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# **Report on E-band (71-76GHz/81-86GHz) Digital Fixed Link Trial**

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Proponent:       ASTRI Communications Technologies Division

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## **Executive Summary**

The Hong Kong Applied Science and Technology Research Institute (ASTRI) was founded by the Government of Hong Kong SAR in 2000 with a mission of enhancing Hong Kong's competitiveness in technology-based industries through applied research.

The ASTRI Communications Technologies Division conducted an E-band (71-75GHz/81-85GHz) digital fixed link trial from 25 November 2014 to 24 May 2015 for technology promotion. This report summarizes the trial system's network architecture, hardware specifications, and experimental results.

## **1 Introduction and Background**

### **1.1 Purposes of the E-band Digital Fixed Link Trial**

The purposes of the E-band digital fixed link trial include:

- To promote E-band (71-76GHz/81-86GHz) communications technologies.
- To investigate E-band signal strength attenuation due to weather conditions.
- To showcase the R&D and network planning capabilities of ASTRI.

### **1.2 Schedule**

The trial was held from 25 November 2014 to 24 May 2015.

### **1.3 Concerned Parties**

- ASTRI
- OFCA

### **1.4 Non-Revenue Generating**

ASTRI used the trial system's network, equipment, and services solely for technology promotion. ASTRI did not open the trial system for public access and did not generate revenue by operating the trial system.

## **2 E-band Digital Fixed Link Trial System Specifications**

### **2.1 Radio Design and Considerations**

#### **2.1.1 RF Equipment and Antenna Compliance**

The RF equipment and antennas used in the trial system comply with ETSI EN 302 217, FCC 47 CFR part 101, CE marked, EMC, and safety UL60950 requirements.

#### **2.1.2 RF Power**

The maximum EIRP (equivalent isotropically radiated power) was 50 dBm.

#### **2.1.3 Class of Emission**

The trial system employed FDD mode, 250 MHz and 500 MHz channel bandwidth, and various modulation techniques (such as QPSK, 16QAM, and 64QAM).

#### **2.1.4 RF Spectrum**

ASTRI has obtained a trial permit from OFCA with the following requirements on frequency and maximum frequency tolerance:

- 74.250GHz/84.250GHz center frequency of 250MHz channel bandwidth; and
- 74.375GHz/84.375GHz center frequency of 500MHz channel bandwidth.

#### **2.1.5 Interferences to Other Equipment**

The E-band trial system operated at the unallocated 71-76GHz and 81-86GHz spectrum, as licensed by OFCA, and did not cause interference to existing mobile phone network or other RF equipment at the installation locations.

### **2.2 Equipment**

The E-band radio unit used is shown in Fig. 1 and the specifications are as follows:

- Compliant with ETSI EN 302 217, FCC 47 CFR part 101, CE marked, EMC, and safety UL60950 regulations;
- 71-76/81-86GHz RF frequency and FDD duplexing
- Vertical and horizontal polarization;
- 250 MHz and 500 MHz channel bandwidth;
- Maximum 7 dBm transmit power;
- Adaptive modulation scheme including QPSK, 16QAM and 64QAM; and
- Integrated 0.31m dish antenna with 43dBi gain.



**Figure 1: E-band radio unit.**

### **2.3 Site Overview**

The trial system consisted of two E-band radio units deployed at two transmission sites in the Hong Kong Science Park (HKSP) (see Fig. 2) including the roof top of Photonics Centre and the roof top of the Science Park Car Park. A remote control station was located at Lakeside 2. The addresses of transmission and remote control sites are summarized in Table 1.



