Response to Infocomm Media Development Authority (IMDA) Second Consultation on 5G Mobile Services and Networks

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About the Advanced Wireless Technology Group, LTD

The Advanced Wireless Technology Group, LTD (hereafter referred to as "AWTG") is an end-to-end engineering services and solutions provider for telecommunications, smart cities, Industry 4.0, smart health, new media, Internet in general including Internet of Things, and other markets that employ digital technologies. AWTG's capabilities include digital deployment and transformation, rapid prototyping, artificial intelligence solutions, and software development.

AWTG pioneers in 5G and other systems at the forefront of mobile technology. This includes the development and provisioning of solutions for:

- Mobile network monitoring and testing.
- Ultra-reliable low-latency communications.
- Massive machine-type communications.
- Connectivity provisioning.
- Emergency service communications.
- Artificial intelligence for the various market verticals.
- Spectrum optimization and sharing initiatives.

AWTG further acts as a communications technology "integrator", and has delivered networks for successful 5G government projects such as the UK DCMS Worcestershire 5G Consortium and the AutoAir 5G autonomous vehicle test bed, among others. Over the past 12 years, AWTG has deployed thousands of Wi-Fi access points, small cells and other mobile communication sites across the three continents of the world.

AWTG provides services and solutions for enterprises, cities and communities. Founded in 2006 by a group of industry experts initially to provide advanced professional services catering to the specific needs of the telecommunications industry, AWTG has built a strong reputation by focusing on customer satisfaction, utilizing its considerable skills and expertise to deliver industry-leading results and returns-on-investments for its customers. AWTG continues to be a leading thought provider; there is much demand for its consulting services among leading communications and technology companies, and in areas such as finance.

General Observations

AWTG would like to thank the IMDA for preparing and inviting responses to this excellent, highly thoughtful and detailed consultation. Although a UK-headquartered company, AWTG is operating extensively internationally with offices across the globe, including a presence in Singapore, and also more generally has an interest in furthering 5G and other wireless communications technologies—recognizing their potentially immense economic impacts and other benefits. This consultation has stood out to AWTG for its strengths and opportunities, hence this response.

AWTG sees Singapore as an excellent location in which to ubiquitously deploy 5G technologies, including even the more challenging aspects such as mmWave provisioning. Whereas near-universal outdoor mmWave coverage will be almost impossible in almost any other country internationally, Singapore is far better placed to realise that. This is because Singapore is graced with:

1) A high population density, or otherwise well-planned and ICT-amenable land usages where population density is lower.
2) A very high GDP per capita and high disposable income per capita.
3) An extremely high level of technology awareness, capability and development among the public, business and industry.
4) A general eagerness to adopt new technologies, and a governmental and regulatory system that strongly supports ICT and related technologies.

However, AWTG does acknowledge that for Singapore as a small country bordering other countries by only relatively narrow waters, issues such as spectrum coordination with other countries can often be challenging—having interference-causing potential across the whole of the land area of Singapore. This is both in terms of interference from deployments in other countries towards Singapore deployments, and interference from Singapore deployments towards deployments in other countries.

Nevertheless, even taking into account such challenging aspects of spectrum coordination, AWTG believes Singapore still represents a unique opportunity to maximally showcase what is possible with 5G. AWTG believes that even the near-total outdoor coverage of mmWave services will be both possible and commercially viable for at least one operator in Singapore, supported by appropriate infrastructure investments and sharing as well as deployment facilitation by government if necessary. This will be greatly beneficial to the economy of Singapore and its citizens, and will further accentuate Singapore's international standing as a leading technology hub. Commercial viability can be achieved through provisioning a range of premium and other 5G services to the general public in highly populated areas, along with 5G service provisioning for transport, vehicular communication, energy, and other utilities and public infrastructure, among many others uses, achieving a range of cost savings and economic and social benefits. Viability will also be assisted through alternative high-benefit and high-revenue usages in less-populated areas—such as provisioning for cutting-edge Industry 4.0-related use cases in the industrial areas. Further, even in view of Singapore's extremely well-developed fibre infrastructure, there are many benefits over fibre broadband that 5G fixed-wireless broadband offers—around flexibility of location provisioning as associated (lack of the need for) wiring, latency and reliability, security, as well as potentially improved capacity although noting that capacity on fibre is of course already very high. These are among various other benefits.

