MITRE ENGENUITY™

Open Generation™

Open Generation

Radical collaboration to solve complex challenges and accelerate 5G innovation

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MITRE Engenuity Open Generation 5G Consortium builds

on the MITRE legacy of innovation to solve challenges no one company can solve alone.

MITRE solves problems for a safer world, through federally funded R&D centers and public-private partnerships. MITRE works across government to tackle challenges to the safety, stability, and well-being of our nation.

MITRE Engenuity shares in MITRE Corporation's heritage to create generational impact by working directly with the private sector to solve complex technology challenges for public good.

MITRE Engenuity Open Generation is an industrial R&D partnership that solves the hard technology problems in 5G that no one company alone can solve to accelerate innovation to market in the public interest.

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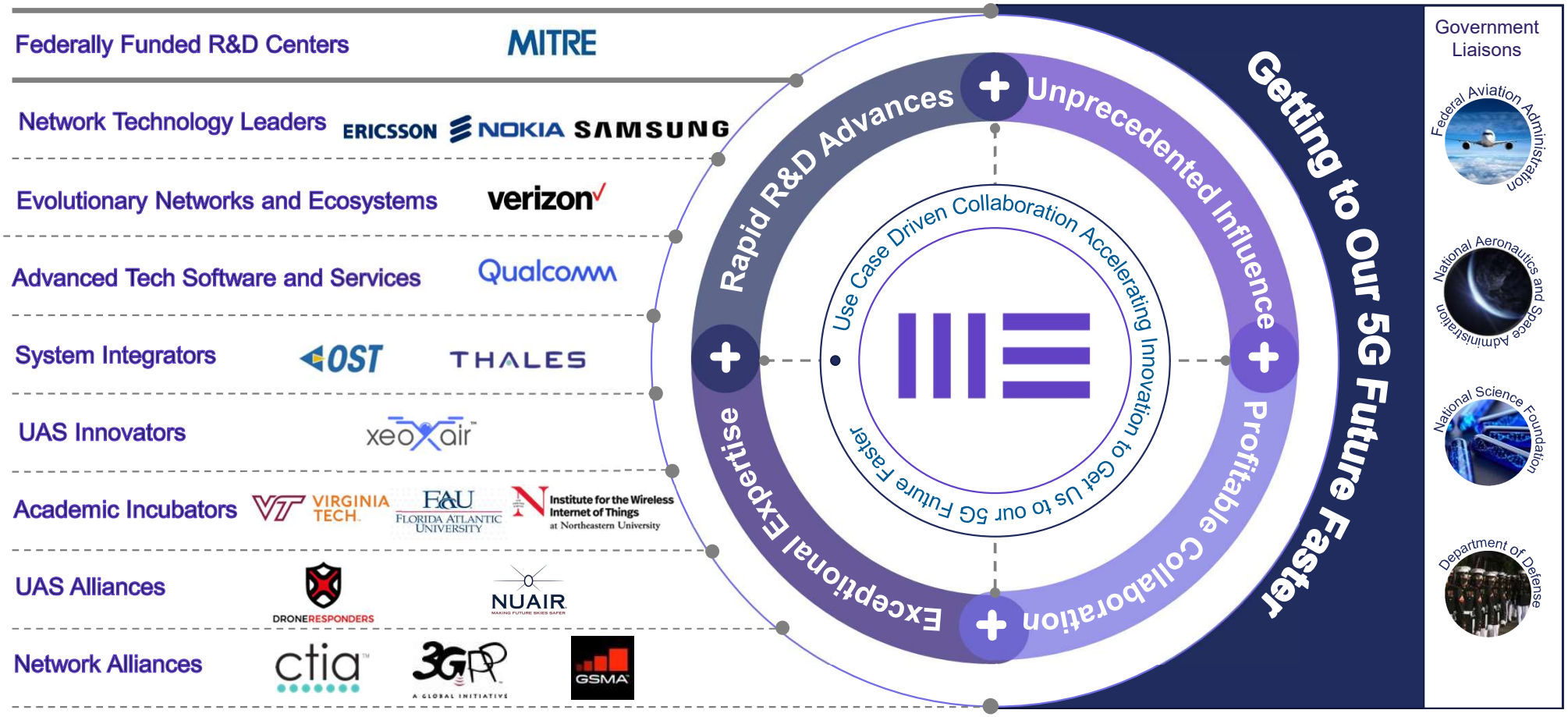
Open Generation | Tackling Real-world Problems



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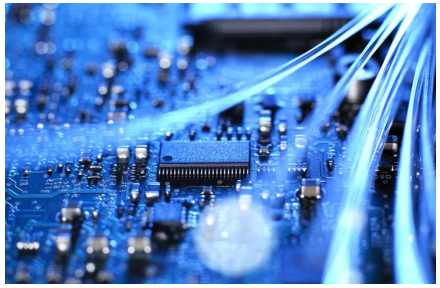
Collaboration through Open Generation 5G Consortium

helps bring new solutions to market, faster, multiplying member return on investment.

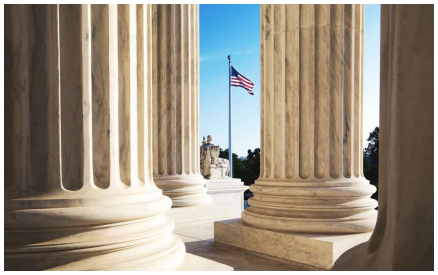


LOWERS OPERATIONAL BARRIERS AND COSTS TO TEST INNOVATION

Run experiments in **private testbeds on commercial-grade networks** with full telemetry jointly funded by members with **only one contract** to sign.

PROVIDES DIVERSE MEMBER EXPERTISE IN CRITICAL AREAS

Access a **diverse ecosystem** of innovators, network operators, system integrators, and advanced technology companies to **ensure depth of ideation**.



PROVIDES RESEARCH DATA TO STANDARDS BODIES & REGULATORS

Engage with liaisons and standards organizations to **ensure focus on key challenges and solutions** needed to advance industry. Provide data to inform regulatory bodies.

LED BY A NEUTRAL AND TRUSTED, PURPOSE-DRIVEN COMPANY

Our **mandate is to collaborate, not compete,** with industry to create broad societal changes that will make the world a safer, better place for future generations.

