



Extensive coverage for 5G – global regulatory best practice to maximise 5G’s socio-economic impact



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Executive summary: Extensive 5G coverage will require NRAs to consider sensible ways to incentivise MNOs to realise the potential of 5G



Worldwide deployment: 57 operators in 33 countries across all major regions have commercial 5G offerings by January 2020



Digital experience and transformation: 5G deployment promises to improve consumers' digital experience and facilitate digital transformation efforts for various industry verticals



Balancing act: Extensive 5G coverage will be required to realise the benefits promised by 5G but this objective of policy makers may be hard to align with mobile network operators' (MNOs') commercial goals



Challenges ahead: MNOs' 5G deployments face a number of challenges that impact their ability to offer extensive 5G coverage, including uncertain business cases



Rich toolkit: National regulatory authorities (NRAs) can tap into a combination of measures to incentivise MNOs to achieve extensive 5G coverage



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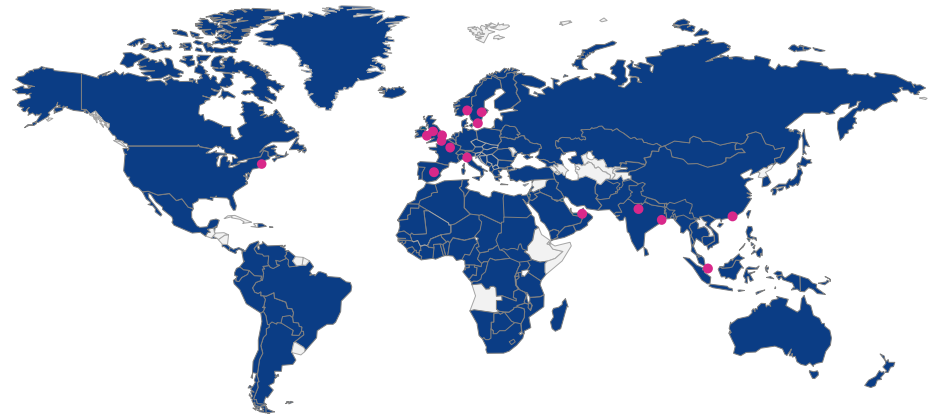
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Analysys Mason has been advising telecoms stakeholders on strategic issues for 35 years with both a global and local perspective

- Analysys Mason is a trusted adviser on telecoms, media and technology. We work with our clients, including operators, regulators and end users, to:
 - design winning strategies that deliver measurable results
 - make informed decisions based on market intelligence and analytical rigour
 - develop innovative propositions to gain competitive advantage
 - implement operational solutions to improve business efficiency
- With around 330 staff in 17 offices worldwide, we are respected internationally for our exceptional quality of work, independence and flexibility in responding to client needs
- For 35 years we have been helping clients in more than 110 countries to maximise their opportunities

Assignments completed



Offices located in Europe, the Middle East,
Asia and the Americas

We have conducted a study on measures available to national regulatory authorities to incentivise MNOs to accelerate 5G network roll-outs

Context

- Mobile network operators (MNOs) have been progressively introducing commercial 5G worldwide.
- 5G is considered equivalent to wireline technologies in access speeds, enabling broadband to all citizens and bridging digital divides.
- Extensive coverage with full 5G capability is considered one of the critical success factors to achieve the full benefits of 5G.
- Several challenges need to be overcome to accelerate MNOs' 5G deployment, including spectrum availability, uncertainties around the business case and high deployment costs.

Methodology

- Analysys Mason has conducted a study to identify the key ways that national regulatory authorities (NRAs) can incentivise MNOs to accelerate 5G network roll-outs to deliver the extensive coverage needed to fulfil the potential promised by 5G use cases.
- Analysys Mason has conducted this study through extensive desk research, combining

A review of documents published by NRAs and international associations, i.e. GSMA

Ad-hoc discussions and interviews with industry stakeholders on 5G coverage and relevant policies

A review of in-house materials

This study was commissioned by a mobile industry stakeholder.

Coverage definitions: the variety of roles 5G is expected to play have led to different types of coverage obligations

Country examples

Geographical/population/
household coverage



- **Germany:** Existing operators are required to provide coverage to 98% of households by 2022

Rural area coverage



- **France:** ARCEP will require 20–25% of 3.4–3.6GHz sites to be deployed in sparsely populated areas (i.e. >2400 sites)

New site coverage



- **UK:** Ofcom will require a minimum of 500 new wide-area macro sites for 700MHz and 3.6–3.8GHz bands

Speed thresholds



- **France:** ARCEP has defined the minimum speed required at each 5G cell site to be at least 240Mbit/s by 2025

Signal strength

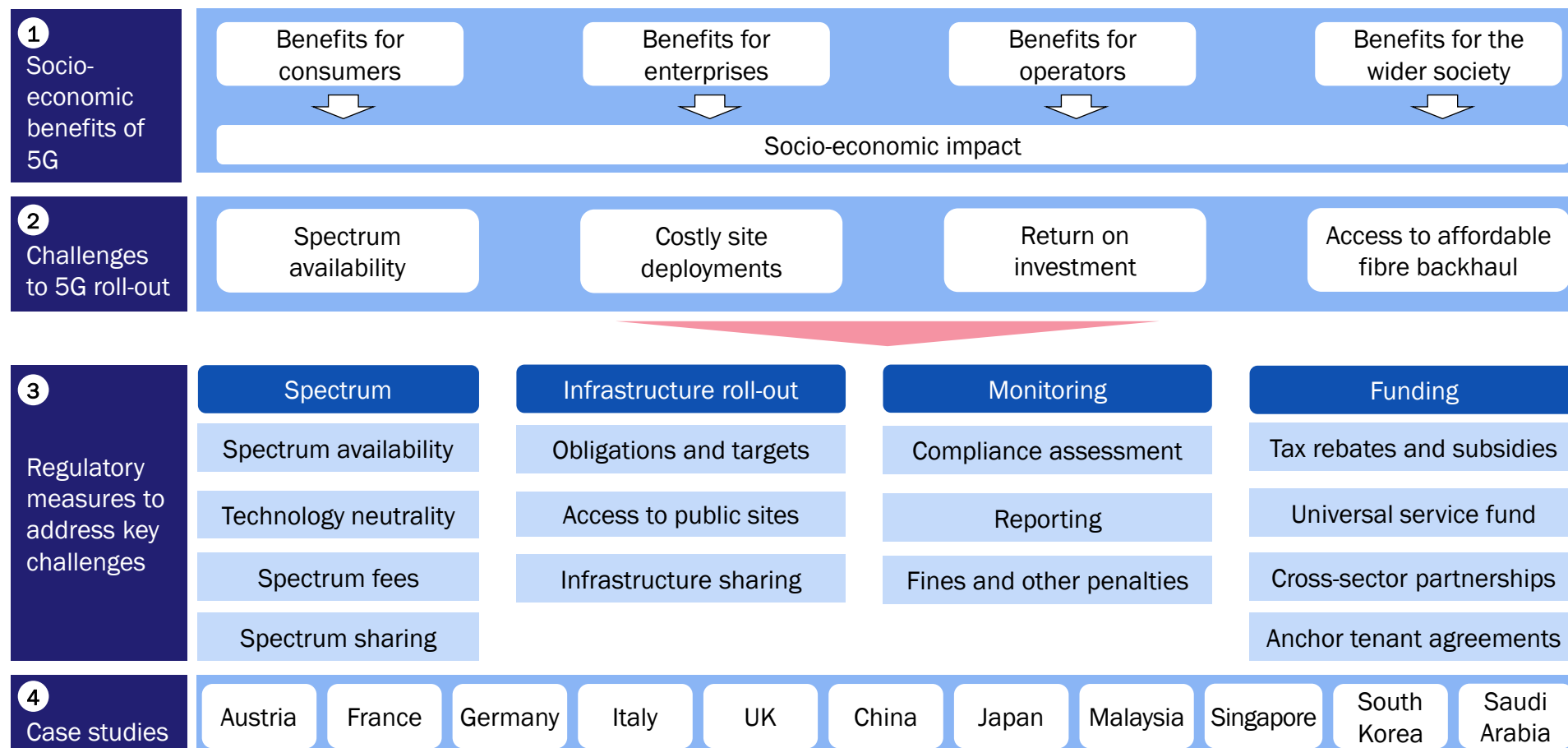


- **UK:** Ofcom has a downlink RSRP* threshold requirement of -105dBm underlying its coverage definition

*: Reference Signal Received Power, the average received power of the downlink reference signal in one radio frame

Sources: NRA websites, Analysys Mason

Structure of the report: the report is arranged into four main sections





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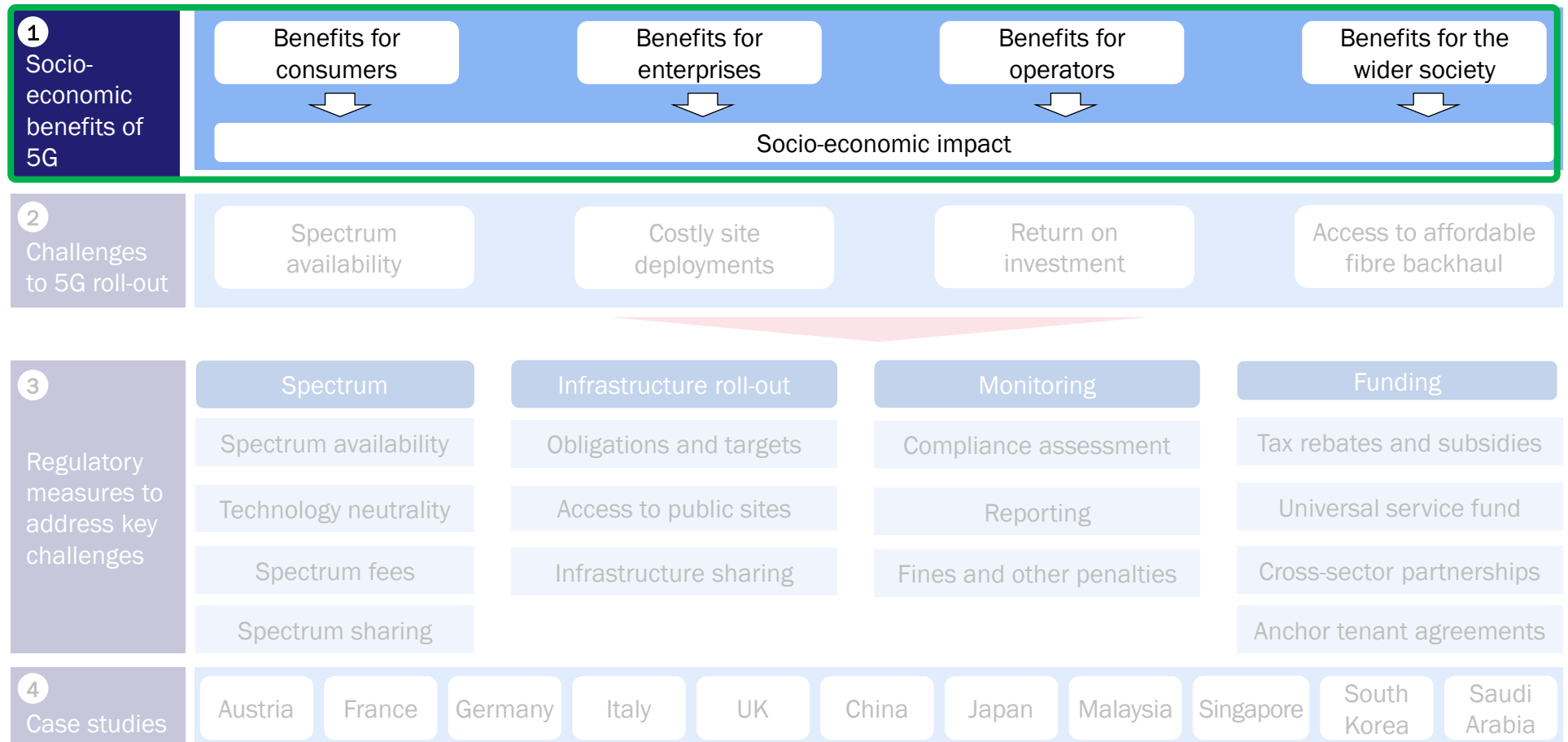
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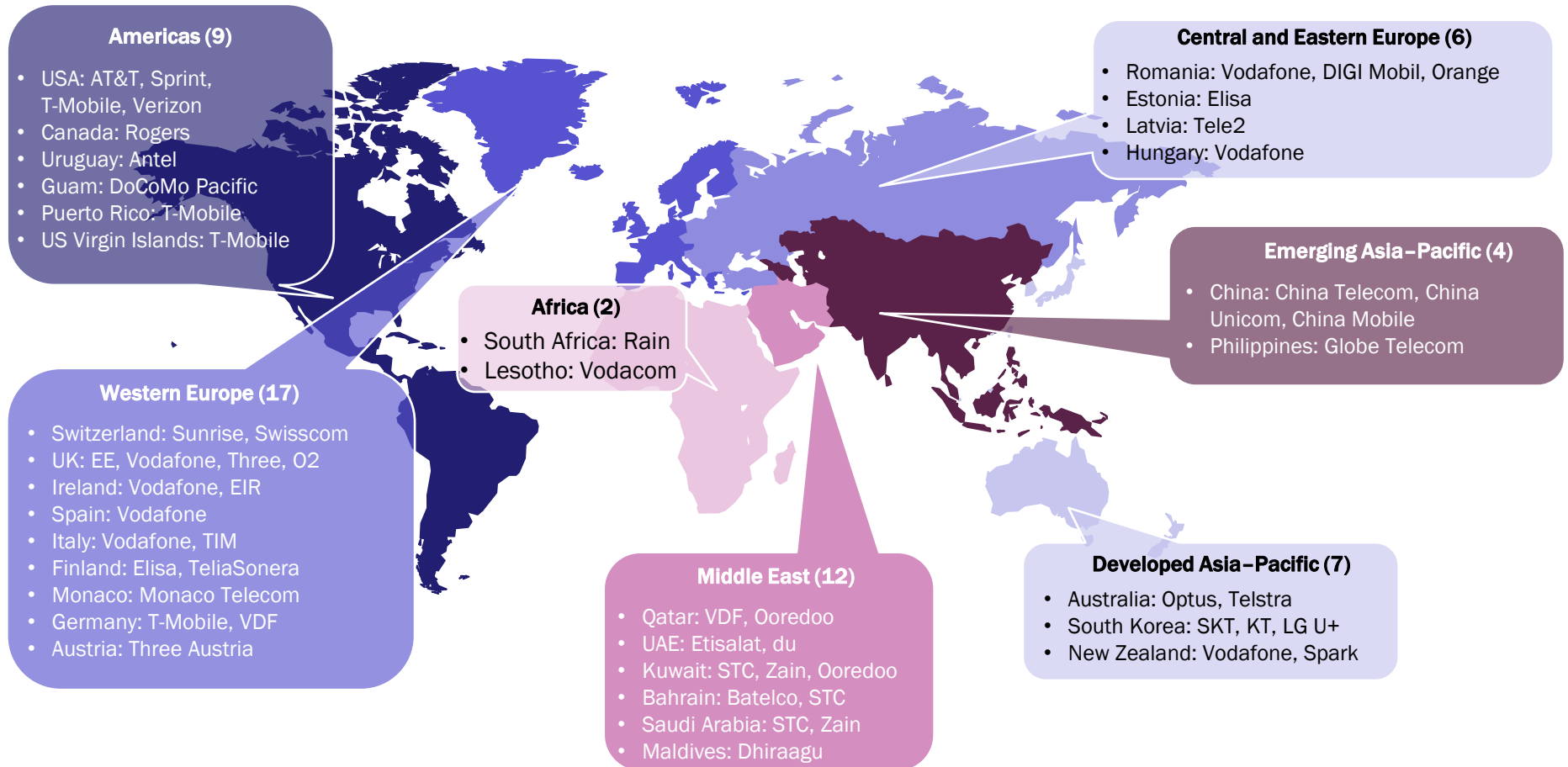
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This section discusses the main economic and societal benefits that 5G is expected to enable

