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EFFICIENT USE OF THE 28 GHz BAND BY SATELLITE SYSTEMS

(Item on the Agenda: 3.3)

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1. Introduction

Growing demand for satellite services has resulted in hundreds of satellites worth tens of billions of dollars already deployed, and continuing to be deployed, in Ka-band, including the 28 GHz (27.5-29.5 GHz) band for Earth-to-space transmission. It is critical to preserve and expand the satellite systems in the 28 GHz band and consider other mmWave bands for 5G terrestrial mobile services, such as 26 GHz, to allow for the growth of both 5G mobile networks and satellite services.[1] This is especially clear when considering the demand for satellite services that already exists in the 28 GHz band, the critical role of satellites in the 5G ecosystem, the adverse impact of repurposing satellite spectrum, and the low likelihood of global harmonization of the 28 GHz band for 5G terrestrial mobile services.

2. Satellite operations in the 28 GHz band

Over the past two decades, the satellite sector has launched a substantial number of Ka-band satellite systems, and has continued to develop even more efficient and powerful space and ground segments.

Today, the 28 GHz frequency portion of the Ka-band plays a key role in current satellite operations with upwards of 130 geostationary (GSO) and non-geostationary (NGSO) satellite systems, including High Throughput Satellite (HTS) systems, using the band globally (see Annex 1) and providing valuable service to end users globally. The number of satellite systems will continue to grow in order to accommodate increasing customer demand for existing services as well as new market opportunities that are currently developing. Latest reports available from the International Telecommunication Union (ITU) show that over 1500 satellite network filings have been submitted in the Ka-band demonstrating the importance of this band for continued satellite uses.

The same developments are taking place in the Americas region, where satellite operators have been deploying or are planning to deploy GSO and NGSO, HTS systems in both low Earth orbit (LEO) and medium Earth orbit (MEO) in the 28 GHz band. Governments and consumers in the region are increasingly relying on the 28 GHz band for a wide range of services that are most efficiently delivered by satellites, and that sometimes can only be delivered over satellites. Brazil, the largest country in both South America and Latin America, is a good example with the SGDC satellite providing government-mandated broadband services as well as commercial services. In the border state of Amazonas, a remote area covering a population of 500,000 currently accesses broadband connectivity using MEO satellite capacity. Table 1 shows a non-exhaustive list of operational and planned GSO Ka-band satellites in Brazil.

Operator	Satellite	Position	Launch Date	Ka-band capacity	Contractors
Telebrás	SGDC	75°W	May 2017	58 Gbit/s	Viasat: to provide government-mandated broadband services as well as commercial data services, and operate capacity to be commercialized by Telebrás
Hispasat/ Hispamar	Amazonas 5	61°W	September 2017	NA	Hispamar, GiLat: Ka-band for white label consumer broadband services (includes Amazonas 3 Ka-band capacity)
Yahsat	Al Yah 3	20°W	January 2018	50 Gbit/s	Yahsat, Eutelsat: 85% of capacity for residential

[1] It is important to retain the other allocations for the fixed satellite service in the bands above 24 GHz including the 40-42 GHz and 48.2-50.2 GHz band consistent with its identified use for HDFSS and other bands including the 37.5-40 GHz, 47.2-48.2 GHz and 50.4-51.4 GHz bands.

					broadband services in 19 African markets and Brazil Telespazio, InternetSat, others: 15% of capacity available for wholesale distribution
Telesat	Telstar 19 VANTAGE	63°W	July 2018	31 Gbit/s	Hughes: Ka-band for broadband in five South American countries; 58,000 subscribers in first 18 months Northwestel: Ka-band for broadband in Nunuvut, Canada
Star One	Star One D2	70°W	2H 2019	20 Gbit/s	ClaroBrasil: Ka-band for wireless backhaul
Viasat	ViaSat-3	NA	NA	1 Tbit/s	Viasat: Ka-band high capacity for Americas
SES	SES-17	Unknown	1H 2021	NA	Thales to offer inflight connectivity over the Americas
EchoStar/ Hughes	EchoStar 24/ Jupiter 3	95°W	2021	500 Gbit/s	Hughes: expansion of consumer broadband services
Eutelsat	Eutelsat 65W	65°W	March 2016	24 Gbit/sps	Hughes: Ka-band capacity for Brazilian market

