2016 Public Safety Broadband Stakeholder Meeting

Day 2

#PSCR2016

Steve Rader

NASA Center of Excellence for Collaborative Innovation (CoECI)

The Power of Crowd Based Challenges

NASA's Practical Toolkit for Open Innovation

NASA's Center of Excellence for Collaborative Innovation (CoECI)

Steve Rader

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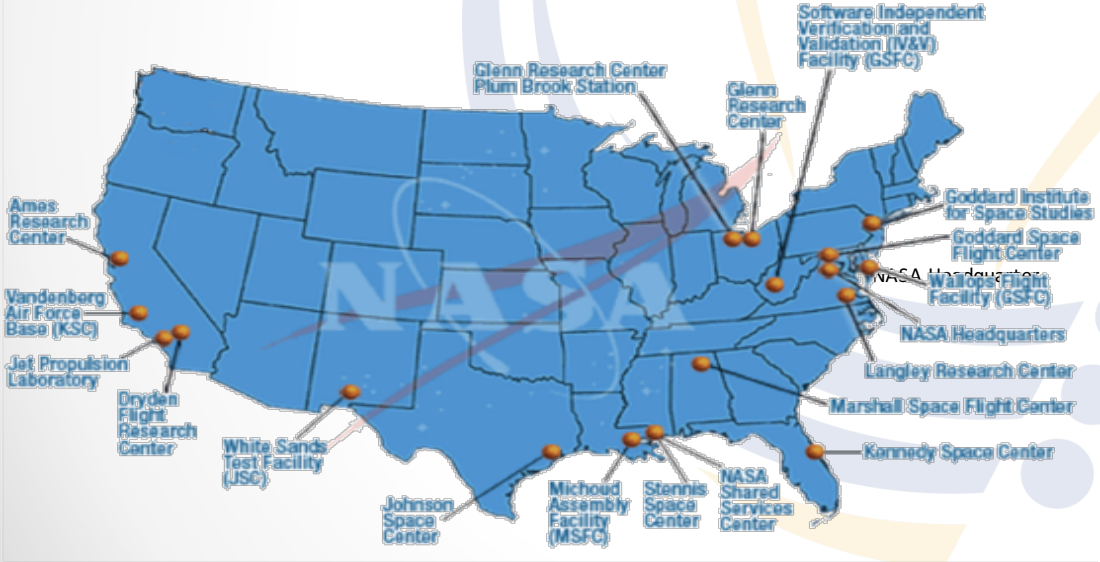
NASA's Center of Excellence for Collaborative Innovation (CoECI)

- The **Center of Excellence for Collaborative Innovation (CoECI)** was officially launched in November of 2011 at the request of the White House Office of Science and Technology Policy (OSTP).
- **CoECI** works across all of NASA and with other federal agencies to *infuse crowdsourcing methods as a set of available tools* to create innovative, efficient, and optimal solutions to real world problems.

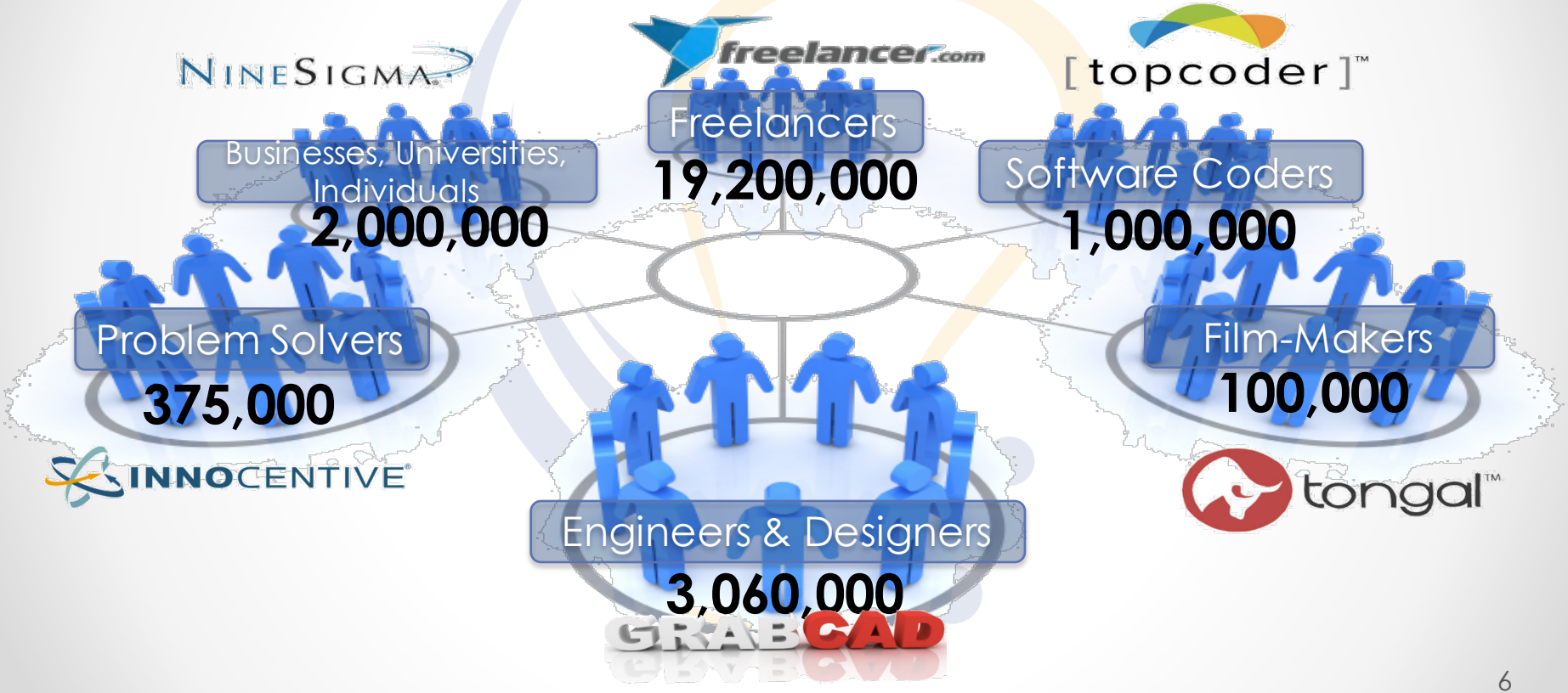


US Federal Agencies

	Duration	Prizes	Product	Participation
Centennial Challenges	Years	$M+	Tech Dev & Demo	
NTL Curated Community Challenges	Months	$1K-$100Ks	Ideas, Designs, Software	
Student-Focused Challenges	Months	Recognition Rewards	Vary in scope, Inspire, Educate, Partner	
Space Apps Challenge	Days/Weeks	Recognition	Software Apps	

Networks & Communities

Curated Communities



Curated Communities

Resources and Tools for Members

User Agreements for Privacy and Payment

Incentives for Members to Participate

Community Building & Communication

Curated communities are built around enabling people to pursue their passion and create a win-win for the company and its community members.

Mechanism for Handling IP Licensing and/or Transfer

They provide structure and incentives.

Communities do NOT like to be exploited!

Formulate the Problem Statement

A well formulated problem statement
(with good success criteria)

Design the Challenge

A well designed challenge
(including setting the right prize amount)

Execute the Challenge

Knowing how to do all of these steps really helps to mitigate the issues associated with this "too many solutions" problem.

Solution Filtering (optional)

Solution filtering mechanisms are offered by some platforms

Pick the Winner(s)
Evaluating

ALL of these steps can help to minimize the number of solutions you end up needing to evaluate.

Get Your Solution
IP licensing and/or transfer

Accessing the Crowd Using Challenges

Why Does The Crowd Contribute?

Earn Money (real or virtual)

Have Fun (or pass the time)

Socialize with Others

Multiple Incentives can often operate in parallel

Obtain Recognition or Prestige
(leaderboards, badges)

Do Good (altruism)

Learn Something New

Obtain Something Else

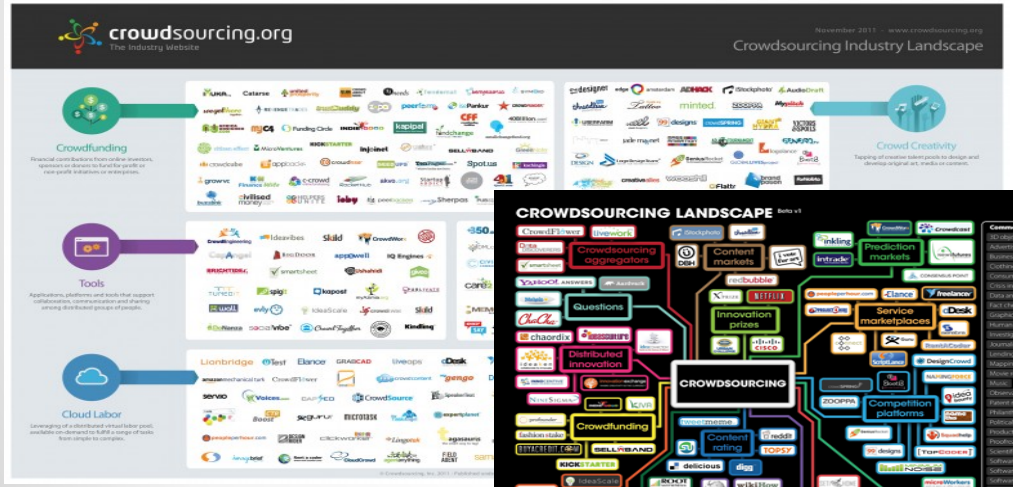
Create Self-Serving Resource

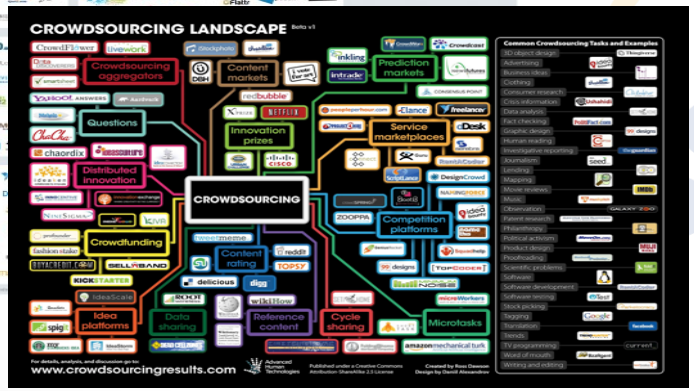
Gold Guts Good Glory

Crowdsourcing is Mainstream

While this may seem new, effective crowdsourcing is widely used across industry to access innovative solutions.

Providers





Users

P&G Procter & Gamble

Pfizer

SAMSUNG DISPLAY

Kraft

xerox

MATTEL

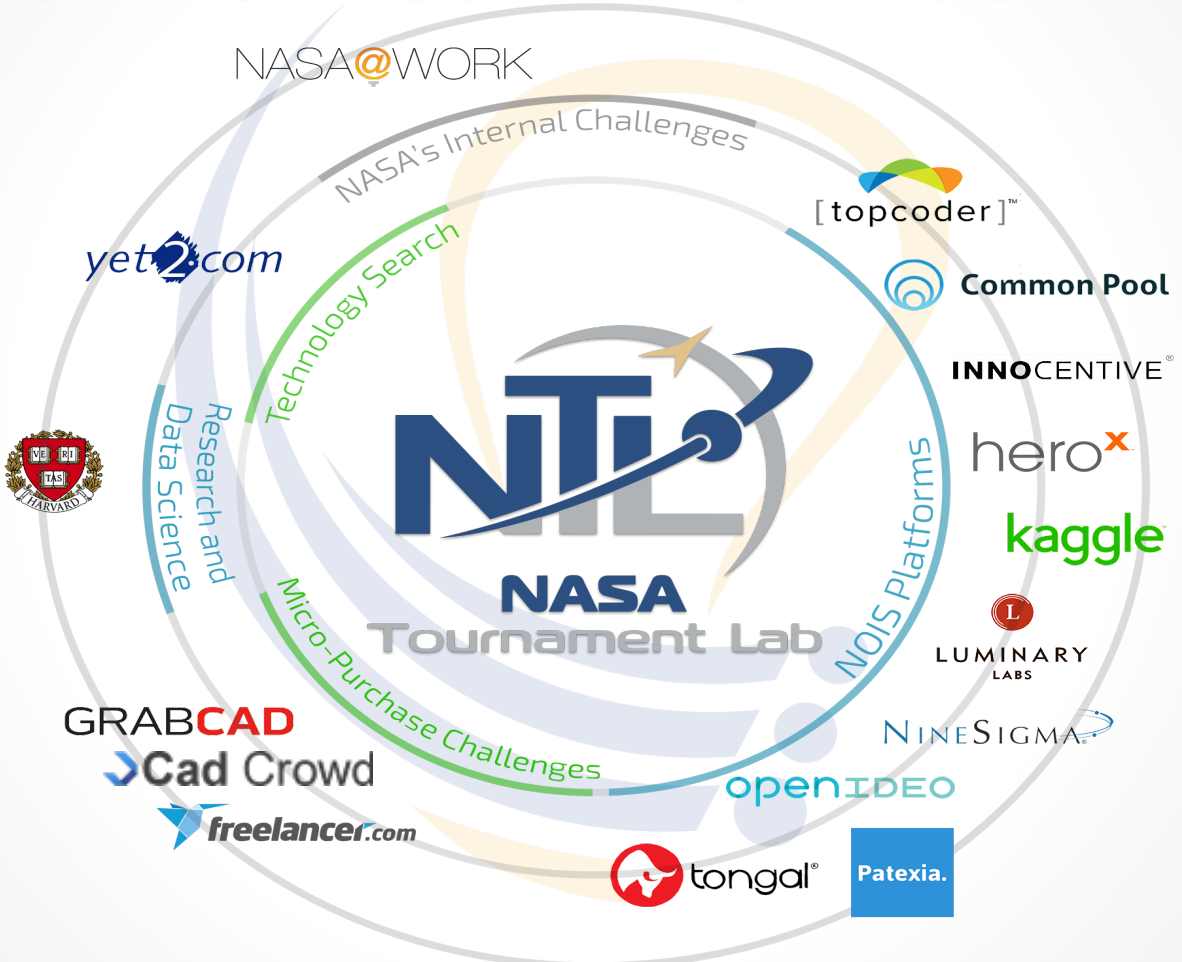
Johnson Controls

NASA

SIEMENS

The NASA Tournament Lab

CoECI's toolkit of contracts to use crowd-based challenges to accomplish various functions

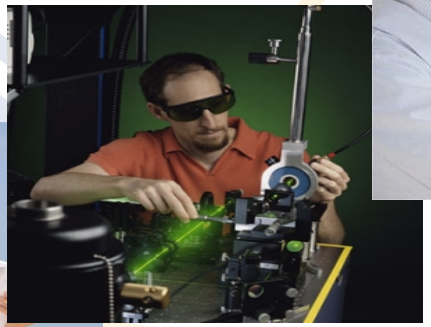


This Toolkit is available to ALL NASA Projects & Federal Agencies (via Inter-Agency Agreement)

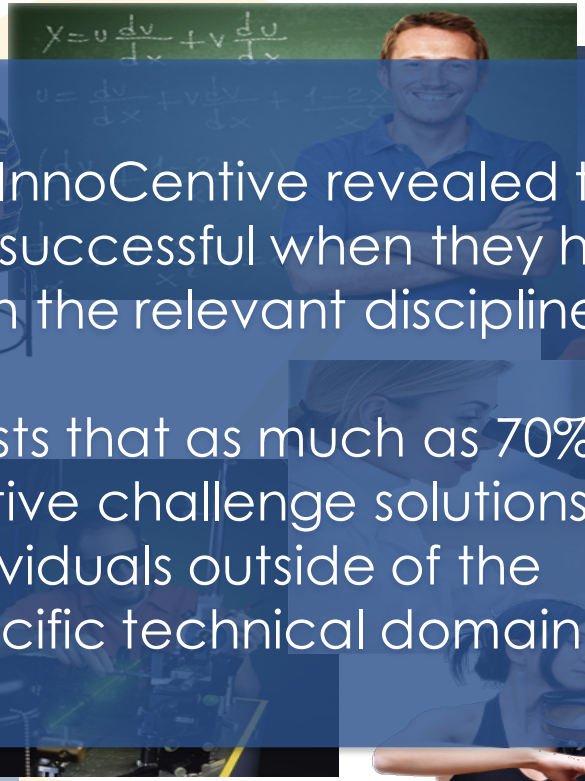
Innovation & Problem Solving Challenge Results

Using Challenges with Diverse Communities to develop unique and innovative approaches to unsolved problems

Diversity is the Key to Innovation



Diversity is the Key to Innovation



One MIT study into InnoCentive revealed that solvers were more successful when they had less experience in the relevant discipline.

Some data suggests that as much as 70% of successful InnoCentive challenge solutions are solved by individuals outside of the challenge's specific technical domain.

Roche

Diagnostics

Swiss company with 80,000 employees, Roche operates in 150 countries and has R&D operations in Europe, North America and Asia-Pacific ($8B+ in R&D annually)

Roche is a world leader in medical diagnostics.

Roche ran an InnoCentive challenge:

A $20,000 prize to develop a better means of measurement in an automated chemical analyzer

"In 60 days, Roche was able to **solve a problem** that it and its partner have been tinkering with and optimizing for the **last 15 years.** The solutions provided actually mirrored the entire history of Roche's R&D programme. **All of the solutions Roche had tried** came in. "

Julian Birkinshaw, MLabnotes, University of London Business School

InnoCentive: Current Industry Challenges

Seeking New Technologies for Denture Adhesives

Masking Salty Taste

Seeking A New Skin Staining Dye

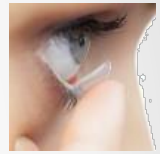
Bonding of Polymeric Materials without Adhesives

Seeking Safe Drug-like Small Organic Molecules for Human Use with Negligible Biological Effects

General Fusion Challenge: Fast Current Switch in Plasma Device

Enel Challenge: Portable Communication System for Tunnels and Confined Spaces

Increased Oxygen Permeability of Non-Silicone Hydrogels



Detecting the Movement of Soils (Internal Erosion) Within Earthen Dams, Canals, Levees, and their Foundations

Accelerated Application of a Super-Insulating Coating

Quantifying Drift Invertebrates in River and Estuary Systems

Portable Roof Damage Detection

InnoCentive: Current Industry Challenges

HeroX	30 open challenges (50+ total)	38M members
NineSigma	27 open challenges (2500+ total)	2M members
InnoCentive	23 open challenges (2000+ total)	375K members
The Common Pool	14 open challenges (30+ total)	100K members
Luminary Labs	11 open challenges (15+ total)	100K members
OpenIDEO	6 open challenges (40+ total)	85K members
Patexia	1 open challenge (170+ total)	12K members

Over 100 government and industry innovation challenges are in progress right now*.

*As of May 13, 2016

MARS BALANCE MASS

Challenge -
Ideas to find dual purpose for balance mass that is jettisoned from Mars landers to balance the aircraft during entry and landing

Total Cost to NASA
$50,000

$2 Challenge
Award 5,000

Concept for Future Lander Designs

INNOCENTIVE

NTL NASA Tournament Lab

Center of Excellence for Collaborative Innovation

Results

- Winner: Concept for ionospheric and atmospheric analysis of Mars via tracer element release
- Honorable Mention: Concept to study Mars winds using deployable micro-balloons

Algorithm & Software Challenge Results

Leverage Competition to Optimize Complex Algorithmic Problems or Build an App

Winning solution performs 120x faster

Improve on NIH MegaBlast algorithm for nucleotide sequence alignment

The Challenge

Improve on NIH MegaBlast algorithm for nucleotide sequence alignment

4.3 hours	**47 min.**	**16 sec.**
$2M+	$120K	$6K Prize
Multi-year	1 year	14 Day
Development	Development	Challenge

Active Software & Algorithm Contests

TopCoder Contests

GE - Customer Training Management Tool Wireframe Challenge (UX)

PepsiCo - Tasty Rewards Mobile Design Concepts Challenge (Conceptual Design)

John Hancock - Game Design Challenge (Conceptual Design)

Living Progress - Disabled Lifestyle Planning - Desktop App Wireframes Challenge (UX)

IBM NPS - Response REST API (Coding)

The Gates Foundation - Binary to Text Software Performance Challenge in C (Algorithm)

Kaggle Contests

Draper Satellite Image Chronology

State Farm Distracted Driver Detection

Expedia Hotel Recommendations

Avito Duplicate Ads Detection

Facebook V: Predicting Check Ins

Titanic: Machine Learning from Disaster

Facial Keypoints Detection

Active Software & Algorithm Contests

Topcoder 80 open challenges (40,000+ Total) 1M members

23 Design
57 Development
2 Data Science

Kaggle 16 open challenges (215 total) 300K members

Almost 100 government and industry algorithm & software challenges are in progress right now*.

*As of May 13, 2016

ASTEROID DATA HUNTER

Challenge - Create an algorithm to detect moving objects using Catalina Sky Survey (CSS) data

Total Cost to NASA $186,980

Challenge Award $71,370

15% Improvement

[topcoder]™

NASA Tournament Lab

Center of Excellence for Collaborative Innovation

Results

- 15% improvement over current methods
- Open Source App available for download on any laptop (9000 downloads as of 3/2016)
- Maintained by Planetary Resources, Inc.

Using Competitions for Software Development

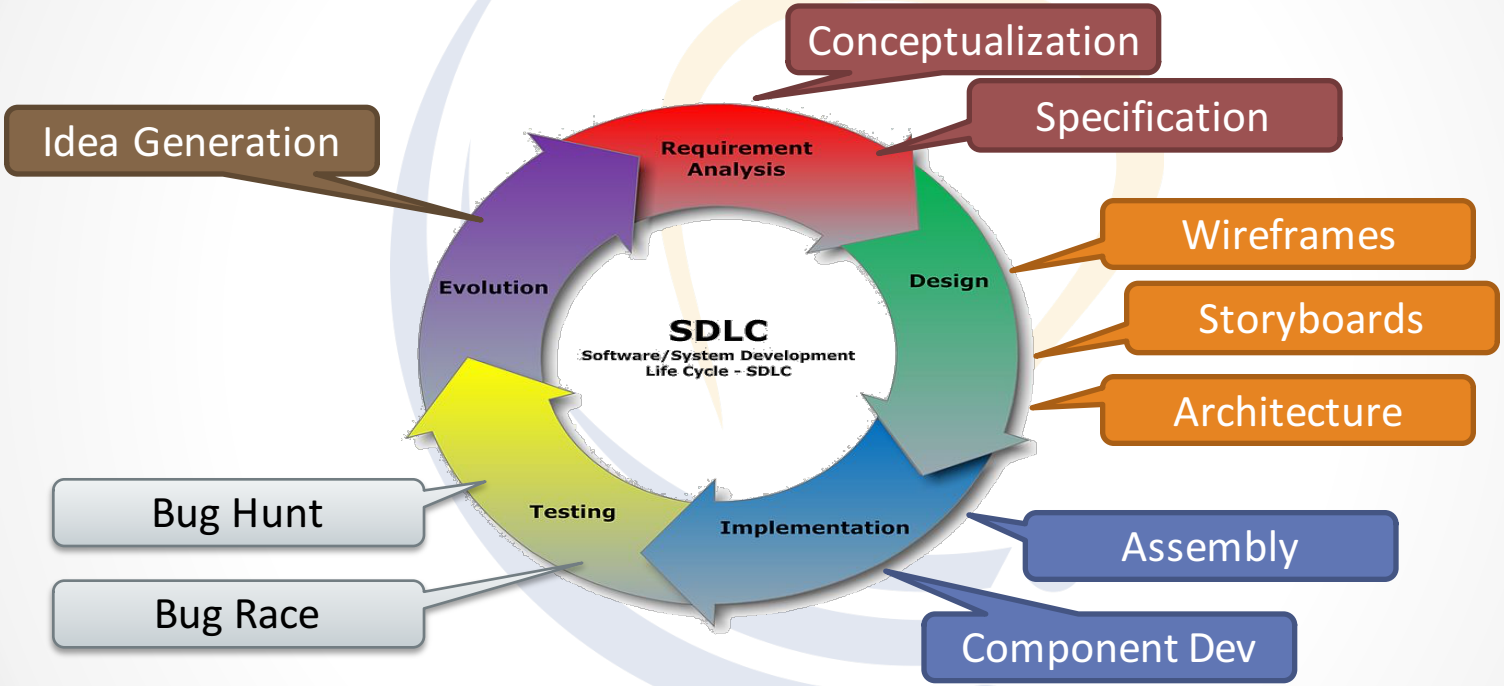


Image Credit: Wikipedia, *Systems development life-cycle*, http://en.wikipedia.org/wiki/Systems_development_life-cycle (as of Mar. 27, 2013, 05:48 GMT).

Source: [topcoder]™

ISS FOOD INTAKE TRACKER

Challenge - Create an iPad application for ISS crewmembers to easily enter their dietary intake

Total Cost to NASA $144,600

Challenge Award $36,288

More Detailed Food Log plus Bar Code Scan

[topcoder]™

NASA Tournament Lab

Center of Excellence for Collaborative Innovation

Results

- Will provide NASA scientists a better understanding of nutrition to help mitigate negative physiological effects of spaceflight
- Final updates in work for upload to ISS for operational use

Micro-Purchase Design Challenges

Leveraging Low Cost Competition to Access Diverse, Innovative Design Space

Cad Crowd

GRABCAD

freelancer.com

GRABCAD NASA Handrail Clamp Assembly

NASA In-Space Manufacturing Group (ISS 3D Printer) sponsored NASA's first GrabCAD challenge to develop a

3D printable ISS Handrail Clamp.

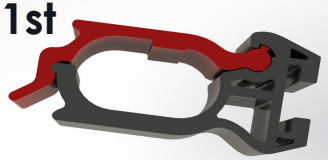
Prize: **$2000** (Total NASA Cost $3000)
30 Day GrabCAD Challenge

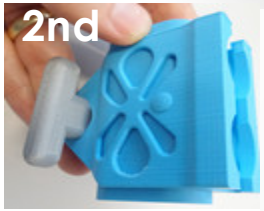
GrabCAD is a community of over **2.8M** Mechanical Engineers and Designers

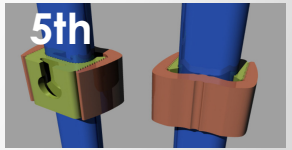
Challenge Resulted in **492 submissions**.
NASA awarded the top 5
(and received the IP for all 5 designs)

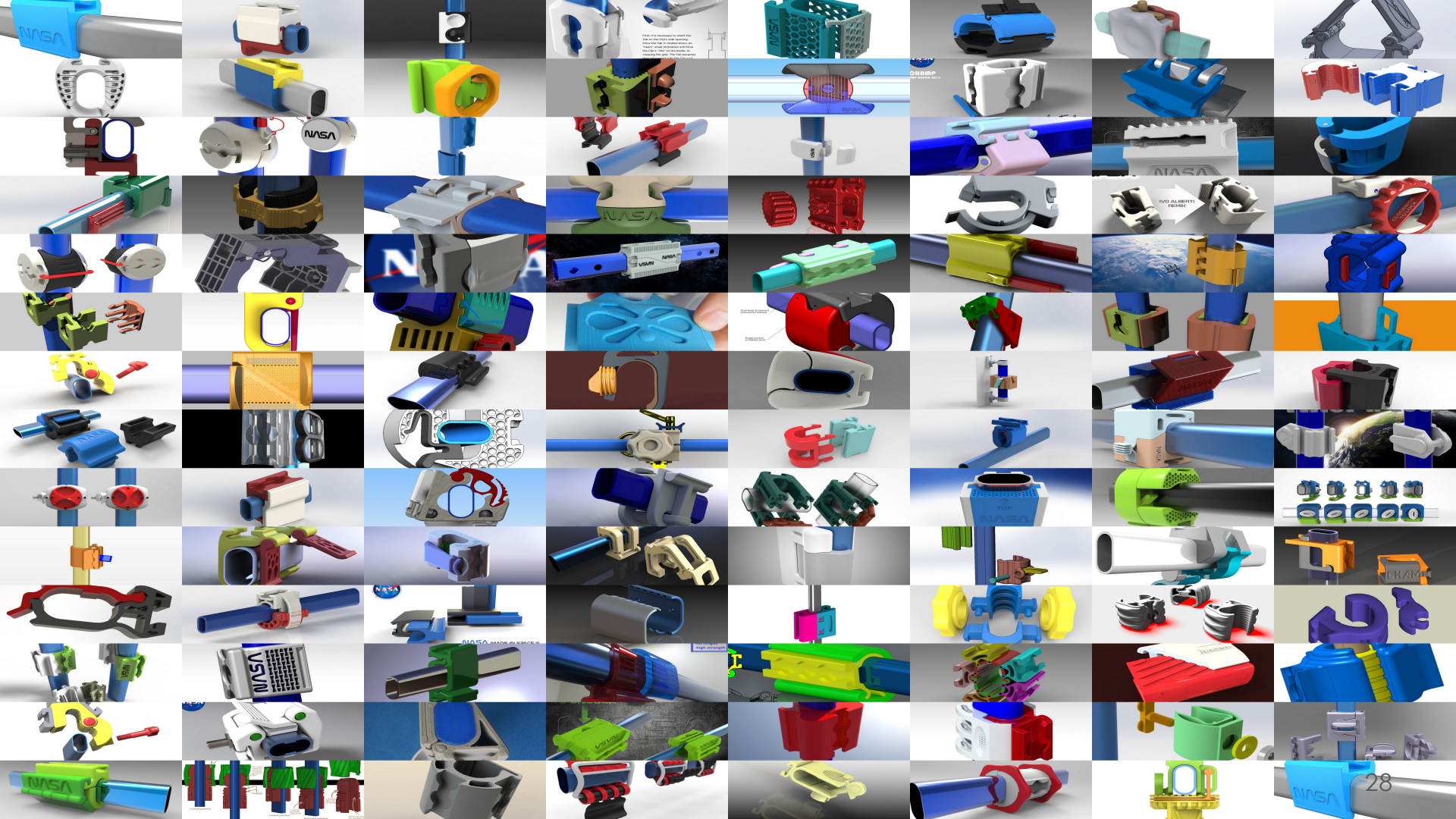
Original Handrail Clamp

Winning Designs








NASA
VSVM

Robonaut Sim Tools CAD Challenge

The Robonaut Project needed **3D models** of 14 pieces to test hardware.

Posted 14, 10-day Freelancer.com challenges:

- 5 $50 Challenges
- 5 $75 Challenges
- 3 $100 Challenges
- 1 $150 Challenge

2.3% challenge overhead w/ a "only pay if there's a winner" option

Received almost **300 submissions** across all 14 challenges.

Spent $1,100 (NASA estimate $13,600 – Demonstrated over **85% savings** over traditional methods)

Smartwatch App Conceptualization Challenge

Challenge to develop a user interface concept for a **smartwatch app** that integrated ISS crew tool features from the crew timeline, communications status, caution and warning, and timers.

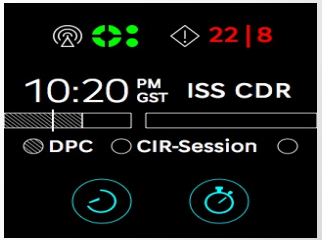
Posted **a 30 day Freelancer.com challenge** with a $1500 prize (total cost $1535).

Received **245 submissions**.

Winning Concept from UX Specialists from Canada.

Current concept is being developed into an **actual application** (with data simulator) by a Freelancer for **under $2700**.

Challenge got **significant worldwide news coverage** (CNET, Time, Wired, Bloomberg, Forbes, etc (over 50 news outlets)



Active Design & Multimedia Contests

GrabCAD Contests

Sense the Pressure Challenge by Microtechnologies

Modular Prosthetic Terminal Device Challenge by Enable Community Foundation

Da Vinci Gear Challenge by Stratasys Education

Connect the Ship Challenge by Asciano Limited

CAD Crowd Contests

Design a stand for a virtual Reality Headset

ATG's Automotive Concepts 2016 - 2

Freelancer Contests

UI/UX of IOS & android mobile app

YouTube Ad

Animate a video lesson

Tongal Contests

Lanovo Day in the Life Video

Lego Stop Motion Music Video

Westin Hotels Video

Allstate Host Advantage Video

Active Design & Multimedia Contests

GrabCAD	4 challenges (160+ Total)	3M members
CAD Crowd	5 challenges (45+ Total)	10K members
Freelancer	1077 challenges (9M+ Total)	19M members
Tongal	47 challenges (500+ Total)	100K members

Over 1100 government and industry design & multimedia challenges are in progress right now*.

*As of May 13, 2016

CoECI's Crowdsourcing Experience

223 Challenges Total Completed or in Progress (with 10 more in formulation)

INNOCENTIVE
- 21 Innovation:
  - 7 Ideation*
  - 13 Theoretical
  - 1 Reduction to Practice
- 1 Video

*3 USAID

NINESIGMA
- 2 Innovation

hero^x
- 1 Innovation
- 1 Video

[topcoder]™
- 16 Algorithms*
- 18 Software** ***
- 5 Ideation
- 4 Graphics

*USPTO, USAID, 2 EPA
**2 CMS, OPM, DOE
*** APPLAUSE

yet2.com
- 9 Tech Surveys*

*1 EPA

NASA@WORK
- 116 Challenges

tongal™
- 3 Videos

GRABCAD
- 4 Eng. Design*

*2 VA

freelancer.com
- 3 Ideation
- 15 CAD Modeling
- 6 Graphics

Plus 1 SW dev task and 30 Architecture tasks

Conclusion

Crowdsourcing is here.

It is established and very effective.

How are you going to leverage it on your project?

SNAPSHOT: Advanced Positioning

Using Improved Timing within an LTE Network

David Howe, NIST Physical Measurement Laboratory (PML)/PSCR

PSCR

NIST 2016 PSCR Public Safety Broadband Stakeholder Meeting

SNAPSHOT:

Advanced Positioning –

Using Improved Timing within an LTE Network

June 8, 2016

Time and Frequency Metrology
Physics Lab
NIST, Boulder, CO 80305
dhowe@nist.gov

http://www.nist.gov/ctl/pscr/nist-public-safety-broadband-stakeholder-meeting.cfm

Commercial companies may be mentioned. No endorsement is implied.

SNAPSHOT: Advanced Positioning – Using Improved Timing within an LTE Network

NIST

Organization of talk

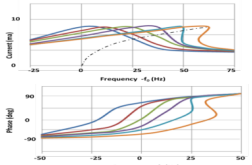
- Introduction
- Statement of Goal: Shared *RF timing system* with *1 m*, *3D* uncertainty in a urban building or high-rise *without comm's*
- Inverse-GPS, eg., event-detection-location
- Technical Criteria met with Ultra Wide Band RF (UWB) shared in 4G LTE
- Techniques: Observed Time Difference Of Arrival (OTDOA), Angle of Arrival (AOA), Frequency Difference of Arrival (FDOA), Time of Arrival (TOA), 4 sites
- OTDOA uncertainty simulations

Future considerations

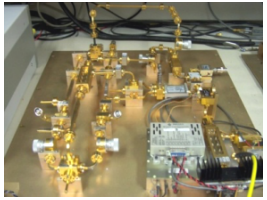
Who are we?

- **NIST Time and Frequency Metrology**
  - Atomic Clock research and development
  - GPS Timekeeping, Synchronization, Measurements and Calibrations, PNT
  - Civil Services, WWVB, ITS, Power Grid, SEC, NASA DSN
- **Special Measurements, Tests, Calibrations:**
  - Collaborate with many commercial co's, eg., Keysight, Rhode, Anritsu, Microsemi, etc.
  - Industrial partners, eg., Raytheon, Lockheed, etc.
  - Government partners: AF Space Command, ONR, DARPA, NSA, CIA, THz Electronics

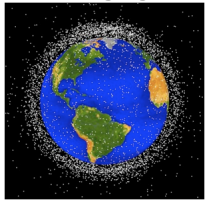
Measurements/Statistics



100 GHz Dual Interferometer

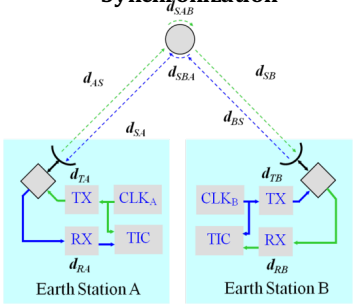


Hi-resolution imaging

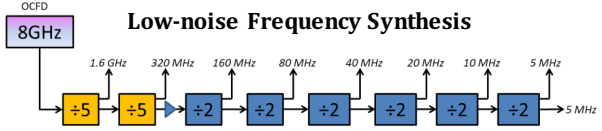


UAS & Satellite Formation Flying

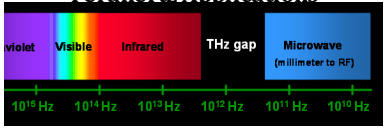
Two-way Satellite Synchronization



Low-noise Frequency Synthesis



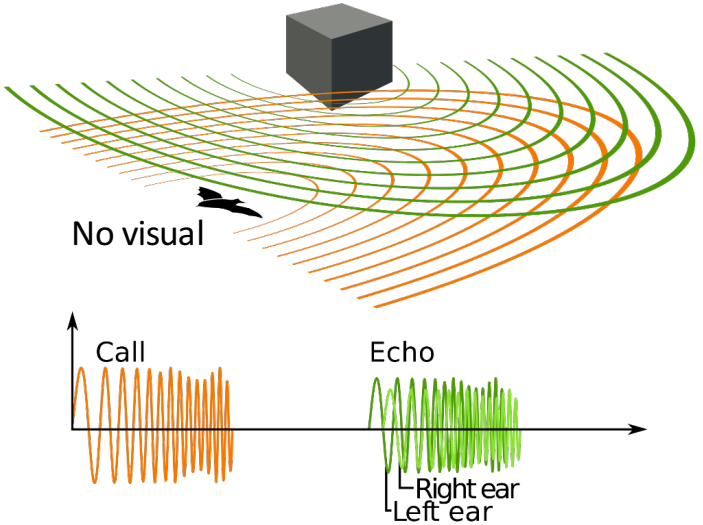
Terahertz Applications



What are we doing?
Provide an assessment of LBS technologies to guide specifications

Some natural location techniques

- Echolation: bats dolphins porpoises (Sonar)
  - Echolocation in Bats and Dolphins 1st Edition by Jeanette A. Thomas (Editor), Cynthia F. Moss (Editor), Marianne Vater (Editor)
- Visual location heat-recognition
  - Infrared location http://www.cs.columbia.edu/~hgs/research/projects/stamptag/Final/clean_index.html



This part of the study is to meet the following criteria:

- **Shared *RF timing system* with *1 m, 3D* real-time uncertainty in urban buildings or high-rises *without communications***

What do we mean by:

Shared –

Can be used with existing communications without interference

Radio-location system –

Example Techniques: OTDOA, FDOA, TOA, AOA, 4 sites

No reliance on UE two-way comms –

Example: GPS event-detection-location

1 m, 3D uncertainty, real-time –

High accuracy, no latency

Urban buildings or high-rises –

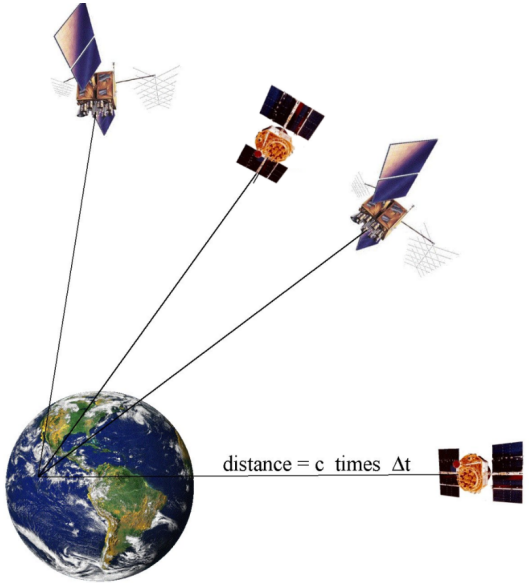
Multipath resistance

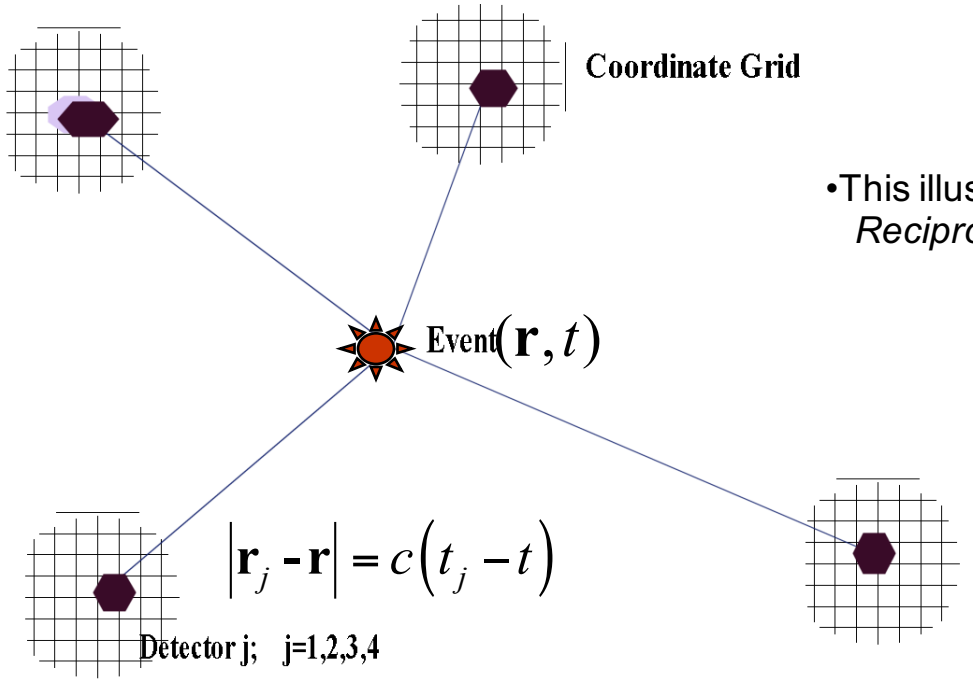
Minimize UE complexity and power draw –

How can we have no reliance on UE two-way comms?

Example (of OTDOA): GPS event-detection-location

A prime example is the GPS nuclear surveillance system,
with synchronized clocks at the detectors: one "event" or transmitter,
with multiple detectors which are sensors/receivers on GPS satellites.

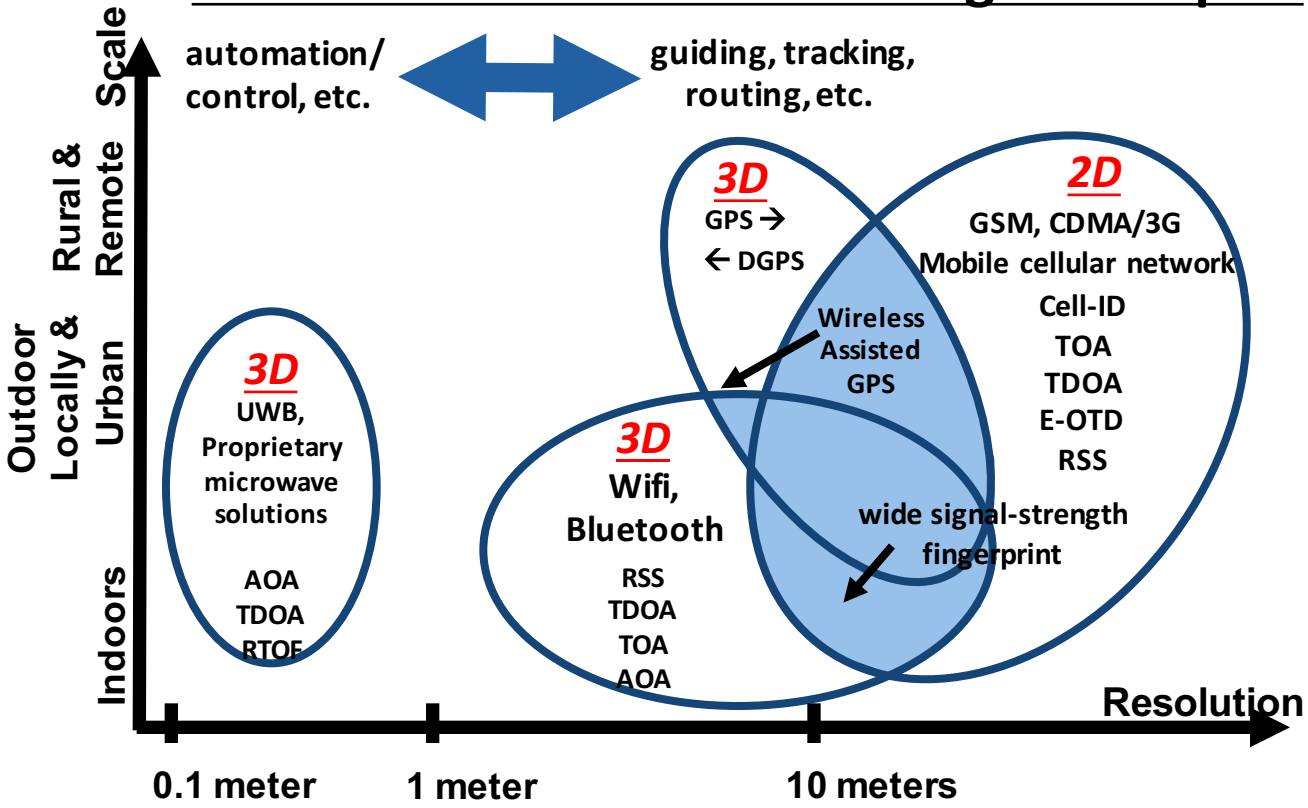




- This illustrates *Reciprocity*

Coverage vs. Resolution

Overview of Radio Positioning Techniques



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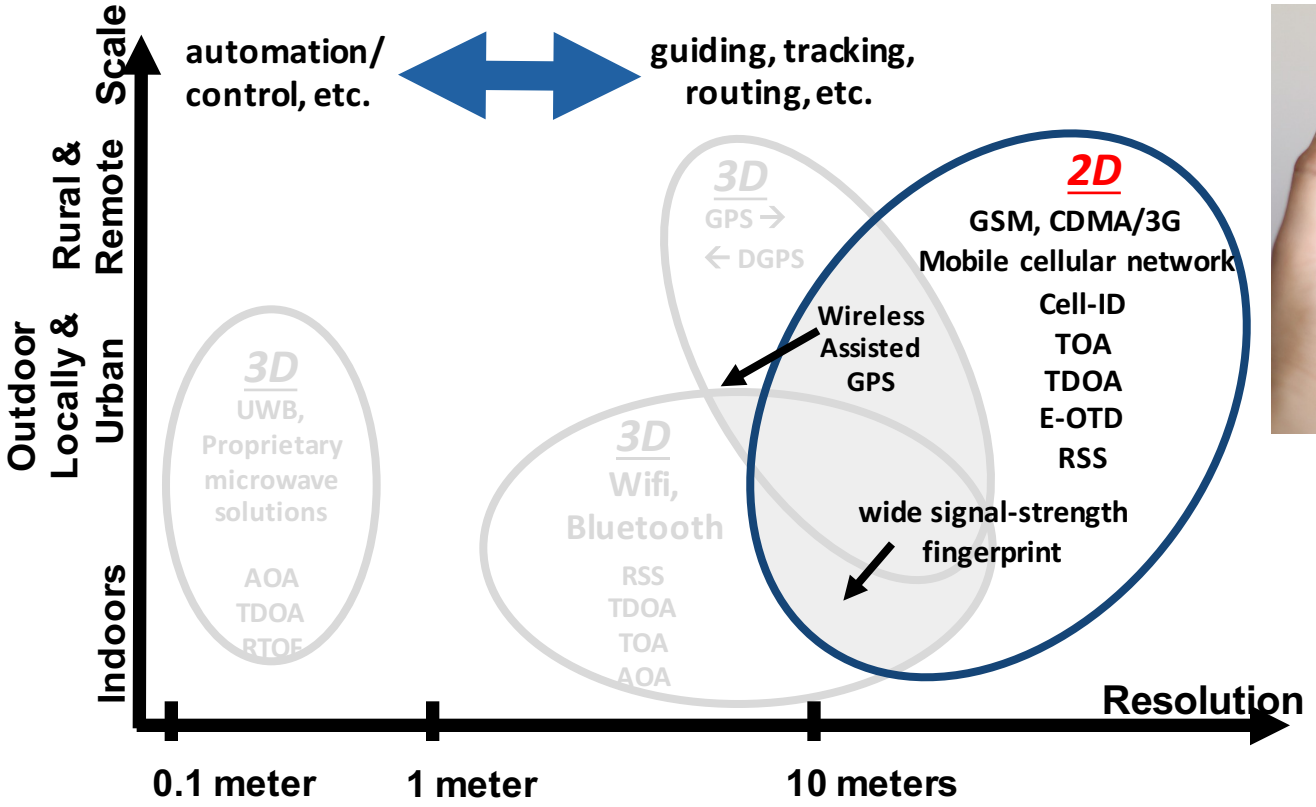

