RASPET FLIGHT RESEARCH LABORATORY

eCommerce, Emerging UAS Network and Implications on NAS Integration
MSU Team

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Overview

Overall project consists of 5 tasks:

• Task 1: Data Examination and Evaluation
• Task 2: Network and Safety Analysis
• Task 3: Emerging Network and NASA's UTM
• Task 4: Emerging Network and Environment Footprints
• Task 5: Emerging Network and Regulatory Framework
Tasks and Relationships

Aerospace Constrains

Social Economic Data

Traditional Freight Network and Demand Models

A2/A3: Choice Models and Network Modelling & Case Studies

B3/B4/B6: 3D Highway Network Route Model, Development and Case Studies

3D Highways

FAA UAS and Managed Flight Safety Data/Reports/Trajectories

FAA: Flight Information Management System

NASA UTM

C2: UAS Traffic and Network Route Design

UAS Routing Plans


UAS Trajectories, Speed, Mobility and Safety Performances

D2: Enviromental Foot Print

Risk and Safety Performance

C2: UAS Traffic and Network Route Design

B5: Bayesian Network Safety Analysis

UAS Trajectories, Speed, Mobility and Safety Performances

D2: Enviromental Foot Print

Risk and Safety Performance

Zone/Warehouse to Zone OD
Task 1: Data Examination and Evaluation

Sub-Task Overview

• Sub Task A1: Data and Literature Review
• Sub Task A2: Choice Models and Network Modeling
• Sub-Task A3: Case Studies & Analysis
Sub Task A2: Choice Models and Network Modeling

Sub-Task Components:

Develop a quantitative approach for:

- An economic analysis of the potential UAS delivery network (incl. demand forecasting)
- A choice model splitting the market demand between multiple delivery modes (e.g., UAS, manned aircraft, and trucks)
- An optimization-based network design model
Sub-Task A.2(a): Choice modeling for multiple delivery models: Implementation

Model Implementation:
- Model: Calculate probabilities for UAS, USPS, FedEx delivery options given demographic, transportation, and survey data for consumers
- Simulate Consumer Information from Data

Data Sources:
- Demographic Data
- Transportation Data
- Customer Survey Data

Analysis:
- Aggregate Demand by Zip Code
- What-if/Sensitivity Analysis
- Predictions for Individual Consumers
- Demand Data
Sub-Task Components:
Leverage the collected data and develop a methodology to:
• Analyze the economic properties of the potential UAS delivery network
• Estimate the projected growth of the network in the future
• Evaluate the potential impact of the network on the traditional road logistics industry.
Task 2: Network and Safety Analysis

Objectives
• Overall: The safe integration of Commercial UAS into the NAS
• 1. The criteria through which a commercial UAS network will operate and interact with other air traffic.
• 2. De-conflict any interactions between manned and unmanned traffic
• 3. The impact of a commercial UAS delivery network on manned traffic.
• 4. The safety risk impact on various classes of airspace

Required Approaches
• Literature surveys
• Stakeholders Interviews of a diverse assortment of,
• Economic and technical analyses
Sub-Task Components

- Determine the fundamental concept of operations for a commercial UAS delivery network. (Note: Leverage NASA’s Unmanned UAS Traffic Management (UTM) construct, to the maximum extent feasible)
- Set baseline assumptions, constraints, coordination, procedures and mitigations to be used in the delivery network design, modeling, simulation and analysis.
- Determine the methodology for UAS interaction under the CONOPS, such as:
  - UAS flight route/altitude changes
  - UAS flights following
  - UAS overtaking
  - UAS intersection rules (virtual traffic signal controller)
  - UAS and manned flight conflict resolution
Sub-Task B3: 3D “Highway” Network Route Model Development

Task Overview

Warehouses->Direct->Customers

Warehouse->3D “Sky Highway”->Customers

Design 3D Highway
Sub-Task B3: 3D “Highway” Network Route Model Development (Cont’d)

Approach

• Minimizing 3D “Sky Highway” Miles
  • Safety: Reduce Exposures in the Sky
  • Mobility: Reduce delivery miles->delivery time

• Two Type of “Sky Highway”
  • Sky Expressways: No overlap with maned traffic paths
  • Sky Arterials: Some interactions with maned traffic

• Subject to FAA Rules and Regulation Constraints
  • Other constrains (OD Traffic etc)
Task Overview
- Create Bayesian Risk/Safety Models/Framework to Evaluate the Safety Performance
- Be flexible for multiple network configuration scenarios/various classes of airspace.