**Figure 2: Trial system transmission sites in HKSP.**

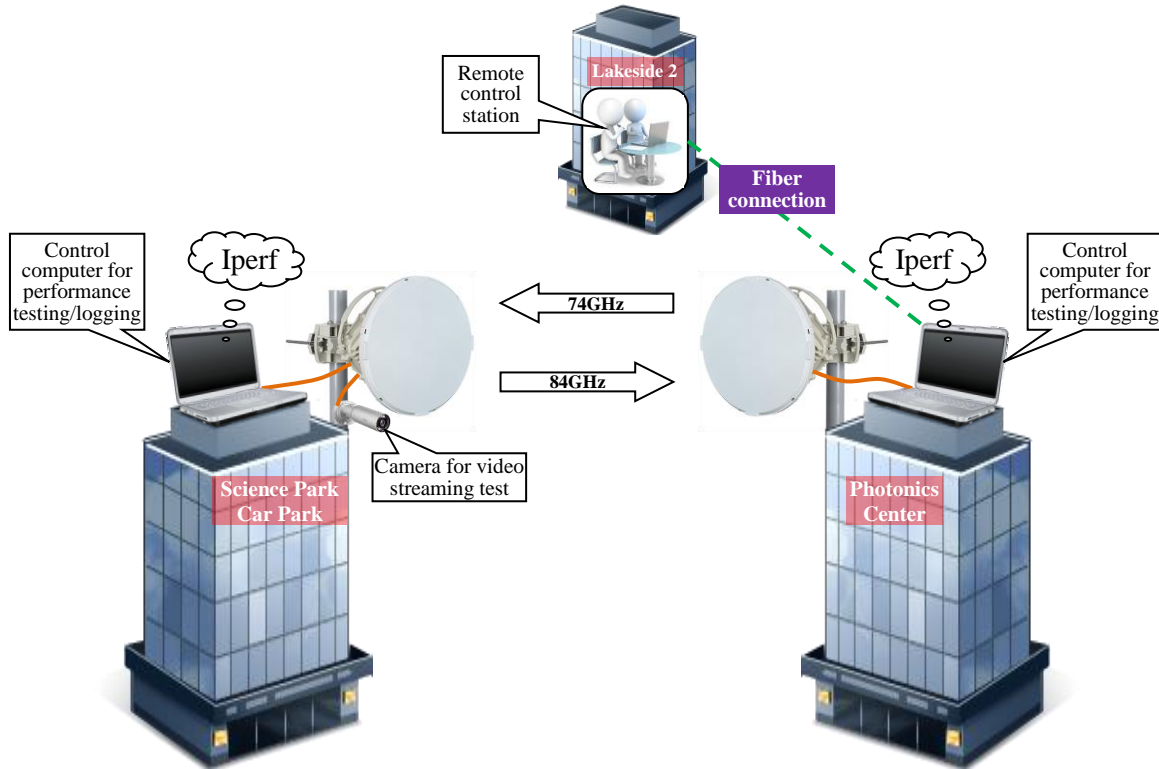
**Table 1: Addresses of the transmission and remote control sites.**

Type	Site	Address
Transmission	Photonics Centre	Rooftop, Photonics Centre 2 Science Park East Avenue Hong Kong Science Park, Shatin, Hong Kong
Transmission	Science Park Car Park	Rooftop, Science Park Car Park 3 Science Park West Avenue Hong Kong Science Park Shatin, Hong Kong
Remote Control	Lakeside 2	Rm 310-318, 3/F, Lakeside 2 10 Science Park West Avenue Hong Kong Science Park Shatin, Hong Kong

## 2.4 Network Topology Overview

The trial network topology is illustrated in Fig. 3. The E-band radio unit deployed at the Photonics Centre transmitted at 74GHz frequency, whereas the E-band radio unit deployed at the Science Park Car Park transmitted at 84GHz frequency. Each E-band radio unit was

connected to a control computer for performing iPerf<sup>1</sup> throughput test. An IP camera was deployed at the Science Park Car Park, and high definition video was continuously streamed over the E-band link and a fiber connection back to the remote control station at Lakeside 2.



**Figure 3: Trial network topology.**

## 2.5 Transmission Sites

The transmission sites are shown in Fig. 4. The E-band radio units had line-of-sight over a distance of approximately 180m. Figure 5 shows a snapshot of the streaming video from Science Park Car Park.

<sup>1</sup> Wikipedia contributors, "Iperf," *Wikipedia, The Free Encyclopedia*, <https://en.wikipedia.org/w/index.php?title=Iperf&oldid=676065261> (accessed August 19, 2015).

