Durham Spectrum Sandbox

Centre for Communication Systems, Durham University
Telet , TRL
Ranplan
London Economics

Consortium introduction

Durham University: Consortium lead, WP0 lead WP1, WP2

- Equipment and facilities to support WP1 and WP2
- Close engagement with key regulators: Ofcom, ITU
- Extensive expertise leading diverse research consortia
- Lead: Professor Sana Salous, Director of CfCS

Telet: WP1

- MNO with several testbeds in key freq bands
- Expert in 5G network deployment & spectrum use
- Close engagement with DSIT (technical and policy)

TRL: WP1 lead

- Purpose-built testbed to trial connectivity solutions
- Testbed is configurable & technology agnostic compatible with WiFi, LoRaWAN, 5G, DSRC, fibre, with digital twin

Ranplan Wireless: WP2 lead

- Software solutions to optimise wireless network design
- R&D in radio propagation, small cells, DAS, and RAN

London Economics: WP3 lead

- Experts in policy, economics, and regulation, including focus on telecoms
- Strong cost and benefit modelling capabilities
- HMT Green Book expertise

WP1 | **WP2** | **WP3**

Spectrum Sharing Pairs

Five pairs with 1-4 in the upper 6 GHz band (6.425-7.125 GHz)

1. Mobile and WiFi
2. Mobile and Fixed links
3. Mobile and Scientific stations: Radio Astronomy Stations
4. Mobile and Ultrawideband: Through wall imaging radar
5. Private networks in the N77 band

- Pairs 1 & 5 to be tested in WP1 testbeds; 1 to 5 in WP2 simulation
- Sharing for Upper 6GHz band for Mobile and WiFi pair: indoor/outdoor split & spectrum sensing

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WP1 & WP2 Measurement & Simulation

WP1

Telet/TRL: set up the 5 GHz Blinq radios in London and the N77 for the first two pairs

Durham University:

- design and build new RF heads in the upper 6 GHz band,
- conduct outdoor propagation measurements in two frequency bands (5 GHz and upper 6 GHz band) for verification of results in the upper 5 GHz bands and calibration of Ranplan network planning tool for WP2

FIGURE 1-1 FW-300i UNIT ON A POLE

5GHz Blinq radio

77 PC802 radio

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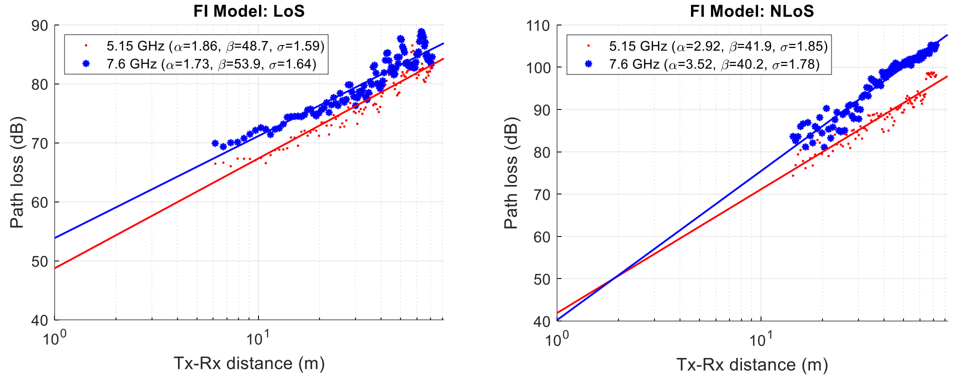
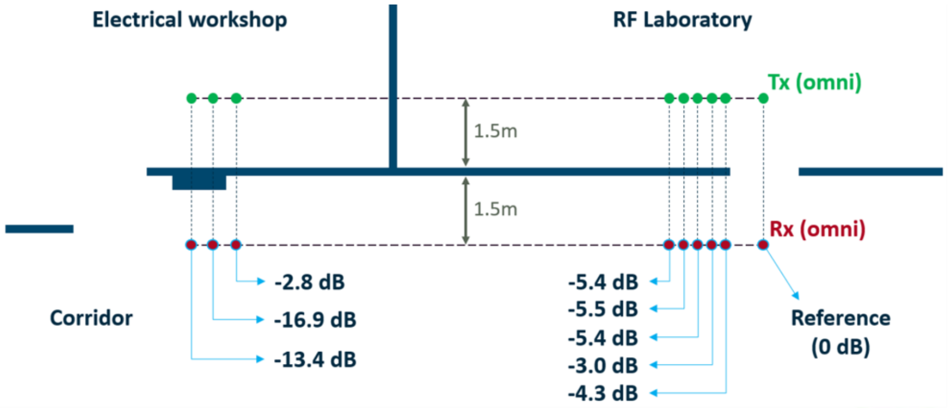
WP1: Path Loss of 5.2 GHz and 7.6 GHz Outdoor Measurements

