Evolution and Future of Broadband Satellite Services

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ITU Satellite Symposium

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ECHOSTAR | HUGHES

Corporate Overview

2018

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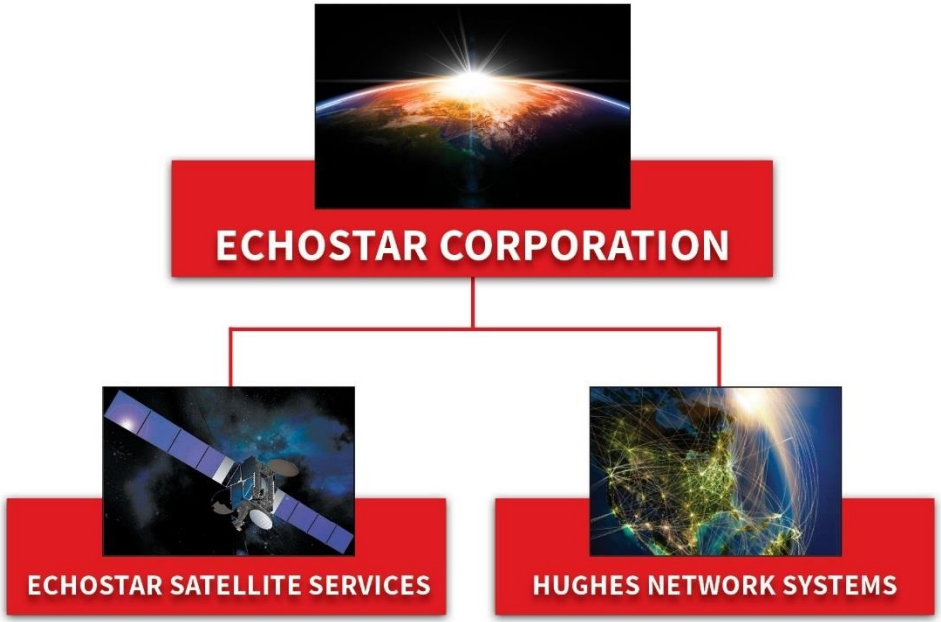
About EchoStar

We are a global powerhouse

- Multibillion-dollar public company (NASDAQ:SATS)
- Operates and manages 24 satellites—the world's 4th largest commercial geosynchronous satellite fleet
- World's #1 consumer high-speed satellite internet service, HughesNet®, with over 1.3 million subscribers in the Americas
- Leading global provider of satellite broadband technology and services—approximately 50% market share with over 7 million systems shipped to customers in over 100 countries on five continents
- First commercial satellite network with Walmart, named one of the top 20 strategic business decisions of the 20th century by Fortune magazine

Company Structure



Worldwide Locations

EchoStar Satellite Services

Satellite Fleet

- 24 owned, leased, and managed satellites
- World's fourth-largest commercial geosynchronous satellite fleet

Satellite Services

- Broadcast Satellite Services (BSS)
  - Capacity for Direct-to-Home (DTH) service providers
  - DISH Network and Dish Mexico
- Fixed Satellite Services (FSS)
  - Full and part-time Ku-band transponder capacity
  - Enterprise, broadcast, and government services applications
- Mobile Satellite Services (MSS)
  - Mobile, public safety, and transportation applications

