# Spectrum management strategies for licence exempt spectrum: Final report

## Presentation to the Radiocommunications Agency


**Presented by** Mark Grieves
Janette Dobson
Dave Tanner
Christian Koboldt
Reka Horvath


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# Format

1. Introduction and context
2. Background
3. Technical analysis
4. Economic analysis
5. Marketing/Industry survey
6. Conclusions
7. Recommendations

# Introduction



- The RA is currently reviewing the regulation of all licence-exempt spectrum
  - The Consultation Document asks specific questions:
    - What new service opportunities exist?
    - Is spectrum congestion a concern?
    - How best to regulate to maximise benefits to the UK?
    - Are there competition concerns?
- The aim is to relax/remove current restrictions on use of licence-exempt spectrum to provide public access systems
  - The bands highlighted as of particular commercial interest are the RLAN bands
  - Comments on the Con Doc can be made until 11 Feb 2002
- As part of this process, Mason and DotEcon were commissioned by the RA to provide independent advice
  - Our report has just been finalised

# Underpinning the consultation is the issue that licence exempt legislation restricts these bands to 'private use' only



**RA working definitions**

*"A **private radio system** may be regarded as a self-provided radio system for the licensee's own use. This may include use by partners and/or contractors working for the licensee"*

*"A **public radio system** is considered to be a radio system provided commercially for use by third parties"*

- Currently, the Exemption Regulations restrict licence-exempt usage in the UK to 'self use' for private or corporate networks
  - Services / airtime can not be 'sold' to third parties
- With future regulatory developments, we expect this to change
  - New operators / existing MNOs could provide services in public 'hot spots' (e.g. airport lounges, banks, coffee shops)
  - RLAN hot spots could be introduced either on a stand-alone basis (e.g. the MobileStar model) or integrated with GSM/GPRS for wider area coverage (e.g. Sonera's 'wirelessGATE' service)

# Licence-exempt bands across the radio spectrum are being considered in the consultation

| Device | Frequency bands **Introduction** |
|---|---|
| Analogue Cordless Telephone (CT1) | 1642 - 1782 kHz (b)<br>47.45625 - 47.54375 MHz (m) |
| Digital Cellular Telephones (UMTS Licence-exempt) | 2010 - 2025 MHz |
| Digital Cordless Telephones (DECT) | 1880 - 1900 MHz |
| IEEE 802.11a RLANs, HIPERLANs | 5.150 - 5.350 GHz, 5.470 - 5.725 GHz and 5.725 - 5.875 GHz |
| PMR 446 | 446.00625 - 446.09375 MHz |
| IEEE 802.11b RLAN | 2400 to 2487.5 MHz |
| Short Range Device Bands | See table below |

| Short Range Device Bands | | | | | | |
|---|---|---|---|---|---|---|
| 9 to 180 kHz | 240 to 315 kHz | 300 to 2000 kHz | 2 to 30 MHz | 34.9 to 35 MHz | 35.3 to 35.5 MHz | 40.66 to 40.7 MHz |
| 49.82 to 49.98 MHz | 161.275 MHz | 173.1875 MHz | 173.2 to 173.35 MHz | 173.5875 to 173.6 MHz | 173.7 to 174 MHz | 173.35 to 175.1 MHz |
| 402 to 405 MHz | 417.9 to 418.1 MHz | 433.05 to 434.79 MHz | 458.5 to 458.95 MHz | 458.96 to 459.1 MHz | 458.5 to 459.5 MHz | 862 to 870 MHz |
| 1389 to 1399 MHz | 2400 to 2483.5 MHz | 5725 to 5850 MHz | 10.577 to 10.597 GHz | 10.675 to 10.699 GHz | 13.5 to 14 GHz | 24.15 to 24.25 GHz |
| 24.25 to 24.35 GHz | 63 to 64 GHz | 76 to 77 GHz | 60 to 63 GHz | 122 to 123 GHz | 244 to 246 GHz | |

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# Context



- In line with the RA Consultation Document, we have concentrated on the bands with the most commercial interest
  - 1880 – 1900 MHz
  - 2010 – 2025 MHz
  - 2400 – 2483.5 MHz
  - 5150 – 5350/5470 – 5875 MHz
- To assess the impact of regulatory changes, three avenues have been examined
  - Technical
  - Economic
  - Industry Consultation

**Our conclusions indicate that there are benefits to the UK in changing the regulation governing use of licence-exempt spectrum**

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# Mason and DotEcon study overview

Background

## We have conducted our work in three work streams:

**Technical Analysis** → **Economic Impact** → **Industry Interviews** → **Regulatory Options**

**Technical Analysis**

- We have used Minimum Coupling Loss and Monte Carlo modelling to assess probability of interference occurring under different scenarios
- We use the City of London as an example to assess interference scenarios assuming peak equipment densities

**Economic Impact**

- We have identified the main drivers of costs and benefits associated with changes in the regulatory regime
- We have analysed the impact of a change in regulation on the development of new services
- We have provided an order-of-magnitude estimate of the benefits that might be generated by public RLANs

**Industry Interviews**

- We have interviewed a number of companies across a range of relevant industry sectors
- These interviews have given us an excellent insight into new service opportunities and the relationship with existing services (e.g. 2G and 3G mobile)

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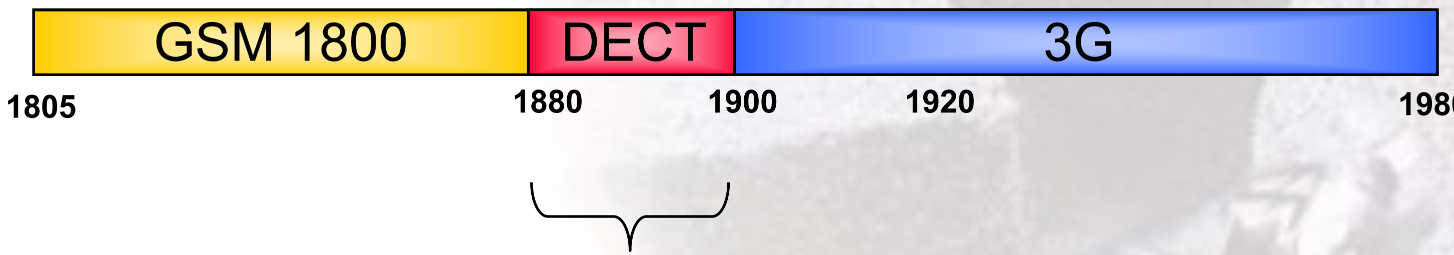
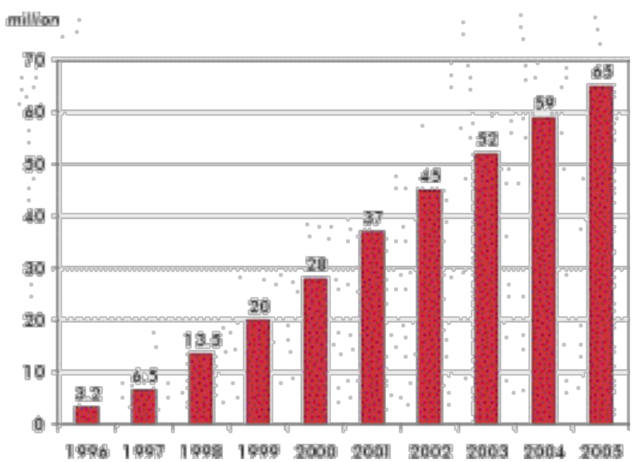
# The 1.9 GHz Band

Background

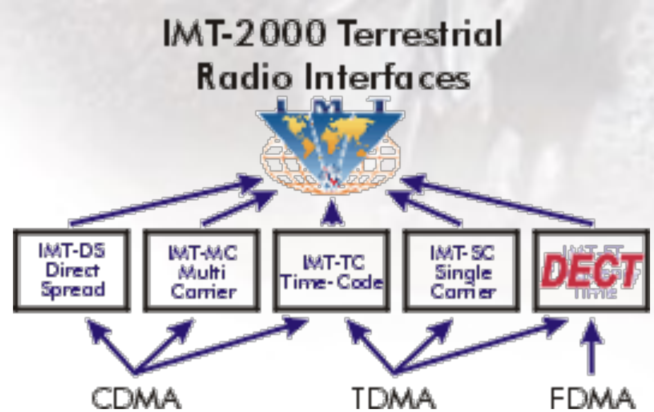
- 1880 – 1900 MHz is assigned across Europe for DECT




**Forecast DECT Sales**

(Source: DECT Forum)




