Spectrum Policy for Satellite and 5G Systems: Focus on 28 GHz Band

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Abstract – **With advances achieved in new technologies, fresh regulatory obstacles happen. As progress on 5G networks advances, consumers look forward to a future of autonomous cars, faster and more reliable data transfers, smart cities, and the Internet of Things (IoT). Our world may become seamlessly connected, with the potential to end the digital divide. Satellite services, which have supported today's 2G, 3G, and 4G networks are set to become an essential part also of the 5G ecosystem. Satellite services will provide traditional assistance to mobile networks, such as backhauling, as well as complementing new aspects unique to the 5G ecosystem. For this reason, it is worth considering spectrum bands essential to current and future satellite performance when considering spectrum policy for 5G. India and many other countries are currently debating the best allocation of mm-Wave (millimeter wave) spectrum for 5G. However, hundreds of satellites worth tens of billions of dollars have already been or will soon be deployed in Ka-band, including the 28 GHz (27.5-29.5 GHz) band for Earth-to-space transmission.**

Over 1500 satellite network filings have been submitted at the International Telecommunication Union which include the Ka-band, while approximately 140 satellites are already operational. It is critical to preserve and expand the satellite systems in the 28 GHz band and consider other mm-Wave bands for terrestrial mobile services, such as 26 GHz, to allow for the growth of both 5G mobile networks and complementary satellite services. This is especially clear when the low likelihood of global harmonization of the 28 GHz band for terrestrial mobile services is considered, and when the role of satellites in the 5G ecosystem is analyzed.

Keywords: Spectrum policy, Spectrum allocation, Satellite communications, 5G mobile telephony, Ka band, Millimeter-wave bands, Terrestrial mobile services

I. INTRODUCTION

OPTIMIZATION of spectrum allocation becomes increasingly important as demand for wireless data and Internet increases, straining networks. As the success of the communication sector has been shown to directly impact a country's GDP growth, it is even more important to ensure spectrum is efficiently managed and allocated to allow the sector to operate at its peak while implementing a global 5G infrastructure, or 5G ecosystem [1]. This requires global cooperation through key organizations like the International Telecommunication Union (ITU) because of the inherently international nature of spectrum use [1].

The global harmonization of spectrum allocation is made complicated by competing interests for specific bands. Critically, mm-Wave bands are contested by both terrestrial mobile services and satellite services as new technology has made the possibility of using mm-Wave bands viable for mobile services. The current spectrum for mobile broadband under 6 GHz has become too crowded and alternative options need to be considered for the future development of 5G [2]. Current regulatory debate centers around the frequency bands identified for study in the ITU but in addition, some equipment manufacturers are pursuing use of the 28 GHz band, where many satellites already operate. Considering this band for use by mobile services is unnecessary based on the low likelihood of 28 GHz being harmonized for mobile services, the availability of other usable bands, and the need to support satellite systems, necessary for the future of the 5G ecosystem.

Spectrum allocation is revised globally at each ITU World Radio-communication Conference (WRC). This is then used as reference when determining national spectrum allocation plans [1]. Notably, the ITU member states did not include the 28 GHz band as a potential option to consider for mobile services in the upcoming WRC-19, under Agenda Item 1.13. This signifies the ITU's recognition of the importance of this band for satellite services (Figure 1). The 28 GHz band is being utilized by high-throughput satellites (HTS) and due to capacity requirements, the entire band is needed for their operations [3]. This band represents tens of billions of dollars of investment in satellite services, which should not be disregarded. Furthermore, the satellites provide essential and irreplaceable services to the population. Instead, focus should be on portions of spectrum with a higher likelihood of global harmonisation and less disruption of current investments, such as the 26 GHz band (24.25-27.5 GHz) and 40.5-43.5 GHz.

