



# SAFELY ENABLING LOW-ALTITUDE AIRSPACE OPERATIONS Unmanned Aerial System Traffic Management (UTM)

NEXTGEN

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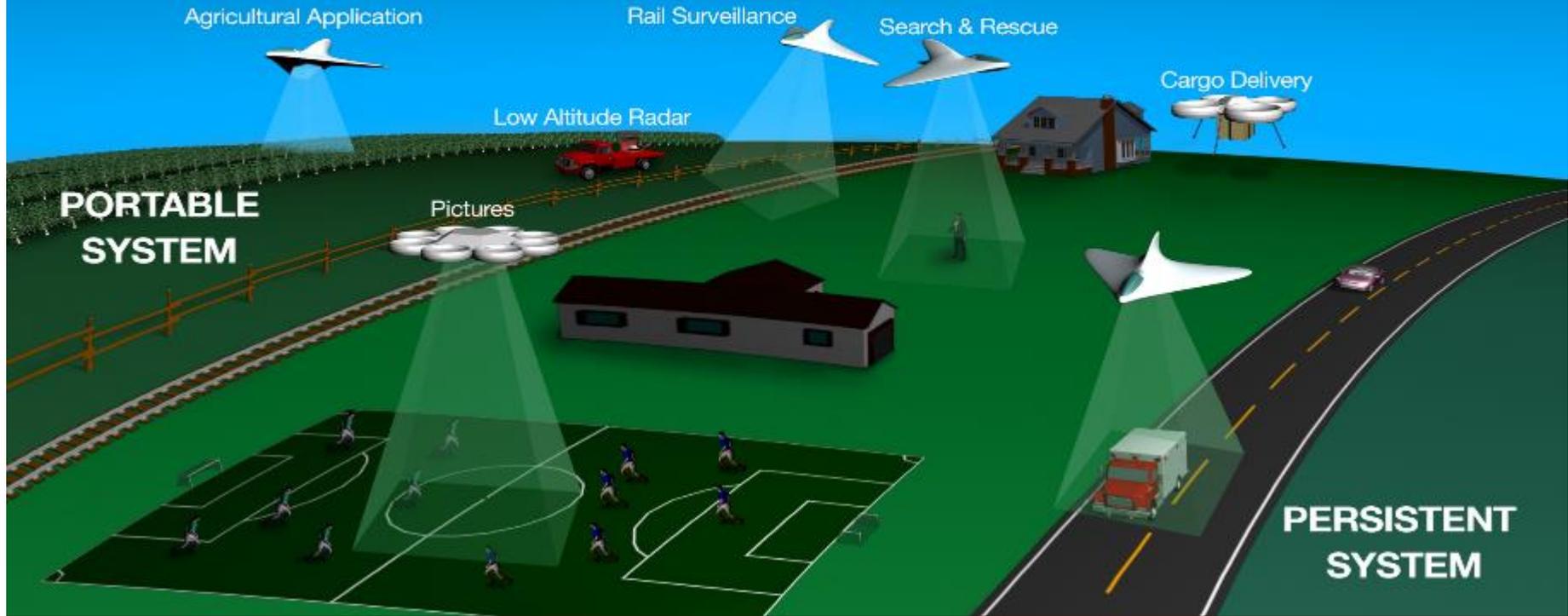
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# UTM Applications



## NOTIONAL SCENARIO



- **Near-term Goal** – Enable initial low-altitude airspace and unmanned aerial system (UAS) operations with demonstrated safety as early as possible, within 5 years
- **Long-term Goal** – Accommodate increased UAS operations with highest safety, efficiency, and capacity as much autonomously as possible (10-15 years)