Material	dB Loss at 5 GHz	dB Loss at 6.515 GHz
Reinforced concrete (203 mm)	55	63
Concrete (203 mm)	48	54
Brick-faced concrete	41	48
Brick-faced masonry block	32	43
Concrete (102 mm)	22	25
Brick	15	15
Masonry block	15	16
Lumber (Dry – 38 mm))	3	4
Glass (6 mm)	1	1

Measurement Results and Model Fitting Results



Frequency	Free Space Path Loss at 21 m
7.6 GHz	76.52 dB (75.94 dB measured)
6.775 GHz	**75.52 dB**
5.8 GHz	**74.17 dB**
5.2 GHz	73.22 dB (73.43 dB measured)



The difference between the measured path loss and the free space path loss is <0.6 dB

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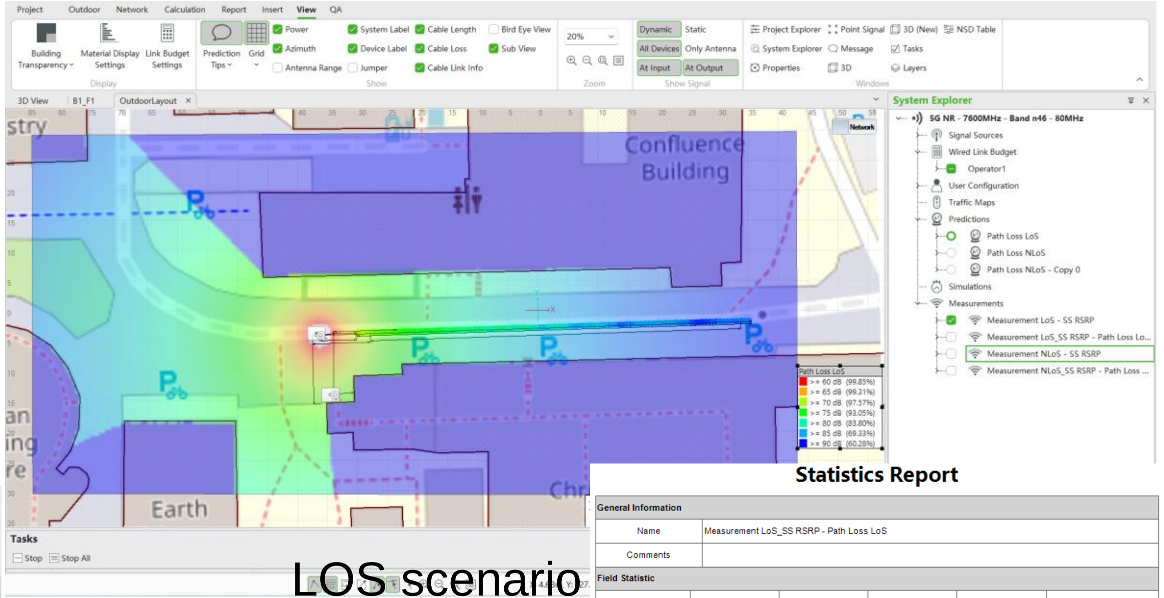
WP2 Simulation Tool Propagation Engine Calibration

