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低空经济与城市轨道交通融合新趋势

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低空经济是2024年的热门话题，作为战略性新兴产业，发展空间和市场潜力巨大，在网络上和资本市场都备受关注。城市轨道交通行业对其探索尚处于初级阶段，既要嗅觉敏锐，捕捉发展良机，也要头脑冷静，谨防盲目跟风。随着城市化进程加快，城市轨道交通的骨干作用越发重要，寻求新技术助力其可持续高质量发展是重大课题，而低空经济战略为城市轨道交通发展提供了新途径。

一、如何认识低空经济

党的二十届三中全会提出，要推动技术革命性突破、生产要素创新性配置、产业深度转型升级，推动劳动者、劳动资料、劳动对象优化组合和更新跃升，催生新产业、新模式、新动能，发展以高技术、高效能、高质量为特征的生产力。2023年中央经济工作会议提出要打造低空经济等战略性新兴产业，工信部等七部门发布了《关于推动未来产业创新发展的实施意见》，提出未来制造、未来空间等六大未来产业，低空经济正成为新的增长空间和发展趋势。各部委及地方政府将其视为发展新质生产力的关键途径，相继出台飞行验证、基础设施建设等方面的鼓励政策，低空经济发展势头强劲，对培育新质生产力意义重大。

二、“轨道＋低空”可行性

2021年，中共中央、国务院印发《国家综合立体交通网规划纲要》，提出促进交通通道由单一向综合、由平面向立体发展，并明确要构建空中、地面与地下融合协同的多式联运网络。综合立体交通系统中各交通方式的融通与协同是重要发展趋势。随着直升机、无人机技术进步，以及政策强化和空域改革推进，低空经济将逐步发展为低空城市交通，其与城市轨道交通在技术、管理、维保、场站等方面的联系将更加紧密。低空经济与城市轨道交通在技术和管理上有相似之处，城市轨道交通成功的运营管理经验可为低空载运工具的运管提供借鉴。

城市轨道交通企业凭借其在控制技术和安全管理等方面的积累与经验，在发展低空经济方面具有便利和优势。低空经济在基础设施共享优化、立体化交通网络构架、企业存量资产盘活等方面均能有效赋能城市轨道交通，将为城市轨道交通带来新的发展增量。构建“轨道＋低空”格局将成为城市轨道交通行业的新机遇。

三、“轨道＋低空”实践路径

面对新事物，不同城市轨道交通企业反应不同，深圳、青岛、合肥、石家庄、福州、昆明、金华等地的城市轨道交通企业，以及交控科技、中国通号等科技企业已开展“轨道＋低空”探索。城市轨道交通行业应顺应趋势，重视低空经济发展，结合实际探索低空交通体系建设运营、应用场景创新等新业务，同时加强技术研发合作、人才培养储备、示范项目建设，推动政策标准制定等，争取先发优势。

中国城市轨道交通协会将发挥桥梁纽带作用，深入调研，协同会员单位谋划探索产业融合模式，挖掘合作潜力，适时提出助力建议。

早谋未来方能拥有未来。低空经济与城市轨道交通深度融合是城市交通发展的重大趋势，面对机遇与挑战，要抓住机遇，应对挑战，加强合作创新，推动低空经济与城市轨道交通深度融合，不断创新发展业态，持续拓展发展空间，积极构建现代化城市交通系统。

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Leveraging Safety by Intrinsic Nature, Promoting High-quality Development of Fully Automatic Operation Systems

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Urban rail transit FAO (fully automatic operation) systems integrate and coordinate professional systems related to train operations, such as signaling, vehicles, communication, platform screen doors, and comprehensive monitoring, to achieve fully automated train operations without driver intervention under normal conditions. Compared with conventional manual driving systems, FAO systems elevate the automation level of train operations and are characterized by safety, efficiency, flexibility, cost-effectiveness, and ease of deployment. Since the launch of the world's first FAO system in 1981—the Port Island Line in Kobe, Japan—the global FAO system has accumulated over 40 years of operational experience, with over a decade of such experience in China. According to incomplete statistics, more than 30 countries and regions worldwide have launched over 110 urban rail transit FAO lines, with a total operating mileage of approximately 2,800 km, nearly one-third of which is in mainland China. According to the International Association of Public Transport (UITP: Union Internationale des Transports Publics), 75% of newly-built lines globally are expected to adopt FAO systems in the future, with the majority of this growth stemming from China. Statistics from the China Association of Metros reveal that, by the end of 2023, over 40 FAO lines has started operation in 21 cities in mainland China, with an operating mileage of 1,051.8 km, alongside over 1,500 km of FAO lines under construction.

