



ST Electronics

Info-Comm Systems

A member of ST Engineering

V2X Applications for Public Transport

Leong Hin Cheong

ST Electronics (Info-Comm Systems)

Agenda

▶ Background

- ▶ Introduction on DSRC Development
- ▶ Singapore Public Transport

▶ V2X Applications for Public Bus Services

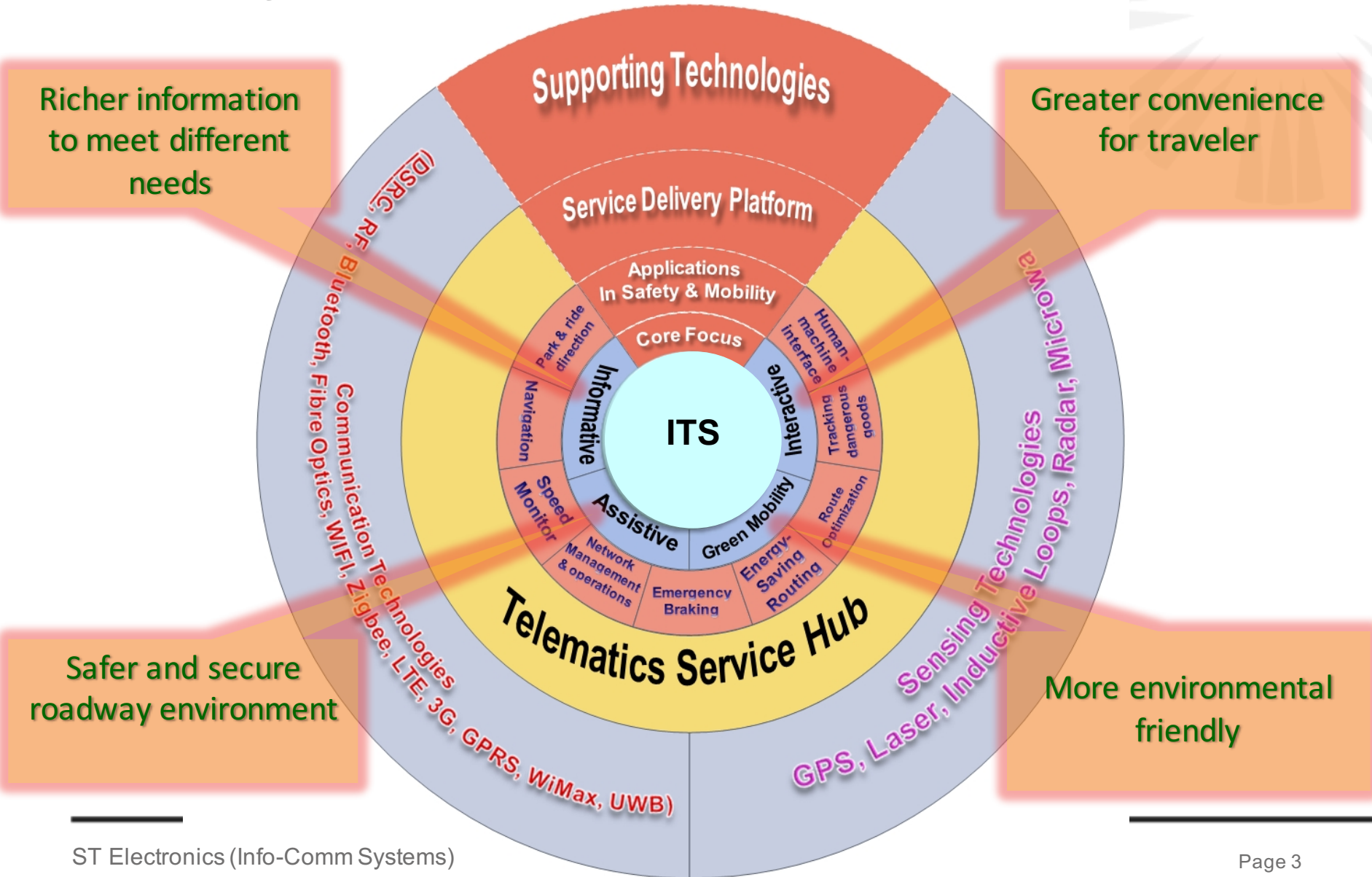
- ▶ Improving Bus Service KPI
- ▶ Improving Estimated Time of Arrival (ETA) Service
- ▶ SPaT (Signal Phase And Time) for Bus Service

