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## **Eixão-UAM: LLM-assisted iterative design of a low-altitude urban air mobility corridor in Brasilia**

**Key words:** Brasilia; Eixão; Genetic algorithm; Large language model (LLM); Unmanned aerial vehicle (UAV); Urban air mobility (UAM); UAM corridor; Unmanned aircraft traffic management (UTM)

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# Overview: Eixão-UAM

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- ❑ This study leverages Brazil's pioneering BR-UTM ecosystem—anchored by SISANT (ANAC) and SARPAS NG (DECEA)—which provides the institutional and regulatory foundation for safe and inclusive UAM deployment.
- ❑ By prototyping a bidirectional aerial corridor above the Eixão corridor and simulating UAV traffic with artificial intelligence (AI)/LLM-assisted optimization, this study bridges the gap between UAM research and operational deployment in Brasilia.
- ❑ This study reactivates Brasilia's founding vision as a rational and experimental urban laboratory, extending mobility planning into the vertical dimension.
- ❑ The results underscore the role of an iterative, LLM-guided development in enhancing classical optimization, demonstrating that generative AI can contribute to simulation acceleration and the cocreation of operational logic.

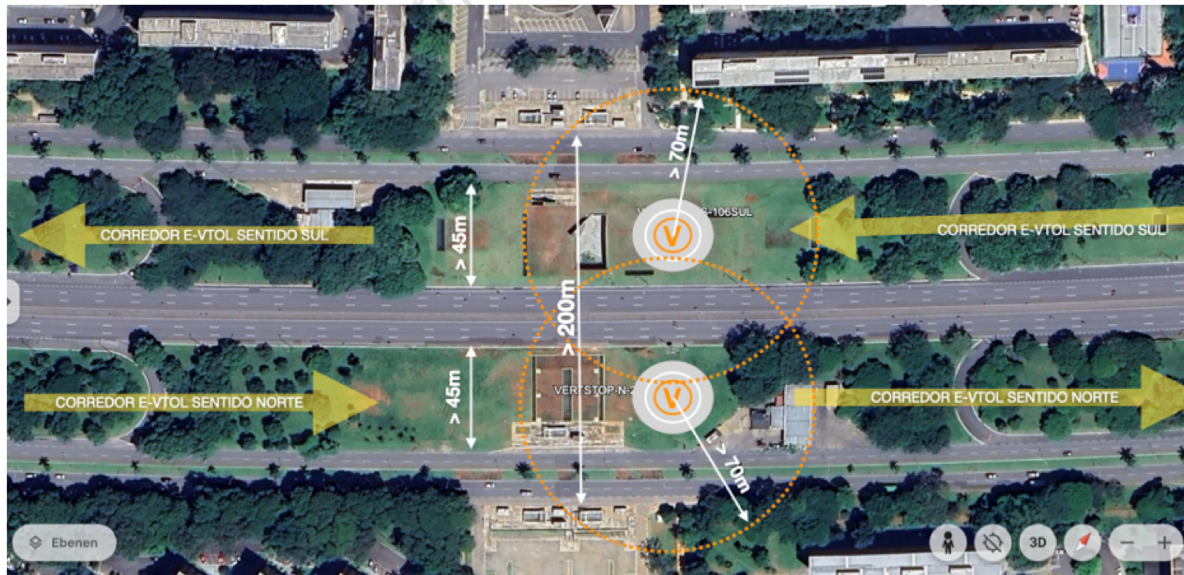
# Brasilia, the federal capital of Brazil

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- ❑ Brasilia presents a rare condition in the Latin American context: a city whose urban morphology not only resists the obsolescence of 20<sup>th</sup>-century models but also supports the rise of scalable UAM.
- ❑ Lucio Costa's modernist plan, structured around clear road hierarchies, low-density zoning, and functional segregation of land use, anticipates solutions aligned with the contemporary logic of flows—including aerial ones.

# Eixão highway of Brasilia

- ❑ The Eixão, the central highway linking the city's North and South wings, forms the backbone of Brasilia's infrastructure, spanning 13.8 km.
- ❑ With high-speed lanes divided by green strips of ~45 m and flanked by secondary roads (Eixinhos), the system creates a continuous linear structure—visible, predictable, and minimally intrusive.
- ❑ This morphological clarity translates into operational safety for aerial routes, particularly for small and unmanned vehicles that depend on unobstructed flight paths.



