CHOOSING THE RIGHT V2X TECHNOLOGY

STRAIGHT TALK ON DSRC AND 5G

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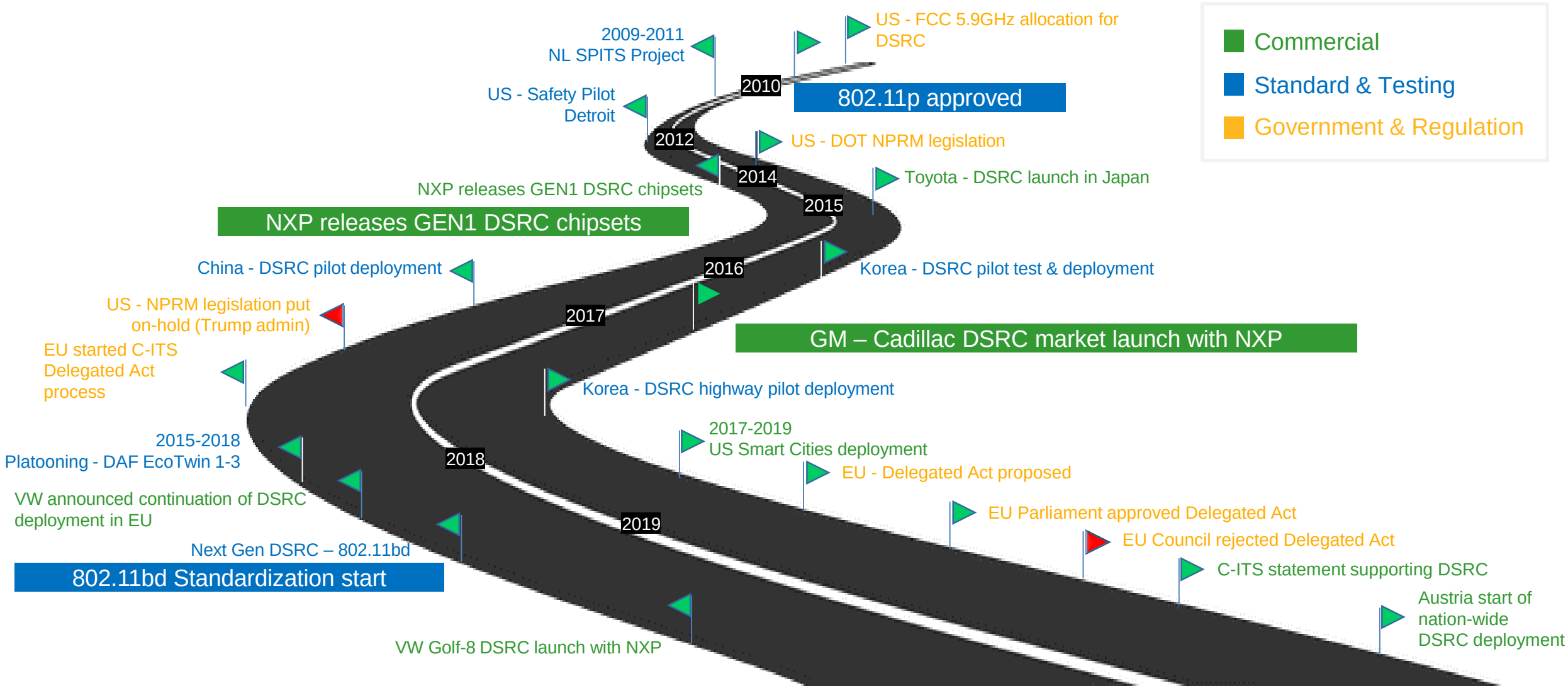
SECURE CONNECTIONS FOR A SMARTER WORLD

