

UK/EU Case Studies on use of 'Shared Spectrum'

Global Perspectives on Spectrum Sharing

22/23 October 2025, London



Bob Stewart

Professor & Director and CTO
Neutral Wireless





<https://nw5g.com/winnforum>

Introduction

- **Spectrum** - *it's everyone's resource (!)*
- **Shared Spectrum** - *TVWS, PMSE, CBRS, n77u, MoD Bands?*
- **Private 5G networks** - *Compete or complement with Public Networks?*
- **How do I license?** - *Statically, Dynamically, Occasionally, Randomly?*
- **Who will license?** - *Regulators, Appointed Agents, AI, Local sensing?*
- **How long to get a licence?** - *secs, hours, days, months? UEs?*
- **Over what area can I license?** - *Indoors, stadiums, campuses, cities?*
- **For how long do I licence & cost?** - *Minutes, Hours, days, years?*
- **The evolution of n77u in UK** - *and now in the EU with CEPT?*
- **What's Next?** *More Technology & Engineering, & even more Politics*
- **And who is policing?** *Interference, pirates, geofences? Prosecute?*

Case Studies - What can you do?

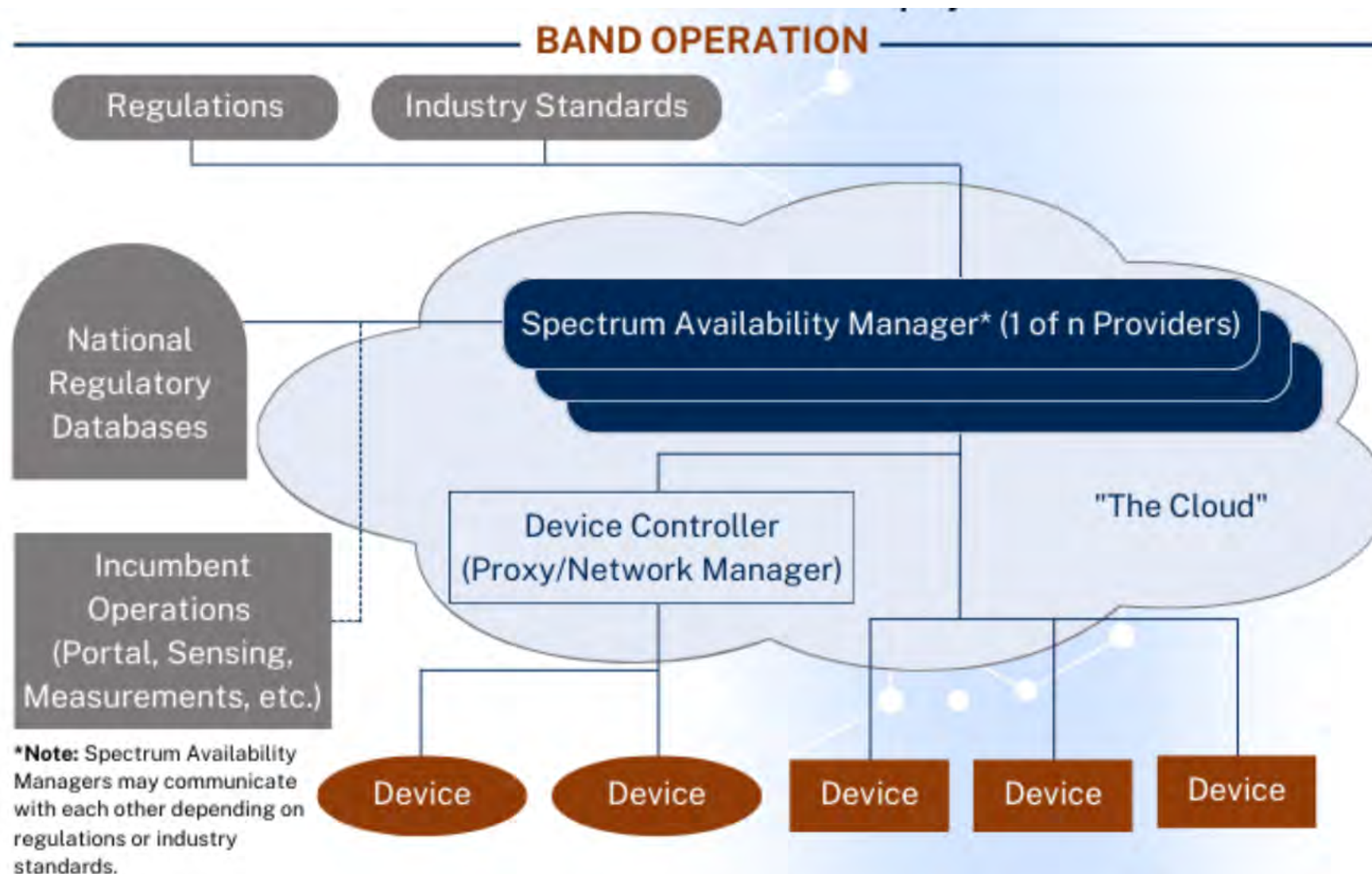
- **UK, MotoGP**, 2021 - *the first live to air private 5G*
- **Denmark / Netherlands**, 2022 **Indoors and popup** - *gNodeBike*
- **UK, King's Coronation, London**, 2023 - *largest multi-cell P5G network*
- **Denmark / Netherlands**, 2022 **Indoors and popup** - *gNodeBike*
- **France, City Networks Paris 2024** - *6km & 11 gNodeBs track River*
- **France, Networks at sea Paris 2024** - *3 floating gNodeBoats*
- **UK, Stadium Networks**, 2025 - *stacked use cases, complement DAS*
- **France**, 2025 **Mobile, Mobile Networks** *gNodePlanes*
- **Ireland**, 2025, **PPDR - Public Protection Disaster Relief**, *Emergency!*
- **Italy**, 2025, **Festivals and Broadcast**, *the gNodeDrone*
- **UK, OnSide**, 2025 - *Uplink centric networks, To synch or not to synch?*

From WinnForum Data Sheet, Oct 2025

BAND OVERVIEW				
The When, Where, How and Why of the Bands				
	TVWS	CBRS*	6 GHz*	Future Bands
When Deployed	2012	2020	2024	2024 and Beyond
Which Band	VHF/UHF	3550-3700 MHz	5925-7125 MHz	3.1 GHz*, 7/8 GHz* 5 GHz (UAV), 37 GHz
Sharing Method	TVWS Database	Spectrum Access System (SAS)	Automated Frequency Coordination System (AFC)	Dynamic Spectrum Availability Manager
Incumbents Protected	TV Broadband, Wireless Microphones	Department of Defense, Fixed Satellite	Licensed Microwave, Radio Astronomy	Various

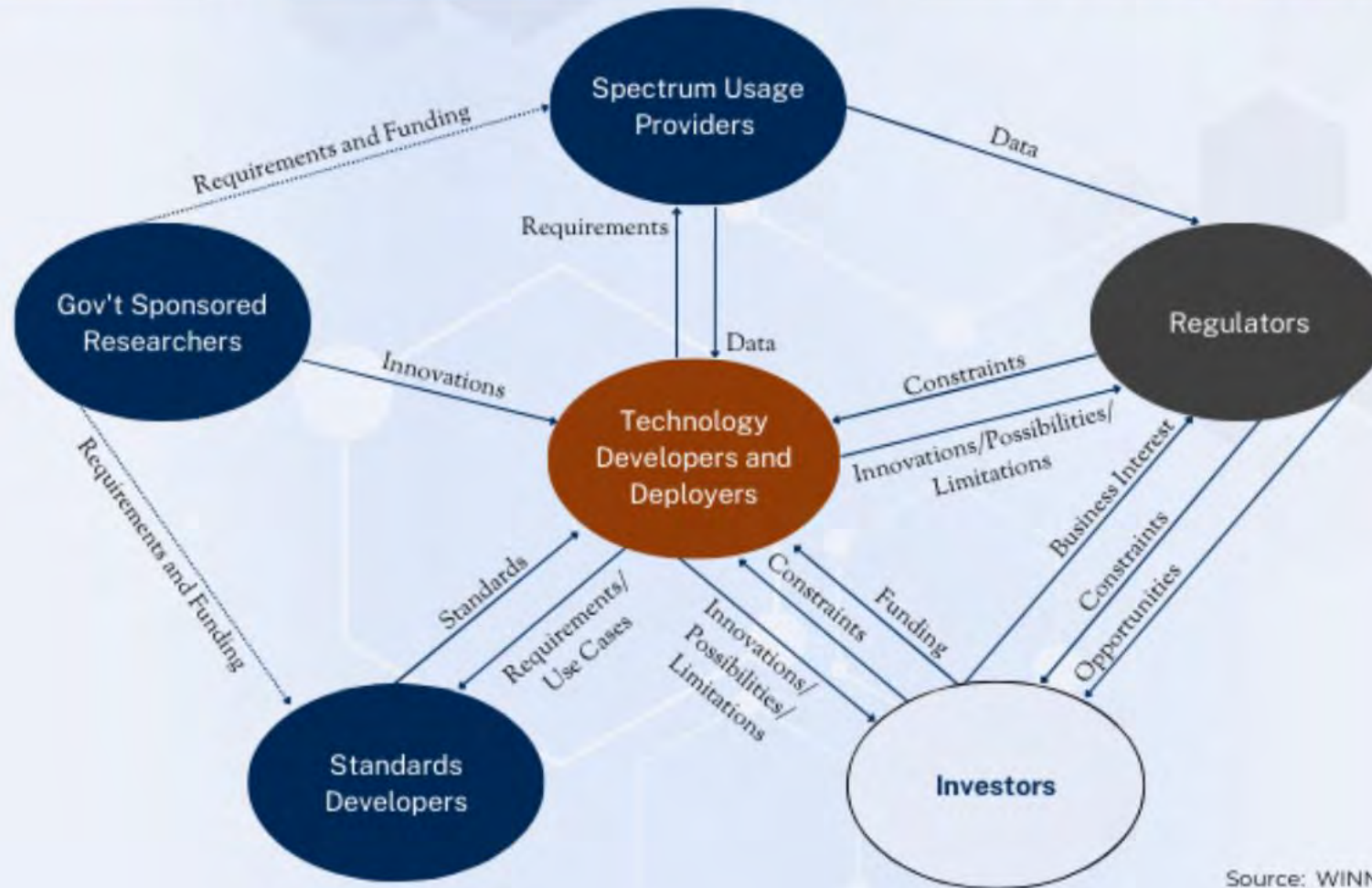
n77u fits around the CBRS band

From WinnForum Data Sheet, Oct 2025



From WinnForum Data Sheet, Oct 2025

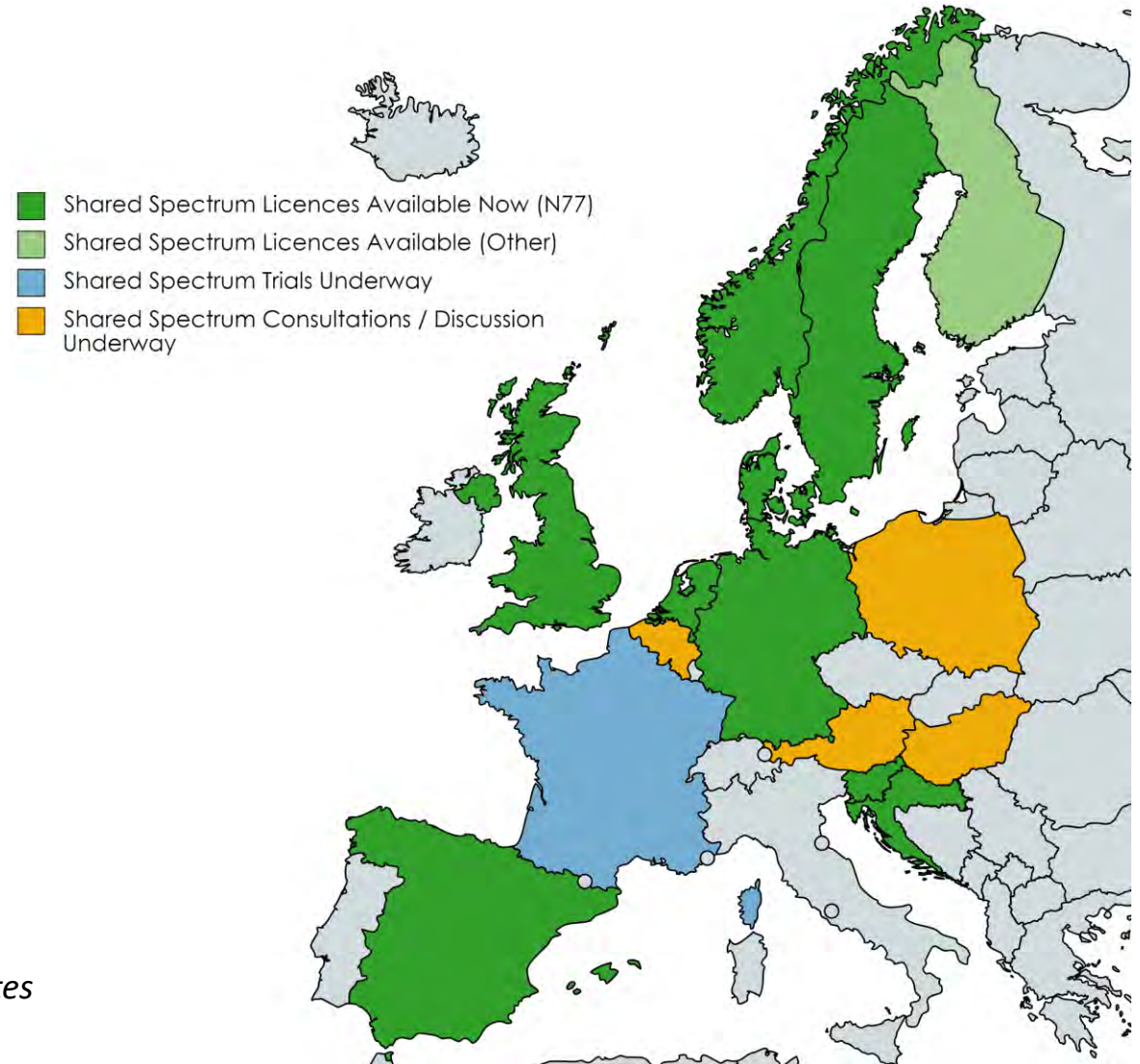
RELATIONSHIPS AMONG SPECTRUM SHARING STAKEHOLDERS



n77u fits around
the CBRS band

Driven by Spectrum – International Private 5G Opportunities

- Open mandate for the CEPT to assess the technical feasibility for harmonised shared use of the 3.8-4.2 GHz (n77u) frequency band to provide local-area network connectivity¹.
- Many countries in Europe now have existing legislation to enable shared spectrum access².
- Deployment options available in the Canada, Brazil, Australia, Japan, and more!
- Speak with a member of our team to find out more about a specific country or region.

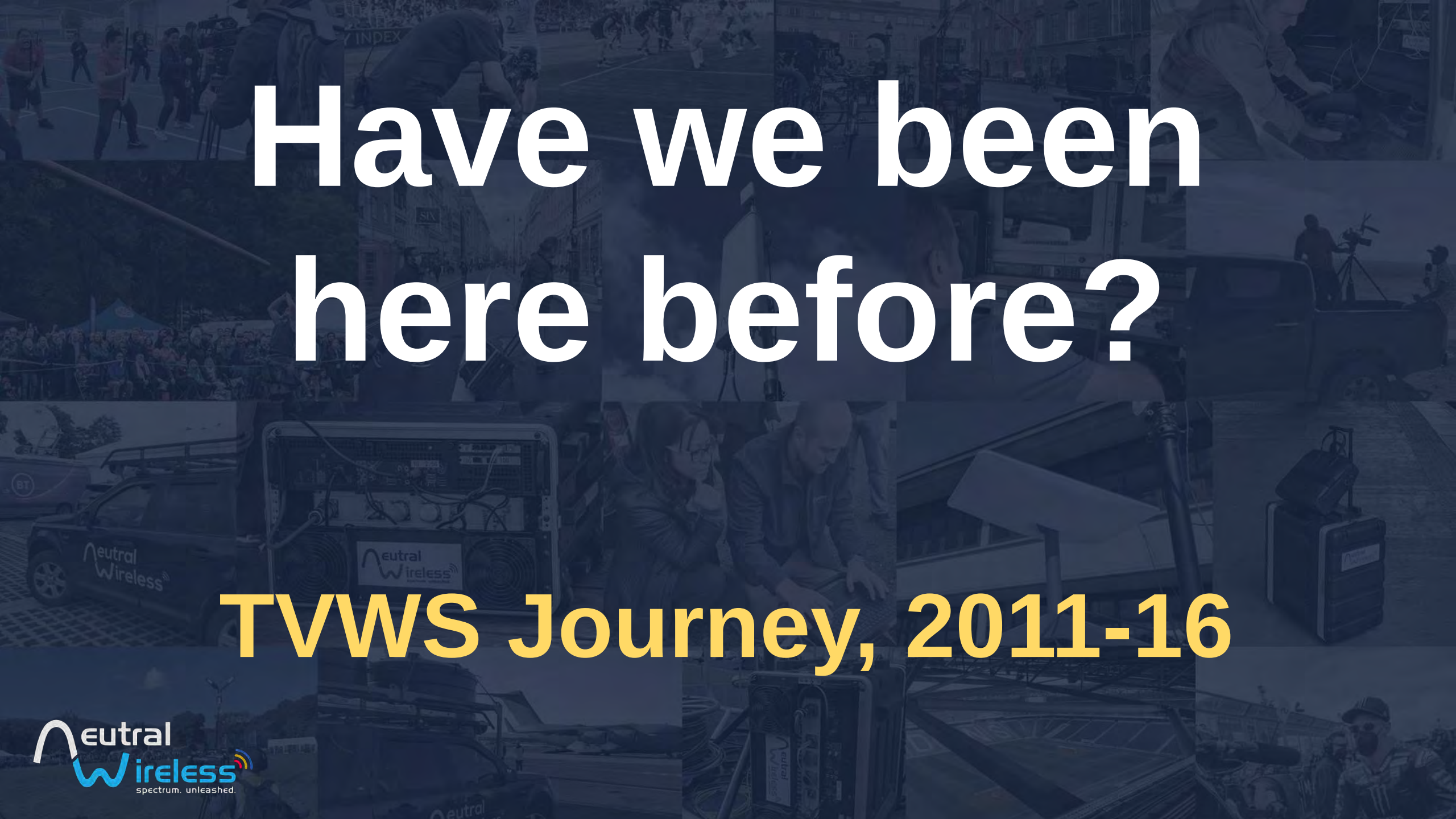


1) digital-strategy.ec.europa.eu/en/library/radio-spectrum-cept-mandates

2) gsacom.com/technology/private-mobile-networks/



- 885 on the streets of London in 1950
- 320 on the streets of Glasgow
- And other cities



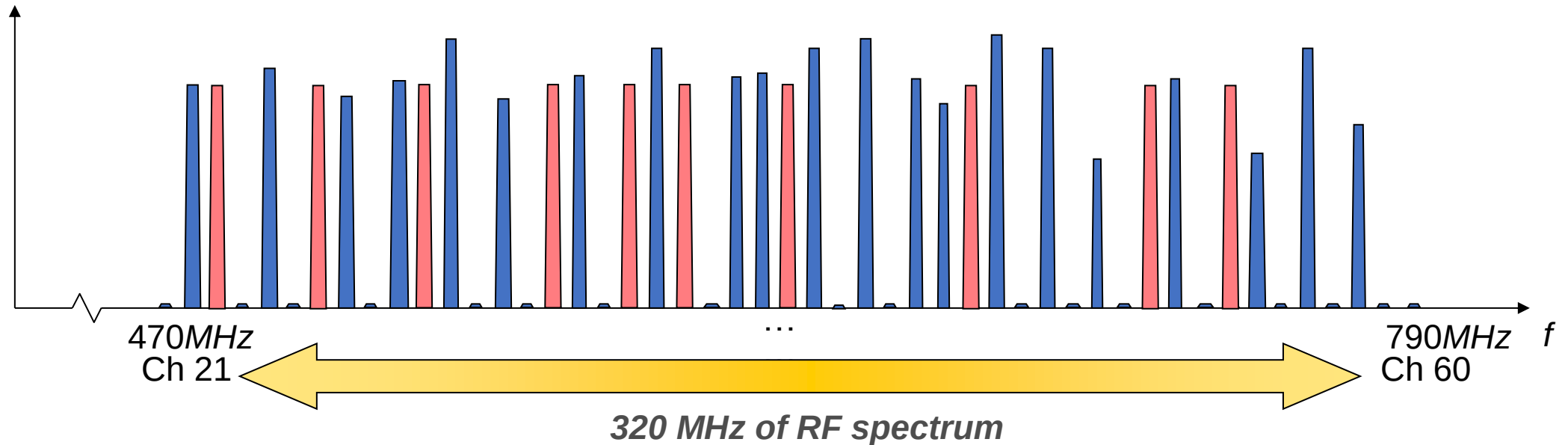
Have we been here before?

TVWS Journey, 2011-16

•TV White Space

2011

Unused spectrum – “White Spaces”:



Benefits of using the white spaces include:

- More efficient use of spectrum
- More effective network coverage
- Good propagation characteristics (e.g. fewer ‘not-spots’)

2012

Isle of Bute TVWS (TV White Space) Shared Spectrum Testbed

(Our renewable days (daze?))





Ofcom TVWS (TV White Space) City Demonstrator (Glasgow)

2014

Connecting ferries and hard-to-reach rural premises in Orkney



UK Spectrum Sharing – New Revolution Hailed in 2019

The screenshot shows the Ofcom website header with the logo and tagline 'making communications work for everyone'. A search bar and a 'Your pages (0)' dropdown are visible. The breadcrumb trail reads: Home > About Ofcom > News and updates > Media and analyst centre > Media releases > Airwaves opened up to support wireless revolution. The main headline is 'Airwaves opened up to support wireless revolution', with 'wireless revolution' circled in red. The date '25 July 2019' is displayed below the headline. A yellow box contains two bullet points: 'Start-ups and small businesses to get easier access to airwaves for new wireless services' and 'Farming and factories among the sectors likely to benefit from innovation'. The text continues: 'Farmers, factories and business parks are some of the groups that could benefit from a revolution in wireless technology, following a decision by Ofcom today to open up airwaves to support innovation and enable new services.' It then states: 'Ofcom manages the UK's airwaves – or spectrum – which are crucial to power services such as mobile phones, wireless broadband and connected devices.' Further down, it says: 'To help promote wireless innovation across the UK economy, we have today decided to open up airwaves that previously could only be used by certain parties. We're also allowing different groups to access airwaves licensed to mobile companies, but not being used by them.' This is followed by: 'Under the a new sharing framework, these airwaves will be available for local use by a range of other parties – such as small businesses or pioneering start-up firms. Ofcom is adding safeguards to ensure that these users do not cause interference to existing users.' A section titled 'Supporting innovation' follows, with the text: 'The new approach could pave the way for a number of new services. For example:'. A final bullet point at the bottom reads: 'Manufacturers could establish connected factories – using a reliable, high-speed wireless networks to connect, control and monitor machinery.'

Ofcom making communications work for everyone

Your pages (0) ▾ Search the Ofcom site...

Home > About Ofcom > News and updates > Media and analyst centre > Media releases > Airwaves opened up to support wireless revolution

Airwaves opened up to support wireless revolution

25 July 2019

- Start-ups and small businesses to get easier access to airwaves for new wireless services
- Farming and factories among the sectors likely to benefit from innovation

Farmers, factories and business parks are some of the groups that could benefit from a revolution in wireless technology, following a decision by Ofcom today to open up airwaves to support innovation and enable new services.

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Supporting innovation

The new approach could pave the way for a number of new services. For example:

- Manufacturers could establish connected factories – using a reliable, high-speed wireless networks to connect, control and monitor machinery.

Shared Spectrum Revolution!

25th July 2019

Shared and Local Licences

**Use it or
~~lose it~~
share it...**



5G RuralFirst

We followed the enthusiasm for
'revolution'. But things in UK just end.

