

# Radiofrequency Radiation Measurements

## Public Wi-Fi Installations in Hong Kong

Office of the Telecommunications Authority  
12 October 2007

*(Updated on 5 March 2009<sup>1</sup>)*

### Executive Summary

1. The increasing popularity of the public Wi-Fi services has given rise to public concerns about the radiofrequency (RF) radiation from Wi-Fi access points (APs) installed in the public areas<sup>2</sup>.

2. The Wi-Fi APs are radiocommunications transceivers for provision of wireless access of Internet service and they are scattered throughout the entire territory, mainly in the populated and built-up areas. According to the World Health Organisation (WHO), the exposure levels due to wireless networks (including Wi-Fi) are generally very low, and **there is no convincing scientific evidence that the weak RF signals from wireless networks cause adverse health effects.** Relevant information can be found in the web-site of WHO at:

<http://www.who.int/mediacentre/factsheets/fs304/en/index.html>

3. However, in view of the public concerns, the Office of Telecommunications Authority (OFTA) has conducted a territory-wide survey of RF radiation generated by Wi-Fi APs in 2007 and subsequently took additional measurements at other locations including those on board public transport. This report<sup>3</sup> presents the details and findings of the

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<sup>1</sup> More survey locations were included.

<sup>2</sup> In this report, public areas refer to the areas that are accessible by the general public.

<sup>3</sup> This report contains information compiled by OFTA for reference only. Whilst OFTA endeavors to ensure that the information in this report is correct, no warranty or guarantee, express or implied, is given as to its accuracy. This report is not a substitute for medical advice. Anyone who wishes to use this report should seek expert and legal advice. The Government of HKSAR, the Telecommunications Authority and OFTA accept no liability for any use reliance upon or otherwise citing this report and any part thereof.

measurements. According to the measurements taken, the RF exposure levels from the APs range from less than 0.03% to 0.3% of the limits as recommended in the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Exposure Guidelines, which has been adopted in Hong Kong for protection of workers and the public. The RF exposure level varies depending on various factors, including proximity to the APs, the surrounding environment and the movement of the concerned object. According to the survey in this report, it is concluded that the non-ionizing radiation **generated by Wi-Fi installations in public areas in Hong Kong is well below the international recommended limits.**

## **Wi-Fi**

1. Wi-Fi<sup>4</sup> refers to the IEEE 802.11 group of standards operating in the 2.4 GHz and 5 GHz bands. It is a wireless access technology for provision of broadband wireless access, which uses radio frequencies for linking up user terminal equipment (e.g. computers, PDA, pocket PC, mobile phone, etc.) and the broadband network for Internet access. The network device providing the Wi-Fi air interface between the broadband network and the user terminal equipment is called Wi-Fi Access Point (AP), which is a radio transceiver itself. The user terminal equipment should have installed/built-in Wi-Fi device for communications with the APs.

2. Wi-Fi devices share the same frequency bands with many other radio apparatus, such as Bluetooth wireless devices, cordless phones and video transmitters, in the 2.4 GHz and 5 GHz bands. Use of these devices for private purpose is covered by an exemption order<sup>5</sup> and no licence under the Telecommunications Ordinance (Cap. 106) is required. Provision of the public Wi-Fi service is permissible under a class licence provided that the service does not cross public streets or unleased

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<sup>4</sup> Wi-Fi devices can operate in the 2.4 – 2.4825 GHz (2.4 GHz), 5.15 – 5.35 GHz, 5.47 – 5.725 GHz and 5.725 – 5.85 GHz (5.8 GHz) ranges. Meanwhile, almost all public Wi-Fi APs in Hong Kong adopt IEEE 802.11b/g standards and operate in the 2.4 GHz band for the time being.

<sup>5</sup> The exemption order refers to the Telecommunications (Telecommunications Apparatus) (Exemption from Licensing) Amendment Order 2005 (the “Exemption Order”) which exempts a number of frequency bands from the licence requirement. Full document of the Order is available at <http://www.ofta.gov.hk/en/ta-regulations/es22005090922.pdf>.