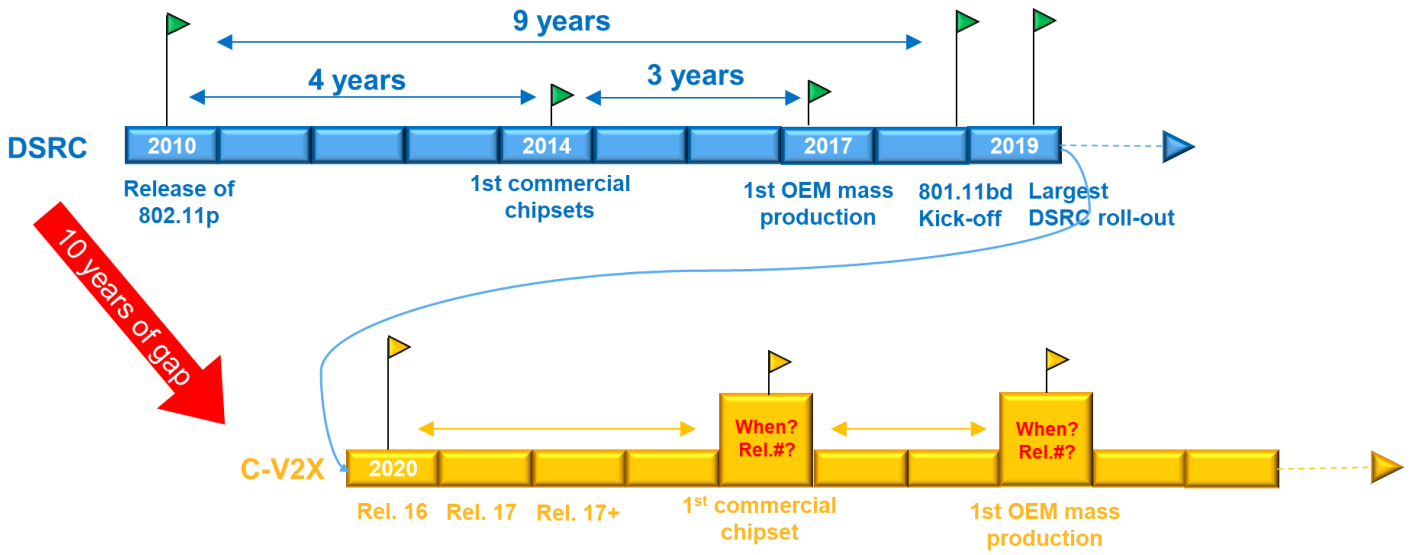
Contents

- The Differences Between DSRC and Cellular-V2X for Vehicle Safety Communication
- Implications of the Changes Proposed by FCC
- NXP V2X System Offering
- Key Takeaways
- NXP White Papers

A BRIEF LOOK BACK OF THE DSRC JOURNEY



TIMING & TYPICAL AUTOMOTIVE REQUIREMENTS



Road fatalities

- US: **36560** casualties (and **2.7 million** injuries) in 2018[1)]
- EU: **25100** fatalities in 2018[2)]
- Worldwide: **1.35M** fatalities in 2016[3)]

Development & Deployment Cycle	**3-4 years**
Product & System Life Cycle	**15 years**
Demand for Mature & Proven Technology	**Critical**
Technology Interoperability & Backwards Compatibility	**Critical**

1) U.S. DOT's March 13, 2020 Response to the FCC Notice of Proposed Rulemaking, https://ecfsapi.fcc.gov/file/10313251510165/5.850-5.925%20GHz%20Band%2C%20ET%20Dkt%20No.%2019-138.pdf
2) European Commission, 2018 road safety statistics: what is behind the figures?, https://ec.europa.eu/commission/presscorner/detail/en/MEMO_19_1990
3) WHO, GLOBAL STATUS REPORT ON ROAD SAFETY 2018 https://apps.who.int/iris/bitstream/handle/10665/277370/WHO-NMH-NVI-18.20-eng.pdf?ua=1

COST IS KEY TO SUCCESSFUL DEPLOYMENT

- Billions of dollar public and corporate spendings in DSRC deployment worldwide
  - Deployment is real and accelerating
- Safety and V2X need to be affordable for all
  - Service running cost
  - Technology access fee
  - Licensing cost[1)2)]

1) "Connected car prices may rise if Qualcomm wins antitrust case -auto makers", https://finance.yahoo.com/news/intel-says-qualcomm-tactics-forced-150229495.html
2) "Commission 'assessing complaints' against Nokia connected car patents, as MEPs back WiFi plans", https://www.euractiv.com/section/5g/news/commission-assessing-complaints-against-nokia-connected-car-patents-as-meps-back-wifi-plans/1333671/

V2X TECHNOLOGY COMPARISON

DSRC

- Strong and proven real-life performance, car OEM production since 2015
- Low latency: < 10ms
- Standalone deployment without dependence on cellular for safety applications
- Stable performance in congestion (PRR, latency)
- Full compatibility with next generation DSRC (802.11bd) by design
- Extended partner network with interoperable solutions proven in global plugfests