AWTG is aware that aforementioned challenges around international spectrum coordination, among others, have led to a situation where Singapore has had to take somewhat longer to get the process of spectrum assignment and large-scale roll-out of 5G underway. However, rather than a hindrance, AWTG believes this can be an opportunity to really "get it right", bearing in mind that other commercial 5G deployments internationally are indeed—as generally observed in the consultation—moving ahead with very early-stage assumptions and equipment that will likely need significant and problematic rectification when some of the remaining technical aspects of 5G (such as standards, and perhaps even the remaining international regulatory decisions at the ITU level) are finalized.

In short, AWTG strongly encourages a highly ambitious, world-leading 5G infrastructure in Singapore, and believes that Singapore is one of the best, if not the best, countries in the world to

achieve that. AWTG therefore supports the IMDA in continuing to aspire to such objectives. Our responses to the specific questions of the consultation are framed with that in mind.

Responses to the Consultation Questions

Question 1: IMDA would like to seek the industry's views on skills requirements and the potential job demands in the future of networks and next generation of application/use-cases with 5G technology.

It is very clear that expertise in high-performance computing and networking installation, configuration, optimization and management, will be at the forefront more-so than ever. This is in addition to expertise in areas such as SDN and other areas of softwarization, as observed in the consultation, including hypervisors and virtualization, containerisation, private/corporate cloud computational management tools such as OpenStack, and reconfiguration management of networks to the level that is possible in order to plan reconfigurations in a way that will seem flawless to the user. Although in saying this it is noted that in many 5G instantiations reconfiguration—and indeed network slicing in general—will be managed automatically by the procedures and protocols that are defined in 3GPP standards and elsewhere.

A key issue here is security. Such "softwarization" and distribution of softwarized entities, outside of the conventional operator-managed physical domains, presents numerous security risks where hacks and vulnerabilities might not be easy to detect. For example, software components or even operating systems of the equipment hosting elements in the 5G network might be hacked to share user information outside of the intended domain, or for other malicious purposes, with the only visible sign being irregularities in network traffic. This is aside from changes in the hash values for software files/elements being obvious (when/if such things are checked/computed).

Expertise is needed on computer and network security specifically in the context of virtualization, containerization and network slicing, software security and secure software and information management, software migration and associated security of that, and trust and trust-management mechanisms among the different domains of operation, among others.

As rightly pointed out in this consultation, the use of higher frequencies, and particularly mmWave, presents propagation uncertainties and challenges. However, a large amount of what 5G can do is based on the bandwidths and technologies—such as massive MIMO—that are largely made possible through the use of those frequencies. Given this, the actual location-availability of many 5G services as compared with propagation projections will be unpredictable and challenging to ascertain for the operator. AWTG therefore anticipates that there will be an *increased* need for expertise in—and use of—propagation measurement and network monitoring solutions, such as walk- and drive-testing. This must particularly concentrate on areas where the higher frequencies are likely to be affected, while also taking into account some of the less-conventional characteristics of 5G and its technologies at such frequencies, such as directionality and use of beamforming affecting multipath and fading characteristics (leading to flat fading). Greater understanding, expertise and training on such aspects is needed, as well as large-scale measurement campaigns to understand what is actually happening or will actually happen—using the expertise imparted to individuals as part of the extensive training regimes.

Question 2: IMDA would like to seek views on:

i) The types of innovative use-cases that could maximise and further enhance Singapore's competitive advantages, trigger new growth potential and/or strengthen Singapore's existing strategic pillars.

