Huawei response to the Ofcom public consultation: Enabling spectrum sharing in the upper 6 GHz band

Shared licences for local, low-power indoor use of the upper 6 GHz band (6425-7070 MHz)

Summary

We thank Ofcom for the opportunity to comment on this consultation on the application of the shared access licensing framework to the upper 6 GHz (6425-7070 MHz) band.

In summary, we are not convinced that it is appropriate for Ofcom to rush ahead and authorise the use of the upper 6 GHz for Wi-Fi-like equipment based on shared access local licensing given

a) ongoing international studies at ITU-R for potential identification of the upper 6 GHz band for IMT,

b) existing expressions of demand for use of the band for macro-cellular 5G mobile networks and their evolution,

c) absence of demand for licensed Wi-Fi,

d) abundance of existing spectrum supply for shared access local licences,

e) the clear risk that Ofcom's proposed approach would restrict – if not foreclose – options for future use of the band by 5G networks, or alternatively result in future revocation of the shared access licences. In either case, the proposed approach would bring market uncertainty that would discourage investments by stakeholders.

Accordingly, we encourage Ofcom to pause and consult more widely on the different potential use cases and the associated connectivity needs and regulatory approaches for the upper 6 GHz band, and to consider what approach will maximise economic and societal benefits. We encourage Ofcom to address a number of alternative options, including not only licensed low-power indoor Wi-Fi-like equipment but also macro-cellular 5G mobile networks, and aim to publish a statement in 2024 accounting for the outcome of international studies at the World Radio Conference in 2023.

Huawei's comments in response to Ofcom's questions

Question 1. Do you agree with our proposals to add the 6425-7070 MHz band to the Shared Access framework?

Question 2. Do you have any comments on potential uses for this licence?

We do not believe that Ofcom's proposals to add the 6425-7070 MHz band to the shared access local licensing framework will maximize the benefits that can be extracted from this frequency band.

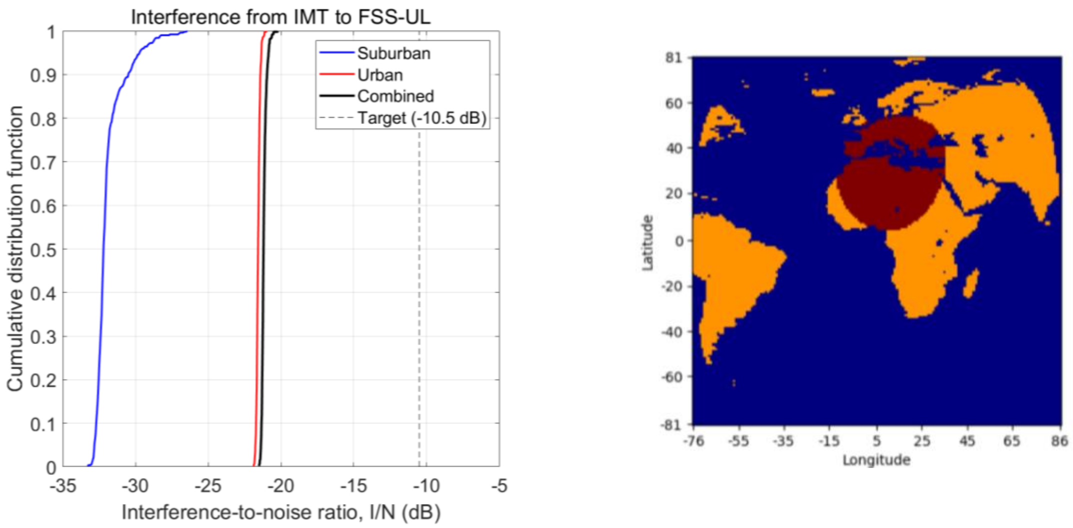
As Ofcom will be aware, the potential for future use of the upper 6 GHz band for 5G networks – for the delivery of services to consumers, businesses and vertical industries – is one of the most important topics of discussion in spectrum management across the globe today. As such, we find Ofcom's consideration of licensed indoor Wi-Fi in this band unconvincing. We highlight a number of key issues in what follows.

