Jim Misener
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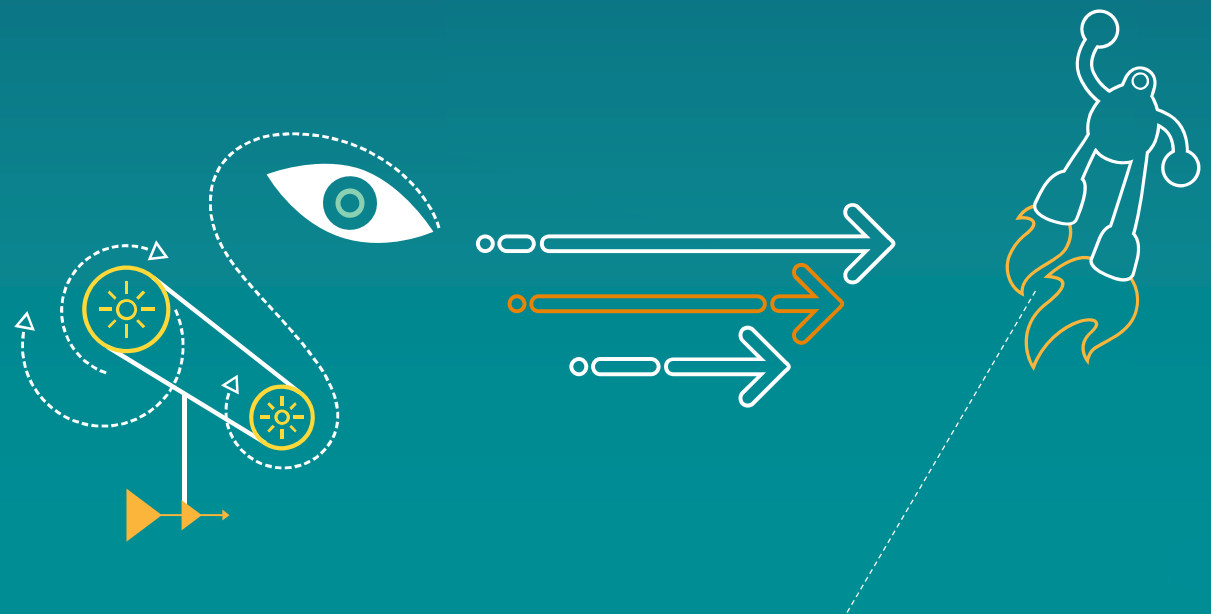
Applying Lessons Learned to V2X Communications for China

