# Utilization of Unmanned System Technology in Transportation Engineering

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# 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

Search...
Search
Buildings
Parking
Faculty/Staff Parking
Handicapped Parking
Remote Parking
Staff/Student Parking
Student Parking
Visitors' Pay Lots
Cherry Street Parking Garage
Welcome Center Parking
Services
Transit
Indiana State University
Office of Communications and Marketing
102 Gillum Hall, Terre Haute, IN 47809
web@indstate.edu
(812) 237-3773
MAP
SATELLITE
ELM ST
CANAL ST
SYCAMORE ST
N 1ST ST
N 2ND ST
N 10TH ST
WABASH AVE
Terre Haute
41
150

# 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

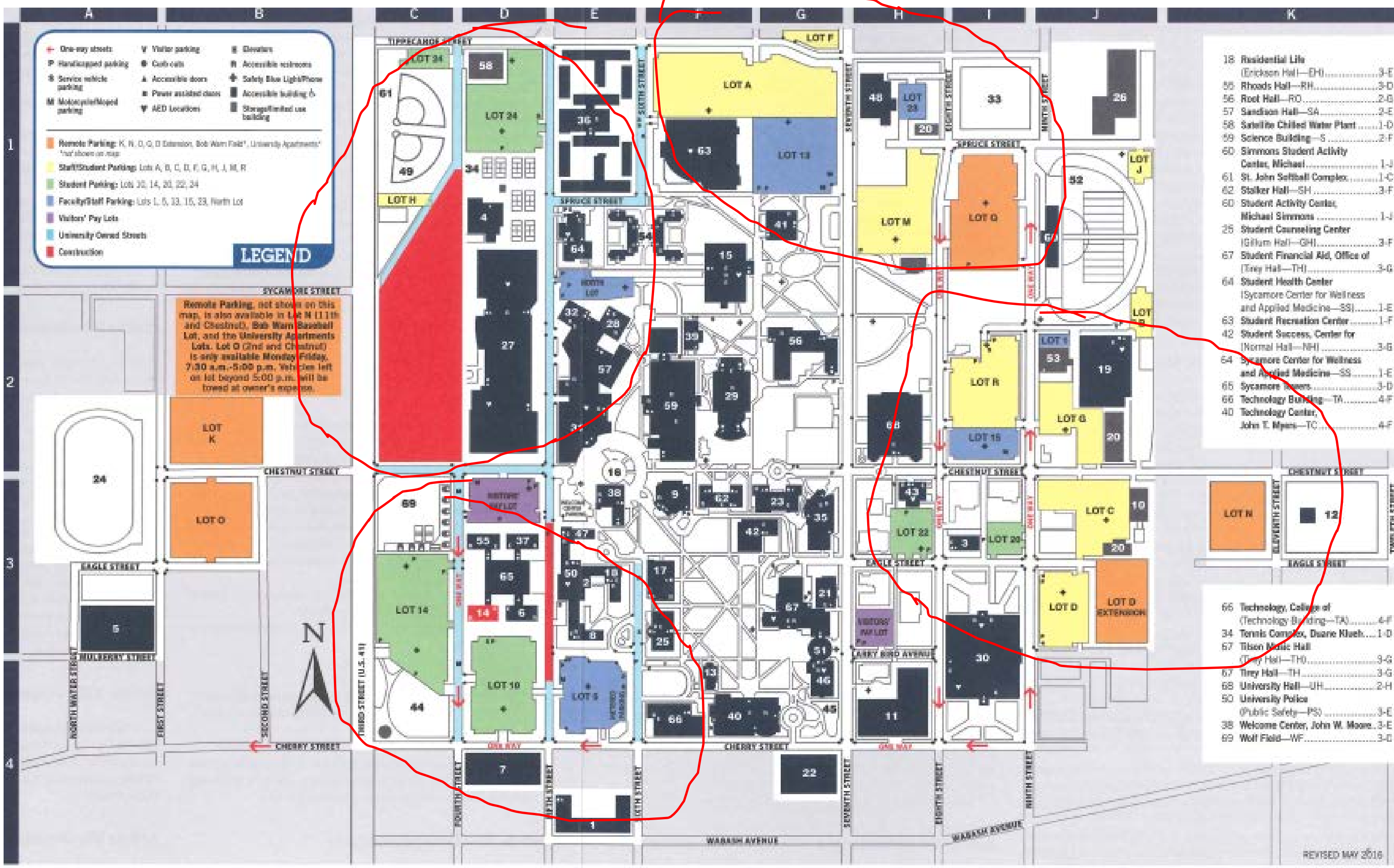
# Parking Accumulation

- 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


LEGEND
One-way streets
Handicapped parking
Service vehicle parking
Motorcycle/Moped parking
Visitor parking
Curb cuts
Accessible doors
Power assisted doors
AED Locations
Elevators
Accessible restrooms
Safety Blue Light/Phone
Accessible building
Storage/limited use building
Staff/Student Parking: Lots A, B, C, D, F, G, H, J, M, R
Student Parking: Lots 10, 14, 20, 22, 24
Visitors' Pay Lots
University Owned Streets
Construction
Remote Parking, not shown on this map, is also available in Lot N (11th and Chestnut), Bob Warn Baseball Lot, and the University Apartments Lots. Lot O (2nd and Chestnut) is only available Monday-Friday, 7:30 a.m.-5:00 p.m. Vehicles left on lot beyond 5:00 p.m. will be towed at owner's expense.