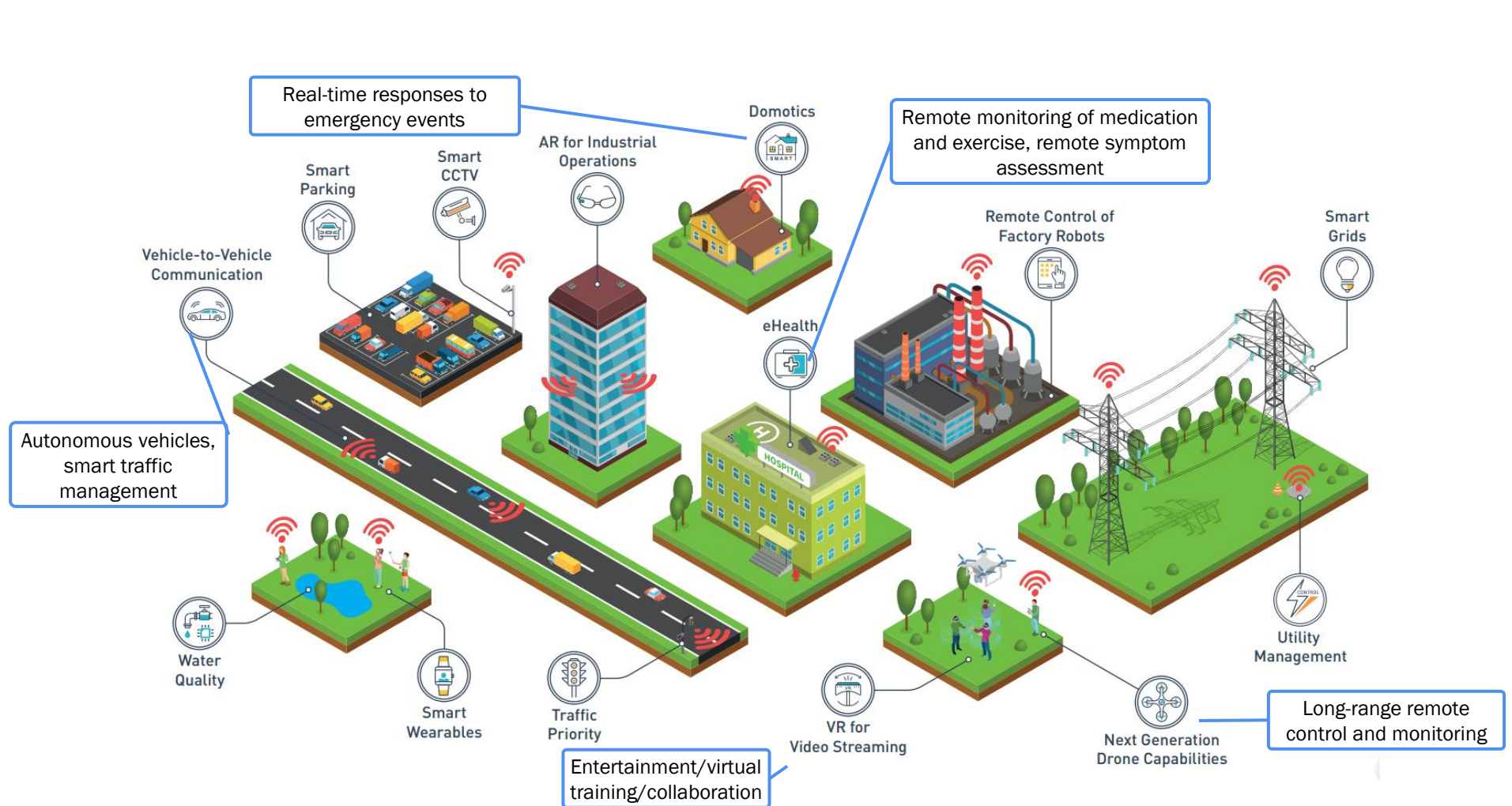


Status update of 5G deployment: commercial 5G offerings are available across 57 operators in 33 countries















Source: GSA

Benefits for consumers: 5G may improve consumers' experience of existing digital services and will support a range of new services



Source: Analysys Mason

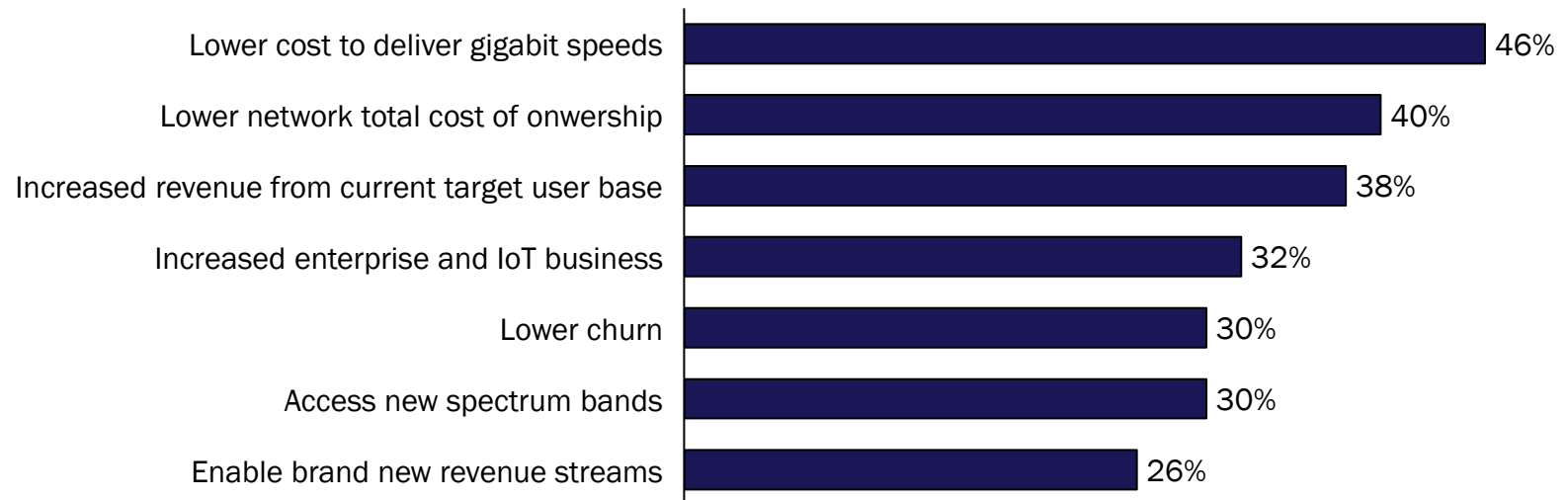
Benefits for enterprises: 5G may accelerate the digital transformation efforts of enterprises in various verticals

Transportation		<ul style="list-style-type: none"> 5G data from smart vehicles will increase public transport efficiency, address complex traffic situations and decrease congestion 		<ul style="list-style-type: none"> Optimised transport routes/improved commutes Reduced pollution Decreased fatalities
Healthcare		<ul style="list-style-type: none"> 5G will enable virtual training, remote co-operation and remote diagnostic services, plus better-connected healthcare devices 		<ul style="list-style-type: none"> Improved healthcare quality and access Lower healthcare costs More wearable sensors and devices
Education		<ul style="list-style-type: none"> VR and AR will allow remote access to high-quality learning, especially for activities that require fine manual skills (e.g. surgery) 		<ul style="list-style-type: none"> Improved access and availability Improved quality (due to real-time feedback during training)
Public safety		<ul style="list-style-type: none"> 5G networks can be used to deliver mission-critical communications, as well as enabling connected ambulances and drones 		<ul style="list-style-type: none"> Faster, more efficient emergency responses Increased safety Better remote monitoring of developing events
Industry		<ul style="list-style-type: none"> Smart factories will be enabled, improving operational efficiency and quality assurance, while remote control will minimise danger 		<ul style="list-style-type: none"> More efficient production processes Increased safety
Agriculture		<ul style="list-style-type: none"> Improved efficiency of processes will contribute to sustainable farming through better remote monitoring and automation 		<ul style="list-style-type: none"> More efficient agricultural production Reduced wastage More environmental sensors and devices

Source: Analysys Mason

Benefits for operators: mobile operators consider 5G to be an opportunity to enable adjacent or new revenue streams

Top 3 drivers of 5G deployment for MNOs*












Most MNOs are quite conservative with their short-term 5G target, focusing on cost reduction to deliver data services

None of the top 3 drivers requires extensive 5G coverage, which makes the cost reduction target harder to achieve

Many MNOs plan to tap into new market segments such as fixed-wireless access (FWA) and enterprise, using their 5G networks to enable new revenue streams

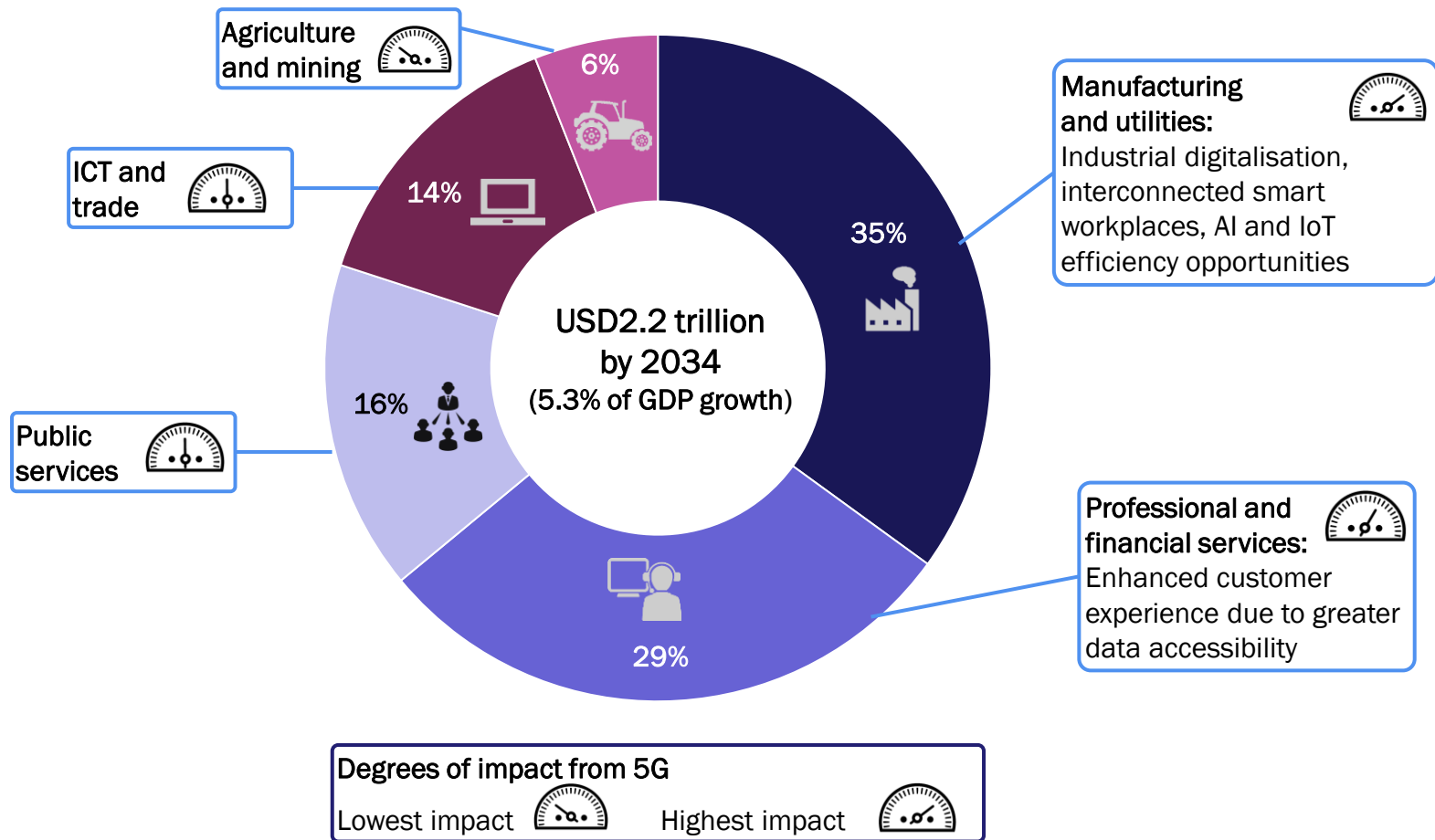
*: Based on a survey of 84 Tier-1 and Tier-2 operators conducted by Analysys Mason in 1Q 2019: 'What are your top 3 drivers for mobile 5G deployment?'

Benefits for the wider society: governments worldwide believe that the introduction of 5G will bring environmental benefits and new job creation

		Objective	Initiative
	\$ 216 billion	 <p>The government worked alongside Future Communications Challenge Group and Network & Information Systems to develop a 5G strategy FCCG report suggests USD216 billion of UK GDP growth over 10 years</p>	 <p>New national programme for 5G testbeds and trials (5GTTP), which tracks evolution of 5G projects such as RuralFirst, Smart Tourism, Worcestershire 5G Consortium USD50 million invested in 5GTTP</p>
	\$ 500 billion	 <p>Wireless industry in the USA plans USD275 billion investment in 5G networks US government estimates 3 million jobs will be created and USD500 billion will be added to the US economy as a result</p>	 <p>FCC is pursuing the '5G FAST' plan Three key components:</p> <ul style="list-style-type: none"> • introduce more spectrum • update infrastructure policy • modernise outdated regulations
	\$ 226 billion	 <p>The government expects to gain USD153 billion in productivity and USD73 billion in revenue from exports It also expects 600 000 related jobs to be created by 2026</p>	 <p>South Korean government announced '5G+ Strategy' to promote creation of new industries and services based off 5G and more efficient 5G ecosystem</p>

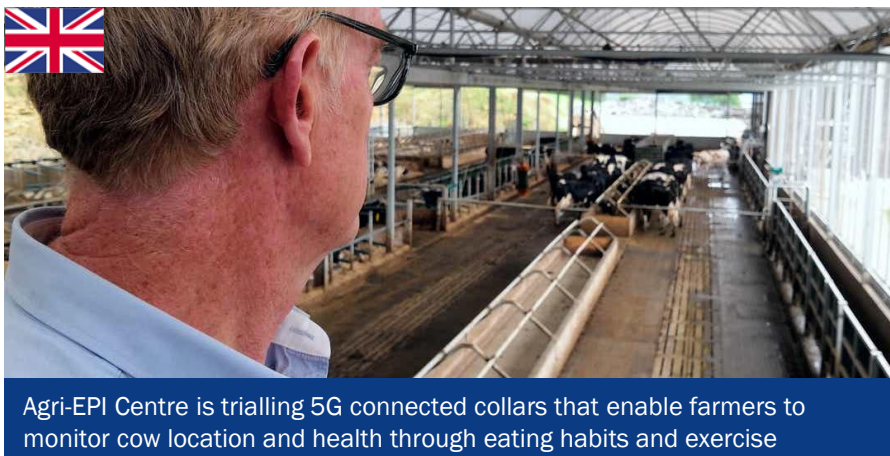
Sources: Government results, Analysys Mason

Socio-economic impact of 5G: the benefits of 5G are expected to have a significant impact on the global economy



Source: GSMA

Socio-economic impact of 5G: 5G has started to bridge the digital divide, with real-world use cases in both emerging and mature markets



Sources: GovInsider, Zipline, Associated Press



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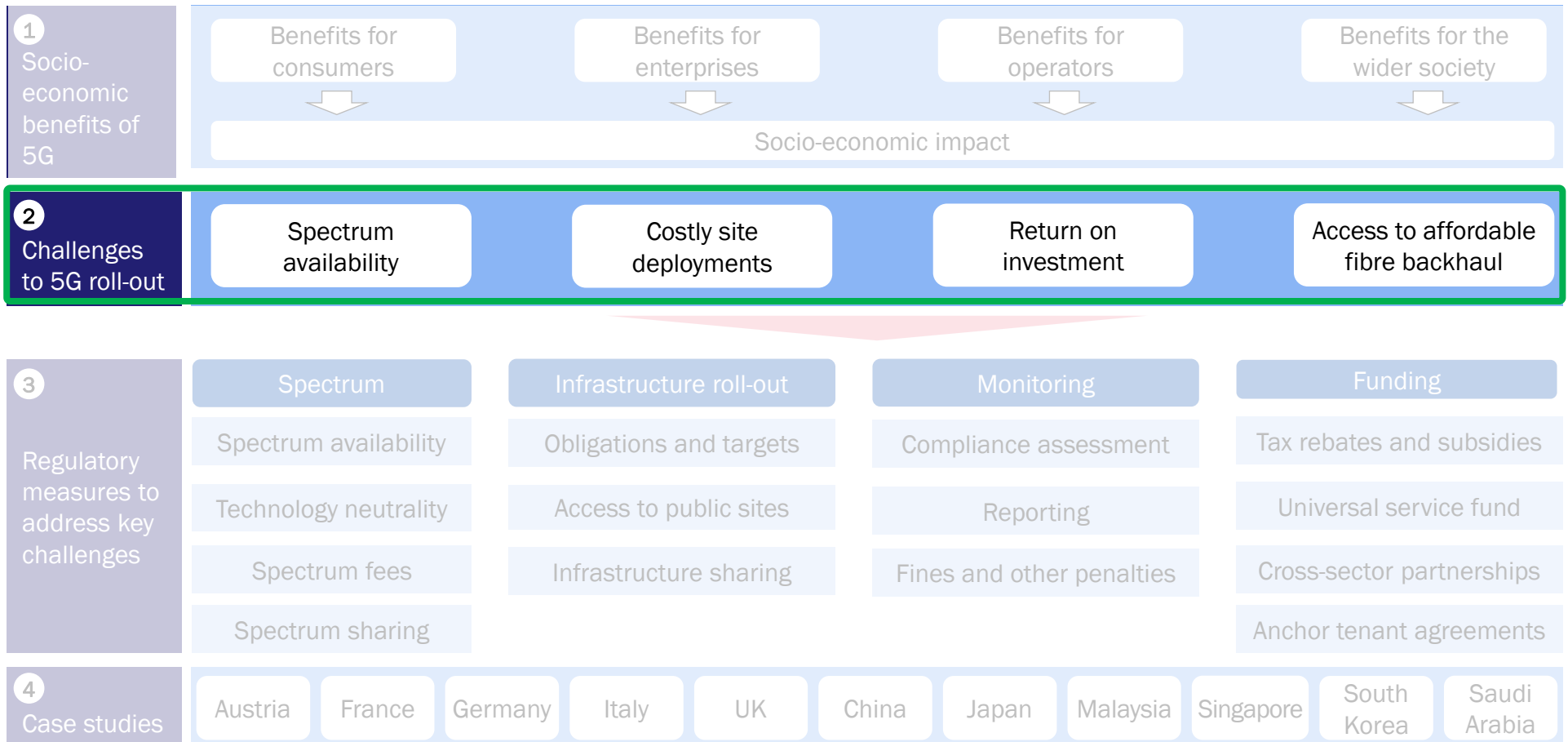
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This section explores the key challenges that are widely considered to be the most critical inhibitors of extensive 5G coverage



Key success factors: comprehensive or high 5G coverage will be required to realise the benefits promised by 5G

In the 5G era, and driven by a range of new concerns, the main objective of policy makers has been to increase coverage. Measures to address these concerns have included some aimed at consumers, and others focusing on locations that play an important role in the delivery of enterprise, industrial and IoT services.

