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Short Communication

Reusing CAV-Supporting Smart Infrastructure for the Low-Altitude Economy

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ABSTRACT: The low-altitude economy is expanding urban mobility and service systems from ground-based networks to three-dimensional urban space. However, its large-scale deployment depends not only on aircraft technologies, but also on reliable operational infrastructure for communication, navigation, surveillance, meteorological sensing, computing, and safety supervision. This paper argues that smart infrastructure originally developed for connected and automated vehicles can provide a reusable foundation for low-altitude operations. Because low-altitude public routes are likely to follow existing urban corridors such as roads, railways, rivers, and utility corridors, there is strong spatial overlap with ground-based intelligent transportation infrastructure. By extending these capabilities upward, cities can reduce duplicate investment, improve infrastructure utilization, and support safe, scalable, and city-level air-ground operation management.

KEYWORDS: smart infrastructure; connected and automated vehicles; urban air mobility; low-altitude economy; air-ground integration

1 Introduction

The low-altitude economy is emerging as an important extension of urban transportation and urban services. Applications such as drone logistics, infrastructure inspection, emergency response, public safety patrol, and future passengers urban air commute are gradually expanding mobility and service systems from two-dimensional ground space to three-dimensional urban space (Lv et al., 2025; Zhang et al., 2026). However, the large-scale development of the low-altitude economy is not simply determined by the maturity of aircraft technologies. A more fundamental issue is whether low-altitude vehicles can be operated safely, efficiently, orderly, and under effective supervision in complex urban environments (Wang et al., 2023; Zhen et al., 2024).

Reliable operational infrastructure is therefore a prerequisite for low-altitude operations. Such infrastructure includes communication, navigation, and surveillance systems, low-altitude meteorological sensing networks, edge computing and cloud platforms, and safety supervision mechanisms (Guo et al., 2024). Without these capabilities, low-altitude applications may remain limited to isolated demonstrations or small-scale trials, rather than becoming regular, networked, and city-level operations.

In parallel, the deployment of connected and automated vehicles (CAVs) has accelerated the construction of smart infrastructure in urban transportation systems (Gao et al., 2025). Although these facilities are primarily designed to support intelligent ground mobility, many of their functions are not limited to road vehicles. Roadside sensing provides urban spatial perception; Vehicle to everything (V2X) and cellular networks provide low-latency communication; positioning infrastructure and high-definition maps provide a spatial reference system; edge computing enables local real-time processing; and cloud platforms support system-level coordination and supervision. These capabilities are also required for low-altitude aviation operations.

A key reason why ground-based smart infrastructure can be reused for low-altitude operations lies in the spatial organization of low-altitude public routes. For safety and social acceptance, low-altitude routes are unlikely to be freely distributed over dense urban areas. Instead, they are often expected to follow existing linear urban corridors, such as expressways, arterial roads, railways, rivers, green corridors, and utility corridors (Xu et al., 2025). Different corridor types may support different low-altitude applications. Road corridors are closely connected with logistics nodes, emergency access, and urban mobility demand, and therefore can support drone delivery, emergency response, and future UAM access. River and green corridors usually have lower population exposure and fewer ground obstacles, making them suitable for inspection, patrols. Railway and utility corridors provide linear infrastructure assets and maintenance demands, and can support infrastructure monitoring, fault inspection, and emergency repair missions. This arrangement can help reduce third-party ground risk, noise exposure, and disturbance to sensitive urban activities. More importantly, these corridors are also where smart transportation infrastructure is most likely to be deployed. This spatial overlap provides a practical basis for extending ground-based infrastructure upward to support low-altitude operations.

It should be emphasized, however, that spatial overlap does not imply operational equivalence. Unlike ground traffic, which is largely constrained by road geometry, lanes, traffic signals, and surface-level