5G profoundly changes what is possible through mobile communication systems, opening up whole new market areas. Among the three main scenarios of 5G operation eMBB, uRLLC and mMTC, there are numerous highly beneficial use cases. These include:

- uRLLC use cases where there is a potential safety risk or significant repair cost should things go wrong, often twinned with low latency requirements, such as:
  - Industrial or manufacturing scenarios where servers are communicating with and controlling robots or otherwise controlling a factory over 5G.
  - Vehicular communications and transport in general, including vehicular remote control (by humans or machines) over 5G.
  - Drone communications/control (by humans or machines) over 5G.
  - Other remote control scenarios controlled by humans or machines over 5G, e.g., remote surgery, remote usage of manufacturing tools, etc. This is often using haptic information, hence the next item.
- uRLLC haptic communications, which generally has far more stringent end-to-end latency requirements than communication for audio-visual applications, as low as 5 ms for human clients of the haptic information and 1 ms for machine clients. E.g., remote interpersonal physical interaction, remote interaction with machinery, and remote interaction with matter and objects generally. In addition to the remote control scenarios listed in the bullet point directly above this one, this includes (among others):
  - Immersive Reality (IR), taking haptics (touch, feel) as one part of that immersion.
  - Remote haptic education/training; remote haptic interaction with training environments in the cloud (e.g., training on equipment/device manual controls using cloud-based representations of their interactions with the environment).
  - Cloud gaming, and conveyance of the haptic gaming environment, e.g., force feedback affecting a steering wheel in a cloud racing game.
  - Numerous others.
- uRLLC/eMBB Virtual Reality (VR), Augmented Reality (AR) and IR, which might be either with somewhat relaxed latency requirements, or low latency requirements, depending on the application. Examples of such applications at low latency are:
  - Cloud consoles/gaming and conveyance of the audio/visual gaming environment.
    - This is one rare example where audio/video could require a low latency.
  - Remote participation in an orchestra/band, noting that musician interaction can require an end-to-end latency as low as 5 ms.
    - This is another rare example where audio/video could require a very low latency, although it should be noted that both for this scenario and the one above, eMBB (4ms latency capability over the radio access network) alone should be able to provide sufficient latency if

the latency added by other aspects of the end-to-end connection is only 1 ms (!), and if only one end of the end-to-end connection is over 5G.
    - Latency-sensitive collaboration.
    - Various others.
- eMBB examples of VR, AR, IR applications that could cope with somewhat higher latency, but nevertheless require a very high data rate through two high-resolution video streams (to the separate eyes) to be convincing on headsets:
    - Remote education and training, with somewhat less emphasis on interaction.
    - Virtual tourism.
    - Remote attendance of meetings, events (e.g., concerts), etc., depending on the level of interactivity required.
    - Numerous others—almost any real environment that would be useful to convey virtually to others.
- uRLLC (perhaps with eMBB elements, dependent on the scenario) emergency services communications, with far greater reliability than is possible in 4G (LTE Advanced) or 4.5G (LTE Advanced Pro) networks.
- uRLLC conveyance of vital and/or time-constrained messages, e.g., events in financial services with human or machine clients that might require an urgent action to react to a changing situation and make a trade to maximise profit or minimise loss.
- mMTC Internet of Things (IoT)—connected "things" including smart TVs, kitchen and other household appliances, CCTV, numerous others. Remote access to and control of those things, status checking, autonomous interaction between the things, etc. Basically, connectivity for any everyday object for which there would be a benefit.
- mMTC sensors, e.g., environmental monitoring, traffic monitoring, weather monitoring, building monitoring, industrial process monitoring, plus many others.
- mMTC smart household, energy efficiency, smart grid, etc., applications.
- Secondary usage applications of information from mMTC/IoT, e.g., for finance purposes (deriving levels of economic activity based on vehicular or environmental sensing IoT information, as one example), general safety and monitoring, etc.
- eMBB 4K or higher streaming, particularly if there are a number of users in an area.
- eMBB high-quality CCTV, as might be twinned with, e.g., cloud facial recognition.
- eMBB/uRLLC precision video monitoring (e.g., by machines), for industrial scenarios.
- In general, any (eMBB) cases where HD streaming, and provision of broadband in general over fixed wireless using mobile communication networks, will become widespread leading to a significant number of connections in an area. 4G networks are challenged to cope in such cases; 5G networks can easily cope at the projected required data rates for fixed wireless broadband provisioning.

ii) Areas of government support that the industry require in order to enable innovation and development in 5G.

