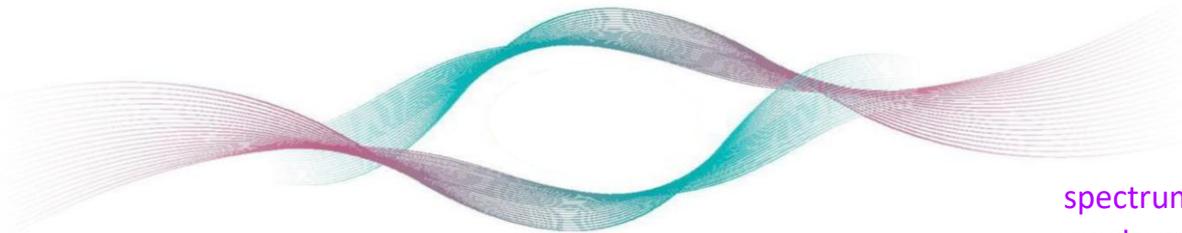


Co-existence in an age of technology neutrality and licence-exemption

Getting back to basics

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Introduction

TOPICS

- What is spectrum sharing?
- Dimensions of spectrum sharing
- ‘Spectrum Space’
- Examples of spectrum sharing
- Lessons from these examples
- The Radio Equipment Directive and receiver parameters
- A proposal for 60GHz band
- Conclusions and Recommendations

DISCLAIMER: This presentation describes my personal views and proposals

What is spectrum sharing?

- Spectrum sharing is inherently political
- It involves defining the priority of rights and responsibilities of different groups of spectrum users

Politics expressed in Decibels and Megahertz

- Spectrum sharing involves one or both of these characteristics:
 - Stations do not have priority over another (primary) user
 - Stations do not have priority over other users of the same type

(unlike local licenses, which assign rights to a user over a specific geographic area)

Primary and Secondary Services

- ITU Radio Regulations:
- Stations of a **primary service** have individual rights for protection
- Stations of a **secondary service**:
- **shall not cause harmful interference** to stations of primary services to which frequencies are already assigned or to which frequencies may be assigned at a later date;
- **cannot claim protection from harmful interference** from stations of a primary service to which frequencies are already assigned or may be assigned at a later date.
- **Harmful Interference**: Interference which endangers the functioning of a radionavigation service or of other safety services or **seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service** operating in accordance with Radio Regulations

Spectrum sharing has a long history

- International Radiotelegraph Conventions of 1906 & 1912
 - Power control
 - Listen before talk
- ERC Recommendation 70-03 on Short Range Devices (SRDs)
 - Defines operating conditions for licence-exempt equipment
 - First version was in 1970
- UK management of UHF radio mics
 - By Radiocommunications Agency since at least 1980s
 - The first TVWS database

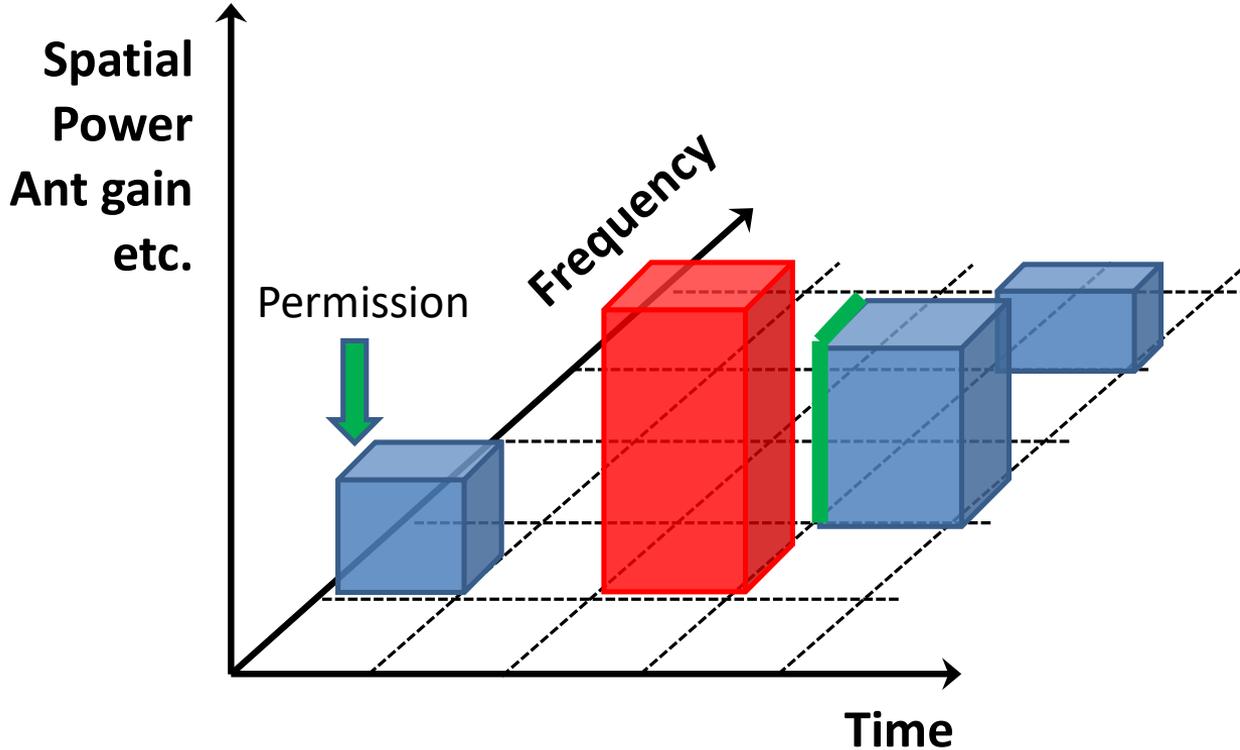
INTERNATIONAL RADIOTELEGRAPH CONVENTION.