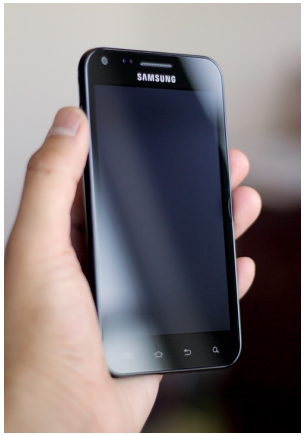

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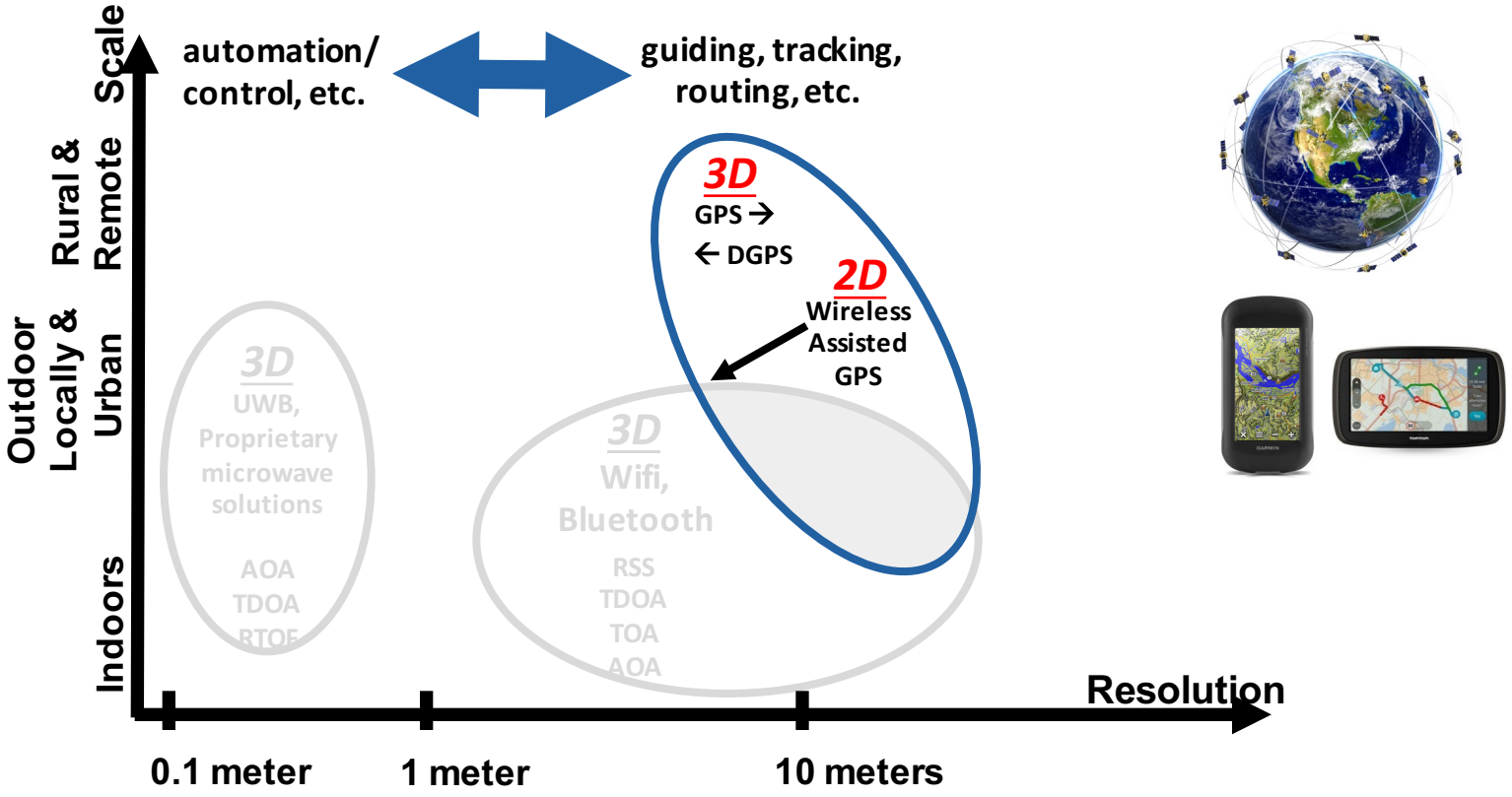
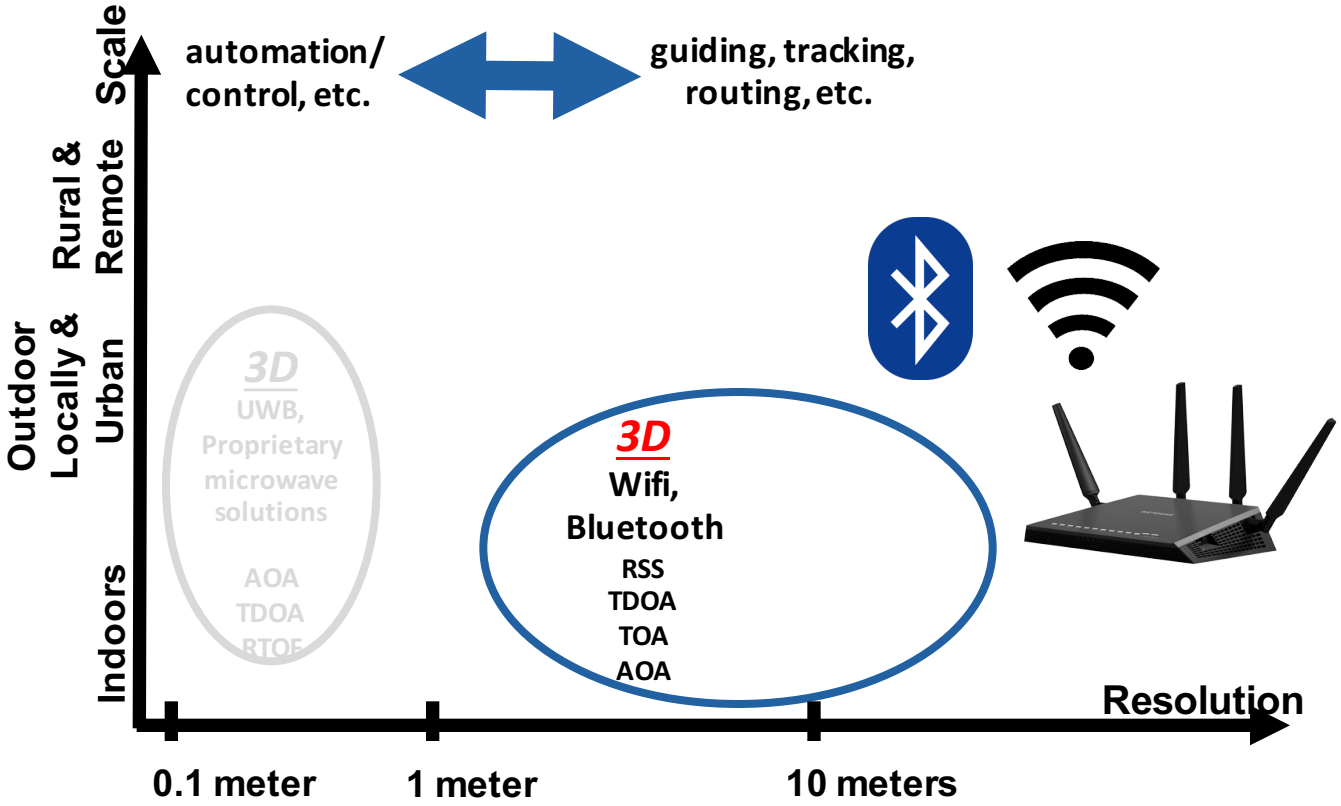
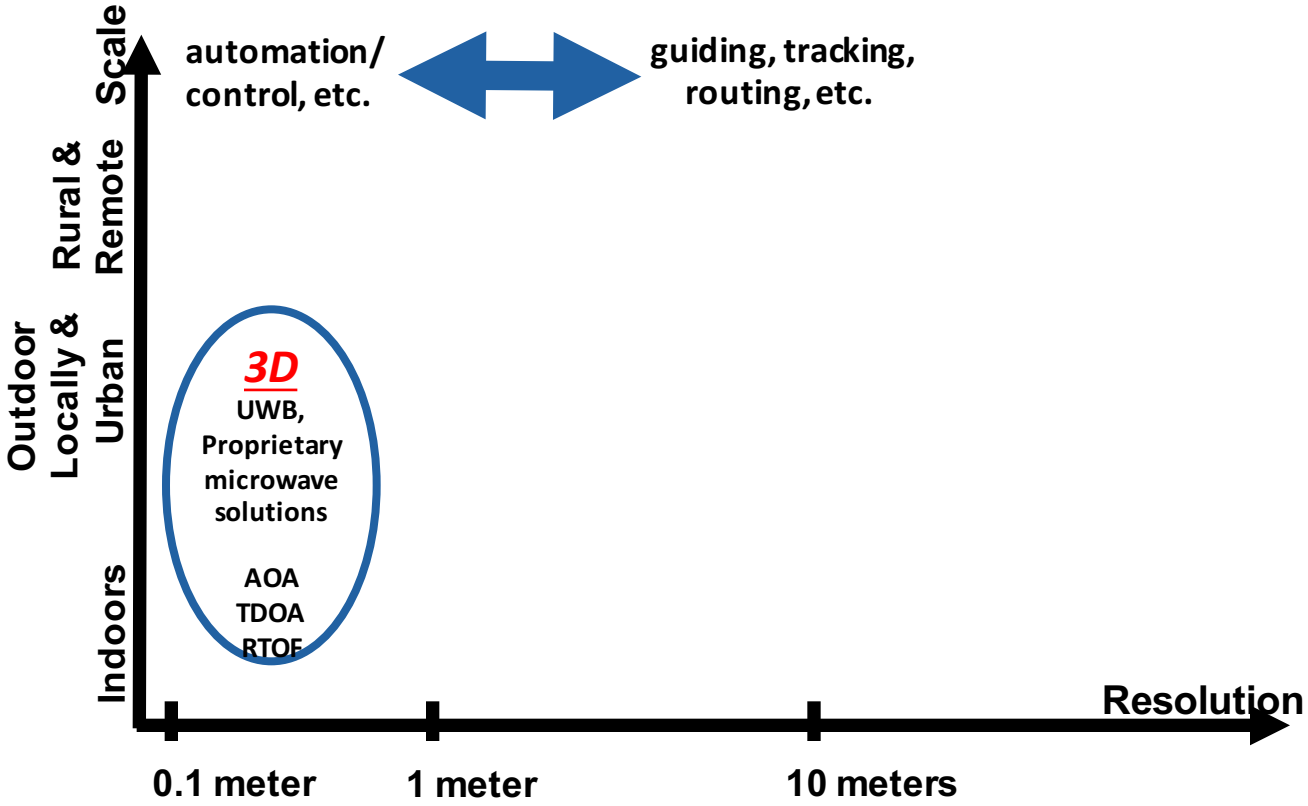


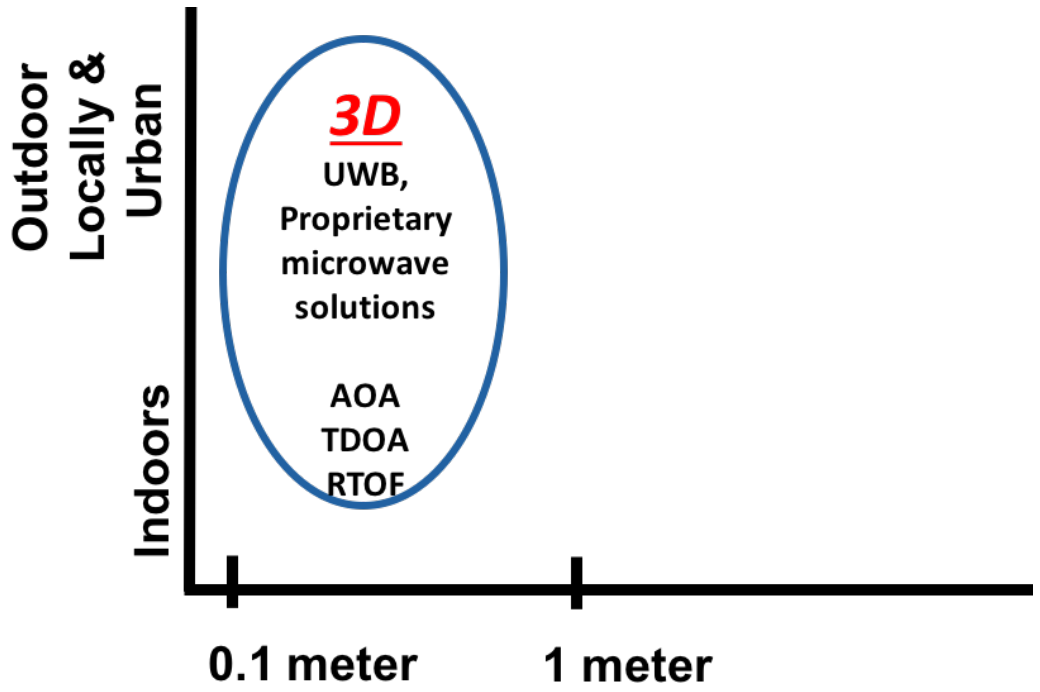
Overview of Radio Positioning Techniques



Overview of Radio Positioning Techniques



Overview of Radio Positioning Techniques



UWB Technical Risk Table

(risks are above zero, either low or high):

CATEGORY	RISK
• Sharing risk:	**Low** since UWB signals have a negligible effect at any bandwidth.
• Cost risk:	**Low** if meter-accuracy, **High** if mm-accuracy with atomic clocks in its infrastructure.
• Integration risk:	**Low** since it is independent of, i.e., does not interfere with established, current communications standards such as 4G LTE.
• Accuracy risk:	**Low** at meter-accuracy, bandwidth flexibility for use in open, multipath free space, **High** as buildings and other urban structures increase multipath.
• Efficiency risk:	**Low** for mission specific situations (firefighter in burning building), **High** for more generic uses.
• Develop. risk:	**Low** since it is based on well established technologies that are becoming COTS and on recent UWB LBS-related research and programs (eg., microPNT).
• Interference risk:	**Low,** can use noise-blanking very effectively (eg., lightning-overload blanking), **Low** even as tag pulses are orthogonal spread-spectrum.

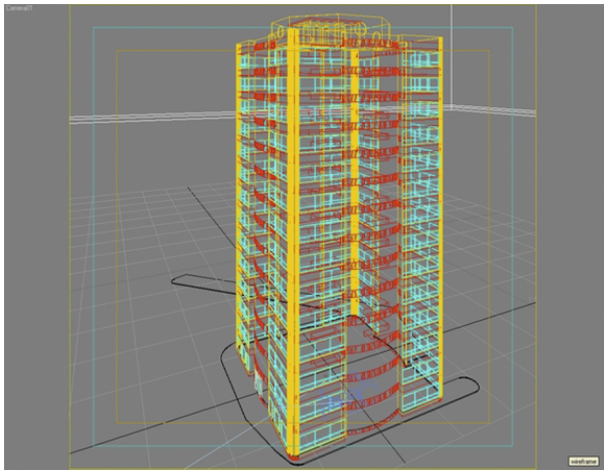
Other

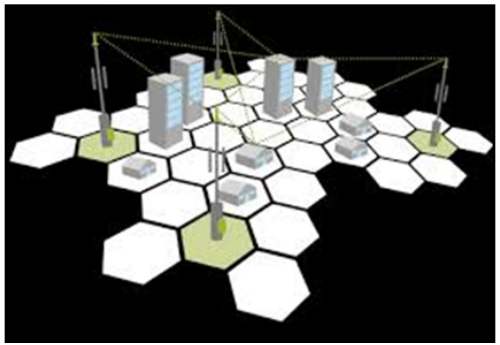
• Public Safety implementation risk:	**UNKNOWN**.
• Scaling risk:	x10 **Low,** x1000 **High**.

Location Determination Using OTDOA

We consider several synchronized stations receiving pulses from a beacon or "tag" in the vicinity whose position is to be determined by time-differences of arrival at the receiver. The receiving stations are at positions denoted by

$$\mathbf{r}_A, \mathbf{r}_B, \mathbf{r}_C, \mathbf{r}_D, \ldots$$

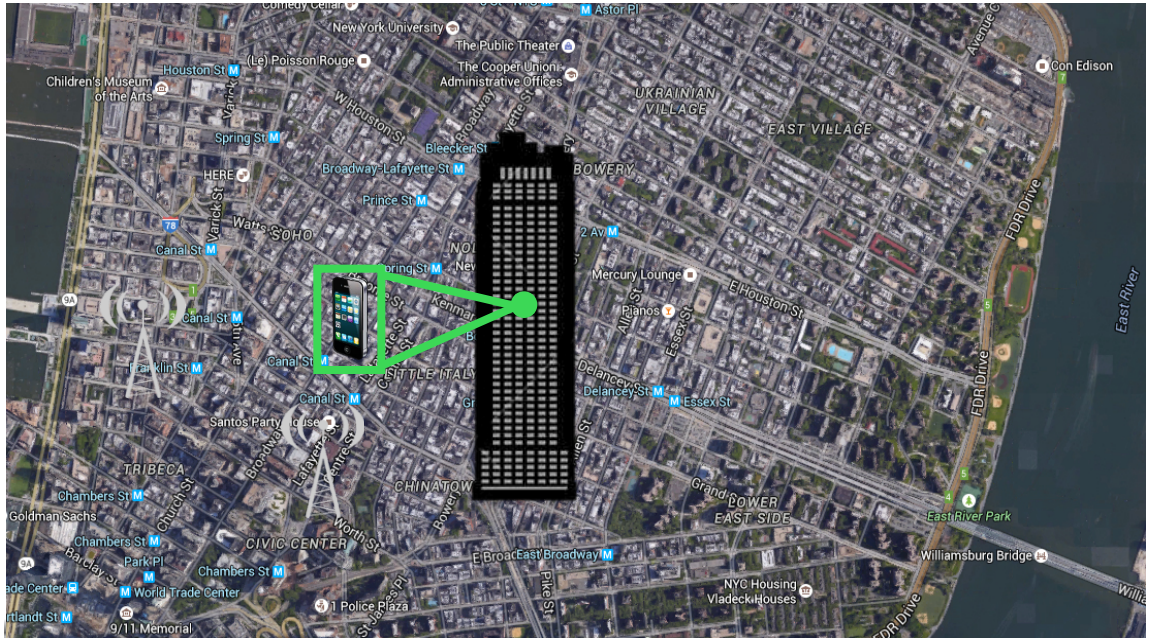




For the time being, these positions are assumed to lie in one plane at ground level, but this is not an essential restriction and will be removed later.

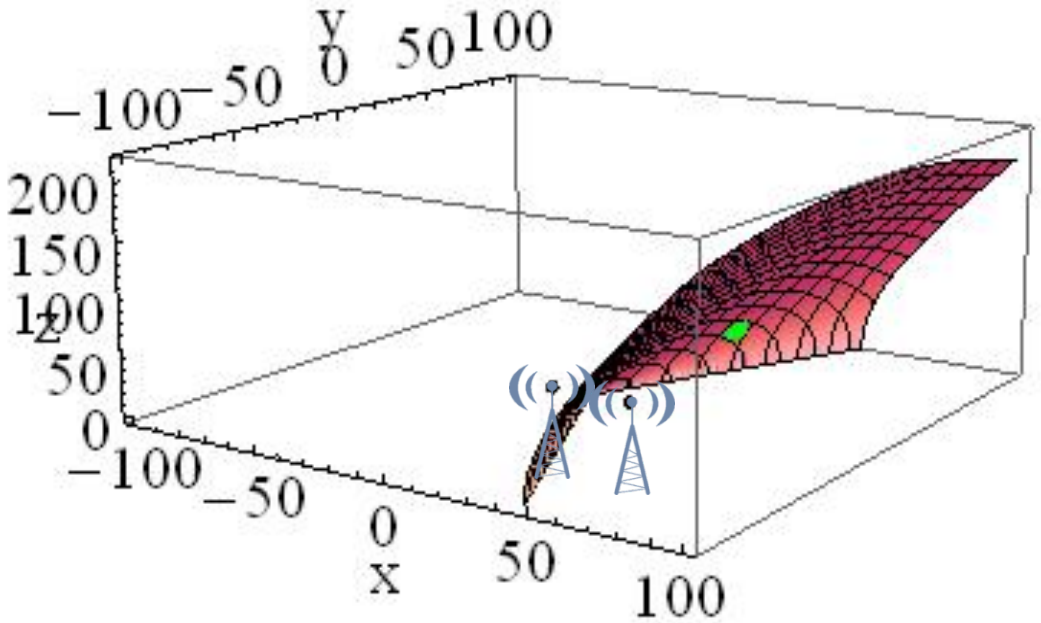
$$\mathbf{r}_A = (x_A, y_A, 0), \quad \mathbf{r}_B = (x_B, y_B, 0), \ldots$$

Two receivers produce one time difference



Two receivers produce one time difference

Simulation of two-receivers

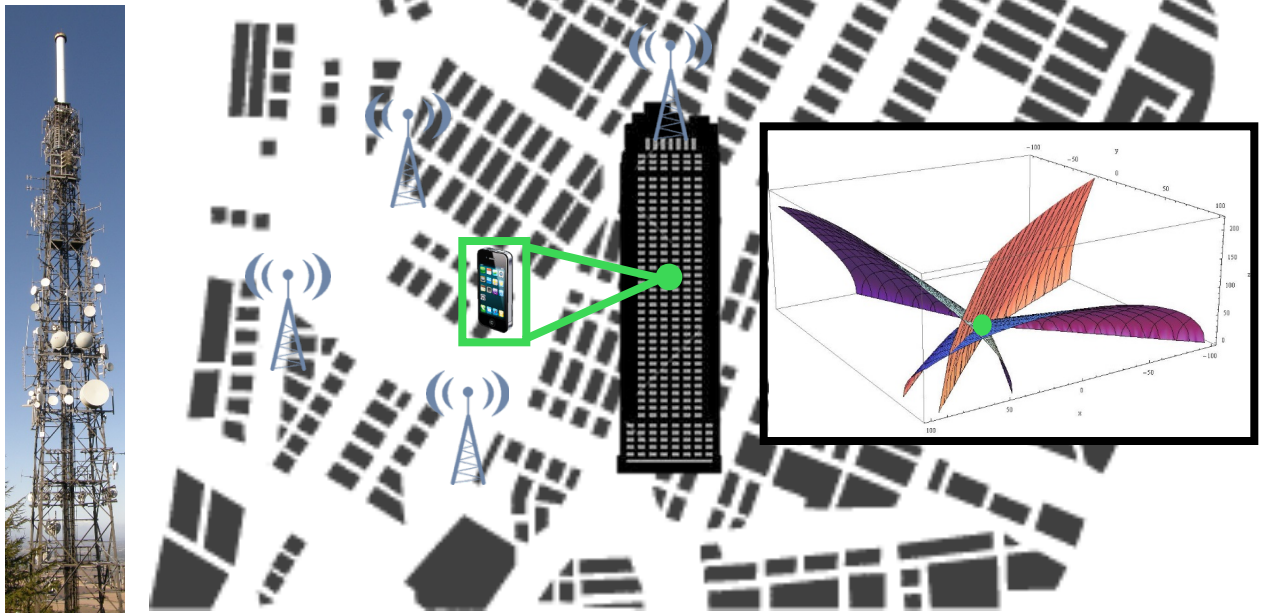


Two-receivers in real-world environment

For triangulation, two more independent surfaces are needed for determination of position,
-----BUT, “independent” is crucial.

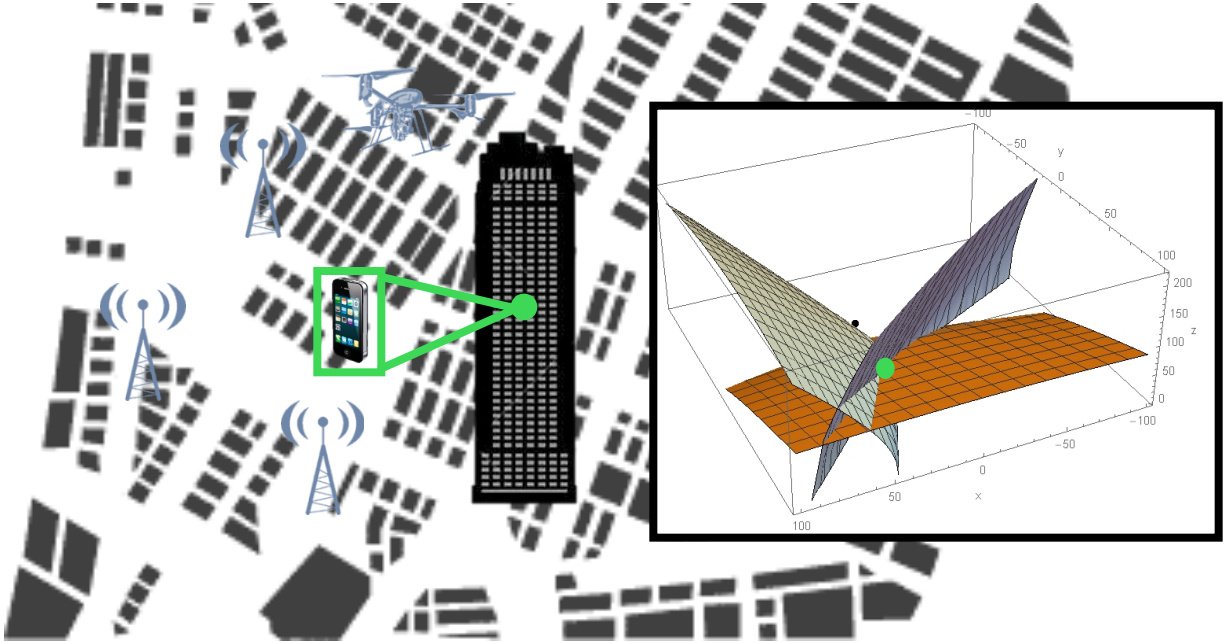
For height, three independent measurements are required!

Four receivers



Three receivers are located ground level, one is located high or on a building.

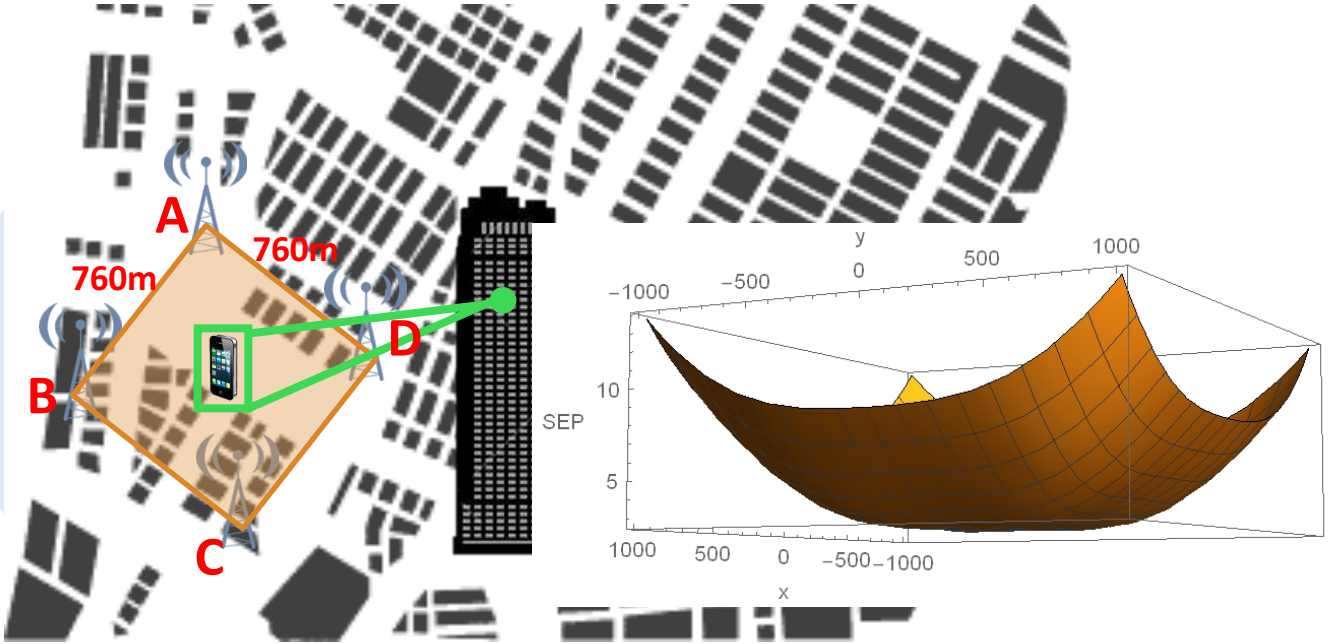
Three independent measurements: Three ground receivers + overhead receiver



Drone as the fourth receiver.

SEP (Spherical Error Probable)

As an example of the computation of SEP, we have constructed the following example: Receivers are at the corners of a square of side 760 meters. The TAG has been placed at altitude 65 meters, and an uncertainty of 10 ns has been assumed. All four independent time measurements are used, entailing an extension of the above theory to include non-square matrices. The SEP is plotted in the following graph (units are meters). (x,y) are the horizontal coordinates of the emitter position.



Future considerations

- Widen the assessment of LBS technologies.
- Define the specifications of timing and precise radio location within the comprehensive roadmap to the technical issues related to LBS systems.
- Use vast experience with **GPS**, as a starting point.
  - Example: 4 satellites are needed for a GPS solution, using a 'decent' UE clock, **better UE clock = better jam resistance**

- UWB has advantages over other RF techniques with respect to:
  - OTDOA (lowest overall technical risk),
  - TOA (with atomic clocks),
  - AOA,
  - Enhancing FDOA,
  - 4 sites needed for OTDOA, one receiver needed overhead (out of 3-site plane).

- To what degree can UWB- OTDOA be integrated into any existing LBS's?
- Technical benefits of using mini-atomic clocks at each of 4 sites (like GPS):
  - Autonomous, negligible site synchronization and clock-recovery BW
  - Increased accuracy and precision for 3D positioning
  - Increased holdover means jam and multipath resistance

Summary

- Three independent measurements, requiring four transmitters, give three independently intersecting hyperboloids and estimate the position of the receiver at the time of measurement.

- The estimate uncertainty (SEP) is determined by the configuration of the transmitters.

- Leading-edge of Ultra-Wide-Band (UWB) timing signals reduces multipath effects.

Public Safety Location-Based Services

Roadmap, Summit, Findings & Project Launch Overview

PSCR

Panel Members

- Tracy McElvaney (Moderator)
  - PSCR Advanced Communications Research Group Lead
- Christian Militeau
  - West Safety Services
- Ryan Felts
  - PSCR Roadmapping Support
- Vihang Jani
  - PSCR Advanced Communications Research Group

we connect. we deliver.

2016 Public Safety Broadband Stakeholder Meeting
Public Safety Location-Based Services (LBS)

June 8, 2016

Indoor Location Accuracy
ATIS Emergency Location (ELOC) Standards

Christian Militeau
ATIS ELOC Task Force Co-Chair
Director, Technical Standards
West Safety Services (formerly Intrado)
christian.militeau@intrado.com
720-864-5245

Agenda

- Background
- FCC 4th Report & Order
- ATIS ELOC Architecture

Background

- Voluntary Agreement
  - Agreed upon by the four major wireless carriers (AT&T Mobility, Verizon Wireless, Sprint, T-Mobile), NENA and APCO
  - Signed November 2014
  - Adopted by CTIA for national carriers and CCA for smaller carriers
  - FCC 4th Report and Order
    - Issued March 2015
    - Adopted the Voluntary Agreement
    - Generally gave smaller carriers an extra year to comply
    - Put specific dates for role out of improved location accuracy
      - Defined Dispatchable Location (civic address) as preference
      - Z-axis – Uncompensated Barometric Pressure (UBP)
      - National Emergency Address Database (NEAD) – a new location database for emergency services

FCC Indoor Location Accuracy 4th Report and Order

- January 29, 2015 FCC Votes to accept 4th Report and Order on indoor location accuracy. March 4, 2015 Final Rules published in Federal Register
- Adds to but does not replace existing Wireless Phase II requirements
- Adopts “dispatchable location” and improved horizontal location requirements
- Requires near term delivery of uncompensated barometric pressure data and long term deployment of Z-axis solution
- Assesses performance using live 9-1-1 call data in representative cities
- Dispatchable location is Public Safety’s “gold standard”
- Leverages Wi-Fi Access Points, Bluetooth beacons, Small Cells and other technologies to provide dispatchable location
- Established National Emergency Address Database (NEAD)
- Set confidence level to fixed value of 90%
- Establish a 30-second maximum period for E9-1-1 location (TTFF)

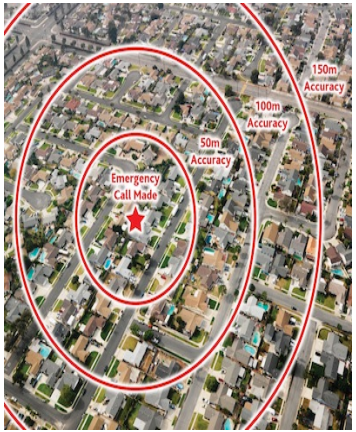
Horizontal & Vertical Location Accuracy Requirements

- Wireless Providers Must provide “Dispatchable location” or “Latitude/Longitude coordinates within 50m” for the caller for:
  - 40% of all wireless 9-1-1 calls within 2 years
  - 50% of all wireless 9-1-1 calls within 3 years
  - 70% of all wireless 9-1-1 calls within 5 years
  - 80% of all wireless 9-1-1 calls within 6 years
- Non-nationwide carriers can extend the 5 and 6 years deadlines by six months and 1 year respectively based upon timing of VoLTE deployment in their networks
- Within 3 years
  - Provide uncompensated barometric pressure data to PSAPs from any capable device
  - Develop z-axis metric proposal to be submitted for commission approval
- Z-axis Metric
  - Populate NEAD with reference points equal to 25% if population of CMA or
  - Deploy Z-axis technology to cover 80% of population of CMA
- Non-nationwide carriers have an additional year to achieve these benchmarks

The value of a Civic Address over X/Y to Public Safety

Public Safety does not dispatch to a X/Y:

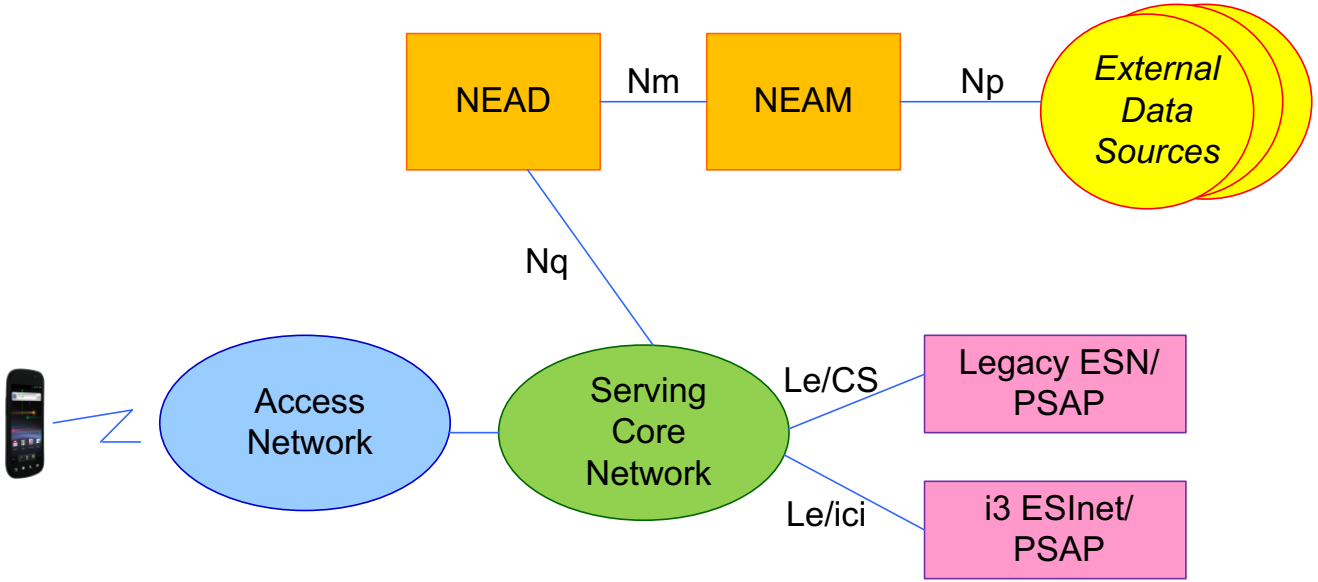
39° 41' 11.93" N Latitude
104° 58' 54.72" W Longitude
50 Meter Point Radius Uncertainty



Public Safety dispatch to a Civic Address

Reverse Geocoding Nearest Intersection	***Reverse Geocoding Address Range***	***Reverse Geocoding Point Match***
S Pennsylvania St & E Iowa Ave Denver, CO	1600-1650 S Pennsylvania St Denver, CO	1615 S Pennsylvania St Denver, CO

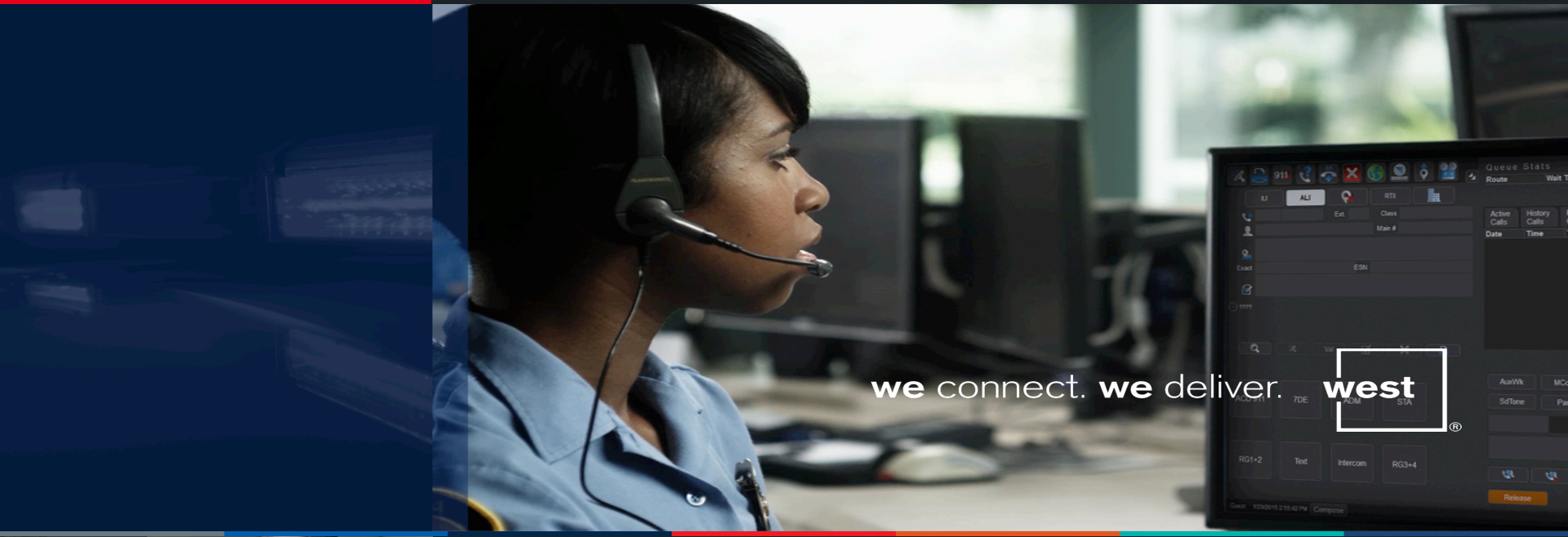
ATIS ELOC Architecture

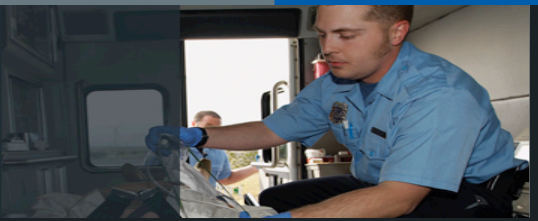


- National Emergency Address Manager (NEAM)
- National Emergency Address Database (NEAD)
- Serving Core Network – includes e-SMLC and e-SLP

ATIS ELOC Architecture

- External Data Sources
  - Enterprises, retail companies, hotels and the like that are responsible for WiFi Access Points and Bluetooth beacons
  - Enter their AP (or Bluetooth) location into the NEAD/NEAM
- NEAM
  - OA&M function that allows users to enter their data, validates the location, geocodes the location and pushes it to the NEAD
- NEAD
  - Real time server that hosts WiFi AP (and Bluetooth) location information
  - Queried by Serving Core Network for WiFi AP (and Bluetooth) location information
- Serving Core Networks
  - Queries the NEAD for Wi-Fi AP (and Bluetooth) location
  - Determines “best” location to be sent to the PSAP
    - Includes IMS components – e-SMLC, e-SLP, LRF
    - Includes some legacy components – GMLC/MPC





Thank You!

christian.militeau@intrado.com

Location-based Services: R&D Summit

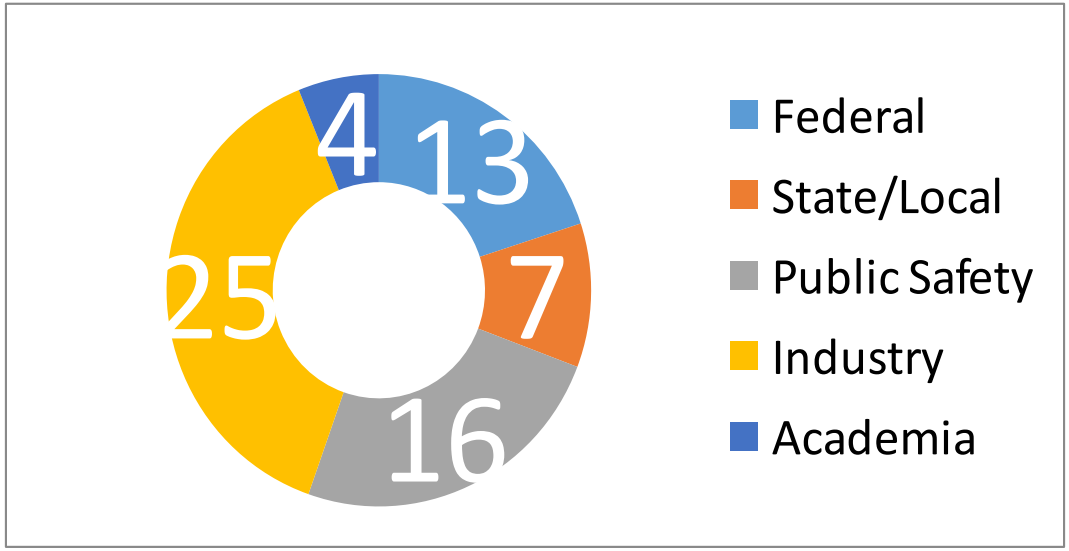
Ryan Felts, PSCR Roadmapping Support

Disclaimer

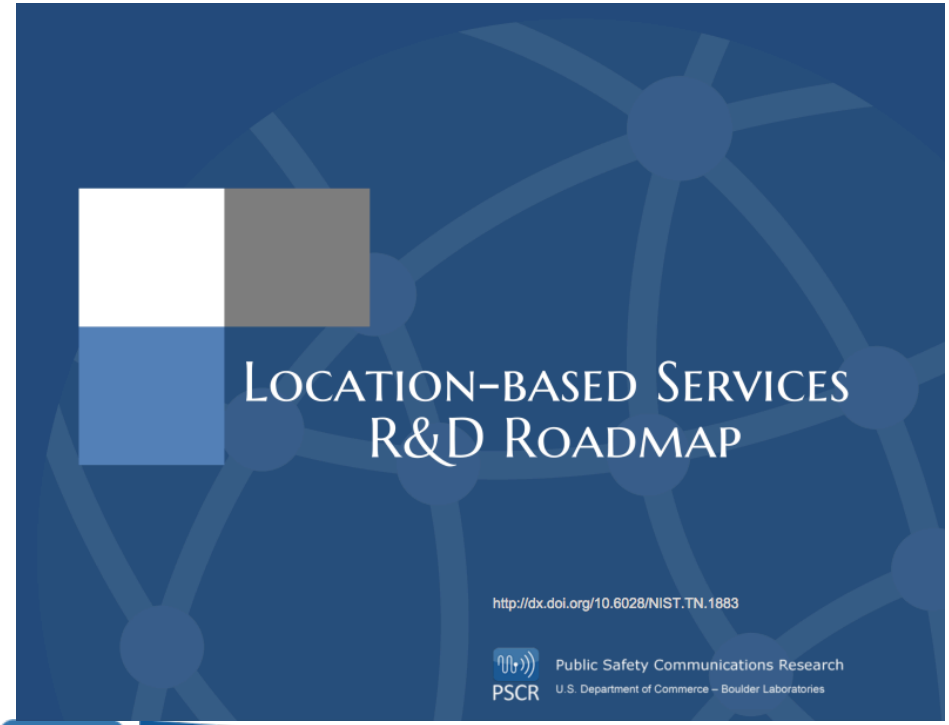
Please note, all information and data presented is preliminary/in-progress and subject to change.

LBS R&D Summit October 21-22, 2015

PURPOSE:
To clearly identify LBS-related R&D gaps that align with public safety needs and requirements



Summit Starting Point



66 LBS R&D Gaps

What makes a 'Good Gap'?

1) Identifies a needed underlying technology capability
2) Measurable
3) Specific
4) Addressing this gap would accelerate the technical time horizon for priority challenges (brings the vision of 2025 to today)
5) Represents "Stand alone value" for public safety – PSCR can deliver success regardless of external actors

Narrowing the Focus

6 → 1

Gap Prioritization

1. Leverage
2. Feasibility
3. Impact on Public Safety Processes
4. Rewards/Results
5. Uniqueness to Public Safety
6. Cost of Ownership
7. Cost of Investment

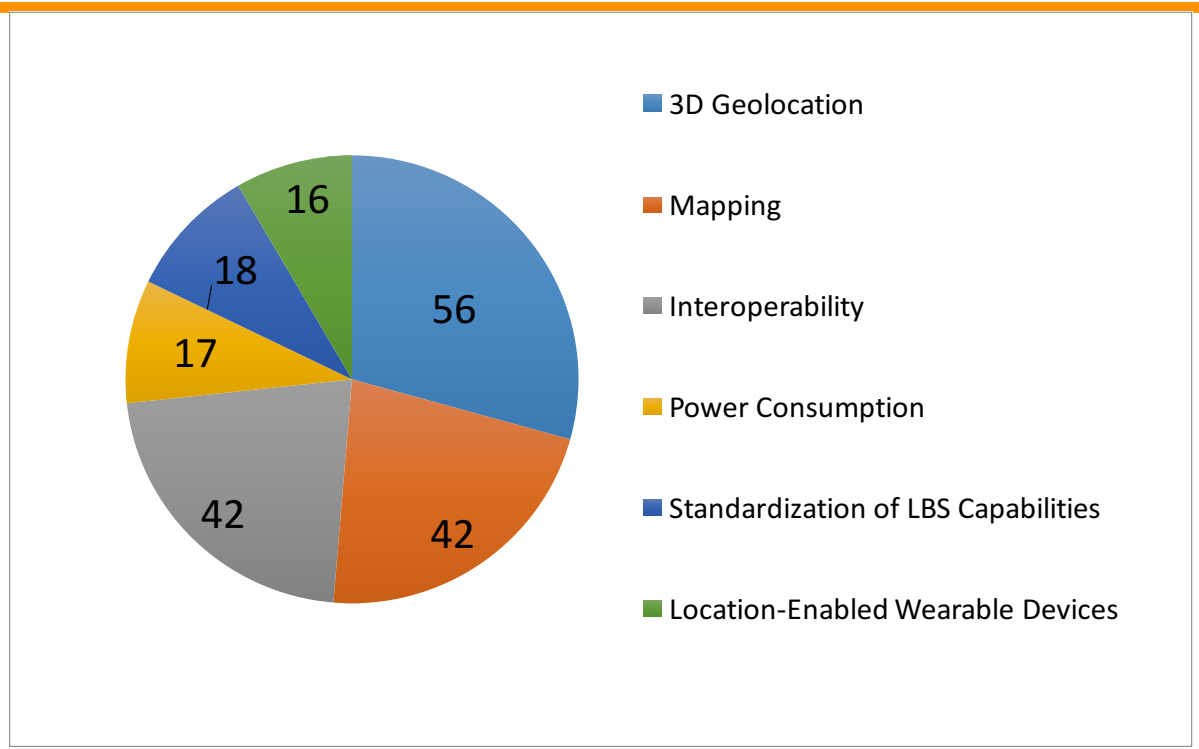
Gap Prioritization

	Leverage	Feasibility	Impact on P.S. Processes	Rewards/Results	Unique to P.S.	Total
Gap 1						
Gap 2						
Gap 3						
Gap 4						
Gap 5						
Gap 6						
Gap 7						
Gap 8						
.....						

Gap Prioritization

	Leverage	Feasibility	Impact on P.S. Processes	Rewards/Results	Unique to P.S.	Total
Gap 1	3			3		6
Gap 2		3	3		3	9
Gap 3		2				2
Gap 4			2			2
Gap 5	2	1			2	5
Gap 6						0
Gap 7	1		1	2		4
Gap 8				1	1	2
……						

Gap Prioritization Results



Problem Statement Definition

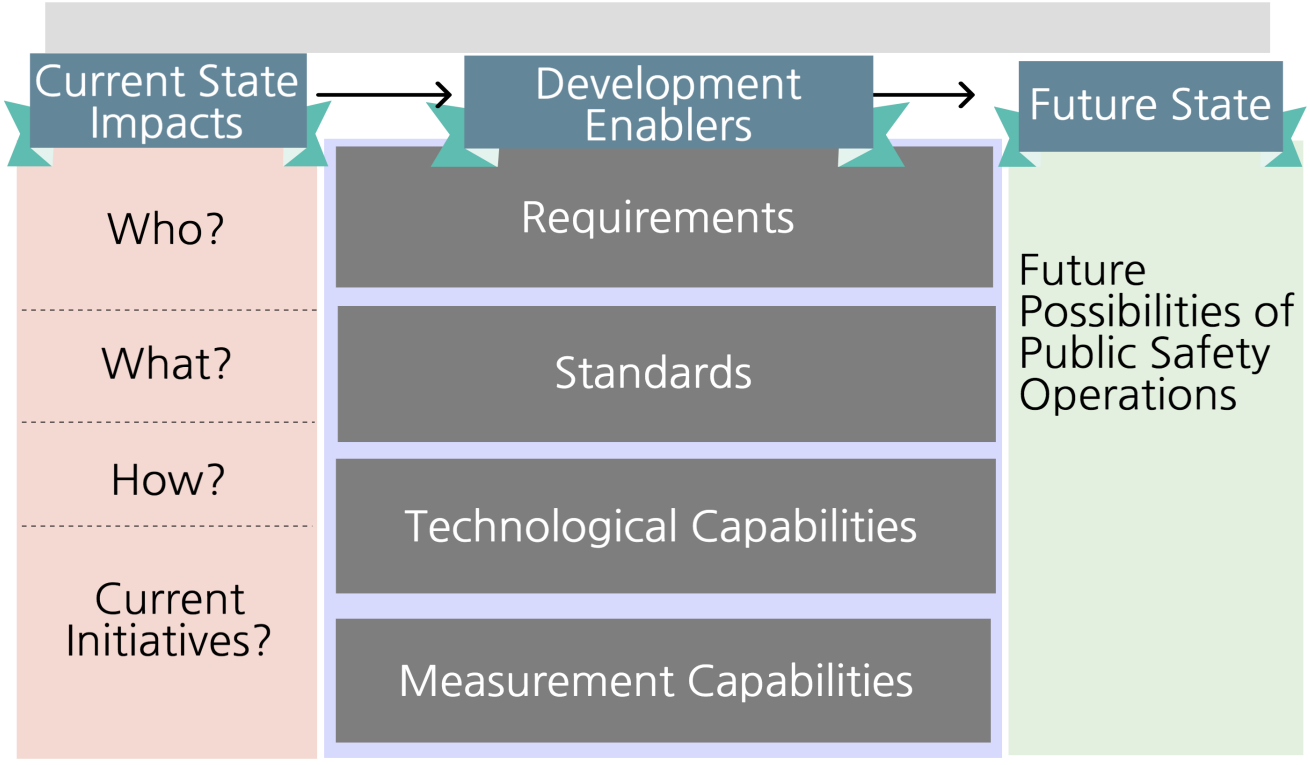
3D Geolocation

"The inability to precisely and persistently locate public safety persons and assets in order to locate responders in trouble and manage public safety personnel and assets in real-time."