**DECT is part of the ITU IMT-2000 family**

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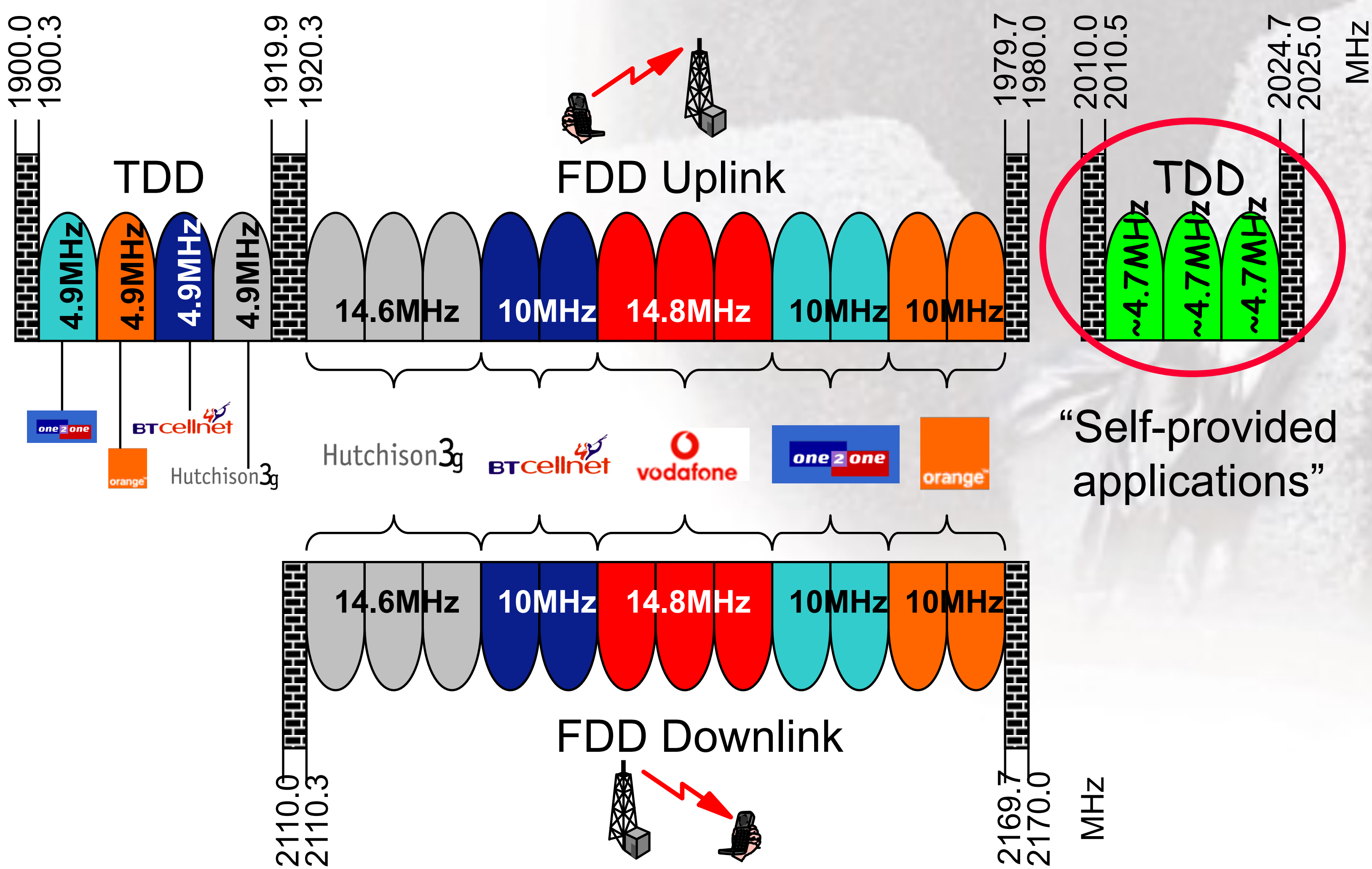
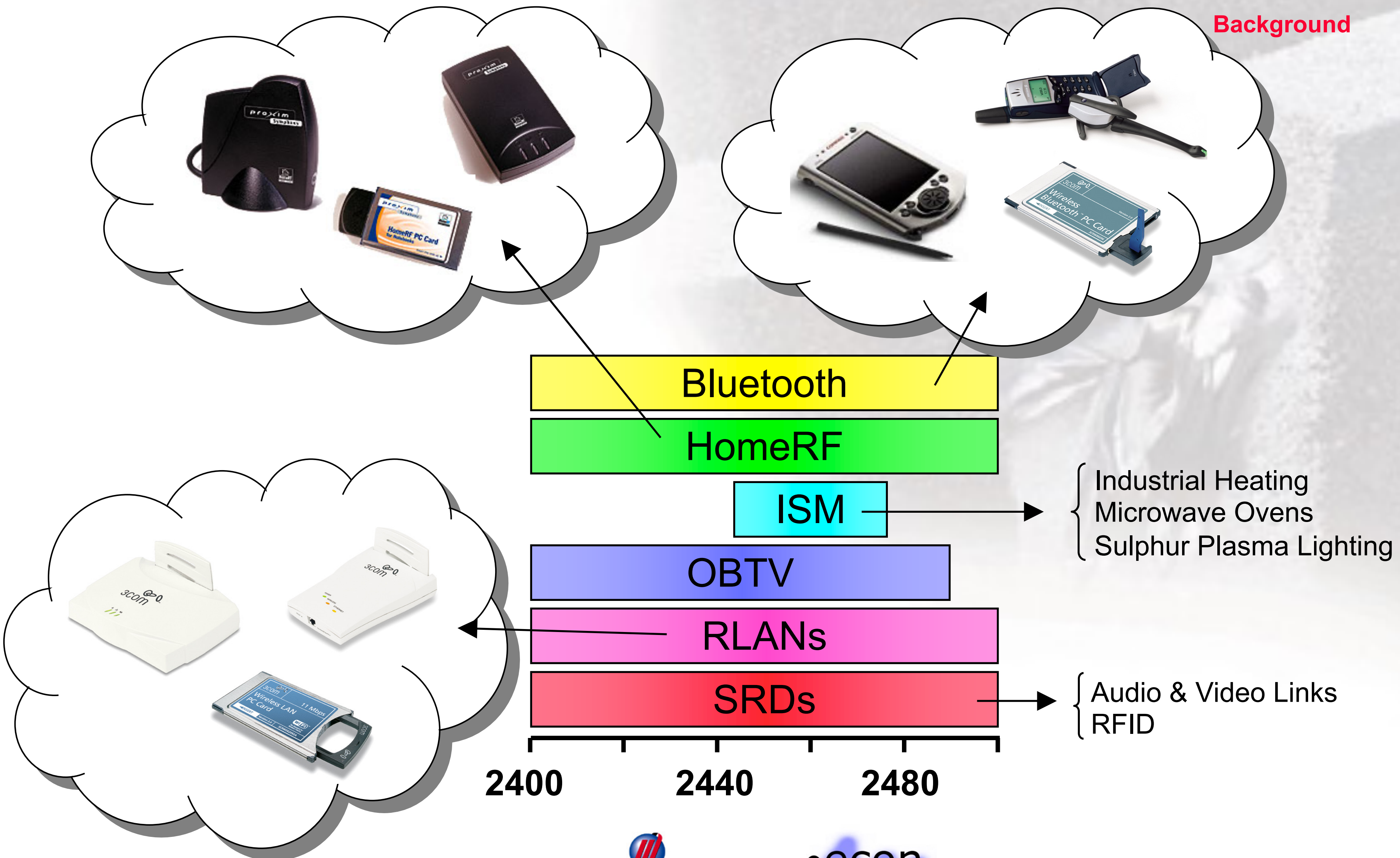
# The 2.1 GHz Band