The industry would benefit greatly from support in the planning, general coordination and permissions processes for 5G deployment, through "linked-up" government. Given aforementioned propagation characteristics, deployments in a large number of varied locations will be necessary—such as on street furniture, street corners, and elsewhere.

Greater information sharing and definition of automated approval procedures among different levels and entities of government will assist.

Perhaps ways of incentivizing or mandating landlords to accept deployments on their properties or land will be necessary—of course, with absolutely minimal disruption to those landlords. Moreover, for the larger sites, the characteristics and looks of deployments are going to be somewhat different from previous mobile generations—with more equipment (hence weight) necessary to be brought up to the top of the cell tower, as well as larger square or rectangular antennas being deployed—resembling panels. These aspects are linked to the need for multiple antenna elements in 5G massive MIMO, and the implications of transmitting at higher frequencies.

5G has exceptional ability to increase the efficiency of industry and simplify or improve a vast range of areas of life. To maximally accelerate the deployment of associated use cases in real environments, AWTG encourages the creation of a government loans or grants system. Within this, government decisions on awarding money to assist the initial 5G use case deployment and process/equipment changes/restructuring (e.g., infrastructure such as robots in the factory served by the use case deployment) could be based on a business case made by the applicant, which highlights exactly how, including all the technical steps, the factory or other use case will be made more efficient through investing in 5G and the equipment changes/restructuring to benefit from 5G capabilities. Such a loan could be paid back as a proportion of gross profit. If taken forward by government as a grant rather than a loan, then in most cases economic gains (and associated increases in tax income) would pay back such a grant.

Question 3: IMDA would like to seek views and comments on the suitable technical parameters, including the reasonable amount of guard band needed to reduce potential interference between IMT and FSS use in the 3.5 GHz band.

AWTG would prefer not to express an opinion on this matter.

Question 4: IMDA would like to seek views and comments on the following:

i) Whether the industry agrees with the timelines on the expected availability of the next wave of 5G spectrum.

AWTG understands the challenges with migration of current users to avail the required spectrum, and the challenges around international coordination. Nevertheless, AWTG encourages the IMDA to explore every avenue to move forward as quickly as possible to have maximum impact and benefit for Singapore, and perpetuate Singapore's status as a world-leading technology hub.

Given that the timescale text in the consultation is referring to sub-GHz (700 MHz) spectrum and the possibility of reconsidering that for 5G in the future, AWTG would like to comment on that. AWTG believes that sub-GHz spectrum is absolutely vital for 5G. Given the requirements placed on 5G around aspects such as reliability and availability, the stability of these lower frequencies is key. AWTG does not believe that a service based on 3.5 GHz and mmWave alone will be able to achieve sufficient availability/reliability to satisfy 5G requirements.

It is noted that aspects such as multi-connectivity are key to realizing low latency while maintaining high reliability—through the additional robustness realised by the use of

multiple different network paths and spectrum/wireless links over which the data will be transmitted. The lack of sub-GHz spectrum greatly reduces or even removes any opportunities for multi-connectivity.

AWTG believes that there is far more to IoT-related applications—and their demands are far more challenging—than expressed in the consultation. As one example, IoT might involve CCTV or municipal monitoring cameras streaming high-quality video to a cloud processing point for, e.g., facial recognition, feature recognition and derivation of context from that (e.g., traffic monitoring), among other aspects. AWTG believes that current communications technologies for IoT will not be sufficient to serve that and numerous other use cases without the use of 5G. Further, IoT security must be addressed through taking it forward within the scope of 5G. Many local end-user IoT devices are connected over Wi-Fi networks where very insecure mechanisms are used in order to simplify configuration for the end-user and deal with aspects such as global IP address changes of local gateway routers. These IoT devices are routinely and widely hacked to attack others, e.g., through distributed denial of service attacks, or to compromise users' privacy or information security without them even being aware of it. AWTG believes that without a comprehensive wide-area 5G cellular connectivity using sub-GHz spectrum for availability/reliability—that IoT devices will near-ubiquitously support in the medium-long term future and which manages aspects such as connection security—this situation will perpetuate. 4G connectivity, which will only be sporadically supported by IoT devices and only by those at the upper end of the market, will not suffice.