EchoStar Mobile

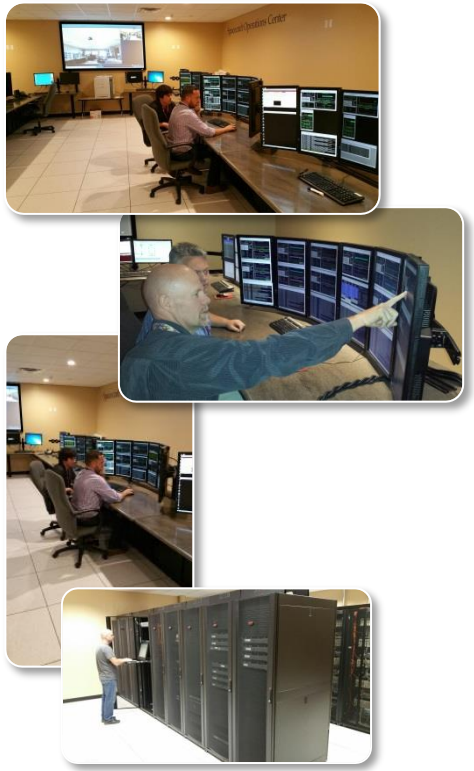
Providing next-generation mobile voice and data communications throughout the European Union

- Acquired in 2013
- Mobile Space-based System (MSS) with complementary ground component
- Terrestrial infrastructure in Germany
- Licenses cover 30 MHz to 500M POPs

Spacecraft Operations

Perform total spacecraft management

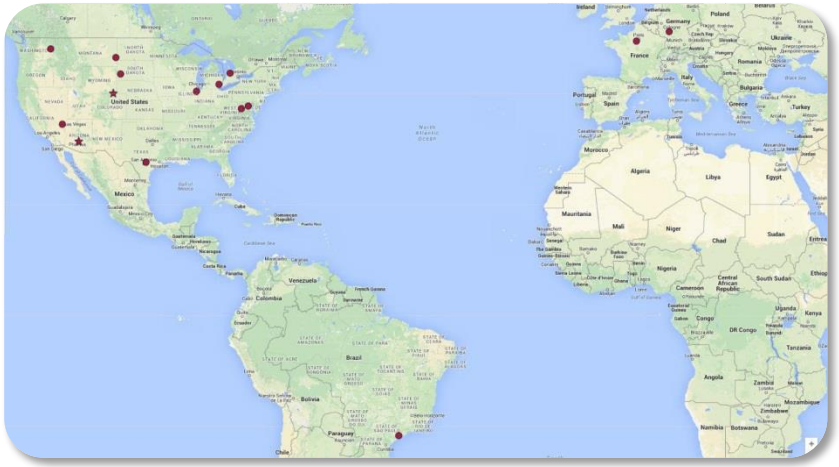
- Operates 14 satellites
  - Orbit raising and in-orbit testing
  - Tracking, Telemetry, and Control (TT&C) operations
  - Real-time telemetry monitoring and anomaly response
  - Bus and payload operations engineering
- Three functional teams supporting 24/7 operations
  - Engineering, operations, and ground systems



Spacecraft Operations Centers (SOC)

Located in Cheyenne, WY, Gilbert, AZ, and Sao Paulo, BR

- Both U.S. locations allow fully redundant service to any satellite
- In addition, we support command and control teleports located in:
  - Spokane, WA
  - Mount Jackson, VA
  - Blackhawk, ND
  - Campinas, Brazil
  - Griesheim, Germany
  - Rambouillet, France



Satellite Broadband Networks and Services

Hughes High-Speed Satellite Internet Service

- Largest satellite Internet service in North and South America
- Over 1.3 million users in U.S., Canada, and Brazil
- Target unserved markets >10M households (U.S.)
- Launched in Brazil in 2016
- Launched in Colombia in 2017
- Launched in Peru in 2018

HughesNet®

Hughes Managed Networks for Enterprise

- Leading provider of managed network services for large blue-chip and medium/small enterprises
- Operating service entities in the U.S., Europe, India, and Brazil
- Largest developer/supplier of satellite networks and terminals to operators/enterprises globally
  - Lottery
  - Retail
  - Hospitality
  - Restaurant
  - Finance/Banking
  - Oil and Gas
  - Airborne Broadband

HughesON™

Hughes Broadband for Government

- High-availability and security networks
- Custom connectivity and tailored fixed/mobility solutions—land, sea, and air
  - Distance education
  - Law enforcement
  - Field offices and teleworking
  - Airborne

