

Response to Views and Comments on the Technical Study Conducted by Plum Consulting in the Submissions to the Second Consultation on the Arrangements for the Frequency Spectrum in the 900 MHz and 1800 MHz Bands upon Expiry of the Existing Assignments for Public Mobile Telecommunications Services and the Spectrum Utilisation Fee

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1 Introduction

This document provides Plum Consulting's (Plum) response to the submissions on the second consultation jointly conducted by the Communications Authority (CA) and the Secretary for Commerce and Economic Development (SCED) on the Arrangements for the Frequency Spectrum in the 900 MHz and 1800 MHz Bands upon Expiry of the Existing Assignments for Public Mobile Telecommunications Services and the Spectrum Utilisation Fee (Second Consultation) in relation to the technical study conducted by Plum (Study). It also sets out subsequent comments raised by the MNOs as a supplement or clarification to their written submissions to the second consultation in the latest round of meetings held with Plum in September 2017 after the close of the Second Consultation.

The Second Consultation was jointly conducted by the CA and SCED from 14 February 2017 to 24 May 2017 with a view to soliciting views and comments of the telecommunications industry and other affected persons on the arrangements for the re-assignment of the frequency spectrum in the 900 MHz and 1800 MHz bands upon expiry of the existing assignments between November 2020 and September 2021. In support of the Second Consultation, Plum was commissioned by the CA through the Office of the Communications Authority (OFCA) to conduct the Study in order to provide an independent and objective assessment of the impacts on service quality arising from the spectrum re-assignment. The Second Consultation paper issued by the CA and SCED as well as the public version of the Study report prepared by Plum are available from the websites of the CA and OFCA respectively.

By the close of the Second Consultation on 24 May 2017, OFCA had received a total of 22 submissions, amongst which the submissions from the following respondents provided comments on the Study:

- (a) China Mobile Hong Kong Company Limited (CMHK)
- (b) Competition Economists Group (CEG)
- (c) Hong Kong Telecommunications (HKT) Limited (HKT)
- (d) Hutchison Telephone Company Limited (HTCL)
- (e) SmarTone Mobile Communications Limited (SMT)

Plum has reviewed all the submissions to the Second Consultation and considered additional information related to the provision of mobile coverage in the Mass Transit Railway (MTR) environment. In this document, Plum summarises the views and comments raised by the respondents specifically relating to the Study and provides responses to address these views and comments.

Before addressing the received submissions, it is worthwhile to first clarify the extensive involvement of each of the four mobile network operators (MNOs), namely, CMHK, HKT, HTCL and SMT, during the information gathering and consultation processes throughout the course of the Study. Plum sought information from the MNOs at the start of the Study.¹ The information requested is set out in Appendix A of the Study report. As noted in the Study report, while the four MNOs were generally cooperative in the information gathering process, not all provided the

¹ See Section 3.3 of the Study report.

full set of historic and forecast data requested by Plum. Where possible, Plum had sought to gather the missing information through the discussions with the MNOs. In some cases, a number of assumptions were made to address the data deficiencies.

Plum held a total of four rounds of individual meetings with CMHK, HKT, HTCL and SMT and met with the MTR Corporation and a mobile virtual network operator (MVNO) – the first round in April 2016 covered the general assessment approach, the key considerations in the Study and the inputs and outputs of the assessment model; the second round in June 2016 involved clarification on the data provided by the MNOs and an update on the assessment model; the third round in September 2016 briefed the MNOs on the preliminary assessment results and key assumptions for the assessment model; and the fourth round in September 2017 for discussions of the MNOs' comments and submissions to the Second Consultation in relation to the Study report. Throughout these exchanges, the MNOs had been afforded opportunities to raise any questions or seek for clarifications in relation to the Study.

The information requested and the individual meetings provided opportunities for all MNOs to comment on aspects of the Study such as the model assumptions, assessment approach and preliminary assessment results. Comments received had been considered by Plum when finalising the model and the Study report.

Section 2 of this document addresses the following specific issues raised in submissions in relation to the Study report:

- Redaction of the Study report
- Mobile traffic forecasts
- Spectrum supply and scenarios
- Technology evolution
- Mitigating measures
- Services in the Mass Transit Railway (MTR) premises
- Right of First Refusal (RFR) spectrum.

Section 3 addresses the further comments made by the MNOs during the meetings held in September 2017. MNOs taking part in the individual meetings included HKT, HTCL and SMT. Further information relating to the Study was also received from the MTR.

2 Summary of the submissions and Plum's response

2.1 Redaction of the Study report

Views and comments of the respondents

Plum notes the general concern raised by HKT and CEG related to the allegedly heavy redaction of the confidential information in the published Study report. HKT claimed that it had been significantly hindered in its ability to provide comments in response to the Second Consultation given that it did not have full visibility of all the relevant matters. CEG further pointed out that even key parts of Plum's assumed spectrum scenarios were not made public even though this was not clearly disclosing any MNOs' confidential information.

