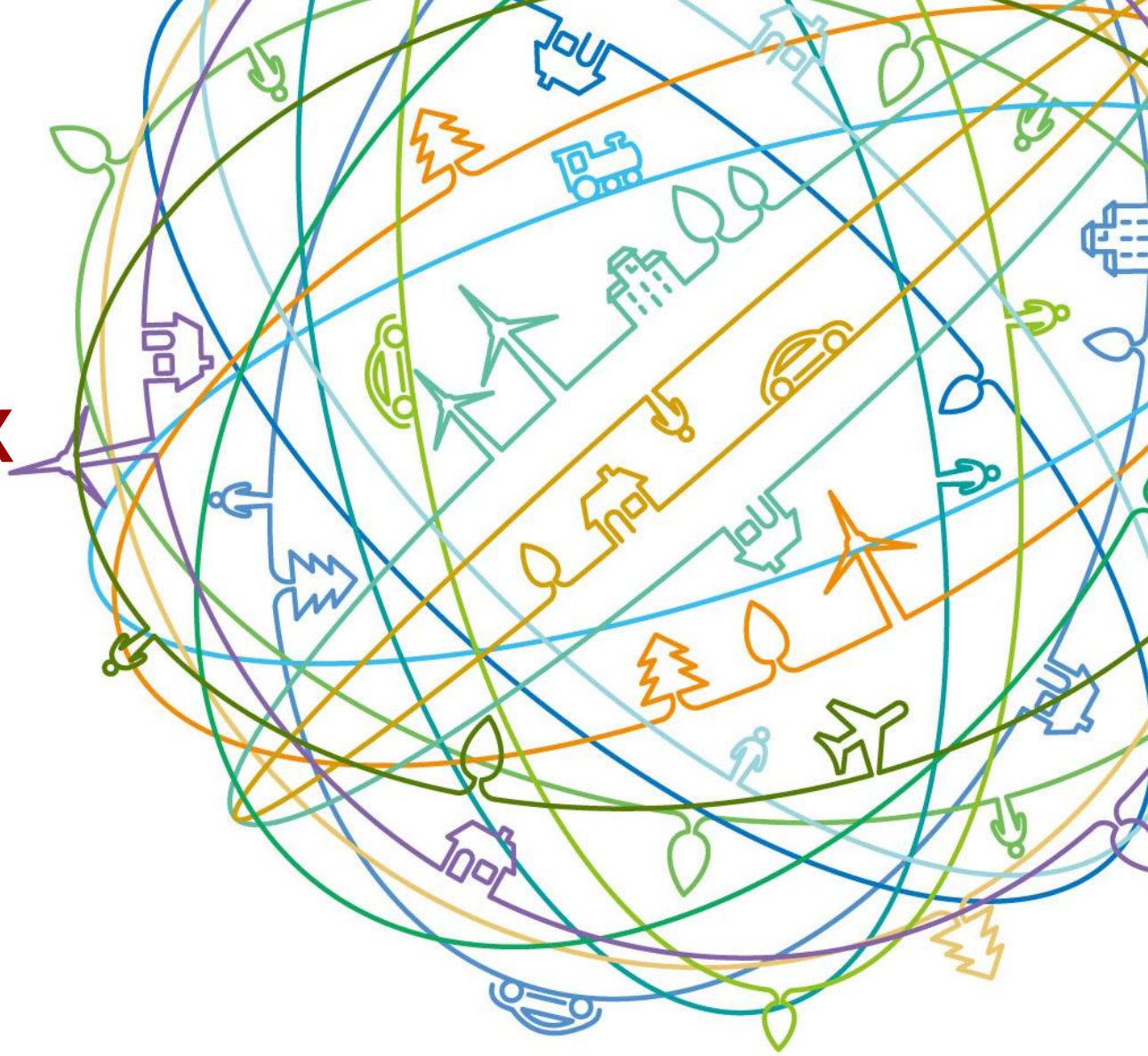
LTE-V: A Cellular-Assisted V2X Communication Technology