Geographical/population/ household coverage			<ul style="list-style-type: none"> Germany: Existing operators are required to provide coverage to 98% of households by 2022
Rural area coverage			<ul style="list-style-type: none"> France: ARCEP will require 20–25% of 3.4-3.6GHz sites to be deployed in sparsely populated areas (i.e. >2400 sites)
New site coverage			<ul style="list-style-type: none"> UK: Ofcom will require a minimum of 500 new wide-area macro sites for 700MHz and 3.6–3.8GHz bands
Speed thresholds			<ul style="list-style-type: none"> France: ARCEP has defined the minimum speed required at each 5G cell site to be at least 240Mbit/s by 2025
Signal strength			<ul style="list-style-type: none"> UK: Ofcom has a downlink RSRP threshold requirement of -105dBm underlying its coverage definition

Sources: NRA websites, Analysys Mason

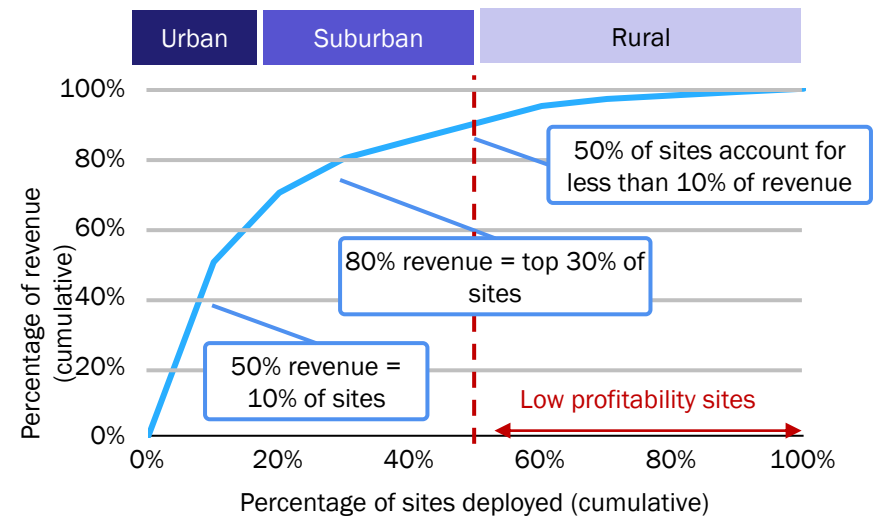
Key success factors: policy makers' objectives for significant 5G coverage may be difficult to align with MNOs' commercial goals

Comparison of unique drivers of 5G roll-out for MNOs and policy makers

MNOs	Policy makers
<ul style="list-style-type: none"> Lower cost to deliver gigabit speeds Increase enterprise and IoT business Enable brand new revenue streams 	<ul style="list-style-type: none"> Reduce digital divide in rural communities Drive industrial digital transformation with 5G to every industrial site Enable unconnected industries, i.e. agriculture

MNOs' commercial goals involve network priorities that are incompatible with 5G objectives of government/policy makers

Illustrative relationship between cumulative revenue and number of sites deployed



MNOs' goals in TCO reduction and profitability improvement will be limited if they are required to build networks in unprofitable areas

Sources: NRA websites, Analysys Mason, Techeconomy

Key challenges: MNO 5G deployments face a number of challenges that will impact the MNOs' ability to offer extensive 5G coverage

Key challenges for 5G development



Summary of key challenges

Spectrum availability

- Lack of access to low, mid or high bands may be an obstacle in some countries

Site deployment

- Current approval processes may be too lengthy/costly for extensive deployment of small cells and larger antennas

Business case

- 5G networks require high capex and operators are unsure how to monetise the new networks; **see the next slide**

Affordable backhaul

- Lack of affordable access to high-quality fibre backhaul may decrease competition unless addressed by NRAs

Stakeholder collaboration

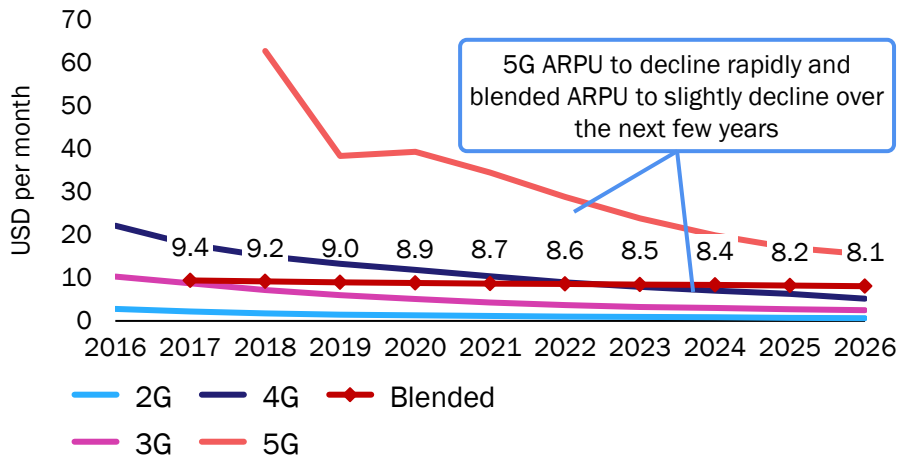
- MNOs may be reluctant to offer service-specific connectivity, whereas enterprises want bespoke connectivity

NRAs will have to be aware of the challenges facing MNOs and intervene when required

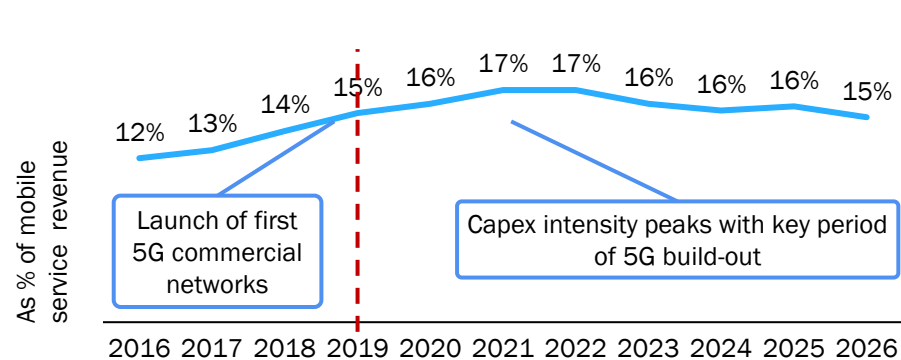
Source: Analysys Mason

Key challenges – uncertain business case: rolling out a new generation of mobile networks is costly and will take time to break even

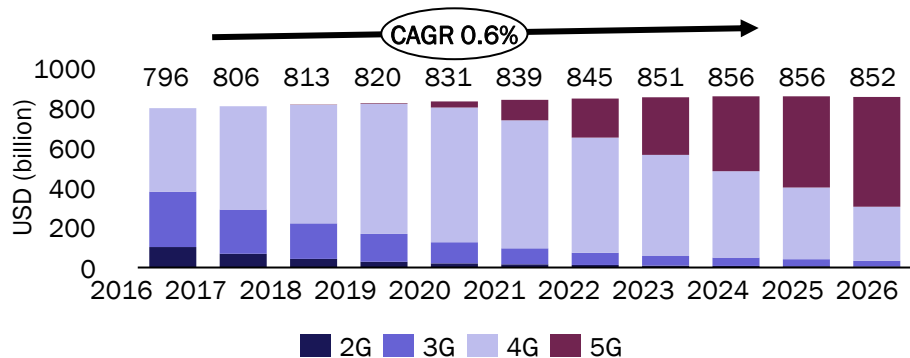
Mobile ARPU by technology, 2016–26



Mobile capex intensity, 2016–26



Mobile service revenue by technology, 2016–26



Source: Analysys Mason

- Capex intensity is set to increase substantially over the coming years with the introduction of new forms of antenna
- Incremental ARPU is expected to be minimal, yielding modest revenue growth at best
- Net effect is that network investment will take a long time to recoup if MNOs manage to capture value from other layers of the value chain



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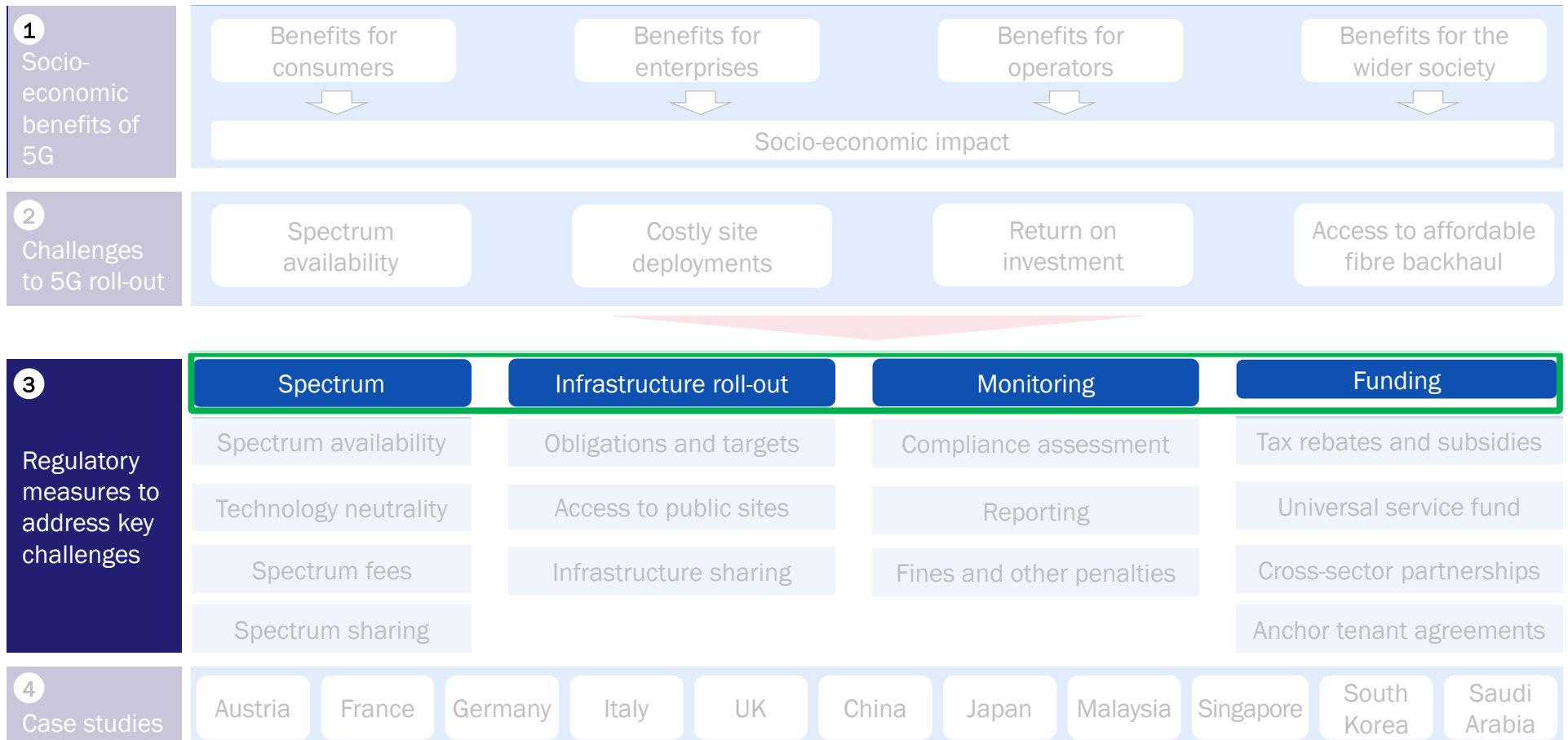
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This section analyses the types of measures that can be adopted by NRAs to achieve high 5G coverage





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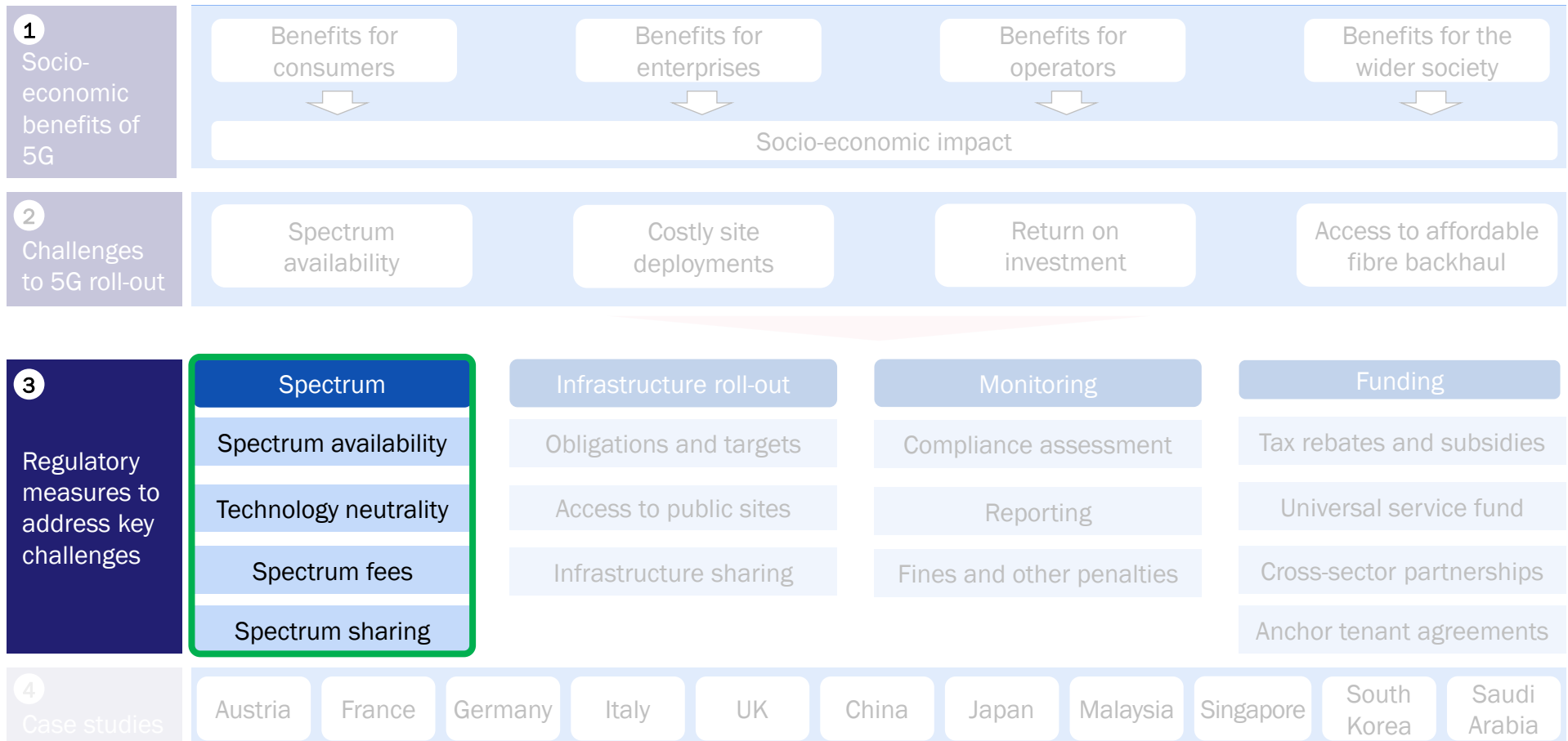
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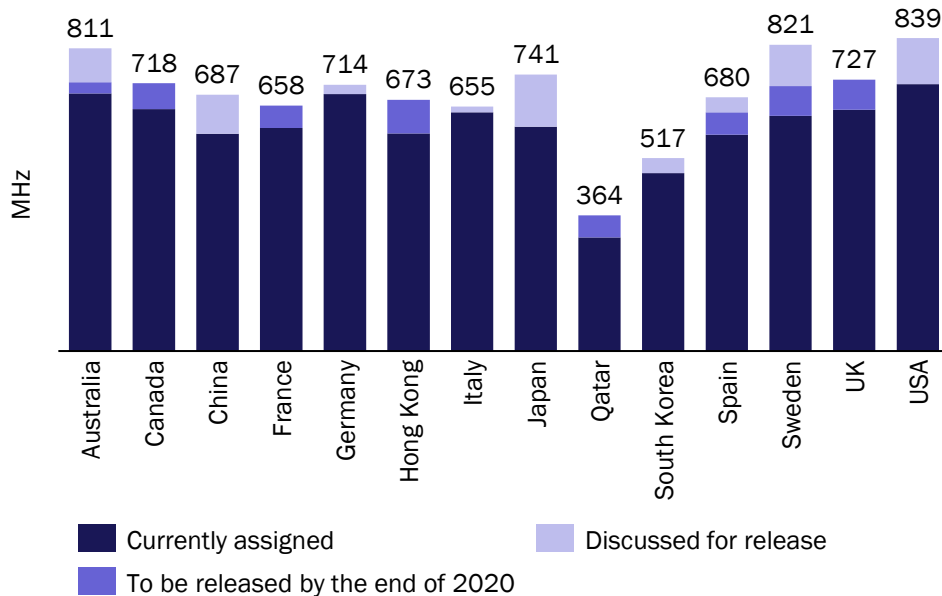
Spectrum: we have identified four main types of initiatives that NRAs can pursue to facilitate 5G network deployments



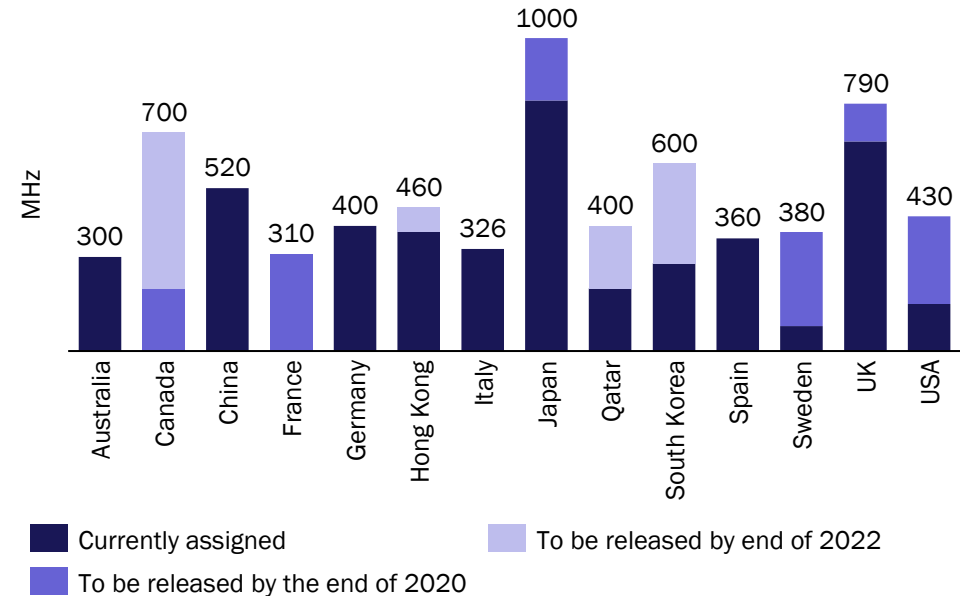
Spectrum availability: a combination of frequencies is necessary for 5G; low-band and mid-band are most important to achieving high coverage

- NNOs will require multiple frequency layers in parallel: contiguous high-band for bandwidth and low-band for coverage
- NRAs have been making 5G spectrum available across several bands: primarily new mid-band
- NRAs have confirmed low-band for 5G, however the popular 700MHz will require re-farming

Sub-3GHz spectrum release timelines



Mid-band (3–6GHz) spectrum release timelines



Sources: NRA websites, Analysys Mason

Technology neutrality: provides an opportunity for operators to reuse certain existing licensed bands for 5G services in the future

- Technology neutrality in spectrum licence allocation allows MNOs to use assigned frequencies with the most appropriate technology. For example, MNOs can use existing spectrum licences to roll out 5G as the technology becomes available, rather than waiting for another spectrum award.



