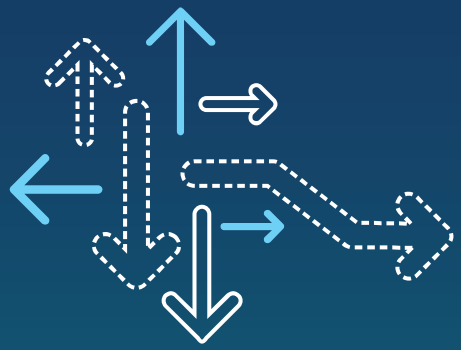
3GPP RAN #75
March 6th - 9th, 2017
Dubrovnik, Croatia
Agenda Item: 9.1



On Evolution of V2X

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Evolution of Sidelink for V2X

Sidelink is critical to evolve V2X

- Evolve 'LTE' sidelink? => Critical not to 'orphan' Release 14 design
- Evolve 'NR' sidelink => offers several new features
  - Take advantage of new NR like features leading to much better performance

Both are "5G-V2X"

- **Evolve using both LTE/NR like features while protecting R-14 design**
  - Plenary decision of not duplicating design for same use case – organic evolution
- Evolving using NR like feature while coexisting with R-14 design is feasible
- V2X sidelink is evolves independent of the Uu & is controllable by both LTE/NR
  - LTE operators can offer '5G/NR' features with no hardware upgrade – like many other features
  - NR operator can also control R-14 LTE V2V design
- Resource pool design allows for co-channel deployment of R-14/R-15/R-16
- NR numerology/TTI allows TDM/FDM co-channel coex. between R-14/R-15/R-16
- Explicitly develop mechanisms for dynamic co-channel coex., e.g., detect & vacate

Evolution of Sidelink for V2X

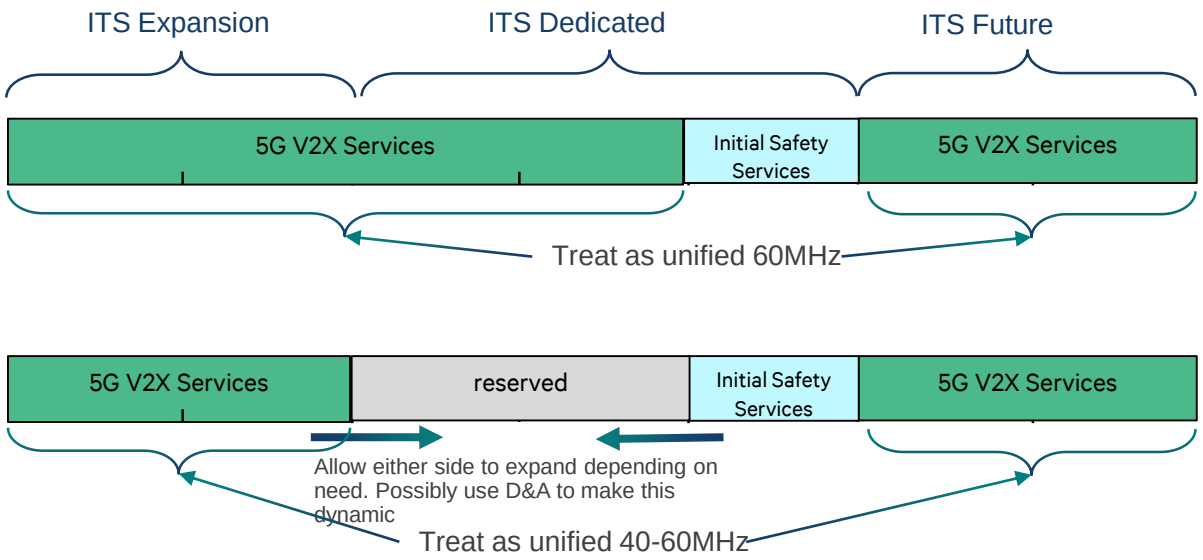
Jointly approve LTE WI and NR SI starting March 2017

