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机场捷运（APM）与传统地铁的差异化设计逻辑及互鉴启示
Differentiated Design Logic and Mutual Learning Insights Between APM and Traditional Subway

——聚焦场景需求，探索互鉴路径Focus on Scenario Needs and Explore Paths for Mutual Learning

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Bombardier NUG Signalling Solutions Co., Ltd. (hereinafter referred to as “BNS”) is a joint venture between Bombardier Transportation Sweden AB and New United Group Co., Ltd., which was established in June 2015. BNS specializes in the integration of urban rail transit signalling system and weak / electromechanical systems centered on signalling systen which can provide one-stop, comprehensive solutions for new line construction, upgrading & maintenance of existing lines, and operation & maintenance for domestic and foreign users.

1.核心差异：服务场景与定位

•Core Differences:

Service Scenarios and Positioning

2.机场捷运（APM）的针对性设计

•Targeted Design of APM

3.两者互鉴启示与总结

•Mutual Learning Insights and Summary

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	机场捷运 （APM-Automated People Mover）	传统地铁 （Subway）
服务场景 Service Scenario	机场枢纽旅客转运 Airport Hub Passenger Transfer	城市全域通勤出行 Urban-wide Commuting
客流特征 Passenger Flow Characteristics	精准分类、波动极强 Precise Classification, Strong Fluctuation	大众化、多目的地 Popularized, Multi-destination
功能定位Functional Positioning	高效、安全、高服务品质 Efficient, Safe, High Service Quality	覆盖广、满足日常通勤 Wide Coverage, Meeting Daily Commuting
关键逻辑 Key Logic	匹配航班动态，聚焦短距离快周转 Matching Flight Dynamics, Focusing on Short-distance and Fast Turnover	适配城市人流，保障全域可达性 Adapting to Urban Passenger Flow, Ensuring Universal Accessibility

（一）服务要求：严苛的时效性与舒适性（Service Requirements: Strict Timeliness and Comfort）

1. 时效性设计（Timeliness Design）

•核心目标：匹配航班时刻表，压缩等候时间，满足短距离快周转

•Core Goal: Match flight schedules, reduce waiting time, and meet the needs of short-distance and fast turnover

•具体方案：Specific Plans

•信号系统：ATP 子系统用移动闭塞技术，优化折返与道岔防护逻辑，最小行车间隔≤90 秒

•Signal System: The ATP (Automatic Train Protection) subsystem adopts moving block technology, optimizes turnback and turnout protection logic, with a minimum train headway of ≤ 90 seconds

•ATO 子系统：自动完成启动、加速、制动、灵活停靠与开关门，无需司机或者中控干预

•ATO (Automatic Train Operation) Subsystem: Automatically completes startup, acceleration, braking, flexible docking, and door opening/closing without the need for driver or central control intervention

•航班信息互联：信号系统联机场航班系统，通过客流预测调整发车间隔与编组（航班密集缩间隔，延误延运营）

•Flight Information Interconnection: The signal system is linked with the airport flight system, and adjusts train intervals and marshalling through passenger flow prediction (shortens intervals during peak flight periods and extends operation time in case of flight delays)

•可靠性原则：以高可靠性和高可维护性，保证系统运行无中断，保障场内高效中转需求

•Reliability Principle: Ensure uninterrupted system operation with high reliability and maintainability to meet the demand for efficient on-site transfer

2. 舒适性设计（Comfort Design）

•核心目标：优化启动制动体验，控制震动与噪声

•Core Goal: Optimize the experience of startup and braking, and control vibration and noise

•具体方案：Specific Plans

•车辆制式：采用胶轮等低震动、低噪声设计

•Vehicle System: Adopts low-vibration and low-noise designs such as rubber tires

•控制逻辑：按线路坡度、曲率等优化启动 / 制动 / 加减速逻辑；信号系统设多运行等级与专用参数接口，适配车辆工况

•Control Logic: Optimize the logic of startup/braking/acceleration/deceleration based on line slope, curvature, etc.; the signal system sets multiple operation levels and dedicated parameter interfaces to adapt to vehicle operating conditions

（二）客流管理：精准分类与波动适配（Passenger Flow Management: Precise Classification and Fluctuation Adaptation）

