Optimizing Campus Electric Scooter Deployment at North Side University

Background & Objectives

E-scooters provide efficient last-mile mobility at North Side University (NSU), but the current 500-scooter system suffers from (i) morning stockouts in residential areas and (ii) midday clutter at major sink locations. Using datasets `Trip_Data` and `Campus_Map`, we (1) profile spatiotemporal demand, (2) optimize 6:00 AM initial deployment to maximize morning coverage (6:00–10:00), (3) design a daytime rebalancing mechanism, and (4) translate results into managerial actions.

Modeling Approach & Results

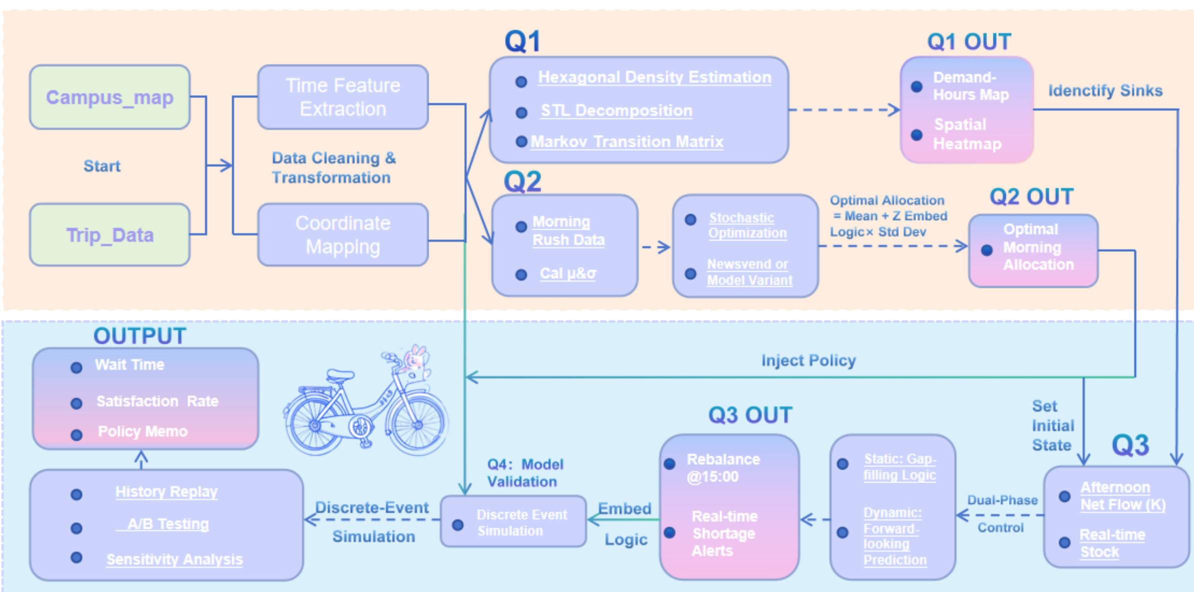

Figure 1: Overview of Our Work

1) Demand Profiling (Problem 1)

Trip endpoints are mapped to campus nodes by nearest-distance matching. Demand is summarized by hour and by origin–destination (OD) flows.

Key patterns.

- **Weekday peak:** 7:00–9:00 AM, dominated by *Dorm* $\rightarrow$ *Academic* tidal flow.

- **Weekend pattern:** flatter demand with a mild midday peak (10:00 AM–1:00 PM).
- **Sink effect:** Student Center accumulates net inflow, causing midday congestion and idle inventory.