2019

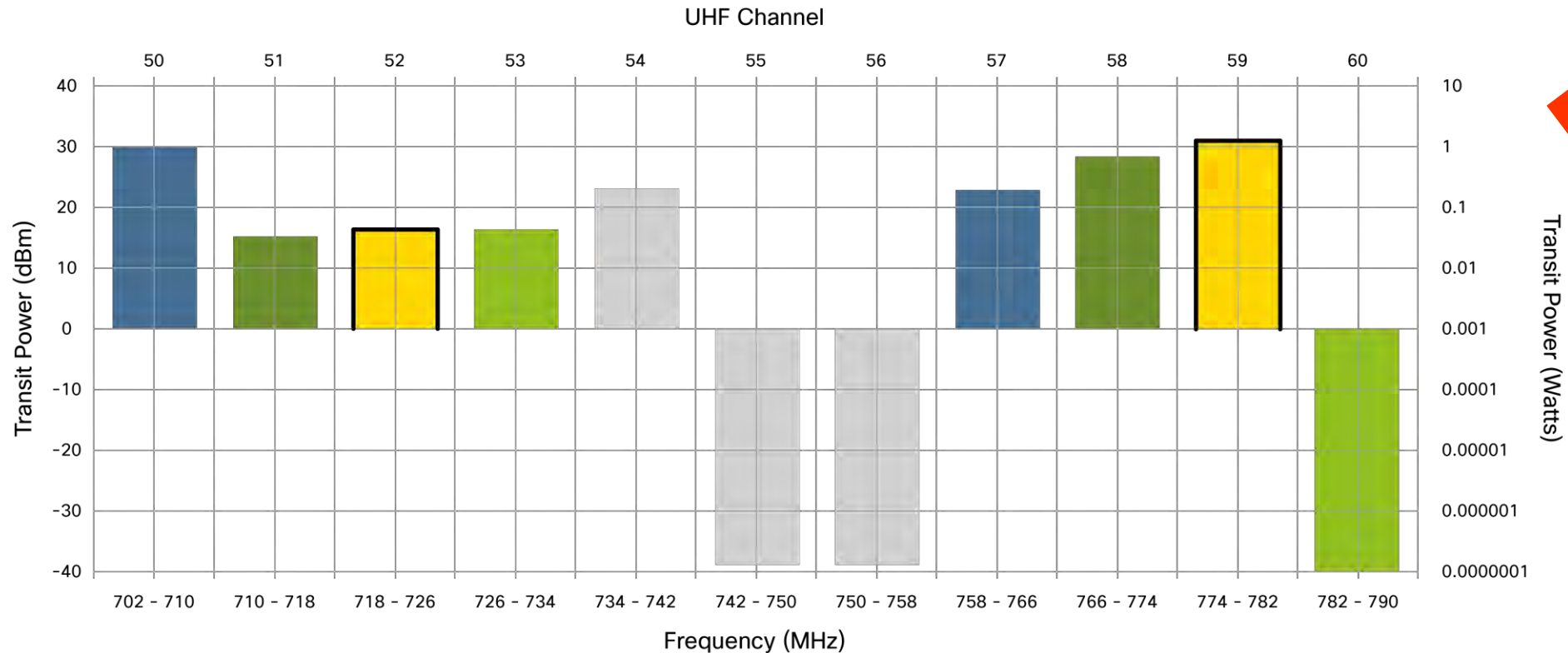
Demonstration of Shared and Dynamic Spectrum for 5G:

Making Effective Use of a Key Resource

22nd August 2019

Dani Anderson

LTE using the existing TVWS Database



2019

Current Frequency

722/777MHz

706/761MHz

Allowed Transmit Power

UL: 16.21 dBm

DL: 31 dBm

Swap Frequency

Update DSA DB

Next DB update in: 3:05

Fairspectrum Incumbent Manager



Incumbent Manager

[Log out](#)

[New reservation](#) [My reservations](#) [Reservations and Blockings](#) [Change Profile](#) [Feedback](#)

New reservation

Transmitter latitude

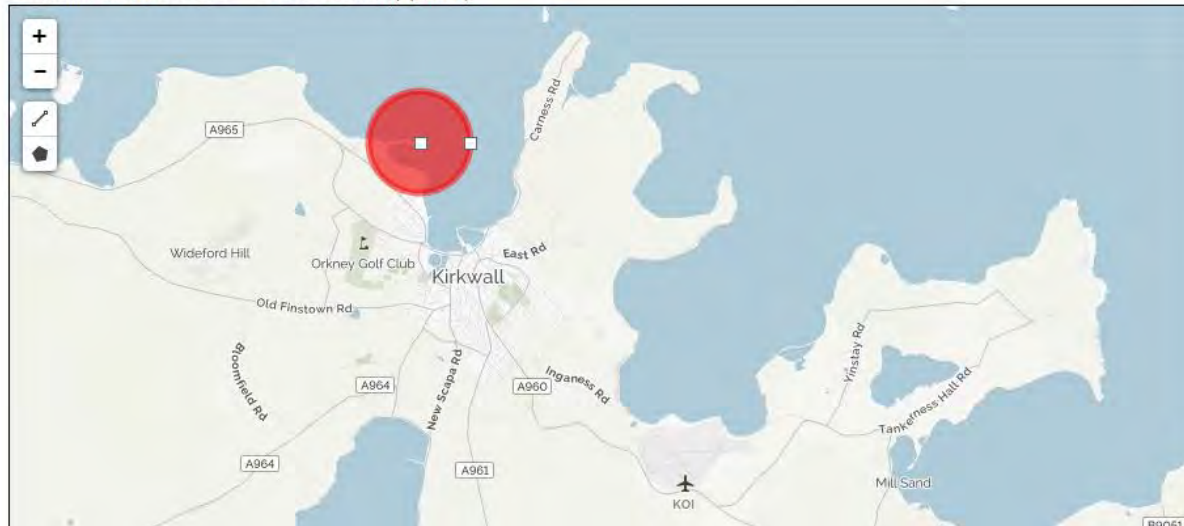
Transmitter longitude

Transmitter coverage (meters)

Receiver latitude

Receiver longitude

☒ Transmitter and Receiver ☐ Fixed receiver (optional)



Start Date and Time

E.g., 2019-08-19

E.g., 19:15

End Date and Time

E.g., 2019-08-19

E.g., 19:15

Low Frequency - Bandwidth 10 MHz

High Frequency - Bandwidth 10 MHz

Transmitter height (In meters above ground level) - Max: 3

Receiver height (In meters above ground level) - Max: 130

☐ Indoor

Radiated Power type

☐ dBm ☒ mW

Radiated Power EIRP: (Max: 33 dBm / 1995 mW)

[Check availability](#)

2019

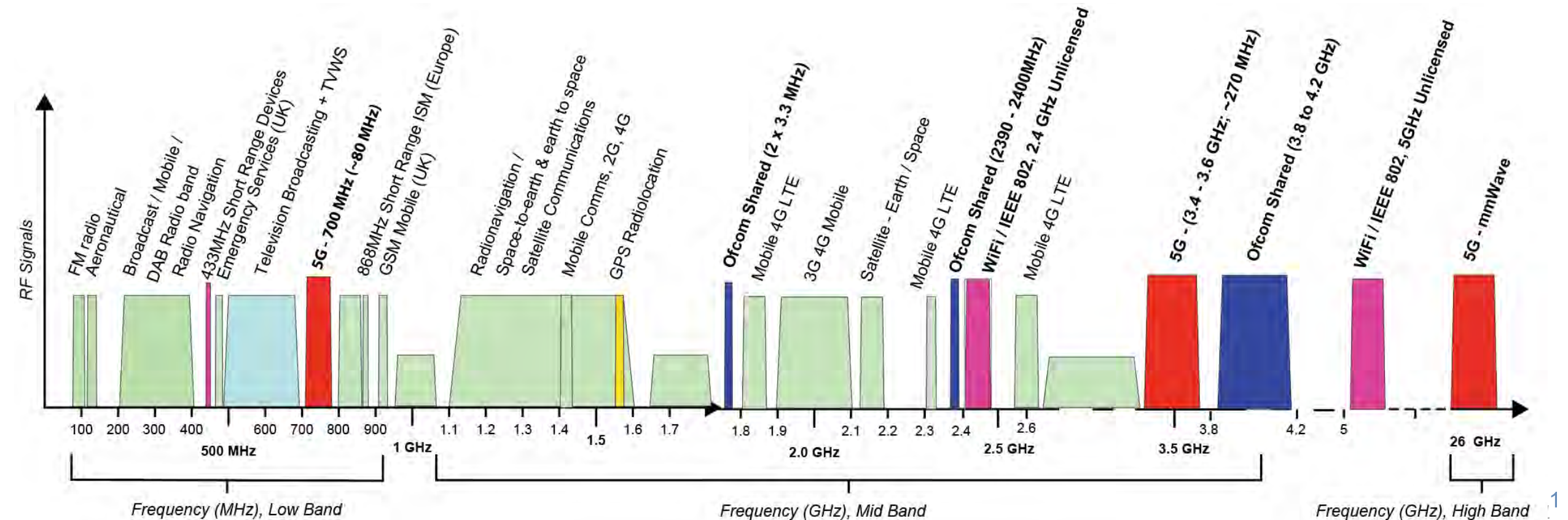
Spectrum Types

1. Licensed
2. Unlicensed
3. 'Shared Bands'

Spectrum Types

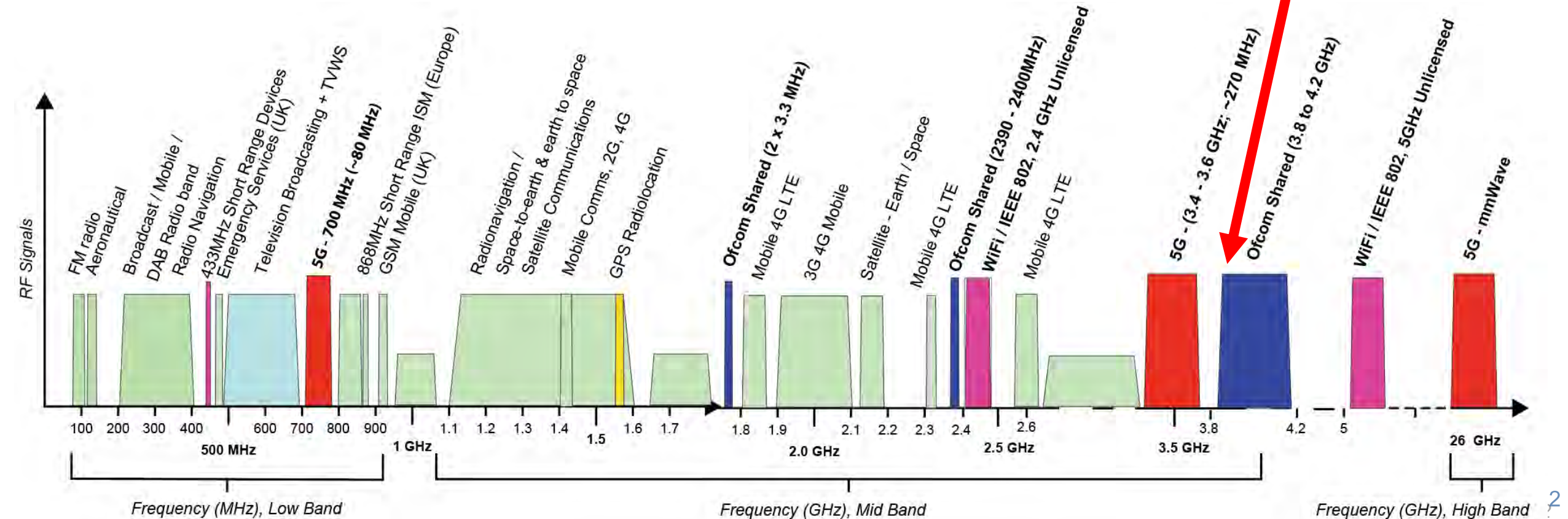
1. Licensed: Networks / MNOs
2. Unlicensed: WiFi, 802.11
3. 'Shared Bands': CBRS, TVWS, n77

Spectrum – Licensed, Unlicensed & Shared



Spectrum – Licensed, Unlicensed & Shared

n77u – Shared Spectrum: 3800 – 4200 MHz (400 MHz)



Low and Mid Bands

400MHz to 5GHz

The Beachfront spectrum. Wide area, through walls. It is full? Naw!

6 Years since 2019 to get Ready for n77 tests

2019-21	Operative:	<i>it just needs to work</i>
2022-23	Performative:	<i>Functional for demo live use case</i>
2023-24	Qualitative:	<i>Delivering QoS on a real world use case</i>
2024-25	Quantitative:	<i>Empirical measurements</i>

- **Operative, performative, and qualitative** experience means we know what to test, where to test and what performance to expect for **quantitative empirical sandbox** measurements.
- But n77u uptake and deployment remains slow and low.

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Operative:

Working and operating the lab & field

from 2019 we created our own n77 radios and networks. UEs were using modems – 5G SA operable handsets only arrived 2023/24
Networks were lab and T&D based

MotoGP

2021 - first live to air network -
Private 5G for Sports

Silverstone MotoGP – The Worlds first 5G SA Broadcast



Conclusion 2021: Seems to work and order of magnitude cheaper than live or similar.

After MotoGP - LiveSports Stone-X – Saracens vs Nottingham



Danish Parliament Opening – Nov 2022

5G SA – inside and outside of Parliament – n77 T&D



Live in Scotland, September 2022

Pitlochry Highland Games – Traditional Scottish Sports and Culture



Live in Ireland – August 2022

Fleadh Cheoil – Mullingar 'The Homecoming' traditional music festival



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Performative:

Robust enough to be deployed & work

From 2022 to 2023 live performing networks for demonstration of live broadcast use case. Sports, civic, and live events demonstrated, but worked so well went live internationally

Overview of NW 5G Solutions

5G Network in a Box (NIB) and Disaggregated Configurations

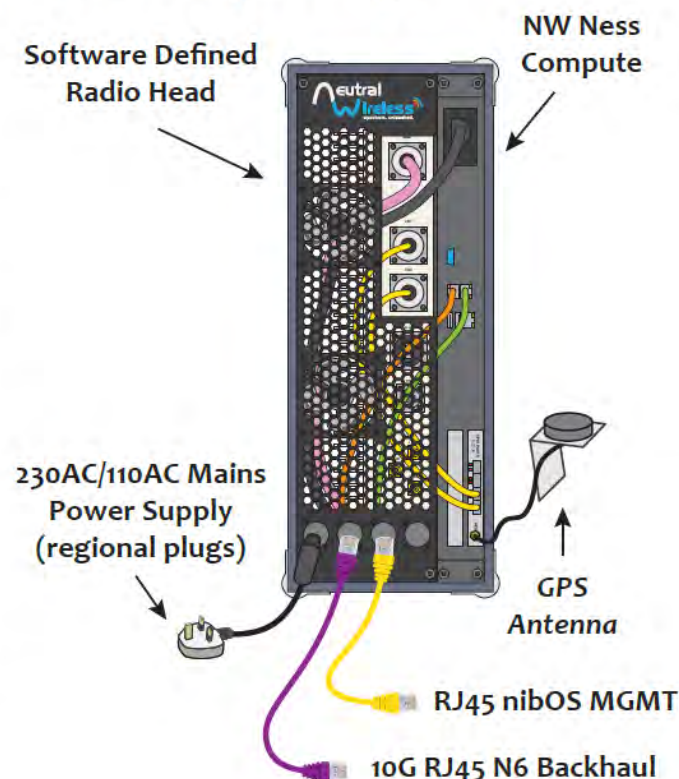


NW Lomond Network in a Box (NIB)

An all-in-one network with the radio head and computer featuring the vBBU gNB stack and mini-5GC, packaged in a rugged wheeled 19 inch rack case. Suitable for the pop up networks, events, and the lab.

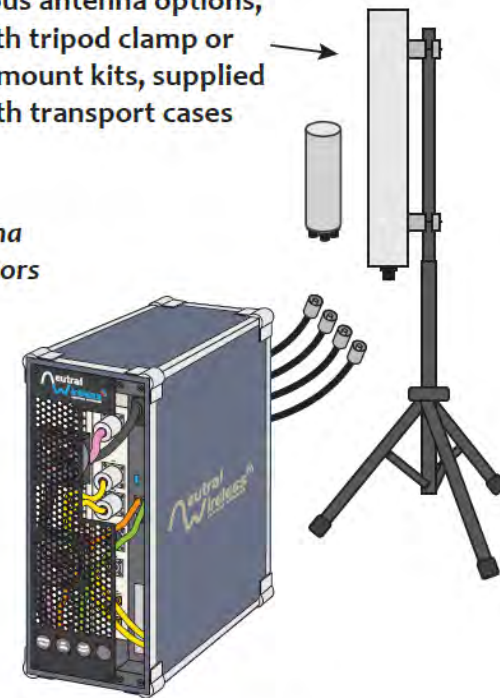
Omni or sector antennas are supplied with a transport case and 3m tripod stand. This solution is not water resistant, and therefore generally not suitable for outdoor use. For outdoor-friendly networks, the Disaggregated Lomond is recommended.

Note: You can start with a NIB, and add on more disaggregated radios to build a multi-cell network



Various antenna options, with tripod clamp or pole mount kits, supplied with transport cases

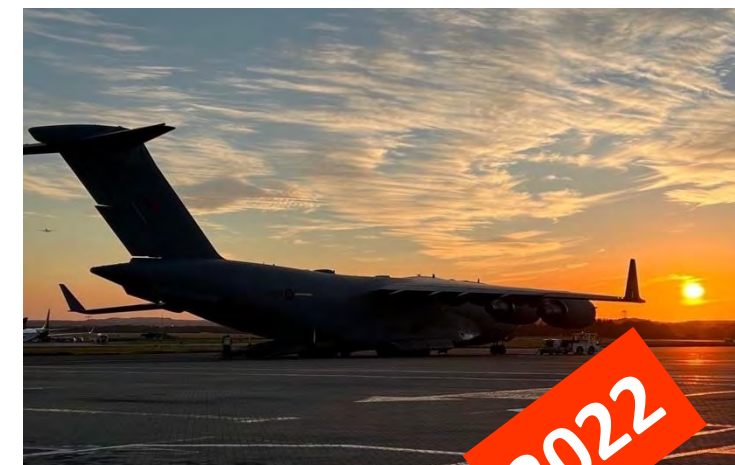
Antenna Connectors



NW Lomond NIB can be transported like a wheeled suitcase



The final journey of HRH from Scotland – September 2022



The Coronation of His Majesty King Charles III – May 2023

Supporting international broadcasters on the world's largest private 5G network

2023



2023

Thanks to all our partners and collaborators

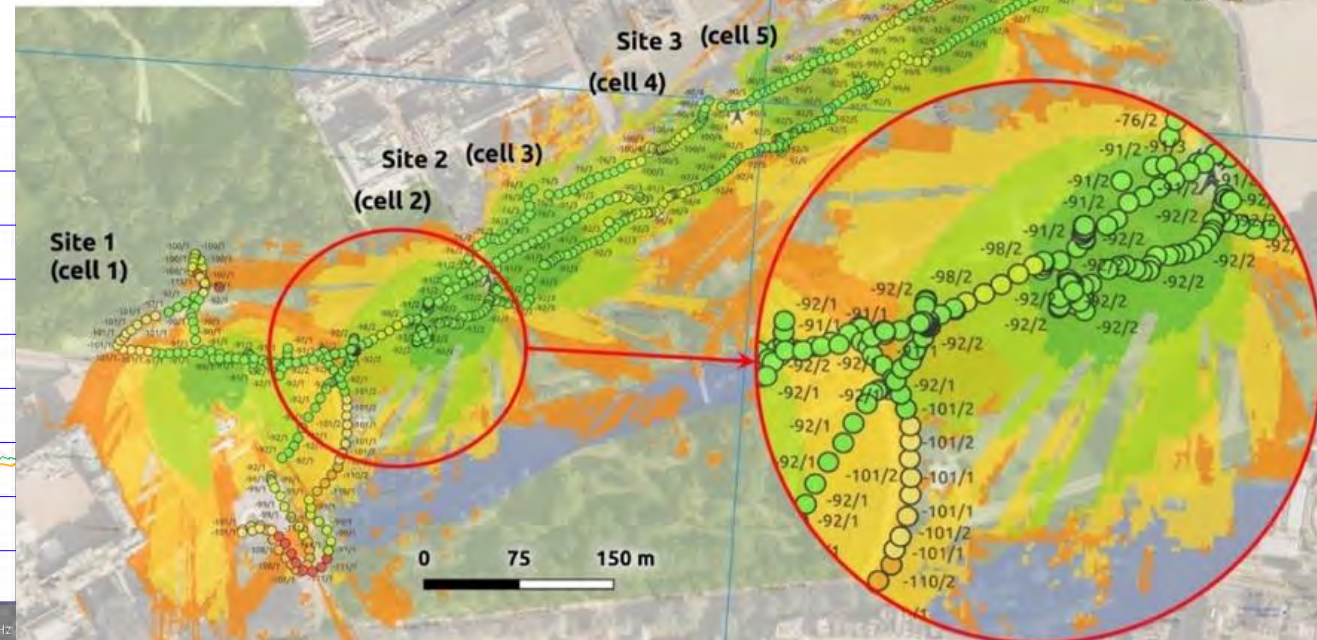
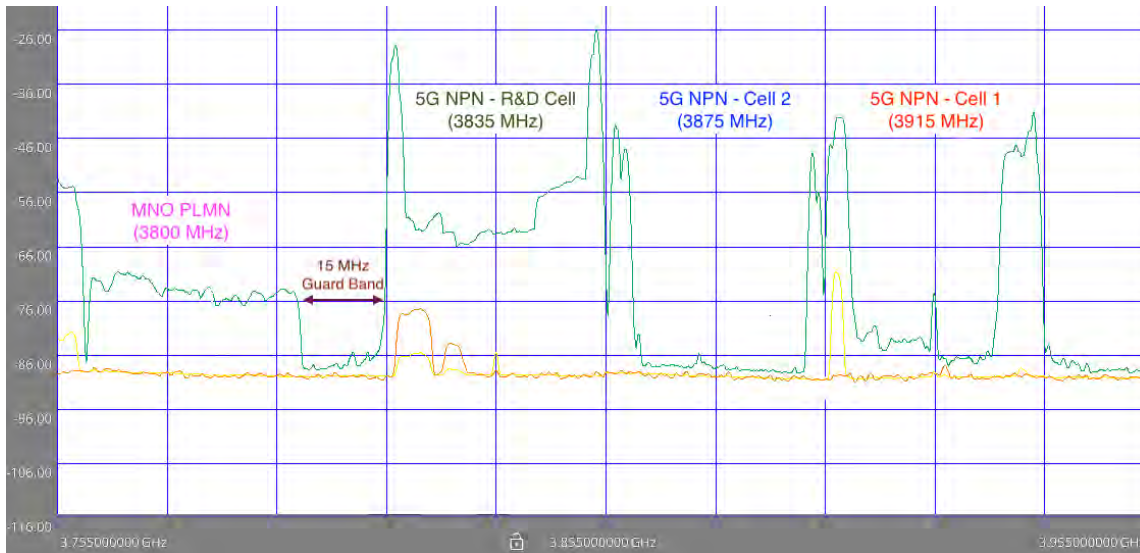


Media Compound Installation

Phase 4 – Network deployment and verification

2023

- ✓ Measurements agree well with RF simulations
- ✓ (Coverage actually *better* than predicted)
- ✓ Allocated 80 MHz spectrum
 - 2x 40 MHz channels (A/B)
 - Original 40 MHz licence at CG (C)
- ✓ Provided over 1 Gbps of uplink
- ✓ connectivity; cell handover



The Coronation of His Majesty King Charles III – May 2023

The World is Watching

Meanwhile, we are looking at this

2023



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Qualitative:

Fully operational and engineered to perform

In 2023 & 2024 Paris Olympics engineered networks to provide live event coverage for international markets with sufficient reliability and quality for broadcasters



