MEASUREMENTS OF GROUND-LEVEL EMISSIONS FROM MOBILE PHONE BASE STATIONS IN BANGKOK USING A LOW-COST RF FIELD MEASUREMENT SYSTEM

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ABSTRACT

The Thai Ministry of Public Health, in collaboration with Product Safety Programme, Health Canada, performed a radiofrequency (RF) electromagnetic field survey of mobile phone base stations in Bangkok and surrounding areas. The survey carried out measurements of ground-level RF power density originating from base stations using an instrumentation system developed by and made available from Health Canada. The system is referred to as "GLOBE" which stands for Geographically Located Observations of Base-Station Emissions. The system measures and records the total power density at a location from all frequency bands used by cellular/digital service providers, simultaneously recording the location using a global positioning system (GPS) receiver. The GLOBE system is battery-powered and designed to be operated from the roof of a car. Ten series of measurements were made in the urban and suburban areas of Bangkok. Measured data were compared with the limits specified in Health Canada's RF exposure guidelines for the general public. The maximum level of exposure measured for any of the locations in this study was found to be at least 1000 times lower than the guideline.

I. INTRODUCTION

The rapid expansion of mobile phone use in Thailand has resulted in the installation of numerous base stations or radio transmitters to relay telephone calls. Base station antennas are mounted on freestanding towers or attached to rooftops or the sides of buildings. In North America, mobile phones operate in two frequency bands-the analog cellular band and the personal communications services (PCS) cellular band. It should be mentioned that the term "analog" is used in this paper for traditional reasons since, originally, only analog mobile services were offered in this band. Currently, digital mobile services are also offered in the same band, while the higher PCS band is used only for digital mobile services. The frequency assignments for these two bands are given in Table 1. The radio transmission from a base station to a mobile phone is called the downlink, while the radio communication from the mobile phone back to the base station is referred to as the uplink. In Thailand, more frequency bands are allocated for cellular communication than in North America (Table 2).

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Table 1 Transmit frequencies used by cellular systems in North America. Note that the transmit frequency used by one terminal of the system is the receive frequency of the other terminal.

	Analog Band	PCS Band
Mobile Handset Transmit (uplink)	824 - 849 MHz	1850 - 1895 MHz
Base-station Transmit (downlink)	869 - 894 MHz	1930 - 1975 MHz

Table 2 Transmit frequencies used by cellular systems in Thailand

System	Uplink	Downlink
AIS	897.5-905.0 MHz	942.5-950.0 MHz
Orange	1710-1722.6 MHz	1805-1817.6 MHz
GSM-1800	1747.9-1760.5 MHz	1842.9-1855.5 MHz
DTAC	1722.6-1747.9 MHz 1760.5-1785 MHz	1817.6-1842.9 MHz 1855.5-1880 MHz
Thai Mobile	1885-1900 MHz 1965-1980 MHz	1965-1980 MHz 2155-2170 MHz
CDMA	824-835 MHz 845-846.5 MHz	869-880 MHz 890-891.5 MHz

AIS = Advance Info Service
GSM-1800 = Global System for Mobile
CDMA = Code Division Multiple Access
Orange = Name of the Mobile Phone Company
DTAC = TotalAccess Communication

Similar to people in other countries, the general public in Thailand has expressed concerns that radiofrequency (RF) emissions from mobile phone base station transmitters, located in their communities, might possibly cause adverse health effects such as cancer. While several countries have issued health protection standards for RF electromagnetic fields, Thailand has just begun the process of developing exposure guidelines. However, in an attempt to address the concerns raised by the general public, the Thai Ministry of Public Health, in collaboration with Health Canada, has carried out measurements of ground-level RF fields near base stations using a system known as Geographically Located Observations of Base-Station Emissions (GLOBE).[1] The objective of this paper is to present the measurement data obtained from RF field surveys in Bangkok and its surrounding areas and to compare them with the exposure limits specified in Health Canada's Safety Code 6-Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz.[2]

II. SURVEY INSTRUMENTATION AND MEASUREMENT METHODS

The GLOBE system, which was developed by and made available from Health Canada, consists of a dual band antenna/diplexer, a direct conversion receiver for each cellular band, an analog-to-digital converter and the GPS receiver (Magellan Meridien). A conceptual block diagram of this system is shown in Figure 1.

Digitally sampled power density outputs are fed to the parallel port of a laptop computer while the GPS data is read from a serial port. The software controls selection of the band, timing of the readings and storage of the data in text files for later use with a spreadsheet. For vehicle-mounted operation, measurements can be taken at either regular time or distance traveled intervals.

