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The Annual Event for Public Safety Technology

10 - 11 MARCH 2020
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ESN Coverage Challenges

and how the Ofcom licence exemption for repeaters that meet its specification can help

Andrew Williams - Nextivity

AGENDA

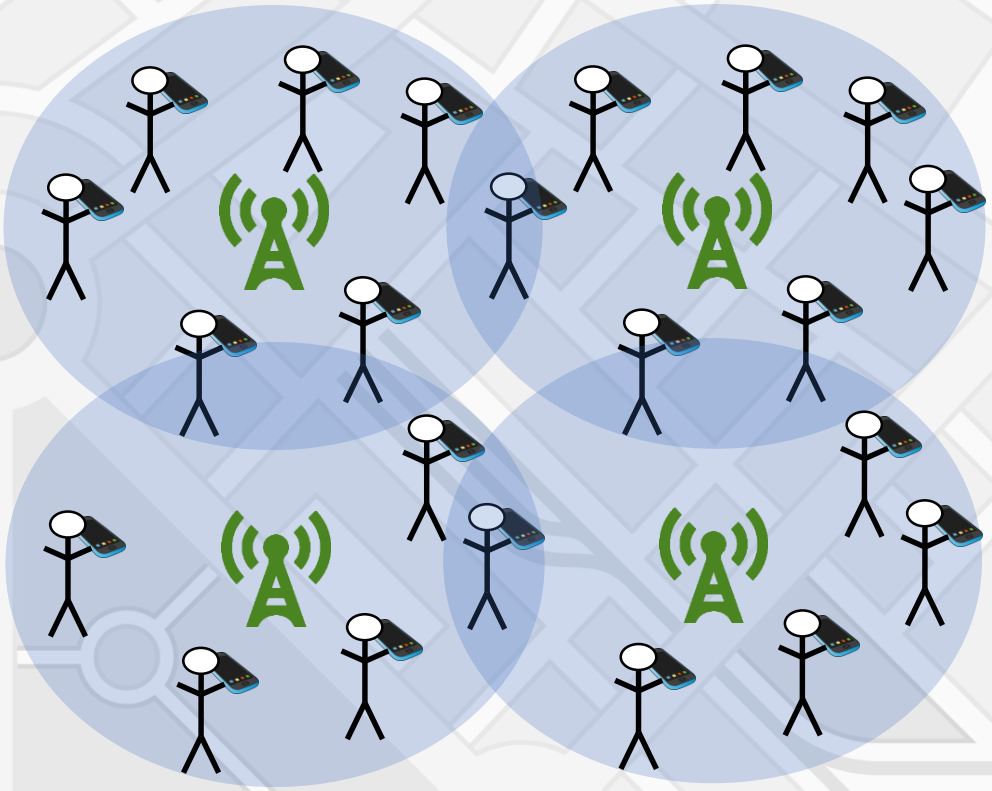
- Mobile Networks Primer
- What is ESN and the ESN coverage challenge
- The Ofcom mobile network repeater licence exemption
- Nextivity's experience with FirstNet in the USA

Mobile network 101

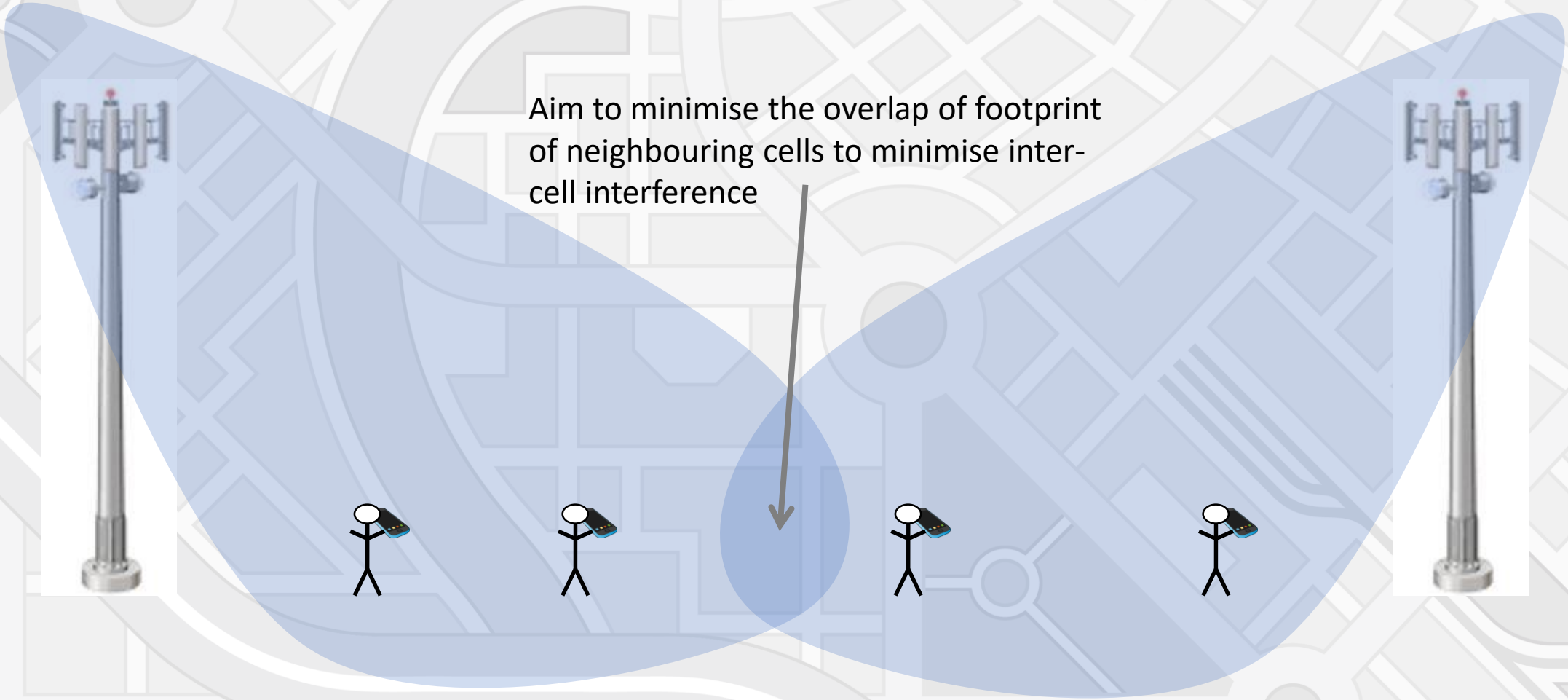
- The key to capacity is spectrum re-use
  - All modern networks, starting with 3G, then moving on to 4G and 5G re-use the same frequency in every cell (within a spectrum band)

Mobile network 101

- The key to capacity is spectrum re-use
  - All modern networks, starting with 3G, then moving on to 4G and 5G re-use the same frequency in every cell (within a spectrum band)
  - If you halve the size of the cell, you need 4x as many base stations, but you get 4x the total capacity in return
  - This typically means the way antennas are placed and pointed is optimised to avoid interference between neighbouring cells