OBS



HAIVISION
SAMSUNG

Private 5G

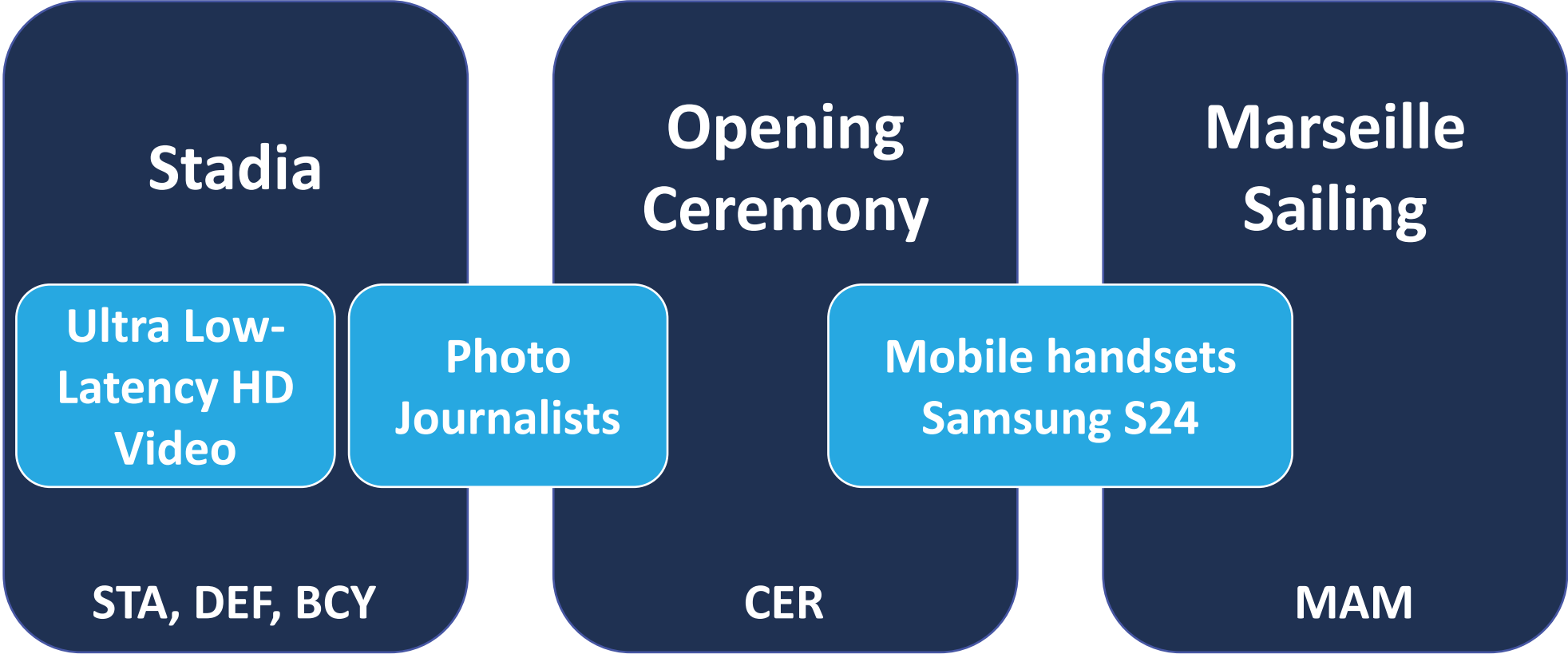
Paris 2024

- Opening Ceremony on River Seine
- 3 Event Stadiums
- Sailing Events, Marseille

2024



P5G SA was used extensively at Paris 2024



STA	Athletics
DEF	Swimming
BCY	Gymnastics

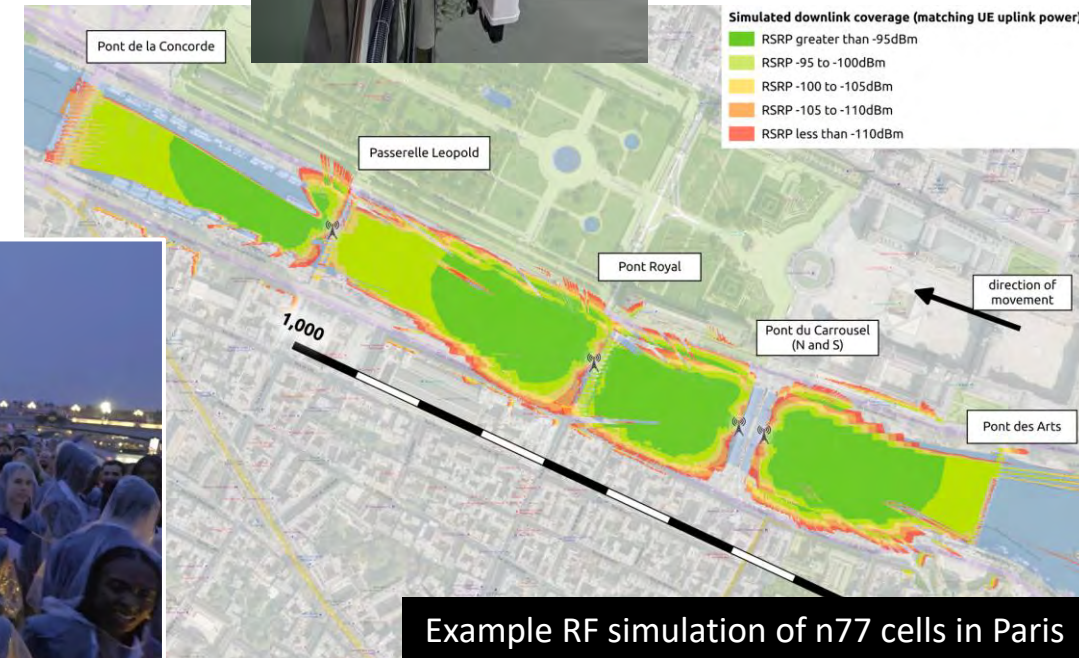
1st Olympic Games
Opening Ceremony
not to take place in
a Stadium

Paris 2024 – Opening Ceremony – River Seine

Boat procession along 6 km of the river

- 22× Uplink-biased private network cells:
 - 11× 60 MHz video cells (2.64 Gbps uplink)
 - 11× 40 MHz photo cells (1.76 Gbps uplink)
- 217× Samsung S24U handsets on 85 boats
- **Hundreds of video feeds!**

2024





2024

Down at the River Seine in Paris



In Marseille with Private 5G at Sea

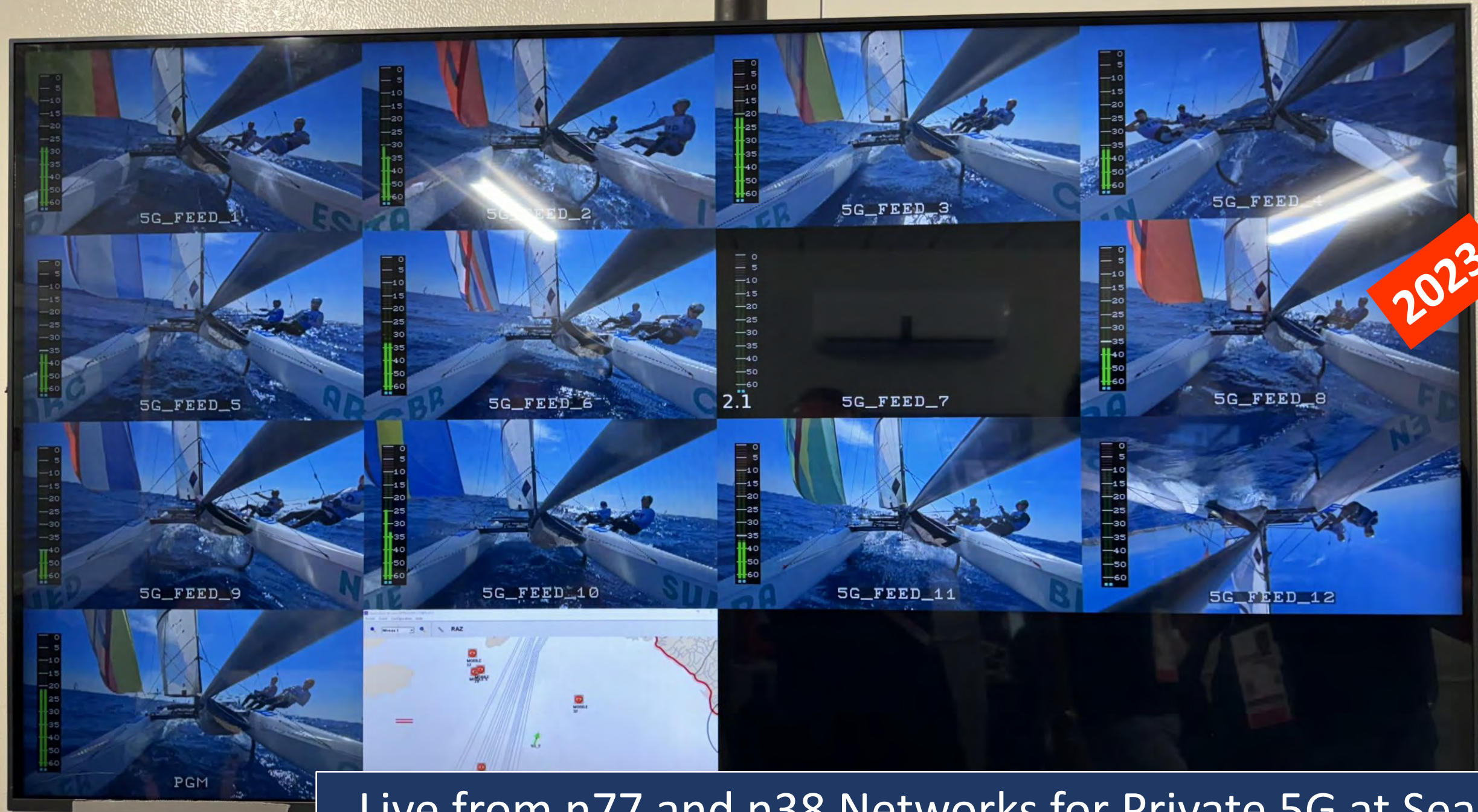
2023



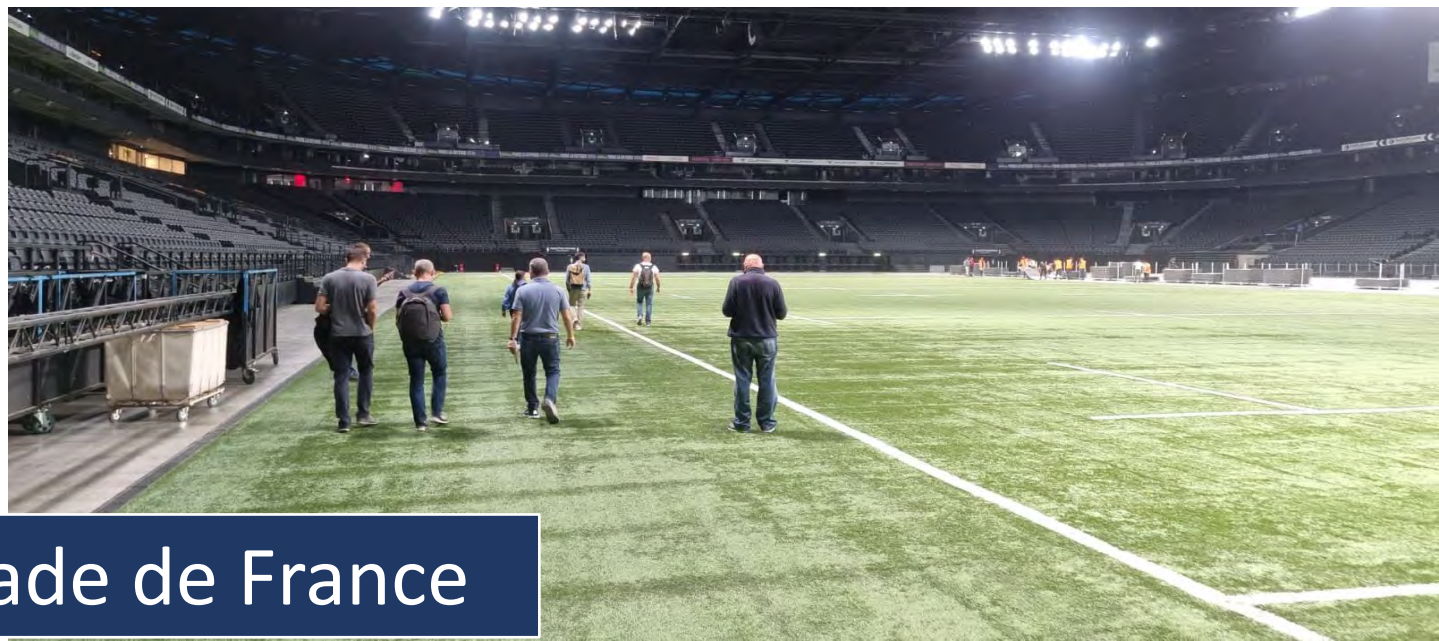
Paris 2024 – Sailing in Marseille

- Multi-cell P5G “out on the water” – a “mobile” mobile network
- 3× **gNodeBoats** move with the field of play (2× n77 + 1× n38)
- Backhauled using high-power highly-directional WiFi 6
- Up to **12× video feeds per race** (S24U / S23 + helmet camera)
- Bluetooth microphones on athletes to provide **on-board audio**





Live from n77 and n38 Networks for Private 5G at Sea



Live in 3 stadiums including Stade de France



2024

Olympic Swimming Venue

Simulated downlink coverage (matching UE uplink power)

RSRP greater than -95dBm

RSRP -95 to -100dBm

RSRP -100 to -105dBm

RSRP -105 to -110dBm

RSRP less than -110dBm

Pont De La
Tournelle

Pont De Sully
(N and S)

2024

direction of
movement

Pont d'Austerlitz

And we planned, deployed, measured and operated ...

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Quantitative

Sandbox Testing, Modelling & Measurement

In 2025 for n77u it can be engineered to work well in challenging environments. We measured, quantified, verified and shared. **Uplink ratios** need NOT always be common. Operating in shadow of high power/high tower is all 'fine'

NW Etive

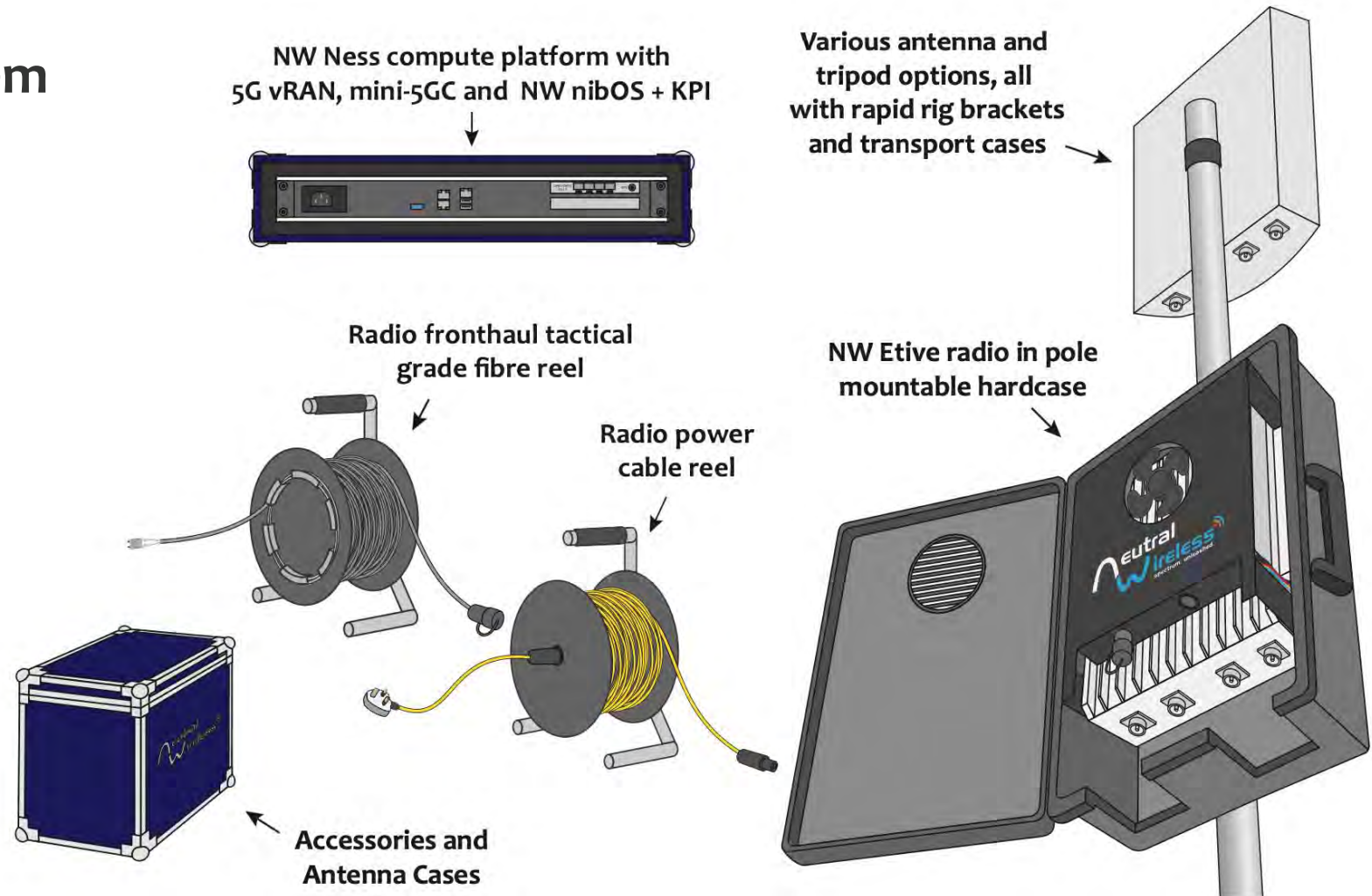
Portable 5G Network Ecosystem



NW Etive Portable 5G Ecosystem

The Neutral Wireless **Etive** is a fully portable 5G network ecosystem, with Release 18 aligned vRAN software stack and integrated mini-5GC for subscriber management and local data breakout. **Etive** is the perfect solution for lab work and field trials, and also for deploying a pop-up 5G network at events for sports broadcasting, music festivals, and conferences.

The NW **Etive** is a truly mobile private 5G SA solution, with radio heads, the NW Ness compute platform, antennas and accessories packaged in rugged transport cases ready for rapid deployment. The hardcase containing the radio (pictured right) can be directly pole mounted, and the 5G network can be unpacked and operational in as little as 5 minutes.



Operational Dashboard: Radio health, network, UE performance



Neutral Wireless operations dashboard presents details and statistics for all connected devices.

n77 Sandbox Testing 2024-5

ON INSIDE



Open Network Shared Spectrum Innovation & Design Environment

Phase 1: Oct 2023 – Sept 2025



High Level Objectives of OnSide Project

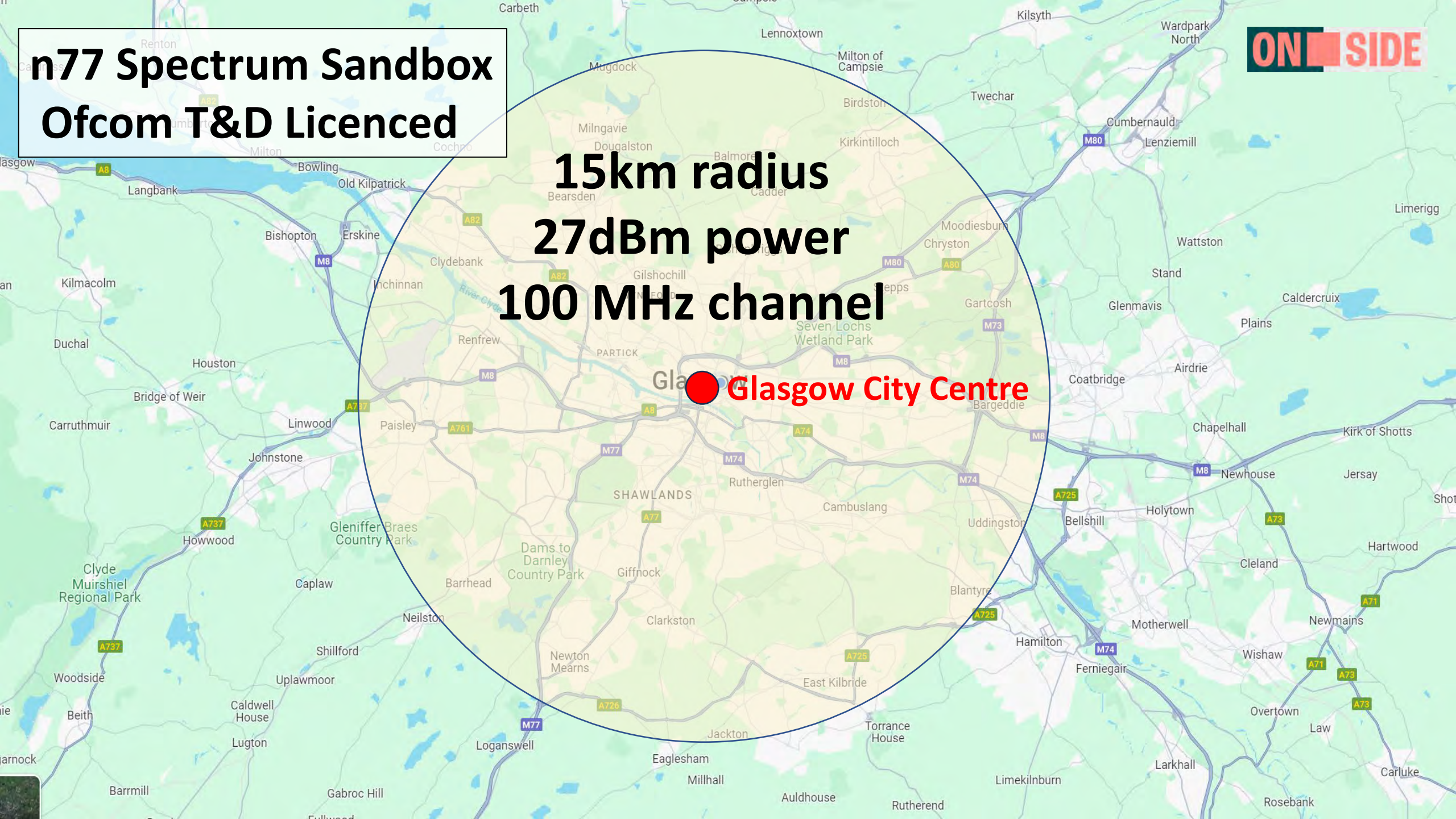
1. Developing **5G private network technology for applications and use-cases** that are not currently well served by public mobile networks.
2. **n77 Spectrum sandbox** – ‘special’ licence covering the Glasgow City area for a period of 2 years, during which time we will aim to explore innovative ways of managing spectrum for pop-up 5G SA networks in the 3.8-4.2 Shared Access band.
3. A '**living lab**' **research, development, and design environment** for testing and demonstrating state-of-the-art communications across the Glasgow City area ...integrating **spectrum sensing & monitoring** and innovative spectrum management
4. **100 MHz of n77 spectrum** allocated in 3.8-4.2 GHz band for interoperability, interference testing, distance, indoor/outdoor testing.
5. **Engaging and reporting to Stakeholders** throughout the project, disseminating findings and learnings & discussing potential innovative approaches to spectrum management.

n77 Spectrum Sandbox Ofcom T&D Licenced

ON  SIDE

15km radius
27dBm power
100 MHz channel

 **Glasgow City Centre**



Use Cases for n77 Private 5G SA

ON  SIDE

- Stadium
- Urban
- Live Events
- Studio/Theatre
- Ports and Industrial
- Rural and Open Area