▶ V2X Applications for Taxi Services

- ▶ Passenger Queue Management
- ▶ Taxi Queue Management

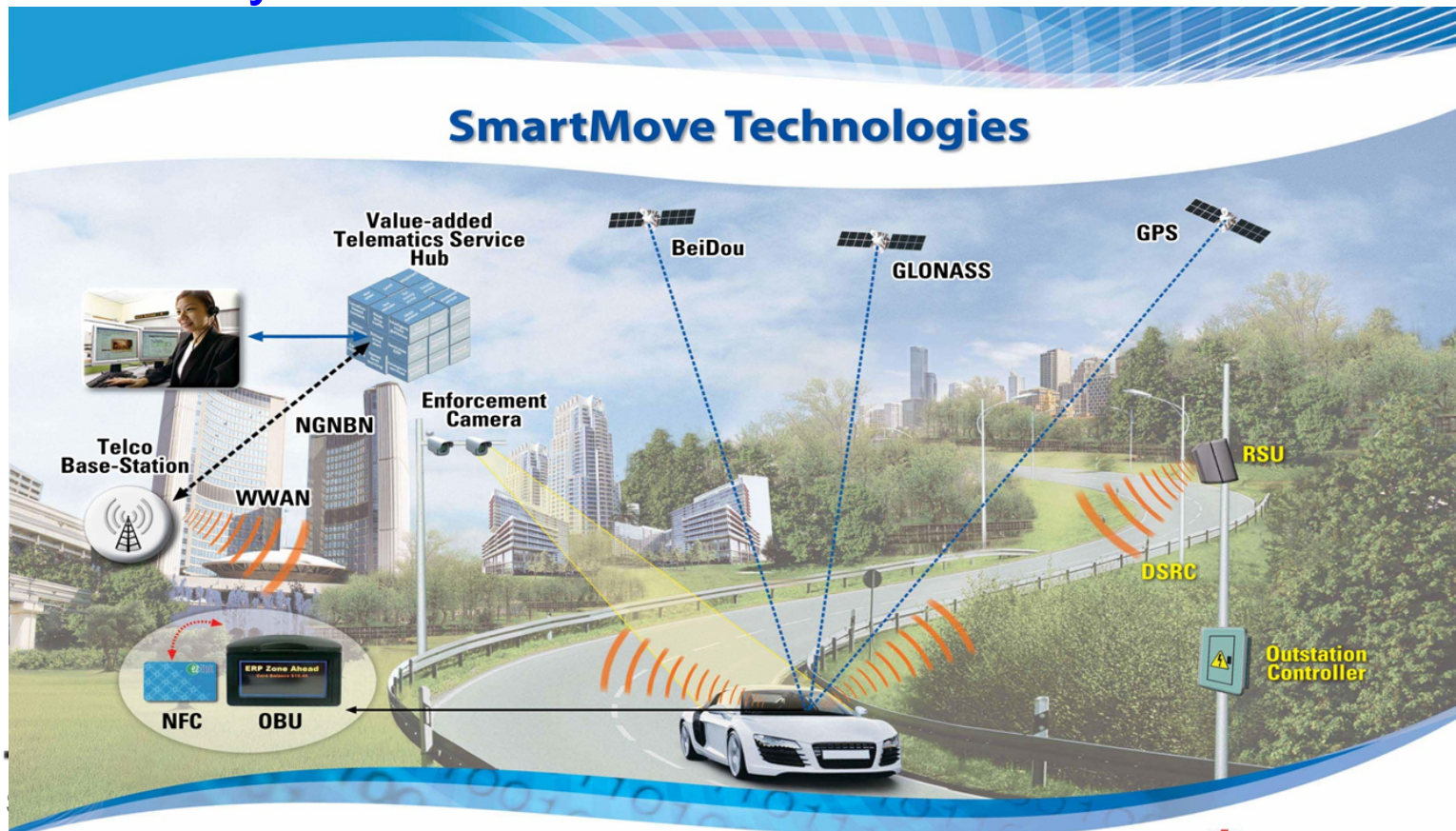
▶ Q&A

Guiding Framework for ITS



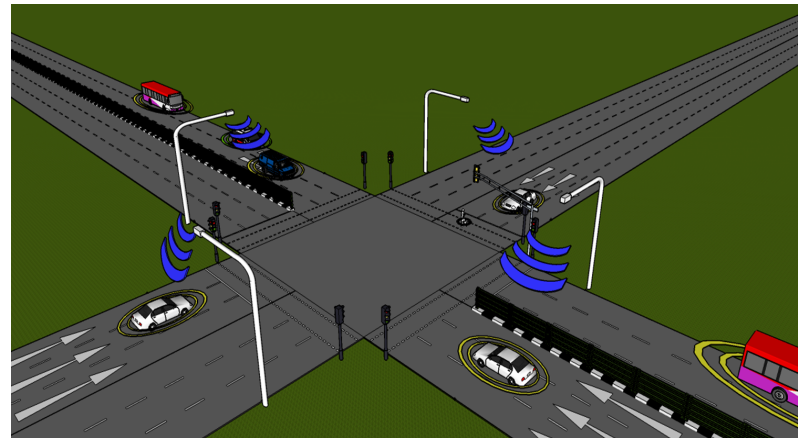
Smart Move thru DSRC Connected Vehicle

- ▶ Unified solution for vehicles tracking & management
- ▶ Informative, interactive, assistive functionalities & Green Mobility

