National Aeronautics and Space Administration

Unmanned Aerial Systems Traffic Management (UTM)

SAFELY ENABLING UAS OPERATIONS IN LOW-ALTITUDE AIRSPACE

NASA

http://www.utm.arc.nasa.gov

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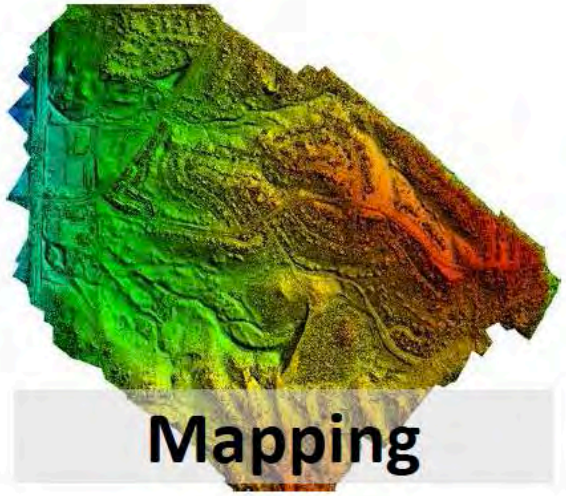
Applications of Unmanned Aerial Systems



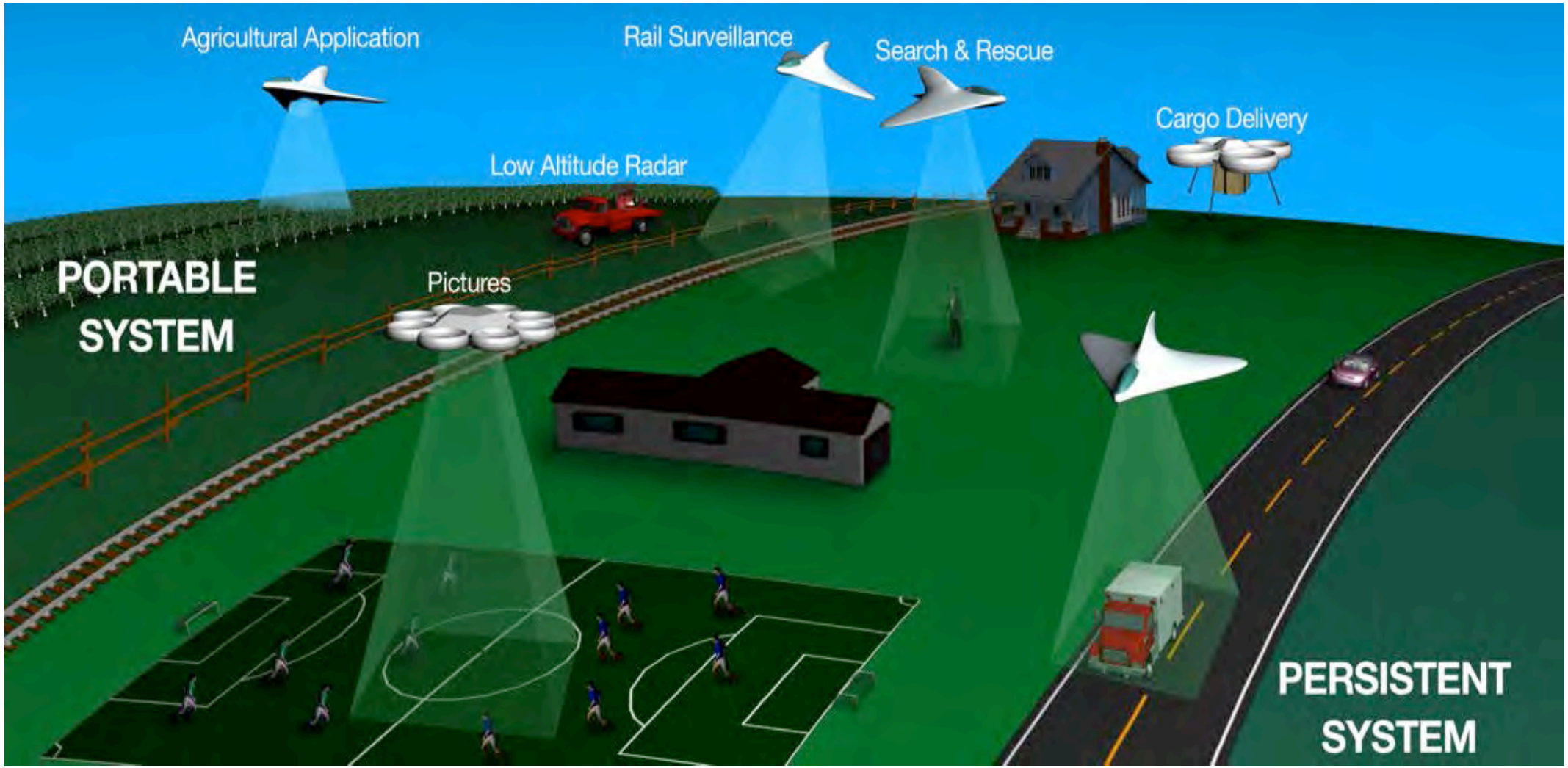
http://www.kcet.org/updaily/socal_focus/history/la-as-subject/7th-and-broadway.html

