Future supply of and demand for telecommunications infrastructure in Hong Kong

Executive summary

March 2019

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Plum Consulting has been commissioned by the Commerce and Economic Development Bureau (CEDB) of the Government of the Hong Kong Special Administrative Region to conduct a study on the future supply of and demand for telecommunications infrastructure capacity in Hong Kong for the period from 2018 to 2028.

Hong Kong is a major global economic centre. The provision of world class telecommunications facilities is key to its success and it is essential that provision of these services continues to meet the high standards of quality and availability currently delivered. These underpin not only communications within Hong Kong but also the connection with the outside world.

Hong Kong has several major competitors in Asia and around the world. All of them will be looking to enhance their competitiveness and attractiveness for economic activity. Investment in infrastructure is essential to strengthen this position (along with investments in people and reputation). Hong Kong cannot lag behind in maintaining or investing in its telecommunications infrastructure if it is to maintain its status as a leading business and financial centre.

The study addresses the following objectives:

1. to take stock of the existing telecommunications infrastructure capacity in Hong Kong and identify a corresponding set of assessment indicators and benchmarks for assessing the supply of and demand for telecommunications infrastructure capacity;

2. to project the supply of and demand for telecommunications infrastructure capacity in Hong Kong in the future;

3. to assess whether the supply of telecommunications infrastructure capacity in Hong Kong will be sufficient to meet the demand for the same in the future and maintain the competitiveness of Hong Kong vis-à-vis other advanced economies; and

4. to make recommendations on what measures, approaches and strategies the Government should take to facilitate the development of telecommunications infrastructure and to ensure that the telecommunications infrastructure capacity in Hong Kong will be sufficient to meet the demand for the same in the future and to maintain the competitiveness of Hong Kong as a leading business and financial centre.

Approach

The approach to the study was structured in terms of the following tasks:

- Stakeholder engagement.
- Benchmarking.
- Modelling.
- Consideration of industry trends.
- Results of benchmarking and modelling work.
- Conclusions and recommendations.

Each of these is described below.

Stakeholder engagement

A stakeholder engagement exercise was carried out with a range of stakeholders in Hong Kong. This was done through face to face meetings between Plum and the main telecommunications infrastructure providers, and questionnaires to different groups of stakeholders including the main telecommunications operators and other telecommunications licensees, key users of telecommunications infrastructure, major equipment vendors, industry groups, academics and other experts.

Benchmarking

The study benchmarked Hong Kong against other major economies on the supply of and demand for telecommunications infrastructure capacity to consider both the current state (i.e. how Hong Kong compares with other advanced economies in 2018) and future projections to 2028. For this, a set of supply and demand indicators for telecommunications infrastructure capacity was developed together with a set of secondary indicators. These are shown in Figure 1.

Figure 1: Potential assessment indicators

Supply indicators	Demand indicators	Secondary indicators
• Coverage (volume of premises / users covered) • Service quality (e.g. data rates, latency) • Network availability, reliability • Network utilisation levels	• Adoption (volume of service subscriptions) • Service consumption levels • Market developments, disruptions • New entrants, vertical demand • Social factors	• Service pricing • Average revenue per user (ARPU) • Lines / connections / revenue per full time equivalent (FTE) • Revenue / earnings before interest, tax, depreciation and amortisation (EBITDA) / net operating profit after tax (NOPAT) • Capex / Revenue

Eight advanced economies for the benchmarking analysis were selected in consultation with CEDB. These were:

- Japan (Tokyo).
- Singapore.
- South Korea (Seoul).
- United Kingdom (London).
- United States (New York).
- Australia (Sydney).
- Mainland China (Shanghai).
- France (Paris).

It should be noted that while the eight economies are like Hong Kong in terms of Gross Domestic Product (GDP) per capita, there are significant differences in the geographic and population characteristics particularly when considering them on a country-level basis. In general, most indicators are reported on a

country basis and city-level statistics for telecommunications are less common. Based on the data available, it was possible to carry out a reasonably robust benchmarking analysis of past and current telecommunications infrastructure for the benchmark economies at a country level. As data on future projections is rather limited, developing a complete picture of the situation for all the benchmark economies over the 10-year period (2018-2028) was more challenging. To the extent possible this is addressed by drawing on industry views gathered from the stakeholder interviews and Plum's assessment to come to an informed view on future projections for the benchmark economies.