Plum's response

It should be noted that Plum is a party to undertakings of non-disclosure of confidential information obtained from each MNO to third parties. For this reason, Plum cannot make available any of the information that has been redacted in the published Study report.

The Study report has already provided the results from the application of the assessment model developed by Plum to different scenarios and the salient assumptions upon which the model is based. With respect to the redaction of spectrum scenarios used for the assessment model, it is not appropriate for Plum to disclose further details of the assumed spectrum scenarios, including the amount of spectrum that the existing MNOs are assumed to win at the auction and therefore their assumed spectrum holdings in the 900 MHz and 1800 MHz bands. To disclose such information would in effect enable all readers to second-guess the identity of the MNOs in the spectrum scenarios, thereby in effect compromising Plum's undertaking of non-disclosure of confidential information as obtained from each MNO.

Lastly, it is also worthwhile to point out that there was full engagement by all the MNOs in the course of conducting the Study including their participation in three rounds of individual meetings with Plum in April, June and September 2016 respectively. Plum provided the relevant scenario assumptions (namely the range of spectrum holding of the concerned MNO in scenarios) to the corresponding MNO during the meetings.

2.2 Mobile traffic forecasts

Plum's approach to the mobile traffic forecasts used in the Study is set out in Section 3.4 of the Study report.

Views and comments of the respondents

In general, both HKT and CEG quoted several other research reports on spectrum supply and demand forecasts to argue that the demand forecast deployed in the Study was too low. They therefore questioned the result of the Study that there would be sufficient network capacity to accommodate the demand forecast based on the assumption of having 552 MHz of spectrum only. The reports or forecasts quoted by HKT and CEG included (a) Cisco forecast, (b) ITU Report, and (c) other forecast/plan on 5G. HTCL also pointed out that the assumptions used by Plum did not take into account the abnormal traffic scenarios and the significant impact on quality of services when the network loading increased.

For (a), HKT and CEG questioned why the growth rate of mobile traffic by Plum (average growth rate of 26% between 2016 and 2023) was lower than those projected by Cisco for Japan (33%), Korea (37%) and China (56%). HKT further expressed the view that Plum should adopt the projection by Cisco and the figures in the “rest of Asia Pacific” under the Cisco Visual Networking Index (VNI)² as the base case for Hong Kong (average annual mobile data growth rate of 51%) and the traffic growth rates for Japan and Korea should be used for the low end of the sensitivity analysis.

For (b), HKT quoted the ITU Report ITU-R M.2290³ which estimated that global spectrum requirements by 2020 could reach a total of 1340 – 1960 MHz of spectrum for each country to provide mobile services.

For (c), HKT considered Plum’s mobile traffic forecast conservative and also suppressed in light of the CA’s press release on 5G. CEG considered Plum’s mobile traffic forecast to be much lower than forecasts relied on by other international regulators and different from that mentioned in the note of a Federal Communications Commission (FCC)’s report about 5G network. CEG also pointed out that the 552 MHz of spectrum that was assumed by Plum over the period of the Study (2016 – 2023) was less than many other key markets for mobile services (average of 603 MHz) and was just a fraction of the spectrum expected to be required by the World Bank, the Office of Communications (Ofcom), the FCC and Industry Canada. Instead, Hong Kong should be expected to require at least as much spectrum to meet demand as other countries with their more dispersed populations.

Plum’s response

First, it should be noted that the assessment model developed by Plum is a tool that provides a representative view of network performance based on data from the MNOs and a set of general assumptions. The assessment model is not intended to be a network planning tool that precisely mirrors the actual operation of the MNO’s networks and their performance. While it provides a good representation of network behaviour across a network of many sites/sectors, its output is less reliable and potentially misleading if the application of the model is made too granular (e.g. looking at a single or small number of network sectors).

² Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2016-2021, published on 7 February 2017. See <http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html>

³ ITU (2014). Future spectrum requirements estimate for terrestrial IMT, Report ITU-R M.2290.

In deriving the overall traffic forecast for Hong Kong for the Study, the individual forecasts provided by the MNOs were taken into consideration to the extent that was possible. The individual forecasts were based on actual historic and forward-looking data from the MNOs as these were considered to be the most reliable information to be used for the assessment. As explained in the Study report (Appendix A.1), there were instances where Plum had to generate forecasts to account for gaps in the data provided or to ensure that the forecast provided was more aligned with other published forecasts for countries with market and technology circumstances similar to Hong Kong. Where there was a need to make any adjustment on the traffic forecast, Plum had fully informed and explained the basis to the concerned MNOs during the previous meetings with MNOs, and the MNOs generally agreed with the assumptions.

The individual forecasts were then aggregated to produce an overall total for the whole Hong Kong market for 2016 to 2023, which is an average of 26% mobile data traffic growth per annum. It was the intention of the Study to use MNO provided forecasts of traffic as the primary forecast source wherever possible and then benchmark against other industry sources, as this was likely to provide a more informed view of the overall traffic forecast for Hong Kong.

