

Wong, Jolly Chun Kau; Xu, Yani

Conference Paper

Public-Private Partnership (PPP): A win-win-win approach for effective public service. A case study of the award-winning indoor communications system of Hong Kong Police Force

2015 Regional Conference of the International Telecommunications Society (ITS): "The Intelligent World: Realizing Hopes, Overcoming Challenges", Los Angeles, USA, 25th-28th October, 2015

Provided in Cooperation with:

International Telecommunications Society (ITS)

Suggested Citation: Wong, Jolly Chun Kau; Xu, Yani (2015) : Public-Private Partnership (PPP): A win-win-win approach for effective public service. A case study of the award-winning indoor communications system of Hong Kong Police Force, 2015 Regional Conference of the International Telecommunications Society (ITS): "The Intelligent World: Realizing Hopes, Overcoming Challenges", Los Angeles, USA, 25th-28th October, 2015, International Telecommunications Society (ITS), Calgary

This Version is available at:

<https://hdl.handle.net/10419/146347>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

Public-Private Partnership (PPP): A Win-Win-Win Approach for Effective Public Service

- A Case Study of the Award-winning Indoor Communications System of Hong Kong Police Force

Jolly Chun Kau Wong, Hong Kong Police Force, jollywong@yahoo.com

Xu Yanⁱ, HKUST Business School, xuyan@ust.hk

Abstract

Public-Private Partnership (PPP) has been popular in information infrastructure development since last decade mainly because of the fact that the information infrastructure has become more and more capital-intensive and it is not economic for one single company or the government agency to fund it. In most of the cases, the end users are normally the general public. One of the examples is the partnership between Telstra and Australian government on Australian Next Generation Network Initiative which aims to provide nation-wide broadband connectivity for Australian citizens.

The case of this study is different – it is an agency under the government that seeks partnership with private sector and the end user is the agency itself, namely Hong Kong Police Force (HKPF). By configuring the enterprise network of Hong Kong Police Force with part of the indoor facilities of mobile operators, the Hong Kong Police Force is able to achieve full coverage of shopping malls and Hong Kong's phenomenon tower buildings so as to provide emergency services. This has on the one hand saved the budget of government, while on the other hand provided extra income for operators despite the fact that all operators have joined the scheme for the intention to demonstrate their corporate social responsibility. Of course, the most significant beneficiary is the public. Currently, this award-winning scheme has been adopted elsewhere including Home Office in the U.K. that her Emergency Services Network (ESN) will be provided by mobile operator in 4G LTE technology.

This study examined operational challenges facing indoor radio coverage to emergency services and argued explicitly that the Public-Private Partnership (PPP) would be an appropriate solution. The outcomes are positive and meaningful. It has significant implications for the future development of the public service.

The success of the project has not only built an efficient and effective indoor communications system for Hong Kong Police Force, but also provided profound experience in formulating an effective public-private partnership model both technically and financially to ensure a quality public service.

Keywords

Public-Private Partnership (PPP); Terrestrial Trunked Mobile Radio (TETRA); indoor radio coverage

I. Introduction

Land mobile radios, whether used in vehicles or as handheld portables, are important tools used every day by police officers to make their jobs safer and more efficient. For the most part, these radio systems function as designed, and serve the end-user with reliable communications. However, when the duties of police officers require them to enter a building, or operate below ground level during emergencies, the ability of their radios to communicate to the command and control center or with each other may become an operational issue.

One physical constraint of land mobile radio communications is its inability to transmit and receive airwaves through obstructions such as buildings or underground structures. Indeed, the failure of a land mobile radio to transmit and receive communications from within a building or below ground level has challenged radio users since the beginning of land mobile radio communications (Hashemi, 1993).

Faced with a public demanding ever-faster police response to incidents and crimes, the need for seamless radio coverage has evolved from a desirable to an essential requirement. HKPF needs clear and reliable radio communications for efficient incident management and enhanced officer safety.

