

A physical infrastructure required for a BRT, LRT and separated lane systems;

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Sustainable Transportation within the Framework of Green Deal - SPHERE

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Agenda

- Introduction
- Bus Rapid Transit (BRT) Infrastructure Requirements
- Light Rail Transit (LRT) Infrastructure Requirements
- Separated Lane Systems Infrastructure Requirements

Introduction

Efficient transportation infrastructure is essential for sustainable urban mobility and economic development. As cities continue to grow, conventional transportation systems face increasing challenges such as traffic congestion, environmental pollution, and limited accessibility. To address these issues, modern urban transportation planning has focused on developing high-capacity and sustainable transit systems.

Bus Rapid Transit (BRT), Light Rail Transit (LRT), and separated lane systems have emerged as important solutions for improving urban mobility. These transportation systems require specialized physical infrastructure, including dedicated corridors, stations, signaling systems, safety facilities, and supporting operational infrastructure. Proper planning and implementation of these systems can significantly enhance transportation efficiency, reduce travel times, improve safety, and promote environmentally sustainable urban development.

This presentation examines the physical infrastructure requirements of BRT, LRT, and separated lane systems, highlighting their key components, design principles, and their role in developing efficient and sustainable transportation networks.





Physical Infrastructure Requirements of BRT, LRT and Separated Lane Systems

A comprehensive engineering analysis of the civil, structural, and systems infrastructure required to design, construct, and operate high-capacity urban transit corridors — covering Bus Rapid Transit, Light Rail Transit, and dedicated separated lane systems.

TRANSPORTATION ENGINEERING

URBAN TRANSIT INFRASTRUCTURE

CIVIL ENGINEERING

PHYSICAL INFRASTRUCTURE REQUIREMENTS OF BRT, LRT AND SEPARATED LANE SYSTEMS



1 BUS RAPID TRANSIT (BRT) INFRASTRUCTURE REQUIREMENTS



BRT systems use dedicated infrastructure to provide fast, reliable, comfortable and high-capacity bus services.



KEY INFRASTRUCTURE ELEMENTS

- Dedicated BRT lanes
- BRT stations & platforms
- Off-board fare collection
- Traffic signal priority
- High-quality shelters & amenities
- Bus depots & maintenance facilities
- Park & ride facilities

TYPICAL BRT CROSS-SECTION



BRT NETWORK CONCEPT



TYPICAL BRT STATION



2 LIGHT RAIL TRANSIT (LRT) INFRASTRUCTURE REQUIREMENTS



LRT systems operate on rail infrastructure and provide high-capacity, reliable and sustainable urban mobility.



KEY INFRASTRUCTURE ELEMENTS

- Dedicated rail tracks & corridors
- LRT stations & platforms
- Power supply systems (OHE)
- Signaling & control systems
- Level crossings & protection
- Maintenance & storage facilities
- Operations control center

TYPICAL LRT CROSS-SECTION



LRT NETWORK CONCEPT



LRT STATION EXAMPLE



3 SEPARATED LANE SYSTEMS INFRASTRUCTURE REQUIREMENTS



Separated lane systems provide safe, efficient and sustainable mobility for bicycles, buses and pedestrians.



KEY INFRASTRUCTURE ELEMENTS

- Dedicated bus lanes
- Protected bicycle lanes
- Wide pedestrian pathways
- Physical separators / curbs
- Clear pavement markings & signs
- Safe crossings & intersections
- Smart traffic management

TYPICAL SEPARATED LANE CROSS-SECTION



SEPARATED LANE NETWORK



EXAMPLE: PROTECTED BIKE LANE



BENEFITS OF WELL-DESIGNED INFRASTRUCTURE



Higher capacity



Improved safety



Travel time reliability



Environmental sustainability



Enhanced quality of life

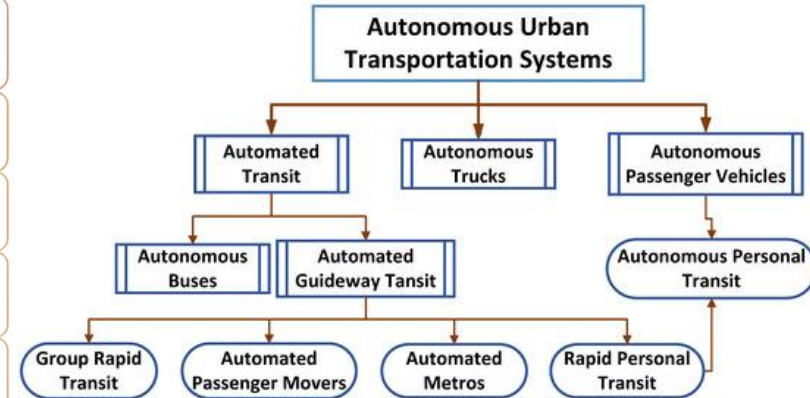
Note: Infrastructure design should be context-sensitive, integrated with land use planning, and built for future scalability.



