Overview of Unmanned Aerial System Traffic Management (UTM)
Motivation

• Many applications of Unmanned Aerial System (UAS) have been proposed
  – Humanitarian
  – Package delivery
  – Precision agricultural
  – Infrastructure monitoring

• Worldwide interest is intense

• UAS will need to operate in uncontrolled airspace

• No infrastructure is available to support these new operations
  – Today’s Air Traffic Management (ATM) started after mid-air collision over Grand Canyon in 1956

• The US needs a system for managing UAS operations in civilian low-altitude airspace
Sense of Urgency

- Business applications are emerging rapidly
- Low-altitude operations could become dominant aviation activity
- Vehicle designs are changing continuously
- Airworthiness certificate relief and Certificate of authorization (COA) are taxing processes
- Visual line of sight is limiting
- Several efforts to integrate civilian UAS into the National Airspace System are underway
- An automation system, operational procedures, flight rules, and regulations are urgently needed to enable the industry
Agenda

• Objectives

• Development Approach
  – Builds
  – Services
  – Simulation Capabilities
  – Field Tests

• UTM Build 1 Field Test Description

• Summary
Objectives

• Develop proof-of-concept UTM system to safely enable low-altitude small UAS operations
  – Automation system
  – Operational procedures
  – Flight rules

• Demonstrate UTM system in field tests in conjunction with a broad set of partners
US Airspace Classification

Source: Pilot’s Handbook of Aeronautical Knowledge, FAA
UTM Applications
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 includes supports the missions and services of the previous builds
• Builds are intended to be developmental milestones as well as self-contained systems.
High-Level UTM Builds

• **Build 1:**
  – Within visual line-of-sight
  – Over unpopulated land or water
  – No manned aircraft
  – Geo-fences separate UAS
  – Contingencies handled manually by UAS pilot

• **Build 2:**
  – Beyond line-of-sight
  – Over sparsely populated land
  – Few manned aircraft
  – Procedures and rules-of-the road separate UAS
  – Contingencies alerted to UAS operator

• **Build 3:**
  – Beyond line-of-sight
  – Over modestly populated land
  – Some manned aircraft
  – In-flight separation of UAS
  – Some contingencies resolved

• **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
UTM System Architecture
UTM Simulations

• Demonstrate and evaluate advanced UTM services and UAS operations in high-fidelity human-in-the-loop 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, 9/11 type scenarios)
NASA Lab Test Bed
UTM simulator with access for external partners

Simulation Manager

Simulation Viewer
(e.g. Google Earth)

UAS Operator/Controller

Simulation Gateway

LVC gateway

External partner Simulator

UTM Services

External Partner Client

UTM API
UTM Field Tests

- Demonstrate, and evaluate current UTM services and UAS operations in conjunction with UTM stakeholders
- Verify tools and procedures to manage UTM operations
- Accelerate deployment of UTM System to FAA UAS test sites
- Validate assumptions made by the UTM Concept of Operations (e.g., vehicle performance, operational conditions, integration with real flight hardware and NAS systems)
- Provide tangible products for technology transfer of UTM requirements and capabilities to the FAA and UTM stakeholders
Build 1 Field Test Scenario

- **Physical Location:** Low Altitude Class G Airspace
  - Outside the Mode-C Veil
  - At least 3 nmi away from airports, helipads, etc.
  - 1,200 feet AGL or lower

- **Risk Criteria**
  - Population Density: Only people involved in operation
  - Structural Density: Only structures related to the operation
  - Manned operations: No non-participating aircraft expected
  - UAS Operations: Segregated by geo-fences or time

- **Test Constraints**
  - Within visual line-of-sight of Pilot-in-Command
  - During daylight hours
  - With visibility greater than 1 statute mile and clear of clouds
Build 1 Field Test Objectives

- Objective 1: Demonstrate UTM Build 1 capabilities and effectiveness under real world uncertainties
- Objective 2: Collect data to support Build 2 development
Build 1 Field Test Approach

Demonstration Airspace

- Operation 1
- Operation 2

- NASA Flight Support Crew
- Partner(s) Flight Support Crew
- NASA GCS/Display
- Partner(s) GCS/Display
- Ad-hoc network

- Visual Observers
- Range Safety Officer
- Mission Manager
- UTM System
- UTM Manager