Modern police radio communications in Hong Kong date back to 1977 and inadequate indoor coverage has invariably been a problem. In 1984, for example, an armed robbery occurred at the Landmark, a large and busy shopping mall in the Central Business District of Hong Kong. The alarm was raised whilst the robbery was in progress, and the police were quickly on the scene. Unfortunately, police beat radios did not function effectively inside the mall and as a result the police operation lacked coordination. The robbers shot their way out of the building and in the general confusion succeeded in getting the police to shoot at each other. By great good fortune, no members of the public or police officers were hurt. The police operation was accurately described at the time as a shambles. In the interests of public relations and at considerable expense, HKPF subsequently installed a repeater inside the mall. The missed golden opportunity to apprehend an extremely violent gang of criminals had serious repercussions in that the gang continued its activities for several years thereafter and killed several members of the public in the process (Gee, 2001).

Despite this ‘wake up call,’ there was no further substantive action to address indoor communications until the project described in this paper. There are, naturally, one or two specific exceptions to this, the Chek Lap Kok International Airport being one.

II. The Hong Kong Police Force

The Hong Kong Police Force (HKPF) is one of the largest metropolitan police forces in the world; in size it rivals the Metropolitan Police Service of London in England and the New York Police Department in the United States.¹ Assets-wise, it is well provided with purpose-built community police stations, modern TETRA radio communications, computer-assisted command and control systems, computerized criminal records and intelligence systems, and other

¹ HKPF has an establishment (as at 2012-12-31) of 28,392 sworn officers supported by 4,695 civilian officers.

equipment (Wong, 2012).

On average, HKPF receives some 6,364 emergency ('999') calls daily.² HKPF pledges to respond to all genuine emergency calls within nine minutes in urban and 15 minutes in rural areas, be they in- or outdoors.³

The rates of crime and public disorder in the Hong Kong Special Administrative Region (HKSAR) are regarded as very low – one tenth of those in London,⁴ for example. In 2014, a total of 67,740 crimes were recorded, representing a crime rate of 936 cases per 100,000 populations. Most categories of crime recorded a slight drop over 2012, the exceptions being deception, rape and indecent assault, pickpocketing, miscellaneous theft and criminal damage. Almost all crimes can take place either in- or outdoors. In addition to crime, there were around 6,816 public order events in 2014.⁵ Many of these take place indoors, particularly in inclement weather.

It would be as well to dispose of one, possibly contentious, issue from the outset and that is the legal position with regard to HKPF officers entering premises. The reader might reasonably ask why police officers are needed to enter what are essentially private premises, commonly patrolled by watchmen and security staff? In a nutshell, the duties of HKPF are ordained by Section 10 of the Police Force Ordinance, Cap. 232, which mandates a police response to all crime and disorder wherever it may occur. Whilst privately employed security staff can very possibly deal with minor incidents, HKPF must be involved where any sort of judicial proceeding may eventuate and such is the case most of the time.

III. HKPF Radio Communications

In the HKSAR, the introduction of two-way radios to foot patrol police officers in the 1970s had a revolutionary effect on 'beat policing'.⁶

Though very basic in comparison with the current system, HKPF's First Generation Command and Control Communications System (CC1), introduced in 1977, was an advanced system at the time. The HKSAR was one of the first cities in the world, for example, to place the extension speaker-microphone conveniently on an officer's shoulder strap, providing much easier and faster hands-free communications. The defining move forward, however, was the creation of regional command and control centres, allowing field officers to be directed and supported from a central coordinating point.

The Second Generation Command and Control Communications System (CC2) was introduced in 1990. Radio communications and computer applications merged together so that CC2 could link to a variety of specialist services that enabled and enhanced operational, investigative and

² In 2014, the Police Regional Command and Control Centres received 2,323,016 calls. Around 80 per cent of these were for non-emergencies, or otherwise, frivolous, but all have to be answered.

³ http://www.police.gov.hongkong/ppp_en/01_about_us/pp.html (accessed 18 June 2014).