Government lands. The operation of public Wi-Fi service over public streets and unleased Government land requires a fixed carrier licence.

3. According to the exemption order, the permissible peak equivalent isotropically radiated power<sup>6</sup> (e.i.r.p) in the 2.4 GHz and 5.8 GHz bands is 4 W. However, it is found that the transmitting power of Wi-Fi devices, including those adopted for public Wi-Fi services, are all in the range of equal to or below 0.1 W effective radiated power (e.r.p.) (i.e. 0.164 W e.i.r.p.) It is believed that such low output power of Wi-Fi device is due to the power limitation of the terminal equipment and the intended usage of Wi-Fi Internet access for short range applications (within 50 meters).

### **Wi-Fi Access Points for Public Wireless Internet Access**

4. In Hong Kong, there are many APs installed in publicly accessible areas, such as shopping malls, coffee shops, restaurants, MTR stations, airports, universities, convenience shops and public payphone kiosks. According to OFTA's record, as of February 2009, there are already over 7,872 APs installed. The locations of these APs for public service are available at:-

[https://apps.ofta.gov.hk/apps/clr/content/public\\_search.asp](https://apps.ofta.gov.hk/apps/clr/content/public_search.asp)

### **Public Health Concerns**

5. Electromagnetic radiation generated by RF transmitters, including the transmitters of the Wi-Fi APs, is classified as non-ionisation radiation (NIR)<sup>7</sup> or RF radiation. Unlike the high energy ionizing radiation, such as X-rays, which has strong ionization and penetration power, the energy of NIR is much lower, and it is associated with all sorts of objects in our daily life (such as computers and cordless phones). According to the World Health Organisation (WHO), over the past 15

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<sup>6</sup> Equivalent isotropically radiated power (e.i.r.p.) refers to the power radiated from an isotropic antenna while effective radiated power (e.r.p.) refers to the power radiated from a half-wave dipole which has a gain of 1.64 over the isotopic antenna.

<sup>7</sup> Please refer to OFTA's leaflet on "Know more on Radiofrequency Electromagnetic Radiation" for more information on NIR which can be downloaded from <http://www.ofta.gov.hk/en/freq-spec/radiation.pdf>

years, studies examining a potential relationship between RF transmitters and cancer have not provided evidence that RF exposure from the transmitters increases the risk of cancer. The only health effect from RF fields identified in scientific reviews is related to an increase in body temperature ( $> 1\text{ }^{\circ}\text{C}$ ) from exposure at very high field intensity found only in certain industrial facilities, such as RF heaters. The levels of RF exposure from base stations and wireless networks are so low that the temperature increases are insignificant and do not affect human health. The exposure levels due to wireless networks (including Wi-Fi) are generally very low, and **there is no convincing scientific evidence that the weak RF signals from wireless networks cause adverse health effects.** Relevant information can be found in the web-site of WHO at: <http://www.who.int/mediacentre/factsheets/fs304/en/index.html>

## **NIR Limits**

6. As a safety precaution to protect public health, the Office of the Telecommunications Authority (OFTA) has adopted the *International Commission on Non-Ionising Radiation Protection Guidelines (the “ICNIRP guidelines”)* published in 1998 on limits of exposure to RF electromagnetic fields in the frequency range up to 300 GHz for the protection of workers and the public against non-ionising radiation hazards.

7. In 2000, OFTA issued a “*Code of Practice for the Protection of Workers and Members of Public Against Non-Ionizing Radiation Hazards from Radio Transmitting Equipment*” (CoP) as guidance for radiocommunications service providers. Copy of the CoP can be downloaded from:

<http://www.ofta.gov.hk/en/code/practice/cop-radiation-hazards.pdf>.

Relevant NIR limits are extracted in Annex 1 for easy reference.