Examining the development and operational trajectory of FAO systems, their advantages are evident: significantly enhancing operational reliability, mitigating safety risks caused by manual operational errors, and improving workforce efficiency. However, there remains debate over the feasibility of adopting a fully unattended operation mode, and a misconception persists that FAO systems are equivalent to driverless operations. While the information comprehensiveness and the overall safety of FAO systems have greatly improved through functions of core systems such as signaling and vehicles, including status monitoring, redundancy design, automated handling, and enhanced interconnectivity between subsystems, these systems have only been automated to the extent of maintaining normal operation without manual intervention. The end-to-end unattended operation with supervision is not fully realized. Some FAO lines operate under a fully unattended and supervised mode, but the associated safety risks warrant attention. These risks arise primarily because safety measures for some FAO application scenarios have not been comprehensively implemented. For example, automatic recovery or remote troubleshooting during faults is not fully developed, environmental perception and emergency handling capabilities for line operations remain incomplete, and operation-management frameworks and operation-maintenance modes are not yet sufficiently robust.

How to further enhance the intrinsic safety of FAO systems and continuously improve efficiency, especially in swift handling and recovery of high-density operational lines under abnormal working conditions to achieve 'fault-imperceptible operations', is closely related to many factors including system design, construction quality, interface management, risk management-control, intelligent operation-maintenance, management modes, and standards and regulations. It is a complex system engineering task involving multiple joints, disciplines, and subjects, that requires refined scenario analysis, strengthened risk assessment and judgement, and technological breakthroughs. The following areas call for exploration, practice, and advancement.

First, carrying out systematic research. Challenges shall be addressed at their root, through systematic research on design, construction, and operation-maintenance, including operational needs and scenario analysis, system integration design, interface management of disciplines, operational environment situation perception, system integration and joint commissioning, key equipment intelligent operation-maintenance. Simultaneously, taking risks as an anchor point, technologies and management measures on risk management-control shall be developed with specificity by thoroughly investigating and assessing risks associated with various operational and maintenance working conditions, passenger behaviors, and environmental factors.

Secondly, overcoming technological barriers. The foundational logic of related systems such as signaling, vehicles, and comprehensive monitoring shall be delved into, actively leveraging emerging technologies like artificial intelligence to enhance FAO system operational efficiency. The redundancy design of key equipment such as train, signaling, power supply, and platform doors shall be continuously improved and automated isolation and restoration/remote handling during faults shall be enhanced to ensure higher reliability and stability of equipment operations. Scenario analysis of obstacle detection in train operation environments for intrusion risks shall be refined, and development and deployment of long-range obstacle detection systems shall be accelerated to mitigate operational safety risks. Gap detection systems shall be integrated and innovated for platform screen doors and train doors to address monitoring blind spots caused by different technological means, thus reducing the safety risks of human/object entrapment incidents.

Thirdly, improving the OM (operation-maintenance) management systems. Enhancing the operational safety and efficiency of FAO systems requires not only advancements in FAO-related technology but also the complementary and applicable OM management modes. Systematic research efforts shall be exerted on OM management systems for FAO line networks of varying scales, such as establishing frameworks for standardized OM regulation, safety risk management-control, and digitalized management support. Operational dispatch and OM strategies shall be designed in alignment with the number of FAO lines in the network. Job standards, post hierarchies, multi-responsibility positions, and talent training program shall be refined according to the OM modes.

As a future direction for China's urban rail transit industry, FAO systems require all professional fields to leverage the intrinsic safety of FAO systems while continuously improving reliability and efficiency, fostering technological innovation and promoting advancements across related industries. Whether retrofitting existing lines or building new ones, cities should adopt technical solutions involving FAO systems that suit local conditions, establish comprehensive FAO operational management frameworks, and prioritize safety as a foundation for improving operational efficiency. Through thoughtful application, the high-quality development of urban rail transit FAO systems will be promoted.

Translated by ZHANG Liman