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5G deployments and rollouts

5G has arrived, but aren’t these testing times?

The team

Project leader: Carole MANERO, Wireless Services Practice Leader

Carole joined IDATE DigiWorld in October 2000.

She is today the leader of IDATE DigiWorld Wireless Services practice.

Carole has been in charge of monitoring the globe's mobile markets, and operators and mobile services development particularly in 3G, LTE and now for 5G. She has also become an expert in spectrum management issues and has evolved her prowess in PPDR issues. She contributes actively to the H2020 5G PPP projects initiated by the EU Commission (Euro-5G/To-Euro5G and METIS-II).

Before coming to IDATE, Carole worked for COGEMA's North American corporate strategy department, where she was involved in several acquisition operations in the nuclear sector.

Carole holds a MS in marketing (EDHEC Business School, Lille, 1991). She also holds a Masters in Human Resources and Corporate Management (ESCP, Europe Business School, Paris, 1992).

Contributor: Tarek JAFFAL, Consultant

Tarek is a consultant on robotics and artificial intelligence at IDATE since May 2018. Before working for IDATE, Tarek made a variety of experiences internationally. He was involved in the configuration and deployment of the Building Management System (BMS) of a new building of the National Bank of Egypt in Cairo during his training at Petrokima. In France, Tarek worked at Pfizer Amboise on the configuration and deployment of a new database management and machine supervision system and the setup of automated processes such as maintenance requests. Tarek have also experienced the research field when he was working on a robotics project for his graduation project in the Artificial Intelligence Lab of Istanbul Technical University in Turkey.
Tarek graduated in France from "INSA de Rennes" in from "EII" department (Electronics and Computer Engineering) and he has a master's degree in International Business and Management from the University of Westminster in London, U.K.

5G deployments in 11 countries worldwide

5G has arrived, but aren't these testing times?

Synopsis and key questions

- This comprehensive and up-to-date report reviews of recent 5G deployments and rollouts in some 11 countries.
- In describing the accelerating pattern of rollouts since 2018, the study records that 5G networks are now live in the three regions of North America, Asia and Europe, with more enroute.
- Through its international scoreboard, the report highlights moves made by national and regional players and scopes their planned rollouts in 2019, 2020 and further. All in, the trends in China, India, Japan, South Korea, Turkey, USA and in EU5 states (France, Germany, Italy, Spain and the UK) are given in full.
- As the race to launch and prelaunch 5G intensifies, the report assesses the growing series of trials and demonstrations which are consolidating provider and consumer interests. This includes an overview of pricing and availability factors, and selection of key cities and placements.
- The enabling role of regulation and network assignments, and investment in joint research is underlined, with further data on how inter-provider and network cooperation has boosted the rollout process together with the drive of special events and infrastructural stimuli.
- In all the report gives many insights in the application of 5G in a wide range of vertical industries, and infrastructure services including transport routes and remote markets and health, agriculture, construction and culture, and media and entertainment.

- What's new on the 5G deployment front?
- Which 5G countries are the most ahead?
- Which players have already launched 5G?
- What kind of 5G services have been launched so far?
- What comes next? What schedules, which timelines?
- Which frequencies is 5G likely to use?

List of players

- Major world MNOs
  - AT&T
  - Verizon Wireless
  - Sprint
  - China Mobile
  - China Unicom
  - China Telecom
  - NTT DOCOMO
  - KDDI
  - SoftBank
- Major world MNOs
  - Türk Telecom
  - Bharti Mobile

List of countries

- Five European countries
  - France
  - Germany
  - Italy
  - Spain
  - UK
- Six non-EU countries
  - China
  - India
  - Japan
  - South Korea
  - Turkey
  - USA

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5G deployments and rollouts: 5G has arrived, but aren't these testing times?

01 | Executive Summary

5G deployments in 11* countries worldwide

- 5G was first launched in 2018, ahead of the initial schedule. The rollout rate has accelerated in recent months.
- In three world regions 5G networks are now live: North America, Europe and Asia.
- Six players (in the 11 countries considered here) have already launched commercial services. Many additional launches are scheduled for the second half of 2019 or in 2020.
  - Verizon Wireless is first in the world. It was followed by AT&T and, some months later, by Sprint.
  - Elisa in Finland was the first to launch in Europe, to be followed by EE in the UK.
  - South Korea is the first '5G country' to go nationwide, with all players launching jointly.
- Less-advanced countries/regions are targeting 2021 or 2022 for 5G commercial launches.
- There are, however, discrepancies in the degree of development and deployment:
  - The US and South Korea are front runner countries, with more than one 5G network up live.
  - Europe is slightly behind but catching up with live networks in the UK and Spain (+Finland and Switzerland outside the country scope).

* *In the countries considered*

5G deployments in 11* countries worldwide

- 5G price plans are very sensitive to (often variable) market conditions
  - Premiums for 5G on 4G plans are very diverse, ranging from low to high
  - 5G offers mostly include unlimited data allowances, with few exceptions (AT&T, KT)
- There are three main spectrum frequencies for 5G: sub 1GHz, mid-frequencies @1-6 GHz and high frequencies @ 26/28/40-45…
- Some government authorities have not yet assigned spectrum for 5G
- Coverage is still a major issue: the coverage obligations set may be ambitious
  - Outdoor coverage is still patchy to date
  - Indoor coverage, as yet, continues to raises many questions
- The rate of 5G adoption in the first few weeks in South Korea has been truly impressive

* *In the countries considered*

02 | International scoreboard

Key outputs

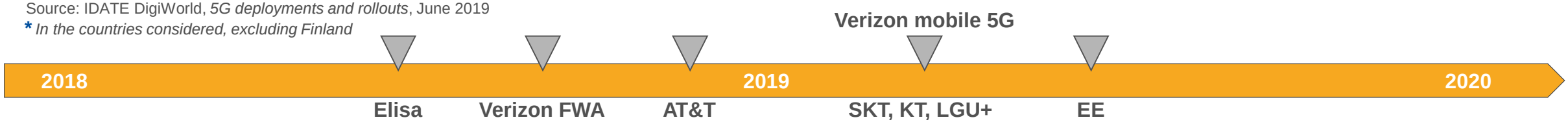
2.1. Six* players have already launched 5G

World firsts

Elisa Finland Summer 2018	On 27 June 2018 a historic 5G video call was made between the Estonian Minister of Economic Affairs in Tallinn and her Finnish colleague in Tampere, Finland. ▪ Speeds of 2.2 Gbps. ▪ First 5G licenses available in the 3.4-3.6 GHz in Autumn 2018
Verizon FWA USA October 2018	Verizon started marketing the 5G Home service on 13 September, 2018 with online orders. The service went live on October 1, 2018 in Houston, Indianapolis, Los Angeles and Sacramento. ▪ Monthly subscriptions cost 50 USD for Verizon customers and 70 USD for new customers. The first 5G home subscribers will have three months free. ▪ YouTube TV will be free for the first three months, as will a free Apple 4K HDR TV or a Google Chromecast Ultra. ▪ 300 Mbps and depending on location up to 1 Gbps without any data caps.
Verizon USA April 2019	▪ Additional 10 USD charged on top of unlimited 4G plans. ▪ Unlimited data included ▪ 450 Mbps with peak rate of 1 Gbps
AT&T USA December 2018	▪ A commercial standard-based mobile 5G network was launched on 21 December, 2018. 5G hotspots were deployed in dense urban areas in 12 cities. ▪ Country-wide deployment is expected soon with more cities to come.
SK Telecom/KT/LGU+ South Korea April 2019	▪ Joint prelaunch of a commercial business-only mobile 5G service on 21 December, 2018 ▪ Joint launch in April 2019 with limited coverage. Different packages (8 GB to unlimited data for 43 to 98 EUR per month depending on the package and on player) ▪ There were 260,000 5G subscribers at April 2019
EE UK May 2019	▪ Launch of a commercial mobile 5G network on 30 May, 2019 (5G Home service, 5G Wifi service, 5G mobile service) in six UK cities, with some 16 more cities by YE2019 ▪ OnePlus 7 Pro 5G, the LG V50 ThinQ 5G, the OPPO Reno 5G and the Samsung Galaxy S10 5G ▪ No additional fee for 5G on smart plans

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

***** *In the countries considered, excluding Finland*



2.2. First details of 5G commercial launches

Unlimited and limited data packages. Very diverse premiums on 5G depending on markets. No Apple phone.

AT&T USA	▪ 70 USD/month for 15 GB of data included ▪ 1.2 Gbps speed successfully tested ▪ 12 cities, 19 at YE 2019 ▪ Netgear Nighthawk 5G hotspot, Samsung Galaxy S10 and Fold when available
Verizon USA	▪ Mobile: 10 USD on top of unlimited 4G plan, unlimited data, 450 Mbps on average, 1 Gbps peak rate ▪ Fixed wireless: 50 USD/month for Verizon customers, 70 USD for non-Verizon customers, 300 Mbps, peak rate of 1 Gbps depending on location ▪ Motorola Z3, Samsung Galaxy S10 and Note, LG V50 ThinQ
KT South Korea	▪ Limited data at 43-101 EUR for various packages and unlimited data ▪ 2.7 Gbps peak rate ▪ Samsung Galaxy S10, hotspot ▪ The flow of building 5G sites has been aggressive
SKT South Korea	▪ 8-300 GB of data included at 43 to 98 EUR/month ▪ 2.7 Gbps peak rate ▪ Samsung Galaxy S10, Motorola Z3 ▪ Aggressive building of 5G sites
LGU+ South Korea	▪ 9-250 GB of data included at 43 to 73 EUR/month ▪ 2.7 Gbps peak rate ▪ LG V50 ThinQ, hotspot, promotional deals with VR headsets and YouTube TV ▪ As elsewhere, the building of 5G sites has been noticeably aggressive
EE UK	▪ No extra charge on 4G for 5G service (mobile 5G, 5G Home service, 5G Wifi service) but new plans ▪ 10-100 GB at 54-74 GBP (61-84 EUR), SIM-only plans: 20-100 GB at 32-52 GBP (36-59 EUR) ▪ Six cities at launch in May 2019, 16 cities by YE 2019 ▪ 5G smartphones when available: OnePlus 7 Pro 5G, the LG V50 ThinQ 5G, the OPPO Reno 5G and the Samsung Galaxy S10 5G

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

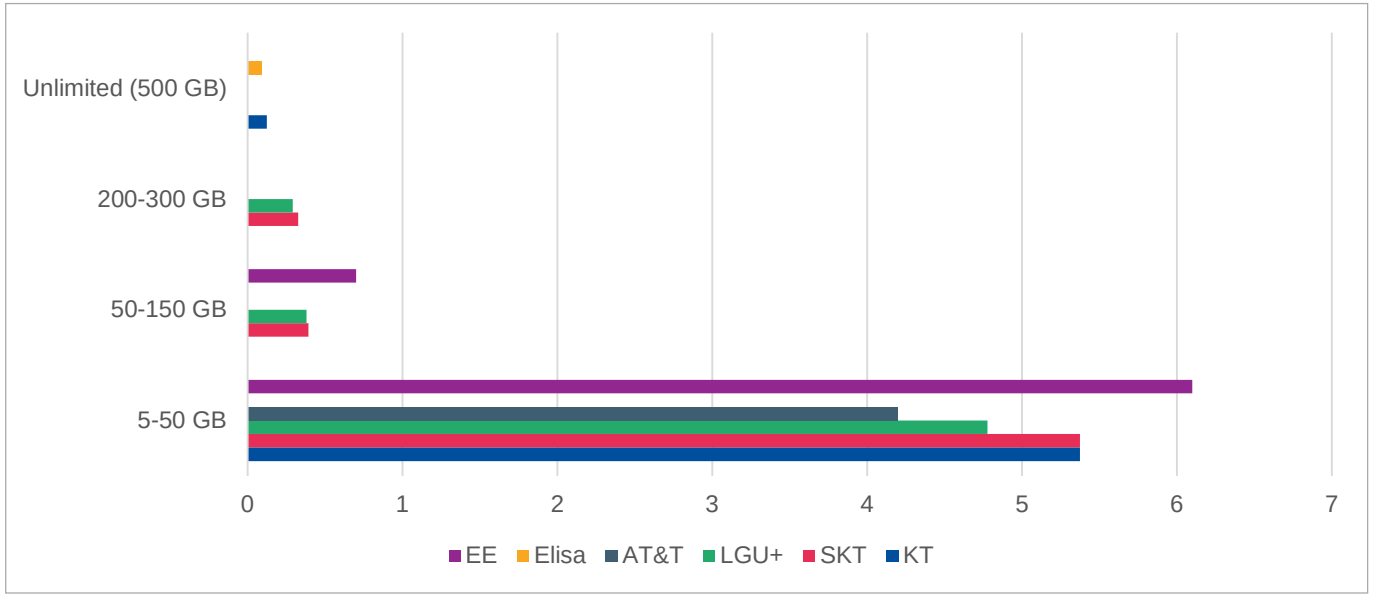
Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

2.3. Average price per 5G GB

Will providers be able to pay back 5G investments?

- 5G premium for higher speeds.
- 5G seems relatively affordable for data-hungry customers and early adopters… expensive for normal users.
- As usual, the price per GB in small data packages is far more expensive than in bigger packages...
- Strong push towards large packages – 5G packages below 10 GB have no purpose.
- But plans with data caps under 20 GB remain in South Korea, the USA and the UK.

Average price per 5G GB (EUR/GB)



Note: unlimited data is compared with 500 GB of included data

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

2.4. International scoreboard (1/3)

European players are actively building 5G: EE launched on 30 May 2019 and Vodafone UK set to launch on 3 July 2019.

T-Mobile, Germany	▪ About 28,000 towers across Germany to be doubled by 2020. 2,000 additional towers per year expected ▪ 20 5G sites in Berlin (June 2018), 70 cells are to be installed in the coming months ▪ In January 2019, DT and Ericsson demonstrated a 40 Gbps data transmission rate with ultra-low latency in the E-band (60-90 GHz)
Orange **Belgium, France, Romania**	▪ Launch dates not announced yet ▪ Many tests in Belgium, France, Romania (including FWA) ▪ In January 2019, Orange announced the installation of 80 antennas in 2019 for a 5G network in the 3.5 GHz spectrum band in Marseille (40 installed before April 2019, the rest before YE)
Telefónica **Spain, Germany**	▪ Not announced yet ▪ Many tests in Spain and Germany (including Fixed Wireless Access)
Vodafone **Europe**	▪ 2019 commercial launch in Europe. The target date for the UK was set at 3 July 2019 ▪ As soon as devices are available ▪ 1,000 5G cell sites in 2020 (Milan covered at 80% with 120 5G sites as at December 2018)
Telia **Finland**	▪ An international call was successfully placed in June 2018 (network launch only) ▪ Service target launch date in 2019

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

2.4. International scoreboard (2/3)

South Korean players have already launched

Sprint USA	▪ Sprint is aiming to launch its 5G service in May 2019 to several cities including New York City, Phoenix, Kansas City, Atlanta, Chicago, Houston, Dallas, Los Angeles and Washington, DC ▪ 2.5 GHz, 5G NR
T-Mobile USA	▪ T-Mobile USA recently signed two contracts for 2.5 billion USD with Ericsson and Nokia for the provision of 5G infrastructure. ▪ Target launch date in 2019 ▪ 600 MHz band.
SK Telecom, LGU+, KT South Korea	▪ 5G joint launch in April 2019 with increasing coverage and rapid subscriber adoption: 82,000 5G sites (up eightfold in two months) and 260,000 subscribers at April 2019 (in 1 month) ▪ Agreement on 5G deployment and network sharing in April 2018: cost savings estimated at 1 trillion KRW over 10 years ▪ Pre-commercial launch on 1 December, 2018 to business customers
NTT DOCOMO Japan	▪ Target is launch on 2020 at the Tokyo 2020 Summer Olympics ▪ Pre-commercial 5G launch expected in fall 2019

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

2.4. International scoreboard (3/3)

Players from advanced mobile markets will launch earlier

SoftBank Japan	▪ Target launch date in 2020
KDDI Japan	▪ 5G services in selected areas by 2019, with full-scale development coming in 2020
China Mobile China	▪ Target launch date in 2020 ▪ Pre-commercial launch expected by YE-2019
Turkcell Turkey	▪ Turkcell launched 5G FW network for trial, using 26 GHz frequencies
Bharti Airtel India	▪ Bharti Airtel seems to be ahead in the 5G race in India. It conducted India's first 5G network trial with Huawei under a test setup at the former's network experience centre in Manesar, Gurgaon. User throughput of more than 3 Gbps was achieved using the 3.5 GHz band with 100 MHz bandwidth and end-to-end network latency of approximately 1 ms.