1. International activities on 6 GHz

The upper 6 GHz band (6425-7125 MHz) is currently subject to compatibility studies by the ITU-R towards potential identification of the band for International Mobile Communications (IMT) under Agenda Item 1.2 of the World Radio Conference in 2023 (WRC-23). This upper 6 GHz is the only remaining mid-bands spectrum of sufficient contiguous bandwidth to meet the demands on 5G and its evolution towards 2030. WRC-23 is a critical opportunity to ensure that the upper 6 GHz is harmonised for wide-area macro-cellular 5G networks for the provision of services to consumers and verticals.

The results of the ITU-R studies currently in progress indicate that spectrum sharing between IMT networks and incumbent services is feasible when accounting for key factors including a) the realistic geographic density of IMT base stations, b) the influence of clutter loss in mitigating interference, c) the impact of IMT base station active antenna systems (AAS) in directing interference towards desired directions (away from the incumbents), and d) realistic incumbent receiver antenna characteristics.

Figure (1) below shows an example of our studies[1] for the case of interference from IMT to the Fixed Satellite Service (FSS) uplink, indicating an 80th percentile interference-to-noise ratio (I/N) of -21 dB at the satellite receiver, compared to a target I/N of -10.5 dB, implying that sharing is feasible. Similar conclusions have been derived by other parties, including Ericsson and the French administration[2].



IMT scenario	80th percentile I/N (dB) experienced at satellite receiver
Suburban	-31.6
Urban	-21.5
Combined	**-21.1** (protection target as agreed at ITU-R: I/N = -10.5 dB)

Figure (1): Interference from IMT deployments falls below the agreed protection threshold.

1 See Huawei contribution to ECC PT1, ECC PT1(21)225, September 2021.

2 See contributions to ITU-R WP5D, 5D/1032 and 5D/1042.

2. Demand for 5G at 6 GHz

Considering the tremendous demand for connectivity by consumers, households, businesses, and industries, GSMA recently published a report on its vision of the future needs for mid-bands spectrum[3].

The study examined 36 cities globally, and quantified their mid-bands spectrum needs accounting for factors such as population density, existing spectrum available for IMT, inter-site distance between macro-cellular IMT base stations, 5G spectral efficiency, massive MIMO upgrades, offload to high bands, indoor small cells and Wi-Fi, and end users' activity factor. Figure (2) shows a sample of the results.

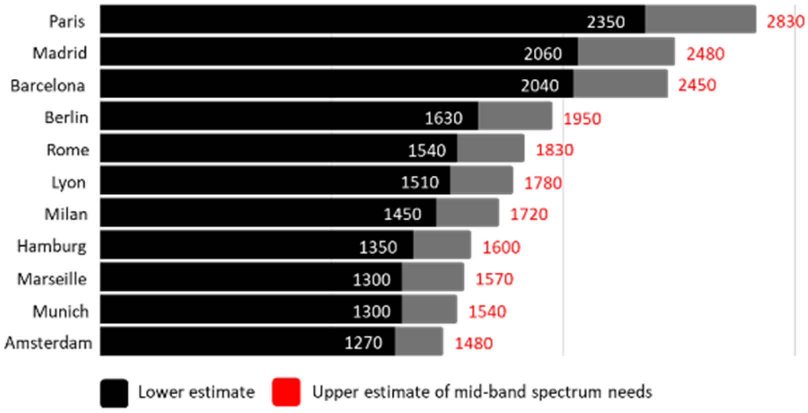


Figure 2: Mid-band spectrum needs for a sample of cities studied by the GSMA.
(*Source: GSMA*)

The report concludes that "The GSMA recommends governments and regulators to plan to make 2 GHz of mid-band spectrum available in the 2025-2030 timeframe. This is the average value needed to guarantee the IMT2020 requirements for 5G", and that "…spectrum is required to deliver the 5G vision of downlink user experienced data rate of 100 Mbit/s across the city, i.e. citywide "speed coverage", and also to satisfy the 50 Mbit/s uplink target."

The report clarifies that mid-bands spectrum is required in addition to the mid-bands that are available to mobile networks today (which the study assumed will eventually be re-farmed for use by 5G), and that this is necessary to achieve the IMT-2020 5G data rates specified by the ITU-R for the delivery of high-capacity coverage across cities and along major transport routes in the 2025-2030 timeframe in support of mobile broadband, smart city, automotive and industrial use cases.

