Utilization of Unmanned System Technology in Transportation Engineering

Dr. Michael R. Williamson
Assistant Professor
Indiana State University

Sam Morgan
Instructor
Indiana State University
Overview

- Parking Project Description
- Setting up the assignment
- Identifying the problem
- Unmanned Systems
- Transportation Engineering Uses
  - Accumulation Graphs
  - Cost Effectiveness
- Lessons learned
- Future uses
Unmanned Systems
Indiana State University

- Terre Haute, Indiana
  - 60,000 Residents

- Indiana State University
  - Enrollment 14,000
  - Campus 435 acres
  - 5 Colleges
  - 30 parking lots
  - 1 parking garage
Campus Map
Parking Study Objectives

- Parking inventory
  - Count the number of available spaces in each lot

- Parking accumulation
  - One hour increments on all campus lots
  - Use unmanned systems if possible to collect data
  - Compare cost of traditional vs. unmanned system
  - Create bar graphs showing parking trends in each campus lot vs capacity
Parking Lots

- 6 Staff
  - 740 Total Spaces
    - 691 Regular
- 6 Student
  - 960 Total Spaces
    - 921 Regular
- 10 Staff/Student
  - 1594 Total Spaces
    - 1552 Regular
- 8 Remote
  - 1605 Total Spaces
    - 1587 Regular
- 1 Parking Garage
  - 590 Total Spaces
    - 572 Regular
- Total Spaces 5498
Parking Inventory

- Determine spaces on campus by type
  - Regular Spaces
  - Handicapped
  - Parking Meters
  - Service
  - Motorcycle
Parking Inventory with Unmanned Systems

- Count in off peak times
- Striping and signage visible
Faculty Led Student Project

- Collaboration outside of departments
- Civil Engineering Students
  - Transportation focus
  - Analyze and interpret data
  - Summarize results
- Aviation Students
  - Unmanned vehicle focus
  - Responsible for collecting data with drones
Setting up the Class Assignment

- Assigned to the 30-student Human Factors of UMS class
- Present to students and allow group collaboration
- Superstar student spearheaded the project
- One trip of all lots took approximately one hour
- Schedule students and UAVs
- Establish grading criteria
- Ensure all students participate
- Emphasize safety
- Side-quest to determine a valid and sustainable contract price
Timeline Considerations

- Number of available UAVs
  - ISU provided one
  - Students had personal drones
- Transfer UAV between parking lot launch sites
- Set-up and tear-down of the UAVs
- Battery charging
- Transfer UAVs between students
- Optimum time for accurate vehicle counts vs. class schedules
  - 5-10 minute difference could show overload vs. empty
- Student availability vs. class schedules
Identify problem

- Take useable pictures of all parking lots
- Schedule the people (30) and UAVs (3-4)
- Transfer UAVs between operators
- Provide pictures with data to know time, date, location
  - Pixilation matters to get accurate count
  - Trees, power lines, towers, buildings, etc. obscure some areas of the lots
- File names from “00001” to “Lot 5_3 Apr_0800”
Identify problem

- Ensure safe operations with limited training
- Coordinate with FAA and police to minimize outside interventions
- Deliver completed data to parking lot team
- Always considering: Safety, man-hours, transportation, regulatory guidance, set-up costs, licensing requirements, scheduling, personnel availability, proficiency training, and checklist development
Unmanned Systems

- Phantom 4 Pro (Plus student-owned models)
- Capabilities
  - Flight time 28 minutes
  - Max Service Ceiling 20,000 feet
  - Max Wind Speed Resistance 22 mph
  - Programmable flight paths
  - Range - Approximately 4 miles
  - Object tracking
- Cost of each drone (Full kits)
  - $3000 to $5000
Determine best options

- Pictures every hour between of each parking lot
  - May be at a low or high spike time between classes, “false” data
- Optimize sensor for max coverage while not overflying people or moving vehicles
- Straight down vs. altitude vs. angled shots (Flashlight effect)
- Data transfer between flights or end of day
- Battery charging and software updates
- Checklists – developed during this project
- Parking lot travel flow to expedite collection
Federal Aviation Administration

- Approached this project with UAV business model
  - (Recreational, Commercial, or public entity)
- Small Unmanned Aircraft Rule (Part 107), 21 June 2016
  - < 55 lbs.
  - Visual Line-of-sight (VLOS) (Spectacles OK, not binoculars)
  - Daylight, or Civil Twilight with anti-collision lighting (3 mi)
  - FAA Certified Pilot in Command
  - Visual Observer optional (Recommended)
  - Maximum altitude of 400 feet above ground level (AGL)
  - Max speed 100 MPH ground speed (GS)
  - Weather: 3 SM visibility, 500’ below clouds, 2,000’ horizontally
  - Don’t fly over people
  - ATC approval (Class D airspace)
Federal Aviation Administration

