5G6E

EGR

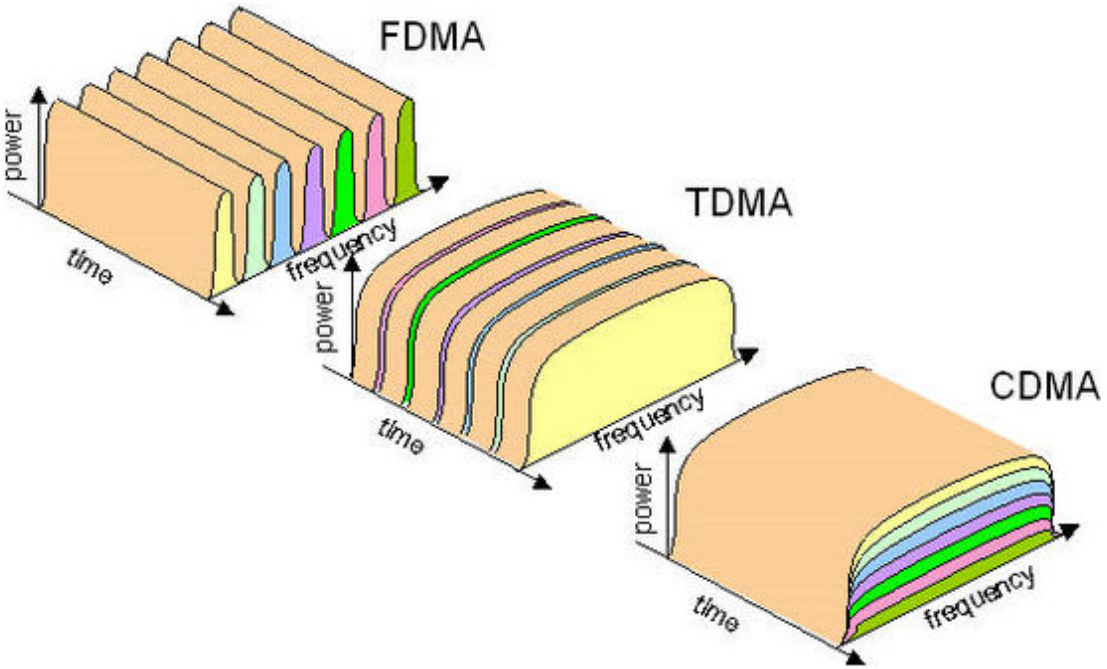
November 22, 2020

Ways of accessing the media

- Code-division multiple access (CDMA) is a channel access method used by various radio communication technologies.CDMA employs a coding scheme: each transmitter is assigned a code, CDMA allows 4.4 trillion different codes (see details further)
- Frequency-division multiple access (FDMA): works by dividing the bandwidth of the channel into separate non-overlapping frequency sub-channels and allocating each sub-channel to a separate user
- Time-division multiple access (TDMA): allows several users to share the same frequency channesl by dividing the signal into different time slots

Ways of accessing the media

- Orthogonal frequency-division multiple access (OFDMA): multi-user version of orthogonal frequency-division multiplexing (OFDM) . Multiple access is achieved by assigning subsets of subcarriers to individual users (see further)