“Flexibility in spectrum management and access to spectrum should be increased through technology and service neutral authorisations to allow spectrum users to choose the best technologies and services”. (Furthermore,) “restrictions on the principle of technology neutrality should be appropriate and justified”.

- Directive 2009/140/EC (November 2009)



- In October 2009, BNetzA lifted restrictions on the assigned frequency usage rights in the 450MHz, 900MHz, 1800MHz, 2GHz and 3.5GHz bands.
- This allows network operators to use the frequencies on a technology-neutral basis for the provision of telecoms services, on request.



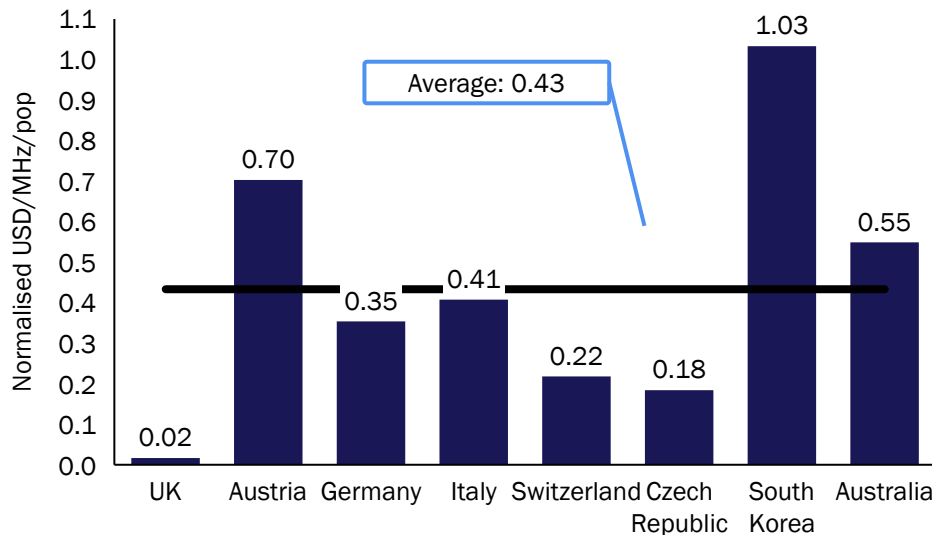
- Austria’s 2019 auction of its 3.4–3.8GHz band assigned technology-neutral licences, with flexibility for use with future standards.
- The 800MHz, 900MHz and 1800MHz bands were converted to be technology-neutral following a 2013 auction.

Sources: NRA websites, Analysys Mason

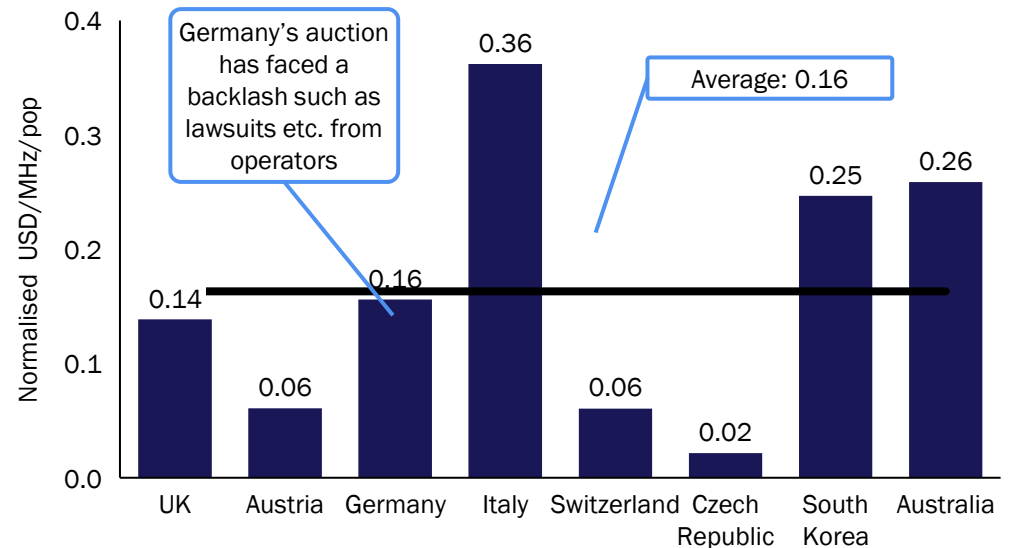
Spectrum fees – auctions: affordable spectrum costs are one factor that may encourage rapid 5G build-out and additional deployers

- NRAs use auctions to award spectrum: MNOs that value it highest tend to use it most effectively
- NRAs can affect auction prices through mechanisms including reserve prices and auction formats
- High prices could tip MNOs into significant debt and may adversely affect their financial viability
- Normalised mid-band 5G spectrum prices* have been lower than for those of 4G

Normalised spectrum price, 1.8GHz 4G band



Normalised spectrum price, 3.4–3.8GHz 5G band








*: The normalised spectrum price is calculated as total price paid for spectrum at auction, divided by the amount of spectrum awarded, country population and duration of licences.

Sources: NRA websites, Analysys Mason

Spectrum fees – usage: setting low usage fees independently of the number of deployed base stations can prevent effects on investment

- MNOs usually also pay annual spectrum usage fees (on top of one-off licence fees)
- Spectrum usage fees are set by regulators to cover administration costs, and provide an incentive to MNOs to use spectrum efficiently and/or to return underused spectrum

Illustration of methods used by NRAs to set spectrum usage fees

 <ul style="list-style-type: none"> ▪ Administrative cost to manage spectrum and opportunity costs of spectrum ownership to other potential users (applied per MHz of spectrum owned) 	 <ul style="list-style-type: none"> ▪ Small fixed component ▪ Variable component based on MHz owned in various frequency bands 	 <ul style="list-style-type: none"> ▪ Proportion of operators' revenue ▪ Proportion is adjusted, up to 8%, based on the amount of MHz owned 	 <ul style="list-style-type: none"> ▪ Amount of MHz owned ▪ Number of base stations deployed ▪ Number of mobile subscribers 	 <ul style="list-style-type: none"> ▪ Proportion of operators' revenue ▪ Proportion is adjusted, up to a maximum of 8%, based on the amount of MHz owned
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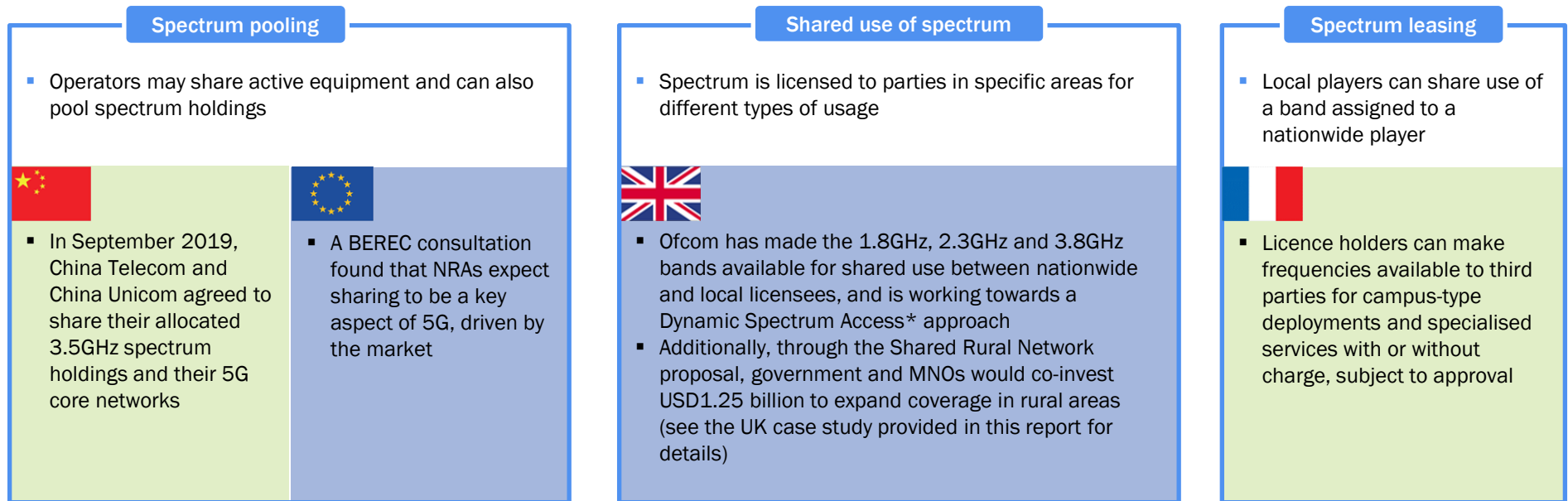
- ! Deployment-based calculation methods can negatively affect 5G coverage by disincentivising MNOs to deploy networks extensively. The additional spectrum usage fee per base station can make network deployments economically unfeasible in rural areas.
- ! Spectrum usage fees that are calculated on the basis of the amount of spectrum owned or revenue generated encourage more flexible network deployments by avoiding distortionary effects on the market.

Sources: GSMA, NRA websites, Analysys Mason

Spectrum sharing: spectrum sharing can increase network capacity and reduce investment costs

- Spectrum sharing is the act of granting multiple players access to the same bands of spectrum
- This could allow maximum utilisation of available spectrum by increasing spectrum efficiency

Illustration of MNO spectrum-sharing implementations allowed by NRAs



*: Dynamic Spectrum Access is an approach that allows devices to be assigned spectrum based on availability

Sources: NRA websites, Analysys Mason



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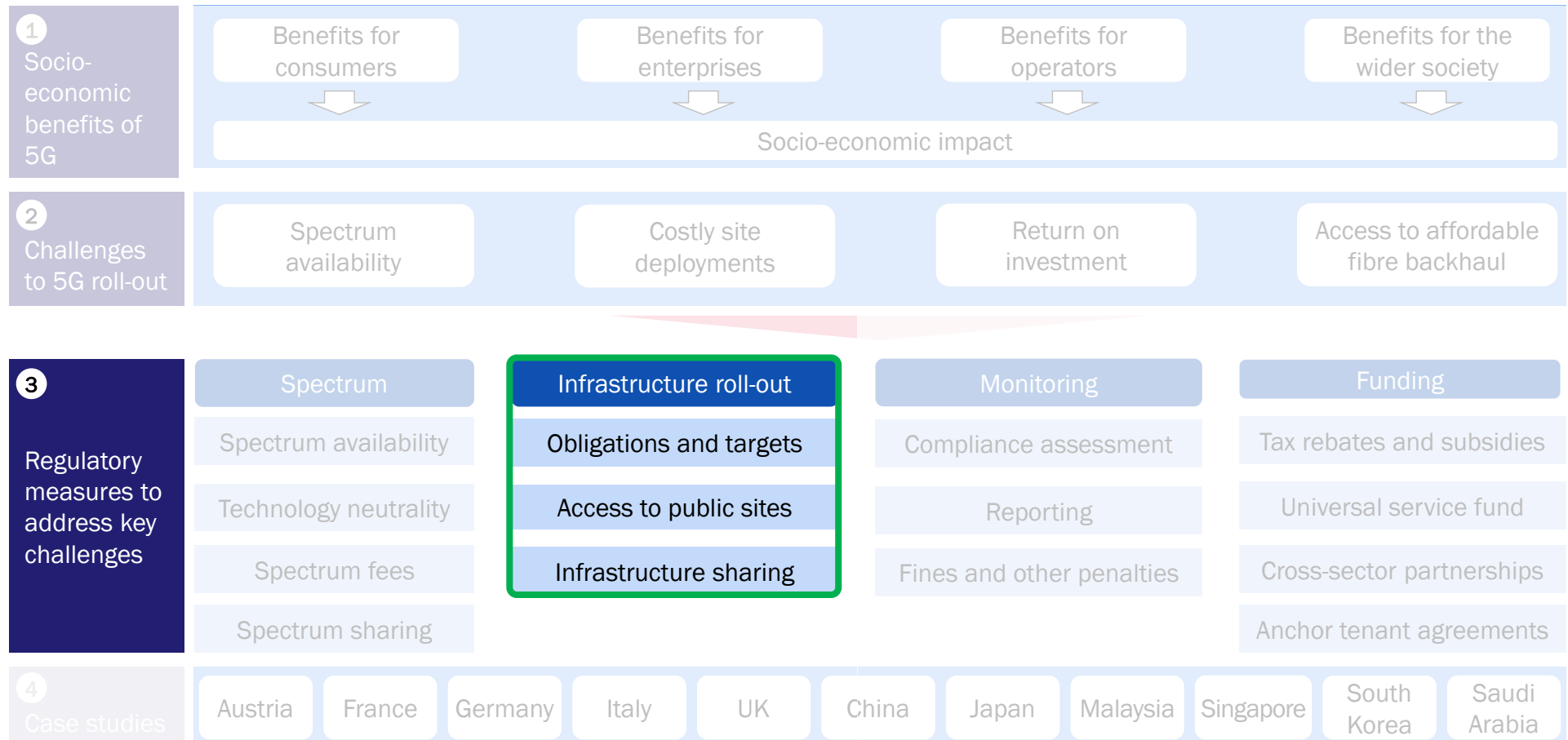
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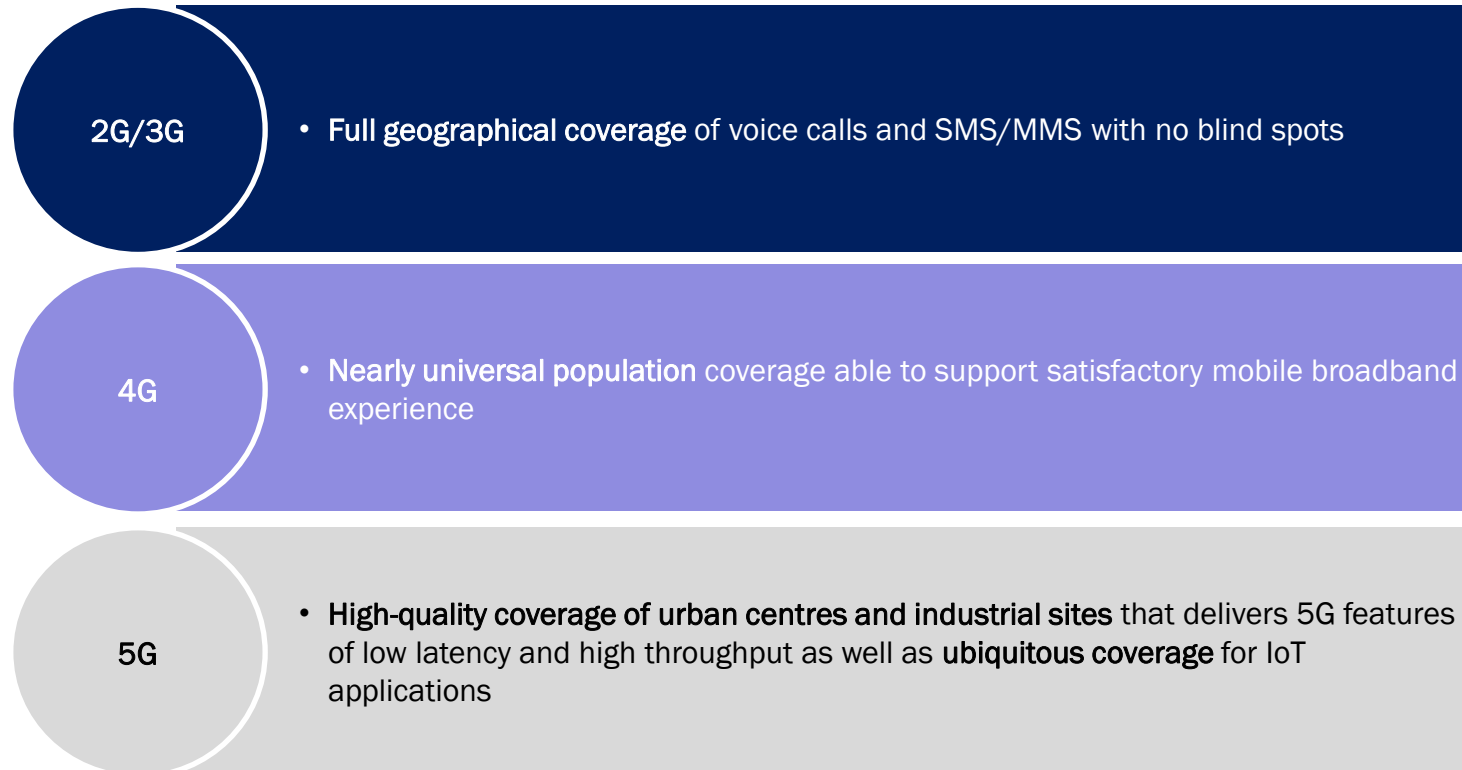
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Infrastructure roll-out: we have identified three types of actions that NRAs can pursue to accelerate the 5G roll-out