Mobile network 101



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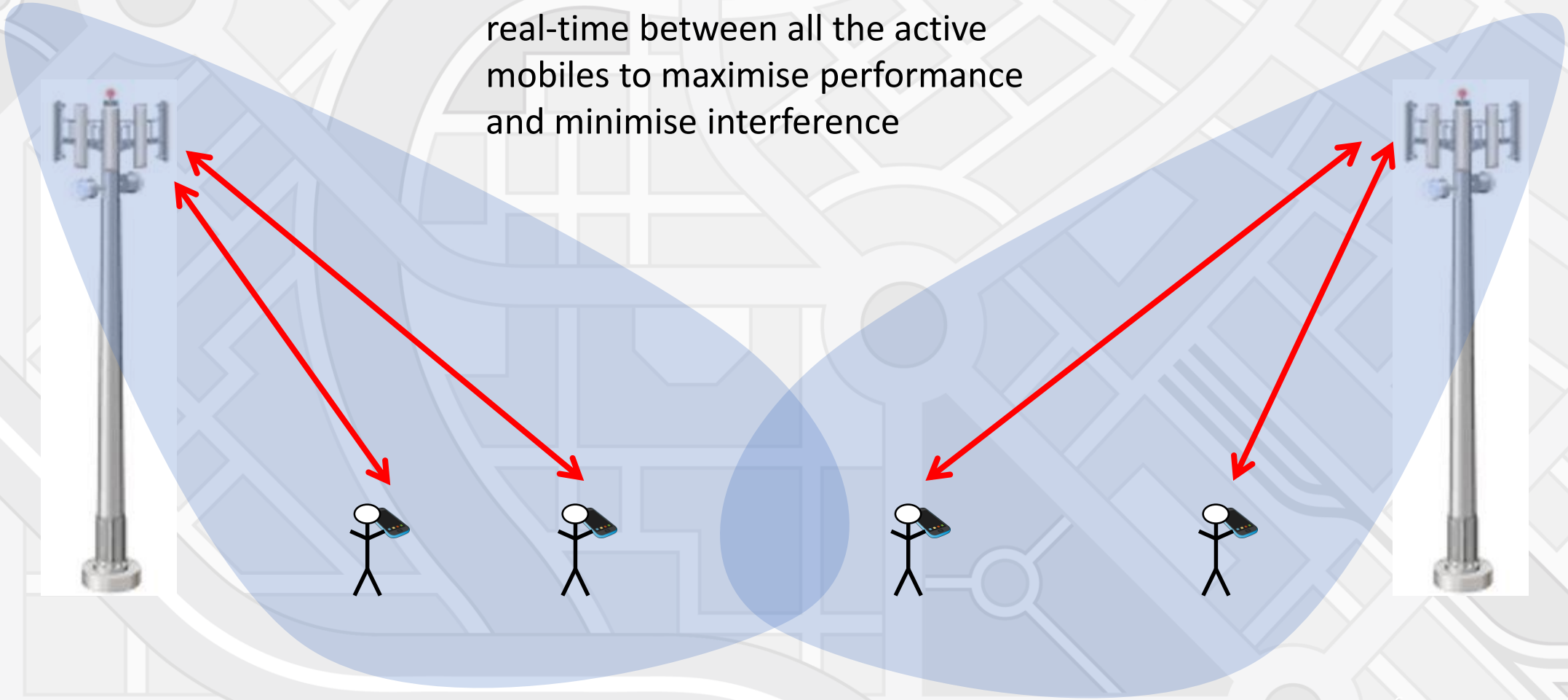
Mobile network 101

mobile behaviour is coordinated in real-time between all the active mobiles to maximise performance and minimise interference



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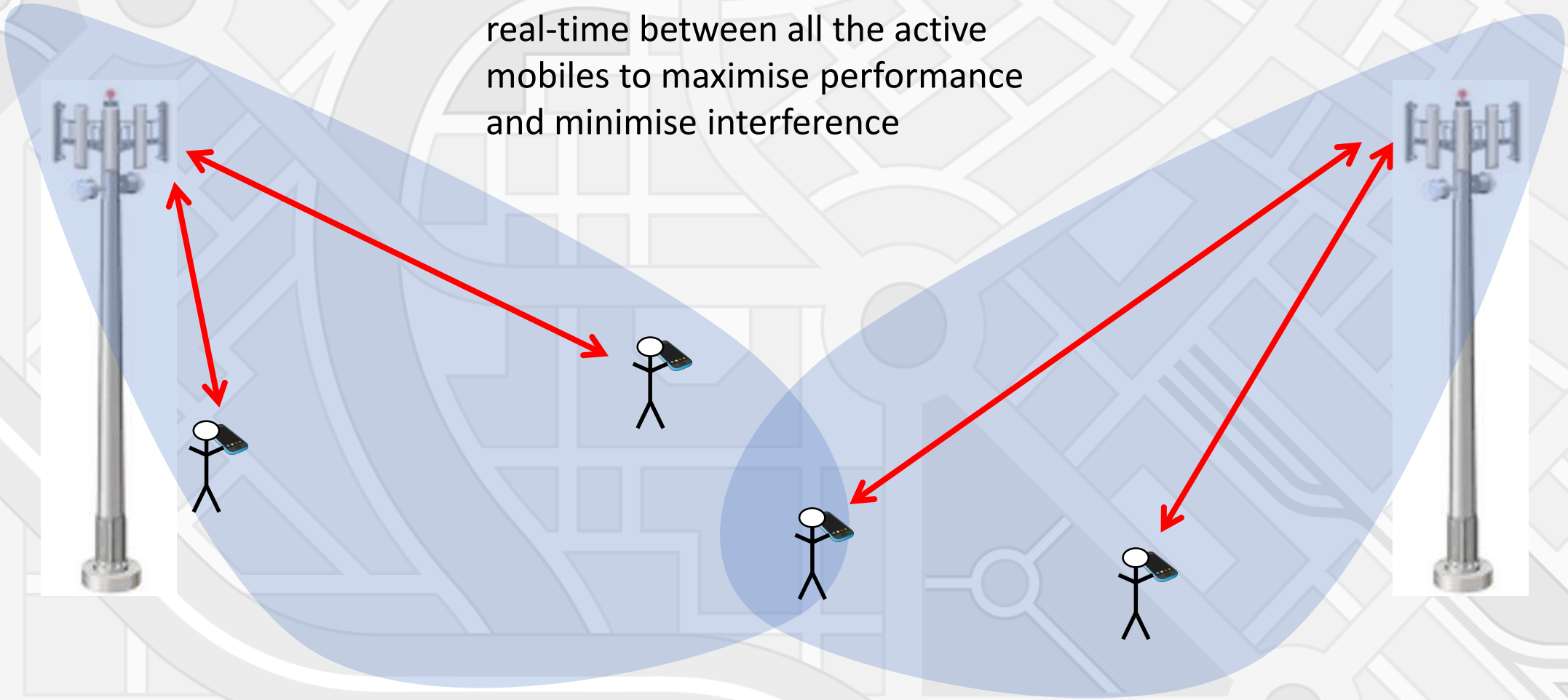

