https://doi.org/10.15302/J-LAF-1-030052 Received Date | 2023-09-01 Accepted Date | 2024-03-06

The Pathway of "Intelligent Construction + Scenario Operation" for Smart Neighborhoods of Future City

Di ZHENG[1,2,3,4], Jianxin WANG[2,4,*]

1 College of Landscape Architecture, Zhejiang Agriculture and Forestry University, Hangzhou 311300, China
2 Future City Operation and Renewal Laboratory, Shanghai Urban Construction Vocational College, Shanghai 201415, China
3 China Intelligent Urbanization Co-creation Center for High Density Region, Shanghai 200092, China
4 Shanghai Industrial Technology Innovation Association, Shanghai 200127, China

*CORRESPONDING AUTHOR
Address: No. 2360, Jungong Road, Yangpu District, Shanghai 201415, China
Email: foresee-future@qq.com

ABSTRACT

Faced with the future decentralization trends of intelligent agent distribution in urban neighborhoods, this article proposes a new, integrated pathway of "intelligent construction + scenario operation." Its innovativeness lies in incorporating intelligent technology into processes of urban design, neighborhood renewal, and scenario operation. The pathway is tested through the empirical research on the case of the Shanghai Vanke Future City (NEXUS) project. In this project, the "intelligent construction + scenario operation" pathway is mainly demonstrated in scenarios of "intelligent transportation," "convenient living," "inclusiveness and security," and "environmental governance." The project becomes the model of combining production, ecology, and living together under Shanghai's new city strategy, and has gained positive social impacts. It verifies that the pathway is conducive to improving the design, construction, and operation qualities of future urban neighborhoods, providing a reference for China's smart neighborhood construction in the future.

KEYWORDS

Smart Neighborhood; Urban Renewal; Intelligent Construction; Scenario Operation; Future City; Intelligent Technology; Neighborhood Design

HIGHLIGHTS

- Proposes a pathway of "intelligent construction + scenario operation" for smart neighborhoods of future city
- Incorporates intelligent technology into processes of urban design, neighborhood renewal, and scenario operation
- The pathway is domonstrated through the building Shanghai's first community-level CIM platform project led by enterprise

RESEARCH FUND

Seed Project of "A Simulative and Extrapolative Technological Framework of the Future of Cities Through Urban Planning Schemes," China Intelligent Urbanization Co-creation Center for High Density Region (No. 2014-898675)

EDITED BY Tina TIAN, Ying WANG

1 Future City and Smart Neighborhood

The current development of future cities is showing an accelerated trend of competitive dynamics, with the frequent emergence of "black swan" events such as pandemics, wars, and socio-economic crises. Although the development of future cities is accompanied by complex uncertainties in terms of society, economy, and environment, the continuous advancement of intelligent technology is a crucial determinant, which will lead to the emergence of a series of innovative intelligent services, products, technologies, and applications, driving the "intelligent evolution and iteration" of future cities[1][2].

As future cities expand rapidly, urban neighborhoods are undergoing network layout and spatial reconstruction with information technologies and technological innovation in addition to boosting its spatial carrying capacity. The future cityscape is envisioned as one composed of networked governance units, and urban services will be organized upon

smart community networks[3]. Here, "networked governance" refers to an organizational structure or operational platform that brings together diverse stakeholders such as governments, enterprises, social organizations, and citizens, to achieve collective governance goals by sharing resources and information[4]. In terms of administrative divisions, a neighborhood often covers a larger area than a community and more specific elements in spatial design. "Smart neighborhood" is a new type of neighborhoods transformed from existing city blocks by utilizing Internet of Things (IoT) intelligent sensing devices and fundamental networks, and characterized by advanced infrastructure, efficient management services, intelligent and user-friendly environment, and distinct future-oriented attributes[2]. However, the linear-reasoning-based and subjective approaches used in traditional urban spatial design have obscured a clear understanding of the developmental characteristics of future urban neighborhoods. This has led to deviations in spatial decision-making and practical operation[5], manifesting in issues such as lack of sensing, assessment deviation, construction delay, operational inefficiency, and inadequate intervention[6].

Simultaneously, in response to the uncertainties in the development of future cities, intelligent technology can devise and evaluate strategies and solutions by leveraging its advantage in vast data processing, autonomous learning, and predictive extrapolation. It formulates a suite of analysis and decision-making methods encompassing goal setting, object sensing, problem diagnosis, and path selection, all rooted in the predictive analytical methodology of "Foreseeing metropolitan future"[1]. In light of the mixed demand for urban renewal and infrastructure upgrading, the intelligent exploration of urban neighborhoods must prioritize the significance of "scenario operation." However, the current scenario research merely centers on technical analysis or product demonstrations[7], making it difficult to coordinate the multi-element spatial design of neighborhood scenarios and the multi-system collaboration mechanisms of cities, either establishing a systematic theory or operational technical system for intelligent scenario design[8].

This article addresses the needs of future urban neighborhoods in terms of living, transportation, safety, and ecological construction. Focusing on the topic of "how to use innovative methods to meet the demands of the renewal and development of future neighborhood scenarios," this article explores the pathway of "intelligent construction + scenario operation" that traditional urban construction can assimilate insights from futurology①[9] and artificial intelligence, so as to delve into a technological framework that simulates and extrapolates the future of cities.

2 The Pathway of "Intelligent Construction + Scenario Operation" for Smart Neighborhood Construction

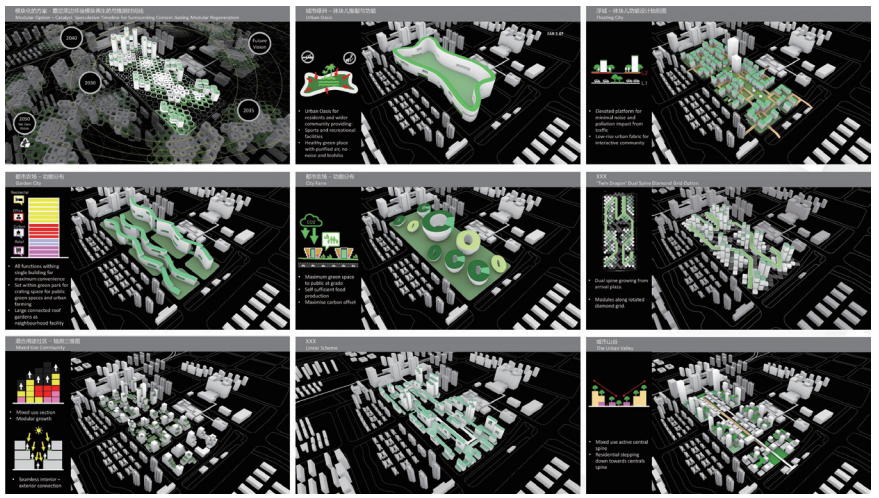
While intelligent technology will undoubtedly serve as a significant driving force for the development and progress of future cities, and even society at large, future urban research must avoid overstating the sole impact of technology. Instead, it should prioritize the integration of technology with cultural, ecological, and humanity needs, contributing to the holistic construction and scenario exploration of future cities[10]. Smart neighborhood involves not only the linear spatial design of streets, but also encompasses the overall construction and operation of communities[11]. Therefore, it is essential to combine the analytical decision-making method of "intelligent construction" with the strategies for "scenario operation."

