Weather-Aware Rider Incentives (Crowd Rebalancing)

Problem & Context

Even with proactive van rebalancing, some stations repeatedly tip into **empty** (no bikes) or **full** (no docks)—especially during rush hours, storms, and one-off events. Vans are costly and slow to reposition. We need a **rider-driven balancing layer** that nudges trips toward stressed stations with **context-aware credits** so availability stays within SLA at lower operational cost.

Goals & KPIs

- **Reduce stockout minutes/station/day ↓ 20–30%** versus planner-only baseline within 6–8 weeks.
- **Incentive efficiency: resolved stress events per $ ↑; $ per resolved event ↓** by 25%.
- **Adoption: incentivized trip conversion rate ≥ 12%** in targeted windows.
- **Guardrails:** no material increase in fraud/abuse; customer CSAT/NPS unchanged or ↑; budget adherence within ±10%.

Scope & Users

- **Users:** Riders (receive offers), Growth/Ops Leads (policy & budget), Dispatch (coordination with vans), Finance/City Partners (cost & compliance).
- **Inputs:** live availability stress signals, short-horizon demand risk, weather & event context, station criticality, fairness constraints, budget.
- **Outputs:** targeted **pick-up** or **return** incentives (credits/discounts) by station and time window; live experiment flags; post-hoc performance reports.
- **Out-of-scope (v1):** surge pricing for standard rides; long-term subscription discounts.

Incentive Policy & Event Semantics

- **Stress window:** a station is predicted or observed to be at risk of empty/full within the next **15–90 minutes**.
- **Offer types:**
  - **Pull Supply:** bonus for **picking up** from surplus (near-full) stations.
  - **Push Supply:** bonus for **returning** to deficit (near-empty) stations.
- **Offer payload:** station (or station pair), **amount**, **eligibility** (rider segments), **time window**, **cap**, **reason tag** (rush hour, rain, event).
- **Dynamic pricing bands:** low/medium/high based on risk score and expected rider elasticity.
- **Fairness guardrails:** enforce geographic coverage and prevent systematic neglect of low-income areas.

Implementation Guide (v1)

1) Risk Scoring

- Compute a **risk score** per station for the next 1–4 time buckets (e.g., 15-min buckets), reflecting probability and impact of breaching availability.
- Boost risk during **rain, extreme heat/cold, wind** and **major events**; decay risk when vans are en-route or recent supply changes occurred.
- Classify into **Deficit** (needs returns), **Surplus** (needs pickups), or **Neutral**.

2) Offer Decisioning

- For **Deficit** stations: create **return-to** offers in nearby catchments (≤800m) and along common routes ending near the station.
- For **Surplus** stations: create **pick-up-from** offers for riders within a short walk (≤300–500m).
- Respect **budget**, **per-rider caps**, and **station caps**; throttle issuance to avoid flooding.
- Use **elasticity tiers**: start with medium band; escalate to high band if stress persists and budget permits.

- Apply **exclusions**: maintenance, safety issues, temporary closures.

3) Targeting & Distribution

- **Moment-based targeting:** present offers at route planning and mid-ride re-routing (if rider consents).
- **Segment filters:** recent activity, tolerance for short detours, historical responsiveness to credits, commuter vs leisure profiles.
- **Channels:** in-app banners at station pages, pre-ride search results, push for opted-in riders near candidate stations, QR signage at docks.

4) Redemption & Fulfillment

- Rider sees clear **"Do X → Get Y"** terms: e.g., "Return to Station A within 15 min → +$1 credit."
- Lock an offer for a short **reservation window** (e.g., 5–8 min) to reduce sniping; show **progress** and **expiry timers**.
- Validate **completion** with check-in/out telemetry; grant credit automatically; show a **receipt** with the reason tag.

5) Anti-Abuse & Quality

- **Limits:** per-rider daily caps; deny back-to-back exploits (e.g., ping-ponging between two stations).
- **Anomaly checks:** excessive claim rates, suspicious routing patterns, device/account mismatches.
- **Transparency:** disclose promotional nature; publish city-friendly **impact summaries**.

6) Coordination with Vans

- If vans are scheduled to resolve a station within **≤10–15 min**, **deprioritize** rider incentives to avoid waste.
- Conversely, if vans are constrained, **raise incentive bands** temporarily to crowdsource balance.

