IET The Institution of Engineering and Technology

Point to Point Microwave Radio Systems

Thursday 6th November 2025

Welcome

The event will start at 7:00pm

Introduction: Kevin Foster FIET, Chairman, Anglian Coastal Local Network

Presenter: Prof. Andy Sutton, MBE CEng. FIET, BT Fellow, BT plc

Questions: Live in the Atrium & via Q&A Messaging in Teams. In Teams, please type in your questions and these will be taken in a Q&A session at the end of the presentation.

Close: Approximately 8:15pm

BT Group

Point to point microwave radio systems

Andy Sutton MBE MSc CEng FIET FITP FBCS

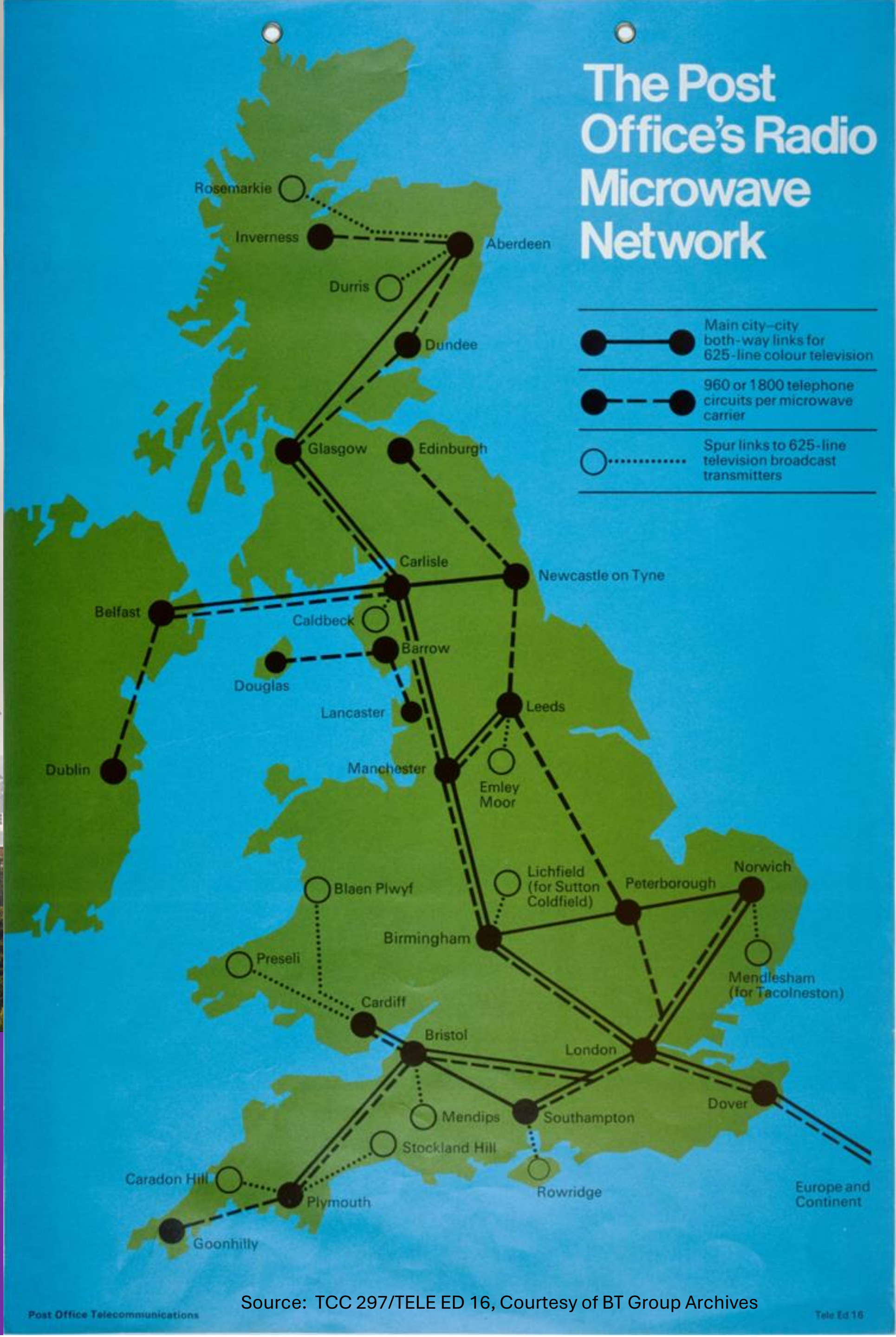
BT Fellow & Principal Network Architect – Wireless Access

Visiting Professor – University of Liverpool & University of Salford

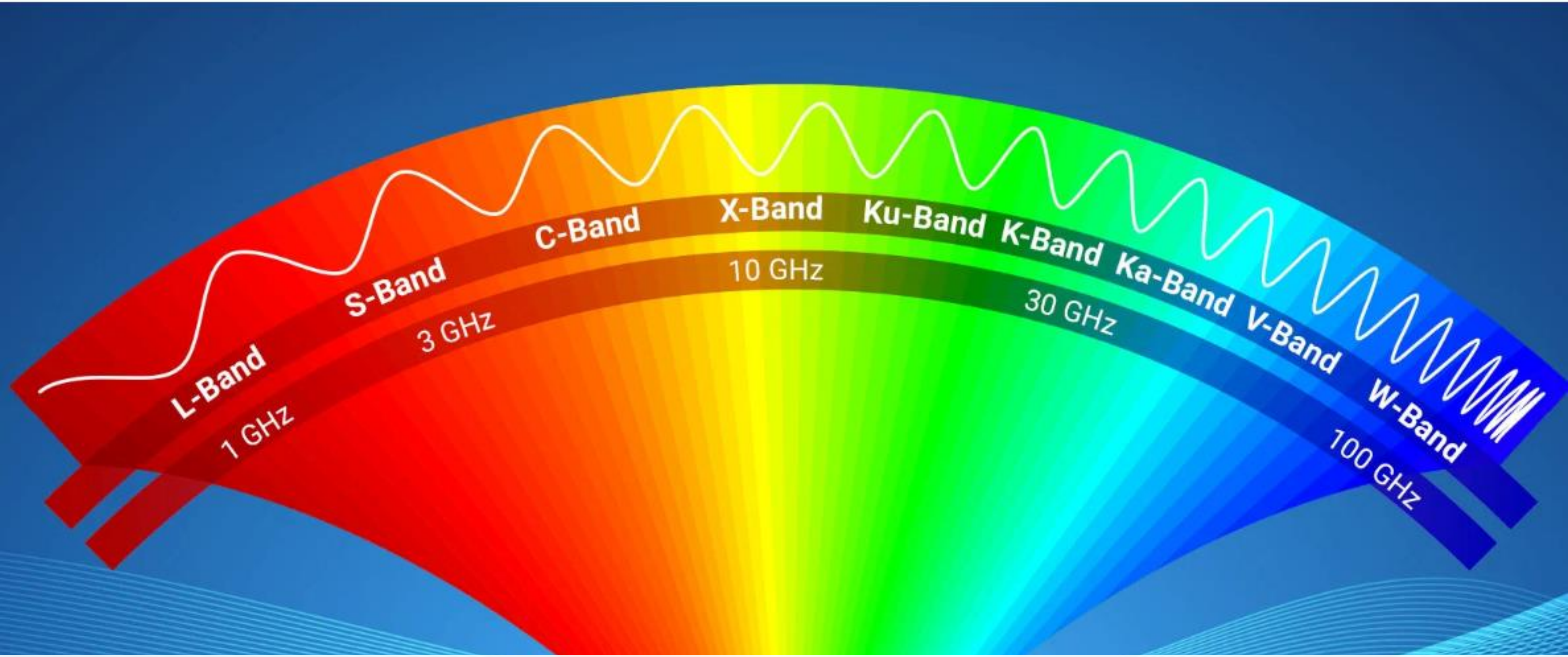
6th November 2025 – IET Anglian Coastal Local Network

Contents

BT Tower (today) and the national microwave radio network (1970)



Source: TCC 297/TELE ED 16, Courtesy of BT Group Archives



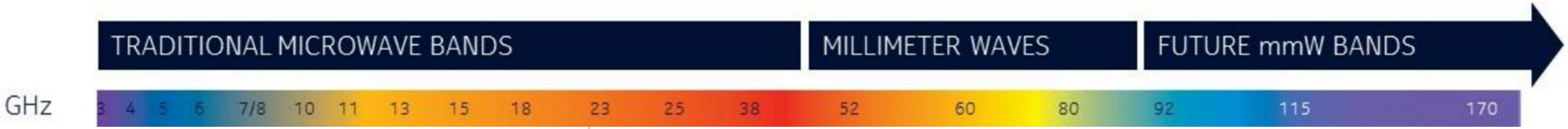
Radio Frequency Spectrum bands

Source: https://www.mpdigest.com/2023/07/13/do-you-know-your-frequency-bands/

Spectrum for microwave and millimetre wave radio links

making communications work for everyone

OfW48 UK Frequency Allocations for Fixed (Point-to-Point) Wireless Services and Scanning Telemetry



Publication date: 5 August 2022

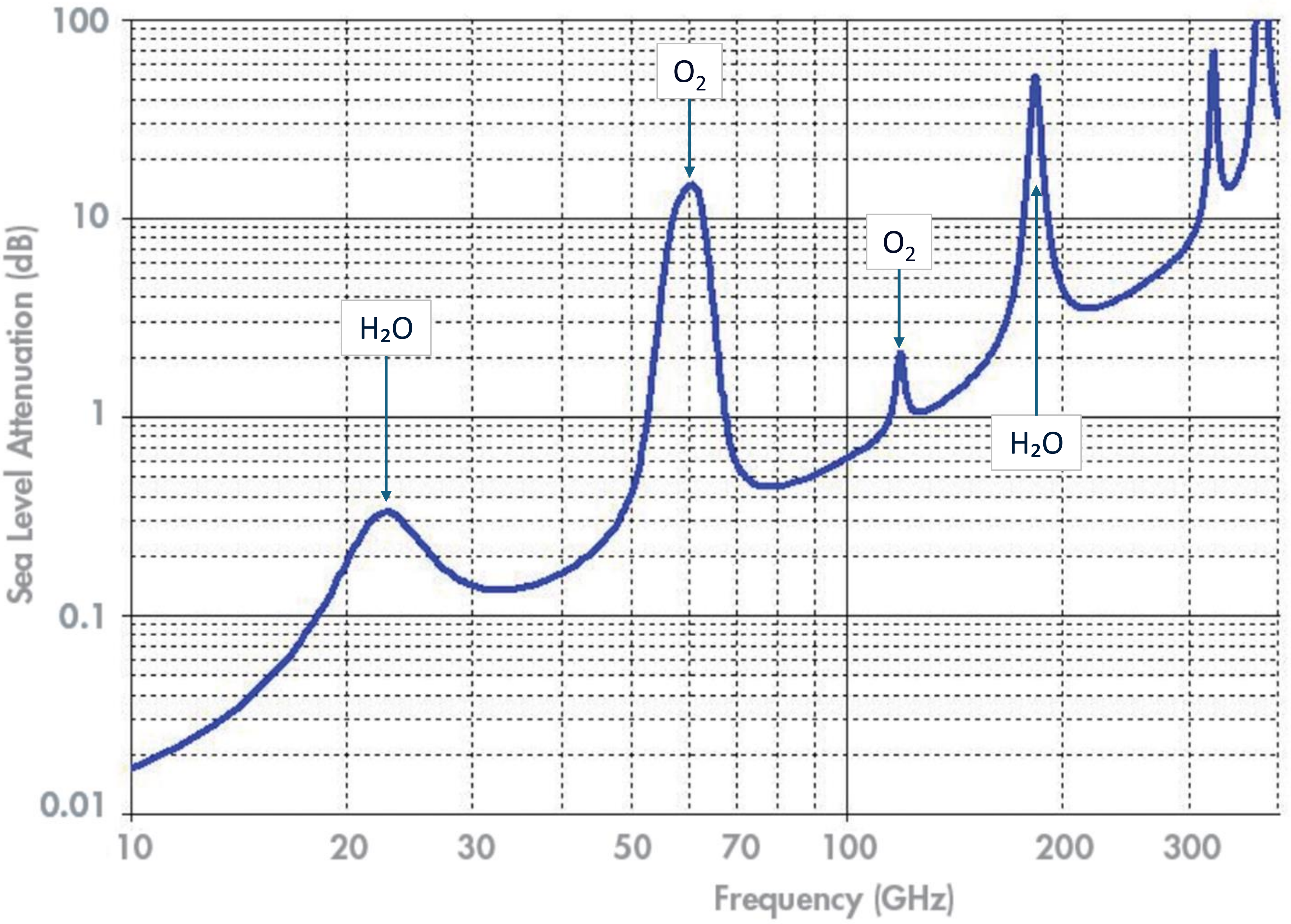
OfW48 source: https://www.ofcom.org.uk/siteassets/resources/documents/manage-your-licence/fixed-terrestrial-links/ofw48.pdf?v=335453

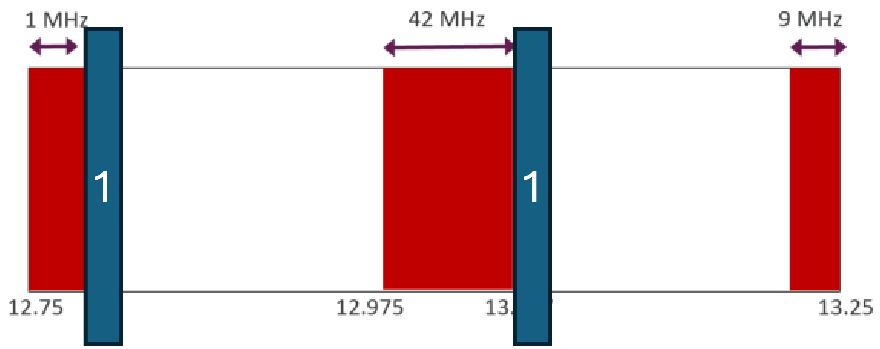
Spectrum plot source: ETSI ISG mWT

Common microwave radio bands in the UK

- Lower 6 GHz
- Upper 6 GHz
- 7.5 GHz
- 10 GHz
- 11 GHz
- 13 GHz
- 15 GHz
- 18 GHz
- 23 GHz
- 26 GHz (cleared)
- 32 GHz
- 38 GHz
- 42 GHz (cleared)
- 52 GHz
- 55 GHz
- 60 GHz (unlicenced)
- 70/80 GHz (E-band)

Atmospheric absorption

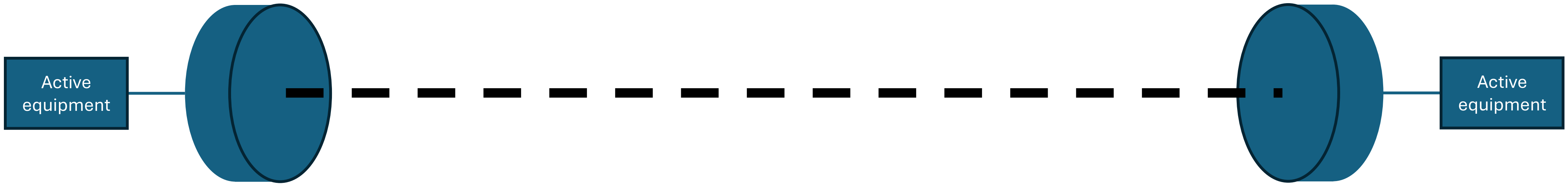


13 GHz	Radio Channels Available in the UK
	128 x 1.75 MHz 64 x 3.5 MHz 32 x 7 MHz 16 x 14 MHz 8 x 28 MHz 7 x 56 MHz
CEPT/ERC/REC 12 – 02 E – Annex A Channel Duplex Spacing: 266 MHz	

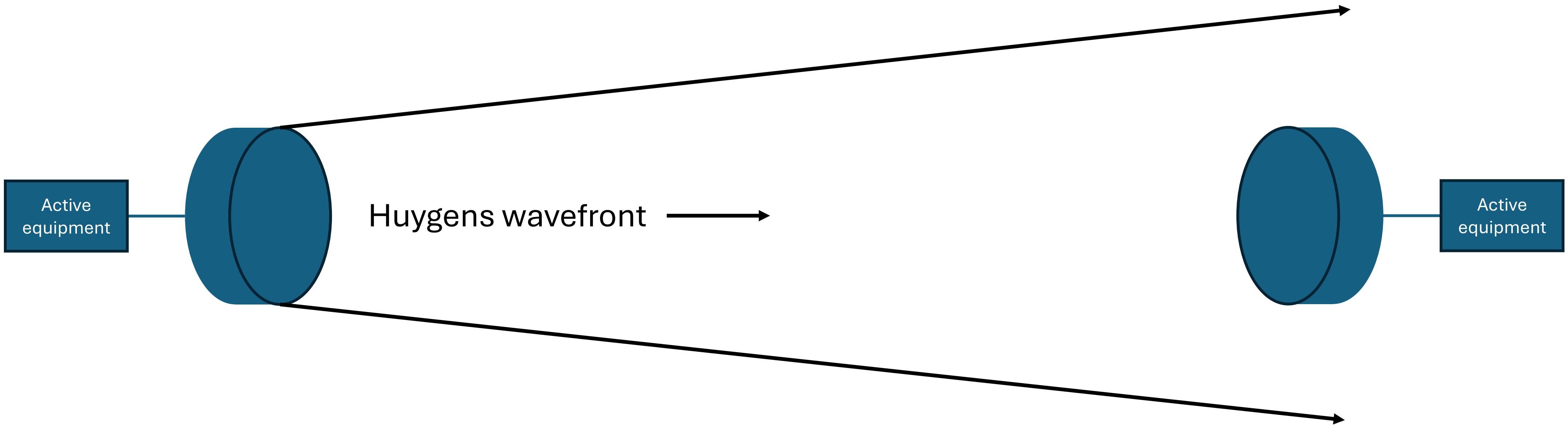
OfW48 source: https://www.ofcom.org.uk/siteassets/resources/documents/manage-your-licence/fixed-terrestrial-links/ofw48.pdf?v=335453

