Exposure to Electromagnetic Fields from Wireless Computer Networks (Wi-Fi) in Schools

Simon Mann
Darren Addison, Stuart Burnett, Carolina Calderon, Mohammed Khalid, Terry Mee, Azadeh Peyman

Physical Dosimetry Department
Health Protection Agency, UK
Overview

1. Background and motives
2. Objectives and tasks
3. Technical aspects of wireless networks
4. Review of equipment in schools
5. Selection of devices for testing
6. Experimental setup for measurements
7. First measurement results
8. Further work

This study is supported by HPA’s R&D Development Fund
In 2007, 50% of UK primary schools and 82% of secondary schools made at least some use of wireless network technology.
Expressions of public concern about Wi-Fi
  • Media articles
  • Enquiries received by HPA

Lack of quantitative information about exposures
  • Comparison with exposure guidelines
  • Context with regard to other sources

Existing precautionary advice to discourage non-essential use of mobile phones by children
  • Chief Medical Officer
  • HPA (NRPB)
HPA Position on Wi-Fi

• The frequencies used are broadly the same as those from other RF applications such as FM radio, TV and mobile phones.
• There is no consistent evidence to date that Wi-Fi and WLANs adversely affect the health of the general population.
• Results so far show RF exposures are likely to be well within internationally accepted (ICNIRP) guidelines.
• Based on current knowledge and experience, exposures from Wi-Fi are lower than those from mobile phones.
• There is no reason why Wi-Fi should not continue to be used in schools. However with any new technology it is a sensible precautionary approach, as happened with mobile phones, to keep the situation under ongoing review.

http://www.hpa.org.uk/HPA/Topics/Radiation/UnderstandingRadiation/1199451940308/
Project Tasks
Year 1

Market research on popular Wi-Fi devices at schools
- British Educational Communications and Technology Agency (BECTA)
- Suppliers of equipment to schools
- Manufacturers, Wi-Fi Alliance

Setting up of Wi-Fi test facilities at HPA’s Chilton site
- Anechoic chamber
- Signal analyser
- Positioning system

Procurement of a selection of example Wi-Fi devices
- Laptops and access points operating in two different frequency bands

Measurements of the EMF strengths around the selected devices during transmission and calculations of radiated powers
- Laptops in 2.4 GHz band
## Configurations

- Typical indoor ranges 75-100 m
- Up to 300 m of outdoor range
- Frequency bands 2.4 GHz and 5 GHz
- Number of users allowed is set by the manufacturer.
- High end access points support up to 100 wireless connections

## Factors affecting human exposure

- Distance
- Frequency
- Output power
- Antenna Pattern
- Duty factor
Technical Standards for WLAN
IEEE 802.11

IEEE 802.11b
- Widely deployed, basic rate of Wi-Fi, 11 Mbps (4.3 Mbps throughput) at 2.4 GHz
- Recommended by some suppliers for teaching resources in large schools

IEEE 802.11a
- Primary standard for WLAN, max 54 Mbps (23 Mbps throughput) at 5 GHz
- Recommended by some suppliers for administration and teacher training

IEEE 802.11g
- 54 Mbps at 2.4 GHz
- Recommended by suppliers for teaching resources in both small and large schools

IEEE 802.11n
- High throughput (74 Mbps), max data rate 248 Mbps at both 2.4 and 5 GHz
- Deployment in schools has recently started

Overall there is no particular trend in the chosen wireless standards in UK schools
# Wireless Networks in Schools (Reports from 2007)

<table>
<thead>
<tr>
<th>Proportion Wireless</th>
<th>Primary Schools</th>
<th>Secondary schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole network</td>
<td>2 %</td>
<td>2 %</td>
</tr>
<tr>
<td>Substantial part</td>
<td>21 %</td>
<td>20 %</td>
</tr>
<tr>
<td>Small part</td>
<td>26 %</td>
<td>60 %</td>
</tr>
<tr>
<td>None of it</td>
<td>50 %</td>
<td>18 %</td>
</tr>
<tr>
<td><strong>Number of respondents</strong></td>
<td>233</td>
<td>257</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Network Variant</th>
<th>Primary Schools</th>
<th>Secondary schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>802.11b</td>
<td>36 %</td>
<td>46 %</td>
</tr>
<tr>
<td>802.11g</td>
<td>70 %</td>
<td>80 %</td>
</tr>
<tr>
<td>802.11a</td>
<td>10 %</td>
<td>16 %</td>
</tr>
<tr>
<td>802.11n (pre-)</td>
<td>2 %</td>
<td>2 %</td>
</tr>
</tbody>
</table>