SYCAMORE STREET
CHESTNUT STREET
EAGLE STREET
MULBERRY STREET
CHERRY STREET
WABASH AVENUE
TIPPECANOE STREET
SPRUCE STREET
ONE WAY
18 Residential Life (Erickson Hall—EH)....3-E
55 Rhoads Hall—RH....3-D
56 Root Hall—RO....2-G
57 Sandison Hall—SA....2-E
58 Satellite Chilled Water Plant....1-D
59 Science Building—S....2-F
60 Simmons Student Activity Center, Michael....1-J
61 St. John Softball Complex....1-C
62 Stalker Hall—SH....3-F
60 Student Activity Center, Michael Simmons....1-J
25 Student Counseling Center (Gillum Hall—GH)....3-F
67 Student Financial Aid, Office of (Tirey Hall—TH)....3-G
64 Student Health Center (Sycamore Center for Wellness and Applied Medicine—SS)....1-E
63 Student Recreation Center....1-F
42 Student Success, Center for (Normal Hall—NH)....3-G
64 Sycamore Center for Wellness and Applied Medicine—SS....1-E
65 Sycamore Towers....3-D
66 Technology Building—TA....4-F
40 Technology Center, John T. Myers—TC....4-F
66 Technology, College of (Technology Building—TA)....4-F
34 Tennis Complex, Duane Klueh....1-D
67 Tilson Music Hall (Tirey Hall—TH)....3-G
67 Tirey Hall—TH....3-G
68 University Hall—UH....2-H
50 University Police (Public Safety—PS)....3-E
38 Welcome Center, John W. Moore....3-E
69 Wolf Field—WF....3-D
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# Drone Data