Evolution of Satellite Broadband

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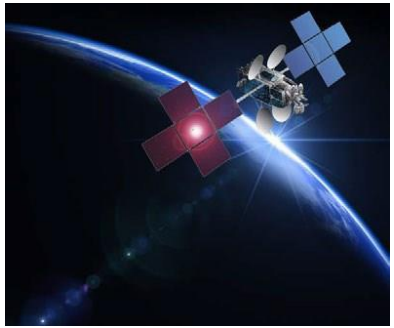
Technical Advancement of Satellite Broadband

- Satellite broadband technology has greatly advanced in the past decade, with spot beams, new coding techniques, and use of higher frequency bands enabling significant advancements in satellite throughput.
- These advancements are illustrated by a comparison of satellite services in the pre-high throughput area and those offered by Hughes's fleet of increasingly sophisticated high-throughput satellites (Spaceway 3, JUPITER 1, and JUPITER 2).

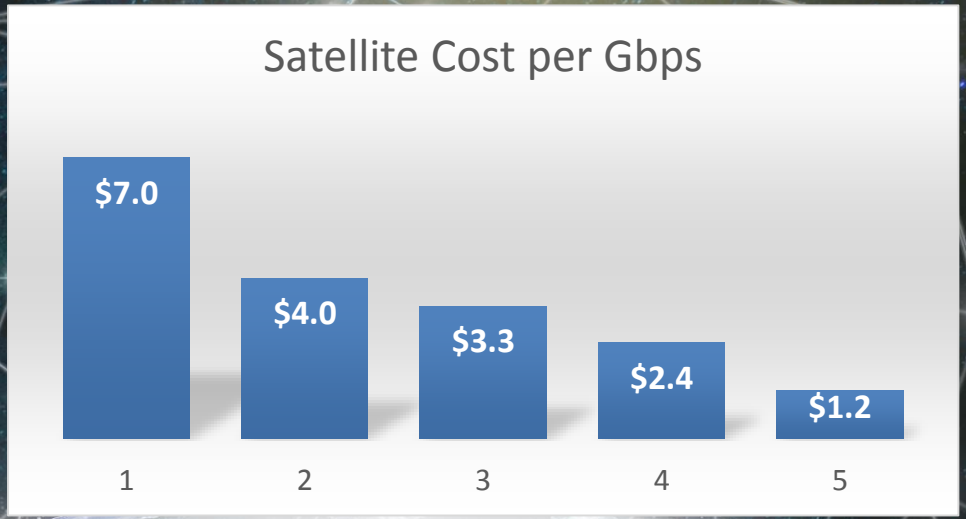
Spaceway 3



JUPITER 1

JUPITER 2 Launch

HUGHES®
An EchoStar Company



Continue Reduced Cost Trend

GEO HTS

Spaceway 3

- As late as 2007, the highest speed offered by a Hughes service plan was 1 Mbps.
- While that seems slow by today's standards, at the time it was well in **excess** of the 200 kbps standard used by the Federal Communications Commission (FCC) to define broadband services through 2008.
- Recognizing demand for higher speeds and greater capacity. Hughes designed and constructed its first broadband satellite, SPACEWAY 3.
- This satellite was Hughes's first the Ka band, utilizing smaller spot beams and greater frequency reuse than the previous generation of satellites.
- Hughes initially offered services of up to 2 Mbps download speeds in 2008 and enhanced the offering to 5 Mbps in 2013.
  - In 2008, less than half of all broadband services in the U.S. had speeds of 3 Mbps or more.
  - Only 34 percent had speeds of 6 Mbps or more.
  - This compares favorably to the customer experience of many wireline DSL customers even today.
- The satellite, which remains in service, has an overall capacity of 10 Gbps, an increase in capacity of nearly 80 times over the pre-broadband generation.

