CONSULTATION PAPER ON:

FIXED-WIRELESS BROADBAND NETWORK DEPLOYMENT AND SERVICE PROVISIONING IN SINGAPORE

SUBMISSION OF:

MILLICOM INTERNATIONAL CELLULAR (ASIA) PTE LTD

PROPOSED APPROACH TO FIXED-WIRELESS BROADBAND NETWORK DEPLOYMENT AND SERVICE PROVISIONING IN SINGAPORE:

SUBMISSION OF MILLICOM INTERNATIONAL CELLULAR (ASIA) PTE. LTD.

Millicom International Cellular (Asia) Pte. Ltd. is a fully owned subsidiary of Millicom International Cellular S.A. ("Millicom"). Millicom is already operating Wireless Broadband services in the United Kingdom and is rolling out services in a number of other countries. Based on our experience, we can see clear benefits from the speedy introduction of Wireless Broadband services in Singapore.

Millicom has carefully considered the issues raised by the Authority, and in developing its response has drawn on the expertise of Millicom's technical staff currently working on Wireless Broadband services. This submission consists of seven sections:

- **Section One** provides background material on Millicom International Cellular S.A., and the Wireless Broadband services we are providing;
- **Section Two** reviews the potential demand for Wireless Broadband services in Singapore;
- **Section Three** considers the spectrum management issues arising from Wireless Broadband services;
- **Section Four** addresses the licensing issues flowing out of Wireless Broadband services;
- **Section Five** sets out the technical issues associated with Wireless Broadband services;
- **Section Six** outlines the other matters Millicom wishes to highlight in its submission; and
- **Section Seven** draws together a summary of Millicom's submission.

SECTION ONE: MILLICOM INTERNATIONAL CELLULAR:

1.1 Millicom International Cellular S.A. is an international telecommunications company, listed on NASDAQ, and based in Luxembourg. Millicom currently has 30 mobile operations in 19 countries, with over 1.7 million mobile customers worldwide. Millicom has its regional headquarters in Singapore, and provides services in a number of countries in the Asia-Pacific region, including: the Philippines, Vietnam, Cambodia, India, Pakistan, and Sri Lanka. Millicom is also very active in the field of Wireless Broadband services.

1.2 In the United Kingdom, Millicom operates Tele2 UK Ltd, a Public Telecommunications Operator. Tele2 UK was the first commercial Wireless Broadband operator in Europe, receiving its licence in 1995, and commencing its service in August 1998. Tele2 UK currently operates in the Thames Valley region, but is expanding its network on an ongoing basis, and plans to be providing coverage to 60% of the UK population by the end of 2003.

1.3 Tele2 UK operates via 2 x 84 MHz of capacity in the 3.4 GHz band. The company provides broadband wireless data communications services at speeds from 128 KBit/s to 384 KBit/s, and can operate up to 2 Mbit/s. The primary focus of Tele2 UK is on high-speed Internet access and Intranet services, principally for small and medium sized enterprises (SMEs) and small office/home office (SOHO) applications. As of 30 June 1999, Tele2 UK reported 335 wireless broadband connections, supporting more than 2,300 broadband users (and the company has grown significantly since this time).

1.4 Millicom is expanding its Wireless Broadband services, and is introducing the service into a number of new countries. Millicom has been awarded licenses to operate Wireless Broadband services in:

- the Czech Republic (commercial licence awarded);
- Poland (commercial licence awarded);
- Argentina (commercial licence awarded);
- El Salvador (commercial licence awarded);
- Paraguay (commercial licence awarded);
- the Netherlands (trial licence awarded);
- Belgium (trial licence awarded); and
- France (trial licence awarded).

1.5 In addition, Millicom plans to launch commercial Wireless Broadband services in one of its Asian operations in June 2000. The comments set out in this submission are based on Millicom's hands-on experience in providing commercial Wireless Broadband services.

SECTION TWO: POTENTIAL FOR FIXED-WIRELESS BROADBAND TECHNOLOGY

Question: IDA seeks comments on the potential of and benefits arising from the deployment of fixed wireless broadband networks, the likely services/applications to be deployed, and the potential demand from business and consumers.

Potential of Wireless Broadband Services:

2.1 Based on Millicom's experience in other markets, we can see considerable potential for Wireless Broadband services in Singapore. Millicom's views are based on the following observations of the Singapore market:

- ***High demand for Internet services***. According to IDA figures, the total number of dial-up internet customers in Singapore grew by over 51% between January 1999 and January 2000, with internet penetration currently standing at 19.2 users per 100 head of population. High-speed internet access is one of the principle applications of Wireless Broadband services.

- ***High charges for leased circuits.*** While leased circuit charges in Singapore are lower than in many other countries in the region, they are still significantly higher than in countries such as the United States. For example, a recent study by the European Commission[1] noted that the monthly charge for a typical 5km 1.5 MBit/s leased circuit in the United States ranges between US$250 and US$375 (S$425 and S$638) per month, which compares very favourably to the rates for equivalent services in Singapore. Millicom believes that high leased line charges are a major reason why "Total Costs" and "Set-up Costs" have been identified by the industry as barriers to e-commerce adoption.[2]

- ***Unmet demand for high speed services.*** There is evidence that there is demand for high-speed services in Singapore that is not being met by existing fixed data services. For example, the ICT Usage Survey 1999 found that less than 2% of all internet users in Singapore access the internet via leased circuits faster than 64 Kbit/s. Looking at regional comparisons, in the Hongkong SAR there is currently 1 customer accessing the internet via leased circuits for every 231 dial-up customers; whereas in Singapore there is only 1 customer accessing the internet via leased circuits for every 324 dial-up customers. Millicom believes that there are a significant number of customers who would benefit from high-speed broadband services, but who have chosen (for whatever reason) not to take fixed leased circuits.

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[1] "Commission Recommendation on Leased Lines interconnection pricing in a liberalised telecommunications market", Commission of the European Communities, 24 November 1999.

[2] See "Key Findings of ICT Usage Survey 1999 on the ICT Adoption of Business in Singapore", IDA.

- ***Development of "bandwidth-hungry" services.*** Demand for services such as application hosting and web-hosting is growing strongly, particularly with SMEs. Forrester Group has estimated that the market for applications hosting will grow from US$993 million in 1999 to US$11.3 billion in 2003, with the majority of demand coming from companies with less than 1,000 employees. As demand for these services grows, demand will also increase for high-speed high-capacity data services. Wireless Broadband services are ideally placed to meet this demand.