MITRE ENGENUITY | Open Generation

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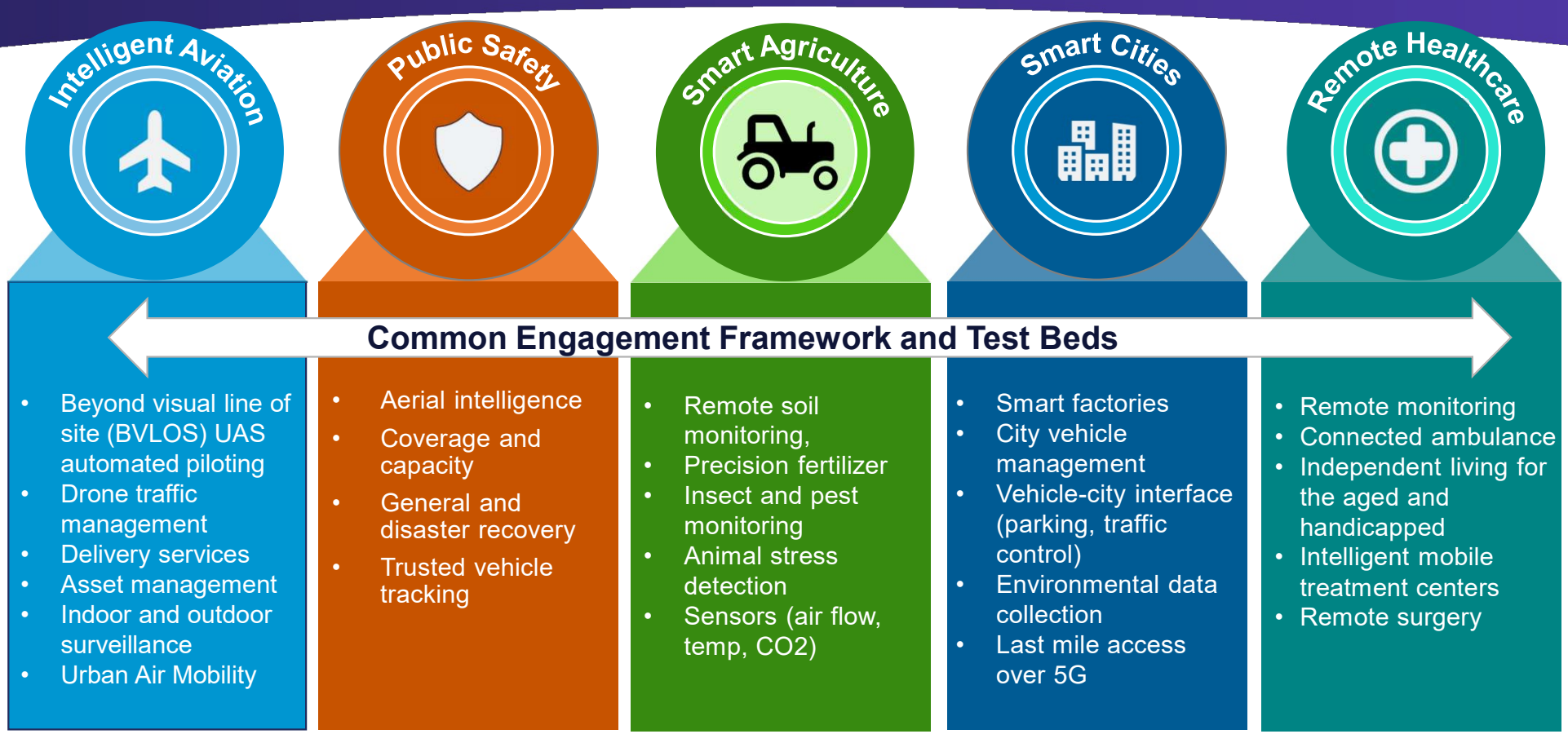
Open Generation | Use Case Focused R&D



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DRONE USE CASES

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Open Generation | Advancing Uncrewed Aircraft Systems (UAS)

Barriers to Market Realization

Safety needs demand high performance requirements.

Complexity of operations demand reliable control.

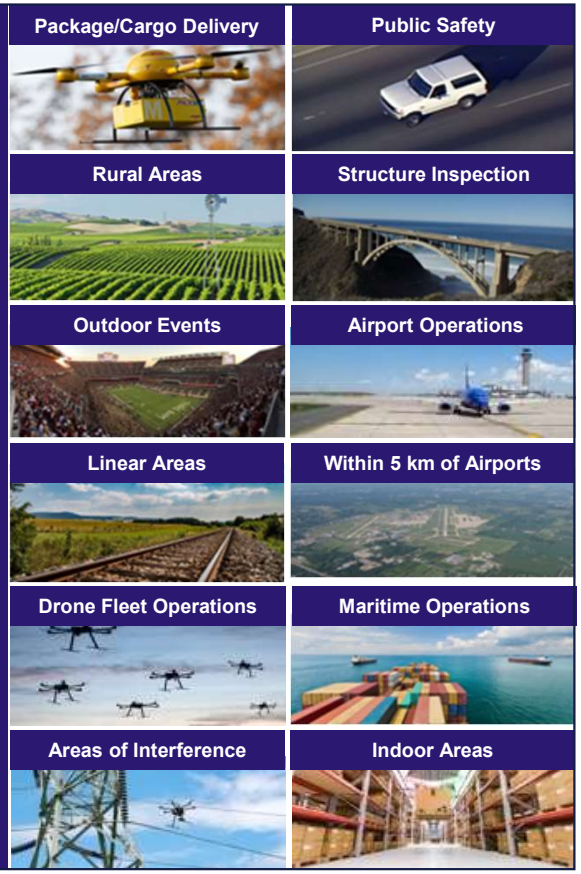
Ecosystem diversity increases complexity and solution variants.

Intelligent Aviation

Impact for Public Good

Real-world experimentation mitigates barriers to market.

Real World Use Cases Realized



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5G Capabilities Enabling UAS Operations

- Network slicing to reserve RAN resources for safety-related drone functions (e.g., C2 and DAA)
- Detect-and-avoid (DAA) functions utilizing drone-to-drone communications or network-based
- Multiple-Input-Multiple Output (MIMO) and Beamforming antennas for interference mitigation
- Applications utilizing Radio Intelligent Controller (RIC) to optimize RAN performance for drones or hybrid services
- Machine learning (ML) and artificial intelligence applications using data at network edge, to maximize mission impact (e.g., computer vision)
- Private networks to complement or augment service in critical areas

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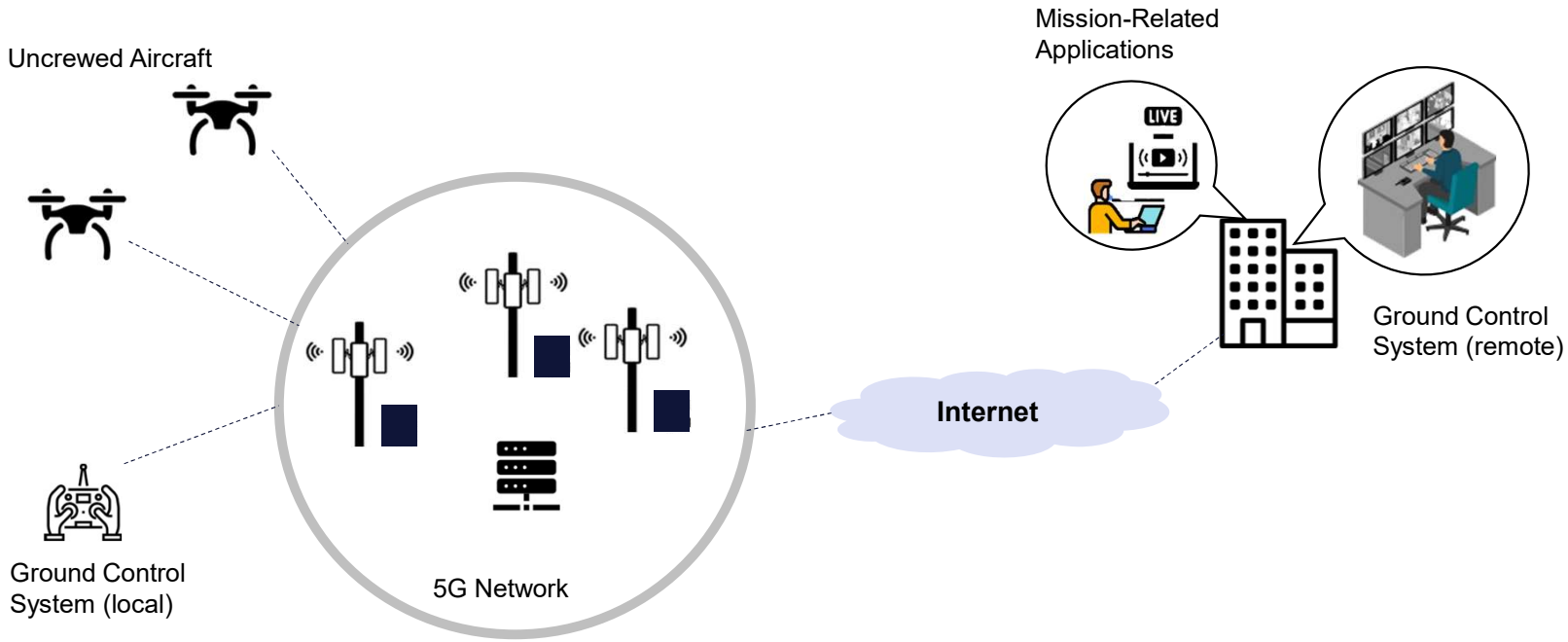
Generic Architecture for UAS Over 5G Network



To learn more about our Initial Use Cases:
[Open Generation Uncrewed Aircraft Systems (UAS) Use Cases - Open Generation (mitre-engenuity.org)]

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Initial plans for 5G UAS experimentation
focused on three principal initial experimental capabilities.