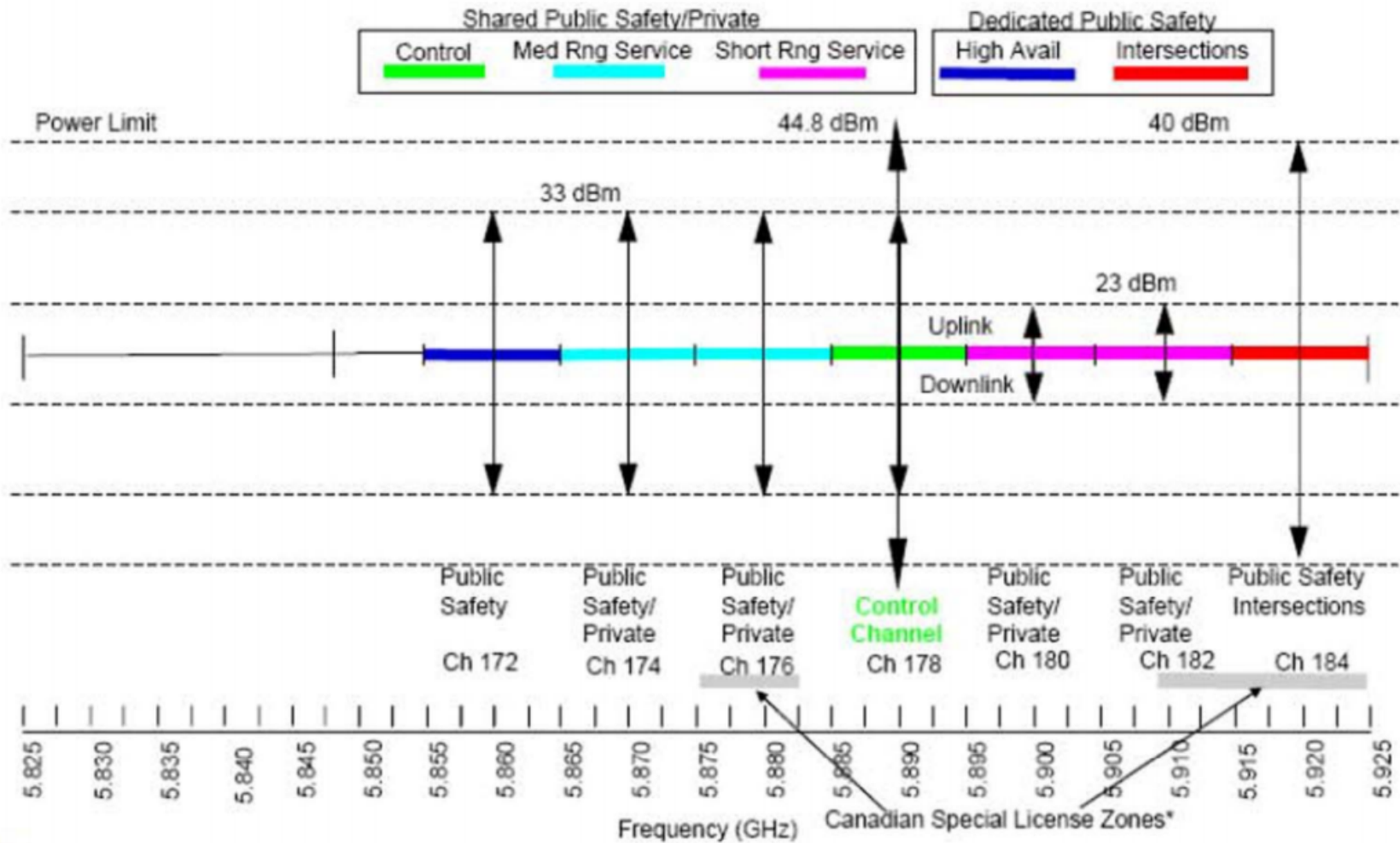


Introduction - 5.9 GHz DSRC

- ▶ 5.9 GHz DSRC is short-to-medium range wireless link for high data, low latency for fast mobility
- ▶ Critical for V2V (Vehicle-to-Vehicle) automobile safety applications as well as V2I (Vehicle-to-Infrastructure)
- ▶ Based on IEEE802.11P/WAVE (Wireless Access in Vehicular Environment) with 1 Control channel and 6 Service channels