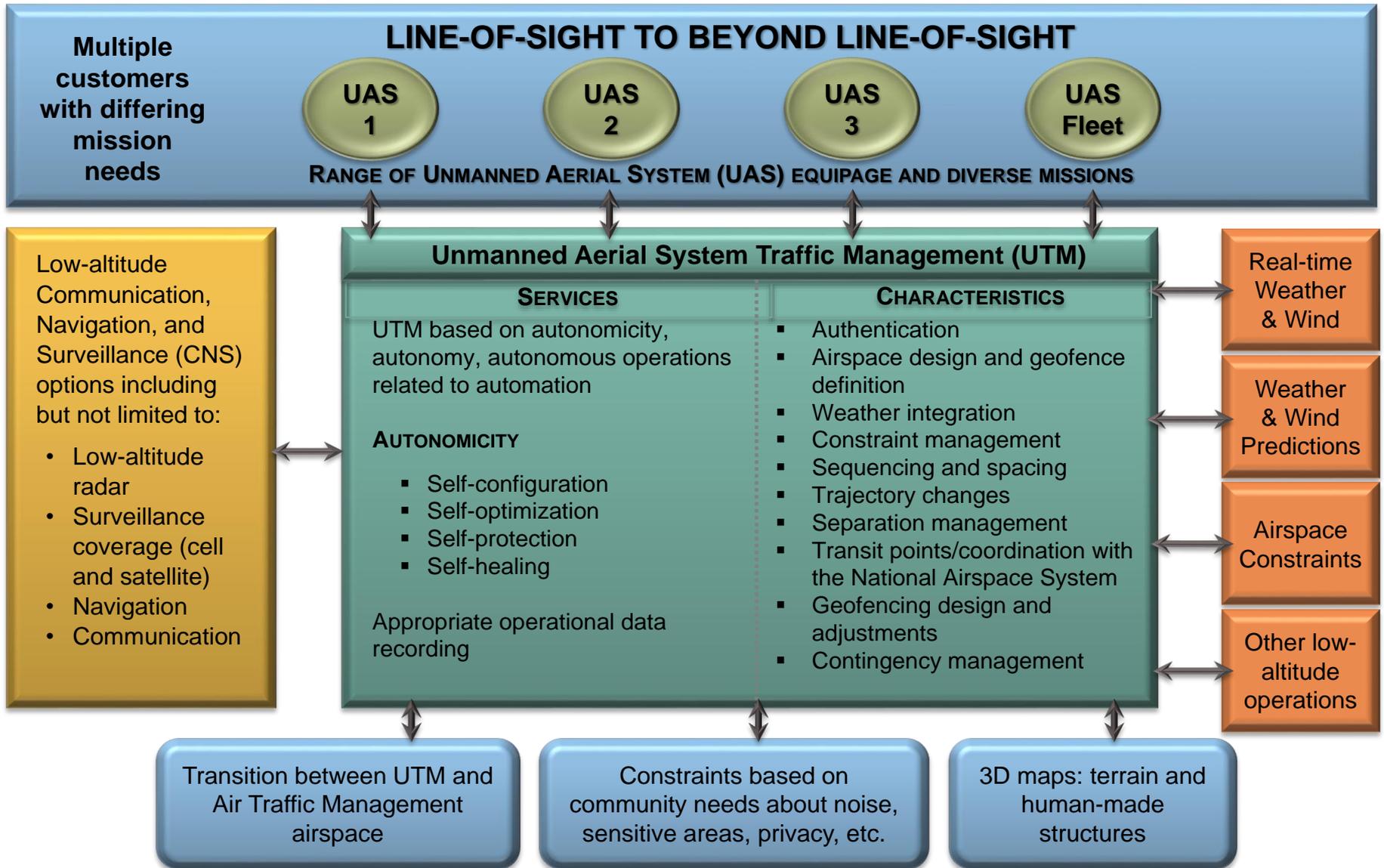


# UTM Design Functionality

- Cloud-based architecture
- UAS operations will be safer if a UTM system is available to support the functions associated with
  - Airspace management and geofencing
  - Weather and severe wind integration
  - Predict and manage congestion
  - Terrain and man-made objects database and avoidance
  - Maintain safe separation
  - Allow only authenticated operations

- **ANALOGY:** Self-driving or person driving a car does not eliminate roads, traffic lights, and rules
- **MISSING:** Infrastructure to support operations at lower altitudes

# UTM - One Design Option - Towards Autonomy





# UTM and Operator Interaction

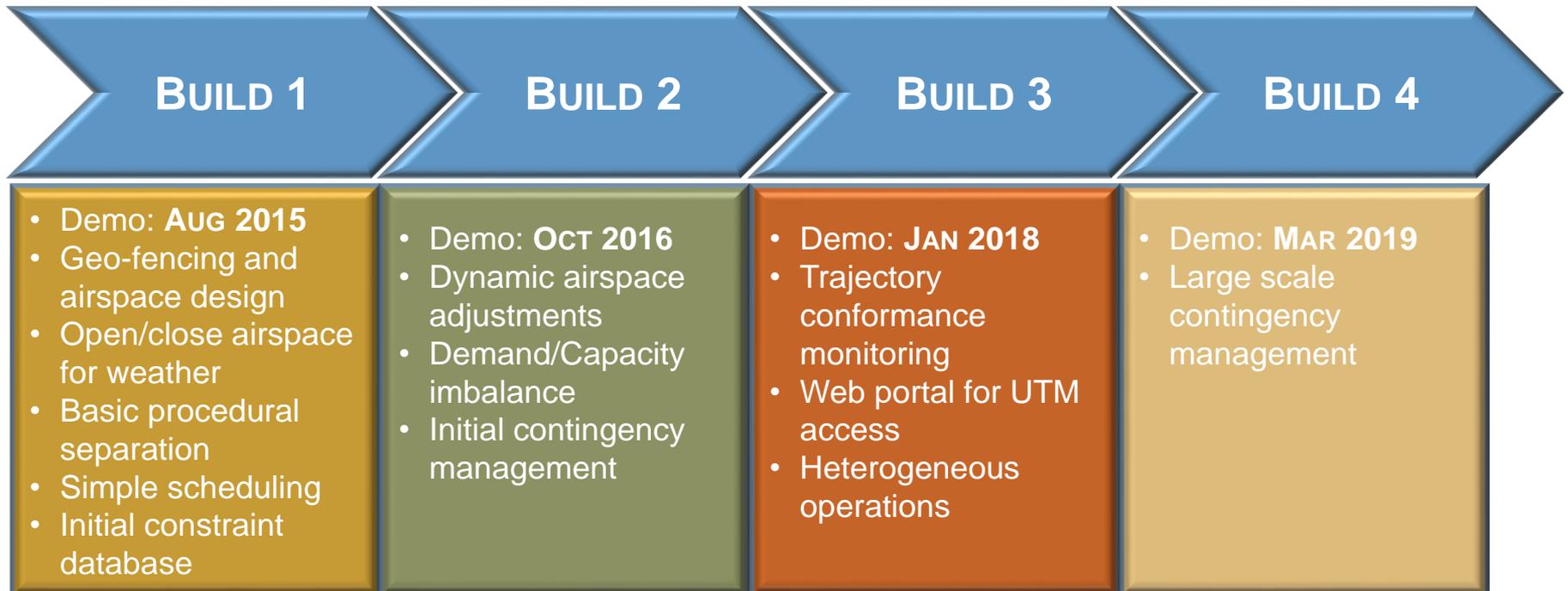
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- Cloud-based: user accesses through internet
- User generates and files a nominal trajectory
- User or UTM may adjust trajectory for
  - Congestion or pre-occupied airspace
  - Obstacle or terrain avoidance
  - Airspace usability and restrictions. Verifies for wind/weather forecast and associated airspace constraints
- Monitors trajectory progress and adjust trajectory, if needed (contingency could be someone else's)
- Supports contingency – rescue
- Allocated airspace changes dynamically as needs and constraints change



