Civil and Environmental Engineering Department

Allocating Bicycle Parking Locations in the University Campus

Faith Kaiza, Elhadji Niang, Ricardo Rivera-Munoz

University of Maryland

A. James Clark School of Engineering

Background and Introduction

As the University of Maryland increasingly turns to sustainable transportation options like traditional bicycles, electric bikes, scooters, and shared micro-mobility solutions, the importance of thoughtfully designed, accessible, and fair parking facilities on campus becomes apparent.

Figure 1,2,3: Assessing the Existing Conditions

Goals and Objectives

This project focuses on 4 areas in order to address the micro-mobility issues:

- **Demand-** Improve the parking spaces to match the ongoing demand for each building.
- **Sustainability-** Come up with innovative sustainable solutions in order to provide a better experience for micro-mobility users on campus.
- **Security-** Establish a safe and secure access of parking infrastructure for all users.
- **Accessibility-** Ensure equitable distribution of parking resources and improve the spatial availability of parking spaces to meet the ongoing demand of each building.

Methodology

- **Demand**
  - Surveys were conducted at the 17 selected parking lot locations in busy buildings. During these surveys, we counted the number of racks available (capacity) and the number of users (demand) to assess the parking situation.

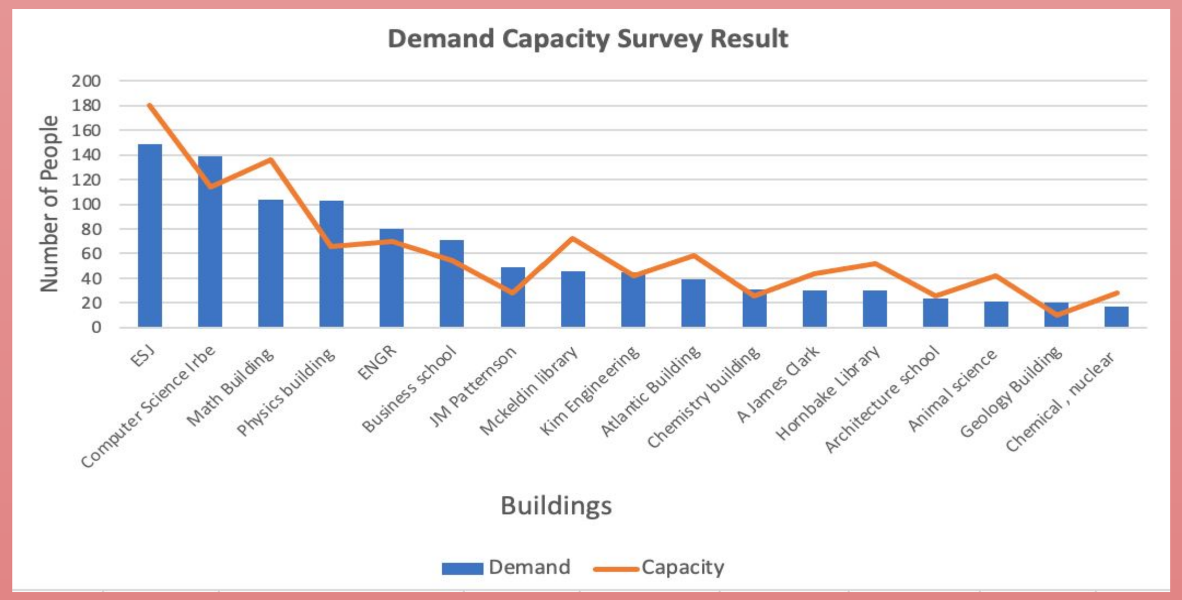

Figure 4: Demand capacity survey results

  - Optimization model: We developed an optimization model using Xpress to minimize the walking distance within our selected system of buildings and parking lots. This model utilizes demand and capacity data obtained from the surveyed buildings and lots, along with a 17 by 17 distance matrix representing the distances from each building to a parking lot. The model is subject to five constraints: demand, budget, space, security, and people. The objective is to identify optimal locations for expansion and determine the number of spaces needed in each lot to accommodate both the current demand and a projected 30% increase.