- Relatively minor update to current LTE R-14 design to have a R-15 release
  - Show continuous evolution to ITS community and regulators
  - Not possible to meet important eV2X SA1 requirements => 1Gbps @ 50m, high accuracy positioning
- **Target a major update for R-16 using NR concepts**
- NR can provide several tools that can lead to significant performance gains
  - Higher reliability: LDPC/Polar codes, advanced resource management, MIMO, phy/mac ACKs
  - Low latency: Self contained sub-frame, flexible numerology, resource mgmt
  - High throughput: MIMO, higher order modulation, wideband/multi-carrier support, mmW
  - Accurate ranging: Wideband carrier support
- 5G-V2X evolution continues to target 5.9 GHz
  - Basic safety will use only a small subset of 70 MHz ITS spectrum
  - **Wideband carrier design needed for accurate ranging & high data rates in 5.9 GHz**
  - **Explicit support for R14/15/16 multiplexing within the 5.9 GHz**
- In addition explore 63 GHz and unlicensed sub 6 GHz (supplementary spectrum)

Evolution of Sidelink for V2X

Example based on EU spectrum situation

- Restrict Day 1 Safety Services to small subset of the band
  - Ideally to 10MHz but lets allow some flexibility up to 30MHz as we talk to OEMs
  - Pick and use a single technology to deliver basic safety i.e. either G5 or R14-V2X
- Allow wideband Advanced Safety Services and Value-add to develop based on 5G Technology
  - Ideally 60MHz, but allow for 40MHz in discussion with OEMs



- 5G-V2X: advanced high throughput, high reliability, low latency, and ranging/positioning use cases automakers can control
  - Up to ~0.65Gbps with 40MHz
  - Up to **~1Gbps** with 60MHz
  - Up to +14dB link budget
- Multiplexing of narrow and wideband services using 3GPP releases as they become available

5G-V2X Requirements

From SA1 requirement to RAN WG design

- SA1 has generated a set of new requirements covering 5 families (S1-163441)

General
including lateral positioning, density, reliability, low latency, relaying, security

Platooning	Advanced Driving	Extended Sensors	Remote Driving
enables the vehicles to dynamically form a platoon travelling together	enables semi-automated or full-automated driving	enables the exchange of raw or processed data gathered through local sensors or live video images	enables a remote driver or a V2X application to operate a remote vehicle

- Initiate a single 5G-V2X area encompassing the current R14 V2X design
  - SA1 has already been working on a single eV2X study (LTE and NR) for R15.
- The new 5G-V2X area will encompass the above technology families in a unified RAN study starting in R15

Mapping SA1 Requirement to RAN

SA1 requirements are quite challenging in some cases

- SA1 use cases can be mapped to development of the following
  - eMBB sidelink
  - URLLC sidelink
  - Wideband ranging and positioning for accurate positioning
  - mmW/unlicensed for very high data rate cases
  - URLLC Uu
    - Uu enhancements can be part of other NR WI

- Several tools needed to achieve the SA1 requirements
  - MIMO, flexible numerology, phy/MAC acks, polar/LDPC coding, etc.

5G-V2X should enhance Autonomous Driving

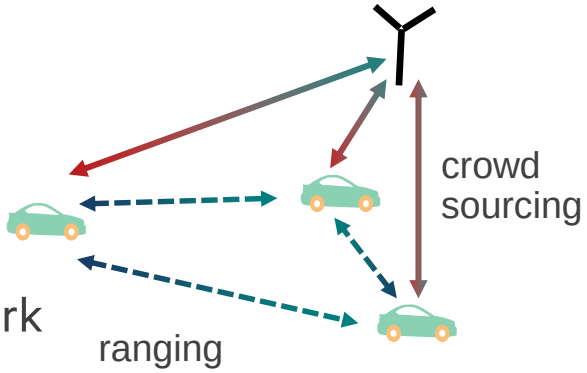
Sensor sharing and positioning/ranging are the key applications