Data as of August 22, 2018.
NA = not available
Source: industry data
Kagan, a media research group within the TMT offering of S&P Global Market Intelligence

Table 1: An Example: Existing and new Ka-band satellites in Brazil

It is imperative that the global, regional and national regulatory landscapes support continued operation and growth of satellite services in the 28 GHz band without constraints in order to protect the substantial, long-term investments of satellite operators. The investments in the (non-exhaustive) list of operational and planned HTS systems in Annex 1, along with associated ground infrastructure, amount to billions of USD. Sudden changes in the regulatory environment would jeopardize these investments and reduce commercial viability of existing satellite services. Indeed, long-term regulatory certainty is required to maintain thriving satellite operations in the 28 GHz band as the design and deployment cycles for satellites approach or exceed 20 years. This includes a design period that ends as early as 30 months prior to launch for a typical geostationary satellite with a design lifetime of 15 years, and which often has an actual service lifetime that is a few years longer.

3. Use of 28 GHz band by satellite earth stations

3.1 Ubiquitously deployed earth stations

There has been significant growth in satellite services that involve the deployment of a large number of small, transmit-receive user terminals. This growth is fueled by consumer demand for high quality broadband connectivity regardless of their location, a demand that satellites are often uniquely positioned to address. The technological developments of space and ground segments are further enabling the ability to service this demand by providing higher data rates at reduced cost. Much of this growth in satellite services is expected to be met by the deployment of small user terminals, particularly in the 28 GHz band. In line with this trend, some satellite operators are planning to move their gateway links into higher frequency bands in order to accommodate more user terminals in the 28 GHz band. This illustrates the demand for a large quantity of spectrum in the 28 GHz band for user terminals. It is essential that the operation of FSS user terminals are not constrained by the addition of any other services in the band.

Because of the importance of the 28 GHz band for satellite systems, the entire 27.5-29.5 GHz band currently is available for broadly deployed FSS earth stations in numerous Latin American countries. For example, in Mexico, the entire 27.5-29.5 GHz band is both exclusively allocated for the FSS and licensed for ubiquitously deployed user terminals on a blanket-license basis. In Brazil, the 27.5-29.5 GHz band is available for "block" (or blanket) licensing of FSS user terminals operating on a primary basis. In fact, in 2017, ANATEL limited the use of the 27.9-28.4 GHz band segment to the FSS. Blanket licensing of

FSS user terminals also is possible throughout the 27.5-29.5 GHz band in Uruguay, among other countries in Latin America. The FCC in the U.S. has made the bands 28.35-29.1 GHz and 29.25-29.5 GHz available only for the FSS, including ubiquitously deployed satellite user terminals. The FCC also has committed to consider allowing ubiquitously deployed satellite user terminals at 27.5-28.35 GHz in light of "the evolving nature of technology and deployment."[2] Millions of satellite broadband user terminals already have been deployed under these types of rules.

As demonstrated above, individual licensing is not feasible for ubiquitously deployed earth stations because of the licensing process required and the siting restrictions that would result. As other countries have found, user terminals are appropriately licensed on a blanket licensing basis. Requiring individual licensing for user terminals would be overly burdensome to regulators, operators and users, resulting in significant delay in end users receiving broadband services

3.1.1 Earth Stations in Motion

Agenda Item (AI) 1.5 of the 2019 ITU World Radiocommunications Conference (WRC-19) will consider the use of the frequency bands 17.7–19.7 GHz (space-to-Earth) and 27.5–29.5 GHz (Earth-to-space) for Earth Stations in Motion (ESIMs) communicating with geostationary space stations in the FSS.

Aircraft, ships and land vehicles need consistent connectivity when they travel long distances, and also operate in areas outside terrestrial coverage. There is soaring demand by passengers to be connected while travelling. This demand is transforming the aviation and maritime industry. Currently, more than a hundred airlines have either installed or committed to install in-flight connectivity (IFC) solutions.