Signed at London, July 5, 1912.

[British Ratification deposited at London, June 2, 1913.]

*Presented to both Houses of Parliament by Command of His Majesty
July 1913.*

Dimensions of spectrum sharing



For licence-exempt applications:

Frequency

- kHz to GHz

Time

- μ Sec to years

Spatial

- <1m to many km

Power – e.i.r.p.

- -43dBm to +55dBm

Power – antenna port

- -Up to +33dBm

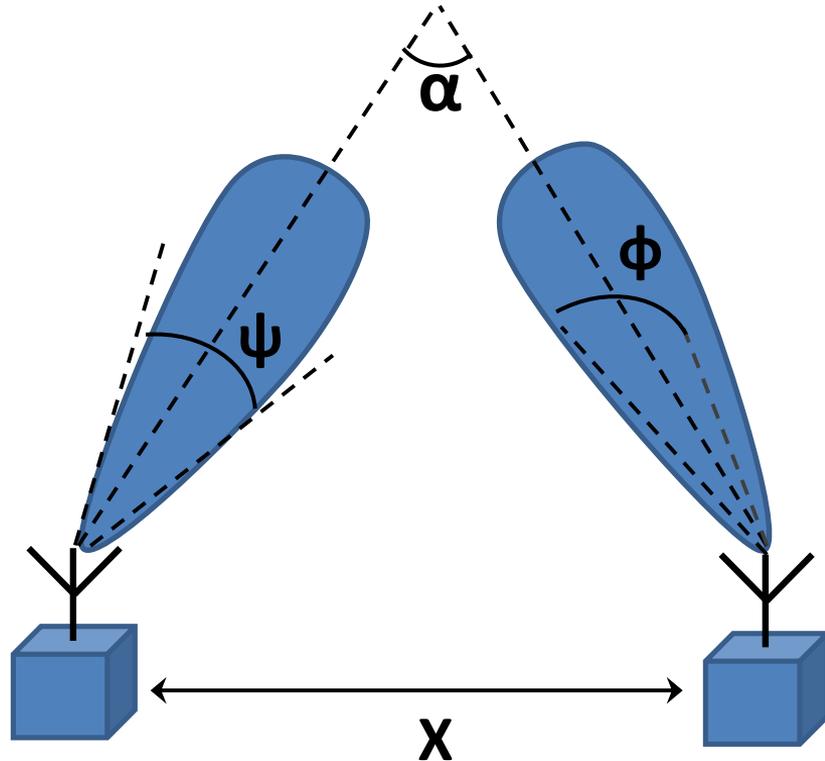
Primary user

Sharing user

Permission

Simon Pike

Spatial Dimensions



These 'dimensions' define the 'space' that one station needs, to avoid causing or receiving harmful interference from another.

