"PROXIMITY SERVICE EVALUATION & EXTENSIONS"
IMPROVING BROADBAND DIRECT COMMUNICATIONS

PSCR Grant Funded (Commerce Dept.)
10 July 2019

HARRIS® TECHNOLOGY TO CONNECT, INFORM AND PROTECT™

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Description/ key features

- Satisfying current and future direct communications requirements for First Responders
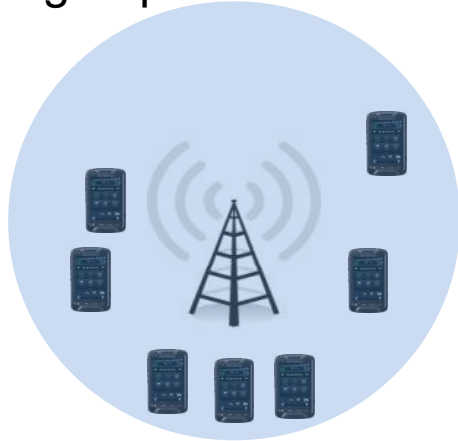
Key success factors

- Matching or exceeding the reliability and coverage of existing LMR direct communication capabilities

- Enabling new services with ease of use, continuity across network domains, and data services

Market

- Direct communication is required for all public safety communication systems

- ProSe is the only broadband direct communication standard designed to address this requirement

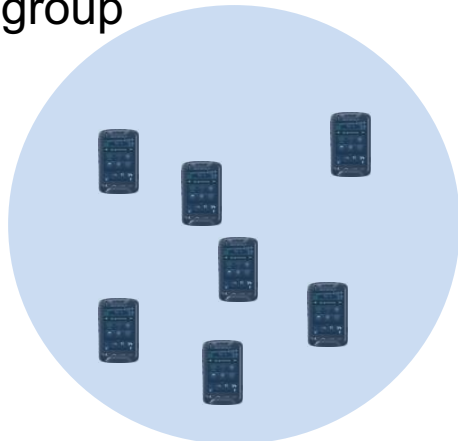- The size of the public safety market has limited enabling hardware (chip sets)

Group domain types

Network group

Direct group

Not efficient in good network coverage

Network communications provides:
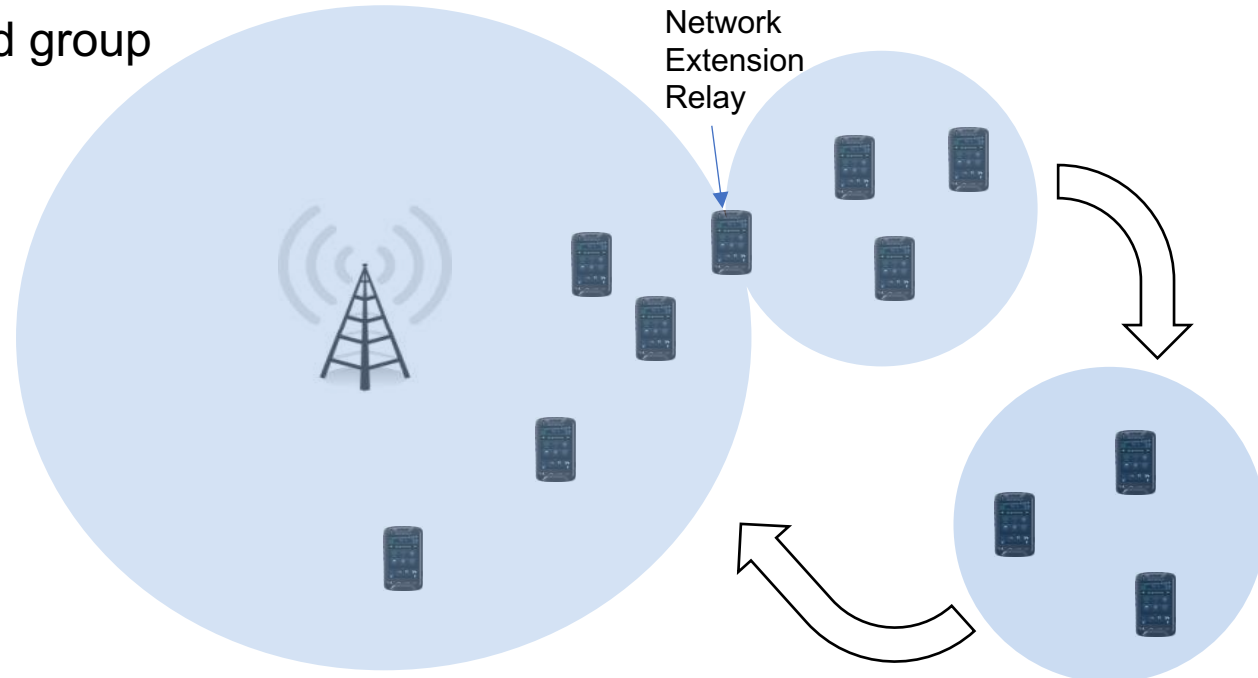
- Greater efficiency
- Less congestion limitations
- Connections for
  - Reporting chain monitoring
  - Evidentiary recording