Coverage definitions: NRAs could have different policy objectives for different network technologies

An illustration of diverging policy objectives for different network technologies



Coverage definitions: defining obligations in 5G licences can ensure that coverage/quality is incrementally improved compared to current levels

Country examples

Geographical/population/
household coverage



- **Germany:** Existing operators are required to provide coverage to 98% of households by 2022

Rural area coverage



- **France:** ARCEP will require 20–25% of 3.4–3.6GHz sites to be deployed in sparsely populated areas (i.e. >2400 sites)

New site coverage



- **UK:** Ofcom will require a minimum of 500 new wide-area macro sites for 700MHz and 3.6–3.8GHz bands

Speed thresholds



- **France:** ARCEP has defined the minimum speed required at each 5G cell site to be at least 240Mbit/s by 2025

Signal strength



- **UK:** Ofcom has a downlink RSRP threshold requirement of -105dBm underlying its coverage definition

Sources: GSMA, NRA websites, Analysys Mason

Facilitation of access to public infrastructure: easier access to street furniture can support cost-effective small-cell deployments

- Higher-frequency spectrum bands will underpin 5G's high-capacity connection, however these bands fall short in the provision of coverage depth relative to low-frequency bands
- NRAs are considering steps to allow access to street furniture and other public infrastructure suitable for small cells: recent focus has been on lamp posts and traffic signals
- Some NRAs have also considered amending small-cell classifications or approval processes to render small cells easier to deploy compared with macro sites



- **Germany:** The 'DigiNetz Law' of November 2016 specifies that public supply infrastructure (including requirements regarding the installation of small cells) is shared. Traffic lights and streetlights are highlighted as ideal locations for the expansion of picocells (because they are particularly cost-efficient due to placement and existing power connections); public buildings, street furniture, guardrails and certain manhole covers can also be considered.



- **South Korea:** MSIT announced a revision to legislation in April 2018, allowing operators greater access to government-owned locations including street lamps and traffic facilities. This includes a new obligation on local governments and facilities to provide access to light poles, traffic sign structures and subway areas for the installation of small cells for 5G.



- **China:** The Shenzhen government plans to facilitate deployments of 5G base stations (especially micro base station/small cells) using utilities such as streetlight poles and monitor poles.

Sources: NRA websites, Analysys Mason

Infrastructure sharing: sharing telecoms and non-telecoms infrastructure can help operators to reduce deployment costs

- 5G network roll-outs require large-scale fibre backhaul connectivity
- NRAs are taking steps to facilitate fibre deployment, including:
 - Reviewing and simplifying open-access regulations for shared telecoms infrastructure
 - Sharing non-telecoms infrastructure, such as underground and overground public infrastructure



- **UK:** In June 2019, Ofcom issued a statement that provides all telecoms providers with 'mixed usage' access to the network of suitable telecoms physical infrastructure – the ducts and poles owned by BT and operated by Openreach. This means that network operators can deploy fibre to provide both broadband and non-broadband services (such as mobile backhaul).



- **Germany:** The 'DigiNetz Law' of November 2016 specifies the need to share public supply infrastructure, including the laying of fibre optics as part of public road construction.



- **South Korea:** MSIT introduced a new policy in 2018, enforcing co-operation over infrastructure. All operators will jointly deploy wireless facilities and must allow sharing of 'last-mile' facilities. In addition, MSIT has imposed obligations on government facilities and management organisations to provide access to non-telecoms public infrastructure.



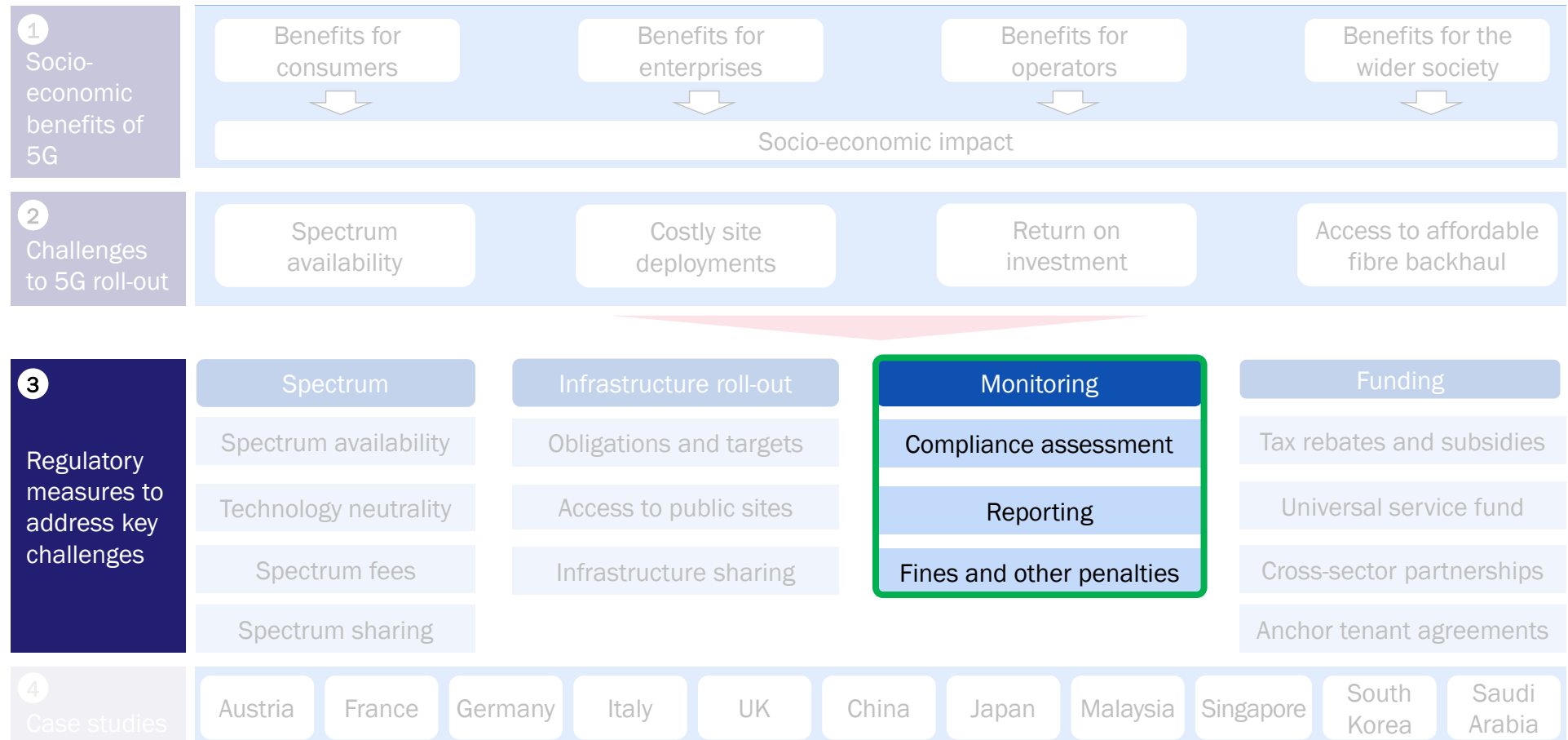
- **China:** MIIT announced in 2019 that "all enterprises' existing poles, pipelines, base station sites and computer rooms, base station access transmission lines, submarine cable core resources, and international submarine cable landing station transmission and lead resources, etc., must be open and shared".

Sources: NRA websites, government websites, Analysys Mason



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Monitoring: We have identified three types of initiatives that NRAs pursue to ensure compliance with coverage targets



Assessment of compliance with coverage obligations: BEREC provides guidance on monitoring of coverage through testing and signal prediction

- For regulatory measures to prove effective, NRAs need to be able to ensure compliance with targets and obligations
- In 2018, BEREC published a report establishing a 'Common Position' for best practice on monitoring mobile coverage,* based on consultations and studies of current NRA practices:




- Specifications for information about mobile coverage should be based on either one of the following criteria:
 - strength of signal received, with areas declared in-coverage if the average received signal power is greater than a pre-specified minimum
 - minimum probability of successful service reception (voice or data), with areas declared in-coverage if service is available at a rate of success greater than a pre-specified minimum




- Coverage calculations should be used when it is impossible to carry out field measurements of the whole country.
- These may be generated from modelling the strength of the signal received or the minimum probability of successful service reception (in line with CP1), through the likes of signal propagation of various bands, terrain information, network topology and geographical topology.
- NRAs may publish information (such as maps and metrics about mobile coverage) through one of the following methods:
 - generating coverage predictions and publishing information themselves
 - obtaining the results of predictions from operators, and publishing information themselves
 - using a third party to both generate coverage predictions and publish information

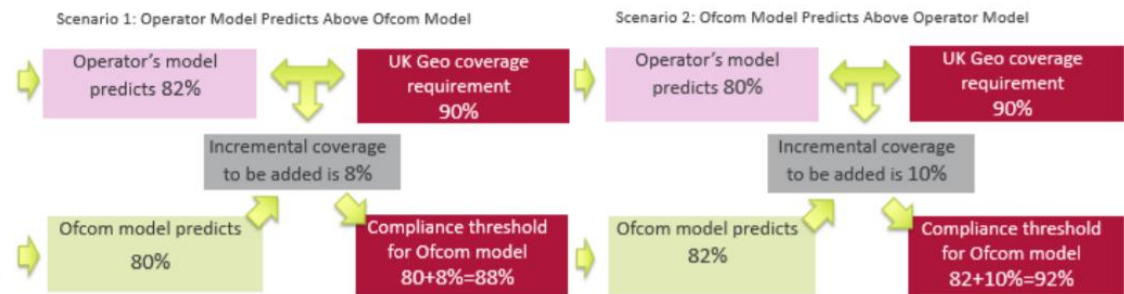
*:Coverage calculations – ARCEP generates results from MNO coverage maps, Ofcom uses maps directly
Source: BEREC

Assessment of compliance with coverage obligations: BEREC provides guidance on monitoring of coverage through testing and signal prediction

Drive testing



Calculations



Country	Drive testing	Walk testing	Crowdsourced	Calculations*
France	✓	✓ (mainly for QoS**)	✗	✓ (from MNO data)
Germany	✓ (signal strength only)	✗	✓	✗
Italy	✓	✗	✓ (error-reporting)	✓
UK	✓	✓	✗	✓ (MNO calculations)
Singapore	✓	✓	✗	✗

*:Coverage calculations – ARCEP generates results from MNO coverage maps, Ofcom uses maps directly

** :Quality of service, walk-testing is used by ARCEP to test data speed and call quality beyond just coverage

Sources: NRA websites, Analysys Mason, RemOpt, Ofcom

Reporting on coverage and performance: publicising coverage can promote competition and incentivise network improvement

- Verifying and publishing coverage information can have additional benefits; MNOs will be incentivised to offer the best coverage, which may lead to improvements in the network
- BEREC's Common Position on monitoring mobile coverage contains two additional positions on how regulators should report on coverage and performance



CP3

- NRAs should verify the reliability of information about mobile coverage using field measurements, ensuring statistical robustness of measurement methodology, processing and analysis. This has multiple benefits:
 - verifying compliance with coverage obligations
 - resolving complaints about performance
 - strengthening competition and incentivising improvement



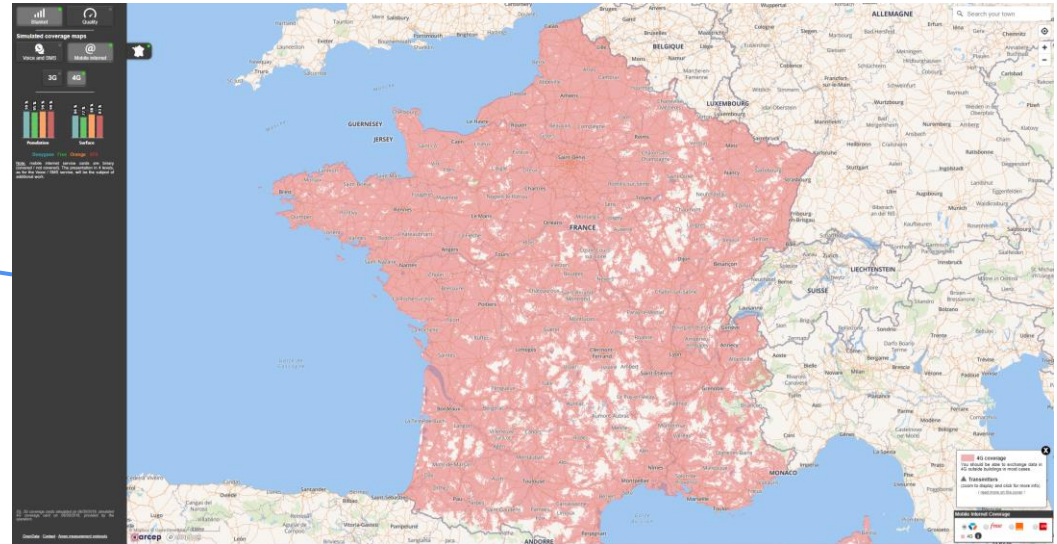
CP4

- NRAs should publish coverage maps and provide easy-to-access information to the widest possible range of customers, via apps and websites (either their own or through third parties). These should:
 - state the source of the data and if, and how, it has been tested for accuracy (note that CP2 specifies that NRAs may use their own data or that of an operator/third party)
 - provide the choice of selecting particular services and technology
 - display layers for different levels of coverage
 - show resolution of lower than 100m

Source: BEREC

Reporting on coverage and performance: publicising coverage can promote competition and incentivise network improvement

- France provides a good example of BEREC's Common Position, with ARCEP publishing service quality data at monreseaumobile.fr (see screenshot on the right)
- ARCEP also tracks investment into new sites in the *New Deal Mobile* dashboard
- In addition, all measurements are available as open data



Country	Coverage map	Levels of coverage	Splits by service or technology
France	✓	✓	✓
UK	✓	✗	✓
Germany	✓	✗	✓
Singapore	✗	✓	✓

Sources: NRA websites, Analysys Mason, monreseaumobile.fr

Fines and other penalties: flexible fines based on annual turnover can be used to motivate operators to comply with obligations and regulations

- Regulators may impose penalties to motivate MNOs to comply with obligations and regulations
- Fines based on a proportion of turnover are more effective deterrents to MNOs than flat fees
- Allowing investment to replace fines may be an innovative method to improve coverage

Flat fines

- Flat fees cannot be set too high without risking the failure of new entrants or smaller players, and cannot be set too low without becoming irrelevant to incumbents and larger operators



- USD111 360 fine is applied but can be repeated or increased with no upper limit; BNetzA states that the fine should be greater than economic benefit of not complying with obligations



- USD36 550 for every instance of non-compliance, but can be increased for serious or continual breaches

Percentage of turnover

- Fees based on annual turnover are set, by design, at appropriate levels according to the size of the operator



- Operators can face fines of up to 10% of annual turnover



- Fines may be levied at up to 3% of the previous year's net turnover, increasing to 5% if the issue is repeated

Investment agreement

- Allowing investment to replace fines may be the best method to improve coverage if operators remain deterred from non-compliance



- Anatel has agreed a settlement with Algar Telecom to cancel fines in exchange for an equivalent investment in infrastructure