# Eixão corridor design—vertical layers

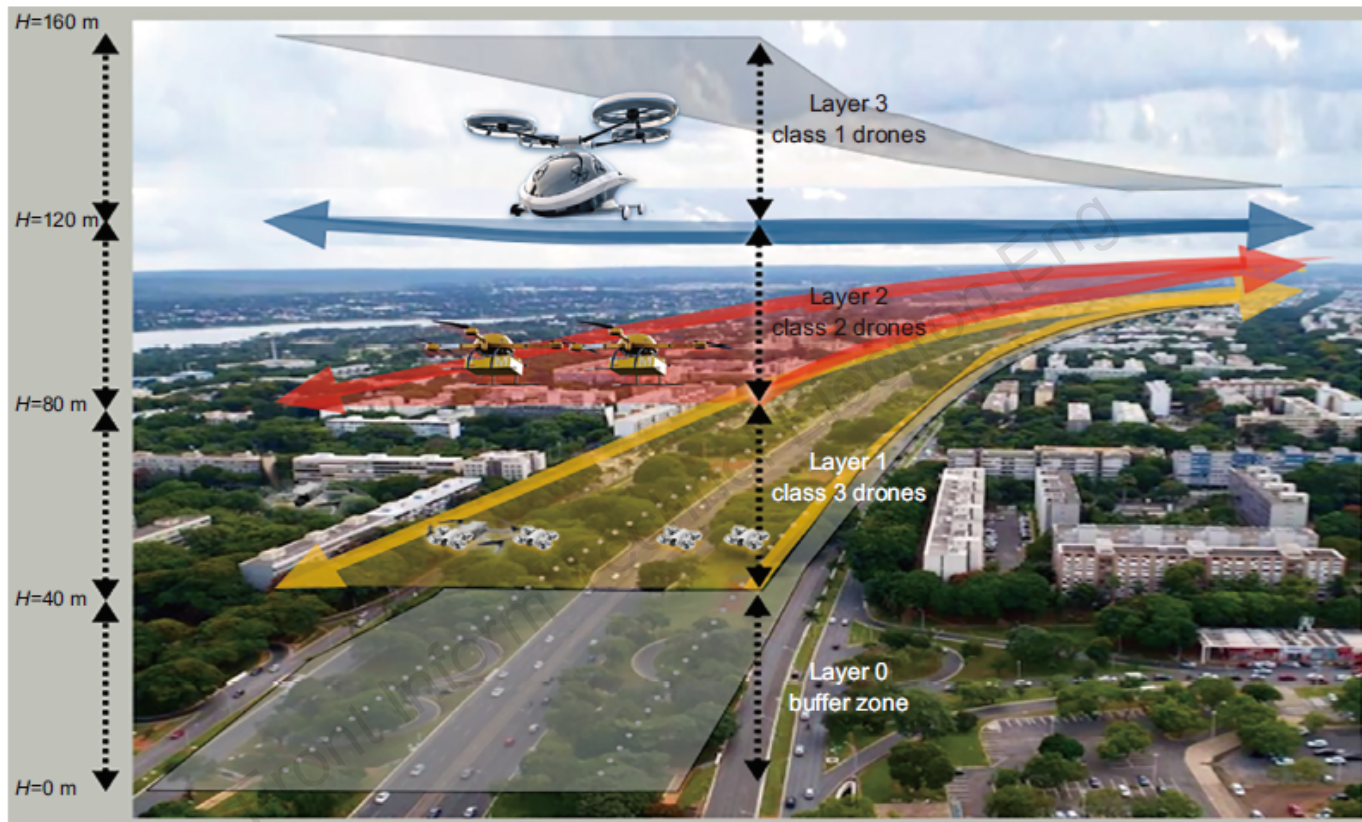


Fig. 1 Concept of the Brasilia Eixão UAM corridor (Eixão-UAM), an integrated urban ground-air mobility corridor leveraging the central highway axis (Eixão). General layout showing the location of both aerial corridors along the green strips. References to color refer to the online version of this figure

Layer 0 (0–40 m): transition; Layer 1 (40–80 m): light UAVs;

Layer 2 (80–120 m): medium UAVs; Layer 3 (120–160 m): heavy UAVs

# Eixão corridor design—vertistops and vertiports

<b>Vertihub:</b> Co-located with the Central Bus & Railway Terminal (logistics hub)	<b>Vertiports:</b> For medium-scale operations, integrated with urban infrastructure	<b>Vertistops:</b> Quick stop points in functional demand zones
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Table 1 Spatial coordinates of the UAV vertihub, vertiports, and vertistops in Eixão-UAM

