时　评

轨道交通的时空技术变革

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2022 年 3 月 17 日，中国北斗卫星导航系统重大专项——北斗铁路行业综合应用示范工程历时 2 年，顺利通过国家验收。2022 年 3 月 20 日，国家重点研发技术——地铁北斗定位系统首都机场线示范应用研究项目举行了启动仪式，我国首个地铁北斗定位系统在北京地铁首都机场线开工建设，这是我国目前规模最大的室内空间导航定位系统，预计今年年内建成。高铁应用北斗技术项目通过验收、地铁应用北斗技术项目开工建设，预示我国轨道交通技术将由于“北斗 +5G”等时空技术的赋能而面临变革。

国铁集团依托国家发展和改革委员会工程项目，形成了铁路北斗应用服务平台，面向铁路勘察设计、施工及运维三大阶段，在铁路工程测量、自动化监测系统、智慧工地系统、位置感知预警防护系统、铁路工务巡检、轨道测量及平顺性检测、“一带一路”中欧班列集装箱定位跟踪、高分遥感地质调查、高铁列车控制系统等 9 大铁路业务版块进行了示范应用，将北斗三号高精度定位和北斗短报文通信技术应用于铁路列车接近预警应用场景。示范工程同步完成了 71 项北斗知识产权布局和专利预警，编制了 4 项企业标准性技术文件，有力促进了中国北斗和中国高铁两张“国家名片”的深度融合。

时间标准与空间定位信息已成为以万物互联、人工智能和大数据应用为特征的智慧城轨建设的基础。上述铁路北斗应用主要用于暴露空间。长期以来，非暴露空间中的定位、导航、授时和通信一直被认为是世界级技术难题，它已成为制约智慧城轨应用北斗技术的瓶颈。建设以北斗为基础的高精度定位网、高精度时间同步网、高通量通信网和空间数字化平台，可以对智慧城轨的建设起到基础性的支撑作用。

地铁北斗定位系统是国家重点研发计划——超大城市轨道交通系统高效运输与安全服务关键技术项目的重要配套示范工程，基于北斗智慧定位导航系统，可应用于实景导览、检修定位、辅助施工、高效调度等地铁场景。北京地铁首都机场线示范工程覆盖 30 km 运行线路和 5 座车站，部署完成后，可使地铁车站地下空间定位精度提高至优于 2 m，实现全景地图导览及高精度定位导航。随着北斗卫星导航系统的完善，到 2025 年全球空间定位精度将提升到厘米级别。综合应用“北斗 +5G + 云平台”等技术，构建由高精度定位网、高精度时间同步网、高通量通信网和城轨云平台组成的时空体系网络，打破城轨暴露空间与非暴露空间之间的壁垒，形成城轨时空基准信息网络，并将其作为智慧城轨建设和运营的基础设施，为城轨提供统一、连续的空间与时间信息以及定位、授时、通信服务。

交通数据是典型的时空数据，不仅具有时间维度属性，还对空间维度有着较强的依赖性。随着不同轨道交通信息系统之间的融合发展，高精度的空间定位与时间标准信息显得更为重要。目前，我国正在建设以北斗系统为基础的综合定位、导航与授时（Positioning, Navigation and Timing，简称 PNT）体系。该体系可利用基于不同原理的多种 PNT 信息源，经过云平台控制、多传感器高度集成和多源数据融合，生成统一的时空基准并实现对室内、水下、深度空间等领域的覆盖。

城市轨道交通每年有近 200 亿位乘客，在地铁里乘客利用手机上网的需求强烈，城市轨道交通引入 5G 公网有天生优势。城轨的 5G 专业应用可以通过 5G 公网的广域切片，通过 QoS（Quality of Service，即服务质量）、网络切片等手段实现业务逻辑隔离，满足对特定网络速率、时延及可靠性的优先保障需求，并按需灵活配置。也可通过局域切片，利用边缘计算技术，实现数据流量卸载、本地业务处理，满足数据不出场、超低时延等业务需求，为客户提供专属网络服务。

随着轨道交通智慧化、网络化、数字化发展，构建具有高精度定位网、高精度时间同步网的 5G 公专网络和 LTE-M（Long Term Evolution for Metro，这里指技术上可长期演进的、服务于城市轨道交通的车地通信系统）网络；应用“北斗 +5G”等时空技术助力旅客服务质量提升、智慧车站建设、智能装备换代、智能运维推广的轨道交通网络化运营新时代即将到来。

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Commentary

Spatial-temporal Technology Revolution of Rail Transit

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On 17th March, 2022, Beidou Navigation Satellite System (BDS) major special project — Beidou railway industry comprehensive application demonstration project successfully passed the national accreditation after 2 years. On 20th March, 2022, the national key research technology — metro BDS Capital Airport Express demonstration application research project held opening ceremony. The first metro BDS launched its construction on Beijing Capital Airport Express, which is the domestic indoor navigation positioning system of the largest scale at the moment, scheduled for completion within this year. Application of BDS technology project in high-speed railway passing accreditation, and construction of applying BDS technology project in metro, both mark the upcoming revolution faced by domestic rail transit technology empowered by spatial-temporal technologies including 'BDS + 5G'.