## **Calculated NIR Level Generated by Typical Wi-Fi APs**

8. A theoretical calculation done by OFTA about NIR level generated from a typical Wi-Fi AP is given in Annex 2. It is shown that at a distance of 0.1m from the antenna of the AP, the maximum NIR level generated by a Wi-Fi access point is  $1.3\text{ W/m}^2$ , which is far below the

limit of the ICNIRP guidelines of  $10 \text{ W/m}^2$  as adopted in the CoP. In theory, the NIR level decreases sharply when the distance from the AP increases. Hence, the theoretical calculated level of the NIR exposure is the worst scenario for the general public when they move around in a Wi-Fi zone. For most of the time, the NIR exposure of the public in a Wi-Fi zone should be much lower than the calculated level. This is confirmed by the survey results as given below.

## **The Survey**

9. Although the transmission power of the Wi-Fi APs is low, there may be concerns whether they have been installed properly, and whether the aggregated NIR levels generated by more than one Wi-Fi AP installed in close proximity to each other might exceed the limits of the CoP.

10. In order to assess the RF radiation emitted by Wi-Fi APs, surveys have been conducted at 55 selected locations with Wi-Fi services which include:-

- (a) cafes, restaurants, convenience shops, etc.;
- (b) public places with a large number of co-located Wi-Fi installations such as MTR stations, ferry piers, the airport, etc.;
- (c) public payphone kiosks with Wi-Fi APs where the APs are close to users due to physical constraint of the kiosks;
- (d) public housing estates and government premises provided with public Wi-Fi services,
- (e) busy districts where signals of public Wi-Fi services and those of domestic and commercial Wi-Fi installations co-exist,
- (f) an educational institution, and
- (g) trains, a bus and a hydrofoil.

## **Measurement Methodology**

11. The methodology of measurements on public Wi-Fi APs generally followed the widely adopted approach for NIR measurements. The measurements were carried out in areas accessible by the general public. The measurement probe was mounted on a tripod at a height of approximately 1.7m which corresponds to the head position of an average

adult. Measurement results were derived on the basis of a continued sampling of the RF signals for 6 minutes in duration. Details of the measurement methodology are explained in Annex 3.

### **Measurement Results**

12. The measurement results are provided in Annex 4 and they generally agree with the theoretical calculation. The levels of RF radiation measured are very low when compared with the limits as stipulated in the ICNIRP guidelines. It should be noted that the NIR levels measured range from less than  $0.003\text{W/m}^2$  to  $0.03\text{W/m}^2$ , or 0.03% to 0.3% of the ICNIRP exposure limit of  $10\text{W/m}^2$ .

### **Conclusions**

13. Based on the measurement results, it is concluded that **Wi-Fi RF exposures in public areas in Hong Kong, including the government premises provided with public Wi-Fi services, are well below the international exposure limits which have been adopted in the CoP. The measurement results also tally with WHO's finding that exposure levels due to Wi-Fi are generally very low. According to the WHO, there is no convincing scientific evidence that the weak RF signals from wireless networks (including Wi-Fi) cause adverse health effects.**

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### NIR Exposure Limits

The health protection standards specified in the CoP are those laid down in the “Guidelines for limiting Exposure to Time-varying Electric, Magnetic and Electromagnetic Fields (up to 300 GHz)” published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in 1998. According to the ICNIRP guidelines, the limits of NIR levels as applicable for Wi-Fi devices are as follows:

**Reference levels for general public exposure  
in the frequency range 2 – 300 GHz to  
time-varying electric and magnetic fields (unperturbed rms values)**

<b>Class of Personnel</b>	<b>E-field strength (V/m)</b>	<b>H-field strength (A/m)</b>	<b>Equivalent plane Wave power density (W/m<sup>2</sup>)</b>
General public	61	0.16	10

Note:

For frequencies between 100 kHz and 10 GHz, the  $E^2$ ,  $H^2$  and the power density are to be averaged over any 6-minute period.

