2016 Public Safety Broadband Stakeholder Meeting

Day 1

Certain commercial equipment, instruments, or materials are identified in this paper in order to specify the experimental procedure adequately. Such identification is not intended to imply recommendation or endorsement by the National Institute of Standards and Technology, nor is it intended to imply that the materials or equipment identified are necessarily the best available for the purpose.

This publication is intended to capture external perspectives related to NIST standards, measurement, and testing-related efforts. These external perspectives can come from industry, academia, government, and other organizations. This report was prepared as an account of a workshop; it is intended to document external perspectives and does not represent official NIST positions.

#PSCR2016

Sue Swenson
FirstNet Chairwoman

PSCR

#PSCR2016

PSCR

NIST's Public Safety Innovation Accelerator

Pulling the Future Forward

Dereck Orr

PSCR Program Manager

Innovation Accelerator
Sessions This Week:

PSCR

Innovation Accelerator

Pulling the Future Forward

NIST's Public Safety Innovation Accelerator

Dereck Orr

NIST CTL Division Chief & PSCR Program Manager

Day 1 - Tuesday, June 7th

9:30am - 10:30am

NIST's Role in the *Middle Class Tax Relief and Job Creation Act*

Section 6303 directs NIST to conduct R&D to advance public safety communications technology and allocates $300 million in funding through 2022

PSCR's Approach

- Requirements & Standards
- Testing & Evaluation/Measurement
- Research & Development
- Modeling & Simulation
- Security Research

PSCR Technology Roadmapping

November 2013 - PSCR hosted a 2-day roadmapping workshop to collect information on priority R&D focus areas for public safety

- Location-based Services
- Analytics
- Enhanced User Interface

PSCR

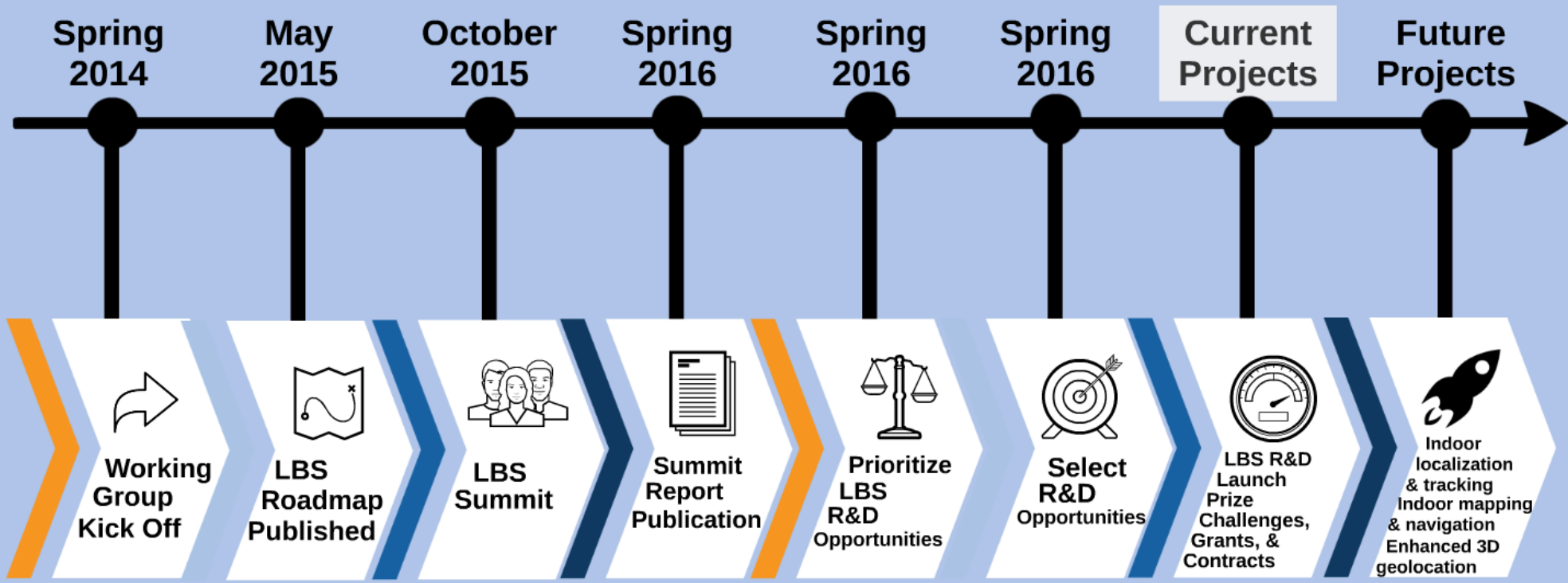
Innovation Accelerator

Pulling the Future Forward

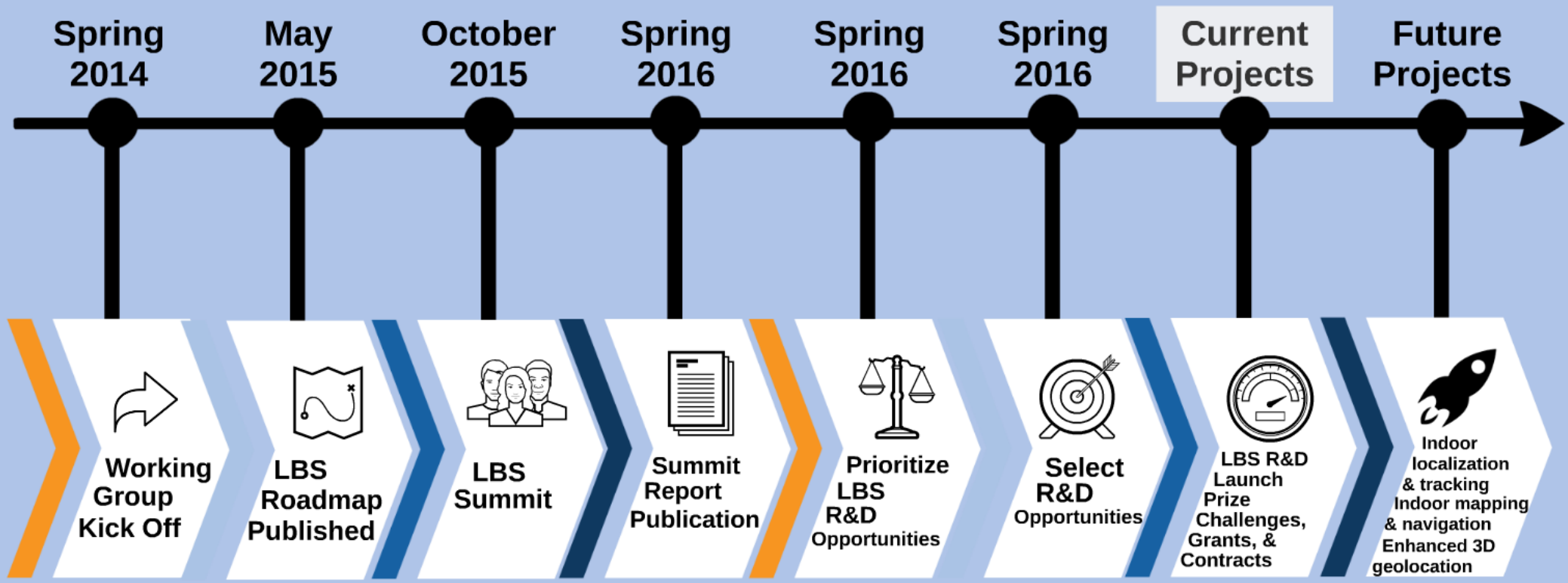
Innovation Accelerator Sessions This Week:

Innovation Accelerator

Location-Based Services



Location-Based Services



Day 2 - Wednesday, June 8th

9:30am - 10:00am

SNAPSHOT: Advanced Positioning
Using Improved Timing within an LTE Network

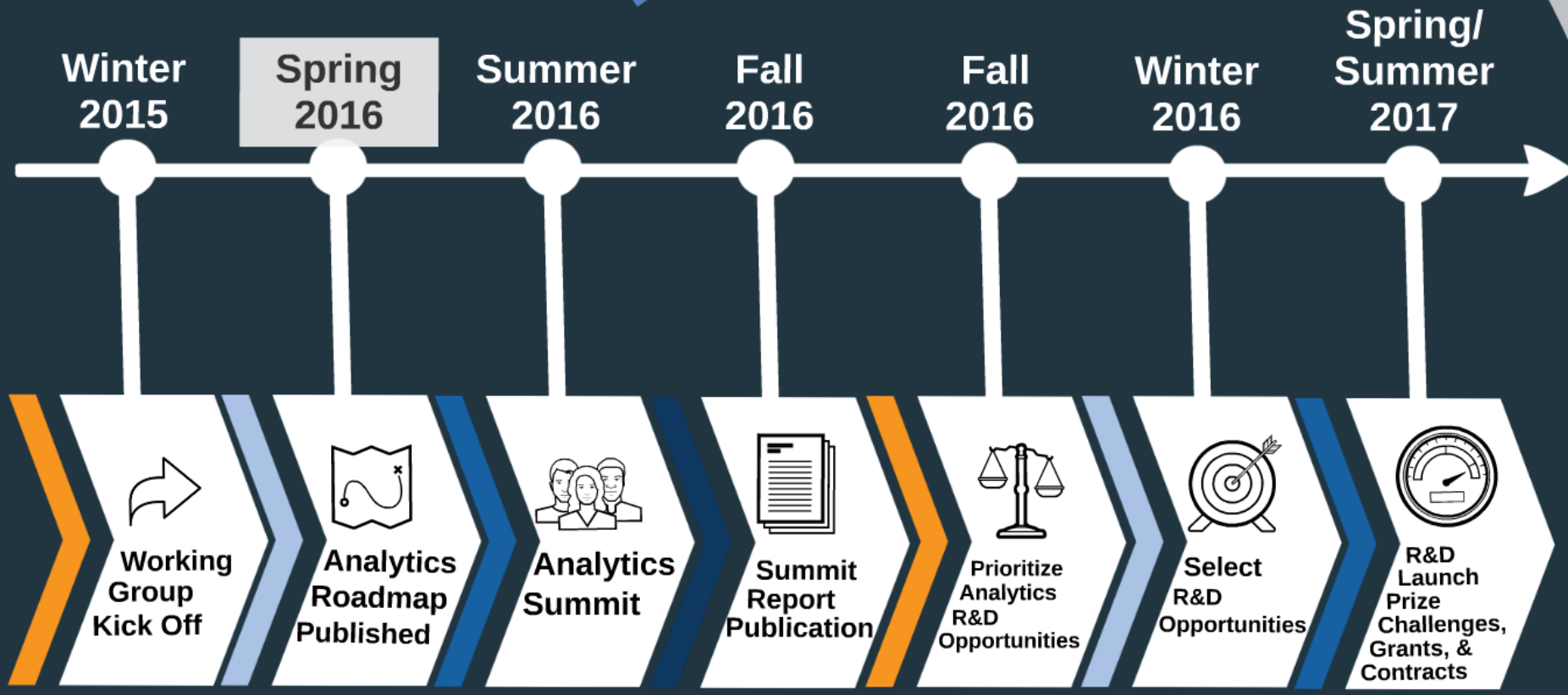
Dave Howe - *PSCR Location-based Services*

10:00am - 11:00am

Public Safety Location-based Services
Roadmap, Summit Findings, & Project Launch Overview

Moderator: Tracy McElvaney, *PSCR Advanced Communications Research Group Lead*
Vihang Jani, *PSCR Advanced Communications Research Group*
Ryan Felts, *PSCR Roadmapping Support*
Christian Militeau, *West Safety Services (formerly Intrado)*

Analytics


Winter 2015
Working Group Kick Off
Spring 2016
Analytics Roadmap Published
Summer 2016
Analytics Summit
Fall 2016
Summit Report Publication
Fall 2016
Prioritize Analytics R&D Opportunities
Winter 2016
Select R&D Opportunities
Spring/ Summer 2017
R&D Launch Prize Challenges, Grants, & Contracts

Analytics

Winter 2015	Spring 2016	Summer 2016	Fall 2016	Fall 2016	Winter 2016	Spring/ Summer 2017
Working Group Kick Off	Analytics Roadmap Published	Analytics Summit	Summit Report Publication	Prioritize Analytics R&D Opportunities	Select R&D Opportunities	R&D Launch Prize Challenges, Grants, & Contracts

Day 3 - Thursday, June 9

3:00pm - 4:30pm **Public Safety Analytics Roadmapping**
Paving the Road to the Summit

Moderator: Jeb Benson, *PSCR Advanced Communications Research Group*
Noah Fritz, *International Association of Crime Analysts (IACA)*
Tom Sorley, *NPSTC, City of Houston Deputy CIO, Public Safety*
Marc Leh, *PSCR Roadmapping Support*
John Garofolo, *PSCR Video Analytics*
Neal Fishman, *IBM*

User Interface

Spring 2016 — Working Group Kick Off

Winter 2016 — UI Roadmap Published

Spring 2017 — UI Summit

Spring 2017 — Summit Report Publication

Summer 2017 — Prioritize UI R&D Opportunities

Summer 2017 — Select R&D Opportunities

Fall 2017 — UI R&D Launch Prize Challenges, Grants, & Contracts

Interface

Spring 2016	Winter 2016	Spring 2017	Spring 2017	Summer 2017	Summer 2017	Fall 2017
Working Group Kick Off	UI Roadmap Published	UI Summit	Summit Report Publication	Prioritize UI R&D Opportunities	Select R&D Opportunities	UI R&D Launch Prize Challenges, Grants, & Contracts

Day 3 - Thursday, June 9th

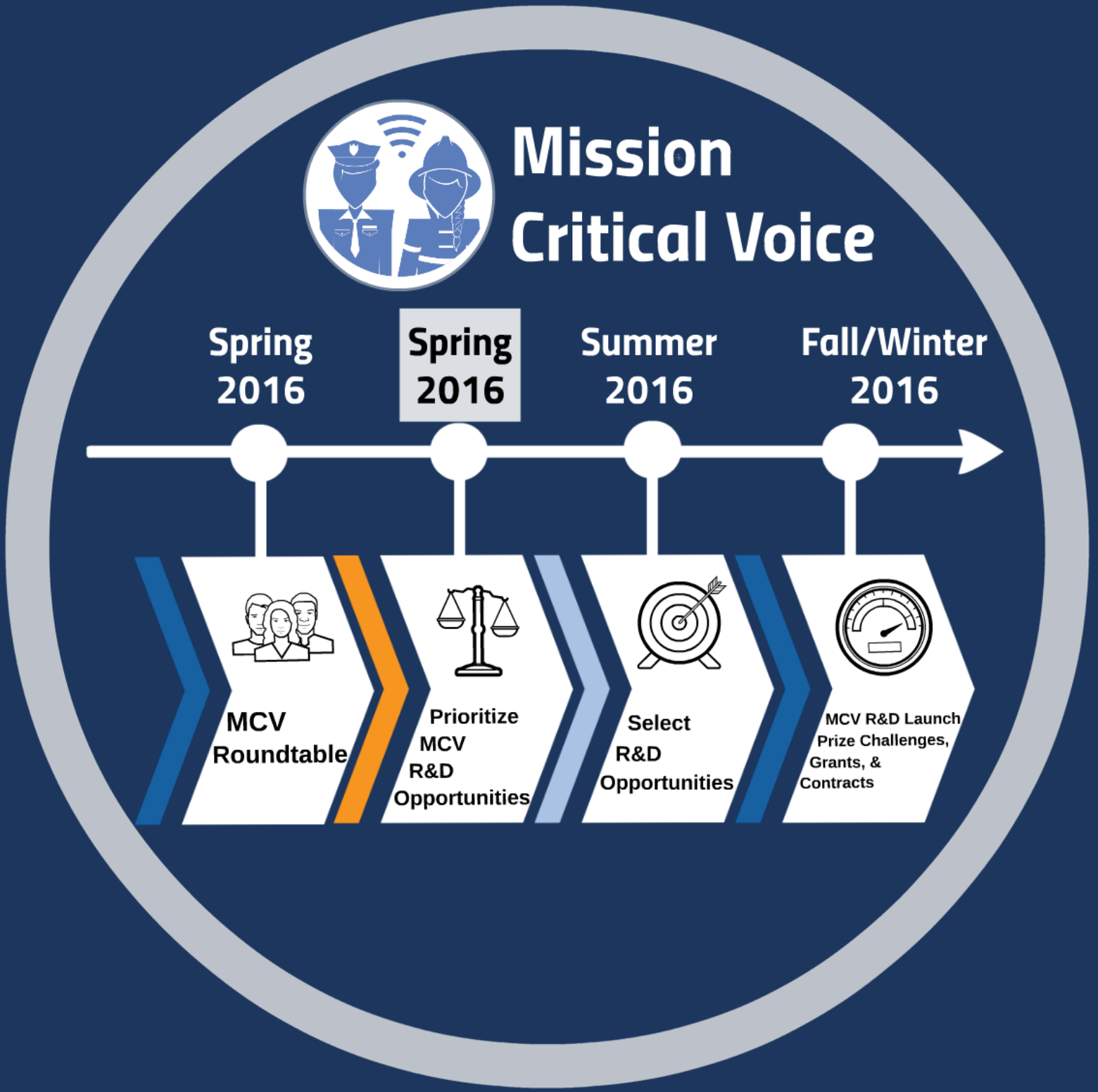
10:00am - 11:30am **User Interface Roadmapping for Public Safety Panel**

Mobilizing the Future from Interface to Experience

Mary Theofanos, *PSCR User Interface*
Brian Stanton, *PSCR User Interface*
Brad Fain, *Georgia Tech Research Institute*
Lexie Spiro, *Motorola*
Ray Bizal, *National Fire Protection Association (NFPA)*

11:30am - 12:00pm **SNAPSHOT: Public Safety's Immersive Test Environment**

Dereck Orr, *NIST CTL Division Chief & PSCR Program Manager*


Mission Critical Voice
Spring 2016
Spring 2016
Summer 2016
Fall/Winter 2016
MCV Roundtable
Prioritize MCV R&D Opportunities
Select R&D Opportunities
MCV R&D Launch Prize Challenges, Grants, & Contracts

Spring 2016

MCV Roundtable

Spring 2016

Prioritize MCV R&D Opportunities

Summer 2016

Select R&D Opportunities

Fall/Winter 2016

MCV R&D Launch Prize Challenges, Grants, & Contracts

Day 1 - Tuesday, June 7th

10:30am - 12:00pm **Mission Critical Voice**
Bridging the Gap & Advancing the Future

Jeb Benson, *PSCR Advanced Communication Research Group*
Richard Rouil, *PSCR Modeling & Simulation*
Andrew Thiessen, *PSCR Standards & Requirements Lead*
Chief Paul Roberts, *Division Chief - City of Boise Fire Department*

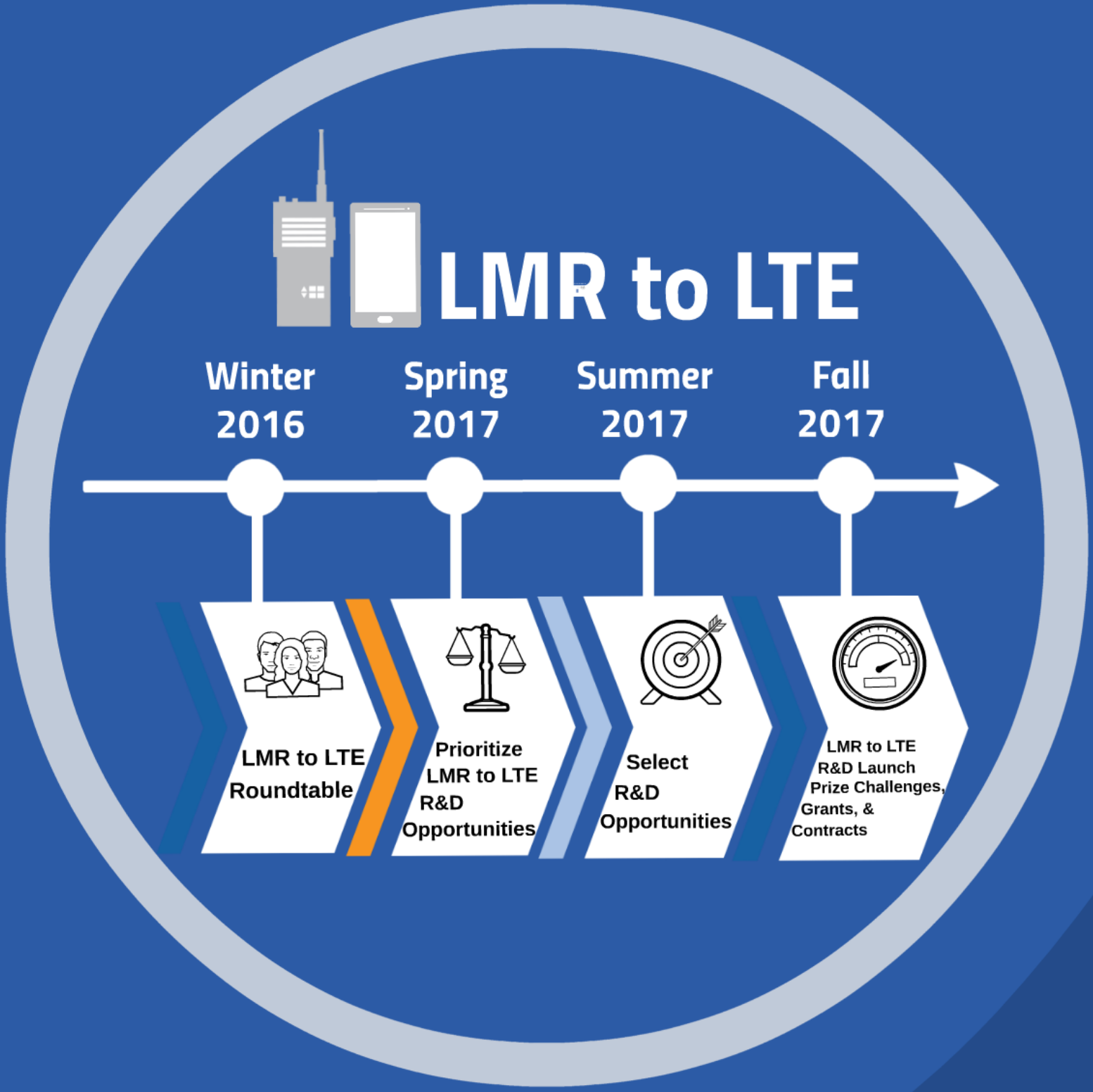
Day 2 - Wednesday, June 8th

1:30pm - 3:00pm **BREAKOUT SESSION A: Tutorial 101A – Mission Critical Voice**
PTT, D2D, & GCSE – Oh My !

Jeb Benson, *PSCR Advanced Communications Research Group*

3:30pm - 5:00pm **BREAKOUT SESSION A: Tutorial 101A – Mission Critical Voice**
PTT, D2D, & GCSE – Oh My !

Jeb Benson, *PSCR Advanced Communications Research Group*


LMR to LTE
Winter 2016
Spring 2017
Summer 2017
Fall 2017
LMR to LTE Roundtable
Prioritize LMR to LTE R&D Opportunities
Select R&D Opportunities
LMR to LTE R&D Launch Prize Challenges, Grants, & Contracts

LMR to LTE

Winter 2016

LMR to LTE Roundtable

Spring 2017

Prioritize LMR to LTE R&D Opportunities

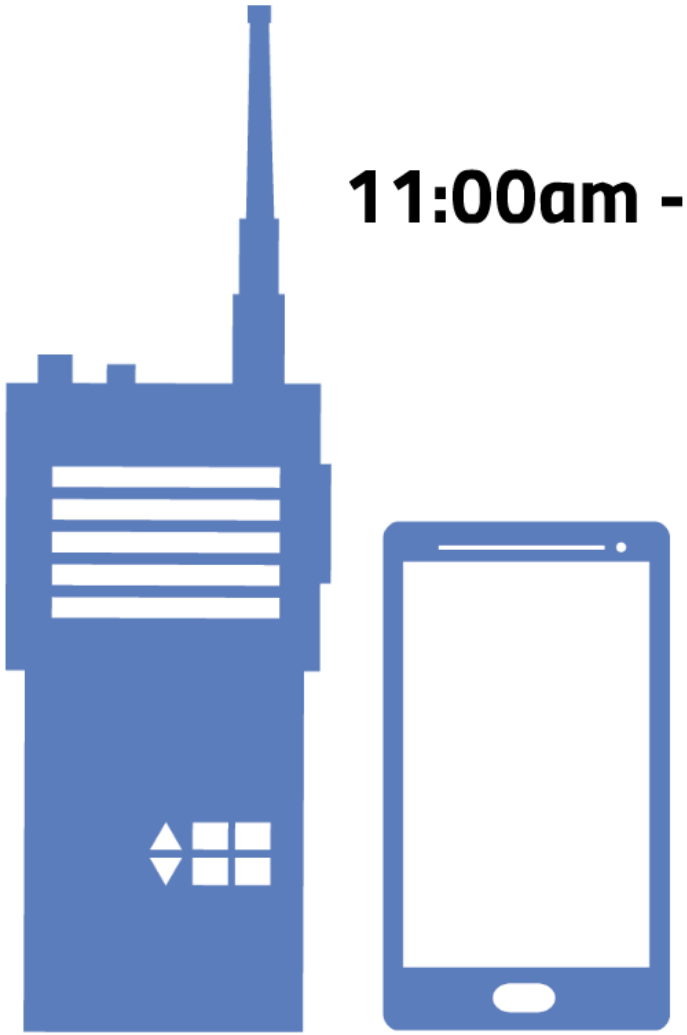
Summer 2017

Select R&D Opportunities

Fall 2017

LMR to LTE R&D Launch Prize Challenges, Grants, & Contracts

Day 2 - Wednesday, June 8th



11:00am - 11:30am **SNAPSHOT: LMR to LTE Standards Update**

Andrew Thiessen, *PSCR Standards Lead*

Prizes & Challenges

Prize Challenges

Federal government increasingly leveraging prize challenges to spur innovation and solve tough problems

- **NIST partnering with Under Armour, NFL, & GE to innovate impact-absorbing materials for use in football helmets**
- **Smart Cities Challenge**
- **DARPA Robotics Challenge**

NIST is partnering with NASA's Center of Excellence for Collaborative Innovation to launch initial Innovation Accelerator prizes

& Challenges

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- DARPA Robotics Challenge

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bit.ly/PSprizes

PSprizes@nist.gov

Grants/Cooperative Agreements

NIST will leverage grants and cooperative agreements as part of the Innovation Accelerator program. These tools will increase collaboration and innovation with external partners in order to advance communications technology for public safety.

Day 2 - Wednesday, June 8th

9:00am - 9:30am **Keynote Address**

Steven Rader, *NASA Center of Excellence for Collaborative Innovation (CoECI)*

1:30pm - 3:00pm **BREAKOUT SESSION B: Prizes and Competitions 101**

How to Engage in Prizes, Grants, Cooperative Agreements, & Competitions

Tammi Marcoullier, *PSCR Prize Architect*
Heather Evans, *NIST Program Coordination Office*

3:30pm - 5:00pm **BREAKOUT SESSION B: Prizes and Competitions 201**

Brainstorming Early Prize Competition Opportunities

PSCR

Innovation Accelerator

Pulling the Future Forward

Get Involved!

Sign up for the PSCR Newsletter on pscr.gov

Attend Innovation Accelerator working groups & technology summits

Consider competing or judging prize competitions

Thank You!

PSCR

Mission Critical Voice

Bridging the Gap & Advancing the Future

Speakers

Paul Roberts	Boise FD, Chief – Special Operations Division
Andrew Thiessen	PSCR/NTIA, Chief – ITS.P Division
Richard Rouil	PSCR/NIST, Wireless Networks Division
Jeb Benson	PSCR/NIST, NIST R&D Team Lead

Questions/discussion at conclusion of speakers

Mission Critical Voice (MCV) – The Charter

Middle Class Tax Relief & Job Creation Act of 2012 §6303

"ACCELERATE the development of mission critical voice… over broadband networks"

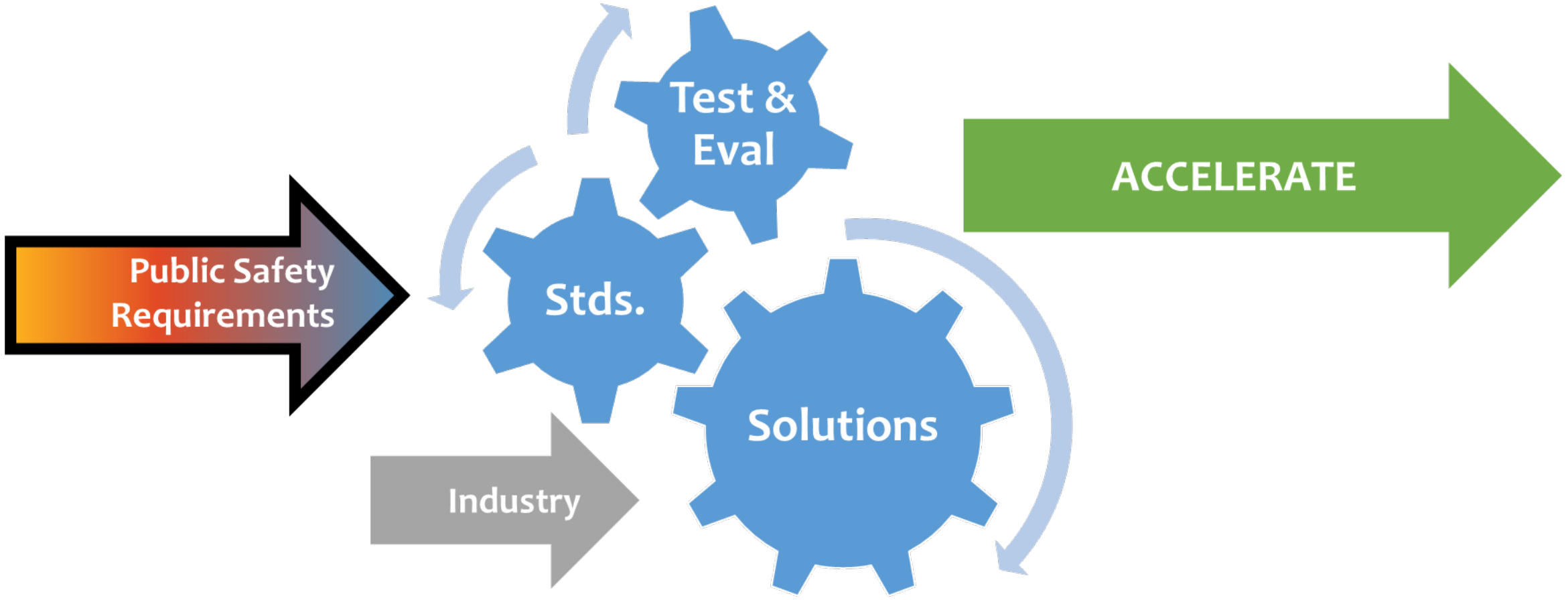
PSCR

Typical LTE Deployment Timeline

Months:	24 - 48	18 - 24	12 - 24
	Standards	**Pre-Deployment**	**Deployment**
	- Specifications	- R&D - Lab certification - Field certification	- Live testing - Sustainment

PSCR

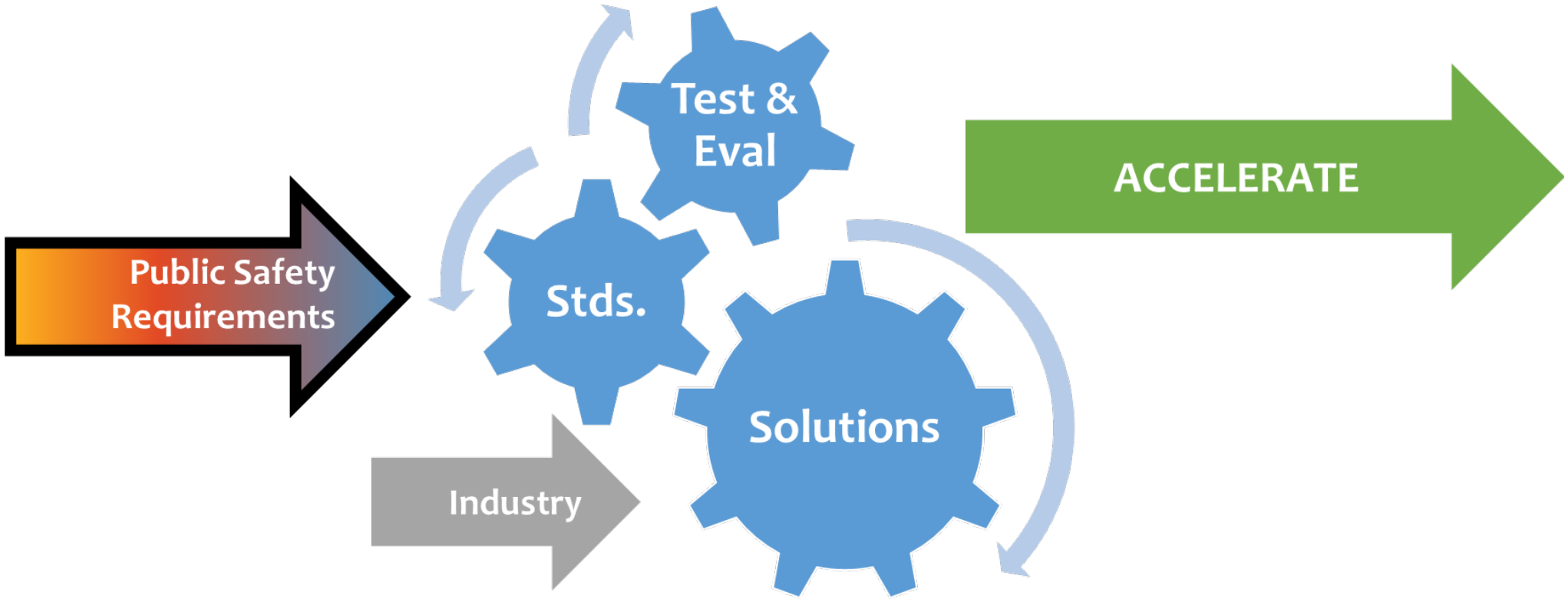
Our Goal


Public Safety Requirements
Test & Eval
Stds.
Solutions
Industry
ACCELERATE

Importance of MCV – Public Safety Perspective

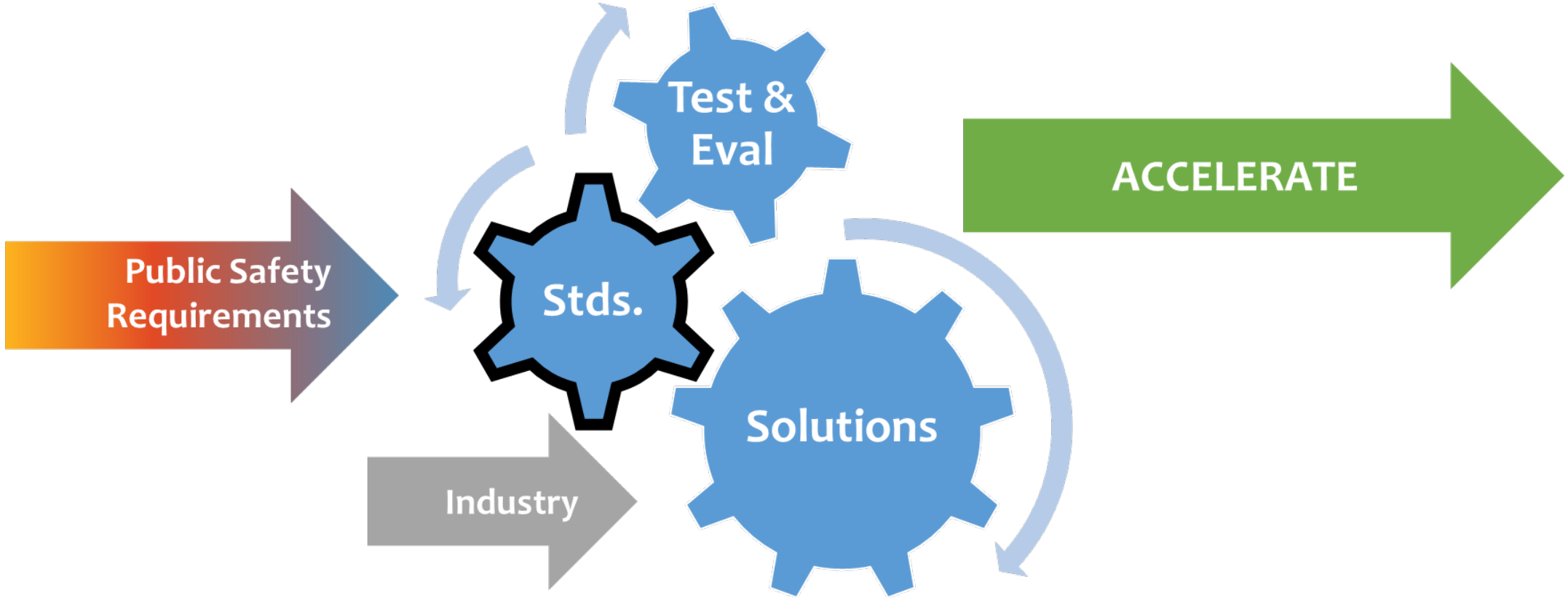
Paul Roberts

Boise FD, Chief – Special Operations Division



From Public Safety to 3GPP Standards

Andrew Thiessen PSCR/NTIA, Chief – ITS.P Division



This work is sponsored by

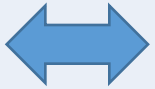
FirstNet
(First Responder Network Authority)