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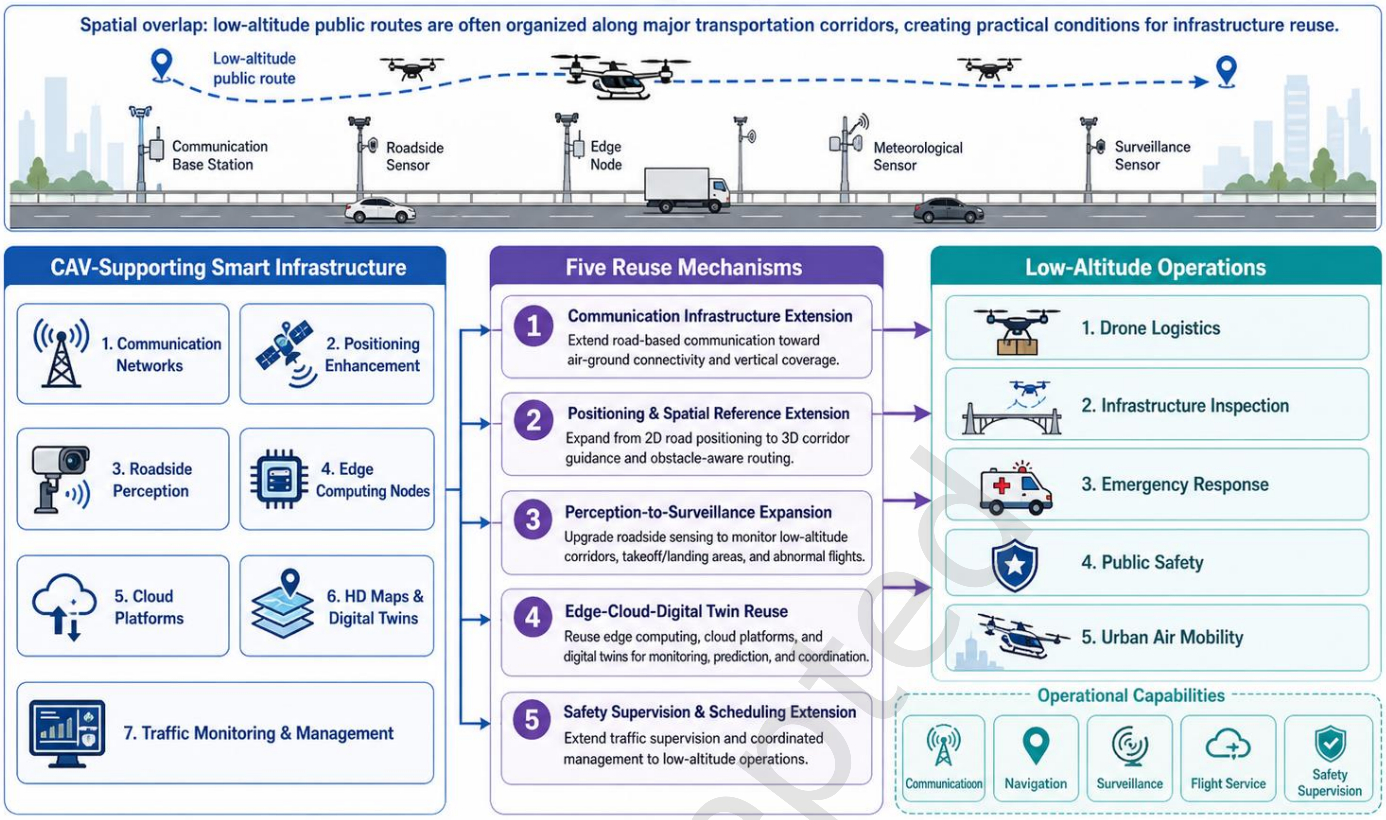

Fig. 1. Infrastructure reuse mechanisms from CAV-supporting smart infrastructure to low-altitude operations.

interactions, low-altitude operations take place in three-dimensional urban airspace and are subject to altitude-dependent communication coverage, complex obstacle environments, micro-meteorological disturbances, limited emergency landing options, and stricter flight safety requirements. Therefore, the reuse of CAV-supporting infrastructure should not be understood as a direct transfer from roads to airspace, but as a selective and carefully upgraded extension of ground-based smart infrastructure toward air--ground integrated operation.

This paper argues that CAV-supporting smart infrastructure can serve as a reusable foundation for low-altitude operations. The core idea is not merely to share physical devices between ground transportation and low-altitude aviation, but to expand the functional scope of urban intelligent transportation infrastructure from road-centered traffic management to integrated air--ground operation management. This transition can reduce duplicate infrastructure investment, improve the utilization of existing urban resources, and provide a practical pathway for the low-altitude economy to move from fragmented demonstrations toward safe, scalable, and city-level deployment.

2 Infrastructure reuse mechanisms for low-altitude operations

Although ground vehicles and low-altitude aircraft operate in different physical domains, they share several fundamental infrastructure requirements, including reliable communication, accurate positioning, continuous perception, real-time computation, operational coordination, and safety supervision. These shared requirements create the technical basis for infrastructure reuse. As shown in Fig.1, CAV-supporting smart infrastructure can be reused for low-altitude operations through five major mechanisms.

