

Report on DVB-H Mobile TV Trial in Underground Railway System

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1 INTRODUCTION

DVB-H (Digital Video Broadcasting for Handheld) is one of the technology standards for the transmission of digital TV to handheld receivers such as mobile phones or PDAs. Published as an international open standard by ETSI, it is a physical layer specification designed to enable the efficient delivery of IP-encapsulated data over terrestrial networks.

Previously from Sep 2006 to Mar 2007, PCCW conducted a trial of DVB-H at Quarry Bay area in Hong Kong; that trial had been conducted successfully to cover mobile TV reception in outdoor, indoor and vehicular at above-ground environments. Like cellular services, it is believed that there are demands for mobile TV service in underground railway system where millions of commuters travel everyday.

In order to explore mobile TV performance in underground train environment, PCCW teamed up with MTRC and Motorola to set up an end-to-end trial DVB-H system network in two MTR stations in Hong Kong. The aim was to evaluate the performance of DVB-H service deployment in enclosed underground public access areas inside the MTR railway system.

The trial was run from May 2007 to Nov 2007 using UHF Channel 47. DVB-H transmitter stations were setup in two MTR stations on Hong Kong Island. Tests and measurements were performed, which included mobile TV reception in underground public accessible areas, inside a moving train and also signal variation during busy and non-busy hours. The results are summarized in this document.

2 TRIAL OBJECTIVES

The main objectives for this DVB-H mobile TV trial were:

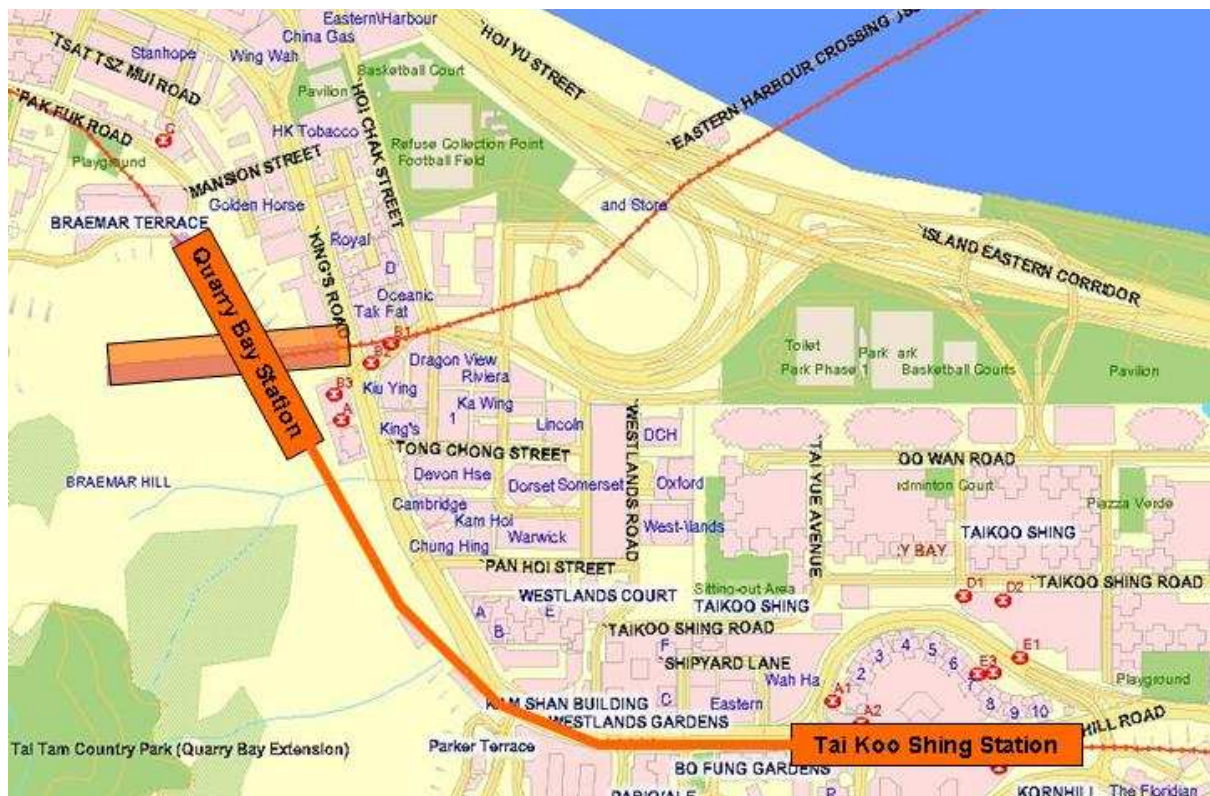
1. To assess radio coverage and performance at various MTR indoor areas such as platform, concourse, passenger corridor and entrance;
2. To assess radio coverage and performance of in-train mobile TV reception within a tunnel where user uses the service inside a moving MTR train;
3. To assess mobile TV coverage during busy and non-busy hours within the stations and inside the train.