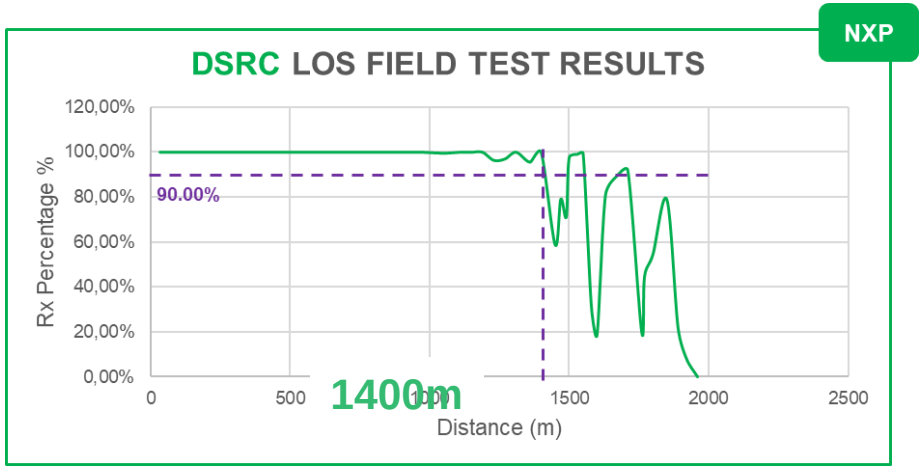
C-V2X

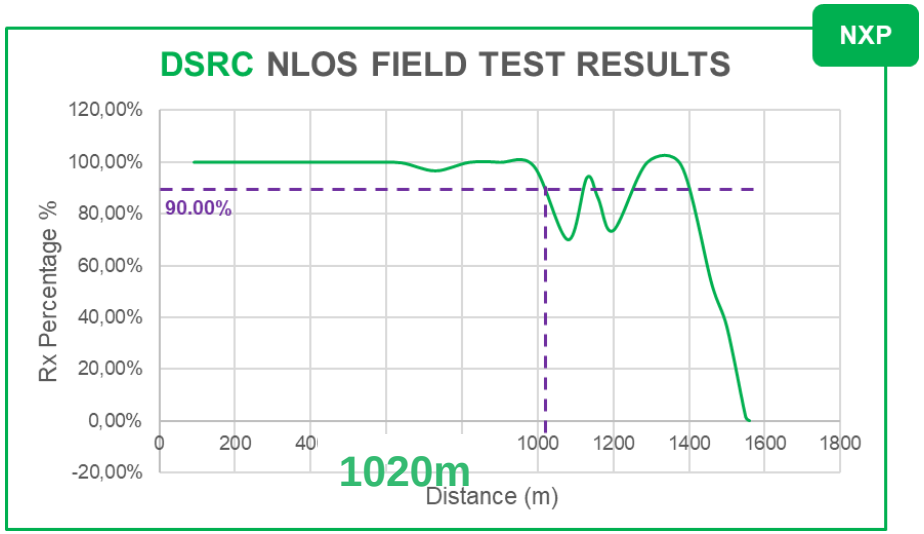
- Field & interoperability tests just started
- Latency: 20ms~100ms
- Need of GNSS clock (PC5 Mode 4) or cellular (PC5 Mode 3 or Uu) for synchronization at PHY/MAC level
- Performance degradation in high vehicle density cases
- Frequent and incompatible releases (Rel.14/15/16)
- Technical limitations
  - Half duplex, near-far problem etc.

V2X FIELD TEST

Test Setup

- Singapore Lim Chu Kang Rd, 2km LOS
- Settings as close as possible to that described by 5GAA[1)]
- Commercially available DSRC OBU with NXP chipsets





LOS: Line-of-Sight
NLOS: Non-Line-of-Sight

Comparable test result for C-V2X published by 5GAA in March 2019 [2)]

Significantly (about 65%) better range than C-V2X result published by 5GAA [2)]

1) https://5gaa.org/wp-content/uploads/2018/11/P-180106-V2X-Functional-and-Performance-Test-Report_Final_051118.pdf
2) https://ecfsapi.fcc.gov/file/104030451515194/5GAA%20Band%20Plan%20Ex%20Parte%20-%20FINAL.pdf

RANGE & LATENCY UNDER CONGESTION – DSRC VS. C-V2X (BY TOYOTA)