1. C2 link performance
   - Signal strength, signal quality, latency, throughput
   - Study and understand handover issues
   - Identify and assess possible improvements for handover and ways to mitigate potential UL interference
2. Performance of 5G for video transmissions from drones as high bandwidth users
   - Latency, near-real-time image processing, edge computing at cell tower
   - Prioritization of C2 over payload video
3. Drone-to-drone traffic separation and management (DAA) using state information
   - Network based, and drone-to-drone based approaches
   - Prototype proposed traffic interchange standards
   - Integration of all available information, supplemental ground-based detection of additional traffic
   - Experiment with Sidelink/PC5/Device-2-Device communications

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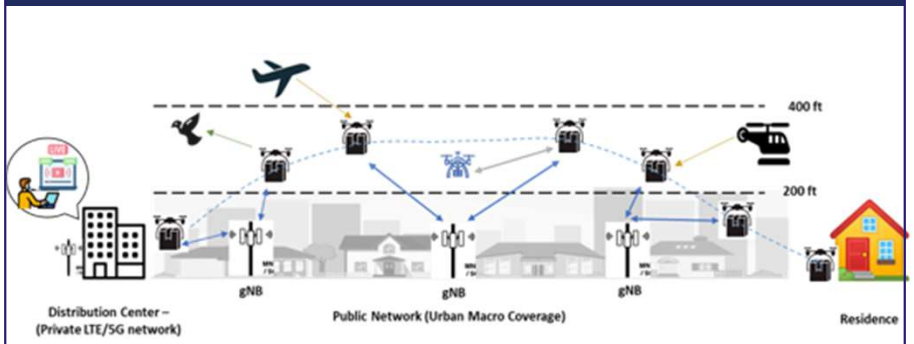
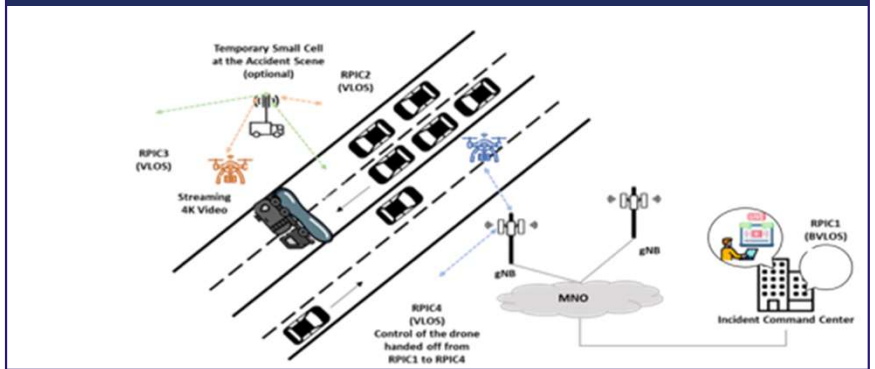
Open Generation | Use Case Focus

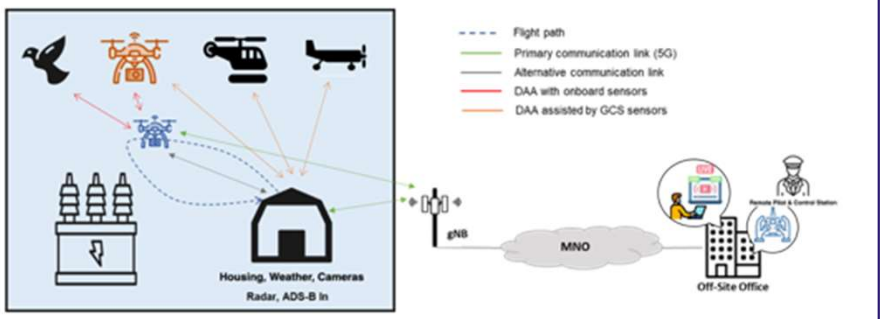
Package delivery



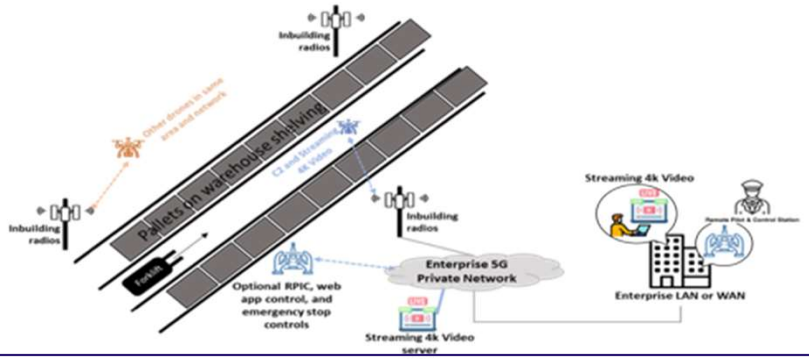
Emergency Response



Infrastructure Inspection



Indoor Inspection



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Use Case 5: Advanced Air Mobility (AAM)

transports passengers and cargo at low altitudes in urban and suburban areas.

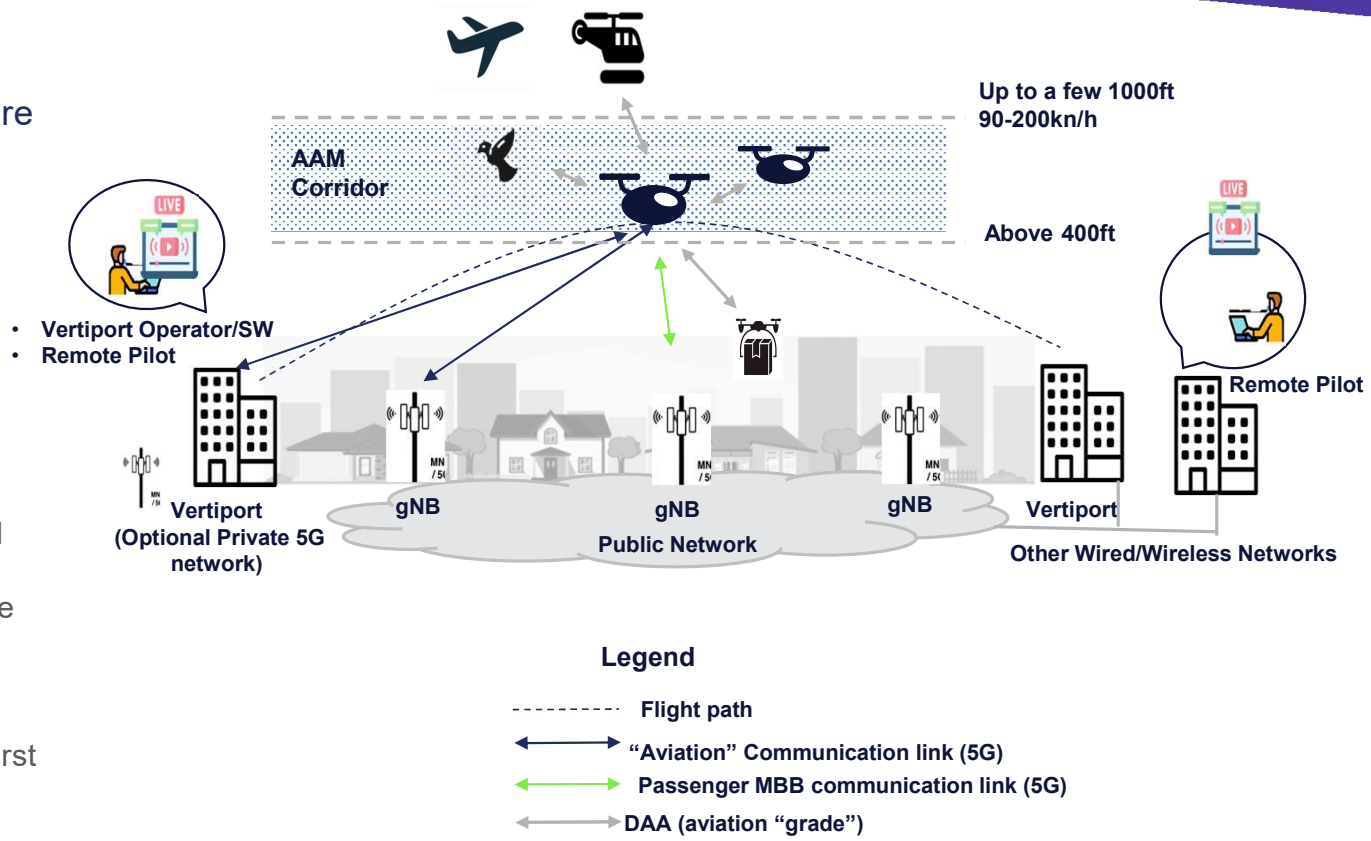
Objective: Develop AAM products that are safe, accessible and readily available to emerge as the global leader