QUALCOMM®



Qualcomm's technology enables the Connected Car experience

Rear Seat Entertainment

Wireless Charging

Internet Access

Social Networking

HD Graphics

Maps

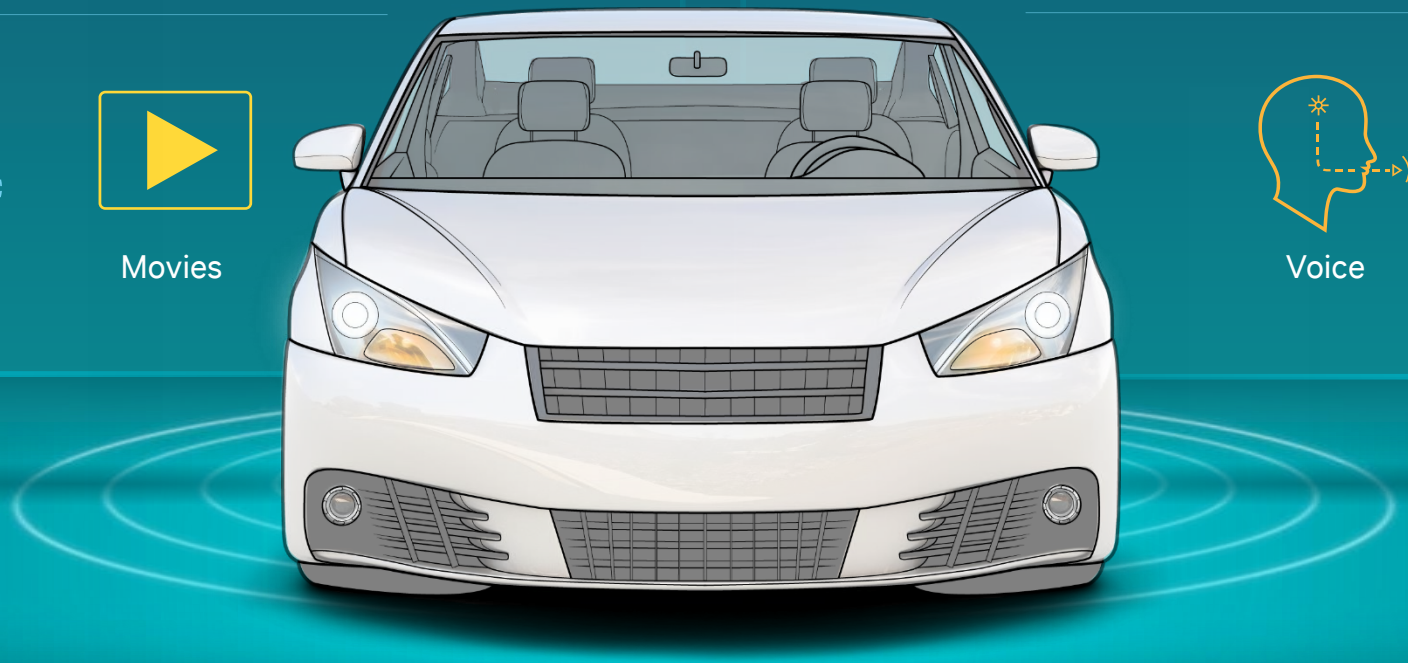
Safety

Video

Audio

Apps

Movies



Voice

Camera

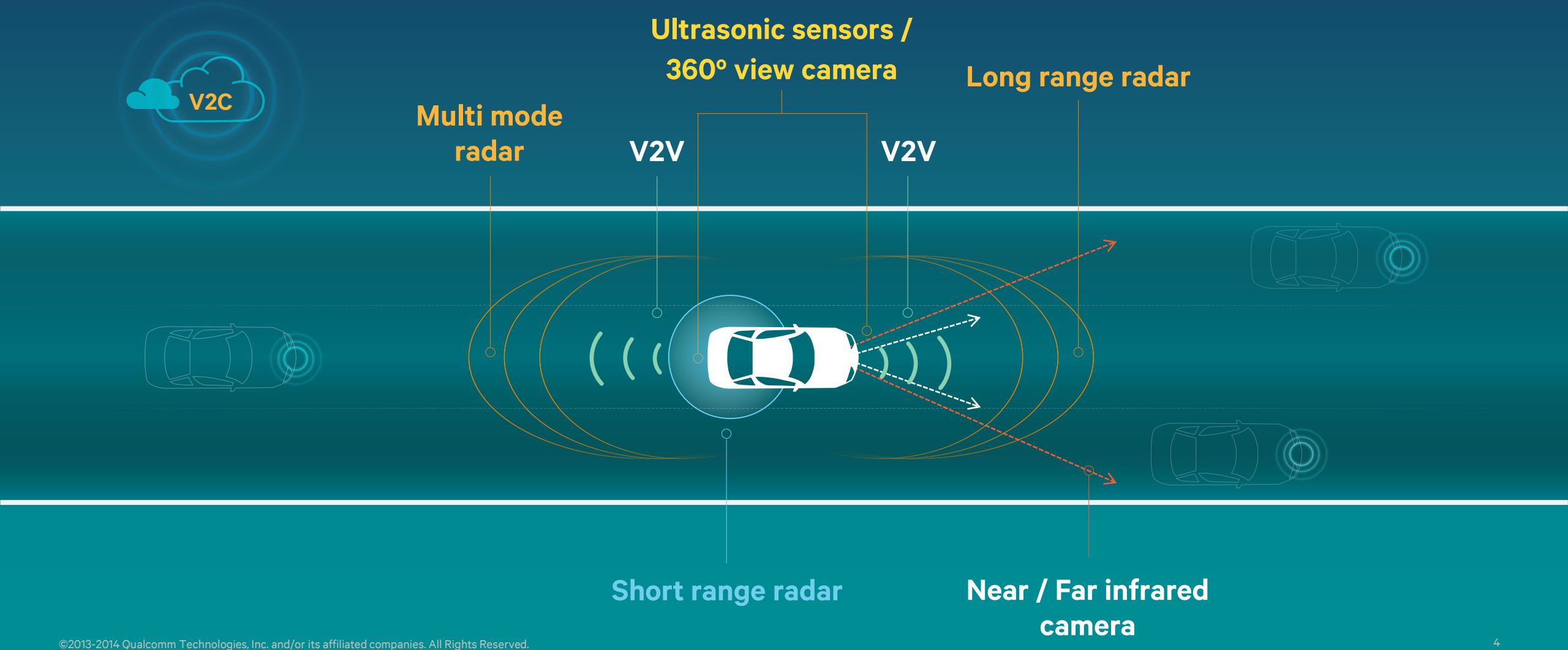
Source: GSMA Intelligence, Apr. '14; UN, Apr. '14

Agenda

1. Applications and End User Perspectives
2. Standards Perspectives (LTE and 802.11p)
3. Synthesizing Perspectives: Going Forward

Qualcomm Vision: Advanced driver assistance systems (ADAS)

Computer Vision and Sensor fusion + V2X communication



Summing the Necessary Developments: Moving from ADAS to Fully Cooperative Automation

Complex Environment, Complicated Requirements:

Japan Energy ITS: > 99 % Packet Reception Probability (“two shots”)