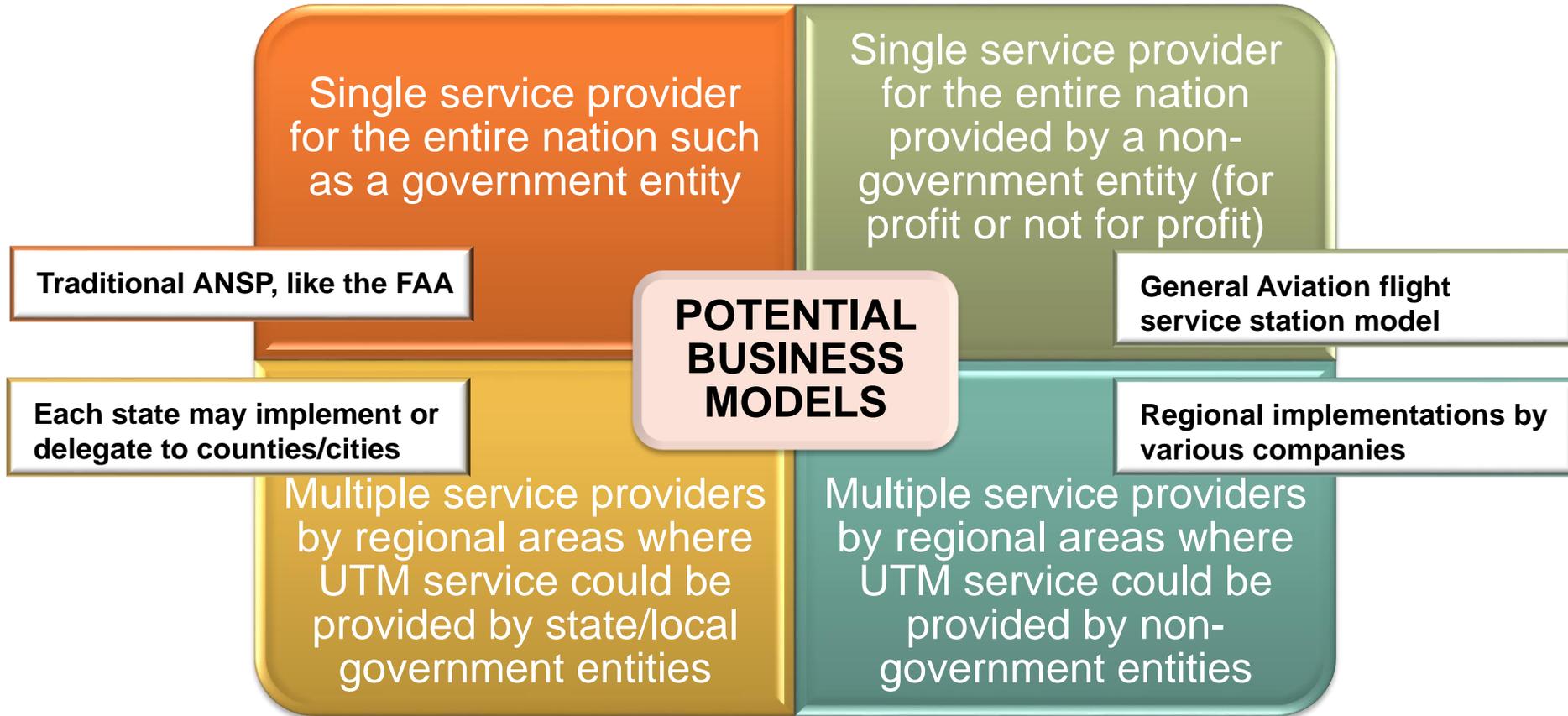
# Schedule

- UTM research and development driven by “Builds”
- Each build adds more services and capabilities