Sources: NRA websites



Contents



Executive summary

Introduction

Socio-economic benefits of 5G

Challenges to 5G roll-out

Regulatory measures to address key challenges

Spectrum

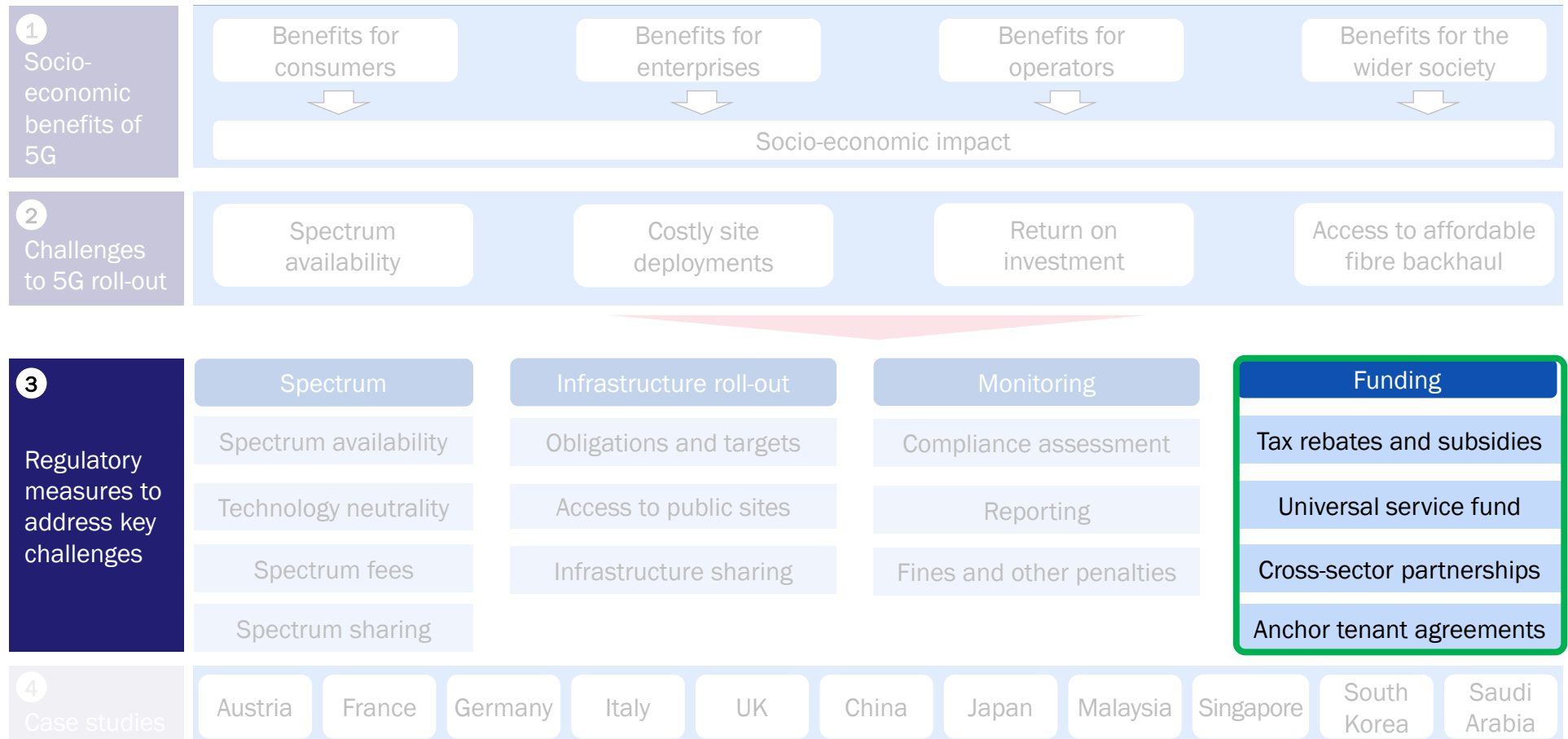
Infrastructure roll-out

Monitoring

Funding








Case studies

Funding: we have identified four types of mechanisms introduced by government bodies to support the development of 5G



Tax rebates, tax reduction and subsidies are being offered by governments to industry players and organisations to support the roll-out of 5G

Country examples

<p>Tax credit</p>	 <p>Directly lower a tax bill by the amount of the credit (dollar-for-dollar)</p>		<ul style="list-style-type: none"> ▪ USA: The federal government in the USA offers tax credits to manufacturers for their adoption of Industry 4.0. This includes investments by wireless companies for their implementation of 5G infrastructure and services, as well as robotics and AI
<p>Tax deduction</p>	 <p>Indirectly lower a tax bill by lowering the taxable income</p>	 	<ul style="list-style-type: none"> ▪ South Korea: The government will cut taxes on network construction by up to 3%. Operators in South Korea are also further incentivised by a reduction of deployment tax, changing from a system based on the number of amplifiers to the number of deployed base stations. This is important because 5G will use massive MIMO* antennas ▪ Japan: There are tax incentives for companies investing in Japan's 5G wireless network. This includes a 15% tax exemption or a 30% write-down on the value of the companies' qualifying 5G investments (capped at 20% of the corporate tax liability in any year)
<p>Subsidies</p>	 <p>Government incentives in the form of financial aid or support</p>		<ul style="list-style-type: none"> ▪ China: Telecoms operators that complete 5G base station construction targets in Shenzhen on time will receive subsidies of USD1427 for every base station constructed using the SA model, up to a maximum of USD21.4 million in compensation per operator

*:Massive MIMO is a Multiple Input Multiple Output (MIMO) system with an especially high number of antennas.

**:Standalone (SA) is one of the two main models of 5G deployment, featuring both 5G radio and 5G packet core

Sources: Governments, news reports, Analysys Mason

Universal service fund: governments can use funds to promote universal 5G/fibre access in unprofitable and underserved locations

- Universal Service Funds (USFs) have been created by governments with the intention of extending connectivity to underserved areas
- Funds are commonly provisioned through levies and reallocated to support targeted investments



- **USA:** In December 2019, the FCC announced a new 5G Fund to motivate operators to deploy wireless services in hard-to-serve rural areas of the country, allocating USD9 billion from the Universal Service Fund over 10 years through reverse auction



- **Canada:** The CRTC established the Broadband Fund in 2018, which awards USD569.5 million over the first 5 years to provide voice and broadband internet access on both fixed and mobile wireless networks, particularly to underserved rural and remote areas



- **Italy:** Italy plans to provide high-speed access (100Mbit/s+) to 85% of the population by 2020. National and regional funds of USD4.5 billion were made available to support ultra-broadband in market failure areas



- **UK:** In 2018, broadband Universal Service Obligation (USO) legislation was introduced to ensure that hard-to-reach locations are connected. Any technology capable of delivering the minimum USO standards can be considered, including 5G



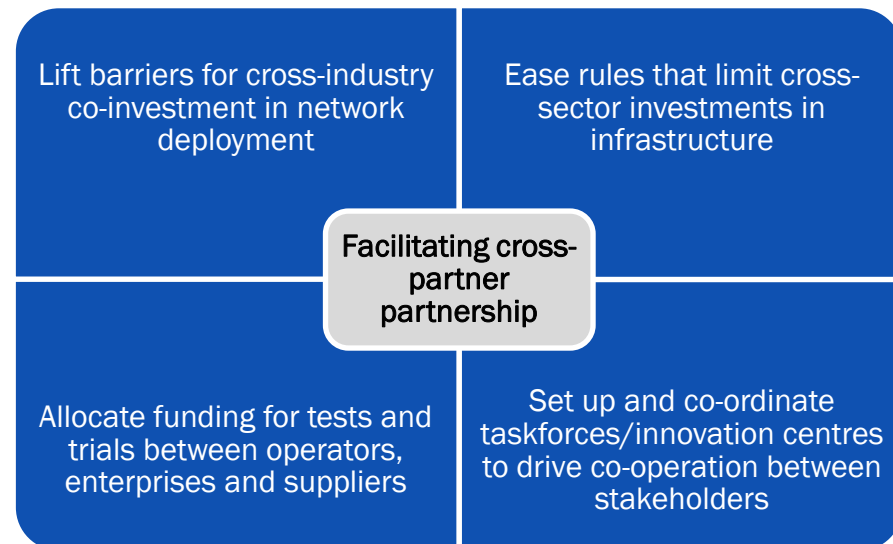
- **Ghana:** GIFEC takes a more active role than other USFs, occasionally going beyond administering of funds. For example, the Common Telecommunication Facility Project and the Last Mile Initiative (with USAID) involve direct provision of equipment and connectivity

Sources: Governments, news reports, Analysys Mason

Cross-sector partnerships: policies for cross-industry collaboration can support cost-efficient deployments of 5G networks

- MNOs need to work closely with a range of industry verticals to cater to enterprise demands
- Governments are well positioned to promote such collaboration through 5G tests and use cases

Key efforts from governments



Country examples



In 2017, Australia established a 5G working group that brought together representatives from across the government and different industries

- ACMA has set aside 900MHz spectrum for 5G IoT trials



In August 2017, 14 private firms took a 35.2% stake in state-owned China Unicom. This 'mixed-ownership reform' was a move towards more demand-driven model for network investment, with industry players now directly involved in 5G investment decisions



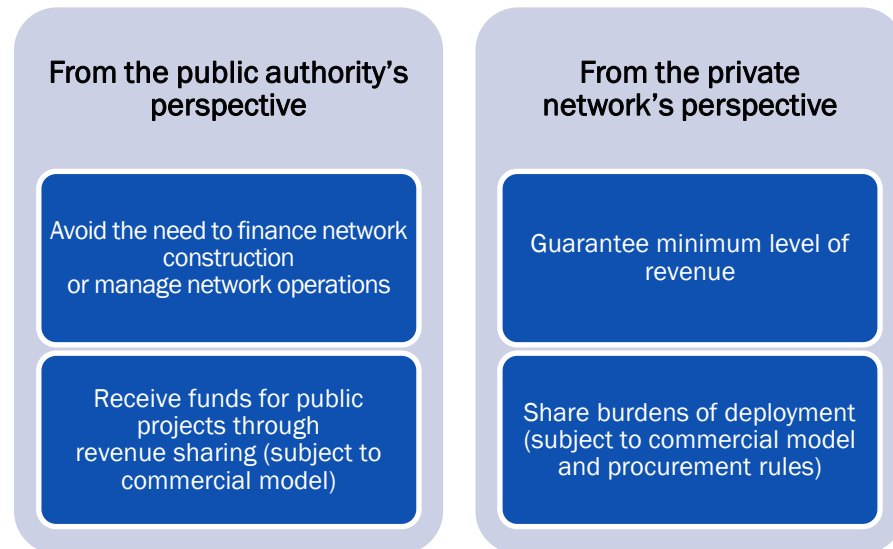
The government is working closely with operators and vendors, including, for example, on consultations about the allocation of spectrum to support new 5G IoT use cases. It is also looking to adjust its regulatory framework around new technologies, including remotely piloted and autonomous vehicles.

Sources: Governments, news reports, Analysys Mason



Anchor tenant agreements: the anchor tenant model means that governments can help guarantee a minimum level of revenue for MNOs as anchor tenants

- The public authority commits to be a customer of an MNO, purchasing a minimum level of service
- This provides financial assurance to the MNO and might also allow it to utilise public assets
- The public authority could be compensated, via revenue sharing and limited free access to the network

Key benefits of the anchor tenant model



Country examples

- | |
|--|
|  <ul style="list-style-type: none"> ▪ Mobilitie partnered with multiple cities: small cells deployed in more than 2000 jurisdictions. 1000 small cells deployed in Los Angeles, NRG Stadium targeted in Houston, network expanded for Sound Transit in Seattle ▪ San Jose, California partnered with AT&T, Mobilitie and Verizon to install small cells on 4000 properties, bringing USD500 million in investment |
|  <ul style="list-style-type: none"> ▪ O2 spent USD100 million to install 1400 small cells across London in 2017. These small cells enhanced both indoor and outdoor mobile signals and laid the groundwork for a speedy 5G roll-out ▪ Simultaneously, O2 built a free public Wi-Fi network for the City of London known as the Square Mile |

Sources: operator and government websites



Executive summary

Introduction

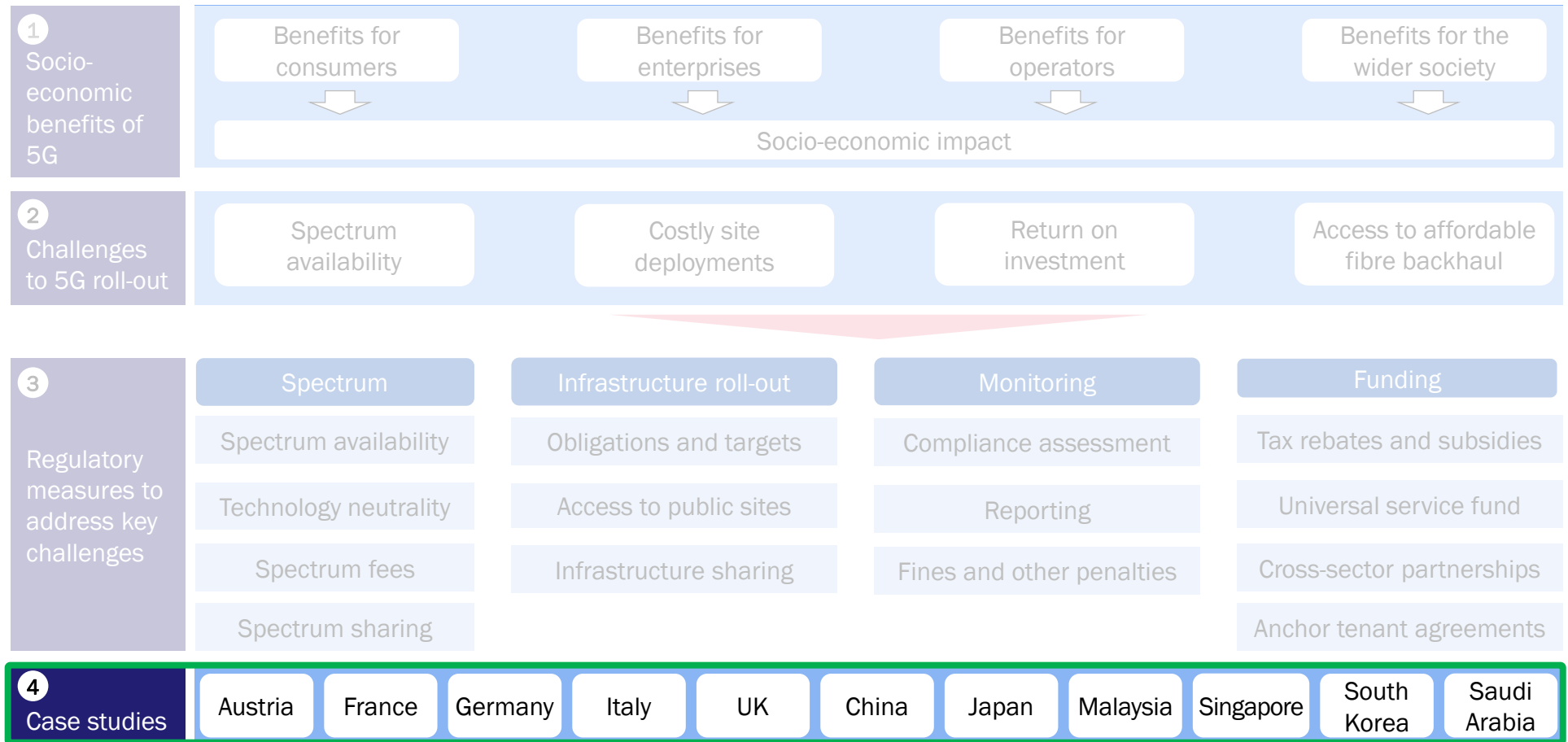
Socio-economic benefits of 5G

Challenges to 5G roll-out

Regulatory measures to address key challenges

Case studies

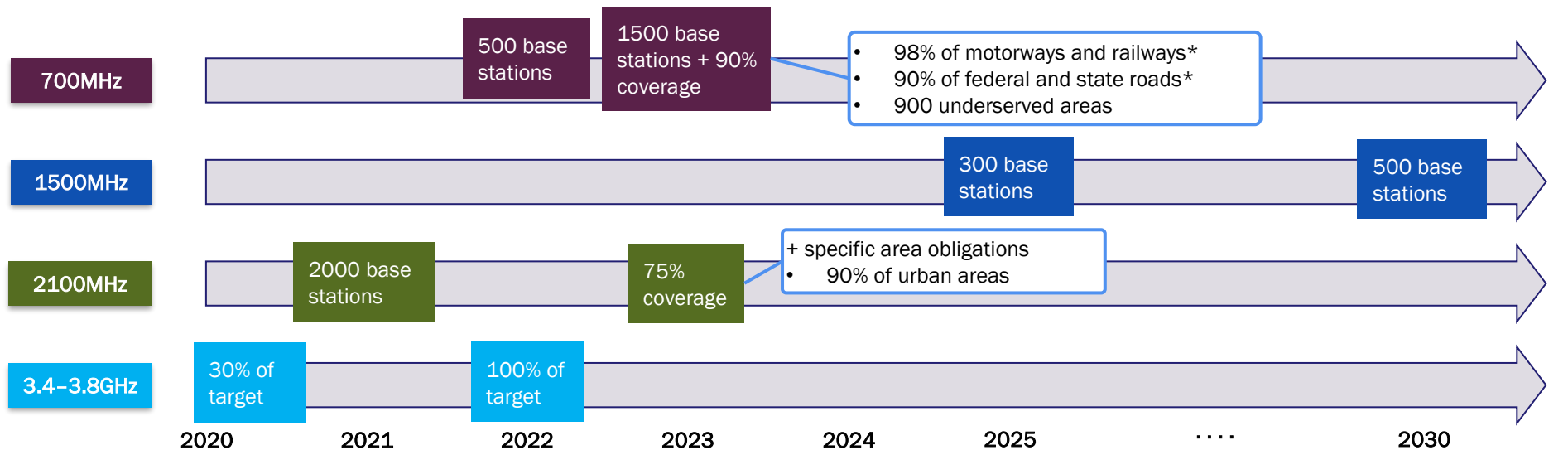
This section includes country case studies, providing examples of regulatory practices that have impacted 5G roll-out



Austria: the NRA set detailed roll-out requirements by timeline and spectrum

Timeline of coverage obligations

Minimum 30Mbit/s download and 3Mbit/s upload



Amount of 3.4-3.8GHz spectrum owned	Base station target
<50MHz	300
50-90MHz	500
>90MHz	1000

- Detailed roadmap for base station roll-out
- Reduction in minimum bid price
- Extension to licence period

*: These obligations only carry requirements of 10Mbit/s download and 1Mbit/s upload.