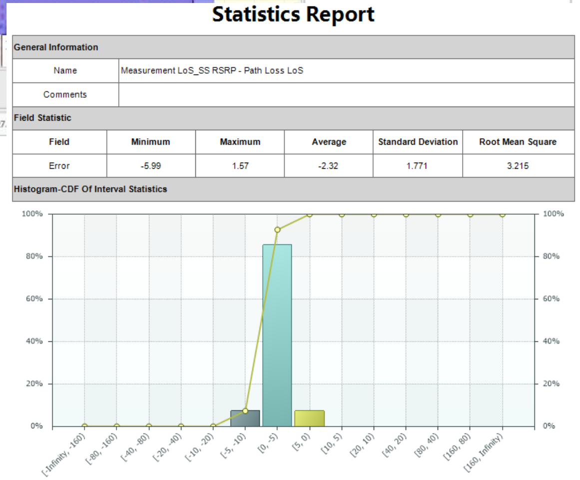
Configuration

- Upper 7GHz band
- LOS and NLOS scenarios

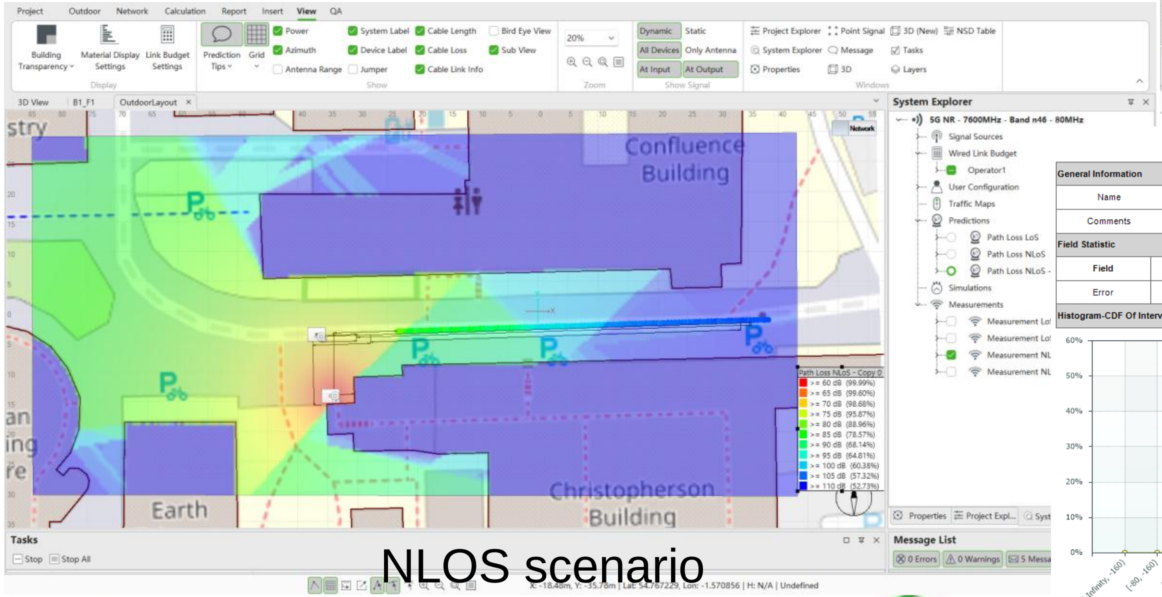
Ray-tracing results meet the measurement results

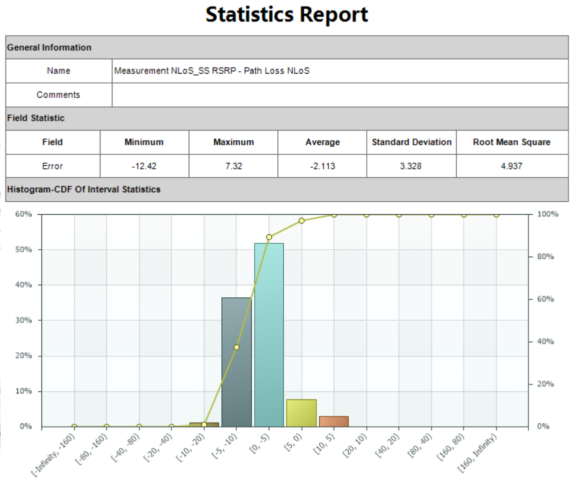
	Average (dB)	Standard Deviation (dB)
LOS	-2.32	1.771
NLOS	-2.11	3.328





LOS scenario





NLOS scenario

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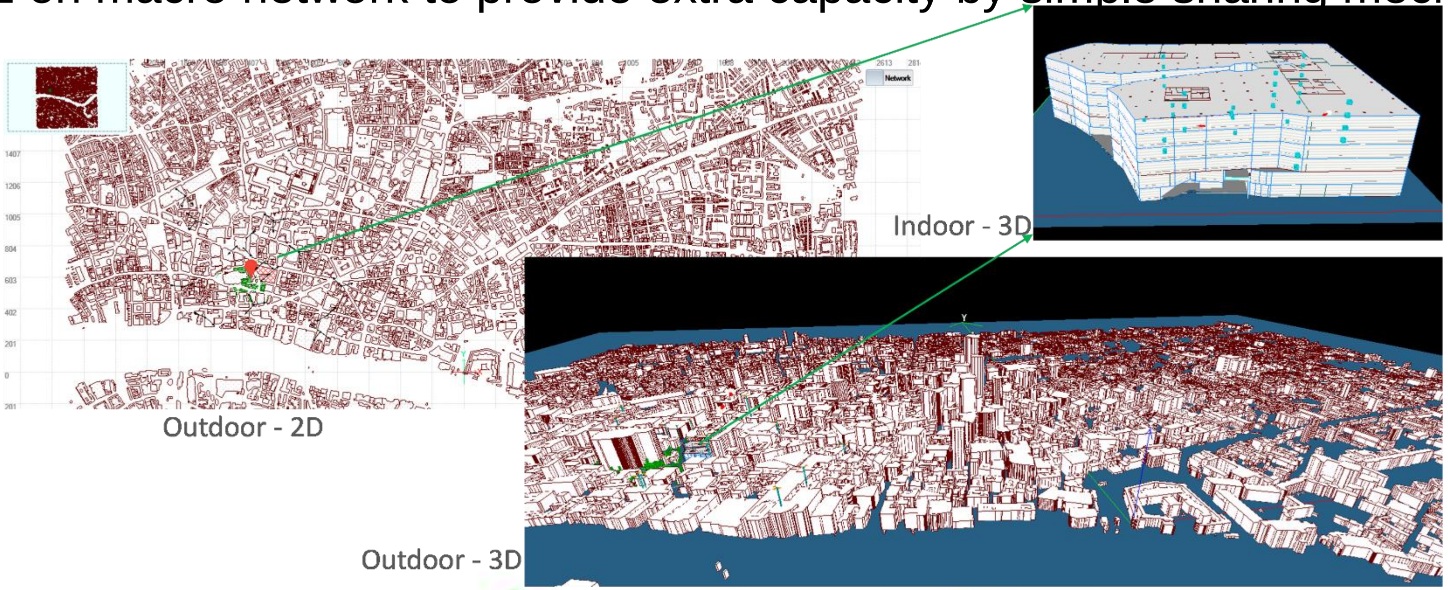
WP2 Simulation: Pair 1 – Mobile and WiFi