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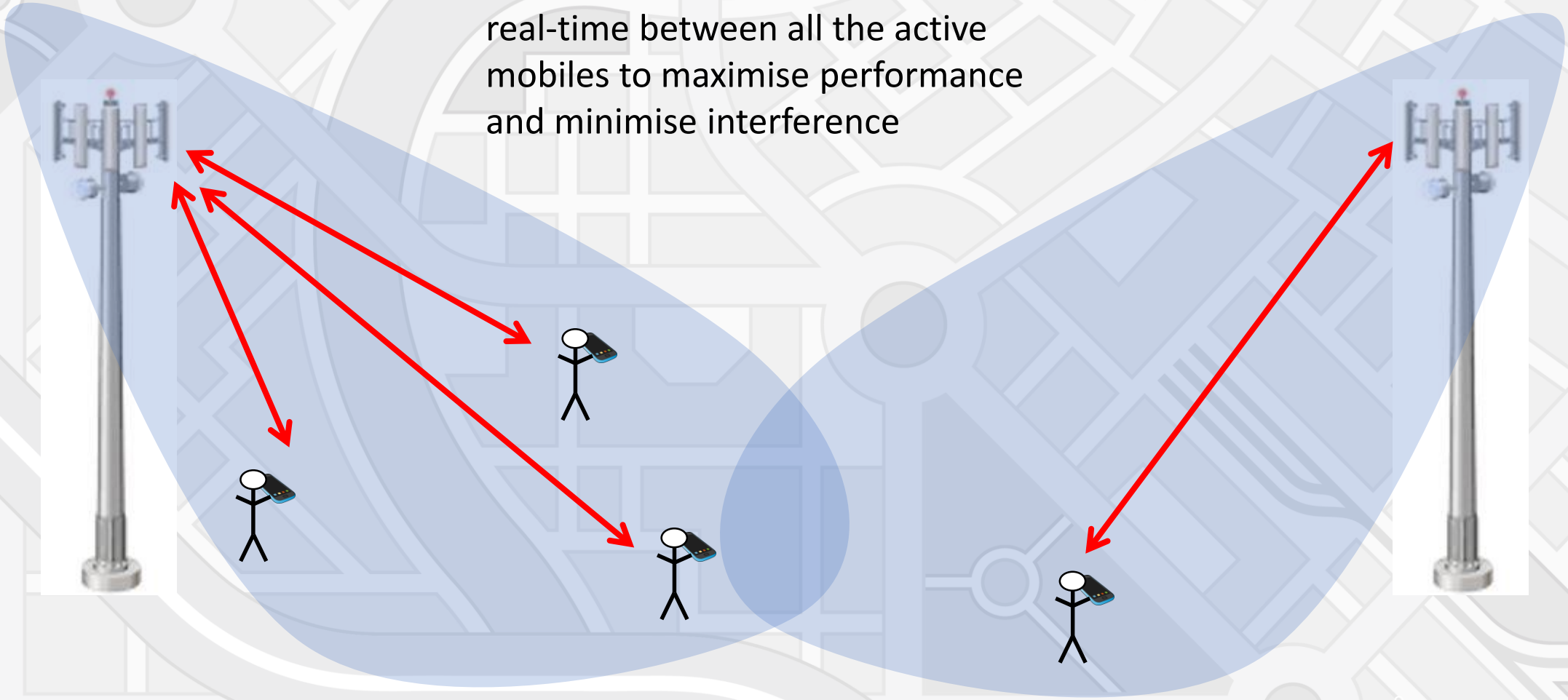

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Mobile network spectrum

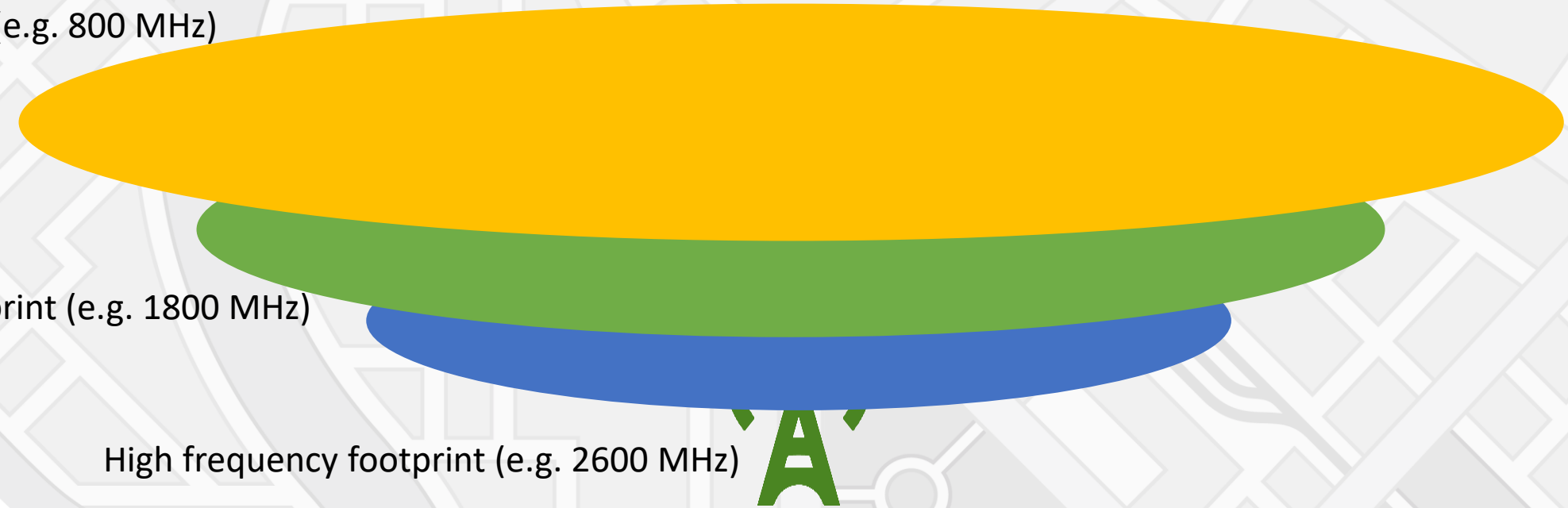
- Mobile networks use multiple spectrum allocations
  - Mobile networks typically have 3 or more distinct pieces of spectrum on air in any given place
    - This is because adding spectrum adds capacity
  - Some spectrum may be allocated to support legacy devices (2G or 3G)
  - Typically for 4G, several different spectrum allocations, or layers are on-air
  - In very remote areas a network might only have a single spectrum layer on air
  - In dense urban areas a network might have 5, 6, 7 or more spectrum layers on-air

