
Policy Brief: Spectrum Regulation, South Africa 2021

Prepared for the

Presidential Economic Advisory Council (PEAC): Macro-dynamics Working Group

Ewan Sutherland and Luci Abrahams, LINK Centre, Wits University

7 May 2021

Problem statement and questions on radio spectrum assignment

1. The telecommunications sector has been identified by the National Treasury as one of the sectors that underpin growth, productivity and competitiveness of an economy:
2. The delay of the spectrum allocation process is (*the*) single biggest constraint on the growth of the telecommunications sector and a bottleneck for broader economic growth:
3. Recognising its importance, President Cyril Ramaphosa called for the immediate release of spectrum and at the SONA21 (Ramaphosa, 2021), he mentioned SA Connect, an old policy which was launched in 2013 and aimed to deliver widespread broadband access to 90% of the population by 2020:
4. The release of spectrum is currently stalled by legal cases against the regulator, ICASA, over the proposed allocation of spectrum to telecommunication companies
5. Given the need for inclusive economic growth, should we not be focused on the
 - i. transformative nature of equitable broadband distribution to consumers instead of
 - ii. the distribution of spectrum to telecommunication companies?
6. In many countries in the world, telecommunications and broadband is distributed by a few companies. Instead of focusing on the bidding companies, a significant measure is the extent to which the release of spectrum will reduce the cost of broadband connectivity, increase coverage and its overall contribution to economic growth.
7. Pertinent to this (*afternoon's*) discussion is that the delays and court cases around spectrum are holding up the proposed Wireless Open Access Network
8. What is the best way to unlock the spectrum deadlock to the benefit South Africans?

The problem statement was prepared by the PEAC Macro-dynamics Working Group. The policy brief is prepared by the LINK Centre and is written in two parts (1) a range of ideas for advice in the context of the problem statement and (2) important background discussion.

Please cite as: Sutherland, E., & Abrahams, L. (2021, May 7). Policy brief: Spectrum regulation, South Africa, 2021. LINK Centre, University of the Witwatersrand.

1 Ideas for advice in the context of the problem statement

1.1 Short-term actions

It seems unavoidable to roll-over the emergency assignments of spectrum for a substantial period, perhaps until after the next election in 2024, to give the operators sufficient certainty to justify some investments. Any additional spectrum that is available should be released immediately in the same way. It would require revocation of two existing policy directions and a new direction to be issued.

An interval of two or three years would allow reviews of the use of emergency spectrum and analyses of markets. In particular it would also allow a review of the Wireless Open Access Network (WOAN), in the light of changed economic circumstances and technological advances.

1.2 Review foci and mechanisms

Reviews are a powerful way of laying the foundation for moving forward. The subjects of possible reviews include:

- Spectrum;
- Broadband policy;
- WOAN; and
- Digital migration.

There are a number of possible forms of review, with the choice related to the problem and, especially, to forms that are most likely to work in South Africa:

1. Green paper, public consultation, White Paper, and legislation;
2. Industry and government forum;¹
3. OECD regulatory review (c.f. Brazil (OECD, 2020) and Mexico (OECD, 2017)), noting that South Africa has three OECD reviews, including the review of innovation policy (OECD, 2007), the territorial review for Cape Town (OECD, 2008) and for the Gauteng City-Region (OECD, 2011b);
4. A panel of wise men and women with experience in economics, regulation and telecommunications;
5. One or more citizens' juries;
6. A Competition Commission sector inquiry in terms of section 43(B)2 of the Competition Act.

1.3 Alternative regulatory approaches

Given its independence and its basis in law, to improve outcomes from ICASA would require new legislation, which could take several years. New sector legislation is necessary but does not address short-term needs. Money could be provided to recruit new staff, but without a much better analysis of its failings, this approach risks repeating past failures. Some of the councillors could be recalled and reassigned, though Parliament struggled to remove a convicted criminal as chairman (Chabalala, 2019), suggesting this might prove a difficult route.

¹ In the early 1990s a forum for open discussion was successful.

One option would be for ICASA to be directed to adopt the practice of the US Federal Communications Commission which has a large number of advisory committees and councils, comprising individuals from business, non-governmental organisations (NGOs) and universities (FCC, 2021b). Two that seem especially relevant are:

- Broadband Deployment Advisory Committee; and
- Technological Advisory Council.

These meet in public and are web-cast, allowing full disclosure. Their output is recommendations to the FCC.

Another practice of the FCC is the appointment of a Chief Economist, working with the Economic Analysis Division (EAD). The creation of a post of Chief Economist, together with an appropriate economics unit, would provide ICASA with the necessary resources to undertake rigorous evaluations and to develop impact assessments for its regulatory decisions. A similar case could be made for a General Counsel or Chief Legal Officer.

It would also be possible to have an institutional review performed by a reputable consulting house, followed by a facilitated change management programme, an approach that has proved of significant value for other public sector organisations. For example, the Competition Commission between 2006 and 2009 and again between 2009 and 2012 undertook processes of facilitated institutional strategy design, with technical support, to improve its performance, aided by a consultancy and by an external facilitator. In the case of ICASA, such an exercise could include the objective of developing a more adaptive and future-oriented regulatory approach.

The regulatory sandbox approach has been used to encourage regulatory innovation, for example in the fintech sector (Eggers, Turley, & Kishnani, 2018; Hagan & Jimenez, 2019). Its use is feasible in the electronic communications sector and already taken up in other parts of the world (Suwanprateep, 2019; Nesta, 2019; BNAmericas, 2021). A regulatory sandbox is a space that creates the opportunity for the regulator and regulated entities to experiment with ideas, proposals and propositions on innovative approaches that might be introduced in the short-term. It allows the collection and analysis of relevant data in order to understand their possible outcomes, and then confirm the best possible regulatory decision for the benefit of consumers and service providers. While regulatory sandboxes are most useful when introducing untested technologies, they can be adapted to the case where a regulatory impasse has been reached and needs unblocking.

South Africa already has an alternative regulatory model to ICASA and one that is generally considered successful, that is the Competition Commission and Competition Tribunal. Given its success and the similar nature of much of the work of ICASA, with the exception of cultural aspects of broadcasting, it would be possible to move ICASA under the Competition Tribunal. ICASA would then operate in a manner similar to the Competition Commission, with its decisions tested before an expert panel, which has already dealt with important telecommunications cases. Given the likely increased workload for the Tribunal it would need additional resources. The legislative text need not be very long, perhaps part of the next Competition Amendment Bill.

The UK was the original model for the regulatory state in South Africa, originating in a meeting between President de Klerk and Prime Minister Thatcher. There may be further

lessons to be learned from the UK. For example, it has focused on the relationship between the use of spectrum and economic growth (DCMS, 2010).