- ***Lack of competing fixed infrastructure.*** If (as reported) StarHub intends to focus its access network primarily on corporate customers in CBD areas, this will mean that: (a) there will be limited competing fixed infrastructure in non-CBD areas; and (b) that non-corporate customers will have little choice as to their data service provider. In this situation, Wireless Broadband services are an ideal technology to deploy, as their deployment requires less time and capital expenditure than fixed networks, but they still provide serious competition to fixed data services.

Benefits from Wireless Broadband Services:

2.2 The Authority has correctly noted the benefits that can accrue from the deployment of Wireless Broadband services in terms of: rapid market entry, rapid network roll-out, and the deployment of innovative services. As an operator of Wireless Broadband services, Millicom would summarise the benefits of Wireless Broadband services as follows:

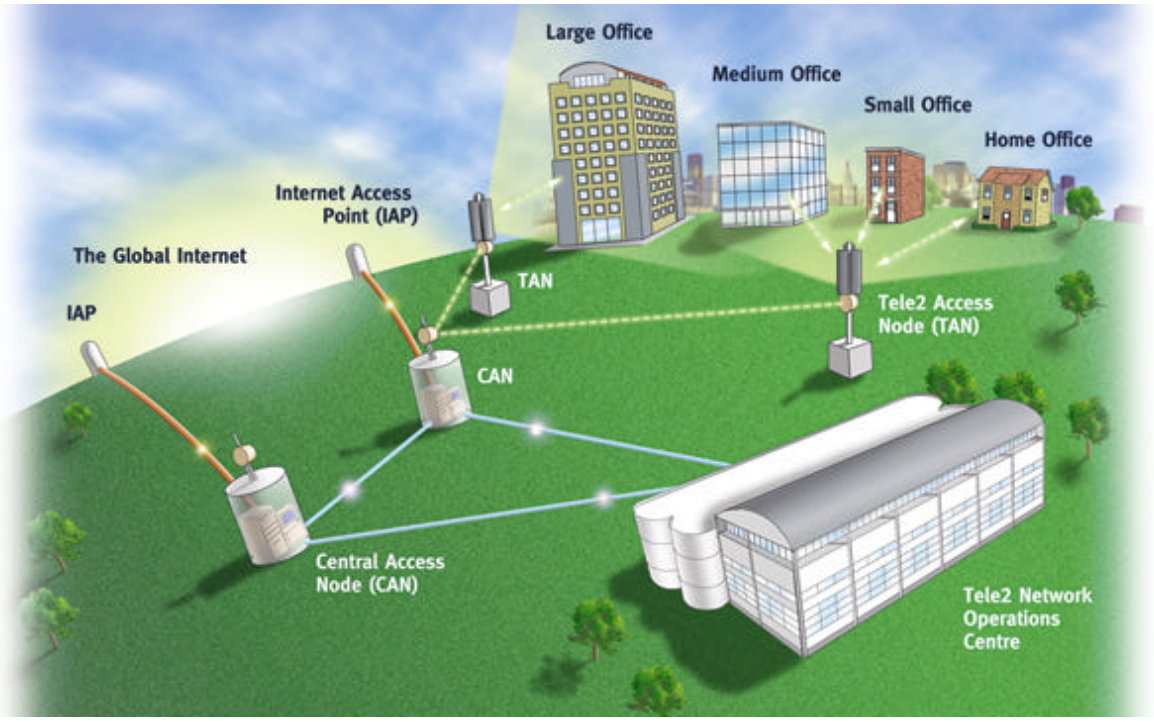
For Customers:
- Lower charges and more innovative pricing structures;
- Faster installation and set up times for services;
- Greater flexibility when re-locating between sites;
- Minimum disruption with installation (e.g. no road excavation required); and
- Scalability.

For Operators:
- Flexibility in network deployment;
- Capital expenditure is related to the winning of customers;
- Ability to avoid having to use unbundled local loops;
- Reduced cost of deploying network; and
- Ability to respond to customer needs quickly.

For Government:
- Rapid development of competition in data services;
- Facilitation of fast internet access and e-commerce services for SMEs;
- Development of competing infrastructure outside of main CBD areas; and
- Minimal impact on the environment (in terms of disruptions from road opening, etc).

Services and Applications to be Deployed:

2.3 In deploying Wireless Broadband services in Singapore, Millicom would want to structure its network with a point-to-multipoint architecture (i.e. with a single "access node" radio with multiple rooftop antennae, each covering a different sector). These access nodes would link into a central access node, and through a Network Operations Centre, linking into the internet. A diagramatic representation of the Tele2 UK Wireless Broadband network is set out below.



2.4 In deploying Wireless Broadband services in the United Kingdom, Millicom is focussed on SME and SOHO customers. Millicom has structured its services and tariffs based on the customer's data speed and the volume of data downloaded (see Table 2.1).

Tele2 UK Services and Tariffs

Data Plan	Monthly Allowance (Mbytes)	128 KBit/s	256 KBit/s	384 KBit/s	Overage (per Mbyte)	Connection (one-time)
Tele2 Internet 500	500	£65	£130	£195	£0.50	£290
Tele2 Internet 800	800	£95	£190	£285	£0.50	£290
Tele2 Internet 1500	1500	£175	£275	£345	£0.50	£290
Tele2 Leased Line	Unlimited	£395	£645	£945	N/A	£465

2.5 Millicom has found that its Wireless Broadband services are used primarily for Internet and Intranet access. A growing numbers of Millicom's customers are using Wireless Broadband services for web-hosting services. Other applications for Wireless Data services are set out in section 3.2 below.

Potential Demand:

2.6 Millicom believes that there would be significant demand for Wireless Broadband services in Singapore. This conclusion is based on our experience in the United Kingdom, and the growth of Wireless Broadband services in the United States.

2.7 In the United Kingdom, Millicom is already experiencing high demand for our Wireless Broadband service. In a recent consultant's report[3] it is stated that in less than 18 months of operation, Millicom achieved a 5% penetration of the business market in the areas it operates in. Millicom would comment that the penetration of its Wireless Broadband service is now significantly higher than 5%.

2.8 In the United States, Wireless Broadband networks have been operational for some time, and their services are commensurately more advanced. A profile of four of the largest Wireless Broadband operators is set out below:

Wireless Broadband Operators in the United States

	ART	**NEXTLINK**	**Teligent**	**Winstar**
Operating Statistics				
Building Access Rights	4,400	NA	7,000	8,000
Installed Lines	NA	428,035	76,000	618,000
Total Customers	NA	30,574	7,500	23,300
Services Offered				
Voice	No	Yes	Yes	Yes
Data	Yes	Yes	Yes	Yes
Internet Access	No	Yes	Yes	Yes
Web-hosting	No	No	Yes	Yes
Application Hosting	N o	No	No	Yes
Target Customers				
Large Businesses	Yes	No	No	Yes
Small/medium Businesses	Yes	Yes	Yes	Yes
Residential	No	No	No	No
Carriers	Yes	No	No	Yes

Source: "Broadband Wireless Access", Robertson Stephens, February 2000

2.9 Based on our knowledge of the UK Wireless Broadband market, we believe that Wireless Broadband operators in Singapore should be able to attain a 10-15% of the businesses within their coverage areas within the first 24 months of operation.