Point to point microwave radio link

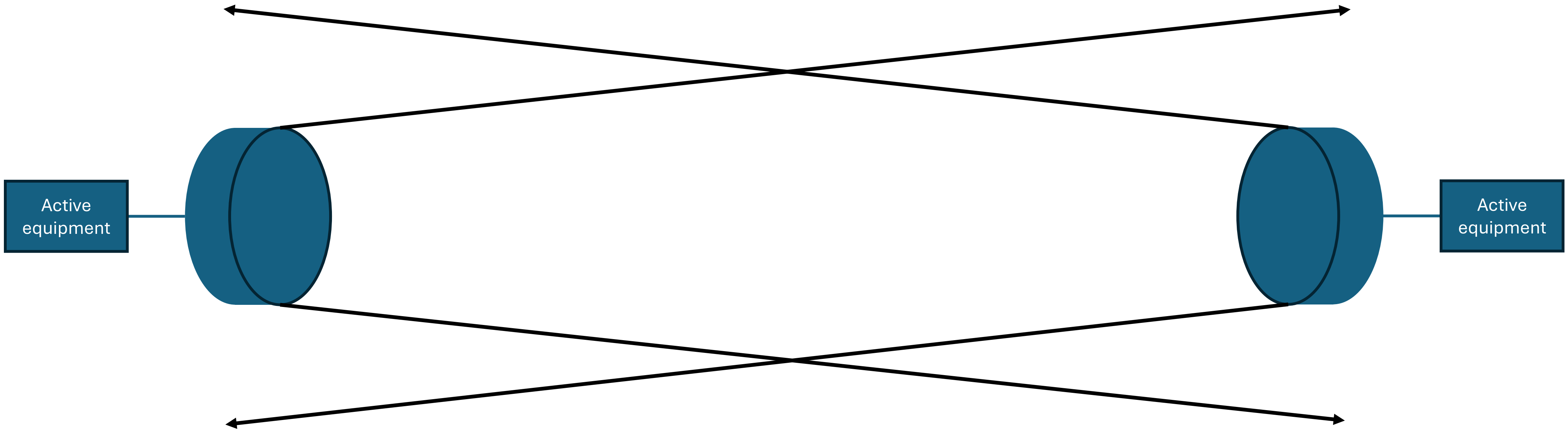
Point to point microwave radio link



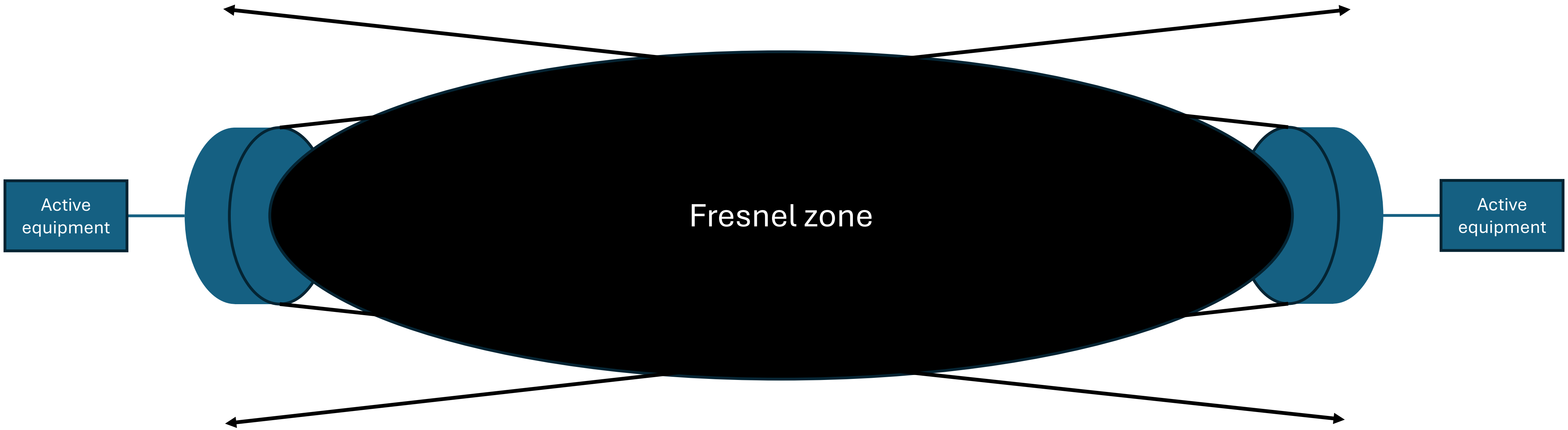
Point to point microwave radio link



Point to point microwave radio link



Point to point microwave radio link

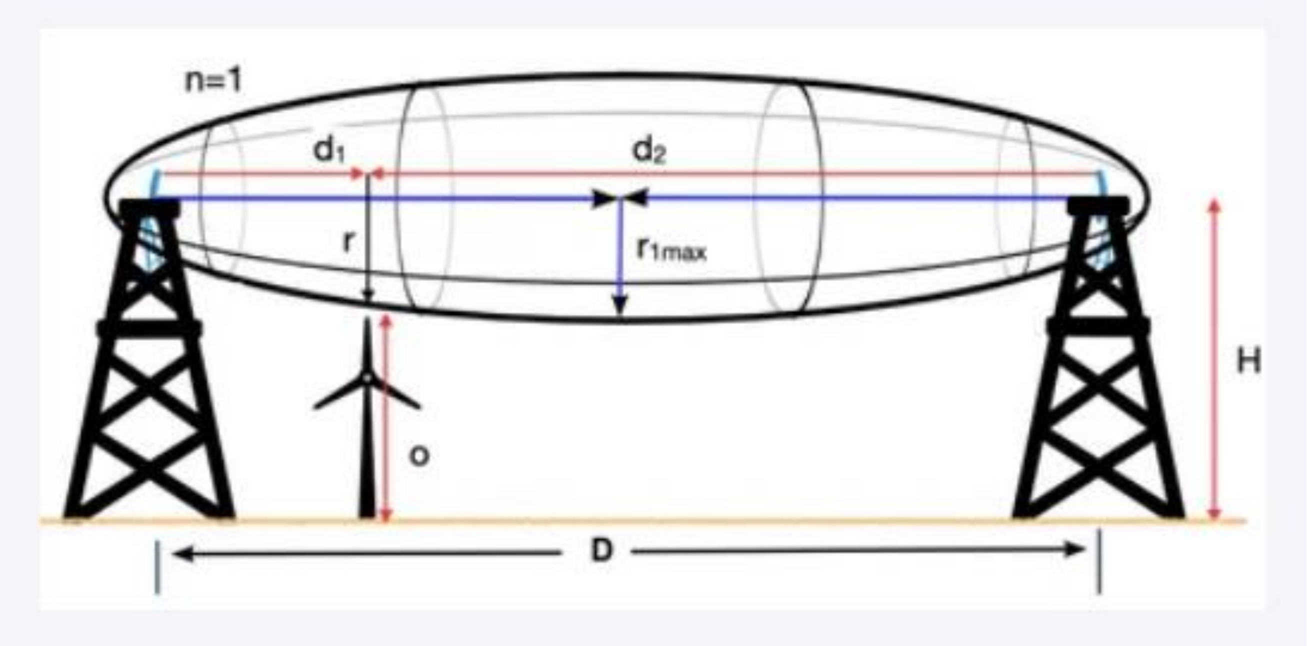


To calculate the radius of a microwave radio's Fresnel zone, you can use the formula:

$$R = 17.32\sqrt{\frac{D}{4f}}$$

R: The radius of the Fresnel zone in meters
D: The distance between the transmitter and receiver in kilometres
f: The frequency of transmission in GHz

Worked example



$$R = 17.32\sqrt{\frac{D}{4f}}$$

Frequency band = 13 GHz (f)

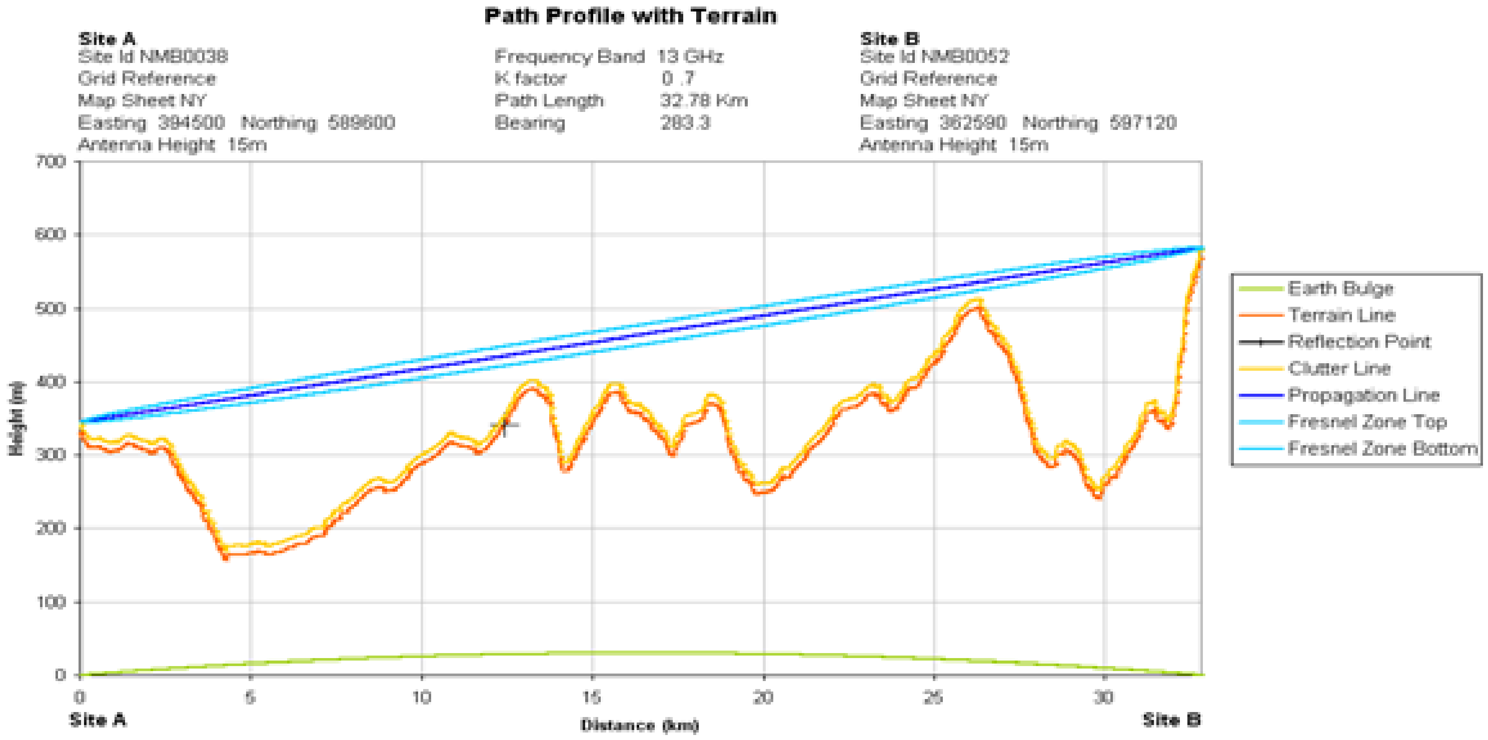
Distance between antennas = 10 km (D)

Largest radius therefore = 7.595m

Practical link design requires at least 60% clearance of the first Fresnel zone, albeit some operators specify 70% as a safety margin, it is not uncommon to specify 100% clearance to allow a margin for tree growth…

Image source: https://www.omnicalculator.com/physics/fresnel-zone

Link path profile

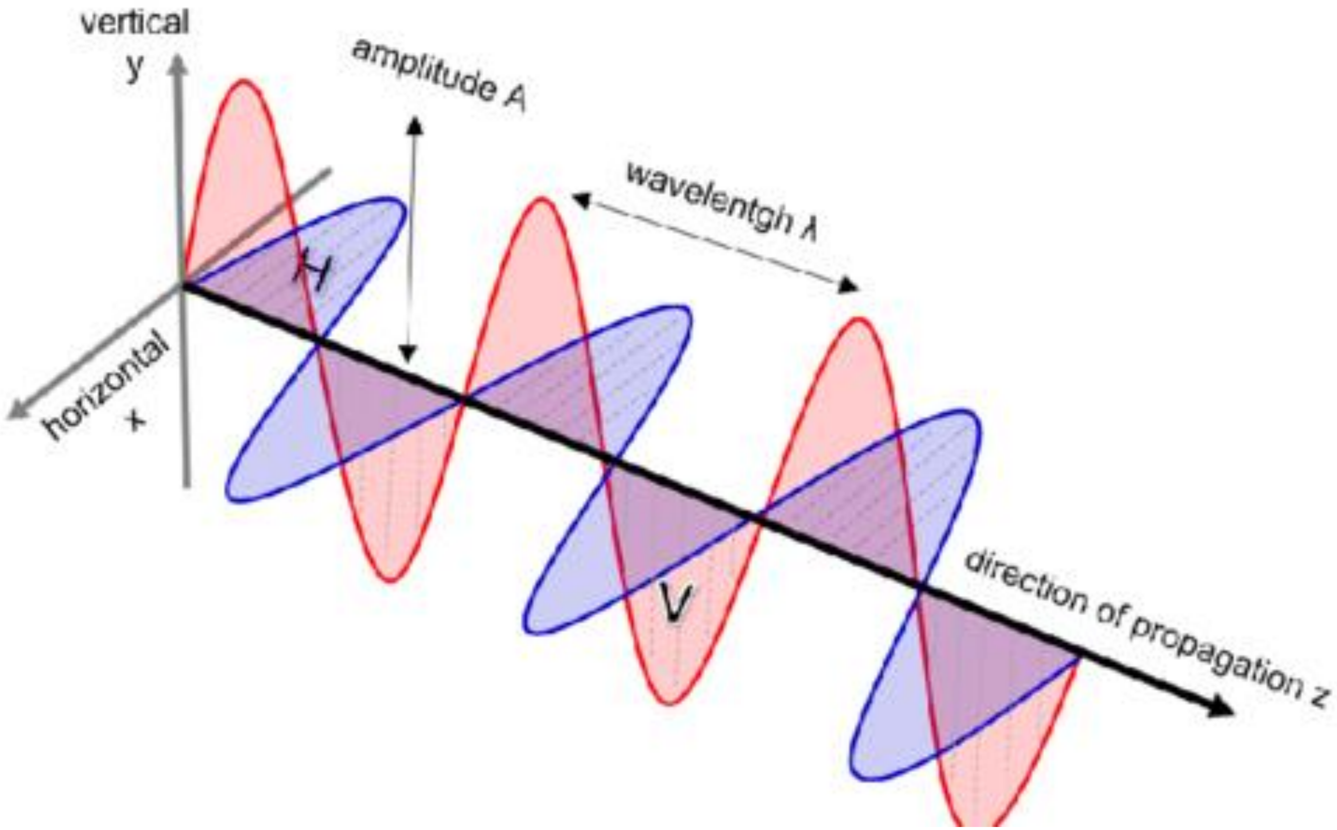


Source: Institute Of Telecommunications Professionals (ITP) Journal Volume 17 - Part 3 - 2023 - Access Microwave Radio Systems by Andy Sutton & Julian Divett

Point to point microwave radio systems

Rooftop point to point microwave radio node

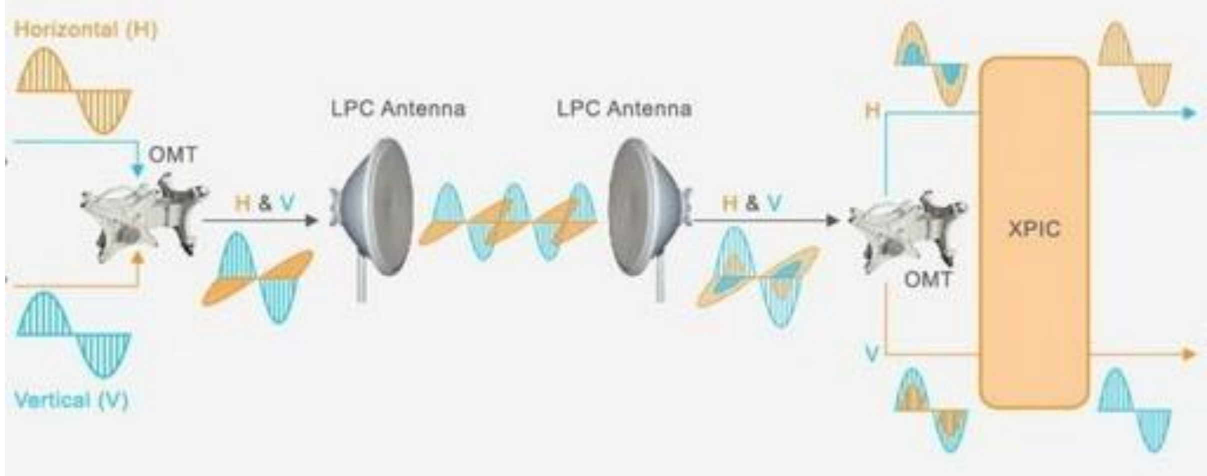
Vertical and horizontal polarisations



Source: https://www.researchgate.net/figure/Horizontal-and-vertical-polarization-of-an-electromagnetic-wave-horizontal-polarization_fig16_338698920

XPIC operation - CCDP (Co-Channel Dual Polarisation)

- XPIC or cross-polarisation interference cancelling technology, is an algorithm to suppress mutual interference between two received streams in a polarisation-division multiplexing communication system
- XPIC is a feature used on carrier-class microwave link installations to increase capacity and spectral efficiency of a link
- A Microwave Link using XPIC capabilities effectively doubles the capacity of a microwave path
- XPIC allows the assignment of the same frequency to both the vertical & horizontal polarisation on a path



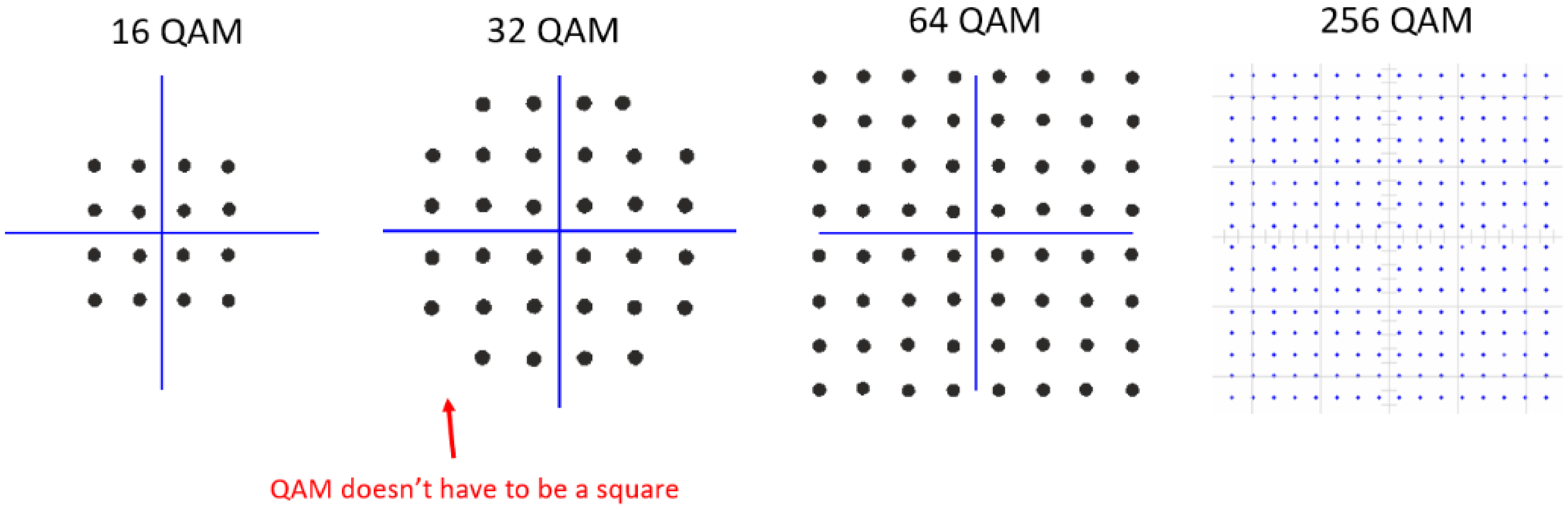
OMT = Orthomode transducer

Link capacity - considerations

- Radio channel bandwidth
  - Typically, 3.5 MHz / 7 MHz / 14 MHz / 28 MHz / 56 MHz / 112 MHz / …
- Modulation scheme
  - QPSK / QAM / 16QAM / 32QAM / 64QAM / 128QAM / 256QAM / 512QAM / 1024QAM / 2048QAM / 4096QAM / …
- Quantity of radio channels on a given link (carrier aggregation)
  - 1 / 2 / 3 / 4 / 5 / 6 / 7 / 8 / 9 / 10 / … - typically implemented with CCDP & XPIC
- Wider radio channels and higher order modulation schemes bring a link budget penalty!

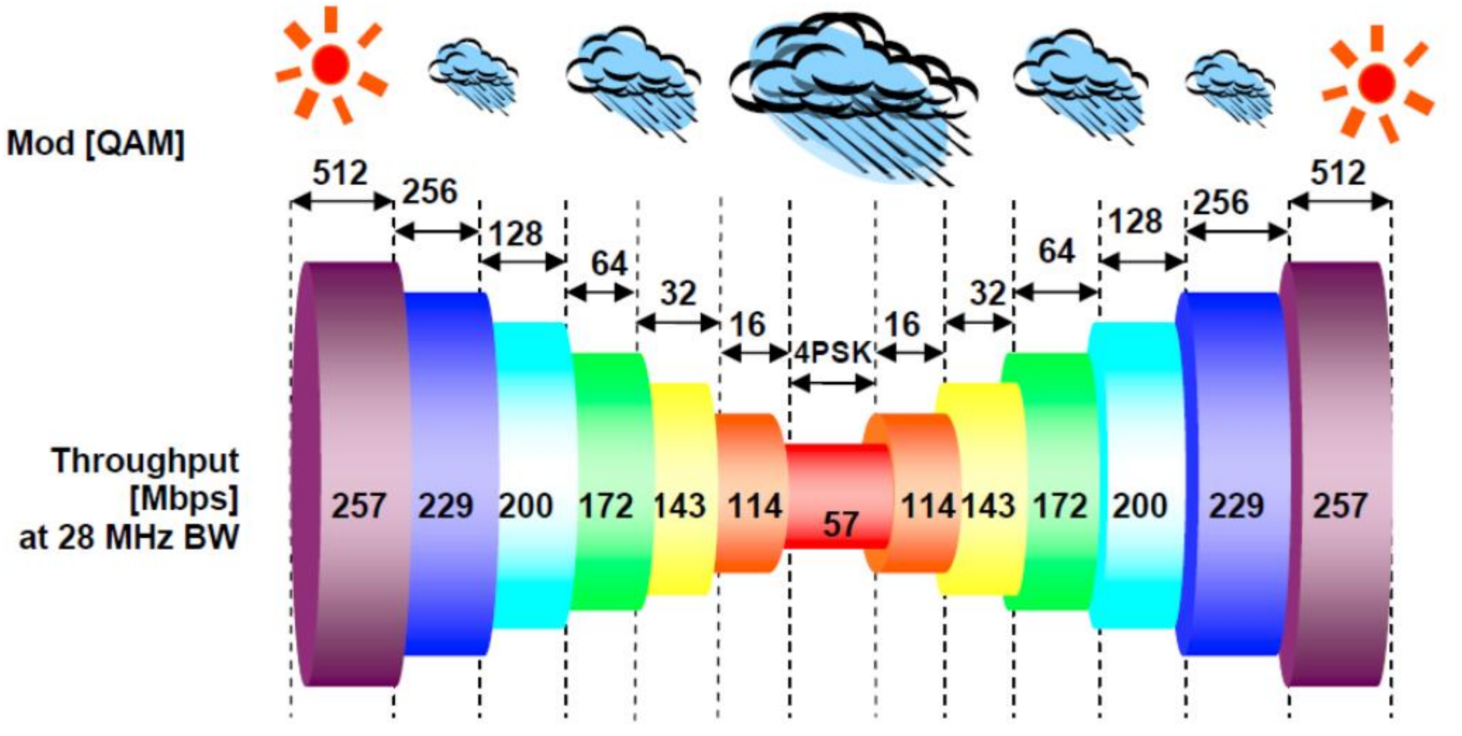
- Reduction in Tx power: Due to increased linearity requirements for the power amplifier in the transmitter, there is a reduction in transmit power when the modulation level is increased. This is approx. 1dB per level
- Reduction in Rx threshold: a single step increase in modulation scheme (e.g. 512 to 1024QAM) results in a -3dB degradation in receiver sensitivity.