# Consideration of Business Models



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

# Notional UTM Scope





# UTM Builds and Services

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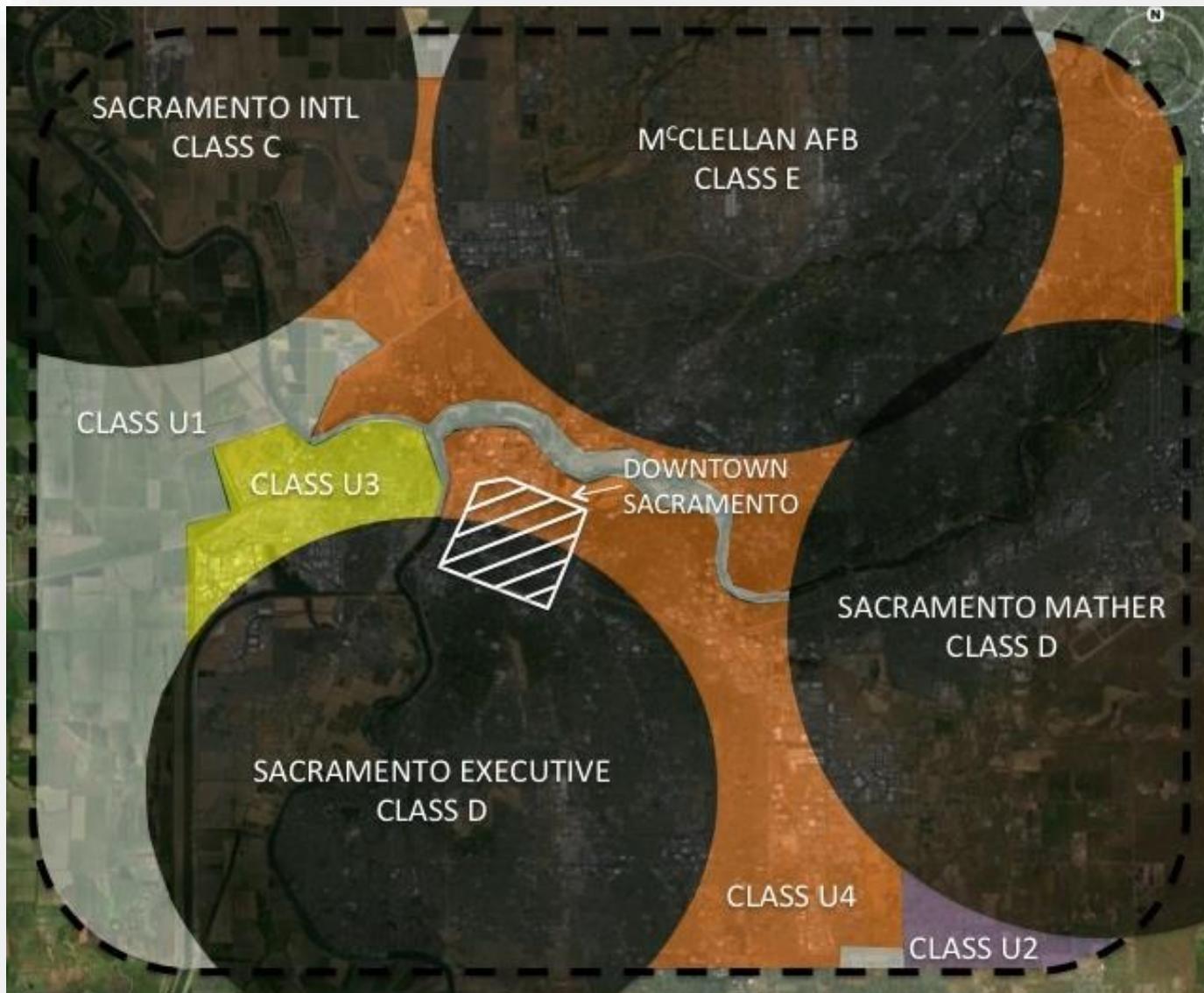
- Based upon four risk-based criteria
  - Density of people on the ground
  - Number of structures on the ground
  - Likelihood of manned operations in close proximity
  - Number of UAS operations in close proximity
- Each build enables certain types of missions and provides certain services
- Each build supports the missions and services of the previous build
- Builds are intended to be developmental milestones, as well as, self-contained systems



# High-Level UTM Builds

- **Build 1**
  - Reservation of airspace volume
  - Over unpopulated land or water
  - Minimal general aviation traffic in area
  - Contingencies handled manually by UAS pilot
  - Enable agriculture, firefighting, infrastructure monitoring, mapping use cases amongst others
- **Build 2**
  - Beyond line-of-sight
  - Sparsely populated areas
  - Procedures and “rules-of-the road” separate UAS
  - Contingencies alerted to UAS operator
- **Build 3**
  - Beyond line-of-sight
  - Over sparsely populated land
  - Some interaction with manned aircraft
  - In-flight separation of UAS
  - Some contingencies resolved
  - Law enforcement, limited package delivery, and other use cases
- **Build 4**
  - Beyond line-of-sight
  - Urban environments
  - Manned aircraft commonplace
  - Autonomous separation of UAS
  - Large-scale system-wide contingencies resolved