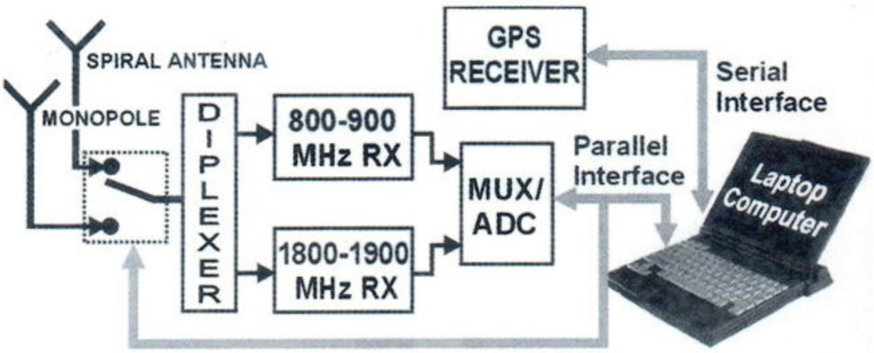

Fig.1 Block diagram of the GLOBE system

Technical characteristics of the GLOBE system are as follows:

Calibrated Measurement range:	Analog/AMPS band, 824 - 894 MHz: 2 x 10^{-2} W/m^2 to 5 x 10^{-7} W/m^2 PCS band, 1850 - 1975 MHz: 2 x 10^{-1} W/m^2 to 5 x 10^{-6} W/m^2
Antenna elevation coverage:	Analog/AMPS band: 0° - 90° (full hemisphere) PCS band: 5° - 90°
Electrical:	Supply Voltage: 6 - 10 VDC, Supply Current: 300 mA max
Computer Interface requirements:	Serial port, DB9 male connector, Parallel port, DB25 female connector Parallel port BIOS setting: EPP (Extended Parallel Port) mode
Minimum Computer requirements:	Pentium II, 200 MHz, 64 MB RAM, 30 MB free disk space Operating System: WIN 95 or 98
Environmental:	Operating temperature range: 0° to +40° C Storage temperature range: -40° to +85° C Not recommended for exposure to rain or extreme moisture.
Mechanical:	Dimensions: 63.5 cm x 35.6 cm x 20.3 cm, Weight: 5.5 kg

The instrumentation uncertainty is estimated to be of the order of ± 4 dB. This may be interpreted by saying that the instantaneous power density level may be 0.4 times lower or 2.5 times higher than what the instrument indicates. This magnitude of uncertainty may seem high but is typical for this type of measurement.

During the RF surveys in Bangkok and its surrounding areas, the GLOBE system was mounted on the roof of a minivan (Figure 2), powered by a 12-V motorcycle battery, and controlled from inside by commands entered into a computer within the vehicle. While the minivan was moving, the total power densities from all base stations in the surveyed area along with the GPS-derived coordinates of measurement locations were recorded. The measurements were then compared with the exposure limits specified in Health Canada's Safety Code 6.