Comparative Overview: Three Transit Infrastructure Systems

Modern urban mobility demands transit solutions that balance capacity, speed, cost, and land use. Three dominant corridor-based systems have emerged: **Bus Rapid Transit (BRT)**, **Light Rail Transit (LRT)**, and **Separated Lane Systems** (including cycle highways and autonomous vehicle corridors). Each carries distinct physical infrastructure requirements across right-of-way, pavement, stations, power, and signalling.

	BRT (Bus Rapid Transit)	LRT (Light Rail Transit)	Separated Lane Systems
RIGHT-OF-WAY WIDTH	rubber-tyred vehicles, flexible alignment	steel-wheel-on-rail, fixed guideway	dedicated corridors for cycles or AVs
PAVEMENT TYPE	asphalt or concrete pavement	ballasted or slab track	minimal structural works
STATION COMPLEXITY	moderate capital cost	high capital cost	lowest capital cost
POWER SUPPLY	20-40 year lifespan	40-60 year lifespan	15-25 year lifespan
SIGNALLING			
CONSTRUCTION TIMELINE			



Bus Rapid Transit (BRT) — Infrastructure Requirements

Bus Rapid Transit is a high-capacity, bus-based transit system that combines the flexibility of road transport with the speed and reliability of rail. Its infrastructure must support high-frequency, high-capacity operations with minimal interference from general traffic. Key design standards are governed by the **ITDP BRT Standard** and national highway design manuals.

Right-of-Way & Corridor Geometry

A minimum corridor width of **25–40 metres** is required for a two-lane BRT system with centre-running alignment. This accommodates two 3.5m bus lanes, 1.5m safety shoulders, station platforms (3–5m), pedestrian access, and drainage margins. Centre-running alignments are preferred for operational efficiency and reduced conflict with turning traffic. Horizontal curve radii must not fall below **30m** for standard 12m buses and **50m** for articulated 18m vehicles.

Pavement & Structural Design

BRT pavements must withstand repeated heavy axle loads (up to 13 tonnes per axle). Structural pavement thickness typically ranges from **400–600mm**, comprising a compacted subgrade, granular sub-base (150–200mm), crushed stone base (200–250mm), and a dense-bituminous macadam or concrete surface course. Concrete pavements (C35/45 grade) are increasingly specified for high-frequency corridors due to superior durability and reduced maintenance cycles.

Station Infrastructure

BRT stations require **level boarding platforms** at 900mm above rail level, matching bus floor height. Platform lengths must accommodate the longest vehicle in the fleet (typically 18–25m for articulated or bi-articulated buses). Stations incorporate weather shelters, real-time passenger information displays, fare collection gates, CCTV, and accessible ramps compliant with disability legislation. Spacing between stations is optimised at **500–800m** to balance access and speed.

BRT — Drainage, Signalling, Depots & Civil Works

Drainage & Utilities

Effective longitudinal and cross-fall drainage is critical to prevent pavement deterioration. Side drains with minimum **1:40 gradient**, catch pits at 30m intervals, and sub-soil drainage beneath the pavement structure are standard. Utility diversions (water, gas, electricity, telecoms) often represent **15–25%** of total corridor construction cost and must be coordinated early in the design phase.

Traffic Management & Signalling

BRT corridors employ **Transit Signal Priority (TSP)** systems that communicate with traffic lights to extend green phases or reduce red phases for approaching buses. Dedicated signal heads, inductive loop detectors, and fibre-optic communication networks are embedded within the corridor. Physical segregation is achieved through concrete kerbs, bollards, or landscaped medians.

Depot & Maintenance Facilities

BRT depots require a minimum area of **2,000–5,000 m²** depending on fleet size, incorporating bus parking bays, refuelling or electric charging infrastructure, inspection pits, wheel-wash facilities, and administrative offices. Electric BRT fleets require high-voltage substation connections and on-route pantograph or depot-based charging infrastructure.

Civil Structures

Where BRT corridors cross existing infrastructure, grade-separated structures are required. Standard underpasses require minimum clearances of **5.0m vertical** and **10.5m horizontal**. Retaining walls (reinforced concrete or mechanically stabilised earth) are needed where the corridor is depressed. Bridge structures must be designed to **HA loading** or equivalent national standards.