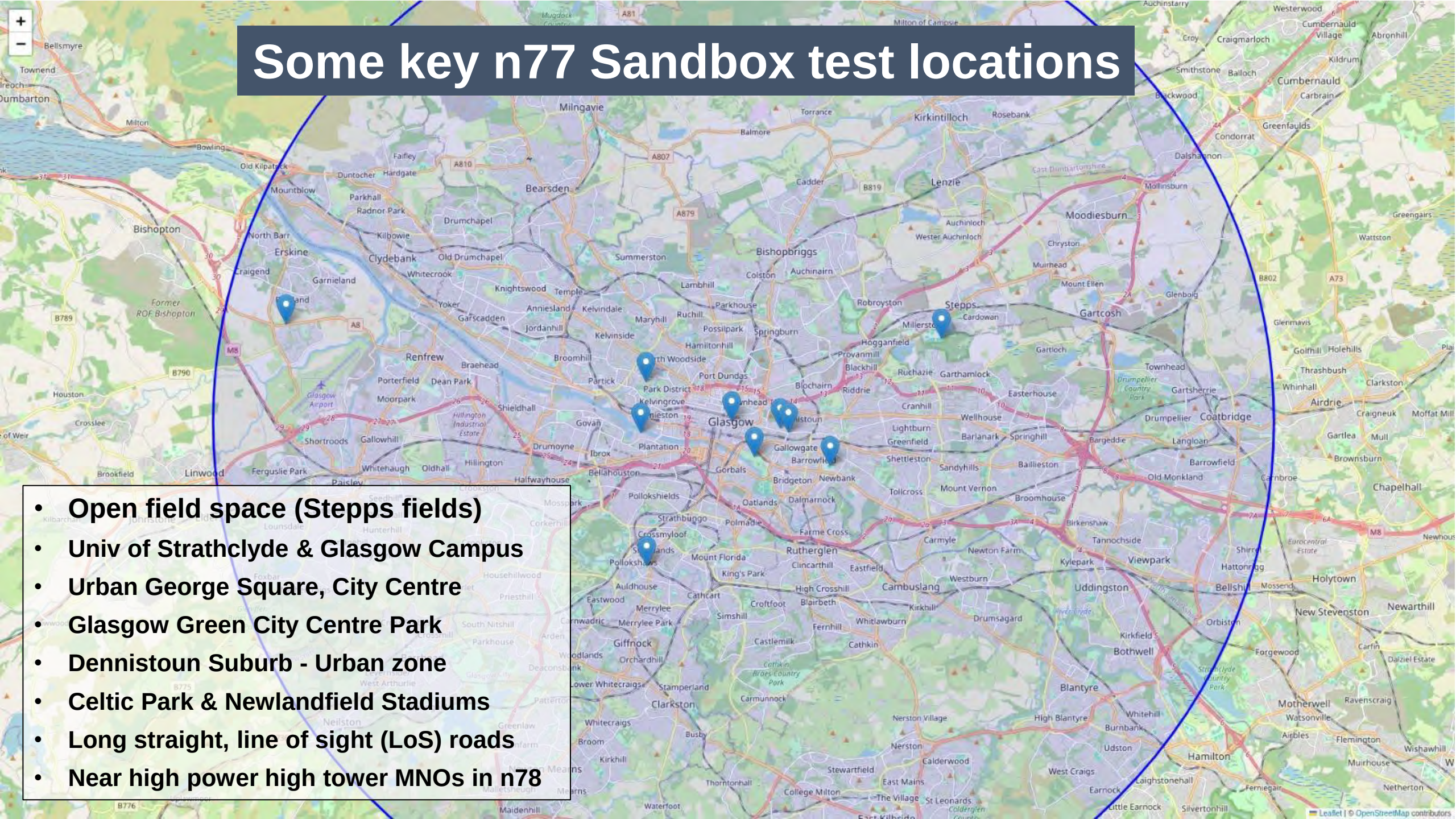


n77 Sandbox: Activities and Measurements

- **Distances achievable** line of sight, bit rates for low power – whisper networks!
- **RF modelling** and prediction with models/lidar
- **Outdoor clutter** performance (city centre buildings, landscape/geography)
- Characterise key **indoor clutter** performance (BBC Studios)
- **Stadium performance**: n77 in empty stadium versus 60,000 people
- Measure on performance aiming to **understand all UEs not equal**
- In-radio **live spectrum monitoring** operational demonstration benefits
- **Radio characterisation**; engineering design optimisation – all radios not equal
- **Vary uplink/downlink ratios** - sync and no-sync operation

Some key n77 Sandbox test locations

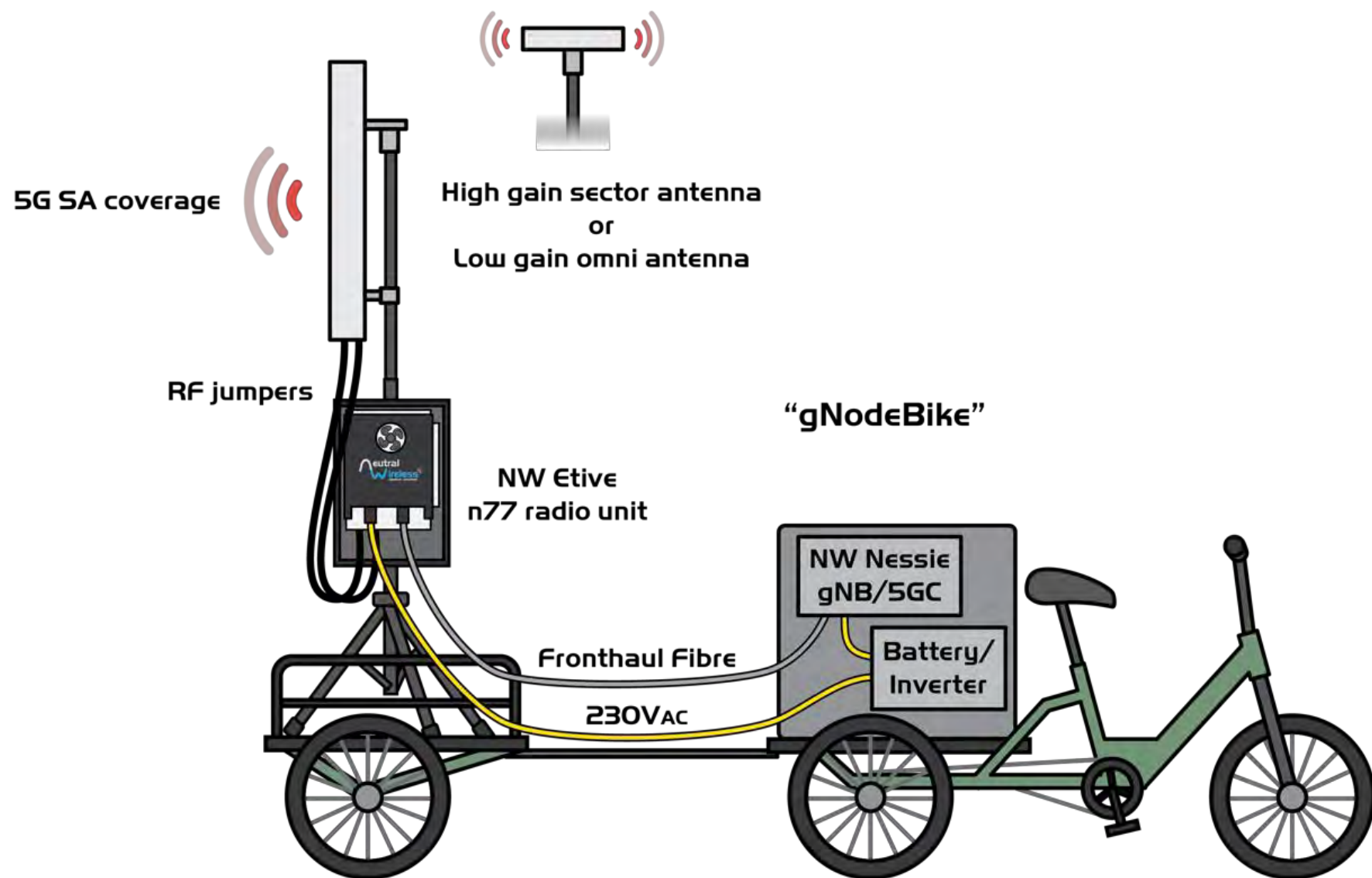
- **Open field space (Stepps fields)**
- **Univ of Strathclyde & Glasgow Campus**
- **Urban George Square, City Centre**
- **Glasgow Green City Centre Park**
- **Dennistoun Suburb - Urban zone**
- **Celtic Park & Newlandfield Stadiums**
- **Long straight, line of sight (LoS) roads**
- **Near high power high tower MNOs in n77**



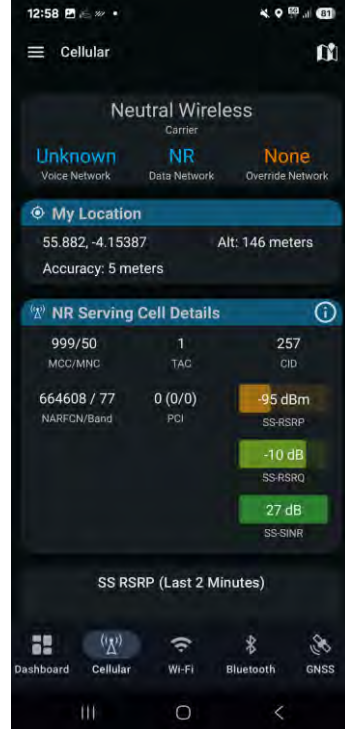
Sandbox Measurements Efforts

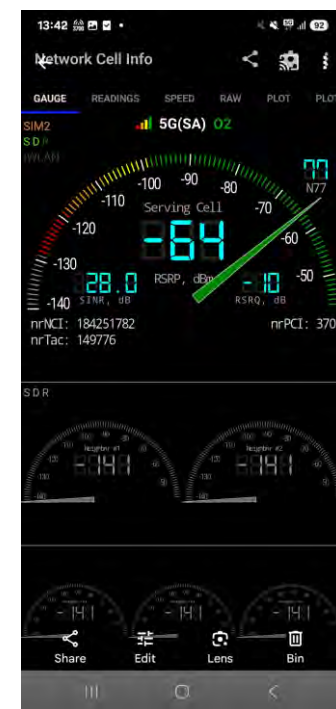
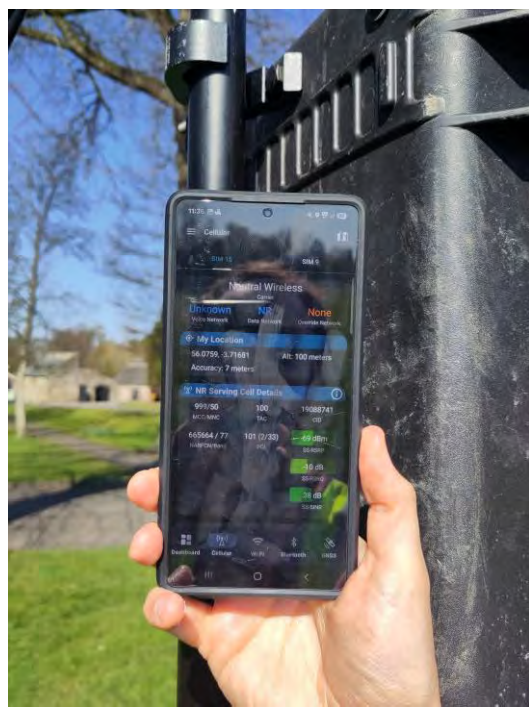
- **105 measurement** campaign files captured for n77.
- **71.8 km** walked with test UEs.
- **1454 minutes** of network operation and recording.
- **71589 sample points** recorded and analysed.

gNodeTrike: Goes 'anywhere' for n77 Testing

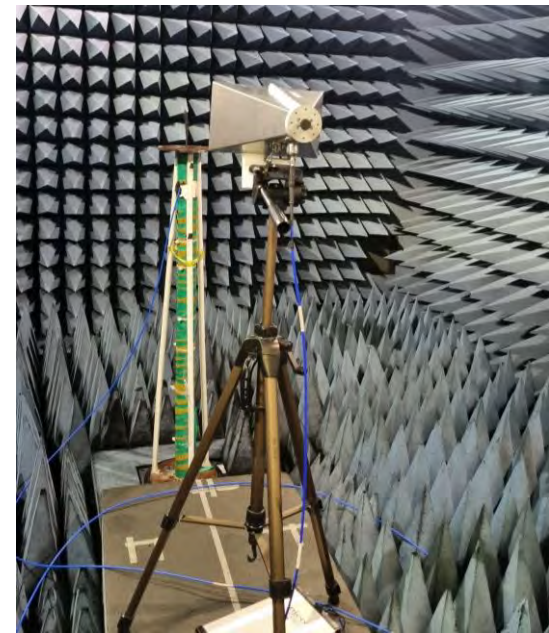


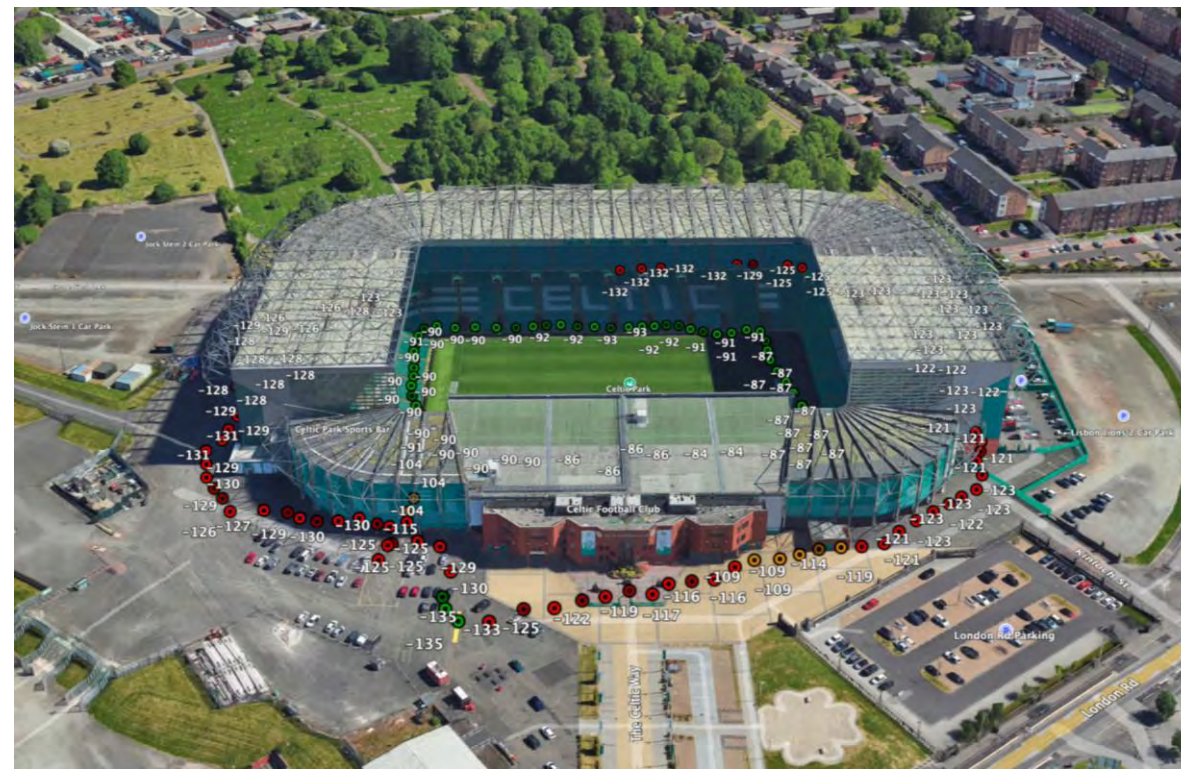








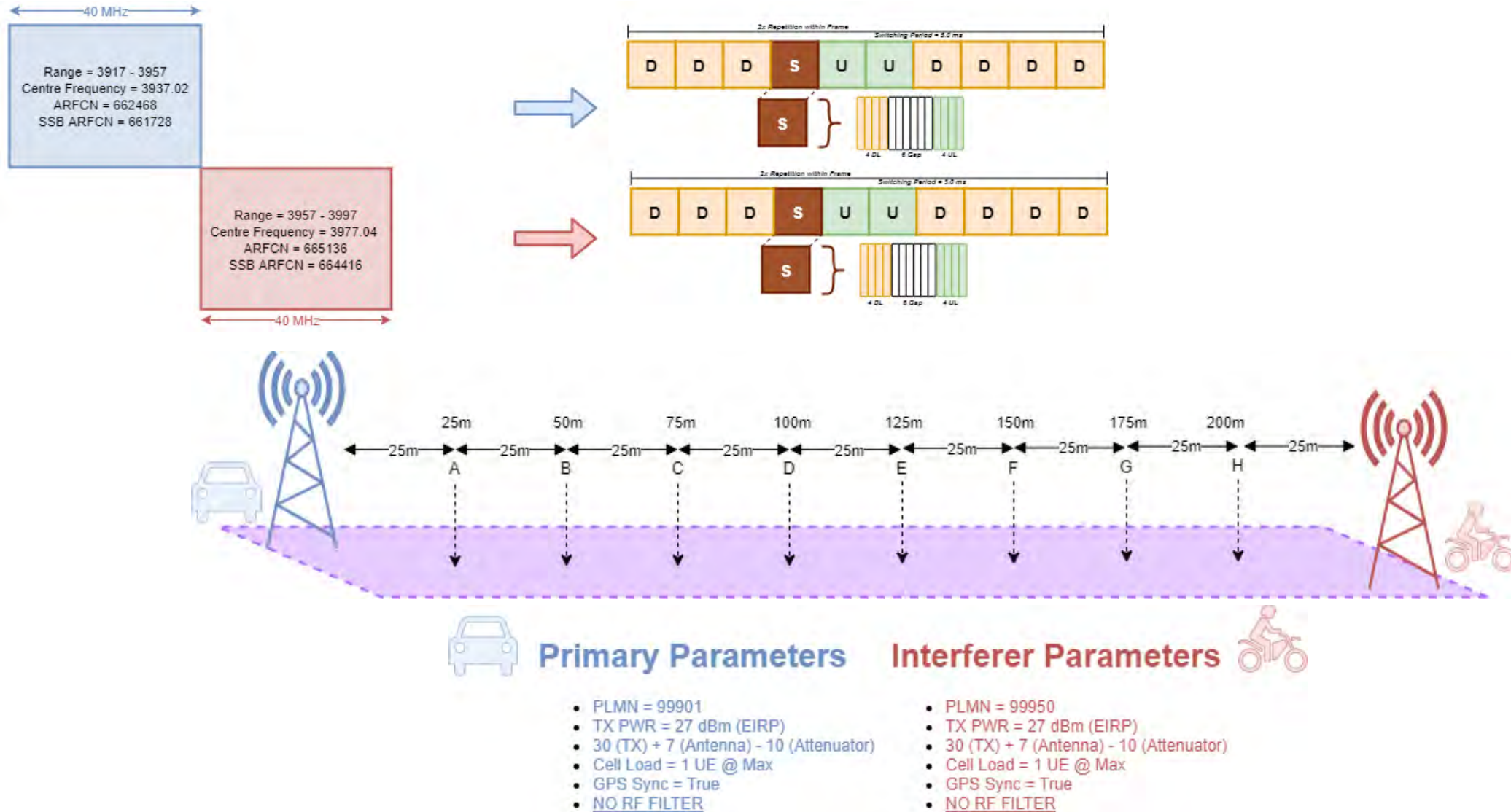




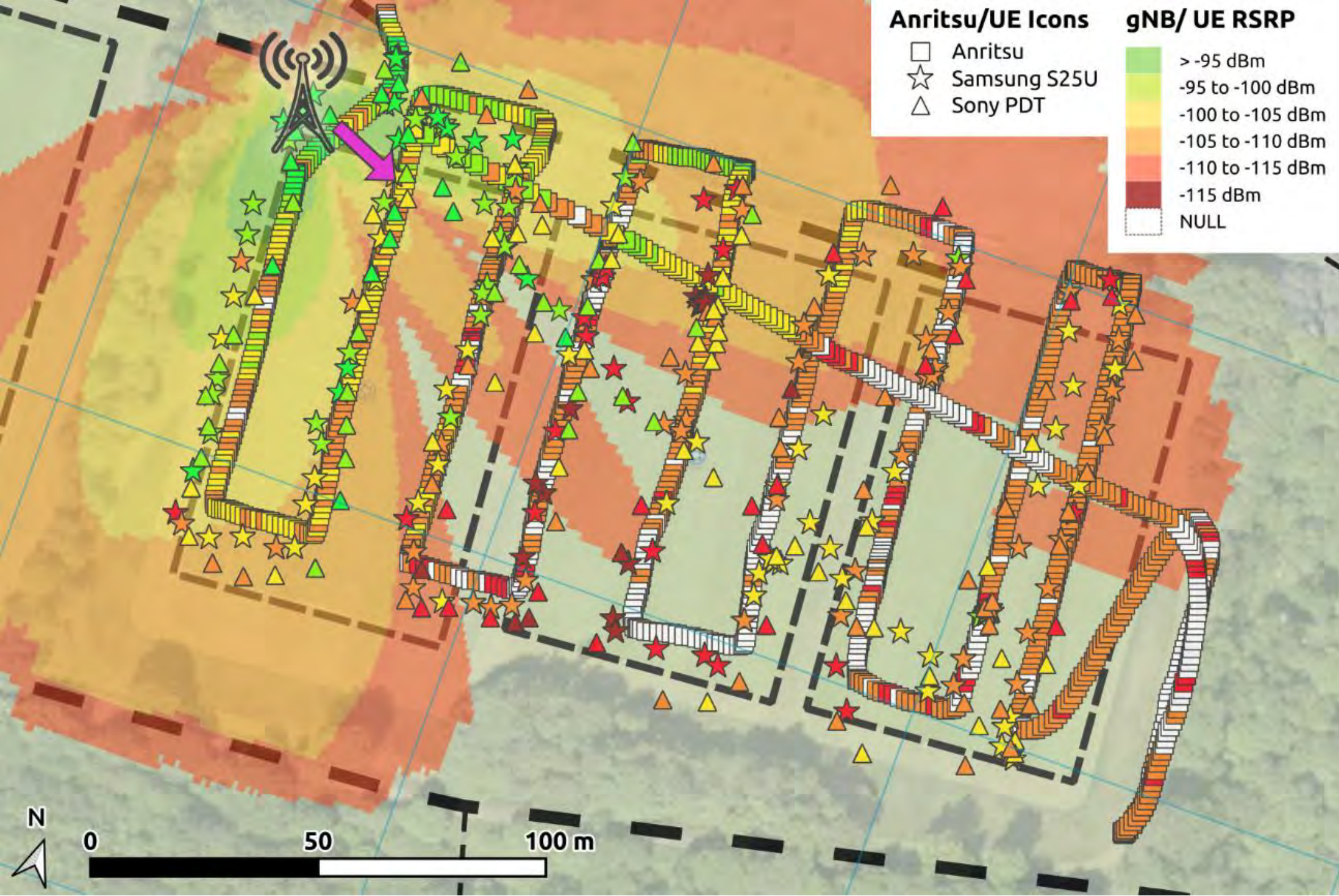
STEPPS PLAYING FIELDS, G33 6ND



Private Network Deployments Using Adjacent Operating Channels – Stepps Playing Field





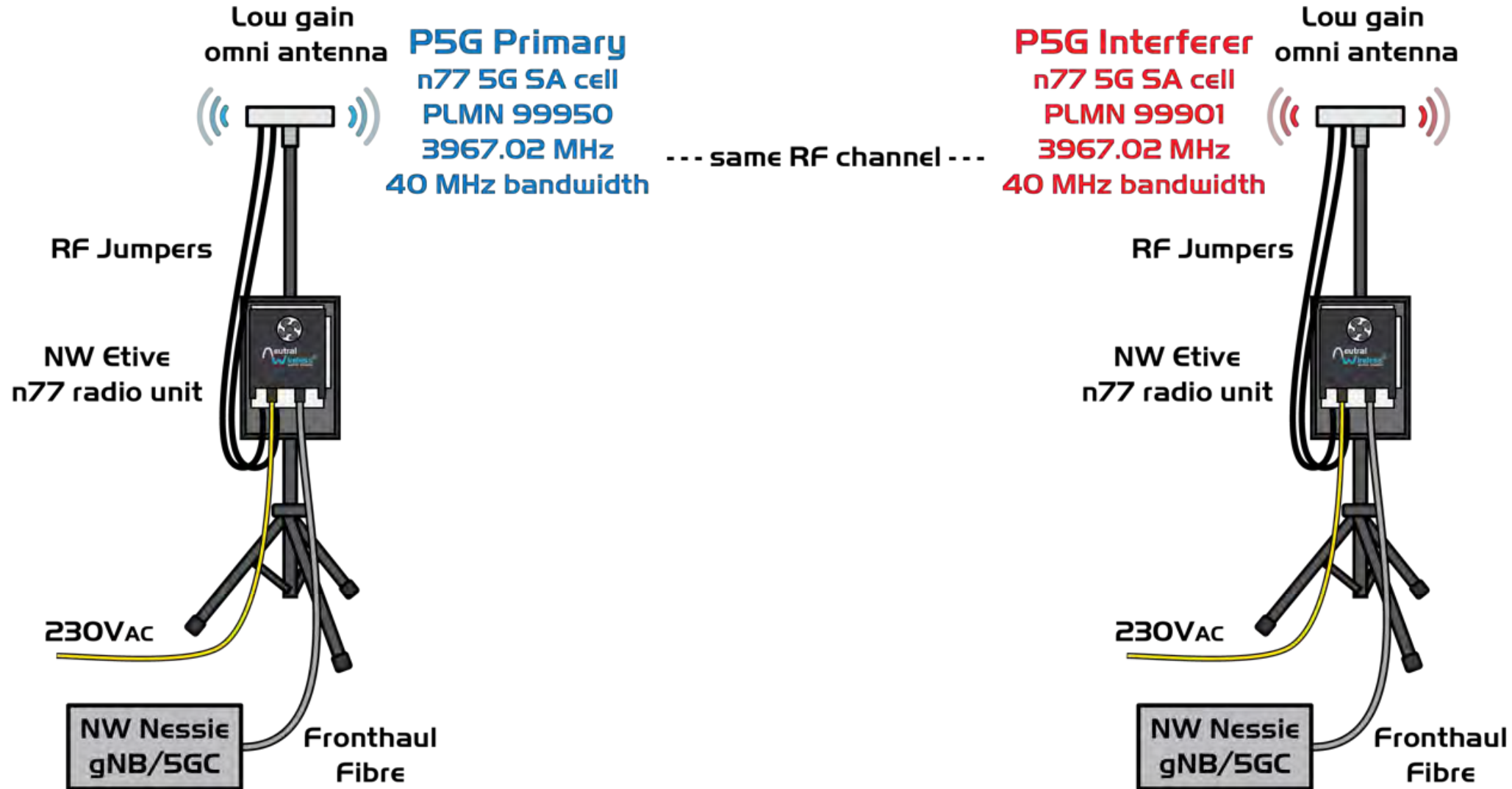






Co-Channel Interference

How close can you get?