One innovation in the UK has been the introduction of the UK Regulators Network (UKRN, 2021), bringing together the Competition and Markets Authority (CMA) and a dozen regulators including energy, financial services, pensions and telecommunications. In addition to a small staff it has an advisory panel of experts. UKRN has developed performance scorecards for regulators, a cost of capital methodology and support for vulnerable consumers. This appears to draw on experience of the European Union, with regulators having been members of one or more sectoral European regulatory networks (ERNs), sharing experiences and problems.

A rather more imaginative structure is the Regulatory Horizons Council (RHC, 2021) created in 2020 as an independent expert committee. It is to identify the implications of technological innovation and provide government with impartial advice on regulatory reforms needed to support its rapid and safe introduction.

An independent National Infrastructure Commission (NIC, 2020) was created to provide government with long-term assessment of infrastructure requirements. It also produces specific studies, such as the report for government that examined “interventions required to position the UK as a world leader in 5G deployment” (NIC, 2016). This is part of a number of 5G initiatives, including industrial test-beds.

Some years ago, the European Commission identified considerable variations in the quality of impact assessments being conducted by its various directorates-general. To ensure consistency and improve their quality it created a body now called the Regulatory Scrutiny Board, comprising senior officials and external experts (EC, 2015; 2020; 2021). It examines and publishes opinions on the quality of draft impact assessment reports and an annual report. A similar body could be created in South Africa covering all the regulators, aiming to improve the quality of regulatory impact assessments (RIAs) and to ensure they cover issues such as distributional equity (Biden, 2021) and environmental effect (e.g., greenhouse gas emissions). This body might be made an independent agency of the Department of Planning, Monitoring and Evaluation.

1.4 A new collaborative regulatory network

It would be possible to create the South African Regulators Network (SARN), comprising the Competition Commission, Information Regulator, ICASA, Financial Services Board, National Credit Regulator, and National Energy Regulator of South Africa (NERSA). This could address common issues, such as:

- universal service;
- affordability;
- vulnerable consumers;
- decarbonisation;
- sharing of street digging, and
- smart cities.

A small secretariat could be created to coordinate this work. It could also be charged with developing a long-term assessment of infrastructure needs.

2. Background discussion

2.1 Radio-frequency spectrum management

The academic literature has viewed auctions as an effective way to assign spectrum, though adoption in practice was delayed by decades (Coase, 1959; 1998; Hazlett, 1998; Cramton, Kwerel, Rosston, & Skrzypacz, 2011). The difficulties encountered in conducting auctions have led to advice on the design of auctions, generating many tweaks and variations to achieve better outcomes (Klemperer, 2002a; 2002b). However, there have been comparatively few auctions in Africa, principally a flawed GSM auction in Nigeria in which one winner was awarded spectrum, that was subsequently tied up in litigation.

Very much less attention has been paid to the previous step in the spectrum regulatory process, namely the decisions of national governments at the International Telecommunication Union (ITU) through its World Radiocommunication Conferences (WRC), concerning the division of spectrum into bands and the allocation of services to those bands (ITU, 2021). These international administrative processes have been subject to rather complex and often well concealed lobbying by manufacturers and trade associations, supported by a few governments engaged in forms of industry policy and state capitalism to support manufacturers. For example, it was at WRCs that decisions were made about the bands for successive generations of mobile telecommunications that were later auctioned to operators. While the work of WRC is generally presented as being technical, nonetheless it was responsible for enabling competition in mobile services by providing a sufficiency of spectrum for multiple operators and enforcing the conversion of the 700 MHz or UHF band from television broadcasting into a cellular wireless network band (Garcia-Pardo, Garro, Gomez-Barquero, & Cardona, 2014; Delgado, 2015).

The principal output of each WRC is a new version of Radio Regulations (ITU, 2020). These are translated into national spectrum plans of considerable complexity that are effectively beyond the reach of politicians, leaving governments little choice but to accept them (ICASA, 2021b; PMG, 2021b).

One policy that has attracted considerable interest from those who view spectrum as property is the introduction of secondary trading (Mayo & Wallsten, 2010). For all the enthusiasm of its advocates, there is limited evidence of its success or, perhaps more importantly, the conditions needed to ensure successful implementation.

Where additional spectrum is assigned to the established players it allows them to deploy services rapidly, because they have infrastructure in place in the form of towers, backhaul and base stations, though they have to add or replace equipment and, in some instances, to upgrade backhaul connections. This was demonstrated by the emergency release of spectrum, which saw reasonably quick use by the mobile operators. The expectation of new market entrants was reasonable in the 1990s or even the early 2000s,² but now it verges on the impossible, with even the massive opportunity of two licences in Ethiopia attracting only two bids (Reuters, 2021b). In any event a new entrant would have to build out infrastructure, which might take years, although this could be accelerated by requiring access to existing

² Government rejected the possibility of a fourth mobile operator in 2000.

towers. A major obstacle here is that ICASA would not be seen as capable of enforcing such an obligation so that a new entrant would have to plan for new masts and towers.

2.2 Emergency spectrum assignment

The Minister issued a policy direction under the Emergency Regulations, requiring ICASA to issue spectrum to operators in a bid to alleviate bottlenecks and difficulties in access to the Internet because of COVID-19 (DTPS, 2020). A number of lockdown measures had been introduced to slow the spread of the SARS-CoV-2 virus that required many people to work from or to study from home, requiring Internet access. In short order ICASA issued spectrum to operators (see Table 1) (ICASA, 2020a; 2020b).

Table 1 Emergency spectrum assignments (ICASA, 2020c)

MTN	40 MHz	700-800 MHz
MTN	50 MHz	2600 MHz
MTN	50 MHz	3500 MHz
Vodacom	40 MHz	700-800 MHz
Vodacom	20 MHz	2300 MHz
Vodacom	50 MHz	2600 MHz
Vodacom	50 MHz	3500 MHz
Rain	20 MHz	2600 MHz
Telkom	40 MHz	700-800 MHz
Telkom	60 MHz	2300 MHz
Telkom	40 MHz	2600 MHz
Telkom	12 MHz	3500 MHz
Liquid Telecoms	4 MHz	3500 MHz

The original issuance was to end in November 2020 but has been extended. Most recently it was extended for two further months until 31st May 2021 (Reuters, 2021a; ICASA, 2021c).

ICASA should be required to produce a review of its deployment of emergency spectrum to cover the costs and benefits for consumers, and the positive and negative effects on competition. Allowing for consultations this could be completed in six months, certainly by the end of 2021.