Background



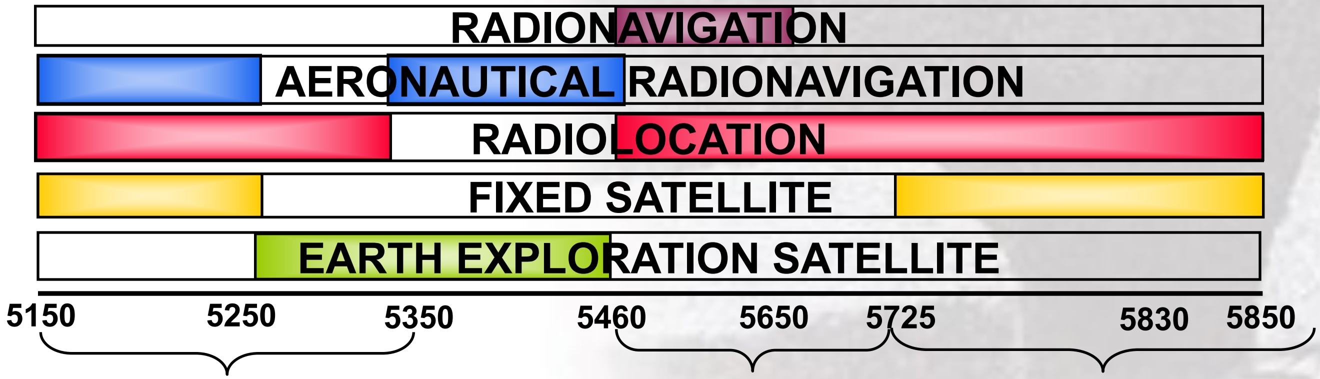
# The 2.4 GHz Band

**Background**



# The 5 GHz Band

**Background**




It is recommended that the UK usage of 5GHz is as follows:

| *Band Abbreviation (for the purposes of this report only)* | *Frequency (MHz)* | *Use* |
|---|---|---|
| A | 5150-5350 | RLAN (see section 4.1.4)<br>Indoor systems<br>Max EIRP 200mW<br>It is recommended that FWA not be considered in Band A |
| B | 5470-5725 | RLAN (see section 4.1.4)<br>Outdoor and indoor systems<br>Max EIRP 1W<br>It is recommended that sharing studies should be undertaken on the use of FWA in Band B. These should take into account studies already undertaken (such as in the development of the ERC Decision), the impact on existing services and any possible associated recommendations/ limitations on FWA operation |
| C | 5725-5875<br>(ISM band) | Short range devices<br>Currently Max EIRP 25mW<br>It is recommended that consideration is given to raising the EIRP in Band C for outdoor devices installed on permanent structures to 2 Watts and possibly 4 Watts (following co-existence studies with other services) |

Source: UK 5 GHz advisory group

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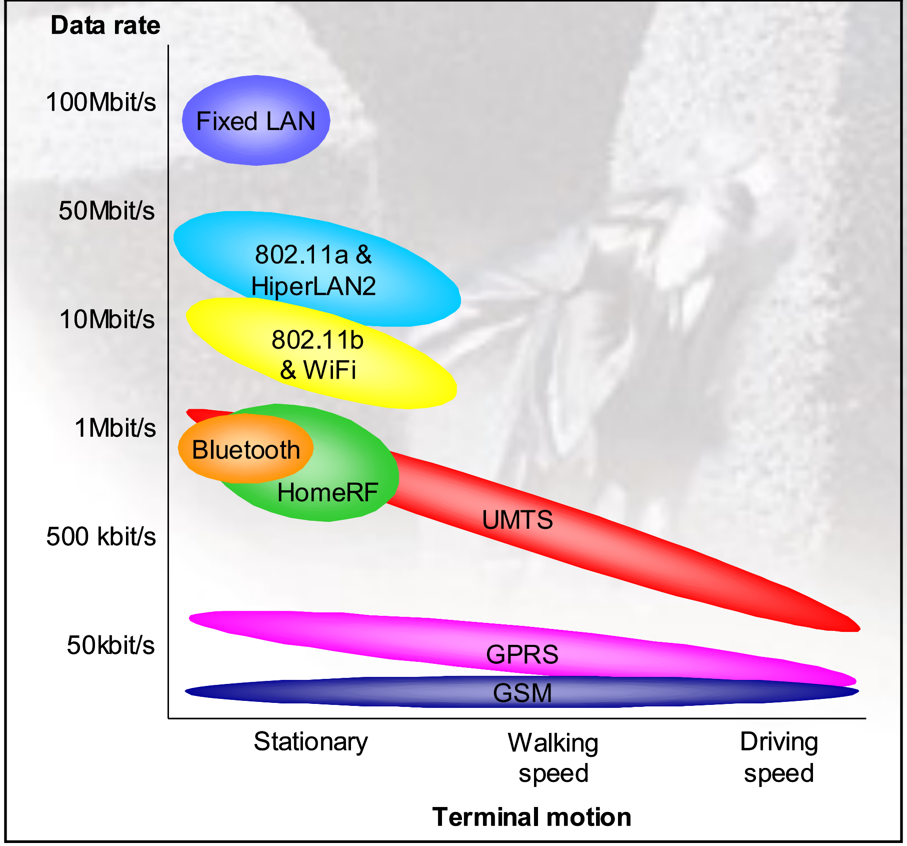
# RLANs provide high data rate wireless connection to intranets/internet

**Background**

- RLANs are increasingly being used by enterprises for
  - Providing increased mobility to their workforce
  - Speedy network roll out
  - Providing additional capacity to existing fixed networks
- Increasingly cheap RLAN infrastructure will fuel further growth
  - E.g. Cisco Aironet: $1,299 per AP and $249 per PC Card
  - New laptops are being shipped with integral RLAN cards

**Capabilities of RLAN technologies**



# Two prominent RLAN standards exist

Background

- ***IEEE 802.11b*** operates in the 2.4GHz band
  - This band is available globally for use by RLANs
  - 802.11b already benefits from significant economies of scale
    - » 802.11b RLAN cards are in widespread use in Europe and the USA
- ***IEEE 802.11a*** and ETSI ***HiperLAN/2*** are future, higher performance RLANs that will operate at 5GHz
  - Providing data rates of up to 54 Mbit/s
    - » 2.4GHz RLANs offer up to 11 Mbit/s
  - Industry is looking at harmonising the two specifications to further foster global economies of scale

# Current RLAN devices operate in the 2.4GHz band alongside Bluetooth; 5 GHz products are starting to reach market

Background

| | IEEE 802.11b Wi-Fi | HiperLAN2 | Bluetooth |
|---|---|---|---|
| Max user data rate | 5Mbit/s (11Mbit/s at physical layer) | 32Mbit/s (54Mbit/s at physical layer) | v1.1: 721kbit/s<br>v2.0: 2Mbit/s |
| Coverage | Indoor/outdoor local area hotspots | Indoor/outdoor local area hotspots | Indoor <10m from access node |
| Frequency Band | 2.4GHz ISM | 5GHz RLAN | 2.4GHz ISM |
| Associated terminal type | Portable PC | Portable PC | Mobile phone/PDA/portable PC |
| Interworking | No major issues | No major issues | Some issues |

**Economies of scale in 5 GHz products will take some time to reach comparable levels with those at 2.4 GHz**

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# Scope of technical analysis

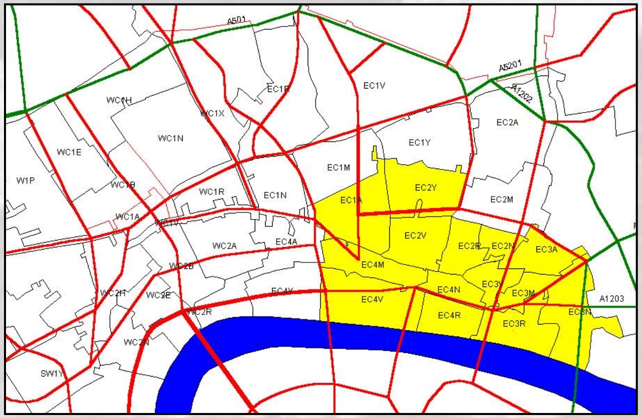


- Our consideration has included
  - Reviewing and updating, if necessary, previous studies
    - ITU
    - CEPT
    - RA
    - others
  - Interference analysis
    - Minimum Coupling Loss analysis
    - Monte Carlo analysis (using SEAMCAT)
- We’ve also made assumptions on, inter alia
  - Peak densities with public and private use
  - Various operational scenarios

# We examined RLAN and FWA interference across a range of densities

**Technical analysis**

- RLAN system densities:
  - Peak; 2,000 RLAN systems per sq.km
    - Based on analysis of the City of London
  - Rural; 0.1 RLAN systems per sq.km




City of London Postcodes

- FWA system densities:
  - Peak; 3 base stations per sq.km
  - Rural; 0.2 base stations per sq.km
    - Lower practical limit based on propagation effects