7) Budget & Controls

- Daily and hourly budgets; **kill-switch** per zone; dynamic reallocation during weather events.
- **Cost dashboards:** spend, cost per resolved event, incremental rides, and cannibalization estimates.

Expected Behavior (End-to-End)

1. **Light rain at PM peak:** Risk scores rise at downtown return stations. The system issues **return-to** credits valid for 20 min within a 600m geo-radius. Riders approaching those areas see offers; stockout risk drops without dispatching extra vans.
2. **Morning surge at residential origins:** Several origins trend near-full; **pick-up-from** offers go live for nearby users planning a ride; small credits unlock idle supply and delay the need for a van sweep.
3. **Event spike near arena:** A pre-scheduled event boosts risk. The system increases bands and widens catchments 60 min prior; as uptake accumulates, it gradually **steps down** offer amounts.
4. **Van overlap:** An S1 alert triggers a van dispatch. Incentives in that micro-zone are paused until the van completes or slips beyond 15 min ETA.
5. **Fraud attempt:** A user circles two stations to farm returns; per-rider caps and route plausibility checks block additional credits.

Experiment & Analysis Plan

- **Design:** Geo-cluster A/B (randomize station clusters). **Treatment:** incentives active; **Control:** planner-only. Duration 4–6 weeks, spanning varied weather.
- **Primary metrics:** stockout minutes/station/day; **resolved events** attributable to incentives.
- **Secondary:** adoption rate, $/resolved event, incremental rides, rider CSAT/NPS.
- **Guardrails:** fraud rate, budget variance, equity coverage.
- **Attribution:** use **uplift modeling** or **switchback tests** on offer availability windows; compare matched demand periods.

- **Success criteria:** ≥20% reduction in stockout minutes with **$ per resolved event** below van-only baseline.

Risks & Mitigations

- **Offer cannibalization (paying for what would happen anyway):** tight eligibility windows, eligibility cooldowns, and uplift-driven targeting.
- **Alert fatigue for riders:** conservative push policy; preference for in-context, pull-based discovery; cap daily messages.
- **Budget overruns in storms:** automatic band throttling when response saturates; dynamic reallocation by zone.
- **Fairness & perception:** publish equity metrics; add minimum coverage per underserved area; maintain clear language on optionality.
- **Fraud/abuse:** per-rider caps, device/account checks, route plausibility, manual review queue.

Trade-offs

Choice	Pros	Cons	Use When
Station-specific offers	Precise relief	Narrow reach	Dense areas, acute stress
Zone-level offers	Broad uptake	Lower precision	Sparse areas, mild stress
Fixed credit	Simple UX	Over/underpay risk	Early rollout
Dynamic credit	Efficient spend	More logic	Mature ops & budget pressure
Push notifications	Fast response	Interruptive	S1/S2 stress, opt-in riders
In-app discovery	Low friction	Slower uptake	Routine balancing

Rollout Plan

1. **Weeks 1–2:** Ship risk scoring, policy engine, and sandbox offers (no rider delivery).

2. **Week 3:** Soft launch in 2–3 neighborhoods with fixed credits; measure adoption and fraud signals.
3. **Weeks 4–6:** Expand city-wide with dynamic bands; integrate with planner and monitoring for coordination; start A/B.
4. **Week 8:** Add equity guardrails, budget throttles, and switchback tests for attribution.
5. **Week 10+:** Introduce event calendars, elasticity learning, and per-rider personalization.

Engineering Work Pack

- **Risk Scorer:** rolling stress predictions with weather/event modifiers and van ETA inputs.
- **Policy Engine:** dynamic bands, fairness constraints, eligibility rules, caps.
- **Offer Service:** generation, reservation window, issuance throttles, and redemption.
- **Anti-Abuse:** caps, anomaly detection, investigations tooling.
- **Client UX:** pre-ride and mid-ride surfaces, clear terms, timers, receipts.
- **Ops Console:** live spend, adoption, resolved events, equity coverage, kill-switches.
- **Measurement:** experiment flags, attribution logic, uplift dashboards, budget vs benefit tracking.
- **Compliance:** audit logs, partner-friendly reports.

Roadmap impact: Incentives provide a **flexible, low-latency** lever that complements vans and forecasting—stabilizing availability during volatile conditions and reducing operations cost per resolved incident.