Hence, there is no convincing ground for Plum to adopt any particular forecast prepared by a third organization or body instead of those prepared by the current industry players based on the local situations and context of Hong Kong. Having said that, some comments or observations are given below in respect of each of the recommended forecasts put forward by HKT and CEG.

Use of Cisco forecasts

It would not be appropriate to directly apply the forecasts for the “rest of Asia Pacific” under the Cisco forecast as recommended by HKT as these countries (in terms of market and technology circumstances, adoption, and geography), are not representative of Hong Kong’s situation.

It should be noted that the forecasts provided by some of the MNOs in Hong Kong are lower than Plum’s overall estimate for the Hong Kong market, and therefore much lower than the forecast growth rate for the “rest of Asia Pacific”. Hence, it is doubtful if the suggested forecasts for the “rest of Asia Pacific” under the Cisco VNI would be appropriate for the purpose of this Study.

ITU-R traffic forecast

It is observed that the methodology used to forecast mobile data traffic in the ITU Report ITU-R M.2290⁴, which estimates global spectrum requirements by 2020, has not been entirely transparent and there are some general concerns raised by other industry experts on several problems relating to input assumptions and data traffic forecast methodology.

For example, the ITU forecasts in M.2290 are based on extrapolations of previous forecasts (in M.2243) rather than actual data. The use of exponential functions in M.2290 leads to ever

⁴ ITU (2014). Future spectrum requirements estimate for terrestrial IMT, Report ITU-R M.2290.

increasing growth rates which may not be a realistic reflection of technology adoption and growth.

In addition, the comment by the European Commission's Radio Spectrum Policy Group (RSPG) in 2016 on the diverging views on the validity of mobile data traffic forecasts should be noted. The RSPG noted that "*reliable data are hard to find and are often based on assumptions of user density and user behaviour that can vary widely from one scenario/situation to another*".⁵ The European Commission noted that "*such forecasts may lead to tensions between those defending 'their spectrum', those claiming the need for that spectrum and administrations*".⁶ This has been evident in debates between mobile, broadcasting and satellite industries leading up to World Radiocommunication Conference 2015 (WRC-15). As a result, the RSPG recommended that "*future discussions on spectrum management decisions avoid setting an arbitrary amount of spectrum to be harmonised*".⁷

Other forecast or plan for 5G

As mentioned in section 1.2.2 of the Study report, given the uncertainty of whether there will be any additional supply of the spectrum within the assessment timeframe of the mobile (2016 – 2023), the Study was conducted based on the total amount of 552 MHz spectrum for mobile services and the potential supply of any spectrum in other bands had not been taken into account in the assessment model. In particular, the objective of the Study is in fact intended to provide a quantitative assessment of the impacts on service quality arising from the re-assignment of the frequency spectrum in the 900 MHz and 1800 MHz bands upon expiry of the existing assignments, in which the services under consideration include only the existing 2G, 3G and 4G mobile services.

The CA's announcement in March 2017 on the work plan for making available additional radio spectrum to meet the demand of public mobile services towards 2020 and beyond has made clear that this is driven by the needs to support the features of 5G services such as enhanced mobile broadband, massive machine-type communications and ultra-reliable, low latency communications, which are not directly relevant to the technical assessment in the Study. While 5G would be a major contributor to future traffic growth, much of this traffic is expected be supported by new spectrum bands (e.g. 3400 – 3800 MHz, mm-wave bands). It will be several years before 5G technology is deployed and it is expected that 5G would coexist alongside 4G (Long Term Evolution Advanced (LTE-A)) for several years (well into the 2020s). The release of these new bands will significantly increase the amount of spectrum available for mobile services in Hong Kong, bringing the total in line with other leading countries around the world.

2.3 Spectrum scenarios

⁵ Radio Spectrum Policy Group, 24 February 2016, RSPG Opinion on the implementation of the current RSPG and its revision to address the next period, RSPG16-006 FINAL, p.22.

https://circabc.europa.eu/d/a/workspace/SpacesStore/4709f36a-f27b-4850-a19b-95df0154d5aa/RSPG16-006final_RSPP_opinion.pdf

⁶ RSPG, 24 February 2016, p.22.

⁷ RSPG, 24 February 2016, p.22.

Views and comments of the respondents

HTCL expressed the view that the Study did not take into account the abnormal traffic scenarios and the significant impact on the quality of experience, which would deteriorate when the network loading increases. Moreover, HTCL considered that the Study underestimated the power and disruption of a new entrant which has strong financial resources to acquire more than 2x20 MHz spectrum in auction.

Plum's response

The spectrum scenarios represented the scenarios at the time when the Study was conducted. The Study report took into account spectrum scenarios that were likely to occur on reassignment including scenarios for a new entrant, which would possibly acquire only between 2x10 MHz and 2x20 MHz of spectrum.