# 1.9 GHz band; Studies & analysis



- Current DECT use is limited to private residential and business systems with IR 2011 limiting peak EIRP to a maximum of 250 mW
- The Smith Group carried out a comprehensive study, on behalf of the RA, on the implications of licensing public services in this band (including CTM and RLL)
  - This study has been re-examined to validate assumptions
- Use of the DECT band to offer licence-exempt public and private services appears technically feasible, if it is assumed that all systems conform to the standard DECT operating parameters
- Use of higher gain antennas to deploy RLL services could cause potential problems to present and future users of DECT private systems

# 2.1 GHz band; Analysis

Technical analysis

- ERC Decision (99)25 provides that, subject to market demand, the band 2010 – 2020 MHz should be made available for the operation of 3G 'self provided applications in a self coordinated mode'
  - The RA, in its 3G Information Memorandum, indicated that the band 2010 – 2025 MHz was to be made available for such operations
- 3GPP has devoted significant effort to the development of the UMTS specifications for operation by MNOs
  - To date, significantly less effort has been devoted to the development of specifications for self-provided applications.
- EP-DECT is understood to have commenced a Work Item to develop the DECT specifications to incorporate operation in this band
  - This Work Item is at a very early stage
- There is currently no UK Interface Regulation applicable to the 2010 – 2025 MHz band
- Given the current state of standardisation, it has not been possible to provide a technical analysis on the potential for future congestion in this band

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# 2.4 GHz band; Studies & analysis



- Aegis undertook a comprehensive study, on behalf of RA, in 1999 on the co-existence of various systems operating in the 2.4 GHz band
  - Some re-examination of results has been undertaken to take account of higher usage densities
- Other studies from Intersil and Ericsson have been examined
  - Interference from Bluetooth devices into RLAN
  - Interference from RLANs into Bluetooth
- At high RLAN densities, interference into RFA from RLANs can be expected. This will become severe at very high densities
  - Interference from outdoor RLANs, even if they represent only a fraction of total RLANs deployed, will tend to dominate over indoor use
- At high RLAN densities, mutual interference will limit RLAN coverage areas and the actual practical densities achieved will be self-limiting
- Bluetooth devices and RLANs are expected to be able to operate in the presence of each other with reasonable limitations at high densities

# 5 GHz bands; Studies & interference analysis

Technical analysis

- ERC Reports 67 and 72, which analyse interference between *RLANs and other services*, have been re-examined:
  - The sharing between RLANs and other services in the 5 GHz bands remains feasible, assuming the restrictions on EIRP and outdoor use already placed on RLAN operations by existing European instruments
- Analysis of *intra RLAN*, *intra FWA* and *inter RLAN/FWA* interference has been undertaken
  - Various scenarios have been studied involving
    - Indoor / outdoor use
    - RLAN densities from ~0.02 to ~2,000 per sq.km
    - FWA densities from 0.2 to 3 per sq.km
    - Omni / directional antennas
    - Reduced EIRP operation
    - Various activity ratios

# 5 GHz bands; Interference analysis results



- Interference *between RLANs* is not expected to be significant, with the exception of RLANs used outdoors
  - Outdoor RLANs are expected to present some interference potential in urban and dense urban environments, but this will be self-limiting (as a reduction of range)
- The operation of *Tx indoor RLANs* in a *FWA BS Rx* coverage area in rural and suburban environments seems practical (for urban and dense urban environments, sufficient margins do not appear to exist)
  - Across all environments, outdoor RLANs have to the potential to cause significant interference to co-frequency FWA BSs
- *Rx RLANs* will not generally be able to operate co-frequency, co-coverage with *Tx FWA BSs*, except for indoor RLANs operating in lower density (suburban and rural) environments
- The use of a suitable frequency re-use plan, to ensure that the frequency used at a particular BS is not reused by adjacent BSs, should permit *intra FWA* interference to be managed sufficiently

# Other licence-exempt bands

Technical analysis

- Detailed technical analysis for these bands has not been conducted in this study
  - These bands exist in various parts of frequency spectrum and are used by a range of SRD technologies
  - Use is on a non-interference, non-protected basis
- Further technical analysis on a band-by-band basis may be desirable if it were considered that a change in regulation would lead to a greater commercial interest in use of these bands
  - The use of SRD's to provide third party services is not generally anticipated
  - This implies that a change in regulation is unlikely to lead to a marked increase in SRD use (with the exception of RLANs)
- From a technical perspective, the general principals arising out of this report will apply to the use of SRD spectrum
  - Systems with homogeneous operating characteristics using 'polite' technologies significantly reduce the potential for interference

# Technical analysis conclusions



| | |
|---|---|
| Generic conclusion | The use of systems with homogeneous operating characteristics, i.e. similar power limits, bandwidths and interference avoidance techniques, will tend to lead to a more benign interference environment |

| | |
|---|---|
| 1.9 GHz | Public and private licence-exempt DECT systems could operate in these bands under the restrictions of the current Interface Regulations. Further analysis will be required on mitigation techniques if this band is to be used by DECT WLL |
| 2.1 GHz | Given the current state of standardisation, it has not been possible to provide a technical analysis on the potential for future congestion in this band |
| 2.4 GHz | With the exception of RFA, the operation of private and public systems in the 2.4 GHz band appears viable assuming they conform to the technical conditions set in the current Exemption Regulations. RLANs will tend to dominate any interference that does arise, and will, in high density areas, tend to be self-limiting<br><br>High densities of RLANs have a severe potential for interference into RFA networks |
| 5 GHz | At densities consistent with anticipated commercial take-up, RLANs should be able to operate without causing undue interference to either other RLANs, or other services in the bands<br><br>The use of mesh FWA technologies could be considered, but limitations on use would be necessary, for instance, limitations to rural and sub-urban environments |

# Economic impact assessment

Economic analysis

## Three questions:

- What is the likely order of magnitude impact of allowing new services such as public access RLANs?
- Might these benefits be outweighed by costs due to interference?
- What is the right balance between mitigating interference and limiting new services?

# New services: general considerations

Economic analysis

## Welfare impact of new services depends crucially on their relationship to existing services:

- Theory and empirical studies show that greatest welfare gains can usually be expected from innovative services that do not substitute for existing services
- New services may also increase the demand for related complementary services (e.g. Bluetooth and 2.5/3G mobile)
- Substitutes for existing services primarily redistribute existing consumer and producer surplus and may lose economies of scale…
- …but can generate benefits where the new service toughens competition