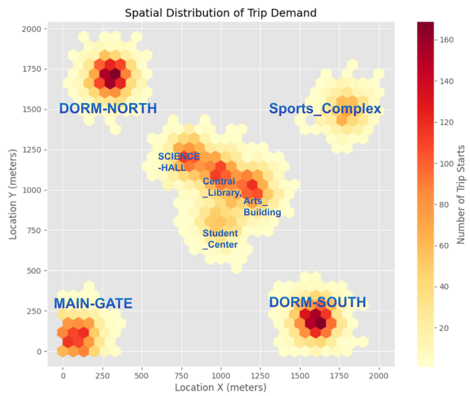

Figure 2: OD tidal flow pattern (Dorm zones → Academic buildings) and demand density hotspots.

2) 6:00 AM Initial Deployment (Problem 2)

We allocate scooters to nodes using a **risk-aware stochastic inventory model** (Newsvendor-style). Let D_i be the morning-peak demand at node i. Using historical mean μ_i and standard deviation σ_i, the target inventory is:

$$S_i = \mu_i + z_\alpha \sigma_i, \qquad \sum_i S_i = 500,$$

where z_α is the service-level parameter (we use a high service level for high-variance residential nodes). This prevents under-supply in volatile locations.

Recommended 6:00 AM allocation (visualization).

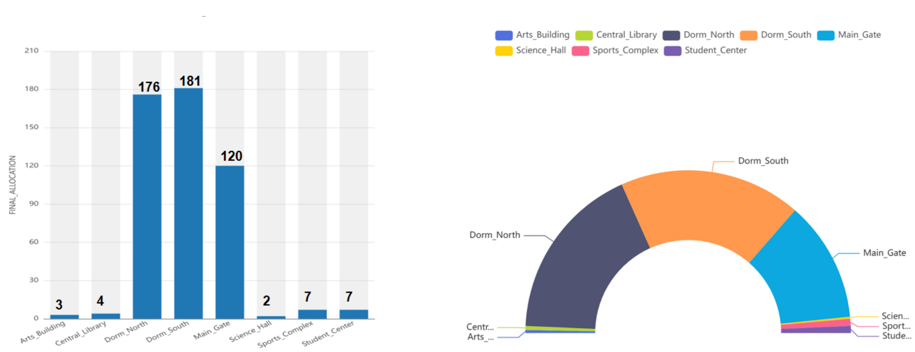

Figure 3: Optimized initial scooter allocation at 6:00 AM, showing concentration in dormitory zones.

3) Daytime Rebalancing (Problem 3)

We propose a **two-stage mechanism** to resolve sink accumulation and prevent evening shortages.

Static Pulse (13:00): During the midday trough, relocate excess inventory from sink nodes (e.g., Student Center) back to source areas (Dorm zones).

Dynamic Alerts: Let $I_i(t)$ be current inventory and $\widehat{D}_i(t, t+3h)$ be the projected demand over the next 3 hours. Trigger dispatch if:

$$I_i(t) < \widehat{D}_i(t, t+3h) \cdot \phi,$$

where ϕ is a busyness factor (e.g., exam week vs. normal day). This minimizes dispatch frequency while preventing imminent stockouts.

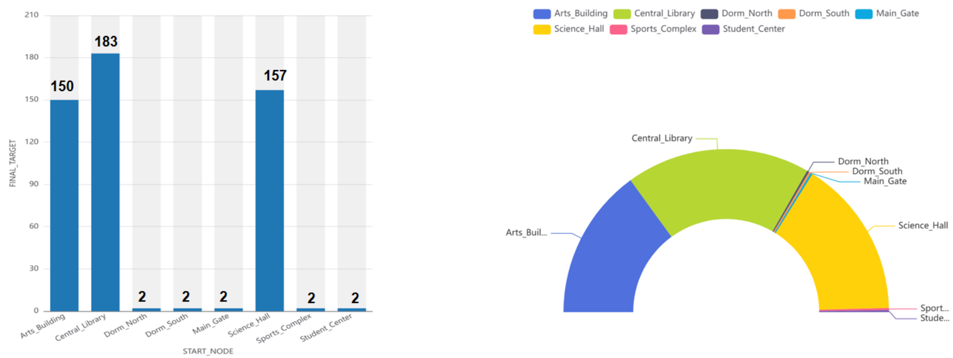

Figure 4: Two-stage rebalancing: 13:00 pulse move + dynamic forecast-based alerts.