Hybrid group

Network Extension Relay

Groups can fragment and reconnect
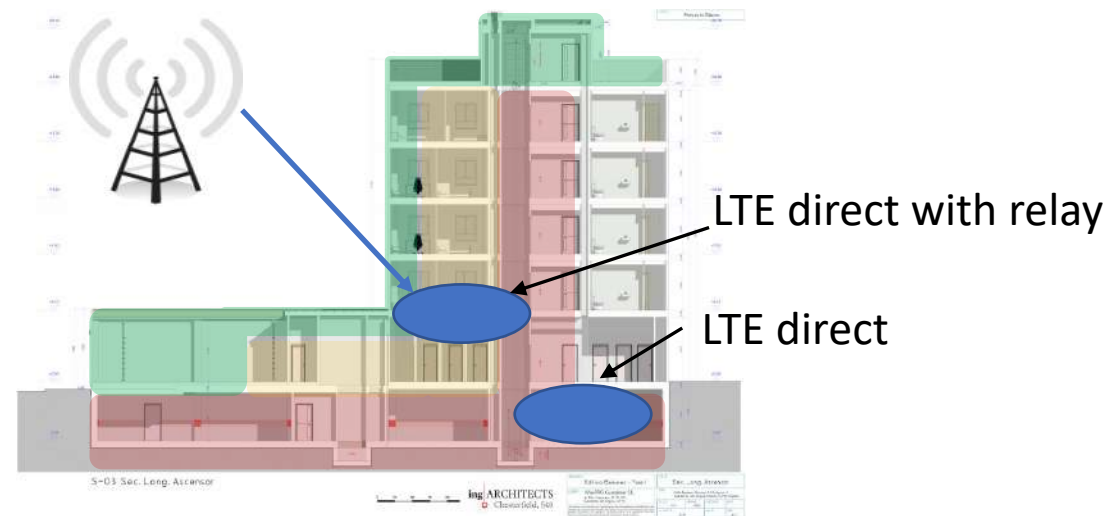
The direct communications use cases

Close communication in hostile situations

- **SWAT/ Building fires**

No macro network

- **Local macro network down**

- **In-building**

- **Remote locations: public safety/ wild fire**

- **Immediate geography: gulley/ obstructions: buildings**

LTE direct with relay

LTE direct

LTE/5G-direct standards development/ releases

ProSe

R11 High Power UE for B14:   March 2013

R12 Study/ Initial ProSe: March 2015

R13 eProSe: March 2016

R14/15 FeProSe: Limited work   June 2017 / Sept 2018

Limited market for public safety only features

V2X interfaces
Source: 3GPP

V2X

R13 V2X March 2016   Feasibility study based on ProSe

R14 V2X June 2017   Sept 2016 RAN announces initial spec
                                           Sept 2017 Qualcomm announces trials (9150)
                                           High power devices allowed for the service

Release 15 5G September 2018   Multi-carrier aggregation/ 64 QAM / power Class 2/ extended sensors
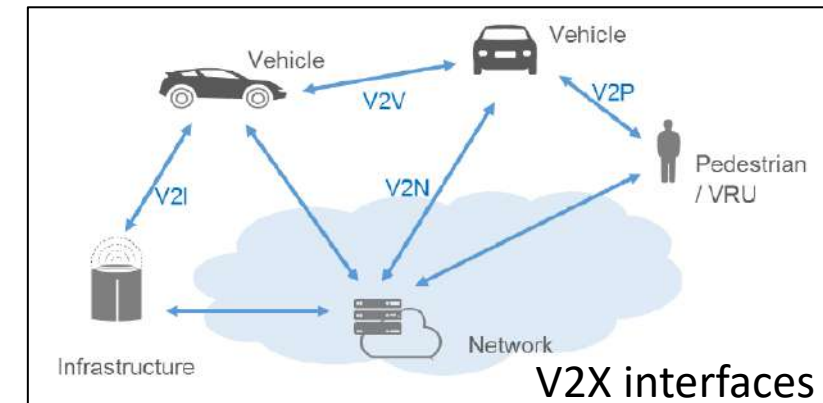   Support for: platooning, advance driving, remote driving

R16 V2X March 2020   Higher throughput, sensor sharing, trajectory sharing

'Direct Comms'

R17 Direct communications: TBD   Study on system enhancement for proximity based services in 5GS
                                                     Direct services have commercial and public safety elements

"it was noted that solutions defined for V2X can also be used for public safety when the service requirement can be met."