### Estimation on the NIR Level Generated from a Typical Wi-Fi Access Point

According to Annex 2 of the CoP, the power density  $S$  for far-field approximation is given by the following equation:

$$\mathbf{S}(\mathbf{r}, \theta, \varphi) = \frac{\mathbf{R}(\theta, \varphi)\mathbf{G}_o\mathbf{P}}{4 \pi r^2} \quad (1)$$

Where

$\mathbf{P}$  = input power of the antenna

$\mathbf{G}_o$  = antenna gain

$\mathbf{G}_o\mathbf{P}$  = e.i.r.p.

$\mathbf{R}$  = radiation pattern

(normalised to unity in the direction of maximum radiation)

$\mathbf{r}$  = distance from the observation point to the antenna

The far field equation (1) can be used when  $\mathbf{r} > \mathbf{r}_n = \frac{\mathbf{h}^2}{2 \lambda}$

$\mathbf{h}$  = maximum dimension of the antenna

$\lambda$  = operating wavelength

Assuming that:

$\lambda$  = 0.123 m

(corresponds to frequency of 2.44 GHz which is the mid-point of 2.4 – 2.4835 GHz)

$\mathbf{G}_o\mathbf{P}$  = 0.1 W e.r.p. (or 0.164 W e.i.r.p.)

(for a typical Wi-Fi transmitter)

$\mathbf{h}$  = 15 cm (corresponds to  $\mathbf{r}_n = 9.1$  cm)

At a distance separation of 10 cm (i.e.  $\mathbf{r} = 0.1\text{m}$ ) from the antenna, which is just greater than  $\mathbf{r}_n$  so that equation (1) can be used, the power density at the direction of maximum radiation of the antenna (i.e.  $\mathbf{R} = 1$ ):

$$\mathbf{S}(\mathbf{r} = 0.1 \text{ m}) = \underline{\underline{1.3 \text{ W/m}^2}}$$

**Conclusion:**  $\mathbf{S}$  decreases at a rate inversely proportional to the square of the distance. It can be concluded that the NIR level generated from a typical Wi-Fi transmitter is far below the limit of  $10 \text{ W/m}^2$ .



### Measurements of Non-Ionisation Radiation from Wi-Fi APs

#### Measurement Equipment

- NIR levels from Wi-Fi APs are measured using a professional radiation meter<sup>8</sup> which is designed for precision measurement of aggregated NIR levels contributed from different radio transmitters in the vicinity and provided direct readout of the required 6-minute average NIR levels<sup>9</sup> as required by the ICNIRP Guidelines.

#### Measurement Arrangement

- Measurement of NIR levels is done in accordance with the following procedures:
  - (a) At each Wi-Fi hotspot location, the NIR meter is moved around in the local area to locate the maximum receivable signal strength. The first measurement will be taken at that position.
  - (b) The NIR meter is then fixed on a tripod at a height of 1.7m (corresponds to the head position of an average adult) for continuous measurement for at least 6 minutes.
  - (c) The NIR level averaged in the 6-minute interval as read out from the meter is recorded.
  - (d) After measurements conducted at the position of highest receivable signal level which is usually close to the Wi-Fi access point, further readings are taken sparsely within the local area where customers normally stay. Some five sampling points will be taken for measurements repeating the procedure (b) and (c) above as far as the situation allows.
  - (e) The minimum and the maximum NIR levels for the different measurements in (d) will be presented in the summary table in Annex 4.

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<sup>8</sup> The model of the NIR meter for the measurements as presented in this report is EMR-300 from Wandel & Goltermann GmbH & Co. The frequency range of the associated measuring probe is 3MHz - 18GHz.

<sup>9</sup> The meter reads out E-field in V/m where the unit is converted into power density in W/m<sup>2</sup> for easy reference.

