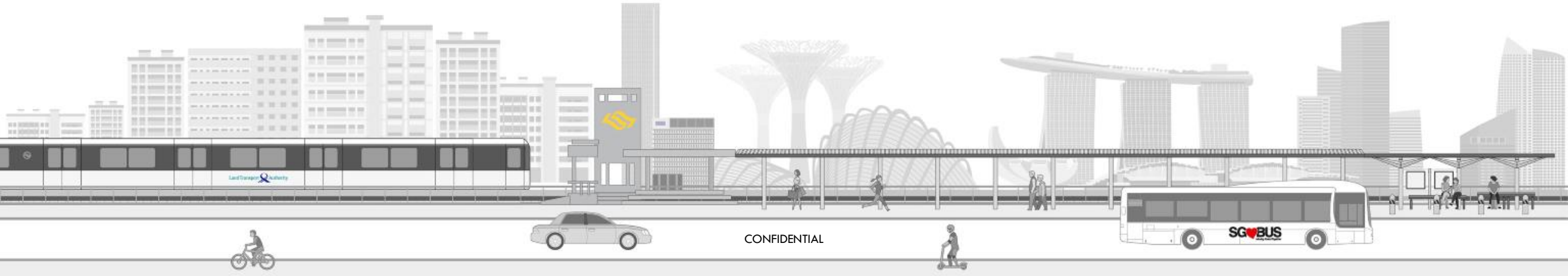
Systems Thinking in Public Transportation

Ngien Hoon Ping | Chief Executive, Land Transport Authority




We keep your world moving

Our work begins…

the moment you step out of your home

143,966
goods vehicles

102,800
street lights

143,052
Motorcycles

603,763 cars

17,554 buses

9,232 Kilometres
of roads

119 MRT stations
43 LRT stations

4,961 Bus stops &
Taxi stands

Land Area is a constraint.

Singapore

Land Area:
721.5 km^2

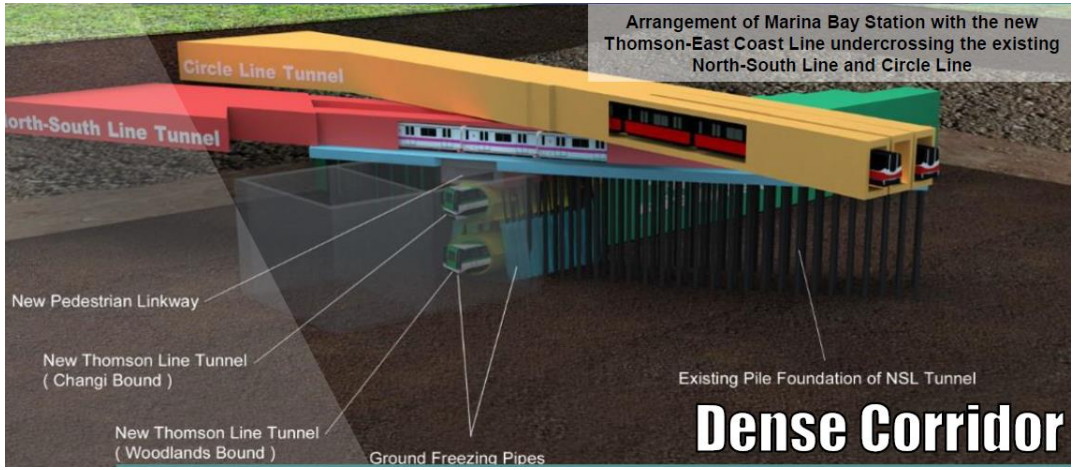
Road Use:
12% of Land Area

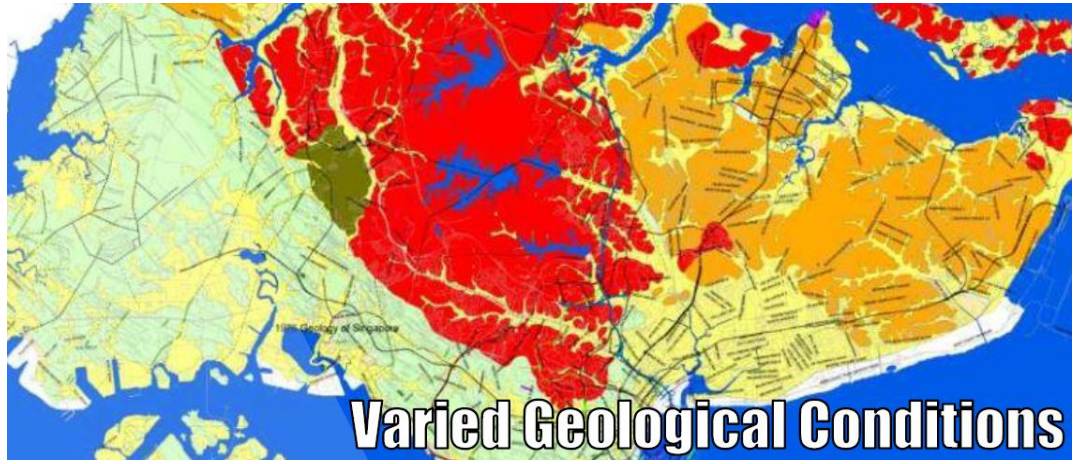
Population:
5.64mil

Nominal Gross Domestic Product : S$447.3billion

Annual Tourist Arrivals:
17.4mil

The land constraint presents many challenges.





Driving Forces

Shrinking Workforce

0.7 citizens entering to one exiting workforce

More Populous

Overall population will grow by 1 to 1.4M; higher travel demand

Ageing Population

Elderly accounts for 60% of population growth

Greater aspirations

Commuters are more vocal but also more willing to contribute

Ageing Assets

Ageing of key roads/rail assets and transport & operational technical systems

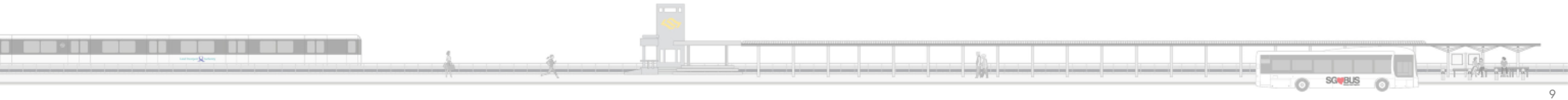
Disruptive Technologies

Rapid advancement of faster and smarter transportation technology is reshaping journeys

The Land Transport Ecosystem

> Public transport… is an **engineering problem**, where the network has to be mapped out to have the right connections and coverage, and designed for easy and effective maintenance. It is also an **economic problem**, where the various players like operators, asset owners, Government and commuters will have the right incentives to do the right things. And at an even more difficult level, public transport is a **sociopolitical problem** – an economic mobiliser and social equalizer.

-PM Lee's views on public transport
– abstract from SUTD ministerial Forum, 5 April 2018

