Automotive V2X Storage Implementation

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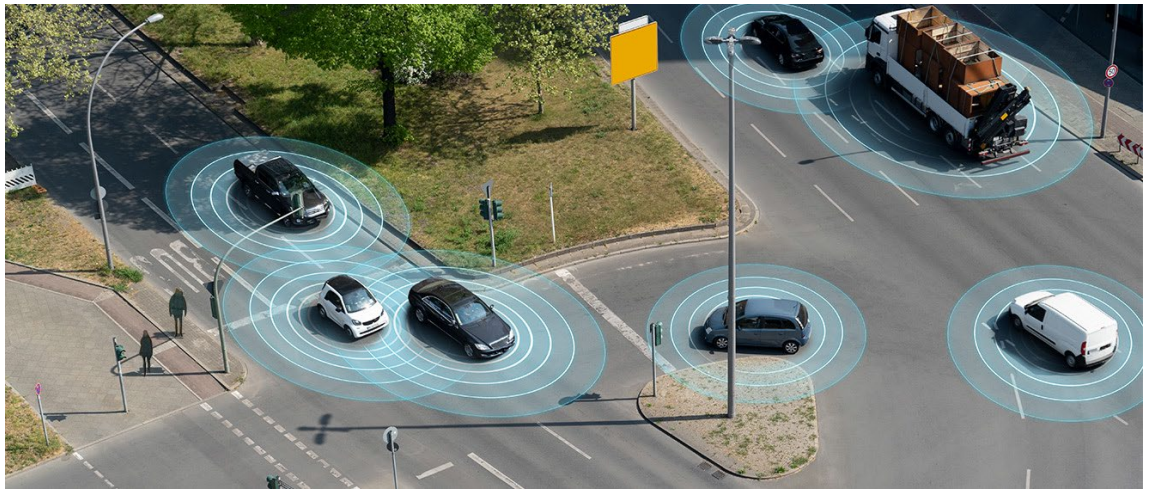
Agenda

- Market Situation Statistics
- Vehicle-to-Everything (C-V2X, DSRC*) Trends (Today→Tomorrow→Future)
  - Enhanced agility
  - Elimination of human factors on autonomy to improve safety and avoid accidents
- Performance Requirements of Different V2X Use Cases
- Key Observations on V2X from Storage Point of View
- Storage Solutions Summary
- Key Takeaways