1920, Photo Collection, Los Angeles Public Library

Unmanned Aerial System Traffic Management (UTM)

Near-term Goal: Safely enable initial low-altitude UAS as early as possible

Long-term Goal: Accommodate increased demand with highest safety, efficiency, and capacity



Challenge and Opportunities

- Challenge: Acceptance of large-scale UAS operations in low altitude airspace
  - Airspace operations requirements: technology and procedures
  - Safety
  - Privacy policy
  - Security
  - Noise
  - Public perception
- Economics: Safe, secure, and scalable “Beyond visual line of sight” operations
- Opportunities: Technology advancements and new business models

UTM: Balancing Multiple Needs

National and Regional Security

Protecting key assets

Safe Airspace Integration

Flexibility where possible and structure where needed

Geographical needs, application, and performance-based airspace operations

Scalable Operations for Economic Growth

Ever-increasing applications of UAS: Commercial, Agricultural, and Personal

What is UTM?

Research software prototype that

(1) Allows UAS operators to submit flight plans to execute a specific mission in low-altitude airspace, and

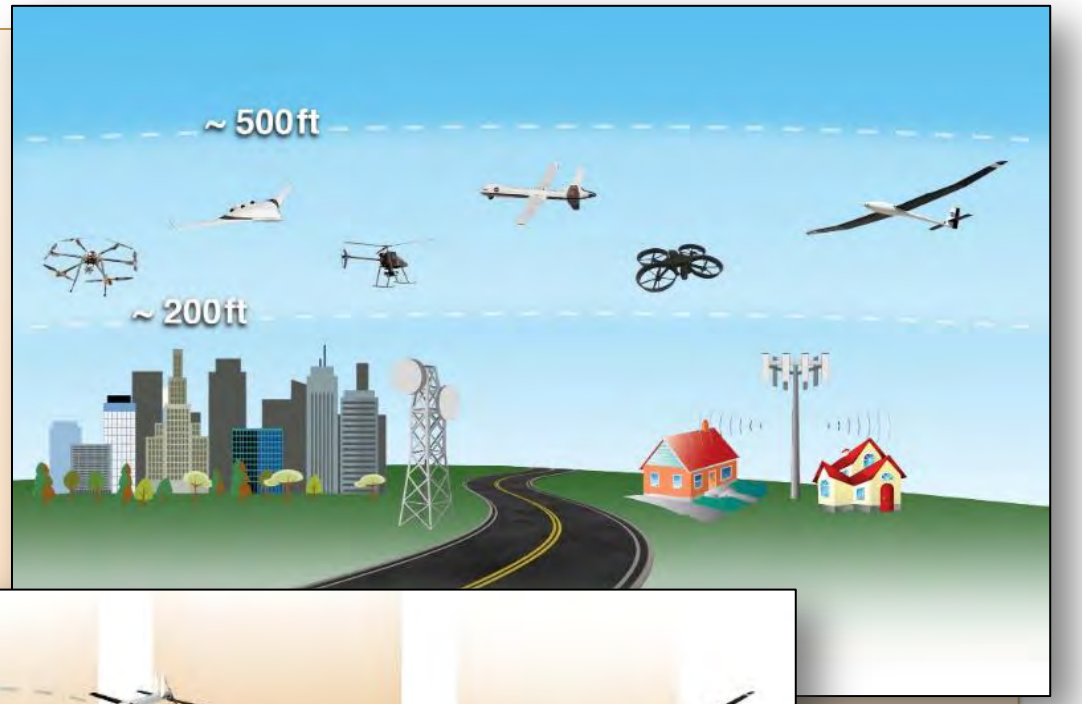
(2) Determines how to safely enable such single or multiple UAS operations either within visual line of sight or beyond visual line of sight