Environmental Mitigation

Noise barriers (minimum 3m height), sustainable urban drainage systems (SUDS), and ecological corridors must be integrated where the BRT alignment passes through sensitive areas.

Light Rail Transit (LRT) — Infrastructure Requirements

Light Rail Transit is a steel-wheel-on-rail urban transit mode offering higher capacity, smoother ride quality, and longer asset life than BRT. LRT infrastructure is substantially more complex, requiring permanent way construction, electrification, signalling, and structural civil works. Design standards include EN 13848 (track geometry), AREMA guidelines, and national rail infrastructure codes.

Track & Permanent Way

LRT track comprises two parallel steel rails (typically 54E1 or 60E1 profile) fixed to sleepers on a prepared formation. Ballasted track uses crushed granite (25–50mm grading) at 300mm depth; slab track uses reinforced concrete (C40/50) with resilient rail fastenings. Standard gauge is 1,435mm. Minimum horizontal curve radius is 25m for street-running and 150m for segregated sections. Superelevation (cant) of up to 150mm is applied on curves to counteract centrifugal forces.

Overhead Line Equipment (OLE)

LRT systems operate on 750V DC (most common) or 1,500V DC electrification. The OLE comprises contact wire (107mm² copper or copper-alloy), messenger wire, droppers, registration arms, and cantilever supports at 50–60m intervals. Section insulators divide the network into electrically isolated zones. Substations are located every 2–4km along the route, each requiring a 33kV or 11kV AC supply from the national grid, with rectifier transformers converting AC to DC.

Platforms & Stations

LRT platforms are typically 30–60m long (accommodating 2–3 car trains) and 900mm above rail level for level boarding. Platform canopies, tactile paving, passenger information systems, and step-free access are mandatory. Underground or elevated stations require additional structural investment including cut-and-cover tunnels, retaining walls, ventilation shafts, or viaduct structures. Station spacing is typically 400–600m in urban cores.

LRT — Signalling, Depots, Structures & Ground Engineering

Signalling & Train Control

Modern LRT systems use **Communications-Based Train Control (CBTC)** or fixed-block signalling with track circuits or axle counters for train detection. Wayside signals, points (switches), and interlocking systems ensure safe route setting. Automatic Train Protection (ATP) enforces speed restrictions. Fibre-optic train-to-wayside communication networks support real-time data transmission. Level crossings at shared corridors require barrier systems with **95% reliability** and fail-safe design.

Depot & Maintenance Facilities

LRT depots require **5,000–15,000 m²** depending on fleet size, incorporating stabling sidings (minimum 150m length per track), inspection pits with 1.2m depth, wheel lathe facilities, overhead crane gantries, and high-voltage isolation sections. Depots also house the Operations Control Centre (OCC), which manages real-time train movements across the network.

Separated Lane Systems — Infrastructure Requirements

Separated lane systems encompass dedicated corridors physically isolated from general traffic, including **cycle highways**, **autonomous vehicle (AV) corridors**, and **pedestrian-priority boulevards**. While structurally less demanding than BRT or LRT, these systems require precise geometric design, robust segregation, and intelligent infrastructure to ensure safety and operational efficiency.



Cycle Highways & Protected Lanes

Separated cycle lanes require a minimum width of **2.0–3.0m** for two-way operation or 1.5m for one-way. Physical segregation is achieved through concrete kerbs, planted buffers, or flexible delineator posts. Surface materials include asphalt (AC 10 dense), coloured concrete, or resin-bound paving. Lighting must achieve **10 lux average** illuminance. Junctions require advanced stop lines, dedicated signal phases, and tactile crossings.



Autonomous Vehicle Corridors

AV-dedicated lanes require embedded **road-embedded sensors**, high-definition lane markings (reflective thermoplastic, minimum 150mm width), and roadside units (RSUs) for V2I communication. Lane width of **3.0–3.5m** is standard. Pavement evenness must meet **IRI $\leq$ 2.0 m/km** to ensure sensor accuracy. Dedicated AV corridors may incorporate inductive charging coils for electric autonomous fleets.



Pedestrian-Priority Boulevards

Shared-space and pedestrian-priority corridors require **5–15m widths** depending on footfall. Surface materials must be slip-resistant ($PSV \geq 65$). Tactile paving (blister and corduroy) is required at all transition points. Street furniture, lighting columns, and drainage must be coordinated to maintain clear pedestrian desire lines. Universal accessibility (DDA/Equality Act compliance) is mandatory throughout.

Thank you for your attention!