The analytical decision-making method of intelligent construction derives from the idea of "Smart Neighborhood Service Platform," which integrates urban construction, product services, and public participation to form an open collaborative mechanism[2]. Adopting the concept of "urban form-flow"②[12], it introduces intelligent technology into fields such as socio-economic forecasting, human settlement improvement, and spatial form optimization, covering the entire workflow from design to construction and operation (Fig. 1). This model not only provides a basis for neighborhood planning but also responds to the practical needs of urban renewal, maximally satisfying the demands of various stakeholders and elevating the standards of urban construction, management, and operation.

On the level of scenario operation, American communication scholar Joshua Meyrowitz argues that scenarios encompass multiple dimensions (including design and development, construction and operation, and application and iteration) and involve specific spatio-temporal environment, behavioral and psychology components, and perceptual ranges, where the virtual information environment shaped by media is equally crucial as the natural environment. Therefore, when defining the boundaries of a scenario, information must be considered a pivotal factor[13]. Scenario operation centers

① Futurology is an interdisciplinary science. It aims to explore the possibilities of future lifestyles and work patterns, as well as the influence of social and technological advancements on human society through systematic, interdisciplinary, and holistic research methods (source: Ref. [9]).

② Different urban forms can lead to disparities in the distribution, intensity, and direction of traffic flow. "Urban form-flow" refers to the interactions and dynamic relations between urban forms and traffic flows (source: Ref. [12]).

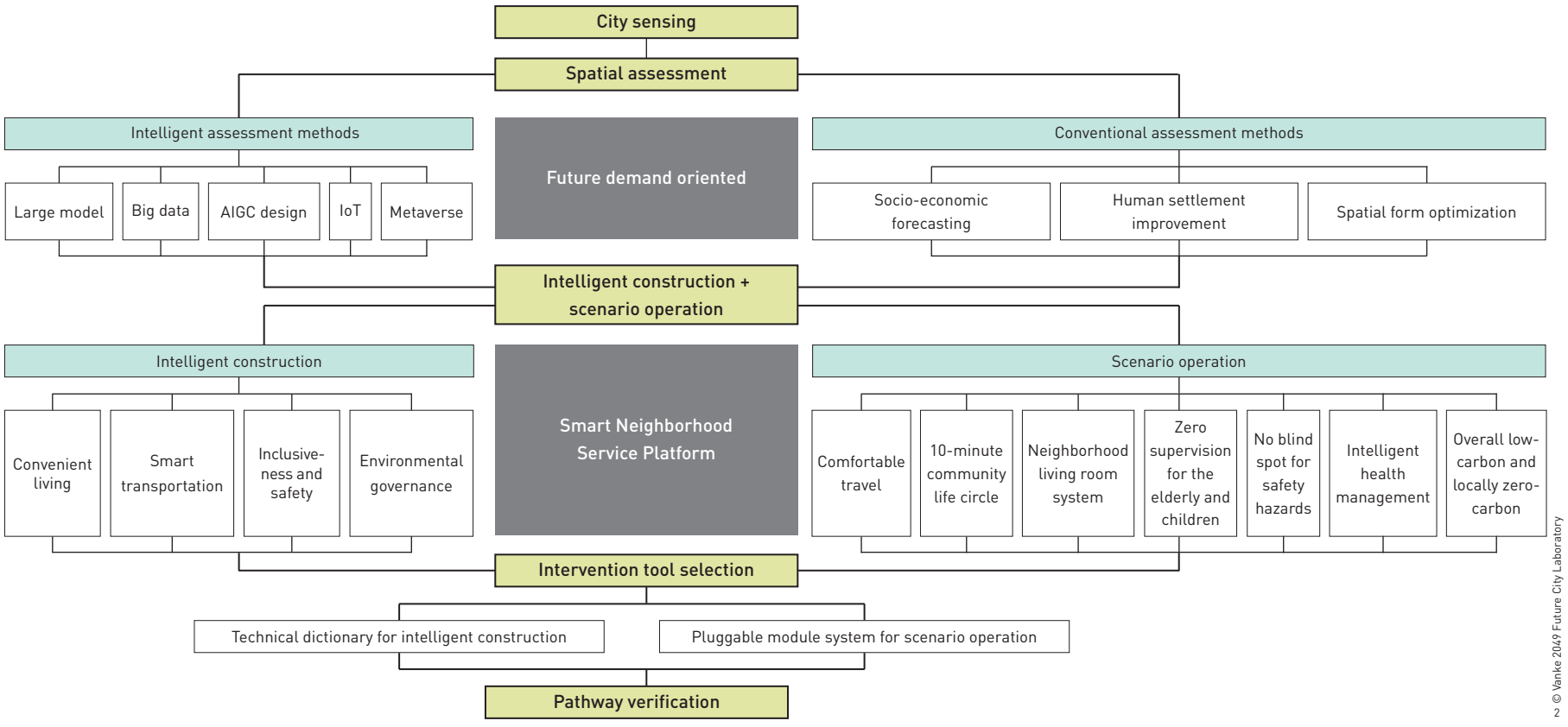


1. An example demonstrating the process of generating plans for a smart neighborhood of future cities.
2. The pathway of "intelligent construction + scenario operation".

on human needs, aiming to enhance user experience and augment spatial functions by creating and optimizing daily scenarios, e.g., transportation, living, safety, environment.

This pathway of "intelligent construction + scenario operation" for smart neighborhood construction proposed in the article highlights its innovative introduction of intelligent technology into the process of urban design, neighborhood renewal, and scenario operation, with the steps as "city sensing—spatial assessment—intelligent construction + scenario operation—intervention tool selection—pathway verification" (Fig. 2). Specifically, the role of sensing and assessment is to enable real-time analysis of urban data, identify future development trends, and thereby enhance the operational efficiency of neighborhood scenarios. The role of construction and operation is to systematize the intricate extrapolative process of neighborhood spaces, where products and applications are combined with spatial design via intelligent construction, while scenario operation encompasses functional organization and project implementation.

In the pathway, intervention tools include the "technical dictionary for intelligent construction" and the "pluggable module system for scenario operation." The first aims to improve residents' living quality and to ensure economic and operational sustainability by providing calibration benchmarks at each implementation stage to guarantee the effectiveness of application. Its content includes spatial positioning, scheme description, resource inventory, and key implementation points, as a reference for subsequent projects in technique selection and decision-making. The second is envisioned as a highland for the application of digital transformation



technologies and scenario demonstrations in future cities, fully demonstrating the technical value, application scenarios, costs, benefits, etc. through collaborations with enterprises. This system introduces experimental modules in aspects of smart transportation, convenient living, inclusiveness and safety, and environmental governance, and supports flexible pluggable products at scenario interfaces, along with provisioning experimental platforms and iterative spaces beforehand[14].