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Contents

1. ITS stages and the role of LTE V2X
2. What is LTE V2X, benefits
3. Standardization status
4. Conclusion

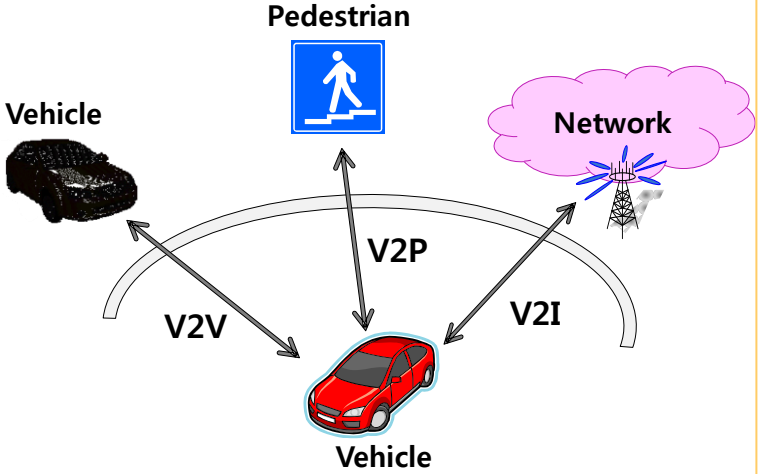
Why Connected Vehicle Technologies Are Needed

Connected vehicle technologies aim to tackle some of the biggest challenges in the surface transportation industry—in the areas of safety, mobility, and environment.

• **Safety:** According to the National Highway Traffic Safety Administration (NHTSA), there were 5.615 million crashes in 2012. The number of fatalities from vehicle crashes is falling but still accounted for 33,561 deaths in 2012. Connected vehicle technologies will give all drivers the tools they need to anticipate potential crashes and significantly reduce the number of lives lost each year.

• **Mobility:** According to the Texas Transportation Institute, U.S. highway users wasted 5.5 billion hours stuck in traffic in 2011. Connected vehicle mobility applications will enable system users and system operators to make smart choices that reduce travel delay.

• **Environment, traffic efficiency:** According to the Texas Transportation Institute, the total amount of wasted fuel topped 2.9 billion gallons in 2011. Connected vehicle environmental applications will give motorists the real time information they need to make "green" transportation choices.



Types of V2X (as defined in TR 22.885)

➢Safety / non safety

➢Proximity services, parameters defined by the operator

ITS Stages and Key Communication Technologies

Wired / wireless for RSU comm

2G/3G/4G Cellular

802.11p

LTE-V2X

New technology?

Stage 1

Stage 2

Stage 3

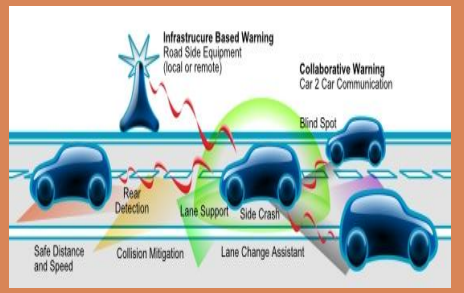
Stage 4

Roadside Comm

Wired or wireless communication for infrastructure

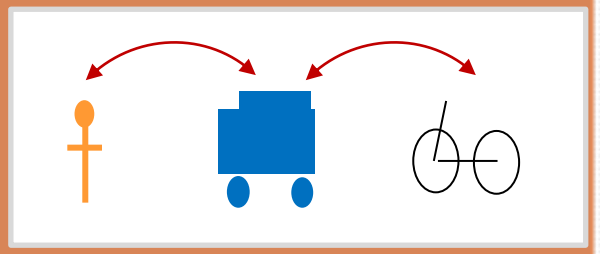
Telematics

infotainment, on-line navigation, remote diagnostics, e-call communications



ITS - BSA

V2V,V2I (V2X) communication to warn drivers potential risks and improve traffic efficiency. (Basic Set of Apps).