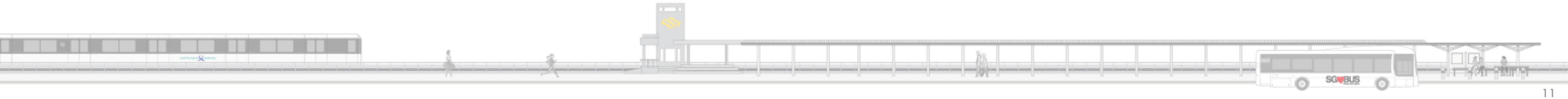


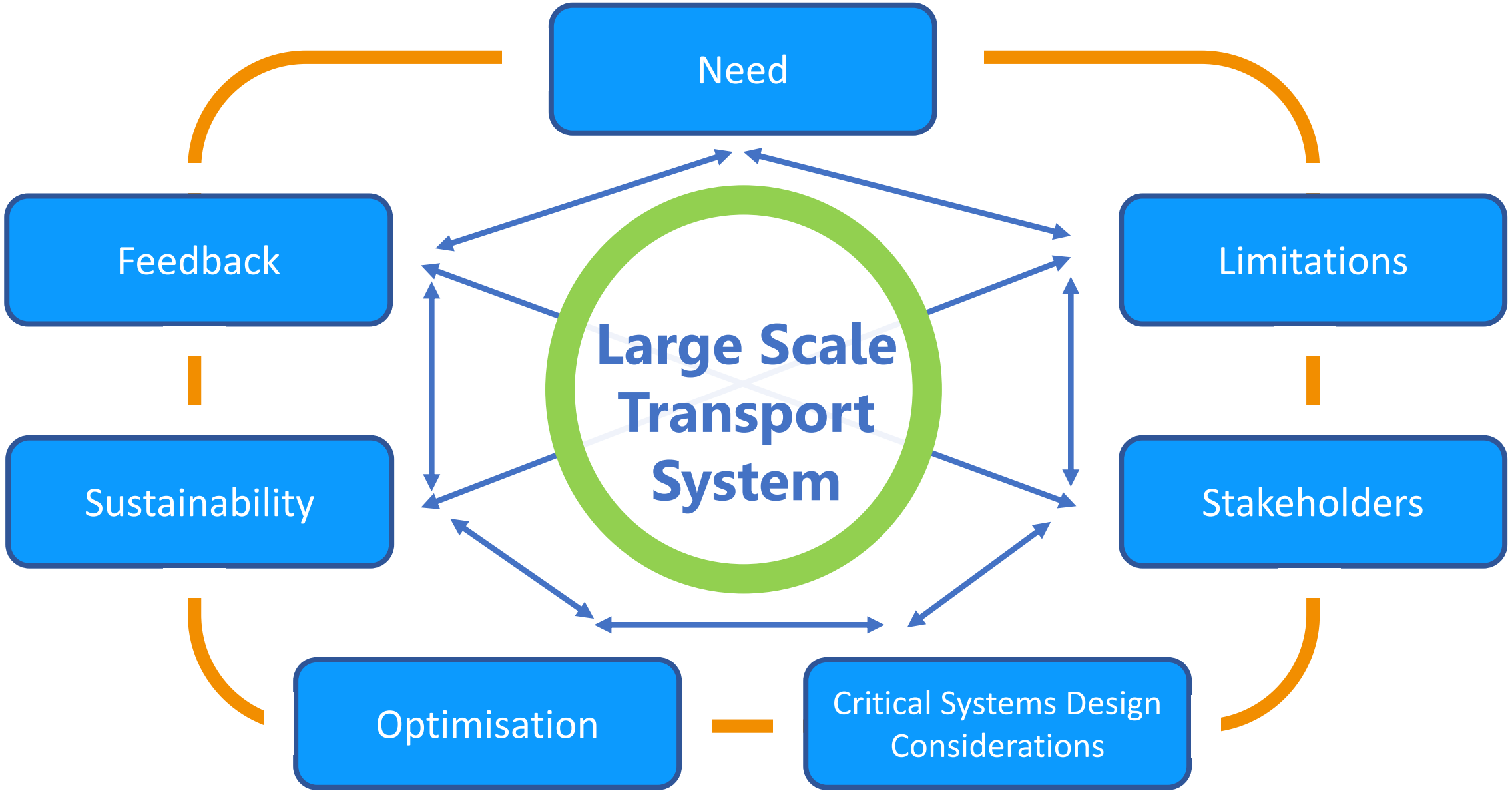
Systems Thinking

"Systems Thinking enables you to grasp and manage situations of complexity and uncertainty in which there are no simple answers. It's a way of learning your way to effective action by looking at connected wholes rather than separate parts."

"Systems Thinking is a framework for seeing interrelationships rather than things, for seeing patterns rather than static snapshots. It is a set of general principles spanning fields as diverse as physical and social sciences, engineering and management."

- International Council on Systems Engineering (INCOSE)




Need
Feedback
Limitations
Large Scale Transport System
Sustainability
Stakeholders
Optimisation
Critical Systems Design Considerations

Walk Cycle Ride SG as our strategy

WCRSG envisions a land transport system that meets the needs of commuters and businesses through *a host of quality options*.

Rail Reliability

Network Effectiveness

Working with our Partners

Rail Reliability

We are working with operators to improve rail reliability, with targeted Mean KM Between Failure (MKBF) for MRT lines at 1 mil by 2020.

As of Nov 2018 MKBF – MRT

661,000km

New Rail Financing Framework

LTA is taking over assets from operations as a move to achieve:

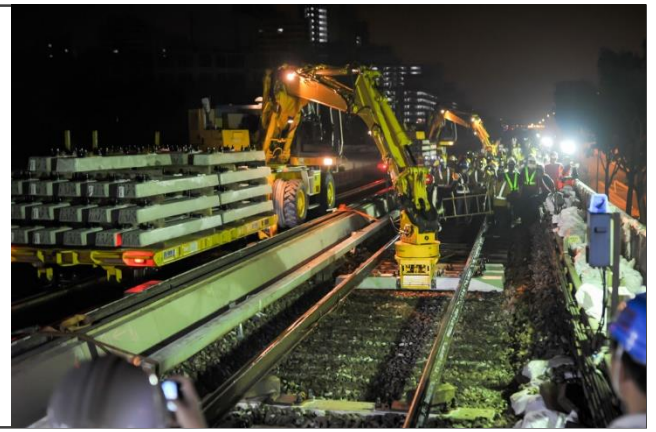
More responsive to increased ridership

Focus on providing reliable services

More competitive rail industry

Rail Renewal

Including sleeper replacement, signaling system, new trains, power supply works, and so on.



A reliable public transport network

Renewal works for North-South and East-West Lines

6 Core Systems – 3 Done, 3 to Go!

Sleeper Replacement **Completed**
- 188,000 wooden sleepers replaced with concrete sleepers

Power Rail Replacement **Completed**
- 12,000 pieces of power rail replaced

Resignalling
- NSEWL **Completed**

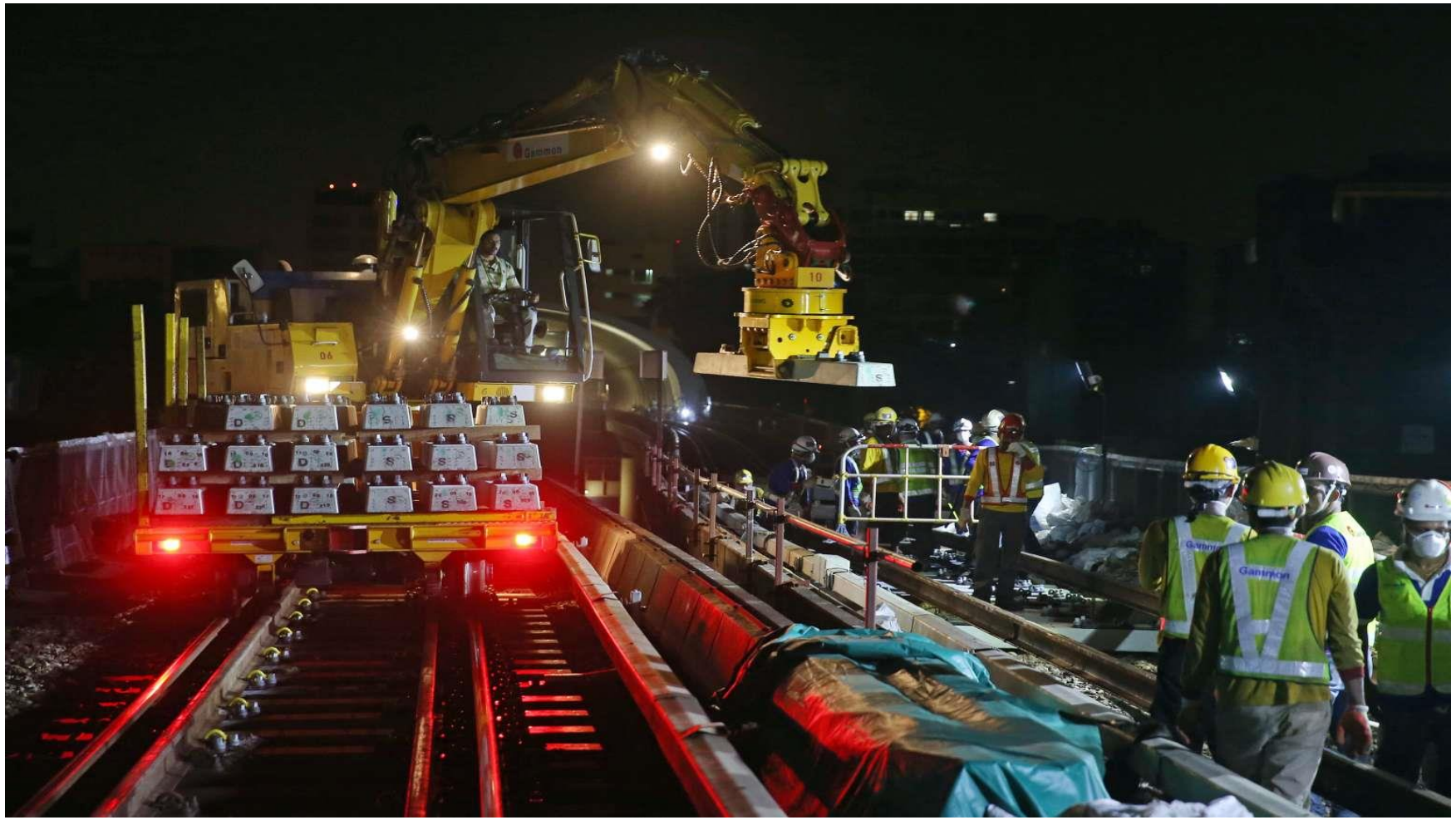
Upgrading and renewal of power supply system
Ongoing
- Reduce power-related faults
- Real-time monitoring
- Better fault prediction, detection and identification