Rather than "may consider permitting this [the 700 MHz] band" for 5G services in the future, AWTG would strongly encourage "will make available this band for deployment of 5G services", for the abovementioned reasons. This should be done as soon as possible after the ASO is complete in neighbouring countries. Even in a limited geographical area such as Singapore, 5G will achieve only a shadow of its true capabilities if it is not supported by extensive sub-GHz spectrum as a near-universal coverage (including indoors) fall-back and to support various use cases. This should be at the level of 20 MHz per operator or more if possible, noting that 20 MHz is the 700 MHz 5GNR band n28 maximum carrier bandwidth and that carrier aggregation options are also supported.

ii) Whether current deployments in the 2.5 GHz FDD spectrum band (based on 3GPP Band 7) and in the 2.5 GHz TDD spectrum band (based on 3GPP Band 38), should be refarmed to 3GPP Band 41 for future 5G services in Singapore, and the views on the associated cost and challenges.

Given the challenges with achieving sufficient spectrum at 3.5 GHz, this would be nice to do if possible. However, AWTG understands the technical challenges with doing this given the usage by legacy 4G services, and that 5GNR band n41 is entirely incompatible with the legacy FDD LTE usage.

One alternative option could be to switch only the TDD duplexing gap to 5G, corresponding to 5GNR band n38 and aggregating carriers therein to achieve 50 MHz spectrum. This would also be amenable to carrier aggregation with one of the 3.5 GHz 50 MHz lots. Thereby, it would be possible to form a scenario where Operator 1 could be assigned the entire 100 MHz of unrestricted TDD spectrum at 3.5 GHz, and Operator 2 the entire 100 MHz of restricted TDD spectrum at 3.5 GHz (as opposed to only 50 MHz, under the current plan), and to make a fairer balance between the two lots for Operator 1 and Operator 2, that could be combined as a lot and aggregated with the 50 MHz 2.5 GHz (we presume unrestricted)

TDD spectrum. This would give Operator 2 150 MHz total spectrum around 2-5-3.5 GHz, all 150 MHz usable indoors and 50 MHz usable outdoors, and Operator 1 100 MHz around 2.5-3.5 GHz, the entire amount of which would be usable indoors or outdoors.

AWTG has no understanding of how amenable the LTE Band 38 spectrum holders would be to such a proposal for reassignment to 5G services, or how the compensation model would work. For Singtel and StarHub AWTG anticipates it would be less of an issue as they already have extensive spectrum, but for TPG it might be more of a challenge as they are nascent with a far more limited spectrum holding, and the removal of the 2.5 GHz TDD 10 MHz would be a lot more significant. A further option to simplify agreement with the currently assigned operators for LTE band 38 and help deal with this imbalance could be mixed 4G/5G usage in LTE/5GNR band 38/n38. AWTG understands that this should be technically achievable.

AWTG would encourage the IMDA to consider all of the above options, if not done so already.

Question 5: IMDA would like to seek views, comments and suggestions on:

i) Whether Singapore should have two nationwide networks as a start given the considerations and trade-offs.

If our proposal in response to question 4 (ii) is viable, then AWTG believes that having two networks is far more viable. However, if not, AWTG believes that the IMDA should ensure that at least one network is able to achieve the maximum that is viable in a 5G context. This would mean giving one network the entire 100 MHz of unrestricted spectrum at 3.5 GHz, although would likely not affect the mmWave assignment where AWTG believes that 800 MHz (two 400 MHz carriers) per operator is indeed sufficient.

AWTG notes that the spectrum is awarded on a competitive basis, so if the process is framed properly the losing operator(s) should not have cause to complain. Moreover, in order to address competition issues in the presence of only one operator, AWTG believes that IMDA should define a suitable formula (broad guidelines) for the service pricing structure that the winning operator would be able to charge to customers. Likely this pricing formula would need to already be declared by the regulator at the stage of competitive bidding by the operator(s), so that the operator(s) fully understand what they are bidding for.