Based on National Development and Reform Commission engineering project, China National Railway Group Limited has established a railway BDS application service platform, facing the three stages of railway investigation and surveying design, construction, operation and maintenance, demonstration application is carried out in 9 railway business sections including railway engineering measurement, automatic monitoring system, smart construction site system, position perception early-warning protection system, railway public work inspection, track measurement and regularity test, positioning and tracking of 'Belt & Road' China-Europe Railway Express containers, high resolution remote sensing geological investigation, high-speed railway train control system. BDS No. 3 high precision positioning and BDS short-message communication technology are applied in application scenario of railway train approaching early-warning. The demonstration project has synchronously accomplished 71 items of BDS intellectual property deployment and patent early-warning, having devised 4 items of enterprise standard technical documents, prompting the deep mergence of 2 'national name cards' China BDS and China High-speed Railway.

Temporal standard and spatial positioning information has become the basis for smart urban rail construction featuring Internet of Things, artificial intelligence, and big data application. The mentioned BDS application in railway is mainly for exposure space, and for a long period of time, the positioning, navigation, time service and telecommunication of hidden space have been considered worldwide technological difficulty, becoming the bottleneck preventing smart urban rail from adopting BDS technology. Building high-precision positioning network, high-precision time synchronization network, high-volume telecommunication network and spatial digital platform based on BDS provides fundamental support for smart urban rail construction.

Metro BDS is major auxiliary demonstration project of national key research and development project-mega city urban rail transit system high-efficiency transportation and safe service key technological projects. Based on BDS smart positioning and navigation, it can be applied in metro scenarios including site tour, maintenance allocation, auxiliary construction, high-efficiency coordination. The Capital Airport Express demonstration project covers operating lines of 30 km and 5 stations. After deployment, the metro station underground space positioning precision is elevated to 2 m, realizing panorama map guidance and high-precision positioning and navigation. With the completion of BDS, the precision of global spatial positioning in 2025 will be elevated to cm grade. By comprehensively applying technologies including 'BDS + 5G + cloud platform', a temporal-spatial system network composed of high-precision positioning network, high-precision time synchronization network, high-volume telecommunication network and urban rail cloud platform is established. The barrier between urban rail exposure space and hidden space is knocked down. Urban rail temporal-spatial baseline information network is formed and is adopted as infrastructure for smart urban rail construction and operation, providing unified, continuous spatial-temporal information, positioning, time service and telecommunication service for urban rail.

Transportation data is typical temporal-spatial data, which not only has temporal dimension property, but also strong dependency on spatial dimension. With the merged development among different rail transit information system, high-precision spatial positioning and temporal standard information is extremely important. Currently, China is constructing a comprehensive PNT (positioning, navigation, and timing) system based on BDS system, which utilizes multiple PNT information sources based on different principles. Through cloud platform control, multi-sensor contemporary integration and multi-source data fusion, unified temporal-spatial baseline are generated, and coverage of fields including indoor, under water, deep space is realized.

There are over 20 billion passengers riding urban rail transit yearly. Mobile internet access is extremely demanding by passengers on metro. Urban rail transit has natural advantages on introducing 5G public network. The 5G specialized application of urban rail can realize business logical isolation and achieve prioritization and flexible deployment accordingly of guaranteed requirements of specified internet speed, time delay and reliability, through WAN slicing of 5G public network, and measures including QoS, network slicing. Through LAN slicing, using edge calculation technology, it is also expected to realize data flow uninstallation and local business treatment, and to meet business demands of data unshown and super-low time delay, providing specialized network service for customers.

With rail transit intelligentized, networking and digitalized development, 5G public network and LTE-M network with high-precision positioning network, high-precision time synchronization network is constructed. The new rail transit networking operation era of applying temporal-spatial technology such as 'BDS + 5G' to advance passenger service quality elevation, smart station construction, smart equipment upgrading, smart operation and maintenance promotion is upcoming. **Translated by ZHANG Liman**