ProSe versus V2X

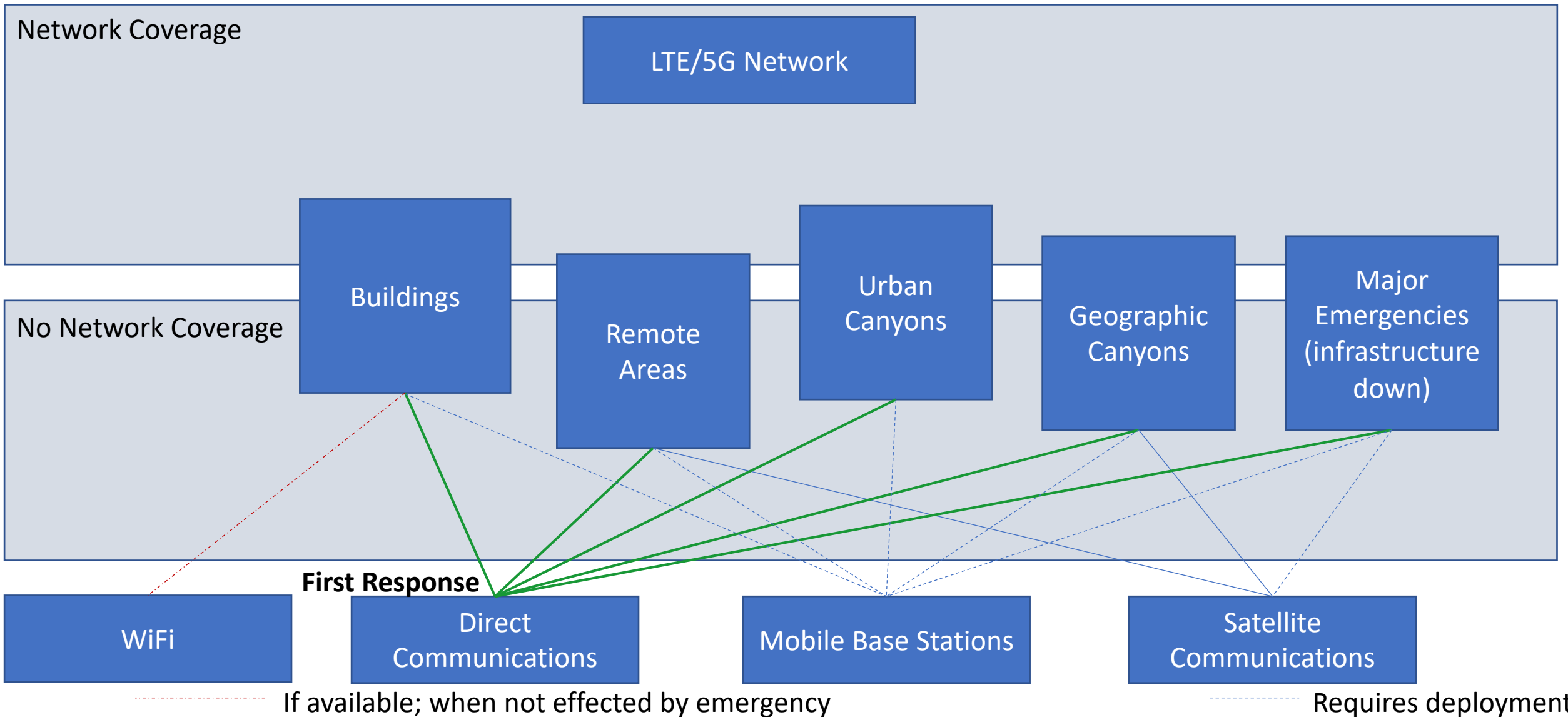| ProSe	V2X
Designed to address public safety off network requirement	Designed to address direct inter-vehicle communications
Distributed sync	Uses GNSS for synchronization when available
Network Relay supported	Proposed relay support
Band agnostic	Designed for V2X bands; but extensible
Limited 3GPP support for separate PS std.	Extensive standards development • Could include PS requirements

Common waveform: PC5

V2X enhancements

- Improved congestion control
- Lower latency
- Improved selective fading performance
- Support for rapidly moving vehicles (radios)
- Larger capacity with 5G

Communication methods in challenging environments

Network Coverage

LTE/5G Network

No Network Coverage

Buildings

Remote Areas

Urban Canyons

Geographic Canyons

Major Emergencies (infrastructure down)

First Response

WiFi

Direct Communications

Mobile Base Stations

Satellite Communications

If available; when not effected by emergency

Requires deployment

Comparable communications range to P25

- Mixed environments
- Inbuilding – high RF losses
- Remote communications - clear line of site – large signal latencies

"In these situations the employed radios need to work under a potentially very large path loss, yet still provide prompt delivery of media. Both network mediated and direct device to device communications are envisioned." TS-22.186

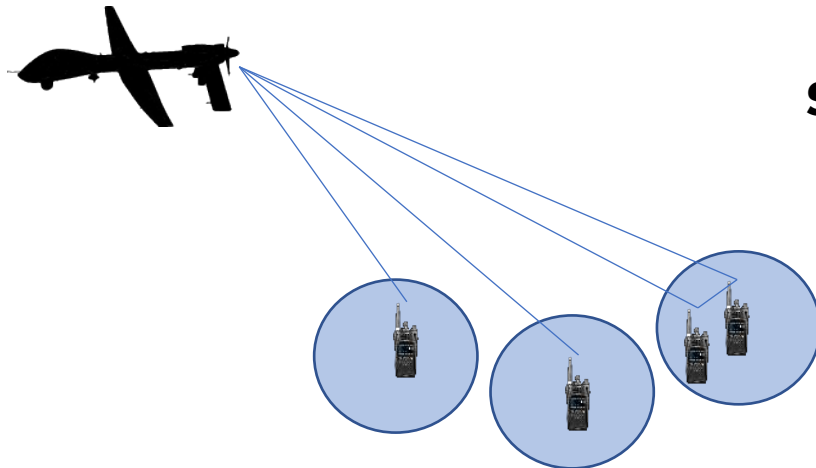# Line of sight propagation – direct communications