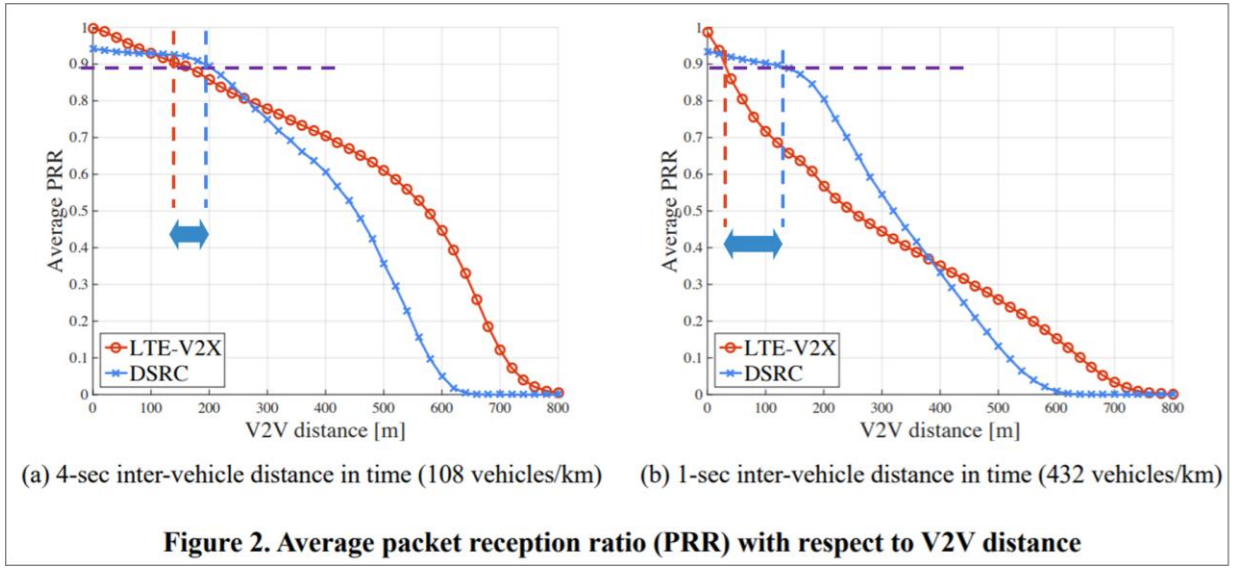


Figure 2. Average packet reception ratio (PRR) with respect to V2V distance

PRR: Packet Reception Rate

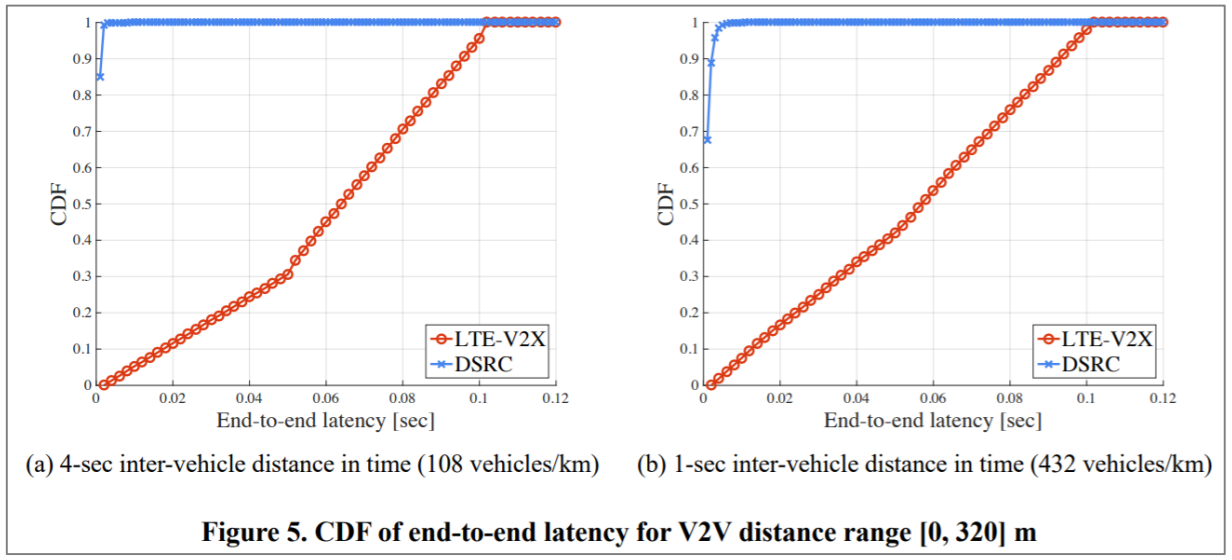


Figure 5. CDF of end-to-end latency for V2V distance range [0, 320] m

CDF: cumulative distribution function

"…in a high vehicle density case, DSRC achieves superior performance than LTE-V2X PC5 mode 4" – Toyota report [1)]

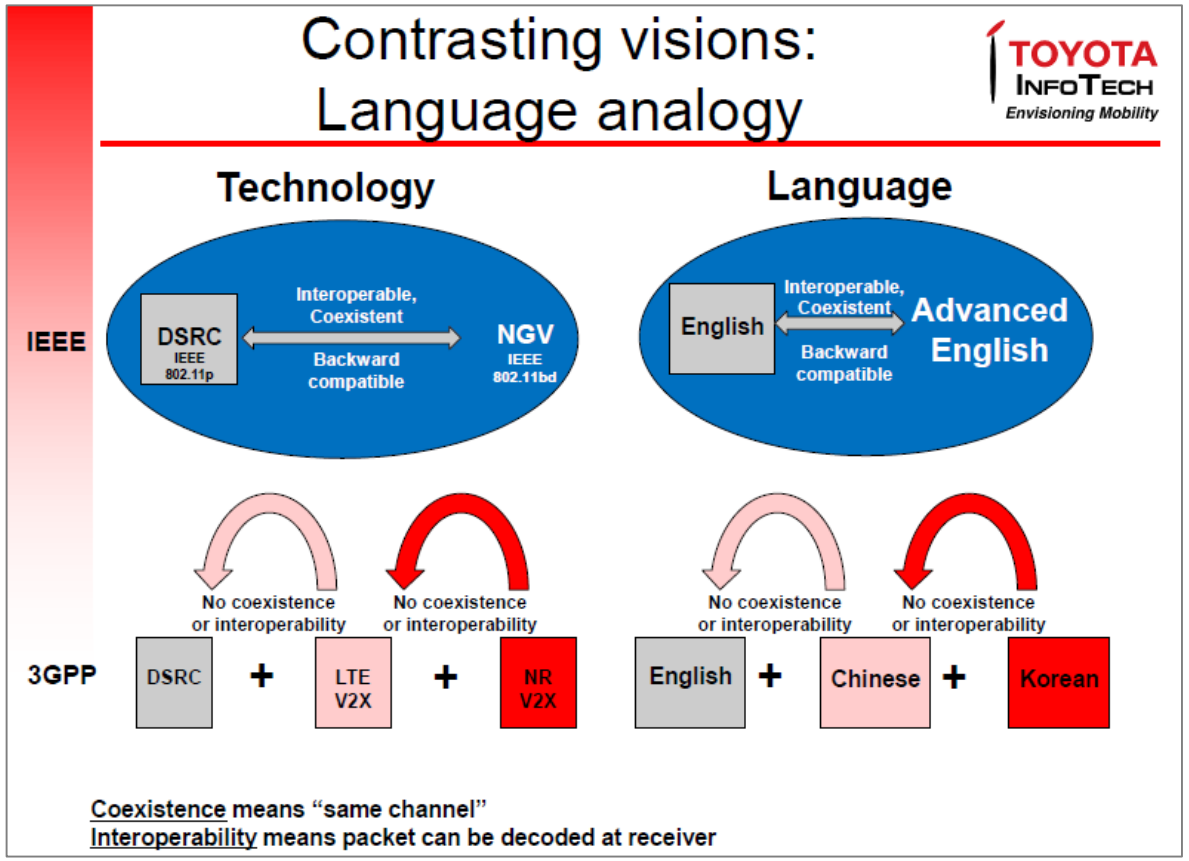
Consistent DSRC reception under congested conditions

DSRC – 90% end-to end latency < 2ms

C-V2X – approximately uniformly distributed up to 100 ms due to resource selection window