Mobile network spectrum

- Not all mobile spectrum is equal
- Higher frequency spectrum has more capacity (there is literally more of it) but has the disadvantages:
  - It has a smaller footprint (not necessarily a problem in urban areas, but certainly a problem in rural areas)
  - It does not penetrate buildings well (a problem everywhere)
- Lower frequency spectrum has less capacity (there is literally less of it) but has the advantages:
  - It has a larger footprint (useful in rural areas)
  - It penetrates buildings better than high frequency spectrum (useful everywhere)

Mobile network spectrum

Low frequency footprint (e.g. 800 MHz)

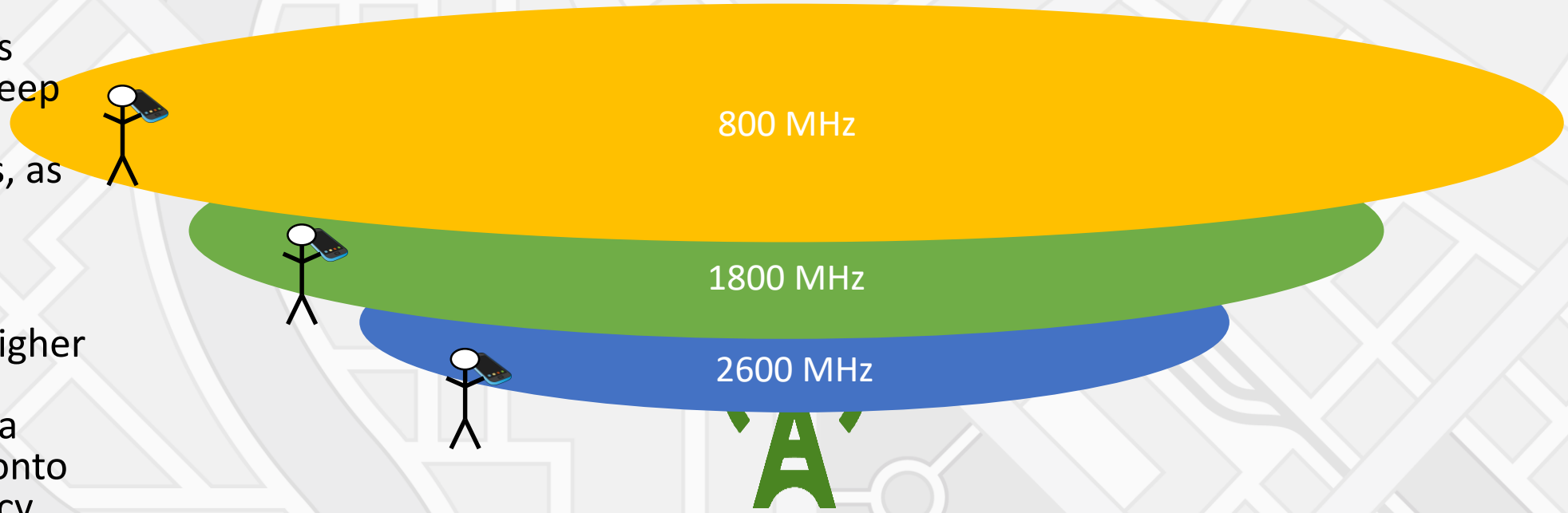


Less high frequency footprint (e.g. 1800 MHz)

High frequency footprint (e.g. 2600 MHz)

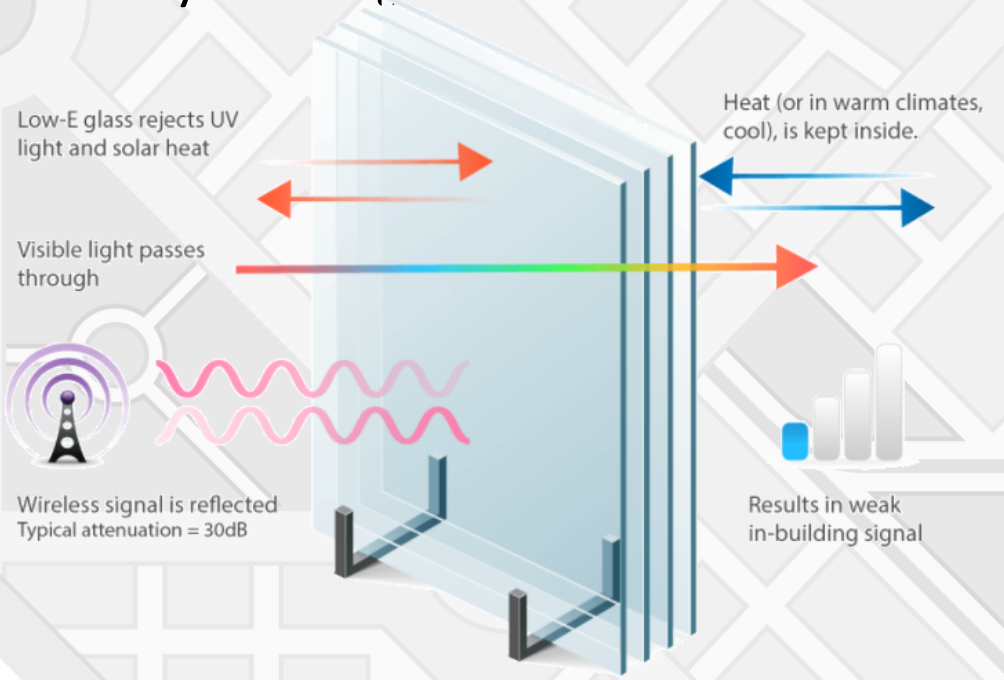
Mobile network spectrum

- Different frequencies are referred to as ‘layers’
  - Mobile networks typically try to keep users on higher frequency layers, as they have more capacity
  - Only when the coverage for a higher frequency layer disappears, will a user be moved onto a lower frequency



Building penetration

- Modern building techniques and materials are good for thermal insulation, but also good at blocking mobile network transmissions
  - Low frequency spectrum will get you further into buildings, but it is not a panacea
  - Because low frequency spectrum gets further into buildings when high frequency spectrum does not, low frequency spectrum is often overloaded in urban areas
  - Ultimately all mobile spectrum is blocked at some point, in many buildings
- Multiple surveys have <u>shown poor mobile coverage to be an issue</u> e.g.
  - 83% of healthcare workers report poor mobile coverage some of the time (*)
  - 43% of the general public report no mobile phone reception at least once a week (**)