Spatial separation sharing mechanism

- Dense urban scenario
  - Building penetration loss to help isolate mobile and WiFi
  - Adjusting BS power to limit the indoor overlap interference
- Simple indoor/outdoor split sharing mechanism for mobile and WiFi
- Upper 6GHz on macro network to provide extra capacity by simple sharing mechanism



Pair 1: Dense Urban London project

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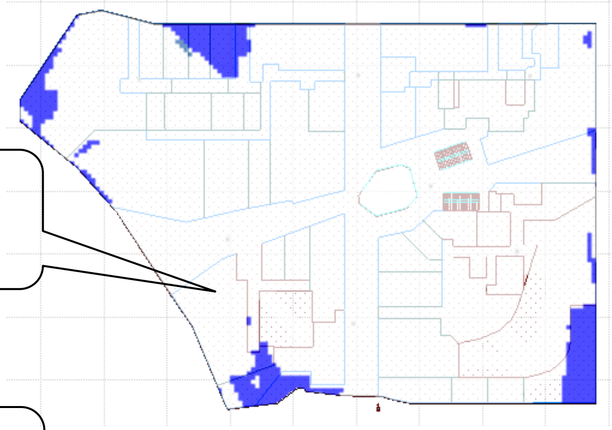
WP2 Simulation: Pair 1 – Mobile and WiFi

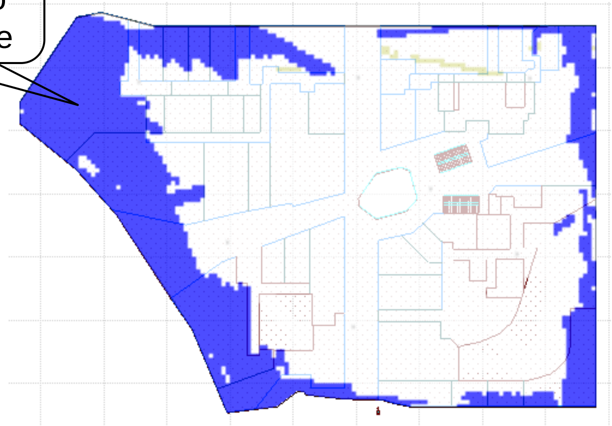
Scenario definition:

- London dense urban with approximately 8.5 km²
- High-rise building and flat terrain
- High-loss concrete wall and loss double-glaze glass
- Dedicated indoor WiFi system for buildings exceeding 50.000 m² in floor area

Configurations:

- Outdoor 5G NR and indoor WiFi 7 with upper 6GHz band
- Penetration loss: Concrete: 34.15 dB/
  Double glazing glass : 4.46dB
- Macro Tx power adjustment from 67dBm to 43dBm
  - Indoor overlap to reduce the interference due to spectrum sharing





Outdoor to indoor isolation scenario

WP2 Simulation: Pair 1 – Mobile and WiFi

Traffic configuration:

- 70% indoor traffic and 30% outdoor traffic

Conclusions:

- Upper 6GHz mobile network average TP degrades by 25.6%, and cell-edge TP degrades by 87.1% when adjusting Tx power from 31 to 67dBm

- Coverage improves by 8.9%, which means reducing Tx power will impact the coverage, and new BS need to be added

- From the simulation results, 43dBm Tx power is the minimum value

Macro TX power dBm	Coverage (%)	DL average user TP (Mbps)	Cell edge user TP (Mbps)
31	87.3	40.3	7.8
37	90.1	38.9	4.4
43	92.2	37.6	1.8
49	93.1	35.3	1.7
55	93.8	32.9	1.3
61	94.6	31.1	1.1
67	95.1	30.2	1.0