[3] See "Broadband Wireless Access", Robertson Stephens, February 2000.

SECTION THREE: SPECTRUM MANAGEMENT ISSUES

Question: IDA seeks comments on the possible uses for the fixed-wireless broadband technology, and how the competing demands for the spectrum be managed, including the allocation process, the timing of the process and criteria to be used. IDA also seeks comments on whether there are interconnection and access issues that may pose problems in achieving IDA's objective of transparent and seamless interconnection and open access; and how these may be practically and realistically addressed. IDA further seeks comments on the type and level of QoS standards, including both type and level of QoS standards, that would be appreciate to benchmark the quality of the network and services deployed.

Use of Fixed Wireless Broadband:

3.1 Millicom considers that the most effective use of fixed-wireless technology is as Wireless Broadband services. Wireless Broadband services are a flexible and efficient way of providing tailored high-capacity services to customers (particularly SME and SOHO customers). Internationally, Wireless Broadband services are being used to provide a range of innovative info-communication services. For example:

- In the United Kingdom, Millicom is promoting Wireless Broadband as a cost-efficient way of providing access for tele-working customers. Wireless Broadband services allow remote-site customers to access their corporate LAN at high speed, without incurring the high cost of leased circuits or ISDN services.

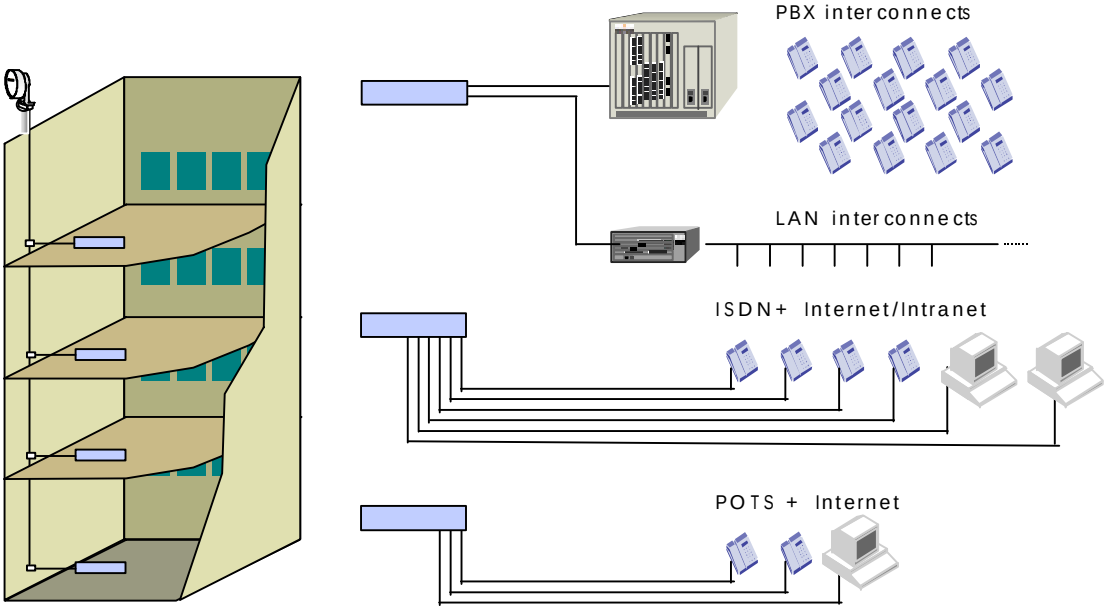
- Millicom is also looking at working with Application Service Providers (ASP) to provide bundled services. While ASP services are tipped to grow significantly (particularly for SMEs), these services will only succeed if customers can access them at high speed, in a cost-effective manner. Wireless Broadband services will have a very important role to play in the deployment of ASP services.

- Hosting of web-pages and e-commerce sites is another area where Wireless Broadband operators have been active. SMEs frequently lack the in-house skills and training to operate web-pages and e-commerce sites themselves,[4] and many are moving to out-source these services. However, such outsourcing will only be effective if customers can have high speed access to their sites, and Wireless Broadband is extremely effective in this role.

[4] Singapore appears to follow this trend. The ICT Usage Survey 1999 found that "Lack of IT Expertise", "Insufficient Training", and "IT Management Shortage" were among the main impediments to computerisation in Singapore.

- Manufacturers of Wireless Broadband technology have a large range of interfaces available to allow a comprehensive range of telecommunication services to the customer through the Wireless Broadband service.

Typical Wireless Broadband Deployment



3.2 The following applications can be provided through Wireless Broadband services:

- ***Bursty/Packet/IP Data services;*** Millicom strongly believes that the main focus of Wireless Broadband applications must be on the delivery of Bursty/Packet/IP data services. The needs of SMEs, SOHOs, and residential customers are no longer served by voice and voice-band services alone.

- ***Leased Circuits;*** Leased circuit services can be provided at the E1 or Fractional N*E1 level (subject to spectrum availability). Typical lease line applications are: PBX connections and WAN connections.

- ***Switched Telephony***; Switched telephony services could be provided to customers via Wireless Broadband, as a supplement to the customer's data service.

- ***Video;*** Wireless Broadband can provide digital video broadcast services such as pay-per-view services, information on demand, and video monitoring. Given the large amount of spectrum required for this service, Millicom considers video monitoring services the most appropriate video application for Wireless Broadband services.

Spectrum Allocation:

3.3 The Consultation Document proposes to make available 3.55 GHz of spectrum, and has noted the potential uses of that spectrum. Millicom considers that the following criteria should be used in allocating this spectrum:

- **Consumer Benefit**, in terms of whether the proposed application of the spectrum provides new services and lower prices to customers;

- **Value-Add**, in terms of the additional value generated to the customer and the operator through the particular application of the spectrum;

- **Generation of Competition,** in terms of whether the use of the spectrum will generate additional competition in the market (particularly in areas of the market unlikely to be served by other operators);

- **Facilitation of Advanced Info-communications Services,** is terms of services that will facilitate Singapore's development as an info-communications hub;

- **Nation-wide Service**, in terms of services that will be available to the general public of Singapore, rather than to a limited geographic subset of it.

