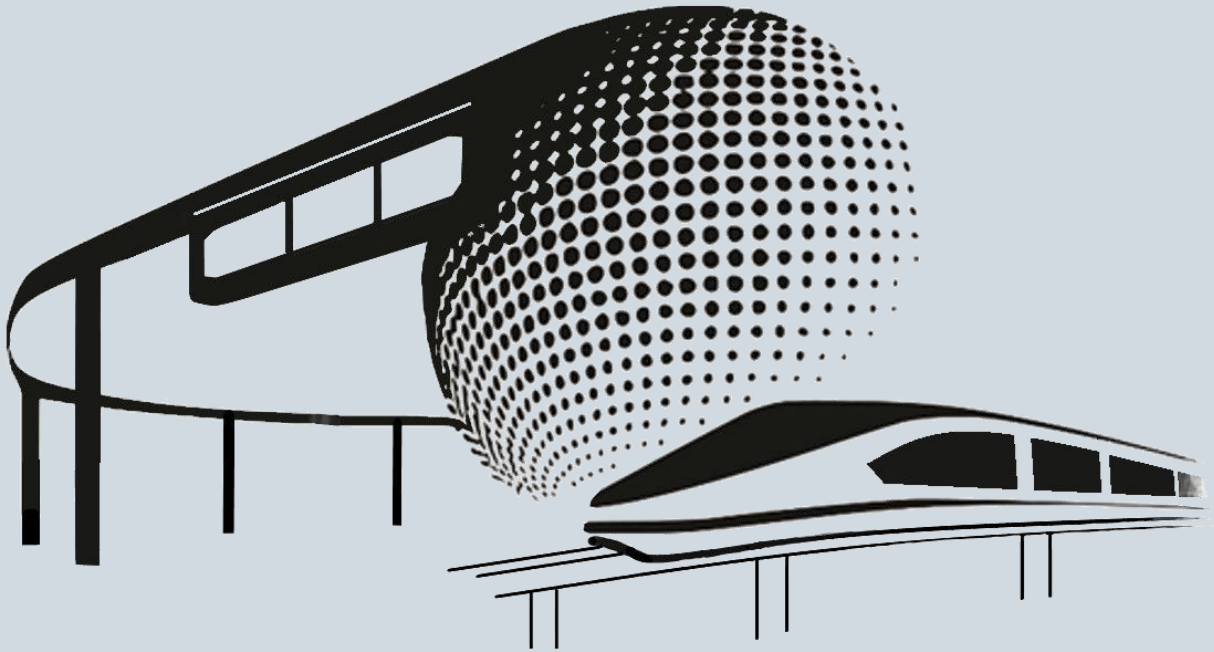


# *IMA- International Monorail Association*

SERVING THE MASS TRANSIT GLOBAL MONORAIL SECTOR

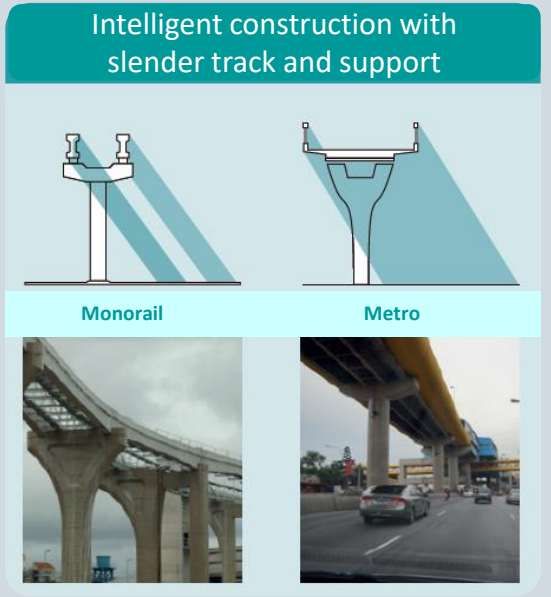
# Monorail – in context

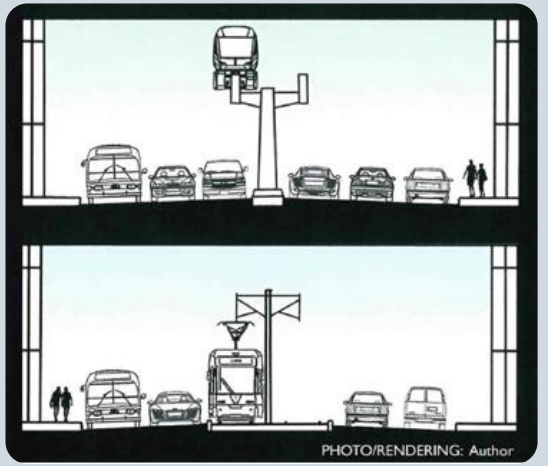
## Market trends

| Urbanisation and congestion | Automation and digital solutions | Comfort | Environmental awareness | Value for money | Safety / cyber security |
|---|---|---|---|---|---|
|  |  |  |  |  |  |
| • Increasing need for mass transit systems<br>• Space/land resources becoming scarce<br>• 24/7 Operation | • More automation, less manual work<br>• Big data collection and analysis<br>• Virtual reality<br>• Artificial intelligence | • Seamless and integrated transport connections<br>• Physical and digital passenger amenities available | • Carbon neutral, emission-free transport<br>• Higher efficiency and less energy consumption | • Life cycle cost optimization<br>• New revenue possibilities | • Increasing safety and security levels<br>• High availability |