The satellite industry commends regulators for taking steps to address this increased demand by releasing the 28 GHz band, or parts thereof, to ESIMs prior to the conclusion of WRC-19. In anticipation of a positive outcome for AI 1.5 at WRC-19, it is expected that regulators in the Americas would consider allowing ESIMs to operate in the entire 28 GHz range.

3.1.2 Consumer broadband

Similar to aforementioned satellite mobility services delivered to aircraft, ships and land vehicles, fixed broadband connectivity services are also expected to grow. Today, in North America, there are approximately 2 million Ka band broadband satellite users and in the Americas, Hughes alone has approximately 1.3 million users. The biggest drivers behind this growth are the demand for the high speed broadband that satellite offers today, as well as government connectivity programs looking to bridge the digital divide and business customers. Furthermore, the Americas have millions of people lacking 3G/4G coverage, which will translate into strong growth in cellular backhaul via satellite.

These Ka band satellite service applications are all delivered through small, ubiquitously deployed terminals which benefit most from a class license regime, because that allows service to be deployed to end users very quickly---typically in a matter of days.

Moreover, the satellite industry can confirm that equipment for both user terminals and gateways have been readily available for several years across the entire 28 GHz frequency range.

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[2] *Use of Spectrum Bands Above 24 GHz for Mobile Radio Services*, Report and Order and Further Notice of Proposed Rulemaking, 31 FCC Rcd 8014, ¶ 69 n. 166 (2016).

3.1.3 Community Wi-Fi

28 GHz satellite-powered Wi-Fi services today connect users in metropolitan areas as well as unserved and underserved markets within the satellite network's coverage area. Satellite-based Wi-Fi is extending high-speed broadband access in unique ways to urban city centers, community recreation centers, airports, stores and shops. At the same time, large numbers of towns and villages worldwide have little to no Internet access. To address these broadband-challenged locations, satellite-powered hotspot service connects people in small villages and towns to the online world – affordably and reliably. Many people in these villages and towns have mobile smartphones, yet many do not have Internet service. By bringing a 28 GHz satellite-powered community 5G Wi-Fi service to these villages, made available through a shared satellite terminal, the residents gain access to high-speed connectivity. For example, today Viasat has 2,000+ Wi-Fi hotspots already in operation with 50,000+ additional Wi-Fi hotspots planned. These locations that don't have 3G or 4G services can now connect their smartphones thanks to satellite-powered community Wi-Fi hotspots.

3.1.4 Additional Satellite Capabilities

Satellites are integral to the 5G ecosystem. Among other things, 28 GHz satellites already provide true geographic ubiquitous coverage, extending connectivity to places that terrestrial networks do not, and may never, reach. These satellites thus have the capability to achieve the promise of seamless, universal 5G coverage and services.

28 GHz satellites today also have the capability to support future 5G applications like Internet-of-Things ("IoT") and Machine-to-Machine ("M2M") such as asset tracking and weather sensor networks. Satellites can even support the low-latency requirements of emerging 5G applications of the future, much in the same way as terrestrial networks, since sub-1ms latencies can only be achieved if the content to be served to end users is located in the immediate vicinity of the end user.[3]

3.2 Individually licensed earth stations

The entire 28 GHz band is allocated to fixed-satellite service (FSS) and is used for both satellite gateways and user terminals in places such as Mexico, for example. Gateways are essential to any satellite network as they enable connections to the Internet and other terrestrial networks in order to deliver required end-to-end connectivity to customers. These stations typically depend on access to large contiguous amounts of spectrum, which the Ka-band (including the 28 GHz band) offers, to support user payloads in the Ka-band as well as other bands (e.g., Ku or S-band).

Indeed, a number of the Ka-band satellite systems indicated in Table 1 provide their services to other parts of the Americas region through gateways in a variety of countries in the Americas. Any part of the 28 GHz band that is not being used by gateways can instead be used to provide even greater capacity for service links and thus enable more and better service to end users.