# Notional UTM Airspace

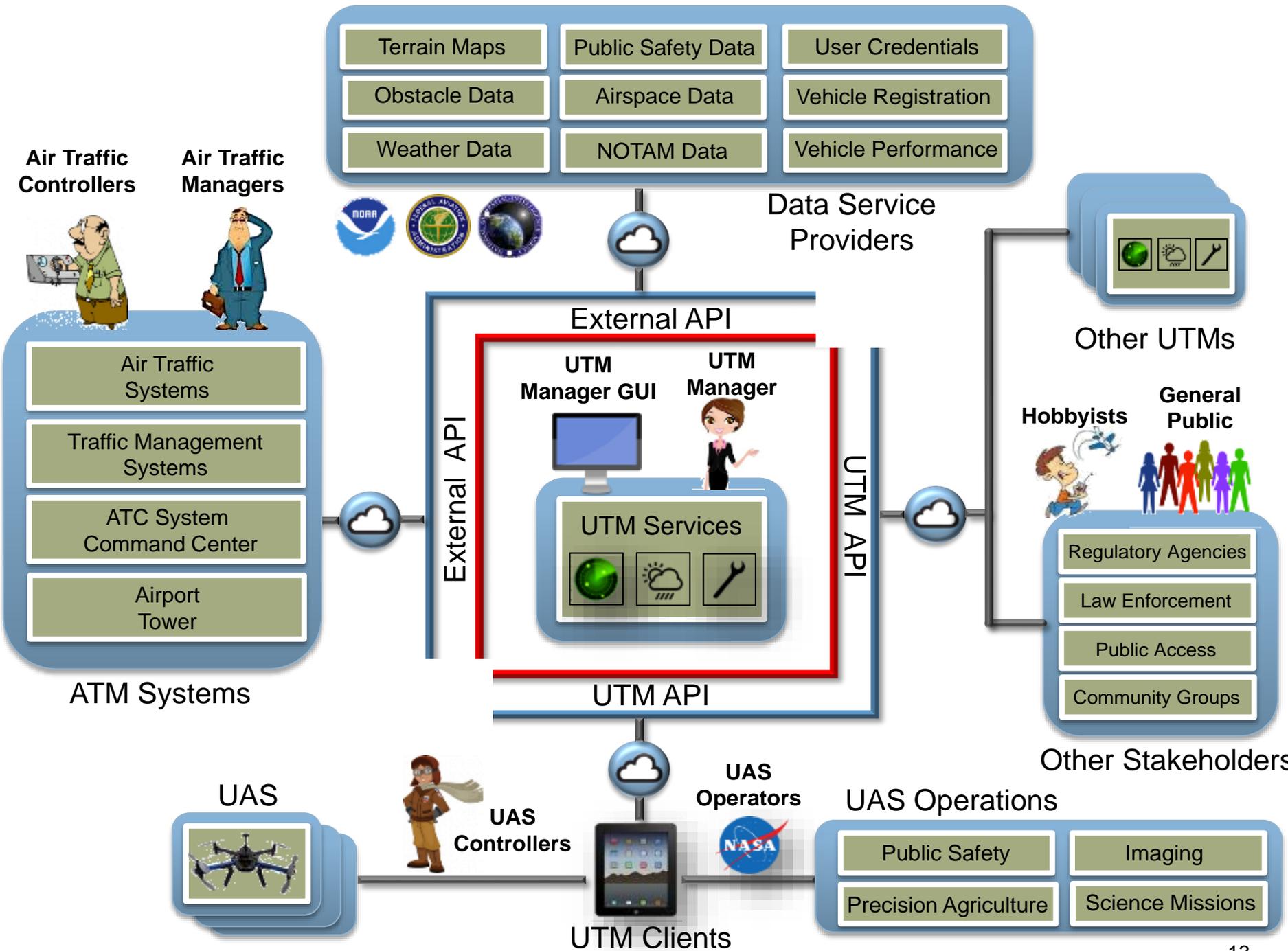




# High-Level UTM Services

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- SECURITY SERVICES
  - System Health Monitoring
  - Vehicle Registration
  - User Authentication
  - Flight Monitoring
- INFORMATION SERVICES
  - Airspace Definition
  - Weather Information
  - Terrain and Obstructions
  - Traffic Operations
- FLIGHT SERVICES
  - Flight Planning
  - Scheduling and Demand Management
  - Separation Assurance
  - Contingency Management