⁴ <http://www.met.police.uk/crimefigures/> (accessed 18 June 2013).

⁵ Line-to-take on Public Order Events, Operations Wing, HKPF, July 2015.

⁶ A foot patrol officer is responsible for patrolling a designated geographical area known as a 'beat.'

intelligence capabilities. CC2 comprised an integrated radio communications system (commonly known as the 'Beat Radio System'); the 999 Emergency Services Telephone Sub-system; and the Enhanced Computer Assisted Command and Control System (ECACCS). CC2 proved effective but reached the end of its useful life in 2004.

HKPF rolled out its Third Generation Command and Control Communications System (CC3) in March 2006 (Wong and Tsang, 2010). CC3 was designed and developed to meet the challenges of a fast changing environment and advancing technology, as well as the ever-increasing public expectation for more sophisticated police services and faster emergency response. It is axiomatic that public safety agencies require communications that are reliable, rapid, responsive and rugged (Killen, Stittleburg, Webb and Siamicki, 2005). For the initial rollout, the design scope focused on effective outdoor radio communications.

CC3 is operated under six regional command and control centres which direct police operations on the ground through radio communication with patrolling officers, and officers in vehicles and on board launches.

IV. Current Status of HKPF Indoor Radio Coverage

With a land mass of 1,104 square kilometres and a population of over seven million people, the HKSAR is one of the most densely populated conurbations in the world. According to the *Guinness Book of Records 2012*, the Mong Kok District in Kowloon has the highest population density (130,000 per square kilometre) of any area on earth.

A strong economy and burgeoning population have resulted in an insatiable demand for new construction for both commercial and residential use, which has made the HKSAR one of the world's most 'vertical cities' (Wong, 2011). A full 40 per cent of the population lives on or above the 14th floor of residential buildings. Shopping malls have blossomed, generally sited underneath commercial and residential complexes. Indoor and underground car parks have also proliferated.

The police requires intelligible and reliable radio communication for effective incident management and officer safety. Seamless radio coverage, in particular indoor coverage has invariably been a challenge (Infonetics Research, 2007; Rappaport, 2002) to mobile radio systems. Police radio communications are no exception. Beat officers patrol inside buildings to combat burglary, robbery, shop thefts, criminal damage, pick-pocketing, and others, and at crime black spots in locations such as shopping malls, basement levels, inter/intra buildings tunnels and car parks. Patrol officers are expected to prevent and detect crime within their assigned patrol areas and beat radios are their primary means of requesting assistance from police command and control centres, and communicating with each other.

The design specification for CC3 stipulated, *inter alia*, that the system need support communications no further than one metre inside buildings (De Toledo, Turkmani and Parsons, 1998). It follows that, unless specifically provided for by way of repeaters⁷ or bi-directional⁸

⁷ Special portable repeaters are available for ad hoc, planned operations.

antenna, police communication inside buildings in the HKSAR cannot be relied upon.

By contrast, the mobile phone operators in the HKSAR have all developed comprehensive networks covering both outdoor and indoor communications. These operators, being commercial enterprises, have invested heavily in mobile phone infrastructure, intending to reap the rewards of such investment by establishing reputations for reliable mobile phone services and hence increasing numbers of (satisfied) customers. The only current method whereby police officers inside buildings can reliably communicate with each other and with their command and control centres is by the use of mobile phones. The carrying of two communication devices, however, is unsatisfactory from both the weight and bulk perspectives, and also because command and control centres cannot monitor operational mobile phone communications.

V. HKPF Indoor Radio Communications Improvement Project

There were two aspects to the improvement project:

1. The technical model, and
2. The financing model

Of the technical options available, it was decided that ‘simple’ extension of existing HKPF’s radio system to the interiors of buildings, by way of extending the infrastructure, was not viable, primarily because of the capital and maintenance costs involved. Accordingly, it was considered that collaboration with the private sector was the road ahead.