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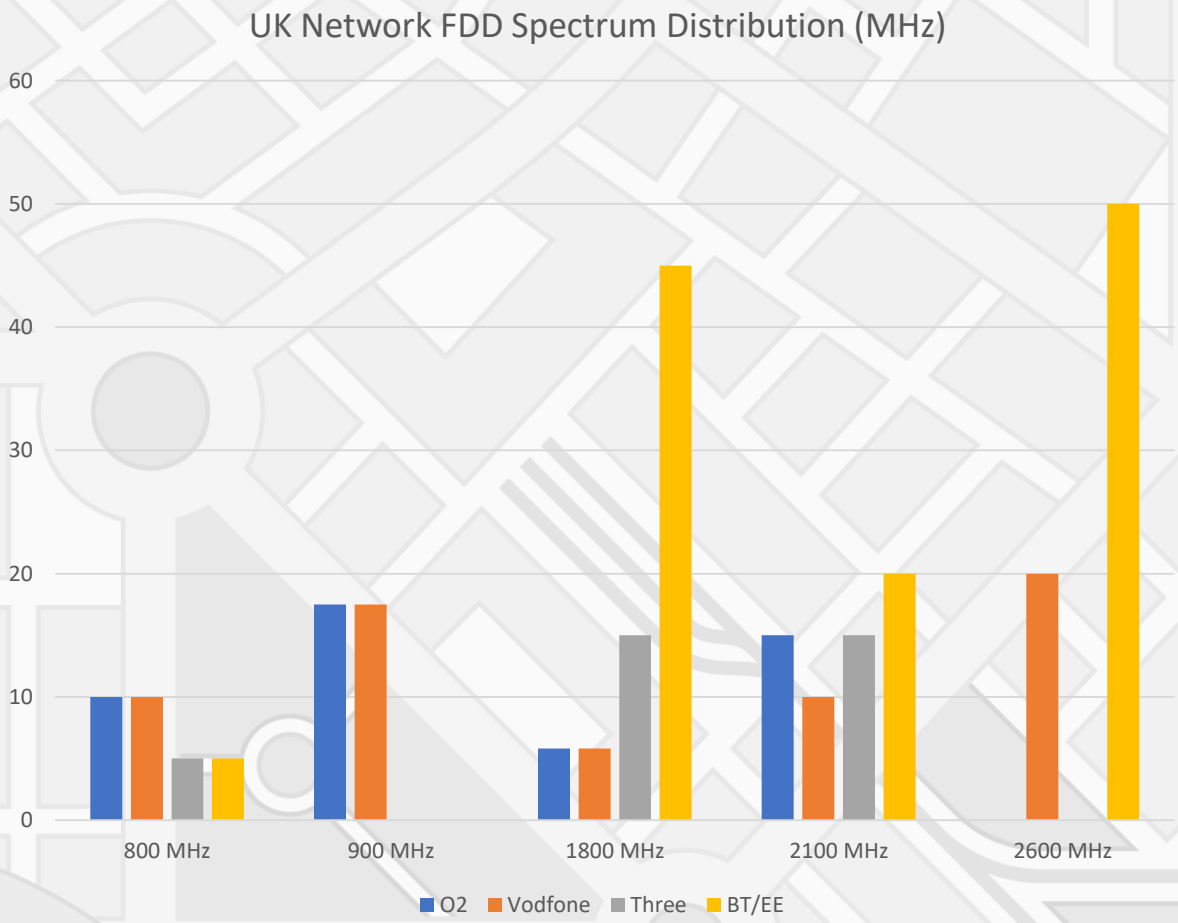
(*) Zinwave 2017 Workplace connectivity survey (**) Ofcom report: Consumer experiences of mobile phone calls

UK Spectrum Allocations

- There is not an equal distribution of mobile spectrum between the UK mobile networks:
  - O2 and Vodafone hold a significant proportion of the available low frequency spectrum
  - EE and Three hold a very small proportion of the available low frequency spectrum
  - EE owns vast amounts of high frequency spectrum and has the highest deployed network capacity as a result



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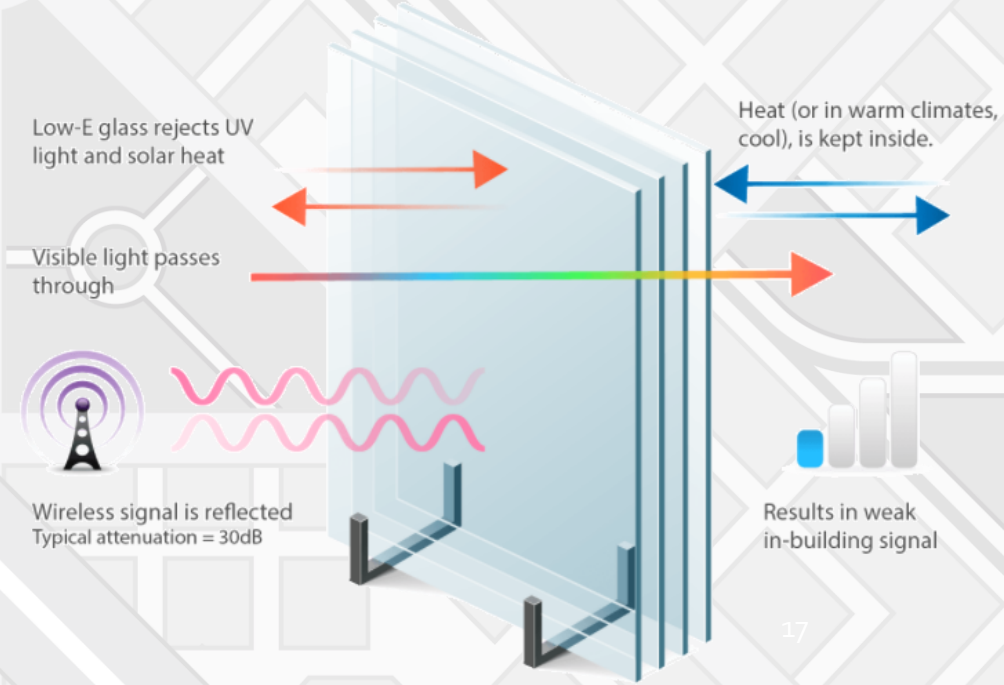
- Nextivity's experience with FirstNet in the USA

ESN

- ESN is a virtual network that runs over the BT/EE public 4G network
  - ESN user traffic is carried over <u>the exact same radio spectrum and base stations as all other users on the BT/EE mobile network</u>.
    - Although ESN users share the radio resources with regular users, they are allocated bearer channels that have a higher priority
    - Therefore in any case of network congestion, ESN users will have service where regular users do not
    - This takes advantage of features in 4G which did not exist in previous generations of mobile network technology
  - ESN supports the classic 'push-to-talk' voice application of previous critical communication systems
  - ESN also supports other features that are made possible by the higher capacity and bandwidth of 4G mobile networking technology

ESN coverage challenges

- Because ESN is a virtual network that runs over the BT/EE public 4G network **<u>it will suffer the same coverage issues</u>**
  - All mobile networks suffer coverage problems in some locations
- There will likely be coverage problems in a significant proportion of the emergency service estate itself
  - Ambulance garages that are essentially metal sheds that form a Faraday cage and block mobile signals
  - Basement areas
  - Any modern buildings built this century are likely to include construction methods that block mobile signals and cause general coverage issues



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ESN coverage challenges

- Many types of public and commercial buildings and structures will have coverage problems
  - Underground car parks
  - Hospital A&E departments
  - Utility-owned buildings and structures
  - Factories, offices, ...
- These issues are potentially exacerbated because BT/EE only owns 5MHz of low frequency spectrum, which penetrates buildings better
  - Therefore even with the higher priority of ESN users, <u>there may still be capacity issues in some circumstances</u>