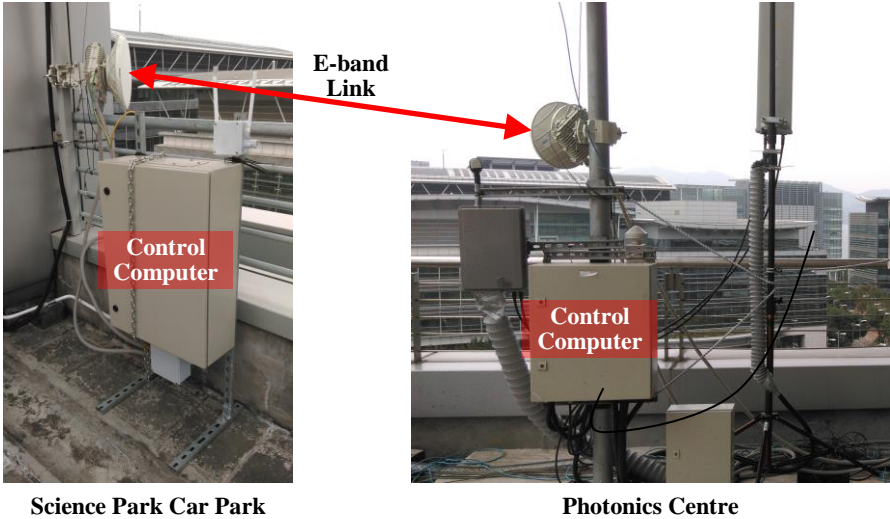


Figure 4: Transmission sites.



Figure 5: Snapshot of video streaming from Science Park Car Park.



### 3 Experimental Results

The E-band radio unit's graphical user interface is shown in Fig. 6. The E-band radio unit internally estimated the physical transmission distance to be 189m, where the map distance is approximately 180m. The E-band radio unit supports adaptive modulation and automatically adjusted the transmission mode (i.e., modulation, subchannels, repetitions, code rate) based on the instantaneous carrier to interference plus noise ratio (CINR).

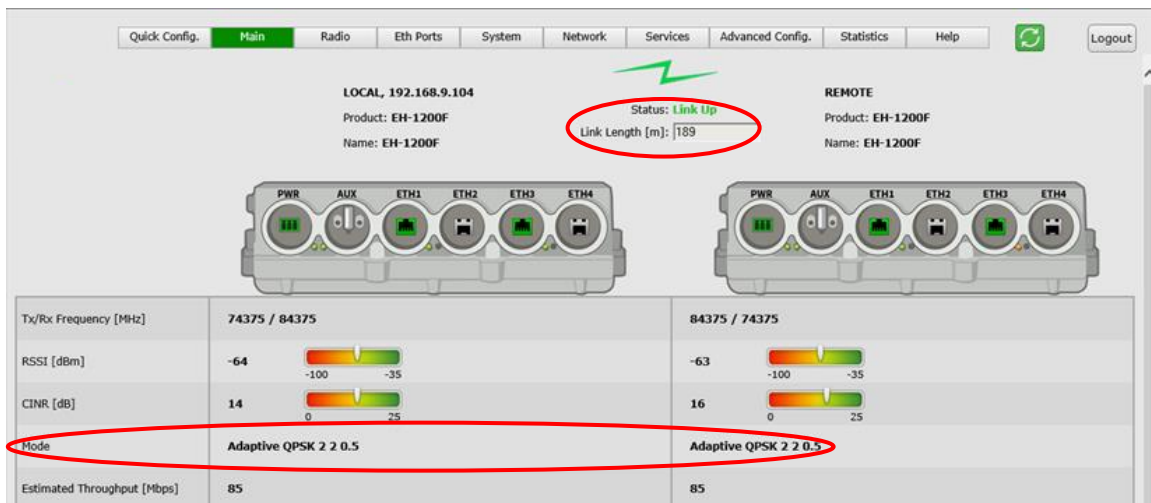


Figure 6: E-band radio unit's graphical user interface.

The following example illustrates the performance of the E-band link under the impact of rain. In April 2015, rainfall was recorded on April 11 (see Fig. 7). Accordingly, it can be observed from Fig. 8 that, using 500MHz channel bandwidth and vertical polarization, the achievable iPerf throughput without rain was 300Mbps/s, whereas the achievable iPerf throughput during rainy days was reduced to 75-200Mbps/s.

Note that, if the transmission mode were manually configured, under sunny weather the maximum stable iPerf throughput was 700Mbps.