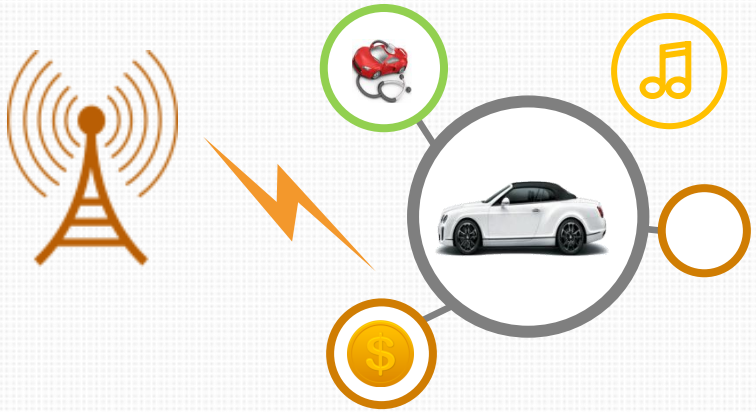
ITS - ESA

Accident-free, driver-less traffic, autonomous driving. Achieve vehicle / road /environment harmony. (Enhanced Set of Apps)

90s' 2000s' 2010s' 2020s' 2030s'

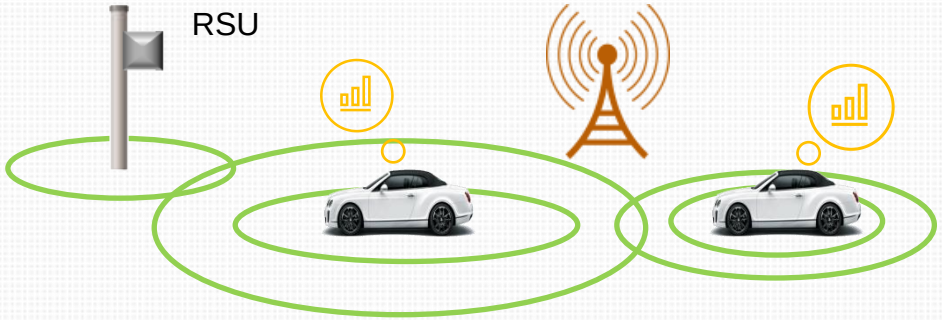
Two Main Applications in IoV

Telematics



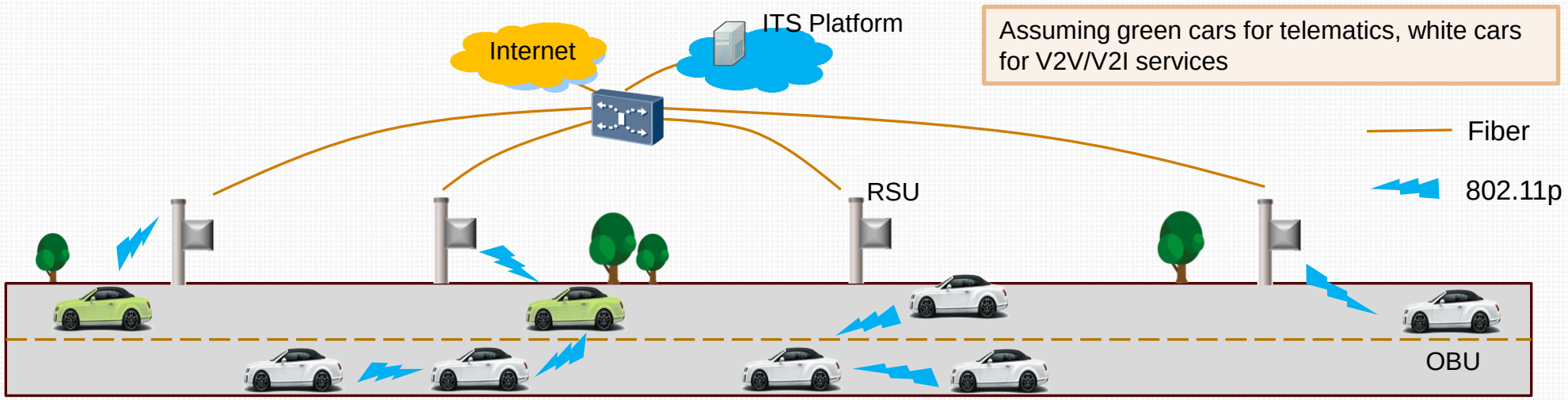
- Communication traffic model and requirements:
  - Infrequent transmission
  - Large coverage
  - Latency insensitivity
- Underlying technologies:
  - Cellular technologies (2G/3G/4G)