3 SYSTEM OVERVIEW / TRIAL CONFIGURATION

3.1 TRANSMITTER SITE LOCATIONS

The field trial was conducted in two MTR stations – the Quarry Bay station and the Tai Koo station. Indoor areas within the stations, such as station platform, concourse, exits, and train tunnel connecting the trial stations & their adjacent stations were covered.

A DVB-H transmitter was installed at each of the two MTR stations. Both sites were operated in single frequency network (SFN) mode. On each site, the transmitter was connected to the existing indoor antenna system inside the station to provide indoor radio coverage for that station. The head-end equipment was installed at PCCW Chai Wan facility and the content was delivered to those sites through a fiber distribution network.



3.2 SYSTEM COMPONENTS

The trial system was consisted of Headend System, Fiber Distribution Network, Radio Sites, and DVB-H handsets.

The Headend System was composed of:

- H.264 video encoders
- Ethernet switches
- ASI converters
- IP encapsulator and manager
- MIP inserter
- Encryption and Conditional Access server (M-Secure)
- Electronic Service Guide (ESG) server

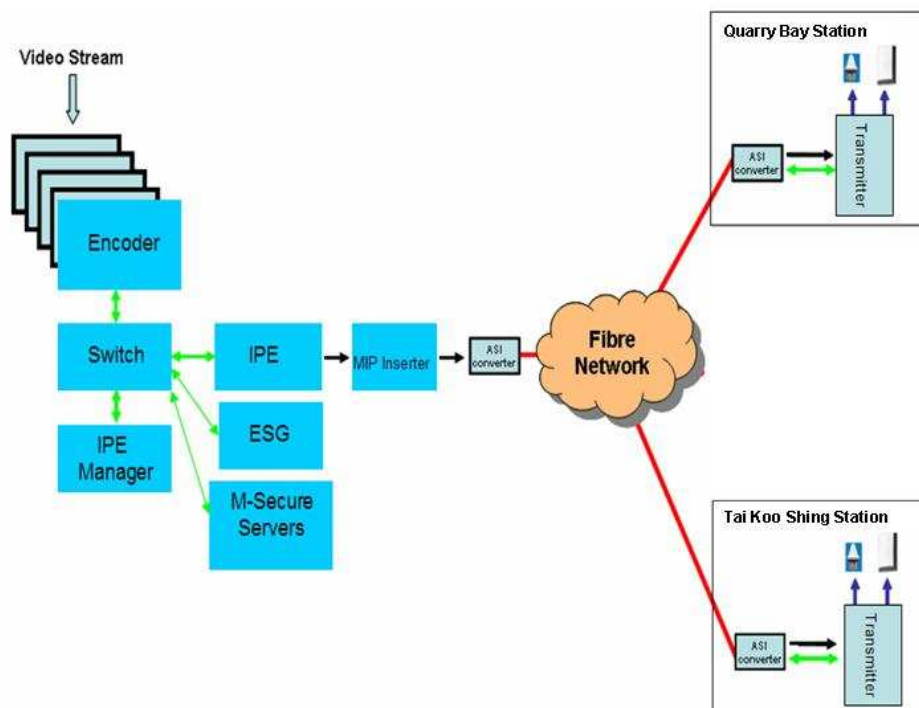
The Fiber Distribution Network was composed of:

- ASI converters
- Ethernet switches
- Fiber network

Each Radio Site was composed of:

- ASI converter
- DVB-H transmitter
- GPS antenna
- Indoor antenna system

A number of DVB-H GSM handsets were used as receiving terminals.



3.3 GENERAL TEST CONFIGURATION

Below is a summary of the major technical parameters of the trial:

Technical Parameter	Value
Maximum Effective Radiated Power	< 100W ERP
Frequency	682MHz (UHF channel 47)
Bandwidth	8MHz non-hierarchical modulation
DVB-H Network	Single frequency network (SFN)
Video & Audio Format	H.264 & AAC
DVB-H Parameters	Mode: 8K Modulation: QPSK Guard Interval: ¼ Code Rate: ½
TV Channels	~11 live streaming TV channels depending on the modulation scheme selected
Service Content	Linear channels of news, infotainment, sports, and general entertainment genres

4 TRIAL RESULTS

4.1 RADIO COVERAGE INSIDE THE STATIONS

The objective of the test was to evaluate the performance and coverage of mobile TV reception in the public accessible areas such as platforms, concourses and corridors within the MTR stations during busy and non-busy hours. Busy hours were defined as 8:00am to 10:00am & 4:30pm to 6:30pm; the remained opening hours were non-busy hours.

