Improving Parking Enforcement Scheduling using Integer Linear Programming

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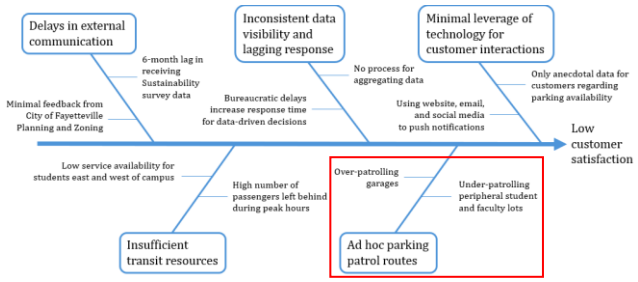
Ad Hoc Parking Patrol Procedures

Transit and Parking (T&P) manages 14,500 parking spaces distributed across more than 100 lots and garages. They offer a wide range of pricing options, from premium reserved lots and garages to more affordable economy lots on the campus perimeter. A 2023 survey conducted by the university's Office for Sustainability revealed that 66% of students, staff, and faculty expressed dissatisfaction with University Parking services. T&P leadership suspected that inconsistent parking enforcement – particularly excessive patrolling of garages and insufficient patrolling of surface lots – were leading to dissatisfaction.



Optimizing Patrol Routes Using Linear Programming

To improve parking enforcement consistency and operational efficiency, we developed an integer linear programming model that generates optimized patrol schedules. Instead of random selection, the model assigns vehicle patrol officers to lots over fixed 30-minute intervals using operational parameters, lot characteristics, and expected commuter behavior. Our objective was to minimize the number of vehicles that depart campus without being patrolled, weighted by customer importance values.

Key Inputs:

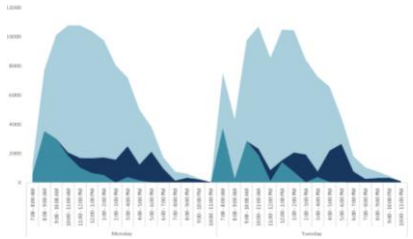
- Lot-specific characteristics (location, size, customer utilization, groups)
- Time required for true and false positive scans, as well as true negatives
- Desired officer utilization rate

Key Constraints:

- No more than one officer can patrol a lot during a time interval
- Each lot must be patrolled at least once a day
- Factoring in officer utilization, officers are not scheduled for more than 30 minutes in a time interval
- All lots that belong to the same group must be patrolled in the same time interval by the same officer
- Specific lots should only be patrolled between 7am - 5pm; others only between 7am – 8pm
- Lots more than 0.65 miles apart are not assigned to the same officer during the same time interval

Determining Unpatrolled Departures

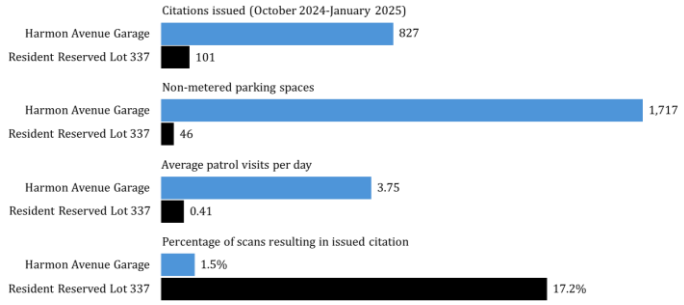
Using Fall 2024 student class schedules, we modeled how parking occupancy fluctuates throughout the day. For each 30-minute interval, we estimated the number of departing vehicles based on this data. Next, we approximated the number of unscanned departures, which increases as time passes since the lot's last patrol. By combining the departure profile with these scan values, our model calculates a lot-specific estimate of unpatrolled departures for every interval. This leads to scheduling patrol visits at the times and locations where the risk of missed violations is greatest.



	Current Time
Most Recent Patrol	1:00 PM
Unpatrolled	3666
7:00 AM	3466
7:30 AM	3435
8:00 AM	3426
8:30 AM	2088
9:00 AM	2082
9:30 AM	908
10:00 AM	857
10:30 AM	0

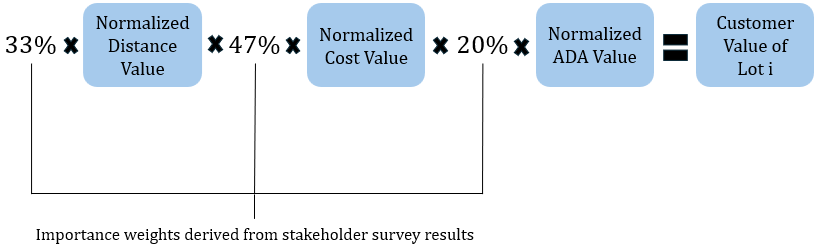
Data Analysis Confirms Inconsistent Patrol Patterns

Data analysis confirmed the uneven nature of enforcement patrols across campus. Garages were frequently visited yet produced fewer violations per inspection, while many surface lots with higher violation rates were rarely checked. This imbalance allowed numerous infractions to go undetected, which in turn lowered space turnover and inhibited drivers who followed the rules.



Determining Importance Value of a Lot

We quantified the relative importance of each campus lot based on three key factors: the average cost per parking space in the lot, the distance of the lot from the campus center, and the percentage of spaces reserved for ADA accessibility in the lot. Using stakeholder input, we applied weighted priorities to each attribute. Lots with higher combined scores received higher patrol priority, aligning enforcement with customer value.



Recommended Patrol Routes

Replacing random enforcement procedures with data-driven patrol schedules would result in a more balanced coverage across campus. The schedules we created would reduce the over-patrolling of low-violation garages and improves enforcement in previously under-patrolled lots.

Previous ad hoc distribution of parking enforcement (left) compared to our model's recommended patrol schedules (right).