QAM constellation plots



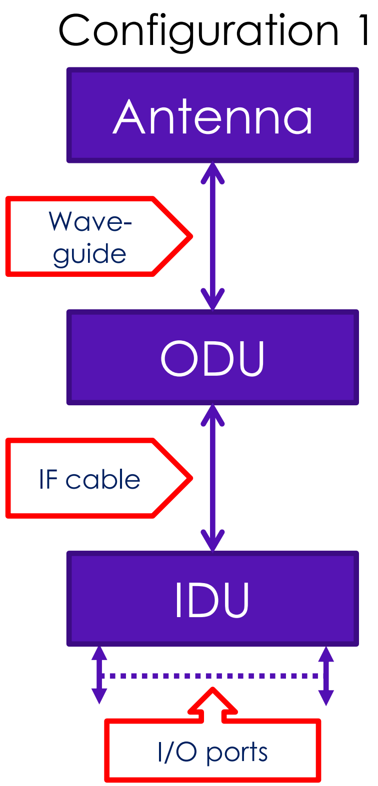
Source: https://pysdr.org/content/digital_modulation.html

Adaptive Coding & Modulation



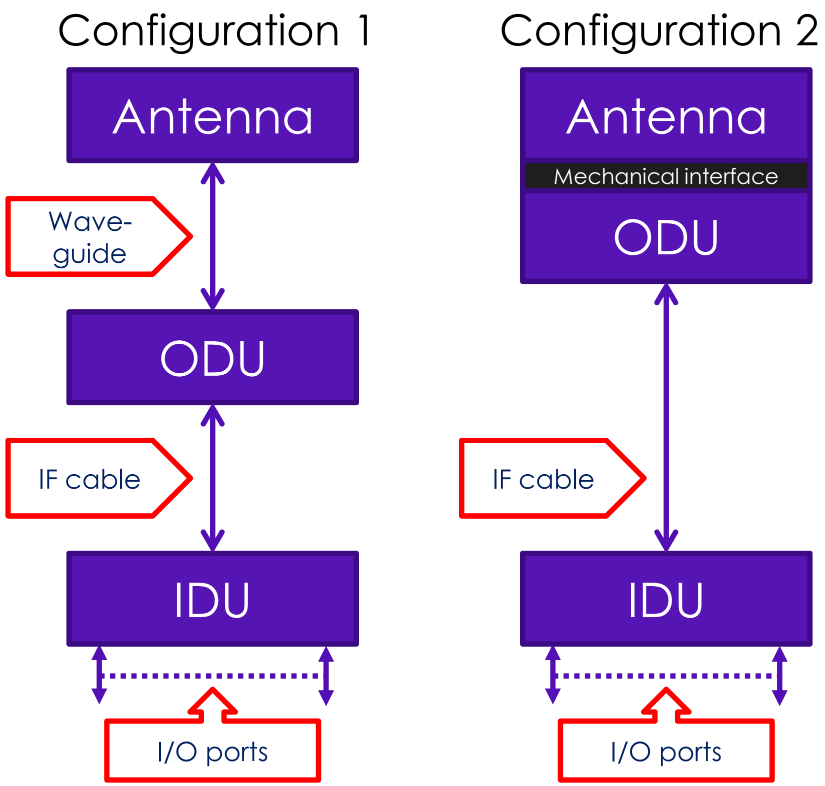
ACM enabled graceful performance degradation rather than complete link failure, as occurs with a fixed modulation scheme - ACM can operate up, or down, from the reference modulation scheme.

Microwave radio components for access radio systems



IDU = InDoor Unit = Baseband and modem / ODU = OutDoor Unit = Transceiver

Microwave radio components for access radio systems



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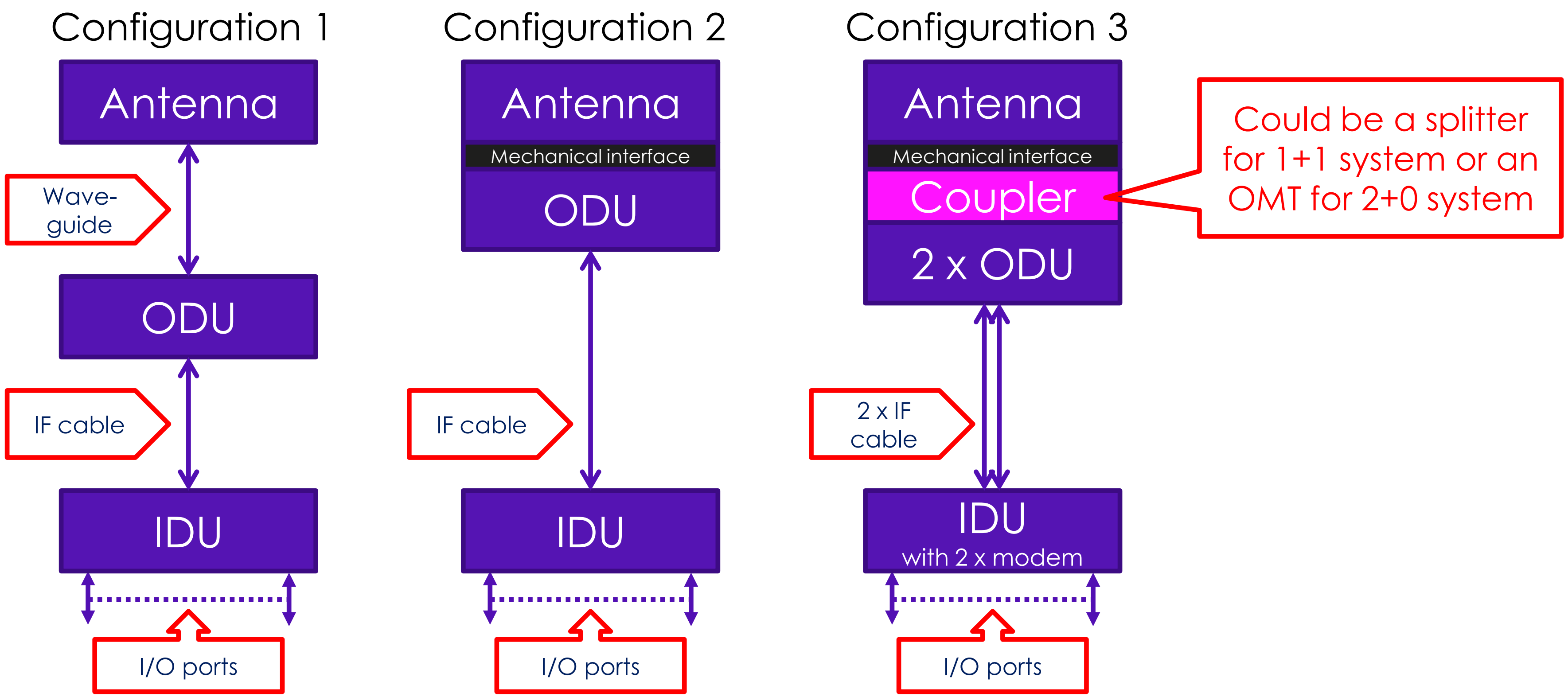
Microwave radio components for access radio systems



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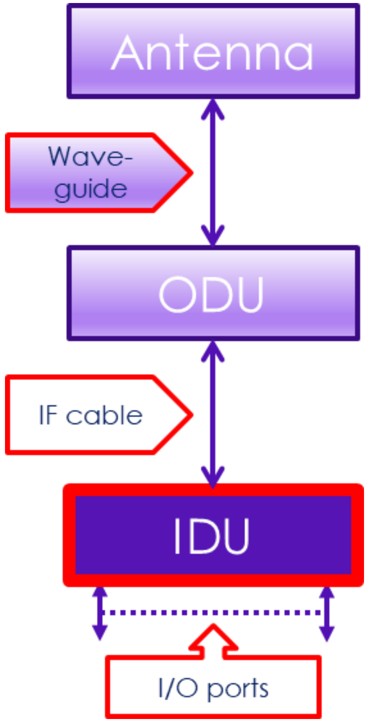
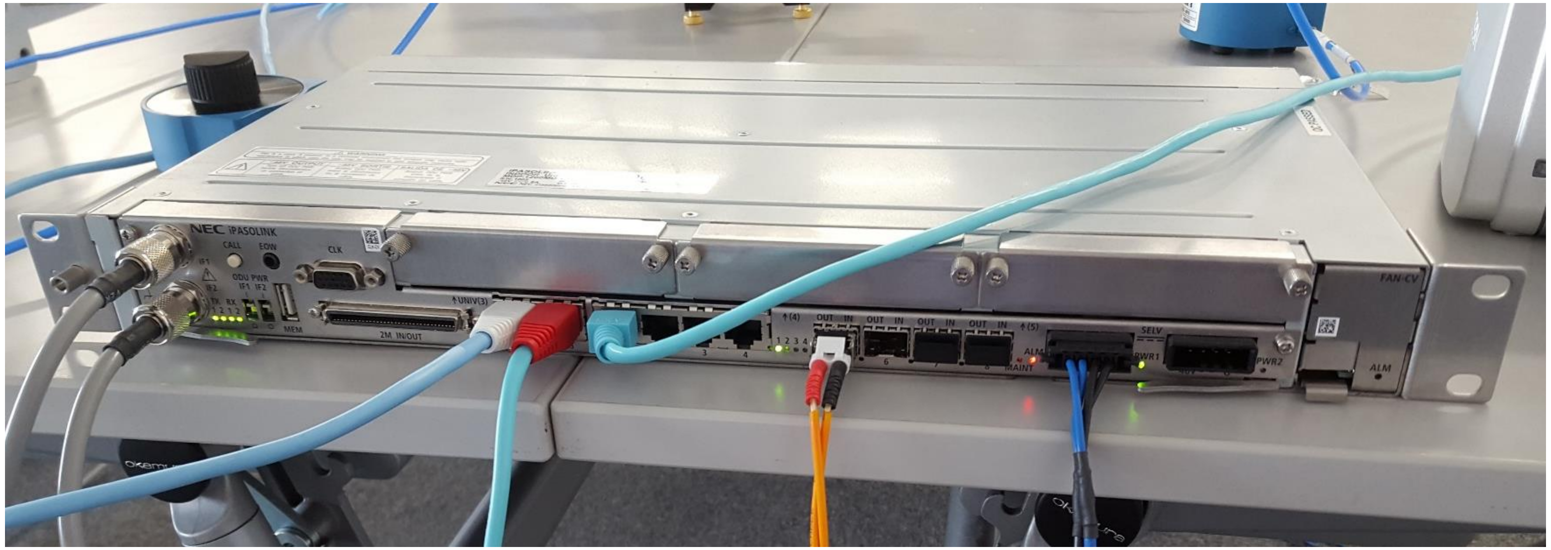
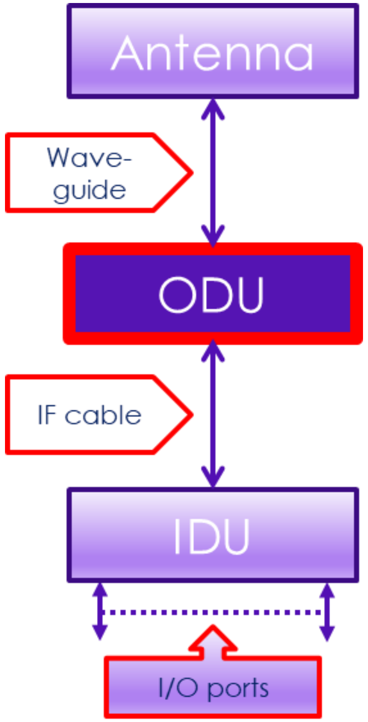
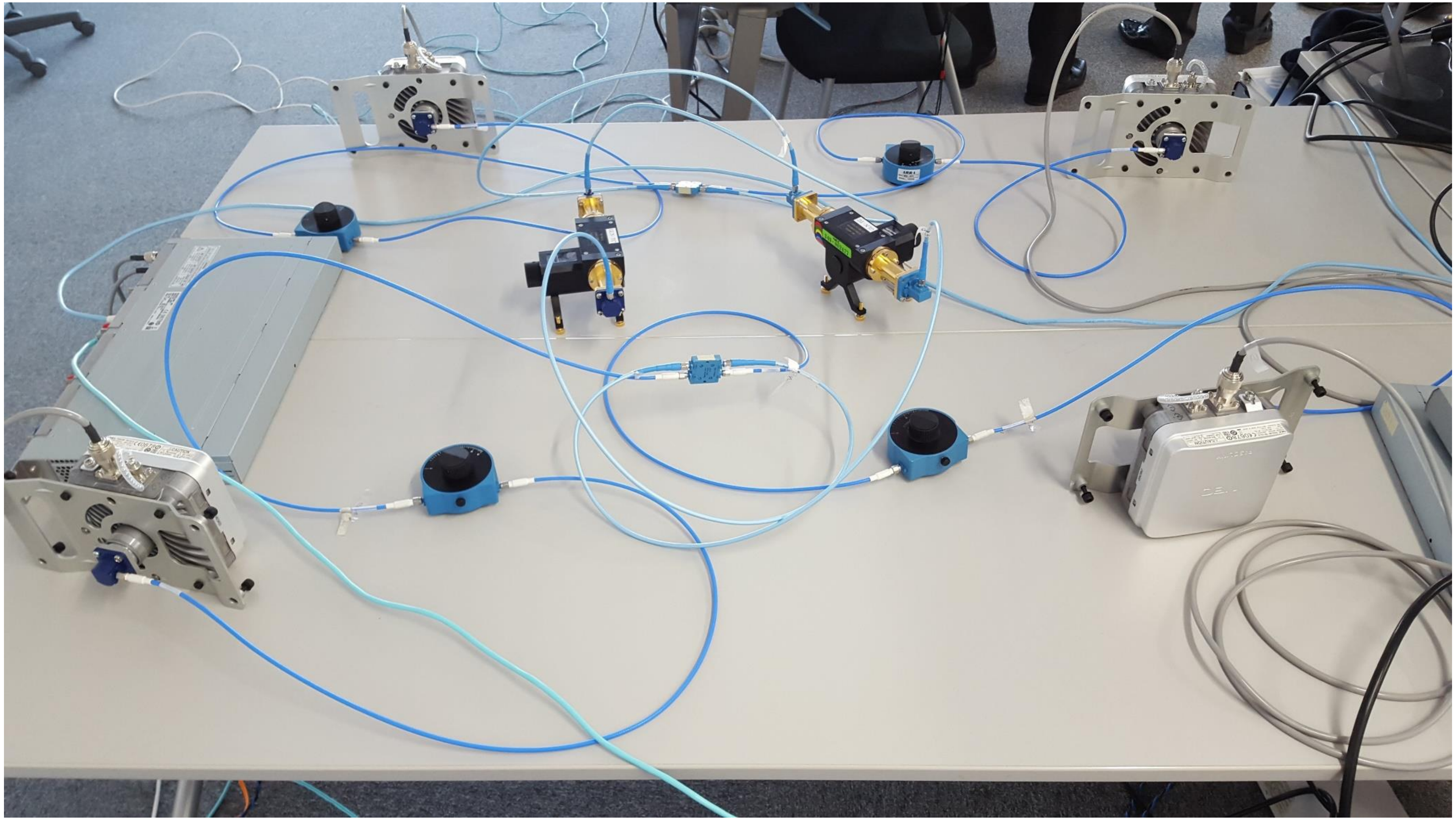
Microwave radio components - IDU