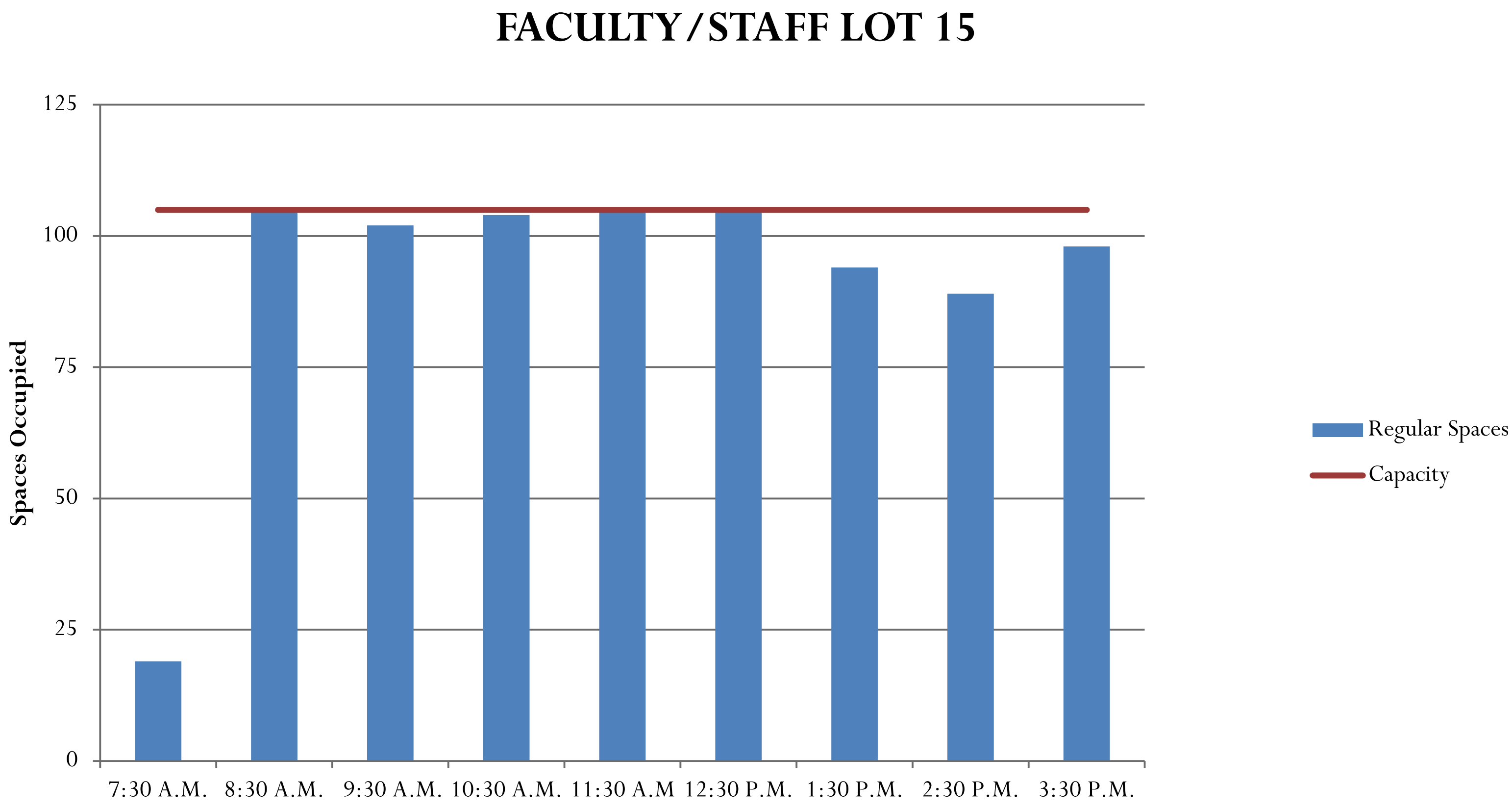
# Parking Garage

- Not accessible via drone
- Manual counts

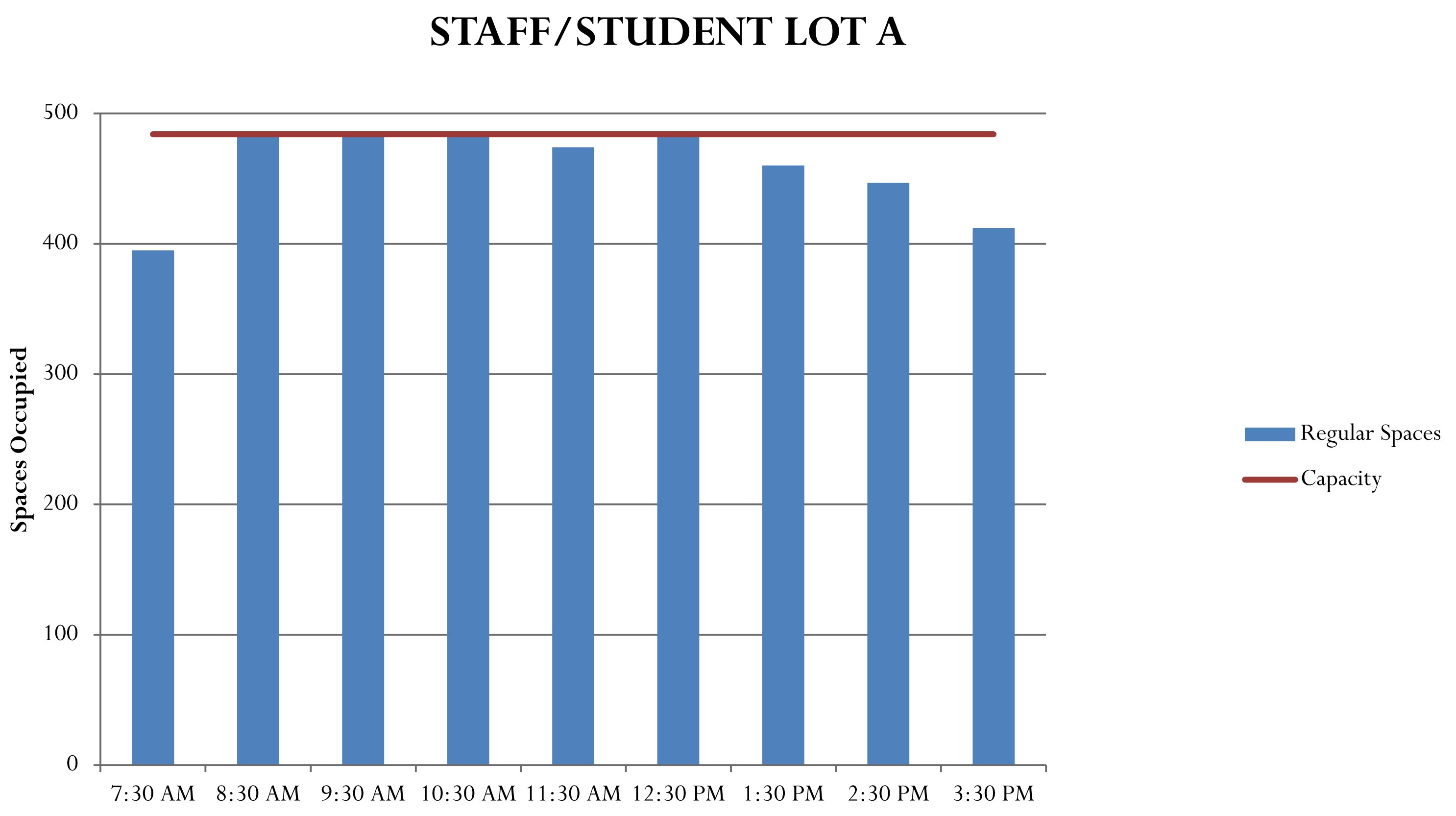