Source: RTR

France: automated renewal of licences for updated 4G coverage obligations



- In 2018, ARCEP reached a 'New Deal' with MNOs
- In exchange for automated renewal of licences, MNOs would commit to:



20 000 additional antennas and masts backed by USD3.3 billion of investment

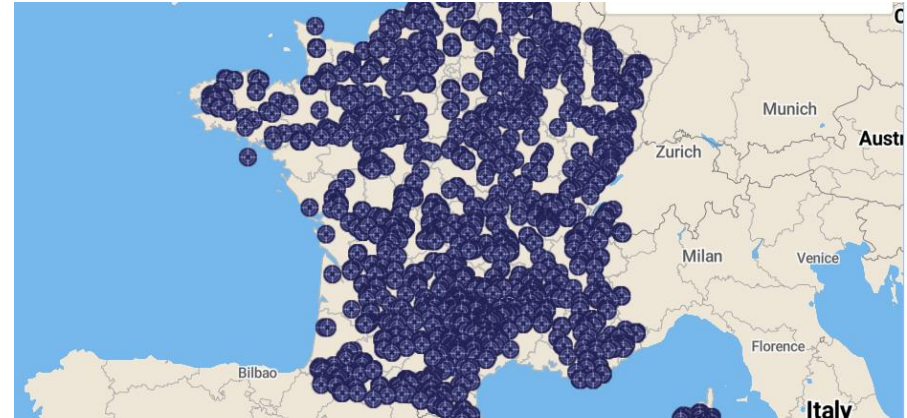


Providing 4G coverage to identified areas in 24 months, incl. 30 000km of railway lines



- The commitments from each MNO and progress are tracked and on display on 'New Deal Mobile' dashboard website for *name and shame*
- Population coverage improved across all operators by 3Q 2019

Targeted 4G coverage points identified by ARCEP



4G mobile coverage by operator, 2017 vs 2019

Operator	3Q 2017			3Q 2019
	As % of total pop.	As % of total landmass	As % of total pop. in low density zones	As % of total pop.
Orange	92%	65%	69%	99%
SFR	91%	65%	74%	99%
Bouygues Telecom	90%	61%	70%	99%
Free Mobile	82%	48%	47%	95%

Source: ARCEP

France: upcoming auctions have coverage obligations and other commitments

- Mixed award mechanism for upcoming 3.4–3.8GHz auctions for 5G
 - 260MHz auctioned with core coverage obligations
 - 50MHz assigned at fixed price if operators agree to additional commitments

Additional commitments for spectrum at fixed price

Indoor coverage

Provision of FWA products

Transparency in network roll-out forecasts

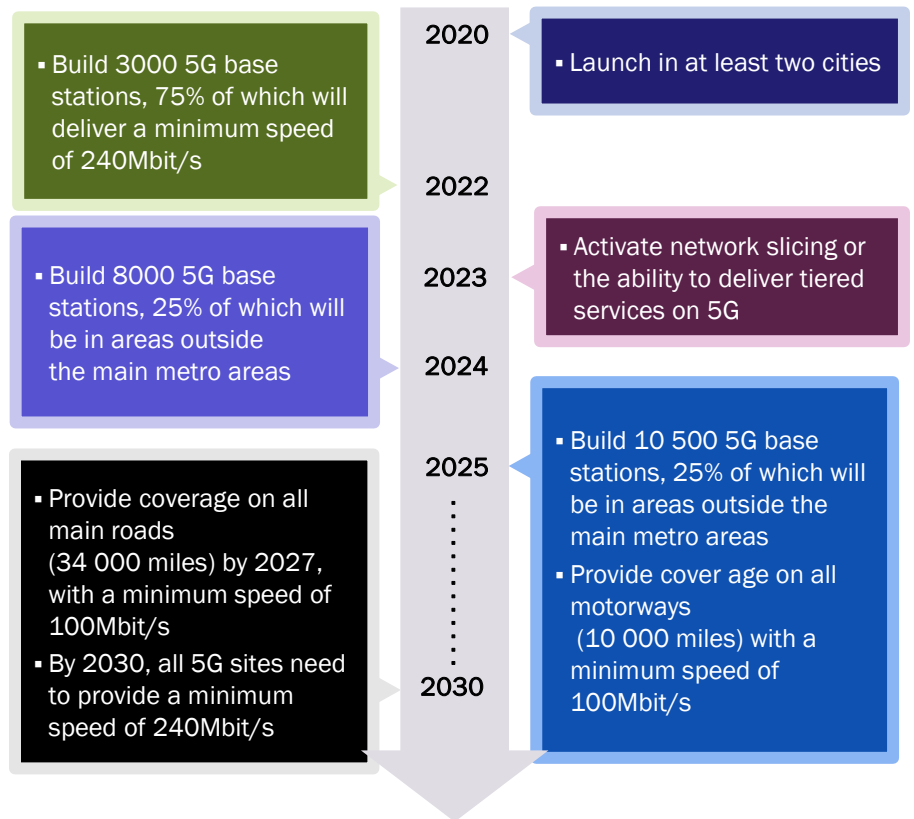
Improving MVNO* hosting for 5G

Offering customised solution to industries

* Mobile virtual network operator

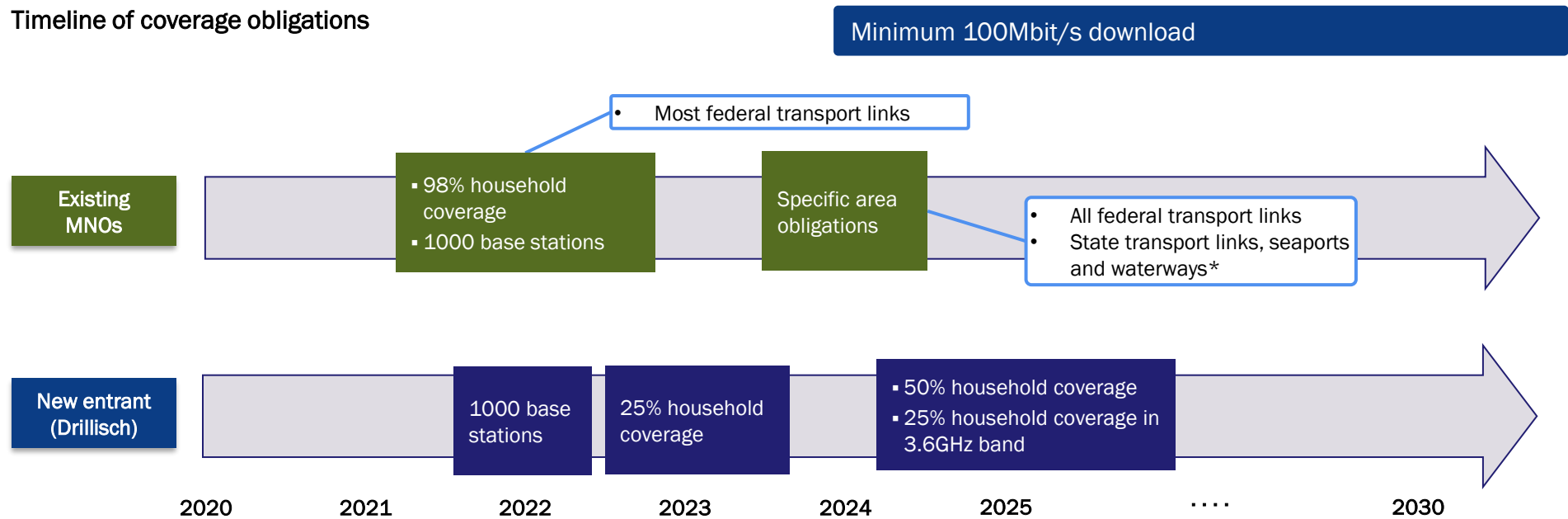
Source: ARCEP

Timeline of core obligations



Germany: 5G comes with high coverage requirements and spectrum costs

Timeline of coverage obligations



- MNOs filed lawsuits against BNetzA, centred around:
 - high auction prices (USD8 billion in total)
 - demanding coverage obligations

*: These obligations only carry requirements of 50Mbit/s download.

Source: BNetzA

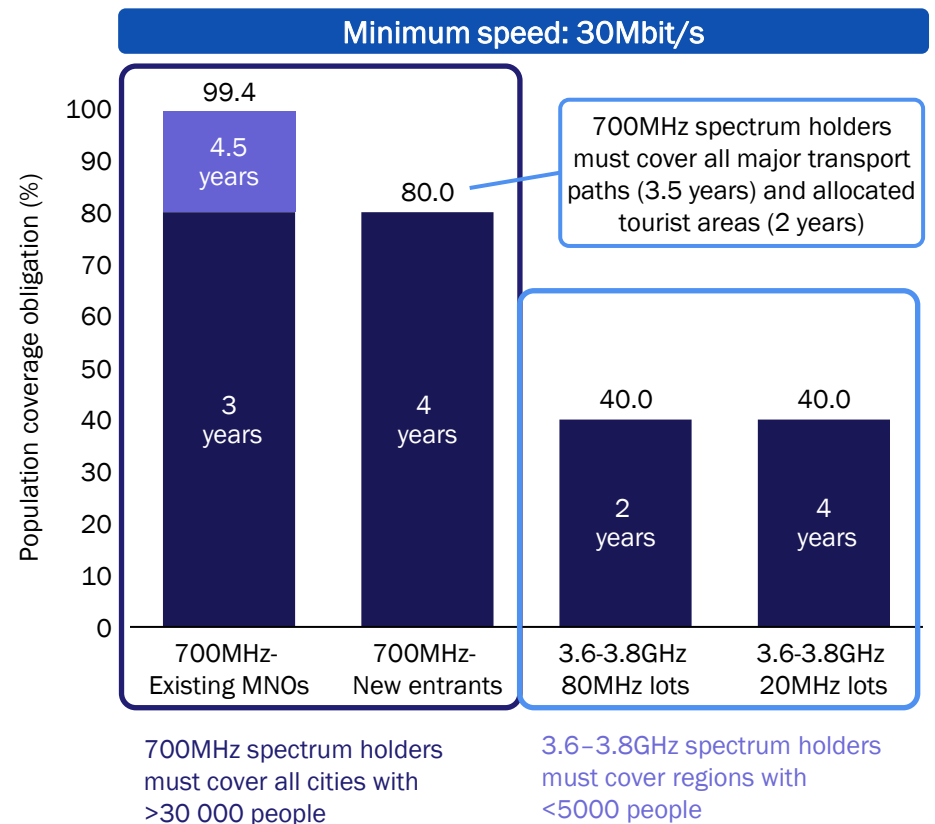
Italy: AGCOM combines clear and detailed coverage targets with high prices for the 3.6GHz band

- The NRA raised USD7.2 billion from the 3.6GHz band due to how the spectrum was packaged
- Coverage obligations take into account the size of spectrum and if MNOs are new entrants
- Obligations entail specific areas, i.e. tourist areas, transport links and underserved zones

Area-specific coverage obligation details

Band	Subset	Area-specific coverage
700MHz	Existing MNOs	All cities with >30 000 people
		90% of populations in 120 targeted areas
3.6–3.8 GHz	80MHz lots	10% of regions with <5000 people
	20MHz lots	5% of regions with <5000 people

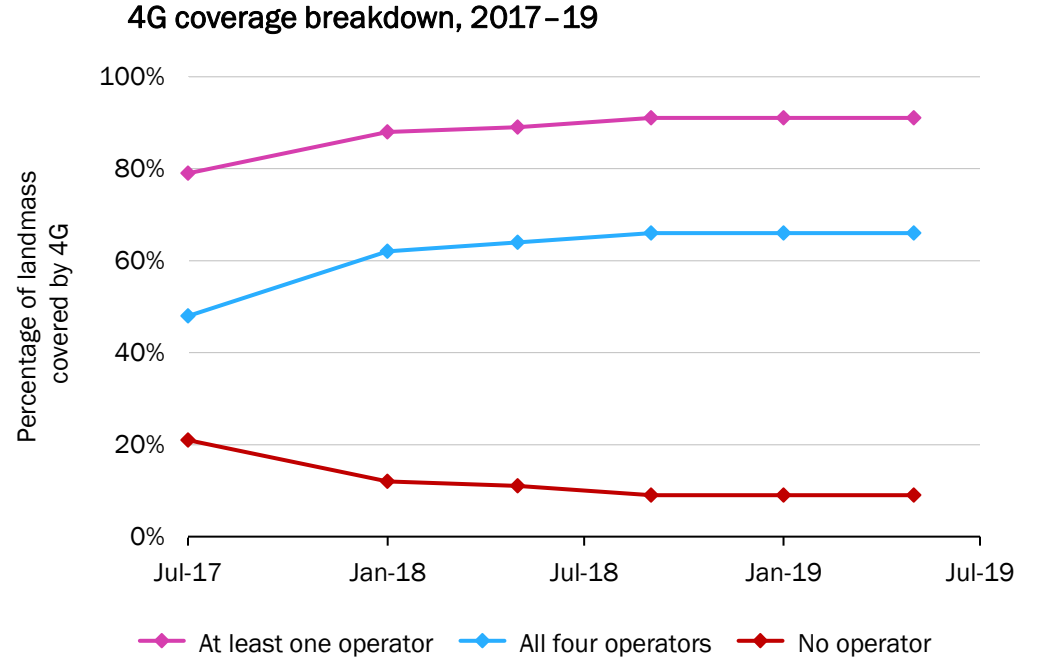
Percentage coverage obligation by spectrum band and timeline to fulfill the obligation



Source: AGCOM

The UK: the government has established a GBP1 billion fund to improve 4G coverage

- Government agreed Shared Rural Network proposal with MNOs
 - co-investment of USD1.3 billion
 - enforced sharing of infrastructure
 - 4G coverage of 95% of the population or 92% of the landmass by 2025
- In return, Ofcom removed 5G-specific coverage obligations from auction
 - planned obligation was 90% landmass coverage by 2025



Committed investment as part of Shared Rural Network proposal

Shared Rural Network investment	MNOs	Government	Total
Amount committed (USD million)	663	625	1288

Source: Ofcom

The UK: Ofcom has introduced measures for spectrum sharing and local licences

- Three ‘mid-band’ spectrum bands will be available through Shared Access licences
- Further spectrum has been made available in the 26GHz band for indoor-only deployment
- Shared Access licences available:
 - low power: per-area licence covering 50m radius
 - medium power: per-base station in rural areas only
- Local Access licences are available for locations where spectrum is not used
 - Ofcom believes this will be limited to private networks in remote locations

Annual fees for shared access licences

Spectrum band	MHz available per licence	Annual cost (USD)
1800MHz	2×3.3MHz	100
2300MHz	10MHz	100
3.8–4.2GHz	10–400MHz	100 per 10MHz
26GHz	50/100/200MHz	400

Potential uses of shared access spectrum

Spectrum band	Private network	Rural mobile coverage	Indoor mobile coverage	Fixed wireless access
1800MHz	✓	✓	✓	✗
2300MHz	✓	Initially limited	✓	✗
3.8–4.2GHz	✓	✗	✗	✓
26GHz	✓ (indoor)	✗	✓	✓

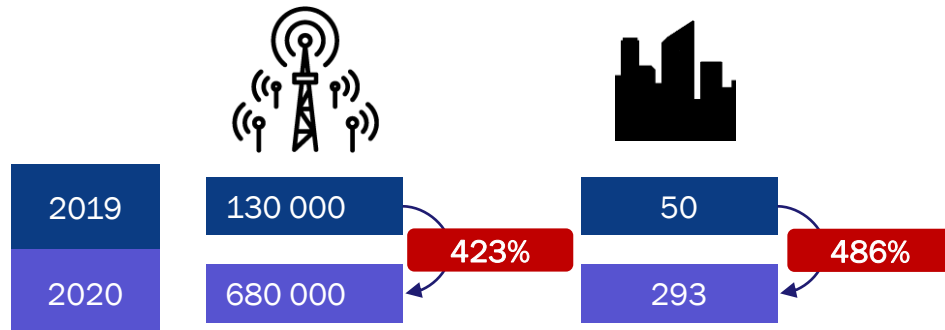
Source: Ofcom

China: MNOs have enjoyed significant support from the government

- The government has:
 - accelerated licence awards by 6 months
 - directly assigned 5G licences to operators
 - removed 5G spectrum fees for the first 3 years
 - provided discounted 5G spectrum usage fees for years 4–6

- 5G and industrial development initiatives:
 - IMT-2020 Promotion Group
 - 13th 5-year plan
 - Made in China 2025
 - Free infrastructure access, i.e. ducts

5G commercial roll-out progress



5G spectrum usage fee

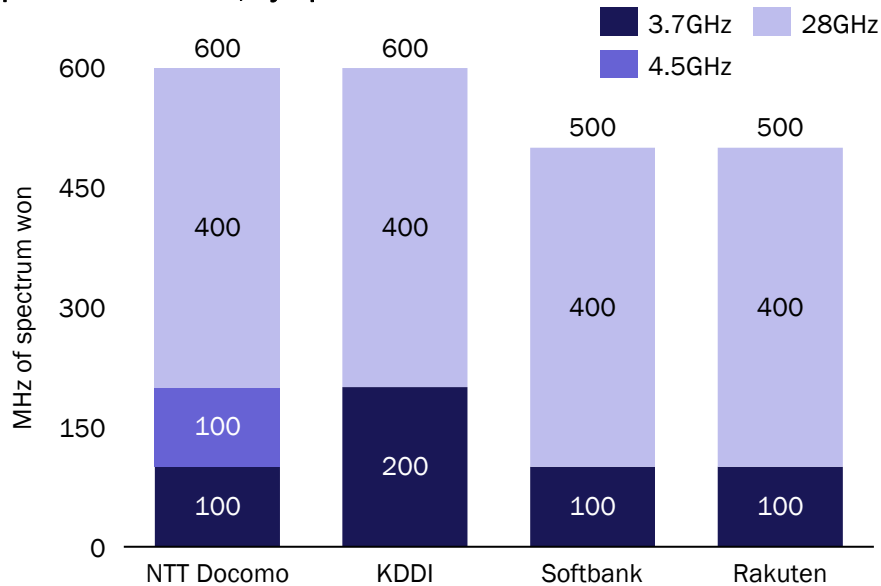
Frequency range	Original annual fee per MHz (USD million)	New annual fee per MHz (USD million)	Effective reduction
3GHz–4GHz	1.2	0.7	37.5%
4GHz–6GHz	1.2	0.4	62.5%
6GHz+	1.2	0.072	93.8%

Sources: MIIT, NRDC

Japan: spectrum awards are based on operator commitments

- Spectrum assigned through a beauty contest process
- Operators had core obligations (top right)
- Spectrum is won through additional obligations (bottom right)

Spectrum awarded, by operator



Core and additional obligations

Core obligations
Launch in every prefecture within 2 years
Deploy in 50% of zones within 5 years
Customised tariffs to end users
Open network access to MVNOs

Roll-out targets	NTT Docomo	KDDI	Softbank	Rakuten	
5G coverage*	97.0%	93.2%	64.0%	56.1%	
5G base stations	<6GHz	8 001	30 107	7 355	15 787
	28GHz	5 001	12 756	3 855	7 948
Investment (USD billion)	7.2	4.2	1.9	1.8	
Number of MVNOs	24	7	5	41	
MVNO subscribers (millions)	8.5	1.2	0.2	0.7	

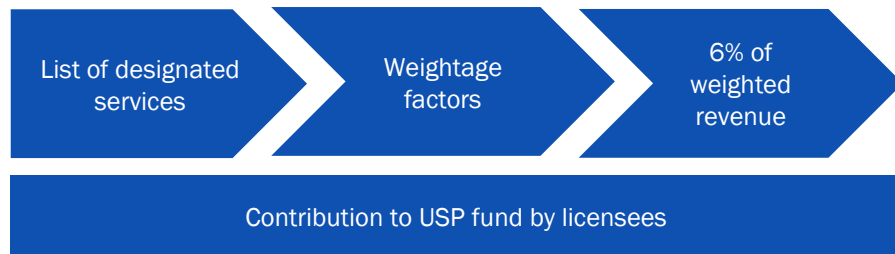
*: MIC divided Japan's territory into about 4500 blocks (zones) with grids of 100km².