JUPITER 1

- In 2012, Hughes launched its JUPITER 1 satellite.
  - Delivered broadband speeds of up to 15/3 Mbps for the first time to consumers in the United States.
  - Service level greatly surpassed the FCC definition of broadband at the time (4/1 Mbps).
  - In the first year of JUPITER 1 operation alone, Hughes saw a 33% increase in its customer base.
  - Utilizing the DVB-S2 standard based on LDPC error correction and 16APSK modulation, achieved aggregate satellite capacity of 120 Gbps, a twelvefold increase in capacity over the prior generation satellite.
  - JUPITER 1 has reliably performed well beyond Hughes' advertised broadband speed promises. In 2016, the FCC reported that Hughes provided its customers actual upload and download speeds of 195 and 152 percent of its advertised speeds.

JUPITER 2

- With more than a three-fold increase in customers in the past ten years, Hughes launched JUPITER 2 in late 2016 and placed the satellite in commercial service in early 2017.
- This satellite brings broadband speeds of 25/3 Mbps and more, once again meeting or exceeding the FCC's current definition of broadband, throughout the continental United States, the southern portion of Alaska, Puerto Rico, the U.S. Virgin Islands, Canada, Mexico and in portions of South Amercia.
- JUPITER 2 utilizes the recently developed DVB-S2X standard, which improves upon DVB-S2 by adding higher-order modulation schemes, smaller roll-off factors, and improved filtering.
- These and other features combine to permit more carriers on more spot beams across the country to support more overall users.
- The satellite achieves a total of 220 Gbps capacity—nearly double JUPITER 1.


JUPITER™
SYSTEM
Global Eagle™
SES
THALES

Increase In Capacity: Summary

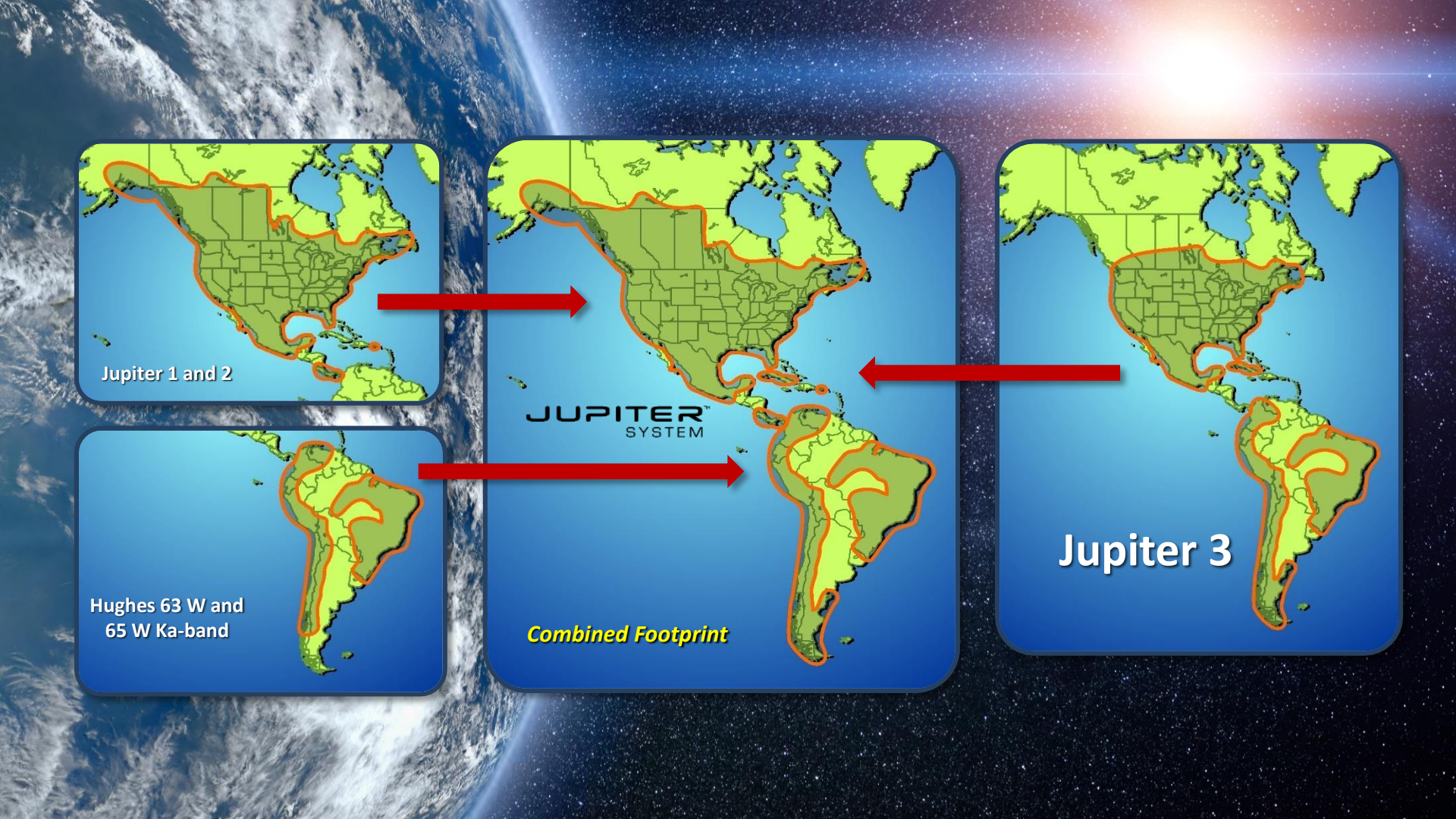
- Hughes has exploited advances in efficiency of spectrum use, modulation, and multiple spot beam technology to grow its business and provide a better quality of experience to its customers.