Sample AAM use cases:

- Commercial inter-city (Longer Range/Thin Haul)
- Cargo delivery
- Public services
- Private/recreational vehicles

Key characteristics:

- Use cost-effective aircraft in both rural and urban areas
- To start, use existing vertiport infrastructure and build out as needed
- Meet national security requirements
- Requires that secure and reliable ATM (air traffic management) systems be in place first



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EXPERIMENTAL CAPABILITIES

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Open Generation | Drone Fleet

Knowledge gained by building 5G enabled UAS with custom apps, modems, robotics platforms.

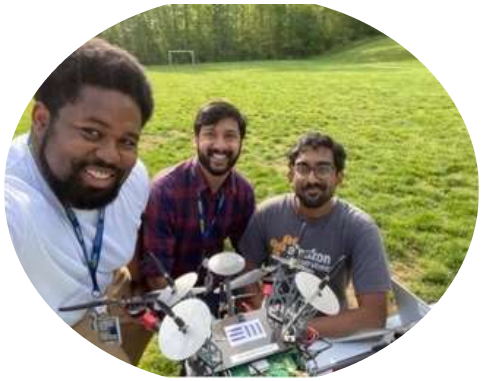
Lynxmotion HQuad500

Tarot 680 Pro

MITRE CASM

Qualcomm RB5/ Modal-AI RB5 5G Platform

Elanus Duo



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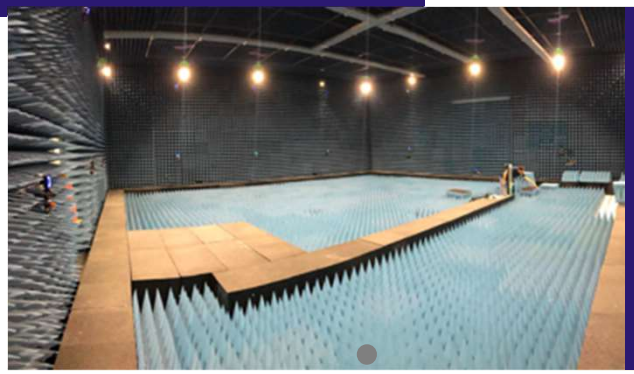
Open Generation | 5G Experimental Hubs within UAS Ranges

NUAIR 5G UAS Range Launched Jul-2022

Virginia Tech UAS Range 1Q23



Northeastern University Indoor UAS Range 1Q23

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Open Generation | 5G Experimentation Hub Technical Capabilities

Network Capabilities

Type: 5G Standalone (SA)
Network: Nokia 3 gNBs

Spectrum: AWS-3 Band 66 J block (FR1)

Aviation Capabilities

Flight ceiling: 400ft
Flight Type: BVLOS testing
UAS : <55 lbs
Range Size: 65 sq mile (5G)

Network Capabilities (Planned '23)

Type: 5G Non-Standalone + SA O-RAN
Network: Vendor (TBA) 2 eNB / gNBs

Spectrum: Non-Standalone (NSA)
- mmWave N261 28 GHz
- Sub-6 PCS Band B2 Anchor LTE

Virginia Tech (SA ORAN-planned)
- 3.5-3.6 GHz (experimental)

Aviation Capabilities

Flight ceiling: 400ft
Flight Type: BVLOS testing
UAS : <55 lbs
Range Size: 350 acres

Network Capabilities (Planned '23)

Type: 5G SA / NSA with SDR
Network: Open Src 5G CN
Open Src OAI srsRAN

Spectrum: All Frequencies
Anechoic Chamber >100db isolation

Aviation Capabilities

Flight ceiling: <50ft
Flight Type: N/A
UAS : <55lbs
Range Size: 50'x50'x22'

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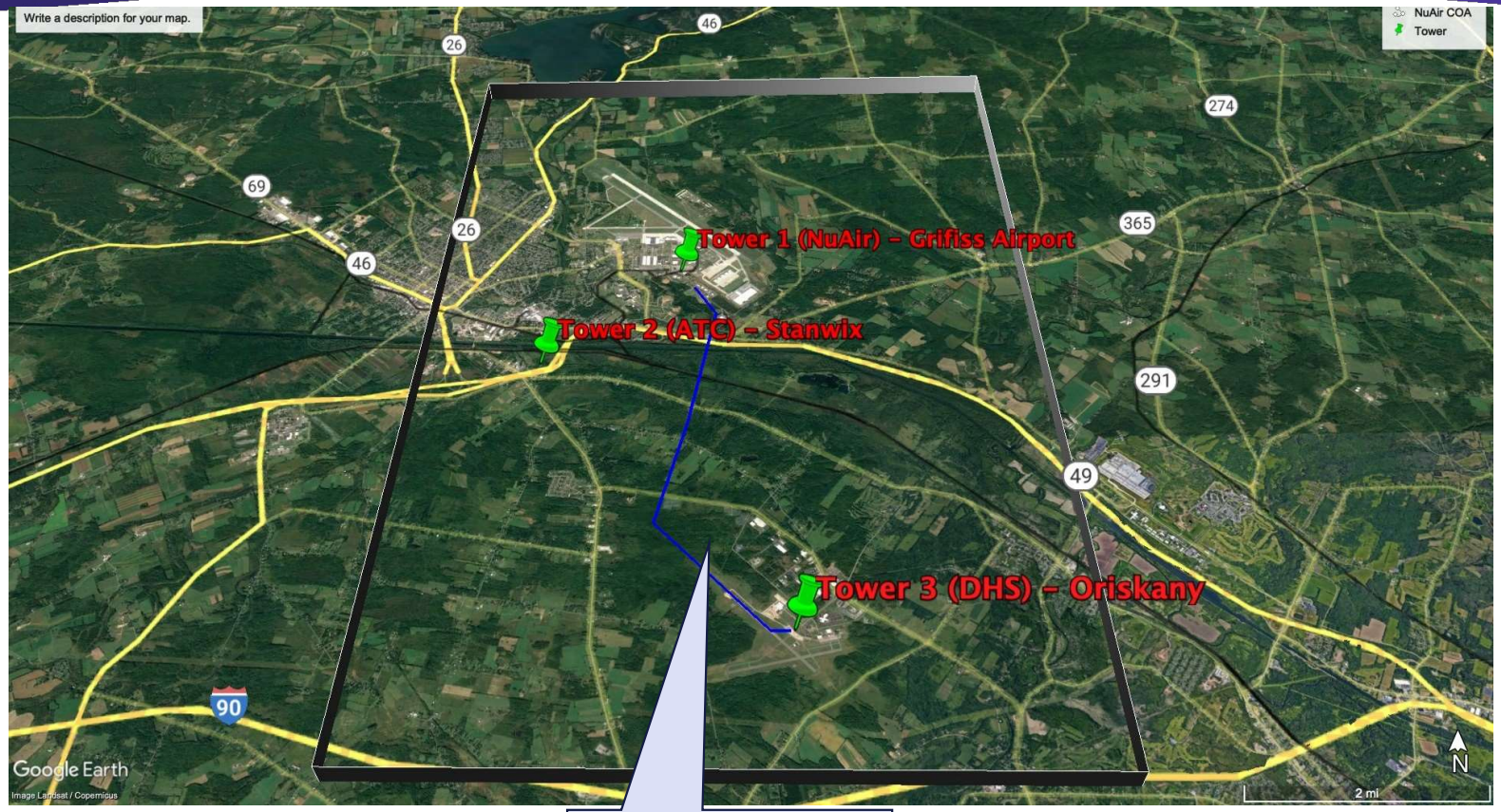
Radio Towers at NUAIR and Sample Drone Flight Path