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

2.5. EE is first 5G network in EU5 countries

After Elisa in Finland

Target: Commercial rollout in 2020 and coverage of main urban and trunk roads by 2025

	France	Germany	Italy	Spain	UK
Regulatory/network backdrop: roadmap					
Regulatory/network backdrop/ frequency assignment					
5G launch/tentative date			**2020**		**EE in May 2019 Vodafone in July 2019?**
Vertical targets	**Media and Entertainment** Automotive and Transport, Industry 4.0, Construction, Logistics, Agriculture, Smart Office	**Future Media and e-Health** Intelligent Mobility, Industry 4.0, Smart grids, Smart Farming	**Media/virtual reality** **Also:** smart port, smart city, smart agriculture, public safety, industry 4.0, health 5.0, road safety, tourism and culture, and environmental monitoring	**Media and Entertainment** **Also:** Automotive and Transport, Industry 4.0, Construction, Logistics, Agriculture, Smart Office	**Automotive, Industry, Transport and Logistics** **Media and Entertainment,** **e-Health, public safety, tourism**
Service coverage (5G-enabled cities)					

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

2.6. South Korea is the first 5G country

Diverging speeds in 5G development in non-EU countries

	China	India	Japan	South Korea	Turkey	USA
Regulatory/network backdrop: roadmap						
Regulatory/network backdrop/ frequency assignement						
Trials maturity						
5G launch/tentative date	**2020** **2019: Pre-5G**	**2022**	**2020** **2019: Pre-5G**	**April 2019**	**2021**	**Q3-Q4 2018** **2019**
Vertical targets	Media and Entertainment Automotive and Transport Industry 4.0	Media and Entertainment Industry 4.0	Media and Entertainment Automotive and Transport Industry 4.0 Construction Logistics Agriculture Smart Office	Media and Entertainment Immersive services Autonomous services Intelligent services PPDR services Smart city	Industry 4.0 and Manufacturing Automotive Smart Energy e-health Media and entertainment	Media and Entertainment Automotive and Transport AR/VR Industry 4.0 Logistics Agriculture
Service coverage (potential of lit cities)						

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

2.7. Spectrum assignments (1/2)

EU5 countries

	700 MHz	3.5 GHz	26-28 GHz
France	Auction in December 2015 Availability: 2019 2,796 million EUR	Auction in H2 2019/H1 2020	2020?
Germany	Auction in June 2015 Availability: 2019 1,000 million EUR	Auction: March-June 2019 6,500 million EUR	2019?
Italy	Auction in October 2018 Availability: 2022 2,000 million EUR	Auction in October 2018 4,350 million EUR	Auction in October 2018 164 million EUR
Spain	Auction in Q1 2020	Auction in 2016-2018 for 4G	Auction in 2020
UK	Auction in 2020	Auction in April 2018 (lower part) 2020 (upper part)	Auction in 2020

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

2.7. Spectrum assignments (2/2)

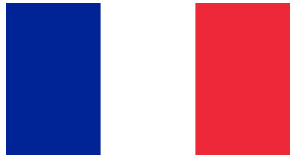
Non-EU5 countries

	700 MHz	Mid-band	26-28 GHz
China		Assignment in 2019	Assignment in 2019
India		Auction in 2020	Auction in 2020
Japan		Assignment in April 2019	Assignment in April 2019
South Korea		Auction in June 2018 2,300 million EUR	Auction in June 2018 480 million EUR
Turkey		Auction in August 2015 3,420 million EUR	Auction in 2020
USA	Auction in Q1 2008 18,958 million EUR 3G/4G	CBRS Auction in 2020	Auction in January 2019 623 million EUR Auction in March 2019

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

2.8. Commercial launches (1/2)

Target dates, coverage, 5G mode and smartphone availability

	Date of launch	Coverage	Smartphones availability	5G mode
France 	2020	11 cities	2019	Mobile 5G FWA
Germany 	2019/20	3 cities	2019	Mobile 5G
Italy 	2020	7 cities	2019	Mobile 5G
Spain 	2020	5 cities	2019	Mobile 5G
UK 	2019	16 cities	2019	FWA/Mobile 5G

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

2.8. Commercial launches (2/2)

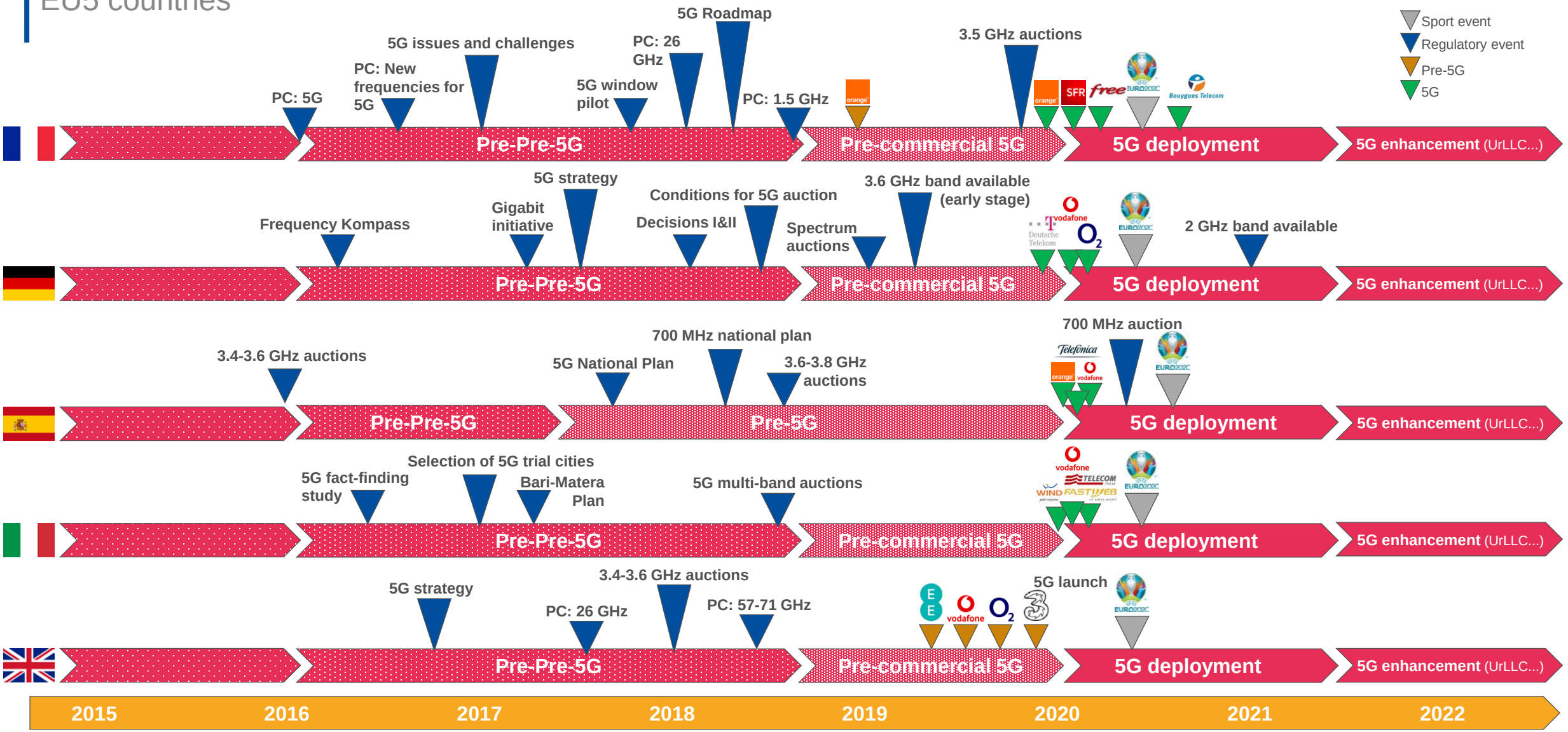
Target dates, coverage, 5G mode and smartphone availability

	Date of launch	Coverage	Smartphones availability	5G mode
China	Q3-Q4 2018: 2/4 2019	> 22 cities	2019	Mobile 5G FWA
India	Q2 2019: 3/3	Busiest parts of 85 cities	2019	Mobile 5G
Japan	2019: 1/3	3 cities	2019	Mobile 5G
South Korea	2019: 1/3 2020	17 cities	2019	
Turkey	2022	3 cities	2019	
USA	2020	3 cities	2019	

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

2.9. Timelines (1/3)

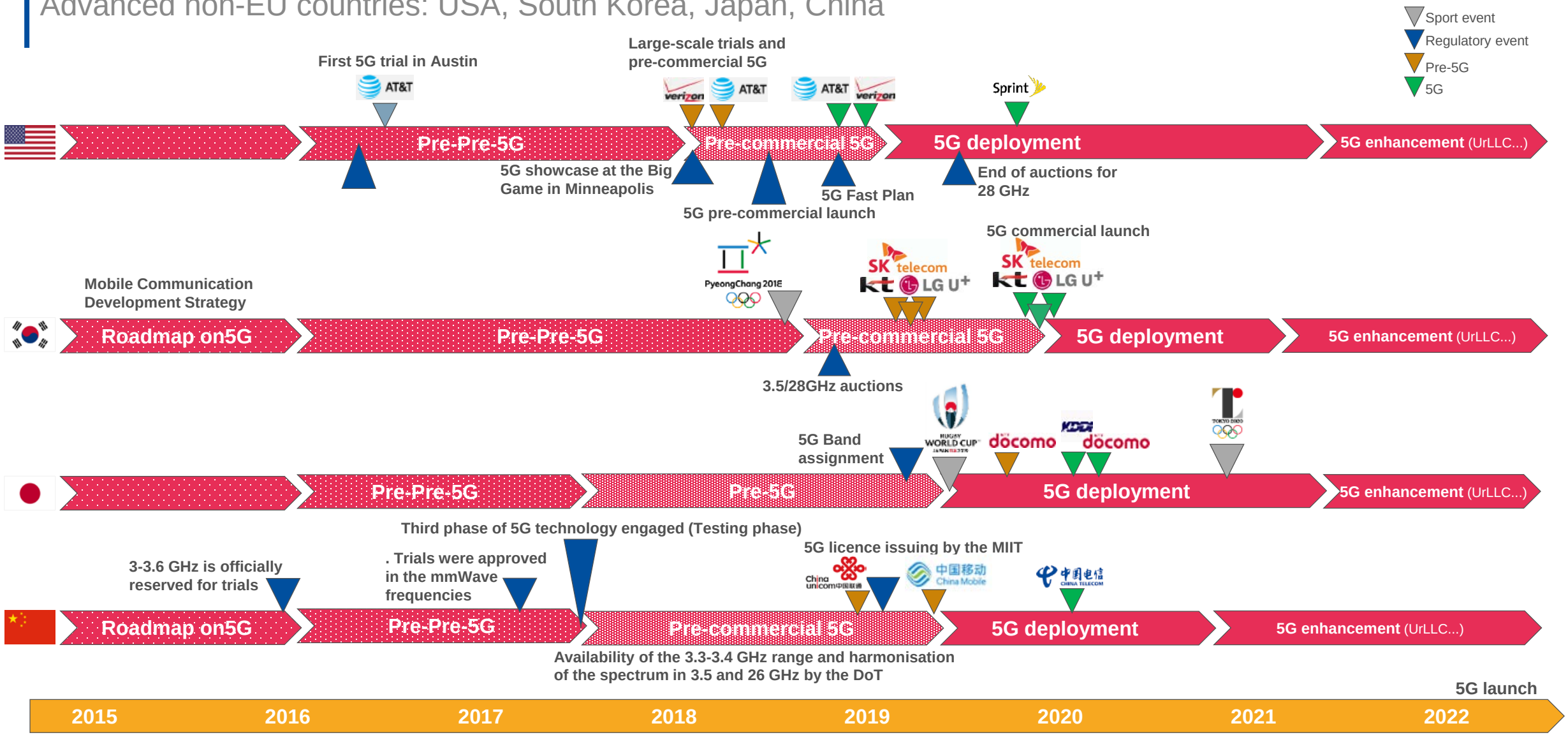
EU5 countries



Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

2.9. Timelines (2/3)

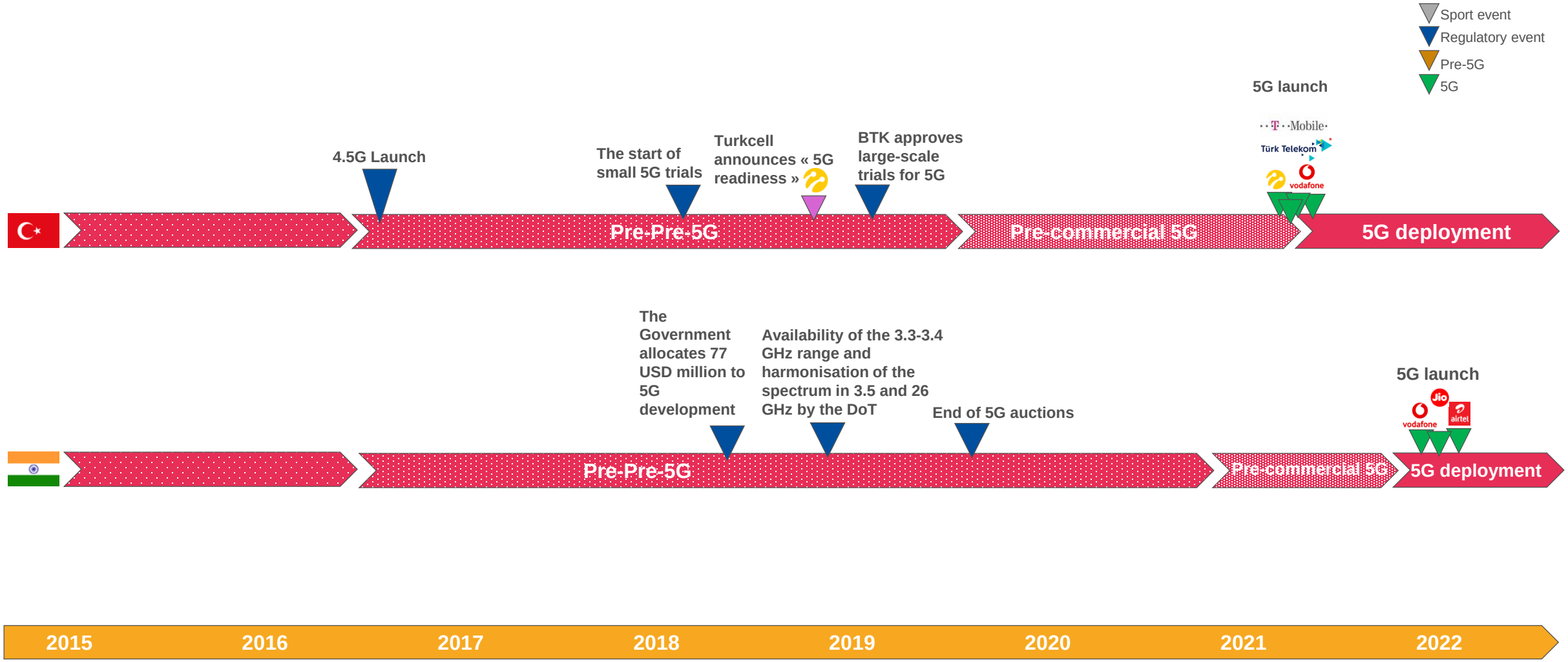
Advanced non-EU countries: USA, South Korea, Japan, China



Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

2.9. Timelines (3/3)

Less-advanced countries: India, Turkey



Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

03 | Country details

3.1 | China

3.1.1. China targets 5G launch in 2020 and prelaunch by YE 2019

Key Facts

- 5G deployment in China is strongly backed by the Government. 5G ranks among the strategic priority for the whole country for the 13th 5-Year Plan for 2015-2020.
- The 'Made in China 2025' initiative aims for a commercial 5G launch by 2020. As part of the country plan and initiative, the authorities awarded grants to local 5G oriented companies including ZTE and Huawei. ZTE and Huawei received 72 million USD for 5G.
- In October 2017, the Chinese Government kicked off the third phase of 5G technology research and development tests. This phase aims to get pre-commercial products ready for when the first version of 5G standard comes out in June 2019. Time has significantly accelerated in 2018 and China Mobile brought forward its scheduled 5G launch by one year and finally plans to offer 5G services by year-end 2019.
- China Mobile is currently trialling pre-commercial 5G and targeting 5G commercial services to be launched by the end of 2019. China Unicom and China Telecom are targeting 2020 for commercial services.