Objective Function:

$$(MIN)\ Z = \sum_{i=1}^{17} \sum_{j=1}^{17} x_{ij} * f_{ij}$$

Where x is the number of people and f the distance from a building j to each parking lot i

- **Sustainability**: We reviewed UMD's existing sustainability goals to tailor our analysis and recommendations accordingly, aiding the university in reaching its objectives through micro-mobility solutions.
- **Security**: Research on previous theft cases and collaborating with UMD to get data for reported micro mobility theft cases to analyze the high theft areas on campus.
- **Accessibility**: Through the field survey, we aimed to identify parking lots with potential accessibility issues. Additionally, we conducted a survey to compare parking distribution between older and newer residential halls on campus, ensuring equitable allocation..

Acknowledgement

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Results and Analysis

- **Demand**: On Xpress, we conducted a series of analyses to evaluate the model's performance under various scenarios, enabling us to formulate recommendations.
  - First, we found the current walking distance: 67,797 ft-user.
  - Then, we set a budget to reduce it to 0 ft-user.
  - Next, we simulated a 30% demand increase: walking distance rose to 719,955 ft-user.
  - Finally, we tested different budgets to see their impact on reducing walking distance.

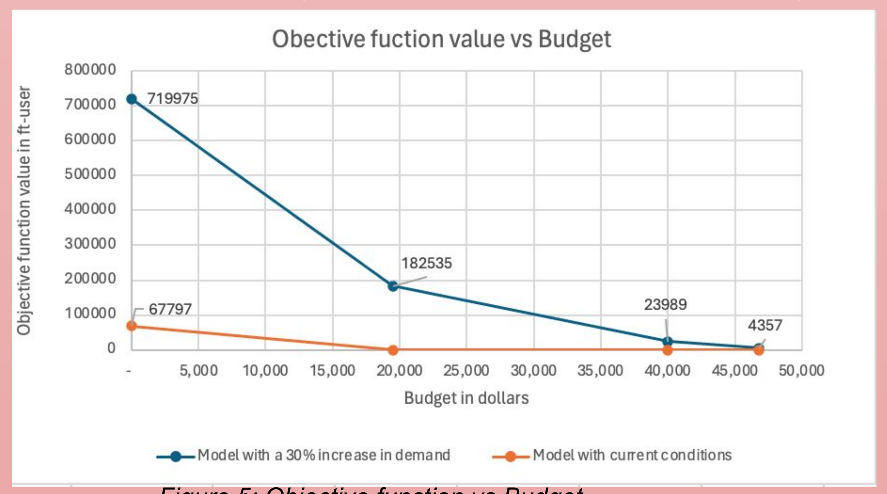
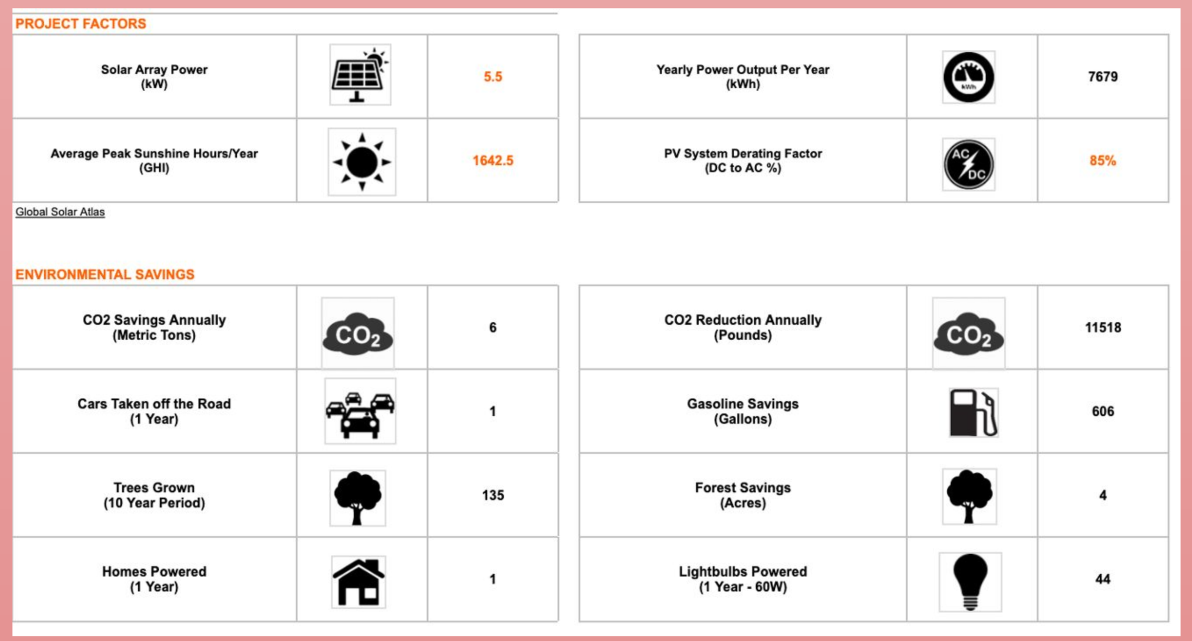