+ 50 Hz Control Messages

Demo 97 I-15, San Diego
Source: UC PATH Program

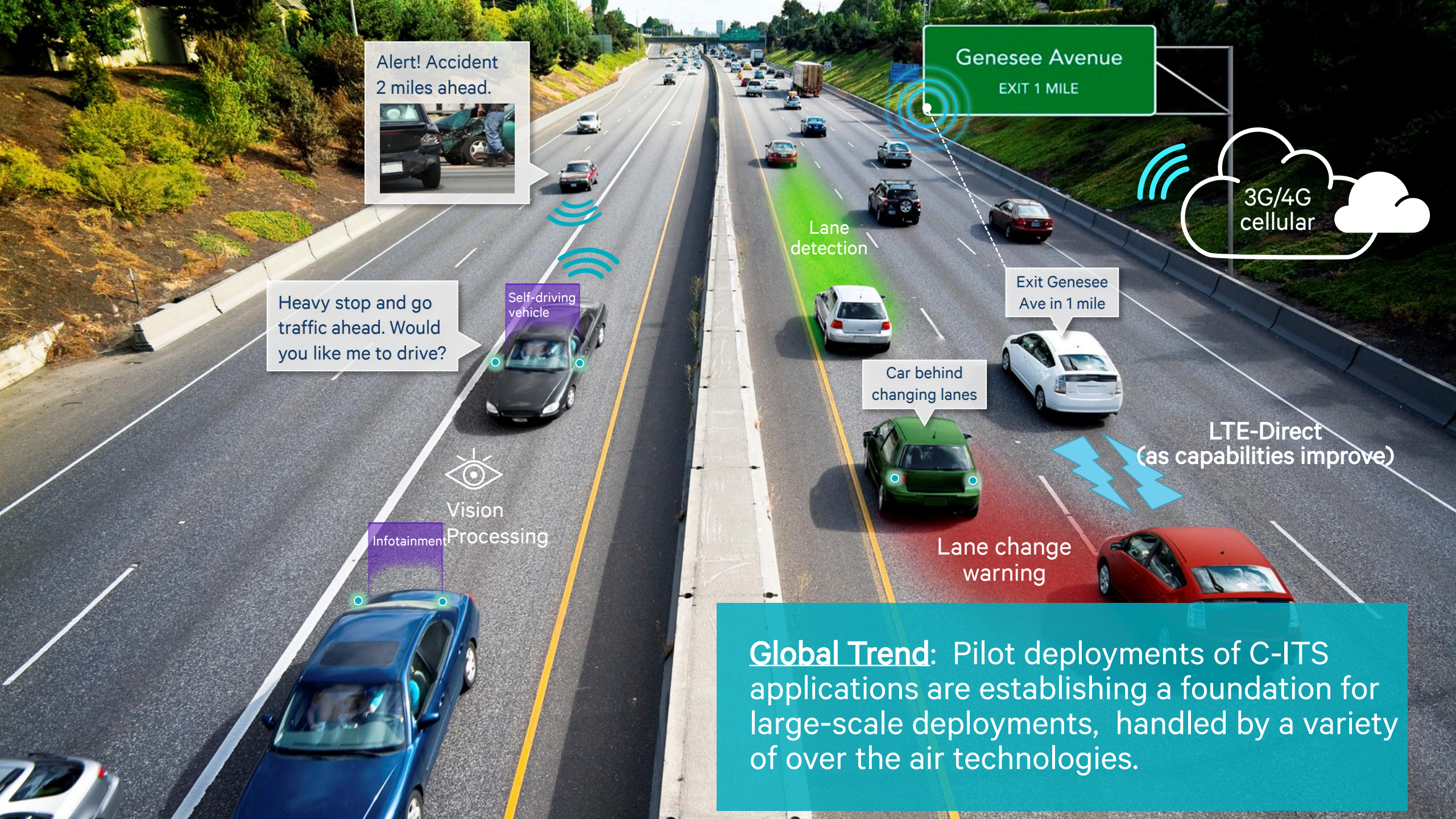
In Vehicle Infotainment and Active Safety
P2020(high)

P2020(high)

P2020(moderate to high)

Autonomous Vehicle
P2020 (low to moderate)

Connected Automation
P = P(CV + AV)



Global Trend: Pilot deployments of C-ITS applications are establishing a foundation for large-scale deployments, handled by a variety of over the air technologies.

All these depicted applications have a foundation of documented research and progress toward Standardization

Illustrative Projects

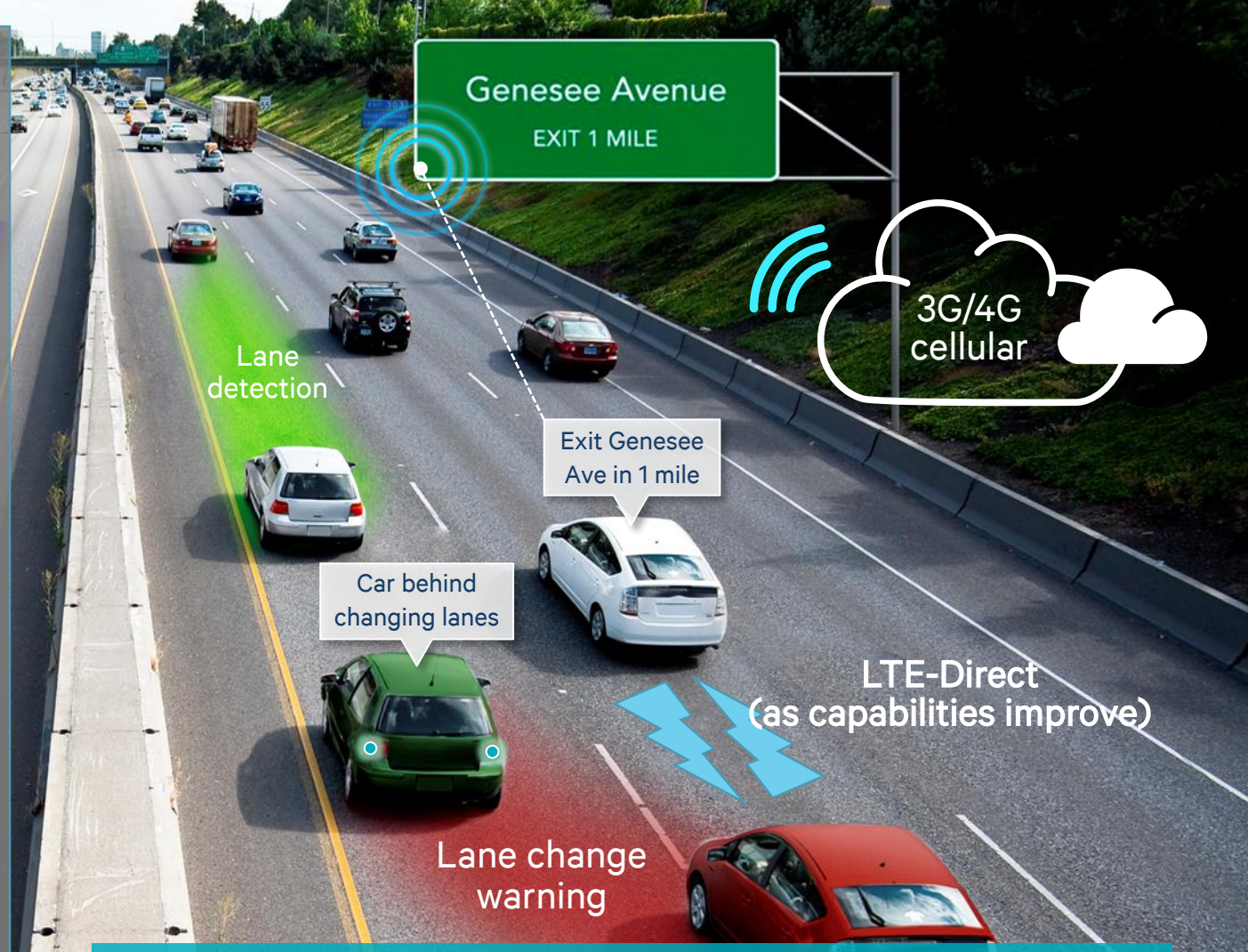
- US Connected Vehicle Reference Implementation Architecture:
  - INFLO and other Dynamic Mobility Applications
  - CACC
- German CONVERGE Project
- Connected Vehicle Model Deployment
- Amsterdam Group: Day One Use Cases
- Japan ITS SPOT
- US Potential FMVSS 150 (V2V Communications Mandate)