Co-Channel from 1.5km down to 500m



Location of fixed Primary Network



Starting Position of mobile "Interfering" Network

Define Test Network Parameters – Primary + Interferer

Parameter	Primary	Interferer
Antenna	n77 Sector, 65 Deg, 18dBi	n77 Sector, 65 Deg, 18dBi
Centre Frequency(MHz)	3,967	3,967
Bandwidth(MHz)	60	60
EIRP(dBm)	27	27
Frame Structure	Uplink Biased (2:7)	Downlink Biased(7:2)
Number of UEs	2	1

At around **800m** (in this test!) all good, 1km no issues

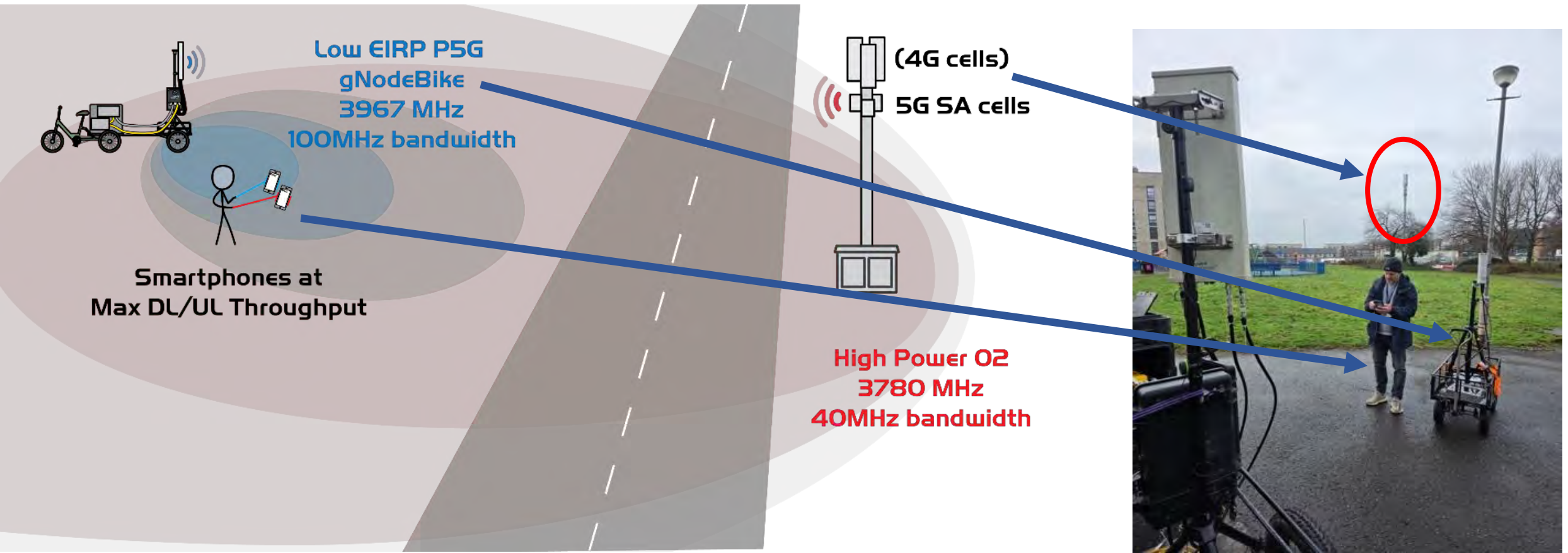
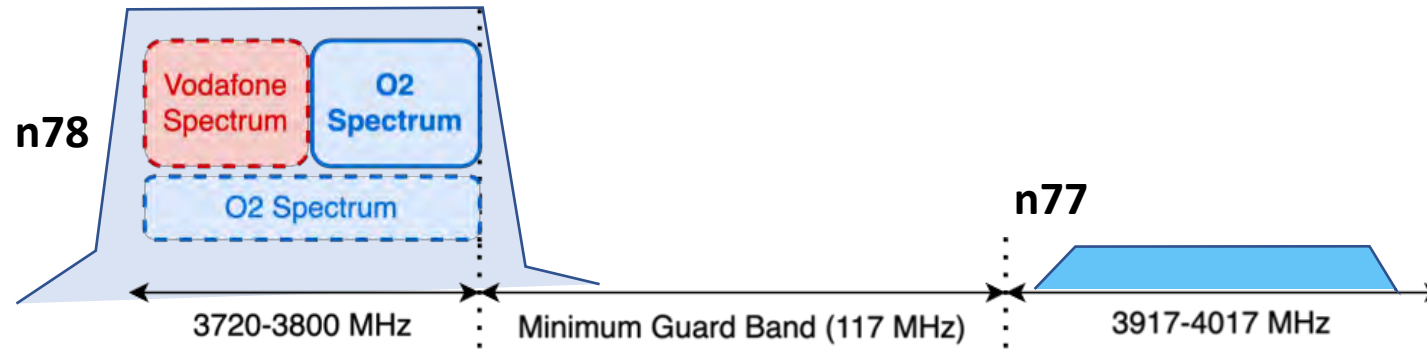
ON  SIDE

- The graph below shows the Uplink and downlink MCS at 1km distance dropping to a low of ~5 as the Trike moved towards the primary cell down to 150m (unuseable).



Performance in Presence of High Power High Tower MNO

n77 in the Shadow of High Power High Tower (HPHT)

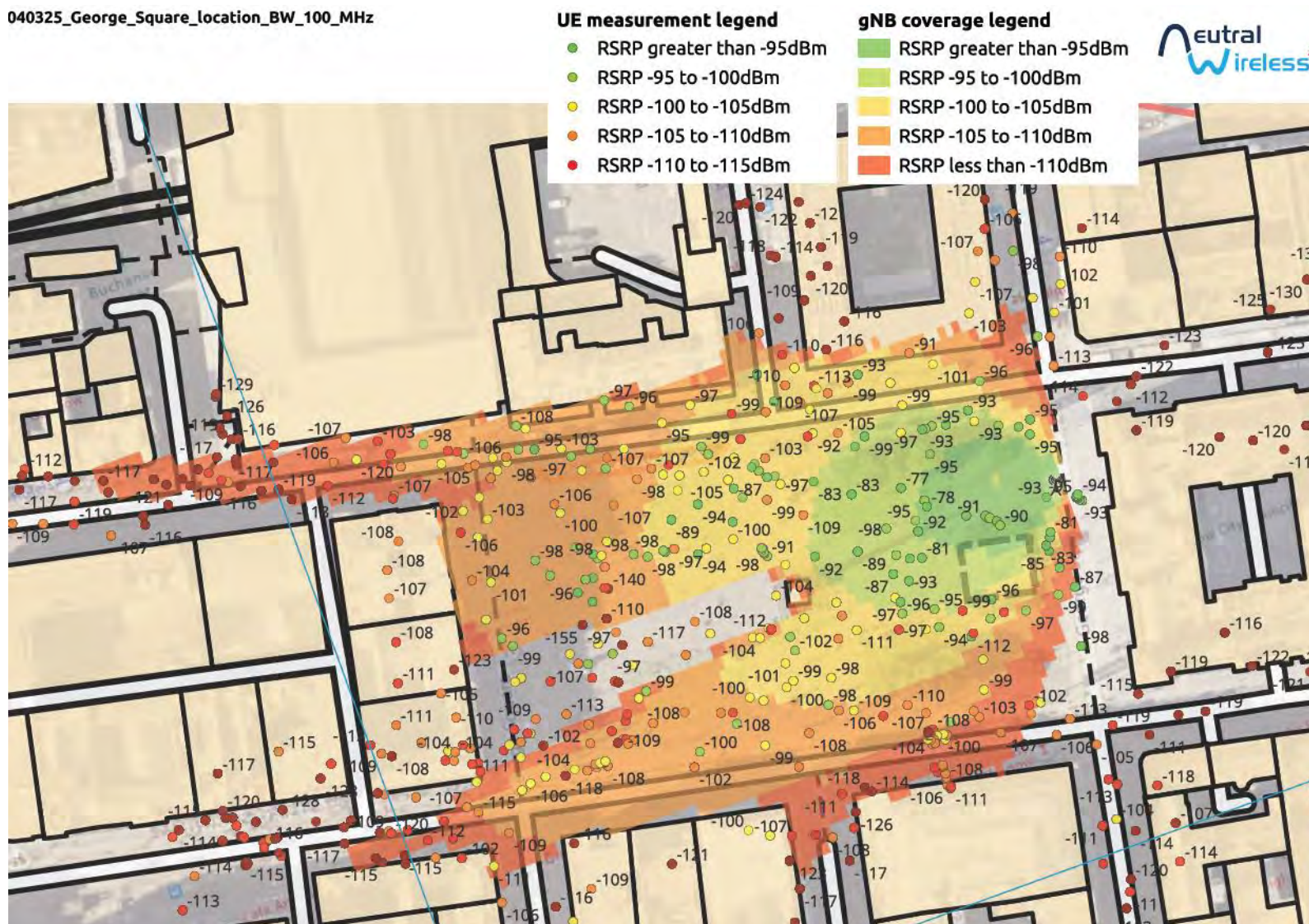


Operating In Proximity to MNO Neighbours

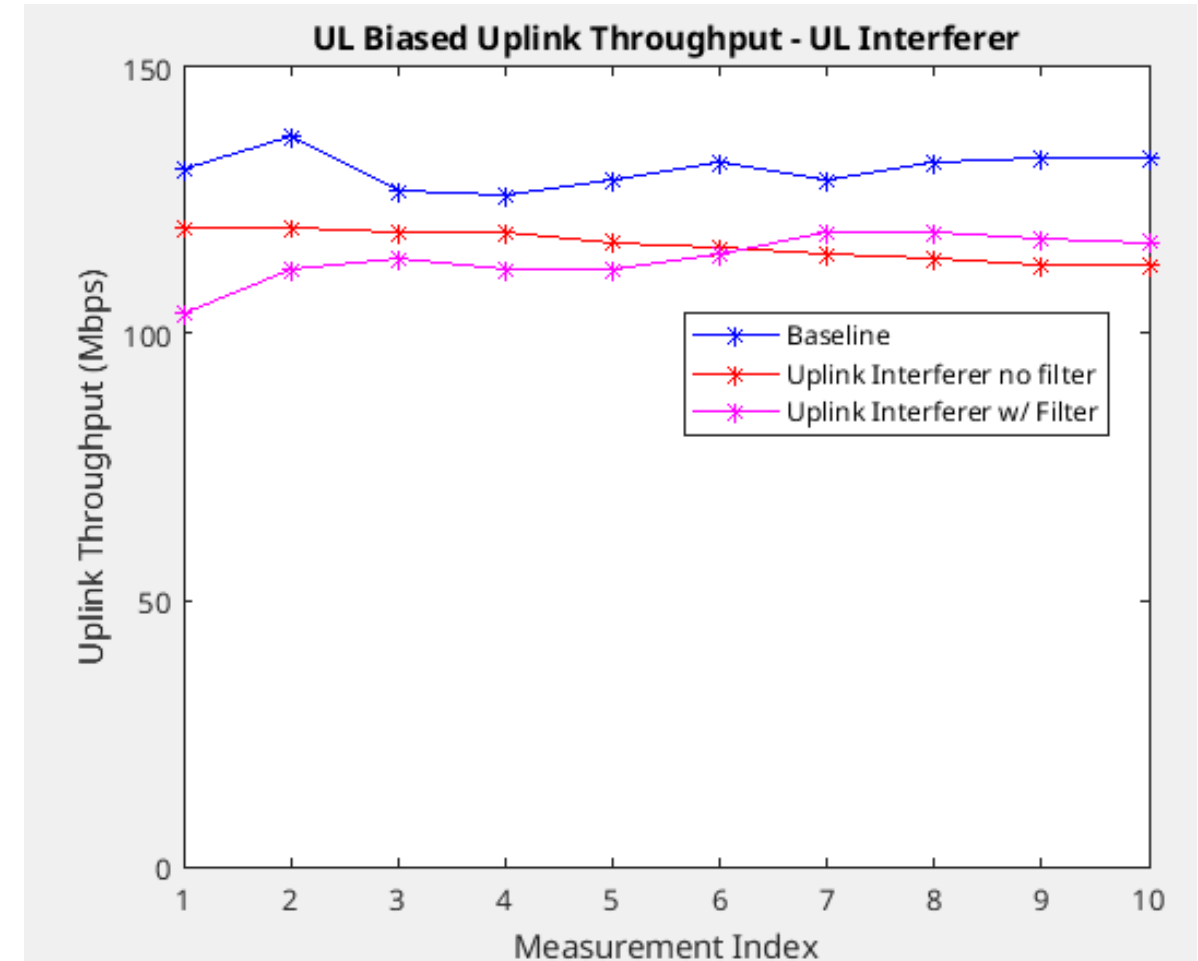
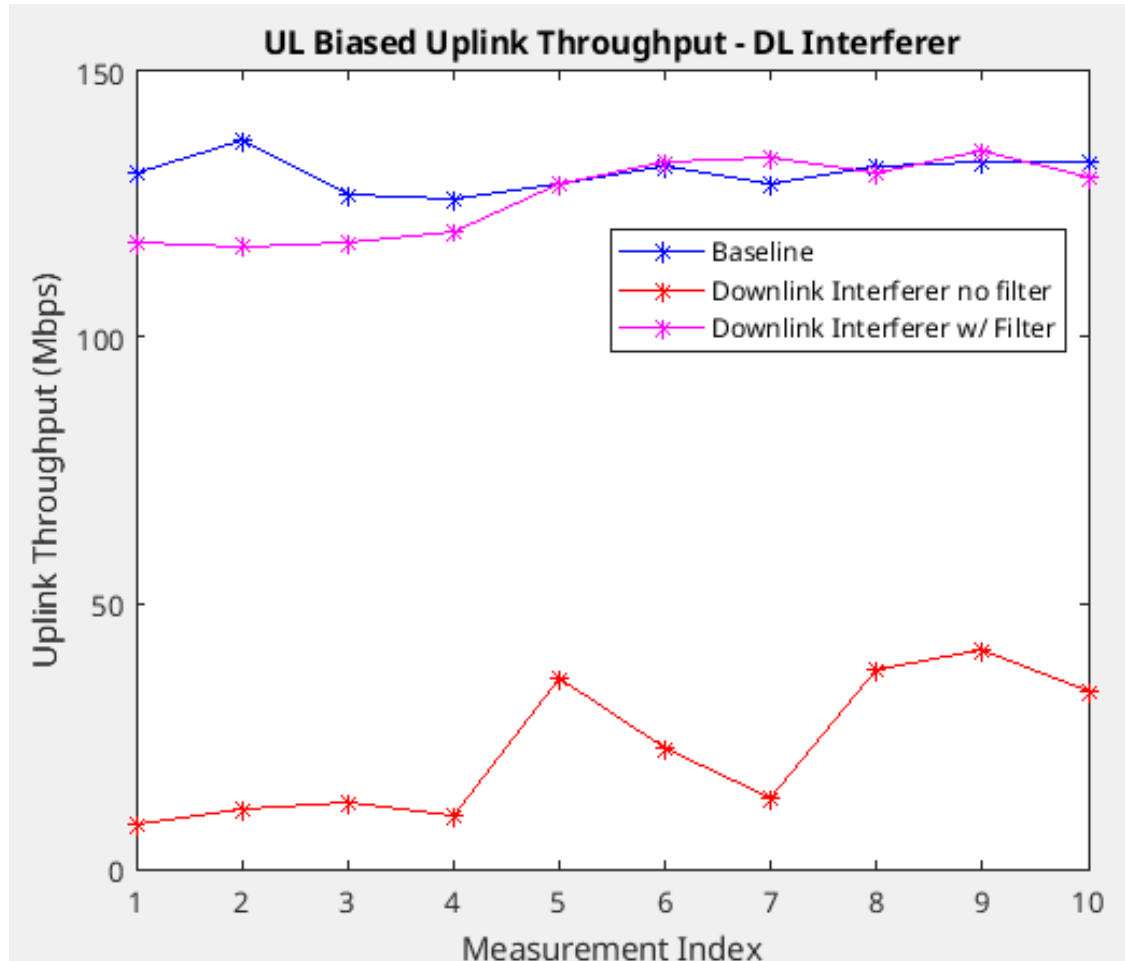


Operating In Proximity to MNO Neighbours

040325_George_Square_location_BW_100_MHz



Filtering and Engineering to Operate Synchronised or unsynchronised



RF Modelling and Planning

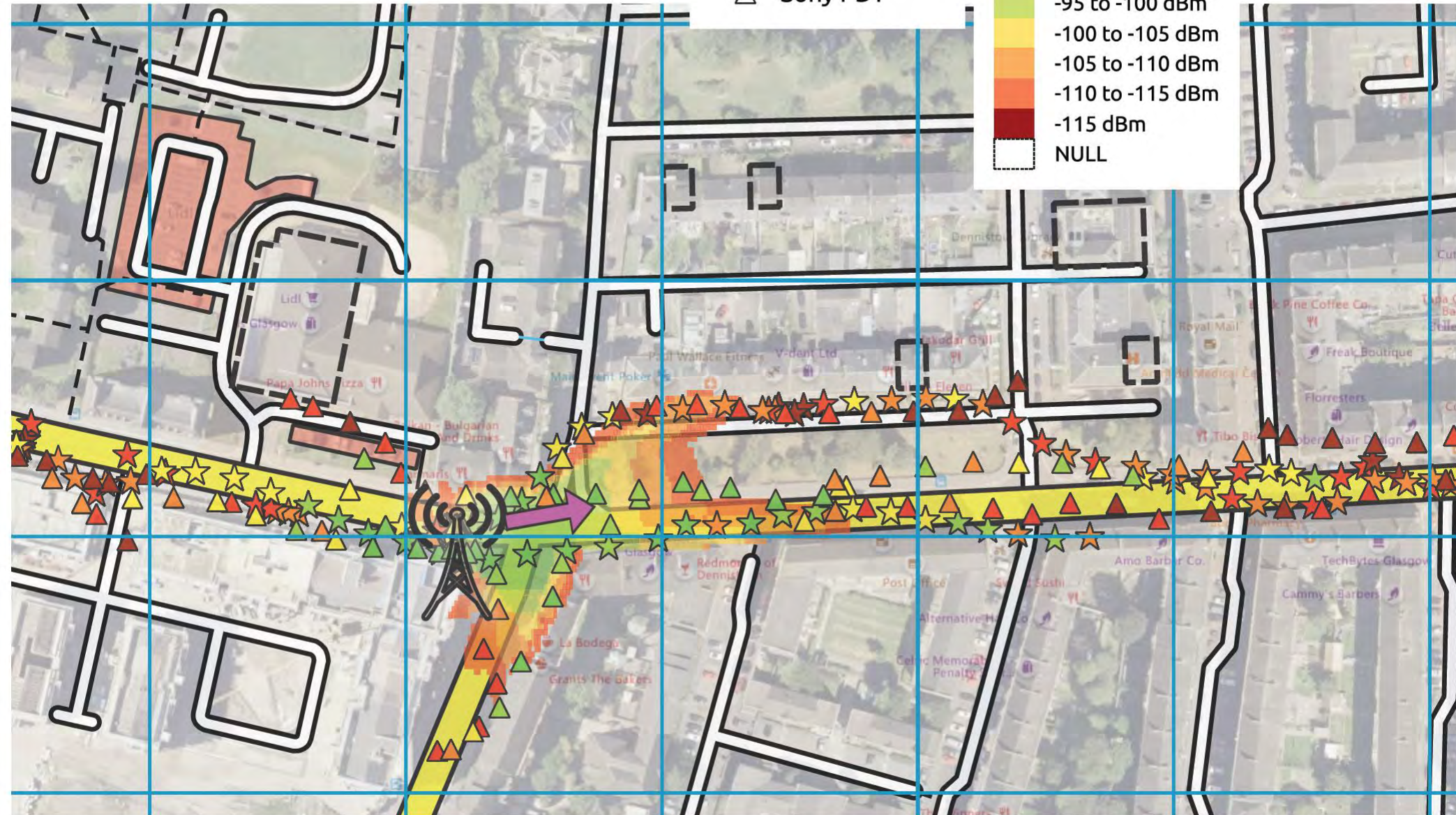
Get the right model & verify
Terrain/Clutter vs 1m Lidar

Each Test has a Key Parameter Set (KPS)

Centre Frequency	3967.02 MHz	Antenna Configuration	2x2 MIMO
Bandwidth	100 MHz	Antenna Model	Alpha Wireless AW3828 17.5 dBi Sector
Transmit Power	27 dBm (24 dBm per port)	Antenna Height	2.0 m
Antenna Latitude	55.861168°	Antenna Azimuth	278°
Antenna Longitude	-4.248787°	Antenna Tilt	0°
Environment Description	High clutter, dense urban environment. George Square is a semi-open concrete square surrounded by high buildings. A large amount of moving clutter from pedestrians and vehicle traffic.		