Years	Platform(s)	Highest Satellite Capacity	Max Number of Spot Beams per Satellite	Max Service Mbps (Downlink)
2006-2007	Prebroadband	1 Gbps	1 (traditional transponder)	1
2008-2011	SPACEWAY 3	10 Gbps	24	5
2012-2016	SPACEWAY 3 + JUPITER 1	120 Gbps	60	15
2017	SPACEWAY 3 + JUPITER 1 + JUPITER 2	220 Gbps	138	50

- This chart illustrates, from the pre-broadband era to today:
  - A 4900 % growth in the maximum download speed service offering.
  - More than a two orders of magnitude growth in satellite capacity.
  - A transformation from the single footprint era to the high-throughput spot beam era, with more than 5 times more spot beams used for JUPITER 2 than for SPACEWAY 3.

Jupiter 3 and Beyond: Not Done Yet

- Satellite operators are looking at higher spectrum ranges above 30 GHz to meet still evolving and increasing capacity demands. The capability of available spectrum on the Ka band is essentially at its limit, necessitating migration toward the Q/V bands.
- Hughes is designing JUPITER 3 to operate in these bands in both the Ka and Q/V bands to meet this demand.
- JUPITER 3 will:
  - provide capacity for the Hughes broadband services throughout the Americas, including for aeronautical and enterprise services.
  - serve traditional markets, including consumer, enterprise, aeronautical, and cellular backhaul, and new markets (e.g., 5G)
  - will have dramatic increase in capacity, allowing over 100 megabits per second of download speeds at a very competitive cost per bit.