Figure 5: Objective function vs Budget

- **Sustainability**: UMD's main goal is to reduce greenhouse emissions by 50% and achieve carbon neutrality by 2025. The following table shows the total power that can be generated from 5 solar charging stations, the amount of carbon dioxide that can be offset, as well as other environmental metrics.



PROJECT FACTORS

Solar Array Power (kW)	5.5	Yearly Power Output Per Year (kWh)	7679
Average Peak Sunshine Hours/Year (GHI)	1642.5	PV System Derating Factor (DC to AC %)	85%

Global Solar Atlas

ENVIRONMENTAL SAVINGS

CO2 Savings Annually (Metric Tons)	6	CO2 Reduction Annually (Pounds)	11518
Cars Taken off the Road (1 Year)	1	Gasoline Savings (Gallons)	606
Trees Grown (10 Year Period)	135	Forest Savings (Acres)	4
Homes Powered (1 Year)	1	Lightbulbs Powered (1 Year - 60W)	44

Figure 6: Environmental Benefits of Implementing Solar Charging Stations

- **Security:** Through a collaboration with UMPD, theft data were obtained for the past 3 years.

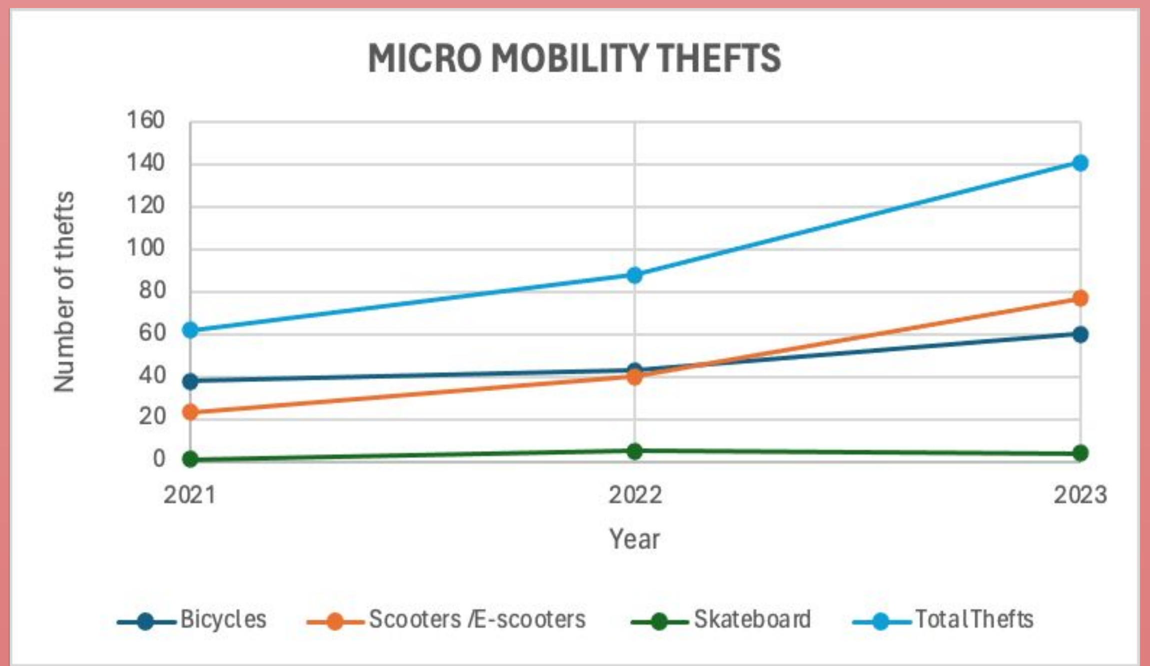


Figure 7: Micro mobility theft on campus over the last three years

Accessibility: There are approximately 6000 micro-mobility parking spots on campus for a demand of around 2000 registered micro-mobility users. This highlights potential accessibility issues rather than a shortage of parking spots in some locations.This analysis focuses on two main aspects: the accessibility challenges in certain parking locations, and the unequal distribution of micro-mobility parking between older and newer residences. In fact, the field survey revealed that despite being in busy areas some parking locations are not fully utilized due to the lack of accessibility. For example: ESJ, and Math building.