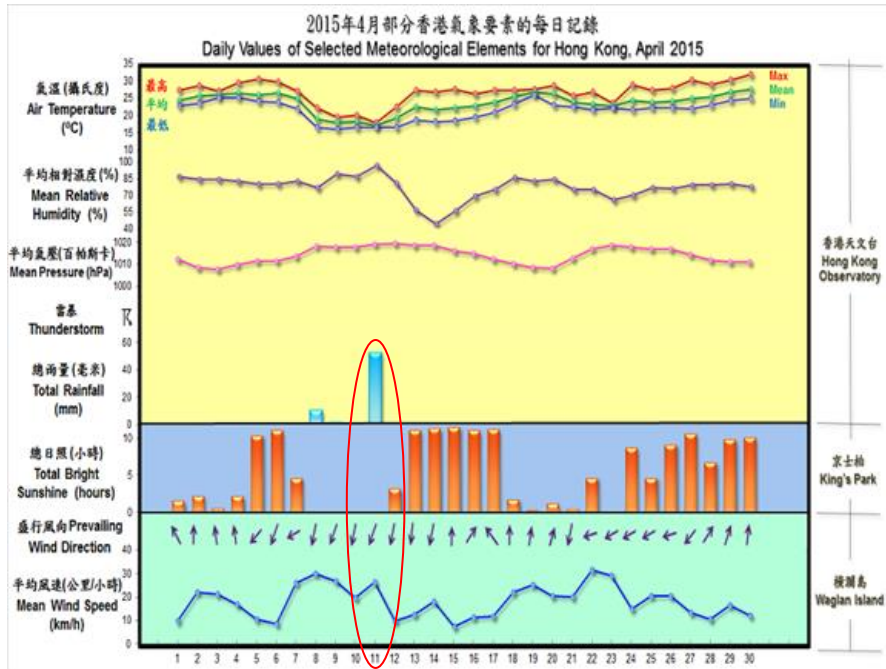


Figure 7: Hong Kong weather for April 2015<sup>2</sup>.

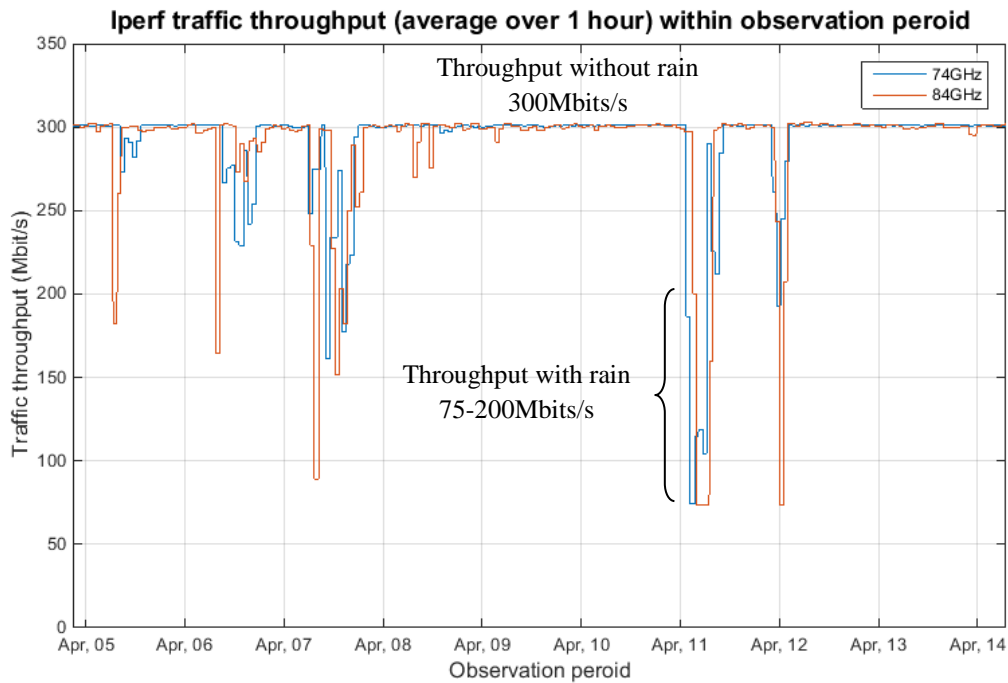


Figure 8: Achievable iPerf throughput averaged over one hour.  
Adaptive modulation, 500 MHz channel bandwidth, and vertical polarization.

<sup>2</sup> Source: <http://www.hko.gov.hk/wxinfo/pastwx/mws2015/mws201504.htm>