Illustrative Standards Activities

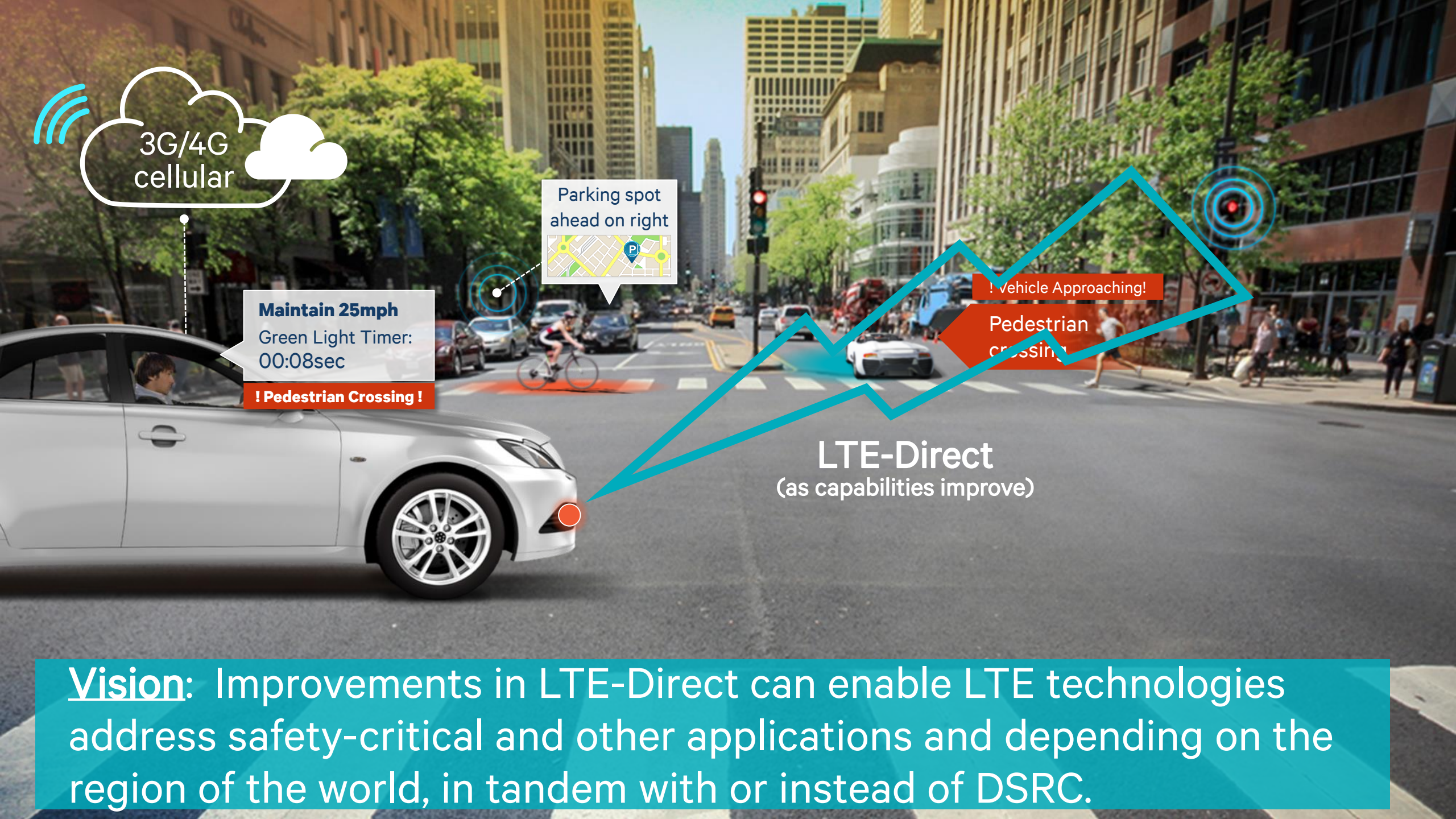
- CCSA V2X
- 3GPP V2X
- TIAA
- C-ITS
- US: SAE DSRC Technical Committee, IEEE 1609 WG
- Europe: ETSI ITS + C2C-CC, CEN 278
- ISO TC204 WG 16 and 18