Overall DL coverage and throughput with Tx power adjustment

WP2 Simulation: Pair 3 - Mobile and Scientific stations

Spectroscopic observations of the methanol molecule 6 650–6 675.2 MHz

WRC-23 passed a Resolution

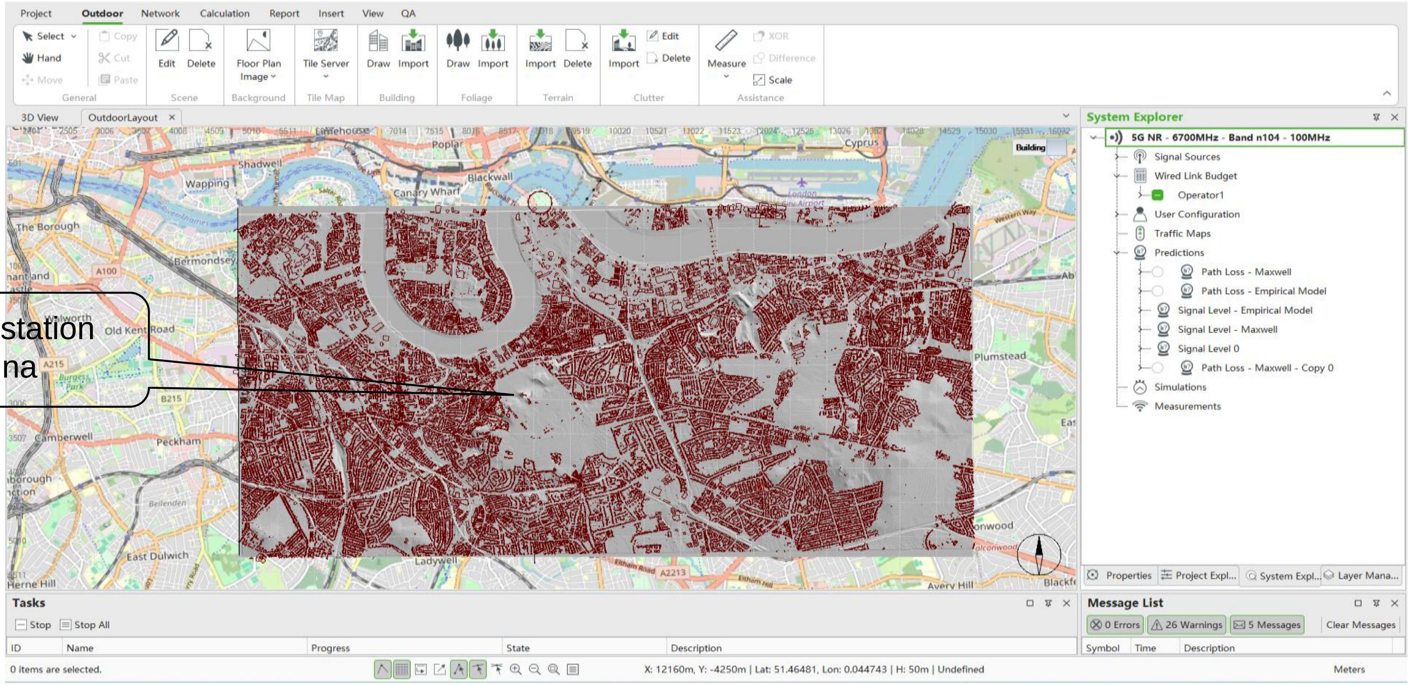
'*inviting the ITU-R* "6 to develop an ITU-R
Recommendation to address methods for the determination
of the **protection** area around existing RAS stations from Mobile
stations in the frequency band 6 650–6 675.2 MHz".

WP2 Simulation: Pair 3 - Mobile and Scientific stations

Interference analysis

- Greenwich project
  - Approximately 10 by 5 km² urban area with flat terrain

Scientific station antenna



UK Stations
Jodrell Bank
Pickmere
Darnhall
Knockin
Defford
Cambridge
Goonhilly
Chilbolton