Frequency (MHz)	Auction revenues (million EUR)
No spectrum fee The Government makes a fair distribution among operators	
Total	**0**

Operators
▪ China Mobile ▪ China Telecom ▪ China Unicom

Manufacturers
▪ Qualcomm ▪ Huawei ▪ Mediatek ▪ Tsinghua Unigroup ▪ Intel ▪ Samsung

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.1.2. China invested in a 5G national action plan

Regulation and trials have moved very fast

Regulatory backdrop including frequency assignments and processes	▪ The Ministry of Industry and Information Technology(MIIT) has approved/reserved a number of bands for 5G: ▪ The 3-3.6 GHz band is officially reserved. Trials were approved in the band in January 2016. The 3.3-3.4 GHz part is limited to indoor use. ▪ The 4.8-5.0 GHz is also reserved for 5G service, China has also solicited opinions on the 24.75-27.5 GHz) and 37-42.5 GHz bands. Trials were approved in the mmWave frequencies in July 2017. ▪ MIIT identified other bands for 5G: ▪ MIIT will likely free up the 3.6-4.2 GHz band ▪ Lower frequencies (below 3 GHz were also mentioned for 5G, notably the 700 MHz band which has the largest spectrum band available. However, the 700 MHz spectrum is not available to China Unicom. MIIT might make available spectrum at 1 GHz or 2.5 GHz to Unicom. China Mobile will receive spectrum in the 4.8 GHz-5.0 GHz frequencies. ▪ 5G assignments could arrive in H2 2019. ▪ In March 2018, the MIIT announced it launched first research on 6G which won't be available before 2030.
5G player trials and launches	▪ **China Mobile** started to conduct 5G trials during the second half of 2016. China Mobile plans to start offering 5G services in 2019, which is a year earlier than originally planned (2020). In 2018, China Mobile announced marge-scale trials in five cities including Shanghai and Hangzhou by the third quarter of 2018 with about 500 base stations (100 first base stations by end June 2018). Trials will be extended to 20 cities early 2019 with another 500 base stations, to test out business applications. The trial network will use 3.5 GHz spectrum and some of the 4.9 GHz band. ▪ **China Unicom** has been trialling 5G in 600 labs of 16 cities including Beijing, Tianjin, Qingdao, Hangzhou, Nanjing, Wuhan, Guiyang, Chengdu, Shenzhen, Fuzhou, Zhengzhou, and Shenyang. In 2019, application experiments and large-scale trials are scheduled. The plan is to build 100 5G base stations in each location. ▪ **China Telecom** started testing 5G in six cities including Xiong'an, Shenzhen, Shanghai, Suzhou, Chengdu and Lanzhou with a view to test 5G in 12 cities in the end. In January 2019, China Telecom announced it had launched 5G in a subway station in Chengdu.

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.1.3. Chinese players are targeting 5G launch in main cities

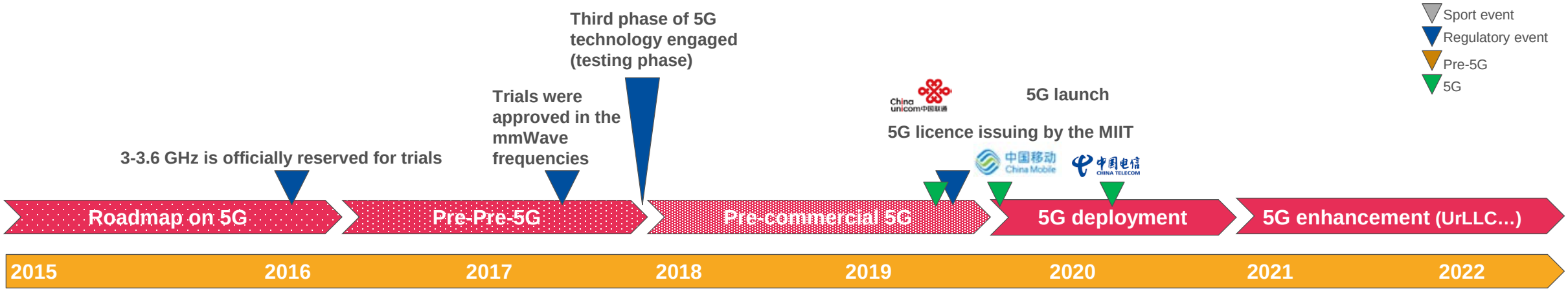
Applications and coverage

Main vertical targets	The major 5G vertical markets are: ▪ Media and Entertainment ▪ Automotive and Transport ▪ Industry 4.0
Service coverage and maturity	▪ China Unicom is piloting 5G in 16 cities. Commercialisation is expected to get underway in 2020 including in Beijing, Tianjin, Shanghai, Shenzhen, Hangzhou, Nanjing and Xiong'an. ▪ China Mobile will offer 5G services and application demonstrations in 12 cities: Beijing, Xiong'an, Tianjin, Fuzhou, Chongqing, Chengdu, Nanchang, Nanning, Shenzhen, Zhengzhou, Shenyang and Lanzhou. China Mobile is expected to push 5G pre-commercial trials in H1 2019 and commercialisation in 2020 when compatible smartphones are available. ▪ China Telecom conducted 5G pilot programmes in six cities, including Shenzhen, Shanghai, Suzhou, Chengdu and Lanzhou, with six to eight stations in each city, mainly in the 3.5 GHz frequencies.

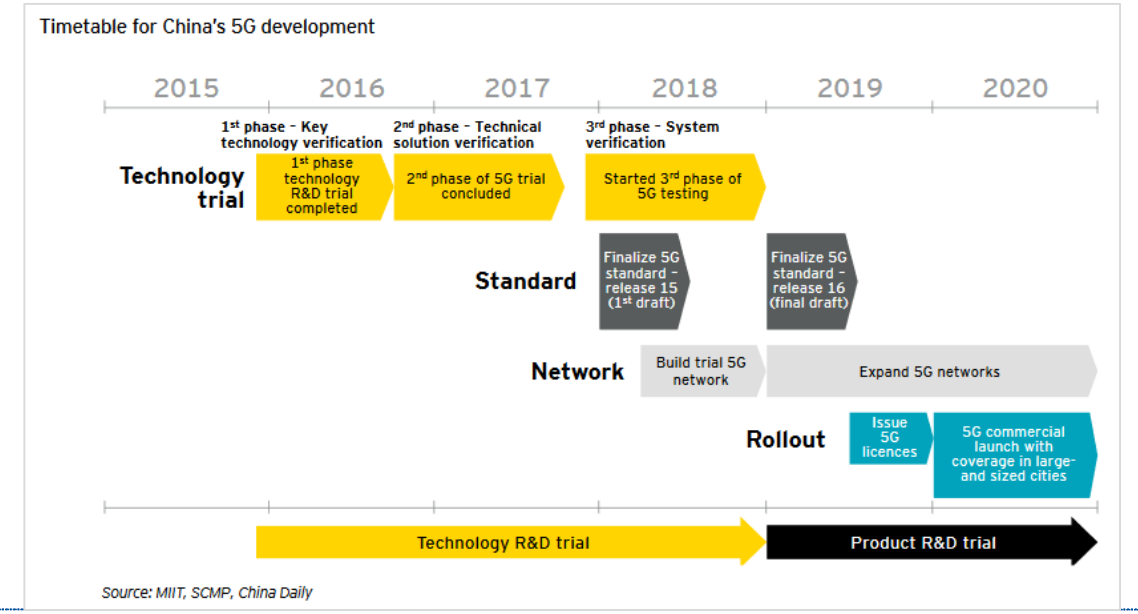
Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.1.4. All Chinese players targeting 2020 for 5G launch

China Mobile ahead, and with their prelaunch expected by YE2019



Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019



3.2 India

3.2.1. India plans its 5G launch in 2022, leapfrogging in some regions from 2G/3G

Key Facts

- The Government of India is backing 5G deployment. Indian authorities established a 5G forum with a budget of approximately 76 million USD dedicated to 5G research and development. The Government launched two strategic initiatives to address these challenges: the India's Smart Cities Mission and Digital India. 5G will be central in achieving these Government-backed initiatives focusing on easing the stress of urban population growth and closing the digital divide among the citizens from different social backgrounds.
- Initially planned for 2020, the commercial launch was postponed to 2022 as it seems to be a more reasonable target
- The majority of mobile subscriptions are still 2G, and MNOs have already begun considering moves to leapfrog from 2G/3G directly to 5G.

Frequency (MHz)	Auction revenues (million EUR)
850	1,316
900	4,434
1800	6,189
2100	1,300
2300	4,242
Total	**17,481**

Operators
▪ Bharti Airtel
▪ Reliance Jio
▪ Vodafone India
▪ Idea Cellular
▪ RCOM
▪ Aircel
▪ BSNL
▪ Augere
▪ Tikona

Manufacturers
▪ Qualcomm
▪ Nokia
▪ Ericsson
▪ Huawei
▪ ZTE
▪ Samsung

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.2.2. India’s 5G is in its very early stages

Regulatory framework and trials

Regulatory backdrop including frequency assignments and processes	▪ India has significant infrastructure challenges that will limit 5G deployment, such as the lack of a robust network to connect cellular sub-networks to core ones. ▪ The Department of Telecommunications (DoT) is harmonising spectrum in the 3.3-3.6 GHz band and 26 GHz band, along with the 71-76 GHz, the 81-86 GHz and the 57-64 GHz frequencies as 5G candidate bands. ▪ The DoT ordered operators to vacate spectrum in the 3.3-3.4 GHz range by the end of September 2018. For the 3.3-3.6 GHz spectrum, the Government and the regulator TRAI suggested a reserve price of 30% of 1800 MHz FDD band i.e. 985 INR per MHz (12.4 EUR) considering the 1800 MHz reserve price of 3285 INR. Mid-frequencies are expected be put up for sale in 20 MHz blocks with a spectrum cap of 100 MHz per bidder. ▪ March 2018: The DoT harmonised spectrum in the 3500MHz band and 26GHz band, along with E-band (71-76 GHz and 81-86 Ghz) and V-band (57-64 GHz) spectrum, these bands can be used as to build wireless backhaul solutions to provide base station connectivity. ▪ December 2018: the Secretary of regulatory authority TRAI announced the move of the telecom sector to 5G by 2022
5G player trials and launches	▪ February 2018: Bharti Airtel and Huawei conducted India’s first 5G network trial under a test setup at the former’s network experience centre in Manesar, Gurgaon. During the test trial, a user throughput of more than 3 Gbps was achieved using the 3.5 GHz band with 100 MHz bandwidth and end-to-end network latency of approximately 1 ms. India plans to roll out 5G services for consumers by 2020. ▪ February 2018: The Indian government was speeding up the 5G process. In its recent annual budget it allocated 5 billion Indian rupees (77 million USD) to 5G development. The IITs at Chennai, Mumbai, Delhi, Hyderabad and Kanpur will work alongside the Indian Institute of Science in Bengaluru on this test bed. ▪ February 2019: Qualcomm and OnePlus announced they will start trialling 5G in India with smartphones powered by the Snapdragon 855 Mobile Platform. Ericsson announced a deal with Vodafone Idea to upgrade the network with 5G-ready radio systems and microwave backhaul solutions.

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.2.3. India’s 5G plans include leapfrogging from 2/3G to 5G

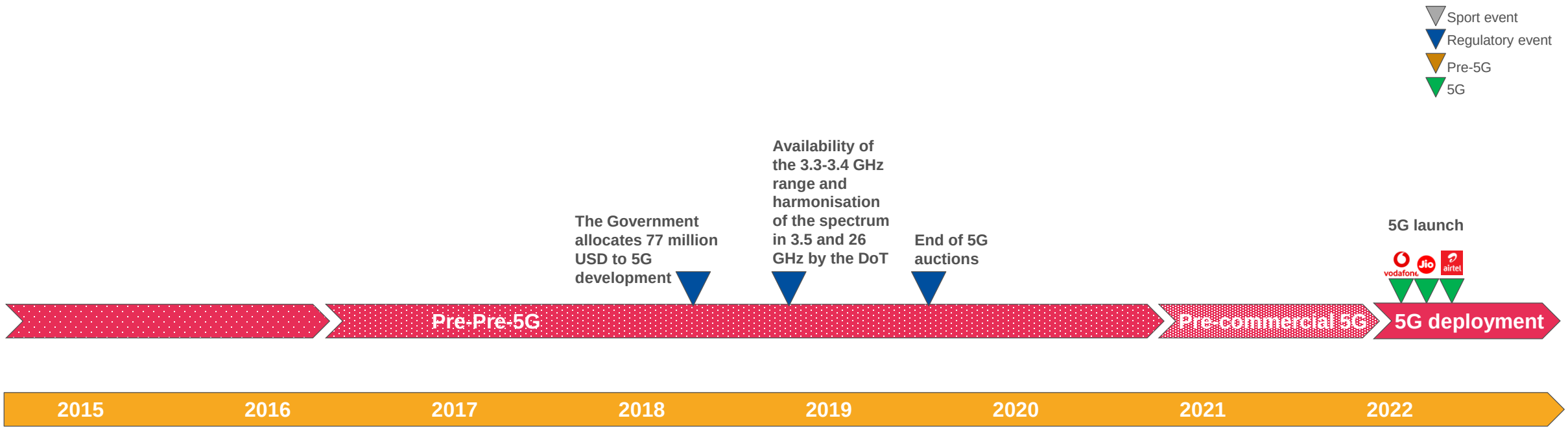
Applications and coverage

Main vertical targets	The main vertical markets are: ▪ Media and Entertainment ▪ Industry 4.0
Service coverage and maturity	▪ The 5G infrastructure in India is still in its very early stages. ▪ Airtel rolled out 5G-ready technology in 2017 in the cities of Kolkata and Bengaluru ▪ Some regions still use 2G/3G. They are expected to leapfrog to 5G, which should be easy since the frequency bands are free ▪ The plan for 5G commercial deployment in New Delhi in 2022 as announced by Telecom Secretary Aruna Sundararajan in 2018

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.2.4. Before launching 5G, India must complete regulation and frequency assignments

Timelines



Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.3. Japan

3.3.1. Players will likely launch 5G at the Tokyo Summer Olympics in August 2020

Key Facts

Historically, Japan has been at the forefront of mobile technology. Japan is aiming to leverage the Tokyo 2020 Summer Olympics to launch 5G. However, NTT DOCOMO announced that it could prelaunch 5G in September 2019 with plans to deploy commercial 5G services across Japan by mid-2020. The three major 5G cities in the country are Tokyo, Yokohama and Nagasaki.

Planned Exhibitions:

- 2020 Tokyo 5G (Summer) Olympics with Huawei, NTT DOCOMO and Tobu Railway
- Rugby WC Tokyo 2019
- Building the Okinawa Cellular Stadium in Japan.
- Test for a 5G train moving at 100 km/h, in a test by KDDI

Commercial Launch:

- KDDI, SoftBank and NTT DOCOMO are targeting commercial launch by 2020.

Frequency (MHz)	Auction revenues (million EUR)
No spectrum fees for operators **An open policy in Japan:** The Radio Regulatory Council frames the spectrum allocation in order to meet demands for radio systems.	
Total	**0**

Operators
▪ KDDI
▪ NTT DOCOMO
▪ SoftBank Mobile

Manufacturers
▪ Ericsson
▪ Samsung
▪ Huawei
▪ Nokia
▪ ZTE

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.3.2. The Government of Japan adopted a roadmap in 2016

5G R&D and trials have moved fast with pragmatism

Regulatory backdrop including frequency assignments and processes

- The Radio Policy Vision Council of the Ministry of Internal Affairs and Communications (MIC) held in 2014 presented the roadmap for 5G. Following that report, 5G Mobile Forum (5GMF) was established late in September 2014.
- Around 300 million USD have been allocated by the Japanese authorities to promote the Industrial IoT and related technologies such as 5G, big data, artificial intelligence and robotics.
- Japanese operators are targeting the rollout 5G in time for hosting the 2020 Summer Olympics and Paralympic Games in August 2020. Japan mainly supports the 28 GHz (27.5-29.5 GHz) band for 5G.The MIC has also approved the 3.6-4.2 GHz and the 4.4-4.9 GHz frequencies.
- Following a consultation held in February 2018, two chunks of spectrum (4.6-4.8 GHz and 28.2-29.1 GHz) will be held back by the MIC for private 5G network use.
- Assignment of 3.7, 4.5, 28 GHz spectrum in a beauty contest in April 2019 to the three incumbent players and Rakuten (NTT DOCOMO: 3.6-3.7 GHz, 4.5-4.6 GHz, 27.4-27.8 GHz, KDDI: 3.7-3.8 GHz, 4.0-4.1 GHz, 27.8-28.2 GHz, SoftBank: 3.9-4.0 GHz, 29.1-29.5 GHz, Rakuten: 3.8-3.9 GHz, 2è.0-27.4 GHz). Licences included coverage obligations: NTT DOCOMO >90%, KDDI >90%, SoftBank 64%, Rakuten 56%.