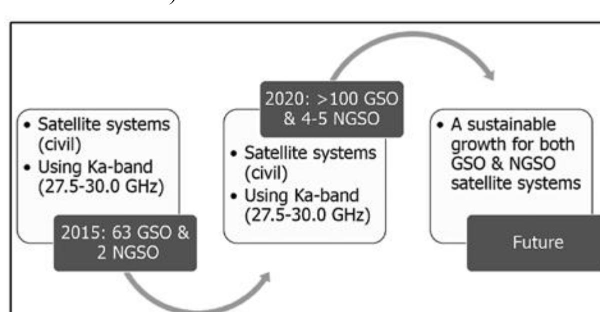

Figure 1. The continued growth of satellite industry in Ka-band.

II. ALTERNATIVES TO 28 GHZ FOR TERRESTRIAL MOBILE SERVICES

Alternative mm-Wave bands that are currently underused have demonstrated their potential for 5G mobile services. Huawei, for example, was able to demonstrate the ability of the 71 GHz and 81 GHz bands to support potential 5G applications in Norway in 2017 [4]. Other mm-Wave bands outside of 28 GHz are also being studied according to the WRC-19 agenda item 1.13, especially the 26 GHz band, totaling to over 31 GHz worth of spectrum for consideration by mobile services. Estimates of total additional spectrum needed by terrestrial mobile services for 5G range from 1.5 GHz to 20 GHz, meaning the 31 GHz worth of spectrum currently being considered for WRC-19 is more than enough to support even the most spectrum-intensive estimates of the future of 5G mobile services [5]. It is therefore unnecessary to consider the 28 GHz band, where satellite developments have already been established, when ample alternative bands exist that are more likely to be harmonized due to their current underutilization.

III. IMPACT ON THE SATELLITE INDUSTRY OF USING 28 GHZ FOR MOBILE SERVICES

The 28 GHz (27.5-29.5 GHz) band is currently recommended to be made available for 5G rollout in India [6]. There are however several considerations to be made from the satellite industry perspective. The 28 GHz spectrum band plays a key role in current satellite operations: there are upwards of 140 geostationary and two non-geostationary satellite systems, including High Throughput Satellites, already using the band. The number has been growing steadily in the past few years and will continue to grow, as the 28 GHz band is key to satellite system innovation on a global basis and will be essential also for the future of Indian satellite services.

Gateways: The 28 GHz band has a primary allocation for FSS (Fixed Satellite Service) and is used in its entirety, due to capacity requirements, for gateways of satellite systems with user payloads in Ka-band and other bands (*e.g*. Ku or S-band). It is essential that FSS gateway operation in the 28 GHz band will not be constrained by 5G deployment, also considering that a domestic gateway is a regulatory requirement in India.

Very Small Aperture Terminals (VSAT) : VSAT use in India will be key to allow remote areas of the country to be connected. Part of the 28 GHz band is also identified, via ITU Radio Regulations No. 5.516B, for use by high-density applications in the fixed-satellite service, *i.e.* ubiquitous VSATs, in the Earth-to-space direction. In Region 3, the relevant portions of the band are 28.45-28.94 GHz, 28.94-29.1 GHz, 29.46-30 GHz.

Earth Station In Motion (ESIM): In addition to the traditional fixed use, the 28 GHz band is also being considered for ESIM under WRC-19 Agenda Item 1.5, to provide broadband connectivity to users on the move and/or in areas not reachable by terrestrial networks (*e.g.* aircraft/vessels). ESIMs are designed to be used on ships, airplanes (Figure 2) and vehicles to supply broadband communication and represent one of the most modern developments in satellite technology. They provide a great service especially to the transportation community and passengers but with their wide – near global – geographic coverage they have potential to impact unconnected communities more generally. ESIMs use specialized terminals to communicate with satellites and presently operate in the 19.7-20.2 GHz and 29.5-30 GHz spectrum. However, the 28 GHz band is under consideration at WRC-19 to allow ESIMs to connect to satellites in this band, with ongoing studies by the ITU regarding the technical, operational and sharing requirements of different types of ESIMs.