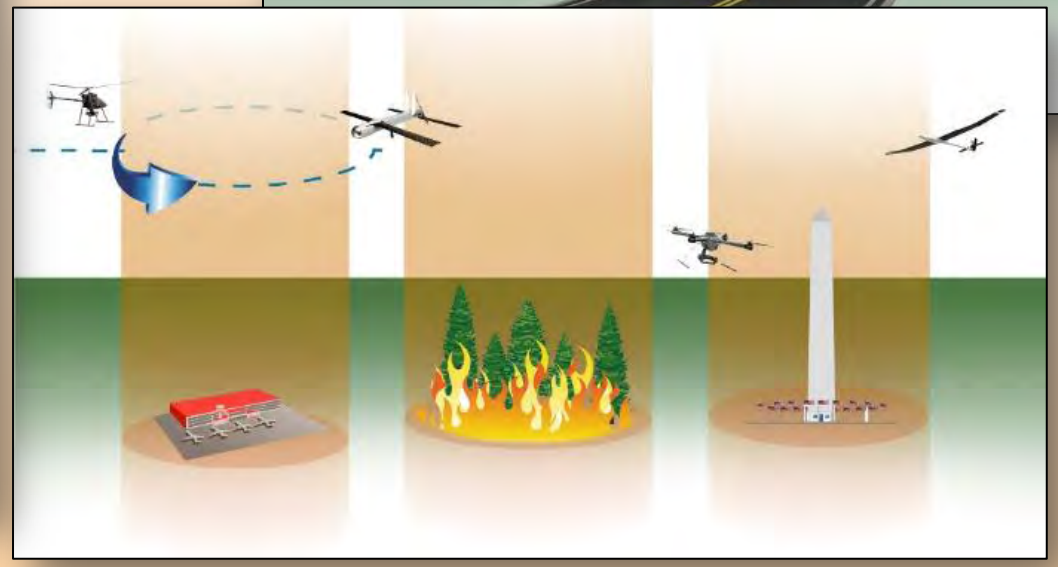
PRODUCT: Validated airspace operations requirements

UTM Functions

Airspace Operations & Management

- ~500 ft. and below
- Geographical needs and applications
- Rules of the airspace: performance-based
- Geofences: dynamic and static