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3GPP standards work has focused on short ranges

- Synchronization search windows limit range, but save battery life
- Default configurations limit range of protocol: e.g. cyclic prefix
- V2X importance is inversely proportional to distance

Public safety uses can be longer range

P25 searches for signals continuously; range is limited by signal loss

Communication by advantaged terrestrial location

Disadvantage position

Advantaged position

Communication by UAV (advantaged aerial location) (relay)

Signal search limitation

Apparent physical distance vs. RF propagation

Propagation distance dilation

Primary RF path

Apparent physical distance
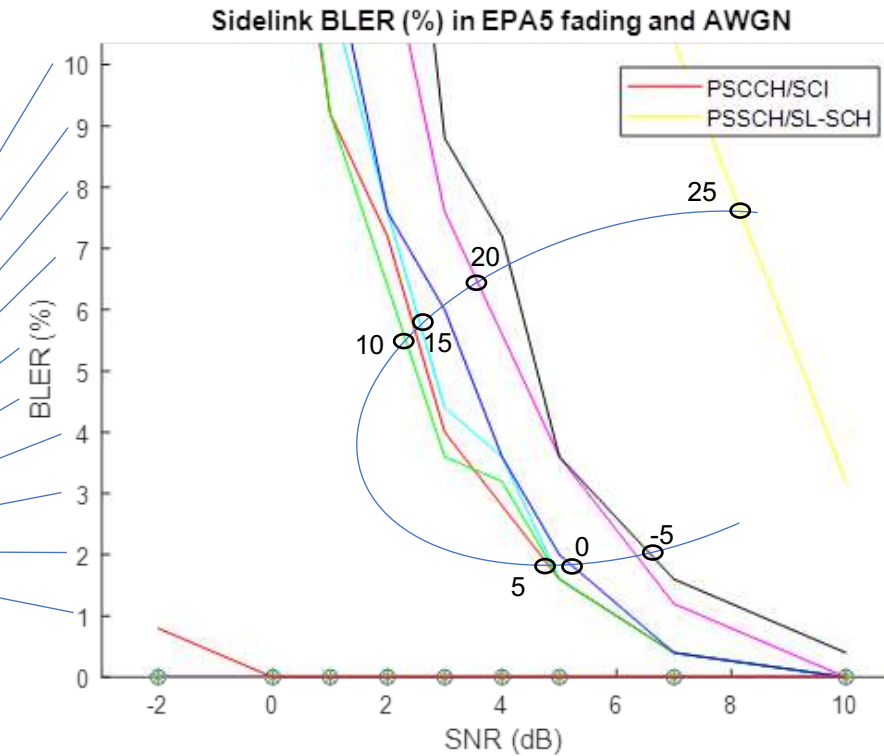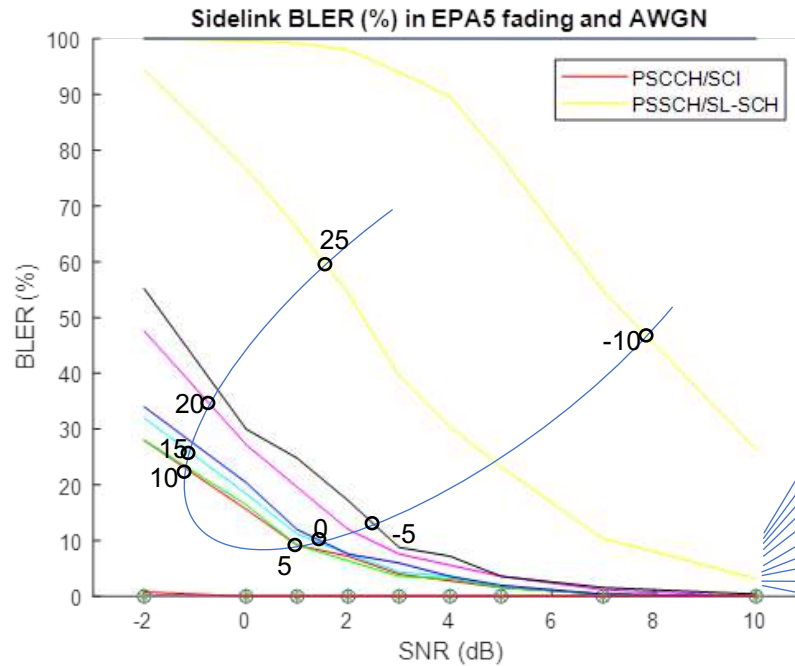