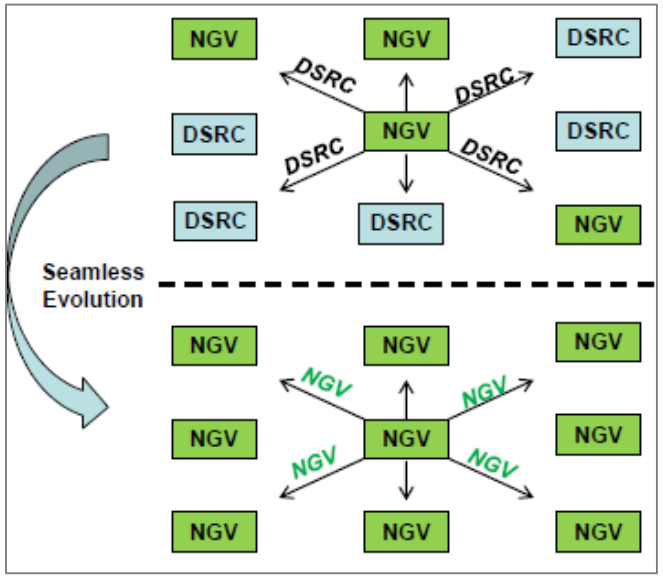
1) https://www.researchgate.net/publication/336768425_Comparison_of_DSRC_and_LTE-V2X_PC5_Mode_4_Performance_in_High_Vehicle_Density_Scenarios

COMPATIBILITY & INTEROPERABILITY



http://www.krishnamoorthy.com/comsoc/docs/V2X%20Communication%20-Getting%20our%20cars%20talking%20-Kenney%20-IEEE%20ComSoc-VTS-July%2010%202019.pdf, courtesy of Toyota, John Kenney

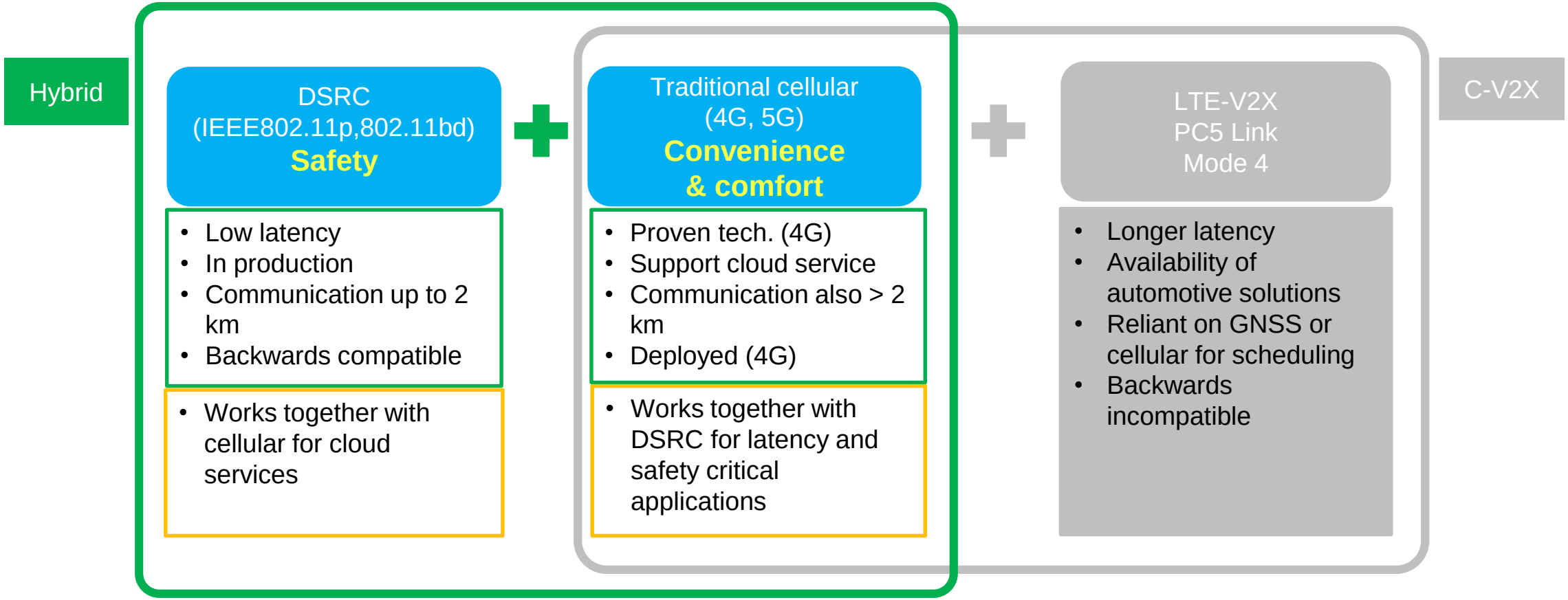
- C-V2X releases are incompatible with each other
  - Rel.14 / Rel.15 and Rel.16 operate in different frequency bands
  - Newer devices have to support multiple releases to keep compatibility with older devices
- Evolution of DSRC guarantees interoperability between 802.11p and 802.11bd by design