# Estimating the benefits of new services

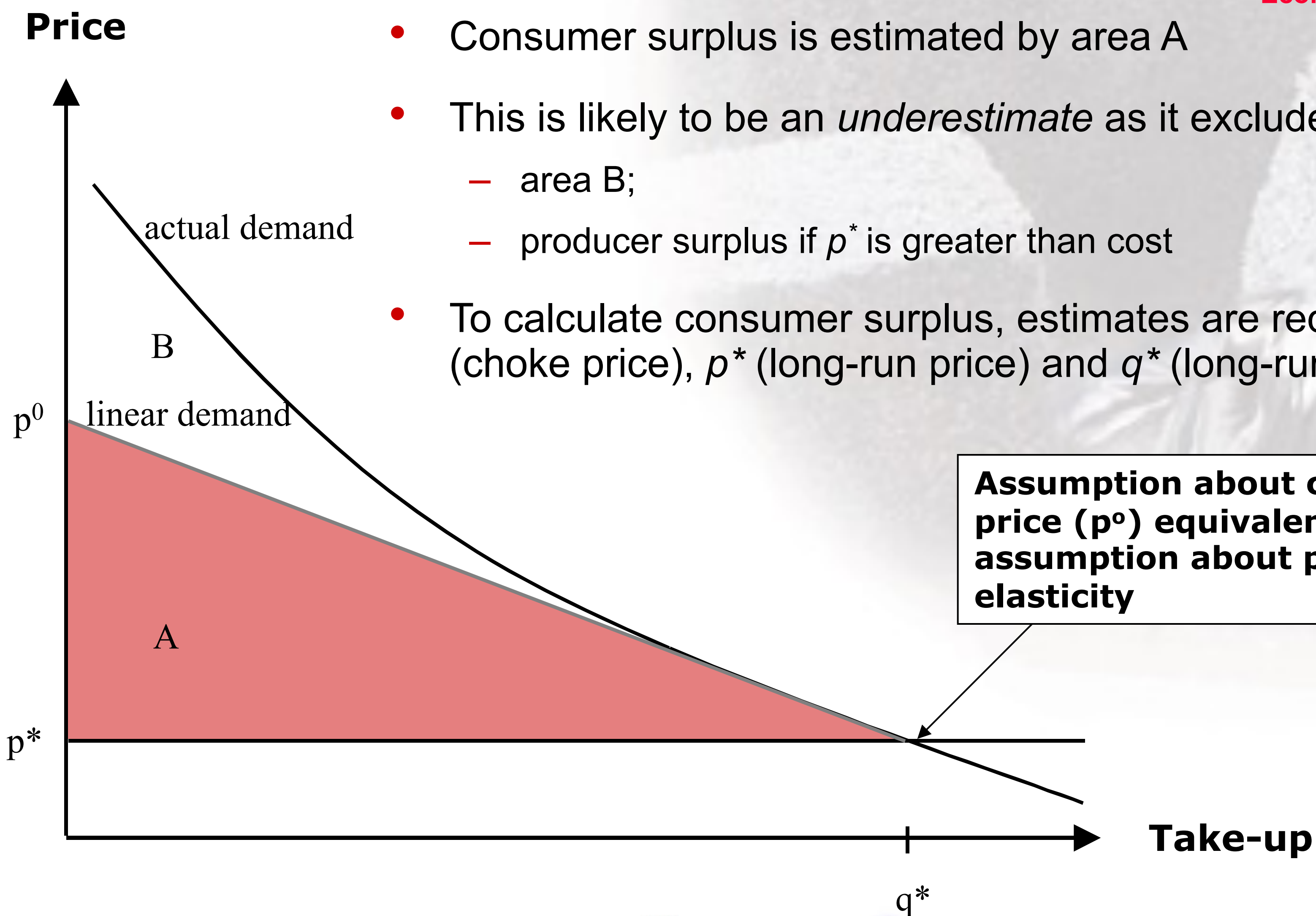


- Allowing public access services over licence exempt spectrum potentially results in the introduction of a wide range of new services
- We concentrate on public access RLANs as the most immediate commercial offering
- However, there may be substantial benefits related to other products that we do not consider
- Our general approach is to produce a *lower bound* on likely benefits

# Calculating the net benefit



- Consumer surplus is estimated by area A
- This is likely to be an *underestimate* as it excludes:
  - area B;
  - producer surplus if $p^*$ is greater than cost
- To calculate consumer surplus, estimates are required of $p^0$ (choke price), $p^*$ (long-run price) and $q^*$ (long-run takeup).



# Assumptions for public RLAN services

Economic analysis

- Gartner forecasts imply 3.25m RLAN equipped laptops by 2005
- Assume ½ of these use public access networks
- Analysys forecasts 20 million public RLAN users in Wetern Europe by 2006, which would imply about 5 million in the UK

## Existing prices

| Service | Monthly Subscription |
|---|---|
| Jippi Freedom | £31.49 |
| MobileStar | £41.12 |
| Telia HomeRun | £98.43 |

## 2005 Consumer surplus at today's prices

| | Scenario 1 | Scenario 2 |
|---|---|---|
| Subscribers | 1.6m | 1.6m |
| Price (£/month) | 31.49 | 31.49 |
| Choke price (£) | 98.43 | 82.28 |
| Consumer surplus (£million/month) | 53.6 | 40.6 |
| Consumer surplus (£million/year) | 643 | 488 |

Assume price elasticity of -0.62, similar to that for mobile take-up and in the range of usual telecoms elasticities

Order of magnitude assessment suggests consumer surplus of £½billion p.a.

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# Congestion costs



- A simple example (based on Scenario 2):
  - Suppose cost and price increased by 10% as a result of congestion (an extreme case given the technical analysis and survey)
  - CS falls from £488m/year to £429m/year
  - Implies welfare loss of £59m/year due to interference
- Unless new services have a *very* substantial impact on existing services, net welfare impact will be positive
- Congestion costs are likely to be minimal (including impact on existing users)
  - System specifications identical to those used for private systems
  - Effective private spectrum management in case of indoor use (provided there are sufficient restrictions on outdoor use)
- Note that the impact of congestion should only be taken into account where congestion is ***caused*** by the change in regulation

# Further considerations



- Public RLANs may both be substitutes for and complements to 3G services – but are overwhelmingly regarded as complements
- We have not attempted to model any knock-on effects on take-up of broadband mobile
- We have not included dynamic benefits
- Deadweight loss should price exceed costs is likely to be small (about £1.8 million in Scenario 2 if price were 10% higher as a result of price-cost margin)
- For regulatory impact assessment, the relevant question is to what extent a change in regulation would lead to new services and congestion
  - Congestion resulting from increased take-up of existing services is not relevant
  - Where congestion is likely to become a problem, regulatory constraints should aim at restricting access to spectrum for services that are:
    - least likely to generate substantial benefits
    - most likely to result in congestion
- Public/private distinction does not appear to be relevant in this context

# Distribution of benefits

Economic analysis

| Affected party | Benefits | Costs | Net benefits |
|---|---|---|---|
| End users | Use of newly introduced public services | Charge for public services<br><br>Possible interference | Positive<br>Order of £500m p.a. |
| Public service providers | Increase in revenue as a result of accessing new spectrum and offering new services | Operating costs | Non-negative, but small if competition is effective |
| Public service customers | Use of newly introduced public services | Charge for public services | Positive (corresponding part of the total consumer surplus) |
| Equipment manufacturers | Revenues from equipment to support new services | Operating costs | Non-negative, but small if competition is effective |

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# RLANs and FWA



- Without explicitly modelling the impact of allowing FWA systems in unlicensed spectrum, there are good reasons to assume that the benefits from such services might be small
  - More likely to substitute for existing fixed line services
  - Alternative dedicated FWA spectrum available, so restrictions would not eliminate the potential for such services
  - Interference likely to be of more concern with regard to FWA than RLANs
- Economic analysis would suggest that, where restrictions are required, these should give preference to RLANs over FWA

# Appropriate regulatory policy

Economic analysis

- Economic charging models are not feasible, so require a rule-based approach to:
  - minimise interference where it is easy to do so (especially where heterogeneous technologies use the same spectrum); and
  - encourage the development of new services that are most likely to be complementary to or independent from existing ones as these services are most likely to create large welfare benefits.
- No rationale for existing public/private rule
- Market incentives are helpful where technology is sufficiently homogeneous

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# Industry interviews

Industry survey

**To analyse potential commercial opportunities, we conducted a series of industry interviews as well as drawing on secondary sources of information**

Results of industry interviews

Other research reports

Research on related market developments outside the UK

Analyse the general trends emerging and areas of broad consensus

Determine new service opportunities and products

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# Scope of industry survey



**The industry survey covered sectors within the telecoms industry that would have a particular interest in the possible change in regulation**

- UK Fixed Network Operators
- UK Mobile Network Operators
- Existing Users
- Manufacturers
- Internet Service Providers
- Service Providers outside UK

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# Commercial opportunities exist primarily in using RLANs or Bluetooth to provide public access services

**Industry survey**

| | Commercial opportunities? | Examples |
|---|---|---|
| RLANs and Bluetooth | Yes | Public access services in 'hot spots'<br><br>Hot spots integrated with wider-area mobile coverage (GPRS) |
| DECT and 3G TDD | Some | Seamless access to mobile services in the home, office and on the move<br><br>Complementary services to licensed 3G TDD spectrum |
| Other SRD's | Limited | Third party security or asset tracking |

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# There was broad consensus from those interviewed on a many of the main RLAN issues addressed