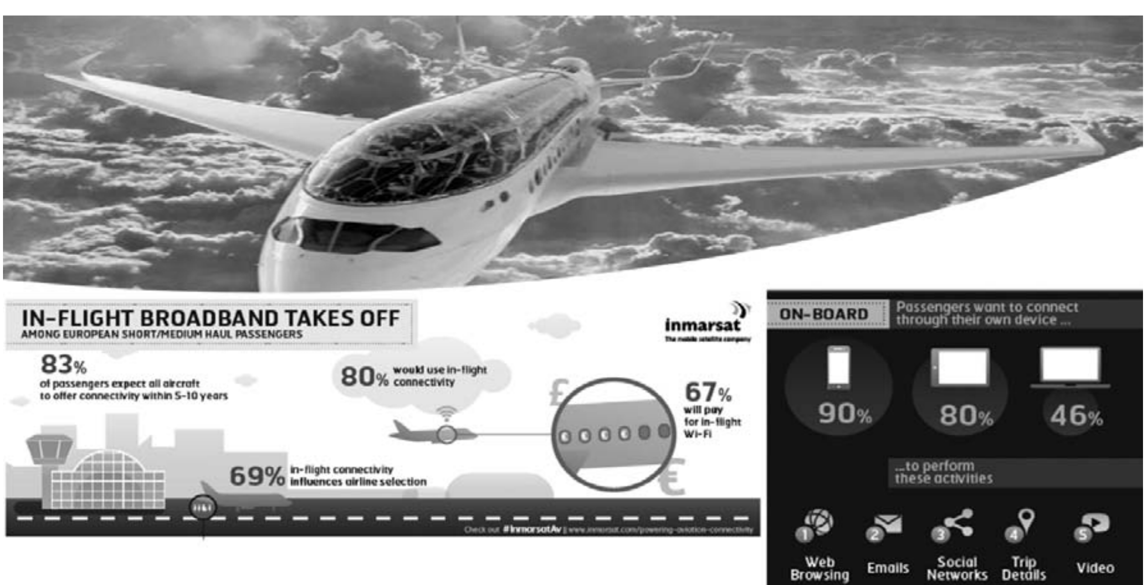

Figure 2. Clear consumer call for connectivity via ESIM.

Finally, there are also interference issues that would arise with any 5G deployment in the band:

- Such deployment will be incompatible with ubiquitous land satellite earth stations, as interference from transmitting earth stations into 5G receivers would be likely to occur. Possible coordination with neighboring countries will also be required, especially given the low probability of international harmonisation in this band.
- There is the potential for aggregate interference by terrestrial 5G transmitters into the GSO and non-GSO satellites receiving in the band.
- Exclusion areas would be required to guarantee the suitable operation of 5G systems in the vicinity of FSS gateways.
- Terrestrial mobile systems would be protected from ESIM operation, via suitable measures: *e.g.* compliance with a power flux density mask on the ground for aeronautical ESIM and a distance from the shore for maritime ESIM.

All the above interference issues would introduce constraints on the use of the 28 GHz band by 5G systems, satellites systems, or both.

IV. SATELLITE'S ROLE IN THE 5G ECOSYSTEM

In the same way satellites have supported 2G, 3G, and 4G/LTE, high-throughput satellites will be an important component of the 5G ecosystem in four main ways. First, the evolution of HTS has lowered the cost for mobile services to use satellite for backhauling of cellular data, especially in rural regions where it would be prohibitively expensive for mobile services to operate with fiber backhaul. Previously, satellite backhauling was more expensive than alternatives, but HTS has lowered the cost [7]. HTS today are capable of supporting higher bandwidth as well, meaning satellite can play a larger role in backhauling in the 5G ecosystem at a lower cost than ever before. This supports one of the primary 5G use cases, enhanced mobile broadband.

Satellite will also be able to support a second critical 5G use case, massive machine-to-machine (M2M) or Internet of Things (IoT) networks. This could be through backhauling communications from remote locations or mobile locations, such as on vehicles or airplanes, but also directly. Innovative, smaller, and more cost-effective ground technologies also make the implementation of IoT more feasible [8]. Supporting IoT via satellite will be critical for IoT's broad success, as well as the success of sectors hoping to utilize IoT, from agriculture to mining, transport and beyond. It is predicted that industrial uses of IoT sensors will make collection of data across the varying stages of production, transport, etc. more feasible. This will allow companies a number of benefits, including streamlining of their operations, increased transparency around ethical sourcing, and improvement of their market analysis to better assess demand [9]. Satellite, in conjunction with mobile services, will provide the communication networks required to transfer, view, and use the data generated by new IoT technologies in real time.