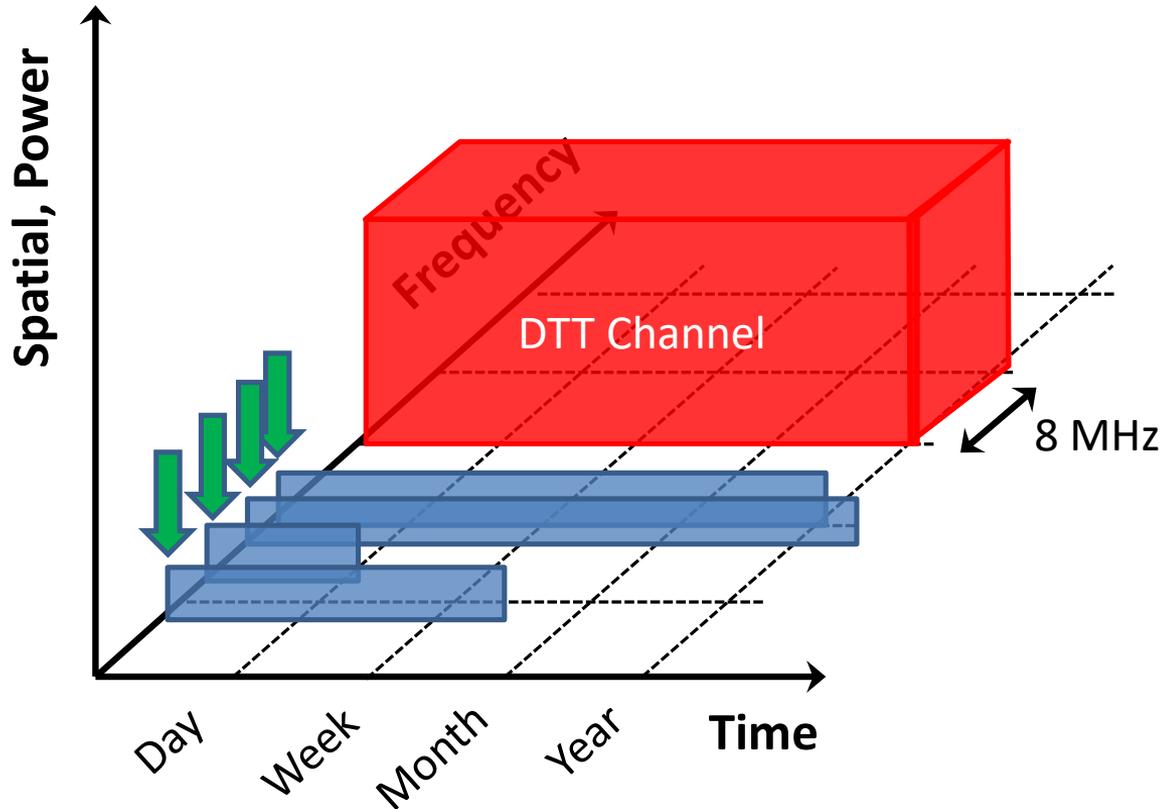
Spatial dimensions include:

- Separation X
- Dependent on e.i.r.p.
- Taking into account:
 - free space path loss
 - propagation effects
- Boresight angle offset α
- Horizontal and vertical beamwidths ϕ and ψ