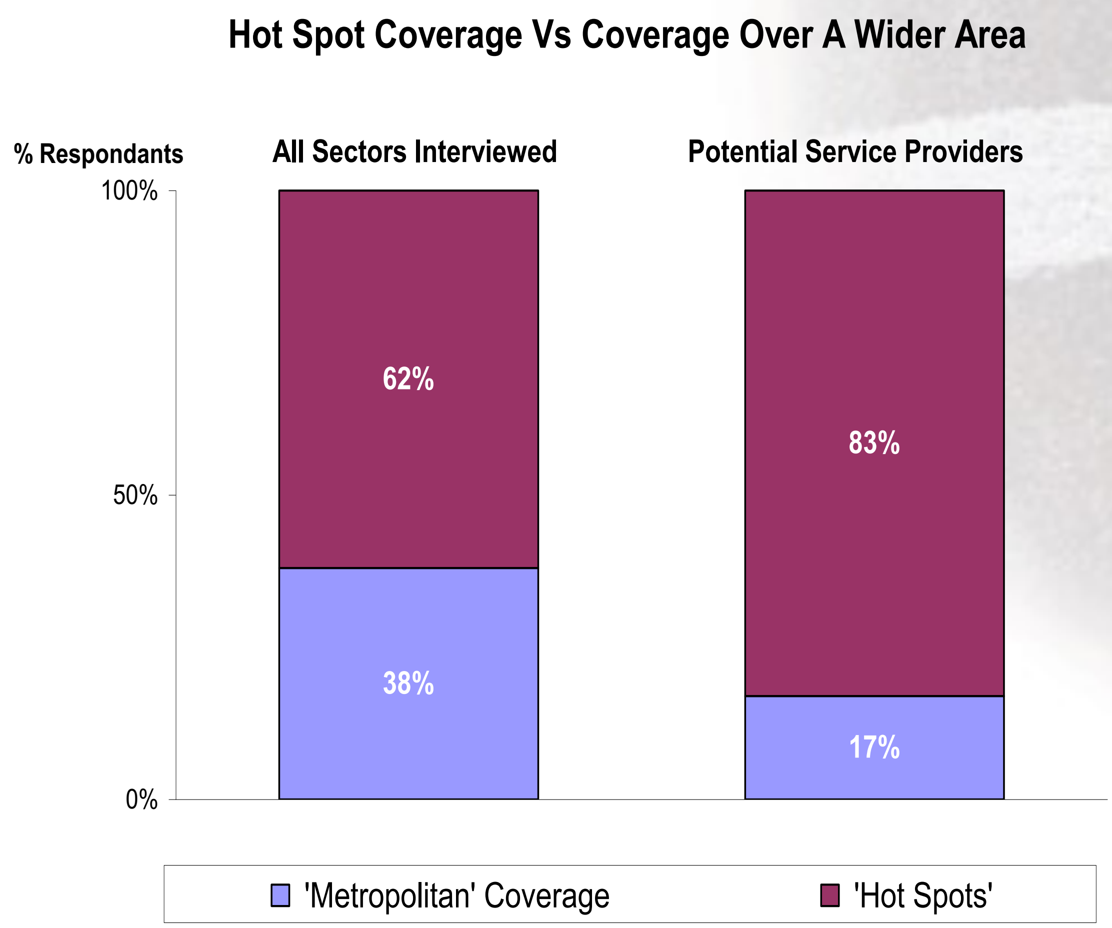
Industry survey

- Whilst economies of scale in 5 GHz products will be fostered in the next few years, 2.4 GHz products will retain their market lead at least for the next 2 – 3 years
- There will be migration to 5 GHz RLANs in future as economies of scale are reached, since these products will provide higher quality, higher performance service
- The most immediate commercial opportunities in public RLANs lie in using 802.11 equipment in the 2.4 GHz band
- Business travellers are already carrying 802.11 RLAN cards and the market is growing

**There are public access RLANs operating in a number of countries outside of the UK already and hence there is a risk of the UK lagging in this market!**

# Views on RLAN coverage prospects were mixed

Industry survey




- 62% of all those interviewed considered RLANs to be suited only to 'hot spot' coverage
- 83% of 'service providers' (fixed/mobile operators, ISP's) considered the hot-spot proposition to be the most commercially viable

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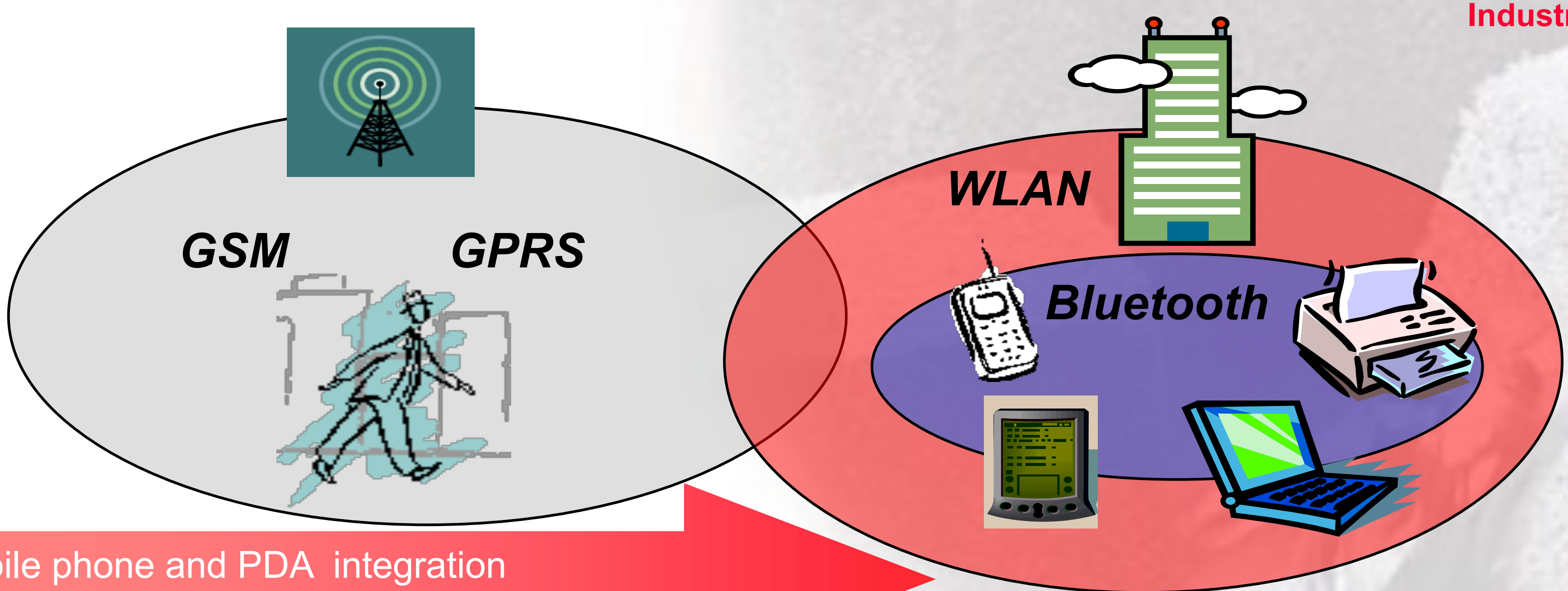
# The different wireless access methods were seen to be complementary

Industry survey

- There was some recognition that an element of crossover did exist (e.g. between RLANs and GPRS/3G)
  - However the extent of this was difficult to quantify
- The take-up of RLANs and Bluetooth could well act as a further driver in the take-up of GPRS/3G, as users become accustomed to high-speed data services
- In general, RLANs and Bluetooth were seen to complement GPRS/3G
  - This is illustrated by the majority view that RLANs and Bluetooth will provide 'hot spot' wireless access rather than wider area coverage

# In future, integration of these different access modes is envisaged

Industry survey




Mobile phone and PDA integration
Provide communication over GSM/GPRS

Mobile phone – GPRS > Bluetooth
Integration with PDA and Voice

PDA – transfer from GPRS to WLAN
and Bluetooth

Laptop– GPRS to WLAN and
Bluetooth for communication with printer

Printer – Bluetooth / WLAN

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# There was not a strong interest in exploiting DECT in public access systems; for 3G TDD, it was felt to be too soon to tell

Industry survey

- DECT is already well established in the private/corporate environment
- Standards for 3G TDD 'licence exempt' in the 2010 – 2025 MHz band are not being progressed in 3GPP
  - The initial TDD specifications are for 'public operator' networks
  - No activity on a 'licence exempt' mode
  - No indication of when products might reach the market
  - This makes it difficult to quantify commercial opportunities
- Services in licensed 3G TDD spectrum are expected to drive use of the 3G licence-exempt spectrum, and vice-versa

# QoS is a concern, but considered to be manageable

Industry survey

- A clear difference exists between QoS in terms of the types of services being envisaged in licence-exempt spectrum (e.g. internet/intranet, which are inherently ‘best effort’) compared to that expected with conventional telecoms networks
- QoS in RLAN systems can be improved by:
  - Installation of additional access points
  - Moving the access point to a different location
  - Adaptive antenna solutions
- RLANs are inherently designed to co-exist with neighbouring devices through TPC and DFS
- Any Bluetooth/RLAN co-existence issues are likely to be addressed by the industry (since most manufacturers make both products)
- Site owners/property managers will act as ‘site managers’ for indoor public RLANs

# The potential for congestion in the 2.4 GHz band appeared less of a concern than earlier reports indicated

**Industry survey**

- In countries outside of the UK where public access RLANs are already operating at 2.4 GHz, spectrum congestion does not appear to be a problem
- System planning plays a big part:
  - In providing RLAN access points in public places (e.g. airport lounges) the operator will need to approach the site owner
    - » This gives the opportunity to negotiate an exclusive arrangement, or
    - » Operators in the same area can co-operate over location of access points
- Operators can monitor the system and identify any trouble spots
- Congestion could arise due to the density of devices, not as a direct result of whether systems are public or private