The scenarios had not considered the case for a new entrant obtaining more than 2x20 MHz of spectrum. While speculation on auction outcomes is outside of the scope of the Study, reasons why the chances of a new entrant obtaining this amount of spectrum are low include:

- The incumbents' valuations are likely to be higher than new entrant's and they should be able to outbid the new entrant (which is bidding rationally).
- Currently the maximum 3GPP carrier bandwidth is 20 MHz; an additional 5 MHz will require an extra carrier to be deployed and the marginal value will be low or even zero as the deployment costs may outweigh the benefits of the capacity provided.
- OFCA is committed to releasing more spectrum so there will be further opportunity for both incumbent operators and the new entrant to acquire spectrum.

Ultimately it is up to individual MNOs and any new entrants to assess their spectrum requirements and bid for spectrum at the auction based on their assessment of factors like demand, revenue and the quality of service they want to deliver on their networks.

2.4 Technology evolution

Factors relevant to technology evolution are set out in Section 3.5.2 of the Study report.

Views and comments of the respondents

HKT disagreed with the assumed average spectrum efficiency for 4G services to increase from 1.3 to 1.6 bits/sec/Hz (2016 – 2023) and cast doubt on the proposed use of higher order Multi-input Multi-output (MIMO) (4x4 and above) for indoor antenna systems at MTR premises and shopping malls. It considered that Plum had disregarded the unique urban and crowded environment in Hong Kong which constantly posed operational challenges to MNOs.

Plum's response

The assumptions used in the Study for spectral efficiency were based on discussion with vendors, MNOs (in Hong Kong and elsewhere) and independent experts from the industry. The assumptions reflected projections from various external sources and would be consistent with rollout of progressively more advanced MIMO, beam forming antennas and other developments. The 4G spectral efficiency assumptions used in the assessment model and Study report are as follows:

- 1.3 bps/Hz in 2016 increasing to 1.6 bps/Hz in 2023.

This profile aligns with views expressed on practical spectral efficiency levels expressed in other reports (rather than the theoretical headline rates that are sometimes quoted). In Section 3.5.2 of the Study report, reference was made to the following expert reports which have considered this matter as follows:

- The Real Wireless report for Ofcom: spectral efficiency is 1.32 bps/Hz (LTE (R8) MIMO 2x2) and 2.6 bps/Hz (LTE-A (R10) MIMO 4x2).⁸
- Peter Rysavy IEEE paper: spectral efficiency is 1.4 bps/Hz (LTE (R8) MIMO 2x2)⁹

Meanwhile, the unique urban and crowded environment in Hong Kong was appreciated and reflected in the Study report by using conservative values of spectral efficiency in the assessment model when compared to those specified in LTE-A (R10) 4x2 (2.6 bps/Hz).

While there may be limitations on deployment of higher order MIMO in some locations such as MTR premises and shopping malls in which indoor antenna systems are installed, Plum does not see this as a barrier to general deployment and believes that it will be advantageous to deploy MIMO solutions where possible.

In this context, Plum notes HKT's recent press announcement on Hong Kong's first LTE-A 600 Mbps mobile network and its use of 256QAM modulation¹⁰, which essentially demonstrates that MNOs in Hong Kong have the technical expertise and capability to overcome the challenging radio environment of Hong Kong and are able to enhance their networks with higher modulation rates and new techniques to achieve higher data throughput using their assigned spectrum.

2.5 Mitigating measures

⁸ Report for Ofcom, 4G capacity gains, January 2011 <http://stakeholders.ofcom.org.uk/binaries/research/technology-research/2011/4g/4GCapacityGainsFinalReport.pdf>

⁹ Challenges and considerations in defining spectrum efficiency, Peter Rysavy

¹⁰ See

https://www.hkt.com/About+HKT/Press+information/Press%20Information%20Detail?pop=Y&quid=f81a6b6c31a3c510VqnVCM1000006a8ba8c0&language=en_US

The approach to mitigating measures is set out in Section 3.8 of the Study report.

Views and comments of the respondents

Three respondents namely HKT, HTCL and CEG questioned whether increasing the number of sectors and the use of Wi-Fi offload could be practical mitigating measures in Hong Kong. They are generally concerned about the physical limitations to implement these mitigating measures.

HKT considered that several practical factors, namely, lack of mobility, possible exhausted use of Wi-Fi bands and slow pick up of Wi-Fi service in Hong Kong, would make Wi-Fi inviable as a real alternative to mobile services. It further elaborated and expressed the views that it was difficult to further increase network capacity without any new spectrum, spectral efficiency was approaching physical limits and there could be limits on the number of concurrent users.