Sub-Task B5: Bayesian Network Safety Analysis

Step 1: UAS Safety Factors Identification
Step 2: BN Structure Learning
Step 3: BN Parameter Learning
Step 4: BN Verification
Step 5: Risk Inference and Analysis
Task 3: Emerging Network and NASA's UTM

Objectives
1. Commercial Delivery UAS network be integrated with UTM-TCL4
2. Identify the likely needs for future solutions.
3. Simulate Different Patterns and Configurations
4. Coordination between a commercial Delivery UAS network, UTM, and the NAS.

Required Approaches
• Analyze UASs in the proximity of airports and populated areas
• Impact on the NASA UTM-TCL4
• Literature surveys
• Interviews of stakeholders,
• Modeling integrated network model development
• Economic and technical analyses
Task 3: Emerging Network and NASA's UTM

Task Overview
Sub-Task C1: Data and Literature Review
Sub-Task C2: UAS Traffic and Network Segment Route Design
Sub-Task C3: UAS Traffic Network Simulator Development
Sub-Task C4: Simulation Analysis and Recommendations
Sub-Task C5: Regional Impact of UAS Operations and Policy Implications
Sub-Task C6: National Impact of UAS Operations and Policy Implications
Sub-Task C2: UAS Traffic and Network Segment Route Design

- UAS Deliveries
- Warehouse
- Ground Deliveries
- Final Ground Delivery
- Not Used Ground Link
- UAS Routes
- Ground Delivery Routes
Sub-Task C2: UAS Traffic and Network Segment Route Design (Cont’d)

Approach
• Give:
  • 3D "Sky Highway" and Ground Delivery Road Network
  • Warehouse Total Delivers
• Find Integrated Ground and UAS Delivery Routes and UAS Delivery Time
• Minimizing Total Delivery Cost Under Time Windows
• Subject to FAA Rules and Regulation Constraints
• Other constrains (Maned Flight etc.)
Sub-Task C3: UAS Traffic Network Simulator Development

Task Overview
• Add UAS 3D Delivery Network to FHWA Open Source Highway Network Model
• Create Interface to Input 3D Highway Delivery Network From Task B3.
• Add UAS into FHWA Open Source Traffic Simulation Model
• Interface with FAA Flight Information Management System
• UTM Interface and Integration.
• Interact/Interface with Manned Aircraft Trajectories through FAA National Aerospace System
• Export UAS Trajectory and Performance Report
Sub-Task C4: Simulation Analysis and Recommendations

Task Overview

- Connect Realistic Data from
  - FAA
  - the Memphis MPO
  - Commercial Delivery Carriers
- Conduct Memphis UAS delivery Network Baseline Simulation
- Generate Scenarios with Low/Medium/High Volumes of UAS Deliveries and Manned Flights;
- Conduct Scenario Based Simulation
- Generate Forecasted 5/10 Year Traffic Scenarios
- Conduct Future Scenario Simulation
- Evaluate UAS Delivery Network in Terms of Capacity, Mobility and Safety Performance
Sub-Task C5: Regional Impact of UAS Operations and Policy Implications

Approach
• Based on Outcomes from C4, Identify Mobility/Safety Gaps
• Generate Strategies to Enable Seamless UAS/Maned Flight Coordination if Needed
  • UTM
  • Future Technological
  • Procedural
• Conduct Future Simulations with Different Strategies
• Evaluate UAS Delivery Network in Terms of Capacity, Mobility and Safety Performance
• Memphis Case Studies
Sub-Task C6: National Impact of UAS Operations and Policy Implications

Approach

• Based on Outcomes from C4 and C5, Identify Mobility/Safety Gaps
• Generate Scenarios to Representative Locations Nationwide, if Needed
  • levels of air traffic density, complexity and volume,
  • Projected commercial UAS delivery network density, complexity and volume
• Conduct Scenario Simulation
• Evaluate UAS Delivery Network in Terms of Capacity, Mobility and Safety Performance
• Summarize Impact Report
  • Categories of Airspace and locations
  • National Implications
Task 4: Emerging Network and Environment Footprints

Task Overview

Sub-Task D1: Literature Review and Surveys

Sub-Task D2: Environmental Footprint Study
- D2.1: Noise Pollution
- D2.2: Air Pollution
- D2.3: Visual Pollution
- D2.4: Regulatory and Technological Solutions
- D2.5: Environmental Cost Benefit Analysis
Task 5: Emerging Network and Regulatory Framework

Task Overview
Sub-Task E1: Existing Regulatory Challenges
Sub-Task E2: New Regulatory/Procedural Options
Sub-Task E3: Regulatory Dependencies
Sub-Task E4: Implementation Schedule