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Editorial:

Engineering and technology for low-altitude economy infrastructure

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The market of low-altitude economy has the potential to reach trillion dollars in 10 years globally. In China, it serves as a hallmark of national strategic emerging industries, and represents new quality productive forces. Exploring innovative engineering and technologies for low-altitude economy infrastructure is expected to promote sustainable growth in this sector. The scope of the low-altitude economy spans from the ground to the air, with its infrastructure encompassing various aspects such as communication, navigation, surveillance, meteorology, and operations. In the future, it is expected to be characterized by "interoperability, intelligent interconnectivity, as well as safety and efficiency." The integration of sixth-generation wireless communication (6G) networks, satellite-based Internet, satellite-based remote sensing, low-altitude micro-meteorology, advanced surveillance systems, and large-scale artificial intelligence (AI) models will significantly enhance the capabilities of low-altitude economy infrastructure, serving as a pivotal driver for its high-quality development. Recent years have witnessed a remarkable progress in novel infrastructure technologies for low-altitude economy. However, fundamental theory deserves more attention, especially breakthroughs in core technological R&D, and technical implementations still face multifaceted challenges.

1. Overall low-altitude infrastructure systems and integrated technologies

Low-altitude infrastructure is evolving toward integrated and intelligent system-level solutions. Its development encompasses the entire chain from top-level architecture design and physical facility construction to digital system building. This includes top-level designs such as the overall "digital low-altitude" system and comprehensive large language models (LLMs) for low-altitude applications, as well as engineering technologies for key physical nodes like vertiports, all aimed at establishing a solid physical and digital foundation for low-altitude activities.

2. Information infrastructure and technologies

The low-altitude economy demands a comprehensive upgrade in information sensing and transmission capabilities toward high precision, high reliability, and extensive coverage. To achieve effective regulation and support for activities in low-altitude airspace, breakthroughs in core information infrastructure technologies—communication, navigation, surveillance (CNS), and meteorology—are crucial. Specific directions include wide-area low-altitude communications,

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high-precision intelligent surveillance and positioning navigation, and efficient, accurate meteorological observation and forecasting services, collectively forming the perception and neural network for low-altitude operations.

3. Digital airspace and operational management infrastructure and technologies

The core of airspace and operational management is shifting toward data-driven and intelligent decision-making. Through digital twins, information fusion, and airspace digitalization technologies, a dynamic digital airspace that mirrors reality is being constructed. On this basis, there is an urgent need to develop intelligent algorithms for precise prediction of airspace operational capacity, intelligent traffic control, multimodal integrated operations, and real-time situational awareness. This will enable efficient, flexible, and automated allocation of airspace resources, as well as intelligent operational management and control.

4. Low-altitude security infrastructure and technologies

Building a comprehensive and in-depth security protection system is the prerequisite for the sustainable development of the low-altitude economy. Security serves as the lifeline of the low-altitude economy, and its infrastructure must incorporate multidimensional technological solutions covering data and communication security, operational control safety, emergency avoidance, environmental protection, and risk characterization. This will establish resilient safeguarding capabilities throughout the lifecycle of the infrastructure and across all operational processes.

To promote intensive collaboration between academia and industry, and to accelerate fundamental research, key technologies, and practical engineering applications for low-altitude economy infrastructure, *Frontiers of Information Technology & Electronic Engineering* (*FITEE* for short), a journal of the Chinese Academy of Engineering, has invited Prof. Zhijie CHEN to lead a special feature on "Engineering and Technology for Low-Altitude Economy Infrastructure." This special feature solicited contributions focusing on key areas such as the overall system architecture design, information sensing, intelligent operations, and safety assurance of low-altitude infrastructure. After a rigorous peer review process, five research papers have been selected. These papers explored frontier issues and innovative solutions related to engineering and technology for low-altitude economic infrastructure from different perspectives.

The scientific siting of low-altitude takeoff and landing facilities is fundamental to constructing urban air mobility networks. Meilong LE and coauthors modeled this facility location problem as a capacitated facility location problem and proposed a deep reinforcement learning solution framework named SPID. This framework effectively integrates the static attributes of candidate sites with the dynamic information of system states through multi-head attention mechanisms and gated recurrent unit networks, achieving end-to-end optimization of siting decisions. Their experiments demonstrate that the SPID framework significantly outperforms traditional clustering methods and graph neural network models in key social benefit metrics such as geographic coverage, effective coverage, and facility utilization. Moreover, it can provide high-quality initial solutions for core solvers, offering an efficient tool for the rapid and intelligent planning of large-scale low-altitude infrastructure.