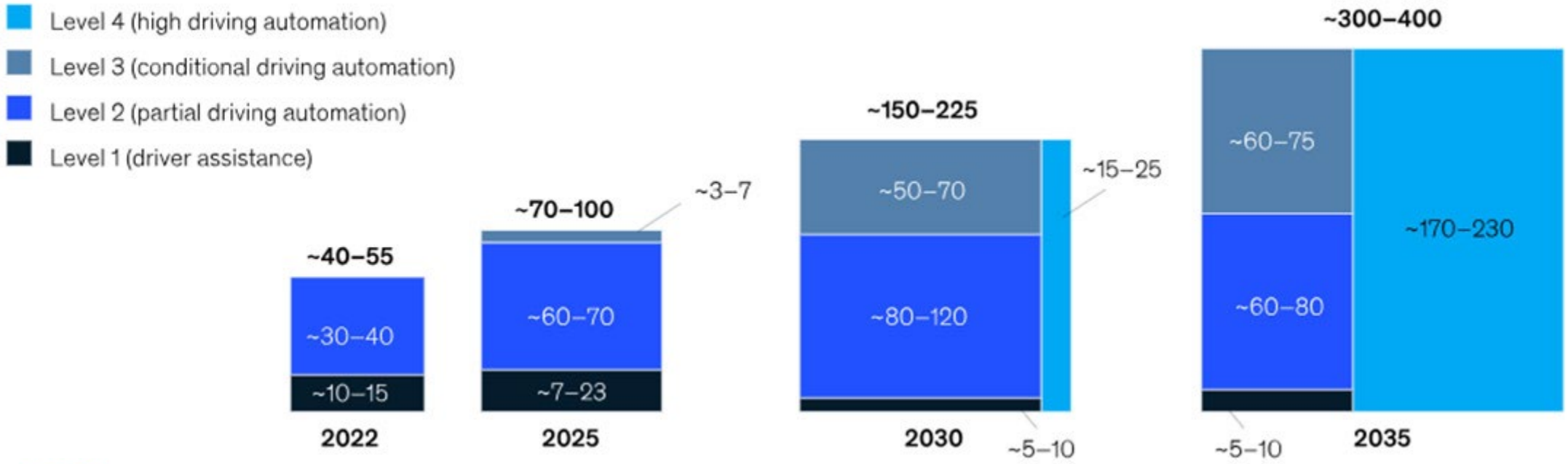


*Dedicated Short Range Communications

Market Situation Statistics

Advanced driver-assistance systems (ADAS) and autonomous-driving systems (ADS) for passenger cars could create $300 to $400 billion in revenues by 2035.

ADAS and ADS revenues ($ billion)

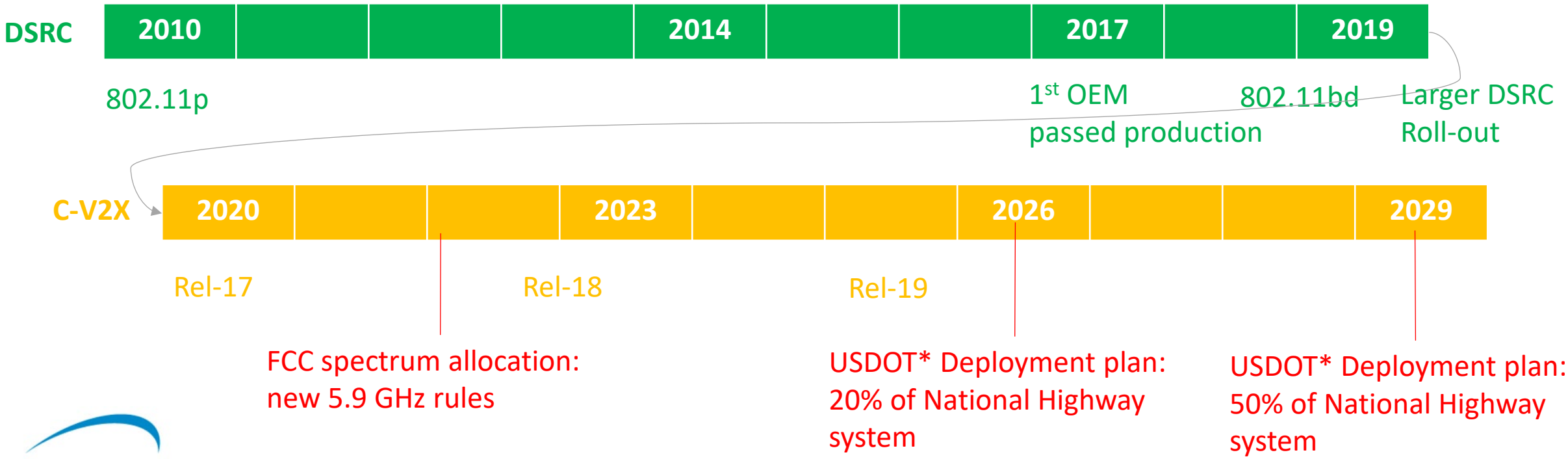


Source: McKinsey Center for Future Mobility

Vehicle-to-Everything Trends

Milestones and Plans of Two V2X Standards

- **DSRC:** The first V2X technology available, deployed 9+ years ahead of C-V2X.
- **C-2VX:** FCC* spectrum allocation: new 5.9 GHz rules after 2021



*FCC: Federal Communications Commission
USDOT: United States Department of Transportation

Summary: DSRC vs. C-V2X Technical Properties

- V2X Direct / Network Communication
- DSRC and C-V2X are rooted from different technologies