Search and rescue multipath limitations
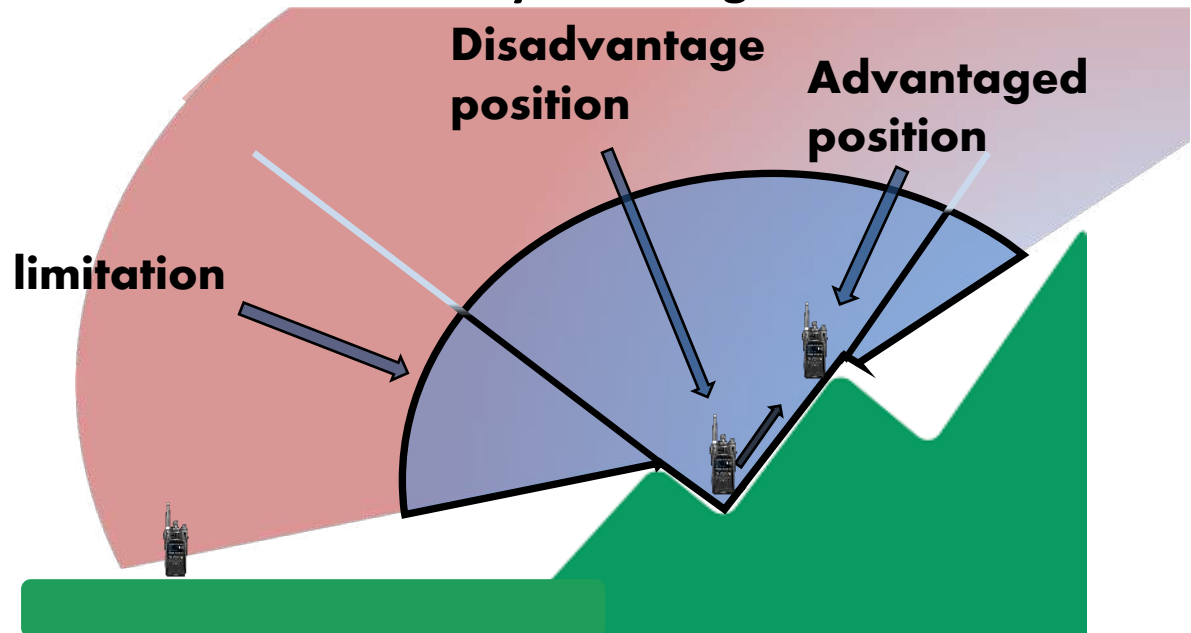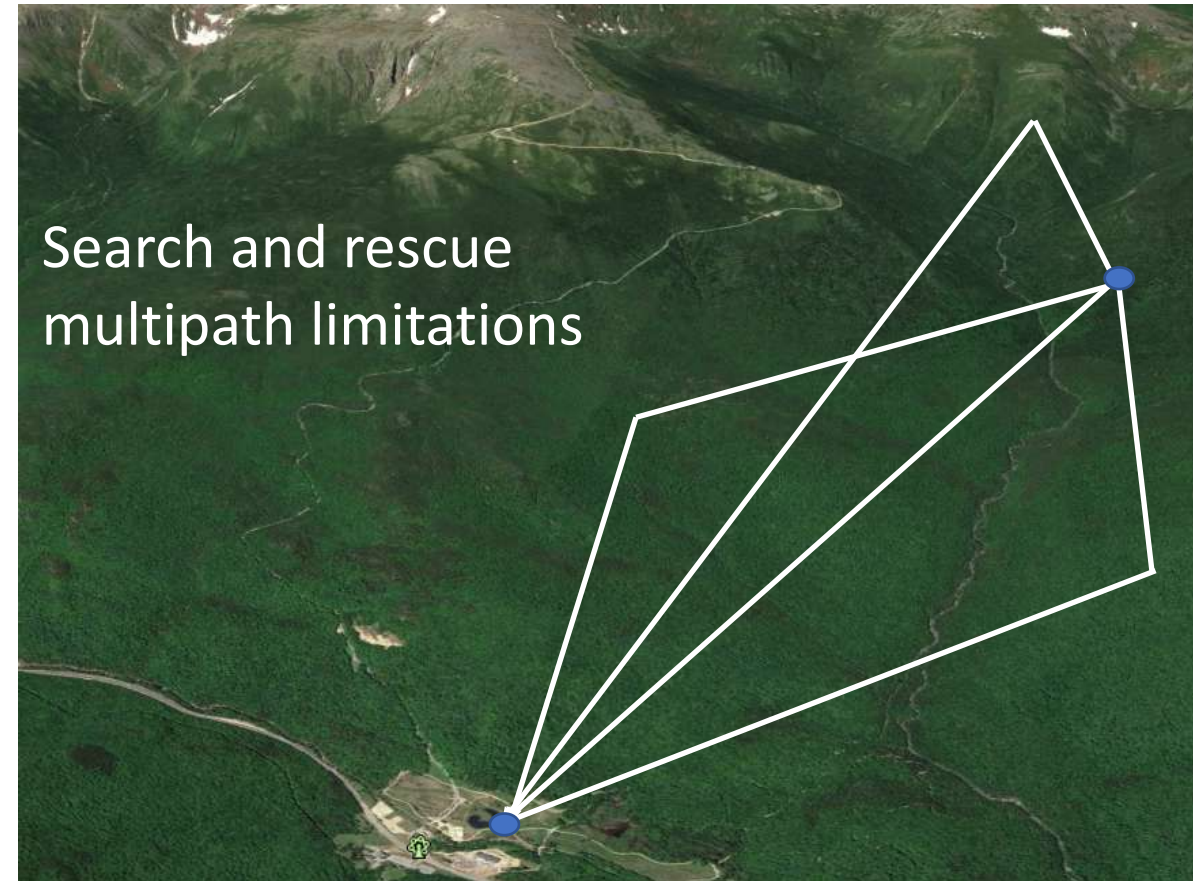
ProSe/ V2X have range limitations
- Multipath - protocol
- Distance – implementation/ protocol