V2V/V2I ITS Road Safety



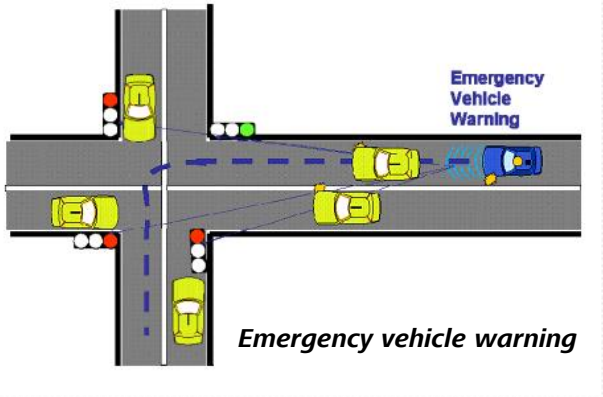
- Communication traffic model and requirements:
  - Frequent transmission (1~10Hz)
  - Short range communication (hundreds of meters)
  - Low latency requirement (<=100 ms)
  - High reliability
- Underlying technologies:
  - 802.11p and LTE-V2X

802.11p Based Deployment

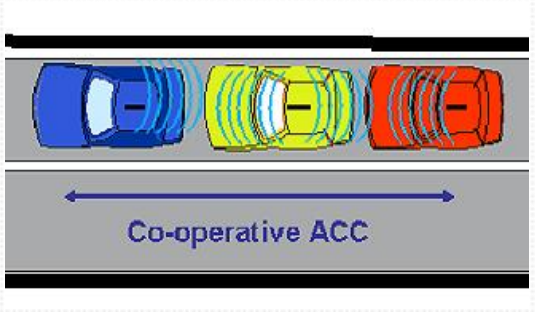


- Issues:
  - Performance cannot be guaranteed, since 802.11p is ad hoc mechanism
    - CSMA/CA based, with hidden terminal and congestion problems
    - Spectrum dedicated for V2V road safety is limited (10MHz for US, 30MHz for Europe)
  - Costly RSU deployment to cover telematics services, yet many already provided by LTE (ITS-G5B left unused).
  - Business model is not clear.
  - Security, maintenance issues (downloading, update, revocation, etc.)
  - No clear evolution path for future services.

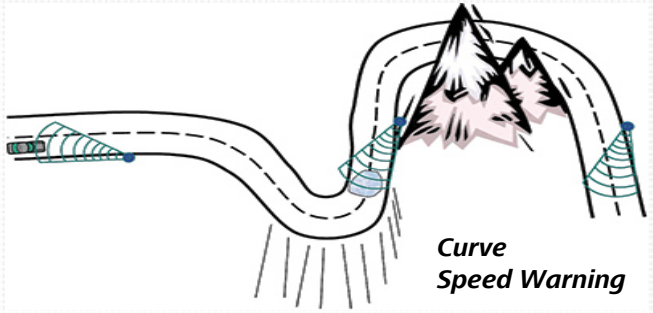
3GPP SA1 Agreed 18 Use Cases in TR 22.885