Indoor coverage solutions

Distributed Antenna Systems (DAS)

- These are typically fibre-based, large scale systems to cover very large spaces.
  - Examples might be a sports arena or large commercial development, such as Battersea
  - Very expensive and require the mobile network to install dedicated base stations to support them (along with the associated connectivity and power costs)

Small Cells

- These are small low-power base stations placed in a building. Larger spaces typically require multiple small cells.
  - These must be installed by the mobile network.
  - The small cells connect back into the mobile network's 'core network' typically over the public Internet, using VPN tunneling technology

RF Repeaters

- These are devices that take an off-air signal, typically from outside a building, then amplify and distribute it within a building
  - Historically illegal to use, unless installed by the mobile network
  - A certain class of these devices are now covered by the Ofcom licence exemption

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The Ofcom Licence Exemption

- Mobile network coverage is an area that Ofcom takes a keen interest in
- It has multiple strategies to address this
- One strand of Ofcom's work in this area has been to create a licence exemption, to allow mobile coverage solutions based on low power RF repeaters to be freely deployed on UK mobile networks <u>without the involvement of the mobile networks themselves</u>
  - The original intention was to provide solutions that consumers and small enterprises can use
  - Technically the solutions are broadly applicable and there is no restriction on where licence-exempt devices can be used

The Ofcom Licence Exemption

Started in 2014, came to fruition in 2018…

2014

2015

2016

2017

2018

May 2014, Ofcom publish Call For Information (CFI) "Mobile Coverage Enhancers and their use in licensed spectrum".

March 2016: results of the 2014 CFI published, and a plan to develop a specification for license exempt repeaters for the UK announced

April 2017, Ofcom public consultation published: "Mobile Phone Repeaters Indoor and in-vehicle".

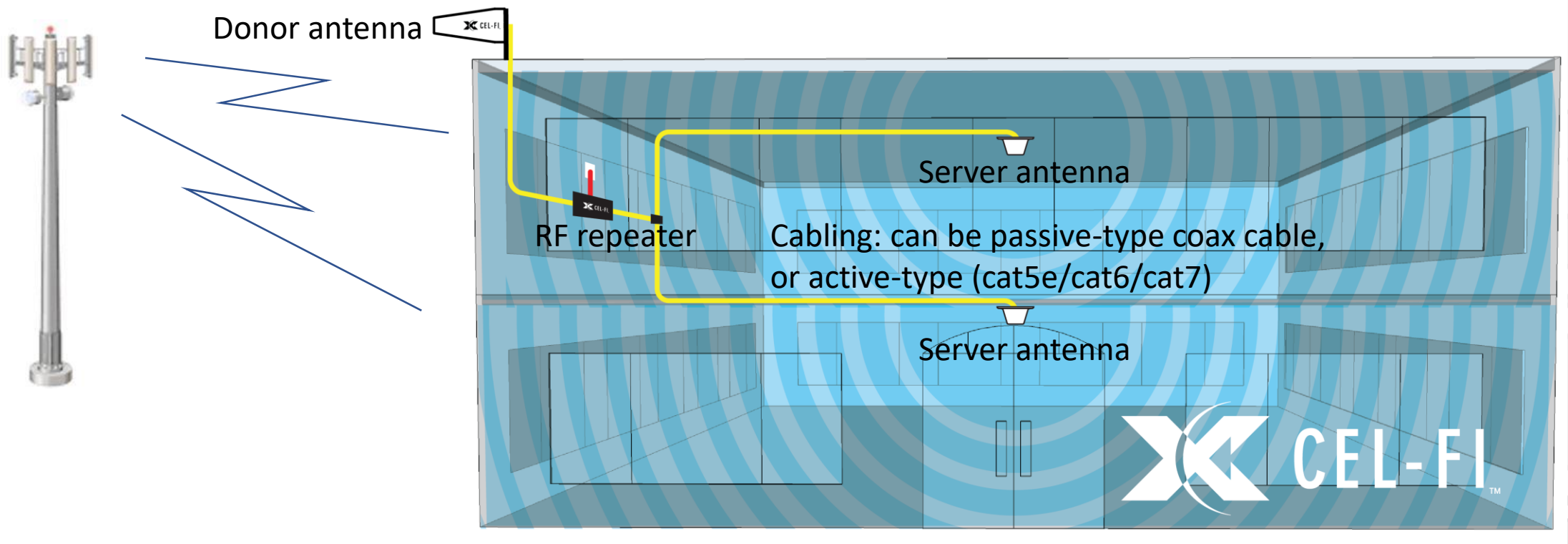
October 2017, Ofcom published the consultation results and the draft license exempt device specification (UK Interface Requirement)

December 2017, draft legal instrument for the new regulation published.

12th April 2018: Revision to the set of UK spectrum license exemptions to include mobile network signal enhancers conforming to **Ofcom SI 2018/399**

What is an RF Repeater?

- Technically an RF repeater is a device which takes an RF signal from one place and sends it somewhere else, typically amplifying it on the way



The Ofcom Licence Exemption

- The document which specifies the technical conditions of the UK licence exemption for mobile network repeaters is entitled: “UK Interface Requirement 2102”
  - It was originally released in 2018, and recently revised in November 2019
  - https://www.ofcom.org.uk/__data/assets/pdf_file/0016/112291/IR_2102.pdf
- The specification consists of 2 parts:
  - IR2102.1: Minimum requirements for the use of: static mobile phone repeaters for indoor use
  - IR2102.2: Minimum requirements for the use of: low gain mobile phone repeaters for in-vehicle use

IR2102.1

- IR2102.1 cites some well-known European EN specifications relating to wireless products
- The specification includes a number of additional requirements for an RF repeater to be licence exempt, including:
  - Limitations on the maximum gain (amplification) and maximum transmit power
  - Limitations on the behaviour of the device to protect the mobile network from interference issues, for instance altering the allowed system gain (amplification) according to Base Station Coupling Loss (BSCL) – i.e. the RF repeater must be able to measure how close to the nearest base station it is, and alter its behaviour accordingly
  - Single network operation: an RF repeater must amplify the frequencies of a single network (effectively the reason for this is to ban wideband repeaters, which amplify all frequencies within a given band)

IR2102.1 – bands included

- IR2102.1 includes these bands:
  - Band 20 / 800 MHz (used by EE / ESN)
  - Band 8 / 900 MHz
  - Band 3 / 1800 MHz (used by EE / ESN – the main 4G layer for EE)
  - Band 1 / 2100 MHz (used by EE / ESN)
- IR2102.1 does not include:
  - Band 7 / 2600 MHz (used by EE / ESN)
  - Band 40 / 2300 MHz (TDD)
  - Any of the 5G bands