PSCR

Agenda

- Mission Critical Voice Defined
- Standards Recap
  - Direct Mode
  - Group Communications
  - Audio Quality
  - Emergency Alerting
  - Talker Identification
  - Push To Talk

MCV Roundtable – Key Elements

	**Push-to-talk**	Ability to (instantly), selectively, and sequentially transmit messages either one-to-one or one-to-many
	**Talker identification**	Ability to identify who is transmitting/speaking
	**Emergency alerting**	Ability to indicate that a user is in a life-threatening condition, needs immediate access to the system, and is given the highest level of priority Transmits data about user location (if available) and alerts other users of the emergency
	**Audio quality (& Intelligibility)**	Listener must be able to understand what is being said, who is speaking, their tone of voice, and background noise information
	**Group communication**	Immediate one-to-many communications between members of a talk group
	**Direct mode**	Ability for a radio or group of radios to operate independent of existing network infrastructure

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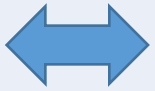
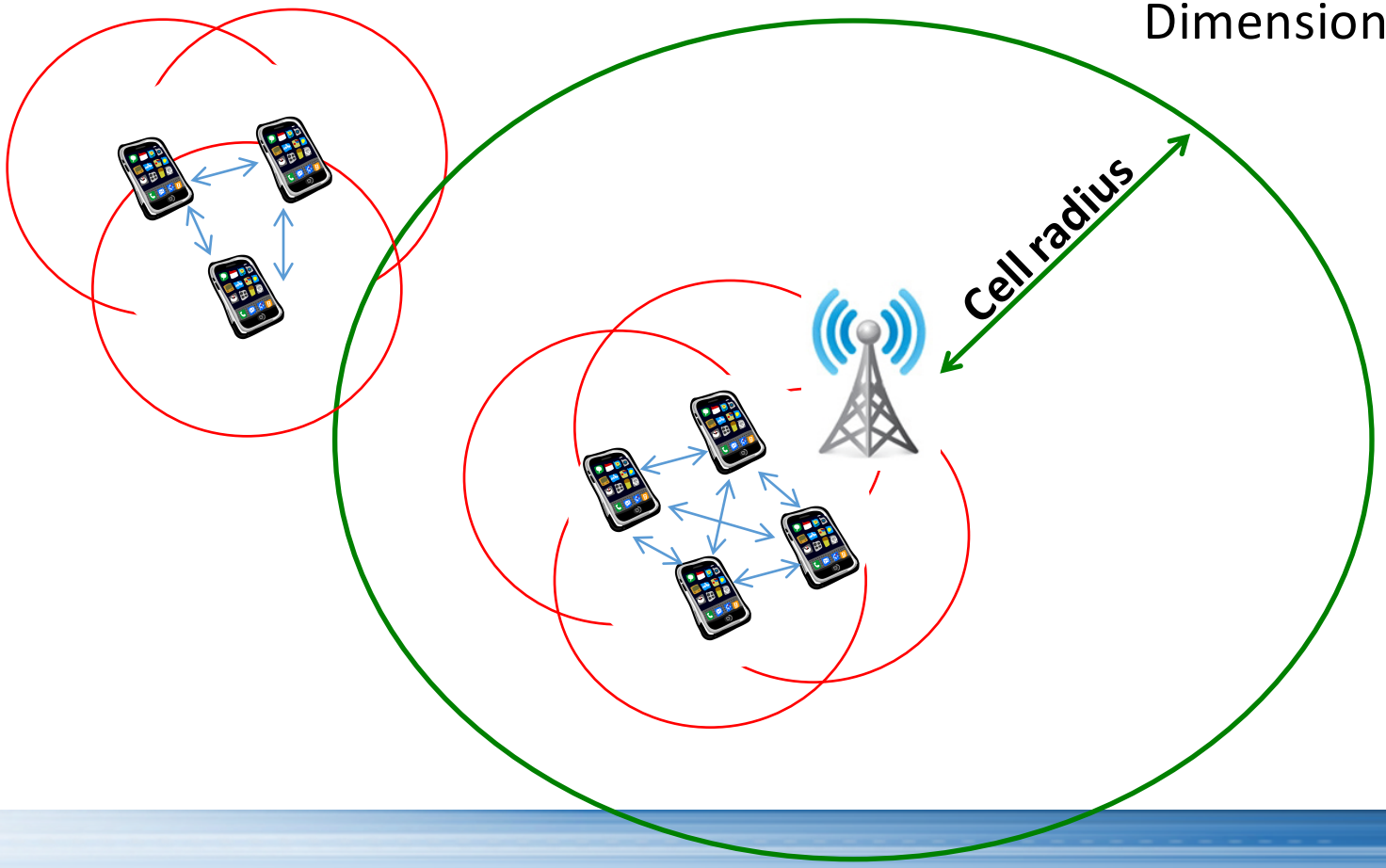
	**Direct mode**	**Ability for a radio or group of radios to operate independent of existing network infrastructure**

Direct Mode

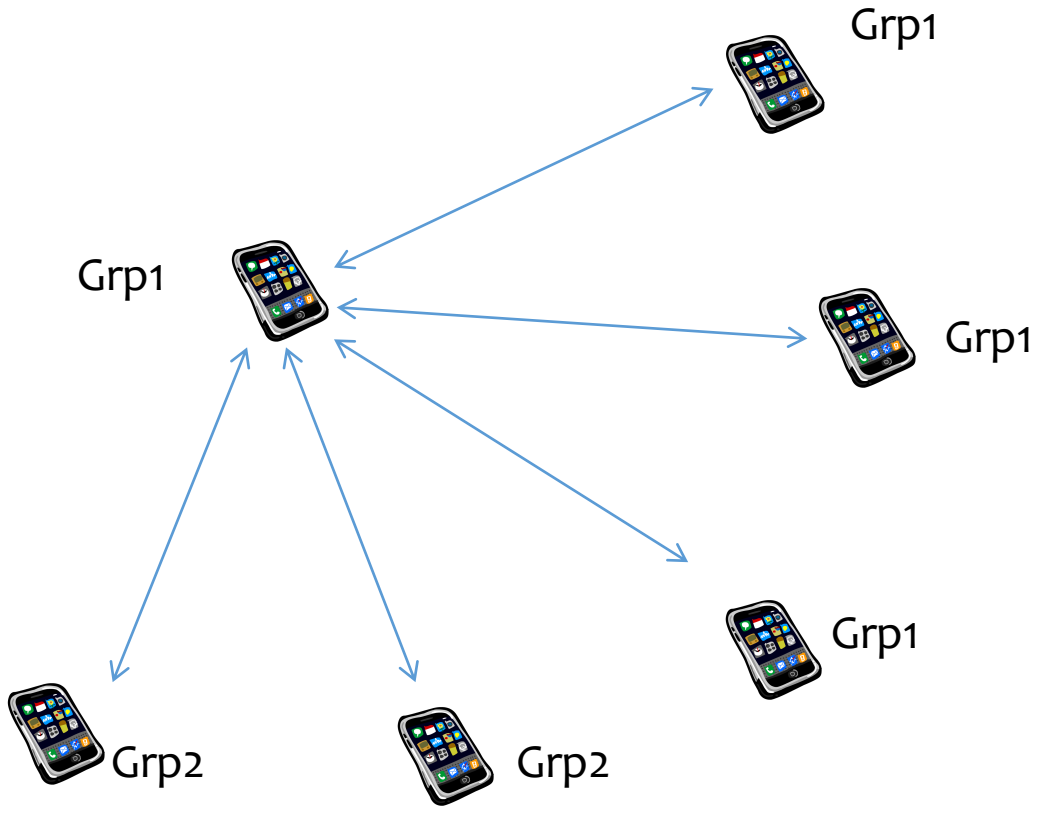
Proximity Services (ProSe)

Dimension 1: In and out of network coverage



Direct Mode (cont'd)

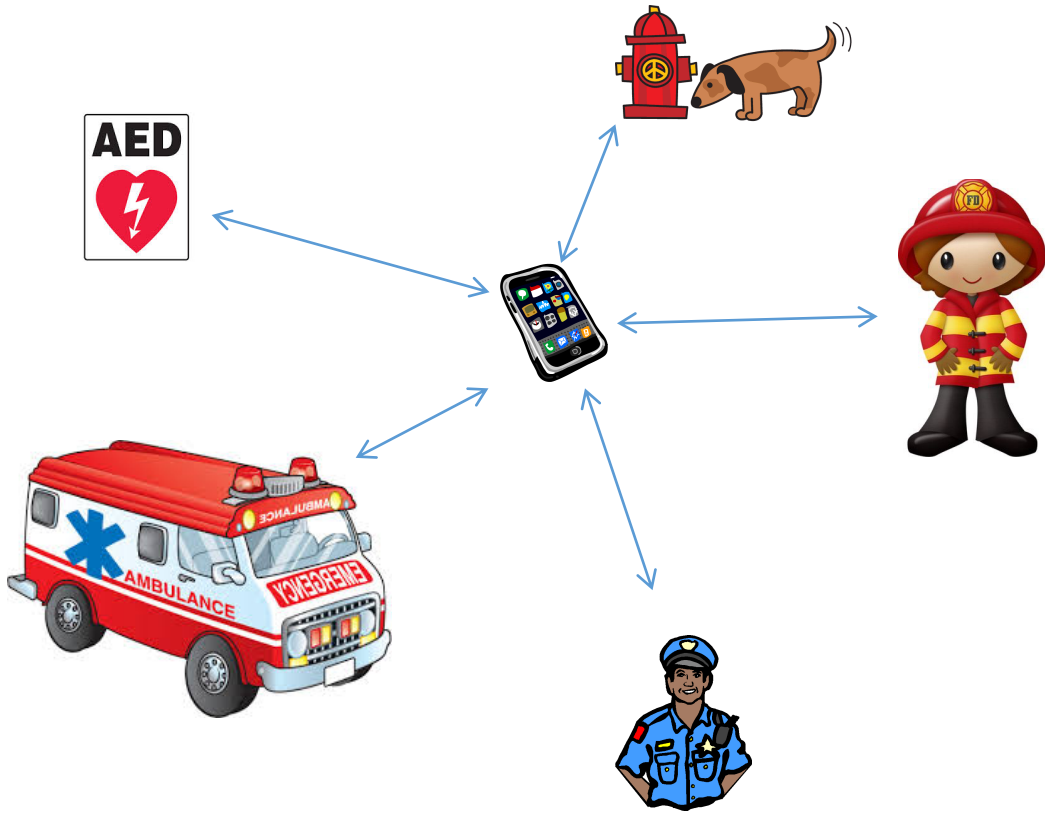
Proximity Services (ProSe)



Dimension 2: 1 to 1, 1 to many, 1 to all

Direct Mode (cont'd)

Proximity Services (ProSe)



Dimension 3: Discovery vs. communication

Direct Mode (cont'd)

- What didn't we get in Release 12
  - UE-to-UE relay
  - Out of network discovery (came in Release 13)
- How is direct mode changing now (Release 14 and beyond)
  - Three new markets popping up
    - Vehicle to X communications
    - Internet of Things
    - Wearables

MCV Roundtable – Key Elements

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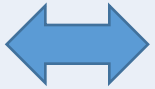
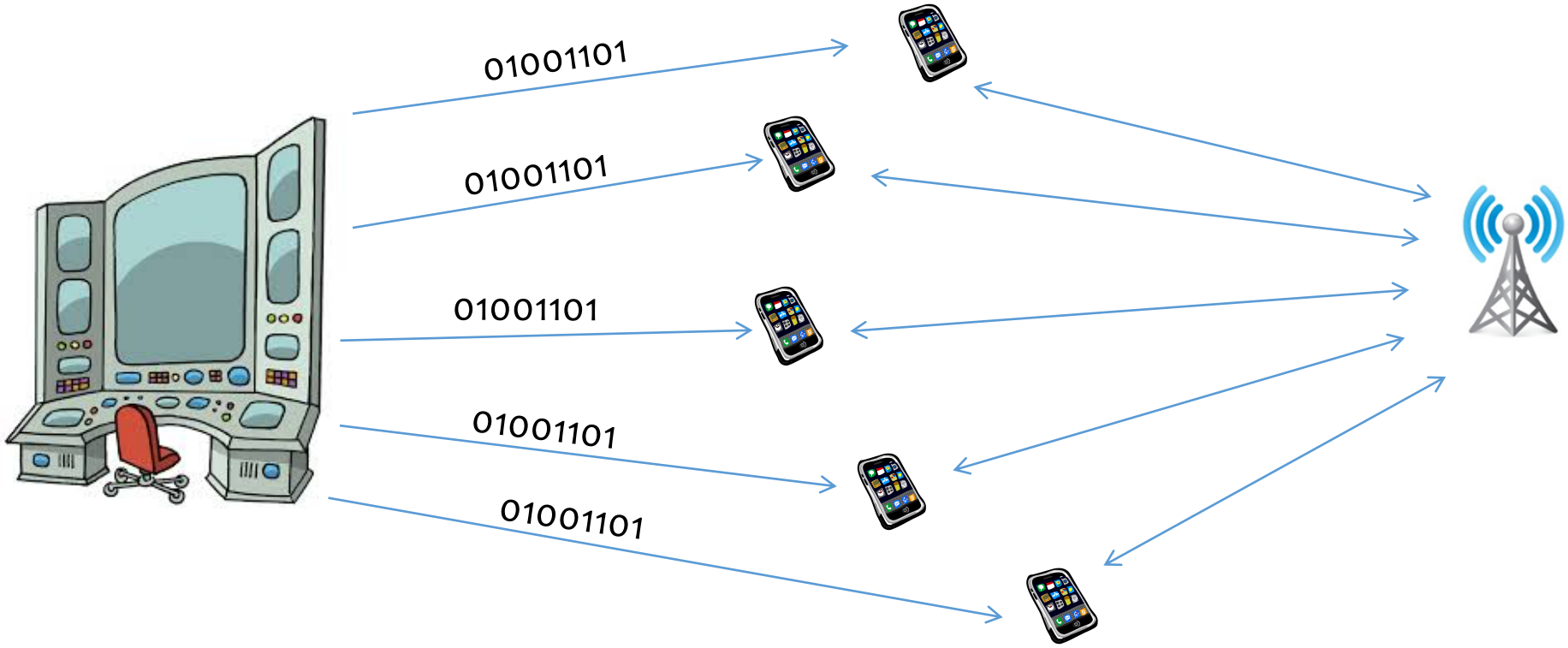
	Direct mode	Ability for a radio or group of radios to operate independent of existing network infrastructure

Group Communications

Group Communications System Enablers for LTE (GCSE_LTE)



Group Communications

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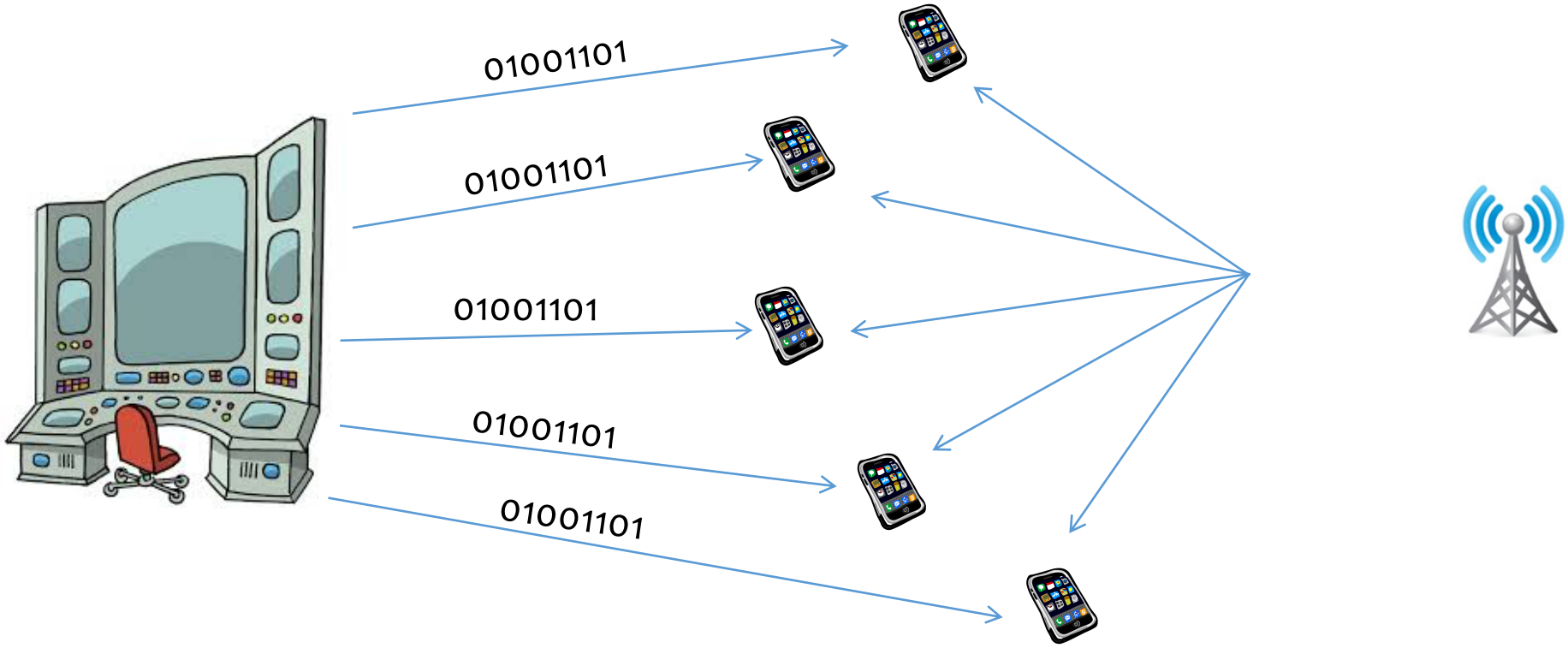

Group Communications

- 3 major standards components of Group Communications
  - GCSE_LTE
    - Establishes the mechanisms through which group communications are routed to eNodeB's
  - eMBMS
    - A method by which multicast and broadcast communications are sent out over a specialized radio link to largely predefined geographies
  - SC-PTM
    - A method that uses the eMBMS architecture but doesn't use eMBMS bearers, thus allowing for more dynamic group communications
- New MCCoRe work draws group comms out of MCPTT into common specs that other services can leverage

MCV Roundtable – Key Elements

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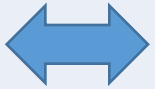	Direct mode	Ability for a radio or group of radios to operate independent of existing network infrastructure

Audio Quality

- Stephen Voran will present about audio codecs for Mission Critical Voice after lunch!
  - SNAPSHOT: Public Safety Audio Quality Research from 1:30pm – 2:00pm

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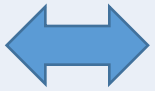	Direct mode	Ability for a radio or group of radios to operate independent of existing network infrastructure

Emergency Alerting

- Two types of alerting based on public safety requirements
  - Emergency
  - Imminent Peril
- Emergency call
  - An urgent MCPTT call that highlights the potential of death or serious injury to the initiator
- Imminent peril call
  - An urgent MCPTT call that highlights the potential of death or serious injury, but is less critical than an MCPTT Emergency Call. For example a call prioritized in the event of immediate threat to any human life such as resulting from an MCPTT user's observation of or engagement in a situation involving imminent peril to the general public (e.g., a forest fire about to encircle campers, tanker truck ready to explode near a school, casualties at the scene of a car bombing)

MCV Roundtable – Key Elements

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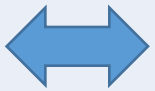	Direct mode	Ability for a radio or group of radios to operate independent of existing network infrastructure

Talker Identification

- Several types of identities created in MCPTT over LTE
  - Mission Critical user ID
    - An identity which is linked to a set of credentials (e.g., biometrics, secureID, username/password)
  - MCPTT user ID
    - Given that a Mission Critical user ID could be used more than just MCPTT, there is also a specific ID for MCPTT
  - MCPTT group ID
    - An ID that represents a set of MCPTT users within an MCPTT system
- MCPTT user profile
  - An MCPTT user is associated with at least one MCPTT user profile
  - Profile contains myriad of information about the user and authorizations the user may have

MCV Roundtable – Key Elements

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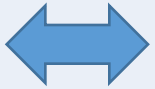
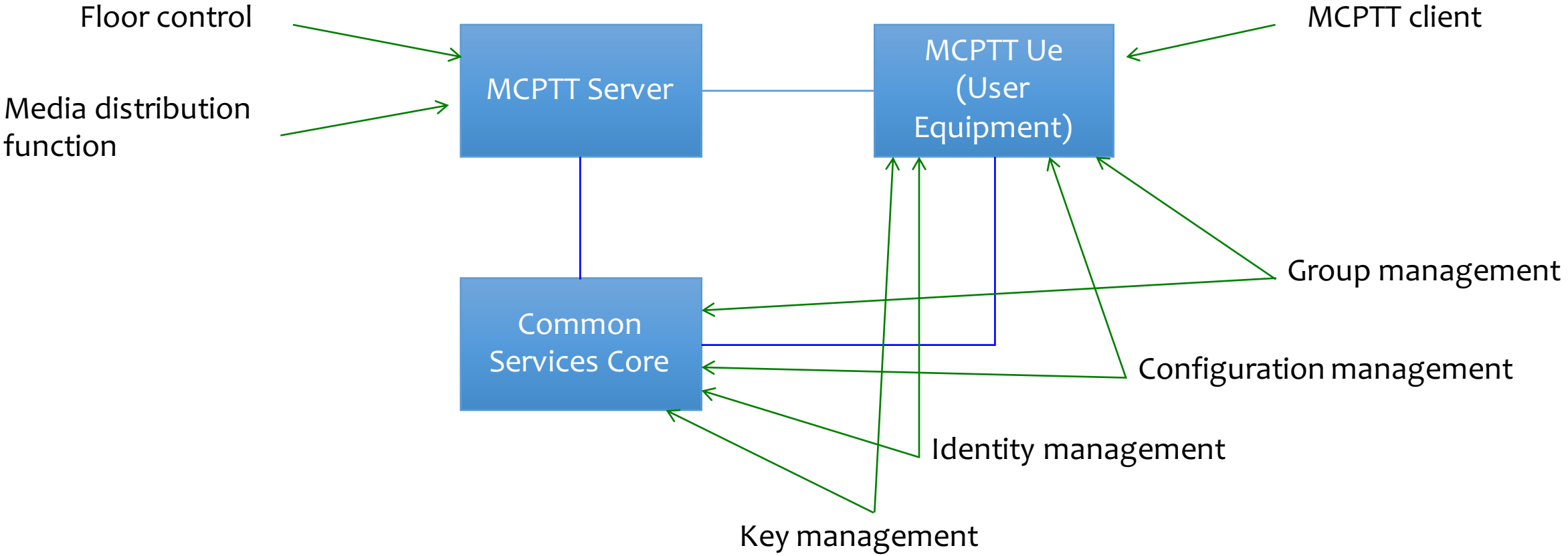
	Direct mode	Ability for a radio or group of radios to operate independent of existing network infrastructure

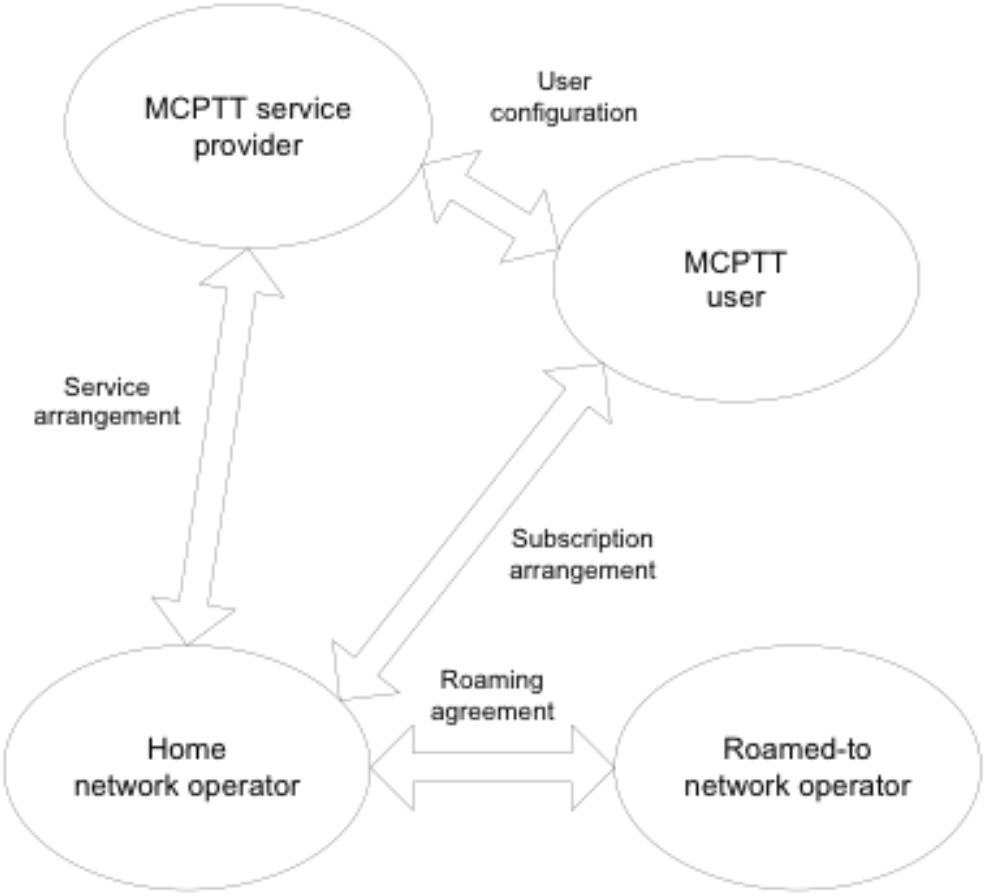
Push To Talk

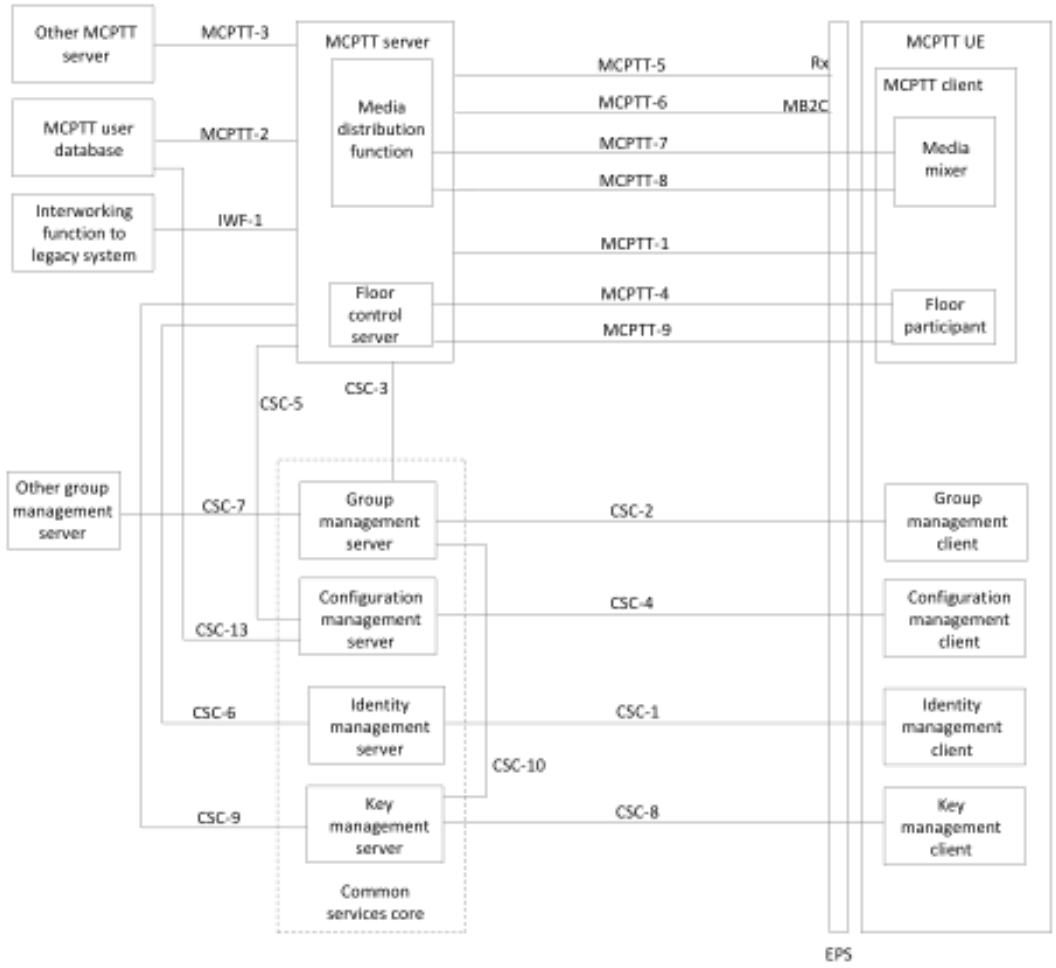
Mission Critical Push To Talk over LTE (MCPTT)



Push To Talk (cont'd)

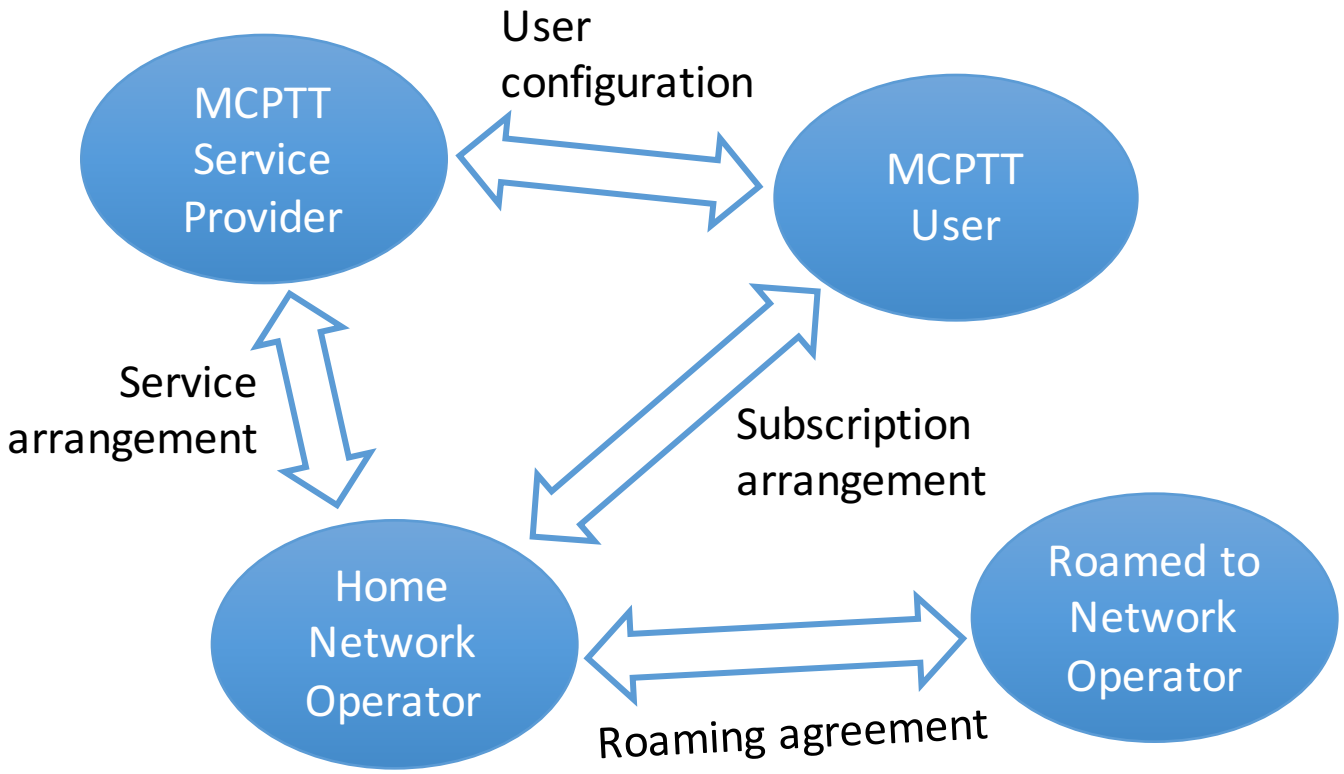
Mission Critical Push To Talk over LTE (MCPTT)





Push To Talk (cont'd)

Mission Critical Push To Talk over LTE (MCPTT)



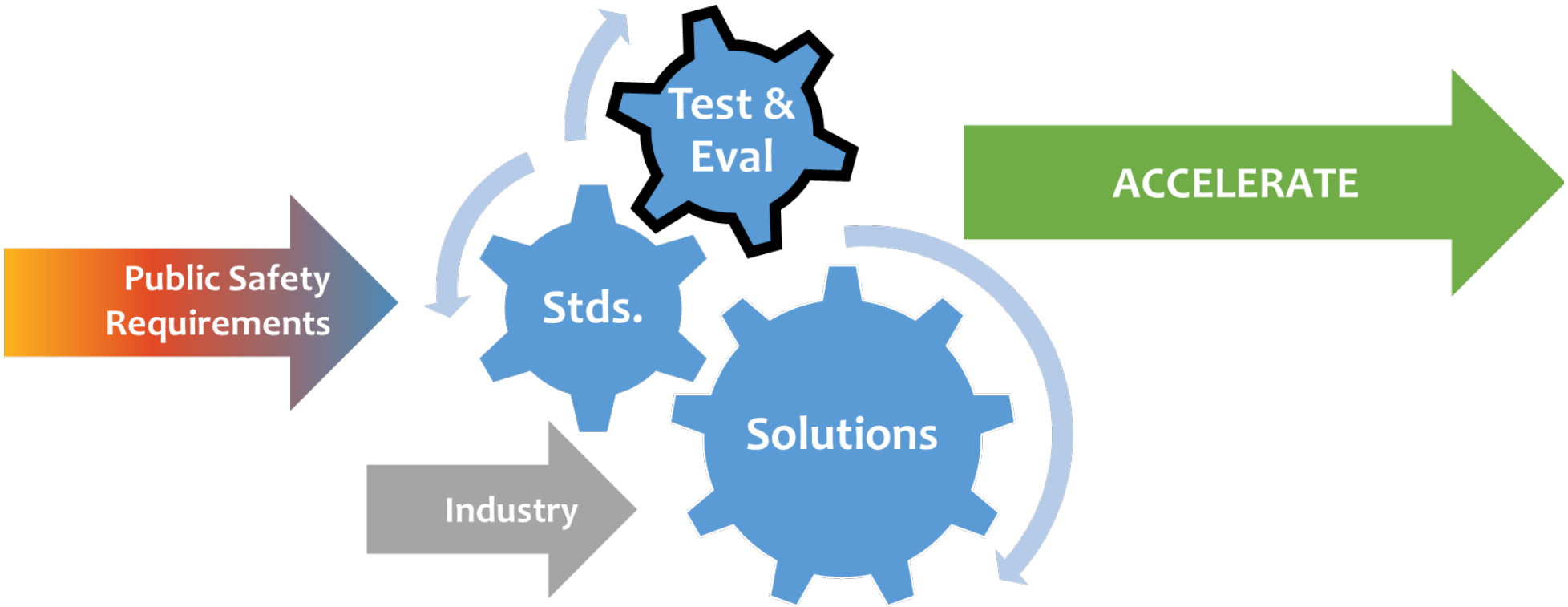
Push To Talk (cont'd)

- In Release 14 we are fixing bugs and closing gaps not filled in Release 13
- Created a study on LMR to LTE connection to be discussed tomorrow

Evaluating Unique Public Safety Requirements

Richard Rouil

PSCR/NIST, Wireless Networks Division



This work is sponsored by

FirstNet
(First Responder Network Authority)

Department of Homeland Security
Science & Technology Directorate
Office for Interoperability and Compatibility
(DHS S&T OIC)