HTCL suggested that the assumptions on the mitigating measures were too optimistic and some of those (including the aspects of Wi-Fi offload and increasing number of sites) were unrealistic. It added that Plum did not address the negative impacts on quality of service. On the other hand, CEG observed that the assumed ability to mitigate the loss of spectrum was overstated and the costs and practicality issues of doing so had been ignored and pointed out that quality of service for HKT customers would be affected as HKT would no longer be able to deliver high speed mobile services similar to those currently on offer by HKT.

Plum's response

Plum's response to points raised in submissions is as follows.

Increasing the number of sectors

As discussed in the Study report, it was considered possible to further increase the number of sectors on networks in Hong Kong. The Study report acknowledged that there were limits as to how much the number of sectors could be increased given the density of the network (see Section 3.5.1) and as a result the scope for increase in high traffic areas was constrained to 10% in the assessment model. There was also scope for further deployment of sectors through greater use of small cells in traffic hot spots in both outdoor and indoor environments.

Use of Wi-Fi

The use of Wi-Fi as a mitigating measure was discussed in Section 3.8 of the Study report. Dual band Wi-Fi systems (5 GHz and 2.4 GHz) are being extensively used for mobile offload in hotspots around the world. Wi-Fi is also an increasing part of vendor strategies being discussed for heterogeneous networks and Wi-Fi capability is already built into much of the small cell architecture being developed.

Contrary to the views expressed in some submissions, Wi-Fi is a viable option for use in traffic hotspots. Experience suggests that constraints arising from lack of mobility are not really an issue as traffic offloaded to Wi-Fi is primarily nomadic or stationary, which leaves capacity provided by mobile services for users on the move.

It should be noted that the 3GPP Release 12 standard covers aspects of WLAN (Wi-Fi) offload. Further work on LTE-WLAN Aggregation (LWA) / Licensed Assisted Access (LAA) operation has been undertaken in the 3GPP Releases 13 and 14 standards under development. Features from these releases will be available in network equipment and devices by the time of the reassignment. These developments are expected to improve the transition between Wi-Fi and cellular networks, among other things. A recent Global Mobile Suppliers Association (GSA) report¹¹ provides more detail on progress with use of LTE in unlicensed spectrum.

It is a strategic decision for the MNOs to decide how to deploy networks and the mix of cellular versus Wi-Fi spectrum to use. Some developments taking place in Hong Kong are noted:

- CSL Wi-Fi provides extensive access in Hong Kong including convenience stores, coffee shops, restaurants, shopping malls, full coverage of MTR stations (include concourses and platforms), Airport Express stations and trains; and that an 802.11ac Wi-Fi service has also been launched.¹²
- SMT has launched a Wi-Fi Calling service which allows an auto switch between the mobile network and Wi-Fi network seamlessly depending on the network strength.¹³

Costs of mitigating measures

The economic aspects of network deployment and investment were not considered in the Study although to the extent possible consideration of cost and practicality issues were taken into account in the model assumptions. For example, stakeholder views, which were provided in the individual meetings, on the feasibility of increasing the number of sectors and sites were taken into account. It should be noted that the purpose of the Study focuses on analysing quantitatively the potential impact on service quality of changes to assignments compared to the base case and the measures that could be adopted by MNOs with a view to mitigating adverse effects of reassignment. Cost benefit analysis of the possible mitigating measures is outside the scope of the Study.

It is understood that the adoption of the different proposed mitigation measures of course would incur additional cost to MNOs, but it is in fact up to the individual MNOs to consider, based on their commercial considerations whether to invest in these mitigation measures or to acquire more spectrum in future spectrum auctions.

Negative impacts of quality of service

Negative impacts of quality of service were addressed through options for mitigating measures as described in Section 3.8 of the Study. While a negative Demand Capacity Overage (DCO) may impact aspects of performance such as data throughput or latency, it does not necessarily mean that the actual service quality offered by a particular MNO will be unacceptably impaired

¹¹ <https://gsacom.com/paper/lte-unlicensed-spectrum/>

¹² <https://www.hkcsli.com/en/csl-wi-fi/>

¹³ http://www.smartone.com/en/services_and_apps/roaming/st_wifi_calling/service.jsp (note that the service includes a feature to alert the user with a "switch on Wi-Fi" message when they are near enabled locations in Hong Kong).

if no mitigating measures are implemented. MNOs are free to acquire more spectrum through future spectrum auctions if they are concerned about the actual service quality of their networks in different environments.

2.6 Services in the MTR Premises

The impacts on the continuity of mobile services at the MTR premises are discussed in Section 5 of the Study report.

Views and comments of the respondents

HTCL questioned the assumptions as it considered Plum flawed in assuming good network upgrade progress (on 2.1 GHz, 2.3 GHz and 2.6 GHz for LTE) ignoring the fact that no agreement had been entered into. In addition, it was doubtful on whether Plum's recommendation could address the service continuity problems in MTR as DCO was not presented in the MTR case and the view was given on a qualitative assessment, rather than a quantitative analysis.