5G player trials and launches

NTT DOCOMO

- NTT DOCOMO trialled 5G with the Chinese vendor Huawei in November 2016. They carried out a large-scale field trial using 200 MHz of spectrum in the 4.5 GHz band in Yokohama, Japan. DOCOMO and Huawei also completed 5G integrated access backhaul trials using the 39 GHz frequencies.
- With Nokia, NTT DOCOMO tested 5G on the 90 GHz band.
- In May 2018, NTT DOCOMO achieved a 5G field trial at 28 GHz, involving a 5G base station and a car travelling at around 293 km/h.

SoftBank

- SoftBank is demonstrating 5G with Huawei. One demo included real-time UHD video transmission (throughput of over 800 Mbps) using ultra-high throughput, remote control of a robotic arm and ultra-low latency transmission as well as remote rendering via a GPU server using edge computing.
- Working together with ZTE, SoftBank achieved DL speeds of 956 Mbps in Nagasaki in October 2017.
- In August 2017, SoftBank and Ericsson performed 5G trials using 4.5 GHz frequencies.

KDDI

- In December 2017, KDDI and Samsung completed a successful 5G demo on a train moving at over 100 km/h. The distance between two stations was approximately 1.5 km. Companies achieved a successful DL and UL handover as well as a peak speed of 1.7 Gbps.
- KDDI has also performed 5G trials, mainly with Ericsson and Samsung Electronics. Between September 2017 and March 2018, KDDI and Ericsson tested a PoC in the 4.5 GHz frequency band in a good many cities across Japan.

Rakuten is a newcomer (announced February 2019) in the mobile industry and for cloud-native mobile network deployment in Japan.

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.3.3. Japan is first focusing on eMBB and then on low latency in major cities

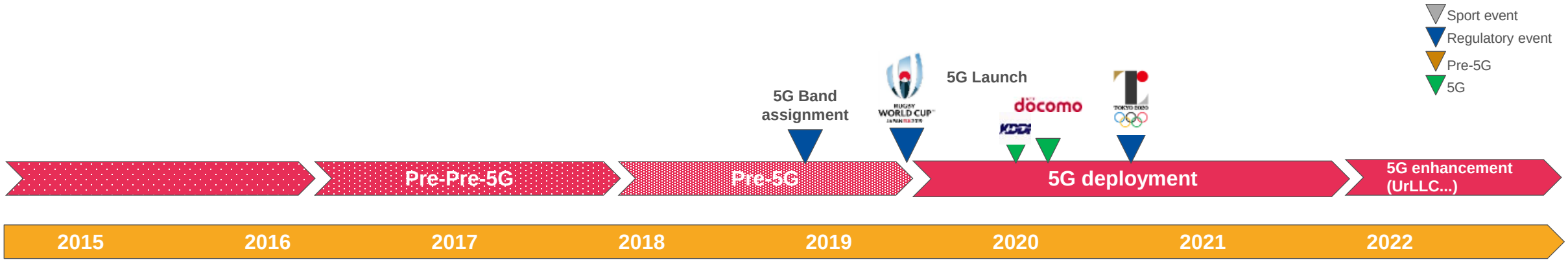
Applications and coverage

Main vertical targets	▪ Main markets are: ▪ Media and Entertainment ▪ Automotive and Transport ▪ Industry 4.0 ▪ Construction ▪ Logistics ▪ Agriculture ▪ Smart Office
Service coverage and maturity	▪ The three main 5G cities covered by SoftBank and NTT DOCOMO are: – Nagasaki (SoftBank) – Tokyo (NTT DOCOMO) – Yokohama (NTT DOCOMO) ▪ NTT DOCOMO achieved 5G speeds of 27 Gbps in a moving car in November 2018 ▪ Japan is one of the most advanced countries in terms of technological maturity of 5G technologies.

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

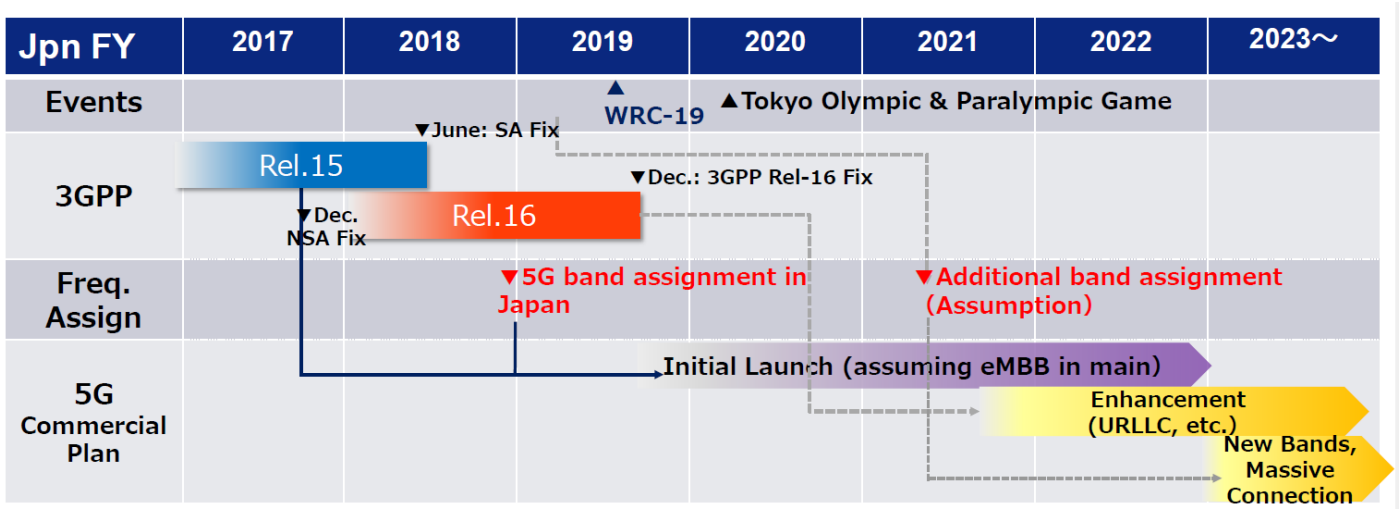
3.3.4. Japan is targeting the 2020 Summer Olympics for the 5G launch

Timelines



Launch initial 5G service mainly for eMBB, then introducing low latency, SA in a phased approach, taking account of 3GPP standardisation.

- Target to start service mainly for eMBB in NSA by FY 2020, targeting the 2020 Summer Olympics.
- Enhance URLLC capability, based on Rel. 16 to be fixed by December 2019.



Source: MIC

3.4 South Korea

3.4.1. 5G has been core to the South Korean economic agenda since 2015

Joint official launch in April 2019 after its demonstration at 2018 Winter Olympics

South Korean MNOs exhibited 5G at the 2018 Winter Olympics in early 2018.

While their initial plan to commercially launch 5G was for 2020, KT, SK Telecom and LGU+ now plan to launch their coordinated 5G commercial services in March 2019. They all launched pre-commercial services in December 2018.

Winter Olympics in PyeongChang

The February 2018 Winter Olympics in PyeongChang, aka the 2018 Winter Olympics, provided a stage for displaying 5G innovation. Samsung and KT provided a 4K streaming video service via a 5G network using 28 GHz spectrum. KT also provided the 5G data network through a collaborative set-up led by Intel with partners including Ericsson, Nokia and Alibaba. Meanwhile, Samsung unveiled its 5G mobile tablet device to deliver a 4K streaming video via Intel base stations. KT demonstrated four types of data-heavy video streaming services on its 5G network: Sync View, Time Slice, 360 VR and Omni Point View. KT also showed a 5G Connect Bus using 5G, capable of autonomous driving using lidar sensors and the V2X technology. Hyundai demonstrated five Level 4 autonomous cars on a 196-km journey to PyeongChang; the cars were connected to the KT 5G network to provide entertainment to passengers.

Players prelaunched 5G in December 2018 and launched in April 2019

SK Telecom, LGU+ and KT launched their 5G service in a number of cities on 1 December, 2018.

The launches took place earlier than initially planned, in fact, in July 2018 all three MNOs announced their intention to jointly launch 5G in March/April 2019. The agreement to share the national 5G network and deployment costs was signed in April 2018.

Frequency (MHz)	Auction revenues (million EUR)
850	440
900	646
1800	1,701
2100	3,039
2600	1,348
3500	2,354
28000	448
Total	**10 016**

Operators
▪ KT
▪ LG U+
▪ SK Telecom

Manufacturers
▪ Samsung
▪ Ericsson
▪ Nokia

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.4.2. The South Korean regulatory system is built upon a partnership of players and Government

Moving fast towards 5G

Regulatory backdrop including frequency assignments and processes	▪ 2G networks were shut down back in 2012 ▪ All three players provide a 100% LTE coverage since 2012 ▪ In June 2018, the regulator released an improved policy on essential facilities ▪ 3.5 GHz and 28 GHz auction was completed in June 2018- Total bids reached 3.6 trillion KRW (2.8 billion EUR) of which 82% was for 3.5GHz spectrum. Spectrum authorisations were issued between September and December 2018). Use of spectrum became possible on 1 December 2018. – Bids for 3.5 GHz (3420 MHz-3700 MHz) spectrum topped 2.3 billion EUR. KT and SKT received 100 MHz while LGU+ were awarded 80 MHz. – Bids for 28 GHz (26.5-28.9 GHz) spectrum totalled 480 million EUR; far less than on the 3.5 GHz spectrum where large chunks of spectrum were on sale. All three players obtained 800 MHz. ▪ The simultaneous launch of 5G by all players was arranged in March 2019 by the Government in 2018.
5G player trials and launches	▪ Several South Korean players were very active in trialling 5G. They started trials in 2016: first, the major focus was on 5G characteristics and the validation of 5G requirements. Larger-scale trials started on the Winter Olympic Games site in mid-2017 using 3.5 and 28 GHz frequencies such as 5G-based IPTV 4K applications and VR drones. ▪ Major broad-scale trials were undertaken at the 2018 Winter Olympics, including intercontinental trials – Immersive broadcasting, 5G Zones, real-time, 360-degree video of athletes competing, video analyses in short time slice, autonomous shuttle buses…. ▪ Major broad-scale trials were performed at the Asian Games 2018 in Indonesia – Catching of various sports games through 5G services (selected different positions/scenes/angles for viewing the games) ▪ All players simultaneously prelaunched 5G on 1 December, 2018. SKT announced it will specifically focus on enterprise users for this initial launch. 5G for consumers will be available in March 2019.

Source: Players

3.4.3. South Korea is expanding its 5G coverage in many cities

82,000 5G sites (April 2019), up 800% in two months!

Main vertical targets	▪ The South Korean regulator decided to take a user-centric view rather than a capability-centric one. The first focus for 5G is on consumer services. Main vertical markets are: – Media (Immersive media, AR/VR, UHD, 360° VR live broadcast): the launch announcement was achieved through live broadcast – Immersive services – Autonomous services – Intelligent services – PPDR services – Smart city ▪ The second focus is on vertical industries with 80 million USD in Government support through the 5G Convergence service project (2018-2020)
Service coverage and maturity	▪ 100% LTE coverage was reached in 2012. There were some 85,000 5G sites at April 2019, the number of 5G sites having multiplied eight times in two months. ▪ KT: 7 cities illuminated, 24 additional cities to be covered soon, with in all 30,000 5G sites (April 2019) ▪ LGU+: 18,000 5G sites (April 2019) ▪ SK Telecom: 34,000 sites (April 2019) ▪ South Korea is one of the most advanced countries in the world in terms of technological maturity for 5G. ▪ After the PyeonChang 2018 Olympics 5G demonstration, the 5G connected bus test by KT is assessed as being one of the most advanced tests ran in the country, achieving 20 Gbps transmission speed.

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.4.4. Comparison of the first South Korean 5G price plans/packages

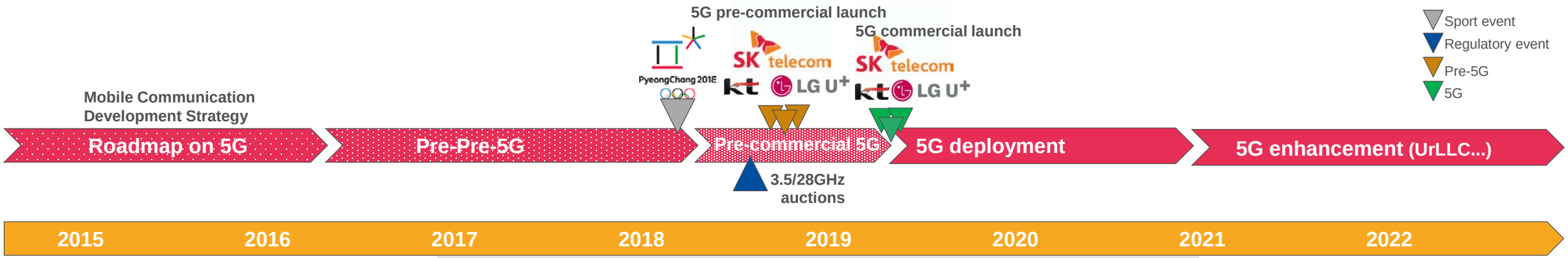
260,000 5G connections (April 2019) in first month

	Monthly subscription	Data cap	Data rate	Other comments
KT South Korea	▪ 43 EUR ▪ 62 EUR ▪ 76 EUR ▪ 101 EUR	▪ 5 GB ▪ 5 GB ▪ 50 GB ▪ 100 GB	Up to 2.7 Gbps	▪ Samsung Galaxy S10 5G ▪ Hotspot
SKT South Korea	▪ 43 EUR ▪ 59 EUR ▪ 74 EUR ▪ 98 EUR	▪ 8 GB ▪ 150 GB ▪ 200 GB ▪ 300 GB	Up to 2.7 Gbps	▪ Samsung Galaxy S10 5G ▪ Motorola Z3
LGU+ South Korea	▪ 43 EUR ▪ 57 EUR ▪ 73 EUR	▪ 9 GB ▪ 150 GB ▪ 250 GB	Up to 2.7 Gbps	▪ LG V50 ThinQ ▪ Hotspot ▪ Promotional deals VR Headsets YouTube TV and insurance users

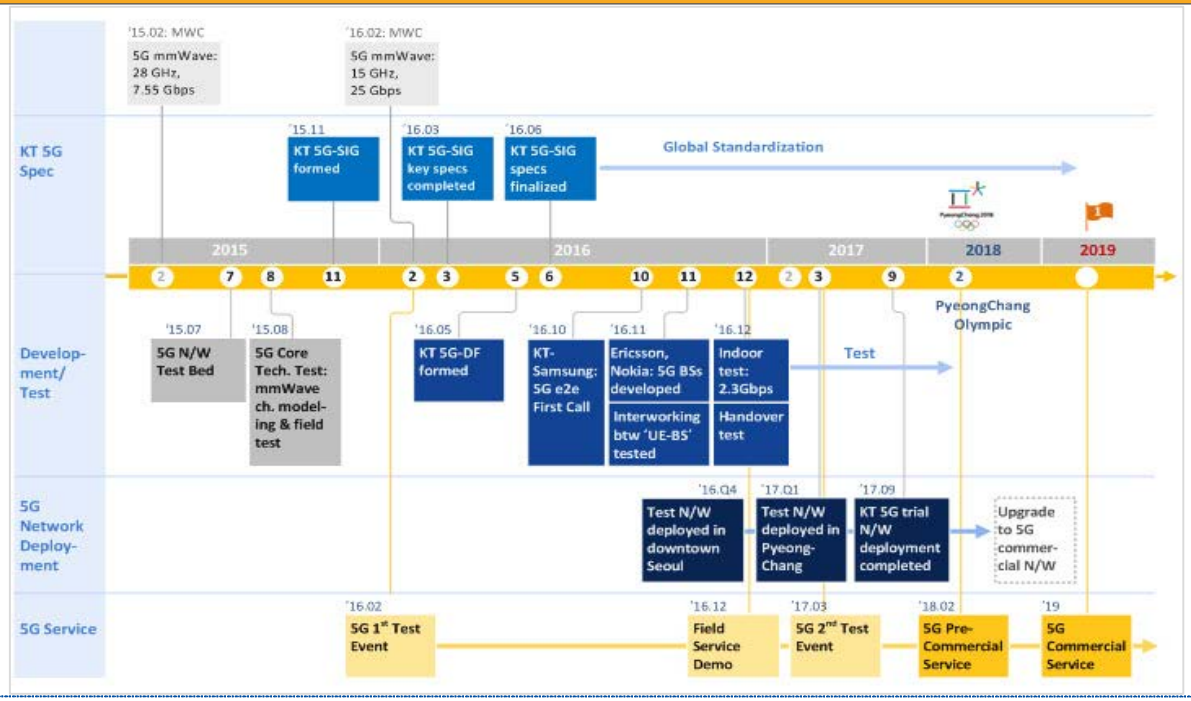
Source players

3.4.5. South Korean players jointly launched 5G, in April 2019, as scheduled

Timelines



Source players



Source: KT

3.5. | Turkey

3.5.1. Turkey is targeting 2021 for 5G launch

Key Facts

- Turkish operators claim they are ready to deploy 5G, but mmWave frequencies have not yet been auctioned. The most recent deployments are an upgraded version of 4G, known as 4.5G, which acts as a transition to 5G. 4.5G was auctioned in August 2015 by 20 separate frequency packages of 800, 900, 1800, 2100 and 2600 MHz spectrum.
- The re-named Information and Communication Technologies Authority Authority of Turkey (ICTA) and the Turkish 5G forum (5GTR) form the framework for 5G deployments in Turkey. The ICTA, known also under its Turkish abbreviation of BTK, provides the regulatory structure for the networks in the country, and 5GTR sets the baseline for 5G in Turkey by supporting the contribution of Turkish companies in EU H2020 programmes and fostering partnerships with European companies.
- Türk Telekom has prepared the '*5G White Book*' to cast light on the Turkey 5G road map. 5G network deployments are due in 2020.