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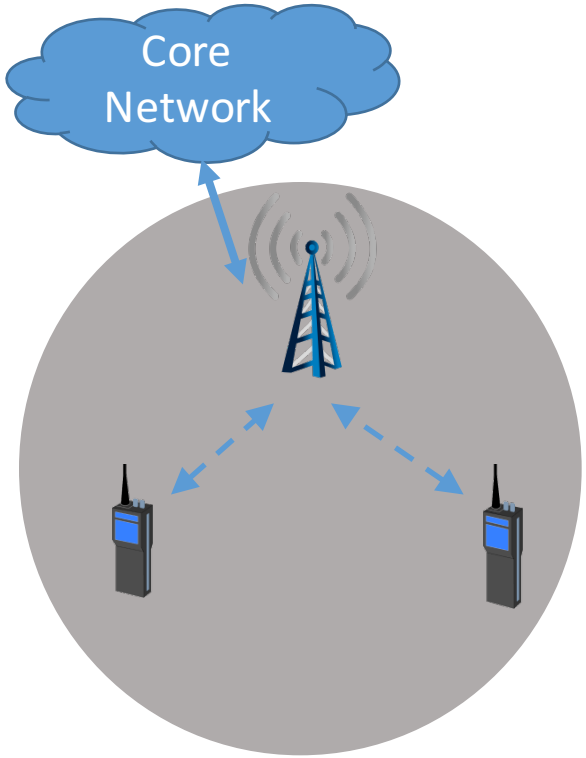
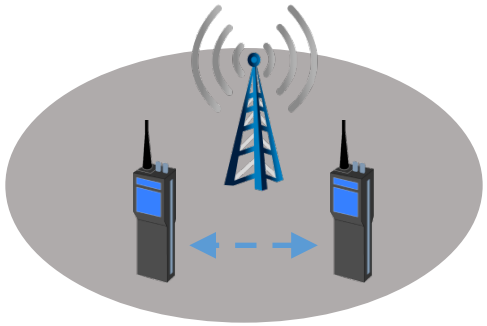
MCV Use Cases

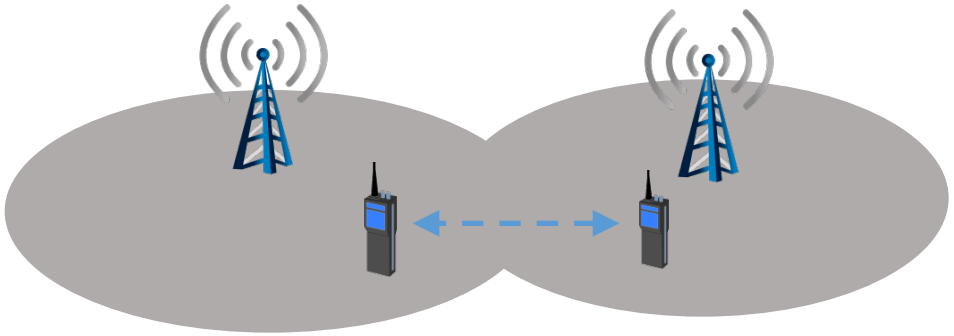
On network (In coverage)



Off network

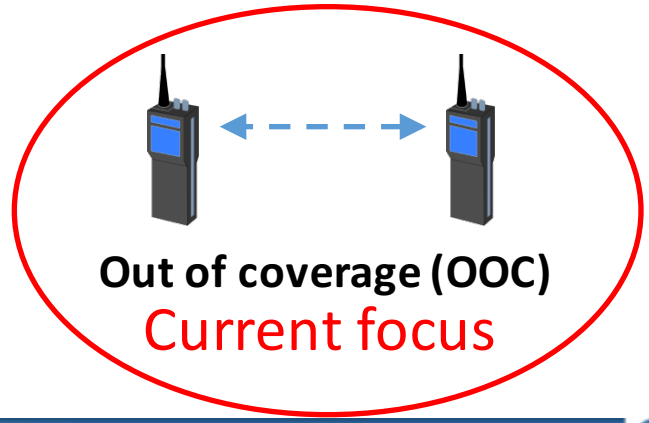


In-coverage, single-cell



In-coverage, multi-cell

Partial-coverage



Out of coverage (OOC)
Current focus

MCV Out of Coverage Architecture

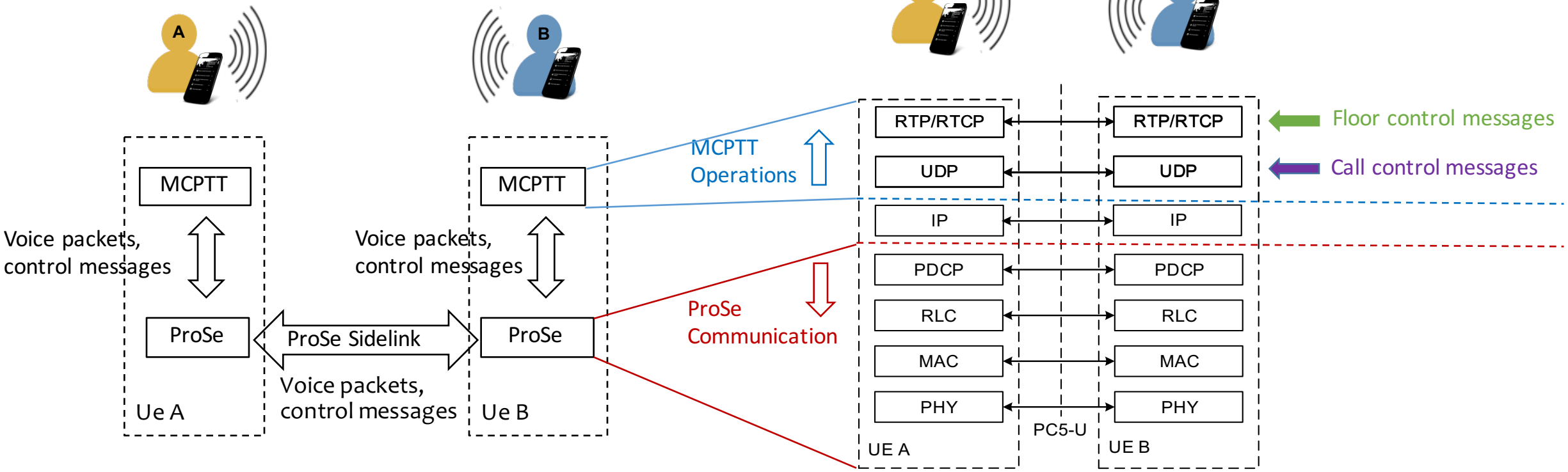


Figure: Simplified Illustration of MCPTT over ProSe (off-network mode)

Figure: Protocol stack of MCPTT off-network over ProSe basic operations

ProSe Functionalities

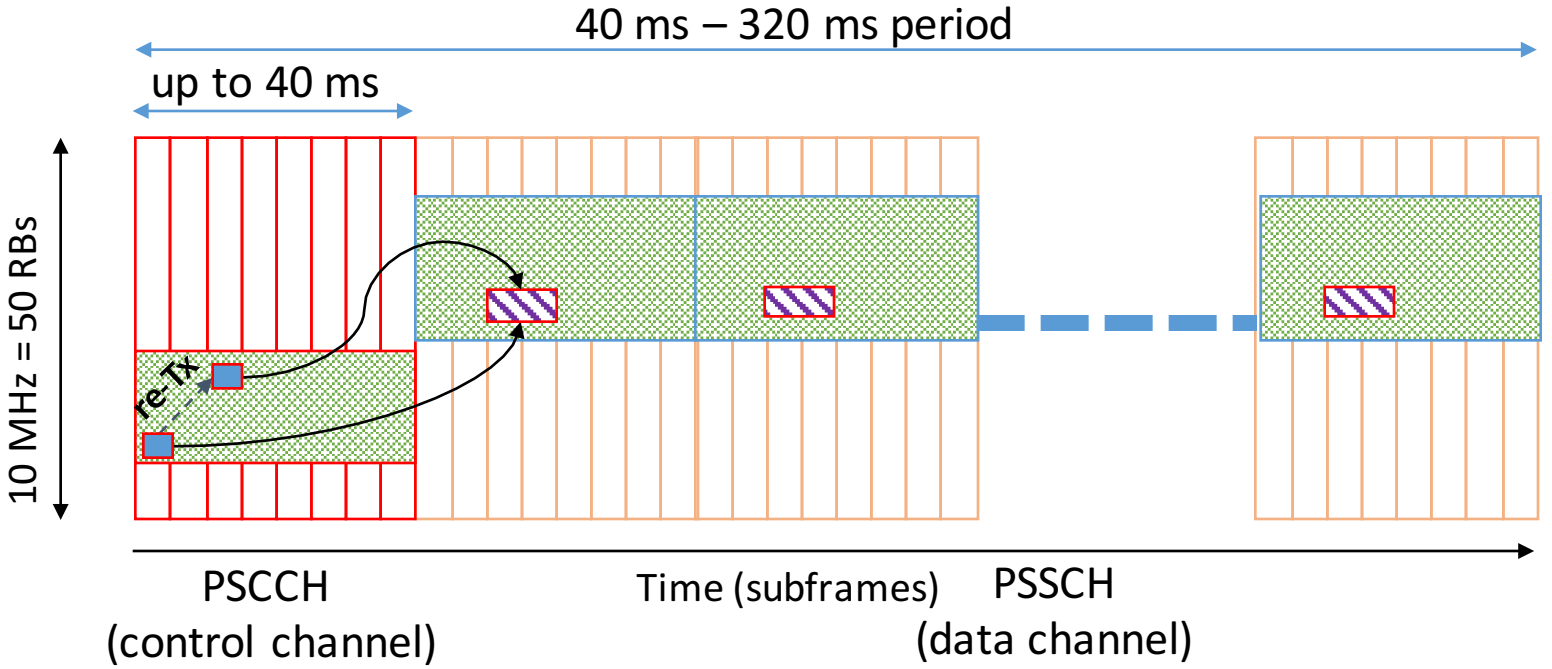
- Services
  - Direct Discovery: The ability to detect the presence of another UE in proximity
    - Announce/Monitor functions
    - Includes Restricted discovery for Public Safety
    - Group discovery
  - Direct Communication: The capability to exchange user traffic without going through the eNodeB
- Requirement
  - Device synchronization

ProSe vs Uplink

Key Differences	Uplink (UE->eNodeB)	ProSe (UE->UE)
Scheduler type	Centralized (eNodeB)	Uncoordinated (UEs)
Scheduling Interval	1 ms	40 ms – 320 ms
Resource allocation	Dynamic	Pre-configured
Reliability	HARQ with acknowledgement	HARQ without acknowledgement (always 4 transmissions)
Physical layer transmission mode	Unicast	Groupcast (Rel 12), Unicast (Rel 13)

Hybrid automatic repeat request (HARQ) is a mechanism to reliably transmit data packets with increasing chance of decoding the packets at each retransmission.

Example of ProSe Resource Allocation



Depicted

- Subframes used in control channel
- Subframes used in shared channel
- Resources assigned to a pool
- resource selected in control channel
- Resources selected for data transmission

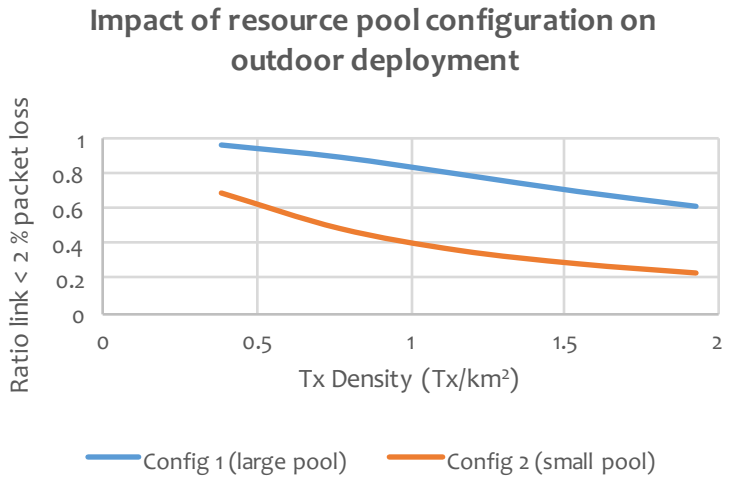
- **Transmitting UEs (Tx mode):**
  - To transmit, a UE selects a **random resource** n in the PSCCH pool to send a Control Information Message, indicating where and how the data will be transmitted in the PSSCH.
- **Listening UEs (Receive mode):**
  - Each UE listens to the control channel to know if another UE is going to transmit

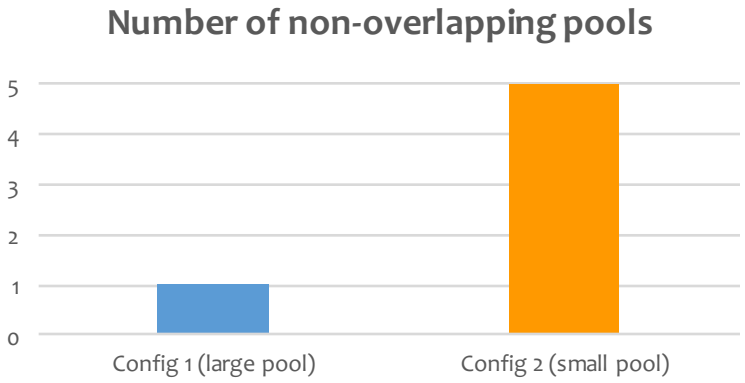
Key Findings on Resource Allocation

- Several constraints to consider
  - No coordination = collisions
    - Multiple UEs transmit on the same resources in time and frequency.
  - Half duplex
    - A UE cannot transmit and receive in the same sub-frame.
  - Layer 1 groupcast communication
    - No HARQ feedback
    - Selection of the Modulation and Coding Scheme (MCS) must take into account the link quality of the various members
  - Pool size
    - Resources have to be shared among multiple pools (different priorities, different agencies)

➢ Adequate dimensioning of the resource pools is necessary to obtain desired level of performance

KPIs: Number of users/groups

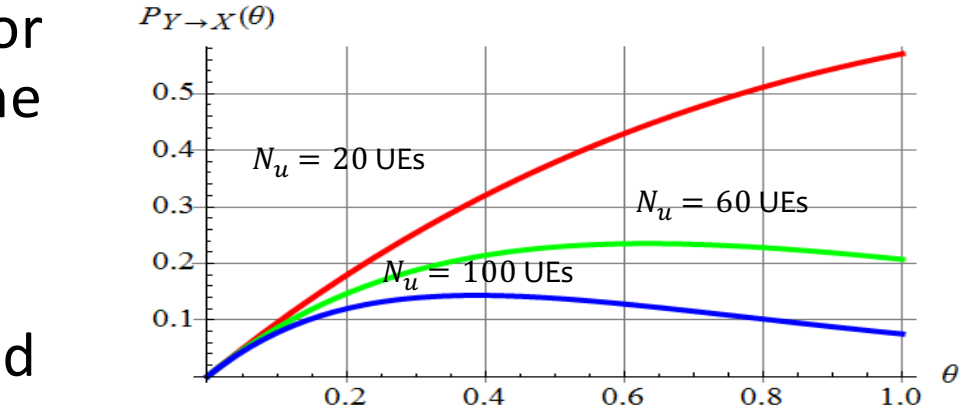


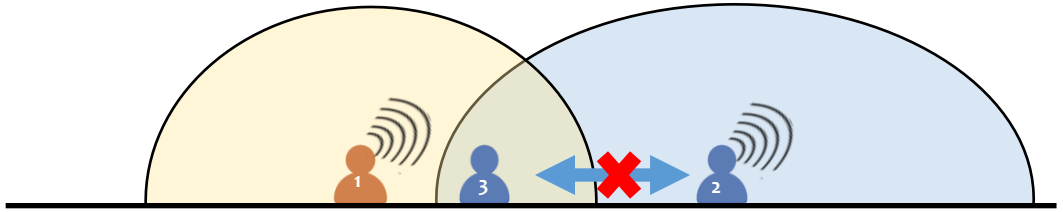


Other Findings on ProSe

- Discovery
  - For a given pool size and number of UEs trying to discover each other, there is an optimal value for the transmission probability θ that optimizes the probability of discovery
- Synchronization
  - Ping-pong effect depending on the method used to perform scanning
  - Hidden node problem where a transmitter UE with a different timing can disrupt the communication between UEs that belong to the same group

Example of probability that a discovery message from UE Y reaches UE X





UE 1's proximity to UE 3 can trigger lost of synchronization with UE 2

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MCPTT and ProSe Interactions

MCPTT Off-network Operation Basic Building Blocks

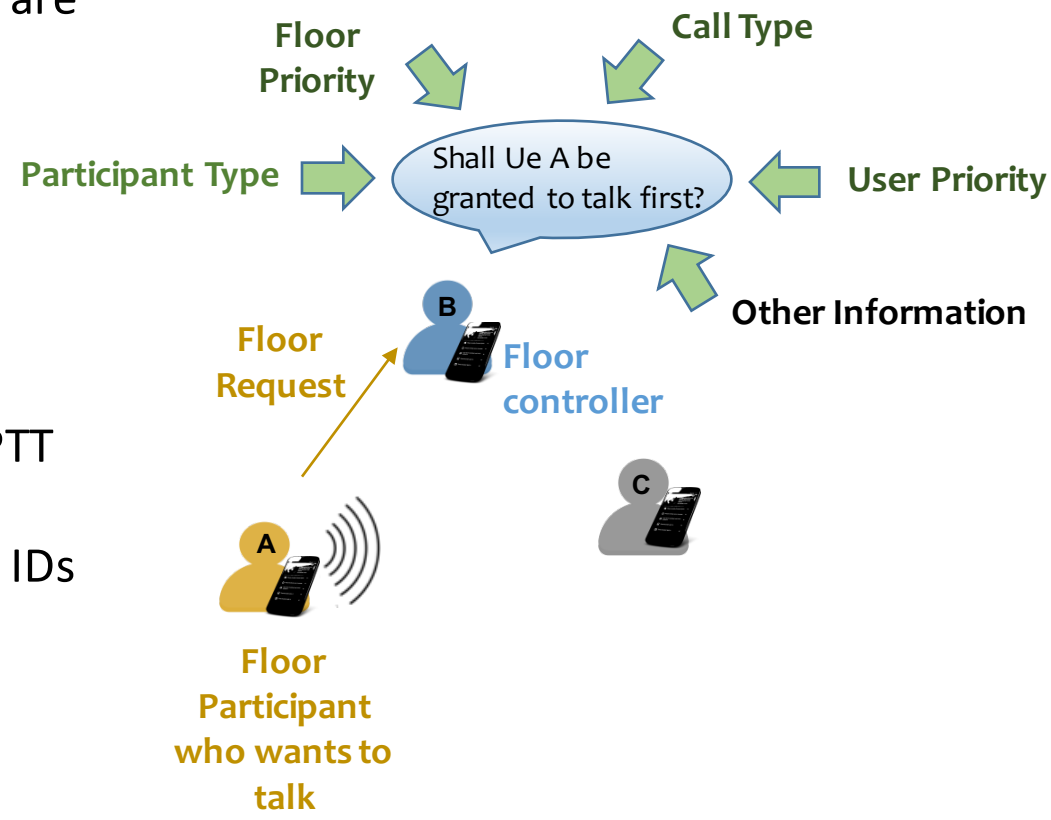
- Call control (e.g. group, private, broadcast group)
- Call type control (e.g. emergency, imminent peril, basic)
- Floor control (e.g. preemption, requests queueing)
- Emergency Alert
- Tx/Rx Media Packets
- Group management
- ID management

ProSe Features

- ProSe-Per-Packet-Priority (PPPP)
- Resource Pool configuration
- Direct discovery
- Direct communication

MCPTT Findings To Date

- Protocol validation
  - MCPTT was officially completed in March 2016
  - In reality, more Change Requests (CRs) and updated versions are on the way
- (Pre-)Configuration and Scheduling of ProSe Resource Pools to Support MCPTT
  - Semi-static, pre-configured
  - Tradeoff between efficiency, flexibility and reliability
- Interaction between ProSe and MCPTT
  - Mapping between ProSe-Per-Packet-Priority (PPPP) and MCPTT Call Types (emergency, imminent peril, basic)
  - Mapping between ProSe Layer-2 Group ID and MCPTT group IDs
- Floor Preemption Decision:
  - No rules defined in 3GPP standards
  - Up to implementation



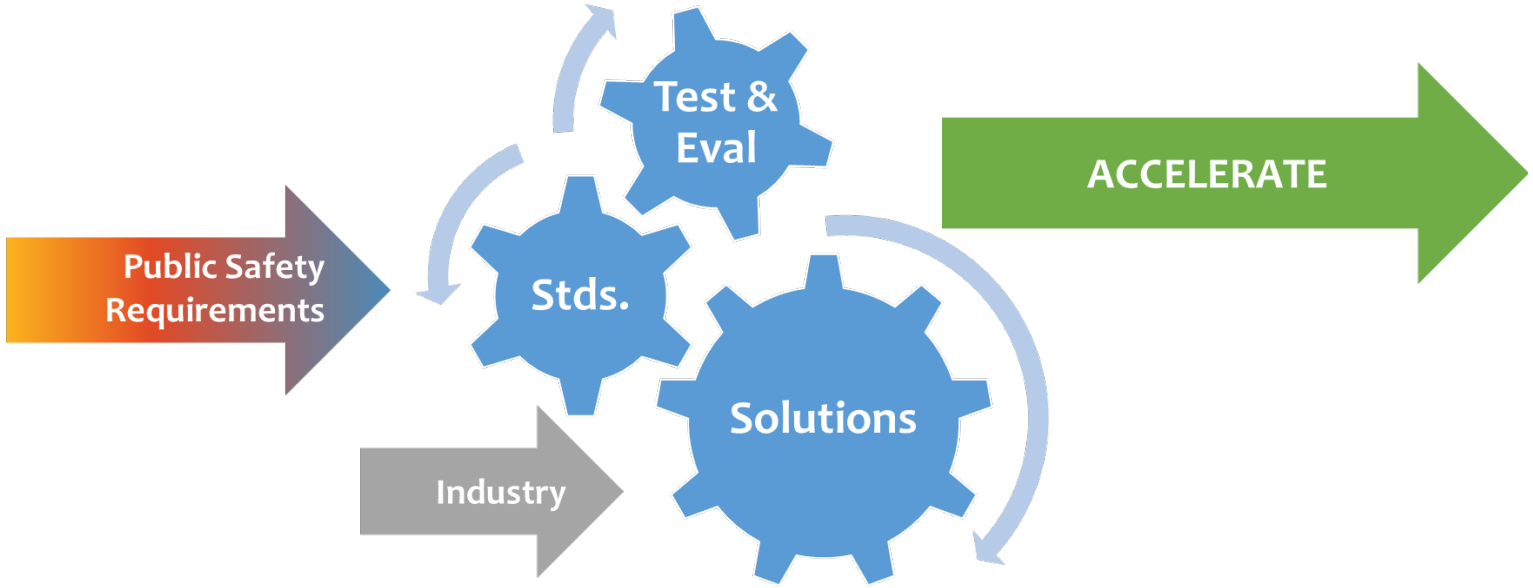
Current Work

- Off network evaluation
  - Partial coverage
  - In coverage
  - MCPTT features
    - Call control
    - Emergency alert
- In network MCV evaluation
  - Core network
  - Network to UE relays

MCV R&D – Public Safety Driven

Jeb Benson

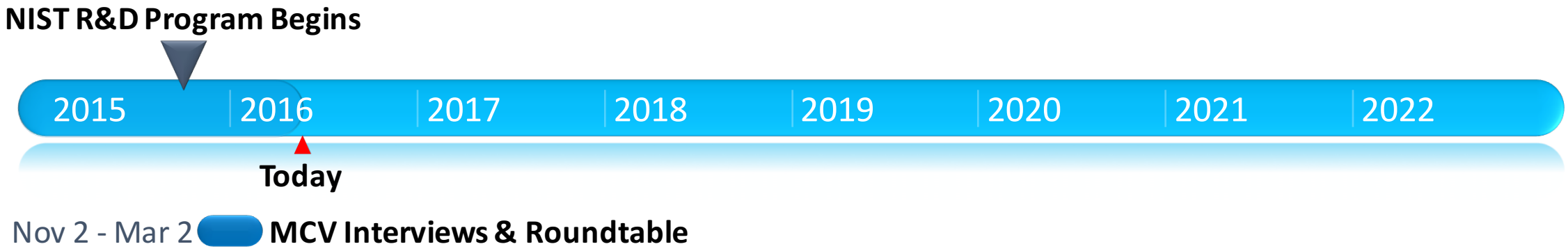
PSCR/NIST, NIST R&D Team Lead



Disclaimer

Please note, all information and data presented is preliminary/in-progress and subject to change.

STAKEHOLDER INPUT



Interviews & Roundtable

- Conducted interviews with ten key public safety stakeholders

Key Element	Features: Context
Key performance indicators (KPIs): Measure	Challenges: Inform

- Hosted one day MCV Roundtable:
  - Public safety
  - FirstNet
  - Public Safety Advisory Council (PSAC)
  - DHS and DOJ

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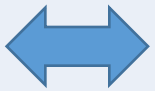
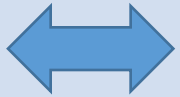
MCV Roundtable – Key Elements

	**Push-to-talk**	Ability to (instantly), selectively, and sequentially transmit messages either one-to-one or one-to-many
	**Talker identification**	Ability to identify who is transmitting/speaking
	**Emergency alerting**	Ability to indicate that a user is in a life-threatening condition, needs immediate access to the system, and is given the highest level of priority Transmits data about user location (if available) and alerts other users of the emergency
	**Audio quality (& Intelligibility)**	Listener must be able to understand what is being said, who is speaking, their tone of voice, and background noise information
	**Group communication**	Immediate one-to-many communications between members of a talk group
	**Direct mode**	Ability for a radio or group of radios to operate independent of existing network infrastructure

MCV KPIs: Benchmarks for Comparison

Coverage & Capacity						
Range / Coverage / Signal Strength	✓					✓
Interference						✓
Capacity / Max # of groups / Max users per group	✓		✓		✓	✓
Efficiency					✓	
Success / Busy / Failure rate	✓	✓	✓			

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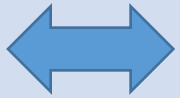
MCV KPIs: Benchmarks for Comparison

Timing						
Latency / Call setup	✓		✓			✓
Hang time / Time-out	✓					✓
Resolution time / Refresh rate		✓				

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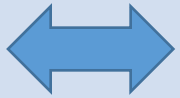
MCV KPIs: Benchmarks for Comparison

Integrity						
Data accuracy			✓			
Intelligibility				✓		✓

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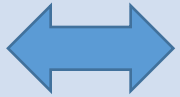
MCV KPIs: Benchmarks for Comparison

						
Coverage & Capacity	3	1	1		2	3
Timing	2	1	1			2
Integrity			1	1		1
TOTALS	**5**	**2**	**3**	**1**	**2**	**6**

- Impossible to talk about PTT without either Group Communications or Direct Mode - totals a bit misleading
- Appropriate focus on Direct Mode - It is a lifeline
- Disproportionate concern about Emergency Alerting highlights importance

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KPI UX Spectrum

USER EXPERIENCE

Range/Coverage/Signal Strength	Interference	Intelligibility
	Hang time / Time-out	Latency / Call setup
Efficiency	Capacity / Max # of groups / Max users per group	Success / Busy / Failure rate
	Resolution time / Refresh rate	Data accuracy

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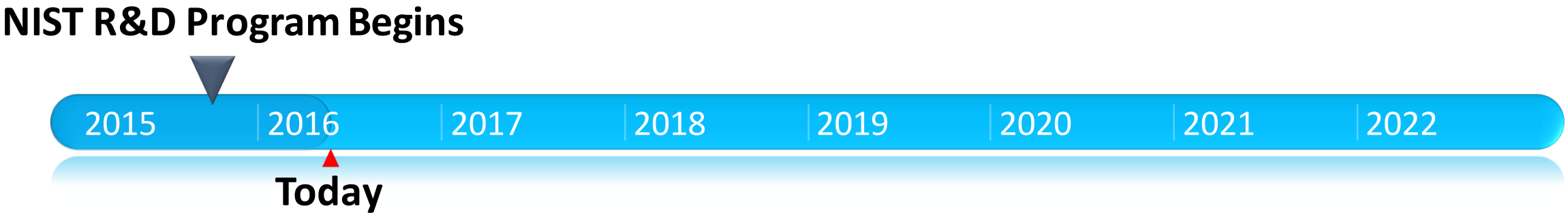
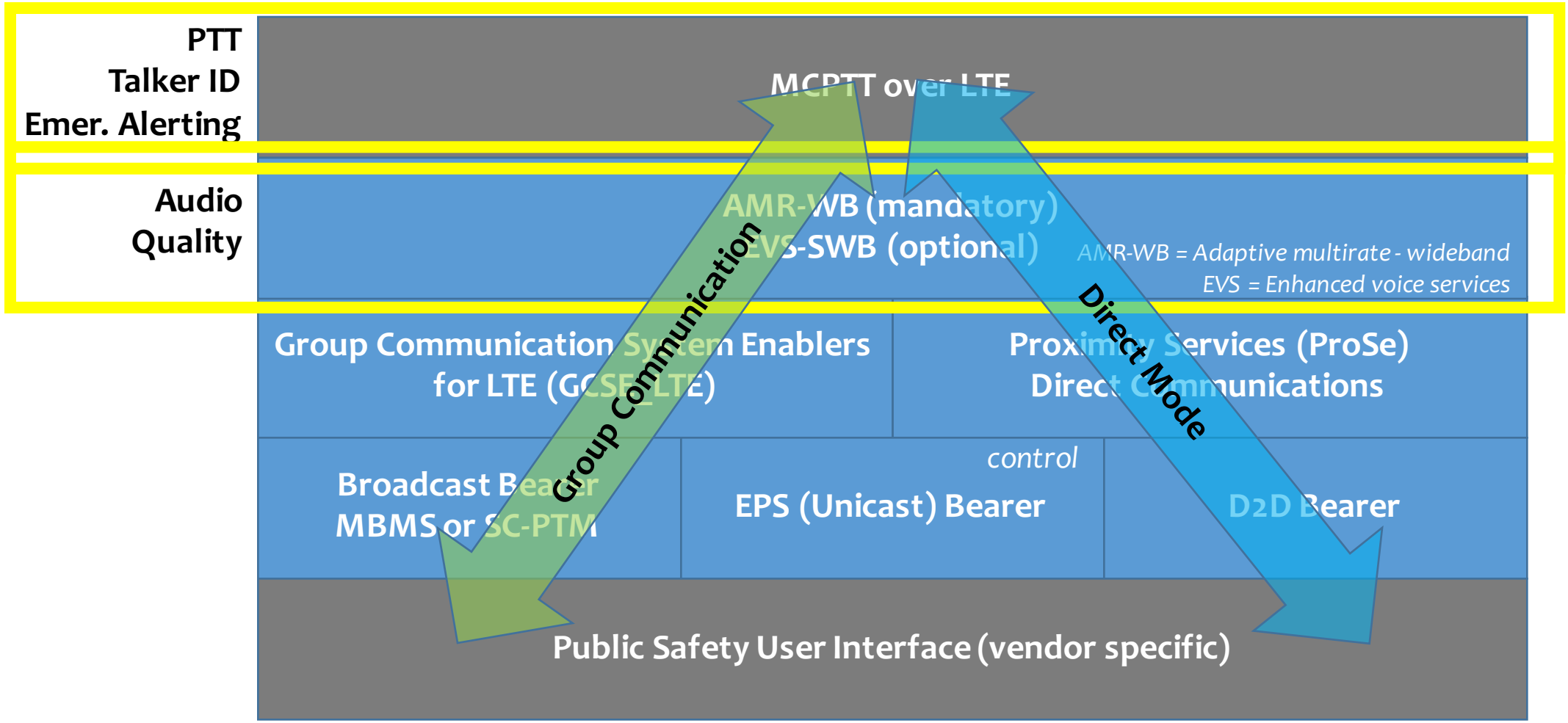
STRATEGY


NIST R&D Program Begins
2015
2016
2017
2018
2019
2020
2021
2022
Today

MCV Technology Stack



MBMS = Multimedia broadcast/multicast service
SC-PTM = Single-cell point-to-multipoint

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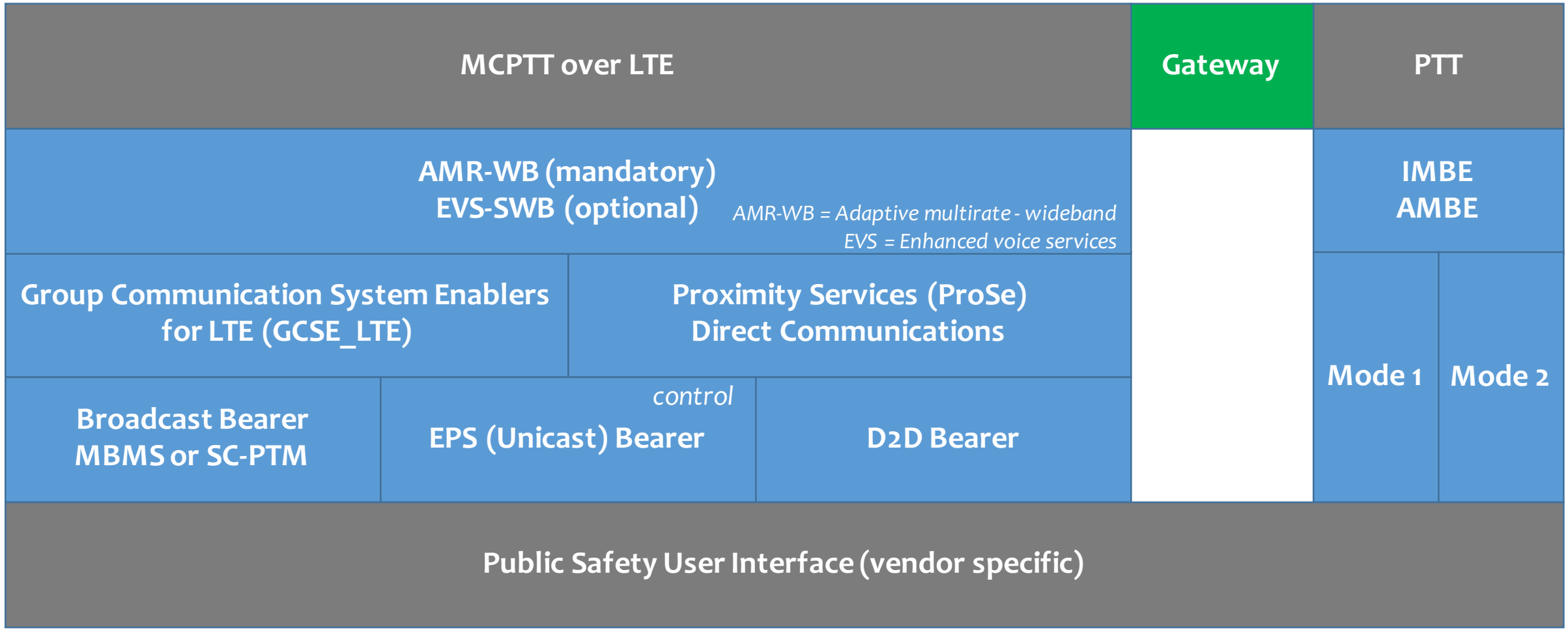
LTE/P25 Interworking



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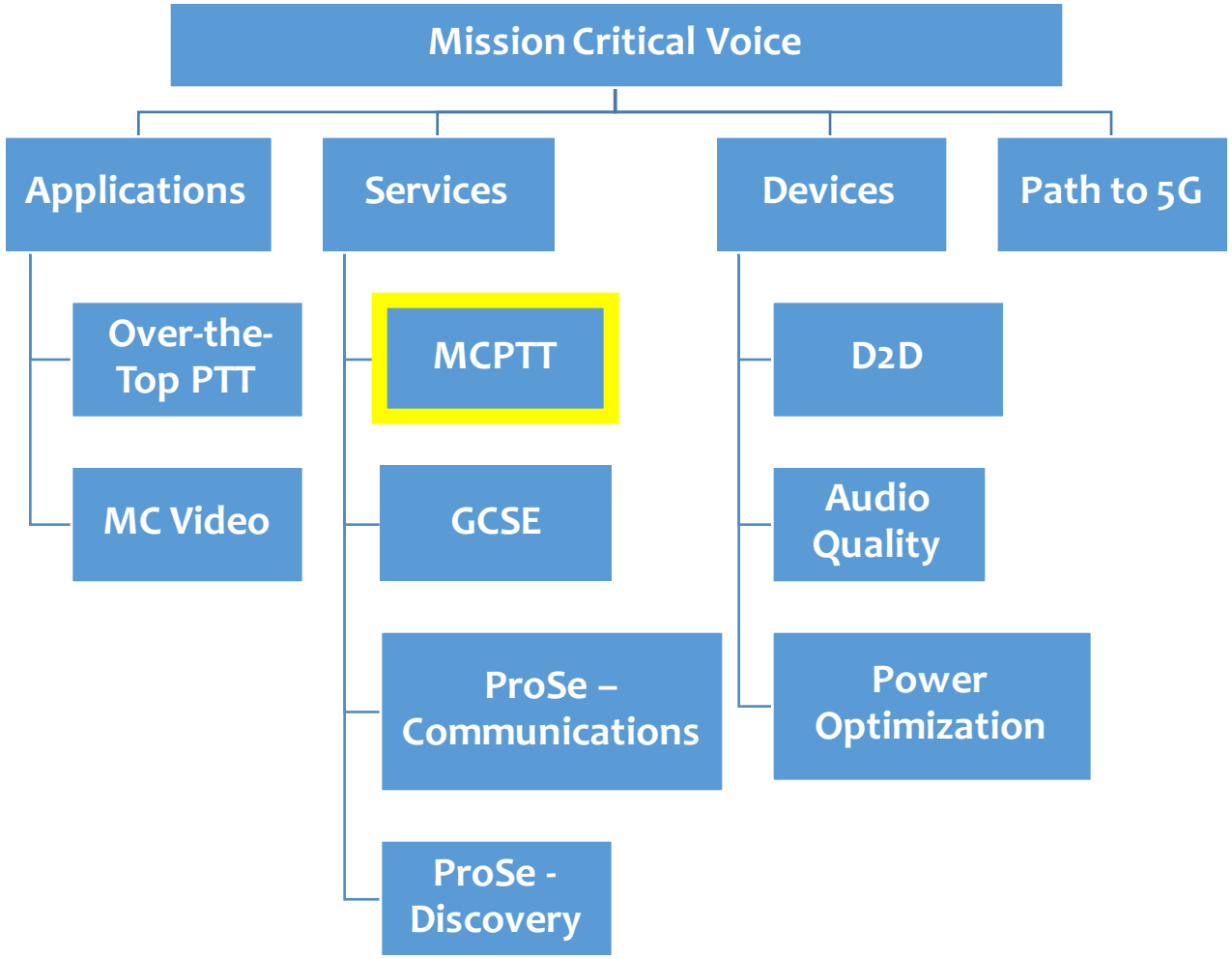
MCV Technology Area Breakdown Structure



Mission Critical Push to Talk (MCPTT)

Objectives

Accelerate development, testing, and implementation of the MCPTT capabilities.