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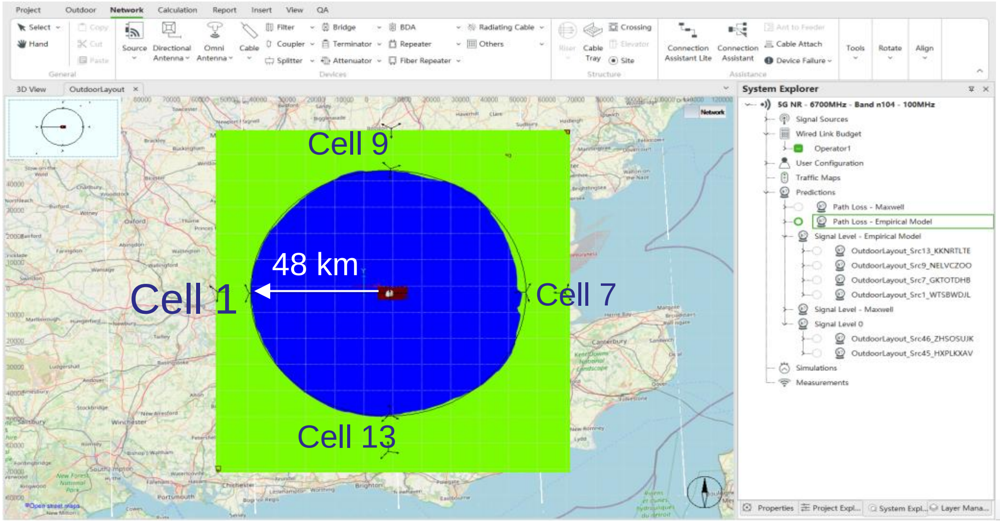
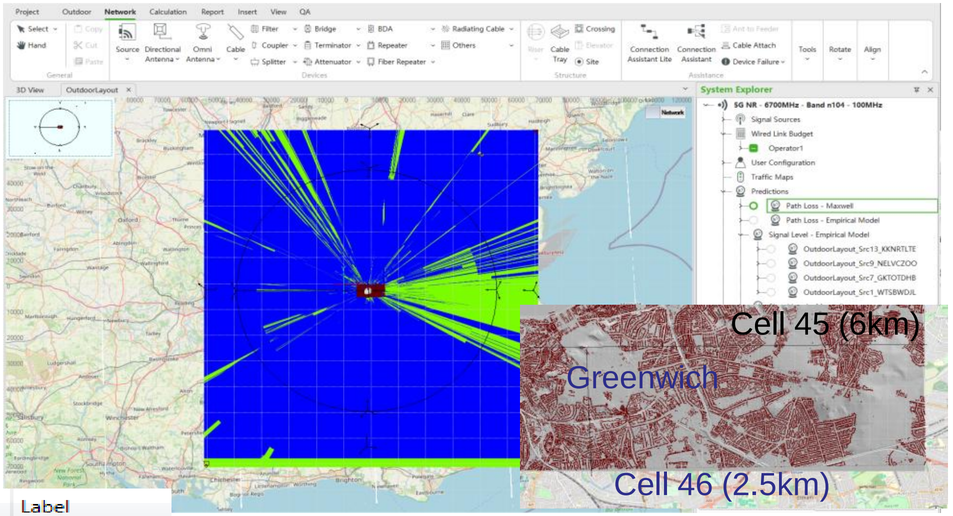
WP2 Simulation: Pair 3 - Mobile and Scientific stations

Simulation with Empirical Model



Simulation with Ray-tracing Model



Label	
(green)	Available area
(blue)	Prohibition area

Configurations:

- Base station height: 20 m
- Macro Tx power: 43 dBm
- RAS height: 50 m
- Interference < -188.1 dBm / 50 kHz

Conclusions:

In rural/urban scenario, the protection distance > 50km

In dense urban scenario, due to the blockage of building, the re-use distance can be reduced

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Next Steps

WP2 Simulation:

1. Testing the other spectrum sharing mechanisms
   – Variable spectrum split

2. Simulation for the other 3 pairs
   – Private network, mobile and fixed link, mobile and UWB

3. Simulation for multiple use cases and scenarios
   – Dense urban, Stadium, Urban, Rural

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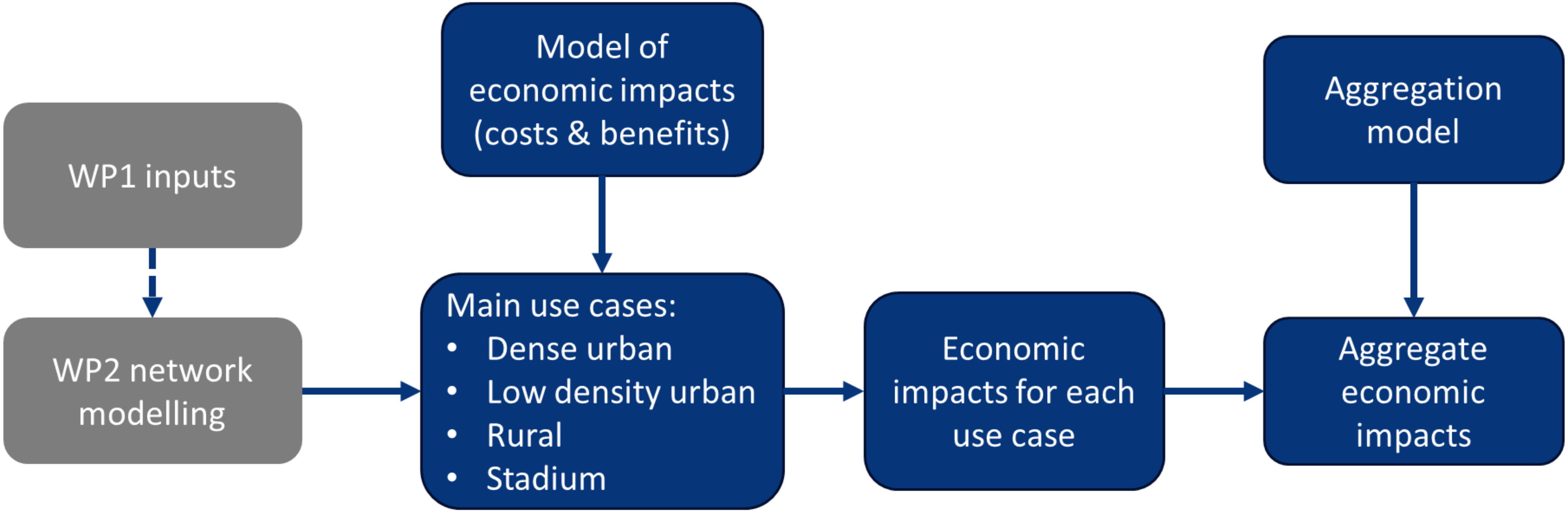
WP3 Economic Analysis