Illustrative Deployment Coalitions

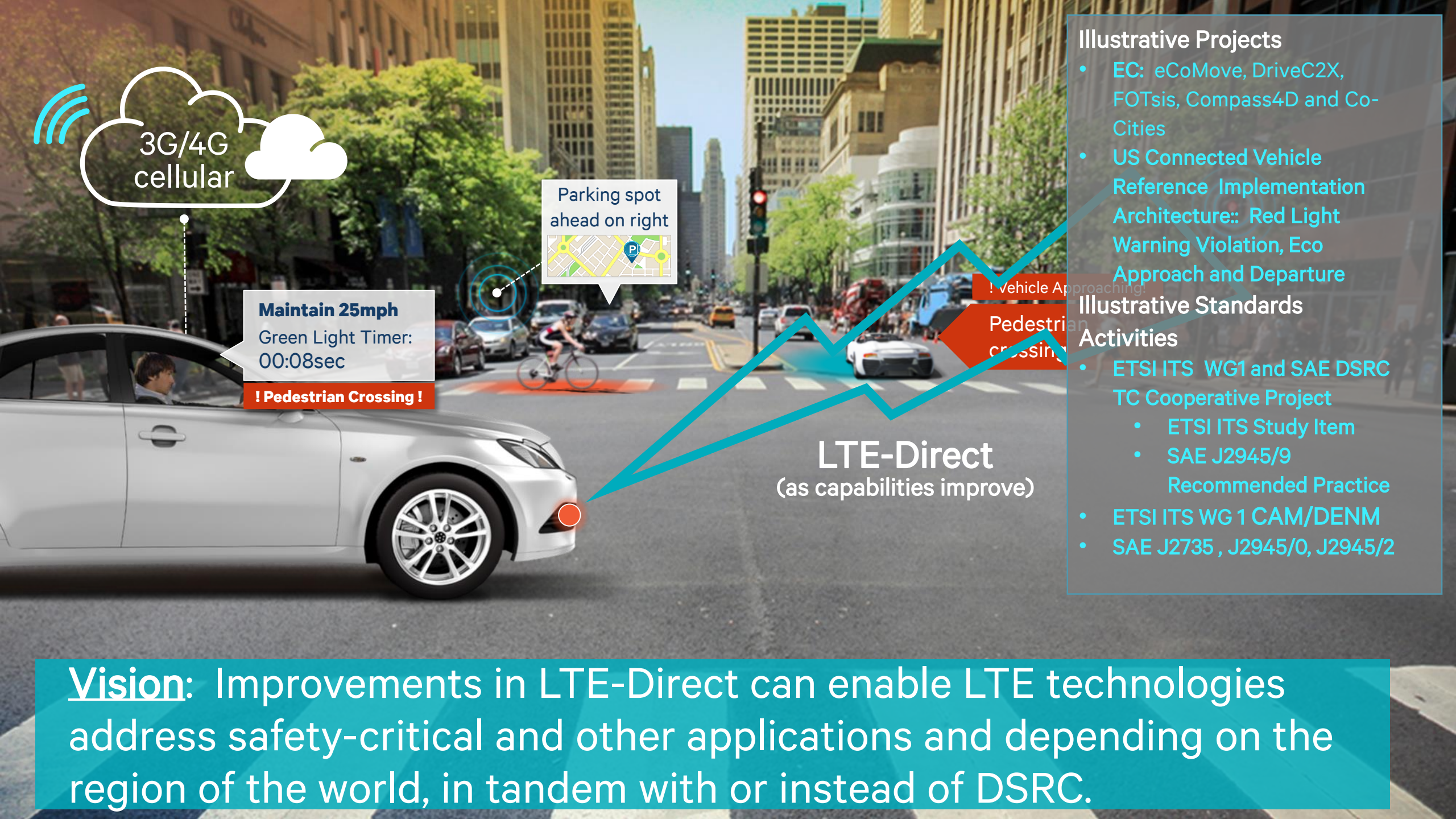
- European Amsterdam Group
- US V2I Deployment Coalition (ITE, AASHTO, USDOT, ITSA)



Global Trend: Pilot deployments of C-ITS applications are establishing a foundation for large-scale deployments, handled by a variety of over the air technologies.



Vision: Improvements in LTE-Direct can enable LTE technologies address safety-critical and other applications and depending on the region of the world, in tandem with or instead of DSRC.



Illustrative Projects

- EC: eCoMove, DriveC2X, FOTsis, Compass4D and Co-Cities
- US Connected Vehicle Reference Implementation Architecture:: Red Light Warning Violation, Eco Approach and Departure

Illustrative Standards Activities

- ETSI ITS WG1 and SAE DSRC TC Cooperative Project
  - ETSI ITS Study Item
  - SAE J2945/9 Recommended Practice
- ETSI ITS WG 1 CAM/DENM
- SAE J2735 , J2945/0, J2945/2

Vision: Improvements in LTE-Direct can enable LTE technologies address safety-critical and other applications and depending on the region of the world, in tandem with or instead of DSRC.