Challenges

New technology for 3GPP vendors and public safety users. Niche market. Lack of common baseline KPIs.

MCPTT

Impact

MCPTT is the most important feature set for public safety.

Candidates

LMR/LTE KPI benchmarks
Application server acceleration

Adaptive/Predictive Floor Control

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LMR/LTE KPI Benchmarks

Description
Measure KPIs for MCV in P.25 and possibly analog LMR systems for comparison to LTE MCPTT rollout

Challenges
Incredible number of variables in LTE; no precedent exists for measuring direct mode

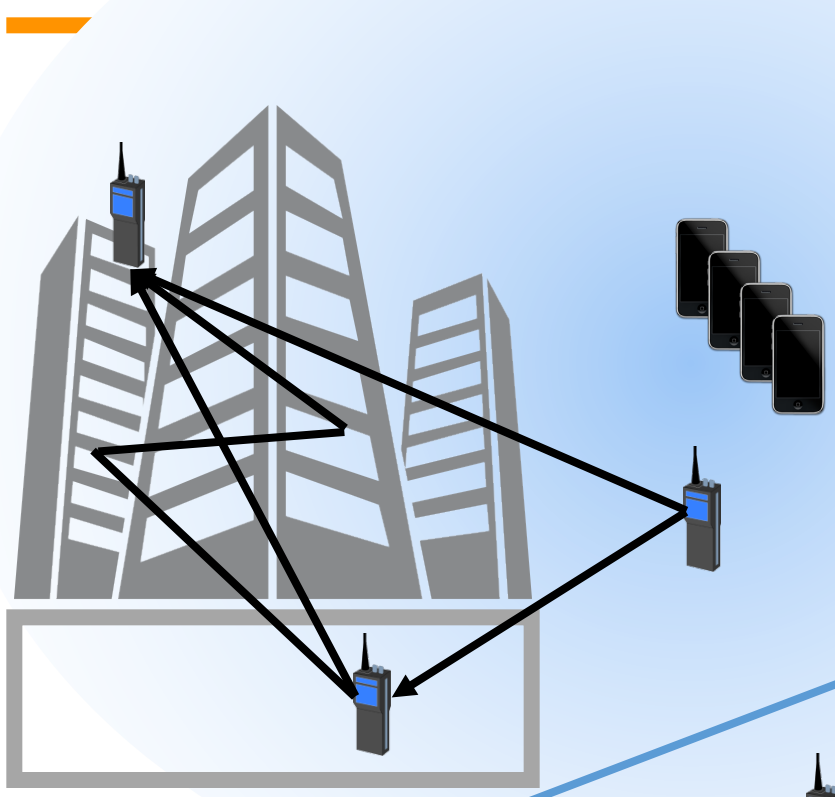
KPIs
Timing: Latency
Timing: Call setup / Hang time / Time-out
Timing: Resolution time / Refresh rate
Timing: Success / Busy / Failure rate
(see following slides)

Performance Goals
Consult TIA-102 and 3GPP specifications where applicable

Deliverables
NIST special publication
Peer-reviewed papers
Test bench

Major Tasks
Spin-up LMR systems in lab, identify test equipment & design, develop test bench, determine test cases

‘Real World’ vs Lab



= PS LTE Device

= Commercial UE

VERIFY

LTE Load Tester

MCPTT GCSE ProSE

Channel Emulator

Σ

eNodeB

EPC

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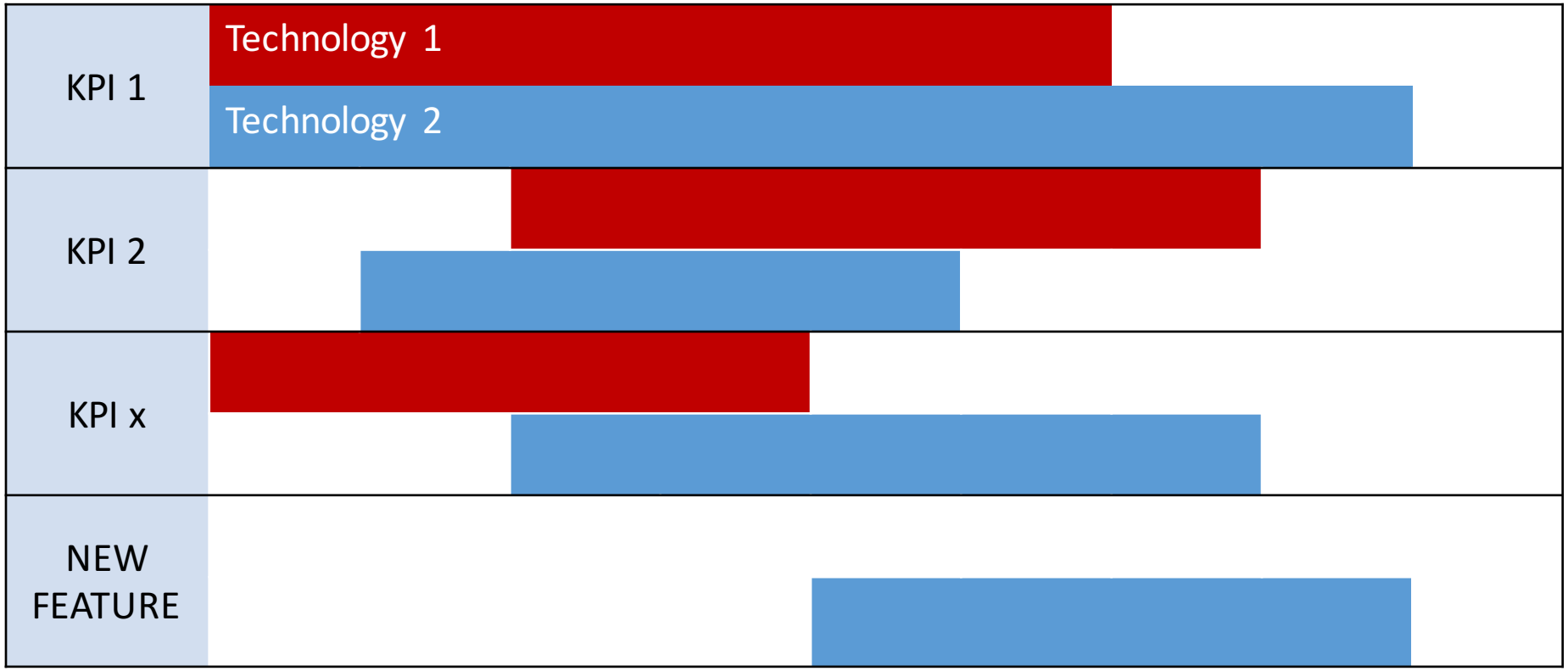
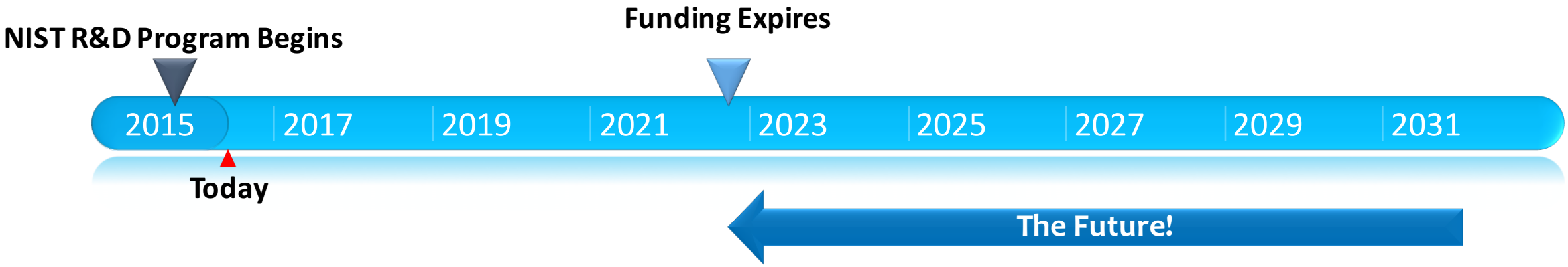
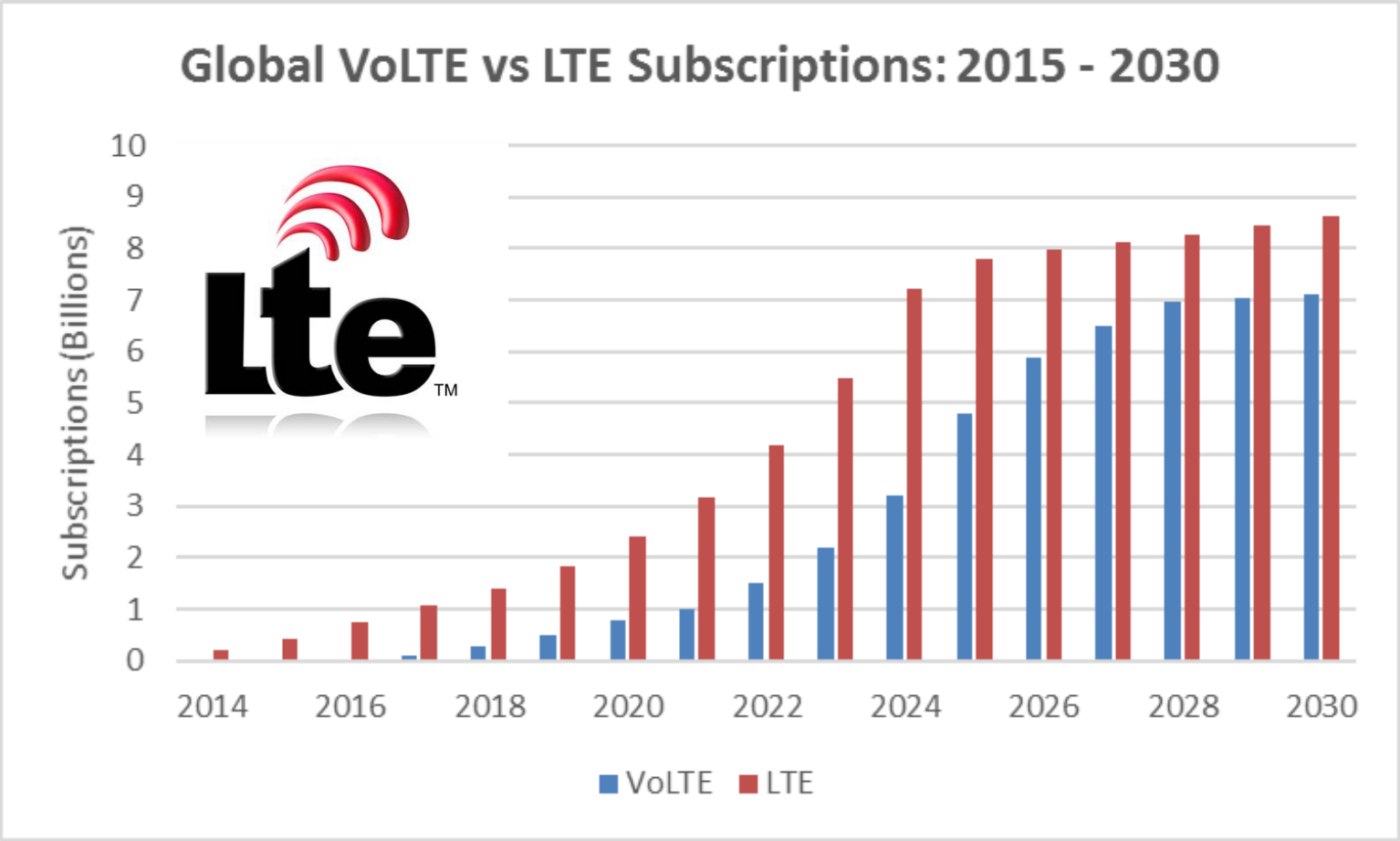
Using KPIs to Inform Adoption & Gaps



TECHNOLOGY ACCELERATION



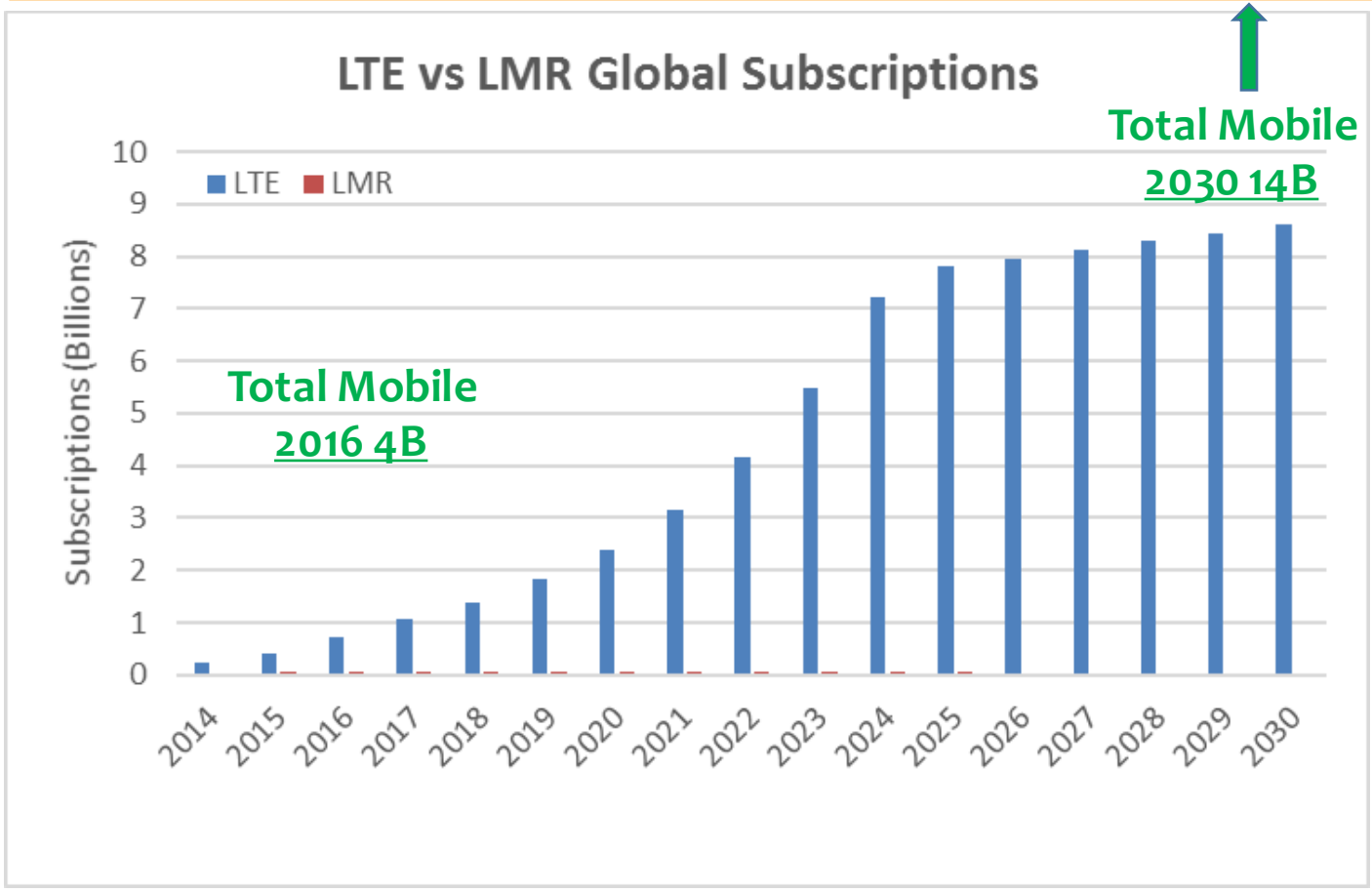
New Technologies Take Time



- MCPTT will as well
  - Public Safety Grade

Source: SNS Research, The Public Safety LTE and Mobile Broadband Market: 2015 - 2030

New Technologies Take Markets



- Incredible economy of scale
- LMR at its peak – 50M

Source: SNS Research, The Public Safety LTE and Mobile Broadband Market: 2015 - 2030

Proximity Services – Initial Markets

- Public Safety requirements revolutionized the 3GPP ecosystem and changed mainstream thinking
- Specification vs Regulations; the push to commercialize
- After a couple releases, they are now identifying new markets & business models…

	Network coverage		
	Inside	Outside	Relay
Direct Discovery	**Commercial**	Uncertain	Uncertain
Direct Communication	**Public Safety**	**Public Safety**	**Public Safety**

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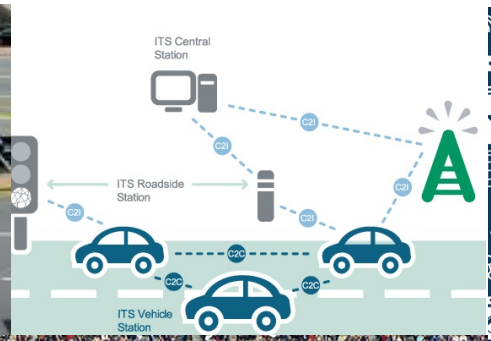
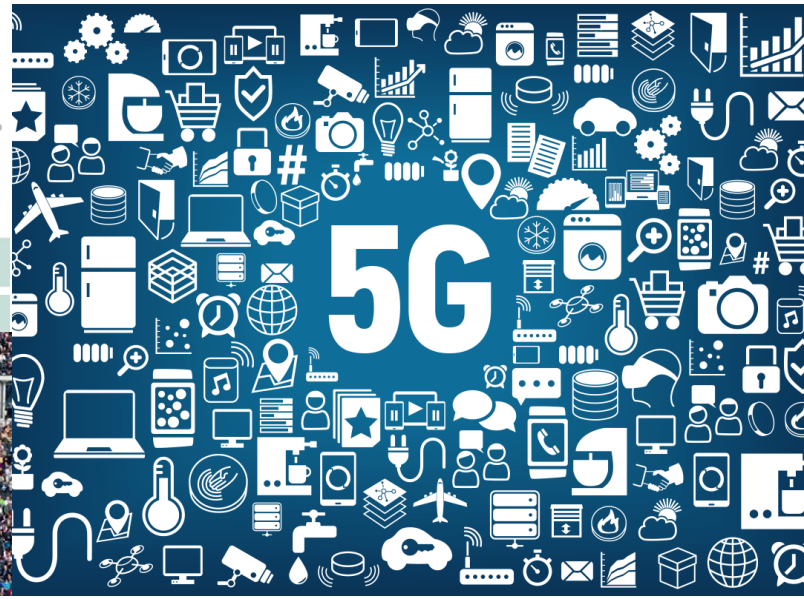
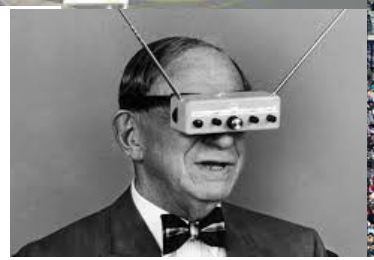
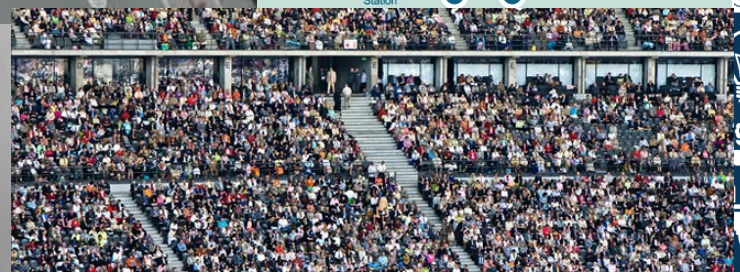
Proximity Services – New Markets









	Network coverage		
	Inside	Outside	Relay
Direct Discovery	Commercial	Commercial	Commercial
Direct Communication	Commercial	Public Safety	Commercial

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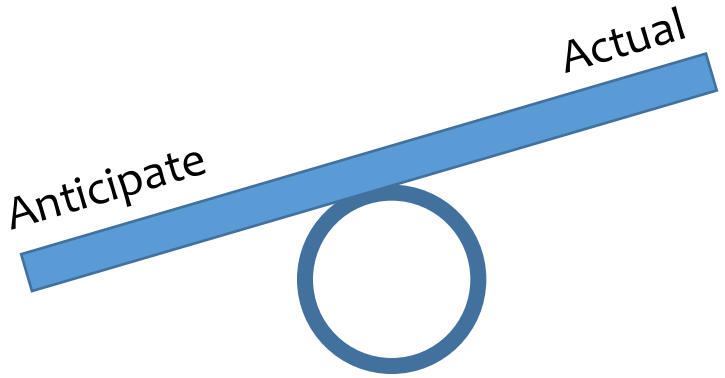
D2D Tech Acceleration

Months:	24 - 48	18 - 24	12 - 24
	Standards	Pre-Deployment	Deployment

ProSe
- Major leap, not incremental
- Only possible because of public safety input

D2D evaluation, modeling & simulation
- Out-of-network
- High-throughput

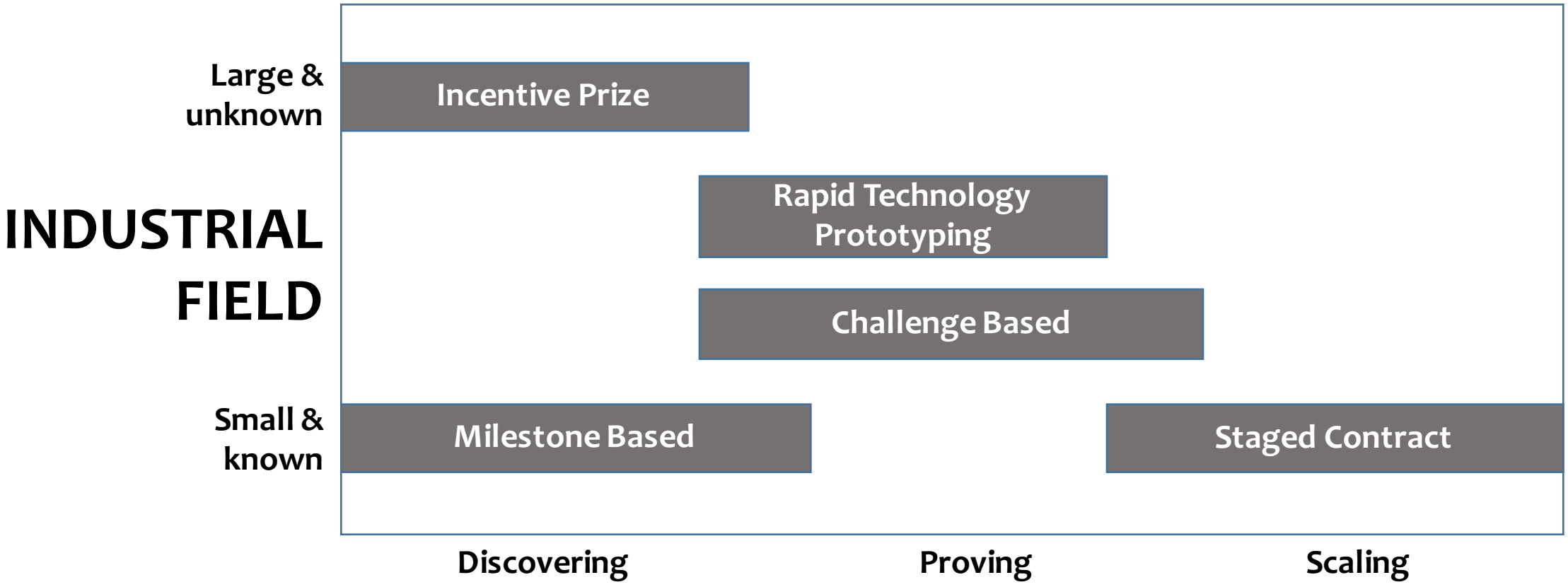
Benchmarking
Anticipatory evaluation
Tech Acceleration



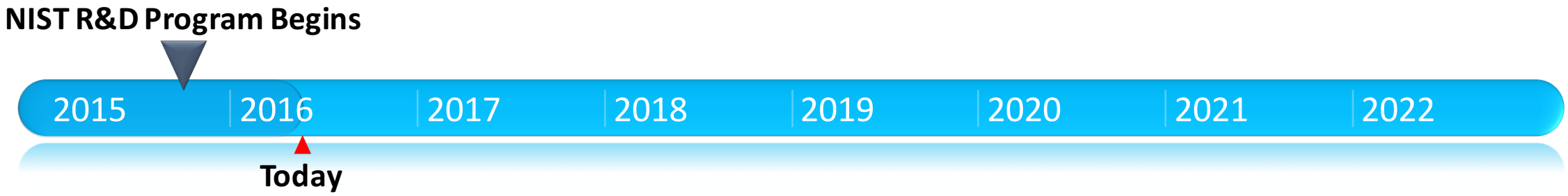
MCV Tech Acceleration - Opportunities

- D2D chipset – direct communications, high power & data rate, out-of-network
- Application Servers – MCPTT, GCSE, ProSe
- Algorithms
  - Adaptive/predictive floor control
  - Sidelink/uplink interference management
  - D2D resource selection – in/out/partial coverage
  - Floor control implementation in UE
- Test equipment
  - Inject and prioritize PS needs in carrier-driven roadmaps
- Network
  - Smart Macro-to-D2D transition
  - Emergency Alert 'fallback' from D2D to Macro
  - Coverage/transition indication app
- Discovery-enabled applications
- Integrating MC Video & Data
- Software Defined Radio
- Path to 5G

Investment Strategies



MISSION CRITICAL COMMUNICATION



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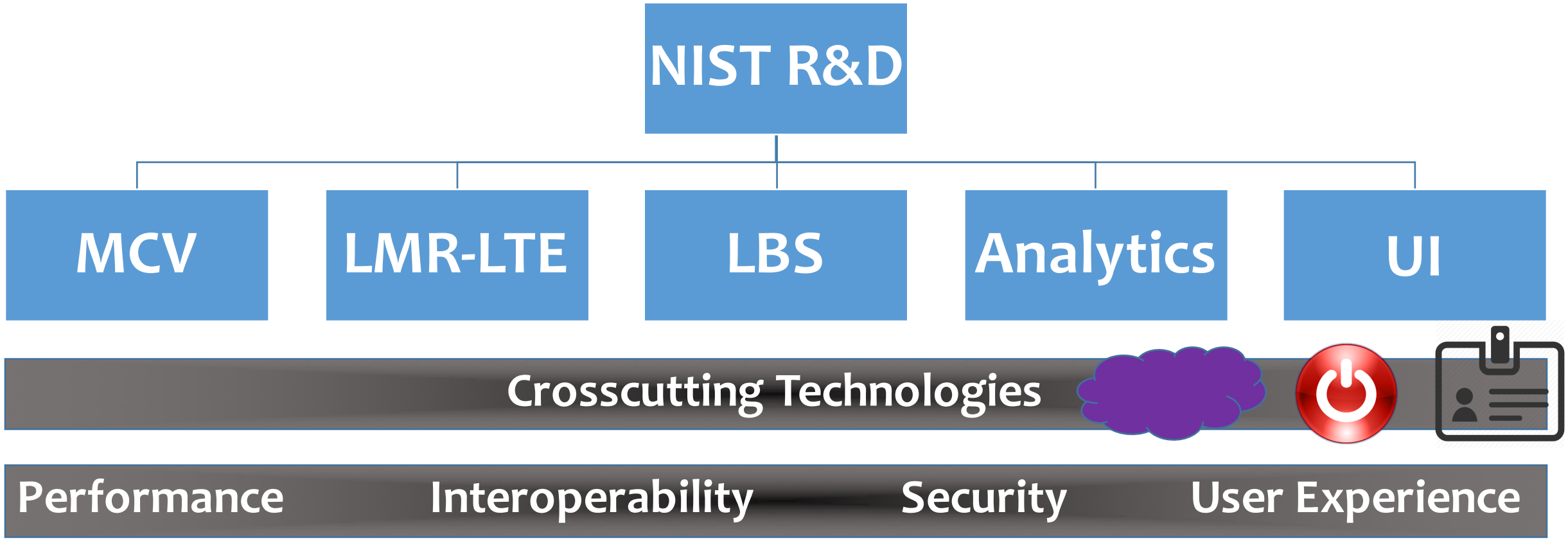
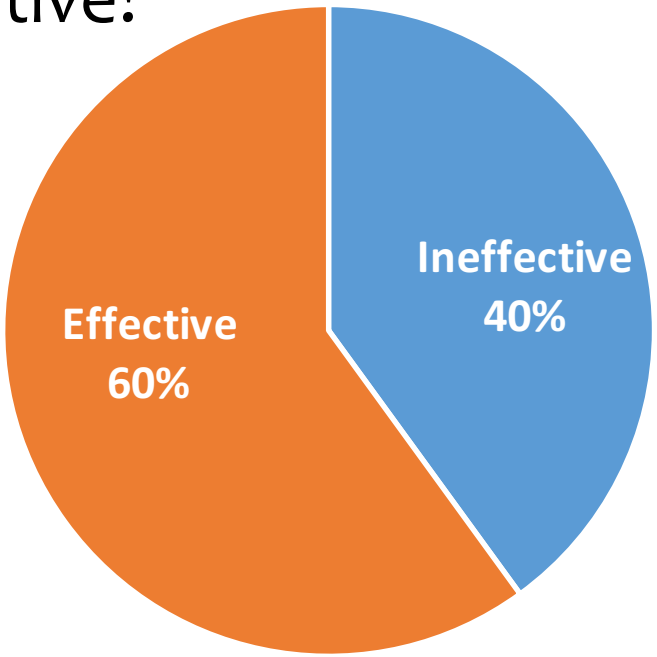
NIST R&D Lanes

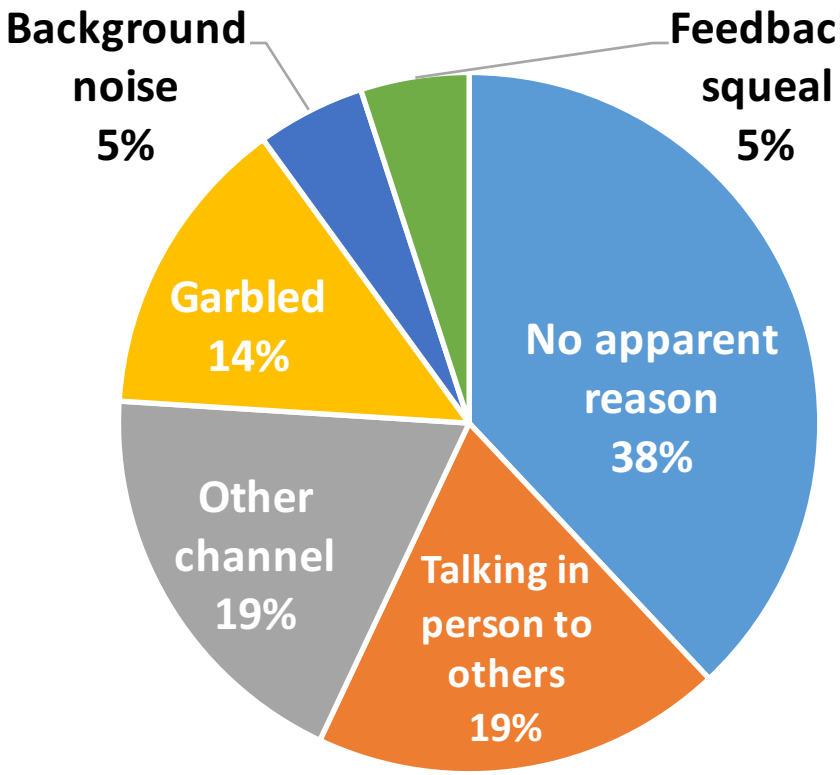


MCV vs Communication

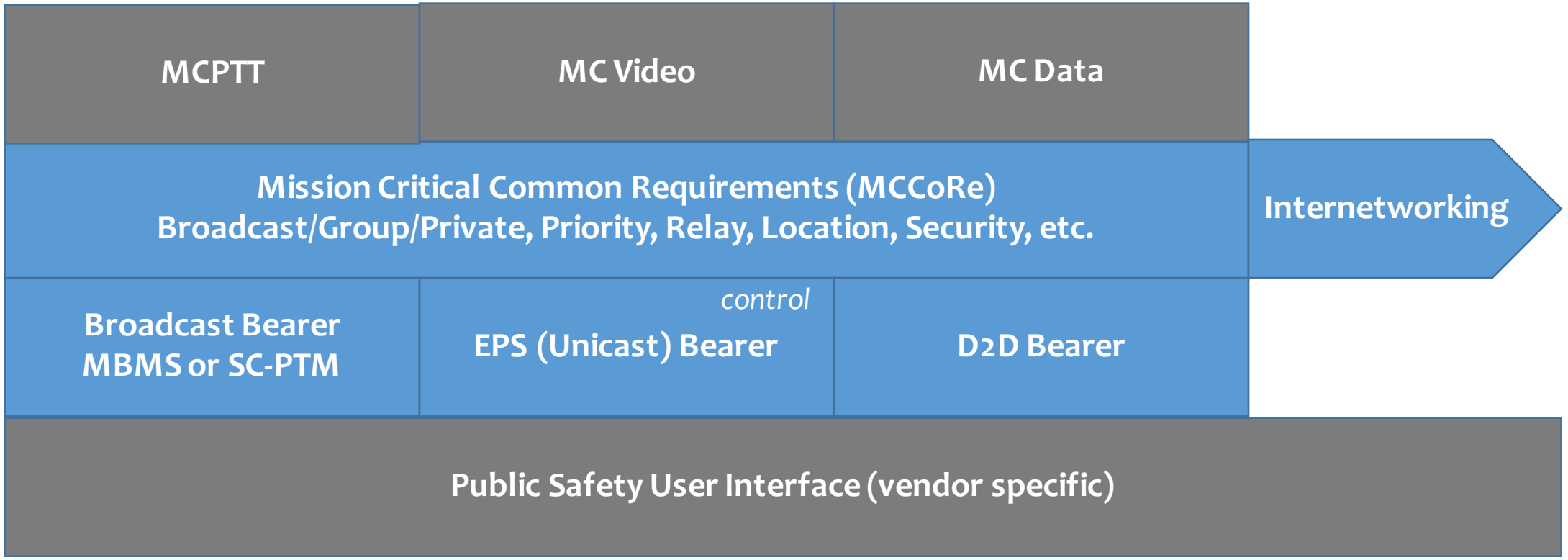
How do we effectively integrate broadband technologies to enable you to become 100% effective?