Propagation Models vs Real World Measurements
High clutter environment - Duke Street/ Bellgrove
gNodeBike EIRP 27dBm



Housing
Area in
East End

RF Model
Terrain /
Clutter
model

Propagation Models vs Real World Measurements
High clutter environment - Duke Street/ Bellgrove
gNodeBike EIRP 27dBm



Housing
Area in
East End

RF Model
1 metre
Lidar
Model

Propagation Models vs Real World Measurements

Low clutter environment - Stepps
AW3828/AW3923 antenna
gNodeBike EIRP 27dBm

UE Icons

- ☆ Samsung S25U
- △ Sony PDT

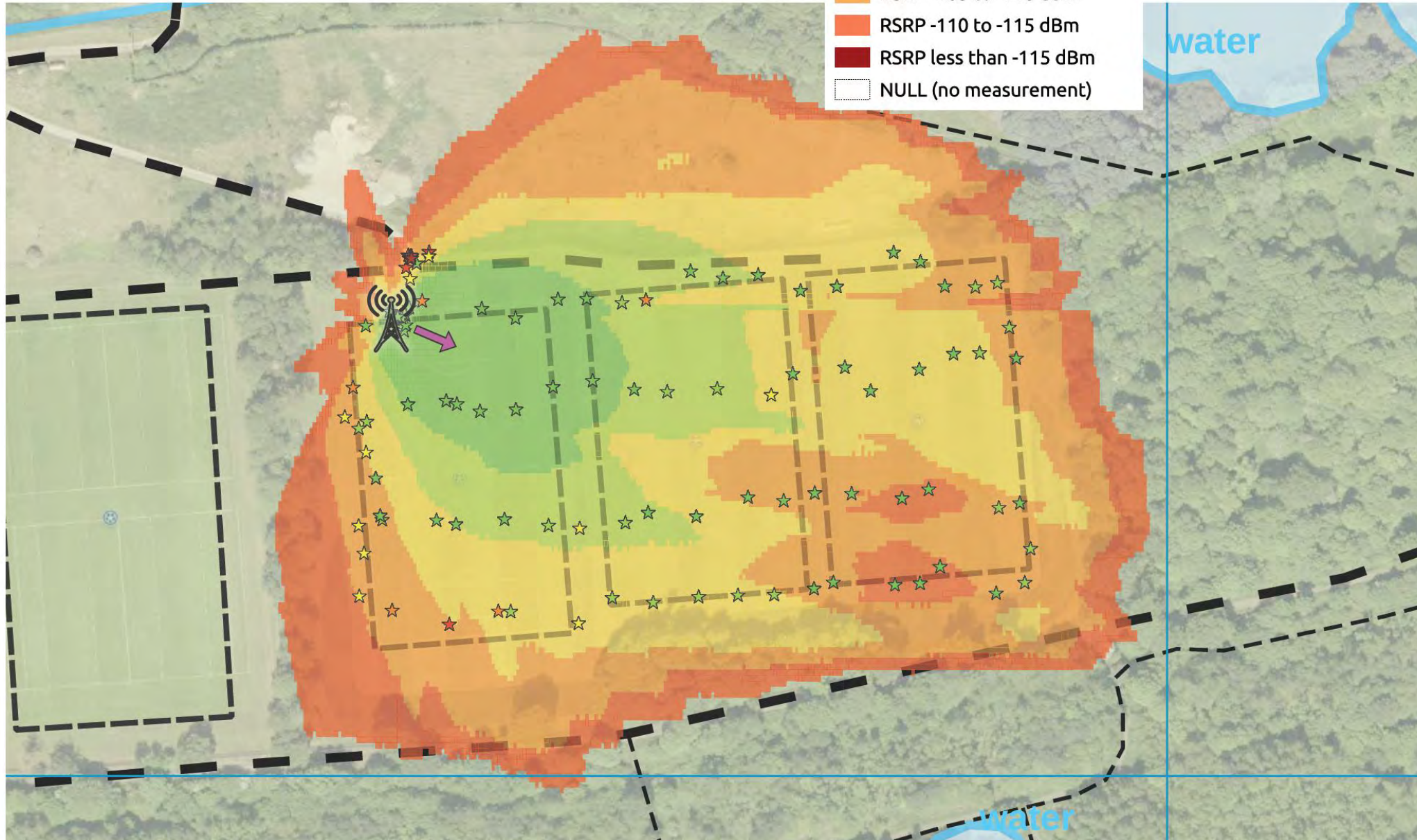
gNB Simulation/ UE Measurement

- RSRP greater than -95 dBm
- RSRP -95 to -100 dBm
- RSRP -100 to -105 dBm
- RSRP -105 to -110 dBm
- RSRP -110 to -115 dBm
- RSRP less than -115 dBm
- NULL (no measurement)



Stepps Open and Flat Parkland Area

RF Model
Terrain /
Clutter
Model



Propagation Models vs Real World Measurements

Low clutter environment - Stepps

AW3828/AW3923 antenna

gNodeBike EIRP 27dBm

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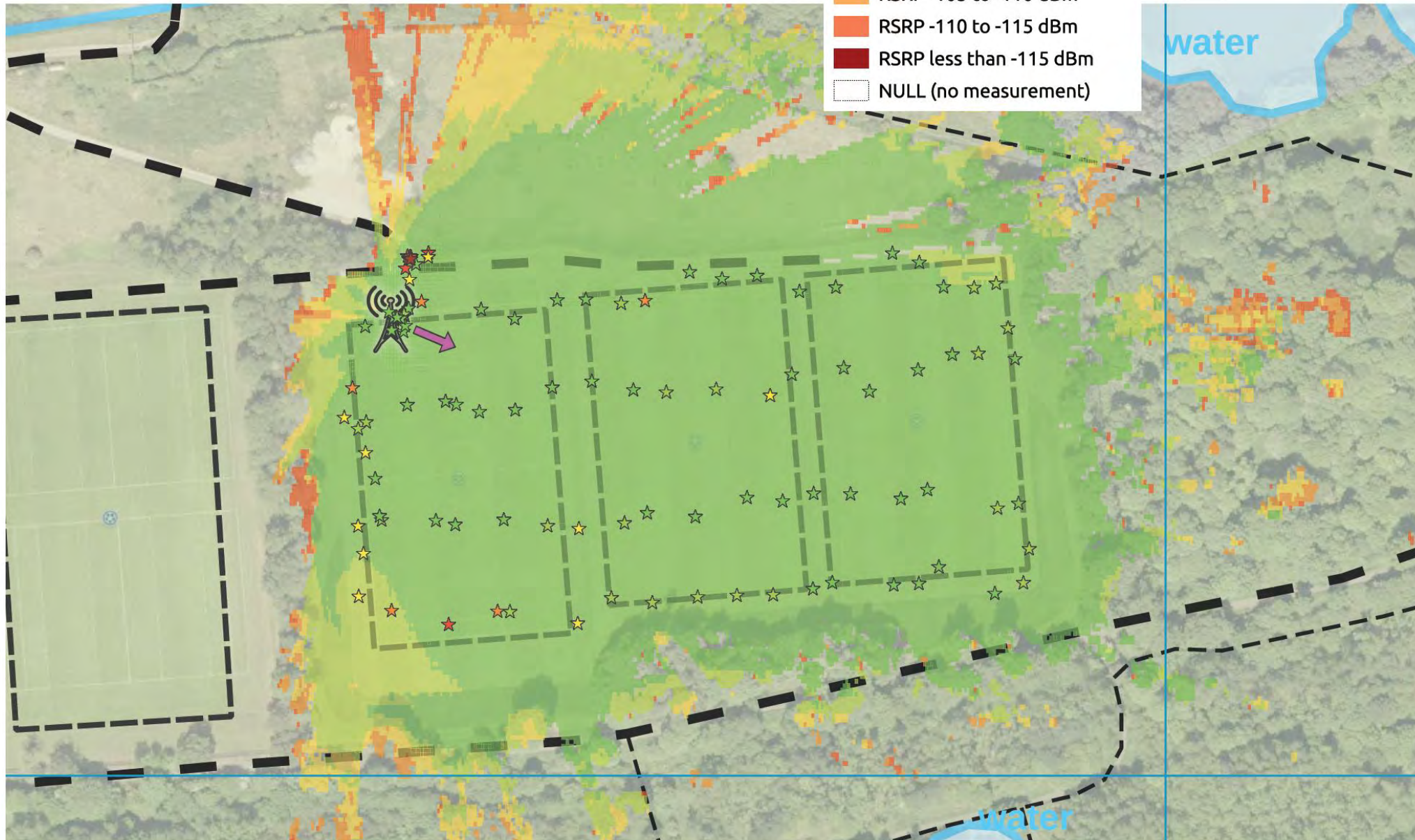
□ NULL (no measurement)



ON SIDE

Stepps Open and Flat Parkland Area

RF Model
1 metre
Lidar
Model



UE Icons

- ☆ Samsung S25U
- △ Sony PDT

gNB Simulation/ UE Measurement

- RSRP greater than -95 dBm
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- RSRP -110 to -115 dBm
- RSRP less than -115 dBm
- NULL (no measurement)

George Square City Centre

RF Model
Terrain /
Clutter
Model



Propagation Models vs Real World Measurements
High clutter environment - George Square
AW3828/AW3923 antenna
gNodeBike EIRP 27dBm

UE Icons

- ☆ Samsung S25U
- △ Sony PDT

gNB Simulation/ UE Measurement

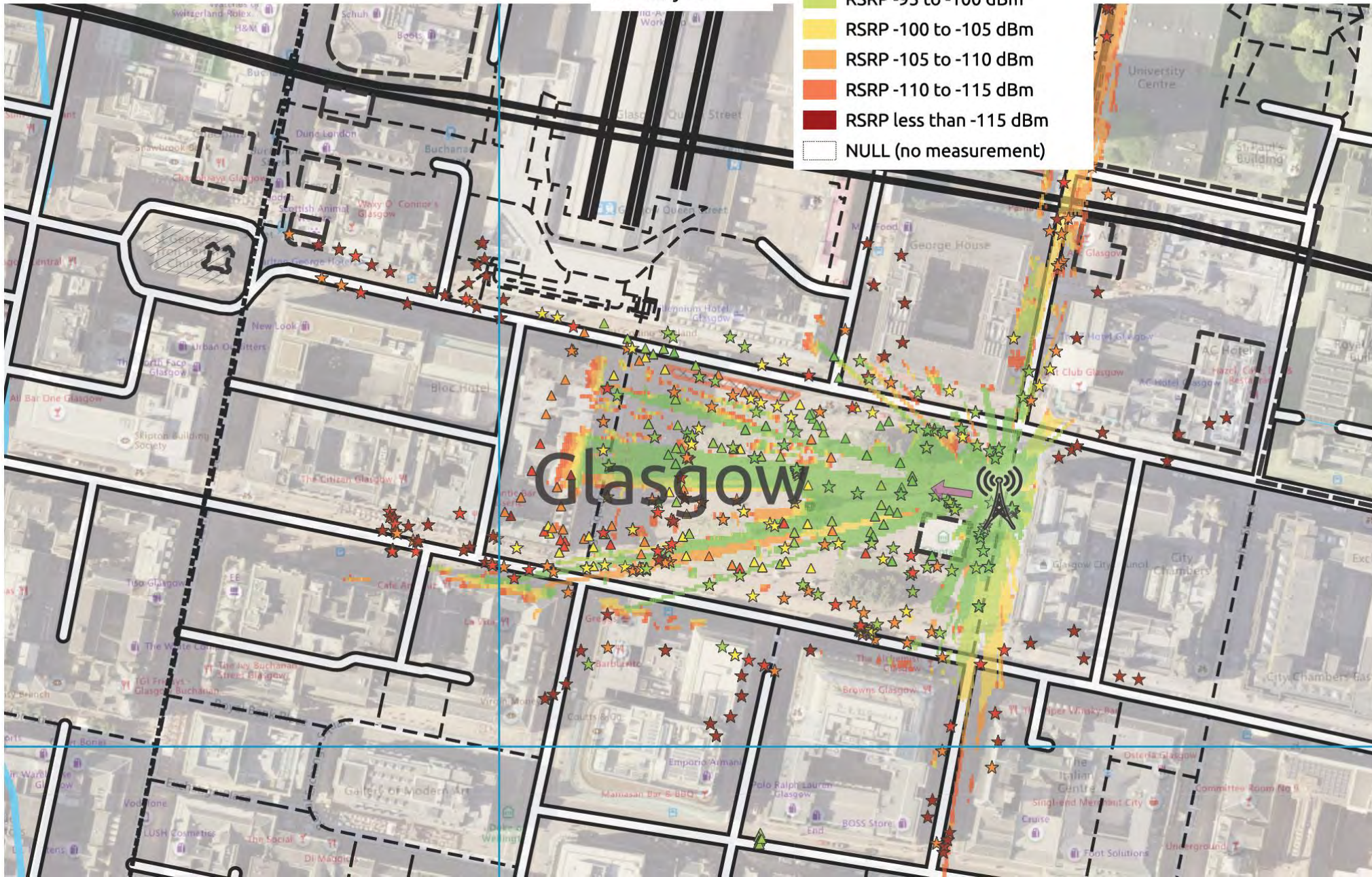
- RSRP greater than -95 dBm
- RSRP -95 to -100 dBm
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- RSRP -105 to -110 dBm
- RSRP -110 to -115 dBm
- RSRP less than -115 dBm
- NULL (no measurement)



ON SIDE

George Square City Centre

RF Model
1 metre
Lidar
Model



ISDR

Takeaway 1:

Know variability, performance, sensitivity, & parameters of:

- Radio front-end and antenna beam patterns
- 5G SA Radio Dynamic range on Tx and Rx
- Radio filtering stages (both analogue and SDR digital)
- RF Planning tools – use appropriate verifiable terrain models
- UE and modem performance varies
- Calibration is challenging - so many variables!

Takeaway 2:

Operable in High Power High Tower (HPHT) Environments

- Front end filtering and radio design will improve n77, less saturation
- Within a 'few 100m' 27dBm n77 operate effectively (power level dependent)
- Front end filtering/screening will greatly enhance performance
- Different uplink/downlink (U/L) ratios – this is OK – engineer it!
- Unsynchronised – this is OK – engineer it!
- Synchronised TDD will always help, but not always essential

Takeaway 3:

Knowing performance: improve SAL & increase P5G use

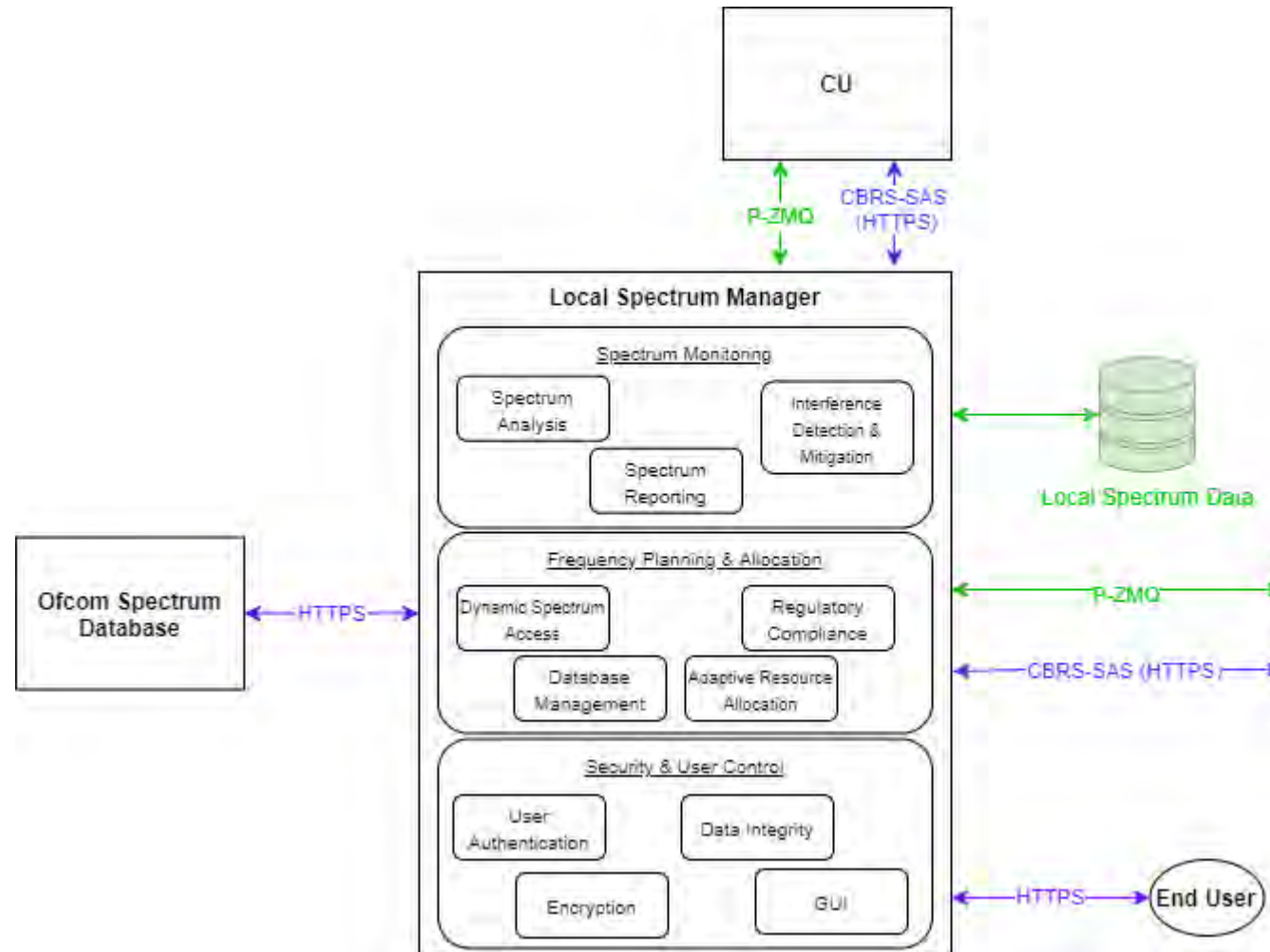
- n77 complementary to public/MNO networks
- If MNO HPHT ‘nearby’, we can engineer networks to work
- n77 ‘whisper networks’ don’t interfere with MNOs (by our measurements!)
- n77 networks can be more densely packed than currently
- In-band on-air spectrum monitoring is operable – bring on the AI.
- CEPT and their n77 mandate – don’t lose the UK lead in SAL!

For real n77u growth?

- We should type approve radio units
- Live Spectrum monitor inside the RU
- RU should report back to **DSA 'managers'**
- Shared access? - **feed into standards 3GPP, Rel 20+**
- In 2025, you need to be **qualified to be deploying**
- To maintain UK lead in shared spectrum ... **need to lead!**

Some NW 2025 Shared Spectrum Activities

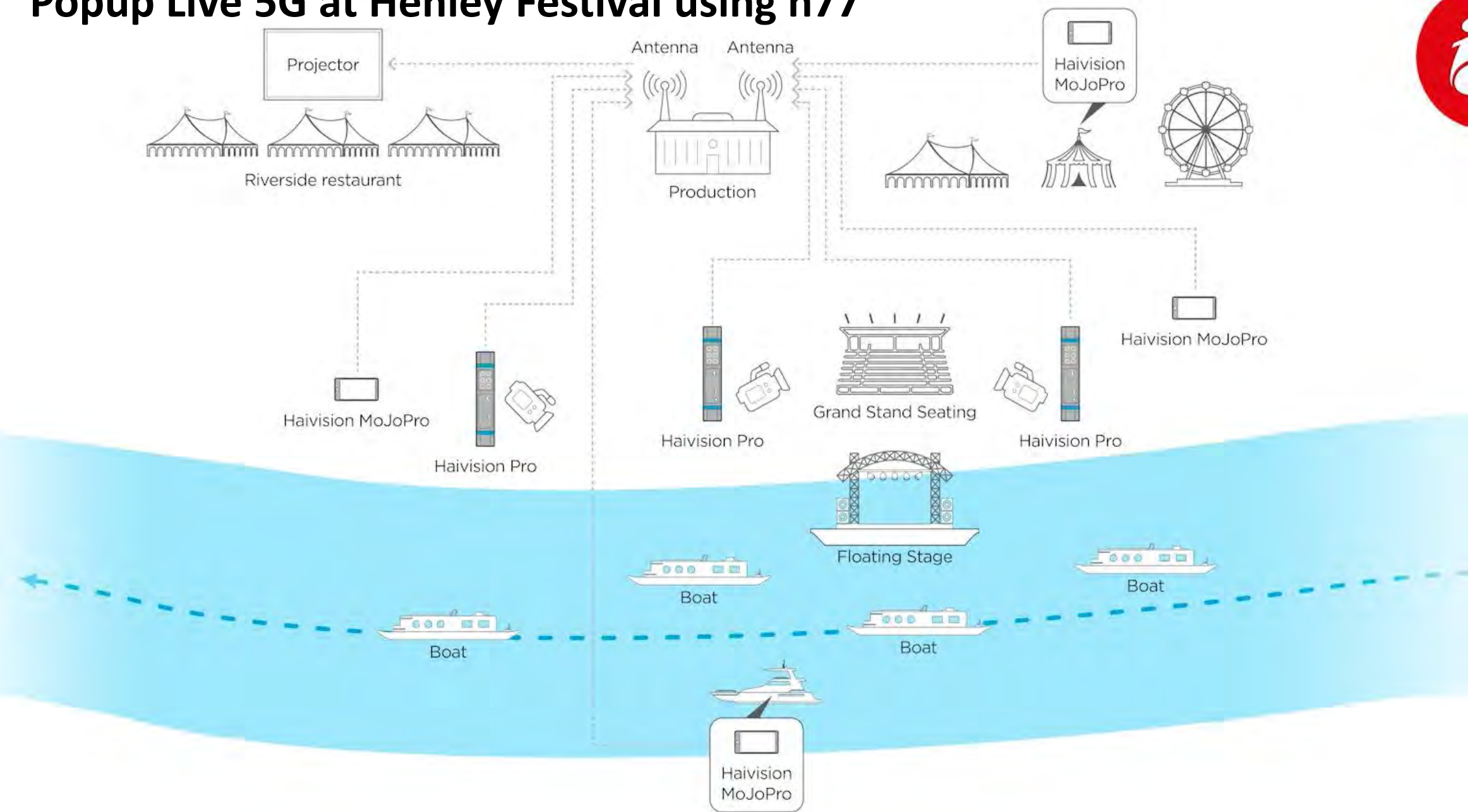
Design for PoC Spectrum Control - ONSIDE



- Coordination:
 - RU registration
 - Sensed Data
 - Interference detection (Cloud RF)
 - ONSIDE licensed bands

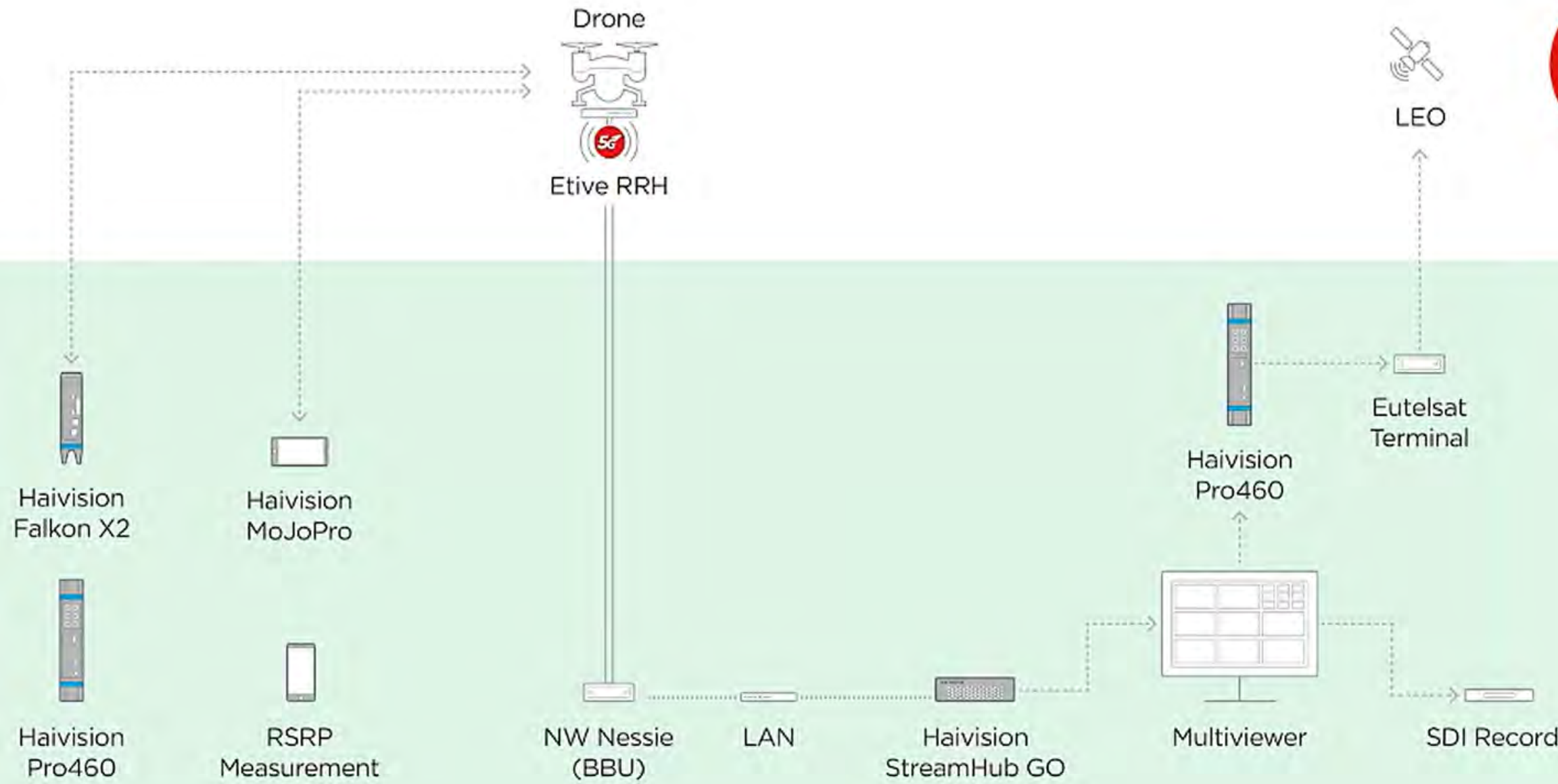
- Tasks:
 - Coordination procedure
 - Local Spectrum Database (LSD) structure

