

Network Expansion & Capacity Sizing

Problem & Context

Chronic **empty/full** stations and OD corridors with unmet demand signal structural gaps: the current network's **locations** and **dock counts** no longer match rider patterns. We need a repeatable process to **identify where to add stations or docks**, estimate ROI, and produce a city-ready proposal with cost, impact, and equity guardrails.

Goals & KPIs

- **Reduce stockout minutes** ↓ $\geq 25\%$ in targeted zones within 8–12 weeks post-deployment.
 - **Incremental rides** ↑ $\geq 15\%$ at upgraded/added sites vs matched controls.
 - **Dock utilization**: keep **peak fill between 35–85%** (avoid chronic under/overfill).
 - **Payback window**: ≤ 24 months for capex projects (measured via incremental net-margin per dock).
 - **Guardrails**: equity coverage maintained or improved; no material rise in nearby station churn.
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Scope & Users

- **Users**: City/Partner PMs (approvals), Strategy (site selection), Ops (install/relocate), Finance (capex), Community/Policy (equity, permits).
 - **Inputs**: historical availability stress patterns, trip flows (origins/destinations, time-of-day), station metadata (capacity, catchments), land-use & transit layers, events/seasonality, costs & permitting constraints.
 - **Outputs**: prioritized **Site Candidates** with **recommended dock counts**, timeline, capex/opex, risk notes, and an **approval pack**.
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Key Definitions

- **Unmet demand:** rides that would likely occur if a nearby station had available bike/dock capacity during the relevant time window.
 - **Catchment:** walk radius (e.g., 300–500m) or network-based travel time contour.
 - **Expansion action types:** (a) **Add docks** to existing station, (b) **New station** in white space, (c) **Relocation** within micro-area, (d) **Seasonal capacity swing**.
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Implementation Guide (v1)

1) Hotspot Detection

- Rank stations & corridors by chronic stress (empty/full streaks, recovery time) and by **turnaway risk** (failed starts/returns during peaks).
- Aggregate by time-of-day and season to separate commuter vs leisure patterns.

2) Unmet Demand Modeling

- Build a counterfactual for rides lost during stress windows using matched periods and nearby, unconstrained stations.
- Attribute unmet demand to specific **origins/destinations** and quantify spillovers.

3) White-Space & Catchment Analysis

- Map areas with high trip density, poor proximity to stations, or last-mile gaps to transit hubs/campuses/venues.
- Layer zoning, right-of-way, lighting/safety, and utility access.

4) Site Scoring & Prioritization

- **Scorecard dimensions:** expected incremental rides, stress reduction to neighbors, equity uplift, install feasibility, capex/opex, and community/permit risk.
- Produce a **Top-N candidate list** per district with rationale.

5) Capacity Sizing (Dock Count)

- Select a **target fill band** (e.g., 35–65%) for peak windows.
- Size docks to keep **forecasted peak inventory** within band with **safety stock** for weather/events; prefer **modular increments** (e.g., ± 6 docks).
- For upgrades, check **ground constraints** (pad size, power, visibility) and **vehicle service access**.

6) Scenario Simulation

- Simulate 3 scenarios per site (conservative/base/aggressive) with changes to rider patterns, seasonality, and neighbor interactions.
- Report **impact deltas** (stockout minutes, rides, utilization), **ops implications** (rebalancing load), and **financials** (NPV/payback).

7) Compliance & Equity

- Validate ADA, fire/egress, and municipal placement rules.
- Enforce **minimum coverage** in underserved areas and include community feedback checkpoints.

8) Delivery Planning

- Create install batches with timelines, vendor tasks, permitting lead times, and fallback locations.
- Define acceptance criteria: signage, power/connectivity, safety checks, and **30-day post-install review**.

Expected Behavior (End-to-End)

1. **Chronic downtown returns:** Model shows unmet evening returns around a transit hub; upgrade two nearby stations by +18 docks total; stockout minutes fall and returns stabilize within target band.
 2. **Residential origin surge:** Morning peaks overflow small stations; add one **new station** mid-block plus +6 docks to two neighbors; AM rides \uparrow and van interventions \downarrow .
 3. **Event venue:** On game nights, simulate a **seasonal swing** (portable docks) that removes pre/post-event spikes without over-building year-round.
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Experiment & Analysis Plan

- **Design:** Staggered rollout (stepped-wedge) across districts; pre/post with matched controls.
- **Primary:** reduction in stockout minutes in the affected catchments.
- **Secondary:** incremental rides, utilization within band, spillover effects on neighbors, rebalancing km/ride.
- **Success criteria:** $\geq 15\%$ stockout reduction with positive unit economics and neutral/favorable ops load.

Risks & Mitigations

- **Permit delays / community pushback:** early engagement, alt-site backups, transparent impact summaries.
- **Over-capacity (idle docks):** modular phases; 90-day review with downsize option.
- **Shifting demand:** quarterly re-scoring; mobile/seasonal units to adapt.
- **Equity concerns:** quota for underserved zones; publish coverage metrics.

Trade-offs

Choice	Pros	Cons	Use When
Add docks (expand)	Fast, low friction	May not fix location mismatch	High demand, good footprint
New station	Access new demand	Higher capex & permits	White space, long walks
Relocation	Fix misplacement	User retraining	Low usage + nearby hotspot
Seasonal docks	Flexible, low capex	Logistics overhead	Event/season spikes

Rollout Plan

1. **Weeks 1–2:** Hotspot & unmet-demand analysis; draft site shortlists.

2. **Weeks 3–4:** Field surveys, utility checks, community pre-briefs; finalize scorecards.
 3. **Weeks 5–6:** Permits, vendor SOWs, procurement.
 4. **Weeks 7–10:** Install in waves; acceptance tests; live monitoring.
 5. **Week 14:** Post-install review + scenario re-tune; publish impact to partners.
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Engineering/Ops Work Pack

- **Scoring engine & scenario simulator** with inputs for demand, stress, and policy constraints.
 - **Site management console** (candidates → approvals → install tracking).
 - **Field survey app** (photos, measurements, checklists).
 - **Financial model module** (capex/opex, payback, NPV).
 - **Equity/compliance rules** baked into scoring and approvals.
 - **Reporting bundle** for city partners (maps, metrics, before/after).
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GenAI Assist (workshop-friendly prompts)

- **Shortlist rationale:** “Explain why each proposed site ranks where it does across demand, equity, feasibility, and ROI—bullet points per site.”
- **Dock sizing brief:** “Given peak patterns and target fill bands, recommend dock increments for the top 10 sites with risk notes.”
- **Partner pack:** “Draft a 1-page city memo summarizing locations, benefits, community safeguards, and timeline.”

Roadmap impact: Establishes a **repeatable, defensible** process for where and how much to build—shrinking outages structurally, lifting rides, and aligning the network with evolving rider demand while meeting equity and compliance goals.