Spectrum Space

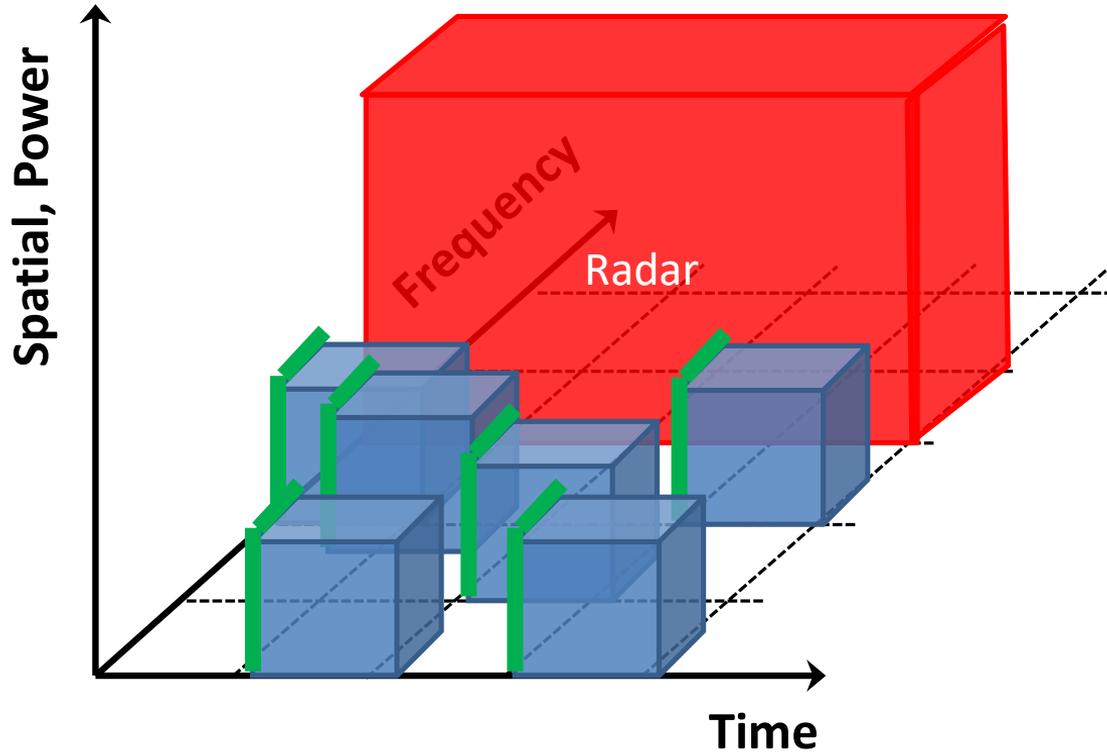
- The 'spectrum space' needed by a user derives from the combination of:
 - e.i.r.p. or e.r.p. (transmitted power multiplied by antenna directivity)
 - Bandwidth (frequency)
 - Duty Cycle (time)
 - Spatial dimensions
- For spectrum sharing to function, the total spectrum space available must be significantly greater than the spectrum space needed by a user multiplied by the number of simultaneous users.
- Regulators manage this availability by setting limits on e.i.r.p., bandwidth, duty cycle and antenna directivity.

Radio Microphones in UHF TV band



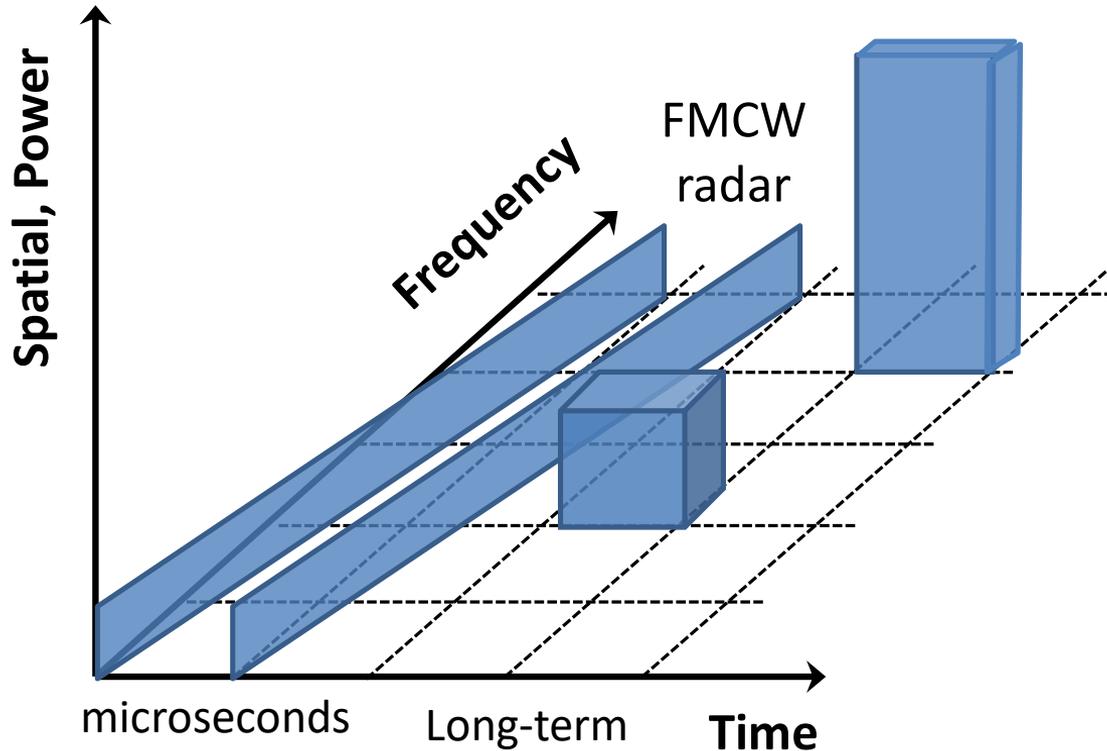
- Use coordinated with both DTT and other radio mic users
- Operation controlled manually by user
- A licence fee is charged