2.3 Issues in high demand spectrum assignment

For several years there had been pressure from mobile operators to release spectrum termed 'high demand', because it allows efficient coverage of large areas (e.g., 825–830 MHz and 870–875 MHz), in the assignment of which South Africa badly lags other nations. The Independent Communications Authority of South Africa (ICASA, 2016) issued an invitation to apply (ITA) to mobile operators. A legal dispute then arose with a new Minister who wanted a different approach, which was settled out of court (DTPS, 2018a). Consequently, ICASA (2018) withdrew its ITA and the Department for Telecommunications and Postal Services (DTPS,

2018b) invited comments on a new draft policy direction. Soon yet another Minister was appointed who wanted further changes, even allegedly withholding funding from the regulator. ICASA announced a legal challenge against the government (SABC, 2019), after which the money was paid. Though the Minister claimed it had never been withheld, nonetheless it caused a further delay in publication of the spectrum policy (Blignaut, 2019). DTPS had to admit serious errors in drafting the Electronic Communications Amendment Bill (PMG, 2019b) requiring its withdrawal from Parliament late in 2018, with the loss of crucial spectrum provisions. The Minister then gazetted her policy direction, principally concerning the creation of the WOAN (DTPS, 2019). Next, in its findings on the mobile data services, the Competition Commission (2019) proposed that spectrum assignment be designed to be pro-competitive, potentially capping the spectrum holdings of the two major operators. This approach was likely to result in litigation to test the legality of any discrimination. A few weeks later National Treasury (2019) suggested a smaller spectrum assignment for the WOAN, with more for existing mobile operators. The COVID-19 emergency delayed the preparations for the auction and the decision about how much spectrum to allocate the WOAN, though the Minister remained adamant about its importance. While there had been a technical assessment of the WOAN (CSIR, 2018), there was no economic evaluation. The specification for the composition of a consortium for the WOAN was very complex, as was the requirement to provide a business plan of considerable detail, wonderfully over ambitious in terms of having a competitive outcome. This would have to be evaluated by ICASA with, once again, a considerable likelihood of litigation by losing bidders.

While the idea of shared resources (as would be the case in a WOAN) is common in telecommunications (e.g., unbundled local loops and undersea cables) it has been less common in radio access networks, with the obvious exception of the unlicensed spectrum bands, popularly used for Wi-Fi (e.g., ISM bands (ITU, n.d.)). Operators prefer and often insist on dedicated spectrum as it allows them to guarantee quality of service to their customers, which is very difficult in shared bands, often even within a home or an office.

Some mobile operators offer wholesale access to mobile virtual network operators (MVNOs), but this business model has often proved unstable and unprofitable, with problems of trust and information asymmetries.

The *Red Compartida* in Mexico might be comparable to the WOAN, though its circumstances are very different (Eberhard & Heuermann, 2018; Leins, 2019). A similar proposal in the United States failed, denounced as being designed to extract value for the spectrum at the expense of government and citizens (Entner, 2019).

A further point on high demand spectrum, a central question is whether it is reasonable to believe the three smaller mobile players (Telkom, Cell-C and Rain) have the capital to deploy 5G networks, which requires many more masts and towers to provide dense coverage in urban areas and the greatly expanded coverage in rural area to increase competition (Gunnion, 2020; Mcleod, 2021b). There are ways to assist them, for example, by reducing costs and sharing infrastructure. It is at best challenging and, perhaps, unlikely they can pay large licence fees and deploy national networks, or not without significant delays.

Mandatory wholesale access and the sharing of masts and poles are commonplace in telecommunications, but not in South Africa. Telkom appealed a ruling requiring it to share unused space in its ducts with Vodacom (*Dennegeur Estate Home Owners Association v Telkom SA*, 2019). Apparently, it has been refused leave to appeal by the Constitutional Court

(McLeod, 2021a). Nonetheless, Telkom may not yet have accepted that such infrastructure must be shared.

A major cost reduction would be to forego auction fees. The argument would be that the economic benefit would be greater by spending money on deployment rather than channelling it from consumers through National Treasury to other projects. Moreover, in the absence of new entrants an auction would yield little information about the real value of the spectrum. Allocation could be made conditional on some sort of commitment to geographical coverage, e.g., no fee would be charged if within three years an operator provided 5G signal coverage for, say, 50 (or 60 or 70) per cent of the people of South Africa or 50 (or 60 or 70) per cent of each of the provinces. Given the very low population densities of parts of South Africa, mere geographic coverage may not be very useful, though some trunk routes and tourist locations might need to be specified. Equally, it should be conditional on continuing to reduce prices, in line with the recommendations of the Competition Commission.

A reverse auction would also be possible, designating a block of spectrum and asking how much coverage the operators could provide with it and how quickly. Clearly, this would favour MTN and Vodacom, if they were allowed to bid. A more complex option would be to do each province separately and require national roaming between them. Thus if, say, MTN won the spectrum in Northern Cape it would be required to allow customers of Cell-C, Rain, Telkom and Vodacom to use the MTN network when in the province, being paid a wholesale price by their operator.

There are simple trade-offs between spectrum and cell sites, that is why it is called cellular. With no more spectrum operators sub-divided cells and that is what they have had to do over many years.

2.4 Digital migration

Digital migration is relevant to freeing up the high demand 700–800MHz bands. Broadcasting has evolved considerably as a result of technological advances, beginning at relatively low frequencies and occupying substantial assignments for each station, before moving to higher frequencies and using less spectrum but much more efficiently. The higher frequencies have shorter ranges allowing re-use and more localised services (e.g, FM radio). Additionally, some services were made available from satellites serving much larger areas (e.g., Multichoice), but requiring special antennas. Digitalisation enabled the use of multiplexers, so that a transmitter on a single frequency could carry several radio or television signals at high quality. Such changes required broadcasters to update their studios and transmitters, including the links between them. Internet access allowed radio and television stations both to ‘broadcast’ content and to make it available on-demand, so that much viewing and listening has become non-linear, sometimes resulting in binge-watching (e.g., a whole series of *Grey’s Anatomy*). Online video services such as YouTube opened access and distribution to many, while TikTok engaged a younger audience for short videos. Thus consumers can access the same or similar content over terrestrial digital broadcasting, satellite digital broadcasting and on the Internet, including streaming on 4G and 5G mobile networks. New methods of payment were introduced, with some channels paid from taxation, some by advertisements and some by subscription (Armstrong & Collins, 2004; Berger, 2012).

In 2006, a Regional Radiocommunication Conference agreed that countries in Africa and Europe would migrate from analogue to digital terrestrial television by June 2015, such

coordination avoiding interference between countries (ITU, 2006). This was later extended to July 2020. Faced with the end of analogue broadcasts it was recognised that consumers would have to purchase set top boxes (STBs) to convert a digital signal for an analogue TV or else purchase digital television sets. It was expected that governments would run promotion campaigns to inform consumers and would, for vulnerable groups, have to subsidise the supply of STBs. The benefit of the digital switchover would be the release of a significant quantity of spectrum that could be put to other uses, the so-called ‘digital dividend’. The mobile network operators and their manufacturers pressed governments at the ITU, promising to pay licence fees for the spectrum and to provide improved rural coverage.