Frequency (MHz)	Auction revenues (million EUR)
850	1,142
900	297
1800	835
2100	348
2300	798
Total	**3 420**

Operators
▪ Turkcell
▪ Türk Telekom
▪ Vodafone
▪ T-Mobile

Manufacturers
▪ Samsung
▪ Ericsson
▪ Nokia
▪ Huawei
▪ Qualcomm

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.5.2. Turkish regulations are halfway to maturity – mmWave auctions to be held

Regulatory framework and trials

Regulatory backdrop including frequency assignments and processes	▪ The Turkish 5G Forum leads the 5G initiative in Turkey known as 5GTR. It developed a 5G roadmap for Turkey. ▪ 4G auctions were held in August 2015 in 800//900/1800/2100/2100 TDD/2600 FDD/2600 TDD) ▪ February 2016: Following the award of 900 MHz spectrum, the 900 MHz reframing process is considered complete. ▪ There is an on-going process for 5G spectrum identification: 26-28 GHz frequencies are considered.. Other bands will be considered. Assignment target date in 2021.
5G player trials and launches	As part of Turkey's 2023 Goals, a number of smart projects are being, or will be, implemented across various cities. These smart city projects will leverage network technologies. In February 2019, Turkey's Information and Communication Technologies Authority (known in Turkish as BTK) authorised 5G trials in Ankara, Istanbul and Izmir for the country's three mobile network operators Turkcell, Vodafone and Türk Telekom (Avea). ▪ January 2017: **Turkcell** collaborated with Ericsson in 5G network equipment tests in Istanbul. They achieved a peak data speed of 24.7Gbps using the 15GHz frequency band. ▪ In June 2017: Turkcell attained speeds of 70GBps by using 71.5-73.5GHz spectrum in its 5G trial with Huawei. ▪ Turkcell launched Turkey's first live 5G fixed wireless network for trial, using spectrum in the 26 GHz frequency band. ▪ March 2017: **Türk Telekom** tested NB-IoT technology in its own network in Turkey working with Nokia as co-operator in an important step of the telco's strategy. Together, Türk Telekom and Nokia held a demonstration that year in a virtual stadium covered by 5G in MWC. ▪ October 2016: Turkish telecommunications regulator BTK organised 5G open field tests at the '5G BTK Market Surveillance Laboratory' located on the campus of Ankara Hacettepe University. The test involved the local operators **Türk Telekom**, **Turkcell** and **Vodafone Turkey**.

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

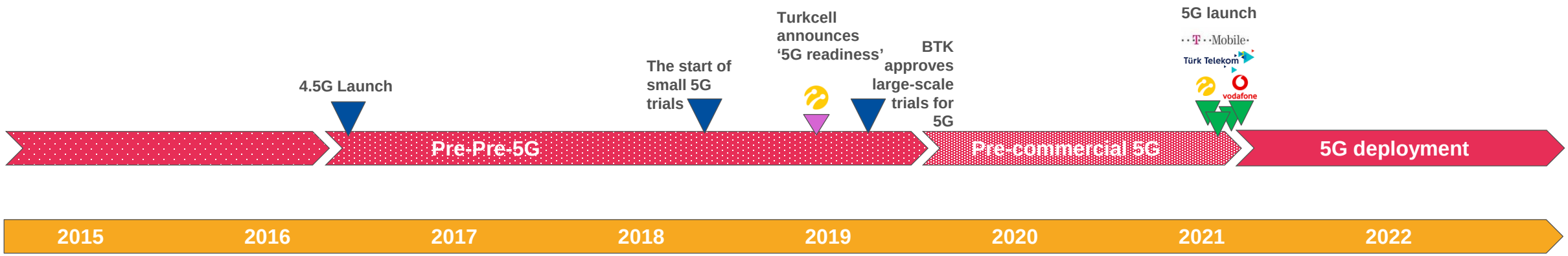
3.5.3. In Turkey, 5G is targeting verticals and smart cities

Applications and coverage

Main vertical targets	The main vertical markets covered by the Turkish roadmap for 5G (The *5G White Book* – p8): ▪ Smart City (mostly for Utility and Energy) ▪ Media and Entertainment (VR, drone experience) ▪ Industry 4.0 and Manufacturing ▪ Automotive (V2X) ▪ e-Health
Service coverage and maturity	▪ Operators claim that the technology is ready ▪ Latest deployments of 4.5G auctioned in 2015 and launched in 2016 ▪ 4.5G auctions include a coverage obligation of 95% of Turkish population, to be reached within eight years. ▪ 5G commercial launch is expected in 2021 in the three Turkish cities Istanbul, Ankara and Izmir, currently authorised by the BTK to trial 5G

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.5.4. Waiting for mmWaves auctions



Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.6. | USA

3.6.1. 5G has been a core component of US strategy since 2015/2016

Key Facts

- The United States is one of the most advanced countries in terms of 5G maturity. The FCC has pursued a comprehensive wireless strategy since 2016 by clearing 11 GHz of high-band spectrum for 5G and devoting a 400 million USD fund to research on 5G.
- 5G Americas is the authoritative lead player in 5G at regional level (partnership agreements with major standardisation bodies and wireless entities).
- Concerns about cyberattacks from China resulted in an attempt by the Trump Administration to build a secure 5G network, possibly under Government control. The FCC and the wireless industry pushed back these attempts, however, and national uses of the technology of Chinese vendors Huawei and ZTE were banned in August 2018.
- AT&T launched a labelled mmWaves 5G standardised as non-stand-alone (NSA) on 21 December, 2018 to selected customers in 12 cities. This outreach is to be extended to 19 in 2019.
- Verizon launched mmWaves 5G FWA services on a proprietary norm on 1 October, 2018 in four cities, and mobile 5G in April 2019.
- Sprint is expected to launch 2.5 GHz 5G NSA services in four cities in May 2019. The pending merger between T-Mobile and Sprint could delay this.
- T-Mobile plans its first deployment in 2019, going nationwide by 2020.

Frequency (MHz)	Auction revenues (million EUR)
600	17,950
700	12,548
PCS	5,787
AWS 1	9,782
AWS 2	43,944
28 GHz	704
24 GHz	1,989*
Total	**92,704**

ongoing

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

Operators

- AT&T
- Verizon
- Sprint
- Dish
- T-Mobile
- US Cellular

Manufacturers

- Qualcomm
- Intel
- Nokia
- Ericsson
- ZTE
- Samsung

3.6.2. The FCC ‘5G FAST’ plan: new spectrum, infrastructure policy, regulations

After an underwhelming 28 GHz auction, 24 GHz frequencies later edged toward 2 billion USD

Regulatory backdrop including frequency assignments and processes

- July 2016: 10.85 GHz made available in the 28 GHz (27.5-28.35 GHz), 37 GHz (37-38.6 GHz), 39 GHz (38.6-40 GHz) and an unlicensed band at 64-71 GHz.
- In November 2017, an additional 1700 MHz of high band spectrum for flexible terrestrial wireless use in the 24 GHz (24.25-24.45/24.74-25.25 GHz) and 47 GHz (47.2-48.2 GHz) bands were made available
- In June 2018, the FCC voted to proceed with making the upper 26 GHz (25.25–27.5 GHz) and 42 GHz (42–42.5 GHz) bands available for 5G services, while examining further aspects of the bands already in the 5G pipeline.
- In July 2018, the FCC considered options for up to 500 MHz of spectrum in the 3.7-4.2 GHz frequencies. Usually, satellite companies use these frequencies.
- On 28 September, 2018, the FCC and the White House organised a session on how to foster private investment in 5G. The FCC announced its *5G Fast Plan*. This one-page strategy document includes three key topics: spectrum, infrastructure and regulations. In each topic, the 5G Fast Plan mentions recent FCC actions and documents.
- The FCC auction of residual 28 GHz (27.5-28.35 GHz) frequencies began in November 2018. The auction closed in January 2019. Bids reached 704 million USD.
- Auction of the 24 GHz frequencies is ongoing. Bidding in the clock phase of the auction concluded on 17 April, 2019. Bidding in the assignment phase began on 3 May, 2019. Barring unforeseen circumstances, bidding was expected to conclude on 28 May, 2019. As that date came closer, the auction amount was approaching 2 billion USD (on 21 May, 2019) after 62 rounds.

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.6.3. Several US players started trialling 5G in 2015

Trials

5G player trials and launches

- Since early 2017, **AT&T** has been implementing fixed wireless and mobile 5G trials. The company works with such partners as Ericsson, Samsung, Nokia and Intel. After Austin, Texas, AT&T expanded trials to Waco, TX, Kalamazoo, MI and South Bend, IN. It observed results above expectations.
- **In Waco, it provided** 5G mmWave service to a retail location more than 150 metres away from the cell site and observed wireless speeds of approximately 1.2 Gbps in a 400 MHz channel. Observing latency rates at 9-12 milliseconds, it supported hundreds of simultaneous connected users using the 5G network.
- **In Kalamazoo**, it observed no impacts on 5G mmWave signal performance due to rain, snow or other weather events. Learning that mmWave signals can penetrate materials such as significant foliage, glass and even walls better than initially anticipated, AT&T measured speeds above more than 1 Gbps under line-of-sight conditions up to 900 feet.
- **At its site in South Bend**, a full end-to-end 5G network architecture was observed, including the 5G radio system and core, demonstrating extremely low latency. The trial successfully provided Gbps on mmWave spectrum in both line-of-sight and non-line-of-sight conditions
- Since 2017, **Verizon** has been testing mmWave 5G service in 11 cities: Ann Arbor, Atlanta, Bernardsville, Brockton, Dallas, Denver, Houston, Miami, Sacramento, Seattle and Washington, DC, with FWA and Mobile 5G.
- **A**head of its planned commercial launch in May 2019, **Sprint** disclosed a number of target markets. In February 2018, it named Atlanta, Chicago, Dallas, Houston, Los Angeles, and Washington DC as its initial surge of mmwave 5G markets. Additional markets were revealed in May 2018, including New York City, Phoenix, AZ and Kansas City, MI. In June 2016, Sprint demonstrated a 5G trial using 73 GHz frequencies, and coordinated with Nokia. Peak download speeds delivered reached 2Gbps. Attendees experienced a live, highly responsive, streaming virtual reality (VR) system, as well as live streamed video in 4K ultra HD.
- **T-Mobile** has announced that it is targeting a mobile 5G launch by 2020 in 30 cities including Dallas, Las Vegas, Los Angeles, New York City amongst other. Unlike its competitors, T-Mobile is not expected to launch 5G in mmWaves. It will use its 600 MHz spectrum primarily, followed by 28 and 39 GHz frequencies in the second stage. This should enable high speeds with a broad coverage.

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.6.4. Players aim to use both FWA and mobile 5G for eMBB services and verticals

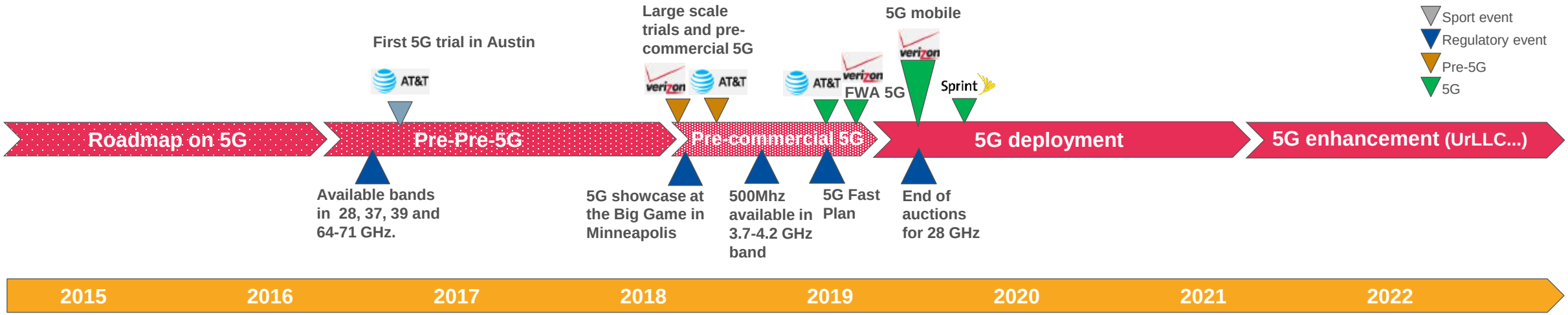
Applications and coverage

Main vertical targets	**A number of US players are targeting both FWA and mobile as two distinct business cases for 5G.** Main vertical markets are: ▪ Media and Entertainment ▪ Automotive and Transport ▪ AR/VR ▪ Industry 4.0 ▪ Logistics ▪ Agriculture
Service coverage and maturity	▪ **AT&T** was first to launch a commercial standard-based mobile 5G network on 21 December, 2018. It deployed 5G hotspots in the densely populated urban areas of 12 cities: Atlanta, Charlotte, N.C., Dallas, Houston, Indianapolis, Jacksonville, Fla., Louisville, Ky., Oklahoma City, New Orleans, Raleigh, N.C., San Antonio and Waco, Texas. The service was due to spread out in parts of seven other cities later in 2019: Las Vegas, Los Angeles, Nashville, Orlando, San Diego, San Francisco and San Jose, CA. ▪ As seen above, **Verizon** has been testing mmWave 5G service in 11 cities: Ann Arbor, Atlanta, Bernardsville, Brockton, Dallas, Denver, Houston, Miami, Sacramento, Seattle and Washington, DC). In September 2018, Verizon successfully transmitted a 5G signal on a commercial 5G NR network in Washington DC and Minneapolis on prototype devices. Verizon started marketing 5G Home service on 13 September, 2018 with orders online. The service went live on 1 October 1 2018 in Houston, Indianapolis, Los Angeles and Sacramento. 5G service is expected to cover 22 cities later in 2019: Atlanta, Boston, Charlotte, Chicago, Cincinnati, Cleveland, Columbus, Dallas, Des Moines, Denver, Detroit, Houston, Indianapolis, Kansas City, Little Rock, Memphis, Minneapolis, Phoenix, Providence, San Diego, Salt Lake City and Washington, DC. Verizon launched its mobile 5G service in April 2019 in two cities. ▪ **Sprint** planned its 5G rollout in May 2019 in 9 of the largest cities in the country: Atlanta, Chicago, Dallas, Houston, Kansas City, Los Angeles, New York City, Phoenix, Washington, D.C.

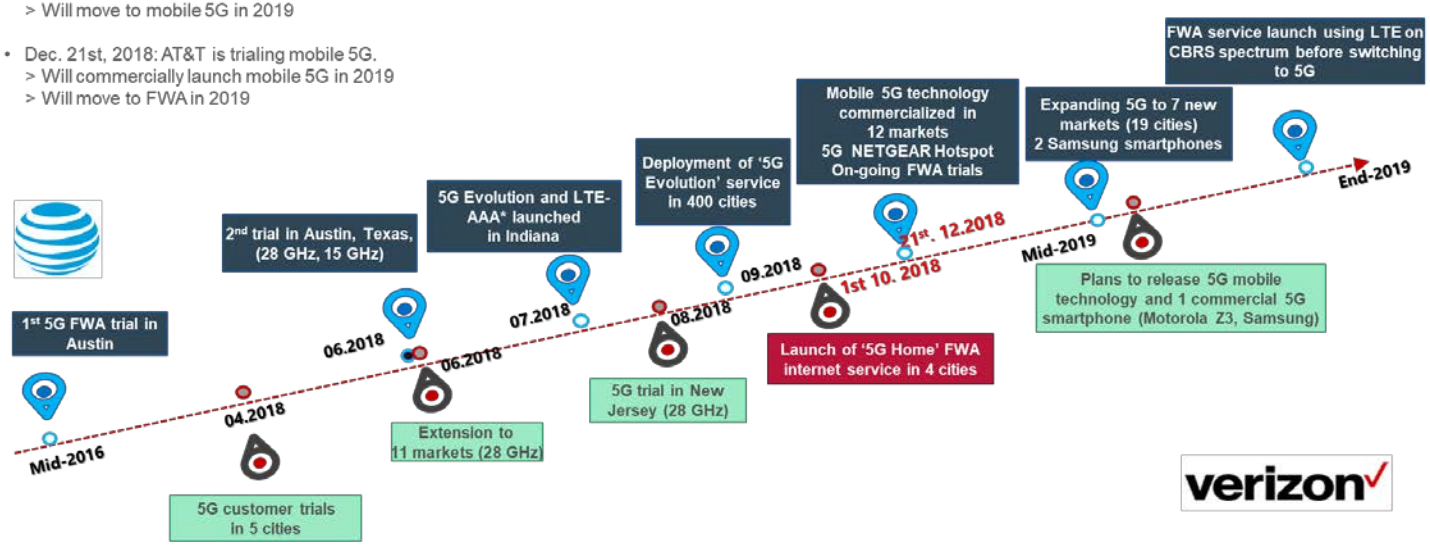
Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.6.5. Almost there: Two of four major US players have already launched 5G, or are about to.