Private sector involvement has been woven into the Government’s reform measures, mainly in the form of outsourcing and public-private partnerships (PPP) (Grimsey and Lewis, 2004). In the HKSAR, PPP continues to be encouraged within the public sector as a means to improve coverage, effectiveness, efficiency and quality in the delivery of public services (Efficiency Unit, 2008).

The take-up of PPP initiatives by public safety worldwide is currently patchy (Colverson, 2012). The City of Los Angeles has a formal programme of collaboration between the Los Angeles Police Department and private security companies and this appears, inter alia, to provide a level of flexibility not achieved in a conventional police-only model (IACP, 2004). In early 2000, in the United Kingdom, the former Police Information Technology Organisation (PITO) signed a framework arrangement with British Telecom for a new national radio service – Airwave - to be rolled out across police forces in England, Wales and Scotland under a Private Finance Initiative (PFI) (Corner, 2006). Nevertheless, the PPP philosophy has yet to achieve meaningful inroads into public safety.

We listed the following specific objectives of the project as follows:

⁸ A bi-directional antenna (BDA) is a device used for boosting the radio reception to the local area by the usage of a reception antenna, a signal amplifier and an internal rebroadcast antenna. These are similar to the cellular broadcast towers used for broadcasting by the network providers, but are much smaller, usually intended for use in one building.

1. A study of the background of police indoor radio communications systems technology
2. A review of mobile networks for public safety in buildings including a discussion on why indoor radio coverage is needed and how it is best implemented worldwide
3. A detailed investigation into indoor coverage solutions from basic directional antenna systems (DAS) through to advanced radio-over-fibre systems
4. The formulation of an effective public-private partnership model with which to implement the selected technical indoor communication solution
5. The documenting of a unique, single-source reference for practical knowledge behind indoor radio planning based on real life examples and implemented systems and results by the HKPF
6. The development of a business-oriented reference model for PPP in the HKSAR Kong and how it might be adapted for use in and by other jurisdictions, and
7. A review of the politics of the industry and the transferability of the reference model

VI. The Pilot Project

The Police Force has been focused to pursue continuous improvement and address the challenge of indoor radio communications blackspots by experimenting various technical solutions since 2007. In 2008, police regions were invited to critically examine the locations where indoor coverages were absolutely essential according to the criterial laid down by CC3 operation Implementation Team. The criteria include:

- Number of Incidents;
- Crime Reports;
- Pedestrian Average;
- Pedestrian Peak;
- High Risk Premises; and
- Public Events

Based on some detailed analysis of user requirement and factual data submitted by police regions, 59 specific indoor locations were selected and endorsed by the Force Management for enhancement with CC3 indoor radio coverage.

To prove the PPP concept, Telford Plaza is selected as a pilot site for the CC3 Indoor Coverage Enhancement Project. As the largest regional shopping and entertainment complex in East Kowloon, Telford Plaza's catchment area will be both far and wide. In addition to the 560,000 East Kowloon residents and the 20,000 residents of Telford Gardens, the close proximity of the Kowloon Bay MTR station provides a steady flow of commuters averaging 150,000 per day.

This service aligned with the HKPF's strategic direction for supporting frontline units (HKPF, 2009). Such professional mobile radio services will empower frontline units with highly responsive and resilient communications capabilities to meet increasing safety and security needs, in particular patrol sub-units and criminal investigation teams. In this connection, the frontline officers can respond public & solicit assistance with effective and rapid manners.

Service Design

1. Efficient, User-friendly and Effective Service

Traditionally the frontline officers had to set-up a gateway repeater in proximity with fairly limited radio coverage to relay the outdoor CC3 signals into the indoor areas or using the Direct Mode Operation (DMO) of CC3 radios for line-of-sight communications. In response to the operational needs from the frontline officers, this service design aims to provide quick-win deployment solution to the frontline officers. Officers can now rely on the enhanced radio coverage inside the Telford Plaza with seamless transition experience and without any communication interruptions or any manual interventions.