3 Pathway Verification: The Shanghai Vanke Future City (NEXUS) Project

The rationality of the pathway of "intelligent construction + scenario operation" needs to be verified through the full-process application of forward-looking projects. This article takes the case of Shanghai Vanke Future City (NEXUS) Project ("Future City Project" hereafter) for demonstration. The project is located in the core area of Jiading New Town, covering an area of nearly 15 hm^2, with a total building area of 578,000 m^2. Representing the smallest spatial unit of future cities, the project is envisioned as a highly complex urban space for living, working, learning, recreation, and ecology within a 10-minute walking radius. The project, initiated in 2019, has been continuously tracked and studied by Vanke 2049 Future City Laboratory. After preliminary scheming by the Shanghai Municipal Government and joint technical demonstrations with enterprises, the project has gradually established a hierarchical technical module system at city, unit, and scenario levels. The city-level technical modules, based on digital twin technology, integrate and upgrade existing urban infrastructure including transportation, energy, water resources, waste, and blue-green networks. The unit-level technical modules are developed upon the "10-minute community life circle" to create a distinctive, highly integrated networked governance unit. The scenario-level technical modules can effectively incorporate technological innovations into diverse daily scenarios such as transportation, life services, security, and ecology. In the Future City Project, the "intelligent construction + scenario operation" pathway is mainly demonstrated in scenarios of "intelligent transportation," "convenient living," "inclusiveness and security," and "environmental governance"[2].

3.1 Scenario of Intelligent Transportation

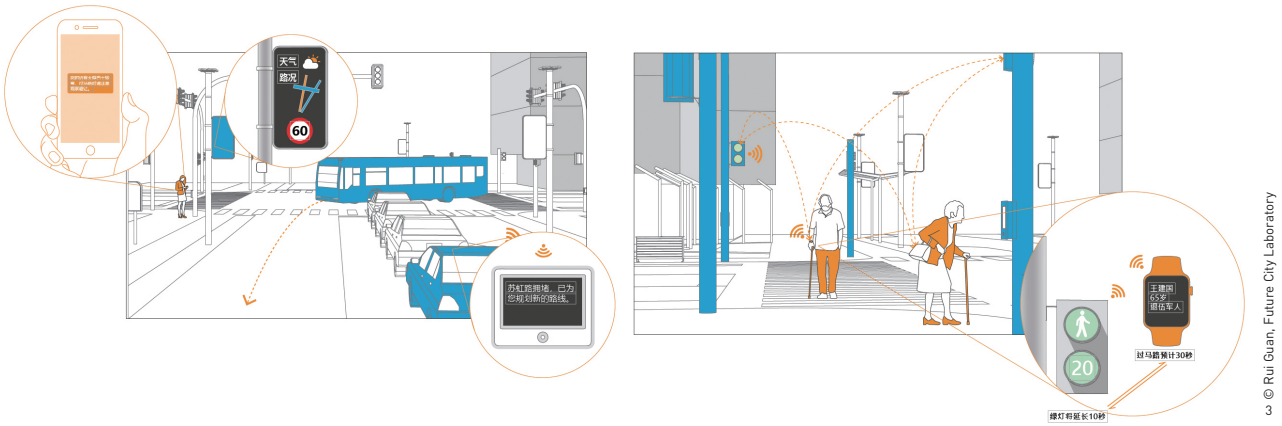
In the construction of this scenario, residents will configure their transportation modes according to their travel needs. The traffic control platform is fully connected with Internet of Vehicles (IoV), shifting the basis of traffic regulation from fluctuating data to real-time, all-spatio-temporal traffic data[15][16]. The coverage mode of intelligent devices on the street segments in smart neighborhoods is determined according to the product penetration rate of smart vehicles and related engineering requirements; roadside sensing devices together with edge computing devices, communication facilities, and cloud service platforms are used to identify and locate traffic conditions, supporting intelligent traffic management and assisting vehicle autonomous driving, so as to ensure traffic safety[17]. The green-wave road③[18] traffic system for vehicles can take active control measures during congestion, accidents, construction, and other incidents, improving traffic efficiency. Smart crossings will coordinate roads, vehicles, and pedestrians by real-time monitoring traffic flow data while recommending vehicle routes or provide warnings for pedestrians. At the same time, based on the needs of specific usage scenarios, roads can be switched from motor lanes to slow pedestrian lanes; the information dissemination system combined with surrounding service facilities, can send announcements (e.g., parking space, restroom, charging pile, road conditions) to nearby vehicles, thereby enhancing traffic supply-demand dynamics. Devices such as smart poles will actively detect the physical data of pedestrians crossing the street, predict the passing time and adjust the green light time (Fig. 3).

Scenario operations of the roads should also be flexible to respond to diverse needs. Spatial design should adopt a curved style as much as possible[17]. Street-front buildings should be set back to save room for time-sharing mixed use for pedestrians and vehicles[19]—prioritizing sidewalks, followed by bicycle lanes, to ensure the safety and connectivity of pedestrians' routes. Meanwhile, continuous, open, and functional composite interfaces are formed in the smart neighborhood, where ground pedestrian spaces, second-floor corridors, and slow neighborhoods are also created to build a slow-traffic network.

3.2 Scenario of Convenient Living

In the construction of the convenient living scenario, residents' needs drive innovation and also stimulate industrial opportunities. With the help of 5G communication technology and the IoT, flexible home space can be used for customized experiential products on demand. The sharing economy promotes the flexible use of

③ Green-wave road is an advanced traffic signal control technology designed to coordinate the timing of a series of adjacent traffic signals allowing vehicles to pass through multiple crossings continuously, thus reducing the number of stops and delays and improving road traffic efficiency (source: Ref. [18]).



3

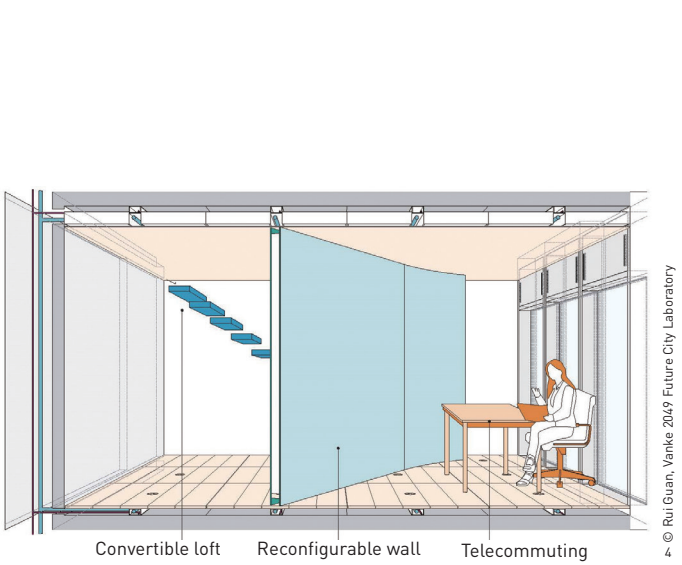
④ Property City is an innovative model of modern urban governance that regards the city as a large-scale entity of property management. By introducing market-oriented and social mechanisms, it achieves the specialization, refinement, and intelligence of urban governance (source: Ref. [23]).

office spaces and the transformation of shared workspaces among companies, homes, and coffee shops (Fig. 4). The scenario operation aims for establishing a 10-minute community life circle, where each block shares a "community living room" for socializing, working, exercising, and other activities. Considering the population aging reality in Shanghai[20], age-friendly community living scenarios were created to cater to both the elderly and the young. Operational costs are comprehensively assessed, including infrastructures, community services, and related expenses; the neighborhood also develops market-driven operational models that support micro home senior-care services (Fig. 5) with clear responsibilities and profitability for multiple parties[21].