Importantly, the GSMA report shows that in the absence of the required additional mid-band spectrum, the mobile radio networks would need to be substantially densified (numbers of base station sites increased) in order to deliver the 5G data rate targets, and that this would lead to a significant increase in energy consumption and radio network cost. Specifically, for a typical large European city, the implication would be a doubling of power consumption, and a four-fold increase in total network costs. This is in addition to the carbon footprint involved in the manufacture of the greater number of equipment.

Further analysis was carried out by the authors of the report to quantify the reduction in downlink and uplink data rates in cities in the absence of the required additional mid-bands spectrum and in the absence of the "extreme" network densification that would be unsustainable citywide. The results show that in the absence of additional mid-bands spectrum, and given the economic and technical limits to extreme network densification, MNOs would only be able to achieve 20% of the 5G data rate requirements of 100 Mbit/s downlink and 50 Mbit/s uplink in densely populated European cities.

[3] GSMA, "5G Mid-Band Spectrum Needs – Vision 2030," July 2021.

3. Socioeconomic benefits of IMT at 6 GHz

A recent report[4] by GSMA Intelligence presents a cost-benefit analysis of options for authorisations at 6 GHz that will maximise the social and economic value of spectrum in 12 specific markets over the 2022-2035 time period:

- Looking at expected traffic demand and supply for 5G and Wi-Fi, whereby supply is partly determined by the amount of spectrum available.
- Relative to the baseline scenario of unassigned 6 GHz spectrum.
- Comparing the socio-economic benefits of three different allocations of the 6 GHz band (5G only, Wi-Fi in the lower 6 GHz and 5G in the upper 6 GHz, and Wi-Fi only).

The study concludes that

a) licensing the entire 6 GHz for 5G will deliver the largest benefits in countries where fixed broadband provides maximum user speeds of up to 10 Gbps and if a portion of Wi-Fi traffic is offloaded to the 60 GHz band, and

b) licensing the upper 6 GHz for 5G, with licence-exemption of the lower 6 GHz for Wi-Fi, will deliver the largest benefits if FTTH/B and cable broadband adoption is widespread, they support maximum user speeds of 10 Gbps and the 60 GHz band is not utilised by Wi-Fi.

Notably, licence exemption of the entire 6 GHz band was not found to be the most beneficial authorisation in any of the considered analyses.

4. Lack of demand for licensed Wi-Fi

We have not observed any demand for licensed Wi-Fi-like equipment in the upper 6 GHz band from businesses, industries or other users.

We recognise that Wi-Fi has been used in the past for communications in industrial applications, and we expect this to continue going forward, well-supported by the 10 Gbit/s peak data rates achievable by high-end Wi-Fi 6 products using advanced MIMO radio technologies (16 spatial streams) in the 2.4 GHz and 5 GHz bands alone[5].

However, we do not expect a huge growth in Wi-Fi use for emerging industrial use cases which require very high data rates, high reliability and low-latency communications. The proposed use of Wi-Fi in licensed spectrum (i.e. spectrum that is individually assigned) does not seem to be consistent with the intrinsic nature of Wi-Fi technology. This is because Wi-Fi's robust medium access control (MAC) protocol is specifically designed and optimised for operation in the uncertain interference environment of licence-exempt spectrum, and therefore cannot match the performance of 5G NR which is designed to deliver extremely high quality of service in the managed interference environment of licensed spectrum[6].

---

4 GSMA Intelligence, "*The socioeconomic benefits of the 6 GHz band considering licensed and unlicensed options*," January 2022.

5 https://e.huawei.com/en/products/enterprise-networking/wlan/wifi-6/new-products-launch

6 As part of our research into industrial applications, we have demonstrated an implementation of *distributed MIMO* with 5G NR in a warehouse of dimensions 104 m × 32 m × 9.7 m. The distributed MIMO involved the reception of signals from 96 UEs (each with a 2Tx/4Rx antenna configurations) by a network of 16 coordinated 5G NR small-cell base stations (each with a 4Tx/4Rx antenna configuration) deployed with a separation of around 12 m throughout the warehouse, all using the same 100 MHz channel (frequency re-use of 1) in the 4.9 GHz band. The distributed MIMO – possible due to the deterministic medium access control protocols of 5G NR – achieved an astounding overall uplink spectral efficiency of around 115 bit/s/Hz.