3.4 Based on these criteria, Millicom considers that the most valuable use for the spectrum is as Wireless Broadband services. Using the spectrum to complement traditional fixed line services will generate little value for users, and is unlikely to facilitate Singapore's development as an info-communications hub. Similarly, using the spectrum for linking mobile base stations will not provide direct benefits to customers, and in addition will not generate additional competition in the market. The final use of the spectrum - television broadcasting - would bring very little "value-add" to the market, and again would fail to make a significant contribution to Singapore as an info-communications hub.

3.5 Millicom therefore believes that the spectrum should be allocated to Wireless Broadband services, and that this allocation should take place as soon as possible. Wireless Broadband services are a commercial reality today, and there are capable companies ready to provide these services in Singapore almost immediately. Holding back the allocation of spectrum would simply delay the introduction of services to customers, and would put Wireless Broadband operators at a serious disadvantage against fixed operators (who will be free to enter the market from 1 April 2000), which would be in conflict with the Authority's technology-neutral approach.

Interconnection and Access Issues:

3.6 If they are carrying voice traffic for their customers, Wireless Broadband operators will need to interconnect with fixed and mobile facilities-based operators. It will be necessary to ensure that Wireless Broadband operators are treated in a non-discriminatory manner (in terms of the price, functionality, quality and performance of the interconnection they receive), compared to other facilities-based operators. However, provided this condition is met, Millicom does not believe that interconnection will pose serious problems for the development of Wireless Broadband services in Singapore.

3.7 Nevertheless, there could be issues with Wireless Broadband services that impact on the Authority's stated objective of open access. To provide Wireless Broadband services to a customer, it is necessary to establish an antenna on the customer's premises, and then to link into the premises. Millicom's strong preference is to lay its own cabling, and will usually site its antennae to minimise the cabling required. However, there could be cases (e.g. in buildings with congested risers) where it is not possible for a Wireless Broadband operator to install its own cabling. In these situations, Wireless Broadband operators would need to lease the existing cabling from a fixed operator. Again, the terms of such leasing should be non-discriminatory.

Quality of Service:

3.8 Millicom considers that quality of services (QoS) will be a critical issue for Wireless Broadband operators, and a key competitive differentiator between the operators. Millicom believes that the most effective way of addressing QoS is to leave it as a factor for each operator to determine as part of its commercial offerings. QoS, like functionality and price, is an important consideration in any service offering, and (like functionality and price) can be left to customers and operators to determine.

3.9 However, if the Authority is seeking to set specific QoS levels, Millicom considers that Wireless Broadband operators should be subject to the same QoS levels as fixed leased circuit providers (in terms of service reliability, repair times, etc). Millicom believes that there is no technical reason why Wireless Broadband services could not meet the same QoS levels as fixed services. Millicom bases this position on the short distances involved in operating in Singapore, and the low BER levels that forward error correction systems can generate. In addition, as the primary role of Wireless Broadband services is IP, which also includes flow control and packet re-transmit if an error occurs, this should ensure that a high QoS is maintained.

Question: IDA seeks comment on the amount of spectrum that should be made available for terrestrial fixed-wireless broadband versus satellite services, including the timing for review of spectrum reservation and allocation, where appropriate.

3.10 The Authority has noted that the frequency band of 28.6 - 29.1 GHz is currently allocated for the up-linking from the Earth to a Low Earth Orbit (LEO) Satellites. Millicom believes that this allocation is unnecessary, and that this frequency band should instead be re-allocated to fixed-wireless broadband (where there is an obvious and immediate demand for the spectrum).

3.11 Millicom believes that there will be little demand for LEO services in Singapore. This lack of demand is due to the fact that a single satellite cell radius would cover a large proportion of the landmass in Singapore. As the satellite service would have to follow a frequency reuse pattern (similar to terrestrial wireless services), there would only be very limited bandwidth for use by customers in Singapore. Given the high capital cost of establishing a satellite earth station facility, with little local demand, this service may not be viable in Singapore.

3.12 Millicom therefore considers that the frequency band 28.6 - 29.1 GHz should be re-allocated to fixed-wireless broadband services. As set out below, this will allow significantly larger amounts of spectrum to be allocated for Wireless Broadband services, allowing the Authority to issue additional licenses, thus stimulating competition in the market.

Question: IDA seeks comment on the optimal amount of spectrum to be allocated to each operator, including the detailed assumptions / basis / calculations used to derive the proposed spectrum bandwidth, and the timing of the allocation where appropriate. IDA also seeks comment on the optimal number of operators that can be licensed, bearing in mind the future growth of the broadband market in Singapore.

3.13 The IDA has identified four operating bands for the supply of Wireless Broadband services:

- 25.25 - 27.00 GHz;
- 27.50 - 28.60 GHz;
- 29.10 - 29.50 GHz; and
- 31.00 - 31.30 GHz.

3.14 Millicom recommends that the IDA apply ITU-R standards F.748-2, F.748-3 and F.755-2 F.758 to the nominated frequency bands. The adoption of the ITU-R standards will allow for the most efficient use of the spectrum and the selection of readily available Wireless Broadband equipment.

Bandwidth required for the Operator:

3.15 Customer density drives the bandwidth required by Wireless Broadband operators and the capital cost of constructing the network. As Singapore has a high-density of customers, the Bandwidth allocated to operators needs to be divided in reasonable segments. Please see the example below.

Capacity Example:

Based on a maximum cell radius for a QoS at 99.9% availability, which is determined by rain attenuation, a radius of 2.1 km can be achieved. This would give a coverage area of approximately 13.8 Km sq.

Assuming a customer density of 1,000 subscribers per sq. km, then the total subscribers covered under the Base station cell is 13,800.

Services offered	5% POTs voice traffic, 10% leased circuit traffic, 85% Internet data traffic

Assuming that the traffic for one POTS subscriber is equivalent to that of a residential subscriber or 0.1 E busy hour traffic, this would require approx. 90 x 64 KBit/s circuits for connection of 690 subscribers at 0.1E with a loss rate of 0.1%, thus a rate of 5.75 MBit/s for telephone traffic.

Leased circuit traffic is a permanent connection and utilizes the Wireless Bandwidth continuously. An assumption of 128 KBit/s is assumed as the average leased circuit (Basic Rate ISDN). This gives a rate of 177 MBit/s for lease line traffic for 1,380 subscribers.