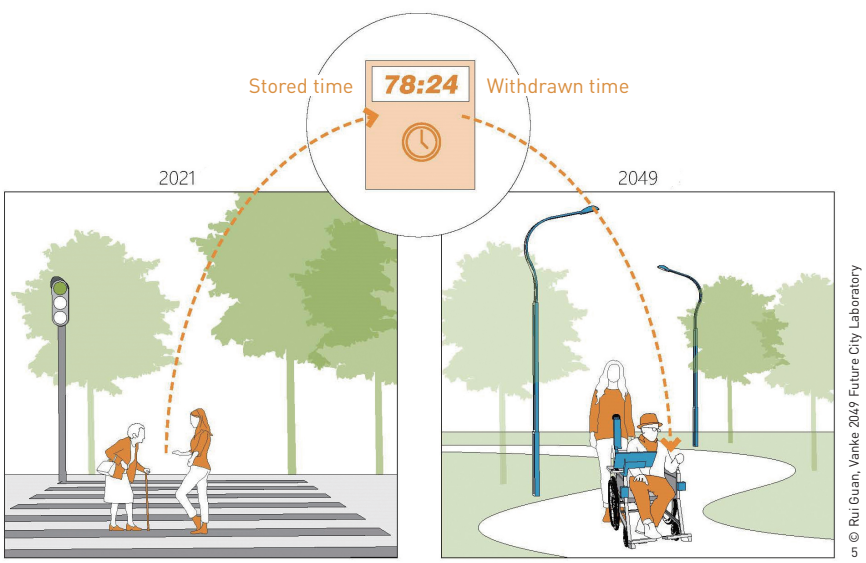
3.3 Scenario of Inclusiveness and Safety

In constructing this scenario, daily service guarantees cover the entire neighborhood and entire life cycles of residents of all ages. People's health and safety can be promoted through innovative products such as sterilization chambers and fresh-air green walls, which can form effective sanitary barriers (Fig. 6). By employing intelligent video detecting technology (Fig. 7), the security system can achieve proactive event extraction, defense alarms, and 24/7 responds to incidents. Integrating residents, communities, and city information service system[22], visions such as "zero supervision for the elderly and children" and "no blind spot for safety hazards" can be realized. The project service team coordinates with the government operation center to build the basic CIM (City Information Modeling) platform that provides unified management and services for the neighborhood and the surrounding communities through Property City④[23]. By

3. Scenario of intelligent transportation: schematic diagram of the smart crossing.
4. Scenario of convenient living: schematic diagram of changeable residence.
5. Scenario of convenient living: schematic diagram of Time Bank. Time Bank, as one of the senior-care services in the neighborhood, allows community members to use their free time to help the elderly and get service time that can be provided by others in future in the form of virtual currency, when they can withdraw the service time and get senior-care services by other community members.

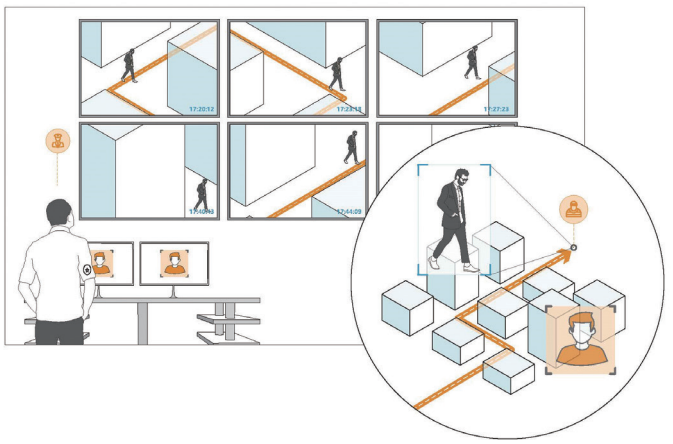


4



5

6 © Guan Rui, Vanke 2049 Future City Laboratory



7 © Rui Guan, Vanke 2049 Future City Laboratory

⑤ Green micro-energy network is an intelligent network for comprehensive energy utilization of a given region. As a fundamental component of the Energy Internet, it is crucial for the construction of a clean, low-carbon, safe, and efficient energy system, contributing to the city's energy revolution and green development (source: Ref. [24]).

cooperating with relevant government departments, on the basis of city smart service responses, residents' health records are linked with the city's public health system, connecting telemedicine resources and improving health management services for residents.

3.4 Scenario of Environmental Governance

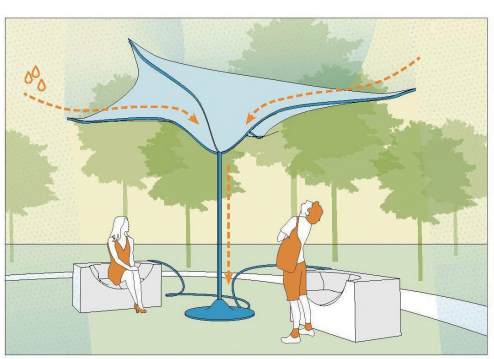
In the construction of this scenario, a green micro-energy network⑤[24]will consist of energy infrastructure with stronger resilience, and intelligent photovoltaic and battery storage solutions make the network affordable. Measures in resilient water environment, sponge city construction, and scientific efficient stormwater management will enhance the site's capability of urban environment to withstand risks (Fig. 8). The use of smart technologies such as Smart Parasols and Cloud Forests will help real-time environmental management and enhance ecological benefits (Fig. 9). The use of passive energy-saving operations is prioritized, supplemented by energy-efficient systems and new energy technologies, to minimize the reliance on electrical equipment.