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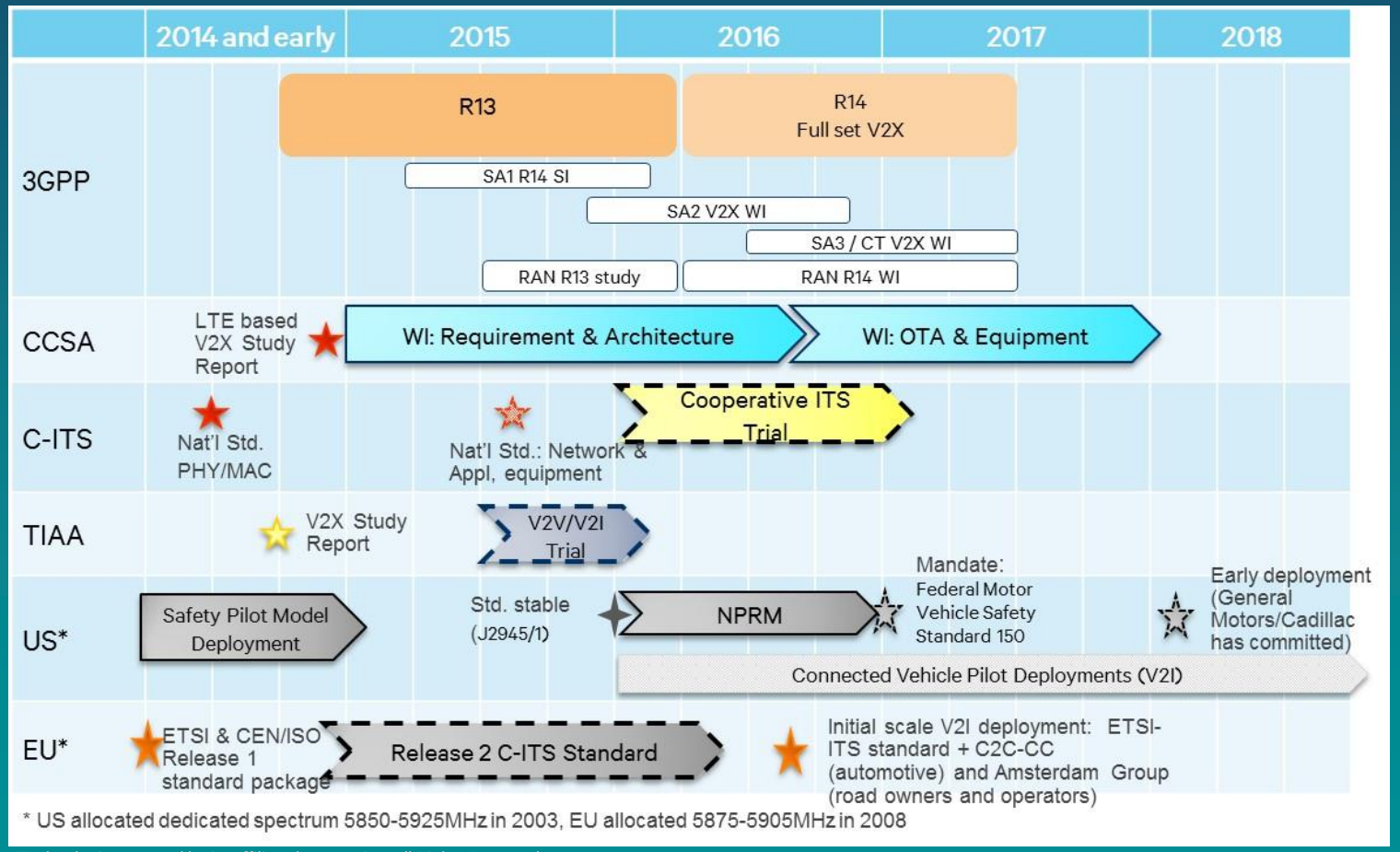
V2X Services Delivered via LTE

Rapid Standardization in the telecommunications Industry

- Overall vision is LTE V2V communication for safety purposes with cellular technology
  - A variant of the already-standardized LTE-Direct (ProSe, 3GPP R12)
  - The timeline to V2V standardization is suitable for may V2X deployments – including connected automation