Popup Live 5G at Henley Festival using n77



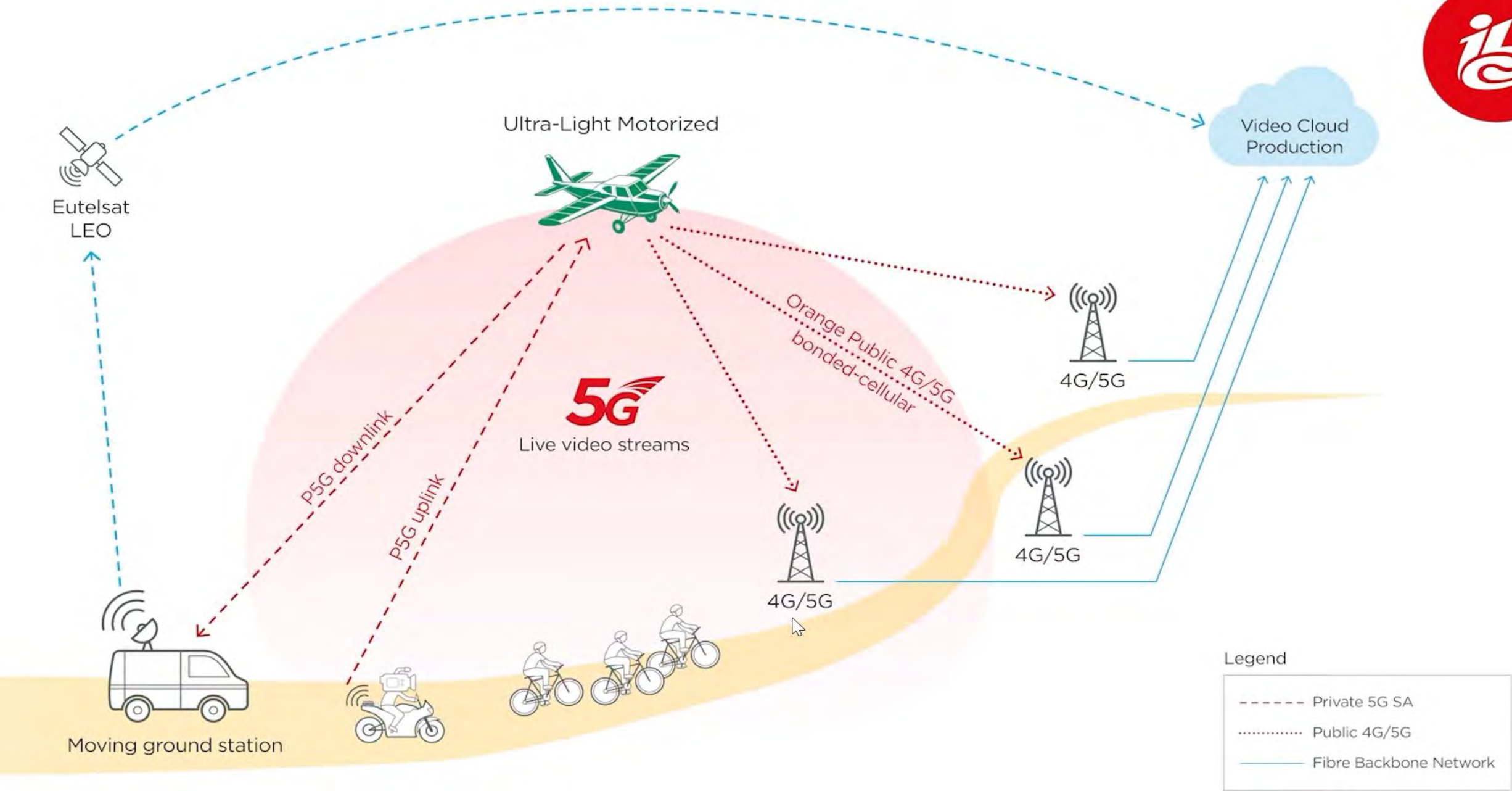
Live tethered drone gNodeB in Italy

Live Private 5G Tethered Drones in Italy



Live Flying private 5G gnodeB in France (MoD spectrum)

Live 5G in the Sky in France, using MoD Spectrum bands



Live 5G in the Sky



Live 5G in the Sky



Live 5G in the Sky



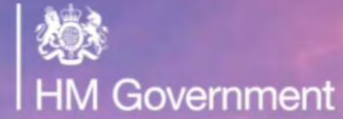
Live at Stadiums, small and large: Twickenham with VMO2



Live with VM02



Live with VM02



Bi-directional 5G-enabled Camera Connectivity and Control for Video Broadcast Production

Single-cell pop-up P5G SA network deployed

N77: 100 MHz

3950 MHz

37 dBm (5 W)

Uplink-biased TDD

Bi-directional (IP)

Remote Camera Control

Tally Light

Talk-back

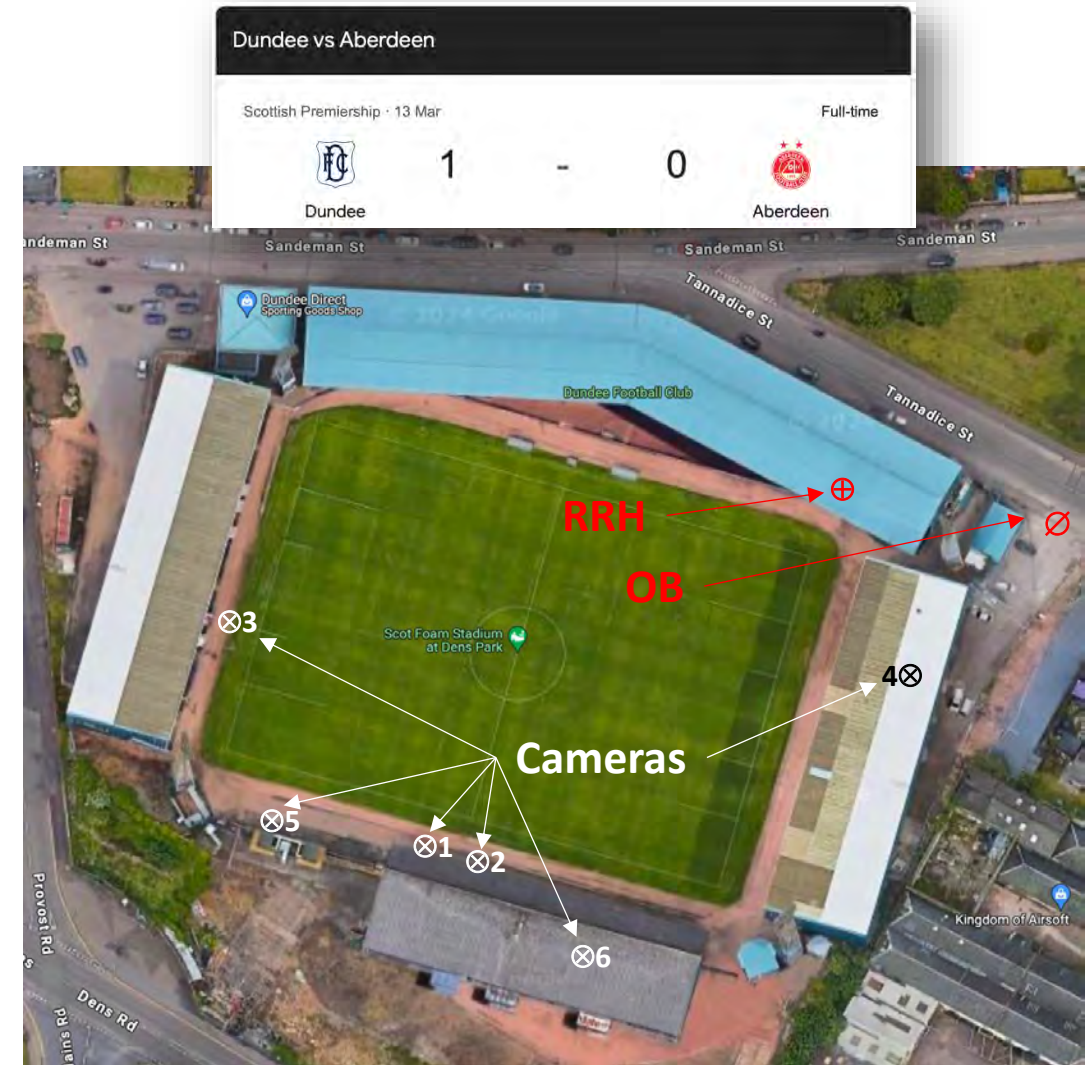
Return Video

Before the game:

- 4x 25 Mbps 1080p50 HEVC 100 ms + 4x 10 Mbps

During the game:

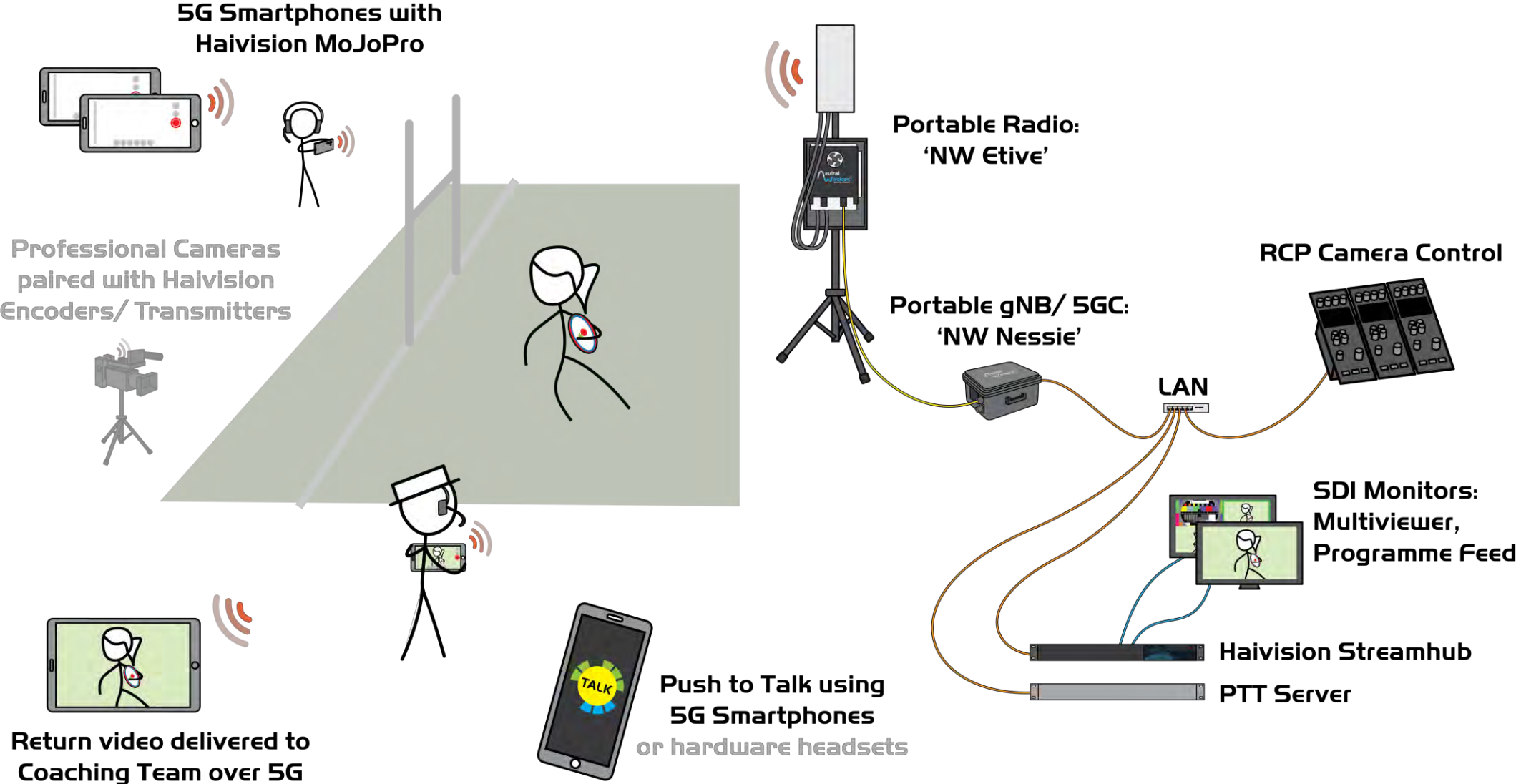
- 6x 25 Mbps 1080i50 HEVC 800 ms + 3x 12 Mbps
- Wireless operation to shadow wired VAR cameras
- VAR operations bay (Glasgow) dedicated to receiving and evaluating the 5G video feeds – tested alongside the formal VAR system



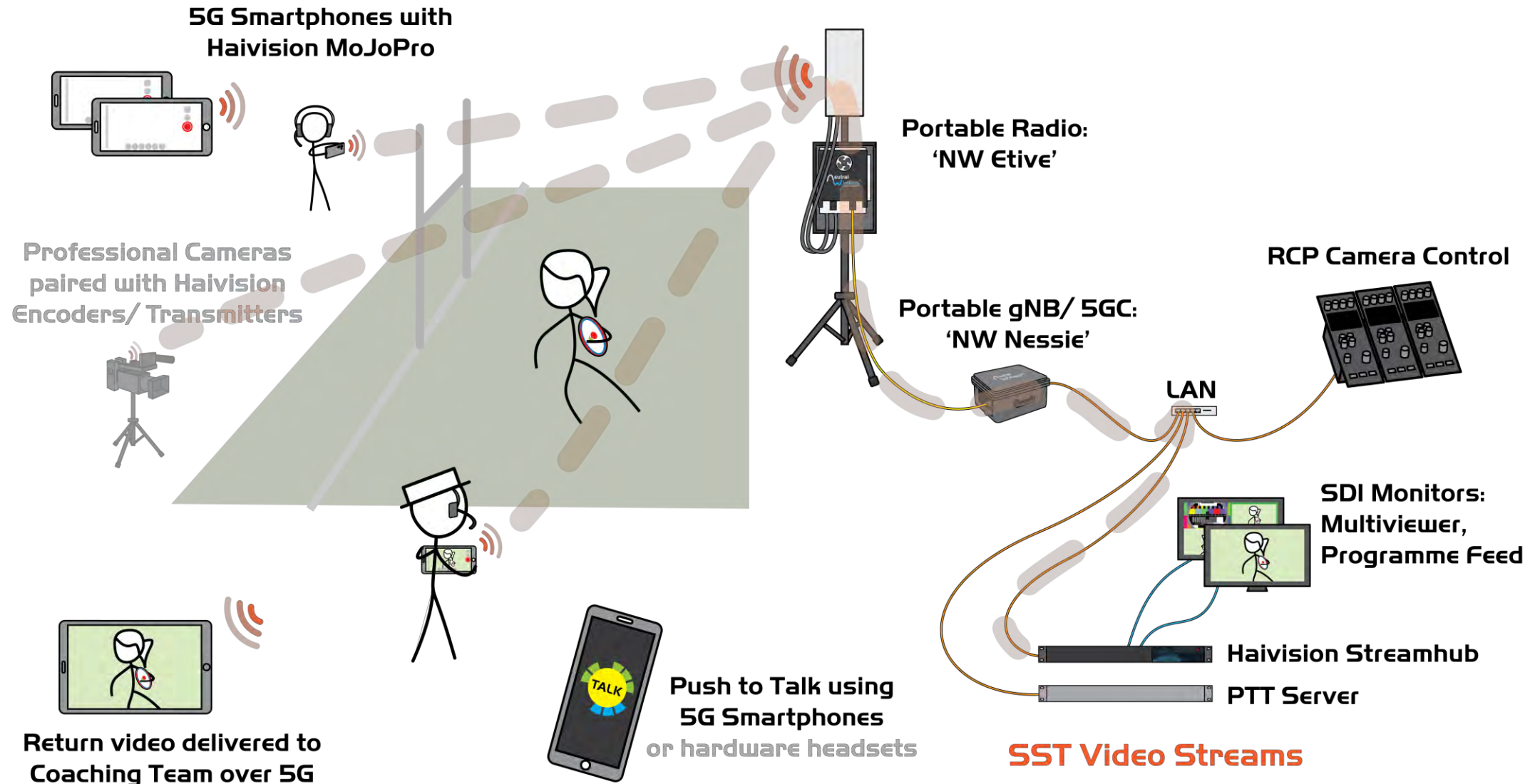
Example Use Case - Live in Stadium

Use Case / Application	UL Data Rate	DL Data Rate	100 MHz Cell No. of Devices	40 MHz Cell No. of Devices	20 MHz Cell No. of Devices	Frame Structure
UHD (4K) Professional Broadcast	50 Mb/s	N/A	5 Streams 1-2 Streams	2 Streams 1 Streams	1 Streams 0 Streams	Uplink Bias "MNO" DL Bias
HD Professional Broadcast	25 Mb/s	N/A	10 Streams 2-3 Streams	5-6 Streams 2-3 Streams	2-3 Streams 0 Streams	Uplink Bias "MNO" DL Bias
Smartphone Camera Broadcast	5-10 Mb/s	N/A	~40 Handsets ~10 Handsets	~18 Handsets ~6 Handsets	8 Handsets 2-3 Handsets	Uplink Bias "MNO" DL Bias
Point of Sales	< 1 Mb/s	< 1 Mb/s	Lots (Depending on utilisation above) ← → Fewer (Depending on utilisation above)			(Any)
Camera Operator Comms	< 1 Mb/s	< 1 Mb/s				
Mission Critical Comms	< 1 Mb/s	< 1 Mb/s				
Pan Zoom Tilt (PZT)	N/A	< 1 Mb/s	Lots ← → Fewer			(Any)
Tally Lights	N/A	< 1 Mb/s				
Return Video Stream	N/A	2-5 Mb/s				

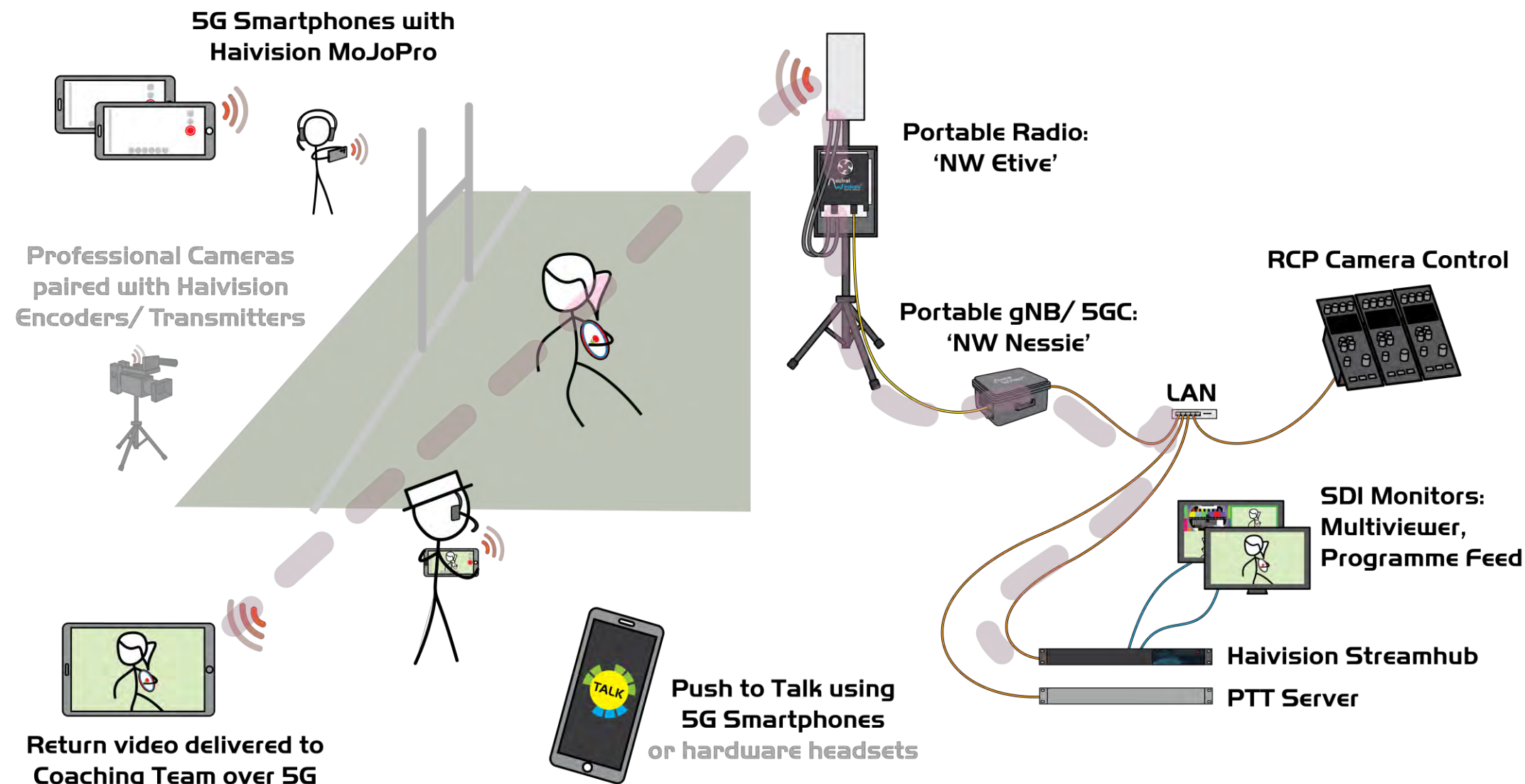
General Layout for Live Events & Communication



SST Video Streams from Cameras to Radio

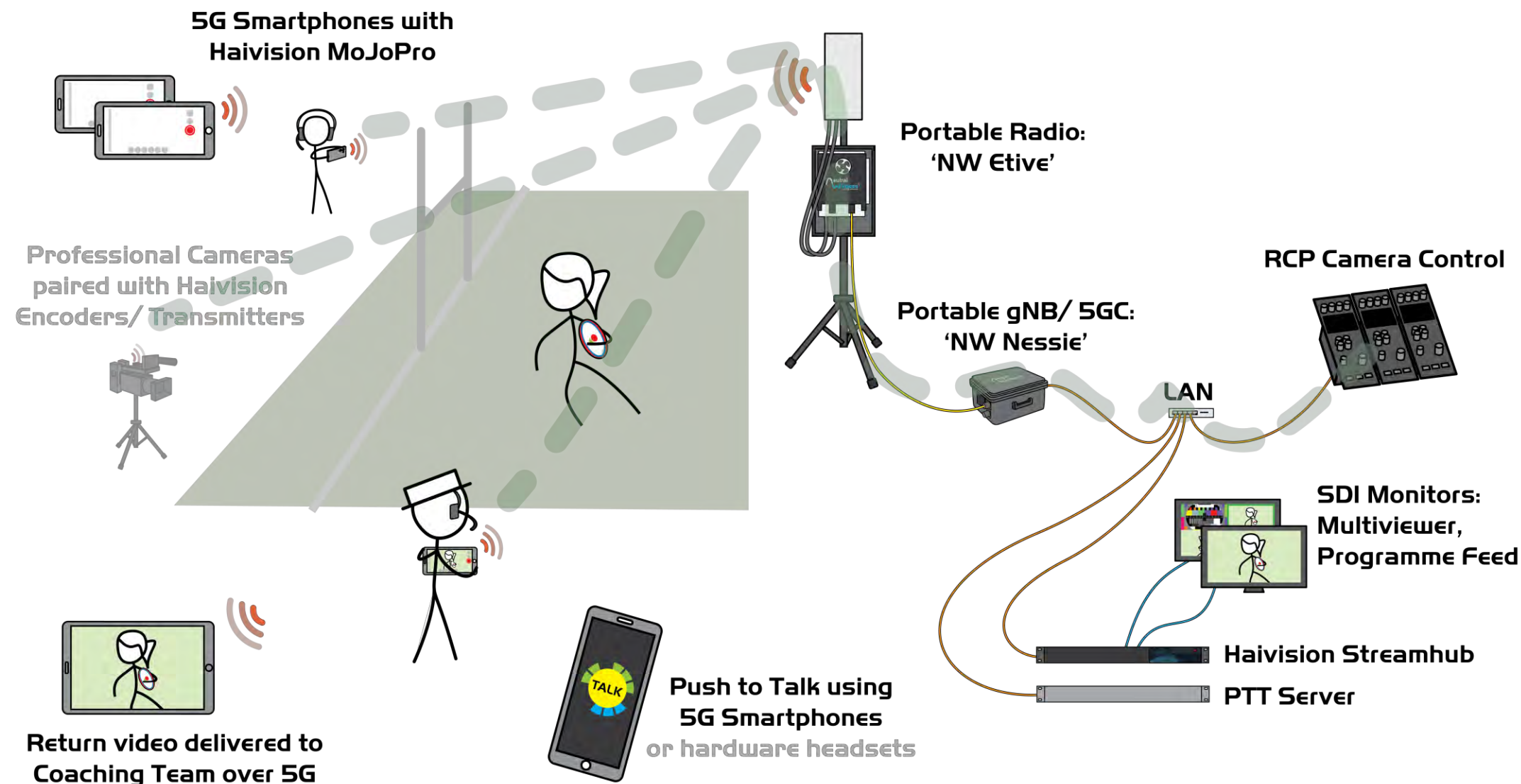


SRT Return Video for Multiviewers (& coaches)