2.1. Communication infrastructure

CAV deployment relies on V2X communication, cellular networks, roadside communication units, and urban private networks to support low-latency information exchange among vehicles, infrastructure, and cloud platforms. Low-altitude vehicles similarly require stable data links with flight service platforms, landing sites, regulatory systems, and other aircraft. By enhancing vertical signal coverage, optimizing antenna deployment along major transportation corridors, and integrating air--ground communication protocols, existing communication infrastructure can support route updates, status reporting, emergency instructions, and real-time supervision for low-altitude operations.

2.2. Positioning and spatial reference systems

CAV systems rely on GNSS, BeiDou, RTK, high-definition maps, and localization enhancement facilities to support lane-level positioning and cooperative driving. Low-altitude operations require similar positioning capabilities, but in a three-dimensional space. Therefore, existing positioning enhancement stations and urban spatial data foundations can be upgraded to support altitude-aware localization, low-altitude corridor guidance, obstacle-aware route planning, and landing-site access management. This transformation requires the spatial reference system to expand from road networks to integrated representations of roads, buildings, airspace boundaries, restricted areas, vertiports, and low-altitude corridors.

2.3. Perception-to-surveillance systems

Cameras, millimeter-wave radar, LiDAR, and multi-function poles deployed for CAVs are mainly used to detect vehicles, pedestrians, cyclists, traffic conflicts, and roadway events. When low-altitude routes are planned along expressways, arterial roads, railways, rivers, or other linear corridors, these sensing nodes can be upgraded to monitor take-off and landing areas, observe low-altitude corridors, identify unauthorized drones, and detect abnormal flight behaviors. Although roadside sensors cannot replace dedicated aviation surveillance systems, they can provide supplementary coverage in infrastructure-rich urban corridors and contribute to early risk detection.

2.4. Edge cloud and digital twin

Low-altitude operations are highly dynamic because aircraft density, route availability, landing-site capacity, weather conditions, and emergency events may change rapidly. Edge computing nodes developed for CAV applications can support local perception processing, target recognition, trajectory monitoring, and risk assessment. Cloud platforms originally designed for traffic management can be upgraded into integrated air--ground operational platforms that coordinate ground vehicles, low-altitude aircraft, roadside sensors, vertiports, weather nodes, and regulatory systems. Similarly, digital twin systems can be expanded from road networks to three-dimensional urban airspace by incorporating buildings, obstacles, low-altitude corridors, landing sites, no-fly zones, temporary restricted areas, and micro-weather information.

2.5. Safety supervision and scheduling platform

CAV-supporting smart infrastructure already supports traffic monitoring, incident detection, warning dissemination, and system-level traffic management. These capabilities can be further extended to low-altitude aviation to support flight monitoring, airspace supervision, risk classification, collaborative scheduling, emergency landing management, and cross-domain coordination. In this sense, the value of existing smart infrastructure lies not only in its physical devices, but also in its ability to provide reusable urban operational capabilities. By extending these capabilities upward, cities can gradually transform road-centered intelligent transportation systems into integrated air--ground operational systems.

The above mechanisms can support typical low-altitude application scenarios, including drone logistics, infrastructure inspection, emergency response, public safety patrol, and future urban air mobility. For example, in drone logistics or infrastructure inspection along road corridors, roadside communication units, sensing devices, and edge nodes can jointly support flight status reporting, corridor monitoring, ground-risk detection, and emergency response. In UAM or vertiport access scenarios, positioning infrastructure, digital twins, traffic management platforms, and roadside perception systems can help coordinate low-altitude vehicles with ground traffic, landing-site capacity, and surrounding urban operations. These examples show that infrastructure reuse is not only a conceptual sharing of devices, but also a practical pathway for air--ground collaborative operation.

To clarify the scope of infrastructure reuse, this study further

Table 1: Asset-level reuse logic of CAV-supporting smart infrastructure for low-altitude operations.