Ineffective communications breakdown:

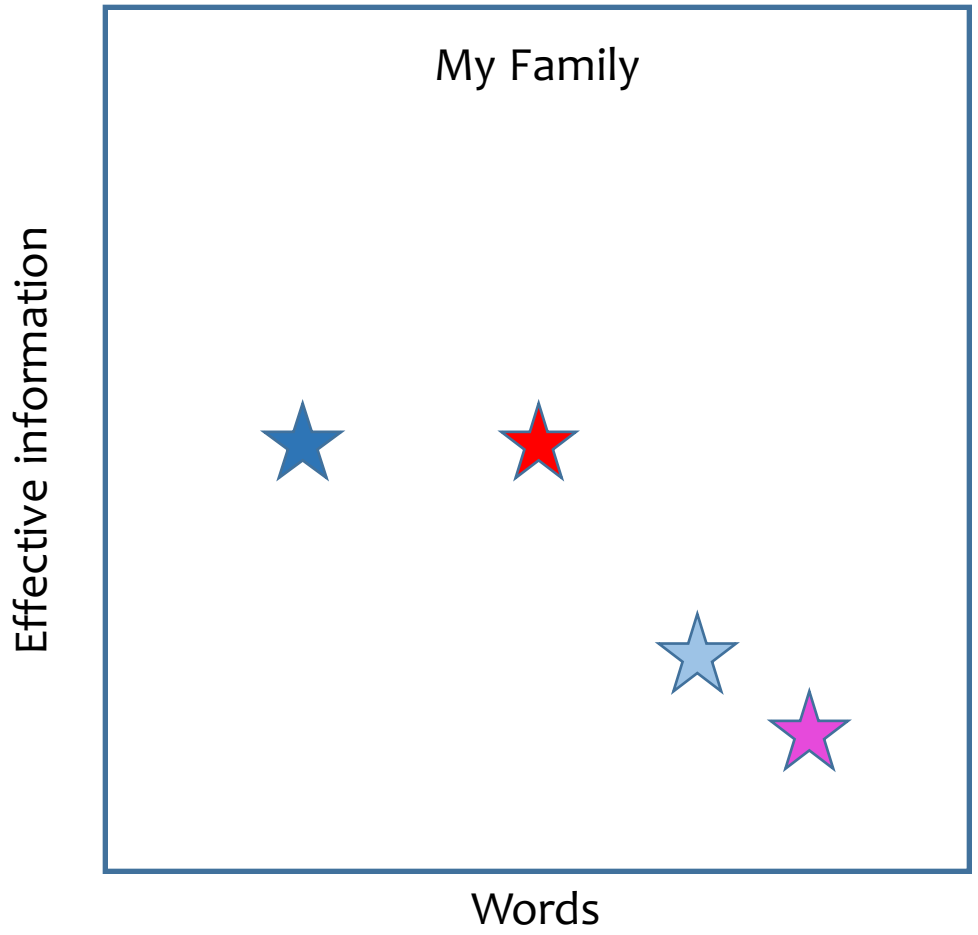


MCX & MCCoRe


MCPTT
MC Video
MC Data
Mission Critical Common Requirements (MCCoRe)
Broadcast/Group/Private, Priority, Relay, Location, Security, etc.
Internetworking
Broadcast Bearer
MBMS or SC-PTM
control
EPS (Unicast) Bearer
D2D Bearer
Public Safety User Interface (vendor specific)

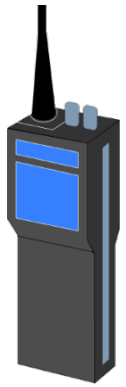
MCV vs Communication

- How do we ‘free up’ MCV to be most effective?
- Not just a technology issue – it’s governance
  - Strategy, policy, training, etc.
- We ALL need to consider these opportunities moving forward.
- Do we need new KPIs, e.g. effectiveness/bit?



Is a Picture Really Worth 1000 Words?

Let's do the Numbers…



"…the bridge has collapsed… there are cars in the water…"

1000 words ≈ 10 minutes

10 mins @ 13 kbps ≈ 8 Mb ≈ 1 MB

1 MB, < 2 sec

- A picture may really be = 1000 words!
- Maybe we should say "A picture is worth 10 minutes"
- How critical are those first 10 – 20 minutes?

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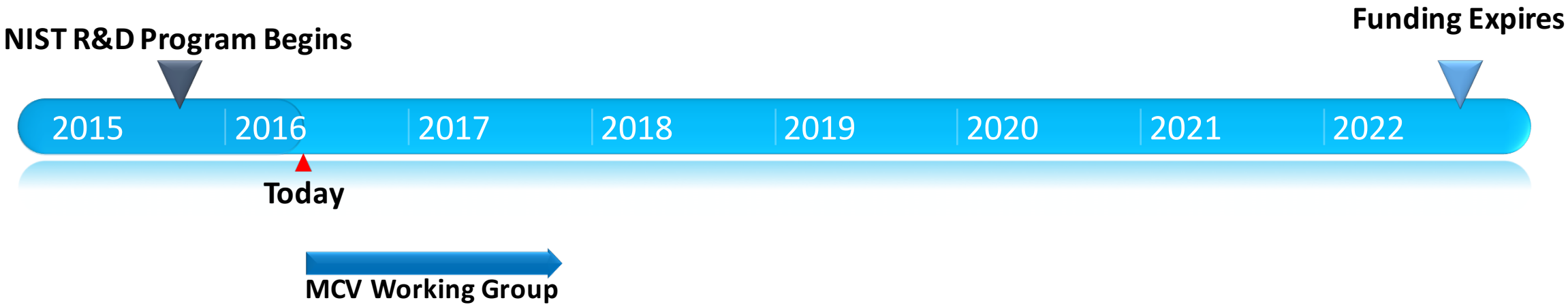
OPPORTUNITIES TO CONTRIBUTE



I'm Excited – How do I Help?

- Ideas – Get started in Prizes & Competitions 201 - Brainstorming
- MCV working group
  - Public safety + Industry + Government + Academia
  - Help us identify and prioritize focus & tech acceleration
  - Influence the future of MCV over LTE
  - Summit Oct/Nov timeframe

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Takeaways – MCV Panel

- MCV over LTE is essential for long term adoption and evolution of the NPSBN
- PSCR will continue to support 3GPP standards development related to MCV from a technical perspective
- PSCR is evaluating critical public safety features in the standards
- Public safety has identified initial KPIs associated with MCV for PSCR to baseline
- There are opportunities to accelerate and innovate MCV over LTE

Closing notes…

- MCV Working Group & Summit
  - jeb.benson@nist.gov
- Analytics Panel
  - Thursday, June 9 from 3:00pm-4:30pm
- MCV 101 for Public Safety
  - Wednesday, June 8 at 1:30pm & 3:30pm
  - Who should attend? Drum roll…

Top ~~10~~ 5 Reasons You Know You Need to Attend MCV 101

5. Last time you used a push-to-talk device it responded 'One. One puppy.'
4. Once when somebody asked you about your hang time, you replied "It was never that great. But, I can shoot the three."
3. You like watching engineers try to be funny. They're so bad, it's actually funny. Like now.
2. Before this panel, you thought an eNodeB was the ship that D2D rode in on a mission to destroy the Death Star.
1. Whenever somebody mentions Mission Critical Voice you shout "They were the best, man. I still have all their albums"

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SNAPSHOT: Public Safety Audio Quality Research

Assessing Codecs for Mission Critical Voice

Stephen Voran

PSCR Audio Quality Lead

This work is sponsored by:

Department of Homeland Security
Science & Technology Directorate
Office for Interoperability and Compatibility
(DHS S&T OIC)

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Disclaimer

Please note, all information and data presented is preliminary/in-progress and subject to change.

Assessing Codecs for Mission Critical Voice

What should Mission Critical Voice deliver?

(Acoustic Domain)

Speech Quality and Speech Intelligibility.

Why Codecs are Critical, Inherent Codec Trade-Offs.

PSCR Speech Intelligibility Tools.

Example Results: Noise, Bit-Rate, Audio Bandwidth.

Looking Forward: Radio Channel Impairments.

What are the Goals for MC Voice?

In acoustic domain:

- Listener can understand what is being said…
- Listener can identify the speaker…
- Listener can detect stress…
- Background noise environment shall be sufficiently clear… (identifying acoustic context)

Quantifying "Listener Can Understand…"

Speech Quality Testing:

Very popular protocol: ACR, produces MOS values.

Excellent (5), Good, Fair, Poor, Bad (1)

Example result: Average opinion of speech quality = 3.5.

Speech Intelligibility Testing:

Quantify success rates for understanding, words, messages, callsigns, etc.

Many different protocols.

Example result: 63% of words correctly understood on average.

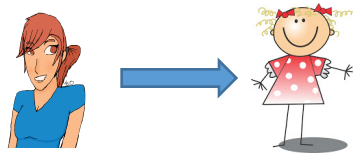
Do they measure the same thing?

Demonstration 1

Quality	Intelligibility
Higher	Imperfect

Transcripts

"We have a forty-two year old female unconscious."



Lower	Perfect

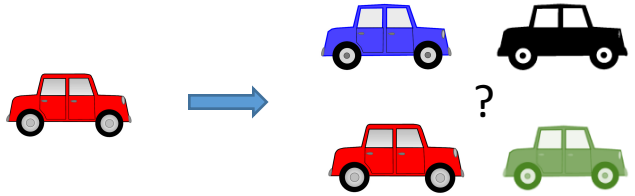
"Let me get my binoculars"

Demonstration 2

Quality	Intelligibility
Higher	Imperfect
Lower	Imperfect

Transcript

"Party is going to be in a red sedan of unknown type."



Demonstration 3

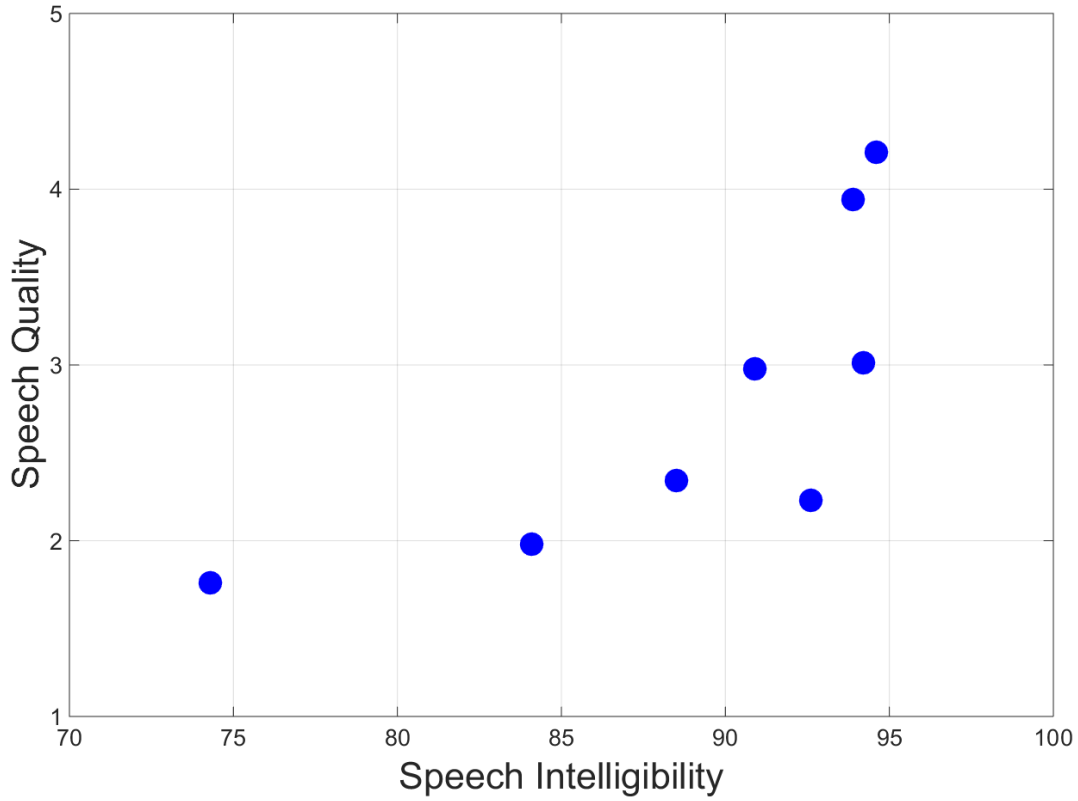
	Quality	Intelligibility
	Lower	Perfect
	Higher	Perfect

Transcript

"Ladder Ten, upgrade this to code red."

Lab Data: 8 Combinations of Handset & Noise

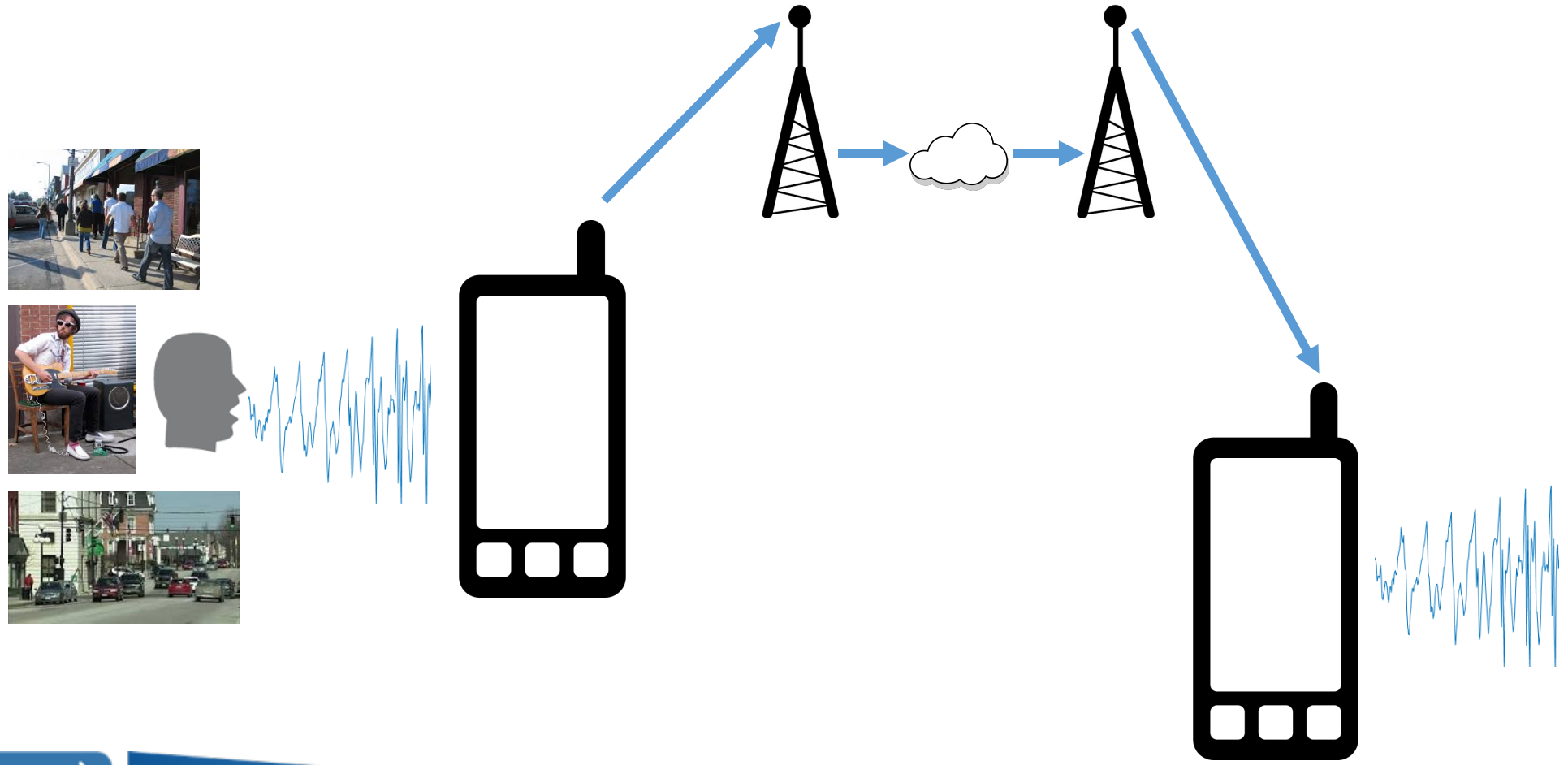
From Dynastat, published in ITU-T, SG12, COM 12-C296, January 2016.



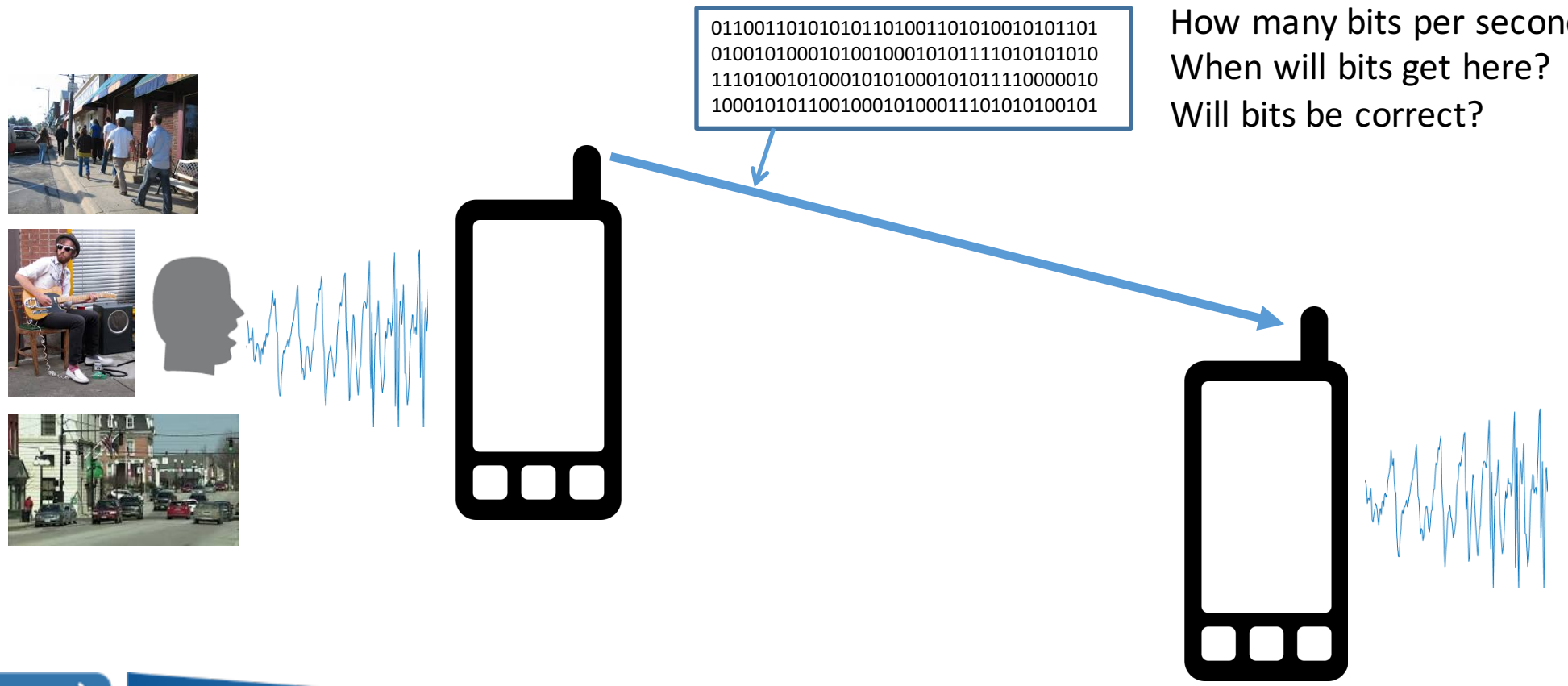
Quantifying "Listener Can Understand…"

- Speech Quality Testing and Speech Intelligibility Testing provide related yet different information.
- Speech Intelligibility Testing is the most direct way to quantify "listener can understand."

Why are Codecs Critical?

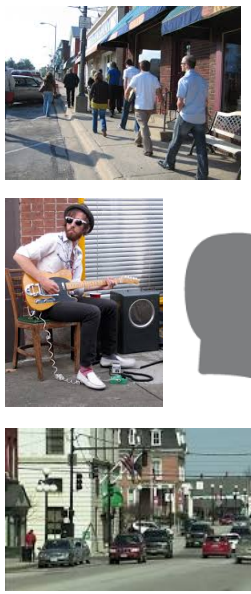


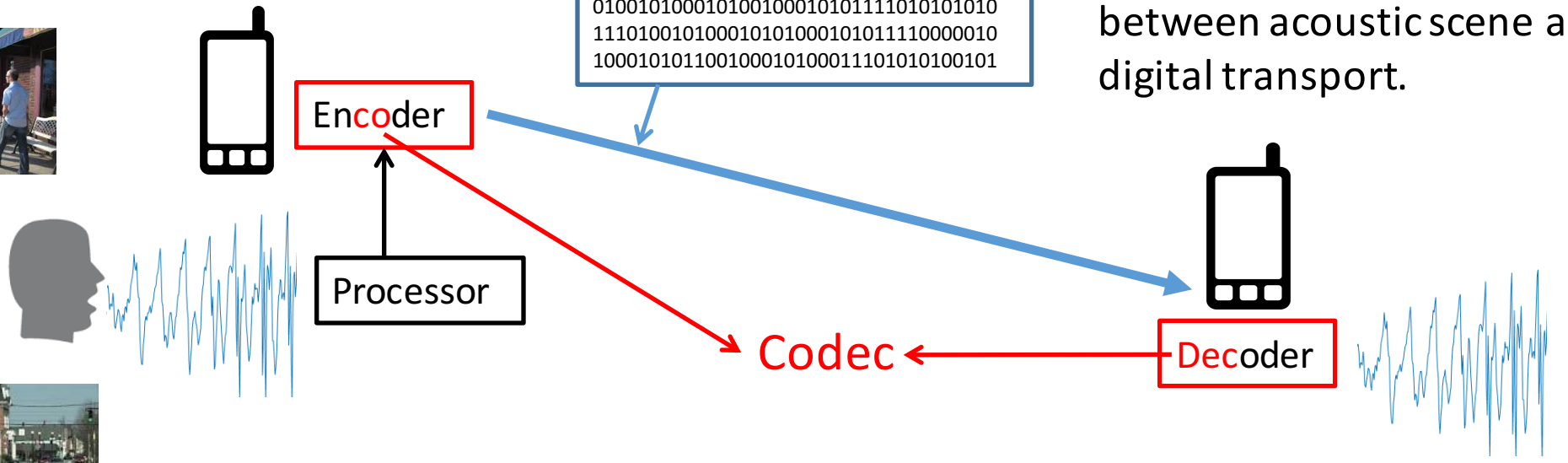
Why are Codecs Critical?



How many bits per second?
When will bits get here?
Will bits be correct?

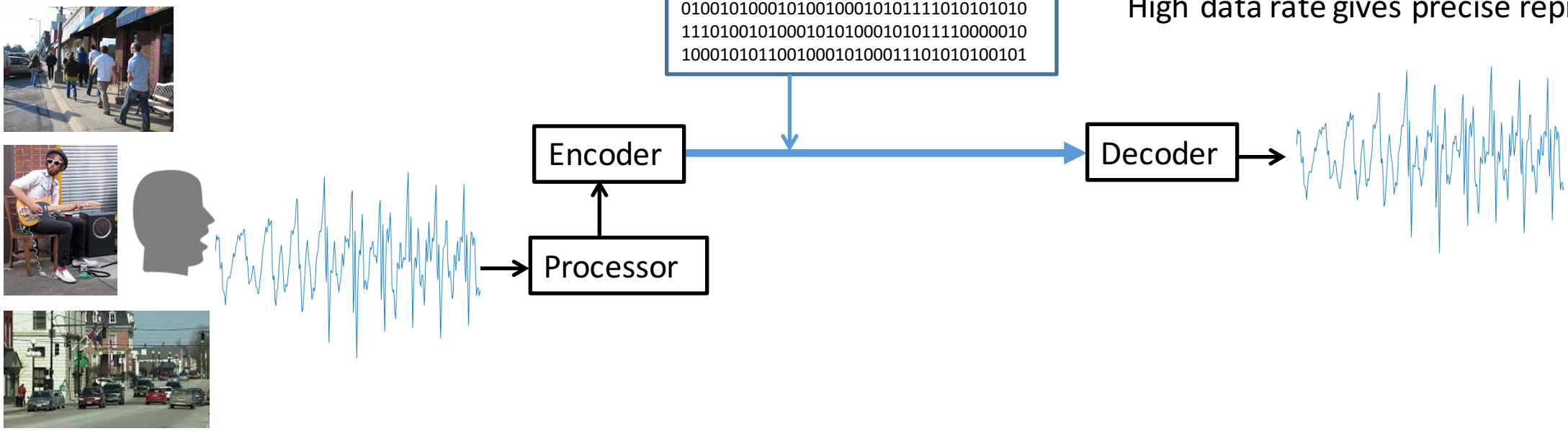
Why are Codecs Critical?



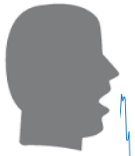


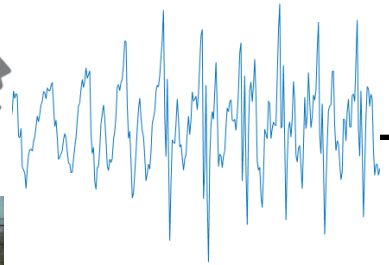
Answer: They are key intermediaries between acoustic scene and wireless digital transport.

Fundamental Codec Trade-Offs

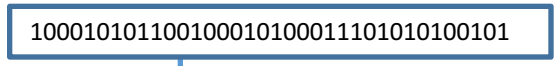


Fundamental Codec Trade-Offs





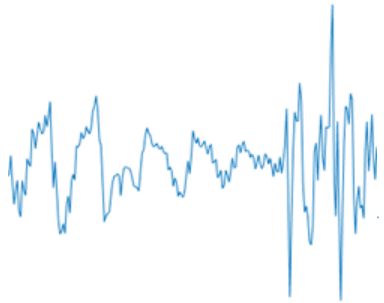
Lower data rate gives coarser reproduction.



Encoder

Processor

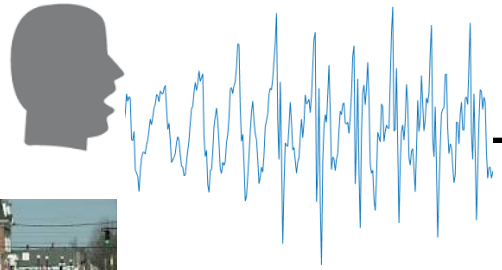
Decoder

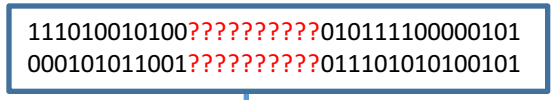


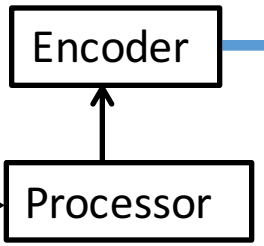
Audio Bandwidth
Bit Rate
Robustness
Algorithmic Delay
Algorithmic Complexity

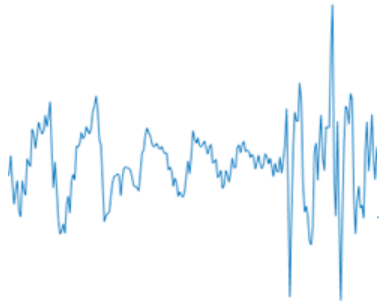
Mission Critical
Voice Goals

Fundamental Codec Trade-Offs



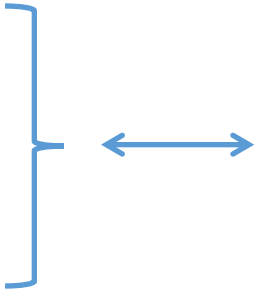






Missing data poses another problem.

Audio Bandwidth
Bit Rate
Robustness
Algorithmic Delay
Algorithmic Complexity



Mission Critical
Voice Goals

Audio Bandwidth Demonstration

Audio Bandwidth Name	Nominal Passband
Original Recording Fullband (FB)	20 – 20,000 Hz
Super Wideband (SWB)	50 – 16,000 Hz
Wideband (WB)	50 – 7,000 Hz
Narrowband (NB)	300 – 3,400 Hz

Including additional audio frequencies can:

- Enhance “presence,” “realism,” or “naturalness.”
- Change the character of speech and background noises.

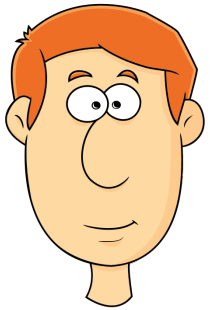
Assessing Codecs for Mission Critical Voice

We are assessing a fundamental requirement **(Speech Intelligibility)** of a fundamental system building block **(Codec).**

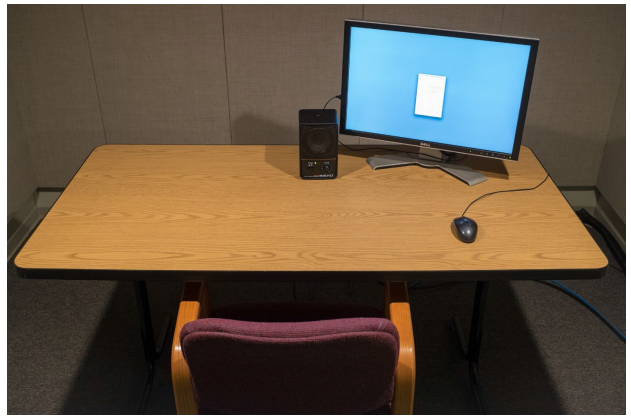
How do we do it?

PSCR Intelligibility Tool Kit: MRT

Modified Rhyme Test (MRT)



20-50 Human Subjects
Sound-Isolated Room
Play Recordings of Systems Under Test

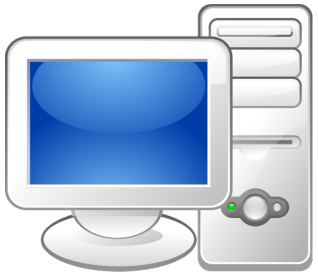


- Went
- Sent
- **Bent**
- Dent
- Tent
- Rent

Each trial is either a success or a failure

4 Talkers, 300 Words each
1200 Trials per condition

Statistical Analysis of 10,000's Trials



Example Result:

MRT Intelligibility is 87.3

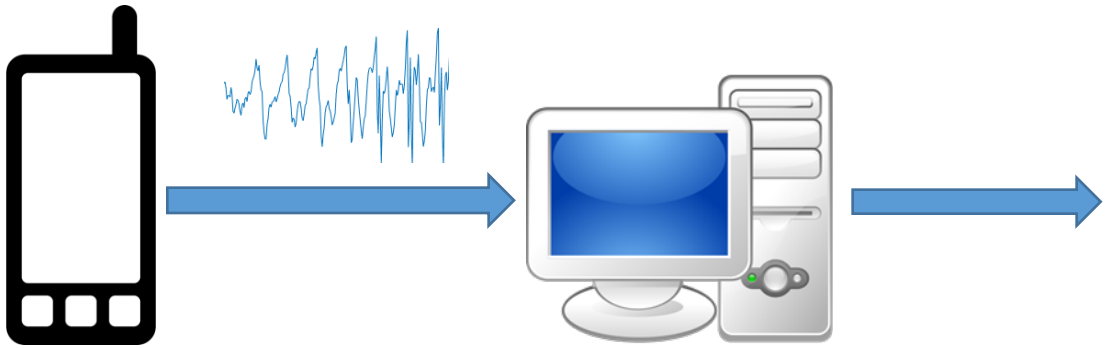
PSCR Intelligibility Tool Kit: ABC-MRT

Articulation Band Correlation - Modified Rhyme Test (ABC-MRT)

A digital-signal processing (DSP) algorithm

Based on human perception and processing

Currently extending to cover more use cases



Example Result:

Estimated MRT Intelligibility is 86.8

MRT
- Takes Months
+/- Requires Humans

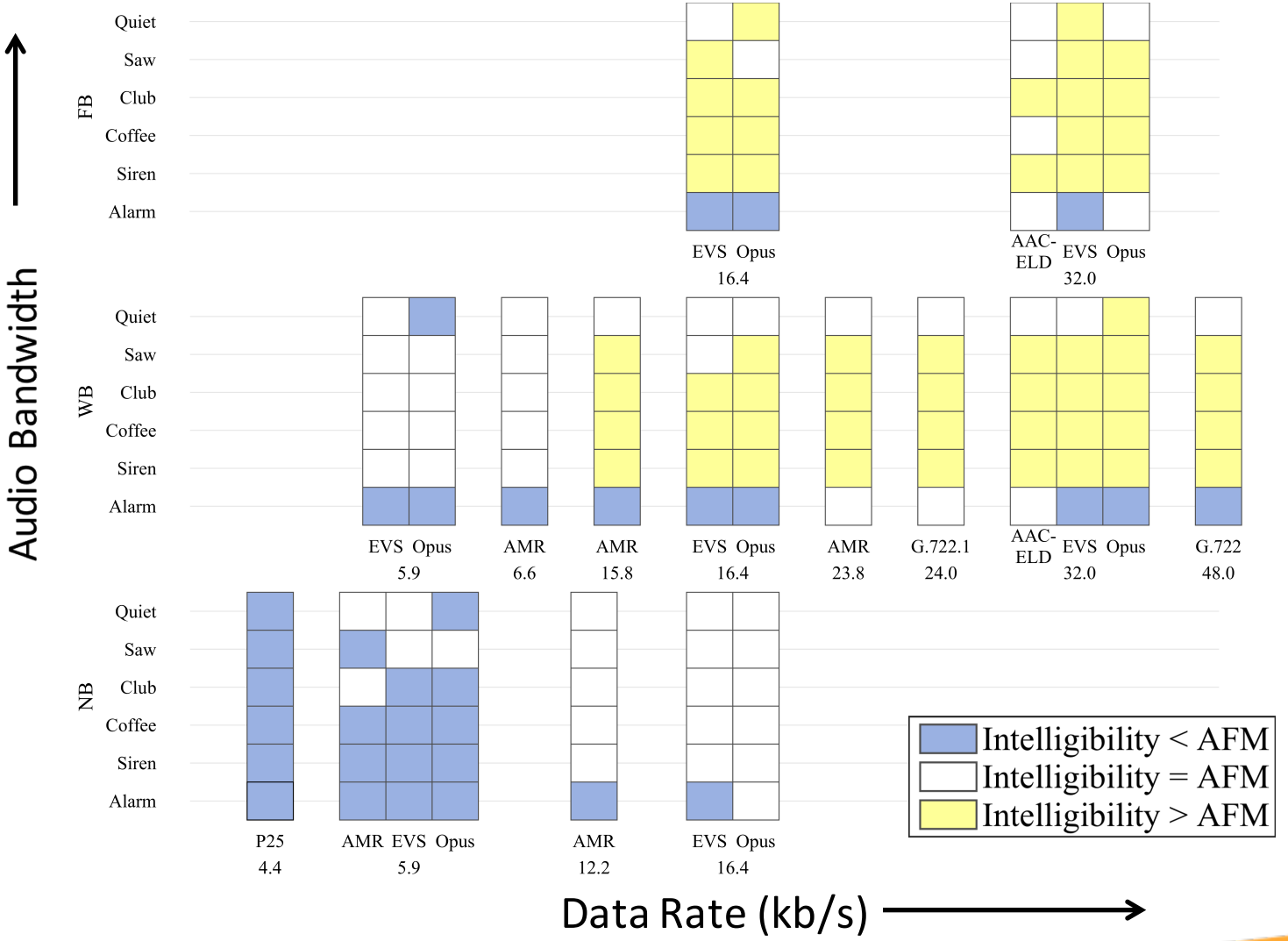
ABC-MRT
+ Takes Hours
+/- Uses DSP to estimate human responses

Published Results 2008-2016

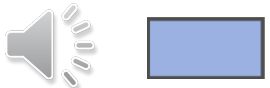
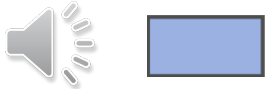
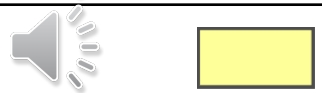
- **Speech Codec Intelligibility Testing in Support of Mission-Critical Voice Applications for LTE**, NTIA Technical Report TR-15-520, September 2015.
- **Using articulation index band correlations to objectively estimate speech intelligibility consistent with the modified rhyme test**, 2013 IEEE International Workshop on Applications of Signal Processing to Audio and Acoustics, October 20-23, 2013.
- **Intelligibility of Analog FM and Updated P25 Radio Systems in the Presence of Fireground Noise**: Test Plan and Results, NTIA Technical Report TR-13-495, May 2013.
- **Intelligibility of the Adaptive Multi-Rate Speech Coder in Emergency-Response Environments**, NTIA Technical Report TR-13-493, December 2012.
- **Intelligibility of Selected Radio Systems in the Presence of Fireground Noise**: Test Plan and Results, NTIA Technical Report TR-08-453, June 2008.
- **Relationships Between Intelligibility, Speaker Identification, and the Detection of Dramatized Urgency,** NTIA Technical Report TR-09-459, November 2008.
- **Speaker Identification in Low-Rate Coded Speech**, *International Measurement of Audio and Video Quality in Networks Conference*, Prague, Czech Republic, May 2008.
- **Listener Detection of Talker Stress in Low-rate Coded Speech**, *IEEE International Conference on Acoustics, Speech and Signal Processing, March 2008.*

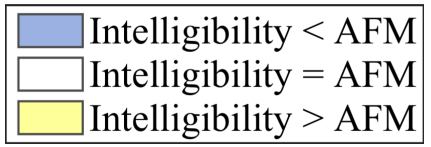
Recent Work

- Goal: Measure intelligibility of codecs suitable for MC voice in different acoustic noise conditions (perfect radio channels)
- Used ABC-MRT (DSP) to evaluate 4482 conditions; broad, coarse preselection
- Selected 168 conditions for MRT (humans); targeted, precise evaluation
- Results reported relative to Analog FM LMR (de facto user expectation)

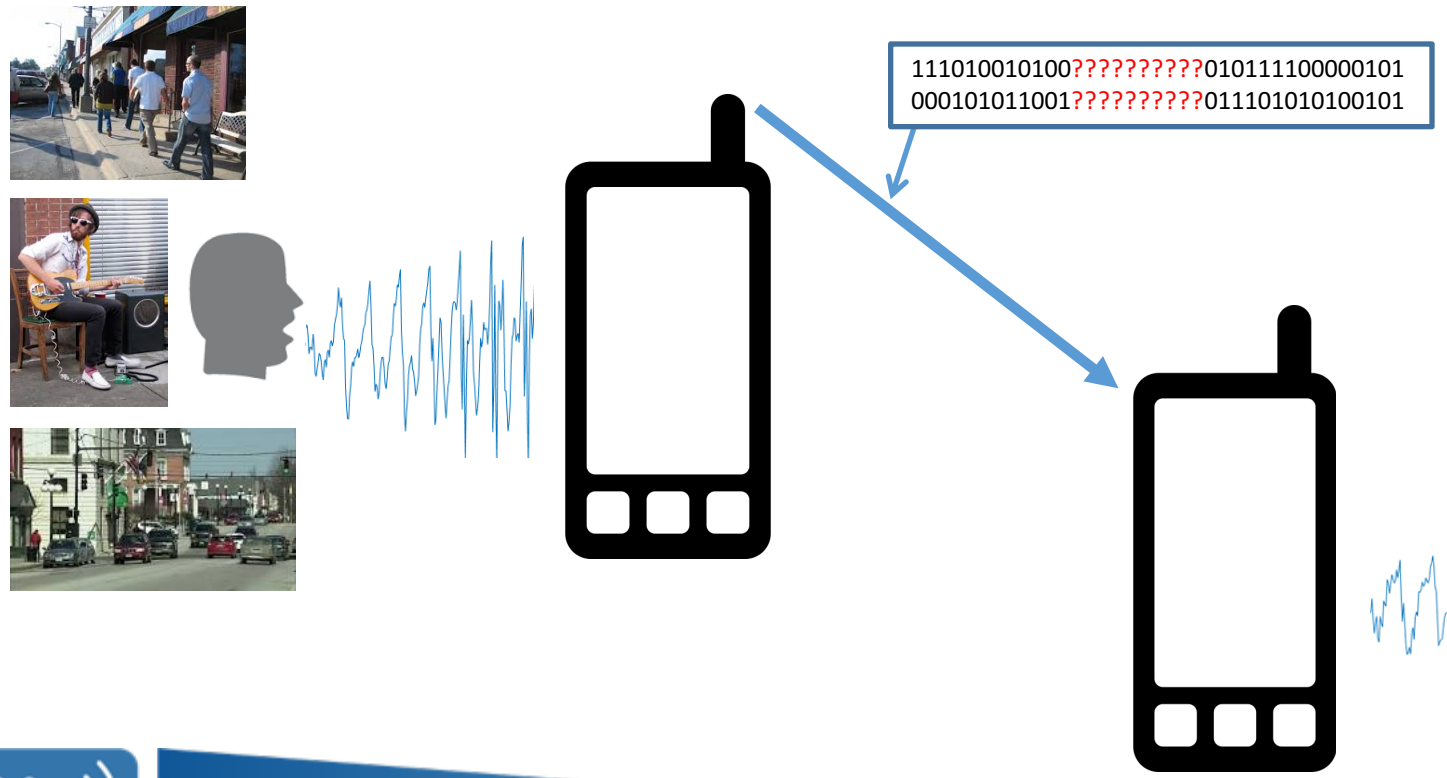


Examples

Noise	NB Codec ≈ 6 kb/s	Analog FM LMR	WB Codec ≈ 16 kb/s
Siren			
Saw			



Considering Channel Impairments



- RAN or core network can produce channel impairments when pushed to limits.
- Severe channel impairments create data outages (frame erasures)at decoder.
- Decoder may partially conceal outages for short durations.
- Ability to conceal is called robustness.
- Robustness is a key codec trade-off.
- Assessment of time-varying intelligibility required.

