5G will require new as well as established spectrum bands, but the availability of new bands is not confirmed

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The process of defining the next generation of wireless communications (5G) now underway, and the economic impact of decisions that national governments will make about the assignment and award of spectrum for 5G is potentially significant. There is already immense interest and lobbying from a wide range of stakeholders in relation to the development of 5G, and the associated market, technology and spectrum issues, even though 5G networks are unlikely to be needed until after 2020 in many markets. A key trend is the potential use of technologies deployed in the millimetre wave portion of radio spectrum. This article considers work in progress towards achievement of a global vision for 5G, and what the spectrum implications might be.

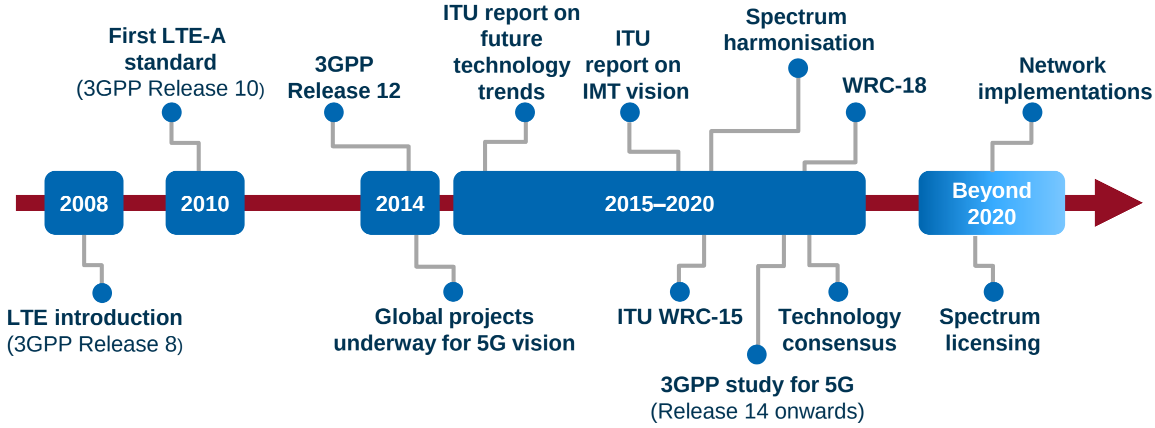
One of the major motivations for 5G is to improve the performance of wireless broadband services beyond 2020

Mobile operators are currently investing heavily in 4G networks, and this investment is likely to continue well beyond 2020. New 4G features such as carrier aggregation make it possible for mobile operators to aggregate two or more radio frequency carriers to boost user-data throughput. Better ways of using spectrum such as adding supplementary downlink bands to cater for significant demand for data download will also improve utilisation of spectrum in many markets. The need to monetise LTE investments is already creating shifts in mobile markets and business models, with a greater focus on sharing between different network elements, network consolidation and new pricing models being launched for mobile data services.

However, despite these advances, 4G networks will not offer a serious challenge to fibre broadband during the next decade and are unlikely to achieve the speeds, coverage, reliability and performance required in future wireless networks. This is partly due to the economics of 4G network build as well as for technological reasons. One of the key motivators for 5G is thus to provide ubiquitous, high-speed, high-quality wireless broadband coverage to meet societal and industrial needs beyond 2020. This positions 5G at the core of many national and regional government targets on next-generation broadband availability and use, such as the Digital Agenda for Europe.

Research programmes, industry collaborations and standardisation debates now underway to define a 5G global vision will ultimately determine the technological, network and spectrum requirements of 5G. Consensus-building and harmonisation are anticipated between 2015 and 2020 ahead of full 5G commercial launches (see Figure 1). At this early stage, a diverging range of business models, applications, market sectors and devices are emerging. Possible technological routes to 5G include entirely new radio technologies and techniques, as well as further evolution and deployment of existing technologies (LTE-A and Wi-Fi, for example).

Figure 1: Timeline towards 5G [Source: Analysys Mason, 2014]



5G technology research focuses on improving spectrum utilisation

A key difference between 5G and earlier generations of mobile technology is that the focus of research is on finding the best techniques to improve spectrum utilisation (that is, bits per Hertz per unit area), rather than on improving spectrum efficiency (that is, bits per Hertz). This is because improvements in spectral efficiency are constrained by background noise, meaning that improvements through coding and modulation design become more difficult and less effective (the 'Shannon Limit'). However, new technological approaches can substantially improve spectrum utilisation, defined in terms of bits per Hertz per cell (or area). They can also enable networks to become more flexible and suitable to carry some of the new applications and use cases being foreseen within 5G.

Proposed technologies such as massive MIMO, super-dense meshed cells and macro-assisted small cells ('phantom cells') are all possible 5G radio access techniques targeting better spectrum utilisation, higher speeds and lower latency. From the user's perspective, the aim is to provide a better and more-consistent service regardless of location.