Verizon FWA and upcoming mobile 5G, AT&T mobile 5G and upcoming FWA



- Oct. 1st, 2018: Verizon launched 5G on a FWA mobile
  > Will move to mobile 5G in 2019
- Dec. 21st, 2018: AT&T is trialing mobile 5G.
  > Will commercially launch mobile 5G in 2019
  > Will move to FWA in 2019



Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.7. | France

3.7.1. Key facts

- France is a relative latecomer in the race for 5G compared to the pioneering countries of USA, Japan, South Korea and China. All the same, it will be ready for 5G commercial launch in 2020 as required by the European Commission and, as required, one city will be selected as '5G city' in the framework of H2020 objectives.
- A public consultation on award procedures, procedure sequencing and requirements was opened between 26 October and 19 December , 2018 to collect ideas and needs from operators, local authorities, vertical market players, economic stakeholders and all other interested parties. ARCEP will be holding a second consultation on the call or calls to tender, which it will then propose to the Government. That call for tenders could be issued in mid-2019.
  - In H2 2018, discussions were organised on verticals, namely the connected vehicle and Industry 4.0.
  - Live-scale tests have been awaited for early 2019.
  - In the first half of 2019, the Government expects to organise a major event on 5G.
  - The call for applications is also scheduled for the second half of 2019
- In its document '*An ambitious roadmap for France, 2018*', ARCEP highlights four priority project tasks to make 5G a success:
  - Free up and allocate radio frequencies
  - Foster the development of new uses
  - Support 5G infrastructure rollouts
  - Ensure transparency and dialogue on rollouts and public exposure

Frequency (MHz)	Auction revenues (million EUR)
700	2,796
800	2,639
900	743
1800	799
2100	2,679
2600	936
3500	268
Total	**10,016**

Source: *An ambitious roadmap for France,* Arcep, 2018

Operators
▪ Bouygues Telecom ▪ Orange ▪ SFR ▪ Free

Manufacturers
▪ Ericsson ▪ Qualcomm ▪ Huawei ▪ Nokia

3.7.2. French regulation took shape and effect in mid-2017

While auction rules are still being debated, extensive tests are underway, using trial licences

Regulatory backdrop including frequency assignments and processes

- **December 2017**: The regulator Arcep allocated frequencies in the 3,410-3,460 MHz band on demand for use as a very high-speed Internet access service in fixed position.
- **March 2018**: Arcep launched a public consultation on the terms and methods for allocating 2.6GHz TDD band spectrum (2575 - 2615MHz band) to support the transition of professional mobile radio networks to 4G.
- **April 2018**: Arcep opened a public consultation on the terms and methods for reallocating long-standing mobile telephony frequencies in the 900 MHz, 1800 MHz and 2100 MHz bands. It planned to redistribute these bands in June of that year.
- **July 2018**: A public consultation on the 1.5 GHz band was opened, from between 30 July and 30 September, 2018.
- **October 2018**: As described in full above. a public consultation on procedures, sequencing and requirements was opened for between 26 October and December 19, 2018, with inputs from all players and stakeholders. ARCEP was also expected to holding a second consultation on calls to tender, which may be issued in mid-2019.

5G player trials and launches

- **Bouygues** opened an experimental 5G station in the department of Gironde in 2018. In February 2018, Huawei and Bouygues Telecom announced a joint innovation programme to experiment with 5G in France. Bordeaux was to host their first 5G network trial, from single site to multi-site coverage. On July 2018, Arcep issued a temporary licence (Decision No. 2018-178) to Bouygues Telecom for 5G pilots in the cities of Bordeaux, Lyon and Villeurbanne. In January 2019, Bouygues, Qualcomm and Ericsson collaborated to complete a 5G call in real conditions in Lyon.
- **Orange** trialled 5G on 3.5 GHz spectrum for twelve months starting June 2018, in over 30 French cities including Lille and Douai. Orange had already started installing its equipment at 30 sites in Lille and 48 sites at Douai in the 3600-3700 MHz frequency band. The operator announced seven new 5G sites for pilot tests on the 3.5 frequency band: six were deployed in the Bouches-du-Rhône department on the southern Rhône delta, and one is in the Hauts-de-Seine department just west of Paris. In February 2018, Orange conducted a technical 5G test in the cities of Lille and Douai, using Ericsson network equipment. The trial ran from mid-2018 until mid-2019, after the necessary authorisations from Arcep. In February 2019, privacy issues on Huawei's 5G equipment led Orange to run tests with Samsung equipment in Saint-Ouen, to prepare for the eventuality that the Chinese vendor is banned from France.
- **SFR** - On July 2018 SFR announced its 5G trials on the cities of Toulouse and Nantes.

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.7.3. France is trialling 5G in major cities, with the aim of deploying 5G in vertical industries

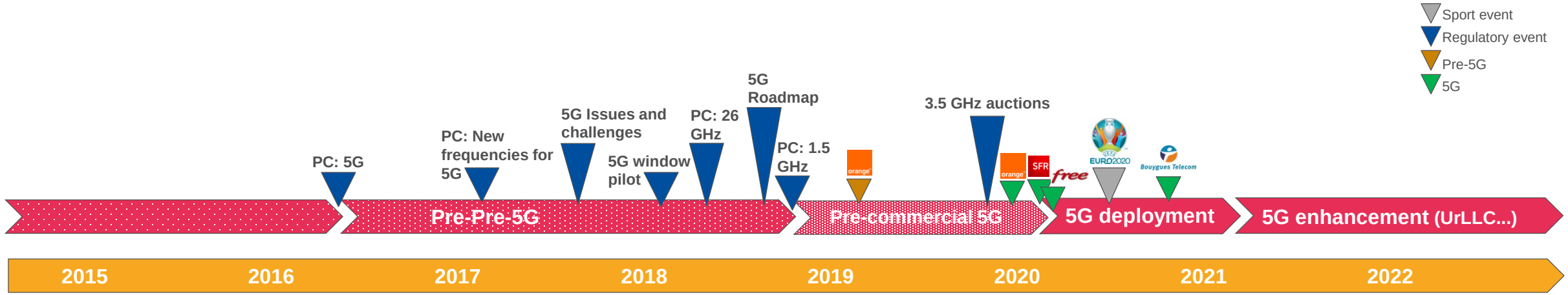
Applications and coverage

Main vertical targets	The plan is to use 5G for consumer services with specific targets on: ▪ Media and Entertainment ▪ Automotive and Transport, Industry 4.0 ▪ Construction ▪ Logistics ▪ Agriculture ▪ Smart Office
Service coverage and maturity	▪ All operators combined: Paris, Marseille, Bordeaux, Toulouse, Nantes, Grenoble, Douai, Le Havre, Gironde, Saint-Etienne, Lille, Montpellier and Lyon – Orange is deploying mainly in Lille, Marseille, Nantes and Paris – Bouygues is deploying mainly in Gironde, Bordeaux and Lyon – SFR is deploying mainly in Toulouse and Nantes ▪ In August 2018, ARCEP has included a new set of coverage obligations in operator authorisations, thus making the commitments of mobile operators for the period 2018-2021 binding and enforceable. They aim to generalise 4G, improve coverage of transport routes and cover 5,000 new areas for each operator. ARCEP included a 2G / 3G and 4G coverage obligation over 1800 MHz frequencies by the end of 2020. They cover priority roads (highways, roads between departmental and district administrative centres and road sections with more than 5,000 vehicles daily, and indoors by 2022 or 2024. On the regional rail networks known as TER and Transilien, the operators using frequencies of 1800 MHz must cover 90% by the end of 2025, and provide Wifi within all train carriages and rolling stock. ▪ The 5G coverage obligations are not yet issued at the national level, but at the EU level, each country is required to select a '5G city' by 2020 (H2020 objectives).

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.7.4. France is aiming at 5G launch in 2020

Timelines



Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

KEY DATES FOR 5G IN FRANCE

2018
Trial and pilots: identifying use cases, and collecting data on exposure

2019
Progressive freeing up of frequency bands
First compatible devices available for sale

2020
Frequency allocation and definition of obligations attached to licences
Commercial deployment of 5G in at least one major city

2025
Coverage of main transport trunk routes

Source: *An ambitious roadmap for France,* Arcep, 2018

3.8. Germany

3.8.1. Germany was an early mover on 5G

Key Facts

The Bundesnetzagentur regulatory agency ('BNetzA') published its 'Frequency Kompass' in July 2016 with the intent to identify areas for regulatory action on spectrum for 5G. More detailed 'Points of Orientation' were published later in December 2016.

- **5G Initiative for Germany**

The Federal Government launched its '5G Initiative for Germany' in the autumn of 2016. In a paper of September 2017, the Government describes the national 5G strategy (context, actions, rollouts) up to 2025. It defines five key actions, milestones and allocates 80 million EUR to 5G research initiatives in 5G research centres. The tasks are to:

  - Step up the network rollout
  - Make available frequencies based on demand
  - Promote cooperation between telecommunications and user industries
  - Targeted and coordinated research
  - Initiate 5G for towns and cities

- **5G BERLIN** is an innovation cluster for testing technologies and driving new 5G applications. The initiative started in early 2018 with the opening of a 5G test field and 5G centre serving as a networking platform for start-ups, SMEs, research institutes, large companies and public authorities.
- **3.4-3.7 GHz auction ended in June 2019, raising 6.55 billion EUR**
- **Commercial launch is expected for 2020**

Unedr the German National 5G Plan, all 5G requirements will have been implemented by March 2020.

Frequency (MHz)	Auction revenues (million EUR)
700	1,000
850	3,576
900	1,355
1800	3,296
2100	2,405
2600	359
3500	344
Total	**46 039**

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

Operators

- Deutsche Telekom
- O2 Telefónica Germany
- Vodafone Germany

Manufacturers

- Ceragon
- Ericsson
- Intel
- Huawei
- Samsung
- Nokia

3.8.2. The German 5G framework started its march to much fanfare

Germany was first to assign 700 MHz frequencies, with game-changing auctions and coverage obligations

Regulatory backdrop including frequency assignments and processes

- 700 MHz frequencies were assigned in June 2015
- The '5G initiative for Germany' roadmap was published late in 2016, the Frequency Kompass also in 2016
- 5G spectrum roadmap in 2018
  - January 2018: draft decision for the allocation of 5G-suitable frequencies. (2×60MHz of paired spectrum in the 1920MHz-1980MHz/2110MHz-2170MHz range will be auctioned off for nationwide use alongside 300MHz of unpaired spectrum in the 3400MHz-3700MHz range).
  - November 2018: detailed conditions for its upcoming 5G spectrum sale, planned to take place early in 2019. The coverage obligations for the 2100 MHz and 3.6GHz licence winners include a requirement to supply speeds of a minimum of 100Mbps to at least 98% of households in each state by the end of 2022. By the end of 2024, operators should ensure speeds of 100Mbps on main roads, while covering the smaller roads with data rates of at least 50Mbps. Furthermore, each operator will have to set up 1,000 5G base stations by the end of 2022, in addition to 500 base stations in unserved rural areas.
- February 2019: ongoing auction of 5G spectrum with bids from Deutsche Telekom, Vodafone and Telefónica Germany (O2) and United Internet (1&1). Strong coverage obligations, especially coverage in rural areas and along motorways, and mandated network sharing with competitors (aka 'domestic roaming'). In May 2019, the ongoing 5G auction passed the 6 billion EUR mark, beating all expectations.

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.8.3. Germany launched trials early in 2017

A whole ecosystem has been put in place, involving many stakeholders and R&D

5G player trials and launches

- In February 2017, **Deutsche Telekom**, Ericsson and SK Telecom established an intercontinental 5G trial network. Trials have demonstrated end-user experiences with 5G roaming, and DT and SK Telecom network slices are now available in the other operator's footprint, connecting Germany and South Korea. In October 2017, Deutsche Telekom and Huawei announced the implementation of 5G antennas in Berlin. Using pre-standard 5G NR, companies achieved a 'live 5G connection in a real-world setting', delivering DL throughputs of up to 2 Gbps to a single user device, as well as a 3 ms latency. DT is using spectrum in the 3.7GHz frequency range coupled with Huawei equipment for its implementation in Berlin. In January 2018, Deutsche Telekom, Intel and Huawei collaborated to achieve 5G interoperability and development testing based on the 3GPP R15 Standard using Huawei's 5G commercial base station and Intel's third generation 5G NR Mobile Trial Platform (MTP), while it also incorporates Massive MIMO multi-antenna and beamforming technology enabled by the standard framework. In February 2018, DT announced it was constructing a 5G test bed for smart energy grid management in Dresden in partnership with the city administration and the Dresden University of Technology. Their aim is to support the decentralized distribution of energy with a real-time, secure 5G communications system, said Telekom. The first tests of smart energy systems were to begin with LTE that year before the project expanded to include 5G. In May 2018, the first six commercial antennas were installed for test operations in downtown Berlin and Schoenberg districts, an area 5 km wide described as a '5G cluster' in Berlin. The antennas use 3.7 GHz trial frequencies, and the operator's pre-commercial set-up enables interaction between 5G equipment and the company's 4G spectrum. Deutsche Telekom plans to install another 70 cells by the summer 2019 across more than 20 sites.
- In 2017, **Telefónica O_2** ran a 3.5 GHz LTE TDD Massive MIMO outfield trial, running 16 terminals simultaneously over 20MHz spectrum on the 3.5 GHz band with a peak DL rate of 650 Mbps on their sub network in Munich. In September 2018, Telefónica and Samsung agreed on 20 FWA trials in Germany. About 20 households in Hamburg tested 5G from November to February. In October 2018, Telefónica Deutschland announced a trial for 26 GHz FWA in Hamburg with Samsung equipment.
- In 2016, **Vodafone** and Huawei performed 5G tests in low and high bands to test mobility in dense urban city scenarios. Using the C-band, 1.5 km cell coverage was demonstrated as well as a 5Gbps throughput for a single user. In November 2018, Vodafone deployed its first 5G mast in the city of Aldenhoven, covering 400,000 square metres. A holographic phone call was performed.