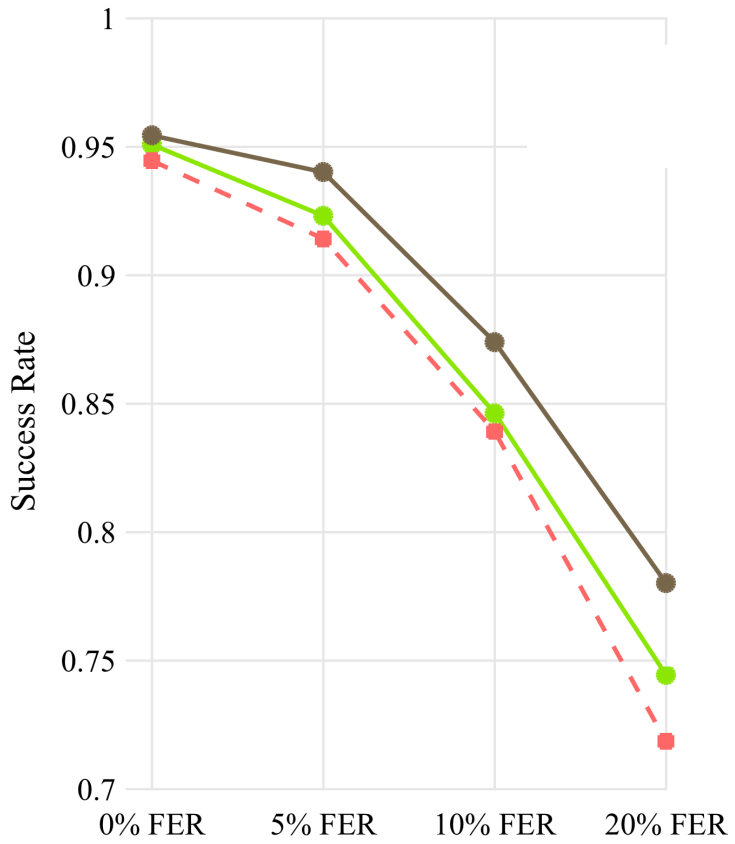
20% FER Example

0% FER Example

Example Results

Test Protocol

- Public safety messages recorded and processed under controlled conditions
- Test subjects report all words heard in messages.
- Subjects' reports compared with transcripts to find fraction of words correctly reported.



Three systems shown, one has somewhat higher robustness.

It does a better job of concealing losses.

Take Away

- Speech intelligibility is key (speaker ID, speaker stress detection, acoustic scene understanding, also desirable).
- Intelligibility and quality not equivalent concepts.
- Codecs drive speech intelligibility, subject to constraints and trade-offs:
  - Audio Bandwidth
  - Robustness
  - Bit-Rate
  - Algorithmic Delay
- PSCR has speech intelligibility toolkit (Human Subjects, DSP).
- We are applying tools for Stakeholder benefit:

  Optimize MC voice attributes given constraints and trade-offs.
- More at PSCR.gov

PSCR

Public Safety & Network Security Enhancements

Identity Management & Data Isolation Solutions

This work is sponsored by:

FirstNet™

FirstNet
(First Responder Network Authority)

PSCR

Disclaimer

Please note, all information and data presented is preliminary/in-progress and subject to change.

Panel Members

- John Beltz (Moderator)
  - PSCR IT Security Manager
- Joshua Franklin
  - NIST Information Technology Laboratory (ITL)/PSCR
  - Primary Research Engineer for Application/Data Isolation Project
- Harlin McEwen
  - Chair, FirstNet Public Safety Advisory Committee (PSAC)
- Paul Grassi
  - National Strategy for Trusted Identities in Cyberspace (NSTIC)/PSCR
  - Primary Research Engineer for PSCR Identity Management Project

Mobile Data & Application Isolation

Joshua Franklin – IT Security Specialist, NIST ITL/PSCR

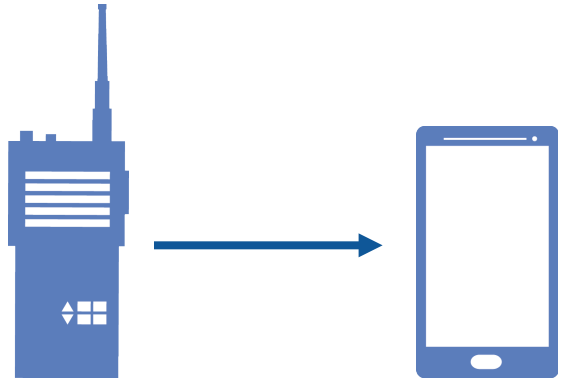
PSCR

Introduction

- The NPSBN enables first responder use of modern mobile devices
- Mobile devices erode traditional network boundaries and increase threat surface by adding new points of compromise
- The data and applications residing on public safety mobile devices need to be secured against modern threats
- Protection mechanisms, such as isolating commercial applications from mission critical ones, need to be identified and validated
  - This enables Bring Your Own Device scenarios for first responders

Mobile Data & Application Isolation

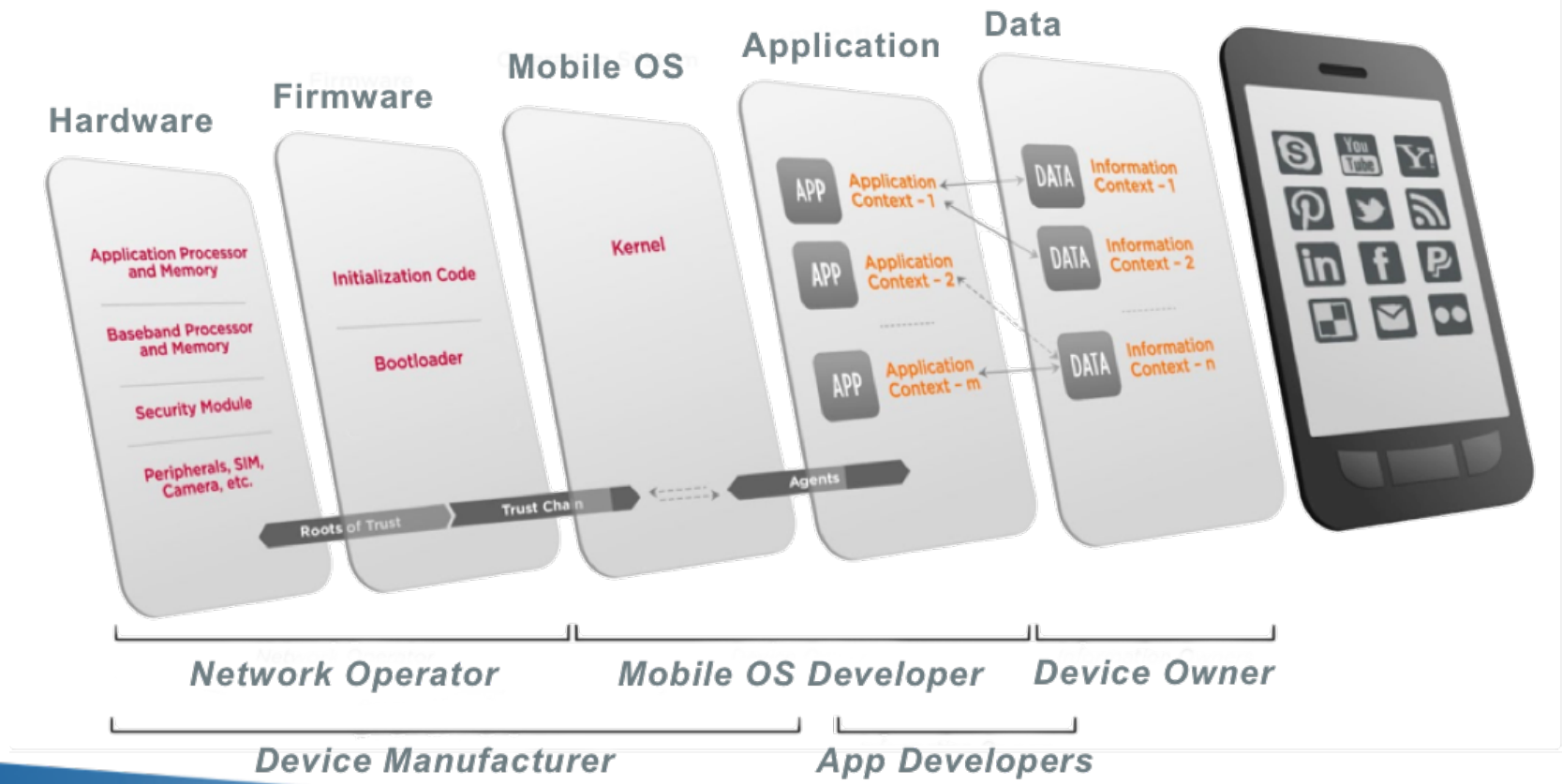
- The *Mobile Data & Application Isolation* project explores methods to manage and isolate applications/data for deployment on the NPSBN
- Devices and data can be compromised in many ways:
  - Lost or stolen devices
  - Network eavesdropping
  - Insecure network interfaces (e.g., WiFi, cellular)
  - Device and user tracking
  - Mobile malware



- This leaves sensitive public safety information at risk
- Need to protect the hardware, operating system, applications, and data to protect public safety information

Mobile Protection Mechanisms

Devices and data can be compromised
at various layers of the mobile security stack



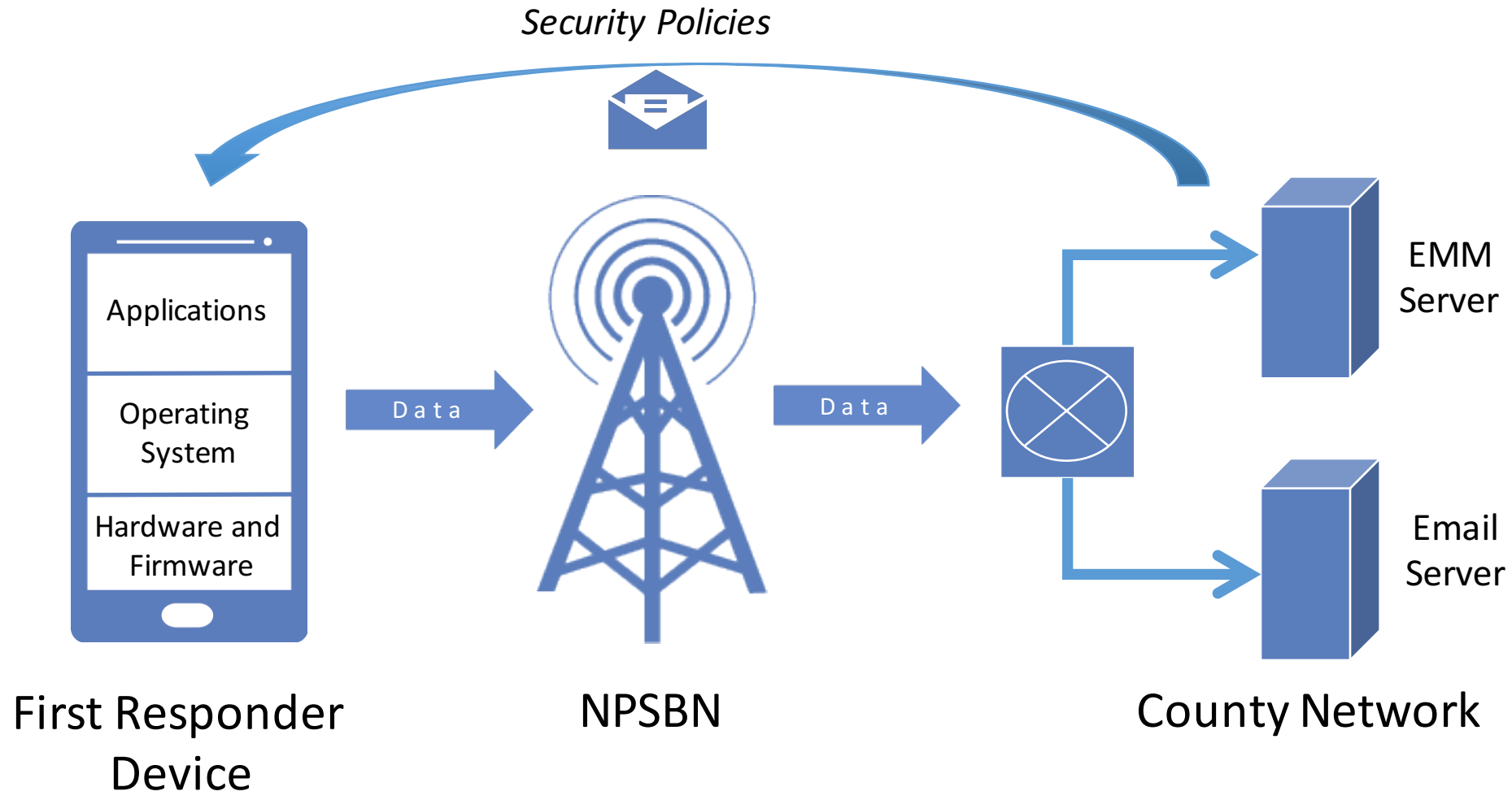
Example Use Cases

- Entering and exiting neighboring jurisdictions
- Securing evidence and other incident data on-device
- Device loss and theft
- Protecting wireless data transmissions
- Volunteers needing to access public safety services
- Bring Your Own Device scenarios
- Notifying user of malicious code on a device

Enterprise Mobility Management

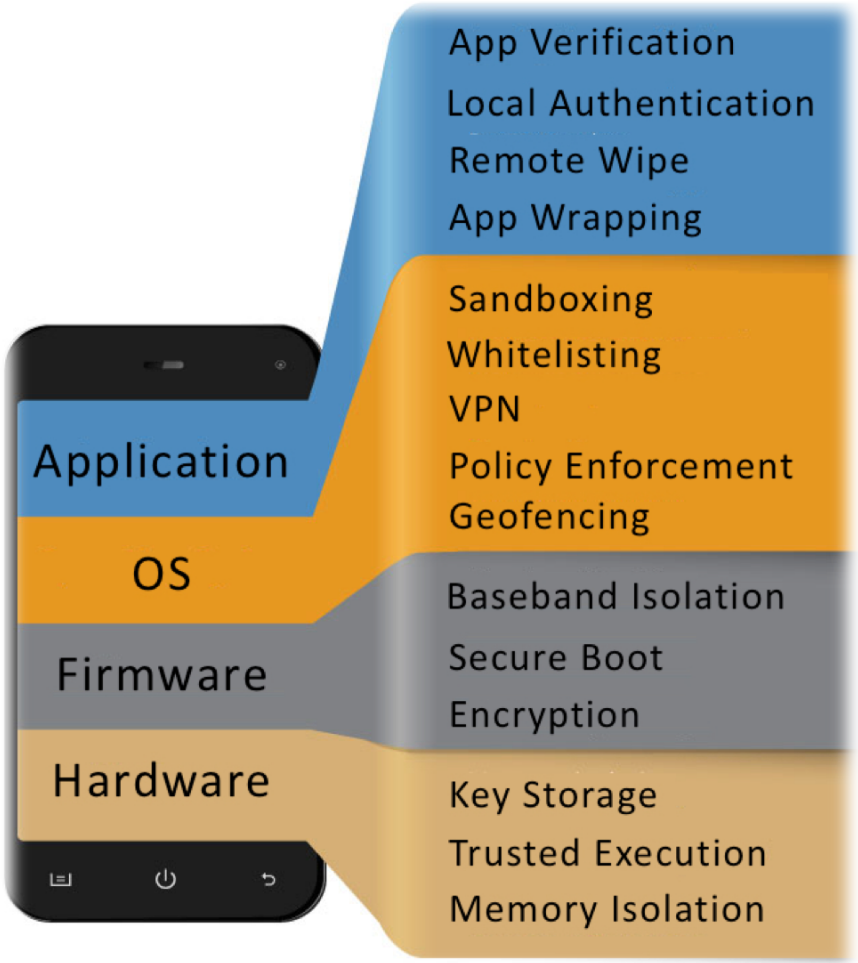
- EMM: Standard method to deploy mobile devices in an enterprise
- MDM: Defines and delivers policies to mobile devices
- EMM applications (or agents) reside on the device
  - Help to enforce policies
- Example policies:
  - Lockscreen security
  - Enable VPN
  - Device encryption
  - Root / jailbreak detection
  - Application whitelisting / blacklisting

EMMs in Action



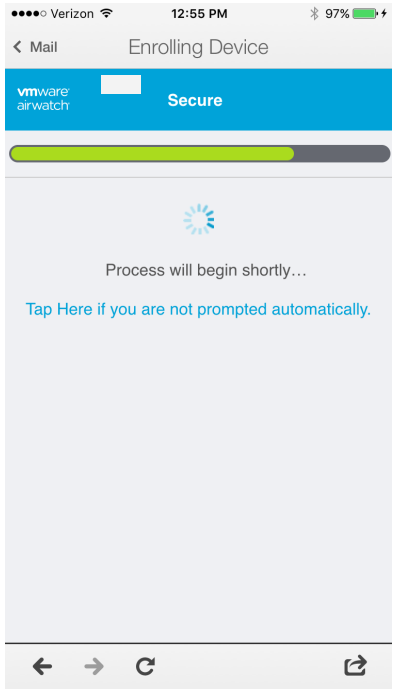
Current Research Efforts

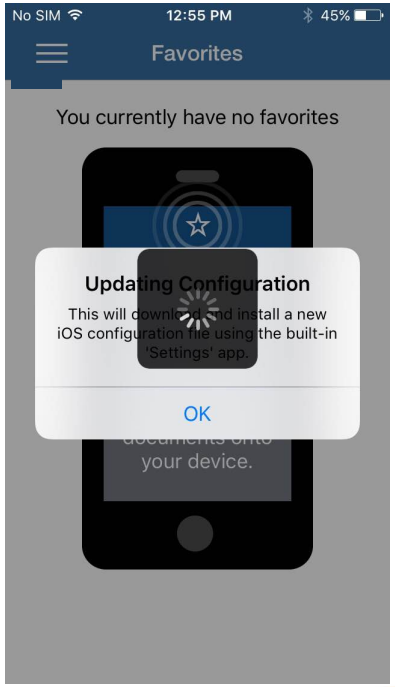
- Completed Research
  - Identified mobile security characteristics
  - Identified relevant mobile security products
  - Understand the degree to which industry products implement mobile security characteristics
- Need to understand gaps in commercially available technologies and what public safety needs
- *Testing is underway*



Preliminary Results

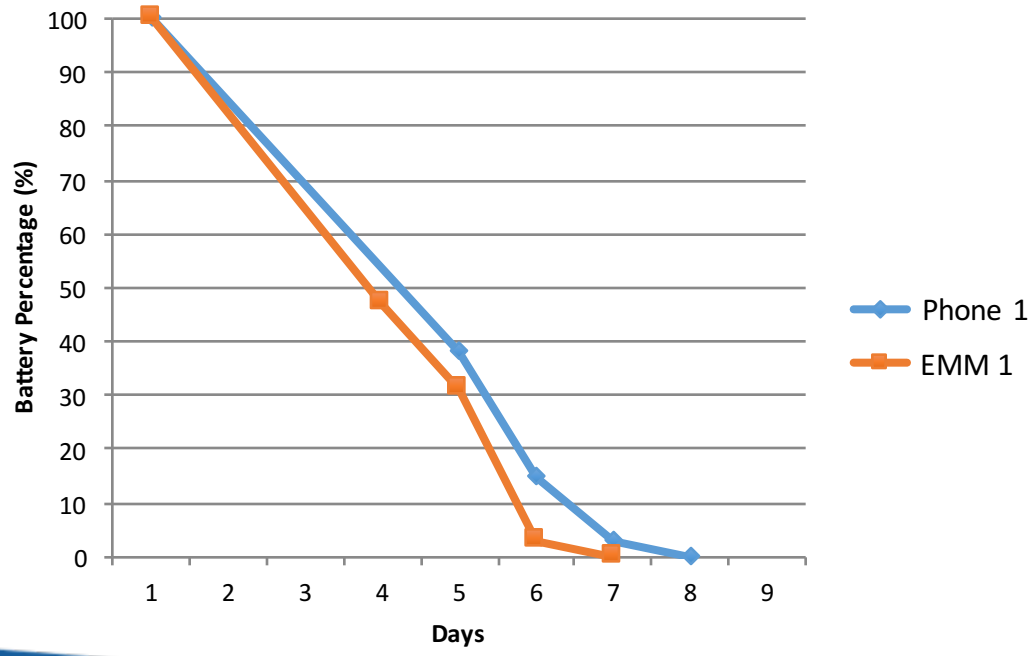
- Since testing is underway, preliminary results are arising
- Interesting results surrounding the following topics:
  - Multiple isolation technologies on a single device (Co-management)
  - Whitelisting and blacklisting
  - Encryption standards
  - Battery consumption statistics
- Capabilities vary widely from EMM to EMM

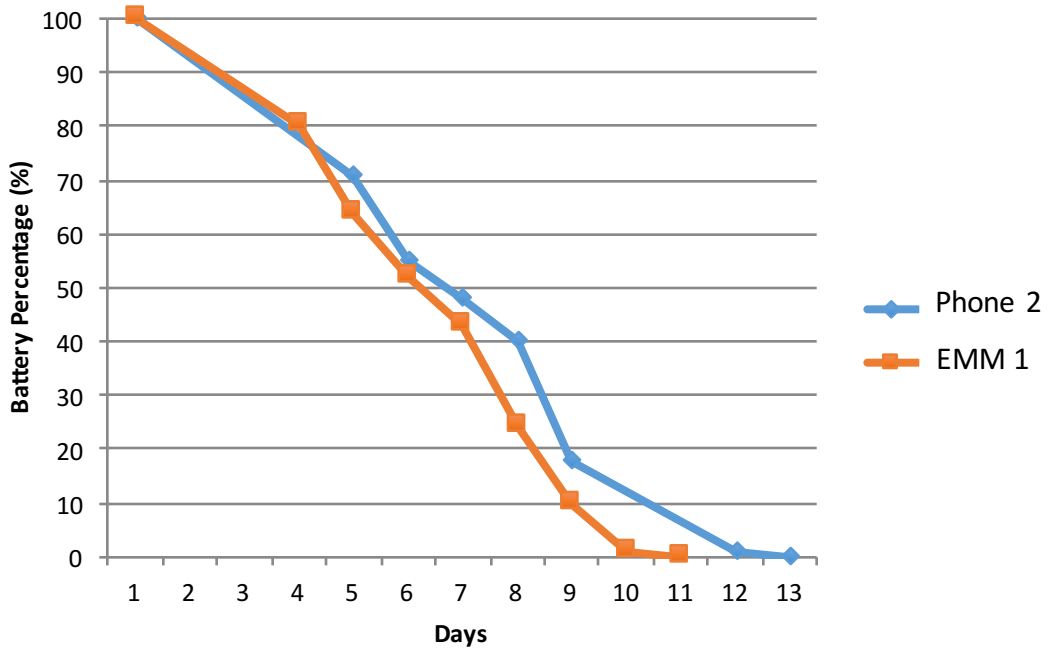




Impact on Battery Life

- EMMs may have an adverse impact on battery life
- We're collecting data to understand the degree of impact
  - Need to identify which functions consume the most power





Conclusion

- First responders need tools and support to accomplish their mission
- Compromised data and devices may allow attackers to access the cellular network infrastructure and other critical resources
- Research efforts currently underway – complete in ~ 3 months
  - Phase 2 of our research is under development
- This research will ensure public safety has the right tools in place to:
  - Protect real-time communication,
  - Secure access to data and services, and
  - Operate in a modern threat environment.

Identity Proofing for a National Public Safety Network

Chief Harlin McEwen, Chair, Public Safety Advisory Committee (PSAC)

PSCR

ICAM: PSAC Task Team Focus Areas

The Public Safety Advisory Committee (PSAC) has a task team that advises FirstNet on Identity, Credential, and Access Management (ICAM) requirements for Public Safety

PSAC has been working on three important aspects of ICAM from a Public Safety perspective

- Different **user types** accessing the network
- **Types of access**
- **Policy and procedures** for proving the identity of Public Safety users

ICAM- Types of Users

- **Public Safety Primary**: Users are generally personnel from the traditional public safety disciplines, both full time and volunteer
  - Emergency Medical Services (EMS), Fire Department/Services, Law Enforcement, Public Safety Communications Centers/PSAPs

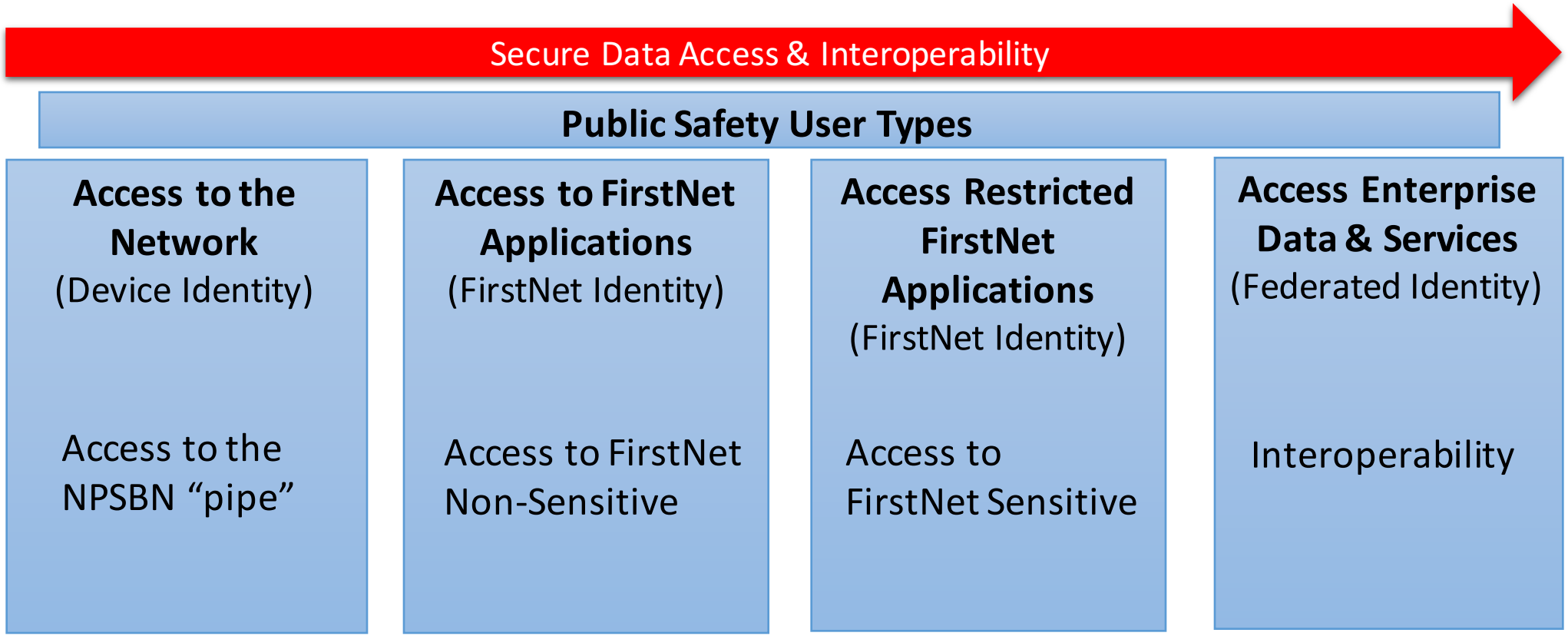
- **Public Safety Secondary**: Users are personnel who may participate or support responses of primary users, who at times, may be elevated to a primary user role
  - Personnel such as Law Enforcement Civilian, Courts, Corrections, Emergency/Disaster Management Departments, Search and Rescue, Family and Protective Services

ICAM-Types of Users

- **Public Safety Support**: Users are personnel, commercial and governmental entities that support Public Safety Primary and Secondary
  - Personnel such as Public Transportation, Utilities, Alarm Companies, Voluntary Organizations Active in Disaster

- **Public**: Public users
  - Treated as a commercial customer and authenticated by FirstNet partner to access the NPSBN-band class 14

ICAM-Levels of Access



ICAM-Types of Access

- Access to the Network (**Device Identity**)
  - Access to the NPSBN “pipe”
  - Use of commercial mobile apps
  - Similar to commercial service
  - Very low barrier to entry

- Access to FirstNet Applications (**FirstNet Identity**)
  - FirstNet app store
  - Local control
  - Static prioritization

ICAM-Types of Access

- Access Restricted FirstNet Applications (**FirstNet Attributes**)
  - Dynamic prioritization
  - Attribute based access control (types of users and other attributes)

- Access Enterprise Data & Services (**Federated Identity**)
  - Interoperability with other agencies
  - Additional Single Sign On (SSO) capabilities
  - Access to third party data (Federated Identity Participants)

Identity Proofing

- **Identity Proofing** - The process by which an individual's identity is vetted and proven to be who they claim to be
  - Identity proofing mechanisms vary in strength/assurance levels
  - PSAC ICAM task team is assisting FirstNet security team in establishing:
    - Guidelines around strength of identity proofing
    - Details of the identity proofing process with emphasis on policy and procedure

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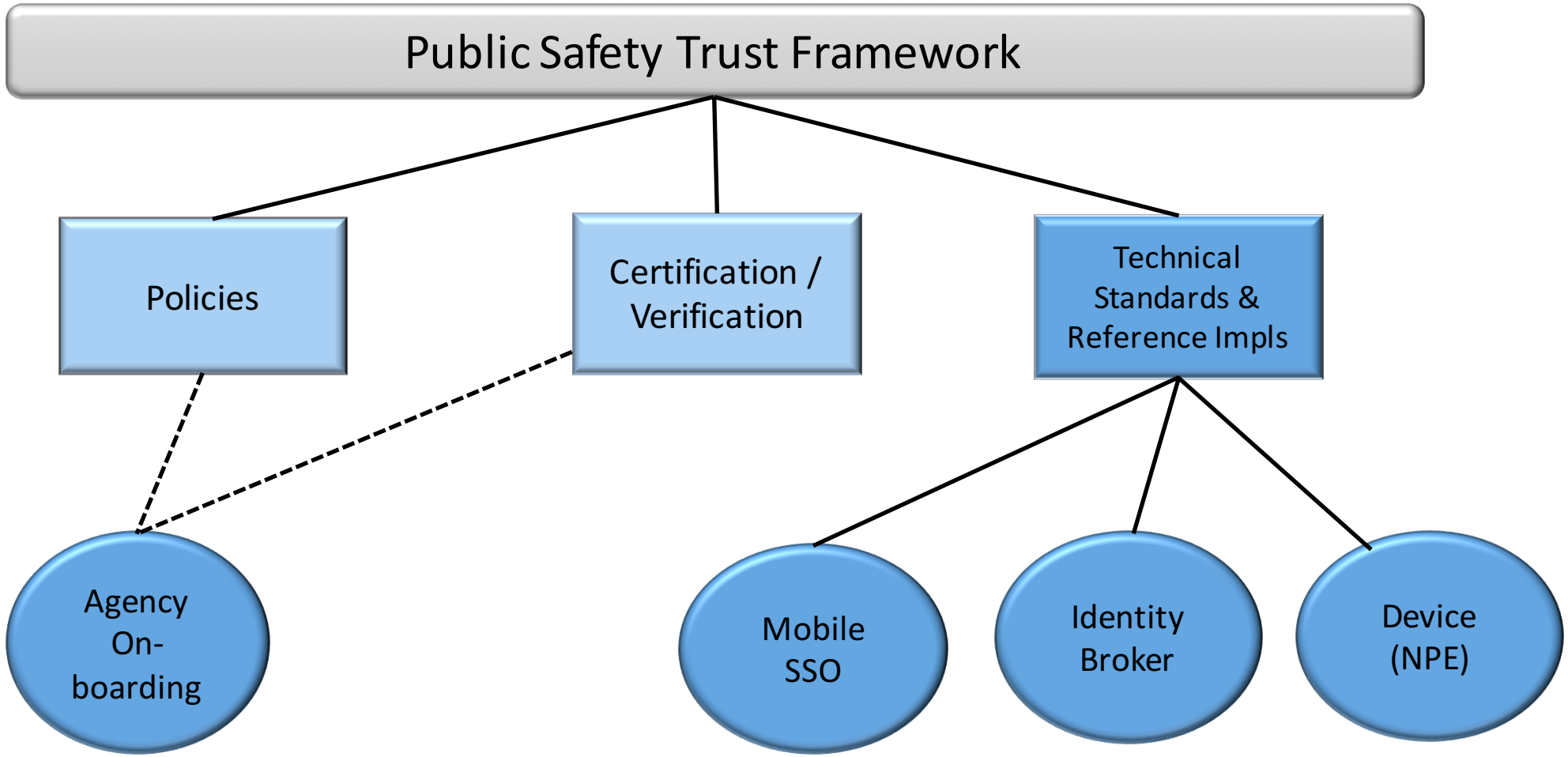
PSCR Identity Management Research