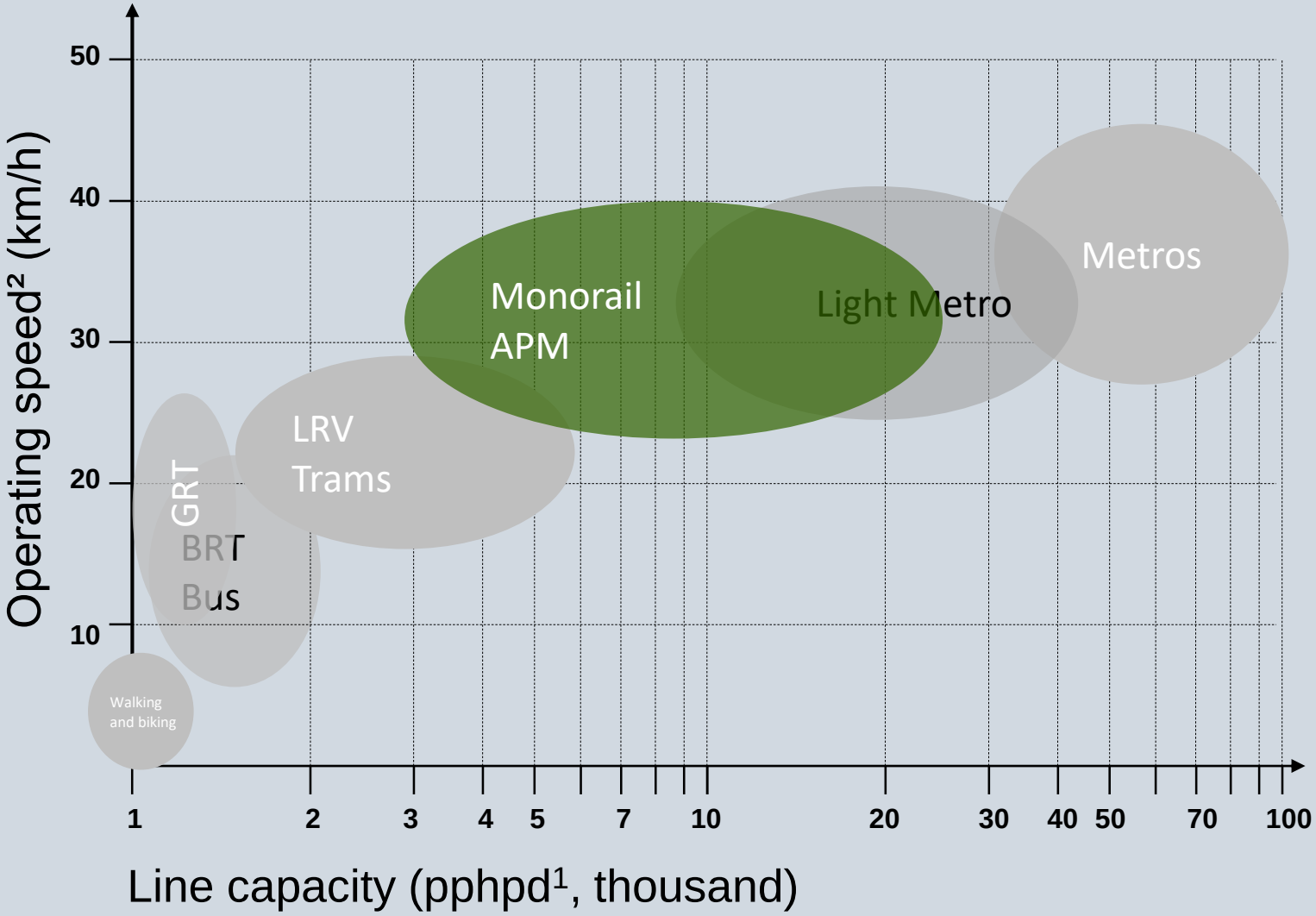
# Monorail – typical system

- Mainly elevated track
- Lower infrastructure for grade-separated systems compared to elevated or underground trams or metros
- Flexible alignment including tunnels or at-grade when needed
- Lowest land usage
- Fully automated and driverless operation (ATO)
- Short and reliable travel times
- Highest safety by ATO (Automated Train Operation) and separated guideway
- Typical passenger capacity per car of 6 pax/m² ca. 140 people per car
- Typical transport capacity of system with 4 car train and 90 sec headway is 22.400 pphpd (people per hours per direction)
- Vehicle design life of 30 years, infrastructure 100 years, and highest reliability



# Monorail – comparison speed and capacity





[pphpd][1] : Passenger per hour per direction

Boperating speed[2]: average trip time (including station time, boarding, dwell time) divided by line length for a typical route.