Thirdly, satellites are currently counted on by governments, mobile services, and broadcasters to provide the most reliable coverage. This will continue to be true as satellites are not as vulnerable to many of the same risks as terrestrial infrastructure, such as natural disasters. The high level of reliability provided by satellites can be utilized by future 5G applications, especially since one of the primary standards set by ITU for 5G to meet is "ultra-reliable and low-latency communications (URLLC)".

In fact, satellite can help mobile service providers achieve the low-latency standard as well. Low latency links will be achievable with recent and upcoming satellite deployments in medium Earth orbits and low Earth orbits [8]. Geostationary and non-geostationary satellite systems would help mobile services by multicasting commonly accessed data to caches at multiple terrestrial 5G base stations, providing data to the network edge and avoiding delays from the backhaul network. Most 5G applications will not require extremely low-latency, however, and can thus be directly supported by existing satellite networks. This would apply to Internet of Things for example, whereas some low-latency applications like virtual reality or autonomous driving would derive more use from the upcoming deployments in medium or low Earth orbit [4].

Lastly, satellite is essential to closing the digital divide, which is perhaps the greatest potential benefit to emerging economies. The digital divide represents one of the greatest economic and social inequalities of the Information Age, caused by the differences in the ability of citizens to access to Internet and other communication technologies. The differing levels of access to information and communication technology can also serve to further reinforce pre-existing inequalities, such as a geographic urban-rural divide. Part of the difference in access results from socio-cultural differences and, but part of the issue is the cost of providing necessary infrastructure to service some regions [10]. This is where satellites can help.

New satellite developments, like HTS and non-geostationary satellite orbit constellations can bring 5G applications to rural and underserved regions of the world, helping the portion of the global population which does not have consistent access to the Internet [11]. These projects are in line with the United Nations' Sustainable Development Goals as well, representing an international effort to reduce inequalities by leveraging satellite's range and reliability [12]. New developments in satellite technology increase the chances of creating a more digitally inclusive society, which will only become more important at the onset of 5G and the increasing integration of 5G applications to daily life. Limiting the growth of the satellite sector would hinder progress in reaching isolated communities and extending the reach of 5G advancements.

VI. CONCLUSION

Possible allocation of 28 GHz spectrum to 5G at the national level runs the risk of hindering the growth of the satellite sector for the benefit of terrestrial mobile services. Overall, current and future satellite deployment in the 28 GHz bands is the main reason why the band was not included in WRC-19 Agenda Item 1.13.

Every effort should be made to avoid disrupting the major and long-term investments related to satellite network deployments, especially when there is ample other spectrum under consideration that is more likely to be globally harmonized.

It is in fact clear that the 28 GHz band will not be internationally harmonized for terrestrial 5G and is therefore a poor candidate for suitable economies of scale for 5G equipment. Further to this, use by 5G on a national basis will disrupt the global harmonisation for satellite use, which is of upmost importance, due to the international nature of satellite service.

However, with appropriate planning and attention to the international guidelines set out by the ITU, countries can support both the satellite sector and mobile services. By allocating bands to mobile services that are likely to be globally harmonized, such as the 26 GHz band, a global 5G ecosystem will be able to operate as seamlessly as possible. Furthermore, by allowing satellite services to proceed unimpeded in the band, the 5G ecosystem will be better poised to meet the standards of enhanced mobile broadband, massive machine-to-machine communications, and ultra-reliable, low-latency communication because of satellite's complementary role to 5G mobile services.

The equity implications of such a successful 5G ecosystem are represented by satellite's ability to reach the most unconnected among us and to bring the benefits of 5G applications to them. In conclusion, regulatory debate on spectrum allocation should focus on one of the many alternative mm-Wave bands outside of 28 GHz for mobile services in order to develop a 5G ecosystem that benefits all.

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