## Results of NIR Measurements for Public Wi-Fi APs

### Remarks

The NIR levels quoted in the table below have nothing to do with the coverage performance of the respective Wi-Fi APs as the measurements were made only in proximity to the APs.

Wi-Fi Installation Locations		NIR Level <sup>10</sup>	
		Measured Minimum/ Maximum Power Density (W/m <sup>2</sup> )	Ratio of the measured Power Density when compared with the exposure limit (10W/ m <sup>2</sup> )
<b>Hong Kong Island (16 locations)</b>			
Haagen-Dazs	Lan Kwai Fong, Central	0.01/0.02	0.1%/0.2%
KFC	D'Aguiar St., Central	<0.003	<0.03%
Circle K	Cochrane Street, Central	<0.003	<0.03%
McDonald's Restaurant	2/F, McDonald's Building, Yee Wo Street, Causeway Bay	<0.003/0.004	<0.03%/0.04%
McDonald's Restaurant	3/F, McDonald's Building, Yee Wo Street, Causeway Bay	<0.003	<0.03%
Mix Café	Shop P112, Podium Level, World Trade Centre, Causeway Bay	<0.003/0.009	<0.03%/0.09%
Pacific Coffee	G/F, Pak Fook Bldg., 208-212 Queens Road East, Wanchai	<0.003/0.01	<0.03%/0.1%
Tai Koo Shing	Outdoor near City Plaza	<0.003	<0.03%
壽司派	Shop P110-111, Podium Level, World Trade Centre, Causeway Bay	<0.003	<0.03%

<sup>10</sup> The specified measurement range of the E-field probe is 3.2mW/m<sup>2</sup> to 2.6 kW/m<sup>2</sup>

PCCW payphone kiosk	Kiosk ID1201, O/S Trust Tower, 68 Johnson Rd., Wan Chai	0.005/0.006	0.05%/0.06%
PCCW payphone kiosk	Kiosk ID1208, O/S, Southern Playground, Luard Road, Wan Chai	0.007/0.008	0.07%/0.08%
OFTA	25/F, 26/F, 29/F Wu Chung House, 213 Queen's Road East, Wan Chai	<0.003	<0.03%
Hong Kong Central Library	66 Causeway Road, Causeway Bay, Hong Kong	<0.003	<0.03%
Harbour Building	38 Pier Road, Central	<0.003/0.019	<0.03%/0.19%
Pier 5	Pier 5 in Central	<0.003	<0.03%
Pier 6	Pier 6 in Central	<0.003	<0.03%
<b>Kowloon (24 locations)</b>			
7-Eleven	Room VA206, Shaw's Amenities Building, Hong Kong Polytechnic University	0.004/0.02	0.04%/0.2%
7-Eleven	23 Lock Road, Tsim Sha Tsui	<0.003/0.008	<0.03%/0.08%
Delifrance	Shop G101, Gateway Arcade Harbour City, Tsim Sha Tsui	<0.003	<0.03%
Delifrance,	Shop 36-37, Level 1 Discovery Park, Tsuen Wan	<0.003/0.006	<0.03%/0.06%
Haagen-Dazs	Shop 3201, Gateway Arcade, Harbour City, Tsim Sha Tsui	<0.003	<0.03%
KFC	Shop No.317, 3/F, Kowloon City Plaza, Kowloon City	<0.003	<0.03%
KFC	Shop 39, Level 1 Discovery Park, Tsuen Wan	<0.003	<0.03%
Maxim	M/F, Hung Hom MTR Station	<0.003/0.005	<0.03%/0.05%
McDonald's Restaurant	3/F, New World Center, Tsim Sha Tsui	<0.003/0.003	<0.03%/0.03%
McDonald's Restaurant	177 Fuk Wa Street, Sham Shui Po	<0.003	<0.03%
Pacific Coffee	Shop L021A G/F, New World Centre, Tsim Sha Tsui	<0.003	<0.03%
Starbucks Coffee	G/F, Restaurant Block, Hong Kong Cultural Centre, Tsim Sha Tsui	0.005/0.006	0.05%/0.06%
Starbucks Coffee	Shop 2313-2314, Gateway Arcade Harbour City, Tsim Sha Tsui	<0.003	<0.03%