Future Works

While performing our surveys, we noticed a need for bike lanes on campus. In fact, bikers at the University of Maryland campus experience inefficiencies while traveling due to the lack of proper bike lanes, large number of students walking on campus, as well as increased traffic due to road closures and altered traffic patterns as a result of continuous construction. To further improve the users' experience and safety on campus for everyone, we are suggesting addition of bike lanes on the major routes on campus.

Recommendations

- **Demand**: .The University should invest in expanding existing parking. Through Xpress, we pinpointed 10 optimal expansion sites (see map), achieving a walking distance of 4357 ft-user with a $46,800 budget. We also prioritized avoiding high-theft areas and planned for a 30% demand increase.
- **Sustainability:** Install 5 solar charging stations at selected locations.

Figure 8: Model ARA-EB2

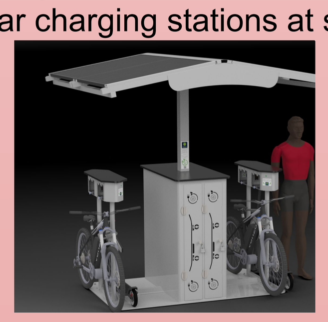


Figure 9: Model Phoenix

- **Security**: Install security cameras/alarms, raise awareness about the use of U locks

Figure 10: Security camera/alarm

Figure 11: U-lock

- **Accessibility:** Utilize posters and flyers in buildings where parking lots frequently reach full capacity, despite having hidden extra parking spots, to enhance parking resource utilization.