The planning and scheduling optimization of structured low-altitude air corridors are crucial for improving the operational efficiency of urban air mobility. Li WEIGANG and coauthors proposed the Eixão-UAM framework for the iterative design and scheduling optimization of low-altitude corridors in Brasilia's urban airspace. This study incorporates Brazil's air traffic management system to design a layered airspace structure and modular ground facilities, and develops a scheduling simulation system. Its innovation lies in introducing LLMs for code generation and diagnostic assistance, enabling intelligent acceleration of algorithm iteration. The results indicate that LLMs can serve as efficient partners for code generation and reasoning, and that scheduling performance depends more on the alignment between the objective function and system goals rather than the complexity of the algorithm itself. This provides a scalable methodological support for the intelligent design and operation of low-altitude air corridors.

Dynamic multi-aircraft task allocation is a core challenge in low-altitude emergency logistics and disaster response. Tong GUO and coauthors address this problem by proposing a novel coevolutionary genetic programming (CoGP) framework. Unlike the traditional single-tree genetic programming methods, CoGP co-evolves two interacting populations dedicated to heuristic search of task prioritizing and aircraft selection, thereby explicitly modeling the coupling between these two interdependent decision phases. The method employs a comprehensive terminal set to capture dynamic states, and uses a low-level heuristic template to translate the evolved tree structures into executable allocation strategies. Extensive experiments on public benchmark instances for post-disaster emergency delivery demonstrate that CoGP outperforms the latest heuristic and genetic programming-based methods, exhibiting strong adaptability, scalability, and real-time responsiveness in complex dynamic environments.

Reliable detection of low-altitude "low, slow, and small" unmanned aerial vehicles (UAVs) is a prominent challenge in airspace safety management. Traditional radar, radio frequency, and acoustic detection methods have limitations in complex environments, making it difficult to achieve long-range, high-precision, and strong anti-interference capabilities simultaneously. Bin ZHOU and coauthors proposed an active optical detection scheme that integrates "cat's eye effect" with deep learning. The system adopts a shared optical path panoramic scanning optical structure, combining near-infrared laser and visible light imaging to enhance echo signals through the strong reflective characteristics of the target's optical window. At the algorithmic level, they constructed an SKNet21 dual-network architecture and embedded a local pyramid attention module, achieving high-precision recognition and false alarm suppression for small targets with low signal-to-noise ratios. Experiments showed that the method achieves a mean average precision at an intersection over union of 0.50 (mAP@0.50) of 0.809 and a throughput of 49.8 GFLOPs, providing a new technical approach for all-weather, highly reliable detection of low-altitude UAVs in complex environments.

The efficient operation of low-altitude digital-intelligent networks urgently requires breaking away from the traditional paradigm of isolated design for communication, sensing, navigation, and control systems. Current separated deployment of multiple systems leads to low resource utilization and low collaborative response speed, making it difficult to support future high-density, highly dynamic low-altitude activities. Qixun ZHANG and coauthors proposed a three-layer integrated architecture named LADIN, aiming to achieve deep synergy from hardware to services across the entire chain. The architecture takes integrated sensing and communication (ISAC) as its core, designing a unified waveform based on orthogonal frequency division multiplexing (OFDM) at the infrastructure layer to achieve functional fusion of communication and sensing. At the data fusion layer, a unified spatiotemporal feature space is constructed through pluggable back-projection adapters. At the service and management layer, it supports intent-driven closed-loop control and resource virtualization. The research team built a multimodal hardware experimental platform, and conducted a series of tests, including multi-frequency collaborative sensing and multimodal fusion positioning, to validate the system's significant performance improvements in target tracking and low radar cross-section target detection. This work provides an important architectural reference and technical verification for system-level integration and standardized deployment of future low-altitude digital-intelligent networks.

Various topics of current research relevant to engineering and technology for low-altitude economy infrastructure is covered in this special feature, from facility siting and airspace design to dynamic scheduling, safety monitoring, and network architecture. We hope that this collection of diverse but interconnected topics will be beneficial to people with interest in engineering and technology for low-altitude economy or related areas.

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