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Technical Report TR-2026-17
Survey / Review · Preprint v1
7 July 2026

THE BAYOU AIR CORRIDOR

The Bayou Air Corridor: Managed Low-Altitude Airspace over Houston's Greenways

Treating a continuous public greenway network as an AI-managed low-altitude volume, with flood search-and-rescue as the first mission and infrastructure inspection as the recurring one.

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Interactive companion: physicalai-bmi.org/research/hiner-lab#thesis

Abstract. Houston's bayous are continuous public greenways: water and parkland that thread the entire metropolitan area. Measured by the standard ground-risk criterion for uncrewed flight, the population exposed beneath a flight path, they are close to the lowest-risk ground in the city to fly over. This report treats the bayou network as a candidate managed low-altitude airspace and describes an artificial-intelligence volume-management layer that keeps drones and, in the longer term, electric vertical-takeoff-and-landing (eVTOL) traffic strategically and tactically separated within shared corridors. Section 2 states that the work is a review and a research position with no original flight data. Section 3 gives the ground-risk argument for over-greenway routing. Section 4 describes the separation logic. Section 5 sets flood search-and-rescue as the first mission and infrastructure inspection as the recurring one. Section 6 relates the concept to NASA and FAA UAS Traffic Management (UTM) and to urban air mobility. Section 7 is explicit that the interactive companion is an illustrative operations twin on Houston's real geography, with all traffic, demand, and conflict events simulated rather than observed. The report reports no new experimental measurements.

1. Introduction

A city that wants to fly small aircraft at low altitude has to answer a geographic question before it answers a regulatory one: over what ground should the aircraft fly. The dominant hazard of low-altitude uncrewed operation is not collision with other aircraft, which is rare, but the consequence of a failure that puts an aircraft on the ground where people are. Ground-risk models for uncrewed aircraft make this precise, and every one of them is dominated by the density of people beneath the flight path[6]. Route selection is therefore a safety decision, not a convenience.

Houston has an unusual asset for this decision. Its bayous, Buffalo, Brays, White Oak, Greens, Halls, Sims, Hunting, and their tributaries, form a connected network of watercourses that the city has progressively turned into linear parks and greenways. The result is a lattice of corridors, each a ribbon of open water and parkland, that reaches across the metropolitan area without passing over dense residential or commercial blocks. The corridors are public land, they are already continuous, and they are close to empty of people for most of their length. This report takes the position that the same network, read as airspace rather than as parkland, is a strong candidate for a managed low-altitude flight corridor, and that the missing piece is a volume-management layer that keeps traffic separated inside it. The argument is geographic first and computational second.

2. Scope and method

This is a review and a research position. It draws on the published concepts of uncrewed traffic management, urban air mobility, strategic deconfliction and geofencing, ground-risk modeling, and disaster-response aviation, and it applies them to a specific geography. It reports no original flight tests, no measured traffic, and no field trial. Where the report describes an operations twin, that artifact is a simulation built on Houston's real bayou geometry; its aircraft, demand, and conflict events are generated, not recorded, and nothing in it should be read as an observed result. The report's principal limitation is that the concept has not been operated: it is an argument that the geography and the existing traffic-management literature fit together well, together with a statement of what would be required to test that claim. Claims about the maturity of any component are marked where they matter.

3. The greenway network as managed airspace

The case for over-greenway routing rests on the ground-risk model that the uncrewed-aviation safety literature has converged on[6]. In its standard form, the expected number of ground casualties from a single loss-of-control event that reaches the ground is

$$E[C] \;=\; A_{\text{exp}} \cdot \rho \cdot (1 - P_s) \cdot P_{f|\text{impact}}$$

where A_{exp} is the exposed impact area swept by the falling aircraft and any debris, ρ is the density of people on the ground beneath the flight path, P_s is a sheltering factor that credits buildings and cover for protecting people from impact, and $P_{f|\text{impact}}$ is the probability that a person struck is killed. Aircraft design and reliability act on A_{exp} and on the rate at which such events occur. Route selection acts on ρ, and ρ enters linearly. Halving the population beneath the path halves the expected casualties for a given failure; routing over ground that is essentially unpopulated drives the term, and therefore the product, toward zero.