4) Simulation Validation (Problem 4)

We validate the strategy via a **discrete-event simulation (DES)** over 7 days, comparing baseline vs. strategy under varying load. The strategy improves reliability and delays system degradation under demand shocks.

Table 1: Key performance improvement (DES summary).

Metric	With Strategy
Service satisfaction rate	89.2%
Demand increase tolerated before degradation	10%
Observed issue reduced	Morning stockouts + midday clutter

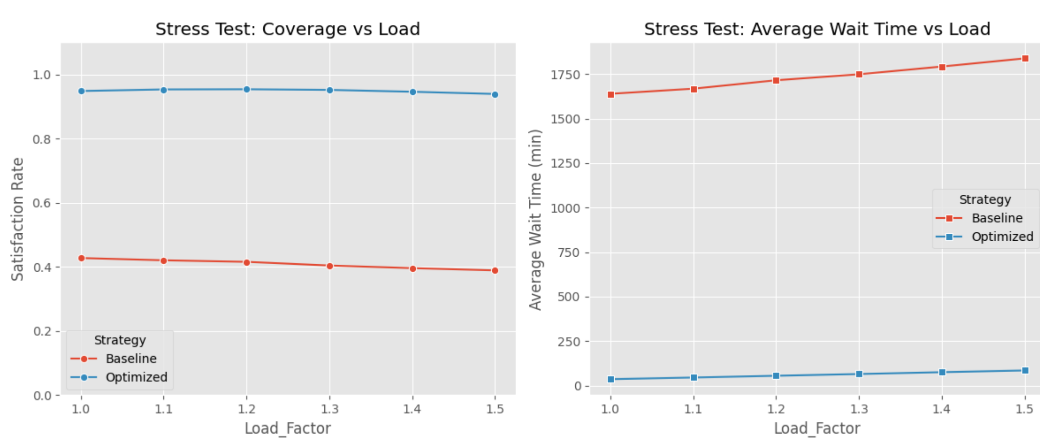

Figure 5: Two-stage rebalancing: 13:00 pulse move + dynamic forecast-based alerts.

MEMORANDUM

TO: Director of Campus Services, Northside University
FROM: Team 202
DATE: January 1st, 2026
SUBJECT: Optimizing "ScootNSU" Fleet Deployment and Rebalancing

Executive Summary. NSU's scooter issues are caused by directional morning commuting and midday sink accumulation—not insufficient fleet size. Using last-month trip data, we propose a risk-aware 6:00 AM deployment and a two-stage rebalancing mechanism that raises service reliability to **89.2%** without purchasing new scooters.

Key Findings.

- **Morning tidal flow:** 7:00–9:00 AM demand is primarily *Dorm* $\rightarrow$ *Academic*; uniform deployment creates dorm stockouts by 8:00 AM.
- **Sink accumulation:** Student Center becomes a daily sink, accumulating large idle surplus by early afternoon.

Recommendations (Actionable).

- **6:00 AM Deployment:** Allocate **71%** of scooters to dorm zones (Dorm South 179; Dorm North 175) and 121 at Main Gate.
- **13:00 Pulse Rebalancing:** Relocate excess scooters from sink nodes back to dorm zones during the midday lull.
- **Dynamic Forecast Alerts:** Dispatch only when `Current Stock < Projected 3-hour Demand` (scaled by busyness factor ϕ).

Expected Impact. Satisfaction stabilizes at **89.2%**, and the system absorbs **+10%** higher demand before performance degrades.

Core Assumptions (Minimal)

(1) Demand patterns are statistically stable across days (weekday/weekend treated separately).
(2) Map matching uses nearest-node Euclidean approximation.
(3) Fleet size is fixed; failures and weather effects are ignored.