Infrastructure type	Direct reuse	Reuse after upgrade	New complementary facilities
Communication networks	Fiber/IP backhaul; cellular networks; roadside power supply	Vertical coverage enhancement; antenna reconfiguration; air-ground protocol integration	Redundant command-and-control links; low-altitude communication gateways
Positioning and spatial reference	GNSS/BeiDou/RTK stations; HD map base layers	3D air-ground mapping; obstacle and altitude constraints; vertiport and corridor layers; dynamic restriction updates	Precision approach/landing aids; dynamic geofencing services; vertiport localization beacons
Roadside perception	Cameras; LiDAR; millimeter-wave radar; traffic-event detectors; multifunction sensing poles	Upward field-of-view extension; sensor re-orientation; cross-view calibration; small-aircraft detection models	Low-altitude radar; Remote ID receivers; acoustic/thermal sensing; aviation surveillance nodes
Edge/cloud computing	Roadside edge servers; signal-cabinet computing units; traffic clouds; digital-twin backbones	Air-ground data fusion; 3D trajectory processing; latency-aware resource orchestration; resilience enhancement	UTM/U-space-like services; vertiport capacity modules; route-availability assessment; contingency management
Safety supervision and scheduling	Traffic monitoring centers; incident detection; warning dissemination; emergency coordination platforms	Flight approval linkage; airspace supervision interface; multi-agency coordination; priority arbitration	Regulatory interfaces; emergency landing coordination; air-ground conflict management; liability and service-level mechanisms

classifies CAV-supporting smart infrastructure into three categories according to its applicability to low-altitude operations: directly reusable assets, assets requiring functional upgrades, and new complementary facilities. Directly reusable assets refer to facilities whose existing physical deployment, power supply, backhaul connection, or management interface can immediately support part of low-altitude operations. Assets requiring upgrades are those that have a reusable foundation but need vertical coverage enhancement, sensing-angle adjustment, three-dimensional spatial modeling, aviation-oriented reliability improvement, or protocol integration. New complementary facilities refer to functions that cannot be reliably provided by existing road-oriented infrastructure and therefore require dedicated construction, such as low-altitude micro-meteorological sensing, aviation-grade surveillance, vertiport operation facilities, and regulatory interfaces. Table 1 summarizes the asset-level reuse logic.

3 Challenges and Future Development

Although CAV-supporting smart infrastructure provides a promising foundation for low-altitude operations, its reuse still requires careful validation. First, the spatial dimension changes from two-dimensional road traffic to three-dimensional airspace operations. This transition requires higher infrastructure performance, wider and altitude-aware communication coverage, adjusted sensing perspectives, and even new mechanisms for coordinating the use of sensing, communication, and computing resources between ground and aerial tasks.

Second, the governance logic becomes more complex. Ground transportation infrastructure is mainly managed within the road traffic domain, whereas low-altitude operations involve airspace management, flight approval, public security, emergency response, communication networks, urban planning, and municipal management. Key practical issues include who can access real-time air--ground data, who has the authority to allocate shared infrastructure resources, and how liability should be determined when communication delay, sensing errors, or unclear control responsibility contribute to an incident. Therefore, infrastructure reuse requires not only technical integration, but also cross-department data sharing, responsibility allocation, and coordinated supervision.

Third, infrastructure reuse may create new coupling risks between ground and low-altitude traffic. When aerial traffic demand increases, or when abnormal weather, or intensive flight activities occur, sensing, communication, and computing resources may be redirected toward low-altitude operations. This could weaken the monitoring of ground traffic and increase the risk of secondary incidents on roads. Therefore, infrastructure reuse should not be treated as a simple cost-saving strategy. It needs further demonstration, stress testing, and system-level evaluation before being applied to regular city-level low-altitude operations.

4 Conclusions

Repurposing CAV-supporting smart infrastructure provides a practical pathway for developing integrated air--ground transportation systems. Different from general discussions on low-altitude infrastructure construction, this article adopts a reuse-oriented ITS perspective, focusing on how CAV-supporting communication, perception, positioning, edge computing, and traffic management resources can be selectively extended to support low-altitude operations. Cities can reduce duplicate investment and improve the utilization of existing urban resources. However, this transition is not a simple transfer from roads to airspace. It requires three-dimensional coverage, adjusted sensing perspectives, coordinated infrastructure resource allocation, cross-department governance, and careful management of new coupling risks between ground and aerial traffic. Therefore, this reuse framework should be further validated through simulation, field testing, and air--ground joint operation experiments before large-scale deployment. With proper design and evaluation, it can support the low-altitude economy in moving from fragmented demonstrations toward safe, scalable, and city-level operations.

Author contributions

Shulu Chen: Writing – original draft, Validation, Methodology, Formal analysis, Conceptualization. **Yuhao Wang:** Writing – review & editing. **Kai Wang:** Supervision, Methodology, Funding acquisition. **Xiaobo Qu:** Supervision, Methodology, Funding acquisition.

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Declaration of competing interest

The authors have no competing interests to declare that are relevant to the content of this article. The author Xiaobo Qu is the Executive Editor-in-Chief of this journal.

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