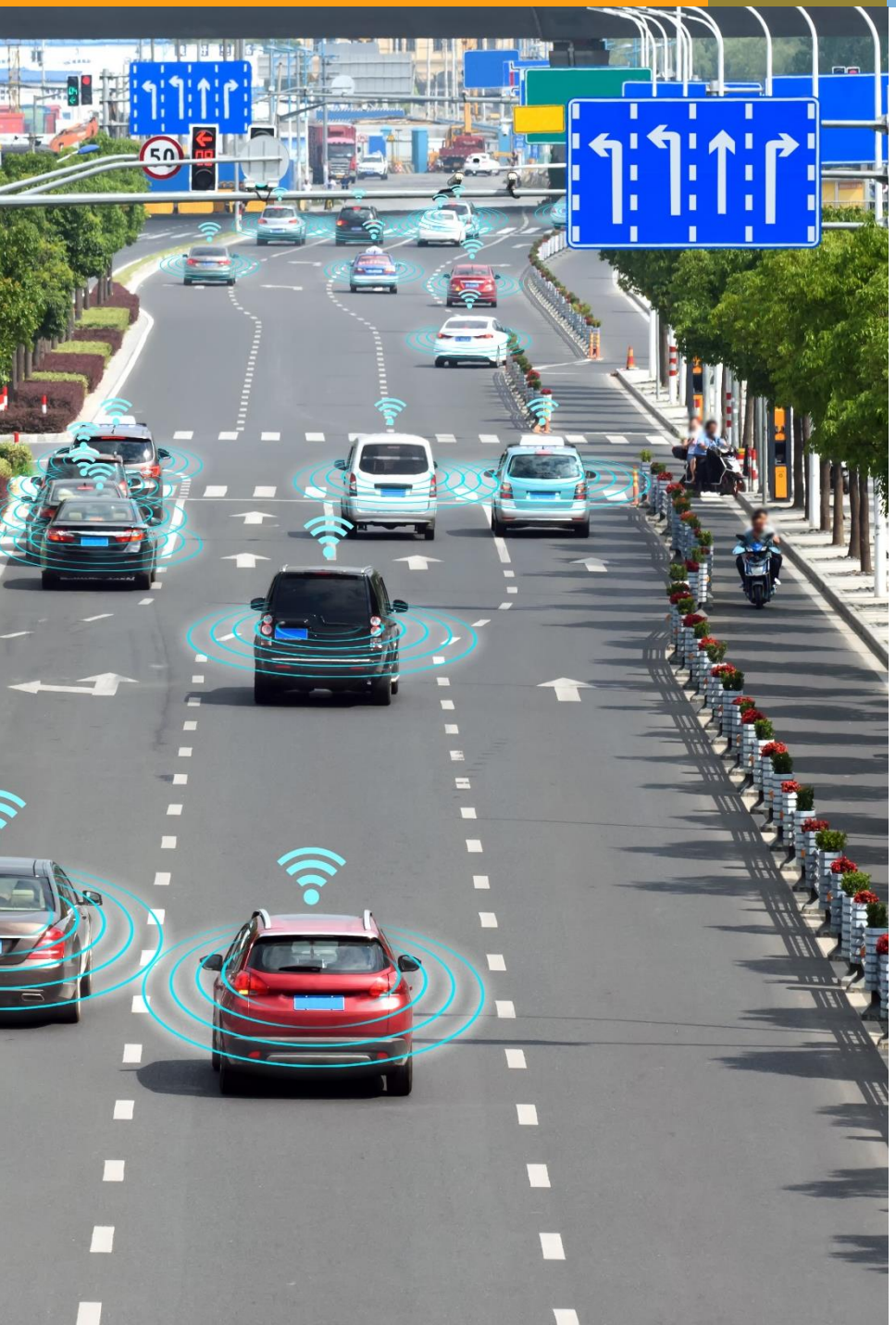
DSRC = 802.11p

NGV = 802.11bd

GO HYBRID = DSRC + TRADITIONAL CELLULAR (4G/5G)



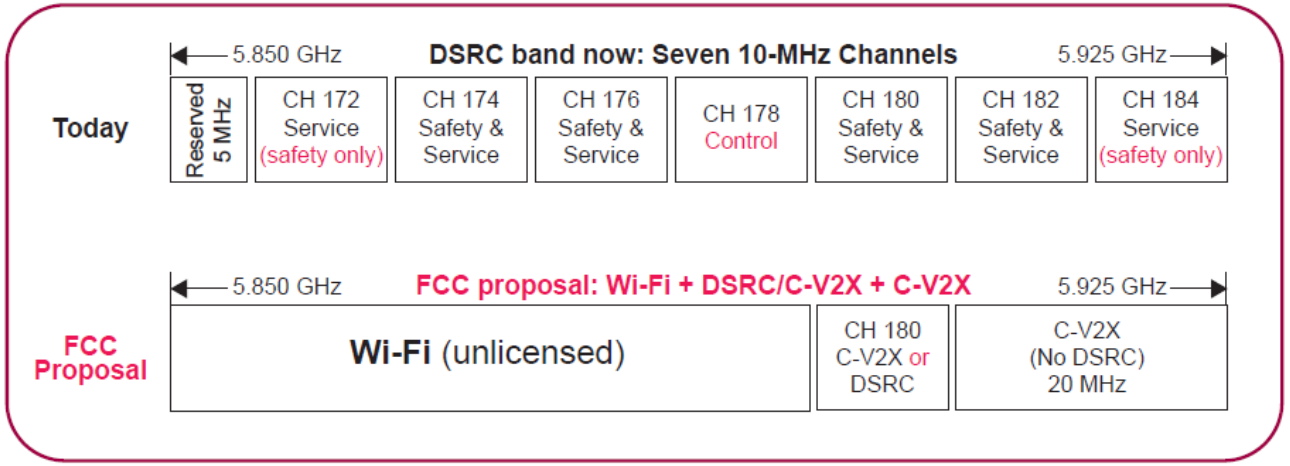
+ Best of WiFi and cellular technologies
+ Separation of concerns (Safety vs Comfort)
+ Flexible technology deployment (timing, model, market)
+ Flexible technology upgrade (timing, model, market)