The Department of Communications (DoC) published a Broadcasting Digital Migration Policy, to be completed in three years and with local manufacturing of STBs, which was to be³:

Achieved in a phased manner, national broadcasting digital signal coverage shall be covering 50% of population by 2008, 80% of population by 2010 and close to 100% by 2011 enabling analogue switch-off. (DoC, 2008).

This was the result of a Digital Migration Working Group (DMWG), established by the Department of Communications in 2005, and a public participation process in 2007. The switch-on date was moved to coincide with the ITU WSA in Kempton Park, performed in front of delegates from all countries (Matsepe-Casaburri, 2008).

The policy was later amended, to reflect considerable delays and in the light of inputs from stakeholders, noting that:

The looming switch-on date in the last quarter of 2012 requires us to work at the speed of light, consistent with our business unusual strategy to enhance the benefits of digital television to all our people (DoC, 2012, p. 4).

It described a “dual illumination” period, when both analogue and digital signals would be available, with switch-off to be determined by the Minister, though still committed to achieving the ITU target of analogue switch-off by 17 June 2015. The Department created a Digital Migration Project Office to oversee implementation.

The DoC (2013a) proposed further amendments to the policy, notably moving the switch-on date to April 2014, with an initial 84 per cent population coverage. The final policy was without fixed dates – these were to be determined by the Minister. At that time:

The total TV-owning households in South Africa are estimated at 13 million, of which approximately 65 per cent rely exclusively on free-to-air broadcasting services (DoC, 2015).

Where it was difficult or uneconomical to provide terrestrial digital signals, they would instead be covered by free-to-air satellite using DVB-S2 technology. The Minister began the process of registration of poor households that were to receive free STBs, expected to amount to more than 5 million (Muthambi, 2015).⁴ The policy was unsuccessfully challenged by a large broadcaster seeking, *inter alia*, to have encryption in the STBs (*e.tv (Pty) Ltd v Minister of Communications and others*, 2015).

³ More accurately this would have been assembly rather than manufacturing.

⁴ Some of the households appear not to have had television sets.

In SONA 2021, the President said:

The completion of digital migration is vital to our ability to effectively harness the enormous opportunities presented by technological change. After many delays, we will begin the phased switch-off of our analogue TV transmitters from next month. It is anticipated that this process, which will be done province-by-province, will be completed by the end of March 2022. (Ramaphosa, 2021).

The Minister reiterated the commitment to analogue switch-off by that date (IT Web, 2021; PMG, 2021a). However, this has to be open to serious doubt, given that the South African Bureau of Standards (SABS) only issued the final standard last October (SABS, 2020), and by then manufacturers were under COVID-19 restrictions. Moreover, the implementation is to be by the South Africa Post Office (SAPO), Universal Service and Access Agency of South Africa (USAASA) and Sentech, none of which has a particularly strong reputation.⁵ On the other hand, access to broadband Internet for watching TV is out of reach for a very large proportion of South African households, hence this is not an option for lower income households.

The failures stretch back over many years, with the project now running a decade behind schedule and with only limited hope of achieving the commitment made by the President. There is limited data on how the use of satellite and terrestrial, and linear and non-linear content is evolving, making it unnecessarily difficult to formulate public policy. There has been a persistent belief that jobs can be created and sustained in manufacturing, despite the vast majority of components for STBs having to be imported. The only jobs are now seen to be in installing STBs and their subsequent maintenance. In the absence of terrestrial digital broadcasting, analogue broadcasting could still be shut down, with consumers moving to 5G or satellite, but that seems many years away. A major reason for the ITU coordination on shutdown was to avoid difficulties with adjoining countries, in the case of South Africa: Botswana, eSwatini, Lesotho, and Mozambique. If those countries did not object, then South Africa could continue with analogue broadcasts.

2.5 SA Connect policy review

The idea of a plan or strategy for broadband deployment arose because it spanned more issues than normally fell within telecommunications policy, allowing governments to develop something encompassing all the issues they considered essential or necessary (OECD, 2011a). One of the dangers of such an approach was that it became a commonplace of public policy, something all countries felt they should have. Thus, some borrowed more from others than was wise and adapted ideas to their national circumstances less than would have been wise. The OECD (2021) has recently issued a revised broadband recommendation.

In the case of South Africa Connect the aims were unexceptionable and aligned with other countries and with the National Development Plan (DoC, 2013b). Yet the mechanisms to improve availability and affordability were overly complex and inadequately monitored. Indeed, there does not seem to be a definition of affordability. There should have been a review of SA Connect after a few years to determine if it was achieving the goals and if it required changes. Instead, it was left in limbo, not helped by changes in government Ministers, who did not seem concerned about initiatives begun by their predecessors.

⁵ USAASA is presently recruiting a new CEO and CFO.

In parallel, commercial operators began to deploy fibre to the home (FTTH), albeit in upmarket settings of posh gated communities. Nonetheless, it became clear that market forces and commercial operators could supply some of the demand and that this ought to be encouraged. There appears to be no central map of these initiatives and planned developments. A major data collection exercise would be the first step to developing a new plan, after a thorough examination of what went wrong with SA Connect and the state of global best practice.

2.6 National security questions

In the United States, the Trump Administration took up an issue that had long concerned the Congress, namely security risks arising from the use of equipment manufactured in China. This was implemented as the Secure and Trusted Communications Networks Act of 2019, requiring operators to rip-and-replace such equipment (FCC, 2020; 2021a). The US persuaded its European allies to follow its example (NIS CG, 2020; Warman, 2021).

However, no similar effort appears to have been made in Africa. Nonetheless, the first issue is whether the use by commercial mobile network operators of Huawei and ZTE equipment is a threat to the security of South Africa. The second issue is for the longer term, concerning whether US actions will split the global market in two, reducing economies of scale and raising costs for consumers. This may require a decision about whether South Africa should sit on the US or Chinese side of the fence.

One of effects of the US move has been a significant boost for Open Radio Access Network (Open RAN) systems, involving a number of US manufacturers and software houses. It is a significant change for operators, requiring either in-house or contracted systems integration, to turn the generic boxes and specialised software into functioning networks. It is claimed by Rakuten, a greenfield 4G and 5G operator in Japan, that it made considerable savings by deploying Open RAN technology (Kapko, 2021).

The adoption of Open RAN by mobile operators is largely a commercial decision, since licences do not specify the manufacturers to be used, only that services conform to international standards. However, some governments (eg. US, UK, Germany) are encouraging the use of Open RAN because they consider it increases competition in the equipment market, reduces costs in rural areas or replaces high risk vendors.