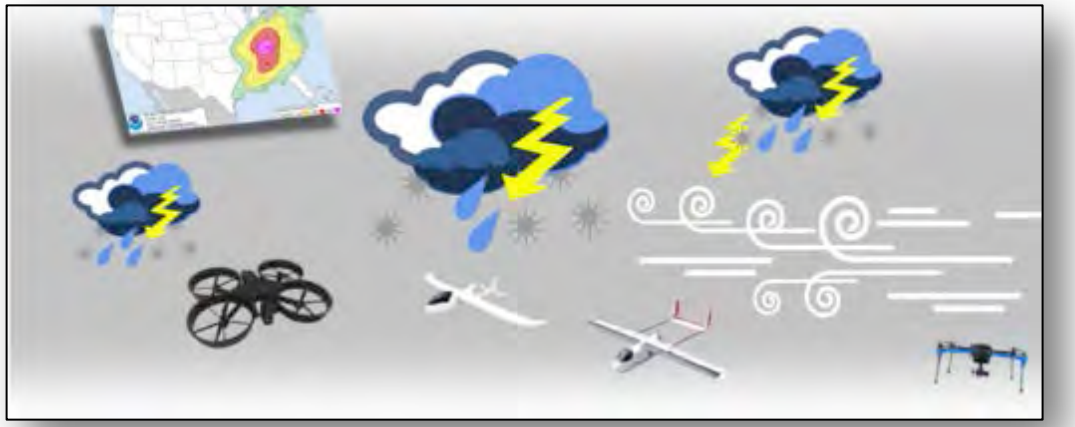




UTM Functions

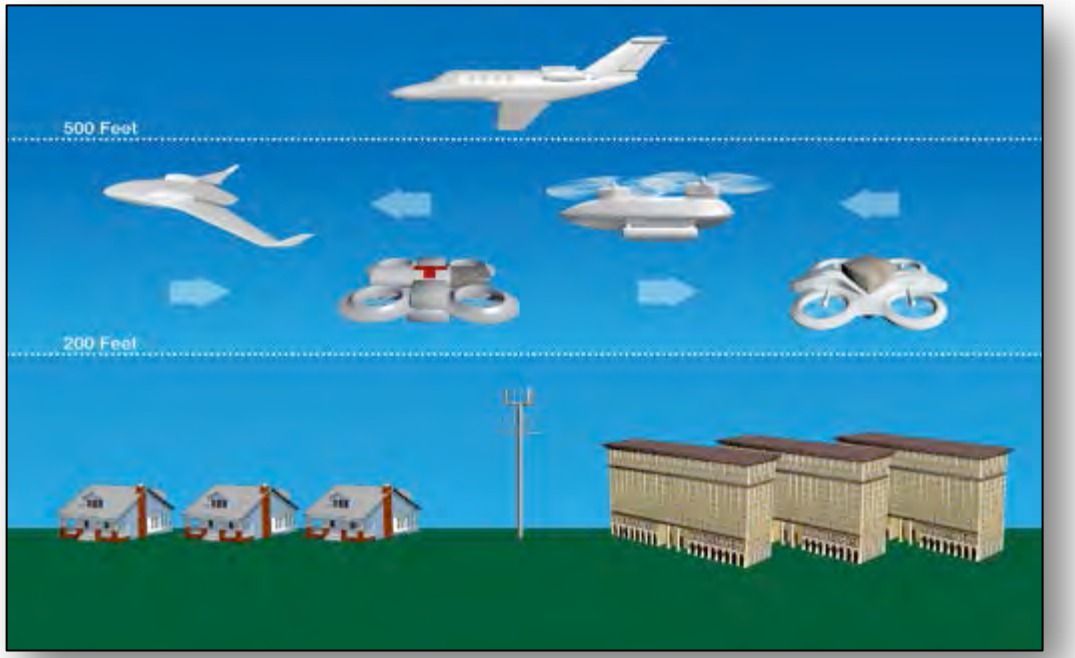
Wind & Weather Integration

- Actual and predicted winds/weather



Congestion Management

- Demand/capacity imbalance