SA1 = Services

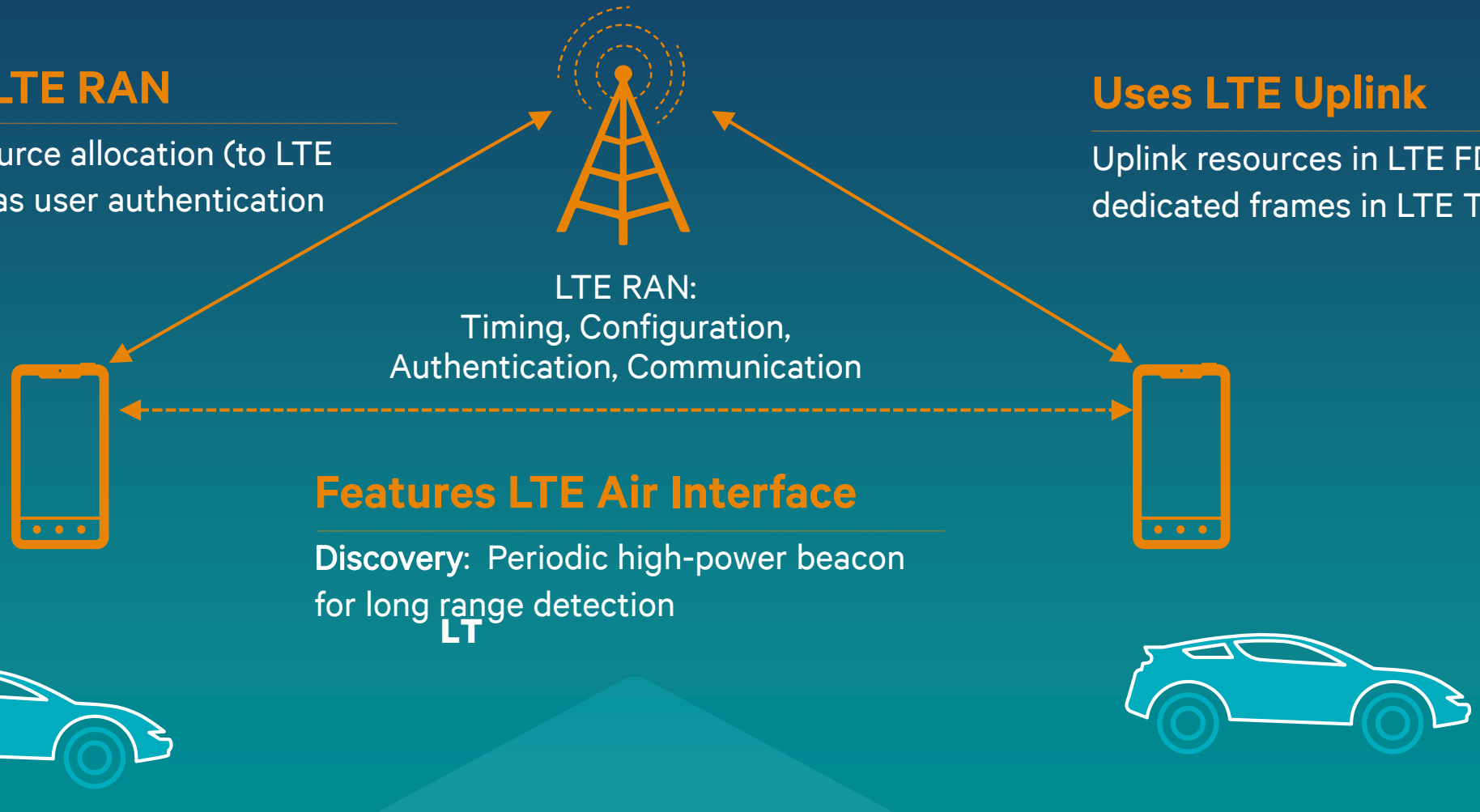
SA2 = Architecture

RAN = Radio Access Network

LTE-D for Automobiles

Leverages LTE RAN

For timing, resource allocation (to LTE Direct), as well as user authentication



Uses LTE Uplink

Uplink resources in LTE FDD system or dedicated frames in LTE TDD system

Features LTE Air Interface

Discovery: Periodic high-power beacon for long range detection

LT

1 Source: Qualcomm simulations; Assumes 20MHz system with ~2,000 expressions

LTE Framework Evolution for V2X

D2D Discovery and D2D Communications Frameworks can be Extended to Satisfy V2X Use Cases

- D2D Discovery
  - Needs longer message sizes
  - Needs faster duty cycles
  - Is not an ideal model for variable size messages
- D2D Communications
  - Handles large and variable size messages
  - Supports fast duty cycles
  - Needs better handling of half duplex and collisions
  - Needs more flexible retransmission configuration

Main items to address

Standardization at Application Layer

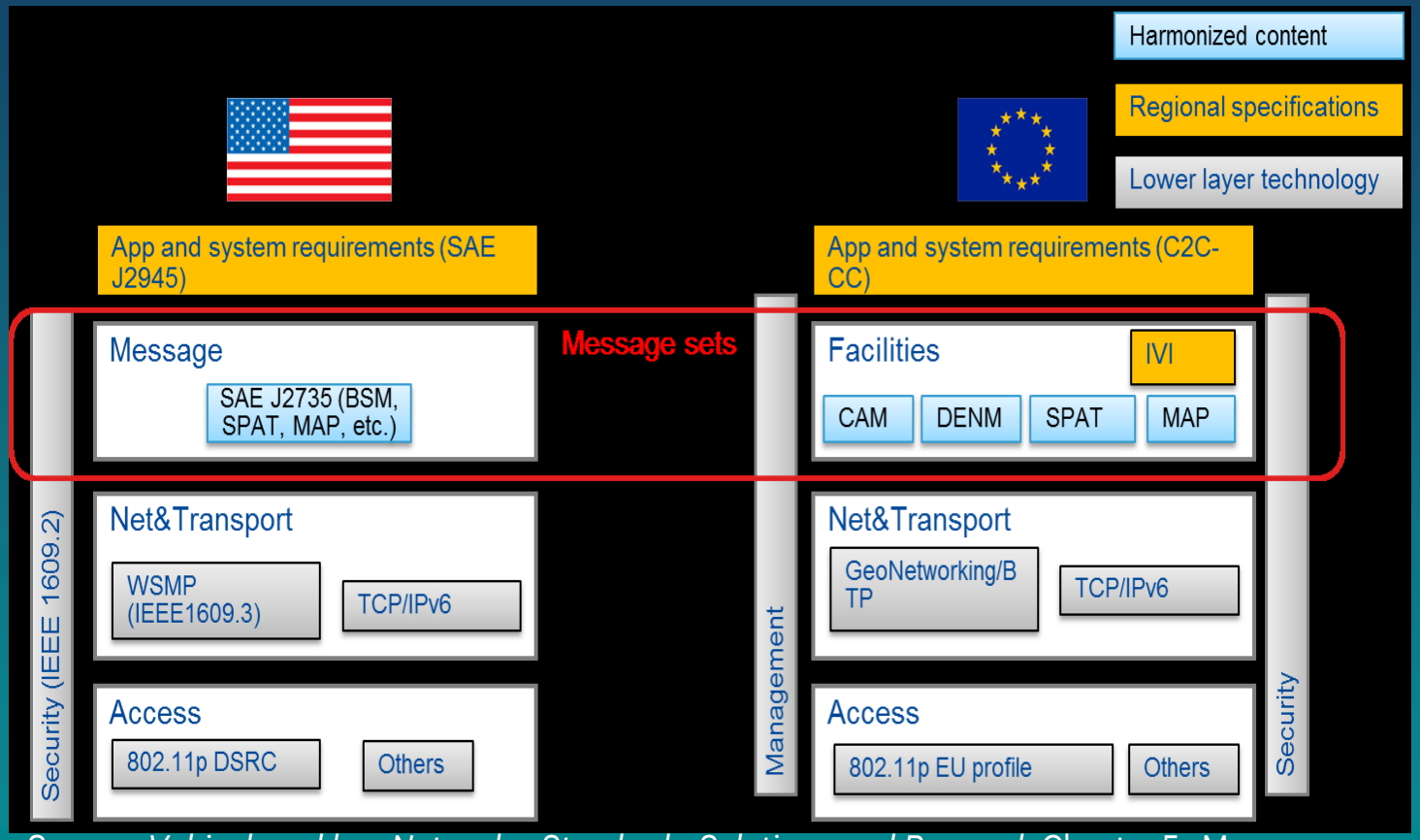
Enables Harmonized Applications

- Standardization moving towards finalizing the overall protocol stack

US: SAE J2945/1 On-Board Performance Requirements – 1st Ballot

- Different congestion control designs under debate
- Security framework design deferred
- End-to-end minimum performance requirement finalized

EU: Release 1 C-ITS Standard → Release 2 and Urban ITS Applications



Source: *Vehicular ad hoc Networks Standards, Solutions, and Research* Chapter 5: Messages Sets for Vehicular Communications, Lin and Misener