5 GHz WiFi



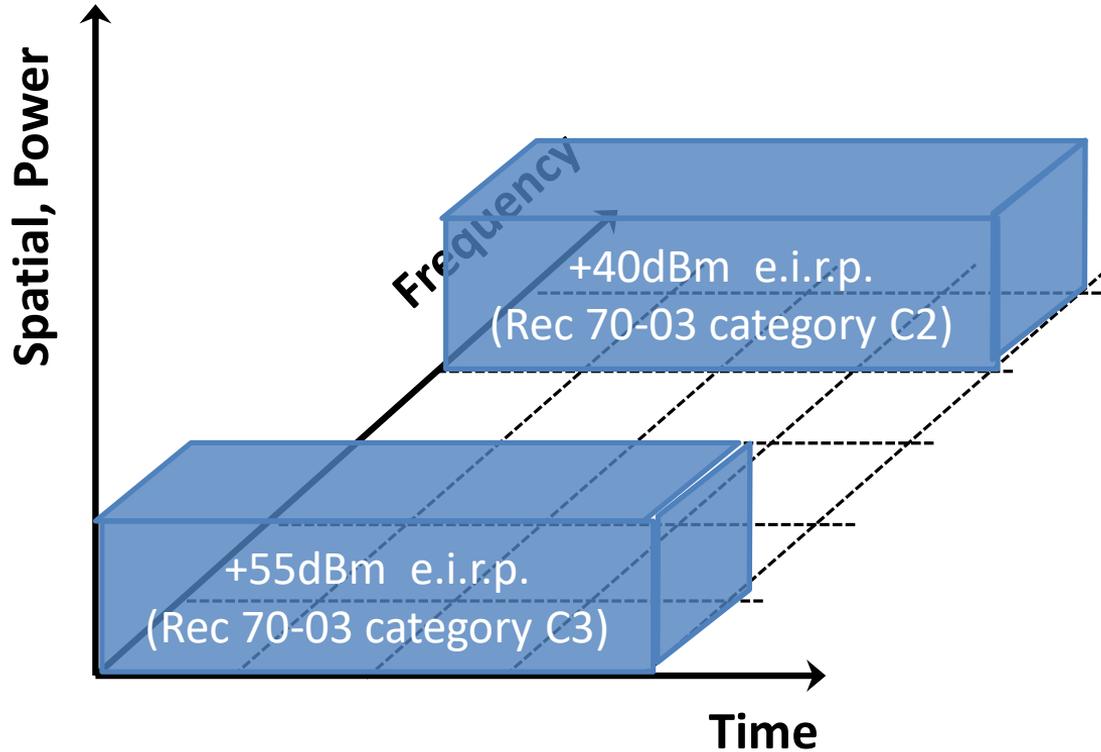
- WiFi devices must have dynamic frequency selection
- To sense and avoid radars
- It does not sense other WiFi devices
- The performance is tested against a variety of radar types