In any case, should demand for Wi-Fi in industrial applications grow beyond our expectations, we consider that the lower 6 GHz band (5925-6425 MHz) available for Wi-Fi in the UK since 2020 on a licence exempt basis would be more than sufficient to meet such demand. Any further demand for licence-exempt Wi-Fi-like equipment for local area networks can be – and should be – met in the licence-exempt 57-71 GHz (so-called 60 GHz) band which has been available in the UK since 2018.

Note that as a rule, the radio propagation characteristics at high-bands makes them far more suitable for high-capacity short-range or local-area communications. This is in contrast to mid-bands which are optimum for macro-cellular wide-area communications.

5. Excess supply of spectrum for indoor local licences

We note that technology-neutral local shared access licences (SALs) at 3.8-4.2 GHz and 24.25-26.5 GHz (indoor) have been available in the UK since 2019. Ofcom's data indicates that – as of February 2021 – Ofcom has issued 143 low-power SALs at 3.8-4.2 GHz and 1 SAL at 24.25-26.5 GHz for business, industry and research users. These figures are aligned with our expectations, and indicate that demand is far from exceeding supply for local licences, indoor or otherwise. We also note that, should demand for locally licensed spectrum grow in the future, the large amounts of bandwidth available at 3.8-4.2 GHz and 24.25-26.5 GHz band will be more than sufficient to address this.

We cannot see how the additional release of the upper 6 GHz for local licensing can be justified given the huge opportunity cost in relation to the precluded use of the band for 5G macro-cellular networks and their evolution.

6. Harmful interference and foreclosure of future options

Our recent field trials of 5G at 6 GHz have indicated that advanced active antenna systems allow the delivery of spectral efficiencies that are comparable with those at 3.4-3.8 GHz both for outdoor-to-outdoor and outdoor-to-indoor (shallow indoor) coverage. See Annex. The implication of this important finding is that any local licensing of equipment at the upper 6 GHz today would undoubtedly result in mutual harmful interference with respect to macro-cellular 5G deployments in the future, resulting in poor performance or failure of both types of system.

This is contradictory to Ofcom's assurances that its proposals would not prevent potential future use of the band by mobile communication networks.

7. Shared co-channel use of 5G and Wi-Fi is not feasible

5G and Wi-Fi are not substitutes and both have important – yet distinct – roles to play. That said, 5G and Wi-Fi are fundamentally different by design, and are optimised for licensed and licence-exempt authorisation models respectively. For this reason, they cannot share the same frequencies in the same geographic area.

Specifically, 5G has a deterministic/scheduled medium access control (MAC) designed for use in licensed spectrum (free of interference from other co-channel 5G networks). 5G is designed to deliver mobility with managed quality of service and reliability. Specifically, 5G can deliver ultra-reliable and low-latency communications. This is not purely a question of technology; it also relies on availability of licenced spectrum.

In contrast, Wi-Fi is designed to operate in licence-exempt spectrum. As such, Wi-Fi relies on a stochastic MAC in order to manage the unpredictable presence of an indefinite number of co-channel Wi-Fi networks and equipment. Wi-Fi is not designed to ensure predictable quality of service, and only addresses low-mobility use cases. Wi-Fi delivers a best-effort service and suffers from non-graceful degradation when subject to congestion.

Considering the above, the simultaneous co-channel use of 5G and Wi-Fi in the same geographic area would substantially degrade the performance of both technologies, with the harmful mutual co-channel interference disrupting the operation of the respective deterministic and stochastic MAC protocols.

3. Do you have any comments on our proposed licence conditions, licence fee or minimum separation distance?
4. Do you have any comments on our technical analysis?

No comments.

Annex – Huawei field tests at 6 GHz

It is well-known that radio signals suffer from increasing propagation path loss and building penetration loss at higher frequencies. This poses the question of whether 5G deployments in the 6 GHz band would be suitable for macro-cellular coverage in order to address high-capacity citywide demand.

To answer this, we performed a number of field tests in 2021 to compare the performance of macro-cellular IMT deployments at 3.5 GHz and 6 GHz. These tests involved two 5G NR base stations operating at 3.5 GHz and 6 GHz, respectively, both co-sited at an existing commercially deployed rooftop macro-cell site[7].

Importantly, we investigated the enhancements provided by active antenna systems (AAS) and MIMO at the 5G NR base stations. The 3.5 GHz base station used 64Tx/64Rx MIMO, whereas the 6 GHz base station used 128Tx/128Rx MIMO, on account of the smaller inter-element antenna spacings possible at the higher frequency (lower wavelength). The user equipment in both bands used 2Tx/4Rx MIMO.