Topic	DSRC+	C-V2X Rel-16/17/18
Technology	IEEE802.11bd NGV (Next Gen. V2X)	5G NR (New Radio)
Compatibility	Full backward compatible. Deployed	Incompatible from Rel 14 to 15/16
Modulation	OFDM	OFDM, SC-FDMA
Communication Range	≤ 2 km	> 2 Km
Mobility	Up to 500 km/h	Upto 500 Km/h
Latency	0.5-10 ms (300m range) 10-100 ms (300m-2 km range)	0.5-10 ms (300m range) 10-100 ms (300m-2 km range)

DSRC / IEEE NGV

5G NR-V2X PC5

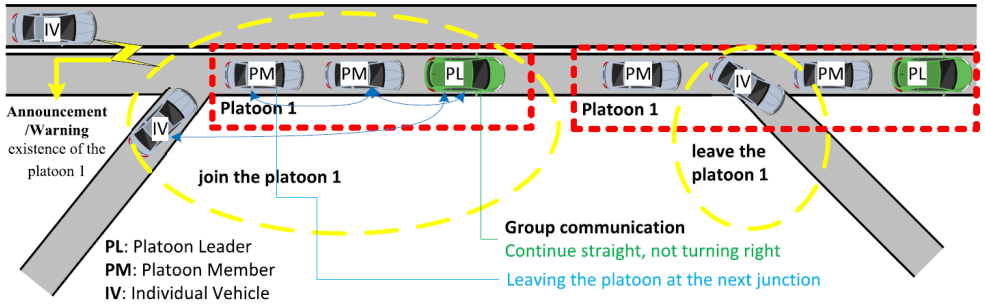
PC5 interface is also called Sidelink in 3GPP

Source: Evaluation of Radio Access Protocols for V2X in 6G Scenario-Based Models

Performance Requirements
of Different V2X Use Cases

Use Case Type	V2X Mode*	End-to-End Latency	Reliability (%)	Data Rate (Mbps)	Min. Range (meters)
Vehicle Platooning	V2X/V2I	10 ms -500 ms	90-99.99	50-65	80-350
Remote Driving Teleoperated Support (TeSo)	V2N/V2X	5 ms	99.999	UL: 25, DL: 1	-
Extended Sensors (Vulnerable Road User, etc.)	V2P	3ms – 100 ms	90-99.999	10-1000	50-1000
Advanced Driving	V2V/V2P/V2I	3ms – 100 ms	90-99.999	10-53	360-700

Sources:
On 5G-V2X Use Cases and Enabling Technologies: A Comprehensive Survey
Use Cases, Requirements, and Design Considerations for 5G V2X



Platooning example

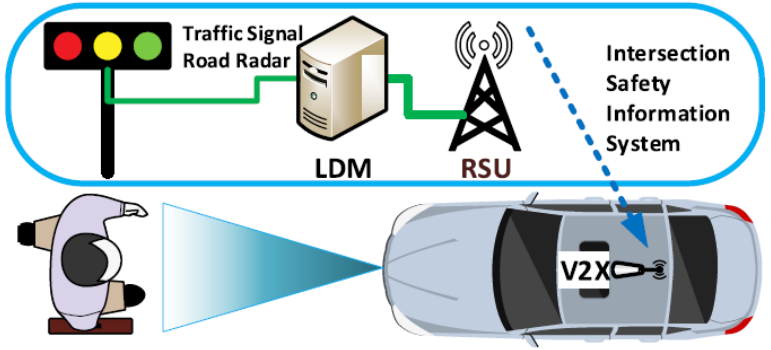
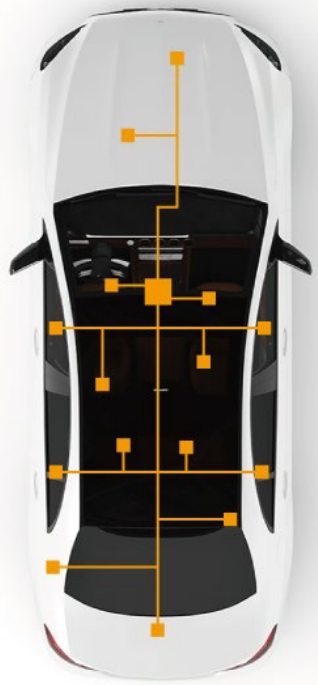