2. Innovation

Following the detailed survey, there are 76.3% (45 locations) with very good public mobile operator coverage at these 59 selected indoor locations. As such, HKPF can enjoy the radio coverage at such locations by riding CC3 radio on the public mobile operators' infrastructure. Currently, there are five public mobile operators in Hong Kong, which deliver seamless mobile phone services inside the shopping malls with general radio penetration of over 95% at public areas.

Three field trials were conducted with the mobile operators at Cheong Hing Square, Yuen Long Neway Karaoke and Fu Chong Shopping Centre in 2007 with encouraging results.

Taking the advantage of the technology, this enhancement project employed the wideband radio equipment (380MHz to 2100MHz) for CC3 radio signal riding on the current public mobile operators' infrastructure. The solution (ride on the public mobile operators' antenna and transmission infrastructure as per figure 1) is proven and the synergy effect has been evident during these field trials. Hence, the creative and innovative ideas were adopted for the delivery of the service.

Also, a new business model (Public-Private Partnership – PPP) between public and private sectors regarding the provision of public services over a private infrastructure is established. Purportedly, this is an effective means of bringing together social priorities with the managerial skills of the private sector, relieving the government from the burden of large capital expenditure, and transferring the risk of cost overruns. Rather than completely transferring public assets to the private sector, as with privatization, government and business work together to provide exceptional services.

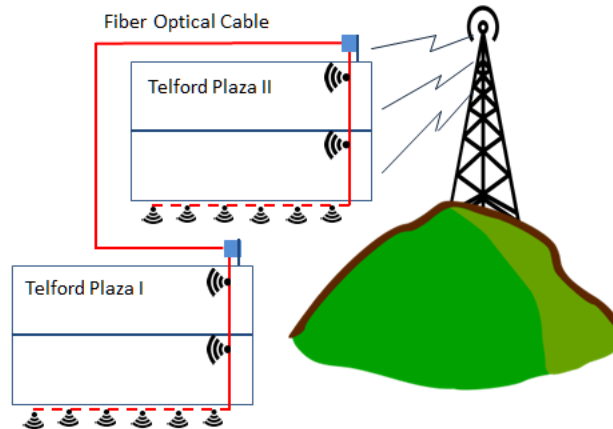


Figure 1. Technical Solution in Telford Plaza

3. Cost effectiveness

The aforesaid solution has been successfully delivered at Telford Plaza since August 2009. The project was commissioned by one of the public mobile operators with collaboration from MTRCL's maintenance contractors, through competitive tendering, at an affordable cost. The cost saving is around 40% in comparison with the other engineering solutions but with an effective use of the existing resources inside the shopping mall. This initiative introduced minimal investment with maximal benefits to HKPF.

For the new business model of PPP that brings the public and private sector together, the government hopes that the management skills and financial acumen of the business sector will create better value for money.

Service Implementation

1. Staff Communication

Communications Branch of the HKPF played a leading role for close liaison with frontline officers to formulate the service strategy and implementation plan for the delivery of services. The disturbance to the end users was kept to minimal.

2. Difficulties and Challenges

At the planning stage, it was anticipated that the following difficulties would happen during the implementation stage:

- Installation works at the shopping mall's public areas and inside the shop may affect the customer flows and will be highly concerned by the Management Office.
- The location of the outdoor antenna may near the residential areas and may cause inconvenience to the residents of Telford Garden.
- The selection of wideband radio component should consider the system scalability to Mobile 4G (Long Term Evolution, LTE) delivery in future.
- The appearance of the indoor antenna should match with the indoor environment and would not affect the corporate image of the Shopping Mall.

These inherent difficulties were factored into the design consideration during the detailed design stage. These challenges had been tackled and handled properly by a flexible and proactive approach of:

- Night works were carried out at public areas after the closing of the shopping mall. For such location, which did not allow for access for installation works, the antenna were relocated and diverted with detailed engineering prediction.
- Close liaison with shopping mall management office to successfully install an outdoor antenna at the podium level of the commercial building and far away from residential areas was achieved.
- Wide band radio components were selected and also fitted for the wideband Mobile delivery in future.
- The appearance and colour scheme of the antenna was approved by the shopping mall prior the installation works.