Downlink and uplink spectral efficiencies were measured for outdoor-to-outdoor (O2O) and outdoor-to-indoor (O2I) scenarios. Apart from the higher-order MIMO used at 6 GHz, the two base stations used the same bandwidth and total radiated power (TRP) at 6 GHz and 3.5 GHz, respectively.

Figure (3) shows the route taken by the user equipment for the O2O measurements. With an average building height of around 20 metres, this implied non-line-of-sight (NLOS) propagation between the rooftop base stations and the user equipment at street level in over 80% of the route. Figure (4) shows the distributions of the measured uplink and downlink spectral efficiencies along the route.

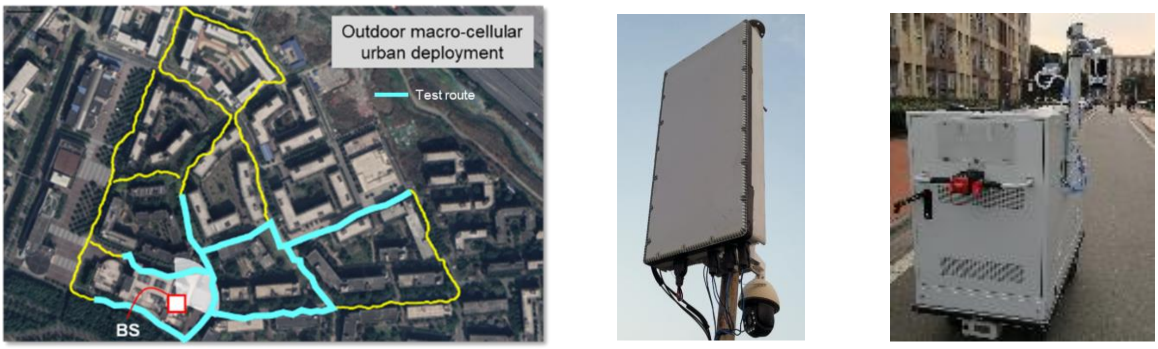


Figure 3: O2O field test scenario.

[7] Inter-site distances in the areas are 350 to 600 metres.

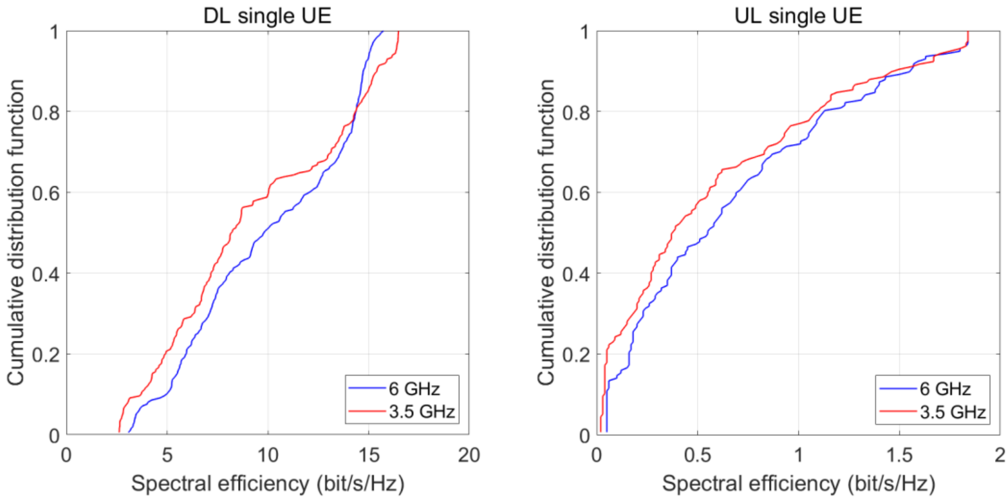


Figure 4: Cumulative distributions of measured O2O spectral efficiencies.

Figure (5) shows measurements of uplink and downlink spectral efficiency with the user equipment located indoors and in the proximity of a window, in what we refer to as a “shallow” rather than “deep” indoor environment. The 5G NR base stations were located a distance of 150 metres outside the building and in non-line-of-sight.