IR2102.1 – bands included

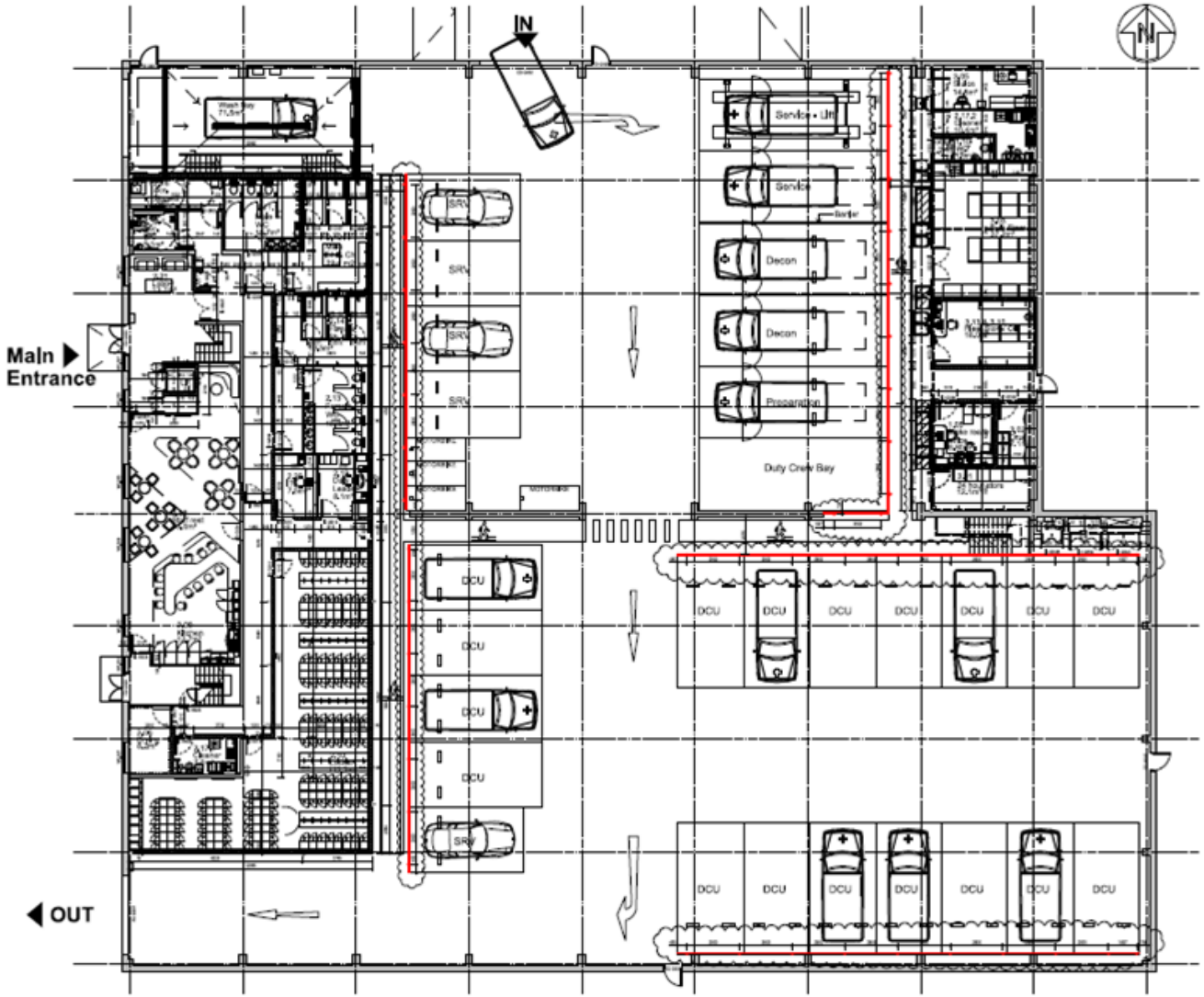
- IR2102.1 includes these bands:
  - Band 2
  - Band 8
  - Band 3
  - Band 1
- IR2102.1
  - Band 1
  - Band 4
  - Any of

Therefore licence exempt RF repeaters can be employed to solve indoor coverage problems for ESN organisations using bands 1, 3 and 20

IR2102.1 - Applications

- Using devices compliant to IR2102.1 it is possible to cover areas from a few hundred m^2 to thousands of m^2.
- In the last 2 years since the licence exemption came into force, a whole eco-system of distributors, dealers, installers and integrators has grown up and there are thousands of installations of licence exempt RF repeaters covering areas from a couple of rooms to thousands of square metres.
- Example applications of licence exempt installations include:
  - An ambulance station for the South Central Ambulance Service
  - Hospital departments at the East Kent NHS Trust
  - The Scottish National Blood Transfusion Service HQ

IR2102.1 - Applications



IR2102.1 Eco-system, a sample

ANIXTER
frequency
antennaPRO
duplexer, combiner, antenna and RF filtering solutions
cneAV
BLACK BOX NETWORK SERVICES
Data Techniques Installing Confidence
Computacenter
SPECTRUM infrastructure.
amazon
NHS East Kent Hospitals University NHS Foundation Trust
Sainsbury's
BOOST PRO SUPERIOR NETWORK COVERAGE
SPRY FOX NETWORKS
DAF
AUTOGRAPH COLLECTION HOTELS
Ministry of Defence
ROYAL OPERA HOUSE
COURTYARD Marriott
strattOpencell you've got network
ISM Independent Site Management
LIDL
SONY MUSIC
Travis Perkins
zonewave MOBILE SIGNAL SOLUTIONS
PAN Rf
INTESA SANPAOLO
GENTING CASINOS UNITED KINGDOM
NHS South Central Ambulance Service NHS Foundation Trust
THE ROYAL BOROUGH OF KENSINGTON AND CHELSEA
sky
Taylor Wimpey
City of Westminster
Collins Aerospace