Track circuit replacement
Ongoing
- Detect location of trains on the track
- Speedier recovery from a signalling system failure

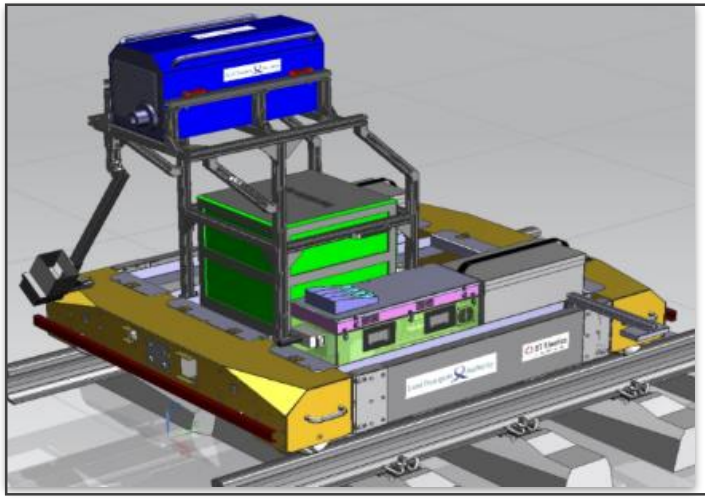
66 first-generation trains
To be replaced

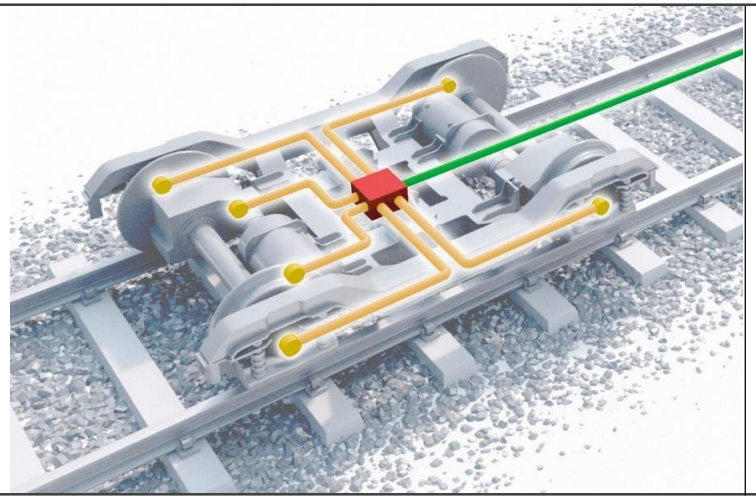
New trains will have:
- Sensors to monitor performance
- Imaging sensors and laser scanners to detect early signs of anomalies

Early Closure Late Opening

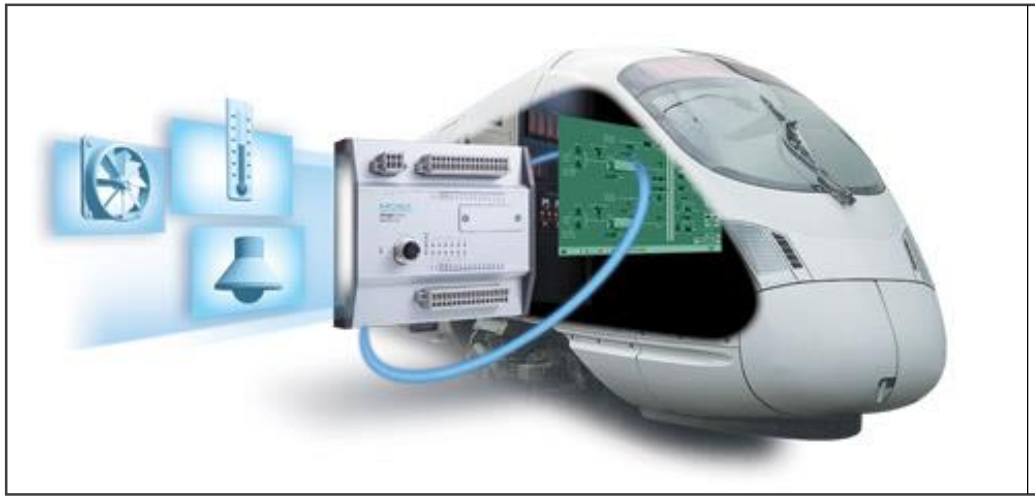


Improvements to enhance maintenance





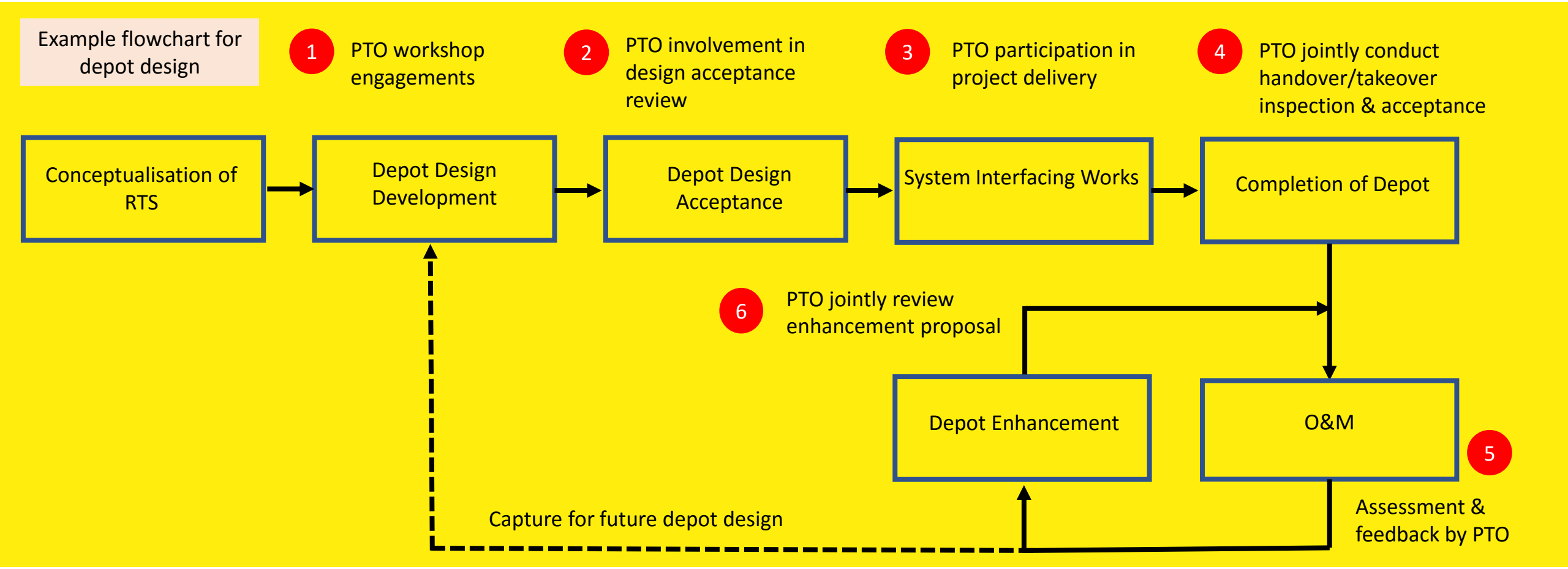
Condition Monitoring Vehicle
Real-time monitoring of rail network to predict and fix faults before they occur



'Smarter' Trains are equipped with condition monitoring tools; tapping on data analytics

Design for O&M

Embedded inputs from PTOs early when designing and building new railway systems.