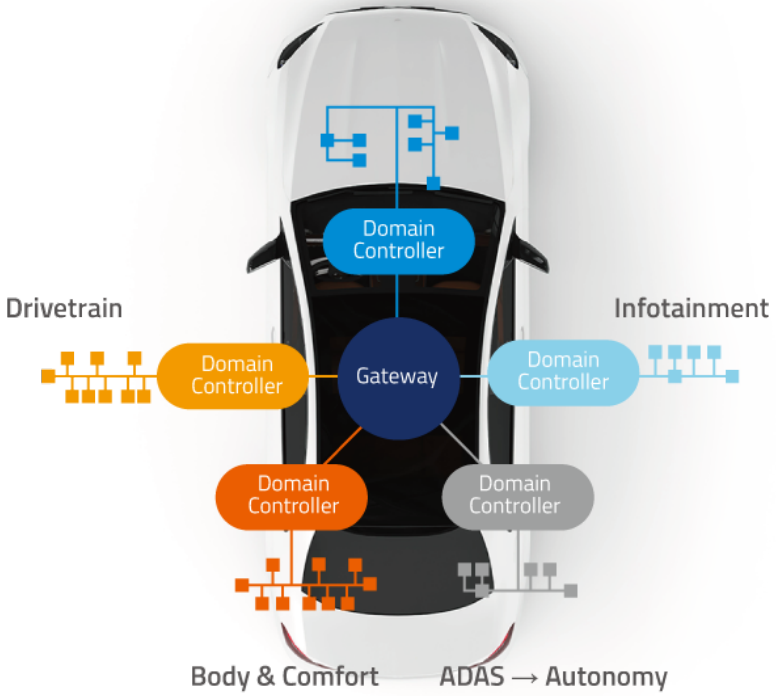
FIGURE 8. Concept of intersection safety information system [26].

Extended Sensors

System Architecture



Today



Tomorrow

Future

Key Observations on V2X
from Storage Point of View

- If every data is uploaded to the Cloud Server, the 5G cost burden will be too high.
  - Estimated basic 25 Gb/hour data generated.
  - Edge Computing is necessary.

- The following varieties of storage on automotive systems/infrastructure will still be available before 2030:
  - e.MMC
  - UFS
  - Edge Computing Storage, such as E1.S, BGA SSD

Edge Computing on vehicles is necessary to upgrade drive performance and reliability.

- Performance (including Thermal Plan cover SSD)
- Low Latency (QoS)
- Bigger Capacity on Domain/Centralize Storage
- Drive Writes per Day (DWPD)
- Thermal Dissipation and Simulation Capability with System
- Removeable preferred (for data reading after collision)
- Centralization Optional (Multi-port, Name Spaces, SRIOV)