Modelling

A series of spreadsheet models were developed to enable a level of quantitative analysis of supply of and demand for telecommunications infrastructure capacity in Hong Kong. Scenarios have been used to assess the various situations that could potentially arise. By assessing these via the use of models, it is possible to gain insight into the scale of potential impacts, which can be useful in recommending on measures, approaches and strategies the Government should take to facilitate the development of telecommunications infrastructure. The modelling spans the period 2018 (current state) to 2028.

Demand and supply aspects were modelled separately. The outputs were then used to run the scenarios used to test supply / demand relationships and potential gaps likely to occur under certain conditions. Three geotypes (urban, sub-urban and rural) were used in the modelling. These are based on population density (pop/km^2) levels, with data sourced from the Hong Kong Census and Statistics Department. The choice of thresholds is based on international benchmarks.

Information and data to inform the modelling work were sought from stakeholders in Hong Kong, including the main fixed network operators (FNOs) and mobile network operators (MNOs). The responses to the data requests yielded less data than anticipated and consequently, the level of data available at the start of the modelling work, whilst useful in many respects, was not of an optimal quality and comprehensiveness expected for a detailed evaluation of infrastructure supply and demand. Where data was lacking, Plum sought to use reasonable modelling assumptions based on experience from other work and international good practice.

Given the limitations in data quality, an approach to modelling was developed that is reasonably robust as far as practicable. Two hypothetical networks were considered for fixed and mobile market segments. In studies of this type, it is not unusual to use hypothetical designs – especially when lacking sufficient real information on the networks deployed. A reasonable level of confidence can be assumed in modelling of demand and the access aspects of supply. Limitations in data quality made it necessary to make assumptions about traffic aggregation and backhauling of traffic from the access network level to the network core.

Consideration of industry trends

There are many developments affecting decisions regarding future supply of and demand for telecommunications infrastructure capacity. Some of these are inter-related and key issues for Hong Kong are set out briefly below.

- **Changing nature of supply and demand.** There are changes occurring to the demand characteristics for telecommunications services, which may have an impact on the requirement for infrastructure. This includes a shift towards more use of streamed content on fixed and mobile networks, including a significant increase in the volume of streamed video content (video is the major driver of increase in downlink bandwidth). This and similar trends are causing equipment vendors and network operators to readjust their dimensioning approaches for networks.

- **Smart cities.** 'Smart city' programmes have been of interest to governments, entrepreneurs, and telecommunications operators, now for over a decade. Essentially, the concept is around the use of communications technologies to enable both public and private services to support citizens' needs when active in the city or other public areas. By their nature, 'smart city' initiatives are broad in scope and can encompass many service areas. A recent consultancy study on formulating the smart city

blueprint for Hong Kong, conducted for the Office of the Government Chief Information Officer (OGCIO), provided various recommendations on smart city development plans covering six areas, namely “Smart Mobility”, “Smart Living”, “Smart Environment”, “Smart People”, “Smart Government” and “Smart Economy”. The Blueprint also notes the potential importance for Public-Private Partnership (PPP) initiatives to enable smart city projects, as well as effective governance in the implementation of smart city initiatives – to enable inter-departmental strategy and policy development and delivery. Smart cities create an impact on telecommunications infrastructure, through demand for more fixed and mobile connections and increased network and datacentre capacity.

- **The move to 5G.** International Mobile Telecommunications (IMT)-2020, or 5G, is the next step for the evolution of the mobile telecommunications ecosystem. It will build on the capability already provided by Long Term Evolution (LTE)-Advanced (LTE-A) through provision of enhanced radio technology, adoption of an end-to-end communications systems philosophy and delivery of a wider range of services to end users (including services specifically focused on industry verticals). There is extensive support for 5G technology from equipment vendors. Standardisation work for 5G technology is taking place at the International Telecommunication Union (ITU) (e.g. on radio spectrum issues), within 3rd Generation Partnership Project (3GPP) (e.g. technical standards) and other industry bodies (e.g. the Global Mobile Suppliers Association (GSA) and GSM Association (GSMA) are considering policy and business issues). There are several issues to address for 5G networks and services for them to become a reality. These include: the business case for 5G services; addressing industry verticals; network technology and deployment; and access to sufficient suitable radio spectrum.