Starbucks Coffee	M/F, Hung Hom MTR Station	<0.003/0.003	<0.03%/0.03%
Golden Centre, Sham Shui Po	1/F	<0.003/0.006	<0.03%/0.06%
Hung Hom MTR Station	G/F, lobby	<0.003/0.005	<0.03%/0.05%
Discovery Park, Tsuen Wan	Inside shopping mall	<0.003/0.004	<0.03%/0.04%
Kowloon City Plaza, Kowloon City	Inside shopping mall	0.004/0.005	0.04%/0.05%
Soy Street, Yau Ma Tei	Near Shanghai Street (outdoor)	0.013/0.014	0.13%/0.14%
Shanghai Street outside Langham Place, Mongkok	Shanghai Street (outdoor)	0.008/0.01	0.08%/0.1%
Hong Kong Heritage Discovery Centre	Kowloon Park, Haiphong Road, Tsimshatsui, Kln.	<0.003	<0.03%
Kowloon East Government Office	12 Lei Yue Mun Road, Kwun Tong, Kowloon	<0.003	<0.03%
Ho Man Tin Estate	G/F Lobby, Tim Man House	<0.003	<0.03%
Oi Man Estate	G/F Lobby, Tun Man House	<0.003	<0.03%
<b>New Territories (11 locations)</b>			
Airport Terminal 1, HK International Airport	Level 5	<0.003/0.01	<0.03%/0.1%
	Level 7	<0.003/0.008	<0.03%/0.08%
Airport Terminal 2, HK International Airport	Level 3	<0.003/0.007	<0.03%/0.07%
	Level 5	<0.003/0.01	<0.03%/0.1%
	Level 6	<0.003/0.003	<0.03%/0.03%
City Gate, Tung Chung MTR station	Haagen-Dazs, G/F, Shop G18	<0.003/0.009	<0.03%/0.09%
	Delifrance, G/F, Shop G19	<0.003	<0.03%
Tsuen Wan Public Library	Tsuen Wan Government Offices, Sai Lau Kok Road, Tsuen Wan	<0.003	<0.03%
Sha Tin District Office	Sha Tin Government Offices, Sha Tin	<0.003	<0.03%
Kwai Tsing District Office – Public Enquiry Service Centre	Kwai Hing Government Offices Building, Kwai Hing	<0.003	<0.03%

Lingnan University	Lingnan University, Tuen Mun	0.003/0.03	0.03%/0.3%
<b>Public Transportation (4 locations)</b>			
Airport Express train	On board an Airport Express train	<0.003/0.007	<0.03%/0.07%
Bus	On board a Cityflyer bus	<0.003	<0.03%
Hydrofoil	On board a hydrofoil	<0.003	<0.03%
MTR train	On board a MTR train from Tsim Sha Tsui East to University	<0.003/0.007	<0.03%/0.07%