Example flight path identified for initial experiments

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5G Radio Sites

Griffiss - Tower

Oriskany - Roof Top

Stanwix Tower

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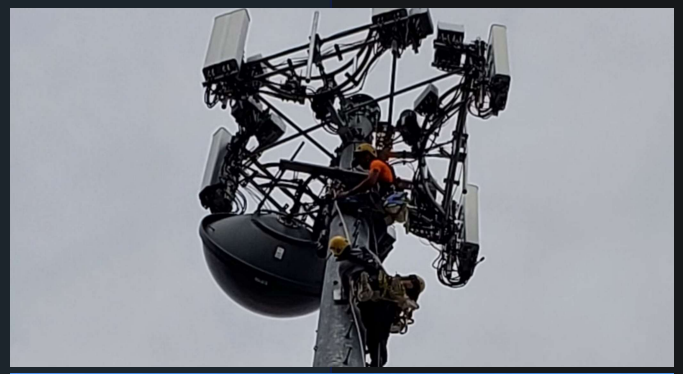

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Drone Takeoff and Landing Location

Takeoff Location - Griffiss

Landing Location - Oriskany

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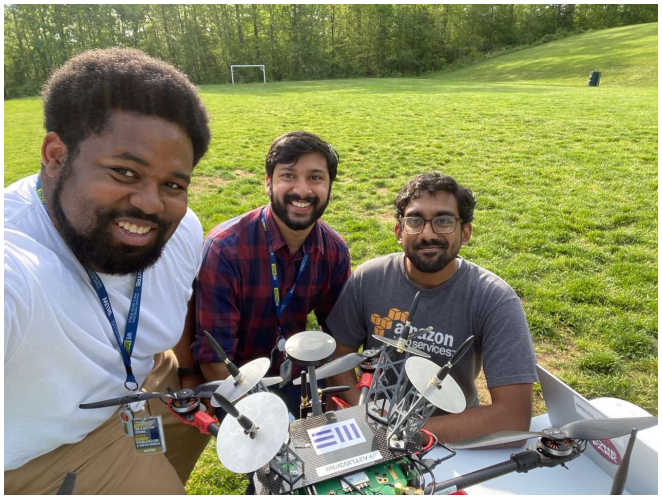
Field Tests



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Virginia Tech - Test site Overview

- The Virginia Tech UAS Test Site
  - FAA-Designated UAS Test Sites in the United States
  - Kentland Farm - Rural farm environment outfitted for UAS operations supporting BVLOS and owned by Virginia Tech (https://maap.ictas.vt.edu/capabilities/facilities.html)
- 5G NSA Network overview – estimated Q2-2023
  - 5G Non-Standalone Private Network
  - Spectrum: mmWave + anchor sub-6 band
- 5G SA Network with O-RAN solution – potential additional network
  - 5G Standalone Private Network, selecting O-RAN solution with Real-time RIC
  - Experimental VT license approved for this use.

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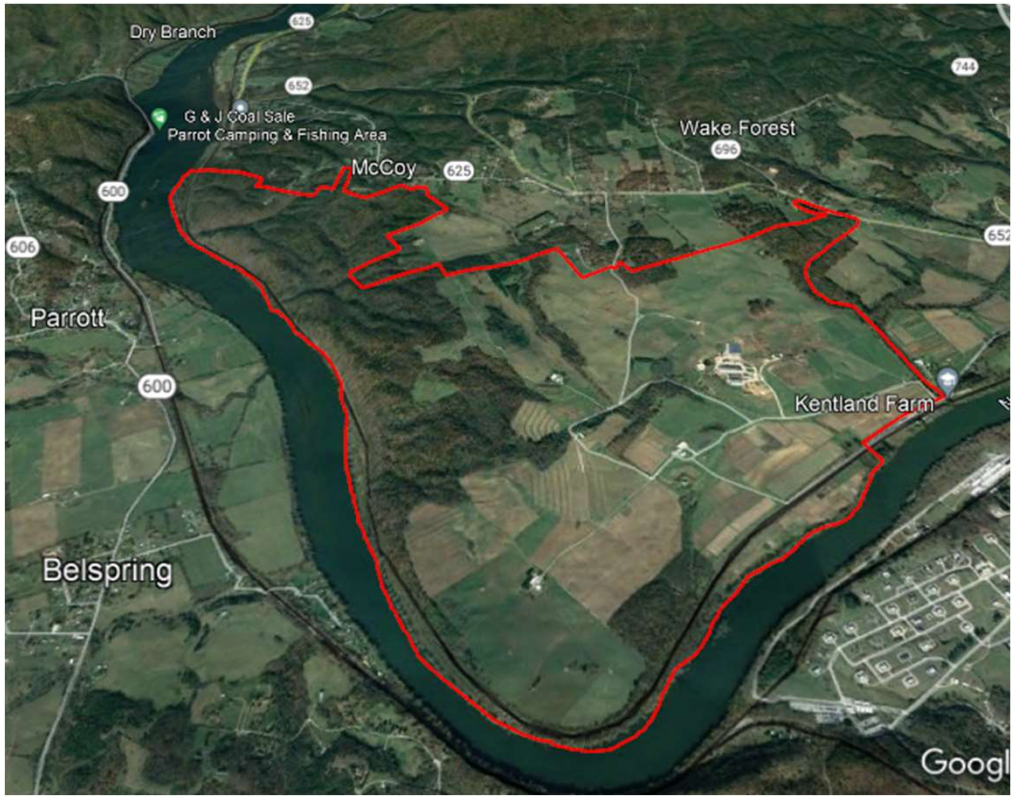
Virginia Tech – Kentland Farm Site