# Deliverable

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

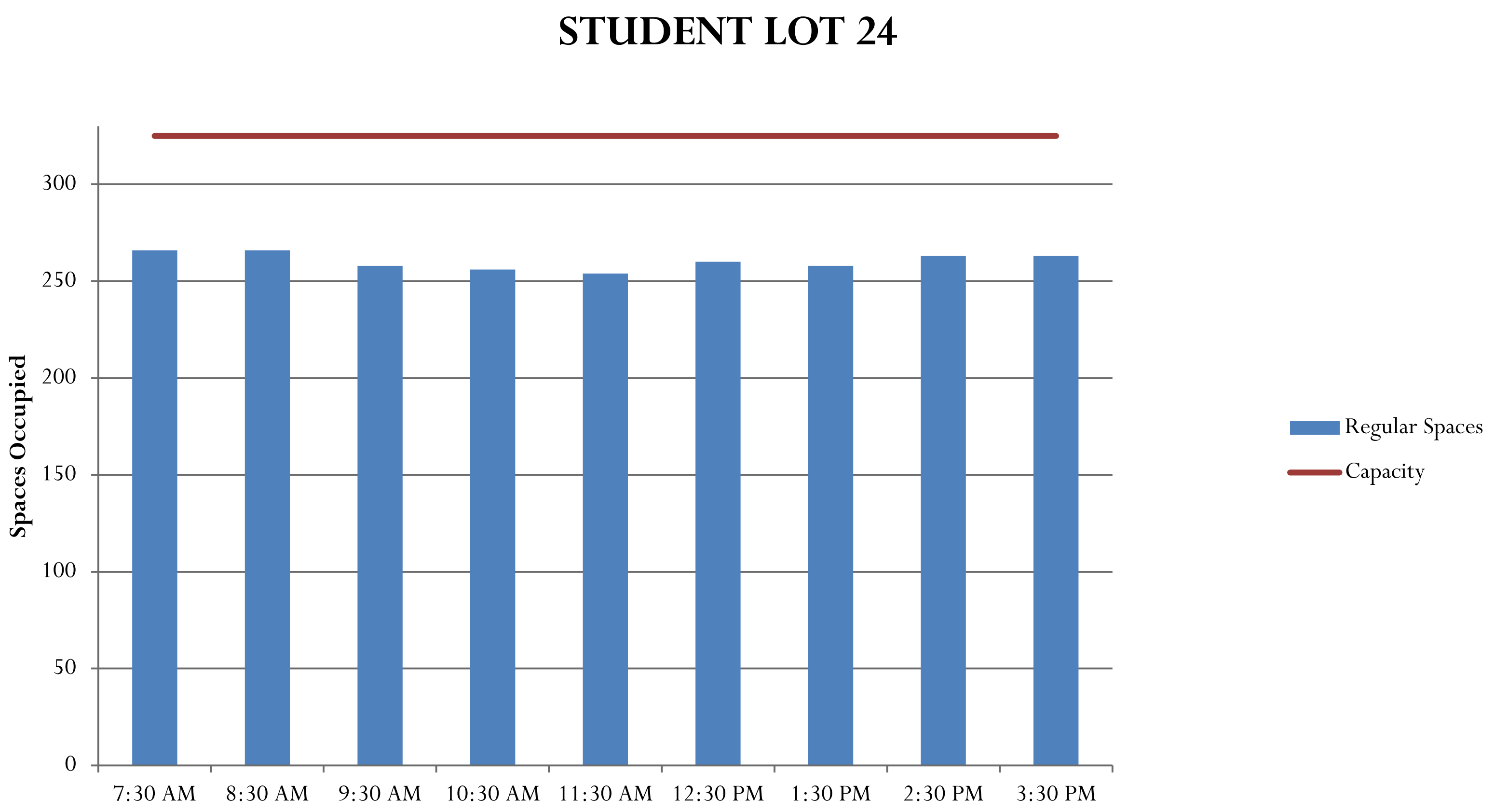
# Bar Graphs


FACULTY/STAFF LOT 15
Spaces Occupied
125
100
75
50
25
0
7:30 A.M.
8:30 A.M.
9:30 A.M.
10:30 A.M.
11:30 A.M
12:30 P.M.
1:30 P.M.
2:30 P.M.
3:30 P.M.
Regular Spaces
Capacity