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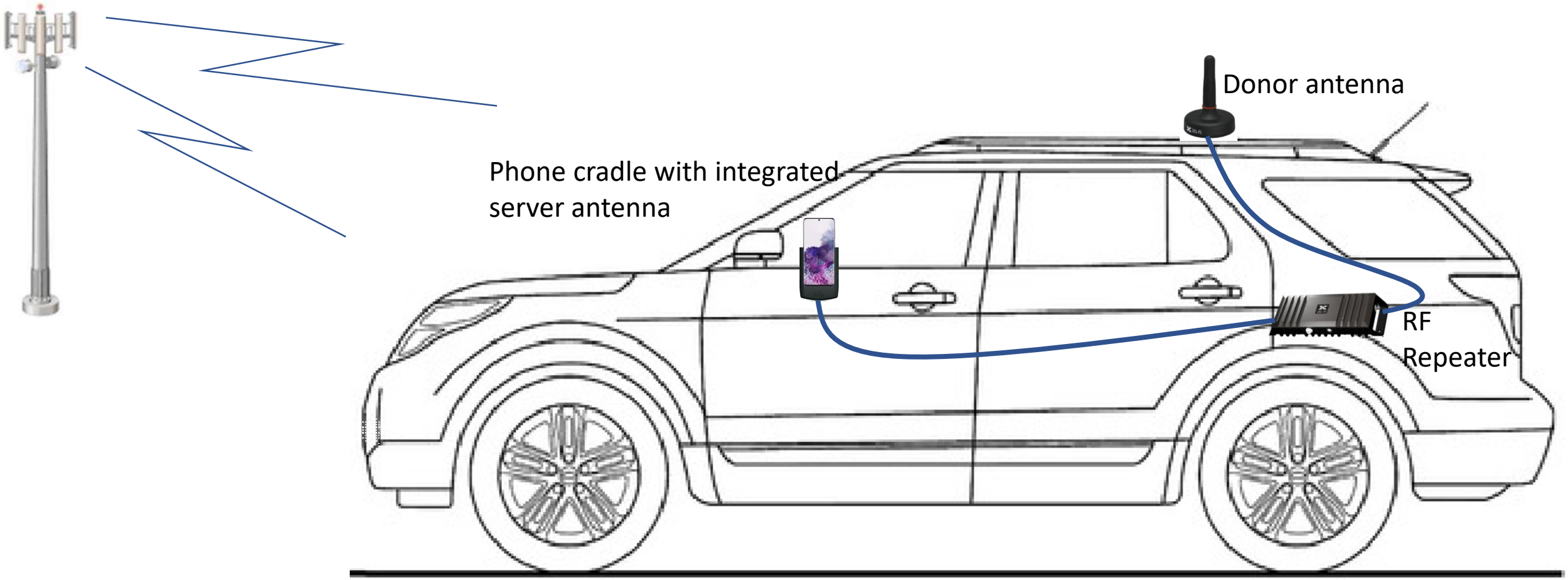
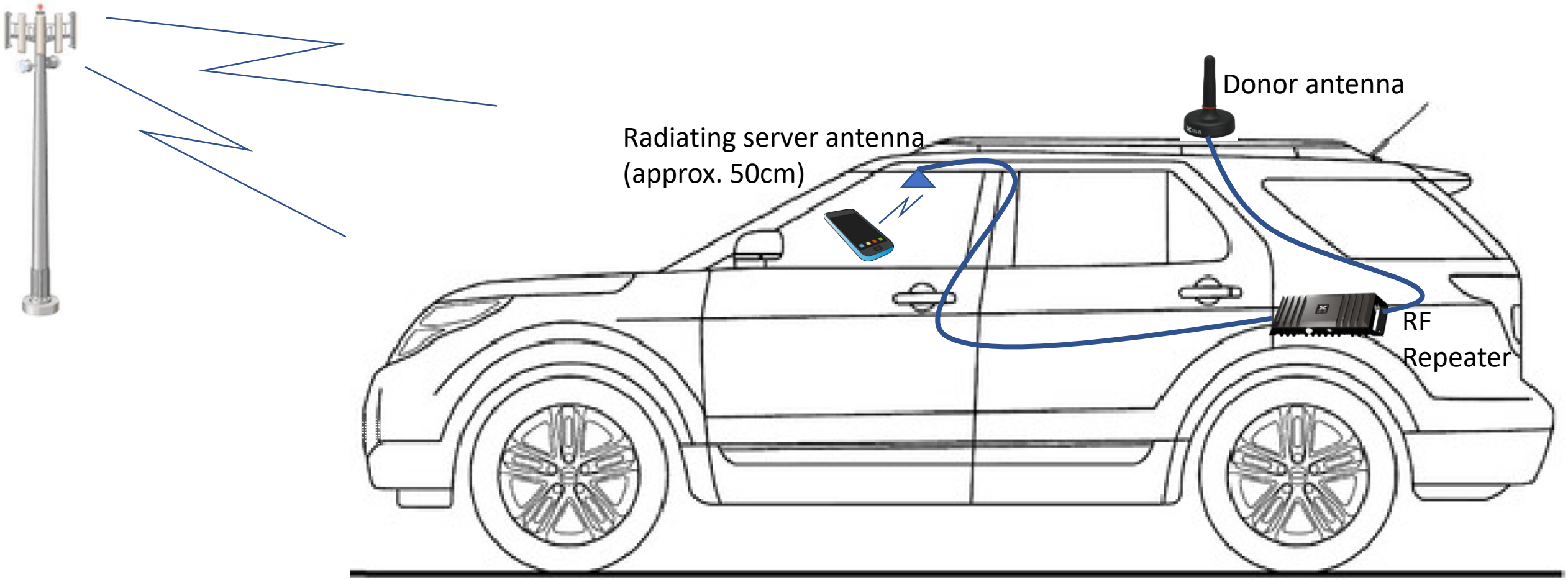
IR2102.2 (for vehicles)

- IR2102.2 cites some well-known European EN specifications relating to wireless products.
- The specification includes a number of additional requirements for an RF repeater to be licence exempt:
  - Limitations on the maximum gain (amplification) and maximum transmit power
    - The gain limitations in the original specification were severe (15dB below 1GHz and 21dB above 1GHz)
    - The gain limitations in the current specification are somewhat greater (30dB below 1GHz and 36dB above 1GHz)
  - Uplink muting (uplink power reduced when there is no uplink activity)
  - In addition to bands 1, 3, 8 and 20, IR2102.2 also includes band 7 (2600MHz)

IR2102.2 (phone cradle)



IR2102.2 (radiating)



IR2102.2 (for vehicles)

- There is no current IR2102.2 compliant solution that is commercially available
- There have been various and ongoing trial activities
  - These have shown that high-band coverage tends to be extended in rural areas by using such a device
- **Nextivity plan to have an IR2102.2 compliant product commercially available in Q2 2020**

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FirstNet

- In the US, critical communications in general is much more fragmented than in the UK and Europe
  - The predominant communications standard is P25 (similar to TETRA) however the responsibility for deploying systems is devolved downwards as far as individual municipalities in some cases
  - Legacy FM radio systems are also still in use in some places by emergency services
- FirstNet is a service offered using 4G on AT&T's network, it runs as an overlay in a similar way to ESN and takes advantage of 4G prioritisation features
  - It is not designed as a replacement, at least initially, for the predominantly P25-based communication systems
  - FirstNet runs across all of AT&T's commercial 4G radio spectrum (bands 2/4/5/12/30) and in addition band 14 (which is 10MHz within the 700MHz band) specifically allocated to public safety use across the USA

FirstNet and FCC Part 20

- FCC Part 20 is the US regulator's regulatory rule to allow low-power mobile network repeaters to be easily installed
  - It is similar in intention, but different in its implementation to the Ofcom licence exemption specified in IR2102
  - FCC part 20 includes the commercial 4G bands 2/4/5/12/30 but not the FirstNet-specific band 14
- Nextivity has products that are deployed under FCC part 20 on the AT&T network, also benefit FirstNet users (similarly to licence exempt repeaters on the EE network in the UK).
- In addition, Nextivity has band 14 capable products, which can be deployed where permission to do so is granted.

Questions?

Andrew Williams

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14:30-15:00, 11 MARCH

CONFERENCE A

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