Location-based Services R&D Opportunities

PSCR

PROBLEM STATEMENT



3D Geolocation

The inability to precisely and persistently locate public safety persons and assets in order to locate responders in trouble and manage public safety personnel and assets in real-time.

Current State: Tracking of public safety personnel on x, y, and z-axis to public safety required levels of accuracy and persistency does not exist

Requirement: Document x, y, and z axis precision metrics to meet public safety requirements. Measure dilution of precision (DOP), time-to-fix, data refresh rate

Barriers: Network (coverage) and sensor performance (ruggedization)

Future State: Increased situational awareness for public safety to improve ability to respond to emergencies and ensure safety of personnel and assets

Mapping

Public Safety lacks a nationwide interoperable 'base map' to provide cross-agency collaboration as well as the ability to capture and integrate data into the 'base map'

Current State: Public safety does not have robust maps or capability to create maps to increase situational awareness improve response

Requirement: Real-time mapping tool that can sense, ingest, and populate indoor/outdoor map data in real time to a central database

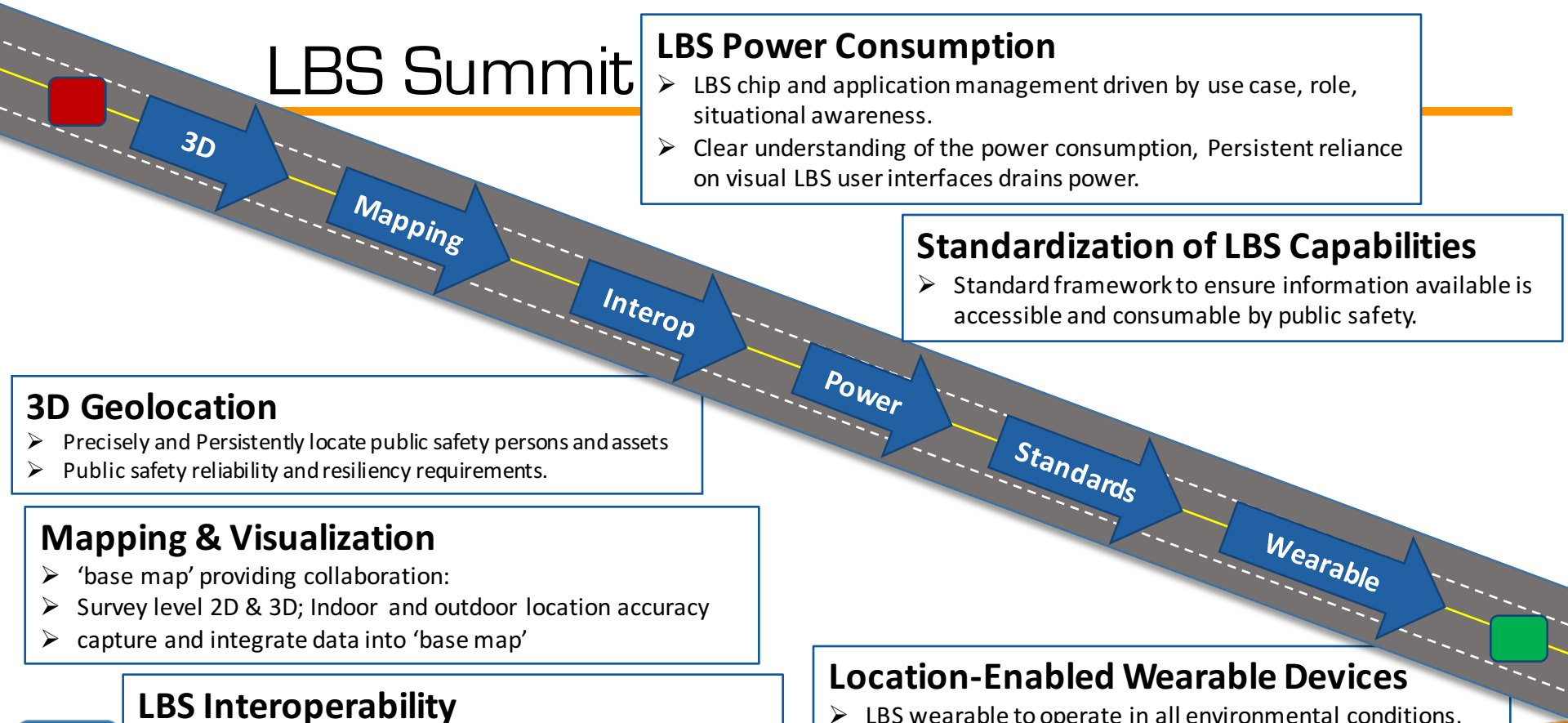
Barrier: Compilation of raw mapping data, map images, and continuous updating is extremely time intensive

Future State: Public safety response is improved by a robust database of indoor/outdoor maps and can create maps in real-time to improve operational capabilities

Location-based Services for Public Safety

Vihang Jani, PSCR Advanced Communications Research Group

LBS Summit



LBS Power Consumption

- LBS chip and application management driven by use case, role, situational awareness.
- Clear understanding of the power consumption, Persistent reliance on visual LBS user interfaces drains power.

Standardization of LBS Capabilities

- Standard framework to ensure information available is accessible and consumable by public safety.

3D Geolocation

- Precisely and Persistently locate public safety persons and assets
- Public safety reliability and resiliency requirements.

Mapping & Visualization

- 'base map' providing collaboration:
- Survey level 2D & 3D; Indoor and outdoor location accuracy
- capture and integrate data into 'base map'

LBS Interoperability

- Interface & interoperability between applications, devices

Location-Enabled Wearable Devices

- LBS wearable to operate in all environmental conditions, usability, operability, redundancy, mapping data, on/off network, user/command interfaces, .

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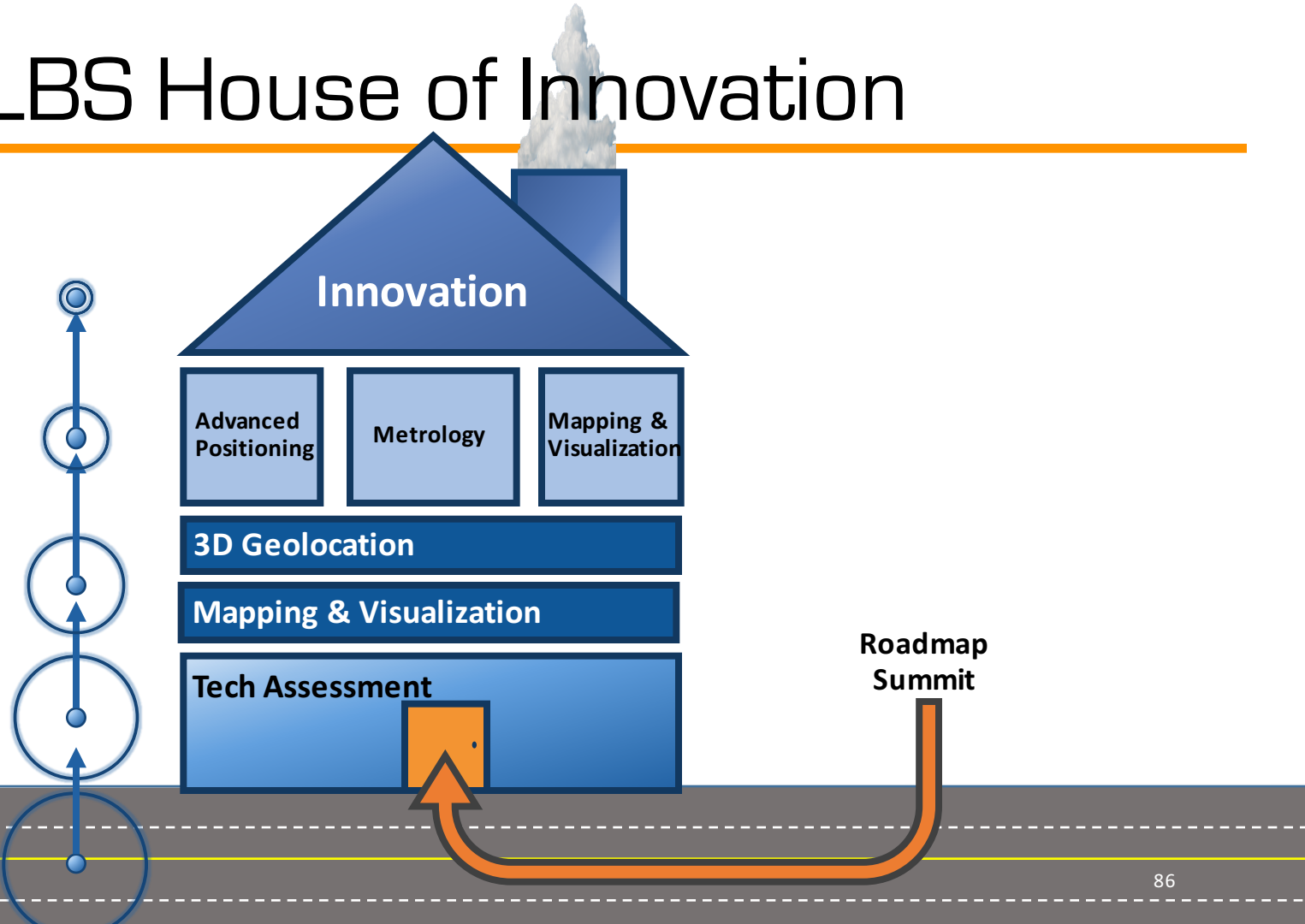
PSCR LBS House of Innovation



3D Geolocation Focus Area

GAP: 3D Geolocation

PSCR

Inability to precisely and persistently locate public safety persons and assets in order to locate responders in trouble and manage public safety personnel and assets in real-time.

Summary: First responders need to obtain the civic address/coordinates of the public safety personnel and asset location, plus additional information such as floor, suite, apartment, or other information needed to adequately identify the location of the first responder and/or assets. Information includes: indoor, outdoor, 3D location, latitude, longitude, altitude, and other pertinent geo-location data. Solutions need to account for public safety reliability and resiliency requirements.

Current State Impacts

Who?

Public safety entities and first responder functions: law enforcement/Fire/EMS, search & rescue, emergency management, and command & control

What?

Public safety activities requiring rapid response and/or detailed planning: incident management, disaster planning, rapid response

How?

Current gap prevents deployment of LBS apps...restricting location to general proximity, preventing public safety officials from locating assets by z-axis

Current Initiatives?

Operational need and Federal guidance (FCC 4th Report & Order) have spawned Industry activity in the space: barometric-based z-axis capability, sensor data for indoor location

Development Enablers

Requirements to collect:

- **Location Accuracy:** Allowable levels of location uncertainty across X, Y, Z axis & associated required confidence levels
- **Signal Specs:** Baseline performance levels for LBS signals including bandwidth, data rate, and immunity to noise
- **Data Refresh Rate:** Operational requirement for LBS data refresh time intervals, referred to as 'Delta t'

Standards to develop:

- **Signal Structure:** WiFi/BT/UWB signal designed for positioning use (in addition to coverage & speed)
- **Location Data Format:** Data format standard for interoperability between units or devices
- **X, Y, Z Axis Minimum Operating Standards:** Define guidelines for public safety geolocation accuracy, update rate, and latency

Technological capabilities to build:

- **Composite Geolocation:** Decipher location from multi-sourced data including, GPS, OTDOA, WiFi, LTE-U, Bluetooth, etc.
- **Pressure Sensor Compensation:** Incorporate real-time barometric pressure variation to support z-axis accuracy
- **Capability Enhancement:** Further develop existing capabilities: GPS/GNSS, TOA, OTDOA, AoA, RSS & models

Measurement capabilities to deploy:

- **X,Y,Z Precision Metrics:** Measure key geolocation metrics: DOP, time-to-fix, delta t: refresh
- **3D Geolocation Test Bed:** Environment to test measurement methods simulating: indoor, outdoor, impairments, geometric dilution of precision conditions
- **3D System Calibration:** Precision reference measurement system for 3D LBS & assess accuracy across devices/systems

Future State

Gap Stakeholders:

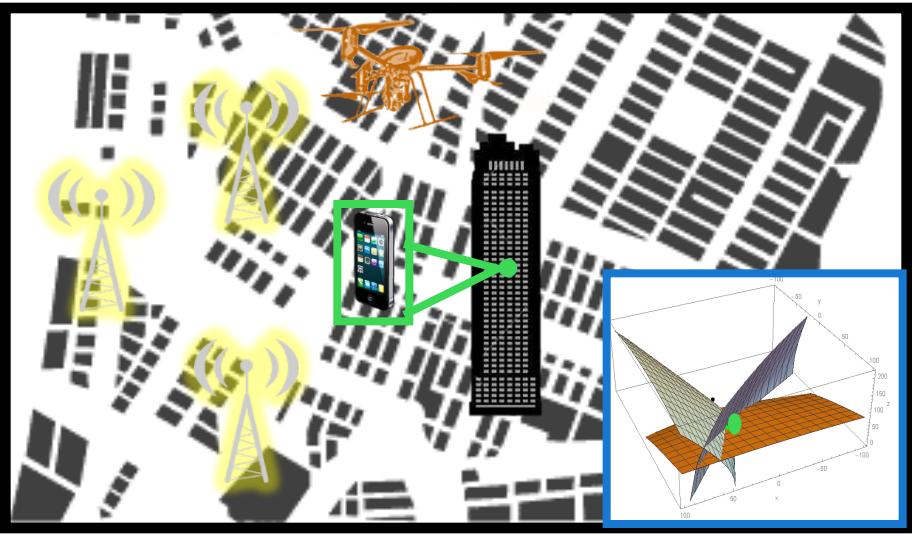
Public safety units responsible for tactical coordination and/or logistics and event planning will benefit greatly from 3D geolocation capability development. Anticipate primarily servicing elements with a first response element

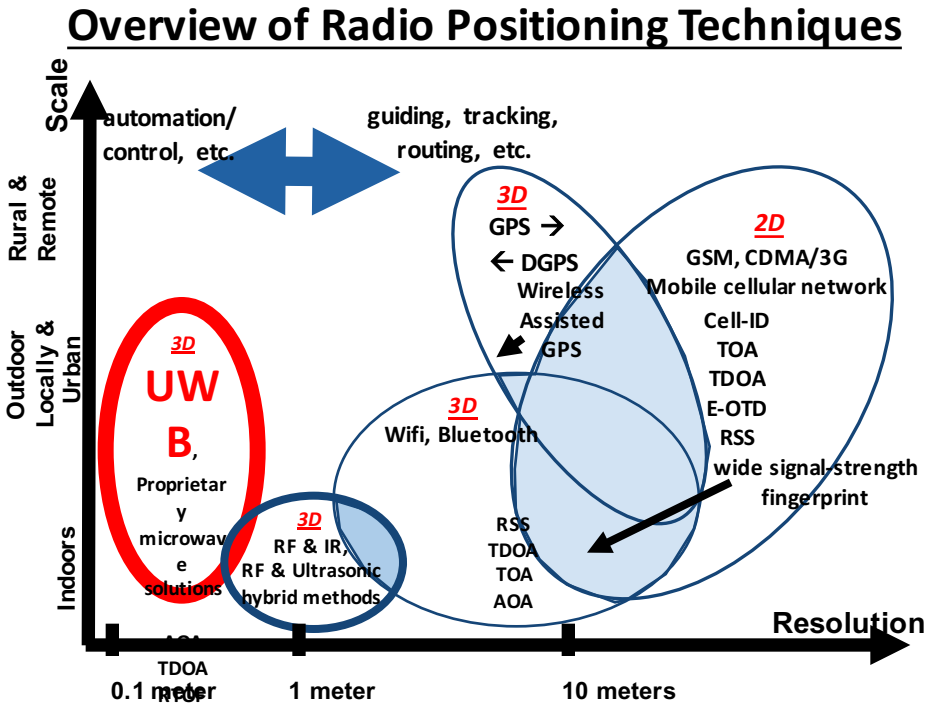
Public Safety Operations:

First responders arrive on scene equipped with real-time environmental & contextual site intelligence (building, floor, room & method of approach data) based on X,Y & Z location-based services data broadcast from critical assets. Data enables complete situational awareness, coordinated search & rescue, and avoidance of dangerous environments including fire flow & friendly fire

Advanced Position Navigation Timing

Sub 3meter persistent 3D location





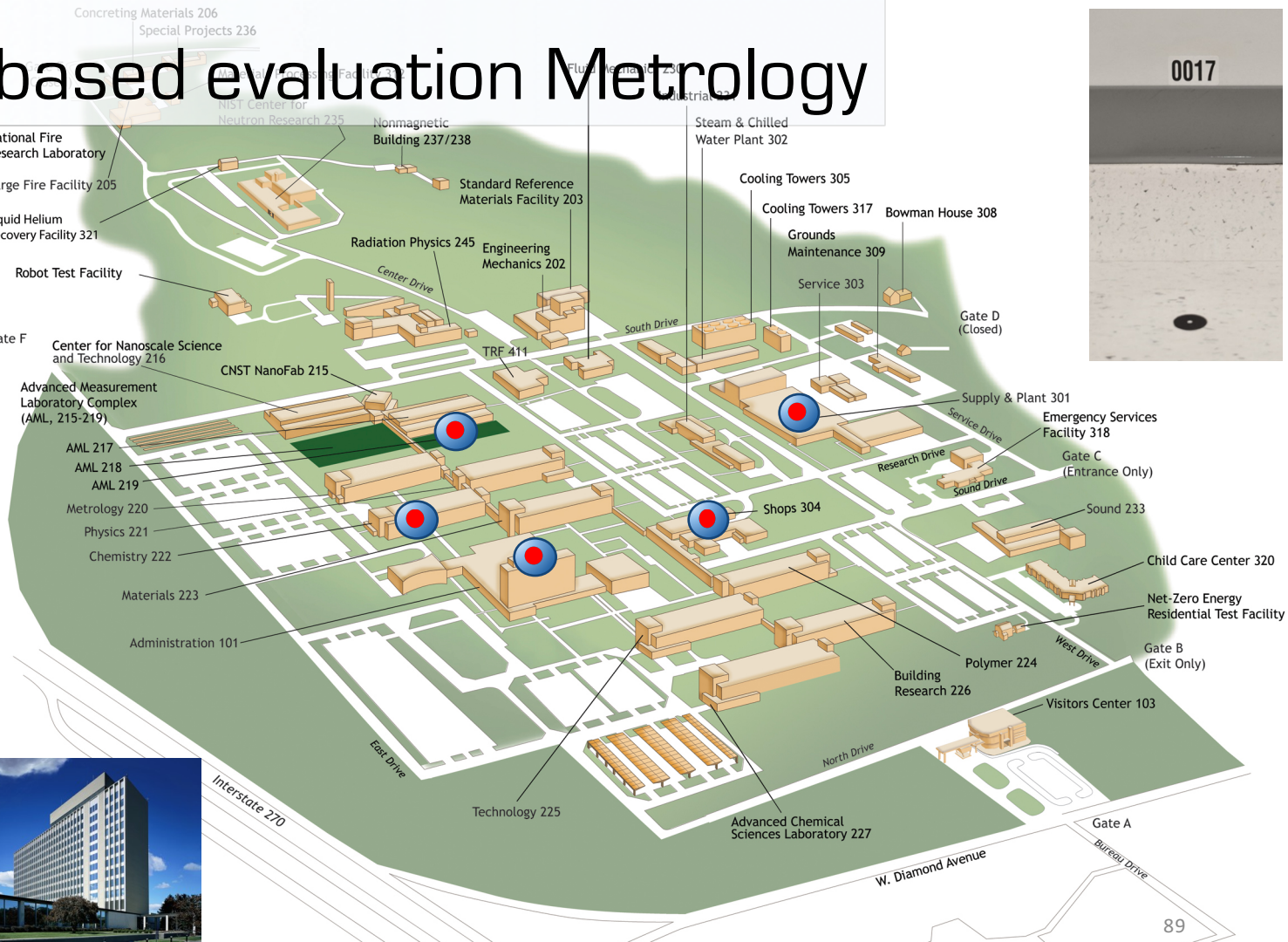
Coverage vs. Resolution

Standards based evaluation Metrology

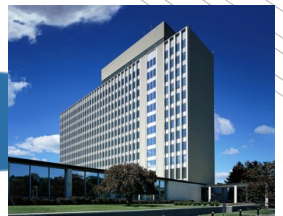
NIST

580-acre
Gaithersburg campus

2000 Laser Surveyed Dots
5 Unique Building Types



PSCR



3D Geolocation PSCR Projects

- ✓ Advanced Positioning
- ✓ Metrology

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Public safety units responsible for tactical coordination and/or logistics and event planning will benefit greatly from 3D geolocation capability development. Anticipate primarily servicing elements with a first response element

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First responders arrive on scene equipped with real-time environmental & contextual site intelligence (building, floor, room & method of approach data) based on X,Y & Z location-based services data broadcast from critical assets. Data enables complete situational awareness, coordinated search & rescue, and avoidance of dangerous environments including fire flow & friendly fire

3D Geolocation PSCR Projects

- ✓ Advanced Positioning
- ✓ Metrology

GAP: 3D Geolocation

PSCR

Inability to precisely and persistently locate public safety persons and assets in order to locate responders in trouble and manage public safety personnel and assets in real-time.

Summary: First responders need to obtain the civic address/coordinates of the public safety personnel and asset location, plus additional information such as floor, suite, apartment, or other information needed to adequately identify the location of the first responder and/or assets. Information includes: indoor, outdoor, 3D location, latitude, longitude, altitude, and other pertinent geo-location data. Solutions need to account for public safety reliability and resiliency requirements.

Current State Impacts

Who?

Public safety entities and first responder functions: law enforcement/Fire/EMS, search & rescue, emergency management, and command & control

What?

Public safety activities requiring rapid response and/or detailed planning: incident management, disaster planning, rapid response

How?

Current gap prevents deployment of LBS apps...restricting location to general proximity, preventing public safety officials from locating assets by z-axis

Current Initiatives?

Operational need and Federal guidance (FCC 4th Report & Order) have spawned Industry activity in the space: barometric-based z-axis capability, sensor data for indoor location

Development Enablers

Requirements to collect:

- **Location Accuracy:** Allowable levels of location uncertainty across X, Y, Z axis & associated reliability & confidence levels ✓
- **Signal Specs:** Baseline performance levels for LBS signals including bandwidth, data rate, and immunity to noise ✓
- **Data Refresh Rate:** Operational requirement for LBS data refresh rate ✓

Standards to develop:

- **Signal Structure:** WiFi/BT/UWB signal defined for positioning use (including additional to coverage & speed) ✓
- **Location Data Format:** Data format standard for interoperability between units & devices ✓
- **X, Y, Z Axis Minimum Operating Standards:** Define guidelines for public safety geolocation accuracy, update rate, & latency ✓

Technological capabilities to build:

- **Composite Geolocation:** Decipher location from multi-sourced data including, GPS, OTDOA, WiFi, LTE-U, Bluetooth, etc. ✓
- **Pressure Sensor Compensation:** Incorporate real-time barometric pressure variations to support z-axis accuracy ✓
- **Capability Enhancement:** Further develop existing capabilities (GPS/GNSS, TOA, OTDOA, AoA, RSS & models ✓

Measurement capabilities to deploy:

- **X,Y,Z Precision Metrics:** Measure key geolocation metrics (DOP, time-to-fix, delta refresh) ✓
- **3D Geolocation Test Bed:** Environment to test measurement methods simulating: indoor, outdoor, impairments, geometric dilution of precision conditions ✓
- **3D System Calibration:** Precision reference measurement system for 3D LBS to assess accuracy across devices/systems ✓

Future State

Gap Stakeholders:

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Mapping & Visualization

GAP: Mapping

PSCR

Public Safety lacks a nationwide interoperable 'base map' to provide cross-agency collaboration and data input

Summary: Interoperable 'base map' needs to include: Uniform, interoperable base layer; Survey level accuracy; Multi-organization collaboration; Interoperable access; Credentialing/User-profile; 2D & 3D; Indoor and outdoor locations. Lack of capability to capture and integrate data into base map.

Current State Impacts

Who?

Public safety first responders and dispatch as private sector, utilities, and infrastructure developers

What?

Public safety operations requiring fire/medical/law enforcement and special ops

How?

Inability to utilize and share a common base map hampers public safety's capability for efficient response across municipalities, jeopardizes first responder safety, and hampers the adoption of emerging GPS & 3D geolocation (z-axis) technologies

Current Initiatives?

DHS is developing the NICS platform, an open source collaborative architecture that integrates LBS and other sensors. DOT is developing the E911 dispatchable location database and mapping technology

Development Enablers

Requirements to collect:

Map Visuals:
Appearance of visual details, visual quality, and organization of layered data sets needed for the operating environment

Map Attributes:
Data elements rendered on Public safety map for operational use, may include: building properties, motion, weather

Data Governance:
Data input, transfer, credentialing and federated nodes of control for adoption of mapping into chain-of-command

Standards to develop:

Base Map:
Common base layer map, symbols, and cartography for uniform adoption

Data Format:
Consistent mapping data format for interoperability and synchronization between entities

Composite Mapping Technique:
Used to deconflict disparate input map types and collate data

Technological Capabilities to build:

'In-Building' Maps:
Data rich building maps for critical buildings in US (malls, airports, stadiums, commercial skyscrapers, gov facilities, etc.)

Real-time Mapping Tool:
Capability to sense, ingest, and populate indoor/outdoor map data in real time to central database

Federated Data System:
Aim to deploy a local control LBS system that 'syncs' with master LBS data in the cloud

Measurement Capabilities to deploy:

Progress Milestones:
Roadmap for mapping capability progress (requirements, standards, testing) against promulgated timeline

Data update rate:
Test time frame between map input/update and receipt by Public safety user

Future State

Gap Stakeholders:

Public safety units responsible for tactical coordination and first response operations will benefit greatly from mapping capability development. Mapping will create opportunities for industry and entrepreneurs to develop applications and tools to leverage mapping data

Public Safety Operations:

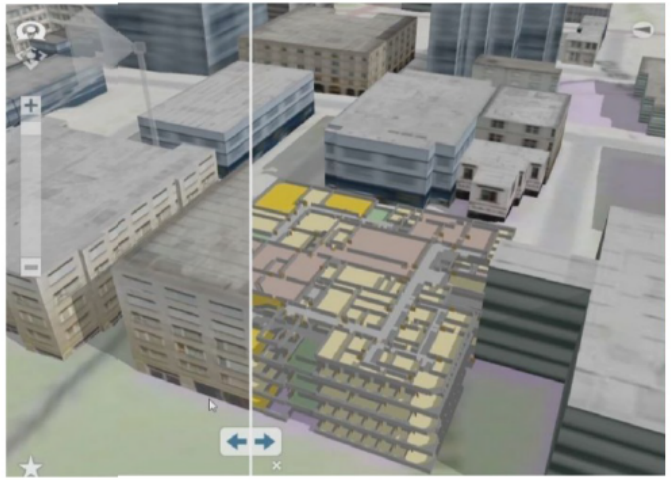
First responders arrive on scene equipped with coordinated plan of engagement for emergency environment based on mapping data. Planning will include advanced strategy & tactical planning, environmentally informed equipment decisions, and real-time data sharing across public safety entities. These capabilities are supported by the free exchange of location information between app developers and CAD vendors

Mapping & Visualization Project

3D-Cordinate tie to 3D Map

Create 3D Map

Standardized 3D Map Technology



ESRI Indoor 3D software showing Cramer hall, Portland State University; Exterior (left) Interior (right)

Mapping & Visualization PSCR Project

Mapping & Visualization

GAP: Mapping

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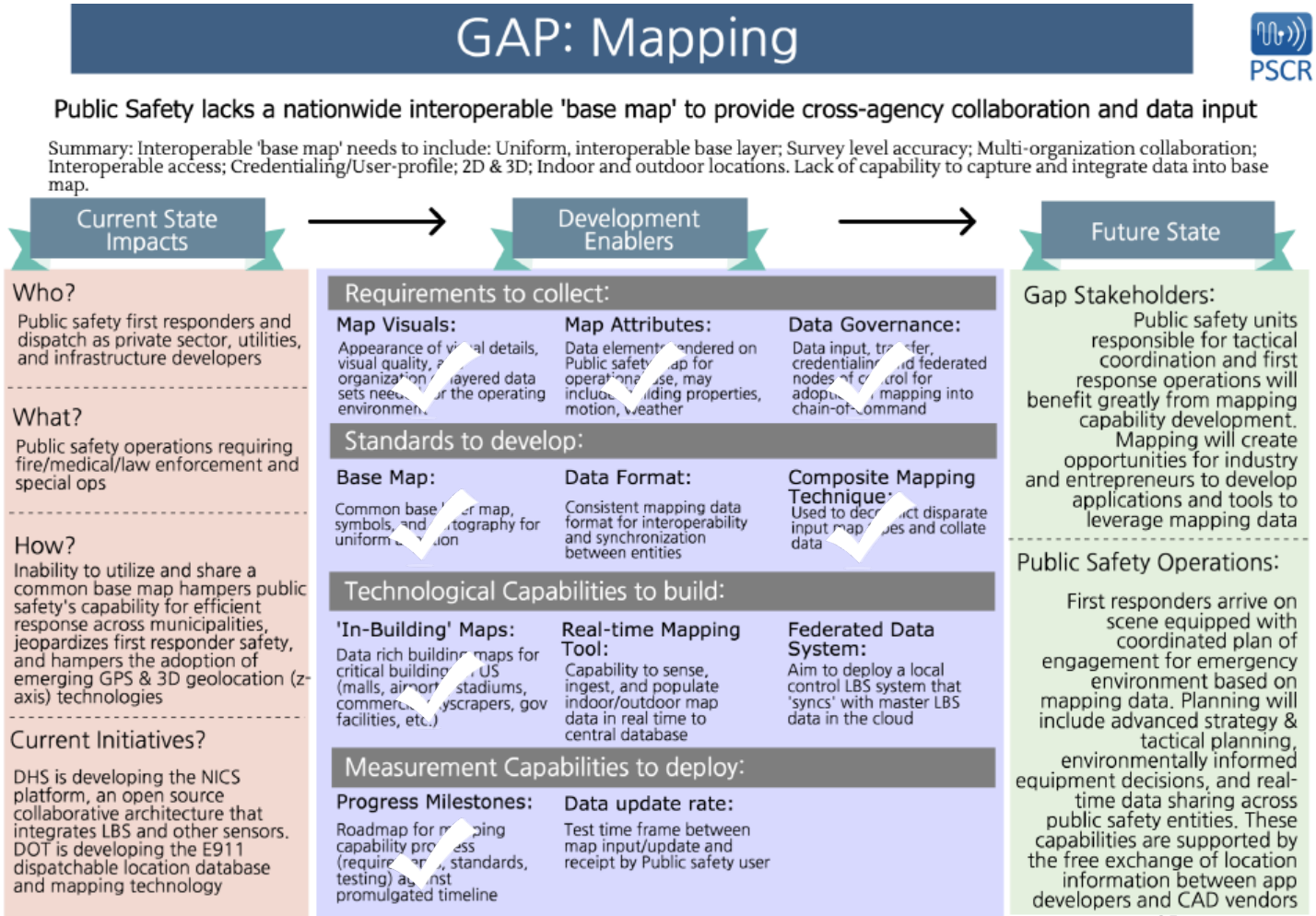
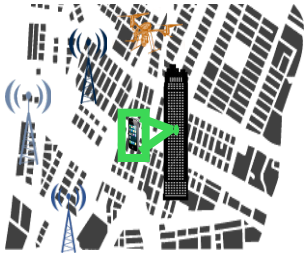
Mapping & Visualization PSCR Project

Mapping & Visualization

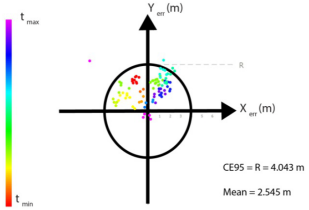


PSCR LBS Demo Network

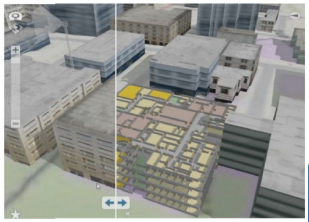
Summary of Program Takeaways



- **Researching Radio Based UWB technology to address Sub-Meter Accuracy**



- **Validating Test specification for International ISO Indoor Location Accuracy**



ESRI Indoor 3D software showing Cramer hall, Portland State University; Exterior (left) Interior (right)

- **Assessing means to create indoor 3D maps with common standards for Public Safety**

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Potential Prizes & Challenges

LBS Channel Interference

LBS Simultaneous Location And Mapping Tools

LBS Data Format & Interoperability

Mapping and Visualization of Complex Structures

Public Safety LBS Test Bed

Isolated Operations LBS Systems

SNAPSHOT: LMR to LTE Standards Update

Bridging LMR and Mission Critical Push To Talk over LTE

Andrew Thiessen
PSCR Standards Lead

June 2016

Agenda

- 3GPP Standards related to LMR to LTE
- ATIS efforts in LMR to LTE
- Some considerations moving forward
- Next steps

3GPP LMR to LTE standards update

- TS 22.179 established stage 1 requirements for MCPTT
- Clause 6.18.3 contains the Interworking with non-LTE PTT systems requirements
- Project 25
  - 21 requirements
- TETRA
  - 14 requirements
- Legacy land mobile radio
  - 11 requirements

3GPP LMR to LTE standards update

- In the April 2016 SA6 meeting in Ljubljana, a new feasibility study was agreed - *Study on Mission Critical Communication Interworking between LTE and non-LTE systems*
  - Feasibility study objectives
    - Identify a generic solution suitable for non-LTE mission critical LMR systems that satisfy TS 22.179 Clause 6.18.3
    - Provide mission critical services in scenarios in which interworking is required with either terminals or infrastructure for providing narrowband mission critical voice, video and data services
    - This study may require interaction with other standards organizations in order to identify interworking issues and their solutions
    - This study will seek to identify an interworking application architecture to satisfy the stage 1 requirements
    - This study will take into account the conclusions reached in mission critical system migration and interconnect between MCPTT systems
  - Expected for approval by plenary in Dec 2016

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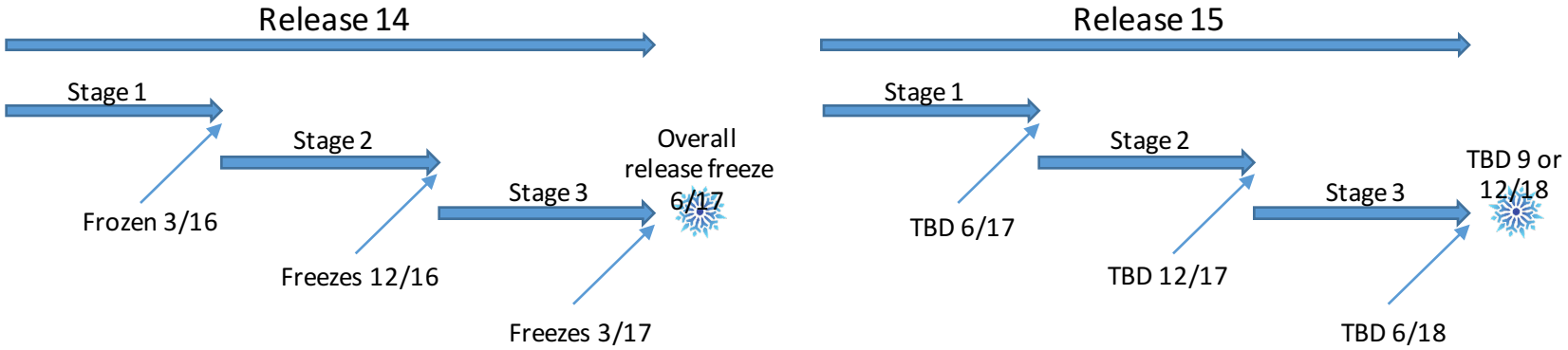
3GPP release schedule overview



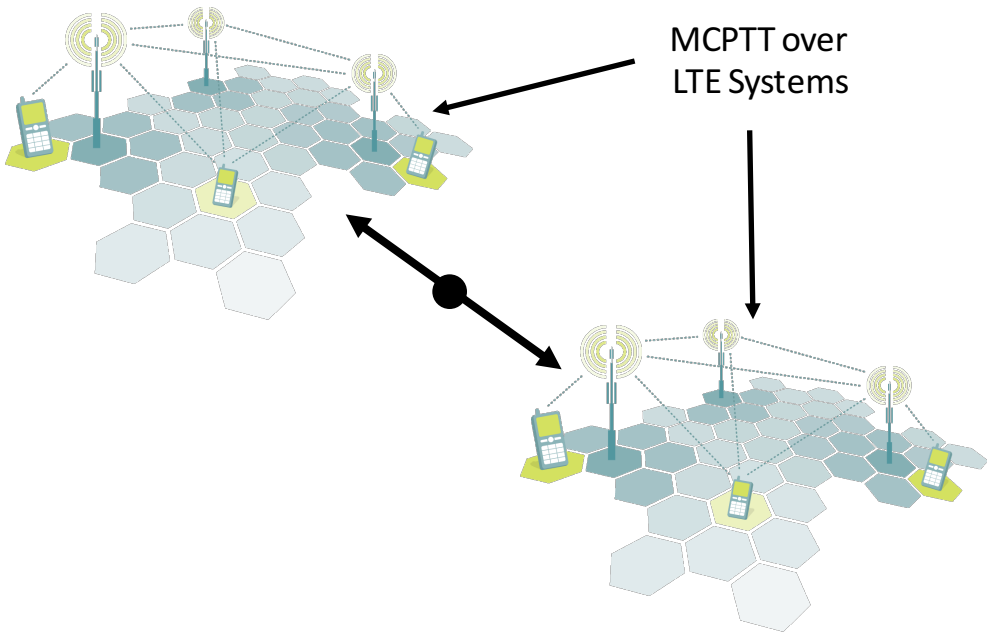
This means a tight timeline for normative work for LMR to LTE in Release 14!

ATIS efforts to date

- ATIS-TIA JLMRLTE is dormant
- Currently wider effort underway - ATIS LMR/LTE Interworking Ad Hoc
  - Comprised of many SDO's, including ATIS, TIA, ETSI, TTA, and 3GPP
    - Soon could also include CCSA and TSDSI
  - This group is a platform where requirements can be formulated for incorporation into 3GPP specifications
  - The group has developed a common nomenclature between North American LMR, the TETRA community, and 3GPP's MCPTT

What to consider

What we got in Release 13…



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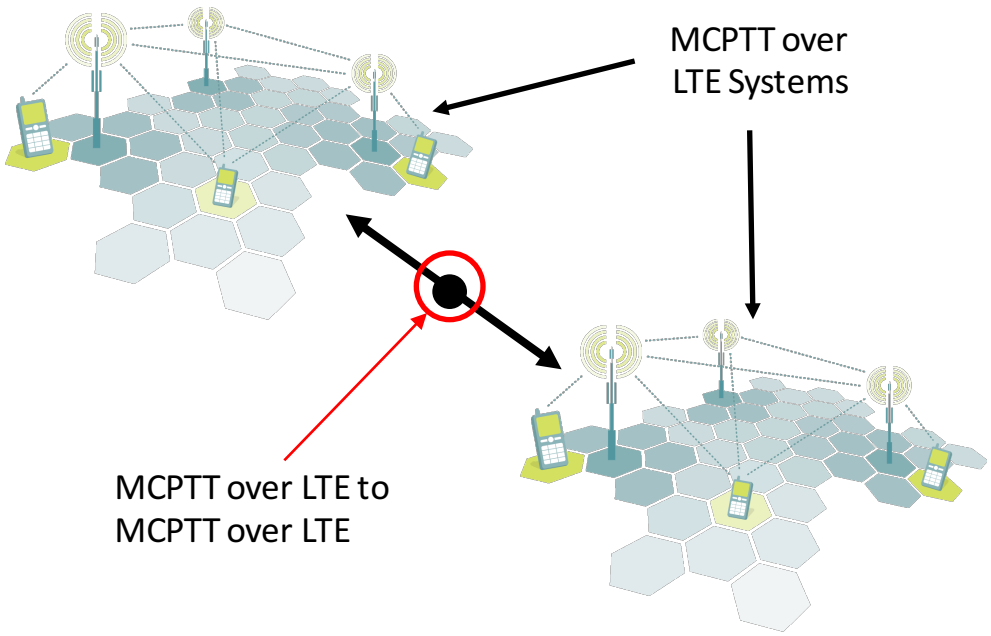
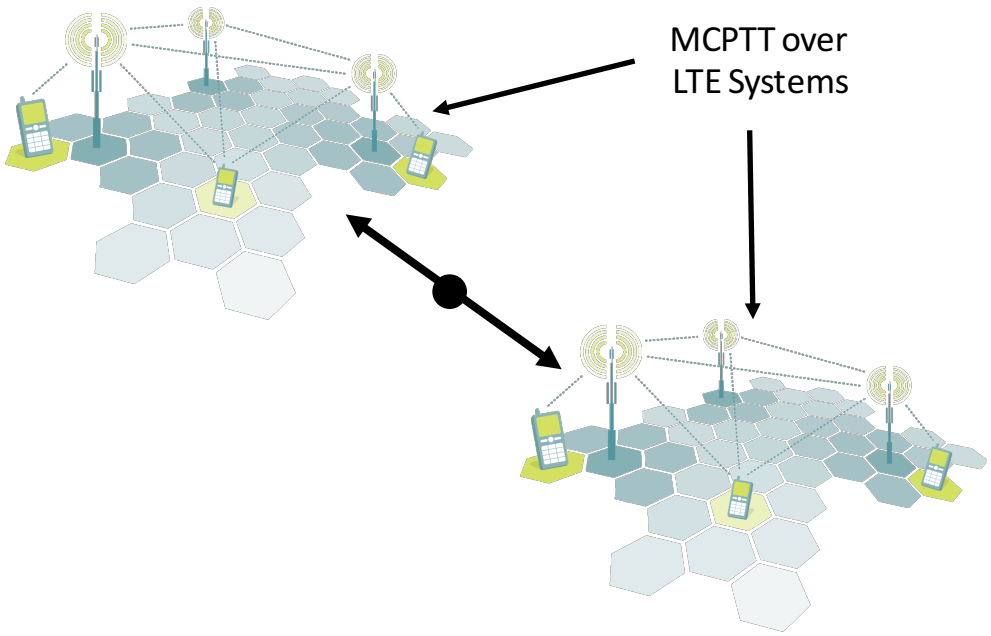


What to consider

What are we working on adding now?