Design for O&M

Incorporated DFOM considerations with PTOs early when designing and building railway systems.

Tuas West Depot

Workshop inspection pit to adopt 1.55m clear height from the rail to the grating provision, compared to varying height in the past.

Mandai Depot

Mechanised Overhead Cranes that are able to lift up to 10ton and improve workflow in depot, compared to 8ton in previous depots.

Enterprise Asset Management

Intelligent BIM

Design

Maintenance Management System

Life Cycle Costs

Rail Systems Data

Operations + Maintenance

Build

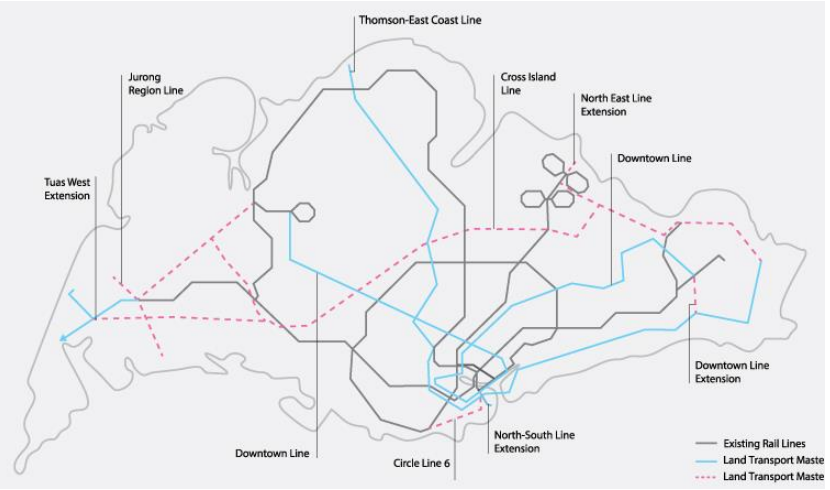
Design for Operations & Maintenance

Sensor Data For Condition Monitoring & Predictive Maintenance

Beyond good engineering design, it is important to bring fore the needs of the O&M Phase to achieve and deliver the full life cycle performance of the rail network.

Network Effectiveness

We are building more rail lines to improve connectivity.



Rail Lines Opening

2019
- Thomson-East Coast Line *Stage 1*
- North South Line: Canberra Station

2020
- Thomson-East Coast Line *Stage 2*

2021
- Thomson-East Coast Line *Stage 3*

2024
- Thomson-East Coast Line *Stage 5*
- Downtown Line 3 Extension

2023
- Thomson-East Coast Line *Stage 4*

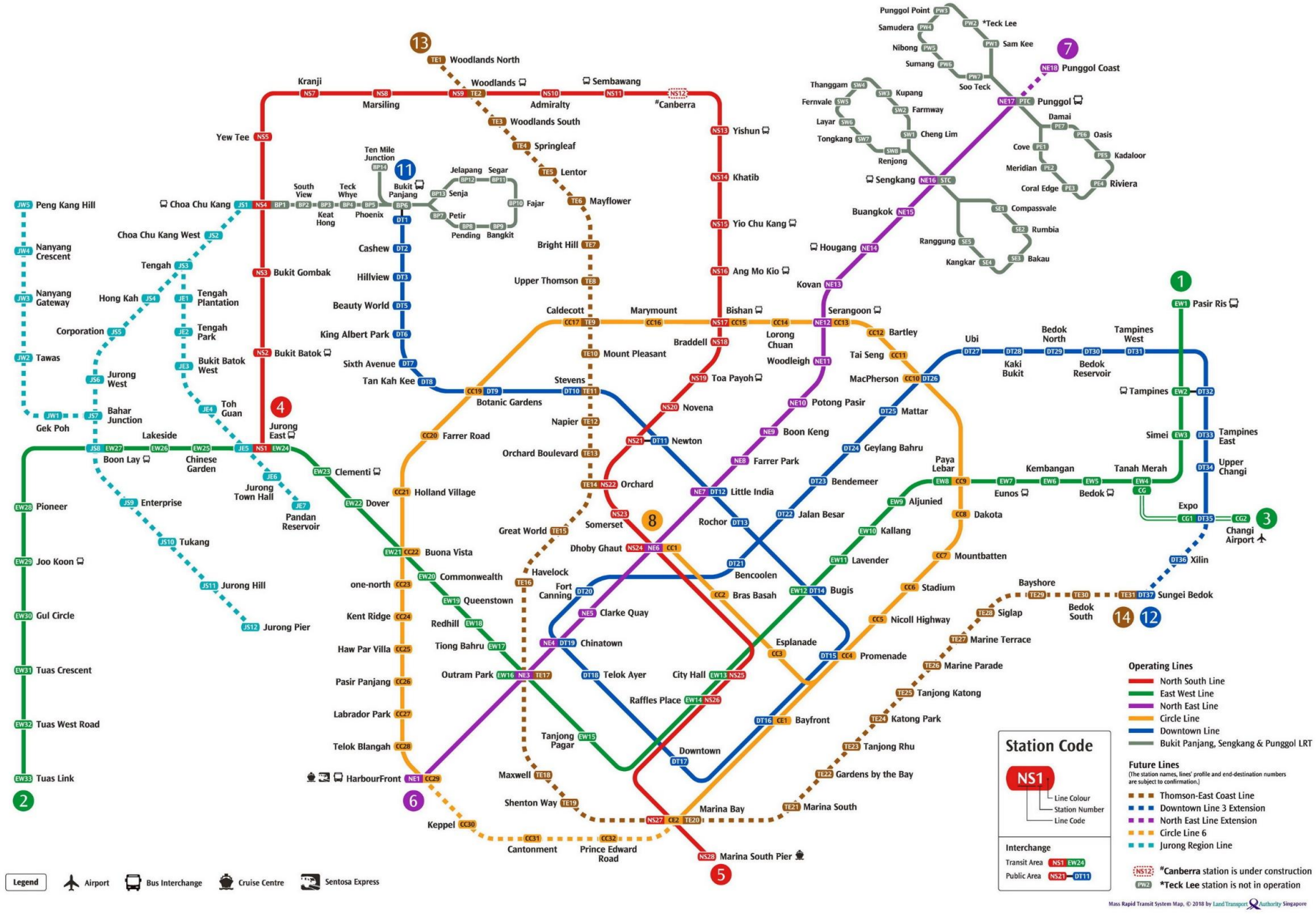
2025
- Circle Line 6

2026-2028
- Jurong Region Line *Stages 1-3***

2030
- North East Line Extension
- Cross Island Line

360km
Rail network by 2030

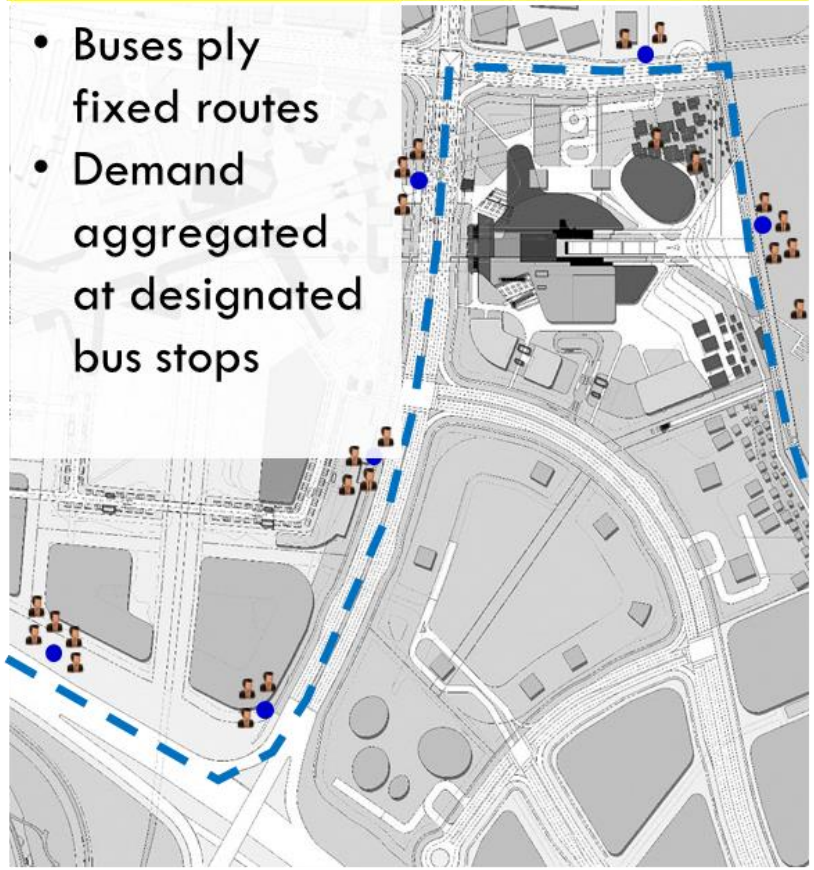
8 in 10
Households will live within 10 minutes walking distance of a train station