Results

Supply benchmarks

The supply benchmarks show that, in many respects, Hong Kong is among the leading economies in the benchmark set. It is a leader in the deployment of ultrafast technologies (mainly fibre-based technologies) and has extensive fibre broadband coverage (although territory-wide Fibre-to-the-Building/Home (FTTB/H) coverage is not yet achieved). Hong Kong also fares well in terms of the number of fixed broadband connections supporting a minimum of 10 Mbps. Coverage of 3G and 4G mobile services is also extensive and on a par with the other leading economies. Service quality delivered on fixed broadband networks is also good. Hong Kong has a significant amount of external international connectivity and is significantly ahead of other benchmark economies in this respect.

However, there are a few indicators where Hong Kong might not appear to score as well as other benchmark economies. Owing to service packaging by MNOs, mobile download throughput in Hong Kong did not rank very high compared to the other economies. Mobile spectrum holdings in Hong Kong are not as much as those of other economies (downlink and in total) and average holdings of spectrum per MNO are currently below the average spectrum holding of the operators benchmarked. On the latter point, it is noted that the Government and the Communications Authority have made decisions on 13 December 2018 to make available an additional 380 MHz of spectrum below 6 GHz[1] and 4,100 MHz of spectrum in the 26 GHz and 28 GHz bands to the telecommunications operators. OFCA is also actively coordinating with the Mainland concerning the use of the digital dividend in the UHF TV broadcasting band in Hong Kong post analogue switch off (ASO).

Demand benchmarks

The demand benchmarks also show that, generally, Hong Kong is among the leading economies in the benchmark set. It is a leader on the adoption of high-speed fixed broadband services. The rate of growth on fixed broadband connections is lower than that in some of the benchmark economies but Hong Kong, as of

[1] Additional spectrum below 6 GHz to be made available for mobile use includes 100 MHz of spectrum in the 3.3-3.4 GHz band (for indoor use only), 200 MHz in the 3.4-3.6 GHz band, and 80 MHz in the 4.83-4.93 GHz.

today, is in a relatively mature position. Hong Kong is a leader in fixed broadband consumption, much of which is driven by the increasing variety of video services available to consumers.

There are aspects of Hong Kong's ranking that have room for improvement when looking at mobile services. While 4G adoption per capita in Hong Kong is on par with the leading benchmarks, there is a significantly higher proportion of 2G and 3G subscriptions in Hong Kong than that in most other economies. Hong Kong's mobile broadband consumption on a per capita basis has been growing steadily but is lower than those of a few others in the benchmark set at present (such as the United States (US), South Korea and Japan).

Fixed network modelling

A number of scenarios were considered, which assumed that both demanded and supplied capacity levels continue to grow at reasonable levels. A further scenario was developed that specifically considered improvement of broadband connectivity to villages in rural and remote areas (i.e. better fibre access).

The results show that in the base case, fixed infrastructure capacity becomes constrained towards the end of the study period (i.e. from 2027). In the other scenarios the outcomes are:

- Where supply of FTTX is increased (increase in premises passed and increase in capacity supplied), supply only becomes constrained at the end of the study period (2028).
- Where customer demanded capacity is increased to around double that in the base case, the capacity supply gap is closed to zero by 2023. This would lead to a shortage of capacity if further fixed infrastructure is not supplied in response.
- In the case of villages in rural and remote areas, an improvement in connectivity shows a decrease in the supply capacity gap to the point where, with base case demand, there should not be a shortfall of capacity until 2027. However, there may still be ongoing issues with low connection speed for consumers remaining on Digital Subscriber Line (DSL). This situation will improve as the Government is rolling out a subsidy scheme to support the operators in the rollout of high-speed broadband to villages in rural and remote areas, with a view to delivering better access infrastructure to these locations.

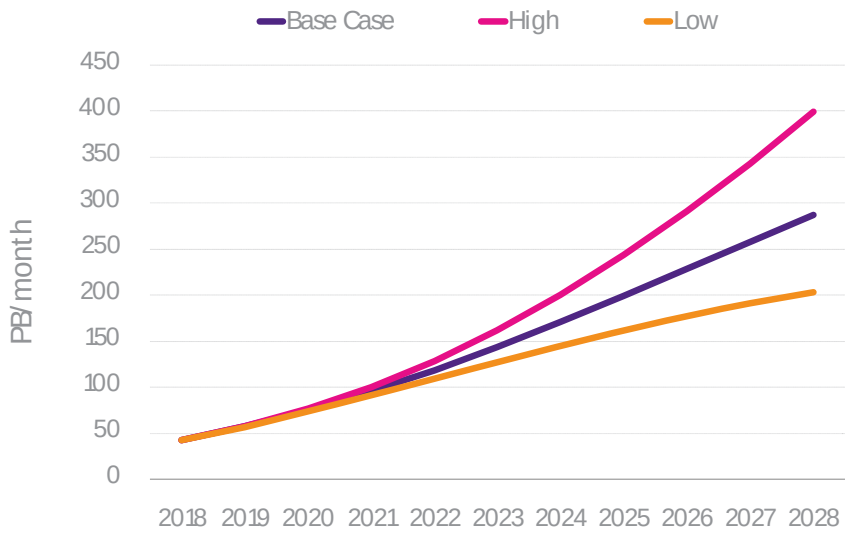
As usage patterns change (e.g. greater use of streamed video and music), demand levels will increase and there is greater likelihood for increased simultaneous demand for capacity across multiple customers. For customers with low speed access lines (e.g. supported on copper), there is also a risk that demanded capacity on a line basis will exceed the capacity supported by the line. In this case there will be material limits on the capability of these lines to support the services demanded.