Given that under our proposal only one operator would have the bulk of prime resource in this case, IMDA might make a decision on whether to:

1) Also include the 100 MHz 3.5 GHz restricted spectrum in the same lot as the unrestricted spectrum. In this case, mmWave spectrum would likely lose any appeal to a potential second operator, so all such spectrum might also be combined into the same single lot.
2) Allow the 100 MHz 3.5 GHz restricted spectrum to also be applied for, by another operator or also by the same operator as the unrestricted spectrum. I.e., let the market decide whether another operator would wish to proceed with having access to restricted spectrum alone at 3.5 GHz plus some of the mmWave spectrum.

In tandem with this, AWTG would like to emphasise again that 700 MHz spectrum is vital and should be made available for 5G services, as soon as practically possible. AWTG believes that 5G without 700 MHz (or other sub-GHz) spectrum will be a pale version of what it is meant to be.

ii) The proposed 3.5 GHz lot sizes and spectrum packages.

Please refer to our answer to 5(i) above.

iii) Whether 5G equipment would be able to support 3.5 GHz bandwidths in multiples of 50 MHz.

AWTG is aware of equipment already supporting multiples of 50 MHz (50 MHz, 100 MHz, among other bandwidths) in the associated spectrum. Further, all the indications in the specifications are that intra-band aggregation of such bandwidths is supported (see Clause 5.5.4.8 in 3GPP TR 21.915 V1.0.0, March 2019, http://www.3gpp.org/ftp//Specs/archive/21_series/21.915/21915-100.zip). However, AWTG understands the added costs and complexities of achieving such aggregation, so whether it transpires as the actual hardware matures remains to be seen.

iv) The value, if any, in assigning the remaining 50 MHz restricted 3.5 GHz spectrum in the same assignment exercise as the unrestricted lots.

In the scenario described in the consultation, AWTG believes there is likely value in assigning this remaining spectrum in the band plan described in the consultation, as per our response to 5(iii) above. However, this fundamentally depends on the capabilities of the actual equipment as it matures.

v) The proposed mmWave lot sizes and preferred band plan option.

AWTG sees little difference between these options—although does have a slight preference for B and C given the better alignment with 5GNR bands definition. AWTG also refers to the options discussed in proposal in response to question 5(i).

vi) The rank order preference of the 3.5 GHz spectrum package and mmWave lot combinations.

At 3.5 GHz, AWTG believes this is referring to the choice between the restricted+unrestricted 50+50 MHz combination, and the unrestricted 50 MHz (plus potentially the 50 MHz non-contiguous restricted spectrum). Of course, the former is strongly preferable. AWTG encourages consideration of its responses to questions 4(ii) and 5(i) above as (hopefully somewhat viable) alternatives.

Question 6: IMDA would like to seek views, comments and suggestions on:

i) The proposed network rollout and performance obligations to be imposed on the spectrum rights holders.

AWTG encourages more ambition in both the network rollout timescales and the performance obligations. As argued elsewhere, AWTG believes that Singapore can be a world-leading example where even outdoor mmWave coverage can be achieved near-ubiquitously, and commercially viably. This would rightly maintain Singapore as a leading technology hub. Further, for a country with such characteristics, it should be relatively easy to achieve near-complete 3.5 GHz coverage, although not to the level of availability (e.g., indoors) that sub-GHz spectrum would achieve. AWTG argues again here that sub-GHz spectrum for 5G is *vital*.

As a minimum, the timescales given in the consultation (24 months and 12 months) should both be halved. Further, AWTG would encourage the definition of an additional deadline to achieve 95% outdoor coverage at 3.5 GHz within 24 months, and 95% outdoor coverage at mmWave within 36 or 48 months. Again, AWTG sees Singapore as being well-placed to be

highly ambitious and achieve such objectives. AWTG would also encourage a timeline being defined for making the 700 MHz spectrum available to 5G, and the assignment of it.

ii) The methodology and measurement criteria for the coverage obligation.