- Only if needed – corridors, altitude for direction, etc.



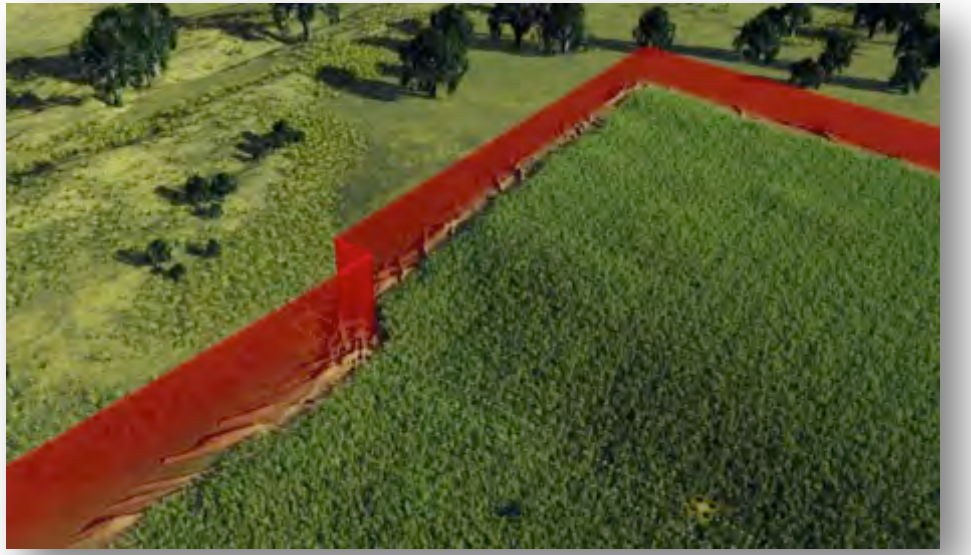
UTM Functions

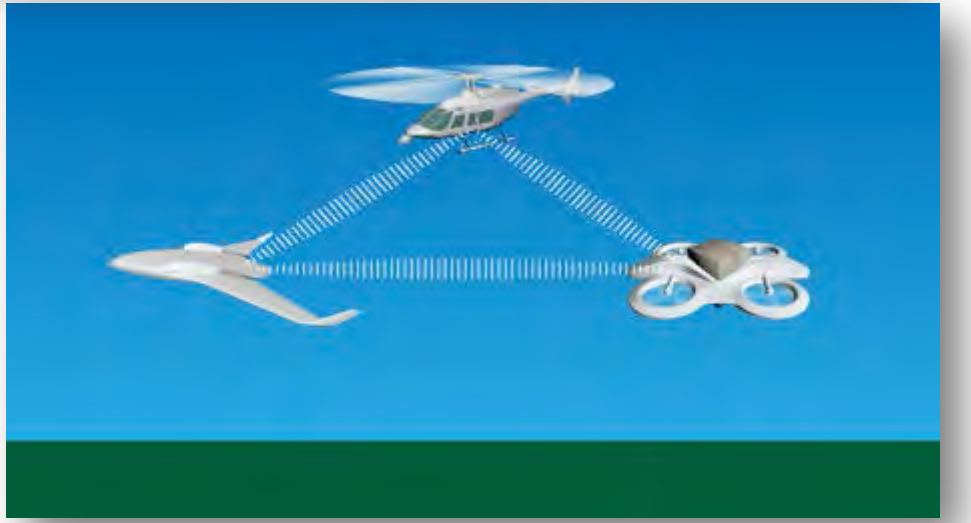
Separation Management

- Airspace reservation
- V2V and V2UTM
- Tracking: ADS-B, cellphone, & satellite based