For internet traffic, we will assume that it is necessary to give customers a connection at least at a rate obtainable with a telephone modem (i.e. 56 KBit/s). As all customers are unlikely to log on at the same time, each subscriber will in fact have access to instantaneous higher rates (up to several MBit/s). This gives us a rate of 66 MBit/s for Internet traffic for 1,1730 subscribers

POTs voice traffic	5.75 MBit/s
Leased circuit traffic	177 MBit/s
Internet data traffic	66 MBit/s
Total for Base Cell Site	248.75 MBit/s

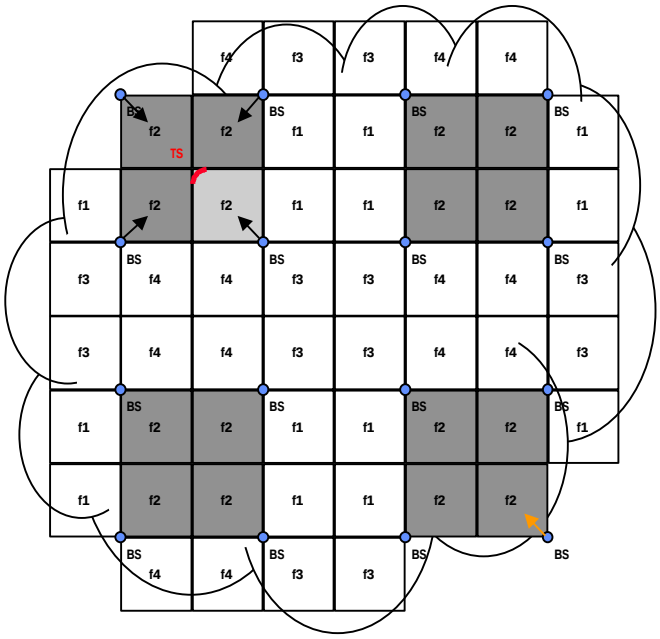
In the example calculations a total of 248.75 MBit/s of traffic would be generated in the proposed area which corresponded to the maximum cell radius of a single base site.

3.16 The key point to note in the above example is the cell radii. Millicom foresees that as demand for the services and for capacity increases, cell radii will be reduced to a few hundred meters in some areas (in order to handle the large volumes of traffic). Rain attenuation and QoS will become less of a problem for operators, given the small cell radii.

3.17 ks should be built using a principle of four-sector cell sites. The arrangement would involve repeating the

polarization to reduce co-frequency interference. Frequency Planning would take into account specific local conditions to optimize the network.

3.18 Square coverage has been optimised by using an antenna with a 90° beamwidth.



Hypothesis:

- Fixed Terminals
- Sectorial antennas in Base Station (90
- Directive antennas in Terminal (3 to 6°)
- Line of sight between BS & TS

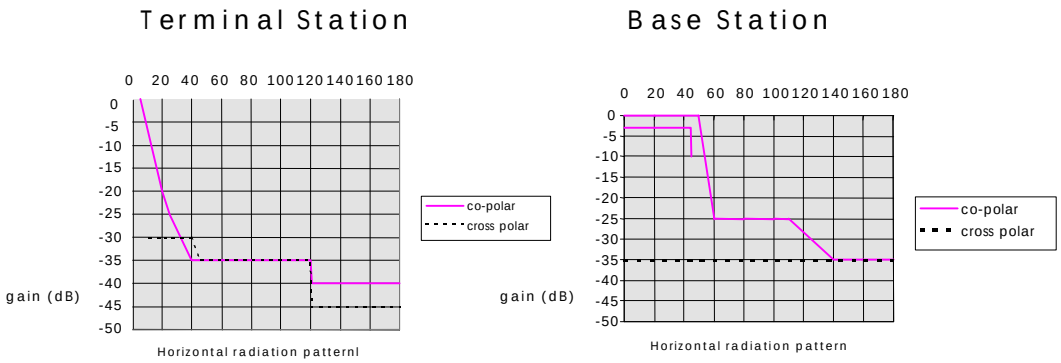
- Eb/No = 12 dB min, C/I = 14 dB

Representation of co-frequency interference sources for a given zone

3.19 With this type of coverage, four frequencies (or four frequency bands) allow one to work with a Carrier/Interference ratio of 14 dB. This value of 14 dB is obtained with the following hypotheses:

- Fr/Back ratio of the sectoral antenna (base station) equal to 35 dB;
- Fr/Back ratio of the directional antenna (terminal station) equal to 40 dB;
- All the terminals are in direct line of sight of the base station;
- Free space propagation;
- Negligible interference on the adjacent channels; and
- The useful signal and the interference are attenuated by the same amount in the event of rain.

3.20 The same frequency reuse scheme can be used with cross-polarization:
in that case F4 = F1' and F3 = F2'. Typical Antenna radiation pattern are:



3.21 If, for a basic square, the calculated capacity exceeds the handling capacity of the maximum usable number of radios, this means that the cell is too large for the capacity, and that it will have to be reduced to ensure adequate coverage. This would obviously be corrected by increasing the number of Base Stations as traffic grows.

Allocation of 25.25 - 27.00 GHz Band:

3.22 The Authority has nominated 25.25 - 27.00 as one of the proposed frequency bands for Wireless Broadband services. Millicom would note that this band does not take full advantage of the available bandwidth that is open to the Authority. Rather than using the proposed band, Millicom would suggest that the IDA adopts the frequency band 24.5 - 26.5 GHz as per ITU-R F.748-2. This range would provide bandwidth of 2.0 GHz of which 1.0 GHz could be allocated for each up-link and down-link path. This frequency band is shown as being available in the IDA's spectrum register.

3.23 Even though there is up to 2 GHz of Bandwidth under the ITU-R recommendation for the 25 GHz band, Millicom recommends that the band be sub-divided into four sub-bands, each of 2 x 224 MHz each as per the ITU-R recommendations.

3.24 Based on the ITU-R, the allocation of the 25Ghz Band is,

Sub Band	**Band-Width allocated**	**Down-Link**	**Up-Link**
25 / 1008 / A	2 x 224 MHz	24.549 to 24.773 GHz	25.557 to 25.781 GHz
25 / 1008 / B	2 x 224 MHz	24.773 to 24.997 GHz	25.781 to 26.005 GHz
25 / 1008 / C	2 x 224 MHz	24.997 to 25.221 GHz	26.005 to 26.229 GHz
25 / 1008 / D	2 x 224 MHz	25.221 to 25.445 GHz	26.229 to 26.453 GHz

The channel separation is 1008 MHz

3.25 Set out below is an example from the ITU recommendations for the Radio-frequency channel arrangements for CEPT administrations in the band 24.5-26.5 GHz. The Recommendation for down-link carrier sizing is 112 MHz, 56 MHz, 28 MHz, 14 MHz, 7 MHz and 3.5 MHz, and is derived as follows (ITU-R F.748-3 extract):