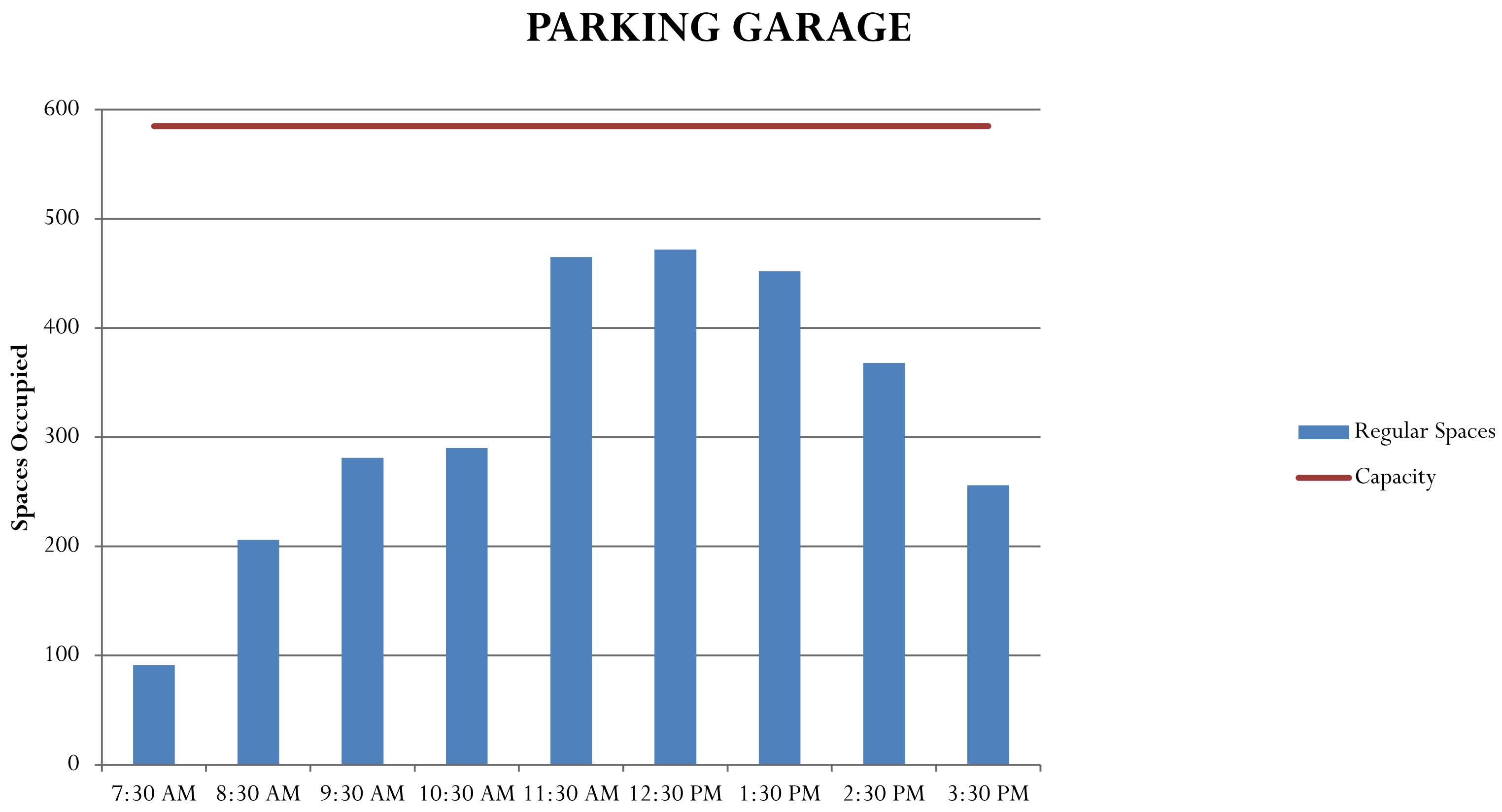
# Bar Graphs


STAFF/STUDENT LOT A
500
400
300
200
100
0
Spaces Occupied
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
Regular Spaces
Capacity

# Bar Graphs


STUDENT LOT 24
Spaces Occupied
300
250
200
150
100
50
0
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
Regular Spaces
Capacity

# Bar Graphs


PARKING GARAGE
Spaces Occupied
600
500
400
300
200
100
0
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
Regular Spaces
Capacity

# 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

| Method | Hours | Weeks | Cost |
|---|---|---|---|
| Traditional Method 4 Students | 512 | 12.8 | $ 6,144.00 |
| Drone Study Student | 40 | 1 | $ 3,480.00 |
| Drone Study is 56.7 percent of the cost<br>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


| id | Lot | Plate_Number | Confidence |
|---|---|---|---|
| 1 | 15 | CE MW 1 | 78.48 |
| 2 | 15 | NR 1967 | 74.51 |
| 3 | 15 | KE 4932 | 86.46 |
| 4 | 15 | TKY 3939 | 78.54 |
| 5 | 15 | BCEM 29 | 95.45 |

# 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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