Woodlands North
Woodlands
Sembawang
Kranji
Marsiling
Admiralty
#Canberra
Woodlands South
Springleaf
Lentor
Mayflower
Yew Tee
Yishun
Khatib
Yio Chu Kang
Ang Mo Kio
Bukit Gombak
Bukit Batok
Bright Hill
Upper Thomson
Caldecott
Marymount
Bishan
Serangoon
Braddell
Mount Pleasant
Toa Payoh
Novena
Newton
Stevens
Botanic Gardens
Napier
Orchard Boulevard
Orchard
Somerset
Dhoby Ghaut
Great World
Havelock
Fort Canning
Clarke Quay
Chinatown
Telok Ayer
City Hall
Raffles Place
Esplanade
Promenade
Bayfront
Downtown
Tanjong Pagar
Outram Park
Redhill
Tiong Bahru
Queenstown
Commonwealth
Buona Vista
Holland Village
one-north
Kent Ridge
Haw Par Villa
Pasir Panjang
Labrador Park
Telok Blangah
HarbourFront
Maxwell
Shenton Way
Marina Bay
Marina South Pier
Marina South
Gardens by the Bay
Tanjong Rhu
Katong Park
Marine Parade
Marine Terrace
Siglap
Bayshore
Bedok South
Sungei Bedok
Xilin
Changi Airport
Expo
Tanah Merah
Bedok
Kembangan
Eunos
Paya Lebar
Aljunied
Kallang
Lavender
Bugis
Mountbatten
Dakota
Stadium
Nicoll Highway
Farrer Road
Holland Village
Farrer Park
Boon Keng
Potong Pasir
Woodleigh
Serangoon
Kovan
Hougang
Buangkok
Sengkang
Punggol
Punggol Coast
Punggol Point
Samudera
Nibong
Sumang
Soo Teck
*Teck Lee
Sam Kee
Thanggam
Fernvale
Layar
Tongkang
Renjong
Kupang
Farmway
Cheng Lim
Damai
Cove
Meridian
Coral Edge
Oasis
Kadaloor
Riviera
Compassvale
Rumbia
Bakau
Kangkar
Ranggung
Ten Mile Junction
Bukit Panjang
Jelapang
Segar
Senja
Petir
Pending
Bangkit
Fajar
South View
Keat Hong
Teck Whye
Phoenix
Choa Chu Kang
Choa Chu Kang West
Tengah
Hong Kah
Tengah Plantation
Tengah Park
Bukit Batok West
Toh Guan
Peng Kang Hill
Nanyang Crescent
Nanyang Gateway
Corporation
Tawas
Jurong West
Gek Poh
Bahar Junction
Boon Lay
Lakeside
Chinese Garden
Jurong East
Jurong Town Hall
Pandan Reservoir
Enterprise
Tukang
Jurong Hill
Jurong Pier
Pioneer
Joo Koon
Gul Circle
Tuas Crescent
Tuas West Road
Tuas Link
Pasir Ris
Tampines
Simei
Tampines East
Upper Changi
Ubi
Kaki Bukit
Bedok North
Bedok Reservoir
Tampines West
Bartley
Tai Seng
MacPherson
Mattar
Geylang Bahru
Bendemeer
Jalan Besar
Little India
Rochor
Bencoolen
Lorong Chuan
Braddell
Beauty World
Hillview
Cashew
King Albert Park
Sixth Avenue
Tan Kah Kee
Operating Lines
North South Line
East West Line
North East Line
Circle Line
Downtown Line
Bukit Panjang, Sengkang & Punggol LRT
Future Lines
(The station names, lines' profile and end-destination numbers are subject to confirmation.)
Thomson-East Coast Line
Downtown Line 3 Extension
North East Line Extension
Circle Line 6
Jurong Region Line
#Canberra station is under construction
*Teck Lee station is not in operation
Station Code
NS1
Line Colour
Station Number
Line Code
Interchange
Transit Area
Public Area
Legend
Airport
Bus Interchange
Cruise Centre
Sentosa Express
Mass Rapid Transit System Map, © 2018 by Land Transport Authority Singapore

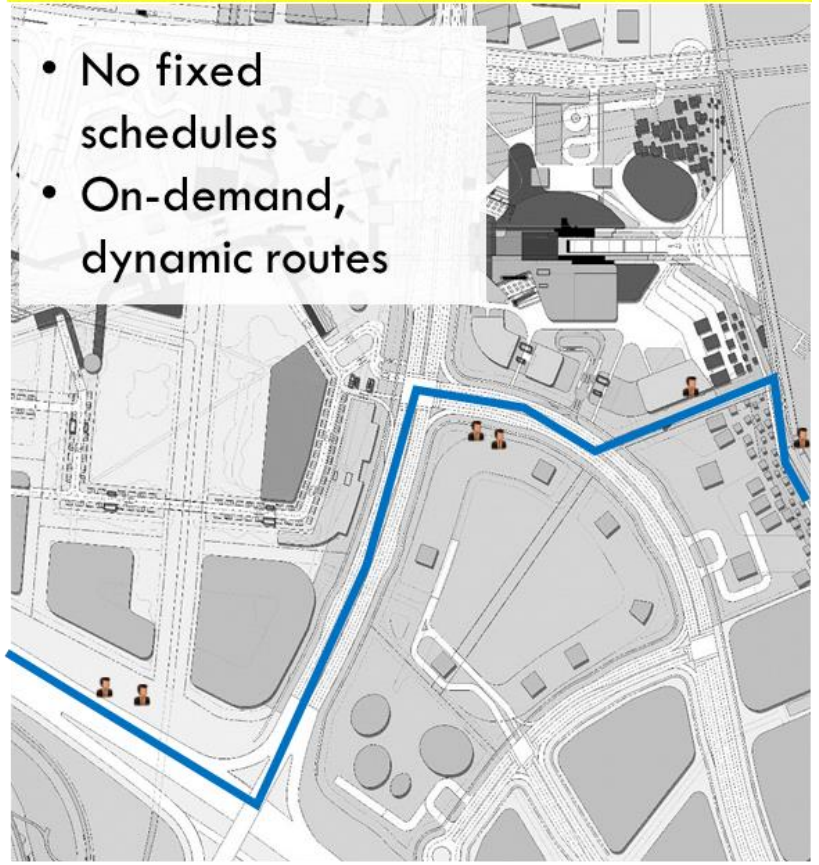
Road Network

Dynamically routed bus services can optimize transport resources and improve demand-response.