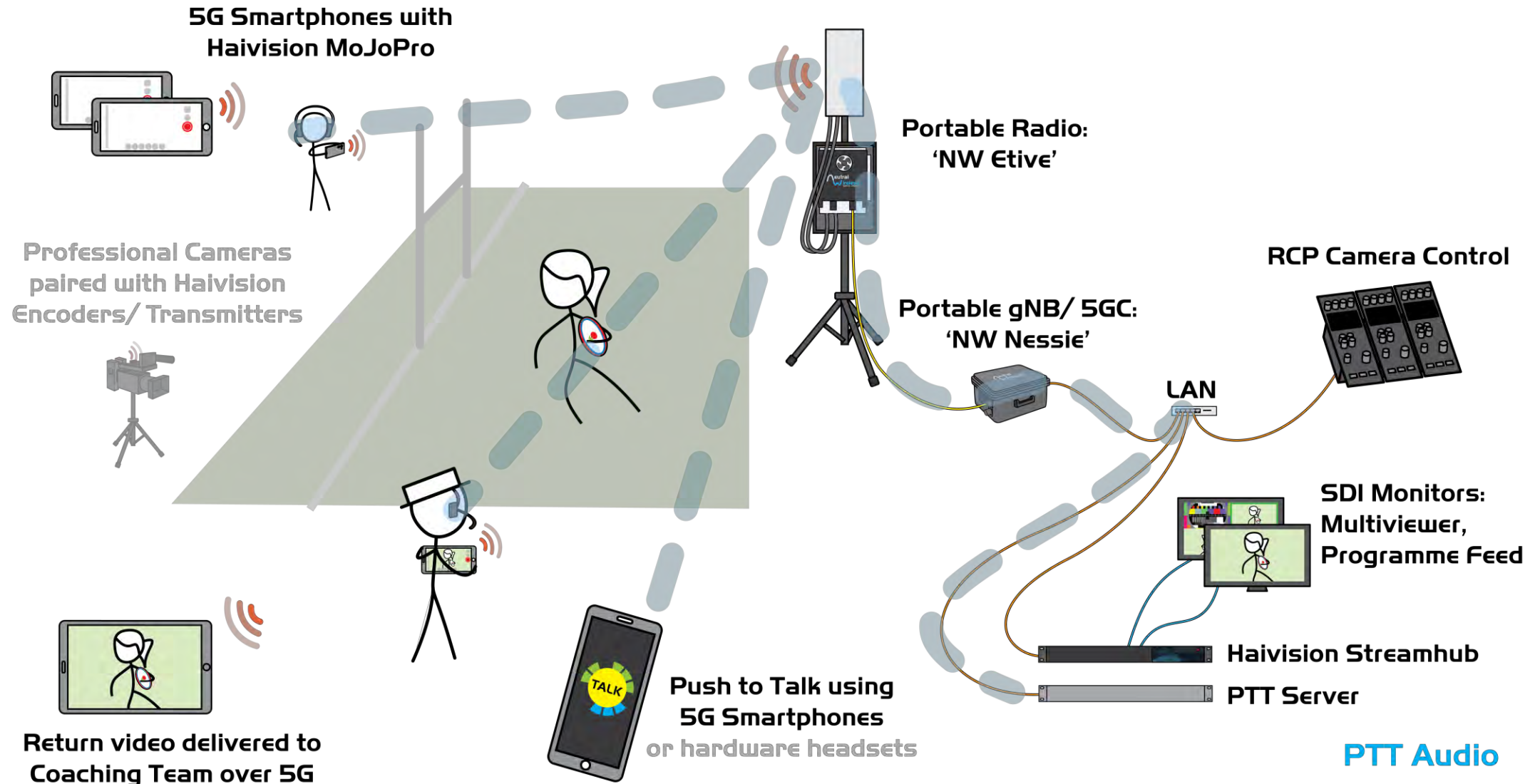
SRT Return Video

RCP (Remote Control Panel) Camera Control

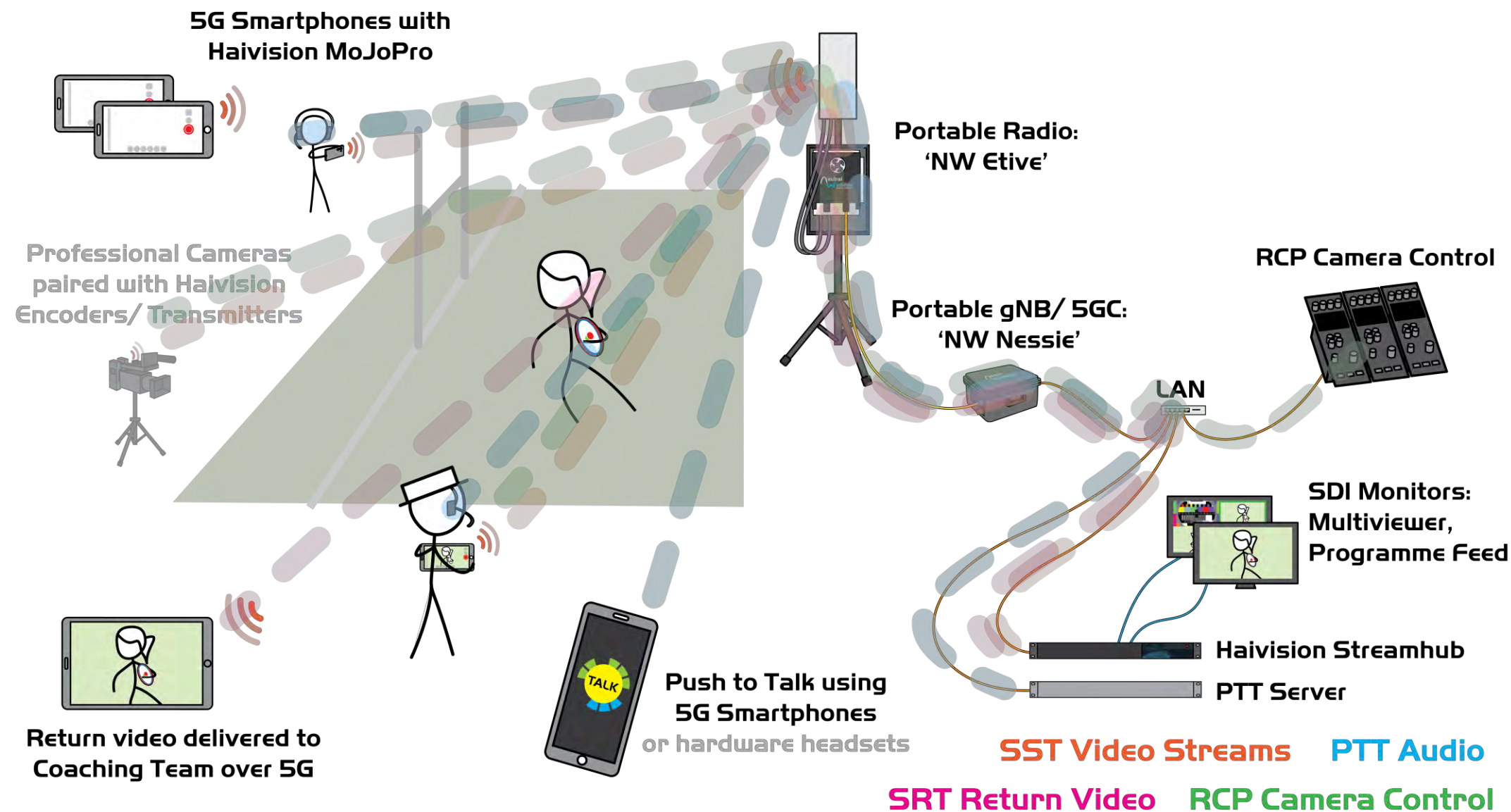


RCP Camera Control

Push-to-Talk (PTT) Audio



All running as one ...



Live in Ireland for PPDR - Public Protection and Disaster Relief



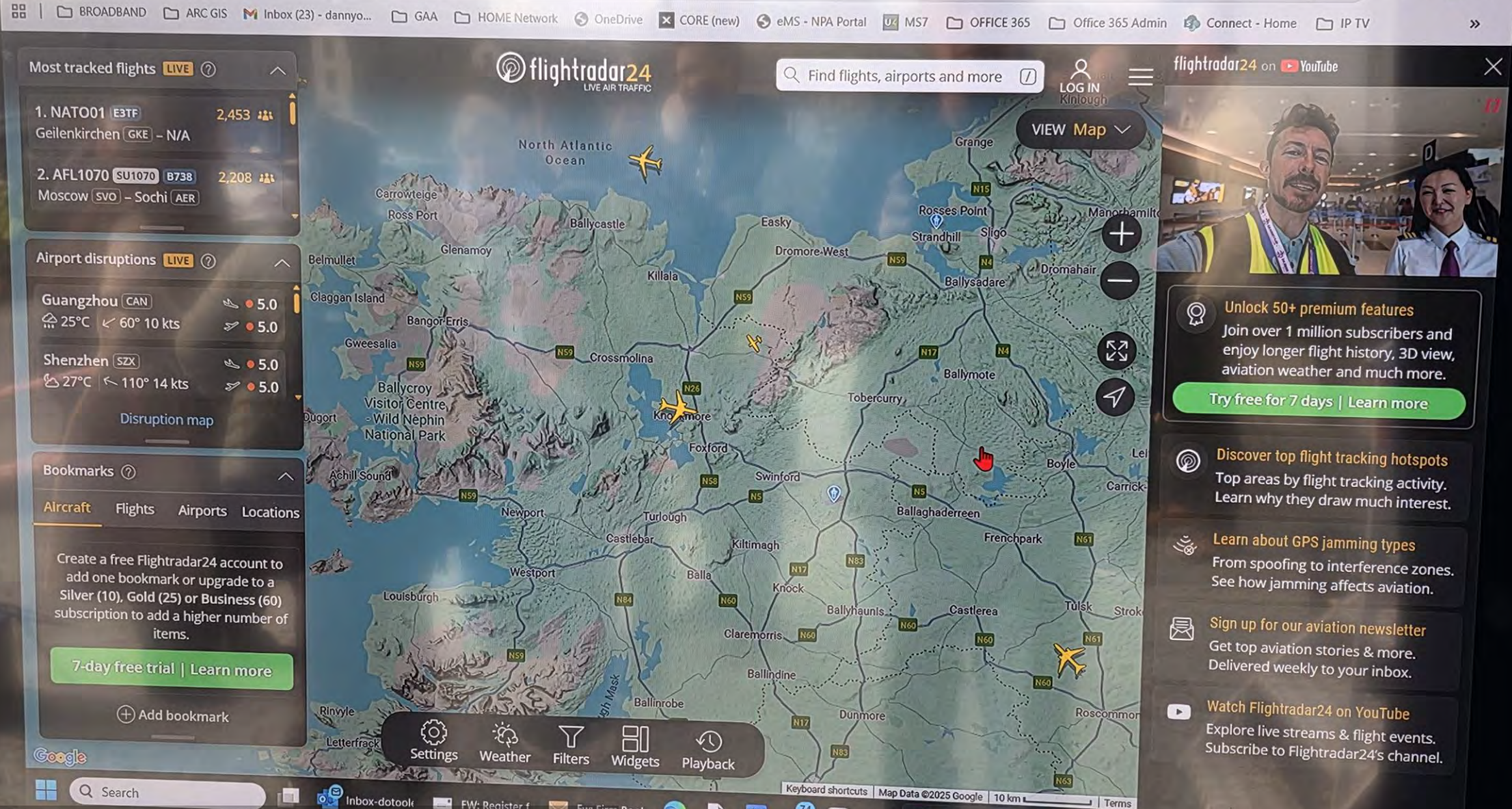
Live with in Ireland for PPDR

Live in Ireland for PPDR - Public Protection and Disaster Relief



Live with in Ireland for PPDR

Live in Ireland for PPDR - Public Protection and Disaster Relief



Live with in Ireland for PPDR

Live in Ireland for PPDR - Public Protection and Disaster Relief



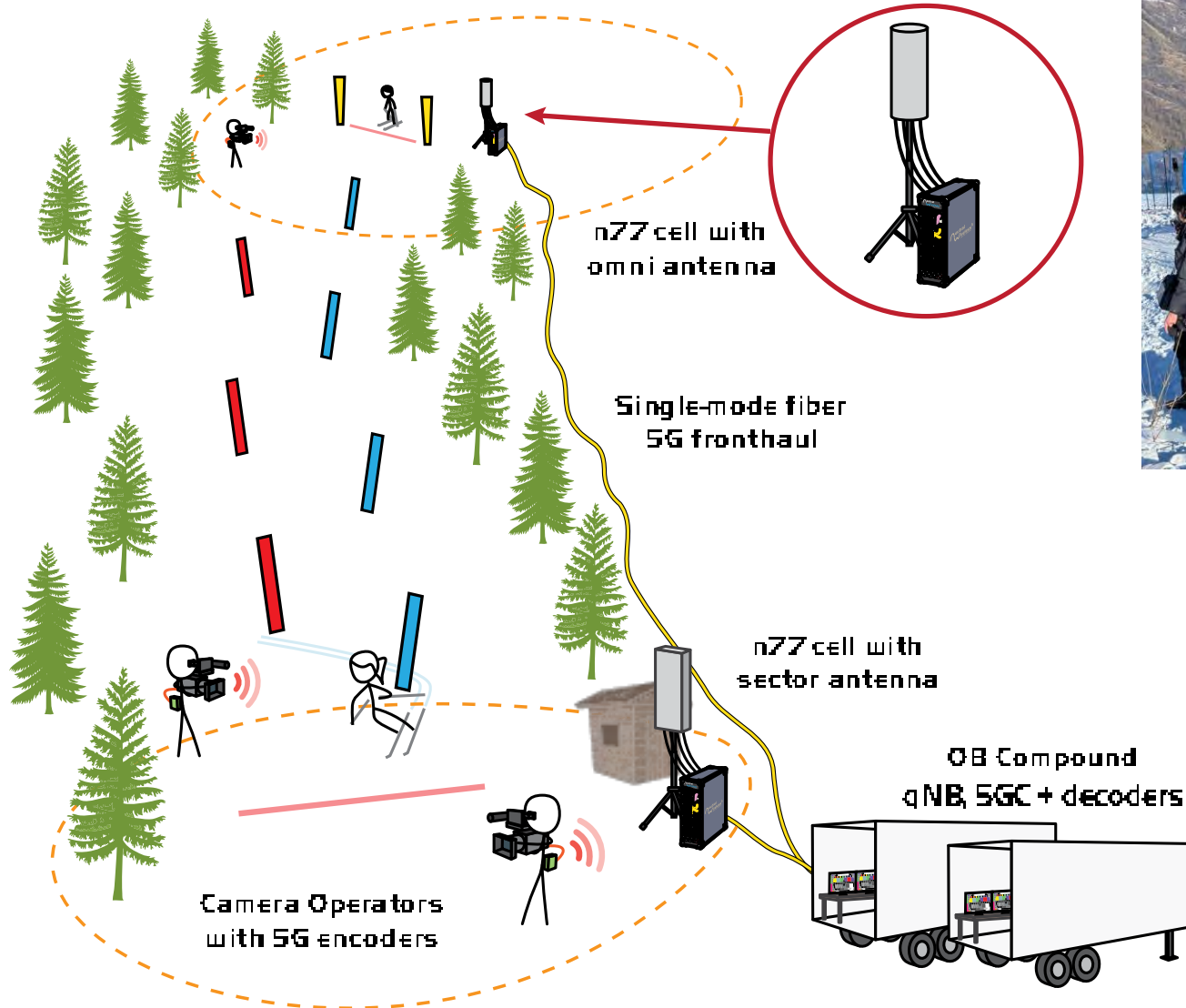
Live with in Ireland for PPDR

Torino 2025

FISU World University Games



Alpine Downhill Skiing – P5G ULL Broadcasting

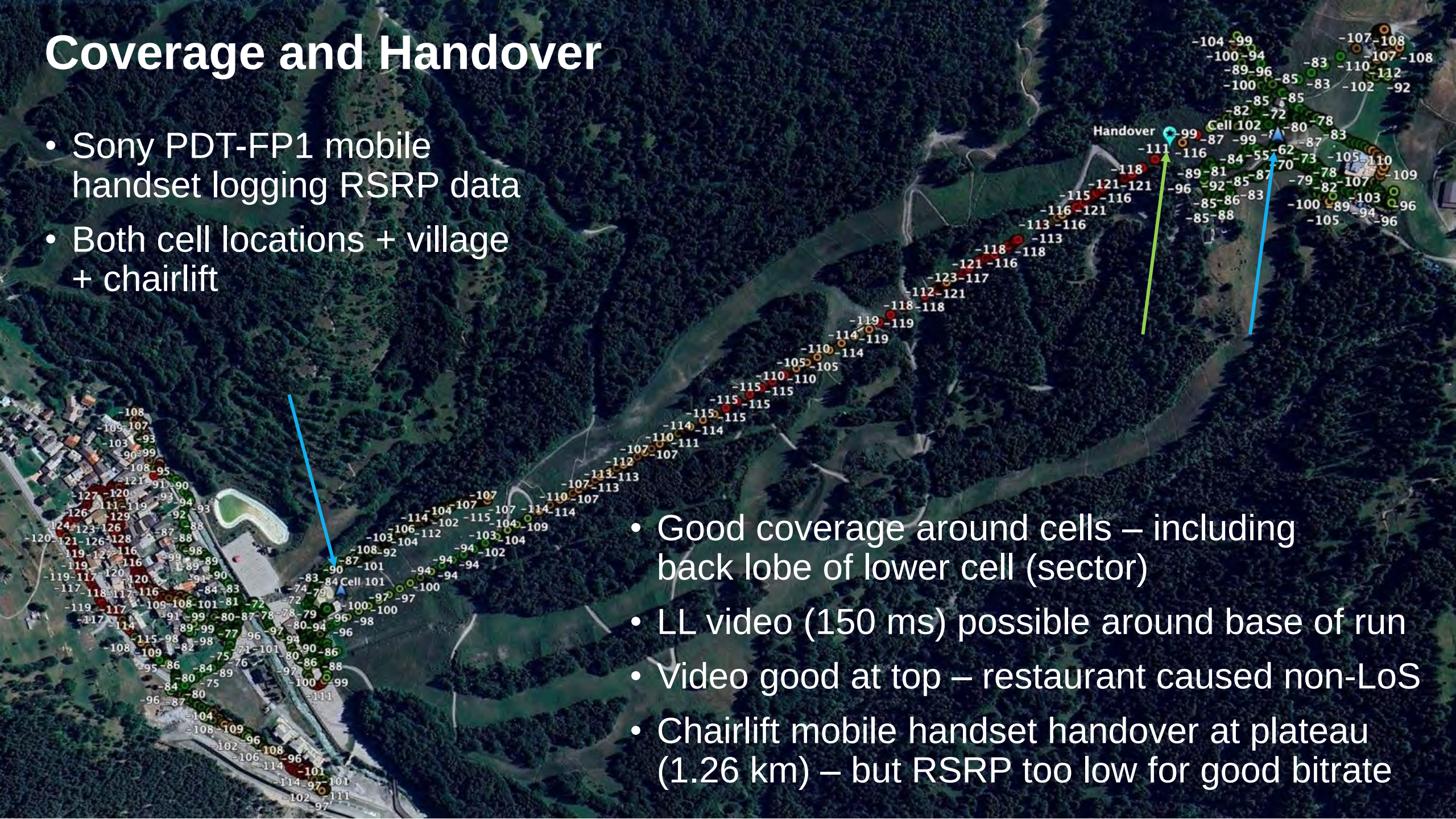


- RAI licensed spectrum
- Two n77 cells – 100MHz
- One BBU in OB truck
- UL-biased frame structure
- Four LL camera feeds + mobile handsets



Coverage and Handover

- Sony PDT-FP1 mobile handset logging RSRP data
- Both cell locations + village + chairlift



- Good coverage around cells – including back lobe of lower cell (sector)
- LL video (150 ms) possible around base of run
- Video good at top – restaurant caused non-LoS
- Chairlift mobile handset handover at plateau (1.26 km) – but RSRP too low for good bitrate

Screen capture video output

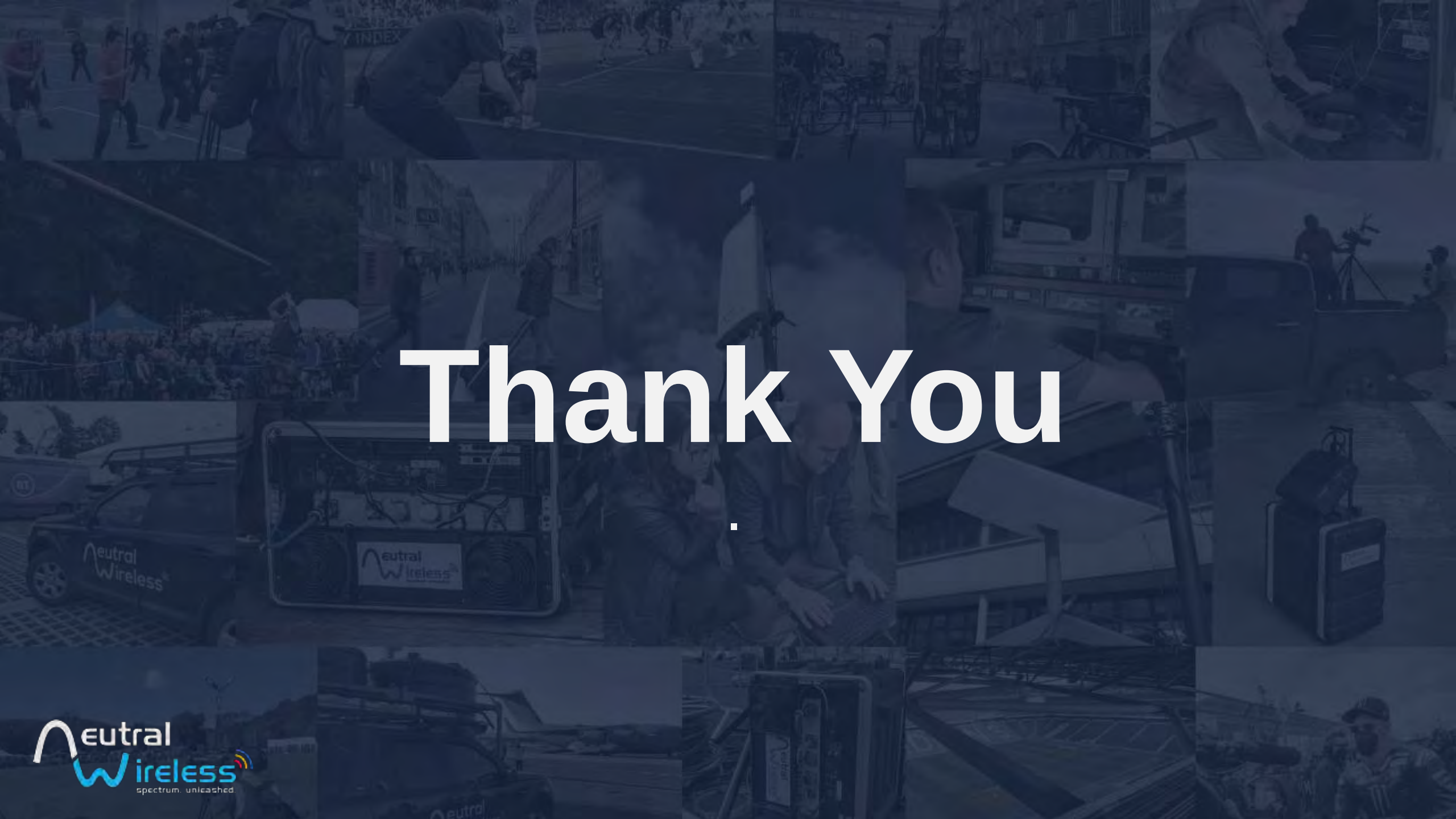


- LL video feeds using codecs from Haivision and Sony + contribution feeds from mobile handsets
- MojoPro app used to capture live content from chairlifts and piste as colleague skied down
- Note iPhone streaming the MojoPro feed and camera with Sony encoder are filming each other

- Potential for cameras to deliver new content from new perspectives and locations (even from the athletes themselves)
- Opens up host of new angles and opportunities for storytelling, bringing audiences closer to the athletes and action

<https://nw5g.com/winnforum>





Thank You