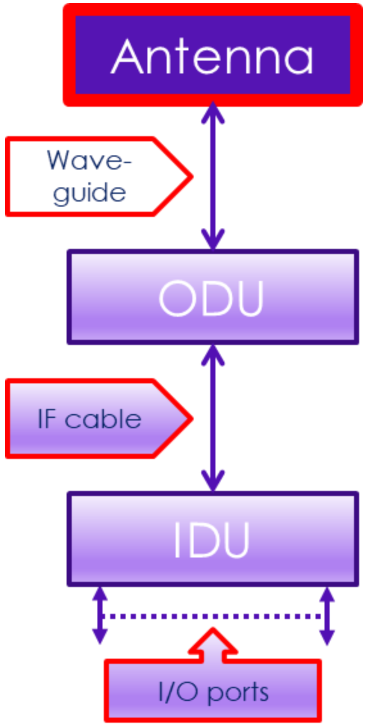


Microwave radio components - ODU

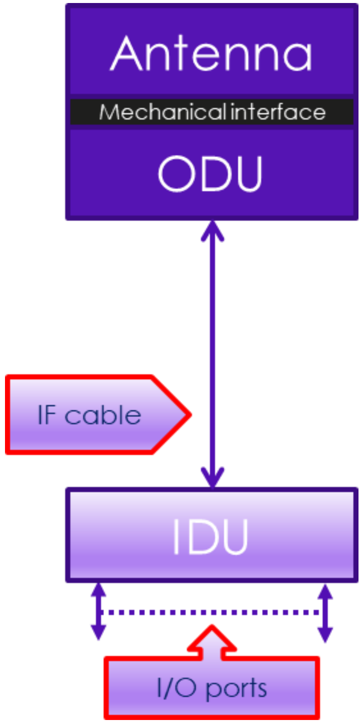


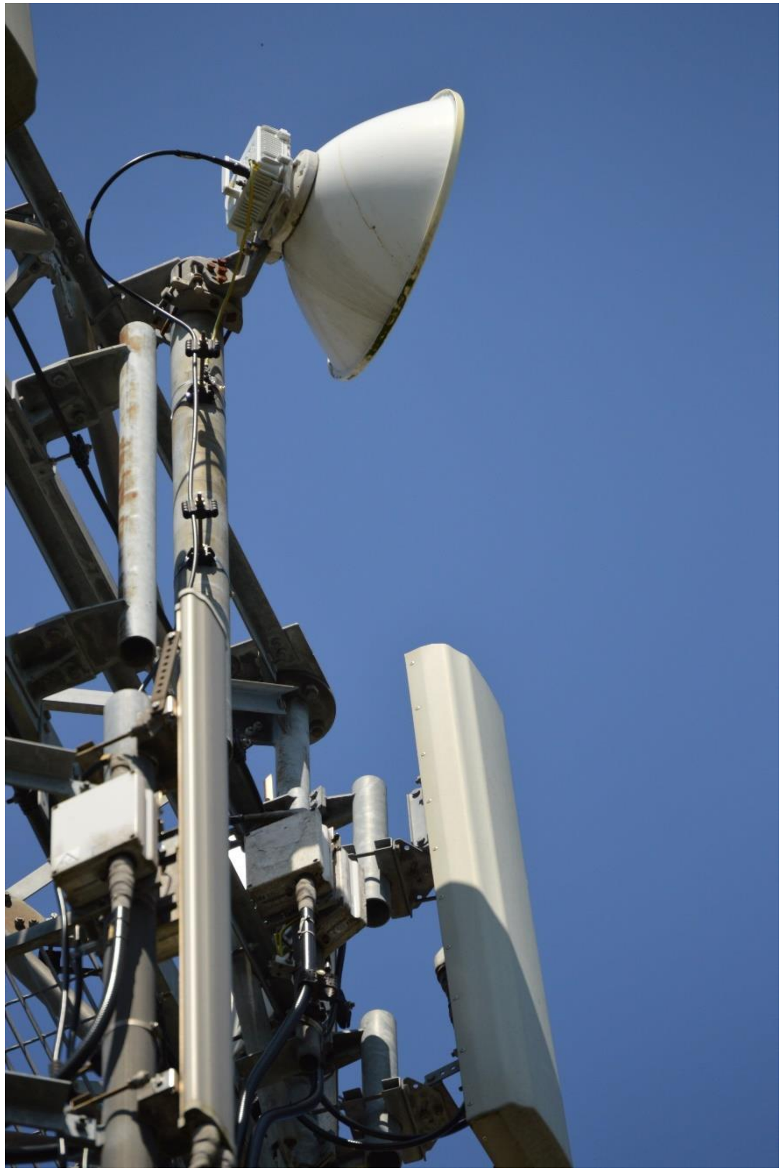


Microwave radio components - Antenna

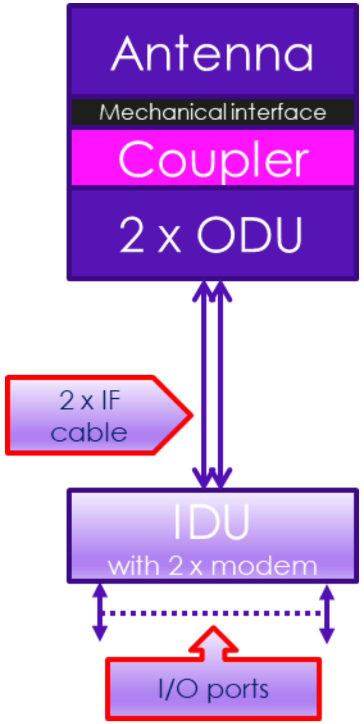


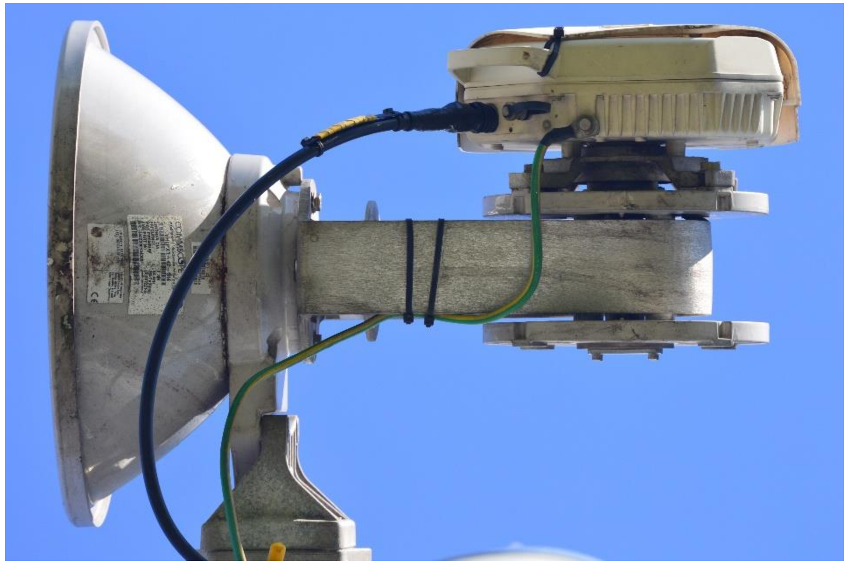
Microwave radio components - Antenna

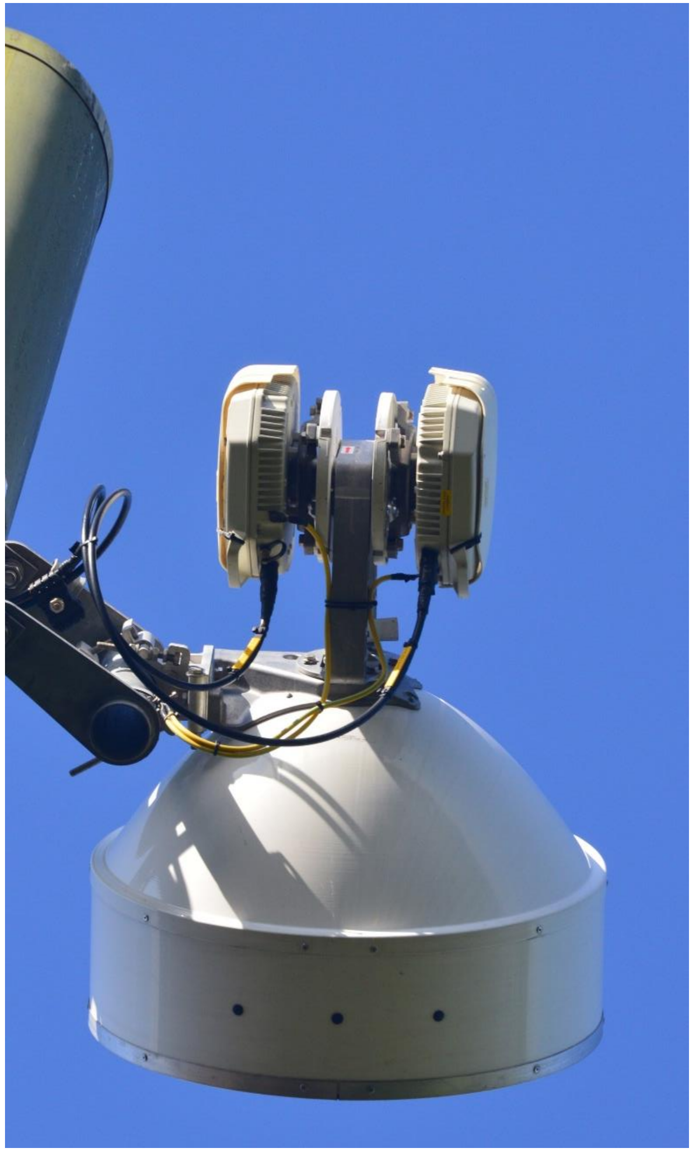




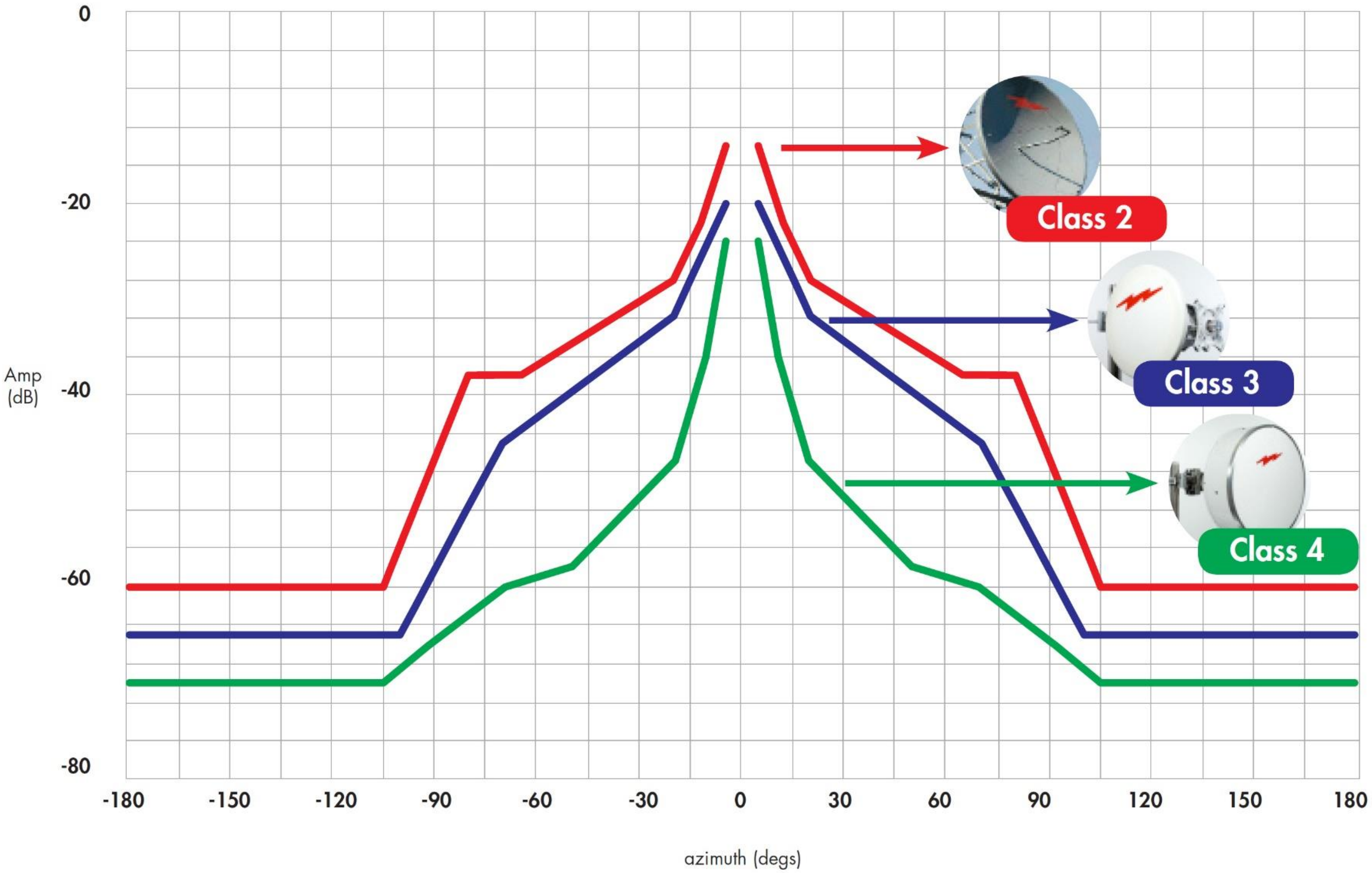
Microwave radio components - Antenna







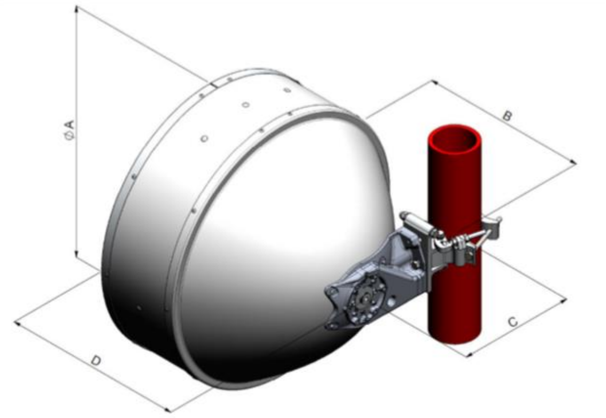
Antenna RPE (Radiation Pattern Envelope)



Source: Commscope

32 GHz dual polarisation ETSI Class 4 antenna

- Enables greater area capacity density through optimised radiation pattern envelope



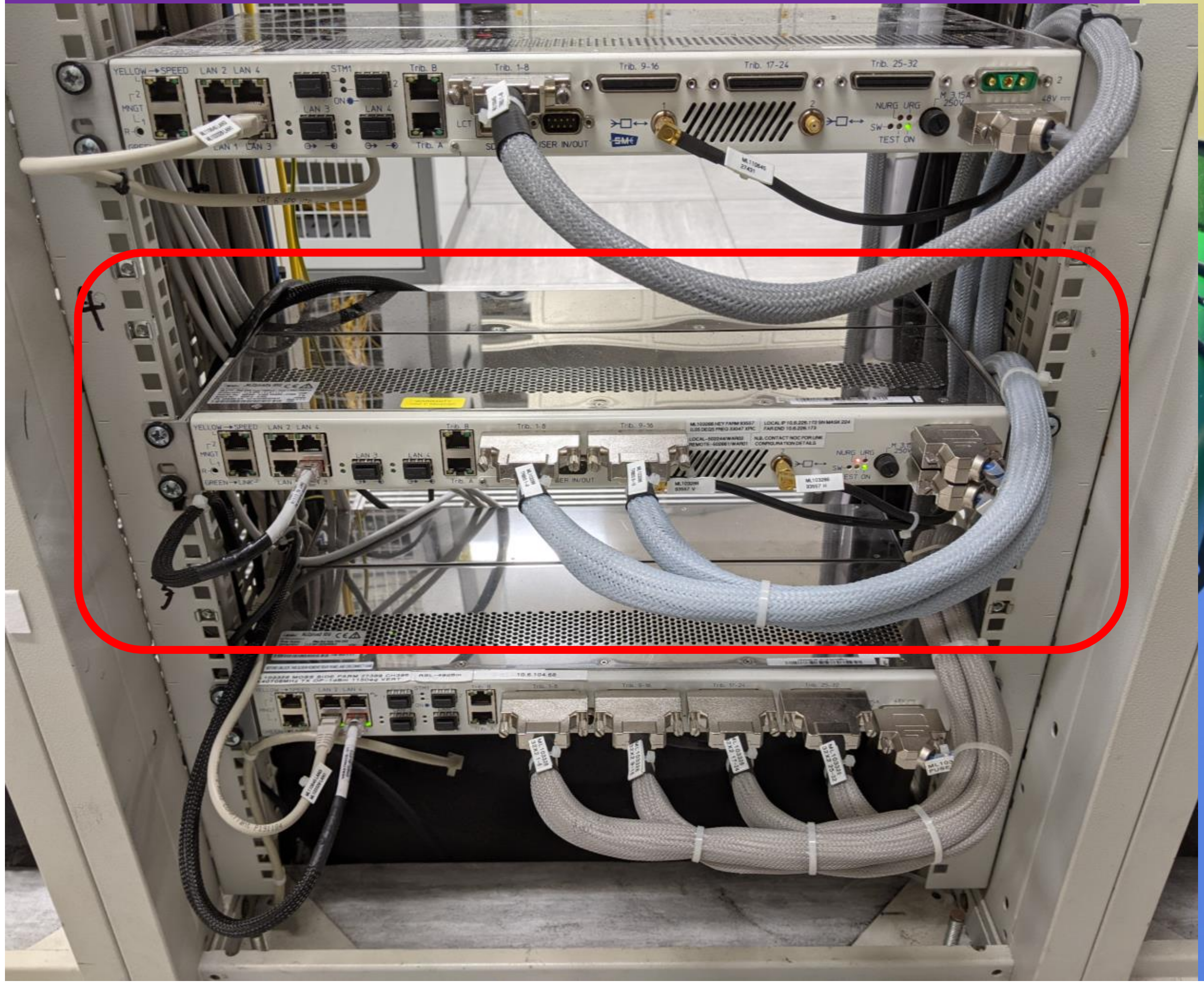
Dimension in Inches(mm)				
Antenna size, ft(m)	A	B	C	D
2(0.6)	26.1(664)	17.4(441)	12.1(307)	18.8(478)

Electrical Specifications

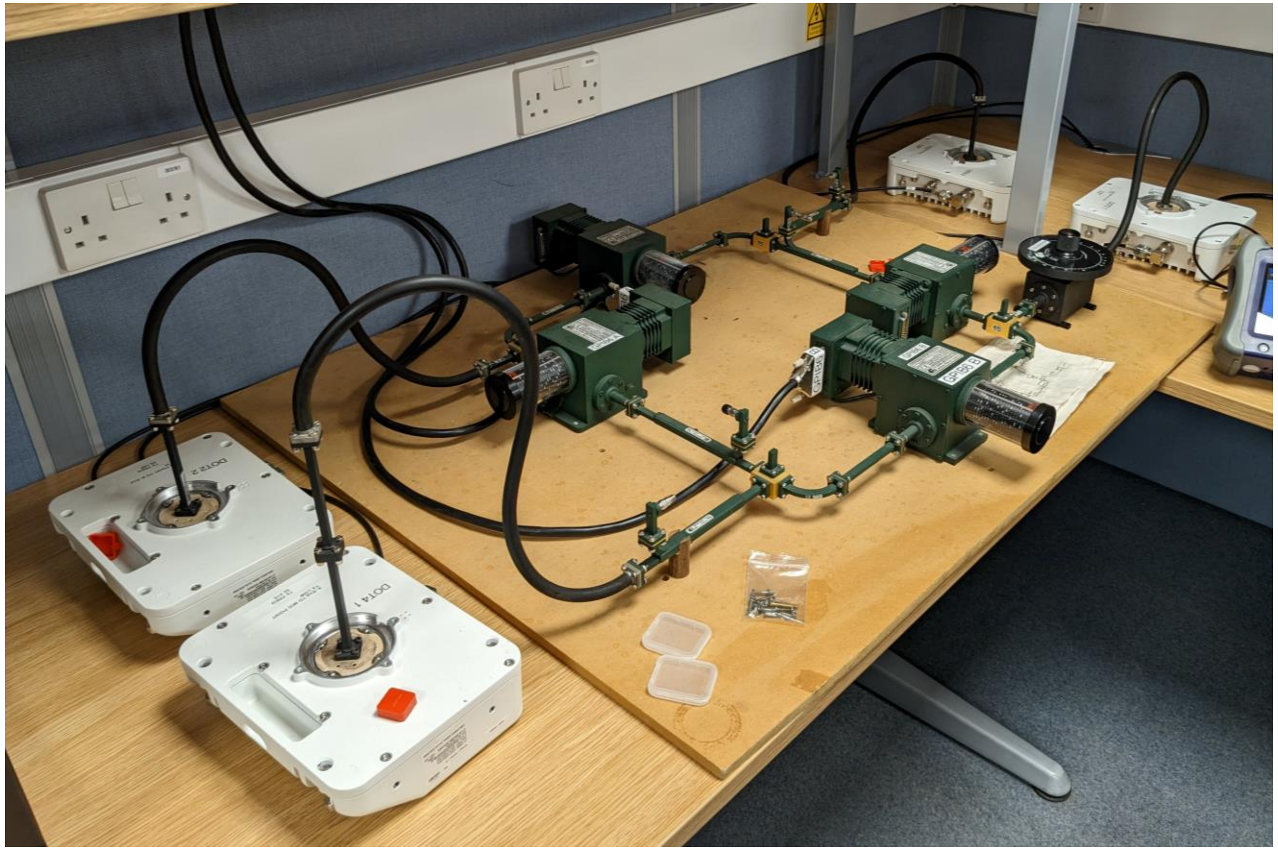
Return Loss	17.7 dB
Beamwidth, Horizontal	1 °
Beamwidth, Vertical	1 °
Boresite Cross Polarization Discrimination (XPD)	30 dB
Cross Polarization Discrimination (XPD) Electrical Compliance	ETSI EN 302217 XPD Category 2
Electrical Compliance	Brazil Anatel Class 2 | ETSI 302 217 Class 4
Front-to-Back Ratio	71 dB
Gain, Low Band	43.2 dBi
Gain, Mid Band	43.5 dBi