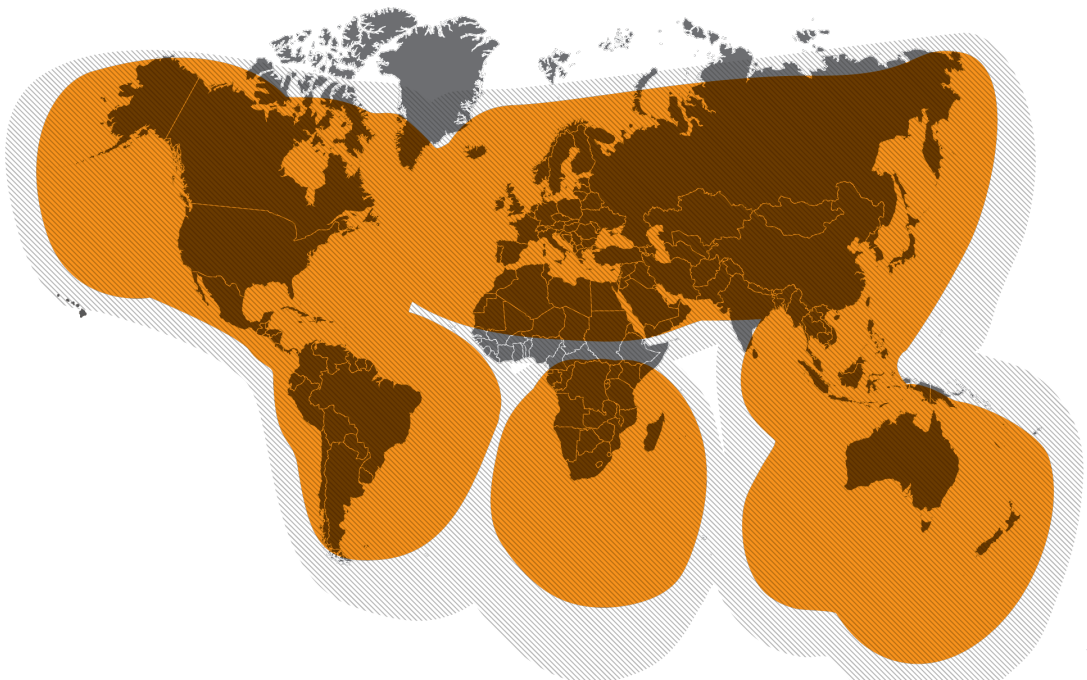


Satellite networks

- HEO, MEO, LEO
- Irridium, Thuraya, Inmarsat
- Globalstar
  low Earth orbit (LEO) satellite constellation for satellite phone and data communications,
  somewhat similar to the Iridium satellite constellation system.
  The Globalstar second-generation constellation consists of 24 low Earth orbiting (LEO) satellites (not covering polar areas)
  SPOT Satellite GPS Messenger
  GSP-1700 handheld portable satellite phone.
  CDMA digital voice quality. Fast data speeds at 9.6 Kbps.
  Position Location Service
  GLOBALSTAR, uses CDMA.
  IRIDIUM, uses TDMA/FDMA.

Globalstar coverage

- C band (4 to 8 GHz)
- L band (1452–1492 MHz)
- Rain fade refers primarily to the absorption of a microwave radio frequency (RF) signal by atmospheric rain, snow, or ice, and losses which are especially prevalent at frequencies above 11 GHz.