Storage Security

- TCG Opal 2.0+
- FW Signature

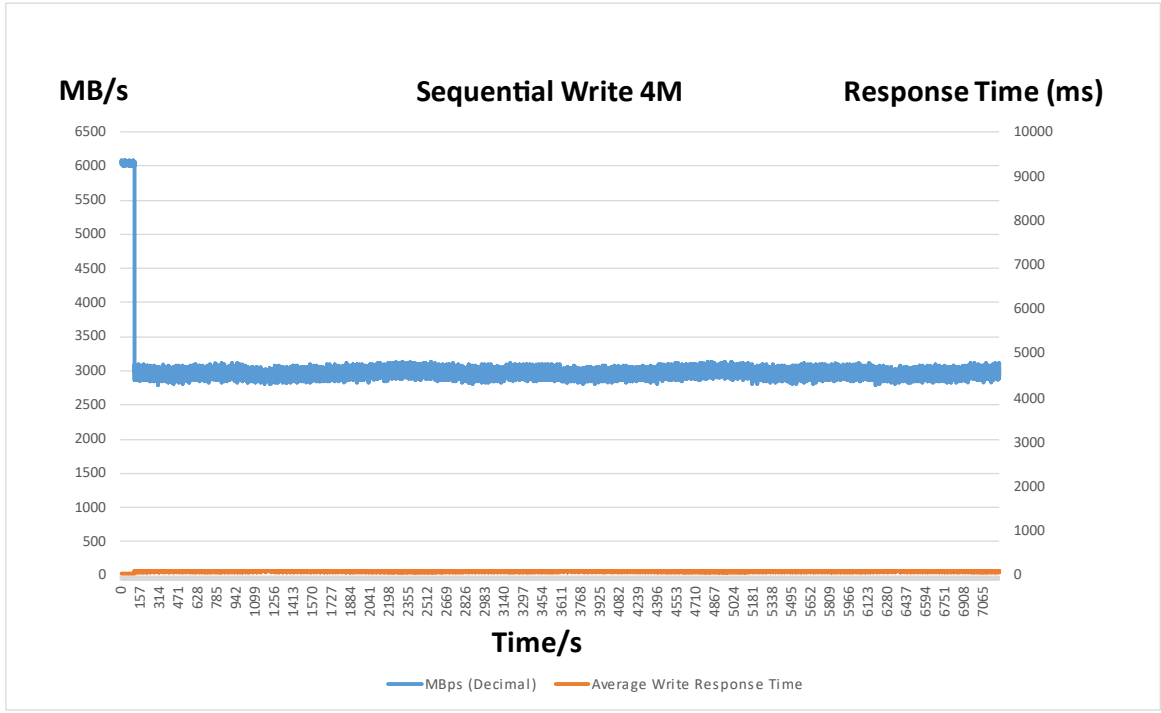
The Best Practice of E1.S Storage

- Latency/QoS of SSD

Specification		7680GB	Unit
		QD=1	
QoS (99%)	Read	0.0832	ms
	Write	0.0152	
QoS (99.9%)	Read	0.0835	
	Write	0.0156	
QoS (99.99%)	Read	0.0837	
	Write	0.0159	
QoS (99.9999%)	Read	0.0840	
	Write	0.0160	

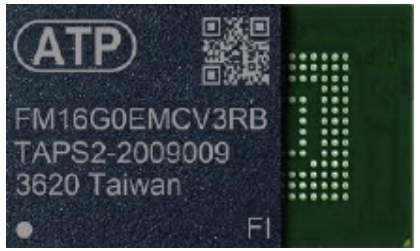
Quality of service (QoS) parameter is the requirement that a given application complete all requested processes under steady and consistent performance within a specified time limit. Measurements are performed at Queue Depth=1 (Read/Write: numjobs x jodepth =1 x 1), Random 4KB transfer size, using FIO, sector size as 512 bytes.

- Data Rate (Sustained Performance)



Storage Solutions Summary

- e.MMC/UFS
  - Simple OS
  - Legacy Performance is moderately
  - Capacity from 8GB-512GB
  - Cost Effective for Suitable applications, such as Telematics…etc
- SSD (BGA SSD/E1.S/CFexpress)
  - Performance (including Thermal Plan cover SSD)
  - Low Latency (QoS)
  - Bigger Capacity from 2TB-8TB on Domain/Centralize Storage
  - High DWPD
  - Removeable at E1.S/CFexpress



Key Takeaways

- The global market size of ADAS/V2X is growing significantly, driven by the demand for enhanced vehicle agility, stringent safety regulations/standards, and advanced safety features that reduce/eliminate human factors on autonomy.

- DSRC and C-V2X are two different technologies/standards being adopted for V2X Work together for Cloud, Latency, and Safety Critical Applications can speed up deployment.

- As V2X becomes more pervasive, different use cases also require different storage solutions, with Edge/Emerging Computing as a necessity due to the cost burden or efficiency of the Cloud.

Thanks for Listening