Paul Grassi, Primary Research Engineer for Identity Management Project

PSCR Identity Management Research

- Relevance to Public Safety- Mobile Single Sign-On will significantly enhance mission effectiveness, communication capabilities and user experience for First Responders:
  - Interoperability – Support multiple secure credential types
  - Reduce, in a secure manner, multiple and inconvenient authentication requirements
  - Integration with EMM solutions to enhance security
  - Enable proper levels of access for levels of users through federated identity management

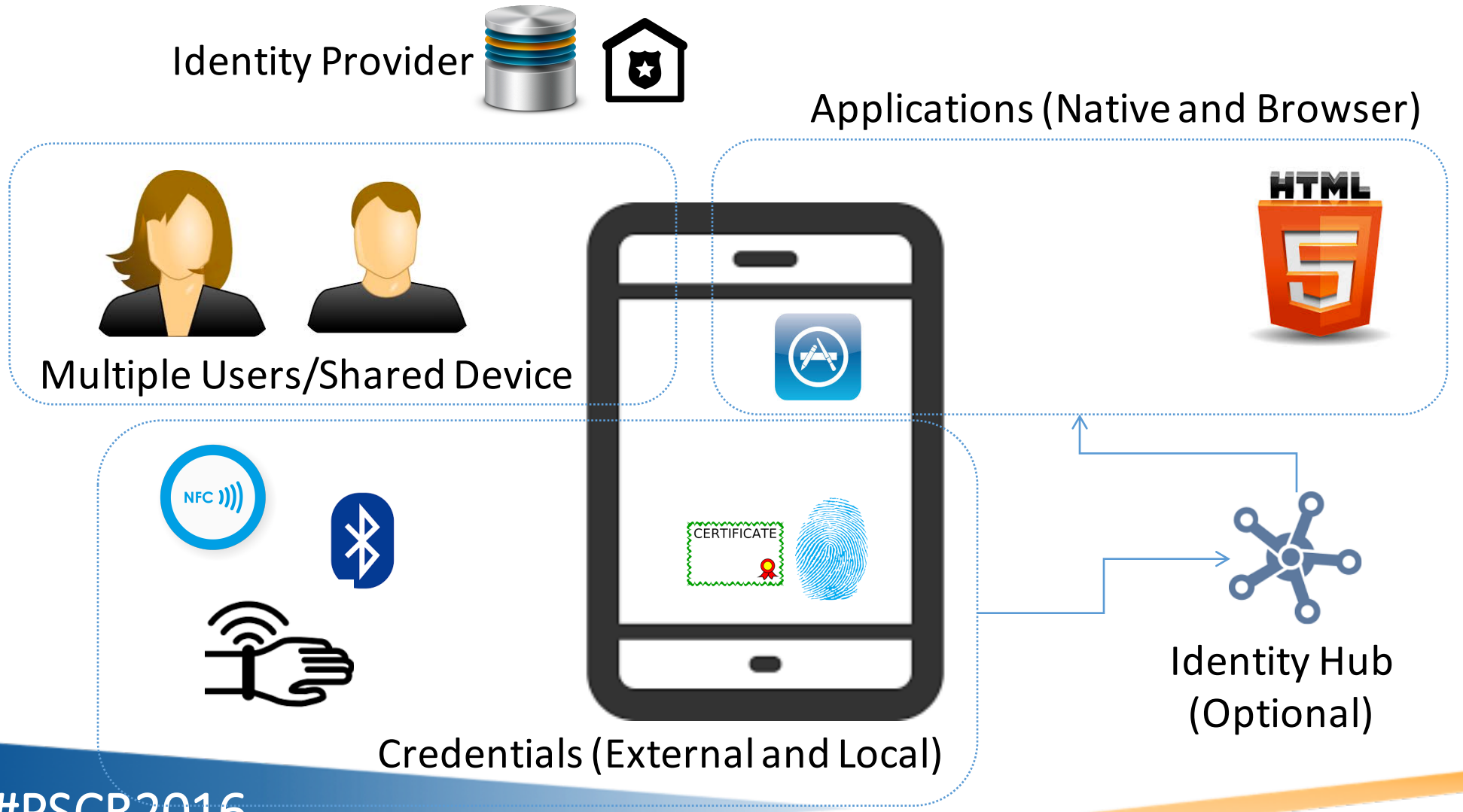
PSCR Identity Management Research



PSCR Identity Management Research

- Applied Research Goal- Build a reference architecture for **Mobile Single Sign-On (SSO)** to understand capabilities of current standards technologies in relation to multiple mobile platforms and user types
  - Mobile SSO is still relatively new, with limited enterprise deployments
  - Industry research is varied and immature
  - Mobile credentials vary
  - Operating system support varies
  - Strong likelihood of valuable outcomes that will directly impact mission

PSCR Identity Management



PSCR Identity Management Research

- **Mobile SSO Research Highlights**
  - SSO between native and browser based apps
  - Integrated into Public Safety application(s)
  - Flexible authentication methods
    - Multiple credentials
    - Shared devices
    - Multiple Levels of Assurance (LOA) / strengths
    - Align each method with use cases and how public safety users carry out their duties
  - Standards based
    - OAuth
    - Fast Identity Online (FIDO)
    - Open ID Connect
    - Security Assertions Markup Language (SAML)

PSCR Partnership with NCCoE

- Research is to be conducted as a partnership with the National Cybersecurity Center of Excellence (NCCoE)
- Funded by PSCR with additional resources provided under NCCoE and the private sector
- Significant industry contribution
- Transparent and Open – All material made publicly available with comment periods
- Expected Outcomes
  - Special Publications Mobile Single Sign On for the Public Safety Community
  - PSCR, FirstNet, and NCCoE gain knowledge and experience with Mobile SSO implementation for Public Safety users
  - Facilitates the adoption of Mobile SSO

NCCoE NATIONAL CYBERSECURITY CENTER OF EXCELLENCE

Complimentary Efforts

- National Strategy for Trusted Identities in Cyberspace
  - Multiple Pilots, for example GSMA
- Digital Authentication Guideline (Draft)
  - https://pages.nist.gov/800-63-3
- Department of Homeland Security Science and Technology Directorate
  - Mobile Device and and Attribute Validation
  - https://kantarainitiative.org/kantara-ccicada/
- Identity Ecosystem Steering Group (IDESG)
  - Identity Ecosystem Framework
  - Self-Assessment Listing Service (SALS)

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SNAPSHOT: PSCR's Demonstration Network

Preparing Today's Network for Tomorrow's Research

Disclaimer

Please note, all information and data presented is preliminary/in-progress and subject to change.

Speakers

- Ellen Ryan
  - PSCR Lab Operations Group Lead
- Donald Harriss
  - PSCR Lab Operations

PSCR Lab Operations: Managing a Secure Network

- **Lessons Learned**
  - Transforming PSCR Network from a small-scale static network to a secure, diverse public safety broadband environment

PSCR Lab Operations: Lessons Learned

Managing Network Resources

- Asset Inventory Tool
- Resource Reservation Tool
- Change Request System
- Network Deployment Process
- Encrypted Data Storage

Secure Network Architecture

- Network Segmentation
- Firewall Implementation
- VPN Access
- Secure Configurations
- Anti-Virus & Vulnerability Scans
- Event Monitoring Systems

Lesson 1: Identify Key Requirements

- Simple and specific
  - Tools should increase productivity
  - Skills to develop tools in-house?

- Understand total costs
  - Base cost
  - Annual support contract; including upgrades?
  - SME contract for configuration and training?
  - Annual network device licenses and other future costs?

- Product Evaluations

Invested In Customized Tools to Manage Network Resources

Change Request System (FixIt)

- Tracks Network Changes

Asset Inventory Tool (TagIt)

- Tracks Network Assets

Resource Reservation Tool (BookIt)

- Manages Resource Conflicts

Implemented a Technology Deployment Process

- Plan for new features
- Documented Network Requirements
- **Minimizes Unnecessary network changes**

- Provides Limited Network Access
- **Implement Security Requirements**

- Approved Level of Security
- **Network Regression Testing**
- **Backward Compatibility and Interoperability Testing**

Lesson 2: Implement an Upgrade & Regression Testing Plan

Complex Research Configurations + Multiple Technologies = Complex Upgrade and Testing Challenge

- Schedule maintenance windows for upgrades we perform
- Coordinate upgrade schedules with vendors
- Plan post-upgrade testing strategies (backward compatibility, interoperability testing)

Security Patching: PSCR Network will never be 100% upgraded at a given time with all available security patches

Lesson 3: Secure Network Architecture

- **The Need to Protect Data:**
  - Maintain Public Trust
    - Do not become an example
  - Staying productive by preventing downtime
    - Time = Money AND Lives for Public Safety

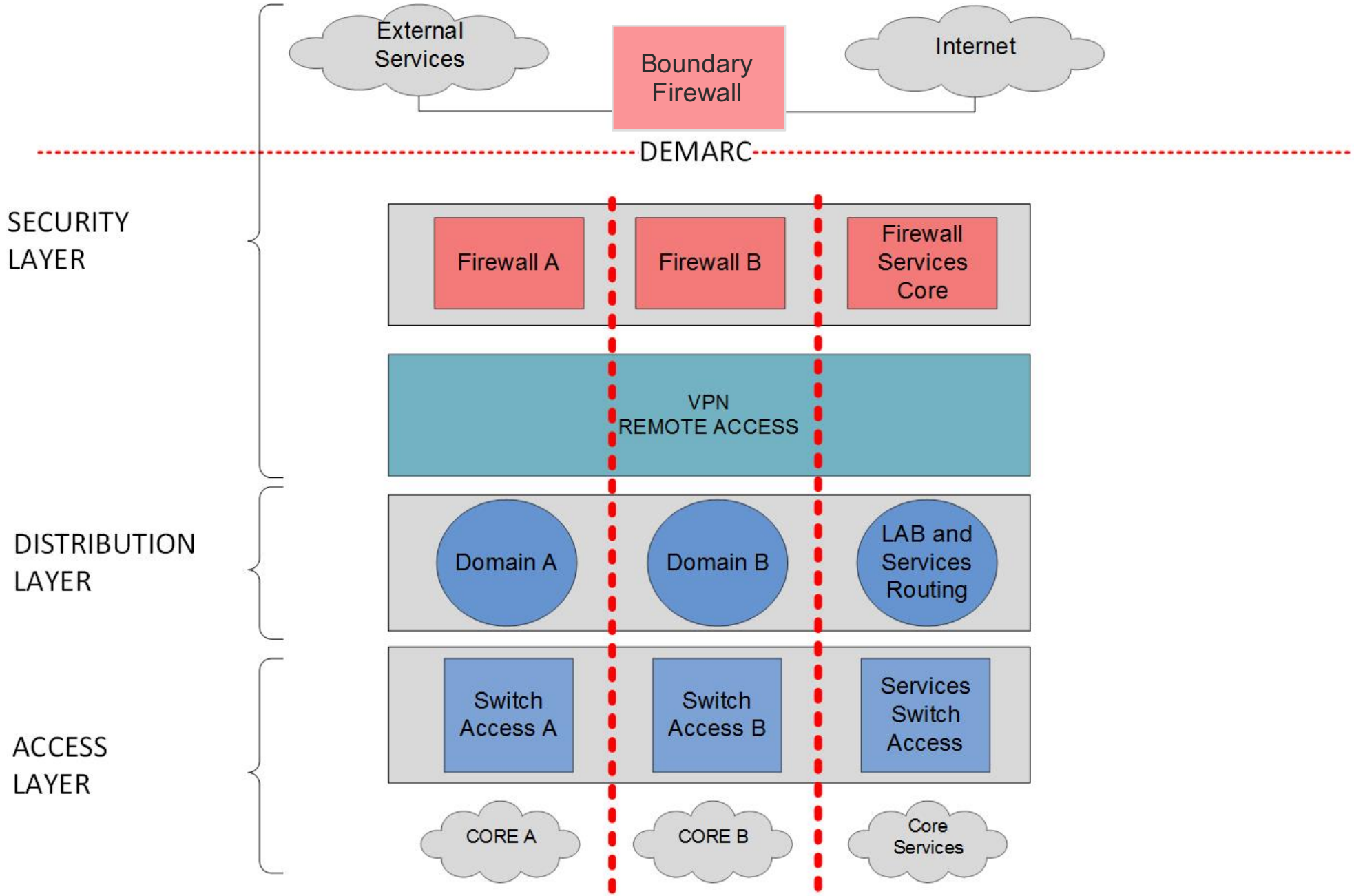
Lesson 3: Secure Network Architecture

- **Threats to data:**
  - Equipment Failure
  - Environmental Disasters
  - Malware: Viruses, Worms, Ransomware
  - Data Leakage

Lesson 3: Secure Network Architecture

- **Methods to Protect Data:**
  - Enhanced access policies
  - Imposes network bandwidth limitations
  - Encrypted devices
  - Secure configurations

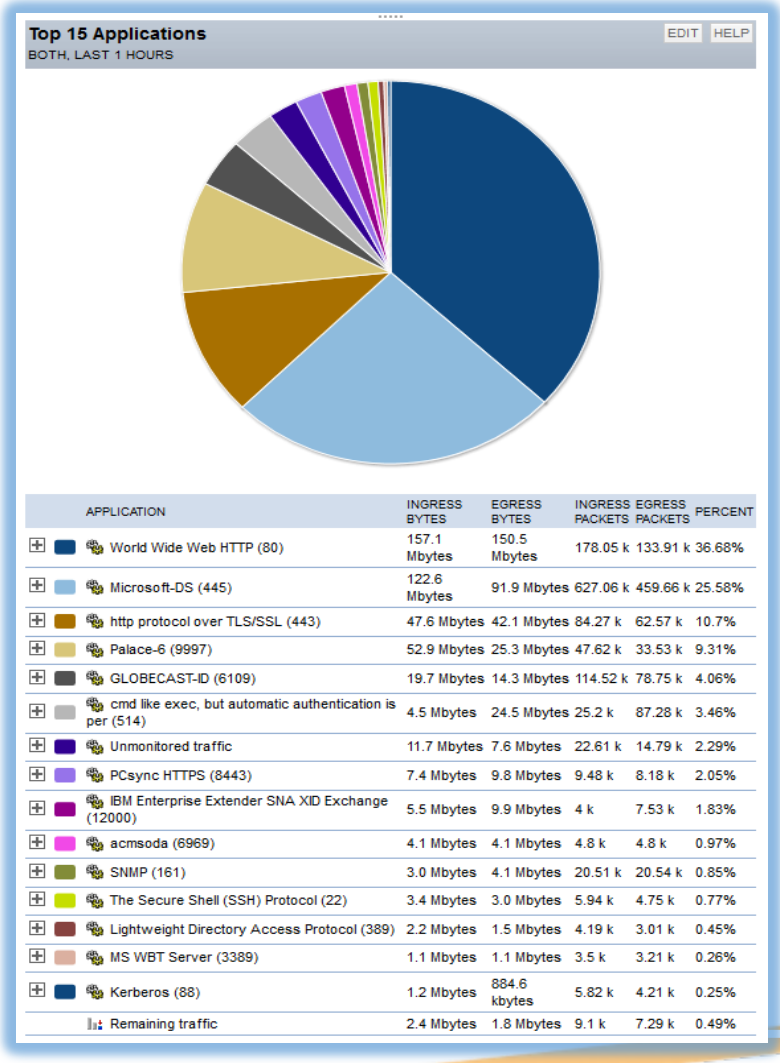
Layered Network Architecture



Secure Network Architecture Reporting Tools

- **Network Monitoring System**
  - Traffic Profiling
  - Top Talkers

- **Log Monitoring**
  - Detailed device logs
  - Hardware failure



APPLICATION	INGRESS BYTES	EGRESS BYTES	INGRESS PACKETS	EGRESS PACKETS	PERCENT
World Wide Web HTTP (80)	157.1 Mbytes	150.5 Mbytes	178.05 k	133.91 k	36.68%
Microsoft-DS (445)	122.6 Mbytes	91.9 Mbytes	627.06 k	459.66 k	25.58%
http protocol over TLS/SSL (443)	47.6 Mbytes	42.1 Mbytes	84.27 k	62.57 k	10.7%
Palace-6 (9997)	52.9 Mbytes	25.3 Mbytes	47.62 k	33.53 k	9.31%
GLOBECAST-ID (6109)	19.7 Mbytes	14.3 Mbytes	114.52 k	78.75 k	4.06%
cmd like exec, but automatic authentication is per (514)	4.5 Mbytes	24.5 Mbytes	25.2 k	87.28 k	3.46%
Unmonitored traffic	11.7 Mbytes	7.6 Mbytes	22.61 k	14.79 k	2.29%
PCsync HTTPS (8443)	7.4 Mbytes	9.8 Mbytes	9.48 k	8.18 k	2.05%
IBM Enterprise Extender SNA XID Exchange (12000)	5.5 Mbytes	9.9 Mbytes	4 k	7.53 k	1.83%
acmsoda (6969)	4.1 Mbytes	4.1 Mbytes	4.8 k	4.8 k	0.97%
SNMP (161)	3.0 Mbytes	4.1 Mbytes	20.51 k	20.54 k	0.85%
The Secure Shell (SSH) Protocol (22)	3.4 Mbytes	3.0 Mbytes	5.94 k	4.75 k	0.77%
Lightweight Directory Access Protocol (389)	2.2 Mbytes	1.5 Mbytes	4.19 k	3.01 k	0.45%
MS WBT Server (3389)	1.1 Mbytes	1.1 Mbytes	3.5 k	3.21 k	0.26%
Kerberos (88)	1.2 Mbytes	884.6 kbytes	5.82 k	4.21 k	0.25%
Remaining traffic	2.4 Mbytes	1.8 Mbytes	9.1 k	7.29 k	0.49%

Lesson 4: Incident Response Plan

An organized approach to addressing and managing the aftermath of an **incident**. The goal is to handle the situation in a way that limits damage and reduces recovery time and costs.

Industry Best-Practices:

- Prepare & Identify
- Contain & Eradicate
- Recovery & Lessons Learned

Lesson 4: Incident Response Plan

Real PSCR Scenario:

2 Day snow storm, 9 hour power outage, rabbit chewed through the wiring for a backup generator….

Conclusion

To Build and Maintain a Secure Network:

- Know Your Requirements
- Understand Maintenance Costs
- Have a Solid Deployment Plan
- Implement a Secure Network and Devices
- Build or Implement Monitoring and Mitigation Tools
- Create an Incident Response Plan

Thank you!

PSCR Lab Operations Team:

Roger Blalock, Christopher Dennis, Jaydee Griffith, Don Harriss, Philip Williams, Ellen Ryan and Wyatt Suess

PSCR Network Security Team:

John Beltz and Scott Ledgerwood

Questions?

PSCR

PSCR

Local Control for Public Safety

A Successful Demonstration of Local Control

Speakers

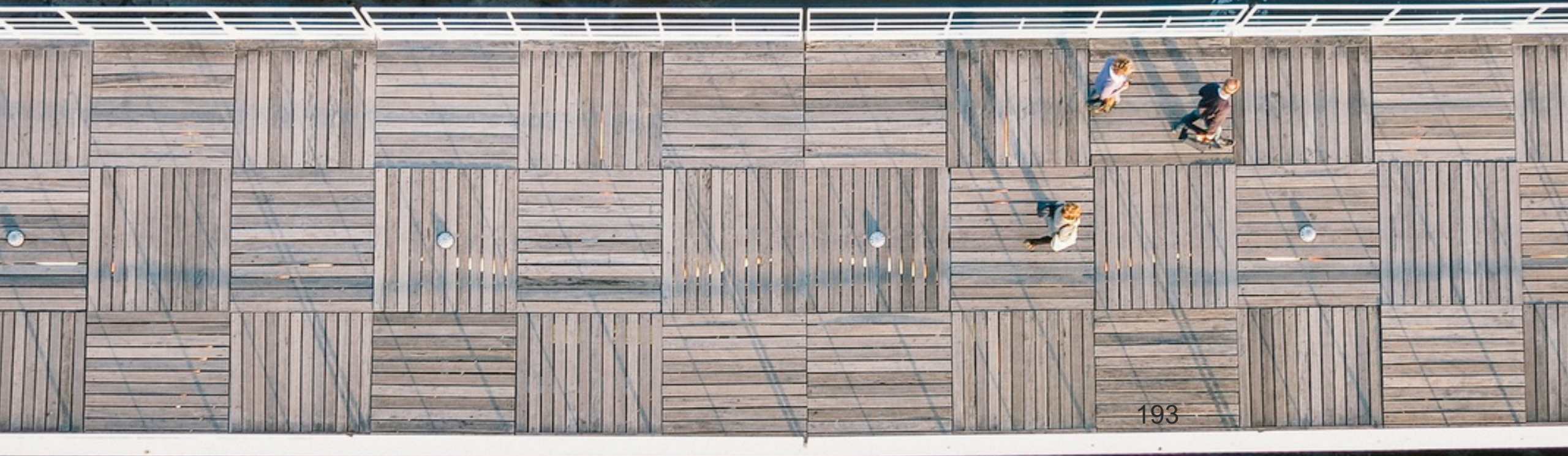
- Tracy McElvaney (Moderator)
  - PSCR Advanced Communications Research Group Lead
- Mika Skarp
  - CloudStreet
- Wim Brouwer
  - Nokia
- Chris Walton
  - PSCR Advanced Communications Research Group

DELIVERING FLAWLESS CONNECTIONS ON MOBILE NETWORKS

USE CASE & SOLUTION OVERVIEW

Mika Skarp
CTO

Cloudstreet



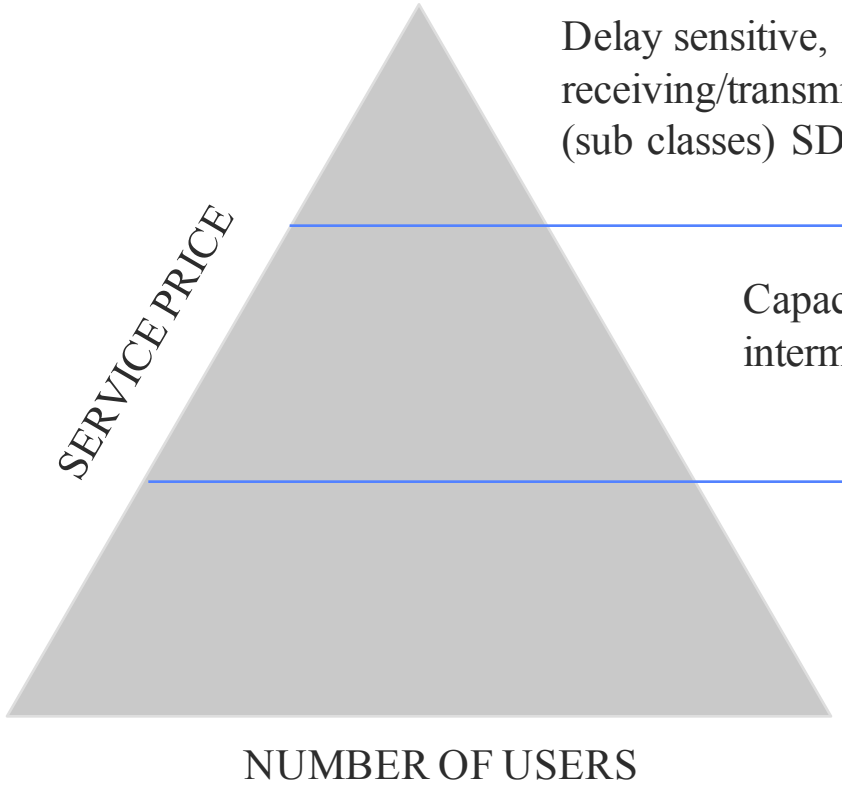
About Cloudstreet

- Network service orchestration platform for mobile operators first developed at Nokia's Silicon Valley campus. Started 2010
- Fully-developed business/network layer application for the delivery of differentiated Quality of Service / Quality of Experience (QoS/QoE) for mobile broadband.
- Real-time, dynamic profile-based service for application-aware bandwidth allocation.
- First LTE/5G mobile network-ready business model to commercialize the delivery of guaranteed bandwidth capacity on-demand.

"In order to avoid congestion, investment in network capacity should be complemented by service and customer-oriented network management."

GSMA, 2015

Differentiating OTT Traffic Classes



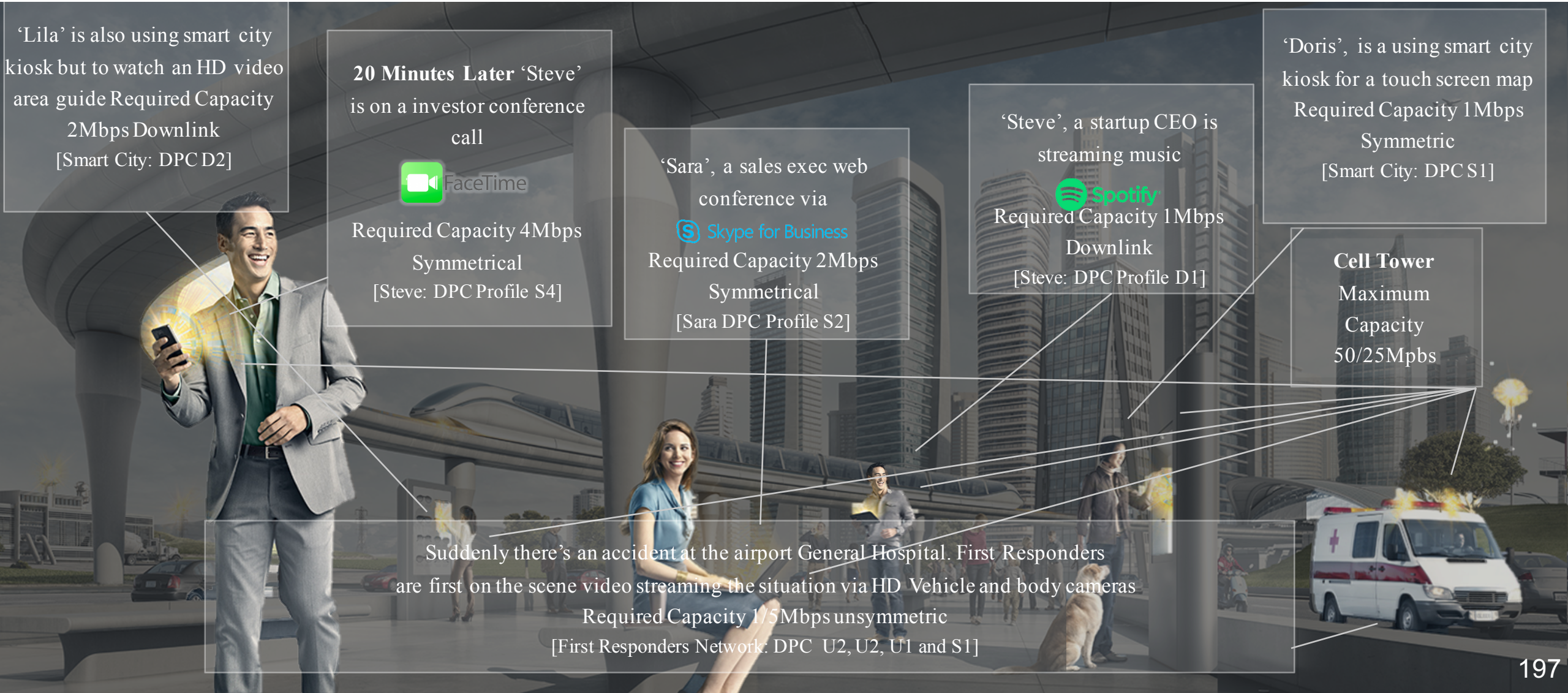
Delay sensitive, live VR & remote video and robotic receiving/transmitting, zero buffering or intermittent resolution (sub classes) SD, HD, 4K etc.

Capacity sensitive, Netflix type service, buffering and intermittent resolution (sub classes) SD, HD, 4K etc.

Best effort, YouTube type service, gaming, social media and downloading short video files

Differentiating Profiles For Assured QoE

Cloudstreet in Practice in the Connected City



Differentiating Profiles For Assured QoE

Cloudstreet in Practice in the Connected City

Status Quo vs. Cloudstreet Capacity Example

ASSUMPTIONS

- Cell has a maximum limit of 100 users or bearers
- Regular users have scheduling weight of "1"
- Cloudstreet users have scheduling weight of "20"
- Maximum cell capacity is 50/25 Mbps
- 100% RF coverage for Cloudstreet users

What if?

RESULTS WITHOUT CLOUDSTREET

Scenario: (Status Quo) All users have an equal scheduling Weight

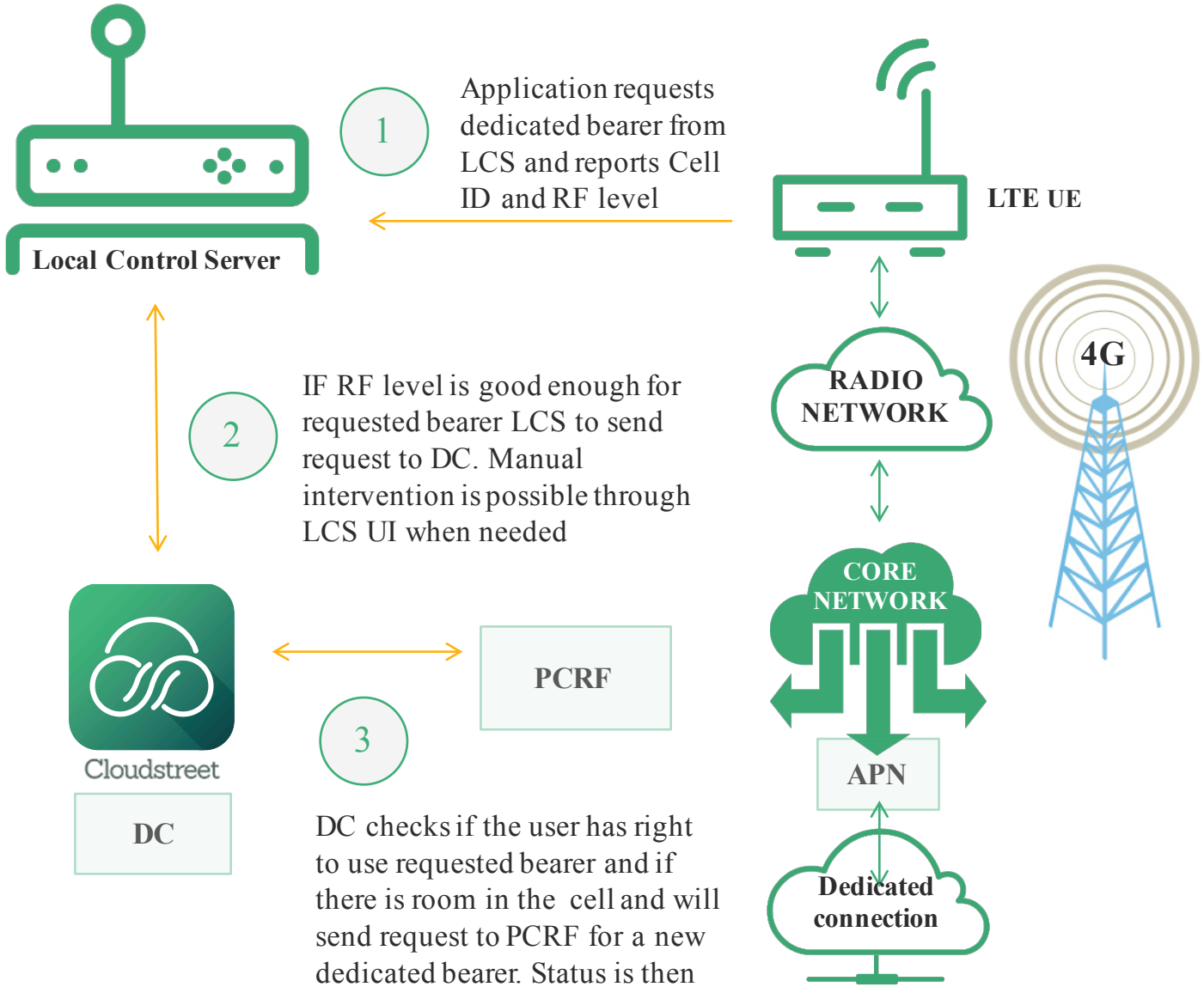
Experience: 0,5/0,25 Mbps for all (Best Case)

RESULTS WITH CLOUDSTREET

Scenario: 1 user with Cloudstreet
Experience: 8.4/4.2 Mbps@20/119 (worst), 0.42/0.21Mbps for the rest

Scenario: 2 users with Cloudstreet
Experience: 7.2/3.6 Mbps@20/138 (worst), 0.36//0.18 Mbps for the rest

Technical Description



FEATURES & BENEFITS

- From 92% reliability to 99,99% (2Mbps)
- 8 simultaneous data bearers through one SIM card
- Not only GBR, 246 different services classes
- Different APN per organization, dedicated connection from APN
- Group functions
- DC has open north and south bound interfaces

Thank-You!