# Monorail – comparison capital costs with line capacity

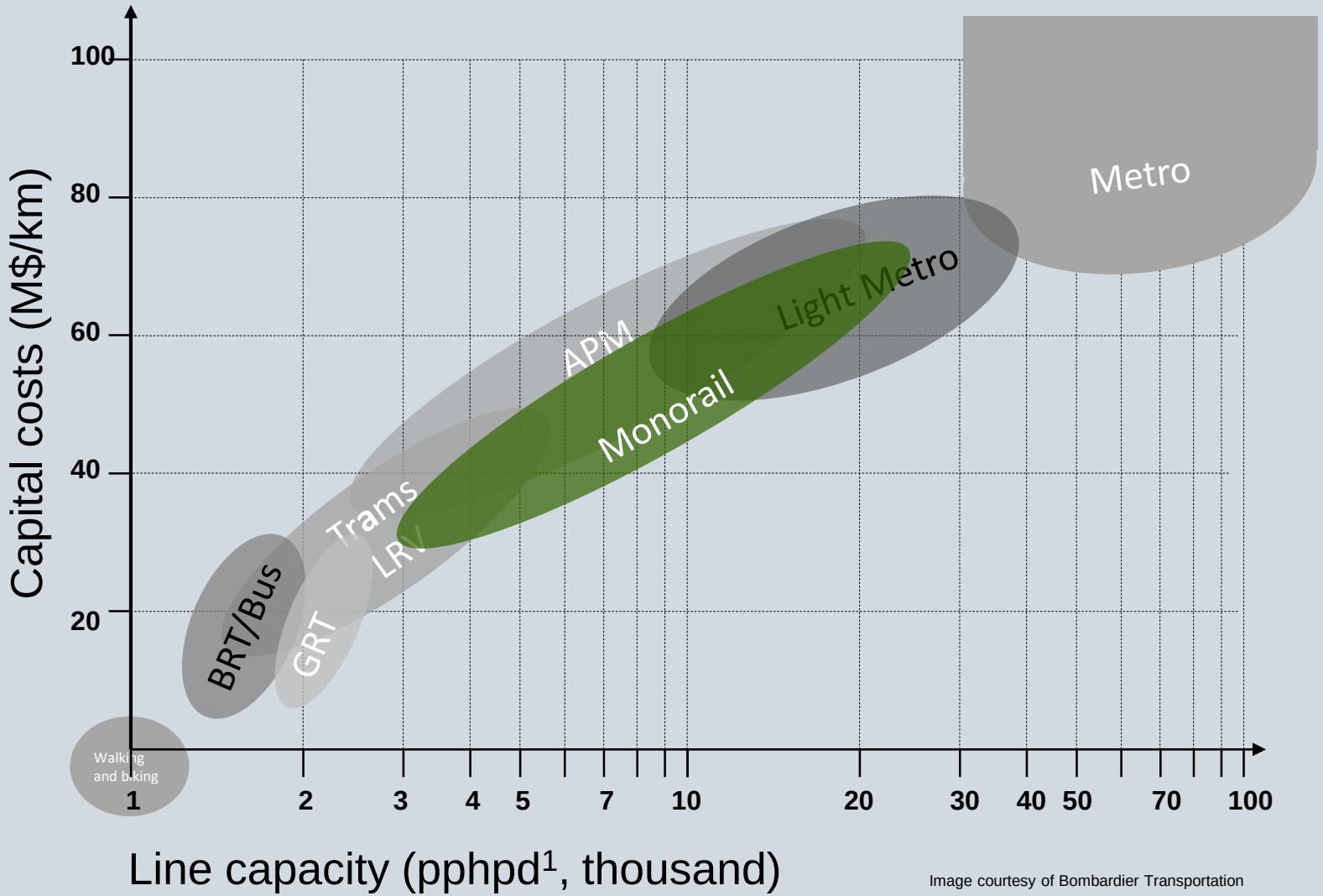



Image courtesy of Bombardier Transportation

Image courtesy of DERAP

Capital costs for each technology is depending on country and intends to give a comparison.

No operating nor maintenance cost are included.

Lower design life (GRT, BRT, Bus for 15 years) are not considered compared to rail with 30 years.

# Monorail – optimized for medium passenger capacity

- **Ideal capacity**
  - 5,000 to 25,000 pphpd
  - Feeder system to mass transit network
  - Or line haul mass transit for medium capacity lines
- **High-capacity Monorail**
  - Design capacity of Sao Paulo Line 15, a 7-car train, 48,000 pphpd. It is in the heavy metro capacity range.
  - Specific reasons such as lower capital cost, faster construction, alignment flexibility and low land acquisition.