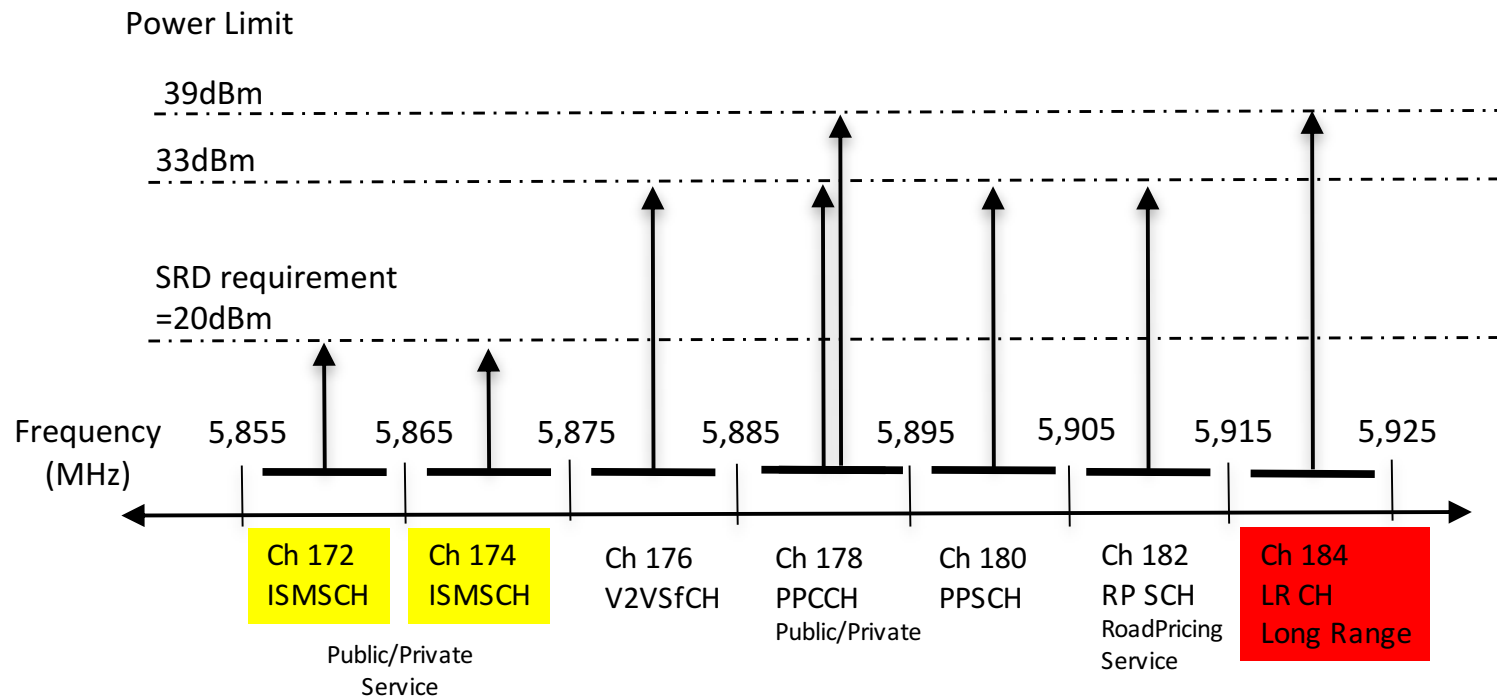


DSRC Spectrum Band & Channels (U.S)



Singapore DSRC Standardization Status

- ▶ IDA Draft the National DSRC Standard
- ▶ Final Stage in Consulting the Public
- ▶ Expected to have 1st released in 3Q 2016

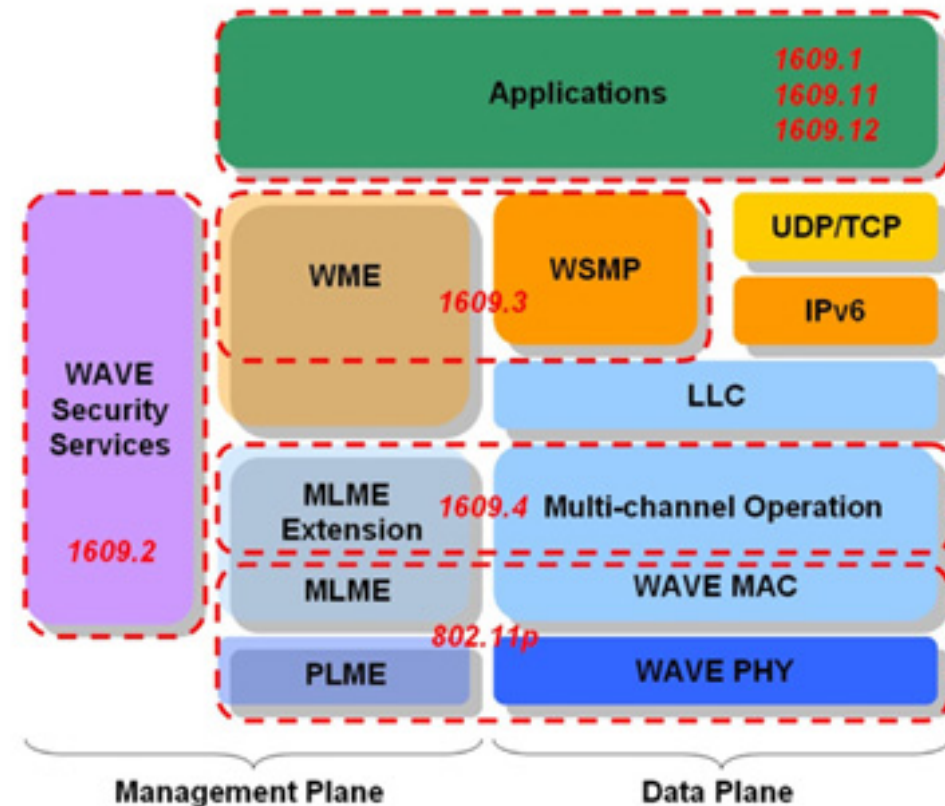
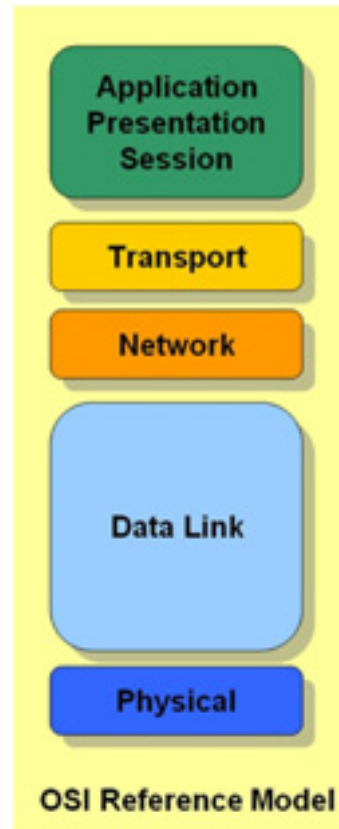