Both MTN and the Vodafone Group have experimented with Open RAN, with suggestions it could be cost effective in rural areas (MTN, 2019; Wieland, 2020).

2.7 5G and 6G spectrum assignment

The fifth generation of mobile telecommunications is gradually emerging. In many countries mobile operators have technology-neutral licenses allowing them to switch from 4G to 5G when they consider there is demand. Many regulators have released additional spectrum, some using auctions but others using administrative measures.

Globally, 5G subscriptions grew by 57 per cent in the fourth quarter of 2020 to reach nearly 401 million, representing 4.2 per cent of the total mobile market (GSA, 2021a).

428 operators in 132 countries or territories are investing in 5G networks in the form of tests, trials, pilots, planned and actual deployments, of which 153 operators in 64 countries or

territories have launched commercial 3GPP-compatible 5G services (either mobile or fixed wireless access (FWA)) (GSA, 2021b).

For the average consumer 5G is just faster 3G or 4G, a change that seems to bring limited increases in revenues for operators. In South Africa a vital digital divide concerns those who cannot afford a smartphone, regardless of its generation, with no plan to close this divide. Many who have smartphones cannot afford to purchase data or have to give up other spending to purchase data (Competition Commission, 2019).

A crucial benefit from 5G arises from its use on commercial and industrial campuses, where its low latency and high bandwidth provide opportunities for new developments. 5G private networks are central to new approaches to industrial automation and are thus a vital building block for the “fourth industrial revolution” (4IR). This requires the licensing of spectrum to organisations such as large manufacturers and universities, to avoid them having to work through the mobile operators. Many of these networks will use Open RAN systems (GSA, 2020; Mobile Europe, 2021; Larmo, von Butovitsch, Campos Millos, & Berg, 2019).

The first four generations of mobile phones were about individuals, initially business and government users, then vast numbers of consumers. The Fifth Generation brings a major class of new uses with the Internet of Things (IoT). Although there are rival wireless technologies, it is expected that 5G will gain significant revenues and offer benefits to businesses. The new massive Machine Type Communication (mMTC) enables efficient transmission of low data volumes intermittently to and from devices with long battery life spread over wide areas. Improved efficiency enables greater capacity networks to serve these vast numbers of devices, though necessarily not all at once. Both Narrowband Internet of Things (NB-IoT) and Long Term Evolution for Machines (LTE-M) are included in mMTC and are operational in many countries. Applications include smart meters, self-driving vehicles, and objects on factory floors, generating benefits including reduced healthcare costs, reducing carbon footprints, and improved transportation safety. Not only should South Africa make the 5G spectrum available, there are a wide range of skills needed in organisations to learn to use these technologies effectively and to devise consumer services using the sensors and actuators. (Rodríguez Ovejero, 2018; Edquist, Goodridge, & Haskel, 2021; Tamsons, 2021).

There has been considerable interest in mmWave band spectrum, 24.25 to 86 GHz, especially in the United States. It would be useful if ICASA could explore the release of this spectrum for 5G services.

One of the important features of 5G is ‘network slicing’, assigning a chunk of capacity to a user or group of users for a particular purpose (Foukas, Patounas, Elmokashfi, & Marina, 2017; Zhang, 2019). This is especially important in South Africa since it allows all operators to provide wholesale access in a variety of ways, leasing different slices to different customers, depending on their needs. This looks similar to the role envisaged for the wholesale open access network (WOAN), though with all the competing operators offering such services, making the WOAN approach rather superfluous. The regulation of the provision of such slices appears not to fit with existing legislation, notably the ECA 2005, though it would fall under the Competition Act.

Given that work is underway on 6G it would be advisable to create a committee to examine inputs from South Africa to that process. This needs to involve various government

departments, various regulators, universities, NGOs, business users and other interested parties.

2.8 Regulatory performance: ICASA

There has been a regrettable sequence of failures at ICASA reflected in adverse judgements in the High Court. To make matters worse there has been actual or threatened litigation between ICASA and the Minister. To be fair, the Minister lost a significant bill in Parliament due to poor drafting (PMG, 2019a), and Telkom verges on being a vexatious litigant claiming to operate a “Stalingrad” defence. Consequently, there is enough blame for everyone.

The recent judgment of Baqwa J may not be perfect, though it was only on interim relief, nonetheless some reasonable points were made against ICASA in its mishandling of the spectrum process (Telkom SA v ICASA, 2021). The intention by ICASA to appeal that judgement risks looking foolish, because the judgement is appropriate to the circumstances and this would encourage further delays, with a full hearing possible only in July (ICASA, 2021a), with the further risk that ICASA or Telkom takes the decision to appeal.

Bibliography

- Armstrong, C., & Collins, R. (2004). *Digital dilemmas for South African TV*. Johannesburg: LINK Centre, University of the Witwatersrand.
<https://www.wits.ac.za/media/migration/files/cs-38933-fix/migrated-pdf/pdfs-5/ddtvcarc.pdf>
- Berger, G. (2012). Theorising African communications: the bad news signalled by broadcast digital migration policy. *South African Journal for Communication Theory and Research*, 38(2), 135-146. doi:10.1080/02500167.2012.717344
- Biden, J. R. (2021, January 20). *Modernizing regulatory review*. The White House: <https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/20/modernizing-regulatory-review/>
- Blignaut, C. (2019, April 28). *Communications minister accused of meddling unlawfully in ICASA*. City Press: <https://city-press.news24.com/News/communications-minister-accused-of-meddling-unlawfully-in-icasa-20190428>
- BNAmericas. (2021, January 21). *Brazil readies telecom regulatory sandbox based on Colombian model*. BNAmericas: <https://www.bnamericas.com/en/news/brazil-readies-telecom-regulatory-sandbox-based-on-colombian-model>
- Chabalala, J. (2019, February 15). *Icasa boss sentenced to 20 years in prison for fraud, money laundering*. Mail & Guardian: <https://mg.co.za/article/2019-02-15-icasa-boss-sentenced-to-20-years-in-prison-for-fraud-money-laundering/>
- Coase, R. H. (1959). The Federal Communications Commission. *The Journal of Law & Economics*, 2(4), 879-915. doi:10.1086/466549
- Coase, R. H. (1998). Comment on Thomas W. Hazlett: Assigning property rights to radio spectrum users: why did FCC license auctions take 67 years? *The Journal of Law and Economics*, 41(s2), 577-580. doi:10.1086/467403