Mobile network modelling

For mobile networks, several scenarios were used to test supply and demand. Three demand scenarios and three supply scenarios were considered. The case where additional spectrum is made available in the 3.3 GHz and 4.9 GHz bands was also considered as a sensitivity assessment.

The demand scenarios are: base case demand, high demand and low demand. These are shown in Figure 2.

Figure 2: Demand scenarios



The supply scenarios are based on the number of sectors that are able to support in the mobile network. This is summarised in Figure 3.

Figure 3: Supply scenarios

Supply scenario	Maximum sectors per site	Additional site roll-out in urban areas
High	4	Additional omnidirectional sites where needed
Base-case (central)	4	No more sites possible
Low	3 (in congested areas)	No more sites possible

The assessment shows that there is no capacity shortfall for 3G services under all scenarios. 3G traffic is declining and is expected to continue to fall, meaning that the current level of infrastructure is adequate to support all future 3G service demand. Hence, the focus is on the analysis of results for 4G and 5G services.

Figure 4 and Figure 5 show the summary of results by scenarios for 4G and 5G services respectively in the case where there is no additional spectrum in the 3.3 GHz and 4.9 GHz bands. The assessment shows that there is no shortfall in rural and suburban areas, notwithstanding there may be a shortfall in some hotspots in urban areas.

If additional spectrum supply in the 3.3 GHz and 4.9 GHz bands is considered, the shortfall will disappear altogether for 4G and there will be no capacity shortfall in all areas under the central case.

Figure 4: Mobile scenario outcomes (4G services)

Supply/demand Scenario	High demand	Base-case demand	Low demand
High supply	Supply meets demand for all years	Supply meets demand for all years	Supply meets demand for all years
Base-case supply	Supply meets demand, except for some hotspots in urban areas	Supply meets demand, except for some hotspots in urban areas	Supply meets demand, except for some hotspots in urban areas

Supply/demand Scenario	High demand	Base-case demand	Low demand
Low supply	Supply marginally meets demand, except for some urban areas, with shortfall peaking in 2024	Supply marginally meets demand, except for some urban areas, with shortfall peaking in 2023	Supply meets demand, except for some hotspots in urban areas

Figure 5: Mobile scenario outcomes (5G services)

Supply/demand Scenario	High demand	Base-case demand	Low demand
High supply	Supply meets demand for all years	Supply meets demand for all years	Supply meets demand for all years
Base-case supply	Shortfall in some urban areas from 2025	Supply meets demand, except for some urban areas from 2025	Supply meets demand, except for some hotspots in urban areas from 2026
Low supply	Shortfall in some urban areas from 2024	Shortfall in some urban areas from 2024	Supply meets demand, except for some hotspots in urban areas from 2025

The assessment of the base-case demand versus base-case supply (excluding spectrum in the 3.3 GHz and 4.9 GHz bands) shows that capacity shortfall for 4G is expected in some urban areas from 2019 with the shortfall growing until a peak in 2023 before declining as traffic migrates over to 5G. While capacity issues on 4G starts to alleviate from 2024, there could, nevertheless, still be problems in hotspots such as commercial centres and rail link stations, which were not explicitly modelled due to a lack of information, but which experience extremely high traffic volume.

For 5G services, the situation looks better, if 5G infrastructure is deployed in the 3.3 – 3.6 GHz band. No capacity shortfall is expected in urban areas until 2025 under the base case demand versus base case supply scenario. However, the gap would widen from 2025 onwards unless more spectrum or infrastructure is added. As noted above, there will be no capacity shortfall in all areas under the central case when spectrum in the 3.3 GHz and 4.9 GHz bands is available.