A bayou greenway is close to that limit. Open water contributes almost no standing population, and the parkland flanking it is sparsely occupied and, being open, offers long unobstructed sight lines and few third parties to shelter. The corridor is also linear and continuous, so a route can stay over low-ρ ground for its whole length rather than crossing populated blocks to connect safe segments. Risk-aware path planning for uncrewed aircraft in cities has been formalized as the search for a route that minimizes an integrated ground-risk cost rather than distance[7]; over a bayou network, the low-risk route and the natural geographic corridor coincide, which is unusual and is the crux of the concept. The greenway is not merely a convenient path. It is the path that the ground-risk objective would itself select.

Two qualifications belong here. First, bayous are not uniformly empty: trailheads, parks, bridges, and events create local peaks in ρ that a real corridor design would have to route around or restrict, and the model above is only as good as the population data behind it. Second, low ground risk is a necessary condition for a managed corridor, not a sufficient one; separation between aircraft, addressed next, is the other half.

4. The AI volume-management layer

A corridor that carries more than one aircraft needs a rule for keeping them apart. The uncrewed-traffic-management literature separates this into two layers, and the corridor adopts both[1,2]. Strategic deconfliction operates before flight: aircraft submit intended four-dimensional trajectories, meaning a path in space plus a time schedule, and the management layer accepts, delays, or reroutes them so that planned trajectories do not conflict. Tactical separation operates during flight, resolving the residual conflicts that arise from wind, delay, and off-nominal behavior, and it is the layer to which geofencing contributes by defining volumes an aircraft must remain within or must not enter[5].

Within a single lane, the governing quantity is longitudinal separation. A following aircraft must remain far enough behind a leader that it can detect a conflict and stop or divert before closing. A minimal spacing rule has the form

$$s_{\min} \;=\; v\left(\tau_{\text{det}} + \tau_{\text{react}}\right) \;+\; d_{\text{man}} \;+\; b,$$

where v is closing speed, τ_{det} and τ_{react} are the detection and command-response delays, d_{man} is the distance consumed by the avoidance maneuver, and b is a buffer absorbing position error and wind. The management layer's task is to schedule entries into each corridor so that this spacing holds everywhere along the lane, which reduces to admitting aircraft at a corridor throughput no greater than $v/s_{\min}$ per lane. The bayou geometry helps twice: corridors are long and roughly one-dimensional, so the scheduling problem is close to a set of coupled single-lane problems rather than a full three-dimensional free-flight problem, and vertical stratification into altitude bands lets outbound and inbound traffic, and fast and slow classes, occupy separate lanes over the same ground.

The role of artificial intelligence in this layer is bounded and specific. It is not to fly the aircraft, which have their own controllers, but to manage the volume: to predict demand and conflicts across the network, to schedule and price corridor access under those predictions, to allocate priority when a search-and-rescue task must preempt a routine inspection, and to detect when observed positions diverge from filed intent and trigger tactical resolution. This is a planning-and-allocation problem over a graph of corridors, and it is the problem the operations twin is built to study.