Let f_0 be the reference frequency of 25 501 MHz $= f_r + (358 \times 3.5)$ MHz,
f_n be the center frequency of a radio-frequency channel in the lower half of the band,
f'_n be the center frequency of a radio-frequency channel in the upper half of the band,
then the center frequencies of individual channels are expressed by the following relationships:

a) for systems with a carrier spacing of 112 MHz:
lower half of band: $f_n = f_0 - 1\,008 + 112\,n$ MHz
upper half of band: $f'_n = f_0 + 112\,n$ MHz
where:
$n = 1, 2, 3, \ldots 8$

b) for systems with a carrier spacing of 56 MHz:
lower half of band: $f_n = f_0 - 980 + 56\,n$ MHz
upper half of band: $f'_n = f_0 + 28 + 56\,n$ MHz
where:
$n = 1, 2, 3, \ldots 16$

c) for systems with a carrier spacing of 28 MHz:
lower half of band: $f_n = f_0 - 966 + 28\,n$ MHz
upper half of band: $f'_n = f_0 + 42 + 28\,n$ MHz
where:
$n = 1, 2, 3, \ldots 32$

d) for systems with a carrier spacing of 14 MHz:
lower half of band: $f\,n = f\,0 - 959 + 14\,n$ MHz
upper half of band: $f'\,n = f\,0 + 49 + 14\,n$ MHz
where:
$n = 1, 2, 3, \ldots 64$

e) for systems with a carrier spacing of 7 MHz:
lower half of band: $f\,n = f\,0 - 955.5 + 7\,n$ MHz
upper half of band: $f'\,n = f\,0 + 52.5 + 7\,n$ MHz
where:
$n = 1, 2, 3, \ldots 128$

f) for systems with a carrier spacing of 3.5 MHz:
lower half of band: $f\,n = f\,0 - 953.75 + 3.5\,n$ MHz
upper half of band: $f'\,n = f\,0 + 54.25 + 3.5\,n$ MHz
where:
$n = 1, 2, 3, \ldots 256$

That all downlink channels should be in one half of any bi-directional band, and all uplink channels in the other;

That the channel spacings, *X*S, center gap, *Y*S, and the lower and upper band limits, *Z* 1 S, *Z* 2 S, should be agreed by the operator and administrations concerned, dependent on the application and the channel capacity available.

3.26 From the example above it can be seen that the 25 GHz band could be licensed for up to 4 operators, each with 2 x 224 MHz of spectrum. Alternatively, the IDA could licence two operators, each with half of the band. However, the two-operator option would provide each operator with excess spectrum, and would generate only limited competition in the market. Millicom therefore considers that the 25 GHz band should be extended to cover 24.5 - 26.5 GHz, and that 4 operators be licensed to operate in it.

Allocation of the 27.50-28.60 and 29.10-29.50 GHz Bands:

3.27 These bands do not form a complete duplex service due to the allocation of the 28.60 - 29.1 GHz band for non-geostationary satellite up-link. As previously stated, Millicom does not foresee a demand in Singapore for the satellite up-link service, and would encourage the IDA to allocate this band to fixed-wireless services. This would give the IDA a full frequency band of 27.5 - 29.5 GHz to licence for wireless broadband services.

3.28 The ITU frequency channel arrangements for CEPT countries for the 27.5 - 29.5 band are as follows:

ITU-R F.748-3 - ANNEX 2
Radio-frequency channel arrangements for some CEPT administrations in the band 28 GHz (27.5-29.5 GHz)

An example of the radio-frequency channel arrangement based on this Recommendation for carrier spacings of 112 MHz, 56 MHz, 28 MHz, 14 MHz, 7 MHz and 3.5 MHz is derived as follows:

Let $f\,0$ be the center frequency of 28 500.5 MHz $= f\,r + (1\,215 \times 3.5)$ MHz,
$f\,n$ be the center frequency of a radio-frequency channel in the lower half of the band,
$f\,'n$ be the center frequency of a radio-frequency channel in the upper half of the band,
then the center frequencies of individual channels are expressed by the following relationships:

a) for systems with a carrier spacing of 112 MHz:
lower half of band: $f\,n = f\,0 - 1\,008 + 112\,n$ MHz
upper half of band: $f\,'n = f\,0 + 112\,n$ MHz
where:
$n = 1, 2, 3, \ldots 8$

b) for systems with a carrier spacing of 56 MHz:
lower half of band: $f\,n = f\,0 - 980 + 56\,n$ MHz
upper half of band: $f\,'n = f\,0 + 28 + 56\,n$ MHz
where:
$n = 1, 2, 3, \ldots 16$

c) for systems with a carrier spacing of 28 MHz:
lower half of band: $f\,n = f\,0 - 966 + 28\,n$ MHz
upper half of band: $f\,'n = f\,0 + 42 + 28\,n$ MHz
where:
$n = 1, 2, 3, \ldots 32$

d) for systems with a carrier spacing of 14 MHz:
lower half of band: $f\,n = f\,0 - 959 + 14\,n$ MHz
upper half of band: $f\,'n = f\,0 + 49 + 14\,n$ MHz
where:
$n = 1, 2, 3, \ldots 64$

ITU-R F.748-3 - ANNEX 2 (Continued)

e) for systems with a carrier spacing of 7 MHz:
lower half of band: $f\,n = f\,0 - 955.5 + 7\,n$ MHz
upper half of band: $f'\,n\,f\,0 + 52.5 + 7\,n$ MHz
where:
$n = 1, 2, 3, \ldots 128$

3.29 Based on the ITU-R recommendations, the 28 GHz Band could be allocated as:

Sub Band	Band-Width allocated	Down-Link	Up-Link
28 / 1008 / A	2 x 224 MHz	27.55 to 27.77 GHz	28.56 to 28.78 GHz
28 / 1008 / B	2 x 224 MHz	27.77 to 28.00 GHz	28.78 to 29.00 GHz
28 / 1008 / C	2 x 224 MHz	28.00 to 28.22 GHz	29.00 to 29.23 GHz
28 / 1008 / D	2 x 224 MHz	28.22 to 28.44 GHz	29.23 to 29.45 GHz

3.30 Under this allocation, 4 additional licenses (each of 2 x 224 MHz) could be awarded for the provision of fixed-wireless broadband services. Millicom considers that this would be a more suitable and efficient use of the spectrum than licensing it for satellite up-linking.

3.31 If the IDA is unable to clear the 28.6 - 29.1 GHz band, Millicom recommends that the IDA allocate the remaining spectrum on a reduced bandwidth basis. The table below is an example of allocating the frequencies available, taking into account the satellite up-link band.

Sub Band	Band-Width allocated	Down-Link	Up-Link
28 / 1008 / A	2 x 206 MHz	27.55 to 27.59 GHz	28.56 to 28.60 GHz
Sat uplink / B	2 x 500 MHz	27.59 to 28.10 GHz	28.60 to 29.10GHz
28 / 1008 / C	2 x 120 MHz	28.10 to 28.22 GHz	29.10 to 29.23 GHz
28 / 1008 / D	2 x 224 MHz	28.22 to 28.44 GHz	29.23 to 29.45 GHz

3.32 Millicom recommends that in the above frequency allocation, the spectrum is shared between two operators in an allocation of 2 x 275 MHz each.