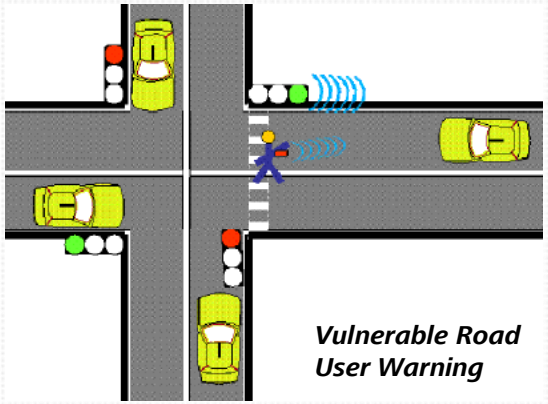
V2V Safety
[5.1-5.4, 5.7, 5.10, 5.12]



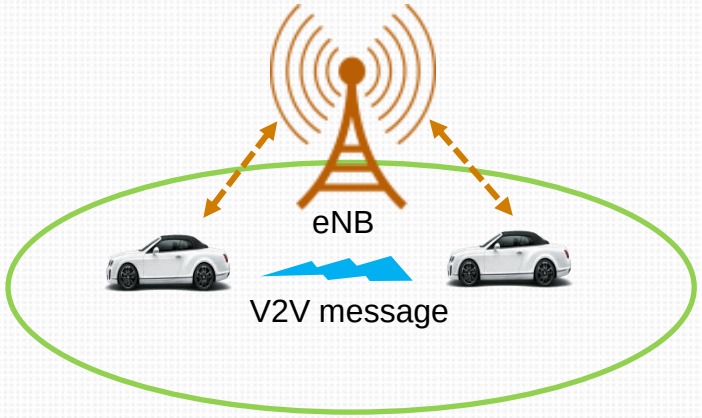
V2V/V2I Traffic Efficiency
[5.5, 5.9, 5.15]



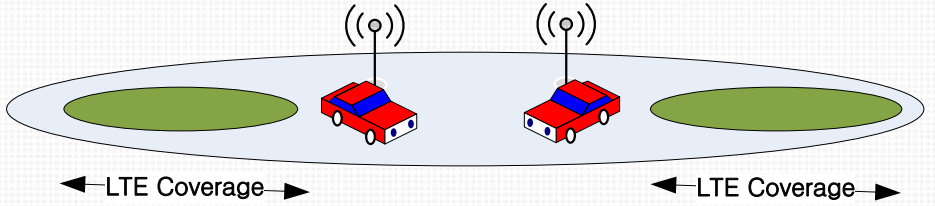
V2I Road Safety
[5.6, 5.8, 5.14, 5.16]



V2P Road Safety
[5.17, 5.18]