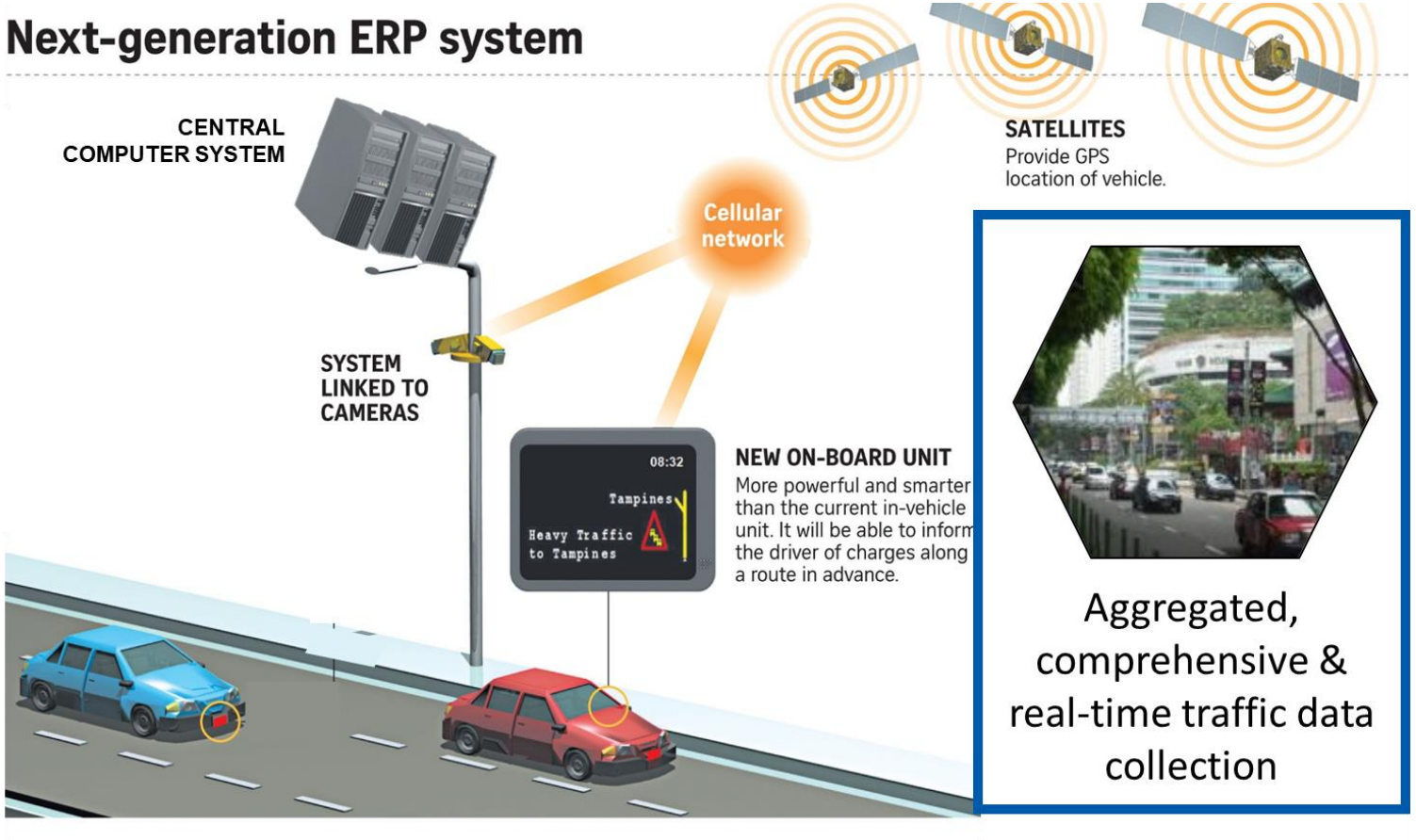
Normal Bus Services



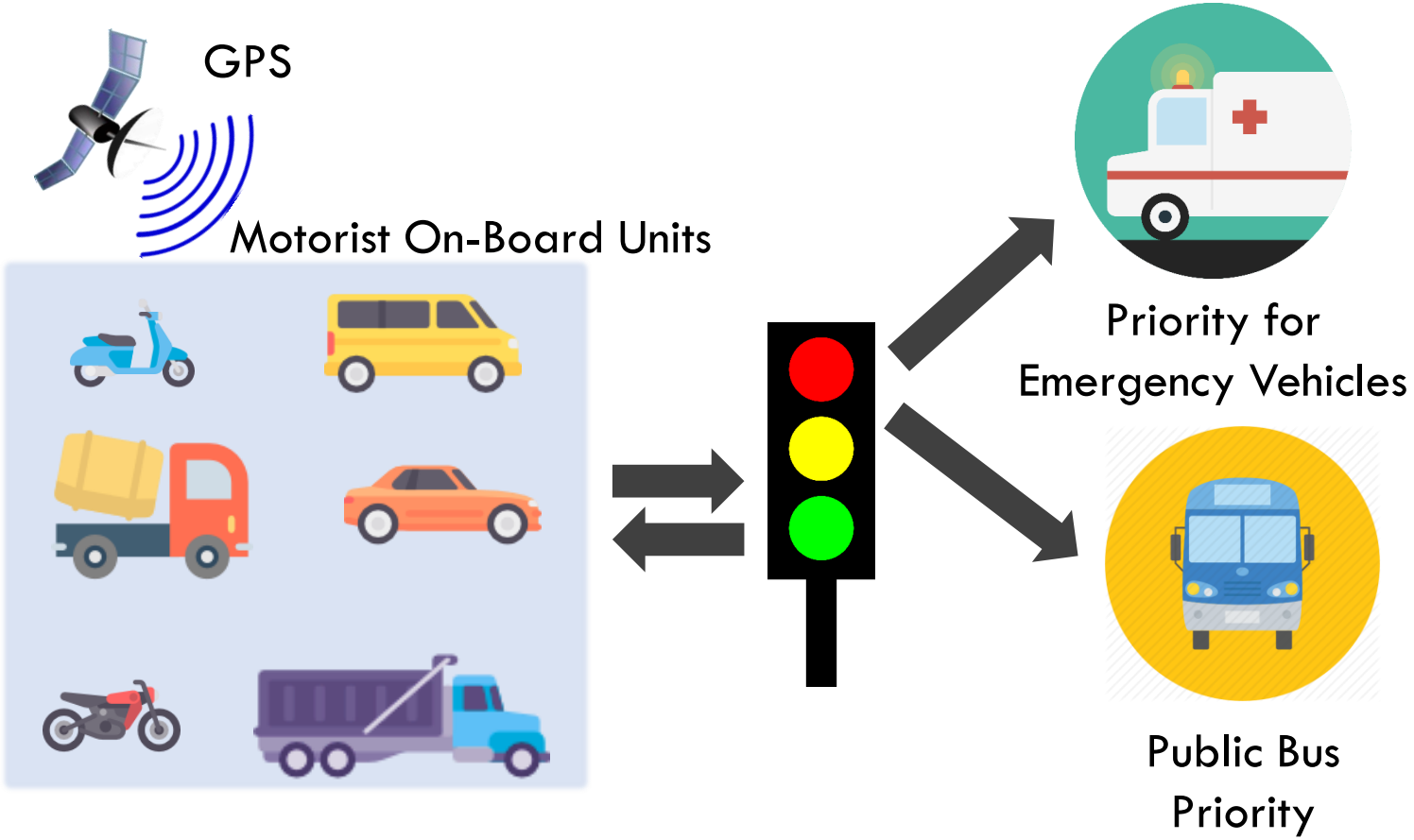
Demand Responsive Bus Service



Satellite technology to enhance road usage with smart and comprehensive road traffic management.