1. 客流分类设计（Passenger Flow Classification Design）

•核心需求：按“安检状态（已检 / 未检）+ 出入境类型（国内 / 国际）”隔离，避免交叉混流

•Core Requirement: Isolate passengers according to "security check status (checked/unchecked) + entry-exit type (domestic/international)" to avoid cross-flow

•具体方案：Specific Plans

•车辆结构：固定编组（贯通车厢），灵活编组（独立车厢），可设独立隔离分区，编组内各车厢可设置不同的属性

•Vehicle Structure: Supports fixed marshalling (through carriages) and flexible marshalling (independent carriages), with configurable independent isolation zones; each carriage within a marshal can be assigned different attributes

•门控系统：信号车门和站台门控制系统，支持单组站台门 / 车厢门独立控制

•Door Control System: Signal-controlled carriage door and platform door system, supporting independent control of individual sets of platform doors/carriage doors

•参数预设：信号系统支持根据各种运营工况预设所需的参数，包括预设进路、预设车辆编组属性、预设站台停车位置、预设上下客开门顺序等。中控操作员可以根据运营需求选取不同的预设配置。

•Parameter Presetting: The signal system supports presetting of required parameters for various operating conditions, including preset routes, vehicle marshalling attributes, platform parking positions, and passenger boarding/alighting door opening sequences; central control operators can select different preset configurations based on operational needs

2. 客流波动适配（Passenger Flow Fluctuation Adaptation）

•核心需求：应对航班 / 季节导致的单日多高峰、低谷空驶问题

•Core Requirement: Address the issue of multiple daily peak hours and empty running during off-peak hours caused by flights/seasons

•具体方案：Specific Plans

•灵活编组：车辆可灵活编组，信号系统快速设置编组变化

•Flexible Marshalling: Vehicles can be flexibly marshalled, and the signal system quickly sets marshalling changes

•共线运营：支持多种编组列车共线运行

•Collinear Operation: Supports collinear operation of trains with multiple marshalling types

•动态调图：RATP/RATO/ATS 子系统实时监控列车状态，动态调整运行图。

•Dynamic Schedule Adjustment: The RATP (Railway Automatic Train Protection)/RATO (Railway Automatic Train Operation)/ATS (Automatic Train Supervision) subsystems monitor train status in real time and dynamically adjust the operation schedule

•混跑模式：固定编组与灵活编组列车混跑，最大化资源利用率，节约能源

•Mixed Operation Mode: Mixed operation of fixed-marshalling and flexible-marshalling trains to maximize resource utilization and save energy

（三）组织运营：全天候灵活调度（Operational Organization: All-weather Flexible Dispatching）

1. 24 小时精准控制（24/7 Precise Control）

•核心目标：全时段匹配旅客 “按航班时间规划换乘” 需求

•Core Goal: Match passengers' demand for "transfer planning based on flight time" at all times

•具体方案：Specific Plans

•实时监控：监控列车速度、位置、载客量，结合航班动态优化参数，到站时间误差≤10 秒

•Real-time Monitoring: Monitor train speed, position, and passenger capacity, optimize parameters based on flight dynamics, with arrival time error ≤ 10 seconds

•自动调整：对比实时轨迹与计划，自动调整运行等级、停站时间，减少延误

•Automatic Adjustment: Compare real-time trajectory with plan, automatically adjust operation level and stop time to reduce delays

2. 多模式灵活切换（Multi-mode Flexible Switching）

•核心需求：高峰 / 低谷、不同站点间切换穿梭 / 单环 / 多环模式

•Core Requirement: Switch between shuttle/single-loop/multi-loop modes between peak/off-peak hours and different stations

•具体方案：Specific Plans

•实时调控：中控按客流调列车数量、编组、运行等级、交路，列车自动按预设参数运行

•Real-time Regulation: The central control adjusts the number of trains, marshalling, operation level, and route based on passenger flow, and trains operate automatically according to preset parameters

•峰谷适配：高峰用最大编组，低谷减列车 / 编组（如 2 节编组跑圈），降低人力压力

•Peak-Valley Adaptation: Use maximum marshalling during peak hours, reduce the number of trains/marshalling during off-peak hours (e.g., 2-car marshalling for loop operation) to reduce labor pressure

