engenuity.org

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