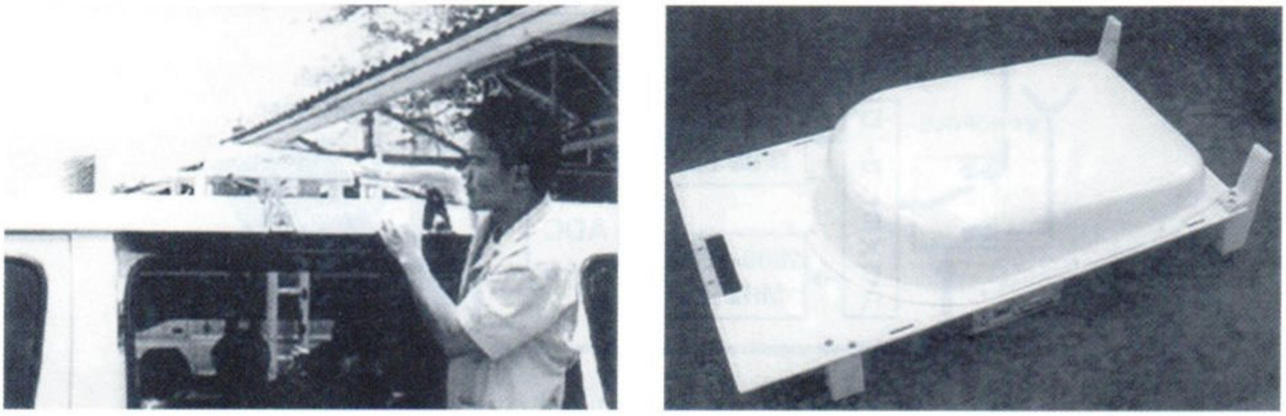

Fig.2 Photograph of the GLOBE system on the roof of a minivan

III. RESULTS

All measurements were taken while driving through a number of communities in Bangkok and its northern suburb of Nonthaburi. Data were plotted on geographical maps using color-coded dots at measurement points. To give a meaningful representation of the scale of the measured power densities, values were normalized to their corresponding Safety Code 6 maximum exposure limit (MEL) for the general public. Safety Code 6 specifies a general public MEL of 5.9 W/m^2 for the analog cellular band (824-894 MHz) and 10 W/m^2 for the PCS cellular band (1850-1975 MHz). Each color represents a range of normalized power density in which the individual datum falls into.

The total power densities from all base-stations signals detected within the analog and PCS cellular bands were measured at ten separate geographical areas. The choice of areas was made with the aim to achieve reasonable coverage while focusing on those locations where some concerns had been expressed. The ten survey areas and the highest measured power densities at these locations are given in Table 3. Figures 3 and 4 show the measurement data plotted on geographical maps for outer and inner regions of Bangkok.

Table 3 RF field survey areas in Bangkok and its surroundings, with frequency bands referenced and measurement results presented

Area	Frequency Band	Highest Power Density (W/m^2)
Inner Bangkok (Khet Phra Nakhon)	Analog PCS	0.006 0.010
Inner Bangkok (Khet Pathumwan)	Analog PCS	0.002 0.003
Bangkok (Din Daeng and Ratchada Phisek Roads)	Analog PCS	0.002 0.003
Bangkok (Ngam Wongwan, Viphawadi Rangsit and Phahonyothin Roads)	Analog PCS	0.002 0.003
Nonthaburi and Bangkok (Tiwanon, Krungthep Mahanakhon-Nonthaburi, Pracharat, Techawanit, Phisanulok and Phetburi Tat Mai Roads)	Analog PCS	0.002 0.003
Nonthaburi and Bangkok (Tiwanon, Rama V Bridge, Nakhon Inn, Sirin Thon and Arun Amarin Roads)	Analog PCS	0.006 0.010
Bangkok (Ratchapluek, Krung Thon Buri, South Sathon, North Sathon, Rama IV, Silom, Surawong and Si Phraya Roads)	Analog PCS	0.002 0.010
Nonthaburi (Non1 - Tiwanon, Sanam Bin Nam and Ratana Thibet Roads)	Analog PCS	0.0006 0.001
Nonthaburi (Non 2 - Tiwanon, Phiboonsongkhram and Krungthep Mahanakhon-Nonthaburi Roads)	Analog PCS	0.0006 0.003
Nonthaburi (Non 3 - Ngam Wongwan, Ratana Thibet, Sanam Bin Nam, Krungthep Mahanakhon-Nonthaburi and Tiwanon Roads)	Analog PCS	0.002 0.003