Contingency Management

- Large-scale GPS or cell outage
- 9-11 like situations





Information Flow

Vehicle Performance Database

UTM Vehicles Registration

Check if UVIN is registered

2

Schedule delivery to …

Operator submits operation (waypoints; vehicle info; operator data)

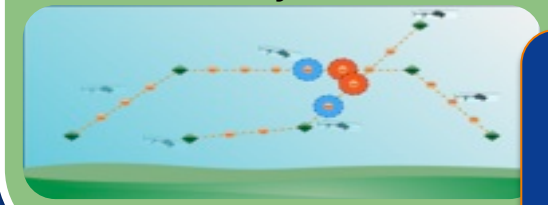
1

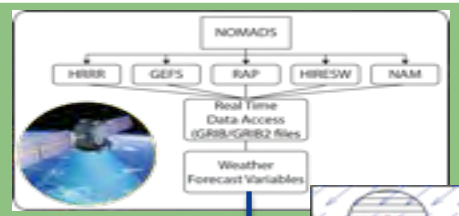
Check static constraints

3

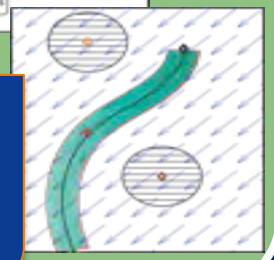
4

Dynamic Constraints
- Weather
- Conflict Detection
- Feasibility





Model-Based Trajectory Constraint Check



Check dynamic constraints

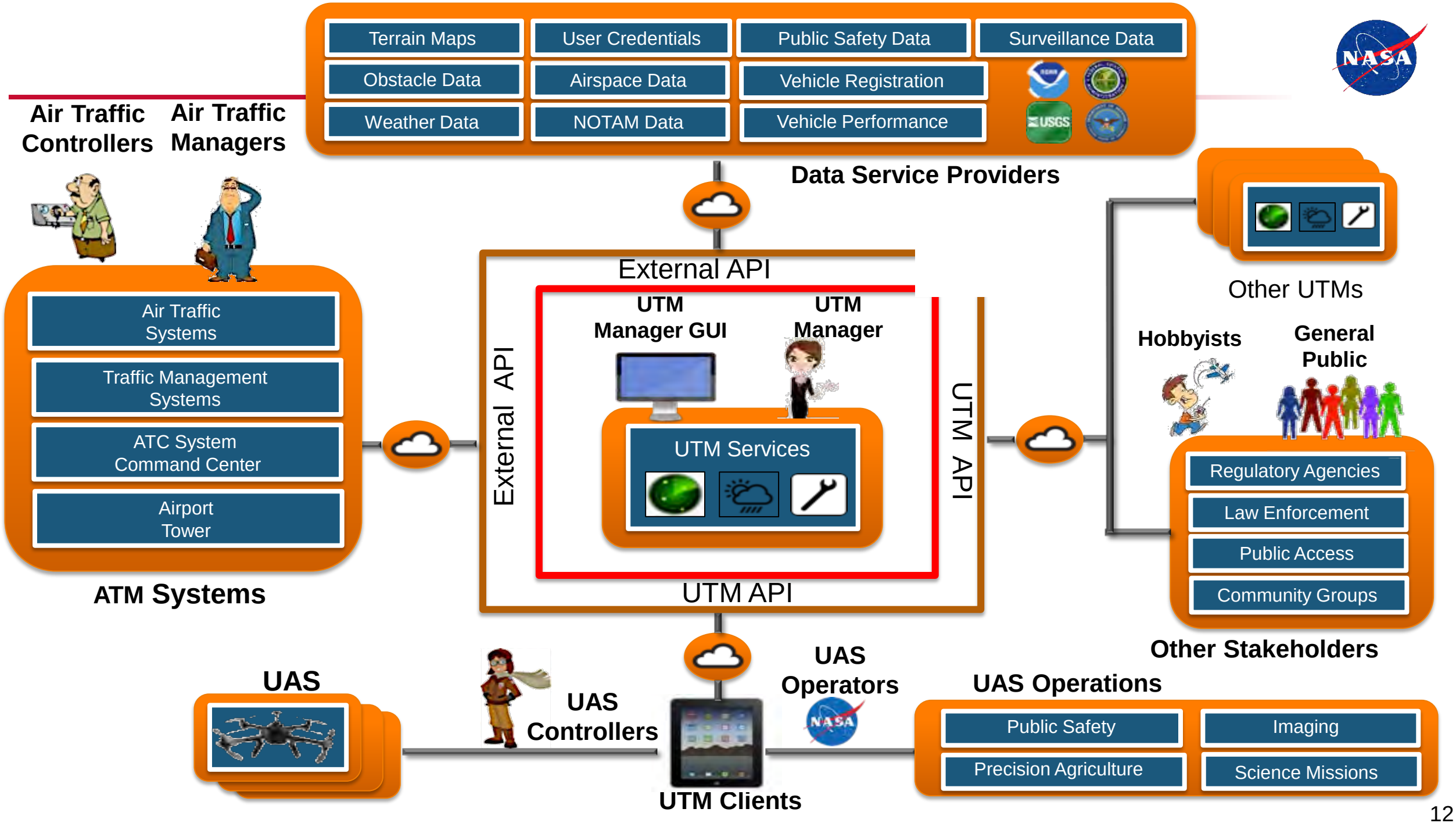
UTM Services

5

Contingency Management
- Geo-fence breach
- Loss of C2
- Emergency responder

6

Operation completed


Terrain Maps
User Credentials
Public Safety Data
Surveillance Data
Obstacle Data
Airspace Data
Vehicle Registration
Weather Data
NOTAM Data
Vehicle Performance
Data Service Providers
Air Traffic Controllers
Air Traffic Managers
Air Traffic Systems
Traffic Management Systems
ATC System Command Center
Airport Tower
ATM Systems
External API
UTM Manager GUI
UTM Manager
UTM Services
External API
UTM API
UTM API
Other UTMs
Hobbyists
General Public
Regulatory Agencies
Law Enforcement
Public Access
Community Groups
Other Stakeholders
UAS
UAS Controllers
UAS Operators
UTM Clients
UAS Operations
Public Safety
Imaging
Precision Agriculture
Science Missions

UTM Target Capability Level

Each capability is targeted to type of application, geographical area and uses risk-based approach

Capability 1 (August 2015)

- Reservation of airspace volume
- Over unpopulated land or water
- Minimal general aviation traffic in area
- Contingencies handled by UAS pilot
- Enable agriculture, firefighting, infrastructure monitoring

Capability 3 (January 2018)

- Beyond visual line of sight
- Over moderately populated land
- Some interaction with manned aircraft
- Tracking, V2V, V2UTM and internet connected
- Public safety, limited package delivery

Capability 2 (October 2016)

- Beyond visual line-of-sight
- Tracking and low density operations
- Sparsely populated areas
- Procedures and “rules-of-the road”
- Longer range applications

Capability 4 (March 2019)