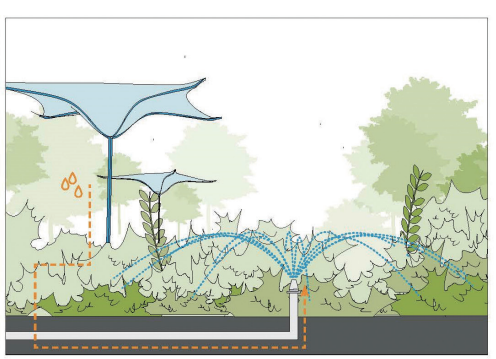
To build a low carbon neighborhood, it is necessary to both upgrade construction and equipment technology but also promote sustainable lifestyles. The scenario operation of environmental management sets goals of "overall low-carbon (reducing carbon emissions by 40%) and locally zero-carbon (reducing carbon emissions by 20%)", which requires integrating proven technologies and pilots of cutting-edge technologies in energy, water, and waste management, to achieve multi-dimensional, full-cycle carbon reduction for the project.

4 Conclusion and Outlook

As a model for the integration of production, ecology, and living under Shanghai's new city strategy, the Future City Project meets the needs for highly mixed community functions, convenient

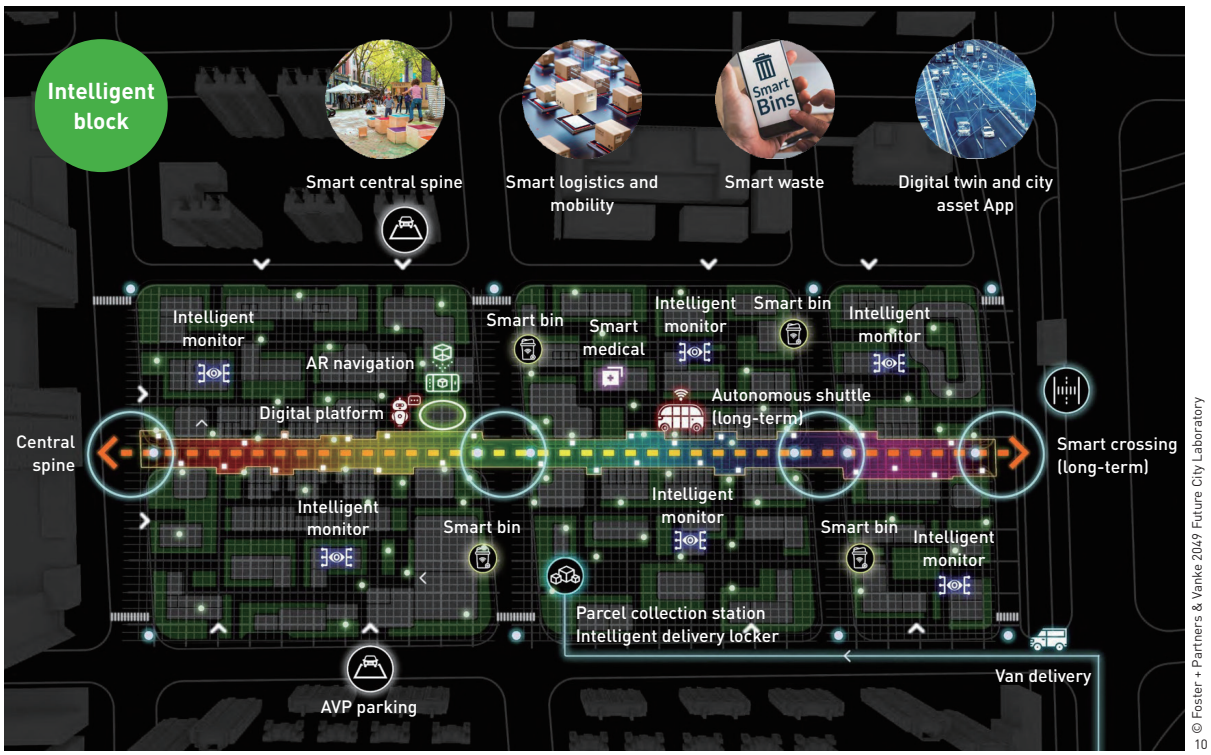
6. Scenario Inclusiveness and safety: schematic diagram of sterilization chamber and fresh-air green wall.
7. Scenario Inclusiveness and safety: schematic diagram of intelligent video detecting system.
8. Scenario of environmental governance: schematic diagram of sponge city and rain garden. Digital systems and sensing devices can enhance the monitoring of rainwater and promote the neighborhood's capability to absorb, store, and reuse rainwater.
9. Scenario of environmental governance: schematic diagram of Smart Parasol and Cloud Forests. These devices can automatically open or close by sensing the changes of light, temperature, and humidity during the day and night, adjusting microclimate and improving users' comfort.





8 © Rui Guan, Vanke 2049 Future City Laboratory

9 © Rui Guan, Vanke 2049 Future City Laboratory



© Foster + Partners & Vanke 2049 Future City Laboratory
10

10. Diagram of intelligent scenarios established in the smart neighborhood. Connected with urban operating systems, this smart neighborhood project achieves intelligent logistics, life services, digital twin, and other operational scenarios.
11. Current construction status of the demonstration section of the Future City Project (taken in May, 2024).
12. Planned vision of the Future City Project.

©Kai Hu, Future City Project
11

public services, and integrated operational development. It reserves technological redundancy in the fields of green and low-carbon development, ecological and environmental protection, healthy living, and smart inclusiveness. The project is rooted in the practices of local urban renewal, community governance, and neighborhood unit construction, and focuses on the full-process from preliminary planning to implementation and operational management. Smart neighborhoods, as a highly complex integration of new resources, new scenarios, and new technologies, inherently face more complexities and challenges in operational management than the construction itself. Therefore, the project holds the demonstrative value for the whole industry. The Future City Project has been approved by the Shanghai Municipal Bureau of Planning and Natural Resources in 2022, and included in the preparation of regulatory detailed planning documents⑥, as Shanghai's first community-level CIM platform led by enterprise (Figs. 10 ~ 12) and the first application of a PEDF (Photovoltaic, Energy storage, Direct current, and Flexibility) microgrid system in a neighborhood project led by Chinese enterprises.

With the changes and reforms in the construction and operation of future cities and related industries, the pathway of "intelligent construction + scenario operation" proposed in this article will help support the iterative upgrading of smart neighborhood construction and operation models, and improve the spatial design, construction, and operation quality of future cities. The research team will also continue to track the performance of authentic application projects and accumulate empirical experience for relevant theoretical and practical research.

©Kai Hu, Future City Project
12

⑥ The Future City Project now is incorporated into Unit JDC1-1901 of Jiading New City, Malu Town, Jiading District, Shanghai.

Competing interests | The authors declare that they have no competing interests.

ACKNOWLEDGEMENTS

Many thanks to Professor Qinxing Bao from the School of Landscape and Architecture, Zhejiang Agriculture and Forestry University and Mr. Weiyang Qiu, former global senior partner of Foster + Partners, for their guidance on this article. Thanks to Mr. Rui Guan, Ms. Jingkun Fang, and Mr. Zongneng Tan (partners of Vanke 2049 Future City Laboratory), as well as Mr. Kai Hu, deputy general manager of the Future City Project, for their help with this article. Thanks to Ms. Siyuan Cheng for her help in translation.