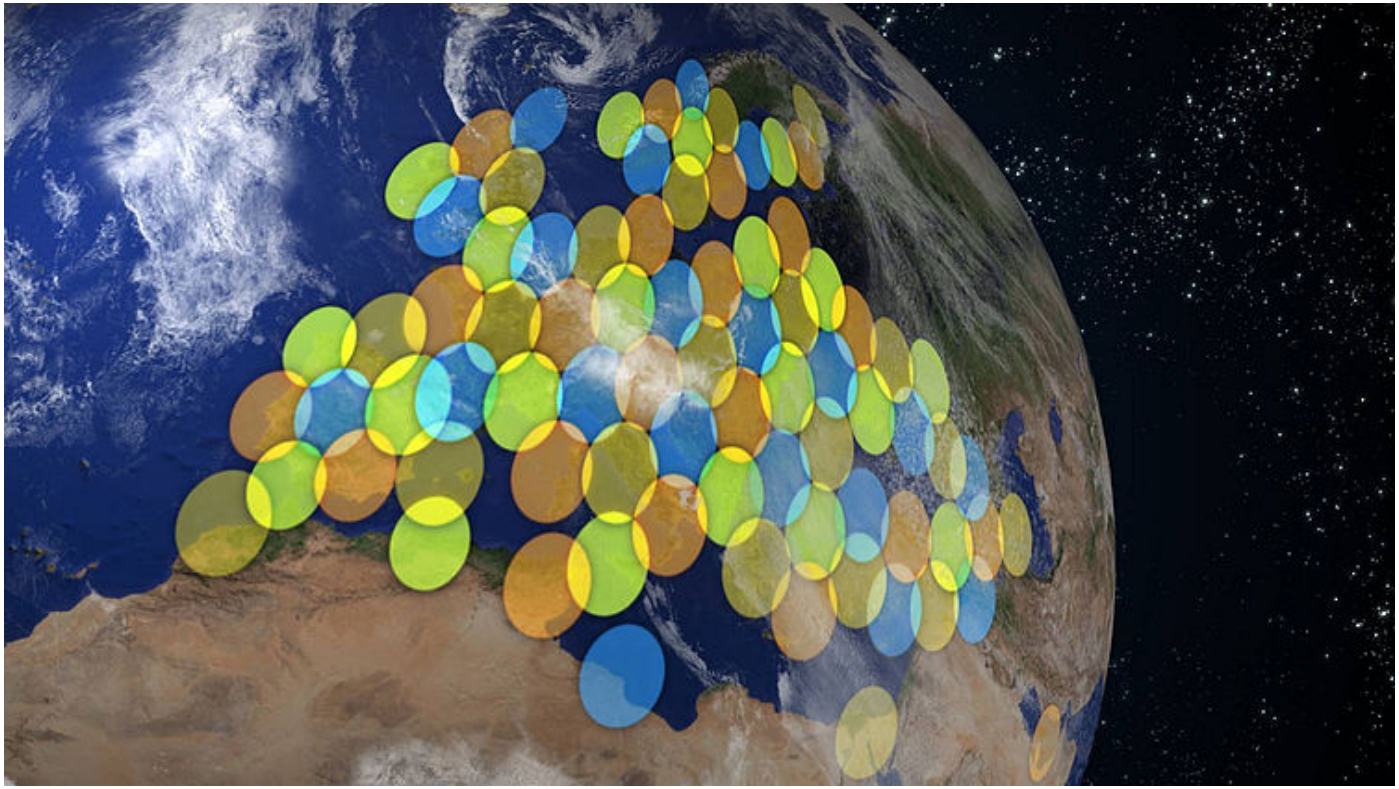
Globalstar Spot

High-throughput satellites

- beam coverage Ku band (12-18Ghz) Ka band 26.5–40
- do provide more than 100 Gbit/s of capacity (ViaSat-1 launch 2012)
- Exede, SES Astra, Inmarsat...
- high-throughput satellites will supply at least 1.34 TB/s of capacity by 2020
- Inmarsat-5 F5 : 72 Ka-band spot beams