Source: Ministry of Internal Affairs and Communications (Japan)

Malaysia: the MCMC encourages co-investment and infrastructure sharing

- Enforced infrastructure co-investment since 2002 through Universal Service Provision (USP) fund
- USP provides USD2.4 billion to National Fibre Connectivity Plan
- Operators provide an additional USD2.8 billion
- USD240 million is set aside for 5G backhaul

USP fund contribution calculation



Services that require contribution to USP fund

Included services (weighted revenue contribution)	Excluded services (no contribution to fund)
International call	Local call
Freephone service	National call
Call termination service provided to foreign network provider	Rental on exchange lines (residential and business)
ISDN	Operator assisted call
Cellular mobile services	Connection service
International roaming service	Reconnection service
IP telephony	Internet access charge
Leased lines	Audiotext hosting service
Other activities subject to an individual or class licence	Directory assistance services

0.5 weighting prior to 2003
 not included prior to 2003 included prior to 2003

All currently included services are equally weighted (weighting of 1)

Source: MCMC

Malaysia: the MCMC issues spectrum to industry consortium and via tender

- 26GHz spectrum assigned through a beauty contest process
- 700MHz and 3.5GHz spectrum assigned to an industry consortium (not individual licensees)
- However, core obligations are strictly monitored:

Speed: >30Mbit/s

Latency: <80ms

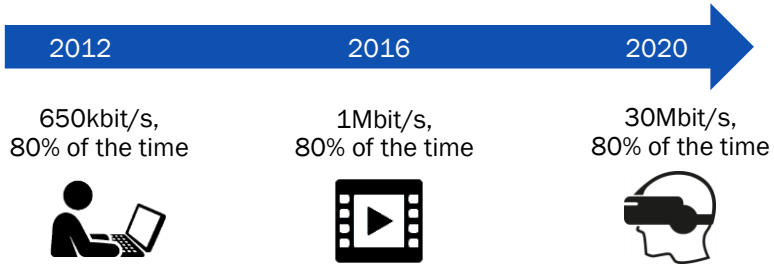
Signal strength: -98dBm

Packet loss: <1%

Laws relating to obligations

Law	Details
Section 242 – General Offence and Penalty	Non-compliance results in fines of up to USD24 000 or 2 years’ imprisonment
Strict and specified testing rule – Mandatory standards for Quality of Service	Any results found to be manipulated will be zeroed, with zeroed results included into overall calculations for compliance

Evolution of minimum speed requirements



4G quality-of-service results, 2019

Operator	Avg download speed (Mbit/s)	% of speeds over 1Mbit/s	% of time that latency <250ms	% of packet loss
Celcom	19.9	96.91	99.83	0.12
DiGi	23.1	98.49	99.36	0.12
Maxis	35.0	99.89	99.94	0.02
U Mobile	13.1	89.07	98.69	0.03
Webe	9.7	87.90	99.01	0.53

Source: MCMC

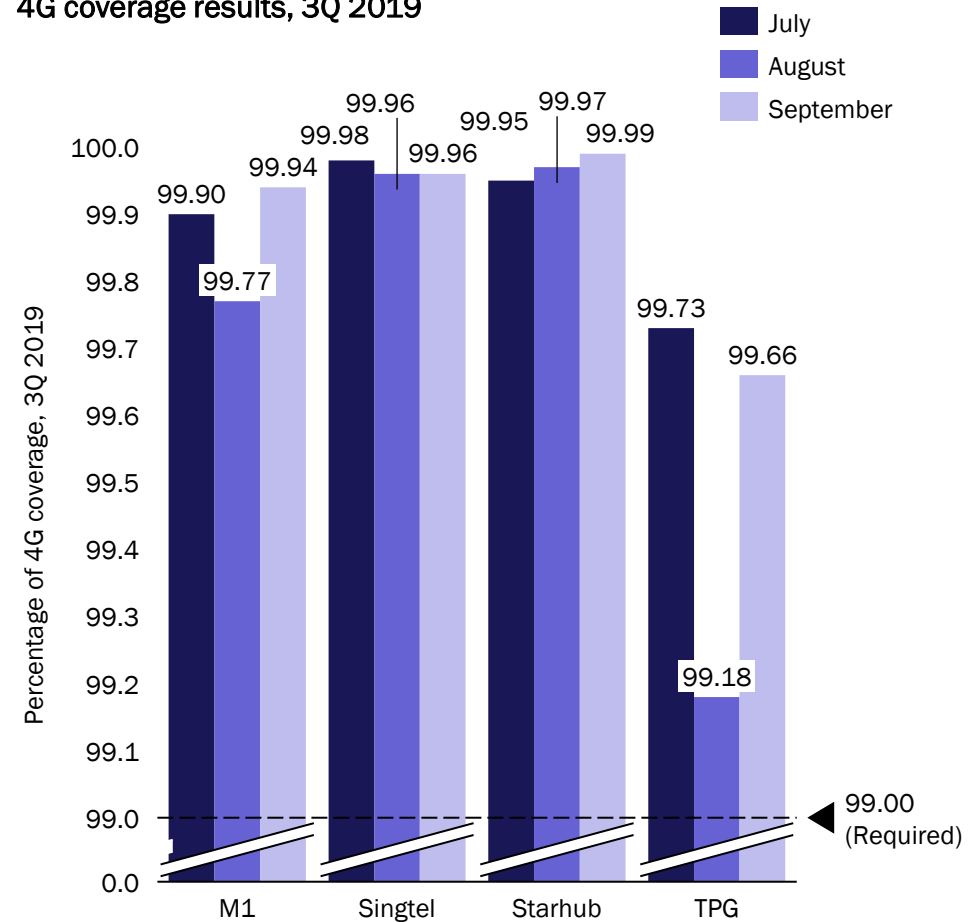
Singapore: the IMDA publishes quarterly signal strength tests

- The IMDA currently proposes 50% outdoor coverage using 3.5GHz within 24 months
- The IMDA will not immediately implement quality-of-service obligations, but may do so in future
- 5G monitoring likely to be similar to 4G (see table below):

4G monitoring details

Monitoring criteria	Nationwide outdoor areas	Road and train tunnels	Inside buildings
Method	Signal strength test of -109dBm from mobile handset		
Probability of coverage required	>99%	>85%	>99%
Frequency	Quarterly		
Results publication	Published on regulator's website		

4G coverage results, 3Q 2019

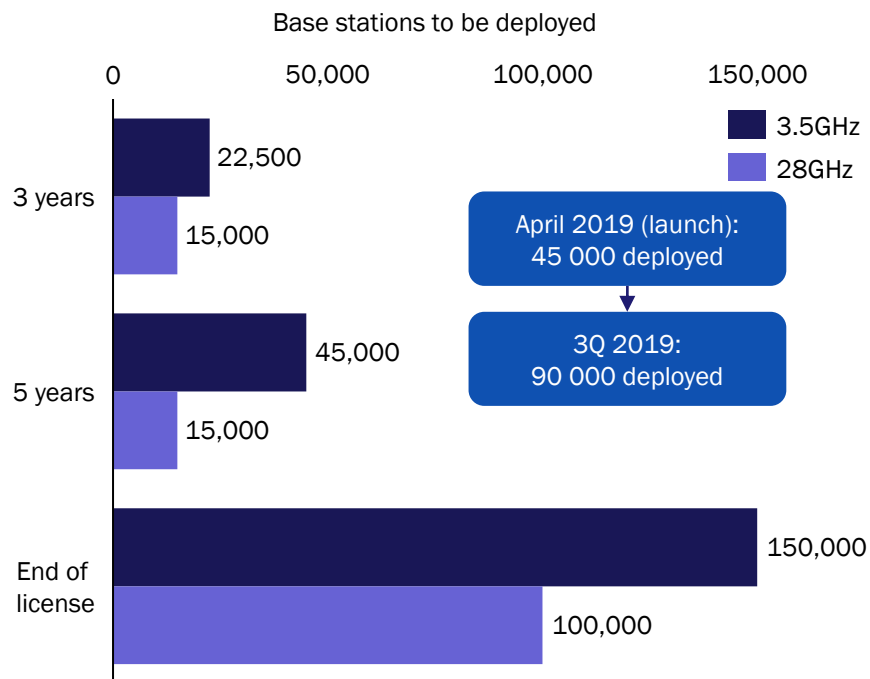


Source: IMDA

South Korea: MSIT has a clear roadmap on roll-out and spectrum release

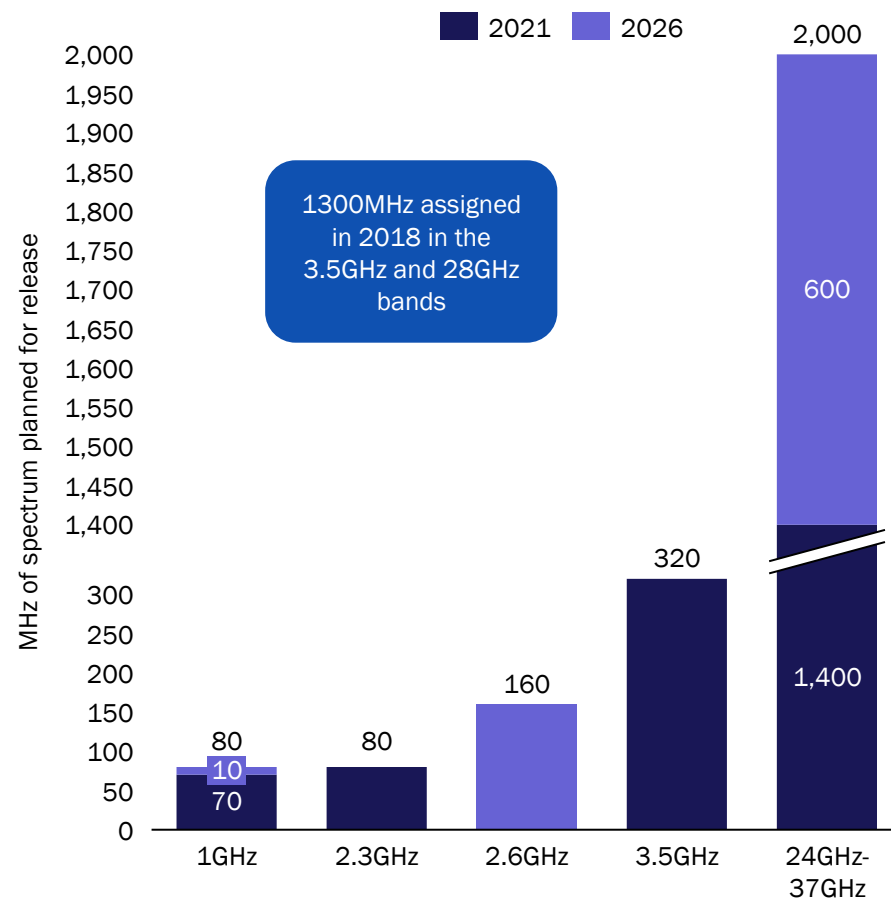
- MSIT has detailed obligations for base station roll-out and a timeline for future spectrum release

Base station deployment obligations



Source: MSIT

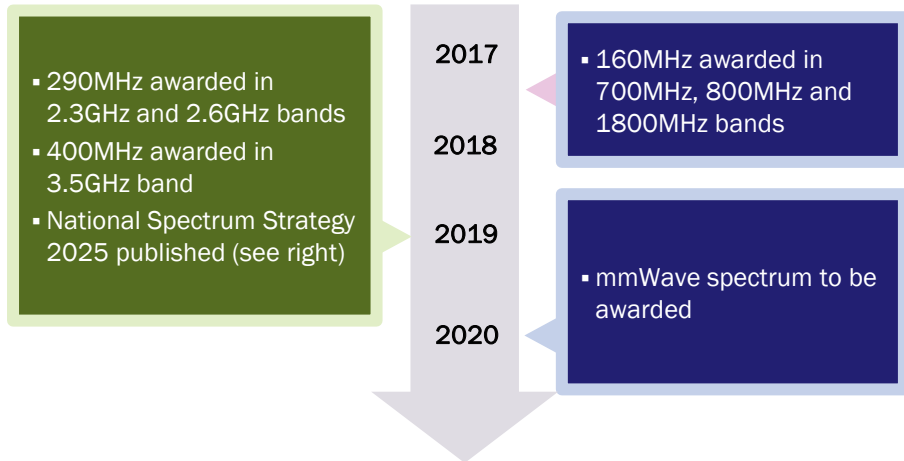
Spectrum planned for release by 2026



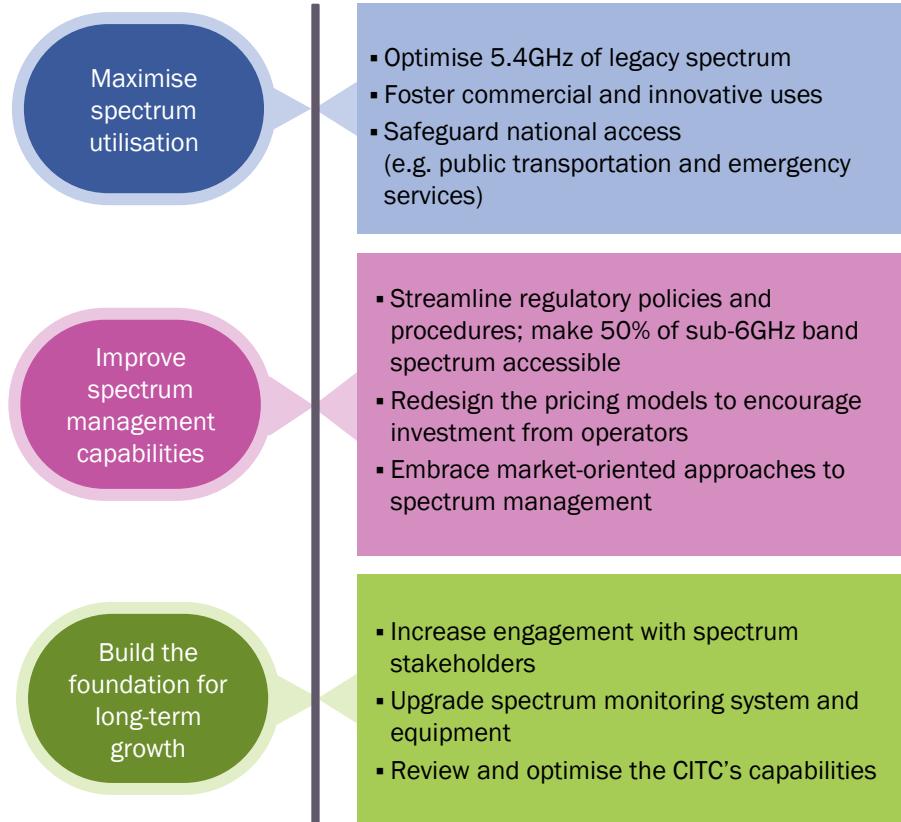
Saudi Arabia: MNOs benefit from the clarity of the National Spectrum Strategy

- The CITC has published the National Spectrum Strategy 2025 (summary on right)
- Immediate impact: Minimum bandwidth size for spectrum fee calculations has been reduced to increase flexibility

Timeline of CITC actions relating to 5G roll-out



National Spectrum Strategy 2025



Source: CITC

Summary: Extensive 5G coverage will require NRAs to consider sensible ways to incentivise MNOs to realise the potential of 5G



Worldwide deployment: 57 operators in 33 countries across all major regions have commercial 5G offerings by January 2020



Digital experience and transformation: 5G deployment promises to improve consumers' digital experience and facilitate digital transformation efforts for various industry verticals



Balancing act: Extensive 5G coverage will be required to realise the benefits promised by 5G but this objective of policy makers may be hard to align with MNOs' commercial goals



Challenges ahead: MNOs' 5G deployments face a number of challenges that impact their ability to offer extensive 5G coverage, including uncertain business cases



Rich toolkit: NRAs can tap into a combination of measures to incentivise MNOs to achieve extensive 5G coverage

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