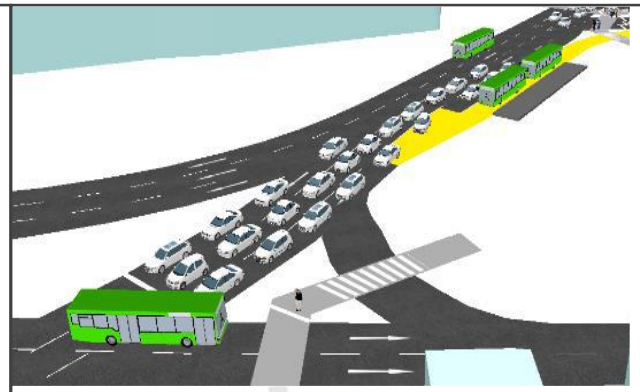
Localised control of traffic with smart traffic lights, giving priority to emergency vehicles and public buses



Smart & adaptive traffic simulation

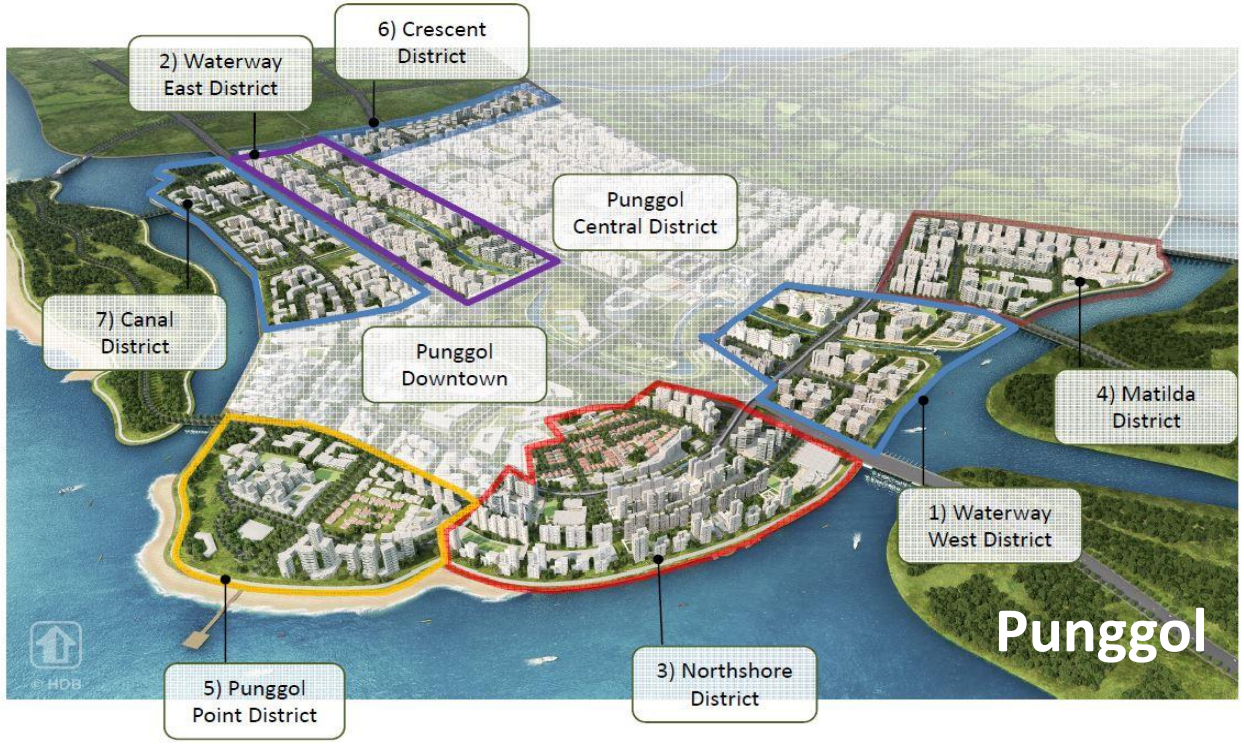
Simulation of traffic schemes and infrastructure to aid planning and design (e.g., KPE & MCE design)

- Highly detailed road geometry & lane markings
- Simulation of drivers' granular behaviours (e.g., lane changing, acceleration, deceleration)
- Capabilities for impact analysis such as delay in travel time, queue length at junction



We are developing AV technologies for public transport and point-to-point mobility services, with pilot deployment in Punggol, Tengah, and Jurong Innovation District.

(Year 2022 and after)



Cycling Network

We are enhancing first-and-last-mile connectivity and experience.

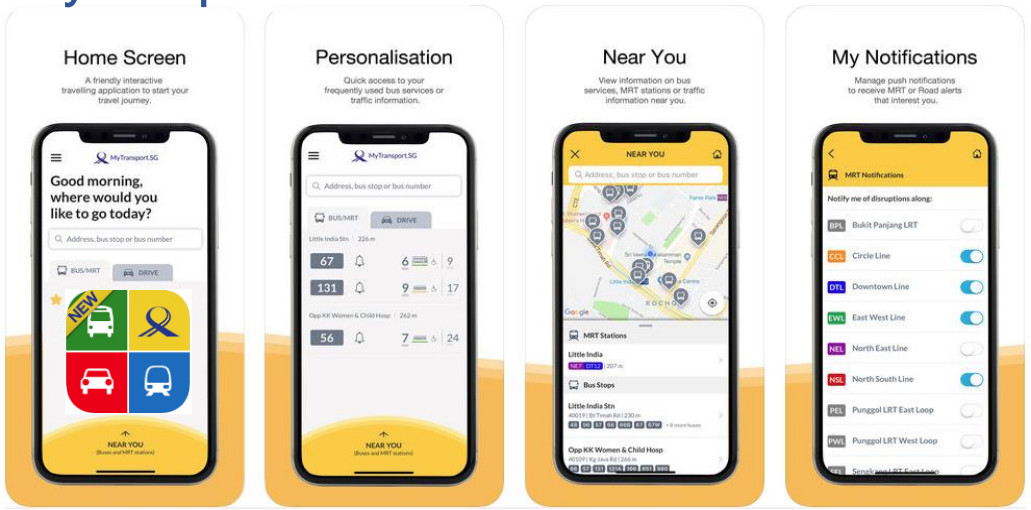
Build more **covered walkways** to allow pedestrians to walk more comfortably

Collaborate with **bicycle sharing** companies to encourage responsible shared bicycle use amongst the public

Implement **licensing** to ensure safety while allowing private hire cars as an alternative to taxis

Enhancing commuters' experience with digital services

MyTransport.SG 2.0



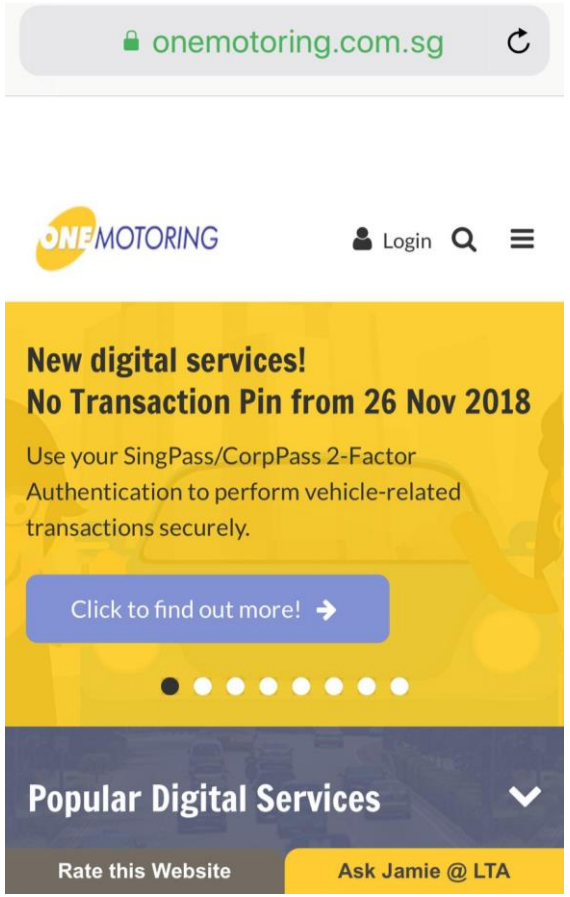
Personalization

Set daily journeys on the home screen and subscribe to real-time transport alerts.

Multimodal Journey Planner

Informs commuters of nearby bus services and MRT stations will help commuters plan journeys across different transport modes.