Point type	Direction	Location	Latitude	Longitude
South wing vertiport		Interchange EPIA/EPGU	15°50'26"S	47°55'45"W
Vertistop - 102 south	N → S	South axis (Eixão)-SQS 102	15°48'21"S	47°53'22"W
Vertistop - 202 south	S → N	South axis (Eixão)-SQS 202	15°48'23"S	47°53'21"W
		...		
Central vertihub		Bus and railway terminal	15°46'31"S	47°56'31"W
Central vertiport		Plano Piloto bus terminal	15°47'39"S	47°52'52"W
		...		
Vertistop - 110 north	N → S	North axis (Eixão)-SQN 110	15°45'19"S	47°53'11"W
Vertistop - 210 north	S → N	North axis (Eixão)-SQN 210	15°45'18"S	47°53'09"W
		...		
North wing vertiport		Roundabout TORTO/EPIT	15°43'58"S	47°53'40"W

EPIA, EPGU, TORTO, and EPIT are Brasilia highways. N, W, and S denote the north, west, and south, respectively

# UAV classification & Pad configuration

1. Classification of UAVs by weight and operational altitude, plus vertistop configuration

2. Takeoff priority defined according to UAV category

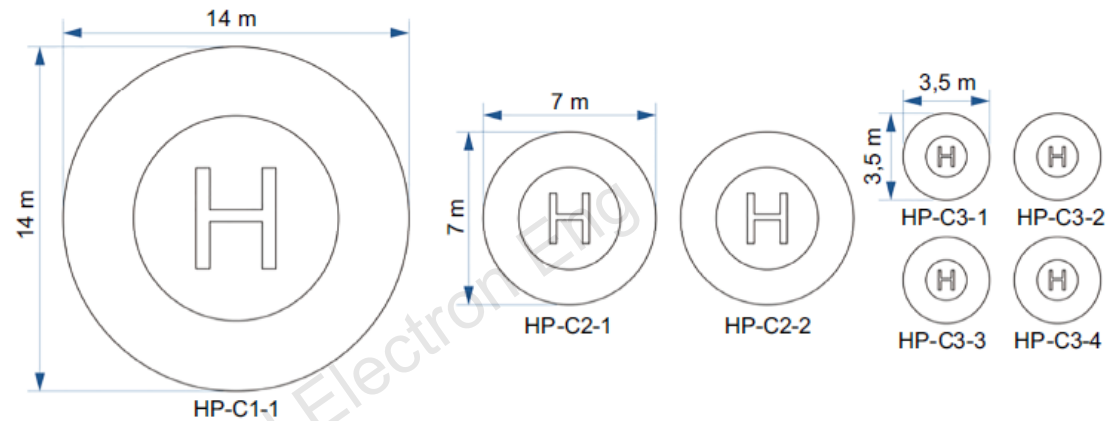


Table 2 UAV classification by weight and operational altitude

Class	Max takeoff weight	Min altitude (m)	Max altitude (m)
1	Greater than 150 kg	120	140
2	From 25 up to 150 kg	80	119
3	From 0.25 up to 25 kg	40	79

Source: ANAC (2017a)

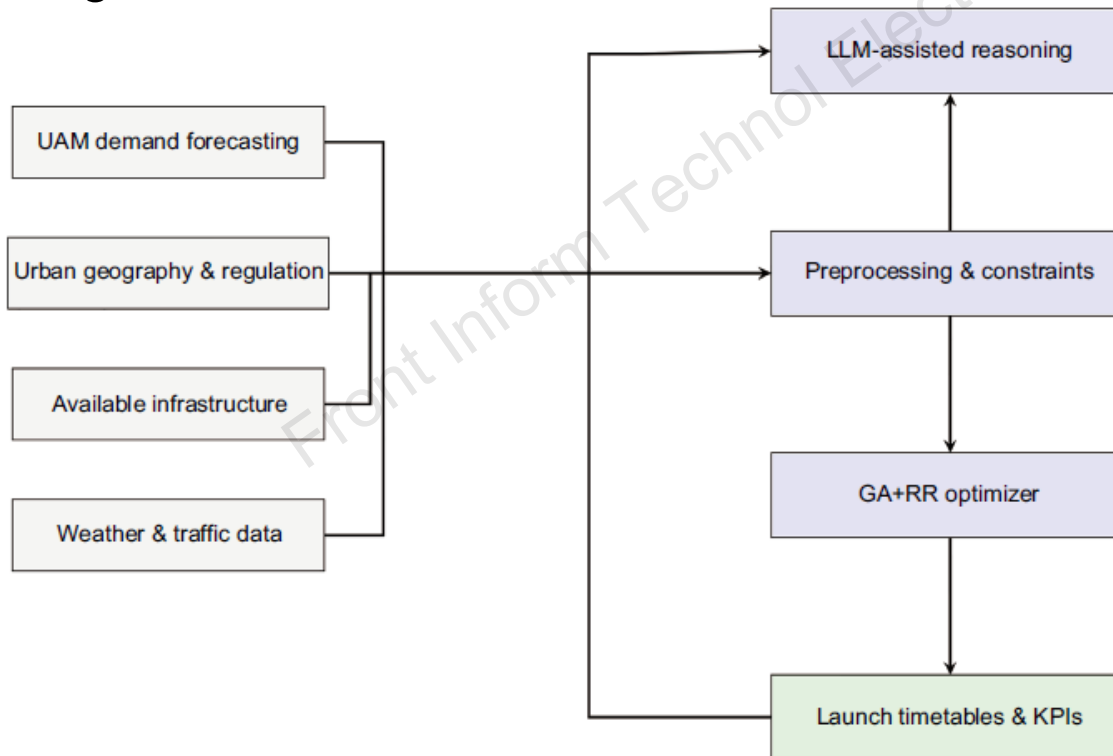
Table 4 Priority rules for takeoff slot allocation at vertiports