Inmarsat's gateways in Lino Lakes, Minnesota, USA and Winnipeg, Manitoba, Canada enable the Global Xpress GEO constellation to provide reliable and assured access to high-throughput communications to customers in the Americas region across aviation, maritime, enterprise and government sectors. Hughes Network Systems, LLC has gateways for its Americas 28 GHz band broadband satellite system in

[3] GSMA Intelligence, *Understanding 5G*, at 12 (Dec. 2014) ("[S]ervices requiring a delay time of less than 1 millisecond must have all of their content served from a physical position very close to the user's device. Industry estimates suggest that this distance may be less than 1 kilometre, which means that any service requiring such a low latency will have to be served using content located very close to the customer, possibly at the base of every cell, including the many small cells that are predicted to be fundamental to meeting densification requirements.").

Canada, the United States, Brazil and Mexico, with expansion to Chile expected shortly for its 28 GHz broadband satellite network comprising six 28 GHz band satellites. Hughes also has under construction its Jupiter 3 satellite network which will provide service throughout the Americas in the 28 GHz and other bands above 24 GHz using gateways in the United States. Viasat has gateways in the United States and Canada for ViaSat-1, ViaSat-2, and the ViaSat-3 satellite is under construction. ViaSat-3 will provide broadband services to all of the Americas. Locating these gateways in the United States and Canada frees up the 28 GHz band entirely for user terminals in Latin America, and thus provides more capacity in that region. The O3b Ka-band MEO constellation provides service throughout the Americas region today with gateways in the United States, Brazil and Peru. In addition, the terminals used by O3b customers on land are coordinated earth stations. New NGSO systems similarly plan to employ multiple gateways to serve the region.

It is essential that neither FSS gateway operations nor the deployment of user terminals are unduly constrained by the addition of other services in the band. Furthermore, the availability of the entire 28 GHz band for gateway earth station operations is consistent with international harmonisation of the band. For example, the entire 28 GHz band is available for individually-licensed earth station operations across the territories of the countries cooperating in the European Conference of Postal and Telecommunications Administrations (CEPT) based on ECC DEC (05)01. In fact, CEPT's "Road Map for 5G" includes the following express policy determination: "Signal clearly that Europe has harmonised the 27.5-29.5 GHz band for broadband satellite and is supportive of the worldwide use of this band for ESIM. *This band is therefore not available for 5G*."[4] Similarly, individually licensed earth station operations are available in the entire 28 GHz band in the United States with different regulatory regimes applying in different portions of the band.

4. Coexistence of terrestrial 5G with existing satellite services

The deployment of advanced HTS systems has reduced the cost per bit for satellite services and significantly increased the bit rates offered to customers. This has allowed satellite operators to offer services at par for cost and quality with terrestrial service providers, which in turn has resulted in an increased number of broadband terminals broadly deployed in metropolitan and rural areas alike. Consequently, there is no clear geographical delineation for the deployment areas of such satellite terminals. This is also true for ESIMs as various transport platforms (planes, trains and cars) operate and will use satellite connectivity within or nearby urban centres in addition to rural areas.

The outcome of this development makes coexistence with proposed 5G mobile systems impractical, as those systems require significant geographic separation from satellite earth stations to meet the stated 5G protection criteria. Extensive deployments of these terrestrial 5G networks in the 28 GHz band would effectively sterilize large areas from earth station operation.

The terrestrial mobile broadband systems proposed for 28 GHz are envisioned to be deployed not only in urban, sub-urban and rural areas but also on major roads, stadiums, airports or open-air festivals which are areas where satellite terminals are regularly deployed. Studies conducted under the auspices ITU-R TG5/1 show separation distances between 100 m to 10 km are needed to achieve stated 5G mobile protection criteria in the adjacent 27-27.5 GHz band. A new recommendation[5] has been initiated in Working Party 5A that shows characteristics for 5G mobile systems which in some cases are 9.5 dB more sensitive towards interference. Deploying 5G systems with these more sensitive characteristics would significantly increase the separation distances required to meet the stated 5G protection criteria.