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.8.4. Germany set ambitious coverage obligations for 5G services in 3.5 GHz spectrum

5G R&D centres and innovation clusters countrywide

Main vertical targets

The *plan* is to use 5G services with specific targets on:

- E-Health
- Future Media (or Media and Entertainment)
- Intelligent Mobility
- Industry 4.0
- Smart grids
- Smart Farming
- The '5GBerlin' innovation cluster to drive new applications

Figure 9 – 5G research centres in Germany (selection)
Source: Federal Government

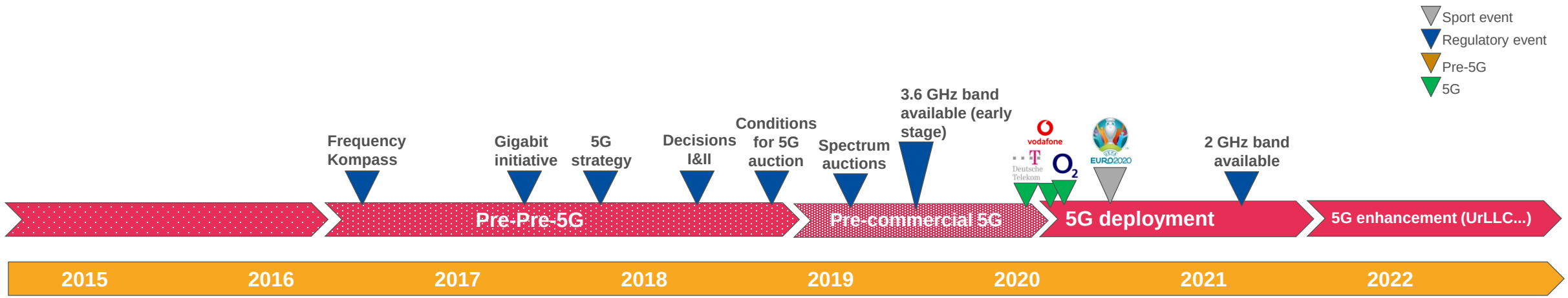
Service coverage and maturity

- Germany made rural coverage a priority in licence assignments and set a coverage target of 98% of households in each Land (state) by the end of 2022 for the upcoming 5G spectrum auction. However, Telefónica is still running behind its 4G coverage target. DT also plans to provide fibre-optic connections to about 5,000 mobile sites and is now deploying 5G in three main cities: with Berlin and Hamburg, Darmstadt is becoming a prime Germany 5G trial location.
- Mobile operators have to work together to provide coverage in economically less-viable regions.
- Germany has reserved the 3700-3800 MHz band for local usage in the country's upcoming 5G auction. On 17 September 2018, BNetzA published its consulting paper for the auction. Successful bidders are not required to provide nationwide 5G coverage, but they need, however, to provide coverage for 98% of the households as well as federal and state motorways, with 100Mbits/s speed by the end of 2022 and 300Mbits/s by the end of 2025.
- The MNO-specific coverage obligation states that within three years of spectrum allocation, any frequency band must provide 50 Mbit/s download speeds per antenna sector so that 10 Mbit/s download speed is reached for at least 98% of nationwide households, at least 97% of the households within every federal state, and on all main traffic routes.

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.8.5. Germany is aiming at 5G launch in 2020

Timeline



Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

2016	2017	2018	2019	2020
▪ First test beds with 5G relevance ▪ Working group of the Federal Government and the Federal states to implement the DigiNetzG ▪ Start of 5G Dialogue Forum	▪ Start of consultations on making 5G frequencies available ▪ Start of 5G competition	▪ Evolution of the support framework with regard to gigabit networks ▪ Procedure for making frequencies available	▪ Evaluation and, if necessary, evolution of the 5G Strategy	5G Rollout

Milestones of the 5G Strategy for Germany (as at June 2017)

Source: Federal Government

3.9. Italy

3.9.1. Starting behind EU counterparts, Italy took lead on 26 GHz frequencies

Key Facts

- The Italian 5G strategy started in late 2016 when the domestic NRA regulator announced the start of a fact-finding survey for the development of mobile and wireless systems towards 5G and the utilisation of the spectrum above 6GHz.
- The Italian strategy for 5G networks aims to develop a high-speed access network enabling service above 100 Mbs, and ensuring a minimum of 30 Mbs for all by 2020.
- In March 2017, the Government selected five 5G trial cities, including Milan (Vodafone), Prato (Wind Tre-Open Fiber), L'Aquila (Wind Tre-Open Fiber), Bari and Matera (Telecom Italia-Fastweb-Huawei Technologies). They will use 100 MHz of 3.6-3.8 GHz spectrum. Provisional licences are valid from September 2017 to 2020.
- At year-end 2017, the "*Bari-Matera plan*" involving MNOs, cities, research centres and equipment vendors was unveiled and began. With 60 million EUR over four years (2018-2021), the plan brings together 55 partners including seven universities and research centres, public interest communities, vertical leaders, start-ups and telecom players (TIM, Fastweb, Huawei). The plan focuses on ten application areas including media/virtual reality, smart port, smart city, smart agriculture, public safety, industry 4.0, health 5.0, road safety, tourism and culture, and environmental monitoring over 70 use cases.
- Italy was first to auction 26 GHz frequencies in October 2018.

Frequency (MHz)	Auction revenues (million EUR)
700	2,040
800	440
1452-1492	462
1800	477
2100	456
2600	506
3500	4,300
26 GHz	167
Total	**8,848**

Operators

- TIM
- Fastweb
- Vodafone
- Wind Tre

Manufacturers

- Altiostar
- Ericsson
- Huawei
- Open Fiber
- Nokia
- Qualcomm
- ZTE

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.9.2. Italy is ahead in spectrum assignment

First EU country to auction 26 GHz frequencies

Regulatory backdrop including frequency assignments and processes

- ‘5G for Italy 2016’ is the 5G strategy elaborated by TIM around identified cities and application areas.
- November 2016: The 700 MHz band will start being released in 2019 with the process due for completion by the end of 2022.
- December 2016: start of a fact-finding survey for the development of mobile and wireless systems towards 5G and the utilisation of the spectrum above 6GHz.
- March 2017: Selection of five cities to organize 5G trials, namely Milan, Prato, L'Aquila, Bari and Matera. The Government made spectrum in the 3.4 and 3.8 GHz bands available for these trials.
- October 2018: Spectrum in the 700 MHz (694MHz-790MHz), 3.6GHz-3.8GHz and 26.5GHz-27.5GHz bands was auctioned in September and October 2018. The whole auction ended after 14 days of intense bidding, far above expectations. Total bids reached 6.55 billion EUR, of which 4 billion EUR for the highly-coveted mid-frequencies. The 26.5GHz-27.5GHz spectrum was split into five lots of 200MHz. Licences will be valid until 2037, though the 700MHz frequencies will not be opened up until mid-2022.

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.9.3. Italy has conducted many trials countrywide

Successful trial strategy

5G player trials and launches

- February 2018: **Fastweb** tested 5G antenna in cooperation with Ericsson and the City of Rome for the development of 5G for public transport, public safety and tourism (VR in archaeological sites and museums).
- January 2019: Cagliari was announced to be the sixth Italian city to test 5G (after Milan, Prato, L'Aquila, Bari and Matera) following Government approval for 5G trials in the city by Fastweb in partnership Huawei for the development of IT solutions and services in the areas of health, transport, waste management, logistics, security and Industry 4.0.
- September 2017: **TIM**, Huawei and Fastweb tested 5G in Bari and Matera / TIM announced 5G with Huawei in Bari (port) and Matera (2019 European capital of culture), to develop first use cases mid 2018 (75% of the city coverage obligation in 2017, and full coverage by the end of 2019). February 2018: TIM partnered with Ericsson and industrial automation specialist Comauto to demonstrate a newly-developed cloud robotics platform at the Mobile World Congress, part of their '5G for Italy' initiative launched that year. March 2018: TIM and Ericsson signed a Memorandum of Understanding with the Municipality of Genoa, the Liguria Region and Liguria Digital to launch a 5G Digital Lab to work on 5G technology and IoT use cases for local citizens, businesses and public offices. May 2018: TIM, Huawei and Fastweb demonstrated virtual reality for tourists as well as an augmented reality tool for ship engine maintenance in Bari and Matera, which are the trialled '5G cities' with a budget of 60 million EUR over four years. The 5G network was implemented through the use of 3.7-3.8 GHz frequency bands made available by the Ministry of Economic Development (MISE).
- May 2018: TIM announced its partnership with Nokia and Qualcomm for the activation of 5G network hubs in San Marino where millimetre wave 5G mobile test devices will be experimented using the Snapdragon X50 modem. The demonstration of 5G technology in the 26GHz band confirmed the contract with Nokia for a 5G network rollout in the 3.5GHz and 26GHz bands. December 2018: The first European 5G NR video call was placed in Rome over the TIM 5G network in mmWaves frequency band, powered by the Snapdragon X50 5G modem equipment from Qualcomm Technologies Inc. The network infrastructure was provided by Ericsson.
- Up to 2.7 Gbps was achieved by **Vodafone** and Huawei in the city of Milan, using spectrum in the 3700-3800 MHz and Massive MIMO technology. November 2017: Both partners also completed a test in Milan, on a full end-to-end (E2E) network, of a technique to enhance the range of high-frequency bands (3.7 GHz bands made available by MISE), possibly used for 5G networks. Instead of using a single frequency band to communicate between a smartphone and the network, companies used different frequency bands for DL and UL transmissions. Vodafone demonstrated up to a 10 decibel coverage range improvement in the uplink when using the low band – customers could have a stronger signal even where 5G coverage is limited.
- October 2017: In partnership with Open Fiber, **Wind Tre** launched 5G pre-commercial trials in the city of Prato, Italy using the 3.6-3.8 GHz bands, and focusing mobility, safety, healthcare and smart energy applications.

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.9.4. Italy is holding city trials in many places and programmes

Successful city trial strategy

5G city trials

- **Turin** has been selected as the country first 5G city, with a MoU signed by the city council and Telecom Italia (TIM) for a 5G mobile network. Under the programme, metropolitan trials were to start in 2018, with the aim of covering the entire city by 2020. TIM will install over 100 small cells in key areas around the city, two universities, and with 3,000 users taking part in the trial process. In October 2018, TIM presented demonstrations of a 5G-controlled driverless car, an environmental monitoring use case using drones, a 5G-connected robot for manufacturing and smart city applications powered by Narrowband IoT (NB-IoT).

  The Ministry for Economic Development is investing in 5G experimental trials through a series of government bids. Several such trials started in early 2018 in the cities of Bari and Matera, Prato39, L'Aquila and Milan involving the operators TIM and Vodafone.

- **The 5G Matera-Bari** project will receive 60 million EUR over four years with the involvement of 52 partners. Started in September 2018, the trials use 5G New Radios alongside a TIM LTE network, targeting to upgrade further from mid-2019 to full 5G coverage using the allocated 5G band. The trials focus, as stated, on smart cities, public safety, environmental monitoring, Industry 4.0, smart port, media and VR, transportation and road safety, smart agriculture, health 5.0, tourism and cultural heritage.

- **The ROMA5G** programme focuses on tourist aspects of the city with virtual reality (VR) and augmented reality (AR) applications featuring traffic mobility and public safety in Rome.

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.9.5. Italy is targeting vertical industries in five cities

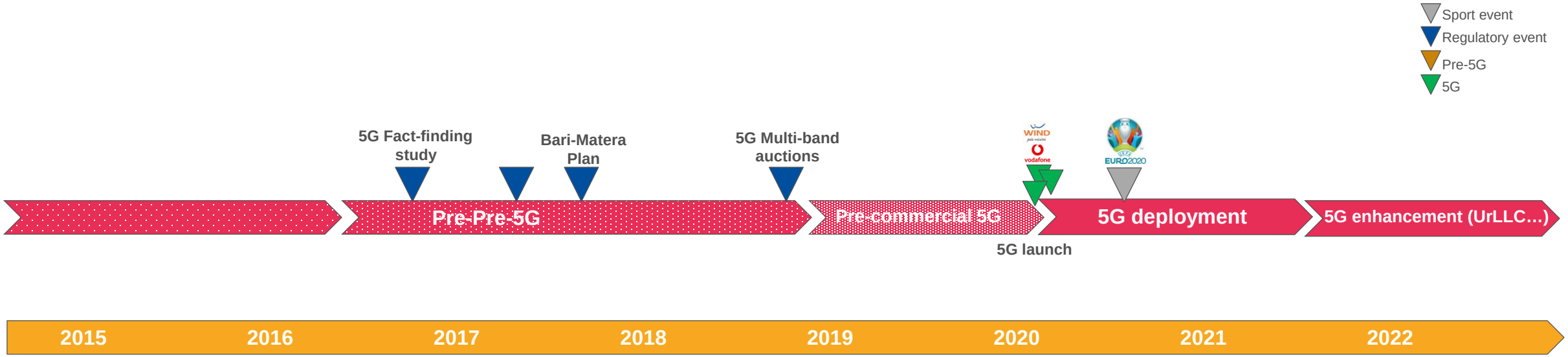
Applications and coverage

Main vertical targets	The 5G Matera-Bari project focuses on smart cities, public safety, environmental monitoring, Industry 4.0, smart port, media and VR, transportation and road safety, smart agriculture, health 5.0, tourism and cultural heritage. The ROMA5G programme focuses on a touristic city with VR/AR applications, traffic mobility and public safety in Rome. In Turin, there have been demonstrations of a 5G-controlled driverless car, an environmental monitoring use case using drones, a 5G-connected robot for manufacturing and smart city applications powered by Narrowband IoT (NB-IoT). The earliest applications planned for 5G will be 3D virtual reconstructions of archaeological sites and museums in Matera, and developed in Matera which is the European Capital of Culture in 2019.
Service coverage and maturity	▪ Italy occupies one of the highest levels of maturity for 5G technologies in Europe. All the same, Italy remains far behind the 5G world leaders of USA, Japan and South Korea) ▪ Covered cities: Cagliari, Milan, Prato, L'Aquila, Bari and Matera ▪ Vodafone is planning to transform Milan into the 5G capital of Europe ▪ Commercial launch is expected in 2020

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.9.6. Italy is targeting 5G launch in 2020 – and prelaunch at YE 2019

Timeline



Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.10 | Spain

3.10.1. Spain started its 5G process in mid 2017

Key Facts

- The 5G process in Spain started in July 2017 when the Government opened a public consultation about the 5G National Plan, dealing with 25 key issues. The *5G National plan 2018-2020* aims at "promoting the development and deployment of 5G technology" via the auction of spectrum in the 1.5GHz and the 3.6GHz bands in early 2018, and at "developing their infrastructure and telecommunications networks with a 5G platform".
- The Government of Spain has allocated just above 1 million EUR to create a national 5G observatory in Barcelona, part of a project designed to boost the candidature of Barcelona as the European capital of 5G technological innovation. The observatory is part of the joint '5GBarcelona' initiative of the regional government of Catalonia with Barcelona City Hall, the Mobile World Capital Barcelona Foundation, the i2CAT Foundation, the CTTC (Centre Technologic de Telecommunication's de Catalunya), Atos and the UPC (Universitat Politecnica de Catalunya).
- The early 5G 3.4-3.6 GHz spectrum assignment process took place in 2016. It is likely to be used for 4G.The 3.6-3.8 GHz auction ended in July 2018 and will be used by 5G networks.

Frequency (MHz)	Auction revenues (million EUR)
800	1,305
900	295
1800	42
2100	460
2600	165
3500	438
Total	**3,420**

Operators
▪ Telefónica
▪ Vodafone
▪ Orange

Manufacturers
▪ Ericsson
▪ Nokia
▪ Huawei
▪ ZTE
▪ Interdigital

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.10.2. The Spanish move to 5G took hold late in 2017

5G spectrum auctions to be scheduled

Regulatory backdrop including frequency assignments and processes

- July 2017: The Spanish Ministry of Energy, Tourism and Digital Agenda (MINETAD) launched a public consultation on 5G technology to release the 700 MHz band for electronic communications.
- December 2017: MINETAD announced plans to 'promote the development and deployment of 5G technology' through the auction of spectrum in the 1452MHz-1492MHz ('1.5GHz') and 3600MHz-3800MHz ('3.6GHz') bands in early 2018.
- February 2018: Launch of the 5G frequency allocation process in the 3.4-3.8 GHz band by the Ministry of Energy, Tourism and the Digital Agenda.
- May 2018: MINETAD launched the 5G auction process for 200MHz of spectrum in the 3.6GHz-3.8GHz band. The spectrum was divided into 40 5MHz blocks, each having a starting price of 2.5 million EUR.
- July 2018: MINECO released 5G spectrum in the 3.6GHz-3.8GHz band for 20 years, generating a total of 437.6 million EUR. Vodafone Spain paid 198.1 million EUR for 18 5MHz blocks. Orange Spain paid 132.1 million EUR for 12 5MHz blocks, while Telefónica (Movistar) offered 107.4 million EUR for the 10 5MHz blocks.
- November 2018: The 700 MHz auction initially scheduled for Spring 2019 was postponed to the early months of 2020.