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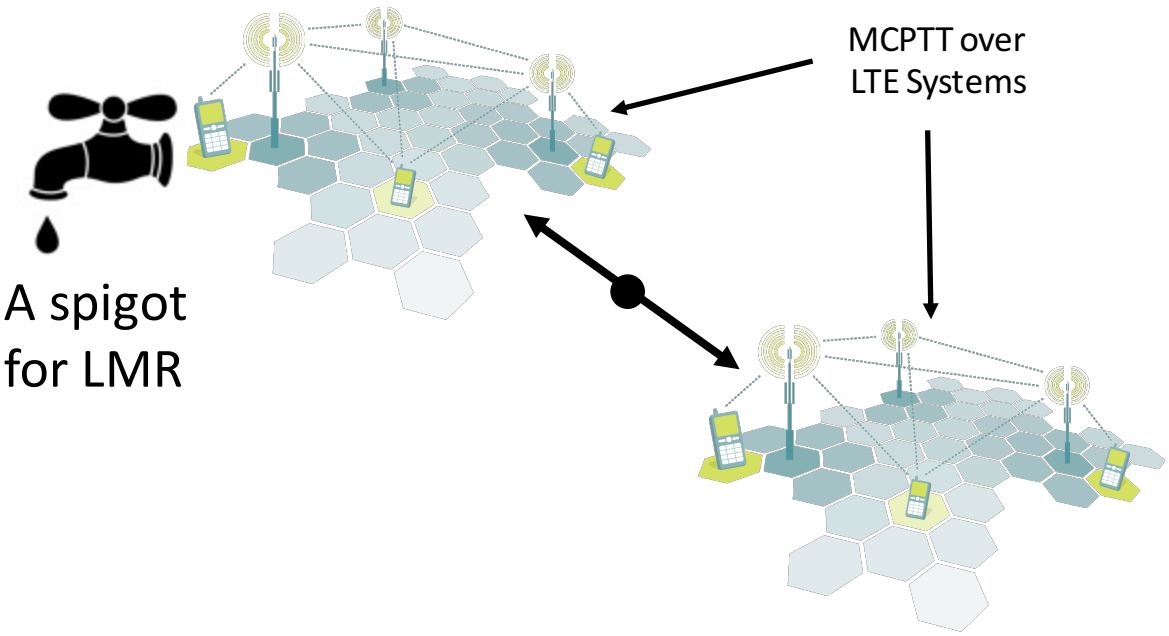

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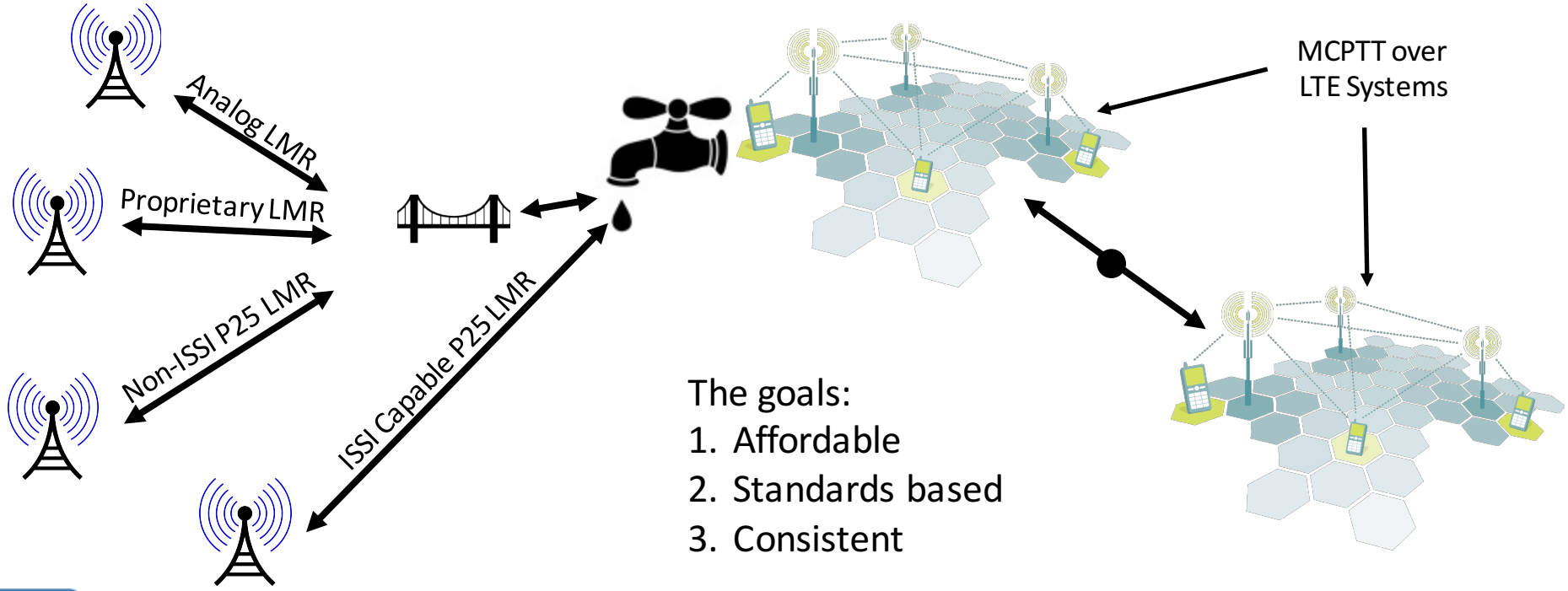
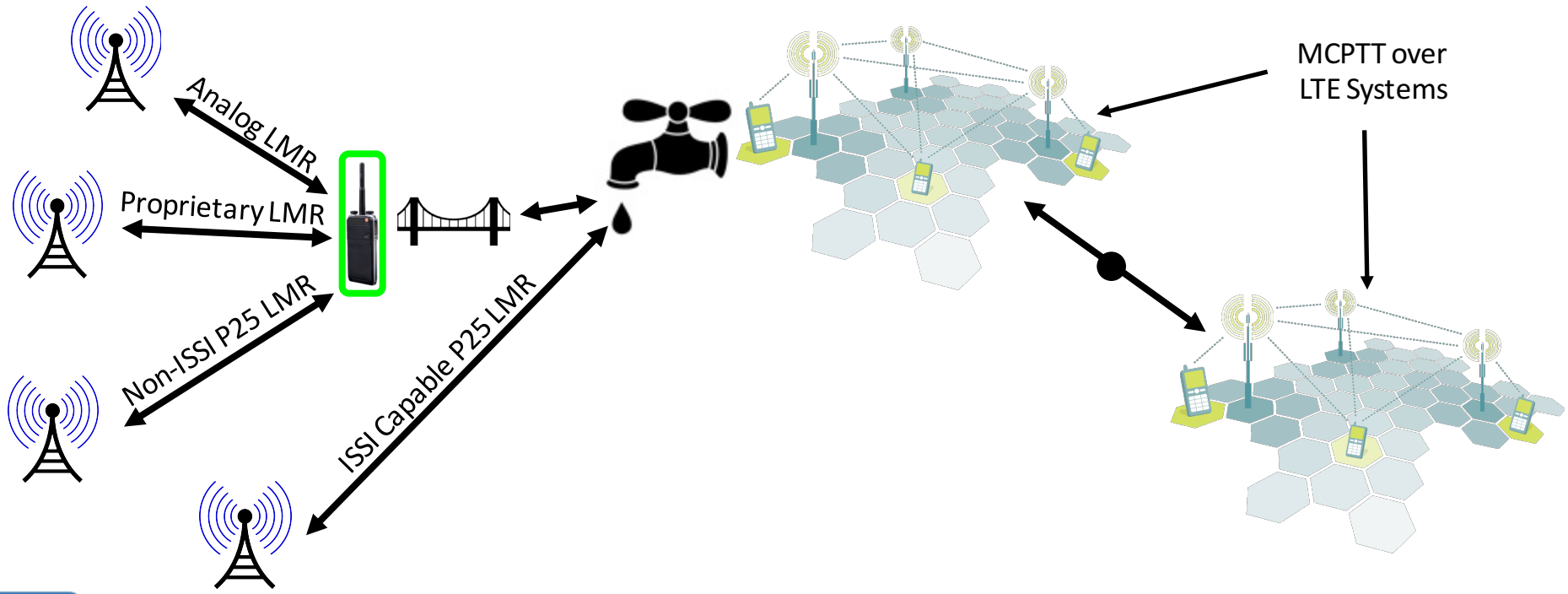


The goals:

1. Affordable
2. Standards based
3. Consistent

What to consider



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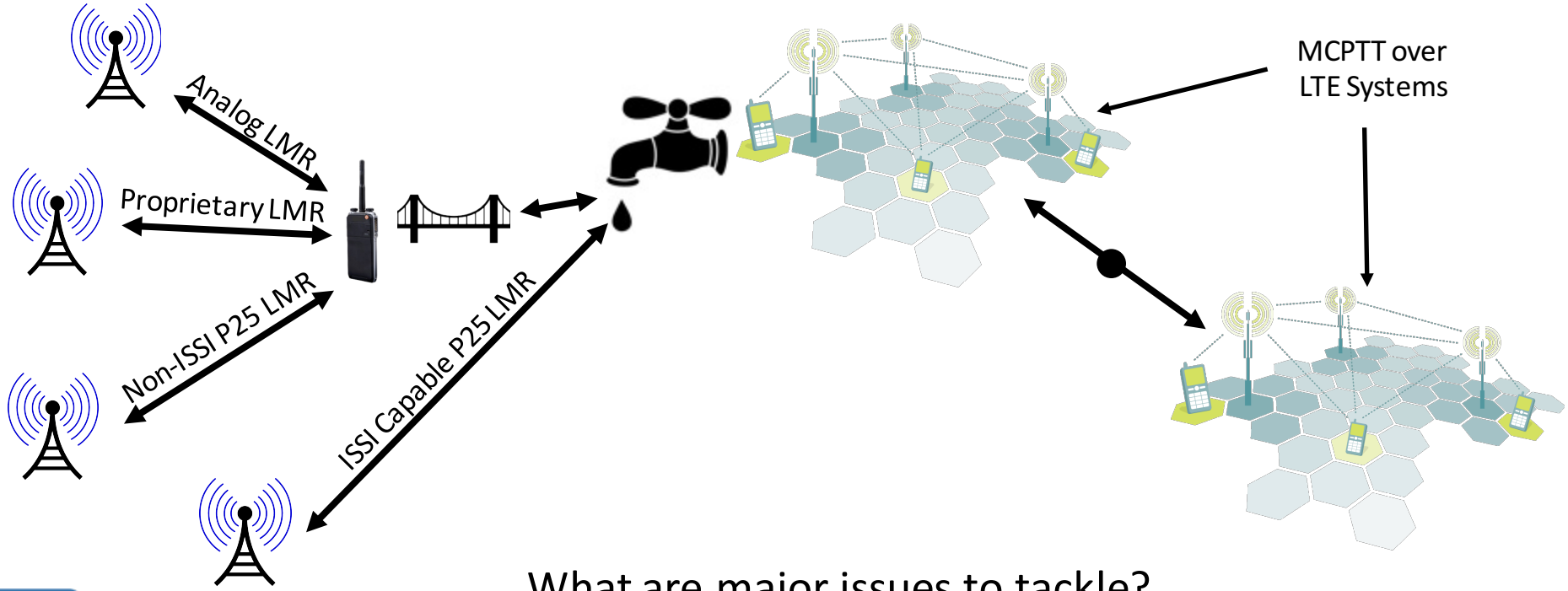
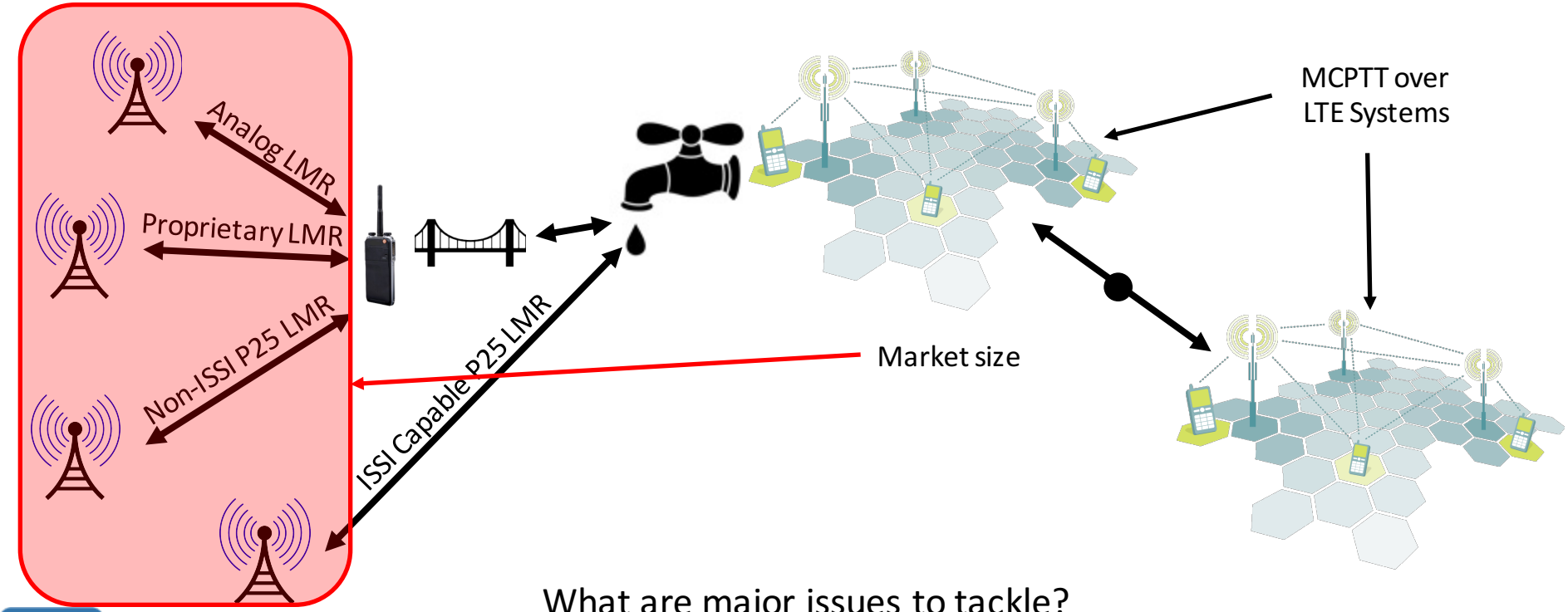


What are major issues to tackle?

What to consider



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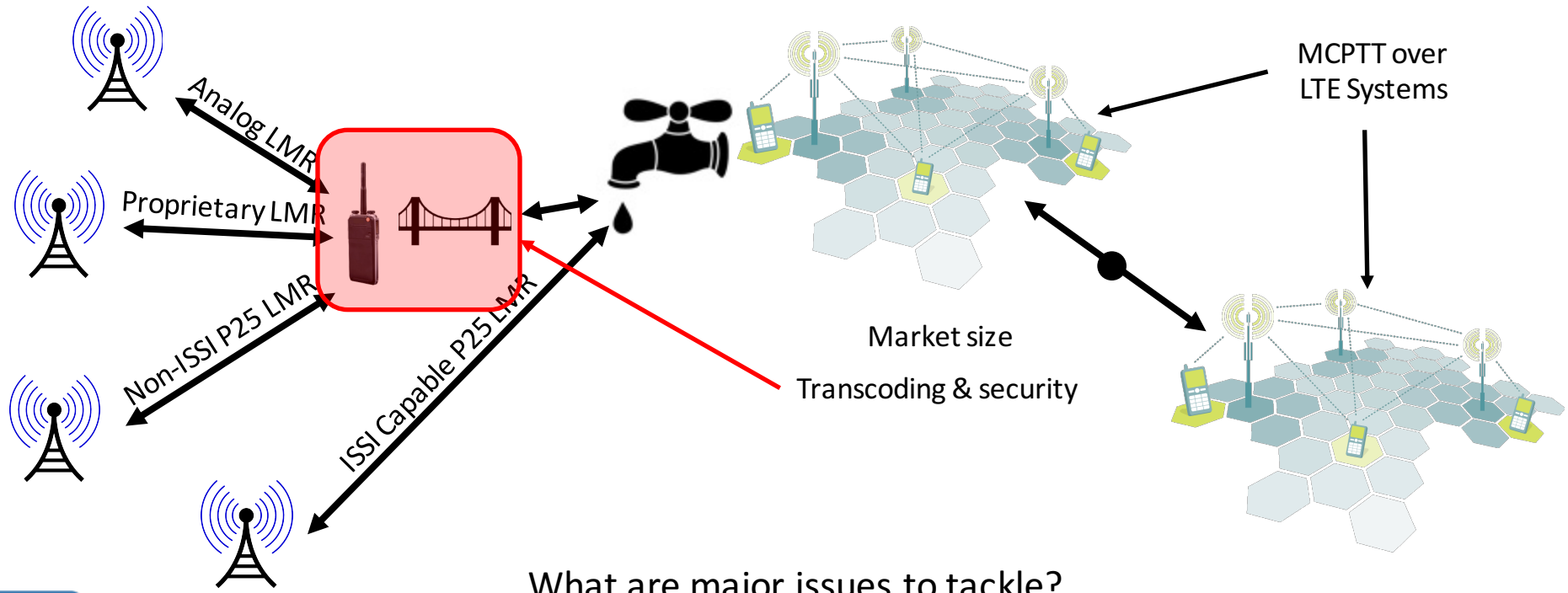

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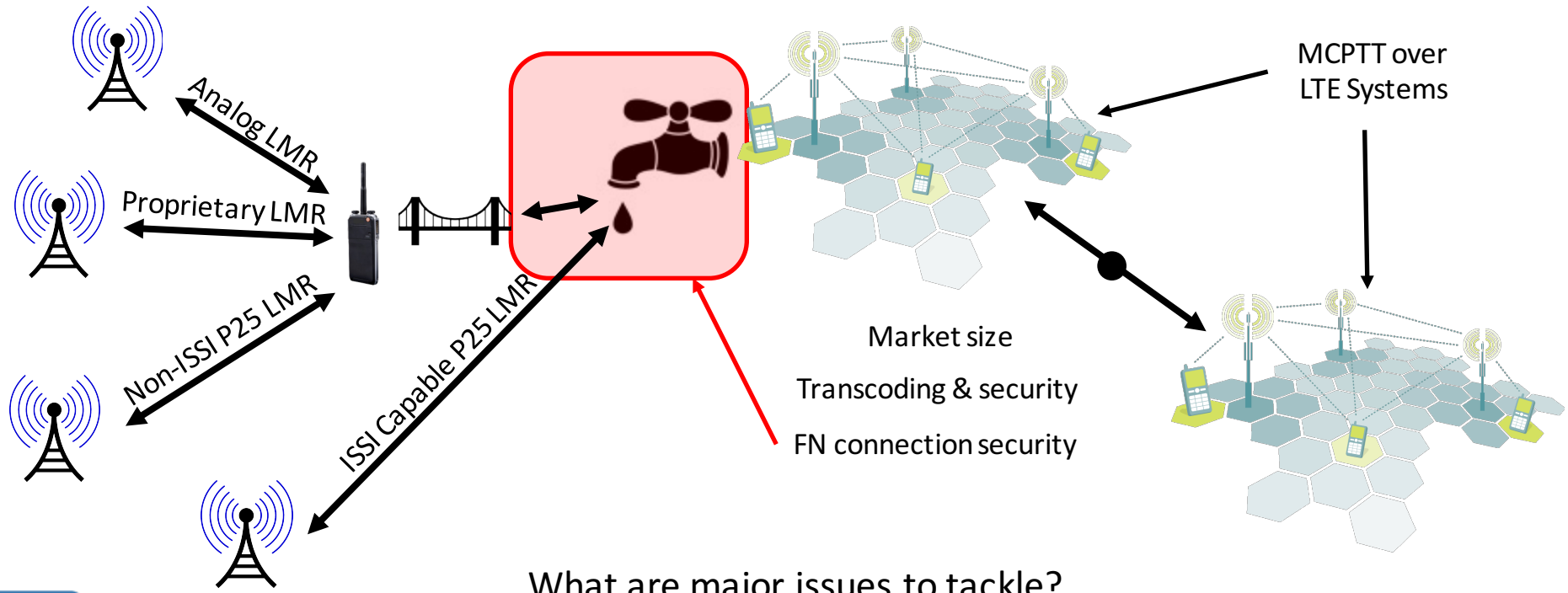

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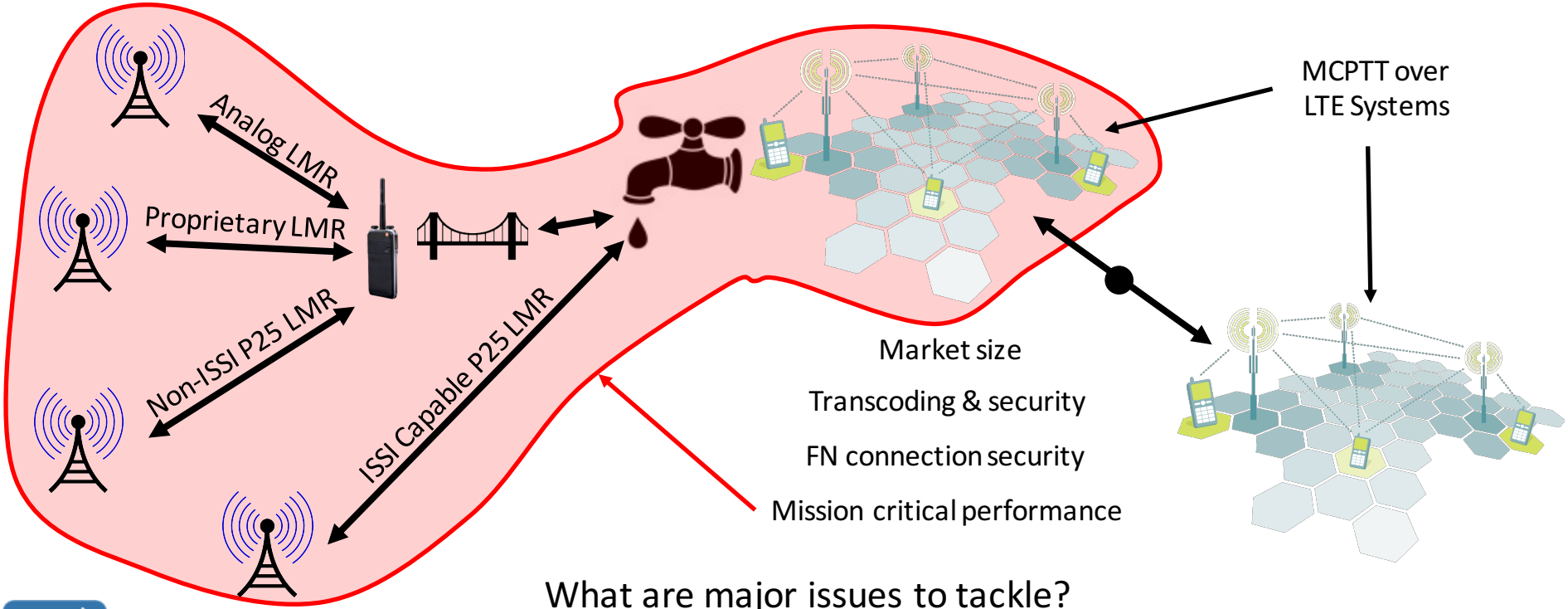


What are major issues to tackle?

Next Steps

- What additional issues does this effort need to consider?
- How far do the standards need to get before more action can be taken?

PSCR

SNAPSHOT: Department of Homeland Security

Office of Emergency Communications (OEC) & Office for Interoperability and Compatibility (OIC) Updates

Homeland Security

OEC, the Emergency Communications Ecosystem, and LMR Sustainment

Public Safety Communications Research (PSCR) Public Safety Broadband Stakeholder Meeting
June 8, 2016

Ronald Hewitt
Director
Department of Homeland Security
Office of Emergency Communications

OEC Mission, Priorities

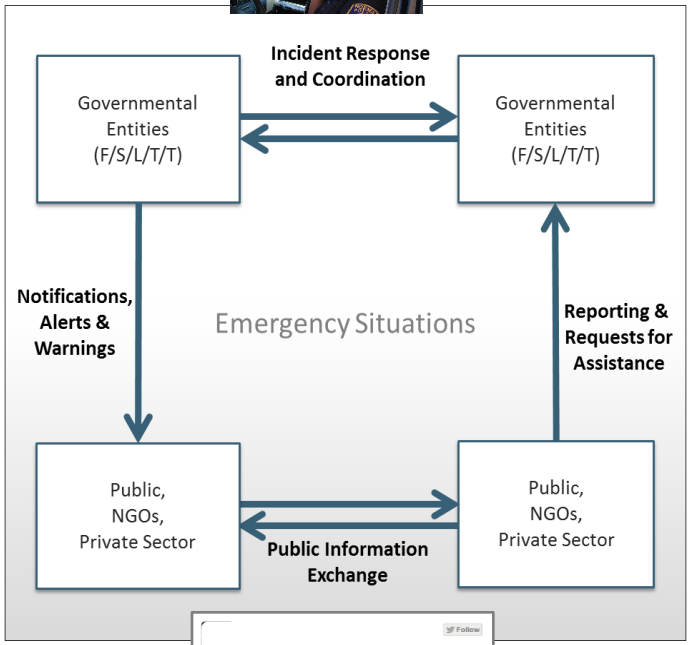
Office of Emergency Communications

Mission: Support and promote communications capabilities used by emergency responders and government officials to keep America safe, secure, and resilient

OEC Priorities

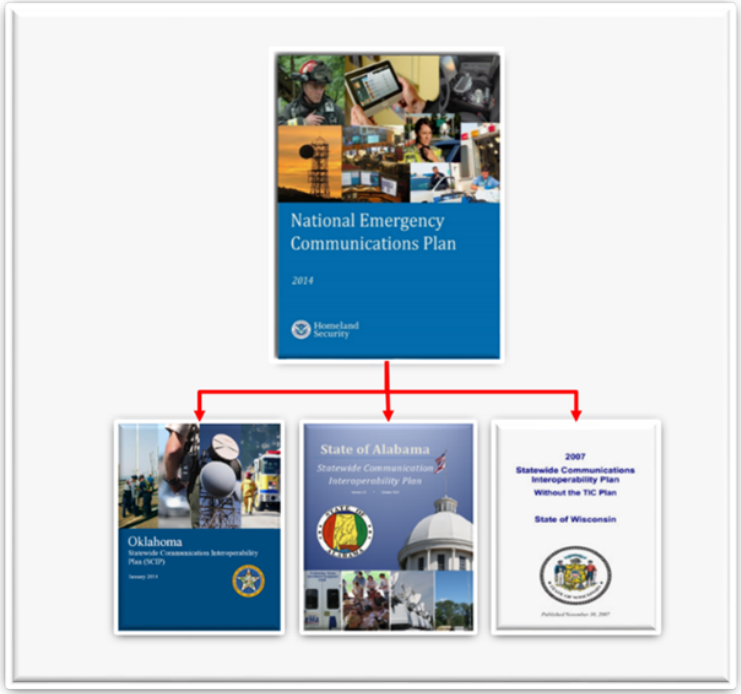
- Sustain Land Mobile Radio (LMR)
- Support Broadband Planning
- Strengthen Governance Structures

Emergency Communications Ecosystem

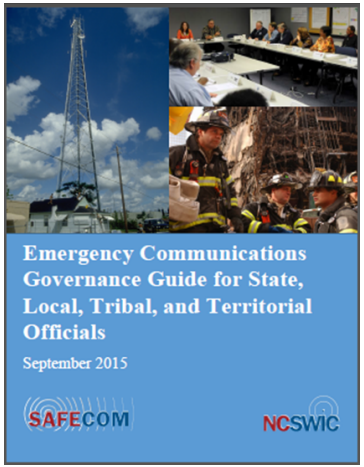


National Emergency Communications Plan

- Nationwide vision to drive interoperability
- Based on SAFECOM Continuum
- All 56 States/Territories have a SCIP that aligns with the NECP.



Statewide Interoperability Governance Board



LMR Sustainment

SAFECOM/NCSWIC released the "LMR Trio" to educate decision-makers and funders about the need to sustain and support LMR systems throughout the development of the NPSBN.

- Land Mobile Radio 101
- Land Mobile Radio for Decision-Makers
- Land Mobile Radio for Project Managers

SAFECOM NCSWIC

Land Mobile Radio (LMR) 101

Part 1: Educating Decision-Makers on LMR Technologies

INTRODUCTION

Every day, dedicated men and women responders at every level of governmer varying size and scope, and assist com coordination among law enforcement a health care professionals. As Figure 1 Communications is a critical part of th negatively affect response, risking life

Emergency Situation

Emergency situation identified

Figure 1. Mis

Public safety agencies rely on land m critical voice communications betwe

WHAT ARE LMR SYSTEMS?

LMR systems are terrestrially-based, w territorial emergency responders, publi communications. LMR systems typica repeaters.

- **Handheld portable radios** ar
- **Mobile radios** are often locate greater transmission range tha
- **Base station radios** are locate tend to have the most powerful transmitter
- **A network** is required to connect the diffe
- **Repeaters** are used to increase the effectiv base station radios by retransmitting receiv

February 2016 LMR 101 Page 1

SAFECOM NCSWIC

Land Mobile Radio (LMR) For Decision Makers

Part 2: Educating Decision-Makers on LMR Technology Issues

SAFECOM NCSWIC

Land Mobile Radio (LMR) for Project Managers

Part 3: A P25 Primer for Project Managers and Acquisition Managers

Public safety agencies use land mobile radio (LMR) systems as the primary means for transmitting mission-critical voice communications and low-speed data between public safety responders. As LMR systems and technologies have evolved over many decades, there are a variety of communications systems in use today. Traditionally, systems are designed to meet specific agency missions and operate on assigned frequencies/channels within appropriate spectrum bands (e.g., very high frequency [VHF], ultra high frequency [UHF], 700 megahertz [MHz], 800 MHz). Vendors built LMR systems and equipment that were non-standard, and offered vendor-specific features, that could inhibit interoperability with surrounding systems and equipment. As a result, disparate LMR systems emerged, and were not always compatible with each other, making it difficult for public safety agencies to communicate across jurisdictions and disciplines. Public safety recognized a need to standardize systems and equipment, to ensure that, regardless of system or vendor, responders could communicate.

As digital and trunking technologies were introduced in the late 1980s and early 1990s, the public safety community and federal government agencies recognized the need for standards to enhance communications interoperability, and to provide a competitive marketplace for public safety agencies.

DEVELOPING STANDARDS

The Federal government, in partnership with the Association of Public Safety Communications Officials (APCO) and the National Association of State Telecommunications Directors (NASTD), signed a Memorandum of Understanding (MOU) with the Telecommunications Industry Association (TIA) to develop digital LMR standards to develop public safety requirements (1992, amended in 1993).

Federal, state, and local public safety representatives worked with the Telecommunications Industry Association (TIA) to develop standards for LMR systems, known as P25. As a result of this public-private collaboration, the P25 standards have gained worldwide acceptance for public safety, security, public service, and commercial applications. Moreover, P25 standards development is continuous, and ongoing as new features, interfaces, and testing procedures are continuously developed, updated, and released.

ADOPTING STANDARDS

Following the tragic events from 9/11, legislation was passed to improve the interoperability of public safety communications systems and equipment. Congress mandated that new or upgraded equipment must be interoperable and meet certain interoperability standards. As a result, the federal government supported the purchase of P25-compliant LMR equipment through grants and policy, to ensure public safety systems can interoperate, regardless of manufacturer.

It's worth noting that while the purchase of P25 equipment provides the technical ability to connect, there is an equally pressing need to establish standard operating procedures that define roles, responsibilities and appropriate usage of dedicated interoperability resources during response operations. Interoperability requires not only the technical ability to connect, but also the agreement between people, agencies, and other players to communicate and cooperatively respond to emergencies and disaster events. Recognizing the great value of standards-based equipment investments, the federal government supports the purchase of P25 equipment to improve interoperability among public safety agencies.

February 2016 Land Mobile Radio (LMR) for Project Managers Page 1

Homeland Security

Office for Interoperability and Compatibility Update

PSCR Broadband Stakeholder Conference – June 8, 2016

John Merrill

Director
Office for Interoperability and Compatibility
Science and Technology Directorate
Department of Homeland Security

Homeland Security
Science and Technology

Project 25 Compliance Assessment Program (P25 CAP)

Description

- Formal, independent process for ensuring communications equipment that manufacturers declare to be P25 compliant meets P25 standards

Value

- Enhances interoperability by helping first responders verify P25 equipment compliance before purchase
- Provides vendors with a method for testing their equipment for P25 compliance
- Promotes effective use of federal grant funding for P25 equipment
- Provides Summary Test Reports (STR) and Suppliers' Declaration of Compliance (SDoC) documentation on the FirstResponder.gov website

Homeland Security
Science and Technology

P25 Stakeholders

- P25 Steering Committee (Chaired by DHS OEC)
  - User Needs Subcommittee
- Telecommunications Industry Association TR-8
  - http://www.tiaonline.org/all-standards/committees/tr-8
  - Next Meeting scheduled for June 7-9 (Kansas City, MO)
- Project 25 Technology Interest Group (PTIG)
  - www.project25.org
  - Capabilities Guide

Homeland Security
Science and Technology

P25 CAP Advisory Panel (AP) Members

- DHS S&T OIC Director selected following AP Members:
  - 5 members administering and supporting statewide P25 systems
    - Marty McCoy - State of Wyoming
    - Mike Kionka - State of Colorado
    - Dan Robinson - State of Michigan
    - Roger Strope - State of Missouri
    - Arnold Hooper - State of Tennessee
  - 3 members administering and supporting county or municipal P25 systems
    - Fire Chief Gerald Reardon - City of Cambridge Massachusetts Fire Department
    - Chris Kindelspire - Grundy County, Illinois
    - Morton Leifer - Town of Clarkstown, New York
  - 2 federal representatives supporting P25 standards by policy and advocacy
    - Joseph Heaps - National Institute of Justice
    - John Evanoff - Federal Communications Commission

P25 CAP AP Next Steps

- Review and recommend updates to Compliance Assessment Bulletins
  - Prioritize and identify P25 CAP testing requirements
- Promote P25 CAP tested equipment across local, state, tribal and federal first responders
- Promote Inter RF Sub System Interface (ISSI) testing
- Consider ways to make P25 CAP information (e.g., Summary Test Reports and Suppliers' Declaration of Compliance) more accessible to first responder agencies
- Help inject user needs into standards process for future feature development

Homeland Security
Science and Technology

P25 CAP Resources

- One stop shop website: www.firstresponder.gov/P25CAP
  - STR and SDoC
  - Participating P25 CAP recognized labs
  - Latest CABs
  - P25 CAP AP information
- Contact Us: P25CAP@hq.dhs.gov
  - STR and SDoC submissions
  - Questions

Homeland Security
Science and Technology

Communications Hub Device

Integrates an array of wireless communications technologies through one centralized hub: land mobile radios, smartphones, Internet of Things sensors, FirstNet, WiFi and mesh networks.

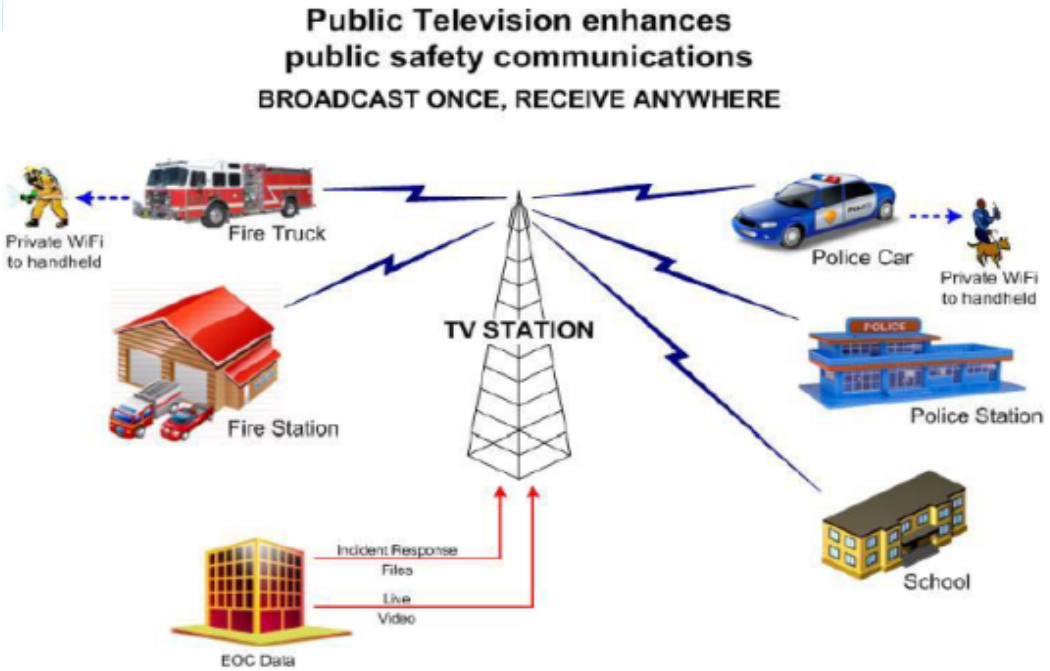
Courtesy of Mutualink

Courtesy of IS4S

Homeland Security
Science and Technology

Datacasting

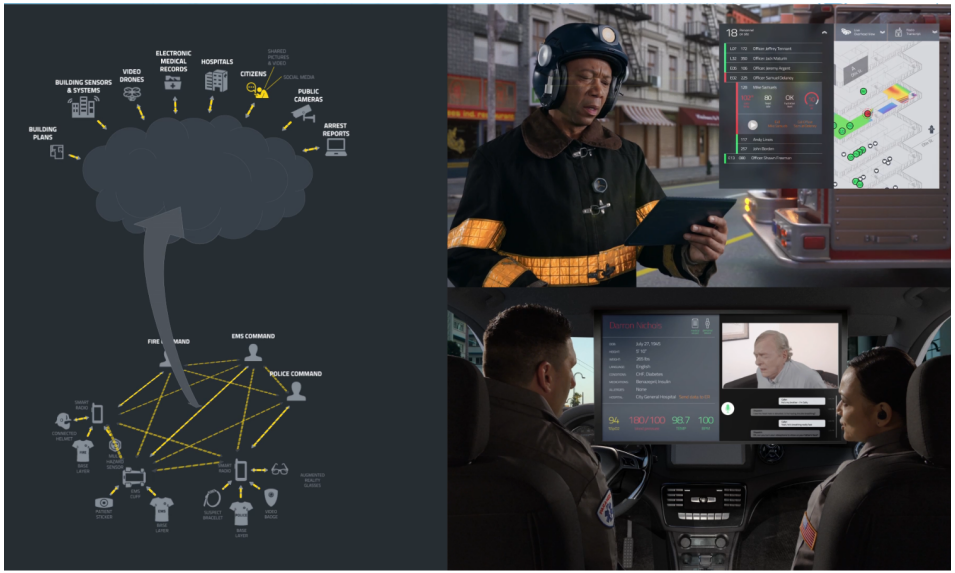
Shares large data files – building blueprints, videos, etc. – with first responders in the field using the public television spectrum.



Homeland Security
Science and Technology

AUDREY

Assistant for **U**nderstanding **D**ata through **R**easoning, **E**xtraction & **s**Ynthesis



Homeland Security

Science and Technology

Homeland Security

Science and Technology

Mission Critical Voice 101

Jeb Benson, *PSCR Advanced Communications Research Group*

Goals of this Tutorial

- Understand how key elements of MCV might be implemented in LTE
- Recognize functionality consistent with LMR
- Begin to think about KPIs relevant to you
- Begin to think about opportunities for innovation
- Consider how extensive testing must be before LTE can be adopted for MCV
- Have a little fun!

KPI Tracker – Look for the

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

PSCR

PUSH-TO-TALK	TALKER IDENTIFICATION	EMERGENCY ALERTING	AUDIO QUALITY	GROUP COMMUNICATIONS	DIRECT MODE
$1	$1	$1	$1	$1	$1
$2	$2	$2	$2	$2	$2
$3	$3	$3	$3	$3	$3

A DETERMINISTIC METHOD TO ARBITRATE BETWEEN REQUESTS TO TRANSMIT THAT ARE IN CONTENTION

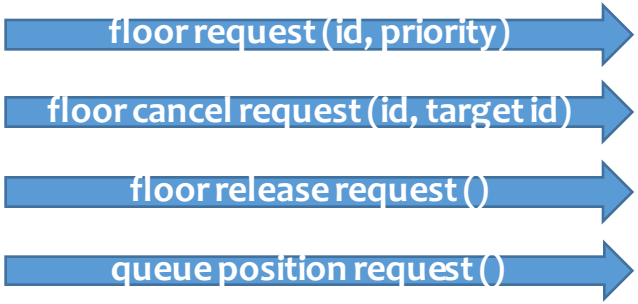
Floor Control

- Literally “who has the floor?”
- Very logical set of call flows (next slide)
- One piece of overall MCPTT Priority and QoS framework (next slide + 1)
- Protocol essentially the same for on and off network, but where functional entities reside is different:
  - ON-NETWORK – MCPTT Application Server
  - OFF-NETWORK – UE 
- Private Call can use floor control or not (full-duplex; only on-network)

PSCR

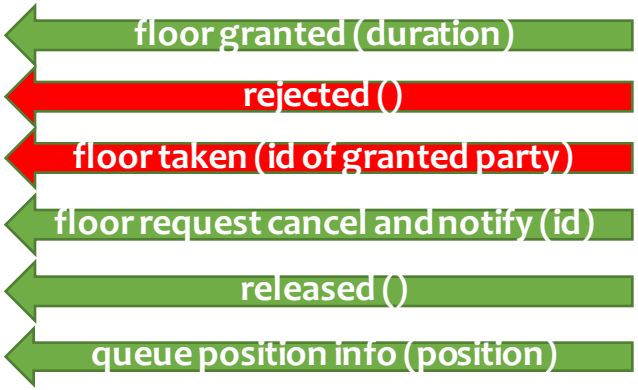
Floor Control Protocol/API

- Four requests:

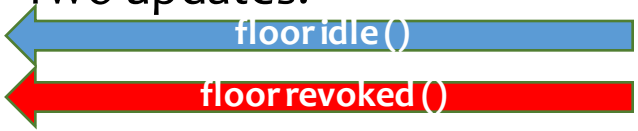


- Items in () are mandatory
- Requests/responses can include additional info
- Up to MCPTT App Server to utilize this set of commands (plus additional) for the best UX

- Six responses:



- Two updates:



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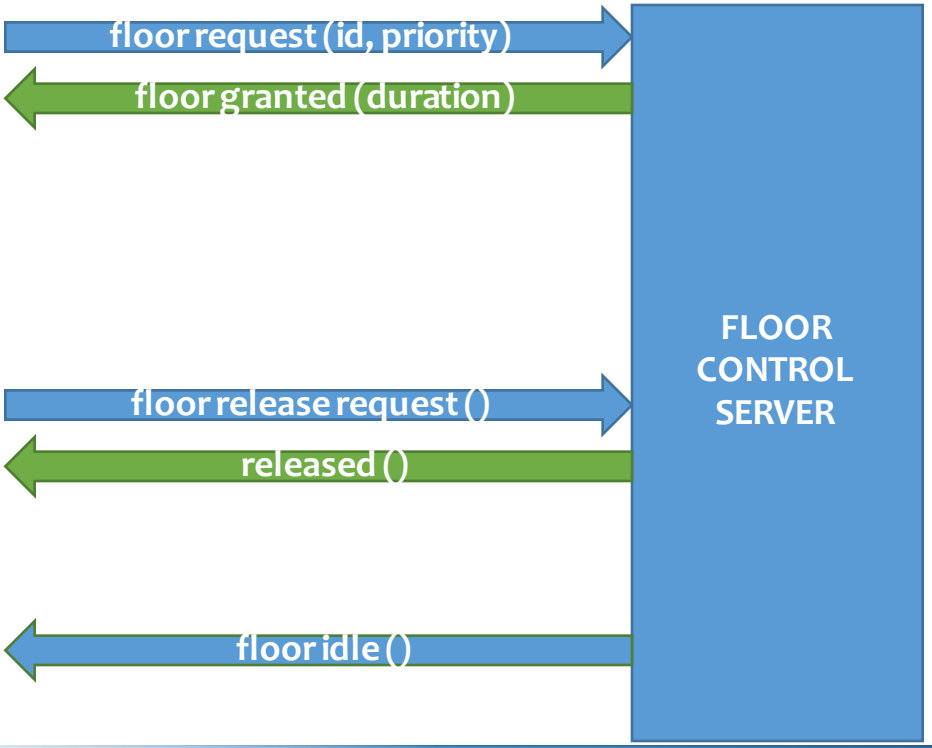
Floor Control Protocol/API



- Floor request & release

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Floor Control Protocol/API

floor request (id, priority)

rejected ()

floor taken (id of granted party)

queue position request ()

queue position info (position)

FLOOR CONTROL SERVER

floor release request ()

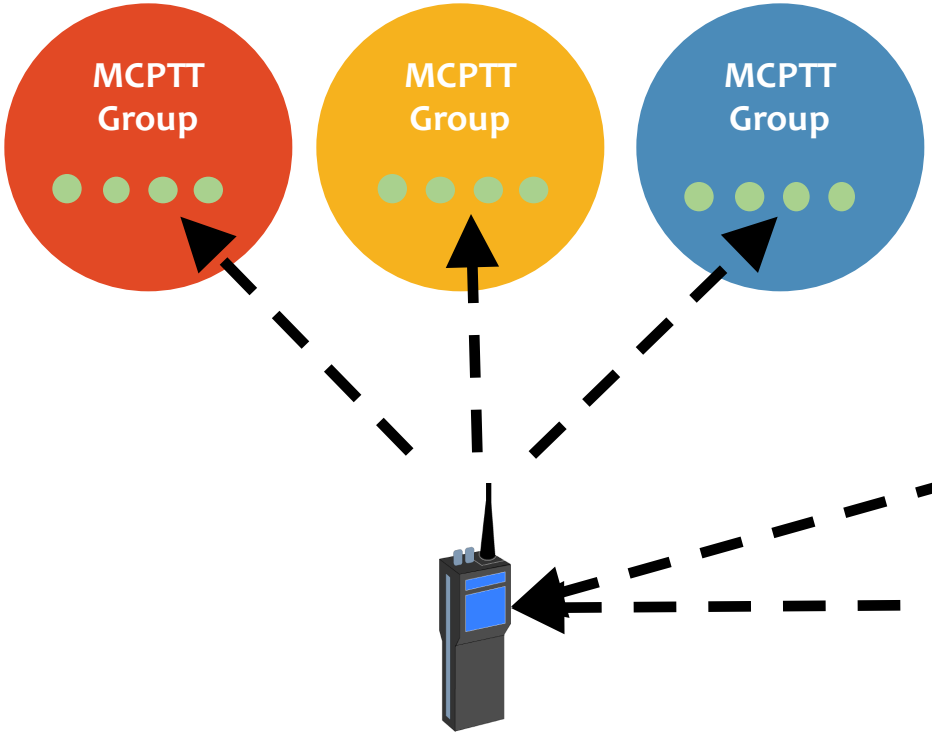
released ()

floor granted (duration)

- Initial floor request rejected

PSCR

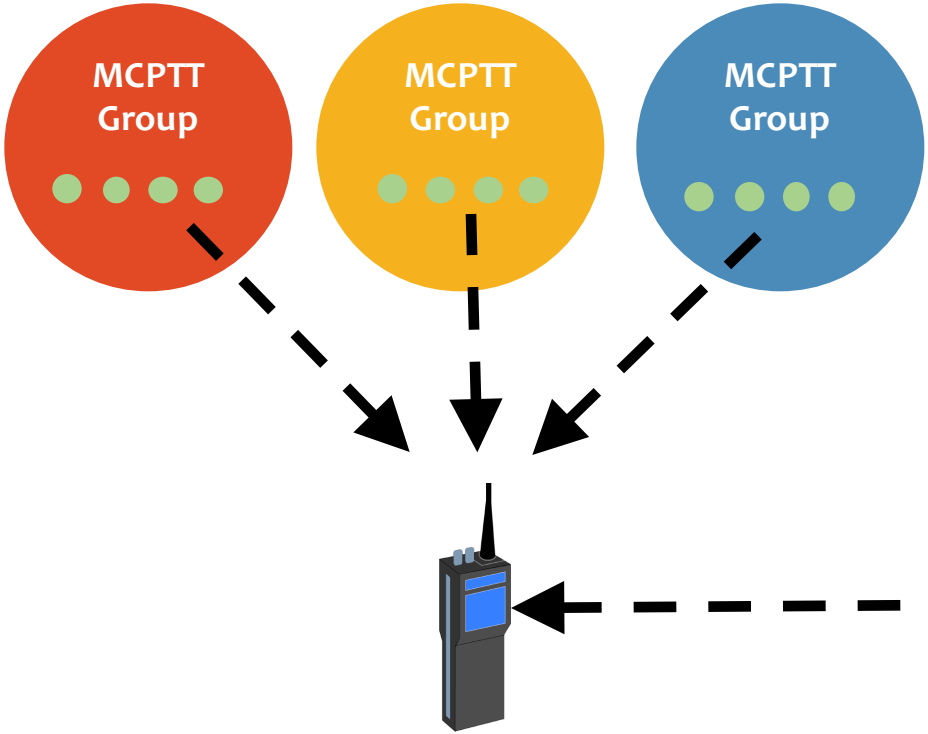
Group/Private Interactions with Floor Control



Simultaneously TX to one or more groups while RX from one or more private calls

PSCR

Group/Private Interactions with Floor Control



Simultaneously RX from one or more groups while TX or RX to/from ONE private calls

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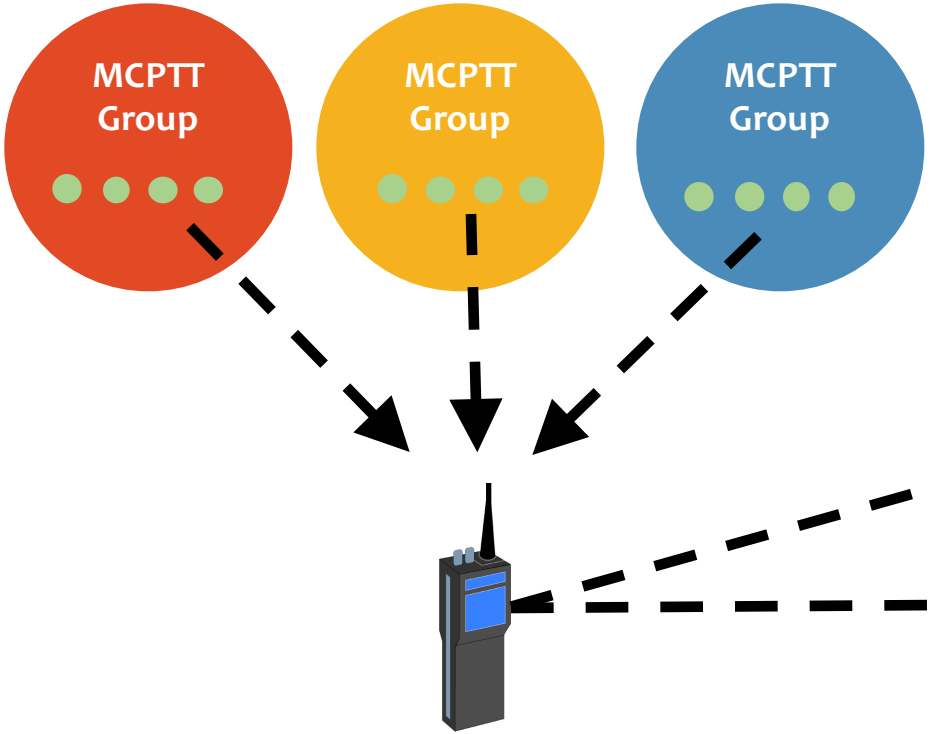
Group/Private Interactions with Floor Control



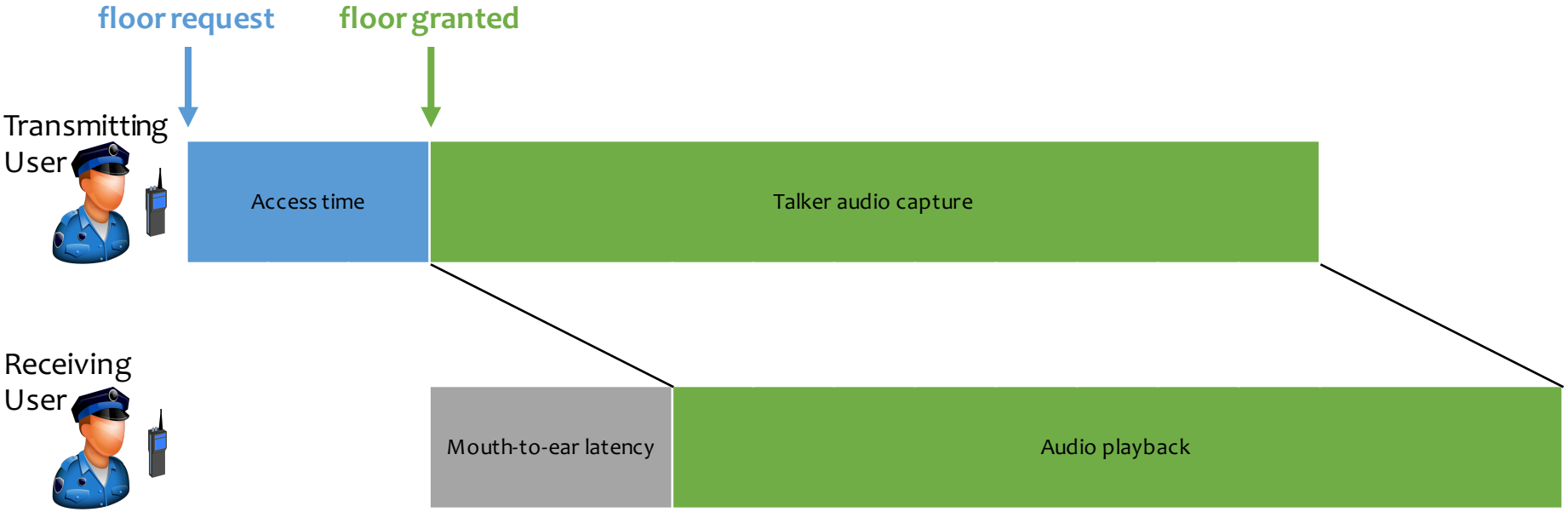
Simultaneously RX from one or more groups while TX to one or more private calls

PSCR

PUSH-TO-TALK	TALKER IDENTIFICATION	EMERGENCY ALERTING	AUDIO QUALITY	GROUP COMMUNICATIONS	DIRECT MODE
FLOOR CONTROL	$1	$1	$1	$1	$1
$2	$2	$2	$2	$2	$2
$3	$3	$3	$3	$3	$3

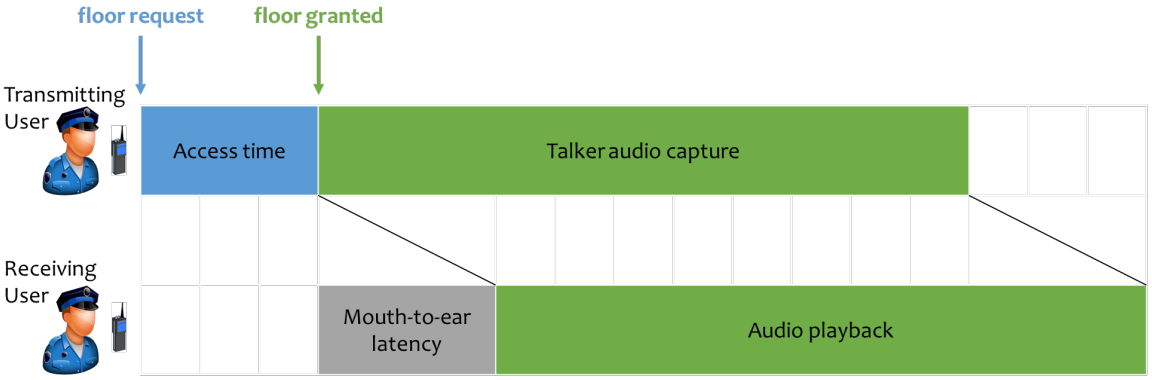
TERM USED TO DESCRIBE TIME BETWEEN A SPEAKER TRANSMITTING AND A LISTENER RECEIVING. NOT TO BE CONFUSED WITH A COMMON VIRUS THAT AFFECTS BABIES.