BLER as a function of synchronization error & multipath

Sidelink BLER (%) in EPA5 fading and AWGN

Sidelink BLER (%) in EPA5 fading and AWGN

Receiver performance degrades with time offset
- Standard cyclical prefix
- ~40 samples per mile
- Best performance ~ 3/8 mile with EPA5 fading

Mitigation
- Extended multipath tolerance: not supported in V2X
- Continuously scanning receivers: may not be defined by standards

V2X limitations

Currently no relay support

No discovery

Communications range

- **Support for isolated worker**
- **Advantaged locations**
  - Aerial vehicles
  - Terrestrial

Communication scenario description		Req #	Payload (Bytes)	Tx rate (Message /Sec)	Max end-to-end latency (ms)	Reliability (%)	Data rate (Mbps)	Min required communication range (meters)
Scenario	Degree							
Sensor information sharing between UEs supporting V2X application	Lower degree of automation	[R.5.4-001]	1600	10	100	99		1000
	Higher degree of automation	[R.5.4-002]			10	95	25 (NOTE 1)	
		[R.5.4-003]			3	99.999	50	200
		[R.5.4-004]			10	99.99	25	500
		[R.5.4-005]			50	99	10	1000
		[R.5.4-006] (NOTE 2)			10	99.99	1000	50
Video sharing between UEs supporting V2X application	Lower degree of automation	[R.5.4-007]			50	90	10	100
	Higher degree of automation	[R.5.4-008]			10	99.99	700	200
		[R.5.4-009]			10	99.99	90	400

NOTE 1: This is peak data rate.
NOTE 2: This is for imminent collision scenario.

3GPP TS 22.186

Fire fighters in building may use direct comms

Potential relays should:

- **Provide automatic operation**

- **Monitor for relay requests**

- **Coordinate with other proximate relays**
  - Multiple relays may be active
  - Minimize and mitigate harmful interference