# The impact on existing users is mainly dependent on whether congestion will arise

Industry survey

- There was little evidence that SRDs can be put to commercial use in providing ‘third party’ services
  - This implies a change in regulation will not impact significantly on use of the SRD bands
- There may be negative impact caused by uncertainty over what future regulation will allow
- The potential for congestion in either the 2.4 GHz or 5 GHz bands depends on the density of devices in operation
  - High densities could in any case occur under existing regulation (due to high take-up for private systems)

# Our study concluded that there are no technical or economic reasons for not allowing 'public' use



- Technical conclusions

| WLAN Band | Conclusion |
|---|---|
| 2.4GHz | With the exception of RFA, the operation of private and public systems appears viable assuming they conform to the technical conditions set in the current Exemption Regulations.<br><br>RLANs will tend to dominate any interference that does arise, and will, in high density areas, tend to be self-limiting.<br><br>High densities of RLANs will cause a severe potential for interference into RFA networks. |
| 5GHz | At densities consistent with anticipated commercial take-up, RLANs should be able to operate without causing undue interference to either other RLANs, or other services in the bands<br><br>The use of mesh FWA technologies could be considered, but limitations on use would be necessary, for instance, limitations to rural and sub-urban environments |

- Economic conclusions

| **Affected party** | **Benefits** | **Costs** | **Net benefits** |
|---|---|---|---|
| End users | Use of newly introduced public services | Charge for public services<br><br>Possible interference | Positive<br>Order of £500m p.a. |
| Public service providers | Increase in revenue as a result of accessing new spectrum and offering new services | Operating costs | Non-negative, but small if competition is effective |
| Public service customers | Use of newly introduced public services | Charge for public services | Positive (correspondin g part of the total consumer surplus) |
| Equipment manufacturers | Revenues from equipment to support new services | Operating costs | Non-negative, but small if competition is effective |

# Our conclusions are drawn based on the technical and economic analysis, plus the results of the industry survey



Strong commercial interest in using the 2.4 GHz and 5 GHz bands for public access RLANs in hot spots

QoS can be managed by technical solutions and system planning

Technical analysis demonstrates that interference will occur in very high density RLAN use is reached

Public access RLANs are already operating outside of the UK

Most public 'hot spots' are indoors, which reduces the potential for interference

Higher potential of interference occurring between 5 GHz FWA mesh systems and RLANs

Economies of scale in 5 GHz RLANs will take a few years to develop

Economic analysis suggests consumer surplus of £500 million per annum from introduction of public access RLANs

UK may be disadvantaged if regulation is not changed

There could be immediate economic benefit from removing the public access prohibition in the 2.4 GHz band

In order to maximise gain, spectrum access restrictions should focus on measures to help minimise the impact of interference

Public systems will not cause a significant increase in interference, assuming similar technical restrictions are applied for public systems as for private

# Our overall recommendations are…



- There appears to be a strong need for action in the 2.4 GHz and 5 GHz bands to remove the public/private distinction for devices currently covered by the exemption regulations
- The public/private question in relation to the 3G TDD spectrum (2010 – 2025 MHz) is difficult to analyse until there is some idea of system characteristics and equipment specifications
- There appears to be no reason to discriminate between public and private systems in licence-exempt spectrum – providing both conform to the same technical characteristics
- There are some outstanding technical issues in relation to access to the 5 GHz band (policy on FWA 'mesh' systems, harmonisation between 802.11a and HiperLAN)
- The licence-exempt nature of bands such as 2.4 GHz has fostered innovation in technology and commercial incentives will continue to exist to overcome any co-existence issues (e.g. between RLANs and Bluetooth)

# Annex for Technical Analysis

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CONCEPTS TO REALITY

BUSINESS SOLUTIONS. TECHNICAL STRENGTH

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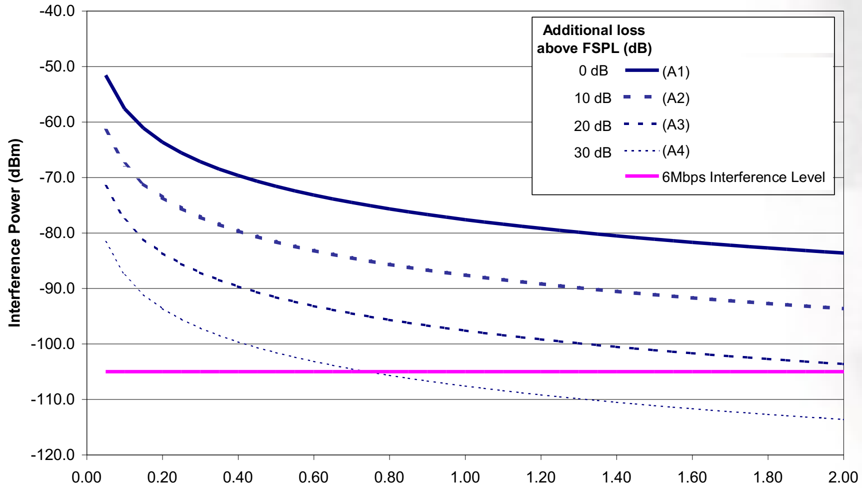
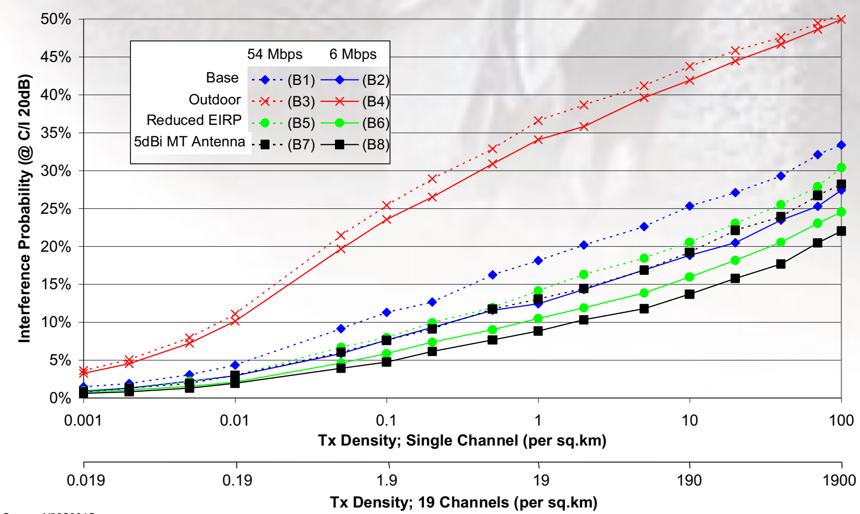
# 5 GHz; Intra RLAN interference analysis results




Source: Y32S005O

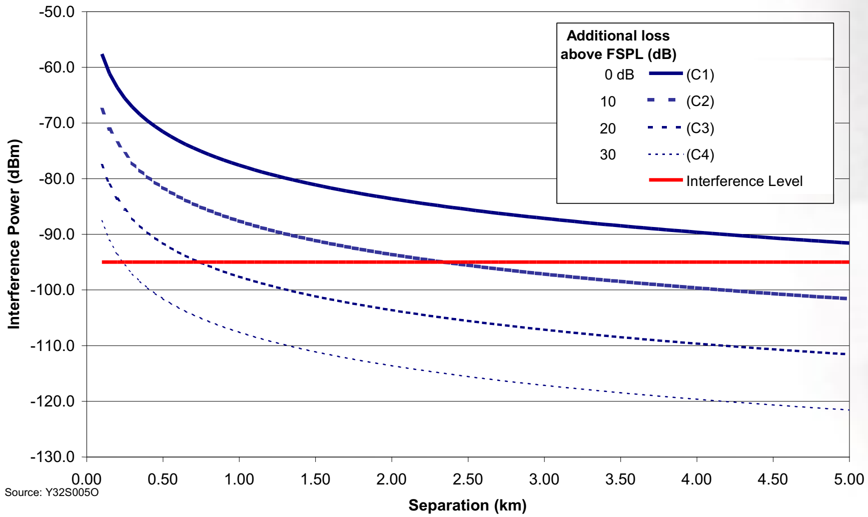
- Additional losses (PAPR, TPC, practical activity ratios, indoor use, lower C/I) for the interference link budget aggregating to at least 35 dB are expected
- In practice sufficient isolation should exist between an interfering transmitter and a wanted receiver, operating co-channel