It should be noted that the modelling has not tried to estimate the demand for and impact of mmWave infrastructure nor has it attempted to capture whether individual users would be provided a sufficient quality of service for what they need. This is due to the limitation of the data available. We would expect significant deployment of mmWave sites by the mid-2020s which should address any capacity shortfall for 5G.

Conclusions and recommendations

The study shows that today Hong Kong has good telecommunications infrastructure, comparable with that of many of the other leading economies considered for the study. Much is already being done in Hong Kong to facilitate the provision of future supply of telecommunications infrastructure. Recent initiatives include:

- The decisions to release a total of 4,480 MHz of spectrum in the 3.3-3.6 GHz, 4.9 GHz, 26 GHz and 28 GHz bands for mobile service. The spectrum in the 26 GHz and 28 GHz bands will be a key enabler for deployment of high density 5G small cell networks.

- The release of the 5 GHz shared band for the provision of public mobile services based on new technology like Licensed Assisted Access (LAA).

- OFCA is actively coordinating with the Mainland with a view to making available spectrum in the UHF TV broadcasting band for use in Hong Kong post ASO.
- Facilitation of access to government premises and public facilities for setting up of radio base stations.
- The creation of a one stop shop process for speeding up deployment of radio base stations at selected government premises.
- The review of the Telecommunications Ordinance is underway, and it will consider the telecommunications regulatory regime and its suitability to handle new telecommunications technologies, including 5G services and internet of things (IoT).
- Creation of a new wireless internet of things (WIoT) licence.
- Establishment of a subsidy scheme to provide financial incentives to operators to extend fibre-based networks to villages in rural and remote areas.

Examples of similar government-driven initiatives in other economies show that there is a growing level of activity to move countries / regions to be in a position where users will have access to advanced telecommunications infrastructure and facilities. In some respects, Hong Kong has already completed part of this journey with the extensive deployment of fixed fibre services. However, it is not as far advanced on mobile services.

Below are recommendations developed from the study. These are grouped according to: issues where action may be required, those where the government / OFCA could facilitate progress and issues to keep a watch on.

Key issues for action

- Working towards releasing the spectrum set out in the spectrum roadmap together with more spectrum as announced recently in the sub-6 GHz bands and mmWave bands, and work to make available spectrum in the UHF TV broadcasting band after ASO subject to frequency coordination.
- The existing procedures for access to land, highways and buildings for deploying telecommunications infrastructure may need to be revisited to ensure that they are sufficient to meet the future needs of network operators going forward. This should take account of the increase of density of networks forecast to occur with 5G.
- Ensuring timely progress with upgrade of infrastructure in villages in rural and remote areas to minimise the risk of an urban-rural digital divide.

Areas for facilitation

- Speeding up and easing the process for implementation of new telecommunications infrastructure and upgrading of existing infrastructure for rail links. It is recognised that the agreements between MNOs and the providers of rail services are commercial arrangements and that the licensed entities are the MNOs, which lack the regulatory locus for intervention
- Continue to strengthen support and facilitation for the telecommunications operators to get access to suitable government premises and public facilities for setting up radio base stations for 5G or other mobile uses by streamlining the process and strengthening the coordination within the Government.

- Ensuring appropriate frameworks for telecommunications infrastructure and services are in place. A key area of interest for 5G is the emerging field of industrial automation and IoT. These new use cases are likely to involve different business models and new players beyond the traditional telecommunications players. New forms of spectrum access and licensing approaches as well as a review into whether the current regulatory regime and licensing rules are appropriate to facilitate such uses may be required.

Things to keep a watch on

- Improving coordination and collaboration of multiple government departments or other public agencies. The nature of developments and initiatives impacting telecommunications infrastructure requires the ability to make changes quickly. In future, there will be a need for effective and efficient inter-departmental working to ensure that deployment occurs in a timely manner.

- Future developments with spectrum bands for 5G and in particular activity at World Radiocommunication Conference (WRC)-19 and within the Asia Pacific Telecommunity (APT) also need to be taken into consideration.

- Monitoring the progress of 5G implementation, in particular:

  - The need for efficient infrastructure build (e.g. sites and backhaul) and whether infrastructure sharing is required on a wider scale than at present.

  - Whether aspects of 5G services face barriers to deployment (e.g. services for verticals).

It is recognised for the items in this category that it may well be too early to make any regulatory intervention. At this time the policy goals should be clear, and the means established to keep the items under review.