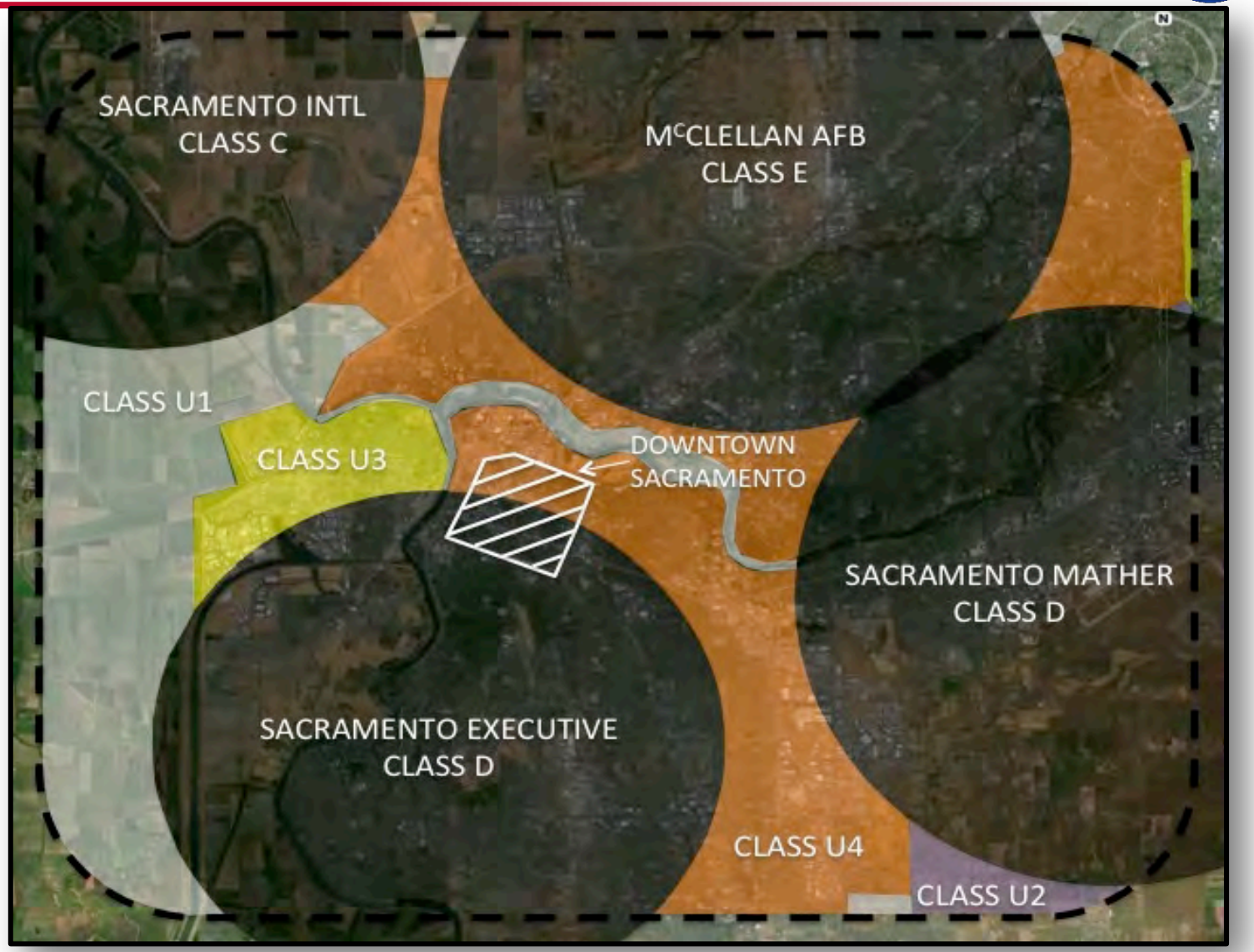
- Beyond visual line of sight
- Urban environments, higher density
- Autonomous V2V, internet connected
- Large-scale contingencies mitigation
- News gathering, deliveries, personal use

Notional UTM Airspace

Multiple providers could offer some UTM services

Tailoring operational services based on geographical area needs

Vehicle performance could be different



Consideration of Business Models

UTM POTENTIAL BUSINESS MODELS

Single service provider: government entity

Traditional ANSP, like the FAA

Single service provider: a non-government entity

Web services - General Aviation flight service station model

Multiple service providers: state/local government entities

Each state may implement or delegate to counties/cities

Multiple service providers: non-government entities

Regional implementations by various companies - customized

Regulator has a key role in certifying UTM system and operations.
All UTM systems must interoperate.

Potential Users of UTM

Air Traffic Controllers

Hobbyists

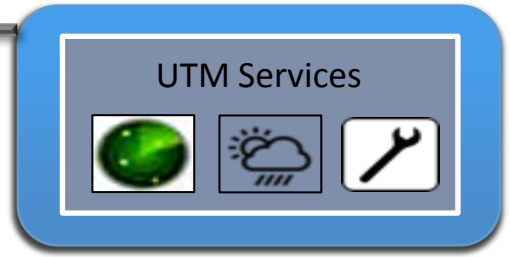
Manned Aircraft Pilot

General Public

UTM Manager

UAS Controllers

UAS Operators



Can use UTM information services for safety

Reviews UAS operations prior to take off, maintains situation awareness for safety

Can use UTM information services for safety, privacy, and security concerns

Makes strategic decisions to ensure safety, efficiency and equity of the UTM Airspace

Responsibly for the safe conduct of UAS vehicle(s)