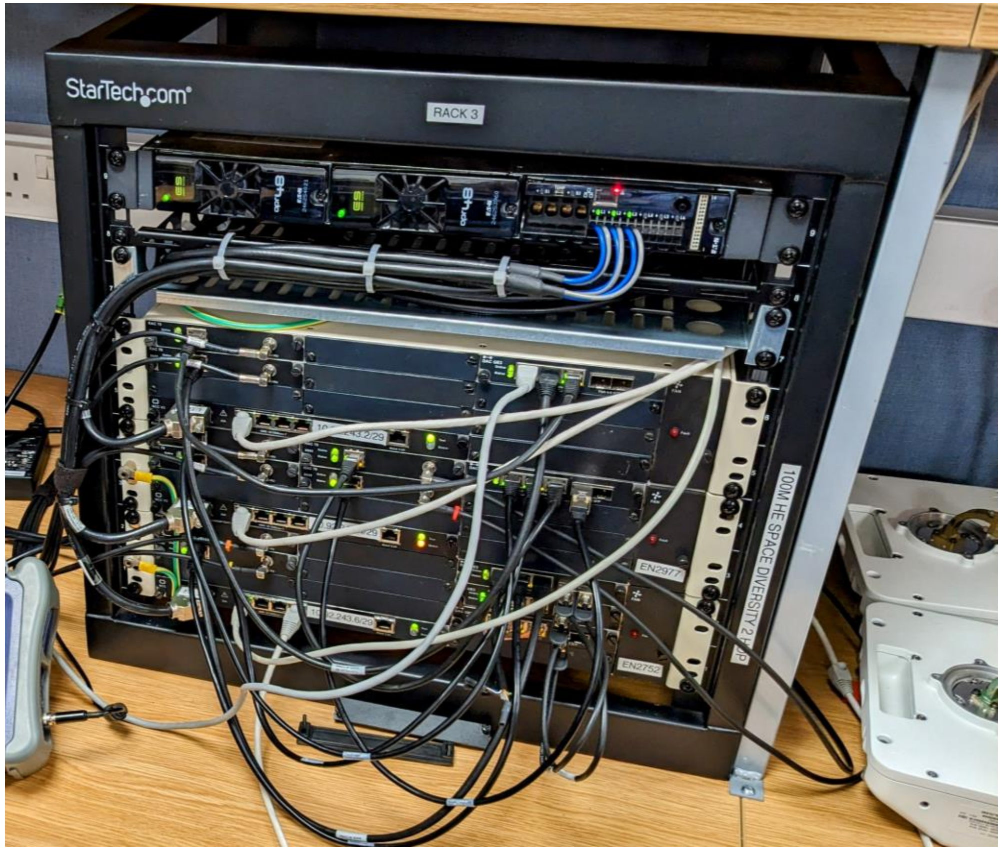
Source: Commscope

Access radio system

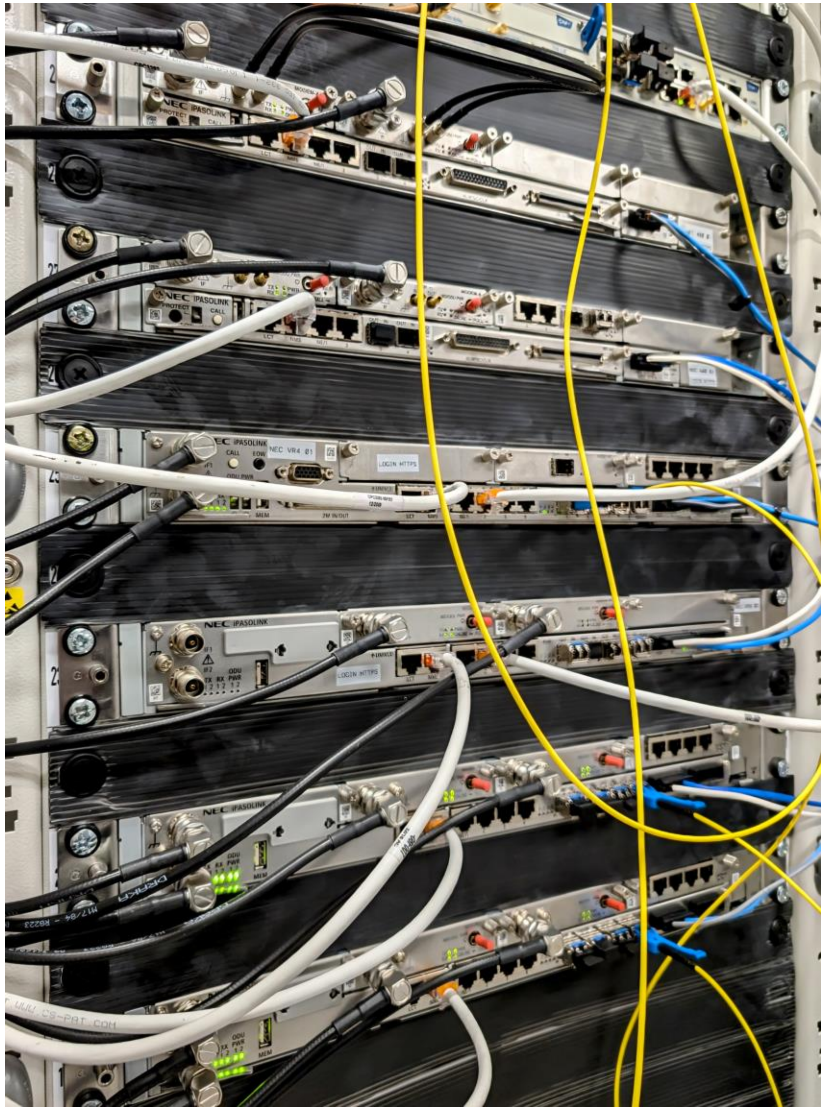


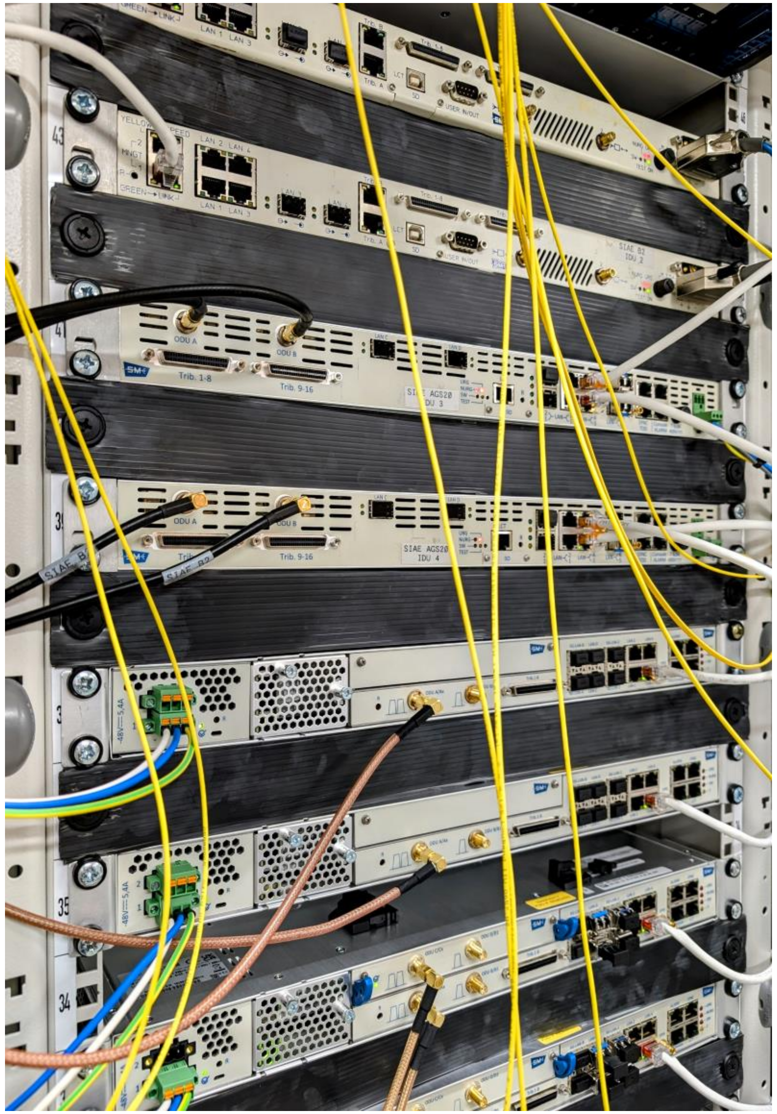
Access microwave radio system on test



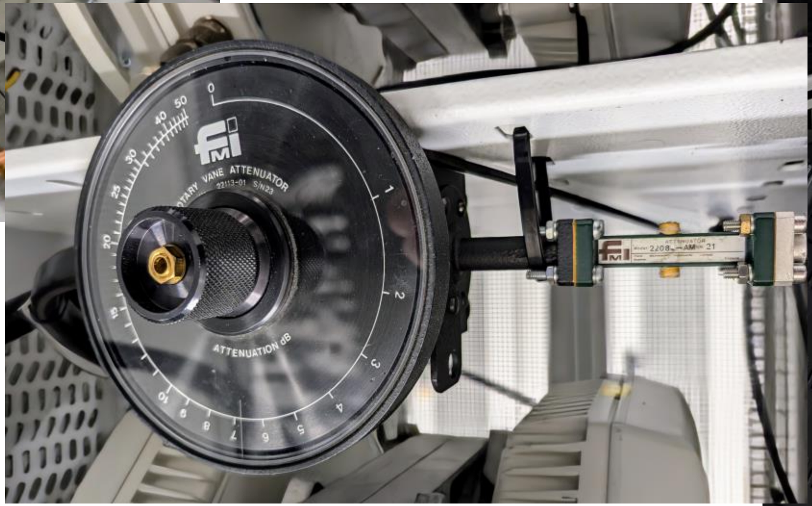


Microwave radio IDUs in the lab





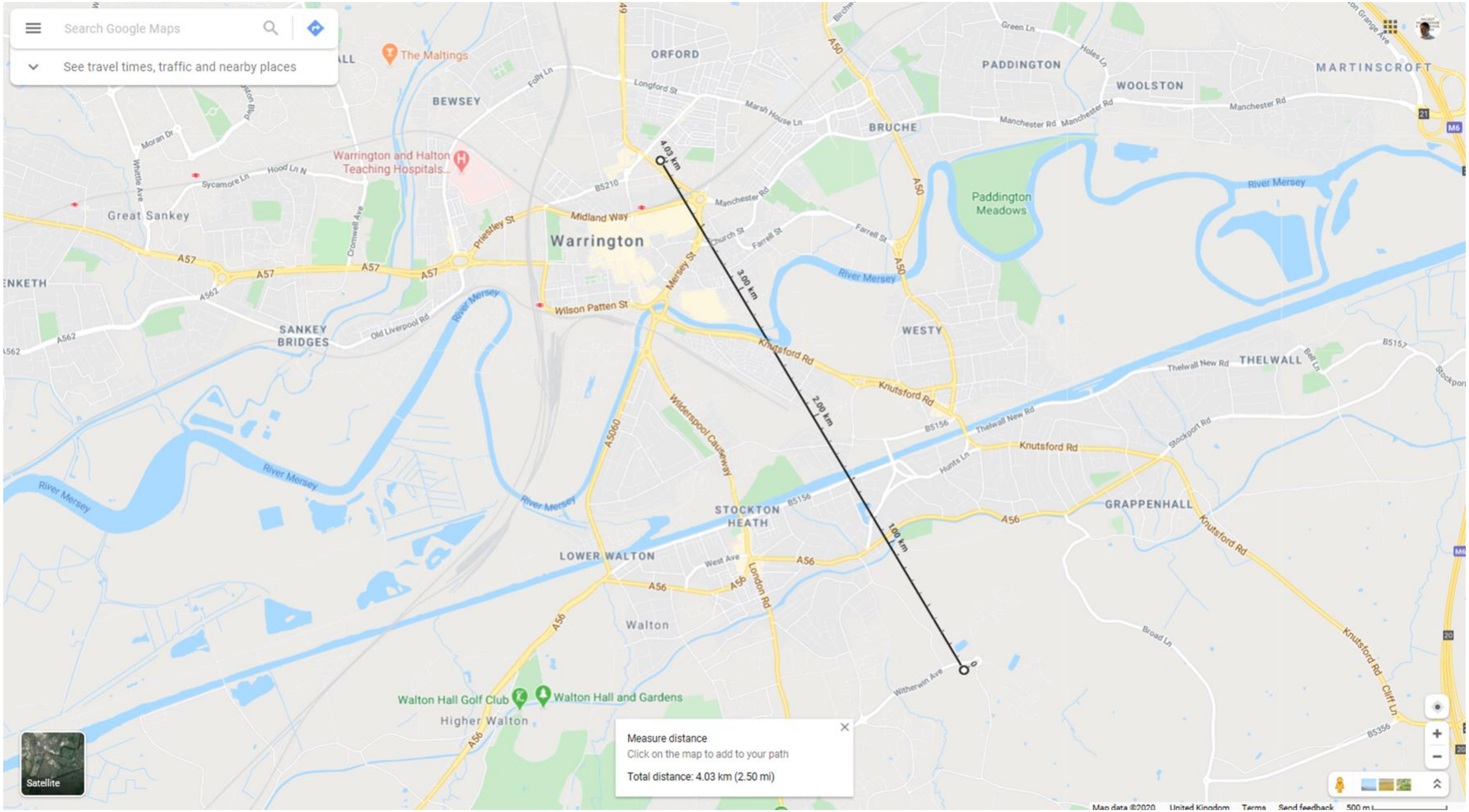
ODUs in the lab



All outdoor microwave radio system

Microwave radio link planning example

- Backhaul connectivity for multi-RAT street-works column (2G, 3G & 4G)
- Siae AGS20/ASN radio
- 32 GHz band
- 56 MHz channels
- XPIC operation (2+0)
- 256QAM
- 60cm ETSI Class 4 Ae


Search Google Maps
See travel times, traffic and nearby places
The Maltings
ORFORD
BEWSEY
PADDINGTON
WOOLSTON
MARTINSCROFT
BRUCHE
Warrington and Halton Teaching Hospitals...
Great Sankey
Warrington
Midland Way
Paddington Meadows
River Mersey
WESTY
SANKEY BRIDGES
Wilson Patten St
Knutsford Rd
THELWALL
4.03 km
3.00 km
2.00 km
1.00 km
STOCKTON HEATH
GRAPPENHALL
LOWER WALTON
Walton
Walton Hall Golf Club
Walton Hall and Gardens
Higher Walton
Satellite
Measure distance
Click on the map to add to your path
Total distance: 4.03 km (2.50 mi)
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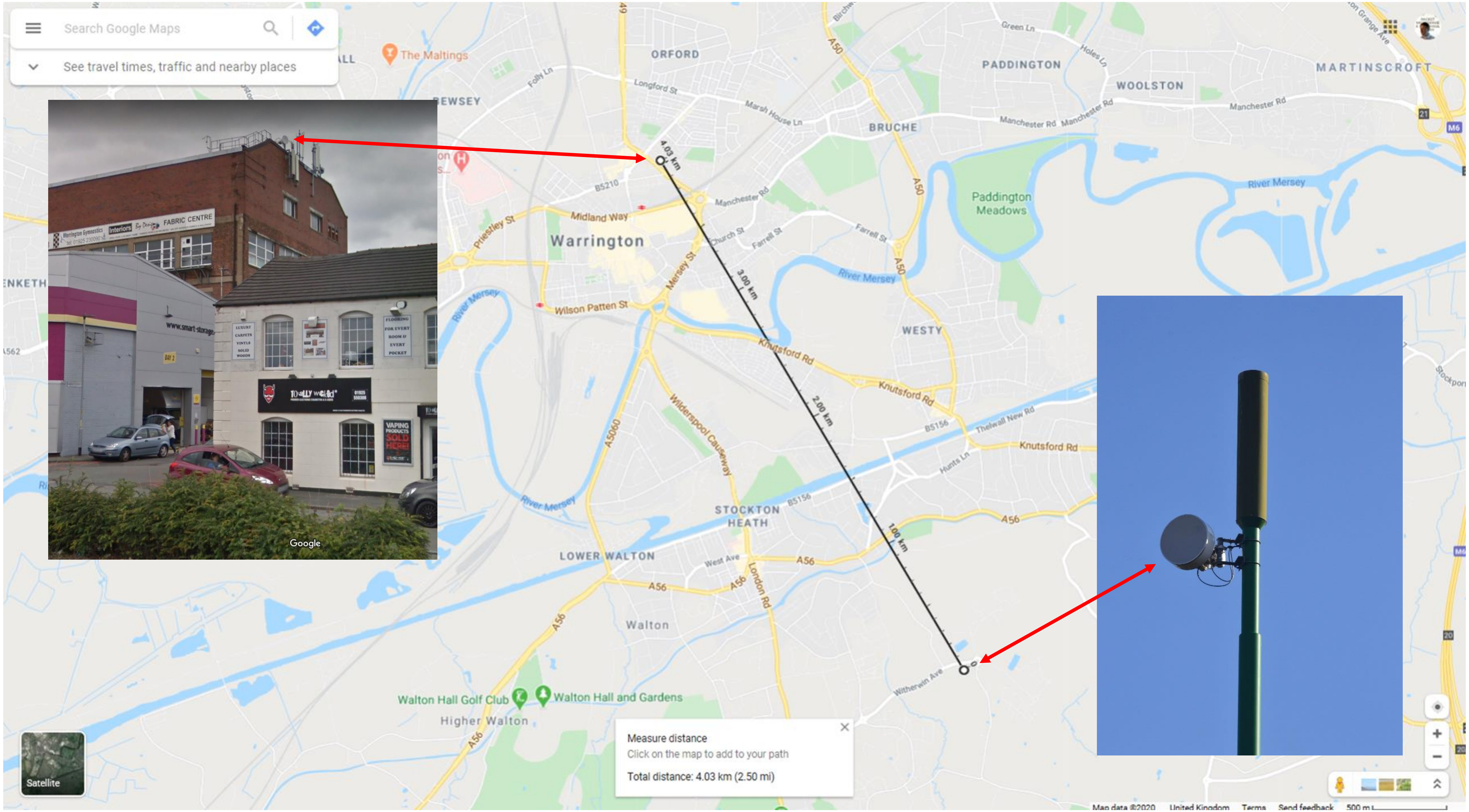
Send feedback
500 m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Midland Way
Wilson Patten St
WESTY
Knutsford Rd
STOCKTON HEATH
LOWER WALTON
Walton
Walton Hall Golf Club
Walton Hall and Gardens
Higher Walton
4.03 km
3.00 km
2.00 km
1.00 km
Google
FABRIC CENTRE
Measure distance
Click on the map to add to your path
Total distance: 4.03 km (2.50 mi)
Satellite
Map data ©2020
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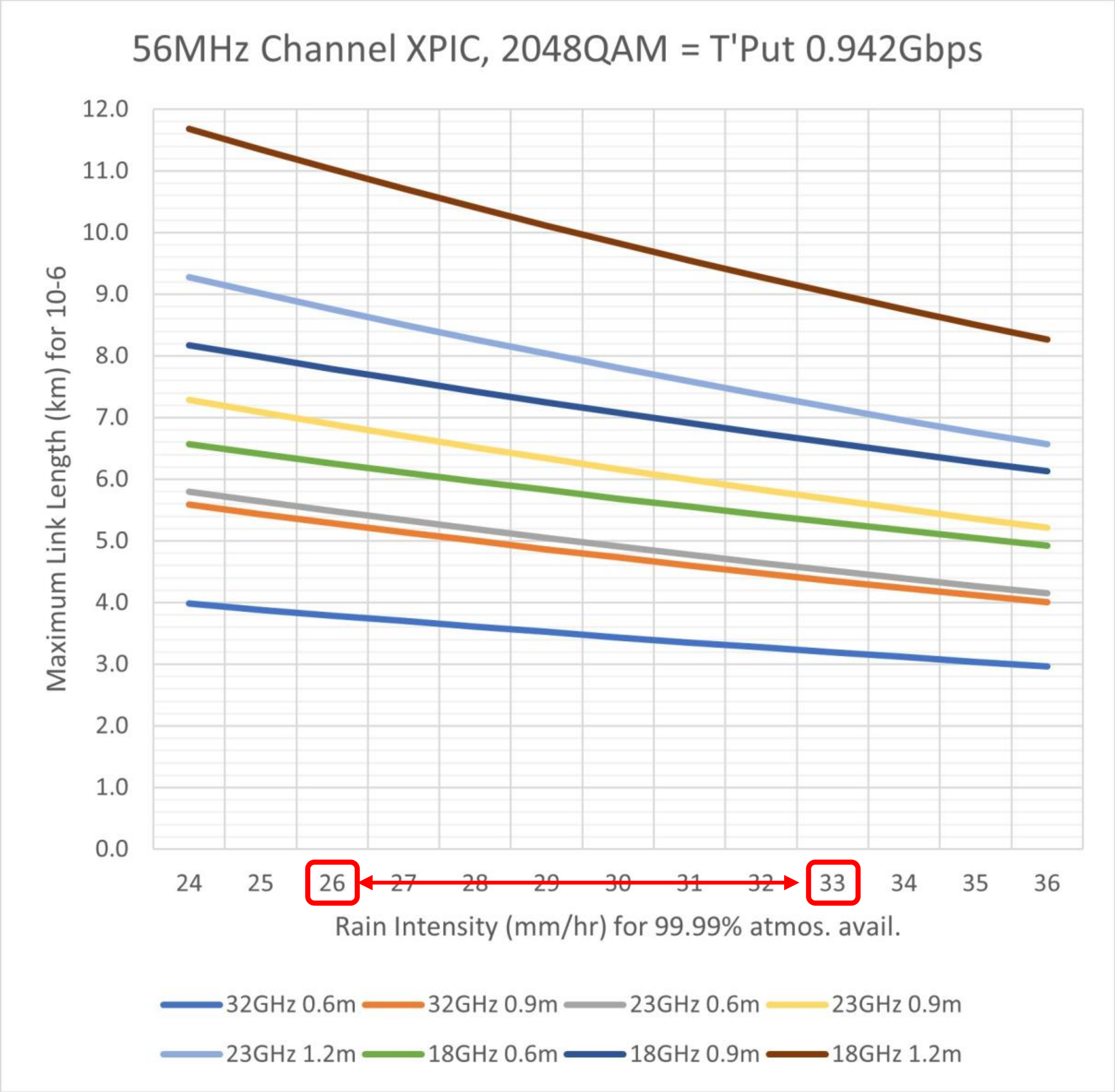
Send feedback
500 m

Radio link path budget

- Design target is 99.99% atmospheric availability
- Link length is 4.03km
- Transmit power = +15dBm (32mW)
- Antenna gain = 43.5dBi
- OMT insertion loss = 1dB
- Free Space Path Loss = 32.44 + 20log(f) + 20log(d) = 134.68dB
- Antenna gain = 43.5dBi
- OMT insertion loss = 1dB
- Receive level = -36.02dBm
- Receiver threshold = -61.5dBm

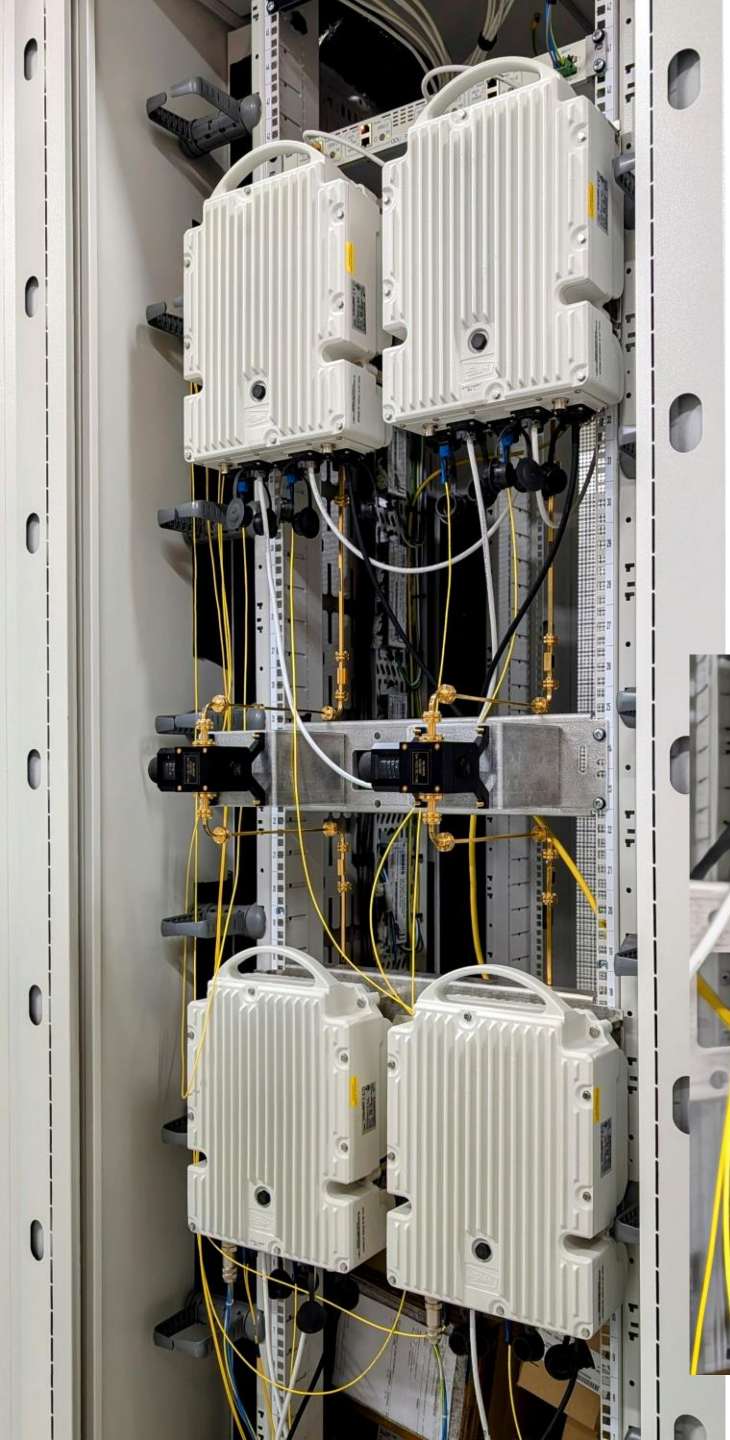
Difference = fade margin

Link length plots for different bands, antenna sizes, and rainfall intensity

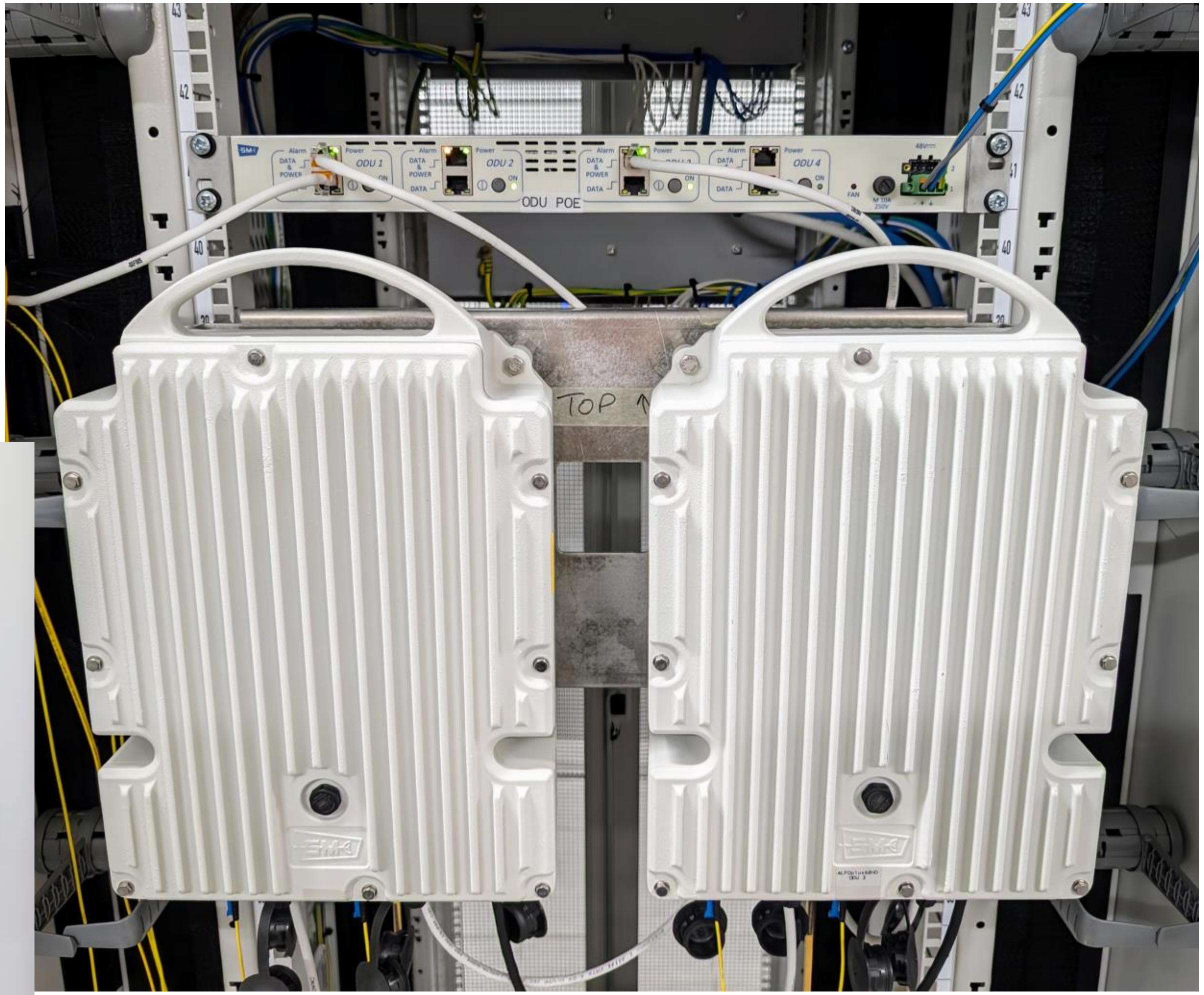


Source: Institute Of Telecommunications Professionals (ITP) Journal Volume 17 - Part 3 - 2023 - Access Microwave Radio Systems by Andy Sutton & Julian Divett