57 – 64 GHz band – generic category



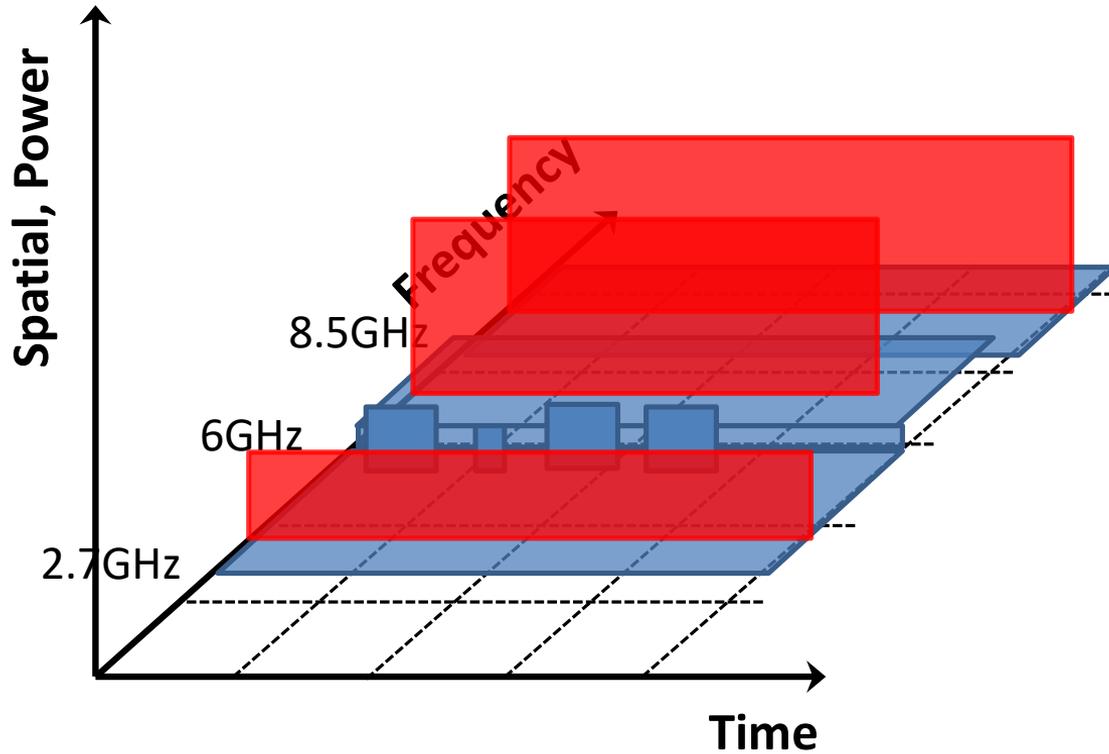
- +20dBm e.i.r.p. power limit (10dBm conducted)
- No bandwidth or other restrictions
- It does not sense other WiFi devices
- The performance is tested against a variety of radar types

57 – 71 GHz band – wideband data transmission



- Two categories:
 - +40dBm e.i.r.p. and +27dBm at antenna port max
 - +55dBm e.i.r.p. max with minimum antenna gain of 30dBi
- Spectrum sharing mechanism must be implemented
- These occupy a similar volume of 'spectrum space'
 - Antenna directivity compensates for higher e.i.r.p.

UWB (ultra wideband)



- Very low power spectral density (general case):
 - -41.3dBm/MHz between 6 – 8.5 GHz
 - -70dBm/MHz or less elsewhere
- Limits determined through extensive co-existence studies

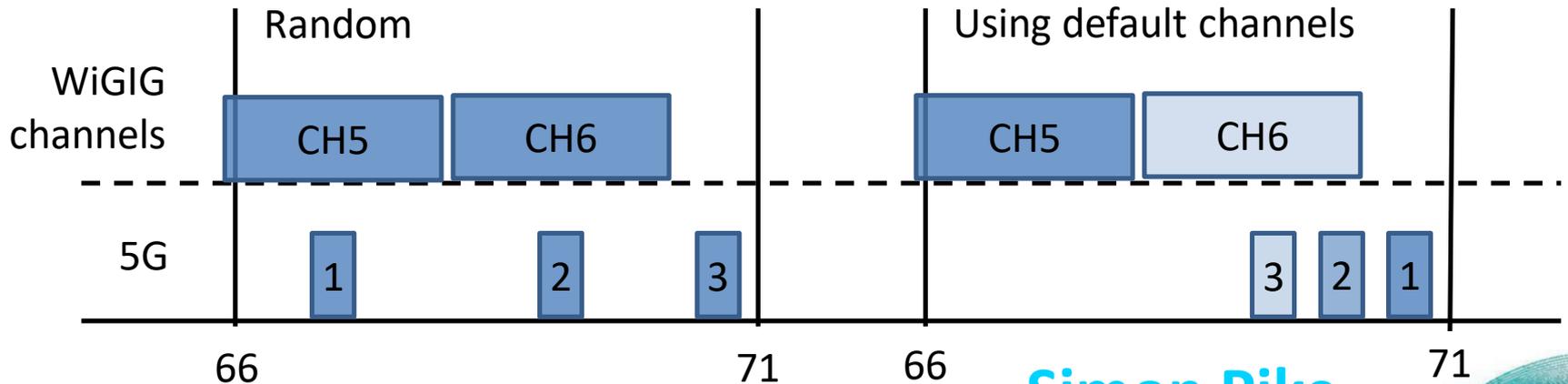
The Radio Equipment Directive and receivers