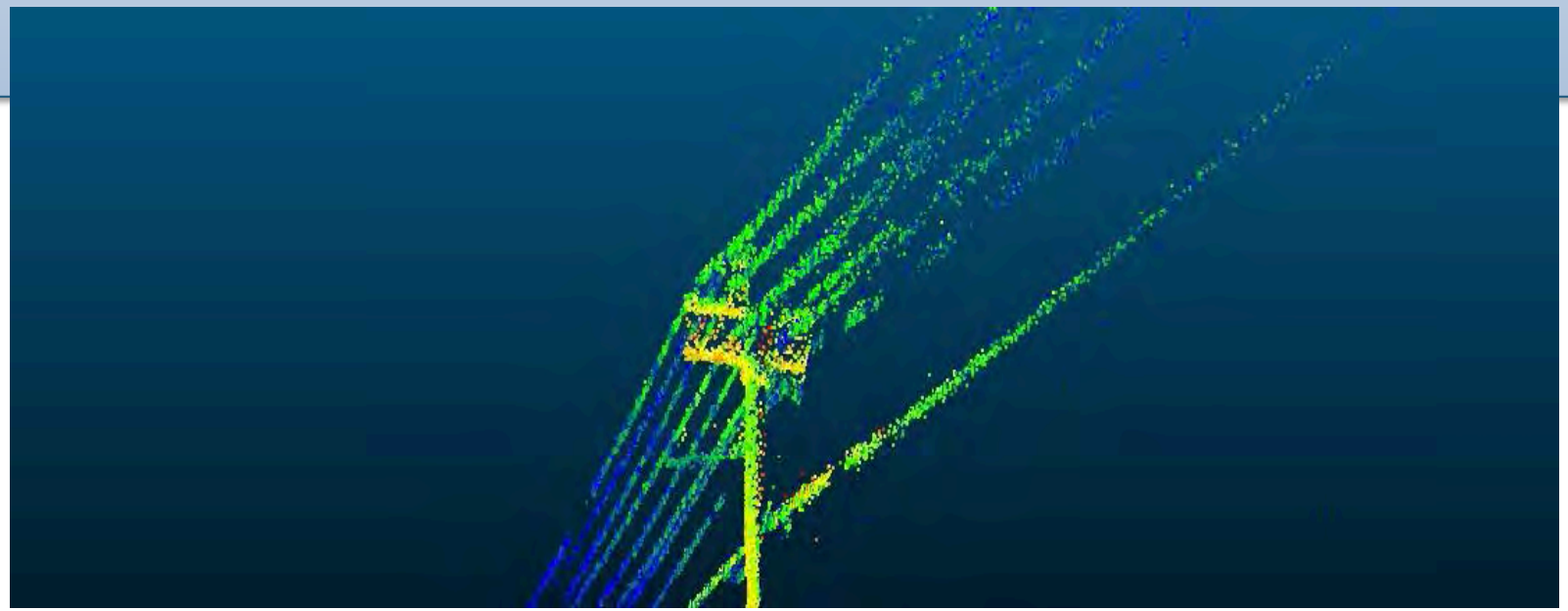
Legal entity that requests access to UTM airspace and manages UAS operations

Progress

- Research Transition Team with FAA, DHS, and DoD
- 200+ industry and academia collaborators and increasing
- Initial UTM Concept of Operations: Industry, academia, and government
- Technical Capability Level 1 with 12 partners completed
- Technical Capability Level 2 in October 2016
- International interest

Opportunities: Research and Technology

- Beyond visual line of sight autonomous operations
- Tracking and locating every vehicle: Cooperative and non-cooperative
  - Cell/wireless, Automatic Dependent Surveillance, Satellite, localized beacon based systems
- Sense and avoid
  - Other vehicles (V2V) as well as objects such as wires
- Command, control, and communications without aviation certified systems: cell phone, etc.
- Last/first 50 feet: sensors, hardware, and software for autonomous operations
- Security



Policy and Public Acceptance

- Policy
  - Acceptable noise
  - Privacy considerations
  - Transportation safety

- Public Acceptance
  - Humanitarian applications: Disaster relief, medicine delivery, etc.
  - Public safety: Traffic, bridge inspections
  - Agricultural: Large remote areas
  - Commercial: Cargo and package delivery
  - Personal applications: roof top inspection

- Crawl-walk-run strategy – from remote areas to urban areas

Next Steps

- Development, simulations, and testing of UTM Builds 2-4
- Safety analysis

- NASA will continue to work with industry, academia, and government groups
  - Refine operational requirements, system architecture(s), prototype, and conduct tests – Continue until safe airspace integration is proven!

- National initial safe UAS integration campaign: coordinated effort for data collection and demonstrations
  - Through FAA test sites and other approved locations

NuSTAR: Towards Self-Regulation

- Self-regulation: responsible, credible, collaborative
- National UAS Standardized Testing and Rating (NuSTAR)
- Parallel: Underwriter's Laboratory, Consumer Reports, JD Powers, Which?
- Credible test bed and scenarios
  - Urban, rural, atmospheric conditions (e.g., fog, smog, rain)
  - Simulated pets
  - Failure modes
  - Sub-system level performance: engine/propulsion, networking, battery, sensor systems, software systems
  - Cyber-security, GPS denied conditions, etc.
- Support UAS manufacturers, consumers, FAA, insurance companies, and public at large through objective assessments
- Forensics analysis: Re-creation of incidents and accidents

Questions

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