Priority level	Description
1	Official or emergency aircraft (e.g., public safety or health missions)
2	Heavier and larger UAVs
3	Scheduled departure time

# UAV Framework architecture: LLM + GA

Development of two algorithms: round robin (RR) and genetic algorithm (GA) to define UAV takeoff sequencing from vertistops.

Framework architecture: LLM-assisted GA optimization for vertiport takeoff scheduling.



# GA variant generation via LLM

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GA v1 (baseline): original setup, combining average wait time and fixed penalties for rarely used platforms.

GA v2 (inverted penalties): weighted for Class 1 platforms, mitigating the unavailability of high-priority UAVs.

GA v3 (dynamic penalties): time-dependent weights (weekly patterns) responding to traffic peaks and environmental pressure.

GA v4 (fairness-oriented): high maximum delays penalized, focusing on the worst-case user experience.

GA v5 (statistical optimization): minimization of wait time mean, standard deviation, and 95<sup>th</sup> percentile waiting time.

# Performance comparison—RR vs. GA variants

Initial results show that RR, a simple online scheduler, consistently outperforms GA v1 in terms of average wait time.

However, RR provides the best possible results. GA can be used for multi-objective optimization.

In this case, LLM-assisted GA v5 delivers results close to RR, improving maximum wait time from 738 s (v1) to 298 s (v5).

Table 9 Final performance comparison: RR and GA variants (v1–v5)

Metric	RR	GA v1	GA v2	GA v3	GA v4	GA v5
Average waiting time (s)	3	10	10	10	9	9
Maximum waiting time (s)	206	738	1048	1091	393	298
Zerowait	77.39%	60.00%	60.00%	60.00%	59.99%	59.94%
Longwait	0.06%	0.31%	0.30%	0.30%	0.27%	0.34%

# Contributions & Impacts

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**Contributions:** secure and efficient framework for UAM operations in Brasilia.

**Impact:** advances in smart city applications and the low-altitude economy in Brazil.

The proposed simulation architecture combines classical scheduling methods (RR and GA) with the adaptive capabilities of LLMs (e.g., GPT-4.5 and Gemini 2.5).

Through prompt-driven interaction and real-time diagnostic analysis, we develop and evaluate five GA variants, progressively refining the fitness function to align with operational objectives such as fairness, robustness, and responsiveness.

# Future work

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The methodology presented here is scalable and replicable, demonstrating how generative AI and public infrastructure can jointly shape the future of aerial mobility in smart cities.

While this proposal focused on UAV takeoff scheduling from distributed ground platforms, future research will address:

1. Arrival sequencing.
2. In-flight conflict detection and resolution.
3. Advancing toward a fully integrated, autonomous low-altitude traffic management system for Brasilia's Eixão corridor and other applications.

# Author bio

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Prof. Li WEIGANG earned his Doctor of Science degree from the Aeronautics Institute of Technology (ITA), Brazil, in 1994, and pursued postdoctoral research at the University of Calgary, Canada, from 2001 to 2002. He is currently a full professor and vice head at the Department of Computer Science (CIC) of the University of Brasilia (UnB). A CNPq productivity researcher (PQ), Boeing inventor, and IEEE senior member, he also coordinates the Laboratory of Computational Modeling and Intelligence for Transport (TransLab.unb.br). His research interests span Artificial Intelligence, Machine Learning, Computational Modeling for Air Traffic Management (ATM), and Natural Language Processing.