Implications of the Changes Proposed by FCC

FCC PROPOSED CHANGES TO THE 5.9GHZ BAND

- **Today**
  - 7x10MHz Safety Band, reserved for DSRC-based license-free automotive use cases
  - Total 75MHz (incl. reserved band of 5MHz)
- **FCC proposed changes**
  - Allocate 45MHz for unlicensed Wi-Fi
  - Remaining 30MHz for transportation and vehicle purposes
    - 20MHz for C-V2X
    - 10MHz for C-V2X or DSRC



IMPLICATIONS ON SAFETY

- The US DOT analysis[1)] indicated that the NPRM in its current form might not benefit the road safety of U.S. citizens, and is likely to delay the introduction of V2X technology in U.S. by more than five years and may cost US DOT and the transportation community over $500 Million

- Growing chance of interference

- Impact on future safety applications due to bandwidth reduction

- Risk of reducing technology benefit by introducing non-interoperable technologies
  - Two sets of cars incapable of “talking” to each other
  - DSRC can address ~80% of crashes involving non-impaired drivers[2)]
  - Two non-interoperable technologies cut crash benefit to ~40%[2)]

1) https://www.transportation.gov/research-and-technology/preliminary-technical-assessment-fcc-59-ghz-nprm
2) http://www.krishnamoorthy.com/comsoc/docs/V2X%20Communication%20-Getting%20our%20cars%20talking%20-Kenney%20-IEEE%20ComSoc-VTS-July%2010%202019.pdf

RECOMMENDATION ON USAGE OF ITS BAND[1)]

- Safety should remain the number one priority and the current allocation of the ITS band should remain unchanged
- Setting priority to IEEE 802.11ax in 6 GHz, offering 1GHz+ bandwidth instead of moving 45MHz out of the Safety Band
- Requirement for FRAND access (Fair, Reasonable, and Non-Discriminatory access) to any patents and license agreements for technologies used for safety

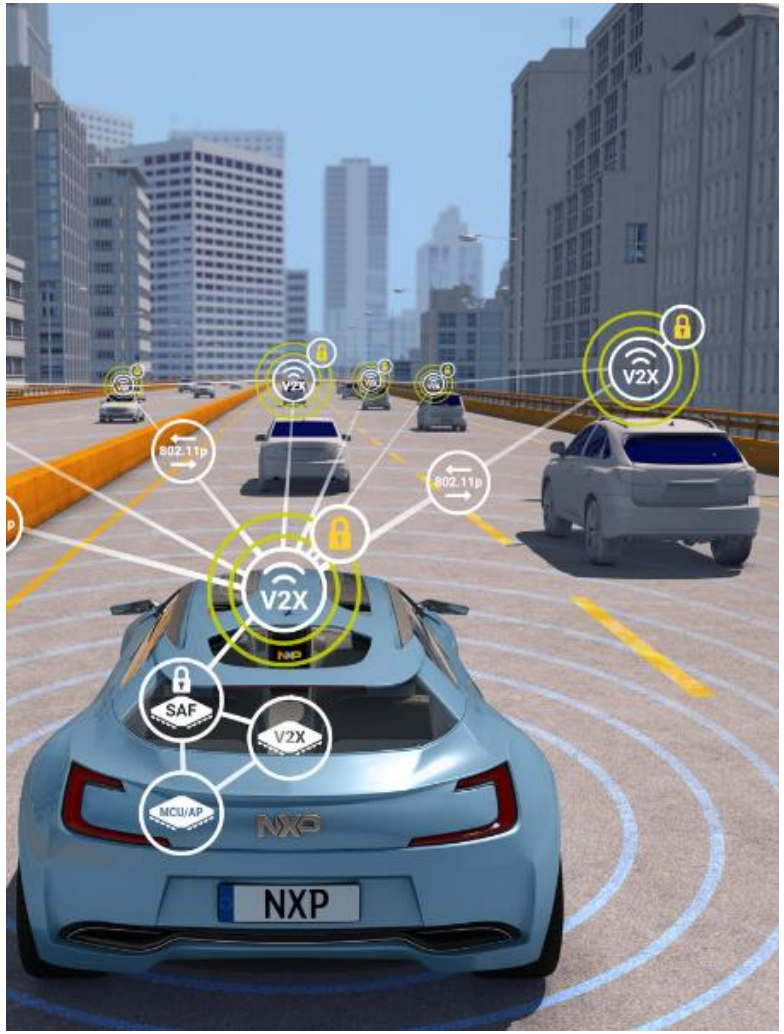
1) https://www.nxp.com/docs/en/white-paper/V2XFCCWP.pdf