Complete Farm Area



Proposed Initial Coverage Area

Kentland Farm
5250 Whitethorne Road
Blacksburg, VA 24060

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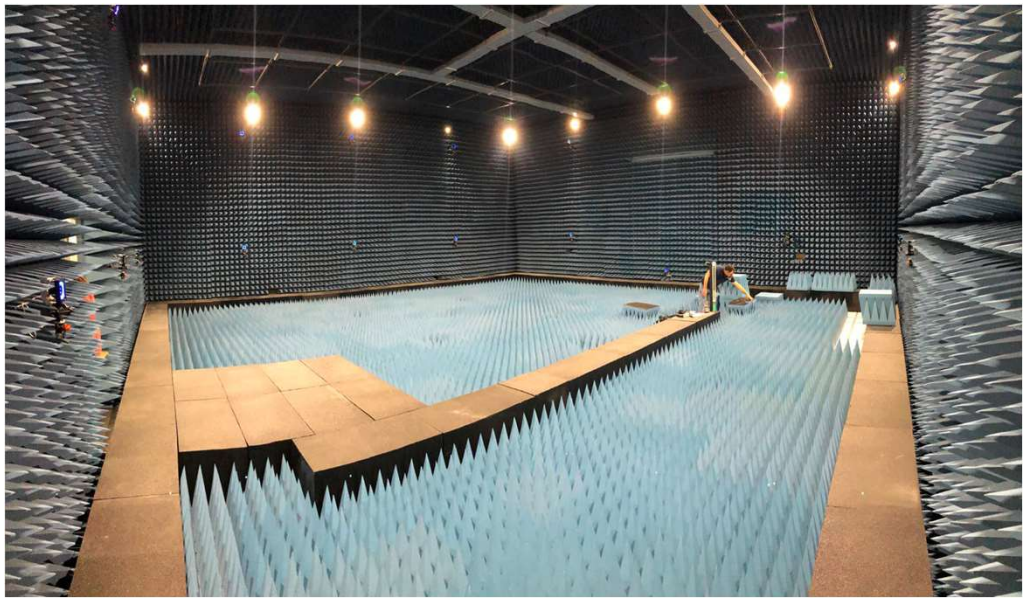
Northeastern University – Indoor Test site

- NE University (Burlington, MA) - Indoor-outdoor Facility with anechoic Chamber
- UAV Lab
  - Large-scale Faraday cage/Anechoic Chamber
- COLOSSEUM: RF Emulator
  - Programmable Radio Nodes, RF channel emulation
- 5G Network
  - Software-defined Radios (SDRs)
  - Private 5G network, SDR-based
  - No restriction on use of spectrum indoors
  - User Equipment (4G/5G): SDR & COTS smartphones



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Test Simulations Used to Reference Real World Flights

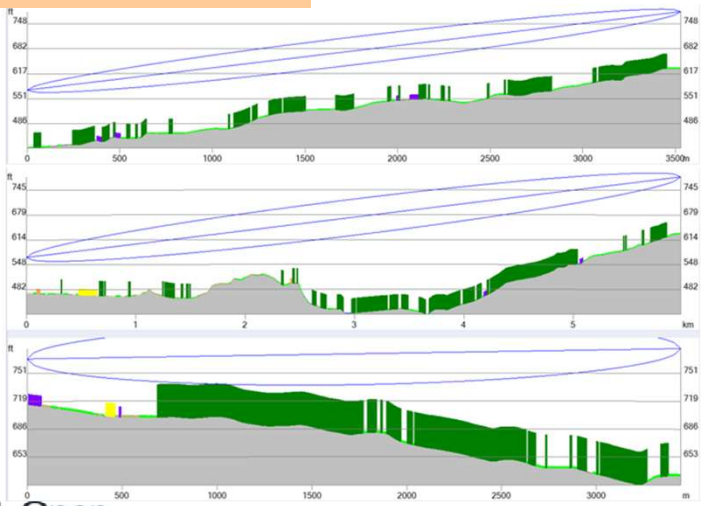
- Monte Carlo simulations
- Propagation channel model for drones
- Assess impact of channel fading on drone connectivity at altitude

Example Path Profiles

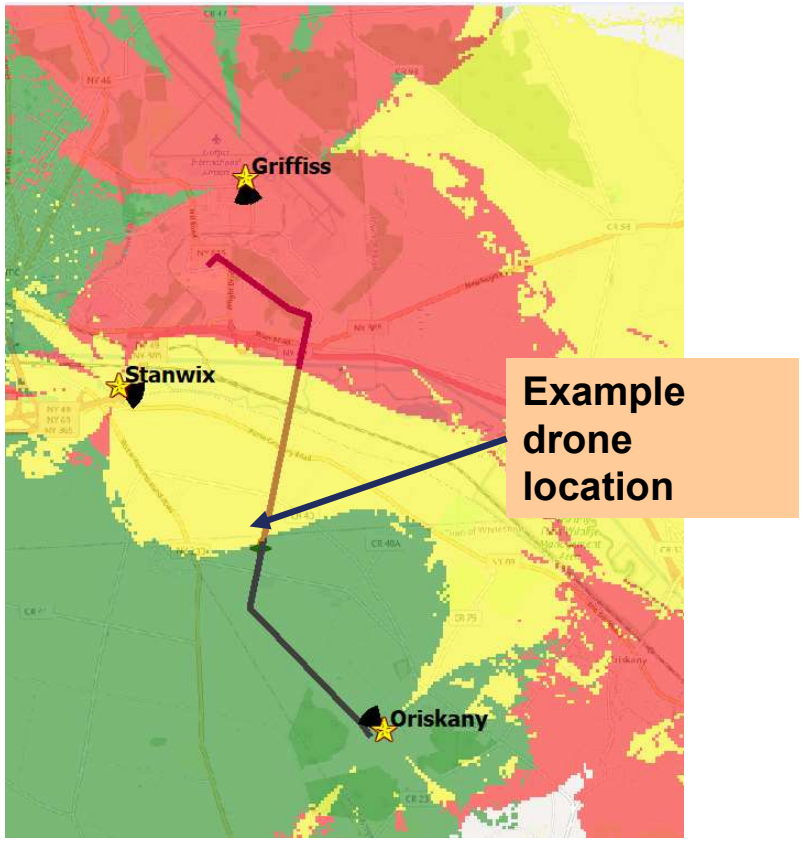
Stanwix to drone

Griffiss to drone

Oriskany to drone



NOTIONAL: Best Server based on Average Signal Level



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2022 Impact

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Impact Highlights

- Established 1st 5G experimental UAS hub at NUAIR – operational
  - Performed early baseline experiments
  - Opportunity to share experience of deploying 5G private network from scratch
- Design and procurement for mmWave NSA testbed at VT
- NEU testbed close to readiness for experiments (ORAN-based, indoors)
- Expanded UAS-related use cases (UAM/AAM)
- Published multiple technical reports
- Contribution to 3GPP on aerial C-V2X test result
- Open Generation 5G Summit had 450+ external attendees
- Identified next verticals to launch in 2023

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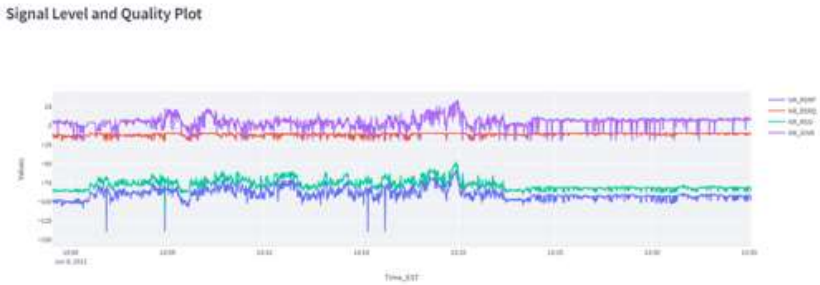
Open Generation | MITRE Drone Flight Testing