- **Maximize relayed coverage**
  - In-building
  - Remote location extension

(R) - Relay capable equipment
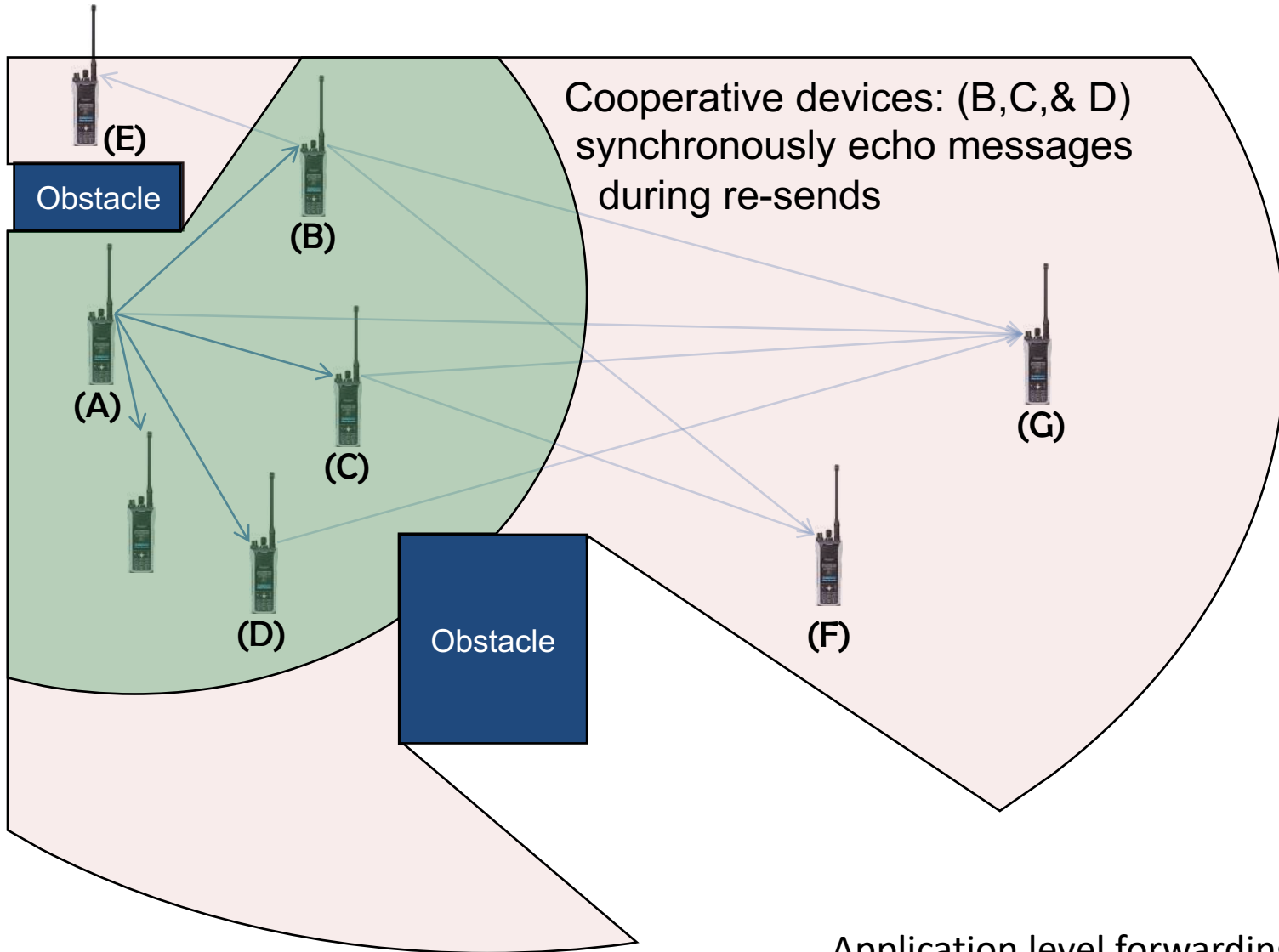
Direct communications extension relay
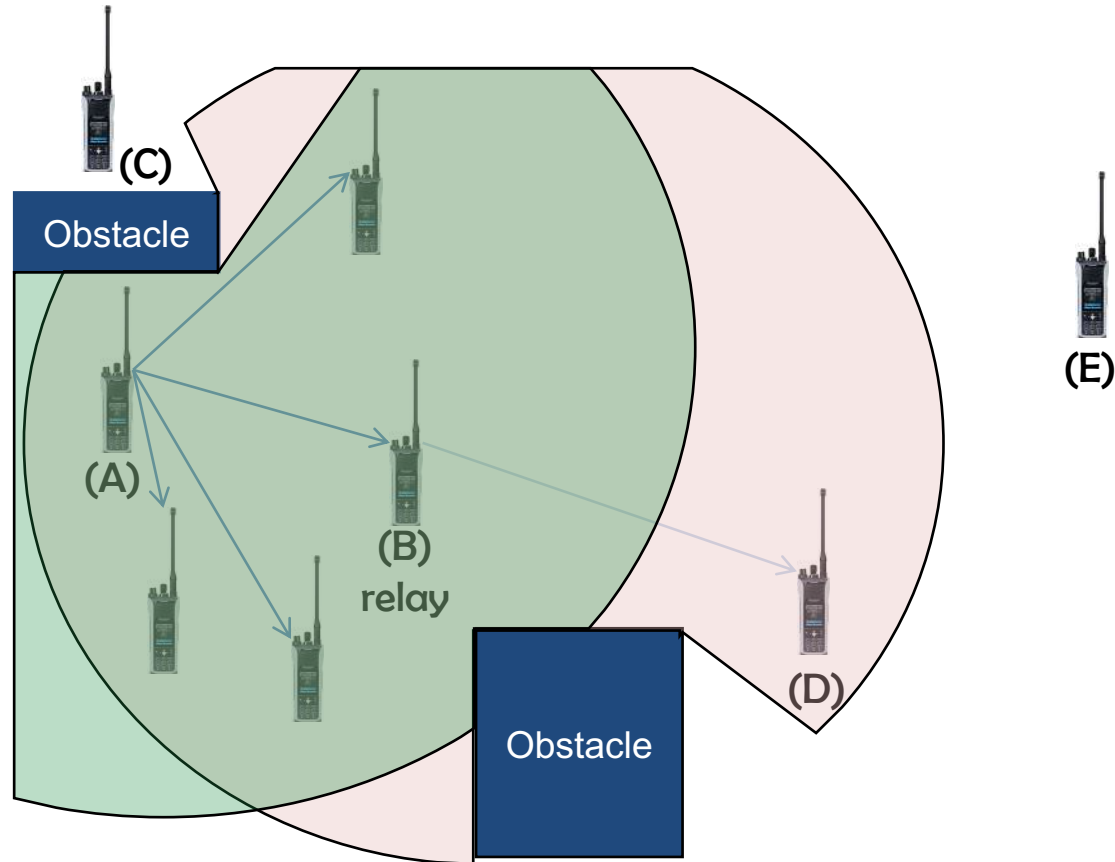
Benefits
- Extended range
- Reduces obstruction effects
- Improve delivery reliability

Disadvantages
- Twice as many radio resources
- Quasi-static deployment
- MIMO capabilities not fully utilized

Cooperative communication (example)