- V2X is a new sensor with the following features
  - Works in NLOS condition as well
  - Works in all environmental conditions e.g. at night etc.
  - Accurately indicates intention of other driver, e.g., indicates 'hard braking'
- V2X can at least enhance potentially enable autonomous driving
  - E.g., how will autonomous cars behave at an intersection where traffic light is malfunctioning?
  - E.g., overtaking on a single lane road: autonomous cars will be conservative
    - Do Not Pass Warning will enable easier overtaking
- Sensor sharing can be used for enhancing autonomous driving
  - Infrastructure can play a critical role in the sensor sharing
  - E.g., RSUs providing high definition real time maps or forwarding V2V messages

Positioning is important to Autonomous Driving

Both relative & absolute positioning needed

- Autonomous driving requires accurate positioning/ranging
  - Absolute positioning is used for placing a car on high definition map e.g., lane
  - Relative positioning is used to avoid collisions to objects & vehicles
- GPS positioning is not good enough – especially in urban areas
  - Several techniques being studied to improve positioning
  - However most GPS improvements do not work in urban areas
- V2X comm. can enable "crowd sourcing" of positions to improve accuracy
  - Step 1: Ranging occurs between vehicles
  - Step 2: Vehicles report position & ranging info. to network
  - Step 3: Network provides updated information



Positioning is important to Autonomous Driving

Infrastructure role & FAQs

- Infrastructure plays a key role in using crowd sourcing
  - Take advantage of good coverage in urban areas
- RSUs with accurate position can correct for correlated GNSS errors
  - Errors are especially correlated in Urban areas
- Standardization with minimum perf. requirement is needed
  - One bad device can spoil performance for all
- Why not use other methods for ranging? camera, radar, ultrasound, etc.
  - Requires more potentially expensive hardware
  - More challenging to mandate
  - Cameras: 360° stereophonic cameras needed to get omni-directional coverage
  - Radar/ultrasound: cannot get omnidirectional ranging
    - Limited accuracy: Time of flight depends on which vehicle part is reflecting

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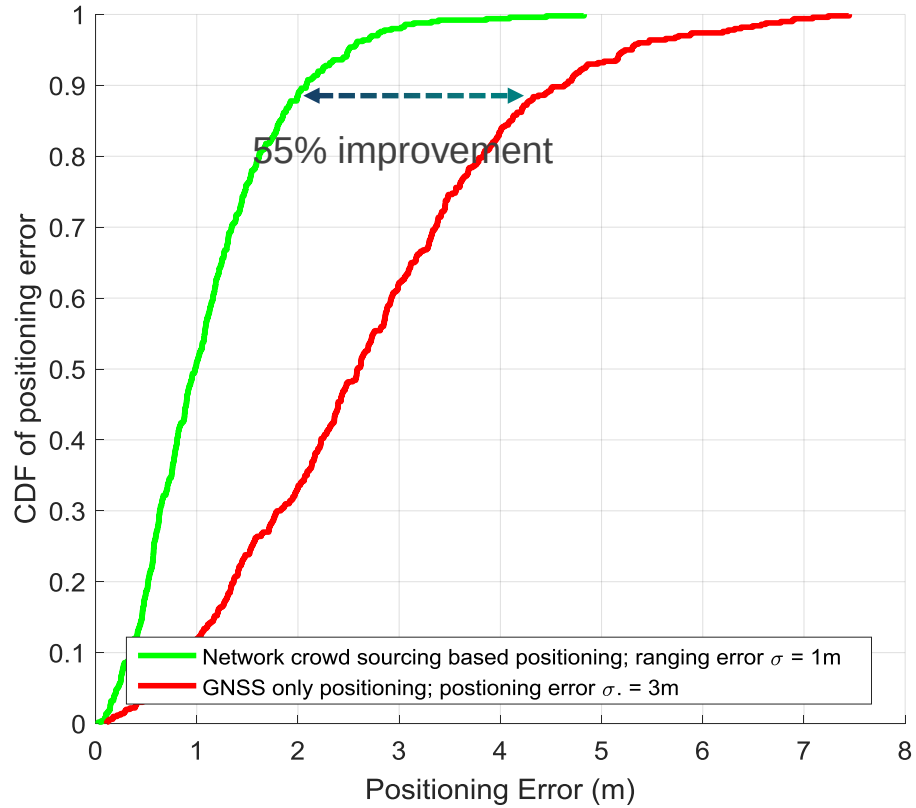
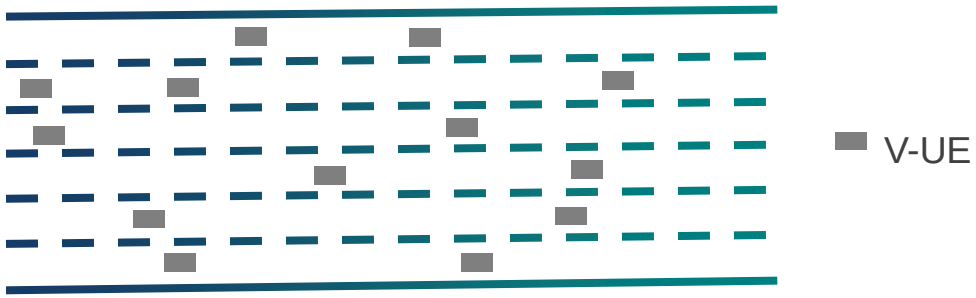
Simulation Results