*NB. Some schools support multiple standards*

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Harnessing Technology schools survey 2007

Wireless Networks in Schools Survey (2007)
Standards and Exposure Recommendations

Limiting Emissions

- Europe (ETSI): Harmonised standards EN 300 328 and EN 301 893
- UK (OFCOM): UK Interface Requirements (IR 2005 for 2.4 GHz and IR 2006 for 5 GHz bands)

<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>Power Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4 – 2.5 GHz</td>
<td>100 mW</td>
</tr>
<tr>
<td>5.15 – 5.35 GHz</td>
<td>200 mW</td>
</tr>
<tr>
<td>5.47 – 5.725 GHz</td>
<td>1 W</td>
</tr>
</tbody>
</table>

Limiting Exposures

- Guidelines from ICNIRP (adopted by HPA)
  - Basic restrictions on rate of energy absorption per unit mass of body tissue
  - Reference levels in terms of radio frequency power density incident on the body
Up to 32 laptops can be used in a classroom,
Usually 1-2 access points in each classroom
Interactive whiteboards and hand held interactive slates often have wireless options enabled
Results: Devices in Schools

ICT Suites

Laptop Trolleys
# Laptops Selected for Testing
(Examples of Typical Equipment)

<table>
<thead>
<tr>
<th>Wi-Fi Project ID</th>
<th>Wi-Fi modes</th>
<th>Dimensions LxWxD (cm)</th>
<th>Available frequency channels</th>
<th>Settable power levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>LT01</td>
<td>b/g</td>
<td>34 x 24 x 4</td>
<td>N/S</td>
<td>N/S</td>
</tr>
<tr>
<td>LT02</td>
<td>b/g</td>
<td>36 x 27 x 4</td>
<td>N/S</td>
<td>N/S</td>
</tr>
<tr>
<td>LT03</td>
<td>b/g</td>
<td>36 x 27 x 4</td>
<td>1–13</td>
<td>25, 50, 75, 100%</td>
</tr>
<tr>
<td>LT04</td>
<td>a/b/g/n</td>
<td>37 x 27 x 4</td>
<td>1–11</td>
<td>36–48</td>
</tr>
<tr>
<td>LT05</td>
<td>a/b/g/n</td>
<td>37 x 28 x 4</td>
<td>1–11</td>
<td>36–48</td>
</tr>
<tr>
<td>LT06</td>
<td>b/g</td>
<td>34 x 25 x 4</td>
<td>1–14</td>
<td>N/A</td>
</tr>
<tr>
<td>LT07</td>
<td>a/b/g</td>
<td>32 x 24 x 4</td>
<td>1–11</td>
<td>36–48</td>
</tr>
<tr>
<td>LT08</td>
<td>a/b/g/n</td>
<td>30 x 25 x 4</td>
<td>1–11</td>
<td>36–48</td>
</tr>
<tr>
<td>LT09</td>
<td>a/b/g/n</td>
<td>33 x 23 x 3</td>
<td>1–14</td>
<td>36–64</td>
</tr>
<tr>
<td>LT10</td>
<td>a/b/g/n</td>
<td>33 x 25 x 4</td>
<td>1–11</td>
<td>36–48</td>
</tr>
<tr>
<td>LT11</td>
<td>a/b/g</td>
<td>26 x 17 x 5</td>
<td>1–14</td>
<td>36–64</td>
</tr>
<tr>
<td>LT12</td>
<td>b/g</td>
<td>23 x 17 x 4</td>
<td>N/S</td>
<td>N/A</td>
</tr>
<tr>
<td>LT13</td>
<td>b/g</td>
<td>23 x 12 x 3</td>
<td>N/S</td>
<td>N/A</td>
</tr>
<tr>
<td>LT14</td>
<td>a/b/g</td>
<td>40 x 29 x 5</td>
<td>1–11</td>
<td>36–48</td>
</tr>
<tr>
<td>LT15</td>
<td>b/g</td>
<td>28 x 24 x 4</td>
<td>1–13</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Experimental Facilities Built at HPA Chilton (CRCE)