E-band millimetre wave radio system

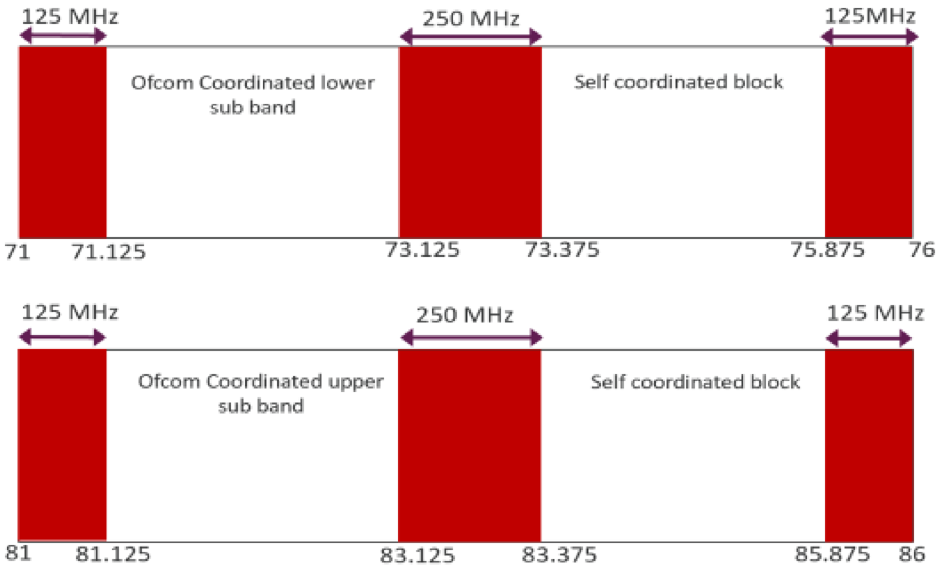


All outdoor radio system



71 to 76 GHz paired with 81 to 86 GHz

70/80 GHz	Radio Channels Available in the UK	
	Self-Coordinated Blocks	**Ofcom Coordinated Blocks**
See band plan below	Channel arrangements are not specified for these bands in the UK for the self-coordinated block.	32 x 62.5 MHz 16 x 125 MHz 8 x 250 MHz 4 x 500 MHz 2 x 750 MHz 2 x 1000 MHz



Channel Duplex Spacing for Self-Coordinated Block: N/A

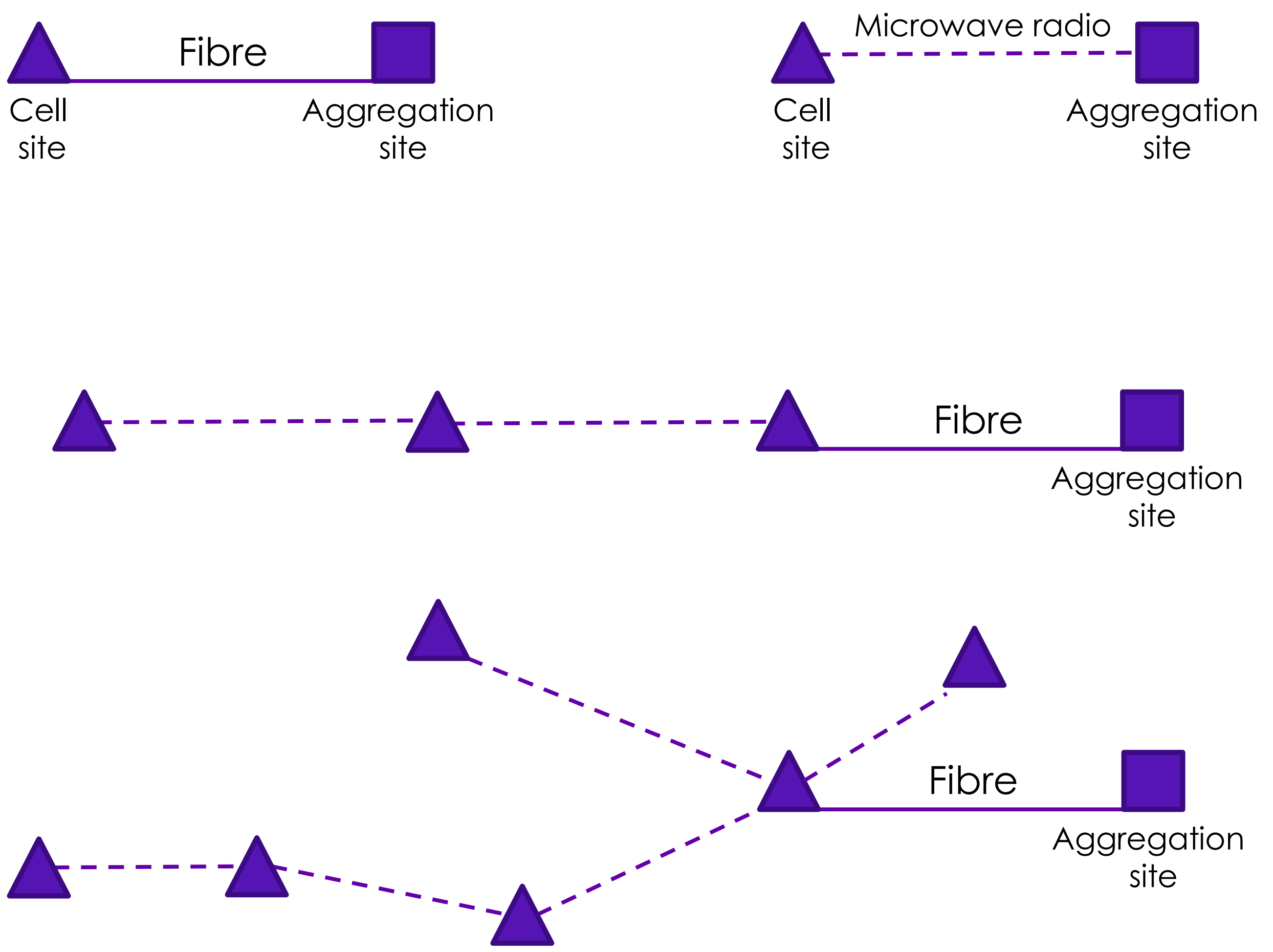
Channel Duplex Spacing for Ofcom Coordinated Block: 10 GHz

CEPT ECC Recommendation (05)07 (Cross band duplex)

* The 70/80GHz band has two separate authorisation approaches: i) Ofcom Coordinated & ii) Self Coordinated. The diagram above shows the frequency band splits and separation gap between the two approaches.

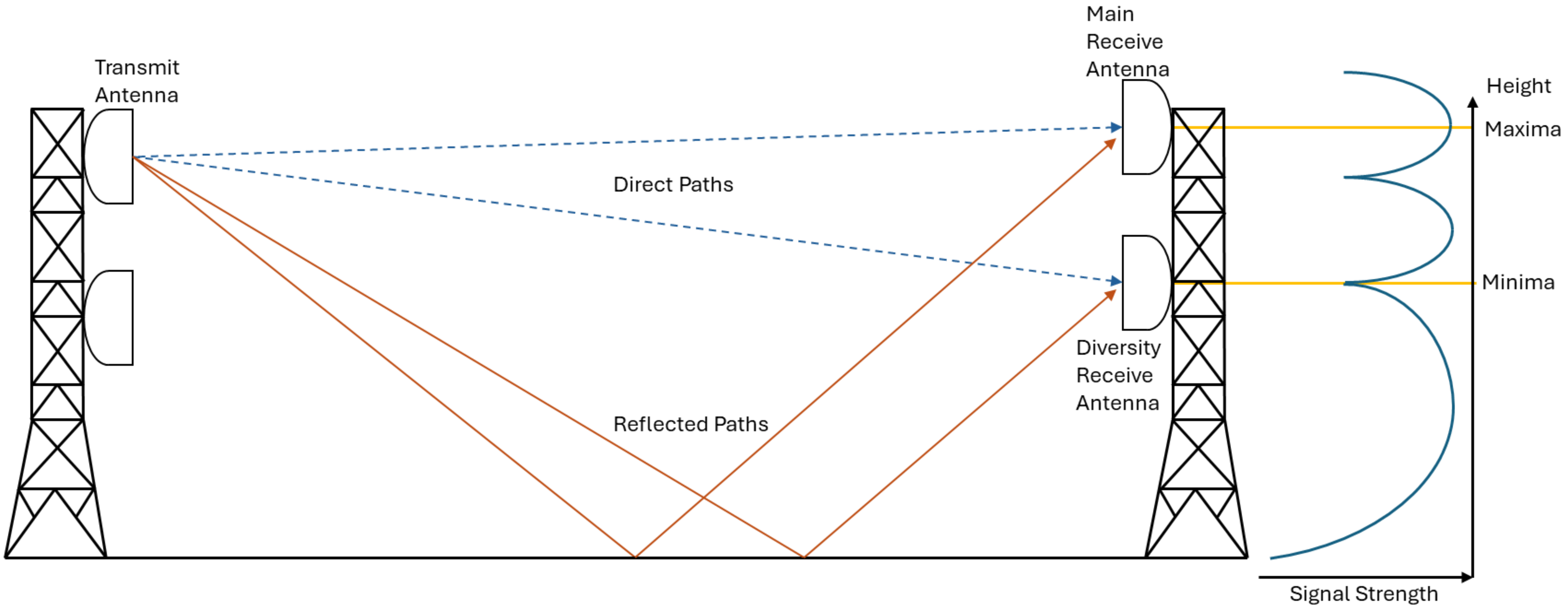
OfW48 source: https://www.ofcom.org.uk/siteassets/resources/documents/manage-your-licence/fixed-terrestrial-links/ofw48.pdf?v=335453

Mobile backhaul network topologies



Many variations of network topology are possible to meet different deployment scenarios

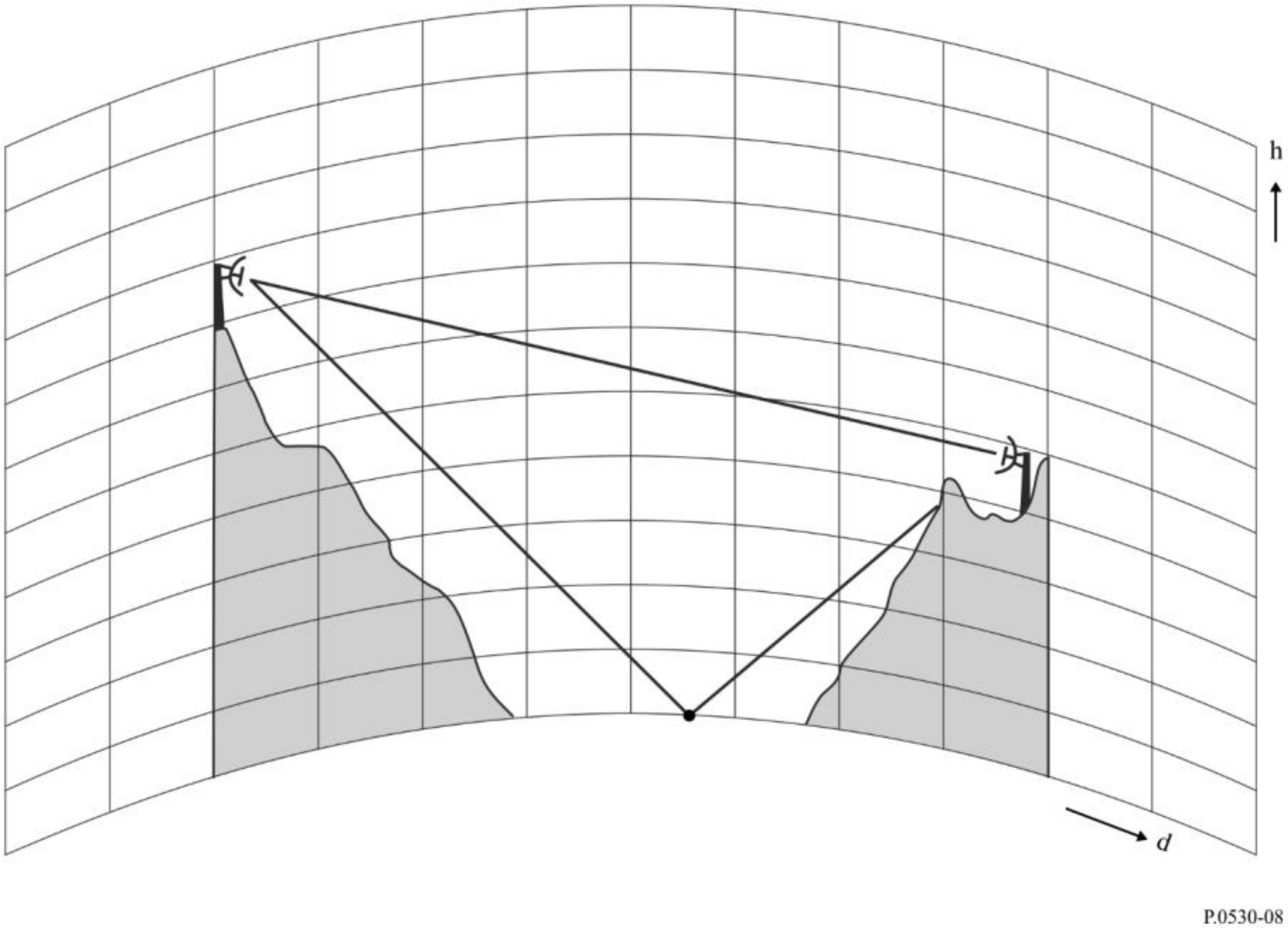
Space diversity operation



Space Diversity is usually achieved using two vertically spaced antennas - By putting a second receive antenna on the tower, with a vertical separation from the first antenna, it is possible to create a second set of delay combinations and improve link availability

Source: Institute Of Telecommunications Professionals (ITP) Journal Volume 19 - Part 2 - 2025 - Trunk Microwave Radio Systems by Andy Sutton & Maurice Gifford

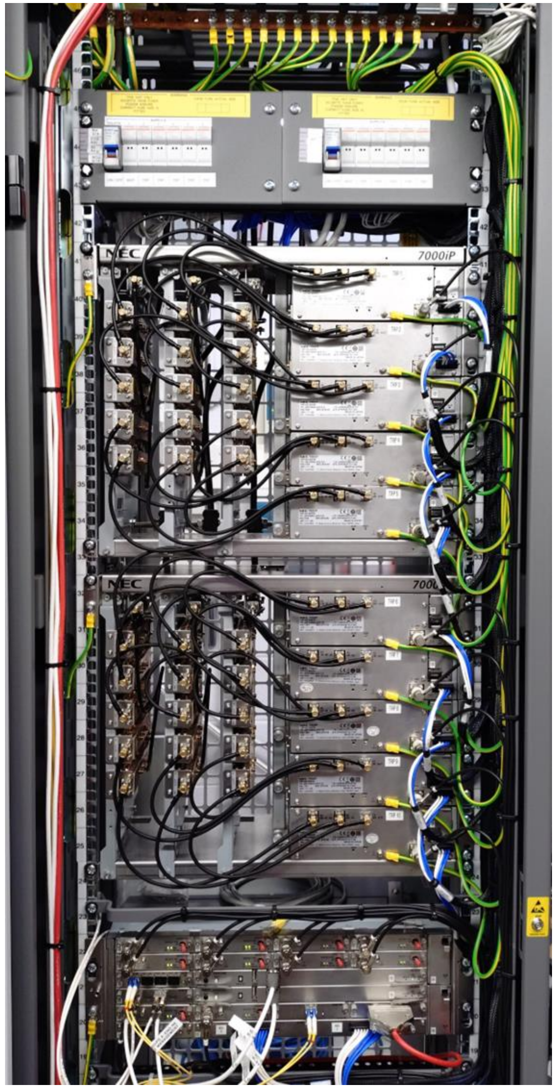
Example of shielding of antenna from specular reflection



Source: https://www.itu.int/dms_pubrec/itu-r/rec/p/R-REC-P.530-18-202109-I!!PDF-E.pdf