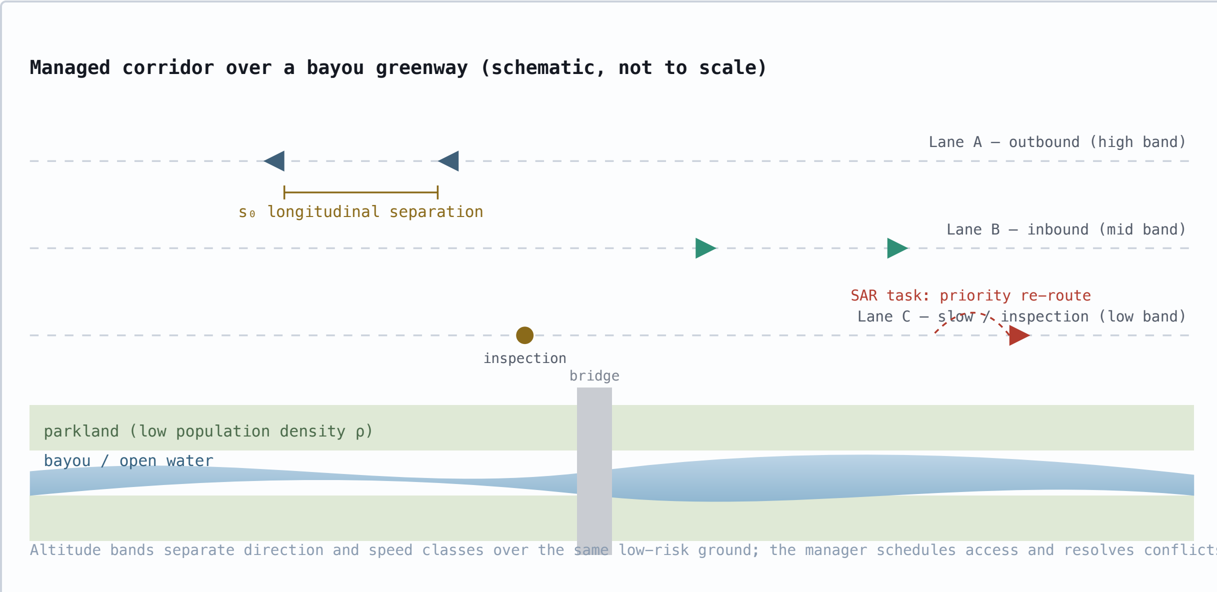

Figure 1. A managed bayou corridor in cross-section. Traffic is stratified into altitude lanes by direction and speed class over the same low-population greenway; longitudinal spacing s_{min} is held within each lane, and the volume manager can preempt routine traffic to insert a search-and-rescue task. The figure is schematic. An illustrative operations twin on Houston's real bayou geometry is at physicalai-bmi.org/research/hiner-lab.

5. First mission: flood search-and-rescue. Recurring mission: infrastructure inspection.

The corridor is proposed with a first mission and a recurring one, because a shared-airspace concept is only worth operating if it earns its keep between emergencies and proves itself during them.

The first mission is flood search-and-rescue. Houston floods, and its bayous are where the water goes; the same corridors that are lowest-risk in dry conditions are, during a flood, the exact locations that responders most need to see. Uncrewed aircraft are a well-studied disaster-response tool for precisely this pattern: rapid wide-area imaging, communication relay, and the location of stranded people when ground access is cut[8]. A pre-established corridor network changes what such a response can assume. Instead of improvising deconfliction over a flooded city under time pressure, responders inherit a mapped set of low-risk lanes, a volume manager that can clear routine traffic and prioritize rescue flights, and geofenced volumes that keep aircraft away from crewed rescue helicopters. The flood turns the greenway's defining feature, that it is where water collects, from a fair-weather convenience into an operational advantage.

The recurring mission is infrastructure inspection. Bridges, culverts, embankments, outfalls, gauges, and pipelines cluster along the bayous, and uncrewed aircraft are an established means of inspecting such structures, with bridge condition assessment among the best-developed applications[9]. Because these assets already line the corridor, inspection flights ride the same low-risk lanes as everything else, and the traffic they generate is regular and schedulable rather than bursty. That steady demand is what keeps the management layer, the geofences, and the operating procedures exercised and current between floods, so that the emergency mission is run on a system that is already working rather than one activated cold. The lead author's background in geology and geophysics is directed here: the same corridors are also the natural lines along which to monitor subsidence, channel change, and the condition of flood-control works over time.