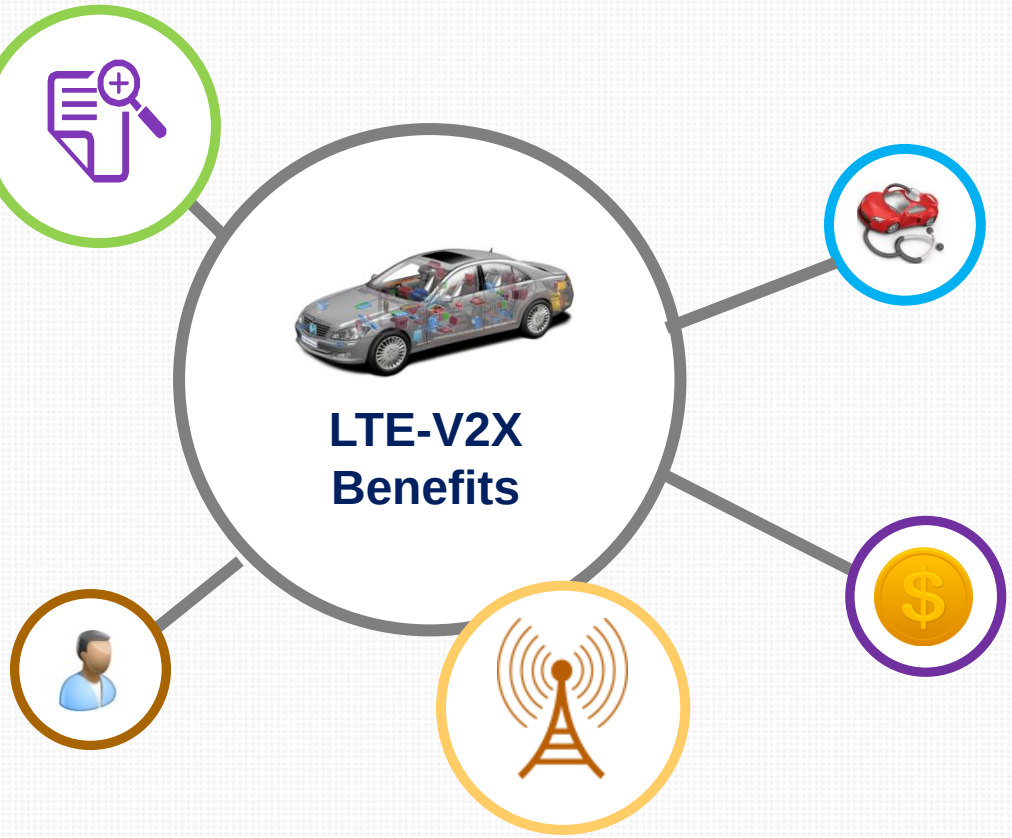


V2V message transfer **under operator control**
[TR 22.885, 5.11]



V2X in areas **outside network coverage**
[TR 22.885, 5.13]