- Competition Commission. (2019, January 1). *Data Market Inquiry*. Competition Commission: <http://www.compcom.co.za/data-market-inquiry/>
- Cramton, P., Kwerel, E., Rosston, G., & Skrzypacz, A. (2011). Using spectrum auctions to enhance competition in wireless services. *The Journal of Law & Economics*, 54(s4), S167-S188. doi:10.1086/661939
- CSIR. (2018, September 27). Spectrum requirements for Wholesale Open Access Network (WOAN). *Government Gazette*, 639(41935), 10-53.
- DCMS. (2010). *Enabling UK growth – Releasing public spectrum – Making 500 MHz of spectrum available by 2020*. London: Department for Culture, Media & Sport. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/77429/Spectrum_Release.pdf
- Delgado, J. (2015). Reallocating the 700 MHz band: should we do it? *info*, 17(1), 9-21. doi:10.1108/info-07-2014-0032
- Dennegeur Estate Home Owners Association v Telkom SA, 366/2018 [2019] ZASCA 37; 2019 (4) SA 451 (SCA) (South Africa Supreme Court of Appeal March 29, 2019). <http://www.saflii.org/za/cases/ZASCA/2019/37.html>
- DoC. (2008, September 8). Notice 958. Broadcasting digital migration policy for South Africa. *Government Gazette*, 519(31408), 3-21. <https://www.gov.za/documents/electronic-communications-act-broadcasting-digital-migration-policy>
- DoC. (2012, February 17). N. 97 Amendment of Broadcasting digital migration policy. *Government Gazette*, 560(35014), 3-13. <https://archive.opengazettes.org.za/archive/ZA/2012/government-gazette-ZA-vol-560-no-35014-dated-2012-02-07.pdf>
- DoC. (2013a, December 6). Notice 954. Proposed amendment of Broadcasting digital migration policy (as amended). *Government Gazette*, 582(37120), 3-6. https://www.dtps.gov.za/index.php?option=com_phocadownload&view=category&download=88:proposed-amendment-of-broadcasting-digital-migration-policy-as-amended&id=3:policies&Itemid=133
- DoC. (2013b, December 6). South Africa Connect: creating opportunities, ensuring inclusion. *Government Gazette*, 582(37119), 3-64. https://www.gov.za/sites/default/files/gcis_document/201409/37119gon953.pdf
- DoC. (2015, March 18). Electronic Communications Act: Broadcasting digital migration policy: Amendment. *Government Gazette*, 597(38583), 3-5. <https://www.gov.za/documents/electronic-communications-act-broadcasting-digital-migration-policyamendment-18-mar-2015>
- DTPS. (2018a, September 26). *Minister Dr Siyabonga Cwele and the Council of ICASA agree to settle the spectrum court challenge and to initiate the licensing of unallocated high demand spectrum*. Department of Telecommunications and Postal Services: <http://tiny.cc/a80tbz>

- DTPS. (2018b, September 28). *Minister of Telecommunications and Postal Services Dr Siyabonga Cwele invites interested persons to provide written inputs on the proposed policy and policy direction to the Authority on licensing of unassigned high demand spectrum*. Department for Telecommunications and Postal Services: <http://tiny.cc/q60tbz>
- DTPS. (2019, July 26). Policy on High Demand Spectrum and Policy Direction on the Licensing of a Wireless Open Access Network. *Government Gazette*, 649(43597), 3-11. <https://www.ellipsis.co.za/wp-content/uploads/2019/07/Policy-Direction-on-High-Demand-Spectrum-and-Policy-Direction-on-the-Licensing-of-the-WOAN-26-July-2019.pdf>
- DTPS. (2020, March 26). Notice No. 417, Electronic communications, postal and broadcasting directions issued under Regulation 10(8) of the Disaster Management 2002 (Act No. 57 of 2002). *Government Gazette*, 657(43164), 3-10.
- e.tv (Pty) Ltd v Minister of Communications and others, (26166/2015) [2015] ZAGPPHC 1148 (North Gauteng High Court, Pretoria June 24, 2015). <http://www.saflii.org/za/cases/ZAGPPHC/2015/1148.html>
- Eberhard, U., & Heuermann, A. (2018). Open access via mobile wholesale network: a new approach to broadband deployment: the case of Mexico. In P. Krüssel, *Future Telco* (pp. 263-271). Cham: Springer International. doi:10.1007/978-3-319-77724-5_23
- EC. (2015). *Regulatory Scrutiny Board: Mission, tasks and staff*. C(2015) 3262 final. Brussels: European Commission. https://ec.europa.eu/info/sites/default/files/communication-on-the-regulatory-scrutiny-board-mission-tasks-and-staff_may2015_en.pdf
- EC. (2020). *Regulatory Scrutiny Board: annual report 2020*. Brussels: European Commission. https://ec.europa.eu/info/sites/default/files/rsb_report_2020_en.pdf
- EC. (2021, April 25). *Regulatory Scrutiny Board*. European Commission: https://ec.europa.eu/info/law/law-making-process/regulatory-scrutiny-board_en
- Edquist, H., Goodridge, P., & Haskel, J. (2021). The Internet of Things and economic growth in a panel of countries. *Economics of Innovation and New Technology*, 30(3), 262-283. doi:10.1080/10438599.2019.1695941
- Eggers, W. D., Turley, M., & Kishnani, P. K. (2018, June 19). *The future of regulation: principles for regulating emerging technologies*. Deloitte Insights: <https://www2.deloitte.com/us/en/insights/industry/public-sector/future-of-regulation/regulating-emerging-technology.html>
- Entner, R. (2019, March 21). *Industry voices — Entner: Can Rivada succeed where the U.S. government has failed?* Fierce Wireless: <https://www.fiercewireless.com/wireless/industry-voices-entner-can-rivada-succeed-where-u-s-government-has-failed>
- FCC. (2020, July 16). *FCC implements the Secure Networks Act*. Federal Communications Commission: <https://www.fcc.gov/document/fcc-implements-secure-networks-act>
- FCC. (2021a, March 21). *FCC Releases List of Equipment & Services That Pose Security Threat*. Federal Communications Commission: <https://www.fcc.gov/document/fcc-releases-list-equipment-services-pose-security-threat>