Cloudstreet

Mika Skarp

Founder & CTO

mskarp@thecldst.com

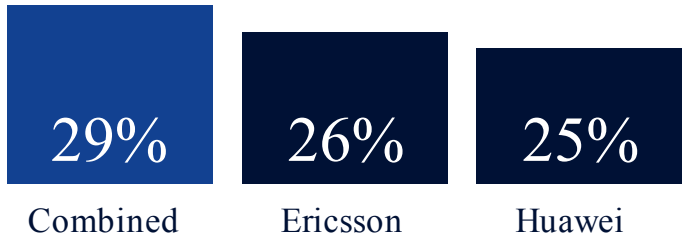
Dynamic Policy Control Possible LTE Implementation

Wim Brouwer
CTO FirstNet/Federal Customers
Wim.Brouwer@nokia.com

NOKIA

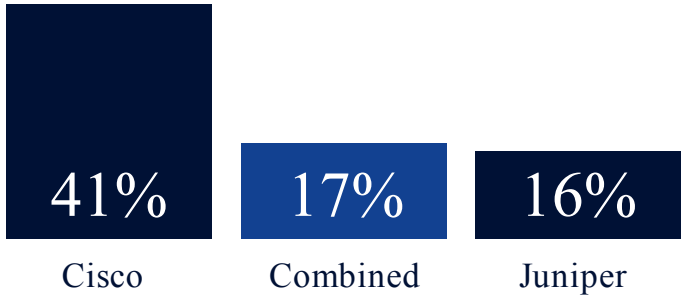
Nokia – A Leader in Key Segments

LTE, #1



Fixed broadband, #1

IP routing, #2



Cloud / Core

#1 Subscriber management
#1 Device management
#1 Voice over LTE
#1 Customer Experience Management

Software Defined Networks, with Nuage Networks

Leadership position in NFV
#3 in Datacenter SDN overlay
Perceived as #2 SDN vendor by SP Customers
Only vendor to offer DC, WAN & Branch SDN solution

Services, #2

Network integration
Customer care
Professional services

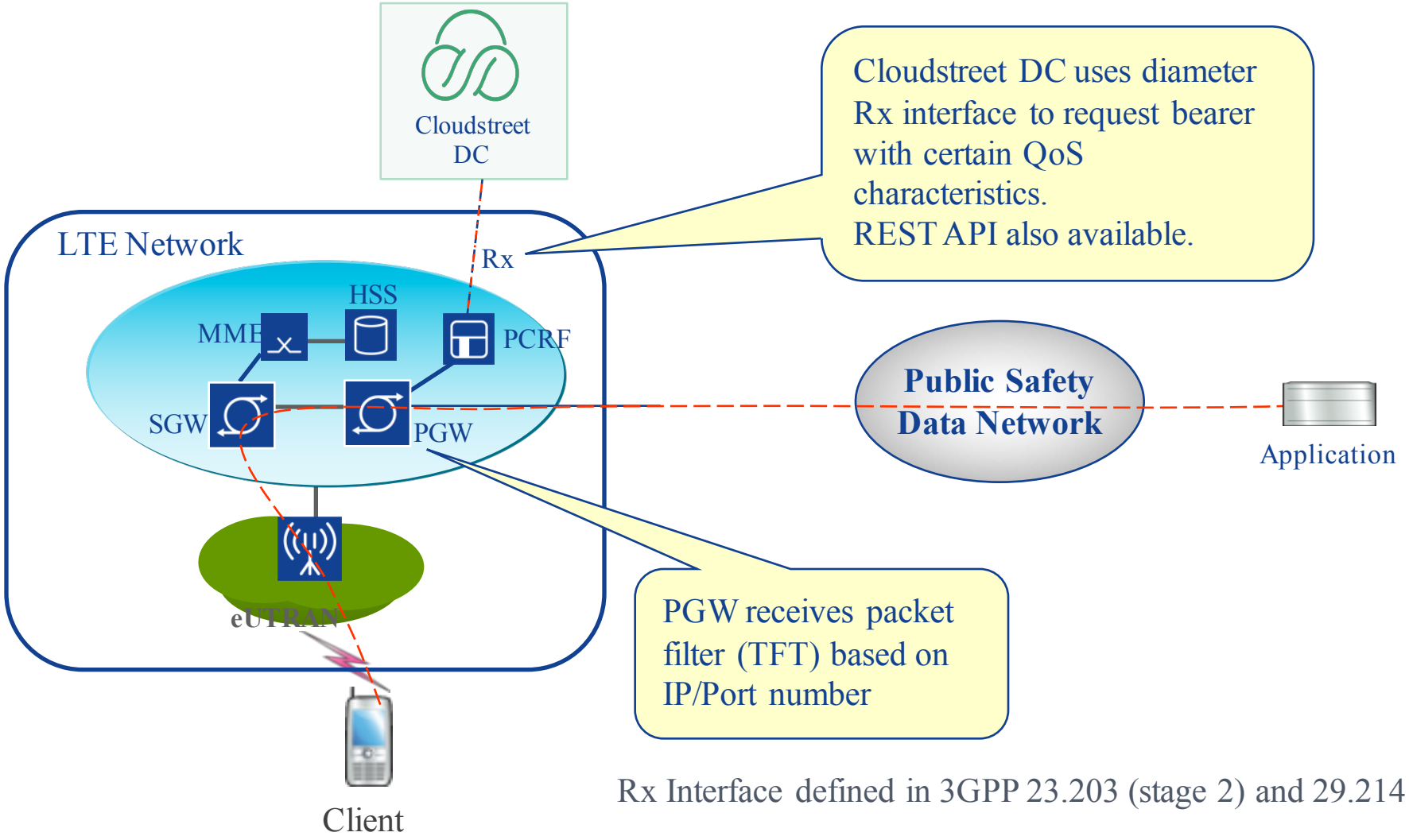
All figures and positions reflect market share, based on combined Nokia and Alcatel-Lucent 2014 year end results

NOKIA

Dynamic Policy Control Strategy

- Dynamic Policy Control must leverage open, standards-based interfaces
- Dynamic policy changes must take effect immediately
- Require minimal, if any, manual intervention

Dynamic Policy Control
Application Request For Dedicated Bearer

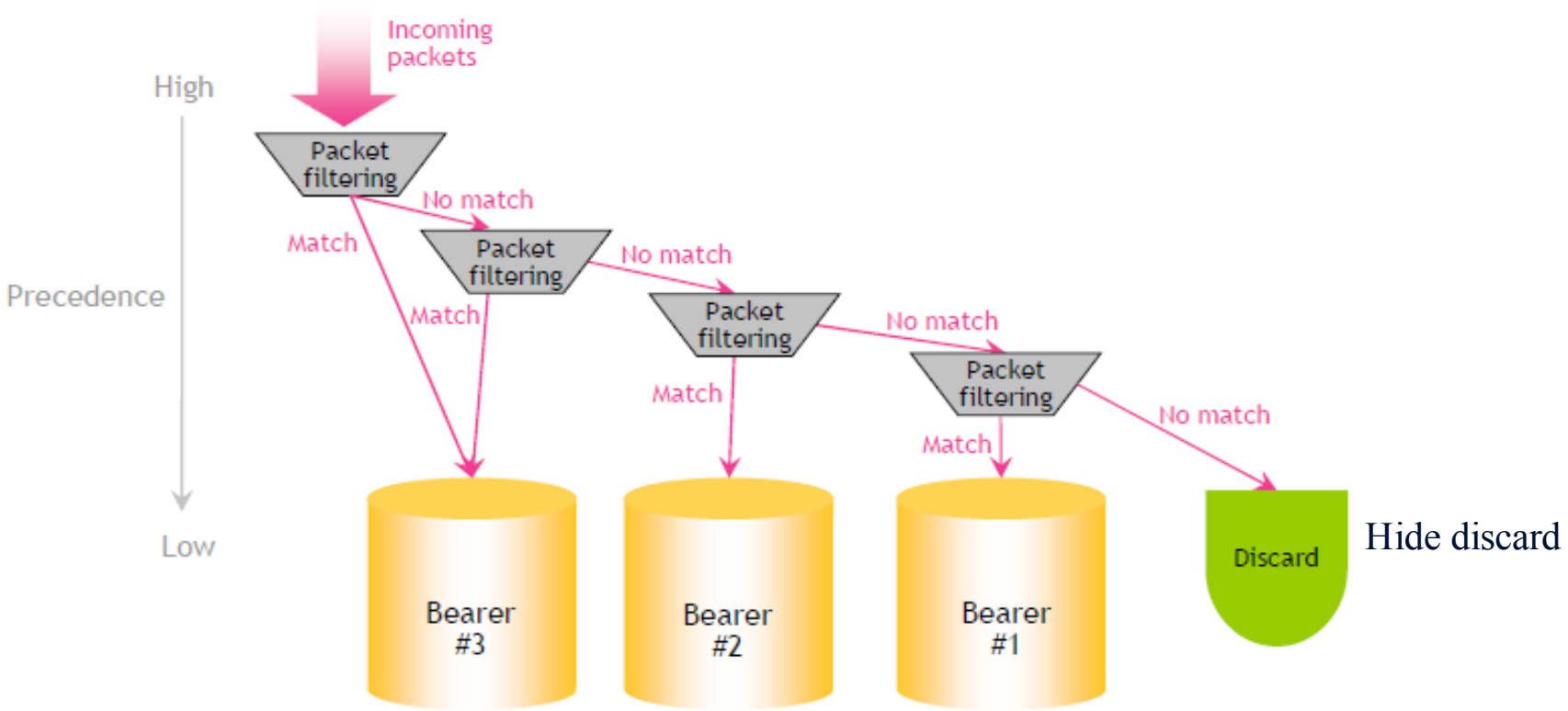


Rx Interface defined in 3GPP 23.203 (stage 2) and 29.214 (stage 3)

Dynamic Policy Control
Traffic Flow Template – Details

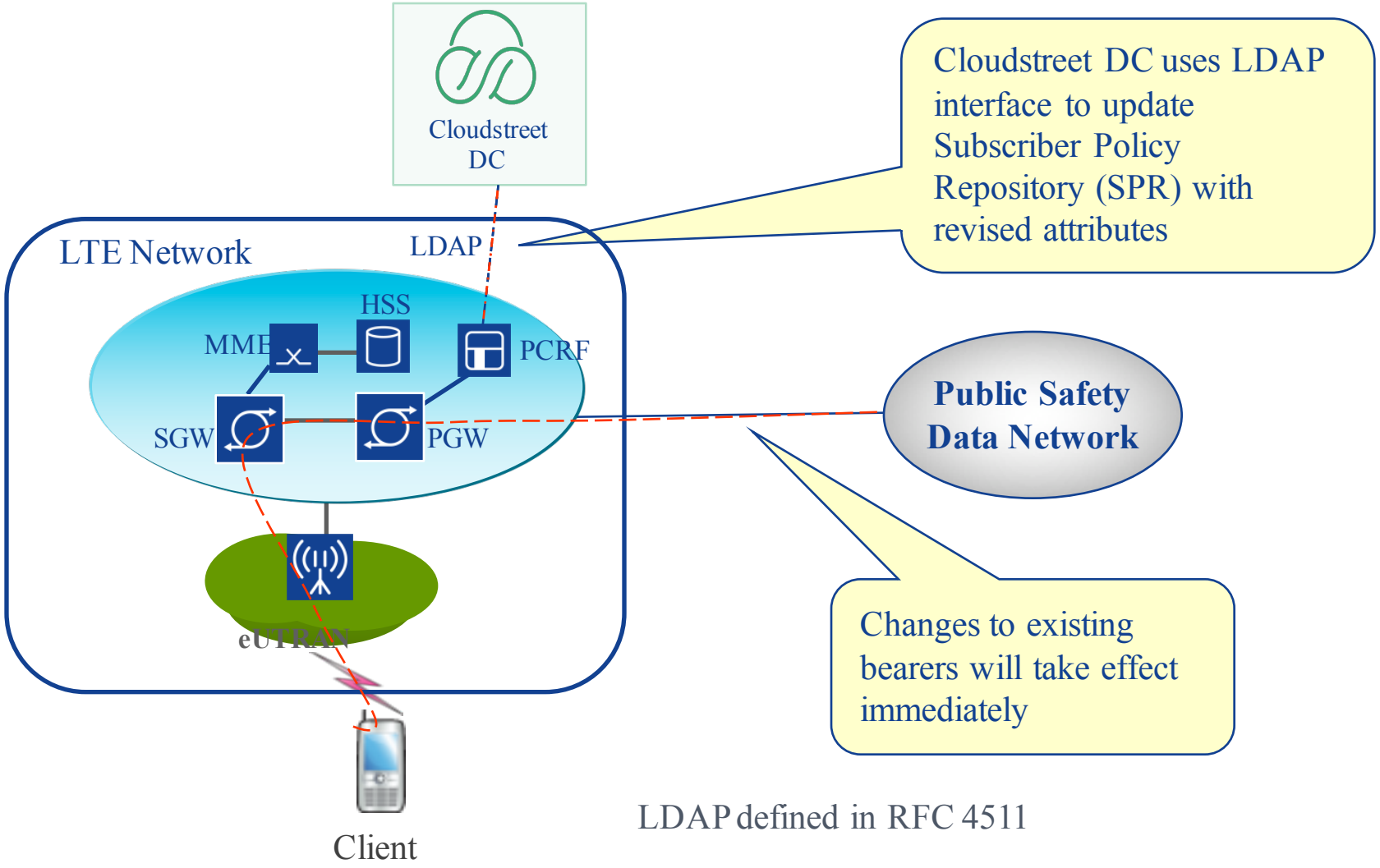
List of packet filters, each containing the following information:

- Identifier of the packet filter
- Precedence of the packet filter
- Direction (UL and DL)
- Filter itself (e.g. pattern matching on IP 5-tuple)



Hide discard

Dynamic Policy Control
Application Request For Updated User Profile/Role



LDAP defined in RFC 4511

NOKIA

Local Control for Public Safety

Chris Walton

PSCR Advanced Communications Research Group

This work is sponsored by:

Department of Homeland Security
Science & Technology Directorate
Office for Interoperability and Compatibility
(DHS S&T OIC)

PSCR

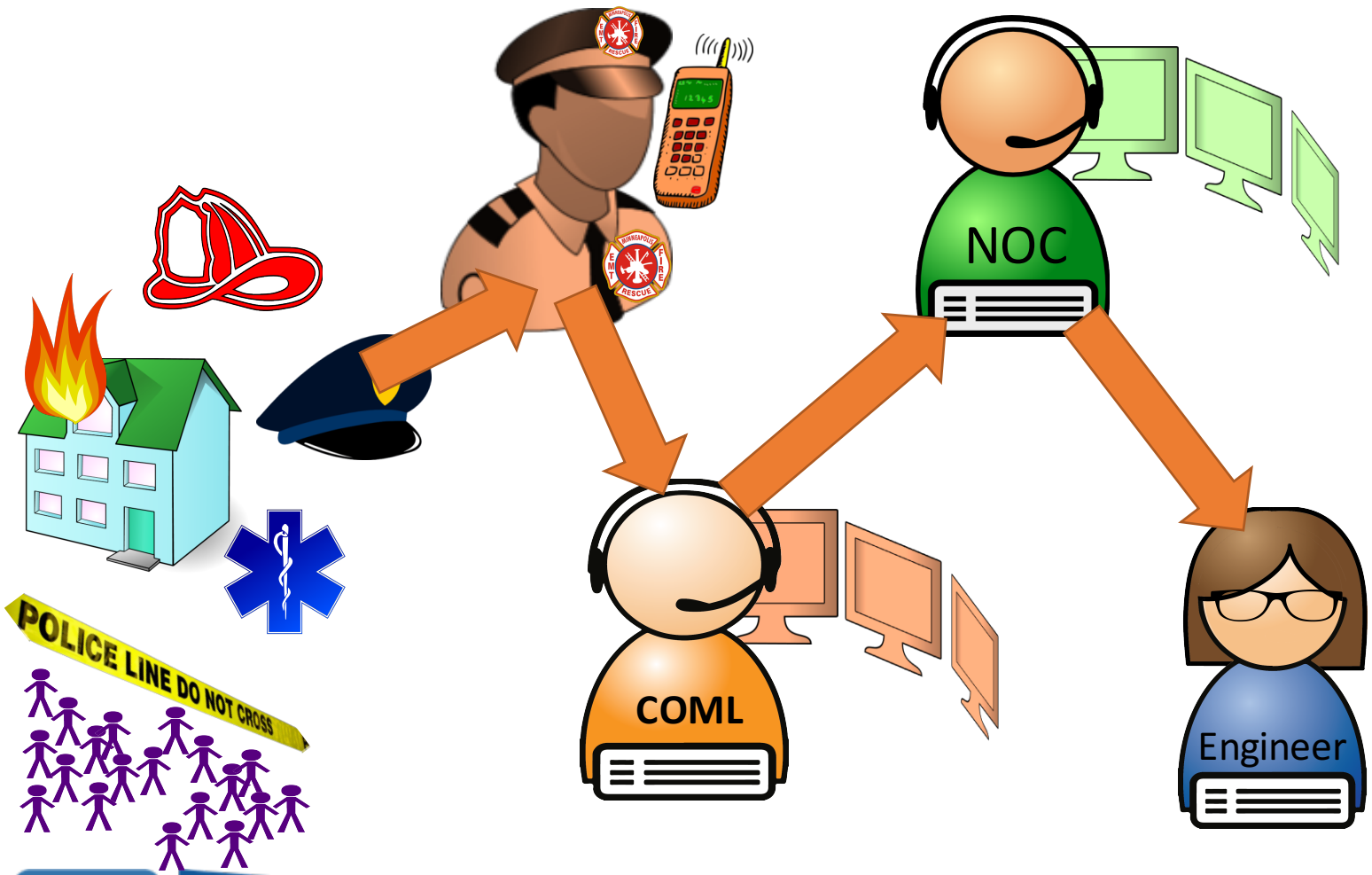
Disclaimer

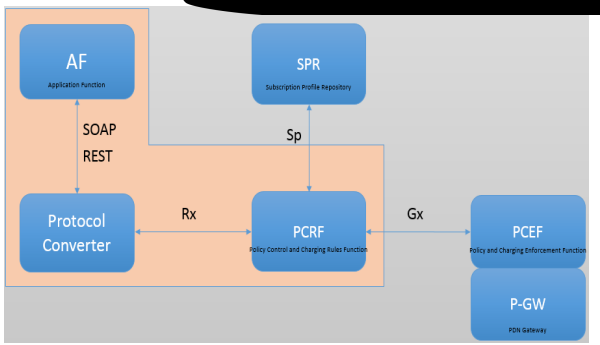
Please note, all information and data presented is preliminary/in-progress and subject to change. Conceptual prototypes developed in PSCR labs were created with proof of concept and research goals in mind, and are not being presented as a complete solution or final architecture for Local Control in broadband networks.

PSCR Local Control Research

- Last year, we stated we were going to develop a conceptual API and a prototype Local Control Server/Simulator that will enable QPP management requests to be generated from outside the LTE core …
- WE DID IT!
- Lessons Learned
- Next Steps

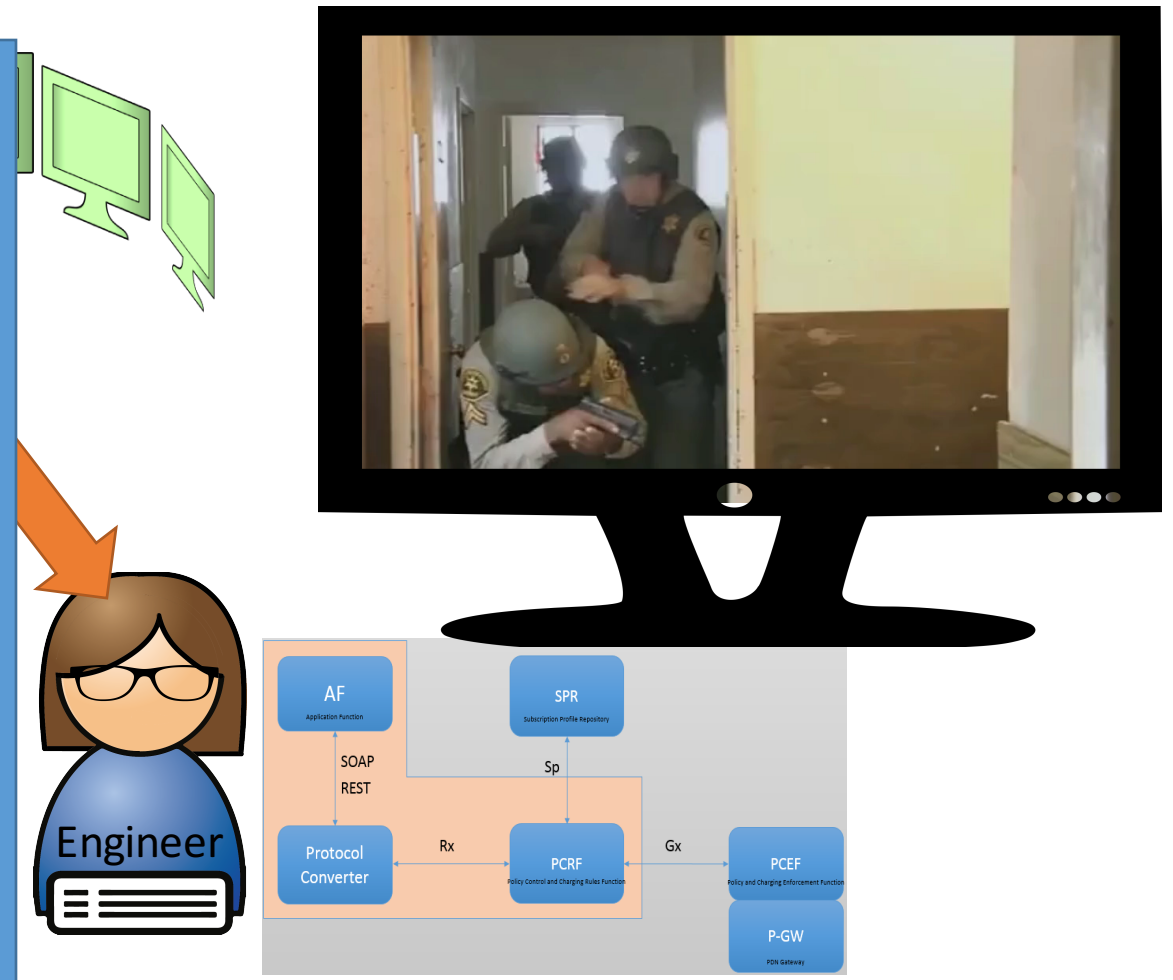
Static Control



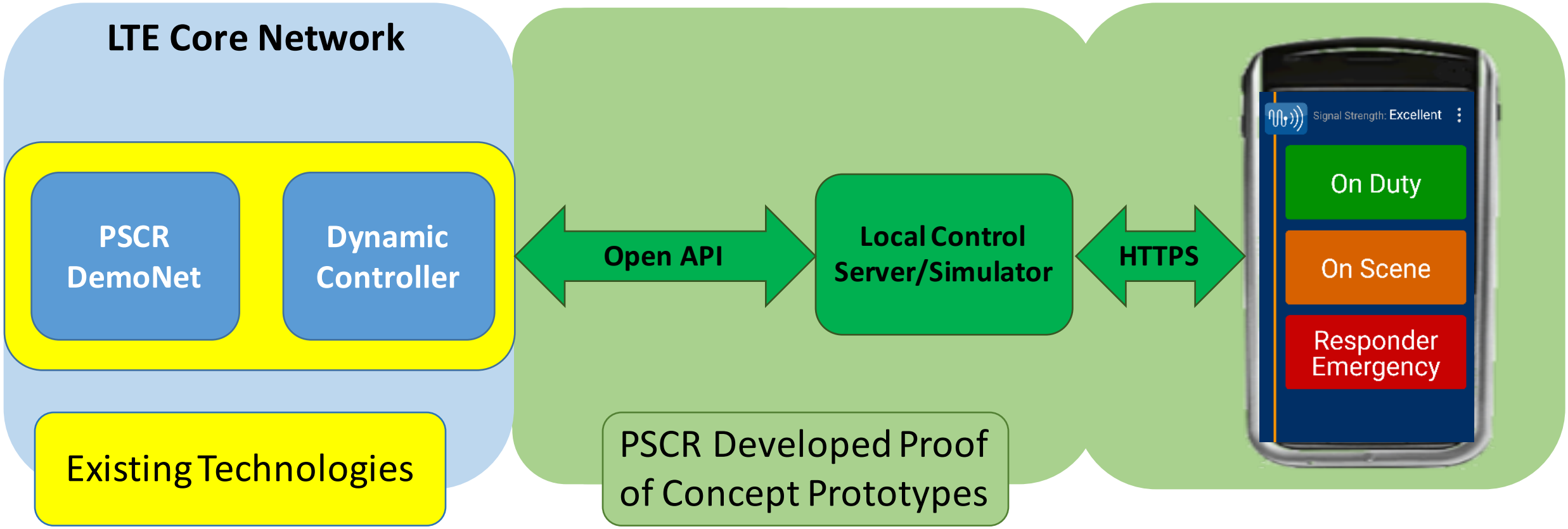


Static Control

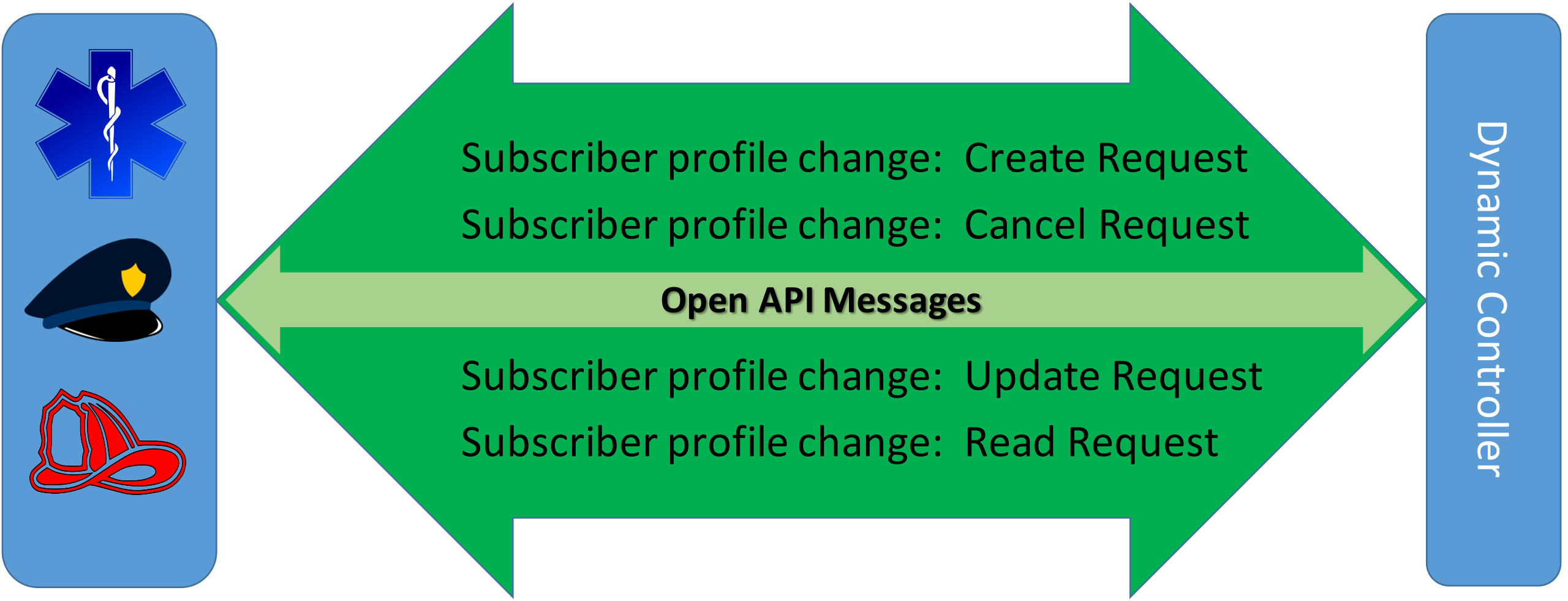
<AttributeAssignment DataType="http://www.net.org/2001/XMLSchoma#string" Attribute="Dia-Avp">GX||RAR||*avp[Charging-Rule-Install;grouped{avp[ChargingRuleDefinition;grouped{avp[ChargingRule-Name;value(secret_rule_3)]#avp[Flow-Information;grouped{*avp[Flow-Description;multiple(value(permit in 15 from 10.20.30.40/32 1-65535 to 10.20.30.40/32 1-65535))]}]#avp[Flow-Status;value(2)]#avp[Precedence;value(10)]#avp[QoS-Information;grouped{avp[Allocation-Retention-Priority;grouped{avp[Priority-Level;value(0)]#avp[PreemptionCapability;value(0)]#avp[Pre-emption-Vulnerability;value(0)]}]#avp[Guaranteed-Bitrate-DL;value(600000)]#avp[GuaranteedBitrateUL;value(000000)]#avp[Max-Requested-Bandwidth-DL;value(3000000)]#avp[Max-Requested-Bandwidth-UL;value(0000000)]#avp[QoS-ClassIdentifier;value(0)]}]}]#avp[Resource-AllocationNotification;value(0)]}]</AttributeAssignment>



Dynamic Control Concept



Open API: Moving Public Safety Information to the Broadband Network



Lesson 1: Get Public Safety Information into the Network

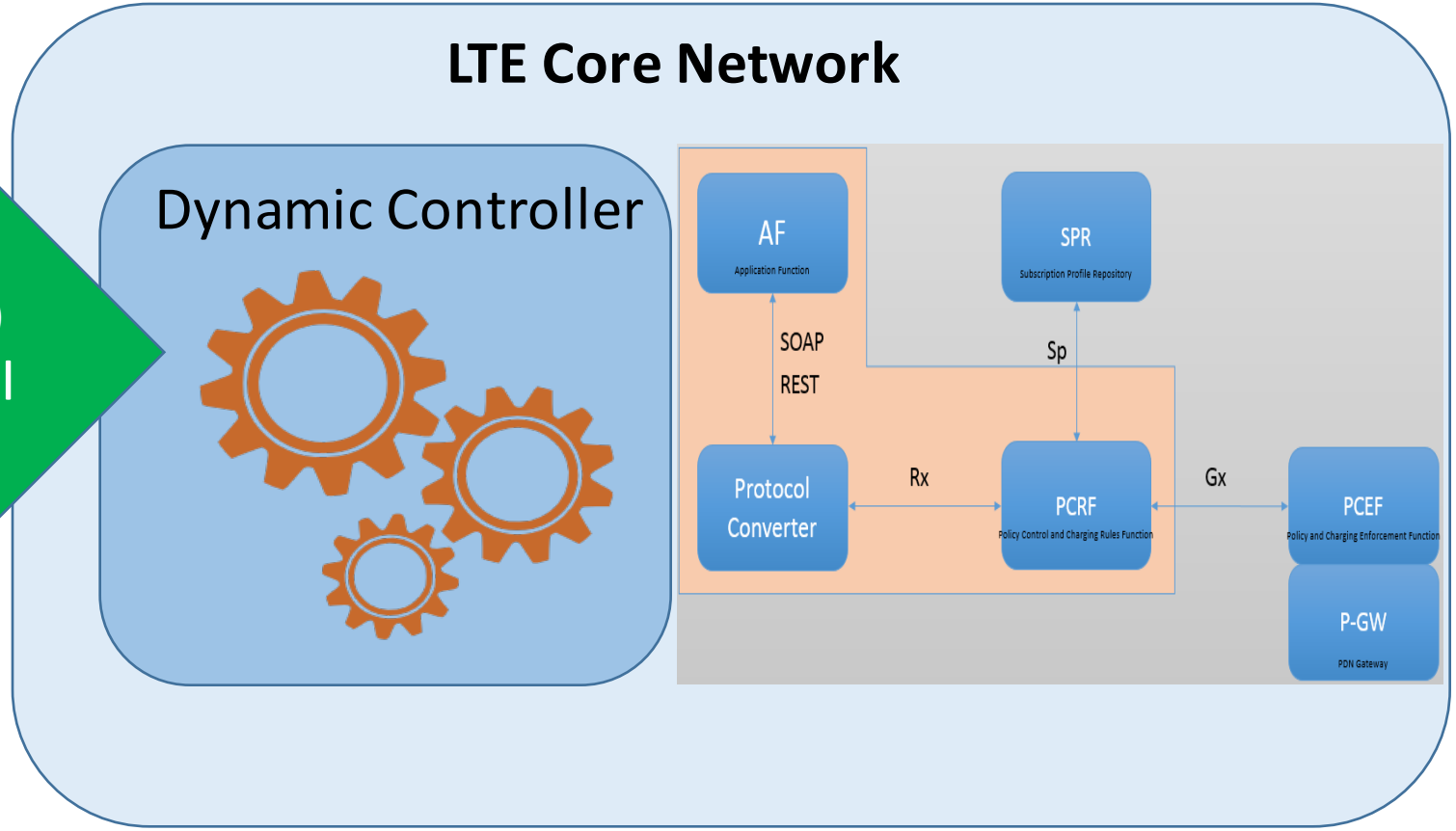
- Public Safety User/Group #1
  - Attribute #1
  - Attribute #2
  - ….
- Public Safety User/Group #2
  - Attribute #1
  - Attribute #2

:

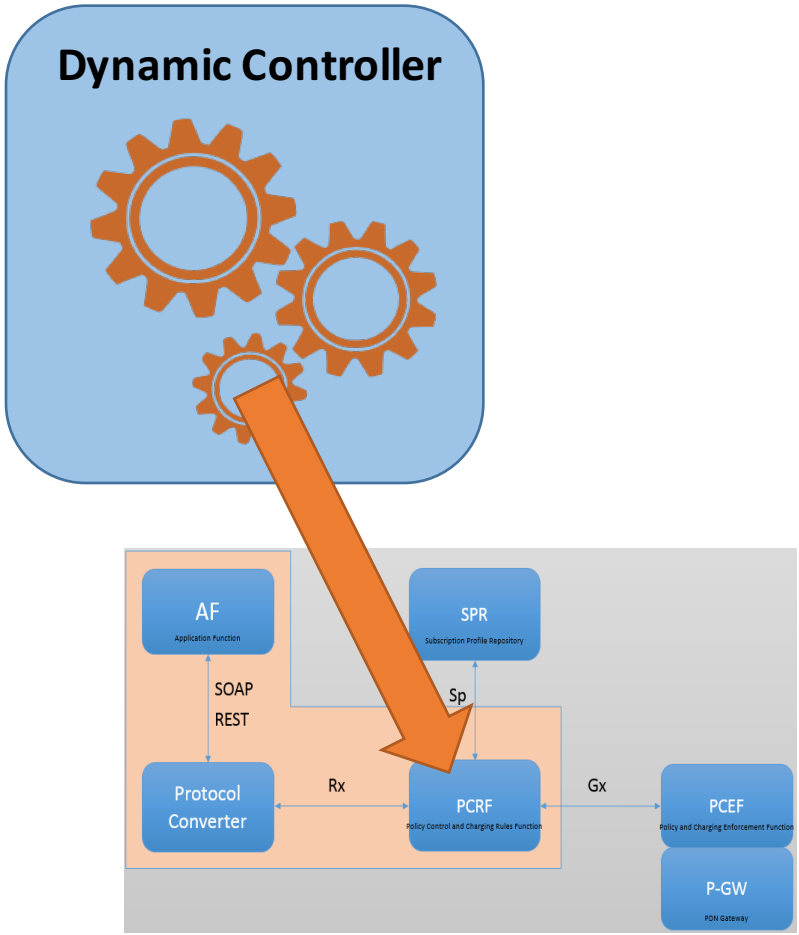
:

- Public Safety User/Group #n

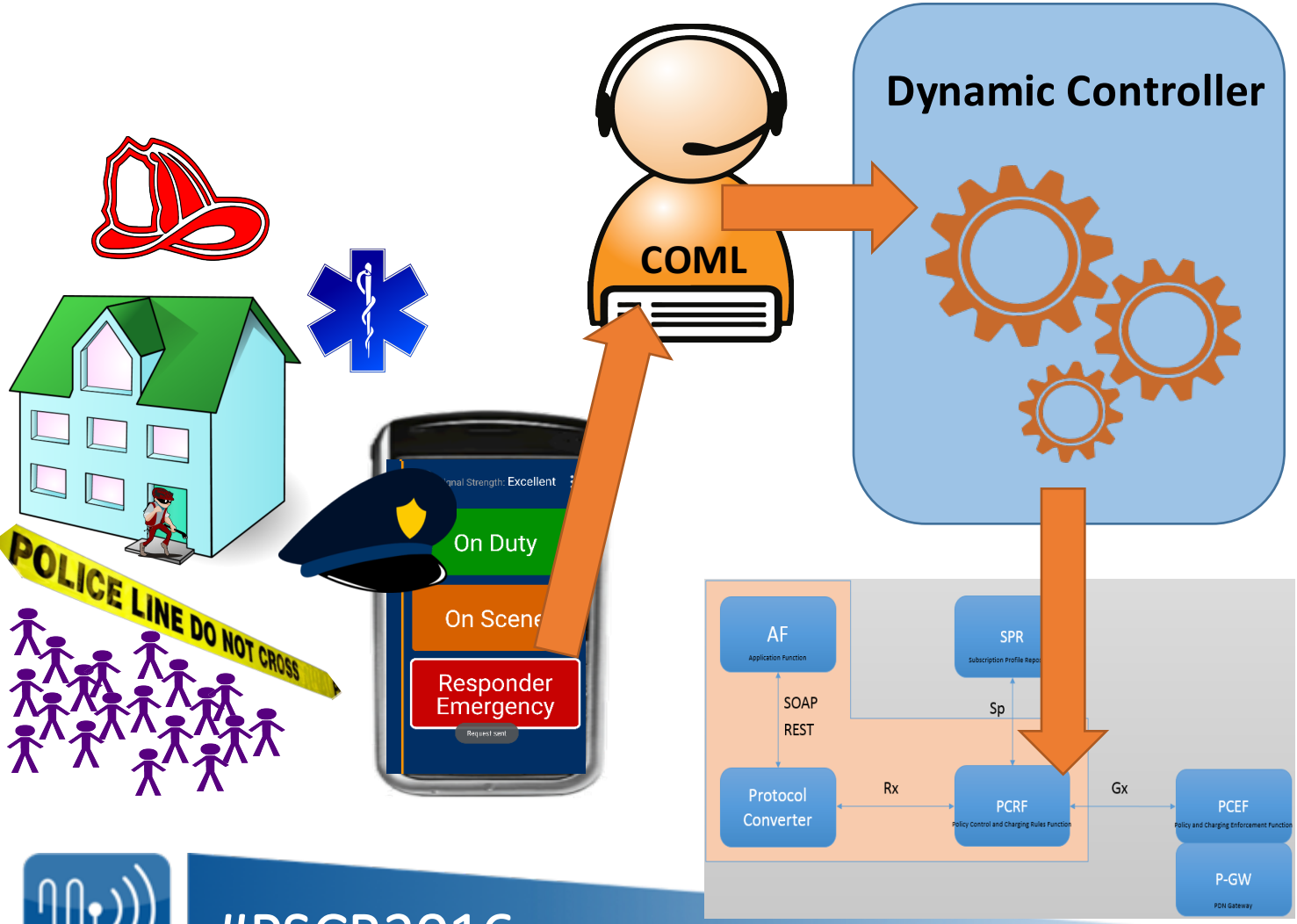
(Expanded)
Open API



Lesson 2: Automate Everything Possible



Lesson 3: You can't automate everything



PSCR's Path Forward in Local Control (2016)

PSCR and Local Control: Up to Now

- Investigation of Current Vender solutions and supporting technologies
  - Proprietary Implementations
  - REST
  - SOAP

- API Creation
  - Open the interface between a future dynamic controller function and PSAP based applications
  - Use standard enterprise messaging formats
  - Allow flow of Public Safety information into the dynamic controller so it can make intelligent QPP decisions
  - Controlled Override State

PSCR and Local Control: What is Next?

- Key Goals
  - Messaging that allows Public Safety user information to be sent to the broadband network
  - Make automatic and intelligent QPP decisions based on Public Safety user information

- Achieving the Goal
  - Expand API to include more Public Safety Information
  - Provide input into 3GPP standards work
  - Work closely with CRADA Partners
  - Remain an objective technical advisor