Unmanned Aircraft Systems
Traffic Management System (UTM)

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PROBLEM STATEMENT / BACKGROUND
Problem Statement

• Exciting new capabilities of autonomous unmanned aircraft systems!
  – Package delivery
  – Infrastructure inspection
  – Personal air vehicles
  – Search and rescue
  – Precision agriculture

• Economic case for Unmanned Aircraft Systems and Personal Air Vehicles demands:
  – Autonomous operation
  – Beyond Visual Line of Sight (BVLOS) operation (away from operator)
  – In some cases, Beyond Radio Line of Sight (BRLOS) operation
Problem Statement

• Beyond Visual Line of Sight (BVLOS) Operation of UAS Requires:
  – Robust detect-and-avoid capability (replace separation and collision avoidance function provided by pilot)
  – Robust control link to maintain positive vehicle control at all times

• Requires an Unmanned Aircraft Traffic Management (UTM) System
  – Ensure safety of flight vehicle, passengers, and people / property on the ground
  – Surveillance for detect-and-avoid / collision avoidance
  – As traffic density increases, the UTM solution must be **SCALABLE** and **ROBUST**
Background on Other Activities

- **NASA UTM**
  - Effort started in about 2015
  - Technology Capability Levels: TCL1 through TCL4

- **NUAIR U-SAFE**
  - 50-mile corridor between Syracuse and Rome, NY
  - $30M investment from NY

- **Nevada UAS Test Site**
  - Recent demos of TCL3

- **European efforts (UK, Poland, etc)**

- Successful UTM relies on more than transponders (ADS-B), and more than one surveillance system (radar)
- Integrated system with many dimensions!
SYNOPSIS AND OBJECTIVES
Proposed Solution

Turnkey UTM solution for the US 33 Smart Corridor, and a scalable solution for Ohio.
UTM Roadmap

TCL 1
Remote Population
Low Traffic Density
Rural Applications
Multiple VLOS Operations
Notification-based Operations

TCL 2
Sparse Population
Moderate-Low Traffic Density
Rural / Industrial Applications
Multiple BVLOS Operations
Tracking and Operational Procedures

TCL 3
Moderate Population
Moderate Traffic Density
Suburban Applications
Manned/Unmanned BVLOS Operations
Detect and Avoid
Public Safety Operations

TCL 4
Dense Population
High Traffic Density
Urban Applications
Dense Urban BVLOS Operations
Large Scale Contingency Management

Johnson et al. 2017
TEAM OVERVIEW
Proven Expertise with BVLOS UAS:

- **World Records** (official record with NAA, pending review by FAI):
  - Speed of 147 mph
  - Out-and-back course distance of 28 miles
- **Aviation Week article**, Sept 18, 2017 issue
Subcontractors and Partners

- AirXOS, a GE venture: UAS Service Supplier
- CAL Analytics: Modeling & Sim
- SRC: Active Radar Systems
- Gannett Fleming: Civil Infrastructure
- MedFlight
- TRC Transportation Research Center Inc.
- The Ohio State University Airport
- City of Dublin, Ohio, USA
- Woolpert
- Midwest Air Traffic Control
- Smart Mobility Corridor
- Union County Marysville Economic Development
- RTCA
- ASSURE
- NASA
OSU Facilities
Grypons Sensors Radar
RESEARCH PLAN
UAS Radar Cross Section Measurement

- Develop extensive library of UAS RCS signatures
  - Expansion of existing RCS library developed at OSU Electro Science Laboratory
  - Multi-band characterization for active and passive radar systems
  - Provides truth data for active and passive radar systems
Active Radar

- **Gryphon R1400 Radar System**
  - Turnkey solution aimed at UTM
  - Designed to track small UAS
    - DJI Phantom tracked to 10 km
    - Cessna to 27 km

- **Spectrum Sensor S1200**
  - Directly track known UAS transmissions

- Leverage existing assets with known performance to minimize integration risk
  - Well characterized sensor performance
  - Successfully demonstrated at New York’s U-SAFE and DFW counter-UAS
  - Scalable solution for high-density corridors
Active Radar

- R1400 and S1200 Integrated into fixed and mobile platforms
Passive Radar

- Radar system utilizing existing “illuminators of opportunity”
  - No active transmitter (no FCC license necessary)
  - Tuned to receive cell, digital TV, radio, etc. signals
  - *Equivalent performance* to active radar systems

- Low-cost, scalable solution
  - Simple hardware components
  - Distributed processing network

- Fills gaps between active radar coverage areas – **critical for statewide implementation of UTM**

- Higher risk research, higher reward
## Need for Sensor Fusion

### Sensor Performance Comparison

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<th>Ground Radar</th>
<th>Passive Radar</th>
<th>Multisensor Suite</th>
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*Drone icons indicate performance level: ![Drone] = GOOD, ![Drone] = FAIR, ![Drone] = POOR*
Control and Communications Link

Will explore integration with fiber network and possible use of roadside data units.
Fusion of Multiple Control Links

- SatCom or other comm links important for filling in radio coverage gaps
- OSU successfully demonstrated fusion of 433 MHz, 915 MHz, and SatCom for BVLOS UAS flight of 28 miles out-and-back
- OSU set world records for speed and distance of a UAS in August 2017, based on this technology
Key Integrated Services

- UAV traffic management
- Coordinated airspace management
- Flight and operational authorization
- Conformance monitoring
- Public and private UTM options
- Cyber-secure architecture
- Integrated with non-cooperative detection solution
Modeling and Simulation Enablers

NAS Integration / Airspace Characterization

Sensor System Development

Scenario Modeling

M&S Framework

Algorithm Development

Demonstrations, Test and Evaluations

Airworthiness Certification / Operational Approval (Safety Case)

Standards and Policy Development
Final Demonstration Flights

Full UTM system tests:

• 4 flight tests aimed at enabling recurring BVLOS operations
  – Task 1: Multi-UAS operations and tracking
  – Task 2: Detect-and-avoid demonstration
  – Task 3: Traffic monitoring along US-33 corridor
  – Task 4: Quick-clear operation

• Minimum regulatory approvals needed (most under part 107), but demonstrate true BVLOS capability

• Final test demonstration will address a key ODOT mission, the quick-clear operation
• Research data to inform:
  – Creation of alternative transportation methods
  – Improvement of transportation system reliability
  – Increase in system resiliency
  – Improved highway capacity in critical corridors
  – Better resource allocation and investment decisions early on in the adoption lifecycles
• Enables air-ground vehicle teaming and enhancing ODOT's ground transportation management system:
  – Real-time feed of traffic information into ODOT's Traffic Management Center
  – Rapid response to traffic accidents, roadside incidents (disabled vehicles) – quick clear operations
  – Ability to track vehicles autonomously (law enforcement)
Conclusion

• **Concept**
  
  *Develop a robust, scalable UTM solution for Ohio*

• **World-Class Team!**

• **Research Plan**
  
  *Active radar, spectrum sensing, passive radar, redundant control links, UAS Service Supplier – MUST use fused surveillance, fused control link*

• **Benefits**
  
  *Economic development, new transportation modes, ODOT traffic management*