Justification: A Markov Chain-Based Methodology for Prioritizing Statewide Funding for Airport and Vertiport Infrastructure in the Electrified Aviation Economy

The proposal is unique in its specific integration of Markov Chains for predicting long-term airport utilization probabilities to identify and prioritize funding for underserved or economically disadvantaged airports, combined with Markov Decision Processes (MDPs) for optimizing new vertiport placements—all tailored to statewide infrastructure in the emerging electrified aviation economy (e.g., eVTOL and battery-electric aircraft networks). While related elements exist in prior work, no focused research or methodology directly matches this comprehensive, equity-focused framework for funding prioritization.

Key Findings from Existing Work

To assess uniqueness, I reviewed academic literature, reports, and discussions via targeted searches on scholarly databases and platforms. Below is a synthesis of relevant prior efforts, highlighting overlaps and gaps:

- <u>Markov Chains in Aviation Contexts</u>: Markov Chains have been applied to airport operations, such as modeling queueing at vertiports for capacity analysis (e.g., using Continuous Time Markov Chains to evaluate steady-state behaviors like waiting times in UAM networks) or stochastic aircraft movements in traditional airports. However, these focus on operational efficiency (e.g., taxiing or departure sequencing) rather than long-term utilization probabilities for funding prioritization in electrified systems. **No instances tie stationary distributions directly to identifying underserved airports or economic equity in electrified aviation.**

- <u>MDPs in UAM and Vertiport Operations</u>: MDPs are commonly used in urban air mobility (UAM) for dynamic problems like fleet scheduling, routing, collision avoidance, and arrival sequencing at vertiports. For example, MDPs model real-time decisions in multi-vertiport networks, often extended with reinforcement learning (e.g., Proximal Policy Optimization) to handle stochastic demand and charging constraints. These are operational (e.g., scheduling eVTOLs to minimize delays) rather than infrastructural placement or funding oriented. **Extensions to add states for hypothetical vertiports are absent.**

- Vertiport Placement Optimization: Research on vertiport locations emphasizes equitable access, demand coverage, and integration with ground transport, using methods like genetic algorithms, clustering (e.g., agglomerative hierarchical), p-median models, or GIS-based approaches. Some address socioeconomic factors (e.g., accessibility for low-income areas) in electrified UAM, but without stochastic models like MDPs for site selection. **Funding prioritization is implied in cost-benefit analyses but not explicitly modeled via Markov processes for statewide equity.**

- Airport Utilization and Funding in Electrified Aviation: Studies on electrified aircraft infrastructure (e.g., FAA reports on vertiport electrical needs) discuss utilization forecasting and equity, but use deterministic simulations or regression, not Markov Chains. **MDPs appear in traditional airport ops (e.g., taxi clearance to reduce emissions) but not extended to electrified fleets or funding for disadvantaged sites.**

- Gaps Confirming Uniqueness: No work combines Markov Chain stationary distributions for utilization-based funding ranking with MDP state extensions for vertiport additions, specifically targeting underserved airports in an electrified context. Related efforts (e.g., MDPs in UAM fleet ops) are narrower and operational, lacking the proposal's equity-driven, statewide funding lens. **Public discussions (e.g., on X) yield no mention of such integrated methodologies.**

If emerging preprints or niche reports surface in future searches, they could overlap partially, but based on current evidence, this proposal innovates by bridging stochastic modeling with policy-oriented funding for sustainable aviation equity.