Both CEG and HKT were concerned that if HKT was unable to retain spectrum in the 900 MHz and 1800 MHz bands, there would be service degradation and quality of services issues in MTR. HKT suggested that more RFR spectrum should be granted to them according to the number of customers.

Plum's response

Plum's response to points raised in submissions is as follows.

Plum's description of the MTR environment

After the Study report was published, Plum has considered additional information relating to the architecture of the Integrated Radio Systems (IRS) implemented in the MTR premises.

Plum notes that the concise description of the provision of mobile services on the MTR set out in Section 5 of the Study report made some descriptive simplifications concerning the architecture and implementation of the IRS. Given that these were issues of description that did not influence the assessment model or the outcome of other analysis in the Study report, they are not expanded upon here, with the exception of accommodating a new entrant.

Section 5.4 of the Study report set out Plum's understanding of the position on use of Wi-Fi at MTR premises. Our current understanding of Wi-Fi deployment at these locations is based on the information available on the MTR website. It is also our understanding that the free MTR Wi-Fi services are provided by HKT and that there are usage limitations placed on the number of usage sessions per device each day.

Complexity of the MTR environment

The Study report set out the view that the MTR is a complex environment with considerable differences from the general mobile environment found in Hong Kong. This complexity included:

- The nature of the radio environment of the MTR operating in confined indoor spaces and in the tunnels (where leaky feeder technology is used).
- The characteristics of the loading of trains and people flow through the stations.
- The technical requirements arising from the distribution system within the MTR environment.
- Issues with handover in the tunnels.

These factors suggested the need for a specialist radio model framed and dimensioned on the real implementation of the MTR and a specific bottom up demand forecast. Development of such a detailed model and forecast was outside the scope of the Study.

The Study acknowledged this (see Section 5.1 of the Study report). For this reason, a qualitative assessment was undertaken using inputs obtained from the MNOs and the MTR Corporation.

MTR upgrade programme

A key aspect of the issues for the MTR on reassignment is the lack of a fully agreed upgrade programme for the IRS across the MTR network. Section 6.3 of the Study report concluded that *“At stations that have been upgraded with frequency agile equipment and in addition support the 2.3 GHz and 2.5/2.6 GHz bands, the potential impacts on service continuity when the re-assignment of spectrum in the 900 MHz and 1800 MHz bands occurs should be reduced. At stations that have not been upgraded (i.e. do not support 2.3 GHz and 2.5/2.6 GHz bands) and are reliant on legacy equipment, the potential impacts on service continuity for 4G services would need attention, if the incumbent MNOs cannot get back some or all of their existing spectrum holdings from auction”*.

Accommodating a new entrant at 900/1800 MHz

Plum notes that accommodating a new entrant following the reassignment cannot be concluded without a detailed assessment being undertaken by the MTR. Technically, the complexity depends on the portion of spectrum taken up by a new entrant and the size and power consumption of the equipment of the new entrant. Key to ensuring a smooth transition for a new entrant is to ensure that planning is done sufficiently well in advance of the reassignment date.

2.7 RFR spectrum

Plum’s recommendation on the Right of First Refusal (RFR) spectrum is set out in Section 5.6 of the Study report.

Views and comments of the respondents

HKT and HTCL shared the view that if they did not obtain sufficient amount of RFR spectrum, the quality of 4G services would be affected. HTCL considered the Plum's proposed portion of the RFR spectrum insufficient to mitigate 4G service continuity problems and submitted a counter proposal on RFR suggesting additional RFR spectrum in the 900 MHz band which was suitable for indoor coverage. Meanwhile, SMT considered that 2x10 MHz of the RFR spectrum in the 1800 MHz band was acceptable in order to address the issue of 4G service continuity at MTR premises.

CEG expressed its concern that if HKT was unable to retain spectrum in the 900 MHz and 1800 MHz bands, there would be service degradation and quality of services issues especially in the stations without the spectrum in the 2.6 GHz band.

HKT claimed that Plum was wrong to suggest that even if the incumbent spectrum holders were unable to retain any of their right to use spectrum through auction they could still rely on the spectrum they hold in other bands (850/900 MHz, 1.9-2.2 GHz, 2.3 GHz and 2.5/2.6 GHz) to continue the provision of 3G and 4G services (which implied that MNOs had excess capacity).

CEG said Plum's findings seemed to imply that MNOs' current investments were excessively creating capacity that they would not need if they were to retain their access to spectrum. It also claimed that Plum's findings were surprising in light of the earlier assessment on the case of HKT/CSL merger¹⁴ by the CA, which had expressed concern regarding service continuity of reduced spectrum allocations for existing MNOs.

Plum's response

Plum's response to points raised in submissions to Plum's recommendation is as follows.