Image courtesy of DERAP AG

Image courtesy of Alstom

# Monorail – urban fit

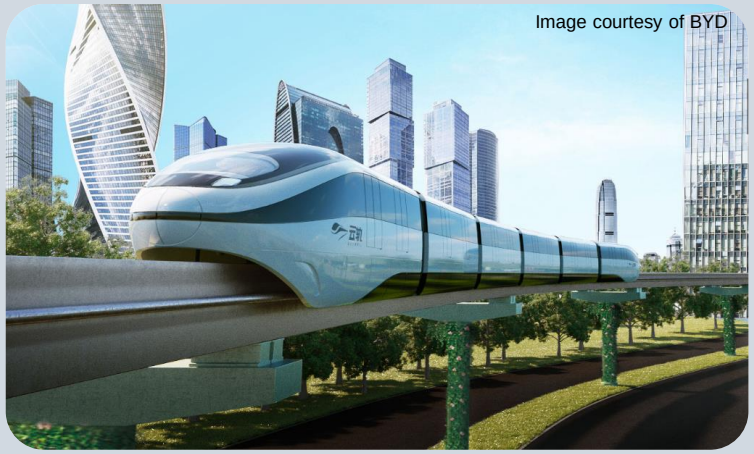


Image courtesy of BYD


Chogqin Line

- Slender guideways are easily integrated into different environments
- Low profile sleek vehicles
- Infrastructure requires minimal land expropriation
- Flexible route alignment
- Sharp curve radii and steep grades
- Designed for seamless integration with buildings and structures
- Unobtrusive stations
- Quiet vehicle operation

# Monorail – minimised infrastructure

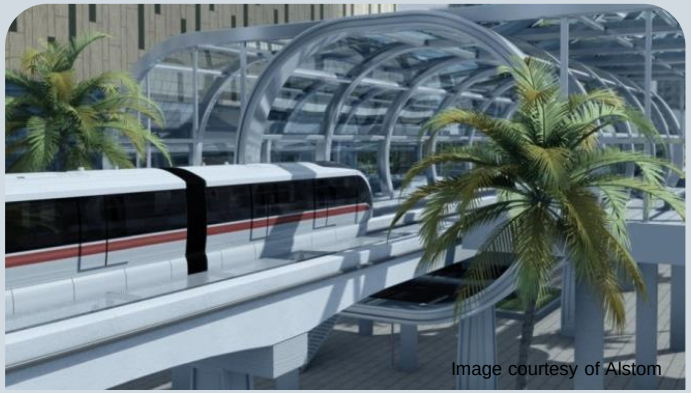


Image courtesy of Alstom

**Concrete structures provide elegant strength and durability as well as:**

- Fast and efficient construction
- Affordability
- Fire-resistance
- Low maintenance
- Full compliance to all norms and standards


Image courtesy of Hitachi

**Grade separated guide beams ensure:**

- Dedicated right-of-way unrestricted operation
- Automated driverless operation
- Accidents with surface traffic are impossible
- Derailment virtually impossible


Image courtesy of Alstom

**Evacuation walkway recommended for safe egress, providing:**

- Passenger safety
- No need for active intervention in an emergency
- Easy access for system maintenance

# Monorail – alignment capabilities

# Monorail – guide beam: cost effective, easy installation

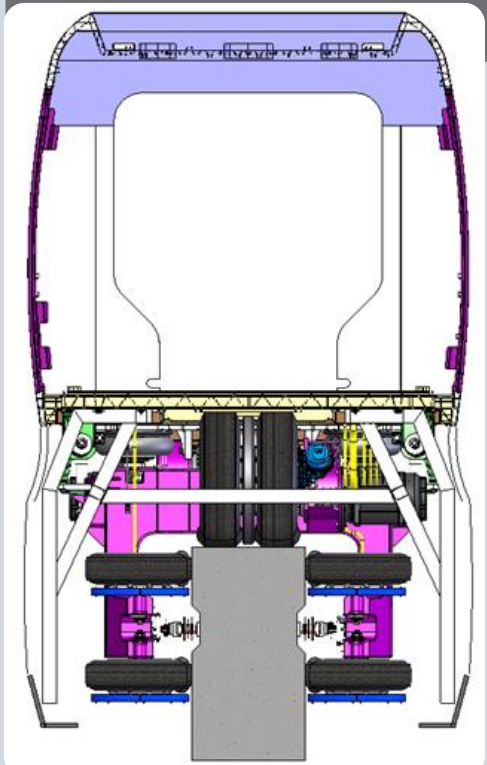
- Infrastructure developed to minimise disruption and the cost of civil construction
- Pre-cast lightweight guideway structures built off-site allow rapid assembly on site
- Low land intake / low expropriation costs reduce delays and allow for quick progress
- Elevated guideway eliminates the need for expensive and time-consuming tunnelling
  - Easy implementation into different environments (suitable for both greenfield and brownfield)