- The EU Radio Equipment Directive 2014/53/EU (RED) calls for Harmonised Standards to include receiver performance requirements.
 - These are inherently more technology-specific than transmitter requirements
 - They test the degradation of the reception, so the test signal and criteria for degradation are technology-specific.
- ETSI ERM has decided to split the HS for generic applications at 60GHz into four parts
- If the HS cannot be application-neutral, there is less case for generic spectrum regulations

RED Recital (11):
Although receivers do not themselves cause harmful interference, reception capabilities are an increasingly important factor in ensuring the efficient use of radio spectrum by way of an increased resilience of receivers against harmful interference and unwanted signals on the basis of the relevant essential requirements of Union harmonisation legislation.

A proposal in 66 – 71GHz for MGWS and IMT

- MGWS (WiGIG) has a channel bandwidth of 2.16GHz
- 5G has a maximum channel bandwidth of 400MHz
- Choosing channels at random could result in inefficient use of spectrum
- The industry bodies could agree voluntary default channels to use in the absence of interference
- This would not prevent use of the whole band when capacity requires it



Conclusions

- Spectrum sharing covers an extremely wide range of applications
 - Some 'short range devices' have a range measured in kilometres
 - Some only a few metres
- No one approach is completely technology and deployment neutral
 - Often, the more technology-neutral, the more specific the deployment
- Spectrum sharing can constrain the development of the Primary service
 - Sensing is only applicable in specific situations
- 'Spectrum Space' is a useful concept for spectrum management policy
 - It is effectively the 'flip-side' to opportunity cost and externalities
 - To help avoid the 'tragedy of the commons'

Recommendations

- Stakeholders for 60GHz systems should consider agreeing amongst themselves default channels for different technologies
 - To use in the absence of interference from other users
- The proportion of 'spectrum space' occupied by a single user as a function of area is a good measure for spectrum sharing of multiple technologies and applications
- Now that Harmonised Standards for radio equipment cannot be generic, the value of generic spectrum assignments could be reconsidered

Backup: International Radiotelegraph Convention, 1912

ARTICLE 7.

1. All stations are bound to exchange traffic with the minimum of energy necessary to ensure good communication.

2. Every coast or ship station must satisfy the following conditions:—

(a.) The waves emitted must be as pure and as little damped as possible.

In particular, the use of transmitting devices in which the production of the waves emitted is obtained by discharging the aerial directly by sparks (plain aerial) shall not be allowed except in cases of distress.

It may, however, be allowed in the case of certain special stations (for example, those of small boats) in which the primary power does not exceed 50 watts.

(b.) The apparatus must be capable of transmitting and receiving at a speed at least equal to twenty words per minute, the word being reckoned at the rate of five letters.

New installations bringing into play an energy of more than 50 watts shall be equipped in such a way that it may be possible to obtain easily several ranges less than the normal range, the shortest being of approximately 15 nautical miles. Installations already established bringing into play an energy of more than 50 watts shall be transformed as far as possible in such manner as to satisfy the foregoing requirements.

(c.) Receiving apparatus must allow of receiving, with the greatest possible amount of protection from disturbance, transmissions made with the wave-lengths specified in the present Regulations, up to 600 metres.

3. Stations serving solely for determining the position of ships (radiophares) must not operate over an area of greater radius than 30 nautical miles.

ARTICLE 27.

Every station which has to make a transmission necessitating the use of high power shall first send out three times the warning

signal — — • • — —, with the minimum of power necessary to reach the neighbouring stations. It shall not then begin to transmit with the high power until thirty seconds after sending the warning signal.

ARTICLE 32.

When the radiotelegram to be transmitted contains more than forty words the sending station shall interrupt the transmission by the signal • • — — • • after each series of twenty words or thereabouts, and it shall not resume the transmission until after having obtained from the station in correspondence the repetition of the last word clearly received, followed by the said signal, or, if the reception is clear, the signal — • —.

In the case of transmission in series, the acknowledgment of receipt shall be given after each radiotelegram.

Coast stations engaged in transmitting long radiotelegrams must suspend transmission at the end of each period of fifteen minutes, and must remain silent during a period of three minutes before continuing transmission.

Coast and ship stations which work in the conditions laid down in article 35, paragraph 2, must suspend work at the end of each period of fifteen minutes, and keep watch on the wave-length of 600 metres during a period of three minutes before continuing transmission.