MITRE CASM Drone

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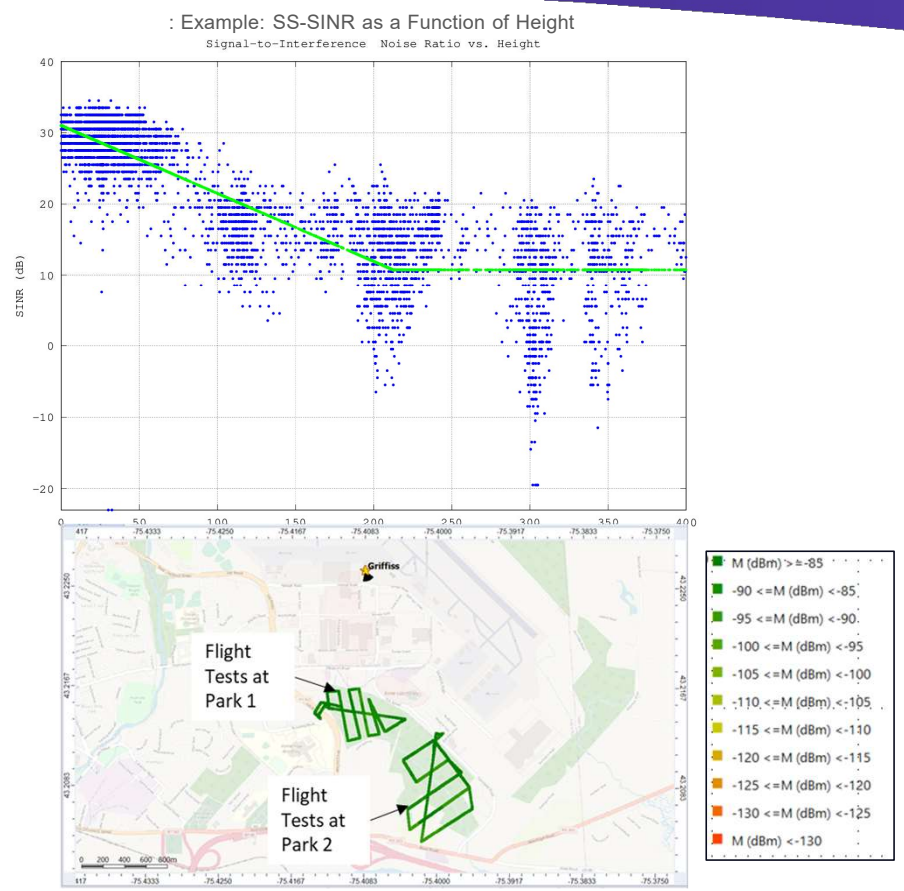
Example 1: Aerial 5G KPI Assessment at NUAIR Testbed

- Following private network deployment at NUAIR
- Performed several drive tests and flight tests at multiple heights
- Collected multiple KPIs
- White paper released with early findings



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Example 2: DAA Experiments Utilizing C-V2X

- Successfully demonstrated that PC5/sidelink can be used to support Detect and Avoid (DAA) and Remote ID
- Equipped drones with C-V2X modems
- Proof of concept experiments to see how functionally performs for UA DAA operations.
- Flying 2 UASs and gathering KPIs
- Open Generation submitted input to 3GPP: SA2#153E , AI#9.5 3GPP TR 23.700-58 3GPP RAN2#119-bis-e, AI#8.8.4
- Expanded white paper released

Map of experimental area

Drone (1 of 2) equipped with C-V2X modem

Example of data collected during tests

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A Pipeline for Innovation Through 5G R&D Collaboration

Open Generation Consortium

Use case driven R&D to address complex challenges

UAS Experimentation Testbeds & Flight Path Realization

Data to inform industry & regulators

Holistic Collaboration

Cellular networks & 5G capabilities

Accelerated Standardization

Accelerated UAS deployment

More use cases coming…

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Smart Cities & Smart Health | New Verticals

- Objective:
  - Enable use cases combining internet of things (IoT) sensing, connectivity, and smart response to benefit urban & suburban environments in several dimensions (e.g., health, safety, mobility)
- Potential early use cases to be considered:
  - **Connected Ambulance**
  - **Smart Downtown Public Safety**
  - **Community Health Monitoring**

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Open Generation | Public Work Group Findings

Sample of recently published MITRE Engenuity Open Generation technical documents.

December 2021

February 2022

April 2022

June 2022

January 2023

February 2023

February 2023

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THANK YOU

Open Generation | Management Committee

Leaders from cross section of industry actively leading use case innovation creation

MITRE
Ajit Kahaduwe,
Chairman

ERICSSON
Paul Challoner

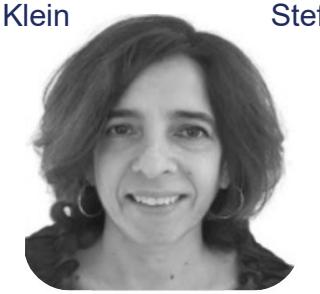
NOKIA
Thierry Klein

Qualcomm
Stefano Faccin

verizon
Ed Diaz

MITRE
Leila Ribeiro,
Chief Technical Director

ctia
Tom Swanobori



OST
Renu Chaudhry

VIRGINIA TECH
Daniel Jakubsin

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Open Generation | Government Liaison Program

March 2022

NASA Langley

April 2022

FAA

May 2022

MassDOT

Feb 2023

AFWERX

March 2023

Interaction

- Government Liaisons advise on programs, policy, and R&D in part through roundtables
- Open Generation Members apprise Government Liaisons of use case development, experimentation, & solutions.
- Together, Government Liaisons and Open Generation Members build awareness of emerging solutions and possibilities through events and demonstrations

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Use Case 1: UAS for Emergency Response
over 5G networks helps first responders save time and lives.

Objective: Surveil the scene before help arrives to inform human action for emergency response

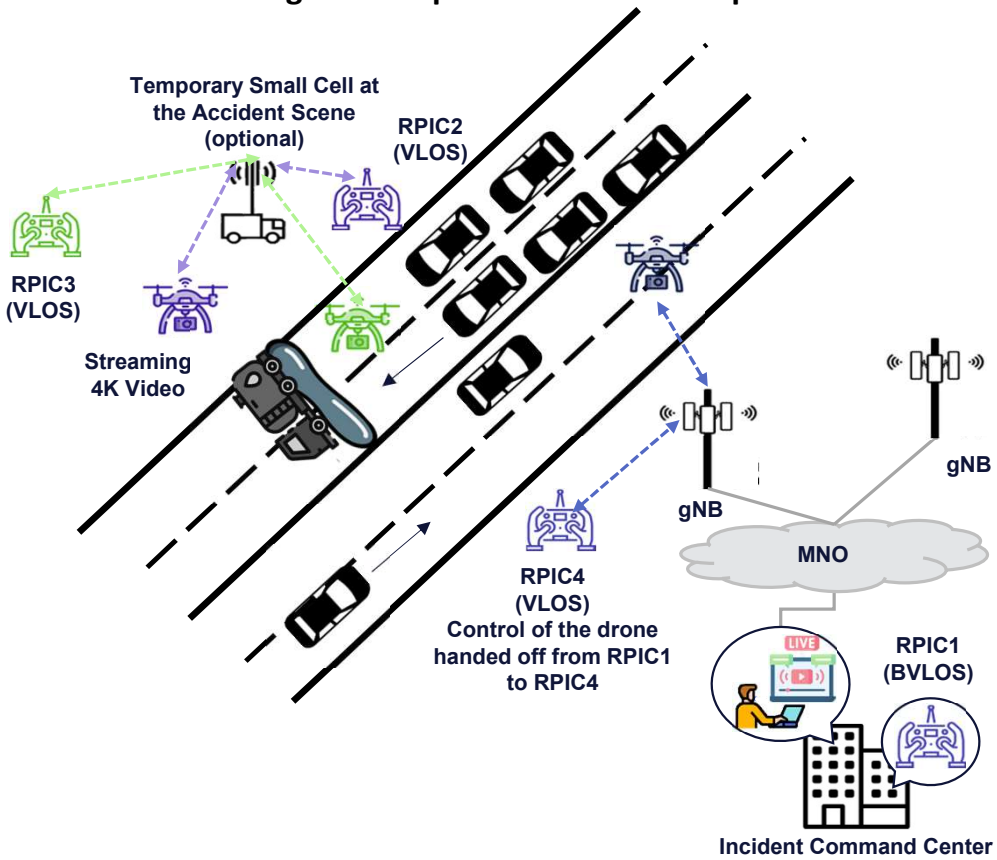
Specific use cases:

- Drone to support first responders
- Hazmat incident response
- Damage assessment
- Border and port inspections
- Overwatch supporting law enforcement
- Lost person search