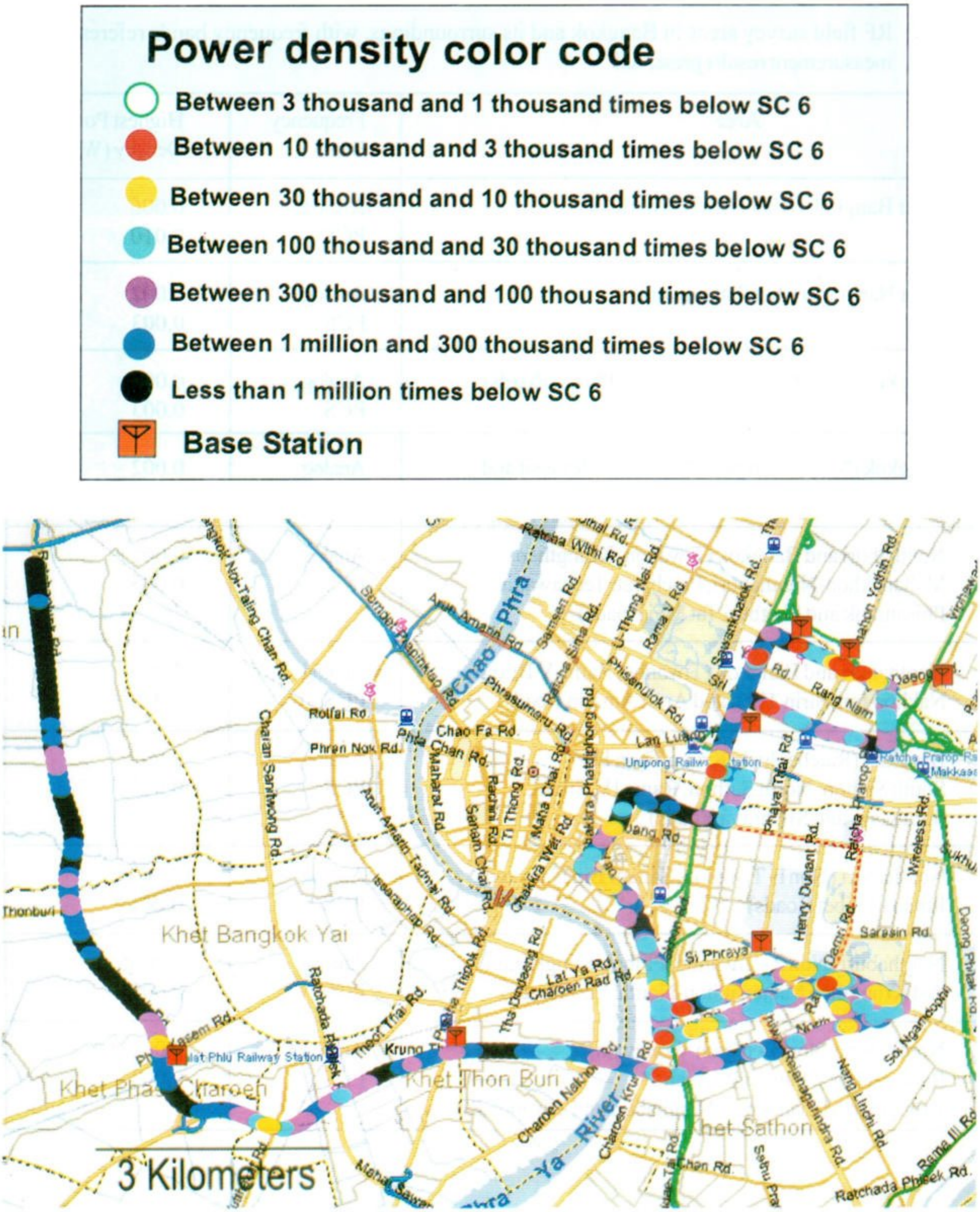

Fig.3 Analog-band power density map of outer and inner Bangkok (Ratchapluek, Krung Thon Buri, South Sathon, North Sathon, Rama IV, Silom, Surawong and Si Phraya Roads)