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[4] ECC(18)104 Annex 17, CEPT roadmap for 5G (Version 6, Rev.6 July 2018)

[5] Preliminary Draft New Recommendation ITU-R M.[MS-RXCHAR-28] (Annex 15 to Document 5A/650)

Finally, it is worth emphasizing that if 5G mobile broadband systems are introduced in the 28 GHz band, there is a significant risk of generating unacceptable uplink interference into satellites operating in that band. While simulations of possible uplink interference may show positive results, the business case and deployments of 5G networks are not yet fully understood for these frequency bands, so the results cannot be fully relied upon. Experience of satellite operators in other bands indicates that aggregate interference can quickly rise to levels unacceptable for satellite operation as the density of terrestrial deployments increase. As remedial action to reduce such interference is difficult, if not impossible, once 5G networks have been deployed by terrestrial operators, the only option for successful interference mitigation remains to limit the individual and aggregate emission of 5G terrestrial networks in the direction of satellites from the outset at the international and national levels.

5. Conclusion

Satellite systems are today making extensive use of the 28 GHz band for both individually licensed gateway-type terminals and for ubiquitously deployed user terminals. There are upwards of 140 satellite systems already operating in the band, both GSO and NGSO, with additional systems planned for the near future. In a number of cases, and for a variety of reasons, the services being provided are most efficiently delivered by satellites, and often can only be delivered over satellites.

Any use of 28 GHz spectrum for 5G at the national level would hinder the growth of the satellite sector and disrupt the major and long-term investments related to satellite network deployments. Overall, current and future satellite deployment in the 28 GHz bands is the main reason why the band was not agreed to be included as a possible candidate band for study in WRC-19 A.I. 1.13.

Based on current and planned future uses, 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.

With appropriate planning and attention to the international framework set out by the ITU, countries can support both the satellite and mobile services sectors. By allocating bands to 5G 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 28 GHz 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 role on the 5G ecosystem.

In conclusion, regulatory debate on spectrum use by 5G mobile broadband should focus on one of the many alternative mmWave bands outside of 28 GHz in order to develop a 5G ecosystem that can achieve its full potential and deliver the greatest public good. The 28 GHz band is and will continue to be a critical band to support the deployment of satellite broadband services to end users in the Americas, no matter where they are located.

ANNEX 1

Information on recently launched and to be launched Ka-band satellites

Date(UTC)	Satellite	Rocket	Site	Position	Comments
180131 21:25	**SES 16/GovSat 1**	Falcon 9	Cape Canaveral	21.5°E	
180306 05:33	**Hispasat 30W-6**	Falcon 9	Cape Canaveral	30.0°W	7 Ka band and 58 Ku tps and 1 C band tp will replace Hispasat 30W-4
180405 21:34	**Hylas 4**	Ariane 5 - VA242	Kourou	33.5°W	
180503 16:06	**Apstar 6C**	Long March 3B	Xichang	134.0°E	19 Ku/Ka tps and 26 C tps
180604 04:45	**SES 12**	Falcon 9	Cape Canaveral	95.0°E	138 Ku tps and 19 Ka tps will replace NSS 6 and be co-located with SES 8
180722 05:50	**Telstar 19 Vantage**	Falcon 9	Cape Canaveral	63.0°W	co-located with Telstar 14R
180925 22:38	**AzerSpace 2/Intelsat 38**	Ariane 5 - VA243	Kourou	45.0°E	will replace Intelsat 12
18 end	**Energia 100**	Soyuz	Vostochny	112.0°E	
1901	**Hellas Sat 4**	Ariane 5 - VA247	Kourou	39.0°E	
1902	**Yamal 601**	Proton	Baikonur	49.0°E	26 Ka tps and 19 Ku tps and 18 C tps will replace Yamal 202
1905	**Hylas 3**	Ariane 5	Kourou		
1904-06	**Amos 17**	Falcon 9	Cape Canaveral	17.0°E	Ka tps and Ku tps and C tps
1907-12	**JCSAT 18/Kacific 1**	Falcon 9	Cape Canaveral		56 Ka tps
19 end	**Star One D2**	Ariane 5	Kourou		24 Ku tps & 28 C tps
20 early	**Galaxy 30**	Ariane 5	Kourou		
NA	**ViaSat 3**	Ariane 5	Kourou	NA	
20	**Arsat 3**	Ariane 5	Kourou		to be located at 72 West or 81 West
2007-12	**Amos 8**	Falcon 9	Cape Canaveral	4.0°W	co-located with Amos 3
21	**Türksat 5B**	Falcon 9	Cape Canaveral	42.0°E	
22	**PSN 7**				Ka tps
	Express AMU5			140.0°E	12 Ka tps and 40 Ku tps and 30 C tps and 2 L tps
	Express AMU6			53.0°E	12 Ka tps and 44 Ku tps and 14 C tps and 2 L tps