Spectrum in the 900 MHz or 1800 MHz band

Section 5.6 of the Study report set out the logic for recommending that RFR spectrum should be in the 1800 MHz band, namely:

- The 1800 MHz band is the core LTE band in most locations in the territory.
- A possible solution is that each MNO is offered 2x10 MHz of spectrum in the 1800 MHz band on a RFR basis.
- This will allow the incumbent MNOs to retain their existing assignments of spectrum in the 1800 MHz band within the frequency range 1720 – 1780 / 1815 – 1875 MHz and it provides a solution that is compatible with the legacy IRS in the MTR premises.

¹⁴ HKT's proposed acquisition to CSL – An economic analysis of competitive effects for the CA, http://www.coms-auth.hk/filemanager/common/policies_regulations/competition/Mergers/consultancy_report_20140505.pdf

- The 900 MHz band is less suitable because only three MNOs currently have holdings in the 900 MHz band.

It should be noted that the 1800 MHz RFR recommendation is aimed at being a measure to reduce disruption during the change of assignments and it is not proposed as a measure to eliminate disruption.

Impact of reassignment on quality of service

The approach proposed in the Study report (i.e. 2x10 MHz of the RFR spectrum in the 1800 MHz band) was based on identifying solutions that potentially minimised the level of disruption at the time of reassignment. It was not intended that the recommendation should be interpreted as preserving the current quality of service experienced by individual MNOs if spectrum holdings change at the reassignment.

If an MNO does not retain its spectrum in the 1800 MHz band we accept that there would be degradation of performance on the MTR. This would in part be mitigated by other spectrum holdings deployed by MNOs on the MTR and migration of other frequency bands to LTE as quickly as possible. The extent of degradation depends on several factors including MNO spectrum holdings and the progress of upgrades taking place on the MTR.

Findings on the HKT/CSL merger

Plum has the following observations on the comparison of the assessment by the CA in respect of HKT/CSL merger¹⁵ and the findings of the Study:

- The regulatory context of the two studies are categorically different, namely an economic analysis of competitive effects of a MNO's acquisition of another vs technical study of re-assignment of spectrum in two particular bands upon expiry of the existing assignments.
- In the merger case, a reasonable remedy was applied to mitigate the competition issues that could arise through the concentration of spectrum holdings for the merged entity. This was a one-off adjustment to its spectrum portfolio to deal with a competition risk. In the case of expiry of assignments of spectrum in the 900 MHz and 1800 MHz bands, it is for each MNO to make the judgement on how it values the spectrum and the portfolio of spectrum it desires, and to bid accordingly in the auction.
- Plum had undertaken a more detailed assessment of network capacity in the Study. Thus, while both the Study and the assessment conducted by London Economics on HKT/CSL merger (LE Report) used a similar (although not identical) approach, a like-for-like comparison of the results is not possible.

¹⁵ HKT's proposed acquisition of CSL – An economic analysis of competitive effects for the CA, http://www.coms-auth.hk/filemanager/common/policies_regulations/competition/Mergers/consultancy_report_20140505.pdf

- The market and technology circumstances have changed since the LE Report which was carried out in 2013. Also, up-to-date data from all MNOs had been used in the Study and such data were not available for the LE Report.

It should be noted that the LE Report refers to the network capacity concentration in assessing the effect of the merger (and the remedies of the merger including the further divestment), whereas in the Study report, the network capacity assessment concentrates on the usage/efficiency of the relevant bands subject to spectrum reassignment. Further, technology parameters of the two studies and assumptions made regarding technology, spectral efficiency and spectrum availability are different.

3 Summary of meetings with MNOs in September 2017

On 14 September 2017, Plum conducted the fourth round of individual meetings with the MNOs. The purpose of the meetings was for discussion of the comments and submissions made by the MNOs to the Second Consultation in relation to the Study report. Three MNOs, namely HKT, HTCL and SMT, attended individual meetings with Plum, whereas CMHK opted not to meet with Plum. During the meetings, HKT and HTCL reiterated their concerns on the Study report, whereas SMT did not have any further comments.

In addition, the MTR Corporation provided further information to Plum through OFCA.

3.1 Redaction of the Study report

Views and comments of the MNOs

HKT reiterated its general concern as raised in its submission to the Second Consultation in relation to the allegedly heavy redaction of the confidential information in the published Study report.

Plum's response

Plum has addressed the issue in Section 2.1 above. In summary, Plum would like to re-iterate that it is a party to undertakings of non-disclosure of confidential information from each MNO to third parties and it cannot therefore make available any of the information that has been redacted in the published Study report.

3.2 Mobile traffic forecasts

Views and comments of the MNOs

HKT reiterated that it did not agree with the aggregate forecast presented in the Study report, and it favoured the use of the forecasts for the "rest of Asia Pacific" under the Cisco VNI.

Plum's response

Plum has addressed the issue in Section 2.2 above. In summary, Plum would like to re-iterate that the Study made use of individual forecasts based on actual historic and forward-looking data from the MNOs as these were considered to be the most reliable information to be used for the assessment. In any case, Plum had fully informed and explained the basis to the concerned MNOs during the previous meetings with MNOs, and the MNOs generally agreed with the assumptions. For reasons already explained in Section 2.2 above, it is considered inappropriate to directly apply the forecasts under the Cisco VNI as suggested by HKT.