RoadLINK

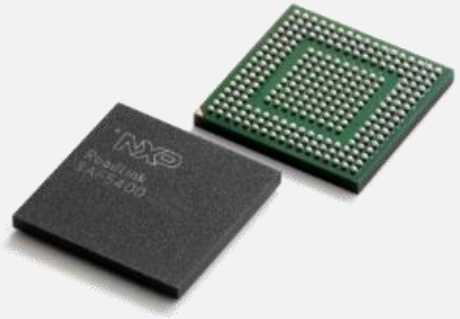
NXP V2X System Offering

GLOBAL SINGLE-CHIP DSRC MODEM

RoadLINK



SAF5400: NXP‘s Single-chip V2X Solution



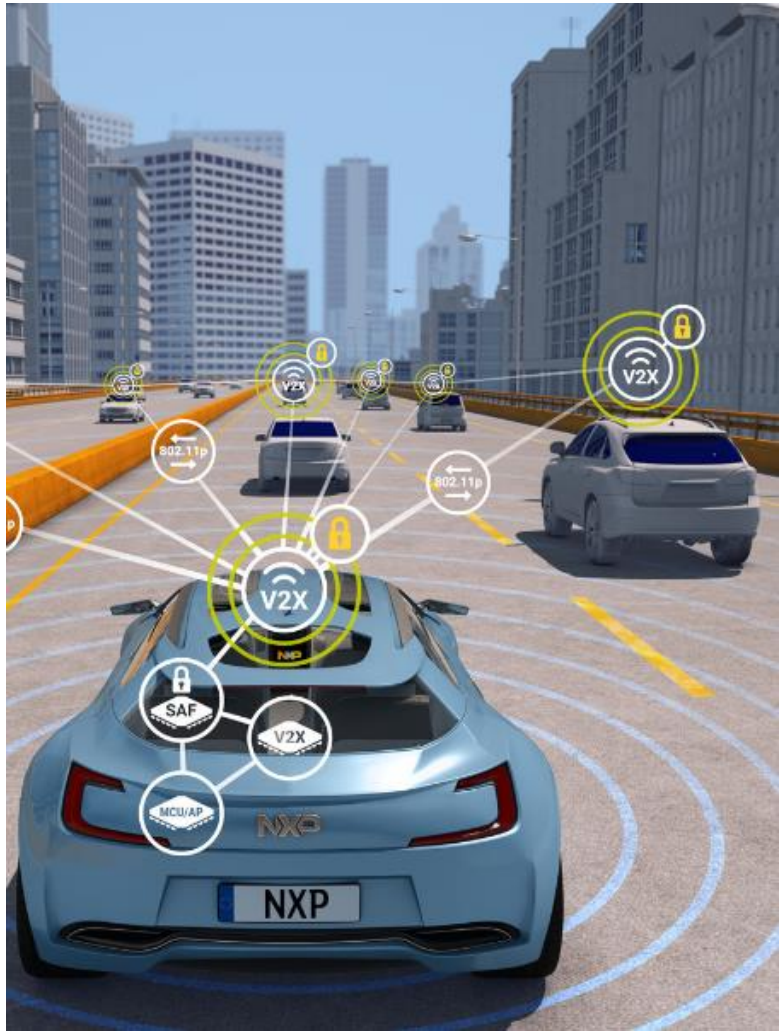
- Global single-chip V2X modem (US, EU, JPN, KOR)
- Scalable system solution with NXP’s i.MX portfolio
- High-performance embedded message verifications
- Excellent performance & range
- Antenna diversity & integrated compensator support for remote antennas
- Variant supporting ASIL-B system implementation

CERTIFIED V2X SECURITY

RoadLINK

SXF1800: V2X Secure Element

- High-class level of security for message signing and protection of private keys
- Cryptographic module boundary limited to device supporting hassle free certification
- OTA update in the field supported
- CC EAL4+ certified, FIPS 140-2 L3 certification ongoing



THE PRODUCTION PROVEN V2X SOLUTION

- VW introduces DSRC as standard feature in the new Golf - Europe best-selling car model [1)2)]
- NXP automotive V2X system solution
  - SAF5100 V2X SDR Baseband
  - TEF5100 V2X RF Transceiver
  - SXF1800 Secure Element
  - i.MX Application processor
- Ongoing DSRC roll-out sets the de-facto standard in Europe for V2X communication together with infrastructure providers
- Further OEM DSRC programs awarded with next start of production in 2021

https://www.volkswagen.de/de/modelle-und-konfigurator/der-neue-golf.html

1) https://focus2move.com/europe-best-selling-cars/
2) https://www.best-selling-cars.com/europe/2018-full-year-europe-best-selling-car-models-in-the-eu/

KEY TAKEAWAYS

- DSRC has gone a long way to reach today's production proven maturity
- NXP advocates to preserve the current 75MHz Safety Band in US
- DSRC is in high volume production today and roll-out continues in different regions
- C-V2X does not show clear benefit over DSRC
- NXP advocates hybrid model to benefit from complementary DSRC and traditional cellular technologies (4G, 5G)
- Act NOW to make our road traffic SAFER!

NXP WHITE PAPERS

IEEE802.11p ahead of LTE-V2V for safety applications
https://www.nxp.com/docs/en/white-paper/LTE-V2V-WP.pdf

C-ITS: Three observations on LTE-V2X and ETSI ITS-G5—A comparison
https://www.nxp.com/docs/en/white-paper/CITSCOMPWP.pdf

On the 5GAA comparison between LTE-V2X and DSRC/IEEE 802.11p
https://www.nxp.com/docs/en/white-paper/LTEDSRC5GCOMWPA4.pdf

How Re-Allocating the 5.9 GHz Band Could Affect Road Safety
https://www.nxp.com/docs/en/white-paper/V2XFCCWP.pdf

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