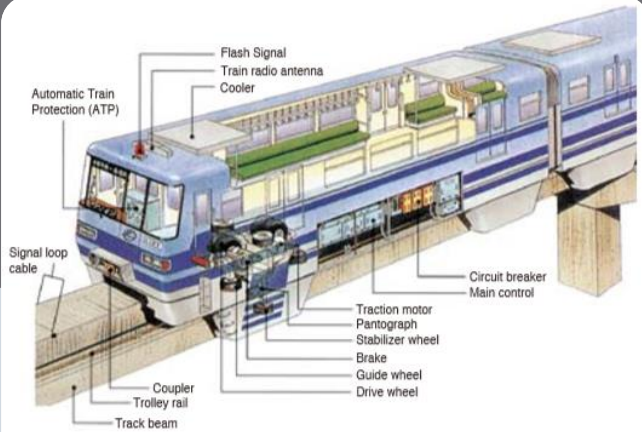
Image courtesy of Alstom

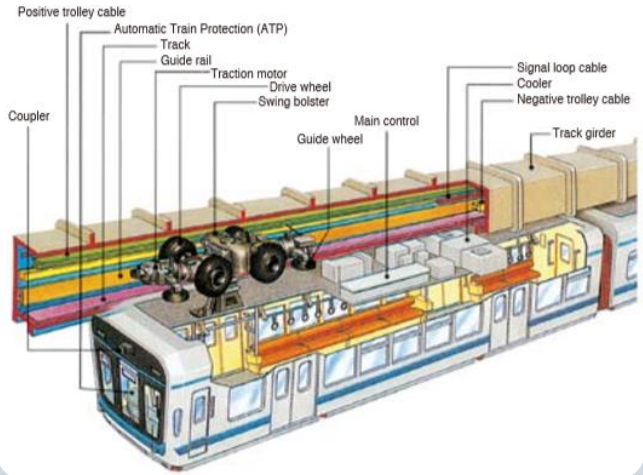
# Monorail – technologies

## Monorail - straddle

*Alweg*
**A**xel **L**ennart **WE**nner-**G**ren





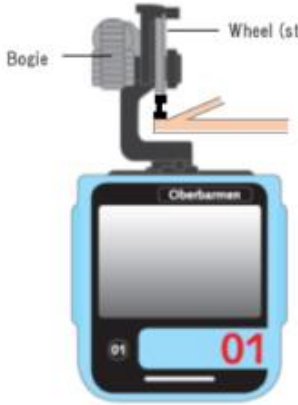

## Monorail - suspended

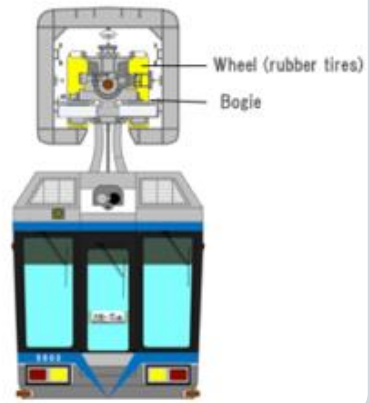
Wuppertaler Schwebebahn

Chiba Monorail

Wuppertal Suspension Railway
Eugen Langen Monorail Suspension Railway

Shonan Monorail
SAFEGE Suspended Monorail



# Monorail – current projects

**Palm Jumeirah, Dubai UAE**
Hitachi Rail Monorail
2009; 4 vehicles; 5,5 km

**Chongqing, China**
Hitachi / Chongqing Rail Transit
2011; 66 km


**São Paulo, Brazil**
*INNOVIA* Monorail 300 System
2014; 378 vehicles; 24 km

**Bangkok, Thailand**
*INNOVIA* Monorail 300 System
2021; 288 vehicles; 64.9 km