- FCC. (2021b, April 25). *Advisory Committees of the FCC*. Federal Communications Commission: <https://www.fcc.gov/about-fcc/advisory-committees-fcc>
- Foukas, X., Patounas, G., Elmokashfi, A., & Marina, M. K. (2017). Network slicing in 5G: survey and challenges. *IEEE Communications Magazine*, 55(5), 94-100. doi:10.1109/MCOM.2017.1600951
- Garcia-Pardo, C., Garro, E., Gomez-Barquero, D., & Cardona, N. (2014). Coexistence of digital terrestrial television and next generation cellular networks in the 700 MHz band. *IEEE Wireless Communications*, 21(6), 63-69. doi:10.1109/MWC.2014.7000973
- GSA. (2020). *Private networks*. Farnham: Global mobile Suppliers Association. <https://gsacom.com/paper/private-mobile-networks-october-2020-update/>
- GSA. (2021a). *LTE & 5G subscribers - March 2021*. London: Global mobile Suppliers Association.
- GSA. (2021b). *Networks, technologies & spectrum snapshot*. London: Global mobile Suppliers Association.
- Gunnion, S. (2020, June 23). *Telkom disconnects dividends for now*. Ince Connect: <https://www.inceconnect.co.za/article/telkom-disconnects-dividends-for-now>
- Hagan, M., & Jimenez, J. G. (2019, November 8). *Regulatory sandboxes for legal services innovation*. Medium: <https://medium.com/legal-design-and-innovation/regulatory-sandboxes-for-legal-services-innovation-7438bb9b658e>
- Hazlett, T. W. (1998). Assigning property rights to radio spectrum users: why did FCC license auction take 67 years? *Journal of Law and Economics*, 41(s2), 529-575. doi:10.1086/467402
- ICASA. (2016, July 15). Invitation to apply for a radio frequency spectrum licence to provide mobile broadband wireless access services for urban and rural areas using the complimentary bands, 700 MHz, 800 MHz and 2.6GHz. *Government Gazette*, 613(40145), 4-61. <https://www.ellipsis.co.za/wp-content/uploads/2015/05/Invitation-to-apply-for-International-Mobile-Telecommunication-Spectrum.pdf>
- ICASA. (2018, October 18). *Withdrawal of the 2016 Invitation To Apply for the licensing of International Mobile Telecommunications (IMT) spectrum*. Independent Communications Authority of South Africa: <https://www.icasa.org.za/news/2018/withdrawal-of-the-2016-invitation-to-apply-for-the-licensing-of-international-mobile-telecommunications-imt-spectrum>
- ICASA. (2020a, April 6). General notice 238: Independent Communications Authority of South Africa Act (13/2000): Information and Communications Technology ('ICT') COVID-19 National Disaster Regulations. *Government Gazette*, 658(43207), 3-15. <https://www.icasa.org.za/legislation-and-regulations/ict-covid-19-national-disaster-regulations>
- ICASA. (2020b, April 6). *Emergency release of spectrum to meet the spike in broadband services demand due to COVID-19*. Independent Communications Authority of South Africa: <https://www.icasa.org.za/news/2020/emergency-release-of-spectrum-to-meet-the-spike-in-broadband-services-demand-due-to-covid-19>

- ICASA. (2020c, April 17). *Temporary radio frequency spectrum issued to qualifying applicants in an effort to deal with COVID-19 communication challenges*. Independent Communications Authority of South Africa: <https://www.icasa.org.za/news/2020/temporary-radio-frequency-spectrum-issued-to-qualifying-applicants-in-an-effort-to-deal-with-covid-19-communication-challenges>
- ICASA. (2021a, March 16). *ICASA reaffirms its position to appeal the judgement on the licensing of spectrum*. Independent Communications Authority of South Africa: <https://www.icasa.org.za/news/2021/icasa-reaffirms-its-position-to-appeal-the-judgement-on-the-licensing-of-spectrum>
- ICASA. (2021b, April 25). *Radio Frequency Spectrum Assignment Plans*. Independent Communications Authority of South Africa: <https://www.icasa.org.za/legislation-and-regulations/radio-frequency-spectrum-plans>
- ICASA. (2021c, March 26). *ICASA extends temporary radio frequency spectrum assignments for licensees*. Independent Communications Authority of South Africa: <https://www.icasa.org.za/news/2021/icasa-extends-temporary-radio-frequency-spectrum-assignments-for-licensees>
- IT Web. (2021, February 17). *Comms minister commits to March 2022 digital migration deadline*. IT Web: <https://www.itweb.co.za/content/Kjlyrvw1oLrMk6am>
- ITU. (2006). *Final Acts of the Regional Radiocommunication Conference for planning of the digital terrestrial broadcasting service in parts of Regions 1 and 3, in the frequency bands 174-230 MHz and 470-862 MHz (RRC-06) Geneva, 15 May - 16 June 2006*. Geneva: International Telecommunication Union. <https://www.itu.int/en/history/Pages/RadioConferencesRegional.aspx?conf=4.129>
- ITU. (2020). *Radio Regulations*. Geneva: International Telecommunication Union. <https://www.itu.int/pub/R-REG-RR-2020>
- ITU. (2021, May 1). *World Radiocommunication Conferences (WRC)*. International Telecommunication Union: <https://www.itu.int/en/ITU-R/conferences/wrc/Pages/default.aspx>
- ITU. (n.d.). *G013. What is meant by ISM applications and how are the related frequencies used?* International Telecommunication Union: <https://www.itu.int/net/ITU-R/terrestrial/faq/index.html#g013>
- Kapko, M. (2021, February 7). *Rakuten claims Open RAN performance gain is imminent*. SDX Central: <https://www.sdxcentral.com/articles/news/rakuten-claims-open-ran-performance-gain-is-imminent/2021/02/>
- Klemperer, P. (2002a). What really matters in auction design. *Journal of Economic Perspectives*, 16(1), 169-189. doi:10.1257/0895330027166
- Klemperer, P. (2002b). How (not) to run auctions: The European 3G telecom auctions. *European Economic Review*, 46(4-5), 829-845. doi:10.1016/S0014-2921(01)00218-5
- Larmo, A., von Butovitsch, P., Campos Millos, P., & Berg, P. (2019, December). *Critical capabilities for private 5G networks*. LM Ericsson: <https://www.ericsson.com/en/reports-and-papers/white-papers/private-5g-networks>