- Anechoic chamber (3.6 m × 2.4 m × 2.4 m)
- Angular positioner
- Access point
- Receiving antenna
- Signal analyser
- Software acquires electric field strength
  - Angular distribution
  - Function of distance
Results: Multiple Antennas

- Field strength measured during 50 captured bursts at each position
- Two (or sometimes three) different levels found
Results:
Typical Antenna locations
Results: E-field Distribution

Measured electric field strength distribution across all laptops

ICNIRP reference level = 61 V/m
## Results: Emitted Powers

<table>
<thead>
<tr>
<th>Laptop ID</th>
<th>θ (°)</th>
<th>φ (°)</th>
<th>E (mVm⁻¹)</th>
<th>EIRP (mW)</th>
<th>Integrated radiated power (mW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LT01</td>
<td>60</td>
<td>−30</td>
<td>1045</td>
<td>36</td>
<td>10</td>
</tr>
<tr>
<td>LT02</td>
<td>−60</td>
<td>−150</td>
<td>1216</td>
<td>49</td>
<td>19</td>
</tr>
<tr>
<td>LT03</td>
<td>−60</td>
<td>−150</td>
<td>1306</td>
<td>57</td>
<td>17</td>
</tr>
<tr>
<td>LT04</td>
<td>−60</td>
<td>−150</td>
<td>1048</td>
<td>37</td>
<td>13</td>
</tr>
<tr>
<td>LT05</td>
<td>−30</td>
<td>90</td>
<td>719</td>
<td>17</td>
<td>6</td>
</tr>
<tr>
<td>LT06</td>
<td>−30</td>
<td>−90</td>
<td>1153</td>
<td>44</td>
<td>12</td>
</tr>
<tr>
<td>LT07</td>
<td>−60</td>
<td>180</td>
<td>1055</td>
<td>37</td>
<td>13</td>
</tr>
<tr>
<td>LT08</td>
<td>30</td>
<td>120</td>
<td>766</td>
<td>20</td>
<td>9</td>
</tr>
<tr>
<td>LT09</td>
<td>−30</td>
<td>120</td>
<td>1009</td>
<td>34</td>
<td>18</td>
</tr>
<tr>
<td>LT10</td>
<td>30</td>
<td>150</td>
<td>1054</td>
<td>37</td>
<td>11</td>
</tr>
<tr>
<td>LT11</td>
<td>−90</td>
<td>150</td>
<td>1144</td>
<td>32</td>
<td>10</td>
</tr>
<tr>
<td>LT12</td>
<td>30</td>
<td>−120</td>
<td>1142</td>
<td>43</td>
<td>17</td>
</tr>
<tr>
<td>LT13</td>
<td>90</td>
<td>60</td>
<td>837</td>
<td>22</td>
<td>8</td>
</tr>
<tr>
<td>LT14</td>
<td>60</td>
<td>180</td>
<td>970</td>
<td>31</td>
<td>12</td>
</tr>
<tr>
<td>LT15</td>
<td>−60</td>
<td>180</td>
<td>909</td>
<td>28</td>
<td>9</td>
</tr>
</tbody>
</table>
• Emitted powers were very low for the 15 laptops
  • Integrated (total) radiated powers ranged from 6 to 19 mW
  • Effective powers (EIRP) ranged from 17 to 57 mW in the direction of maximum emission
    – Within the regulatory maximum of 100 mW
• Results consistent with HPA’s present position that exposures are
  • well within exposure guidelines and
  • less than from mobile phones
Project Tasks
Year 2

• Phase 2 measurements of the EMF strengths around the selected devices during transmission and calculations of radiated powers
  • Laptops in 5 GHz band
  • Access points in 2.4 GHz band
  • Access points in 5 GHz band
• Measurements of the proportion of the time that individual Wi-Fi computers transmit during typical school lessons
  • Establish protocol and validate
• Computer modelling of energy absorption in the body when using Wi-Fi equipment under various scenarios
  • Computer model of laptop and exposed person
• Health risk review drawing on the exposure measurements and modelling
Thank You

 .......... Any questions?

Simon.mann@hpa.org.uk