- Mitigation factors (additional losses, non-co-location, lower C/I) will reduce probability of interference significantly
- With mitigation, all the interference scenarios modelled meet the 10% criteria except outdoor
- For outdoor RLANs, with mitigation, a 10% interference probability occurs at 0.2 – 10 per sq.km. Outdoor RLANs are therefore expected to present interference potential in environments outside of rural and suburban




Source: Y32S004O

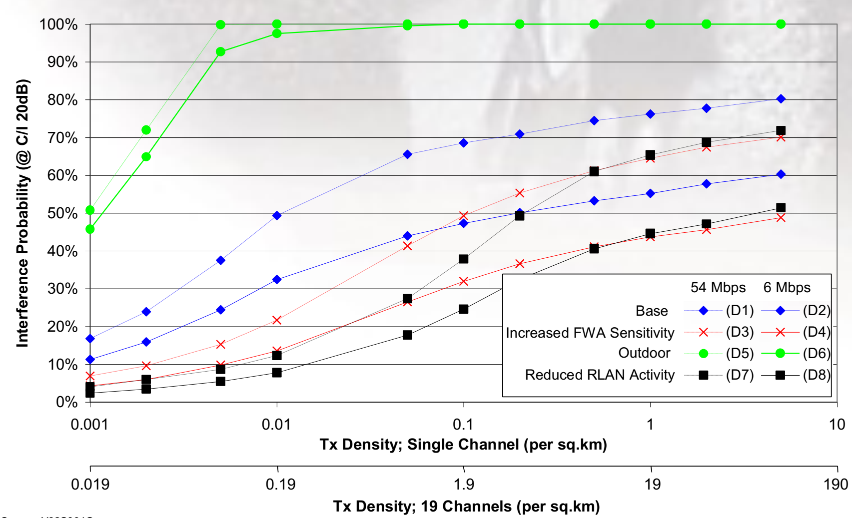
# 5 GHz; Transmitting RLAN/receiving FWA interference analysis results



Source: Y32S005O

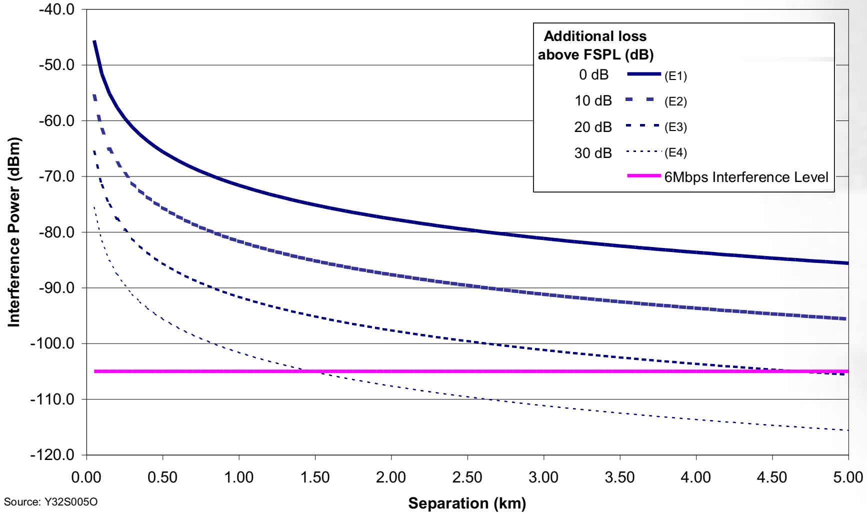
- Additional losses (PAPR, TPC, practical activity ratios, indoor use, lower C/I) for the interference link budget aggregating to at least 35 dB are expected
- In practice therefore, required separation distances of less than a few hundred metres are expected
- High-density RLAN implementations can be expected to present some problems for FWA system operation therefore, but in most environments sufficient isolation should exist between an interfering transmitter and a wanted receiver, operating co-channel.

- Mitigation factors (additional losses, lower C/I) will reduce probability of interference
- The operation of co-frequency RLANs in the FWA BS coverage area, in urban and dense urban environments, does not seem feasible
- Across all environments, outdoor RLANs have to the potential to cause significant interference
- In the rural and suburban environments, with mitigation, a 10% interference probability occurs at a indoor RLAN density of 0.5 per sq.km. The operation of indoor RLANs in rural and suburban environments does therefore seem practical



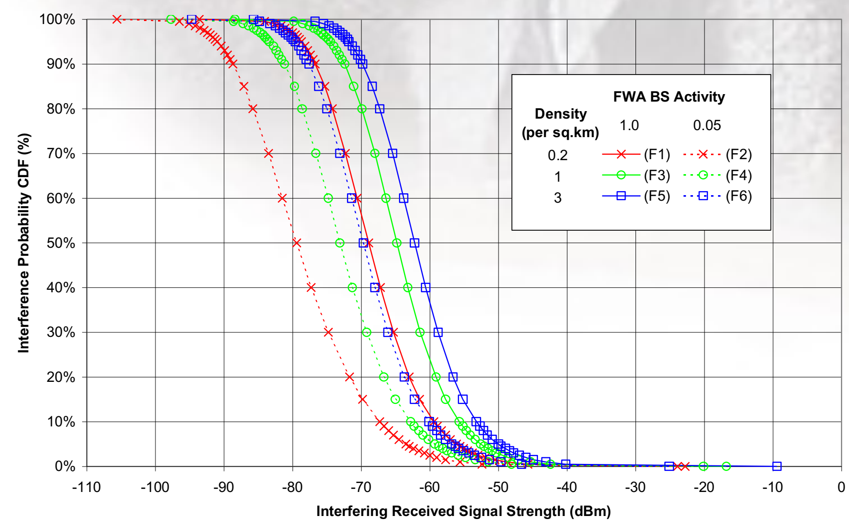
Source: Y32S004O

# 5 GHz; Transmitting FWA system/receiving RLAN interference analysis results



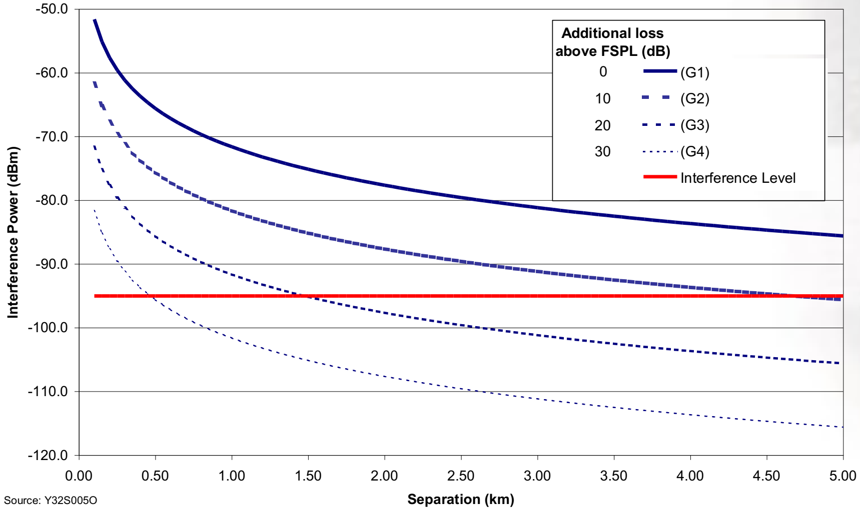

- Additional losses (PAPR, directional antennas, actual activity ratios, indoor use lower C/I) for the interference link budget aggregating to at least 30 dB can be expected
- Even with such additional losses, separation distances remain significant
- It will not be possible for an RLAN to use the same frequency as an FWA BS in the coverage area of that BS. DFS in the RLAN should permit service to be offered in this case, however reduced capacity can be expected

- Additional losses (PAPR, directional antennas, lower C/I) for the interference link budget can be expected
- RLANs will not generally be able to operate co-frequency, co-coverage with FWA BSs, except for indoor RLANs are operating in lower density (suburban & rural) environments
- In urban/dense urban environments, RLANs within a FWA BSs coverage may have difficulty operating even on a non co-frequency basis due to the lack of available channels with which to operate on




INDOOR

# 5 GHz; Intra FWA interference results




Source: Y32S005O

- Additional losses (PAPR, directional antennas, actual activity ratios, lower C/I) for the interference link budget aggregating to at least 20 dB
- With such additional losses, separation distances begin to become manageable
- The use of a suitable frequency reuse plan, to ensure that the frequency used at a BS is not reused by adjacent BSs, should permit interference to be managed sufficiently
- Use of directional antennas employing down tilt should further enhance this