6. Relation to UTM and urban air mobility

The concept is deliberately not novel in its mechanisms. It adopts the architecture of uncrewed-aircraft-system traffic management as set out in the NASA UTM concept of operations[1] and the FAA UTM concept of operations[2]: a federated set of service suppliers, operators who file intent, strategic deconfliction of trajectories, and airspace-authorization and geofencing services, tested in the NASA field demonstrations that reached Technical Capability Level 4 in dense environments[3]. It is compatible with the longer-horizon vision of urban air mobility and eVTOL passenger and cargo transport, which shares the same need for managed low-altitude structure and is reviewed in the recent literature[4]. Table 1 states plainly what the corridor takes from that body of work and what is specific to a bayou.

Table 1. What the bayou corridor adopts from UTM/UAM, and what is specific to the geography.

ELEMENT	ADOPTED FROM UTM / UAM	SPECIFIC TO THE BAYOU CORRIDOR
Airspace structure	Federated service suppliers; operator-filed intent	Corridors follow an existing public greenway lattice
Separation	Strategic deconfliction plus tactical geofencing	Near one-dimensional lanes; altitude stratification over one right-of-way
Route objective	Risk-aware path planning	Low-risk route and natural corridor coincide over water/parkland
Anchor mission	Disaster response as a UAS use case	Flood SAR on the very channels that carry the floodwater
Recurring demand	Inspection as a UAS use case	Assets (bridges, outfalls, gauges) already line the corridor

What is specific to a bayou is not a mechanism but a fit. UTM supplies the how of separation and authorization; the greenway supplies a where in which the ground-risk term is already small, the corridor is already continuous and publicly owned, and the anchor mission is co-located with the corridor itself. The claim of this report is that this alignment is strong enough to be worth operating and studying, not that any new traffic-management primitive is required.

7. Position and discussion

The interactive companion to this report is an illustrative operations twin. It renders Houston's real bayou geometry and lets a reader place corridors, set altitude lanes, and watch a volume manager schedule and deconflict traffic across the network, including the preemption of routine flights by a search-and-rescue task. Every aircraft, every unit of demand, and every conflict in it is simulated. It contains no live traffic, no measured demand, and no field-trial results, and it is intended to make the concept legible and to expose the scheduling problem, not to report performance.

Operationalizing the concept would require what the twin cannot supply. It would need population and land-use data along the corridors accurate enough to trust the ground-risk term, including its local peaks at parks and events, and validated aircraft reliability figures to fix the event rate that route selection cannot change. It would need airspace authorization under the prevailing regulatory framework, integration with a certified UTM service supplier, and coordination with crewed operations, especially the rescue helicopters that share the airspace during floods. It would need the volume-management policies tested against demand that is measured rather than assumed. Until those exist, the honest status of the concept is a geographically grounded research position supported by an established traffic-management literature and a simulation, and nothing more. Its strongest claim is also its most testable: that on this particular network, the safest route and the natural route are the same route.

8. Conclusion

Houston's bayou greenways are a continuous, publicly owned network that happens to be close to the lowest-risk ground in the city to fly over, because the ground-risk that dominates low-altitude uncrewed operation scales with the population beneath the path, and the greenways are nearly empty of people. Read as managed low-altitude airspace and paired with an artificial-intelligence volume-management layer that handles strategic and tactical separation in shared corridors, the network is a coherent candidate for structured low-altitude flight, with flood search-and-rescue as the first mission and infrastructure inspection as the recurring one. The mechanisms are adopted from existing UTM and urban-air-mobility concepts; what is specific is the geography, in which the safe route and the natural corridor coincide. The results here are a position and a simulation, not a demonstration, and the path to operation runs through data, regulation, and measured demand that this report does not claim to have.

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AI-use disclosure. Preparation of this report used a large language model (Claude, Anthropic) for drafting and editing text, organizing the reviewed literature, and preparing the figures and the interactive companion. Cited references were checked to resolve to their sources. The author reviewed the content and is solely responsible for it. Consistent with ICMJE, COPE, and IEEE guidance, the model is a tool and is not credited as an author.

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