- Air Traffic Control (ATC) permission required in Class B/C/D airspace
  - Contact airports when within their controlled airspace
  - Notification is required when operating inside 5 statute miles and/or controlled airspace (Terre Haute – 5.7 NM)
- Require a part 107 certification for commercial operations
- Airspace Authorization
  - Available through internet request
  - 3-4 month wait
  - Once approved, still need to contact the ATC control tower
- Must yield right of way to all manned aircraft
Federal Aviation Administration

- Requires Preflight inspection prior to every flight
- No operation over moving vehicles
- May not operate over any persons not directly involved
- Restrictions may be lifted in near future
- Can also request a waiver to most Part 107 rules, with a 90-120 day response time
Local Restrictions

- Must notify University Police
  - New policy after data collection began
  - 48 hour notice
- May get an escort
- Concerned with filming near dorms
- Air vs. Ground jurisdiction
Contingencies

- **Crashes**
  - Lost UAV day 2, memory chip destroyed
    - Didn’t download data from other flights
    - Poor training led to possible pilot error

- **Weather**
  - Rain the first week reduced successful ops
  - Winds, temps (UAV, battery, controller, person)

- **Software glitches – no-fly, geo-fence**

- **Data transfer issues**
  - Drone to folders to thumb drives or cloud
  - Many high-res JPGs, label and file, transfer to students
Parking Inventory Results

- Discrepancies
  - Most lots were off by 2 to 5 regular spaces
  - No accurate count for several years
Parking Accumulation

- Defined: total number of vehicles parked at any given time
- Establish the distribution of parking accumulation over time
- Determine the peak accumulation and when it occurs
- Determine space availability
- Collect vehicle occupancy each hour
- Due to the nature of arrival patterns
  - 7:30 am to 3:30 pm
    - Class schedule
    - Faculty hours
Parking Accumulation

- Preliminary Analysis
  - Always open spaces
    - Handicapped
    - Parking Meters
    - Service
    - Motorcycle
  - Spaces full
    - Regular Spaces
Campus Map
Drone Data

Open Spaces
Parking Garage

- Not accessible via drone
- Manual counts
Deliverable

- Accumulation graphs
- All parking lots on campus
- Assist travelers in choosing parking based on time of day
Bar Graphs

STAFF/STUDENT LOT A

Spaces Occupied

- Regular Spaces
- Capacity
Bar Graphs

PARKING GARAGE

Spaces Occupied

Regular Spaces
Capacity

0 100 200 300 400 500 600

7:30 AM 8:30 AM 9:30 AM 10:30 AM 11:30 AM 12:30 PM 1:30 PM 2:30 PM 3:30 PM
Cost Effectiveness

- **Wages**
  - $12/hour, per student

- **Hours**
  - Large lots require full day counts
  - Drone capture multiple lots per flight

- **Drone Cost**
  - $3000
## Cost Effectiveness

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<th>Method</th>
<th>Hours</th>
<th>Weeks</th>
<th>Cost</th>
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<tr>
<td>Traditional Method 4 Students</td>
<td>512</td>
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<td>Drone Study Student</td>
<td>40</td>
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Drone Study is 56.7 percent of the cost
92.2 percent of cost savings when drone is recouped
Lesson Learned

- Labeling the pictures
  - Date
  - Time
  - Parking lot(s)

- Multi lots per picture
  - Reducing flights

- Key to flights
  - Get certified ASAP
  - Practice
  - Schedule and communicate
  - Study and know rules
  - Determine lucrative value

- Sun angles
  - Shadows
  - Glare

- Drone capabilities
  - Battery efficiency
  - Data storage

- Weather
  - Including wind
Future use with Software

- OpenALPR
  - Plate detection system
- Compatible with most cameras
- Create flight plan to collect data
  - Issue tickets as necessary
- Conduct studies on:
  - Duration
  - Turnover rate

<table>
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<td>2</td>
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<td>5</td>
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Unmanned Uses Within Limitations

- Parking
  - Inventory
  - Accumulation/Occupancy
Unmanned Uses Within Limitations

- Before and after traffic queues
  - Signal timing
  - Other improvements
Unmanned Uses Within Limitations

- Work zone
  - Inspections
  - Traffic monitoring
Unmanned Uses Within Limitations

- Road Networks
  - Pavement inspections
  - Bridge inspections
Contact Information

• Michael R. Williamson Ph.D.
  • Assistant Professor, Dept. of Civil Engineering, Indiana State University, Terre Haute, IN 47809 Phone: 217-343-7512; email: michael.williamson@indstate.edu

• Sam Morgan
  • Director, Unmanned Systems. Instructor, Department of Aviation, Indiana State University, Terre haute, IN 47809. Phone: 812-237-2660; email sam.morgan@indstate.edu