Mouth-to-Ear & Access Time



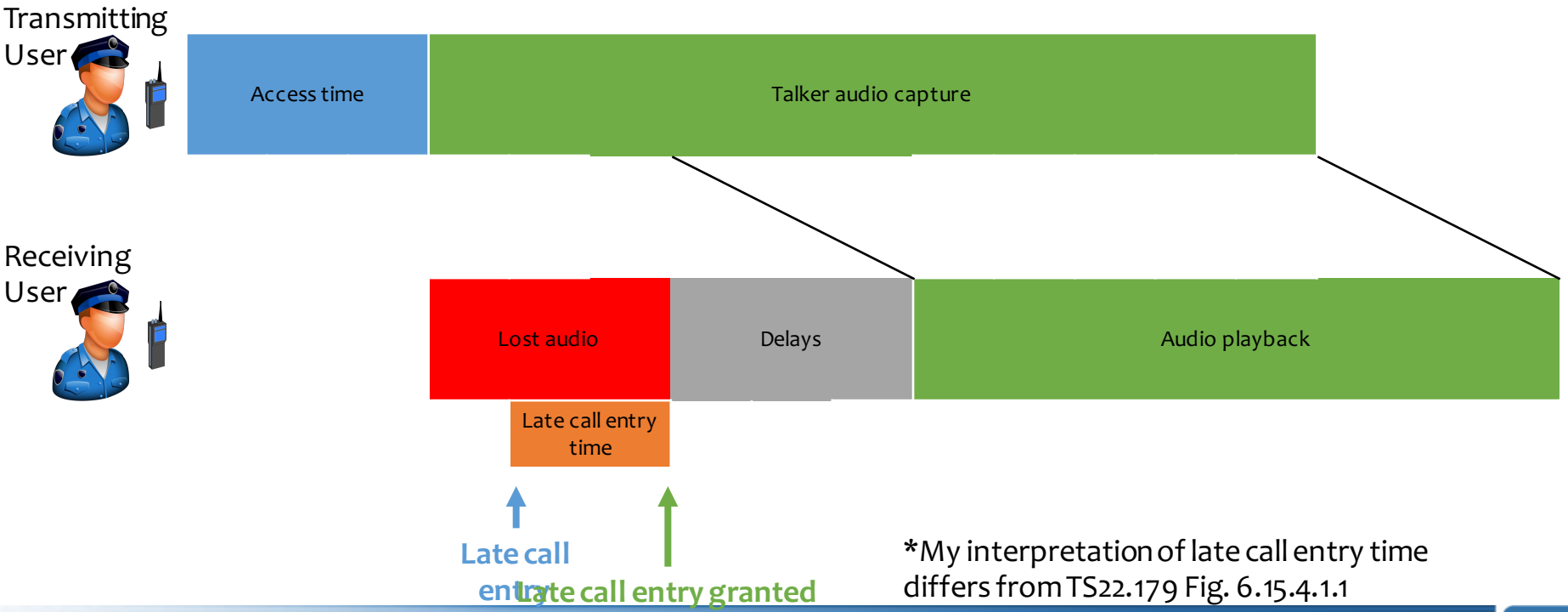
Mouth-to-Ear & Access Time

- Assumptions:
  - User already registered & affiliated
  - NEGLIGIBLE BACKHAUL
  - Overall network traffic load < 70%
  - For networks with QoS, total sector load < 70% for users with priority ≥ subject
- Access time < 300 ms for 95% of all MCPTT requests;
  - 99% for E&IP calls
- Mouth-to-ear < 300 ms for 95% of voice bursts
- Transcoding + 40 ms
- 0 ms initial or trailing lost audio



Thresholds not defined for out-of-network

Late Call Entry



*My interpretation of late call entry time differs from TS22.179 Fig. 6.15.4.1.1

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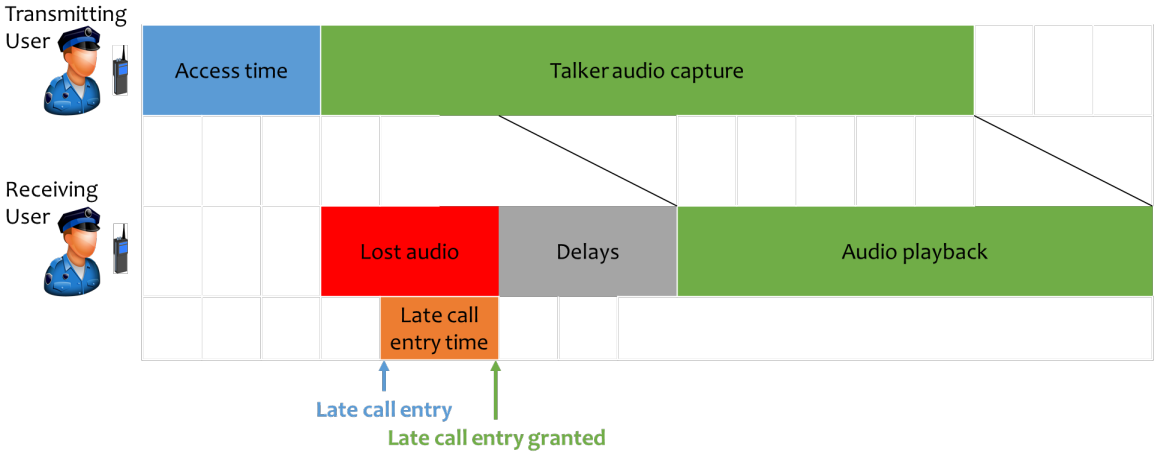
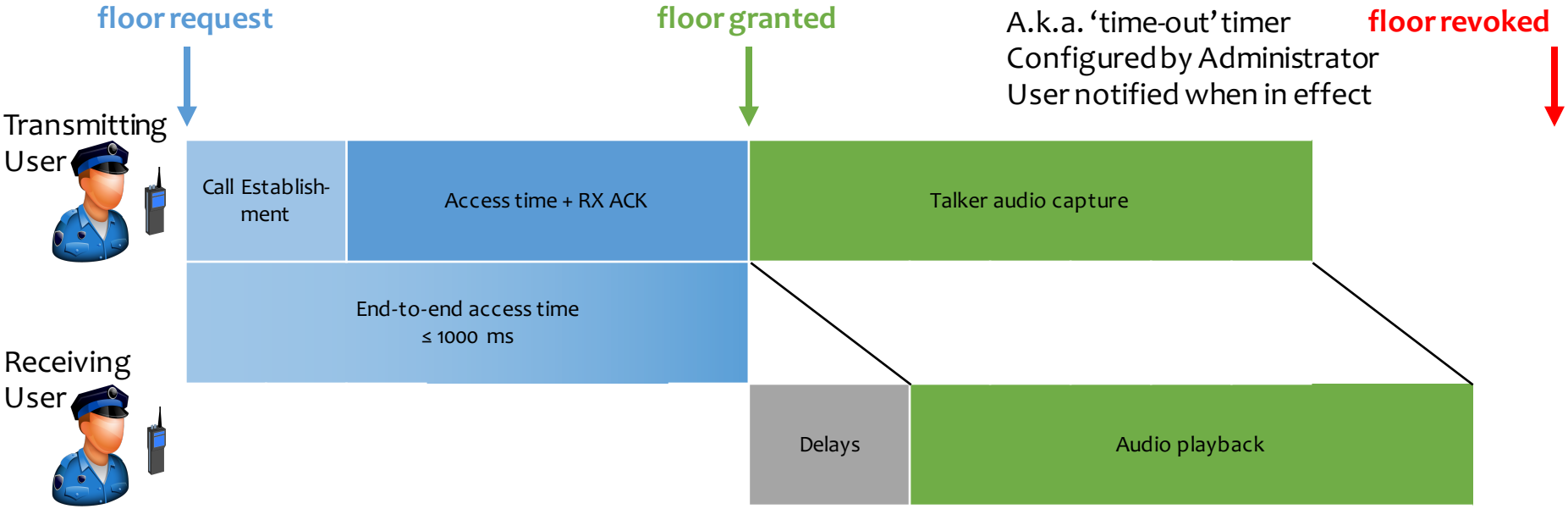
Late Call Entry

- Assumptions: same as before
- Except late call entry mentions encryption & interworking. Why not for access time and mouth-to-ear?
- Late call entry time:
  - Unencrypted < 150 ms for 95% of all Late call entry requests
  - Encrypted < 350 ms
- Interworking:
  - NTE encrypted; unencrypted not specified



Thresholds not defined for out-of-network

End-to-end Access Time & Transmission Time Limit



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FLOOR CONTROL	$1	$1	$1	$1	$1
MOUTH TO EAR	$2	$2	$2	$2	$2
$3	$3	$3	$3	$3	$3

MECHANISM TO ALLOW USER WITH HIGHER PRIORITY OR URGENT TRANSMISSION TO BE GRANTED FLOOR ACCESS EVEN WHEN BUSY

Override

floor request (id, priority)

floor granted (duration)

FLOOR CONTROL SERVER

floor request (id, priority)

floor taken (id of granted party)

floor cancel request (id, target id)

floor revoked ()

floor taken (id of granted party)

floor granted (duration)

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Static and Dynamic Attributes

ATTRIBUTES	Static	Dynamic
User	Role: first responder, supv, admin, dispatch, etc. Jurisdiction Priority	Operational status Location and boundaries Type of incident, severity Acting individually or managed Assigned role
Group	Type of group MCO Jurisdiction Group priority and pre-emption relative to others	Operational status Location and boundaries Type of incident, severity

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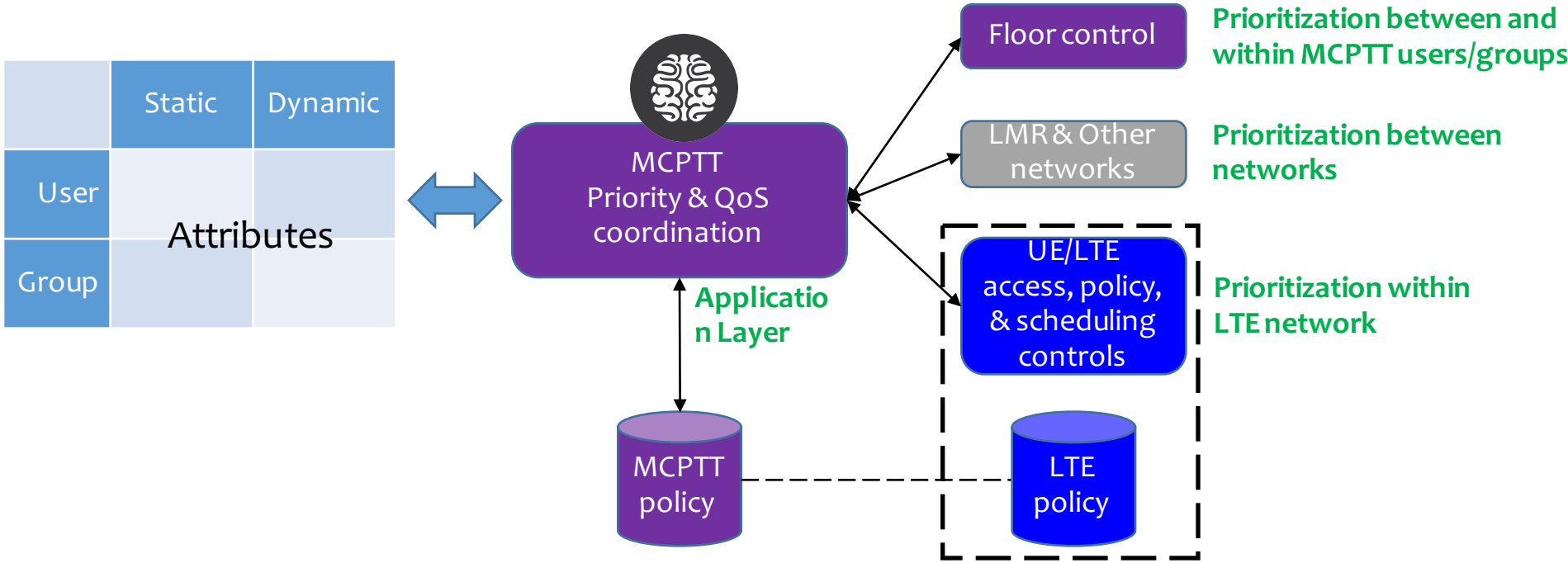
MCPTT Priority Model



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MCPTT Priority and QoS

- Gold / Silver / Bronze, 'Flat' or FIFO may not work
- Should be:
  - Situational
  - Anticipatory
  - Adaptive
  - Transparent to user
  - Interactive with CAD
  - Behavioral

CAD = computer aided dispatch

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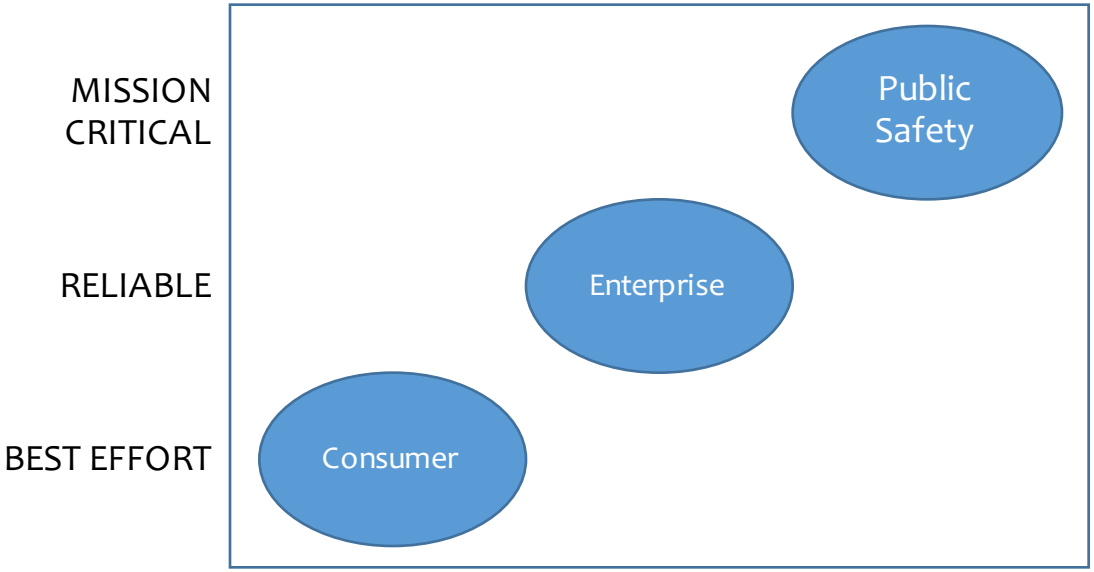
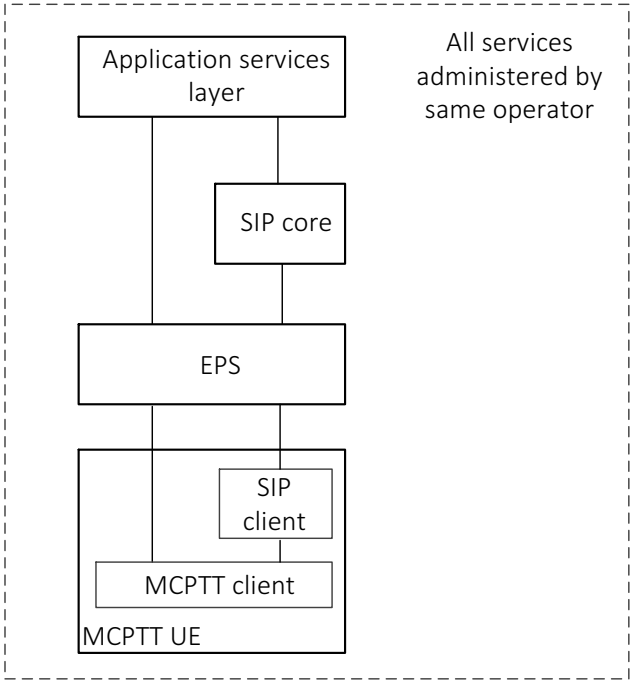
PTT Tiers

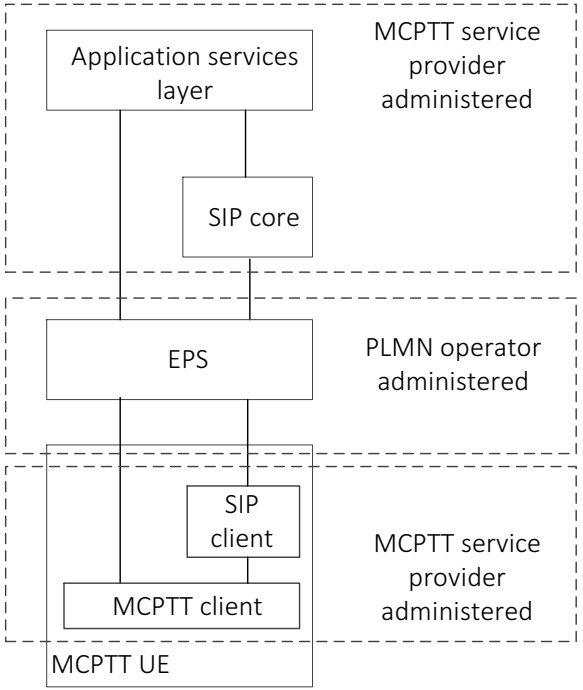


*Slide concept from Harris

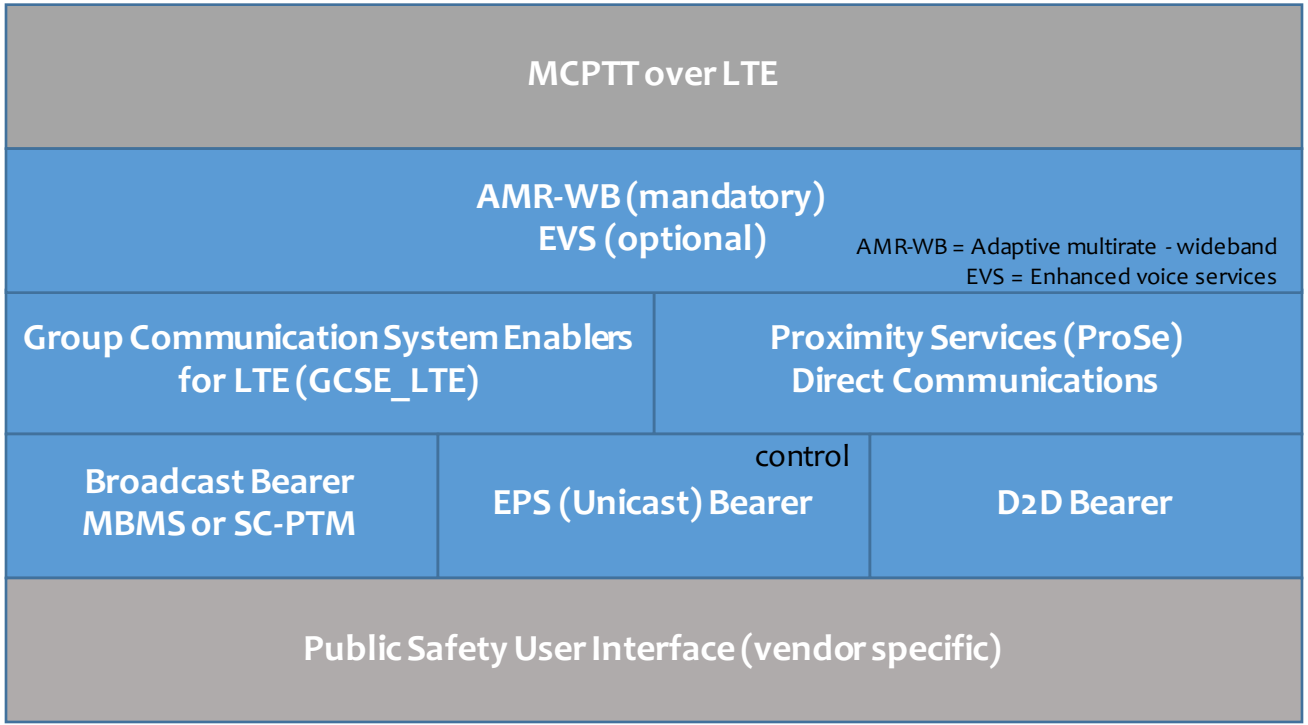
MCPTT Deployment Scenarios

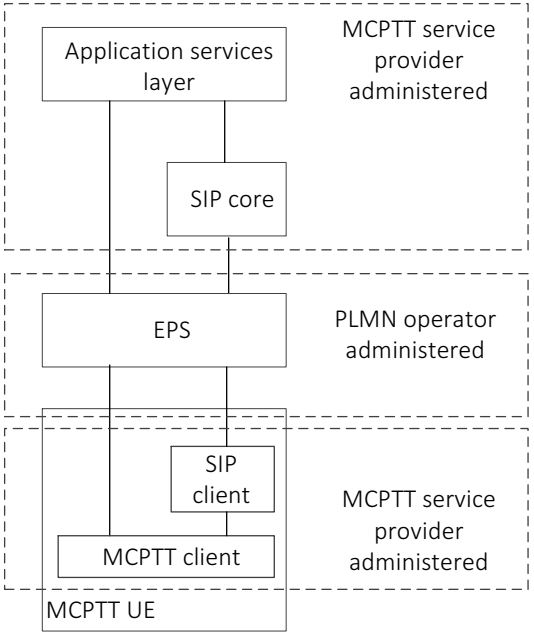


- Many variations, only two shown:
  - LEFT: All-in-one
  - RIGHT: Independent network & MCPTT



MCPTT Deployment Scenarios





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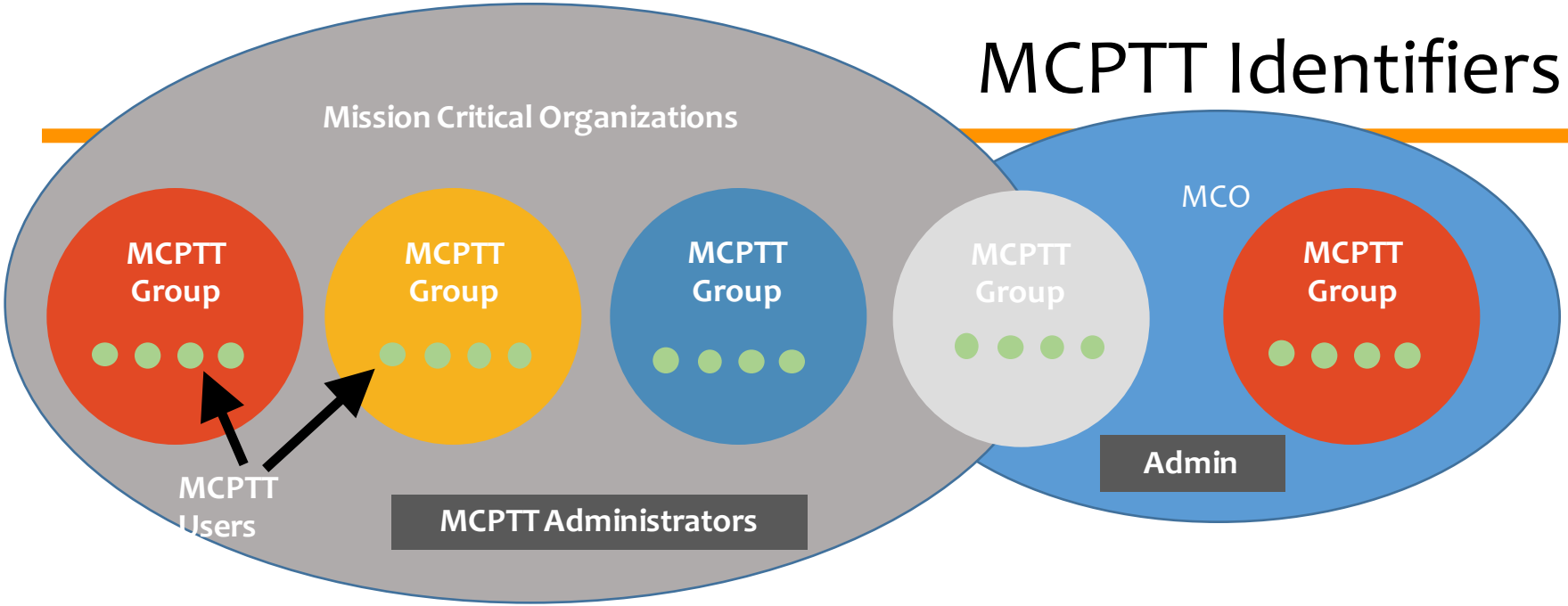
MOUTH TO EAR	$2	$2	$2	$2	$2
OVERRIDE	$3	$3	$3	$3	$3

ABBREVIATED MCO, A MCPTT GROUP MAY BELONG TO ONE OR MORE OF THESE

MCPTT Identifiers



- Each has unique ID within an identity domain (e.g. state, region, NPSBN)
- Can be hierarchical
- Can have aliases, e.g. for display, for signaling, for public, etc.
- Can have different values for each application, but not practical

MCPTT User ID – Profile Framework

Globally unique, independent of IMSI
Typically pre-configured
Some user-specific configurations, e.g. display preferences

Serves only 1 user at a time
User signs on and authenticates
Some user-specific configurations, e.g. display preferences
MUST BE PRECONFIGURED for off-network access
MCPTT UE w/o specific User ID operates in off-network mode (if already pre-configured for access)

MCPTT Application Server

Stored permanently
Application layer authentication (after registering with network)
Synchronization – auto or on-demand
May have multiple user profiles (incl. default), but only one active at a time
Profiles may be associated with specific devices, modes (on/off netw), or operational scenarios

IMSI = international mobile subscriber identity

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MCPTT User ID – Profile Framework

MCPTT Application Server

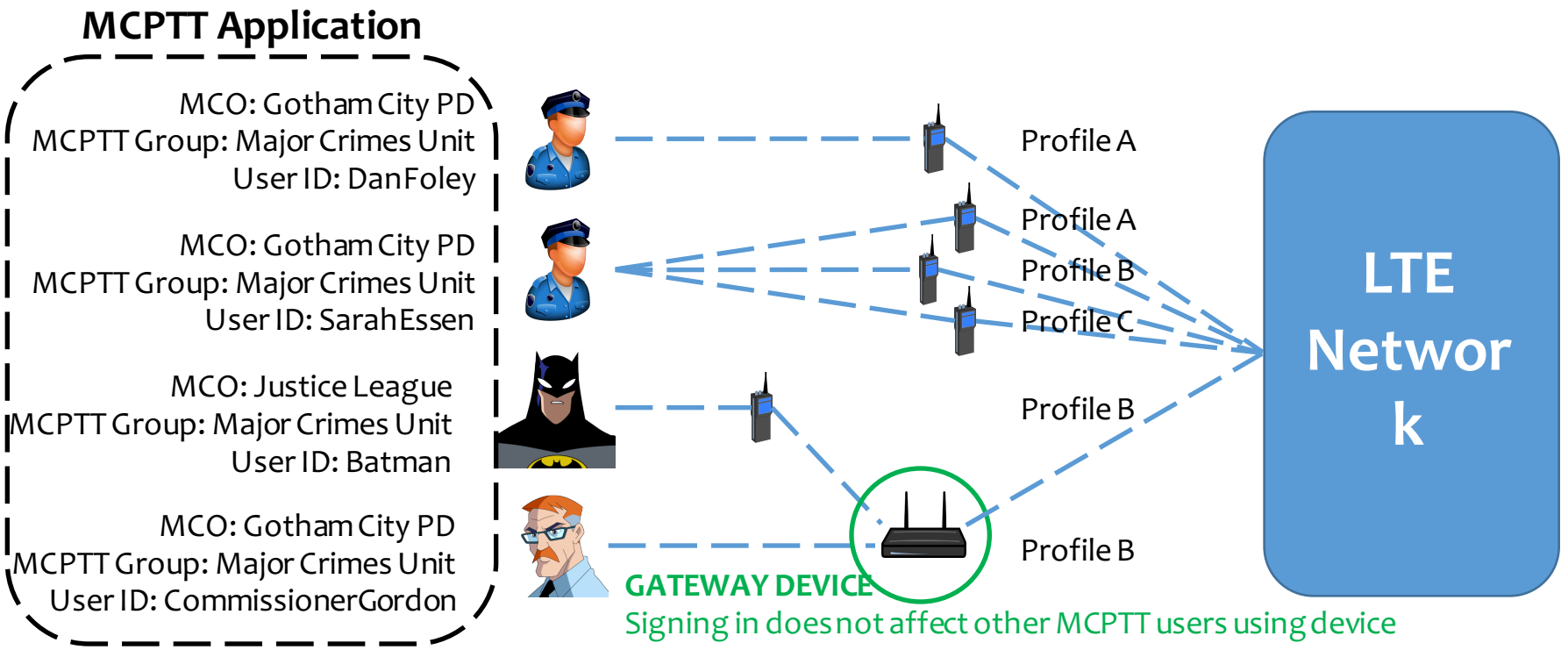
Globally unique, independent of IMSI	Se[illegible] at a time	Stored permanently
Typically pre-configured	User signs on and authenticates	Application layer authentication (after registering with network)
Some user-specific configurations, e.g. display preferences	Some user-specific configurations, e.g. display preferences	Synchronization – auto or on-demand
	MUST be PRECONFIGURED for off-network access	May have multiple user profiles (incl. default), but only one active at a time
	MCPTT UE w/o specific User ID operates in off-network mode (if already pre-configured for access)	Profiles may be associated with specific devices, modes (on/off netw), or operational scenarios

IMSI = international mobile subscriber identity

PUSH-TO-TALK	TALKER IDENTIFICATION	EMERGENCY ALERTING	AUDIO QUALITY	GROUP COMMUNICATIONS	DIRECT MODE
FLOOR CONTROL	MISSION CRITICAL ORGANIZATION	$1	$1	$1	$1
MOUTH TO EAR	$2	$2	$2	$2	$2
OVERRIDE	$3	$3	$3	$3	$3

TERM FOR A DEVICE USED TO BRIDGE TWO SYSTEMS

Gateway & Shareable MCPTT UEs



PUSH-TO-TALK	TALKER IDENTIFICATION	EMERGENCY ALERTING	AUDIO QUALITY	GROUP COMMUNICATIONS	DIRECT MODE
FLOOR CONTROL	MISSION CRITICAL ORGANIZATION	$1	$1	$1	$1
MOUTH TO EAR	GATEWAY	$2	$2	$2	$2
OVERRIDE	$3	$3	$3	$3	$3

TERM TO DESCRIBE HOW OFTEN INFORMATION IS UPDATED

Refresh Rate – User Location

- MCPTT service must support conveyance of location information provided by UE; not required, just supported
- Location must represent current position of the user and not the initial call establishment
- Admin can configure REFRESH RATE based on trigger conditions (e.g. call initiation, elapsed time, cell change, etc.) and geographical boundaries
- Location updated when emergency or imminent peril are initiated

PUSH-TO-TALK	TALKER IDENTIFICATION	EMERGENCY ALERTING	AUDIO QUALITY	GROUP COMMUNICATIONS	DIRECT MODE
FLOOR CONTROL	MISSION CRITICAL ORGANIZATION	$1	$1	$1	$1
MOUTH TO EAR	GATEWAY	$2	$2	$2	$2
OVERRIDE	REFRESH RATE	$3	$3	$3	$3

THIS TYPE OF GROUP CALL IS INITIATED BY A MCPTT USER FOR ASSISTANCE TO OTHER MCPTT USERS OR THE GENERAL PUBLIC

Imminent Peril & Special MCPTT Group Calls

- Broadcast – Only one MCPTT transmission
- Emergency
- Imminent Peril

Inactivity period set to infinity
All transmissions part of same group call

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Emergency & Imminent Peril

- User or dispatcher can initiate
  - Emergency Alert
  - Emergency Group Call
  - Emergency Private Call
- Receive pre-emptive priority over ALL other calls except:
  - System Calls
  - Other emergency group or private calls
- All members of the group receive elevated priority
- Alert can be audio, visual, anything – configurable & UI specific
- Can be pushed to dedicated Emergency Group ID
- Priority is removed once alert is cancelled or timed-out
- Imminent Peril treated basically the same; however, interaction of emergency calls and imminent peril calls are not yet specified

PUSH-TO-TALK	TALKER IDENTIFICATION	EMERGENCY ALERTING	AUDIO QUALITY	GROUP COMMUNICATIONS	DIRECT MODE
FLOOR CONTROL	MISSION CRITICAL ORGANIZATION	IMMINENT PERIL	$1	$1	$1
MOUTH TO EAR	GATEWAY	$2	$2	$2	$2
OVERRIDE	REFRESH RATE	$3	$3	$3	$3

FEATURE THAT ALLOWS A RADIO TO TRANSMIT WITHOUT ANY INDICATION TO USER OR ANYBODY AROUND SO THAT DISPATCHER CAN ‘LISTEN IN’

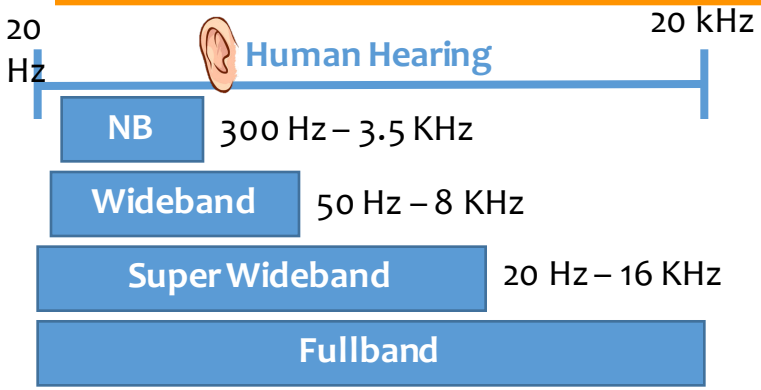
Ambient/Discreet Listening

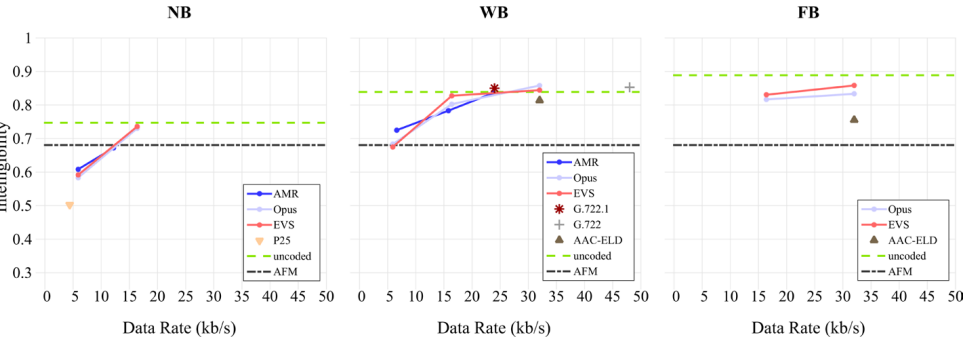
- Private call
- Used for:
  - Stolen devices
  - Officer safety
  - Cover operations
- No indication to user or anyone around
  - Should even persist if someone attempts to turn off active UE being listened to.
- Can be initiated and terminated either locally or remote

PUSH-TO-TALK	TALKER IDENTIFICATION	EMERGENCY ALERTING	AUDIO QUALITY	GROUP COMMUNICATIONS	DIRECT MODE
FLOOR CONTROL	MISSION CRITICAL ORGANIZATION	IMMINENT PERIL	$1	$1	$1
MOUTH TO EAR	GATEWAY	AMBIENT LISTENING	$2	$2	$2
OVERRIDE	REFRESH RATE	$3	$3	$3	$3

THIS PATENTED AUDIO CODING STANDARD BEING ADOPTED BY 3GPP IMPROVES SPEECH QUALITY BY CAPTURING A WIDER SPEECH BANDWIDTH (50 – 7000 Hz) COMPARED TO THE CURRENT NARROWBAND IMPLEMENTATION

AMR-WB Adaptive multi-rate - wideband

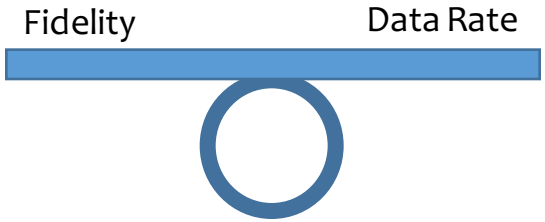




Codec Name	Audio Bandwidth	Target Data Rates (kb/s)	Number of Data Rates
P25 AMBE+2™	NB	2.45, 4.4	2
G.711 PCM	NB	64	1
G.722 ADPCM	WB	48, 64	2
G.722.1 MLT	WB	24, 32	2
AMR	NB	4.75, 5.15, 5.9, 6.7, 7.4, 7.95, 10.2, 12.2	8 (All available)
AMR-WB	WB	6.6, 8.85, 12.65, 14.25, 15.85, 18.25, 19.85, 23.05, 23.85	9 (All available)
EVS	NB	5.9, 7.2, 8.0, 9.6, 13.2, 16.4, 24.4	7
	WB	5.9, 7.2, 8.0, 9.6, 13.2, 16.4, 24.4, 32, 48, 64	10
	FB	16.4, 24.4, 32, 48, 64	5
Opus	NB	5.9, 7.2, 8.0, 9.6, 13.2, 16.4, 24.4, 32	8
	WB	5.9, 7.2, 8.0, 9.6, 13.2, 16.4, 24.4, 32, 48, 64	10
	FB	16.4, 24.4, 32, 48, 64	5
AAC-LD	WB	32, 48	2
	FB	32,48,64	3
AAC-ELD	WB	32, 48	2
	FB	32,48,64	3
AAC-ELDsbr	WB	32	1
	FB	32, 48, 64	3
Total			83

VOCODER

- **VO**ice en**coder**
- Samples at given rate (samples/sec) and resolution (bits/sample)
- Splits human speech into frequency bins
- Analyzes characteristics
- Interpolates & predicts (i.e. look ahead)
- Error correction
- May send parameters, downsampled version, or both rather than pure digitized waveform



PUSH-TO-TALK	TALKER IDENTIFICATION	EMERGENCY ALERTING	AUDIO QUALITY	GROUP COMMUNICATIONS	DIRECT MODE
FLOOR CONTROL	MISSION CRITICAL ORGANIZATION	IMMINENT PERIL	AMR-WB	$1	$1
MOUTH TO EAR	GATEWAY	AMBIENT LISTENING	$2	$2	$2
OVERRIDE	REFRESH RATE		$3	$3	$3

CATEGORY BASED RATING SYSTEM COMMONLY USED BY THE CELLULAR INDUSTRY TO GRADE VOICE QUALITY

MOS, DAQ, PESQ, POLQA, WHAT?!!!

METHODS	STANDARD	OBJ/SUBJ	NOTE	SCORING
POLQA: Perceptual Objective Listening Quality Assessment	ITU-T-REC-P.863	Objective	Objective estimator of MOS-LQS; Successor to PESQ	MOS-LQO: Mean Opinion Score – Listening Quality Objective
PESQ: Perceptual Evaluation of Speech Quality	ITU-T-REC-P.862	Objective		MOS-LQO
ACR: Absolute Category Rating	ITU-T-REC-P.800	Subjective		MOS-LQS: Listening Quality Subjective
E-model:	ITU-T-G.107	Computational	Calculated based on network impairments	1 – 100
DAQ: Delivered Audio Quality	TSB-88.3?	Subjective; not published	Usually linked to coverage	DAQ

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Why use MOS?

USER EXPERIENCE

RSS	BER	FER	MOS
Received Signal Strength	Bit Error Rate	Frame Error Rate	Mean Opinion Score
- Aligns with coverage - Was great for FM when all RXs were essentially the same quality, but digital radio landscape is different.	- Requires context (what type of data? Is this good?) - Less meaning in 'bursty' channel - Vocoder decisions made on frame-by-frame basis	- Closer to UX, but… - Depending on digital techniques, e.g. frame repeating, and particular error pattern FER does not repeatedly equate to same MOS/DAQ	- Directly interpretable by user - Can be labor intensive and/or expensive

High RSS ≠ High MOS

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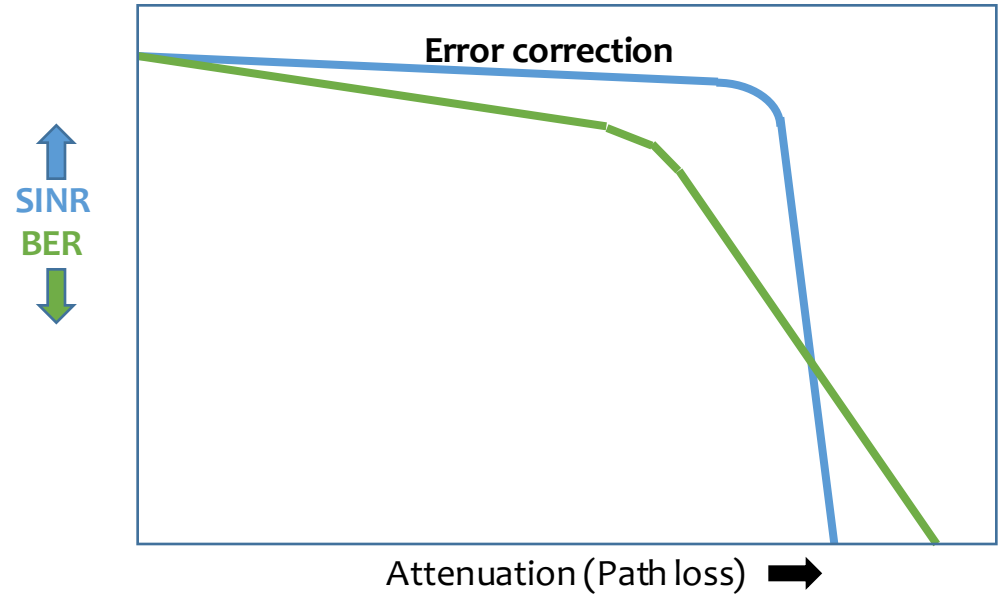
Coverage & 'Digital Cliff'

- Analog & P25 Phase 1 Conventional about same TX power
- But, behave different with increasing attenuation
- Same principle applies to LTE
- How will you know when you're about to go off-network?
- Will it be seamless?



MCPTT Audio/voice quality

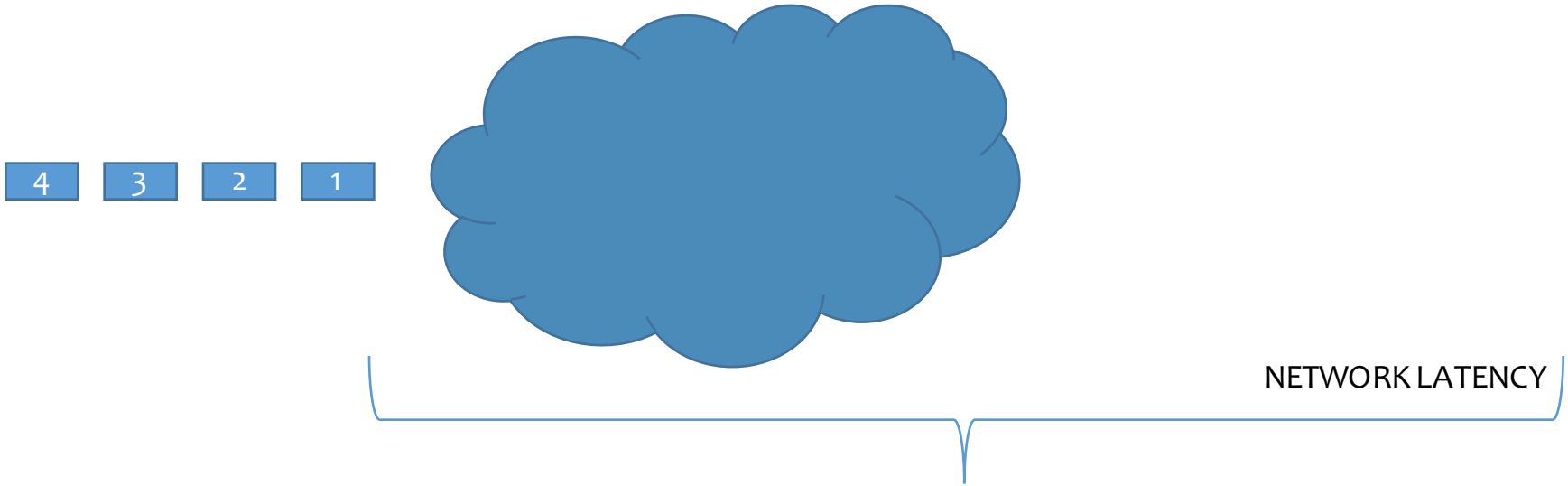
- MCPTT UE MUST support AMR-WB
  - Enhance voice services (EVS) optional
  - May include other non-3GPP codecs, e.g. P.25, TETRA
- Must achieve noise reduction performance ≥ P25 full rate and half-rate vocoders specified in TIA-102.BABG
  - P25 Enhanced Vocoder Methods of Measurement for Performance

	MOS-LQO	Method
Within MCPTT system	3.0	PESQ and POLQA
Interworking	2.7	PESQ and POLQA

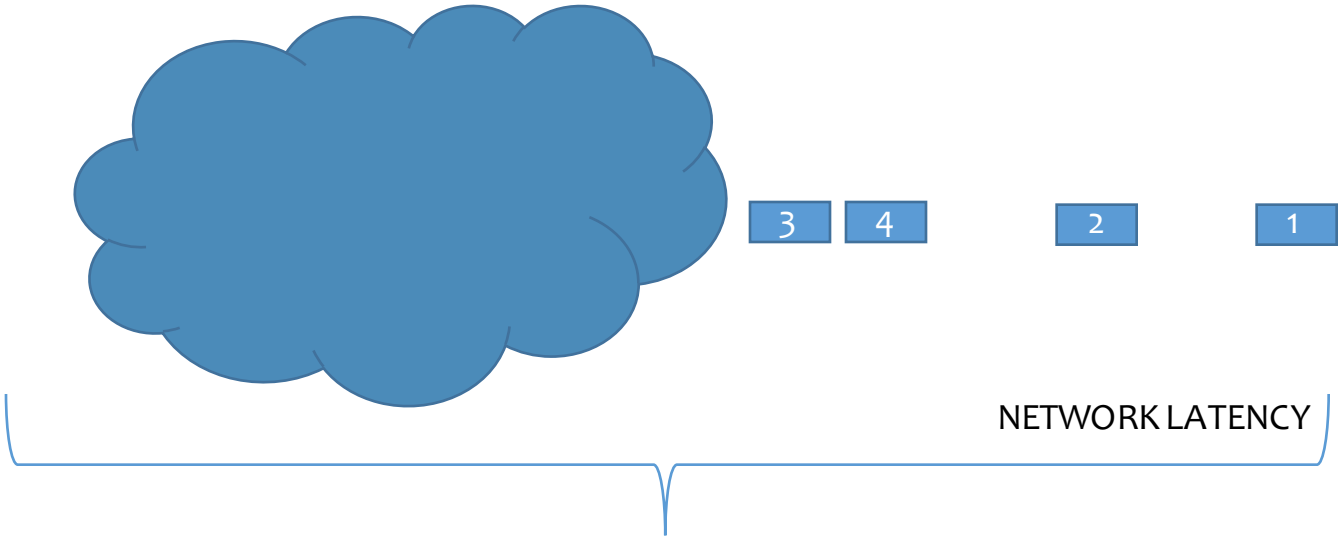
PUSH-TO-TALK	TALKER IDENTIFICATION	EMERGENCY ALERTING	AUDIO QUALITY	GROUP COMMUNICATIONS	DIRECT MODE
FLOOR CONTROL	MISSION CRITICAL ORGANIZATION	IMMINENT PERIL	AMR-WB	$1	$1
MOUTH TO EAR	GATEWAY	AMBIENT LISTENING	MOS	$2	$2
OVERRIDE	REFRESH RATE		$3	$3	$3

TERM DESCRIBING THE DEVIATION FROM A PERIODIC SIGNAL (OFTEN RELATIVE TO A REFERENCE SOURCE), THE VARIATION IN DELAY OF RECEIVED PACKETS, OR FEELINGS OF EXTREME NERVOUSNESS

Jitter



Jitter



Jitter

- Variation in delay of receive packets
  - Network congestion
  - Transmission impairments
  - Inconsistent buffering / alternate paths
- Use playout delay (de-jitter) buffers
  - Add delay, i.e. tradeoff with latency, therefore should be minimized
  - QoS has a direct impact on size of de-jitter buffer

Playout Delay Buffer & De-jittered Stream

Buffer removes gaps and puts packets in correct order

PSCR

QoS Class Identifiers – Ranked by Priority

QCI	Type	Priority	Delay (ms)	Packet Error	Example Services
69	Non-GBR	0.5	60	10^{-6}	MC delay-sensitive signaling (MCPTT)
65	GBR	0.7	75	10^{-2}	MCPTT voice
5	Non-GBR	1	100	10^{-6}	IMS signaling
66	GBR	2	100	10^{-2}	PTT voice – non-MC
1	GBR	2	100	10^{-2}	Conversational voice
3	GBR	3	50	10^{-3}	Real time gaming
2	GBR	4	150	10^{-3}	Conversational video (live streaming)
4	GBR	5	300	10^{-6}	Non-conversational video (buffered streaming)
70	Non-GBR	5.5	200	10^{-6}	MC data; Video (buffered streaming), TCP-based (Internet, e-mail, chat, etc.)
6	Non-GBR	6	300	10^{-6}	Video (buffered streaming); TCP-based apps (Internet, e-mail, etc.)
7	Non-GBR	7	100	10^{-3}	Voice, video (live streaming), interactive gaming
8	Non-GBR	8	300	10^{-6}	Video (buffered streaming), TCP-based apps (Internet, e-mail, etc.)
9	Non-GBR	9	300	10^{-6}	

PUSH-TO-TALK	TALKER IDENTIFICATION	EMERGENCY ALERTING	AUDIO QUALITY	GROUP COMMUNICATIONS	DIRECT MODE
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MOUTH TO EAR	GATEWAY	AMBIENT LISTENING	MOS	$2	$2
OVERRIDE	REFRESH RATE		JITTER	$3	$3

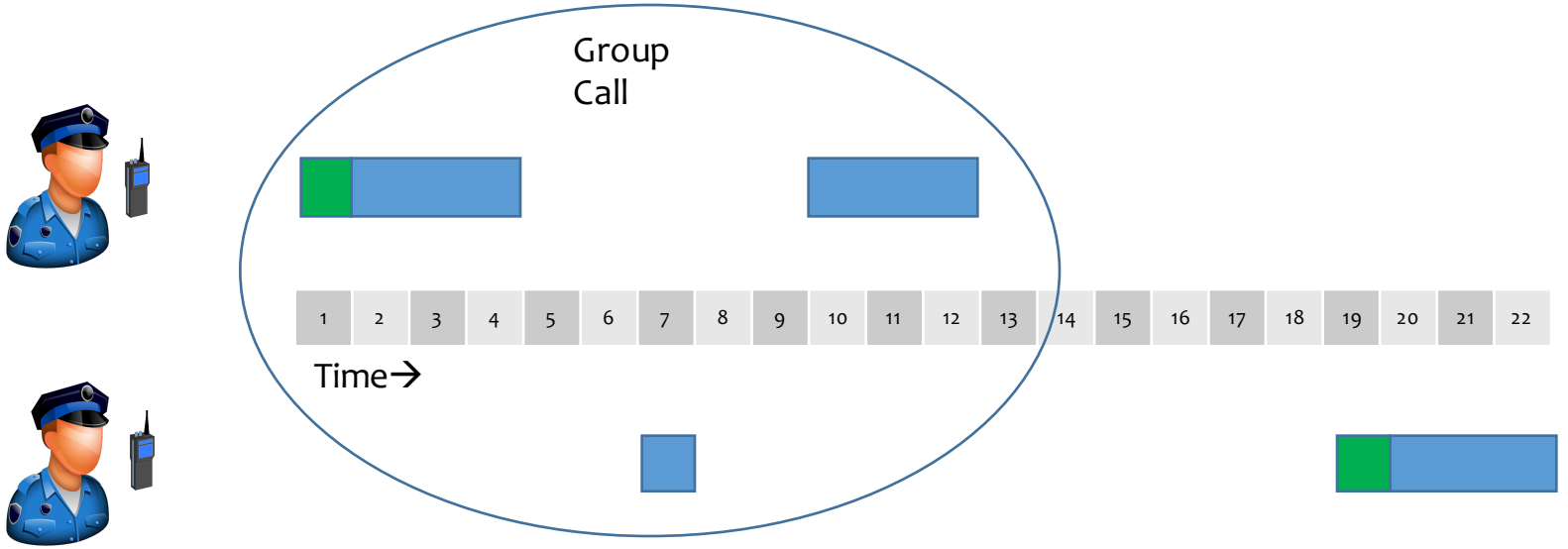
A CONFIGURABLE MAXIMUM LENGTH OF INACTIVITY (SILENCE) BETWEEN CONSECUTIVE PTT TRANSMISSIONS (TALK BURSTS) WITHIN THE SAME GROUP CALL OR 0.92 SECONDS FOR MICHAEL JORDAN

Hang Time

- Group Call – One or more MCPTT transmissions (could be broadcast)
- Whether two or more consecutive MCPTT transmissions are part of SAME group call depends on HANG TIME
- Hang Time timer starts at end of previous TX, resources stay assigned to the call (except in pre-emption)
- PURPOSE: Reduces latency of future floor requests for this group (remember KPI 2 from latency discussion?)
- Configurable – typically around 6 seconds
- Tie-up Resources
  - Channel, time-slot, resource blocks

Hang Time Example

Hang Time – 6 sec.