Singapore DSRC Spectrum Power Limit

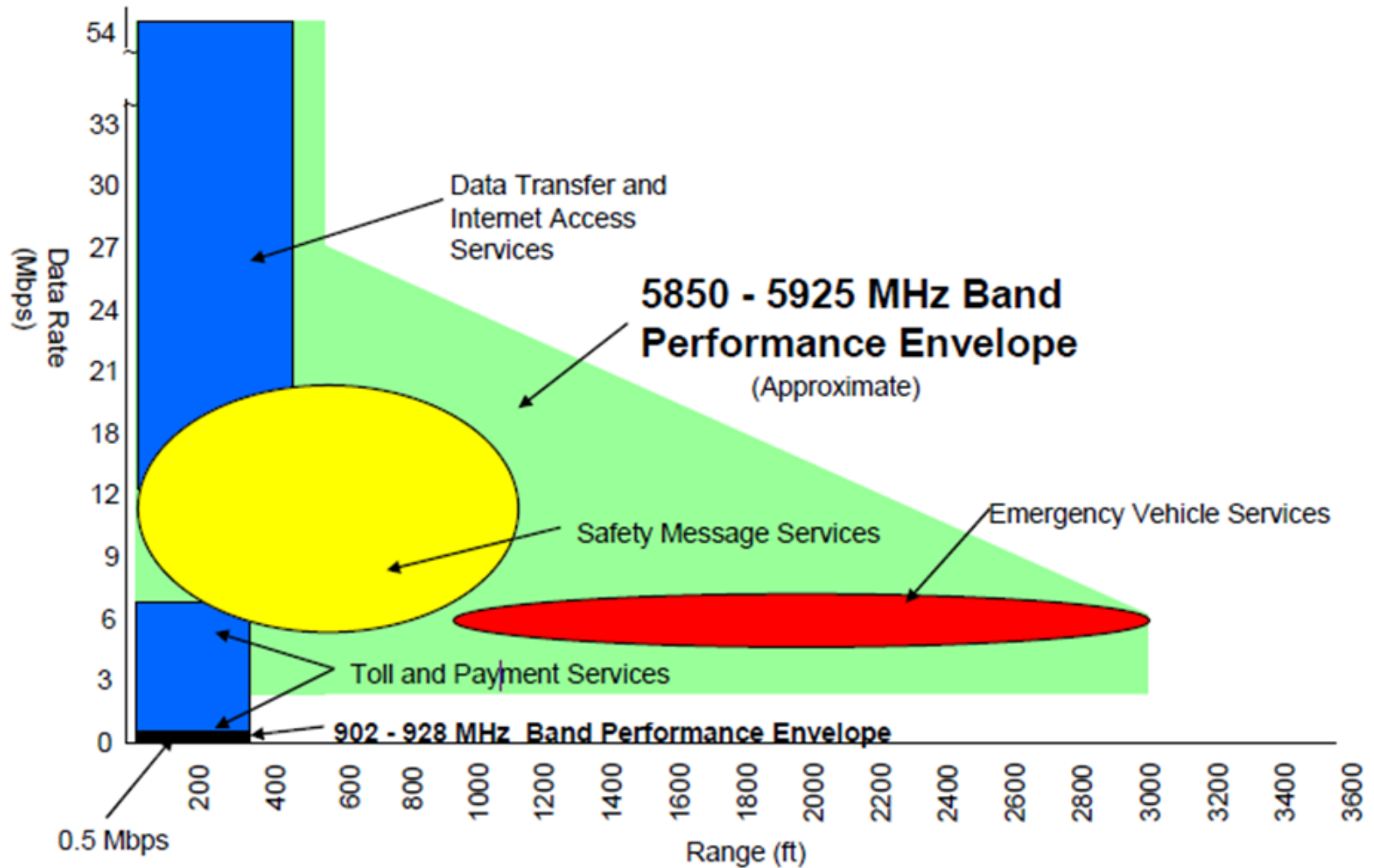
DSRC / WAVE Standards

- ▶ 802.11p physical Layer
- ▶ WAVE (Wireless Access in Vehicular Environment)