The following measurements were taken in this test:

- Signal level during non-busy hours in the stations
- Signal level during busy hours in the stations
- C/N difference between non-busy and busy hours
- C/N requirement for 5% MFER
- Coverage percentage at different areas in the stations

Signal level during non-busy hours in the stations

The Carrier to Noise ratio (C/N) measurement results, as logged on the DVB-H handsets, at a number of stationary test points during non-busy hours are summarized below.

Signal level during non-busy hours in Quarry Bay Station:

Concourse Area		Upper Platform Area		Lower Platform Area	
Location number	Non-Busy Hours C/N (dB)	Location number	Non-Busy Hours C/N (dB)	Location number	Non-Busy Hours C/N (dB)
1	19.9	1	20.2	1	15.2
2	19.5	2	20.7	2	13.8
3	19.9	3	19.4	3	13.1
4	20.5	4	20.0	4	18.4
5	20.2	5	18.2	5	19.1
6	20.9	6	19.5	6	20.0
7	20.2	7	21.0	7	15.5
8	20.6	8	19.0	8	19.9
9	20.5	9	19.5	9	18.2
10	20.8	10	20.5	10	18.6
		11	19.7	11	18.3
		12	19.8	12	19.9
		13	20.5	13	13.8
		14	20.7	14	17.3
		15	20.0	15	21.3
		16	20.4	16	19.4
				17	19.1
				18	20.2

Signal level during non-busy Hours in Tai Koo Station:

Concourse Area		Platform Area	
Location number	Non-Busy Hours C/N (dB)	Location number	Non-Busy Hours C/N (dB)
1	22.4	1	23.0
2	22.6	2	24.0
3	23.6	3	21.8
4	22.9	4	22.5
5	22.8	5	22.1
6	23.3	6	21.4
7	23.0	7	23.4
8	21.2	8	22.7
9	23.6	9	21.8
10	21.6	10	23.3
11	22.6	11	23.4
12	21.6	12	23.2
13	19.6	13	23.4
14	23.8	14	22.8
15	22.9	15	22.3
16	21.7		
17	23.5		
18	22.0		
19	22.1		
20	22.6		
21	22.7		
22	20.2		
23	20.9		
24	18.7		
25	8.0		
26	12.3		
27	22.3		
28	23.1		
29	16.3		
30	22.3		
31	22.9		
32	23.0		
33	23.0		

Signal level during busy hours in the stations

The C/N measurement results, as logged on the DVB-H handsets, at a number of stationary test points during busy hours are summarized below.

Signal level during busy Hours in Quarry Bay Station:

Concourse Area		Upper Platform Area		Lower Platform Area	
Location number	Busy Hours C/N (dB)	Location number	Busy Hours C/N (dB)	Location number	Busy Hours C/N (dB)
1	18.9	1	19.6	1	8.4
2	20.3	2	19.5	2	7.6
3	14.5	3	16.6	3	11.1
4	22.1	4	16.5	4	8.4
5	19.5	5	12.4	5	14.4
6	24.0	6	14.9	6	19.6
7	24.0	7	20.7	7	10.0
8	21.2	8	13.5	8	12.8
9	23.6	9	21.6	9	14.0
10	22.7	10	24.0	10	7.8
		11	11.4	11	15.6
		12	18.6	12	12.1
		13	21.6	13	9.1
		14	23.0	14	7.7
		15	15.1	15	9.8
		16	19.3	16	13.8
				17	8.5
				18	13.9

Signal level during busy hours in Tai Koo Station:

Concourse Area		Platform Area	
Location number	Busy Hours C/N (dB)	Location number	Busy Hours C/N (dB)
1	23.4	1	23.7
2	23.8	2	24.0
3	23.5	3	22.7
4	23.2	4	23.5
5	23.0	5	21.8
6	22.7	6	21.2
7	23.1	7	22.3
8	23.6	8	22.9
9	23.6	9	21.8
10	22.7	10	23.5
11	22.1	11	22.3
12	16.4	12	22.8
13	15.3	13	21.8
14	17.5	14	23.2
15	24.2	15	22.2
16	20.9		
17	23.0		
18	22.6		
19	20.3		
20	23.0		
21	21.2		
22	21.2		
23	20.2		
24	20.3		
25	8.8		
26	18.3		
27	22.8		
28	22.8		
29	13.6		
30	21.4		
31	23.9		
32	22.7		
33	23.3		