**Air Traffic Controllers**

**Air Traffic Managers**

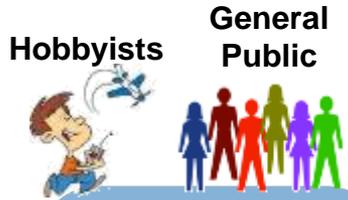
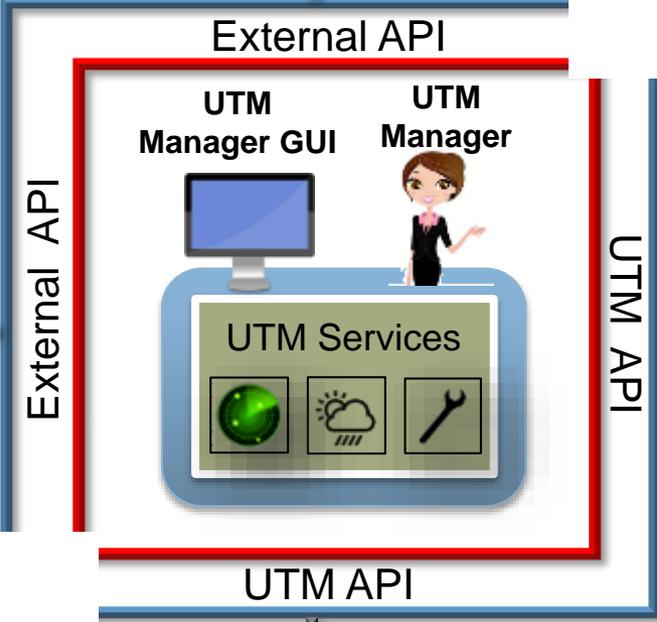


**Data Service Providers**

|               |                    |                      |
|---------------|--------------------|----------------------|
| Terrain Maps  | Public Safety Data | User Credentials     |
| Obstacle Data | Airspace Data      | Vehicle Registration |
| Weather Data  | NOTAM Data         | Vehicle Performance  |

**ATM Systems**

|                            |
|----------------------------|
| Air Traffic Systems        |
| Traffic Management Systems |
| ATC System Command Center  |
| Airport Tower              |



**Other Stakeholders**

|                     |
|---------------------|
| Regulatory Agencies |
| Law Enforcement     |
| Public Access       |
| Community Groups    |



**UAS Operations**

|                       |                  |
|-----------------------|------------------|
| Public Safety         | Imaging          |
| Precision Agriculture | Science Missions |



# External Partnerships

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- Request for Information for collaborating with NASA on UTM garnered over 100 responses from companies, universities, and other government agencies
- Relationships are non-reimbursable
- Several UAS technology domains represented
  - Vehicle manufacturers
  - Surveillance technologies
  - Control systems
  - Mission planning software
  - Data providers

# Demonstration



The image displays a flight planning interface. On the left, a map of California shows a flight path from San Francisco to San Jose. A large orange arrow points from the map to the right-hand form. The form, titled 'Propose new flight plan', includes the following fields:

- Flight number:** UMCX-UM-0041966
- Name:** Thomas Adelon
- Phone:** +1708.207.333
- Email:** thomas@palmyra
- Additional Comments:** (empty text area)
- Flight Dates:** From Mar 27 2015 14:00:01 to Mar 27 2015 14:55:01
- Start Coordinates:** Flight start location
- End Coordinates:** Flight end location
- Altitude range:** up to 2000
- Aircraft Type:** Aeryon Skyfarger
- Buttons:** Cancel, Send Proposal

The interface also features a sidebar menu with options like 'Home', 'Cross flight plan', 'Approved plans', 'Active plans', 'Cancelled plans', and 'Profile settings'. The top right corner of the form shows '8:08 AM' and '8:08 AM'.



# Build 1 Field Test Scenario

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- Physical Location: Low altitude Class G airspace
  - Outside the Mode-C Veil
  - At least 3nmi away from airports, helipads, etc.
  - 1,200 feet above ground level (AGL) or lower
- Risk Criteria
  - Population Density: only people involved in operation
  - Structural Density: only structures related to the operation
  - Manned operations: only participating aircraft expected
  - UAS Operations: segregated by geofences or time
- Test Constraints
  - Within visual line-of-sight of Pilot-in-Command
  - During daylight hours
  - With visibility greater than one statute mile and clear of clouds