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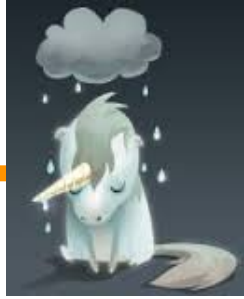
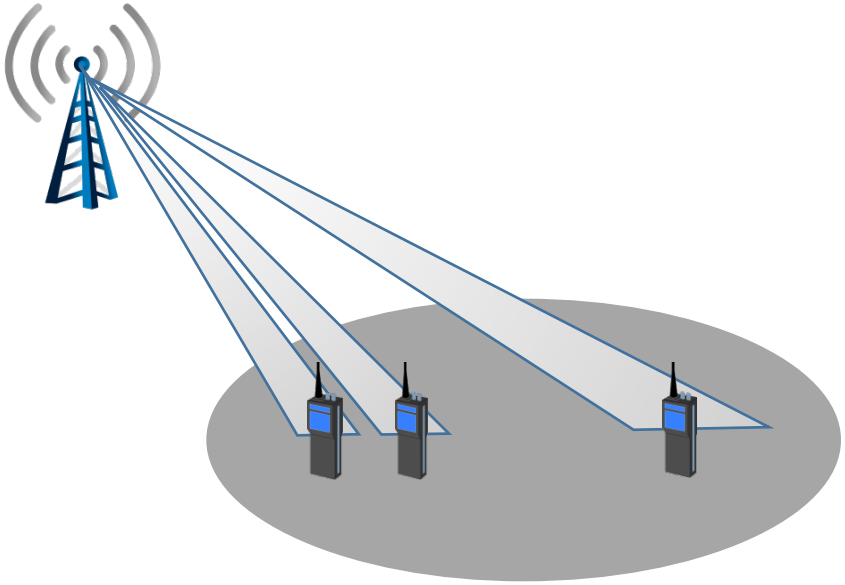
MOUTH TO EAR	GATEWAY	AMBIENT LISTENING	MOS	$2	$2
OVERRIDE	REFRESH RATE		JITTER	$3	$3

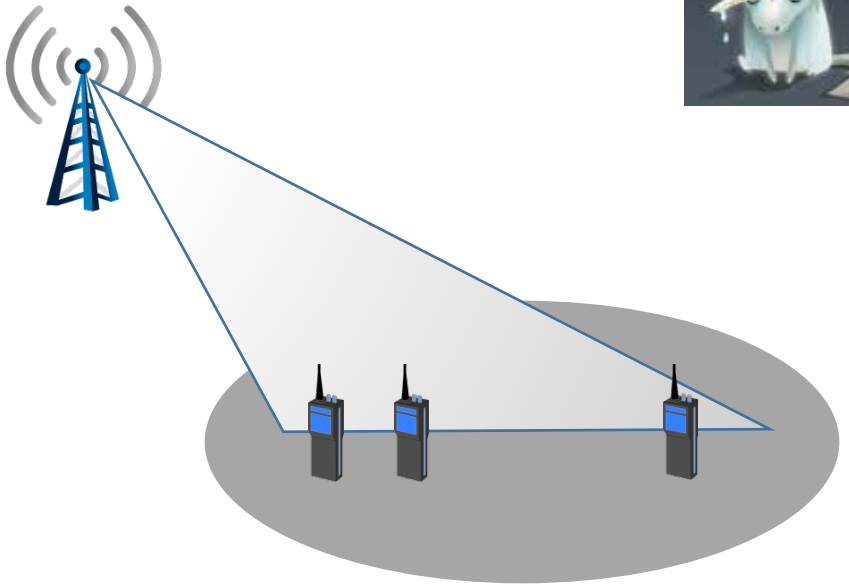
CONNECTION BETWEEN A SINGLE SENDER AND A SINGLE RECIEVER OR A REJECTED MYTHICAL CREATURE

Unicast vs. Broadcast





Unicast

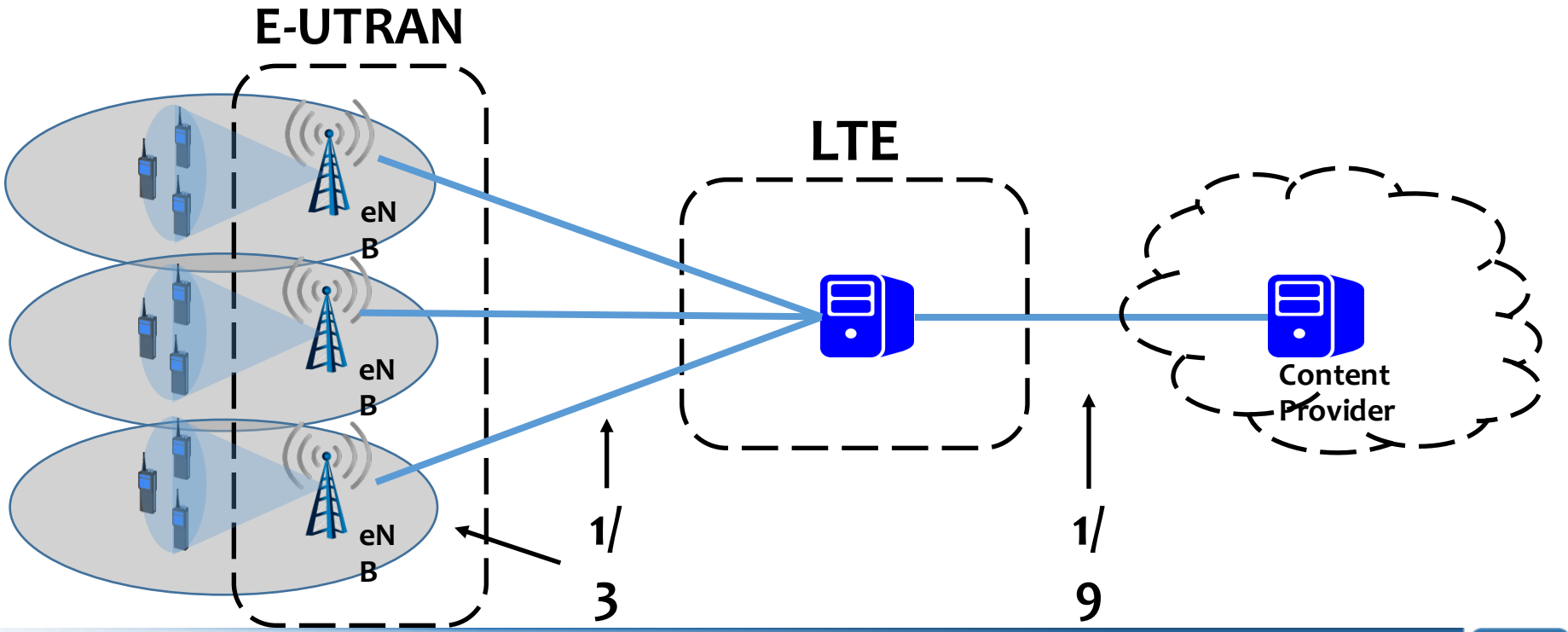


Broadcast

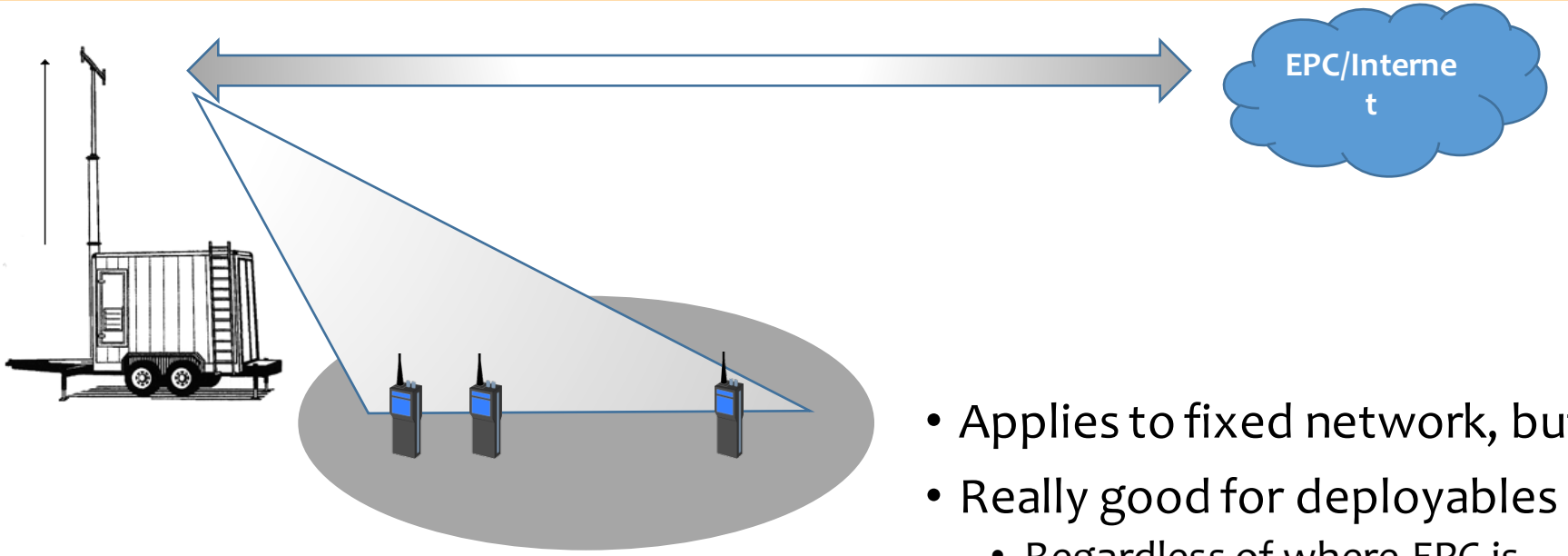
What if we could use broadcast in LTE for voice, video, etc.?

PSCR

More Efficient Transport



More Efficient Backhaul



- Applies to fixed network, but
- Really good for deployables
  - Regardless of where EPC is

PUSH-TO-TALK	TALKER IDENTIFICATION	EMERGENCY ALERTING	AUDIO QUALITY	GROUP COMMUNICATIONS	DIRECT MODE
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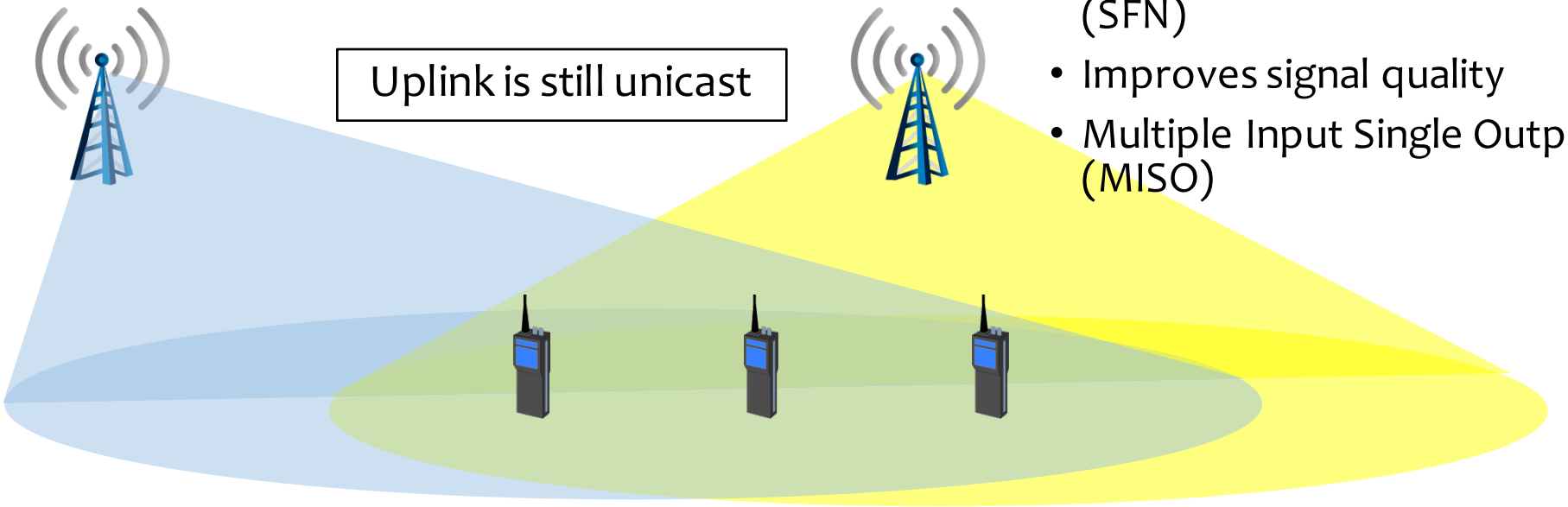
OVERRIDE	REFRESH RATE		JITTER	$3	$3

A UNIDIRETIONAL POINT-TO-MULTIPOINT TECHNOLOGY ADOPTED BY 3GPP TO EFFICIENTLY DELIVER BROADCAST TRANSMISSIONS WITHIN A CELL OR NETWORK

Multimedia Broadcast/Multicast Service

- Can deliver broadcast with one cell



- But can enhance by delivering from multiple cells via single frequency network (SFN)
- Improves signal quality
- Multiple Input Single Output (MISO)

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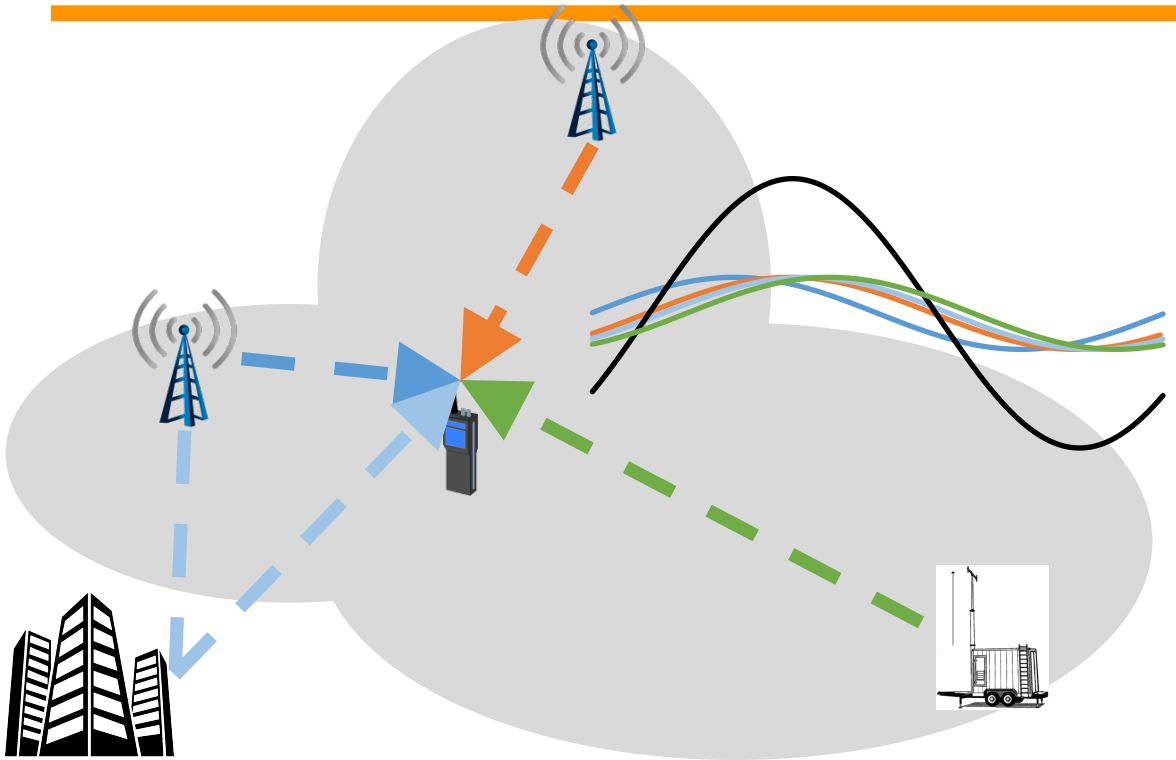
MBSFN Synchronization



- Cells in same area transmit same content
- Tight coordination, time, & freq stability
  - ±500 ns, ±50 ppb = ±38.4 Hz @ 768 MHz
  - Both of the above are no problem with GPS.
  - Is GPS Public Safety Grade?
- Permits **ΔL** ≤ 5 km to accommodate for long range propagation (normal is 1.5 km)

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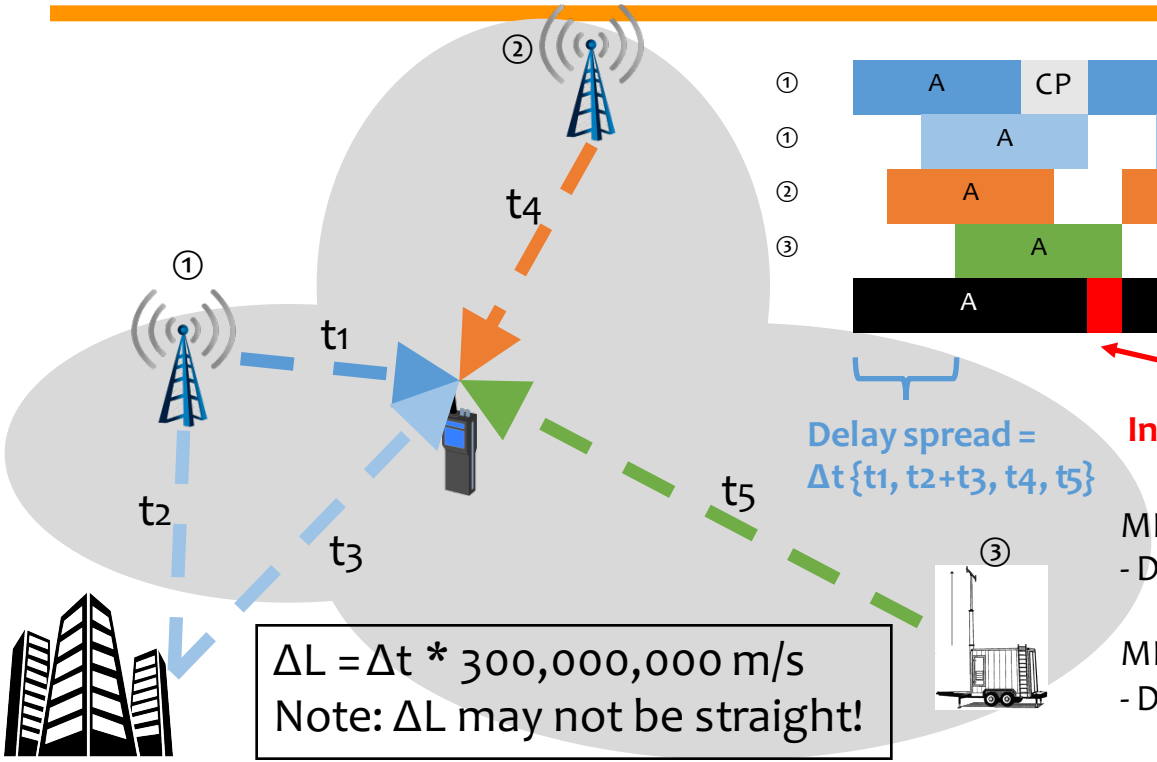
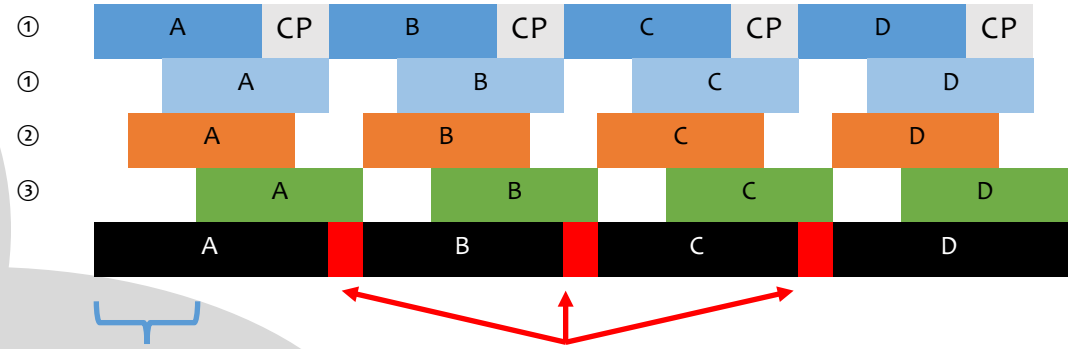
Delay Spread = Effective Range





ΔL = Δt * 300,000,000 m/s
Note: ΔL may not be straight!

MBSFN mixed mode (i.e. MBMS/unicast):
- Delay spread ≤ 16.7 us ➔ ΔL = 5 km

MBSFN dedicated mode (carrier entirely MBMS):
- Delay spread ≤ 33.3 us ➔ ΔL = 10 km

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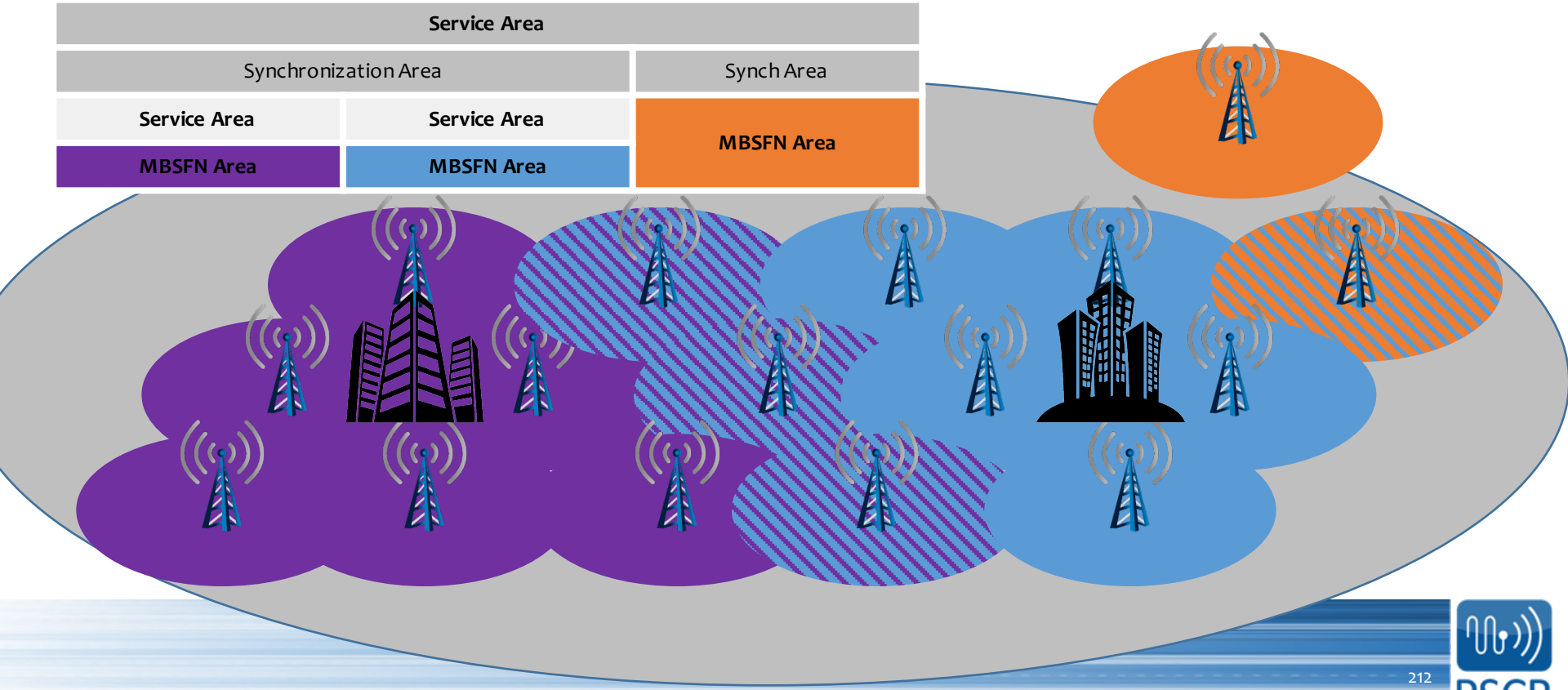
MBSFN Areas



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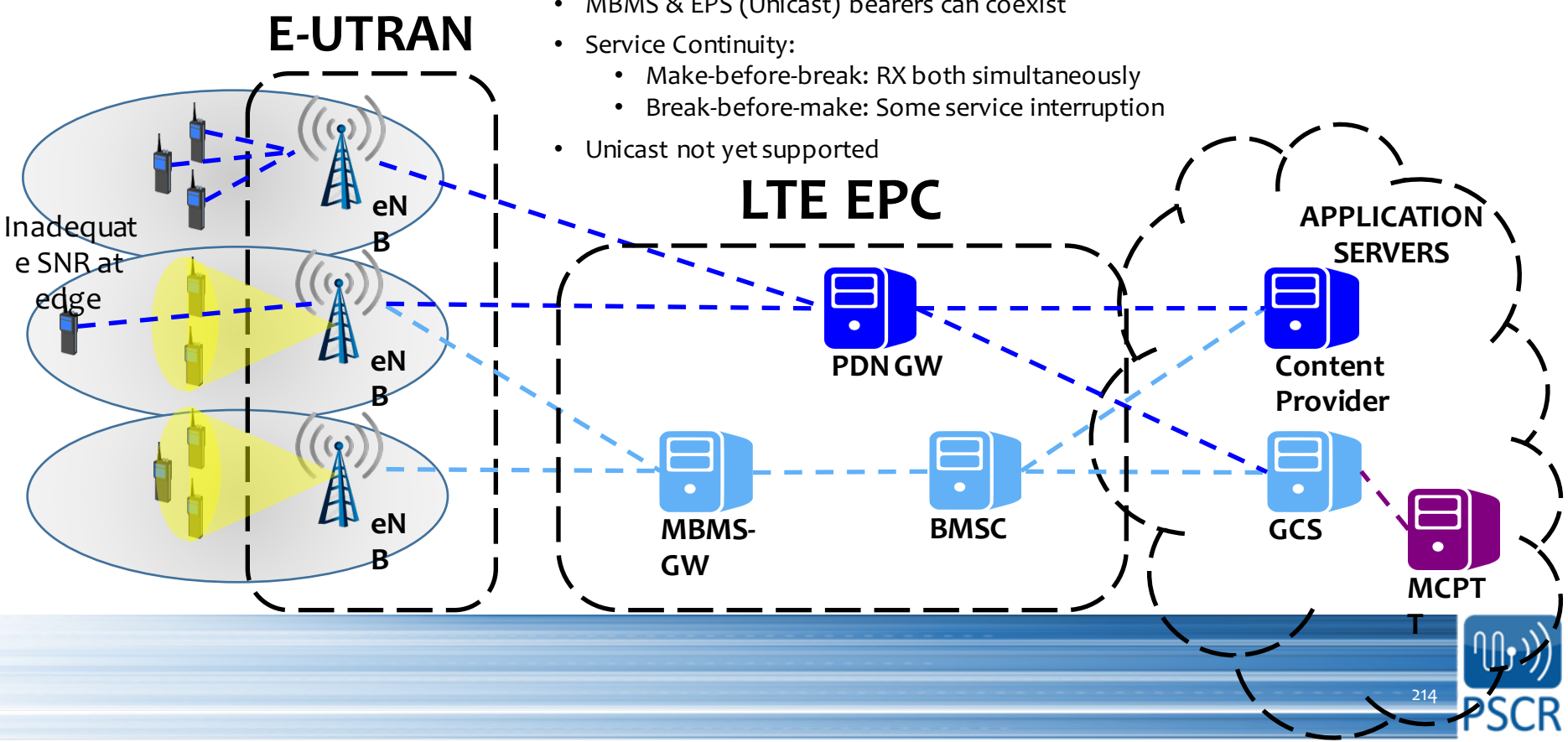
Synchronization – Implications

- Strict, reliable (PSG) synchronization amongst eNodeBs
- UEs must be time aligned within 16.7 us
- Downlink only, no retransmission (ARQ, HARQ) or feedback
  - Transmit additional reference signals for coherent demodulation and channel estimation
- Cells within same MBSFN must use same modulation & coding scheme
  - Operators tend to be conservative, e.g. QPSK, when they could use 16QAM or 64QAM
- Longer cyclic prefix (16.7 us) means higher overhead (25% vs 7%) and lower throughput compared to normal
- SFN limits effective **ΔL** to 5 km, but really less due to multipath
  - Possibly 10 km if using dedicated mode (MBMS exclusive carrier)

Mixed Mode & Service Continuity

- MBMS & EPS (Unicast) bearers can coexist
- Service Continuity:
  - Make-before-break: RX both simultaneously
  - Break-before-make: Some service interruption
- Unicast not yet supported



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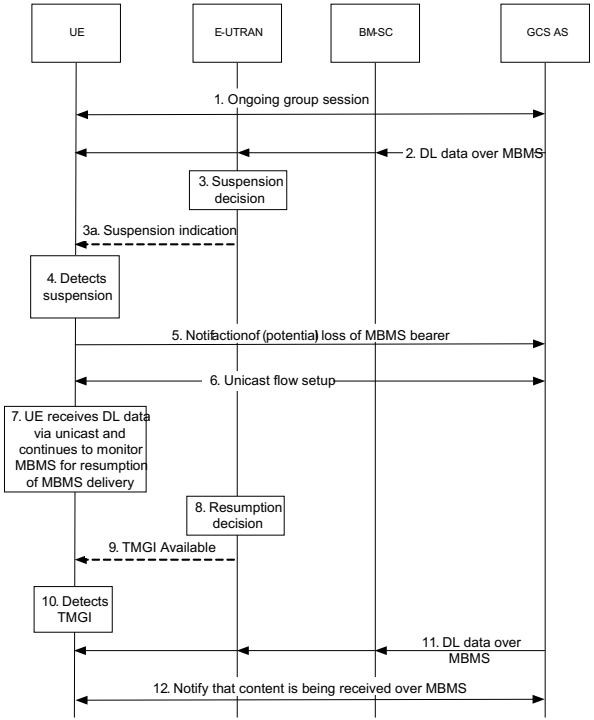
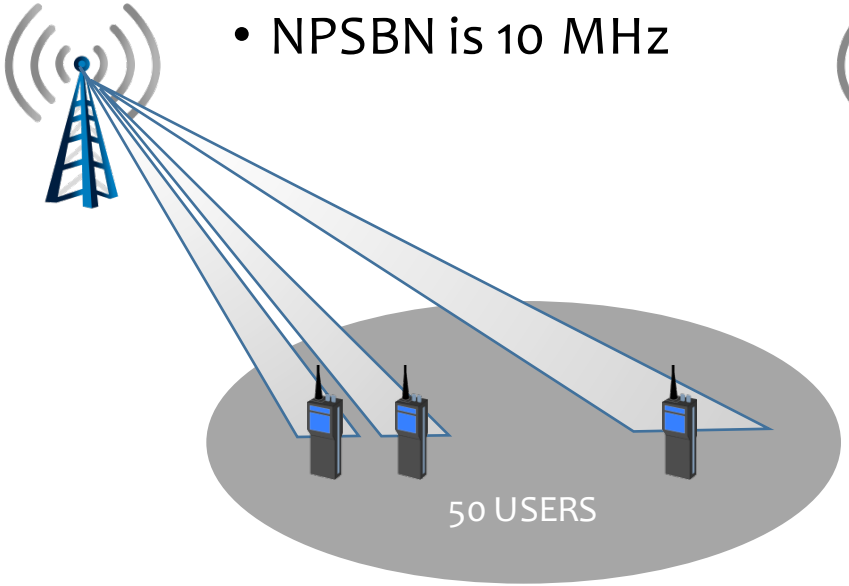
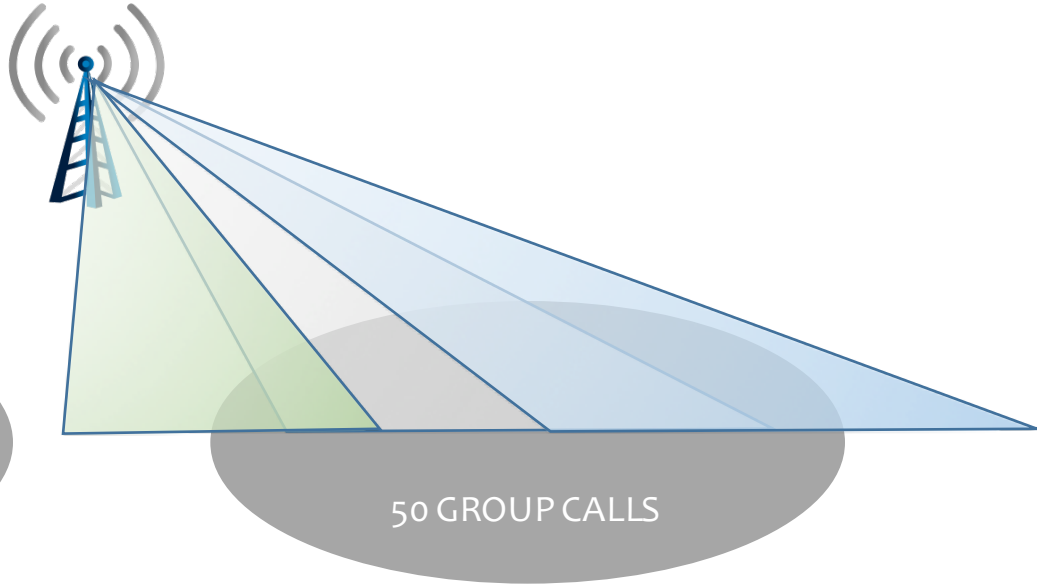
Switching from MBMS to Unicast following bearer suspension and subsequent resumption



Capacity – MBMS vs. Unicast

- VoIP capacity is about 50 USERS/MHz/Cell
- Compare to 50 SESSIONS/MHz/Cell
- NPSBN is 10 MHz





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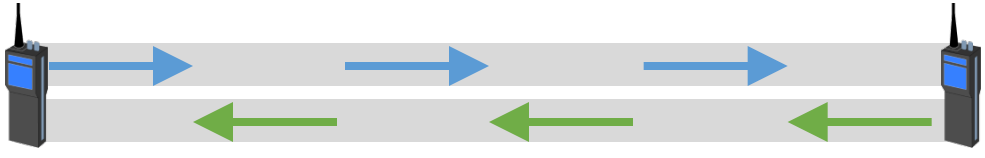
OVERRIDE	REFRESH RATE		JITTER	MBMS	$3

TWO WAY COMMUNICATION, BUT NOT AT THE SAME TIME

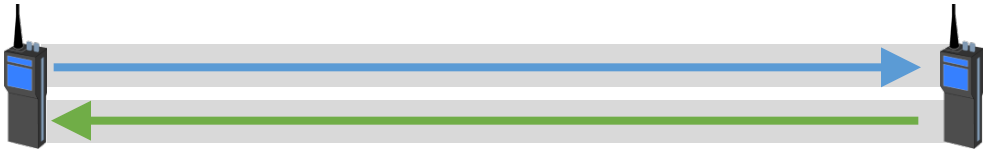
Channel Modes of Operation

Simplex

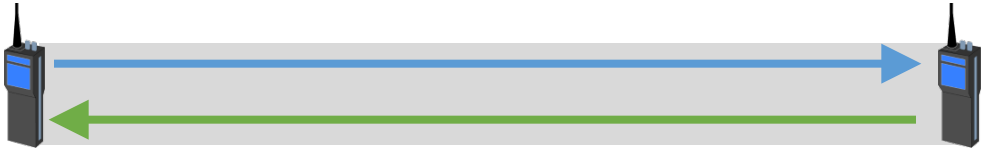
Half-duplex



Full-duplex



(True) Full-duplex



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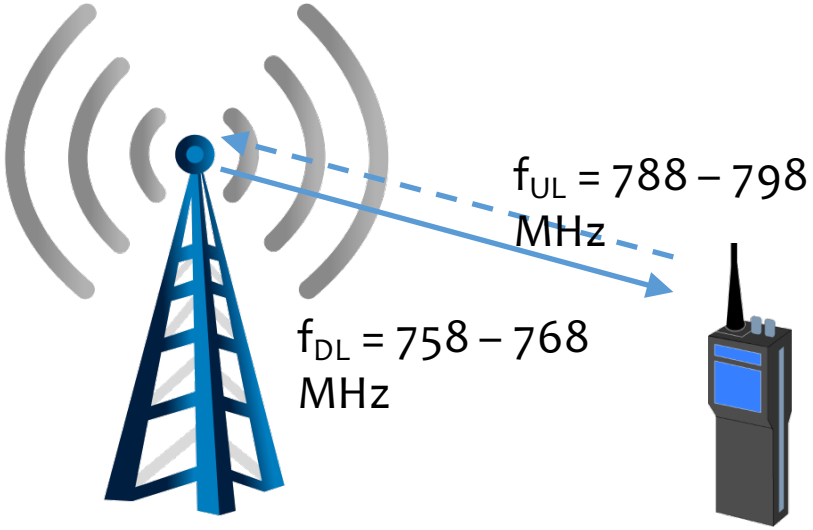
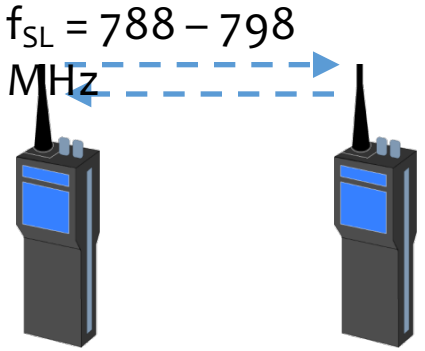
MOUTH TO EAR	GATEWAY	AMBIENT LISTENING	MOS	UNICAST	$2
OVERRIDE	REFRESH RATE		JITTER	MBMS	$3

NEW TERM FOR THE LINK BETWEEN ONE UE TO ANOTHER UE

SIDELINK

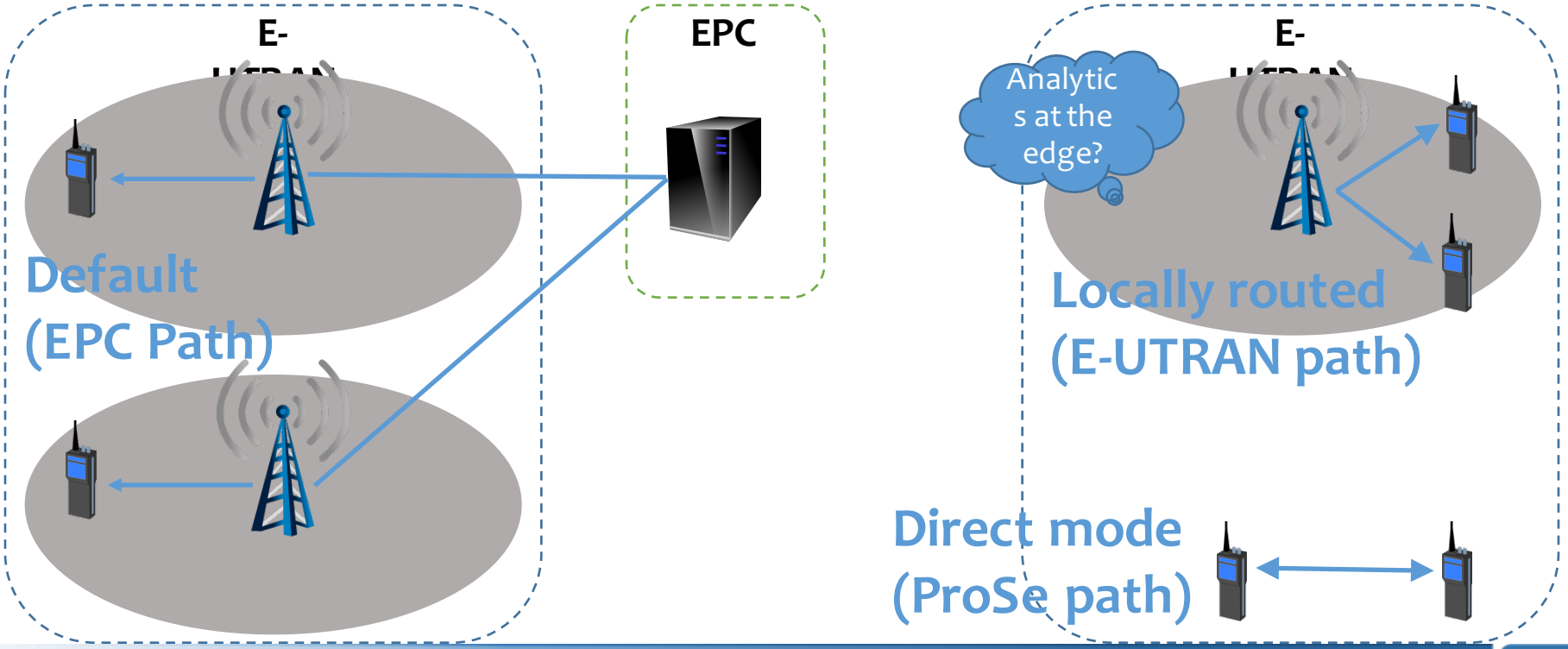


$F_{uplink} = F_{sidelink}$
TDD (Half-duplex)
Open-loop (no feedback)
TX unaware of RXs (w/o discovery)
Pmax = 200 mW (Rel 14 → 400 mW; LMR = 5 W)



*UE must add SC-FDMA RX for uplink channel

Data Paths



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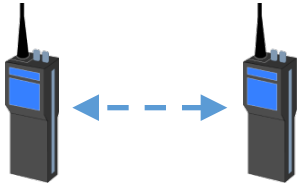
Proximity Services (ProSe)

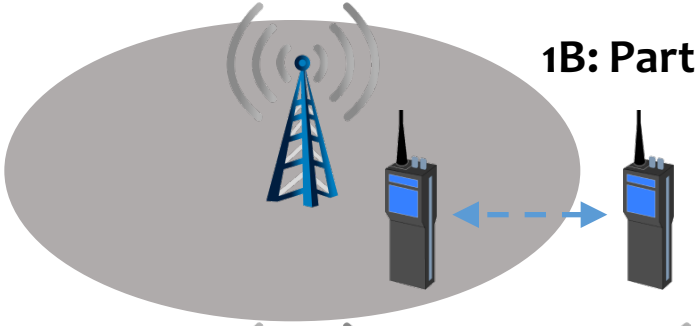
- Four features
  - Direct Discovery
  - EPC-level Discovery
  - Direct Communications (D2D)
  - EPC support for WLAN direct discovery and communication
- 'Proximity' determined by operator and user
  - Different than location
  - Greater range than beaconing
  - Better battery-life

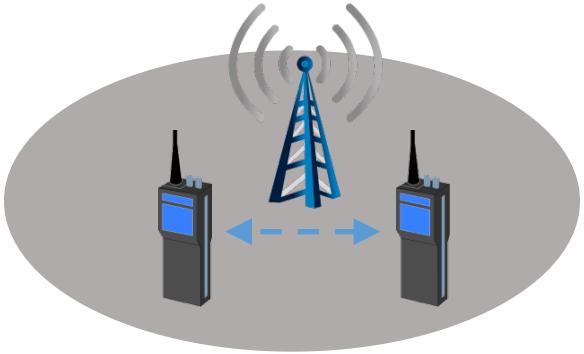
Deployment Scenarios – Rel 12

1A: Out-of-coverage

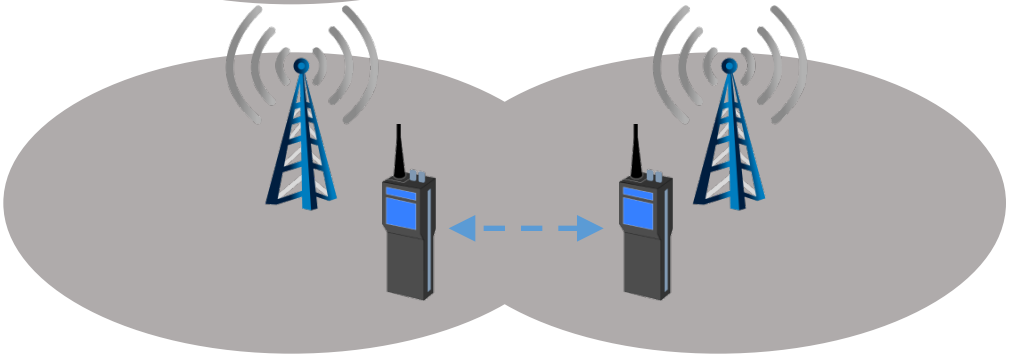


1B: Partial-coverage





1C: In-coverage, single-cell

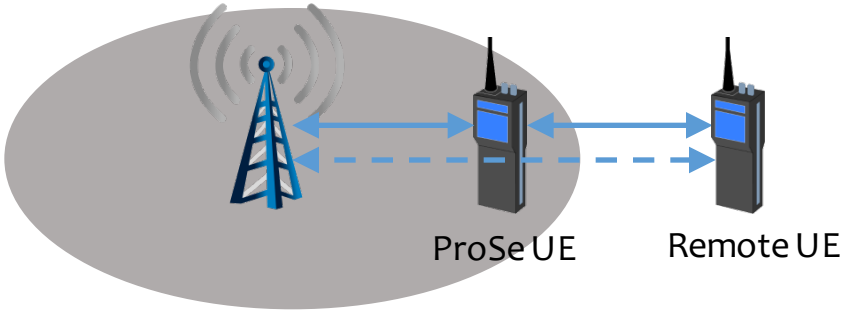


1C: In-coverage, multi-cell

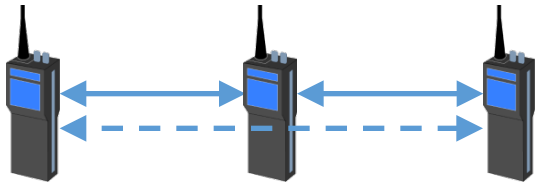
PSCR

Other Direct Communication Scenarios

UE-to-network relay (eProSe)



UE-to-UE relay (Future)



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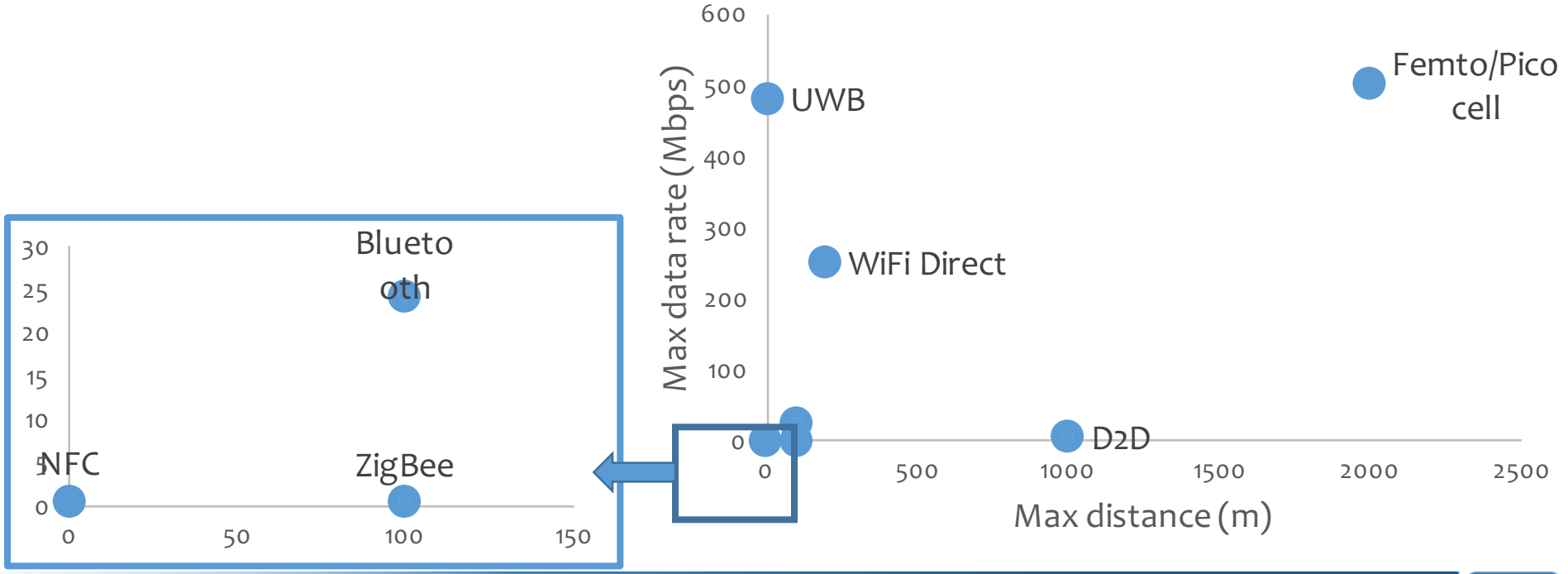
D2D Technology Comparison