Trunk radio systems

Also known as trunking, or core network radios



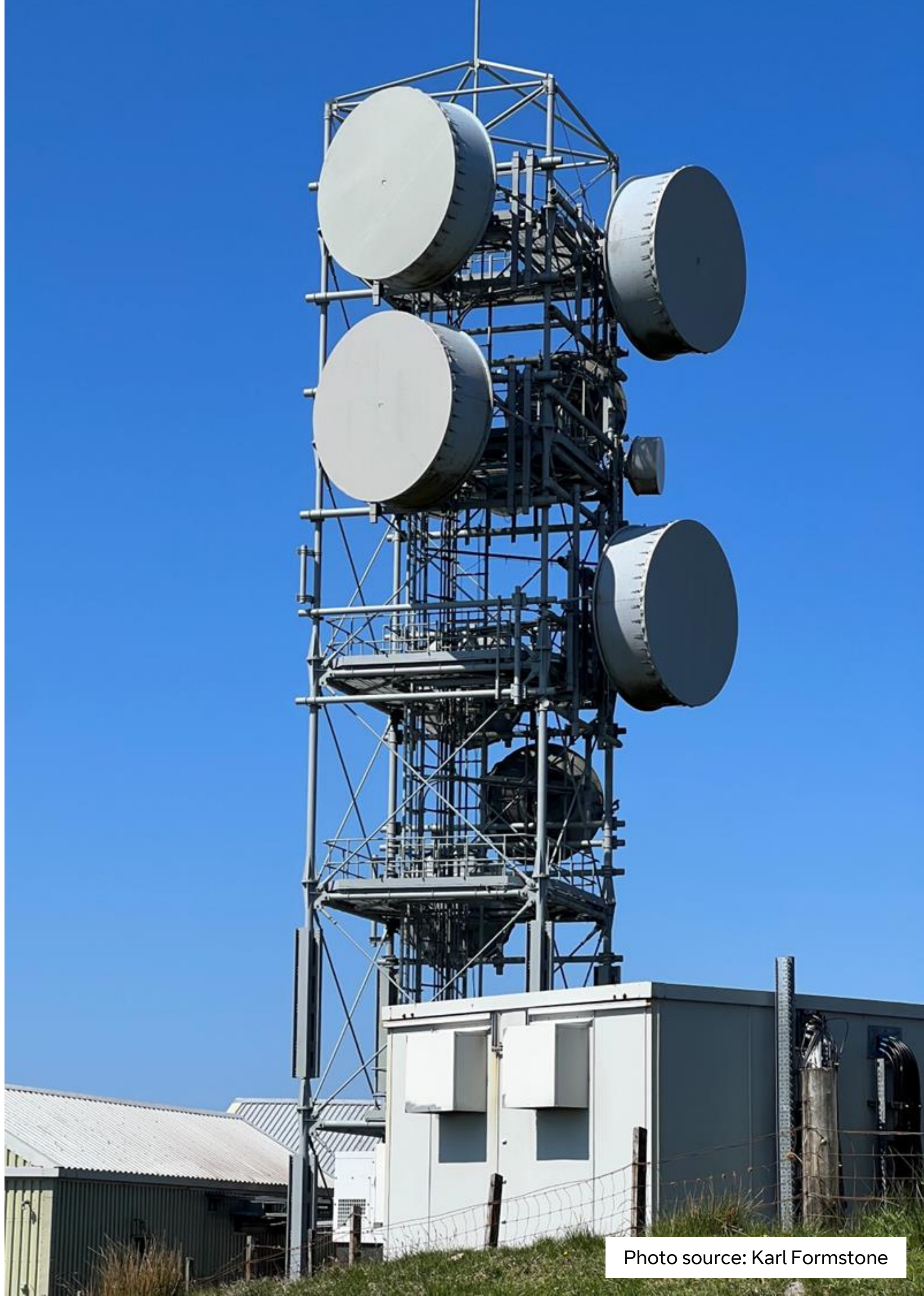
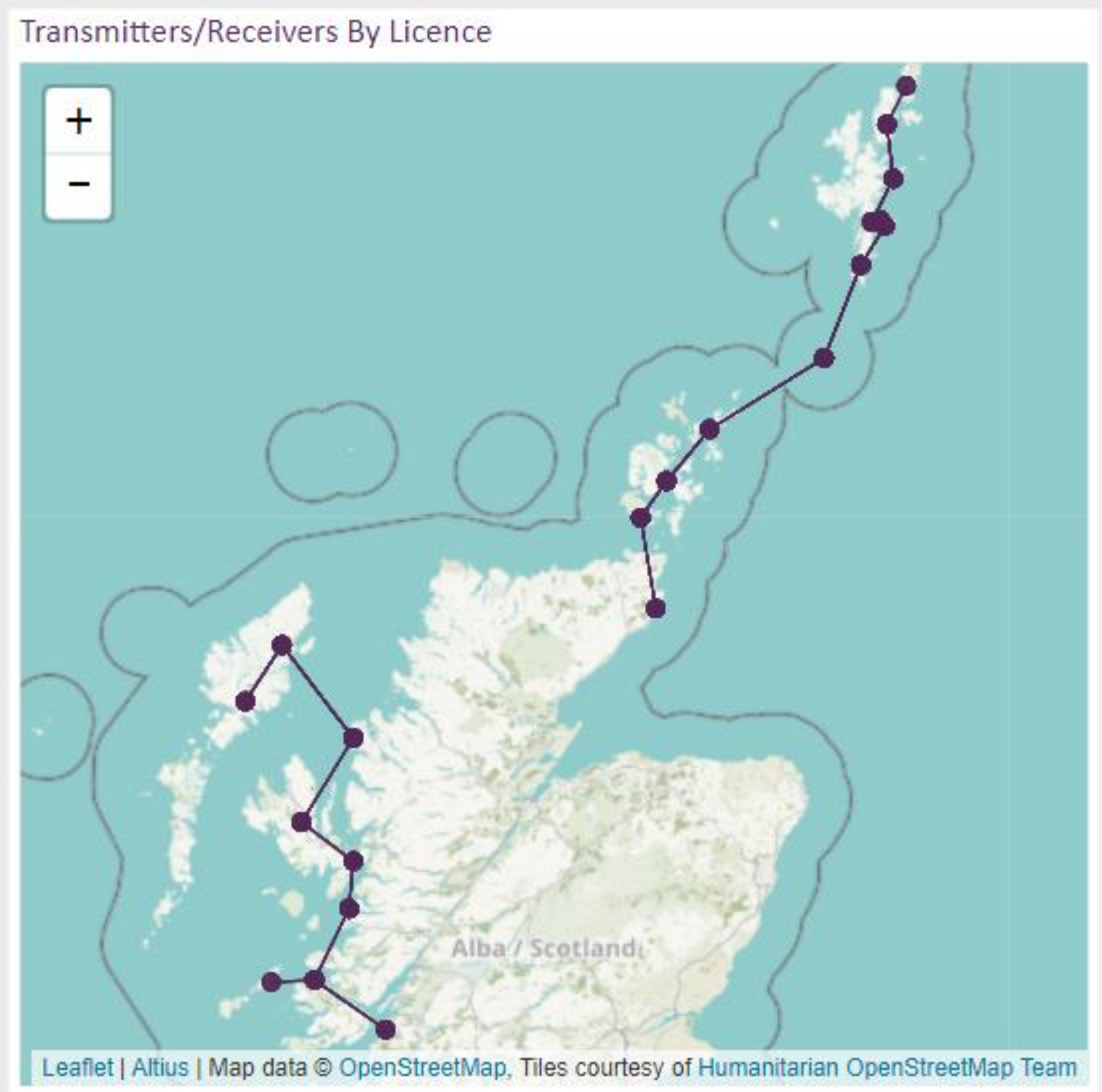


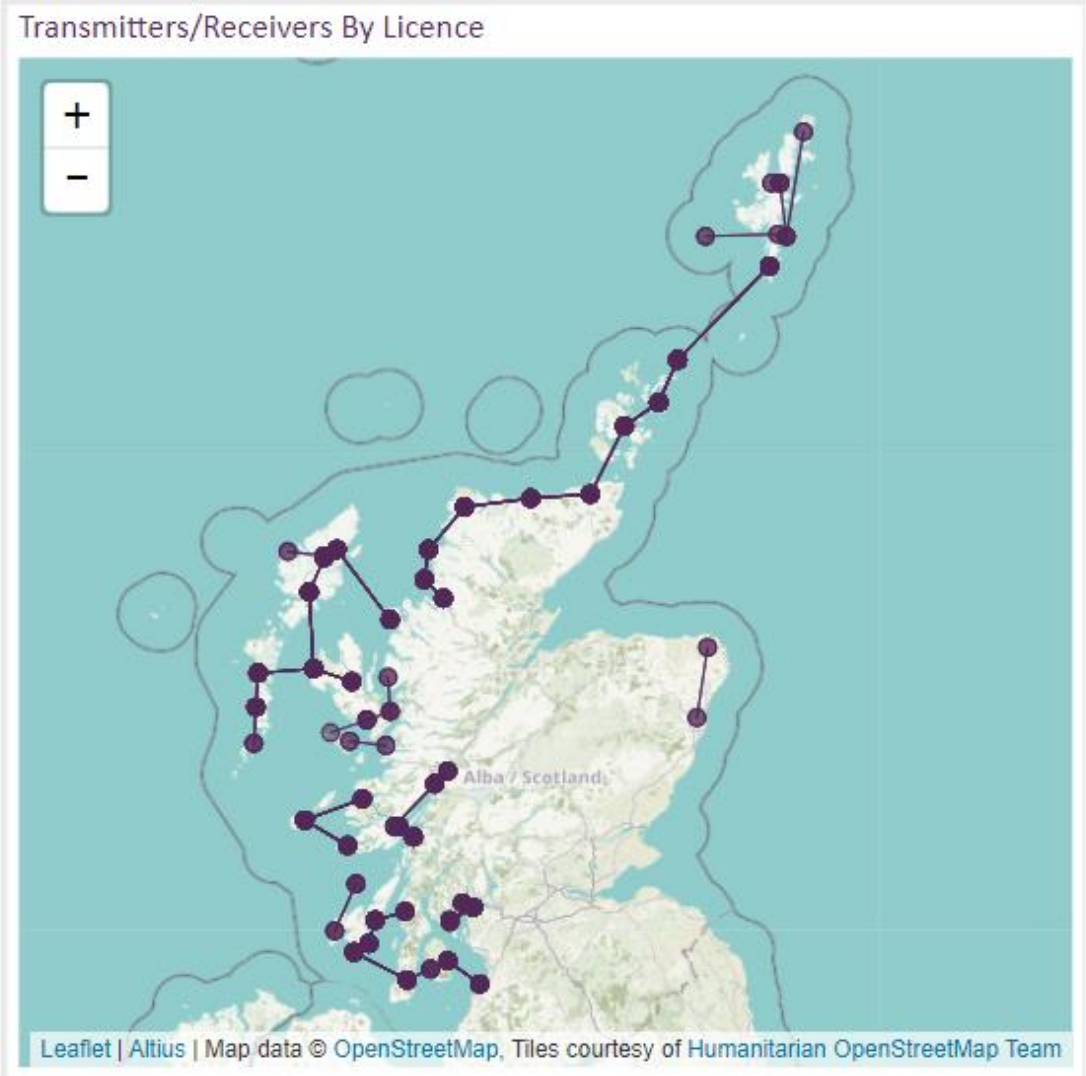
Photo source: Karl Formstone

BT Tower - enabling national microwave communications...

Trunk radio in L6 GHz + U6 GHz bands
Majority of links are in Scotland

Note, the following links exist but aren't illustrated here: : L6 GHz link between Isle of Wight and mainland + U6 GHz links between Isles of Scilly & mainland , along with Heysham and Dalton in Furness





133 licences in L6 GHz frequency band + 239 licences in the U6 GHz frequency band - note: typically, multiple radio channels per MW hop

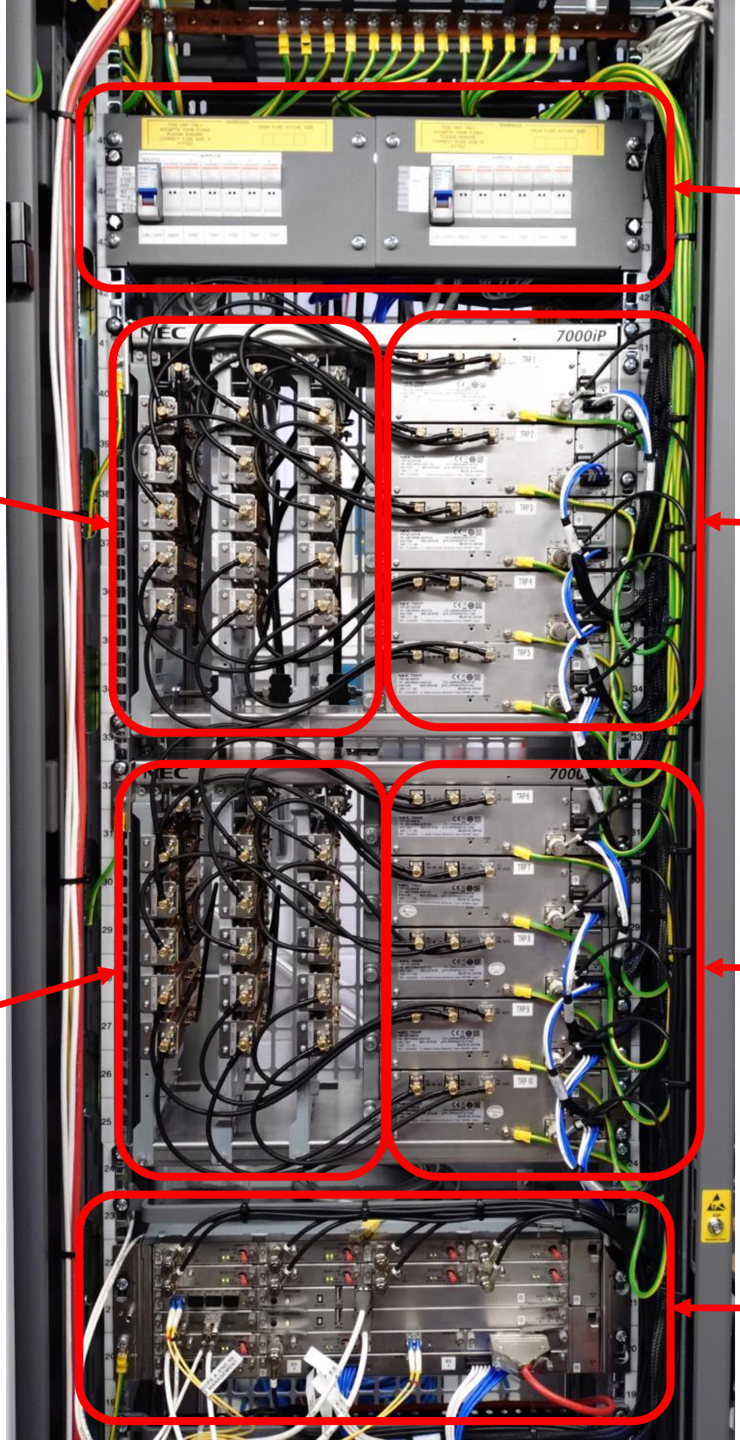
Source: https://www.ofcom.org.uk/spectrum/information/spectrum-information-system-sis/spectrum-information-portal

Trunk radio sites

Trunk radio

Branching Networks Vertical Polarisation (1 x transmit 2 x receive)

Branching Networks Horizontal Polarisation (1 x transmit 2 x receive)



Power Distribution

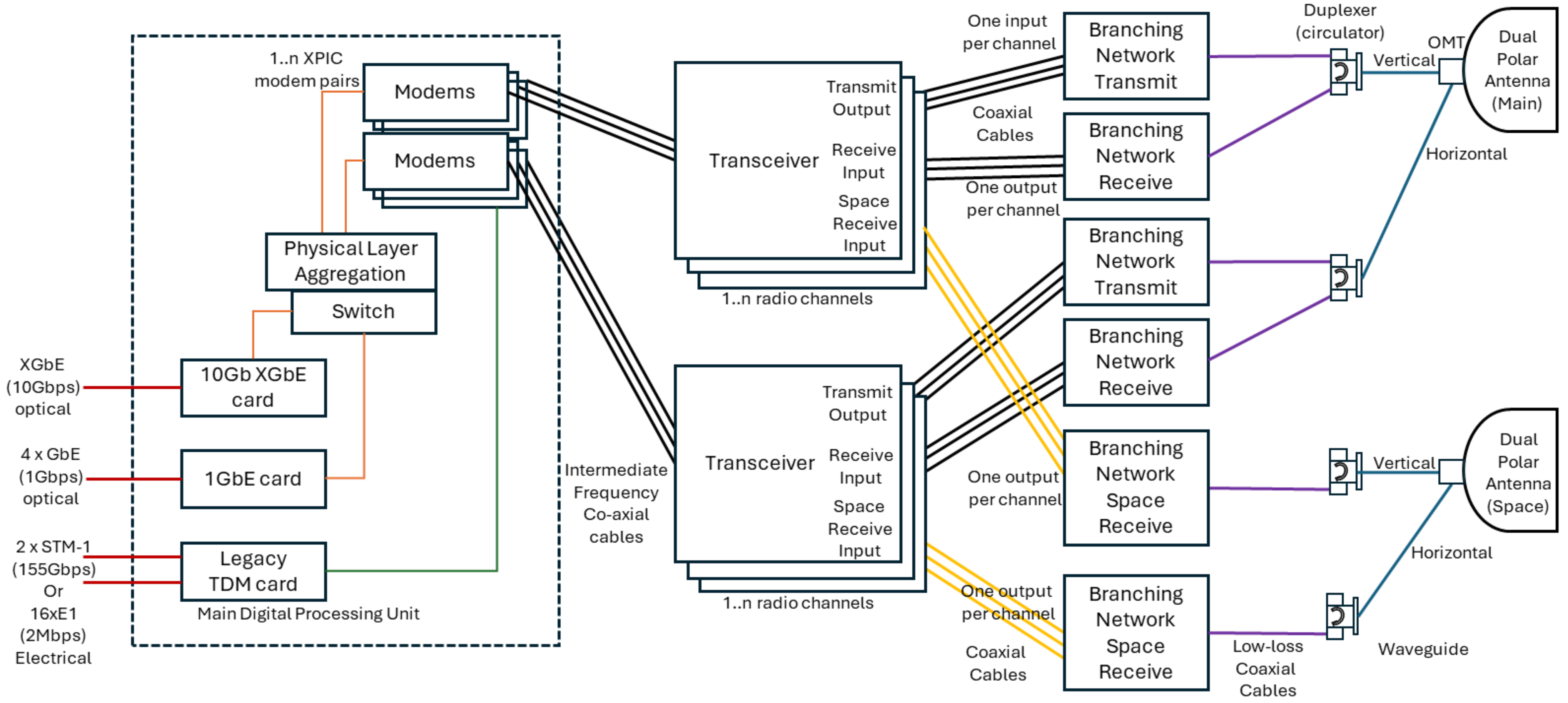
Transceivers - Vertical polarisation

Transceivers - Horizontal polarisation

Main Digital Processing Unit (baseband)

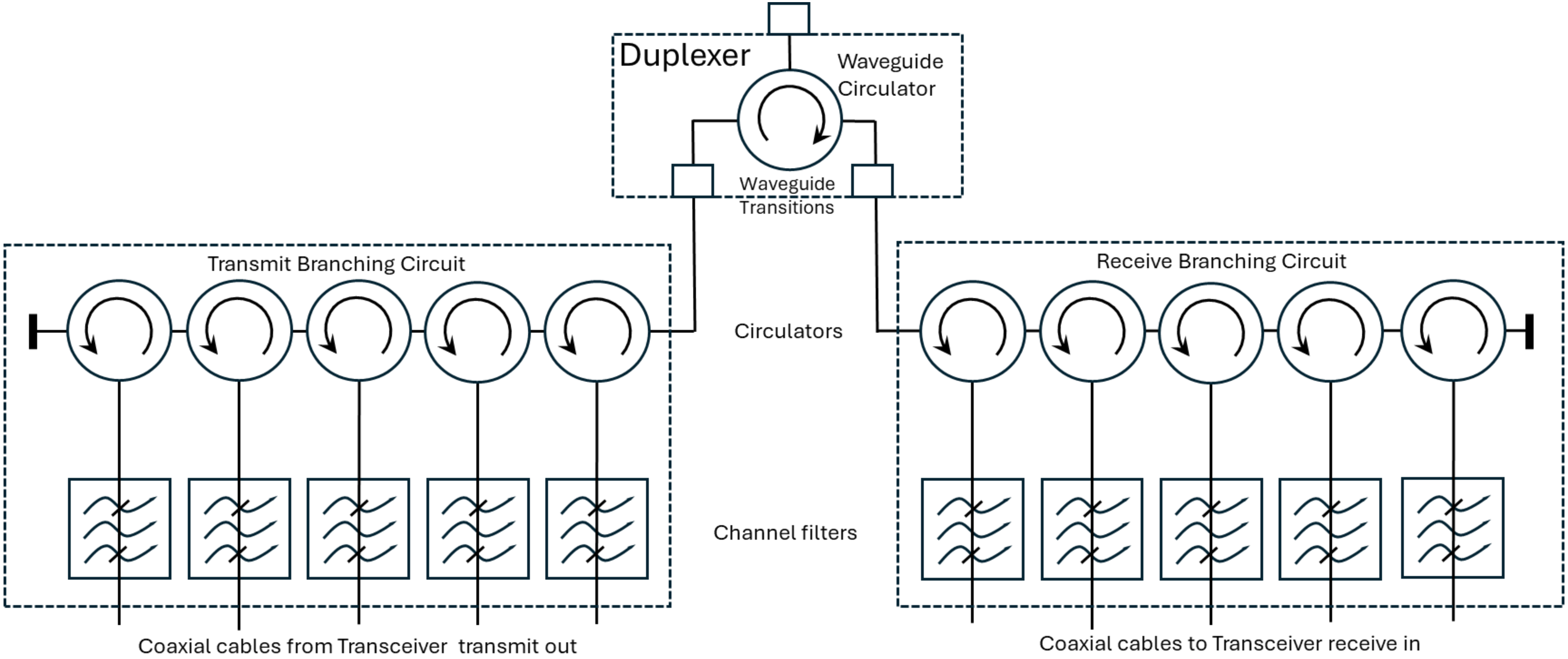
Source: Institute Of Telecommunications Professionals (ITP) Journal Volume 19 - Part 2 - 2025 - Trunk Microwave Radio Systems by Andy Sutton & Maurice Gifford

