SAFELY ENABLING LOW-ALTITUDE AIRSPACE OPERATIONS

Unmanned Aerial System Traffic Management (UTM)

Parimal Kopardekar, Ph.D.
Principal Investigator, UAS Traffic Management
Manager, Safe Autonomous System Operations Project

Core Team: Dr. Joey Rios, John Robinson, Dr. Marcus Johnson, Dr. Thomas Prevot, Dr. Jaewoo Jung, Corey Ippolito, Dr. Chris Belcastro, and Louis Glaab

Parimal.H.Kopardekar@nasa.gov
**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

LINE-OF-SIGHT TO BEYOND LINE-OF-SIGHT

UAS 1  UAS 2  UAS 3  UAS Fleet

RANGE OF UNMANNED AERIAL SYSTEM (UAS) EQUIPAGE AND DIVERSE MISSIONS

Unmanned Aerial System Traffic Management (UTM)

SERVICES
UTM based on autonomicity, autonomy, autonomous operations related to automation

AUTONOMICITY
- Self-configuration
- Self-optimization
- Self-protection
- Self-healing

Appropriate operational data recording

CHARACTERISTICS
- Authentication
- Airspace design and geofence definition
- Weather integration
- Constraint management
- Sequencing and spacing
- Trajectory changes
- Separation management
- Transit points/coordination with the National Airspace System
- Geofencing design and adjustments
- Contingency management

Multiple customers with differing mission needs

Low-altitude Communication, Navigation, and Surveillance (CNS) options including but not limited to:
- Low-altitude radar
- Surveillance coverage (cell and satellite)
- Navigation
- Communication

Transition between UTM and Air Traffic Management airspace

Constraints based on community needs about noise, sensitive areas, privacy, etc.

3D maps: terrain and human-made structures

Real-time Weather & Wind

Weather & Wind Predictions

Airspace Constraints

Other low-altitude operations
UTM and Operator Interaction

• 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

**BUILD 1**
- Demo: **Aug 2015**
- Geo-fencing and airspace design
- Open/close airspace for weather
- Basic procedural separation
- Simple scheduling
- Initial constraint database

**BUILD 2**
- Demo: **Oct 2016**
- Dynamic airspace adjustments
- Demand/Capacity imbalance
- Initial contingency management

**BUILD 3**
- Demo: **Jan 2018**
- Trajectory conformance monitoring
- Web portal for UTM access
- Heterogeneous operations

**BUILD 4**
- Demo: **Mar 2019**
- Large scale contingency management
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

• 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

• **SECURITY SERVICES**
  – System Health Monitoring
  – Vehicle Registration
  – User Authentication
  – Flight Monitoring

• **FLIGHT SERVICES**
  – Flight Planning
  – Scheduling and Demand Management
  – Separation Assurance
  – Contingency Management

• **INFORMATION SERVICES**
  – Airspace Definition
  – Weather Information
  – Terrain and Obstructions
  – Traffic Operations
Air Traffic Controllers  |  Air Traffic Managers
---|---
Air Traffic Systems  |  Traffic Management Systems
ATC System  |  Command Center
Airport Tower

ATM Systems

UAS
UAS Controllers

UTM Services
- Terrain Maps
- Obstacle Data
- Weather Data
- Airspace Data
- NOTAM Data
- User Credentials
- Vehicle Registration
- Vehicle Performance

External API
UTM Manager GUI
UTM Manager

Data Service Providers
- Regulatory Agencies
- Law Enforcement
- Public Access
- Community Groups
- Hobbyists
- General Public
- Other Stakeholders

Other UTMs
- ATM Systems
- UTM API
- UTM Clients

UTM API

UAS Operations
- Public Safety
- Imaging
- Precision Agriculture
- Science Missions
External Partnerships

• 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

UTM-Client Communication
Build 1 Field Test Scenario

• 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

• 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 11th-type scenarios)
NASA Lab Test Bed

Simulation Gateway

Simulation Manager

Simulation Viewer (e.g. Google Earth)

UAS Operator/Controller

Simulation Viewer (e.g. Google Earth)

UAS Operator/Controller

LVC Gateway

External Partner
Simulator

External Partner Client

UTM API

UTM Services
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
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

- 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