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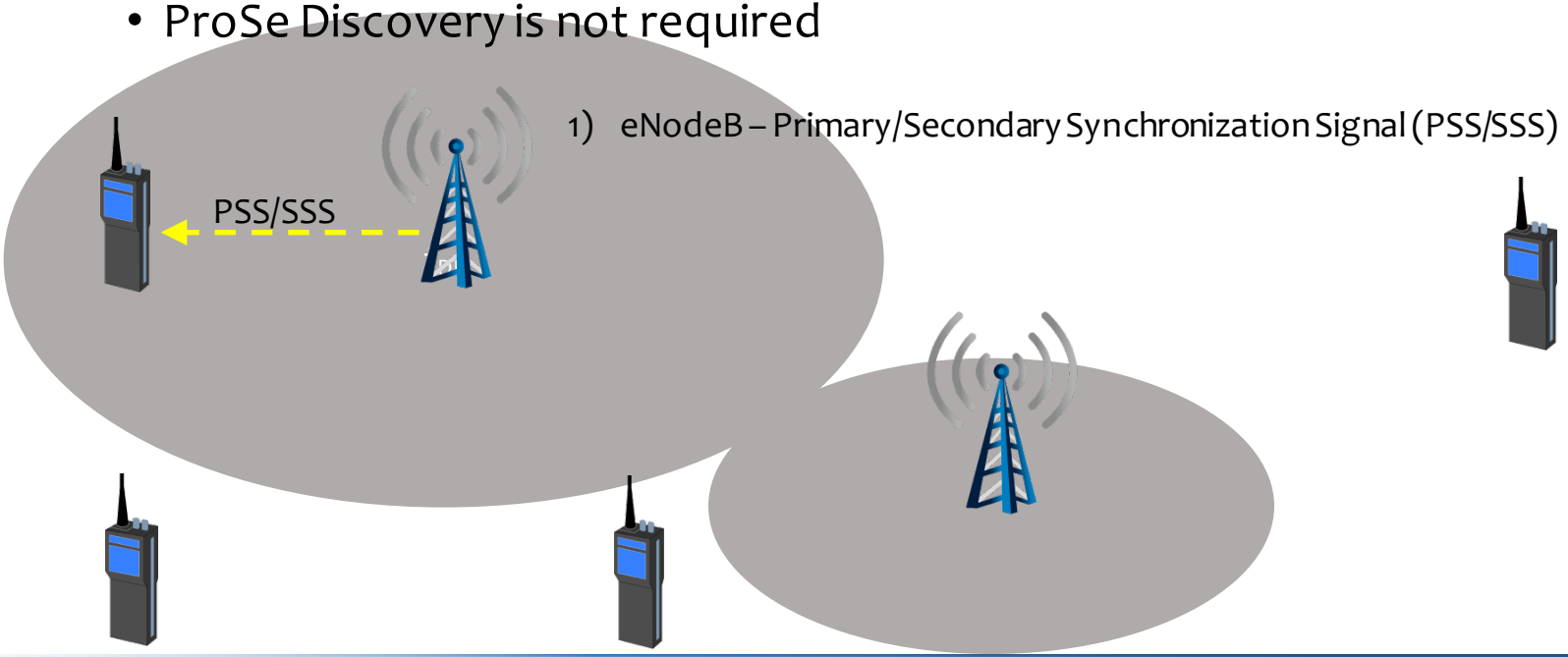
MOUTH TO EAR	GATEWAY	AMBIENT LISTENING	MOS	UNICAST	SIDELINK
OVERRIDE	REFRESH RATE		JITTER	MBMS	$3

PROCESS OF ALIGNING FREQUENCY AND TIME REFERENCES BETWEEN EQUIPMENT AND DEVICES

Synchronization

- Prior to TX, UE synchronizes to source according to priority
- ProSe Discovery is not required



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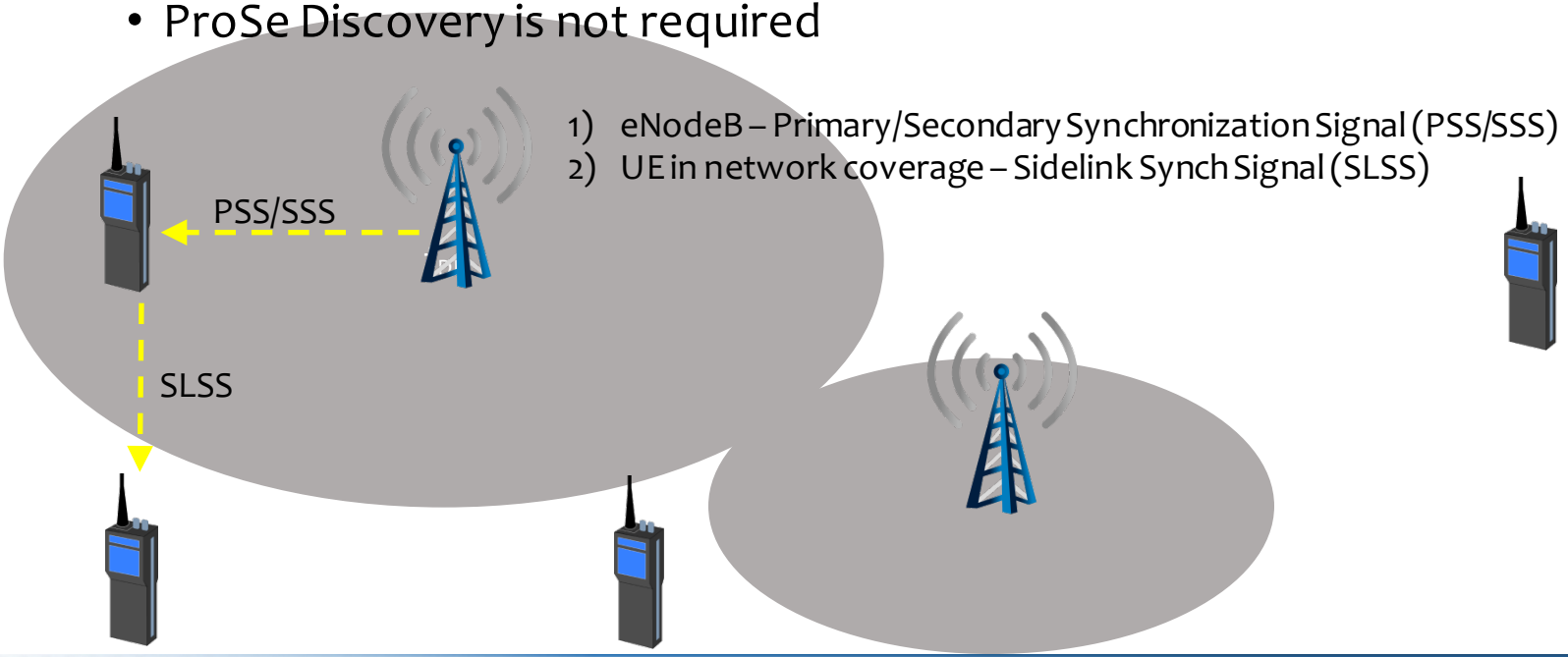
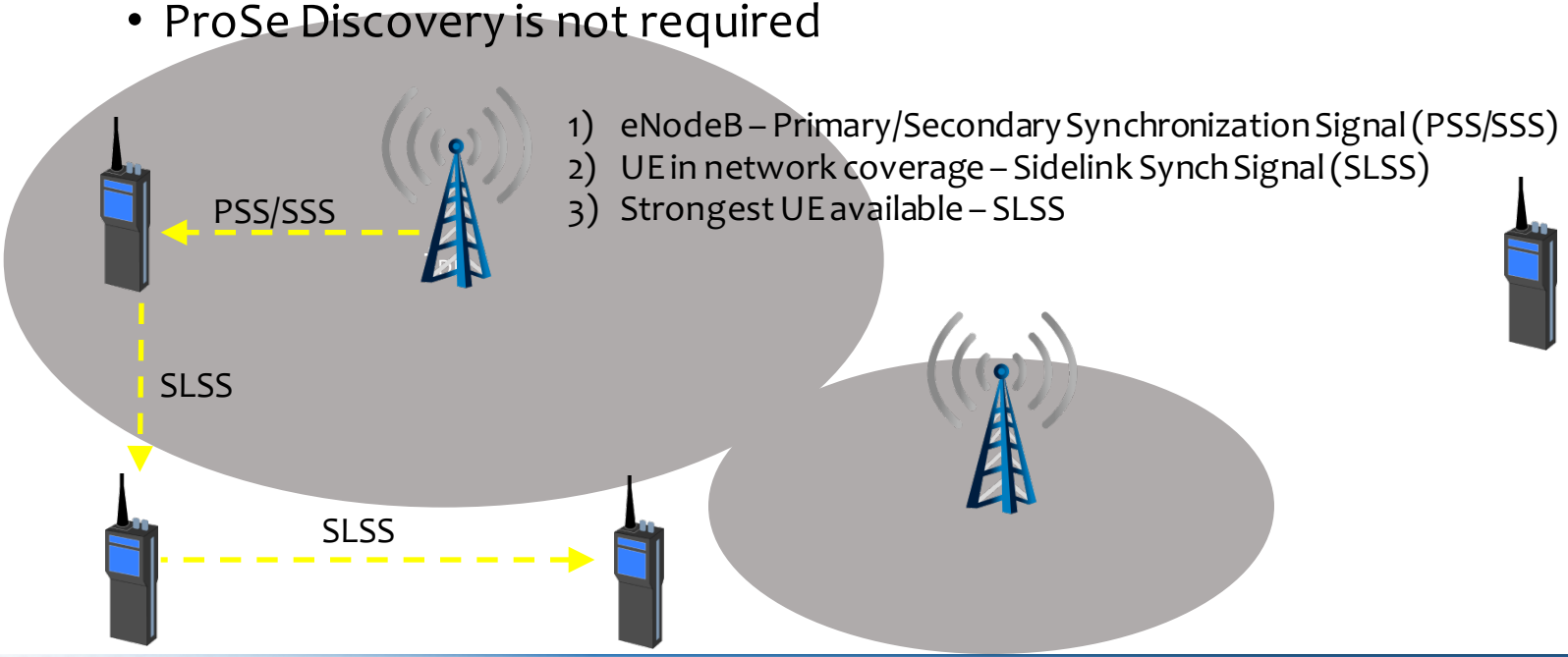


1) eNodeB – Primary/Secondary Synchronization Signal (PSS/SSS)
2) UE in network coverage – Sidelink Synch Signal (SLSS)

PSCR

Synchronization

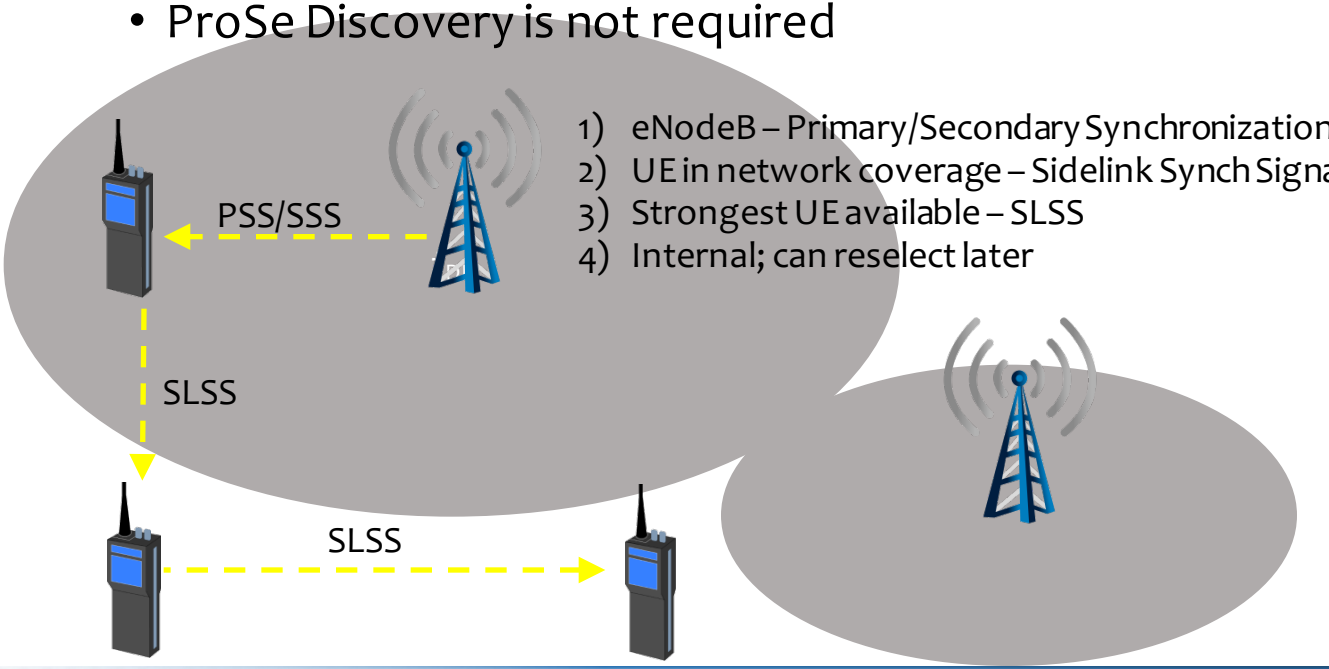
- Prior to TX, UE synchronizes to source according to priority
- ProSe Discovery is not required



1) eNodeB – Primary/Secondary Synchronization Signal (PSS/SSS)
2) UE in network coverage – Sidelink Synch Signal (SLSS)
3) Strongest UE available – SLSS

Synchronization

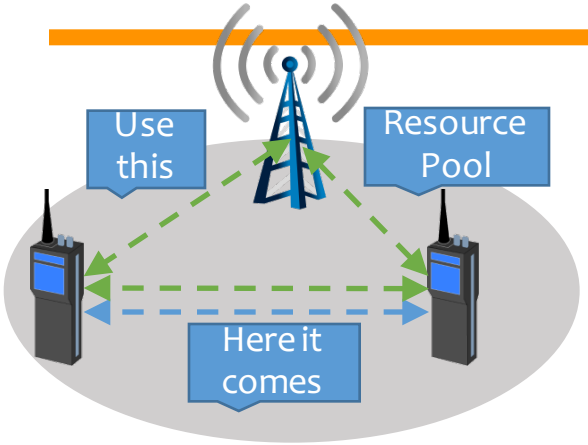
- Prior to TX, UE synchronizes to source according to priority
- ProSe Discovery is not required



1) eNodeB – Primary/Secondary Synchronization Signal (PSS/SSS)
2) UE in network coverage – Sidelink Synch Signal (SLSS)
3) Strongest UE available – SLSS
4) Internal; can reselect later

PSCR

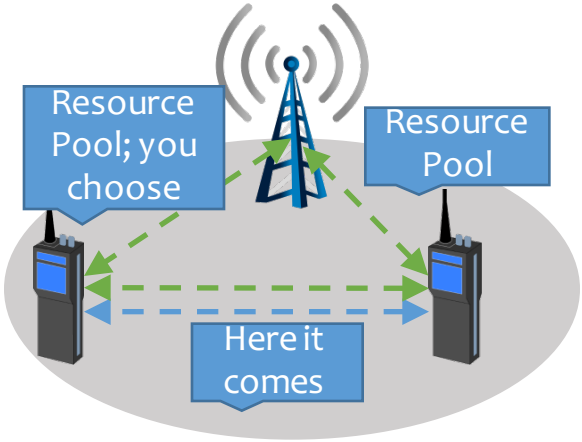
Resource Selection



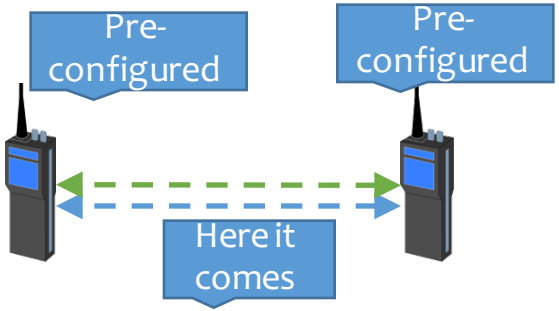
Mode 1: eNB schedules exact resources; dynamic, no pre-allocation

Control
Data

- In coverage, eNB determines mode (1 or 2)
- Out-of-coverage, UE can only use mode 2



Mode 2: UE selects from resource pools, either assigned (in-network) or pre-configured (out-of-network)



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Interference

- Sidelink and Uplink share same frequency channel
- Not a problem when in Mode 1 (eNB scheduled), but what about Mode 2 (autonomous) when off-network?
- Band 14 is currently only 1 of 2 bands in North America authorized for D2D, including Direct Discovery. Public can only use in-network.
- When PS users go to direct mode off-network, but within range of other PS and non-PS users will interference be an issue?

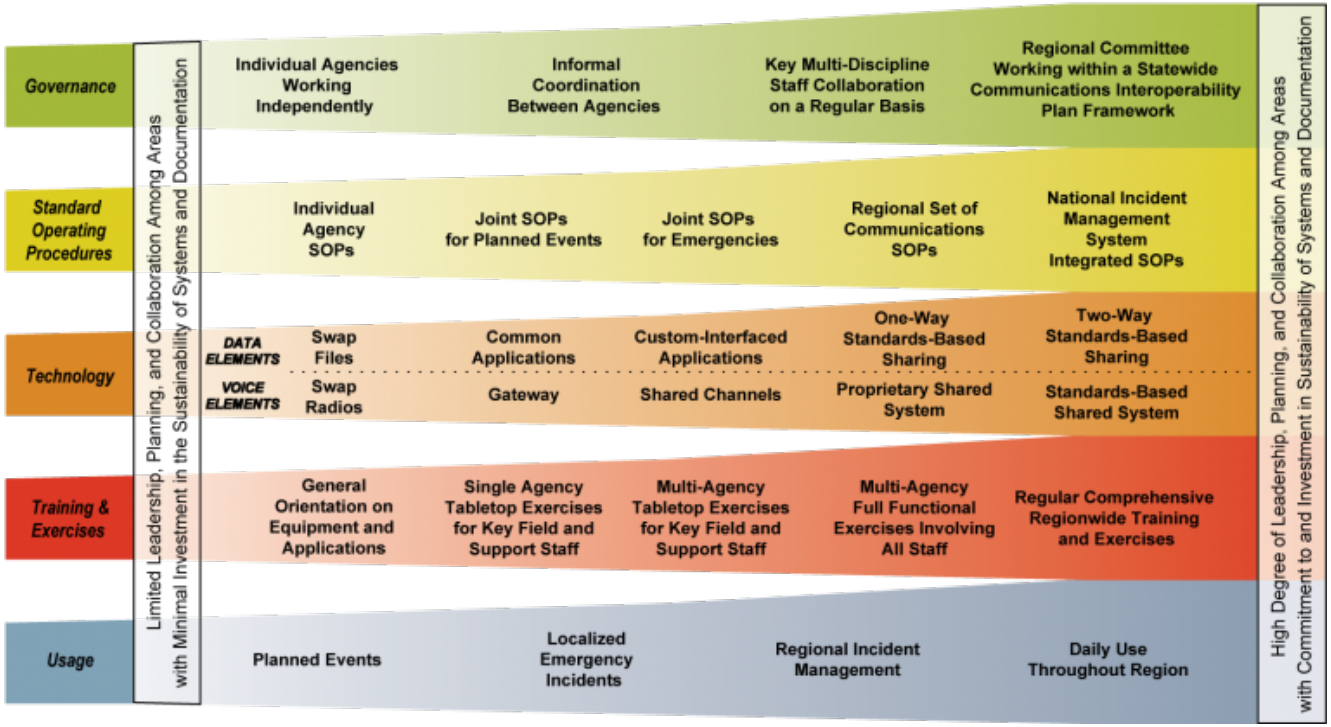
PSCR

PUSH-TO-TALK	TALKER IDENTIFICATION	EMERGENCY ALERTING	AUDIO QUALITY	GROUP COMMUNICATIONS	DIRECT MODE
FLOOR CONTROL	MISSION CRITICAL ORGANIZATION	IMMINENT PERIL	AMR-WB	HANG TIME	HALF-DUPLEX
MOUTH TO EAR	GATEWAY	AMBIENT LISTENING	MOS	UNICAST	SIDELINK
OVERRIDE	REFRESH RATE		JITTER	MBMS	SYNCHRO-NIZATION

THIS CANADIAN INVENTOR CREATED THE FIRST ‘WALKIE-TALKIE’ IN 1937

DONALD HINGS
11/6/1907 – 2/25/2004

Interoperability Continuum



PSCR

MCV over LTE Interoperability

VOICE ELEMENTS	Swap Radios	Gateway	Shared Channels	Proprietary Shared System	Standards-Based Shared System
	Loan out pre-configured UEs	OTT Applications over LTE	Roaming agreements	Carrier PTT	MCPTT core services

PSCR

KPI Tracker

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

PSCR

What KPIs Are Most Important to You?

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

PSCR

To Dig Deeper

- MCPTT
  - TS 22.179 & TS22.280
  - TS 23.179
- GCSE
  - TS 22.468
  - TS 23.468
- ProSe
  - TR 22.803
  - TS 23.303

3GPP Specification Numbering (Rel 99 & beyond)

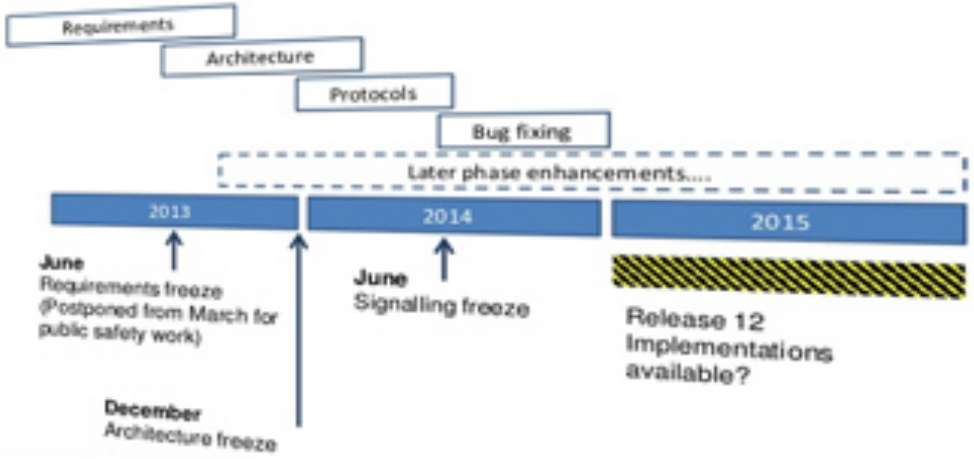
- TS = Technical Specification TS xx.yyy
  - xx = Series, e.g. 36
  - yyy = Specification
    - yy for series 01-13; yyy for series 21-55
- TR = Technical Report
  - TR XX.8yy; TR XX.9yy; TR 30.yyy
- Versioning - Vxx.yy.zz
  - xx = Major
    - 0 = immature draft; 1 = presented to TSG for approval; 2 = presented to TSG for approval; ≥ 3 or **REL** = approved by TSG and under change control
  - yy = Substantive change, e.g. technical, corrections, updates
  - zz = Editorial change

21 = Recommendations
22 = Service aspects (stage 1)
23 = Technical realization (stage 2)
24 = Signaling protocols – UE to network (stage 3)
25 = Radio aspects
28/29 = Signaling protocols – network (stage 3)
33 = Security
36 = RAN

3GPP Specifications Groups

	TSG RAN Radio Access Network (RAN)	TSG SA Service & Systems Aspects (SA)	TSG CT Core Network & Terminals (CT)
WG1	Radio layer 1	Services	MM/CC/SM (Iu)
WG2	Radio layer 2, radio layer 3 RR	Architecture	Internetworking with ext. networks
WG3	Iub, Iur, Iu, UTRAN O&M req'ts	Security	MAP/GTP/BCH/SS
WG4	Radio performance protocol aspects	Codec	Smart card application aspects
WG5	Mobile terminal conformance testing	Telecom management	
WG6	Legacy RAN radio and protocol	**Mission-critical applications**	

Release Timeline



Example Timeline for a Release

PSCR

Mission Accomplished?

- Do we recognize…
  - Key elements of MCV & how they might be implemented in LTE
  - Functionality consistent with LMR
  - KPIs relevant to you
  - Opportunities for innovation
  - Extensive testing will be needed before LTE can be adopted for MCV
- And did we have a little fun?

LTE Network Security Tutorial: Public Safety Security Enhancement through Identity Management & Data Isolation

PSCR

Disclaimer

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

Security Tutorial Topics

- Data and Application Isolation
- Application Security (Vetting)
- Identity Management/Single Sign On

Panel Members

- John Beltz (Moderator)
  - PSCR IT Security Manager
- Joshua Franklin
  - NIST Information Technology Laboratory (ITL)/PSCR
  - Primary Research Engineer for PSCR Application/Data Isolation Project
- Michael Ogata
  - NIST Information Technology Laboratory (ITL)/PSCR
  - Primary Research Engineer for PSCR Application Security Vetting Project
- Paul Grassi
  - National Strategy for Trusted Identities in Cyberspace (NSTIC)/PSCR
  - Primary Research Engineer for PSCR Identity Management Project

Data Isolation

Joshua Franklin – IT Security Specialist

Poll Question #1

Which best explains your agency's use of broadband mobile devices (smartphones, tablets) in your Public Safety work?

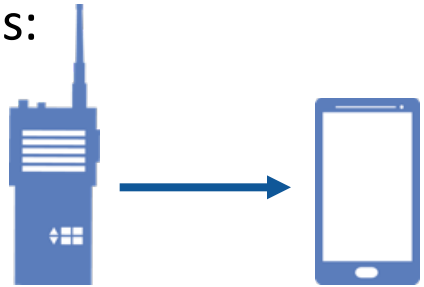
A. Personnel use mobile devices that are supplied by the agency. (text A to 22333)
B. Our agency does not supply mobile devices, but personnel are authorized to use their personal devices to accomplish their mission. (text B to 22333)
C. Our agency does not provide mobile devices, and use of personal devices is not authorized, but we are aware that personal devices are still used to perform duties. (text C to 22333)
D. We do not use mobile devices. (text D to 22333)

Data Isolation 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

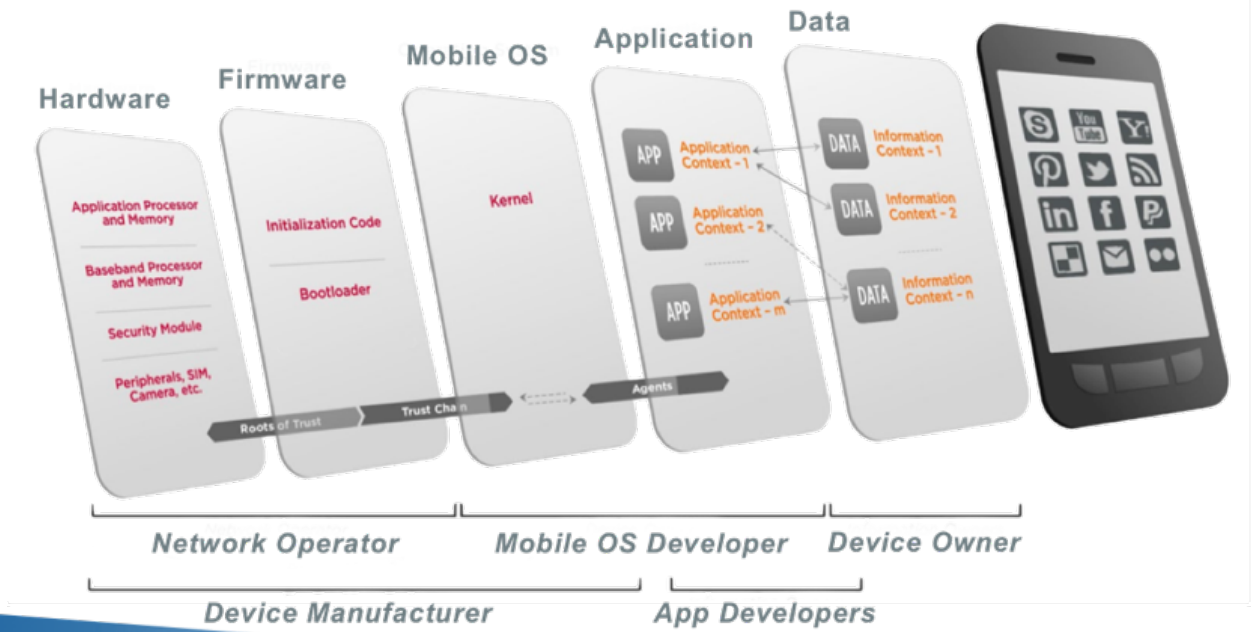
- The *Mobile Data & Application Isolation* project explores methods to manage and isolate applications/data for deployment on the NPSBN
- Devices and data can be compromised in many ways:
  - lost or stolen devices
  - network eavesdropping
  - Insecure network interfaces (e.g., WiFi, cellular)
  -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

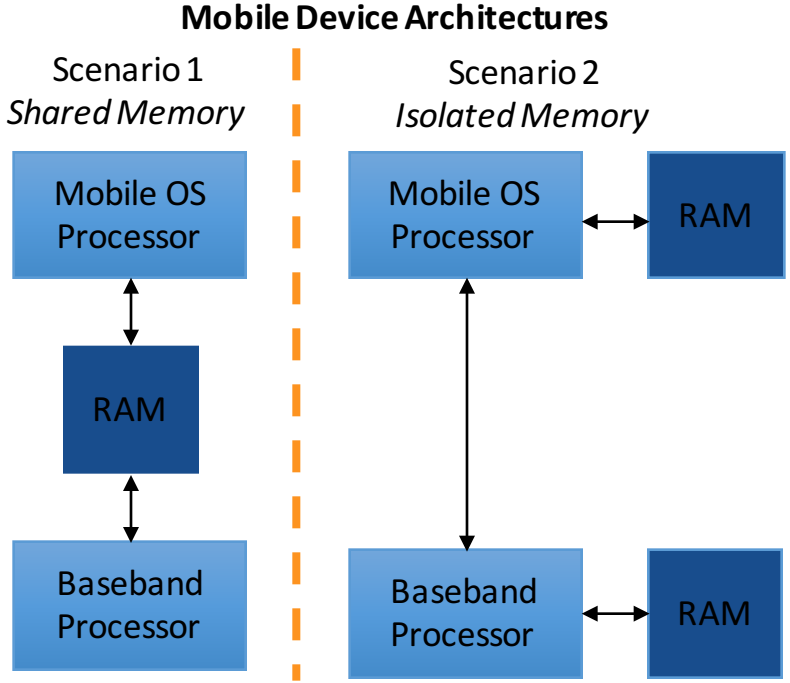
Mobile Security Stack

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



Hardware & Firmware

- Multiple mobile device architectures exist
  - Isolated memory may offer greater security
- Need to mitigate attacks against the Mobile OS processor and baseband processor
- Attacks at these layers circumvent any protections by the mobile OS
  - Device drivers, bootloaders, etc
- Carrier unlocks, jailbreaks, roots occur at this layer



Ralf-Philipp Weinmann - WOOT 2012
Baseband Attacks: Remote Exploitation of Memory Corruptions in Cellular Protocol Stacks

Operating System

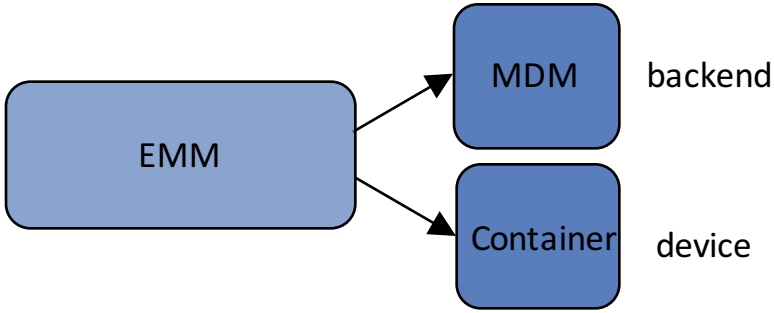
- iOS and Android use Unix and Linux as a foundation
- Many of the same security mechanisms found on each:
  - Secure boot
  - Data Execution Prevention (DEP)
  - Address Space Layout Randomization (ASLR)
  - Sandboxing
- Support for, and timeliness of, security updates becoming a differentiator
- Attacks at this layer often don't affect the cellular functionality, but can often undermine mobile applications

Applications & Data

- Ensuring applications are free of software vulnerabilities is a difficult task
- Also need to ensure mobile malware does not attack the system
- Google's Potentially Harmful Applications Categories
  - SMS fraud
  - Spyware
  - Data Collection
  - Hostile Downloaders
  - Phishing Applications
  - Ransomware
  - Spam
  - DoS
  - Non-Android Threat
  - Privilege Escalation Apps
  - Rooting Apps
  - Trojans

Enterprise Mobility Management

- EMM: Standard method to deploy mobile devices in an enterprise
- MDM: Backend system defining and delivering policies to mobile devices
  - May be enforced by the operating system or by an EMM application installed on the mobile device
  - EMM applications (or agents) often run at higher privilege level or with large permissions
- Containerization: mobile app to protect data
  - Can enforce policies, but may rely on OS-level management APIs.



Public Safety Mobile Security Capabilities

Data Protection	• Data encryption, Remote wipe
Isolation	• Application wrapping, whitelisting
Integrity	• Device integrity reports, policy verification
Access Control	• Single Sign On, Multiple profiles on a device
Monitoring	• Jailbreak and root detection, geofencing
Services	• Private enterprise application store

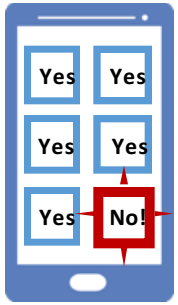
Note: This is an illustrative subset of capabilities

Example Security Policies

Lockscreen Security

Root & Jailbreak Detection

Application Whitelisting



- Example policies:
  - Remote lock
  - Enable VPN
  - Remote wipe
  - Device encryption
  - Disable screen capture
  - Disable camera
  - Require encrypted backup
  - Disable synchronization
  - Use private app stores
  - Advanced authentication
  - Manage network interfaces
  - Detect policy violations

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

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Mobile Application Security

Michael Ogata

Poll Question #2

Where do you obtain the mobile apps are you currently using to support your mission?

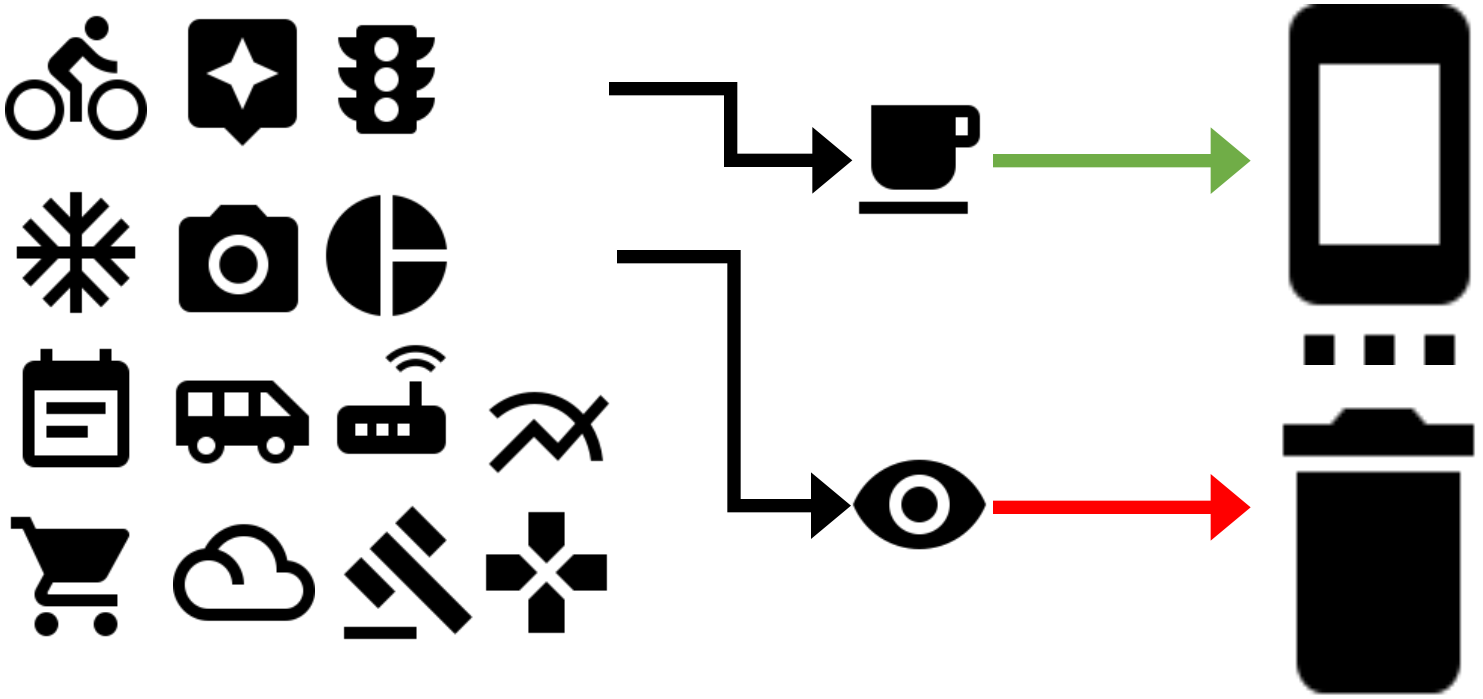
A. My agency developed/provided apps (text A to 22333)

B. Other agencies developed/provided apps (text B to 22333)

C. Applications from Google Play, Apple Store, or other public app stores (text C to 22333)

D. We are not currently using any apps to support our mission (text D to 22333)

Mobile Application Vetting



Mobile Application Threats

New threats

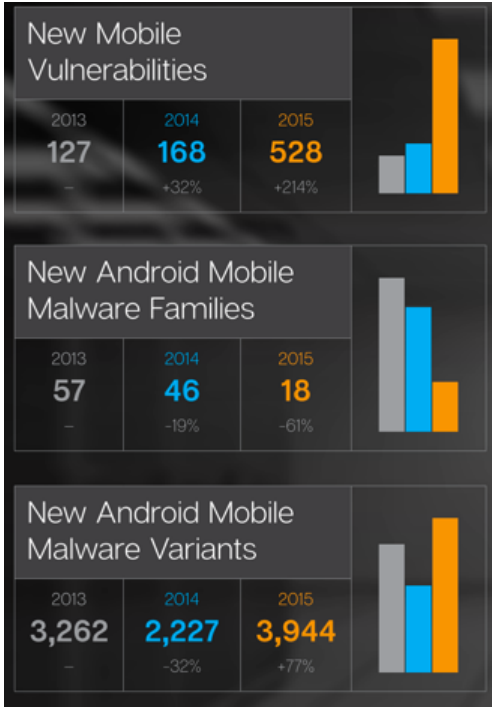
- XcodeGhost
- Stagefright

Zero-day vulnerabilities

Ransomwear

Madware

Cross-over threats



	2013	2014	2015
Total Apps Analyzed	6.1 Million	6.3 Million	10.8 Million
Total Apps Classified as Malware	0.7 Million	1.1 Million	3.3 Million
Total Apps Classified as Grayware	2.2 Million	2.3 Million	3.0 Million
Total Grayware Further Classified as Madware	1.2 Million	1.3 Million	2.3 Million

OWASP Mobile Top Ten

- Improper Platform Usage
- Insecure Data Storage
- Insecure Communication
- Insecure Authentication
- Insufficient Cryptology
- Insecure Authorization
- Client Code Quality
- Extraneous Functionality
- Code Tampering
- Reverse Engineering

https://www.owasp.org/index.php/Mobile_Top_10_2016-Top_10

OWASP Mobile Top Ten

- Improper Platform Usage
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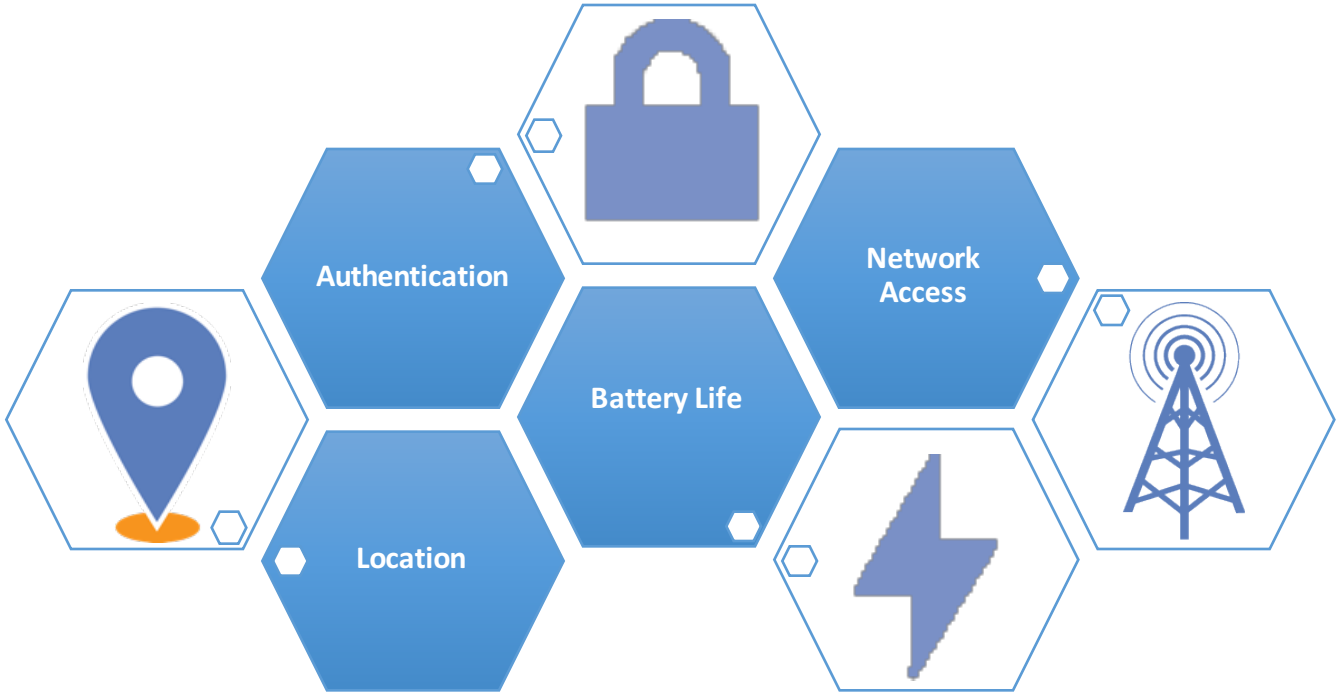
- ~~Code Tampering~~
- ~~Reverse Engineering~~

https://www.owasp.org/index.php/Mobile_Top_10_2016-Top_10

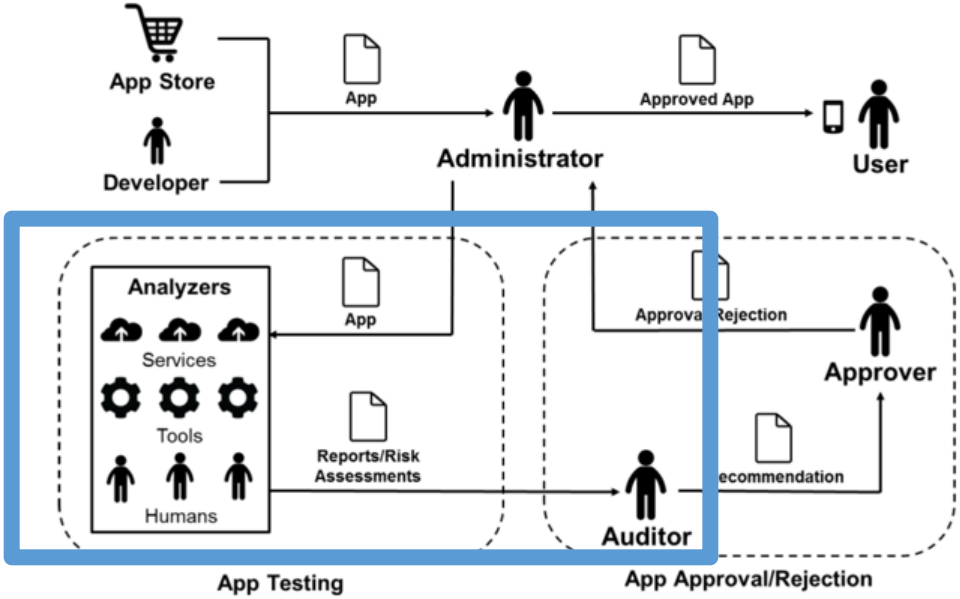
Public Safety Mobile App Threats



Mobile Application Vetting

- Defined in NIST SP 800-163
- Verifies an app meets security requirements
- Two primary activities
  - App Testing
  - Approval/Rejection

Mobile Application Vetting Process



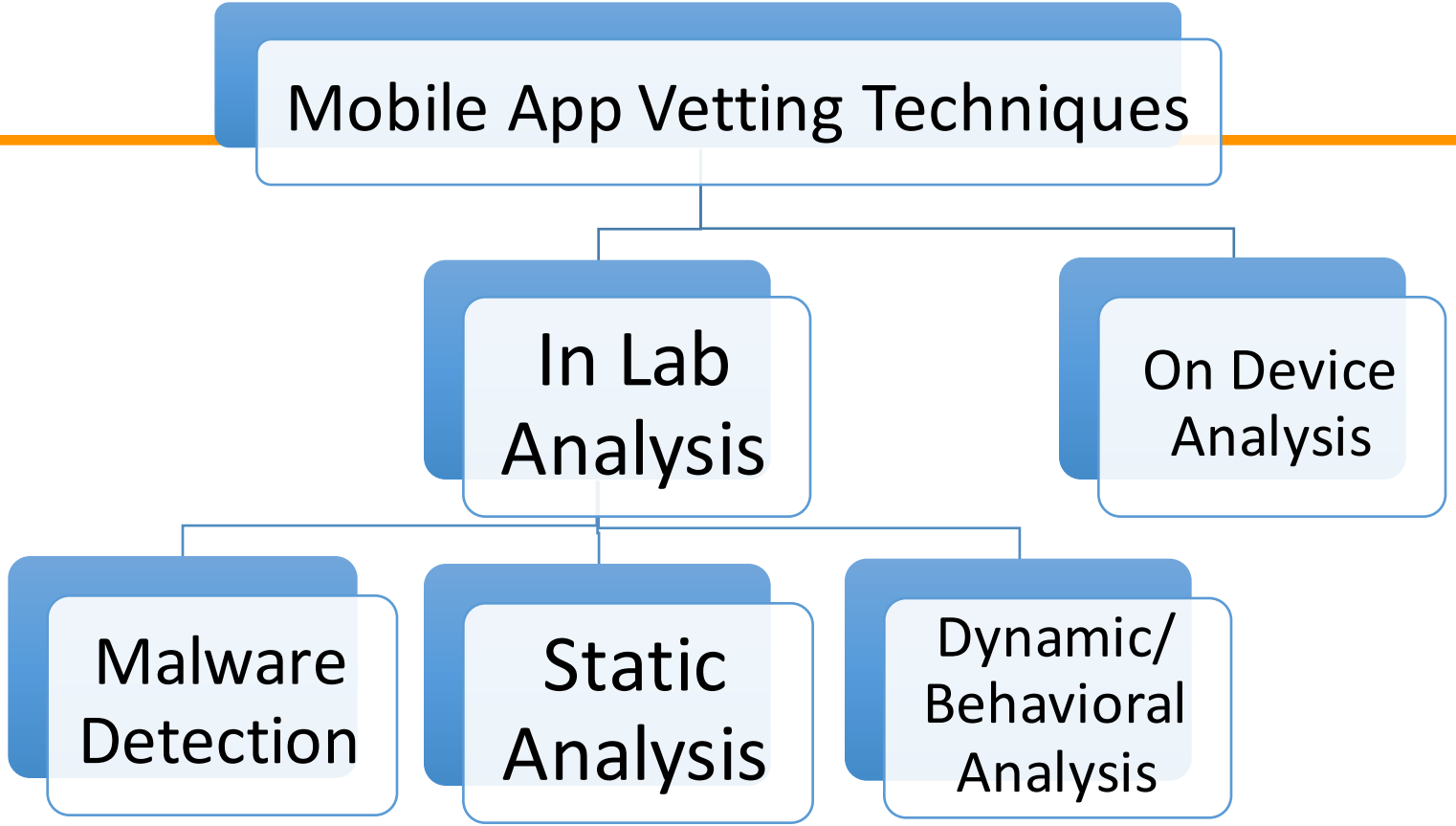
http://dx.doi.org/10.6028/NIST.SP.800-163

Federal Examples

DHS Carwash

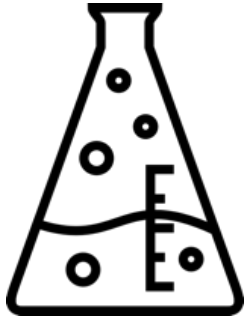
DISA Mobility Applications

Veterans Affairs


Mobile App Vetting Techniques
In Lab Analysis
On Device Analysis
Malware Detection
Static Analysis
Dynamic/ Behavioral Analysis

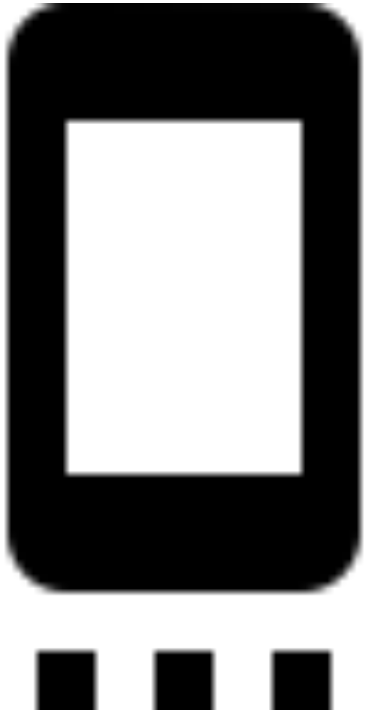
Lab Analysis

- **Malware Detection**
  - Signature Based
  - Code profiling
- **Static Analysis**
  - App permissions
  - Code analysis
  - Decompilation