Trunk radio block diagram, 3 radio channels, cross polar with space diversity

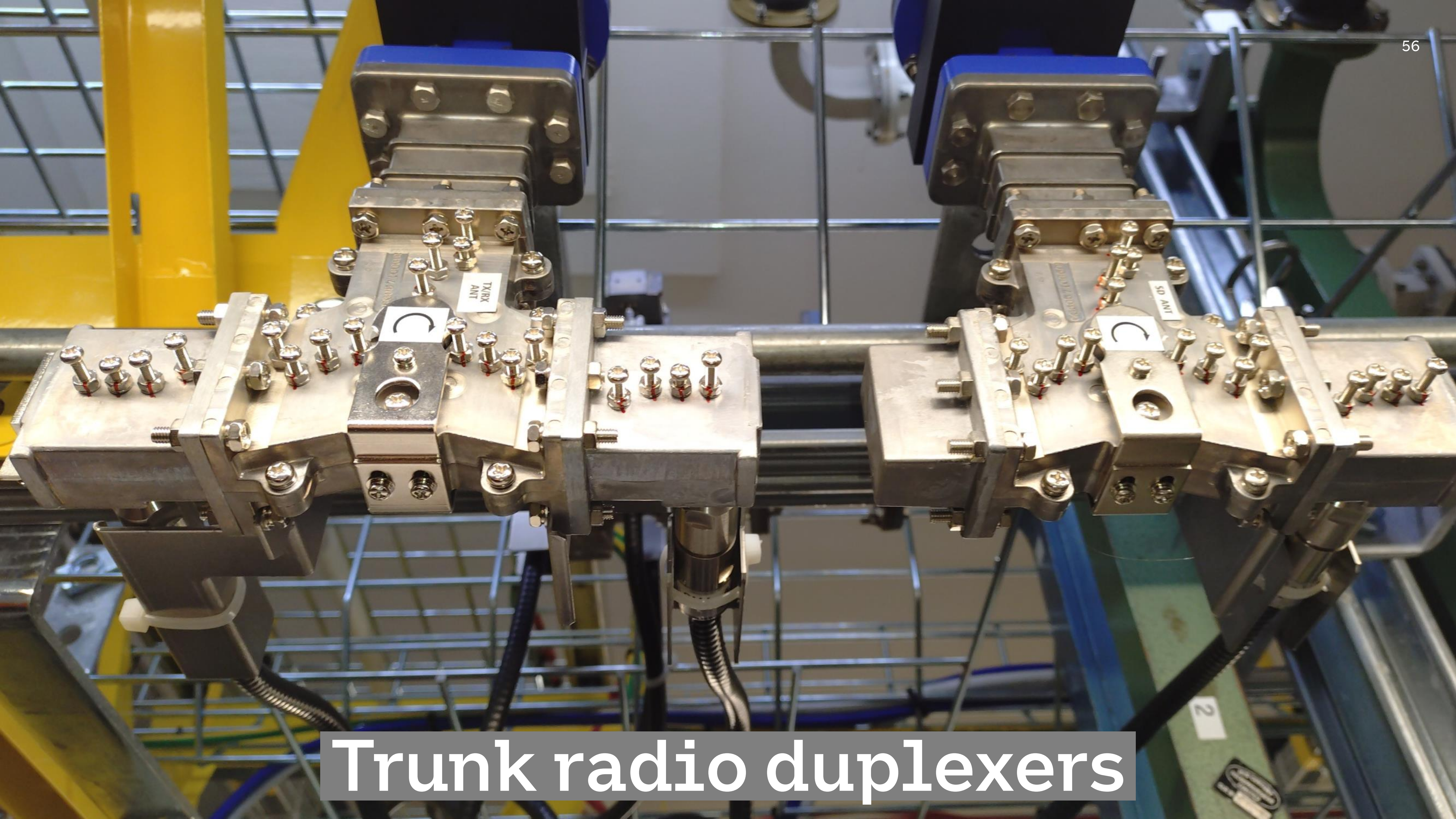


Source: Institute Of Telecommunications Professionals (ITP) Journal Volume 19 - Part 2 - 2025 - Trunk Microwave Radio Systems by Andy Sutton & Maurice Gifford

Typical main path branching circuit for 5 radio channels, showing duplexer and waveguide port



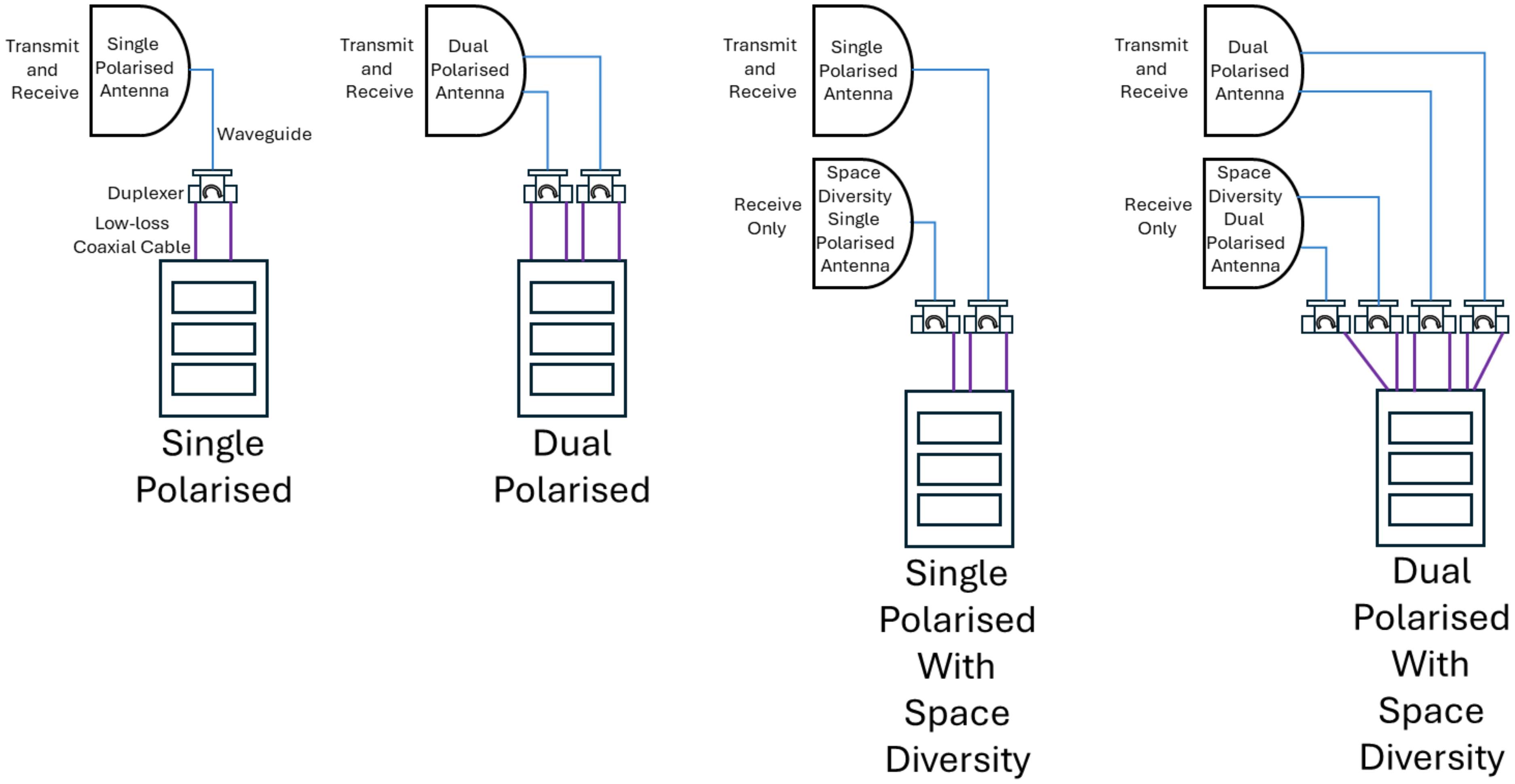
Source: Institute Of Telecommunications Professionals (ITP) Journal Volume 19 - Part 2 - 2025 - Trunk Microwave Radio Systems by Andy Sutton & Maurice Gifford



Trunk radio duplexers

Internal waveguide installation

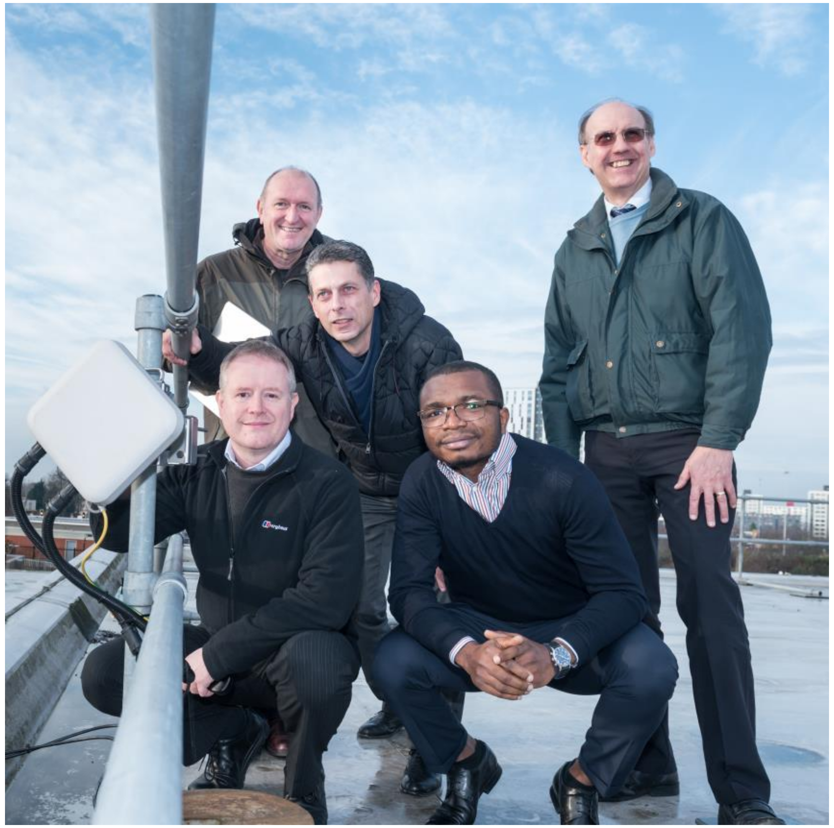
Core radio antenna system configurations



Source: Institute Of Telecommunications Professionals (ITP) Journal Volume 19 - Part 2 - 2025 - Trunk Microwave Radio Systems by Andy Sutton & Maurice Gifford

The future…

- Higher frequency bands
- Wider radio channels
- Higher order modulation schemes
- Higher power amplifiers
- Improved receiver sensitivity



Atmospheric impact on the performance of a 60GHz point-to-point link for 5G infrastructures

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***Abstract*—There is growing interest in the use of millimeter-wave spectrum as a potential candidate for the provision of high capacity, short range, back-haul solutions within future 5G ultra-dense network infrastructures. However, it is recognized that these frequencies are highly susceptible to atmospheric conditions and therefore a more detailed understanding of such behavior is required. This paper presents the initial results from a long-term trial of a 60GHz short range point to point link that is under test at the University of Salford, UK. Results clearly show the direct correlation between path loss and rainfall but also prove that link throughout can be maintained except in the most extreme conditions. Data for the month of August 2017 is presented during which there was only one brief occasion where an 18% drop in throughput was recorded.**

***Index Terms*—millimeter wave, microwave, back-haul.**

I. Introduction

The high system capacity and end-user data rates demanded of 5G will see the emergence of ultra-dense network infrastructures based on a small cell architecture [1,2]. However, such architectures will bring new challenges in the provision of back-haul and it is here where significant interest is being shown in the adoption of millimeter-wave solutions (30GHz to 300GHz).

Millimeter-wave spectrum offers high speed wireless communications but suffers from attenuation loss caused by atmospheric and moisture absorption which greatly limits its effective range. Nevertheless, these characteristics are precisely those required within ultra-dense networks. Short transmission paths coupled to high propagation losses limits the amount of interference between adjacent point-to-point back-haul links. Operating at these frequencies also allows for narrow beam technology to be employed which in turn aids security. A favorable license regime, often unlicensed, applies to frequencies within V-Band (57 to 66GHz) which further makes it an attractive proposition for network providers [3].

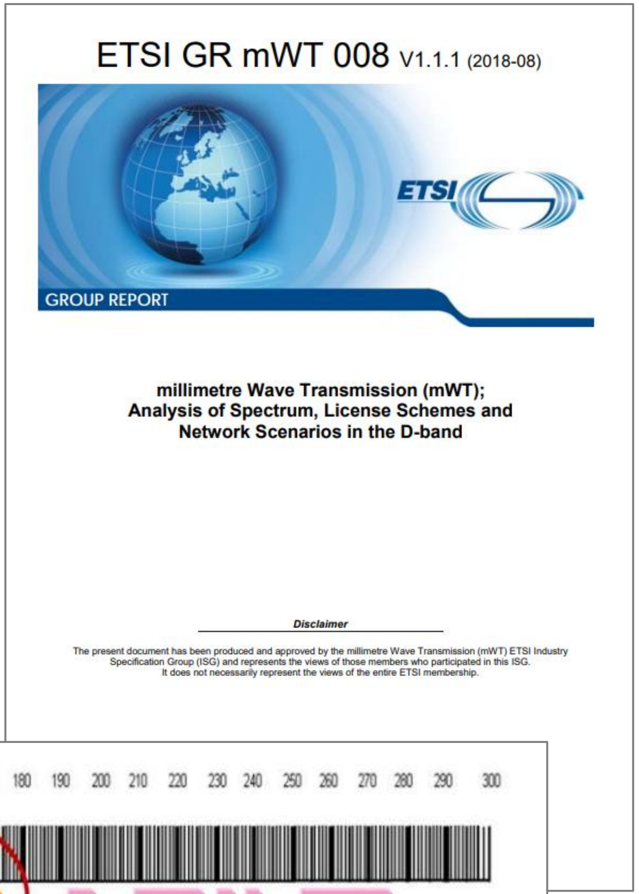
Consequently, the unlicensed 60GHz band is seen as a potential candidate to provide back-haul in future 5G network architectures. However, there is also a need to better understand its resilience against varying weather conditions and over an extended period of time. Hence, this paper reports on, and presents initial results from, a new project being undertaken at the University of Salford, UK in partnership with both NEC and BT, to investigate atmospheric impacts on point-to-point links operating at 60GHz over a period of one year.

II. Salford Test-Bed Network Configuration

The University of Salford's main campus is set in 160 acres of parkland on the banks of the River Irwell, adjoining Peel Park, 1.5 miles west of Manchester City Centre. A test-bed network has been created on this campus to provide a 60GHz point-to-point link operating over 210m and connecting the Newton and Maxwell buildings as shown in Fig. 1. A weather station is conveniently located on the nearby Cockcroft building from which local climatic data is obtained.

Fig. 1. University of Salford 60GHz test-bed network location

The radio link itself comprises two NEC iPASOLINK SX IP packet radios. These compact units are designed for small cell deployment, comprise an integral small antenna and advanced Ethernet functionality. The Newton end of the link is configured to transmit at 61.025GHz whereas the Maxwell end is configured to transmit at 59.025GHz. The transmit power at both ends is set to -10dBm and the gain



ETSI GR mWT 008 V1.1.1 (2018-08)

millimetre Wave Transmission (mWT); Analysis of Spectrum, License Schemes and Network Scenarios in the D-band

Disclaimer

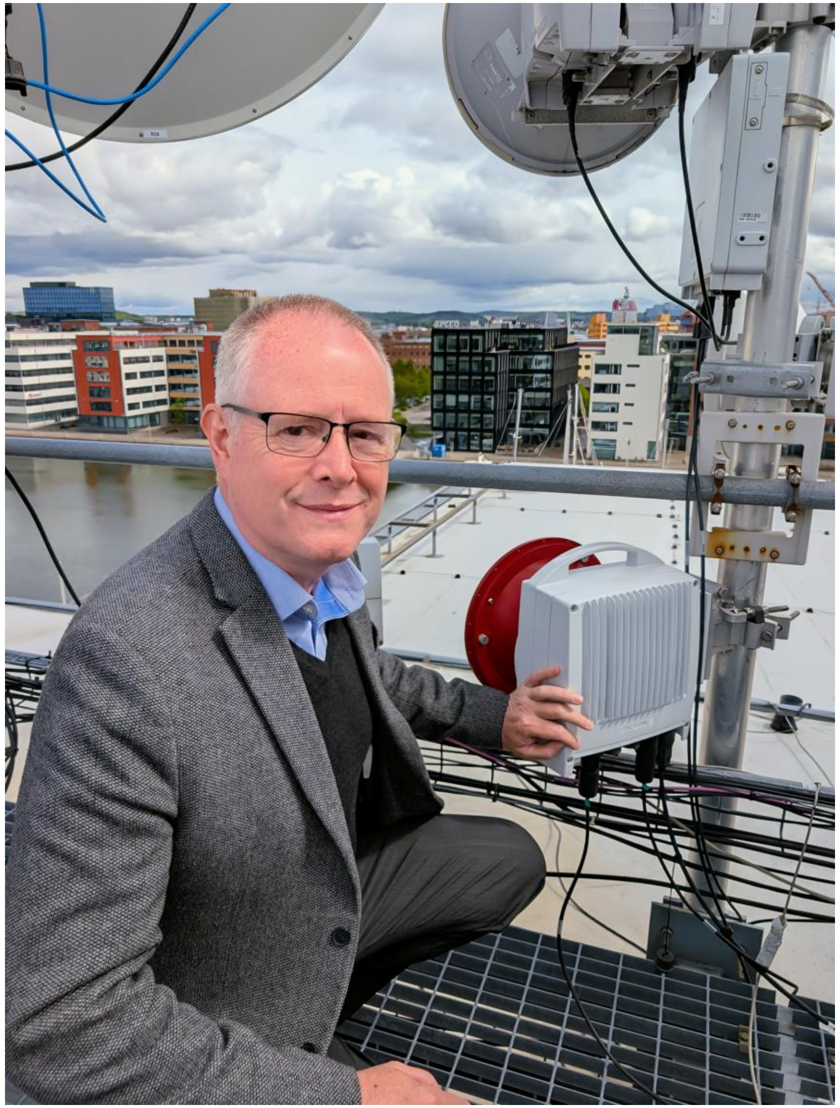
The present document has been produced and approved by the millimetre Wave Transmission (mWT) ETSI Industry Specification Group (ISG) and represents the views of those members who participated in this ISG. It does not necessarily represent the views of the entire ETSI membership.

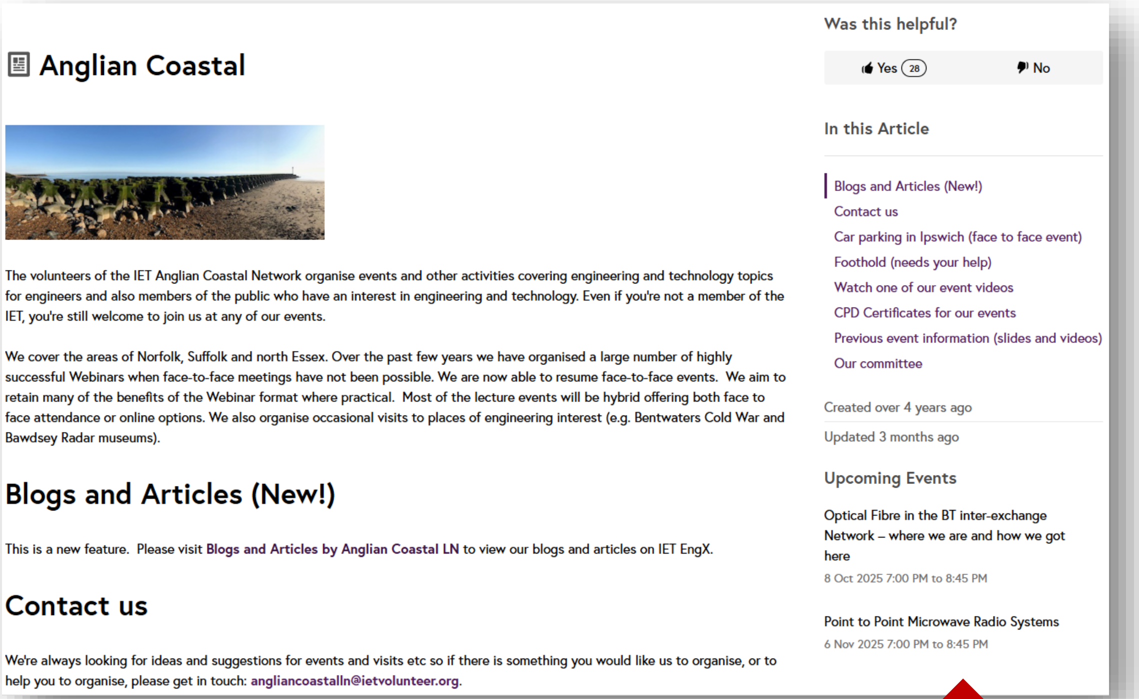
Read more at: https://www.etsi.org/committee/1426-mwt

Summary

- Point to point microwave radio systems provide cost-effective, high-availability, transmission solutions
- Radio solutions are defined as access radios, or trunk (core) radios - albeit there is some overlap in use cases
- Radio systems can scale to multiple Gbps of throughput
- Wider radio channels, higher order modulation schemes, and carrier aggregation features are increasingly common
- Adaptive Coding and Modulation (ACM) enhances throughput and/or atmospheric availability
- Trunk radio demand is reducing however access radio systems continue to be in significant demand
- Research is on-going into ever higher frequency bands, wider radio channels, higher modulation schemes and improved power amps and receivers…

Thanks for your attention, any questions?





Was this helpful?

Yes 28 No

Anglian Coastal

The volunteers of the IET Anglian Coastal Network organise events and other activities covering engineering and technology topics for engineers and also members of the public who have an interest in engineering and technology. Even if you're not a member of the IET, you're still welcome to join us at any of our events.

We cover the areas of Norfolk, Suffolk and north Essex. Over the past few years we have organised a large number of highly successful Webinars when face-to-face meetings have not been possible. We are now able to resume face-to-face events. We aim to retain many of the benefits of the Webinar format where practical. Most of the lecture events will be hybrid offering both face to face attendance or online options. We also organise occasional visits to places of engineering interest (e.g. Bentwaters Cold War and Bawdsey Radar museums).

Blogs and Articles (New!)

This is a new feature. Please visit **Blogs and Articles by Anglian Coastal LN** to view our blogs and articles on IET EngX.

Contact us

We're always looking for ideas and suggestions for events and visits etc so if there is something you would like us to organise, or to help you to organise, please get in touch: angliancoastalln@ietvolunteer.org.

In this Article

Created over 4 years ago

Updated 3 months ago

Upcoming Events

Optical Fibre in the BT inter-exchange Network – where we are and how we got here

8 Oct 2025 7:00 PM to 8:45 PM

Point to Point Microwave Radio Systems

6 Nov 2025 7:00 PM to 8:45 PM

Thank you for your attendance

Future IET Anglian Coastal Local Network events:

- 11 December 2025 (hybrid), **The Road to Self-driving Vehicles – are we nearly there?**, Paul Flowers & Kirit Bedia, ECS
- 14 January 2026 (hybrid), **From Advice Notes to Intelligent Automation**, Dave Milham, Chief Architect, TM Forum

For more details and how to register please visit:

https://engx.theiet.org/local-networks/ea1

Event CPD Certificate and Slides/Video will be posted on this site.