3. End-users Early Buy-in

Upon the completion of works, the frontline officers were invited to take part in the User Acceptance Test at Telford Plaza. This ensured the services delivered would meet the user operational requirement in action.

4. Continuous Improvement

Project review was carried out by the senior management with post-implementation customer feedback. The lessons learned in the pilot scheme would be adopted for the full deployment works at the remaining 58 locations. Under the new indoor premises, pre-provision of Radio Injection Ports for HKPF is to be considered with the policy support from Office of the Communications Authority (OFCA). That will be beneficial and minimal retrofit works are required for extending police radio coverage into the new indoor premises.

Results

On average the HKPF receives ten thousand 999 emergency calls daily. It is HKPF's performance pledge to strive to respond to all genuine emergency calls within 9 minutes in the urban area and 15 minutes in the rural territory. As a continuous improvement initiative, the pilot scheme at Telford Plaza was implemented successfully in Aug 2009 with the following key

achievements:

- A creative, innovative and sensible solution was evident with the new business model of Public-private Partnerships (PPP) (Grimsey et al, 2004).
- Services delivered timely, within budget and met all User's requirements. The implementation period had been shorten 3 to 6 months with projected the cost saving of around 40% in comparison with the other engineering solutions achieving same results.
- CC3 indoor radio coverage at Telford Plaza had been enhanced covering over 640,000 sq. feet of floor space.
- Rental and electricity charges waivers were granted by the Shopping Mall.
- Excellent feedback from the end-users.

VII. Business Model Innovation by Public-Private Partnership

Starting in 2009 with a pilot scheme in Telford Plaza and utilising the bidirectional amplifier and cabling infrastructure of one mobile phone operator (selected by an open tender), HKPF has now embarked upon a programme of extending CC3 coverage to inside buildings, by way of PPPs. 60 locations – mostly shopping malls – have been identified and the programme is due for completion by mid-2014.

Indoor communications at the selected locations now match mobile phone coverage. There have been major cost savings and frontline user feedback has been positive. The operational challenge of extending radio communication support to frontline officers in the discharge of their duties at the indoor shopping malls has been met by this novel approach. The operational efficiency and personal safety of frontline officers were achieved and the public safety to the community were enhanced.

Moreover, there are three perceived benefits of “PPP Model” to both Government and Community: First, the private sector resources, expertise and creativity have been exploited. Second, the commercial potential of government-held project (value-added commercial services are normally not government's core business) has been maximized. And third, the costs and risks have been transferred in proper manner and under control.

CC3 is a mission critical system for emergency response. Its productivity cannot be quantified but it enables the police to respond faster to emergencies. The time saved greatly enhances the chance of saving life in life and death situations. It is the Force's vision that Hong Kong remains one of the safest and most stable societies in the world.

We do not claim the sharing approach to be entirely novel. Very little – if anything – we do today has not at least been thought of down the ages. Telephone and even electricity cables have been used to transmit multiple radio waves simultaneous sly for some considerable time. However, a government agency sharing an infrastructure with a private enterprise represents a move forward in public-private cooperation demonstrably in the public interest. It is to the great credit of the mobile phone operators in the HKSAR that when this concept was floated

those years ago, there was almost immediate interest and enthusiasm. Naturally, the prospect of additional revenue was attractive but the Candidate has no recollection, during the tendering process and subsequent contract negotiations, of this having been the private sector's *raison d'être*; quite the reverse, in fact. The mobile phone operators all displayed a keen sense of mission and public spiritedness.