- ▶ IEEE 1609.1 core system
- ▶ IEEE 1609.2 Security Service
- ▶ IEEE 1609.3 Network Service
- ▶ IEEE 1609.4 Multi channel management



DSRC Performance Envelopes



DSRC in Urban Mobility Landscape



Evolution of ITS

Operation Efficiency

- Congestion Management
- Incident Management
- Traffic Enforcement
- Traffic Surveillance
- Fleet Management

1995 - 2005

Information Sharing

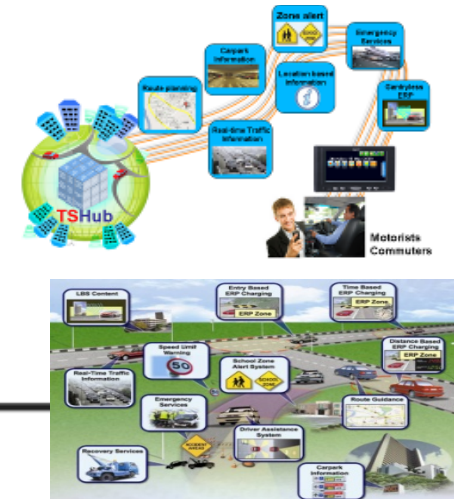
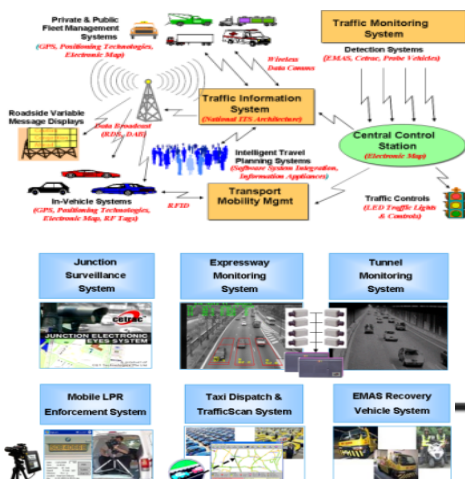
- Public Information Dissemination
- Integrated Transport Management

2005 - 2010

Interactive & Customized Service

- Personalized Multi-modal Information
- Vehicle to Vehicle (V2V)
- Vehicle to Infrastructure (V2I)
- Vehicle to Pedestrian (V2P)

2010 - now



About Singapore Public Transport



▶ Main Public Transport Operator (Bus)

- ▶ SBS Transit Ltd
- ▶ SMRT Buses Ltd
- ▶ Tower Transit Singapore

▶ Key Monitoring Standards

- ▶ Land Transport Authority and the Public Transport Council work closely together to monitor the level of service and performance of bus services in Singapore
- ▶ Performance based on:
 - ▶ Operating Performance Standards
 - ▶ Service Provision Standards

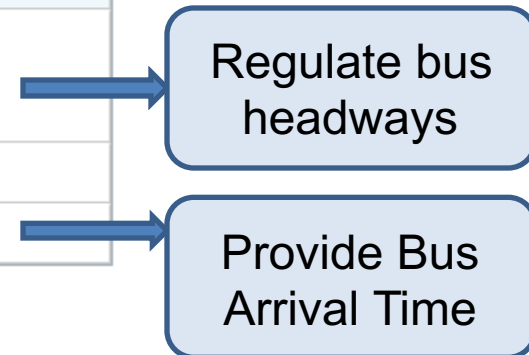
About Singapore Public Transport

▶ Operating Performance Standards

Operating Performance Standards	
Reliability	Scheduled bus trips Punctuality Bus breakdown rate
Loading	Passenger load during peak hour
Safety	Accident rates

▶ Service Provision Standards

Service Provision Standards	
Availability	Provision of direct connections Bus operation hours Bus frequency
Integration	Bus service times at interchanges/terminals
Information	Provision of up-to-date information



About Singapore Public Transport



- ▶ Main Public Transport Operator (Taxi)