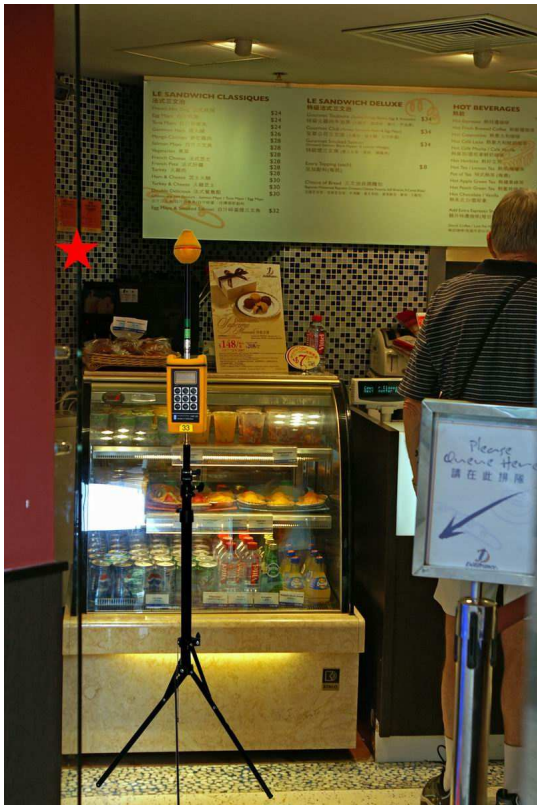
Some photos of the measurement locations are given in Annex 4a.

**Photos of Certain Wi-Fi Locations where Measurements were Taken**

	
<p>Starbucks Coffee inside Hung Hom MTR Station.</p>	<p>Haagen-Dazs at Shop 3201, Gateway Arcade, Harbour City, TST.</p>
	
<p>Pacific Coffee at Shop L021A, G/F, New World Centre, TST.</p>	<p>Starbucks Coffee at G/F, Restaurant Block, Hong Kong Cultural Centre, TST.</p>



PCCW Kiosk near No.68 Johnson Road,  
Wanchai.



Delifrance at Shop G101, Gateway Arcade,  
Harbour City, TST.



McDonalds at 3/F, New World Centre, TST



Pacific Coffee at G/F, New World Centre, TST



Seven Eleven at No.23 Lock Road, TST



Seven Eleven at No.57 Haiphong Road, TST

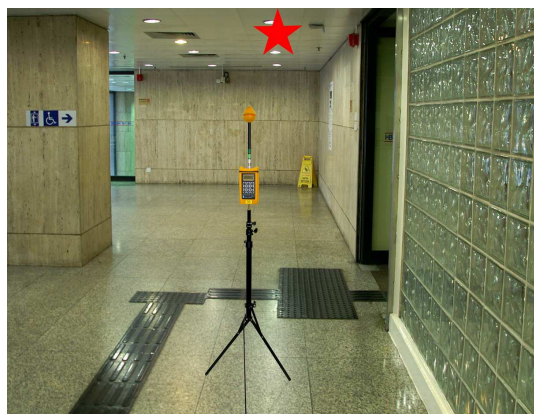


KFC at D'Aguilar St., Central



HK Heritage Discovery Ctr., Kowloon Park,  
Tsimshatsui.