Independent GPS error

- Length 500m
- 6 lanes, lane width 4m
- 50 V-UEs (vehicle UEs) uniformly dropped
  - LOS between V-UEs
  - GPS error are i.i.d. or correlated
- No wrap-around for distance computation
- One shot simulation – expect better results with mobility





R-16 5G-V2X sidelink features - summarizing

Start SI in R-15 in March 17 & target a Rel-16 WI

- Wideband ranging and positioning mechanism
  - Distributed and centralized designs; ranging mechanism between vehicles
- Sensor sharing mechanism among vehicles
  - Resource selection mechanism; support for multicast
- High data rate
  - MIMO, wideband/multiple carrier, higher order modulation
- Reliability
  - MIMO, physical ACK for multicast/unicast
- Low latency
  - Flexible numerology
- Spectrum assessment
  - Target 5.9GHz, ETSI ITS 63GHz and unlicensed (as a supplementary spectrum)
- Flexible, dynamic multiplexing between R-14/R-15/R-16

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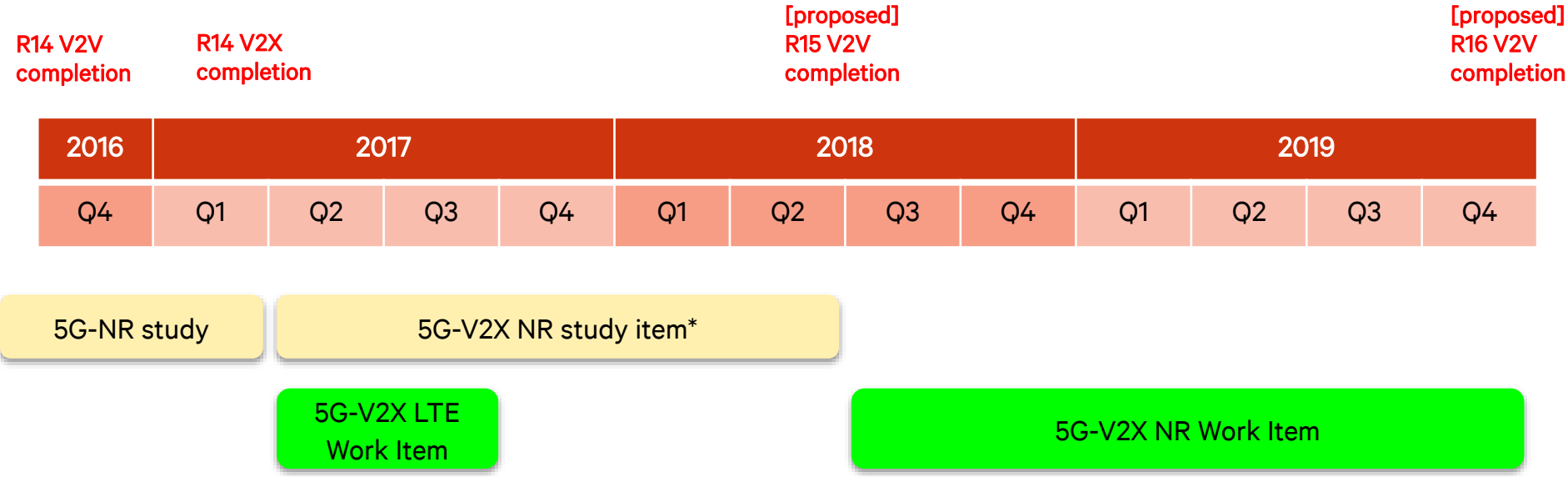
Project management