Source: https://www.lyngsat.com/launches/ka.html

Satellites operating in the Ka-band:

	Satellite		Satellite		Satellite		Satellite
1	SES 15	36	Amazonas 5	71	Astra 3B	106	Luch 5V
2	Galaxy 23	37	Inmarsat-5F2	72	Eutelsat 25B	107	Chinasat 2A
3	Anik F3	38	Intelsat 29E	73	Badr 5	108	Chinasat 2C
4	Spaceway 1	39	Intelsat 32e	74	Badr 7	109	Asiasat 7
5	ViaSat 1	40	Hispasat 36W-1	75	Astra 2F	110	Gaofen 4
6	Anik F2	41	Skynet 4F	76	Astra 2E	111	DFH 165
7	Wildblue 1	42	Hylas 1	77	Astra 2G	112	Chinasat 16
8	Echostar 17	43	Hylas 4	78	Hylas 2	113	Koreasat 5A
9	AMC 15	44	Hispasat 1F	79	Astra 5B	114	Koreasat 5
10	Spaceway 1	45	Hispasat 1E	80	Skynet 4C	115	Koreasat 7
11	Directv 15	46	Spainsat 1	81	Express AMU1	116	ABS-7
12	Directv 12	47	Nimiq 2	82	Athena Fidus	117	Thaicom 4
13	Directv 10	48	AlComSat 1	83	HellasSat 3	118	Asiasat 9
14	SDO	49	Al Yah 3	84	Turksat 4A	119	Cosmos 2526
15	Directv 9S	50	Intelsat 37e	85	Nigcomsat 1R	120	COMS 1
16	Directv 8	51	Telstar 12V	86	Cosmos 2520	1212	Chinasat 1A
17	Directv 14	52	Cosmos 2473	87	Syracuse 3A	122	APSTAR 6C
18	Directv 11	53	Nilesat 201	88	Yahsat 1B	123	Express AM5
19	Spaceway 2	54	Syracuse 3B	89	GSAT 19	124	NBN-Co 1A
20	Echostar 19	55	Amos 3	90	Turksat 4B	125	Kizuna
21	Spaceway 3	56	Amos 7	91	Yahlive	126	NBN-Co 1B
22	Echostar G1	57	Skynet 4E	92	Express AM6	127	Mtsat 2
23	Galaxy 28	58	Thor 7	93	Intelsat 33e	128	Jcsat 16
24	Tupac Katari 1	59	Eutelsat 3B	94	Inmarsat-5F1	129	DFH 139
25	SES 2	60	Astra 4A	95	Amos 4	130	Superbird B2
26	AMC 16	61	Eutelsat 7A	96	Intelsat 20	131	Superbird B3
27	Star One D1	62	Eutelsat 7B	97	UHF 10	132	Inmarsat-5F3
28	Nimiq 4	63	Eutelsat KA-SAT 9A	98	GSAT 14	133	O3b-A
29	Venesat 1	64	Inmarsat 5F4	99	ABS-2		
30	SGDC 1	65	Sicral 1B	100	DFH 76		
31	Viasat 2	66	Eutelsat 16A	101	Cosmos 2520		
32	Astra 1H	67	Sicral 1A	102	Chinasat 1C		
33	Eutelsat 65 West A	68	Astra 1L	103	TDRS 8		
34	Telstar 19V	69	Arabsat 5C	104	NSS 6		
35	Amazonas 3	70	SES 16	105	SES 8		