3.3 Output of the assessment model

Views and comments of the MNOs

HKT reiterated views similar to those raised by CEG that while the assessment model provided an assessment of potential network congestion, it did not assess the impact on the quality of service experienced by users. In particular, potential loss of spectrum could negatively impact its recently launched LTE-Advanced tri-band carrier aggregation feature.

Plum's response

Plum has addressed the issue in Section 2.5 above. In summary, the assessment model is a tool that provides a representative view of network performance based on data from the MNOs and a set of general assumptions. Negative impacts on quality of service were addressed through options for mitigating measures as set out in Section 3.8 of the Study report. While a negative DCO may indicate that there may be an impact on performance (such as data throughput or latency), it does not mean that the actual service offered by a particular MNO will be unacceptably impaired. In any case, if potential reduction of spectrum holdings would impact quality of service, MNOs would be free to acquire more spectrum through future spectrum auctions.

3.4 Mitigating measures

Views and comments of the MNOs

HKT reiterated its view that the feasibility of Wi-Fi and the provision of additional sectors as mitigating measures were flawed since they had not taken into consideration various environmental and commercial constraints.

HKT also reiterated the point raised by CEG that a full cost benefit analysis of mitigating measures had not been performed in the Study.

Plum's response

Plum has addressed the issues in Section 2.5 above. In summary, the Study report has already taken into account the constraints and limitations on the use and effectiveness of the suggested mitigating measures and therefore in the assessment model, the scope for increase of the number of sectors was constrained to 10% and the amount of traffic offloading using Wi-Fi was constrained to less than 10% of traffic.

3.5 MTR

The MTR Corporation provided further information relating to the Study report. In particular, there are two corrections that Plum wishes to make to the Study report:

- In Sections 5.2.1, 5.2.4, & 5.3 of the Study report, it was mentioned that “*the IRS supporting the 900 MHz band, except for the East Rail Line and the West Rail Line, is planned to be upgraded with frequency agile equipment which will be ready for service by 2021*”.

Plum notes from the further information that the upgrade for the 900 MHz band was in fact completed in 2015. However, the frequency agility feature of the equipment is not yet in use pending written confirmations from equipment suppliers and additional tests to be carried out.

- In Section 5.2.2 of the Study report, it was stated that “*in future it may be possible to deploy dual feeders with sufficient diversity to provide MIMO capability in the tunnels and that it is unclear when this enhancement will take place and how long it will take to deploy*”.

Plum notes from the further information that the IRS in the new / extension lines (West Island Line, Kwun Tong Line Extension & South Island Line) and that in two phases of the coverage enhancement programme, MIMO capability has been / will be adopted.

Notwithstanding the above, Plum considers that neither of the above points will have a material impact on the conclusions of the Study.

3.6 RFR spectrum

Views and comments of the MNOs

HTCL sought clarification on Plum’s assessment for the MTR and the rationale for the recommendation of 2x10 MHz for the RFR spectrum in the 1800 MHz band.

In the above connection, HTCL clarified two points in relation to the RFR spectrum in the 900 MHz band:

- Spectrum in the 900 MHz band would be necessary to maintain voice coverage in tunnels especially during emergency situations as it considered the spectrum in the 900 MHz band to be more useful than that in the 1800 MHz band due to its superior propagation characteristics in the MTR environment (and especially for 2G circuit switched voice fall back).
- Given the significant development in the Narrowband Internet of Things (NB-IoT) in the 900 MHz band, the potential reduction of the spectrum holdings in the 900 MHz band for the concerned incumbent MNOs would put their investments in NB-IoT at risk.

HKT asked for an explanation of the rationale for 2x10 MHz of the spectrum in the 1800 MHz band for RFR and whether Plum had considered the potential service degradation during the transitional period when MNOs switch over to their new holdings.

Plum's response

The explanation for Plum's recommendation on RFR spectrum and the use of the 1800 MHz band vs the 900 MHz band was provided in Section 5.6 of the Study report. Further, Plum would like to point out that the recommendation made in the Study report was not aimed at the elimination of any disruption that could occur arising from the reassignment but rather as a mitigating measure for potential disruption.

In respect of the use of the 900 MHz band for emergency services and NB-IoT, if potential reduction of spectrum holdings by MNOs would impact such services, MNOs are free to acquire more spectrum through future spectrum auctions.

As regards the degradation of service during the transitional period when MNOs switch to their new spectrum holdings, it should be noted that degradation in the mobile network in general is likely to be limited and short term in nature as MNOs should be able to coordinate changes in an efficient manner between themselves. In the MTR premises, the process of equipment reconfiguration due to spectrum reassignment is a matter which the MNOs need to coordinate with the MTR Corporation to ensure a smooth switchover process.