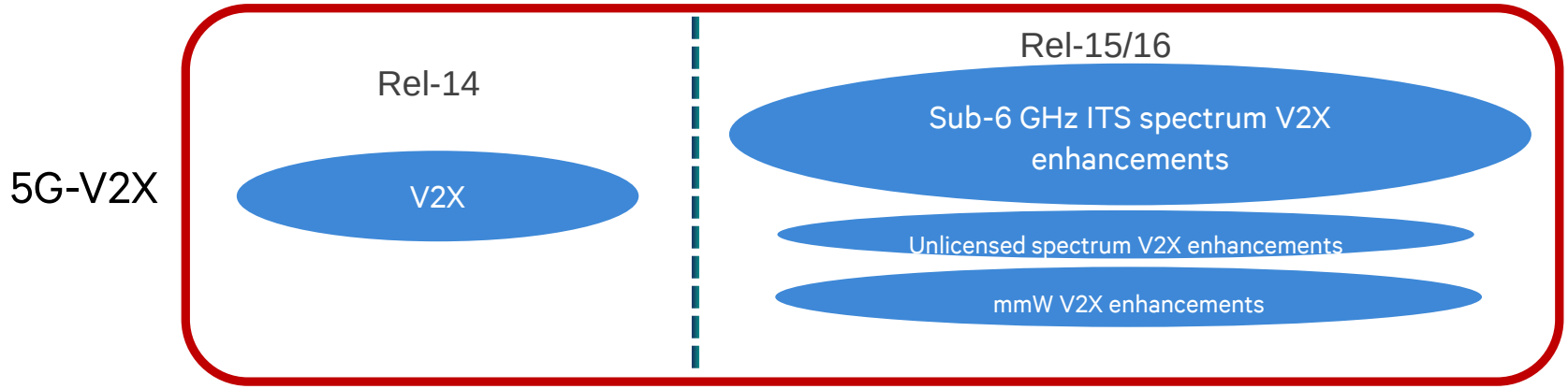
Start SI in R-15 & also consider a Rel-15 WI for subset of features



*5G-V2X NR study can start with limited #TUs for a couple of quarters

Conclusion

- A new 5G-V2X area should be established encompassing R-14 V2X and its R15/16 and future evolutions
  - Target relatively minor LTE update in R-15 and a major NR based update in R-16
  - Approve the R-15 WI and R-16 SI together starting March 2017
  - 5G-V2X contains NR and LTE waveforms, TTI, etc. that can exist on the same channel
    - The coexistence can be both dynamic and static
  - Continue to focus on sub-6 GHz ITS
  - Add features on mmW and sub-6GHz unlicensed spectrum
  - Sidelink enhancements should be made to work with both NR Uu and LTE Uu
    - R14 V2X should be made to optionally work with NR Uu in addition to LTE Uu, to ensure it can be sustained into an standalone NR future



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