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.10.3. Spain launched its 5G trials in Q3 2017

Several initiatives are emerging together with the recently created 5G National Observatory (ON5G)

5G player trials and launches

- **October 2017**: Telefónica and ZTE completed the 'first phase' of a 5G transport trial in Madrid, by using ZTE's new '5G Flexhaul' transport solution. They will now be focusing on E2E 5G solutions. November 2017: An open research and innovation lab focusing on 5G technologies was conducted in Madrid (Spain) at 5TONIC. From 2015 to 2017, the 5G-Crosshaul consortium (with InterDigital, Ericsson, Nokia, UC3M, NEC and CND) has developed a novel 5G integrated fronthaul/backhaul transport solution, named 5G-Crosshaul; it enables flexible transport reconfiguration via SDN in a multi-tenant, multi-domain environment. January 2018: Telefónica presented the 5G Technological Cities project, with the initial deployment of 5G capabilities in the cities of Segovia and Talavera de la Reina, in partnership with Nokia and Ericsson. Telefónica announced plans to convert the two cities into 5G living laboratories between 2018 and 2020. February 2018: Telefónica and Huawei completed the world's first proof-of-concept test of 5G-V2X radio for URLLC assisted driving, as well as VR service using 5G end-to-end (E2E) network-slicing technology underpinned by the Telefónica UNICA programme. April 2018: Telefónica presented in Talavera de la Reina, the first 5G use case with an EZ10 autonomous driving electric minibus. The demonstration used the 3.5 GHz band in mobility via an autonomous electric vehicle from the EasyMile company, in which an Ericsson 5G terminal and the CarMedia Solutions platform have been installed, in order to enjoy multimedia content, digital services, and virtual office applications during the journey. July 2018: Telefónica announced its 5G technological cities project: The operator has partnered with the manufacturers Nokia and Ericsson for the initial deployment of 5G capabilities in the cities of Segovia and Talavera de la Reina. Speeds of 12 Gbps to 17 Gbps were reached at street level. The Spanish Government granted temporary permission to use 800 MHz of spectrum in the 28 GHz band for the test.
- **February 2018**: Vodafone Spain partnered with Huawei to perform a 5G call between Castelldefels in Barcelona and Madrid using spectrum in the 3.7GHz band. July 2018: launch of 5G trials announced in the cities of Madrid, Barcelona, Valencia, Bilbao, Málaga and Seville by Vodafone. September 2018: Vodafone with Huawei have installed 5G network nodes at La Nave in Madrid. The network used 3.7 GHz band, enabling download speeds of up to 2.2 Gbps. February 2019: Using Huawei's E2E products and solutions, Vodafone deployed high performance 5G networks in multiple sites across Barcelona city centre (Plaza Catalunya, Paseo de Gracia, Balmes and Universitat) where users could test 5G service using Huawei 5G smartphones. For the demonstration, 80MHz of the C-Band spectrum were used to achieve 1.7Gbs download peak rate with an average of 800Mbps downlink throughput over the covered geographical area. The multiple gNodeBs (5G) provided the same coverage as the eNodeBs (4G LTE).
- **September 2017**: Orange and Ericsson completed testing 5G technology in central Madrid, Spain. Trials reached speeds of up to 17Gbps and latency to under 1 ms. Companies used a 5G base station as well as Multi-User MIMO (MU-MIMO) and beamforming technology. Tests used 800 MHz in the 28 GHz band, which also saw a moving vehicle access a 4K film in real time while driving around Ericsson's offices. February 2018: Orange Spain announced at 5G trials in four Spanish cities in 2019 using the 40MHz of spectrum in the 3.5GHz band. October 2018: Orange Spain announced 5G pilot tests in seven cities until the end of 2019: Barcelona, Seville, Santiago de Compostela, Vigo, Málaga, Valencia and Bilbao, to trial 35 use scenarios of 5G networks applied to connected cars, industrial automation and virtual classrooms.

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.10.4. Spain is targeting vertical industries

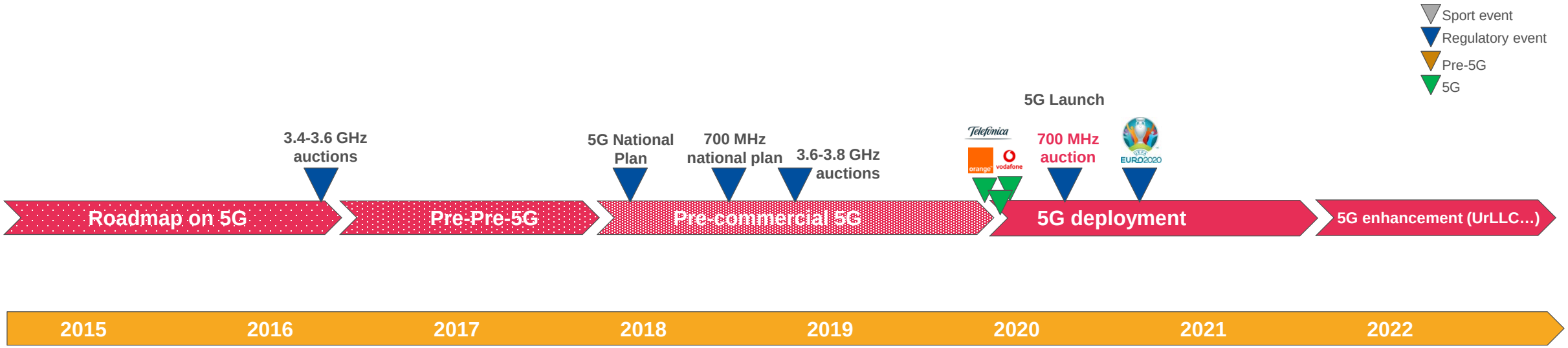
5GBarcelona is a public and neutral initiative at the 5G frontline

Main vertical targets	▪ eHealth, automotive, VR/AR ▪ 5GBarcelona showcased pilots at MWC 2019: – a pilot between Vodafone and Hospital Clinic to demonstrate the first operation with 5G support for remote surgeons – a pilot led by Telefónica and SEAT demonstrated V2X and Intersection Collision Avoidance (ICA) between cars and bikes, and a pilot led by Orange and Nissan to validate impact of 5G in logistics and Industry 4.0 ▪ The focus of the Spanish Regional Catalan Government with its Advanced Digital Technologies Research and Innovation programme is a 'mission-driven' model appropriate to the Government's strategic objectives. – The first 5G challenge consists in adapting a mountain road and an autonomous bus for a 4.5 km journey through a natural park with real-time services and autonomous (self-driving) control. – The second challenge deals with the impact of 5G in non-dense areas. The Government is requesting a set of indicators that analyse 5G technical and commercial viability, together with a new set of political policies in remote areas. It is specifically targeting industrial estate areas and small remote towns.
Service coverage and maturity	▪ Seven cities covered by Vodafone including Madrid, Barcelona, Sevilla, Valencia, Bilbao and Málaga by June 2018. ▪ 5G network in La Nave, Madrid (Sep, 2018).

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.10.5. Spain is targeting its 5G launch in 2020

Timeline



Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.11 | United Kingdom

3.11.1. A fast mover towards 5G, UK planning prelaunch by YE 2019

Key Facts

- 5G was initiated in 2016 when the British Government announced its National Productivity Investment Fund (NPIF) worth total of 23 billion GBP, of which 740 million GBP funded by the Government aiming at 5G trials and full fibre deployment across the UK by 2020-2021. Projects must complete all grant-funded activities by 31 March 2019.
- In July 2018, Ofcom decided to change the authorisation approach for fixed wireless systems in the 64-66 GHz band to be 'license exempt' and to implement common technical conditions across the 57-71 GHz band for short-range wideband data transmission systems and fixed wireless systems.
- In November 2018, the UK Government published the "*National Infrastructure and Construction Pipeline*" *report* for 2018, an overview of public/private investments for 5G and full fibre (FTTP) between 2018/19 and 2020/21 (financial years). 6.85 billion GBP should be devoted to full fibre and 5G upgrades by 2021.
- Funding is allocated for a 5G Testbeds and Trials Programme, an Urban Connected Communities Project and for testing the security of 5G networks to build and test capabilities in collaboration with the National Cyber Security Centre (NCSC).
- Commercial launch is planned in 2020, with a pre-commercial 5G starting by the end of 2019. Spectrum bands that are the most likely to be used are 26 GHz and 3.5 GHz. Ofcom has set out a 5G UK work plan for 2019/20. It provides details on their priority work areas and work plan. Since publishing the proposed Plan, they added several projects following regulatory announcements.

Frequency (MHz)	Auction revenues (million EUR)
800	1,825
2100	36,913
2300	235
2600	963
3400	1,329
Total	**41,265**

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

Operators

- Three
- EE
- Vodafone
- Arquiva
- Telefónica

Manufacturers

- Ericsson
- Huawei
- Samsung
- Nokia
- Qualcomm

3.11.2. UK first to auction 5G spectrum in EU

Regulatory framework

Regulatory backdrop including frequency assignments and processes

- 5G strategy for the UK, 2016
- March 2017: spectrum strategy for 5G and proposed several frequency bands that could become available and suitable for 5G technology:
  - 700 MHz (from 694 MHz to 790 MHz which are being relocated, 2018/19)
  - 3.4 GHz (150 MHz of spectrum from 3.4 to 3.6 GHz): they were expected to be auctioned by Ofcom during 2017.
  - 3.6 GHz - 3.8 GHz (3605-3689 MHz currently assigned to electronic communications services and licensed to UK Broadband)
  - 24.25 GHz - 27.5 GHz: being looked at across Europe as a harmonised band for future 5G technologies (but other public sector users in 26.5-27.5 GHz).
  - Above 30 GHz: Ofcom particularly notes the potential of 32 GHz, 40 GHz and 66 GHz bands, and sees the first two as longer-term prospects.
- July 2017: Rules for the 2.3 GHz and 3.4 GHz spectrum auction: 40 MHz in the 2.3 GHz band (2350-2390 MHz) for mobile broadband services, 150 MHz in the 3.4 GHz band (3410-3480 MHz/3500-3580 MHz). Two spectrum caps apply: a cap of 255 MHz on the 'immediately useable' spectrum for any operator, an additional cap of 340 MHz on the 'overall amount' of spectrum an operator can hold after the auction process. The latter spectrum cap amounts to 37% of all the mobile spectrum useable by 2020, including the 700 MHz band.
- April 2018: Auction of 2.3 and 3.4 GHz spectrum (3 UK: 151 million GBP for 20 MHz of 3.4 GHz spectrum; EE: 303 million GBP for 40 MHz of 3.4 GHz; O2: 378 million GBP for 40 MHz of 2.3 GHz spectrum and 40 MHz of 3.4 GHz spectrum; Vodafone: 378 million GBP for 50 MHz of 3.4 GHz)
- December 2018: consultation on annual licence fees charged to UK Broadband for its spectrum licences in the 3.4 GHz and 3.6 GHz bands. It also issued a consultation on its Annual Plan for 2019/2020. It includes information about its plans to auction the 700 MHz and 3.6 – 3.8 GHz bands.

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.11.3. Fast regulation led to a coordinated initiative

The 5G Testbed and Trials Initiative

5G player trials and launches

- Funding is allocated for a 5G Testbeds and Trials Programme, an Urban Connected Communities Project and for testing the security of 5G networks to build and test capabilities in collaboration with the National Cyber Security Centre (NCSC), as detailed above.
- The 5G Testbeds and Trials Initiative, April 2018-March 2019
- The scheme includes 5G RuralFirst: Rural Coverage and Dynamic Spectrum Access Testbed and Trial (Orkney, Shropshire and Somerset), 5G Smart Tourism (Bath and Bristol), Worcestershire 5G Consortium Testbed and Trials (e.g. Worcester, Kidderminster), Liverpool 5G Testbed, AutoAir: 5G Testbed for Connected and Autonomous Vehicles (Millbrook), 5G Rural Integrated Testbed (Cumbria, Northumberland, North Yorkshire, Inverness-shire, Perthshire and Monmouthshire).
- Funding has also been awarded to the West Midlands Combined Authority, as featured in the Government's bid winner announcement in September 2018, to create the UK first multi-city 5G test bed with trials of new high-speed connectivity with hubs in Birmingham, Coventry and Wolverhampton.
- Funding from the National Productivity Investment Fund (NPIF) will be used to upgrade the Network Rail test track in Melton Mowbray and for the installation of trackside infrastructure along part of the Trans Pennine route with the rollout of full-fibre and, to a lesser extent, 5G networks.

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.11.4. Fast regulation led to numerous 5G trials

Private trials

5G player trials and launches

- In 2016, a **BT/Huawei** partnership set out to explore various aspects of 5G, including network architecture, interface between devices and base stations, network slicing, M2M communications in IoT applications, and security technologies. The agreement on 5G technologies with Nokia was to work on potential customer use cases for 5G technologies, the creation of 5G trials and the development of the emerging technology. In November 2017, EE/Huawei demonstrated data speeds of up to 2.8 Gbps using a 5G end-to-end test network in its UK mobile lab. Tests used 100 MHz of 3.5 GHz spectrum and linked a virtualised 5G network with a 64*64 Massive MIMO antenna. In June 2018, BT has announced its plan to launch a live trial of 5G services in 2018 in 10 sites around the East London tech hub. This will enable the use of prototype 5G devices in five small businesses and five homes. In November 2018, EE opened nine additional sites in busy areas of East London for 5G trials. The tests aimed at evaluating customer experience with businesses and consumers in the areas selected.
- In 2016, 20 Gbps DL throughputs were demonstrated by **Vodafone UK/Huawei** using the E band (70-80 GHz) outdoors. This throughput leverages a single user MIMO solution using multipath to augment throughputs. Another test with a multi-user MIMO solution provided 10 Gbps on a longer range. Vodafone has also started trialling vehicle-to-vehicle communications (LTE-V2X) in the UK. LTE-V2X enables cars to chat with each other to improve road safety and efficiency. In February 2017, Vodafone, Ericsson and Qualcomm collaborated on a 5G New Radio (NR). The trial focused on 5G NR technologies that used wide bandwidths in order to increase overall network capacity and achieved multi-Gbps data rates. Vodafone UK and Ericsson, in partnership with academics at King's College London successfully tested standalone pre-standard 5G using a prototype device in a central London 3.5 GHz spectrum field trial. The trial also showcased advanced 5G technologies including Massive MIMO, beamforming, multi-user MIMO and beam tracking.
- In June 2018, Vodafone tested 5G in seven British cities. Deployments started in 2019 in dense urban areas. The groundwork for 5G services already deployed at 40 locations (around Birmingham, Bristol, Cardiff, Glasgow, Liverpool, London and Manchester) is complementary to 4G networks .
- In December 2018, **Telefónica/Huawei** announced 5G trials at over 200 sites in London.
- On 30 May, 2019, EE launched its 5G home/mobile service in six UK cities

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.11.5. The UK aims to cover major cities

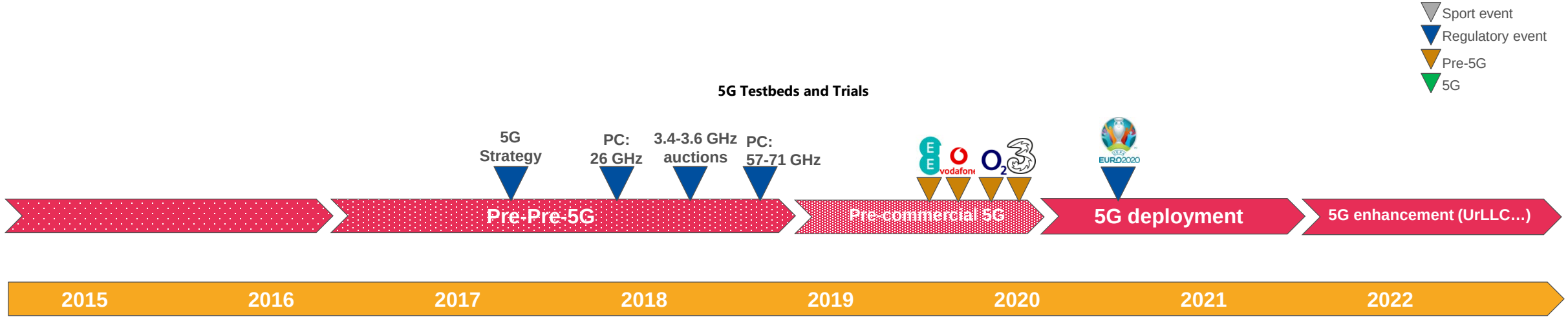
>16 cities

Main vertical targets	The UK 5G Programme includes automotive, industry (factories and process automation; construction; farming and agriculture), health, public safety, tourism, transport and logistics.
Service coverage and maturity	▪ EE launched its 5G home and mobile service on 30 May, 2019 in six UK cities. 10 additional cities will follow by YE 2019, meeting the initial target of 16 cities covered by that time. ▪ In January 2019, Vodafone UK signed a network sharing partnership with Telefónica UK to enable faster and cheaper deployment of 5G. Both companies look to step up competition with market leader BT. They will cover 2,500 sites representing 15% of total sites outside of capital London. Vodafone is expected to launch 5G in June 2019. ▪ 3 UK aims to have 5G available in 2019, although the speed and scale of the rollout have not been disclosed. ▪ In Q4 2018, O2 and Vodafone expanded an existing UK network-sharing partnership to include 5G, to speed up deployment and lower the cost of rollout. ▪ Ofcom has detailed plans for spectrum licence obligations and spectrum sharing in a bid to address the ongoing issue of poor mobile coverage in rural areas. The 2018 coverage obligations in the award of the 700 MHz spectrum band require that successful bidders cover 92% in England, 92% in Northern Ireland, 83% in Wales and 76% in Scotland.

Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

3.11.6. EE was first to be launched in the UK on 30 May, 2019

Vodafone is expected to follow in June 2019



Source: IDATE DigiWorld, *5G deployments and rollouts*, June 2019

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