Allocation of 31.0 to 31.3 GHz Band:

3.33 The 31.0 - 31.3 GHz band provides a total of 300MHz of spectrum. The 300 MHz bandwidth is insufficient to provide a duplex service due to carrier offset requirements. If the IDA is unable to make available an additional band to correspond to the nominated 31.0 - 31.3 GHz band, Millicom recommends that this bandwidth be used for simplex transmission services, such as Pay-per -View TV.

SECTION FOUR: LICENSING

Question: IDA seeks comments on the most appropriate licensing and spectrum allocation approach to adopt. Views are also sought on whether spectrum should be assigned in a phased manner or allocated fully to the operator at the grant of licence. Should there be a separate component for licence fees payable in addition to spectrum fees payable.

Licensing and Spectrum Allocation:

4.1 Millicom considers that, of the options proposed by the IDA, the most effective means of allocating spectrum and licenses is by way of a "beauty contest". The option of allocating licenses and spectrum through a tender has several risks:

- First, there is a very real risk that the tender would impair the ability of firms to invest in their networks, because of the funds they have had to invest in their tender bids (the so-called "winners curse");

- Second, there is no guarantee that the party bidding the highest amount in the tender will be the best placed to provide the service, or to invest in the network; and

- Third, the issuing of a tender may generate inefficient speculative bidding in the licenses.

4.2 The option of allocating spectrum on a per-link basis has some superficial advantages, in terms of limiting spectrum use to an "as needed" basis. However, the policing of this option, in terms of ensuring that the spectrum actually is required, would be controversial and time-consuming. In addition, allocating spectrum on a per-link basis could cause Wireless Broadband networks to be deployed in an inefficient piecemeal manner. Millicom therefore considers that the IDA should issue, by way of a beauty contest, 8 licenses for Broadband Wireless services, each 2 x 224 MHz of spectrum.

Phasing of Allocation:

4.3 Millicom considers that Wireless Broadband spectrum should be allocated fully to the operator at the grant of licence. Commercial Wireless Broadband services are operational around the world today, and these services are sought after by customers. Delaying the allocation of spectrum would simply create an artificial demand for spectrum, and delay the provision of services to customers (without any offsetting benefits). Furthermore, restricting spectrum allocation would put Wireless Broadband operators at a commercial disadvantage compared to fixed broadband operators, which would be in conflict with the IDA's policy of technology neutrality.

Licence Fees:

4.4 Millicom believes that Wireless Broadband operators and fixed broadband operators should be treated in a non-discriminatory manner. If fixed operators are required to pay a licence fee of 1% of their Annual Gross Turnovers, the same fee should also apply to Wireless Broadband operators. In addition, Millicom can see that there is a cost to the IDA of allocating, co-ordinating, and policing spectrum. Millicom considers that (if the IDA's spectrum fees are cost-based), Wireless Broadband operators could be charged a spectrum fee in addition to the licence fee payable.

Question: IDA seeks comments on whether the proposed spectrum band in para 2.4.1 should be reserved primarily for IBBMM services or whether they should be assigned for broadcasters' usage.

4.5 Millicom does not believe that there is uncertainty surrounding capacity demands and uptake rates for Wireless Broadband services. Millicom's experience in the United Kingdom, and our observations of other markets (particularly the United States), shows that there is a high demand for Wireless Broadband services, if sufficient spectrum is made available to make those services viable (see section 6.3 on this point).

4.6 Based on the factors set out in Section 3.3, Millicom considers that the spectrum set out in paragraph 2.4.1 of the Consultation Document should not be allocated for the use of broadcasters. Such an allocation would provide very little consumer benefit, would not engender greater competition in the market, and would add little to Singapore's development as an info-communications hub. Furthermore, given the large amount of spectrum required for broadcasting in this range, allocating the spectrum to broadcasters would seriously impede the development of Wireless Broadband services in Singapore. Millicom considers that the proposed spectrum bands should be allocated to Wireless Broadband services.

Question: IDA seeks comments on the appropriate licence duration for the provision of fixed-wireless broadband services.

4.7 As set out in Section One, Millicom has been awarded Wireless Broadband licenses in eight markets. Based on our experience, we would expect a typical Wireless Broadband license to have a duration approaching 20 years. This duration is sufficient to allow operators to fully deploy their networks, gives some certainty as to the ability to recoup investments, and also provides customers with some certainty as to the long-term viability of their supplier. Shorter licence terms could be considered, but (in Millicom's experience) this tends to encourage operators to limit their investments, and to focus on short-term profit generation. Millicom does not believe that short-term licenses are in the best interests of customers or the market.

Question: IDA seeks comments on the timeframes for award of licence as well as the time needed by operators to roll-out their networks and offer commercial services to the public.

Award of Licenses:

4.8 Millicom believes that the award of licenses should take place as soon as possible. Wireless Broadband services can be provided today, and there is certainly demand for such services in Singapore. Millicom considers that the allocation of Wireless Broadband licenses should be possible within a three-month timeframe. It should be possible for the IDA to prepare and disseminate its criteria for assessing licence applications within 4 weeks; potential licensees should be able to respond with their proposals within 3-4 weeks of receiving the criteria; and for the IDA to carry out its review and evaluation 3-4 weeks after having received the proposals. Delay in allocating spectrum will have two consequences:

- First, it will delay the provision of services to customers in Singapore;
- Second, it will place Wireless Broadband operators at a competitive disadvantage compared to the operators of fixed broadband networks.

Roll-out of Network:

4.9 To provide a Wireless Broadband service, it is necessary to have deployed several key network components (in particular the billing systems, links to an internet access provider, and the central access nodes). However, once these components are in place, it is possible to provide Wireless Broadband services reasonably easy. To service a customer, it is only necessary to establish an access node with line of sight to both the central access node and the antenna on the customer's building, and to put in place the cabling within the customer's premises.

4.10 Based on our experience in other markets, we believe that it should be possible for a Wireless Broadband operator to be providing services to its customers within 3 months of its equipment arriving in Singapore.

SECTION FIVE - TECHNICAL ISSUES

Question: IDA Seeks comments on how the issues of rain attenuation and compliance with QoS standards would be addressed.

5.1 Millicom operates radio-based networks in such countries as Cambodia, Vietnam, and the Philippines. As such, Millicom is familiar with the impact of tropical rainstorms on signal propagation. Rain attenuation is (in theory) a key issue in the network design, as it will limit the maximum cell radius distance.