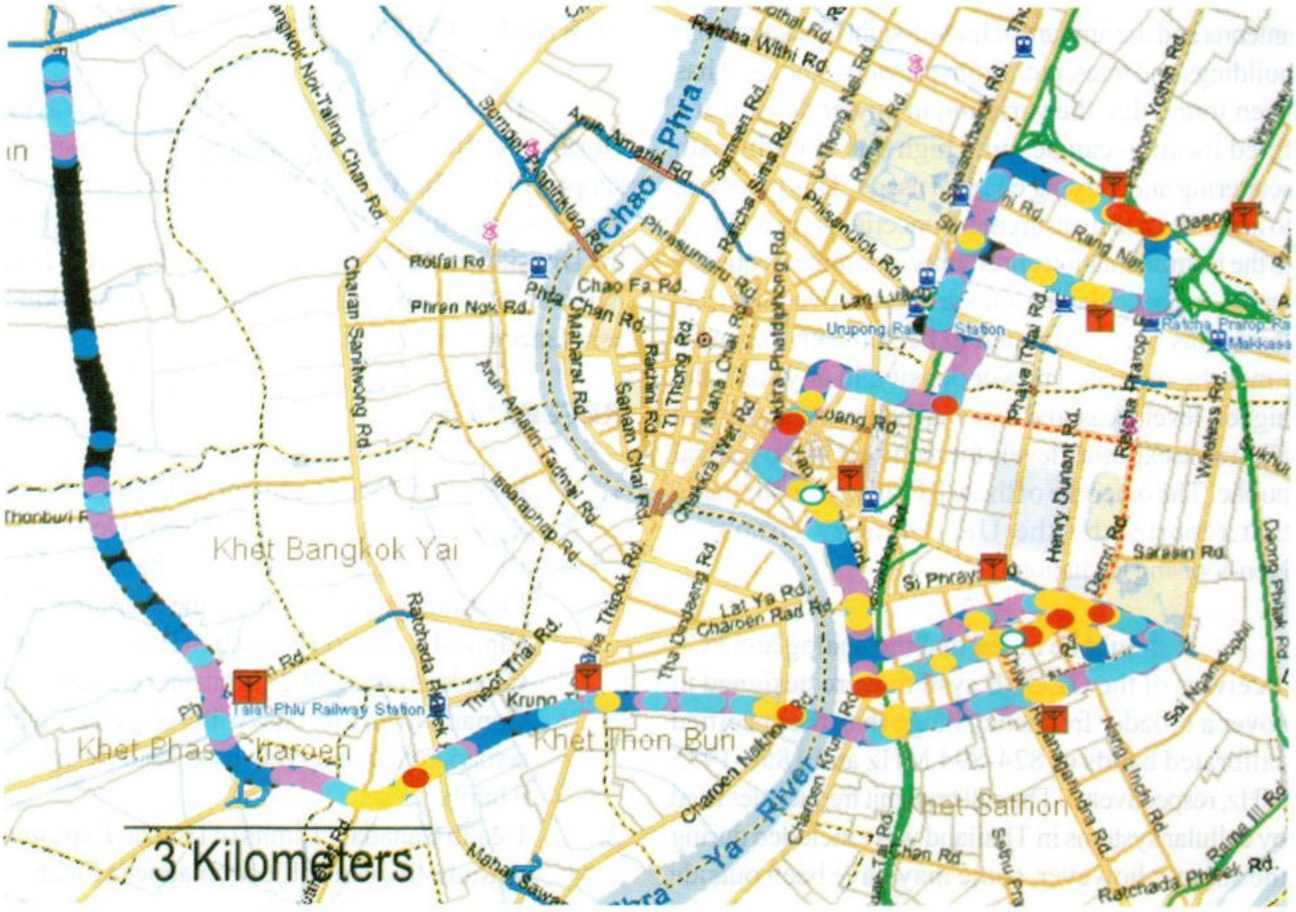

Fig.4 PCS-band power density map of outer and inner Bangkok (Ratchapluek, Krung Thon Buri, South Sathon, North Sathon, Rama IV, Silom, Surawong and Si Phraya Roads)

IV. DISCUSSION AND CONCLUSION

Based on the measurement results presented in Table 3 and on the maps, it can be stated that:

1. All measured power densities do not exceed the exposure limits specified in Safety Code 6.
2. Measured power densities generally increase in strength as one gets closer to a base station but vary in an irregular fashion. They do not follow the simple "inverse squared-distance law" principle.
3. Two closely spaced points can have significantly different power densities.
4. The maximum level of RF fields from base station antennae is at least 1000 times lower than the exposure limit specified in Safety Code 6 for any of the locations.
5. Power densities in the suburbs tend to be lower than those in the urban areas.
6. Power densities in the analog band have a tendency to be lower in relation to the exposure limits than those in the PCS band.

It can be seen from the plots that the power density level drops off with distance away from the cellular tower or building with antennae on it. Also, some adjacent measurements located only 50 m apart often have power densities differing by a factor of 10 or more. This is due to the radiation patterns of the antenna and the amount of line-of-sight blockage from buildings and trees, etc. From previous studies, it has been found that the variation in power density at a fixed location can be quite high due to multi-path scattering and varying channel usage. This gives rise to an additional measurement uncertainty in addition to the instrumentation uncertainty. For some frequency bands, in particular the analog one, the overall uncertainty has been estimated to be between 0.2 and 5 times the indicated power density. In any case, the highest level measured was well below the maximum allowable exposure levels for members of the general public. The outcome of these RF surveys is similar to that reported by the UK Advisory Group on Non-ionising Radiation.[3]

It should be noted that the analog and PCS receivers of the GLOBE system were designed to cover a broader frequency range than the specified calibrated bands of 824-894 MHz and 1850-1975 MHz, respectively.[1] Thus all transmit frequencies used by cellular systems in Thailand were included during the survey; however, some may have been outside the calibrated range. Since all components in the GLOBE were sufficiently broad of bandwidth, there is no reason to suspect that frequencies outside the published calibration range were detected differently than those inside the calibrated one.

Based on the measurement results, it can be safely concluded that RF fields from the base stations surveyed should not be considered a health hazard. However, additional surveys in other parts of Thailand would be advisable for proper risk assessment.

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