**Panama-Canal**
Hitachi Rail Monorail
Under construction; 168 vehicles; 25 km

**Cairo, Egypt**
*INNOVIA* Monorail 300 System
Under construction

# Monorail – conclusion

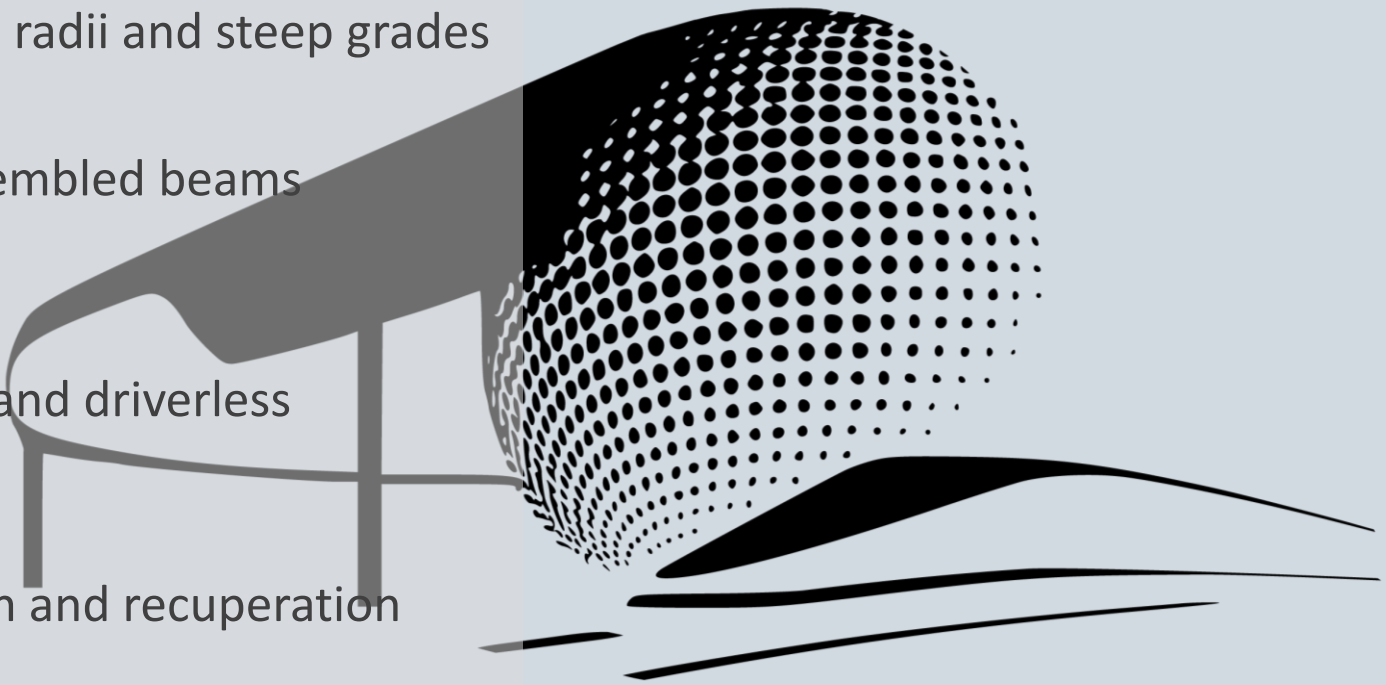
**Monorail system inherent advantages**

**Track**

- Dedicated right-of-way unrestricted operation on elevated track
- Minimal land usage by small track pillars
- Deviate existing infrastructure by small curve radii and steep grades
- Lowest shadow impact by small track beam
- Short project installation phase with pre-assembled beams

**Vehicle**

- Highest safety standards by fully automated and driverless operation
- Short waiting times by short headways
- Energy efficiency by fully electrical propulsion and recuperation
- Low noise by rubber tires



INTERNATIONAL MONORAIL ASSOCIATION