Harbour Building in Central



Hong Kong Central Library, Causeway Bay



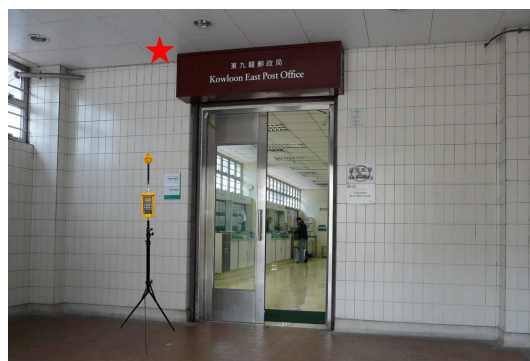
Sha Tin District Office



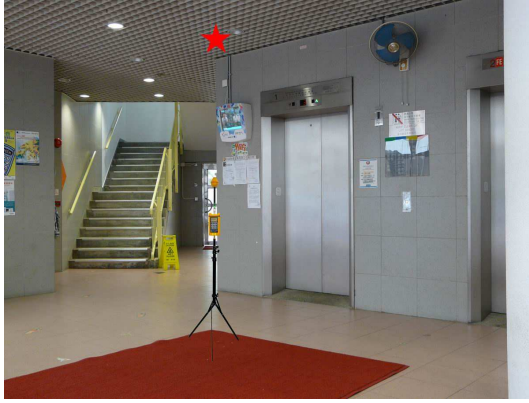
Tsuen Wan Public Library



Kwai Tsing District Office



Kowloon East Post Office



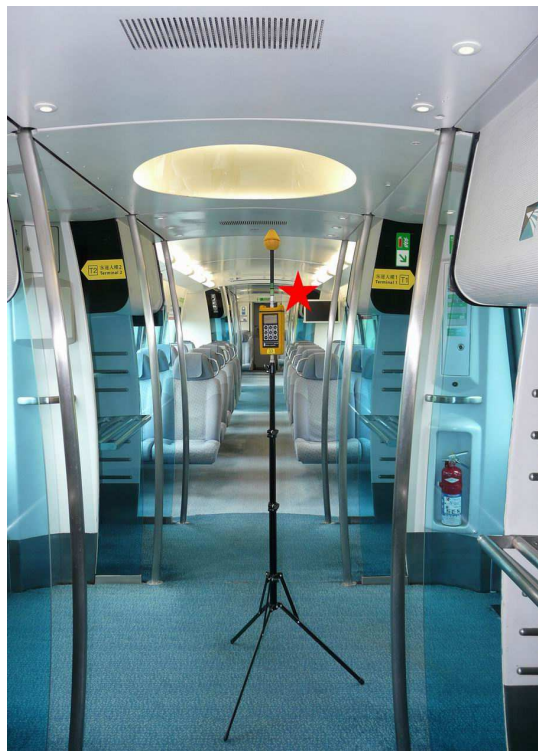
Tim Man House, Ho Man Tin Estate



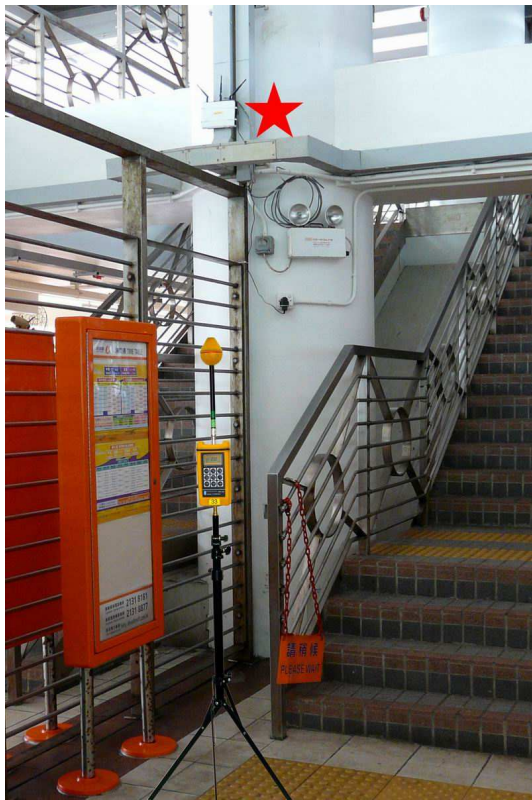
Tun Man House, Oi Man Estate



Lingnan University



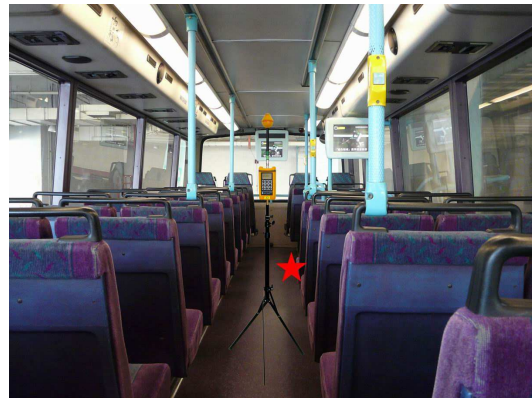
Airport Express Train



Pier 5 in Central



On board a hydrofoil



On board a CityFlyer Bus