Cooperative devices: (B,C,& D) synchronously echo messages during re-sends

Benefits
- Higher effective transmitter power
- Diversity: M x 2
- Dynamic cooperative communications
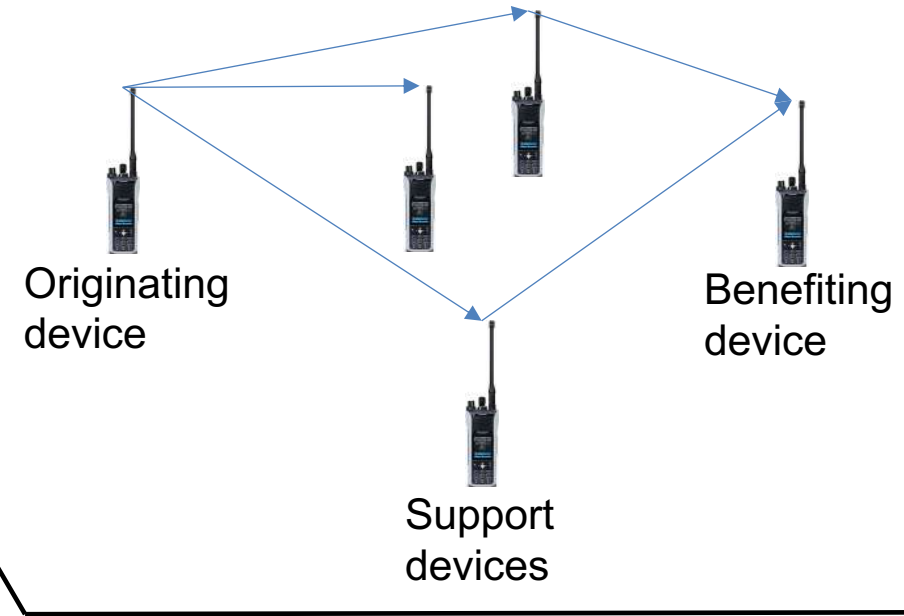- Improves communication with obstructions

Challenges
- Managing congestion with many groups

Application level forwarding or lower level coverage enhancement

Cooperative support algorithm

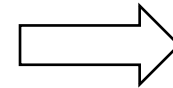**Each device acts independently**

Originating device

Benefiting device

Support devices

Configuration
- System policy
- Local policy

Priority
- Protocol
- Application

Radio Metrics
- Signal quality
- Signal loading

CSA (Cooperative Support Algorithm)

Transmission Support Decision

Relative coverage

Basis for coverage comparison between P25 and ProSe
- Represents best case scenario
- Coverage decreases with increasing throughput for data services

	P25 Portable	Portable	HP-UE Portable
Nominal Tx Power	35	23	31
MIMO	1x1	1x2	1x2
Rx Effective IF Bandwidth (kHz)	6	360	360
Rx Noise Figure (dB)	6	7	7
Faded Performance Threshold DAQ3.4 (dB)	17.7	-2.2	-2.2
Maximum RF Coupling Loss (dB)	147.5	136.6	144.6
Antenna Efficiency. (dB)	0	-4	-4
Maximum Link Loss	147.5	128.6	136.6
Radial Coverage Relative	1.00	0.34	0.53
Area Coverage Relative	1.00	0.11	0.29

Internal antenna

Relative coverage
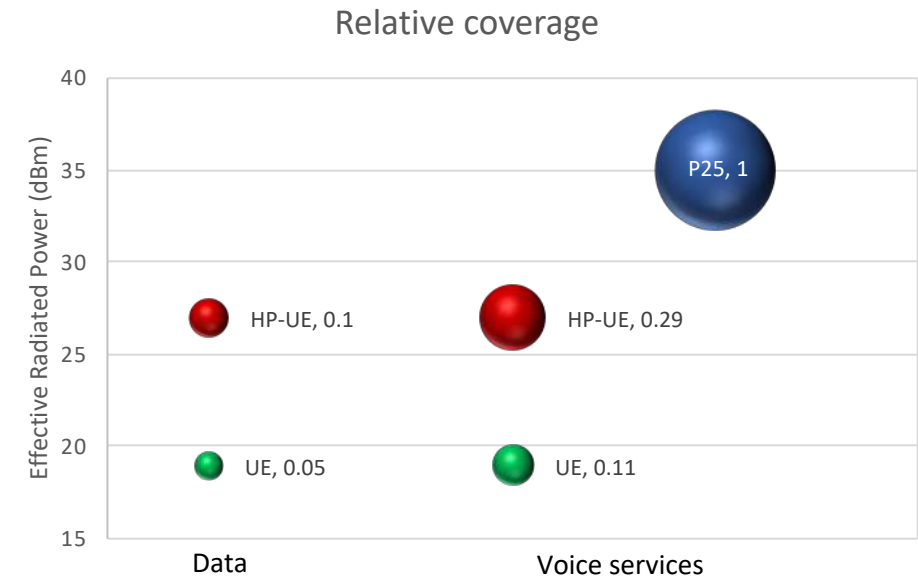
Staying within the standards

- **High power UE (standardized for band 14 & others)**

- **High efficiency antennas** VS.
    - Integrated antennas generally have much lower efficiencies
- **Singular transmission schemes in time (configuration)**
    - For example: single service per ProSe period (40 msec.)
    - Counter example: Video, Text, and Voice as separate physical packets
- **Lower rate voice CODECs**
    - For example: P25; maybe required for end to end encryption
    - Or negotiated by a device in limited coverage

Push the standards forward
- **Linking PS requirements to other verticals**
- **Extended coverage range**
    - Rural & in-building

Interim solutions

LMR/ proprietary for direct voice communications

When available ProSe/ V2x for direct services at closer range

Broadband for network communications

Integrated device
P25 network/direct

Separate devices
P25 network/direct

Direct mode sleeve
Proprietary airlink

Carry direct and broadband devices

Carry device with integrated capabilities

Field qualified broadband direct solution

dericson@harris.com

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Come back for the

Next Session

2:40 PM

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