One.Motoring Site



Vehicle Owners can use SingPass or CorpPass two-factor authentication (2FA) for new digital services:

- Transfer of vehicle ownership
- Transfer of PARF and COE rebate
- Transfer of temporary COE
- Vehicle Deregistration

Enhances productivity and reduces the transaction time required

Enhancing commuters' experience with smart technologies

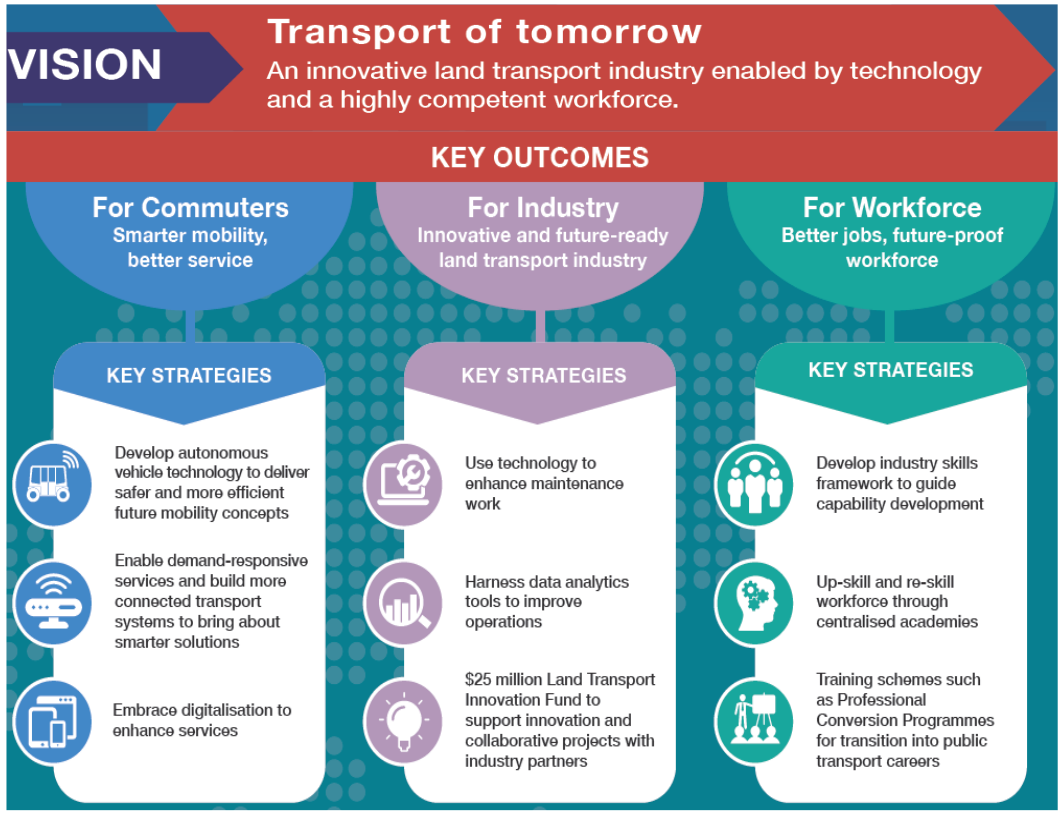
Hands-free Fare Gates will enable people with disabilities to enter and exit train stations with ease by eliminating the need to tap their fare cards at the gates.

Account Based Ticketing (ABT) enables commuters to use their credit or debit cards with contactless function for fare payments. There will be no need for upfront top-ups and your train and bus fares will be processed and charged to your credit card.

Working With Our Partners

Land Transport Industry Transformation Map (ITM) to prepare the industry for the next lap

Officially launched in Feb 2018, together with tripartite partners



Targets by 2030:

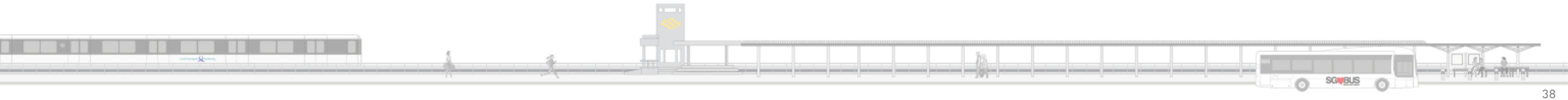
- 75% of peak hour trips by public transport
- 1,000,000 train-km travelled between delays >5 min by 2020
- 85% of public transport trips (<20km) completed within 60 min
- Up to 8,000 new bus and rail jobs

Working closely with tripartite partners

Vision: An innovative land transport industry enabled by technology and a highly competent workforce

Leverage Technology	Workforce Planning and Development	Enterprise Development
Leverage emerging technologies to improve productivity and deliver safe, efficient and reliable transport system for commuters	Upskill/reskill public transport workers to keep pace with technological advancement and encourage continual learning	Build local capabilities especially in mission-critical areas to enhance value capture and internationalisation

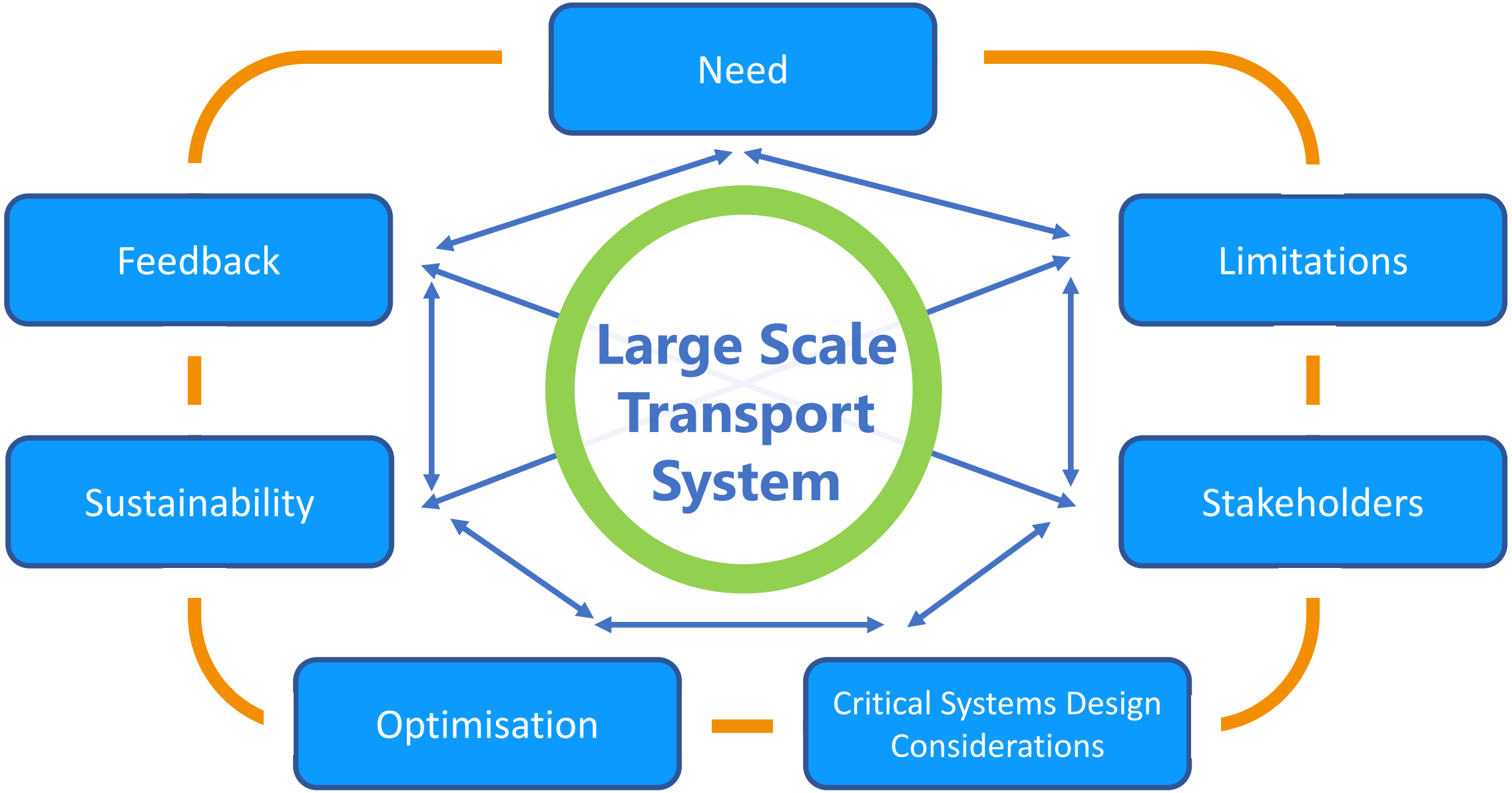
LTA, industry companies and the union working together to implement the ITM



1. Make WCR your **preferred way to travel**, as the future of land transport must be **car-lite** to be sustainable;

2. Make WCR travel options to be **easier** and **more inclusive** to meet the needs of all Singaporeans as our society ages and matures; and

3. Enhance land transport system for **liveability**, through safer roads and paths, cleaner and quieter environments, or freeing up land for more community spaces.


Need
Limitations
Stakeholders
Critical Systems Design Considerations
Optimisation
Sustainability
Feedback
Large Scale Transport System

Thank You

Walk Cycle Ride SG