For maximum acceptance, the LTE V2V solution should be able to use other service layers (US and EU)

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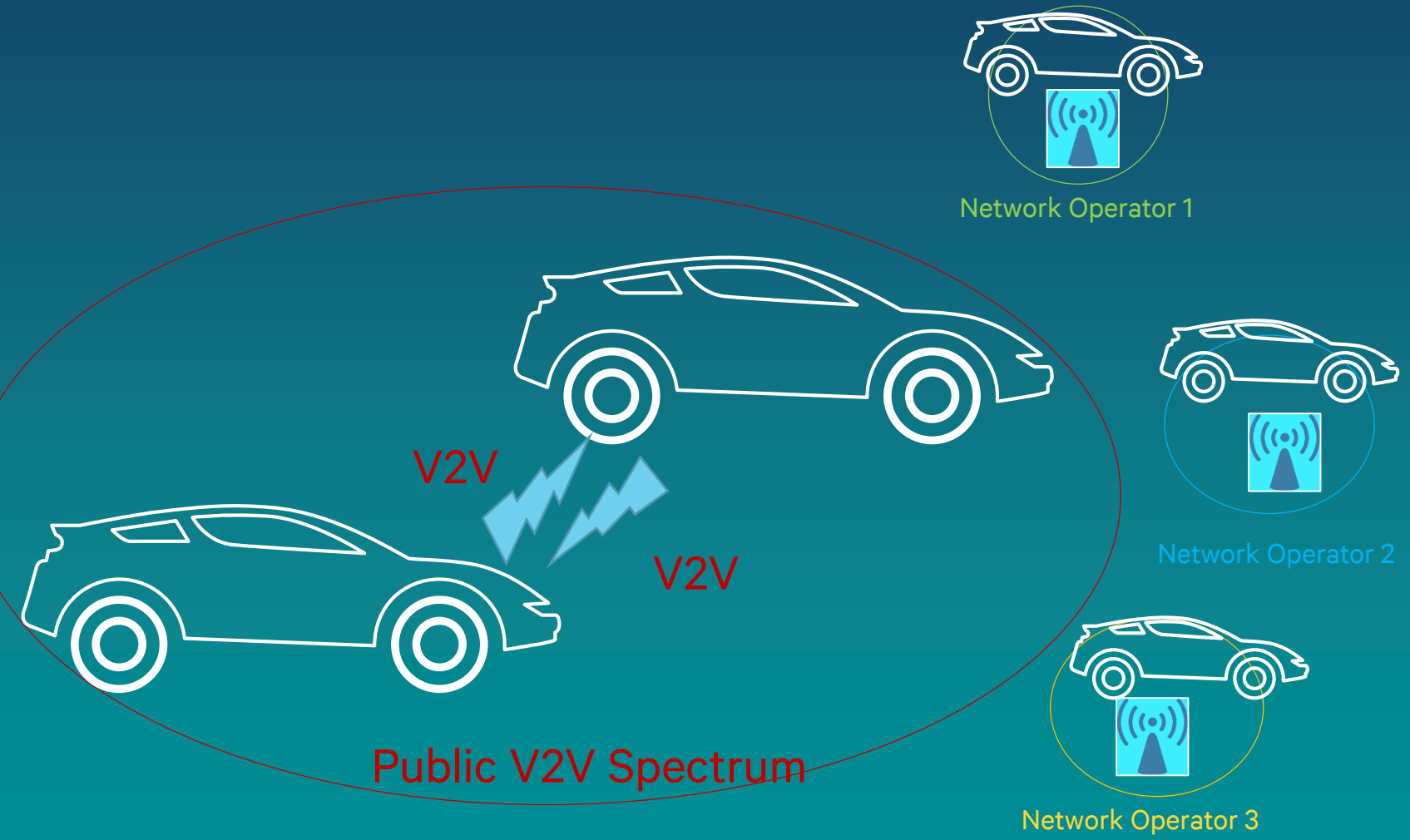
Key Consideration: Availability of Spectrum

Safety communications must be delivered via common spectrum



Mobile network operators would be able to deliver differentiating non-safety V2V applications on their spectrum

Could be new operator, existing operator or combination

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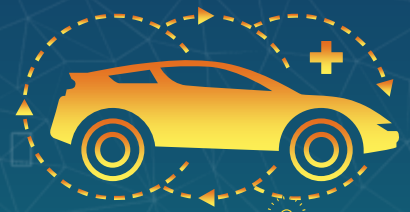
Going Forward

Great opportunity for China to substantially improve road safety and reduce congestion

- Around the world, concepts and standards are congealing
- V2X testbeds have been in operation for > 10 years → Initial deployments are occurring
- LTE Direct for V2X is being conceived to be:
  - Complimentary to DSRC for some use cases in some regions
  - Used instead of DSRC for all use cases in other regions
- Key issues for V2X deployment will be
  - Spectrum for interoperability
  - Conducive regulatory environment
  - Solid business models
- Future concepts and technologies will likely enable cooperative automation

Qualcomm connectivity solutions are part of the current and future car

LTE VEHICLE-TO-VEHICLE (V2V)



VEHICLE-TO-INFRASTRUCTURE (V2I)

WI-FI HOTSPOT

REAL-TIME NAVIGATION

DIAGNOSTICS

TOMORROW

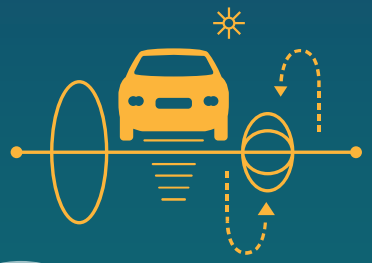
TODAY

YESTERDAY

CONNECTED INFOTAINMENT

SAFETY

EVOLUTION



DEDICATED SHORT RANGE COMMUNICATION (DSRC)

NAVIGATION

REMOTE FIRMWARE UPDATES

Thank you

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