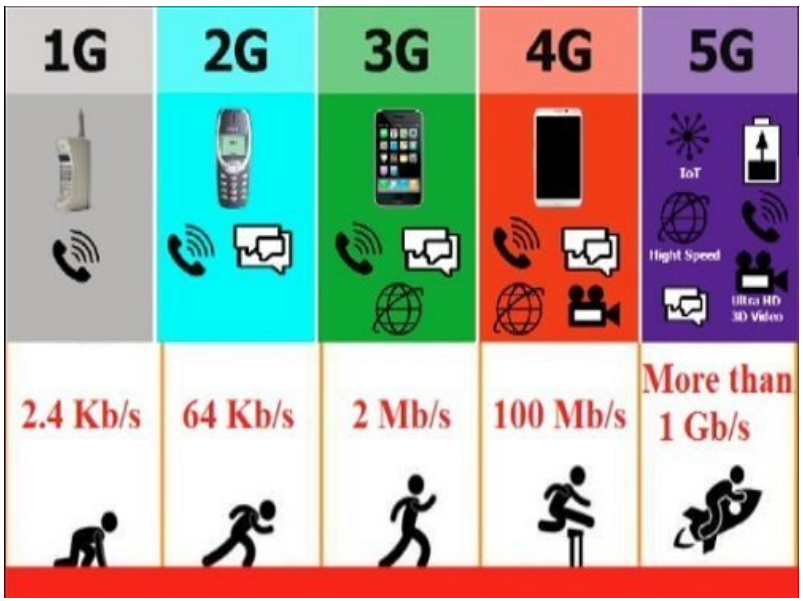
Satellites

- C band (4 to 8 GHz)
- L band (1452–1492 MHz)
- Q band: up to 50 GHz



2G to 5G

- 1G was analogic
- 2G: gsm: voice and sms
- 3G
- 4G
- 5G

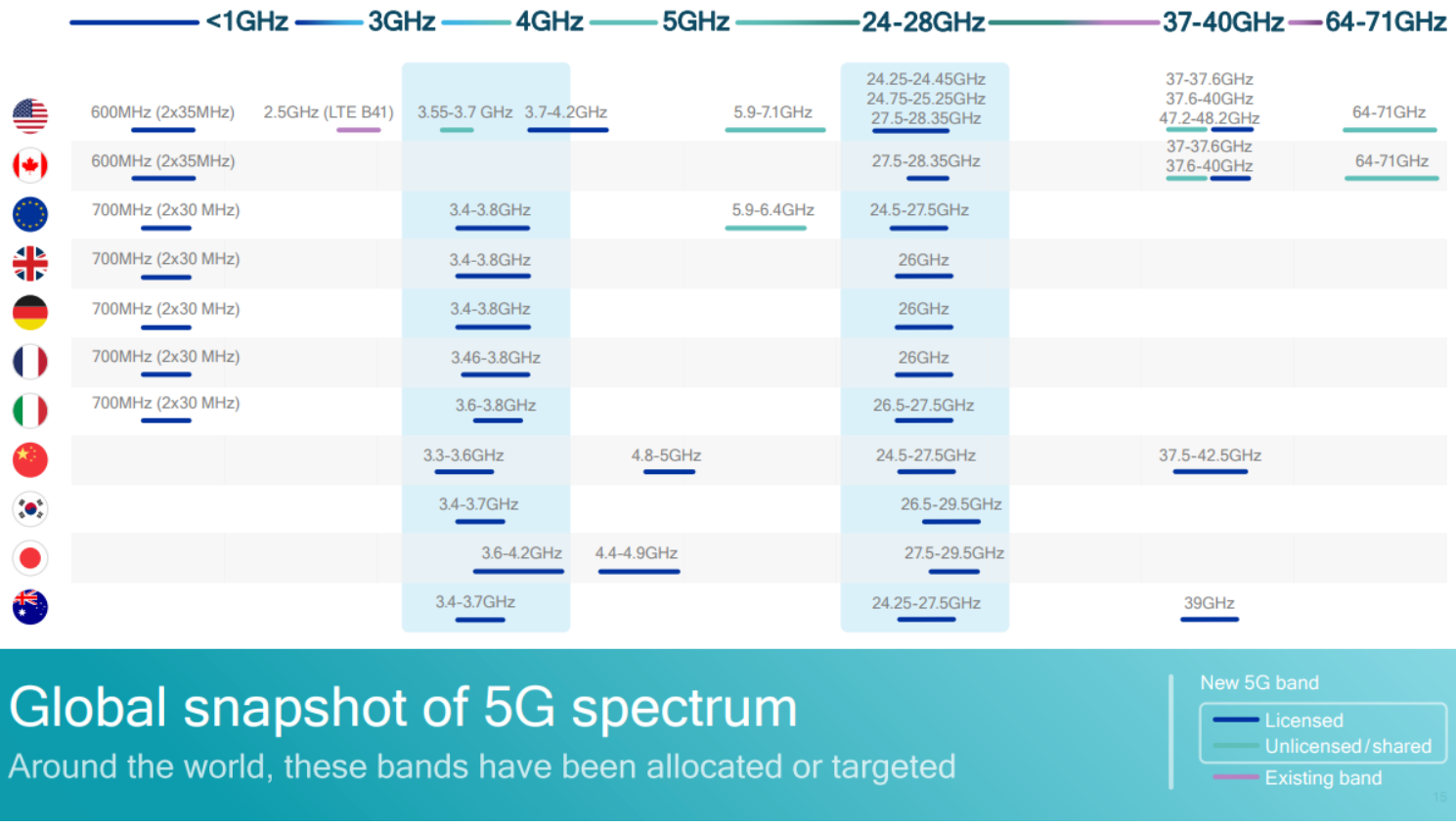


Gsm bands

Range	Band	Frequency Band	Bandwidth	Frequency Range
Low	71	600 MHz	81 MHz	617MHz - 698MHz
	44	700 MHz	100 MHz	703 MHz - 803 MHz
Mid	66	(AWS) 1700.2100 MHz	100 MHz	1710-1780 and 2110-2200 MHz
	40	2.3 GHz	100 MHz	2.3 – 2.4 GHz
	41	2.5 GHz BRS/EBS in US	194 MHz	2496 - 2690 MHz
	42	3.5 GHz	200 MHz	3400 - 3600 MHz
	43	3.6 GHz	200 MHz	3600 - 3800 MHz
	C-band	4.4 GHz	590 MHz	4400 - 4499 MHz
High	n258	24 GHz mmWave	3.25 GHz	24.25 - 27.5 GHz
	n257	26 GHz mmWave	3.00 GHz	26.5 - 29.5 GHz
	n261	28 GHz mmWave	850 MHz	27.5 - 28.35 GHz
	n260	37 GHz mmWave	1 GHz	37.0 - 38.6 GHz
	n260	39 GHz mmWave	2 Ghz	38.0 – 40.0 GHz
	n257	47 GHz mmWave	1 GHz	47.2 - 48.2 GHz

Source: 5G Americas, 3GPP 5GNR NSA specification and Wireless 20/20, December 2018