•夜间服务：“站厅呼叫” 功能，待命车辆自动接客，平衡服务与节能

•Night Service: "Hall Call" function, where standby vehicles automatically pick up passengers to balance service and energy conservation

（四）集成化设计：突破传统限制的尝试（Integrated Design: Attempts to Break Traditional Limitations）

1.早期无人驾驶：固定闭塞时代即实现全自动（如北京首都机场 2008 年 APM，CITYFLO550 系统）

•Early Unmanned Driving: Fully automatic operation was realized in the fixed block era (e.g., the 2008 APM of Beijing Capital Airport, using CITYFLO550 system)

2.逻辑集成：将联锁、闭塞逻辑整合到 RATC 系统，ATP 承担道岔控制、进路开放等功能

•Logic Integration: Integrate interlocking and block logic into the RATC (Railway Automatic Train Control) system, and the ATP undertakes functions such as switch control and route opening

3.设备精简：取消计轴、有源应答器等轨旁设备，靠列车自主定位 + 车地无线网络实现 ATP 精准防护

•Equipment Simplification: Cancel wayside equipment such as axle counters and active balises, and realize precise ATP protection through train autonomous positioning + train-ground wireless network

（一）互鉴启示（Mutual Learning Insights）

1. 以 “用户需求” 重新定义技术路线（Redefine Technical Routes Based on "User Needs"）

•现状：传统地铁受历史沿革、既有标准限制，定制空间小

•Current Situation: Traditional subways are restricted by historical evolution and existing standards, with limited customization space

•启示：机场捷运（APM）在保障安全的同时优先用户需求，传统地铁可审视现有限制，增加需求导向的技术定制空间

•Insight: APM prioritizes user needs while ensuring safety; traditional subways can review existing restrictions and increase demand-oriented technical customization space

2. 降本增效与安全的平衡之道（The Way to Balance Cost Reduction, Efficiency Improvement and Safety）

•传统地铁痛点：依赖轨道电路、计轴等设备，存在冗余、运维复杂、改造难问题

•Pain Points of Traditional Subways: Relying on equipment such as track circuits and axle counters, with problems of redundancy, complex operation and maintenance, and difficult transformation

•启示：借鉴机场捷运（APM）集约化设计，用 RATC 系统整合定位、检测、传输功能；案例：上海 6 号线改造取消传统轨旁设备，精简布置；上海8号线三期和广州珠江新城APM，以APM作为传统地铁运能补充；

•Insight: Learn from the intensive design of the Airport Automated People Mover (APM), and integrate positioning, detection, and transmission functions through the RATC system;Cases: The renovation of Shanghai Metro Line 6 has eliminated traditional wayside equipment to simplify the layout; Shanghai Metro Line 8 Phase III and Guangzhou Zhujiang New Town APM have adopted APM as a supplement to the transport capacity of traditional subways.

3. 更高效精准的运营调节（More Efficient and Precise Operational Regulation）

•城市需求：大型城市对地铁承载能力、运营效率要求提升，需适配客流规律变化

•Urban Demand: Large cities have higher requirements for subway carrying capacity and operation efficiency, and need to adapt to regular changes in passenger flow

•启示：机场捷运（APM）在 “三站两区间” 有多年精准运营实践（如动态调编组、自动调运行图），传统地铁可借鉴系统介入调节，减少人工干预

•Insight: APM has years of precise operation experience in the "three-station and two-section" scenario (e.g., dynamic marshalling adjustment, automatic operation schedule adjustment); traditional subways can learn from system intervention for regulation to reduce manual intervention

（二）总结（Summary）

•机场捷运（APM）与传统地铁同源异流，差异源于场景需求，技术演化可相互赋能

•APM and traditional subway share the same origin but develop in different directions; differences stem from scenario needs, and technological evolution can empower each other

•未来方向：以场景为核心，融合两者优势，推动轨道交通系统向更高效、精准、人性化发展

•Future Direction: With scenarios as the core, integrate the advantages of both to promote the development of rail transit systems towards higher efficiency, precision, and humanization

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