C/N difference between non-busy and busy hours

Based on C/N measurement results, the C/N difference between non-busy and busy hours are summarized below:

Quarry Bay Station	Average C/N during Non-Busy Hours (dB)	Average C/N during Busy Hours (dB)	C/N Difference (dB)
Concourse	20.3	21.1	-0.8
Upper Platform	19.9	18.0	1.9
Lower Platform	17.8	11.4	6.4

Tai Koo Station	Average C/N during Non-Busy Hours (dB)	Average C/N during Busy Hours (dB)	C/N Difference (dB)
Concourse	21.4	21.2	0.2
Platform	22.7	22.6	0.1

No significant C/N difference was observed between busy and non-busy hours at most areas in the two platforms. The only exception was at the lower platform of Quarry Bay station, there was a 6.4dB C/N difference.

C/N requirement for 5% MFER

MFER (Multi-protocol encapsulation Frame Error Rate) is the ratio of uncorrectable MPE-FEC frames over a period of time; and it is an indicator of the signal reception quality. A threshold value, typically MFER 5%, is considered to be the limit of acceptable signal reception quality for DVB-H service.

To find out the C/N requirement for 5% MFER, C/N and MFER measurement were taken on 33 stationary test points in Quarry Bay Station during busy and non-busy hours. Additional attenuation loss was introduced to the handset in order to facilitate the finding of the C/N requirement for 5% MFER. The results as logged on the DVB-H handsets are summarized in the table below. Busy hours were defined as 8:00am to 10:00am & 4:30pm to 6:30pm; the remained opening hours were non-busy hours.

Locations	QUB Non-Busy		QUB Busy	
	C/N (dB)	MFER (%)	C/N (dB)	MFER (%)
1	12.41	0.72%	8.78	8.29%
2	10.09	13.22%	11.76	1.37%
3	2.10	63.91%	-8.80	100.00%
4	4.82	21.99%	4.53	35.07%
5	3.27	66.00%	3.65	23.19%
6	-0.06	87.05%	5.23	8.15%
7	9.82	0.00%	10.30	0.00%
8	1.33	47.37%	1.73	53.69%
9	2.99	48.08%	3.13	67.91%
11	2.78	98.62%	9.05	0.00%
12	6.42	27.50%	0.79	63.69%
13	3.92	52.21%	4.00	45.24%
14	2.12	92.16%	1.73	95.42%
15	2.98	61.83%	-10.45	100.00%
16	1.81	70.32%	11.52	0.00%
17	8.19	0.00%	10.26	4.32%
18	2.21	32.72%	2.65	59.73%
19	5.83	3.97%	12.56	0.00%
20	7.24	10.37%	0.56	75.19%
21	4.31	46.50%	2.28	88.98%
22	7.56	16.34%	2.97	41.14%
23	5.64	22.15%	0.79	92.13%
24	10.63	0.00%	6.54	4.58%
25	6.54	21.05%	3.75	47.06%
26	6.71	34.44%	4.09	67.09%
27	5.25	35.00%	2.27	86.01%
28	5.62	25.65%	3.11	61.43%
29	7.15	5.16%	9.63	0.00%
30	9.95	0.00%	9.15	2.92%
31	5.11	47.65%	4.54	37.91%
32	13.49	0.00%	10.76	0.00%
33	10.78	0.00%	6.26	4.83%

From the test results, the average C/N required to achieve MFER < 5% was about 9.6dB for non-busy and 9.8dB for busy hours.

Coverage percentage at different areas in the stations

With service quality threshold of MFER=5% and C/N requirement of 9.8dB, based on the C/N measurement results, the coverage percentages at different areas within the stations are calculated and tabulated in below tables:

The calculation formula is:
$$\frac{\text{Number of locations with C/N} \geq 9.8\text{dB}}{\text{Total number of test locations}}$$