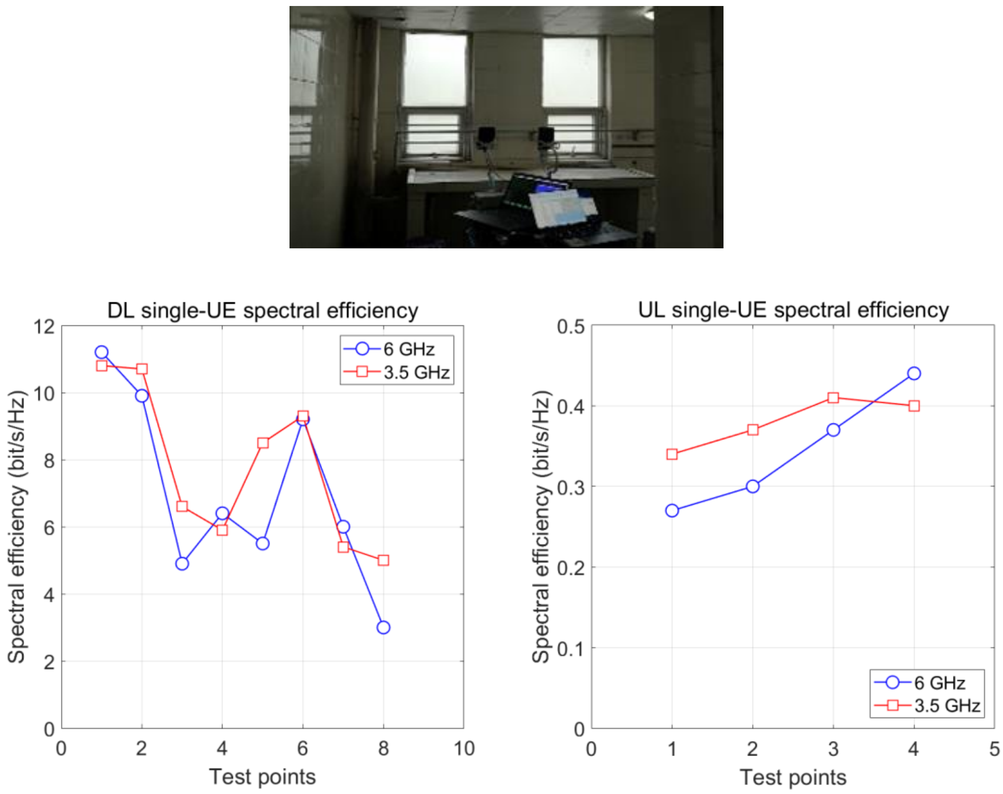


Figure 5: Measured O2I spectral efficiencies.

Figure (6) shows measurements along a corridor, and how the downlink throughout reduces with distance from a door at the end of the corridor.

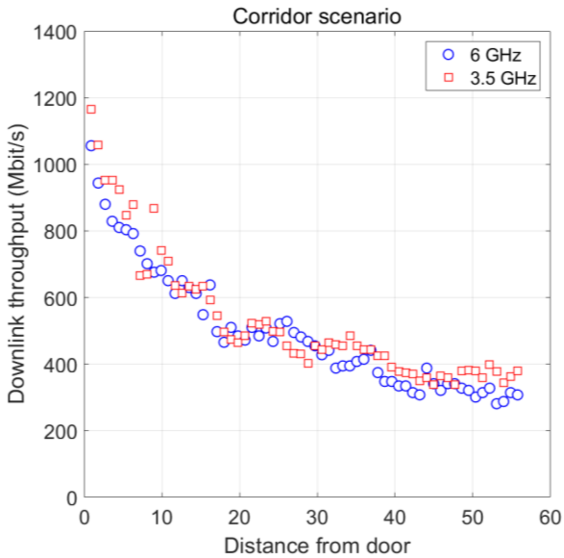


Figure 6: Measured O2I throughput as a function distance from a door at the end of a corridor.

Our field tests indicate broadly similar downlink and uplink spectral efficiencies for both outdoor-to-outdoor and outdoor-to-indoor (shallow indoor) scenarios in the 6 GHz and 3.5 GHz bands. This is justified by the higher-order MIMO implemented in the 6 GHz base station.

In addition to AAS and MIMO, further user equipment and base station physical layer enhancements are being investigated and developed.

■