REFERENCES

[1] Wu, Z., & Zheng, D. (2023). *Foresee Metropolitan Future: Strategic Prediction Methodology to Explain Uncertainty*. Shanghai SDX Joint Publishing Company.

[2] Zheng, D., Sun, H., Jiang, Q., & Jiang, Y. (2016). Space guide and innovation platform of smart street. *Shanghai Urban Planning Review*, (6), 75–83.

[3] Long, Y., Li, W., Zhang, E., Yan, T., Chen, J., Li, P., & Tong, C. (2023). The spatial prototype and realization path for future city. *Journal of Urban and Regional Planning*, 15(1), 1–17.

[4] Wang, X. (2020). Grassroots social governance: From grid management to network governance. *Theoretical Exploration*, (2), 76–80.

[5] Wu, Z., Wang, J., Ding, L., Dang, A., Zhen, F., Yang, T., Liu, H., Yang, J., Long, Y., Niu, Q., Zhao, M., Pan, H., Wang, D., & Wang, G. (2022). Calmly thinking of smart city boom. *Urban Planning Forum*, (2), 1–11.

[6] Meng, F., & Wu, X. (2022). Revisiting “Smart City”: Three basic research questions—Based on a systematic review of English literature. *Public Administration and Policy Review*, 11(2), 148–168.

[7] Ye, Y., Zhang, G., & Han, Y. (2022). Built environment auditing based on multi-source data and embodied evidence-based technology: A case study of Dishui Lake Station Square in Shanghai. *Landscape Architecture*, 29(9), 55–61.

[8] Long, Y., & Shen, Y. (2015). Data augmented design: Urban planning and design in the new data environment. *Shanghai Urban Planning Review*, (2), 81–87.

[9] Deng, J. (1983). Gray system theory and econometrics of futurology. *Future and Development*, (3), 20–23.

[10] Li, M., Wang, W., Hua, Y., & Yang, T. (2022). Smart city planning and design based on space and technology application scenarios. *Intelligent Building & Smart City*. (3), 59–63.

[11] Zheng, D. (2021). The strategic implementation path of smart streets. *Regional Governance*, (4), 35–36, 49.

[12] Wu, Z. (2023, October 26). *Empowering the future of cities through intelligent planning* [Conference presentation]. 2023 High-level Talent Training Program “Pujiang Academy” of Shanghai Urban Planning & Design Research Institute, Shanghai, China.

[13] Meyrowitz, J. (1985). *No Sense of Place: The Impact of Electronic Media on Social Behavior*. Oxford University Press.

[14] Liu, Q. (2021). Smart community classification and integrated development from the perspective of product application. *Urban Planning International*, 36(6), 71–78.

[15] Salazar-Miranda, A., Zhang, F., Sun, M., Leoni, P., Duarte, F., & Ratti, C. (2023). Smart curbs: Measuring street activities in real-time using computer vision. *Landscape and Urban Planning*, (234), 104715.

[16] Lees, S., Jang, K. M., Kang, N., Kim, J., Oh, M., & Kim, Y. (2022). Redesigning urban elements and structures considering autonomous vehicles: Preparing design strategies for wide implementation in cities. *Cities*, (123), 103595.

[17] Yang, Z., Jia, P., & Zuo, Z. (2006). Optimization of road route and alignment based on road engineering and transport planning. *Journal of Highway and Transportation Research and Development*, 23(2), 56–60.

[18] Editorial Department of China Journal of Highway and Transport. (2016). Review on China’s traffic engineering research progress: 2016. *China Journal of Highway and Transport*, 29(6), 1–161.

[19] Akindipe, D., Olawale, O. W., & Bujko, R. (2022). Techno-economic and social aspects of smart street lighting for small cities—A case study. *Sustainable Cities and Society*, (84), 103989.

[20] Ding, Z. (2023). *New media and transformation of the life style of the aged people in Shanghai* [Doctoral dissertation]. Shanghai University.

[21] Liu, Q., Chen, Y., Huang, D., Li, Y., & Qian, Z. (2023). Modular urban design method for integrated cyber-physical-social scenarios in smart cities: The case of conceptual design of Huaqiangbei future street. *Urban Planning Forum*, (2), 110–118.

[22] Wang, Z., Zheng, Z., Zhou, B., & Zhao, Y. (2019). Analysis of experience and prospects of smart city development. *Artificial Intelligence VIEW*, (6), 16–30.

[23] Dou, Y. (2022, September 11). Shenzhen is building a “Property City” and exploring new modern management paths for megacities. *Shenzhen Special Zone Daily*.

[24] Yang, S. (2022). *Multi-energy cooperative operation optimization and benefit allocation model for new energy microgrid* [Doctoral dissertation]. North China Electric Power University.

https://doi.org/10.15302/J-LAF-1-030052 收稿日期 | 2023-09-01 录用日期 | 2024-03-06 中图分类号 | TU986 文献标识码 | B

面向未来城市智慧街道的“智能建构+场景运营”路径

郑迪[1,2,3,4]，王剑新[2,4,*]

1 浙江农林大学风景园林与建筑学院，杭州 311300
2 上海城建职业学院未来城市运营更新实验室，上海 201415
3 长三角城市群智能规划省部共建协同创新中心，上海 200092
4 上海市产业技术创新促进会，上海 200127

***通讯作者**
地址：上海市杨浦区军工路2360号
邮编：201415
邮箱：foresee-future@qq.com

摘要

面对城市街道智能体的分布去中心化的未来发展趋势，本文提出“如何利用创新方法来应对未来街道场景的更新发展需求”的问题，整合“智能建构”与“场景运营”形成新的路径。其创新之处在于将智能技术融入城市设计、街道更新与场景运营过程，“城市感知－空间研判－‘智能建构+场景运营’－干预工具选择－路径验证”等环节。本文基于上海市万科未来城市（理想之地）项目进行实证研究——在该项目中，“智能建构+场景运营”路径主要贯穿了“交通智行、生活便利、普惠安全、环境治理”四大场景，成为了上海新城战略的生产、生态、生活融合样板，获得积极社会影响——验证了这一建设路径有助于提高未来城市街道空间的设计、建设及运营品质，将为中国未来的智慧街道建设提供借鉴。

关键词

智慧街道；城市更新；智能建构；场景运营；未来城市；智能技术；街道设计

文章亮点

- 提出了面向未来城市智慧街道的“智能建构”与“场景运营”路径
- 将智能技术融入城市设计、街道更新与场景运营过程
- 通过上海首个由企业主导的社区级CIM平台项目进行了路径验证

基金项目

长三角城市群智能规划省部共建协同创新中心种子项目“以城市规划方案对于城市未来的模拟推演技术架构”（编号：2014-898675）

编辑 田乐，王颖

1 未来城市和智慧街道

当前，全球未来城市发展呈现竞争加剧的趋势，疫情、战争等“黑天鹅”事件和社会经济危机层出不穷。虽然未来城市发展伴随着社会、经济及环境因素的复杂不确定性，但智能技术的不断进步是重要的确定性影响因素，随之将涌现出一系列创新性智能服务、产品、技术和应用项目，未来城市也将进行智能进化迭代[1][2]。