AWTG simply suggests drive-/walk-testing assessing performance based on the criterion of minimum required SINR to achieve a service in each of the given bands. AWTG believes that complete coverage of Singapore through such testing should be achievable, at least of all roads via drive-testing at a total road-length for Singapore that AWTG understands to be around 3,500 km. Such a drive-testing campaign should be viable to complete within 10-15 days.

iii) The network design and resilience challenges of 5G (in particular, enabling technologies, such as SDN, NFV and Cloud Computing that may fundamentally change how the network would be designed and deployed) and possible measures to address them, and whether there are other aspects that should be considered to enable trusted and resilient 5G network.

This is broadly covered in the responses to other questions.

Softwarization and distribution of key elements of the 5G network produce numerous potential security and privacy challenges. Secure virtualisation and/or containerisation solutions are required, as well as trust models defining who/what, and in which circumstances, is allowed to provide the physical infrastructure on which 5G software elements are hosted. Further, checks and an assurance/certification process for providers might be necessary, as well as the checking and certification of the integrity of 5G software elements as well as the host system. Likely network monitoring and Network Behaviour Anomaly Detection (NBAD) can be deployed to assist detection of whether something has gone wrong.

The use of mmWave spectrum presents numerous challenges related to its propagation and other aspects. This, and proposed solutions, have been discussed elsewhere.

iv) The framework for the provision of 5G wholesale services.

For eMBB, the current framework could apply. However, for uRLLC and mMTC services it is extremely difficult to establish an appropriate approach, because the true values of services based on these scenarios—and nuances of those values—are simply not understood at this stage. Nevertheless, it is clear that those values are immense. Moreover, AWTG understand that such capabilities, particularly where uRLLC is concerned, will likely come to the forefront at a later stage of 5G development/deployment.

The provision of wholesaling for such capabilities should be based on modelling/understanding of the values for uRLLC and mMTC scenarios. This will only be possible some years in the future.

Question 7: IMDA would like to seek views, comments and suggestions on the spectrum assignment framework, including:

i) The proposed assignment approach.

AWTG agrees with his approach. However, AWTG emphasizes the need to make sure that all aspects are very precisely detailed and applicants are informed, at the time of the CFP. This is to ensure that the applicants really understand what they are applying for.

AWTG does believe in packaging or otherwise linking the mmWave and 3.5 GHz spectrum together. Aside from point-to-point links for highly specialised scenarios, the mmWave spectrum will have very limited usage in a wider 5G context without the availability of lower frequency spectrum.

ii) The spectrum right duration of the 3.5 GHz package and mmWave lots.

AWTG broadly agrees with the proposal. However, for increased stability and value, AWTG would aim towards the top end (15 years). Perhaps a mechanism to extend the rights duration and license could be defined if it were thought to be in-line with potential future usages and needs for spectrum to do so.

iii) The evaluation criteria, sub-criteria and weights to assess the proposals.

Given the wide range of new use cases and markets for 5G, and associated benefits, AWTG would encourage the derivation and use of a way of assessing the following additional evaluation criteria:

1) Scope for large-scale adoption, e.g., affordability.
2) Societal benefits of the network deployment.
3) Economic benefits of the network deployment.

The proposed criteria and weighting after the addition of these items could be:

1) Network Rollout and Performance (25%)
2) Network Design & Resilience (20%)
3) Financial Capability (15%)
4) Offer Price (10%)
5) Scope for large-scale adoption (10%).
6) Societal benefits (10%).
7) Economic benefits (10%).

iv) The assessment methodology, including evidence (documentary or otherwise) to evaluate the proposals.

To help towards assessing the additional items proposed in 7(iii), AWTG would encourage IMDA to require applicants to submit a wide range of detail on the use cases that their networks could support under the proposed bid, and for each use case:

1) Provide an estimate with historical (numerical) evidence on the uptake, and timescale of the uptake, of that use case. E.g., percentage of the population that will adopt the case, percentage of companies/manufacturers (e.g., for an Industry 4.0 case), etc. AWTG recognises that this might be very difficult in many cases as the use cases will be so new, however, a best effort should be made.
2) Provide qualitative arguments on the benefits to society of the use case, as well as quantitative arguments where possible (e.g., average life expectancy increases in the case of healthcare-related use cases).
3) Provide quantitative estimates on the benefits for the economy of the use case, and the timescales of those benefits, backed up by historical studies and real historical data.
4) Provide a projection of what the cost for the end-user will be in order to realise the use case, as a result of the mobile network access and communication costs. Also provide an estimate, including numerical evidence, of the disposable income that the end-user will

have in order to pay for the deployment or access. The term “end-user” is well understood in the context of conventional use cases such as generic conversational voice, data and other provisioning over the mobile network, however, in the context of innovative 5G use cases the end-user could be, e.g., the manufacturer using 5G to control/monitor their factory, the transport operator using 5G to contribute to operations management, etc.

v) The enforcement and/or audit mechanisms to ensure that applicants are able to deliver on their proposals.

The applicant should be compared against the submitted application some years after the award—through independent network testing, customer satisfaction surveys and other methods. A fine should be levied if the projections in the submitted application are significantly missed. Appropriate structuring of that fine is for further study. Interesting, flexibility could be given for the applicant to define their own proposed fine structure in the submitted application, where of course those that propose they are fined higher should be given a higher scoring for that aspect—given that they therefore have higher confidence in their offering and deployment, and that any financial/economic losses through the shortfall compared with what would be achieved by a more successful network will be at least be somewhat offset by the size of the fine.

Question 8: IMDA would like to seek views and comments on the trade-offs (particularly on resilience, 5G capabilities) and technical feasibility of the various levels of infrastructure sharing.

AWTG strongly recommends a requirement to allow site sharing, as long as there is no negative impact, e.g., in terms of RF interference and related effects given such closely-spaced radio equipment. RF equipment sharing, at least at the level of antennas, would be preferable at least in the context of non-MIMO/beamforming and AAS deployments, noting that such sharing would often be extremely challenging if such technologies were used due to physical configuration conflicts among the site sharing operators.

Question 9: IMDA would like to seek views and comments on the following:

i) The synchronisation approach for 5G TDD networks in a multi-operator environment for the 3.5 GHz and mmWave bands, specifically for the following:

a. Synchronised networks: the required frame alignment, compatible frame structures and BEM specifications for AAS and non-AAS base stations.

AWTG would prefer not to comment on this.

b. Unsynchronised networks: the amount of guard band, geographical separation and BEM specifications for AAS and non-AAS base stations.

AWTG would prefer not to comment on this.

ii) The adoption of other suitable mitigation measures to mitigate interference between unsynchronised networks; and

AWTG would prefer not to comment on this.

iii) The need for IMDA to mandate a regulatory requirement for synchronisation across the 5G TDD networks or leave it to operators to co-ordinate their network deployment and parameters in order to reduce interference between networks.

Without delving into the technical detail, AWTG believes that operators alone can coordinate.

Question 10: IMDA would like to seek views and comments on the following:

i) The interest from industry players to leverage 5G spectrum or other mobile spectrum bands for fixed-wireless services that support mobile connectivity.

This is a strong area of interest in other countries where the fibre infrastructure is not nearly as advanced. AWTG does believe, despite the excellent fibre infrastructure in Singapore, that there will be some interest in this in Singapore too. AWTG believes that 5G can compete with fibre provisioning—particularly for those cases that are able to realise mmWave coverage, and some users may prefer the flexibility of not having to plug in their router via a network cable, e.g., given freedom of being able to move to different locations in the home.

ii) The policies (e.g., spectrum allocation, numbering) that should be considered to facilitate such use-cases.

Due to the range of frequencies and associated characteristics of the 5G networks, AWTG believes that no additional spectrum allocations are necessary. The choice of frequencies depends on the scenario, however, for dense networks in dense urban contexts the mmWave spectrum, line-of sight, will provide for fixed wireless; in less dense cases 3.5 GHz or other spectrum will suffice—although with something of a hit to performance. AWTG still strongly encourages doing everything possible to make available 700 MHz spectrum as a fall-back option for challenging cases such as where gateway routers have to be deeper indoors—although performance in such cases using 700 MHz spectrum will take a further significant hit.

AWTG has no comment on numbering.

Contacts

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