Many of the technologies being researched are inherently better suited to being deployed in very high frequency bands – in the 'millimetre' range of radio spectrum (current 5G research includes trials conducted in bands such as 15GHz, 28GHz, 60GHz and 70GHz, for example – substantially higher bands than mobile communications has traditionally used). This spectrum can better support the use of multiple, miniaturised antennas (since the wavelength of higher frequency bands is shorter and antenna spacing is based on wavelength, so more antenna elements can be accommodated). Furthermore, substantially more bandwidth is available in these bands than in the bands below 1GHz, which is beneficial for providing much wider channels and higher speeds as envisaged by 5G, without the need for multiple antennas.

However, millimetre-wave bands do not lend themselves to providing wide area coverage for mobile devices (and coverage will be essential for some envisaged 5G services, such as IoT applications such as for the automotive industry). Therefore, further spectrum below 1GHz is expected to be needed in many countries to improve mobile broadband coverage.

The spectrum needs for 5G might therefore encompass a range of existing and new bands, which potentially span a wide section of radio spectrum. Different bands will serve different purposes and a key aspect of 5G will be to integrate the various approaches and bands within a harmonised global framework (Figure 2 summarises examples of different spectrum possibilities). Early indications suggest that spectrum sharing is likely to be used in a far greater way, which may signal an end to further spectrum being reserved for 'exclusive' mobile broadband use as 5G is introduced.

Figure 2: Comparison of spectrum possibilities for 5G [Source: Analysys Mason, 2014]

Band and bandwidth available	Merits	Spectrum packaging/number of licences
700MHz Varies in different markets, from around 2×30MHz to 2×45MHz	Ideal for providing wide area coverage, needed for certain envisaged applications (for example, IoT)	Channel size likely to be similar to other mobile bands in use below 1GHz, for example, multiples of 5 or 10MHz, and spectrum packages will be similar to other bands below 1GHz, for example, 3 or 4 licences of 2×10MHz per operator maximum
3.4–3.8GHz Up to 400MHz either in a paired or an unpaired arrangement	Depending on use by existing services this band could provide substantially more bandwidth than bands below 1GHz (for example, 100MHz and above)	Channel sizes likely to be multiples of 20MHz, meaning 4 or more licences of 50–100MHz could be feasible depending on the available spectrum in the band
5GHz This band is being considered at the ITU World Radio Conference in 2015 (WRC-15) – in total over 300MHz in new spectrum could be allocated	If agreed at WRC-15, a contiguous band from 5150 to 5925MHz would be created using a combination of existing and new spectrum	Channel sizes likely based on current Wi-Fi use, in multiples of 20MHz, and the band is likely to remain as a licence-exempt band in line with current Wi-Fi
15GHz Potentially over 500MHz depending on the sub-band used and sharing with existing uses	Very high speeds are achievable – for example, peak speeds of 5Gbps have been demonstrated already[1]	Channel sizes could be very wide, for example, multiples of 100MHz Depending on the bandwidth available, the band could accommodate multiple operators, with the opportunity for companies other than established mobile operators to offer some 5G services with an assignment of 100MHz per operator, or more, depending on national availability and sharing with existing services
28GHz Similar to the 15GHz band, for example, over 500MHz depending on the sub-band used and sharing with existing uses	Similar to the 15GHz band	Channel sizes could be very wide, for example, multiples of 100MHz Depending on the bandwidth available, the band could accommodate multiple operators with the opportunity for companies other than established mobile operators to offer some 5G services with an assignment of 100MHz per operator, or more, depending on national availability and sharing with existing services
60-80GHz Potentially up to 5GHz depending on the selected sub-band (for example, 71–76MHz and/or 81–86GHz)	Similar to the 15GHz and 28GHz bands	Channel sizes could be very wide, for example, multiples of 100MHz Depending on the bandwidth available, the band could accommodate multiple operators with the opportunity for companies other than established mobile operators to offer some 5G services with a 100MHz assignment per operator, or more, depending on national availability and sharing with existing services

It is noted that all of these bands will be 'new' bands for mobile use, and, at present, are used for other types of wireless communication, such as terrestrial TV or fixed wireless links. Sharing arrangements within established services will therefore ultimately determine the available bandwidth, and possibilities for 5G use.

[1] Ericsson (Stockholm, Sweden, July 2014), *Ericsson 5G delivers 5Gbps speeds*. Available at http://www.ericsson.com/news/1810070.

Analysys Mason has conducted world-leading research into 2G, 3G and 4G networks and continues to be at the forefront of technology and spectrum consulting with 5G.

For further insight into what 5G might mean in terms of services, business models, technologies and spectrum, please contact Janette Stewart, Principal, at janette.stewart@analysysmason.com.