- ▶ Six major taxi operators

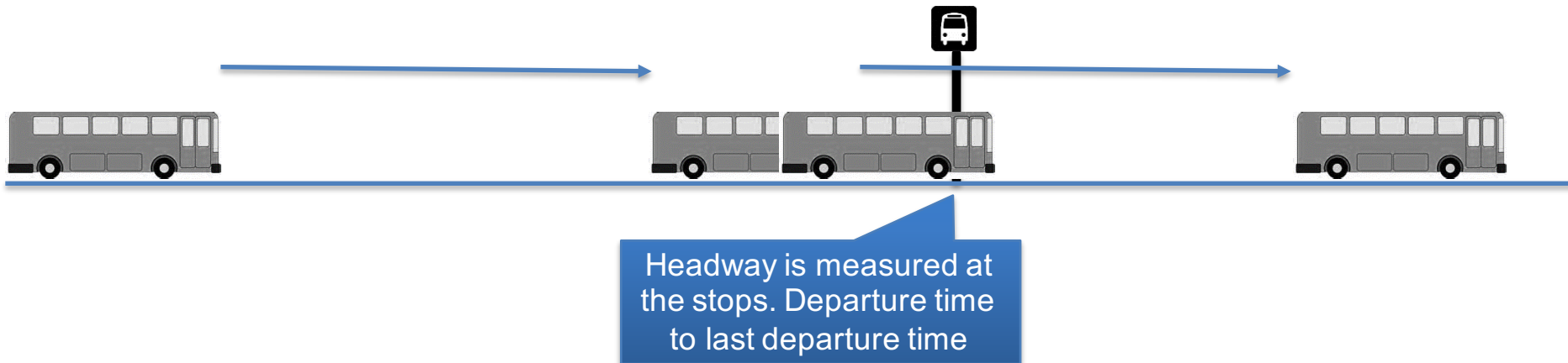
- ▶ Key Monitoring Standards

- ▶ Land Transport Authority monitors the service and safety performance of taxi operators and drivers
 - ▶ Taxi Booking Service
 - ▶ Safety
 - ▶ Taxi Driver's Conduct
 - ▶ Taxi Availability
 - ▶ Waiting time at taxi stands

V2X Application for Public Bus Service

▶ Improving Bus Service KPI: Regulate Bus Headway

- ▶ Public Transport Operators track and manage bus fleet in real-time through a Common Fleet Management System
- ▶ For headway operations, the time is defined by the regularity required at a bus stop
- ▶ Bus Captains provided with indicators to follow



Improving Bus Service KPI

▶ Challenges Faced

- ▶ Road conditions – traffic jams, accidents, etc.
- ▶ Long dwell time at bus stops

▶ Road Conditions

- ▶ Currently road conditions are feedback through Bus Captains that encounter the situation. There is a time lag between the occurrence and the reporting. Through V2X, road conditions information can be shared through other vehicles to public buses. Affected routes can be quickly identified and corresponding actions can be swiftly taken.

Improving Bus Service KPI

▶ Challenges Faced

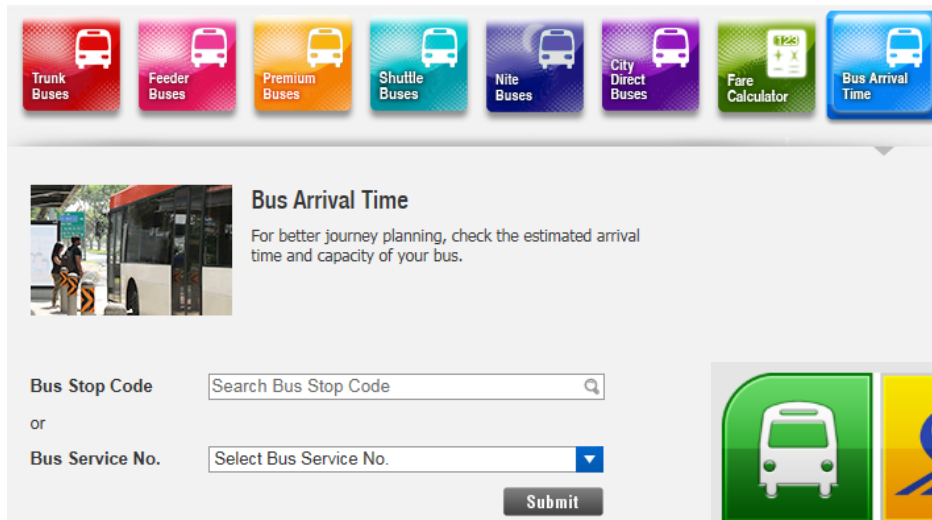
- ▶ Road conditions – traffic jams, accidents, etc.
- ▶ Long dwell time at bus stops

▶ Long Dwell time at bus stops

- ▶ Typically caused by buses pile up at bus stops. Through V2X, expected vehicles arriving at a bus stop can be regulated at real time and avoid jamming up
- ▶ Special needs – wheel chair needs or senior citizens. Provision of “special needs” button at bus stops to relay information to Bus Captains to prepare to assist. The information can be relayed through V2X infrastructure to the designated bus captain

V2X Application for Public Bus Service

- ▶ Dissemination of the bus arrival time information on LTA MyTransport.SG mobile application/web portal and selected bus stops



The screenshot shows a mobile application interface with a top navigation bar containing icons for Trunk Buses, Feeder Buses, Premium Buses, Shuttle Buses, Nite Buses, City Direct Buses, Fare Calculator, and Bus Arrival Time. Below this, the 'Bus Arrival Time' section is highlighted, featuring a search bar for 'Bus Stop Code' and a dropdown for 'Bus Service No.', with a 'Submit' button.