Surveillance Weather
Build 1 Field Test Example
Summary

• UTM is a unique and necessary effort to enable safe operations

• Collaboration is welcome: private sector, university, and government agencies

• Field testing and simulations will demonstrate UTM feasibility
Backup Slides
UTM Services: Security Services

- **System Health Monitoring**
  - Monitors the status of the internal subsystem and external system components required to provide each UTM service

- **Vehicle Registration**
  - Ensures that only registered vehicles are approved for operations within UTM airspace and receive the appropriate UTM services

- **User Authentication**
  - Ensures that only credentialed users can access the system and are provided the appropriate UTM services

- **Flight Monitoring**
  - Monitors both UAS and non-UAS operations within the UTM airspace in terms of their safety and security risk to each other
UTM Services: Flight Services

- **Flight Planning**
  - Assesses proposed UAS operations against airspace availability and operational constraints

- **Scheduling and Demand Management**
  - Schedules UAS operations to reduce congestion, conflicts, and improve overall safety as traffic demand increases

- **Separation Assurance**
  - Provides temporal, procedural and in-flight separation services from other traffic, weather, terrain, and vertical obstructions

- **Contingency Management**
  - Resolves off-nominal conditions that occur during an operation such as flight non-conformance and lost communication
UTM Services: Information Services

• **Airspace Definition**
  – Provides users with the physical extents of its UTM airspace as well as regions within that airspace where operations are not permitted – either permanently or temporarily

• **Weather Information**
  – Provides users with information about the current and predicted weather conditions in the UTM airspace

• **Terrain and Vertical Obstructions**
  – Provides users with information about the terrain, man-made structures, and vertical obstacles in the UTM airspace

• **Air Traffic Operations**
  – Provides users with information about the planned and current UAS operations in the UTM airspace
Standalone Testbed: UTM-PS
Personal Simulator for UTM

Functionality
- Create and control UAS scenarios in MACS
- Visualize in Simulation Viewer
- Communicate to UTM via UTM API
- MACS Messaging Window to display UTM comm.

Automated messages:
- MACS flight plan->Operational plan
- ALL CLEAR (TBD sec) before activating aircraft
- MACS flights state -> UTM position updates
- CLOSED message -> UTM (landed)

Manual messages:
- UTM messaging window in MACS for viewing UTM messages and sending responses from MACS
NASA Lab test bed: UTM-LS

Lab Simulator for UTM

Functionality
- Simulate multiple UAS clients
- Create and control UAS from multiple operator station in MACS
- Visualize in Simulation Viewer
- Communicate to UTM via UTM API
- MACS Messaging Window to display UTM comm.
NASA Lab Test Bed
UTM simulator with access for external partners

Simulation Manager

UAS Operator/Controller

UTM System

UTM Services

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LVC Gateway

Simulation Gateway

Simulation Viewer (e.g. Google Earth)

Simulation Viewer (e.g. Google Earth)
Build 1 Location and Layout

- Test Location: Crows Landing Airfield
  - 35 miles east of Moffett Field, CA
  - NASA Ames Research Center has a Use Agreement with Stanislaus Co. which owns most of the property.
  - Vehicles would be operating under a NASA MOA*
  - There are no usable facilities or services at Crows Landing. Users must be 100% self-sufficient and bring all their own equipment, power, bathrooms, shade, water, and food.
  - There are services several miles away in the towns of Crows Landing or Patterson.

- Test Duration: 1 Week
  - Dates: TBD (August 17-20th 2015)
Build 1 Flight Test Scope

Block A: Singleton Operations
- Testing UTM Services in Nominal Conditions
- Testing Operational Procedures in Nominal Conditions
- Testing Vehicle Conformance
- Data Collection: Vehicle and Surveillance Performance

Block B: Sequential Operations
- Testing UTM Services in Nominal and Off-Nominal Conditions
- Testing Operational Procedures in Nominal and Off-Nominal Conditions
- Testing Vehicle Conformance
- Data Collection: Vehicle and Surveillance Performance

Block C: Coincidental Operations
- Testing UTM Services in Nominal and Off-Nominal Conditions
- Testing Operational Procedures in Nominal and Off-Nominal Conditions
- Testing Vehicle Conformance
- Data Collection: Vehicle and Surveillance Performance
• Trajectory conformance depends on:
  • Aerodynamic characteristics
  • Vehicle performance (e.g. thrust)
  • Automatic flight control

• Three ongoing efforts:
  • Vehicle modeling with available data
  • Model validation with field tests
  • Assessing feasibility of wind tunnel tests