5G



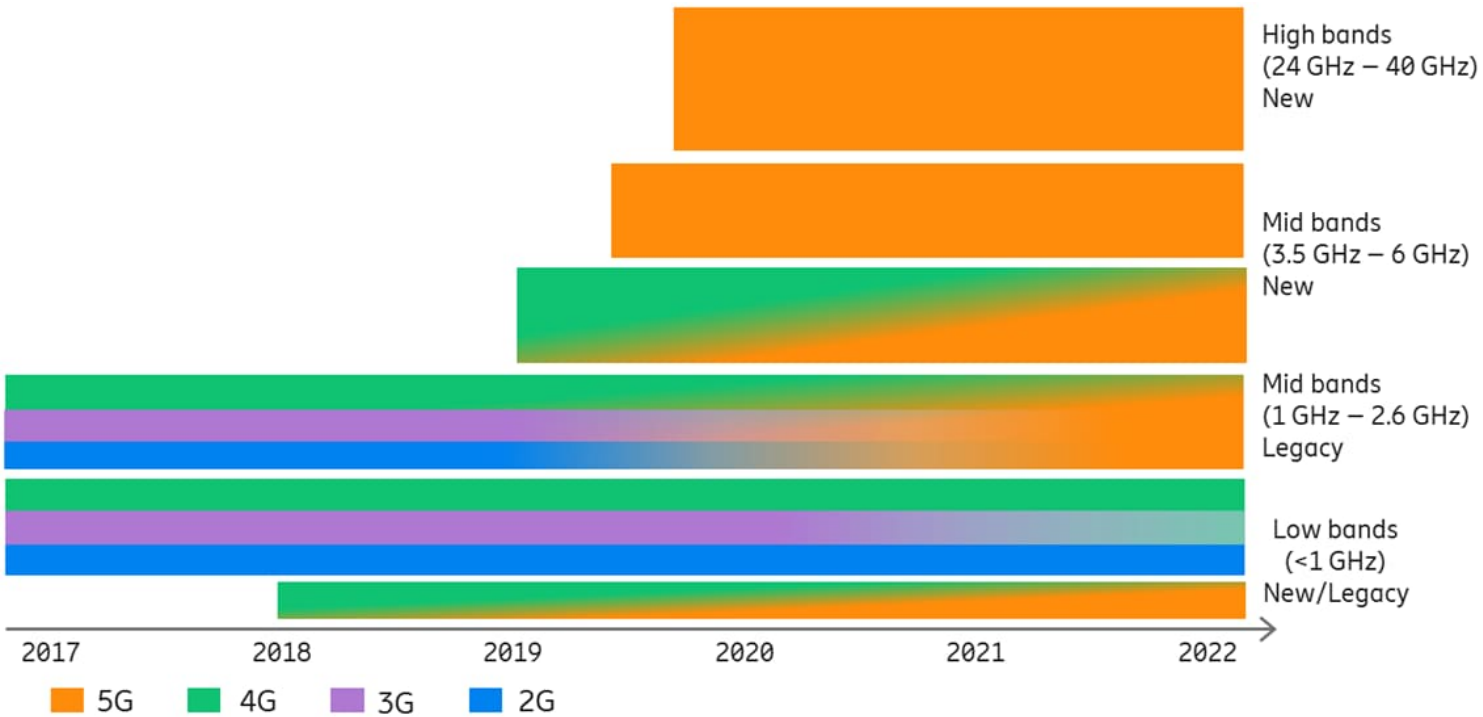
Global snapshot of 5G spectrum

Around the world, these bands have been allocated or targeted

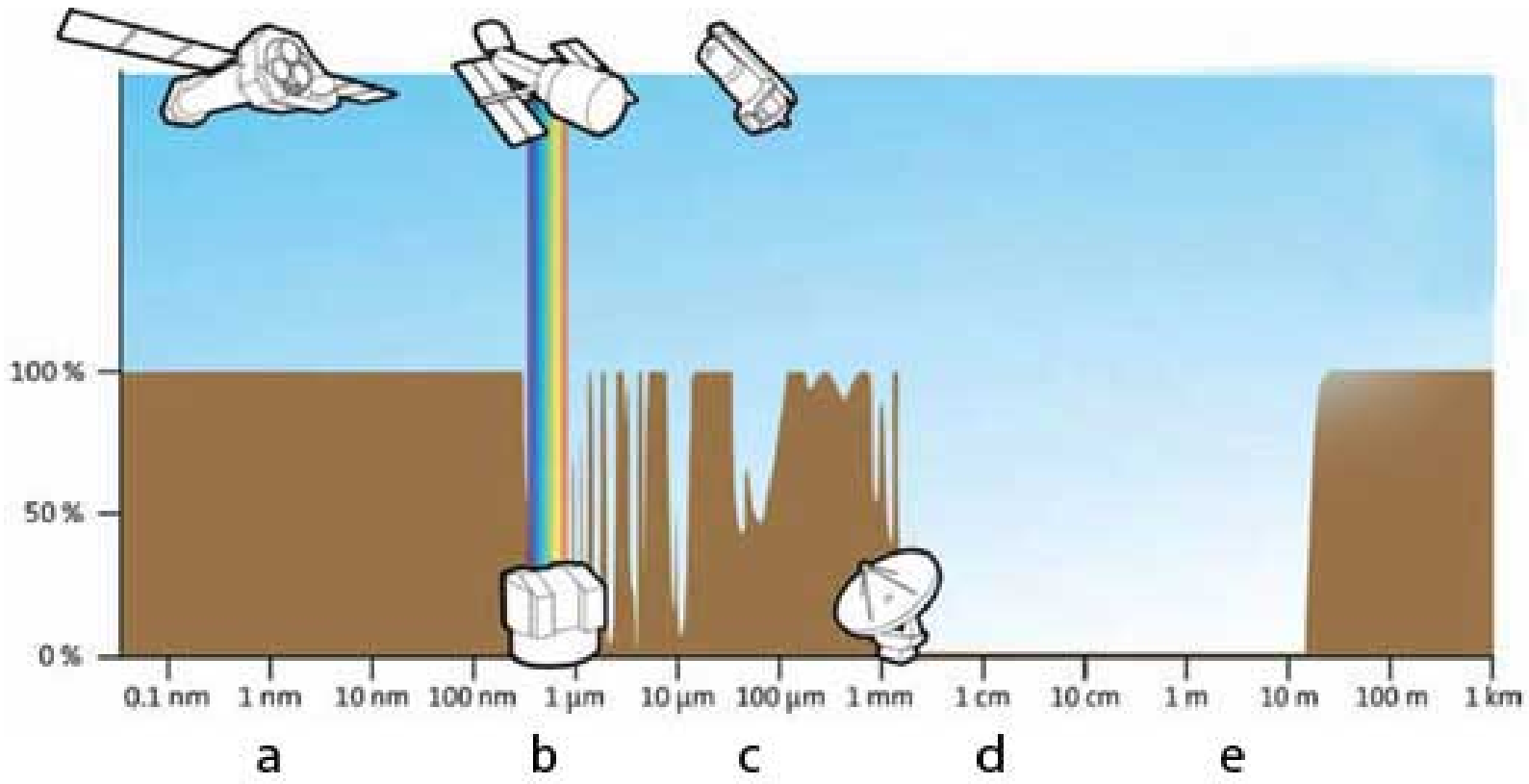
New 5G band

- Licensed
- Unlicensed/shared
- Existing band

Allocation


High bands
(24 GHz – 40 GHz)
New
Mid bands
(3.5 GHz – 6 GHz)
New
Mid bands
(1 GHz – 2.6 GHz)
Legacy
Low bands
(<1 GHz)
New/Legacy
2017
2018
2019
2020
2021
2022
5G
4G
3G
2G

IR windows


100 %
50 %
0 %
0.1 nm
1 nm
10 nm
100 nm
1 µm
10 µm
100 µm
1 mm
1 cm
10 cm
1 m
10 m
100 m
1 km
a
b
c
d
e

Wifi

- 802.11 standard and a 2.4GHz or 5GHz frequency
- 802.11a 5 GHz up to 54 Mbps smaller coverage area less effective at penetrating building structures not interoperable with the 802.11b and 802.11g
- 802.11b 2.4 GHz up to 11 Mbps longer range than 802.11a better able to penetrate building structures
- 802.11g 2.4 GHz 54 Mbps backward compatible with 802.11b
- 802.11n 2.4 GHz 5 GHz from 150 Mbps to 600 Mbps multiple antennas using MIMO technology backward compatible
- 802.11ac 5 GHz 450 Mbps to 1.3 Gbps MIMO technology Up to eight antennas backwards compatible with 802.11a n
- 802.11ax 2.4 GHz 5 GHz (2019)
  higher data rates, increased capacity, handles more connected devices 1 GHz and 7 GHz capable when available