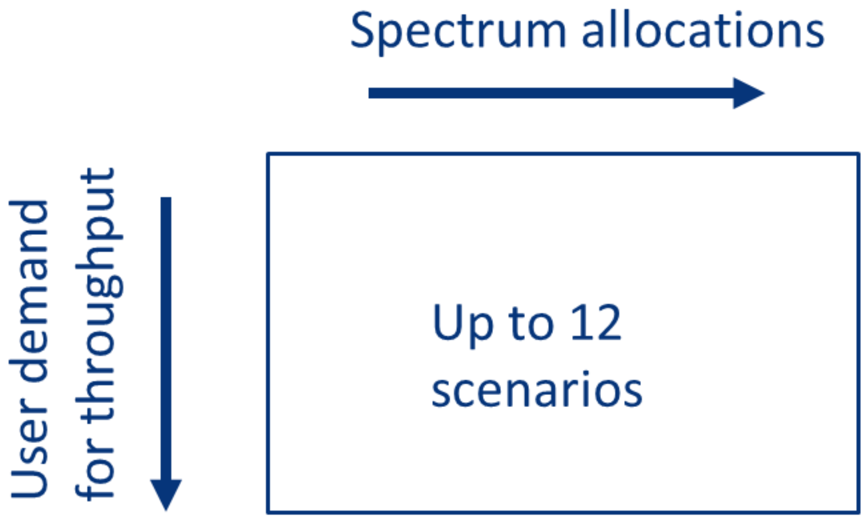
WP3 Overview



Main use cases

Area type	Location	Characteristics
▪ Dense urban area	Central London	• Numerous connected devices in a relatively small area. • Urban canyons block line of sight • High user densities • Peak demand potentially greater than network capacity
▪ Low density urban area	Bath	• Medium user densities • Good existing connectivity
▪ Rural area	Northumberland	• Low user densities • Relatively low existing connectivity
▪ Stadium	Football stadium in London	• Very large number of connected devices in a small area • Supply bottlenecks may last for a few hours (eg football matches) to a few days (e.g. festivals)

Main scenarios



- Varying user numbers and throughput per user
- Varying the allocation of (e.g. Upper 6GHz band) spectrum: None allocated, WiFi only, Mobile only, Mobile-WiFi sharing

- The WP2 network modelling is static and so the scenarios where user numbers and throughput requirements are varied will be used to inform the economic modelling which is dynamic (impacts are modelled over 10 years).
- Varying the spectrum allocation approach will allow us to estimate the impact of mobile-WiFi sharing compared to no allocation, mobile only or spectrum only allocation of the spectrum.

Use cases: Dense Urban, stadium

Relevant band for sharing: Upper 6GHz band for both WiFi and mobile

Scenario	WiFi	Mobile
0 Current provision	Mimic existing provision of Wi-Fi using existing 2.4/5Ghz bands based on Ofcom connected nations data	Mimic existing provision of mobile using existing n78 bands based on Ofcom connected nations data
1 No Sharing, 6GHz allocated to mobile only	Retain use of existing 2.4/5 Ghz bands as Scenario 0	Full allocation of the Upper 6 GHz Band to Mobile
2 No sharing, 6GHz allocated to Wi-Fi only	Full allocation of the Upper 6 GHz Band to Wi-Fi	Retain existing n78 spectrum band as Scenario 0
3 Sharing Upper 6Ghz	Sharing of the Upper 6 GHz band between Mobile and Wi-Fi as modelled in WP2	

Explanation: Exploring the economic benefits of spectrum sharing of the Upper 6 GHz band between mobile and Wi-Fi.

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Use cases: Low Density Urban, Rural

Relevant band for sharing: n77 Band for mobile

Scenario	Mobile
0 Current provision	Mimic existing provision of mobile using existing n78 bands based on Ofcom connected nations data
1 Sharing in n77 band	Permissive licensing of n77 band enabling new operators to deploy n77 mobile technologies to improve speed and fill black-spots/under provision under scenario 0

Explanation: Exploring the economic benefits of enabling permissive licensing of the n77 band. Propagation characteristics of Upper 6GHz band make it less relevant in these areas.