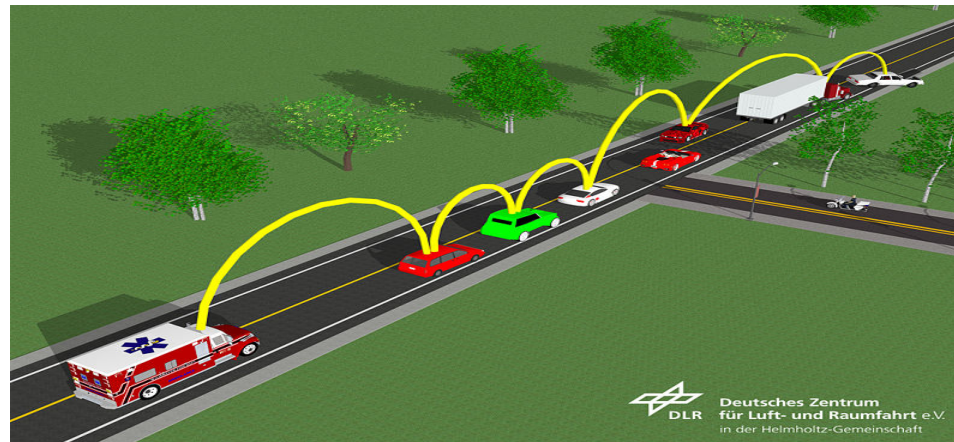
Improving Estimated Time of Arrival (ETA) Service

► Challenges Faced

- Road conditions – traffic jams, accidents, etc.
- Bad coverage areas for GPS

► Real-time information from affected vehicles to send to backend for re-calculation of ETA

► V2X infrastructure to improve coverage



SPaT (Signal Phase And Time)

▶ Synchronization with Traffic Light for Bus Services

- ▶ Reduce number of times Public Buses needed to stop at traffic junction
 - ▶ Reduce Emission
 - ▶ Fine-tuning of bus performance due to local adjustments



V2X Applications for Taxi Services



▶ Key Monitoring Standards

- ▶ LTA monitors the service and safety performance of taxi operators and drivers
 - ▶ Taxi Booking Service
 - ▶ Safety
 - ▶ Taxi Driver's Conduct
 - ▶ Taxi Availability
 - ▶ Waiting time at taxi stands

V2X Applications for Taxi Services

Passenger queue alerts



Monitoring and managing taxi queue



Passenger Queue Management

► Current Implementations

- Sensors at taxi stands to detect passenger queue
- Demands at taxi stands are sent to the taxi operators

Average Hourly Passenger Waiting Time in Minutes (Apr 2016)
Orchard Cluster

Surveyed Time Period	(1) Tanglin Shopping Centre (F55)	(2) Orchard Towers (F50)	(3) Liat Towers (F49)	(4) Far East Plaza (F52)	(5) ION Orchard	(6) Lucky Plaza (A01)	(7) Paragon Shopping Centre (A02)	(8) Cairnhill Place (A06)	(9) Wisma Atria (A08)	(10) Ngee Ann City (A09)	(11) Centrepoint (A11)	(12) Plaza Singapura (A16)	(13) Cathay Building (A17)
5pm-6pm	5	4	6	7	10	5	12	-	5	5	4	4	2
6pm-7pm	3	3	4	6	7	6	9	-	7	7	3	4	2
7pm-8pm	2	2	2	4	5	4	4	-	4	2	3	2	2
8pm-9pm	2	2	3	3	6	2	2	-	2	2	2	2	2
9pm-10pm	2	2	5	5	6	2	4	-	3	3	2	2	2
10pm-11pm	5	3	6	3	5	2	4	-	5	4	2	2	2
11pm-12am	3	3	6	7	4	2	2	-	2	2	2	2	2

Note:
 1. Surveys were conducted from 1 - 4 (Fri-Mon) Apr 2016 at all locations except Cairnhill Place.
 2. Survey at Cairnhill Place was not conducted in Apr 2016 due to temporary closure of taxi stand.
 3. The above figures represent the number of minutes a passenger may need to wait for a taxi.

Passenger Queue Management



▶ V2X Applications

- ▶ By making use of V2X, information from sensors can be quickly relayed to taxis within the vicinity
- ▶ Demands are instantly sent to nearby available taxis.
- ▶ Unmatched demands will then lead to enlarged vicinity area

Taxi Queue Management



▶ Current Challenges

- ▶ Taxis spent long periods queuing for passenger in airport and places of interests
- ▶ Taxis may missed on the taxi availability KPI if long hours are spent on the waiting time

▶ V2X Applications

- ▶ Optimize the demand and supply conditions
- ▶ Demands to be sent via V2X infrastructure to available taxis in vicinity, or with common destination match

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Preliminary Programme

18 Oct 2016 (Tue)	19 Oct 2016 (Wed)	20 Oct 2016 (Thu)	21 Oct 2016 (Fri)
-	Opening Ceremony Exhibition	Exhibition	Exhibition
Technical Visits	Congress Programme Day 1	Congress Programme Day 2	Congress Programme Day 3
Welcome Reception	-	Gala Dinner	Closing Ceremony





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Thank You