Jupiter 1 and 2
Hughes 63 W and
65 W Ka-band
JUPITER™
SYSTEM
Combined Footprint
Jupiter 3

Our Services in Action

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Always-On Connectivity for PPDR

- Satellites, by virtue of being well above the Earth, provide capacity that is resilient to atmospheric forces.
- In 2017, Hughes provided essential public protection and disaster relief (PPDR) communications in the wake of several hurricanes, performing when terrestrial networks could not.
- Examples:
  - The National Weather Service used a generator to power a Hughes satellite terminal to alert agencies in the U.S., of the status of Guajataca Dam, in Puerto Rico, facilitating an ordered evacuation for 70,000 nearby residents and businesses and an eventual controlled breach.
  - Response Force 1, a government contractor for disaster response and recovery logistics, deployed solar generators at Puerto Rico airports to power VSAT terminals and laptops. This arrangement lasted for weeks before the all of the airports became regularly functional again due to limited power sources and structural damage.

Puerto Rico 2017

Hurricane Maria wiped out 2,400 miles of transmission lines, crippling communications in the wake of the storm.

Puerto Rico 2017

The Guajataca Dam threatened 70,000 residents and businesses who were saved thanks to satellite communications

Always-On Connectivity for Telehealth

Regulatory Issues

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A Critical Component of 5G Delivery

High expectations for 5G

Faster, higher capacity, more ubiquitous, versatile, more reliable…

…and be a seamless user experience

Satellites are an important piece of the puzzle

- Coverage for users out of range of other networks
- Always-on connectivity for critical services
- Economical and resilient backhaul
- High capacity for point-to-multipoint, multimedia distribution, downloads and updates, and push content

5G is only possible if spectrum is allocated in a manner that enables competition among platforms and the regulatory regime is technology neutral

Challenge: Spectrum

- Consumer demands for increased capacity are driving satellite operators to look toward higher frequency bands.
- These same higher frequency bands are of interest to terrestrial operators for the same reasons.
- When addressing the growing and real spectrum needs of each of component of the 5G network of networks it is imperative to remain technologically neutral.
- Technology Neutrality does not mean equal but does mean balanced.
- **No single technology meets all needs; must be a reasonable mix to meet user needs any time, anywhere.**

Big Challenges Require Many Solutions
The only right answer is a MIX of TECHNOLOGIES

Source: OpenSignal

5G Frequency bands: Enabling long term Digital development

26 GHz (24.25 - 27.5 GHz)
Candidate Band for Global Harmonisation

- Protect existing & planned use by FSS, ISS, SRS, EESS passive
- Sustainable basis without undue constraint

28 GHz
NOT on the shopping list!

- Many satellite networks extensively use 28GHz globally
- US position comes from a historically different approach to this band

38 GHz (37 - 40 GHz)
NOT Candidate Band for Global Harmonisation

- Needs appropriate shared basis for coordinated FSS earth stations

40-42 GHz / 48.2-50.2 GHz
NOT Candidate Band for Global Harmonisation

- **Future satellites (in construction) will use 40/50 GHz**
- 40-42GHz/48.2-50.2GHz for HDFSS user terminals; requires dedicated spectrum

Above 66 GHz (66 - 71 GHz & above)

- Close to 57-66 GHz: already designated / used for WiGig
- Existing primary ITU allocation to for terrestrial mobile
- Doubles available spectrum for terrestrial mobile 5G services so provides future-proofing for 5G/IMT-2020

PP-18 Resolution 203

Connectivity to broadband networks

The Plenipotentiary Conference of the International Telecommunication Union (Dubai, 2018),

. . .

recognizing

a) that connectivity to broadband networks is directly and indirectly enabled and supported by many diverse technologies, including fixed and mobile terrestrial technologies and fixed and mobile satellite technologies;

b) that spectrum is essential both for the direct provision of wireless broadband connectivity to users by satellite and terrestrial means and for the underlying enabling technologies;

. . .

invites Member States

. . .

4 to facilitate connectivity to satellite and terrestrial broadband networks, including enabling access to spectrum, as appropriate, as one important component of access to broadband services and applications, including to remote, underserved and unserved areas . . . .

CONCLUSIONS

Satellite Technology Continues to Evolve

Satellite Technology Provides Vital Connectivity

Spectrum Needs Can Be Met with Balanced Approach

Thank You

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