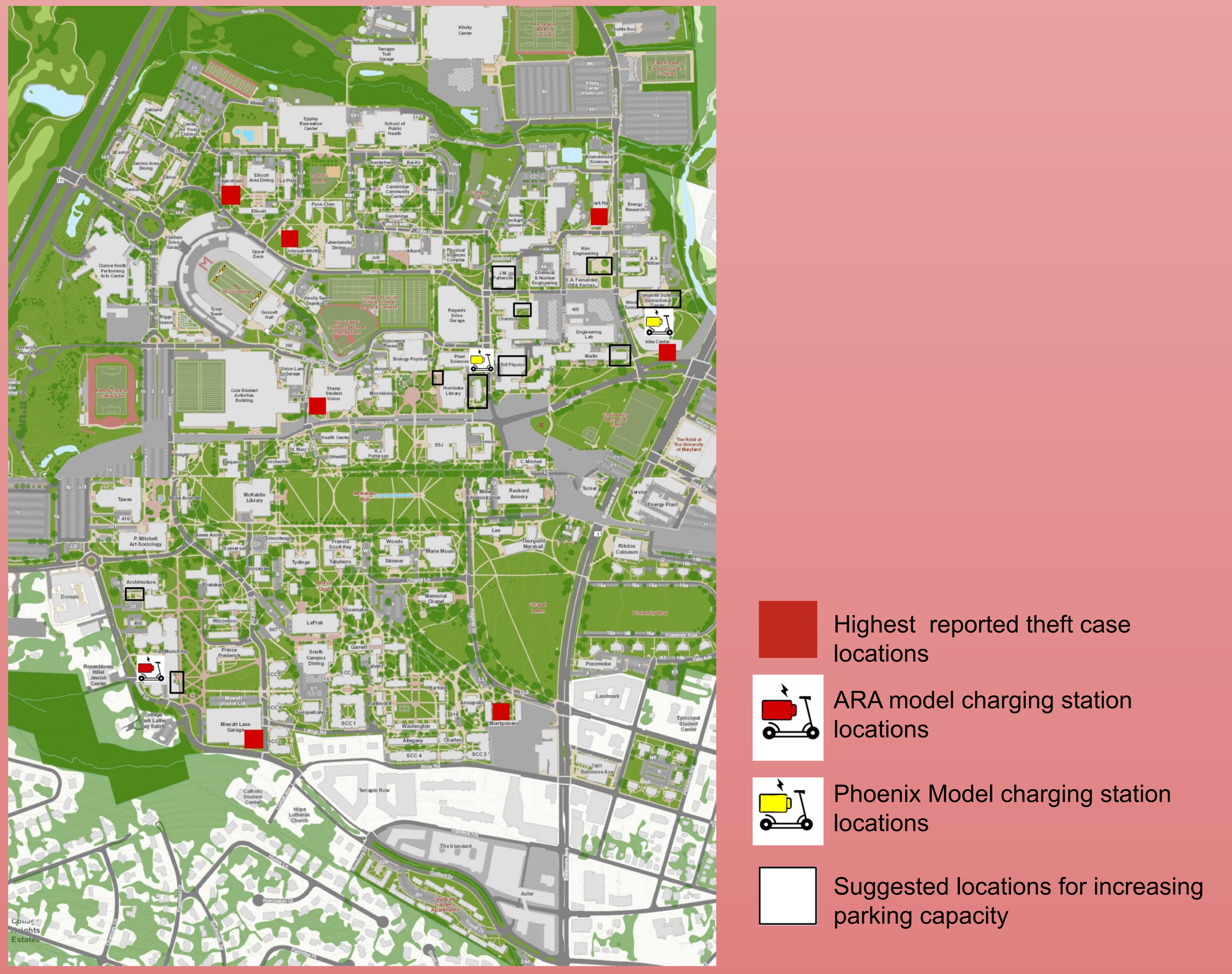


Figure 12: Final Recommendation Map

Benefit Cost Analysis

Benefit Cost analysis table

Recommendation	Total Project Cost	Total Project Benefit	Benefit Cost Ratio
Expanding parking lots and benefits in travel time savings	$ 46,800	$ 385,339	8.23
Installing security cameras, alarms, and raising awareness about U-locks	$ 13,993	$ 26,500	1.89
Solar charging stations	$ 129,600	$ 354,586	2.74
Accessibility (infographics will be sent to students for free)	$ -		
Total cost/ benefit of improvements	$ 190,393	$ 766,425	4.03

Table 1: Benefit cost analysis

Summary/Conclusion

In summary, our research highlights the importance of better parking facilities at UMD for a greener, safer, and more convenient campus life. We identified the need to improve micro-mobility parking by adding more spaces, installing solar charging stations, and boosting security. These steps aim to make transportation more sustainable and accessible for everyone on campus. Our project plays a key role in supporting environmental efforts, enhancing safety, and meeting the varied mobility needs of students and staff.