5.2 However, in practice, Millicom does not see rain attenuation as a major issue for the Singapore market. In order to deal with the predicted customer density, it will be necessary for Wireless Broadband providers to operate with relatively small cell radii. These distances will be smaller than those required to address rain attenuation. In addition, the Wireless Broadband equipment that Millicom uses has the ability to track and offset signal variances due to rain attenuation. Therefore, Millicom does not believe that rain attenuation will have a significant impact on the QoS of services in Singapore.

Question: IDA seeks comments on how operators plan to install their own internal wiring, the potential difficulties faced and the cost of doing so. IDA also seeks comment on how these difficulties can be practically and realistically addressed by potential operators and how IDA can facilitate the installation.

Installation of Internal Wiring:

5.3 In deploying its service in the United Kingdom, Millicom has had to install its own in-building cabling within customers' premises. Millicom's choice of cabling on these occasions depends on the speed and volume of data the customer is seeking to transmit. The cost of this cabling is generally not high, particularly when measured against the capital cost of the equipment required to provide Wireless Broadband services.

5.4 In general, Millicom seeks to minimise the length of in-building cabling (for example, by locating antennae within the buildings themselves). In operating in Singapore, Millicom is aware that cabling could be more complex (given the height of the buildings, and hence the length of cabling required). As stated previously, there could be cases where the installation of in-building cabling is not possible due to riser congestion.

Measures to be taken by IDA:

5.5 In cases where it is not possible to deploy its own in-building cabling, Millicom would seek access to the existing cabling of a fixed operator. Millicom considers that the terms of such access should be non-discriminatory, compared to other fixed operators (in terms of price, availability, performance, etc). However, given the ability of Wireless Broadband operators to locate their antennae within their customers' buildings, Millicom does not believe that internal wiring will seriously impede service deployment.

SECTION SIX: OTHER MATTERS

6.1 In considering Wireless Broadband services, Millicom considers that there are two issues the IDA should take into consideration: the synergies between wireless and optical fibre services; and the advanced state of the Wireless Broadband market.

Wireless / Optical Fibre Synergies:

6.2 It is important to note that the ability of an operator to provide Wireless Broadband service to a particular customer will depend (*inter alia*) on the density of Wireless Broadband customers in a particular area and the applications they are operating. Over time, as customer densities increase, it may be necessary for Wireless Broadband operators to supplement their networks in some geographic areas with terrestrial technologies (DSL, optical fibre cable, etc). Millicom therefore considers that any licence issued to Wireless Broadband operators should also allow those operators to use terrestrial links, where necessary. Millicom believes that such an approach would be in line with the IDA's stated policy of technology neutrality.

Wireless Broadband Operators:

6.3 It is sometimes suggested that Wireless Broadband services are "untested" and that there is "uncertainty" surrounding their viability in the marketplace. As an operator in the Wireless Broadband market, Millicom believes that the technology and applications for Wireless Broadband are already well established. To demonstrate this fact, set out below is a (non-exhaustive) list of operators currently providing Wireless Broadband services:

Table 6-1: Wireless Broadband Operators

Operator	Operator's Website
Adelphia Business Solutions Inc	www.adelia-ab.com
Advanced Radio Telecom Corp	www.art-net.net
BroadbandNow! Inc	www.bbnow.com
Diginet Americas Inc	www.diveo.net
Formus Communications Inc	www.formus.net
Maxlink Communications Inc	www.maxlink.net
Millicom International Cellular S.A.	www.millicom.com
NEXTLINK Communications Inc	www.nextlink.com
Teligent Inc	www.teligent.com
Touch America Inc	www.in-tch.com
VeloCom Inc	www.velocom.com
Winstar Communications Inc	www.winstar.com

Source: "Broadband Wireless Access", Robertson Stephens, February 2000

6.4 The list of Wireless Broadband operators is likely to increase dramatically in the near future as operators (including Millicom) start providing services in new markets.

SECTION SEVEN: CONCLUSIONS

7.1 From Millicom's perspective, we can see strong benefits in encouraging the development of interactive broadband multimedia services, as well as e-commerce services, in Singapore. Such services will add to Singapore's development as an info-communications hub and will provide Singapore-based businesses with a significant competitive advantage. However, the development of these services is dependent on the development of broadband infrastructure, and it now appears unlikely that competing fixed operators will be deploying such infrastructure in areas outside of the CBD.

7.2 The most effective way of providing competitive broadband infrastructure is to licence Wireless Broadband operators, each with sufficient spectrum to deploy high-speed high-capacity networks. Wireless Broadband services are operating commercially in such markets as the US, the UK, and in Latin America; and have already shown the benefits they can bring.

7.3 Based on Millicom's experience, we consider that there will be significant demand for Wireless Broadband services in Singapore, particularly from SMEs and SOHO users. E-commerce, web-hosting, application hosting, and fast internet access will all drive demand for high-speed high-capacity services. The only limit we see to the success of Wireless Broadband services is the availability of licenses and spectrum.

7.4 Based on our experience with Wireless Broadband services in other markets, we consider that the optimal spectrum allocation in Singapore is to:

- Licence 4 operators in the 24.5-26.5 GHz band (extending the band beyond the 25.25 - 27.00 range proposed by the IDA), giving each operator 2 x 224 MHz of spectrum;

- Licence 4 operators in the 27.5-29.5 GHz band (after having re-allocated the 28.60 - 29.1 GHz band to Wireless Broadband services), giving each operator 2 x 224 MHz of spectrum. If it is not possible to re-allocate the 28.60 - 29.1 GHz band, the IDA could licence 2 operators, each with 2 x 275 MHz of spectrum; and

- Licence the 31.0 - 31.3 GHz band to simplex transmission services, such as Pay-per - View TV.

7.5 Millicom believes that licensing 6 - 8 Wireless Broadband operators would be sufficient to ensure dynamic competition in the market, whilst providing each operator with sufficient spectrum to operate effectively. The alternative option, of licensing fewer operators, but giving each operator additional spectrum, would seriously limit competition and hence the benefits to consumers. Millicom does not support this option.

7.6 Millicom believes that 6 - 8 Wireless Broadband licenses should be issued by the IDA by way of a standard "beauty contest" over the next 3 months (as any delay would simply deny services to customers and disadvantage the wireless operators). We do not consider that the issues of interconnection and access will provide serious difficulties for Wireless Broadband operators, provided the issues are subject to standard regulatory oversight, on a non-discriminatory basis.

7.7 Given the flexibility inherent in Wireless Broadband networks, Millicom considers that the services could be launched commercially in Singapore within 3 months of equipment reaching Singapore.

Millicom International Cellular (Asia) Pte Ltd
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