在未来城市高速扩张的同时，城市街道也在利用信息化和技术创新，在有效提升空间承载力的同时进行网络布局与空间重构。未来城市的格局将由网络化治理单元构成，城市服务也将依托智慧社区网络来布局[3]。“网络化治理”指由政府、企业、社会组织和公民等多元主体构成的组织结构或运作平台，通过资源和信息共享，共同达成治理目标[4]。就行政区划范畴而言，街道比社区更大，而在空间设计层面则比社区涉及更多具体要素。“智慧街道”是基于现有街道、以物联网智能感知设备和基础网络为基础设施而建立起来的一种基础设施先进、管理服务高效、环境智慧友好和未来特质明显的新型街道[2]。然而，传统城市空间设计中依赖线性推理及设计师主观判断的工作模式，影响了人们对未来城市街道空间发展特征的清晰认知，造成空间决策与实际运营的偏差[5]，进而出现感知缺失、研判偏差、建构滞后、运营低效、干预不力等问题[6]。

与此同时，针对未来城市发展的不确定性，可通过智能技术的大规模数据处理能力、自主学习和预测推演能力，生成方案并评价，并在“预见大都市未来”预测分析方法[1]的基础上，形成从目标制定、对象感知到问题诊断、路径选择等一系列分析决策方法。为应对当下城市更新、基础设施升级的融合需求，城市街道的智能化探索需要更进一步强调“场景运营”的重要性。但现有相关场景研究重点仅限于技术分析或产品展示[7]，街道场景多要素空间与城市多系统协同机制难以协调，尚未形成针对智能场景设计的系统理论与运营技术体系[8]。

本文面向未来城市街道的生活、交通、安全及生态建设需求，以“如何利用创新方法应对未来街道场景的更新发展需求”为研究议题，

探讨传统城市建设如何从未来学①[9]及人工智能当中汲取养分，通过“智能建构+场景运营”的路径，探索城市未来的模拟推演技术架构。

2 智慧街道建设的“智能建构+场景运营”路径

虽然智能技术将是未来城市乃至社会整体发展进步的重要推动力，但未来城市研究不应过分强调技术因素对未来发展的影响，而应加强技术与文化、生态和人性需求的融合，即加强关于未来城市的整体建构和场景探讨[10]。智慧街道不仅仅涉及街道的线性空间设计，更涵盖社区的整体建设和运营[11]，因此需要将“智能建构”的分析决策方法与以“场景运营”为导向的策略相结合。

智能建构的分析决策方法来源于“智慧街道服务平台”概念。智慧街道服务平台整合了城市建设、产品服务和公众参与，形成开放协作机制[2]，以“城市形流”②[12]为基础，将智能技术融入社会经济预测、人居环境提升、空间形态优化等方面，介入街道从设计、建设至运营的全工作流程（图1）。这种模式不仅能够为街道空间规划编制提供依据，还能回应城市更新的现实需求，最大程度地满足各利益相关方的诉求，提升城市建设与管理运营水平。

在场景运营层面，美国传播学者约书亚·梅洛维茨认为，场景具有设计研发、建设运营、应用迭代的多重含义，涵盖特定时空环境、行为心理构成和感知范围，由媒介构成的虚拟信息环境与物理环境同样重要，在确定场景的运营模式时应把信息作为关键因素考虑进去[13]。场景运营以人的需求为核心，通过创造和优化日常场景（交通、生活、安全、环境等）来提升用户体验、增强空间功能。本文提出的智慧街道建设路径，创新之处在于将智能技术融入城市设计、街道更新与场景运营过程，包括“城市感知—空间研判—‘智能建构+场景运营’—干预工具选择—路径验证”等环节（图2）。其中，感知和研判的作用在于能够实时分析城市数据，识别未来发展趋势，从而提高街道场景的运营效能；建构和运营的作用在于将复杂的街道空间演绎过程系统化，其中“智能建构”衔接产品应用和空间塑造，“场景运营”覆盖功能组织和项目实施。

路径中的干预工具选择包含“智能建构技术字典”和“场景运营可拔插体系”两大工具。前者以改善居民生活、保障经济和运营可持续性为前提，为项目实施的各个阶段提供校核基准，保证应用效果。内容包括空间落位、方案说明、提资清单和实施要点，可供后续项目在技术选择与决策时参考查阅。后者作为未来城市数字化转型技术应用与场景示范高地，与企业合作充分论证技术价值、应用场景、成本与效益等内容，其重点是在交通智行、生活便利、安全普惠、环境治理场景中引入试验性模块，在场景端口可灵活插拔使用产品，预留试验平台与迭代空间[14]。

3 路径验证：以上海市万科未来城市（理想之地）项目为例

“智能建构+场景运营”路径的合理性需要借助前瞻性项目的全工作流程来验证。本文以上海市万科未来城市（理想之地）项目（简称“未来城市项目”）为例进行论证。项目位于嘉定新城核心区域，占地面积近15hm^2，总建筑面积57.8万平方米。作为构成未来城市的最小空间单元，项目旨在在10分钟步行范围内打造生活、工作、学习、娱乐、生态高度复合的城市空间。项目于2019年启动，由万科2049未来城市实验室全程跟踪研究。经过上海市政府的前期谋划与企业的联合技术论证，项目逐步建立了“城市级—单元级—场景级”的分级技术模块体系。城市级技术模块以数字孪生为基础，整合并升级交通、能源、水资源、废弃物、蓝绿网络等现有基础设施；单元级技术模块以“10分钟生活圈”为基础，建设各具特色、高度复合的网络化治理单元。在未来城市项目中，“智能建构+场景运营”路径主要涵盖交通智行、生活便利、普惠安全、环境治理四大场景[2]，让技术创新真正融入居民的日常生活场景。

3.1 交通智行场景

在交通智行场景建构中，市民将按出行需求配置交通方式。交通管控平台与车联网全面联通，使交通调控的依据从浮动数据调整为全时空实时交通数据[15][16]。智慧街道路段根据智能载具的产品渗透率和工程实施要求确定智能设备覆盖方式；路侧感知设备配合边缘计算设备、通信设施和云服务平台，能对车辆运行状况进行识别和定位，并开展交通智能管理，辅助车辆自动驾驶，保障交通安全[17]。车行绿波道路③[18]系统可以使车辆在拥堵、事故、施工等事件发生时接收到主动管控措施，提升道路通行效率；智慧道口可以通过实时监测车流数据、推荐车辆路径及提供行人警示，做到路、车、人协同。同时，道路可根据使用场景需求将机动车道切换为人行道，信息发布系统通过与周边服务设施结合，向附近车辆下发信息公告（车位、卫生间、充电桩信息和道路情况等），从而实现交通供需联动。智能合杆等设备主动检测过马路的行人体态数据，预判出行人过马路所需时间并实时修正绿灯时间（图3）。