This sharing of infrastructure, of course, has been rather more than a case of simply 'plugging in' CC3 to the mobile phone operator's network. The CC3 infrastructure comprises a combination of a microwave network core coupled with some 120 low power base stations. These cannot be simply plugged in and a considerable amount of front-end work was necessary to establish the various linkages. As has been seen, this work was expensive, but markedly cheaper than HKPF simply extending its own infrastructure inside the selected buildings. These considerations give further justification to the concept of a complete merger of HKPF and mobile phone operator infrastructure in the future.

And there is a further consideration: Supporting radio communications is not part of police core business. HKPF is in the business of law enforcement. True, there have probably been little alternative to current arrangements, i.e. a dedicated HKPF infrastructure, over the years, but times and priorities change. It is under no illusions as to the potential political obstacles of such an integrated approach in the future and it is likely that attempts will be made to play the 'security card' as well. Any such complete merging will have to take account of the fact that HKPF communications are mission-critical. Reliability and redundancy issues will have to be considered. The mobile phone operators will have to become true government partners sharing a common mission and values.

References:

Colverson, S. (2012) *Harnessing the Power of Public-Private Partnerships: The Role of Hybrid Financing Strategies in Sustainable Development*, International Institute for Sustainable Development, Winnipeg, Canada

Corner, D. (2006) The United Kingdom Private Finance Initiative: The Challenge of Allocating Risk, Organization for Economic Cooperation and Development, *Journal of Budgeting*, Vol.5, No.3, pp.37-55

De Toledo, A., Turkmani, A. and Parsons, D. (1998) Estimating Coverage of Radio Transmission into and within Buildings at 900, 1800 and 2300 MHz, *IEEE Personal Communications*, Vol.5, No.2, pp.40-47, April

Efficiency Unit (2008) *Serving the Community by Using the Private Sector: An Introductory Guide to Public Private Partnership*, 2nd ed, March 2008, at http://www.eu.gov.hk/en/reference/publications/ppp_guide_2008.pdf (accessed 10 Oct. 2015)

Gee, A. (2001) Fugitives ‘Teeth Dog’ Meets His Match, *Asiaweek*, at <http://web.archive.org/web/20061018033714/http://www.asiaweek.com/asiaweek/96/0531/feat3.html> (accessed 10 October 2015)

Grimsey D. and Lewis, M. (2004) *Public Private Partnerships: the Worldwide Revolution in Infrastructure Provision and Project Finance*, Edward Elgar Publishing, Cheltenham, U.K. and Northampton, Massachusetts

Hashemi H. (1993) The Indoor Radio Propagation Channel, *Proceedings of IEEE*, Vol. 81, No.7, pp.943-968

Hong Kong Police Force (HKPF) (2009) *Strategic Directions and Strategic Action Plan 2010-2012*

IACP (International Association of Chiefs of Police) (2004) *National Policy Summit: Building Private Security/Public Policing Partnerships to Prevent and Response to Terrorism and Public Disorder*, at http://www.cops.usdoj.gov/Publications/national_policy_summit.pdf (access 3 January 2014)

Infonetics Research, (2007), *An Evaluation of In-building Wireless Coverage*, at <http://www.infonetics.com/whitepapers/Infonetics-In-Building-Wireless-white-paper.pdf>, (Accessed 3 January 2014)

Killen, B., Stittleburg, P., Webb, W. and Siamicki, R. (2005), *Radio Communications for the Fire Service: A Planning Guide for Obtaining the Communications System You Need for Enhanced Safety and Emergency Preparedness*, International Association of Fire Chiefs

Rappaport, T. (2002) *Wireless Communications Principles and Practices*, Prentice Hall, New Jersey

Wong, J. (2011), A New Public Private Partnership Business Model. *The Institution of Engineering and Technology, International Communications Conference on Wireless, Mobile and Computing (CCWMC) 2010*, Shanghai

Wong, J. (2012). Hong Kong's Innovative Coverage Model: How Public Safety Extends Signals into Buildings, *Radio Resources International Magazine*
(<http://digital.olivesoftware.com/Olive/ODE/RadioResource/>)