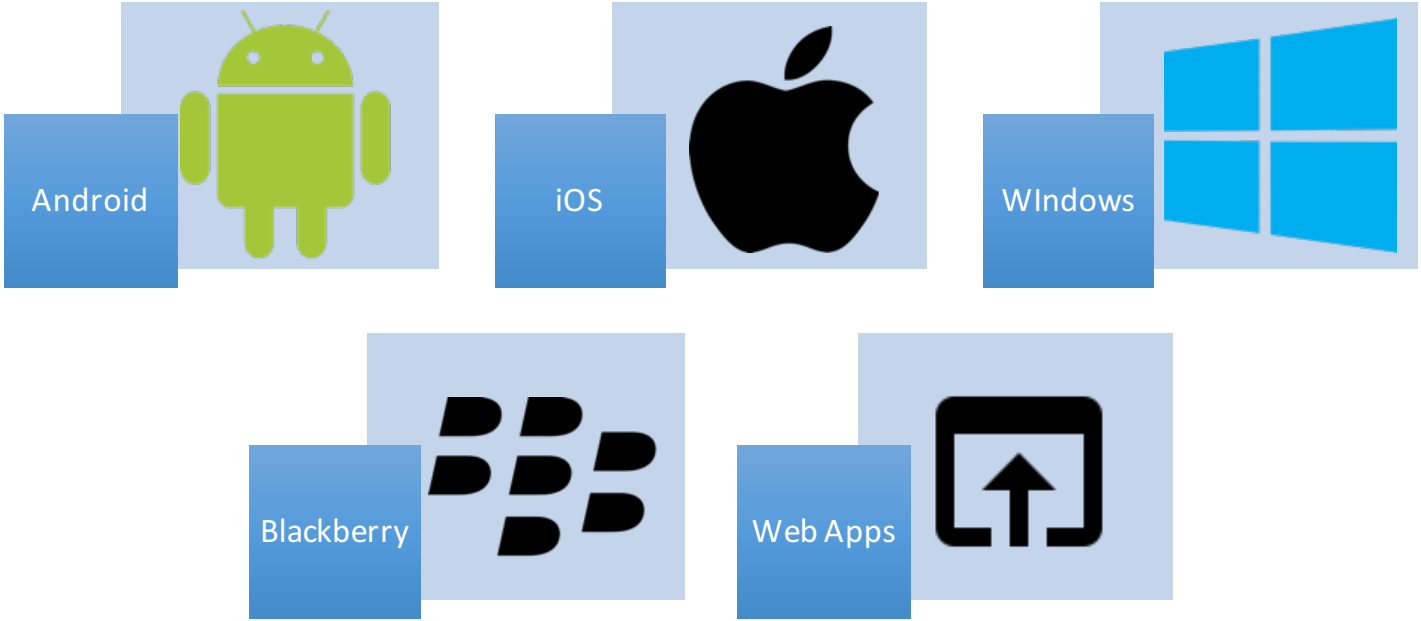
- **Dynamic/Behavioral Analysis**
  - Memory Analysis
    - Deadlocking
    - Memory Leaks
    - Race Conditions
  - Network traffic analysis
  - Benchmarking and resource usage

On Device Analysis

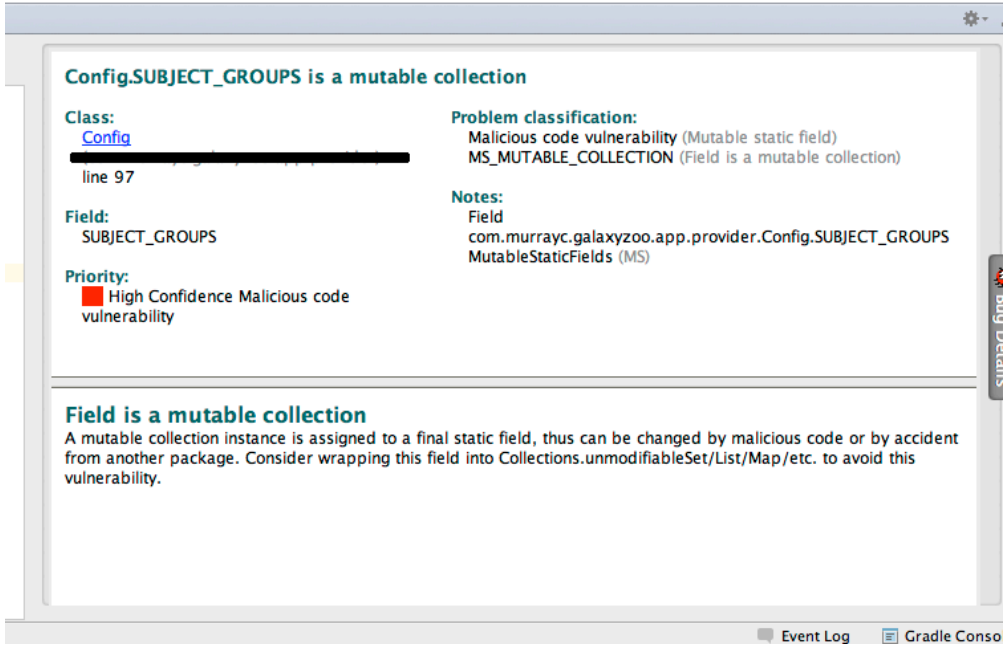


- Installs client on device
- Sends information to home server
- Uses device resources

Target Platforms – Different Techniques



Static Analysis Example



Analysis Strengths and Weaknesses

The Good

- Detecting
  - Reused malware
  - Identifying potential data egress (confidentiality)
  - Weak or missing encryption (confidentiality)
  - Hard coded passwords and other bad engineering practices

The Not so Good

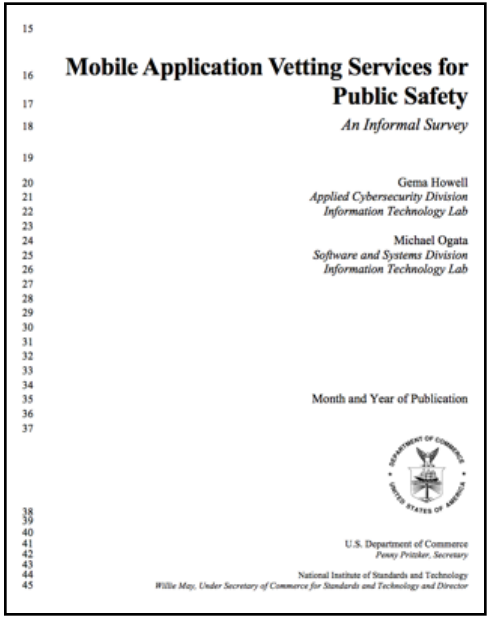
- Proving
  - Benevolent intent (availability, integrity)
  - Application correctness
  - Solid engineering (crashes)
- Identifying false positives

Areas of Consideration

- Public Safety Specific Analytic Features
  - Network usage
  - Battery usage/impact
  - Location information
- Reporting mechanisms
- Report redistribution

Mobile Application Vetting Services for Public Safety

- High level service survey
- Enumerate traits useful for public safety
- Out for public comment
  - MobileAppSurveyDraft@nist.gov



Mobile Application Vetting Services for Public Safety

An Informal Survey

Gema Howell
Applied Cybersecurity Division
Information Technology Lab

Michael Ogata
Software and Systems Division
Information Technology Lab

Month and Year of Publication

U.S. Department of Commerce
Penny Pritzker, Secretary

National Institute of Standards and Technology
Willie May, Under Secretary of Commerce for Standards and Technology and Director

PSCR

Identity Management/Single Sign On

Paul Grassi, Primary Research Engineer for Identity Management Project

Poll Question #4

How many different times do you have to authenticate to your broadband devices and applications during a typical day on the job?

A. Only once. (text A to 22333)

B. Two to four times. (text B to 22333)

C. Five or more times. (text C to 22333)

D. I don't have to authenticate at all (text D to 22333)

Terminology Baseline

1. Identity Management – Technology and processes responsible for the lifecycle of establishing and maintaining a single digital identity for each public safety stakeholder
2. Access Management – Technology and processes responsible for the administration and enforcement of access control policies
3. Federated Identity – Ability to utilize the digital identity established and managed by one organization in another organization – often cross internet domains
4. Single Sign-On – Login once, authenticated session propagates to applications you access so you don't need to supply credentials again
5. Reduced/Simplified Sign-On – Logon fewer times than normal, hopefully with the same credential, but sometimes not

What is likely to happen?

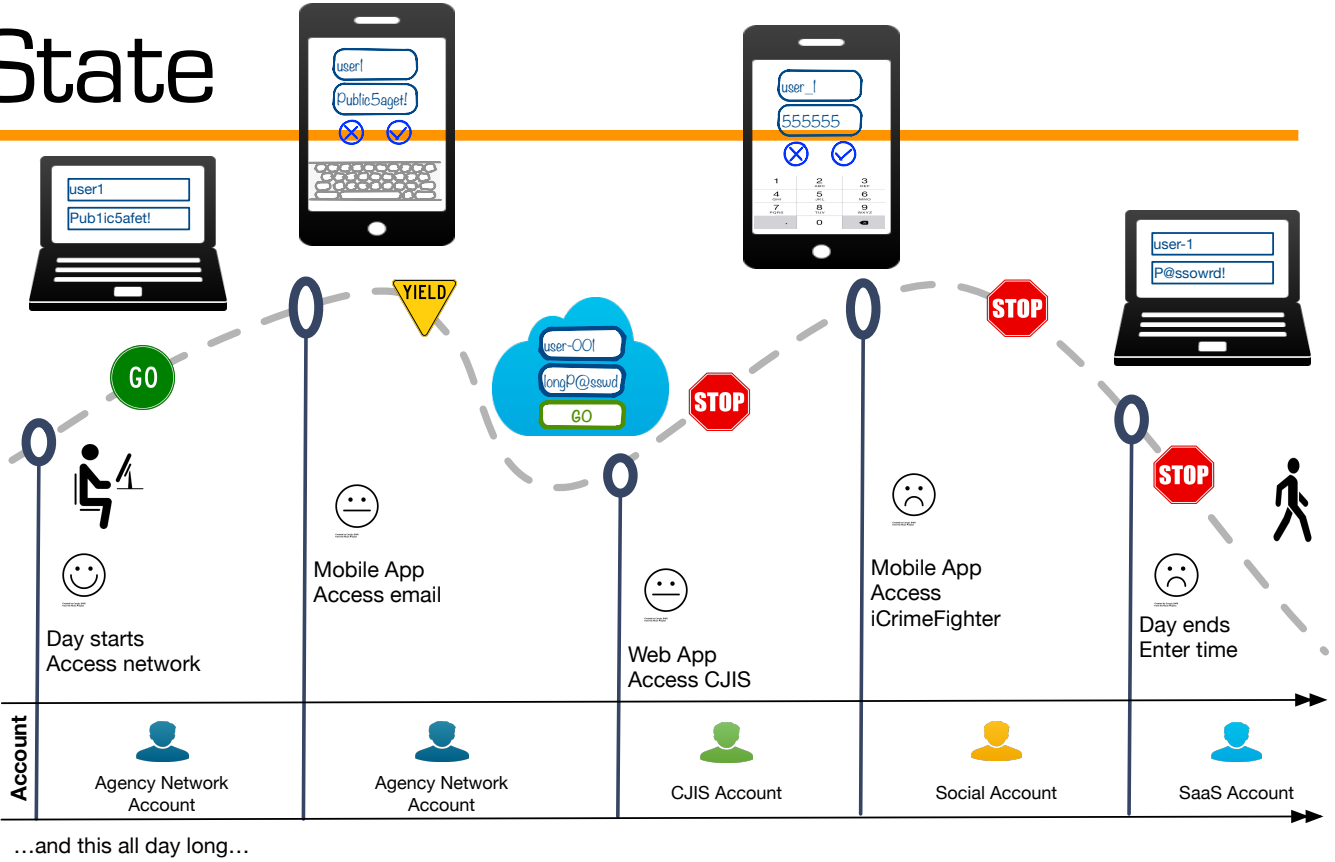
SSO is a great goal…

RSO is much more achievable.

Current State

IMPACT

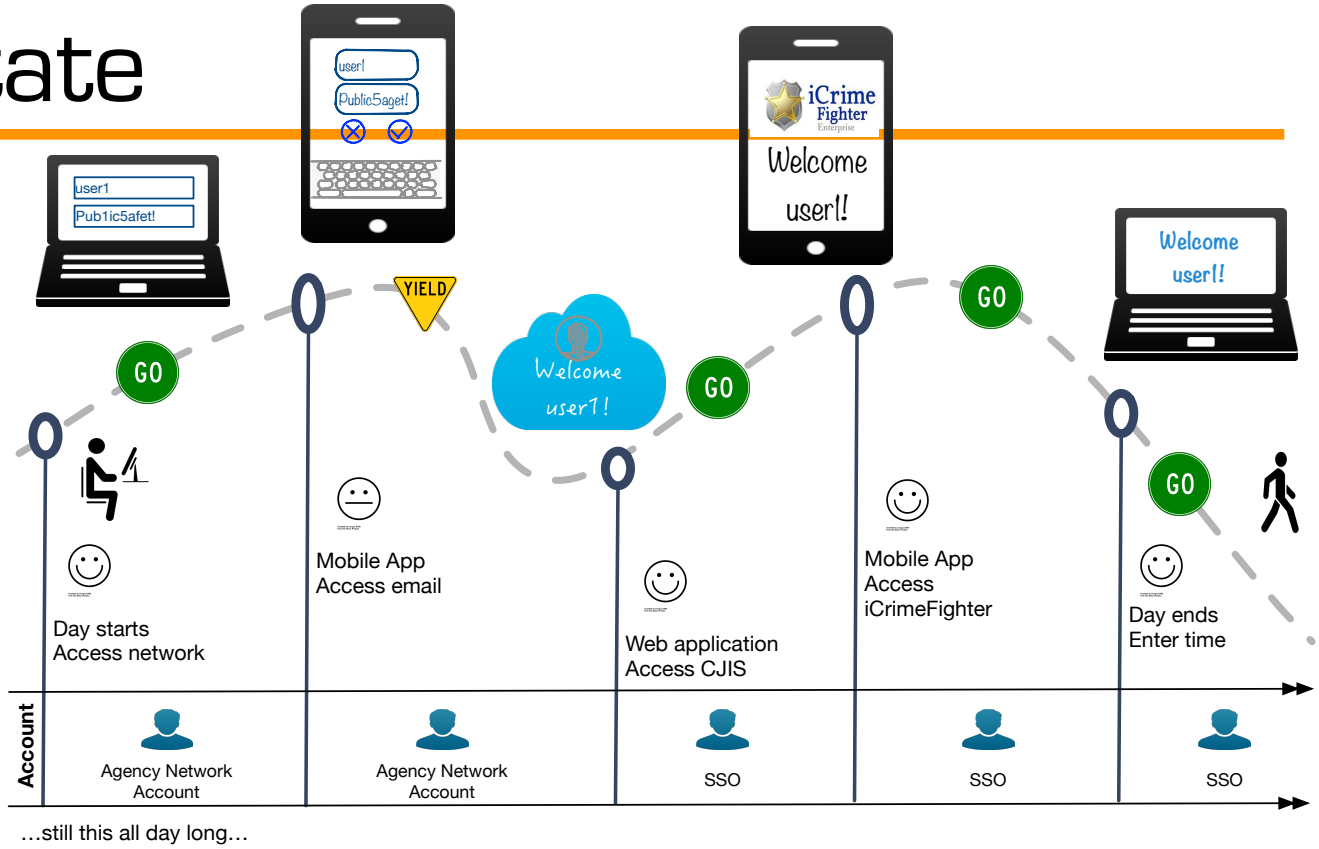
- Poor UX
- Insecure
- Inefficient
- Costly
- Proprietary
- …



Future State

IMPACT

- Happy user
- Secure
- Efficient
- Reduced Expense
- Interoperable
- …



Key elements of secure identity

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Identity Proofing

Verify that the individual is actually who they claim to be

Common Misnomer

Identity proofing is used to determine eligibility or suitability to access something.

You may get some attributes that assist in this, but it's not the goal of proofing

Authentication

Ensure it's the same person that you successfully identity proofed

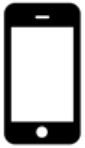
Common Misnomer

Passwords are user friendly and enough for multiple profiles

Multi-factor authentication can't exist on a single mobile device

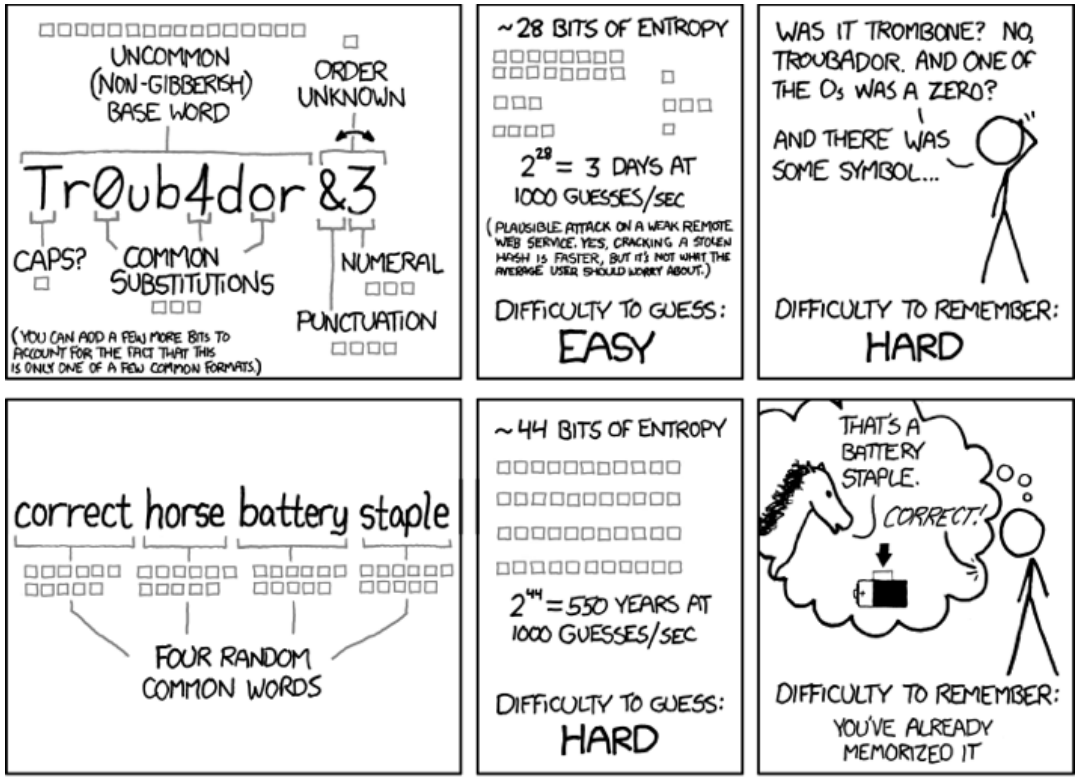
Old vs. New: Passwords

- >=8 characters
- Special characters
- Expire
- No spaces



- As big as the user wants
- If its long enough, special characters don't matter
- Never expire, unless compromised
- Phrases are good

This doesn't feel right, but it is!

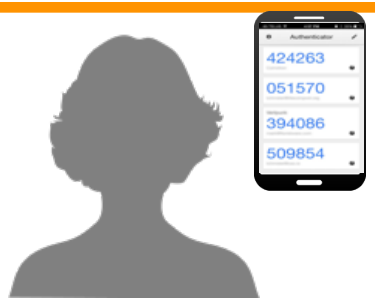


SOURCE: HTTP://XKCD.COM/936/

MFA Defined

Authentication Factors

Something you know



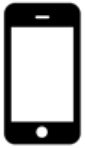
Something you have

Something you are

Combine 2 or more factors to achieve MFA
(3 is overkill)

Old vs. New: Multi-Factor AuthN

- Password always a factor
- Separate “channels”
- SMS One time password typical
- Limited support for biometrics



- Password-less
- Delivery channel doesn’t matter
- SMS is weak, host of better options
- Greater support for biometrics

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Open Innovation: Crowdsourcing and Prize Competitions

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

Meet the Winners

VIDEO

Series is available:
https://www.youtube.com/playlist?list=PLd9b-GuOJ3nFeJeAHAn3Z5opohjxIw8OC

History of Prize Competitions

Competitions have been around for hundreds of years:

- England's Longitude Prize of 1714 that sought to develop an accurate method of calculating longitude at sea.
- Napoleon's food preservation prize competition resulting in canning.
- The 1927 Orteig Prize, the transatlantic flight that made Charles Lindbergh famous.

Defining Open Innovation

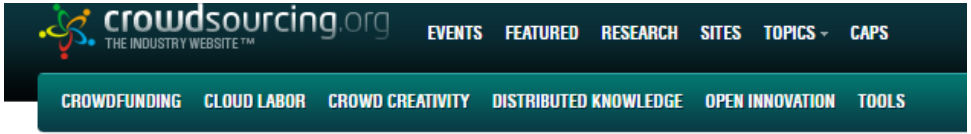
"No matter who you are, most of the smartest people work for someone else." ~Bill Joy, co-founder Sun Microsystems

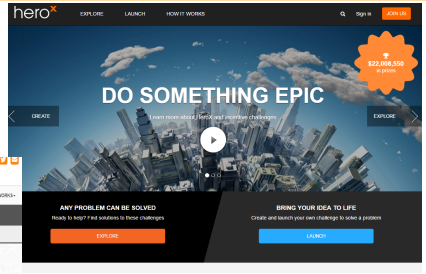
- Define a problem to be solved or a goal to be reached.
- Participation is open to anyone,* regardless of credentials, experience, connections, or past performance.
- The solver has the flexibility to be creative and innovative in how they get to the solution.

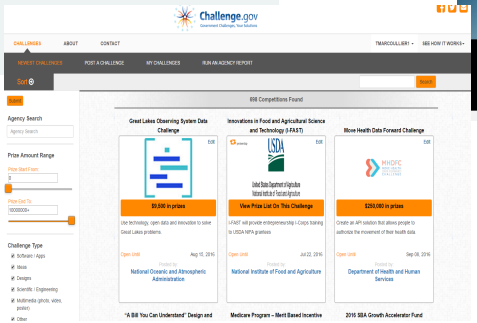
How We Work in Open Innovation

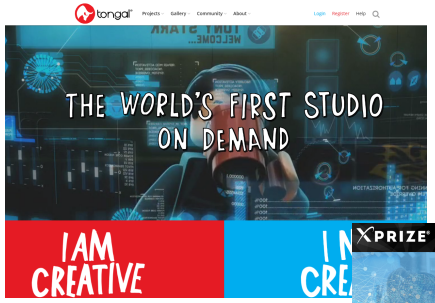
- Crowdsourcing
- Incentive Competitions
- Hack-a-thons
- Data Jams
- Citizen Science
- Collaborative Innovation

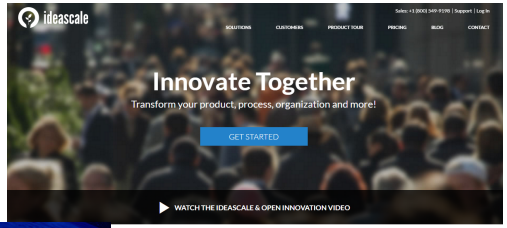
Crowdsourcing Across the Industry

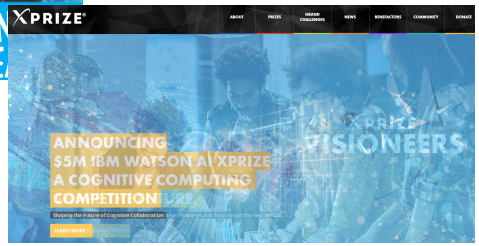












nnovation management platform that uses crowdsourcing to help you find and develop the next big thing.

bit.ly/PSprizes

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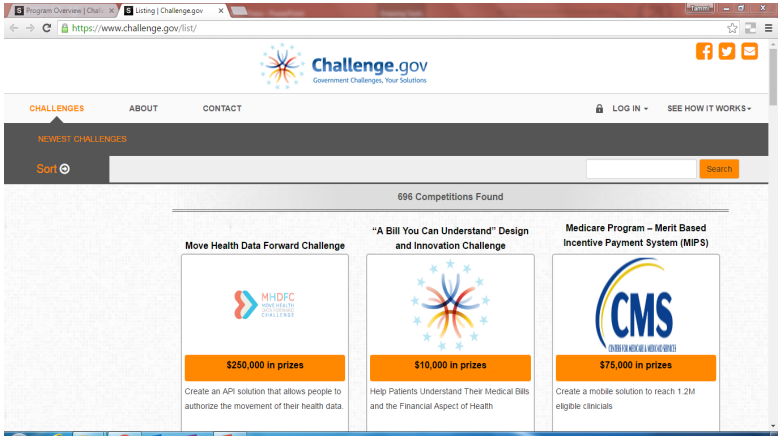
Prize & Challenge Competitions in Federal Government

Benefits:
- Attract new and diverse talent
- Discover new concepts and techniques
- Stimulate the marketplace
- Accelerate the timeline for innovation

Precedent for Success:
- 970+ competitions since Sept. 2010
- 100 agencies launched programs
- $250+ million in prizes offered
- 400,000+ solvers engaged



Prize & Challenge Competitions in Federal Government

Desal Prize

Lunar Lander

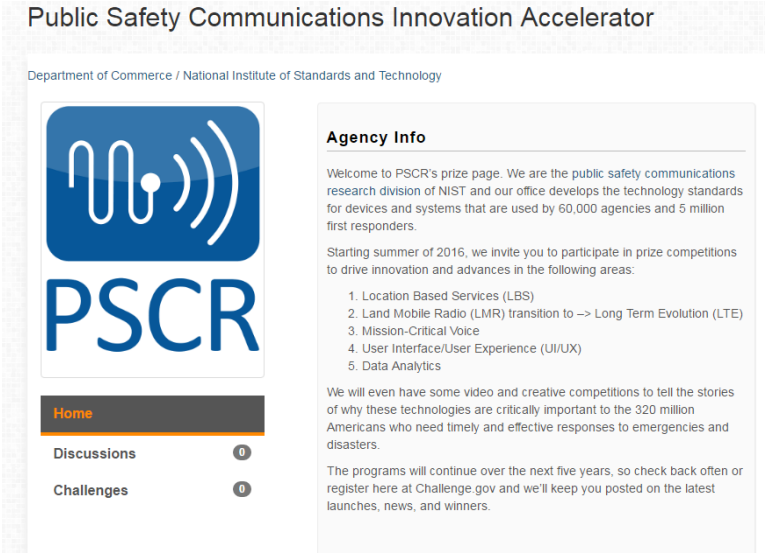
Sun Shot Catalyst Prize

Ultra High Speed Apps

Robocall Challenge

Success Stories: https://www.challenge.gov/success-stories/

PSCR Prize Mission



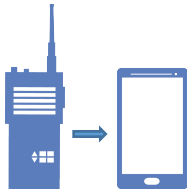
- Solve mission-centric problems in Public Safety Communications Technologies and set goals for future innovation.
- Engage broadly and openly, including entrepreneurs, inventors, start-ups, experts, academics, and industry.
- Measure and report impact.

Public Safety Prizes: 5 Key Areas

Mission Critical Voice

Location Based Services

LMR to LTE



UI/UX

Analytics

Public Safety Prizes

- Mission Critical Voice
- Proximity Services Discovery
- Integrating Video & Data

- Location Based Services
- Z-Axis
- Indoor mapping accuracy

- Virtual Reality – Environment Creation

Public Safety Prizes

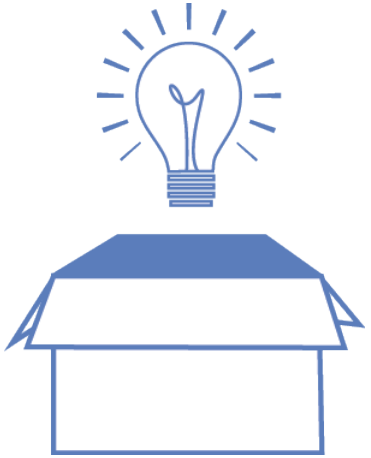
*"Challenges are becoming an increasingly important tool for societal problem-solving**; they unite problems with problem-solvers, filling holes in business models** that cater mostly to traditional buyer-seller relationships. Prize programs engage problem-solvers often neglected by government's traditional procurement and research- grant systems."*

– Anesa Parker, Deloitte, in Government Problems and the Power of Prizes (Governing, Aug. 6, 2014)

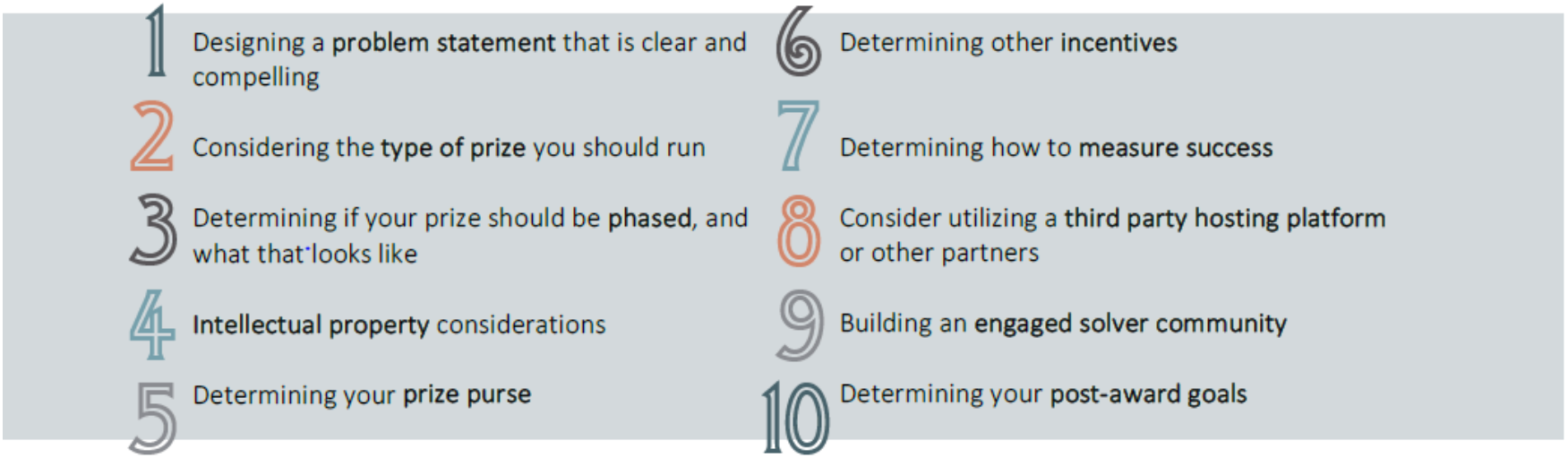
Public Safety Prizes

Benefits to participation:

- Winning a prize and valuable incentive
- Access to peers & experts
- Exposure to business opportunities and VC funding
- Labs and testing facilities
- Access to grants and cooperative agreements
- Future collaboration and partnerships



Launching a Challenge: 10 Critical Decision Points



Running a successful program requires a significant amount of research, planning, and resources.

The three primary spectrums that need to be managed carefully throughout the design and execution of prizes are cost, time, and complexity.

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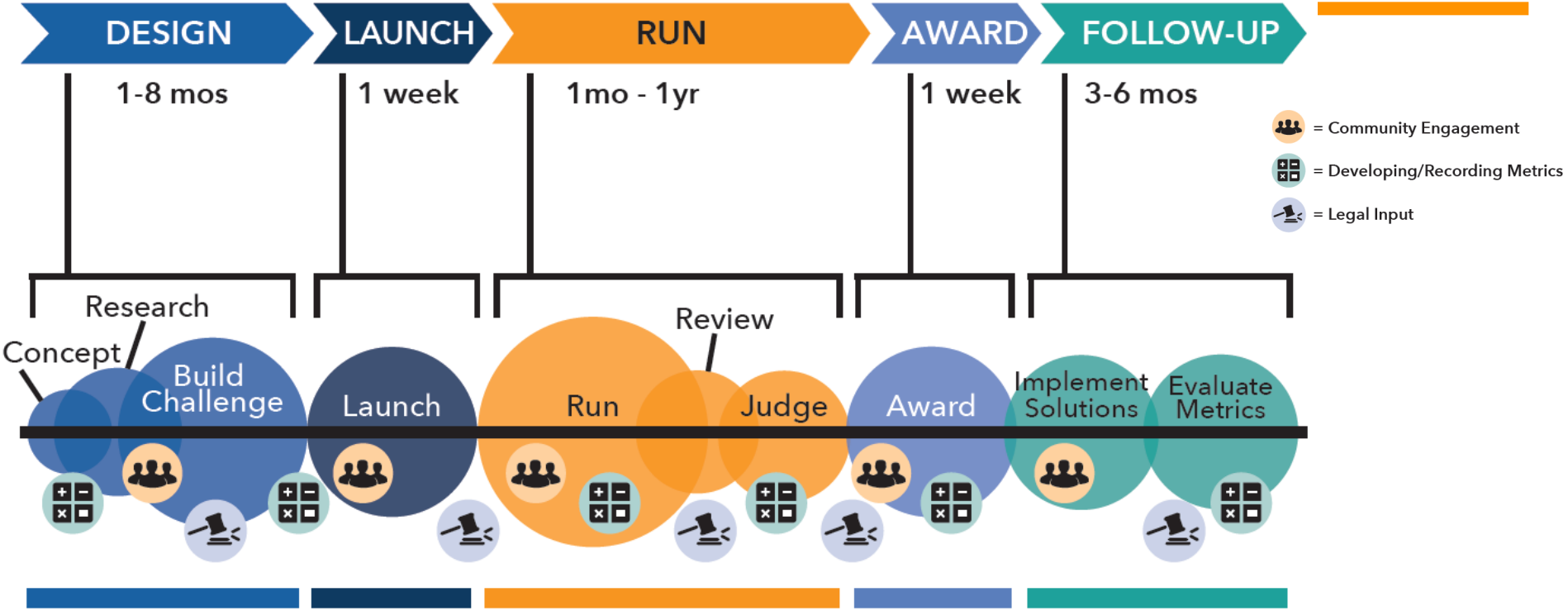
Prize Challenge Lifecycle



Public Safety Innovation Accelerator

YOU are the key to success in solving these mission-critical problems and YOU have the **intelligence, capabilities, and brilliance** to drive the innovative leaps.

How you can get involved:

Problem Definition | Expert Input/Working Group | Judging
Co-sponsoring | Solving

Public Safety Innovation Accelerator

Finding Prize & Challenge Competitions

- Register on challenge.gov (bit.ly/Psprizes)
- Email signup at conference table
- Federal register notice (FedBizOps)
- Social media #PSprizes and @ChallengeGov

Public Safety Innovation Accelerator

Next: Heather Evans, NIST

PANEL Q&A

Closing Remarks

Challenges as an Innovative Partnership Mechanism at NIST

Heather Evans

Program Coordination Office

Heather.evans@nist.gov

NIST: who we are and what we do

World Leading Scientific and Engineering Research

Manufacturing Extension Partnership Centers

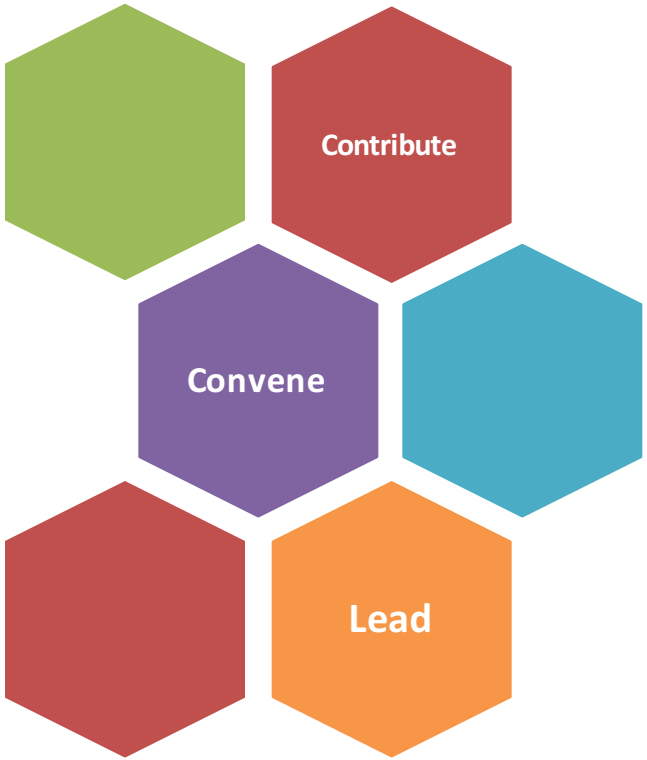
Baldrige Program in Performance Excellence

Advanced Manufacturing National Program Office

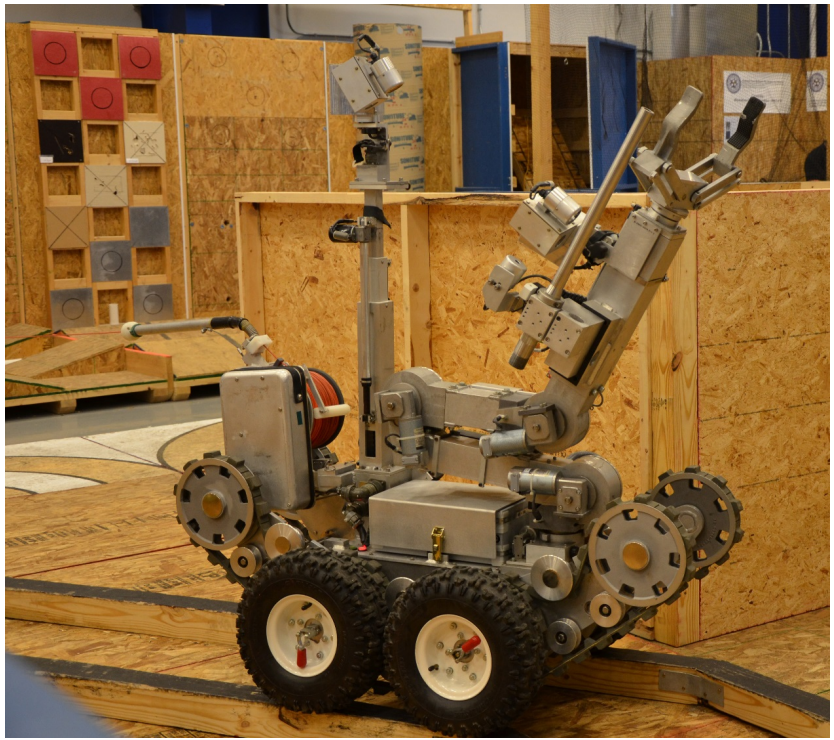
Challenges help NIST accomplish its mission

The NIST mission:

to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life.



NIST contributes expertise to challenges



DARPA ROBOTICS CHALLENGE

http://www.theroboticschallenge.org/

NIST program details: http://www.nist.gov/el/isd/

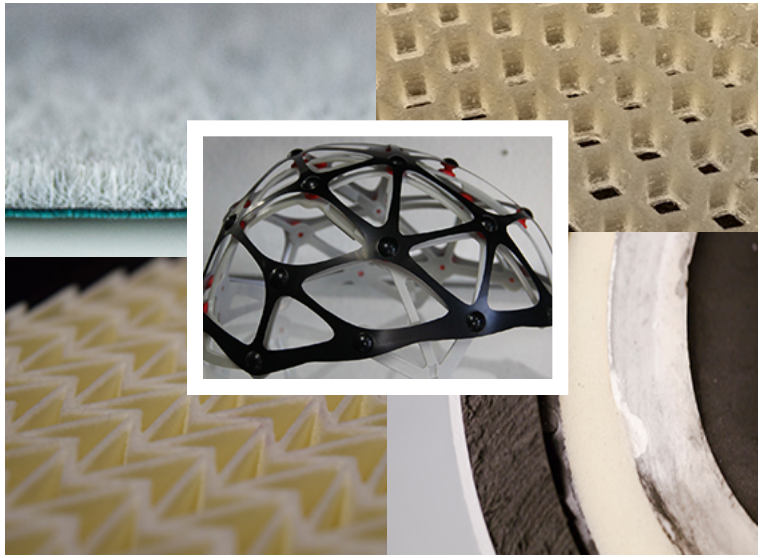
NIST uses challenges to convene communities

- Challenge: develop a new **cryptographic secure hash algorithm**
- Multiple rounds of feedback and crypto community engagement
- Winner announced in Oct. 2012 – ending 5 year competition
- **Aug 2015**: NIST Released final version of SHA-3 Standard, FIPS PUB 202

http://csrc.nist.gov/groups/ST/hash/sha-3/


GLOBAL CITY
TEAMS CHALLENGE
https://us-ignite.org/globalcityteams/

NIST leads: Head Health Challenge III



Seeking advanced materials with improved impact resistance

125 Abstracts

21 Full Proposals with Material Samples

5 First Round Winners were awarded $250,000 ea.

December 2016: Grand Prize Winner **$500,000**

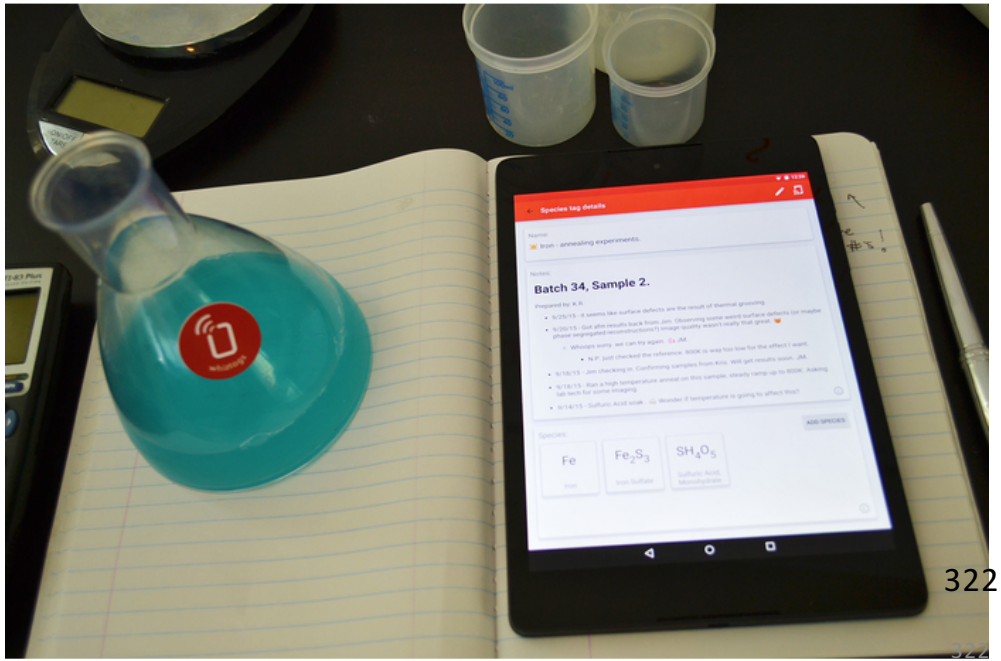
REFERENCE DATA CHALLENGE

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

Is there a better way to share NIST data with those who need it?

$45,000 in prizes	**130+** Participants
26 Apps built	**3** Winners

The Judges:



Benefits

Prizes and challenges advance our mission, by:

- Forging new partnerships
- Advancing the state of science and technology
- Disseminating NIST products
- Increasing awareness about NIST

Earthday Hackathon at GSA HQ, April 22, 2016
http:///open.gsa.gov/EarthDayHackathon

Public Safety Innovation Accelerator

YOU are the key to success in solving these mission-critical problems and YOU have **the intelligence, capabilities, and brilliance** to drive the innovative leaps.

Contact: Tammi Marcoullier

PSprizes@nist.gov

Website: bit.ly/PSprizes

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bit.ly/PSprizes

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Open Innovation: Public Safety Prize Design Workshop

Tammi Marcoullier, PSCR Prize Architect

Welcome! Prize Competition Design Workshop

Choose a Table by Topic

- Mission Critical Voice: Leveraging ProSe Discovery
- Mission Critical Voice: Integrating Video & Data
- Location Based Services: Z-Axis
- Location Based Services: Indoor Mapping
- Virtual Reality: Environments

Fill Out a Nametag

- Write your first name.
- Write your area of expertise or interest (related to the table topic).
- Meet your neighbors. Share two things you know and one thing you'd like to learn.

We'll get started soon!

Welcome!

What we learned in Prizes & Challenges 101

- Mechanisms for achieving results through open innovation
- Have clearly defined problems and goals
- Invite a diverse and broad group of people to participate
- Award performance with money and incentives
- Measure and report impact

Workshop Goals: Prize Competition Design

Put prize competition principles into action

5 topic areas arranged by group

Timeline:

- Table introduction activity (5 minutes)
- Instruction (20 minutes)
- Complete up to 4 tasks (25 minutes)
- Record and rapid report (2 minutes per table = 30 minutes)
- Q&A (10 minutes)
- Closing

Public Safety Prize Design Workshop

The Facilitators:

Mission Critical Voice
- Nancy: Integrating Video & Data
- Ryan: Leveraging ProSe Discovery

Location Based Services
- Heather: Z-Axis
- Marc: Indoor mapping

Virtual Reality
- Steve: Environments

"Contests work well when it's not obvious what combination of skills or even which technical approach will lead to the best solution for a problem. Running a contest is akin to running a series of independent experiments in which, ideally, we can see some variation in outcomes. Therefore, of the four forms of crowdsourcing, **contests are most useful for problems that would benefit from experimentation and multiple solutions.** …the assessment of many submissions can provide insight into where the "technical frontier" lies, especially if the solutions cluster at some extreme. (In contrast, internal R&D may generate far less information—and a lingering question about whether an even better solution might still be found.)" – Lakhani, Using the Crowd as an Innovation Partner

Public Safety Prize Design Workshop

1. Designing a **problem statement** that is clear and compelling
2. Considering the **type of prize** you should run
3. Determining if your prize should be **phased**, and what that looks like
4. **Intellectual property** considerations
5. Determining your **prize purse**
6. Determining other **incentives**
7. Determining how to **measure success**
8. Consider utilizing a **third party hosting platform** or other partners
9. Building an **engaged solver community**
10. Determining your **post-award goals**

bit.ly/PSprizes

PSCR

Public Safety Prize Design Workshop

Write a problem statement that is clear and compelling:

- Bad ☹ Taxpayers deserve better online services. Reimagine the taxpayer experience of the future.

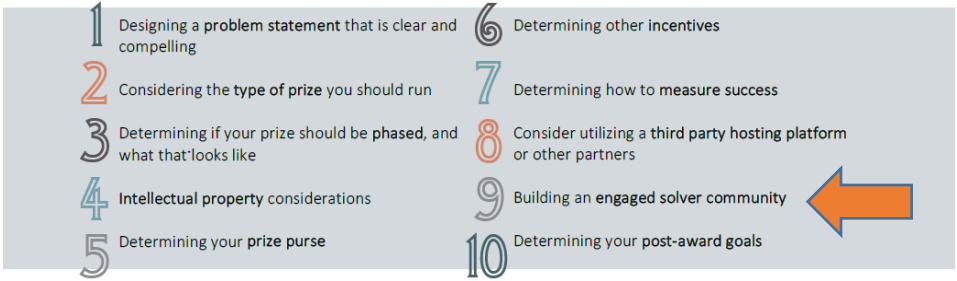
Public Safety Prize Design Workshop

Write a problem statement that is clear and compelling:

- Bad ☹ Taxpayers deserve better online services. Reimagine the taxpayer experience of the future.

- Good ☺ Taxpayer data isn't easy to find without going to multiple pages, which means thousands of calls to the help line every day. Design a new taxpayer interface that includes six key data categories so it is available in one, easy to find place.

Public Safety Prize Design Workshop

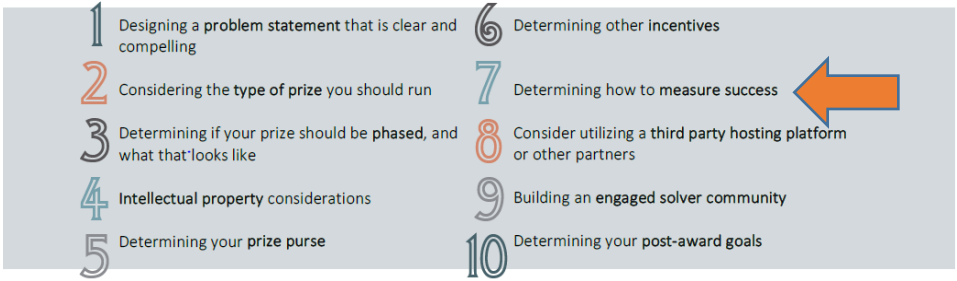


- Identify and build engaged solver communities.
  - Experts
  - Hobbyists
  - Academia and students
  - Similar-industry
  - Related skills

Public Safety Prize Design Workshop

- Determine the prize purse and other incentives.
  - What does the community value?
  - For cash prizes, what feels like too little/too much?
  - Non-cash incentives (introductions, promotional opportunity, access, etc.)

Public Safety Prize Design Workshop



- How will you measure success? Consider factors such as:
  - Achieving goal
  - # of participants
  - # of viable solutions
  - Tracking innovation beyond the desired solution
  - Projected costs savings
  - Impact on industry
  - Acceleration of timeline to solution
  - Acquisitions or partnerships with competitors/solutions

Public Safety Prize Design Workshop

- Write a problem statement that is clear and compelling
  - Yes, AND…
  - Do not try to solve the problem.
- Identify potential solver communities
  - Who is inside the industry, close to/similar, on the fringes, possibly interested.
- Brainstorm options for the prize purse and other incentives
  - What will motivate people to take action and be involved?
- Determine how you will measure success
  - Reach the goal or beyond goal, # people involved, acquisition/partnerships, etc.

Public Safety Prize Design Workshop

- Reports by Table
- Q&A
- What's next & how to get involved

Public Safety Prize Design Workshop

- How to get involved:
  - Share suggestions for problems to solve.
  - Sign up at the Innovation Accelerator table.
  - Follow the prize page at bit.ly/PSprizes
  - Partner with people and companies to bring solutions.

Thank you!

Website: www.bit.ly/PSprizes

Contact us: PSprizes@nist.gov

PSCR