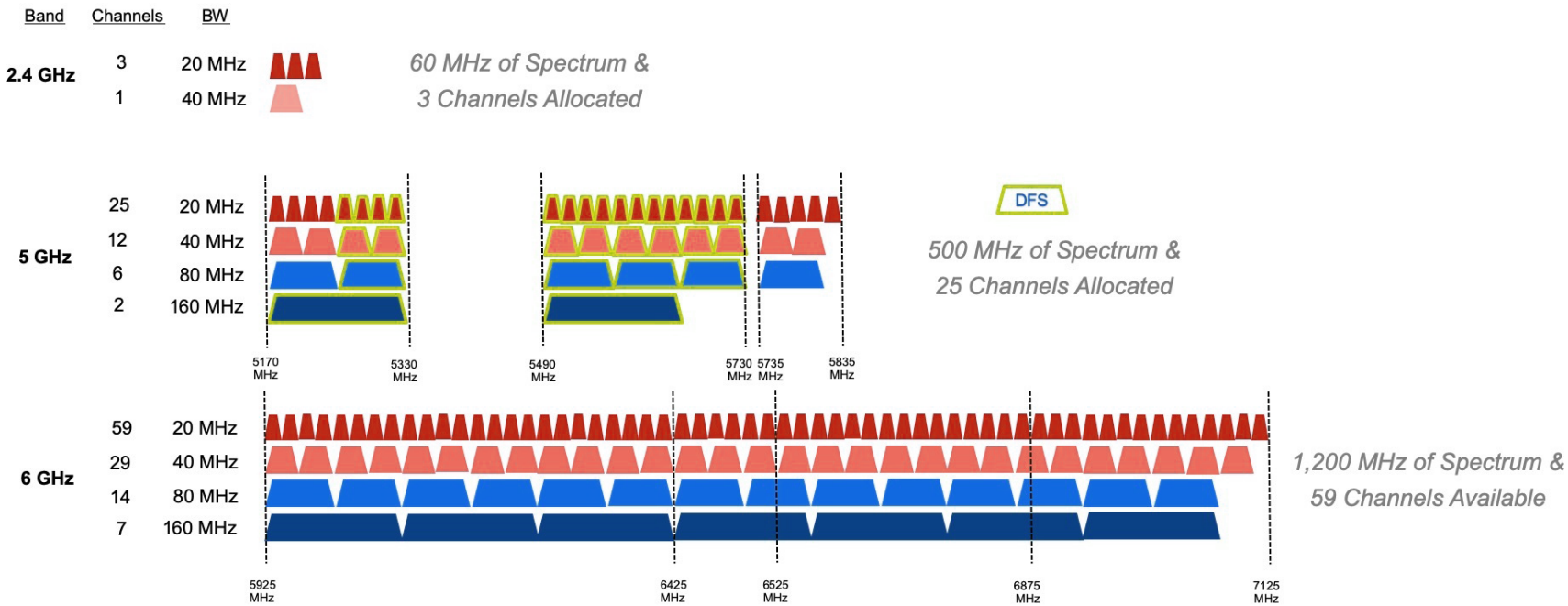
WLANs

- adhoc frame address 4
- WLANs are half-duplex, shared media configurations.
  Half-duplex: only one client can transmit or receive at any given moment. Shared media: clients can all transmit and receive on the same radio channel. This creates a problem: a wireless client cannot hear while it is sending, which makes it impossible to detect a collision.
- To solve this, WLANs use carrier sense multiple access with collision avoidance (CSMA/CA) to determine how and when to send data on the network
  Listens to the channel to see if it is idle (i.e. if no other traffic is currently on the channel/carrier). Sends a ready to send (RTS) message to the AP to request dedicated access to the network. Receives a clear to send (CTS) message from the AP granting access to send. If the wireless client does not receive a CTS message, it waits a random amount of time

WLANs

- Direct-Sequence Spread Spectrum (DSSS)
- Orthogonal Frequency-Division Multiplexing (OFDM): a subset of frequency division multiplexing in which a single channel uses multiple sub-channels on adjacent frequencies. Sub-channels are orthogonal to one another which allow the sub-channels to overlap without interfering. OFDM is used in 802.11a/g/n/ac; 802.11ax uses a variation of OFDM called Orthogonal frequency-division multiaccess (OFDMA).

Wi-Fi 6E



- operates in the newly allocated 6 GHz frequency band
- 1200 MHz of newly added spectrum from 5.925 to 7.125 GHz
- up to 14 additional 80 MHz or seven 160 MHz channels
- more simultaneous connections, reduced power consumption.

802.15, FHSS

- Uses low powered transmitters for a short-range network, usually 20 to 30 ft. (6 to 9 meters). Bluetooth and ZigBee based devices are commonly used in WPANs. WPANs are based on the 802.15 standard and a 2.4-GHz radio frequency
- Bluetooth Low Energy (BLE) - This supports multiple network technologies including mesh topology to large scale network devices.
- Bluetooth Basic Rate/Enhanced Rate (BR/EDR) - This supports point to point topologies and is optimized for audio streaming.
  FHSS was used by the original 802.11 standard.
  Walkie-talkies and 900 MHz cordless phones also use FHSS, and Bluetooth uses a variation of FHSS.