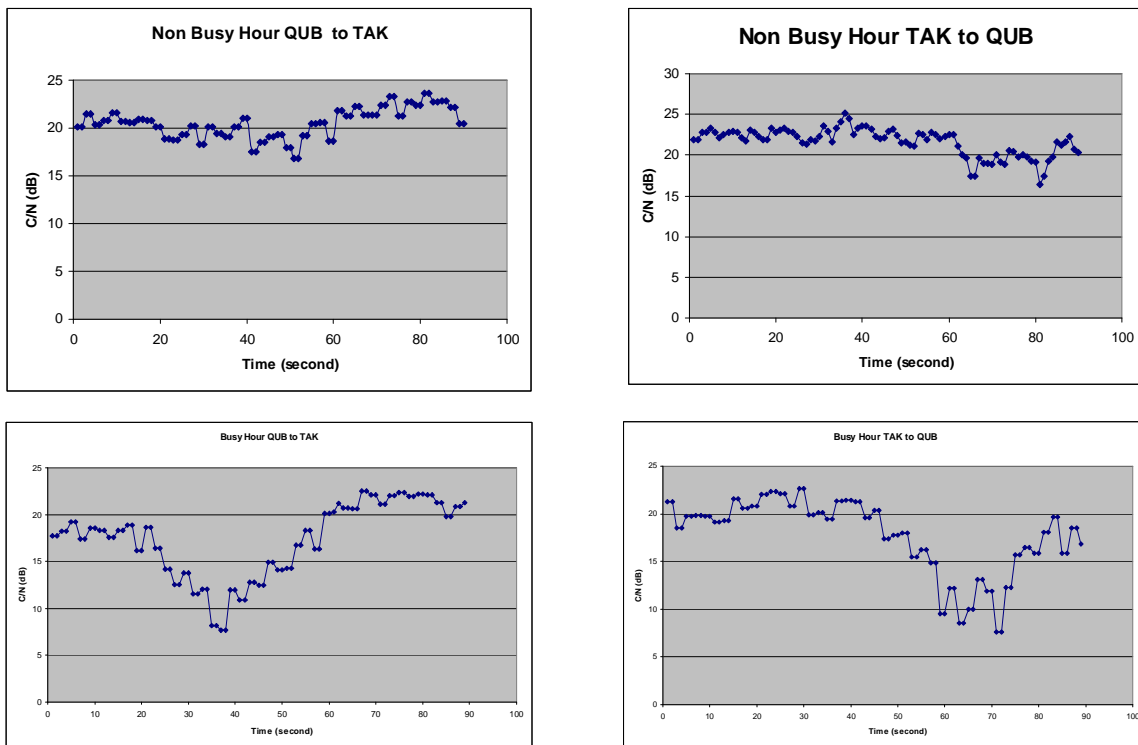
Quarry Bay Station	Coverage (%)	
	Non-Busy Hours	Busy Hours
Concourse	100	100
Upper Platform	100	100
Lower Platform	100	61.1

Tai Koo Station	Coverage (%)	
	Non-Busy Hours	Busy Hours
Concourse	97.9	97.9
Platform	100	100

4.2 IN TRAIN MOBILE TV RECEPTIONS UNDER VEHICULAR SPEED

The objective of the test was to evaluate the DVB-H performance operating in a high speed train traveling inside a tunnel during busy and non-busy hours. The test was conducted on the tracks between Tai Koo and Quarry Bay MTR Stations. Mobile TV transmitters at those two stations provided radio signal coverage inside the tunnel. Measurements were taken on each direction during non-busy hours. Busy Hour was defined as 8:00am – 10.00am & 4:30pm to 6:30pm, the remained opening hours are non-busy hours.

The average C/N and MFER plots for busy and non-busy hours on both tracks are shown below.



The average C/N and the MFER of the tests results are depicted in the following table:

Tracks	Non-Busy Hours		Busy Hours	
	Average C/N (dB)	MFER (%)	Average C/N (dB)	MFER (%)
TAK -> QUB	21.57	0.00	17.67	3.79
QUB -> TAK	21.79	0.00	17.46	3.63

On non-busy hours, there was no observable degrade in video quality along the tracks and also during handover between the two transmitting stations.

During busy hours, on a few occasions, brief service interruptions were observed at the intersection point of these stations.

5 CONCLUSION

The radio coverage and performance of DVB-H system in underground public accessible areas, inside a moving train and also signal variation during busy and non-busy hours were evaluated in Quarry Bay and Tai Koo MTR stations.

DVB-H provides good coverage on most of the public access areas of the two stations tested during busy and non-busy hours. The only exception was during busy hours at the lower platform of Quarry Bay station, signal level was found to be insufficient for DVB-H service.

It was also found that during non-busy hours, high speed mobility inside a moving train inside a tunnel did not affect the reception of the service and service handover between transmitters along the tunnel was possible as well. However, during busy hours, there was observable video quality degrade at the middle of the tunnel between two stations.

In summary, DVB-H technology demonstrated its capability to provide mobile TV service in enclosed underground public access areas inside the MTR railway system. To support commercial DVB-H services in the MTR railway system in the future, it is believed that system fine-tuning and network improvement work are needed.

The results and data collected in this trial are valuable and will definitely be helpful in planning for future deployment of mobile TV service in Hong Kong.

- END -