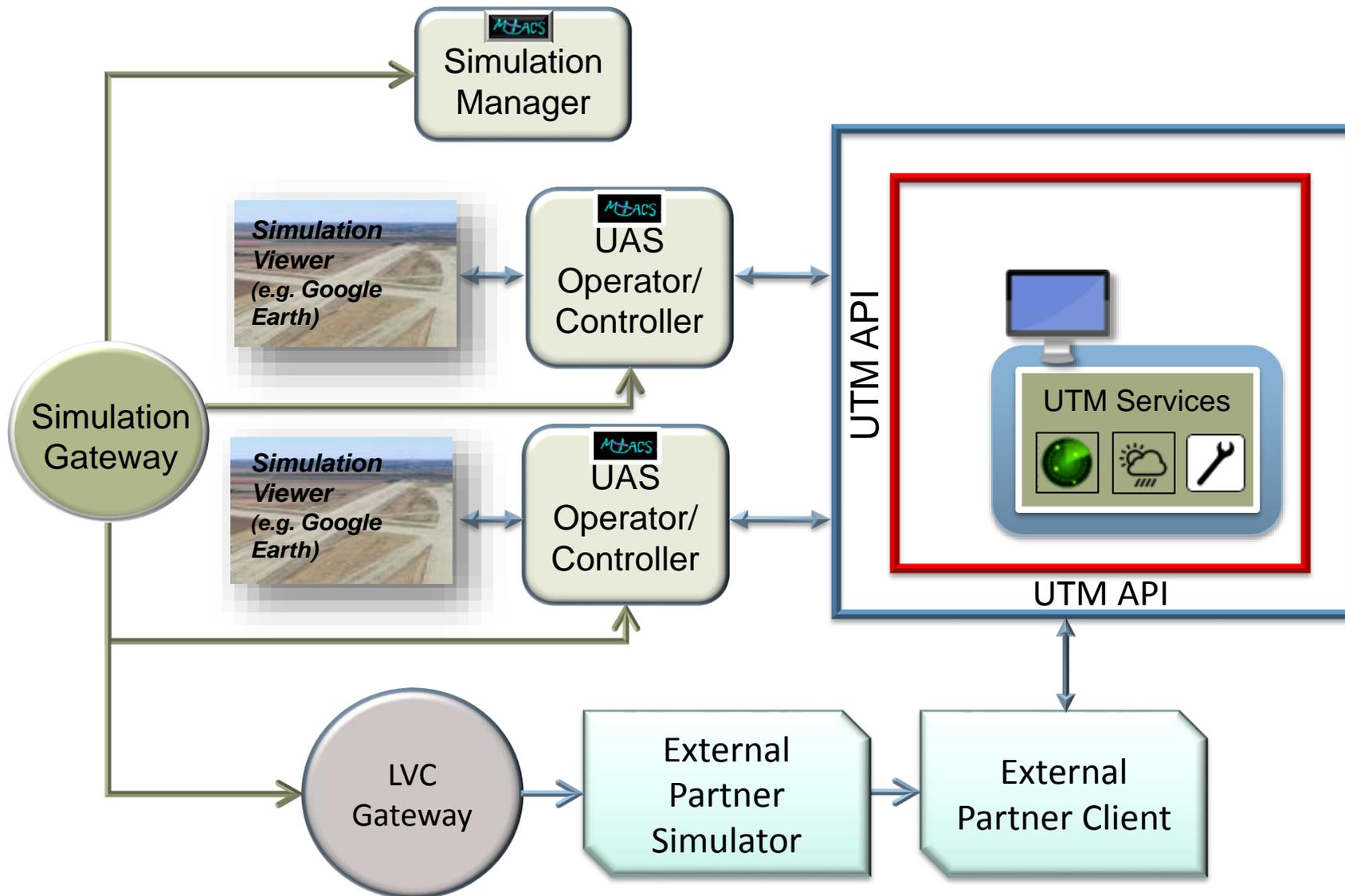


# UTM Simulations

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- Demonstrate and evaluate advanced UTM services and UAS operations in high-fidelity human-in-the-loop (HITL) simulations
- Define human's roles, responsibilities and procedures for managing UTM operations
- Perform verification and validation testing of UTM system prior to field tests
- Simulate complex operations that cannot be done during the field tests (e.g., urban operations, September 11<sup>th</sup>-type scenarios)

# NASA Lab Test Bed





## SAVE THE DATE

### UAS Traffic Management (UTM) Convention July 28-30, 2015 NASA Ames Research Center

We are entering a new era of aviation where unmanned aerial systems (UAS) will be used for new commercial and civil applications. UASs will be remotely piloted and fully autonomous. Their safe and effective integration into the national airspace is a critical requirement for achieving their true potential.

Join NASA in exploring the future direction of these unmanned systems and how technology and policies can keep pace with these emerging opportunities. This three-day convention aims to bring together a broad audience of government and civilian representatives, industry, and academia to discuss, understand, and define the UAS impact and challenges ahead.

#### Convention Themes

- Discuss policy issues, including privacy, safety, and security
- Examine strategies for low-altitude traffic management
- Learn about different autonomous aircraft platforms and future technology needs
- Identify future markets and missions for UAS operations.

#### Collaborative Format

Through keynote and plenary addresses, participants will gain an appreciation of what industry and authorities need for future integration of unmanned flight systems. Invited speakers will provide a vision of the possible, and breakout sessions will offer time to share requirements, opportunities, challenges, and solutions. In addition, NASA will host an open forum where experts can exchange ideas, and public comment will help define future goals to ensure UAS safety and acceptance into everyday applications. Exhibit space will be available, and demonstrations will showcase current UAS technology capabilities to attendees.