- Leins, T. (2019, July 30). *Can Red Compartida disrupt the Mexican mobile market?* Telegeography: <https://blog.telegeography.com/can-red-compartida-disrupt-the-mexican-mobile-market>
- Matsepe-Casaburri, I. (2008, October 21). *Opening address at WTSA-08*. International Telecommunication Union: https://www.itu.int/dms_pub/itu-t/oth/26/07/T26070000010000PDFE.pdf
- Mayo, J. W., & Wallsten, S. (2010). Enabling efficient wireless communications: the role of secondary spectrum markets. *Information Economics and Policy*, 22(1), 61-72. doi:10.1016/j.infoecopol.2009.12.005
- Mcleod, D. (2021a, March 23). *Supreme court blocks Telkom in fight with Vodacom over ducts*. Tech Central: <https://techcentral.co.za/supreme-court-blocks-telkom-in-fight-with-vodacom-over-ducts/105952/>
- Mcleod, D. (2021b, April 20). *Cell C reports R5.5-billion full-year loss on impairments, once-off costs*. Tech Central: <https://techcentral.co.za/cell-c-reports-r5-5-billion-full-year-loss-on-impairments-once-off-costs/106637/>
- Mobile Europe. (2021, March 30). *1.56 million private 5G cells deployed by 2027*. Mobile Europe: <https://www.mobileeurope.co.uk/press-wire/15648-1-56-million-private-5g-cells-deployed-by-2027>
- MTN. (2019, November 12). *MTN Group drives innovative rural coverage using OpenRAN technology*. MTN Group: <https://www.mtn.com/mtn-group-drives-innovative-rural-coverage-using-openran-technology/>
- Muthambi, F. (2015, September 29). *Minister Faith Muthambi takes the first TV households registration process to Keimoes, Northern Cape*. Government of South Africa: <https://www.gov.za/speeches/minister-muthambi-takes-first-tv-households-registration-process>
- Nesta. (2019). *Renewing Regulation: 'anticipatory regulation' in an age of disruption*. London: Nesta. <https://www.nesta.org.uk/report/renewing-regulation-anticipatory-regulation-in-an-age-of-disruption/>
- NIC. (2016). *Connected Future*. London: National Infrastructure Commission. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/577906/CONNECTED_FUTURE_ACCESSIBLE.pdf
- NIC. (2020, January 31). *National Infrastructure Commission*. National Infrastructure Commission: <https://www.nic.org.uk/>
- NIS CG. (2020). *Cybersecurity of 5G networks - EU Toolbox of risk mitigating measures*. Brussels: European Commission. <https://digital-strategy.ec.europa.eu/en/library/cybersecurity-5g-networks-eu-toolbox-risk-mitigating-measures>
- OECD. (2007). *OECD Reviews of Innovation Policy: South Africa 2007*. Paris: Organisation for Economic Cooperation and Development. doi:10.1787/19934211
- OECD. (2008). *OECD territorial review for Cape Town*. Paris: Organisation for Economic Cooperation and Development. doi:10.1787/9789264049642-en

- OECD. (2011a). *National broadband plans*. Paris: Organisation for Economic Cooperation and Development. doi:10.1787/5kg9sr5fmqwd-en
- OECD. (2011b). *OECD Territorial reviews: the Gauteng City-Region, South Africa*. Paris: Organisation for Economic Cooperation and Development. doi:10.1787/9789264122840-en
- OECD. (2017). *OECD Review of telecommunication policy and regulation in Mexico*. Paris: Organisation for Economic Cooperation and Development. doi:10.1787/9789264278011-en
- OECD. (2020). *OECD Telecommunication and broadcasting review of Brazil*. Paris: Organisation for Economic Cooperation and Development. doi:10.1787/30ab8568-en
- OECD. (2021, February 24). *Recommendation of the OECD Council on Broadband Development*. Organisation for Economic Cooperation and Development: <https://www.oecd.org/digital/broadband/connectivity-for-all-oecd-recommendation-on-broadband-connectivity.htm#recommendation>
- PMG. (2019a, February 12). *Electronic Communications Amendment Bill: withdrawal, with Minister; Committee Legacy and Annual Reports*. Parliamentary Monitoring Group: <https://pmg.org.za/committee-meeting/27847/>
- PMG. (2019b, February 25). *Electronic Communications Amendment Bill (B31-2018)*. Parliamentary Monitoring Group: <https://pmg.org.za/bill/833/>
- PMG. (2021a, February 16). *Implementation of Broadcast Digital Migration policy; with Minister and Deputy Minister*. Parliamentary Monitoring Group: <https://pmg.org.za/committee-meeting/32263/>
- PMG. (2021b, March 10). *Ratification of World Radio Conference; with Deputy Minister*. Parliamentary Monitoring Group: <https://pmg.org.za/committee-meeting/32516/>
- Ramaphosa, C. (2021, February 11). *State of the Nation Address*. Parliament of South Africa: <https://www.parliament.gov.za/project-event-details/1283>
- Reuters. (2021a, March 6). *South African telecom regulator extends use of emergency radio frequency spectrum*. Reuters: <https://www.reuters.com/article/uk-safrica-spectrum-idUSKBN2BI2BU>
- Reuters. (2021b, April 27). *Ethiopia receives two bids for two telecoms operating licences*. Reuters: <https://www.reuters.com/world/africa/ethiopia-receives-two-bids-two-telecoms-operating-licences-2021-04-26/>
- RHC. (2021, April 25). *Regulatory Horizons Council (RHC)*. UK Government: <https://www.gov.uk/government/groups/regulatory-horizons-council-rhc>
- Rodríguez Ovejero, J. M. (2018). *The economic impact of the Internet of Things*. London: Frontier Economics. <http://www.frontier-economics.com/uk/en/news-and-articles/articles/article-i2352-the-economic-impact-of-the-internet-of-things/>
- SABC. (2019, April 29). *ICASA threatens legal action against Minister Ndabeni-Abrahams*. YouTube: <https://www.youtube.com/watch?v=3BvNXuyVrly>

- SABS. (2020). *SANS 862:2020 Set-top box decoder for free-to-air digital terrestrial television*. Groenkloof: South African Bureau of Standards. <https://store.sabs.co.za/sans-862-ed-3-00-1>
- Suwanprateep, D. (2019, September 27). *Thailand's NBTC Introduces Regulatory Sandbox*. Baker & McKenzie Limited: <https://www.bakermckenzie.com/en/insight/publications/2019/09/thailands-nbtc-introduces-regulatory-sandbox>
- Tamsons, Å. (2021, January 2021). *My IoT predictions for 2021: Smarter tech will make better business*. LM Ericsson: <https://www.ericsson.com/en/blog/2021/1/iot-predictions-2021>
- Telkom SA v ICASA, 66778/2020 [2021] 120 (High Court of South Africa, Gauteng Division, Pretoria (ZAGPPHC) March 8, 2021). <http://www.saflii.org/za/cases/ZAGPPHC/2021/120.html>
- Treasury. (2019). *Economic transformation, inclusive growth, and competitiveness: Towards an Economic Strategy for South Africa*. Pretoria: National Treasury. http://www.treasury.gov.za/comm_media/press/2019/Towards%20an%20Economic%20Strategy%20for%20SA.pdf
- UKRN. (2021, April 25). *UK Regulators Network*. UK Regulators Network: <https://www.ukrn.org.uk/>
- Warman, M. (2021, April 30). *Telecommunications (Security) Bill*. UK Parliament: <https://bills.parliament.uk/bills/2806>
- Wieland, K. (2020, July 14). *Vodafone makes candid open RAN admissions*. Vodafone Watch: <https://www.telcotitans.com/vodafonewatch/vodafone-makes-candid-open-ran-admissions/1875.article>
- Zhang, S. (2019). An overview of network slicing for 5G. *IEEE Wireless Communications*, 26(3), 111-117. doi:<https://doi.org/10.1109/MWC.2019.1800234>