场景运营还应灵活可变，促使道路空间应对多元需求。空间设计上充分进行曲线化处理[17]，沿街建筑退缩空间，退缩的道路用地可人车混合使用并进行分时管理[19]——以人行道为主、自行车道为辅，确保行人

① 未来学是一门综合性科学，旨在通过系统性、跨学科和整体性的研究方法，探索人们未来可能的生活和工作方式，以及社会和技术进步对人类社会的影响（来源：参考文献[9]）。

② 由于不同的城市形态会导致交通流的分布、强度和流向产生差异，“城市形流”指的是城市形态与交通流之间的相互作用和动态关系（来源：参考文献[12]）。

③ 绿波道路是一种先进的交通信号控制技术，旨在通过协调一系列相邻交通信号灯的配时，使得车辆行驶时能够连续直接通过多个交叉口，从而减少停车次数和延误，提高道路的通行效率（来源：参考文献[18]）。

可沿期望线路行进。促进连续开放、功能复合界面的形成，结合地面步行空间、二层连廊及慢行道路打造慢行网络。

3.2 生活便利场景

在此场景建构中，居民需求引导创新并激发产业机遇。在5G通讯技术与物联网的助力下，家居空间可以按需创造定制化体验产品；共享经济促进办公空间灵活使用，促使公司、家庭、咖啡厅等共享办公空间相互转化（图4）。场景运营以“10分钟生活圈”为目标，每个组团共享“邻里客厅”，可开展社交、办公、健身等活动。针对上海市社区呈现出老龄化的特点[20]，营造了老幼友好的社群生活场景，全面评估基础设施及各类社区服务及相关运营成本，积极寻求市场主导的运作模式，开拓“微养老模式—居家养老服务”（图5），责任划分清晰并实现多方盈利[21]。

3.3 普惠安全场景

在此场景建构中，居民日常服务保障涵盖街道的全域全龄全周期。街道环境以健康安全为主导，通过除菌仓、绿植新风墙等新式健康产品形成有效卫生屏障（图6）；利用安防叠加智能视频分析技术（图7），实现主动事件提取、主动防御警告，全天候响应处理事件；重点打通居民、社区与城市信息服务系统[22]，实现“老幼零监护、社区无死角”；项目内的服务团队与政府运营中心联动，搭建城市信息模型（CIM）基础平台，通过物业城市④[23]对项目红线内外进行统一管理和服务。通过与相关政府部门协作，在城市智慧服务响应的基础上，打通居民健康档案与城市公共卫生系统，链接远程医疗资源，为居民提供健康管理服务。

3.4 环境治理场景

在环境治理场景建构中，绿色微能源网络⑤[24]将提供更具韧性的能源基础设施，智能光伏及电池存储解决方案让微能源网络变得可负担；韧性水环境、海绵城市建设、科学高效的雨洪管理措施将加强街道抵御风险的能力（图8）；“智慧阳伞”“云雾森林”等智能技术的运用将有助于实时环境管理和生态效益提升（图9）；优先采用被动式节能运营，辅以节能机电和新能源技术，尽可能减少对电气设备的依赖。

要实现低碳，不仅仅需要升级建造技术和设备，更需倡导可持续的生活方式。环境治理场景运营以“全域达低碳（降碳排40%）、局部近零碳（降碳排20%）”为目标，在能源、水资源、废弃物等方面进行成熟技术集成与前沿技术试点并行，实现项目全周期、多维度的减碳。

4 绩效评述与未来展望

未来城市项目作为上海新城战略的生产、生态、生活融合样板，承接社区功能高度混合、便捷的公共服务及一体化运营开发的需求，在绿色低碳、生态环保、健康宜居、智慧普惠等领域充分预留技术冗余度，立足于城市更新、社区治理、街道单元建设实践，涉及前期谋划、实质开发、运营管理的全过程。而智慧街道作为“新资源、新场景、新技术”的高度复杂集成，决定了其运营管理的复杂性显著高于开发建设本身，因此项目具有推动行业发展的应用示范价值（图10~12）。项目已于2022年通过上海市规划和自然资源局审批，智慧街道的建设运营也已被纳入控制性详细规划文件的编制⑥中，成为上海首个由企业主导的社区级CIM平台，这也是光储直柔系统在由中国企业主导的街道项目中的首次运用。

随着未来城市的建设运营及相关行业的变革，本文提出的“智能建构+场景运营”路径将支持未来智慧街道建设与运营模式的迭代升级，提高未来城市的设计、建设及运营品质。研究团队也将对于实践项目的绩效进行持续追踪，为相关理论与实践研究积累实证经验。

致谢

感谢浙江农林大学园林与建筑学院鲍沁星教授与原福斯特建筑事务所全球高级合伙人邱维炀先生对本文的指导。感谢万科2049未来城市实验室合伙人管睿、房静坤、谭宗能及未来城市项目副总经理胡凯对本文的帮助。感谢成思圆老师对翻译工作的帮助。

④ 物业城市是城市治理现代化的创新模式，它将城市视为一个大型的物业管理对象，通过引入市场化和社会化机制，实现城市治理的专业化、精细化、智慧化（来源：参考文献[23]）。

⑤ 绿色微能源网络是一种智慧型能源综合利用的区域网络，作为能源互联网的基本组成部分，是构建清洁低碳、安全高效能源体系的重要内容，将推动能源革命和实现绿色发展（来源：参考文献[24]）。

⑥ 未来城市项目纳入上海市嘉定区马陆镇嘉定新城JDC1-1901单元。

图1. 未来城市智慧街道方案生成过程示例
图2. “智能建构+场景运营”路径
图3. 交通智行场景：智慧道口示意图。
图4. 生活便利场景：可变住宅示意图。
图5. 生活便利场景：养老服务之一——时间银行示意图。时间银行是指社区成员利用自己的时间帮助他人，并将提供的服务时间以虚拟货币的形式存储起来；当这些成员自己需要养老服务时，可从中支取“已存储时间”以换取其他社区成员的帮助。
图6. 普惠安全场景：除菌仓和绿植新风墙。
图7. 普惠安全场景：智能视频分析系统示意图。
图8. 环境治理场景：海绵城市与雨水花园示意图。利用数字系统和感知设备增强对雨水的监测，可促进场地的雨水吸纳、蓄渗、回收利用能力。
图9. 环境治理场景：智慧阳伞和云雾森林示意图。智慧阳伞和云雾森林可根据日夜光照、温度、湿度差异，自主动打开或关闭，调节微气候，保障居民舒适度。
图10. 智能场景总体展示图。通过对接城市运营系统，该智慧街道项目实现了智慧物流、生活服务、数字孪生等运营场景。
图11. 智慧街道示范段建设现状（拍摄于2024年5月）。
图12. 未来城市项目规划愿景。