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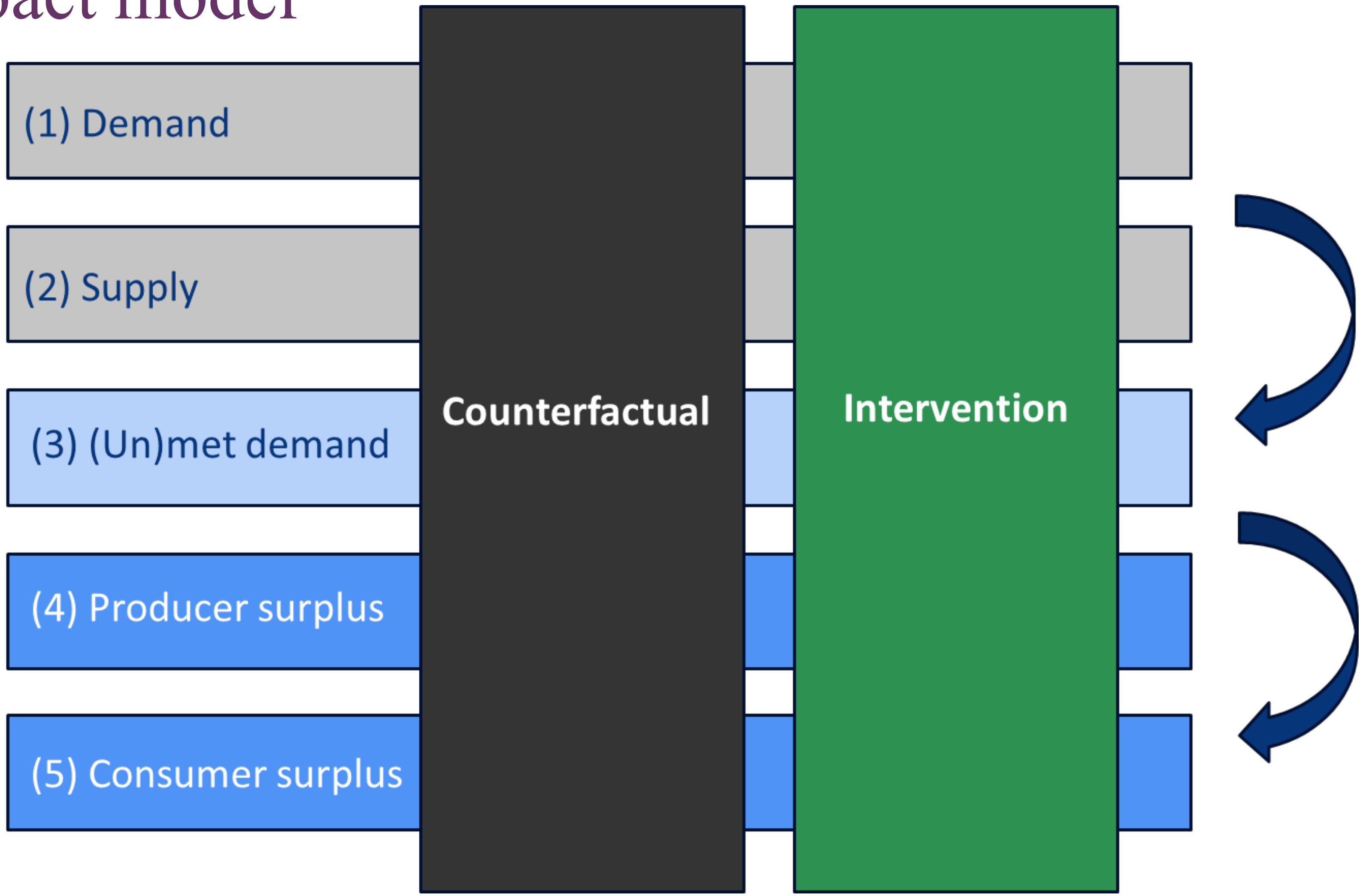
Economic impact model



Aggregation of results from use case analysis

Main insights into economic impacts will be from the use case analysis. But additional modelling to aggregate use case analysis to the UK level

Approach will use a geospatial mapping approach:

- Using Ofcom Connected Nations data at the Parliamentary Constituency level
- Match relevant characteristics of each area with characteristics of our use case areas
- model the relationship between geospatial characteristics and economic impacts in the use case areas to infer impacts for each Parliamentary Constituency and in aggregate.
- Relevant characteristics for this analysis include: working and residential population, pop density per km^2, mobile coverage, upload/download speeds, mean building height

Outputs provide an indication of aggregate impacts but are based on a very limited number of use cases. Network & economic modelling of more areas is a potential avenue for future research.

Next steps

Economic modelling using the outputs of the WP2 network modelling

Further stakeholder engagement

- Innovation session
- Scenarios
- Assumptions
- Regulatory implementation of sharing mechanism

Reporting