#### Audience

- Those exploring UASs for commercial and public service opportunities
- UAS technology suppliers and developers
- UAS operators
- Local, state, and federal entities
- Insurance companies and authorities
- Venture capitalists
- Researchers from government and academia
- Any interested members of the general public

#### Additional Information

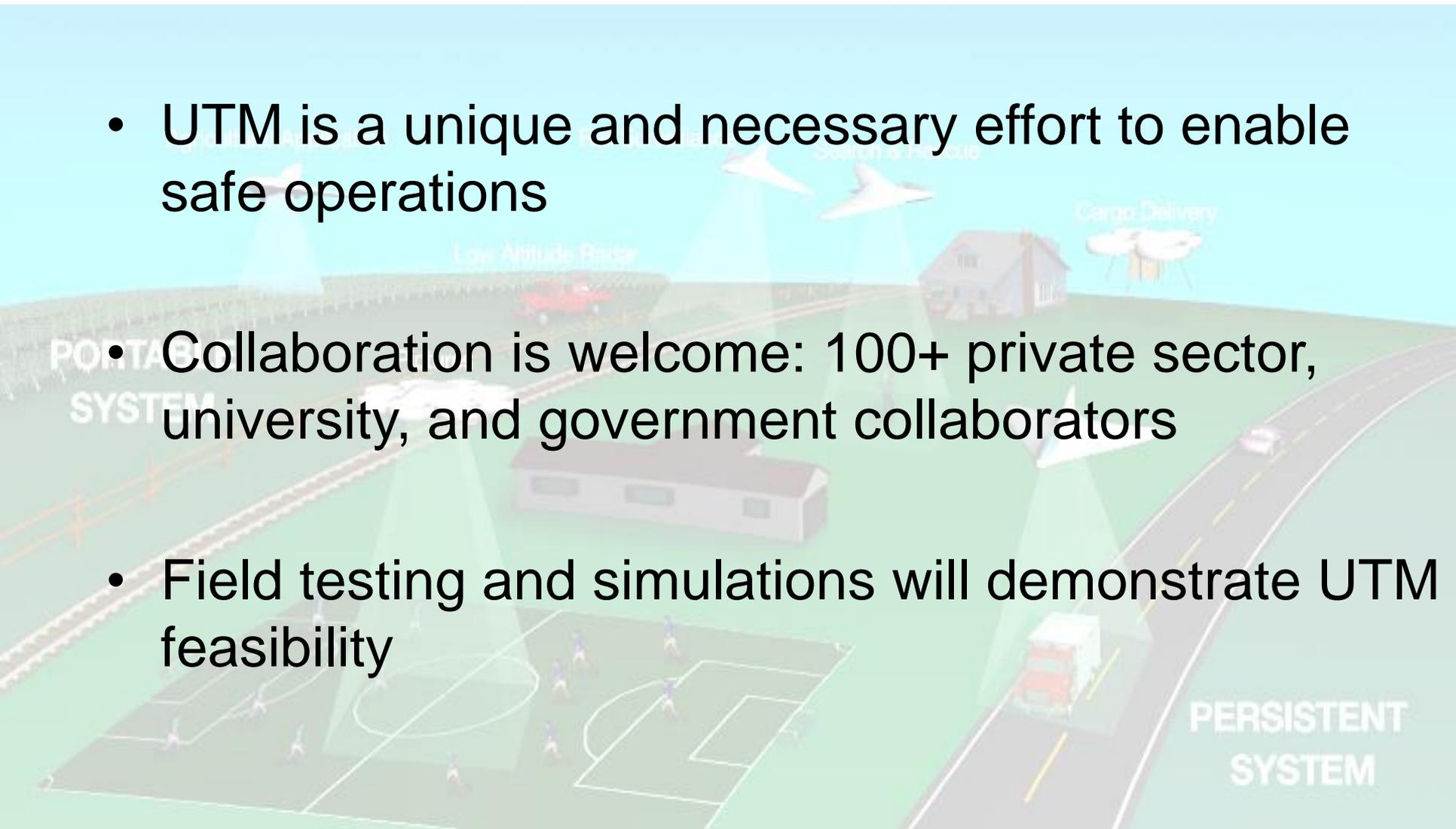
Watch for future registration and exhibit announcements.

For additional inquiries, please contact [UTM2015@nasa.gov](mailto:UTM2015@nasa.gov)

# Summary



- UTM is a unique and necessary effort to enable safe operations
- Collaboration is welcome: 100+ private sector, university, and government collaborators
- Field testing and simulations will demonstrate UTM feasibility



**BACKUP**



# Consideration of Business Models

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- Single service provider for the entire nation such as a government entity
- Single service provider for the entire nation provided by a non-government entity (for profit or not for profit)
- Multiple service providers by regional areas where UTM service could be provided by state/local government entities
  - Needs to be connected and compatible
- Multiple service providers by regional areas where UTM service could be provided by non-government entities
  - Needs to be connected and compatible
- Regulator has a key role in certifying UTM system and operations



# NuSTAR: Idea under consideration

- National UAS Standardized Testing and Recording (NuSTAR)
- Parallel: Underwriter's Laboratory, Consumer Reports, JD Powers
- Credible test bed and scenarios
  - Urban, rural, atmospheric conditions (e.g., fog, smog, rain)
  - Simulated pets
- Data oriented rating, acceptance, and assurance
- Every UAS vehicle model goes through
- Support UAS manufacturers, consumers, FAA, insurance companies, and public at large through objective assessments
- Initial feedback from industry members has been positive
- Your feedback is requested