Benefits of LTE-V2X



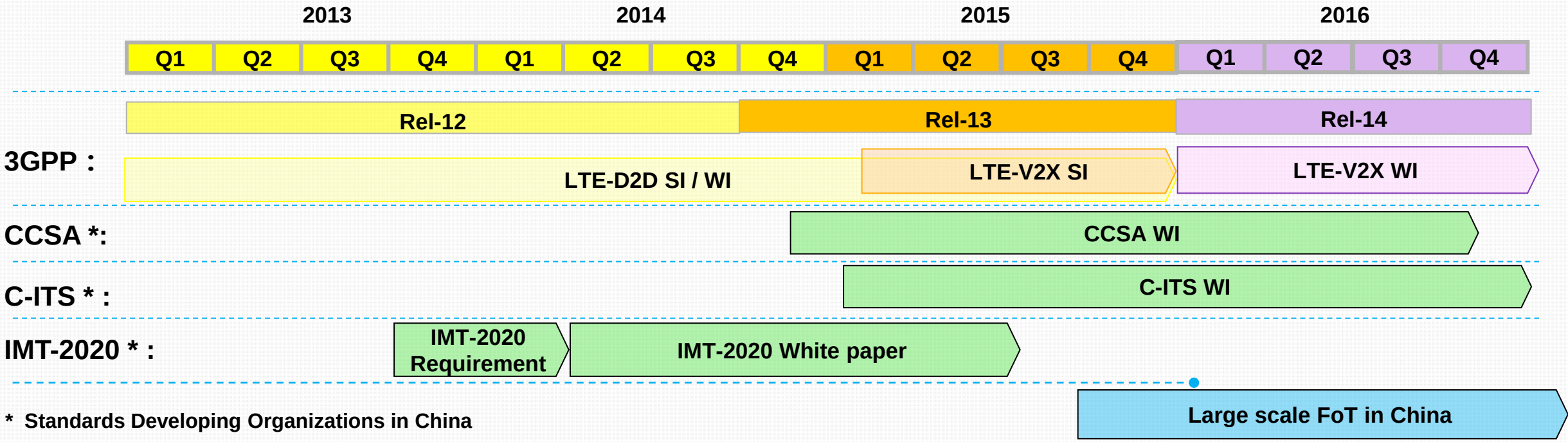
Benefits

- Fast, cheap deployment of ITS network, by reusing MNOs' network infrastructure
- One chipset for all; lower integration costs for car OEMs; more users, vulnerable users (pedestrians), also for smartphones and aftermarket
- Advanced, reliable technology, half distributed half centralized mechanism
  - Qos, latency PDR always under control, wider reach
- LTE coupled solution to support telematics/infotainment and V2X more efficiently, and innovative business models for….
  - Safety, non safety, mobility, semi autonomous car
  - Telematics/infotainment on same link
  - V2X also for MBB services and comfort driving (e.g. Walkie talkie, see through car in front, etc)
- Further evolve to 5G and support more use cases including pedestrian, cyclist…

Critical factors follow for a succesful LTE V2X Strategy

- **Prove the technology, comparing with 11p in field**
- **Spectrum:**
  - industry agreement, then lobbying. Dedicated? harmonized?
- **Discuss business case among stakeholders**
  - Improved safety with simple LTE V integration is already a business case for car maker?
  - Monetization opportunities for MNO when entering in ITS market
  - Benefits/cost analysis (e.g. Liabilities Vs revenues Vs other advantages)
- **Time to integrate new technology into cars (lifecycles misalignment)**
- **Industry/standards discussions, take market window, promotion:**
  - 3GPP, ETSI, GSMA, ERTICO, C2C comm. consortium, etc.
- **Ecosystem, interoperability**

LTE-V2X Standardization Progress



* Standards Developing Organizations in China

- LTE-D2D has paved the way for V2X communication
- 3GPP SA1 has started Rel-14 LTE-V2X SI from 2015 Feb with most companies' support.
- 3GPP RAN has started LTE-V2X SI from June 2015, V2V part to complete in 2015, the rest in 2016 (Rel-14)
- In China, a series of LTE-V2X SI/WI have been setup at CCSA and C-ITS.
- LTE-V2X is the first step for V2X in 3GPP. When it comes to 5G, even lower latency and higher reliability will be supported

SA1 V2X SI: LTE Support for V2X Services (TR 22.855)

Study Item	Target Completion	04/2015	12/2014	SA1 Status
LTE support for V2X services	SA#70 (12/2015)	50%	-	New study item

Agenda item xx

S1-150284 SID V2X

Remarks:

- The objective is to study use cases and potential requirements for LTE-based communication between:
  - vehicles (V2V)
  - a vehicle and a device carried by an individual, e.g. handheld terminal carried by a pedestrian, cyclist, driver or passenger (V2P)
  - a vehicle and a roadside unit (V2I)
- The study also aims to take into account V2X services and parameters defined in other SDOs (e.g. ETSI ITS, US SAE) or related governmental agencies.

——— **3GPP Official Report**

Supporting IM name
ALU
AT&T
CATT
Ericsson
ETRI
Fujitsu
Huawei
III
InterDigital Communications
ITL
ITRI
KT Corp.
KPN
LG Electronics Inc.
LG U+
NEC
Nokia Networks
Qualcomm Incorporated
SK Telecom
Telecom Italia
Telia Sonera
ZTE

3GPP SA1 V2X Highlights

- V2V, V2I and V2P use cases were included with associated potential requirements. Study of V2V use cases was prioritized during discussions.

- Several important agreements reached:
  - MNO in control of V2V communication (e.g. authorization, session establishment, resource allocation, etc).
  - Out of coverage V2V communication use cases.
  - Performances values to support V2V messages were agreed, many apply to V2I as well. Some values are informative
  - The Roadside Unit (RSU) entity is implemented either in an eNodeB or a stationary UE.
  - A liaison statement (LS) is sent back to RAN#68 (June 15-18), with the current V2X technical report (TR) attached

TR22885 v020

Service values for V2V agreed in the Study (many apply to V2I)