Key characteristics:

- Need to provide high-quality visual (video stream) as well as other types of sensor data to incident responders
- Need option to manually pilot drones or maneuver the drone into proper positions (given fluid situations as incidents unfold and due to the unstructured environments in which drones needs to operate)
- Sophisticated detect-and-avoid (DAA) solutions need to be in place as multiple drones may be in use concurrently or other crewed aircraft, (e.g., helicopters, at low altitude in the same area)

Figure: Sample UAS Incident Response



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Use Case 2: UAS for Package Delivery

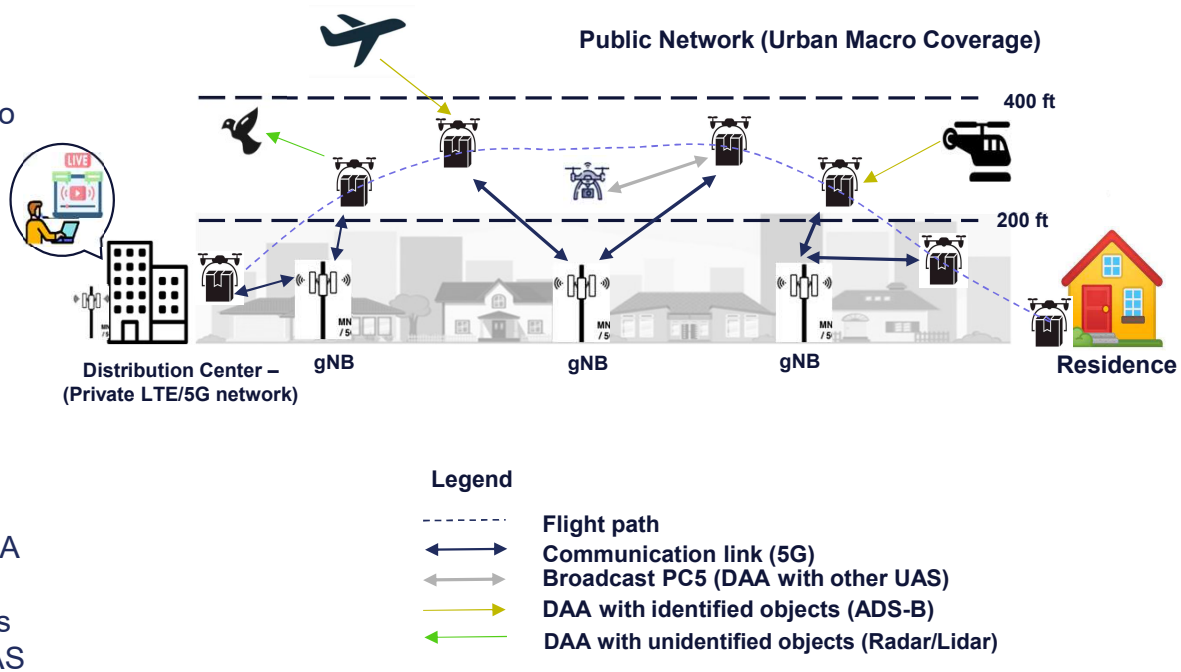
over 5G networks reduces delivery times while increasing possible distribution.

Objectives: Utilize UAS to increase product distribution, reduce product delivery times and achieve corresponding cost savings

- Focused on the last delivery segment of a package to its final destination from a distribution center
- Assumes that the delivery drones are stationed at a warehouse infrastructure that allows loading and unloading of packages, and take-off and landing of multiple drones

Key characteristics:

- The warehouse and its immediate proximity are covered by a private 5G network while the actual delivery segment of the flight may be supported by a public 5G network.
- Flight operations are mostly automated including DAA mechanisms.
- Deliveries can be in urban, suburban, and rural areas each of which presents unique challenges for the UAS operation as well as for the communication technology.



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Use Case 3: UAS for Static Infrastructure Inspection over 5G

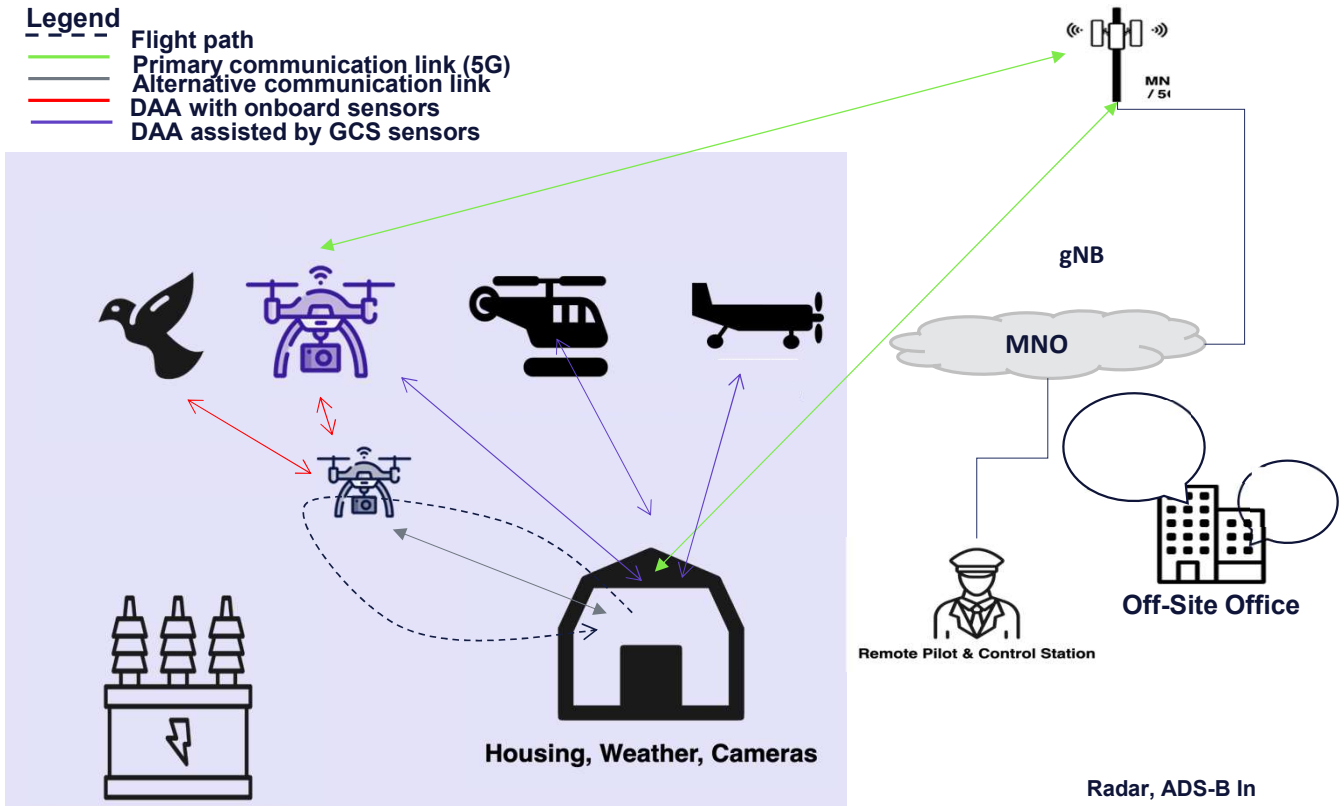
supports infrastructure maintenance over large, distributed, terrain in often remote areas.

Objective: provide potential remedies for costly inspections

Sample Use Case: "Drone-in-a-box" UAS solutions

Key characteristics:

- Limited and known geographical area where drone inspection flights take place (provides opportunities to relax some operational requirements)
- Command and control (C2): connection for flight control in different operation modes (autonomous & 'remote controlled) depending on inspection needs
- High-resolution video/imagery streaming needed for mission payload (and possibly to support flight path control in some circumstances)



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