Mandatory values

Name	Value
Maximum absolute velocity	160 km/h
Maximum relative velocity	280 km/h
Typical message size	50 - 400 bytes
Maximum message size	1200 bytes
Maximum message frequency	10 Hz
Maximum latency	100ms (20ms*)
Communication range	4 s response time

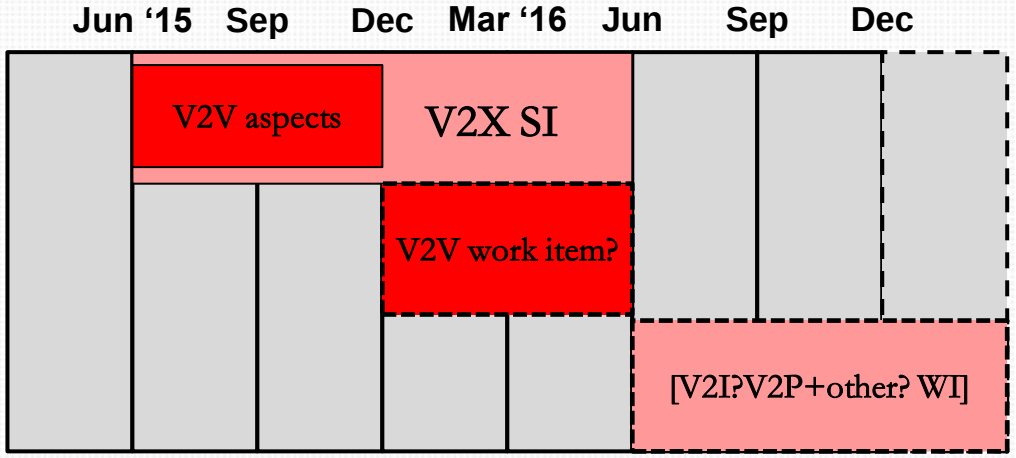
*20ms latency comes from the V2V pre-crash sensing use case, which is agreed to support with lower priority.

Informative values (in TR informative Annex)

	Effective range	Absolute velocity of a UE supporting V2X Services	Relative velocity between 2 UEs supporting V2X Services	Maximum tolerable latency	Minimum application layer message reception reliability
#1 (suburban)	200m	50kmph	100kmph	100ms	90%
#2 (freeway)	320m	160kmph	280kmph	100ms	80%
#3 (autobahn)	320m	280kmph	280kmph	100ms	80%
#4 (NLOS / urban)	100m	50kmph	100kmph	100ms	90%
#5 (urban intersection)	50m	50kmph	100kmph	100ms	95%

RAN V2X Study Item (approved RAN#68, June 2015)

- Includes V2X operation in coverage, out-of-coverage, in dedicated LTE-based V2X spectrum, and in licensed spectrum which is also used for normal LTE.
- Will use SA1 requirements, and external information from e.g. ETSI ITS, SAE, CCSA
- Three main objectives to prepare for potential normative work in 2016:
  1. Evaluation methodology: deployment scenarios, vehicle density and mobility, data traffic models, and performance metrics. V2V over D2D sidelink to target Sept 2015, but objective continues for other parts.
  2. V2V over D2D sidelink enhancements study to complete first, by Dec. 2015.
     - D2D resource allocation enhancements to be identified
     - D2D support in high Doppler environments: up to 280kph at around 5.9 GHz, and GNSS-based synchronization.
  3. V2V over cellular, and D2D sidelink and cellular enhancements studies for V2I/N and V2P to complete by Jun. 2016.



Possible 3GPP RAN timeline for V2X (based on RP-151082)

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Conclusions, LTE-V2X:

- Standardization work has started, across 3GPP.
- A promising evolved technology for V2X services and will further evolve for future V2X.
- A new cellular network assisted service based on LTE-D2D that gives better business opportunity and an easier business case for all C-ITS stakeholders.
- Industry alignment/forum is needed among car makers, MNOs, road operators, authorities, for standard, spectrum, deployment and business model definition.

Thank you

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